Practical Aspect of IMR in AMI and Stable Angina

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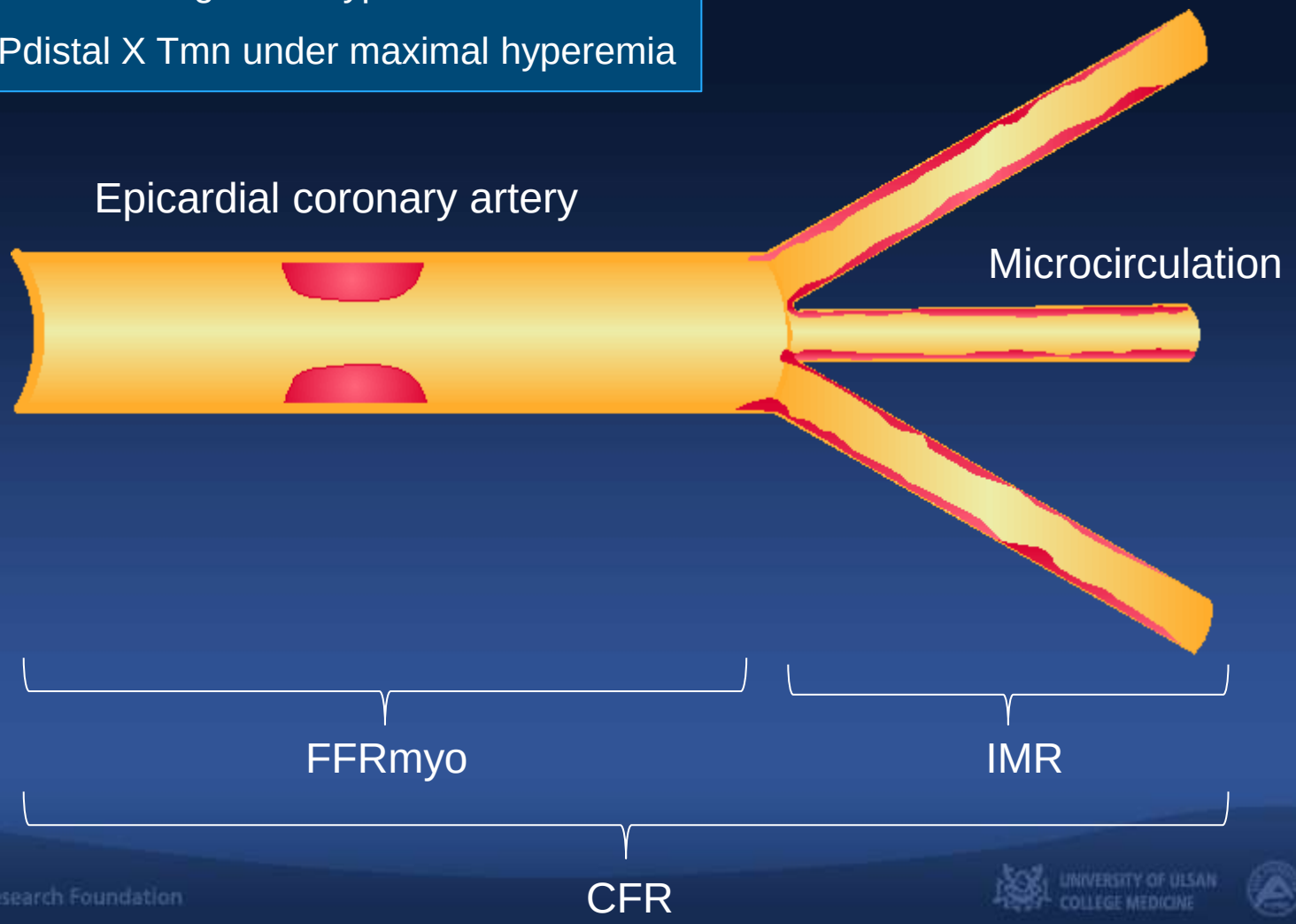
Comprehensive Physiologic Evaluation

FFR: Pd/Pa under maximal hypermia

CFR: Tmm resting/Tmm hyperemia

IMR: Pdistal X Tmn under maximal hyperemia



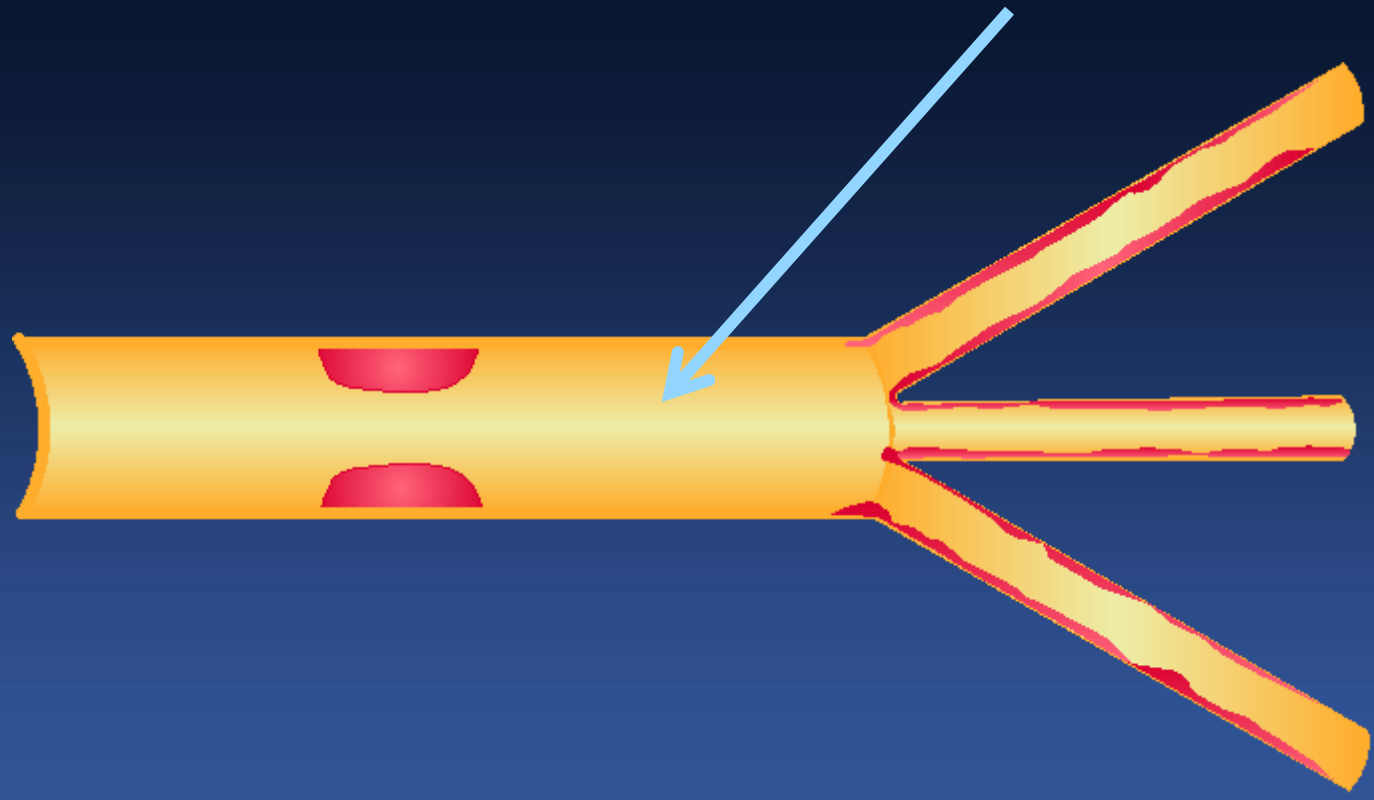
Invasive Assessment of Microcirculation

	Specific to microcirculation	Hemodynamic independence	Reproducibility	Quantitative data	Availability
TIMI myocarial perfusion grade	-	-	+/-	-	++
TIMI Frame count	-	-	+	+	++
Myocardial blush	+/-	-	+/-	-	+
CFR	-	-	+/-	++	+/-
IMR	++	++	++	++	+/-

Martinez et al. Coronary Artery Disease 2015:26:e15-e26

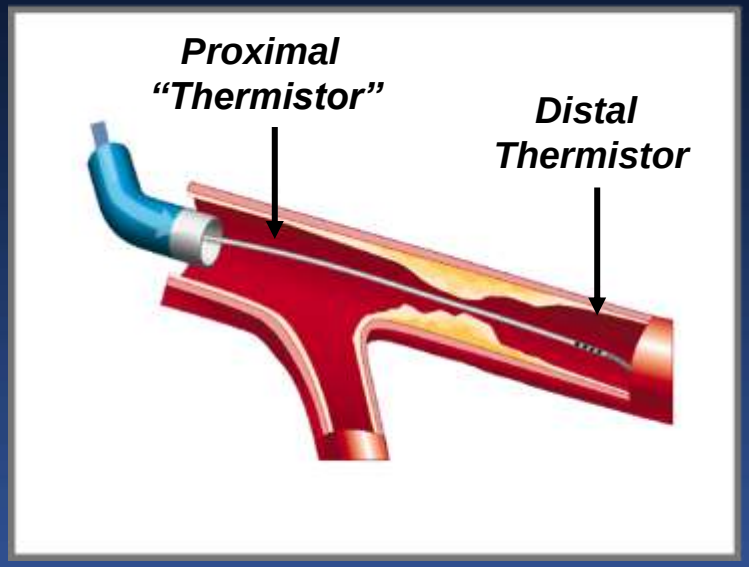
Ohm's Law

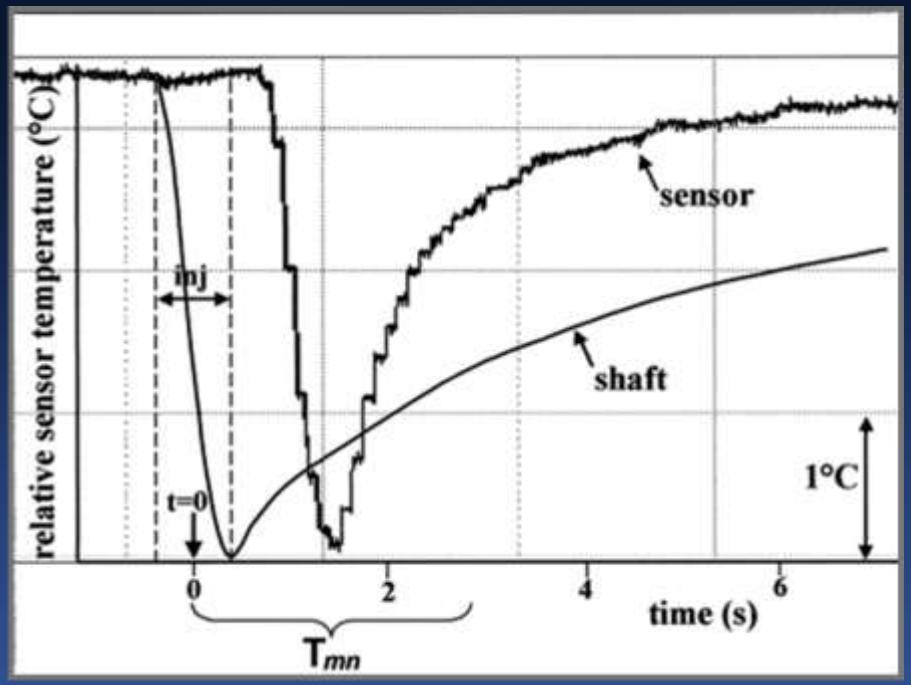
(Myocardial) Resistance = Pressure / Flow



Coronary Flow Assessment
Mean Transit Time by Thermodilution

Inject 3cc saline
(Room Temperature)



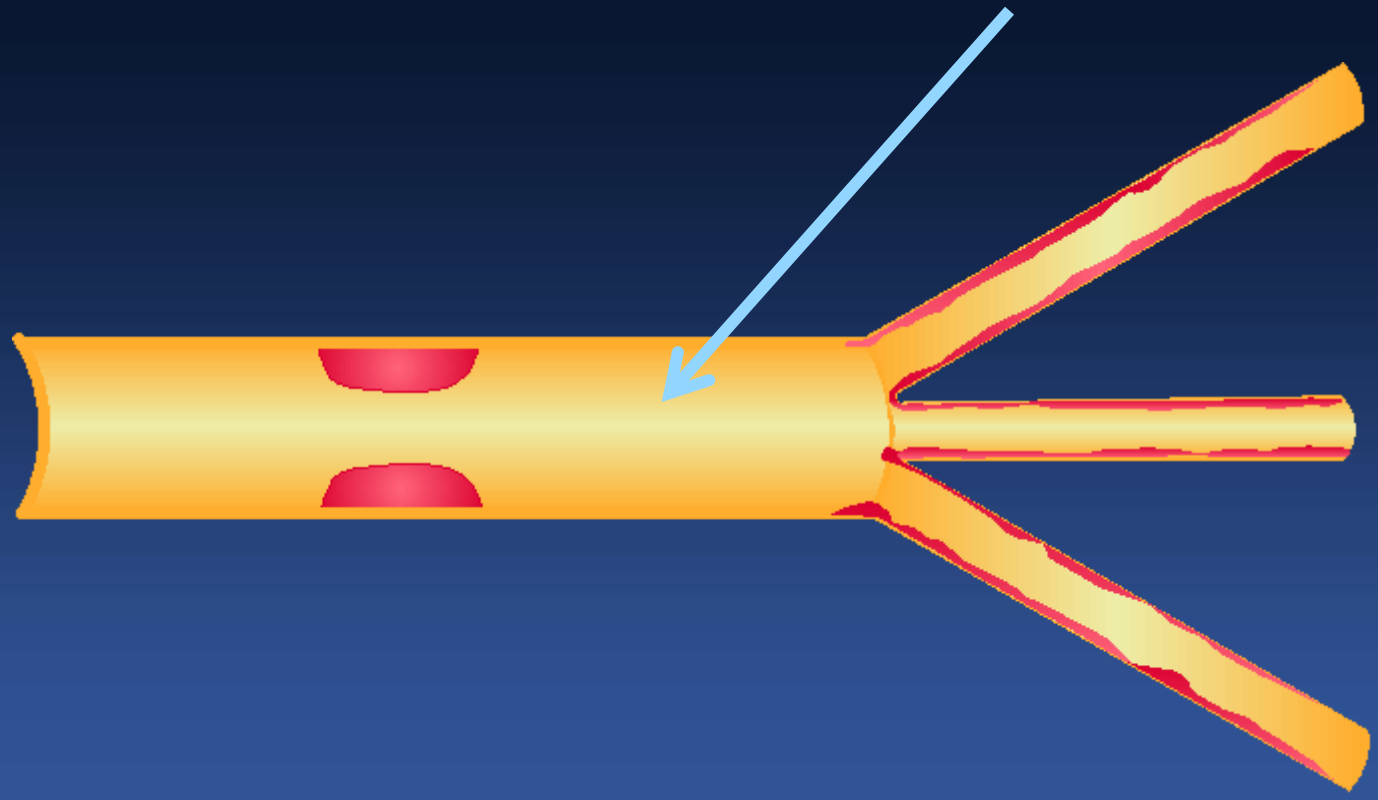


If flow increase, Tmn decrease
If flow decrease, Tmn increase

Flow ≅ 1/Tmn

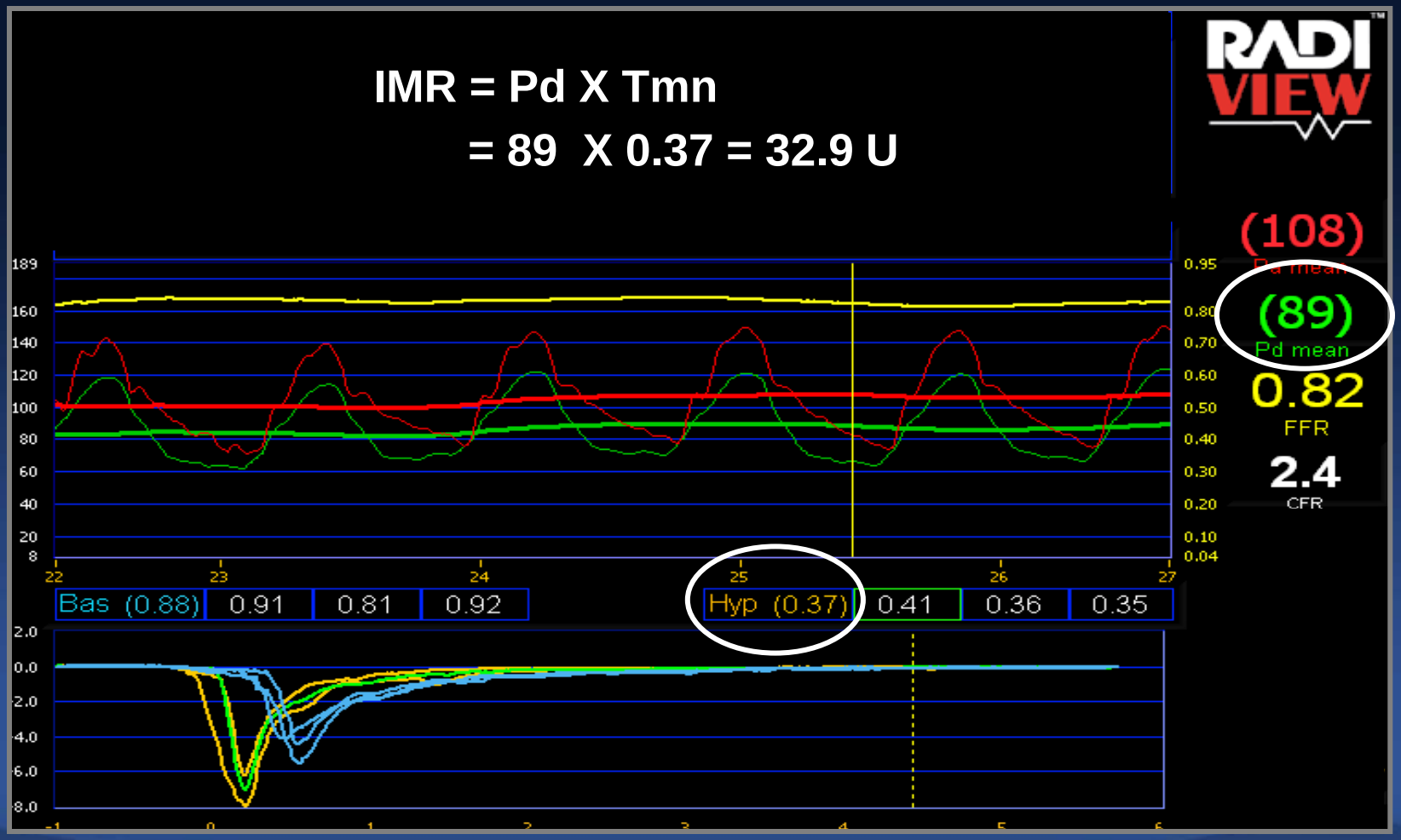
Ohm's Law

(Myocardial) Resistance = Pressure / Flow



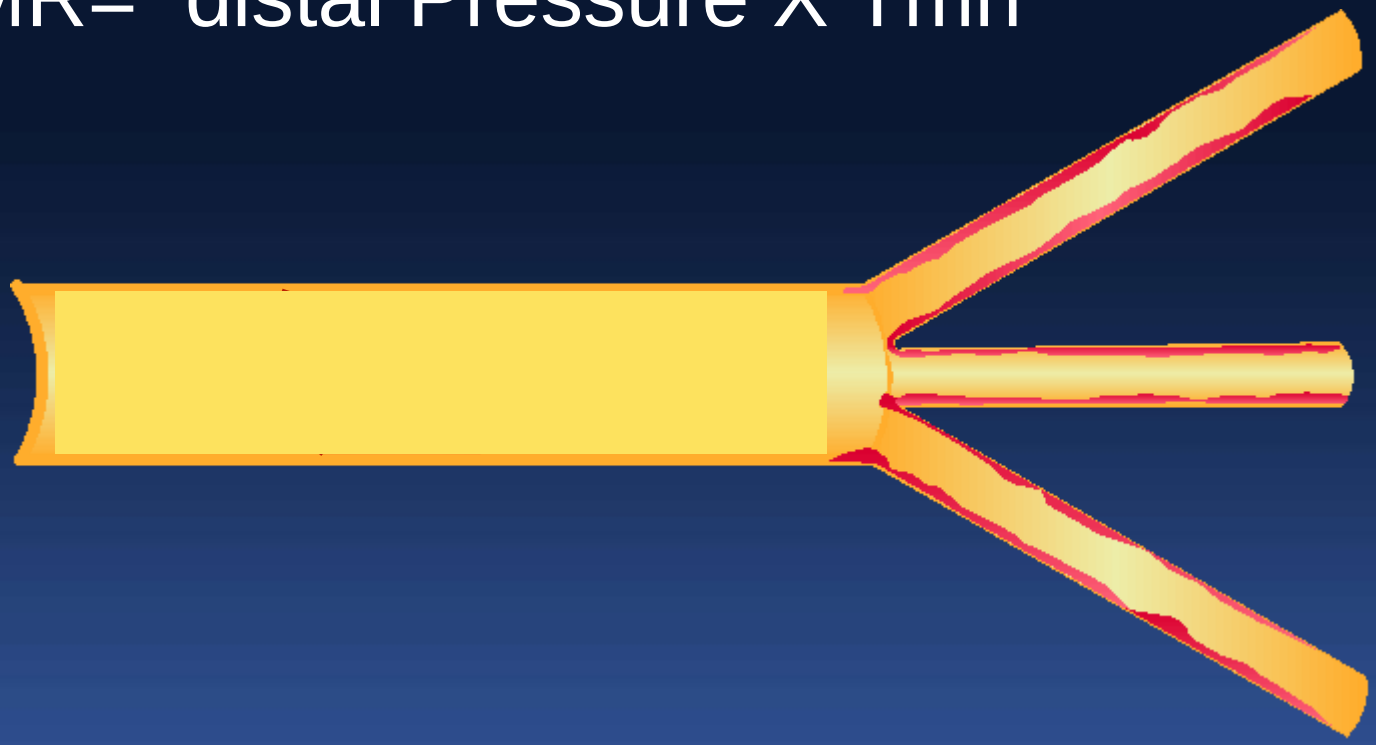
- IMR = Distal Pressure / (1 / T_{mn}) = Distal Pressure x T_{mn}

IMR =Distal Pressure / (1 / Tmn)= Distal Pressure x T_{mn}



Epicardial Stenosis with Collateral Circulation

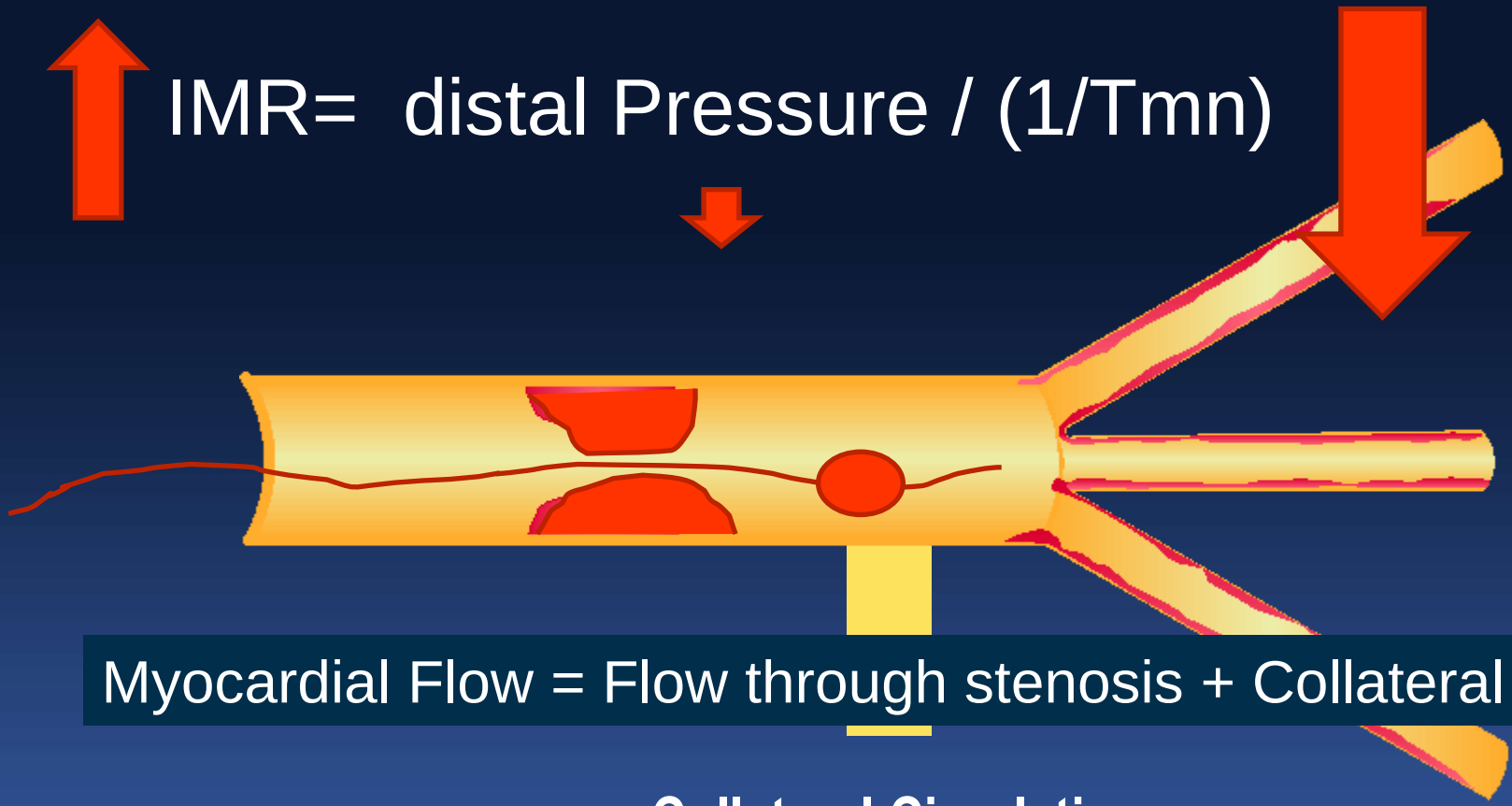
IMR= distal Pressure X Tmn



Young et al. J Am Coll Cardiol Intv 20103;6:53–8

Epicardial Stenosis with Collateral Circulation

IMR= distal Pressure / (1/Tmn)



Myocardial Flow = Flow through stenosis + Collateral flow

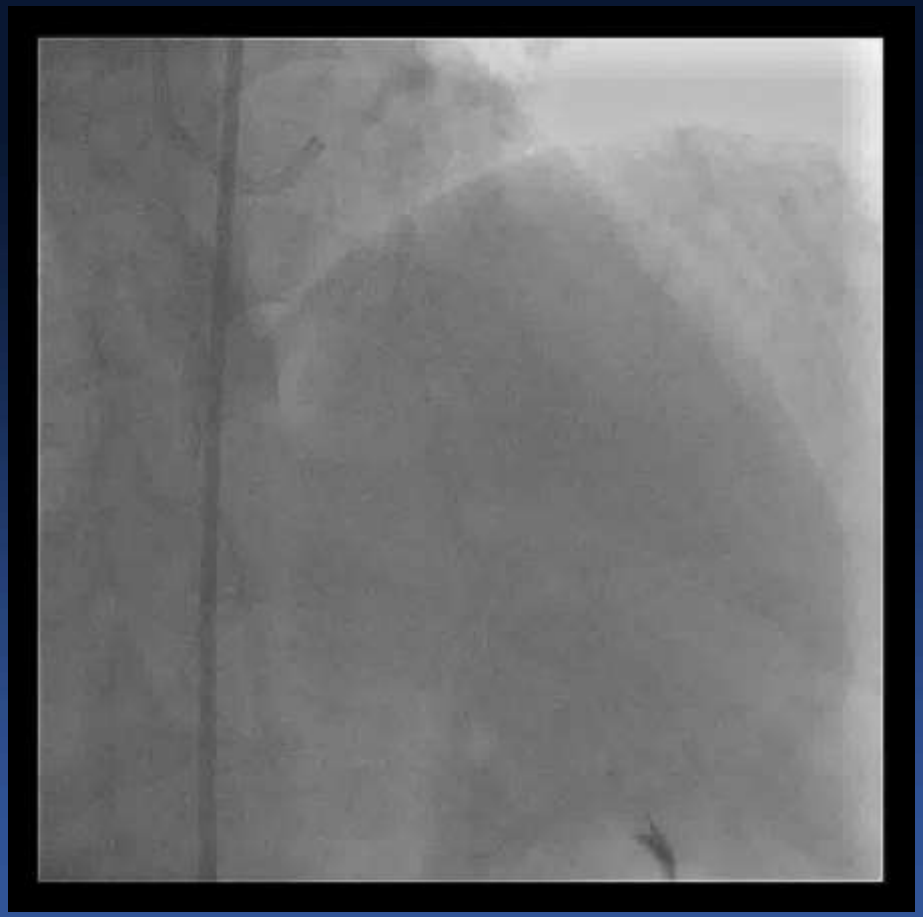
Collateral Circulation

1. Pd x Tmn x (Pd - Pw)/(Pa - Pw)
2. Pd x Tmn x ([1.35 x Pd/Pa-0.32)

Young et al. J Am Coll Cardiol Intv 20103;6:53–8

No Reflow or Slow Flow After PPCI

Only 35 % had Optimal Reperfusion (TIMI3, MBG2/3, and STR>70%)



J Am Coll Cardiol 2009; 54:281–292

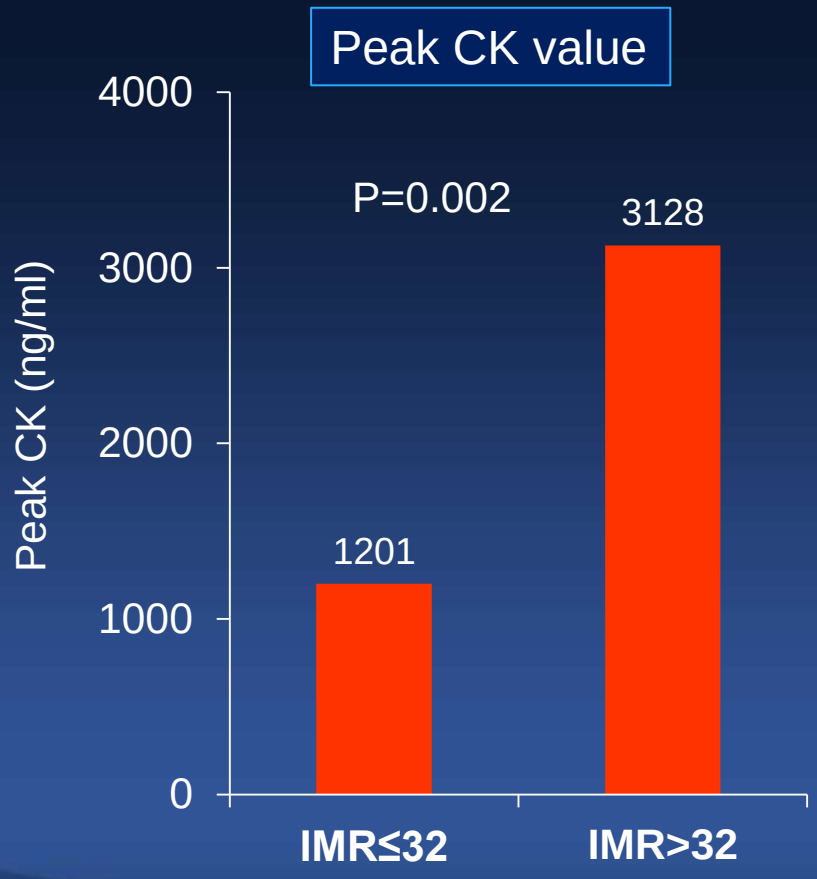
Clinical Value of IMR in STEMI

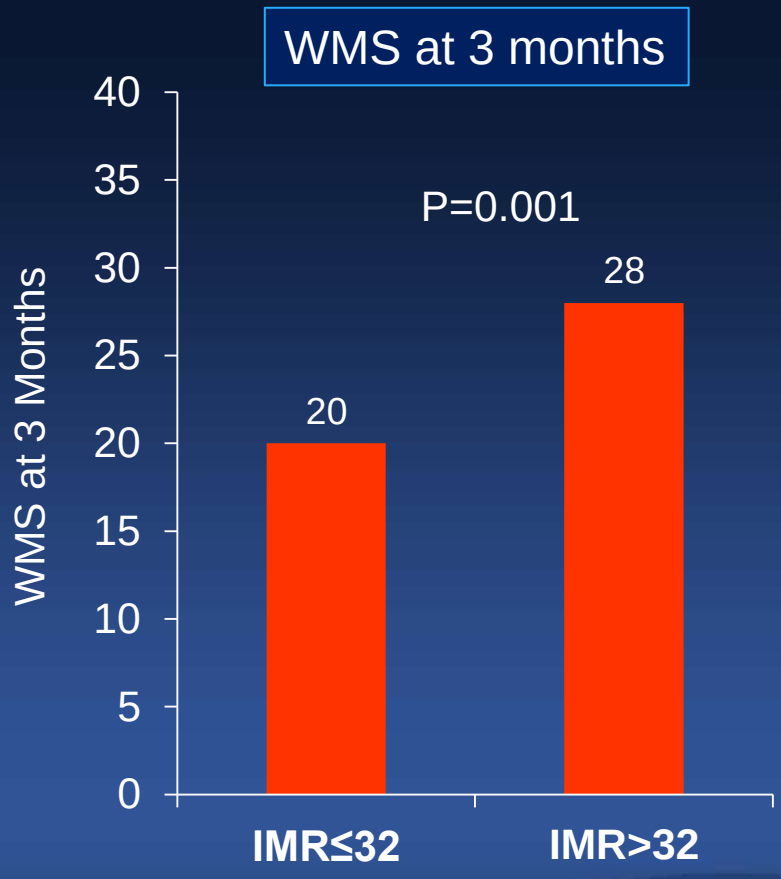
	Number	Main findings	IMR cut-off
Fearon et al	29	IMR correlates with infarct size and less ventricular function recovery at 3 months	IMR >32
Lim et al	40	IMR predicts myocardial viability and 6-month left ventricular recovery	IMR >33
McGoech et al	57	IMR independently predicts left ventricular function and infarct size	IMR 38
Payne et al.	108	IMR inversely correlates with myocardial salvage and predicts microvascular obstruction and myocardial hemorrhage	-
Sezer et al	41	Intracoronary streptokinase improves IMR measured 48 h after a STEMI	IMR 16.26 vs. 32.49
Sezer et al	35	IMR improvement 5 months after STEMI is associated with reduced infarct size and ventricular dimensions	Improvement of 33% at 5 months compared with immediately after STEMI
Fearon et al	253	IMR predicts death and rehospitalization at 12 months	IMR >40

Martinez et al. Coronary Artery Disease 2015:26:e15-e26

Infarct Size

IMR was the strongest predictor of peak CK and 3-month WMS

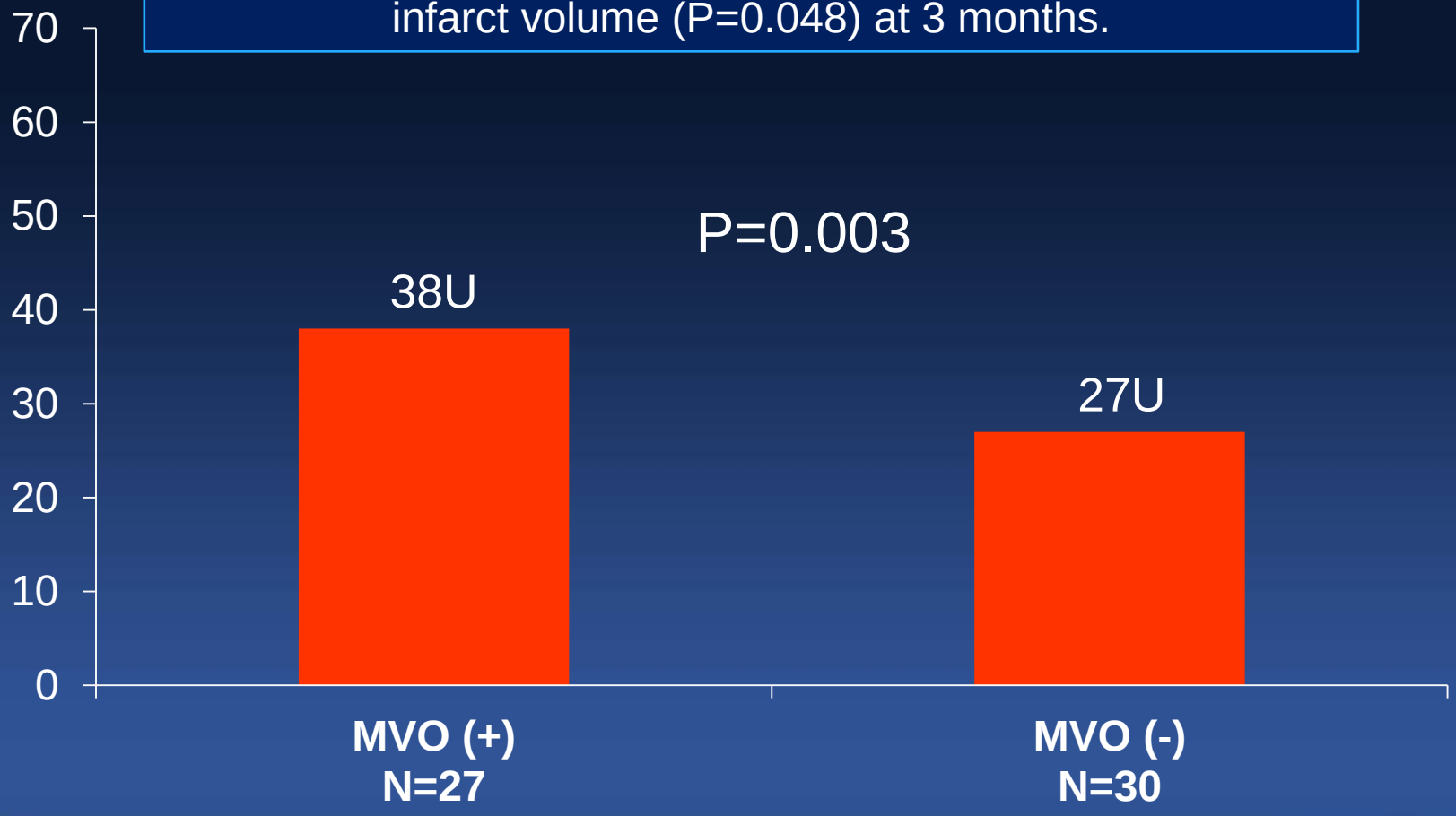




Fearon et al. J Am Coll Cardiol 2008;51:560–5

Microvascular Obstruction by MRI

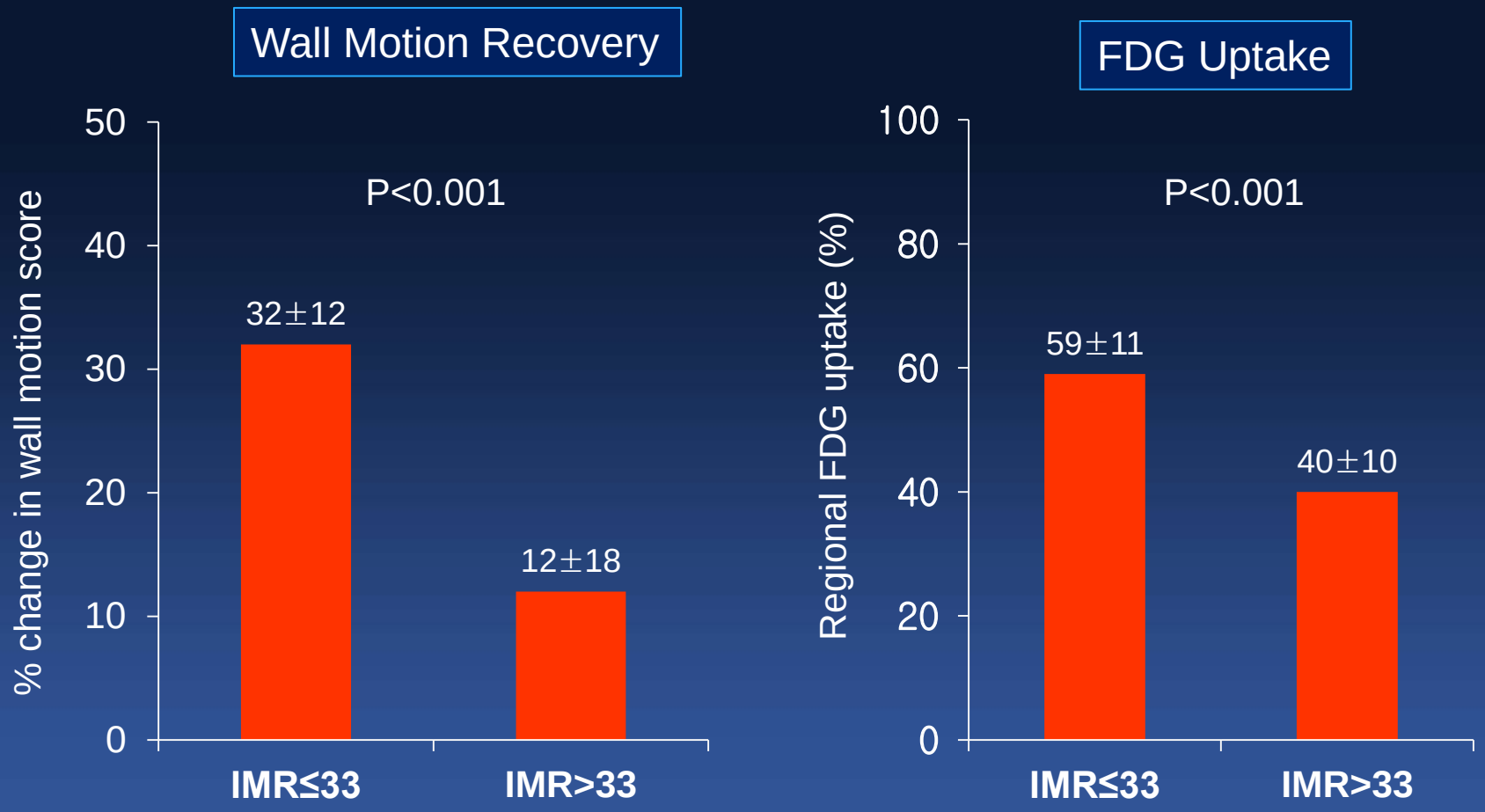
IMR was a multivariable predictor of LV EF (P=0.028) and infarct volume (P=0.048) at 3 months.



McGeoch et al. J Am Coll Cardiol Intv 2010;3:715–22

Myocardial Viability

The ACU of IMR for predicting LV function recovery was 0.89



Lim HS et al. European Heart Journal (2009) 30, 2854–2860

Determinant of IMR

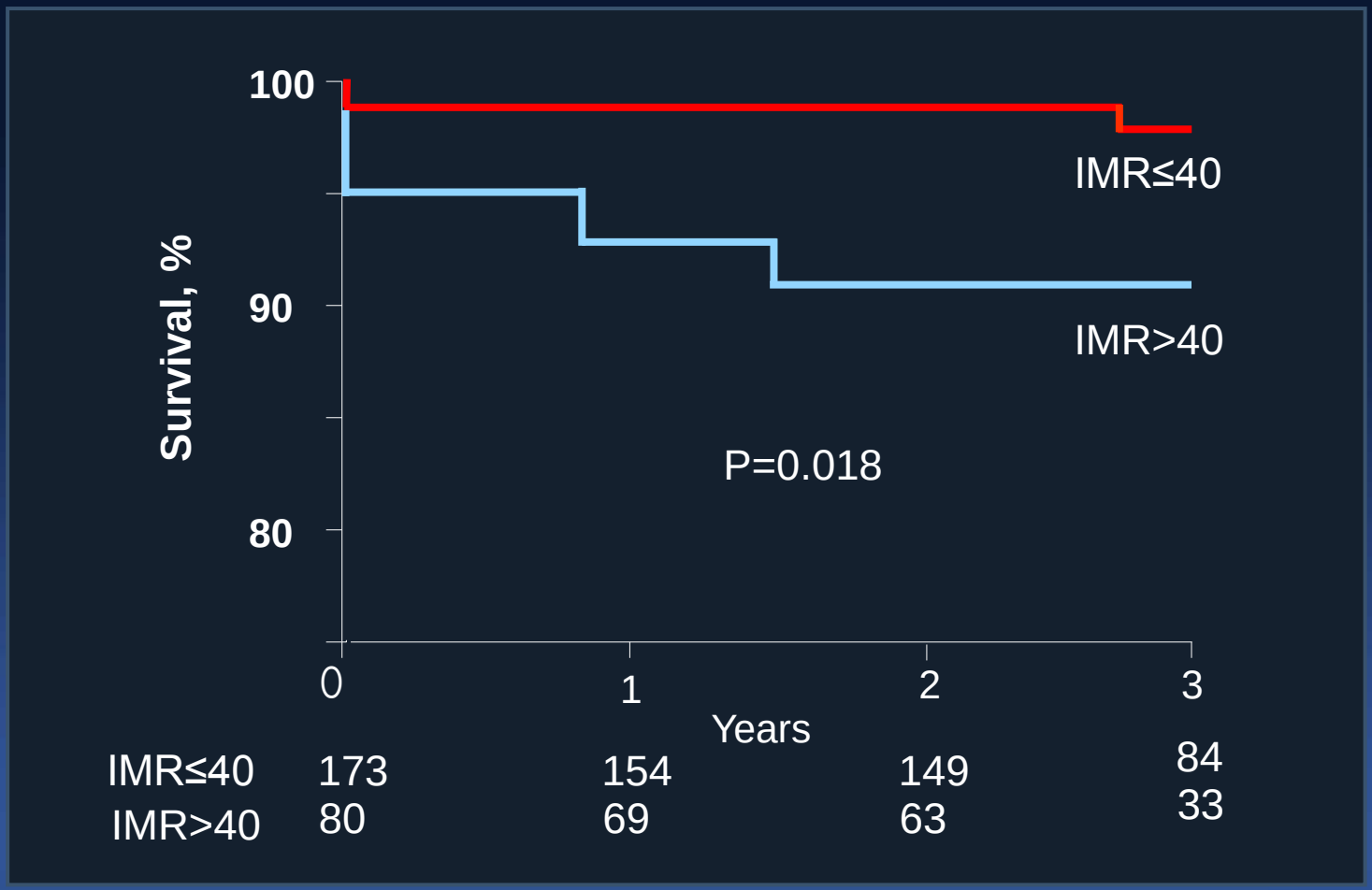
In 108 patients with ST-elevation myocardial infarction after primary PCI

Multivariable Associations with a 20% Increased in IMR at 2 days			
Area at risk, %	0.98	0.33 to 1.64	0.004
Infarct size, %	1.68	1.01 to 2.34	<0.001
Myocardial salvage index, %	-3.43	-4.86 to -2.00	<0.001
MVO, %	0.21	0.02 to 0.40	0.028
Hemorrhage, %	0.19	0.08 to 0.31	0.002
LVEF,%	-0.64	-1.16 to -0.12	0.017

Payne et al. J Am Heart Assoc. 2012;1:e002246

Survival After Primary PCI

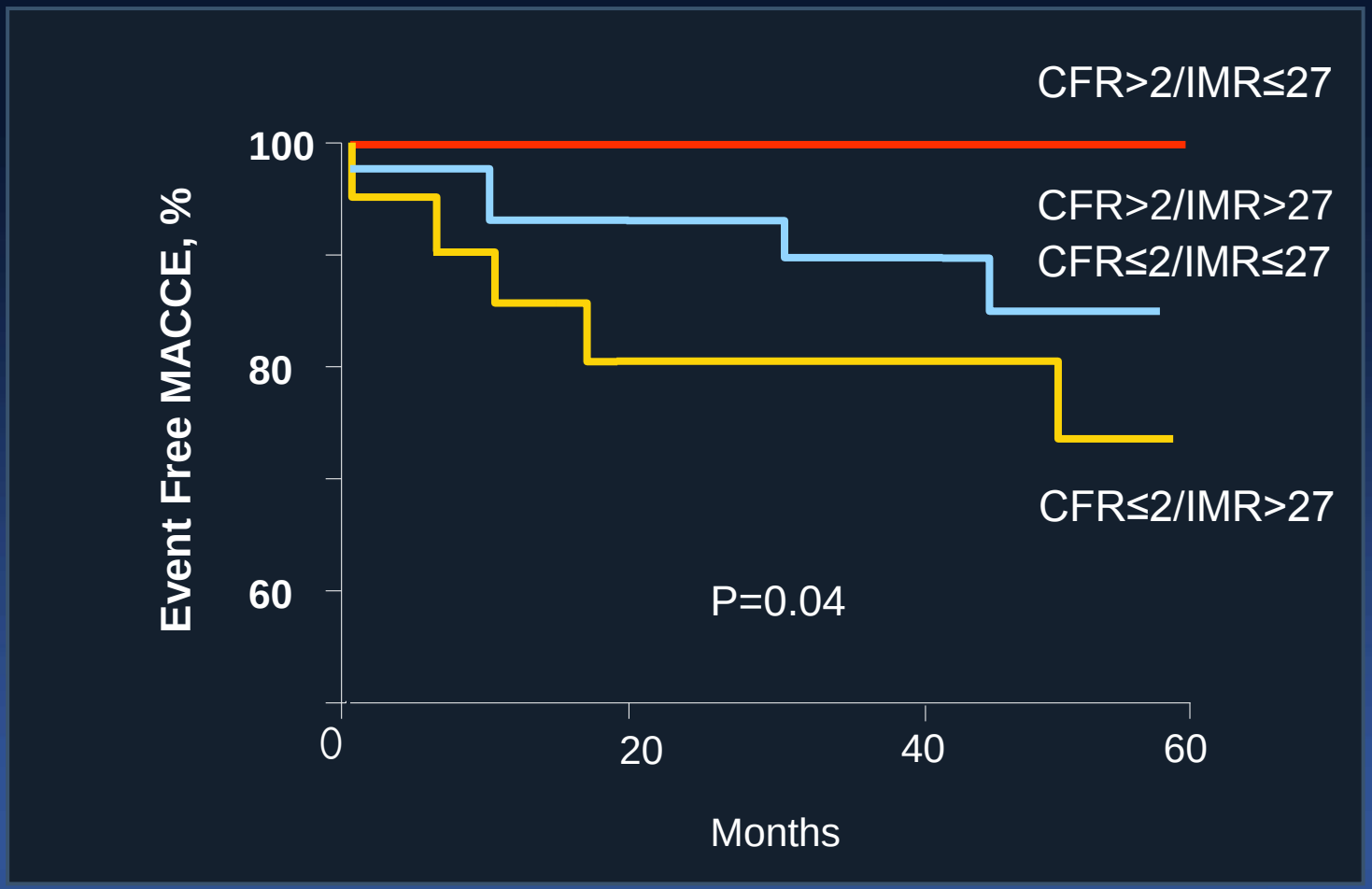
An IMR >40 was the only independent predictor of death alone (HR, 4.3; P=0.02)



Fearon et al Circulation. 2013;127:2436-2441

MACCE After Primary PCI

CV death, TVR, Heart Failure, and Stroke

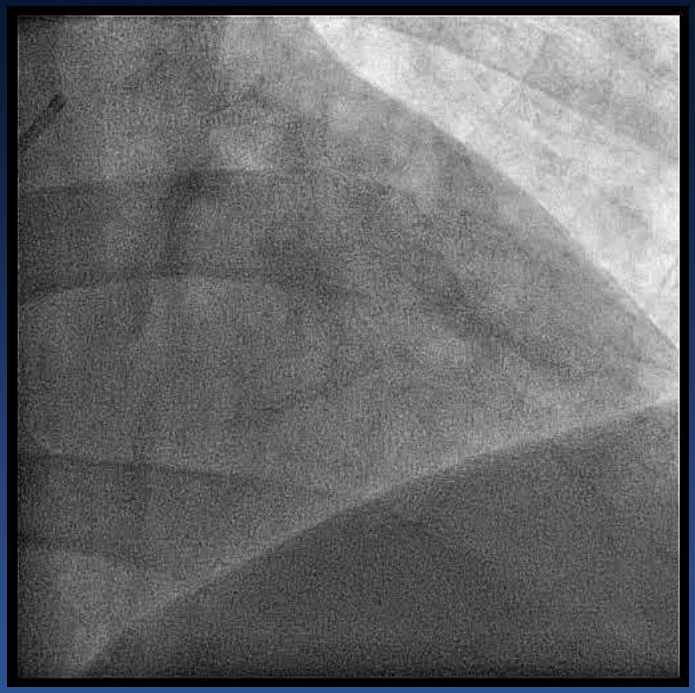


Park SD et al Coronary Artery Disease 2016, 27:34–39

Chest Pain and Normal CAG

Mystery, Hysteri or Reality

52 year-old woman complained effort-related chest pain



Coronary microvascular reactivity to adenosine significantly improves prediction of major adverse outcomes

WISE study. J Am Coll Cardiol. 2010 Jun 22;55(25):2825-32

Normal IMR Value

An ***IMR≤25*** is considered normal

Authors	Clinical Setting	Number	Median (or Mean)
Melikian et al.	Control group	15	19±5
Luo et al.	Control group	18	18.9±5.6
Solberg et al.	Normal person	20	12.6 (95% 7.3-27.2)
Lee JM et al.	Non-MI	1452	16.6 (12.4, 23.0)
Lee JM et al.	Non-MI	663	15.7 (12.0, 21.6)
Park SD et al.	Intermediate LAD	67	24±10

Eurointervention 2010;5:939-945

Circ Cardiovasc Interv. 2014;7:43-48

EuroIntervention. 2014:22;9(9)

Circ Cardiovasc Interv. 2015;8:e002857

J Am Coll Cardiol 2016;67:1158–69

Intern Med 55: 97-103, 2016

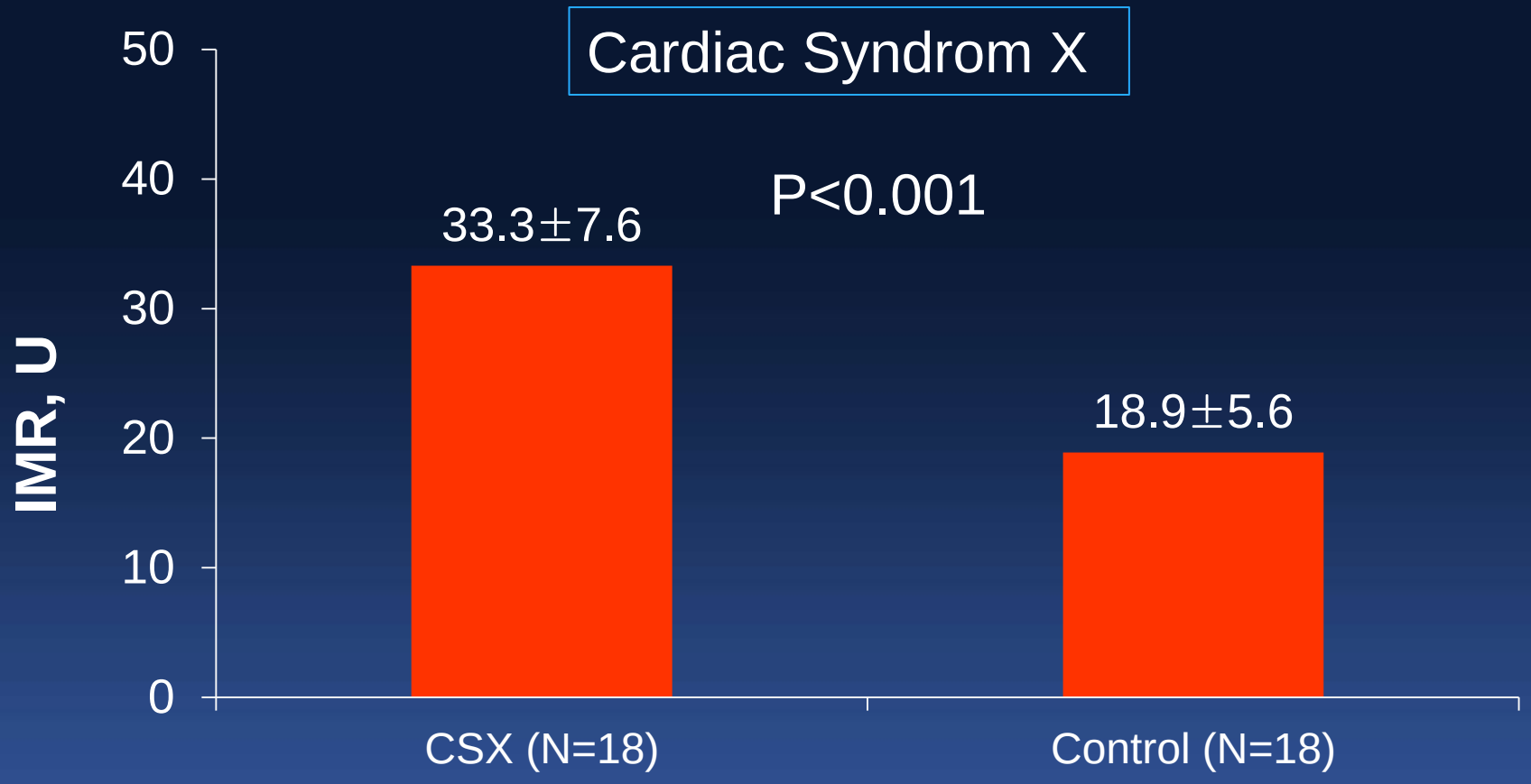
Independent Predictors for High IMR

International IMR Registry
(1096 non-MI patients)

Variables	OR	95% CI	P value
Previous MI	2.16	1.24-3.74	0.01
RCA	2.09	1.54-2.84	<0.01
Female	1.67	1.18-2.38	<0.01
Obesity	1.80	1.31-2.49	<0.01

Circ Cardiovasc Interv. 2015;8:e002857

Chest Pain with Normal CAG

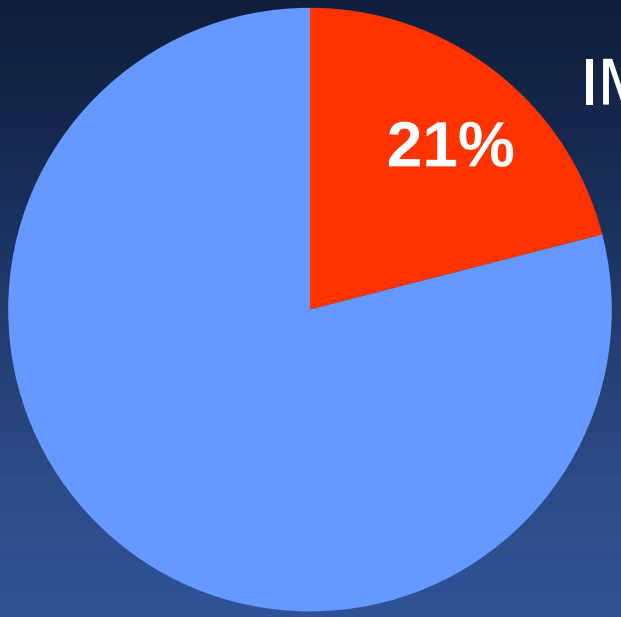


The Duke treadmill score was correlated to negatively to index of microvascular resistance (r=−0.742; P<0.001) in patients with CSX

Luo et al. Circ Cardiovasc Interv. 2014;7:43-48

Chest Pain with Normal CAG

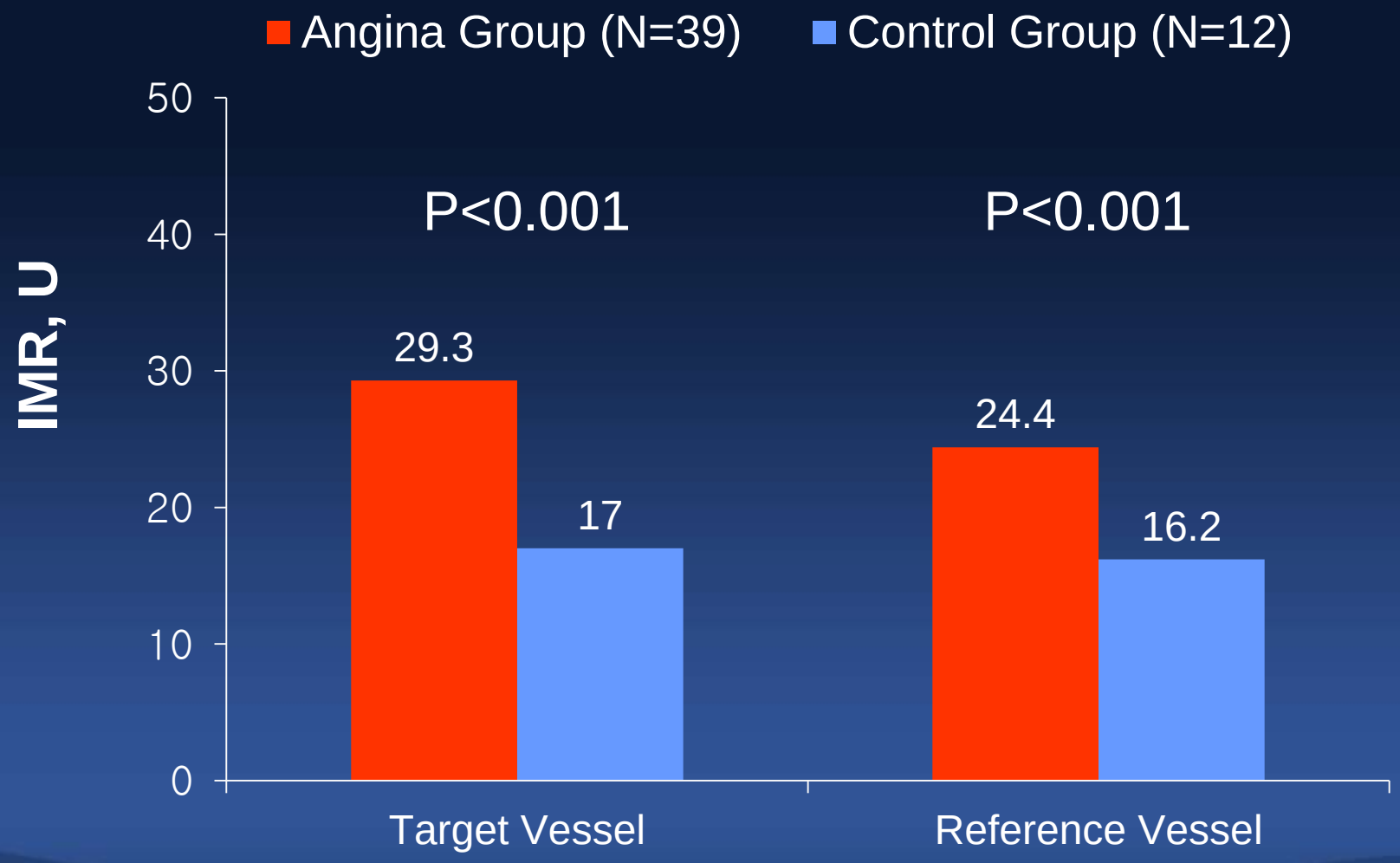
A total of 139 patients with chest pain and ‘Normal CAG”



Age
DM
HTN
BMI

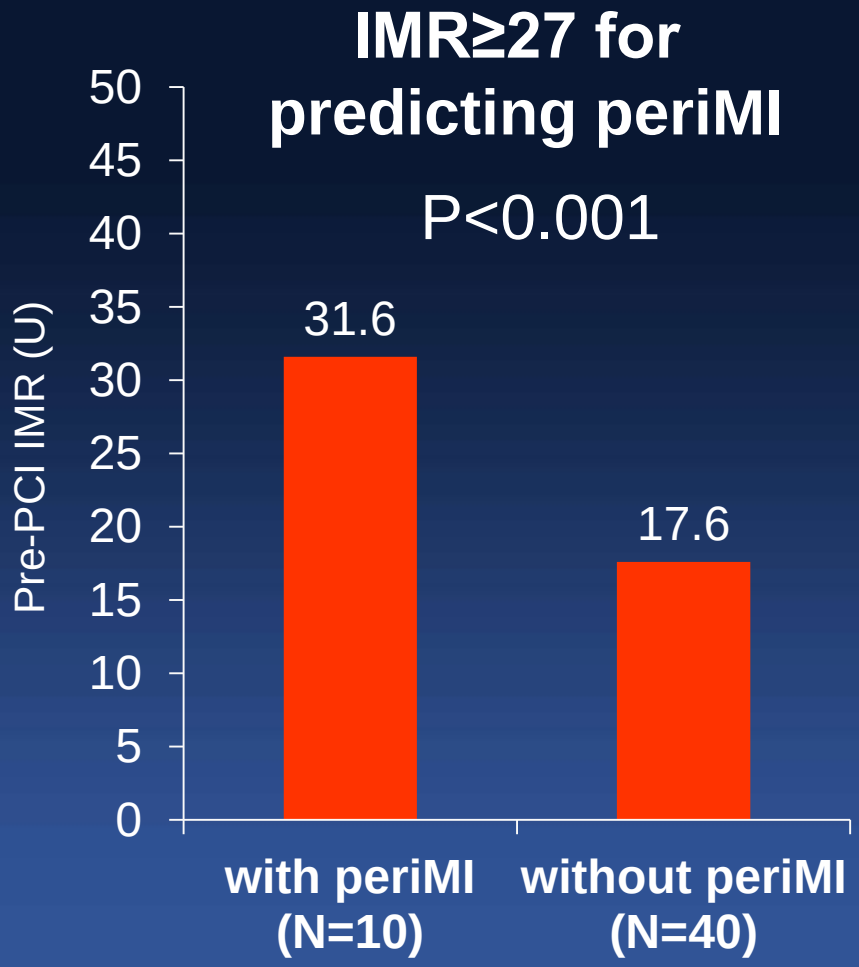
Lee BK etal. Circulation. 2015 Mar 24;131(12):1054-60

Chest Pain After PCI

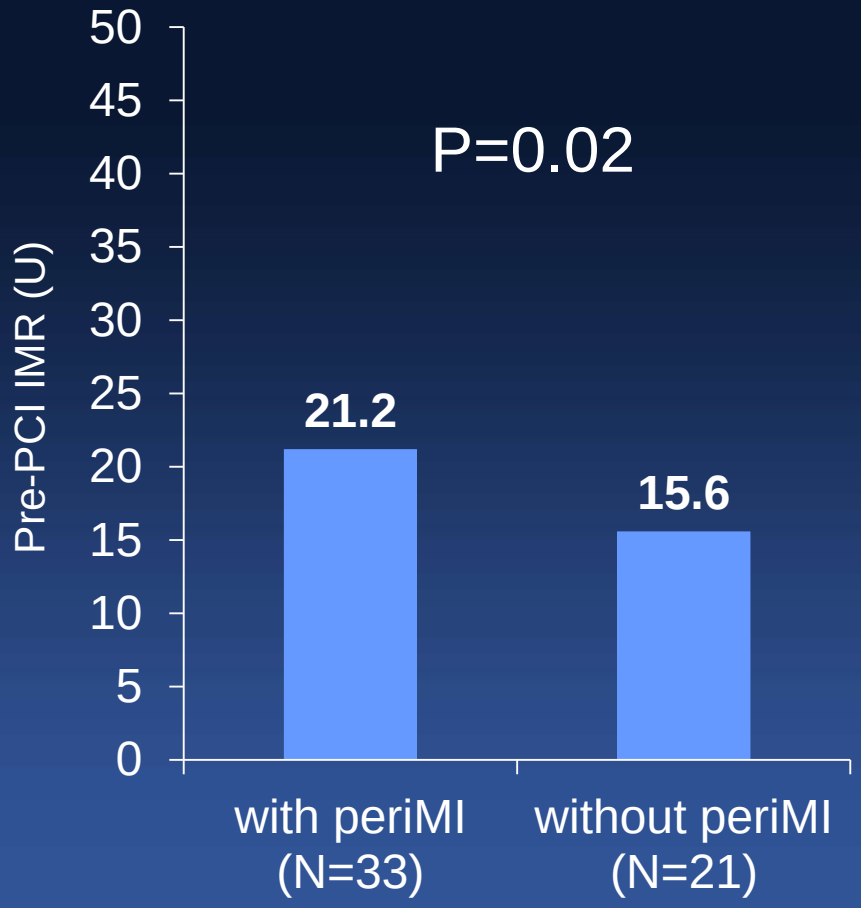


Li et al. Canadian Journal of Cardiology 31 (2015) 989-997

Prediction of Peri-Procedural MI



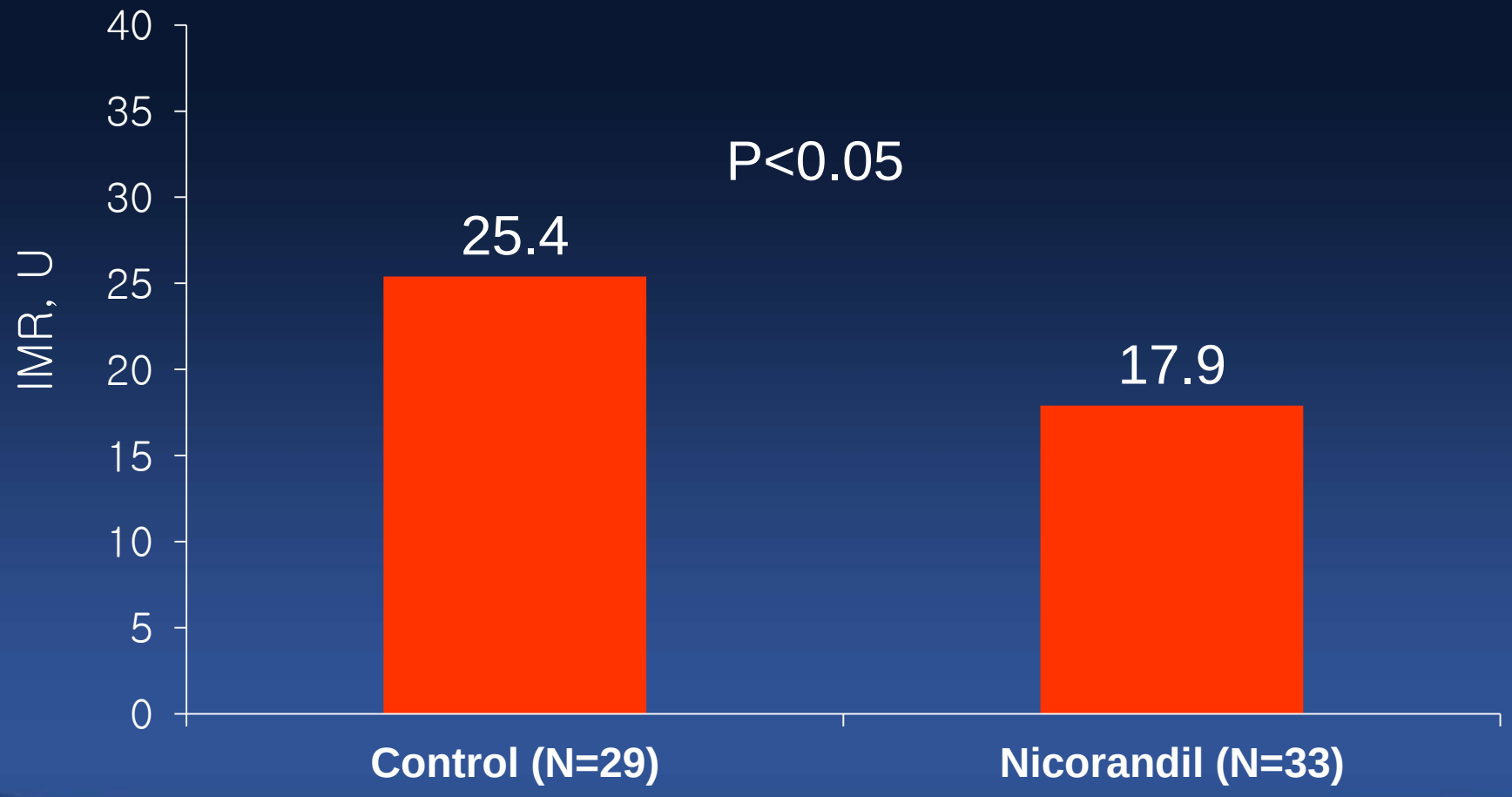
Circ Cardiovasc Interv 2012;5:515–522



Heart 2012; 98:1492–1497

Drug-Effect Monitoring (1)

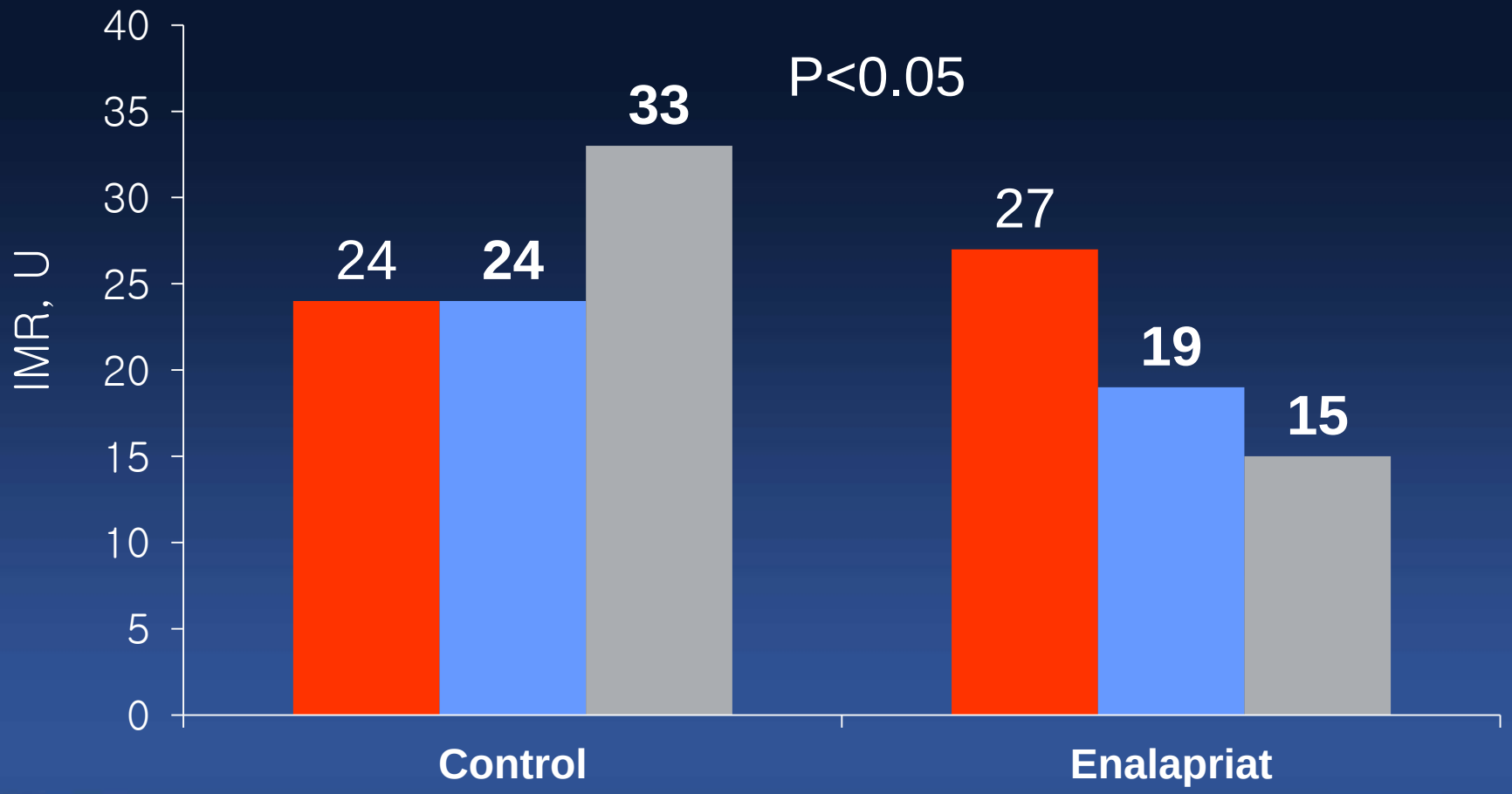
Nicorandil for Preventing PCI Induced MV injury



Hirohata et al. EuroIntervention 2014; 1050-1056

Drug-Effect Monitoring (2)

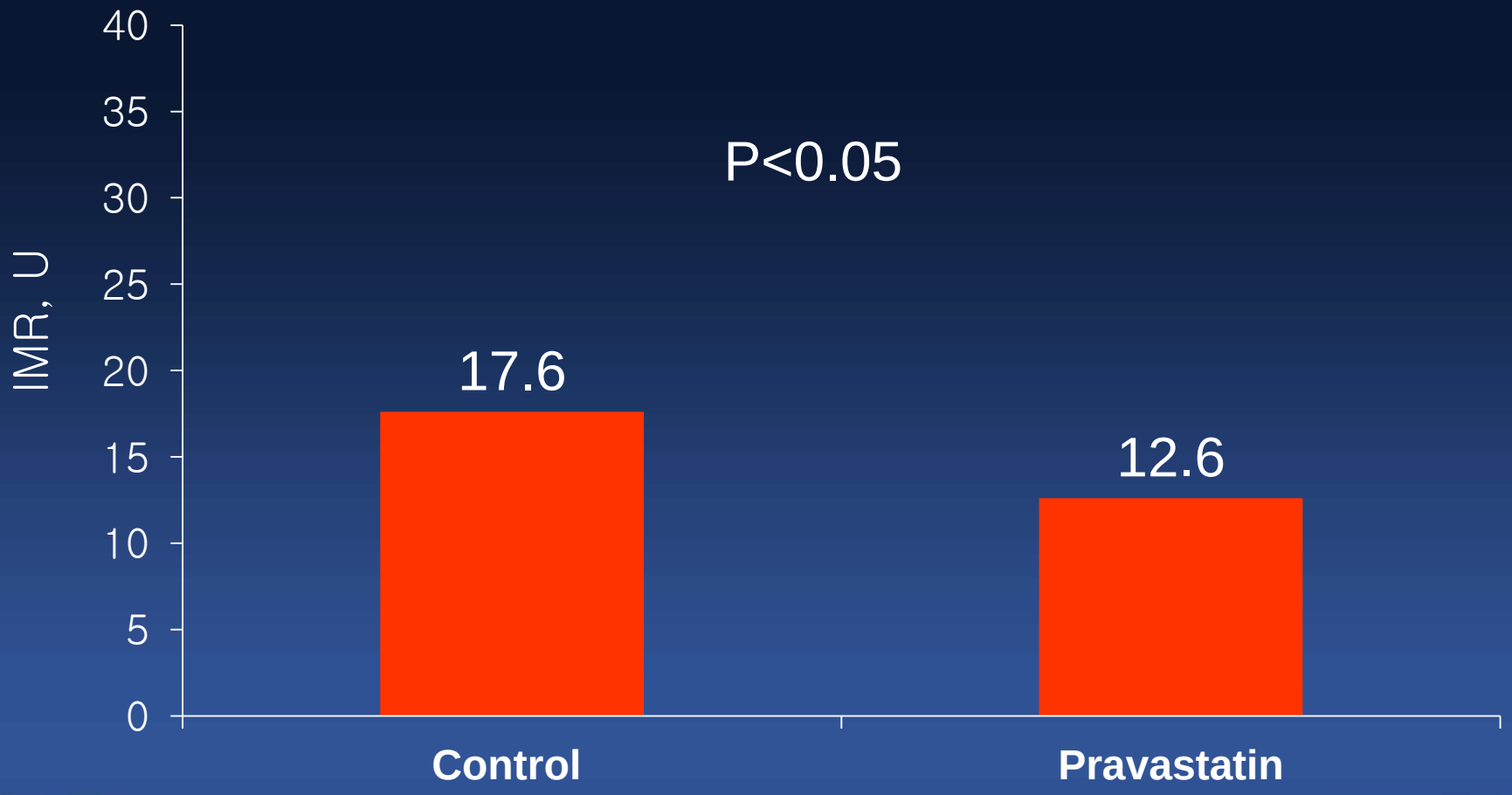
Enalaprilat for Preventing PCI Induced MV injury



Mangiacapra F et al. J Am Coll Cardiol 2013;61:615-621

Drug-Effect Monitoring (3)

Pravastatin for Preventing PCI Induced MV injury

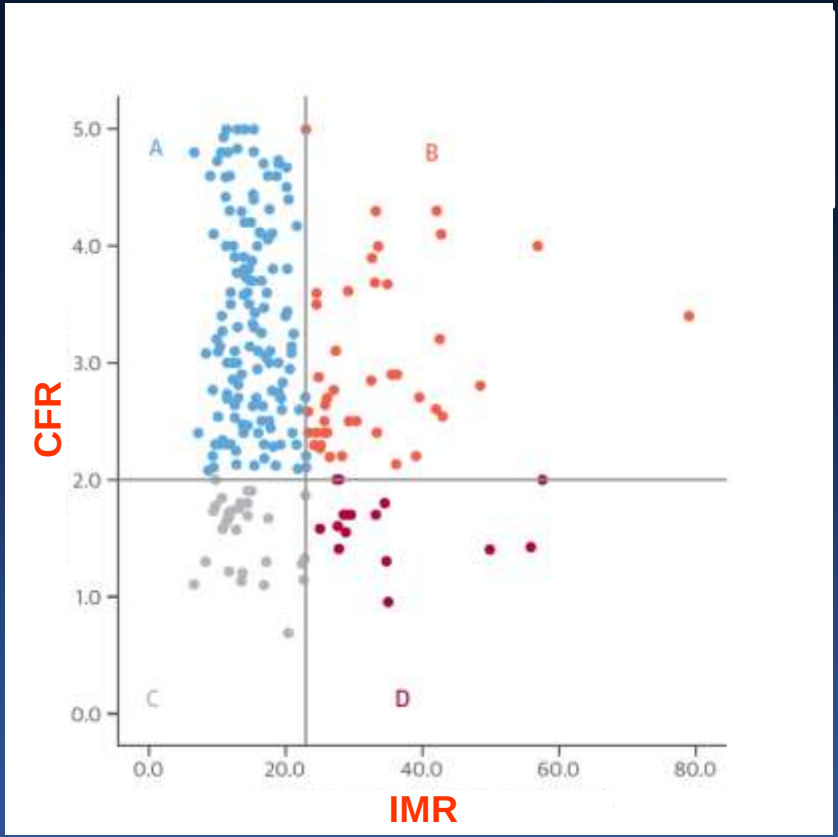


Fujii K et al. JACC Cardiovasc Interv 2011:4:513–520

IMR and CFR in FFR>0.80

663 lesions

55% (N=283)
Concordant
Normal



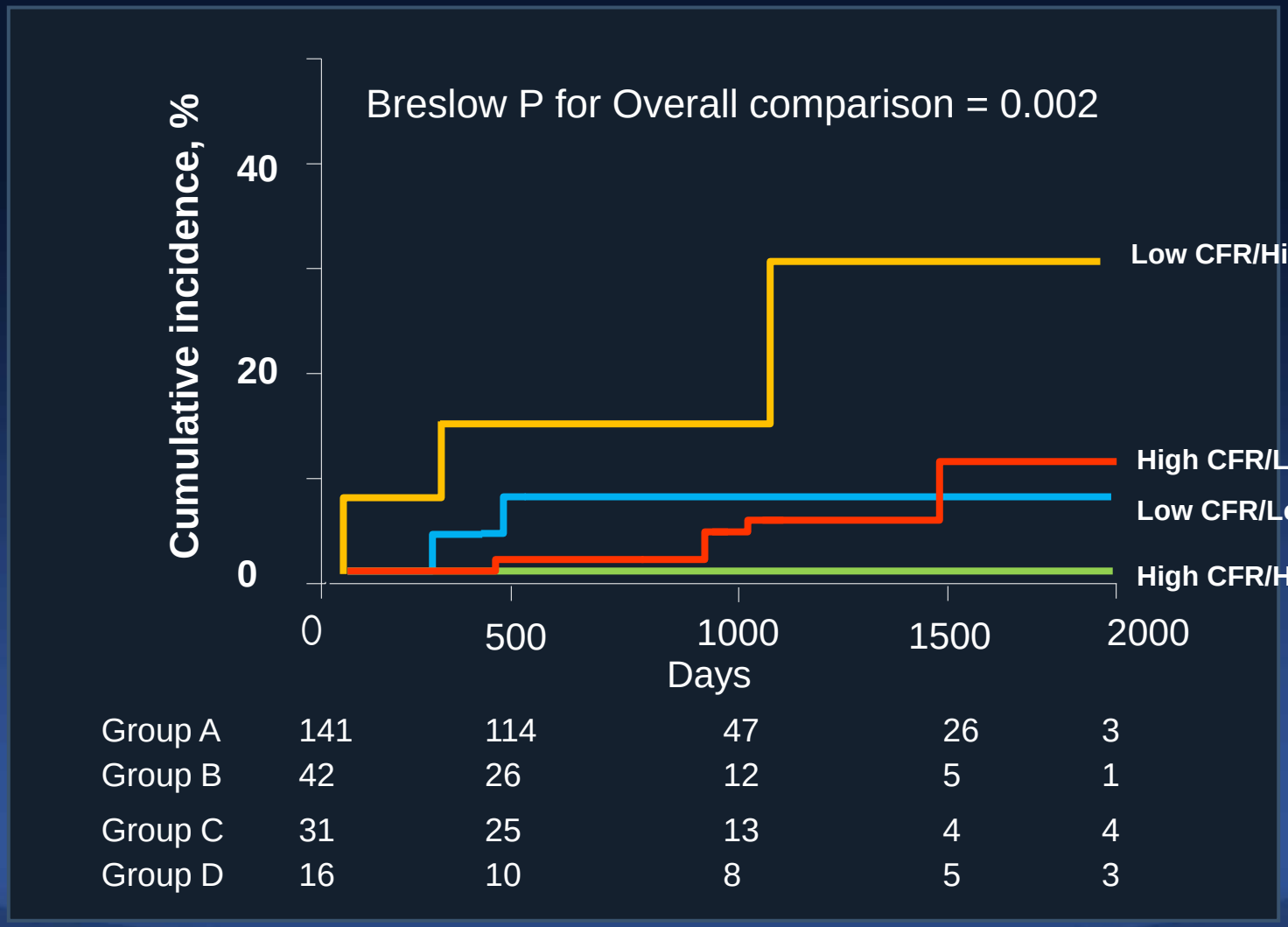
19% (N=99)
High resistance
with preserved CFR

18% (N=94)
Normal resistance
With low CFR

8% (N=40)
Concordant abnormal
Overt MVD

Lee JM et al. J Am Coll Cardiol. 2016 Mar 15;67(10):1158-69

IMR and CFR in FFR>0.80



Group A	141	114	47	26	3
Group B	42	26	12	5	1
Group C	31	25	13	4	4
Group D	16	10	8	5	3

Lee JM et al. J Am Coll Cardiol. 2016 Mar 15;67(10):1158-69

Summary

- IMR measurement is easy, specific for the microvasculartur e, quatitative, reproducible, and independent of hemodynamic changes
- In patients with STEMI, IMR is associated with infarct size, LV recovery, and long-term outcomes
- IMR may help to predict and to guide treatment to prevent PCI injury for patients with PCI
- IMR may have potential roles in diagnosis or treatment for patients with chest pain and normal CAG, and in risk stratification in patients with stable coronary artery disease.