Magnetic Resonance is Useful in Heart Valvular Disease

Marcelo Nigri, Carlos Eduardo Rochitte, Max Grinberg
Instituto do Coração do Hospital das Clínicas – FMUSP, São Paulo, SP, Brazil

In valvular heart diseases, diagnosis may begin with the stethoscope and end with cardiovascular magnetic resonance (CMR). CMR has been increasingly used in Cardiology, because it provides the morphological and functional information necessary for clinical decision-making in cardiovascular diseases.

Superb soft tissue definition, acquisition and three-dimensional reconstructions, together with the absence of ionizing radiation and use of non-nephrotoxic contrast medium (gadolinium), are undeniable advantages of CMR.

The diagnosis of valvular heart disease may benefit from CMR when echocardiography poses technical difficulties (such as inadequate acoustic window) or when there is divergence with other examinations, such as cardiac catheterization. CMR provides accurate information on heart chamber dimensions, ventricular function and mass, plus valve regurgitant volume, as well as on the myocardial fibrosis associated with valvular heart diseases.

Among CMR primary techniques, cine-MRI is the most widely used to evaluate heart valves. The segmented acquisition of dynamic images over some cardiac cycles allows assessing structure motions in any anatomical plane; heart chamber diameters and volumes can be accurately measured, as can ventricular mass and function. According to Simpson's rule, left ventricular ventricular ejection fraction is calculated from the systolic and diastolic volumes of several cross-sections to the main axis of the heart, spanning the entire ventricle[1]. Cine-MRI also permits the valve area to be measured by direct planimetry. The presence of calcification, which creates a signal void on CMR images, may lead to an overestimation of valve opening by planimetry, but this method usually shows excellent correlation with echocardiography[2]. Measurements of flow velocity, valve area, and transvalvular pressure gradient performed by phase-contrast CMR demonstrate a close correlation with Doppler and catheterization in patients with mitral and aortic stenosis[3,4].

One of CMR's strengths in evaluating valvular heart diseases is its ability to accurately quantify regurgitant volume and fraction in valve regurgitation. Therefore, CMR was considered a first-line imaging method in the consensus on cardiovascular MRI of the Brazilian Society of Cardiovascular Magnetic Resonance Imaging[5].

Its advantages over two-dimensional echocardiography include the fact that it is not limited by the patient's chest conformation, it shows low intra- and interobserver variability and allows right ventricle quantification, a chamber usually difficult to access on echocardiograms. These qualities are the CMR's calling card for inclusion in the follow-up of ventricular function and mass of patients with valvular heart disease (such as aortic stenosis), as well as for functional comparison after surgical intervention.

Velocity-encoded cine-MRI allows the assessment of blood flow velocity across a cardiac vessel or valve. It is equivalent to Doppler echocardiography, but offers the advantage of accessing blood flows in any orientation without being limited by an acoustic window. Using the modified Bernoulli equation, it is possible also to derive transvalvular pressure gradient.

One of the cardiologist's biggest concerns is that of CMR safety in patients with a mechanical prosthetic valve. It is well established that it is safe to expose a patient with this type of prosthesis to the magnetic fields generally used on CMR (1.5 Tesla). The magnetic force acting on the material is too weak compared to that imposed by the surgical attachment of the prosthesis. On the other hand, these prostheses produce artifacts of signal void (dark area on the MRI image), because the magnetic field becomes distorted by the metallic content. These artifacts often extend to the surrounding structures, depending on the pulse sequence used (this is usually less marked in spin-echo sequences). Consequently, the evaluation of turbulent jets, especially those of lower magnitude, is compromised. With bioprostheses, this effect is usually restricted to the valve annulus and does not interfere significantly in the MRI interpretation.

Described around six years ago, the delayed-enhanced technique consists in acquiring images approximately 10 to 20 minutes after the intravenous injection of a contrast medium (gadolinium) preceded by an inversion-recovery pulse6. In addition to allowing the visualization of minimal areas of myocardial necrosis/fibrosis, this technique shows excellent correlation with the pathological anatomy in several heart diseases[6-9].

Using delayed-enhanced MRI in patients with severe aortic valve disease (stenosis or regurgitation) but normal coronary arteries, both before and after heart valve surgery, areas of myocardial fibrosis could be identified in 60% of the cases, with good accuracy (78.5%) compared to the myocardial biopsy performed during surgery. Moreover, the diagnosis of myocardial fibrosis (MF) by CMR and biopsy was directly

Key words

Reperfusion injury, hemodynamics, blood volume.

Mailing Address: Marcelo Nigri •
InCor – Av. Dr. Enéas de Carvalho Aguiar, 44 - O5403-000 - São Paulo, SP, Brazil
E-mail: marcelonigri@uol.com.br
Manuscript received December 30, 2005; revised manuscript received March 31, 2006; accepted April 24, 2006.

proportional to the ventricular dysfunction, expressed by ejection fraction< 45 %[9-11].

However, as with all examinations, CMR imaging has some limitations, which should be taken into account when indicating it. All cardiac pulse sequences rely on ECG-gating. In patients with arrhythmias, which are common in valvular heart disease patients, this gating is impaired, thereby compromising the quality of examination. In addition, image acquisition is almost always performed during a few seconds of breath-holding. Usually, patients with dyspnea or decompensated heart failure do not tolerate this, which also contributes to reducing image quality. Approximately 2% of the patients are unable to tolerate MRI examination due to claustrophobia. Metal implants in the patient's brain, in turn, are formal contraindications to MRI, unless they do not have ferromagnetic properties. Finally, the presence of a pacemaker or Implantable cardioverter-defibrillator is also a contraindication to the examination, although some studies have demonstrated its safety in 1.5-Tesla MRI scanners.

Therefore, CMR has already earned its place as an adjunct method in helping cardiologists to define important features of valvular heart diseases' natural history. It seems that its use will be widely expanded in the coming years.

References

1. Rehr RB, Malloy CR, Filipchuk NG, et al. Left ventricular volumes measured by MR imaging. Radiology. 1985;156:717-9.
2. Mohiaddin RH, Kilner PJ. Valvular heart disease. In: Manning WJ, Pennell DJ, editors. Cardiovascular Magnetic Resonance. Philadelphia, PA: Churchill Livingstone, 2002: 387-404.
3. Mohiaddin RH, Longmore DB. Functional aspects of cardiovascular nuclear magnetic resonance imaging. Techniques and application. Circulation. 1993;88:264-81.
4. Wagner A, Mahrholdt H, Holly TA, et al. Contrast-enhanced MRI and routine single photon emission computed tomography (SPECT) perfusion imaging for detection of subendocardial myocardial infarcts: an imaging study. Lancet. 2003;361:374-9.
5. Pinto IM, da Luz PL, Magalhães HM, et al. Consenso SOCESP-SBC sobre Ressonância Magnética em Cardiologia. Arq Bras.Cardiol. 1995; 65(5): 451-7.
6. Simonetti OP, Kim RJ, Fieno DS, et al. An improved MR imaging technique for the visualization of myocardial infarction. Radiology. 2001;218(1):215-18.
7. Mahrholdt H, Goedecke C, Wagner A, et al. Cardiovascular magnetic resonance assessment of human myocarditis: a comparison to histology and molecular pathology. Circulation. 2004;109:1250-8.
8. Serra JJ, Monte GU, Mello ES, et al. Images in cardiovascular medicine. Cardiac sarcoidosis evaluated by delayed-enhanced magnetic resonance imaging. Circulation. 2003;107:e188-e9.
9. Nigri M. Fibrose miocárdica em valvopatia aórtica: estudo comparativo entre a ressonância magnética e biópsia intra-operatória miocárdica – Tese apresentada ao Departamento de Cardiopneumologia da FMUSP para obtenção do titulo de Doutor em 16/12/2004. São Paulo, 2004.
10. Nigri M, Rochitte C, Tarasoutchi F, et al. Myocardial fibrosis detected by MRI and biopsy is associated with worse left ventricular function in patients with severe chronic aortic valve disease. Circulation. 2003;108[17(S-IV)]:567 (abstract).
11. Nigri M, Rochitte C, Tarasoutchi F, et al. Delayed-enhanced magnetic resonance imaging detects myocardial fibrosis in patients with chronic aortic valve disease. J Am Coll Cardiol. 2004;41[6 (SA)]:450 (abstract).