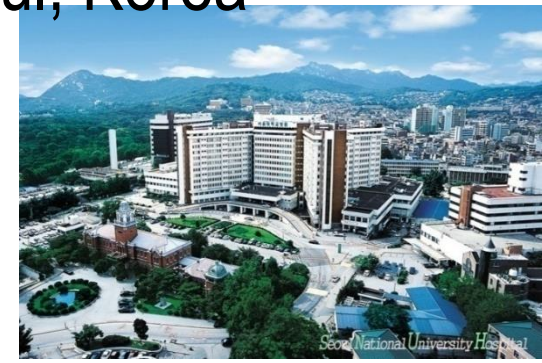
How to Make Optimal Resting and Hyperemic Status for Coronary Physiologic Assessment?

Bon-Kwon Koo, MD, PhD

Seoul National University Hospital, Seoul, Korea

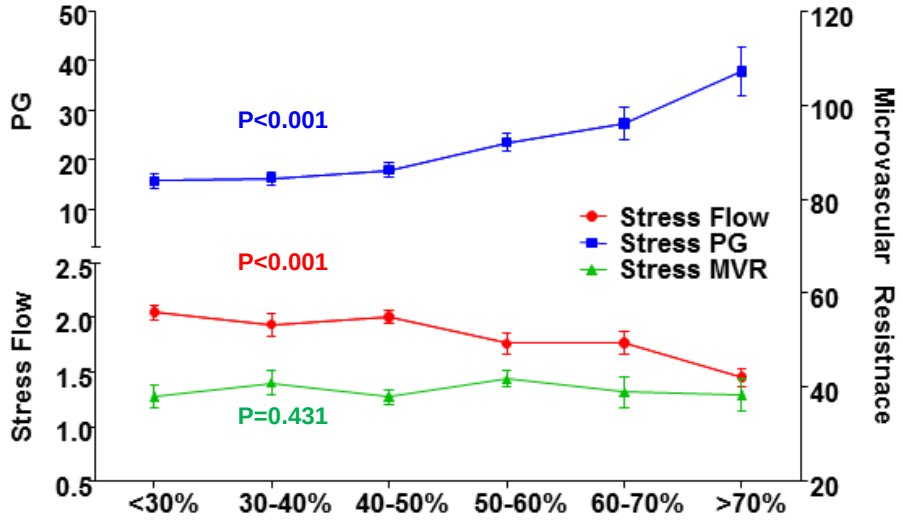


Coronary Circulatory Response to Epicardial Stenosis

Resting

*MV, microvascular; PG, pressure gradient

Hyperemia



As stenosis severity (epicardial resistance) increases

- Minimal and stable MV resistance
- Hyperemic flow ▼
- **Hyperemic pressure gradient ▲**

Lee JM, Koo BK, et al. Circulation 2017

Experimental Basis of Determining Maximum Coronary, Myocardial, and Collateral Blood Flow by Pressure Measurements for Assessing Functional Stenosis Severity Before and After Percutaneous Transluminal Coronary Angioplasty

Nico H.J. Pijls, MD; Jacques A.M. van Son, MD; Richard L. Kirkeeide, PhD; Bernard De Bruyne, MD; and K. Lance Gould, MD

Coronary Flow Reserve Calculated From Pressure Measurements in Humans

Validation With Positron Emission Tomography

Bernard De Bruyne, MD; Thierry Baudhuin, MD†; Jacques A. Melin, MD, PhD; Nico H.J. Pijls, MD, PhD; Stanislas U. Sys, MD, PhD; Anne Bol, PhD; Walter J. Paulus, MD; Guy R. Heyndrickx, MD, PhD; William Wijns, MD, PhD

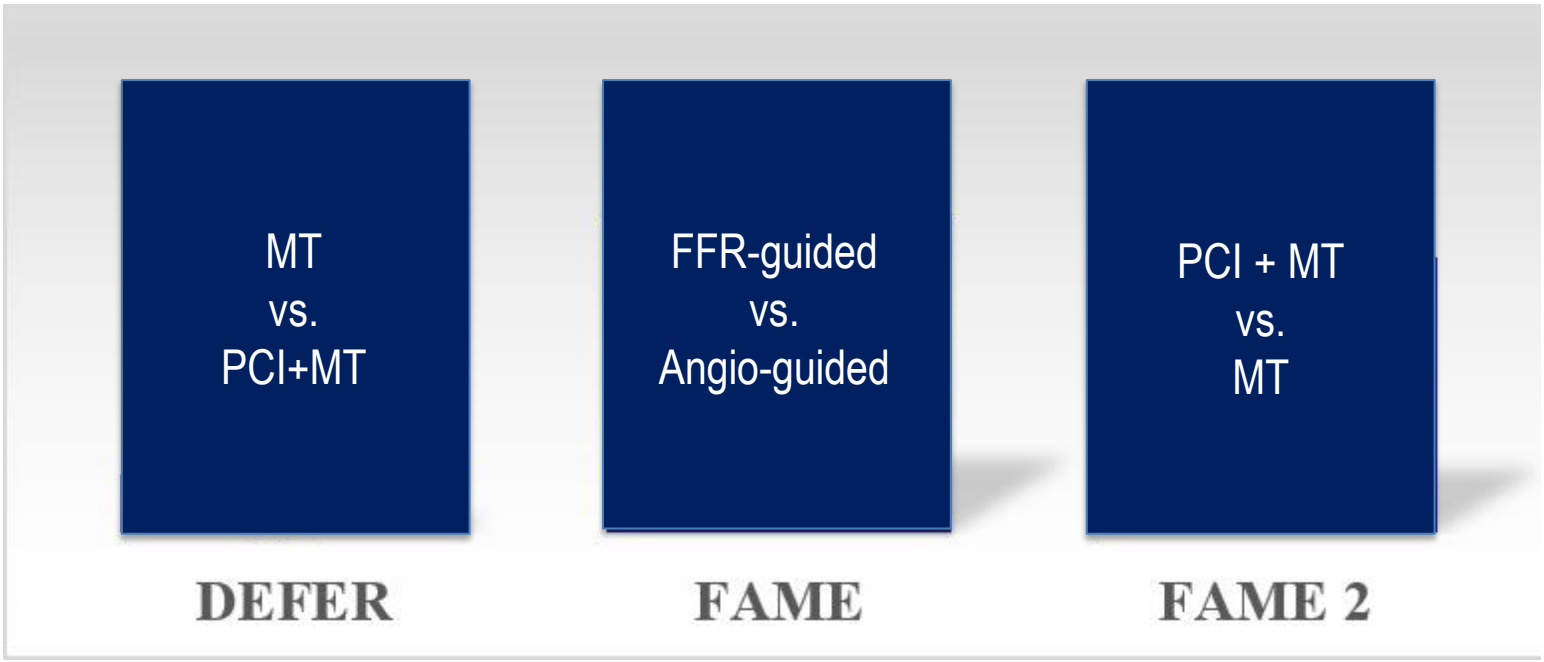
FFR and Hyperemia

$$FFR = \frac{Q^{S}_{max}}{Q^{N}_{max}} = \frac{(Pd-Pv)/R}{(Pa-Pv)/R} = \frac{P_d}{P_a}$$

At constant Pa, determinants of Pd

- Epicardial stenosis
- Myocardial resistance

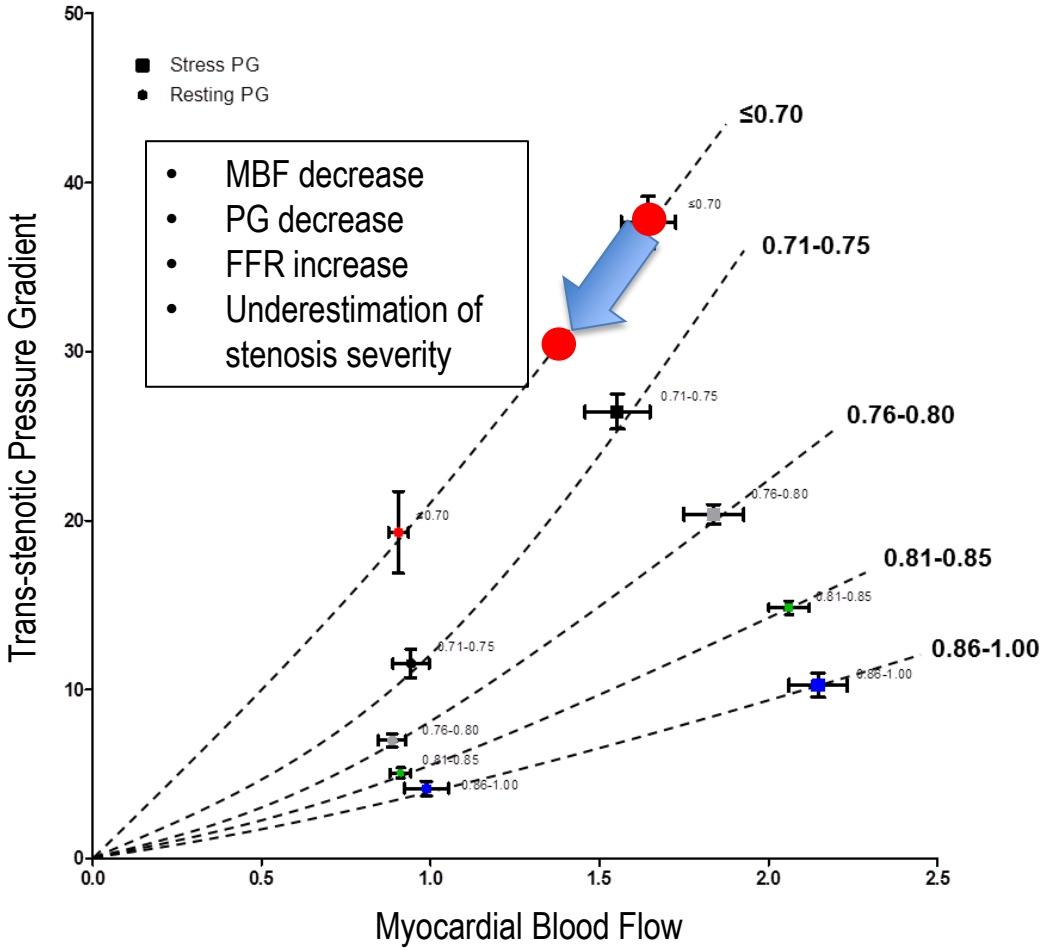
FFR-guided PCI: Gold standard approach for CAD



- Pressure ratio under hyperemia = Degree of flow reduction
- Degree of flow reduction = Presence (degree) of ischemia
- Relieving certain level of pressure gradient = Better clinical outcomes

FFR– ISCHEMIA – REVASCULARIZATION - OUTCOMES

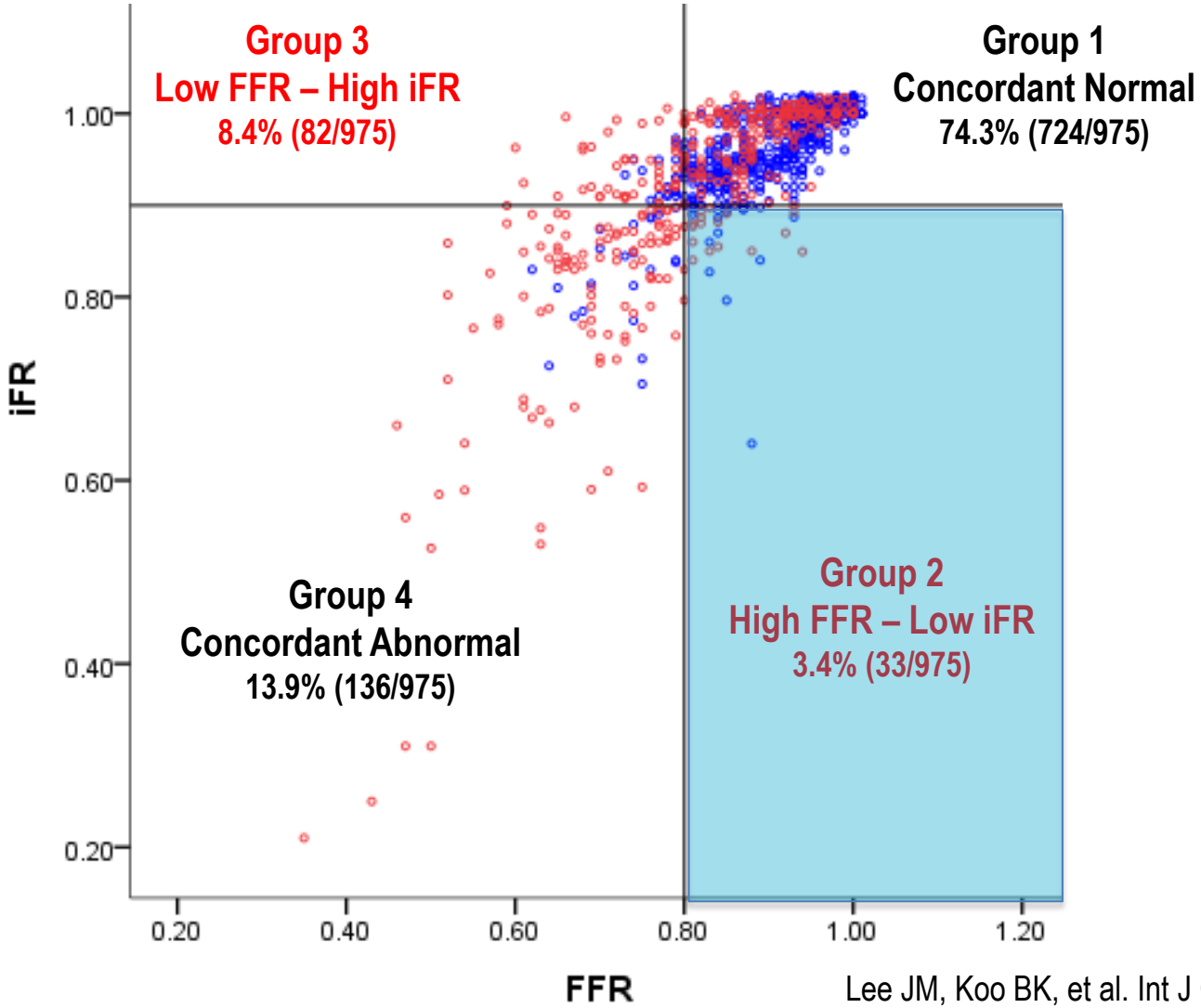
Influence of inadequate hyperemia



Lee JM ,Koo BK, et al Circulation 2017

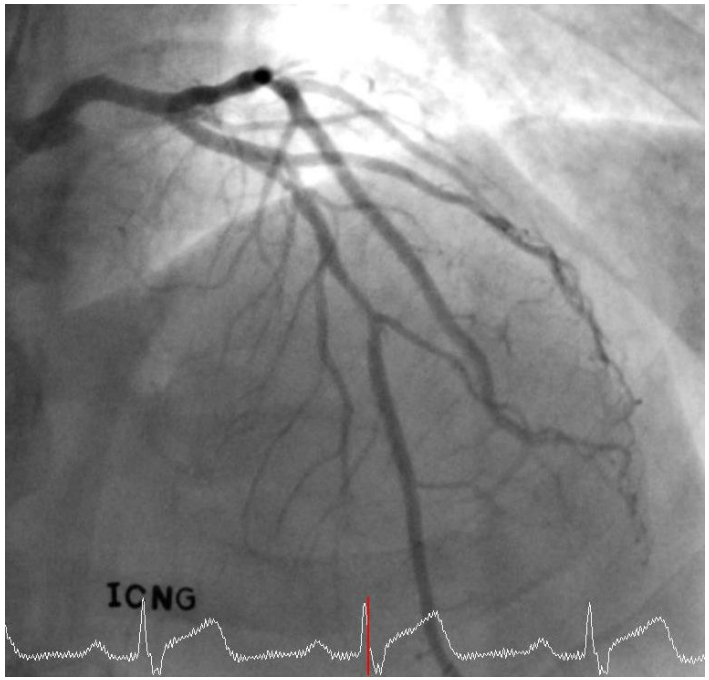
Resting Index vs. Hyperemic Index

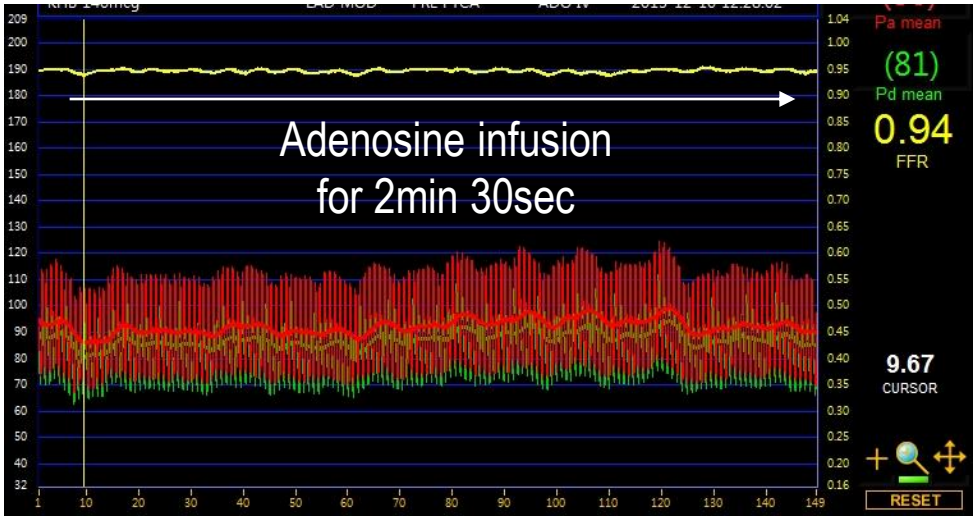
(from 3V-FFR FRIENDS study)

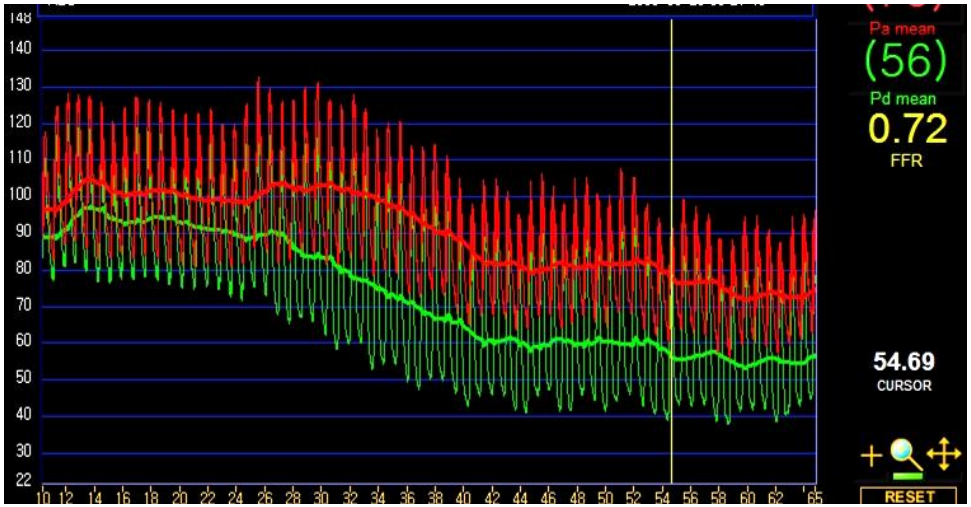


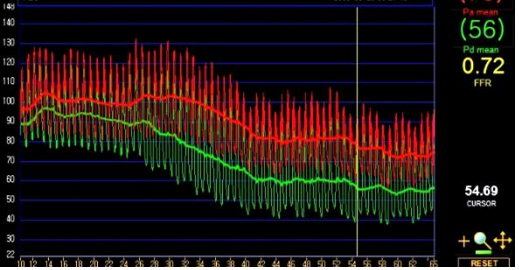
Lee JM, Koo BK, et al. Int J Cardiol 2017
Lee JM, Koo BK, et al. Eur Heart J 2018

Are you happy with this number?







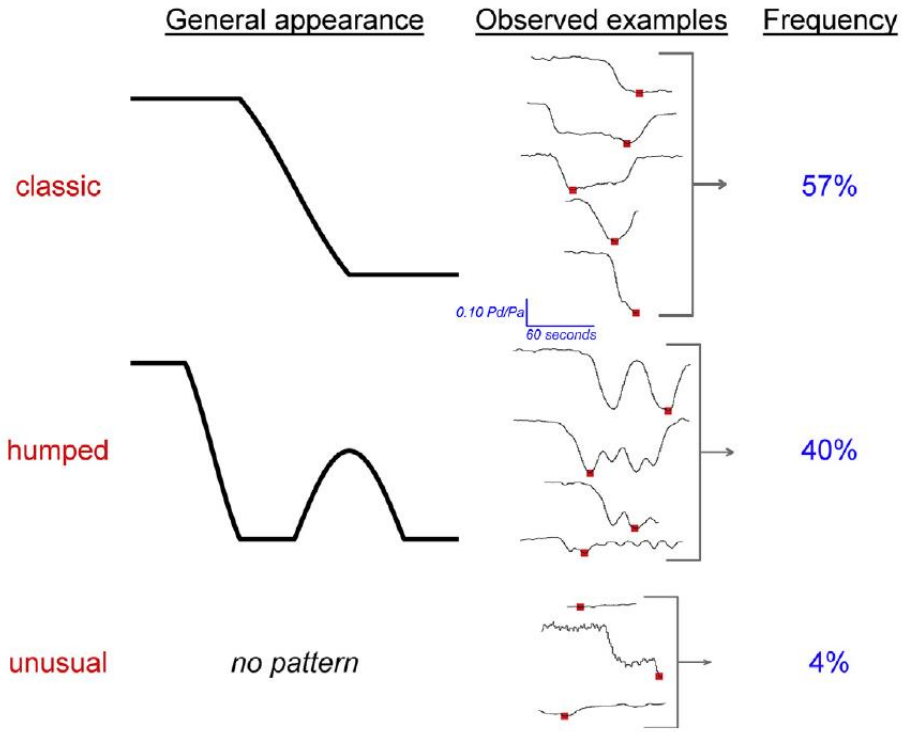


Hemodynamic changes with adenosine

	Femoral vein	Forearm vein	P value
Δ Blood pressure	-9.8±8.0 %	-9.6±6.3 %	0.86
Δ Heart rate	5.5±6.7 %	7.0±7.2 %	0.07
AV block	1 (1.6 %)	1 (1.6 %)	<0.0001

Seo MK, Koo BK, et al. Circ Cardiovasc Interv 2012

Patterns of pressure changes and Concept of "smart minimum"

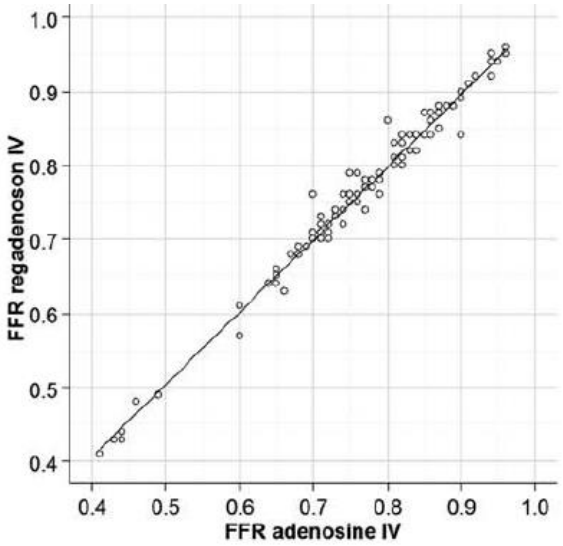


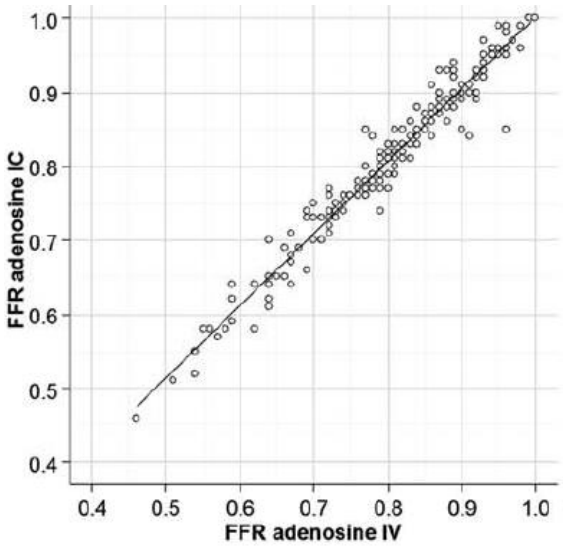
"Smart minimum" FFR

- The lowest average of 5 consecutive cardiac cycles of sufficient quality within a run of 9 consecutive quality beats.
- Excellent repeatability: bias 0.001, SD 0.018

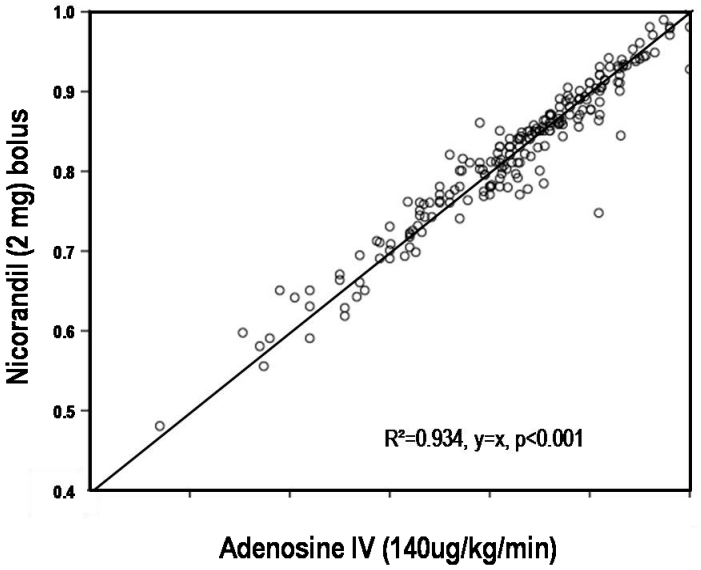
Johnson N, et al. JACC intervention 2015

FFR with 2 different hyperemic methods





Lim WH, Koo BK, et al. Cath Cardiov Interv 2014



Jang HJ, Koo BK, et al. Eur Heart J 2013

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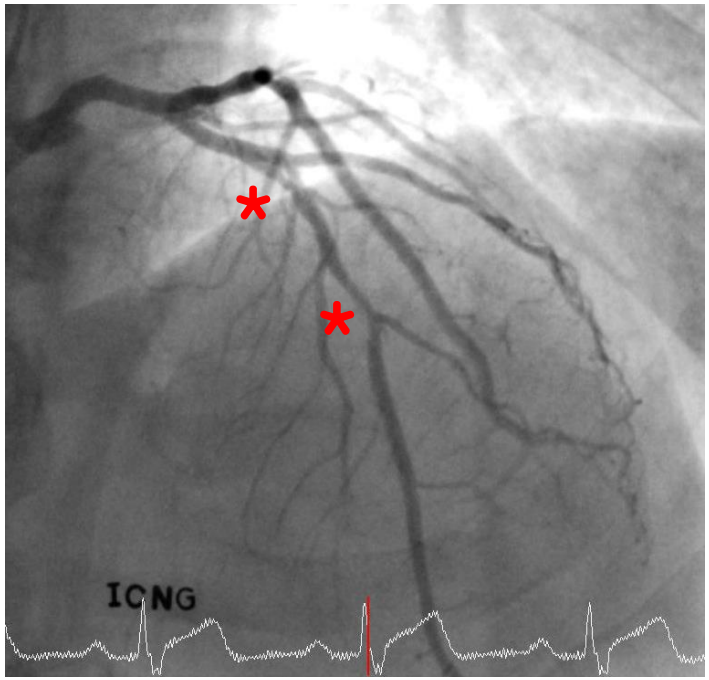
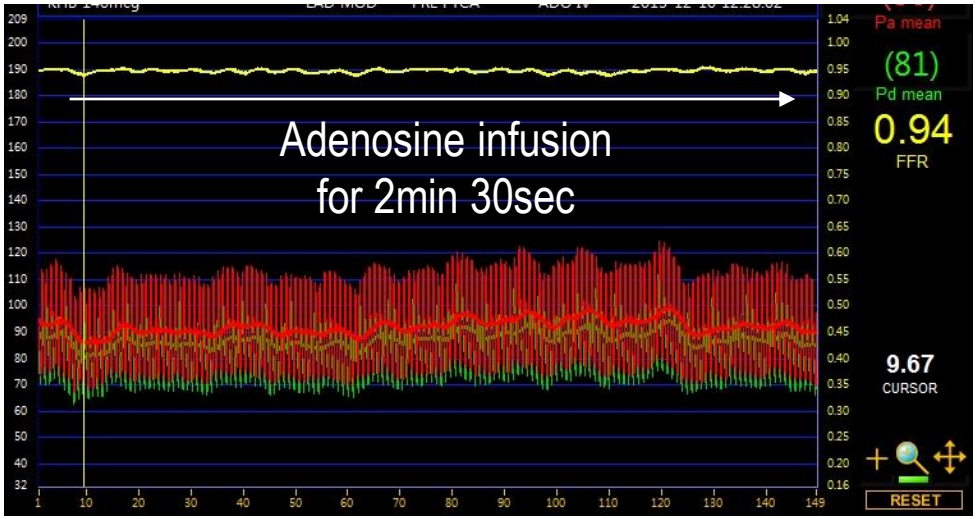
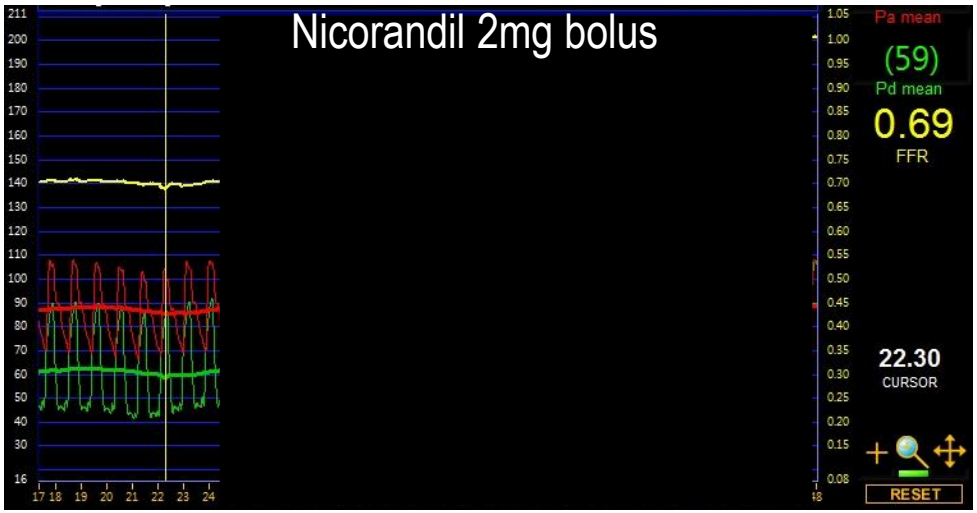
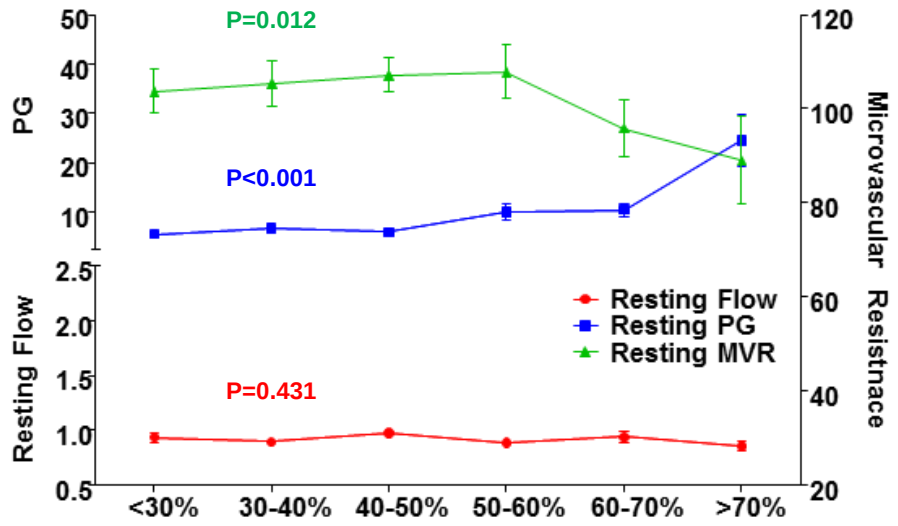






Coronary Circulatory Responses to Epicardial Stenosis

Resting



As stenosis severity (epicardial resistance) increases

- No change in resting flow
- MV resistance ▼
- **Resting pressure gradient ▲**

*MV, microvascular; PG, pressure gradient

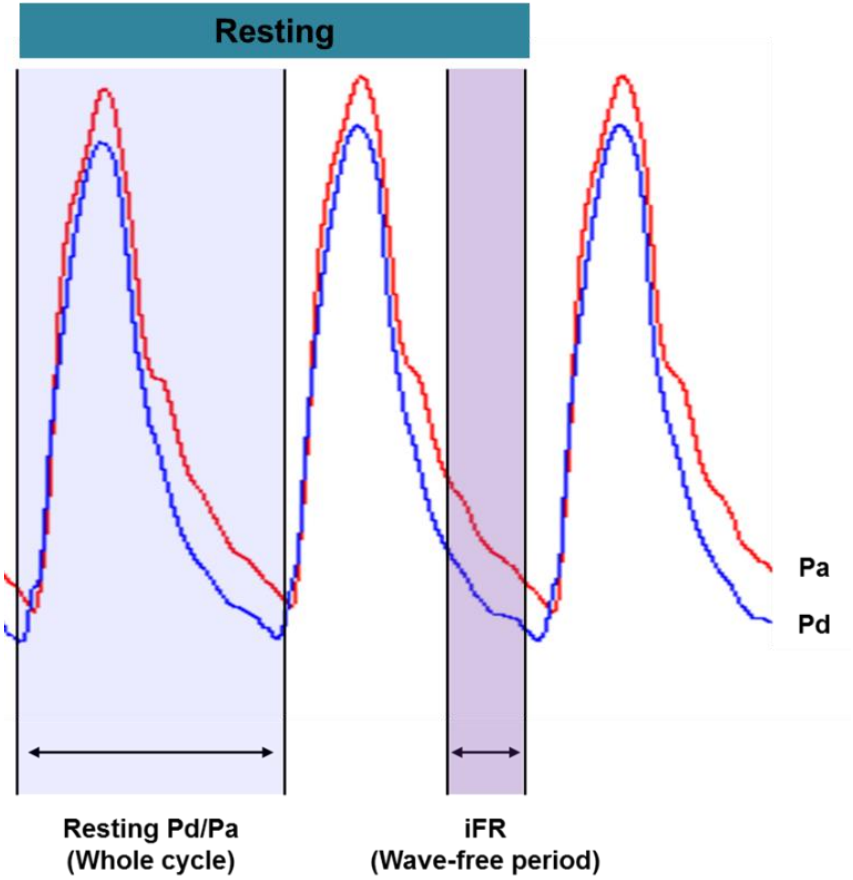
Hyperemia

As stenosis severity (epicardial resistance) increases

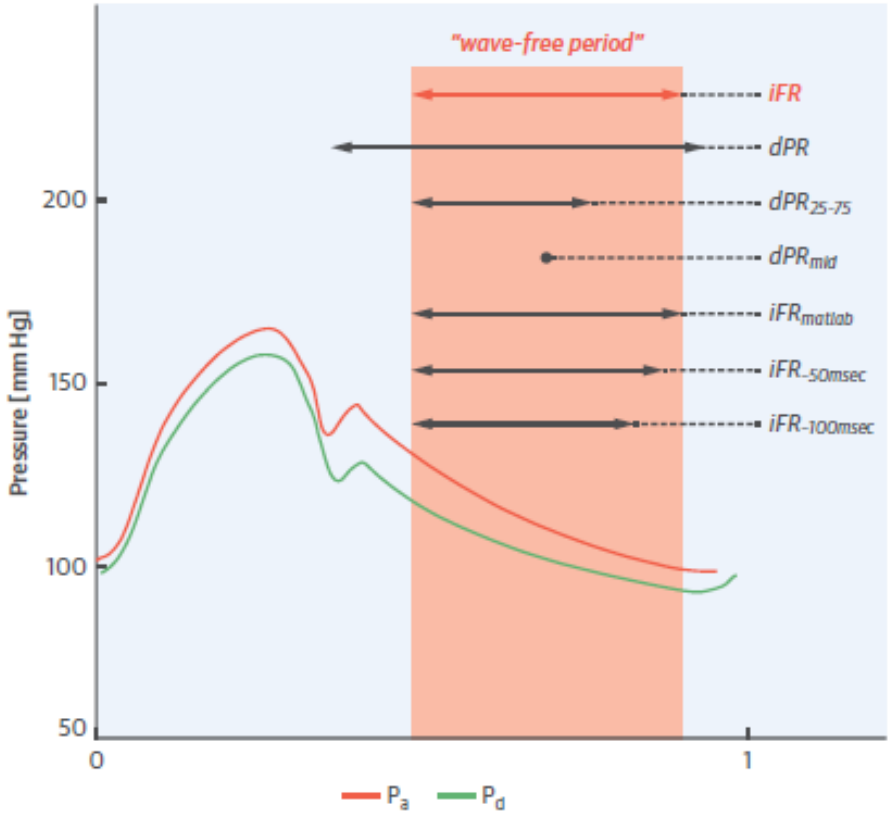
- Minimal and stable MV resistance
- Hyperemic flow ▼
- Hyperemic pressure gradien ▲

Lee JM, Koo BK, et al. Circulation 2017

Resting Pressure Indexes: Resting Pd/Pa, iFR, DPR, RFR……



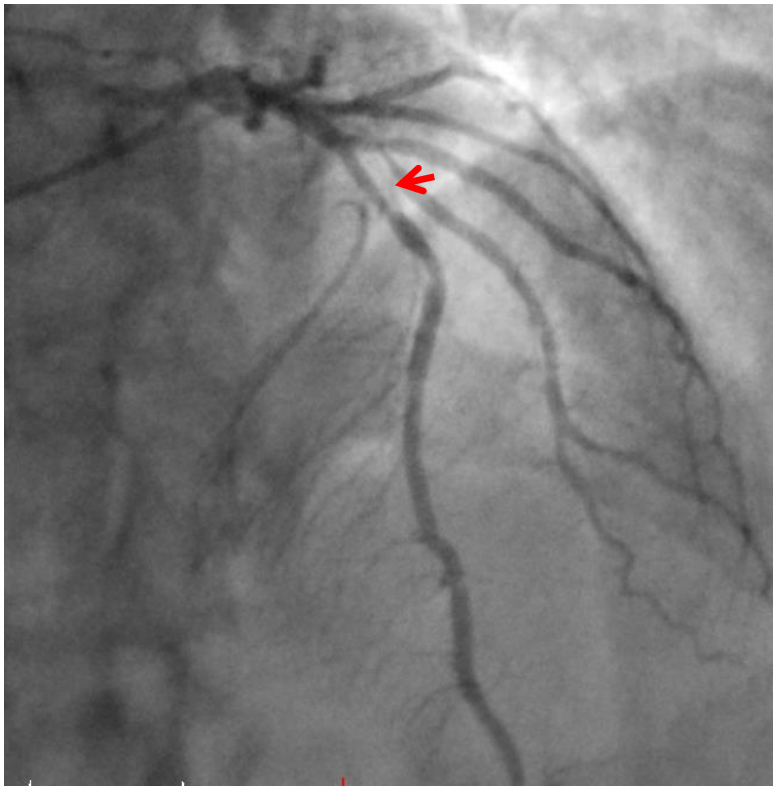
Lee JM, ……, Koo BK, J Am Coll Cardiol 2017



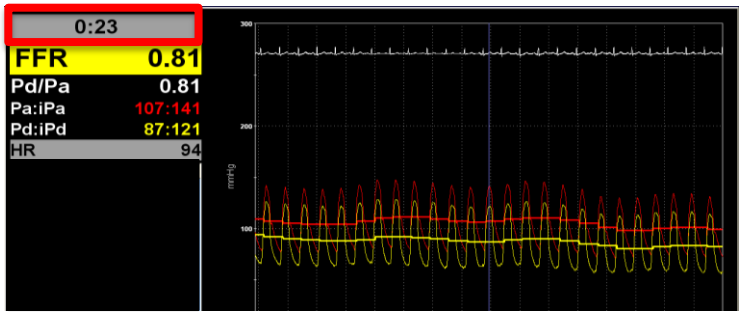
van't Veer, M. et al. J Am Coll Cardiol 2017

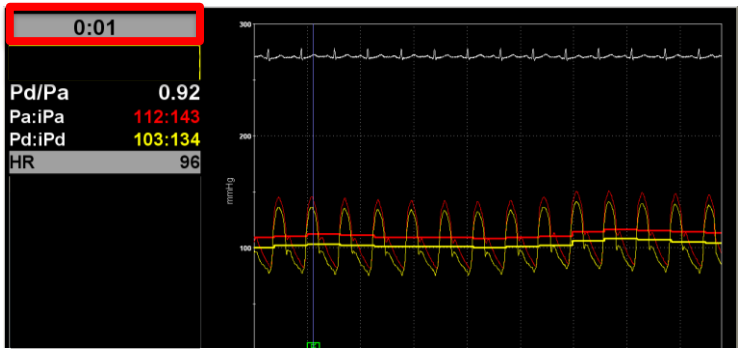
iFR doesn't need hyperemia and measurement is instantaneous.

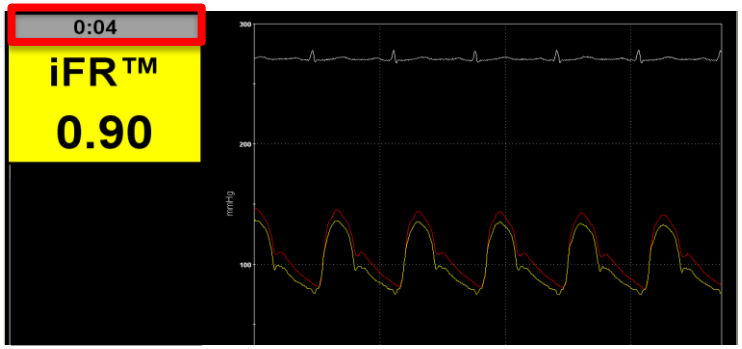
iFR, How easy?



20 sec with adenosine, chest discomfort…..

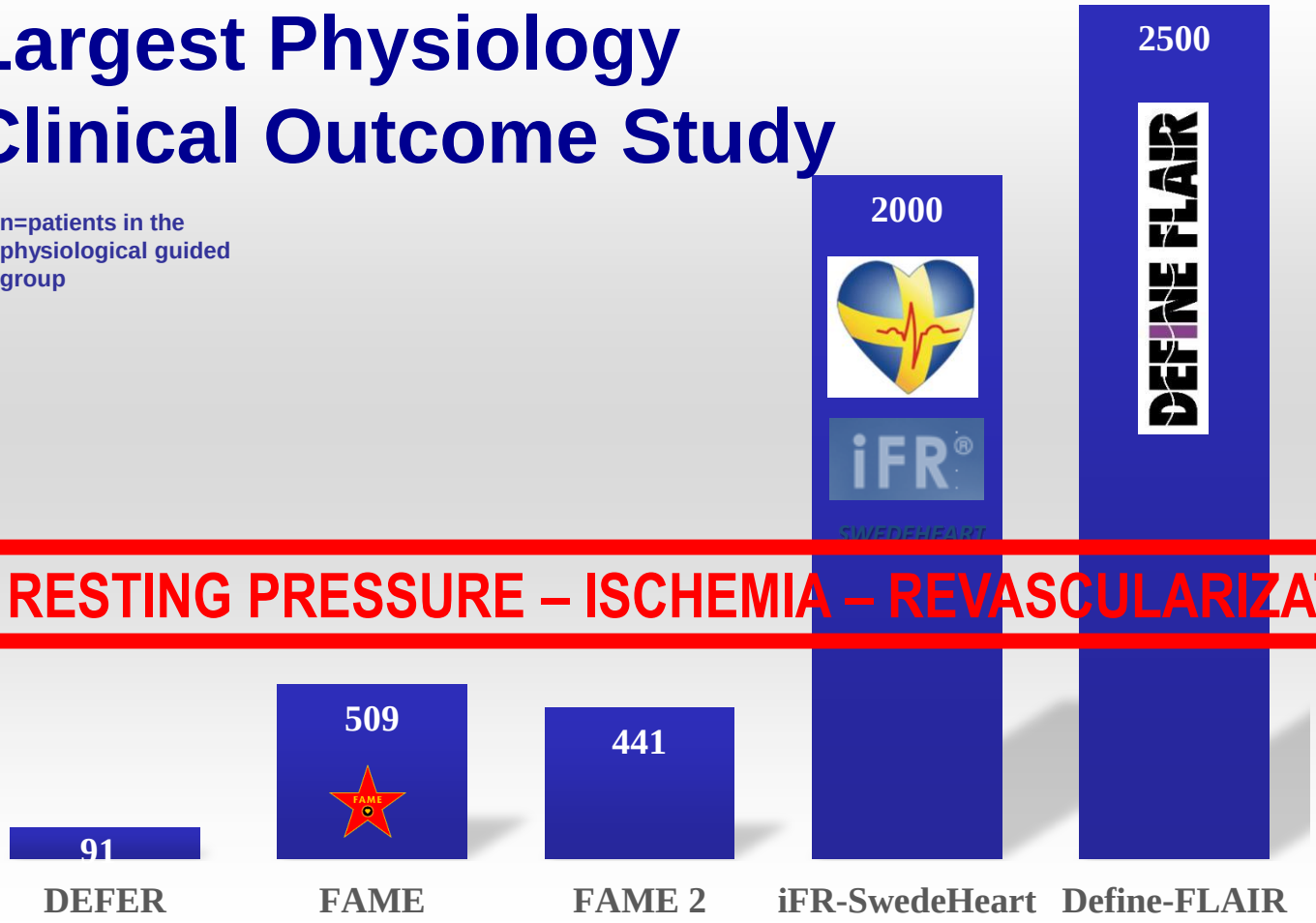






DEFINE-FLAIR
Largest Physiology Clinical Outcome Study

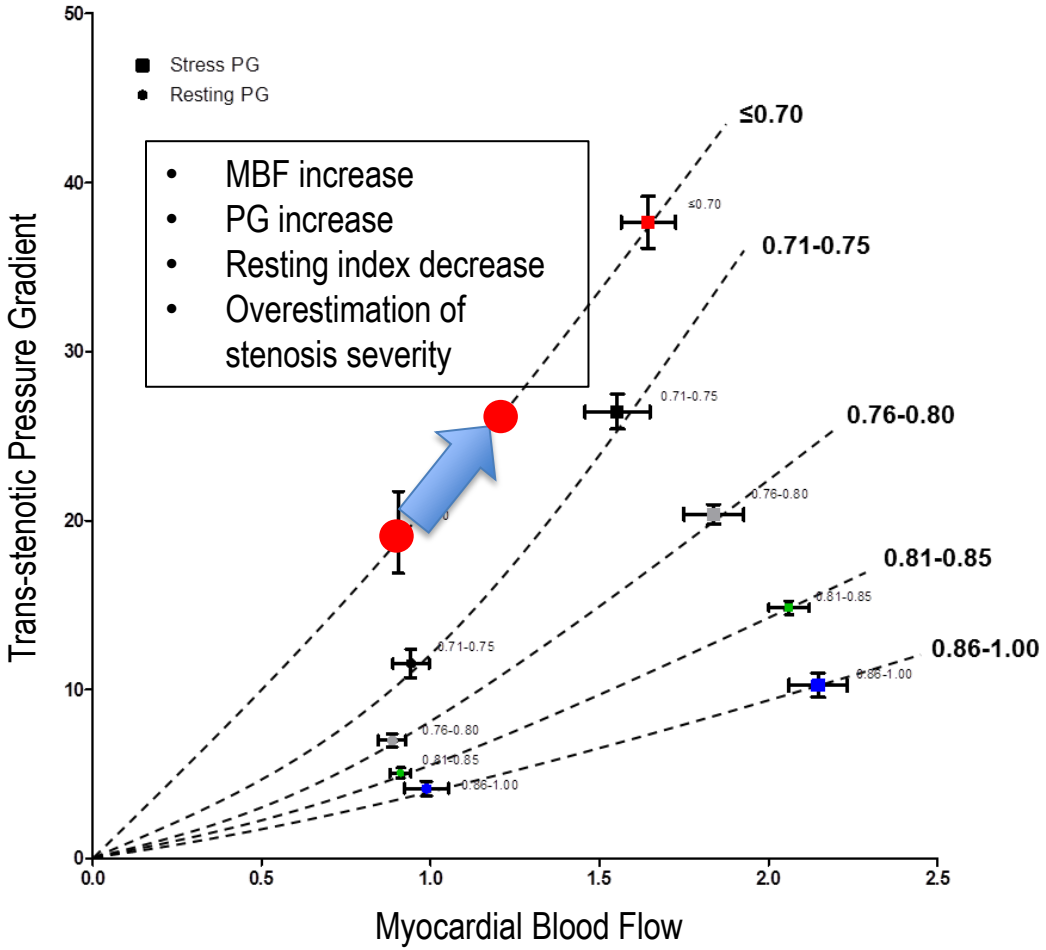
n=patients in the physiological guided group



RESTING PRESSURE – ISCHEMIA – REVASCULARIZATION - OUTCOMES

Modified from Dr Escaned's presentation

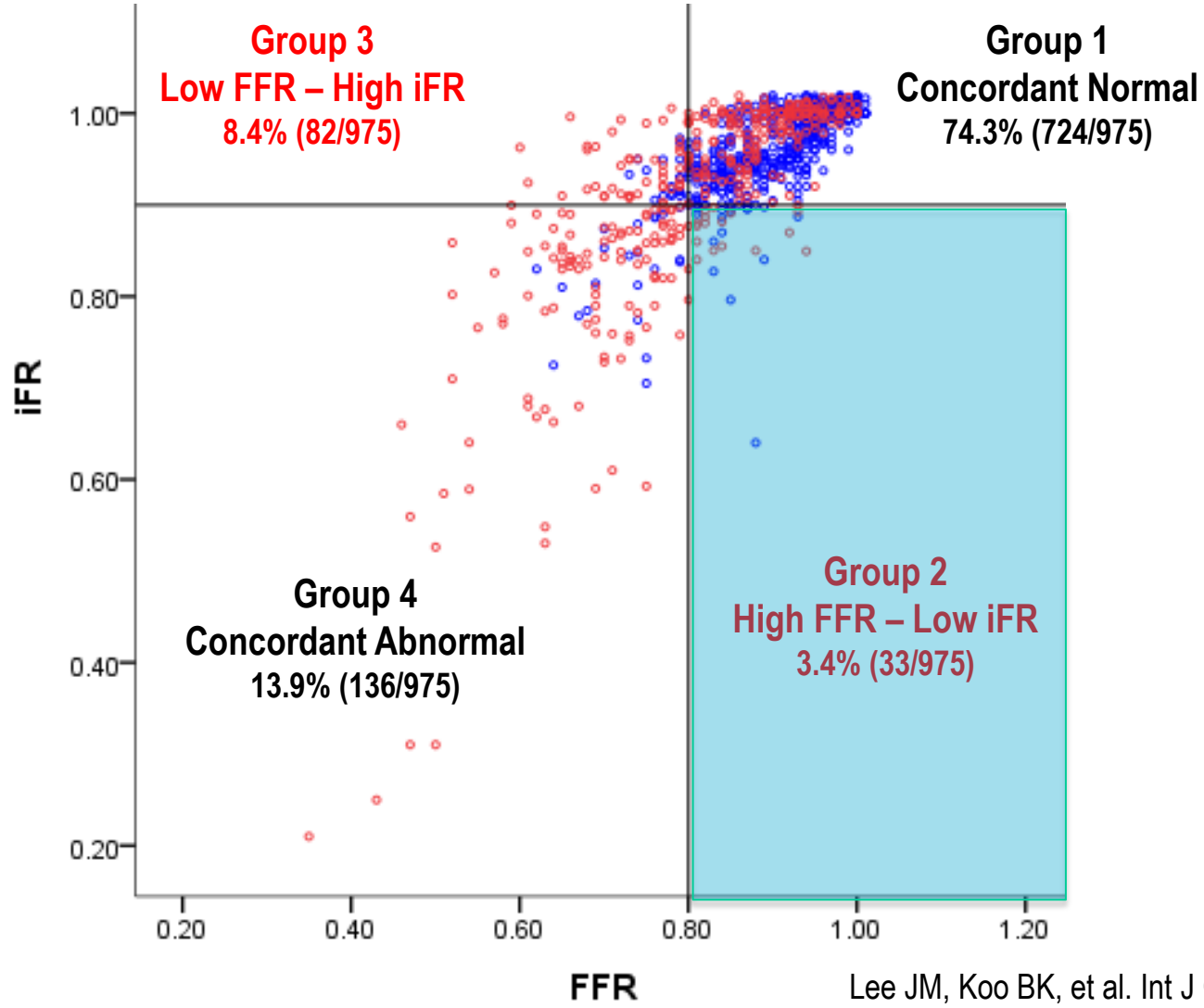
Influence of inadequate resting status



Lee JM ,Koo BK, et al Circulation 2017

Resting Index vs. Hyperemic Index

(from 3V-FFR FRIENDS study)



Lee JM, Koo BK, et al. Int J Cardiol 2017
Lee JM, Koo BK, et al. Eur Heart J 2018

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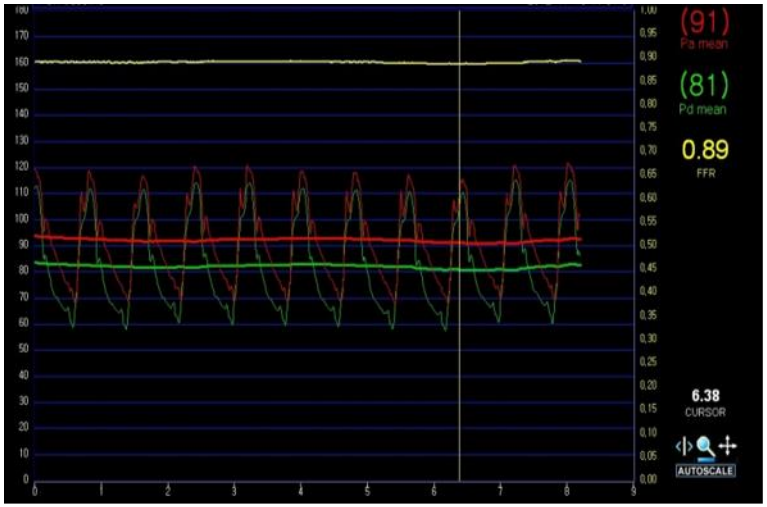
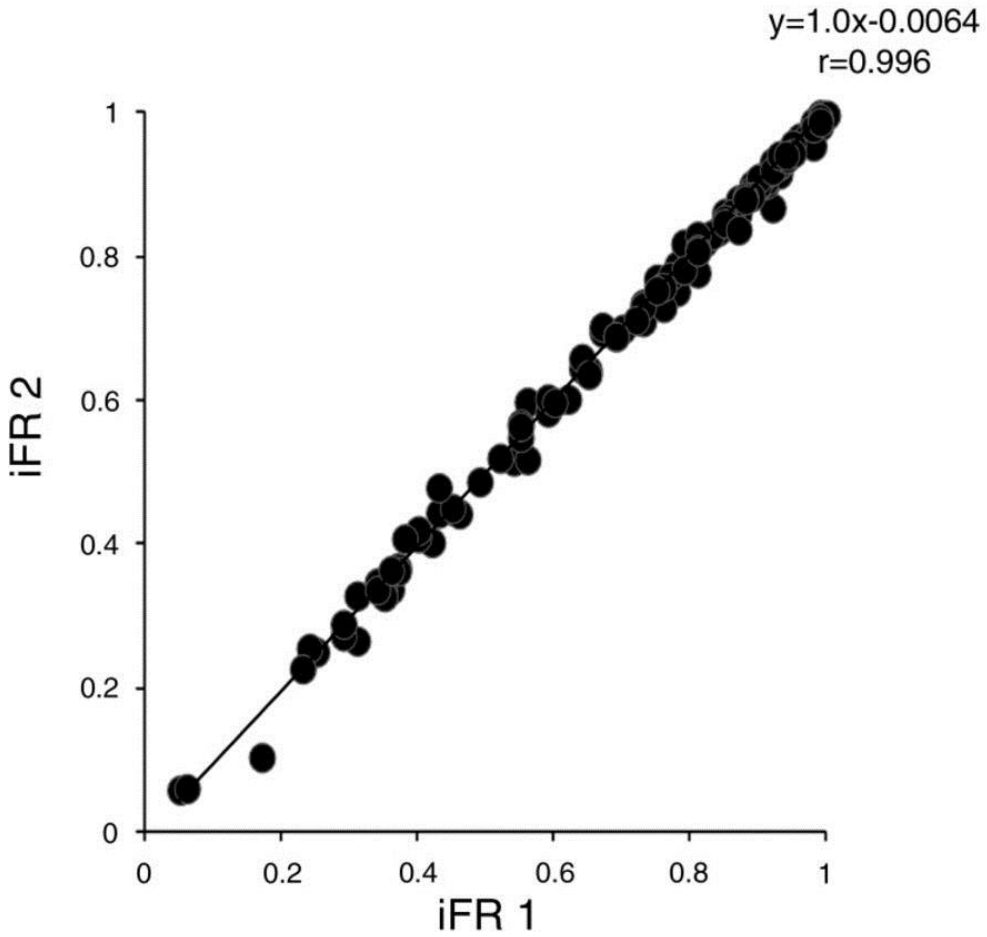


Reproducibility of resting index



Sen S, et al J Am Coll Cardiol 2012

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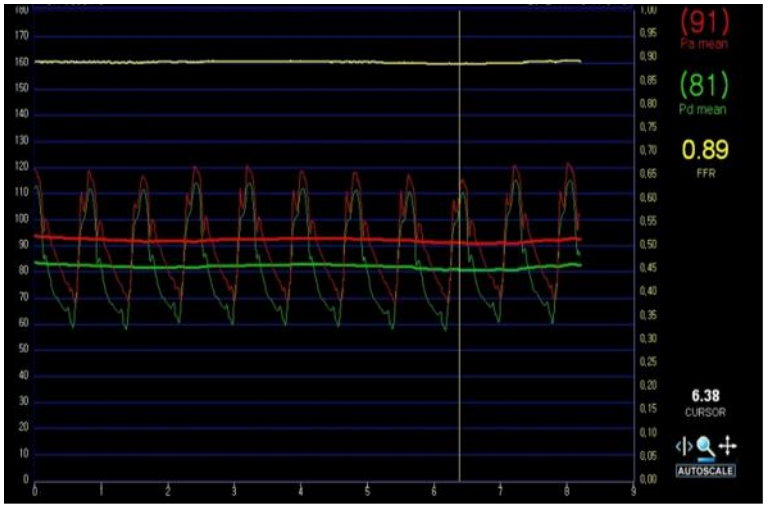
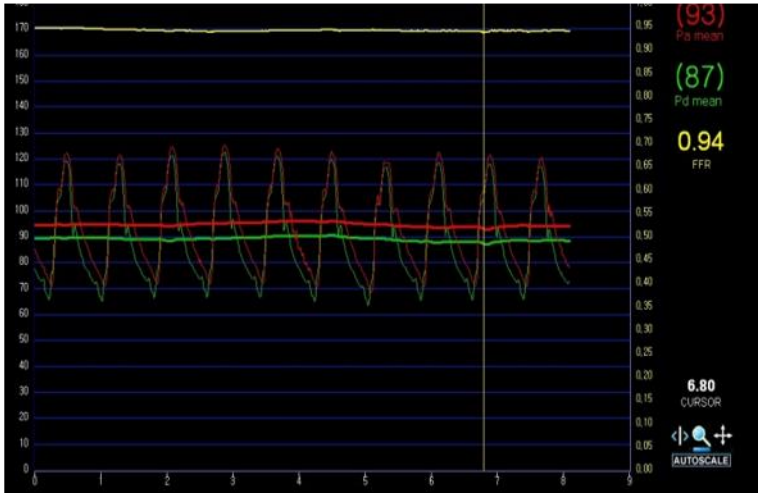


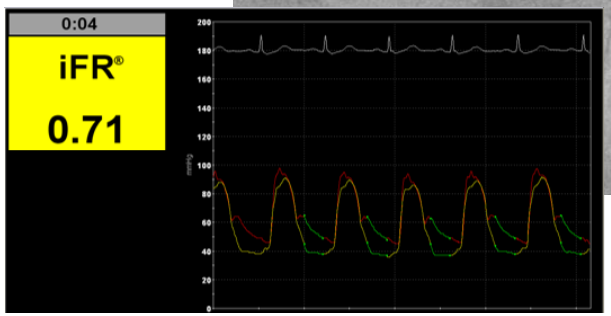


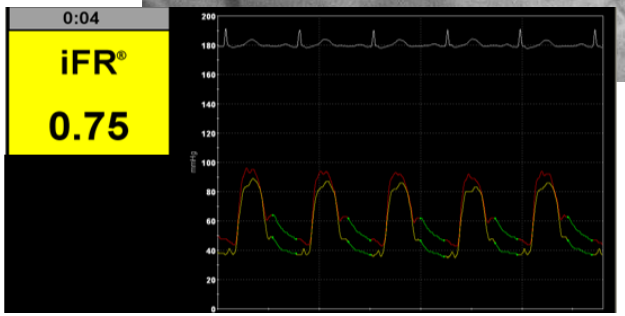
2min later

M/78 Atypical discomfort, Dyspnea

s/p Lung cancer surgery, COPD

s/p Stomach cancer surgery





Summary

- In general, optimal hyperemia or resting status is easily and reliably achievable.
- In case of doubt….
  - **When you are using resting index,**
    - Just wait for 1-2 min and repeat the measurement
    - Use hyperemic index
  - **When you are using hyperemic index,**
    - Refer to the value of resting index
    - Increase the dosage or use different agent/route