Φαινόμενο No-Reflow.
Απεικόνιση με CMR, κλινική συσχέτιση και προγνωστική σημασία

Θεόδωρος Δ. Καραμήτσος MD PhD

Honorary Consultant in Cardiology
University of Oxford
Centre for Clinical Magnetic Resonance Research
(OCMR)

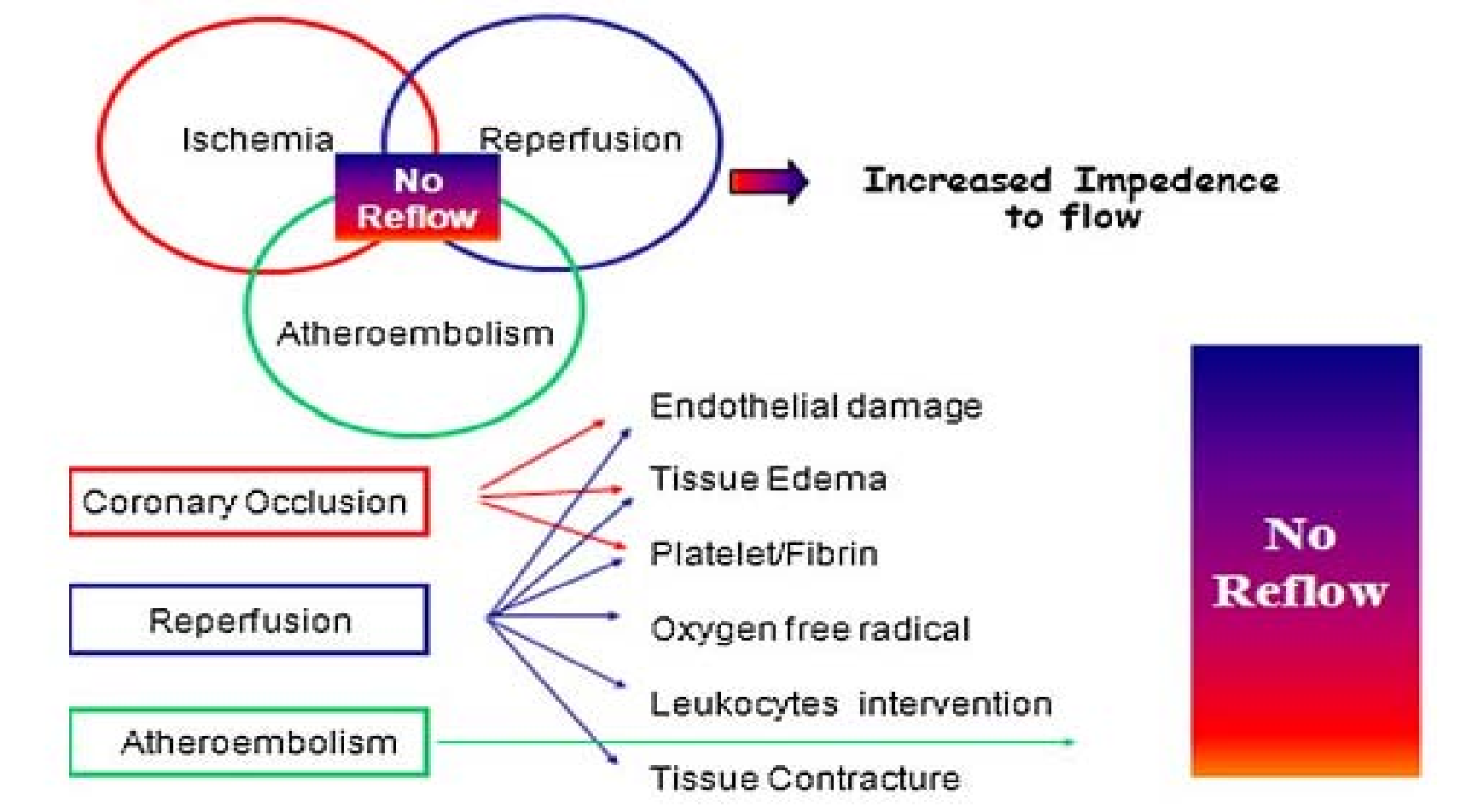
OCMR

UNIVERSITY OF OXFORD

Overview

- How to assess non-reflow (MVO)
- CMR validation studies
- Clinical importance
- Prognostic significance
- Infarct haemorrhage & MVO

Pathophysiology of No-Reflow



J Nucl Cardiol. 2009;16(5):811-31

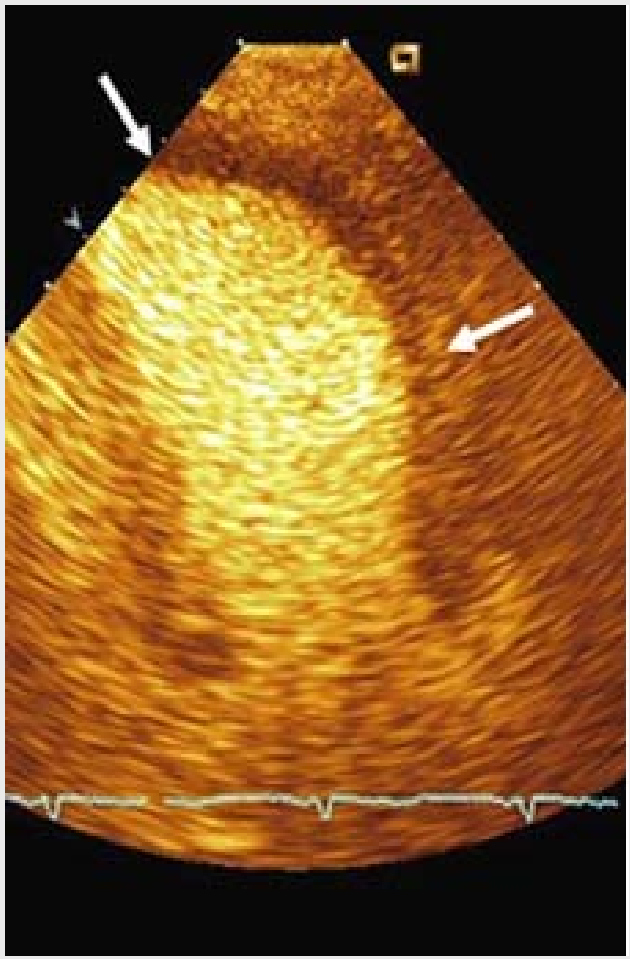
How to assess non-reflow

OCMR

UNIVERSITY OF OXFORD

How to assess No-Reflow

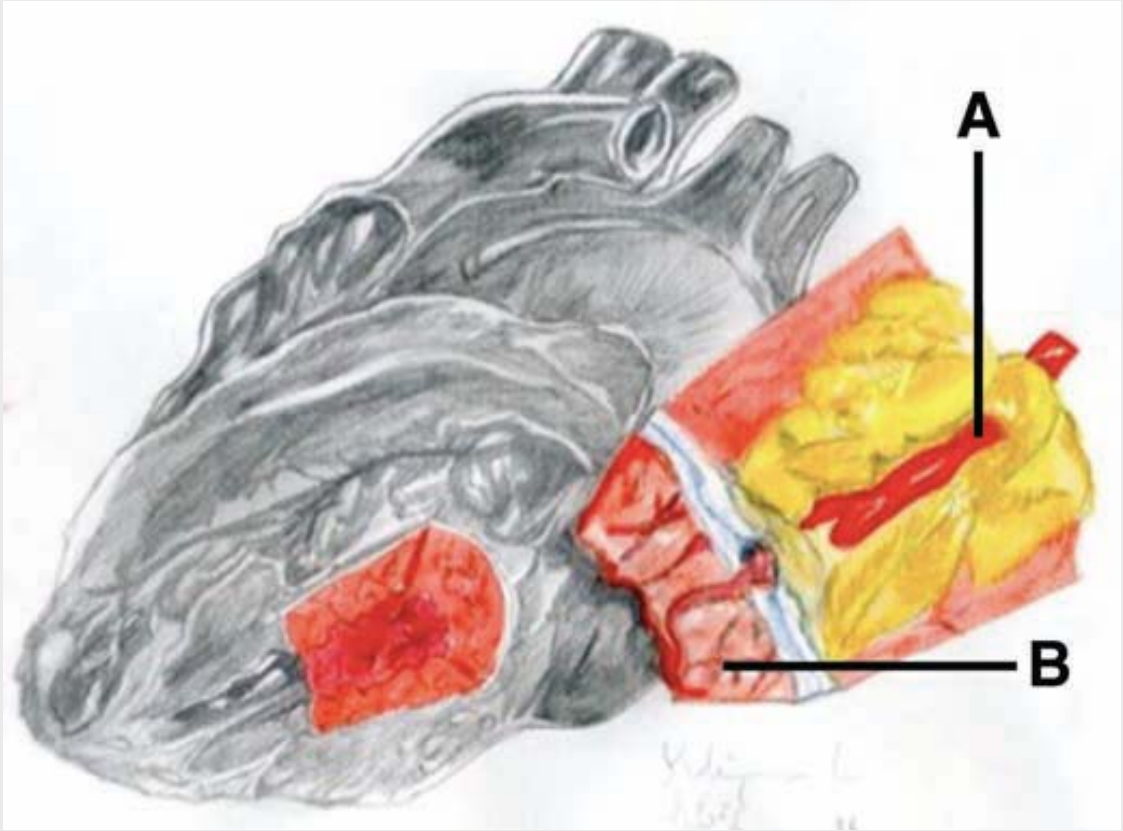
- TIMI flow score/frame count
  - 0, 1, 2, 3
- TIMI myocardial perfusion grade
  - 0, 1, 2, 3
- Coronary Doppler Imaging
  - Systolic & Diastolic flow
- SPECT 99mTc micro-albumin aggregates
- Myocardial Contrast Echo (MCE)
  - Area of no-reflow
  - Infarct size not accurate



J Am Coll Cardiol 1985;5:593-8

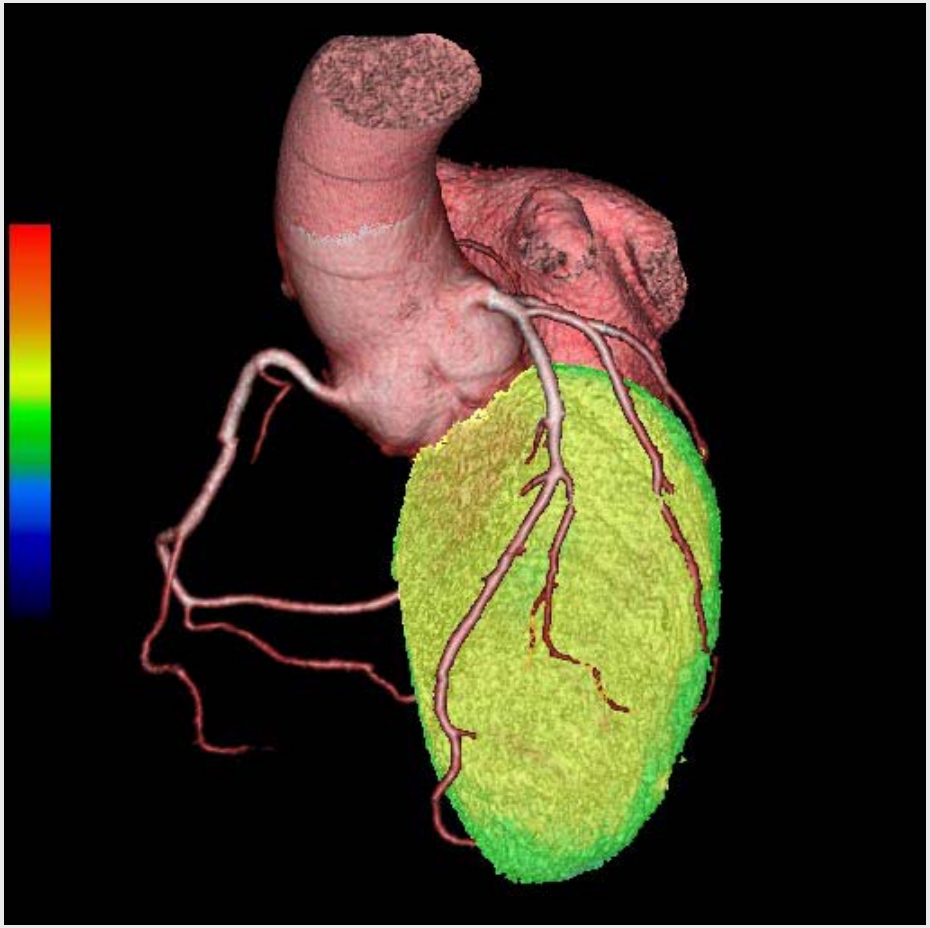
J Nucl Cardiol. 2009;16:811-31

Not Only Epicardial Coronary Flow matters



AJR 2008; 191:73–79

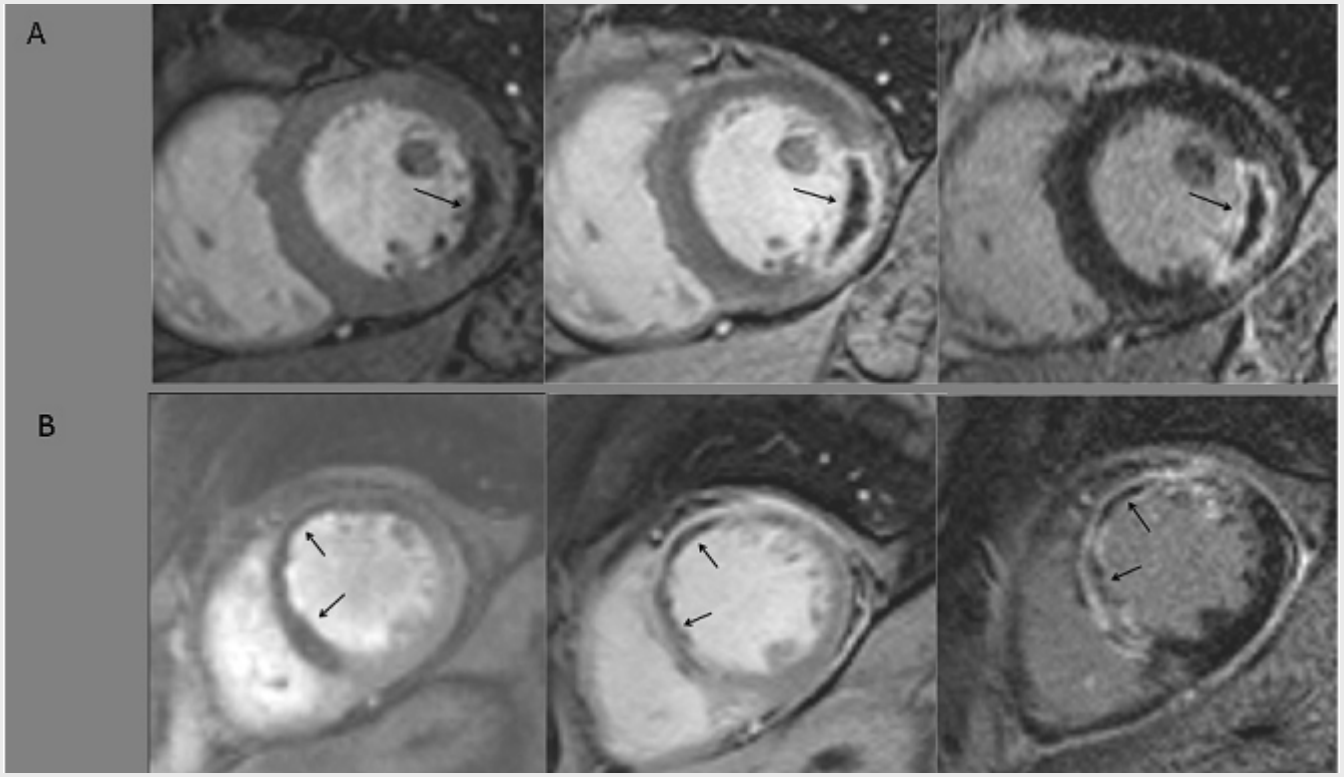
“The tip of the Iceberg”



The CMR approach to No-Reflow

EARLY MVO **PERSISTENT MVO**

First-pass Perfusion | Early Gadolinium Enhancement | Late Gadolinium Enhancement



< 1min **1-3 min** **>10 min**

JCMR 2009;11:33

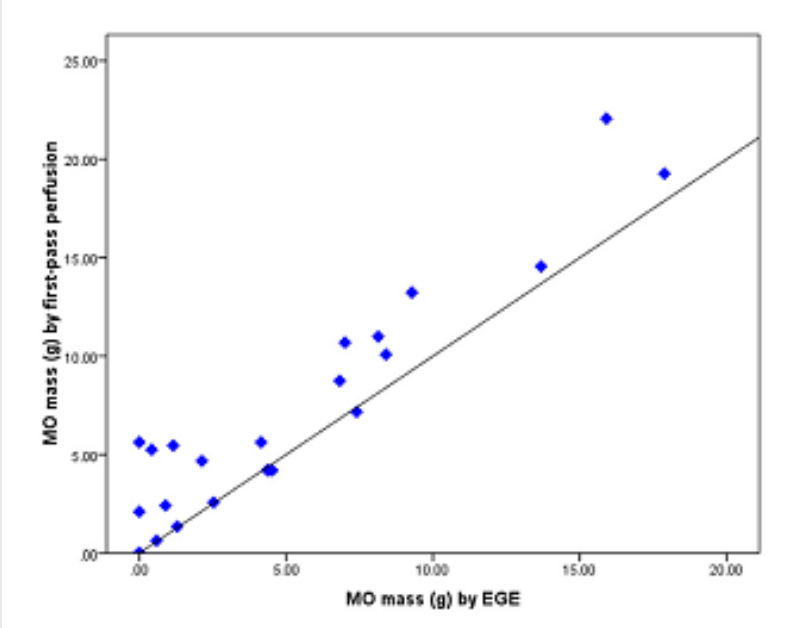
Technical notes

Open Access

Appearance of microvascular obstruction on high resolution first-pass perfusion, early and late gadolinium enhancement CMR in patients with acute myocardial infarction

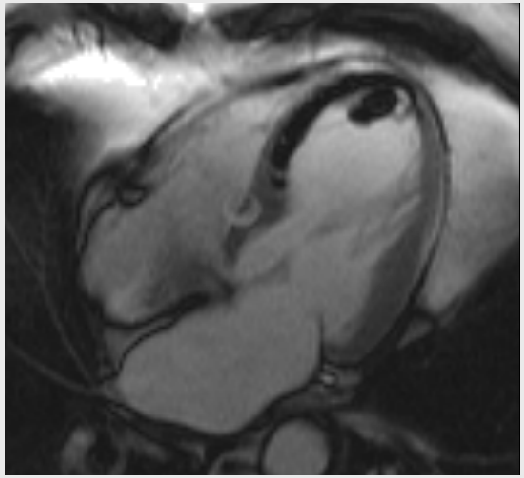
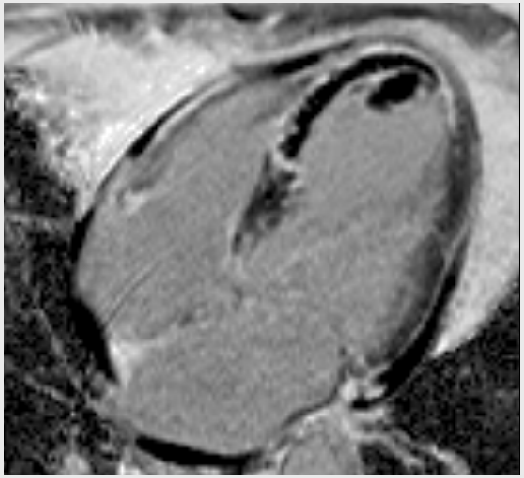
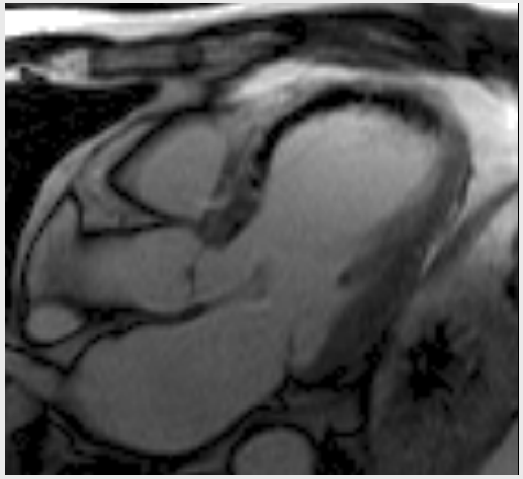
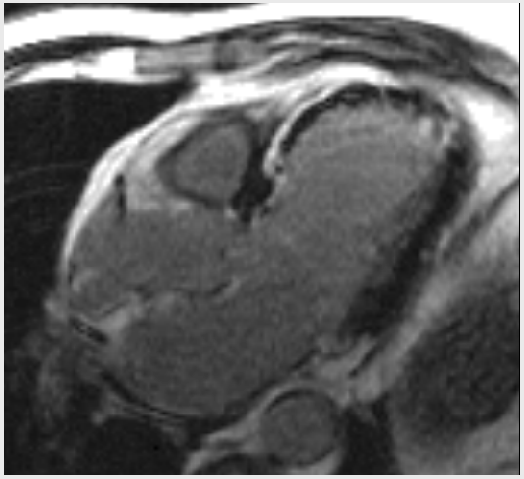
Adam N Mather[1], Timothy Lockie[2,3], Eike Nagel[3], Michael Marber[2], Divaka Perera[2], Simon Redwood[2], Aleksandra Radjenovic[4], Ansuman Saha[1], John P Greenwood[1] and Sven Plein*[1,3]

- 34 pts with acute STEMI treated with pPCI
  - 85% TIMI 3, 15% TIMI 2
- 1st pass perfusion detected more cases of MVO than EGE & LGE
  - 22 vs. 20 vs. 14



JCMR 2009;11:33

Case: acute MI & MVO

	EGE	LGE
HLA		
LVOT		

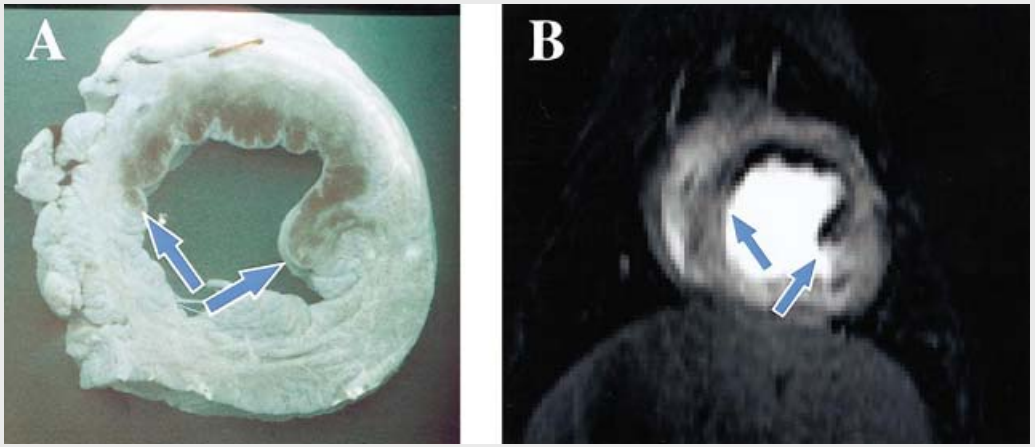
Validation Studies

OCMR

UNIVERSITY OF OXFORD

Validation Studies CMR-MVO (1)

- CMR 2, 6, 48h after reperfusion
- The MRI hypoenhanced area (MVO) increased 3-fold 48h after reperfusion



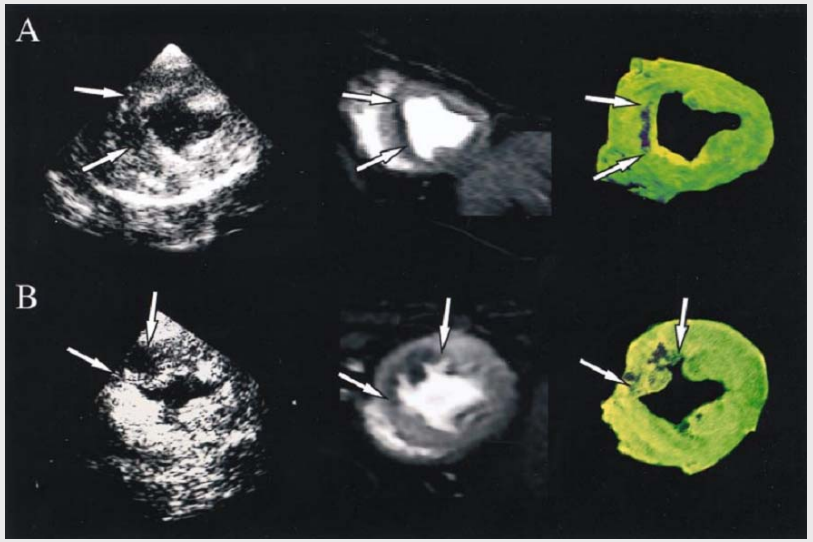
- The area of MVO by CMR correlated well with microvascular obstruction by radioactive microsphere MBF and staining with thioflavin S.

Rochitte et al. Circulation 1998;98:1006-1014

Validation Studies CMR-MVO (2)

- 10 dogs 90min LAD occlusion and reperfusion
- CMR and CE 2 & 9d after reperfusion
- Microspheres for MBF
- Thioflavin-S staining post-mortem
- Correlation of MVO with thioflavin and:
  - CMR (r= 0.91)
  - CE(r= 0.79)

Time course of MVO



1. **CMR can detect regions of MVO with MBF< 40% of remote (CE <60% remote)**
2. **The extent of MVO is unchanged at 2 and 9 days after reperfusion**

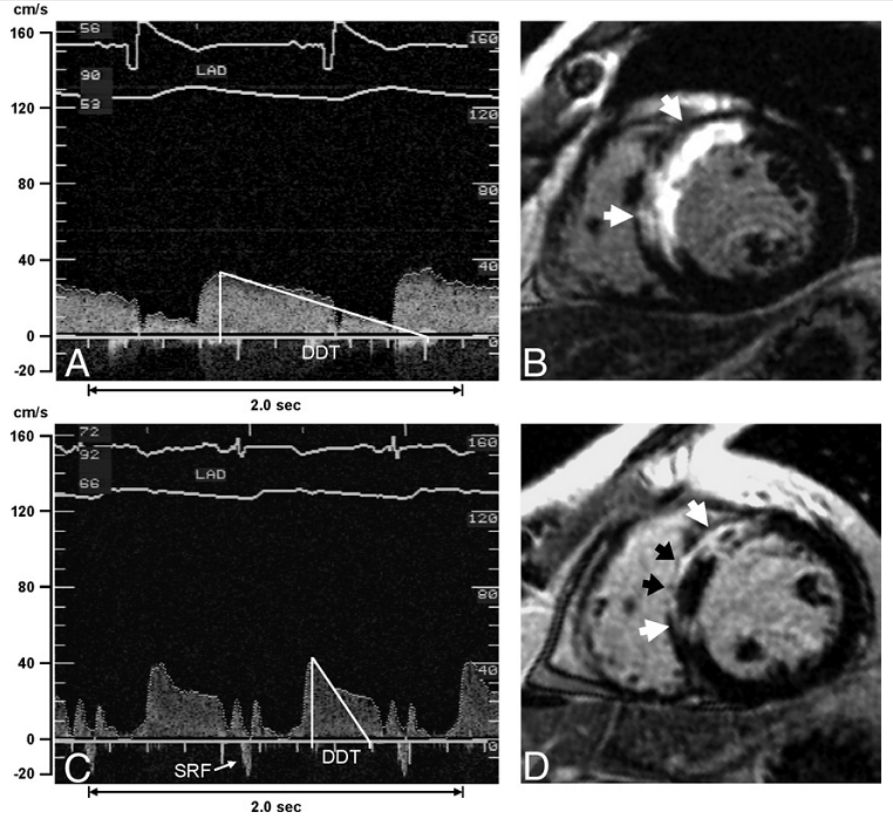
Wu et al. J Am Coll Cardiol 1998;32:1756-64

Validation against Coronary Doppler

27 patients with first anterior STEMI successfully treated with primary PCI

<u>Coronary blood flow velocity & no-reflow</u>
early systolic retrograde flow (SRF)
rapid deceleration of diastolic flow

Early systolic retrograde flow present in:
- 0 of 8 pts without MVO on LGE CMR
- 10 (53%) of 19 pts with MVO



J Am Coll Cardiol 2008;51:2230–8

CMR, ECG , Angio Measures of MVO

60 patients with AMI treated with primary stenting

CMR (2-9 d post PCI): early MVO, late MVO, infarct size
CMR (4 m post PCI): volumes and EF

ECG: ST resolution 1h
Angio: TIMI flow grade, myocardial blush grade

Table 2 Relationship Between Angiographic/Electrocardiographic Parameters, and First-Pass Perfusion and Late Gadolinium-Enhanced Imaging

	MVO During First-Pass Perfusion			MVO on LGE Images		
	No	Yes	p Value	No	Yes	p Value
TIMI flow grade						
2	2 (18%)	9 (82%)	0.48*	5 (45%)	6 (55%)	1.0*
3	17 (35%)	32 (65%)		21 (43%)	28 (57%)	
MBG						
0/1	3 (33%)	6 (67%)	1.0*	4 (44%)	5 (56%)	1.0*
2/3	16 (31%)	35 (69%)		22 (43%)	29 (57%)	
ST-segment resolution						
Incomplete	6 (17%)	30 (83%)	0.002†	11 (31%)	25 (69%)	0.01†
Complete	13 (54%)	11 (46%)		15 (63%)	9 (37%)	

J Am Coll Cardiol 2008;52:181–9

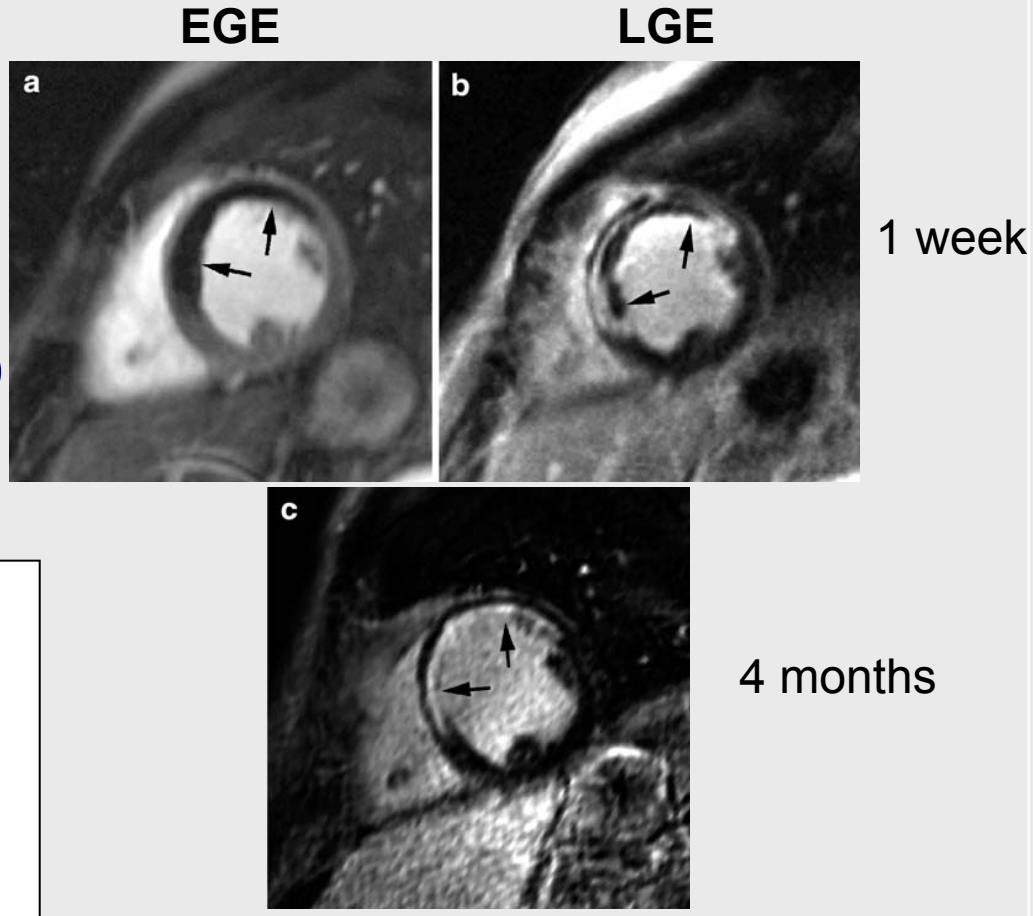
Clinical Importance

OCMR

UNIVERSITY OF OXFORD

CMR, MVO and LV Remodelling

- 52 pts STEMI
- Primary PCI
- TIMI flow 2/3
- Early MVO 32/52 (62%)
- Late MVO 27/52 (52%)



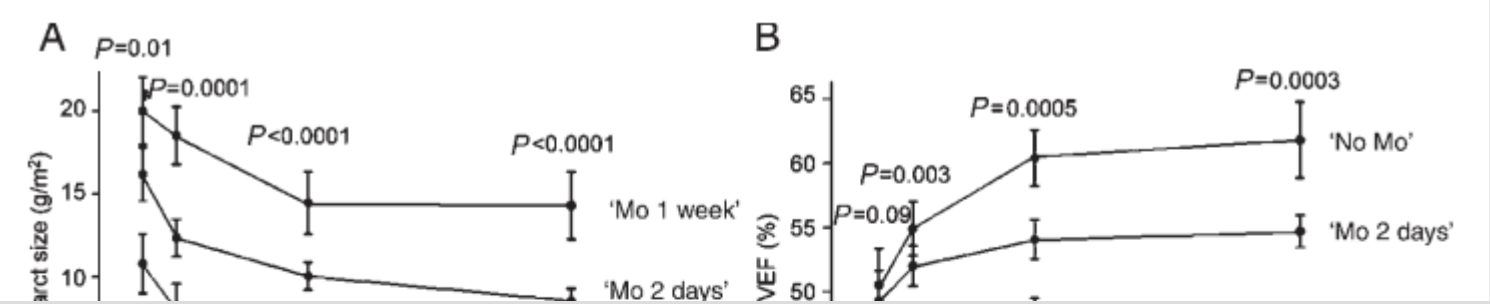
MVO associated with:

- Lower TIMI flow
- Larger infarcts
- Adverse Remodelling & no functional recovery

Bogaert J, Kalantzi M et al.
Eur Radiol 2007;17: 2572–2580

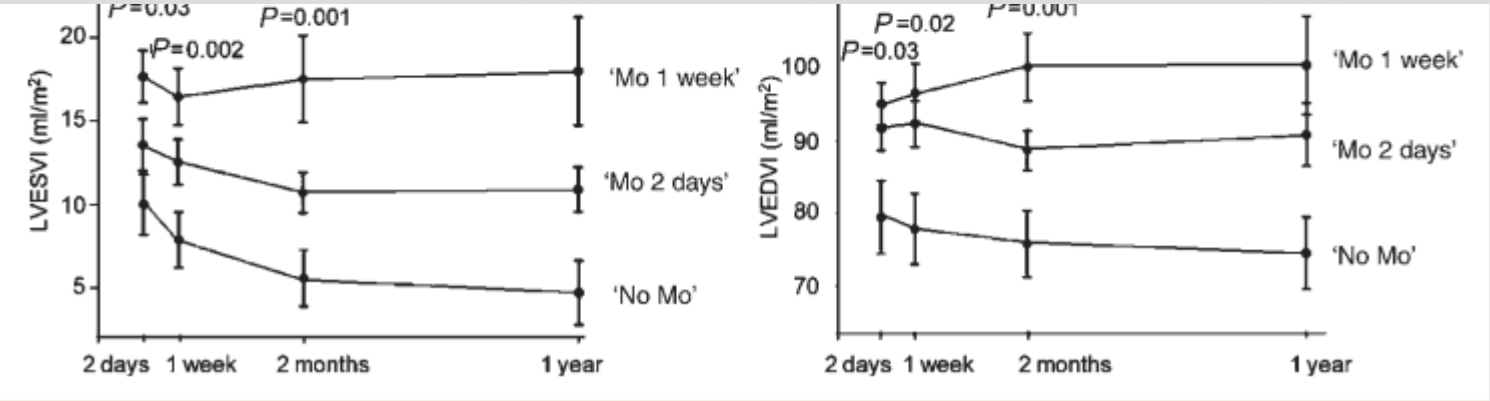
MVO, Infarct size & LV Remodelling

42pts
1st STEMI
pPCI



Detectable MVO at 1 week is an independent predictor of infarct size at 1 year f-up, associated with adverse LV remodelling, increased LV volumes, and lower ejection fraction

1 year

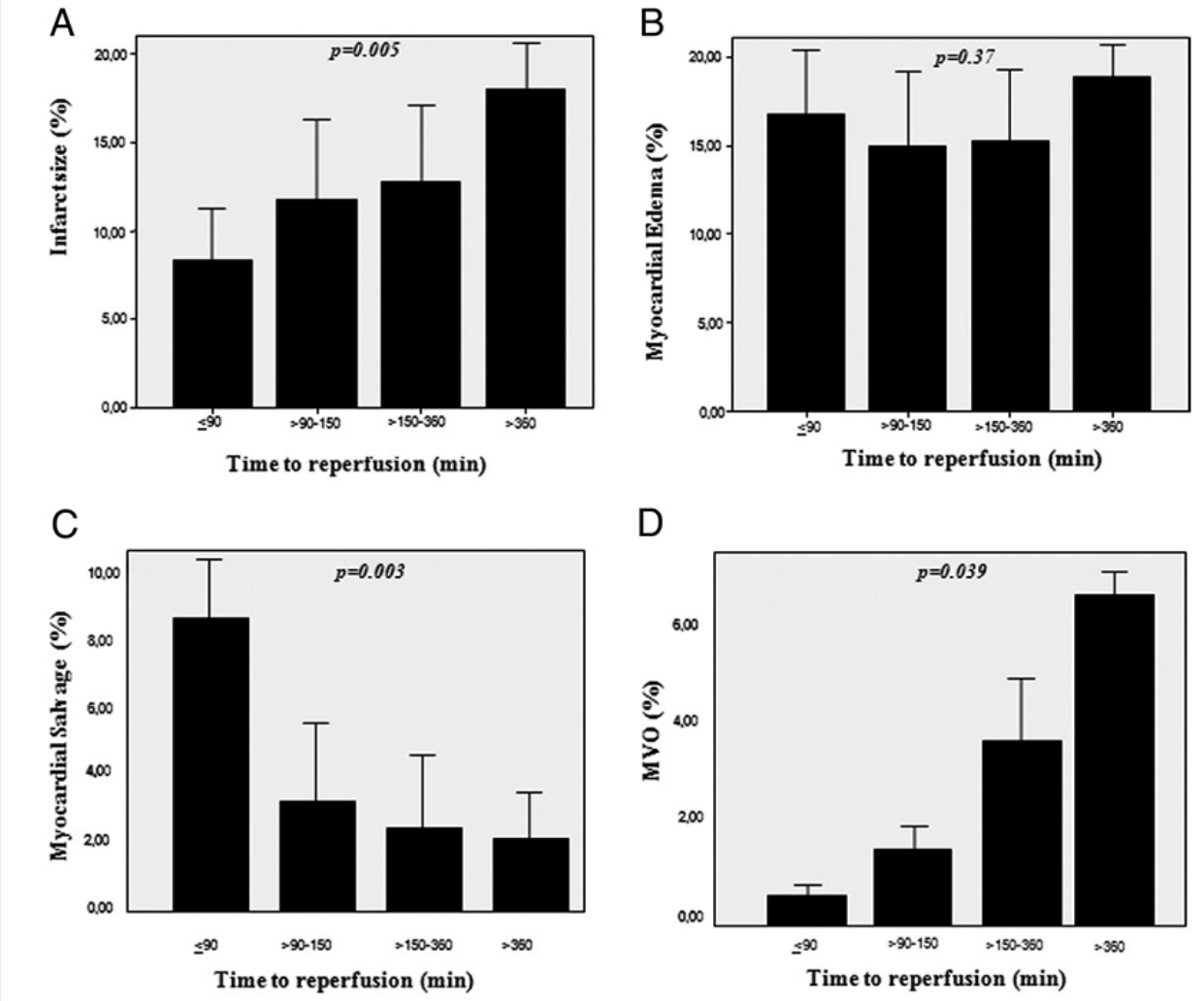


European Heart Journal 2009;30:1978–1985

Primary PCI delay & Infarct size - MVO

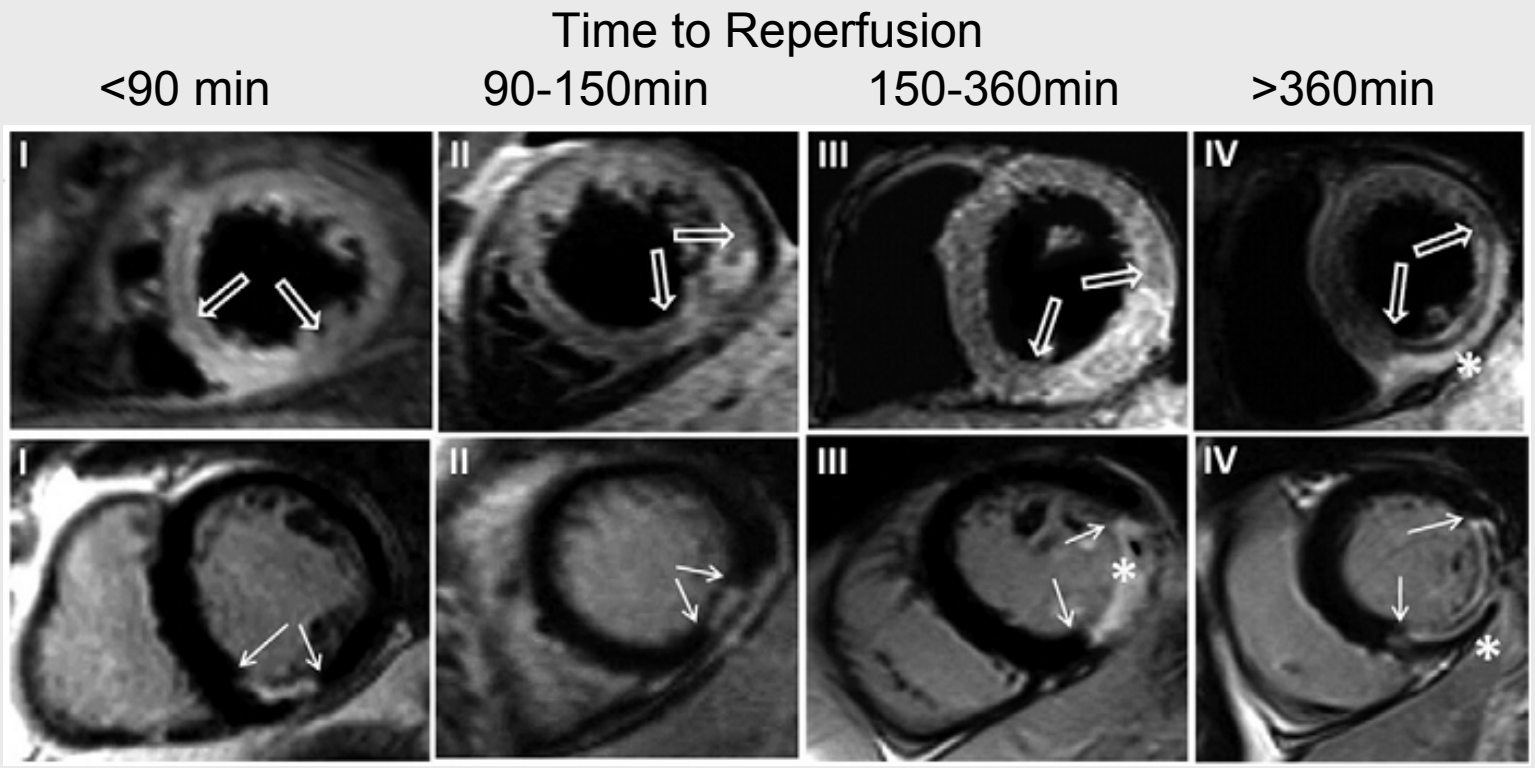
- 70 pts STEMI - pPCI
- CMR @ 3±2 days and 6 months

- TIMI flow 3
- < 30% residual stenosis



J Am Coll Cardiol 2009;54:2145–53

Primary PCI delay & Infarct size - MVO



J Am Coll Cardiol 2009;54:2145–53

Prognostic Significance

OCMR

UNIVERSITY OF OXFORD

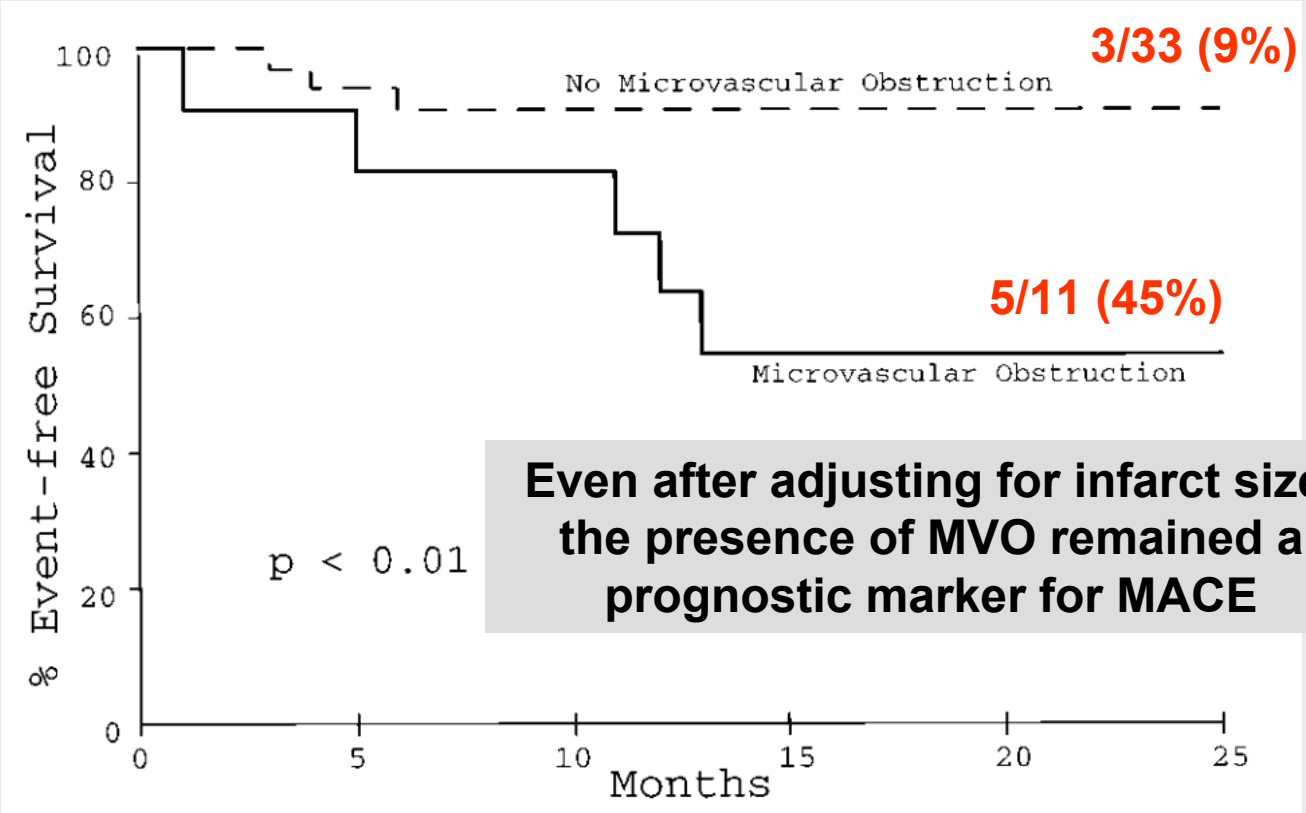
Prognostic Implication of MVO

44 patients

CMR 10±6d postMI
1min post contrast

F/up 16±5 months

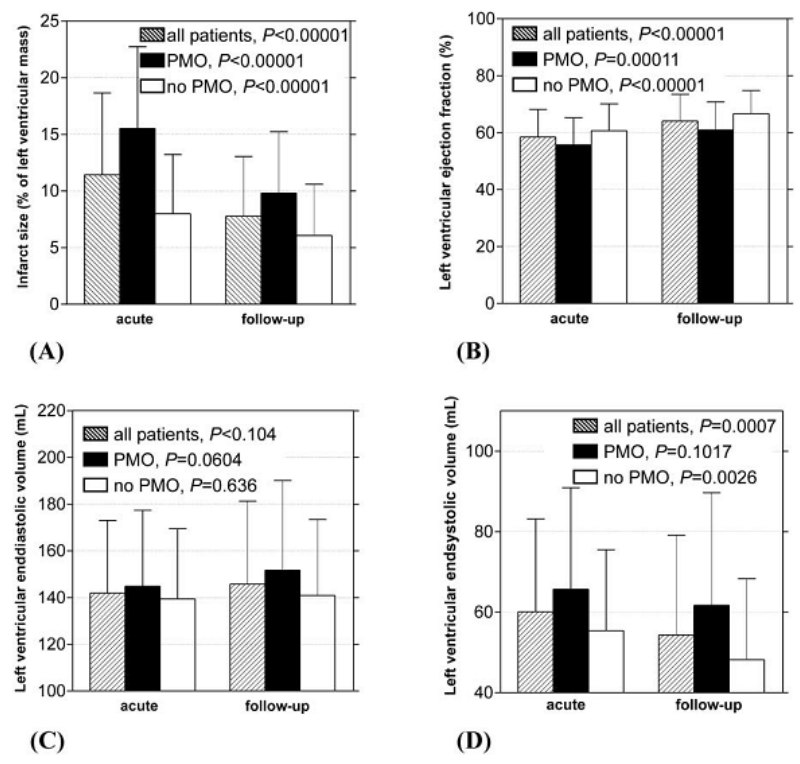
<u>MACE</u>
Cardiac death
Nonfatal re-infarction
Heart failure
Ischemic CVA
Unstable angina

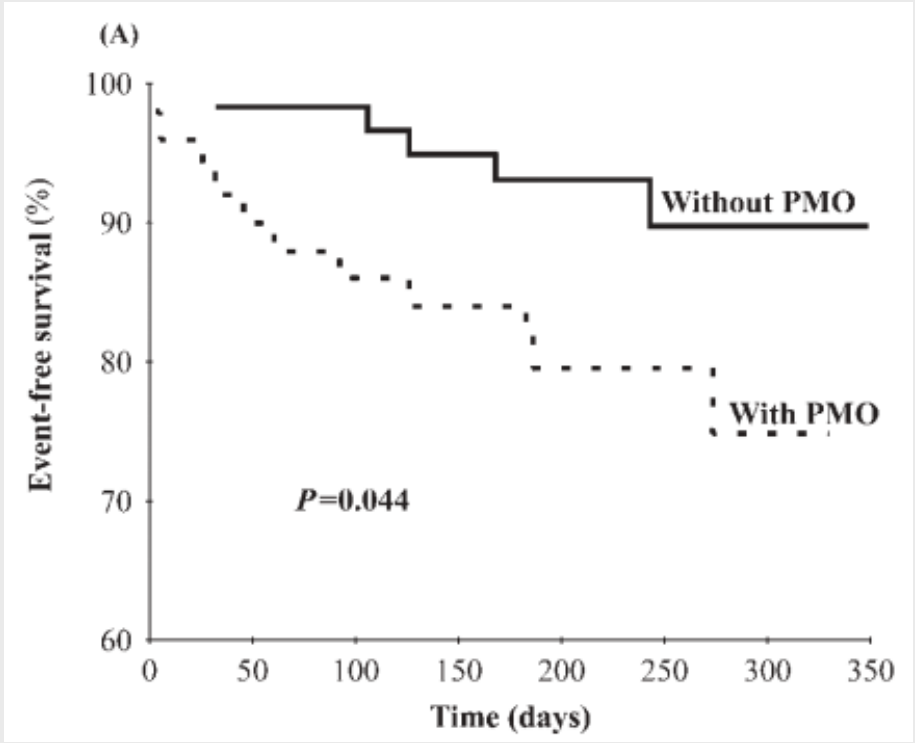


Even after adjusting for infarct size, the presence of MVO remained a prognostic marker for MACE

Circulation 1998;97:765-772

Prognostic Implication of pMVO





- 110 patients with acute STEMI and revascularisation
- LGE CMR
- Follow-up 6 months

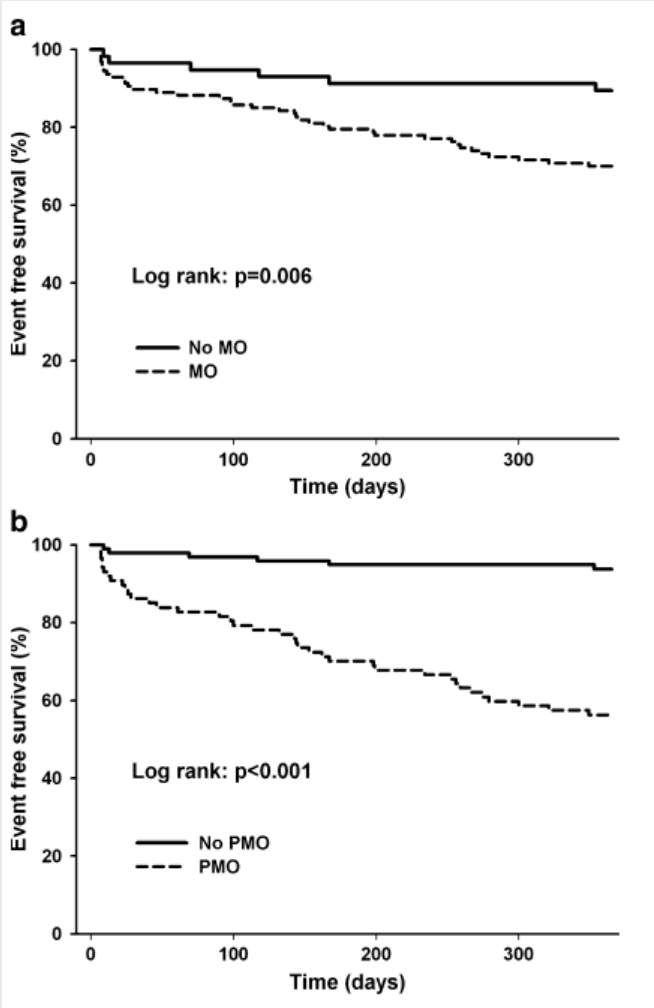
European Heart Journal 2005;26:549–557

Early vs Persistent MVO

- 184 pts 1 week post pPCI
- MVO (1st-pass perfusion)
- pMVO – infarct size (LGE)
- MACE (1 year f/up)

- 127 (69%) MVO - 87 (47%) persistent MVO
- 38 MACE

Persistent MVO reflects the presence of extensive severe microvascular damage with likely higher prognostic significance than MVO on 1st-pass perfusion images



Eur Radiol 2009;19:2117–2126

Infarct Haemorrhage & MVO

OCMR

UNIVERSITY OF OXFORD

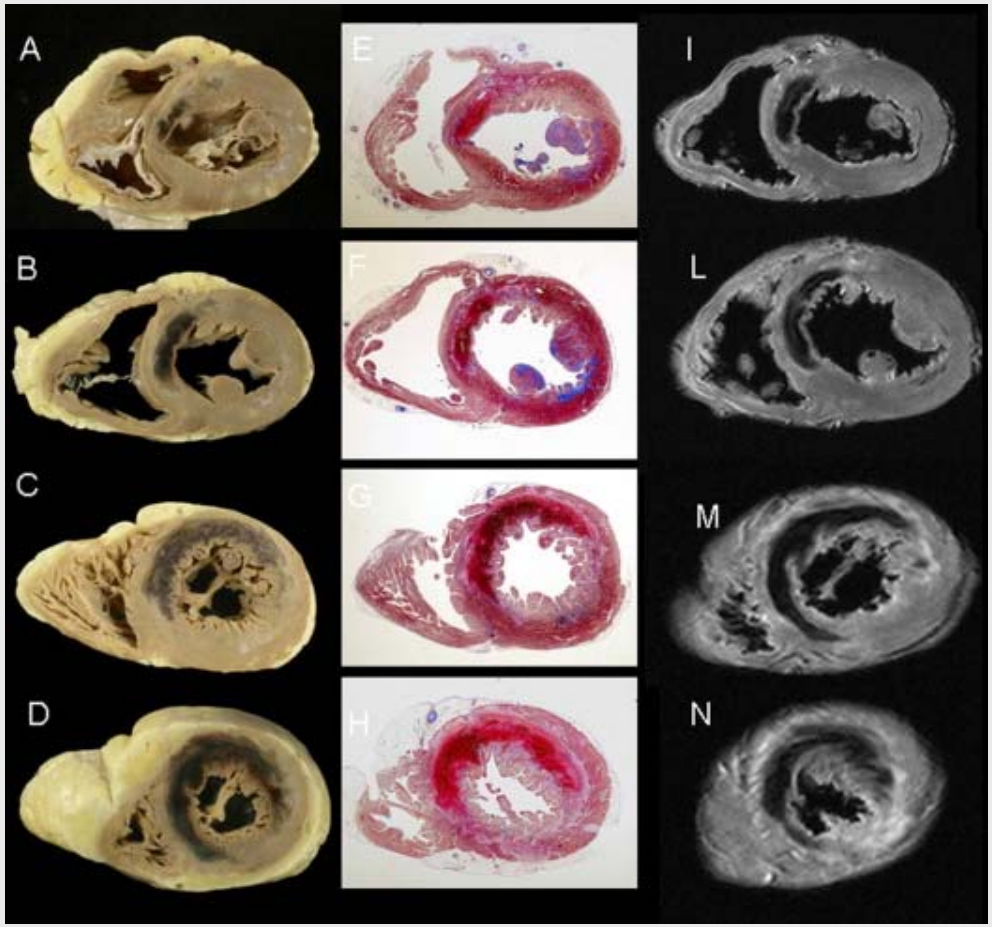
Infarct Haemorrhage & MVO

Infarct Haemorrhage

- reduced T2 signal metHb paramagnetism in the core of the infarct

- increased T2 signal from the surrounding tissue oedema

Histology **ex vivo T2 CMR**



Heidenhain trichrome stain

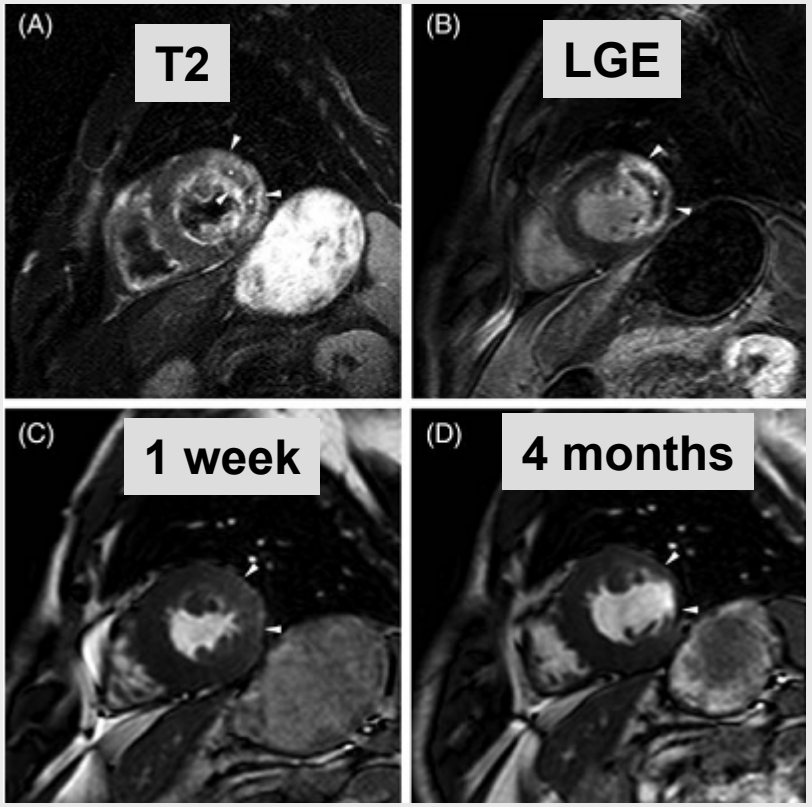
Am J Cardiol. 2007;100:1322-7

Infarct Haemorrhage & MVO

- 98 STEMI pts - pPCI TIMI≥2
- Haemorrhage 24/98 (25%)
- MVO 63/98 (64%)

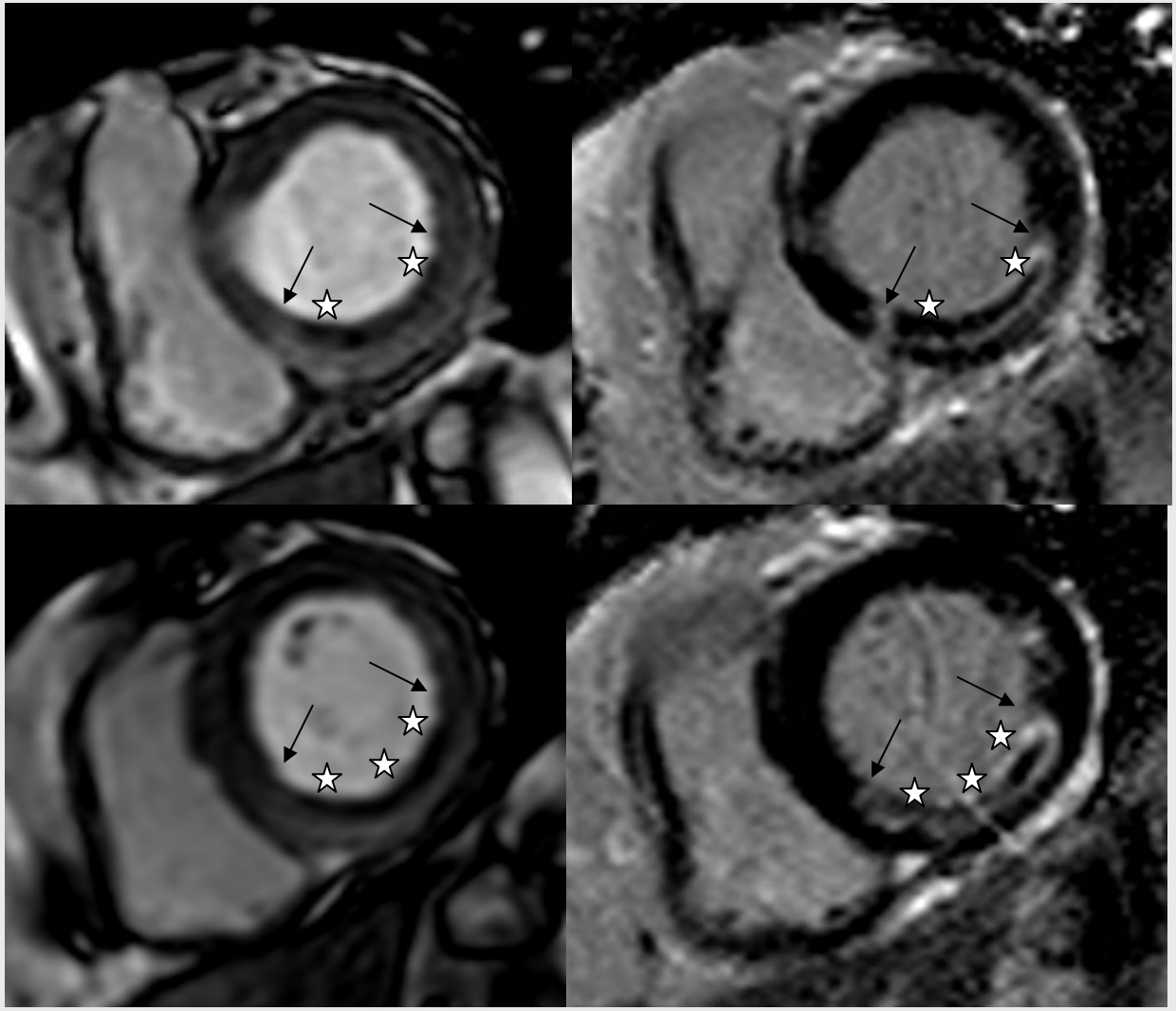
39 pts with MVO *without* haemorrhage

Haemorrhage independent predictor of adverse LV remodelling regardless of the initial infarct size.



European Heart Journal 2009;30:1440–1449

Infarct Haemorrhage & MVO
Case



CMR Imaging Protocol for MVO

Gad 0.1-0.2 mmol/kg

0

<45 min

8-15 min

Anatomy

Cine

T2-weighted imaging

First pass perfusion

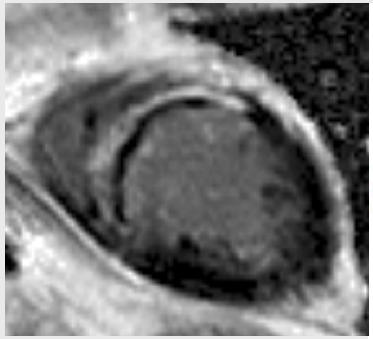
Early gad

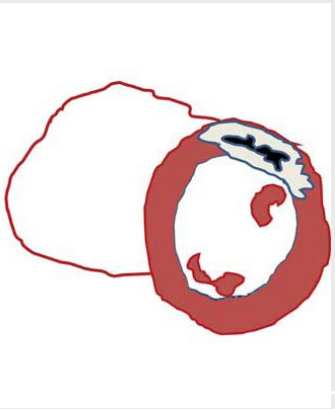
Late gad

Oedema
Haemorrhage

Early MVO

Late MVO
Infarct size

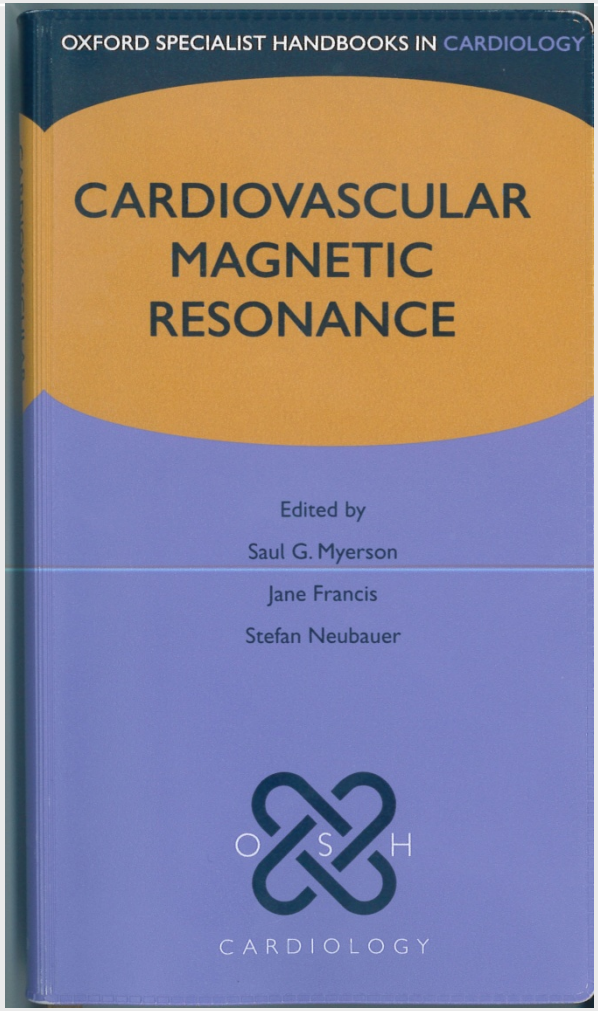




Conclusions

- CMR is an excellent method & has several ways to detect and quantify MVO
- MVO is associated with adverse LV remodelling and lack of functional recovery
- MVO carries adverse prognosis for MACE (independent of infarct size)
- T2-w CMR can also detect cases of myocardial haemorrhage (? histology)

Oxford CMR Handbook



Flexicover, 496 pages
Apr 2010

TABLE OF CONTENTS

Acknowledgements

Clinical Director

Prof. Stefan Neubauer

OCMR

Jane Francis
Saul Myerson
Joe Suttie
Erica Dall' Armelina
Sairia Dass
Vanessa Ferreira
Ntobeko Ntusi

Boston

Michael Jerosch-Herold

Adelaide

Joseph Selvanayagam

Funding

British Heart Foundation