The Value of Stress MRI in Evaluation of Myocardial Ischemia

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Introduction

- Ischemic heart disease (IHD) is the leading cause of death worldwide.
- 7 million deaths reported in 2008.
- The burden of IHD has shifted from high-income countries to other parts of the world.
- Early detection and management of IHD is vital in decreasing mortality.
Diagnostic Tests

- ECG
- Invasive Coronary Angiography (ICA)
- Echocardiography (Echo)
- Coronary CT Angiography (CTA)
- Single photon emission computed tomography (SPECT)
- Cardiac positron emission tomography (PET)
- Cardiac MRI (CMR)
Complement - Not Compete
Test Selection

- Ask yourself 3 questions:
  1. What is the clinical pre-test probability (PTP)?
  2. Can the patient exercise?
  3. Does the patient suffer from conditions that limit or contraindicate the use of any of the modalities?

- Stress imaging test (echo, CMR, SPECT, PET) if:
  - Intermediate risk of IHD (PTP: 15-85%)
  - Known stenosis of unknown significance
  - Bad ECG
  - Cannot exercise
Summary of Guidelines for Stress CMR Use in SCAD

1. In clinical evaluation of patients with chest pain for initial diagnosis of SCAD if patients have intermediate to high PTP of obstructive IHD and are:
   - able to exercise but have an uninterpretable ECG.
   - OR
   - unable to exercise.

2. Risk assessment in patients with known SCAD who are:
   - being considered for revascularization of known coronary stenosis of unclear physiological significance.

3. ESC guidelines state that patients with suspected SCAD and intermediate PTP of 15-85% should be considered for stress testing (echo, CMR, SPECT, PET) if:
   - PTP 15-65% and LVEF ≥ 50%
   - OR
   - PTP 66-85% or LVEF < 50% without typical angina
Advantages of CMR

- Non-invasive modality.
- No radiation exposure.
- Provides additional information regarding cardiac morphology, function, detection of scar tissue and hence prognostic value.
- Detection of thrombus and microvascular obstruction that are not detected by most of the other modalities.
- Detection and quantification of valve diseases if present.
(Potential) Uses of CMR

- In the emergency department (ED)
- Differential diagnosis of chest pain
- Diagnosis of complications post myocardial infarction
- Assessment of complications due to or after interventions
- Prediction of myocardial recovery
- Detection of inducible ischemia in patients with known IHD
- Differentiating ischemic from non-ischemic heart failure
- Risk stratification
Stress Cardiac MR Imaging
The Role of Stress Functional Assessment and Perfusion Imaging in the Evaluation of Ischemic Heart Disease

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KEYWORDS
- Imaging of myocardial ischemia • Non-ischemic heart failure • Left ventricular dysfunction
- Coronary artery disease • Myocarditis • Adenosine stress CMR • Dobutamine stress CMR
- Myocardial ischemia

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In the Emergency Department

- In a multicentric study in the USA, 10,689 patients presented to ED with acute chest pain, data collected over 7 months.

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<tr>
<th>23% (2,459 patients) had true Acute Cardiac Ischemia (ACI) (36% acute MI, 64% unstable angina)</th>
<th>77% (8,230 patients) did not have Acute Cardiac Ischemia</th>
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<tr>
<td>94% admitted, 6% discharged</td>
<td>59% admitted, 41% discharged</td>
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At this rate of discharge, the estimated number of missed ACI is more than 11,000 patients/year in the USA with potential dire consequences.

At this rate of admission, the estimated number of unnecessary admissions is more than 3.6 million patients/year in the USA, with huge financial burden.

In the Emergency Department

- Patients with acute ST elevation MI (STEMI) need reperfusion therapy ASAP; CMR is not for these patients.

- Kwong, evaluated 161 patients who presented to ED with acute chest pain, but no signs of ST-elevation on ECG. All patients had a resting CMR examination.

- Concluded that resting CMR imaging is suitable for triage of patients with chest pain in the ED, especially those with enzyme-negative unstable angina.

- Other studies suggested the use of CMR after resolution of chest pain to aid in risk stratification.

Protocol and Findings in Acute MI

- **Protocol:**
  - LV function module
  - Myocardial edema module (T2W)
  - First-pass myocardial perfusion in rest (+/- in stress)
  - Late (+/- early) gadolinium enhancement.

- **With T2W imaging (myocardial edema), area at risk (AAR) can be measured:**
  - Includes both reversible and irreversible myocardial injury.

- **With LGE:**
  - Irreversible injury (scar) is measured.

- **Salvageable myocardium = AAR - LGE**
Edema – Scar = Salvageable Myocardium
Myocardial edema

Subendocardial Scar

Acute myocardial infarction in the anteroseptal region
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Most important causes of chest pain from CMR point of view

- Acute myocarditis
- Acute myocardial ischemia
- Takotsubo cardiomyopathy
- Acute pericarditis
- Dilated cardiomyopathy (DCM)
- Hypertrophic cardiomyopathy (HCM)
- Pulmonary embolism
- Aortic dissection
48 y/o male, presented to ED with acute chest pain and high troponin levels
53 y/o female, presented to ED with suspected ACS and high troponin.
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Post MI Complications

- Ventricular aneurysm.
- Ventricular free wall rupture.
- Rupture of the interventricular septum.
- Rupture of the papillary muscle.
- Formation of LV mural thrombus.
• Ischemic dilatation of the LV with apical thrombus.

• Key feature: No contrast medium uptake in late enhancement images with high TI of 600 ms.
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Complications due to or after Interventions

- These include:
  - Coronary dissection
  - Side-branch occlusion
  - Plaque embolization

- A strong correlation was found between increasing troponin levels at 24hrs post intervention and areas of new myocardial LGE.
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Viable myocardium?

- “The extent of infarction in each segment determines the likelihood of functional recovery post-revascularization”. (Kim et al. 2000)

<table>
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<tr>
<th>% Wall thickness infarction</th>
<th>Likelihood of functional recovery</th>
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<tr>
<td>1-25</td>
<td>60%</td>
</tr>
<tr>
<td>26-50</td>
<td>40%</td>
</tr>
<tr>
<td>51-75</td>
<td>10%</td>
</tr>
<tr>
<td>&gt;75</td>
<td>Almost nil</td>
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- In clinical practice, we use 50% cutoff to define “potential” viability.
• Upper row: severe hypo- to akinesia in multiple segments

• Lower row: subendocardial scars, <50% transmurality

• → Viable myocardium → Intervention
• Upper row: pre-intervention

• Lower row: post-intervention

• Significant improvement in function.
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Types of Stress CMR

- Pharmacological stress testing with **catecholamines**:  
  - Dobutamine (+/- Atropine) Stress CMR  
    - Positive inotropic and chronotropic effect $\rightarrow$ increased cardiac workload $\rightarrow$ increased myocardial oxygen demand

- Pharmacological stress testing with **vasodilators**:  
  - Adenosine perfusion stress CMR  
  - Regadenoson perfusion stress CMR  
    - Both cause primary coronary vasodilatation $\rightarrow$ used for assessment of coronary flow reserve
In our practice, Adenosine perfusion MRI is preferred to Dobutamine stress MRI due to its higher safety profile.
Perfusion in Stress

Perfusion in Rest
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Ischemic vs. Non-ischemic Heart Failure

- Both ischemic and non-ischemic cardiomyopathy can cause LV dysfunction, dilatation, and heart failure.

- Identification is important due to different therapeutic approach (interventional vs. medical).

- The pattern of LGE plays a major role in distinguishing ischemic from non-ischemic cardiomyopathy.
  - LGE in IHD: subendocardial to transmural, correlates to coronary distribution.
  - LGE in DCM: midmyocardial, most commonly in the mid-interventricular septum.
Transmural & subendocardial LGE in LAD territory.

Mid-myocardial LGE → DCM
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Risk Stratification

- Patients who had:
  - Stress inducible perfusion defect
  - LGE
  - > 3-fold association with cardiac death or acute MI.

- Patients without a perfusion defect or LGE had a 98.1% negative annual event rate for death or MI.

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Take Home Message

- Cardiac MRI is a powerful tool for the diagnosis of ischemic heart disease.
- It can reveal additional or different pathologies and aid in differential diagnosis of chest pain.
- It can guide therapy and predict prognosis.
- Unfortunately, it’s underutilized mostly due to lack of knowledge of referring physicians or lack of CMR experts.
THANK YOU!

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