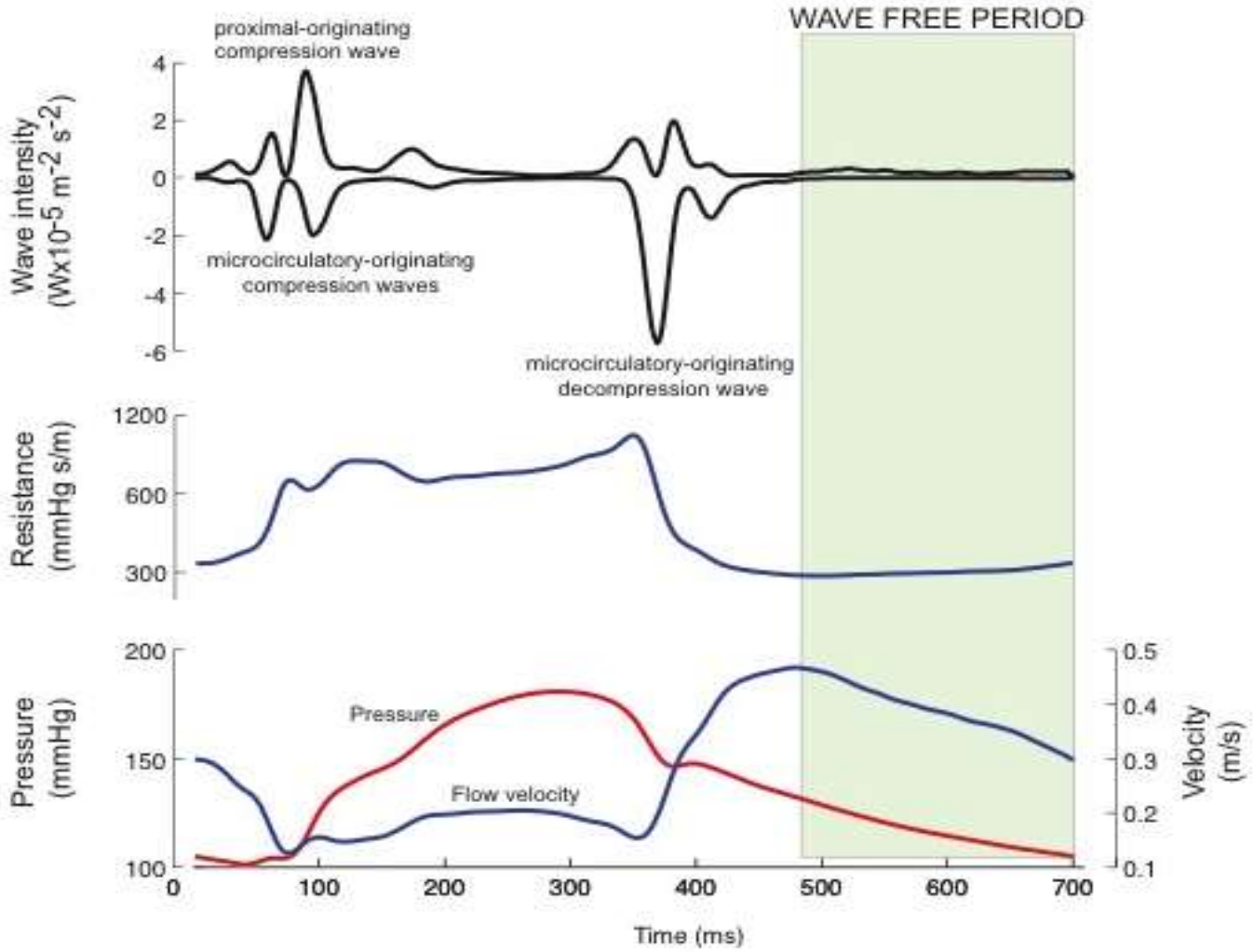
instantaneous wave free ratio (iFR) and resting index for functional evaluation

HITOSHI MATSUO M.D.,
The Department of Cardiovascular Medicine,
Gifu Heart Center, Gifu, Japan

Physiological Indices

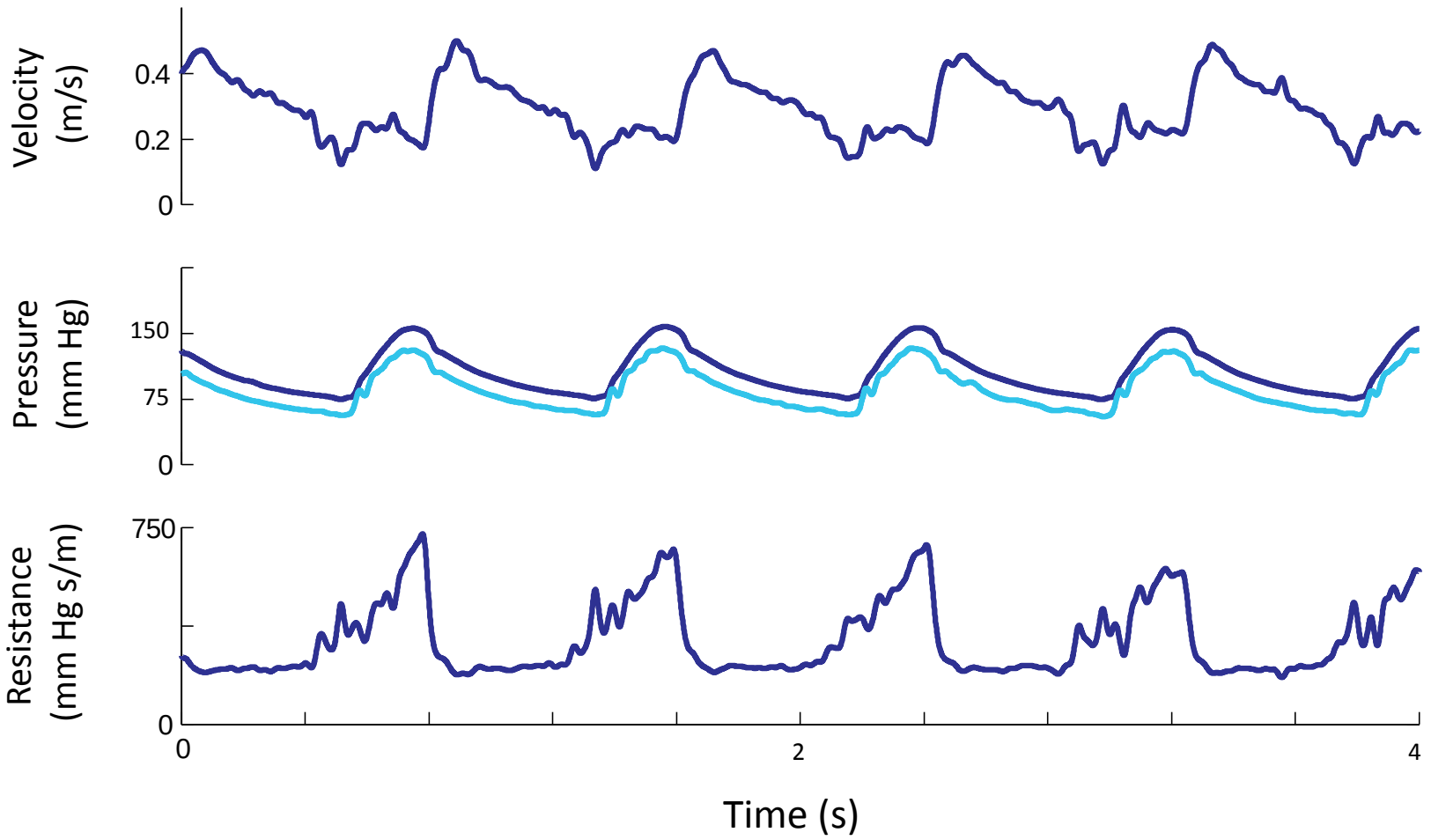
	Resting	Hyperemic
Pressure	Pd/Pa	Pd/Pa (FFR)
	iFR (Pd/Pa wave free period)	iFR (h)
Flow	Velocity (eg APV)	CFVR
		CFR (thermo)
Combined	Lesion resistance (BSR, HSR)	
	Myocardial Resistance (MVRI, IMR)	
	Wave Intensity Analysis (eg BEW)	
	Pressure/flow loops (eg PzF)	

Identification of the naturally occurring diastolic wave-free period using wave intensity

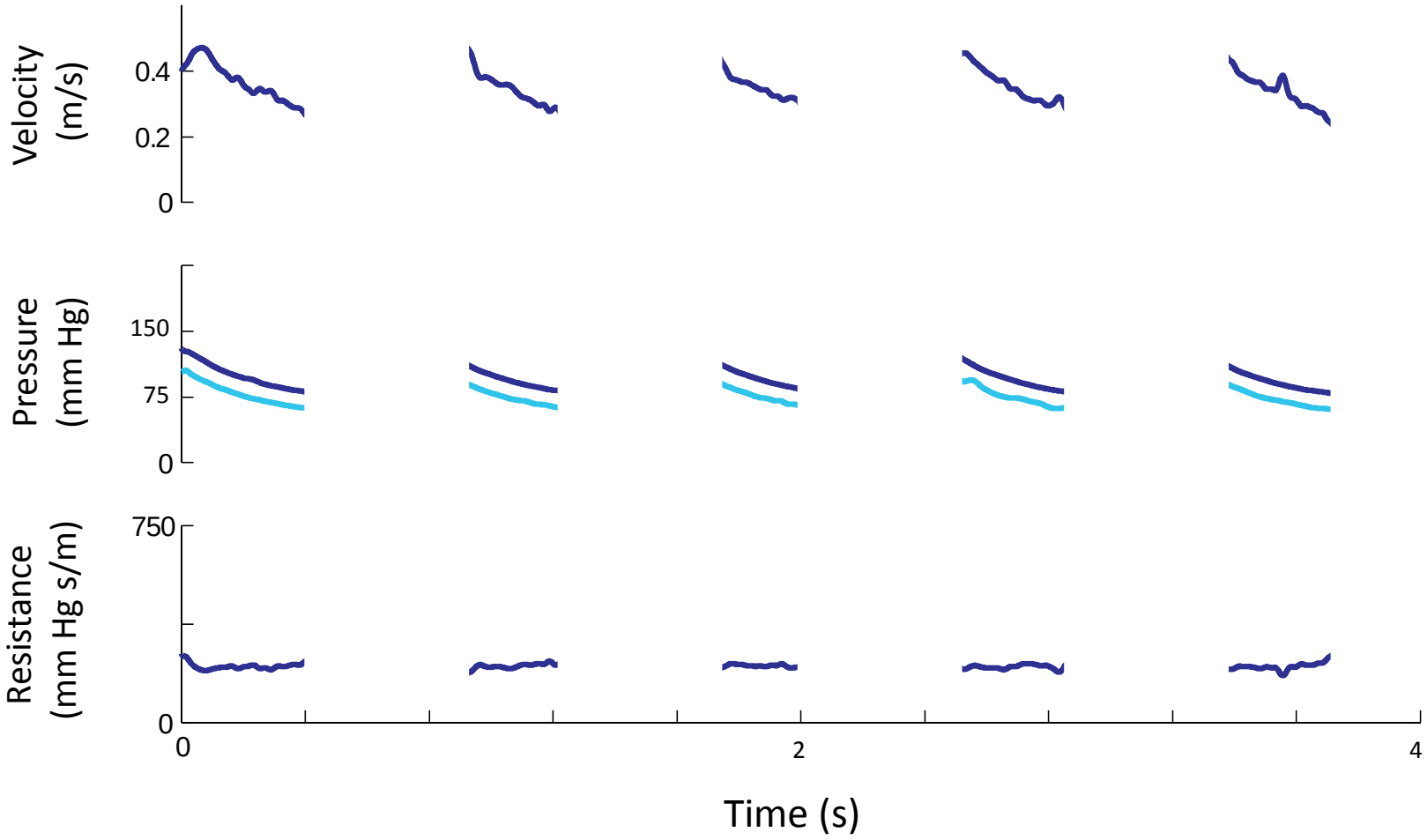


Sen S, Mayet J, Davies JE et al. JACC (in press Nov 2011)
Davies JE, Francis DP, Hughes AD, Mayet J et al. Circulation 2006;113:1767-1778
Davies JE, Parker KH, Hughes AD, Mayet J et al. Circulation 2011;124:1565-1572

Using iFR to identify stable resistance phase



Resistance is stable during the wave-free window

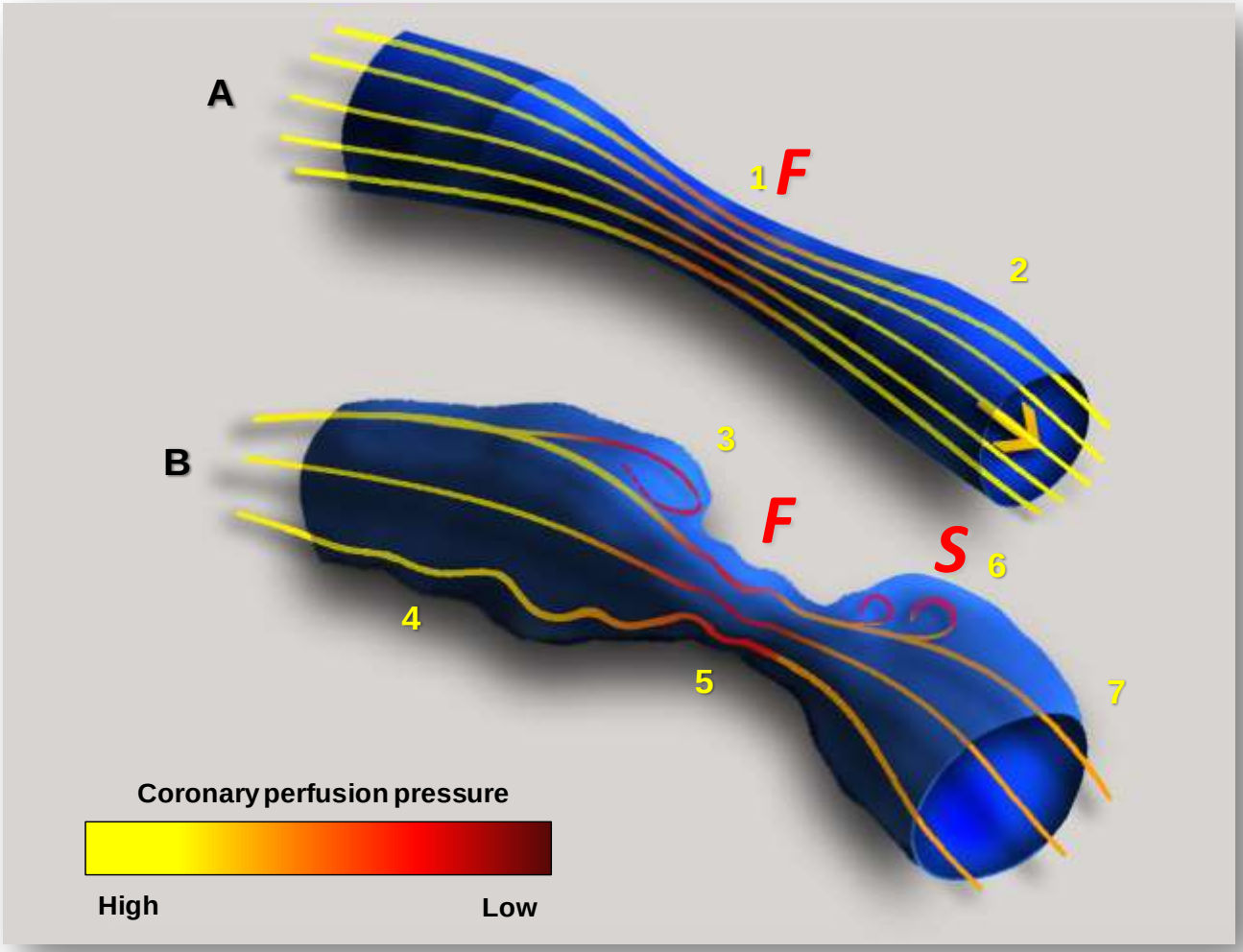


Necessary condition to measure iFR

- Why should it be measured at rest?
- Why is iFR better than whole cycle Pa/Pd?

Haemodynamic impact of a coronary stenosis

Mechanisms of energy dissipation



$$\Delta P = F\,v + S\,v^2$$

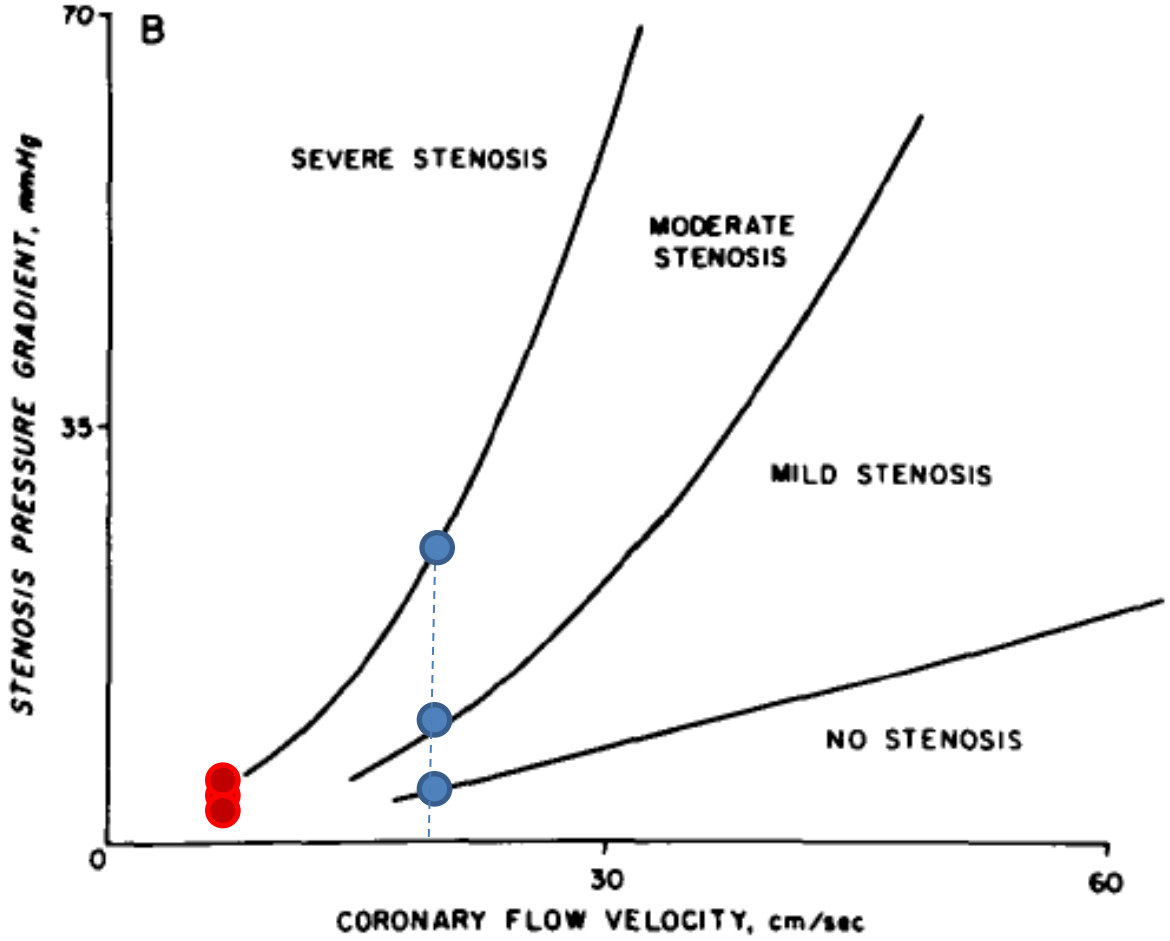
(*F* and *S* coefficients)

Friction

Separation

F and *S* coefficients reflect the anatomical stenosis severity

A minimal velocity is required for stenosis discrimination

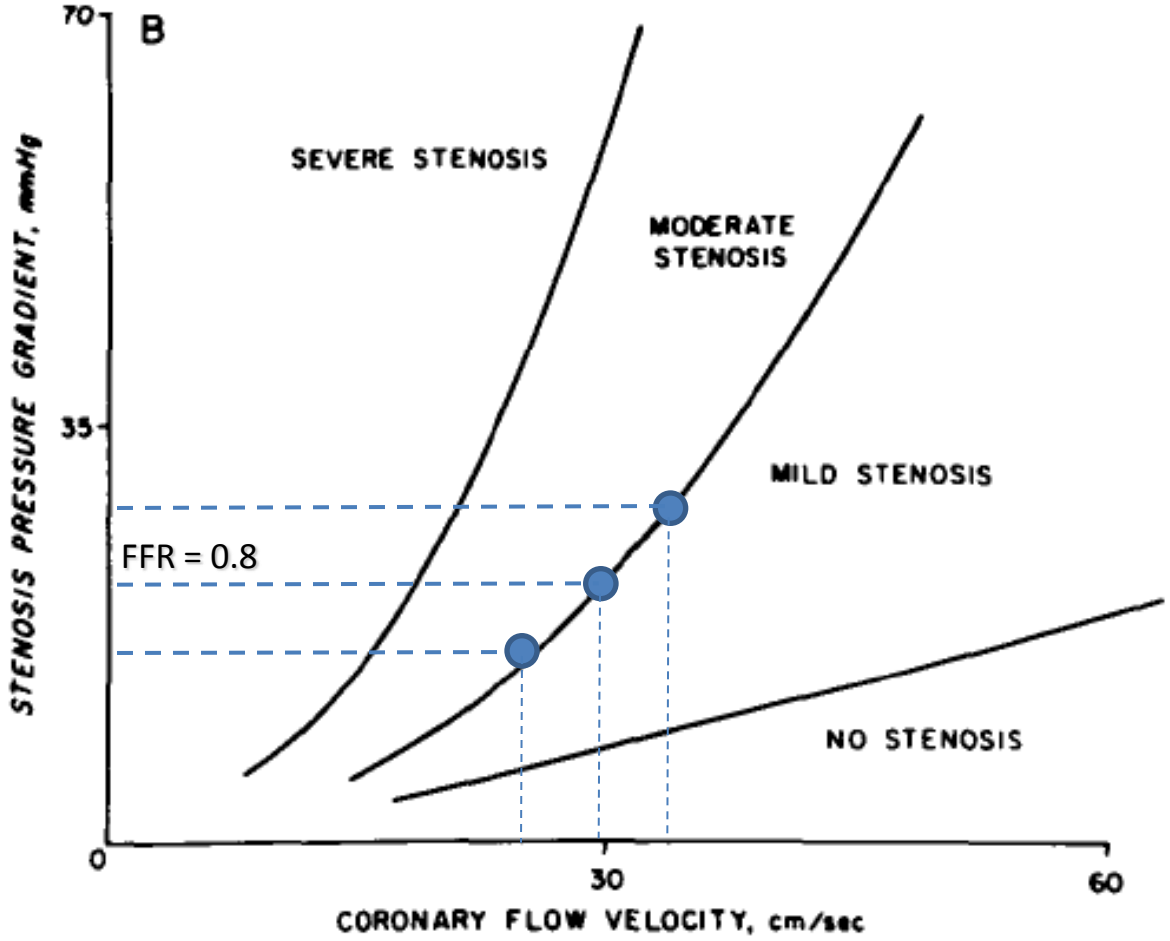


Gould, K. Circulation research 1978;43:242-253

Different stenosis severities can generate a similar low pressure drop (iFR/FFR) if interrogated with low velocities.

Therefore a minimal velocity is required

Consistent velocity is required for stenosis discrimination

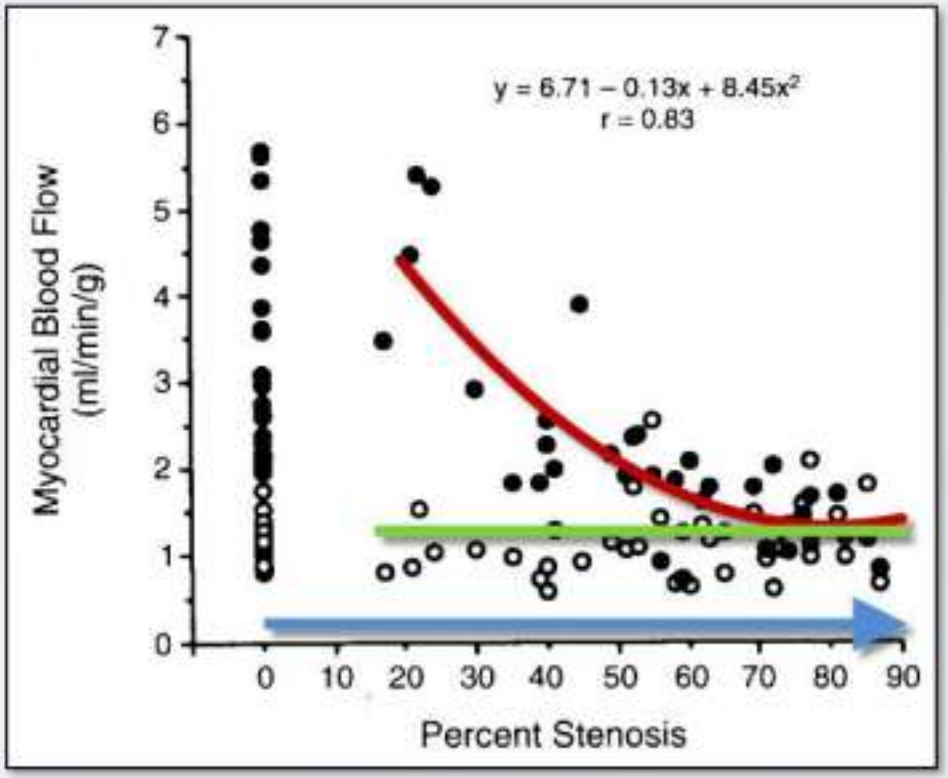


The same stenosis can generate different pressure drops (iFR/FFR) depending on the underlying velocity.

Therefore the consistency of velocity is essential

Gould, K. Circulation research 1978;43:242-253

Hyperemic Versus Baseline Blood Flow



As percent stenosis increases from 10 to 90

Hyperemic blood flow decreases substantially

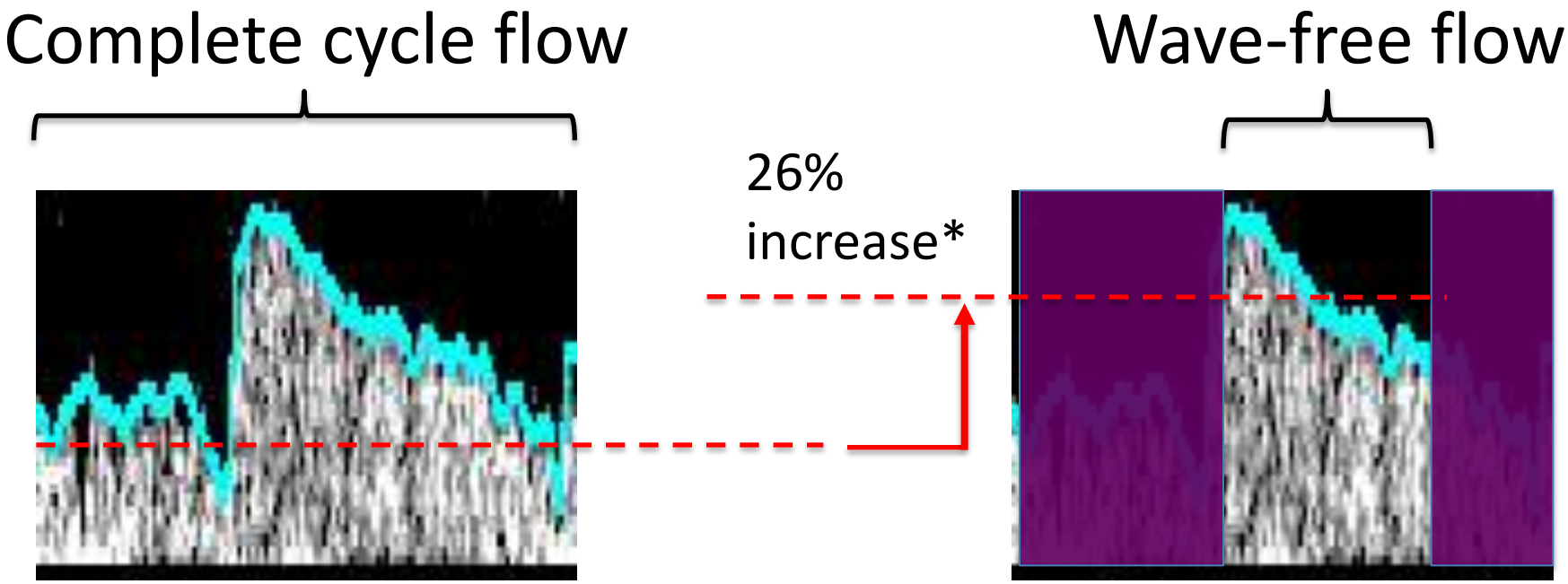
While base line blood flow does not decrease

Uren N, et al. Relation between myocardial blood flow and the severity of coronary artery stenosis. The New England Journal of Medicine 1994; 330: 1782-1788

Figure 8： iFR should be measured at rest. Hyperemic response such as contrast injection and use of hyperemic agent induce flow increae which result in the iFR value lower. A:iFR at rest B:iFR after contrast injection、C:30seconds after contrast injection、D.iFR at maximum hyperemia induced by ATP infusion.

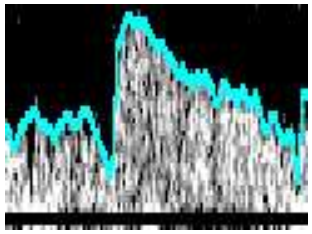
CLARIFY an ADVISE sub-study

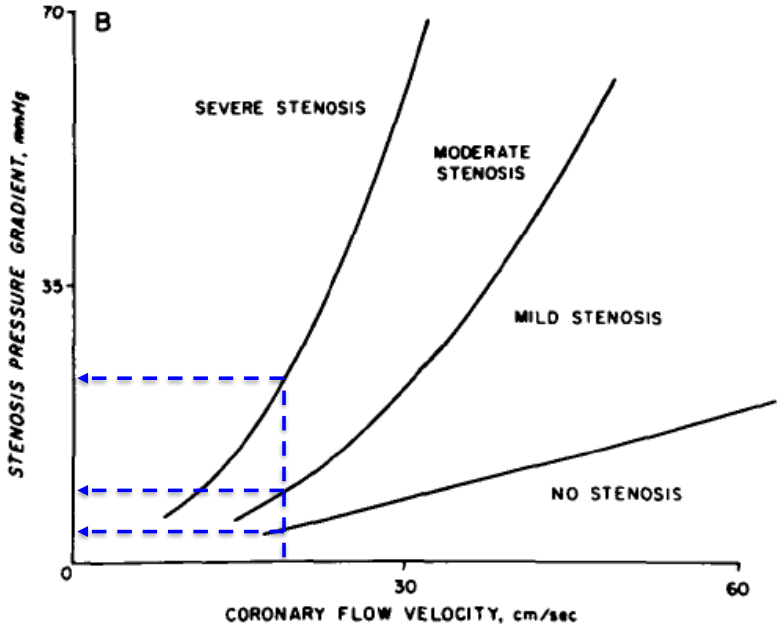
Why does iFR improve diagnostic accuracy than whole cycle Pd/Pa?



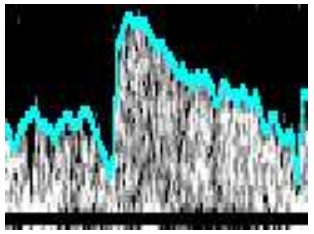
Mean velocities from ADVISE

Complete cycle flow



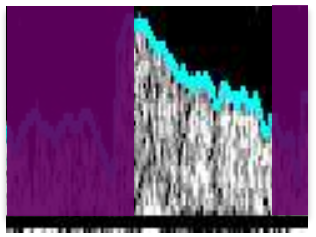


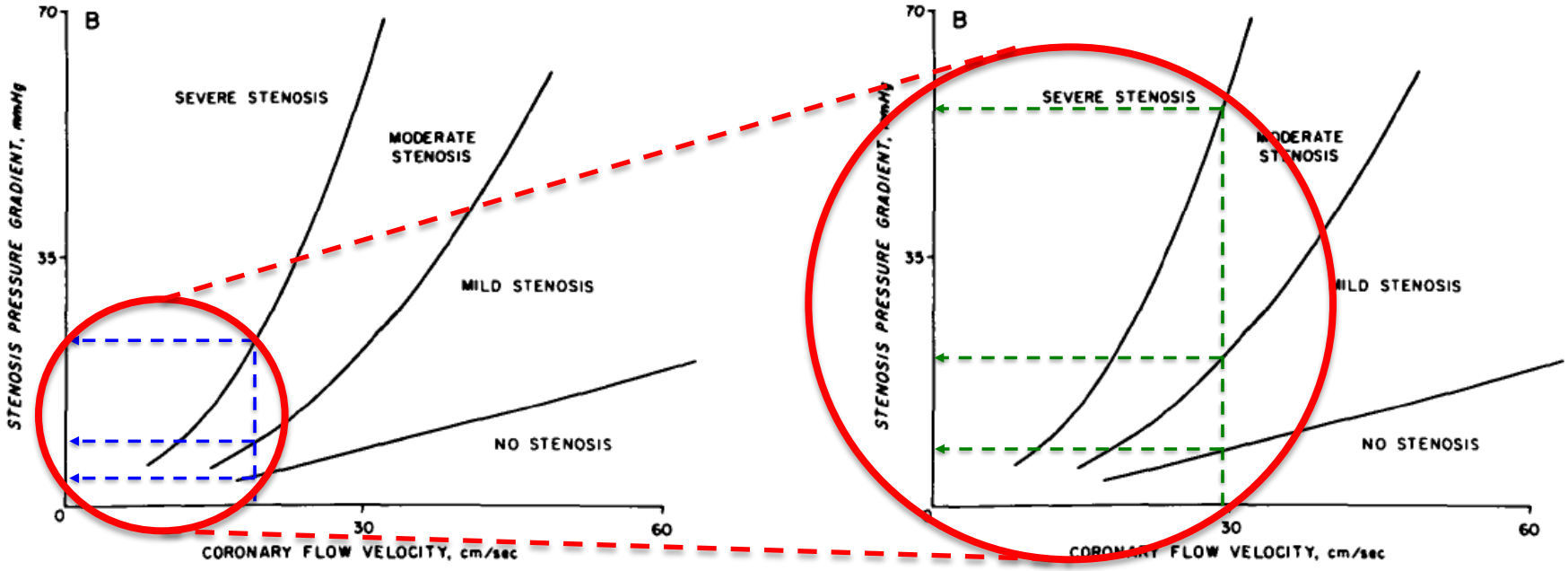
Complete cycle flow



Increased sensitivity

Wave-free flow





iFR :A New Adenosine-Independent Index of Stenosis Severity
～ Experience in Gifu Heart Center ～

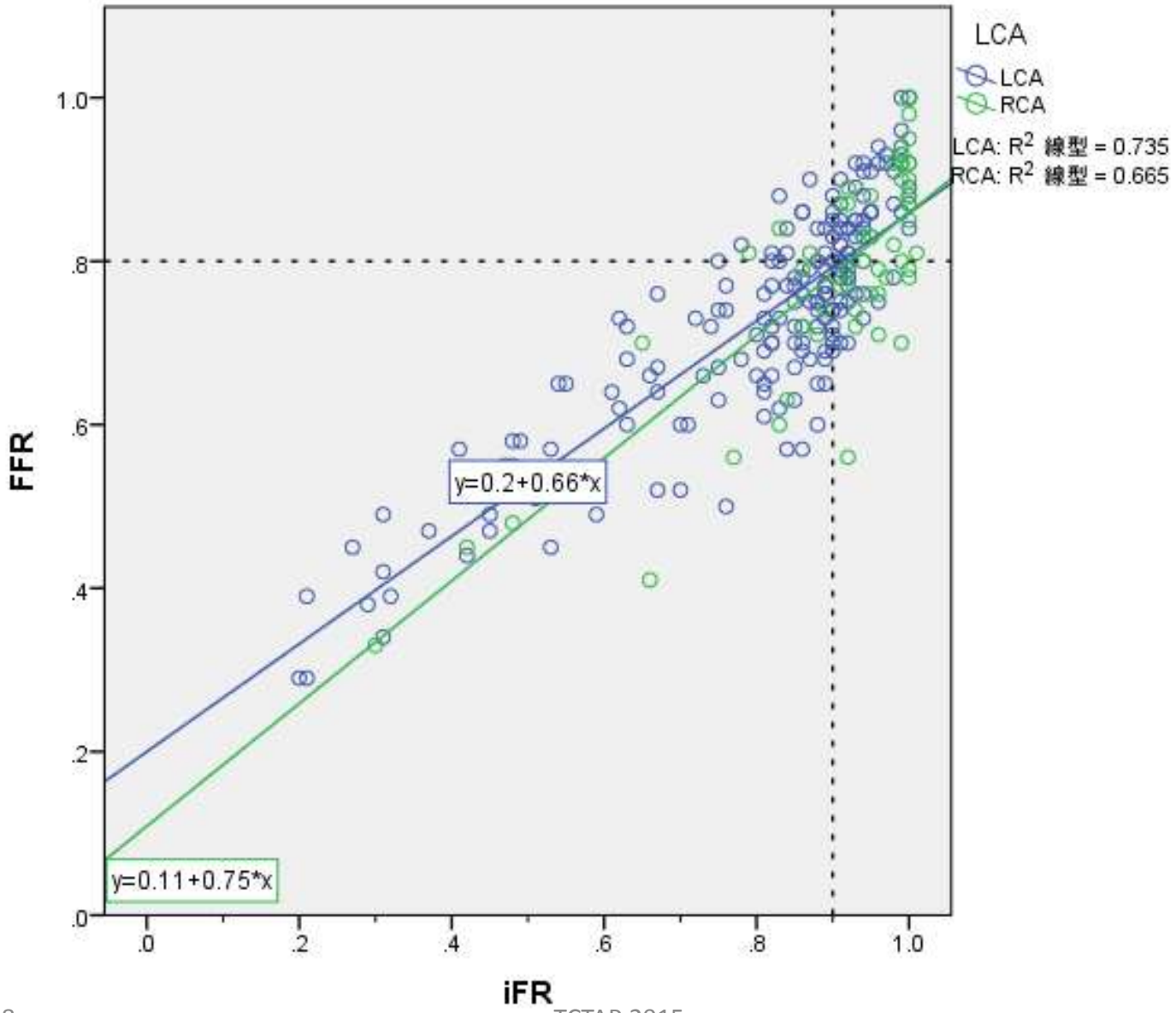
Patients Characteristics

Patient base analysis	n=191
age	71.3±9.4
gender(M:F)	M 128 F 63
CCS class	none 23 Ⅰ 90 Ⅱ 70 Ⅲ 8
HT	128（67%）
HL	109（57%）
DM/IDDM	66(35%)/9(4.7%)
smoking /past smoking	50(26%)/37(19.4%)
CKD	Ⅲa 62 Ⅲb 17 Ⅳ2 Ⅴ9
HD	9
OMI	46
ACS	67
SVD:MVD	1VD 101, 2VD 69, 3VD 19
previous PCI	98
previous CABG	8

Lesion Characteristics

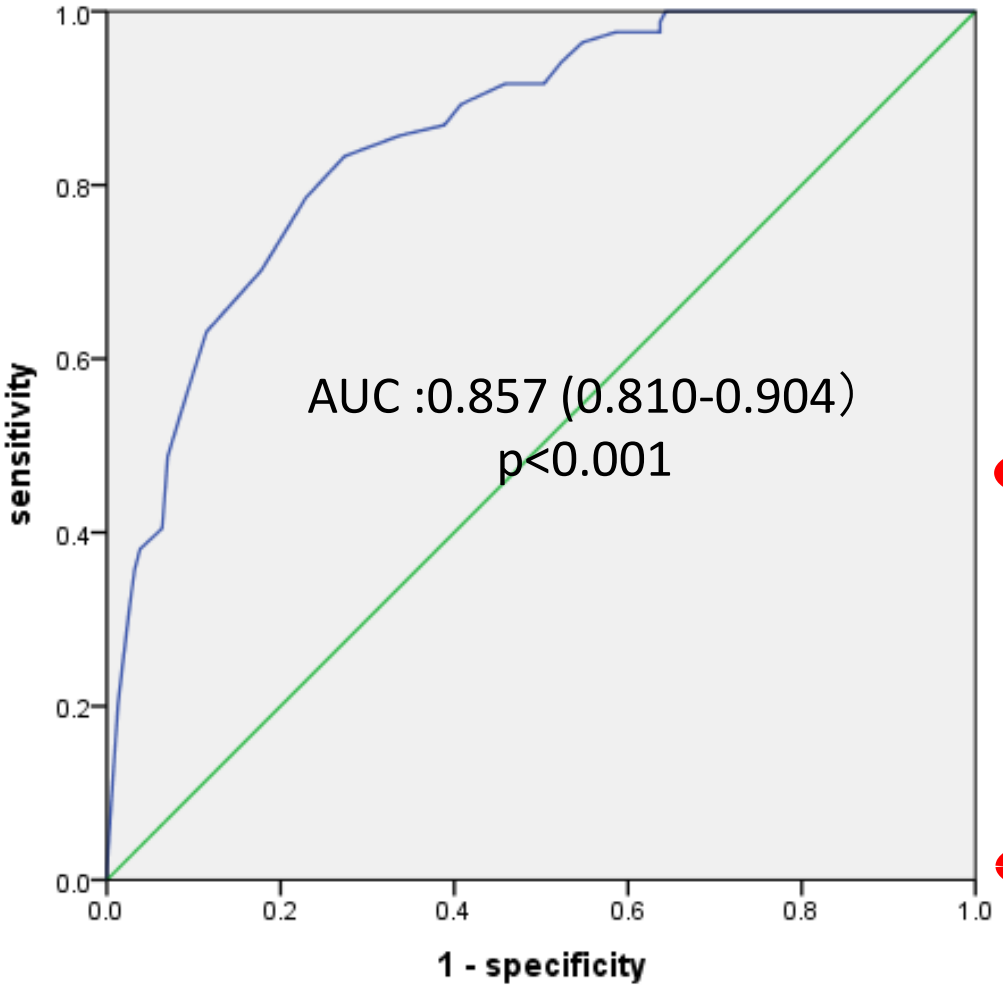
Lesion base analysis	n=241
measured vessel	RCA 58 LCA 183
MI related	12
Lesions with stable pt	155 (64.7%)
Lesions with unstable pt	85 (35.3%)
FFRmyo	0.74±0.14
FFR≦0.80	157 (65.1%)
iFR	0.83±0.18
MLD	1.20±0.40
Ref VD	2.87±0.65
LL	24.1±14.1
%DS	57.8±10.5

Correlation of iFR with FFR



Diagnostic characteristics of iFR in all

All lesions
N=241



iFR Best cutoff ：0.90
Sensitivity : 77.1%
Specificity ：79.7%
P.P.V ：87.7%
N.P.V : 65.0%
Accuracy: 78.0%

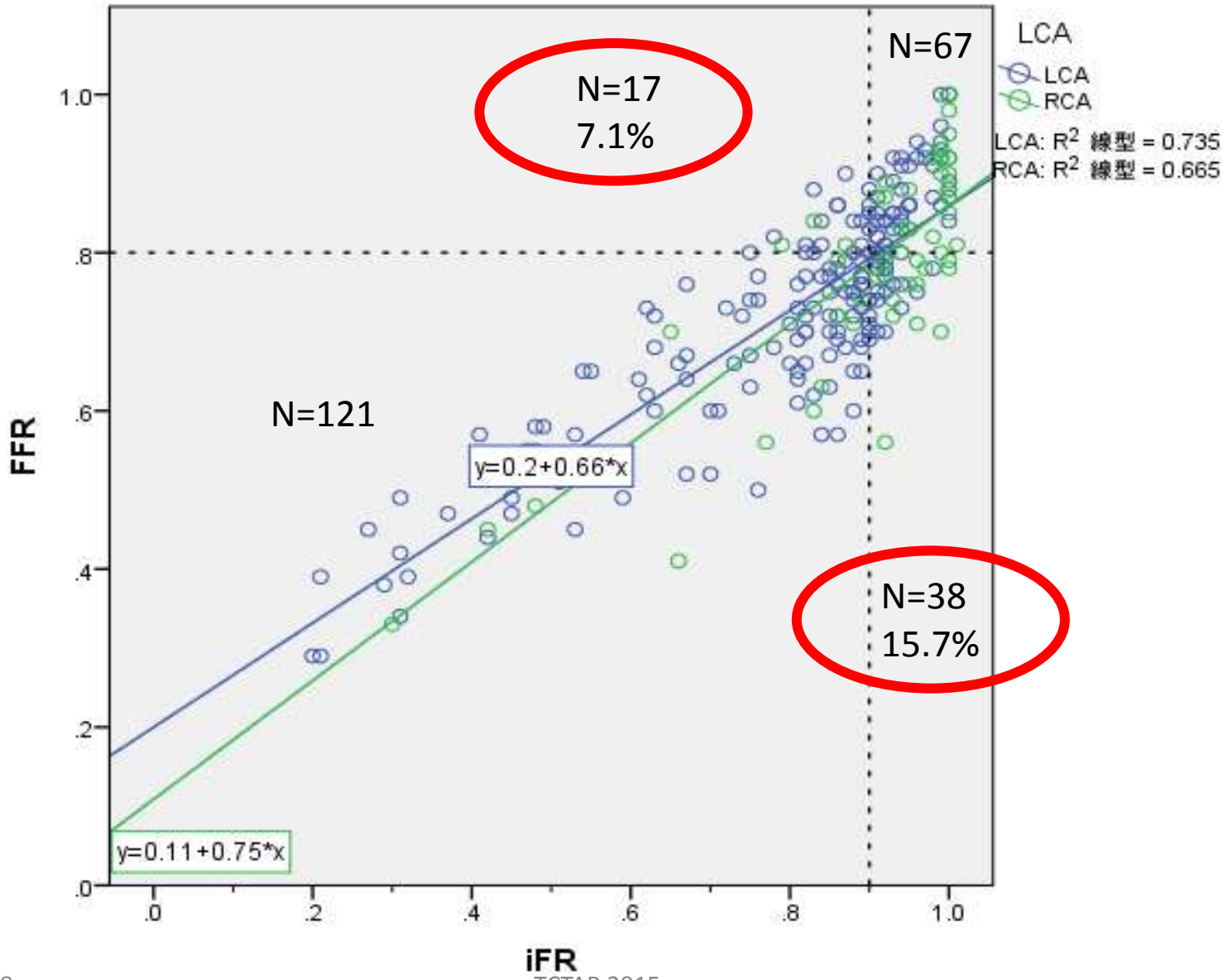
Consistent iFR cut-points

IFR value with best classification for FFR≤0.80

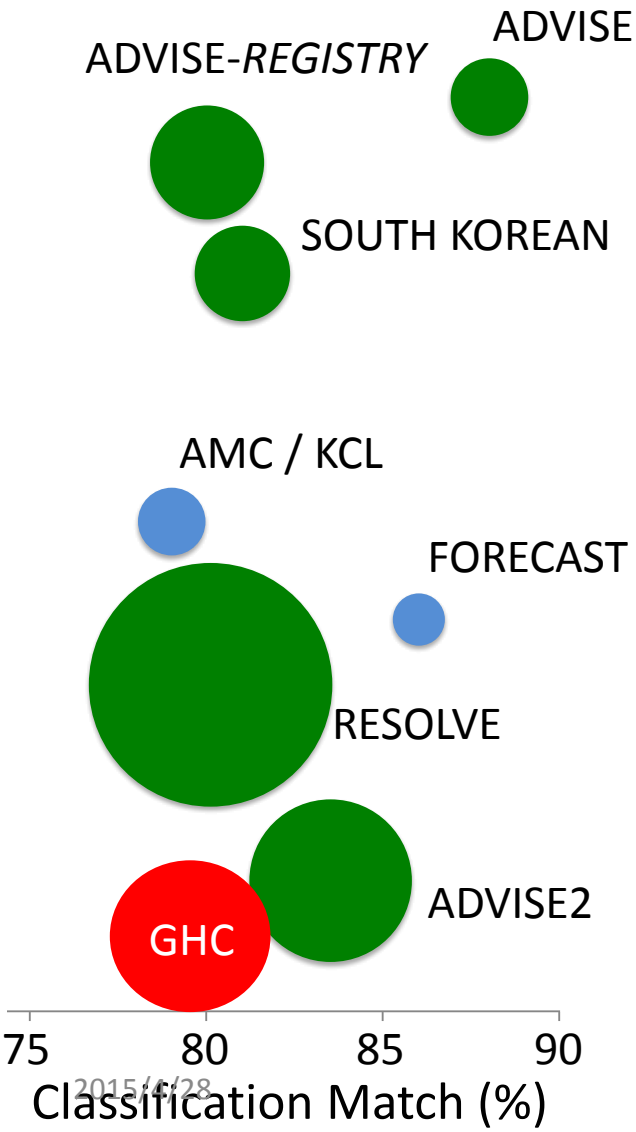
- ADVISE-Registry(n=339) 0.89
- South Korean Study(n=238) 0.90
- RESOLVE(n=1593) 0.90
- ADVISE-*in Practice*(n=392) 0.90
- ADVISE 2 (n=689) 0.89
- GHC (n=241) 0.90

FDA Labeling iFR = 0.89

Correlation of iFR with FFR



Excellent iFR-FFR classification match using independently validated algorithm



- n>3000 stenoses
- Independent core-lab blinded analyses
- Investigators studies
- Multi-centre collaborative studies

Adapted from Sen S et al. J Am Coll Cardiol. 2013;62(10):943-5

case1 : iFR and FFR Why discrepant?

73 y.o female

PHx : none

PI : asymptomatic. MDCTCA

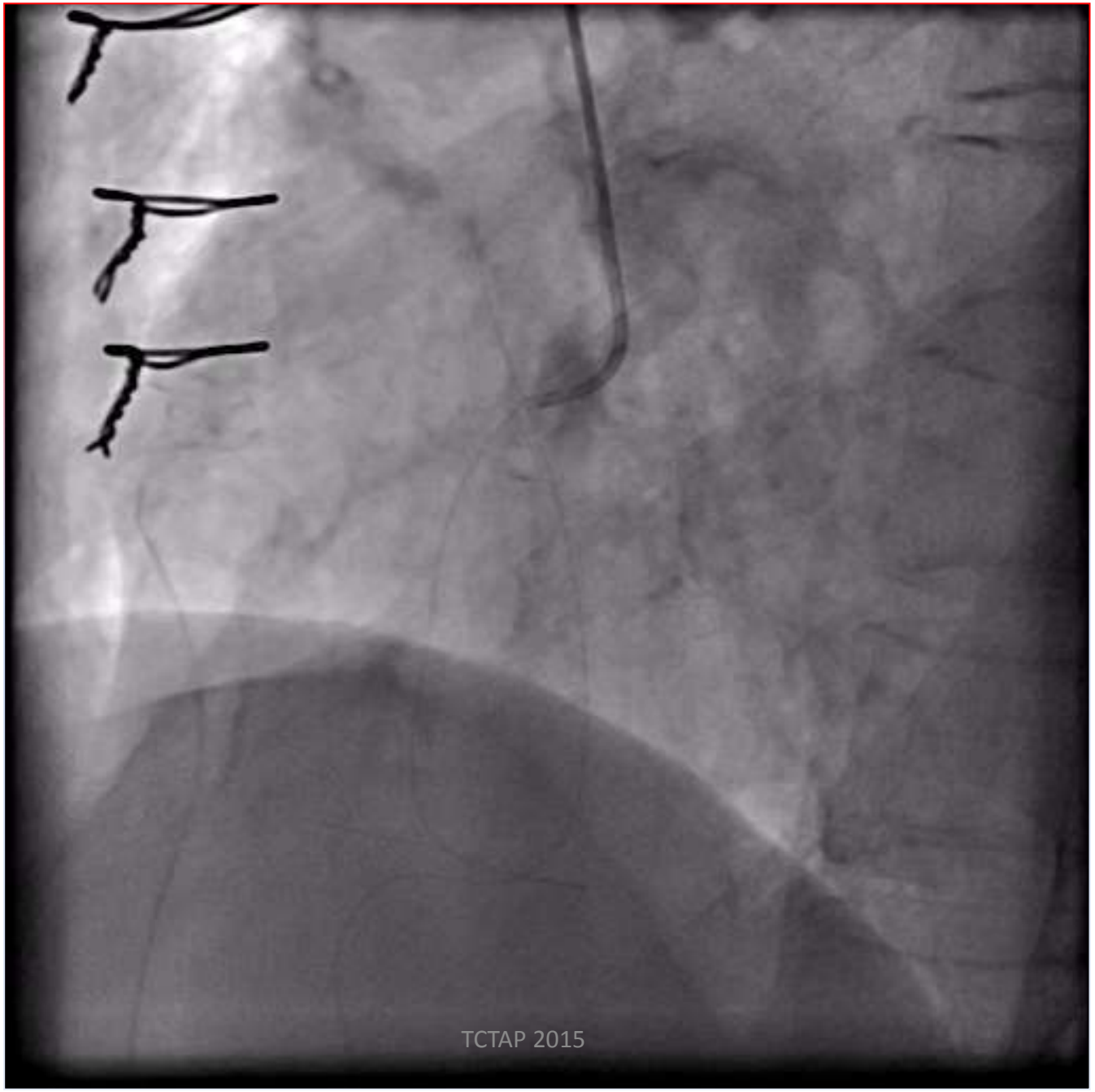
Problem list

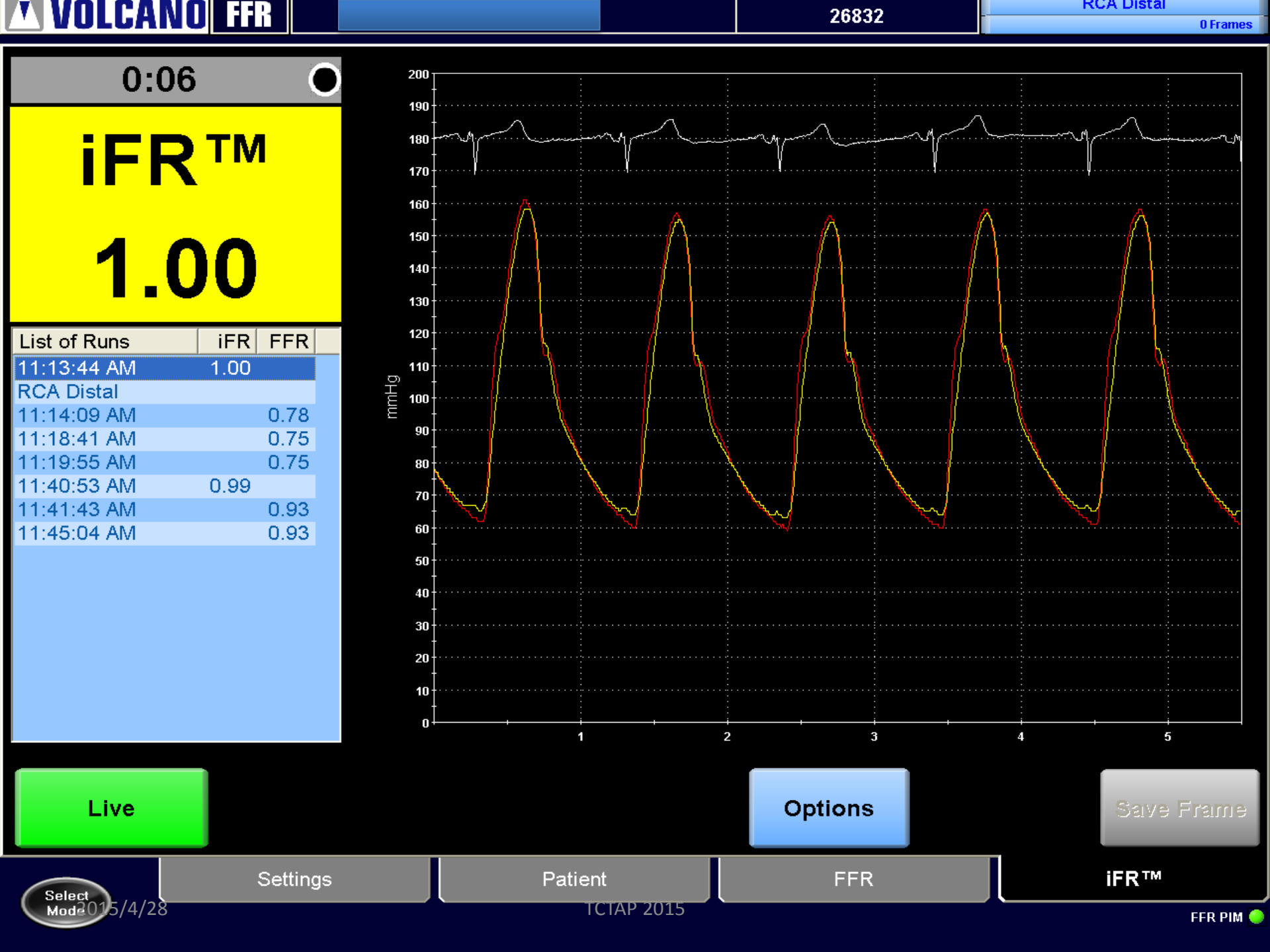
#1. HT #2. Ascending Aortic replacement due to TAA. #3. CAA aneurysm #4. VA aneurysm #5. CKD. #6. effort angina

MDCTCA findings

- #1. intermediate focal stenosis in proximal RCA
- #2. intermediate stenosis in mid LAD
- Cr : 1.4mg/dl eGFR : 36 ml/min/1.43m2

case1 : iFR and FFR Why discrepant?




VOLCANO
FFR
26832
RCA Distal
0 Frames
0:06
iFR™
1.00
List of Runs
iFR
FFR
11:13:44 AM 1.00
RCA Distal
11:14:09 AM 0.78
11:18:41 AM 0.75
11:19:55 AM 0.75
11:40:53 AM 0.99
11:41:43 AM 0.93
11:45:04 AM 0.93
mmHg
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1
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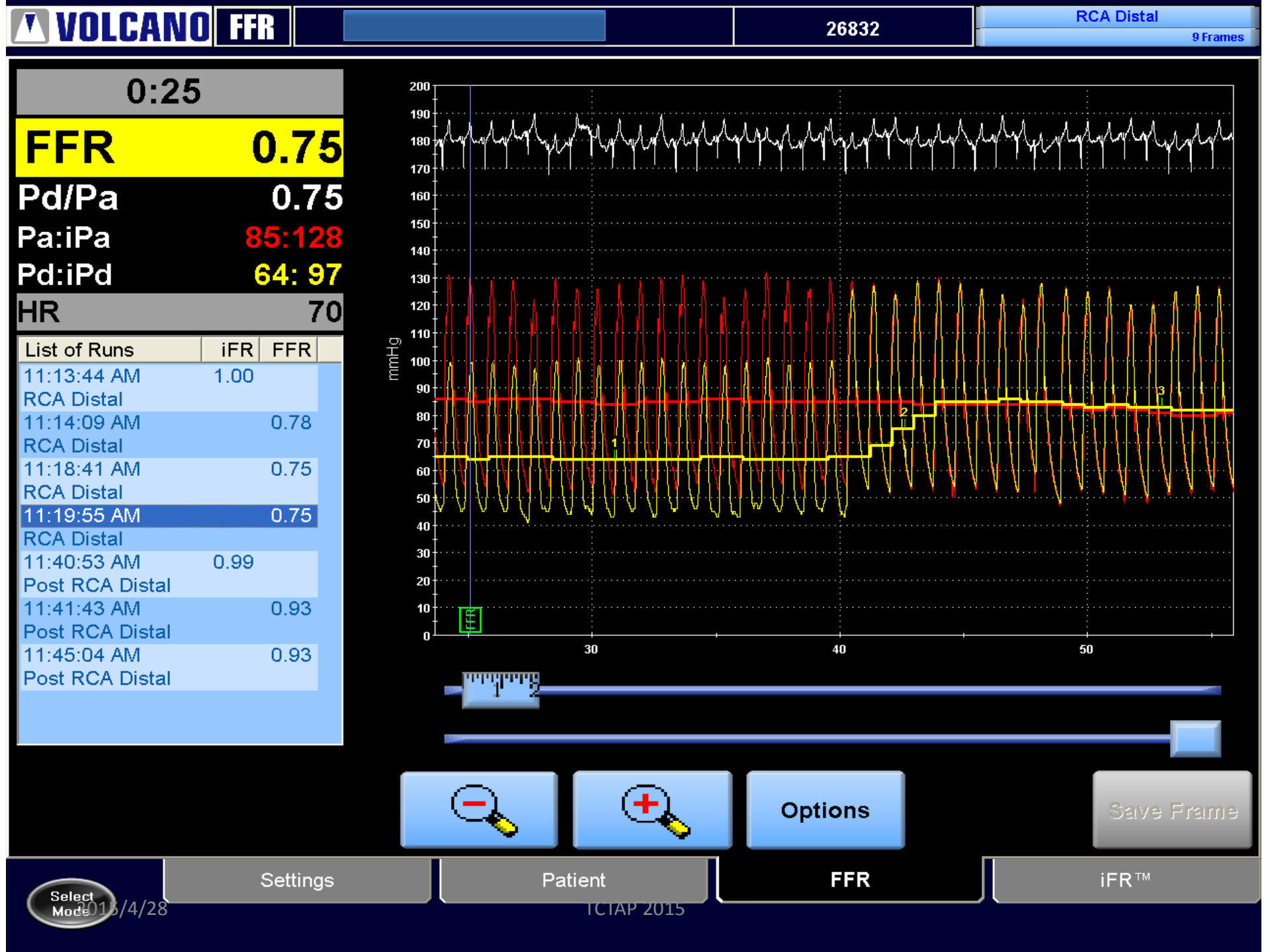
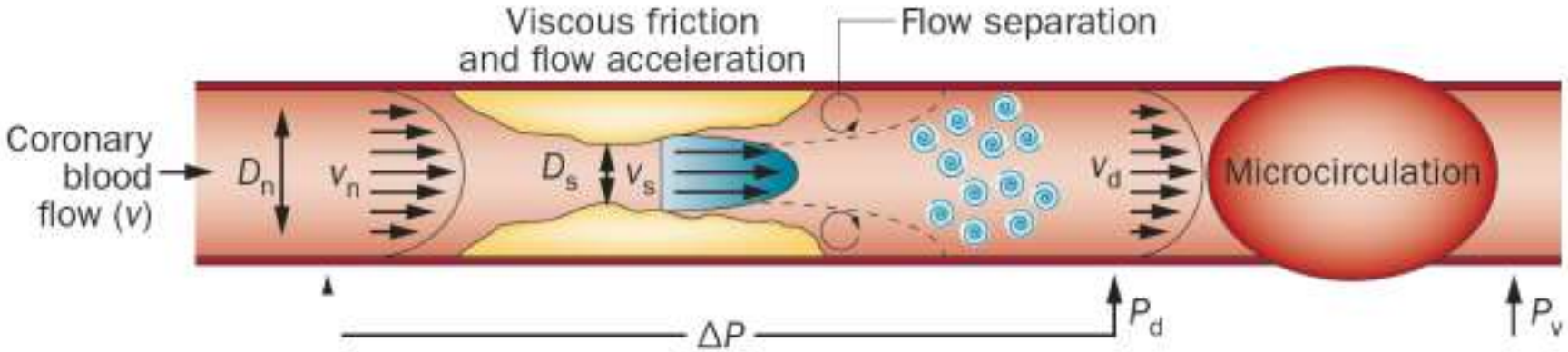
5
Live
Options
Save Frame
Settings
Patient
FFR
iFR™
Select Mode
FFR PIM

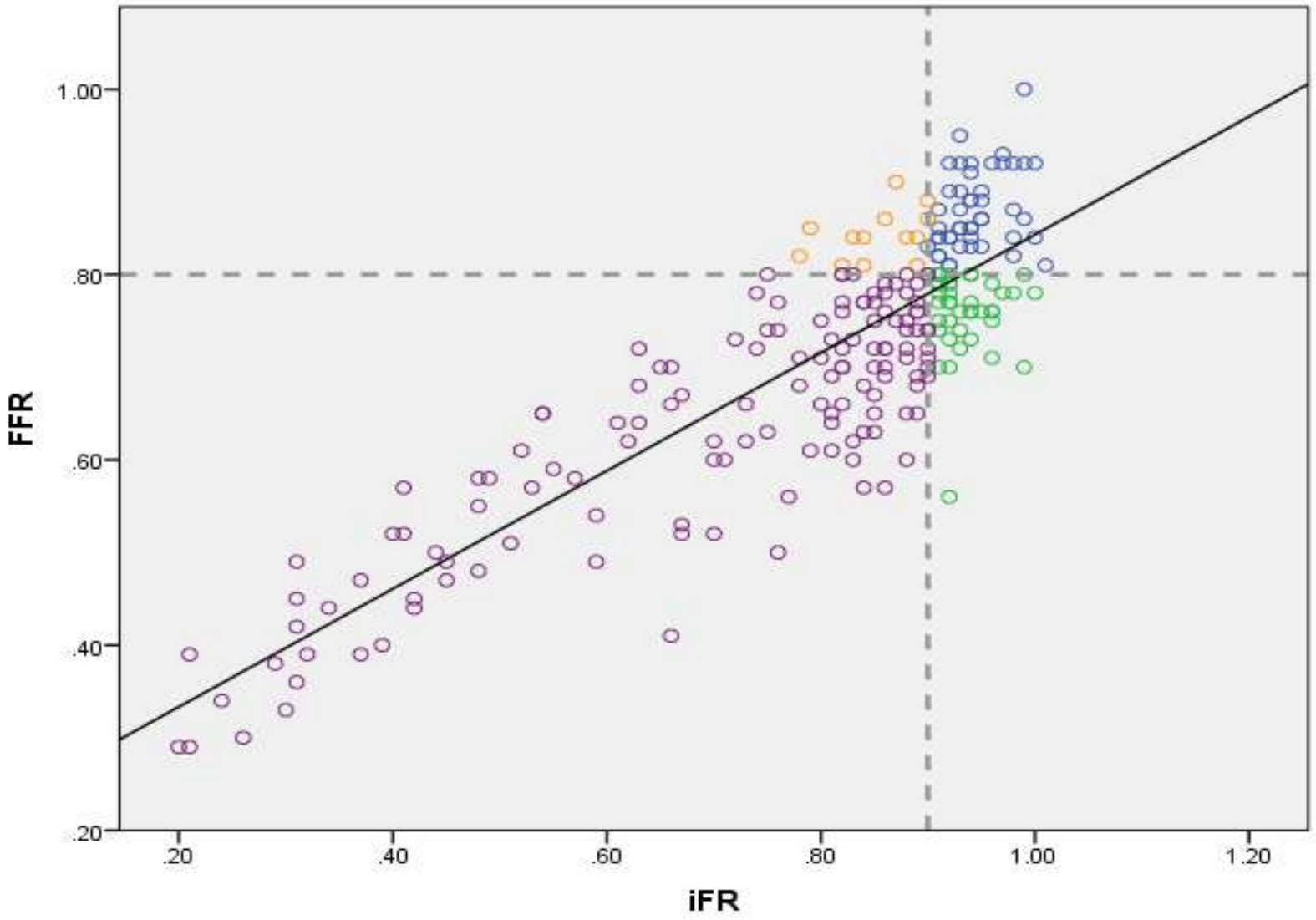

VOLCANO
FFR
26832
RCA Distal
9 Frames
0:25
FFR 0.75
Pd/Pa 0.75
Pa:iPa 85:128
Pd:iPd 64: 97
HR 70
List of Runs iFR FFR
11:13:44 AM 1.00
RCA Distal
11:14:09 AM 0.78
RCA Distal
11:18:41 AM 0.75
RCA Distal
11:19:55 AM 0.75
RCA Distal
11:40:53 AM 0.99
Post RCA Distal
11:41:43 AM 0.93
Post RCA Distal
11:45:04 AM 0.93
Post RCA Distal
mmHg
Options
Save Frame
Settings
Patient
FFR
iFR™
Select Mode

Pressure drop depends on *Flow*

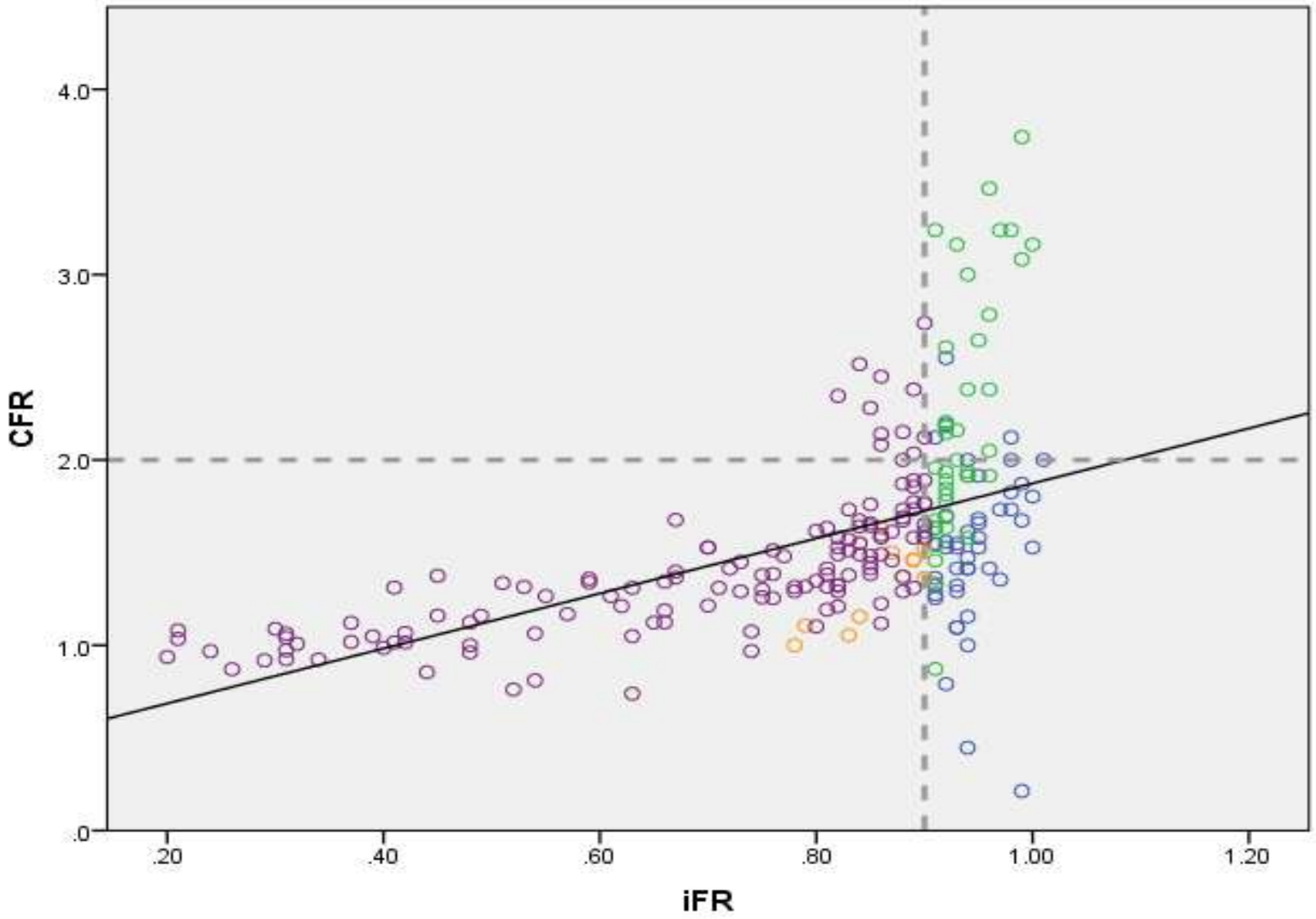


The general equation relating pressure loss, ΔP, to flow velocity, V, is:

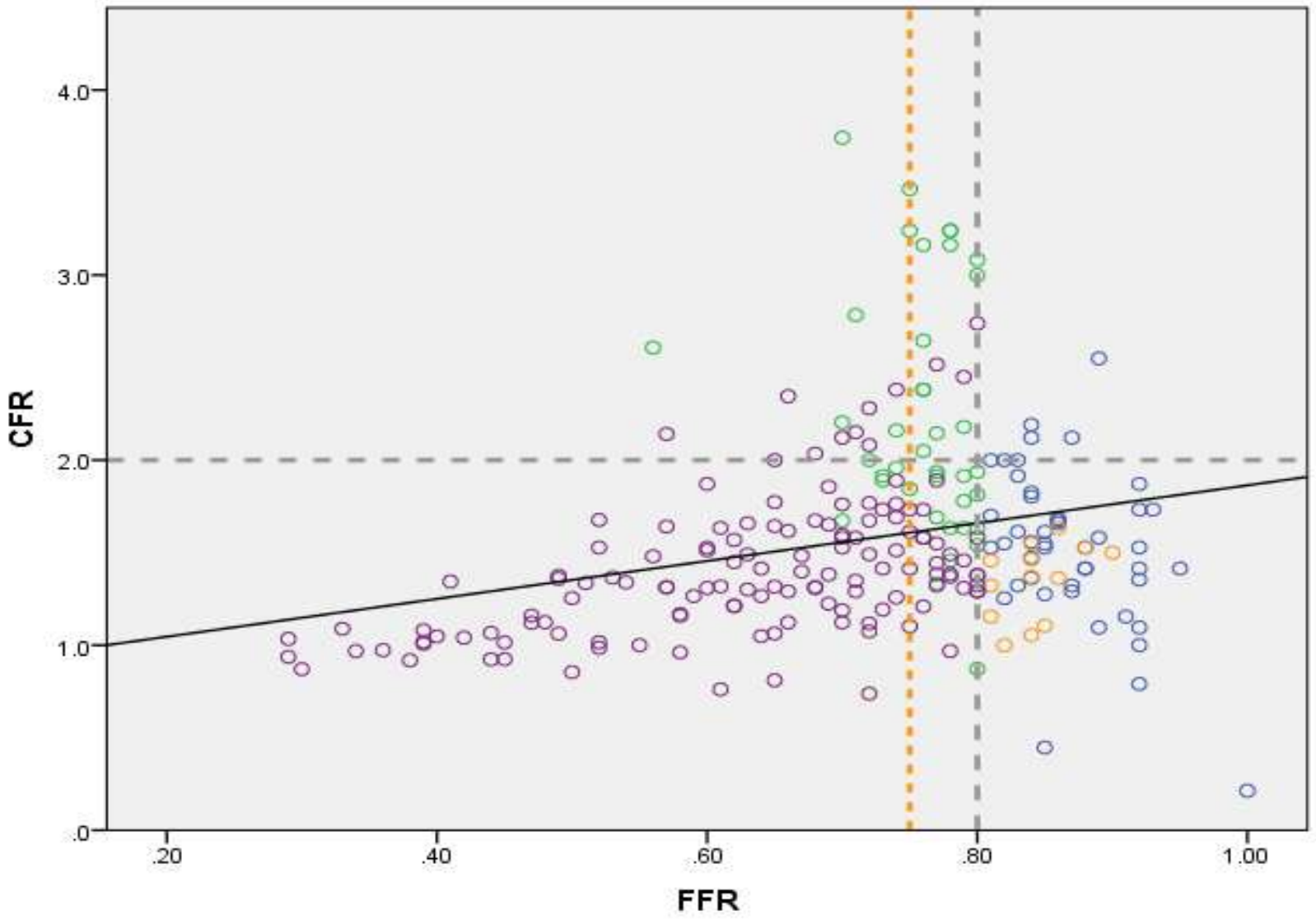
$$\Delta P = FV + SV^2 \qquad (1)$$



r=0.863 (95%CI: 0.589 - 0.685), p<0.001

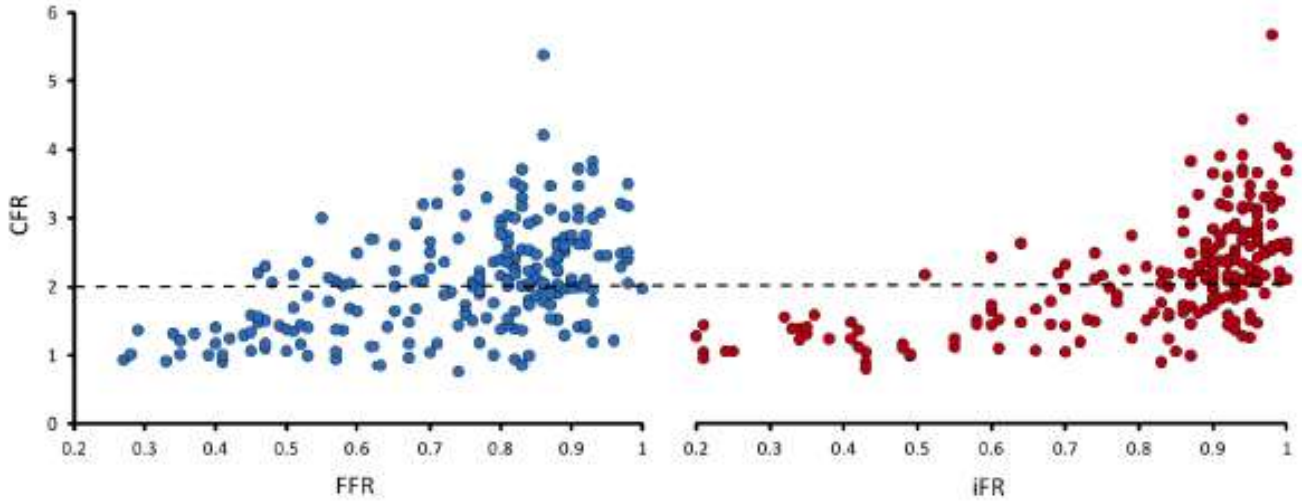


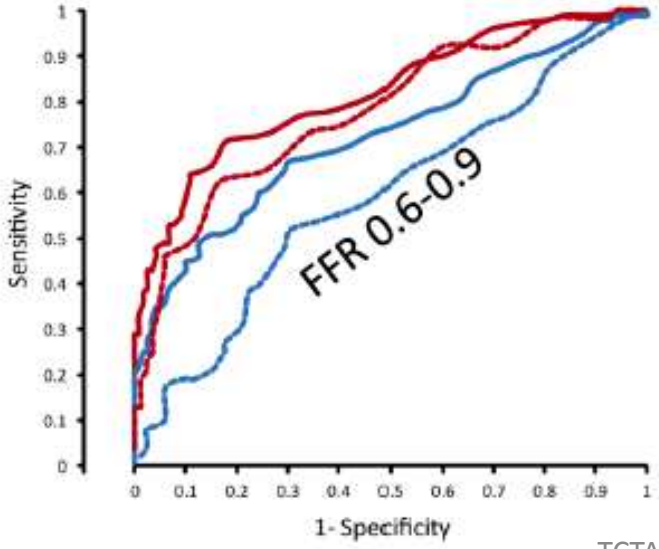
r=0.537 (95%CI: 1.183 - 1.787), p<0.001



r=0.273 (95%CI: 0.556 - 1.489), p<0.001

Resting pressure measurements provide a better estimate of hyperaemia flow





AUROC

ENTIRE RANGE

iFR 0.82

FFR 0.72

P<0.01

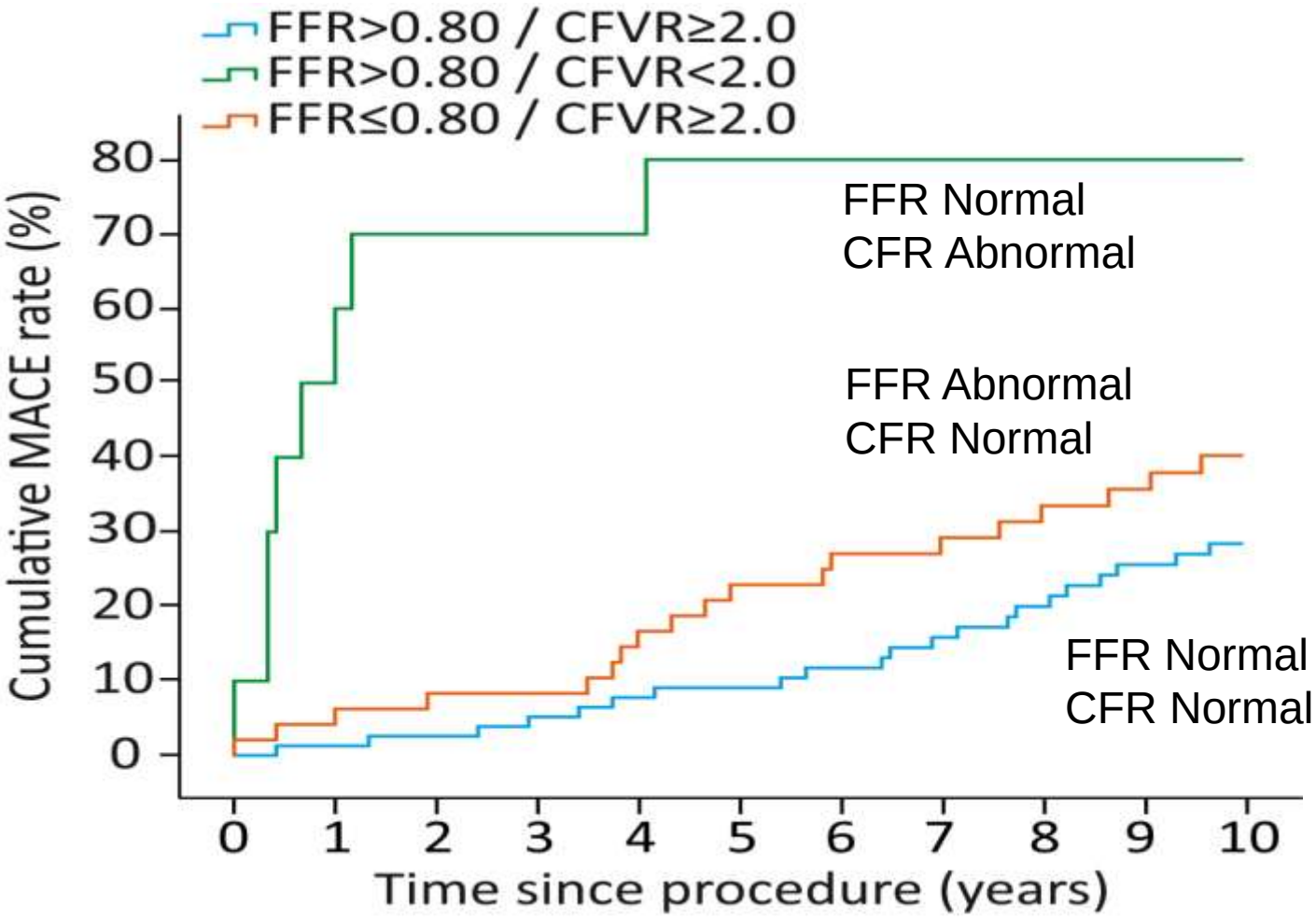
0.6-0.9 RANGE

iFR 0.78

FFR 0.59

Petraco, Hoef, Piek, Escaned, Davies (under review)

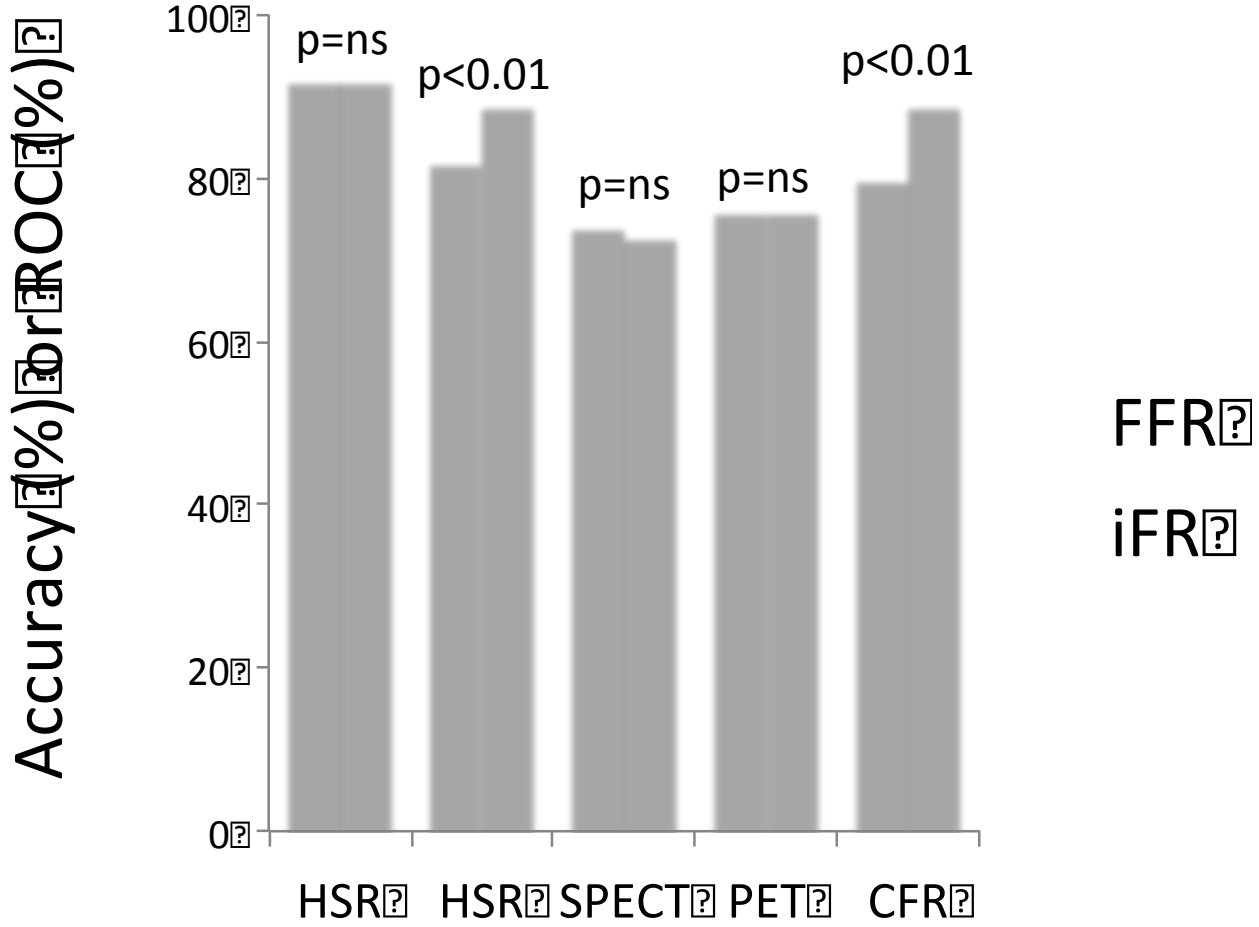
Flow adds significant benefit to FFR in predicting outcomes



FFR significance ≤0.80
CFR significance <2.0

Van de Hoef T., et al. Circ int. (in press)

Vasodilators ***do not*** improve physiological diagnostic accuracy



1. Van de Hoef et al. Circ Cardiovasc Interv. 2012;5(4):508-14
2. Sen et al. J Am Coll Cardiol. 2013;61(13):1409-20
3. Van de Hoef Euroint. (*in press*)
4. Sen et al. J Am Coll Cardiol. 2013;62(6):566
5. Petraco et al. Circ. Int. (*in press*)
6. de Waard et al. (ACC 2014)

FFR vs iFR

	FFR	iFR
Concept	myocardial flow reserve	coronary vessel resistance
Necessary condition	steady minimum resistance	constant flow velocity
measurement	maximum hyperemia	resting state
ischemia cutoff	0.8	0.89
correlation with CFR	poor	fair
linkage with clinical event	DEFER, FAME, FAME II	FLAIR (ongoing)

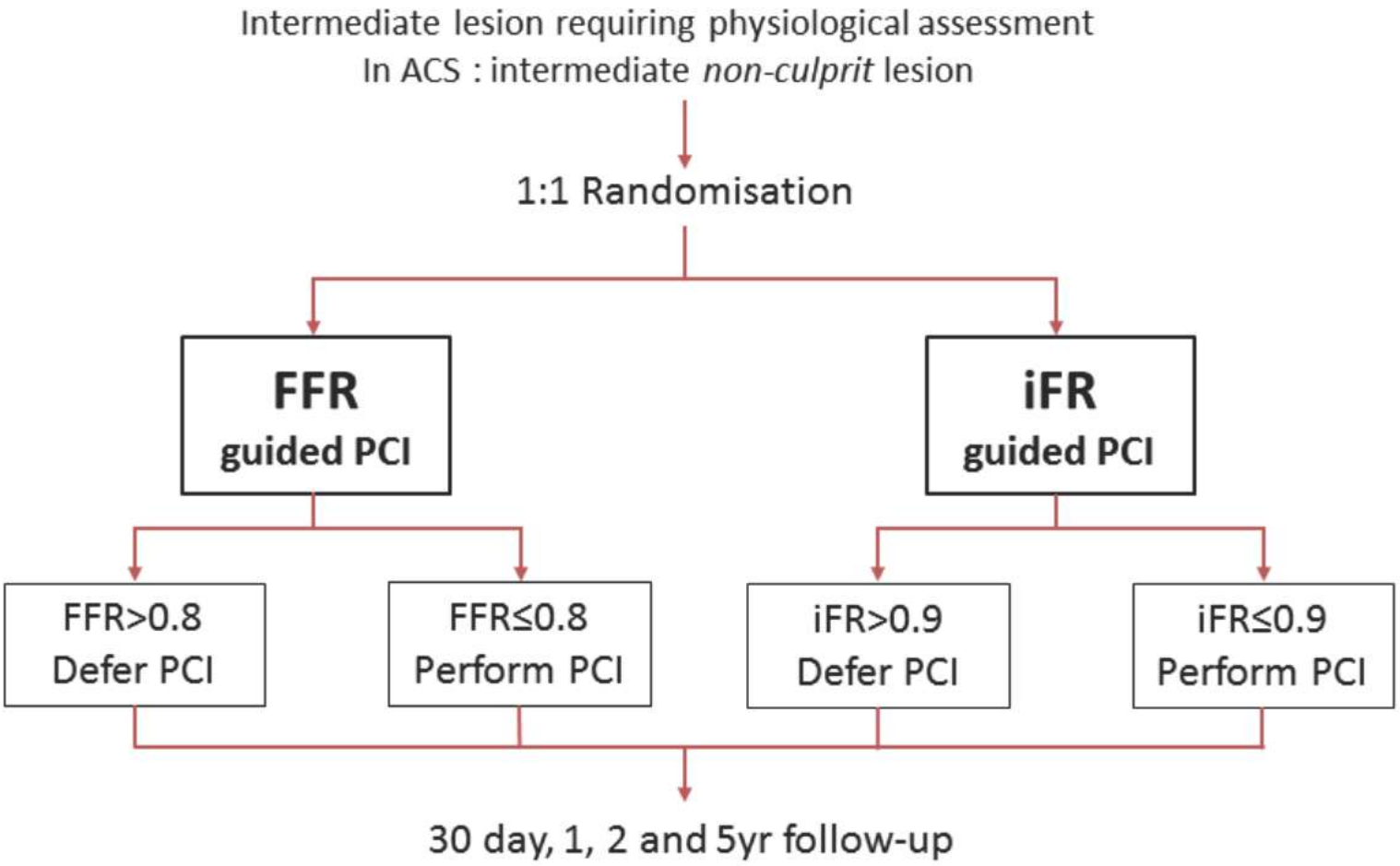
FLAIR trial

Functional Lesion Assessment of Intermediate stenosis to guide Revascularisation

Main sponsor:	**Imperial College London**
Funders:	**Unrestricted Educational grant from Volcano Corporation**
Study coordination centre:	**Imperial College London**
NRES reference:	**TBC**
Principal Investigators:	**Justin Davies & Javier Escaned**
Study Chairman:	**Manesh Patel**
Medical Lead:	**Sayan Sen**
Steering Committee:	**Eric Van Belle, Farrel Hellig, Raj Kharbanda, Martin Mates, Hitoshi Matsuo, and Nob Tanaka**

Evaluation including cost、complication、procedure time、as well as pt satisfaction

Study design



Thank you for your attention!!!