MRI Myocardial Perfusion

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Conclusion. In this large multicenter (33 centers), multivendor study (n=533) the diagnostic performance of perfusion-CMR to detect CAD was superior to perfusion SPECT in the entire population and in sub-groups. Perfusion-CMR can be recommended as an alternative for SPECT imaging.

Results apply to SPECT and gated SPECT, single and multi vessel disease, men and women, pre- and post infarct patients.
Prognosis of Negative Adenosine Stress Magnetic Resonance in Patients Presenting to an Emergency Department With Chest Pain

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Prognostic value of a normal adenosine stress only perfusion MR

- 135 pts with chest pain and
- NPV after 1 year follow-up: 100%

- 218 pts with suspected CAD (no MI)
- NPV after 1 year follow-up: 99.1%

Ingkanisorn W.P. et al, J Am Coll Cardiol, 2006
Pilz G. et al, Am J Cardiol, 2008
• 139 pts with suspicion of ischemia and no prior myocardial infarction
• Sensitivity of adenosine perfusion MR for MACE is 93.3%, specificity and PPV are 100%.
Results:

• 14/139 pts (10.1%) had a perfusion defect indicative of ischemia

• 125 patients with a normal myocardial perfusion entered follow-up (median 672 days, range 333–1287 days)
  – 1st year FU: 1 MACE, 1 pt new onset chest pain with a confirmed coronary stenosis. NPV MACE = 99.2%, NPV any coronary event = 98.4%
  – 2nd year FU: no additional MACE
Modified strategy in patients with stable chest pain (> 45 years)

<table>
<thead>
<tr>
<th>Pre-infarct (80%)</th>
<th>Post-Infarct (20%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal ECG</td>
<td>Myocardial Infarction</td>
</tr>
<tr>
<td>No history of CAD</td>
<td>CABG</td>
</tr>
<tr>
<td>First visit to the cardiologist</td>
<td>PCI</td>
</tr>
<tr>
<td>Normal rest-perfusion</td>
<td>Abnormal rest-perfusion</td>
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</tbody>
</table>

- **Adenosine PMR stress-only**
  - Normal Check
  - Ischaemia CAG / CT-Angio
  - No Ischaemia Follow up Risk factors

- **Adenosine Perfusion MR Stress-Rest-LE**
Indications

- new or recurrent ischemic heart disease
- follow-up after interventional treatment

Contraindications

- Severe asthma: bronchospasm !*
- 2° or 3° atrioventricular (AV) block*
- Sinus bradycardia (heart rate <45 bpm)
- Hypotension (< 90 mm Hg)

* No contra for regadeneson
Adenosine Perfusion MR

- adenosine 140 mcg/kg/min iv during 3 min per injector
- regadenoson bolus injection manual iv in 1 min (400 μg).

Adenosine is a strong vasodilator:
- normal coronary arteries: flow increase 5x
- stenotic coronary arteries already show maximal compensatory dilatation

Hypoperfusion of stenotic areas = perfusion defect
Adenosine Perfusion MR

Patient instruction

- no coffee, tea, chocolate or cigarettes
- Caffeine blocks the effects of adenosine!
- no aminophyline or nitrates
- no dipyridamole (Persantin)

for at least 24 hours prior the study

Side effects

- warmth
- flushing
- headache
- non-specific chest pain
- arrhythmias: temporary AV blocks

- effects are transient and do not require medical intervention
Monitoring

- heart rate and rhythm continuously
- blood pressure every minute
- symptoms continuously
- no cardiologist necessary in the MR suite

Antidote

- stop adenosine infusion
- Aminophylline i.v. (250 mg slowly i.v., under ECG)
Only minor complications

series of 3174 adenosine MR studies:

- arrhythmias: temporary AV blocks: 3%
- dyspnea or mild chest pain: 30%
- nausea: 2%

- all minor complications will resolve in a few minutes without further therapy

Bernhardt P et al, Clin Res Cardiol 2006
**Contraindications**

- Asthma / COVID / Eosinophilic
- No caffeine 24 h before the MR study
- Body weight

**Medication:**
- MI / CABG / ETCA

**Radiologist:**
- Cardiologist

**Technicians:**
- Date: CT Calcium Score
- Time: Diabetes Metabolism

**Body weight**

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**CT Calcium-score**

**DM / RR**

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**Blood pressure / Heart rate**

**Time Adenosine injection**

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**Complaints / side effects**

- Perfusion deficit Index
- Quantitative assessment 16 segment model
  - (17 = apex)

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**Body weight**

**Adenosine pump ml / hr**
MR Imaging procedure: short axis imaging

- **cine wall imaging:** exclude rest wma
- **test perfusion:** exclude wrapperound

Start adenosine infusion 3 min.

- **Gd perfusion**
Normal perfusion study

High spatial resolution enables distinction between subendocardial and transmural perfusion defects
Adenosine Perfusion MR

Fals-negative study

Adjust Window-Level

Review of 750 Adenosine Perfusion MR studies
Classic perfusion defects criteria
 (>50% CA stenosis)

1. defect is present during:
   upslope, downslope and equilibrium phase
   of enhancement

2. defect size is continuous from frame to
   frame

3. defect is present in ≥ 2 myocardial
   segments
Adenosine Perfusion MR

Classic perfusion defect: anterior wall of LV
Other perfusion defects

Artefacts
- subendocardial “dark rim” focal perfusion defect
- only during upslope
- transient
- seen in the majority of the studies

- truncation artefacts
  - appear on blood-myocardium interface
  - perpendicular to the phase-encoding direction

Adenosine Perfusion MR

truncation artefact
Other perfusion defects

Small Vessel Disease
- subendocardial “dark rim” perfusion defects
- during up- and downslope of enhancement
- transient

- microvascular dysfunction
  - Diabetes
  - Hypertension

Berhardt P. et al, Int J Cardiol 2007
Adenosine Perfusion MR

Small Vessel Disease in Diabetes Mellitus

perfusion defects
Other perfusion defects: Myocardial scar

Adenosine Perfusion MR

[Images showing ischemia anterior and infarction posterior]
Adenosine Perfusion MR

Quantitative analysis: Signal Intensity Curves

Most accurate method:
MPRI upslope Stress / upslope Rest

Myocardial perfusion reserve index (MPRI): Ratio of the upslope values of the stress and rest examination

Huber A. et al, Radiologe 2007
Visual analysis of MR perfusion

Patient: man 62 yr, no prior MI, chronic stable chest pain
CT calcium-score: 488

Perfusion: transmural defect lateral (LCX)
Adenosine Perfusion MR

Perfusion imaging

Ischemia LCX
CAG: LCX stenosis

Persistent Perfusion Deficit
Papillary Muscle Dysfunction
Septal Artefact
Adenosine Perfusion MR

Perfusion imaging after adenosine: Stress-only approach

Female 57 yr, chest pain, normal ECG
CT calcium-score = 246 (Agatston)
CAG: severe LAD stenosis

Perfusion: Hypoperfusion antero-septal (LAD)

basal

mid
Adenosine perfusion MR has undergone many technical improvements and levels of validation and outperforms SPECT diagnostically.

Very high NPV results in excellent 3 yr prognosis towards non-fatal MI and cardiac death.

Clinically accepted now as a very efficient non-invasive stress-test to diagnose myocardial ischemia.

Stress-only approach results in examination time less than 15 min.

NO RADIATION
Conclusion

MR Myocardial Perfusion

- MR Perfusion has the highest NPV for excluding clinically relevant CAD of all non-invasive imaging modalities.
- Adenosine myocardial perfusion MR for the detection of myocardial ischemia in a “stress-only” protocol in patients without prior myocardial infarctions, has a high diagnostic accuracy.
- This fast examination can play an important role in the daily routine evaluation of patients without prior myocardial infarctions and a necessity to exclude ischemia.

Lubbers et al, Int J Cardiov Imaging 2012