

For your eyes only CMR

Dr Chai Ping, THI @ NUH & Dr Seto Kar Yin, Department of Diagnostic Imaging @ NUH

WHAT IS CARDIOVASCULAR MAGNETIC RESONANCE (CMR)?

Magnetic Resonance Imaging (MRI) involves the measurement of signals emitted by protons when they are placed in an external magnetic field and subjected to the influence of radio waves that have the same natural (resonant) frequency as the protons themselves. MRI is one of the most important imaging modality in clinical practice. Since the 1980s, investigators have employed MRI to evaluate cardiac structures and function but it was not until the 1990s with further refinement of MRI technology and development of fast imaging sequences that cardiovascular MRI catapulted from the research arena into widespread clinical service.

WHAT IS THE ATTRACTION OF CMR?

The advantages of CMR include:

1. A wide field of view for visualization of cardiac anatomy and adjacent structures, unrestricted by windows of access;
2. The ability to obtain anatomic, morphologic, functional and flow information as well as tissue characterisation in a single study;
3. High spatial and temporal resolutions with modern scanners;
4. Its non-invasive nature, free from ionizing radiation;
5. The gadolinium contrast used is well-tolerated and not nephrotoxic.

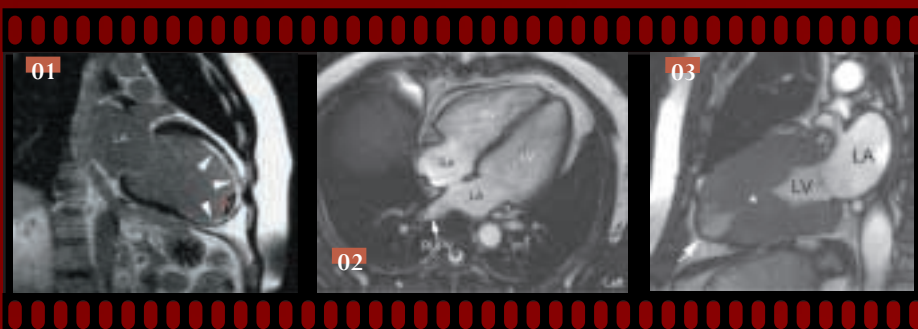
WHAT ARE THE INDICATIONS FOR CMR?

Most congenital cardiac conditions are indications for CMR. These include situs anomalies with complex congenital heart disease, anomalous venous connections, ventricular septal defects, aortic coarctation, pulmonary artery stenosis, evaluation of pulmonary regurgitation and measurement of pulmonary to systemic shunt ratios (Qp:Qs). Measurements of right and left ventricular volumes and function are integral to the evaluation and follow-up of patients with congenital heart disease. CMR is also ideal for the non-invasive follow-up of patients who have undergone surgical repair or correction of congenital cardiac defects.

Ischaemic heart disease and its sequelae are often studied with CMR. Indications include detection and assessment of acute and chronic myocardial infarcts, assessment of global ventricular function and dimensions, and assessment of myocardial viability. CMR is also useful for assessment of anomalous coronary arteries.

CMR can be used to differentiate ischaemic from non-ischaemic aetiologies in dilated cardiomyopathy. CMR is also indicated for the diagnosis and follow-up of hypertrophic cardiomyopathy and arrhythmogenic right ventricular cardiomyopathy. There is a major role for CMR non-invasive detection of myocardial iron overload and siderotic cardiomyopathy in patients with thalassaemia major.

- 01 A gradient echo image showing the 4-chamber view of the heart. LV indicates left ventricle; RV, right ventricle; RA, right atrium; LA, left atrium; RUPV, right upper pulmonary vein.
- 02 Image of the 2-chamber view acquired 10 minutes after gadolinium administration. Normal myocardium appears black while infarcted myocardium has taken up the gadolinium and appears white (indicated by white arrows). There is almost full-thickness myocardial infarction of the anterior wall and apex. The red asterisk indicates an apical thrombus.
- 03 Contrast-enhanced magnetic resonance angiogram of the abdominal aorta showing concomitant saccular and tubular aneurysms.
- 04 Picture of NUH's 1.5Tesla Siemens Magnetom Symphony MRI scanner.



Other conditions in which CMR can play a major role in diagnosis and management include constrictive pericarditis, cardiac and paracardiac tumours, assessment of valvular regurgitation, aortic aneurysm and chronic stable dissection. For all the above cardiac conditions, a variety of pulse sequences and MR techniques, including gadolinium administration, may be employed.

HOW IS CMR PERFORMED?

An MRI safety checklist needs to be filled out when a patient is referred for CMR.

The patient need not fast and no prior preparation, except for insertion of intravenous cannula for patients requiring contrast administration, is necessary. The patient will be briefed on the conduct of the study. Af-

ter removal of all metallic objects, the patient lies on the scanner couch while electrocardiographic leads are attached to the chest. Headphones are worn to protect the ears as the scanner emits noise during image acquisition. A lightweight receiver coil is then placed on the patient's chest before the patient is moved into the bore of the magnet. The scanner is activated and controlled via the operator's console in the control room. There is full communication between the patient and the operator at all times. A typical study takes about 45 minutes. During image acquisition, the patient is typically instructed to arrest respiration at end-expiration. Clear instruction to inhale, exhale and stop breathing will be given. Each breath-hold is typically 7 to 15 seconds long, well within the capability of most patients.

WHAT ARE THE ADVERSE EFFECTS AND CONTRAINDICATIONS?

MRI is a relatively safe imaging technique with no known hazardous bio-effects of the magnetic field. The magnetic gradients may induce peripheral nerve stimulation and a tingling sensation in extreme cases but this is harmless. The gadolinium contrast is well-tolerated and adverse reactions are rare. Occasionally, some patients may feel transient nausea,

headache or altered taste during administration. The major contra-indications for MRI are as follows:

1. Patients with permanent pacemaker or cardioverter-defibrillator implanted;
2. Patients with certain ferromagnetic implants should not undergo MRI. However, many modern implants are MR-safe and are not contraindicated, including most joint prosthesis, heart valve prosthesis and annuloplasty rings, coronary stents and sternal wires.
3. Patients who are unable to lie down or who are clinically unstable should not undergo CMR.

If in doubt, it is best to discuss the patient with a radiologist or radiographer before referring the patient for CMR.

WHAT ARE THE LIMITATIONS?

CMR is prone to motion artifacts, resulting in suboptimal images. Respiratory motion artifacts and gating artifacts due to arrhythmias may pose problems for image interpretation. About 1% to 2% of patients are claustrophobic and may not tolerate the confined space of the magnet bore. Often, the claustrophobic patient can be reassured by adequate explanation of the procedure, the presence of a companion in the scanner room or the use of an anxiolytic medication.

CONCLUSIONS

CMR is now an important non-invasive imaging modality in the armamentarium of the physician for the diagnosis and follow-up of cardiovascular disease conditions. Rapid advances in the field of CMR promise more applications of this technology for our patients in the very near future.

