1. Indications for cardiovascular magnetic resonance in cardiovascular disease

Cardiovascular magnetic resonance (CMR) is now well established in clinical practice for the diagnosis and management of cardiovascular diseases.

Cardiac MRI is helpful in the diagnosis of most cardiac conditions: (1) Coronary artery disease (CAD), (2) Myocarditis and Cardiomyopathy, (3) Congenital heart disease and Valve disease.

A complete CMR examination includes the following CMR pulse sequences which are used routinely for cardiac diagnosis: (1) spin echo (SE) acquisitions such as T1 and T2-weighted images, (2) Functional steady-state free-precession (SSFP) sequences, (3) Phase-contrast (PC) velocity sequence for measurements of velocity and flow volume, and (4) Gadolinium-enhanced MR angiography (MRA). Other CMR sequences include three-dimensional steady-state free-precession (3D-SSFP), Tissue characterization by Late gadolinium enhancement (LGE), first pass perfusion images, Blood oxygen level detection (BOLD) images, myocardial Tagging, and myocardial T2*. 

2. The role of CMR in diagnosis and prognosis of CAD

CMR provides valuable information in patients with CAD which may not be available from other diagnostic tools such as echocardiography and nuclear cardiology.

These include the visualization of the effects of induced ischemia (wall motion, perfusion) and direct visualization of coronary arteries (coronary angiography and flow). The advantage of CMR’s flexibility is the potential to combine techniques in a single examination. CMR can assess myocardial perfusion in a manner equivalent to SPECT but with improved spatial resolution. Dobutamine stress CMR
has a sensitivity of 83% and a specificity of 86%. The combination of adenosine-stress and rest perfusion-CMR, and LGE have a sensitivity and specificity of 89% and 87%, respectively, for CAD diagnosis, in contrast with 84%, and 58%, respectively, for rest perfusion-CMR alone (Nandalur et al., 2007).

Left ventricular EF and myocardial viability are important prognostic indicators after acute MI which can be evaluated by CMR.

The likelihood of improvement in regional contractility after revascularization decreases progressively as the transmural extent of LGE increases.

The severity of the seems to be best measured with MRI-detected microvascular obstruction.

SSFP-based BOLD imaging provides a novel method for questioning myocardial perfusion abnormalities secondary to coronary artery disease. BOLD imaging may detect myocardial oxygen deficits caused by acute coronary artery stenosis.

3. CMR tissue characterization in myocarditis and cardiomyopathy

The high spatial resolution of CMR which enables accurate assessment of ventricular volumes, ejection fraction, myocardial mass and tissue characterization and wall thickness makes it valuable for the assessment of myocarditis and cardiomyopathy.

CMR appears suitable to identify patients with significant ongoing inflammation.

In myocarditis CMR shows (1) focal increases of myocardial signal on T2-weighted; (2) early gadolinium enhancement CMR (1–2 min) in acute myocarditis, and (3) also with late enhancement. The combination of 2 or more tissue markers is required for diagnosis of myocarditis (Friedrich et al., 2009).

Tissue characterization by LGE could provide a definitive diagnosis of different types of non-ischemic cardiomyopathy with specific pattern.

Segmental subendocardial and/or transmural enhancement point out ischemic cardiomyopathy, while non-segmental subepicardial or mid-wall fibrosis is visualized in dilated cardiomyopathy. A characteristic pattern of diffuse, endomyocardial delayed enhancement is 80% sensitive and 94% specific for the diagnosis of cardiac amyloidosis. Cardiac sarcoidosis and hypertrophic cardiomyopathy are associated with patchy LGE. Increasing myocardial iron content as assessed by myocardial T2* correlated with decreasing left ventricular EF in thalassemia.

Newer methods such as CMR myocardial tagging quantifies local myocardial segment shortening, and diastolic function.

4. Structural and functional assessment of valvular and congenital heart disease

CMR may play a complementary role when transthoracic acoustic windows are poor and a transesophageal echocardiogram (TEE) approach is undesirable, or when results of echocardiography and catheterization are inconsistent.

SSFP can visualize the turbulence created by valvular stenosis and regurgitation. In addition, CMR determined ejection fraction and ventricular volumes can help to determine the timing of valvular surgery.

Planimetry of aortic valve area and mitral valve orifice by MRI can be performed with better image quality as compared with TEE. However MRI slightly overestimates aortic valve area as compared with catheterization.

PC sequence generates quantitative velocity information that is functionally similar to Doppler imaging (Debl et al., 2005). Total flow is calculated by summing velocity across the luminal cross-section. In this manner, cardiac output, shunt ratio, and valvular stenosis and regurgitation can be quantified.

Evaluation of patients with congenital heart diseases (CHD) is a significant strength of CMR; spin echo, SSFP and MRA can precisely define the dimensions and extent of simple CHD like aortic coarctation, or complex CHD like repaired transposition of great arteries (TGA) and facilitate follow up assessment of complications.

PC sequence non-invasively can be helpful for sequential monitoring of the severity of pulmonary regurgitation after repair of tetralogy of Fallot (r-TOF), and accurately measure the ratio associated with residual shunts (Gutiérrez et al., 2008).

Coronary MRA may be particularly useful for the detection of anomalous coronary arteries and for monitoring coronary artery aneurysms.

Newer methods such as (3D-SSFP) CMR may allow simplified image acquisition and reformatting of a single set of images into any desired projection plane.

Recently published data of LGE can also detect areas of fibrosis in patients with r-TOF and TGA as a possible marker of late adverse outcome.

References


