

## THE ROLE OF CMR IMAGING FOR THE DIFFERENTIAL DIAGNOSIS OF RIGHT-SIDED INTRACARDIAC MASSES: A CASE REPORT

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**Key words:** intracardiac masses, intracardiac thrombus, cardiovascular magnetic resonance imaging, transthoracic echocardiography, transesophageal echocardiography, *crista terminalis*, lung adenocarcinoma, pulmonary embolism, thrombosis.

### Summary

Materials and methods: intracardiac masses are described as abnormal structures inside the heart or immediately concerned to the heart [1] and can be classified as a cardiac tumor, metastasis, „*thrombus in situ*“, „*embolus in transit*“, vegetation or iatrogenic material [2, 3]. The precise diagnosis is essential due to the necessity of the expedient well-timed treatment. We report a case of 58 year old woman with recently diagnosed left lung adenocarcinoma, admitted to the emergency department with pulmonary embolism. The case report presented here describes the findings of transthoracic echocardiography that suggested a right atrial mass – thrombus versus embolus. However, the subsequent CMR imaging helped to differentiate a true right atrial mass from a prominent *crista terminalis*.

Conclusions: the cardiovascular magnetic resonance imaging is a valuable diagnostic method for the differentiation of the intracardiac masses when the transthoracic and/or transesophageal echocardiography is inadequate in some clinical cases. This noninvasive, cost-effective imaging technique has a larger field of view and differentiates various conditions of the heart therefore the expedient well-timed treatment could be applied.

### Introduction

Intracardiac masses are described as abnormal structures inside the heart or immediately concerned to the heart [1] and can be classified as a cardiac tumor, metastasis,

„*thrombus in situ*“, „*embolus in transit*“, vegetation or iatrogenic material [2, 3]. The precise diagnosis is essential due to the necessity of the expedient well-timed treatment in most of clinical cases [2, 4, 30]. Although the transesophageal echocardiography has been shown to be a superior diagnostic method for the identification of the intracardiac mass, both transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) are the most commonly applied diagnostic tools. They provide the good accuracy, relatively low costs and rapid evaluation of the tentative diagnosis which can indicate the prompt life-saving treatment in some clinical cases [2, 3, 5-7, 30]. Z. Kucukdurmaz et al. presented a case of snake-like thrombus in the right side of the heart which caused the massive pulmonary embolism, due to which the patient underwent the embolectomy and died at the early postoperative period because of the cardiopulmonary arrest [5]. The case signified the necessity of the rapid diagnose and timely treatment at such status. Nevertheless, the identification of the cardiac mass using the TTE or TEE for some groups of patients is complicated and the risk of misdiagnosis is higher due to the adjacent pathology that has already been diagnosed [8, 10, 11]. Several studies have shown that patients with recently diagnosed oncological process are at higher risk of the metastatic heart disease [11] and 15 % of the patients with any type of cancer may present with cardiac metastases [10]. On the other hand, although the exact pathogenetic mechanisms of the hypercoagulability in oncology remain obscure, there are evidences that patients with a history of oncological process are at higher risk of the right-sided thromboembolism and its related complications [12-14]. In addition, masses inside the heart detected by echocardiography usually require further precise investigation in order to separate the artefacts and innocent anatomic structures from the true cardiac masses. Consequently, the differential diagnosis between tumor, metastasis, thrombi/embolus and normal cardiac structures is essenti-

al for patients with cancer. At this point of view, the TTE or TEE becomes the limited diagnostic tool because of the incapacity to visualize the tissue composition whereas the cardiovascular magnetic resonance (CMR) imaging is highly valuable diagnostic method in the assessment of cardiac masses due to its larger field of view of both intracardiac and extracardiac structures, the multiplanar 3-dimensional imaging with the excellent spatial resolution and the opportunity to discriminate various tissue types based on the CMR properties [15-18]. Moreover, W. Staab et al. recommended to apply CMR as the first line imaging tool to detect or to rule out intracardiac masses and thrombi in specific clinical cases [18]. The case report presented here describes the findings of TTE that suggested a right atrial mass – thrombus versus embolus - in the patient with pulmonary embolism and recently diagnosed lung cancer. However, the subsequent CMR imaging helped to differentiate a true right atrial mass from a prominent *crista terminalis*.

**The aim this study:** to demonstrate the role of cardiovascular magnetic resonance imaging for the differential diagnosis of right-sided intracardiac masses.

#### Clinical case report

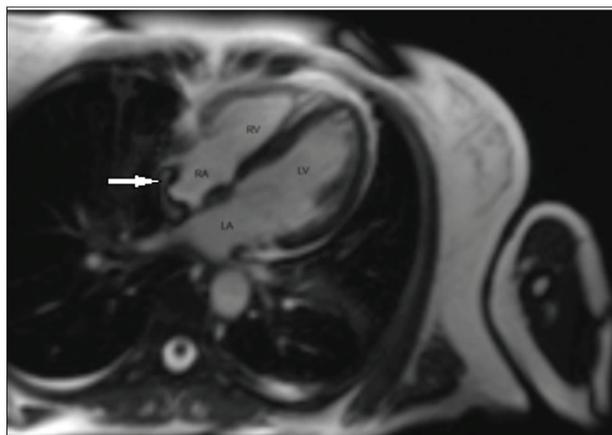
A 58-year-old female with recently diagnosed left lung adenocarcinoma presented with a two week history of an increasing shortness of breath and the pain of the both calves for the last two days before the admission to the emergency department. The patient underwent the total hysterectomy due to the granulosa cell tumor of the ovary in 1999. At her age of 57 years, an adenocarcinoma in the lower lobe of her left lung was diagnosed. The patient underwent the surgical treatment of the cancer and the course of the chemotherapy afterwards. Despite the applied treatment, the illness has been in progress. The CT scan of the chest detected the multiple metastases in the supraclavicular, mediastinal and hilar lymph nodes and in the spinal bones (the greatest in Th 9 vertebra). Because of the deteriorating status, which was combined with an increasing shortness of breath for the two weeks, the patient was admitted to the emergency department. The physical examination revealed no obvious signs about the etiology of the dyspnea. Her heart rate was 100/bpm and the blood pressure was 100/70 mmHg. The blood clotting tests revealed the disbalance of the coagulation process: the level of D-dimer was 26100 mkg/l. A coincidental TTE in apical four-chamber view depicted the multiple non-homogenic non-mobile round masses in the right atrium, filling more than 50 percent of the capacity of the right atrium, mimicking a thrombus or a tumor without the increased pressure of the inferior vena cava. Performed CT angiography revealed the findings consistent with the

massive pulmonary embolism of both pulmonary arteries. The lower limbs venous ultrasonography was performed in order to find out the origin of the thromboembolism and the deep vein thrombosis of the right calf was diagnosed. The patient underwent the anticoagulation therapy with the low-molecular weight heparin (LMWH) and vitamin K antagonists. The CMR was applied for the differential diagnosis of the intracardiac masses because of being incapable to deny a tumor or metastasis as the lung neoplasms frequently metastasize to the heart [34]. The short-axis cine images demonstrated the normal left ventricular size and function. The regional wall motion was normal as well. The right ventricular size and function also appeared without abnormalities. The morphologic images, obtained in the second row, demonstrated no definite cardiac mass that was suggested by TTE. The images of the 4-chamber projection demonstrated a linear stranding of the smooth muscular ridge, identified as a prominent *crista terminalis* on a posterolateral wall of the right atrium (Figure 1), extending between the opening of the superior and inferior vena cava in a craniocaudal direction. The images, obtained with late gadolinium enhancement, showed no evidence of fibrosis/necrosis, and no additional masses were detected (Figure 3, 4).

#### Discussion

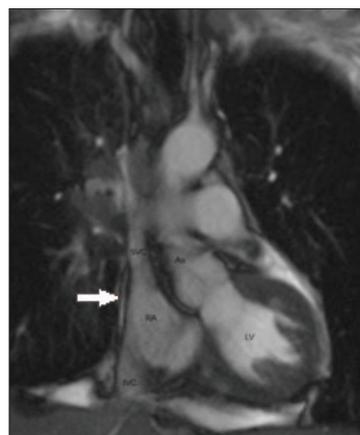
In clinical practice, the TTE and/or TEE play the major role for the identification of an intracardiac mass [2, 3, 5-7]. Unfortunately, some groups of patients require the detailed and precise examination of a cardiac mass because of the adjacent pathology that has recently been diagnosed, thus making the basic echocardiography (TTE or TEE) a limited diagnostic procedure due to its visualization technique based on the anatomical appearance of the cardiac mass (the location, size and mobility) whereas the tissue composition is prior in these cases [8, 10, 11].

Mostly the thrombogenesis occurs in the left side of the heart due to the atrial fibrillation or the aneurysm which has been formed after the acute myocardial infarction [2, 7, 19]. The formation of thrombi in the right side of the heart is rare and more presumable source could be „thrombi in transit” from peripheral veins that could embolize and lodge in the mechanism of the tricuspid or pulmonary valves or right ventricular trabeculations during the pathway from the veins toward to the pulmonary arteries [3, 5]. Although a lower limbs venous ultrasonography or a CT angiography of the pulmonary arteries remain the main screening tests for the thrombosis or thromboembolism [9], due to the frequent asymptomatic appearance of the thrombotic disease, the accidental TTE increasingly becomes the prime diagnostic tool for the detection of the hypercoagu-

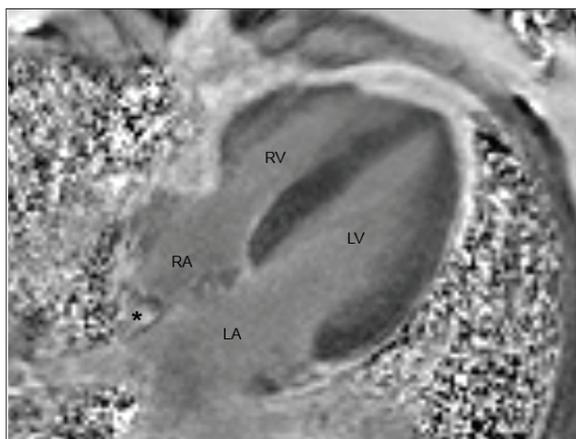


**Figure 1**

ECG-gated CMR imaging cine gradient-echo 4-chamber view (Figure 1) and cine gradient-echo small field-of-view targeted to the right atrium and inferior and superior vena cava (Figure 2) demonstrate the prominent *crista terminalis* (arrow), extending from the inferior vena cava into the right atrium and to the opening of the superior vena cava without any definite mass in the right atrium.

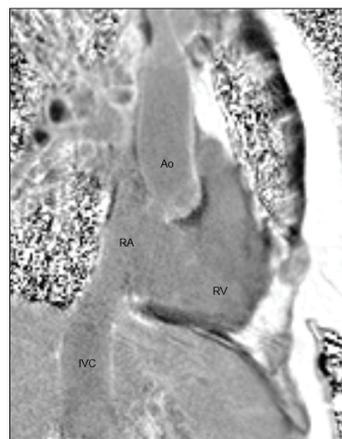


**Figure 2**



**Figure 3**

Late gadolinium enhancement images show no evidence of mass or fibrosis/necrosis. Note of the enhancement in prominent fibromuscular ridge (\*), representing fibrous connective tissue in *crista terminalis* on a posterolateral wall of the right atrium.



**Figure 4**

lable state, especially for chronic patients whose clinical status require permanent routine observation of the heart function [2]. Thus, the routine TTE or TEE detects such thrombotic masses of the heart. Nevertheless, the risk of misdiagnosis remains while using these methods due to the several reasons. Firstly, the detection of thrombus in the chambers of the heart by echocardiography can be difficult as thrombus is not usually adhered to the typical structure of the heart chamber (mainly typical locations are the auricles of the right or left atrium) and its motion may be highly erratic [8]. For instance, the thrombus, which has been formed due to the potential endothelial injury or em-

bolus from deep veins, may develop or lodge at the site of patent foramen ovale thus making it difficult to discriminate between the clot and tumor such as a myxoma which stalk is attached to the interatrial septum. Moreover, the lesion, such as myxoid material, may contain thrombus, necrotic, cystic, calcified masses and areas of hemorrhage that make it almost impossible to distinguish one from another by using only the TTE or TEE [20]. Secondly, the potential false positive results may be because of the ultrasound artifacts, such as the clutter of the near field (it could be difficult to visualize the apical abnormalities because the native tissue harmonic echocardiography is weak at the

near field), the reverberations or the side-lobe artifact [18, 21]. Thirdly, some normal cardiac structures may be confused with the cardiac masses, such as the *Eustacian valve*, *crista terminalis*, *Chiari network* or pectinate muscles. At these points of view, the differential diagnosis of the intracardiac masses, which include thrombus, vegetations, tumor or metastases, becomes complicated by using only basic TTE or TEE.

The clinical case presented in this report describes the detailed investigation of the intracardiac masses and timely and adequate treatment that was applied to a patient with a history of cancer. Patients with recently diagnosed oncological process are at higher risk of the metastatic disease [11] to the heart which is more common than primary cardiac neoplasia [34] and 15% of the patients with any type of cancer may present with cardiac metastases [10], which can occur through the direct invasion (lung or breast cancer), lymphatic (lymphomas or melanomas) and hematogenous (renal cell carcinoma) spread [10, 11, 34]. On the other hand, the hypercoagulable states, resulting in the venous thrombosis, the right heart and/or pulmonary thromboembolism, remain the significant causes of the morbidity and mortality for patients with cancer [12, 13, 23, 24]. Furthermore, some publications maintain that the thrombosis or thromboembolism, especially when unprovoked, may declare a diagnosis of the cancer in a subset of patients without known malignancy and sometimes is called as the primary face of the cancer [25, 26]. Although the exact pathogenetic mechanisms of the hypercoagulability in oncology remain obscure, there are obvious evidences that this type of patients have a wide variety of risk factors for the formation of the thrombus or migration of the embolus in the circulation through the right-side of the heart. The risk factors include the main oncological pathology with its pathogenic mechanisms that have a contagious cohesion with hypercoagulable states (the interaction of monocytes and macrophages with malignant cells, the production of the pro-coagulants or other substances as sialic acid from mucine in tumor cells), the applicable treatment (chemotherapy, surgery), a bed rest due to the critical condition or even the medical implements such as central venous catheters, commonly used in clinical practice, especially for patients with oncological process [13, 24]. Alkindi et al. presented the case of the catheter-related right atrial thrombosis in a patient with the history of cancer, treated by chemotherapy, and determined its related factors that could predispose the hypercoagulable state while using these medical implements [2]. Thus, due to the possibility of having both conditions (the hypercoagulable state and the progression of the malignant disease), the risk of mis-

diagnosis using the TTE and/or TEE increases in patients with cancer because of the inability to describe tissue composition or provide definitive etiology of the mass (tumor versus thrombus) while using these techniques. At this condition, the TTE and /or TEE, with good accuracy and relatively low costs, remain only prime diagnostic tools for the rapid differential diagnosis which can lead to or eliminate the necessity for the expensive and more specific diagnostic methods. The CMR imaging could take the first place in the differentiation of the intracardiac masses, when the TTE and/or TEE methods are inadequate [18]. This noninvasive, cost-effective imaging technique has a larger field of view and differentiates various conditions of the heart due to the ability to visualize tissue composition, to assess flow measurements, cardiac function, stress and rest perfusion of the heart, applying the early and late gadolinium enhancement and new developments as T1/T2 mapping [15-18]. Discussing about patients with a history of cancer, the CMR imaging has major advantages in distinguishing tumors from thrombi because of the opportunity to assess the perfusion of the mass, which is the component of the neoplastic lesions and enhances after gadolinium contrast application whereas the hematic thrombi has no vascular appearance [27]. Although the metastases do not have the specific appearance on the CMR, the accurate evaluation is capable due to the different signal intensity on T1 or T2 weight sequences and post-contrast enhancement. Furthermore, the signal intensity varies according to the "age" of the thrombi due to the phase of the hemoglobin degradation, thus making it possible to recognize the appearance and features of thrombus (the composition and chronicity), consequently the anticoagulation therapy or the other treatment can be applied promptly [4, 17, 28, 30]. As concerns the visualization of the heart structural features, the CMR is capable of acquisition of the precise cardiac and extracardiac anatomic views, thus making it possible to exclude or assess normal or abnormal structures which may be compound to tumor or thrombus [15, 19].

The right atrial pseudomasses are fairly common sources of confusion in echocardiography and should not be mistaken with a cardiac mass or thrombus. Common structures, that may mimic or raise the concern of true cardiac tumors because of incomplete coverage or visualization include prominent *Eustachian valves*, *Chiari network*, *crista terminalis*, lipomatous interatrial septum, pericardial cysts, and large hiatal hernias [32]. Most of these pseudocardiac tumors are incompletely categorized on other noninvasive cardiac imaging studies. In patients with cardiac masses, CMR can be applied to characterize tissue within the mass [33]. Consequently, an understanding of

the anatomy and the proper identification of physiological structures in the right atrium on TTE or CMR imaging can allow avoiding the misdiagnosis and unnecessary additional tests. For instance, nodular thickening or linear stranding of the posterior right atrial wall is a common finding on majority of CMR imaging studies and may resemble a mass lesion [30]. Anatomically this nodular thickening corresponds to the *crista terminalis*, which marks the embryological division between the portion of the right atrium that is derived from the sinus venosus, i.e., smooth-walled sinus venarum, and the embryonic atrium, i.e., trabeculated atrium proper and auriculum. The *crista terminalis* is a prominent muscular ridge which extends along the posterolateral aspect of the right atrium between the orifices of the superior and inferior venae cavae. Inferiorly, it merges with the valve of the inferior vena cava (*Eustachian valve*) and the valve of the coronary sinus (*Thebesian valve*). In addition, strand-like fibrous structures, known as the Chiari network, may arise from the region of the inferior *crista terminalis* and/or *Eustachian valve* and extend into the right atrial chamber. These structures of the variable prominence, have a similar signal intensity to myocardial tissue and are routinely observed on CMR imaging, therefore should not be mistaken with neoplasms, thrombosis or inflammation [31]. The *crista terminalis*, presented in this case report, is the example of a pseudomass that can be mistaken for a right atrial lesion. Due to the great variety of image planes and excellent ability to distinguish tissue types, CMR imaging allows to identify the presence of intracardiac masses, to assess accurately the exact position and extension of fibromuscular prominent structures and to make a differential diagnosis between neoplasms and variant anatomic structures.

Despite the fact that CMR imaging is generally considered to be a safe and expedient diagnostic method in clinical practice, some disadvantages of this technique cannot be denied. The CMR can not replace the TTE or TEE in cases while the patient has undergone the implantation of CMR incompatible metallic devices, such as heart pacemaker or pacing wires. Moreover, the claustrophobia or obesity may technically limit the ability to apply this diagnostic procedure [29]. What is more, the safety issues, related to underlying renal function, have to be concerned prior to administration of gadolinium contrast agent.

Nevertheless, the advantages of CMR outweigh the disadvantages in many clinical cases. The obvious benefit of CMR has been demonstrated in this report.

## Conclusions

The CMR imaging is a valuable diagnostic method for the differentiation of the intracardiac masses when the transthoracic and/or transesophageal echocardiography is inadequate in some clinical cases. This noninvasive, cost-effective imaging technique has a larger field of view and differentiates various conditions of the heart that the expedient well-timed treatment could be applied.

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**ŠIRDIES IR STAMBIŪJŲ KRAUJAGYSLIŲ  
MAGNETINIO REZONANSO REIKŠMĖ  
INTRAKARDINIŲ MASIŲ DIFERENCINEI  
DIAGNOSTIKAI: KLINIKINIS ATVEJIS  
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Raktažodžiai: intrakardiniai dariniai, intrakardinis trombas, širdies ir stambiųjų kraujagyslių magnetinis rezonansas, transtorakalinė echokardioskopija, transezofaginė echokardioskopija, *crista terminalis*, plaučių adenokarcinoma, plaučių arterijos trombinė embolija, trombozė

Saotrauka

Tikslas: įvertinti širdies ir stambiųjų kraujagyslių magnetinio rezonanso tyrimo reikšmę, diferencijuojant intrakardinius darinius.

Metodas ir tyrimo medžiaga: intrakardiniai dariniai yra apibūdinami kaip atipiniai dariniai, nustatomi širdies ertmėse ar glaudžiai susiję su širdimi [1], ir gali būti skirstomi į širdies navikus, tolimąsias metastazes, trombus/embolus, vegetacijas ar įatrogenines medžiagas [2, 3]. Tiksli diagnozė yra būtina, siekiant užtikrinti racionalų ir nepavėluotą gydymą. Pristatomas 58 m. amžiaus pacientės, kuriai diagnozuota kairio plaučio adenokarcinoma ir plaučių arterijos trombinė embolija, klinikinis atvejis. Transtorakalinės echokardioskopijos metu pacientei nustatyti intrakardiniai dariniai dešiniajame prieširdyje, įtariant trombus ar embolus širdies ertmėse. Tačiau atliktas širdies ir stambiųjų kraujagyslių magnetinio rezonanso tyrimas leido diferencijuoti intrakardinius darinius ir anatominę širdies struktūrą - *crista terminalis*.

Išvados: širdies ir stambiųjų kraujagyslių magnetinio rezonanso tyrimas yra vertingas metodas, diferencijuojant intrakardinius darinius, kuomet transtorakalinė ir/ar transezofaginė echokardioskopija yra neisavertis tyrimas tam tikrais klinikiniais atvejais. Atsižvelgiant į tyrimo kainos ir naudos santykį bei galimybę gauti plataus spektro vaizdus, šis neinvazinis diagnostinis tyrimas leidžia diferencijuoti daugybę kardiologinių būklių, siekiant racionalaus ir savalaikio gydymo.

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