University of Glasgow | Institute of Cardiovascular & Medical Sciences

Index of Microcirculatory Resistance Clinical Outcome Data

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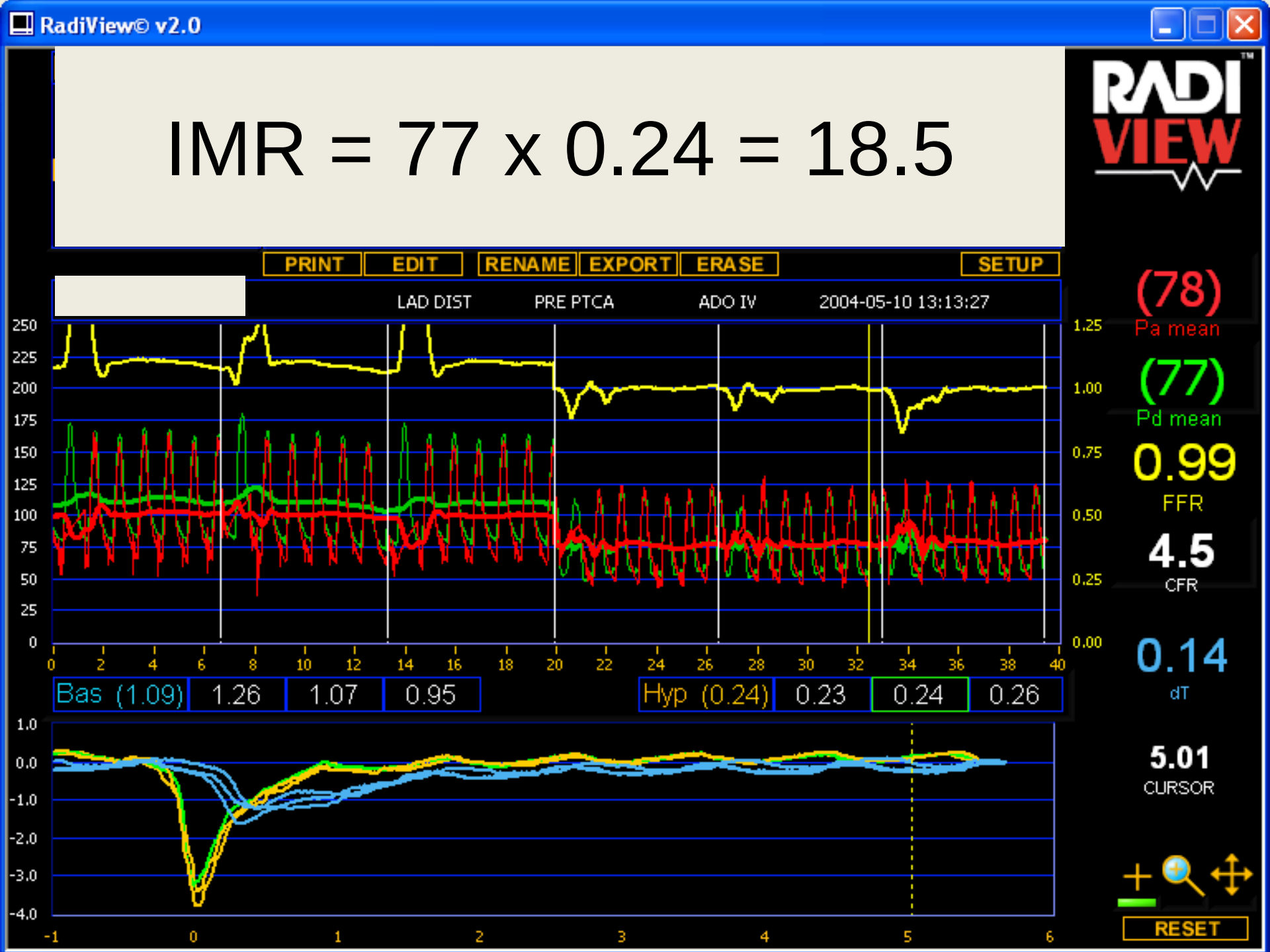
RadiView© v2.0
IMR = 77 x 0.24 = 18.5
RADI VIEW
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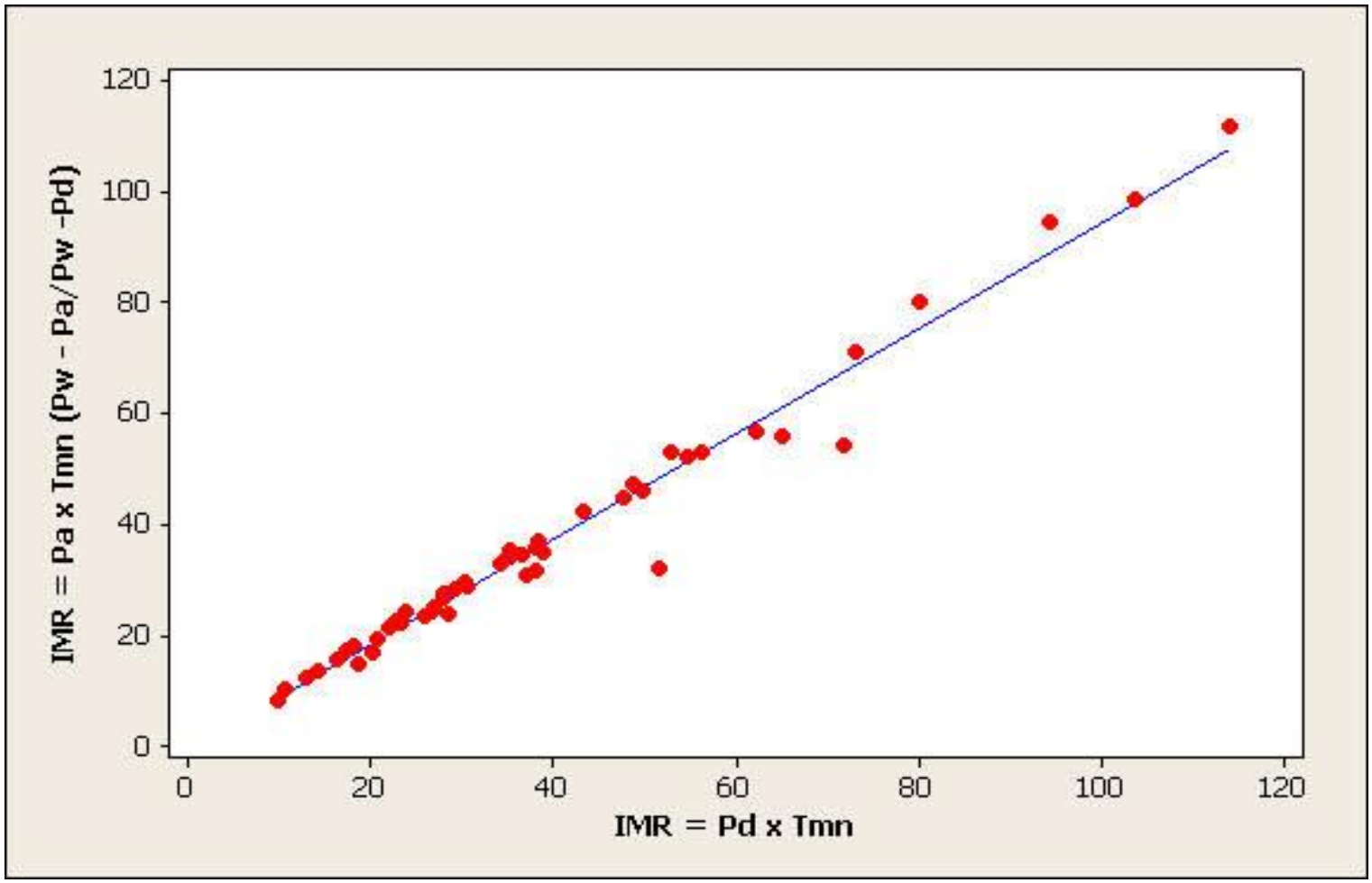
ADO IV
2004-05-10 13:13:27
(78)
Pa mean
(77)
Pd mean
0.99
FFR
4.5
CFR
0.14
dT
5.01
CURSOR
RESET
Bas (1.09) 1.26 1.07 0.95
Hyp (0.24) 0.23 0.24 0.26

Effect of Including Coronary Wedge Pressure on IMR Values in STEMI Post Stenting



Calculated IMR

- In the absence of any epicardial stenosis (post PCI)

  $IMR = Pd \times Tmn$

- In the presence of any epicardial stenosis

  $IMR = Pa \times Tmn \times ([Pd - Pw]/[Pa - Pw])$

- $FFR_{cor} = 1.34 \times FFR_{myo} - 0.32$, $r^2 = 0.87$, $p = 0.001$

Yong et al. J Am Coll Cardiol Intv 2013;6:53–8

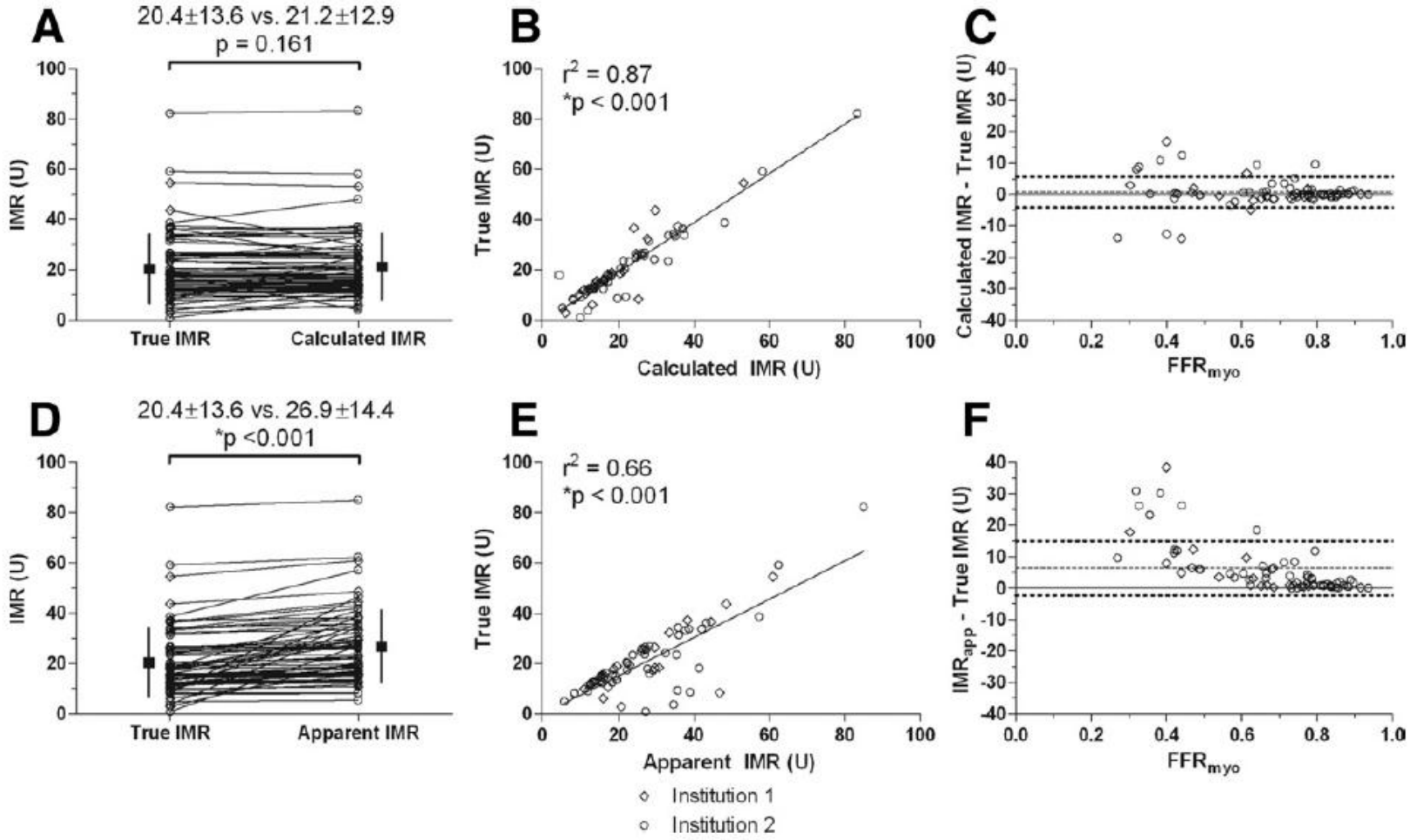


Figure 3. Validation of Method to Calculate IMR

(A) Comparison between true index of microcirculatory resistance (IMR) and calculated index of microcirculatory resistance (IMR_{calc}). **Solid square boxes** and **error bars** represent mean ± SD. **(B)** Linear regression of true versus IMR_{calc}. The r^2 represents the fit of the regression models, and p values reflect significance of the fit. **(C)** Modified Bland-Altman plot showing the effect of myocardial fractional flow reserve (FFR_{myo}) on the difference between IMR_{calc} and true IMR. **Dashed line** denotes the bias of the agreement, and **dotted lines** represent SDs of the bias. **(D to F)** Corresponding comparison between true IMR and apparent index of microcirculatory resistance (IMR_{app}).

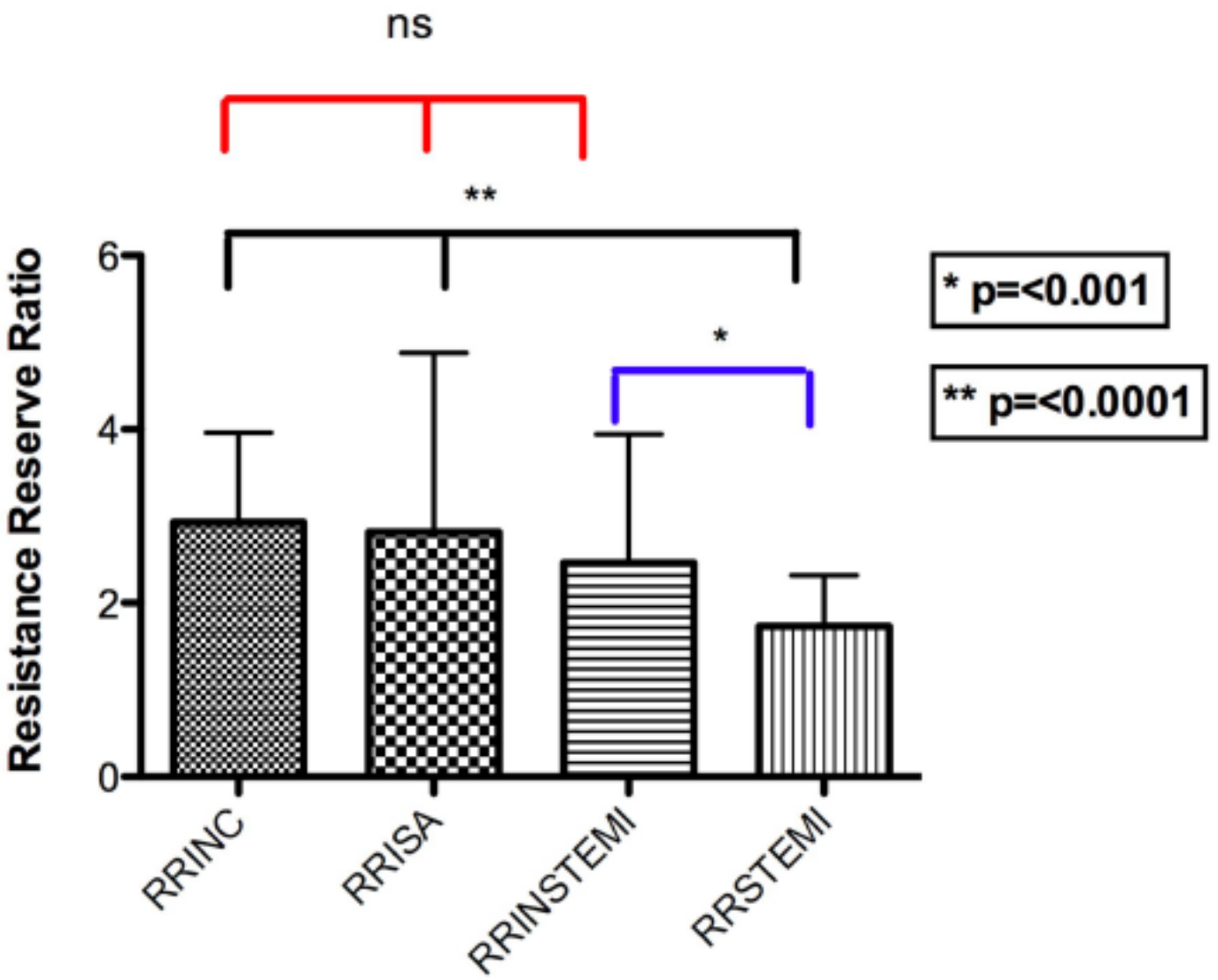
Resistive Reserve Ratio

- Baseline resistance index
  = Pa_R x Tmn_R x $[(Pd-Pw)/(Pa-Pw)]_R$

- Resistive Reserve Ratio (RRR)
  = Baseline Resistance Index/IMR

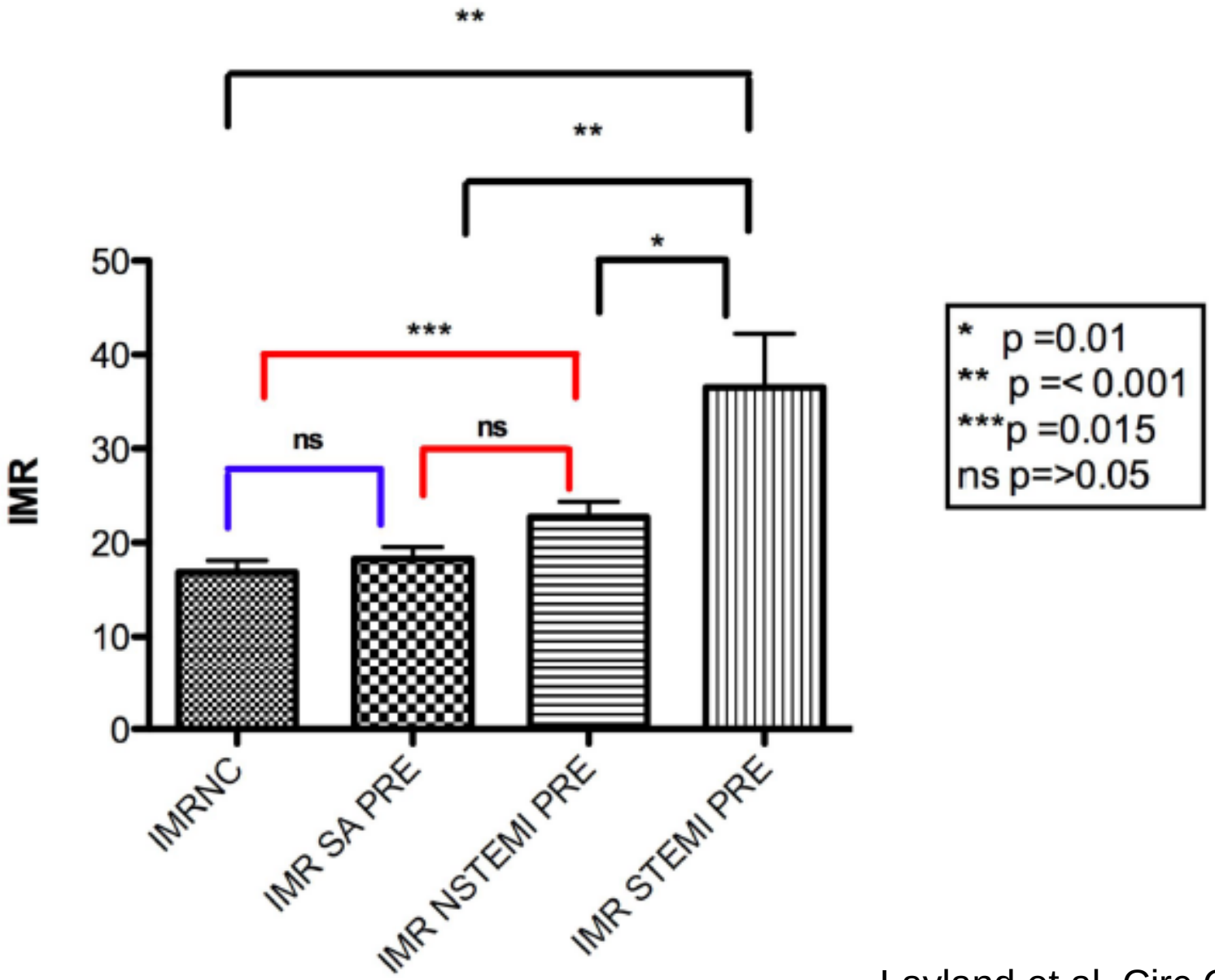
Layland et al. Circ CVI 2013

Median Resistance Reserve Ratio Across Patient Subgroups



Layland et al. Circ CVI 2013

Mean IMR Across Patient Populations



Layland et al. Circ CVI 2013

IMR as a Surrogate End-Point

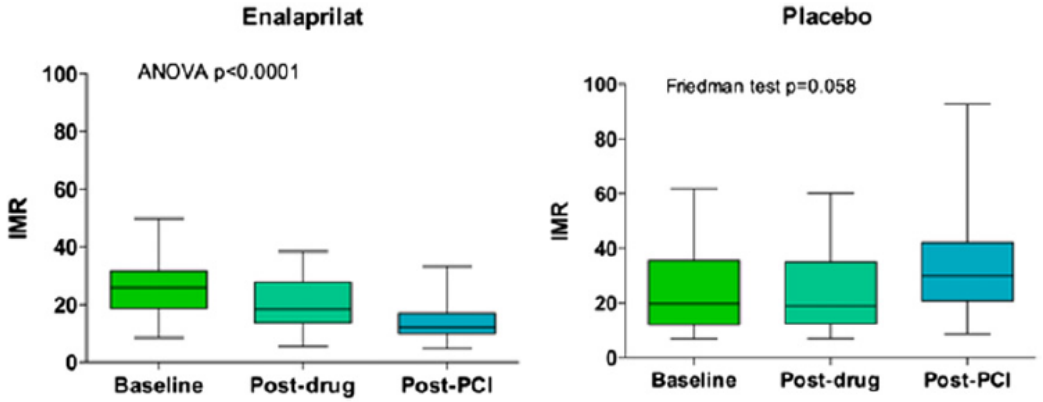


Figure 1 **Variations of Microvascular Function During Percutaneous Coronary Intervention**

The index of microvascular resistance (IMR) at baseline, after drug administration (either enalaprilat or placebo), and after percutaneous coronary intervention (PCI). **(Left)** Patients treated with enalaprilat. **(Right)** Patients treated with placebo. **Boxes** extend from the 25th to the 75th percentile, with a line at the 50th percentile (median). **Whiskers** show the highest and the lowest values. ANOVA = analysis of variance.

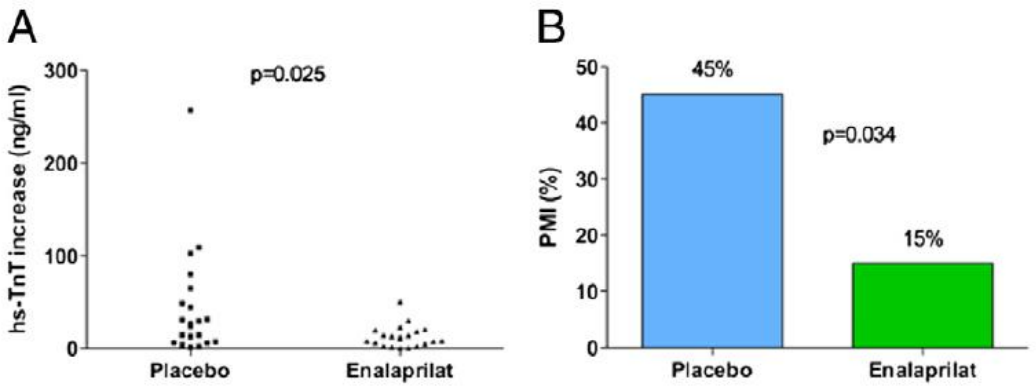


Figure 2 **Peri-procedural Myocardial Necrosis**

(A) Peri-procedural increase in high-sensitivity cardiac troponin T (hs-cTnT) and **(B)** incidence of peri-procedural myocardial infarction (PMI) in the 2 study groups.

Mangiacapra et al. JACC 2013

Predictive Value of IMR in STEMI

- 29 patients undergoing pPCI for STEMI
  - STE resolution
  - TMPG (blush) and cTFC
  - CFR and IMR
- Of these, only IMR correlated significantly with peak CK
  - $R = 0.61$, $p = 0.0005$
- Of these, only IMR correlated significantly with 3/12 echo WMS
  - $R = 0.59$, $p = 0.002$
- IMR was the only significant predictor of recovery of LV function
  - $R = 0.50$, $p < 0.01$

Fearon et al. JACC 2008 Feb 5;51(5):560-5

Predictive Value IMR in STEMI

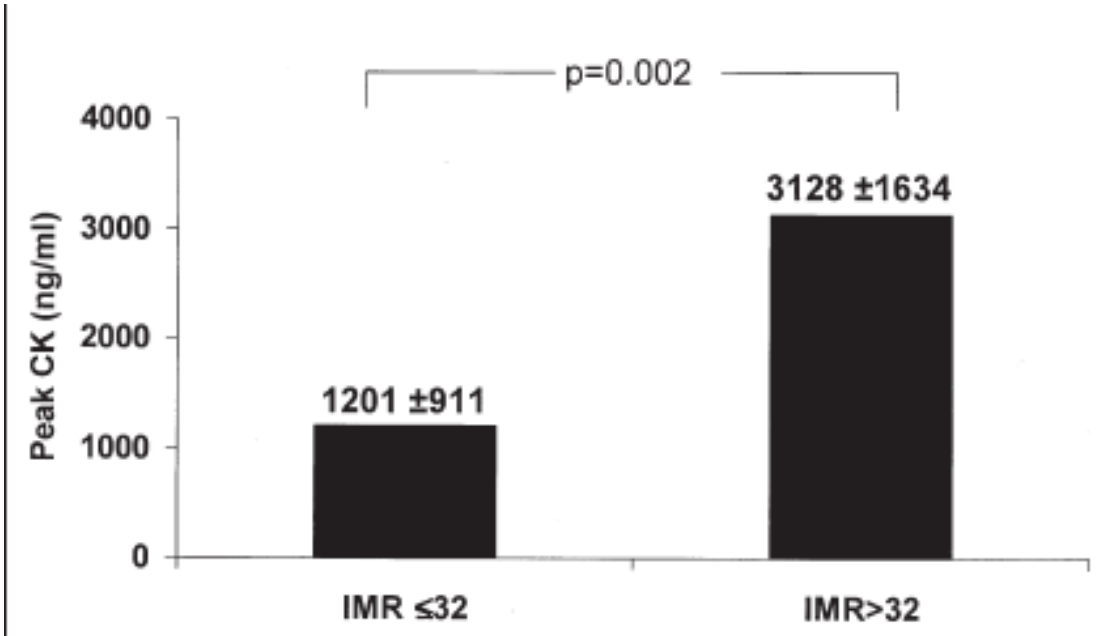


Figure 1 **Peak CK With Low Versus High IMR**

A comparison of the average peak creatine kinase (CK) in patients presenting with an index of microcirculatory resistance (IMR) less than or equal to the median value with those presenting with an IMR greater than the median value.

Fearon et al. JACC 2008 Feb 5;51(5):560-5

IMR vs PET in Anterior STEMI (n=40)

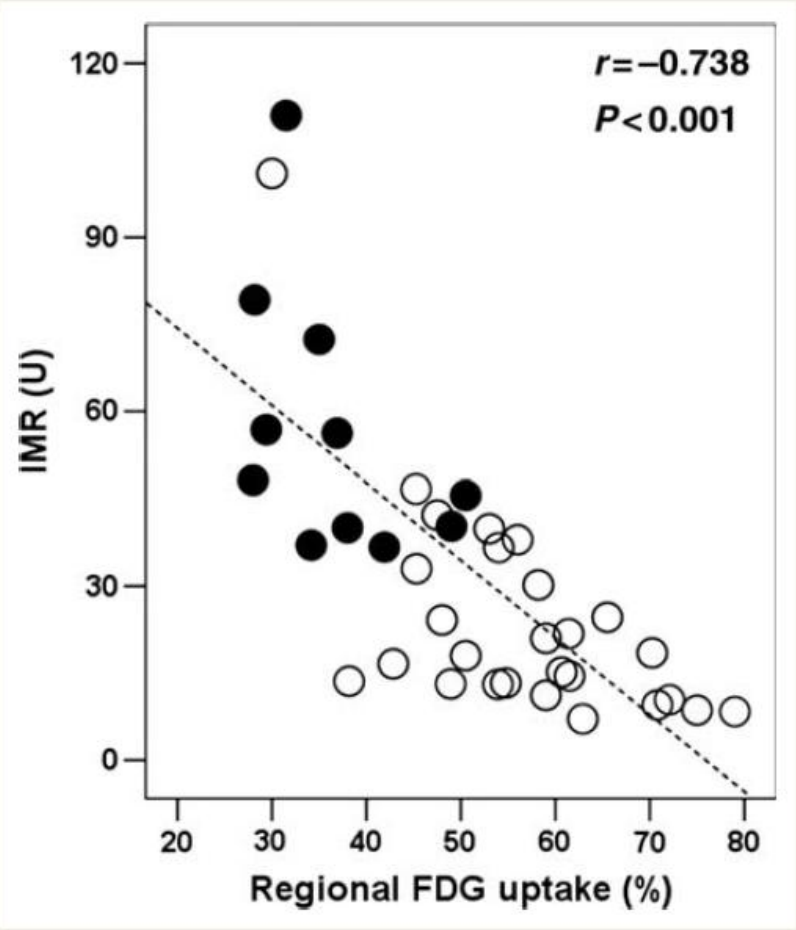


Figure 3 Correlation between the index of microcirculatory resistance and regional 18F-fluorodeoxyglucose (FDG) uptake imaged by positron emission tomography (PET). Solid circles indicate patients without recovery of LV wall motion and open circles represent patients with recovery of LV wall motion at 6-month follow-up.

Lim et al. EHJ 2009

IMR vs PET in Anterior STEMI (n=40)

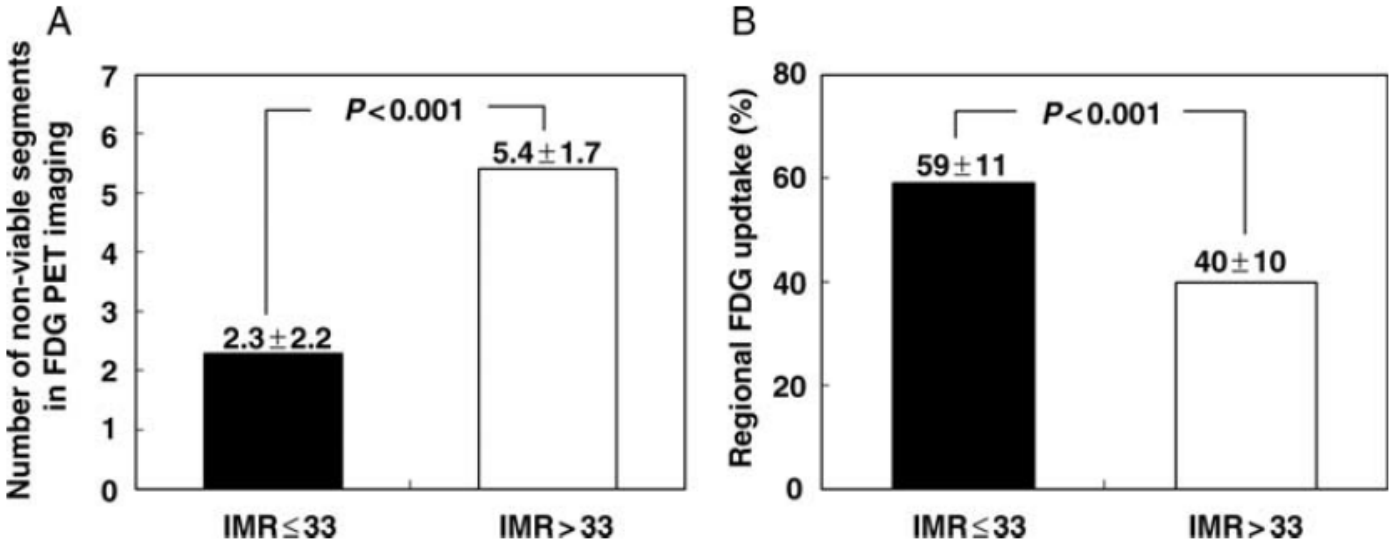
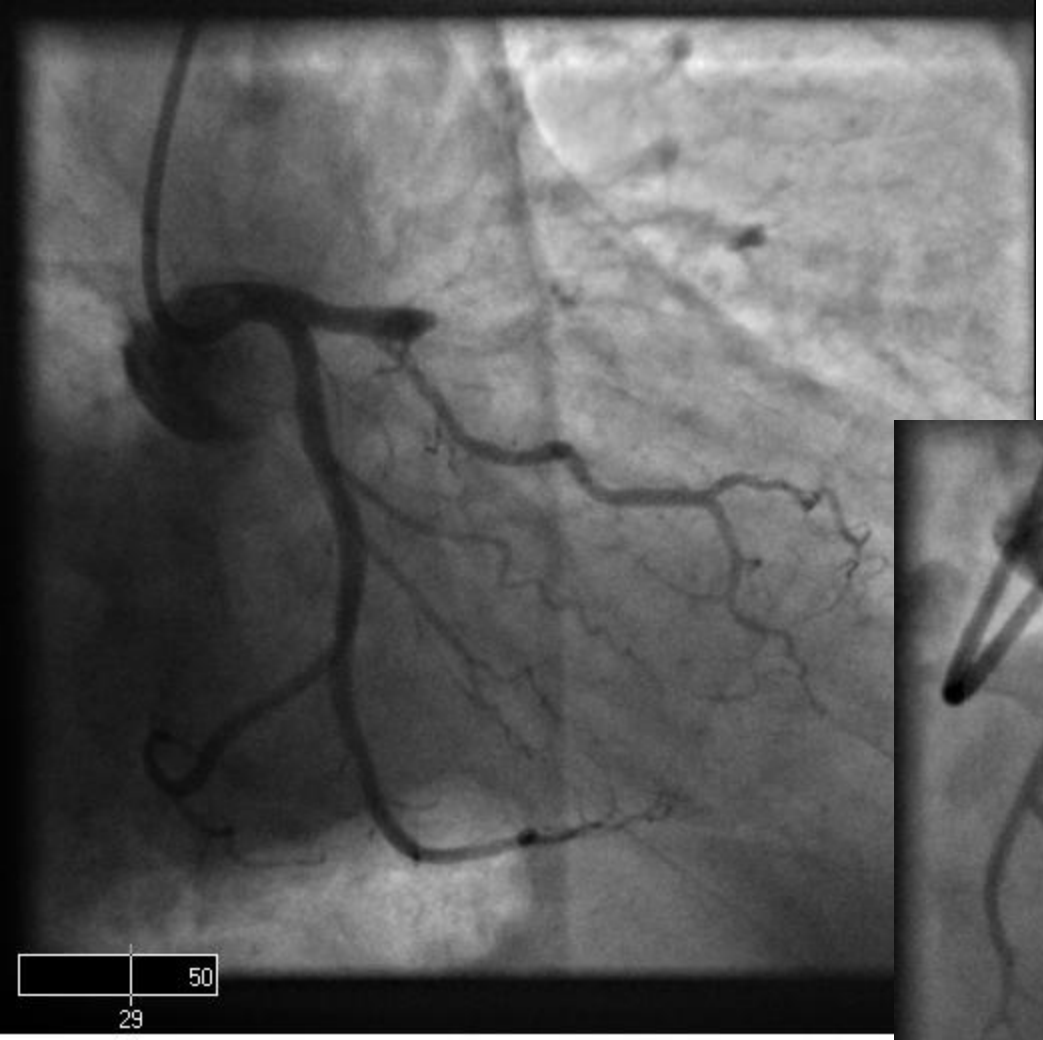


Figure 4 Comparison of the number of non-viable segments in 18F-fluorodeoxyglucose (FDG) uptake imaged by positron emission tomography (PET) imaging (*A*) and regional FDG uptake (*B*) in patients presenting with an index of microcirculatory resistance (IMR) less than or equal to the optimal cut-off value for left ventricular wall motion recovery (=33 U) with those presenting with an IMR > 33 U.

Lim et al. EHJ 2009


50
29


54
28

TB_ECG_Pg1

ID: 2809415196 22-Jul-2009 6:09:49 GJNH

69years
Male Caucasian

Room: 5

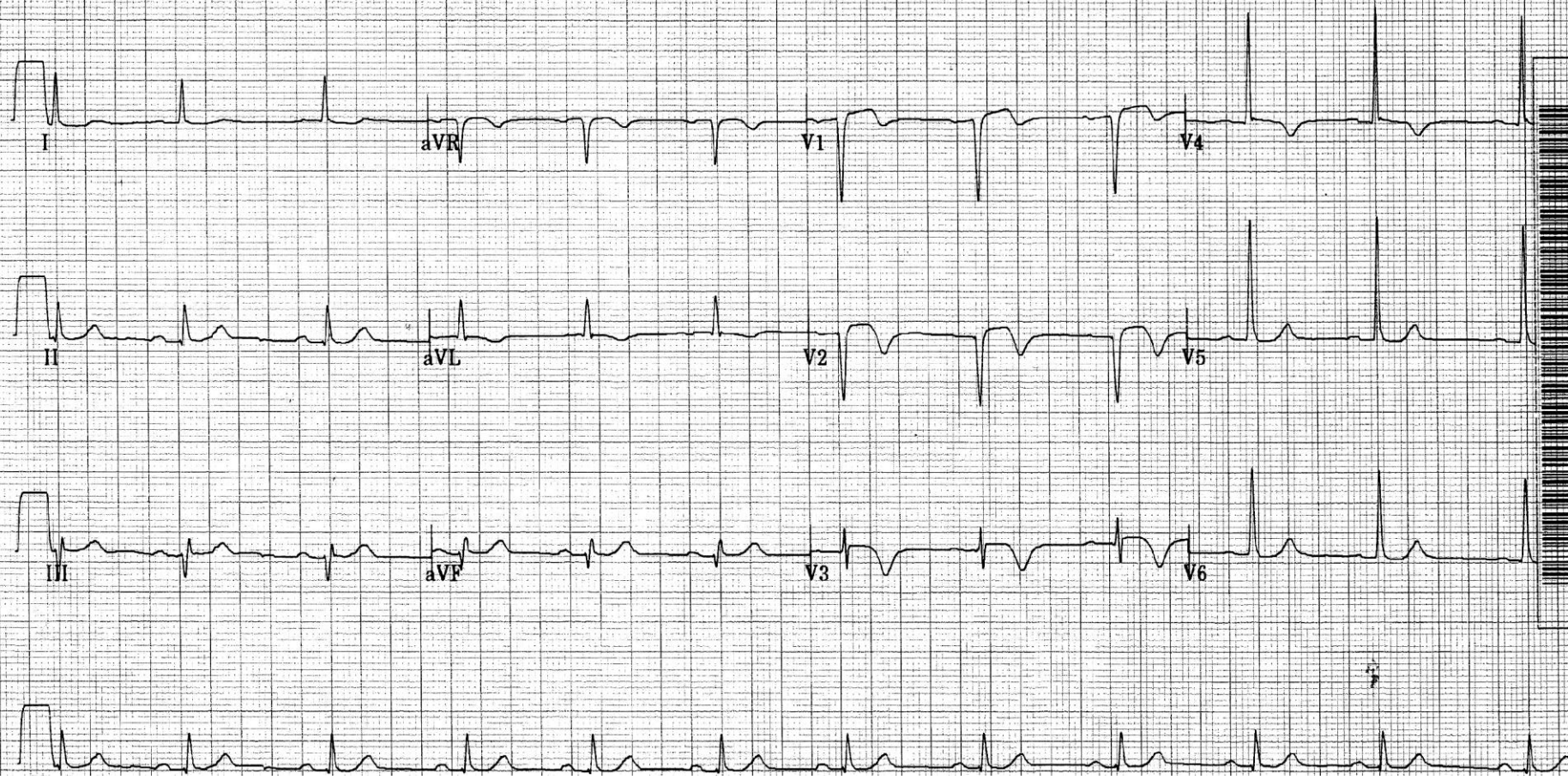
Vent. rate	68	bpm
PR interval	176	ms
QRS duration	84	ms
QT/QTc	396/421	ms
P-R-T axes	71 15 81	

Normal sinus rhythm
Minimal voltage criteria for LVH, may be normal variant
Septal infarct, age undetermined
T wave abnormality, consider anterolateral ischemia

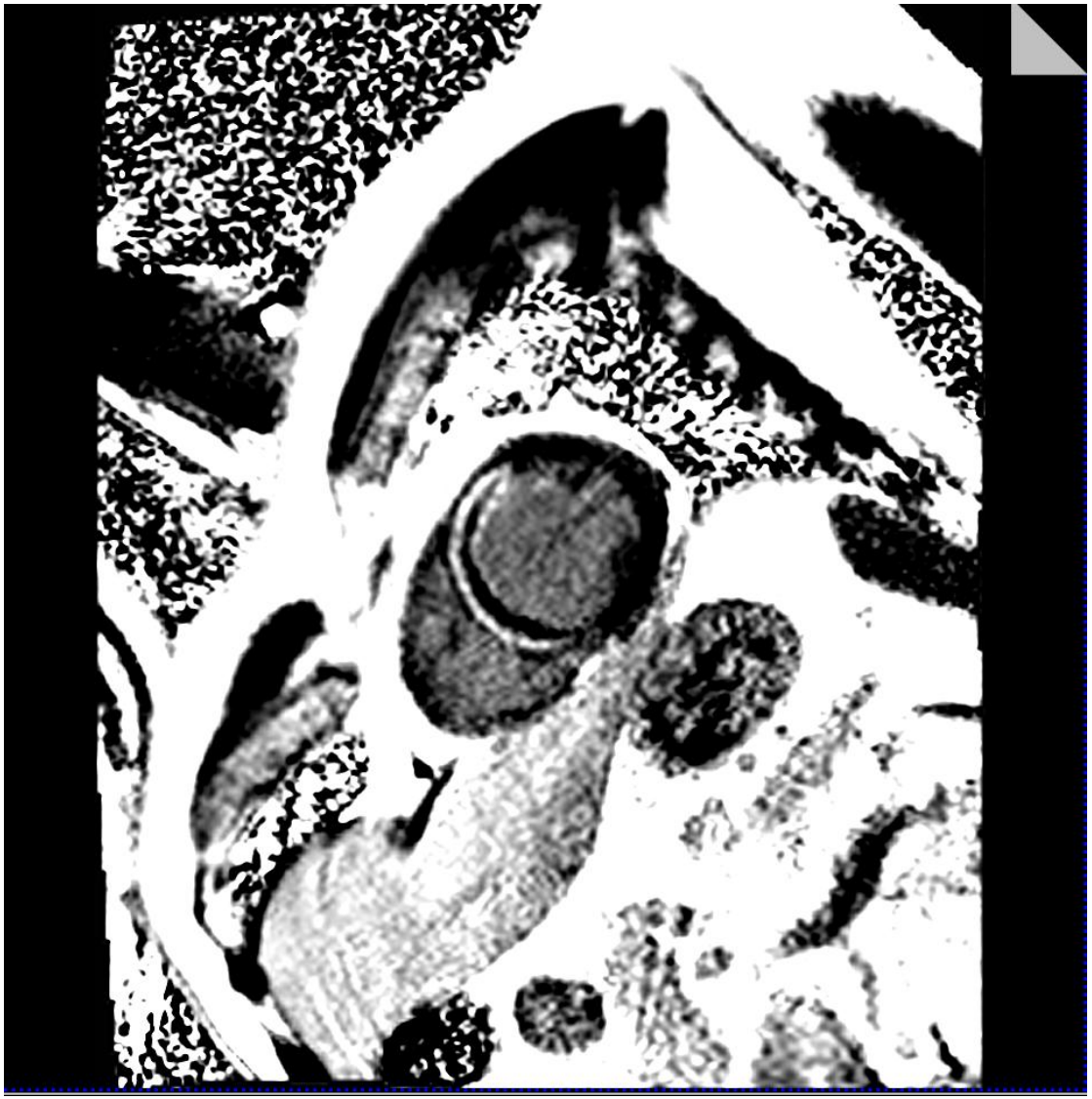
Technician: MS
Test ind: ROUTINE

Referred by:

Unconfirmed



TB – CE-CMR Day 1



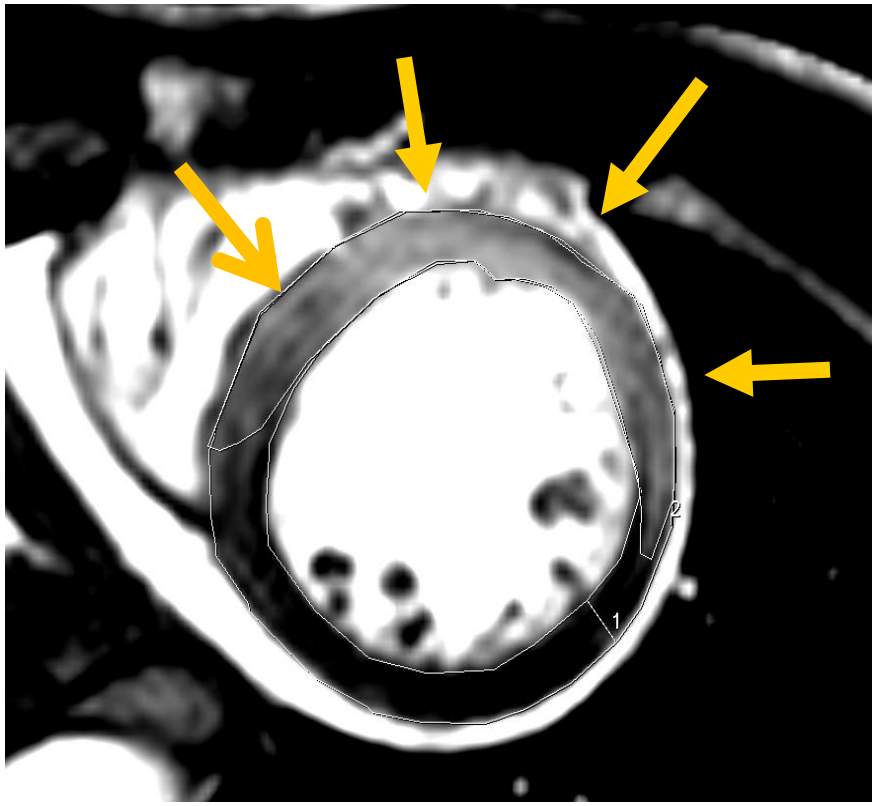
PCI for STEMI (Primary and Rescue)

	Microvascular obstruction CE-CMR		
	Present (n=27)	Absent (n=26)	p
IMR median(IQR)	38.1 (29 – 55)	26.9 (18 – 36)	0.003

McGeoch et al. JACC Int 2010; 3:715-722

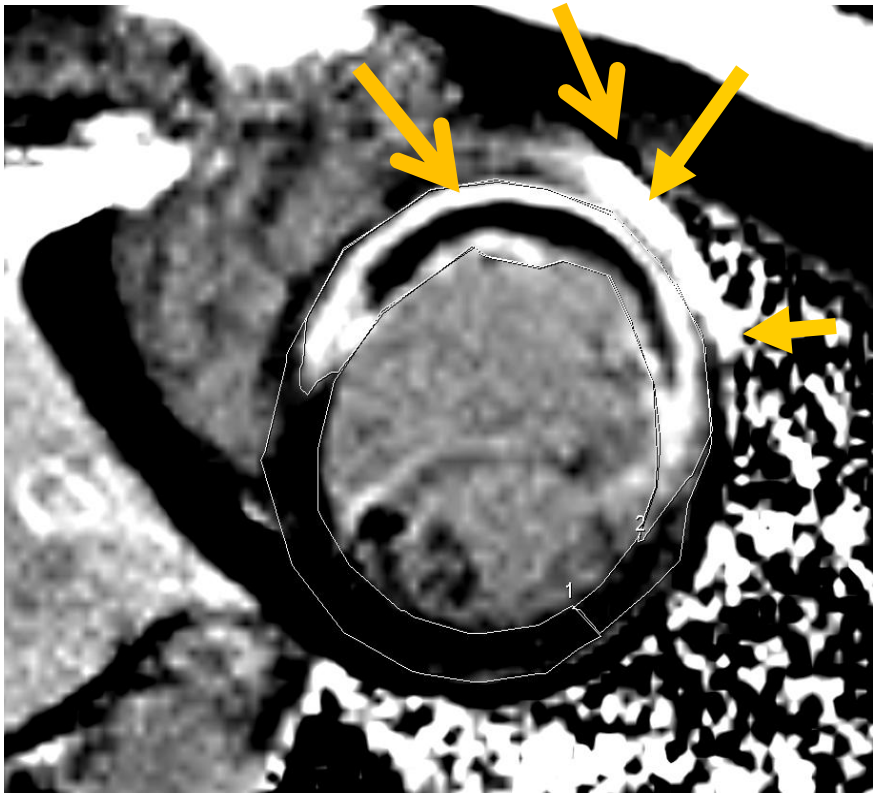
Myocardial Salvage

Area-at-risk



Oedema T_2 weighted MRI

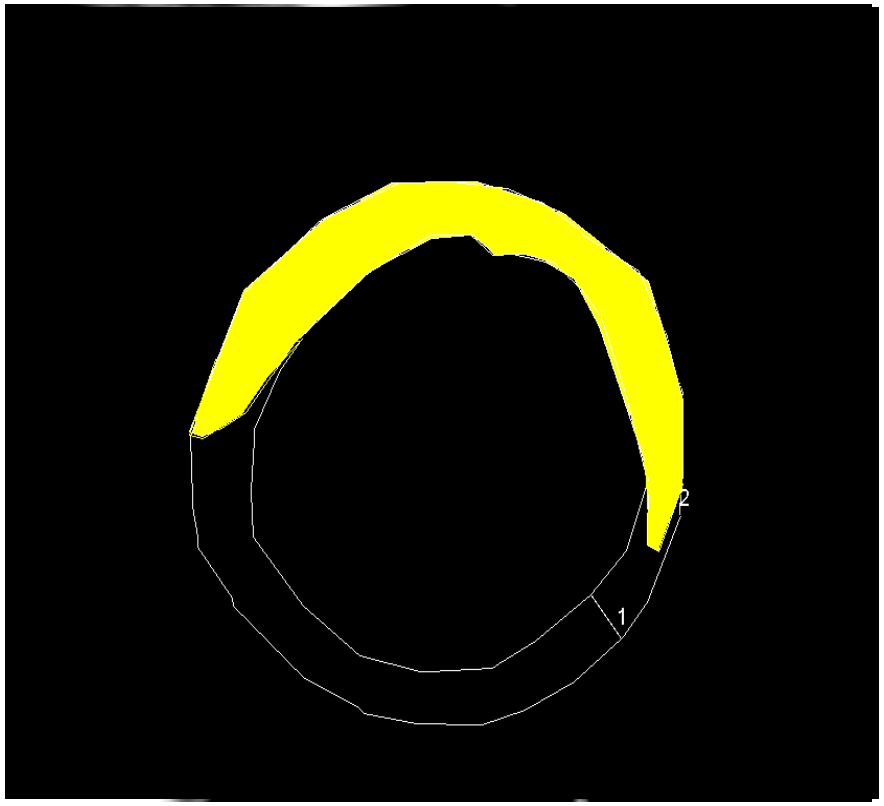
Infarct size



Contrast MRI

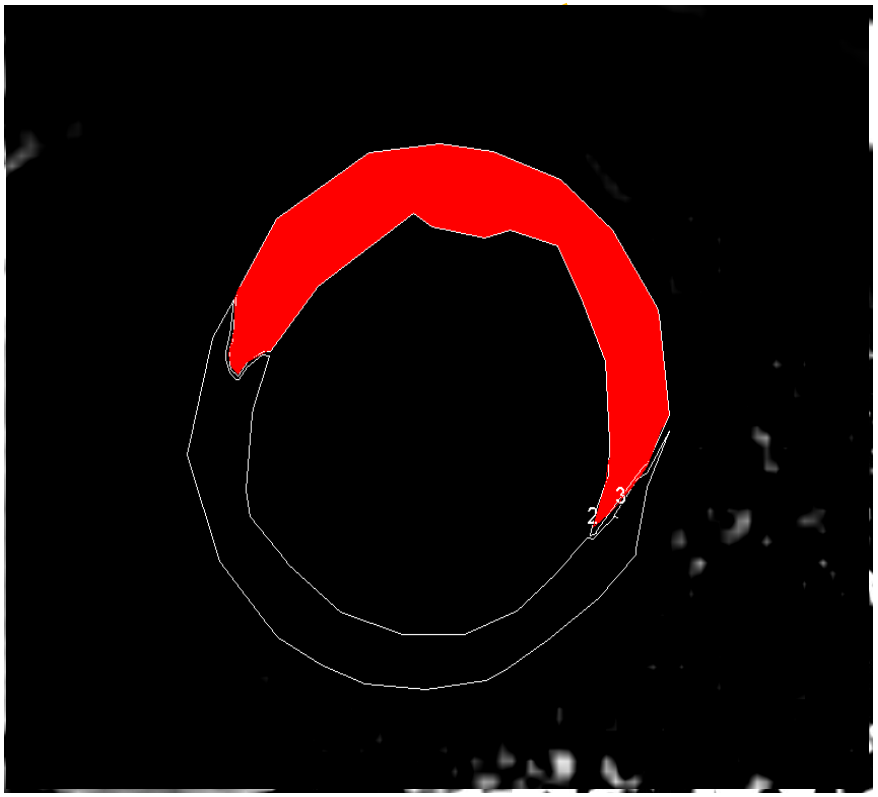
Myocardial Salvage

Area-at-risk



Oedema T_2 weighted MRI

Infarct size

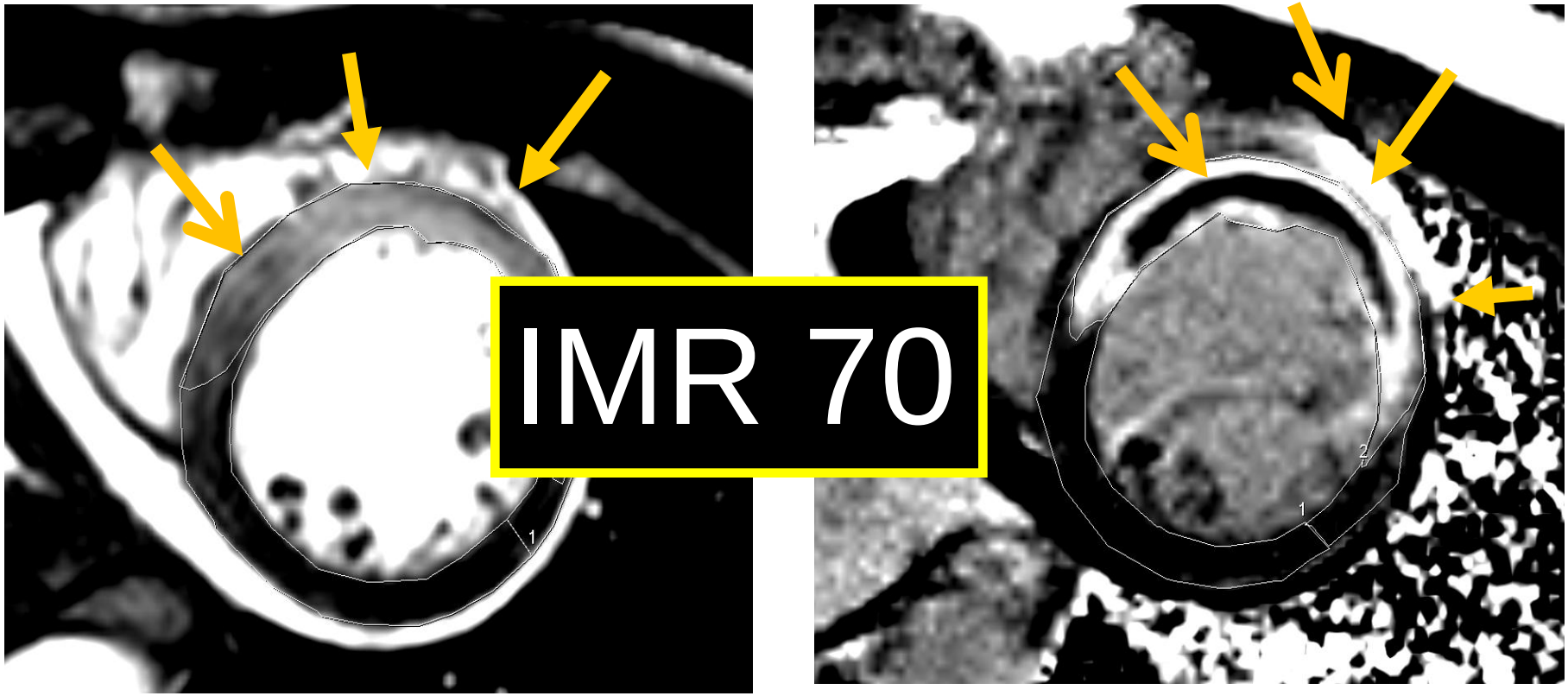


Contrast MRI

Myocardial Salvage

Area-at-risk

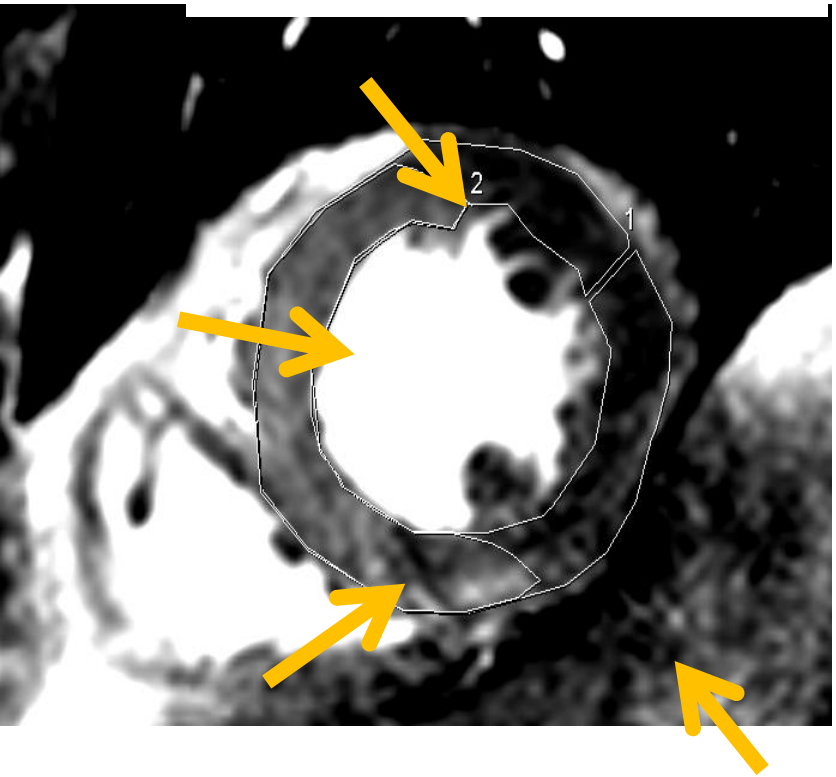
Infarct size



Area-at-Risk	57.5%	Infarct size	57%
Salvage	0.5%	Salvage index	1%

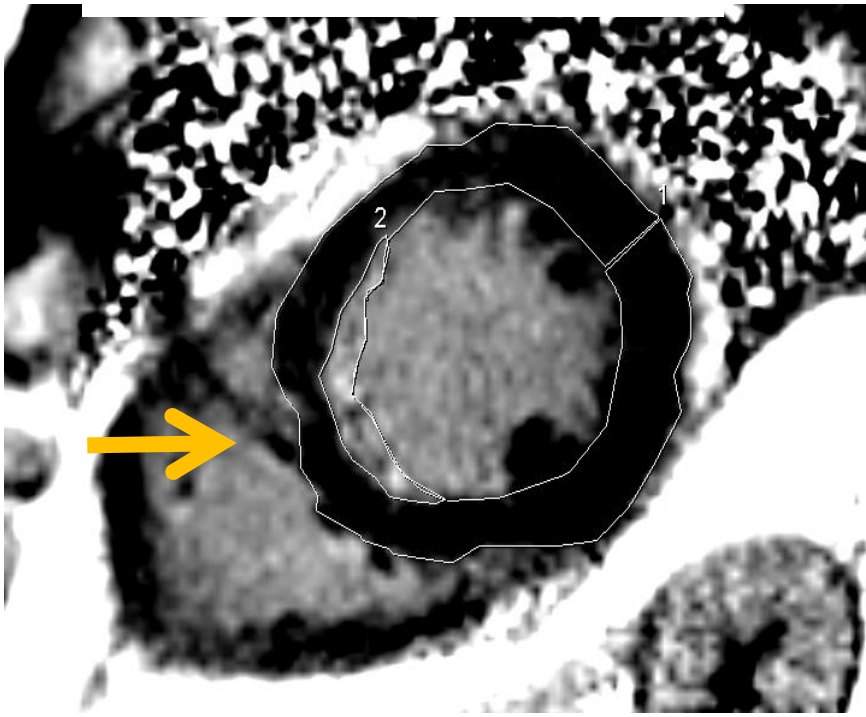
Myocardial Salvage

Area-at-risk



Oedema T_2 weighted MRI

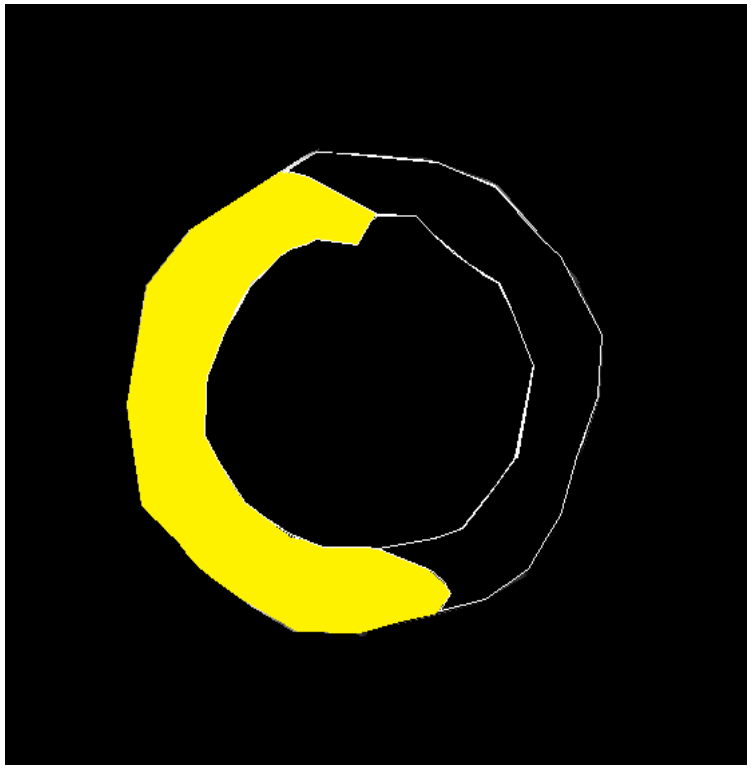
Infarct size



Contrast MRI

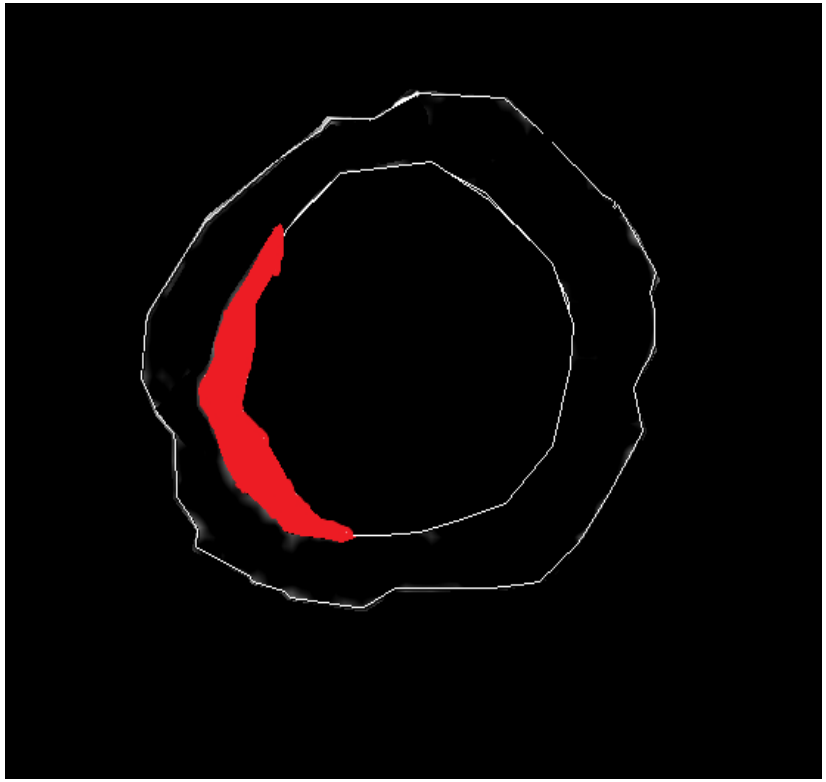
Myocardial Salvage

Area-at-risk



Oedema T_2 weighted MRI

Infarct size

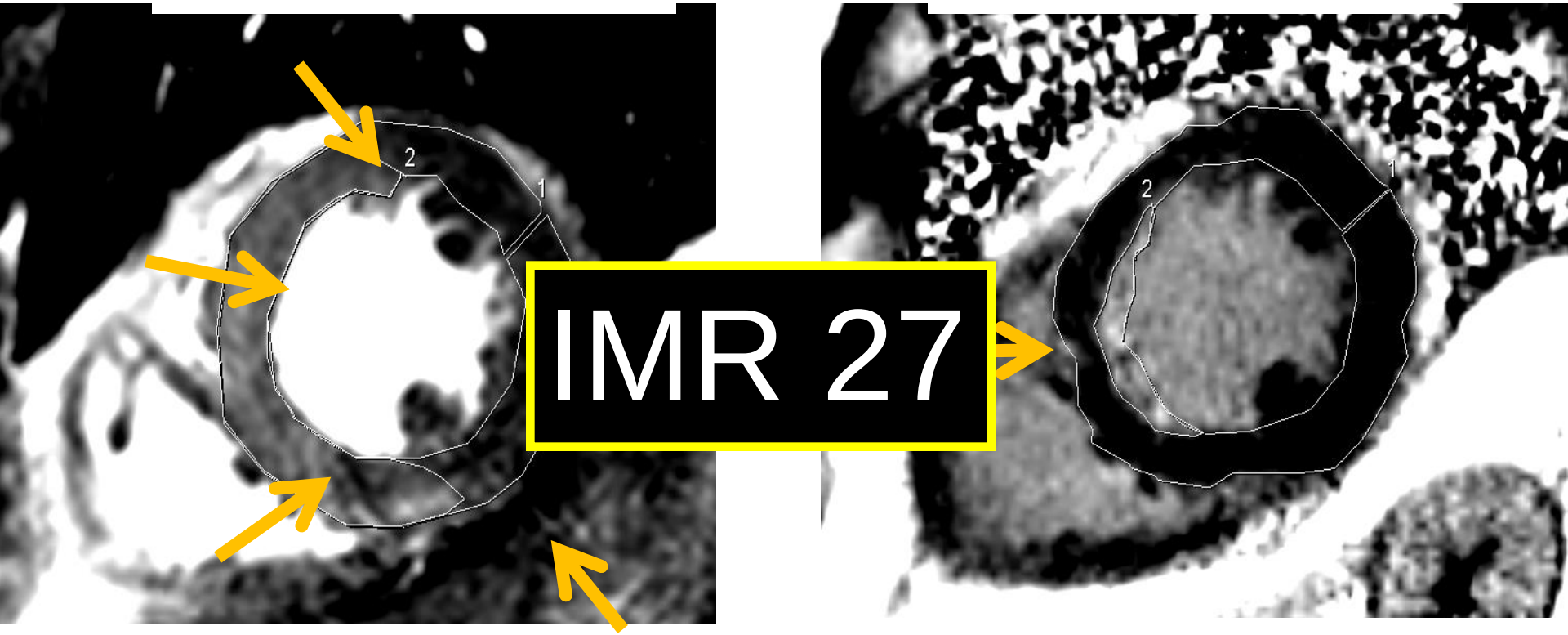


Contrast MRI

Myocardial Salvage

Area-at-risk

Infarct size



Area-at-Risk	57%	Infarct size	14%
Salvage	43%	Salvage index	75%

Primary PCI (n=108)

	Spearman Rank Correlation	p value
Infarct size	0.42	0.0005
MVO (% of LV)	0.38	0.0015
Myocardial salvage	-0.32	0.010
Myocardial salvage index	-0.42	0.0005

Correlations adjusted for age, gender, smoking status, BMI, pain to balloon time, CFIp, use of thrombectomy catheter or glycoprotein IIbIIIa inhibitors

Payne AR et al. J Am Heart Assoc. 2012

Primary PCI (n=108)

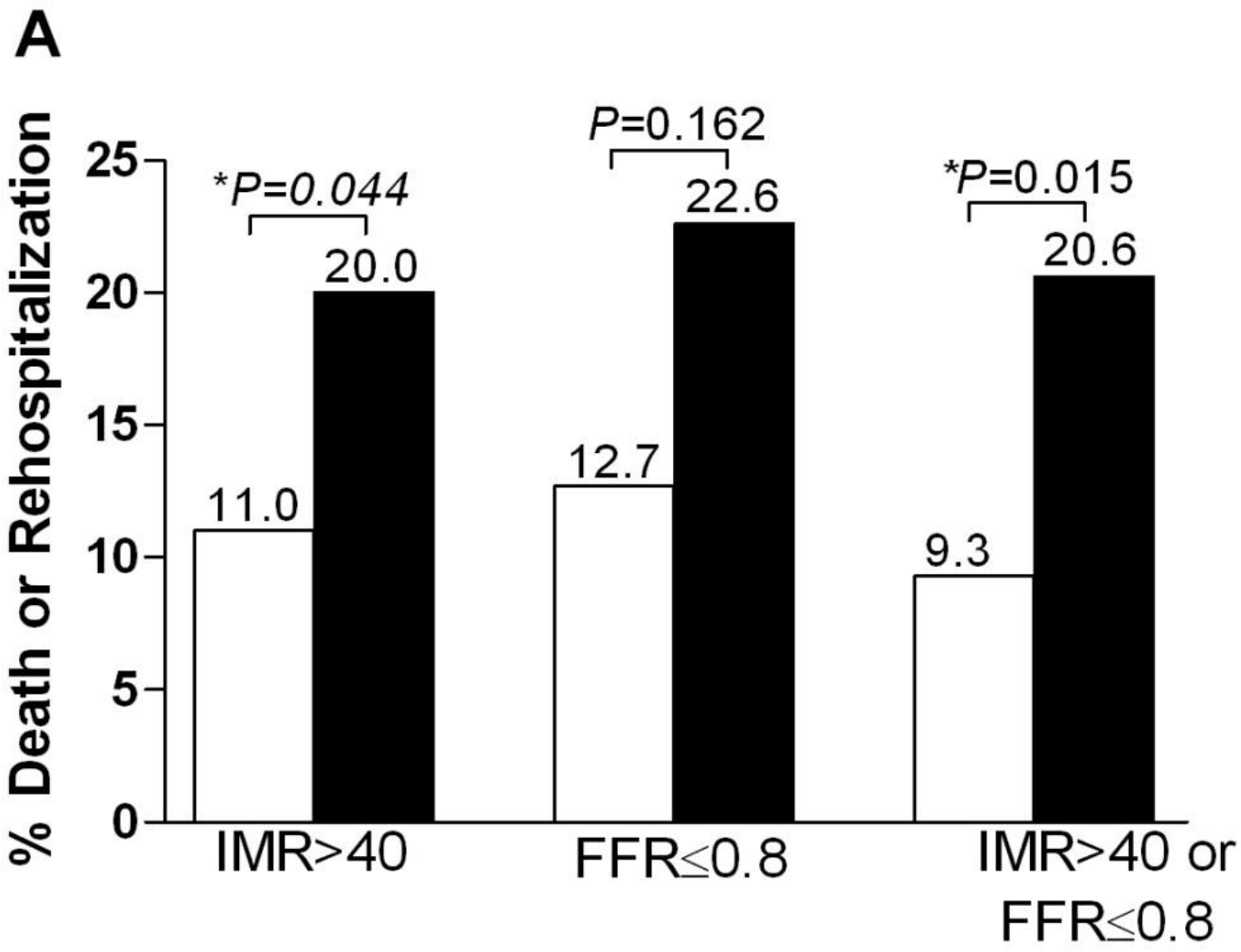
	IMR				
	<17	18-27	28-42	>42	p (trend)
Infarct size (%)	17±13	18±13	24±12	32±13	<0.001
MSI (%)	28±40	18±48	21±38	14±25	<0.001
LVEF (%)	54±8	54±10	51±10	46±9	0.005

Payne AR et al. J Am Heart Assoc. 2012

IMR-STEMI Registry

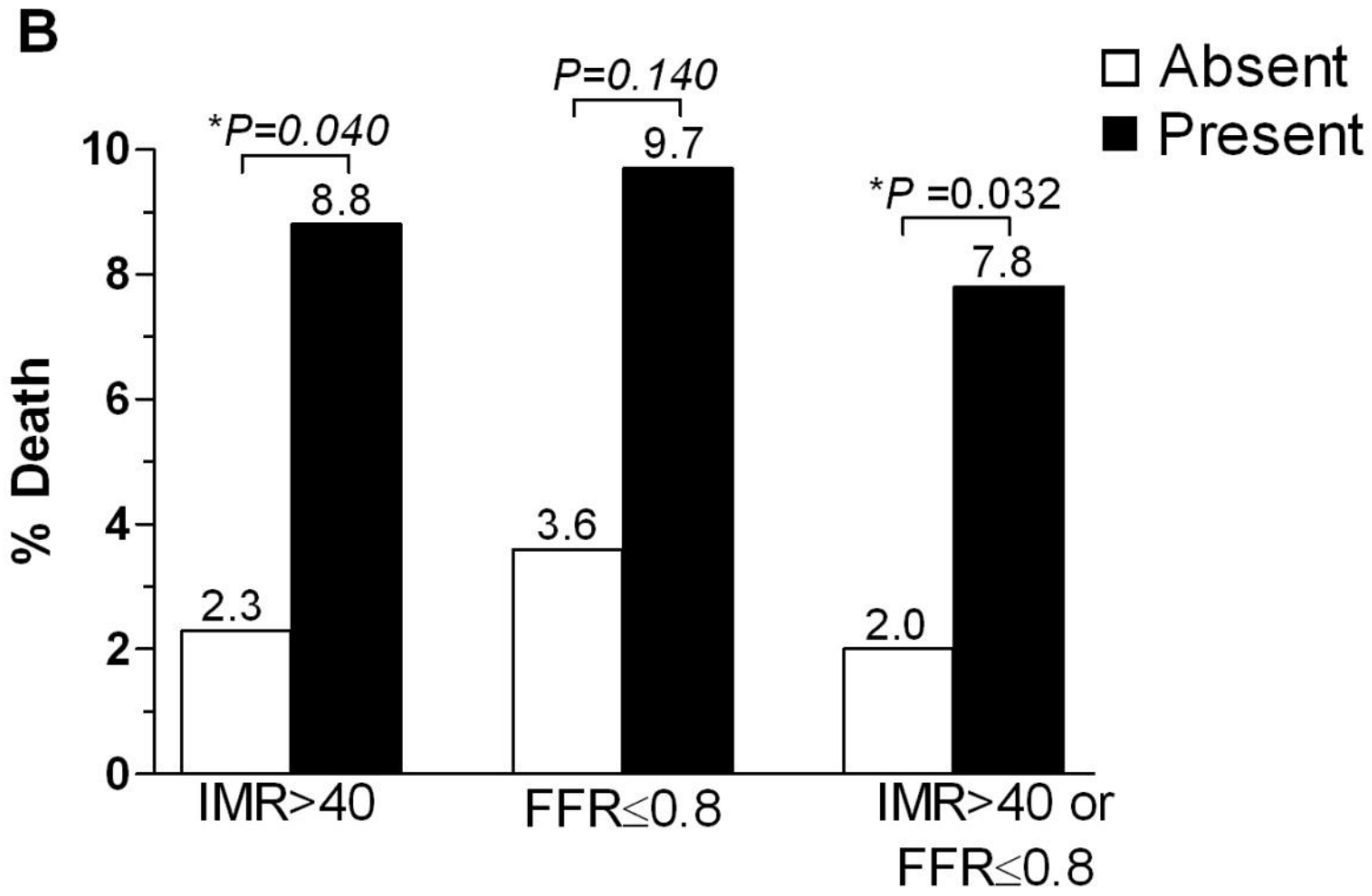
- 253 patients from Stanford, Singapore and Glasgow
  - Mean(SD) IMR was 40 ± 32
- IMR>40 was associated with an increased risk of:
  - death or rehospitalization for HF (HR 2.1, p=0.034)
  - death alone (HR 4.0, p=0.028)
- Independent predictors of death or rehospitalization for HF
  - IMR > 40 (HR 2.2, p=0.026)
  - FFR ≤ 0.8 (HR 3.2, p=0.008)
  - DM (HR 4.4, p<0.001)
- IMR>40 was the only independent predictor of death
  - (HR 4.3, p=0.02)

Fearon et al. Circ 2013; 127(24): 2436-41



Prevalence, no. (%): 80 (31.6) 31 (12.3) 102 (40.3)

Fearon et al. Circ 2013; 127(24): 2436-41



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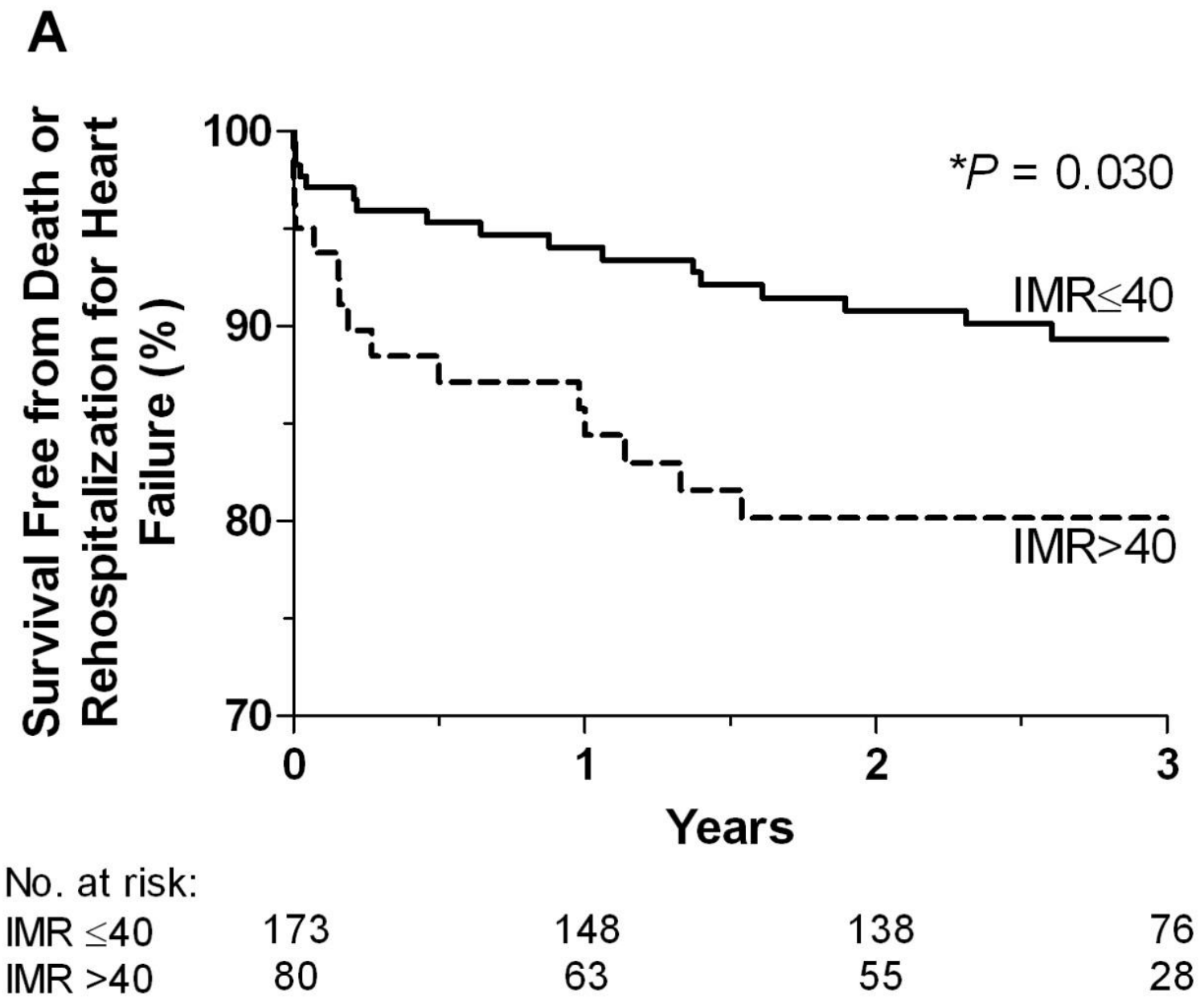
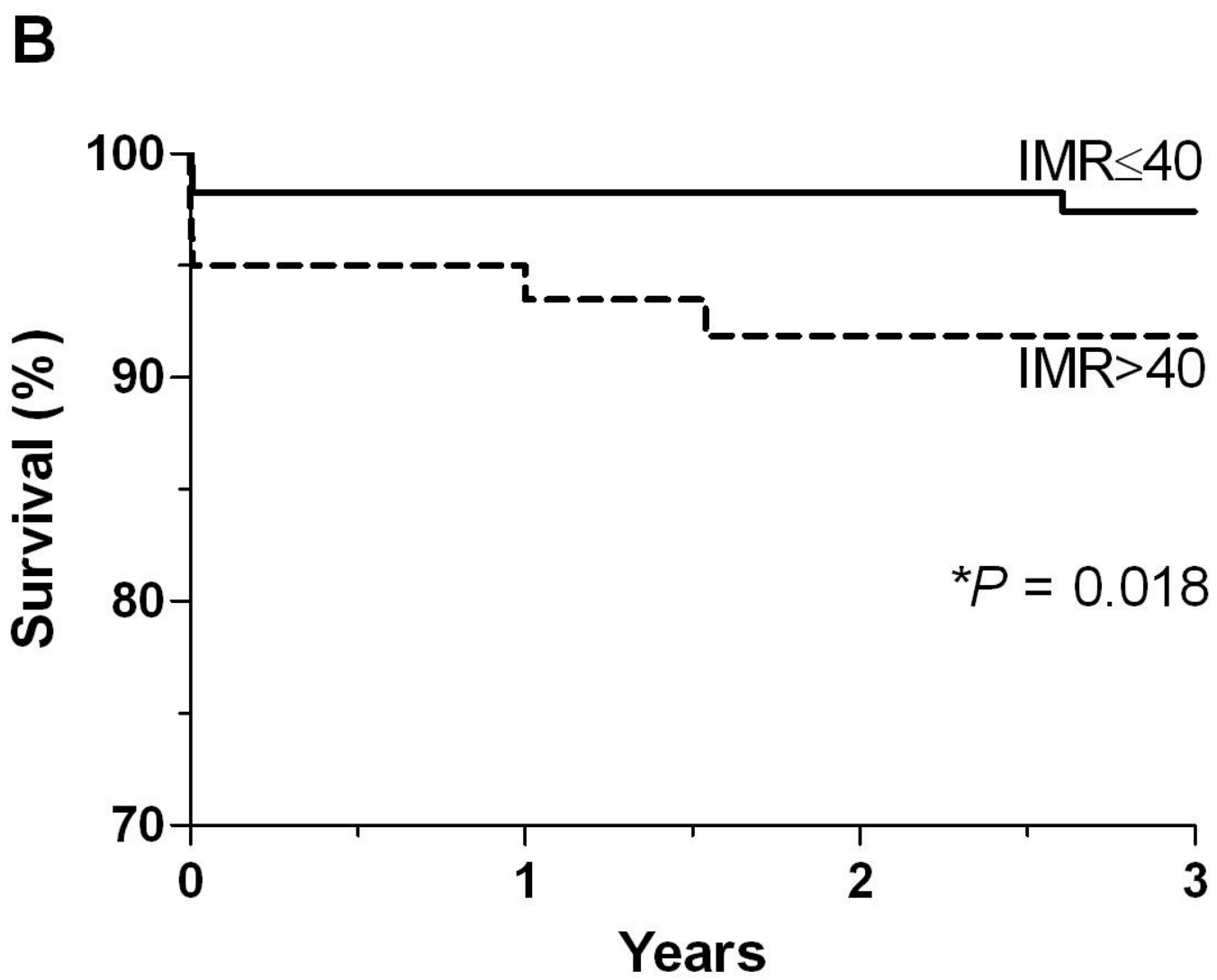


Fearon et al. Circ 2013; 127(24): 2436-41



No. at risk:

IMR ≤40	173	154	149	84
IMR >40	80	69	63	33

Fearon et al. Circ 2013; 127(24): 2436-41

So what's the value of knowing

in the cath lab

that myocardial salvage

will be poor?

? IABP

? Adenosine infusion

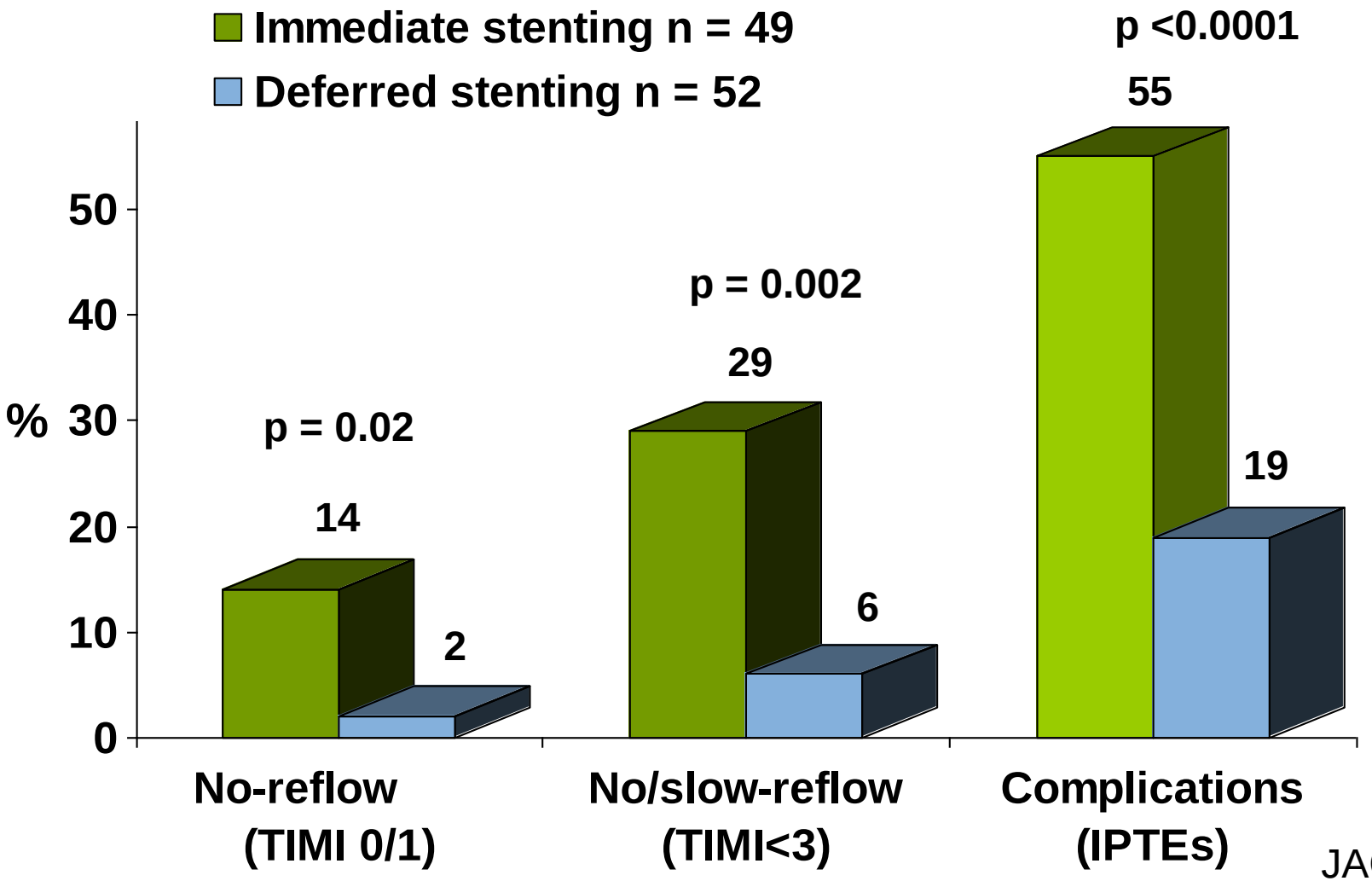
? No stent

? Different stent

? Deferred stenting

DEFER-STEMI

438 STEMI patients, n = 101 randomised



JACC 2014

DEFER-STEMI

438 STEMI patients, n = 101 randomised

Table 3. Contrast-enhanced cardiac MRI findings during the index hospitalization and after 6 months follow-up.

Characteristics*	Immediate stenting	Deferred PCI †	p value
MRI 2 days post-MI	*n = 47*	*n = 48*	
Microvascular obstruction, n (%)	29 (61·7%)	23 (47·9%)	0·155
MRI 6 months post-MI	*n = 44*	*n = 45*	
Myocardial salvage, % left ventricular mass¥	14·7 (8·1, 23·2)	19·7 (13·8, 26·0)	0·027
Myocardial salvage index, %	56 (31, 72)	68 (54, 82)	0·031
Infarct size, % of left ventricular mass	14·3 (6·3 , 20·3)	9·0 (4·3 , 16·0)	0·181

JACC 2014

Thank You

Predictors of LVEF at Day 1

	Univariate R^2 value	P value	Multivariate analysis
Age	2.6	0.23	
Male	2.6	0.23	
Smoking	5.4	0.08	
Hyperlipidaemia	0.1	0.94	
Hypertension	0.4	0.63	
Diabetes	**12.1**	**0.008**	**p = 0.03**
GP2b3a inhibitor	3.7	0.15	
Thrombectomy	1.9	0.31	
IMR	**29.1**	**<0.001**	**P ≤ 0.001**
CFIp	0.7	0.54	
Pw	0.1	0.93	

McGeoch et al. JACC Int 2010; 3:715-722

Infarct Volume at Day 1

	Univariate R^2 value	P value	Multivariate analysis
Age	0	0.87	
Male	0.5	0.62	
Smoking	1.9	0.33	
Hyperlipidaemia	3.6	0.18	
Hypertension	2.6	0.25	
Diabetes	0.2	0.77	
GP2b3a inhibitor	5.3	0.09	
Thrombectomy	1.2	0.43	
IMR	**18.6**	**0.001**	**p = 0.002**
CFIp	0.8	0.53	
Pw	0.1	0.81	

McGeoch et al. JACC Int 2010; 3:715-722

Predictors of LVEF at 3 months

	Univariate R^2 value	P value	Multivariate analysis
Age	0	0.97	
Male	2.0	0.34	
Smoking	1.7	0.37	
Hyperlipidaemia	**12**	**0.01**	**p = 0.017**
Hypertension	0.7	0.56	
Diabetes	2.0	0.34	
GP2b3a inhibitor	**10.8**	**0.02**	**p = 0.014**
Thrombectomy	3.2	0.22	
IMR	**14.5**	**0.007**	**p = 0.004**
CFIp	0.1	0.81	
Pw	0	0.95	

McGeoch et al. JACC Int 2010; 3:715-722

Infarct Volume at 3 months

	Univariate R^2 value	P value	Multivariate analysis
Age	0.1	0.84	
Male	1.1	0.49	
Smoking	0.9	0.52	
Hyperlipidaemia	9.1	0.04	
Hypertension	0.8	0.55	
Diabetes	0.9	0.52	
GP2b3a inhibitor	5.5	0.11	
Thrombectomy	2.8	0.26	
IMR	**15.6**	**0.006**	**p = 0.008**
CFIp	0.4	0.67	
Pw	0.3	0.72	

McGeoch et al. JACC Int 2010; 3:715-722