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# Cardiac MRI-based multi-modality imaging in clinical decision-making: Preliminary assessment of a management algorithm for patients with suspected cardiac mass

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ABSTRACT

*Background:* Cardiac masses are rare with high morbidity and mortality that challenging the management. The purpose of this study was to evaluate the potential role of cardiac-MRI based multi-modality imaging in the clinical decision-making for patients with cardiac mass.

*Methods:* From November 2011 to May 2014, 59 consecutive patients (33 females; mean age, 48.2 ± 21.1 [range, 0.6–85] years) with suspected cardiac mass were enrolled in this prospective single center study, underwent MRI based multi-modality imaging and were followed up for survival status. Management strategy (surgery, chemotherapy or observation) was based on patient's clinical status and cardiac mass imaging characteristics (location, morphology, hemodynamics, embolization risk, metastasis, and resectability).

*Results:* Using cardiac MRI, 39 patients were diagnosed with intra-cardiac neoplasm (28 benign, 11 malignant) and 20 with pseudo-tumors (13 thrombi, 4 cysts and 3 fat infiltration); 34 masses (23 neoplasms, 11 pseudo-tumors) were eligible for surgical removal, and 4 underwent PET-CT scan to further delineate characteristics and metastasis. Pathological examination revealed high accuracy of cardiac MRI in differentiating benign from malignant tumors (96%), and neoplasm from pseudo-tumors (100%). As for the 16 patients with cardiac neoplasm not surgically treated, the 9 with "benign" masses as per MRI-based multimodality imaging survived during follow-up, while all 7 with "malignancy" died; the 9 with pseudo-tumors not surgically treated also survived with good condition. The median follow-up period is 2 years (10 days–3 years).

*Conclusion:* Cardiac MRI based multimodality imaging appears useful for risk stratification and clinical decision making for patients with suspected cardiac mass.



## 1. Introduction

Cardiac masses, which are relatively rare with high morbidity and mortality [1–3], require multidisciplinary management based on mass (nature, type, location, invasiveness, metastatic spread, and embolism risk) and patient (age and hemodynamic status) characteristics [1,2]. Differential diagnosis of cardiac masses is broad and encompasses distinguishing between neoplastic and non-neoplastic, and further between benign and malignant masses [1–3]. Among imaging modalities currently used in the diagnosis and evaluation of patients with cardiac mass [4–8], echocardiography is preferred for initial cardiac mass evaluation but limited by poor acoustic window in some patients and no tissue characterization [8]; cardiac MRI, considered as primary modality, allows for high spatial resolution and multi-planar imaging comprehensively characterizing mass morphology, tissue and blood perfusion [4–6]; while PET-CT, using an $^{18}$F-FDG-contrast agent allows molecular imaging of tumor metabolism, and at the expense of radiation exposure, could facilitate noninvasive preoperative determination of malignancy and metastases [7]. Because of limited clinical evidence and lack of standardized algorithm, this study evaluated cardiac MRI-based multimodality imaging in diagnosis and management of patients with cardiac mass.

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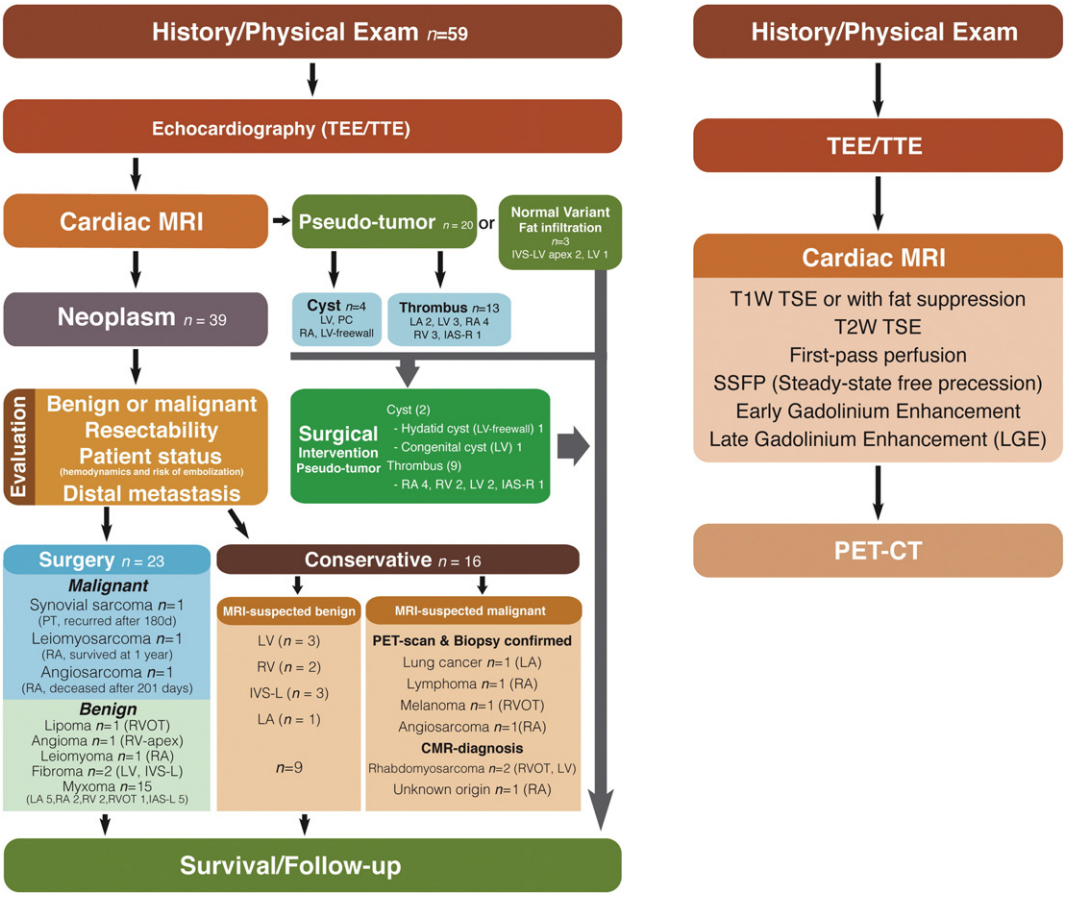


**Fig. 1.** Flowchart of cardiac MRI based multimodality imaging approach used in diagnosis, clinical decision making, and management strategy of patients with suspected cardiac mass. Left panel: Algorithm for diagnosis, evaluation, management and follow-up of suspected cardiac masses by multimodality imaging. Right panel: Strategy of using multimodality imaging: Multi-Sequence cardiac MRI was performed after initial assessment with echocardiography for the suspected cardiac mass. PET-CT scan was done for patients with diagnosis of malignancy for confirmation and to detect possible metastasis. RA: right atrium, LA: left atrium, RV: right ventricle, LV: left ventricle, IAS: inter-atrial septum, IVS: inter-ventricular septum, IVS-L: inter-ventricular septum—left ventricular side, IAS-L/R: inter-atrial septum—left/right atrium side, RVOT: right ventricular outflow tract, PT: pulmonary trunk, PC: pericardium. T1w: T1 weighted, T2w: T2 weighted, TSE: turbo spin echo.

## 2. Patients and methods

### 2.1. Study population

This prospective single center cohort study enrolled a total of 59 consecutive patients (33 females; mean age, 48.2 ± 21.1 [range, 0.6–85] years; and mean body weight, 53.60 ± 16.36 [range, 6.5–80] kg) diagnosed with suspected cardiac mass by routine transthoracic echocardiogram (TTE) from November 2011 to May 2014 at the West China Hospital, Sichuan University, whose ethics review board approved the study with informed consent obtained from all patients. Six patients received further preoperative trans-esophageal echocardiogram (TEE) due to suboptimal TTE image. Among them, presenting symptoms included heart failure (5 patients), transient ischemic attack (TIA) or stroke (4 patients), syncope (2 patients), acute chest pain (2 patients) and pulmonary embolism (1 patient). One patient was diagnosed with intra-cardiac mass located in intra-atrial patch by TTE in 7th postoperative day after ASD repair. Two patients were diagnosed with cardiac mass during tumor staging. In the remaining 42 patients, the mass was revealed accidentally during elective work-up for heart-murmur, weight loss, dyspnea on exertion, hypertension, as well as arrhythmias or even in routine health examination. Multi-sequence cardiac MRI was then performed on all enrolled patients. Further PET-CT was done in 4 patients for further defining the character of the suspected malignant cardiac mass or detecting the potential metastasis.

## 3. Multimodality imaging evaluation protocols

### 3.1. Echocardiography

TTE served as an initial diagnosis and screening tool for patients with suspected cardiac mass. Tumor location, size, mobility, relationship with intra-cardiac structure especially to the heart valve were carefully evaluated in classic 2 dimensional section images. Color Doppler imaging was used for evaluation of the hemodynamic disturbance caused by the cardiac mass. TEE was done for patients with suboptimal TTE image and for intra-operative guidance including resection completeness confirmation in all those who underwent surgery.

### 3.2. Cardiac MRI scanning protocol

All patients with suspected cardiac mass after initial evaluation by echocardiography received a comprehensive cardiac MRI examination on a 3.0 T MRI scanner (Tim Trio, Siemens, Erlangen, Germany) using dedicated phase array body surface receiver coils [4,9,10]. All images were acquired by ECG- or pulse-gated breath-hold technique. As per guideline, cardiac MRI protocol consisted of T1 weighted Turbo spin echo (T1w TSE) without and with fat saturation, T2 weighted Turbo spin echo (T2w TSE) with fat suppression, fist pass perfusion imaging (FPP) after intravenous injection of 0.15 mmol/kg of gadopentetate dimeglumine (Bayer Schering Pharma, Berlin, Germany), early gadolinium enhancement imaging (EGE), Steady-state free precession (SSFP)