Cardiac MRI and Ischaemic Heart Disease

Hong Kong Core Cardiology Certificate Course

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Applications of CMR

- Coronary heart disease
  - Myocardial ischaemia
  - Myocardial infarction
  - Ventricular function
- Non-ischaemic cardiomyopathy
- Valvular heart disease
- Cardiac Masses
- Pericardial disease

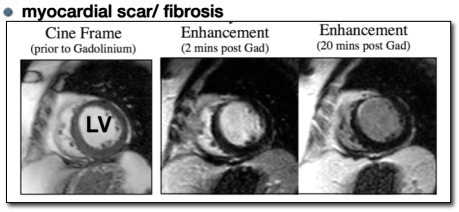
Ischemic Cardiomyopathy

- 3D capabilities
- high spatial and temporal resolution
- high contrast resolution
- reference standard for quantitative assessment
  - RV/LV volumes
  - Ejection Fraction
  - regional function

Myocardial ischemia

- Stress myocardial perfusion imaging
- at rest and during adenosine vasodilator stress
- myocardial signal increase in well-perfused myocardium; the increase is impaired in regions of myocardial ischemia

- Delayed gadolinium enhancement
  - myocardial scar/ fibrosis



- Transmural delayed enhancement
  - No functional recovery even after revascularization

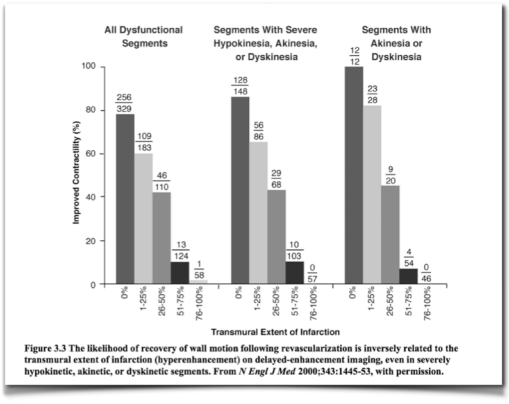
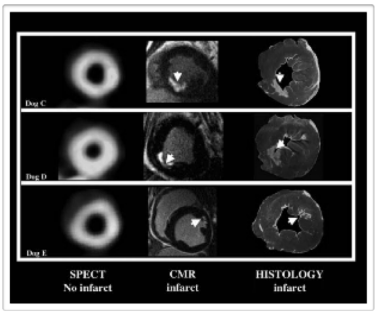
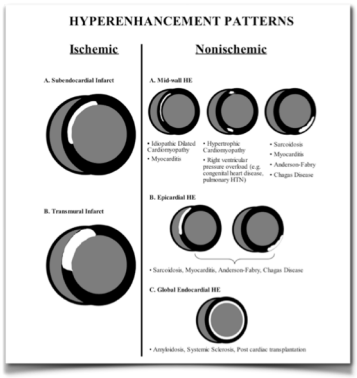


Figure 3.3 The likelihood of recovery of wall motion following revascularization is inversely related to the transmural extent of infarction (hyperenhancement) on delayed-enhancement imaging, even in severely hypokinetic, akinetic, or dyskinetic segments. From *N Engl J Med* 2000;343:1445-53, with permission.

Comparing with SPECT



A dog model of infarction
Superiority of CMR relative to SPECT in the detection of subendocardial infarction



CAD-progress as a wavefront from subendocardium to the epicardium

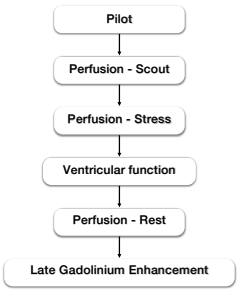
Evidence based practice

- Diagnostic value of stress perfusion CMR
- Prognostic value of stress perfusion CMR
- Potential use of stress perfusion CMR to guide cardiovascular interventions

Role of CMR in stable CAD

- **Clinical indications**
  - **Suspected CAD (low to intermediate risk)**
  - **Guiding revascularisation**
    - **Haemodynamic relevance (severe/mild)**
    - **Viability study**
  - **CMR modalities available**
    - **Dobutamine CMR**
    - **Perfusion CMR (extent of hypoperfusion)**
    - **Late gadolinium enhancement (extent of infarction)**

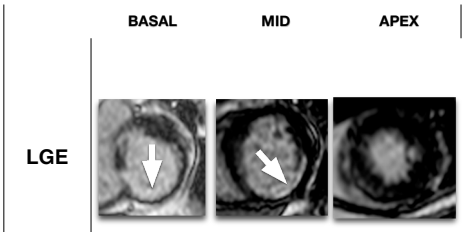
CMR Ischaemia Protocol



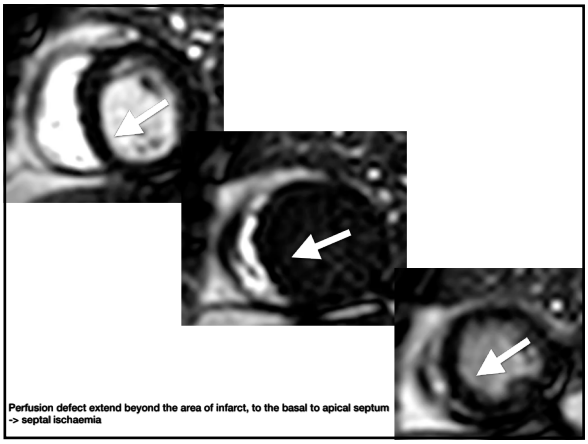
What can CMR tell us?

	Cine function	Rest perfusion	Stress perfusion	Late Gadolinium Imaging
Normal	Normal	Normal	Normal	Normal
Ischaemia	Normal	Normal	**Defect**	Normal
Stunned	Hypokinesia	Normal	**Defect**	Normal
Hibernating	Hypokinesia	**Defect**	**Defect**	Normal
Infarction	Thinned, abnormal	**Defect**	**Defect**	**Hyperenhancement**

What does CMR tell us?



Hx of AMI, PCI to RCA in 2000 & 2008
Angina
LGE in the basal to mid inferior and infero-lateral segment



Perfusion defect extend beyond the area of infarct, to the basal to apical septum
-> septal ischaemia

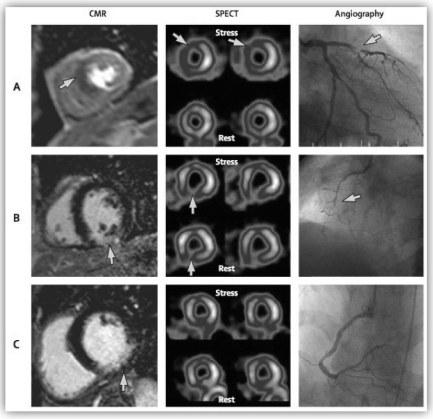
Can CMR affect patient outcomes?

Diagnostic performance of CMR

CE-MARC

Cardiovascular magnetic resonance and single-photon emission computed tomography for diagnosis of coronary heart disease (CE-MARC): a prospective trial.
Lancet. 2012 Feb 4;379(9814):453-60

- Prospective, Single centre
- CMR vs SPECT, randomised order
- n=752
  - suspected angina
  - at least one cardiovascular risk factor
- Primary outcome
  - Diagnostic accuracy of CMR
  - X-ray coronary angiography as the reference standard

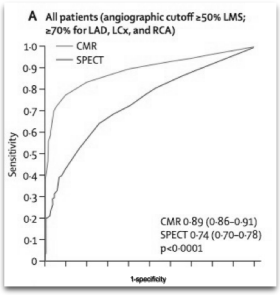


Results

	CMR	SPECT	*p* value
Sensitivity	86.5%	66.5%	<0.0001
Specificity	83.4%	82.6%	0.916

Conclusion:

- **CMR's high diagnostic accuracy in CAD**
- **CMR's superiority over SPECT**



Superior diagnostic performance

MR-IMPACT II

Magnetic Resonance Imaging for Myocardial Perfusion Assessment in Coronary artery disease Trial: Perfusion-cardiac magnetic resonance vs. single-photon emission computed tomography for the detection *of coronary* artery disease: a comparative multi centre, multivendor trial.
Eur Heart J. 2013 Mar;34(10):775-81.

- **Multi-centre**
- **n=533, 33 centres (US, Europe)**
- **Primary Endpoint**
  - **Non-inferiority of CMR vs SPECT**
- **Secondary Endpoint**
  - **Safety profile of CMR**

Results

	CMR	SPECT
Sensitivity	0.67	0.59
Specificity	0.61	0.72

Conclusion:

- **CMR's high performance in detecting CAD**
- **CMR's superior sensitivity to SPECT**
- **CMR's inferior specificity to SPECT**

Table 3 Safety profile of the cardiac magnetic resonance examination

Safety population (patients received MR contrast medium)	515
Serious adverse events[a]	6 (1.2)
Angina pectoris	1 (0.2)
Prolonged hospital stays	5 (1.0)
Death	0 (0)
Adverse events (in 74 patients)	114 (22.1)
Requiring treatment	12 (2.3)
Angina pectoris	4 (0.8)
Headache	4 (0.8)
Chest pain	3 (0.6)
Injection site bruising	1 (0.2)
Mild	91 (17.7)
Moderate	23 (4.5)
Severe	0 (0)
Subject withdrawal due to adverse events	0 (0)

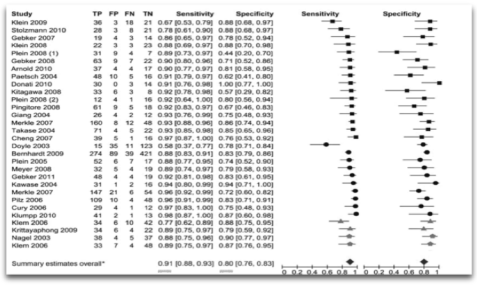
[a]Safety: all six serious adverse events were classified by the treating physician as not drug-related. Prolonged hospital stays were due to treatment by PCI/CABG of severe CAD during the same hospitalization.

Meta-analysis

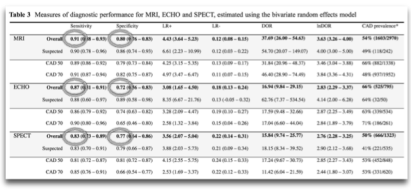
Diagnostic performance of stress myocardial perfusion imaging for coronary artery disease: a systematic review and meta-analysis.

Eur Radiol. 2012 Sep;22(9):1881-95

- **Medline and Embase**
- **CMR/ECHO/SPECT/PET for the diagnosis of obstructive CAD**
- **2,970 CMR**



Overall sensitivity of CMR: 91% and specificity is 80%



CMR is superior for the diagnosis of obstructive CAD compared to ECHO and SPECT.

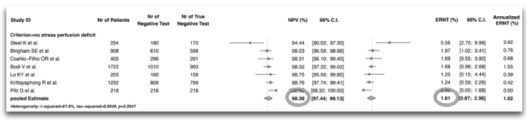
Prognostic performance of CMR

Meta-analysis

The prognostic value of normal stress cardiac magnetic resonance in patients with known or suspected coronary artery disease: a meta-analysis.

Circ Cardiovasc Imaging. 2013 Jul;6(4):574-82.

- 1985 - 2012
- CMR to evaluate subjects with known or suspected CAD
  - providing primary data on clinical outcomes of nonfatal MI or cardiac death
- Mean follow-up of 25.3 months
- n=12,178



- Pooled estimates of
  - NPV: 98.4% (97.4 - 99.1)
  - Estimated event rate after negative test:1.61% (0.87 - 2.56)

Meta-analysis

Prognostic value of stress cardiac magnetic resonance imaging in patients with known or suspected coronary artery disease: a systematic review and meta-analysis.

J Am Coll Cardiol. 2013 Aug 27;62(9):826-38.

- PubMed, Cochrane CENTRAL, metaRegister of controlled trials
- to evaluate subjects with known or suspected CAD
  - providing primary data on clinical outcomes of MI or cardiovascular death
- n=11,636

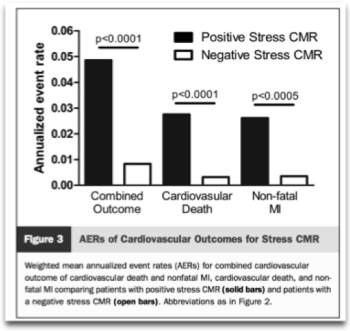
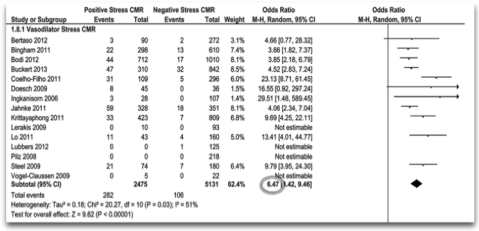


Figure 3 AERs of Cardiovascular Outcomes for Stress CMR

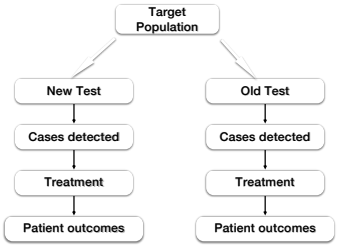
Weighted mean annualized event rates (AERs) for combined cardiovascular outcome of cardiovascular death and nonfatal MI, cardiovascular death, and non-fatal MI comparing patients with positive stress CMR **(solid bars)** and patients with a negative stress CMR **(open bars)**. Abbreviations as in Figure 2.



- A pooled estimate of odds ratio 6.47 (4.42;9.46)
- A negative CMR is associated with very low risk of cardiovascular death and MI.

Decision making

How to close the evidence gap?

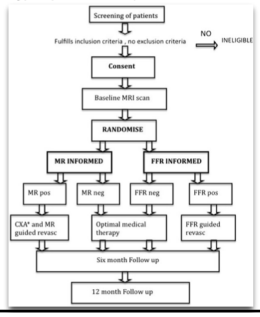


MR-INFORM

Stress perfusion cardiovascular magnetic resonance imaging to guide the management of patients with stable coronary artery disease

- **Revascularisation decisions based on invasive fractional flow reserve (FFR) have shown improved event free survival (FAME, DEFER)**
- **Prospective, multi-centre, randomised controlled non-inferiority, outcome trial**
- **To compare the efficacy of two investigative strategies for the management of patients with suspected CAD**

- **Inclusion criteria:**
  - **Stable angina (Class II-III)**
  - **Either >= 2 risk factors(smoking, DM, HT, hyperlipidaemia, FH) or +ve treadmill test**
- **Exclusion criteria:**
  - **EF<30%**
  - **CCS class IV**
  - **Previous CABG**
  - **PCI within 6 months**
  - **Contraindications to MRI**



Randomization (1:1)

MR-INFORM

FFR INFORMED

- Invasive angiography in all patients
- FFR in all arteries >2.5 mm with a stenosis of 40-95%
- If FFR <0.8 revascularization (PCI or CABG) recommended
- CTO regarded as positive

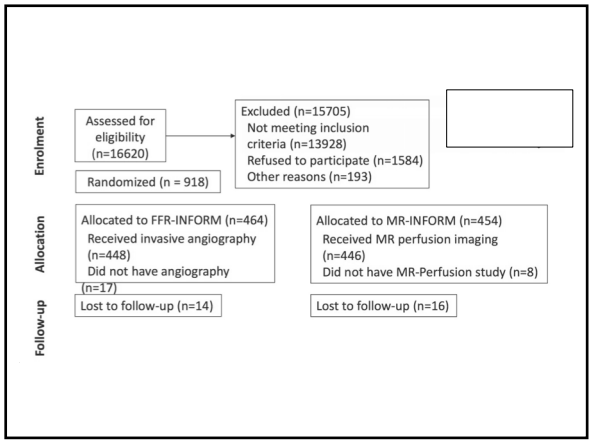
MR INFORMED

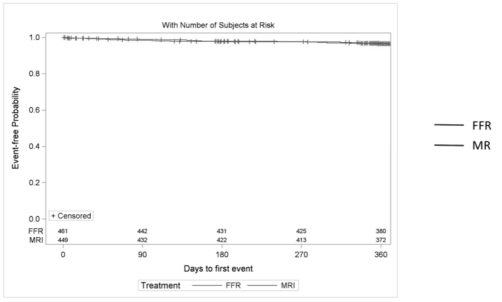
- 1.5T multivendor
- Cine imaging
- Adenosine stress/rest first pass perfusion imaging using 0.075 mmol Gadovist / kg body weight for first pass
- Late gadolinium enhancement after top-up to 0.2 mmol/kg body weight
- If transmural defect or subendocardial defect >2 segments or in 2 adjacent slices was found, angiography with aim of revascularization recommended

Primary Endpoint

Composite endpoint of

- All cause mortality
- Nonfatal myocardial infarction (clinical presentation of ACS AND Q-waves OR troponin ≥99th percentile)
- Re-revascularization of a vessel targeted at the index revascularization procedure





MACE

	FFR (n = 462)	MR (n = 450)
Events (n)	18 (3.9%)	15 (3.33%)
• Death	1 (Angio +, CABG planned, death before CABG)	4 (2 non-cardiac, 1 MR+, Angio+, CABG planned, death before CABG 1 death after CABG)
• Myocardial Infarction	8	8
• Re-revascularization	9	3
Absolute Risk Difference [95% CI]	-0.56 [-2.98; 1.86]	
Hazard ratio [95% CI]	-0.852 [-0.43; 1.69]; p = 0.62	

Discussion

- **MR-perfusion imaging is non-inferior to a strategy with invasive angiography supported by FFR during FU of 1 year in guiding the initial management of patients with stable angina and an intermediate to high risk of CAD.**
- **Both strategies are safe and result in a low total event rate**

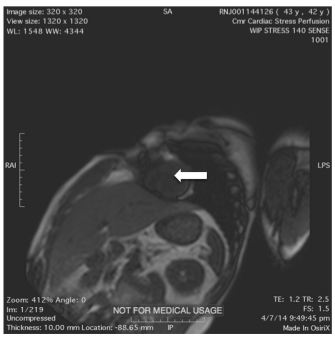
Suspected/stable coronary artery disease	Class[a]	Level[b]	Guideline
Whenever history suggests myocardial ischaemia, a stress ECG test is recommended, and, if positive or ambiguous, an imaging stress test (stress echocardiography, stress CMR or nuclear scintigraphy) is recommended.	I	C	[22]
In subjects with intermediate pretest probability for suspected coronary artery disease and stable symptoms, stress CMR, stress-echo, SPECT or PET are recommended	I	A	[16]
In patients with suspected stable coronary artery disease and intermediate pretest probability of 15 % - 65 % and LVEF =50 %, stress imaging is preferred as the initial test option if local expertise and availability permit.	I	B	[20]
An imaging stress test is recommended as the initial test for diagnosing stable coronary artery disease if the pretest probability is between 66-85 % or if LVEF is <50 % in patients without typical angina.	I	B	[20]
An imaging stress test is recommended in patients with resting ECG abnormalities, which prevent accurate interpretation of ECG changes during stress.	I	B	[20]
Stress imaging for risk stratification is recommended in patients with a non-conclusive exercise ECG	I	B	[20]
Risk stratification is recommended based on clinical assessment and the results of the stress test initially employed for making a diagnosis of stable coronary artery disease	I	B	[20]
In patients with stable coronary disease after a significant change in symptom level, risk stratification using stress ECG (unless they cannot exercise or display ECG changes which make the ECG non evaluable) or preferably stress imaging if local expertise and availability permit is recommended	I	B	[20]
In patients with known stable coronary artery disease and a deterioration in symptoms, stress imaging is recommended for risk stratification if the site and extent of ischemia would influence clinical decision making	I	B	[20]
An exercise ECG or stress imaging if appropriate is recommended in the presence of recurrent or new symptoms once instability has been ruled out.	I	C	[20]

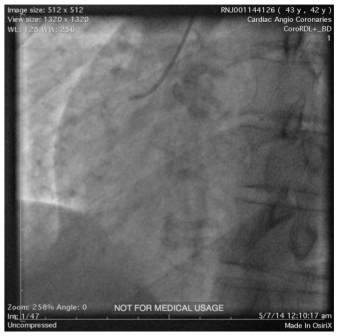
ESC recommendations

Case study

M / 48
Smoker
Good past health

Angina for 3 months
ECG: SR





Barts Health NHS
NHS Trust

AS/DAS/9671076
24 July 2014

Dr H Hutson
43 Granville Road
DA14 4TA

Dear Dr Hutson

Pre-operative Assessment: 42 year old gentleman who was admitted through the HACS service with chest pain and some ST changes anteriorly. He had a angiogram which showed critical lesion in his proximal LAD. In view of this it was decided that the preferable way of managing this problem would be to do a bypass operation.

His risk factors only include current smoker.

Operation: **Emergency CABG x 1**
LIMA to LAD off pump

Date of Operation: 04.07.14

Surgeon: **Mr A Shipolini**
Assistant: **Mr M Yasin**
Anaesthetist: **Dr C Broomhead**
Referring Cardiologist: **Dr A Wragg**

Operation: Routine mid line sternotomy was performed. Left IMA was taken down, it was a good vessel with excellent flow. The LAD was opened in its mid section off pump. The IMA was anastomosed to the LAD with 8/0 Prolene. There was good distal run off.

Two chest drains were inserted one in the anterior mediastinum and the posterior pericardium. The left pleura had been kept in tact.

The chest was closed in layers using stainless wires to the sternum and No. 1 Vicryl to the subcutaneous tissues and 3/0 subcuticular Monocryl to the skin.

The patient was transferred back to ITU in a stable condition with infusions of GTN, Morphine and Propofol.

Alex Shipolini
Consultant Cardiothoracic Surgeon

Summary

- **Good evidence on diagnostic accuracy of CMR perfusion**
- **Good evidence on prognostic accuracy of CMR perfusion**
- **As a safe guiding tool for patients with stable angina and an intermediate to high risk of CAD**

Thank you