FFR vs iFR
Usefulness & Limitation

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Disclosure Statement of Financial Interest

Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

Affiliation/Financial Relationship

- **Grant/Research Support** : **Abbott Vascular Japan**
  Goodman Inc.
  St. Jude Medical Japan
  Terumo Inc.

- **Consulting Fees/Honoraria** : **Daiichi-Sankyo Pharmaceutical Inc.**
  Goodman Inc.
  St. Jude Medical Japan
  Terumo Inc.

Agenda

- Estimation of myocardial ischemia by FFR
- Assessment of myocardial ischemia by iFR
- FFR vs iFR: advantages & disadvantages
- FFR or iFR based on coronary physiology

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- Estimation of myocardial ischemia by FFR
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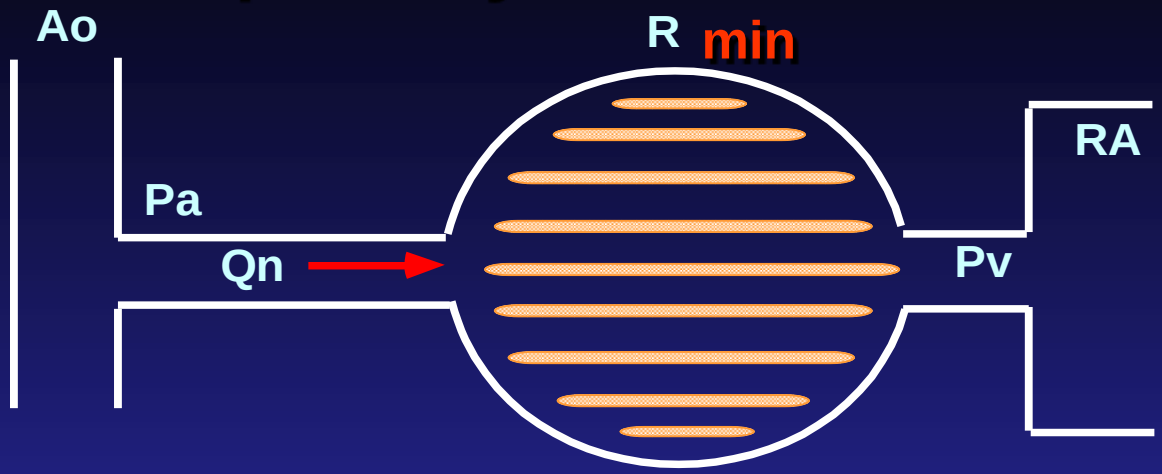
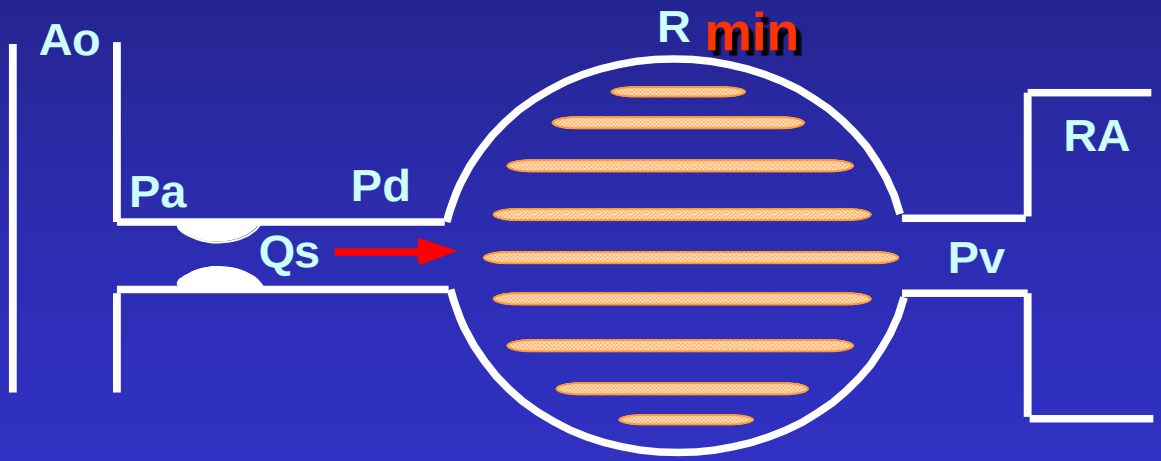
Concept of myocardial fractional flow reserve (FFR myo)



Qn = (Pa - Pv) / R min

Q	Myocardial blood flow
Qn	Max. Q without stenosis
Qs	Max. Q with stenosis
R	Resistance of vascular bed
Pa	Mean aortic pressure
Pw	Coronary wedge pressure
Pv	Coronary venous pressure

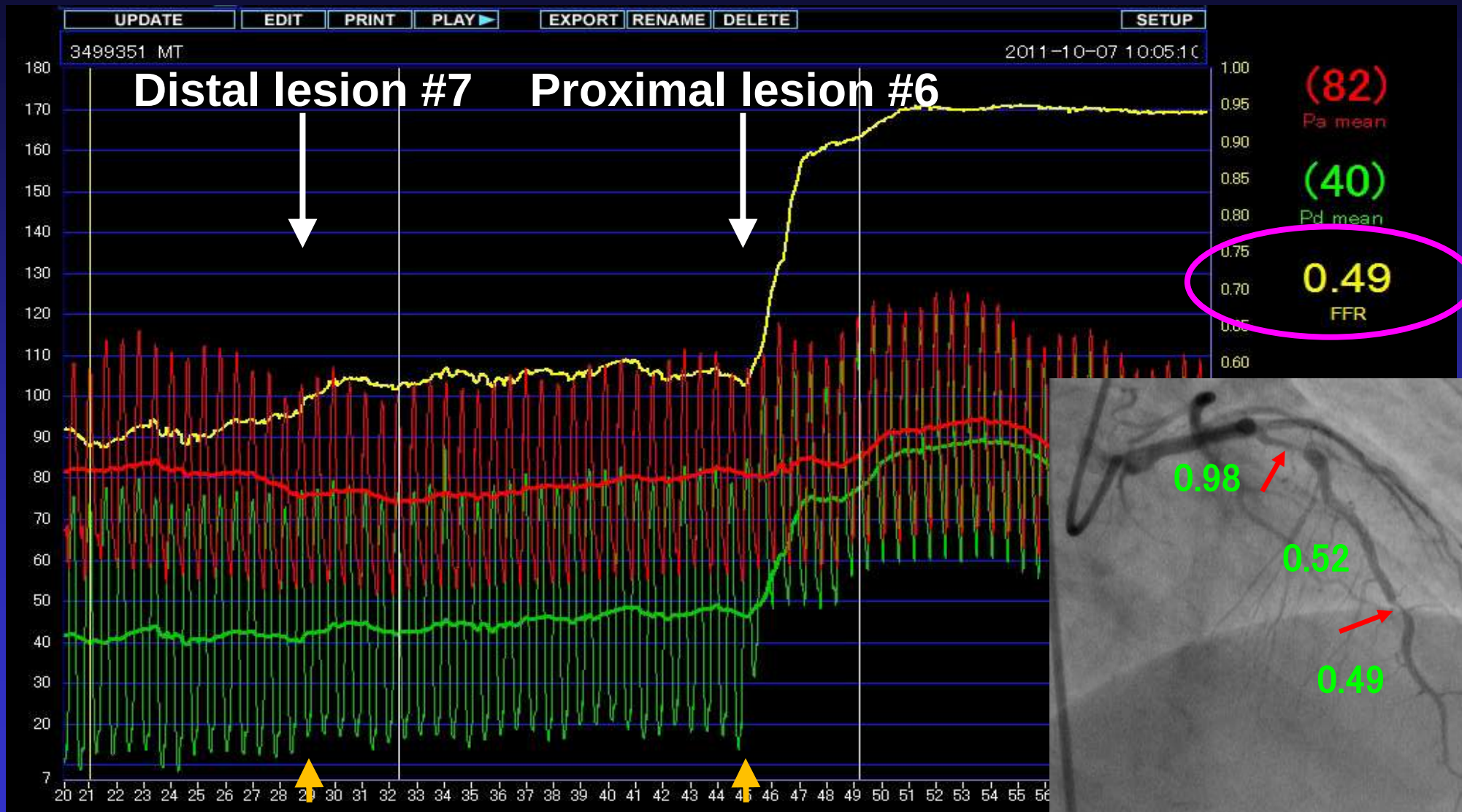


Qs = (Pd - Pv) / R min

$$\text{FFR myo} = \frac{Qs}{Qn} = \frac{Pd - Pv}{Pa - Pv} \fallingdotseq \frac{Pd}{Pa}$$

It is very important to make coronary resistance minimum to compare between the different flow conditions with and without stenosis

FFR (prePCI)


UPDATE
EDIT
PRINT
PLAY
EXPORT
RENAME
DELETE
SETUP
3499351 MT
2011-10-07 10:05:1
Distal lesion #7
Proximal lesion #6
(82)
Pa mean
(40)
Pd mean
0.49
FFR

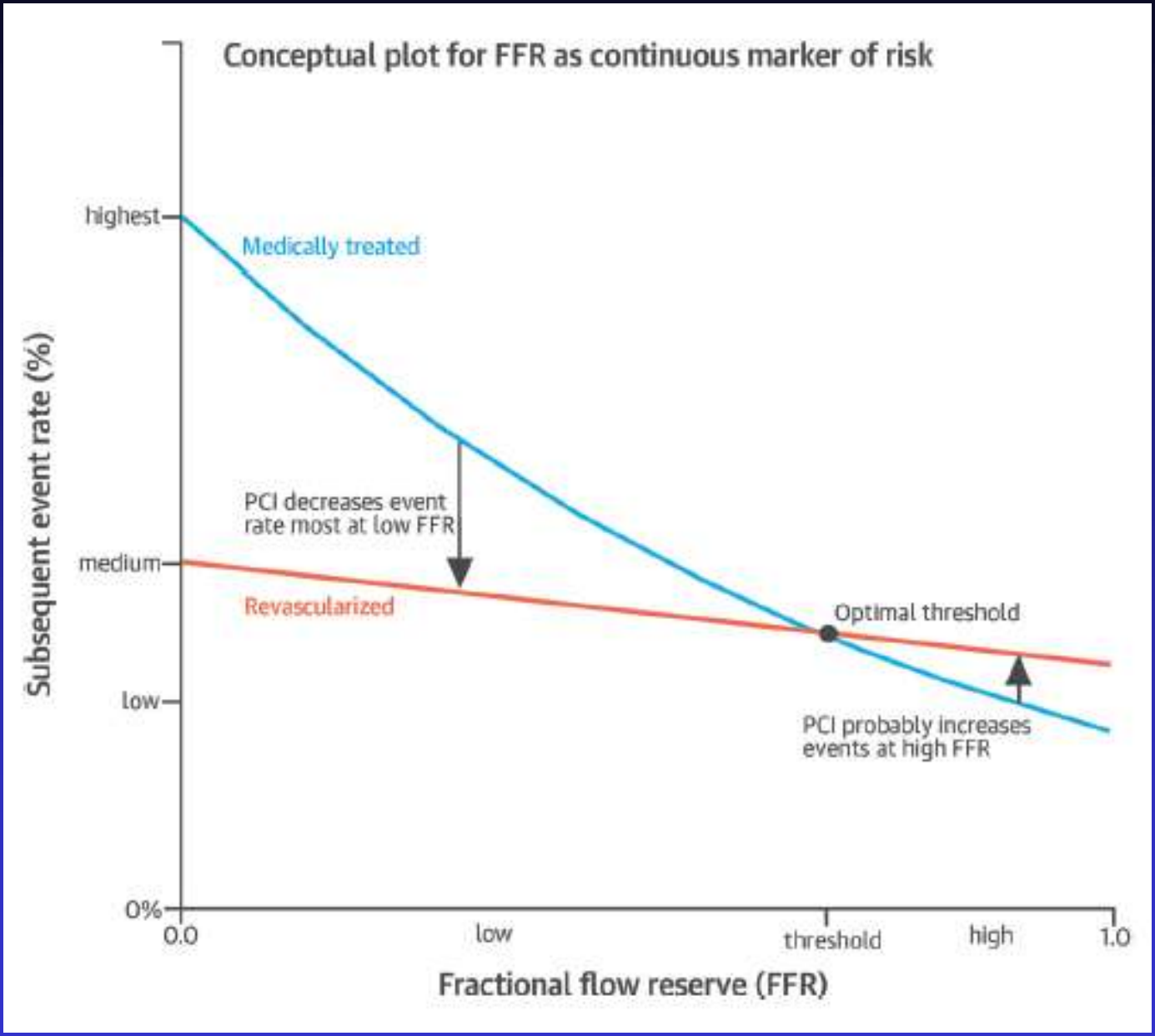
0.98
0.52
0.49

Relationship between FFR & other tests

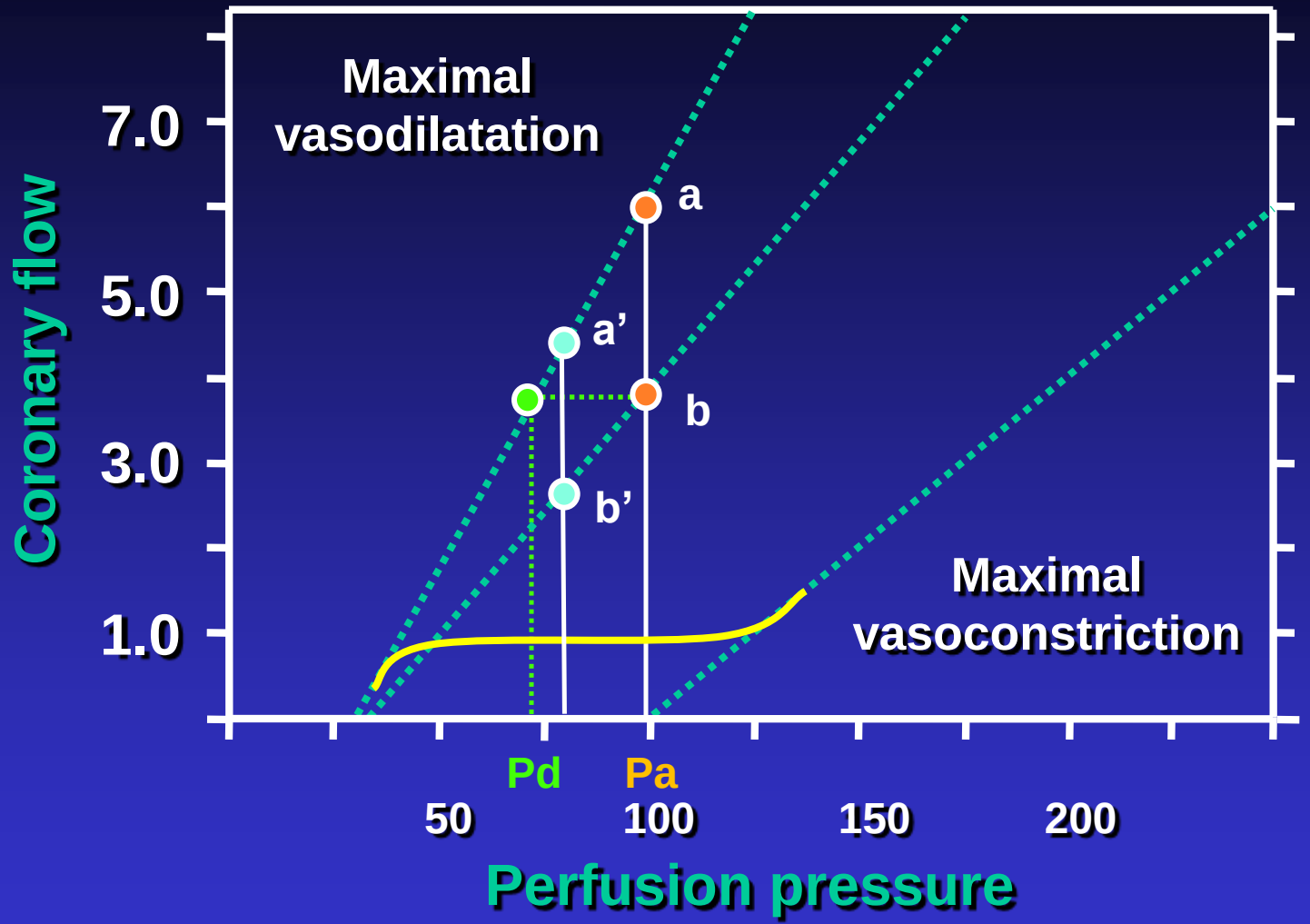
Authors	Number	Ischemic tests	Best cut-off value	Accuracy
Pijls et al.	60	X-ECG	0.74	97
DeBruyne et al.	60	X-ECG/SPECT	0.72	85
Pijls et al.	45	X-ECG/SPECT/pacing/DSE	0.75	93
Bartunek et al.	37	DSE	0.68	90
Abe et al.	46	SPECT	0.75	91
Chamuleau et al.	127	SPECT	0.74	77
Caymaz et al.	40	SPECT	0.76	95
Jimenez-Navarro et al.	21	DSE	0.75	90
Usui et al.	167	SPECT	0.75	79
Yanagisawa et al.	167	SPECT	0.75	76
Meuwissen et al.	151	SPECT	0.74	85
DeBruyne et al.	57	MIBI-SPECT post-MI	0.78	85
Samady et al.	48	MIBI-SPECT post-MI	0.78	85

(Kern MJ & Samady H. J Am Coll Cardiol 2010;55:173-185)

Conceptual relationship between FFR & outcomes

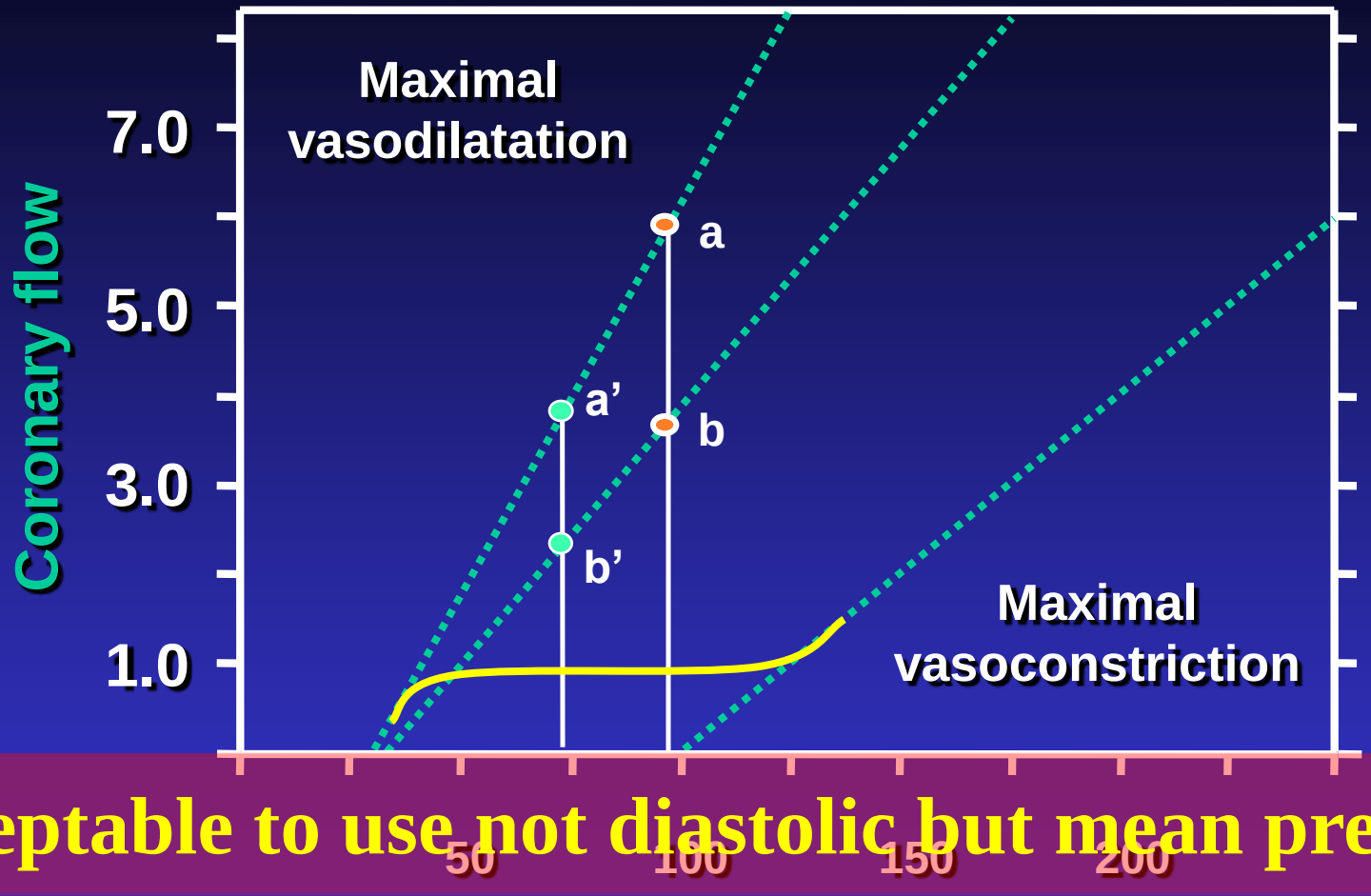


Diastolic pressure－flow relationship & FFR



$$FFR = \frac{b}{a} = \frac{Pd}{Pa} = \frac{b'}{a'}$$

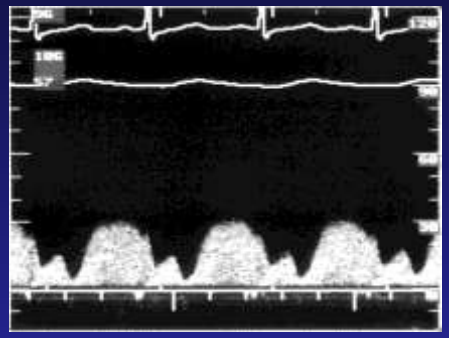
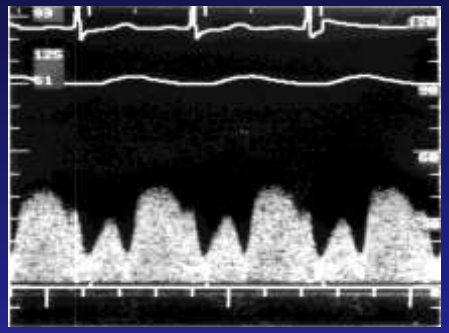
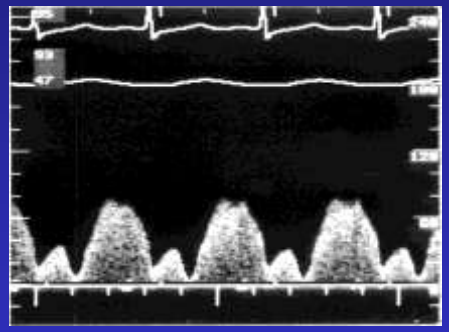
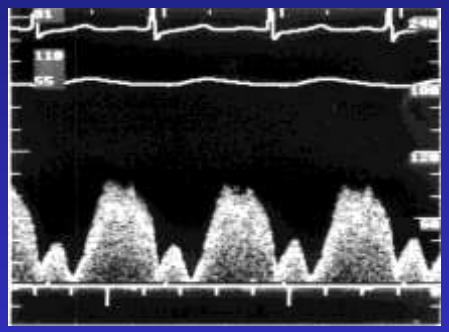
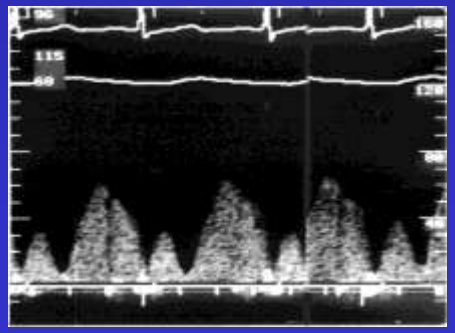
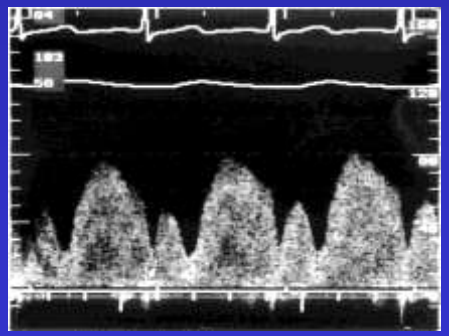
Diastolic pressure－flow relationship & FFR



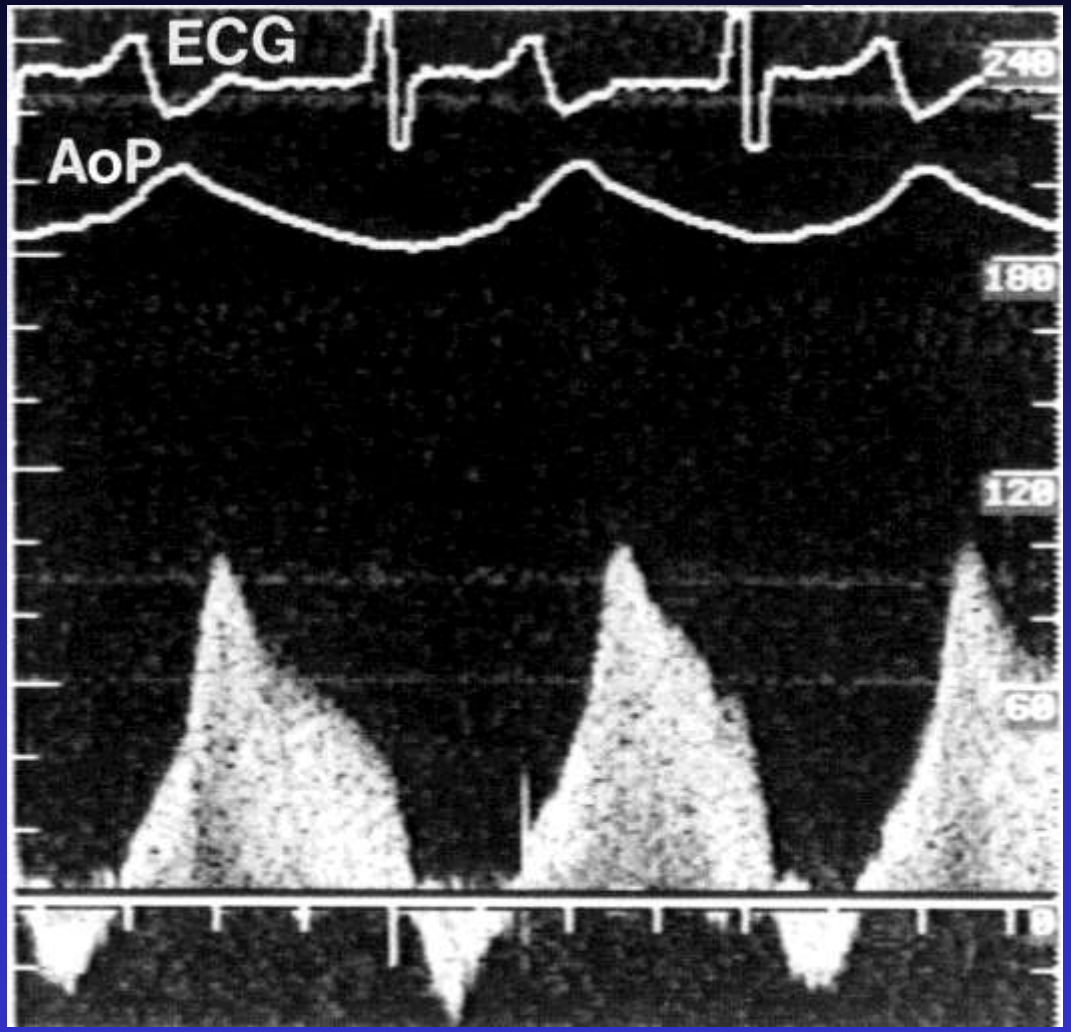
Is it acceptable to use not diastolic but mean pressure?

$$FFR = \frac{b}{a} = \frac{b'}{a'}$$

Coronary Flow Velocity Recordings

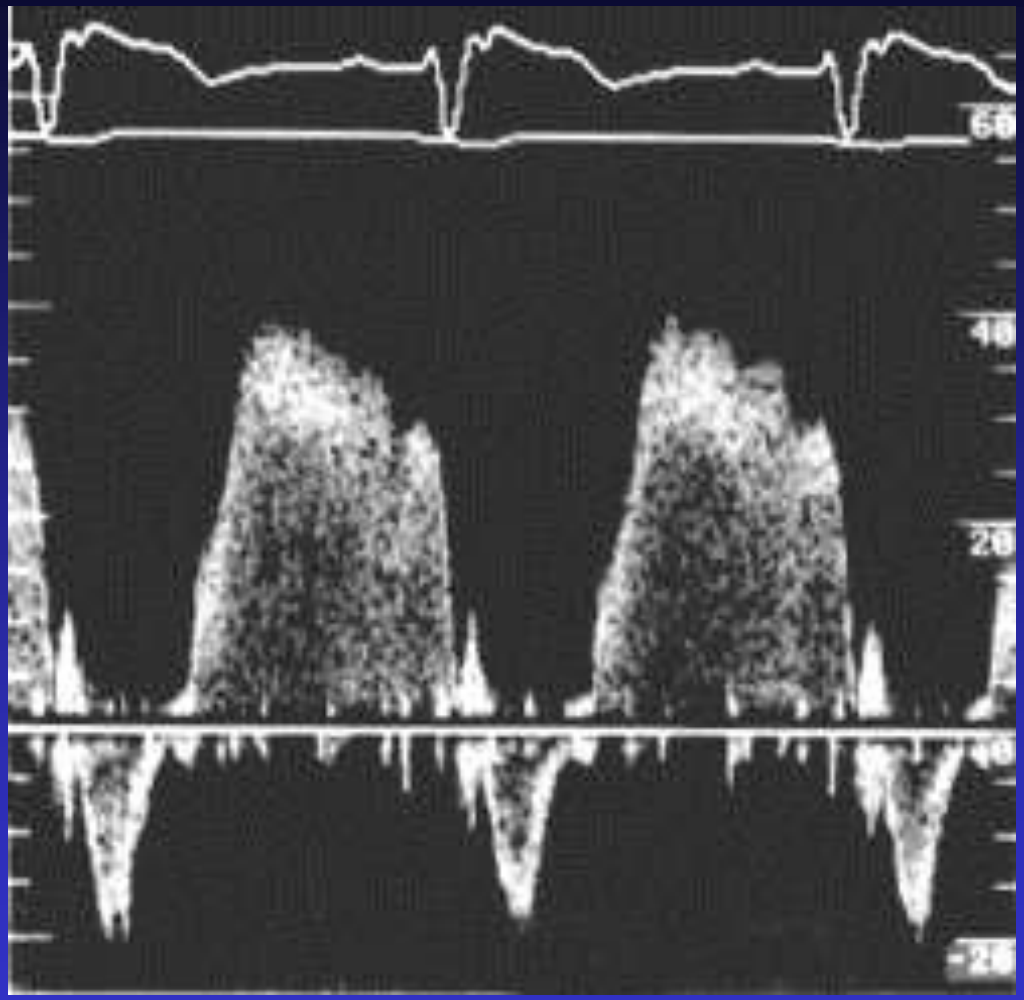
	Baseline	Hyperemia	CFVR
LAD			30 / 25 = 1.2
LCx			60 / 54 = 1.1
RCA			52 / 36 = 1.4

Aortic stenosis



(Yoshikawa J, Akasaka T et al. J Am Soc Echocardiogr 1993; 6:516-524)

HCM



(Akasaka T, et al. J Am Soc Echocardiogr 7:9-19, 1994)

Diastolic Fractional Flow Reserve to Assess the Functional Severity of Moderate Coronary Artery Stenoses

Masayuki Abe, Hirofumi Tomiyama, Hideo Yoshida, and Nobutaka Doba

Circulation 2000;102(19):2365-2370

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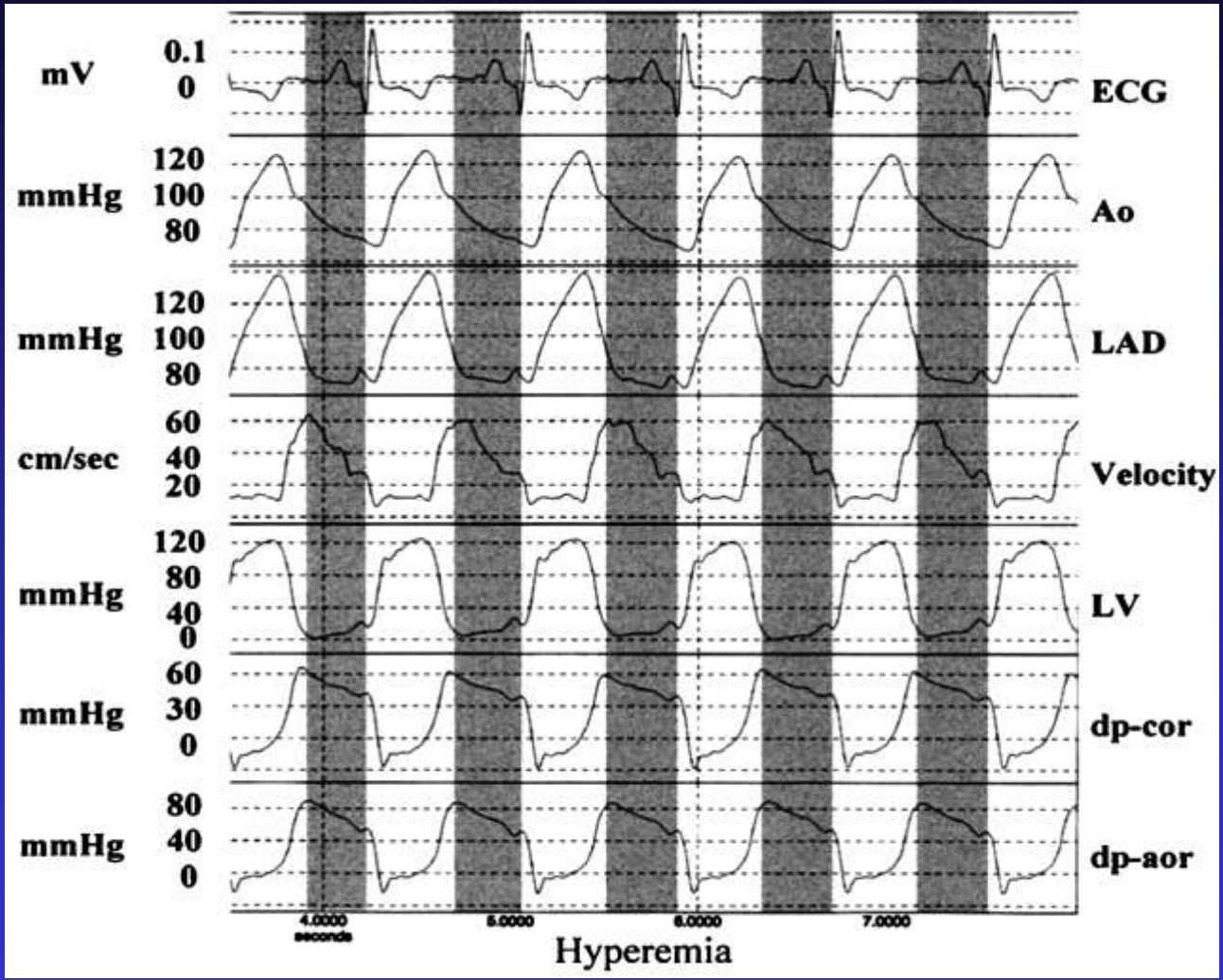
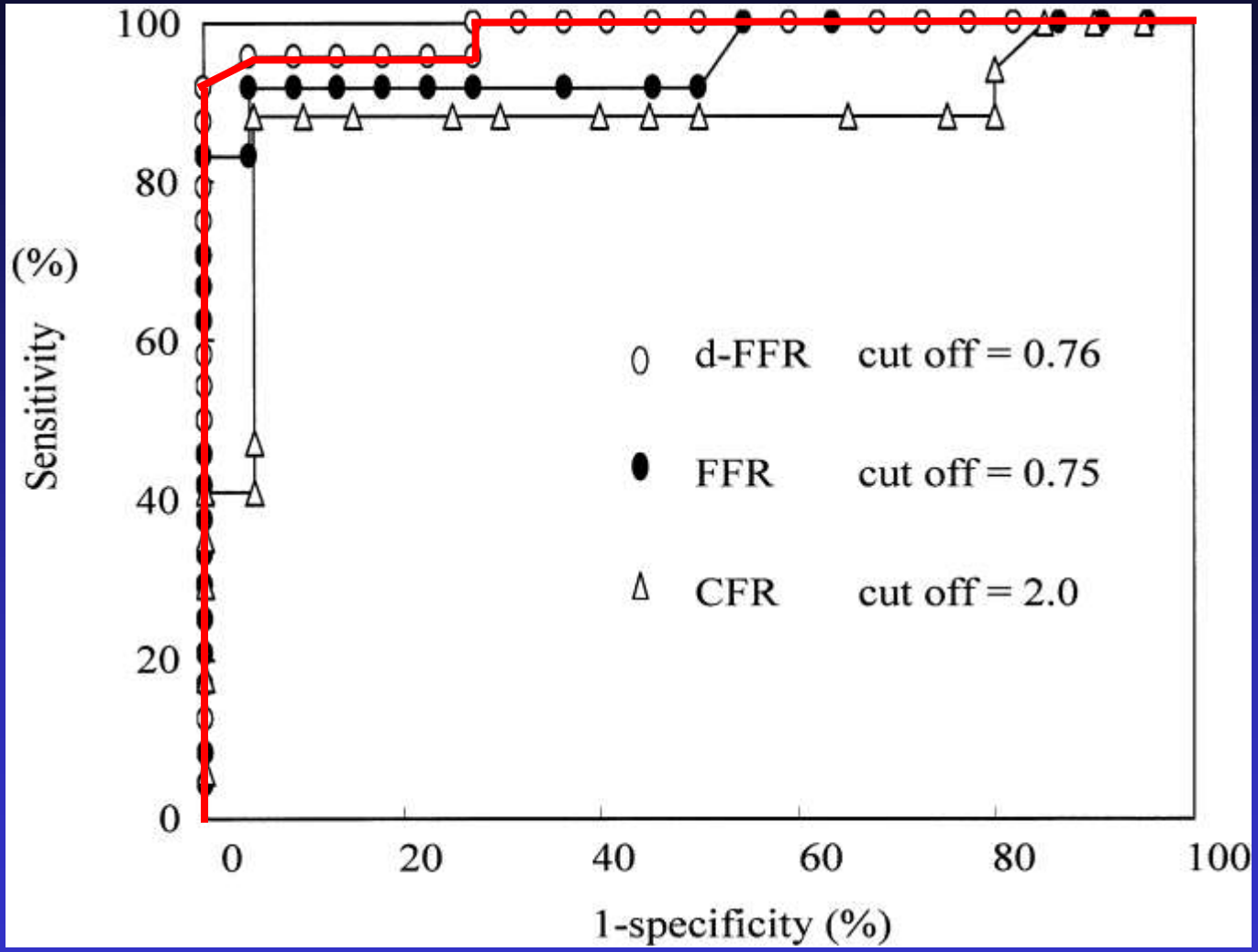
Diastolic Fractional Flow Reserve to Assess the Functional Severity of Moderate Coronary Artery Stenoses



Abe M et al. Circulation 2000;102:2365-2370

ROC curves for FFR, diastolic-FFR, and CFR used to discriminate noninvasive test–positive and –negative results.

Abe M et al. Circulation 2000;102:2365-2370



DIASTOLE

Observational study for demonstrating superiority of d-FFR to FFR is now ongoing prospectively up to 400 patients.

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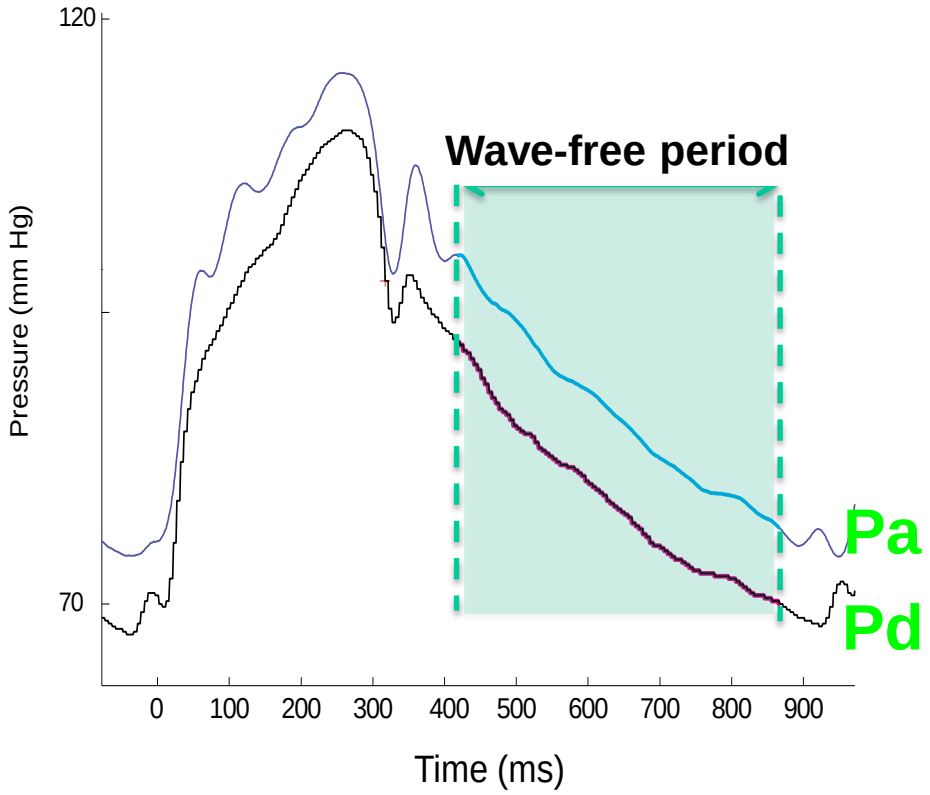
Agenda

- Estimation of myocardial ischemia by FFR
- **Assessment of myocardial ischemia by iFR**
- FFR vs iFR: advantages & disadvantages
- FFR or iFR based on coronary physiology

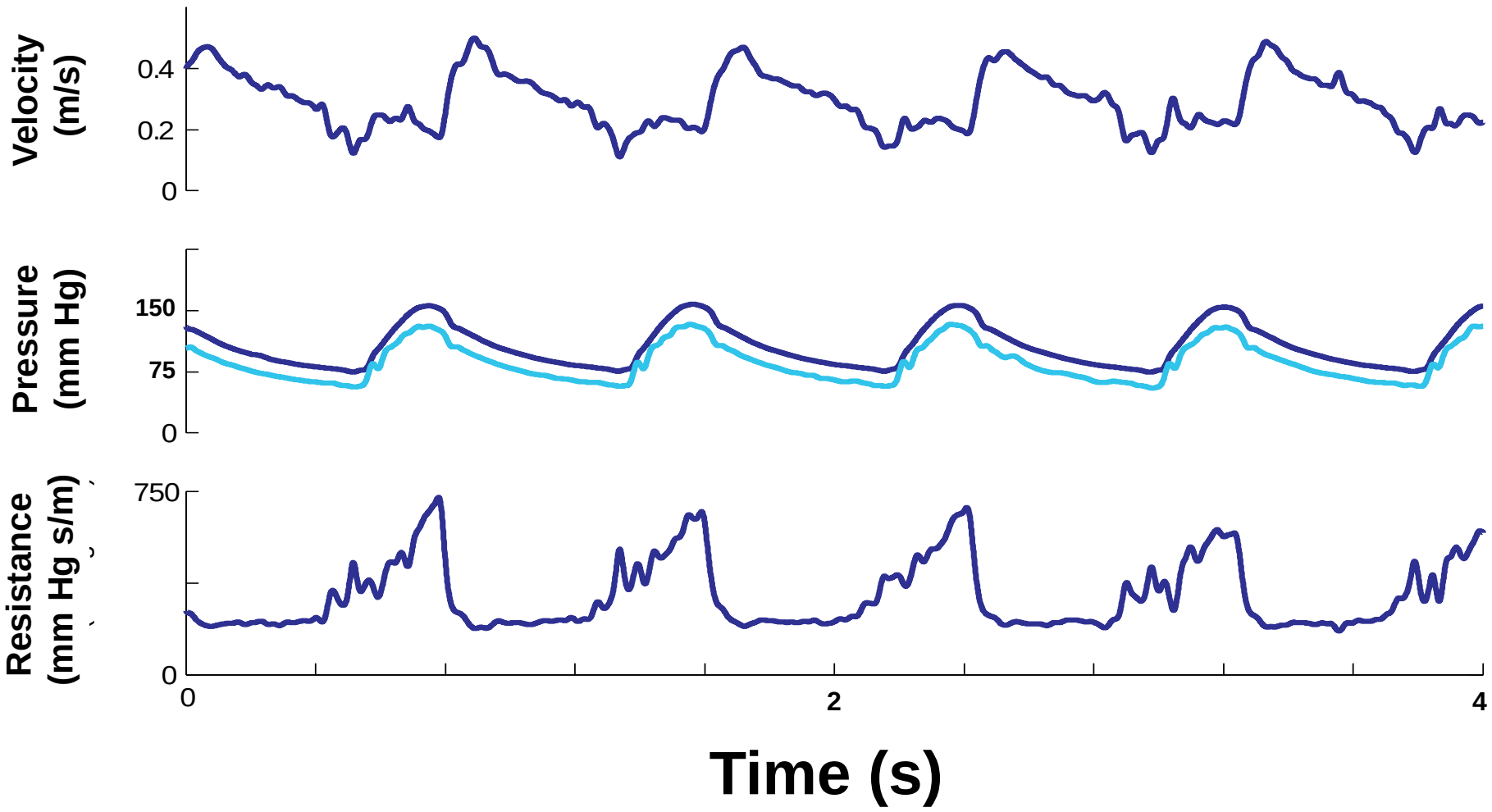
iFR = instantaneous wave-free ratio

Sen S et al. J Am Coll Cardiol. 2012;59(15):1392-402

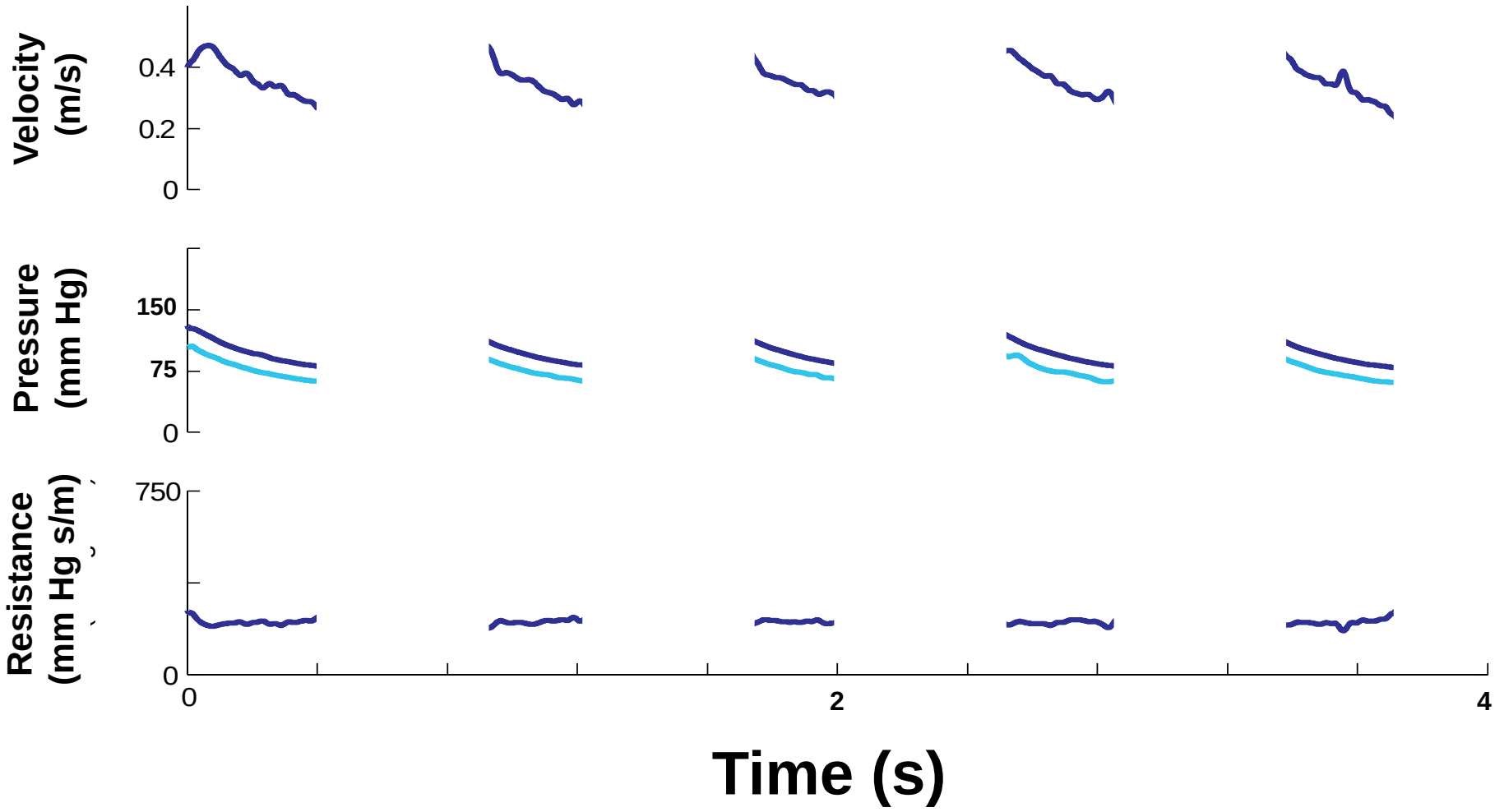


Instantaneous pressure gradient between proximal and distal to coronary stenosis during wave-free period（minimum resistance phase during cardiac cycle）

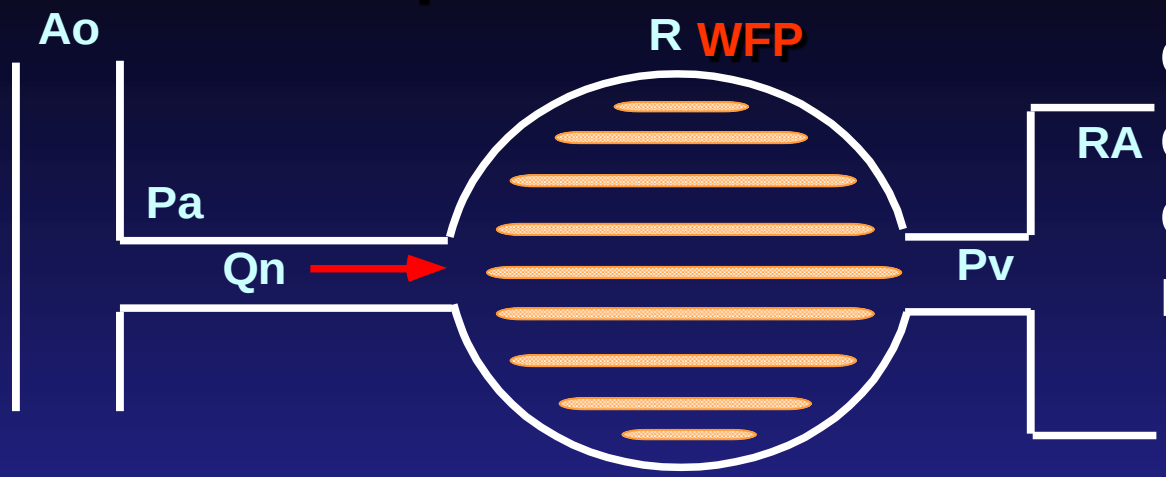
Using iFR to identify stable resistance phase



Resistance is stable during the wave-free window



Concept of instantaneous wave free ratio (iFR)



$Qn = (Pa - Pv) / R_{WFP}$

Q	Myocardial blood flow
Qn	Wave free Q without stenosis
Qs	Wave free Q with stenosis
R	Resistance of vascular bed
Pa	Mean aortic pressure
Pw	Coronary wedge pressure
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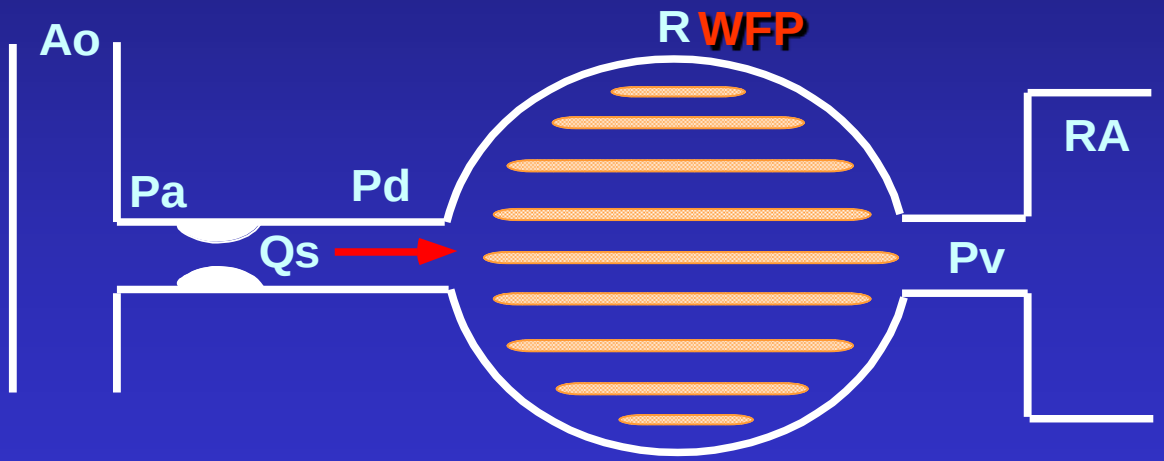


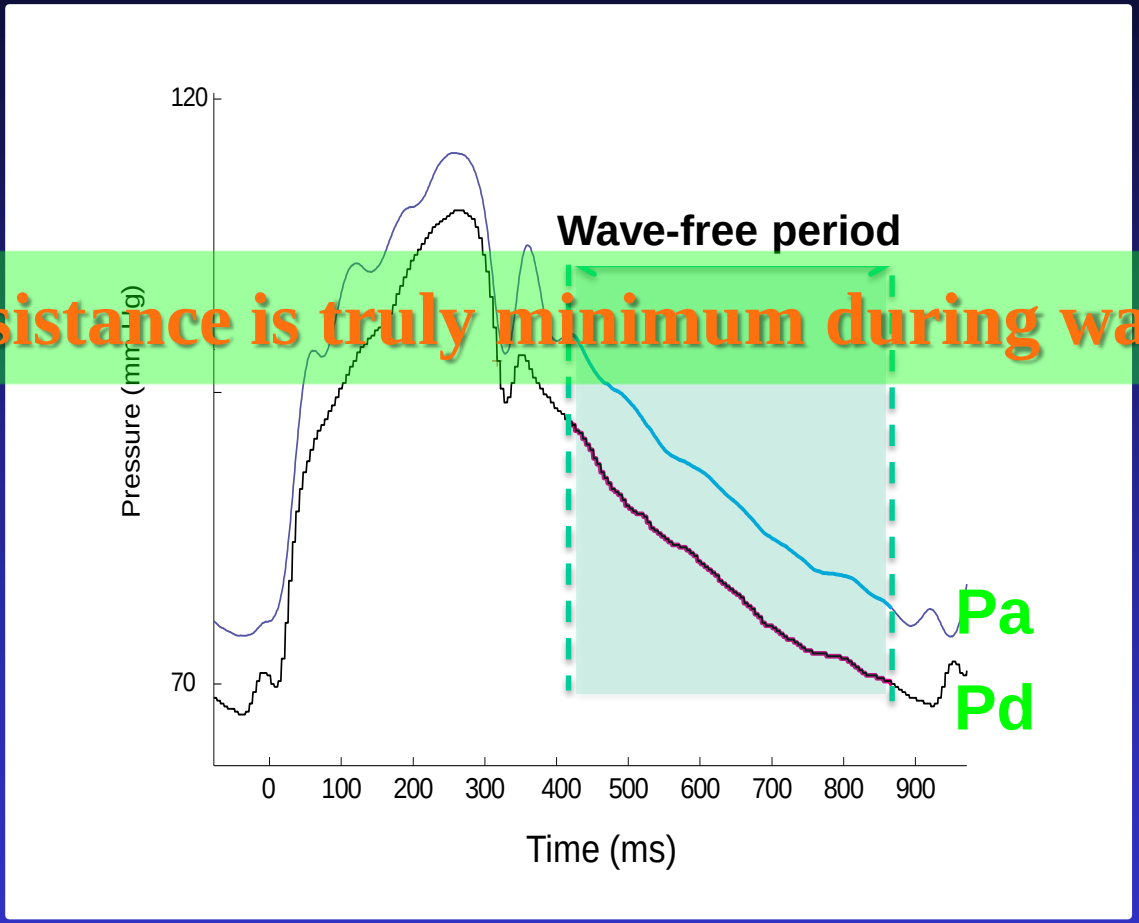
$Qs = (Pd - Pv) / R_{WFR}$

$$iFR = Qs / Qn_{WFP} = \frac{Pd - Pv}{Pa - Pv} \fallingdotseq Pd / Pa_{WFP}$$

It is important to measure coronary pressures prox. & dist. to the stenosis at wave-free period instantaneously to compare between the different flow conditions

iFR = instantaneous wave-free ratio

Sen S et al. J Am Coll Cardiol. 2012;59(15):1392-402

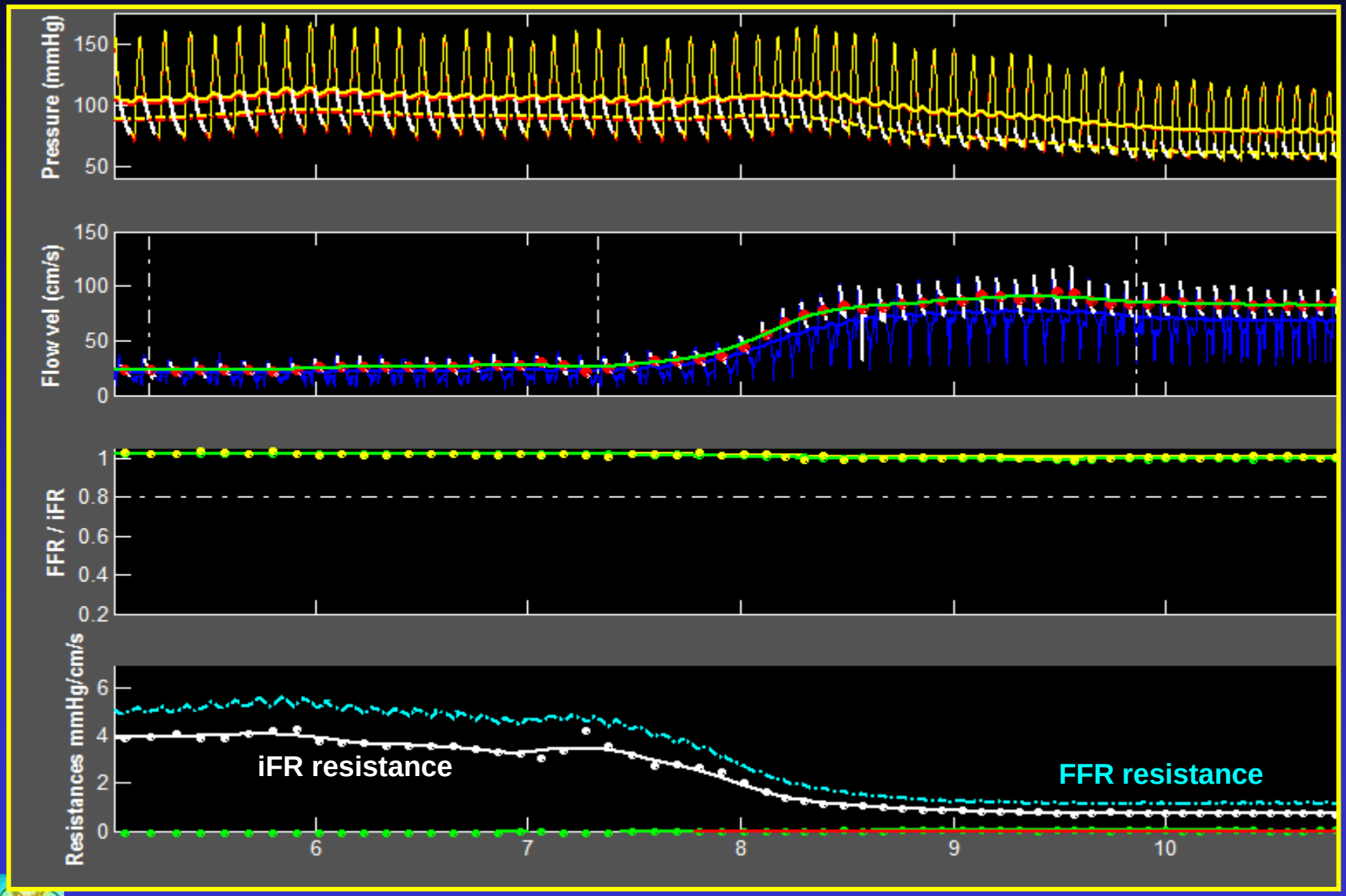


Coronary resistance is truly minimum during wave-free period?

Instantaneous pressure gradient between proximal and distal to coronary stenosis during wave-free period（minimum resistance phase during cardiac cycle）

Example of a case when FFR resistance goes down significantly

Non obstructive artery



Flow is normal
CFR=3.2
HSR=0.1

iFR and FFR normal

FFR resistance equal to iFR resistance.

iFR resistance decreased significantly !!!

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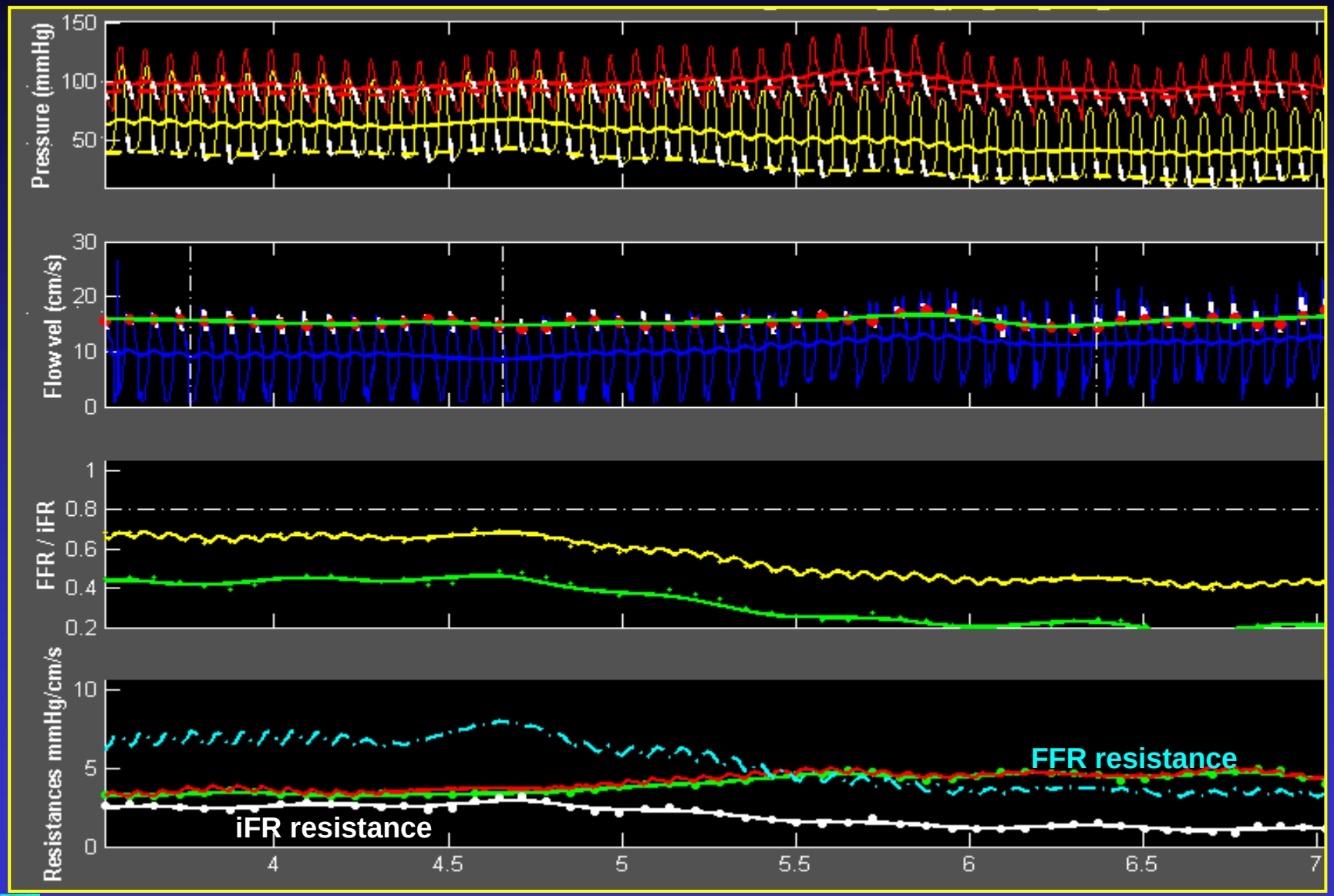
Example of a case when FFR resistance higher than iFR resistance

Obstructed artery



Flow abnormal
CFR=1.3
HSR=4.5

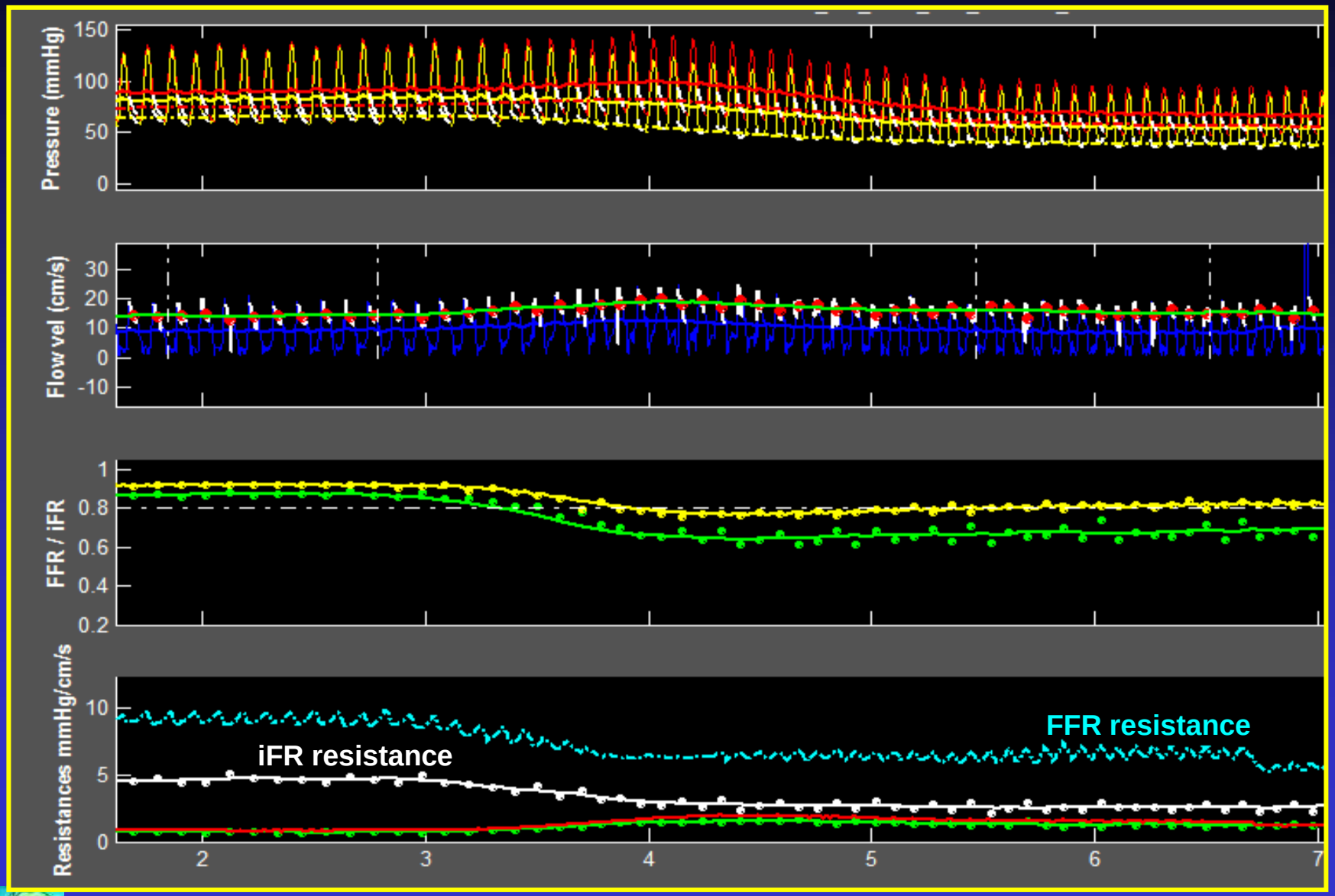
iFR=0.44
FFR=0.42

FFR resistance higher than iFR resistance.

iFR resistance decreased significantly !!!

Example of a case when FFR resistance higher than iFR resistance

Obstructed artery



Flow abnormal
CFR=1.0
HSR=1.5

iFR=0.87
FFR=0.80

FFR resistance higher than iFR resistance.

iFR resistance decreased significantly !!!

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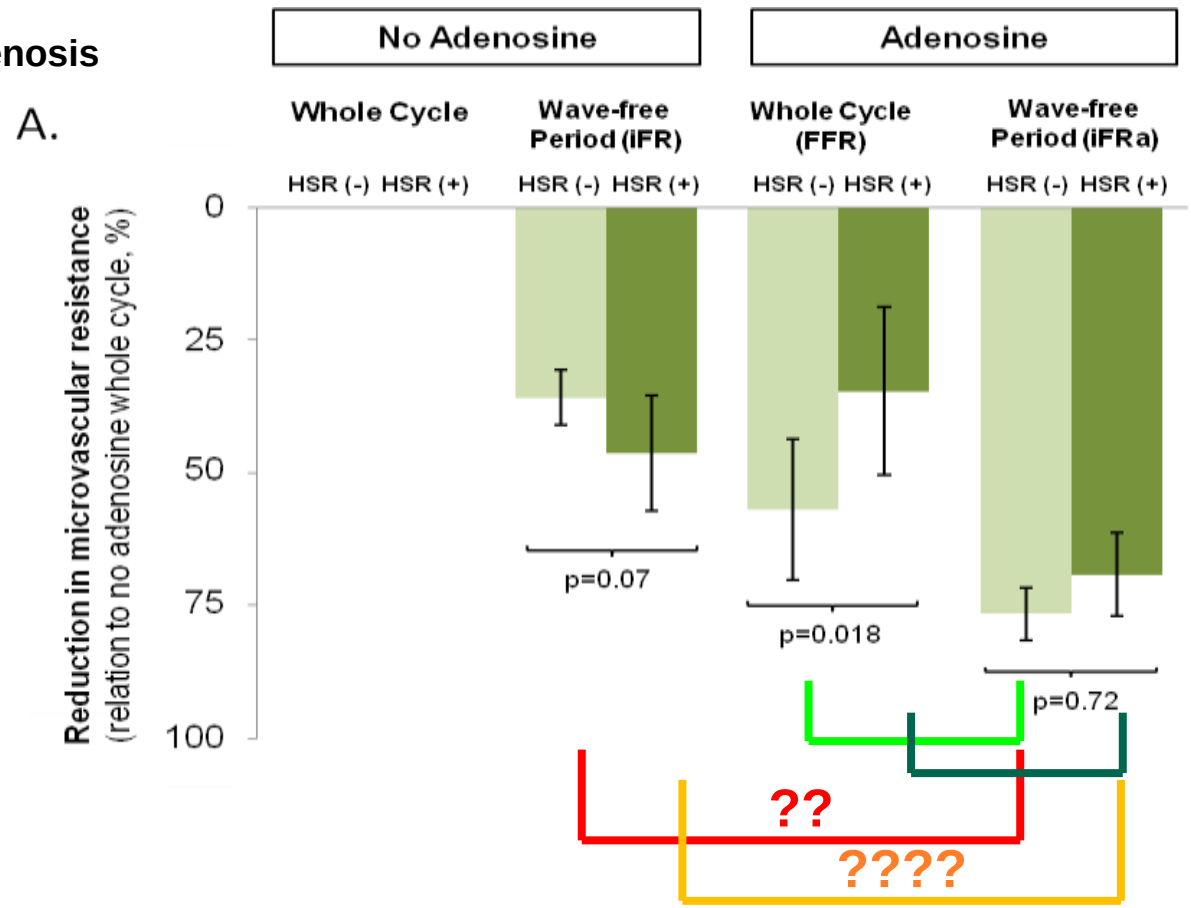
CLARIFY an ADVISE sub-study

Summary of microvascular resistance (MVR) reduction with & without hyperemia by adenosine infusion in cases with or without significant stenosis

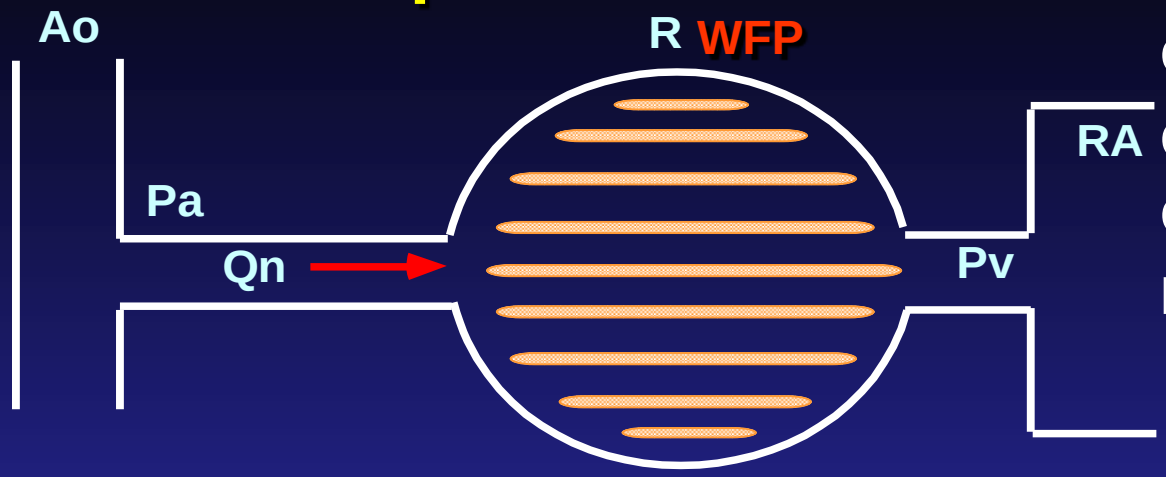
HSR(−); no stenosis

HSR(+); stenosis



Although there are no significant difference in MVR during wave free period in cases with & without stenosis, MVR is higher in cases with stenosis compared with that in cases without stenosis.

Concept of instantaneous wave free ratio (iFR)



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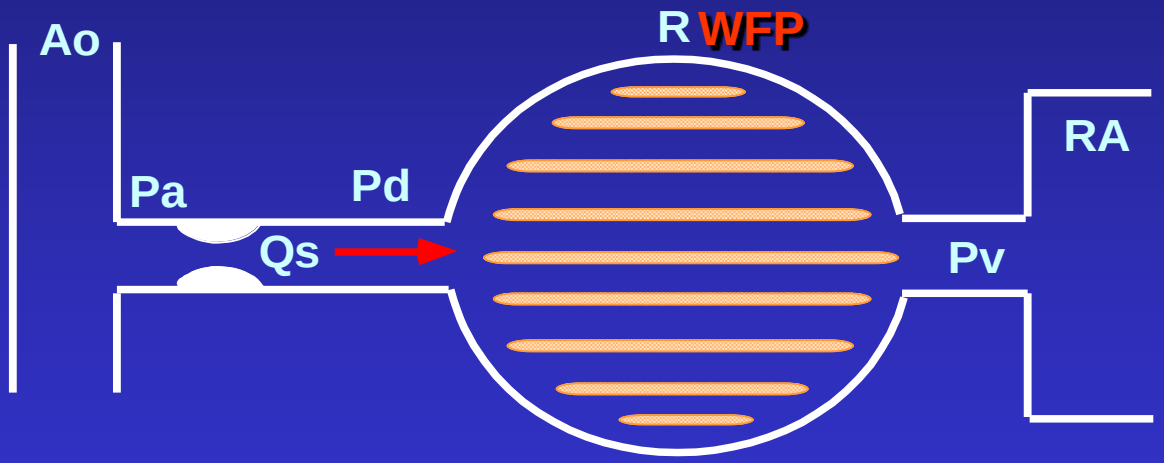
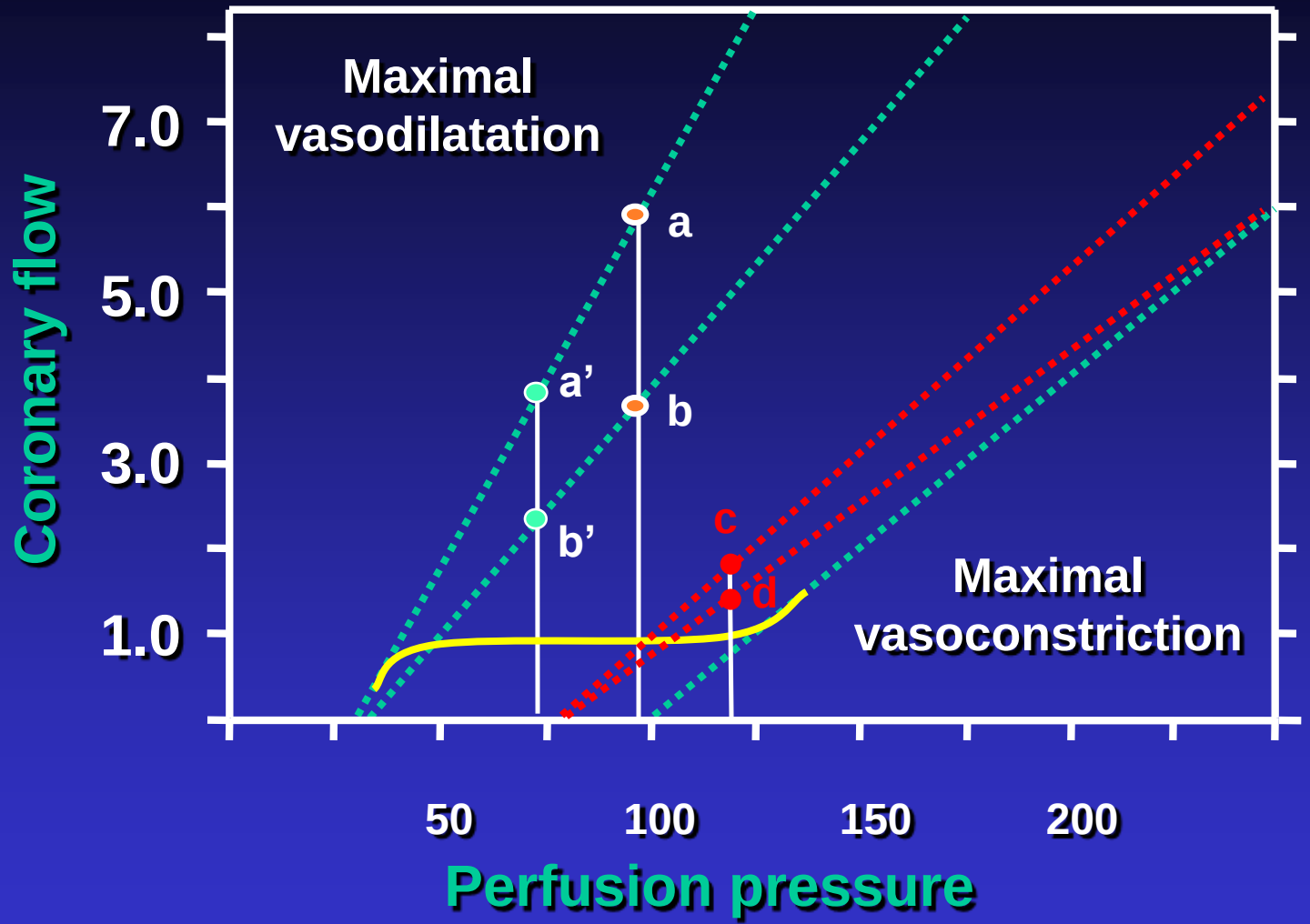


Qs = (Pd - Pv) / RWFR

$$iFR = Qs / Qn_{WFP} = \frac{Pd - Pv}{Pa - Pv} \fallingdotseq Pd / Pa_{WFP}$$

Can we really apply this equation to evaluate myocardial ischemia based on concept of coronary physiology ?

Diastolic pressure－flow relationship & FFR



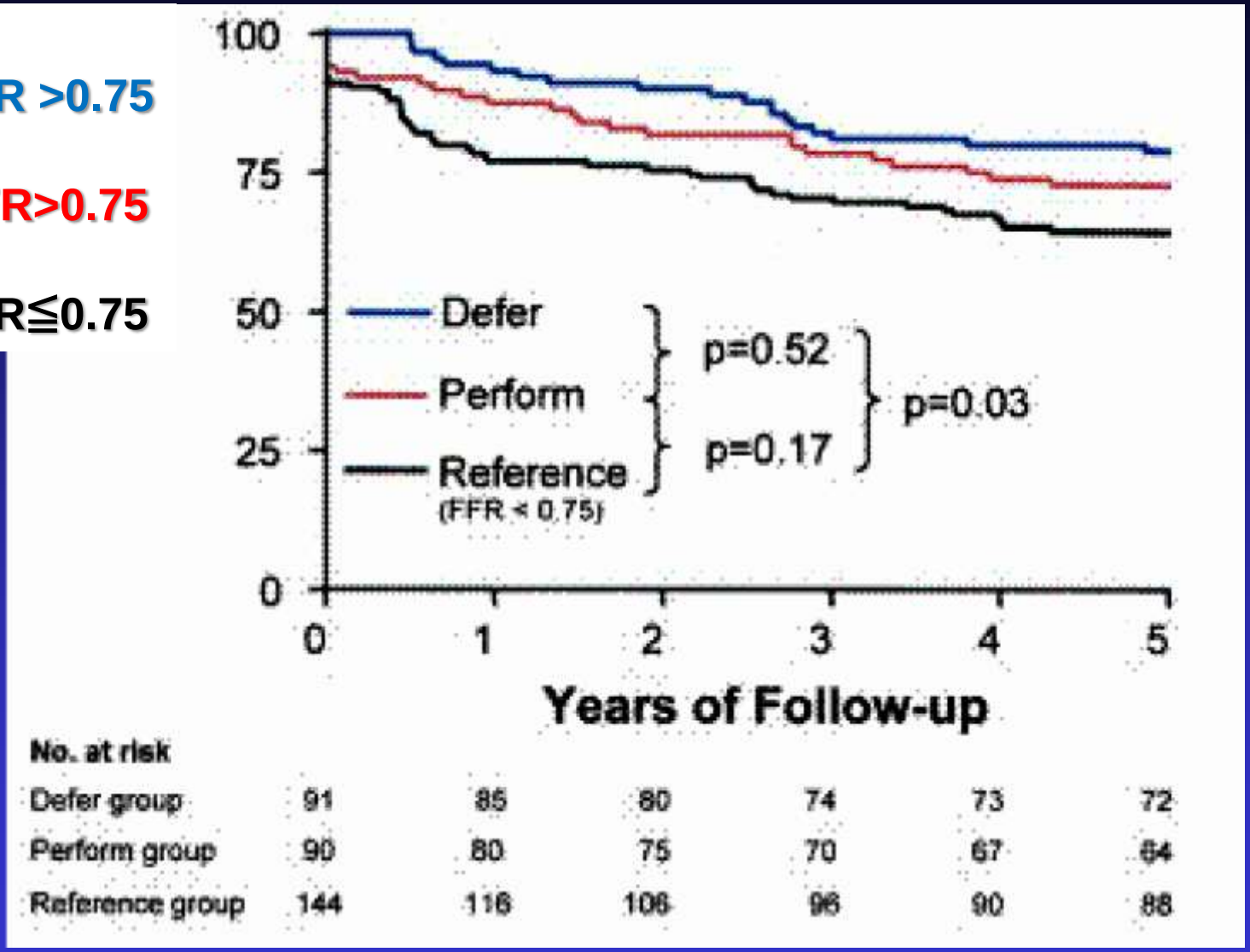
$$FFR = \frac{b}{a} = \frac{b'}{a'} \propto \frac{d}{c} \text{???}$$

Agenda

- Estimation of myocardial ischemia by FFR
- Assessment of myocardial ischemia by iFR
- **FFR vs iFR: advantages & disadvantages**
- FFR or iFR based on coronary physiology

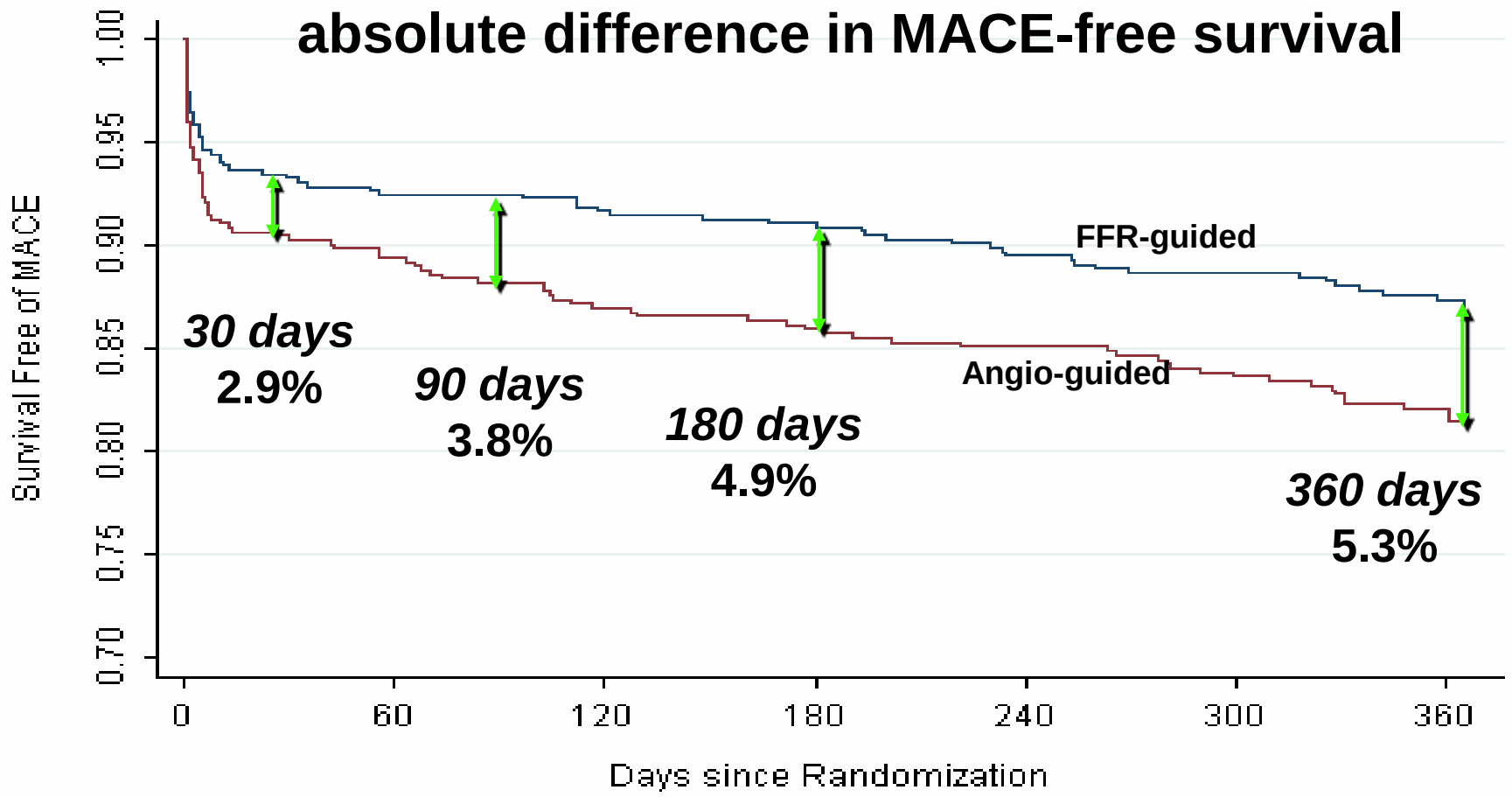
Event Free Survival

Defer: defer PCI
due to FFR >0.75
Perform: perform PCI
even if FFR>0.75
Reference: perform PCI
due to FFR≦0.75



Pijls NHJ, et al. J Am Coll Cardiol 49:2105-2111, 2007

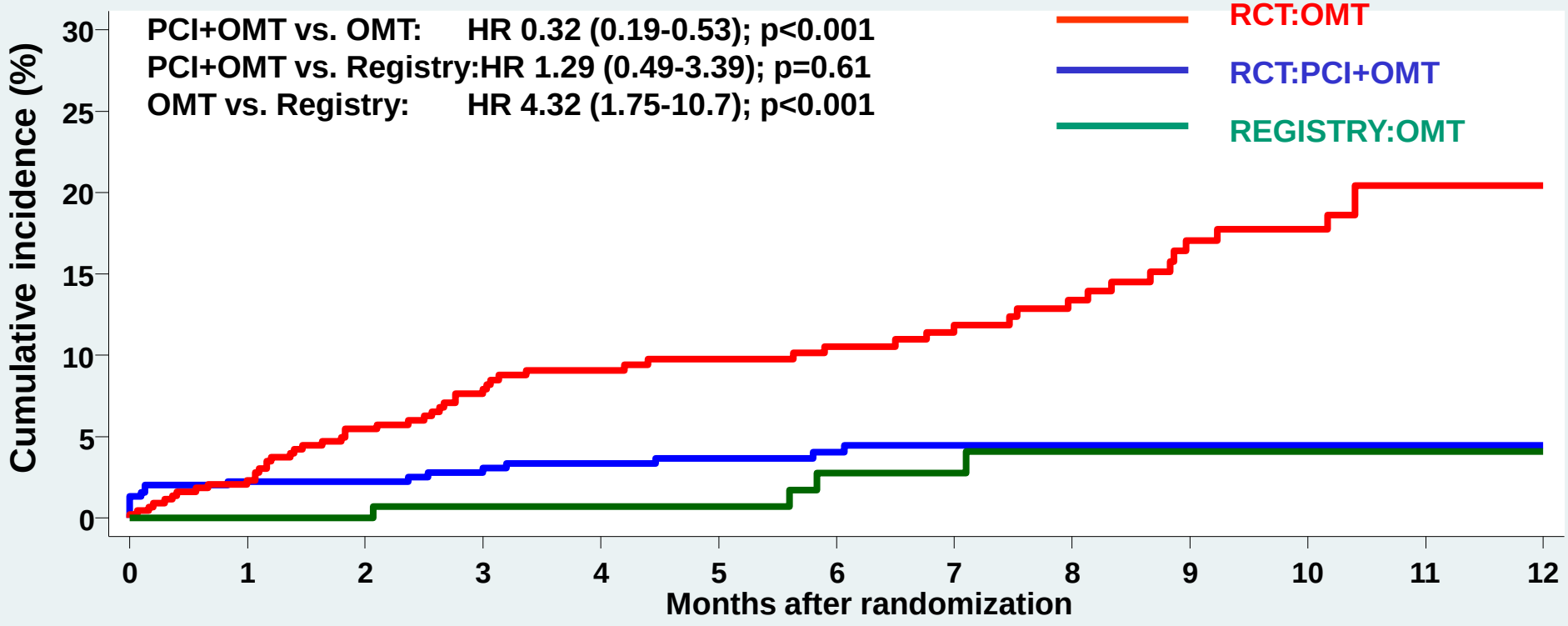
FAME study: Event-free Survival



Tonino, et al. New Engl J Med 2009;360:213-24.

Primary Outcomes in FAME II

Rate of any revascularization



No. at risk

MT	441	414	370	322	283	253	220	192	162	127	100	70	37
PCI+MT	447	414	388	351	308	277	243	212	175	155	117	92	53
Registry	166	156	145	133	117	106	93	74	64	52	41	25	13

Use of fractional flow reserve, intravascular ultrasound, & optical coherence tomography in SCAD

Recommendations	Class	Level
FFR is recommended to identify hemodynamically relevant coronary lesion(s) when evidence of ischaemia is not available.	I	A
Revascularization of stenoses with FFR <0.80 is recommended in patients with angina symptoms or a positive stress test.	I	B
IVUS or OCT may be considered to characterize lesions.	IIb	B
IVUS or OCT may be considered to improve stent deployment.	IIb	B
Revascularization of an angiographically intermediate stenosis without related ischaemia or without FFR <0.80 is not recommended.	III	B

FFR = fractional flow reserve; IVUS = intravascular ultrasound; OCT = optical coherence tomography; SCAD = stable coronary artery disease.
This slide corresponds to Table 31 in the full text.

www.escardio.org/guidelines

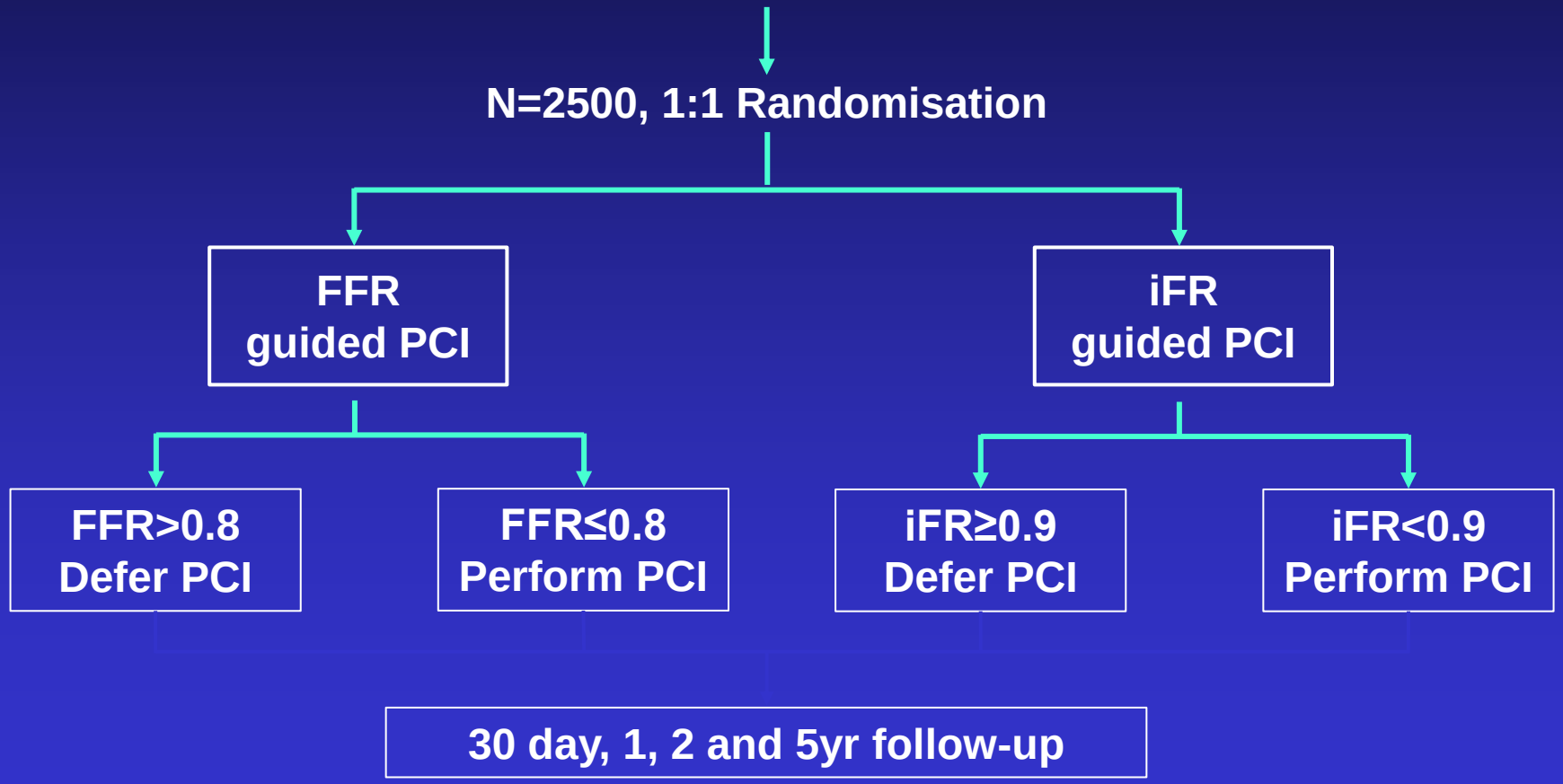
Eur Heart J 2013;34:2949–3003. doi:10.1093/eurheartj/eht296

EUROPEAN SOCIETY OF CARDIOLOGY®

DEFINE FLAIR

Functional Lesion Assessment of Intermediate stenosis to guide Revascularisation

Intermediate lesion requiring physiological assessment
In ACS : intermediate *non-culprit* lesion



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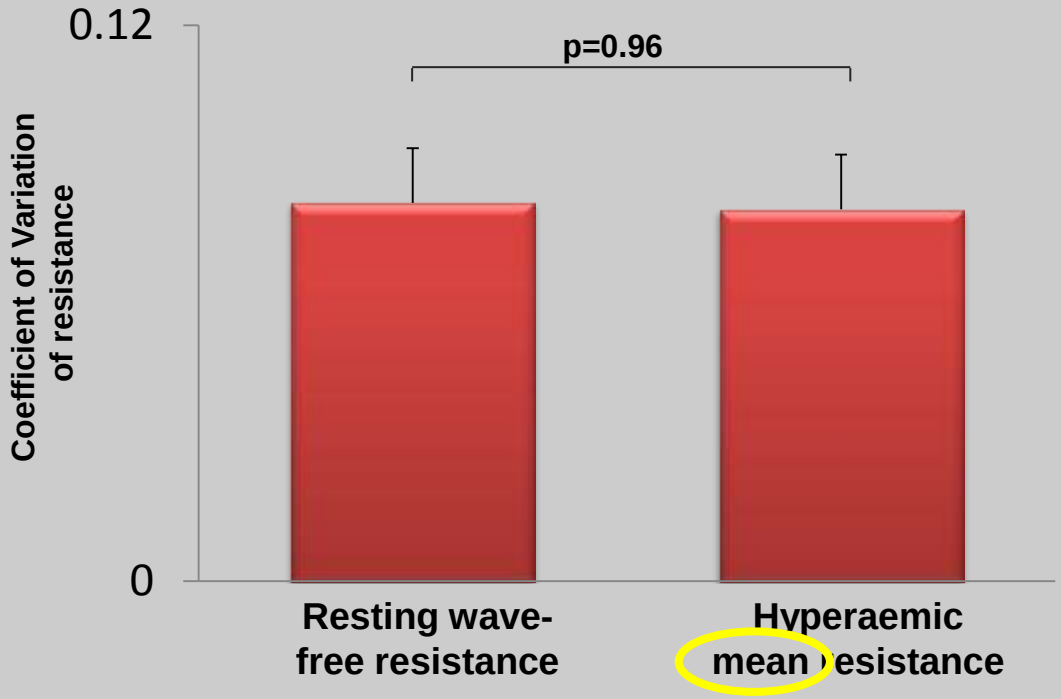
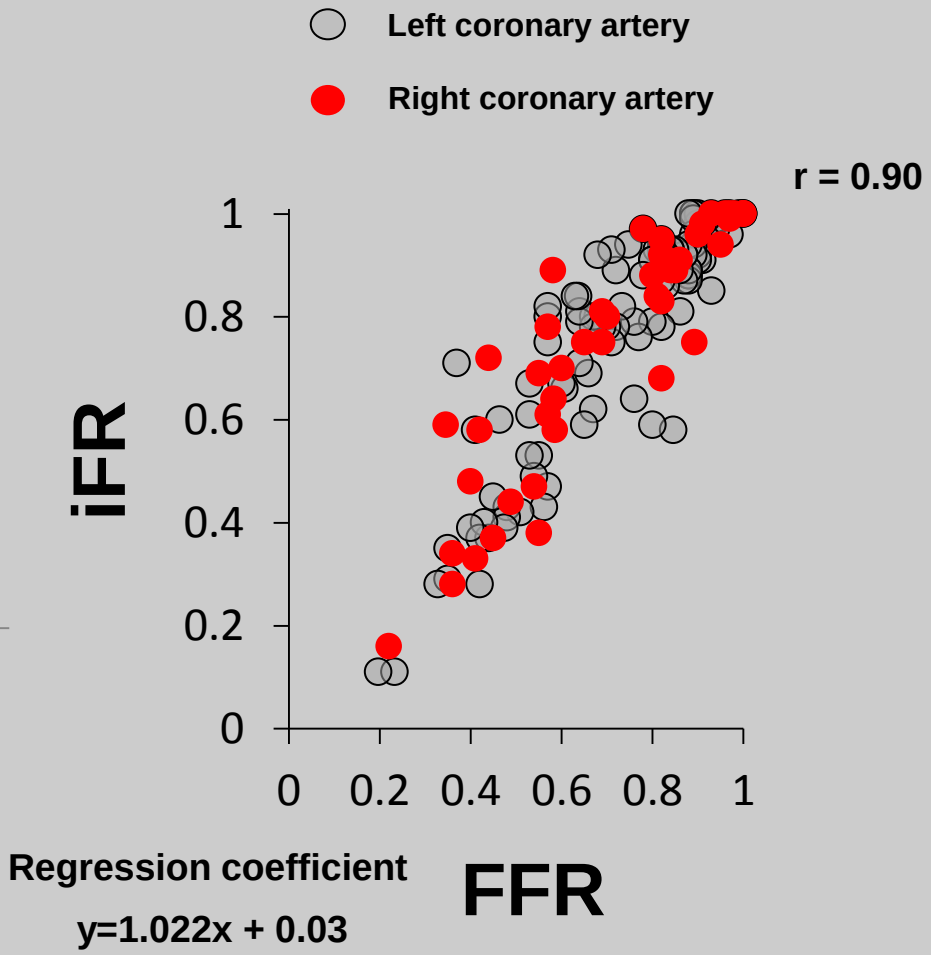
ADVISE study

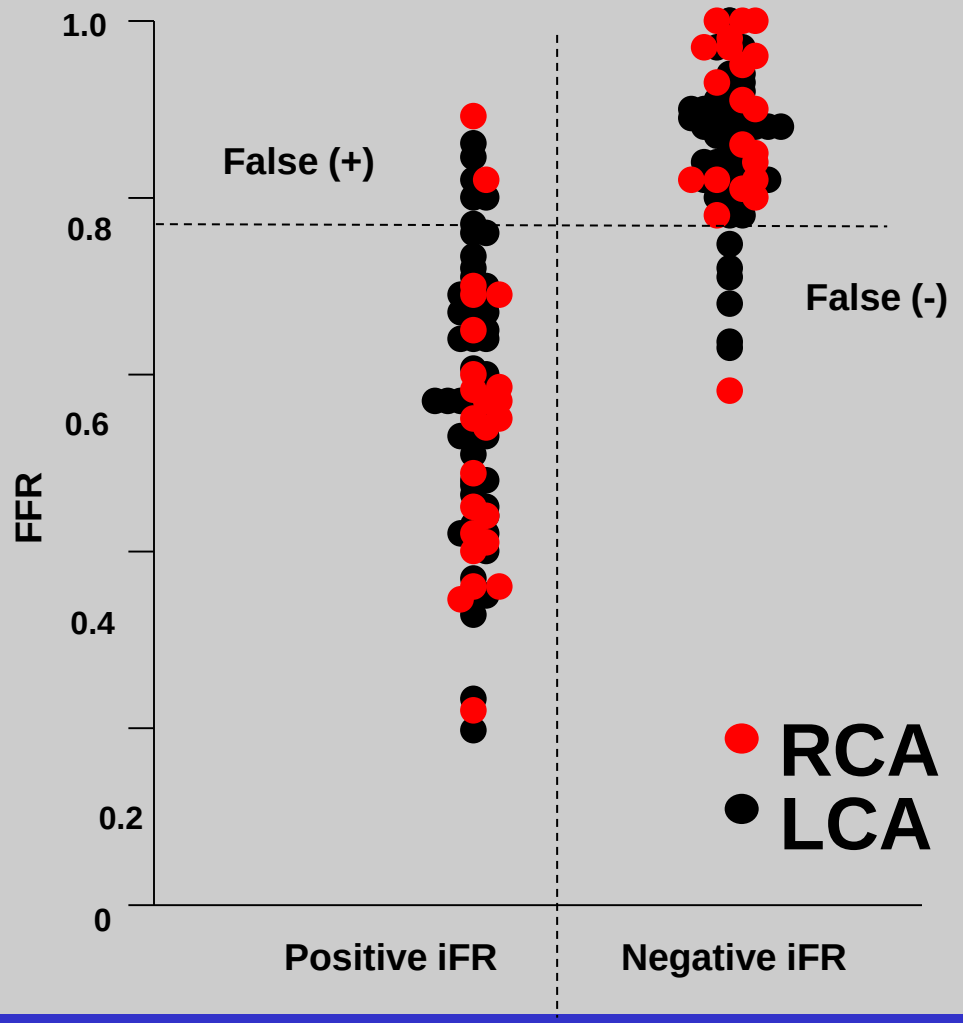
ADenosine Vasodilation Independent Stenosis Evaluation

Sen S et al. J Am Coll Cardiol. 2012;59(15):1392-402





iFR vs. FFR - diagnostic characteristics



FFR; 0.80 ⇒ iFR; 0.83

Diagnostic accuracy, 88%

(+) predictive value, 91%

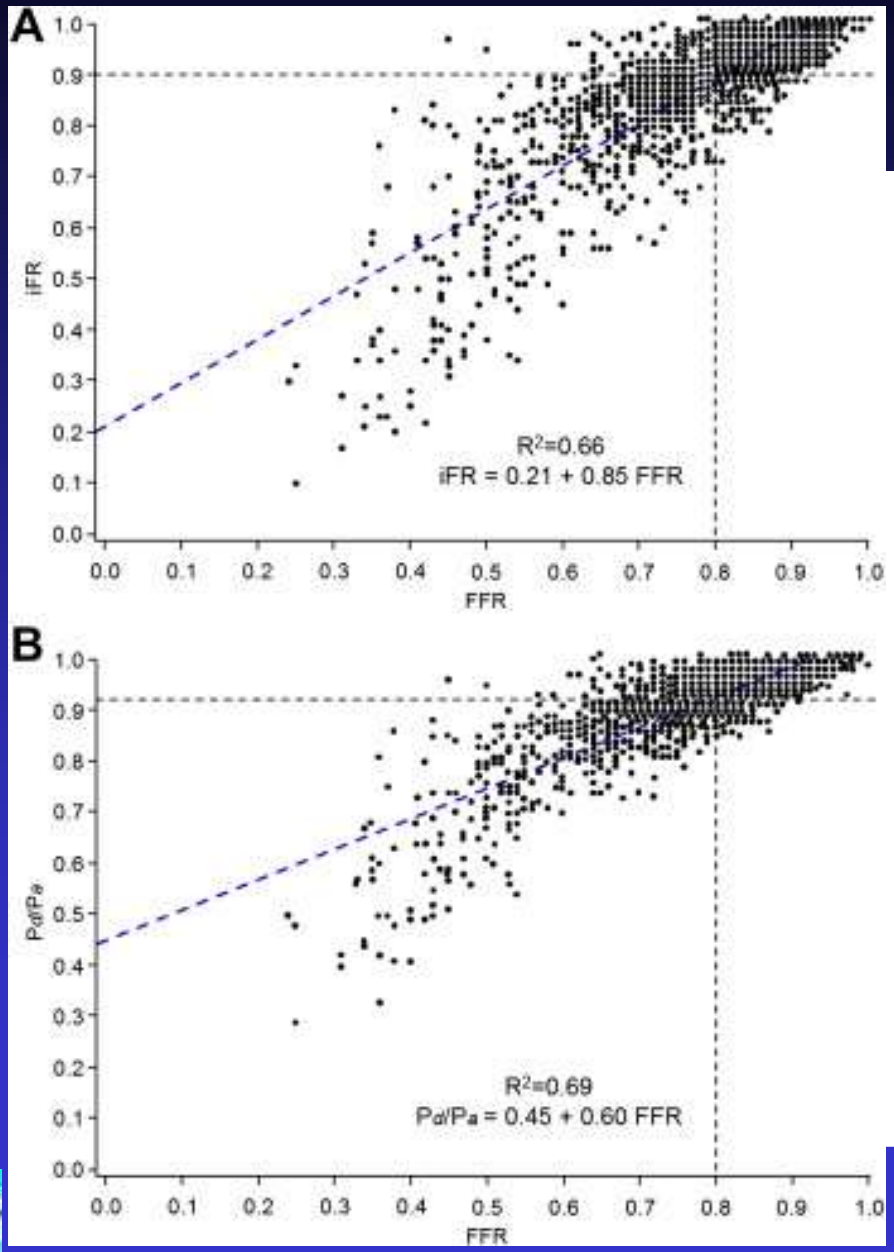
(-) predictive value, 85%

Sensitivity, 85%

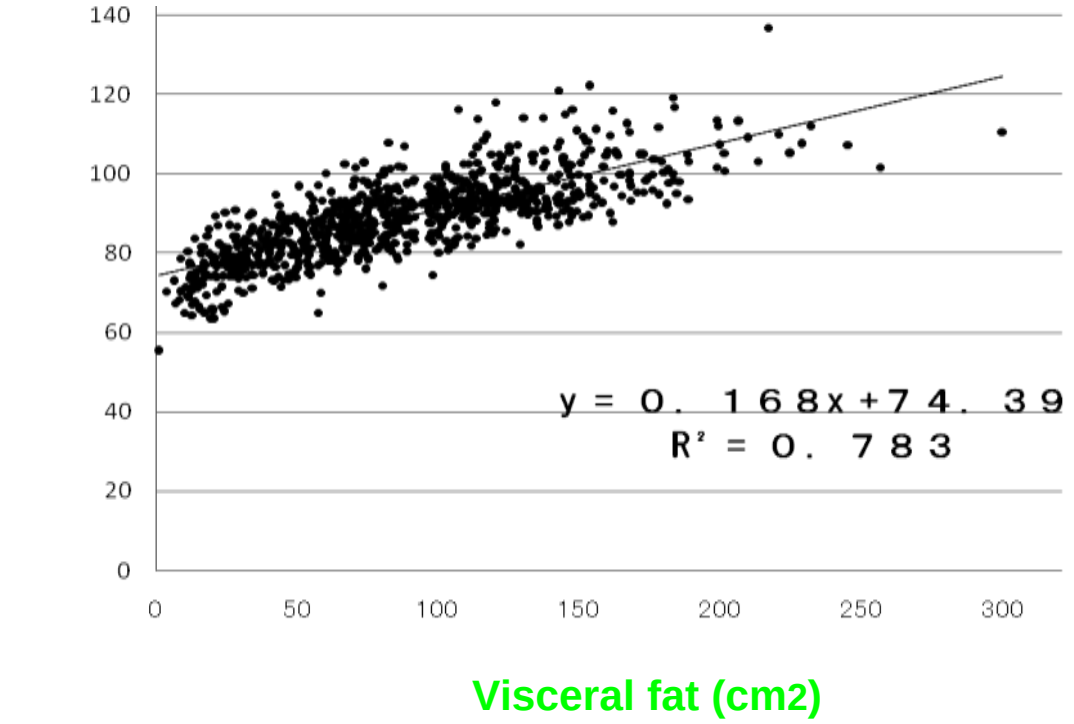
Specificity, 91%

Relationship Between iFR & FFR and Pd /Pa & FFR

Jeremias A, et. Al. J Am Coll Cardiol, 2014;63:1253-1261



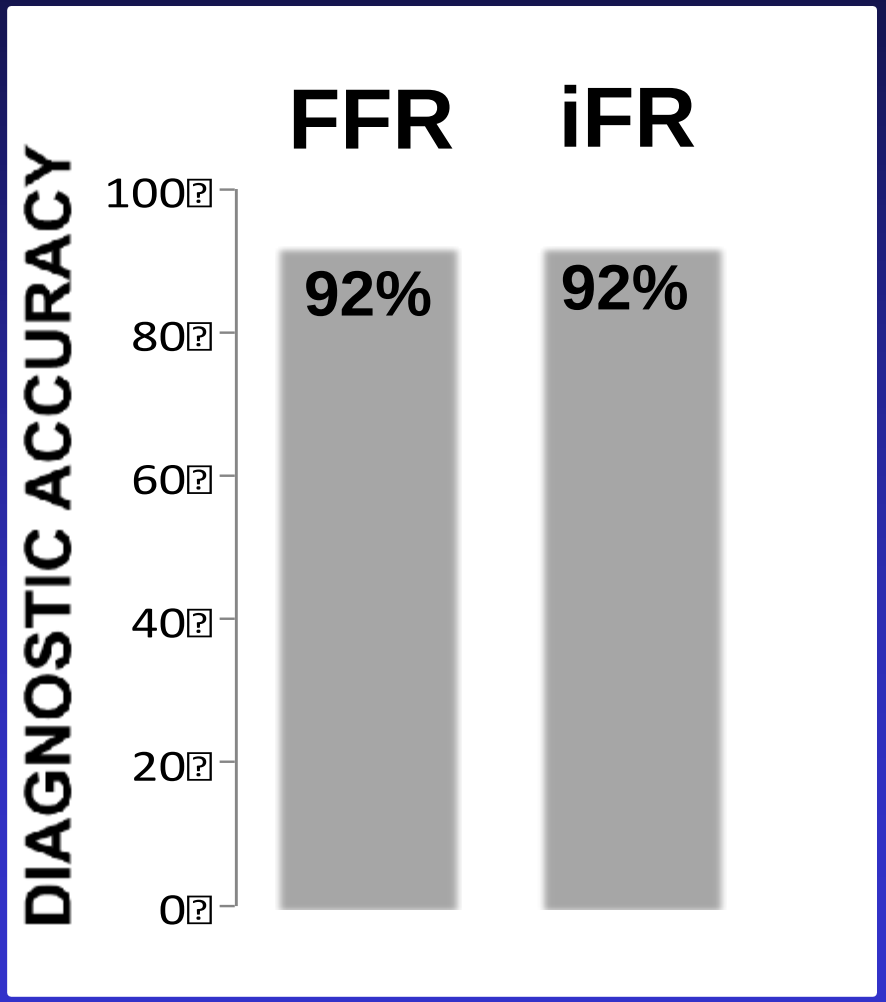
Relation between waist size and visceral fat



CLARIFY

Sen et al. CLARIFY. J Am Coll Cardiol. 2013;61(13):1409-1420

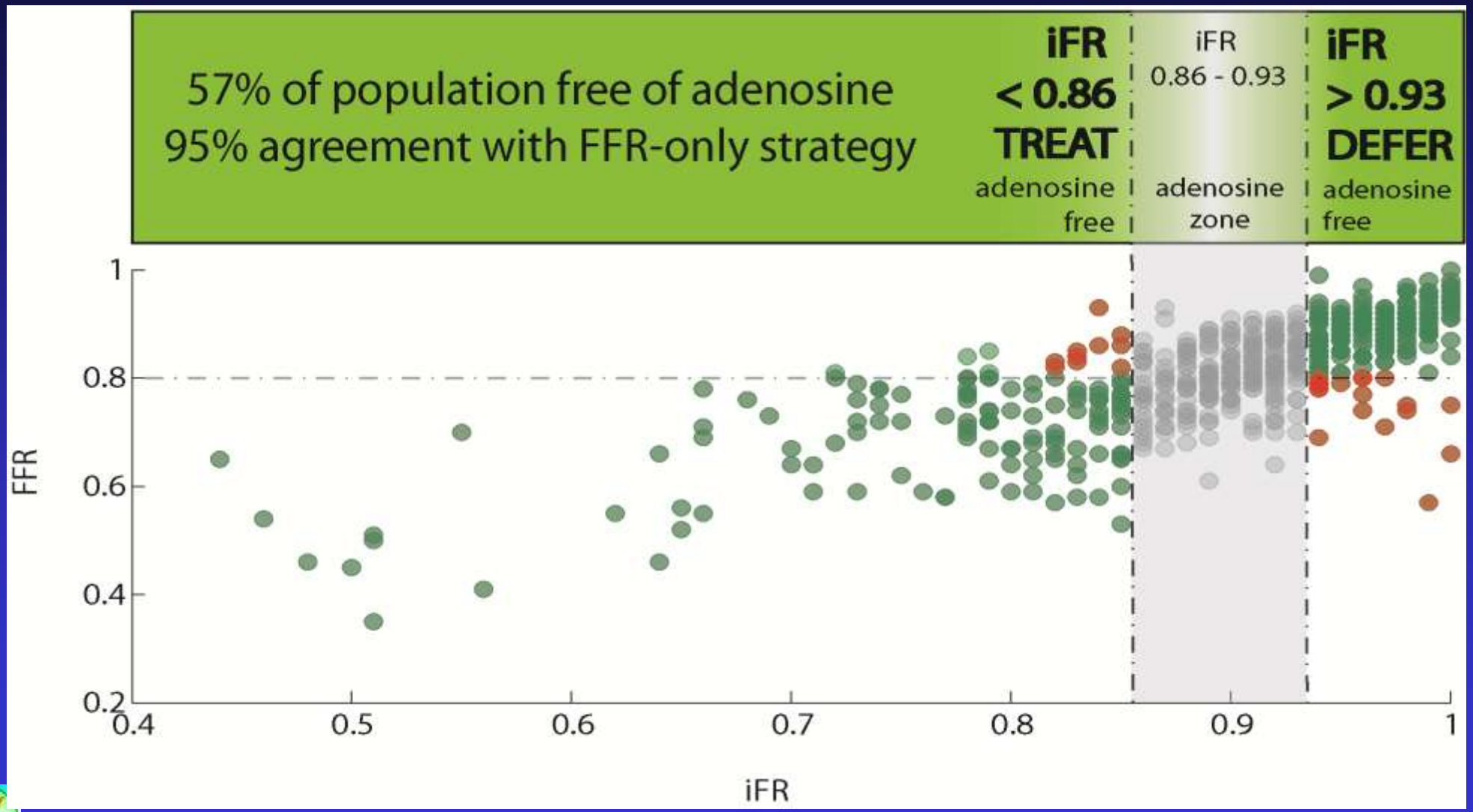
iFR has similar diagnostic accuracy to FFR



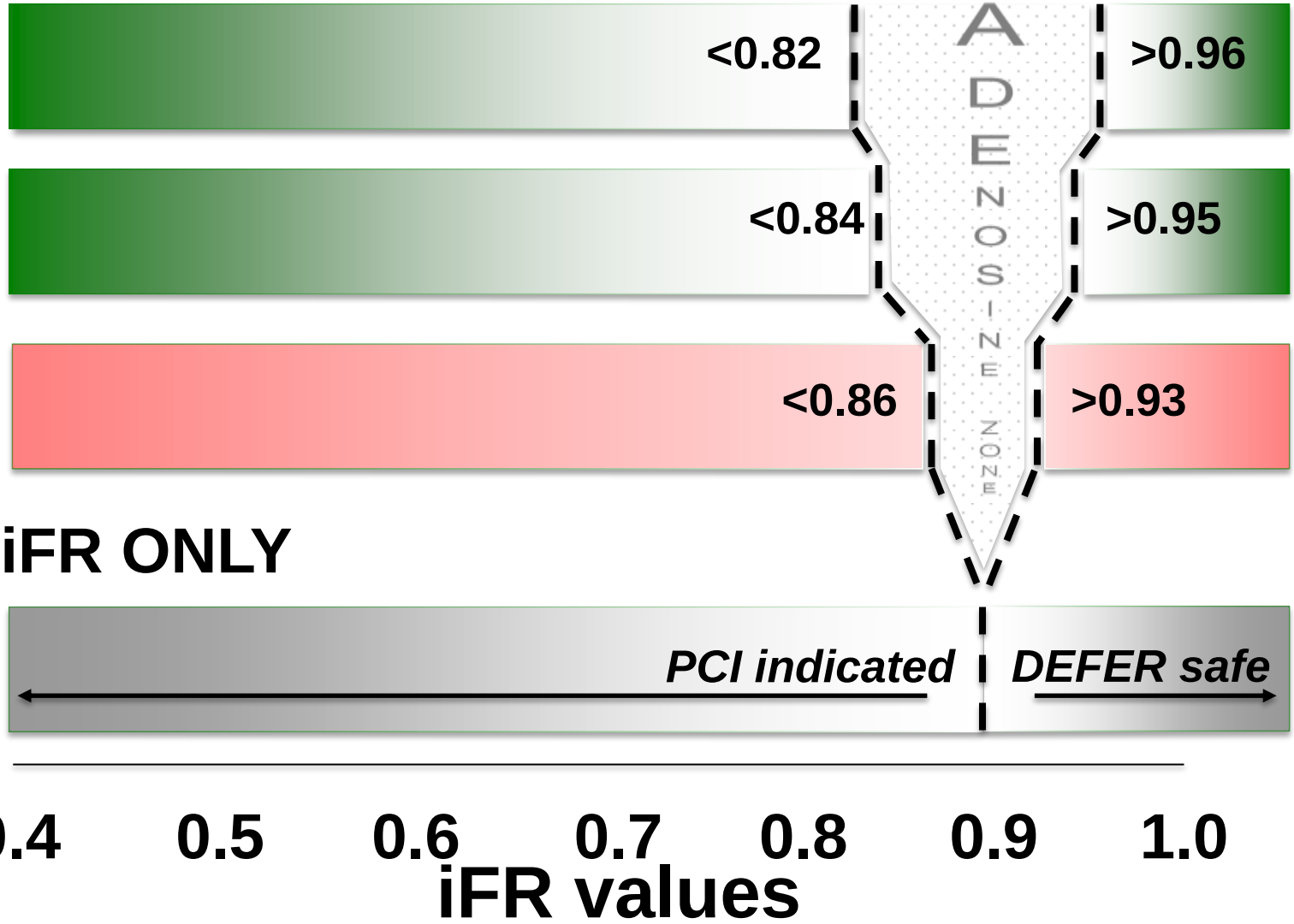
iFR and FFR have similar diagnostic accuracies

Hybrid iFR-FFR strategy

Increasing adoption of physiology-guided PCI

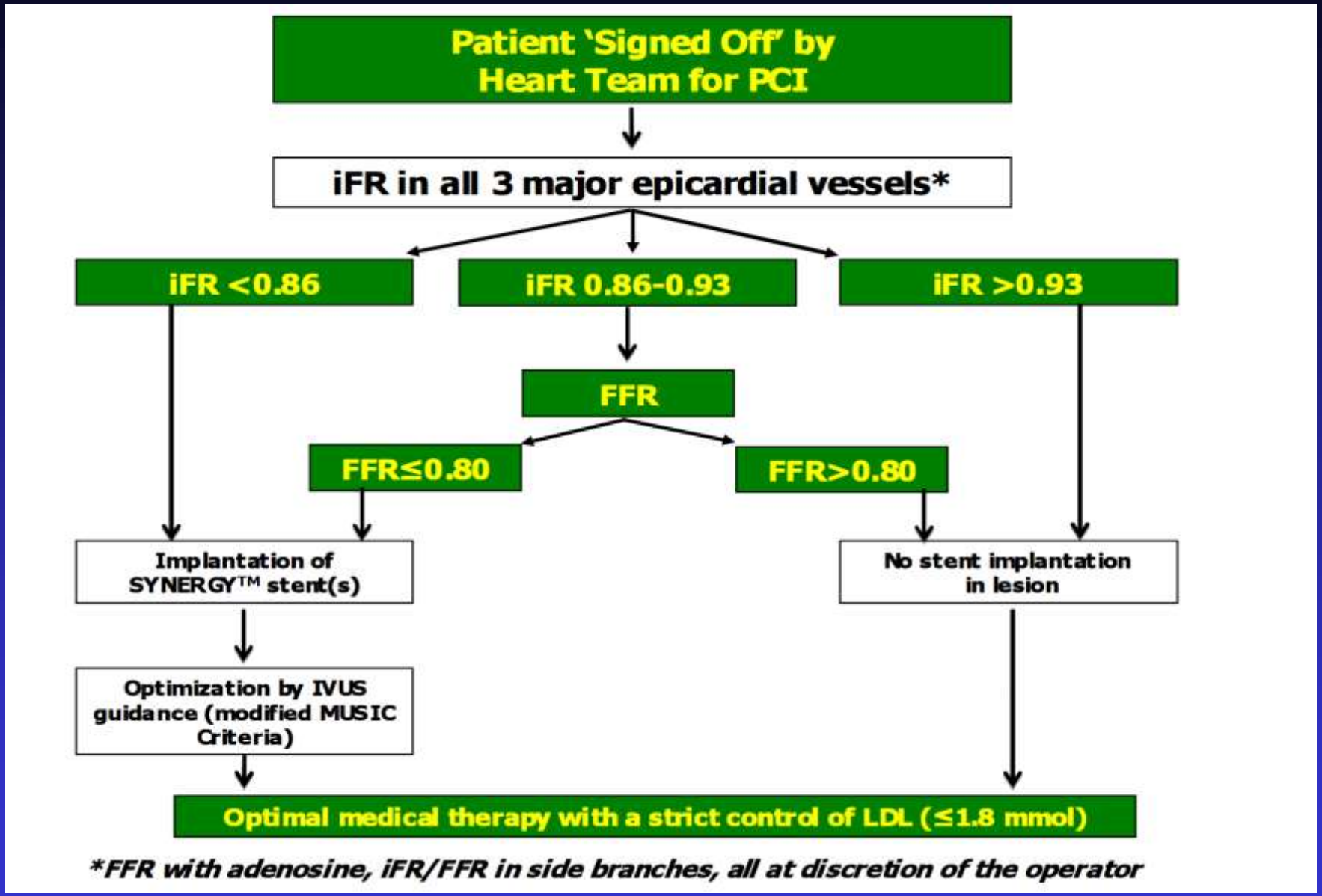


HYBRID IFR-FFR



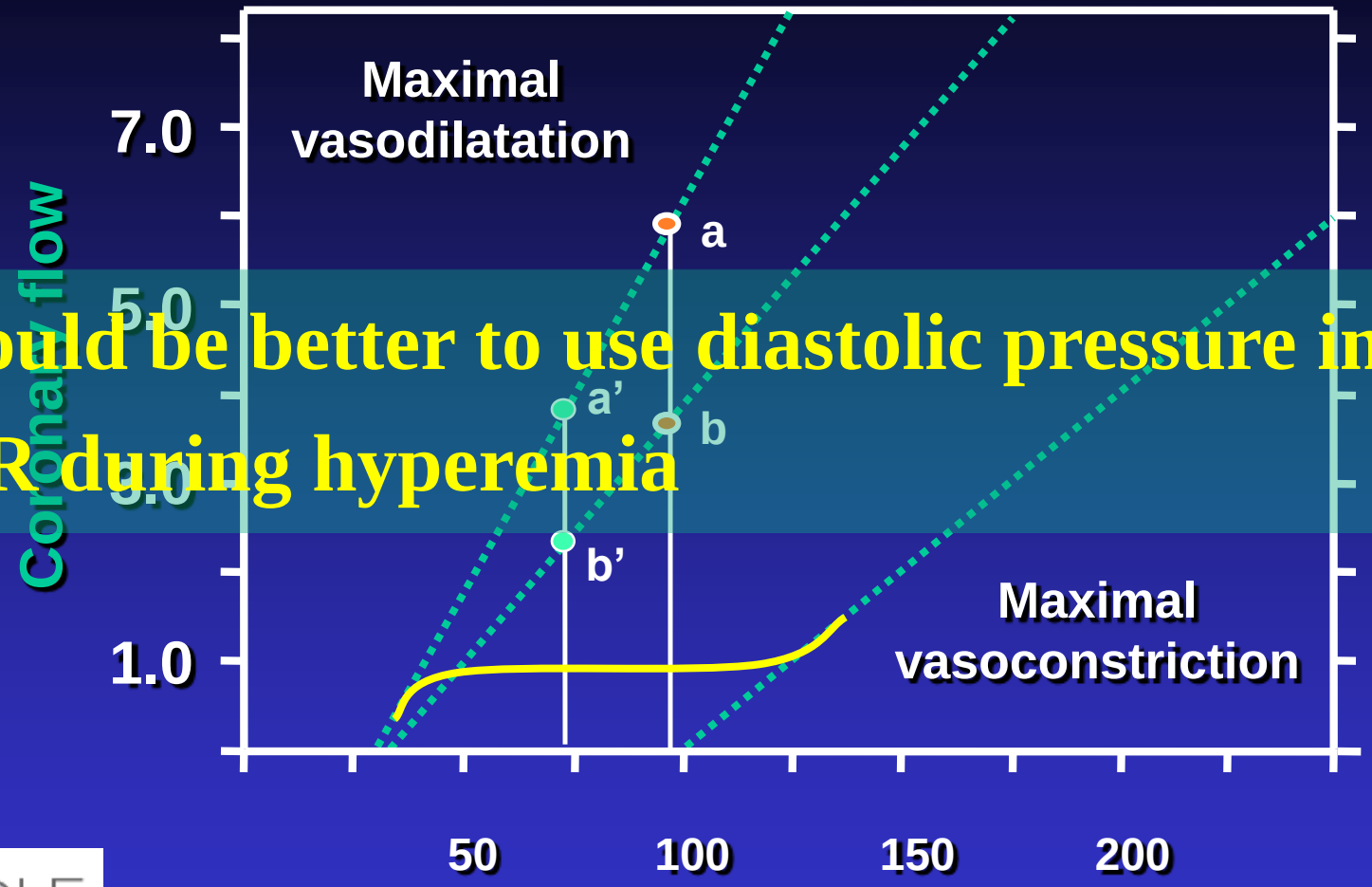
Match with FFR	% more than PdPa
99%	72%
97%	40%
95%	33%
81%	

SYNTAX II



Serruys P et al. EUROPCR 2013

Diastolic pressure－flow relationship & FFR



It should be better to use diastolic pressure in FFR & iFR during hyperemia

DIASTOLE

$$\text{Diastolic FFR} = \frac{b}{a} = \frac{b'}{a'} = \text{Hyperemic iFR}$$

	FFR	iFR
Pressure Wire	○	○
Hyperemia free	✗	○
Typical measurement time	5-10 min	1-2 min
Pressure damping unlikely	✗	○
Cost saving(add to FAME)	✗	Adenosine / Time Equipment
Optimised for pullback	✗	○
Peri-PCI assessment	○	✗
Evidence against ischaemia	○	△
Clinical outcome data	○	Coming!

Summary
FFR vs iFR

- iFR might be useful clinically as an index of cut-off point to differentiate significant stenosis, although original concept of iFR might be questionable based on coronary physiology.
- FFR may be correct theoretically according to pressure-flow relationship in diastole, although there might be some limitations if we use mean pressure.
- Although diastolic FFR (d-FFR) or hyperemic iFR (iFRa) should be the most ideal concept according to coronary physiology to identify myocardial ischemia, there is no significant difference between FFR in diastole and whole cardiac cycle in the assessment of ischemia based on the previous study by Abe M, et al..