Myocardial MR imaging in ischemic heart disease

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Abstract

Purpose: To prospectively determine the diagnostic performance of resting myocardial magnetic resonance imaging at 3 T for depiction of clinically relevant coronary artery stenosis (≥ 70% diameter) in patients with suspected or known to have coronary artery disease, using conventional coronary angiography as the reference standard and comparing results with SPECT findings.

Materials and Methods: Cine MR imaging, first-pass perfusional images and delayed enhancement of the entire left ventricle were acquired in 31 patients at rest. Stress SPECT scan and selective coronary angiography were performed in all patients. Evaluation was performed on a per territory basis.

Results: The overall sensitivity and specificity of MR imaging for depicting coronary artery disease was 83% (44 of 53 diseased territories) and 92% respectively. The overall sensitivity and specificity of SPECT for depicting coronary artery disease was 77% (41 of 53 diseased territories) and 95% respectively. The sensitivity of SPECT was higher than MR imaging for depiction of one vessel disease, yet cardiac MR showed higher sensitivity for depiction of double and triple vessel diseases. The sensitivity of cardiac MR and SPECT for detection of myocardial ischemic tissue was 68.9% and 72% respectively. The sensitivity of SPECT in detection of subendocardial scarring and scarred (non viable) myocardial segments was 14% and 54% respectively as referred to cardiac MR viability findings.

Conclusion: Resting cardiac MR could be valuable in detection of significant coronary artery disease with relatively higher sensitivity values compared to stress SPECT study. In addition, it shows high accuracy in detection and delineation of myocardial scarring, particularly the subendocardial scarring.

Key words: Coronary artery disease (CAD), Cardiac magnetic resonance (CMR), Single photon emission computed tomography (SPECT), Conventional coronary angiography.

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List of abbreviations

AHA	American Heart Association
AMI	Acute myocardial infarction
ATP	Adinosine tri-phosphate
AV	Atrioventricular
BSA	Body surface area
b-SSPF	Balanced steady state free precession
CABG	Coronary artery bypass graft
CAD	Coronary artery disease
CE-IR	Contrast enhanced inversion recovery
CI	Cardiac index

CMR	Cardiovascular magnetic resonance
CO	Cardiac output
CT	Computed tomography
CTA	Computed tomographic angiography
DCMR	Dobutamine stress cardiovascular magnetic resonance
DE	Delayed enhancement
DE-CMR	Delayed enhancement cardiovascular magnetic resonance
DICOM	Digital Imaging and Communications in Medicine
Double-IR FSE	Double inversion recovery fast spin echo
DSE	Dobutamine stress echocardiography
DTPA	Diethylenetriaminepentaacetic acid
ECG	Electrocardiography
ED	End diastole
EDV	End diastolic volume
EDWT	End diastolic wall thickness
EF	Ejection fraction
EPI	Echoplanar imaging
ESV	End-systolic volume
FDA	Food and Drug Administration
FDG	Fluorodeoxyglucose
FGRE	Fast gradient recalled echo
FIESTA	Fast imaging employing steady-state acquisition
FISP	Fast Imaging with Steady State Precession
FOV	Field-of-view
GBCA	Gadolinium-based contrast agents
GE	Gradient-echo
HASTE	Half Fourier acquisition turbo spin-echo
HDL	High density lipoprotein

HR	Heart rate
HRPI	High-resolution first-pass myocardial perfusion imaging
IR FSE	Inversion recovery fast spin echo
IR GRE	Inversion recovery gradient echo
IR TSE	Inversion recovery turbo spin echo
IR-b-TFE	Inversion recovery balanced turbo field echo
IR-FFE	Inversion recovery fast field echo
IR-FFE	Inversion recovery fast field echo
IR-FLASH	Inversion recovery fast low angle shot
IV	Intravenous
LAD	Left anterior descending coronary artery
LCA	Left coronary artery
LCx	Left circumflex coronary artery
LGE	Late gadolinium enhancement
LM	Left main stem
LV	Left ventricle
MI	Myocardial infarction
MRA	Magnetic resonance angiography
MRCA	Magnetic resonance MR angiography
MRI	Magnetic resonance imaging
MVO	Microvascular obstruction
NPV	Negative predictive value
PCI	Percutaneous coronary intervention
PET	Positron emission tomography
PPV	Positive predictive value
PTCA	Percutaneous trans-luminal coronary angioplasty
RCA	Right coronary artery
RV	Right ventricle

SA	Short-axis
SE	Spin echo
SEH	Subendocardial enhancement
SENSE	Sensitivity encoding
SMASH	Simultaneous acquisition of spatial harmonics
SNR	Signal to noise ratio
SPAMM	Spatial modulation of magnetization
SPECT	Single photon emission computed tomography
SSFP	Steady state free precession
STIR	Short TI inversion recovery
SV	Stroke volume
T	Tesla
TFE	Turbo field echo
TGE	Turbo gradient echo
TSE	Turbo spin echo
TTC	Triphenyltetrazolium chloride
VL	Vessel
VS	Versus
VCG	Vectorcardiography

INTRODUCTION

INTRODUCTION

Heart disease continues to be a major source of morbidity and mortality in the world. Ischemic coronary diseases and heart failure as well as a range of other cardiac conditions, often require advanced imaging modalities to provide effective diagnosis and patient management. As a result, cardiac magnetic resonance imaging (MRI) and other imaging techniques have been introduced to supplement the echocardiography that has been traditionally performed in patients suspected to be suffering from cardiac dysfunction ***(Rosamond W et al 2008)***.

A variety of tests are available in routine clinical practice for the noninvasive diagnosis of coronary artery disease (CAD), such as exercise electrocardiography (ECG), echocardiography, single photon emission computed tomography (SPECT), positron emission tomography (PET), and cardiovascular magnetic resonance imaging (CMR). Many noninvasive diagnostic tools are suboptimal, and both patients and physicians want a reliable diagnosis. Consequently, 40% to 60% of all patients who undergo invasive cardiac catheterization procedures do not require a revascularization procedure such as bypass surgery or angioplasty. Thus, a noninvasive test with a higher rate of diagnostic accuracy might reduce the number of overall cardiac catheterization procedures ***(Higgins et al, 2006).***

The clinical role of cardiovascular magnetic resonance (CMR) continues to expand, supported by ongoing technological advances that have shortened acquisition times while maintaining and often improving image quality. New applications of CMR in cardiovascular imaging continue to emerge, and results from larger clinical trials are beginning to define the role of CMR in a range of clinical scenarios. In recent years, MRI has become a widely used non-invasive imaging modality in detection and evaluation of different cardiovascular diseases. Cardiac MRI is currently considered a clinically accepted modality for assessment of cardiac structure and function, ventricular mass and volume, myocardial perfusion and to determine the size of infarction ***(Pennell DJ et al, 2004)***.

CMR has evolved into a new technique for the noninvasive detection of obstructive CAD. The ability of CMR to visualize global and regional wall motion and systolic thickening of the left ventricle (LV) with a high degree of spatial and temporal resolution makes it possible to detect abnormalities of wall motion ***(Higgins et al 2006)***.

Assessment of the first passage of paramagnetic contrast material through the myocardium can be used to evaluate myocardial blood flow and detect perfusion defects that reflect coronary artery disease. The technique is attractive as it allows for studying myocardial perfusion at rest and during stress, it offers high spatial resolution, does not expose patients to ionizing radiation and the acquired data can be analyzed using quantitative or semi-quantitative methods ***(Plein S et al, 2005)***.

Dynamic MRI with a bolus injection of contrast material enables assessment of first-pass myocardial enhancement with or without pharmacologic stress, which can provide information regarding the presence and extent of coronary artery disease. Recent studies revealed that perfusion MRI has a high sensitivity and specificity, considering the conventional coronary angiography as the gold standard ***(Sakuma H et al, 2005).***

Perfusion deficits identify areas of myocardial infarction, as well as viable myocardium with limited coronary flow reserve ***(Klocke FJ et al, 2001)***. Recently, delayed-enhancement MR imaging has been established as a robust MR imaging technique to detect myocardial infarction, even small subendocardial infarcts, with better results than those of nuclear medicine techniques because of the improved spatial resolution ***(Lee VS et al, 2004)***.

Cardiac MRI is an advanced modality that continues to offer challenges to radiology professionals. Cardiac wall motion, the morphology of cardiac chambers, ejection fraction, cardiac perfusion, and myocardial viability are all effectively imaged with the use of cardiac MRI. However, due to the rapid evolution and