

# Assessment of cardiac masses: magnetic resonance imaging versus transthoracic echocardiography

## Kardiyak kitleleri değerlendirmede manyetik rezonans ve transtorasik ekokardiyografinin karşılaştırılması

Burcu Narin, Alper Arman<sup>1</sup>, Deniz Arslan, Masum Şimşek, Ahmet Narin<sup>2</sup>

Department of Radiology, Haydarpaşa Numune Education and Research Hospital, İstanbul

<sup>1</sup>Department of Radiology, Euromed Visualization Center, İstanbul

<sup>2</sup>Department of Cardiology, Dr. Siyami Ersek Education and Research Hospital, İstanbul, Turkey

### ABSTRACT

**Objective:** The purpose of this study is to compare the role of magnetic resonance imaging (MRI) with transthoracic echocardiography (TTE) for characterization of cardiac masses.

**Methods:** Twenty-three patients were examined with a 1.5T MRI Scanner and TTE for the evaluation of suspected intracardiac masses. MRI examinations were performed with a protocol of steady cine imaging, HASTE and 3D IR-FLASH sequence after administration of gadolinium chelate. All patients were examined with MRI within a period of 1-2 weeks after TTE.

**Results:** According to the results of MRI, 15 patients underwent cardiac surgery. All of the operated patients were proven to have cardiac tumors with no false positive diagnosis on MRI. In 3 of 8 unoperated patients who were diagnosed to have cardiac tumors on TTE, cardiac thrombi were identified on MRI. Two patients with Eustachian valve in the right atrium on MRI were misinterpreted as having cardiac masses on TTE. In one patient with known renal cancer, metastases were diagnosed within the myocardium on MRI. TTE demonstrated a mass in the left atrium in one patient with a history of myxoma operation, whereas MRI was able to show the paracardiac extension of the mass into pulmonary veins and lung metastases, which are indicators of malignant transformation. In one patient, a mediastinal mass compressing the left atrium on MRI was misinterpreted as an intracavitary lesion with TTE.

**Conclusion:** Contrast enhanced MRI is a noninvasive method superior to TTE in diagnosis, differentiation, and detection of extension of cardiac masses. (*Anadolu Kardiyol Derg 2010; 10: 69-74*)

**Key words:** Transthoracic echocardiography, cardiac tumor, thrombus, pulmonary vein, magnetic resonance imaging, diagnostic value of tests

### ÖZET

**Amaç:** Bu çalışmanın amacı kardiyak kitleleri karakterize etmede transtorasik ekokardiyografi (TTE) ve manyetik rezonans (MR) tetkiklerini karşılaştırmaktır.

**Yöntemler:** Kardiyak kitle şüphesi olan 23 hasta TTE ve takiben 1.5 Tesla MR cihazı ile incelendi. Manyetik rezonans tetkiki *steady cine* incelemesi, HASTE, gadolinium verilmesini takiben 3D FLASH IR sekansları ile gerçekleştirildi. Transtorasik ekokardiyografiyi takiben 1-2 hafta içerisinde tüm hastalara MR tetkiki uygulandı.

**Bulgular:** Manyetik rezonans incelemesi sonuçlarına göre 15 hasta opere edildi. Tüm opere hastalarda kardiyak tümör saptandı ve MR incelemesine ait yalancı pozitif bulgu tespit edilmedi. Opere edilmeyen 8 hastanın 3'üne TTE'de kardiyak tümör tanısı konurken MR incelemesinde lezyonların trombüs oldukları belirlendi. İki hastada da ekokardiyografide sağ atriyumda kitle tarif edilirken lezyonların MR incelemesinde östaki kapakçığı olduğu izlendi. Renal hücreli kanser öyküsü olan bir hastada ise miyokardiyal metastazlar MR tetkiki ile görüldü. Miksoma hikâyesi olan bir hastada sol atriyumda kitle saptanırken MR incelemesinde kitlenin malign transformasyona işaret eden pulmoner venlere parakardiyak uzanımı ve akciğer metastazları tespit edildi. Bir hastada ise TTE'de izlenen sol atriyum kitlesinin sol atriyuma bası yapan mediastinal kitle olduğu görüldü.

**Sonuç:** Kontrastlı MR incelemesi kardiyak kitlelerin tanı, karakterizasyonu ve uzanımlarının saptanmasında TTE'ye göre üstün noninvazif görüntüleme yöntemidir. (*Anadolu Kardiyol Derg 2010; 10: 69-74*)

**Anahtar kelimeler:** Transtorasik ekokardiyografi, kardiyak tümör, trombüs, pulmoner ven, manyetik rezonans görüntüleme, testlerin tanısallık değeri

**Address for Correspondence/Yazışma Adresi:** Burcu Narin MD, Haydarpaşa Numune Education and Research Hospital, Department of Radiology, İstanbul, Turkey  
Phone: +90 216 542 20 20 E-mail: burcu\_narin@yahoo.com

**Accepted/Kabul Tarihi:** 09.12.2009

© Telif Hakkı 2010 AVES Yayıncılık Ltd. Şti. - Makale metnine [www.anakarder.com](http://www.anakarder.com) web sayfasından ulaşılabilir.

© Copyright 2010 by AVES Yayıncılık Ltd. - Available on-line at [www.anakarder.com](http://www.anakarder.com)

doi:10.5152/akd.2010.016

## Introduction

Primary cardiac tumors are rare, with an incidence of 0.001-0.003% in autopsy series (1, 2). Benign cardiac tumors are most common, accounting for 80% of all primary cardiac tumors. The most frequent benign cardiac neoplasm is myxoma, followed by lipoma, papillary fibroelastoma and hemangioma (3).

Transthoracic echocardiography (TTE) is the primary modality for imaging of cardiac tumors with high sensitivity and specificity (4). Two-dimensional (2D) echocardiography detects tumor sizes and exact localization, whereas Doppler technique is used to measure the flow of blood through heart chambers and assess hemodynamic effects of cardiac tumors such as valvular stenosis, insufficiency and blood flow value changes. Obesity, narrow rib spaces, and pulmonary diseases (emphysema or chronic obstructive pulmonary disease) limit the ability to obtain satisfactory images of heart chambers (2, 5, 6).

Magnetic resonance imaging (MRI) shows the localization of cardiac masses and also provides information on the extension of tumor within cardiac chambers and outside the heart, due to its wide field of view; including the pericardium, great vessels, adjacent mediastinal and pulmonary structures (1). Gated-cine-loop images show the pathophysiological effects of cardiac tumors on cardiac valves (5). Additionally, MRI permits increased specificity for the evaluation of tissue characteristics such as hemorrhage, calcification, cystic necrosis, which commonly present in the stroma of these tumors and helps to differentiate them from thrombi. Beyond tumor characterization, MRI confirms the diagnosis through the addition of contrast material, which helps to distinguish the tumor from the myocardium, thrombi and blood flow artifacts (5, 7).

In this study, TTE and MRI were compared in terms of the localization, characterization and extension of cardiac tumors.

## Methods

Twenty-three patients (12 men, 11 women; age range 7-81 years, median 58.8 years) who were diagnosed with cardiac tumor on TTE were enrolled in this study. Local ethical committee approval and informed consent were obtained. These patients were studied by cardiac gated MRI within a week of TTE for the comparison of two modalities. Records of all patients were reviewed retrospectively. Patients were referred to our institution because of symptoms including arrhythmia, angina pectoris, pulmonary embolism, arthralgia, weight loss and anemia.

Twelve patients were examined with 1.5 Tesla System MR Scanner (Philips Intera Achieva; Philips Medical Systems, Netherlands) with cardiac gated steady-state precession sequence (TR/TE/flip angle-3,5/1,7/60) with slice thickness of 8 mm. Eleven patients were examined with 1.5 Tesla scanner (Magnetom Sonata; Siemens Medical Solutions, Erlangen, Germany) with a protocol of steady-state precession sequence cine imaging (true FISP, TR 3 ms, TE 1.5 ms, FA 65 degrees) in standard short- and long-axis orientation, HASTE (half Fourier acquisition single shot turbo spin-echo; TR/TE/FA 700/23ms/160 degrees) and 3D

IR-FLASH sequence with fat suppression (TR 4 ms, TE 1.5 ms, FA 10 degrees; TI 300 ms) after administration of gadolinium chelate. Contrast-enhanced imaging was performed after administration of 0.2 mmol/kg gadolinium diethylene triamine pentaacetic acid (Magnevist; Schering, Berlin, Germany) with a flow rate of 2 mL/sec. The studies were electrocardiographically gated and all patients in this study were in sinus rhythm during examination.

Echocardiographic examination was performed in all study patients by using a commercially available system (Acuson Sequa S12 Machine with a 3-Mhz transducer, Siemens, Mountain View, CA, USA). Measurements were made during normal breathing at the end of expiration. Echocardiographic measurements were obtained on the basis of the standards of the American Society of Echocardiography. The localization and extension of cardiac tumors were noted and the sizes of tumors were measured.

## Statistical analysis

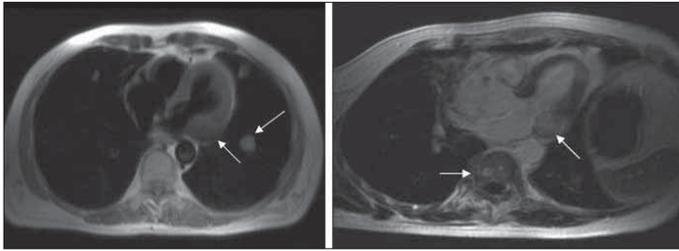
Statistical analysis was performed with NCCS 2007 & PASS 2008 Statistical Software (Utah, USA) using Mc Nemar test and Cohen Kappa test for comparison of the results of echocardiography and MRI findings with final diagnosis. The p values were regarded as significant when <0.05.

## Results

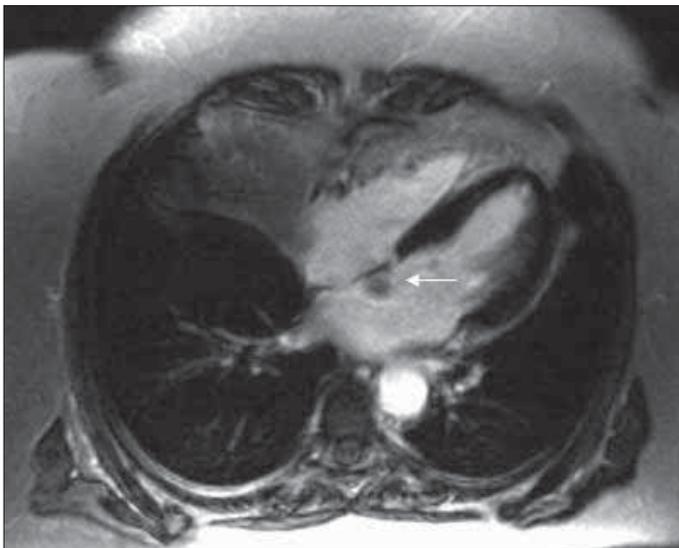
Cardiac masses cause various symptoms related to their size, localization and extension. Patients describe obstructive cardiac symptoms, constitutional symptoms or embolic events.

In our study, the most common clinical presentation was arrhythmia (ventricular tachycardia in one patient, atrial fibrillation in one patient, and atrial arrhythmia in seven patients). Nine patients with angina pectoris and two patients with a prior history of pulmonary embolism were found to have cardiac tumors on TTE. One patient with cardiac tumor presented with arthralgia, weight loss and anemia. Cardiac masses were also detected during routine follow-up examinations in one patient with renal cell cancer and in another one with aplastic anemia and paroxysmal nocturnal hemoglobinuria (Fig. 1a, b).

On both TTE and MRI, mass lesions were detected in the right atrium in 10 patients, in the left atrium in 2 patients and in the right ventricle in 1 patient. Tumors were found to be attached to the mitral valve in 5 patients, to the aortic valve in 2 patients and within the left ventricular myocardium in 1 patient (Fig. 2-5). MRI proved to supply diagnostic information in 2 patients with suboptimal echocardiography. TTE misdiagnosed thrombi in 3 patients and anatomic variations such as Eustachian valve in 2 patients as cardiac tumors. In one patient with known renal cancer, metastases were diagnosed within the myocardium on MRI, but not on TTE. A 46-year-old woman with a prior surgical history for myxoma of the left atrium demonstrated a huge mass (7x5 cm) in the left atrium on TTE. MRI showed extension to lateral and superior atrial walls as well as to pulmonary veins, thus causing occlusion, all of which were indicators of malignant transformation of the previously operated myxoma. One patient diagnosed with an intracavitary mass in the left atrium



**Figure 1.** Metastases within the myocardium in a 70-year-old man with renal cell cancer. An axial T1-weighted image (a) and axial T1-weighted gadolinium enhanced breath-hold FLASH sequence (b) show the peripheral contrast enhancement of the tumor, with a central low signal intensity area suggestive of necrosis. Moreover, lung and bone metastases are also identified (arrow)



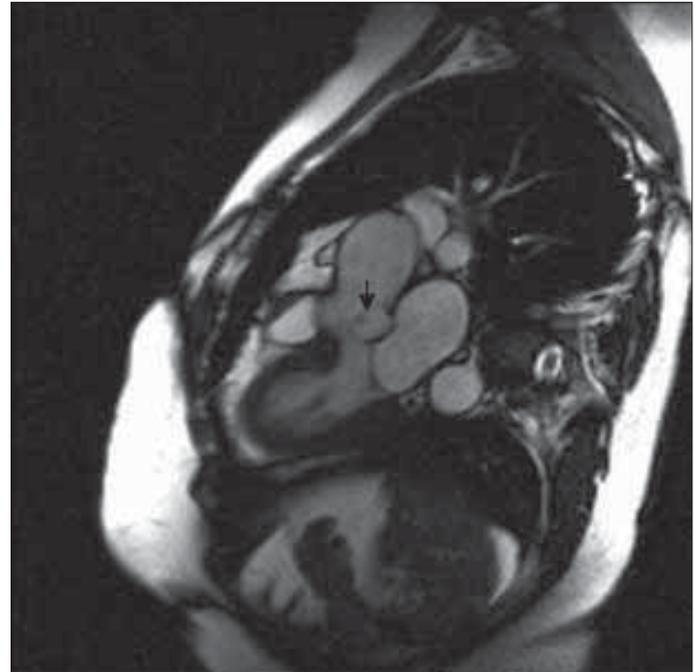
**Figure 2.** Left atrial myxoma in a 52-year-old woman with angina pectoris. Axial 3D IR-FLASH sequence (TR 4 ms, TE 1,5 ms, FA 10 degrees; TI 300 ms) gadolinium-enhanced MR image demonstrates an ovoid homogeneous mass attached to the interatrial septum of the left atrium

MR - magnetic resonance

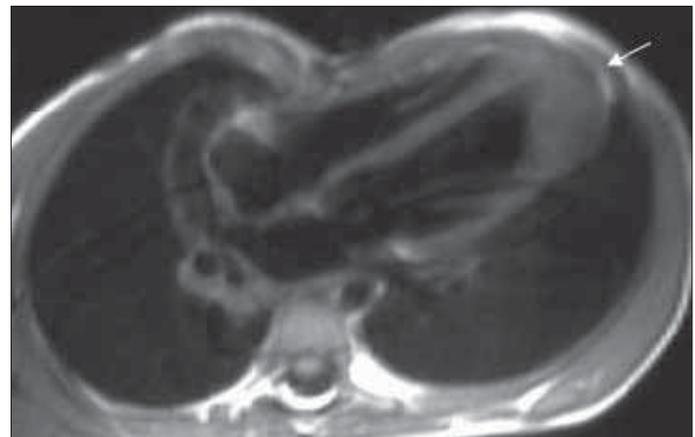


**Figure 3.** Right atrial myxoma in a 71-year-old man. Axial HASTE MR image demonstrates a 1.5 cm papillary mass connected to the right atrial wall, demonstrating similar to myocardium signal intensity

MR - magnetic resonance



**Figure 4.** Papillary fibroelastoma of the aortic valve. Coronal vertical long-axis TrueFISP image demonstrates a pediculated low signal intensity mass arising from the aortic surface of the aortic valve leaflet



**Figure 5.** Rhabdomyoma in a 7-year-old boy. Axial HASTE image shows homogeneous thickening of the myocardium of the left ventricular apex, with similar to the adjacent myocardium signal intensity

on TTE was shown to have an extracardiac tumor in the mediastinum with compression of the left atrium on MRI (Fig. 6). Table 1 summarizes TTE, MRI findings and final diagnoses of all patients.

Comparison of results of echocardiography and MRI in terms of the diagnosis of cardiac tumors demonstrated that the diagnostic value of MRI was significantly higher than of transthoracic echocardiography (65.2% by echocardiography, Mc-Nemar test: 0.008 and 100% by MRI Mc-Nemar test: 1.000; Cohen Kappa: 1.000).

## Discussion

In this study, results of MRI correlated with the pathological findings in all of the operated 15 patients. Transthoracic echocardiography depicted cardiac masses, whereas MRI was able to

**Table 1. Transthoracic echocardiography and MRI findings with final diagnosis of patients**

Patients	Echocardiographic findings	MRI findings	Final Diagnosis
1*	Myocardial mass in left ventricular apicolateral wall; 1.9x1.8 cm	Myocardial mass, 2.3x1.9 cm. Isointense relative to myocardium on T1 ve T2 weighted images, high homogeneous contrast enhancement	Rhabdomyoma
2,3*	Right atrial mass, 1 cm	Right atrial mass, 1 cm Hyperintense on T1 weighted images, not easily visible on T2 weighted images and reduction of signal intensity on fat suppressed T1 images, no contrast enhancement	Lipoma
4,5,6	Right atrial mass connected to right atrium inferior wall, 1 cm	Right atrial mass, 1 cm, located at the inferior right atrium wall extending to lateral wall Isointense to myocardium on T1 and T2 weighted images, isointense to myocardium after contrast administration	Eustachian valve
7-10*	Right atrial mass with narrow stalk to interatrial septum, 1 cm	Right atrial mass, 1 cm, connected to interatrial septum with thin peduncle Hypointense on T1 and hyperintense on T2 weighted images, contrast enhancement of tumor and peduncle	Myxoma
11	Left atrial mass, arising from lateral wall of left atrium, 7.5x4x5 cm	Left atrial mass, 7x4.5x5 cm, connected to interatrial septum with extension to lateral and superior wall and to pulmonary veins leading to occlusion. Heterogeneous signal intensity on T1 and T2 weighted images with heterogeneous contrast enhancement Additionally pulmonary metastases were detected	Myxoma with malignant transformation
12*	Left ventricular mass arising from the right aortic cusp by a short pedicle, 1 cm	Left ventricular mass , 1 cm, connected to aortic valve Isointense relative to myocardium on T1 and hyperintense on T2 weighted images, heterogeneous contrast enhancement	Aortic valve papillary fibroelastoma
13-17*	Mass arising from mitral valve, 1 cm	Left atrial mass attached to mitral valve, 1 cm Hypointense on T1 and hyperintense on T2 weighted images with heterogeneous contrast enhancement	Papillary fibroelastoma
18*	Left ventricular mass arising from aortic valve, 1 cm	Left ventricular mass, 1 cm, broad based, arising from aortic valve Hypointense on T1 and hyperintense on T2 weighted images with heterogeneous contrast enhancement	Papillary fibroelastoma
19	Myocardial mass, arising from apicolateral wall of LV, 4x3 cm	Myocardial mass of left ventricular wall, 4x3 cm Isointense relative to myocardium on T1 ve T2 weighted images, high homogeneous contrast enhancement Moreover lung and bone metastases were identified.	Metastases
20	Suspect of right atrial and right ventricular mass around tricuspid valve	Right atrial and right ventricular mass attached to tricuspid valve Isointense relative to myocardium on T1 and T2 weighted images, no contrast enhancement	Thrombus
21	Suspect of left atrial mass	Left atrial mass, 1 cm Hypointense to myocardium on T1 and T2 weighted images, no contrast enhancement	Thrombus
22	Right atrial mass in right atrium appendix, 3.2x2.5 cm	Right atrial mass, 3x2.5 cm Isointense to myocardium on T1 and T2 weighted images, no contrast enhancement	Thrombus
23*	Left atrial mass, 3.2x4 cm	Mass in anterior mediastinum with external compression to left atrium, 3x4 cm Isointense to myocardium on T1 and hyperintense on T2 weighted images, peripheric contrast enhancement with central necrosis	Hemangiopericytoma
MR- magnetic resonance Asterisk (*) indicates operated and pathologically proven cases			



**Figure 6. Mediastinal mass (Hemangiopericytoma) in 50 year-old man with angina pectoris. Coronal T1- weighted gadolinium enhanced images (TR 4 ms, TE 1,43 ms, FA 10 degrees, TI 300 ms) demonstrates a round mass in the anterior mediastinum with heterogeneous contrast enhancement and central necrosis**

characterize the tumors, including even suspicious masses and could differentiate thrombi as well as anatomic variations. In our study, transthoracic echocardiography misinterpreted a Eustachian valve as cardiac mass in one patient and was not able to differentiate thrombi from cardiac masses in 3 patients. Also in a patient with hemangiopericytoma located in the anterior mediastinum the mass was misinterpreted as tumor in the left atrium on TTE. Malignant transformation of atrial myxoma after operation in one patient was identified by MRI by demonstrating extension of the tumor to the lateral and superior walls of the left atrium and occlusive involvement of pulmonary veins.

2D echocardiography is a routine diagnostic method and plays a significant role in the detection of cardiac tumors, with a sensitivity and specificity of 90% and 95% respectively (8, 9). The sensitivity of 2D echocardiography is related to localization, size and sonographic acoustic properties of tumors (8). Shyu et al. (10) reported that TTE may incorrectly identify the fat accumulation on tricuspid valve, hypertrophic moderator band, artifacts around mitral annulus as cardiac masses. Left atrial appendage is difficult to evaluate adequately with echocardiography but it may be better assessed by MRI. Fusion of Eustachian valve may also be misinterpreted as a cardiac mass on TTE (8).

Myxomas are the most common primary cardiac neoplasms, comprising about half of cardiac tumors. Cardiac myxomas typically arise from the interatrial septum from a narrow base of attachment (11). The surface of myxomas is often covered with thrombi, causing a 20-45% incidence of systemic embolus (12).

MRI of myxomas provides the assessment in terms of size, localization and point of attachment of the tumor in multiple

planes, thus helps in planning of surgery. Myxomas often have a similar signal intensity relative to the myocardium on T1-weighted images and high signal intensity on T2-weighted images; however, various intensity patterns have also been described (13). Myxomas were the most frequent tumors in the current study. MRI characteristics were apparently adequate to diagnose the type of tumors in all cases.

Lipomas are the second most frequent benign cardiac tumors after myxomas. Cardiac lipomas are distributed throughout the heart in endocardial, myocardial, epicardial locations; although the majority appear to be subepicardial. At MRI, lipomas have homogeneous increased signal intensity on T1-weighted images that decreases with fat-saturated sequences (13).

Thrombi do not have a specific signal intensity on spin echo MR sequences (11). They usually tend to have a low signal intensity on T1- and T2-weighted images compared to most cardiac tumors which depict high signal intensity on T2-weighted images (4). Hyperacute thrombi show intermediate signal intensity which limit tumor differentiation (14). Thrombi may be differentiated from myxomas since they do not show contrast enhancement (15). In our study all thrombi were interpreted as mass lesions on echocardiography, however on MRI examination diagnoses were relevant as the lesions did not enhance after contrast administration.

Sarcomas are the second most common primary cardiac tumors after myxomas and are encountered in adults with a mean age of 40 years (5). The most common type of sarcomas are angiosarcomas, frequently involving the right atrium. Other sarcoma types are undifferentiated sarcomas, malignant fibrous histiocytoma and leiomyosarcoma affecting the left atrium (4). These tumors are diagnosed on MRI as heterogeneous invasive masses with hemorrhage, necrosis, valvular destruction, extra-cardiac invasion and metastases.

Another cardiac tumor type causing embolic events is papillary elastoma accounting for 75% of valvular tumors. Papillary fibroelastomas occur in elderly patients (age range 60±16 years) and reach sizes of 9±4 mm over the cardiac valves (16, 17). Embolic events may not originate from the tumor itself but from thrombi accumulating on the tumor mass (2).

Excluding myxomas, a lesion in the right side of the heart is always suspicious of malignancy. Metastases via transvenous invasion are 20-40 times more common than primary malignant cardiac tumors (14). Beyond hematogenous spread, lymphatic or direct continuous extension to the myocardium or pericardium may also occur. Melanoma has the highest frequency of metastases to the heart of any neoplasm followed by malignant germ cell tumor, leukemia, lymphoma, cancer of the lung and the various sarcomas (18).

Arrhythmia is the most frequent complaint caused by metastatic tumors and suggests involvement of the myocardium, just as it was the case for our patient with renal cell carcinoma.

Lymphomas have a very high frequency of metastases to the heart. Nearly 25% of patients with disseminated lymphoma have cardiac metastases, while primary cardiac lymphoma is very rare.

Typically lymphomas infiltrate the myocardium and pericardium. At MRI they are isointense relative to the myocardium on T1 weighted images and isointense-heterogeneously hyperintense on T2-weighted images; they demonstrate heterogeneous enhancement after administration of gadolinium contrast material (5).

In infants and children, rhabdomyomas should be considered when myocardium thickening is observed. These tumors have a similar signal intensity relative to normal myocardium on T1- and T2-weighted images (5). Spontaneous regression of rhabdomyomas has been reported in 60-100 cases under age 4 (19-21). Cardiac fibromas are the most common benign primary cardiac tumors after rhabdomyoma. Because of their dense, fibrous nature, fibromas appear as isointense or hypointense masses on T1-weighted images and homogeneous, hypointense on T2-weighted images (22).

The first diagnostic tool for cardiac masses is TTE, which is an efficient method to show the localization, size, extension, hemodynamic effects and vascularization of cardiac tumors. Differentiation of cardiac tumors from thrombi on echocardiography is not always possible (23). MRI provides diagnosis of tumors and their types and also differentiates thrombi. Rarely, mediastinal masses may also be misdiagnosed as cardiac tumors due to external compression of cardiac walls. MRI provided more information compared to echocardiography concerning multiplanar and non-invasive evaluation of cardiac masses, together with their extension to mediastinal structures (24-27).

### Study limitations

There are some limitations of this study. Cardiac MRI can depict false-negative or false-positive findings without prior knowledge of the echocardiography results. Respiratory artifacts and frequent arrhythmias result in a lower quality of image. Our study revealed that MRI of cardiac tumors helps us to classify the type of tumors. However, this study has limited number of patients and should be evaluated with larger clinical trials.

### Conclusion

In conclusion, although the diagnosis of cardiac tumors relies on transthoracic echocardiography, MRI provides significant data for the diagnosis of cardiac tumors with its superior structural definition as well as its ability to delineate tumor extent and its relationship to adjacent organs. Contrast-enhanced dynamic imaging further supports the diagnosis.

**Conflict of interest:** None declared

### References

- Kalra MK, Abbara S. Imaging cardiac tumors. *Cancer Treat Res* 2008; 143:177-96.
- Basso C, Bottio T, Valente M, Bonato R, Casarotto D, Thiene G. Primary cardiac valve tumors. *Heart* 2003; 89:1259-60.
- Yopp AC, Vaynblat M, Cunningham JN, Lazzaro RS. Cardiac valve papillary fibroelastoma: surgical excision for revealed or potential embolisation. *J Card Surg* 2007; 22: 72-3.
- Gulati G, Sharma S, Kothari SS, Juneja R, Saxena A and Talwar KK. Comparison of echo and MRI in the imaging evaluation of intracardiac masses. *Cardiovasc Intervent Radiol* 2004; 27: 459-69.
- Grebenc ML, Rosado de Christenson ML, Burke AP, Green CE and Galvin JR. Primary cardiac and pericardiac neoplasms: Radiologic-pathologic correlation. *Radiographics* 2000; 20: 1073-103.
- Go RT, O' Donnell JK, Underwood DA, Feiglin DH, Salcedo EE, Pantoja M, et al. Comparison of gated cardiac MRI and 2D echocardiography of intracardiac neoplasms. *AJR Am J Roentgenol* 1985; 145: 21-5.
- Barkhausen J, Hunold P, Eggebrecht H, Schuler WO, Sabin GV, Erbel R, et al. Detection and characterisation of intracardiac thrombi on MR imaging. *AJR Am J Roentgenol* 2002; 179:1539-44.
- Mügge A, Daniel WG, Haverich A and Lichtlen PR. Diagnosis of noninfective cardiac mass lesions by two-dimensional echocardiography. *Circulation* 1991; 83: 70-8.
- Rienmüller R, Lirot JL, Tiling R, Groh J, Manert W, Müller KD, et al. MR imaging of pediatric cardiac tumors previously diagnosed by echocardiography. *J Comput Assist Tomogr* 1989; 13: 621-6.
- Shyu K-G, Chen J-J, Cheng J-J, Hwang J-J, Kuan P and Lien W-P. Comparison of transthoracic and transesophageal echocardiography in the diagnosis of intracardiac tumors in adults. *J Clin Ultrasound* 1994; 22:381-9.
- Kim EY, Choe YH, Sung K, Park SW, Kim JH, Ko YH. Multidetector CT and MR imaging of cardiac tumors. *Korean J Radiol* 2009; 10: 164-75.
- AP, Virmani R. Cardiac Myxoma *Am J Clin Pathol*. 1992; 100: 671-80.
- Sparrow PJ, Kurian JB, Jones TR, Sivananthan MV. MR imaging of cardiac tumors. *Radiographics* 2005; 1255-76.
- Paydarfar D, Krieger D, Dib N, Blair RH, Pastore JO, Stetz JJ Jr, et al. In vivo magnetic resonance imaging and surgical histopathology of intracardiac masses: distinct features of subacute thrombi. *Cardiology* 2001; 95: 40-7.
- Hoffmann U, Globits S, Schima W, Loewe C, Puig S, Oberhuber G, et al. Usefulness of magnetic resonance imaging of cardiac and paracardiac masses. *Am J Cardiol* 2003; 92: 890-5.
- Goeda RM, Khan IA, Nair CK, Mehta NJ, Vasavada BC and Scchi TJ. Cardiac papillary fibroelastoma: A comprehensive analysis of 725 cases. *Am Heart J* 2003; 146: 404-10
- Sun JP, Asher CR, Yang XS, Cheng GG, Scalia GM, Mased AG, et al. Clinical and echocardiographic characteristics of papillary fibroelastoma. *Circulation* 2001; 103: 2687-93.
- Chiles C, Woodard PK, Gutierrez FR and Links KM. Metastatic involvement of the heart and pericardium: CT and MR findings. *Radiographics* 2001; 21: 439.
- Beghetti M, Gow RM, Haney I, Mawson J, Williams WG, Freedom RM. Pediatric primary benign cardiac tumors: A 15-year old review. *Am Heart J* 1997; 134: 1107-14.
- Umeoka S, Koyama T, Miki Y, Akai M, Tsutsui K, Togashi K. Pictorial review of tuberous sclerosis in various organs. *Radiographics* 2008; 28: e32.
- Kivelity DE, Muhler M, Rake A, Scheer and Chaoui R. MRI of cardiac rhabdomyoma in the fetus. *Eur Radiol* 2006; 16:1858-9.
- Araoz PA, Muluagh SL, Tazelaar HD, Julsrud PR, Bren JF. CT and MR imaging of benign primary cardiac neoplasms with echocardiographic correlation. *Radiographics* 2000; 20: 1303-19.
- Karpuz V, İktimur B, Karpuz H. Kalp tümörlerine genel bakış: Klinik ve ekokardiyografik yaklaşım. *Anadolu Kardiyol Derg* 2007; 7: 427-35.
- Baerman JM, Hogan L, Swiryn S. Diaphragmatic hernie producing symptoms and signs of a left atrial mass. *Am Heart J* 1988; 116: 198-200.
- Nishimura RA, Tajik AJ, Schattenberg TT, Seward JB. Diaphragmatic hernia mimicking an atrial mass: A two-dimensional echocardiographic pitfall. *J Am Col Cardiol* 1987; 5: 992-5.
- Manisalı M, Yılmaz E. Kardiyak tümörlerin MRG ile incelenmesi. Tanı ve Girişimsel Radyoloji 2001; 7: 220-4.
- Winkler M, Higgins CB. Suspected intracardiac masses: evaluation with MR imaging. *Radiology* 1987; 165:117-22.