

**REVIEW ARTICLE**

**CME**

## **Role of Cardiovascular Magnetic Resonance Imaging in the Diagnosis and Management of Ischaemic Heart Disease**

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### **ABSTRACT**

*Magnetic resonance imaging has assumed an increasingly important role in the diagnosis and monitoring of patients with ischaemic heart disease. For patients presenting with acute chest pain, it is essential to diagnose acute coronary syndrome and to treat these patients as soon as possible. Recent studies have shown that cine magnetic resonance imaging and magnetic resonance perfusion are feasible in patients presenting with acute chest pain. Magnetic resonance imaging allows the detection of transmural and non-transmural ischaemia, and is more specific and accurate than observing echocardiographic changes. Magnetic resonance viability scanning also allows the evaluation of the extent of infarction and might play a role in the selection of patients for angioplasty. Magnetic resonance coronary artery angiography is currently more of a research than diagnostic tool. The spatial resolution and contrast-to-noise ratio of magnetic resonance imaging are expected to improve further with parallel imaging, high-field magnets, and the development of new intravascular contrast.*

**Key Words:** Coronary vessels; Heart diseases; Magnetic resonance imaging; Myocardial ischemia

### **INTRODUCTION**

With recent advances in both hardware and software, there have been significant improvements in image quality. Clinical application of magnetic resonance imaging (MRI) in the diagnosis of cardiovascular disease has therefore gained popularity. Indeed, MRI has assumed an increasingly important role in the diagnosis and monitoring of patients with ischaemic heart disease.

### **MAGNETIC RESONANCE IMAGING IN CARDIOVASCULAR DISEASE** **Diagnosis of Acute Coronary Syndrome**

One of the major challenges that cardiologists face is to distinguish patients with acute coronary syndrome

(ACS) from the large number of patients presenting with chest pain due to non-cardiac causes. In one study, ACS was diagnosed in only 77 of the 972 patients recruited,<sup>1</sup> which amounts to a frequency of 7.9%. This figure is small but important, because the mortality among these patients will be high if appropriate treatment is not given.

Clinical features such as age, male sex, nature of pain, pattern in which pain radiates, and smoking history are useful independent predictors of ACS. However, diagnosis of ACS on the basis of clinical features is not sufficiently reliable.<sup>1</sup> Electrocardiography (ECG) is one of the standard investigations performed in patients who present with chest pain, and this test might be helpful to establish the correct diagnosis in patients with typical ECG changes. However, because patients with ACS can be divided into 3 types — those with ST segment elevation, those without ST segment elevation, and those with unstable angina — a normal ECG scan cannot exclude a diagnosis of ACS.

Nuclear medicine imaging has long been used to diagnose ACS, especially when the ECG results are non-conclusive. Technetium cardiac imaging has been shown

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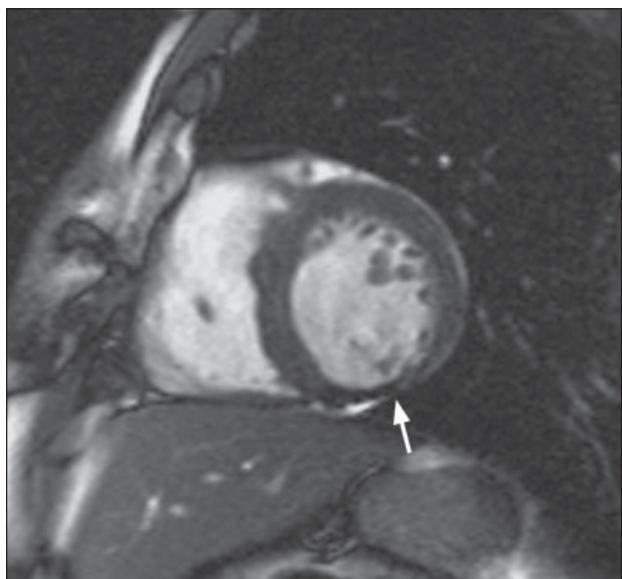
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to have a high sensitivity (range, 90%-96%) and a high negative-predictive value (up to 99%).<sup>2-4</sup> It is, however, important to understand the limitations of nuclear medicine imaging. Firstly, the low spatial resolution of this approach limits the diagnosis of small areas of ischaemia. Secondly, because the sensitivity of nuclear medicine decreases as the pain-free interval increases, scanning within 6 hours of the clinical onset of symptoms is recommended, and the availability of radio-pharmaceuticals in such a short period of time might impose practical difficulties. Heller et al<sup>2</sup> found that 12 of 35 patients with ACS had normal cardiac vascular imaging results. Because published studies recruited low-risk patients, only a small number of patients actually had myocardial infarction. Evaluation of the performance of nuclear medicine will give low and wide confidence intervals. Thus, nuclear medicine might not be an ideal method of identifying patients with genuine ACS.

Cine cardiac MRI such as true, fast imaging with steady-state precision ('true FISP') can be used to perform a dobutamine stress test. This test allows the detection of abnormality in wall thickening, which remains observable even as late as 12 hours after clinical presentation (Figure 1).<sup>5</sup> The examination, which is similar to stress ECG, has an important role when there is a narrow or no acoustic window for ECG. Quantitative assessment of myocardial straining can be achieved with the analysis of tagging images. However, the



**Figure 1.** Scan from true, fast imaging with steady-state precision of the short axis showing thinning of the inferior wall of the left ventricle (arrow) in a 45-year-old man who presented with acute chest pain.

relatively long data-processing time precludes the routine clinical application of this analytical method.

Perfusion imaging allows the assessment of regional myocardial blood flow. Perfusion may be performed with a blood oxygen level-dependent technique that does not require any injection of contrast.<sup>6</sup> The relative low signal-to-noise ratio, however, hampers its usefulness. Most of the MRI perfusion studies now performed are first-pass examinations that are conducted with the administration of gadolinium. By way of dynamic scanning, the flow of contrast into the right ventricle and then the left ventricle can be identified. Any focal perfusion defect of the myocardium would be detectable as a hypointense segment, which represents a delay in contrast enhancement relative to the adjacent myocardium. This technique is thus most sensitive in detecting single-vessel disease. Besides qualitative assessment, quantitative analysis by evaluation of maximal signal intensity,<sup>7</sup> measurement of upslope of the perfusion curve, and the measurement of the maximum upslope can be performed.<sup>8</sup> For clinical application, especially for the diagnosis of ACS, quantitative analysis is usually not performed; one reason is that the method takes time for data processing. Hence, the diagnosis will rely mainly on qualitative evaluation.

Kwong et al<sup>5</sup> recruited a total of 161 consecutive patients with suspected ACS and used MRI perfusion studies to diagnose ACS. These researchers achieved a sensitivity of 84% and a specificity of 85%. Their results were superior to those based on abnormal ECG findings, which had a sensitivity of 80% and specificity of 61%. Perfusion scanning was also more sensitive than diagnostic tests based on strict ECG criteria, such as the detection of ST depression and T-wave inversion and the analysis of troponin I level, which had a sensitivity of 16% and 40%, respectively.<sup>5</sup>

### Assessment of Myocardial Infarction

Cardiac MRI has additional value in patient management, even when the diagnosis of myocardial infarction can be established clinically. A series of short-axis scans from the base to the apex allows the measurement of the ejection fraction and end-systolic volume, both of which carry significant prognostic value (Figure 2). Volume measurement using ECG is based on assumptions about the geometrical shape of the ventricle, which introduces error — particularly in an infarcted heart.<sup>9</sup> An infarcted myocardium shows up as an enhanced focus when scanning is started 5 to 10 minutes after the



**Figure 2.** Series of short-axis images allows evaluation of end-systolic volume and ejection fraction. The ejection fraction of this patient on admission was relatively low, and the patient later developed congestive heart failure.

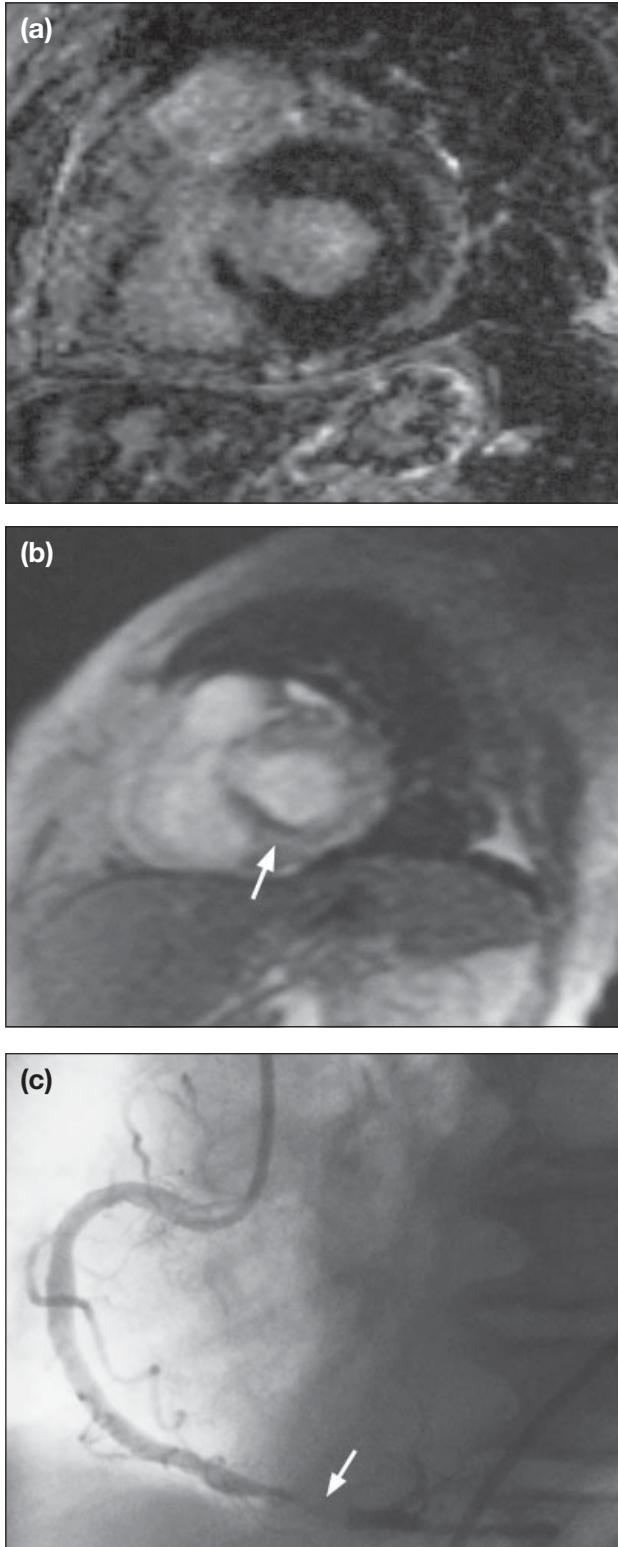
administration of intravenous contrast agent.<sup>10</sup> The good spatial resolution of the technique allows the detection of small and non-transmural infarction, which is not possible in nuclear medicine imaging. Information that is obtained from combined perfusion and viability scanning can allow cardiologists to plan the course of disease management<sup>11</sup> (Figure 3). Vessels with stenosis but which have viable myocardium might warrant further intervention, such as angioplasty. In contrast, patients might not benefit from revascularisation of a stenosed vessel with a transmural infarct.

Finally, MRI is useful in the detection of complications from myocardial infarction, such as valvular

regurgitation, thrombus formation, and the development of ventricular aneurysm. It could be difficult for ECG to detect these abnormalities, particularly when a thrombus or ventricular aneurysm involves the apex.

### Diagnosis of Ischaemic Heart Disease

Patients may present with signs and symptoms of ischaemic heart disease; yet, they may not experience an acute cardiac event. The myocardium is normally perfused when the patient is at rest. Such patients are best evaluated by perfusion scanning while the patient is under pharmacological stress. Intravenous dipyridamole (0.56 mg/kg for 4 minutes) or adenosine (140 µg/kg per minute for 6 minutes) is usually given



**Figure 3.** Radiological images of a 55-year-old woman who presented with acute chest pain. (a) Viability scan shows homogeneous signal of the myocardium and no evidence of myocardial infarction; (b) perfusion scan under pharmacological stress shows hypoperfused segment in the inferoseptal and inferior wall of the left ventricular (arrow), corresponding to right coronary artery territory; and (c) cardiac catheterisation showing short segment of severe stenosis of right coronary artery (arrow).



**Figure 4.** Breath-hold magnetic resonance angiogram of the right coronary artery using true, fast imaging with steady-state precision, showing good delineation up to the third part of right coronary artery.

for this purpose.<sup>12,13</sup> The correlation between perfusion at rest and perfusion at stress would allow the detection of ischaemic segments.

Non-invasive assessment of coronary artery disease by different MRI techniques such as true FISP has also received attention recently (Figure 4). MRI angiography of the coronary artery might help in the diagnosis of ischaemic heart disease.<sup>14</sup> In a study by Kim et al,<sup>15</sup> 83% of significant stenoses in proximal and middle segments of the coronary artery were detectable. The accuracy was 100% for diagnosis of significant stenosis of the left main coronary artery, and the accuracy reached 87% for three-vessel disease. Although these results are not superior to those achieved by multidetector row computed tomography or electron-beam computed tomography,<sup>16</sup> MRI has the added advantage of being able to non-invasively assess plaque vulnerability.<sup>17</sup> The MRI results from the assessment of the composition of the coronary artery plaque might form the scientific basis for drug therapy.

## CONCLUSION

Cardiovascular MRI has established a definite role in the diagnosis, prognosis, and management of ischaemic heart disease. With further advancements in hardware and software, the application of higher-field magnets, and parallel imaging, we can expect

further developments in contrast techniques, such as the use of intravascular contrast agent and use of contrast for plaque imaging. Cardiovascular MRI will thus evolve further in the assessment and management of ischaemic heart disease.

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