FFR Evaluation in STEMI and NSTEMI

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Faculty Disclosure

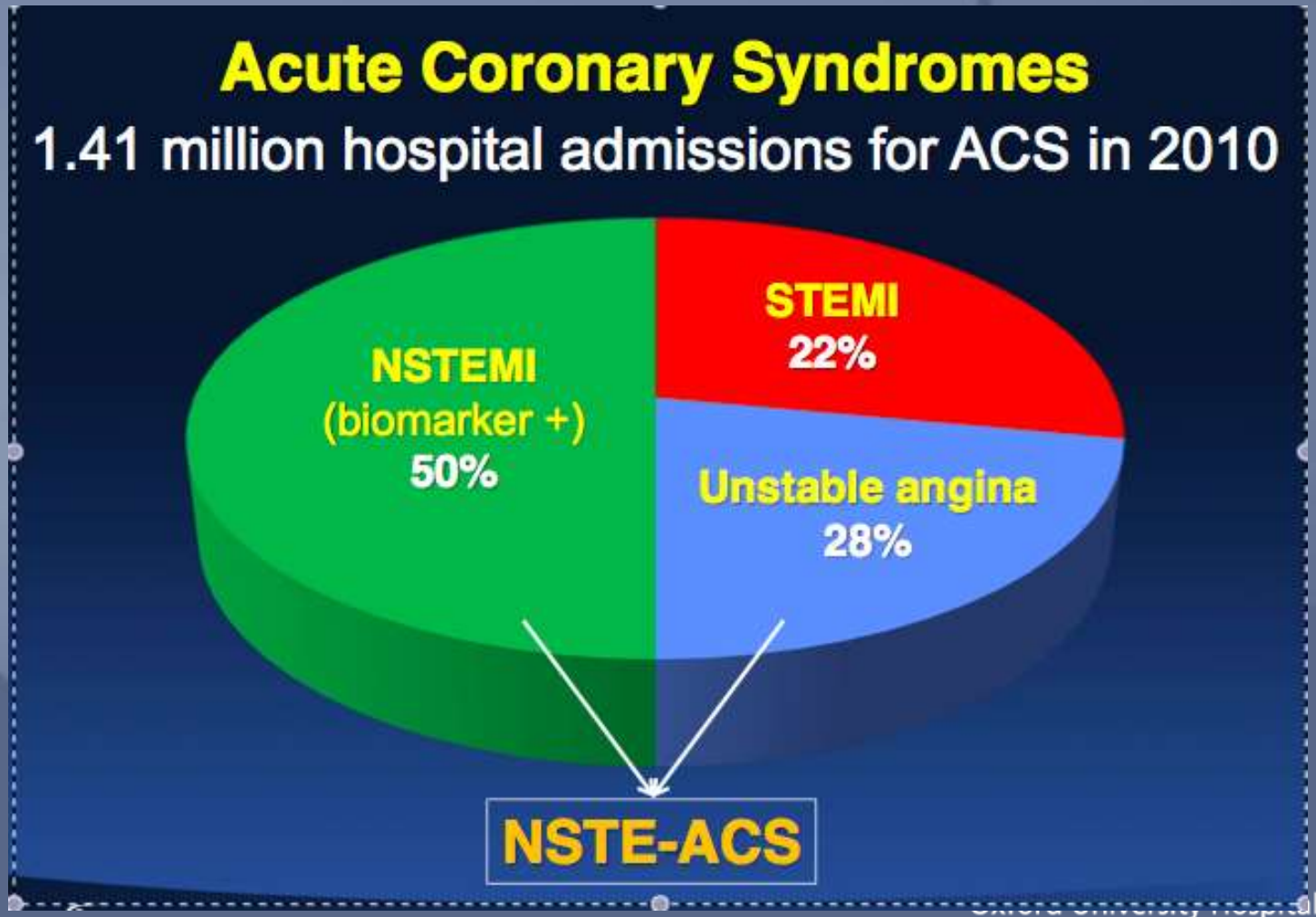
- Boston Scientific - Institutional educational grant for fellowship

- Speakers fees (modest)
- Boston Scientific, Abbott, Medtronic,Volcano, Miracor

Plan for the talk

- FFR in NSTEMI
  - Historical data
  - Recent data – FAMOUS NSTEMI
- FFR in STEMI
  - non-culprit lesions
  - Culprit lesions- Pathophysiology of recovery
  - IMR in STEMI
    - Is this a useful index to guide therapy

It's a big problem -still



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NSTEMI

- We know (generally)
  - Intervention beneficial vs medical therapy
- We can define high risk patients (eg GRACE score)
  - These are the patients where most of the benefit is evident.

- BUT- Intervention is a blunt tool
  - We treat too many lesions…in too many patients
  - Because we don't know which ones need to be done and which don't

So ……

Surely pressure wire can save us from uncertainty!

FFR is reliable in non culprit in STEMI

Fractional Flow Reserve for the Assessment of Nonculprit Coronary Artery Stenoses in Patients With Acute Myocardial Infarction

J Am Coll Cardiol Intv
2010: 3;1274-81

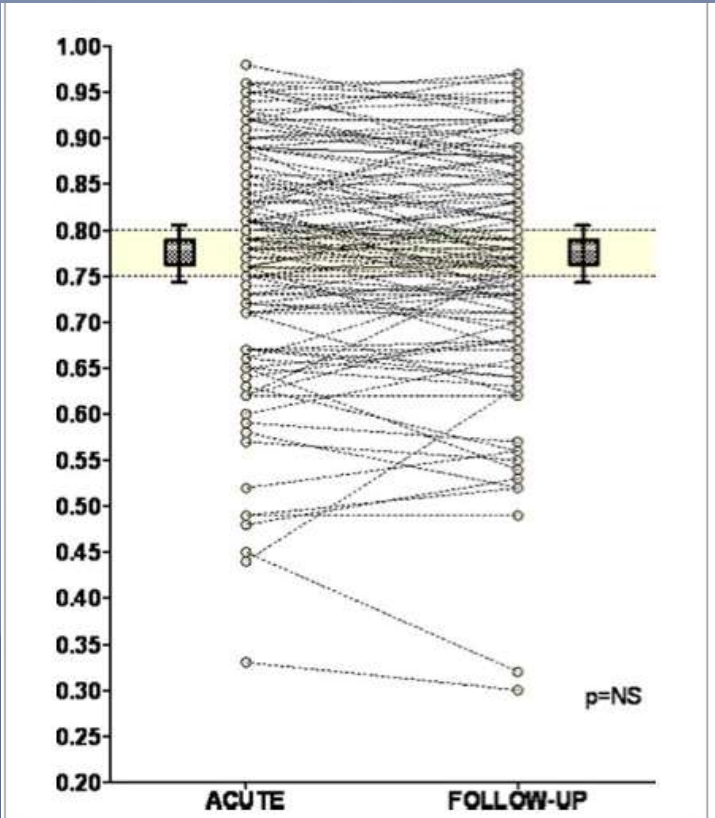

Figure 1. Plot of FFR Values of Nonculprit Coronary Artery Stenoses During the Acute Phase and at Follow-Up

During the acute phase of ACS culprit stenosis can be reliably assesed by FFR

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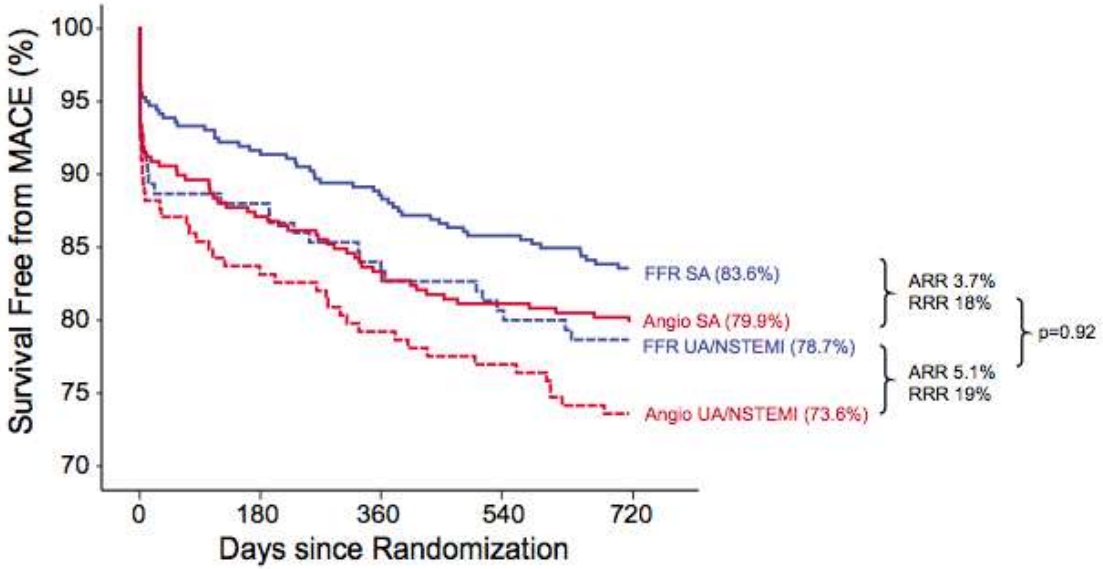
FFR may be reliable for culprit in ACS

Fractional Flow Reserve in Unstable Angina and Non–ST-Segment Elevation Myocardial Infarction

Experience From the FAME (Fractional flow reserve versus Angiography for Multivessel Evaluation) Study

J Am Coll Cardiol Intv 2011: 4;183-9



In the FAME study .. No hetrogeneity of benefit of guidance of pci with FFR when comparing stable and ACS patients

Fractional flow reserve vs. angiography in guiding management to optimize outcomes in non-ST-segment elevation myocardial infarction: the British Heart Foundation FAMOUS–NSTEMI randomized trial

European Heart Journal
doi:10.1093/eurheartj/ehu338

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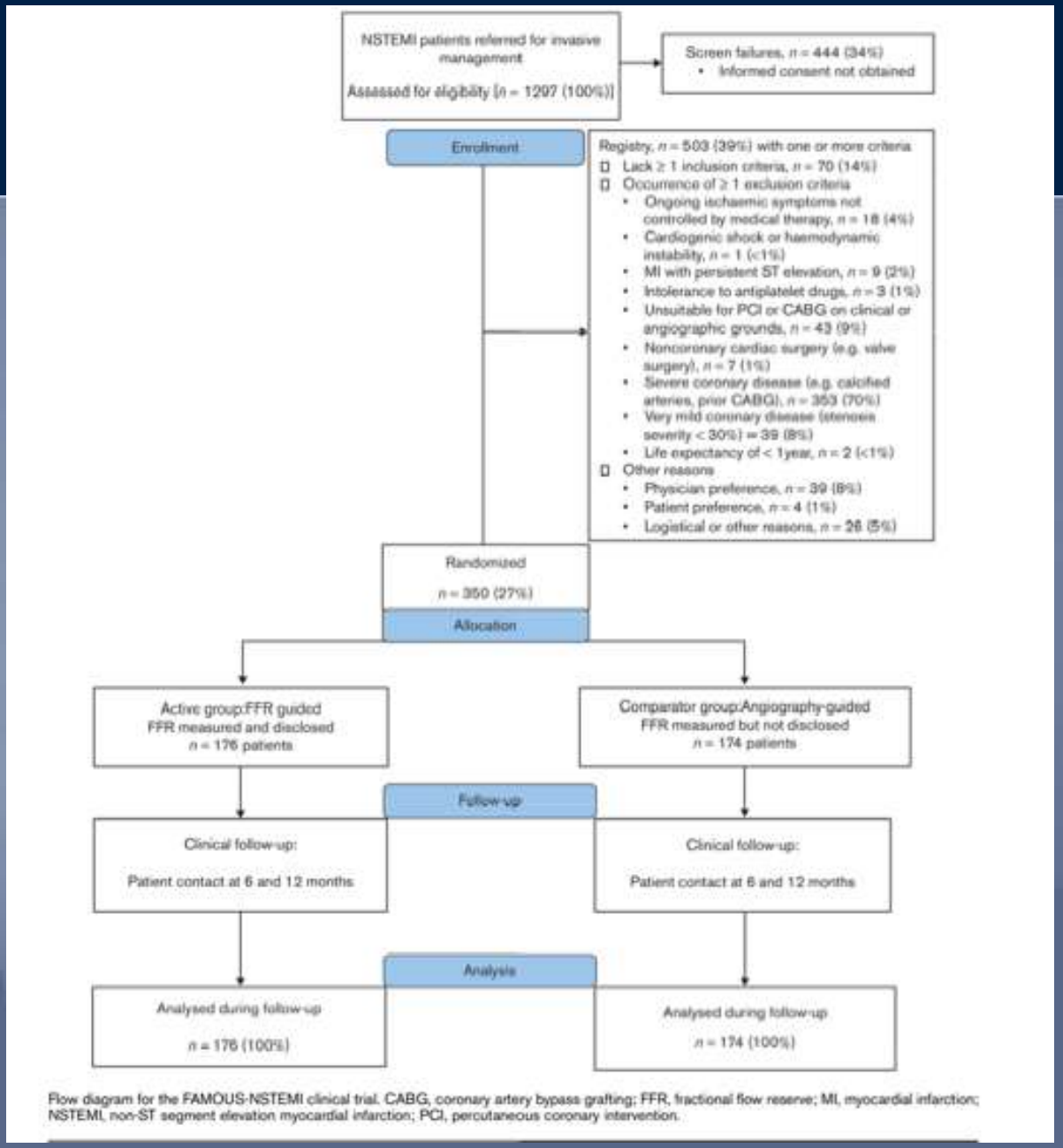
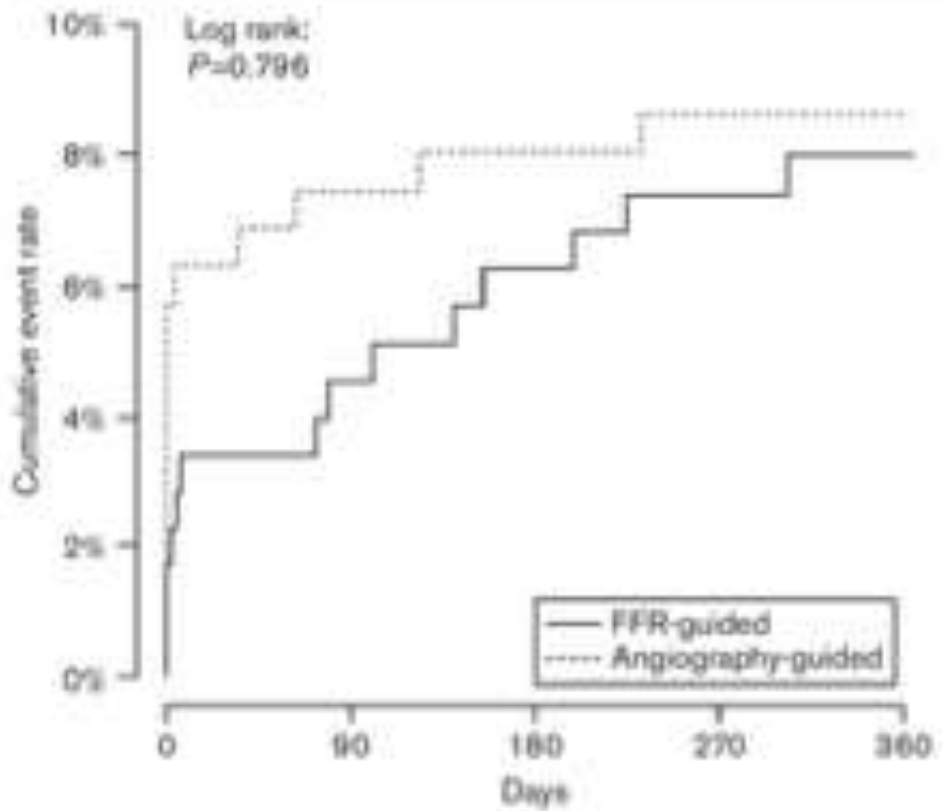


Flow diagram for the FAMOUS-NSTEMI clinical trial. CABG, coronary artery bypass grafting; FFR, fractional flow reserve; MI, myocardial infarction; NSTEMI, non-ST segment elevation myocardial infarction; PCI, percutaneous coronary intervention.

Pressure wire alone may not be perfect



Kaplan–Meier plots for major adverse cardiovascular events during 12-month follow-up in the fractional flow reserve (FFR)-guided group and the angiography-guided group.

350 patients included

20% management changed by FFR disclosure

Similar outcomes but less stents

Underpowered

Famous NSTEMI

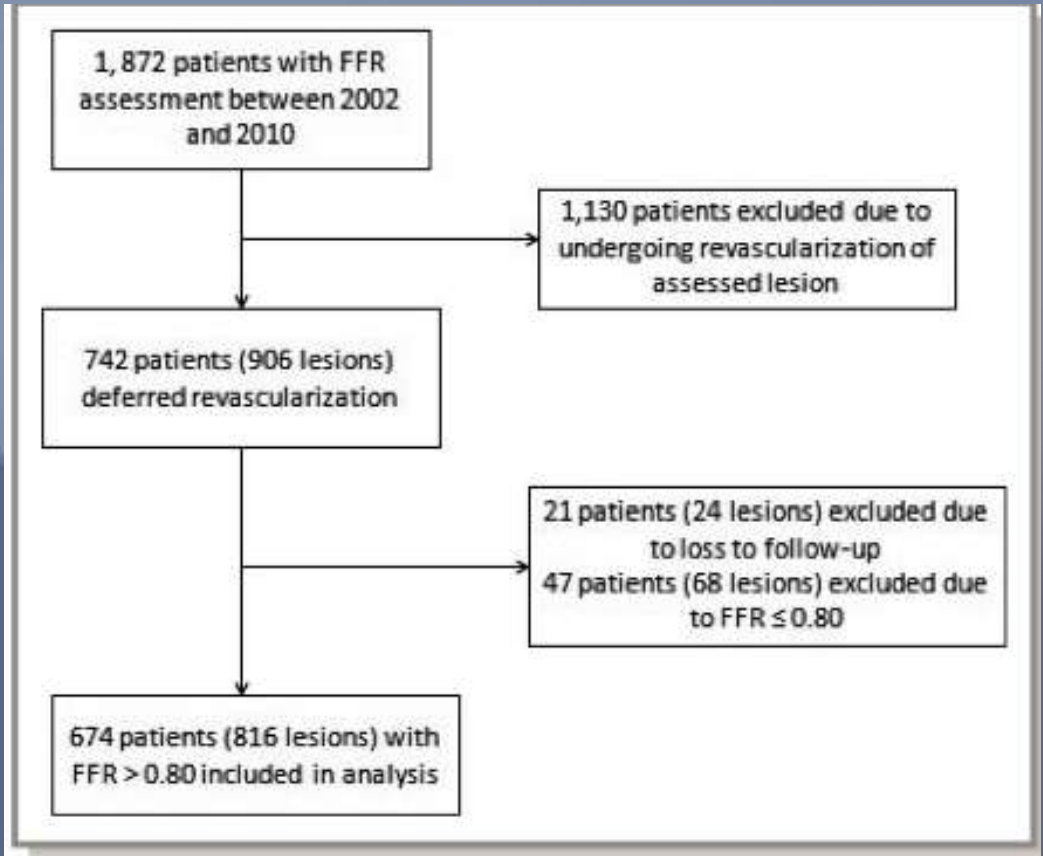
	FFR	No FFR		
Health outcomes at 12 months, *n* (%)				
Cardiovascular death, non-fatal myocardial infarction, unplanned hospitalization for stroke or transient ischaemic attack (MACCE)	13 (7.4)	16 (9.2)	−1.8% (−7.9, 4.2%)	0.56
Cardiac death, non-fatal myocardial infarction or unplanned hospitalization for heart failure (MACE)	14 (8.0)	15 (8.6)	−0.7% (−6.7, 5.3%)	0.89
MACE, excluding procedure-related myocardial infarction[d]	10 (5.7)	5 (2.9)	2.8% (−1.6, 7.6%)	0.25
All-cause death	5 (2.8)	3 (1.7)	1.1% (−2.4, 5.0%)	0.54
Fatal or non-fatal myocardial infarction[d]	11 (6.2)	15 (8.6)	−2.4% (−8.2, 3.3%)	0.49
Myocardial infarction related to coronary revascularization (Type 4a, Type 4b and Type 5 myocardial infarction)	5 (2.8)	11 (6.3)	−3.5% (−8.5, 1.1%)	0.12
Spontaneous myocardial infarction	7 (4.0)	5 (2.9)	1.1% (−3.1, 5.5%)	0.69
Heart failure	1 (0.6)	0 (0.0)	0.6% (−1.6, 3.2%)	0.51
Stroke or TIA	0 (0.0)	1 (0.6)	−0.6% (−3.2, 1.5%)	0.52

More (2x) events in FFR guided group
Less procedural MI

FFR >0.8 in ACS

Association of Lower Fractional Flow Reserve Values With Higher Risk of Adverse Cardiac Events for Lesions Deferred Revascularization Among Patients With Acute Coronary Syndrome

Shriti Masrani Mehta, MD; Jeremiah P. Depta, MD, MPHS; Eric Novak, MS; Jayendrakumar S. Patel, MD; Yogesh Patel, MD; David Raymer, MD; Gabrielle Facey, MD; Alan Zajarias, MD; John M. Lasala, MD, PhD; Jasvindar Singh, MD; Richard G. Bach, MD; Howard I. Kurz, MD



J Am Heart A 2015
4:e002172 doi:
10.1161/.115.002172

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Less good outcomes in ACS when FFR is closer to 0.8

Table 5. Cox Proportional HR Per 0.01 Unit Decrease in FFR

	ACS HR (95% CI)	Non-ACS HR (95% CI)	Interaction *P* Value*
Cardiovascular death/MI/DLI	1.08 (1.03 to 1.12)†	1.01 (0.96 to 1.06)	0.04
Cardiovascular death/MI	1.05 (0.998 to 1.11)	0.98 (0.92 to 1.05)	0.14
MI/DLI	1.09 (1.04 to 1.14)†	1.00 (0.95 to 1.05)	0.01
DLF	1.12 (1.06 to 1.18)†	1.00 (0.95 to 1.06)	0.004
Cardiovascular death	1.04 (0.95 to 1.14)	0.98 (0.82 to 1.17)	0.57
MI	1.07 (1.00 to 1.14)†	0.97 (0.90 to 1.04)	0.05
MI lesion	1.12 (0.996 to 1.26)	0.91 (0.79 to 1.04)	0.02
DLI	1.12 (1.06 to 1.18)†	1.01 (0.95 to 1.06)	0.01

For each increment of 0.01- more risk
However
this is not all going to be to do with the “lesion” alone
Some of it may not be correctable with a stent

So whats the conclusion? FFR for culprit in NSTEMI

- FFR is not the "perfect" answer but
  - If its positive (<0.8) treatment is probably appropriate
  - and you can this can guide the extent of revascularisation (multi vs single lesion)
  - If is *just* negative you can either
  - Defer – medical – usual
  - or image and very occasionally stent-
  - eg LAD When high plaque (>70%) volume low MLA (<4)---- PREVENT trial

FFR in STEMI.. Non culprit

Complete revascularisation versus treatment of the culprit lesion only in patients with ST-segment elevation myocardial infarction and multivessel disease (DANAMI-3—PRIMULTI): an open-label, randomised controlled trial

Thomas Engstrøm, Henning Kelbæk, Steffen Helqvist, Dan Eik Høfsten, Lene Kløvgaard, Lene Holmvang, Erik Jørgensen, Frants Pedersen, Kari Saunamäki, Peter Clemmensen, Ole De Backer, Jan Ravkilde, Hans-Henrik Tilsted, Anton Boel Villadsen, Jens Aarøe, Svend Eggert Jensen, Bent Raungaard, Lars Køber, for the DANAMI-3—PRIMULTI Investigators*

Complete revasc with FFR guidance *vs* culprit vessel only

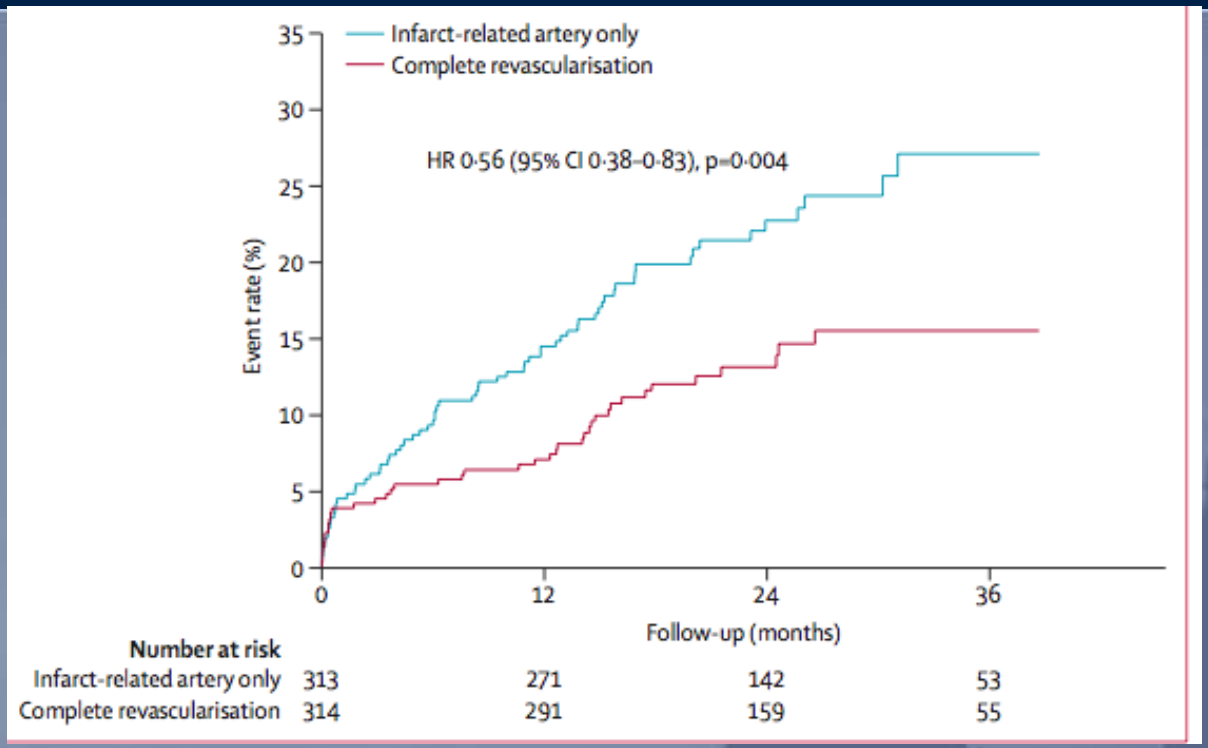
Procedures done 48 hrs after index

Lancet 2015 386;9994;665-671

	Infarct-related artery only (n=313)	Complete revascularisation (n=314)
Median age (range, years)	63 (34–92)	64 (37–94)
Men	255 (81%)	251 (80%)
Women	58 (19%)	63 (20%)
Medical history		
Diabetes	42 (13%)	29 (9%)
Hypertension	146 (47%)	130 (41%)
Current smoking	151 (48%)	160 (51%)
Previous myocardial infarction	27 (9%)	17 (5%)
Infarct location		
Anterior	112 (36%)	105 (33%)
Inferior	179 (57%)	195 (62%)
Posterior	20 (6%)	10 (3%)
Left bundle branch block	2 (1%)	4 (1%)
Three-vessel disease	100 (32%)	97 (31%)
Stenosis on proximal portion of left anterior descending artery	86 (27%)	80 (25%)

Data are number of patients (%), unless otherwise stated.

FFR in STEMI.. Non culprit



Lancet 2015
386;9994;665-671

	Infarct-related artery only (n=313)	Complete revascularisation (n=314)	Hazard ratio (95% CI)	p
Primary endpoint*	68 (22%)	40 (13%)	0·56 (0·38–0·83)	0·004
All-cause mortality	11 (4%)	15 (5%)	1·40 (0·63–3·00)	0·43
Non-fatal reinfarction	16 (5%)	15 (5%)	0·94 (0·47–1·90)	0·87
Ischaemia-driven revascularisation	52 (17%)	17 (5%)	0·31 (0·18–0·53)	<0·0001

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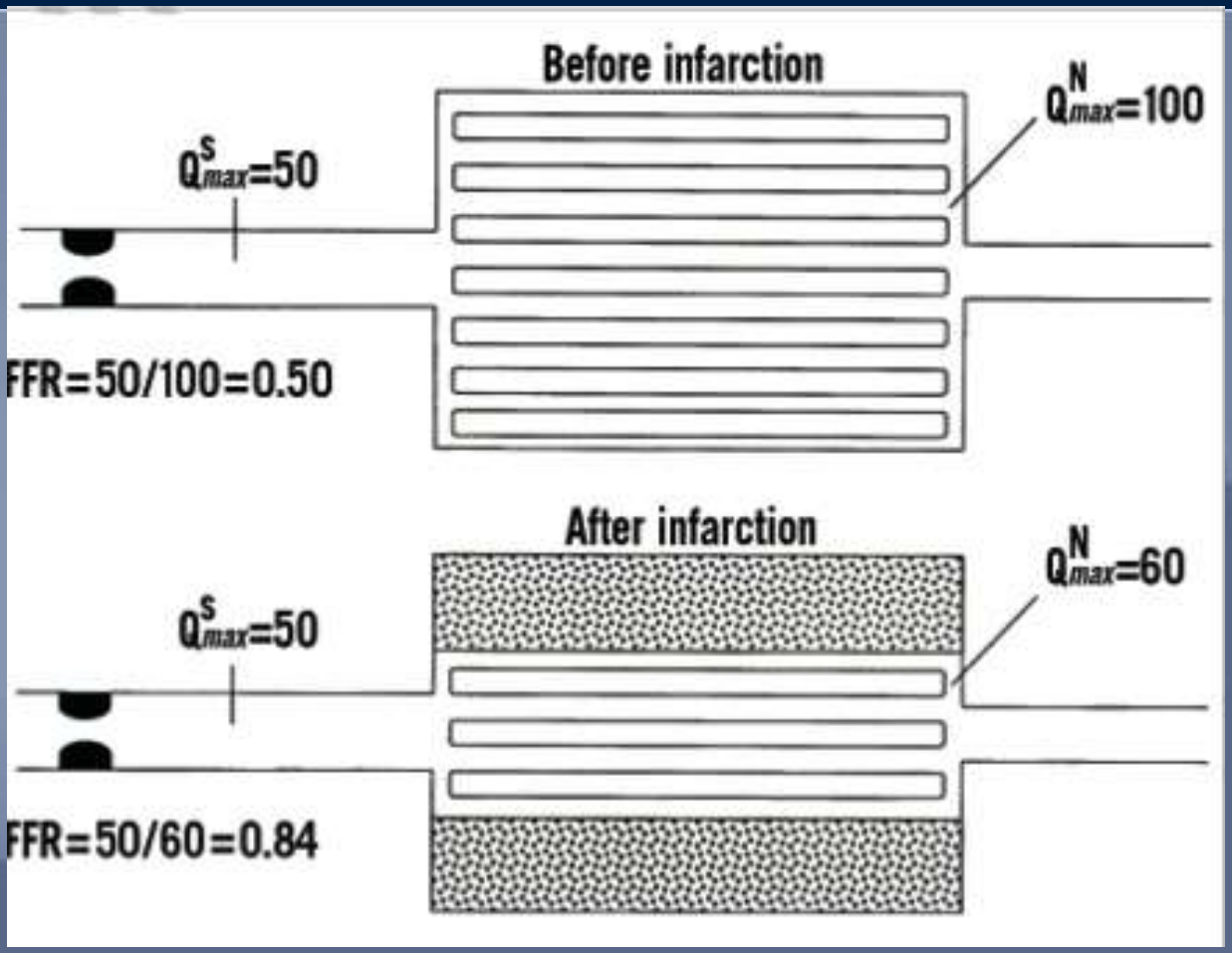
FFR in NTEMI & STEMI

- NSTEMI
  - Non culprit - FFR validated to guide revasc
  - Culprit FFR *good* if FFR <0.8
- STEMI
  - Non culprit - FFR validated to guide revasc
  - Culprit ????

FFR in STEMI - theory



19. De Bruyne B, Pijls NH, Bartunek J, Kulecki K, Bech JW, De Winter H, Van Crombrugge P, Heyndrickx GR, Wijns W. Fractional flow reserve in patients with prior myocardial infarction. *Circulation*. 2001;104:157-62.

FFR acute false negative

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Impact of Microvascular Obstruction on the Assessment of Coronary Flow Reserve, Index of Microcirculatory Resistance, and Fractional Flow Reserve After ST-Segment Elevation Myocardial Infarction

Florim Cuculi, MD,*† Giovanni Luigi De Maria, MD,† Pascal Meier, MD,† Erica Dall'Armellina, MD, DPhil,†
Alberto R. de Caterina, MD,* Keith M. Channon, MD,† Bernard D. Prendergast, MD,* Robin C. Choudhury, MD,†
John C. Forfar, MD, PhD,* Rajesh K. Kharbanda, MD, PhD,* Adrian P. Banning, MBBS, MD*

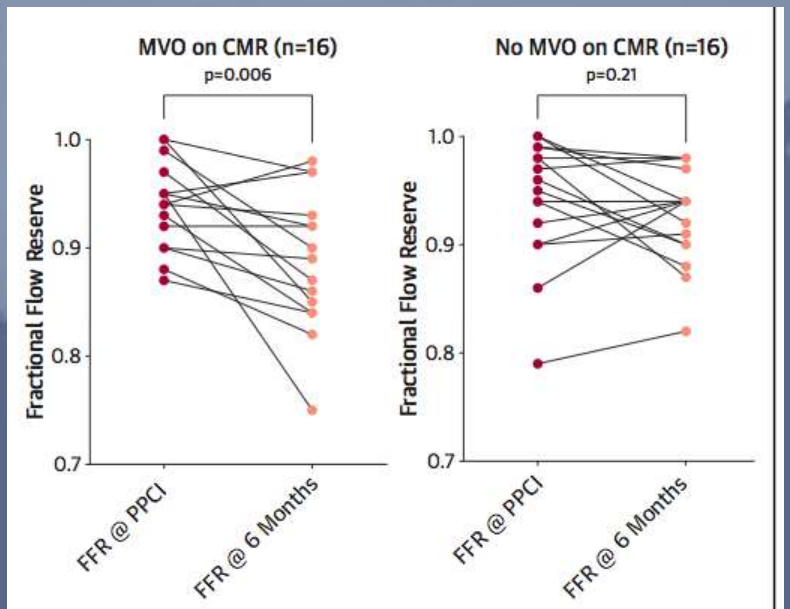

FIGURE 4 Change of FFR From PPCI to 6 Months According to MVO Presence on CMR

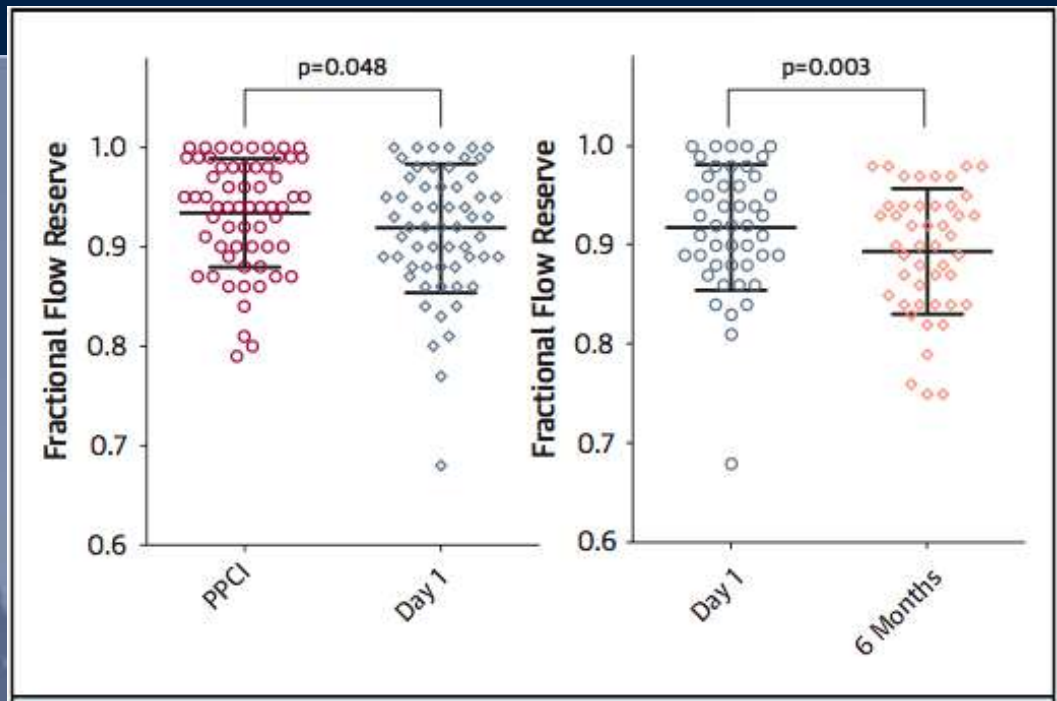

FIGURE 3 Change of FFR From PPCI to Day 1 and From Day 1 to 6 Months

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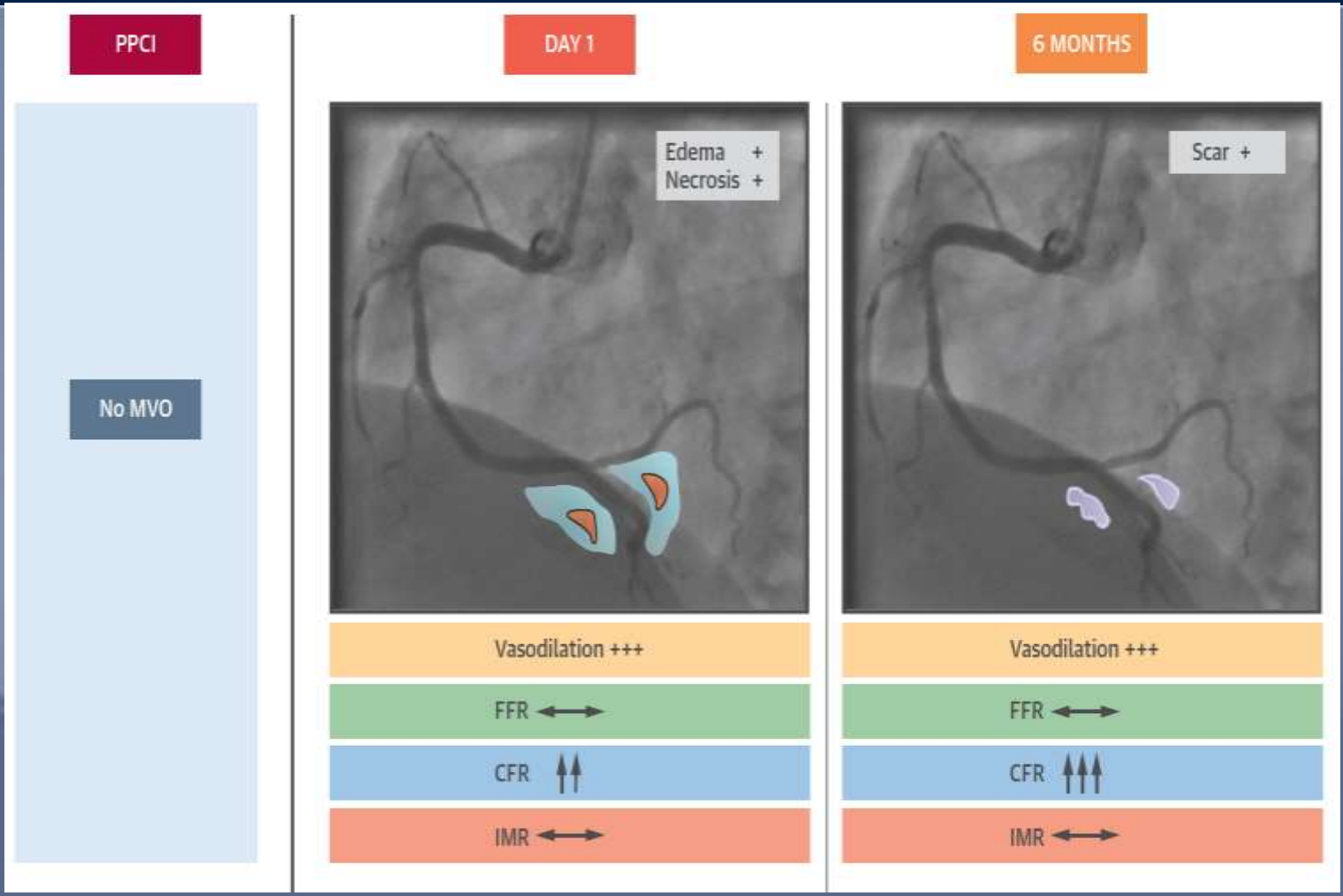
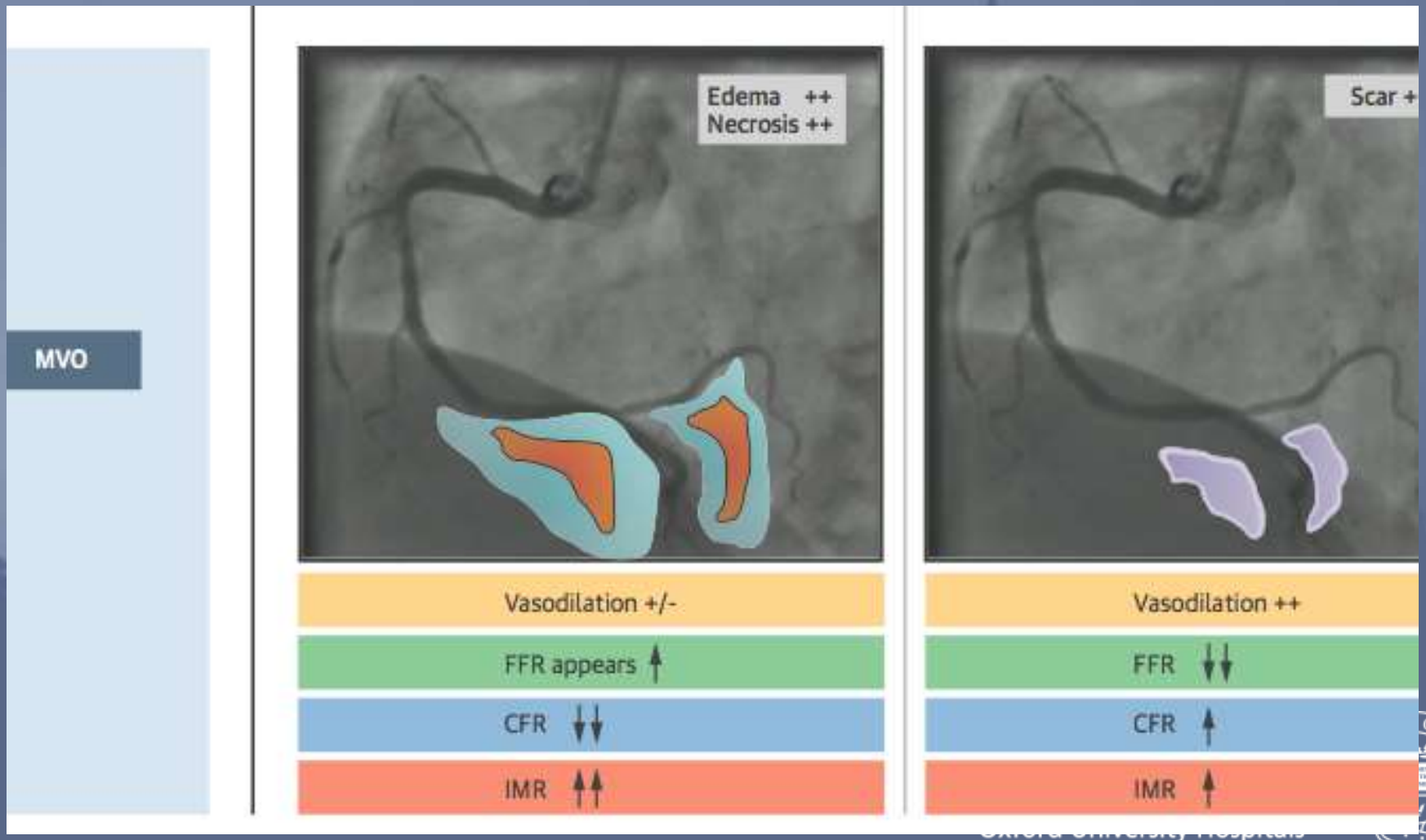
Small infarcts – no MVO



Large infarcts – with MVO



FFR change is in the "salvaged" group

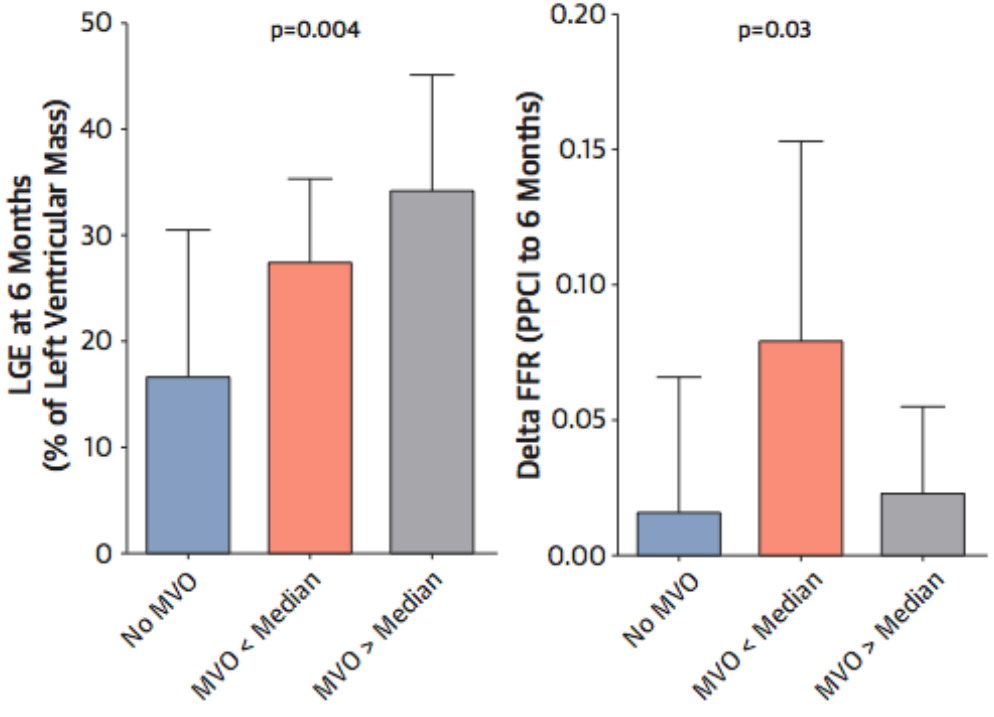


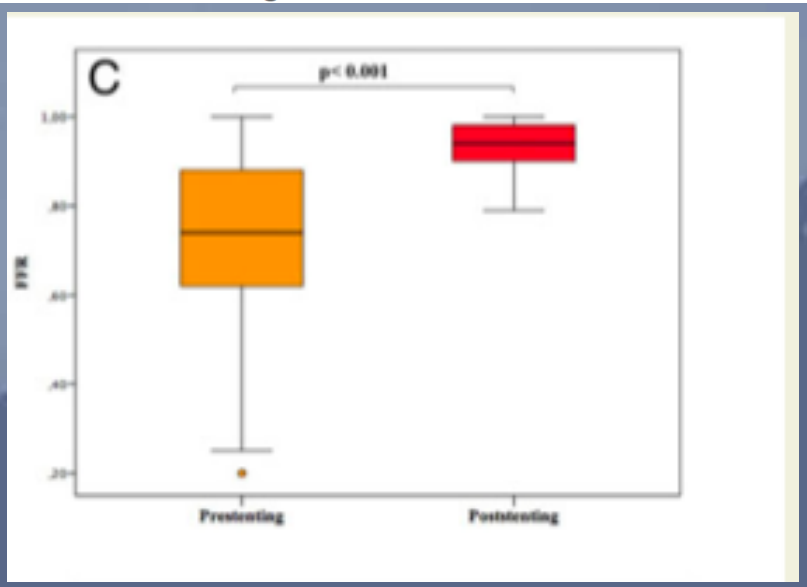
FIGURE 5 **LGE at 6 Months and ΔFFR According to Presence and Severity of MVO on Day 1 CMR**

LGE at 6 months is expressed as percentage of left ventricular mass **(left)**; ΔFFR is defined as FFR PPCI minus FFR 6 months **(right)**. Abbreviations as in Figures 1 and 3.

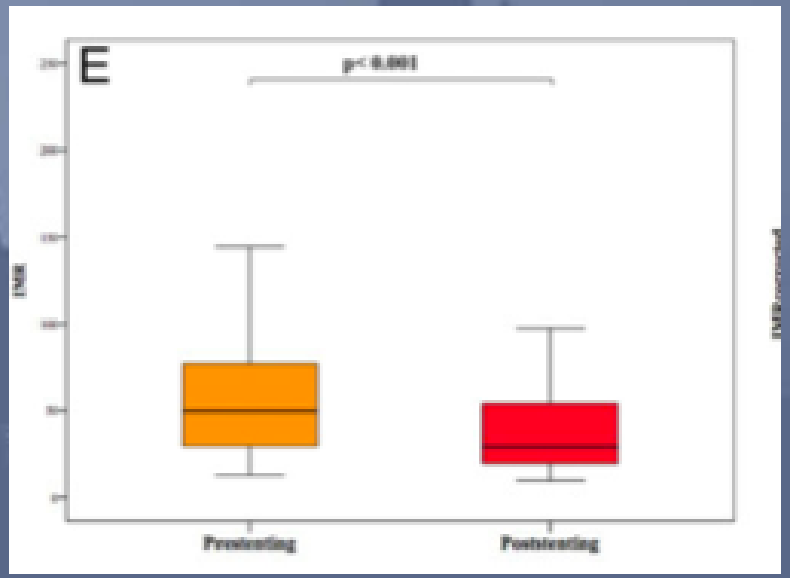
What is the impact of placing the stent in STEMI

How does coronary stent implantation impact on the status of the microcirculation during primary percutaneous coronary intervention in patients with ST-elevation myocardial infarction?

Giovanni Luigi De Maria[1], Florim Cuculi[1,2], Niket Patel[1], Sam Dawkins[1], Gregor Fahrni[1], George Kassimis[1], Robin P. Choudhury[3,4], John C. Forfar[1], Bernard D. Prendergast[1], Keith M. Channon[1], Rajesh K. Kharbanda[1†], and Adrian P. Banning[1*†]



FFR falls



IMR falls too

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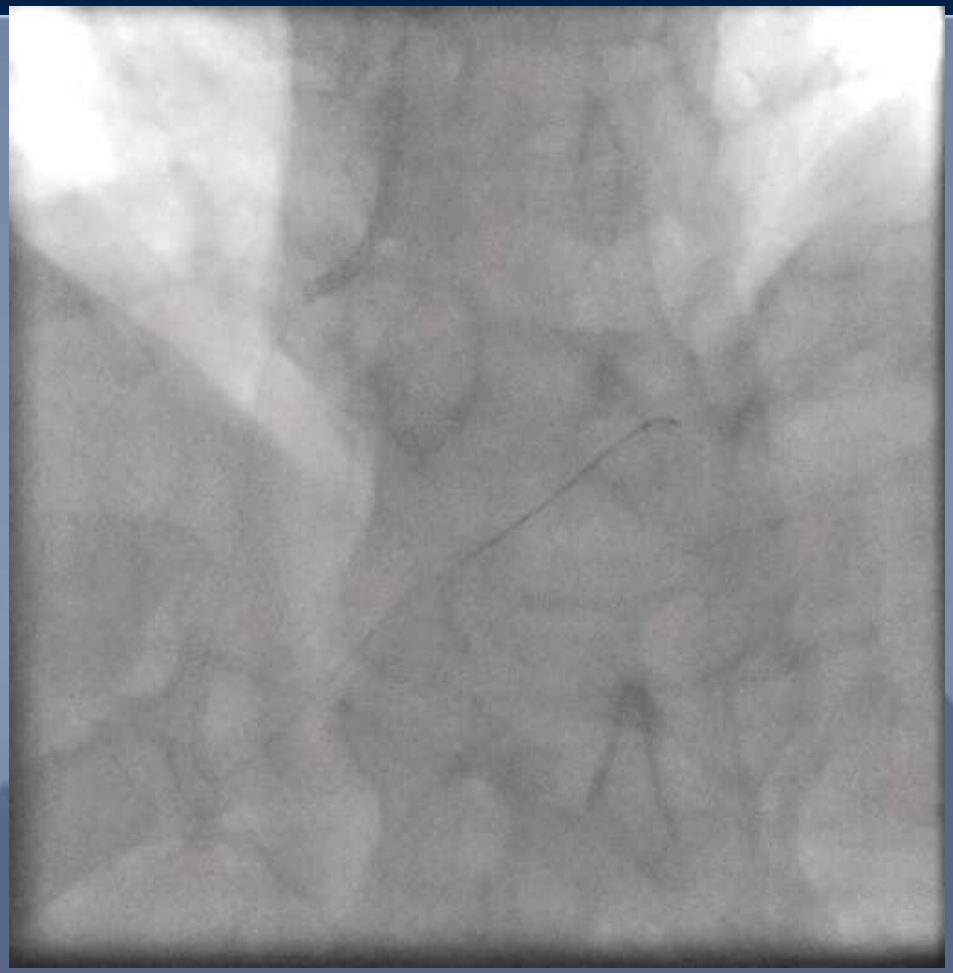
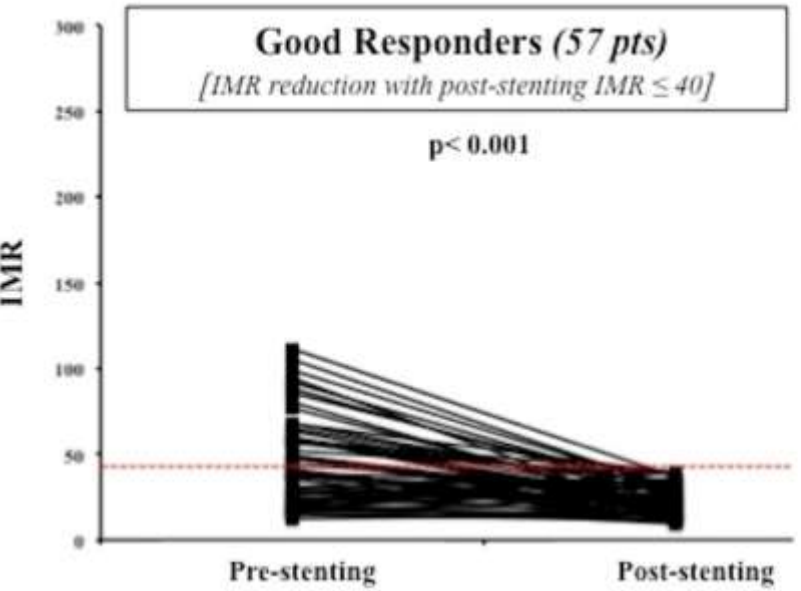
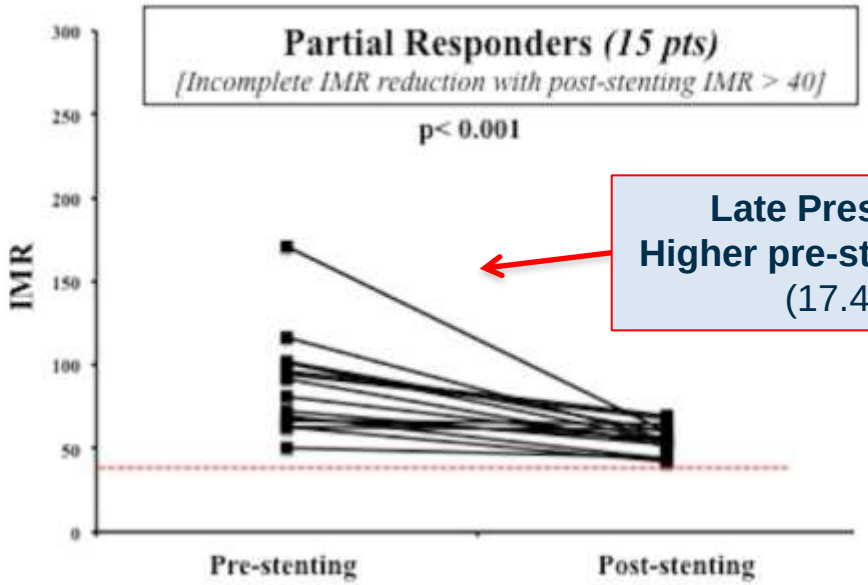
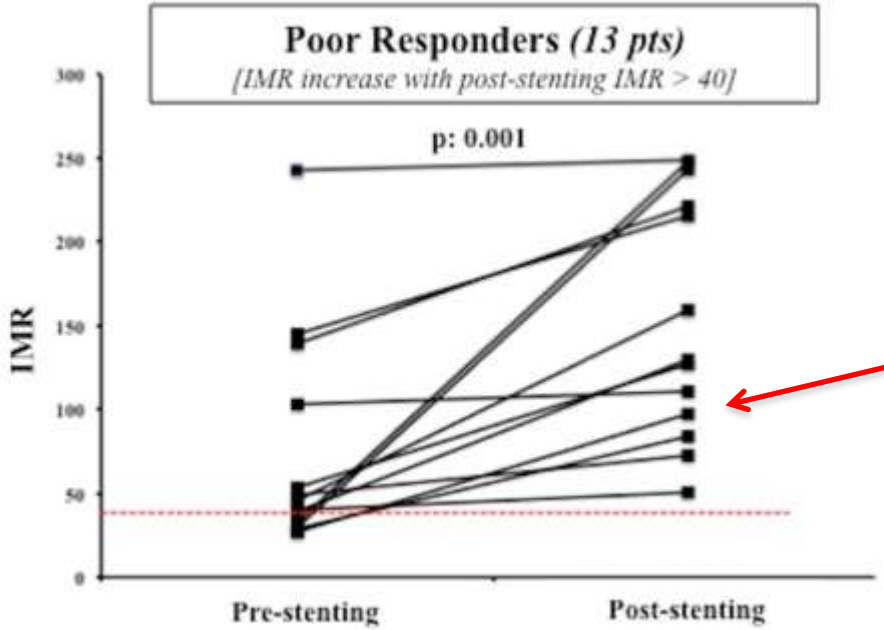
Why does outcome vary so much after stent implnatation in STEMI?









Late Presenters
Higher pre-stenting IMR
(17.4%)

33%

High thrombotic burden
(15.3%)

So in patients presenting with STEMI

60-65% will get reasonable perfusion & LV function with routine treatment including a stent

15-20% will still have limited improvement following (despite) stenting

10-15% Placement of a stent *worsens* perfusion and LV function

When can we predict the outcome in STEMI?

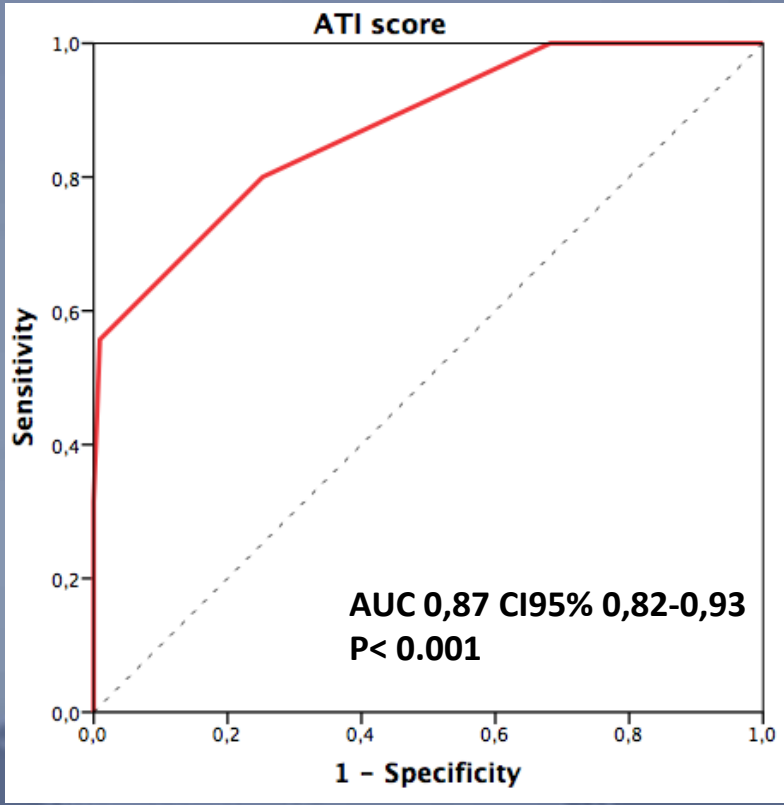
Table 4 Predictors of post-stenting index of microcirculatory resistance >40

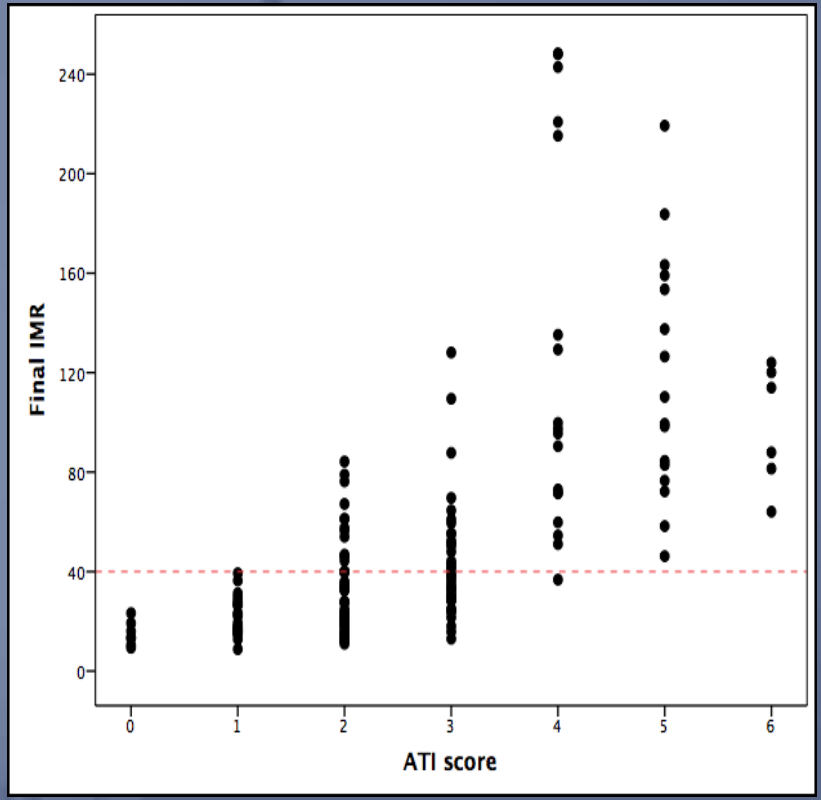
	Univariable analysis		Multivariable analysis	
	OR (95% CI)	*P*-values	OR (95% CI)	*P*-values
Age	1.05 (1.01–1.11)	**0.03**	1.04 (0.99–1.11)	0.13
Gender male	0.78 (0.22–2.76)	0.70	—	—
Diabetes	0.46 (0.17–1.25)	0.13	—	—
Hypertension	0.84 (0.34–2.07)	0.70	—	—
Pain to wire time	1.01 (1.01–1.03)	**0.05**	1.38 (0.64–2.96)	0.41
Culprit vessel (LAD vs. non-LAD)	1.11 (0.45–2.75)	0.82	—	—
BARI jeopardy score	0.96 (0.90–1.01)	0.14	—	—
TIMI flow 0 at presentation	1.78 (0.52–6.04)	0.36	—	—
MLD	1.02 (0.38–2.75)	0.97	—	—
DS%	0.99 (0.96–1.03)	0.71	—	—
Lesion length	0.98 (0.92–1.04)	0.45	—	—
Thrombus score	2.04 (1.12–3.71)	**0.02**	2.82 (1.35–5.88)	**0.006**
Thrombus aspiration	1.10 (0.34–3.54)	0.87	—	—
Stent volume	1.00 (0.99–1.01)	0.58	—	—
Postdilation	1.35 (0.5–3.61)	0.55	—	—
Upstream GPIIbIIIa inhibitors	0.54 (0.21–1.36)	0.19	—	—
Pre-stent IMR >40	1.03 (1.01–1.04)	**0.001**	1.03 (1.01–1.05)	**0.007**

BARI, Bypass Angioplasty Revascularization Investigation; DS%, percentage diameter stenosis; GPIIbIIIa, glycoprotein IIbIIIa; IMR, index of microcirculatory resistance; LAD, left anterior descending; MLD, minimal lumen diameter; OR, odds ratio; 95% CI, 95% confidence interval.

De Maria GL, Banning AP Eur Heart J 2015

When can we predict the outcome in STEMI?





	Strata
Age	≤ 50
	> 50
Thrombus Score	0-1-2-3
	4
	5
Pre-stent IMR	≤ 40
	40 - 100
	> 100

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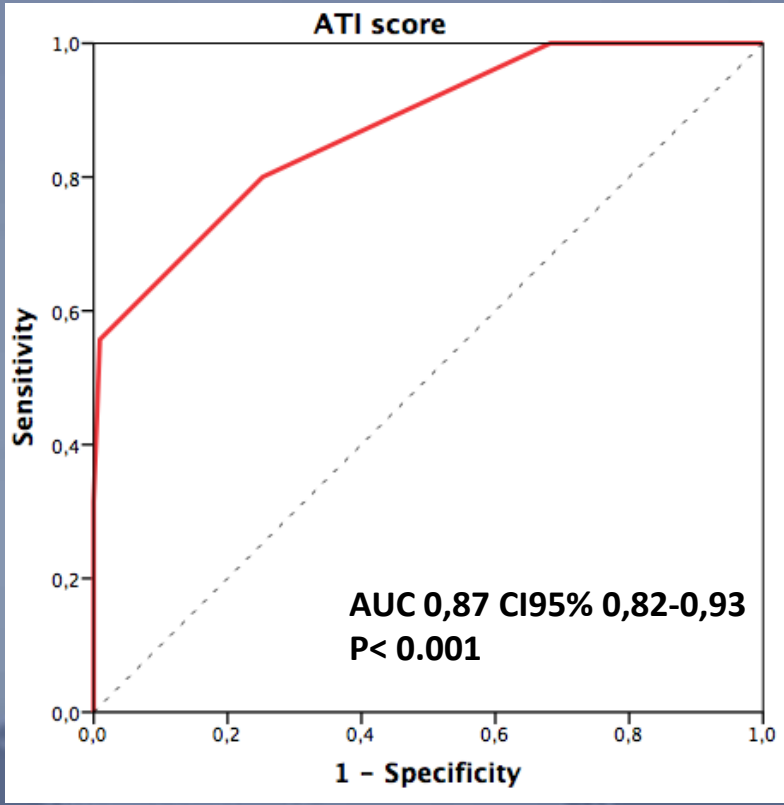
Use a score to tailor treatment?



	Strata
Age	≤ 50
	> 50
Thrombus Score	0-1-2-3
	4
	5
Pre-stent IMR	≤ 40
	40 - 100
	> 100

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FFR in STEMI - culprit

- Can probably be used "reliably" in infarcts with low IMR – the small ones
  - FFR <0.8 is reliable
- Is unreliable in larger infarcts especially those with oedema which may recover
  - FFR will fall towards treatment zone
- IMR measurement in AMI has potential to give insights into pathophysiology and may have a role in triaging additional therapy

Acknowlegements/thanks

- Dr SJ Park and the organizing committee
- Fellows /Consultant colleagues -@ Oxford and Cath lab teams
- Audience

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