ADENOSINE-STRESS MR IMAGING
Imaging evaluation CAD

- Anatomic demonstration of the coronaries
- Functional imaging
  - SPECT
  - Stress echocardiography
  - Stress MRI
    - Myocardium perfusion (adenosine)
    - Wall motion abnormalities (dobutamine)
Stress induced MRI in diagnosis of CAD

- dynamic first-pass perfusion imaging
  - perfusion defects induced by a vasodilator (adenosine)
  - gadolinium injection
- stress induced wall motion abnormalities imaging
  - induced by dobutamine
Adenosine-stress MR imaging

- Adenosine
  - small, ubiquitous heterocyclic compound
  - produced endogenously in vascular smooth muscle and endothelium, or derived via the extracellular dephosphorylation of adenosine triphosphate (ATP) and adenosine diphosphate (ADP)
Adenosine-stress MR imaging

- Adenosine action
  - 4 known receptors subtypes (A1, A2A, A2B and A3)
  - A2A receptors (cardiac-specific) - triggers several reactions leading to coronary vasodilatation
Coronary vasodilatation induced by adenosine

- patients without CAD
  - the resistance vessel blood flow is increased 3 - 5 x above the baseline
- patients with CAD
  - the resistance vessels distal to a hemodynamic significant stenosis are usually maximally dilated in order to maintain normal resting flow, and consequently not affected by adenosine
Adenosine-stress MR imaging

- Proximal coronary
- Distal coronaries
- Flow

- Without significant stenosis
- Dilated with adenosine
- 3-5X↑

- With significant stenosis
- Already maximally dilated
- Don’t change with adenosine

adenosine
Adenosine-stress MR imaging

- Indications

- American College of Cardiology (2006)
  - symptomatic patients with an intermediate pretest probability
    - with uninterpretable electrocardiograms
    - or unable to exercise
Adenosine-stress MR imaging

- Contraindications to the administration of adenosine
  - history of bronchospasm or asthma
  - persistent hypotension (systolic blood pressure < 90 mmHg)
  - unstable angina
  - recent acute myocardial infarct (< 2 days)
  - high-grade AV block
  - uncontrolled arrhythmias
  - critical aortic stenosis
Adenosine-stress MR imaging

Adenosine side effects

- Bernhardt et. al (2005)
  - adenosine stress MRI
  - 3.174 patients
  - 35% patients reported minor complications
  - mild chest pain or dyspnea (30%), temporarily and asymptomatic AV block (3%) and nausea (2%).

- resolve rapidly upon termination of the infusion, as the half life of adenosine is very short (seconds)
- Aminophylline may be used as an antidote, but is rarely necessary
- Adenosine is an extremely safe pharmacologic stress agent
Adenosine-stress MR imaging

Preprocedure routine
- not eating or drinking for more than 4 hours before testing
- not taking xanthine derivatives (aminophylline)
- not having caffeine-containing products for 24 hours prior to testing

Devices required
- MR-compatible infusion system
- transfer
- advance support table including an external cardio defibrillator
Adenosine-stress MR imaging

Exam protocol

IR True-FISP sequences after gadolinium (0.1 mmol/Kg, 4 ml/sec) during pharmacological stress (at the end of 4th minute).

IR True-FISP sequences after gadolinium (0.1 mmol/Kg, 4 ml/sec) at rest (15 min after).

Perf. Cine function: True-FISP; global and regional wall motion

Perf. DE.
IR-GE

Adenosine perfusion (140 μg/kg/min)

30 min
Adenosine-stress MR imaging

- Perfusion imaging: Inversion Recovery Steady State Free Precession
  - 4 sections in the short-axis LV
  - 3 sections in the short-axis LV + long-axis 2 chamber-view LV
  - RT: 182 ms; ET: 1,1ms
  - ETL: 1; Flip angle: 15°
  - Matrix 128x75; FOV: 320x81
  - Thickness: 8mm
  - Saturation pulse: 90°
  - IT: 100ms
Adenosine-stress MR imaging

- Cine function: Steady State Free Precession
  - Cine images in the long-axis LV and in the short axis (25 phases /cycle)
  - RT: 55.6ms; ET: 1.3ms; Flip angle: 80°; Thickness: 6 - 8mm
Adenosine-stress MR imaging

- Delayed enhancement imaging
  - 4 sections in the short-axis and 3 sections in the long-axis LV (2D)
  - IR Gradient echo
  - Phase-sensitive inversion recovery (PSIR)
  - For optimal nulling of viable myocardium, use the TI-Scout sequence in conjunction with the PSIR image reconstruction
Adenosine-stress MR imaging

- Image interpretation

**CORONARY ARTERY CONDITION**

<table>
<thead>
<tr>
<th>Normal</th>
<th>DISTAL FLOW</th>
<th>PERFUSION REST</th>
<th>PERFUSION STRESS</th>
<th>DELAYED ENHANCEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>Without defects</td>
<td>Without defects</td>
<td>“All black”</td>
</tr>
</tbody>
</table>

**Stenosis (Ischemia)**

<table>
<thead>
<tr>
<th>Stenosis (Ischemia)</th>
<th>Normal at rest (maximally dilated)</th>
<th>Without defects</th>
<th>With defects</th>
<th>“All black”</th>
</tr>
</thead>
</table>

**Stenosis (infarct)**

<table>
<thead>
<tr>
<th>Stenosis (infarct)</th>
<th>Absent</th>
<th>With defects</th>
<th>With defects</th>
<th>Bright Signal</th>
</tr>
</thead>
</table>
Adenosine-stress MR imaging

- **Perfusion Rest**: Without defects
- **Perfusion Stress**: Without defects
- **Delayed Enhancement**: “All black”
Adenosine-stress MR imaging (hypertension)

- **Perfusion Rest**: Without defects
- **Perfusion Stress**: Without defects
- **Delayed Enhancement**: “All black”
Adenosine-stress MR imaging

- Normal (hypertension)
Adenosine-stress MR Imaging

- Ischemia

- Perfusion Rest
  - Without defects
- Perfusion Stress
  - With defects
- Delayed Enhancement
  - "All black"
Adenosine-stress MR Imaging

- Ischemia
  - Perfusion Rest
    - Without defects
  - Perfusion Stress
    - With defects
  - Delayed Enhancement
    - “All black”
Adenosine-stress MR imaging

Infarct:
- Perfusion Rest: With defects
- Perfusion Stress: With defects
- Delayed Enhancement: Bright signal
Adenosine-stress MR imaging

Infarct with residual ischemia

Perfusion rest

Perfusion stress

Delayed enhancement

With defects

With defects

Bright signal
Adenosine-stress MR imaging

Infarct + Ischemia

- Perfusion Rest: With defects
- Perfusion Stress: With defects (↑↑)
- Delayed Enhancement: Bright signal
Adenosine-stress MR imaging

Validation

- Meta-analysis 2007 by Nandalur et al.
- Diagnostic performance of stress cardiac MRI
- 37 studies
  - 14 (754 patients) using stress-induced wall motion abnormalities
  - 24 (1,516 patients) using perfusion imaging
- Specificities
  - 81% for perfusion imaging
  - 86% for stress-induced wall motion abnormalities imaging
- Sensitivities
  - 91% for perfusion imaging
  - 83% for stress-induced wall motion abnormalities imaging
### Adenosine-stress MR Imaging Validation

<table>
<thead>
<tr>
<th>Analysis and Parameter</th>
<th>≥ 50% stenosis in coronary angiography</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per-segment/vessel</td>
<td>LAD</td>
</tr>
</tbody>
</table>

Positive stress cardiac magnetic resonance (CMR): Validation with coronary angiography
Bruno Graça1; Paulo Donato1; Natália António2; Pedro Monteiro2; Henrique Rodrigues1; Lino Gonçalves2; Luís Providência2; Filipe Caseiro-Alves1
1Department of Radiology; 2Department of Cardiology; University Hospital of Coimbra; Portugal
• ESCR 2007
• 18 patients with positive stress perfusion MRI
Adenosine-stress MR imaging

Future perspectives

- Adenosine selective A2 receptors
  - regadenoson (CVT3146), binodenoson (MRE0470 or WRC0470) and apadenoson (BMS068645 or ATL146e)
  - Administration in bolus
  - Without infusion
  - Less side effects

- More comparative studies
  - Noninvasive evaluation of CAD
  - Considering the safety, cost-effectiveness, exposure radiation
  - Adapt the established guidelines for diagnostic workup

- At which level of risk should an individual patient undergo diagnostic workup?
Adenosine-stress MR imaging

Conclusions

- Safe and practicable diagnostic tool in the diagnosis of CAD
  - higher spatial and temporal resolution (compared to SPECT)
  - provides functional and viability information
- Repeatable / radiation free technique
- Good diagnostic performance
  - already shown in patients with high prevalence of disease
Coimbra