

*Imaging and Physiology Summit*  
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# **Concept and Set-up for Fractional Flow Reserve**

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**Assistant Professor**

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## **AHA Scientific Statement**

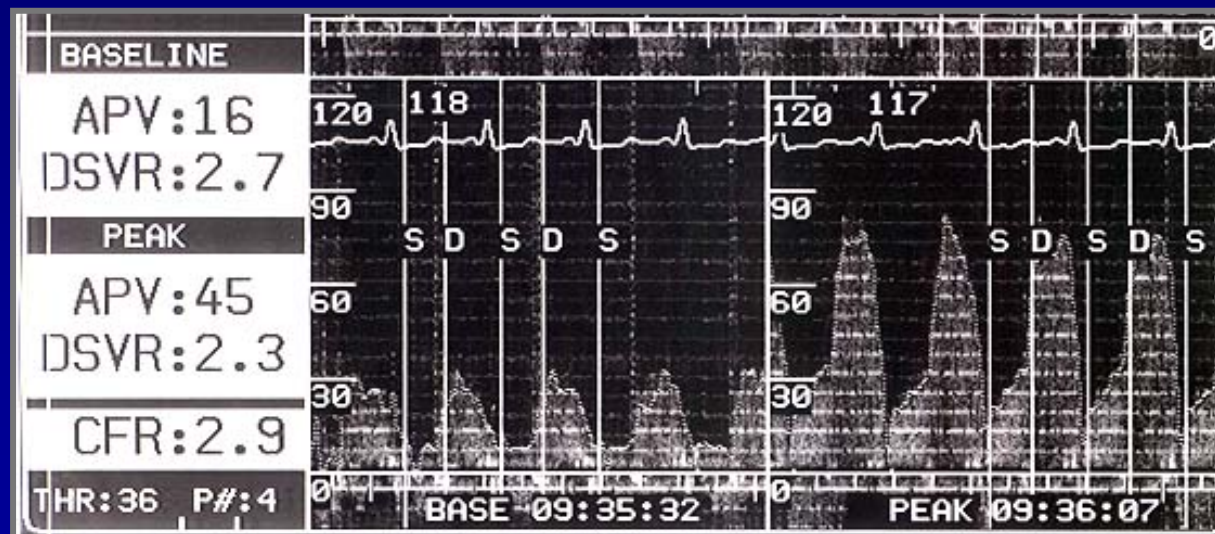
# **Physiological Assessment of Coronary Artery Disease in the Cardiac Catheterization Laboratory**

**A Scientific Statement From the American Heart Association  
Committee on Diagnostic and Interventional Cardiac Catheterization,  
Council on Clinical Cardiology**

Morton J. Kern, MD, FAHA, Chair; Amir Lerman, MD, Co-Chair; Jan-Willen Bech, MD;  
Bernard De Bruyne, MD, PhD; Eric Eeckhout, MD, PhD; William F. Fearon, MD;  
Stuart T. Higano, MD, FAHA; Michael J. Lim, MD; Martijn Meuwissen, MD; Jan J. Piek, MD;  
Nico H.J. Pijls, MD, PhD, FAHA; Maria Siebes, PhD; Jos A.E. Spaan, PhD, FAHA

# Coronary Flow Reserve

$$\frac{\text{Maximal coronary flow (or velocity)}}{\text{Resting coronary flow (or velocity)}}$$



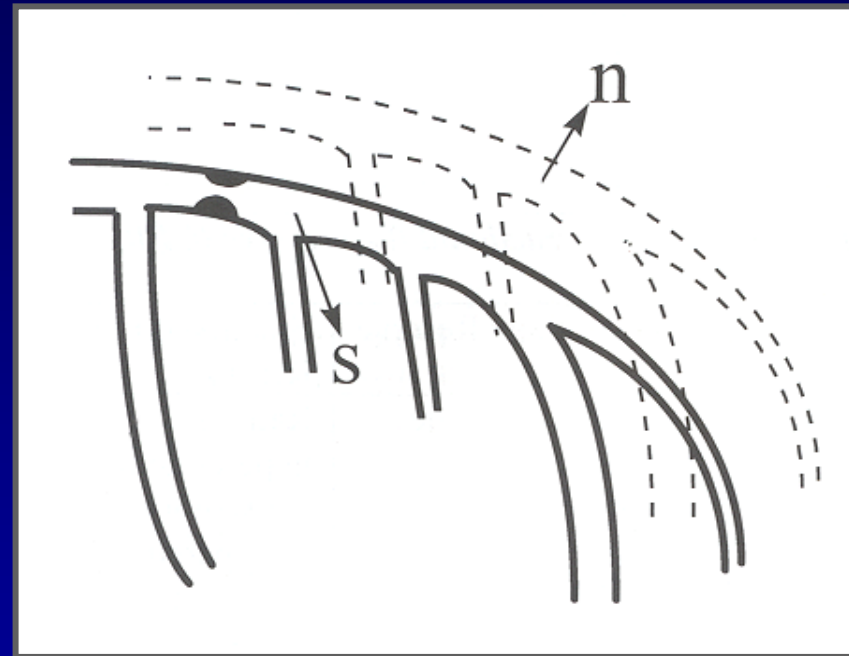
# Coronary Flow Reserve

- $\text{CFR} < 2$  implies a significant stenosis
- No clearly defined normal value
- Affected by hemodynamics
- Does not distinguish epicardial from microvascular disease

# Fractional Flow Reserve (FFR)

Maximum flow down a vessel in the presence of a stenosis...

...compared to the maximum flow in the hypothetical absence of the stenosis



Pijls and De Bruyne, Coronary Pressure  
Kluwer Academic Publishers, 2000

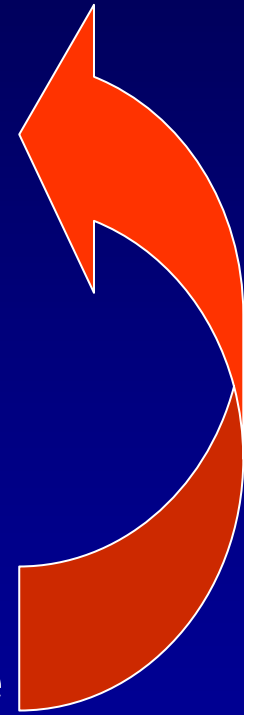
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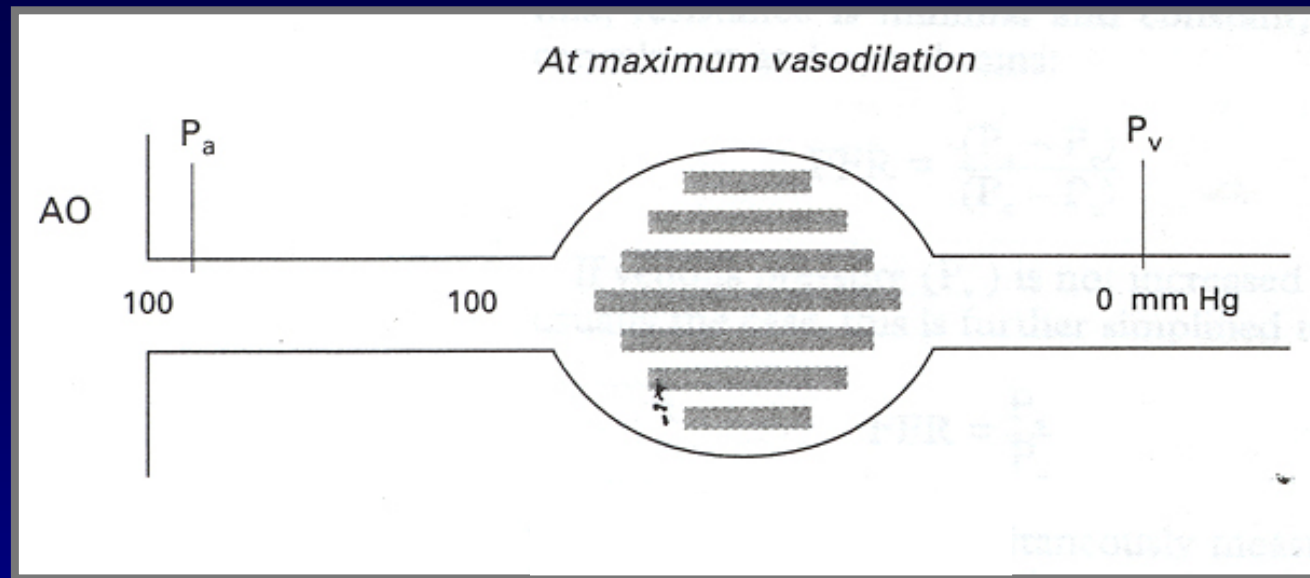
# Derivation of FFR

- $FFR = \frac{\text{Coronary Flow}_{\text{(Stenosis)}}}{\text{Coronary Flow}_{\text{(Normal)}}}$
- $\text{Coronary Flow} = \frac{\text{Pressure}}{\text{Resistance}}$
- *at maximal hyperemia*  $\text{Coronary Flow} \approx \text{Pressure}$

# Derivation of FFR

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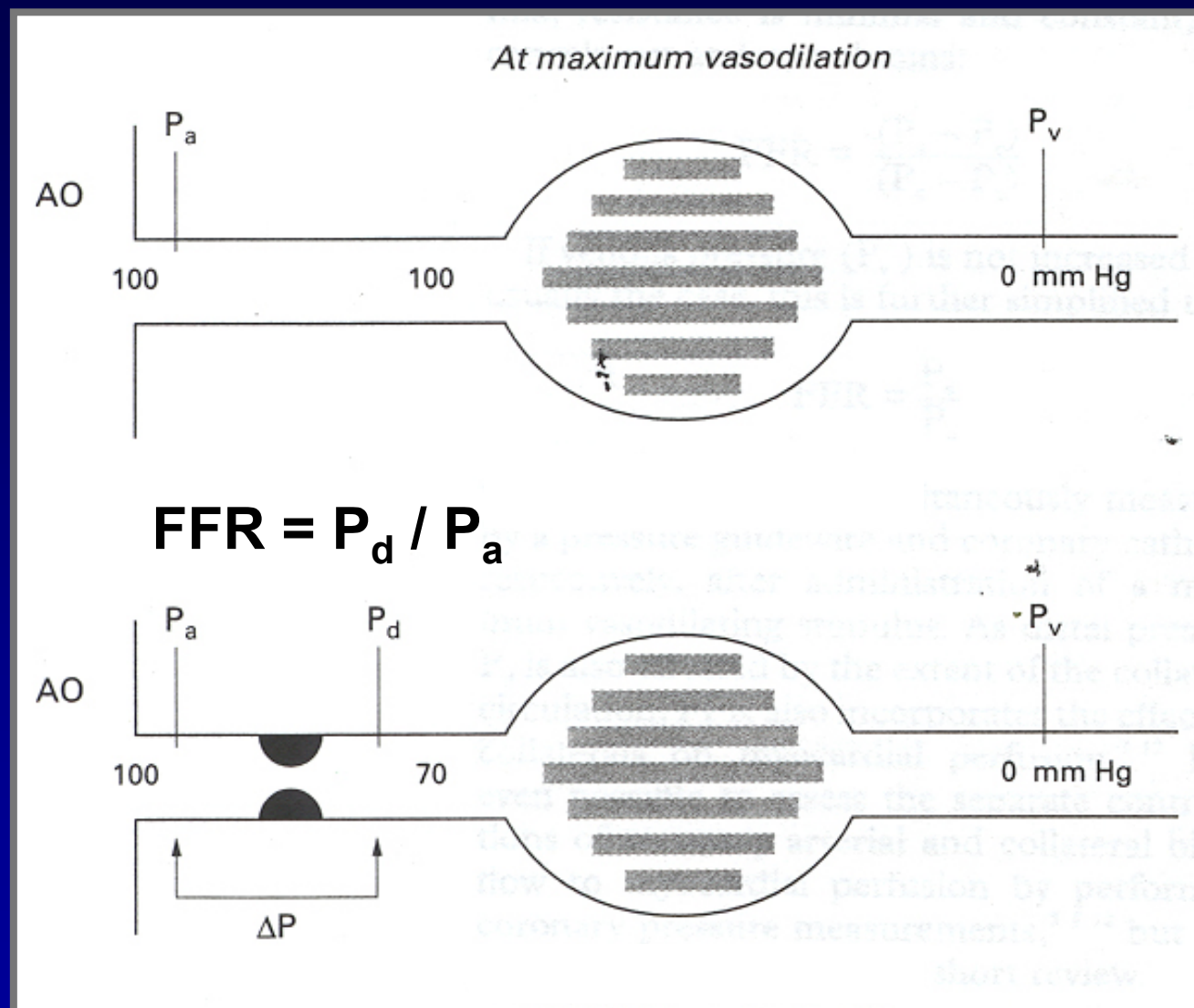




Adapted from: Pijls and De Bruyne, Coronary Pressure  
Kluwer Academic Publishers, 2000

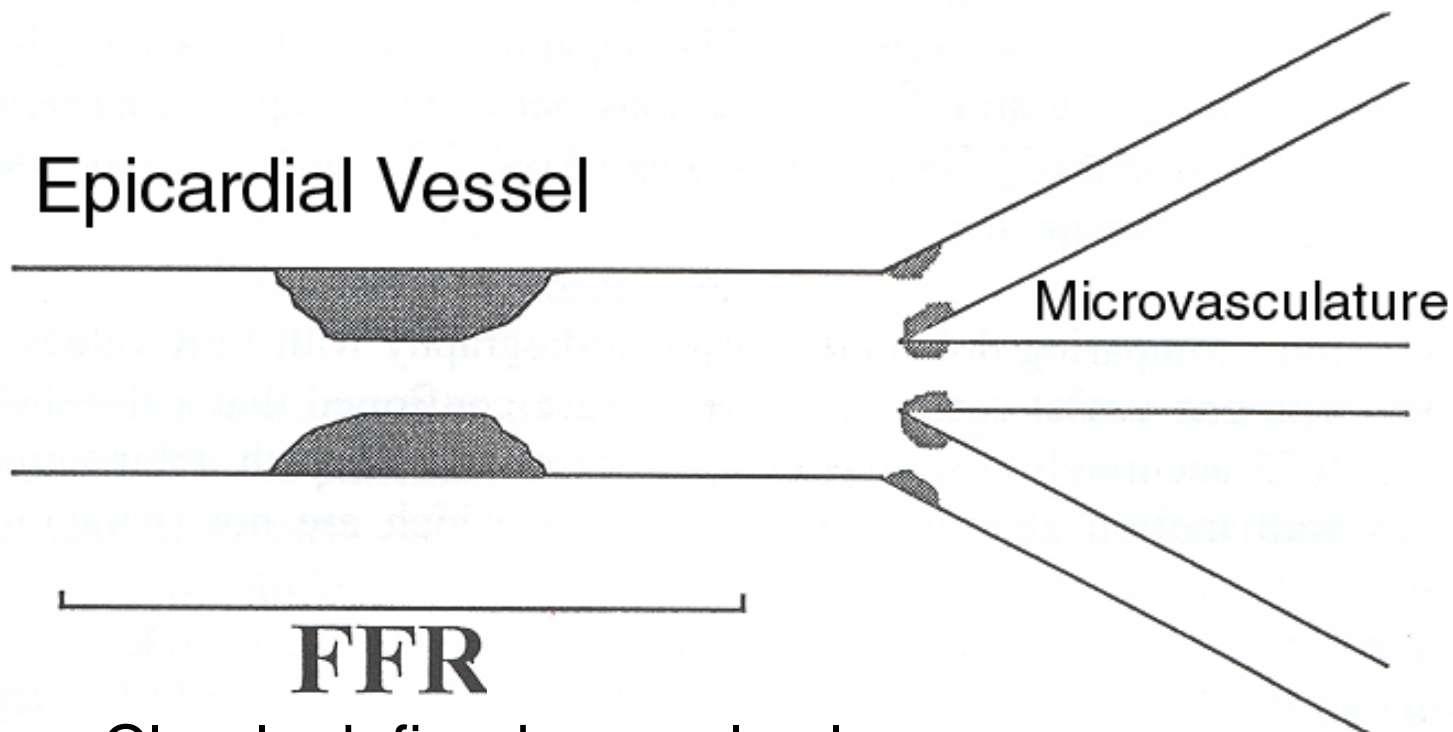
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Adapted from: Pijls and De Bruyne, Coronary Pressure  
Kluwer Academic Publishers, 2000

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- Clearly defined normal value
- Not affected by resting hemodynamics
- Relatively easy to perform

## CFR

*Hyperemic Flow*



*Resting Flow*



## FFR

*Hyperemic Flow with Stenosis*

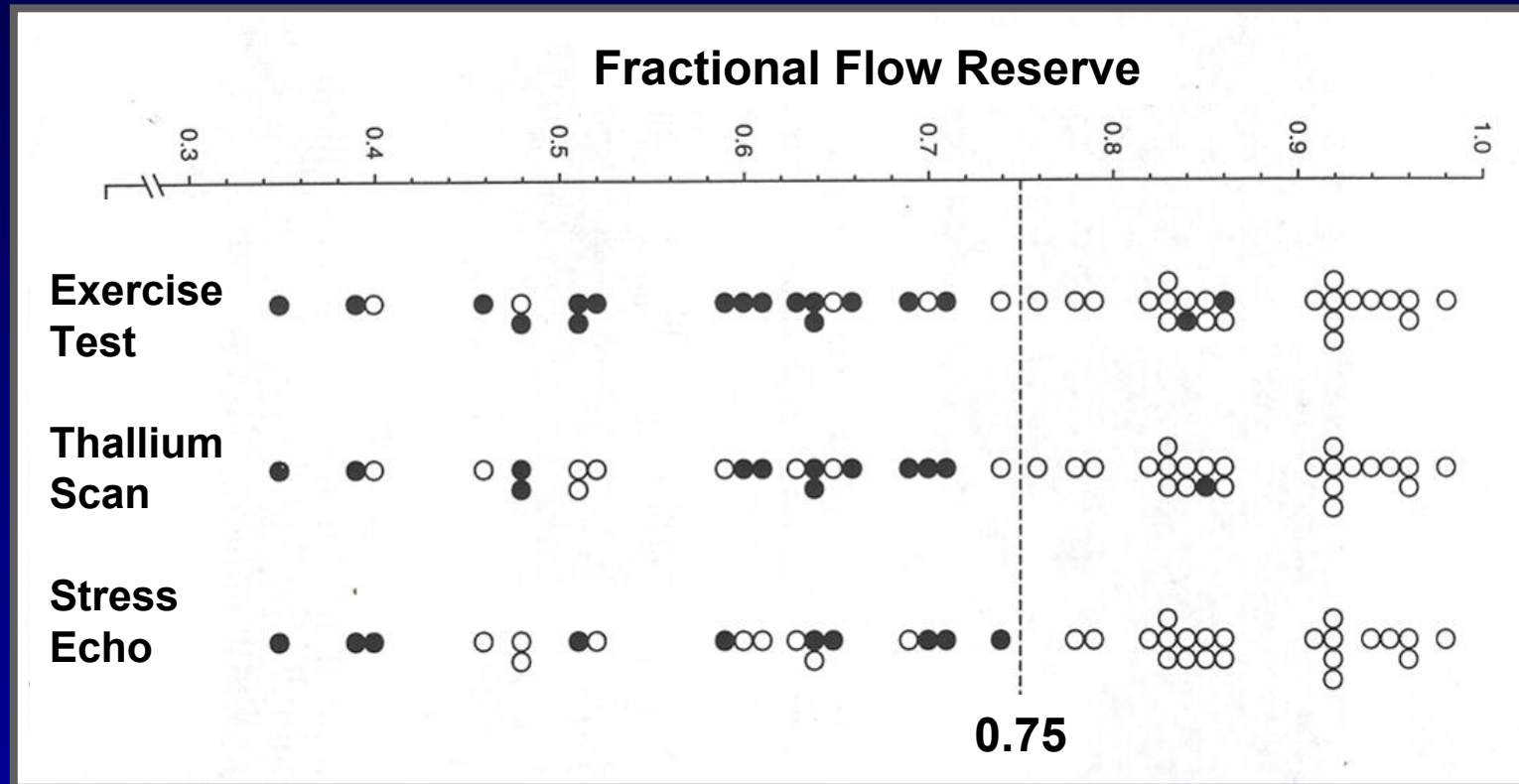


*Hyperemic Flow without Stenosis*



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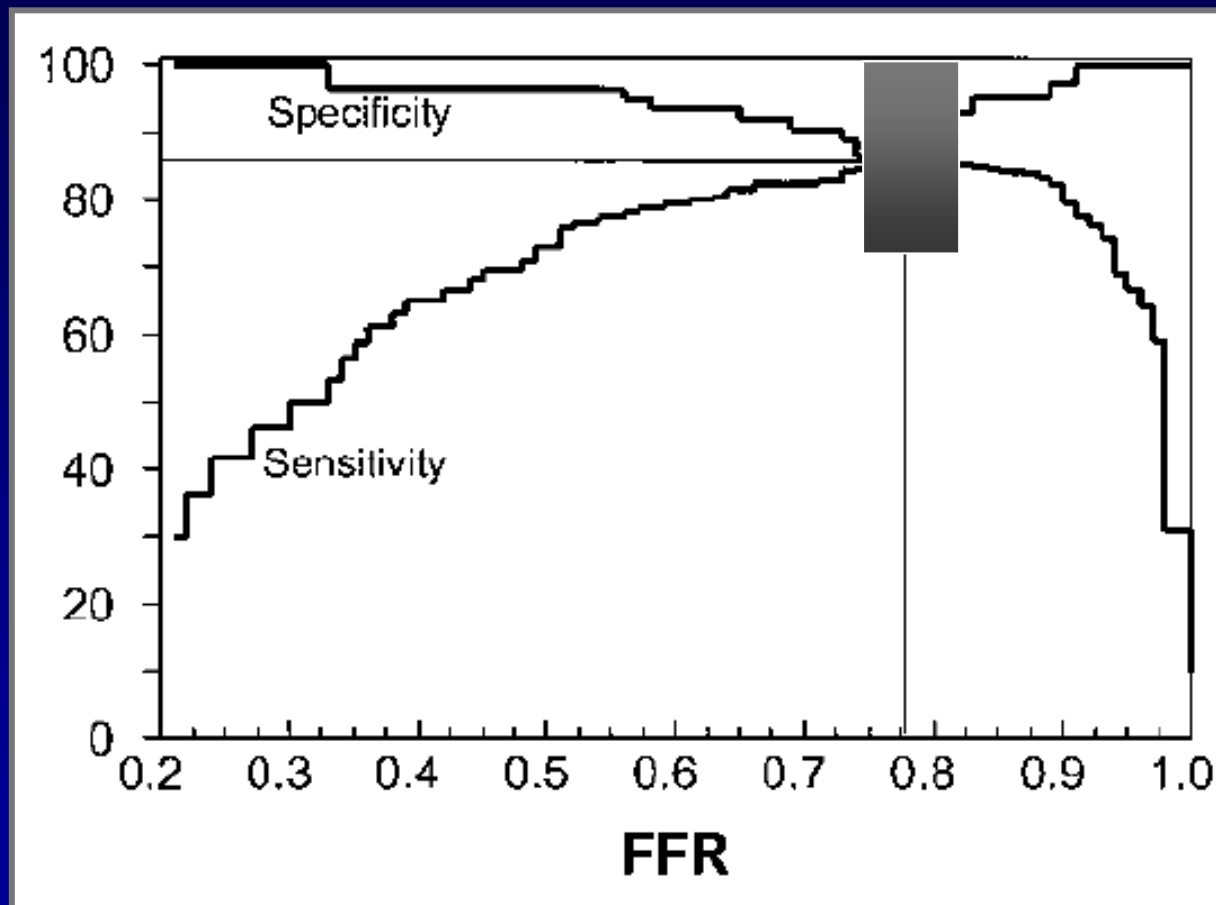
# FFR in Intermediate Lesions



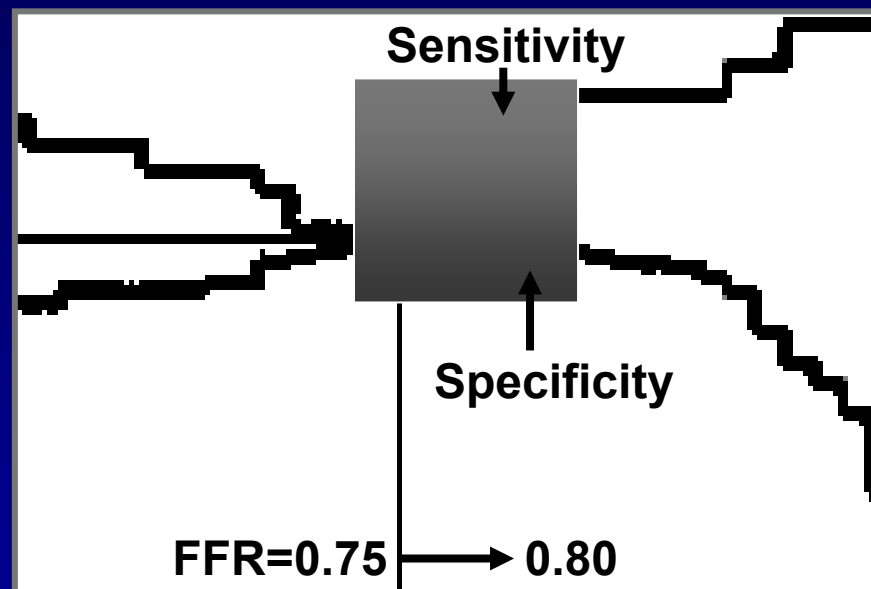
$FFR < 0.75$  : Sensitivity = 88%  
Specificity = 100%

Reference	Reference No.	n	Ischemic Test	BCV	Accuracy, %
<b>FFR</b>					
Pijls	16	60	X-ECG	0.74	97
De Bruyne	20	60	X-ECG/SPECT	0.66	87
Pijls	19	45	X-ECG/SPECT/pacing/DSE	0.75	93
Bartunek	79	37	DSE	0.67	90
Abe	80	46	SPECT	0.75	91
Chamuleau*	47	127	SPECT	0.74	77
Caymaz	81	40	SPECT	0.75	95
Fearon	82	10	SPECT	0.75	95
De Bruyne†	57	57	SPECT	0.78	85
Jimenez-Navarro	83	21	DSE	0.75	90
Meuwissen	23	151	SPECT	0.74	75
Usui†	84	167	SPECT	0.75	79
Yanagisawa	85	165	SPECT	0.75	76

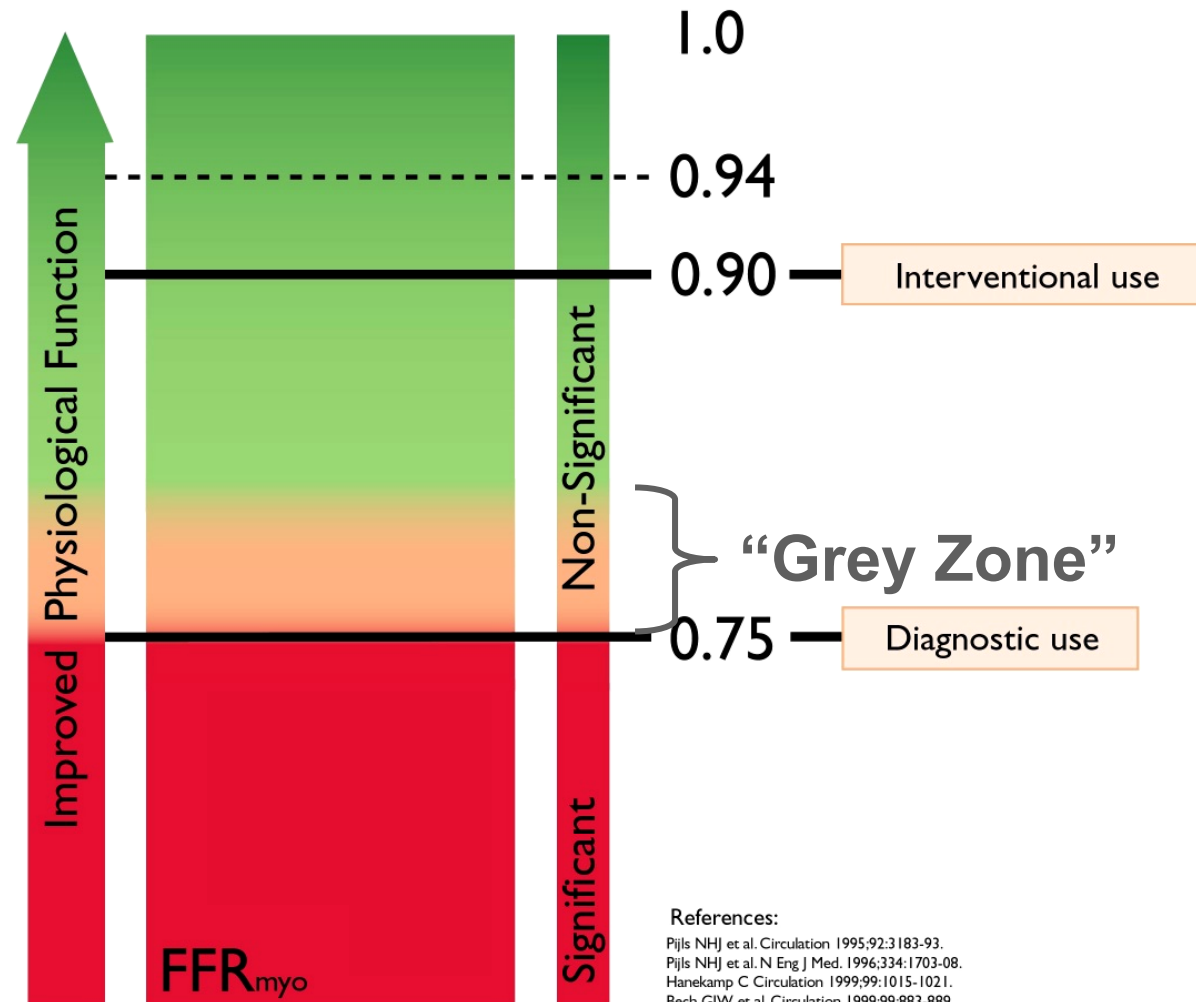
# FFR and the “Grey Zone”



# FFR and the “Grey Zone”



## FFR for decision-making in the cath lab



Based on the teaching file of Paul G. Yock MD, Stanford University.

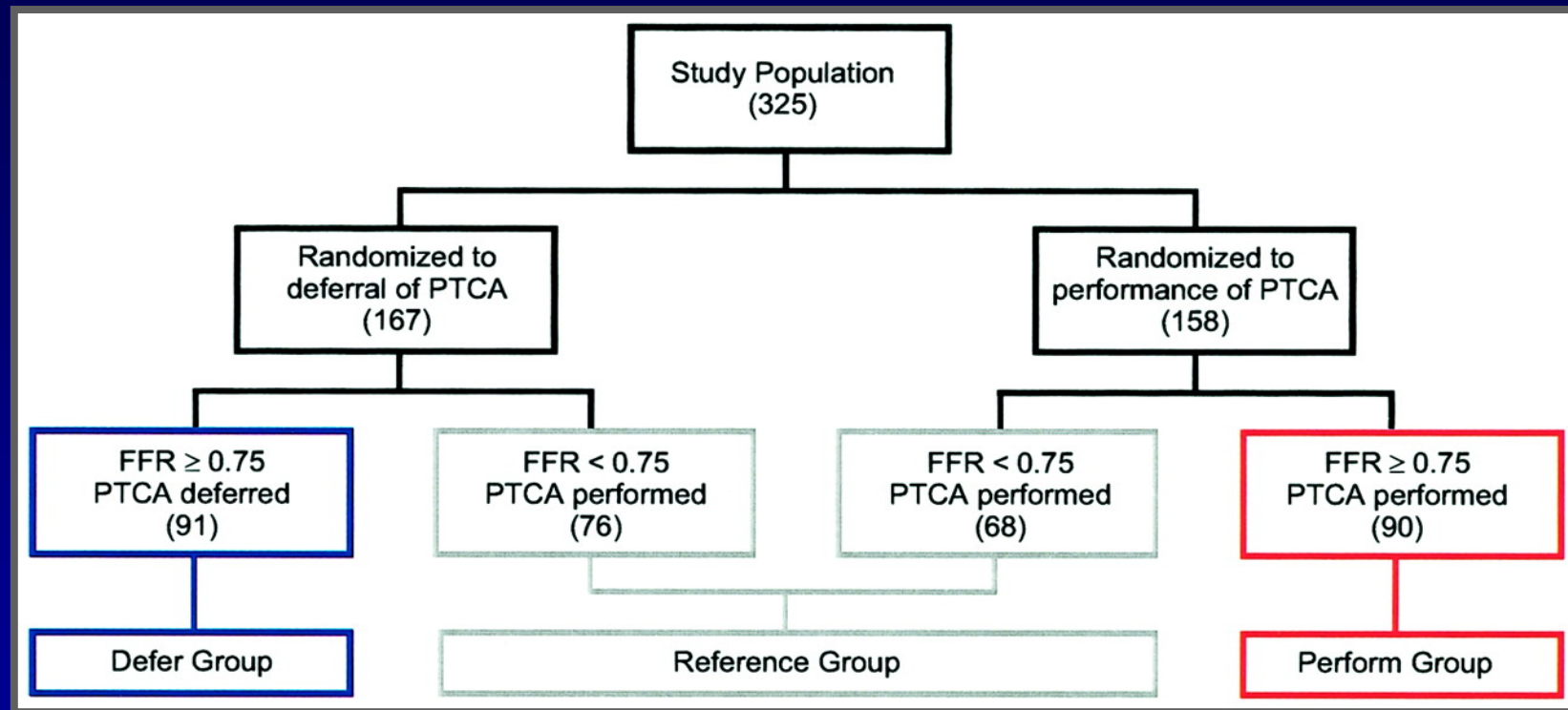
Note: The specificity of this cut-off value is 100% and the sensitivity is 88%.

### References:

Pijls NHJ et al. Circulation 1995;92:3183-93.  
 Pijls NHJ et al. N Eng J Med. 1996;334:1703-08.  
 Hanekamp C. Circulation 1999;99:1015-1021.  
 Bech GJW et al. Circulation 1999;99:883-889.  
 Pijls NHJ and De Bruyne B. 2000.  
 Coronary Pressure 2nd Edition. Kluwer Academic Publishers

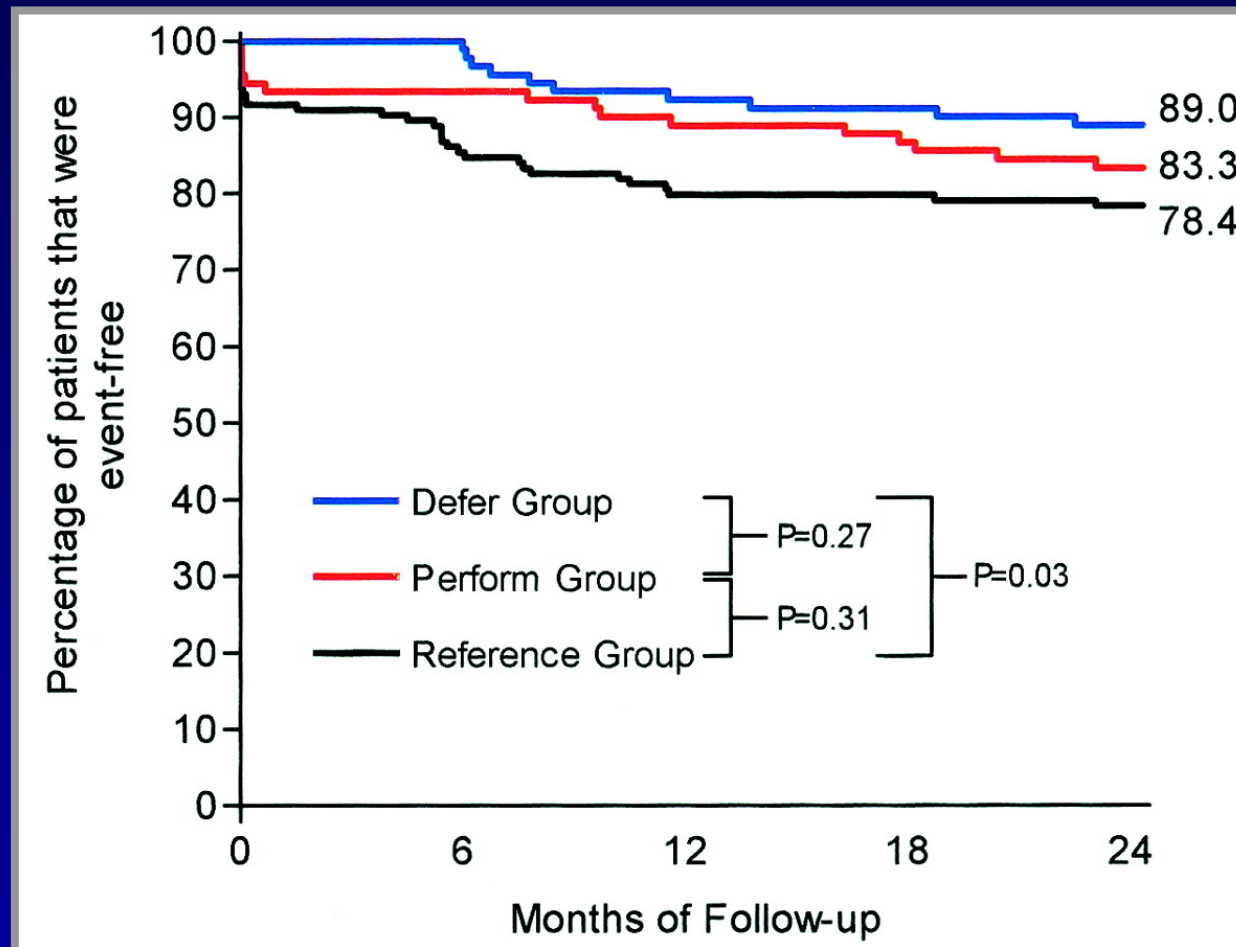


# Is Deferral of PCI Safe if FFR $\geq 0.75$ ?

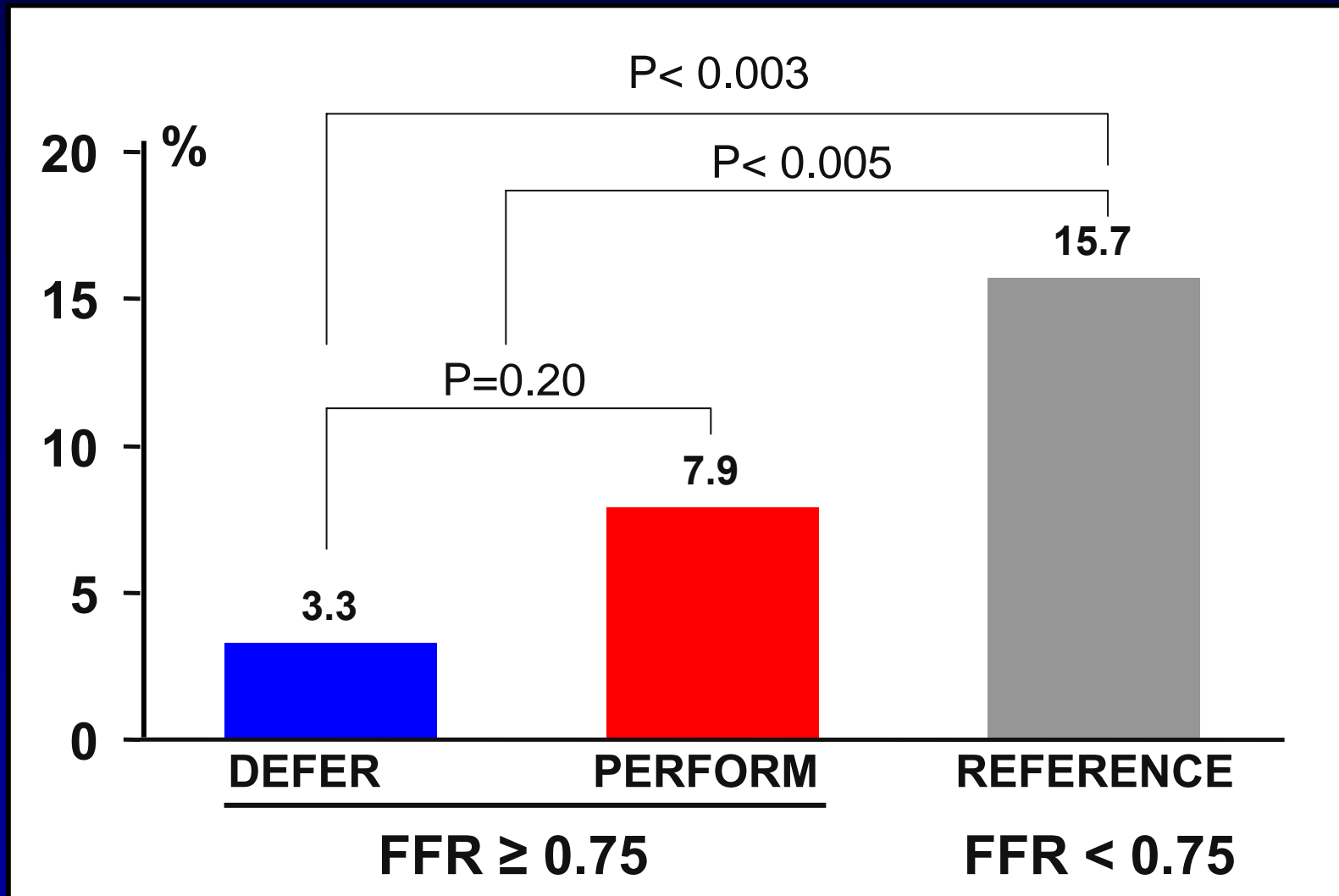


# DEFER Study: 2 Year F/U

## *Freedom From MACE*

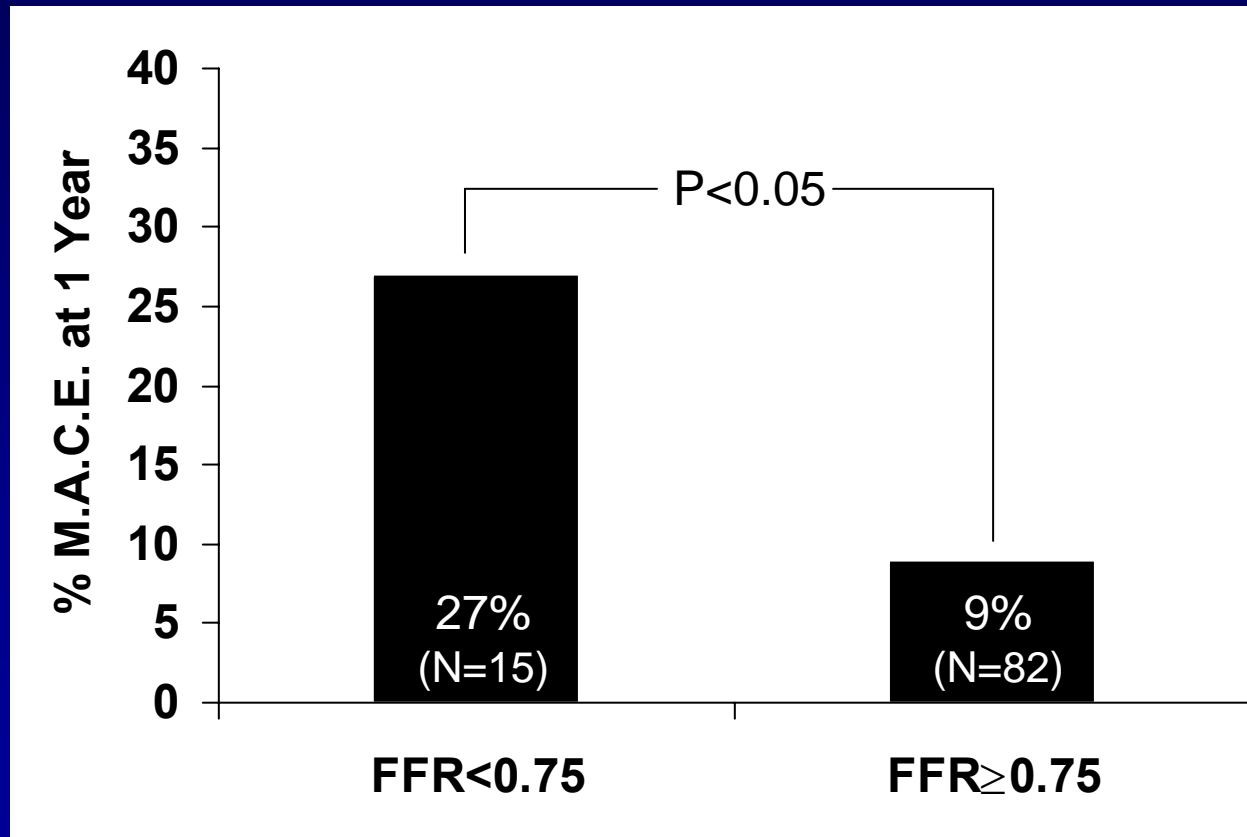


## Cardiac Death And Acute MI After 5 Years



# ***Danger of Deferring PCI if FFR < 0.75***

97 patients with intermediate lesions and normal NPS



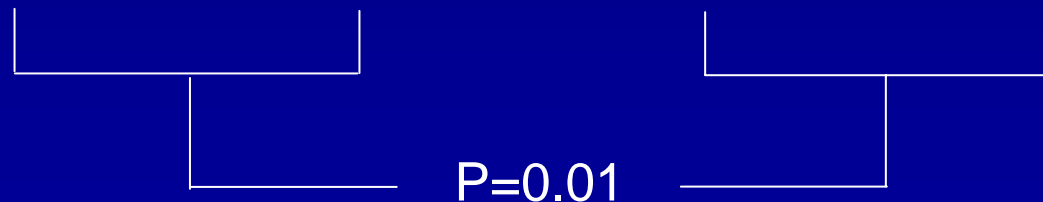
# ***Danger of not Heeding FFR Result***

*71 patients in whom FFR was ignored:*

34 deferred despite FFR < 0.80

37 stented despite FFR > 0.80

	Non-compliance group (n = 71)		Compliance group (n = 336)	
	No revasc (n = 34)	Revasc (n = 37)	No revasc (n = 237)	Revasc (n = 99)
Clinical events	7/34 (21%)	4/37 (11%)	14/237 (7%)	6/99 (6%)
Death	2/34 (6%)	1/37 (3%)	3/237 (1%)	0/99
Acute coronary syndromes	2/34 (6%)	1/31 (3%)	2/237 (1%)	0/99
Vessel revascularization	3/34 (9%)	2/37 (5%)	9/237 (4%)	6/99 (6%)

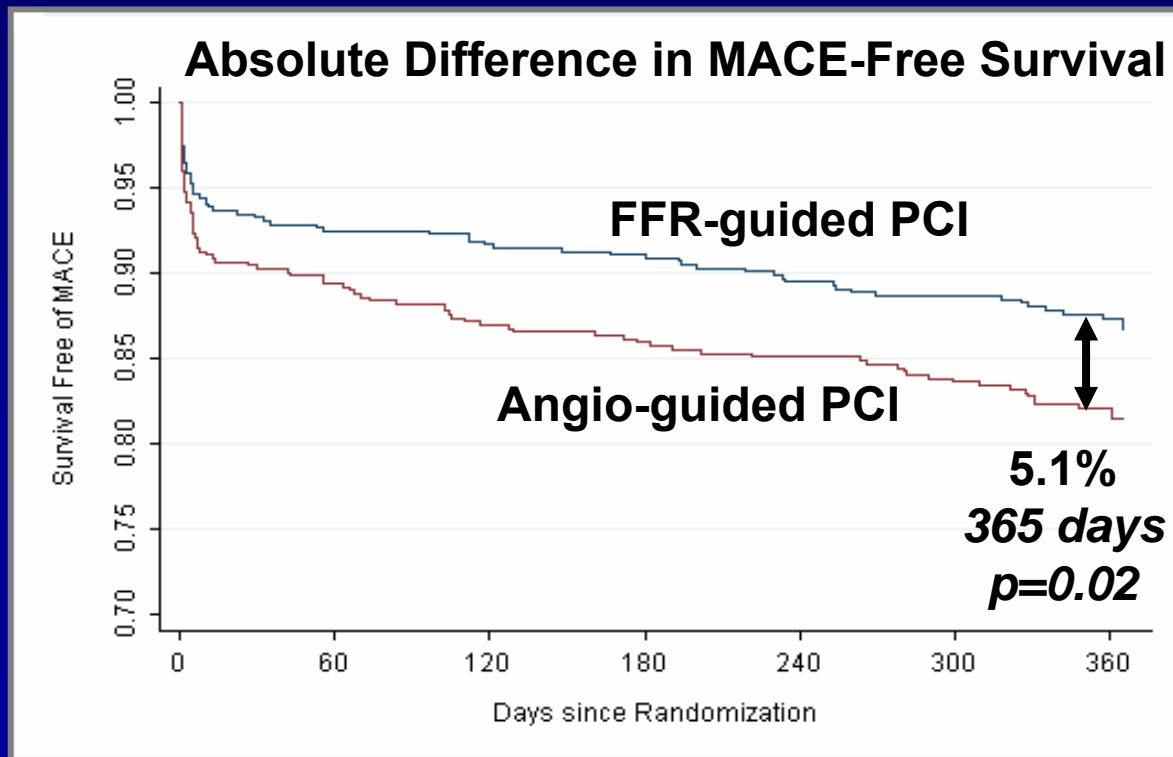


# FFR-Guided PCI vs. Angio-Guided PCI



## *Results of the FAME study:*

1. Improved outcomes
2. Decreased cost
3. Less contrast use
4. Similar procedure time



### Angio      FFR

\$6,007 vs \$5,332,  $p < 0.001$

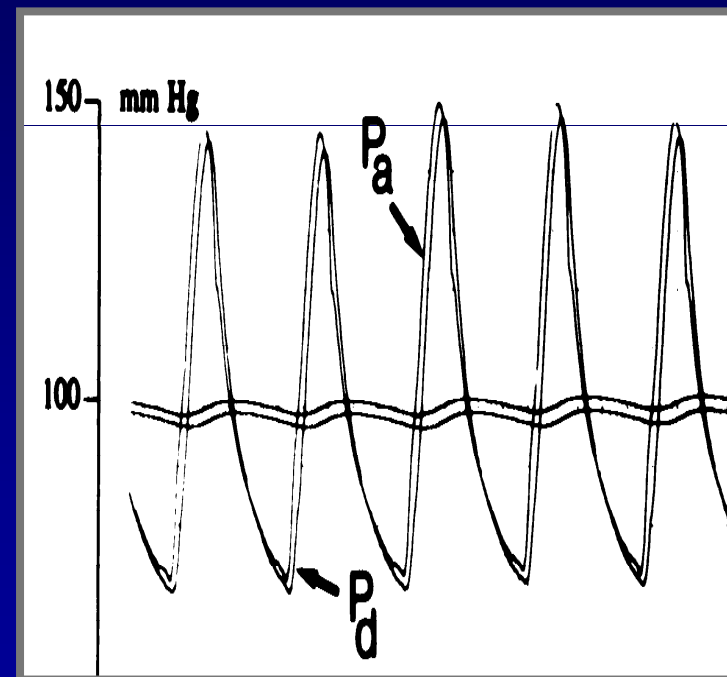
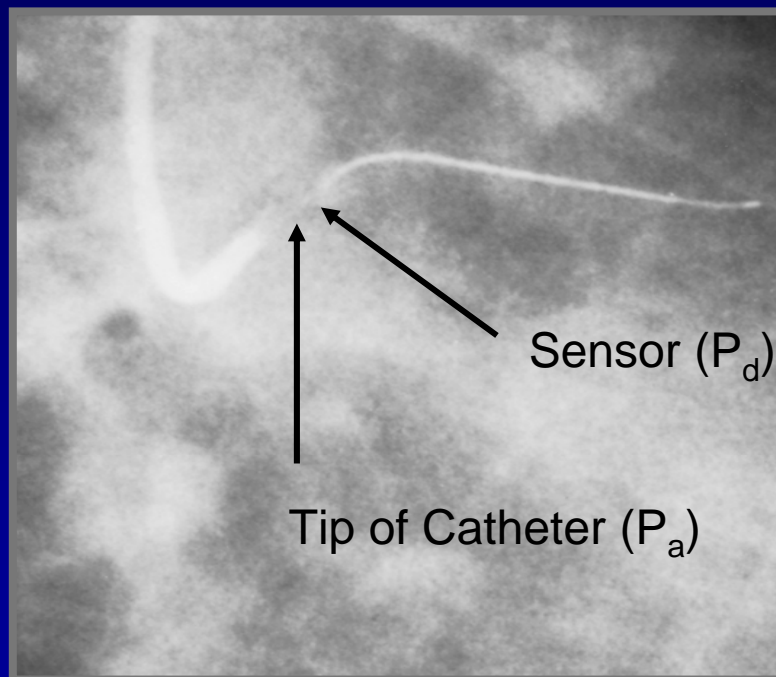
302 ml vs 272 ml,  $p < 0.001$

70 min vs 71 min,  $p = 0.51$

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# Performing FFR

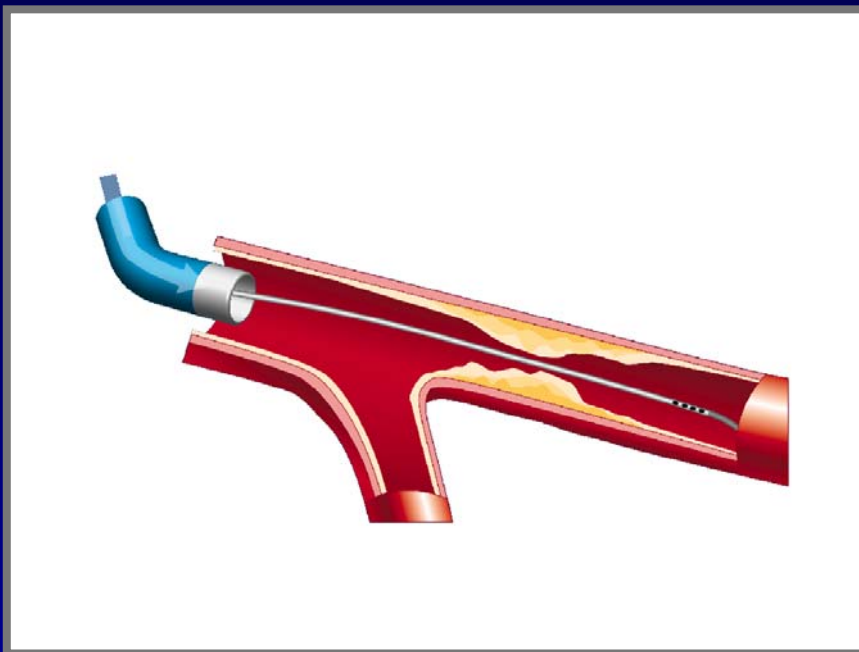
## *Equalizing Pressures*



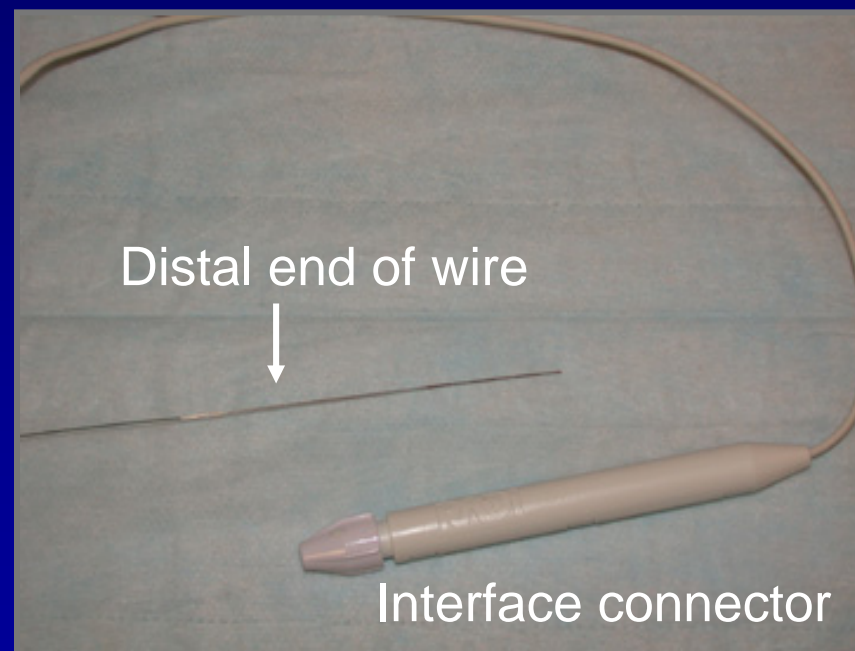
*Note: To be perfectly accurate the wire introducer should be removed*

# Performing FFR

## *Wiring the Lesion*



- 100-200 ugs IC NTG
- 50-70 units/kg IV Heparin
- Consider disconnecting the wire from the interface connector





# Performing FFR

## *Inducing Hyperemia*

### Intravenous Infusion (Preferably Central Line)

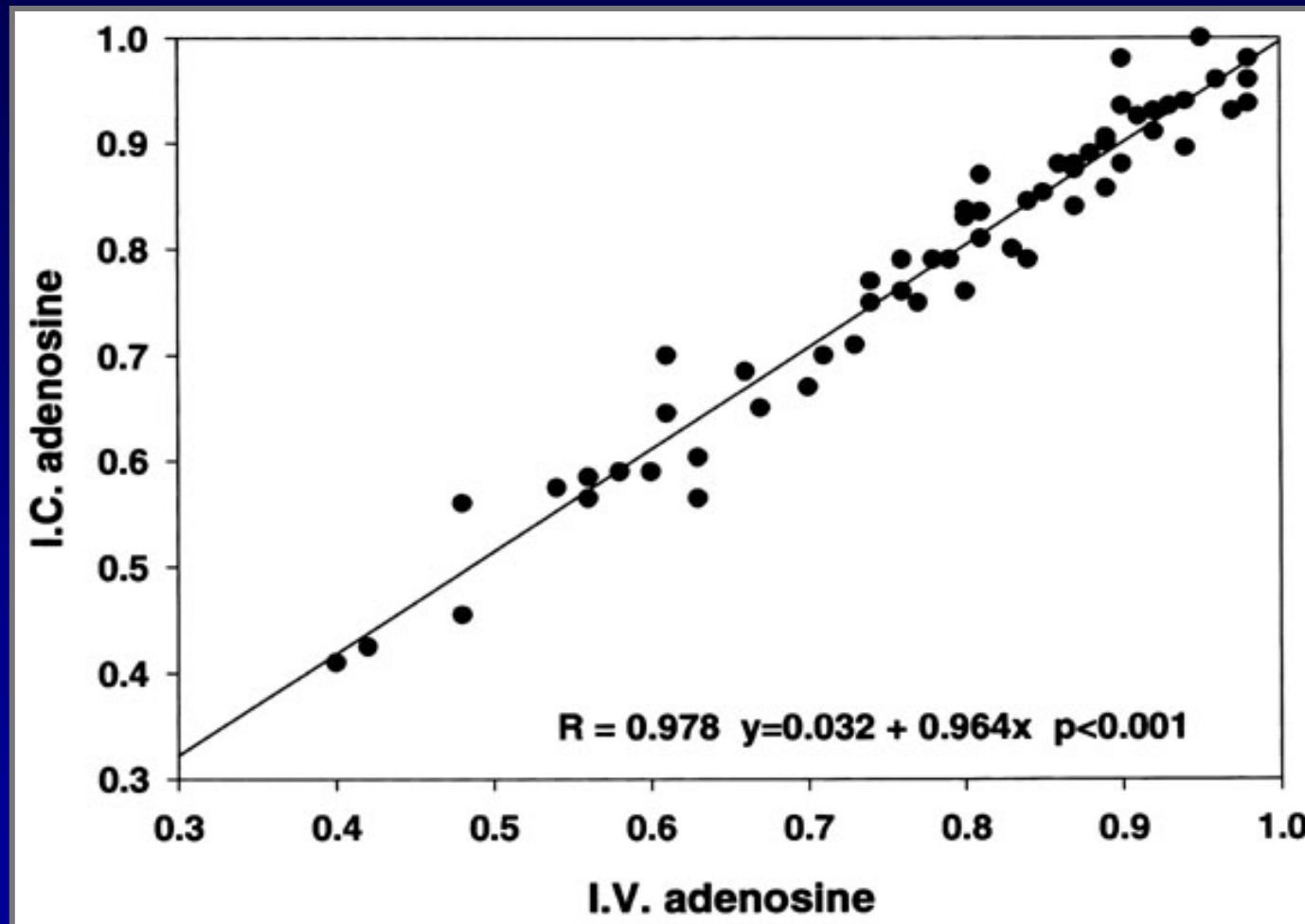
- Adenosine 140 mcg/kg/min
- Dobutamine 40 mcg/kg/min

### Intracoronary Bolus

	LCA	RCA
- Adenosine	>72 µg	>48µg
- Papaverine	12 mg	8 mg

# Performing FFR

## *Inducing Hyperemia*

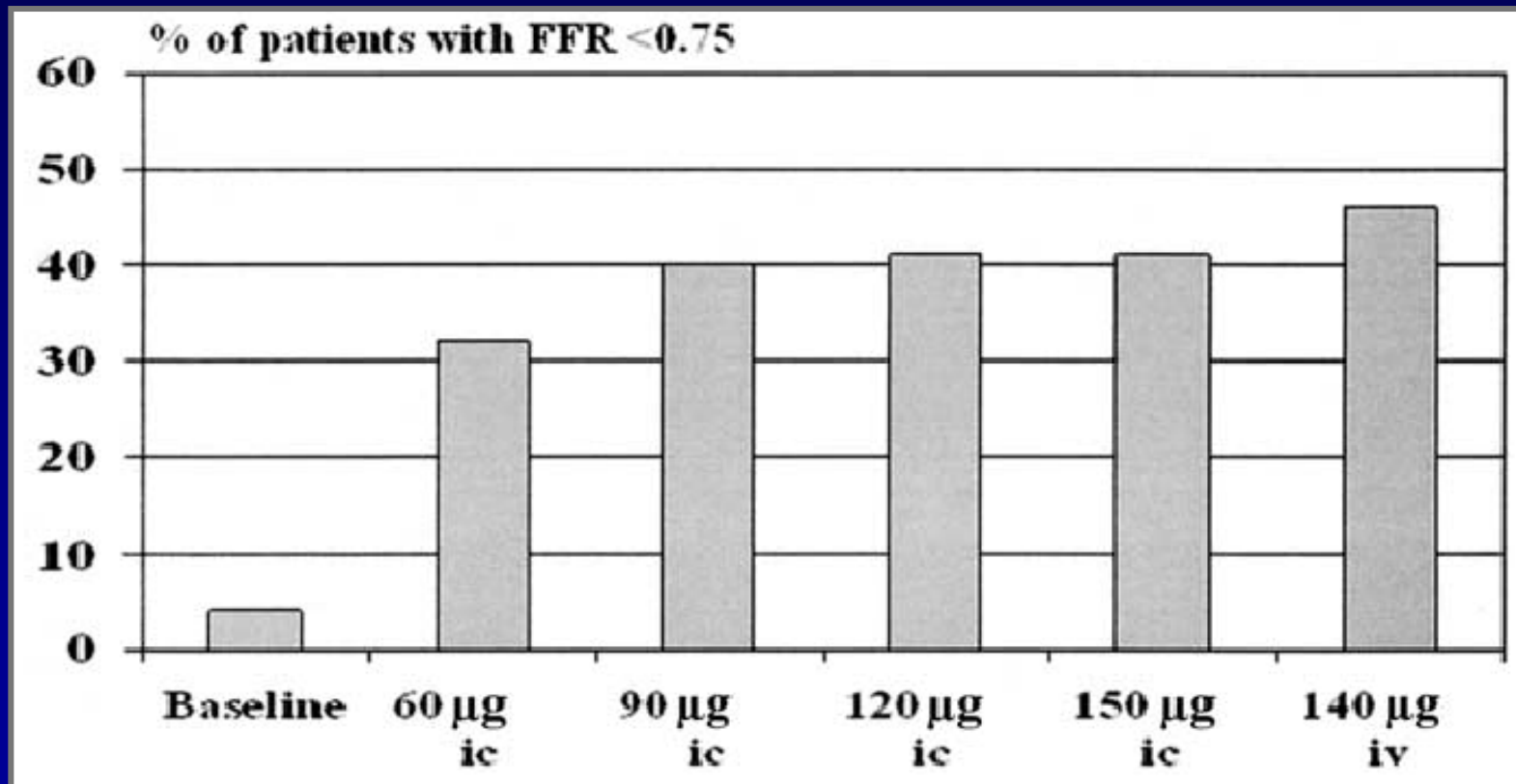


Jeremias et al. Am Heart J 2000;140:651-657.

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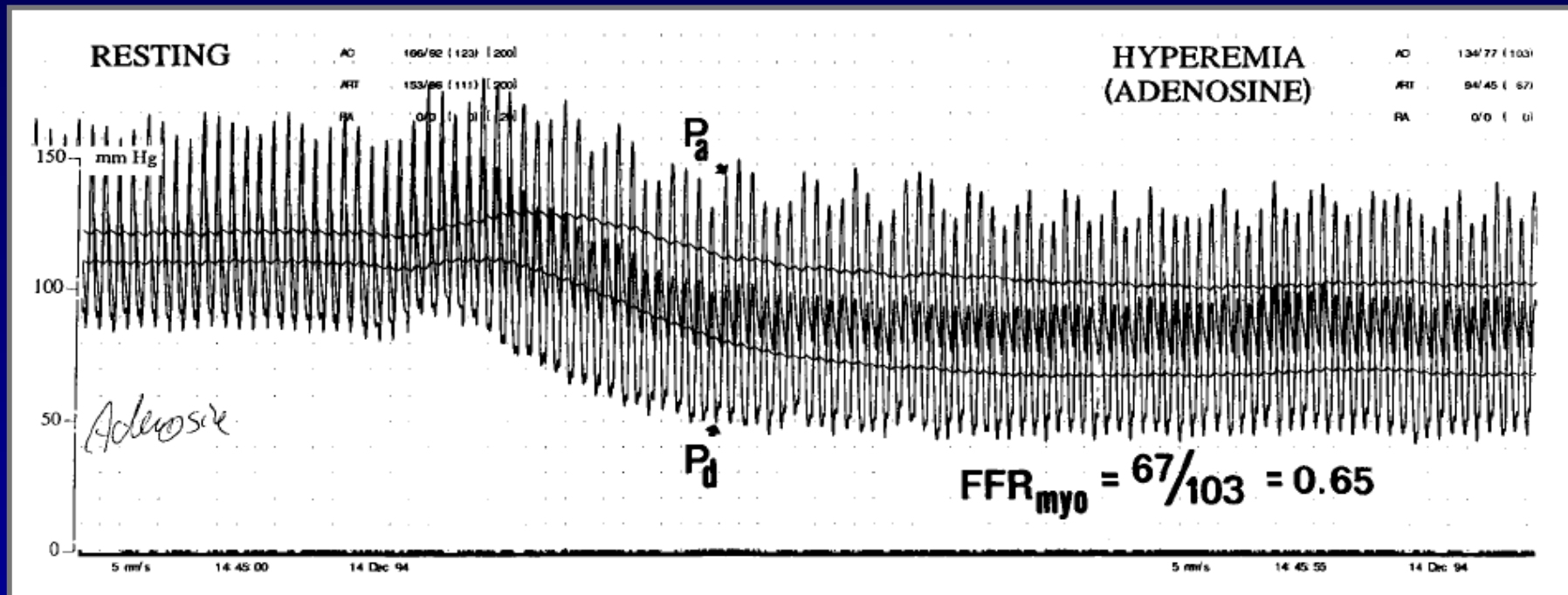
# Inducing Hyperemia

*FFR measured in 50 patients with intermediate lesions*

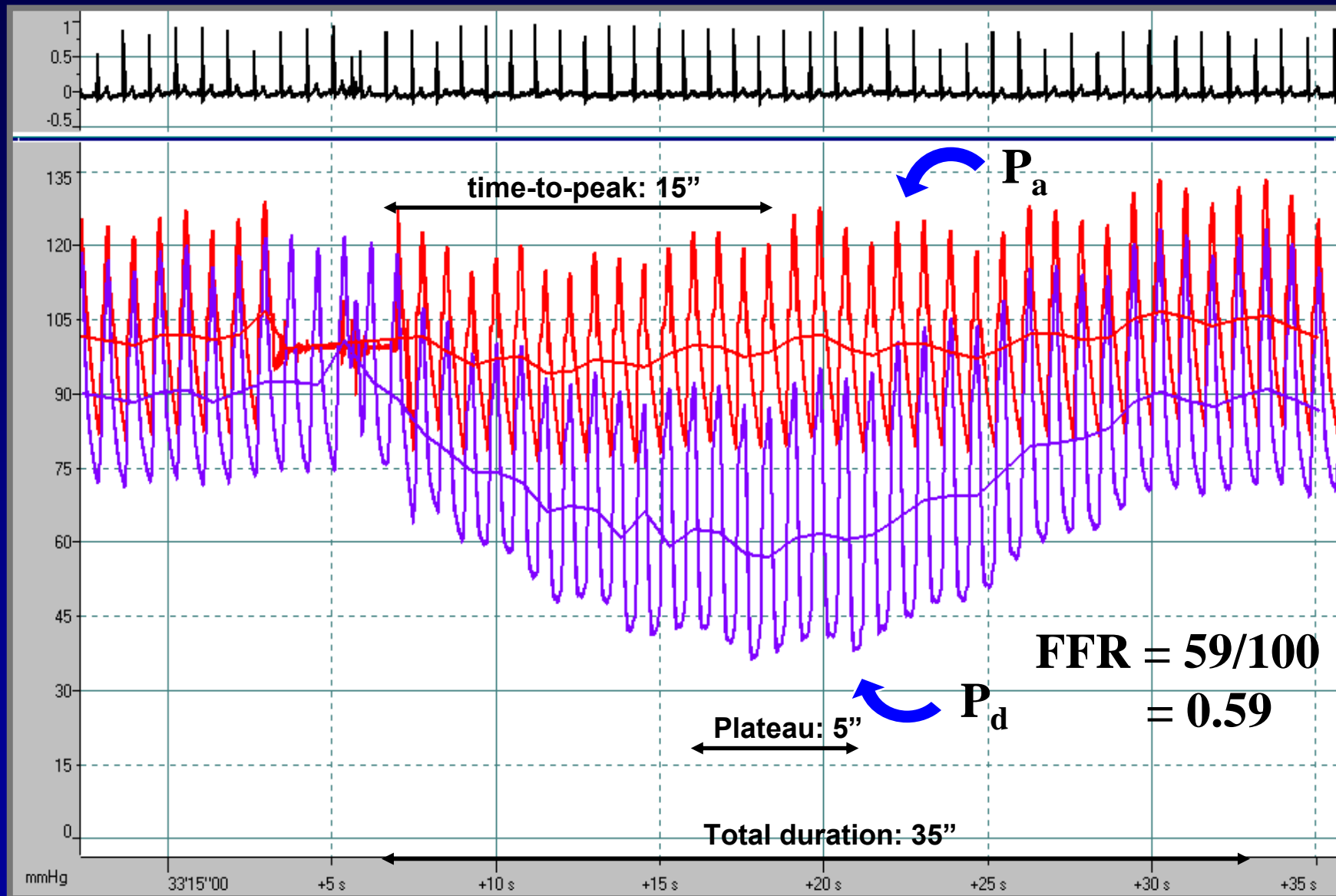


# Inducing Hyperemia

## *Intravenous Adenosine*



## Intracoronary Adenosine

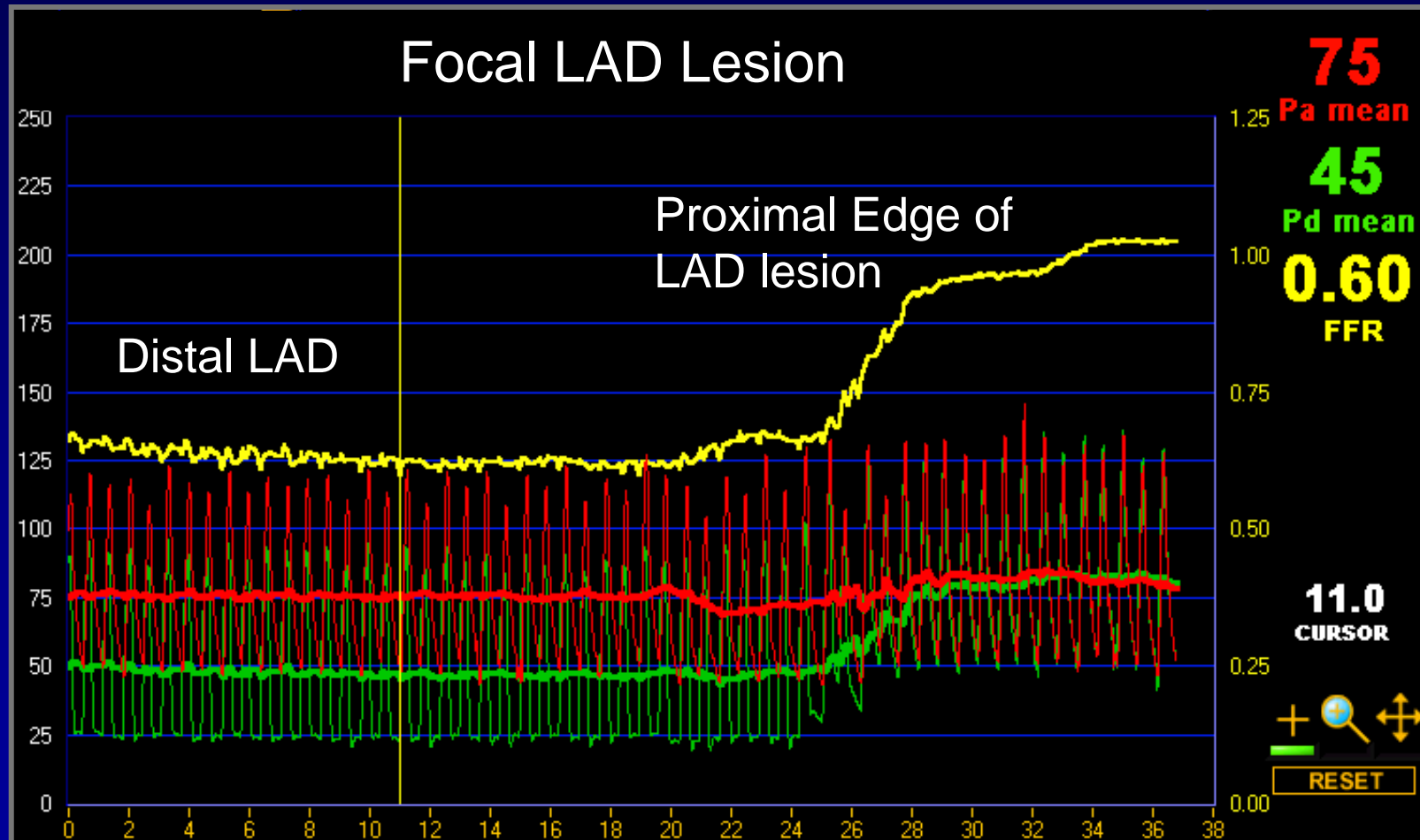


Courtesy of B. De Bruyne

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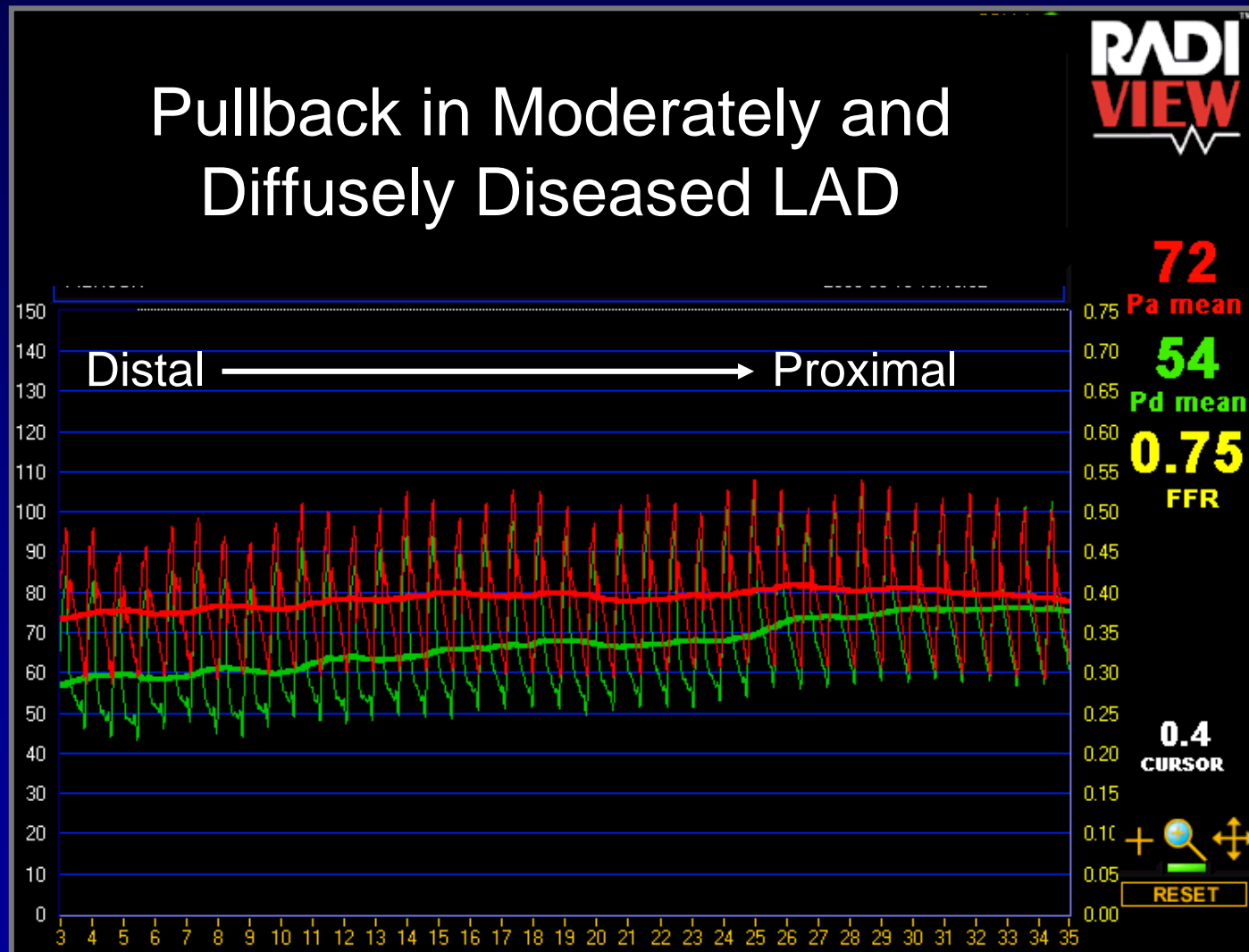
# Performing FFR

## Pressure Pullback



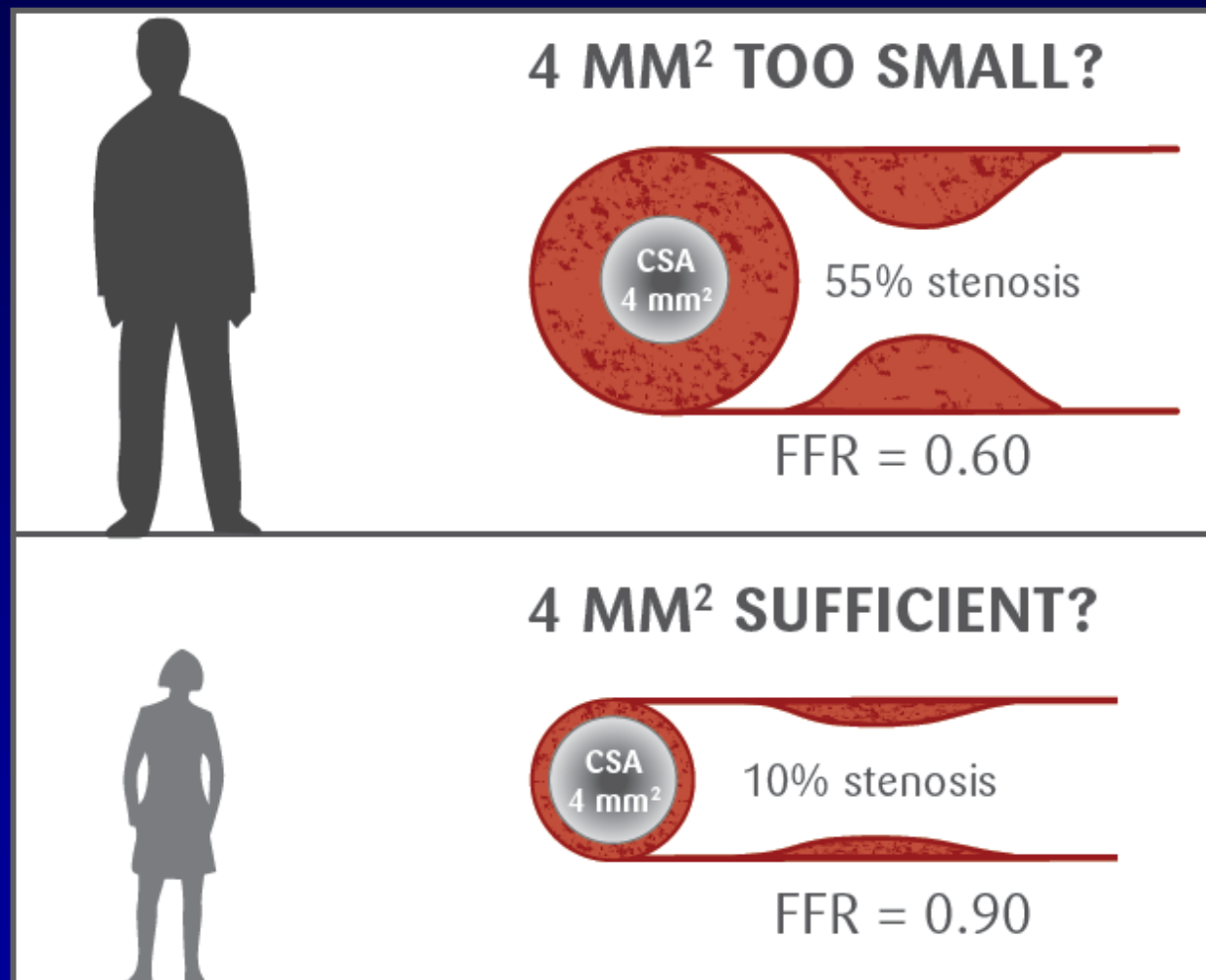
# Performing FFR

Pullback in Moderately and  
Diffusely Diseased LAD



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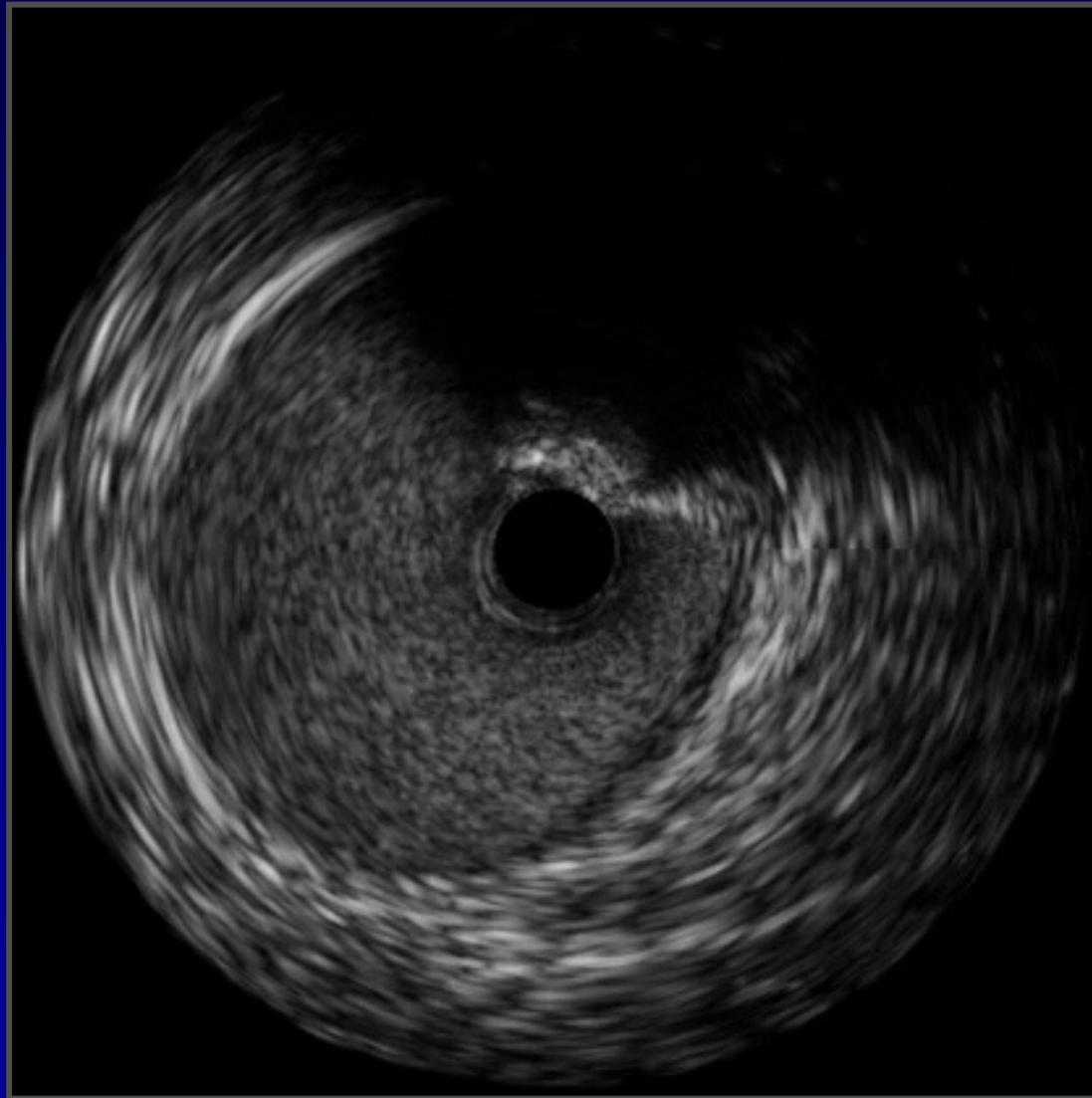
# IVUS cutoff is affected by size of vessel



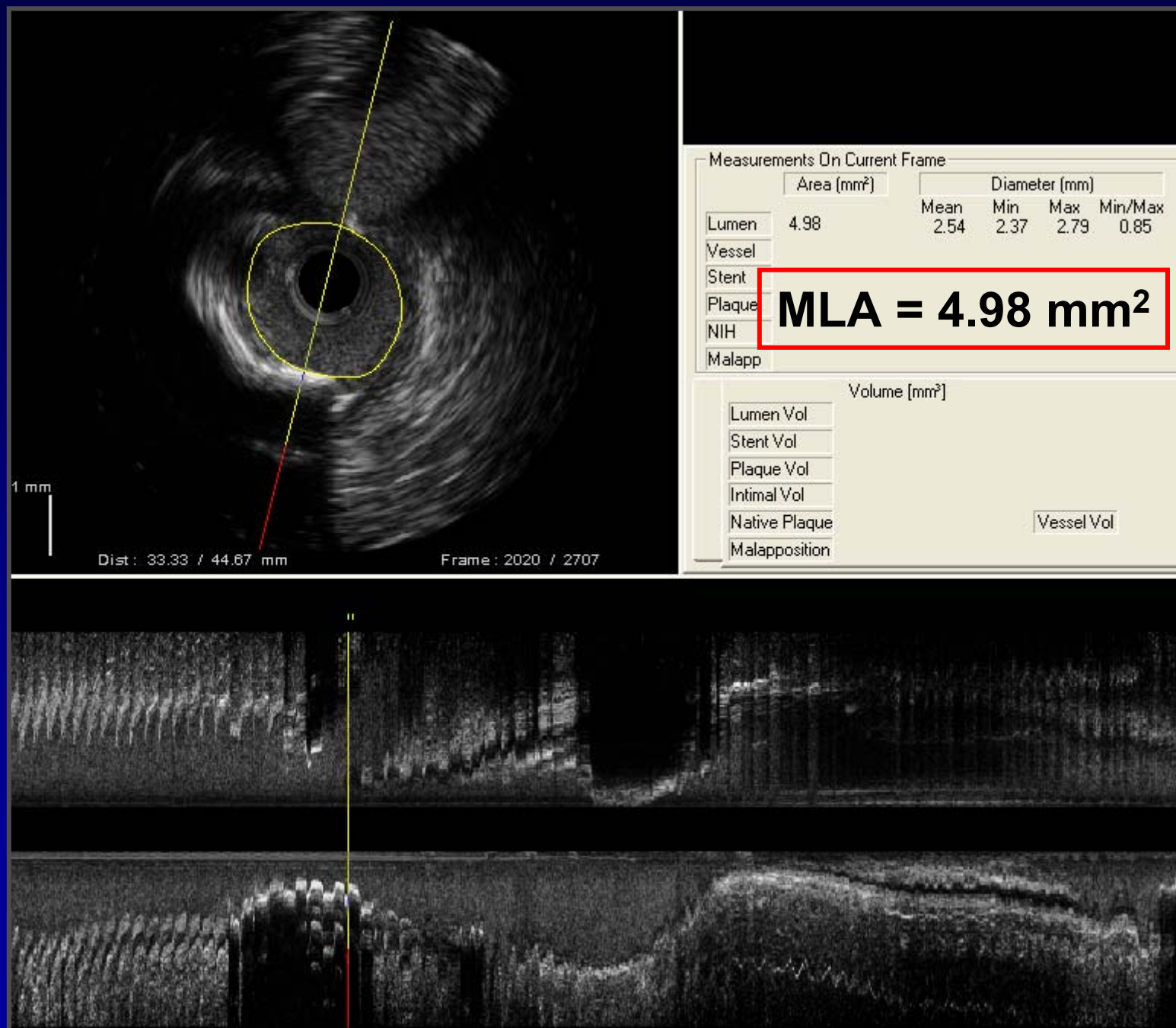




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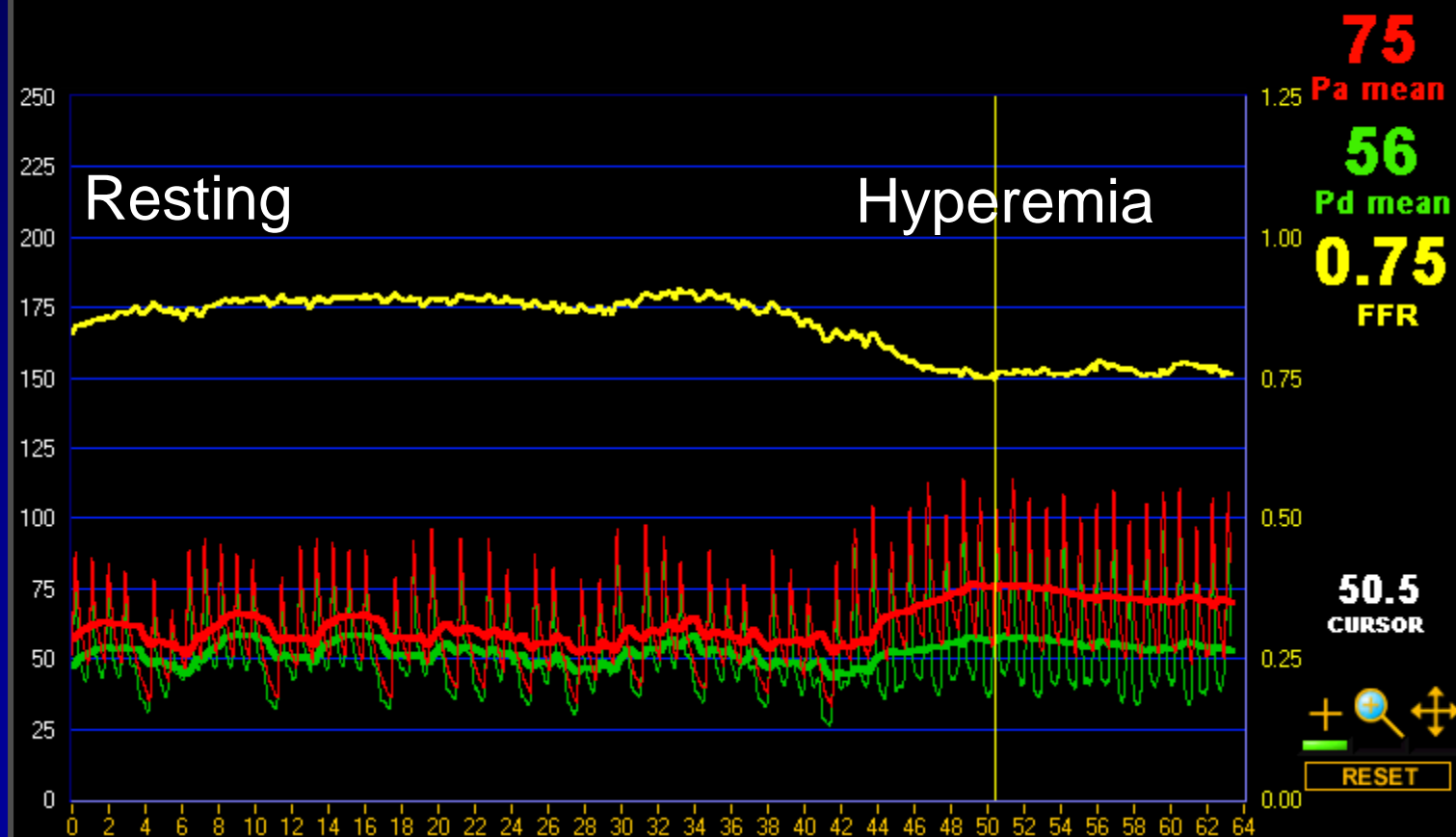


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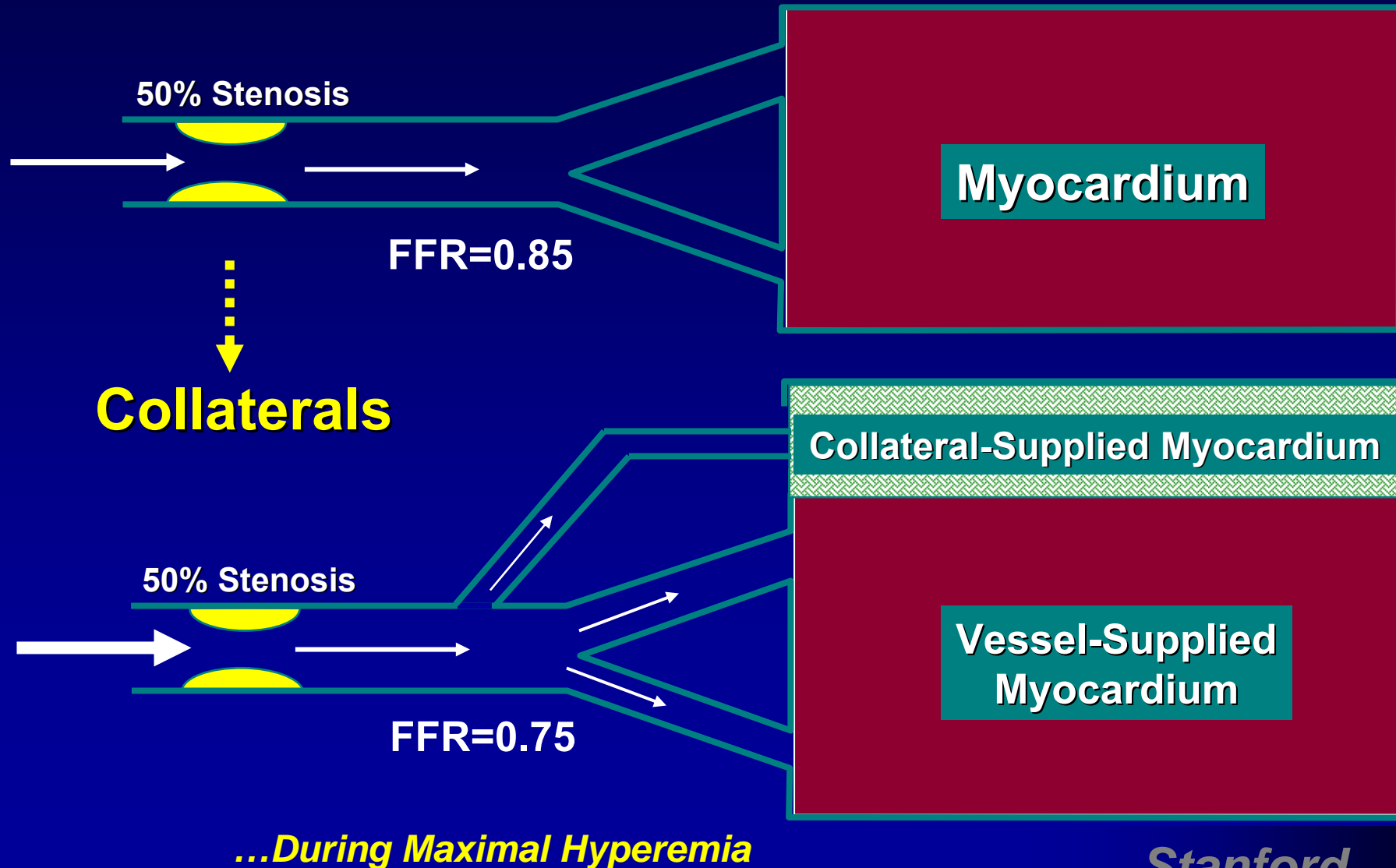
**FFR = 0.75**

**RADI  
VIEW**



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# Disconnect between Anatomy and Physiology



# Summary

- FFR is an index specific for the epicardial coronary vessel.
- It is relatively easy to perform.
- A value  $< 0.75$  indicates ischemia and identifies higher risk lesions.
- A value  $> 0.80$  indicates the absence of ischemia and identifies low risk lesions.
- FFR-Guided PCI improves outcomes and saves money.