Myocardial stress perfusion magnetic resonance imaging (MRI) assessment of myocardial blood flow in coronary artery disease

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Myocardial stress perfusion magnetic resonance imaging (MRI) assessment of myocardial blood flow in coronary artery disease

Target group
Assessment of risk for coronary artery disease (CAD) in:
- Symptomatic patients with prior coronary angiography indicating stenosis of uncertain significance.
- Asymptomatic or symptomatic patients considered to be at intermediate risk of CAD by standard risk factors, with or without equivocal stress tests results (exercise, stress SPECT or stress echo).

Technology description
Magnetic resonance imaging (MRI) is a non-invasive, x-ray free imaging technique in which the patient is exposed to radiofrequency waves in a strong magnetic field, and the pattern of electromagnetic energy released in response is detected and analysed by a computer to generate detailed visual images. Cardiovascular magnetic resonance imaging (CMR) is an application of MRI which takes around 30-45 minutes to perform. It cannot be used in patients with metallic implants such as pacemakers or stents. Claustrophobia during the procedure may be problematic in around 2% of patients. CMR is also difficult to perform in patients with irregular cardiac rhythms or who cannot breath-hold for 10-15 seconds.

Myocardial stress perfusion MRI is a specific functional application of CMR that is in development for the evaluation of myocardial blood flow. It requires the use of a contrast agent, and is used to analyse the adequacy of the flow of oxygenated blood to the heart muscle - with impaired blood flow indicating the presence of CAD (myocardial ischemia). Pharmacologic stress is usually induced by administering a coronary vasodilator such as adenosine. The resulting blood flow images are compared with those obtained under normal (unstressed or resting) conditions.

Innovation and/or advantages
Myocardial stress perfusion MRI is similar in accuracy to myocardial stress single-photon emission computed tomography (SPECT) and stress echocardiography, but does not incur the high radiation burden of SPECT. Its use may avoid the need for invasive diagnostic coronary angiography in patients with intermediate risk factors for CAD. At the same sitting, and without additional scanning time, it can also assess left and right ventricular dimensions, function, and cardiac mass.

Place of use
- Secondary care e.g. general, non-specialist hospital
- General public e.g. over the counter

Availability, launch or marketing dates, and licensing plans:
Myocardial stress perfusion MRI requires enhanced software and fast gradient magnets with field strengths of at least 1.5 Teslas. There are a number of UK centres using stress...
perfusion MRI for myocardial perfusion studies in clinical practice, and availability is increasing rapidly.

**NHS or Government priority area:**

- [%] Cancer
- [%] Cardiovascular disease
- [%] Children
- [%] Diabetes
- [%] Chronic conditions
- [%] Mental health
- [%] Older people
- [%] Public health
- [%] Renal disease
- [%] Women's health
- [%] None identified
- [%] Other:

This topic relates to National Service Framework for coronary heart disease.

**Relevant guidance**

- British Cardiovascular Society working group report on the role of non-invasive imaging in the management of coronary artery disease 2007.\(^2\)
- European Society of Cardiology and the Society for Cardiovascular Magnetic Resonance consensus panel report. Clinical indications for cardiovascular magnetic resonance (CMR) 2004.\(^3\)
- American College of Radiology. Practice guideline for the performance and interpretation of cardiac magnetic resonance imaging (MRI) 2006.\(^4\)
- American College of Cardiology Foundation. Appropriateness criteria for cardiac computed tomography and cardiac magnetic resonance imaging 2006.\(^5\)
- American College of Cardiology/American Heart Association/American College of Physicians. Clinical competence statement on cardiac imaging with computed tomography and magnetic resonance 2005.\(^6\)

**Clinical need and burden of disease**

CAD is the leading cause of mortality in the UK, causing 88,271 deaths in England and Wales in 2005,\(^7\) and costing the UK economy over £1.7 billion per annum.

The current standard diagnostic method for assessing the need for revascularisation is invasive coronary angiography (ICA), with 201,000 performed in the UK in 2004 (excluding percutaneous coronary intervention).\(^2\) Estimates of the number of catheterisations that prove to be negative vary: one US study has suggested 25-50%,\(^8\) and a UK expert suggests a local normalcy rate of 14-20%. The ICA procedure is estimated to carry a 1 in 1,000 risk of heart attack or stroke.

**Existing comparators and treatments**

- *Myocardial stress single-photon emission computed tomography* (stress SPECT). This procedure involves radiation exposure, takes around 30 minutes, and is currently the main technique used for the assessment of myocardial perfusion.
- *Stress echocardiography with dobutamine* (stress echo). This procedure takes around 45 minutes.

Other techniques that can assess myocardial blood flow include:

- Exercise electrocardiography (ECG).
- Myocardial positron emission tomography (PET). Rarely used in the UK due to high costs and lack of availability.
Invasive coronary angiography (ICA) is the current gold standard for assessing the need for interventional management in coronary artery disease. However, although it can detect obstructive coronary lesions, it cannot detect ischemia (their functional consequence). Diagnostic ICA is costly and invasive, and carries a small risk of serious complications, and is usually reserved for high-risk symptomatic patients.

**Efficacy and safety**
A 2004 consensus panel of the European Society of Cardiology and the Society for Cardiovascular Magnetic Resonance concluded that for myocardial stress perfusion, MRI compared well with ICA, PET, and SPECT. A summary of evidence of diagnostic accuracy

### Myocardial perfusion MRI relative to ICA

<table>
<thead>
<tr>
<th>Study</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detecting stenosis of ≥ 70% in at least one coronary artery in 104 patients with CAD.</td>
<td>90%</td>
<td>85%</td>
<td>---</td>
</tr>
<tr>
<td>Detecting stenosis of ≥ 75% in 84 patients referred for diagnostic ICA.</td>
<td>88%</td>
<td>90%</td>
<td>89%</td>
</tr>
<tr>
<td>Detecting stenosis of ≥ 50% in 48 patients with suspected CAD.</td>
<td>87%</td>
<td>85%</td>
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</table>

### Myocardial perfusion MRI versus PET

<table>
<thead>
<tr>
<th>Study</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detecting CAD (reduced coronary flow reserve) in 48 patients with suspected CAD, as defined by PET.</td>
<td>91%</td>
<td>94%</td>
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</table>

### Myocardial perfusion MRI and SPECT relative to ICA

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<th>Study</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
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<tbody>
<tr>
<td>Detecting abnormal coronary territories in 26 patients with CAD.</td>
<td>79%</td>
<td>83%</td>
<td>80%</td>
</tr>
<tr>
<td>Thallium SPECT</td>
<td>70%</td>
<td>78%</td>
<td>73%</td>
</tr>
<tr>
<td>Detecting significant stenosis of at least one coronary artery in 69 patients with CAD.</td>
<td>MRI 94%</td>
<td>SPECT 82%</td>
<td></td>
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**Estimated cost and cost impact**
Although estimates for the cost of myocardial stress perfusion MRI vary, it is likely to be cheaper than SPECT, and more expensive than stress echocardiography.

**Potential or intended impact – speculative**
Myocardial stress perfusion MRI may well become the preferred option if MRI imaging capability were to be expanded through training and capital investment.

- **Patients**
  - Reduced morbidity
  - Reduced mortality or increased survival (reduced short-term risk from ICA and long-term risk of cancer from SPECT radiation)
  - Improved quality of life for patients and/or carers
  - Quicker or more accurate diagnosis
  - Earlier identification of disease
  - Changed pathway of care or outcome
Services
☐ Increased use e.g. length of stay, out-patient visits
☐ Service reorganisation required
☐ Staff training required
☐ Decreased use e.g. shorter length of stay, reduced referrals
☐ Other: reduced demand for SPECT and ICA, but longer procedure times than SPECT possible

Costs
☐ Increased unit cost compared to alternative
☐ Increased costs: more patients coming for treatment
☐ Savings: cheaper than SPECT; fewer ICAs
☐ Other: staff training needed
☐ Increased costs: capital investment needed

References

4 American College of Radiology. Practice guideline for the performance and interpretation of cardiac magnetic resonance imaging. 10/01/2006.