Stress Myocardial Perfusion MRI and Fractional Flow Reserve in Patients with Three-Vessel Coronary Artery Disease

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I have nothing to disclose.
Stress Myocardial perfusion MRI

CMR study with stress myocardial perfusion MRI allows for accurate assessment of flow-limiting coronary artery disease (CAD).

40-year-old man, chest pain on effort
Stress Myocardial perfusion MRI

Recent studies demonstrated a high diagnostic accuracy of stress perfusion MRI for predicting reduced FFR.

Lockie, T. Ishida, M, et al  JACC 2011;57: 70
Stress Myocardial perfusion MRI

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However, in patients with multi-vessel CAD, the relation between myocardial ischemia on stress perfusion MRI and reduced FFR may be complex, because assessment of regional myocardial ischemia is more difficult due to diffuse atherosclerosis and subsequent impaired endothelial function.
Purpose

• To evaluate the accuracy of stress myocardial perfusion MRI for predicting reduced FFR in patients with three-vessel coronary artery disease (3VD).
• To determine the value of CMR study combining stress/rest myocardial perfusion MRI and global coronary flow reserve (CFR) measurement using stress/rest MR blood flow quantification in the coronary sinus.
Patients Population

• Twenty-nine patients (19 men, age 70.2 ± 9.8 years) with known or suspected CAD.

• Exclusion criteria
  • Hx of recent ACS, OMI and CABG
  • LVEF<50% and LV regional wall motion abnormality
  • Arrhythmia
  • Contraindication to CMR or gadolinium contrast agents
Method

• All subjects underwent
  • CMR with 1.5 stress perfusion MRI
  • FFR measurements in the vessels with >50% stenosis on coronary angiography.
CMR image acquisition

- 1.5T MR imager (Achieva, Philips, The Netherlands)
- CMR protocol
  - Cine MRI
  - Perfusion MRI during ATP stress
  - MR flow measurement in the coronary sinus during ATP stress
  - Perfusion MRI at rest
  - MR flow measurement in the coronary sinus at rest
  - Late gadolinium enhanced MRI
CMR image analysis

- Qualitative assessment of myocardial ischemia
  - Two observers visually assessed presence or absence of myocardial ischemia in each major coronary arterial territory.

- Calculation of global coronary flow reserve (CFR)

\[
\text{Global CFR} = \frac{\text{Stress MR coronary sinus flow}}{\text{Rest MR coronary sinus flow}}
\]
Fractional Flow Reserve (FFR)

- Intracoronary pressure/temperature sensor-tipped guide wire (Certus Wire, Radi Medical Systems, Uppsala, Sweden)
- Central infusion of adenosine (140 μg/kg/min)

FFR = \( \frac{P_d}{P_a} \) during maximal flow

- FFR<0.80 was considered hemodynamically significant CAD.
# Characteristics of Study Population (N=29)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
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<tbody>
<tr>
<td>Age, y</td>
<td>67.1 ± 9.4</td>
</tr>
<tr>
<td>Sex, n (%)</td>
<td>Women, 8 (44%)</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td>24.5 ± 3.2</td>
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<tr>
<td>Body weight, kg</td>
<td>58.2 ± 10.6</td>
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<tr>
<td>Coronary risk factor</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>23 (79%)</td>
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<tr>
<td>Diabetes mellitus</td>
<td>14 (48%)</td>
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<tr>
<td>3-vessel disease</td>
<td>9 (31%)</td>
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<tr>
<td>Vessels with FFR &gt; 0.80</td>
<td>16 (44%)</td>
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<tr>
<td>Vessels with FFR &lt; 0.80</td>
<td>20 (56%)</td>
</tr>
<tr>
<td>Late gadolinium enhancement</td>
<td>6 (21%)</td>
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</table>
Global CFR was 3.1 by MR blood flow quantification in the coronary sinus.
A Case with single vessel disease
A Case with triple vessel disease

LAD FFR 0.68

LCx FFR 0.78
A Case with triple-vessel disease

Global CFR was 1.4 by MR blood flow quantification in the coronary sinus.
Distribution of FFR value according to myocardial ischemia detected by stress-rest perfusion MRI

Fractional flow reserve

Ischemia (-)       Ischemia (+)

0.74

P<0.05
Area under ROC Curve (AUC) for visual assessment of stress perfusion MRI in predicting FFR < 0.8

Patients with 1VD and 2VD

AUC = 0.86

Patients with 3VD

AUC = 0.61
Distribution of FFR value according to myocardial ischemia detected by stress-rest perfusion MRI

Fractional flow reserve

Ischemia (-)  |  Ischemia (+)

0.74

0.81

P<0.05

Global CFR <2.5
Distribution of FFR value according to myocardial ischemia detected by stress-rest perfusion MRI

Fractional flow reserve

Ischemia (-)    Ischemia (+)

0.73

0.85

Global MPR < 2.5

P < 0.05
Area under ROC Curve (AUC) for visual assessment of stress perfusion MRI in predicting FFR < 0.8 in patients with triple-vessel disease

Stress-rest perfusion alone

- AUC=0.61

Multiparametric CMR*

- AUC=0.79

*Myocardial ischemia on stress/rest perfusion MRI or CFR <2.5 by coronary sinus flow
Summary

• The mean FFR value in the territories without myocardial ischemia on stress perfusion MRI was significantly higher than the mean FFR in the territories with myocardial ischemia.

• Visual assessment of stress perfusion MRI provided high diagnostic accuracy in predicting reduced FFR in 1VD and 2VD.

• In 3VD, however, visual assessment of stress perfusion MRI alone showed limited diagnostic performance in predicting reduced FFR.

• Multi-parametric CMR combining stress/rest perfusion MRI and global CFR determined by MR flow measurements in the coronary sinus substantially improved the diagnostic accuracy of CMR in predicting reduced FFR in patients with 3VD.
Conclusions

• Visual analysis of stress perfusion MRI has limited concordance with FFR in patients with 3VD.
• Multi-parametric CMR using MR flow measurement in the coronary sinus permits detection of diffuse myocardial ischemia, and is useful for detecting reduced FFR in 3VD.