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British Heart Foundation

IMR in acute STEMI and clinical outcomes

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ETP Coronary Physiology

24 April *2015*

Disclosures

Speaker - Shire Pharmaceuticals, AstraZeneca, Bristol Myers, St Jude Medical.

Institutional agreements, University of Glasgow and St Jude Medical

Introduction

IMR in STEMI

1. Pathophysiology
2. Practical considerations
3. Prognosis
   - Surrogate outcomes
   - Health outcomes

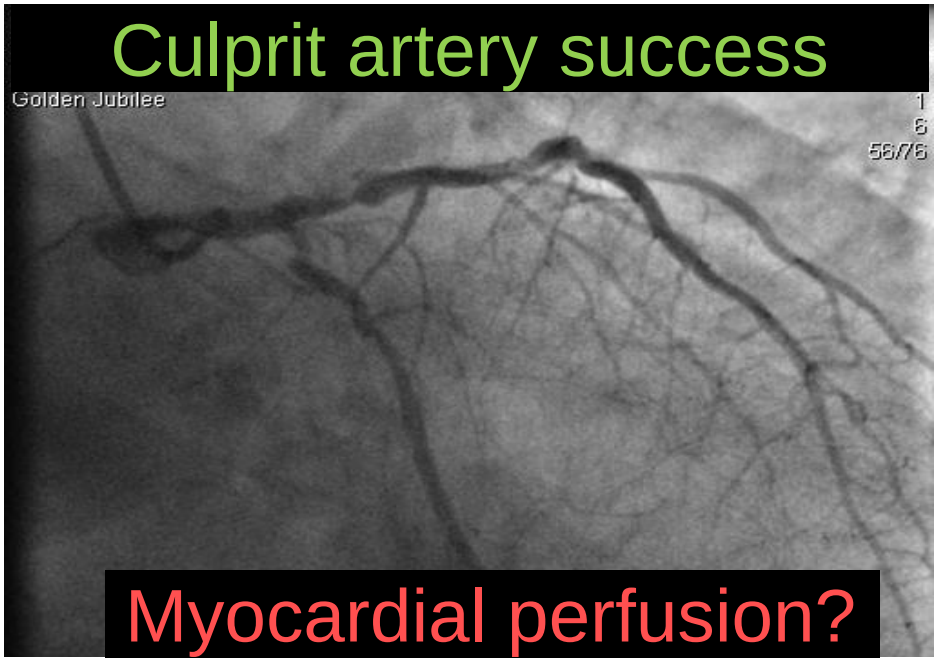
3. Conclusions

STEMI patient pathway

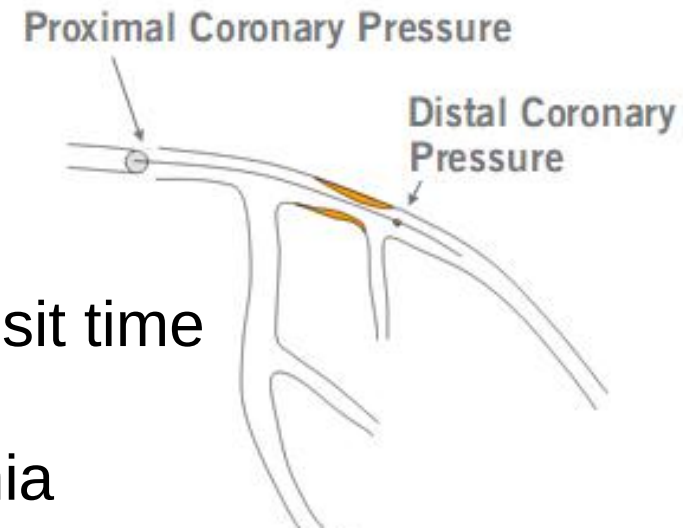
Acute STEMI

Primary PCI → IMR → MRI → Outcome

Acute STEMI : coronary vs. myocardial reperfusion – both equally achieved ?



Use of a diagnostic wire for prognostication at the end of primary PCI

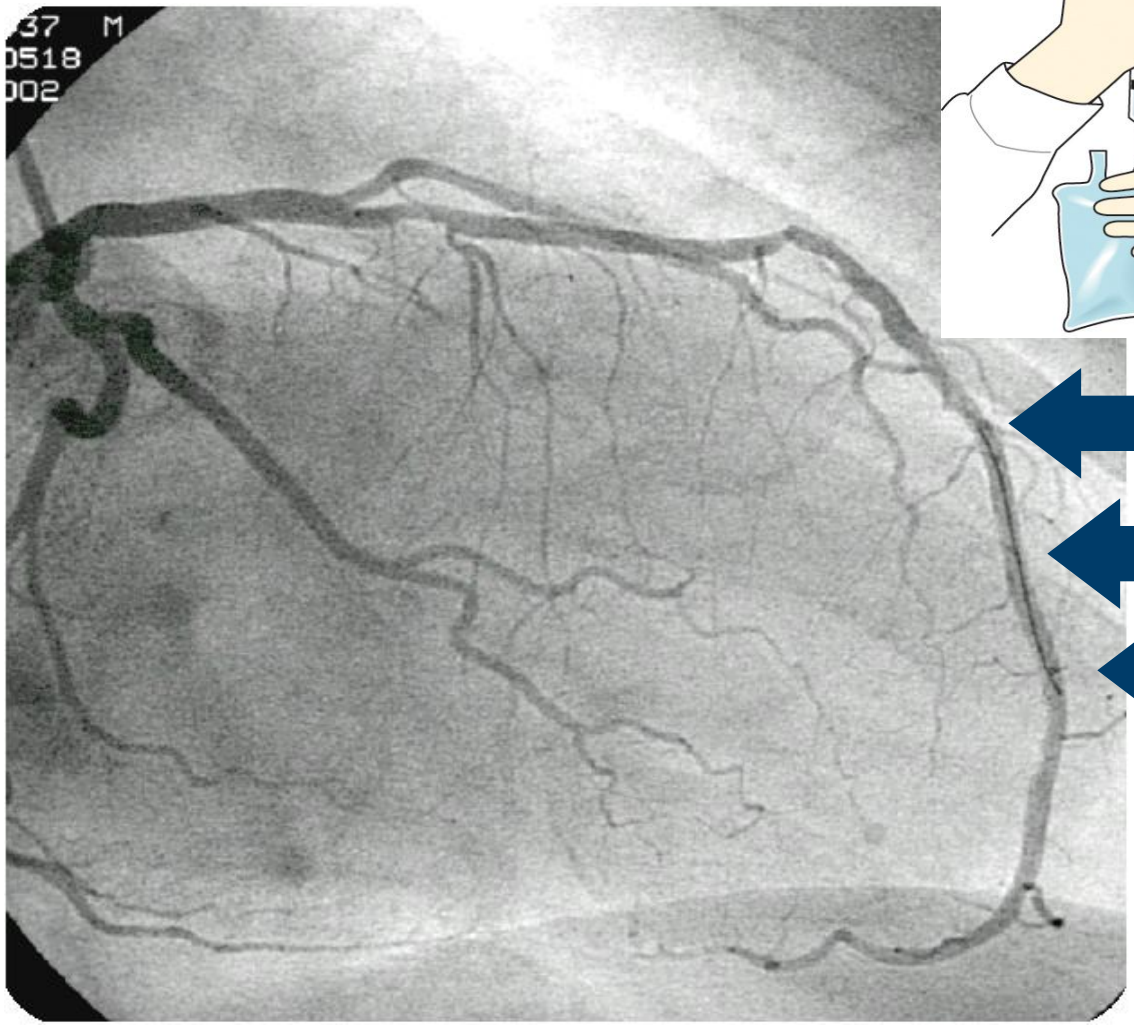


IMR

= Pd x mean transit time

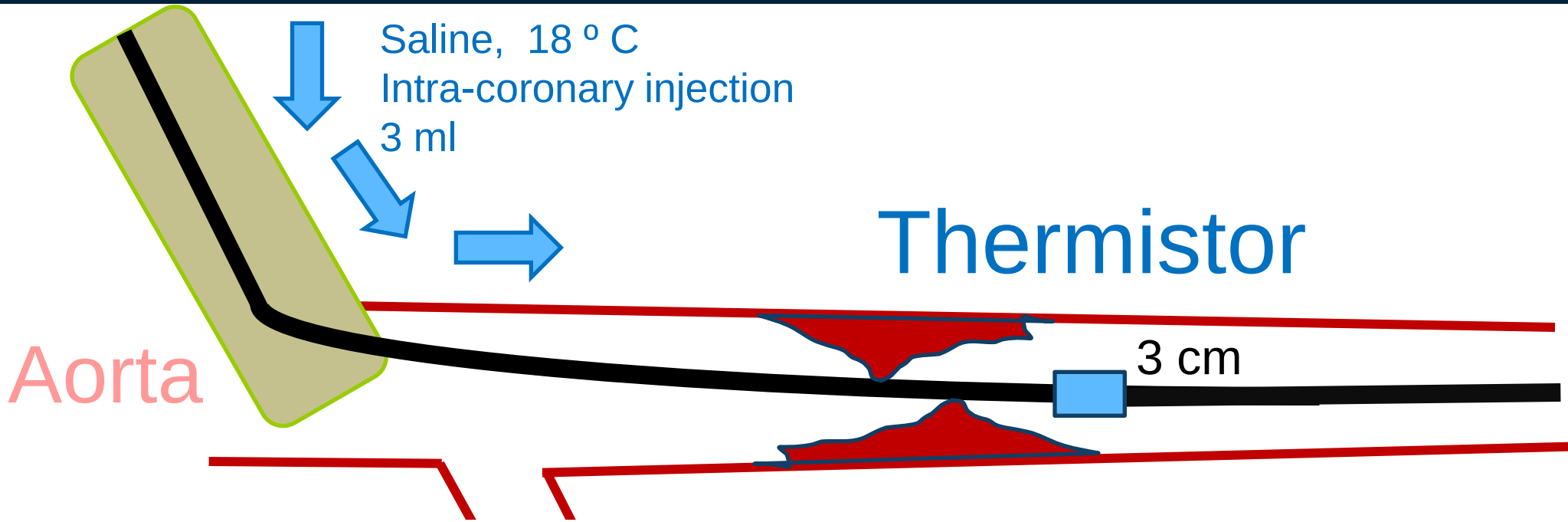
During hyperaemia

PressureWire sensor is placed in the coronary artery, distal to the atherosclerotic plaque.



PressureWire Sensor in the artery.

Microvascular function with thermodilution



Coronary flow reserve, CFR

= Tmn rest / Tmn hyperaemia

Index of microvascular resistance, IMR

= Distal coronary pressure x mean transit time during hyperaemia

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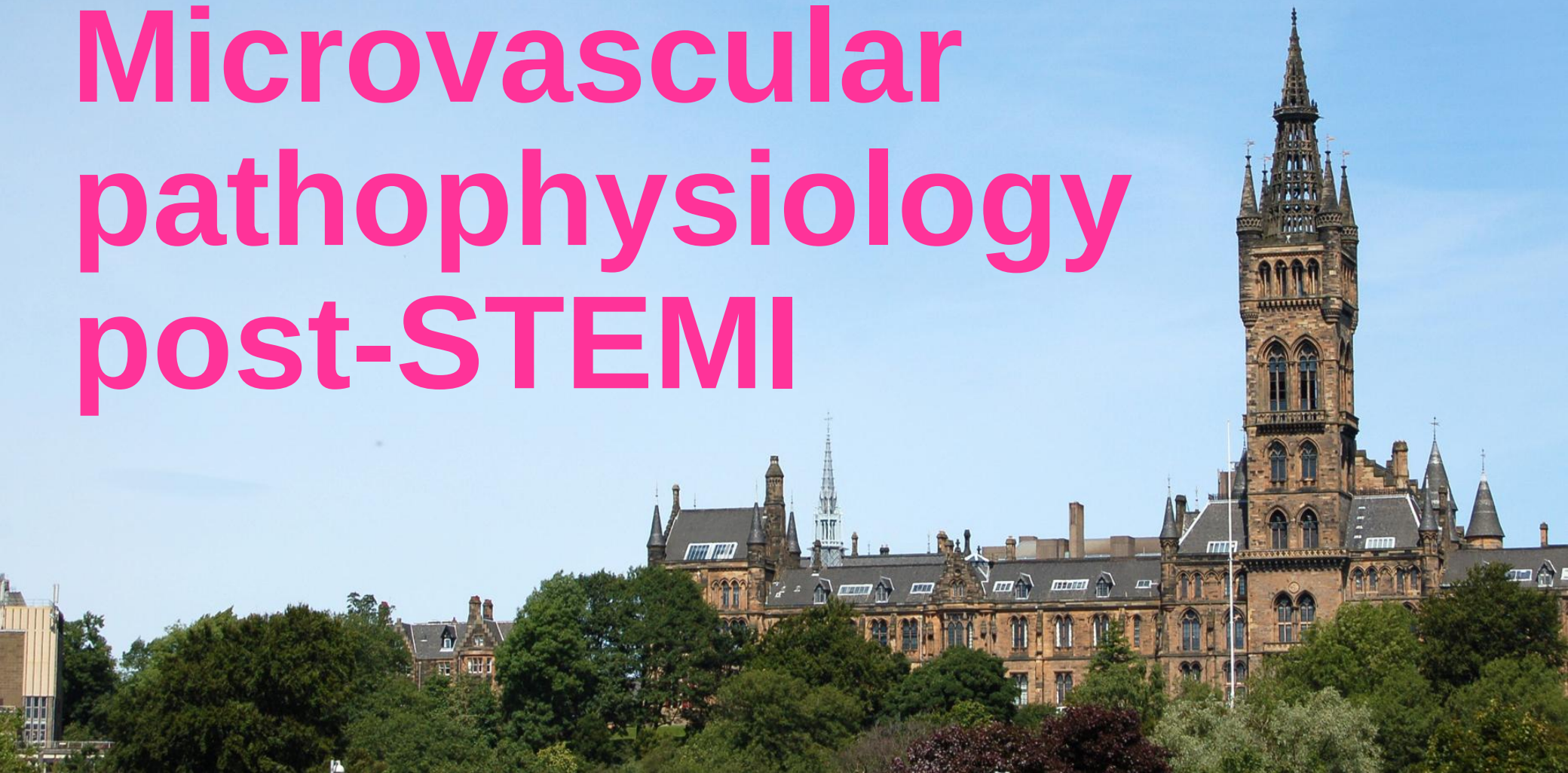
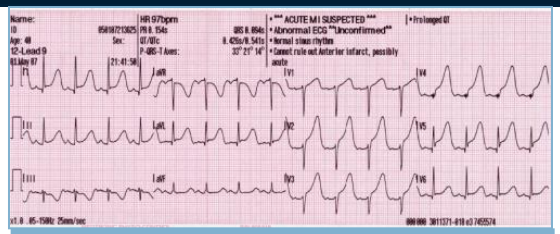
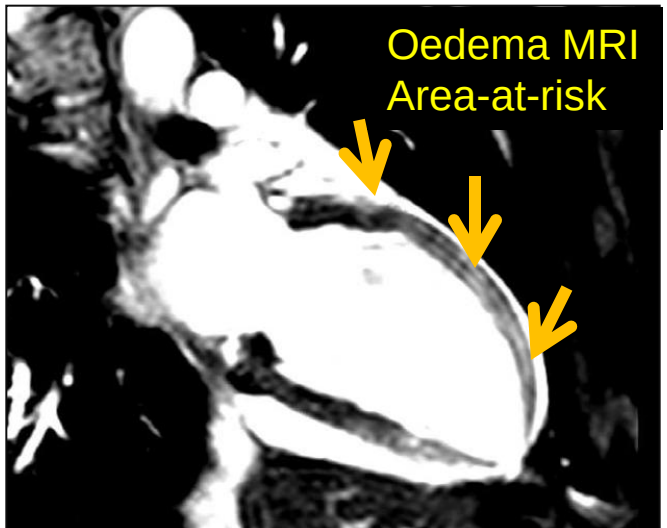
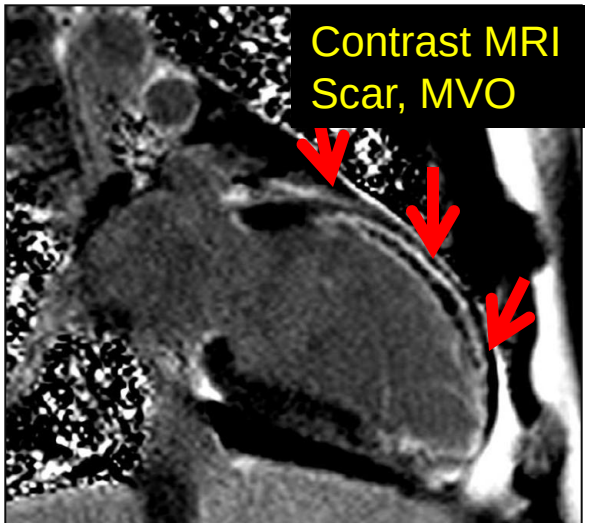
Microvascular pathophysiology post-STEMI



Serial MRI to quantify infarct pathology post-STEMI

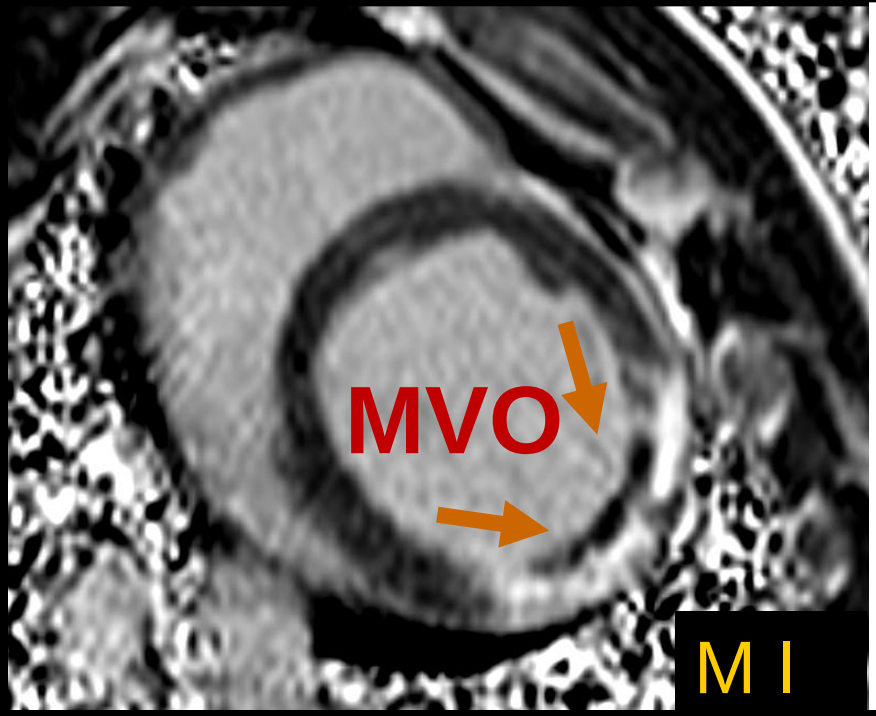


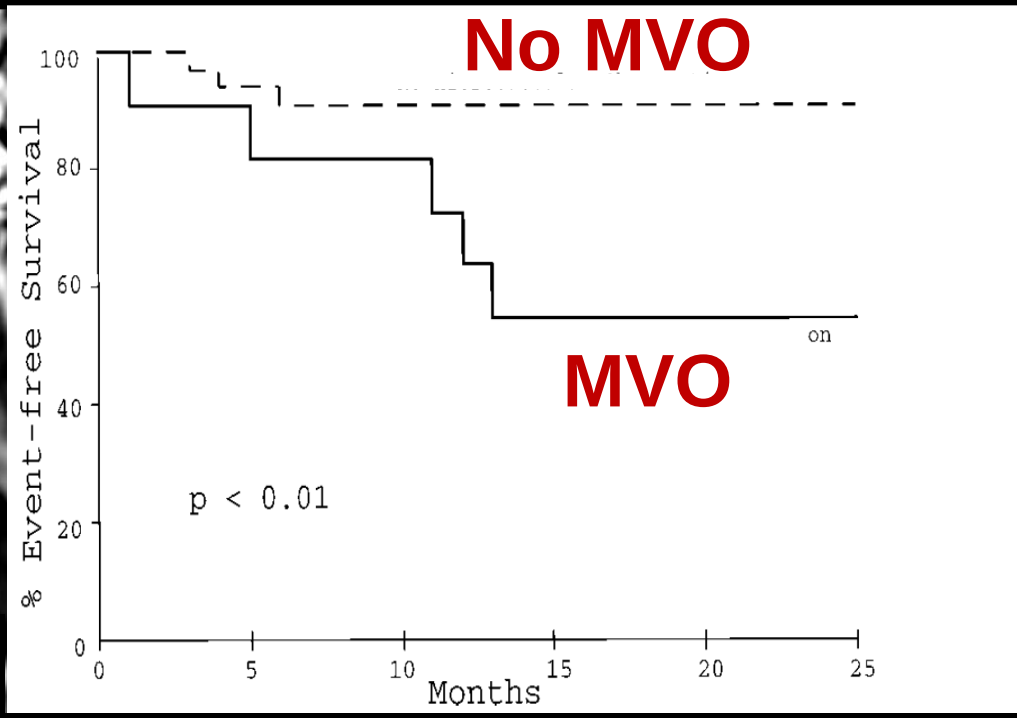




Independent prognostic importance of MVO

One third of acute MIs are complicated by microvascular obstruction (MVO)

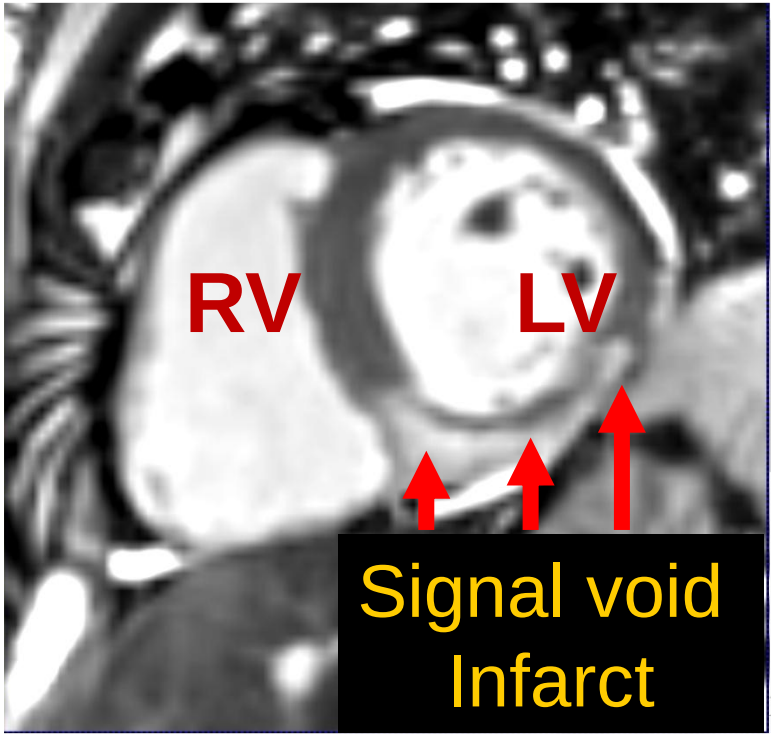




Wu et al Circulation 1998

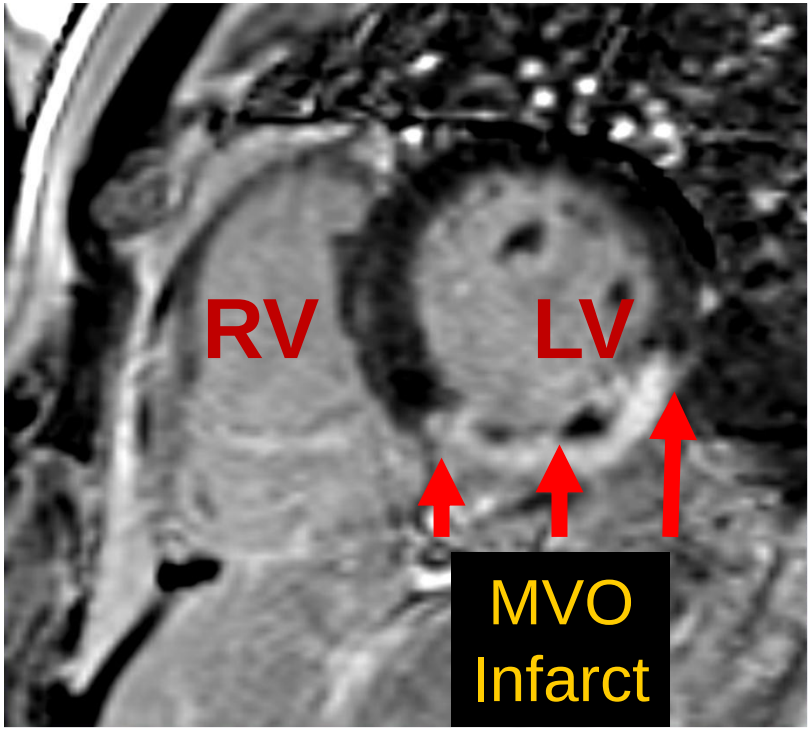
MRI reveals cardiac pathology

T2-Oedema MRI



No contrast agent

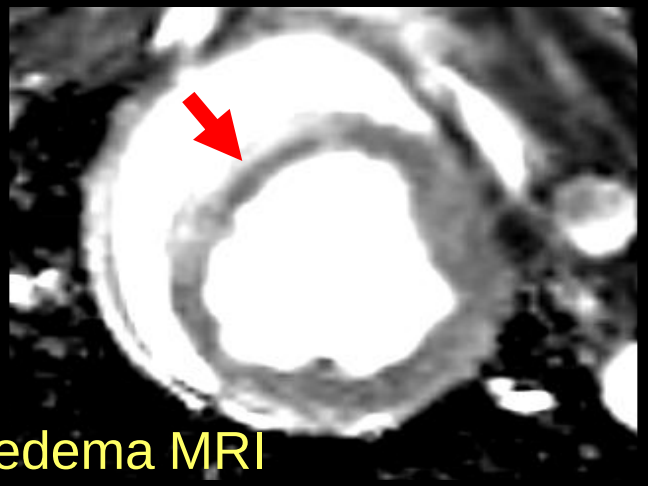
Infarct MRI

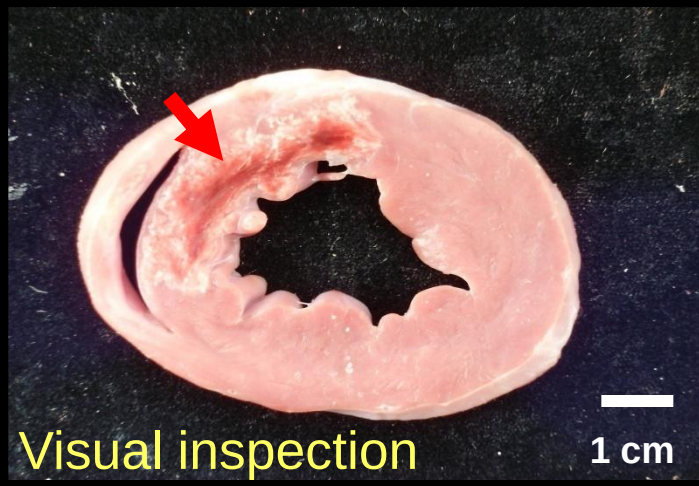


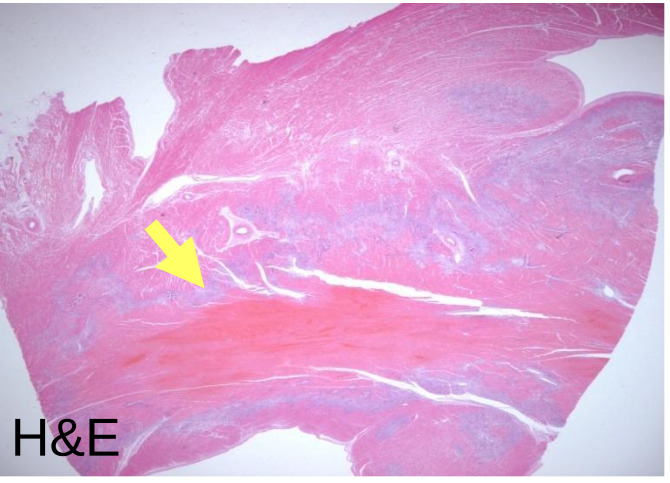
IV gadolinium contrast

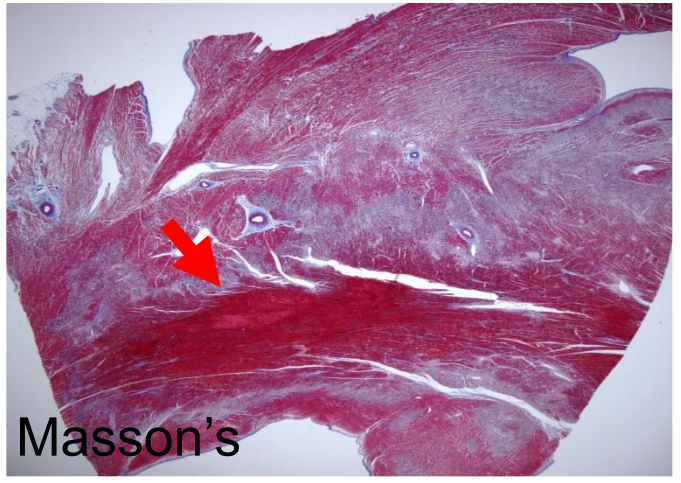
Berry C et al Circ Cardiovasc Imaging 2010

Detection of myocardial haemorrhage with MRI



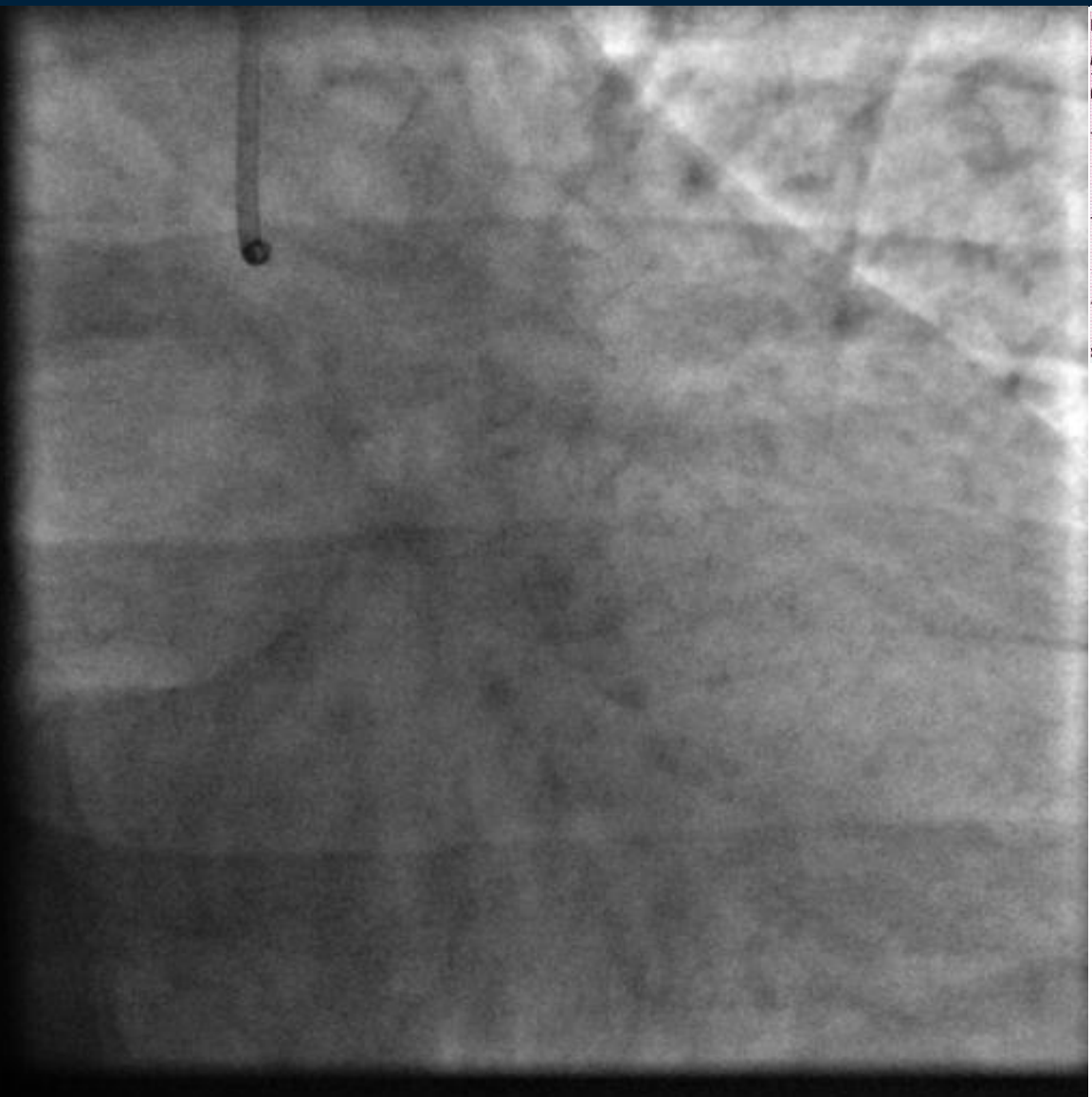


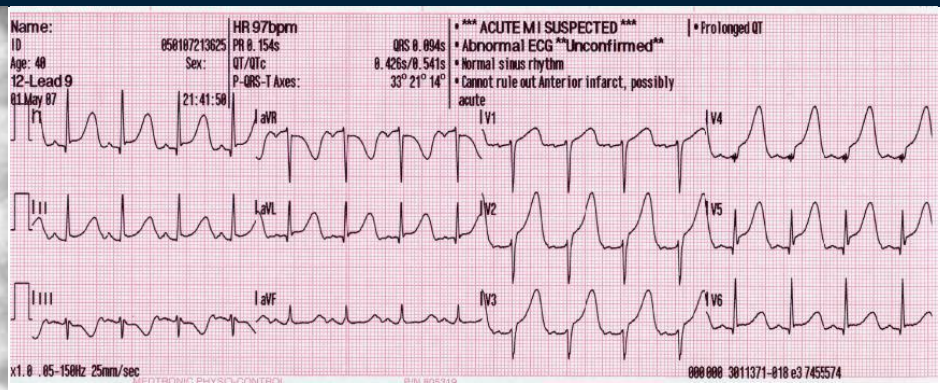




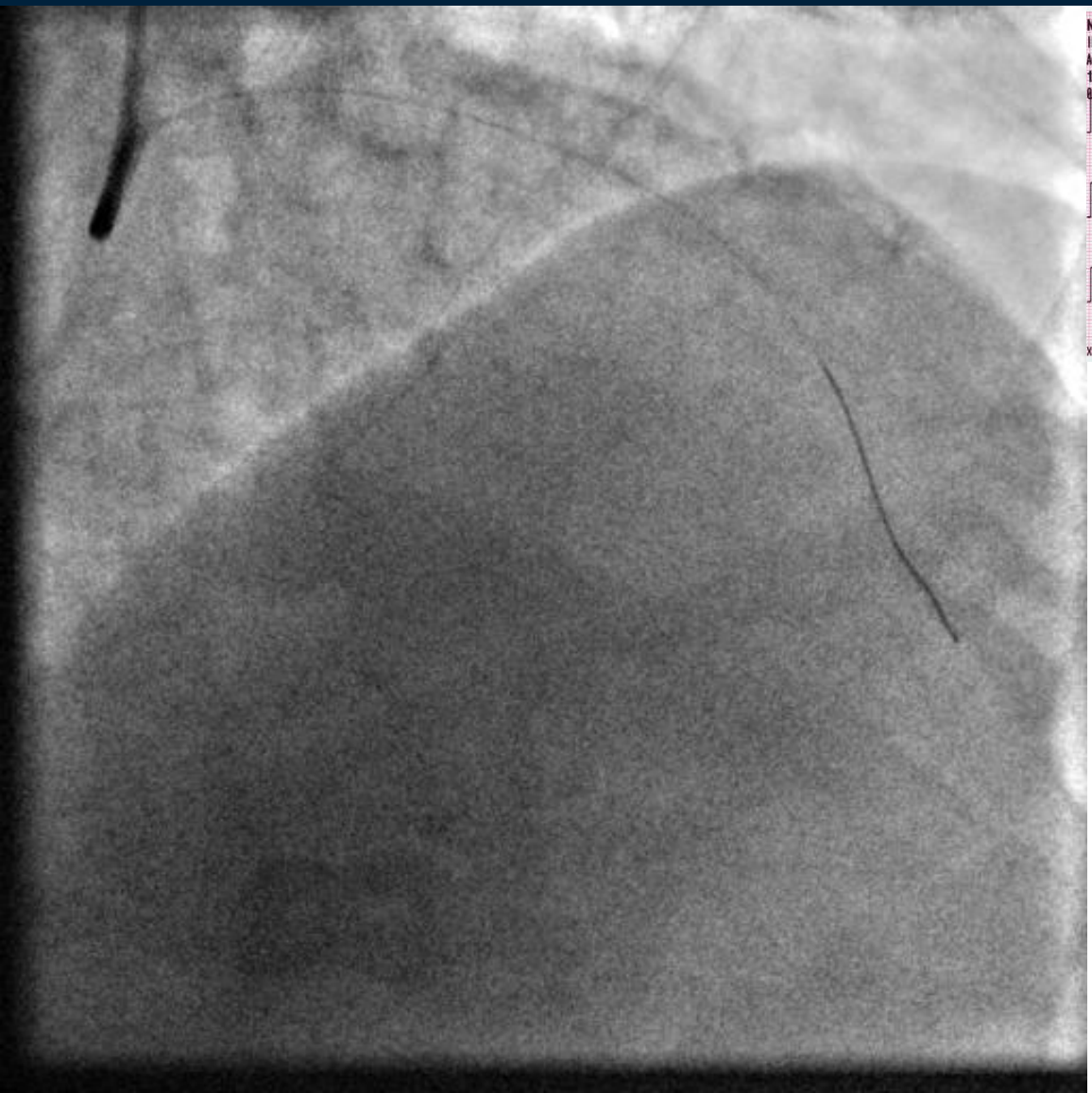
Berry C et al *Circ Cardiovasc Imaging* 2011

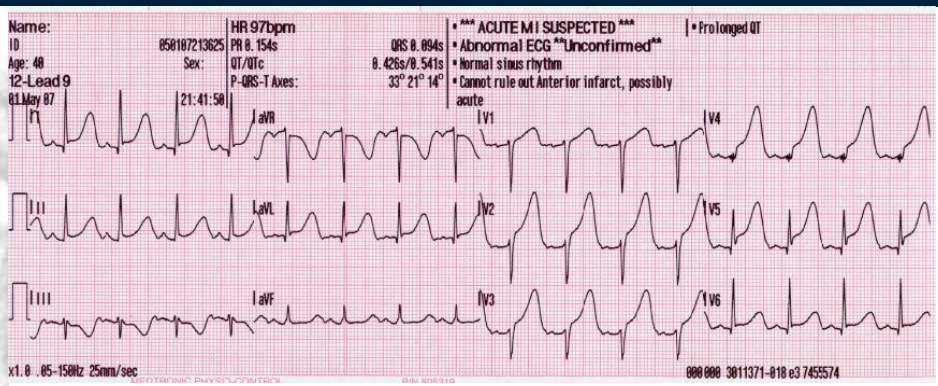
Anterior STEMI





Proximal occlusion of the LAD coronary artery





Clot aspiration

TIMI grade II Improved, subnormal flow

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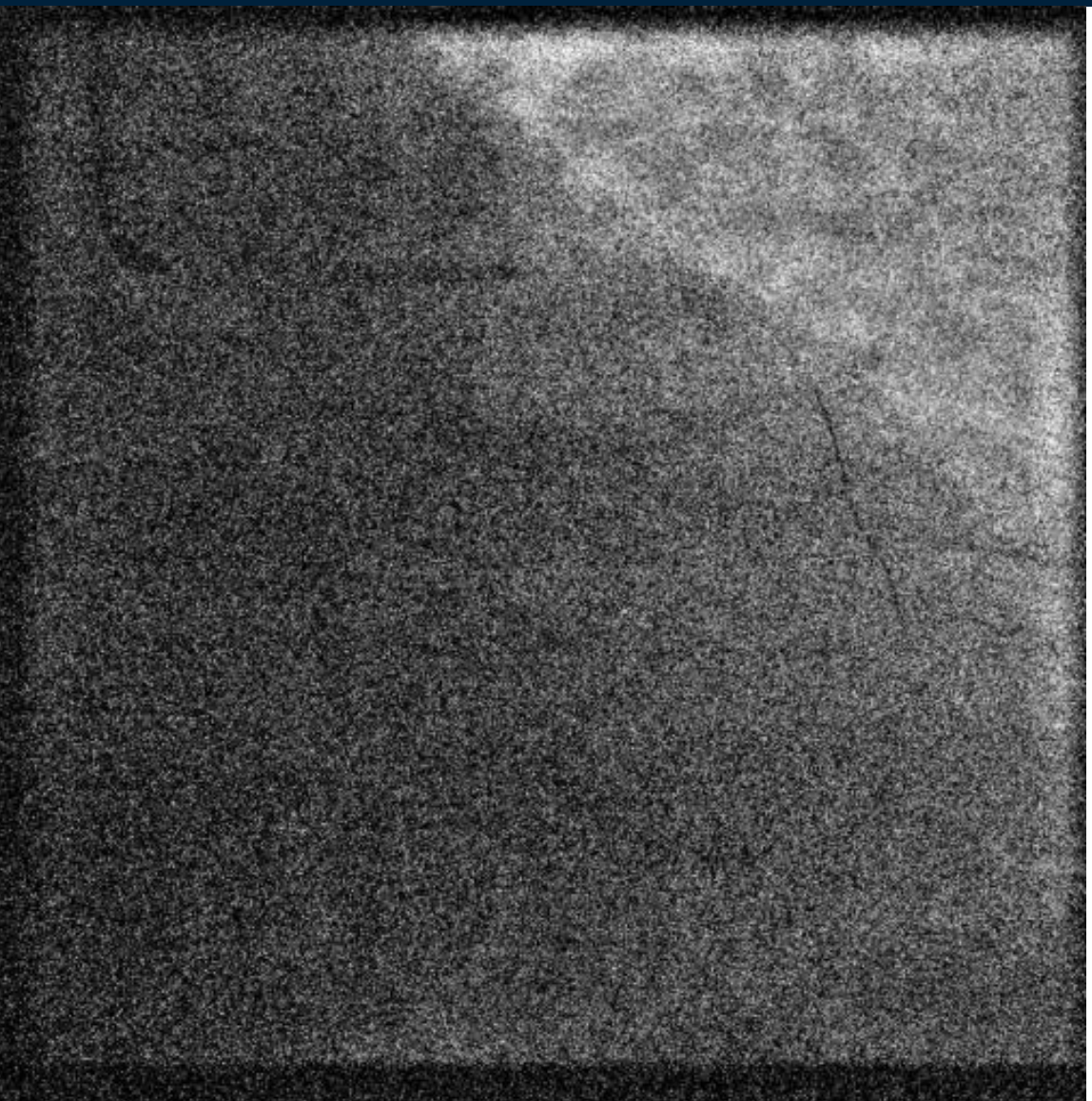
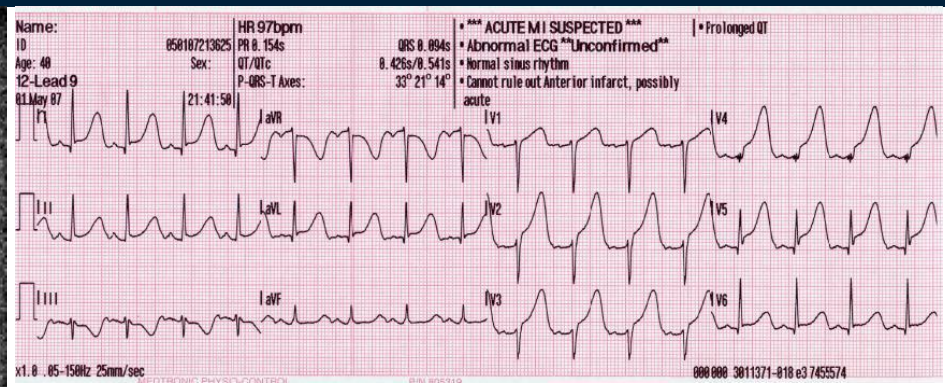
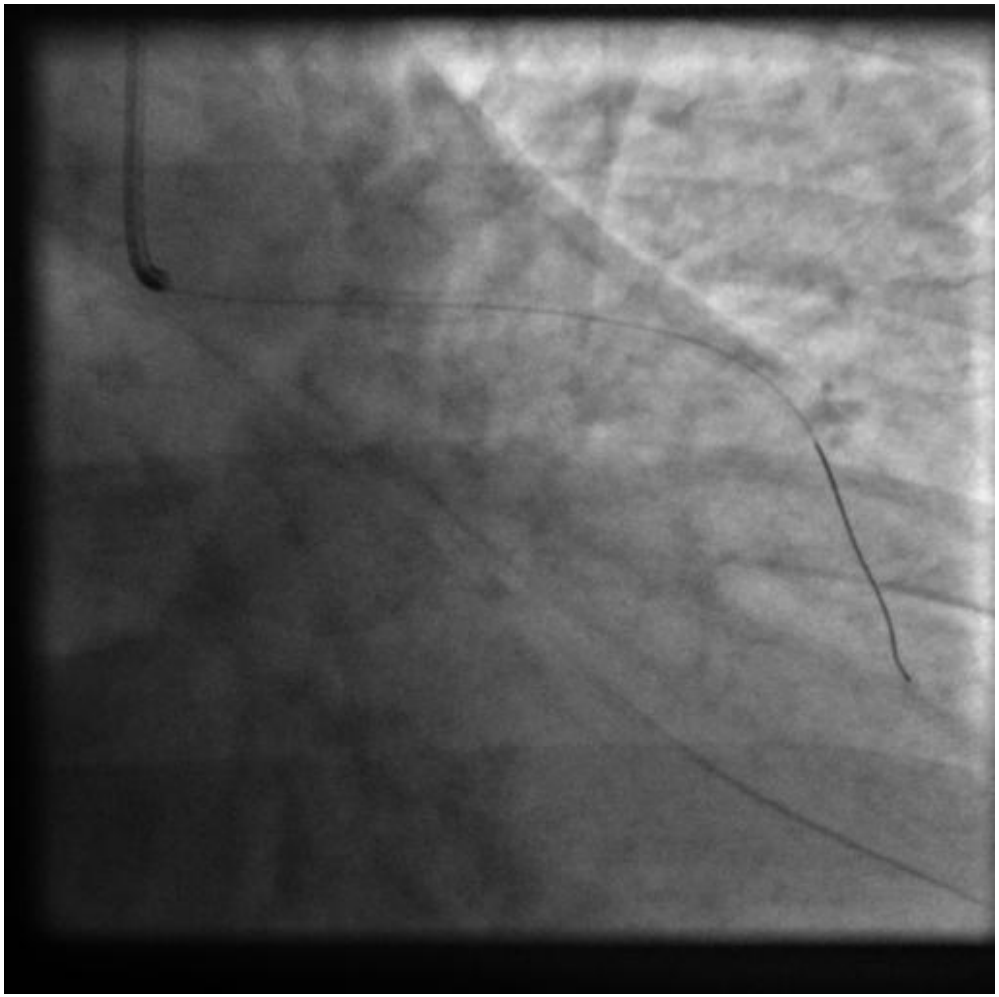




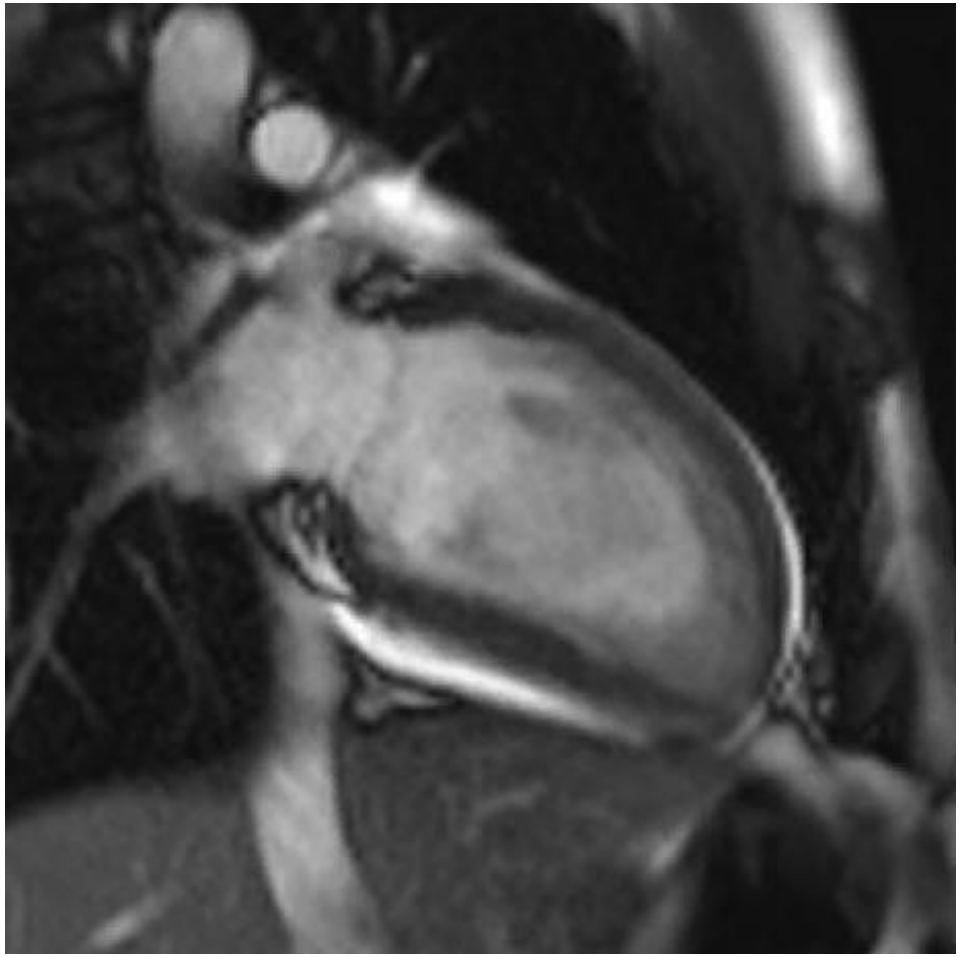
Stent deployed in LAD

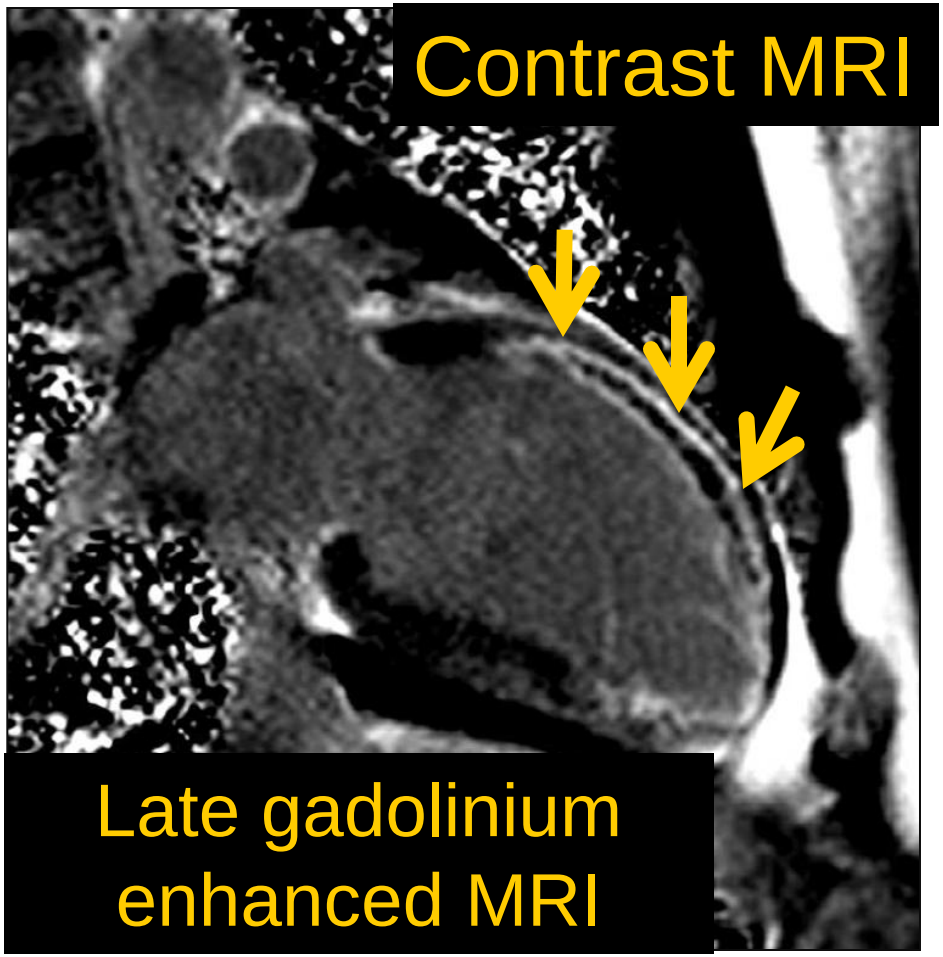
Anterior STEMI

- ✓Excellent PCI result
- ✓Normal flow
- ✓*Procedure success!*



Day 2 MRI reveals extensive scar and MVO





Despite good PCI result, infarct burden and MVO were severe

Primary PCI

Successful coronary reperfusion √

Failed myocardial perfusion √

MVO, usually not measured, unknown

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IMR and outcome post-STEMI

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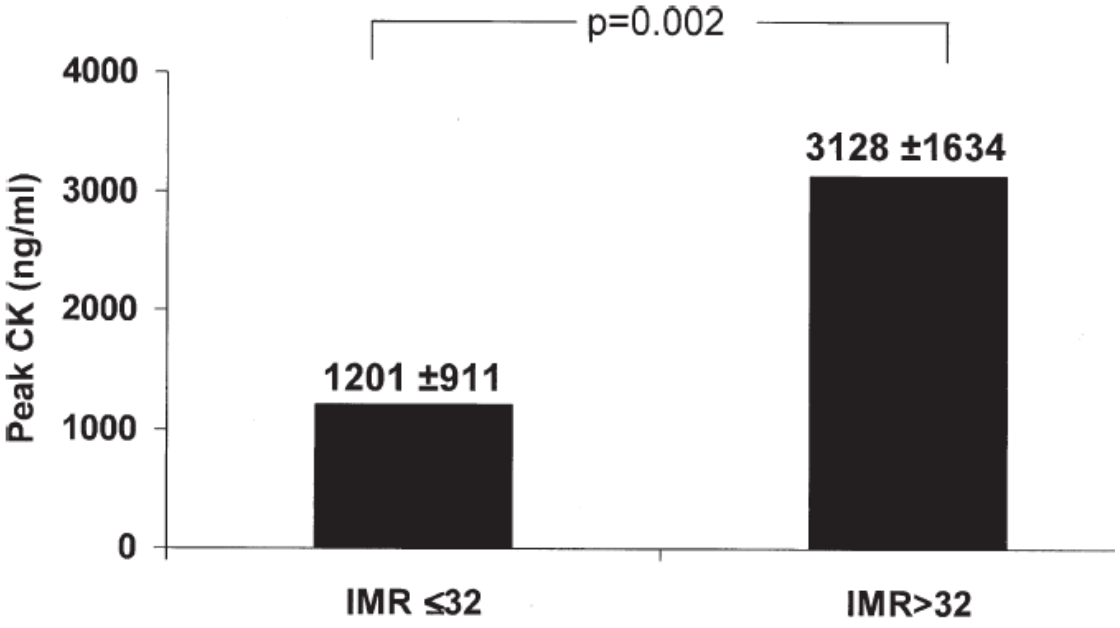
Predictive Value of the Index of Microcirculatory Resistance in Patients With ST-Segment Elevation Myocardial Infarction

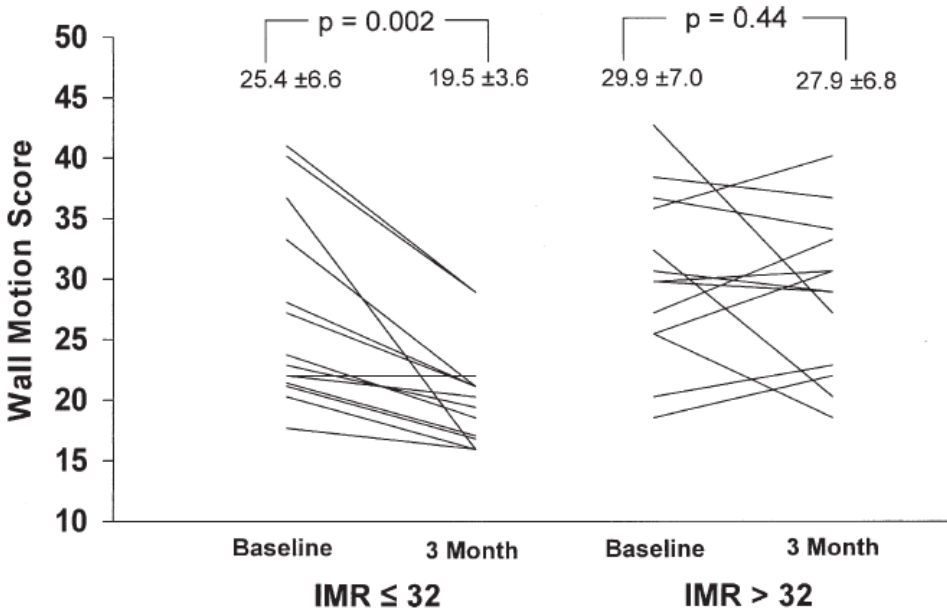
William F. Fearon, MD, Maulik Shah, MD, Martin Ng, MD, Todd Brinton, MD, Andrew Wilson, MD, Jennifer A. Tremmel, MD, Ingela Schnittger, MD, David P. Lee, MD, Randall H. Vagelos, MD, Peter J. Fitzgerald, MD, PHD, Paul G. Yock, MD, Alan C. Yeung, MD

Stanford, California

29 STEMI patients post- primary PCI
Cardiac biomarkers early post-MI
Echocardiography – 3 months post-MI

IMR associates with peak troponin and change in wall motion score post-STEMI





Fearon et al JACC 2008

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JACC: CARDIOVASCULAR INTERVENTIONS VOL. 3, NO. 7, 2

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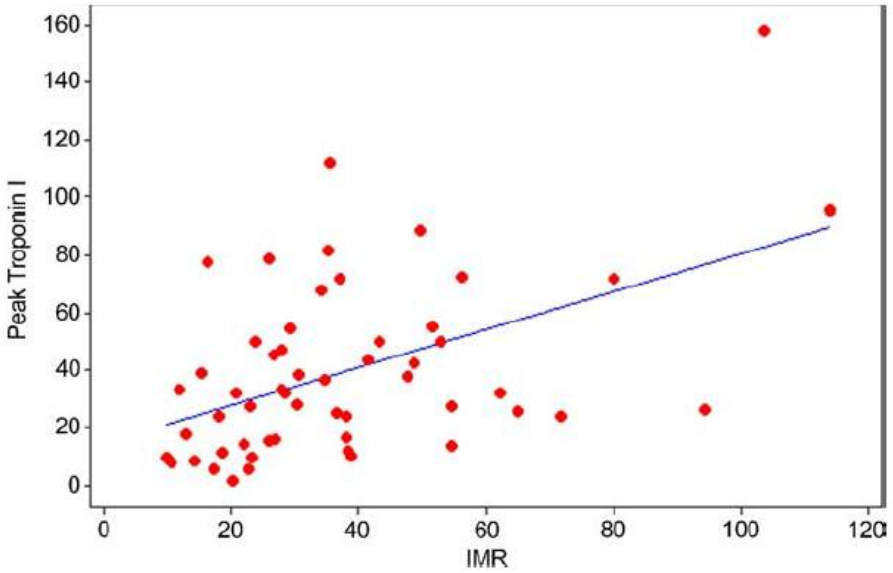
PUBLISHED BY ELSEVIER INC. DOI: 10.1016/j.jcin.2010.04.

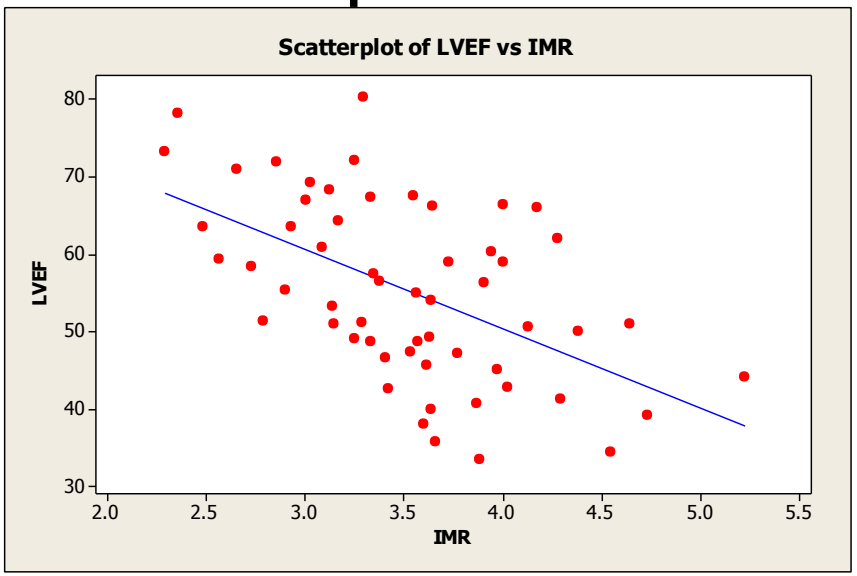
The Index of Microcirculatory Resistance Measured Acutely Predicts the Extent and Severity of Myocardial Infarction in Patients With ST-Segment Elevation Myocardial Infarction

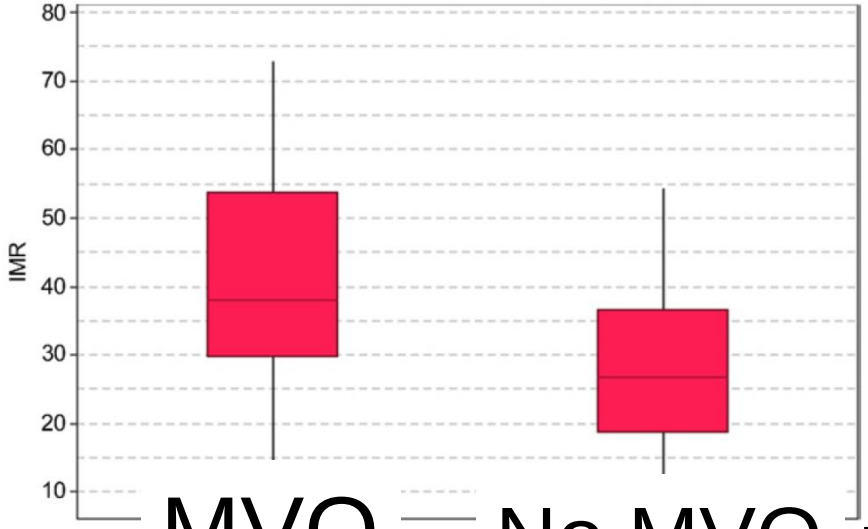
Ross McGeoch, MB, ChB,*† Stuart Watkins, MB, ChB, MD,* Colin Berry, MB, ChB, MD,*†
Tracey Steedman, BSc,* Andrew Davie, MB, ChB, MD,* John Byrne, MB, ChB, MD,*
Stewart Hillis, MB, ChB, PhD,* Mitchell Lindsay, MB, ChB, MD,*
Stephen Robb, MB, ChB, MD,* Henry Dargie, MB, ChB, MD,*
Keith Oldroyd, MB, ChB, MD*

Glasgow, Scotland

IMR associates with peak troponin & LVEF acutely and microvascular obstruction post-STEMI







McGeoch et al JACC 2008

Journal of the American Heart Association
OPEN ACCESS
American Heart Association | American Stroke Association

ORIGINAL RESEARCH

American Heart Association | American Stroke Association

Microvascular Resistance Predicts Myocardial Salvage and Infarct Characteristics in ST-Elevation Myocardial Infarction

Alexander R. Payne, MRCP*; Colin Berry, BSc, PhD, FRCP*; Orla Doolin, MSc; Margaret McEntegart, MRCP, PhD; Mark C. Petrie, MD, MRCP; M. Mitchell Lindsay, MD, MRCP; Stuart Hood, MD, MRCP; David Carrick, MRCP; Niko Tzemos, BSc(Hons), MRCP MD(Hons); Peter Weale, BA, DCR(R); Christie McComb, MSc; John Foster, PhD; Ian Ford, PhD; Keith G. Oldroyd, MD(Hons), FRCP

IMR is inversely associated with myocardial salvage

108 STEMI patients,

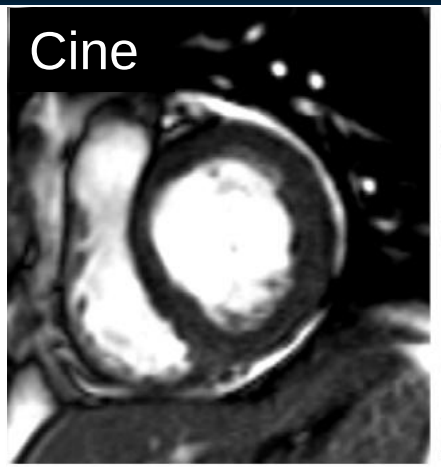
96 with CMR at 6 months

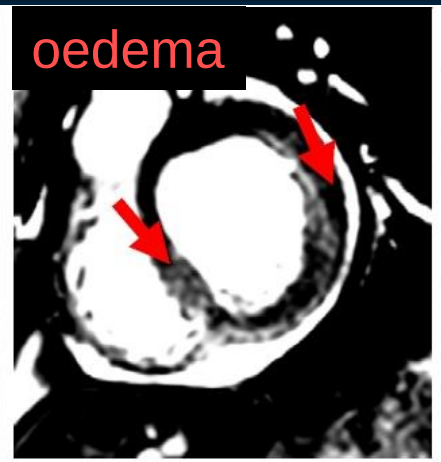
Area-at-risk = 32 (24 – 41) %

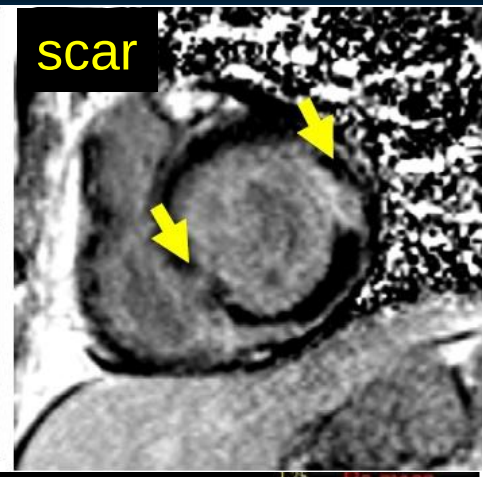
Salvage = 21 (11 – 43)%

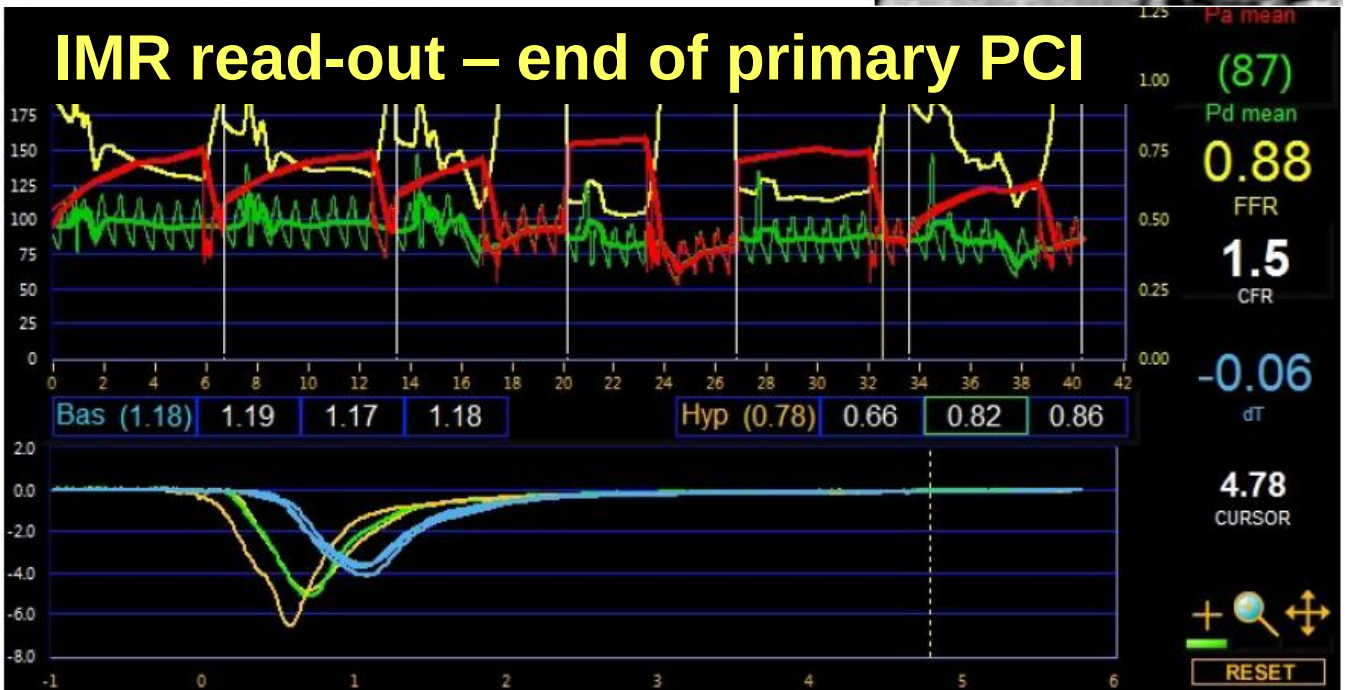
Median IMR ~ 28

IMR = Pd x Mean Tm, hyperaemia









Payne, Berry et al JAHA 2012

Conclusion
IMR & LV pathophysiology post-STEMI

IMR end primary PCI correlates with

1. Infarct pathology

- **infarct size**
- **microvascular obstruction**
- **myocardial salvage**

2. LV systolic function

- Baseline
- Within subject change during FUp.

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association

Prognostic Value of the Index of Microcirculatory Resistance Measured after Primary Percutaneous Coronary Intervention

William F. Fearon, Adrian F. Low, Andy C. Yong, Ross McGeoch, Colin Berry, Maulik G. Shah, Michael Ho, Hyun-Sook Kim, Joshua P. Loh and Keith G. Oldroyd

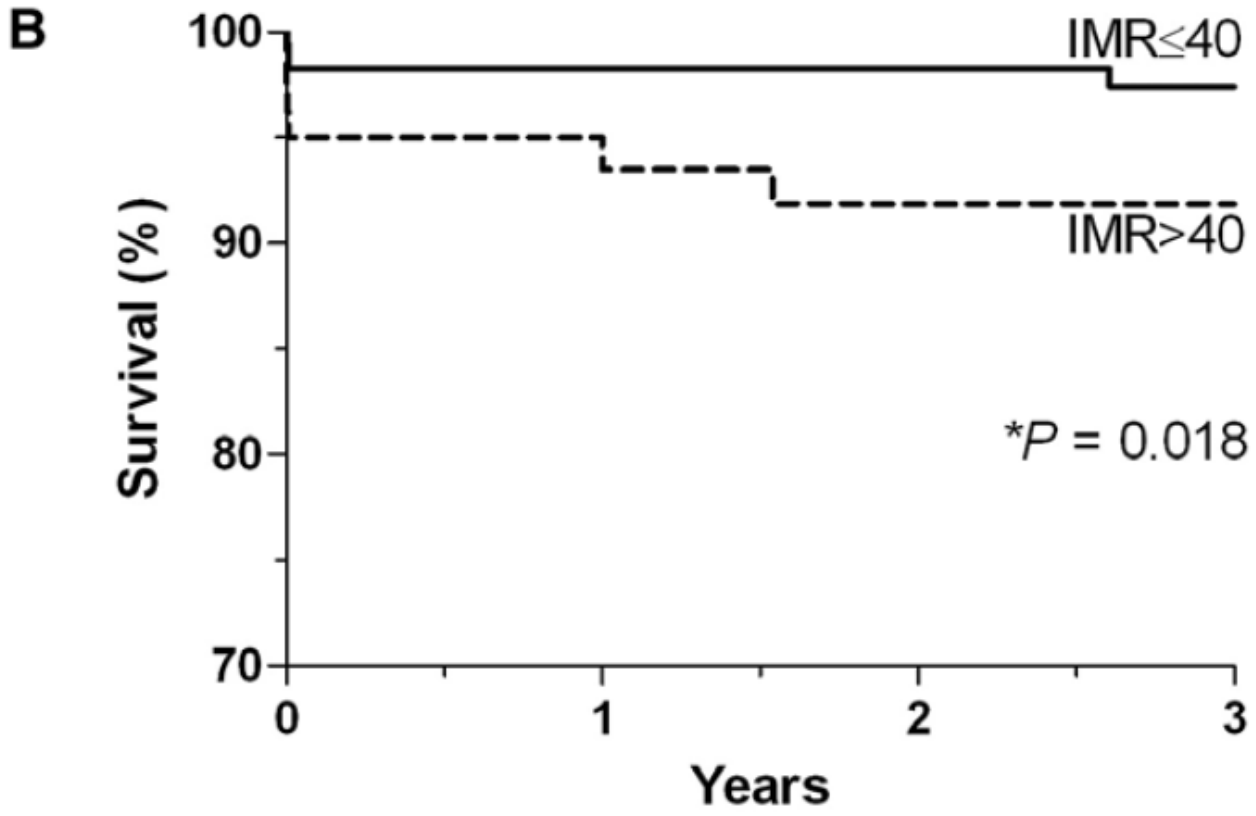
- 3 primary PCI centres

  (Stanford, Glasgow, Singapore), n=253 patients
- Primary endpoint = death or HF hospitalisation
- Mean Fup = 2.8 years, 13.8% PEP, 4.3% died
- Prognostic value of IMR compared to CFR, TMP, clinical variables.

IMR > 40 predicts death post-STEMI

IMR hazard ratio, p-value

Death or HF hospitalisation 2.1, p=0.034



Fearon et al
Circulation 2013

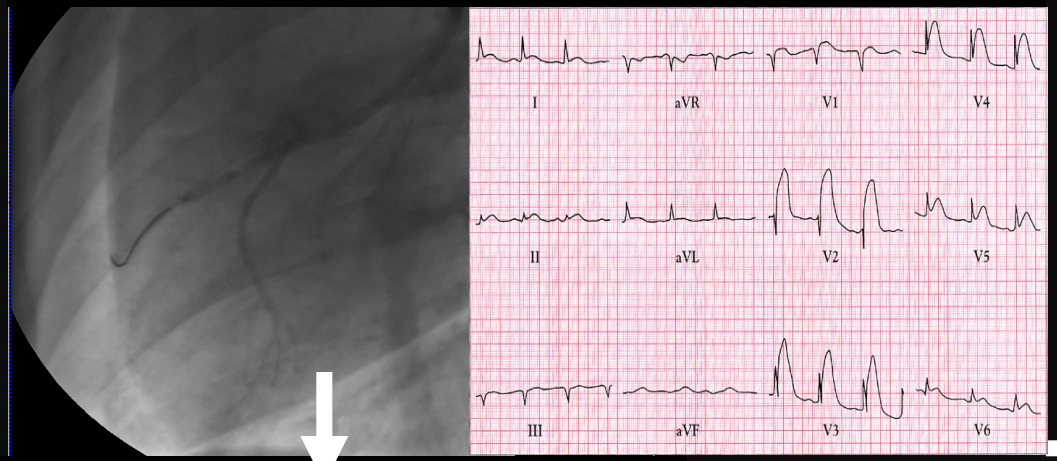
IMR: a multivariable predictor of death or HF hospitalisation post-STEMI

	P Value	Hazard Ratio	95% CI
Univariable predictors			
Diabetes mellitus	<0.001	3.98	2.05–7.75
CFR <2	0.021	3.40	1.20–9.66
Hypertension	0.030	2.15	1.08–4.27
IMR >40	0.034	2.08	1.06–4.07
Age	0.058	1.03	1.00–1.06
FFR ≤0.8	0.072	2.15	0.93–4.94
TIMI myocardial perfusion grade <3	0.087	1.95	0.91–4.18
Multivariable predictors			
Diabetes mellitus	<0.001	4.44	2.22–8.88
FFR ≤0.8	0.008	3.24	1.35–7.76
IMR >40	0.026	2.23	1.10–4.49

Fearon et al Circulation 2013

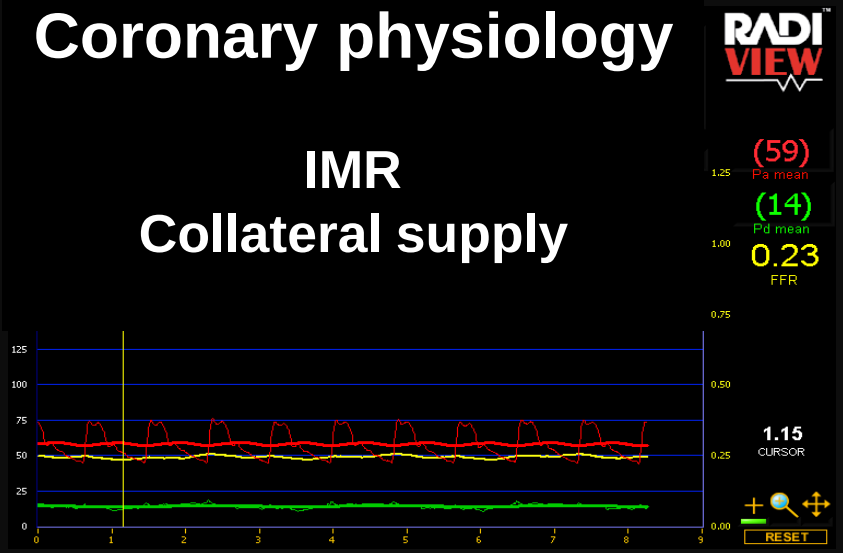
Clinical significance of MI haemorrhage

343 acute MI patients

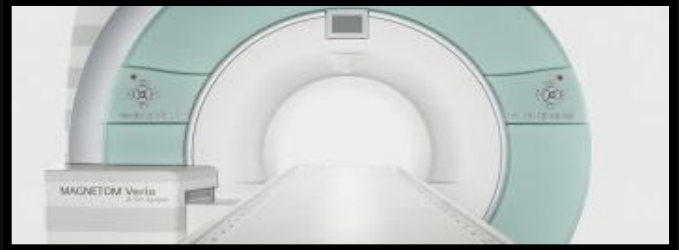


Coronary physiology

IMR
Collateral supply



Cardiac MRI



Prognostic study

> 1 year and 5 years

British Heart Foundation

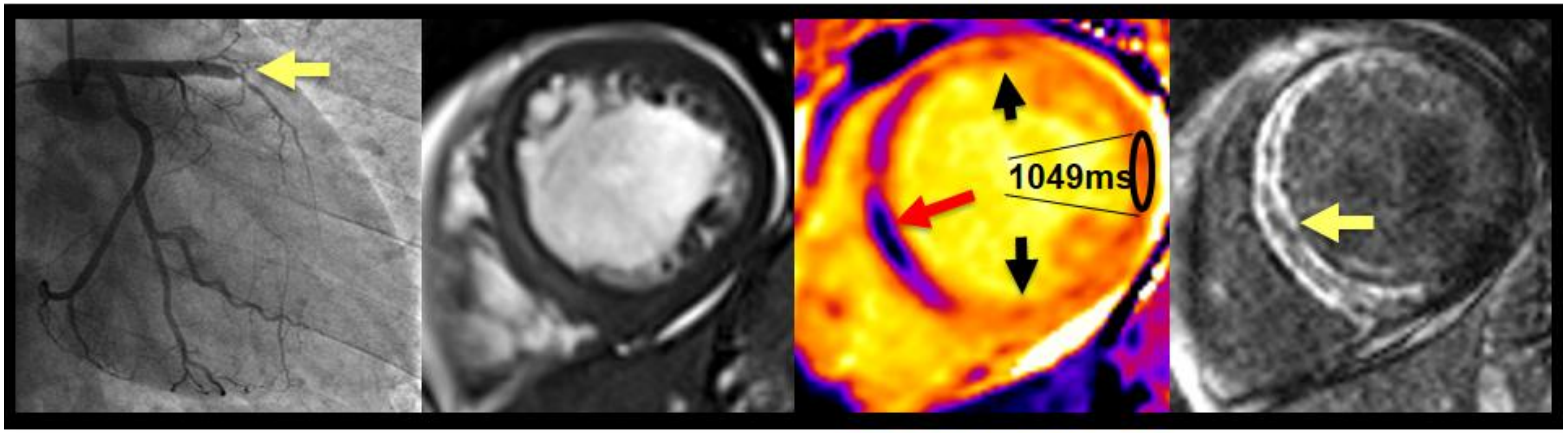
Siemens Healthcare

University of Glasgow

University of Glasgow

BHF MR-MI

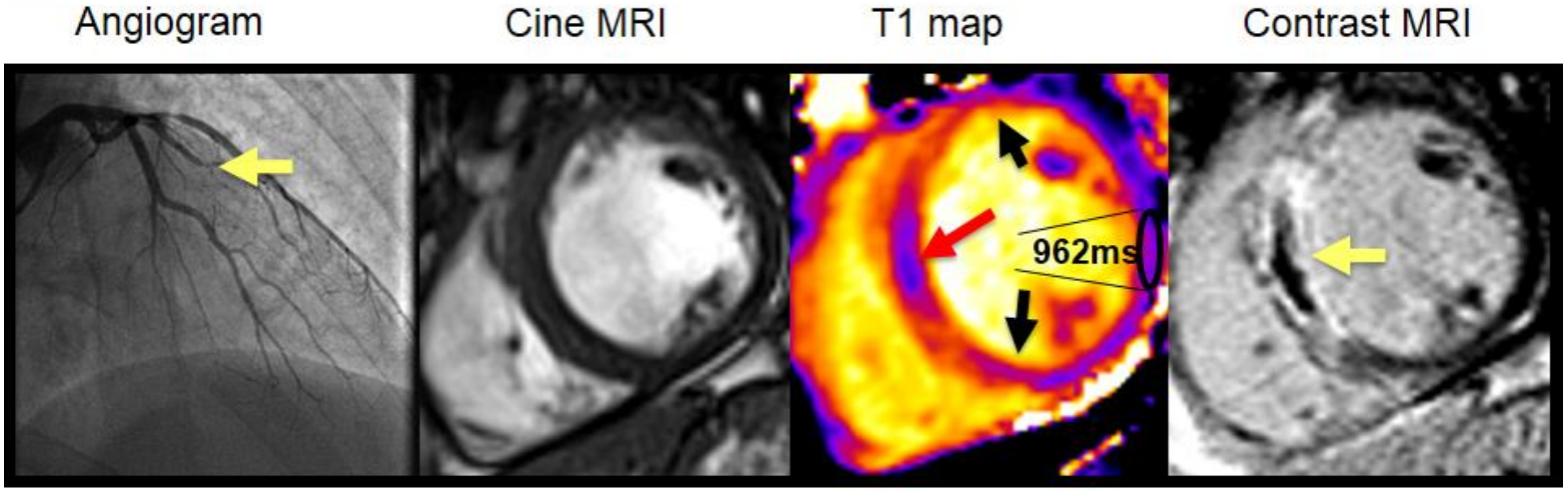
British Heart Foundation



MRI Day 2

Scar

b.



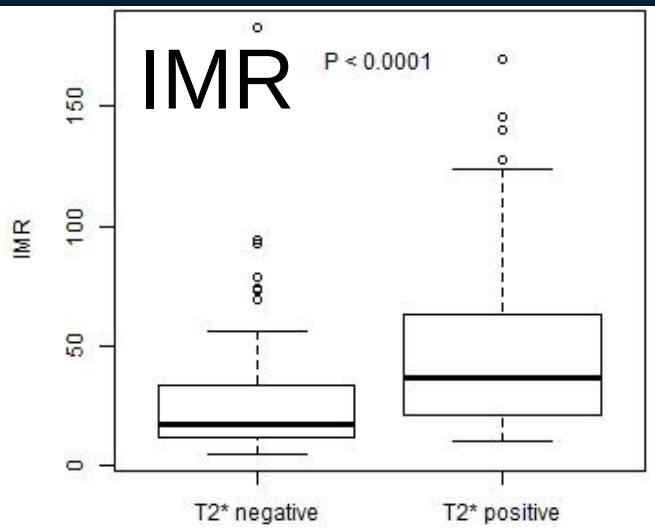
MVO

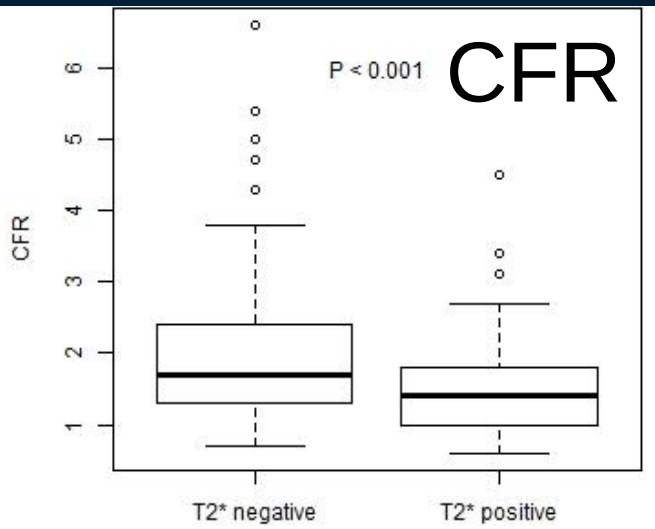
Hemorrhage

Transition in microvascular damage

Early (functional) MVO → Persistent MVO → Myocardial haemorrhage (T2*-MRI positive)

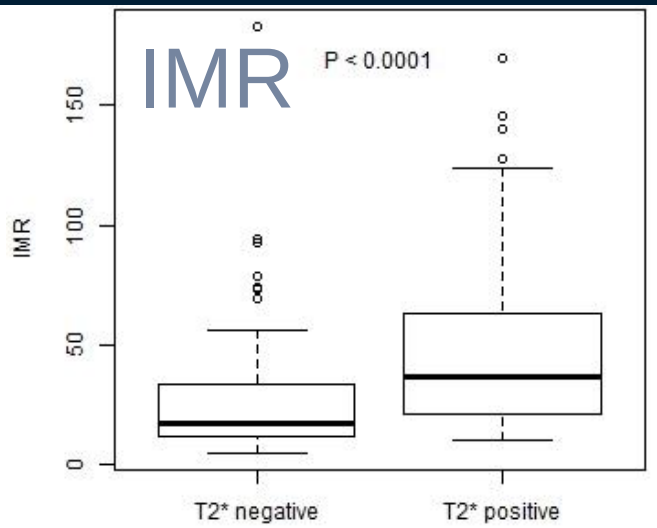
STEMI
n = 219

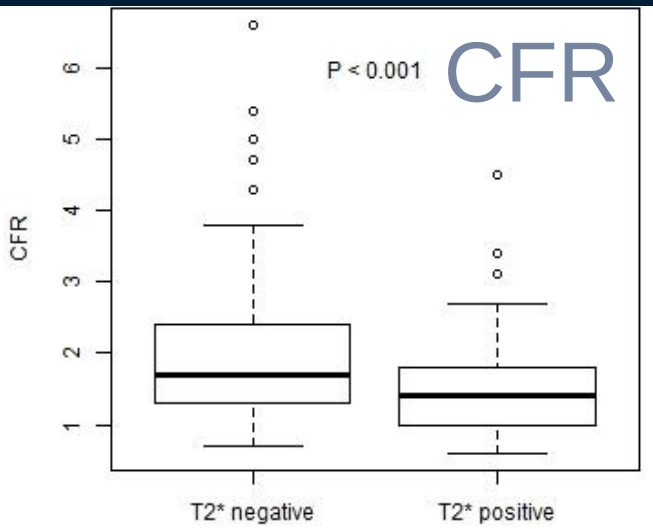




Transition in microvascular damage
Early (functional) MVO → Persistent MVO → Myocardial haemorrhage

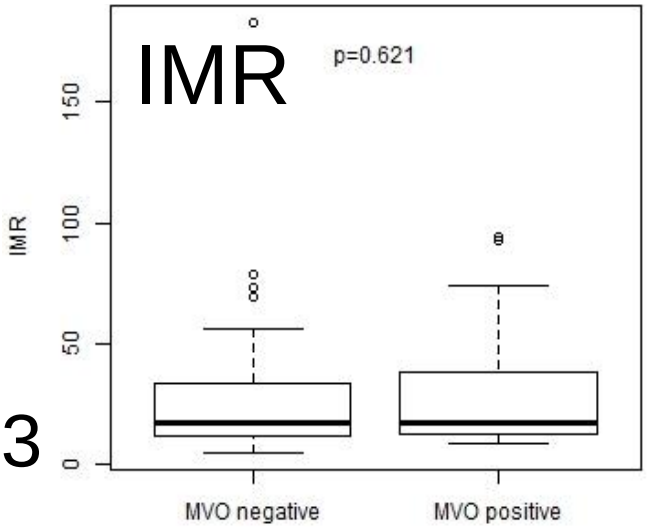
STEMI
n = 219

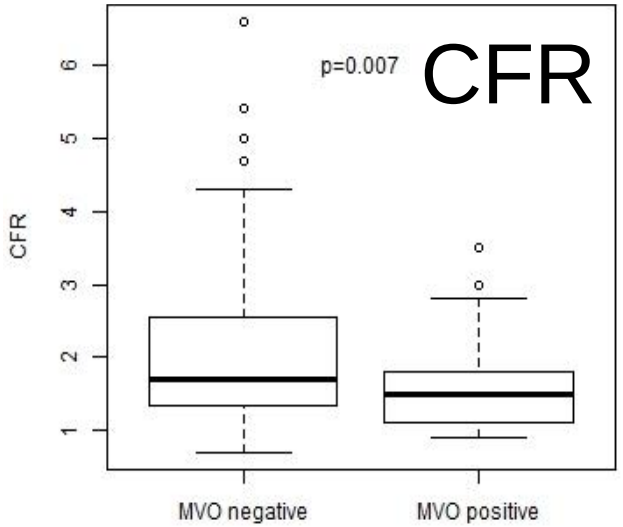




No Haemorrhage
n = 128

MVO, n = 85
No MVO, n= 43





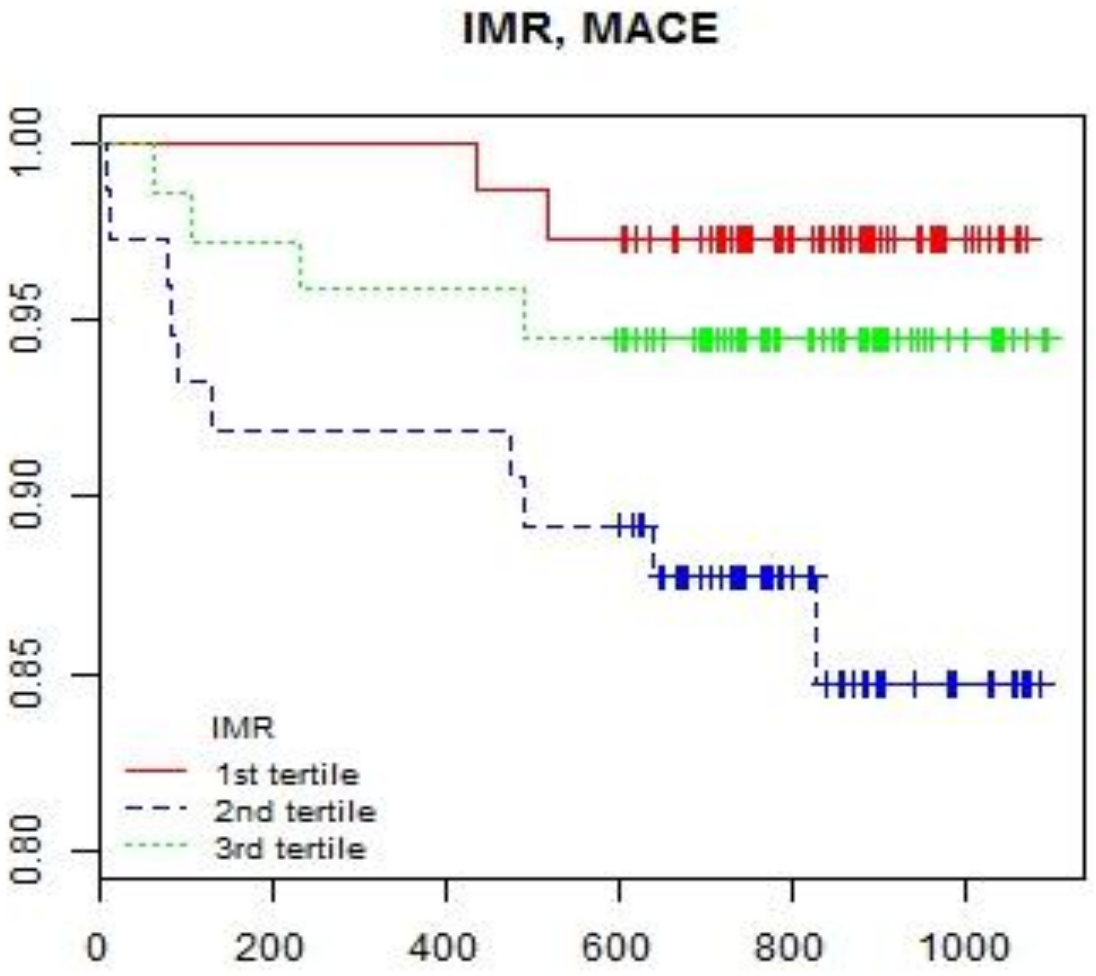
IMR predicts prognosis

Post-discharge MACE
n = 16 events

IMR tertile 2
HR 5.34, p = 0.03

CFR, tertile 3
HR 2.6, p=0.065

FFR, tertile 3
HR 0.60, p=0.44



Carrick, Oldroyd, Berry, et al, Unpublished, 2015

Conclusions

1. CFR vs. IMR: different associations with microvascular injury; different meaning.
2. IMR is associated with severe infarct pathology, incl. MVO and haemorrhage.
3. CFR is discriminative of less severe forms of pathology (ie MVO in patients without haemorrhage).
4. IMR and to a lesser extent CFR at end of primary PCI are prognostically important.

Future directions

1. To date, evidence lacking on whether reduction of IMR or CFR during primary PCI might improve prognosis.
2. Randomised trials of interventions to reduce IMR in STEMI patients are warranted.

University of Glasgow | Institute of Cardiovascular & Medical Sciences

British Heart Foundation

Thank you for your attention

Diagnostic coronary wire to measure microvascular function in vivo

0.014”

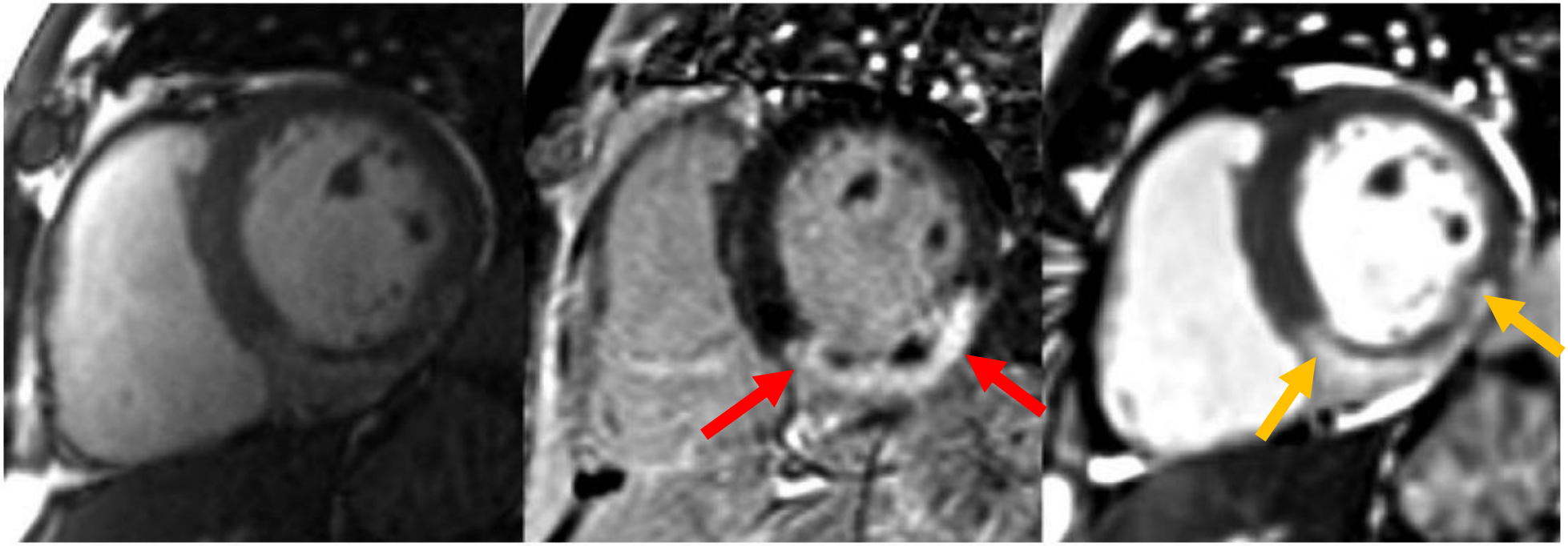
PressureWire to measure pressure inside the coronary arteries

RadiAnalyzer Xpress to calculate the pressure measurements and show them on a screen

Hyperemic drug to simulate exercise

T_2 MRI delineates the area-at-risk & myocardial salvage

Cine | late gadolinium scar | T_2 MRI oedema



Myocardial salvage = 'Area–at–Risk' *minus* Infarct Size

Berry C et al Circ Cardiovasc Imaging 2010