MR Imaging of Cardiac Masses

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Primary cardiac tumors are rare with an autopsy incidence of only 0.02% and an echocardiographic incidence of 0.15%.[1,2] Among primary cardiac tumors, about 75% are benign, and 25% are malignant.[3] Cardiac metastases are by far more common than primary cardiac malignancies, with incidence rates 20 to 40 times that of primary cardiac tumors.[4,5] Autopsies in patients who have malignancy have demonstrated metastatic involvement of the heart in 10% to 12% of cases, although a much smaller proportion come to clinical attention.[6,7]

A comprehensive knowledge of the characteristics of cardiac tumors is essential for generating a meaningful differential diagnosis or even a specific diagnosis in some cases. Many tumors have specific predilections for certain cardiac chambers or valves. Other features, such as tumor mobility and attachment site, also may be helpful for offering a specific diagnosis. Furthermore, it is important to develop a sense of the aggressiveness of a cardiac tumor. Features such as invasion of extracardiac structures, involvement of more than one cardiac chamber, right-sided location, inhomogeneous tumor tissue, poor border definition, and the presence of a pericardial effusion are aggressive features and suggest a malignant tumor.[8–10] A detailed evaluation of these imaging characteristics is essential, regardless of the imaging modality used.

A variety of imaging modalities are available for the comprehensive evaluation of cardiac masses. Echocardiography often is the initial imaging modality because it is inexpensive, rapidly performed, ubiquitous, portable, and provides high-resolution real-time images. Echocardiography suffers from significant limitations, however, including limited acoustic windows, a restricted field of view that hinders visualization of adjacent mediastinal structures, difficulties in patients who have large body habitus resulting in degraded image quality, inadequate evaluation of the right heart, and limited ability to provide tissue characterization. CT, especially ECG-gated multislice CT, is developing an important role in the assessment of cardiac masses. Newer scanners allow multiplanar reconstructions using isotropic voxels, resulting in high-resolution imaging in virtually any plane, thus matching a previous advantage enjoyed by MR imaging. Dynamic cinematic displays of cardiac motion, usually reserved for echocardiography and MR imaging, are now possible, albeit with lower temporal resolution. CT can depict calcification (better than MR imaging) and fat and also allows excellent visualization of extracardiac anatomy. Significant limitations of CT include the use of ionizing radiation, which in the case of gated multislice CT can exceed the radiation dose of cardiac catheterization, and the need for iodinated contrast media, which carries a risk of nephrotoxicity and allergic reactions.

For various reasons, MR imaging presently is the modality of choice in evaluating cardiac masses. It offers direct multiplanar imaging, a large field of view, and high spatial and temporal resolution with newer cardiac sequences that allow good delineation of the anatomic extent of a mass and any associated functional consequences. Unlike

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echocardiography, there are no limitations with regard to acoustic windows, field of view, or assessment of the right heart. Unlike CT, there is no requirement for radiation or iodinated contrast. The most important advantage of MR imaging is that it provides better tissue characterization than either echocardiography or CT.

MR IMAGING TECHNIQUES

A standard cardiac examination for cardiac masses should incorporate static morphologic images and dynamic imaging with high-resolution cine images of the heart. Administration of gadolinium is helpful, with perfusion and delayed enhancement (DE) imaging assisting in tissue characterization.

Static morphologic imaging usually is performed by means of ECG-gated fast spin-echo sequences that allow image acquisition in a single breath-hold. Newer (eg, single-shot fast spin-echo) sequences may allow significantly faster image acquisition, albeit with a slightly lower signal-to-noise ratio. In addition to morphologic information, fast spin-echo T1- and T2-weighted imaging is valuable in tissue characterization. For example, malignant cells generally are larger and have higher intracellular water content than normal cells, and malignant tissue also often has increased extracellular fluid. The higher free water content of malignant tissue results in longer T1 and T2 relaxation times, resulting in inherent contrast between tumors and normal tissue. Fat suppression prepulses can be added to these sequences to characterize further suspected fatty tumors such as lipomas or, when combined with T2 weighting, can be used to demonstrate the edema associated with aggressive malignant processes.

Dynamic assessment of cardiac masses and of their effect on cardiac and valvular structures can be performed with cine gradient-recalled echo techniques. Older gradient-recalled echo techniques, although still useful, largely have been supplanted by steady-state free precession (SSFP) techniques, which provide excellent contrast between the myocardium and blood pool that is relatively flow insensitive and which have the added advantage of very short repetition times, resulting in shorter breath-holds and faster acquisition times. Signal intensity in this technique depends on the T2/T1 ratio. Structures with a high T2/T1 ratio, such as fat, fluid, and blood, appear bright, whereas myocardium has low signal intensity. The excellent contrast between myocardium and blood pool is especially helpful in the assessment of small intracavitary lesions. Occasionally sequences using myocardial tagging may be performed to evaluate noncontractile masses in the myocardium (eg, rhabdomyomas).[11]

Administration of gadolinium allows further tissue characterization. Perfusion sequences that are heavily T1 weighted can provide information regarding tumor vascularity. DE imaging, using segmented T1-weighted inversion-recovery, gradient echo, or SSFP sequences, can demonstrate areas of heterogenous enhancement resulting from regional variations in capillary permeability and distribution volumes (eg, increased inflammatory extracellular fluid or areas of necrosis within a tumor). Both these techniques also are helpful in detecting nonenhancing thrombus.

These techniques demonstrate the superior tissue characterization of MR imaging compared with CT and echocardiography. Nevertheless, specific tumoral characterization often is possible only in cases of myxoma, lipoma, fibroma, cysts, and hemangioma.[9]

Benign Cardiac Tumors

Although histologically benign, benign cardiac tumors often cause clinical symptoms related to hemodynamic obstruction, arrhythmias, embolization (of tumor or adherent thrombus), and altered myocardial contractility. MR imaging plays a vital role in early detection and characterization and in providing information that facilitates surgical removal. **Table 1** provides an overview of benign cardiac tumors.

Myxoma

Myxomas are the most abundant primary cardiac tumor, accounting for 50% of all cardiac tumors.[12,13] They primarily affect adults between 30 and 60 years old and have a higher prevalence in women (3:1).

Histologically these tumors consist of scattered cells within a mucopolysaccharide stroma. The tumor cell is thought to originate from multipotential mesenchymal cells that persist as embryonic residues during septation of the heart.[12,14] Macroscopically, they are gelatinous in consistency because of abundant myxoid matrix, with a smooth and lobular or villous and friable surface.[15] They vary considerably in size, ranging from 1 to 15 cm in diameter. They frequently have organized thrombi on the surface. Internally, myxomas are heterogenous and frequently contain cysts, necrosis, calcification, and hemorrhage.[13,16]

The classic triad for the clinical presentation of myxomas consists of constitutional symptoms (fever, malaise, arthralgias, and weight loss), embolic phenomenon (tumor fragments or thrombi),