IMR in acute STEMI and clinical outcomes

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Disclosures

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

Institutional agreements, University of Glasgow and St Jude Medical
IMR in STEMI

1. Pathophysiology

2. Practical considerations

3. Prognosis
   - Surrogate outcomes
   - Health outcomes

3. Conclusions
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

\[ \text{IMR} = P_d \times \text{mean transit time} \]

During hyperaemia
PressureWire sensor is placed in the coronary artery, distal to the atherosclerotic plaque.
Coronary flow reserve, CFR

\[ = \frac{T_{mn \, \text{rest}}}{T_{mn \, \text{hyperaemia}}} \]

Index of microvascular resistance, IMR

\[ = \text{Distal coronary pressure} \times \text{mean transit time during hyperaemia} \]
Microvascular pathophysiology post-STEMI
Serial MRI to quantify infarct pathology post-STEMI

Cine MRI

Oedema MRI Area-at-risk

Contrast MRI Scar, 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

Signal void Infarct

Infarct MRI

IV gadolinium contrast

MVO Infarct

Berry C et al Circ Cardiovasc Imaging 2010
Detection of myocardial haemorrhage with MRI

Berry C et al *Circ Cardiovasc Imaging* 2011
Proximal occlusion of the LAD coronary artery
Clot aspiration

TIMI grade II Improved, subnormal flow
Stent deployed in LAD
✓ Excellent PCI result

✓ Normal flow

✓ Procedure success!
Despite good PCI result, infarct burden and MVO were severe.
Successful coronary reperfusion √

Failed myocardial perfusion √

MVO, usually not measured, unknown
IMR and outcome post-STEMI
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
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*

*Glascow, Scotland
IMR associates with peak troponin & LVEF acutely and microvascular obstruction post-STEMI.
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
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.
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

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

MRI Day 2
Scar

MVO
Hemorrhage
Transition in microvascular damage
Early (functional) MVO $\rightarrow$ Persistent MVO $\rightarrow$
Myocardial haemorrhage (T2*-MRI positive)

STEMI
n = 219
Transition in microvascular damage
Early (functional) MVO $\rightarrow$ Persistent MVO $\rightarrow$ Myocardial haemorrhage

STEMI
n = 219

No Haemorrhage
n = 128

MVO, n = 85
No MVO, n= 43
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
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.
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.
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
Myocardial salvage = ‘Area–at–Risk’ \( \text{minus} \) Infarct Size

Berry C et al Circ Cardiovasc Imaging 2010