

## Case-Based Learning from Experts LM and Tandem Lesion

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# Why We Need FFR in LM Disease?

- Inaccuracy of Coronary Angiogram
- Insufficiency of Non-Invasive Functional Study
- FFR guided PCI in LMCA showed favorable outcomes

# Major Randomized Studies in LM

**ORIGINAL ARTICLE**

**Outcomes in Patients With De Novo Left Main Disease Treated With Either Percutaneous Coronary Intervention Using Stents or Coronary Artery Bypass Grafting**

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**Acute and Long-Term Outcomes in Coronary Artery Bypass Grafting vs. Percutaneous Coronary Intervention in Unprotected Left Main Disease**

Marijanecic, Ted H, Dangas, et al.

Background: Tandem stenting versus vein grafting for unprotected left main disease has been compared in smaller studies. Objectives: To compare outcomes in patients with de novo left main disease treated with either percutaneous coronary intervention (PCI) using drug-eluting stents or coronary artery bypass grafting (CABG). Methods: A total of 711 patients were randomly assigned to PCI or CABG. Primary end points were all-cause mortality and major adverse cardiac events (MACE) at 5 years. Secondary end points were all-cause mortality and MACE at 1 year. Results: The PCI group had a significantly lower rate of primary end points than the CABG group at 5 years (3.2% vs 11.8%, P < .001), which was consistent with the confidence interval of the primary analysis. The PCI group had a significantly lower rate of all-cause mortality at 5 years (3.2% vs 6.7%, P = .03) and MACE at 1 year (5.6% vs 11.8%, P = .002). Conclusions: In patients with de novo left main disease, PCI using drug-eluting stents is associated with better long-term survival and reduced rates of MACE compared with CABG.

**CLINICAL RESEARCH** **Interventional Cardiology**

**Randomized Comparison of Percutaneous Coronary Intervention With Sirolimus-Eluting Stents Versus Coronary Artery Bypass Grafting in Unprotected Left Main Stem Stenosis**

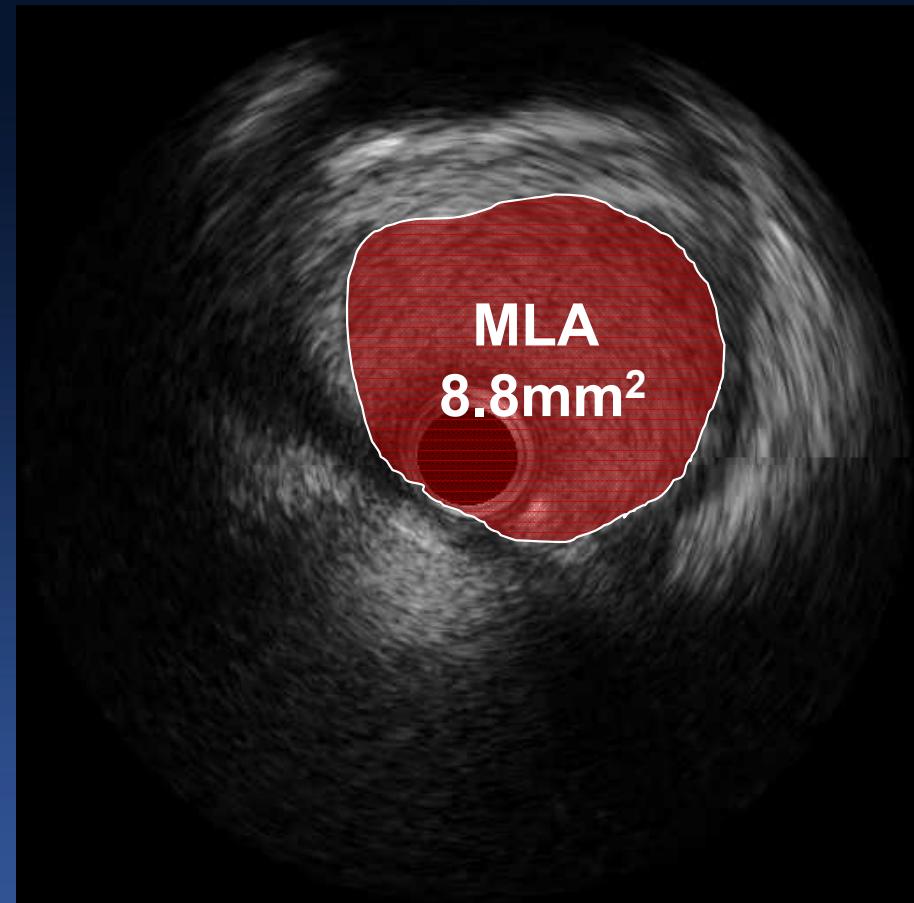
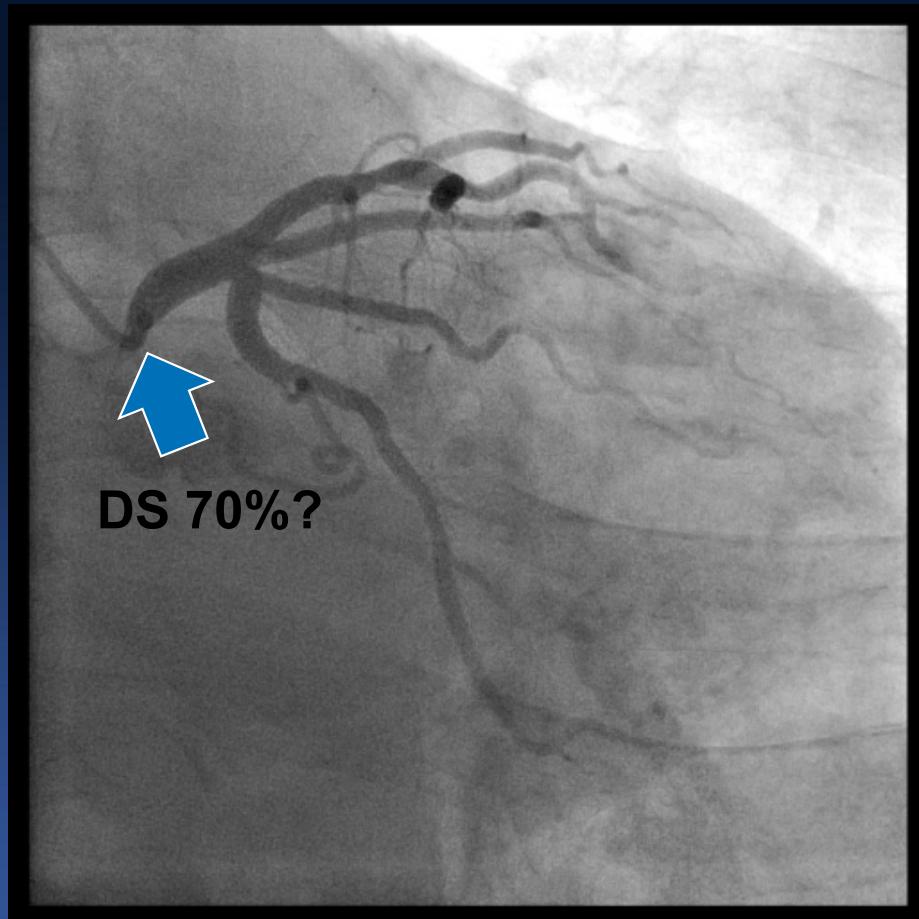
Enno Boudriot, MD,\* Holger Thiele, MD,\* Thomas Walther, MD,† Christoph Liebenthal, MD,\* Peter Boenigk, MD,\* Tillmann Dahl, MD,\* Rainer Raab, MD,‡ Stephan Moeller, MD,§

Patients age 18 to 80 years with stenosis ( $\geq 50\%$ ) of the ULM with or without additional multivessel coronary artery disease were included in this multicenter study. Patients had

**Background** CABG is considered the standard of care for treatment of ULM. Improvements in percutaneous coronary intervention (PCI) with use of drug-eluting stents might lead to similar results. The effectiveness of drug-eluting stenting versus surgery has not been established in a randomized trial.

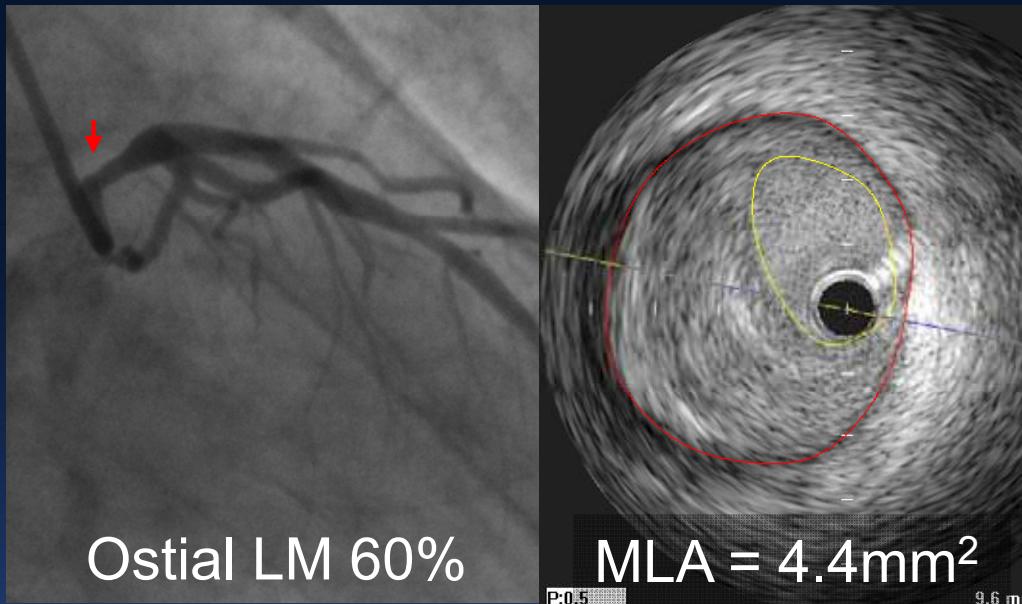
**Methods** In this prospective, multicenter, randomized trial, 201 patients with ULM disease were randomly assigned to

# Why We Need FFR?

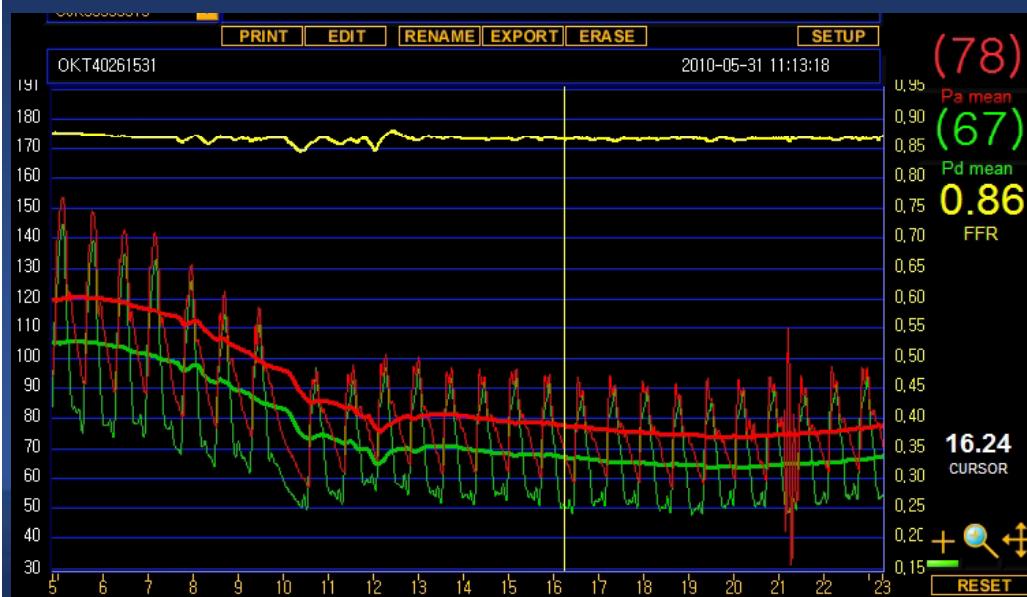
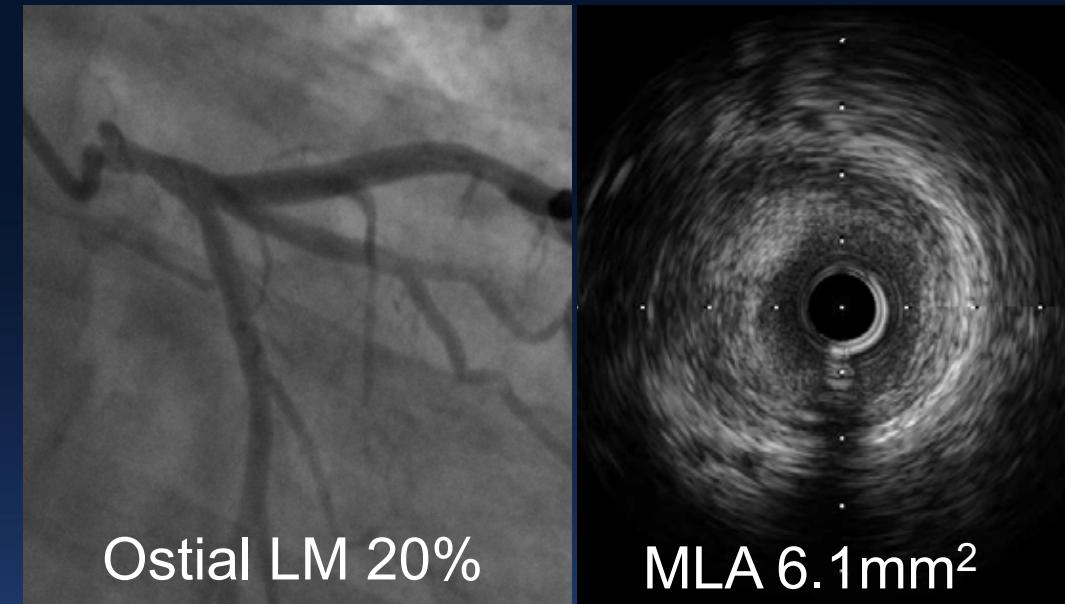


# Why We Need FFR in LM?

47/M Stable angina

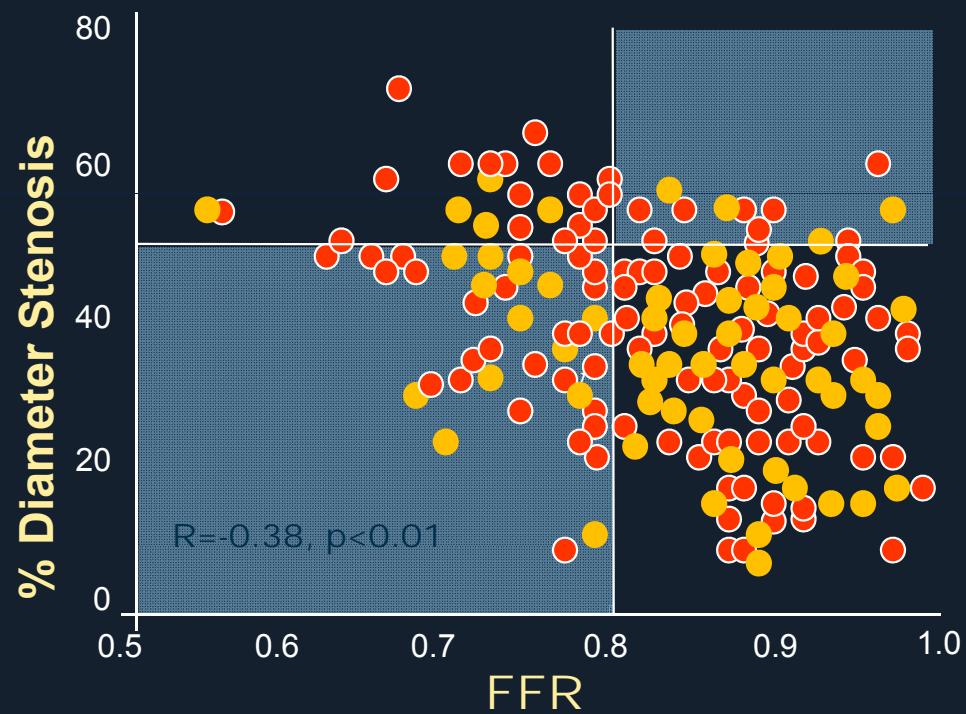


50/M Stable angina



# FFR and %DS in Equivocal LMCA

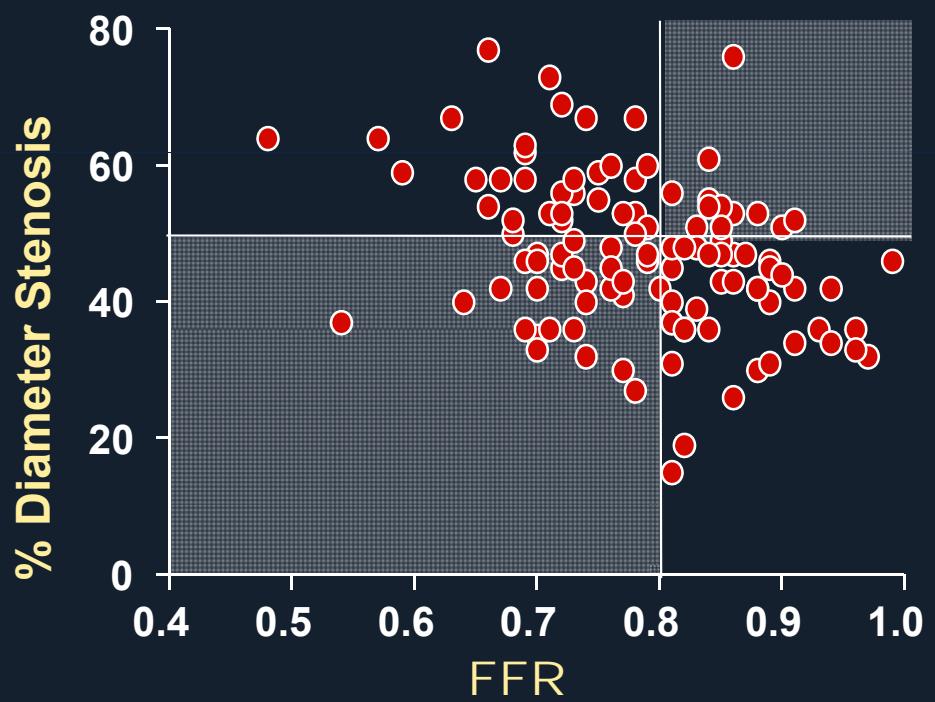
"Mismatch" is 29% in equivocal LMCA



Hamilos M et al. *Circulation* 2009;120:1505-1512

● Isolated LMCA disease

"Mismatch" is 37% in equivocal LMCA



Park SJ et al. *JACC-CI (In Press)*

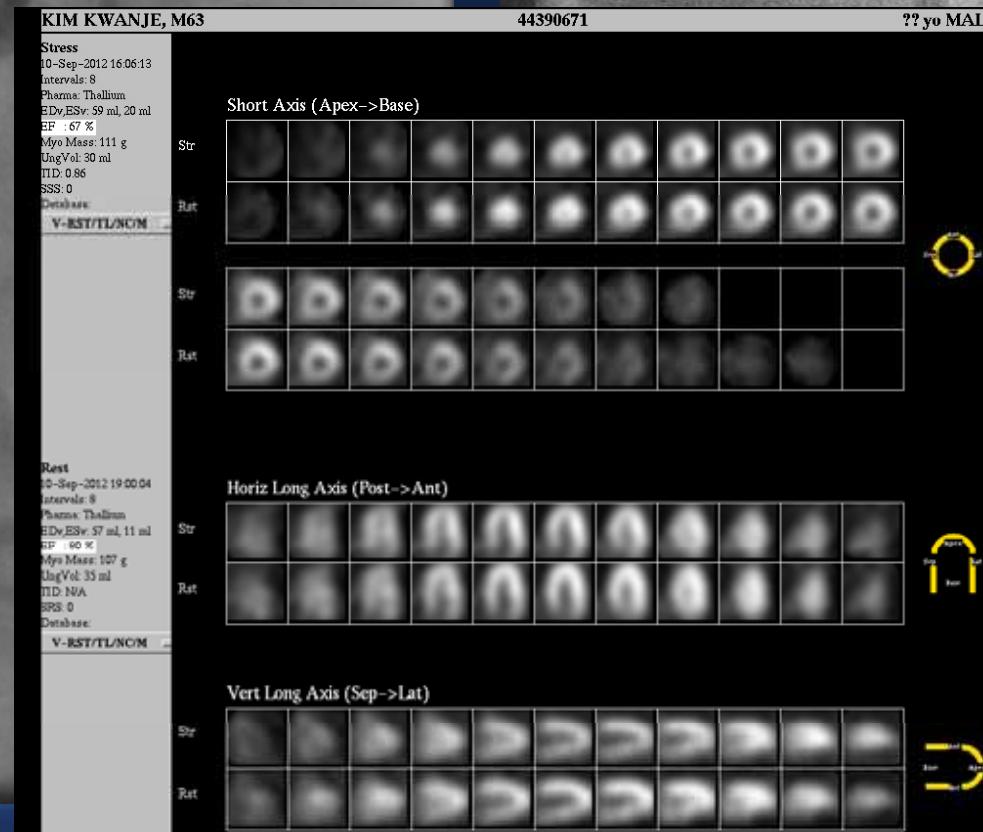
# LM with 3VD

65yrs/M, eCP

RCA

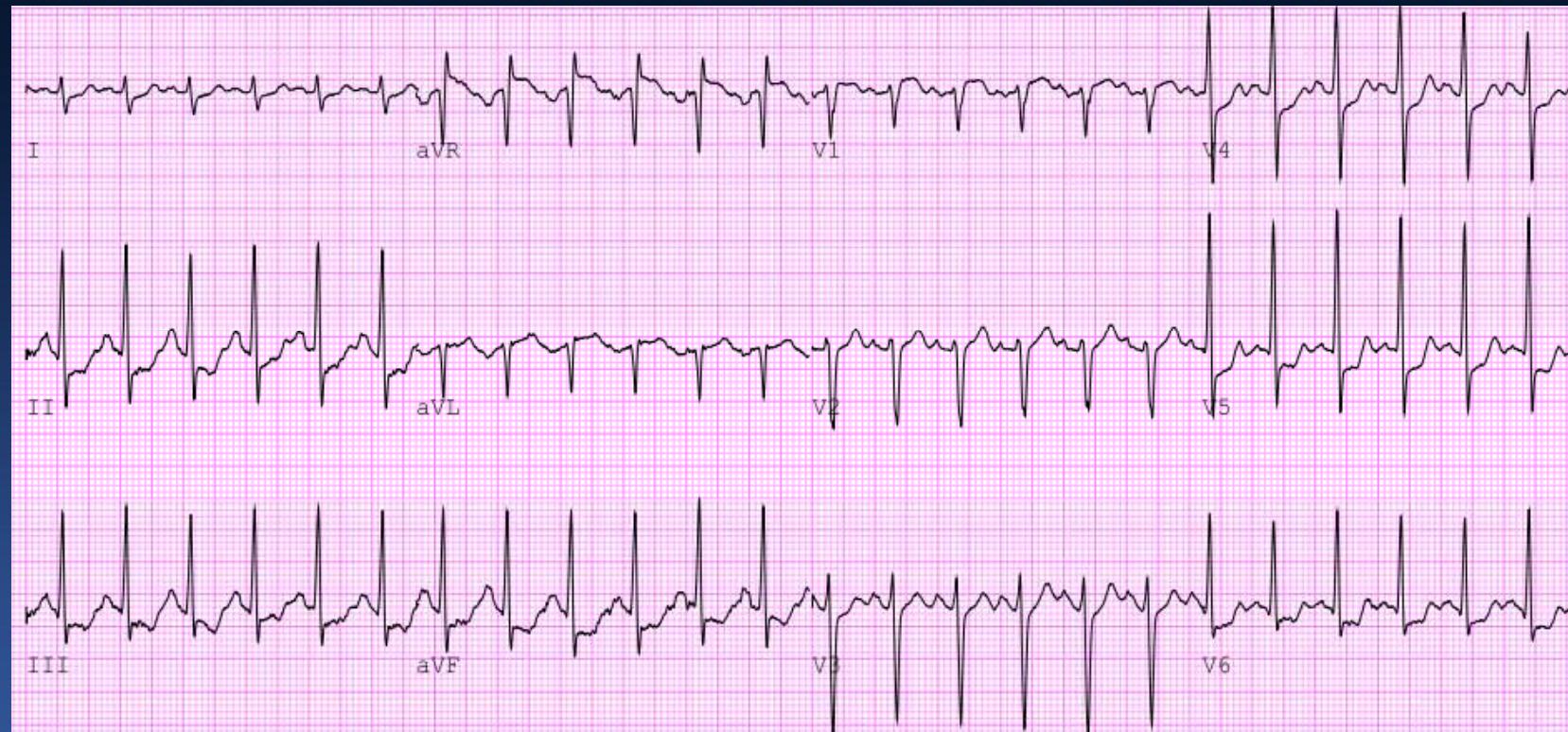
LCA

Normal Perfusion in Thallium SPECT



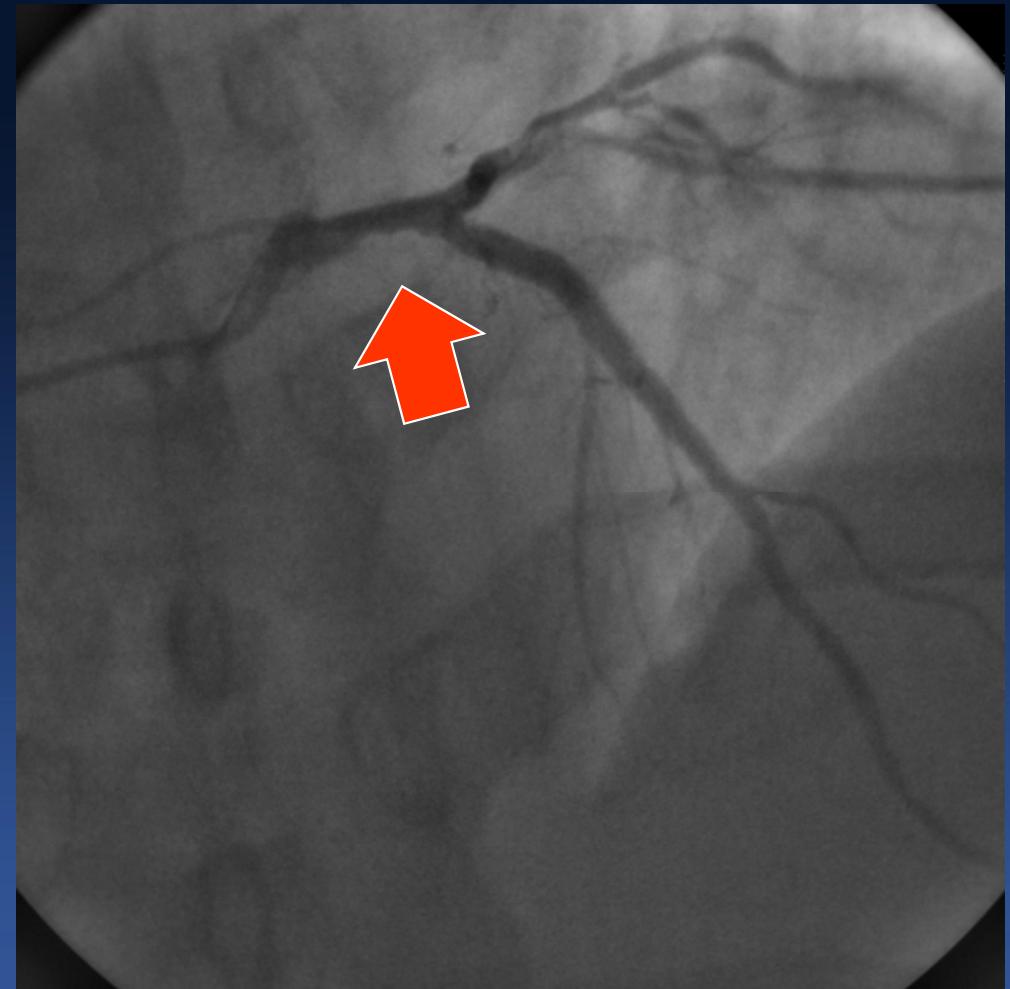
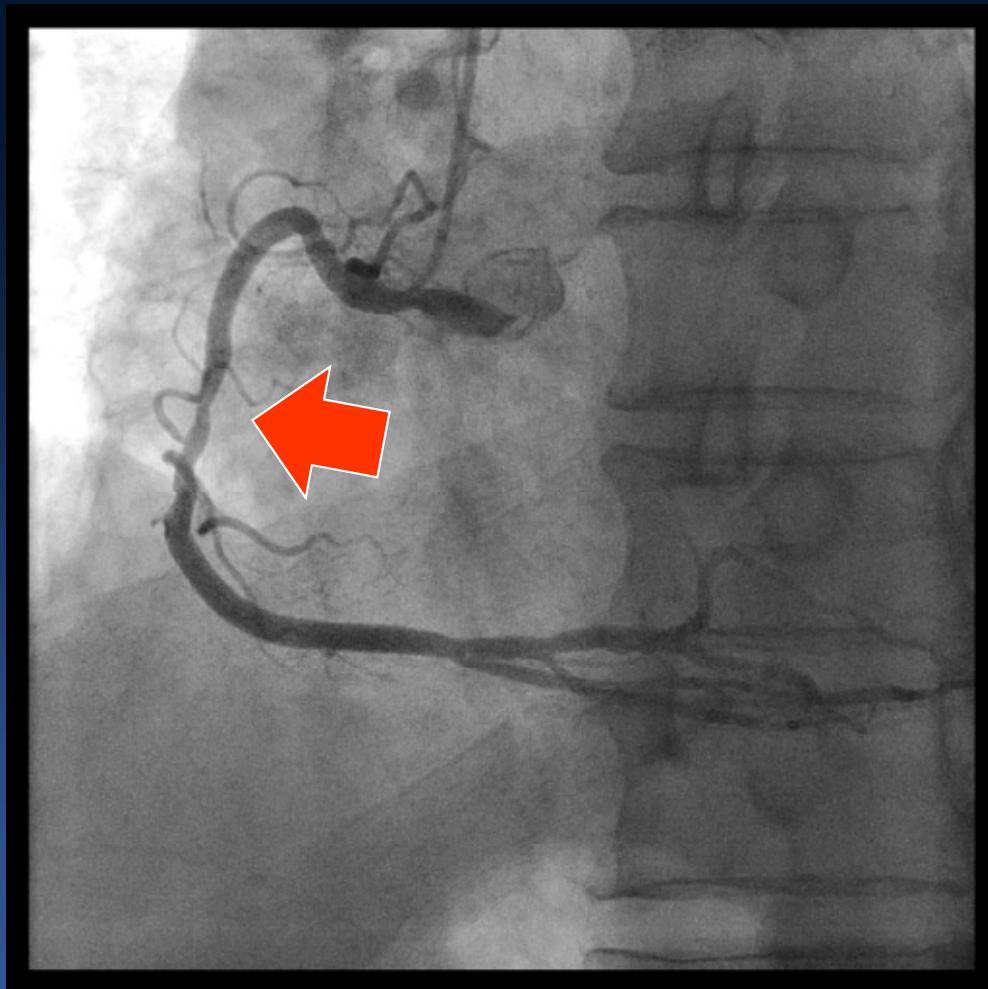
# M/76, eCP

## Treadmill Test

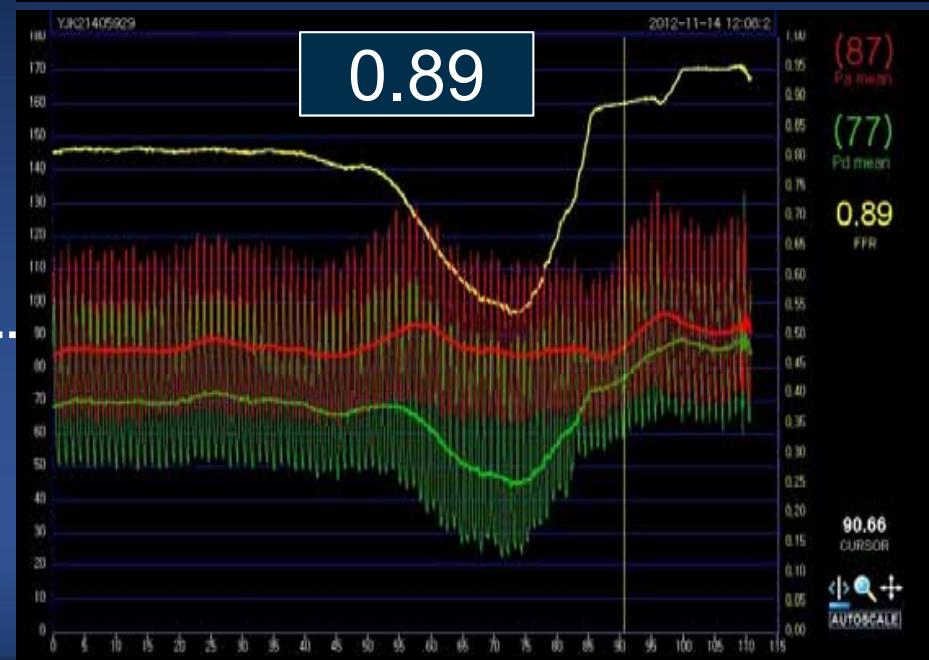
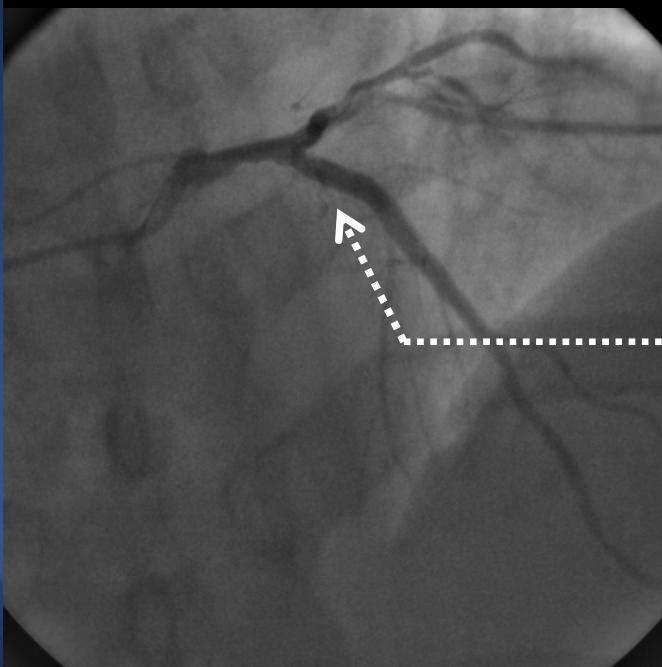
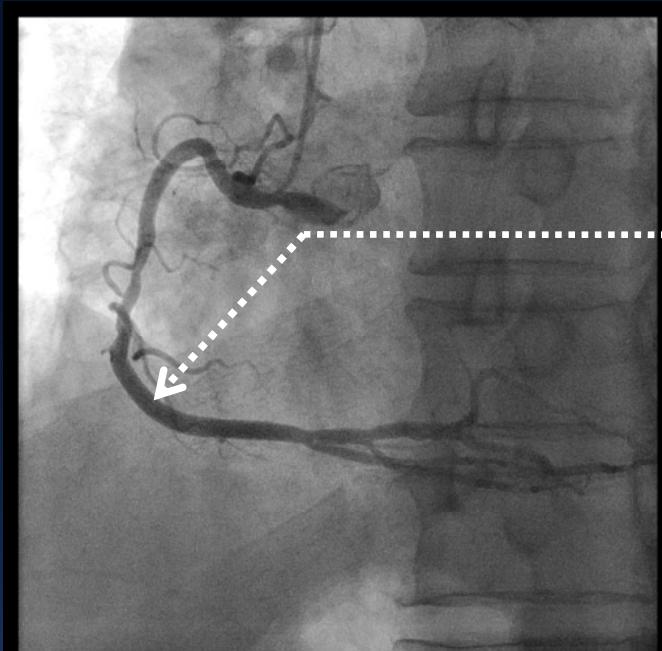


Positive at Stage 4

# Coronary Angiography

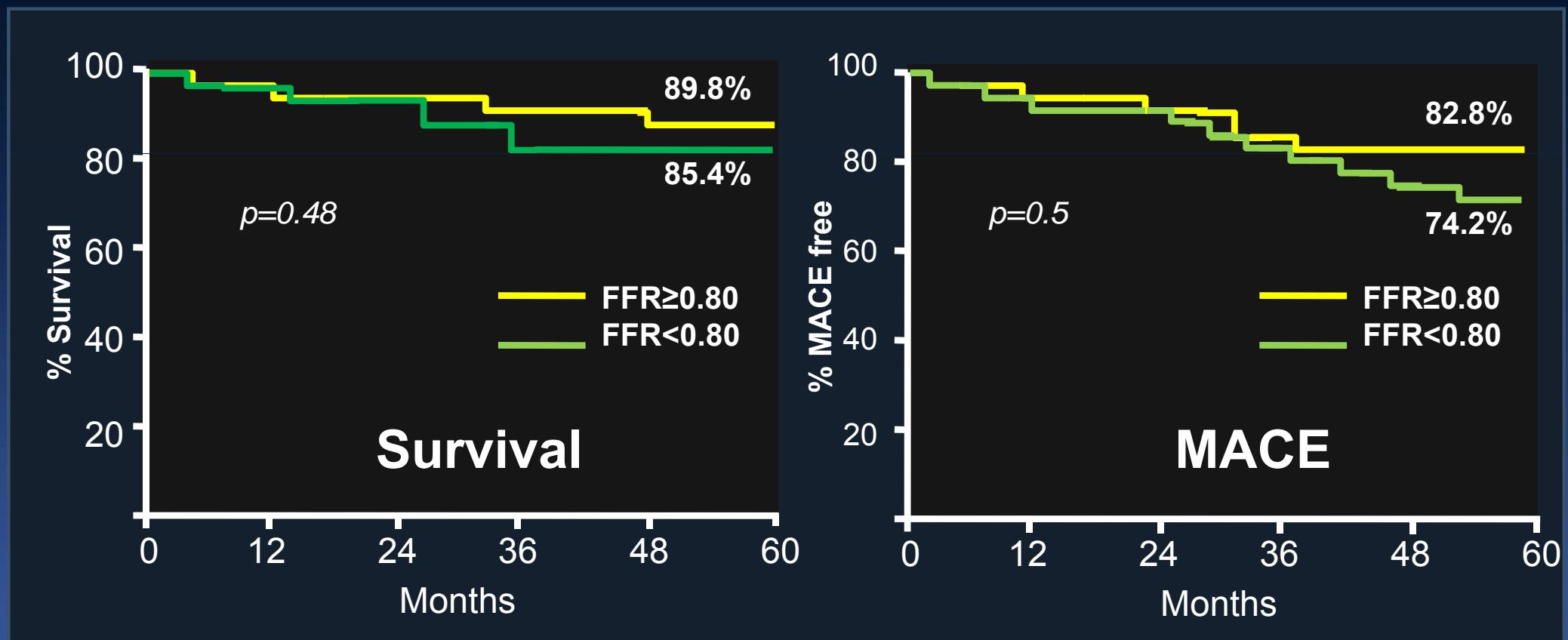


# FFR



# FFR Guided PCI in Equivocal LMCA

- In 213 patients with an equivocal LMCA stenosis
- FFR  $\geq 0.80$ : Medication (n=138) vs. FFR < 0.80: CABG (n=75)



An FFR-guided strategy showed the favorable outcome.

# FFR Guided Decision Making in LM Disease

	<b>Hamilos et al <sup>1</sup></b>	<b>Bech et al <sup>2</sup></b>	<b>Courtis et al <sup>3</sup></b>	<b>Lindstaedt et al <sup>4</sup></b>	<b>Jasti et al <sup>5</sup></b>					
<b>Age, y</b>	64 ± 9	68 ± 11	63 ± 9	60 ± 9	61 ± 10	63 ± 10	61 ± 10	64 ± 9	<b>62 ± 11</b>	
<b>Mean follow up, mo.</b>	<b>35 ± 25</b>		<b>29 ± 15</b>		<b>13 ± 10</b>	<b>14 ± 12</b>	<b>29 ± 18</b>	<b>29 ± 14</b>	<b>38</b>	
<b>No. of patients</b>	75	138	30	24	60	82	27	24	14	37
<b>FFR cut off value</b>	<0.80	≥0.80	<0.75	≥0.75	<0.75	>0.80	<0.75	>0.80	<0.75	≥0.75
<b>Clinical outcomes</b>										
<b>Death, n (%)</b>	7 (9.6)	9 (6.5)	1	0	3 (5)	3 (4)	4 (14.8)	0	0	3
<b>MI, n (%)</b>	0	1	1	0	1 (2)	4 (5)	1 (3.7)	0	0	0
<b>RR, n (%)</b>	<b>4 (5.5)</b>	<b>17 (12.3)</b>	<b>2</b>	<b>5</b>	<b>0</b>	<b>9 (11)</b>	<b>1 (3.7)</b>	<b>6 (25)</b>	<b>0</b>	<b>4</b>

<sup>1</sup>Circulation 2009;120:1505-1512; <sup>2</sup>Heart 2001;86:547-552; <sup>3</sup>Am J Cardiol 2009;103:943-949;

<sup>4</sup>Am Heart J 2006;152:156.e151-156; <sup>5</sup>Circulation 2004;110:2831-2836

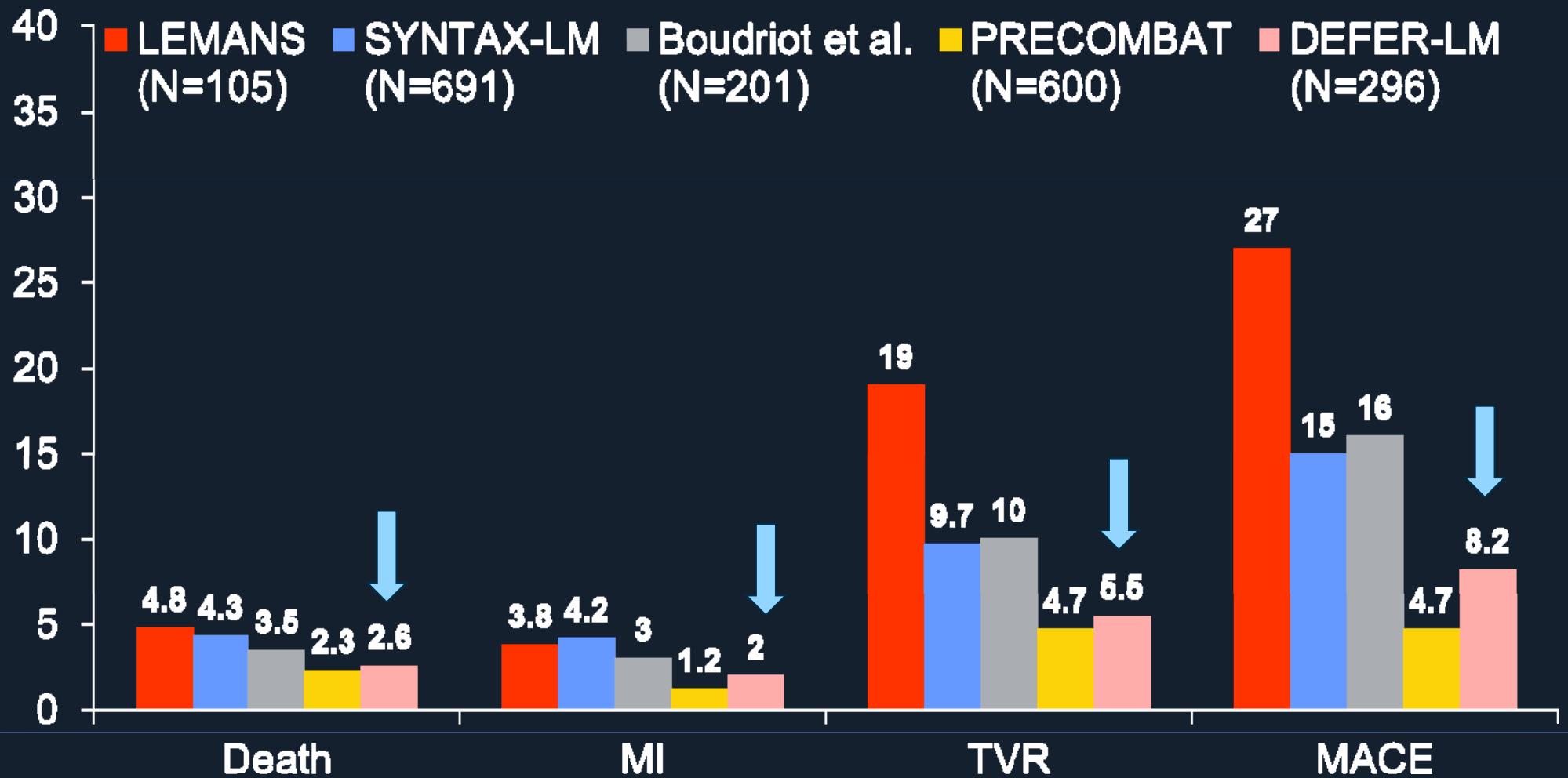
# Clinical Outcomes After Deferral of LM Disease (6 studies, 296 patients)

Outcomes	Incidence (%/year)
All Death	2.6 (1.3-5.2)
Cardiac Death	2.6 (1.3-5.2)
Myocardial Infarction	2.0 (0.7-5.1)
TVR	5.5 (3.3-8.8)
MACE	8.2 (5.5-12.1)

Hamilos M, Circulation. 2009;120:1505-1512  
Bech GJ, Heart. 2001;86:547-552  
Courtis J, Am J Cardiol. 2009;103:943-949

Lindstaedt M, Am Heart J. 2006;152:151-159  
Jasti V, Circulation. 2004;110:2831-2836  
Sueman, Heart Vessels. 2005;20:271-7

# Clinical Outcomes After Deferral of LM Disease (6 studies, 296 patients)



# Why We Need FFR in LM?

- Inaccuracy of Coronary Angiogram
- Insufficiency of Non-Invasive Functional Study
- FFR guided PCI in LMCA showed favorable outcomes

**So, We have to measure LM FFR directly**

# How Can We Implement FFR in Real Practice ?

# LMCA Anatomy

(A) Ostial/Shaft



(B) Bifurcation

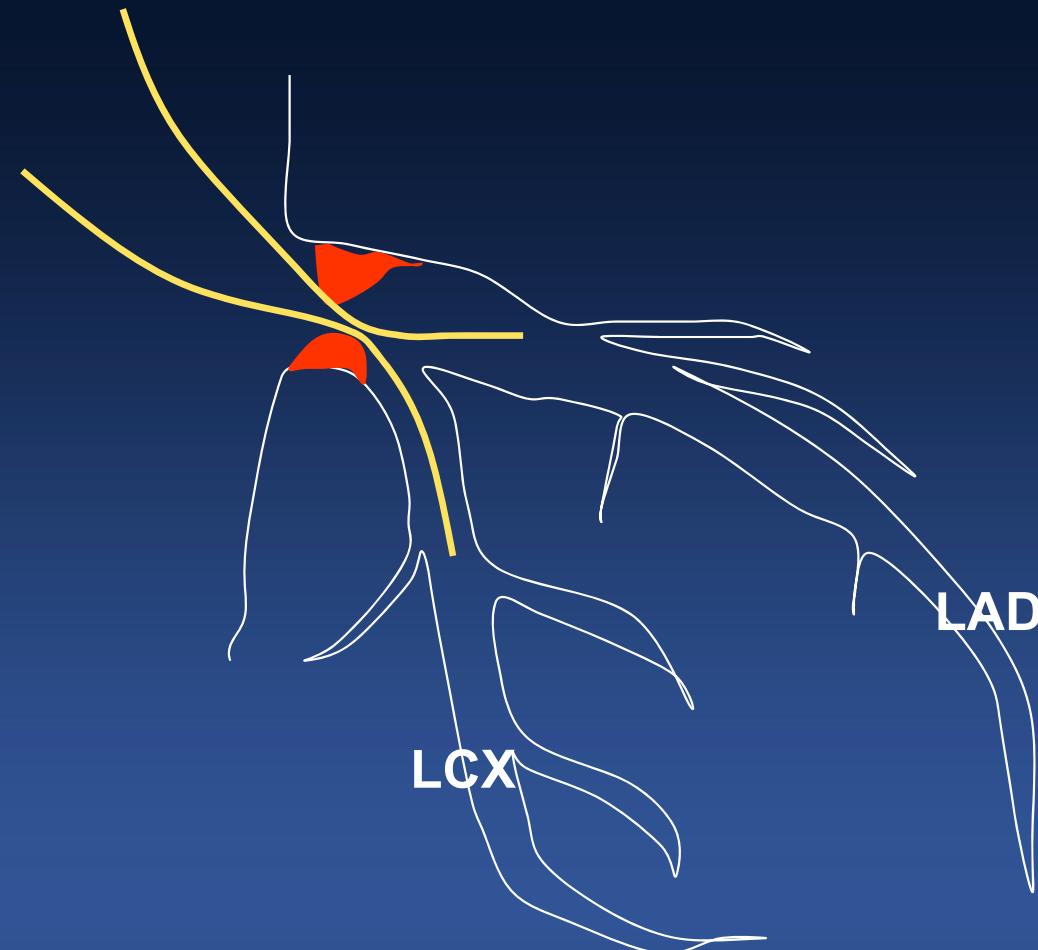


(C) LM with distal Dz



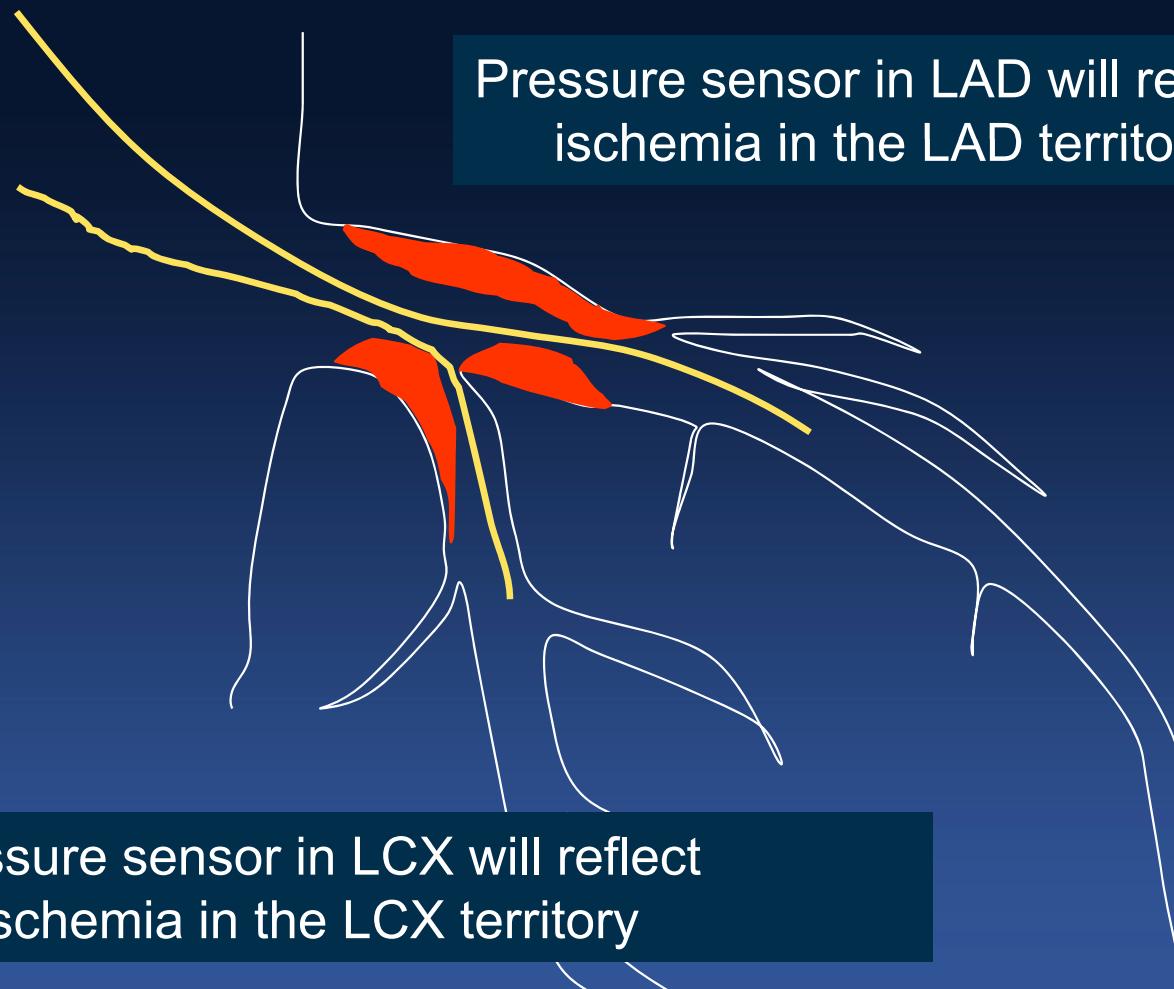
# For the Undetermined, Intermediate Ostial and Shaft LM Lesion,

Theoretically, LAD FFR = LCX FFR



# For the Intermediate LM Bifurcation Lesion,

**LAD FFR = or ≠ LCX FFR**



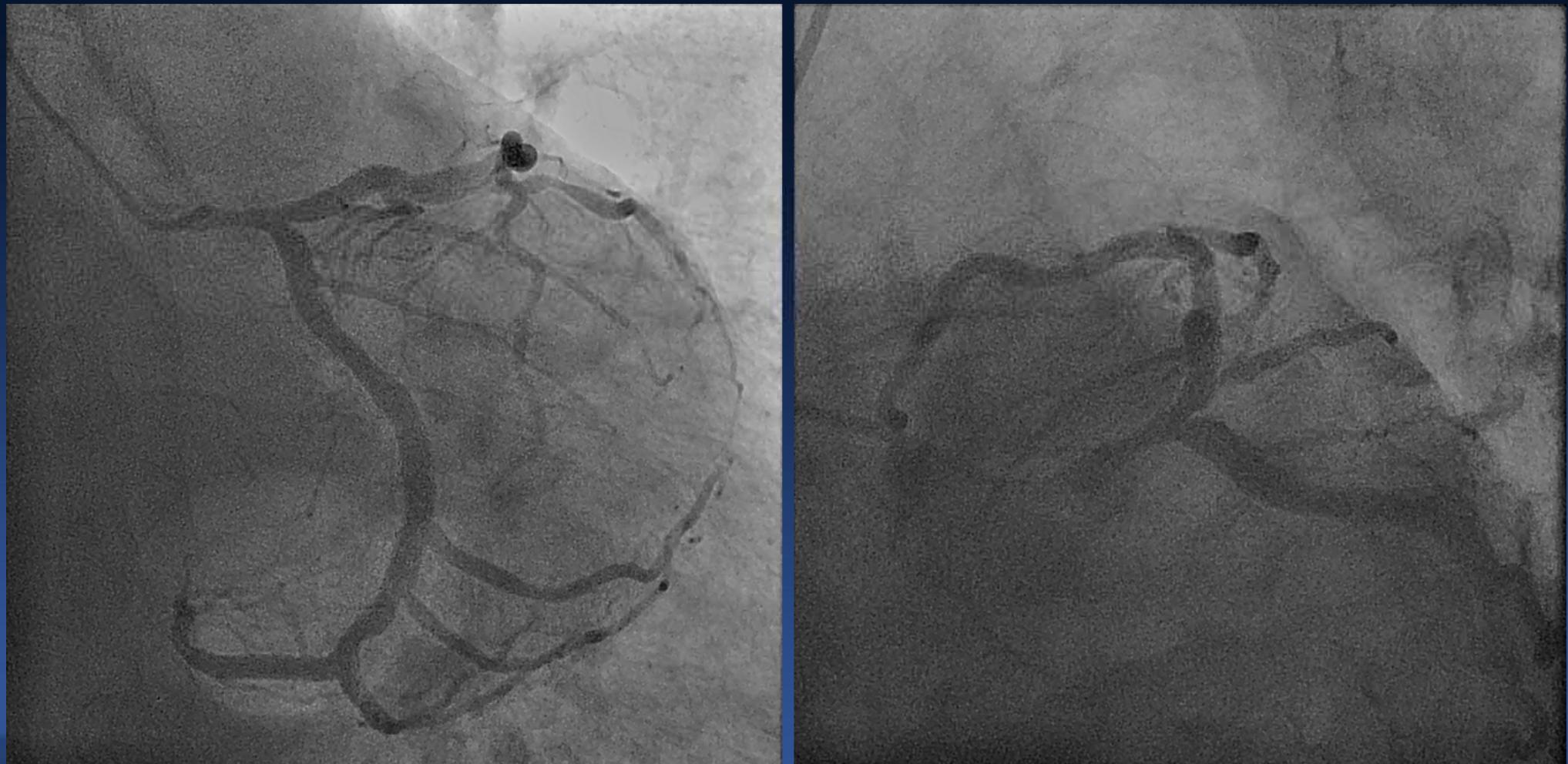
**For the Intermediate LM Bifurcation Lesion,  
Main Concern is to Determine  
Single Stent Cross Over or 2 Stents Technique.**



**We Can Not Treat Separately**

# LM Bifurcation Lesion (Medina 1,0,0) with Minimal LCX Disease

55/M, Stable angina,

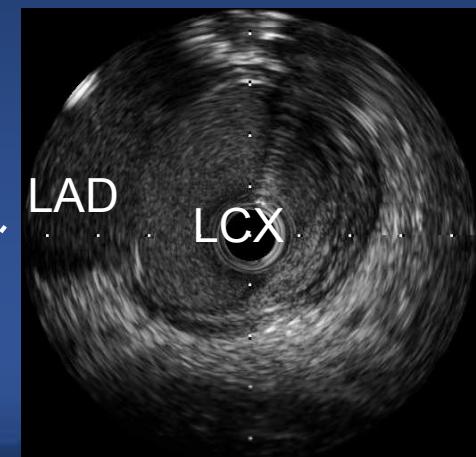
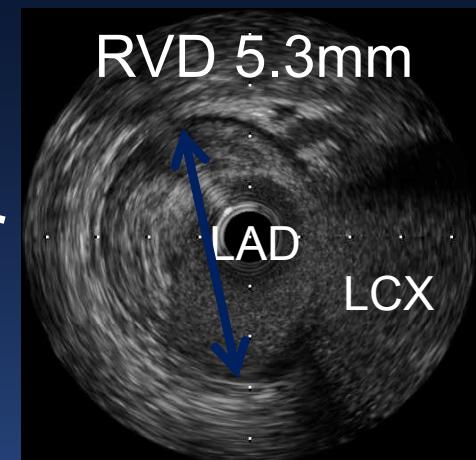
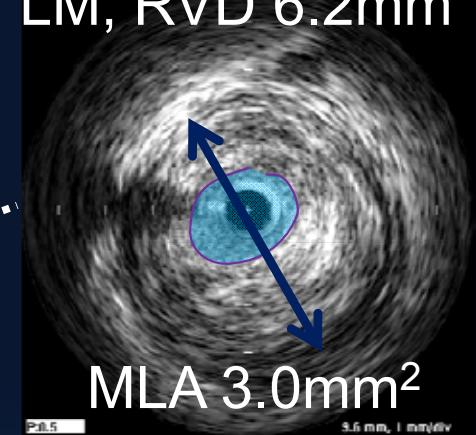
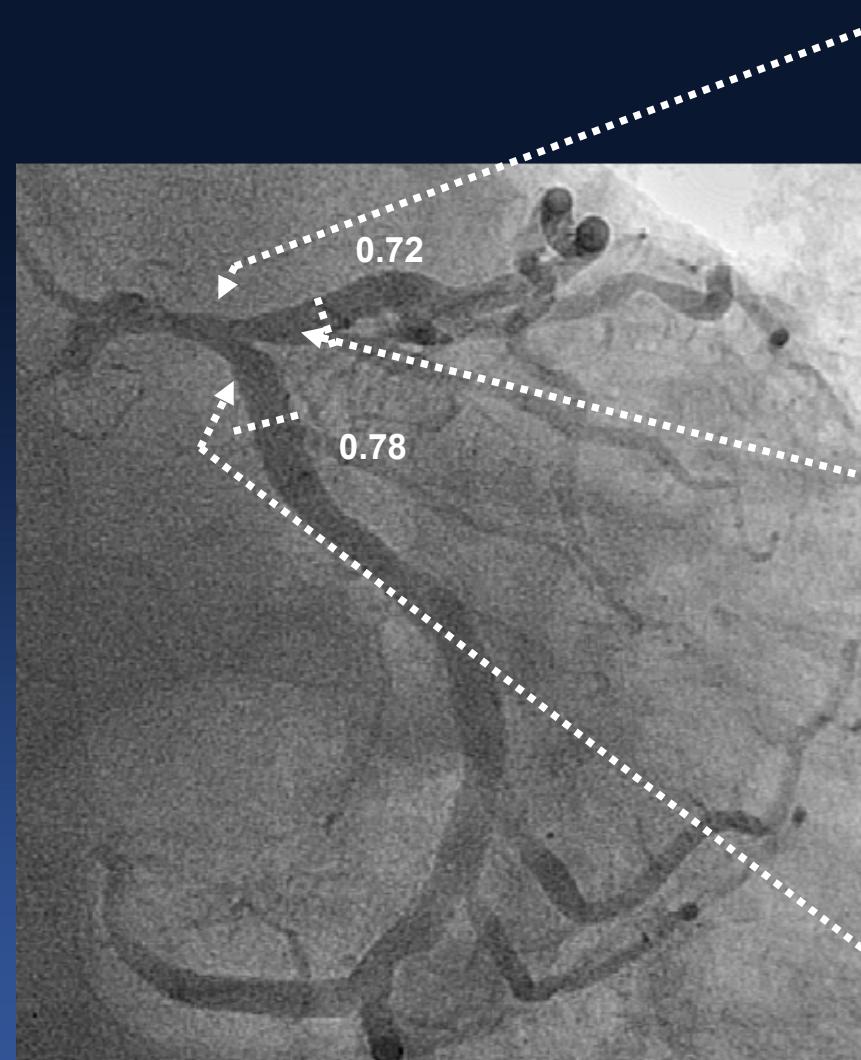


# FFR in Both LAD and LCX,



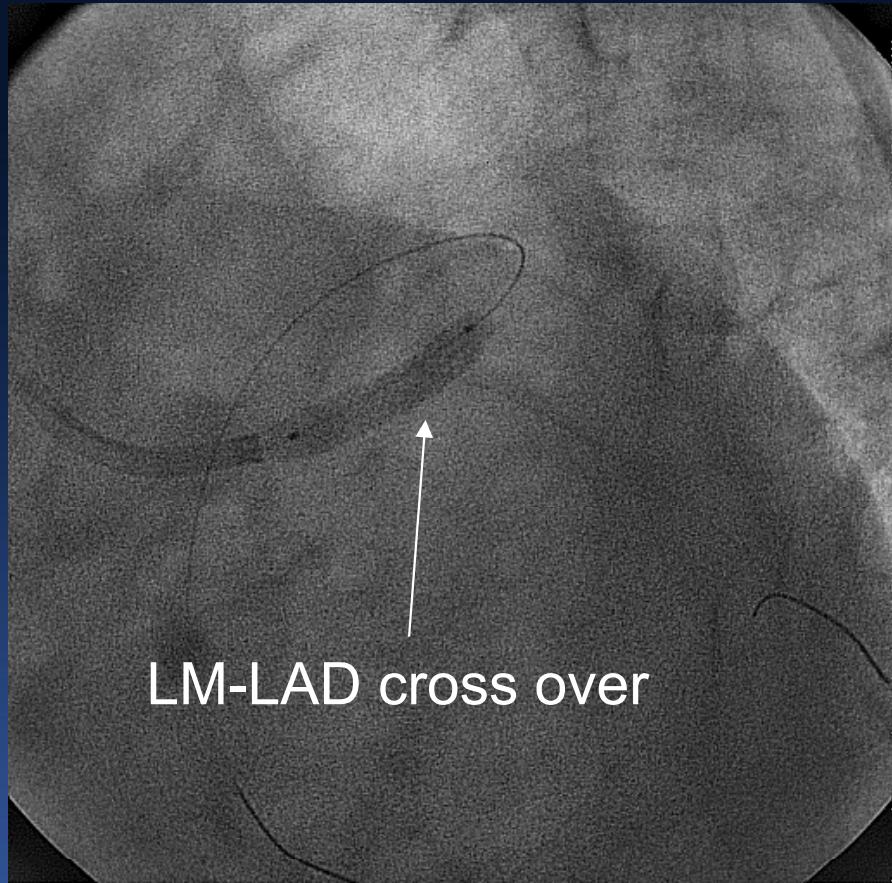
# IVUS in Both LAD and LCX,

Distal LM, RVD 6.2mm

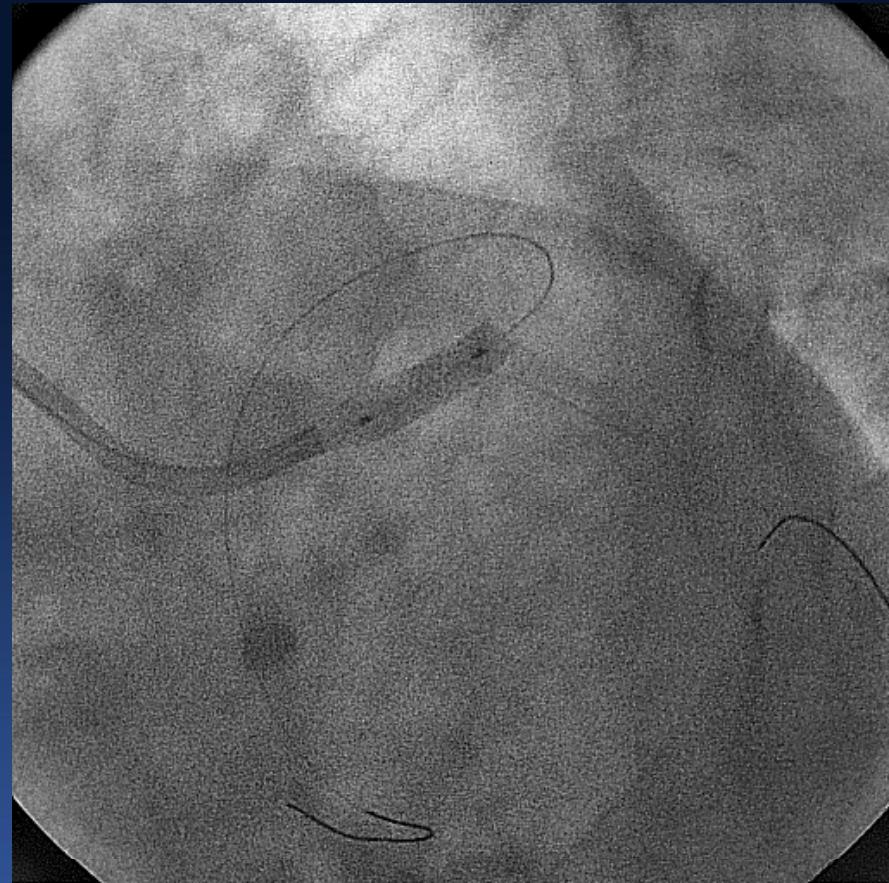


Minimal disease at LCX ostium

# Single Stent Cross-Over with minimal-disease at LCX OS



Promus Element  
4.0x20

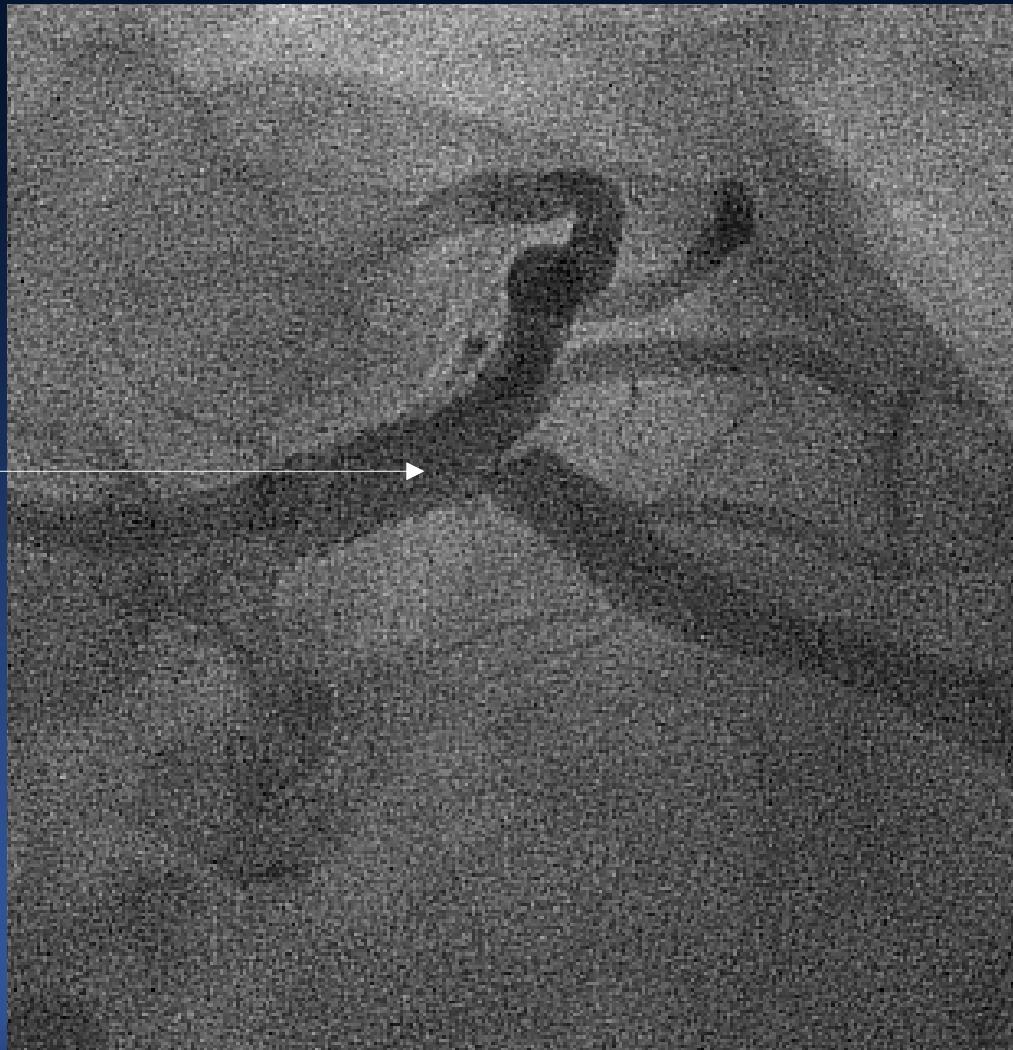


Additional high pressure  
Inflation with 4.0 mm  
non-compliant balloon

# After Single Stent Cross-Over, Angiographic Compromise of LCX Ostium.



# What Would You Do ? To Treat or Not To Treat



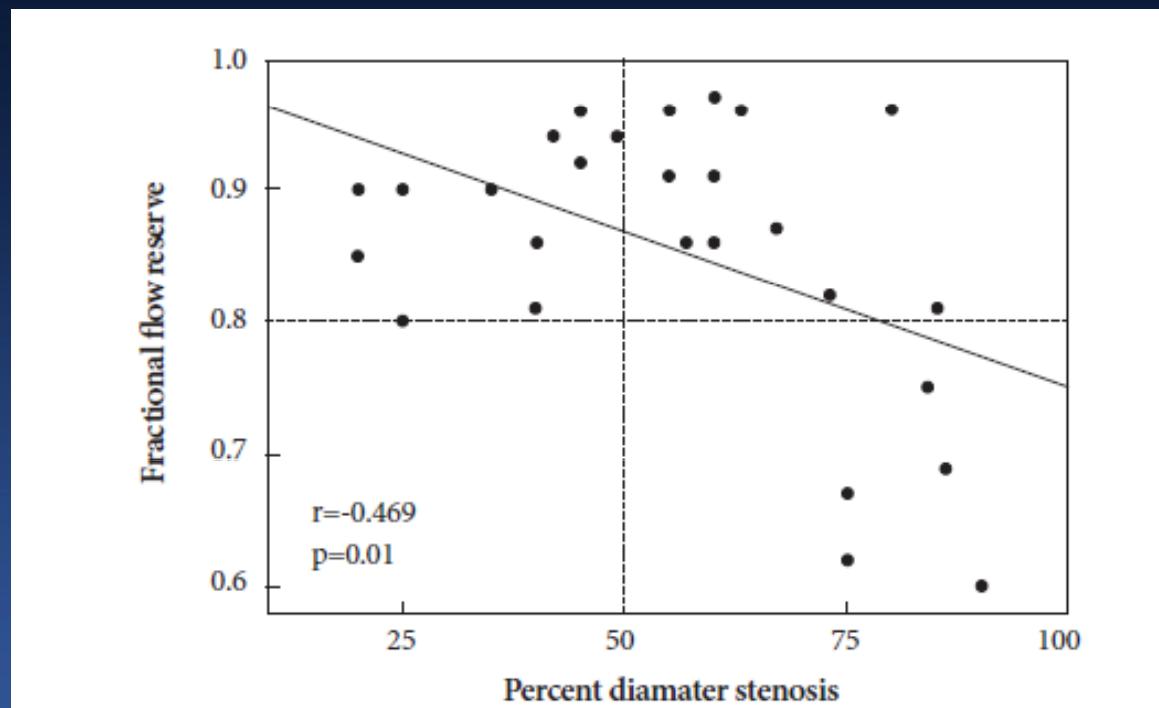
# Consider FFR, First !

FFR is 0.92



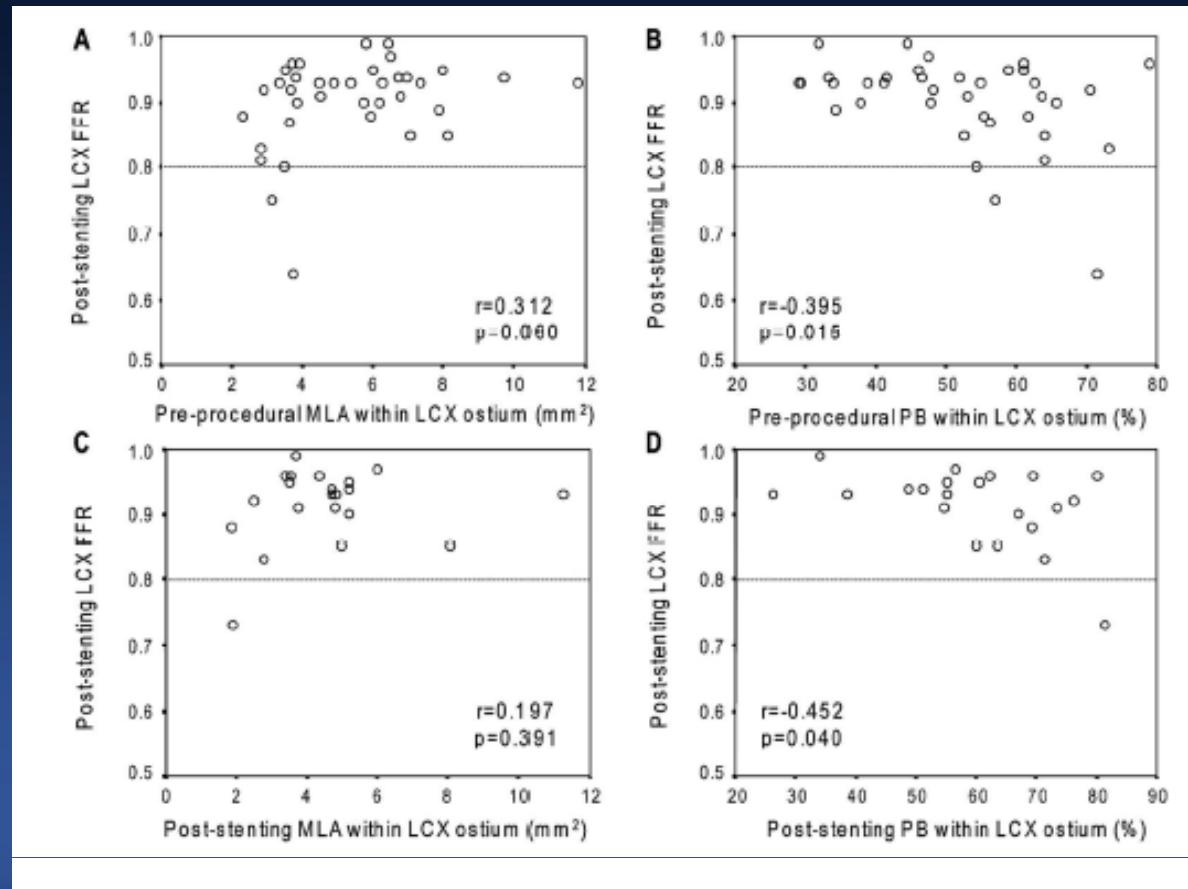
# FFR post LM stenting (1)

- 29 pts with LM lesion, PCI with 1 stent
- Post PCI ostial LCx stenosis >50% in 17 (59%) of the cases
- Only 5 (29%) of them functionally significant



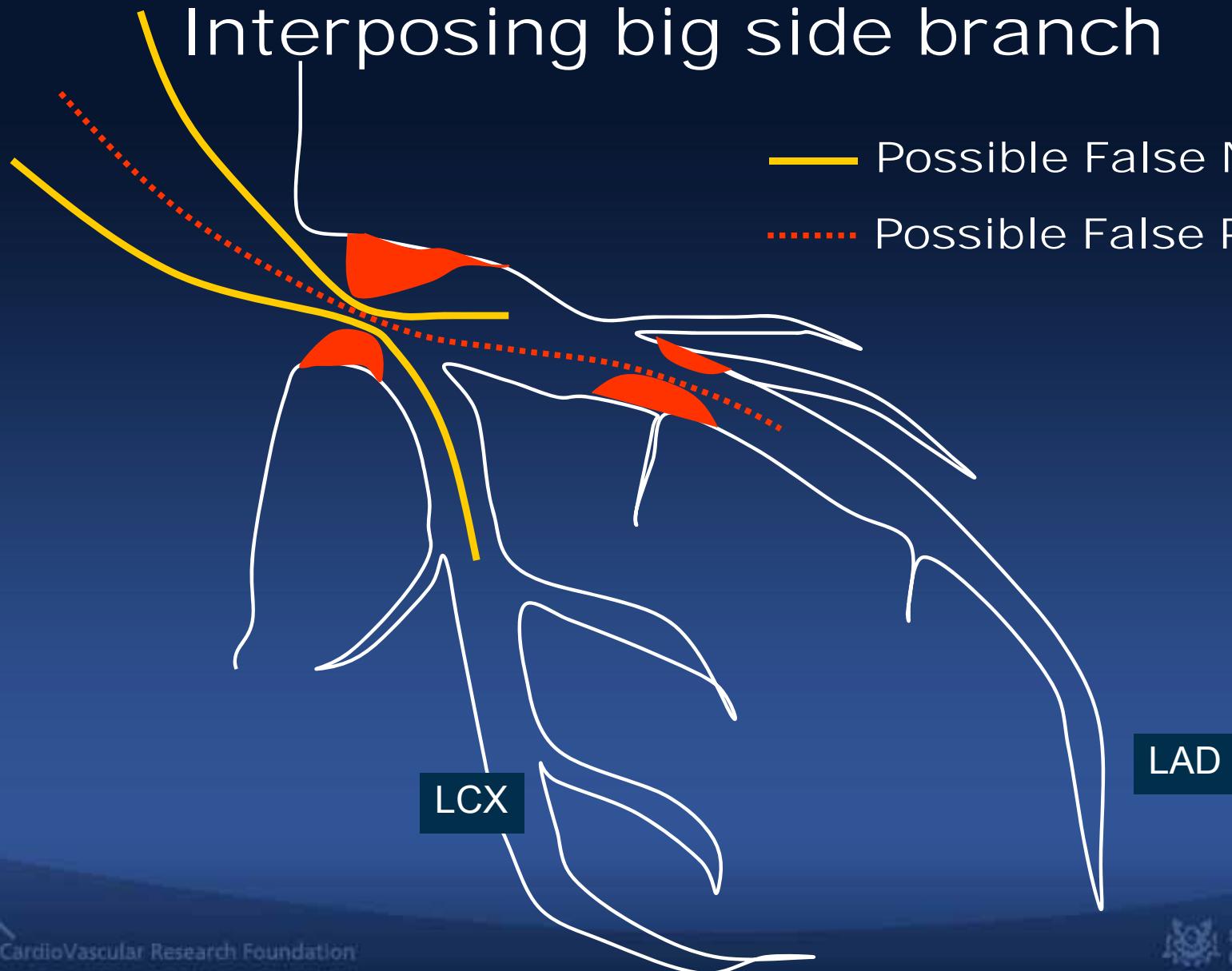
# FFR post LM stenting (2)

- 43 pts with LM bifurcation lesions
- Functional compromise of LCx ostium after LM stenting is rare (3 pts)
- Deferral of non significant LCx ostia is safe



# For LMCA stenosis with distal LAD/LCX stenosis

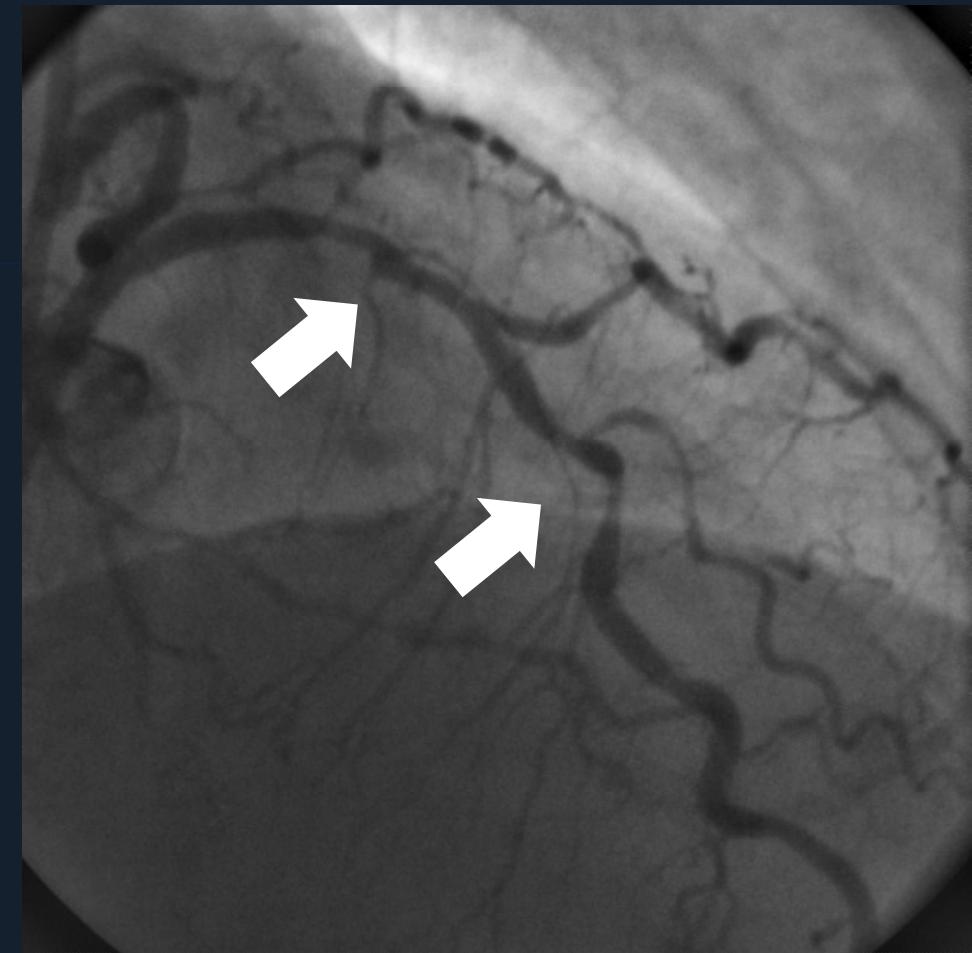
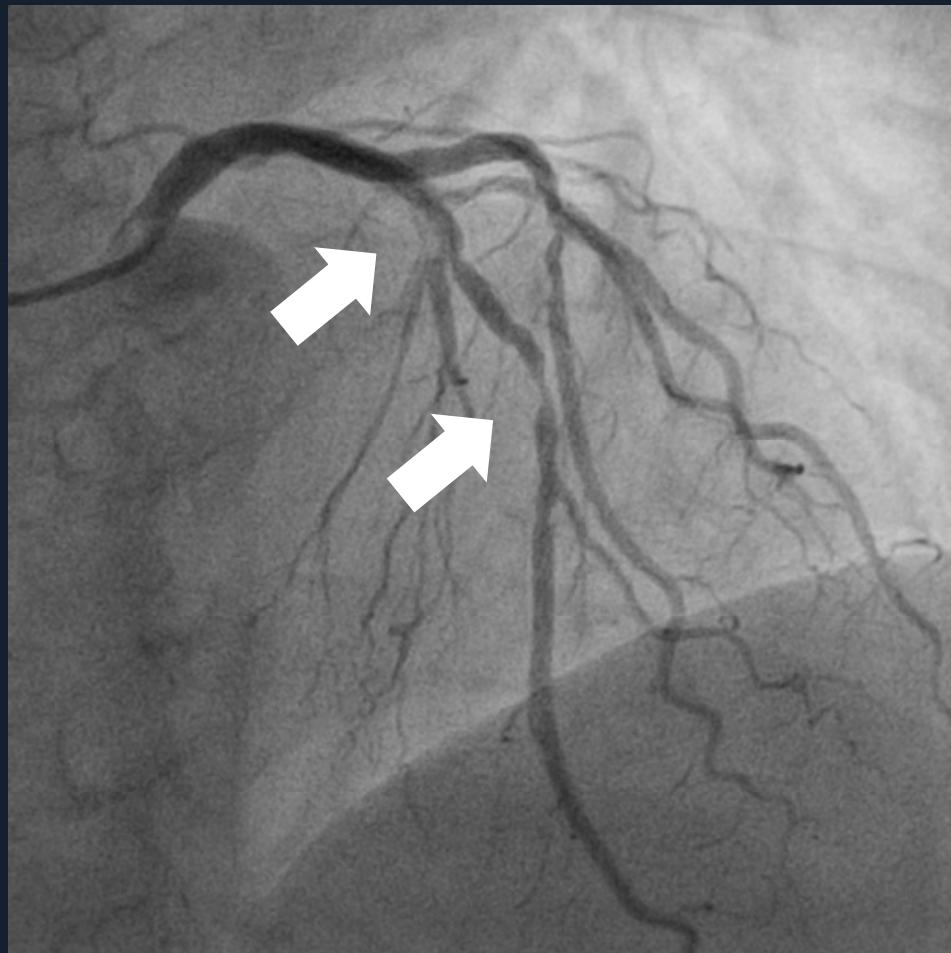
Tandem Lesions with  
Interposing big side branch



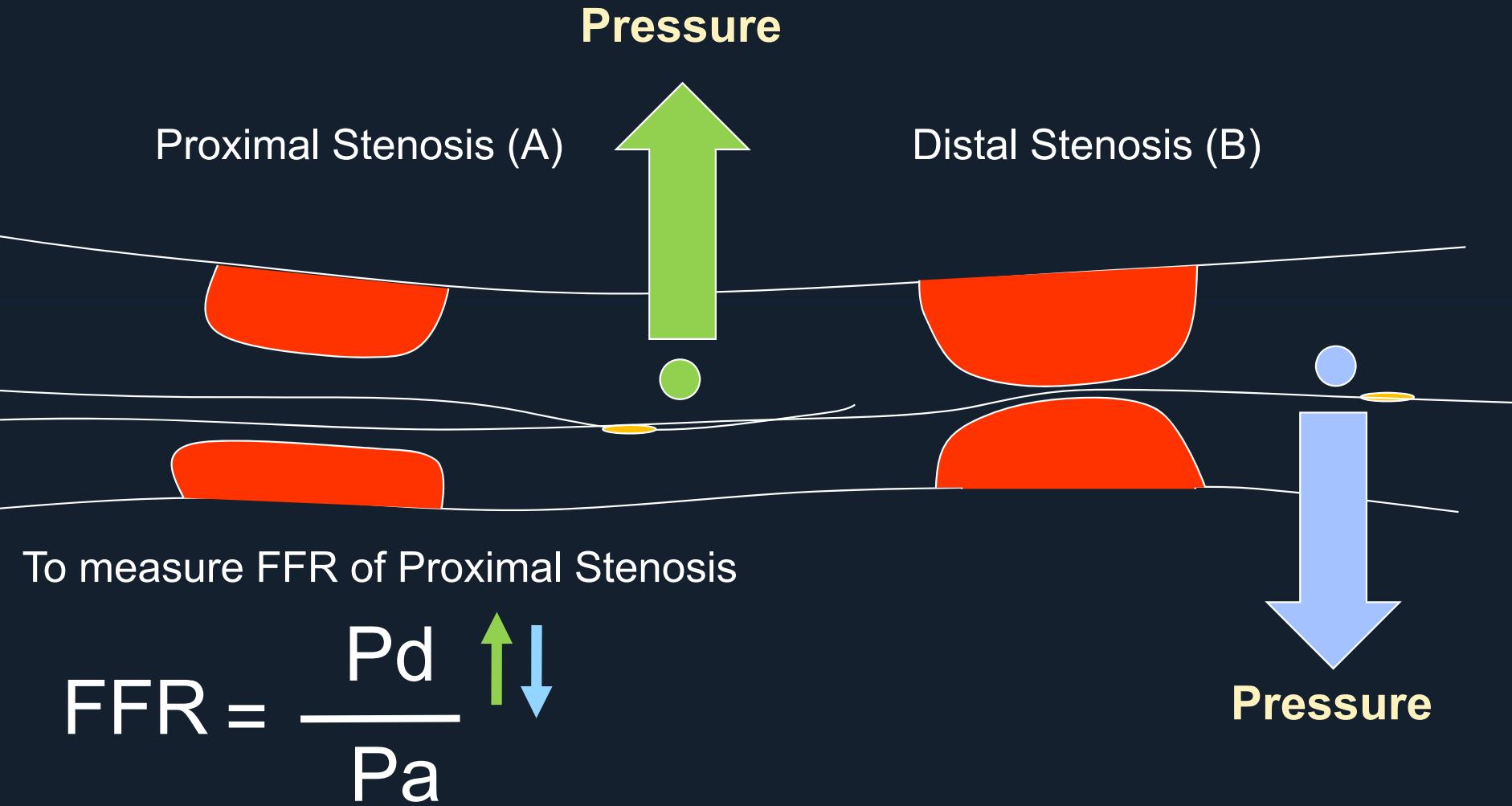
- Possible False Negative FFR
- Possible False Positive FFR

# Coronary Tandem Lesions

**Multiple stenoses in series along one coronary artery**



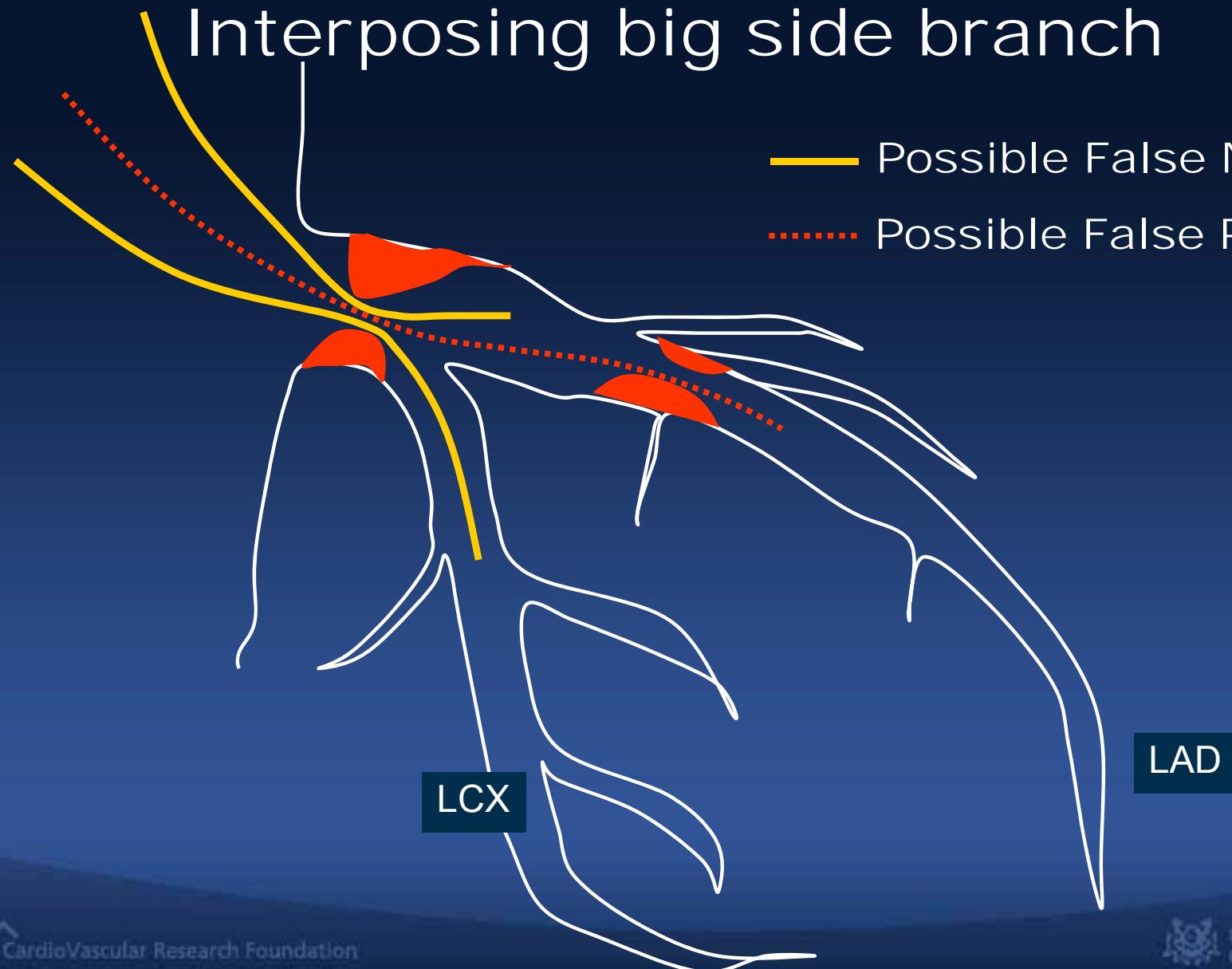
# Hemodynamic Interaction in Tandem Lesion



FFR value of proximal stenosis should be underestimated

# For LMCA stenosis with distal LAD/LCX stenosis

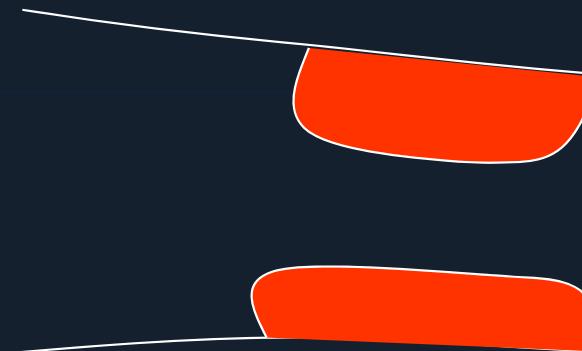
Tandem Lesions with  
Interposing big side branch



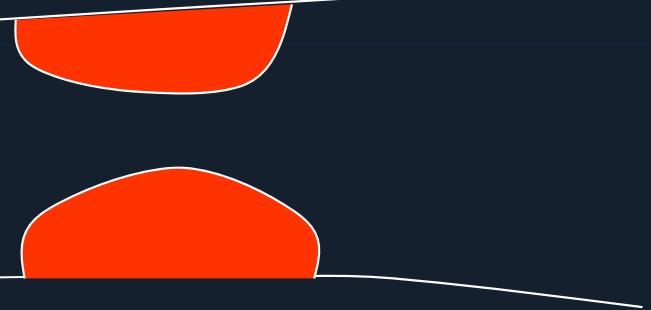
- Possible False Negative FFR
- Possible False Positive FFR

# Tandem Lesion

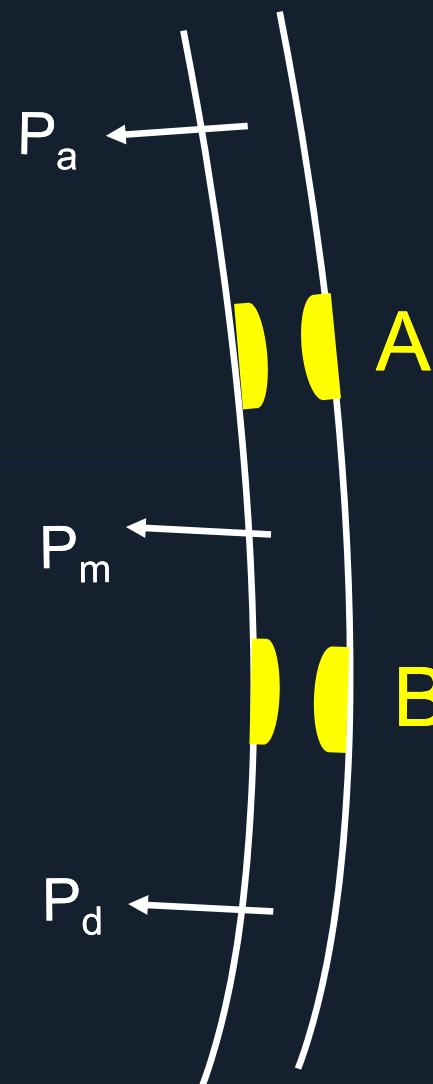
Proximal Stenosis (A)



Distal Stenosis (B)



# The Separate Functional Significance of Tandem Stenoses



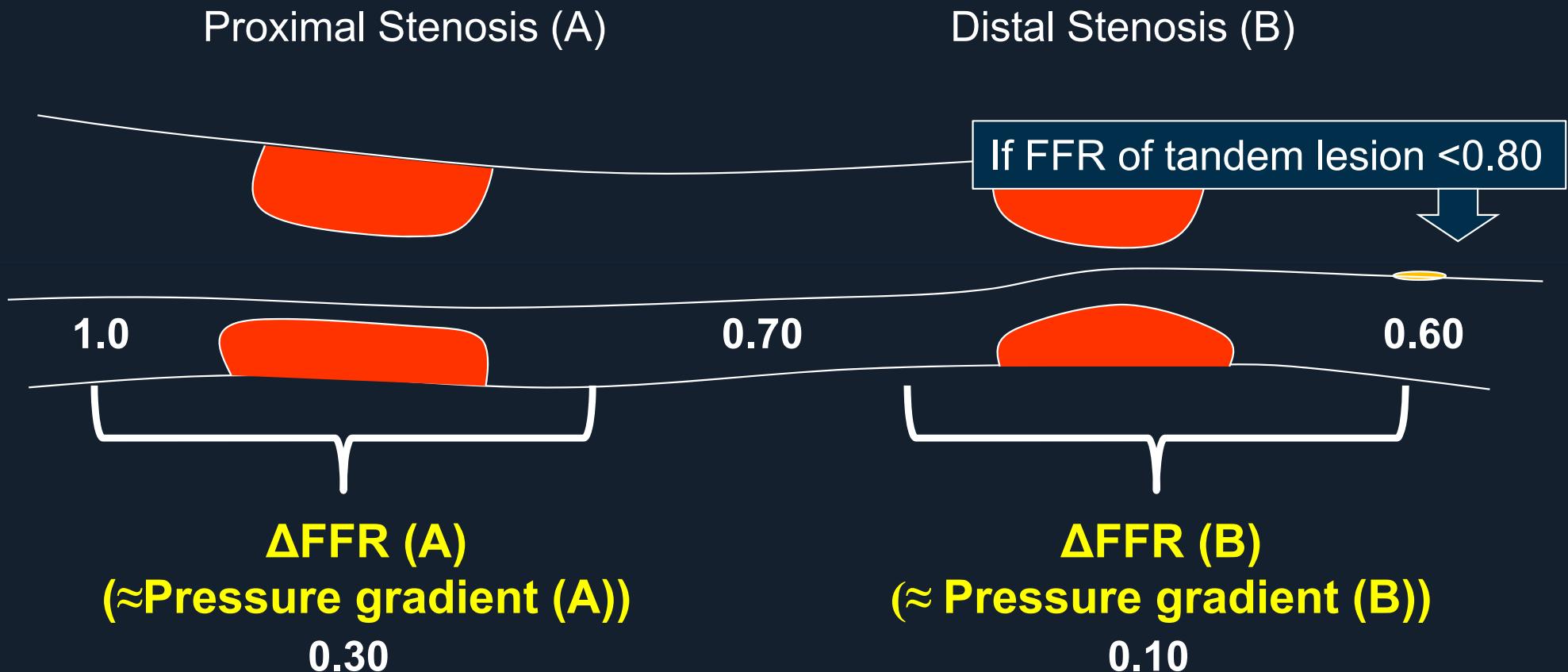
$$\text{FFR(A)}_{\text{pred}} = \frac{P_d - (P_m/P_a) P_w}{P_a - P_m + P_d - P_w}$$

$$\text{FFR(B)}_{\text{pred}} = \frac{(P_a - P_w) (P_m - P_d)}{P_a (P_m - P_w)}$$

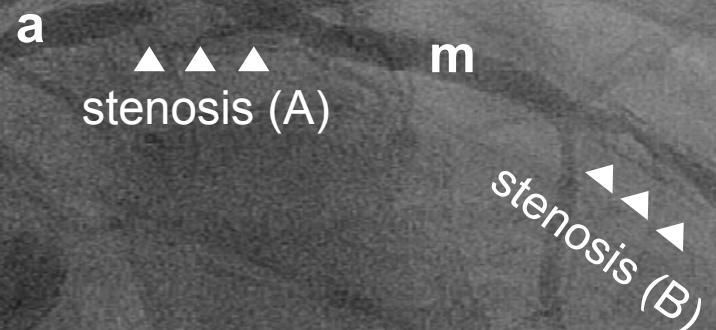
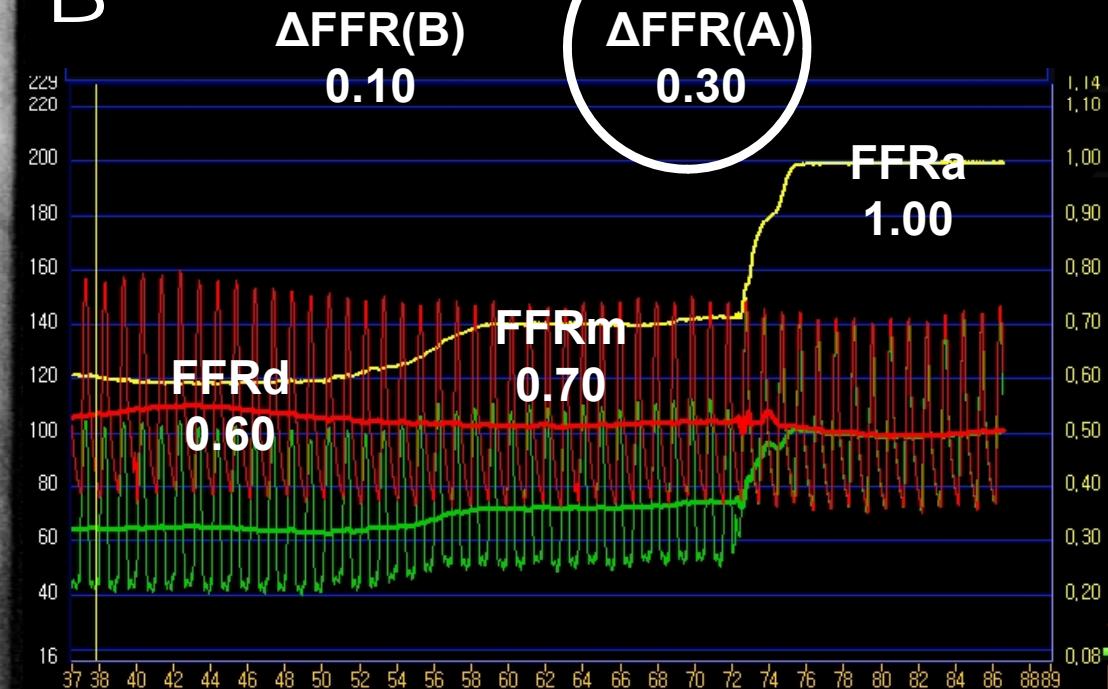
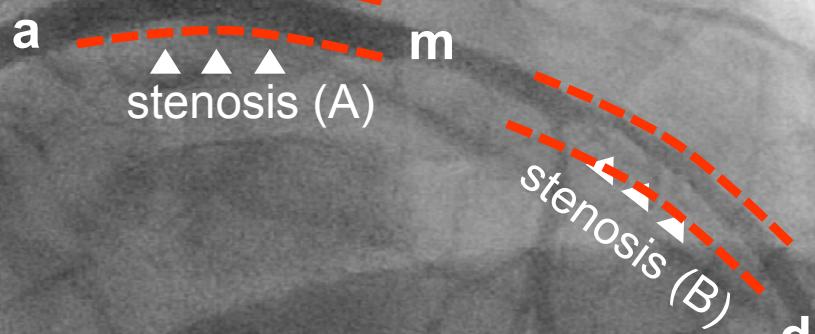
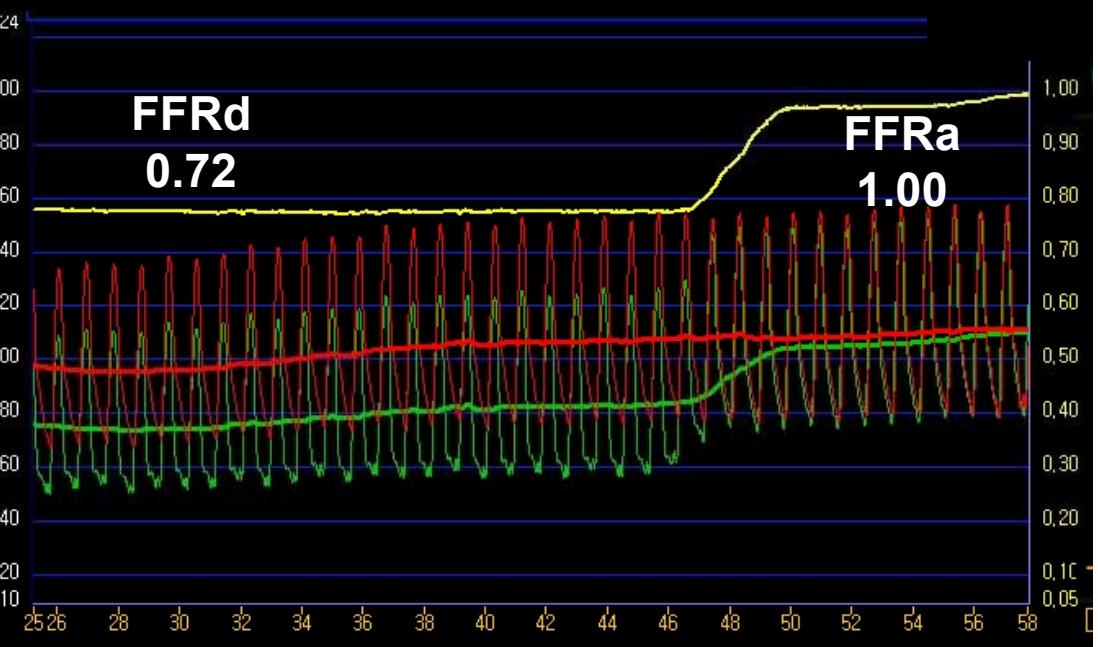
$P_w$  = Coronary occlusive pressure

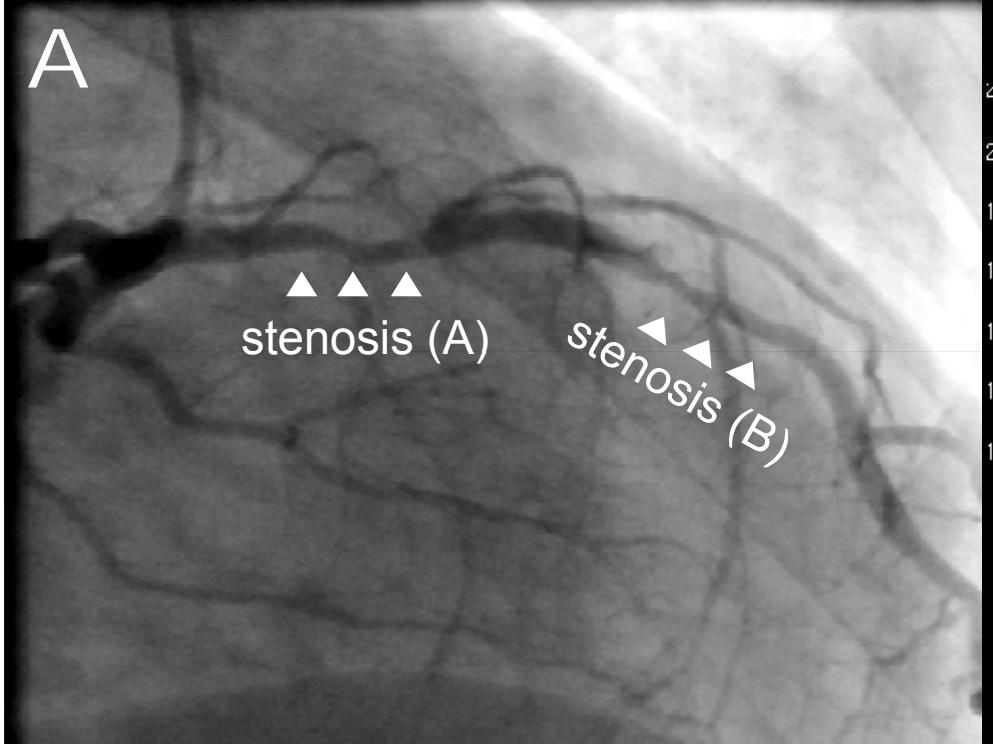
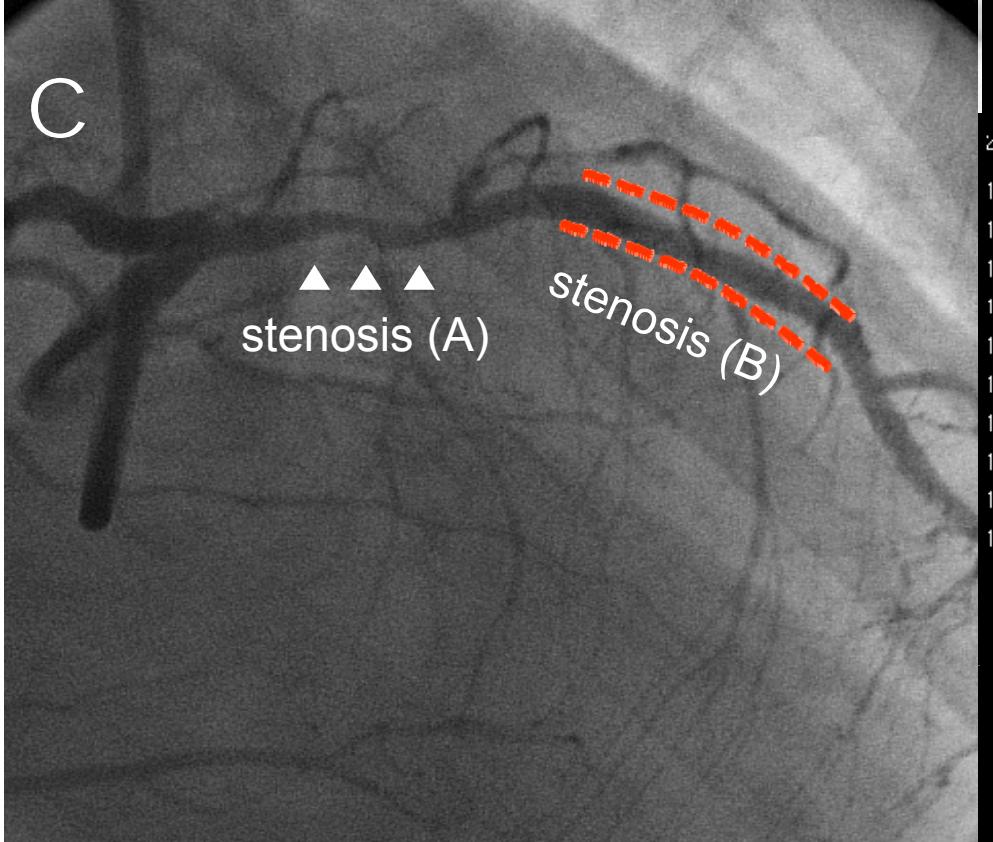
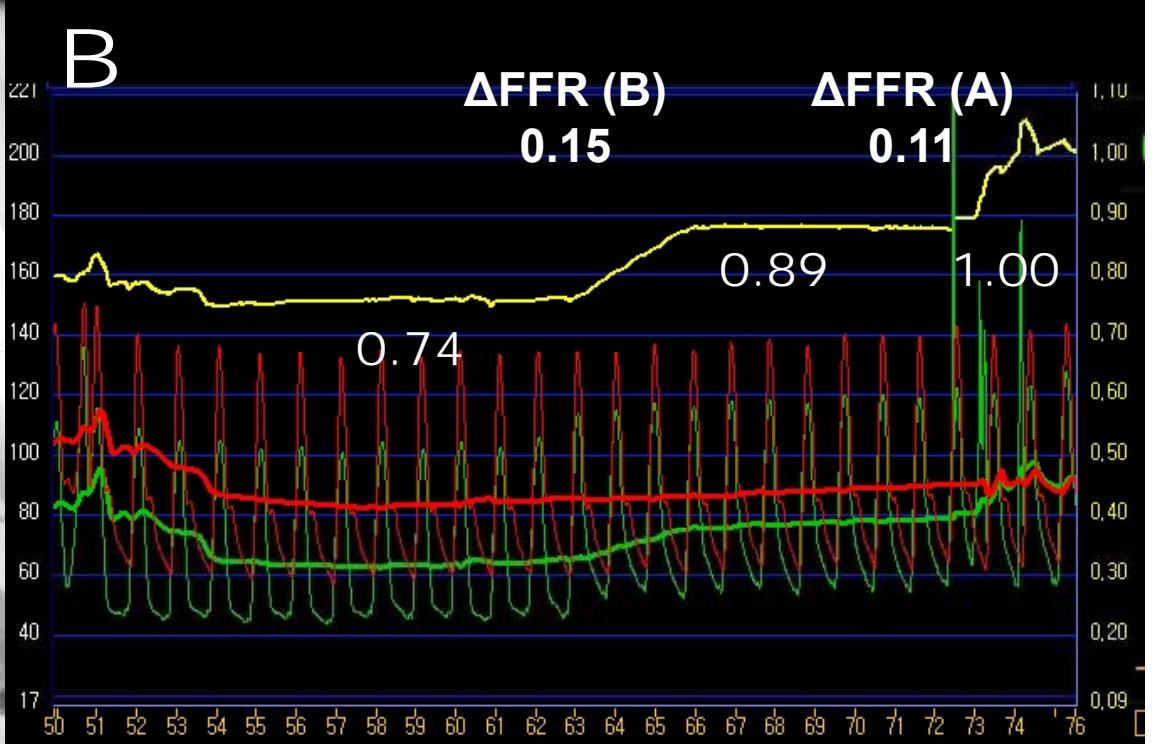
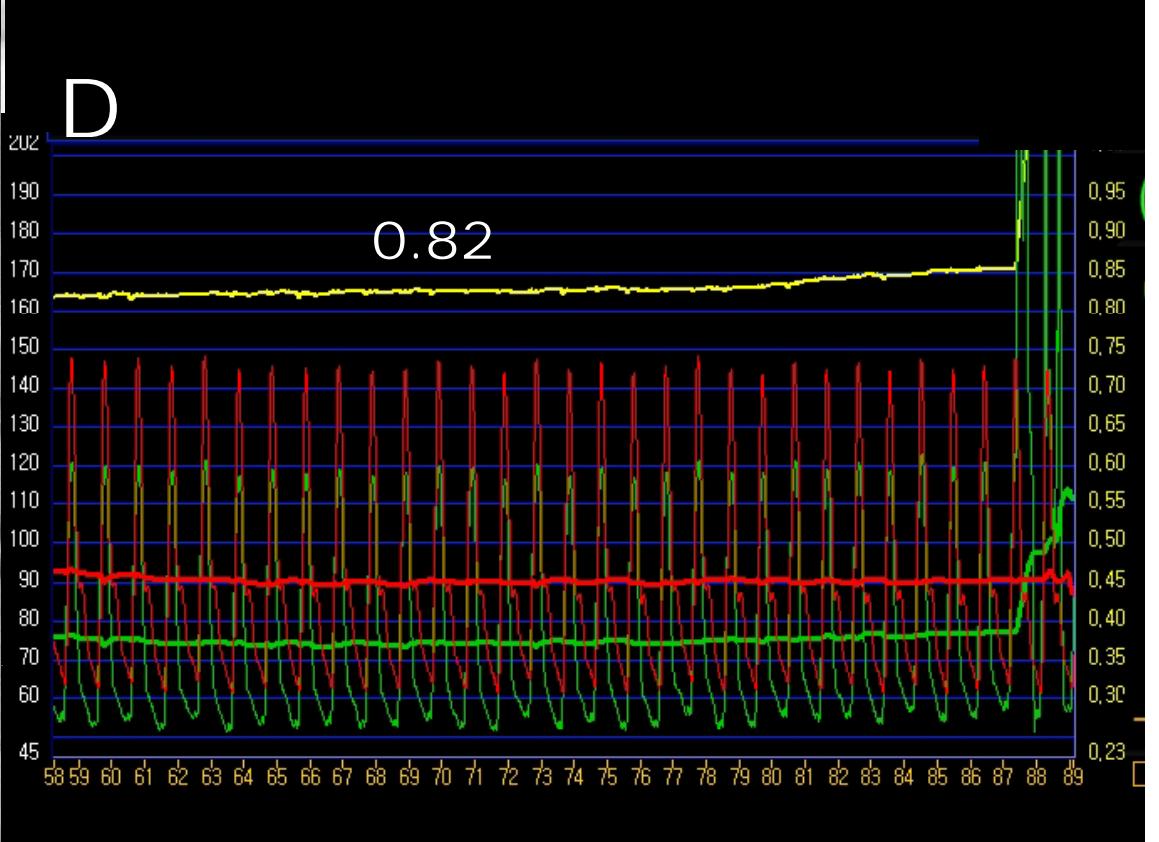
Nico H.J. Pijls and Bernard De Bruyne et al. Circulation 2000;102:2371-2377

# Practical Approach: Rule of Big $\Delta$



1.  $\Delta\text{FFR}$  corresponds to relative functional severity
2. Performing revascularization first for lesions with more functional severity could increase the chance of deferring PCI for the remaining lesions.

**A****B****C****d****D**

**A****C****B****D**

# According to the Rule of “Big Delta”

52 patients with coronary tandem lesion with FFR  $\leq 0.80$

Prioritizing the treatment according to FFR (“rule of big delta”)

- 28 (53.8%) patients had only single-lesion Tx
- 28 (26.9%) lesions were deferred

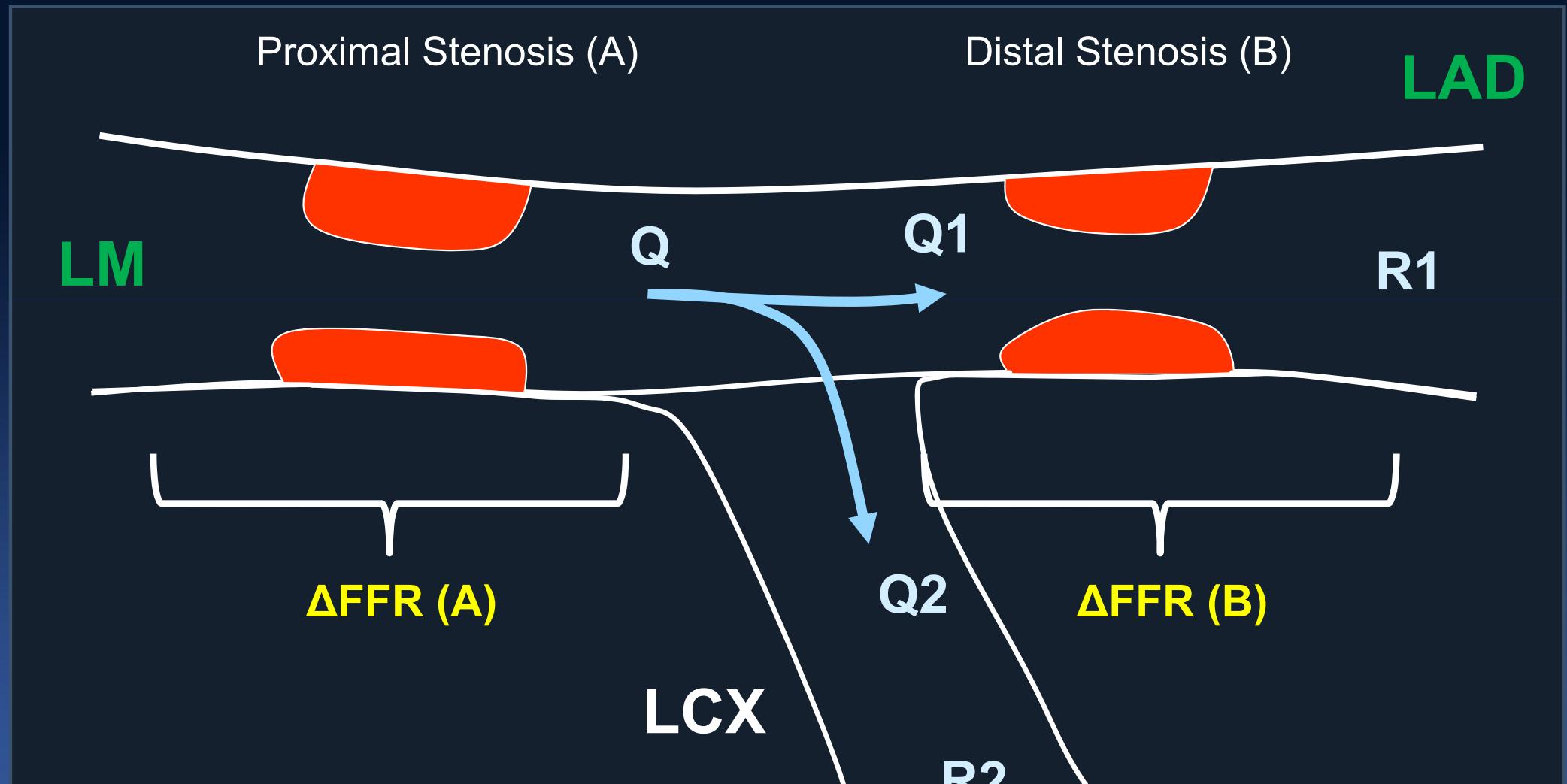
Proximal stenosis  
treated only  
N=16

Both stenoses  
treated  
N=16

Distal stenosis  
treated only  
N=12

Both stenoses  
treated  
N=8

# Tandem Lesion with Interposing Side Branch like LM

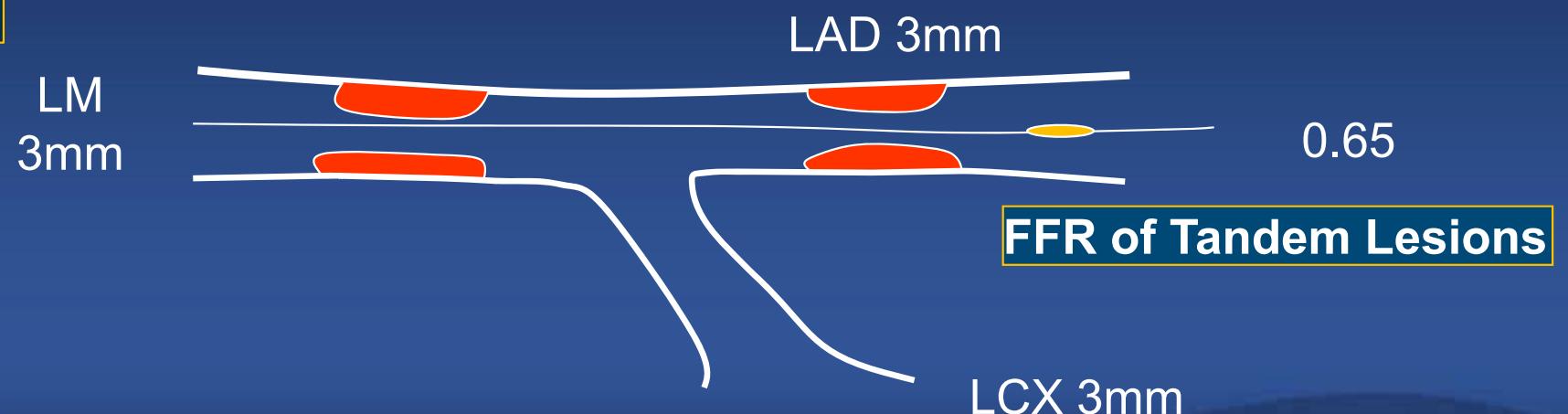


Could  $\Delta FFR$  ( $\approx PG$ ) be a Surrogate of Relative Functional Singificance ?

# In Vitro Simulation

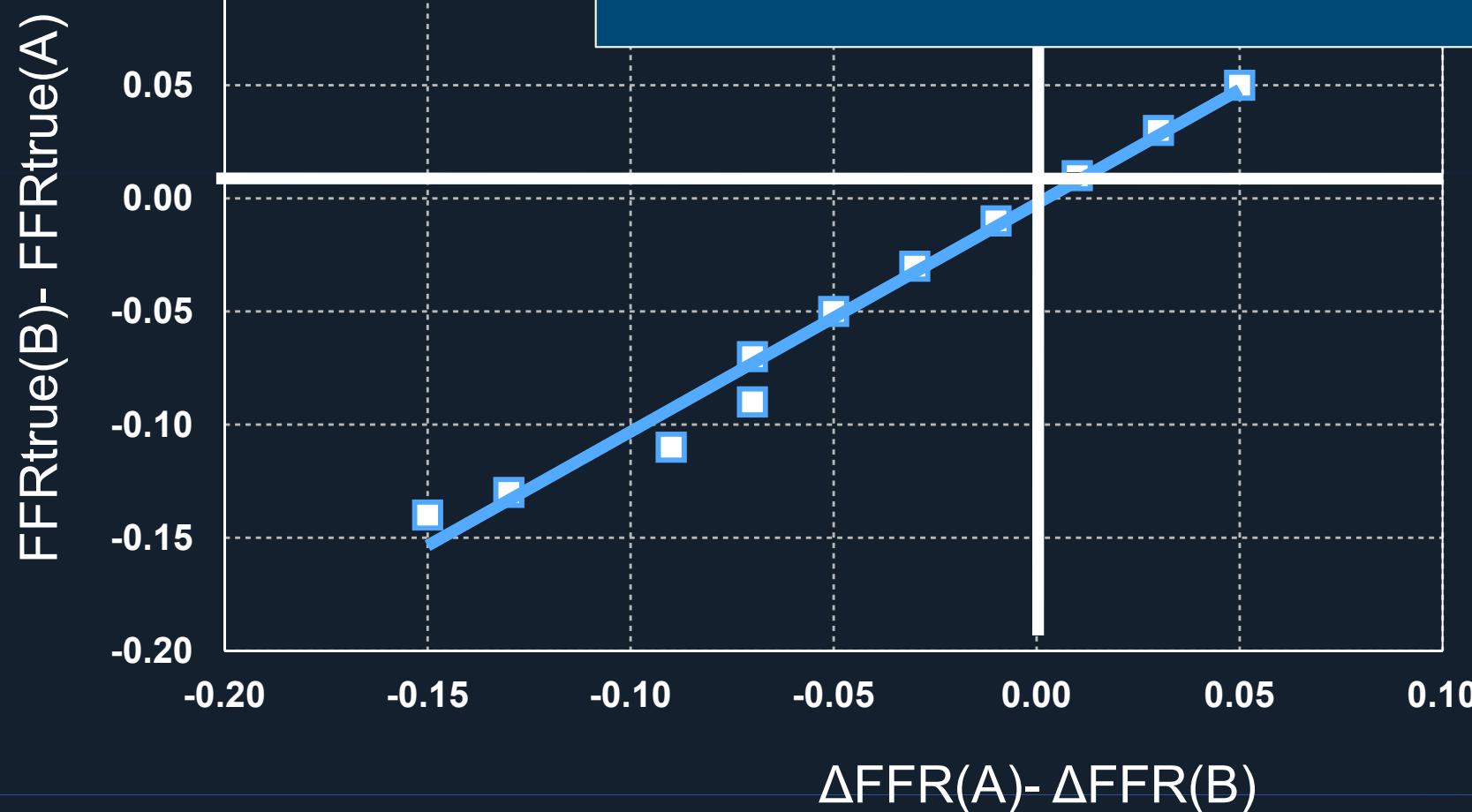


Assumption

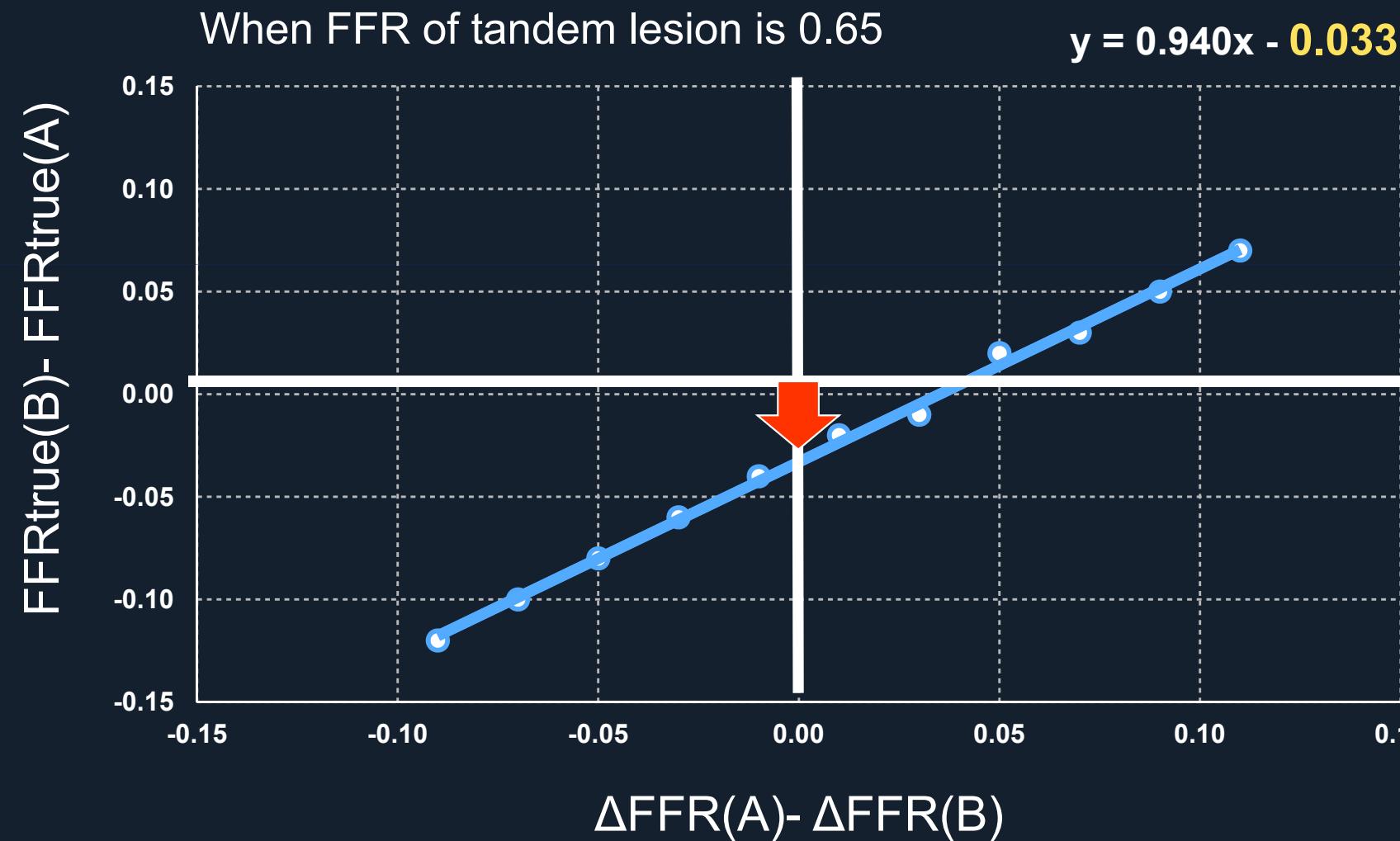


# Without

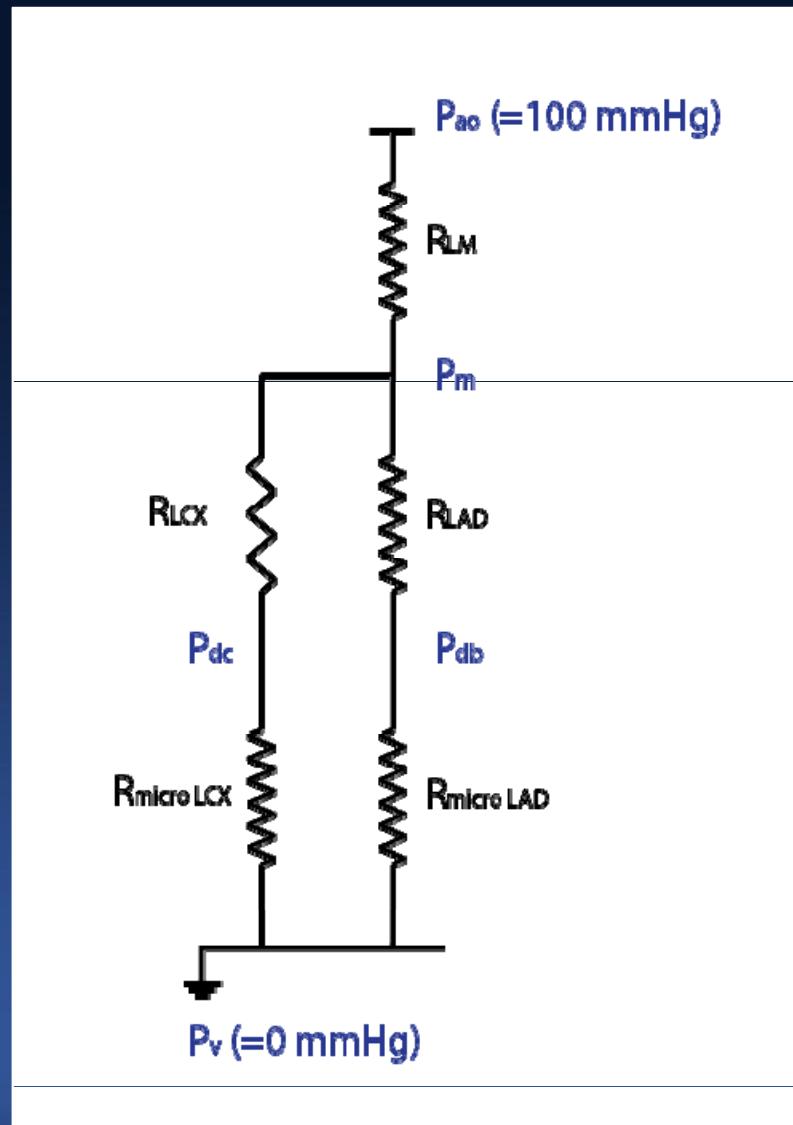
When FFR of tan



# With Side Branch

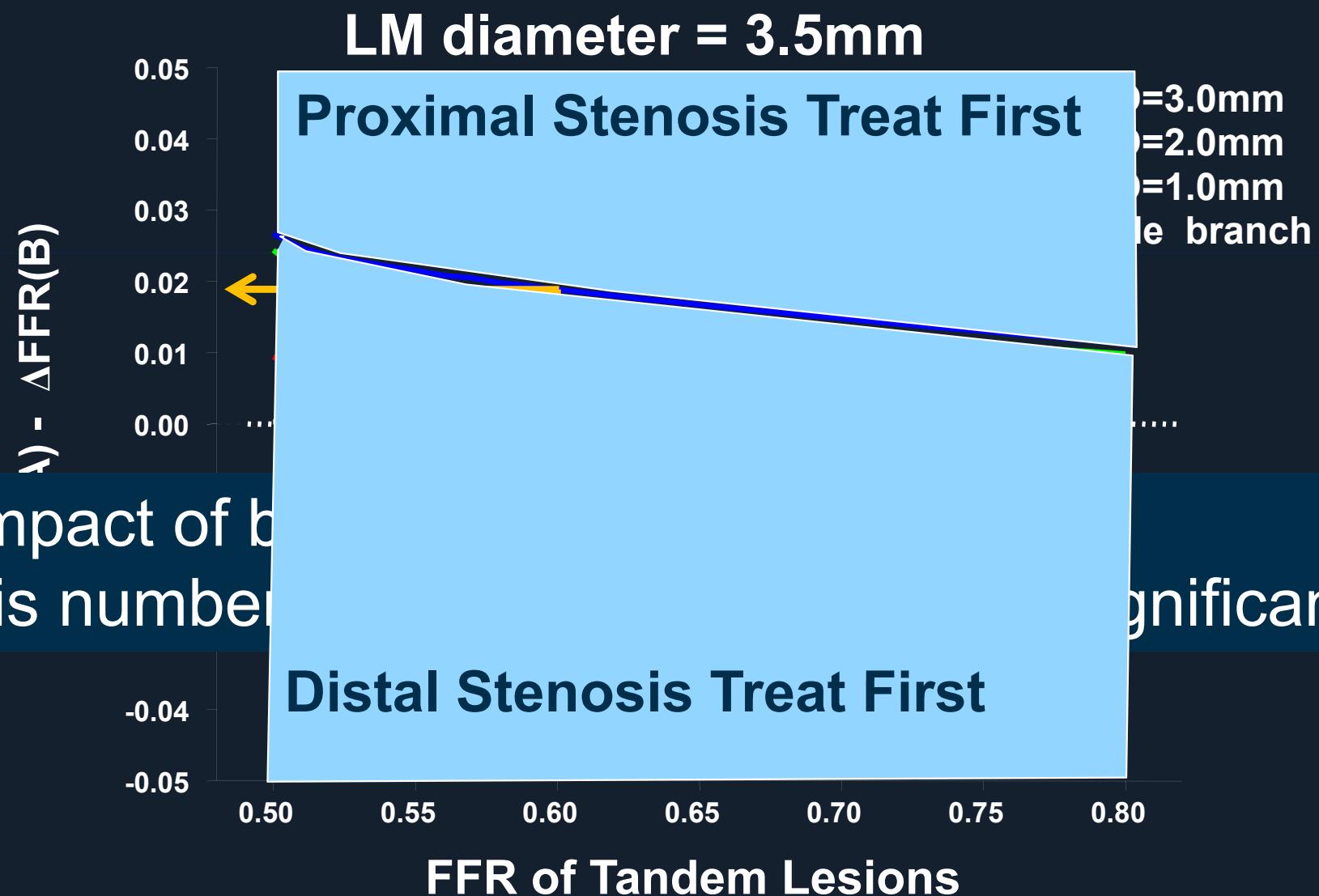


# Simulation Study



# When Two lesions are functionally equal,

$$(FFR(A)_{\text{true}} = FFR(B)_{\text{true}})$$



# Conclusions

1. LM Disease has the greatest angiographic variability. Angiographic assessment is Not Always Enough. Direct FFR should be measured when the ischemic potential was not defined.
2. For the treatment of the coronary tandem lesion,  $\Delta$ FFR may be useful index for prioritizing the treatment sequence and optimizing stent outcome with or without interposing side branches.