6th Imaging & Physiology Summit 2013

Case-Based Learning from Experts

LM and Tandem Lesion

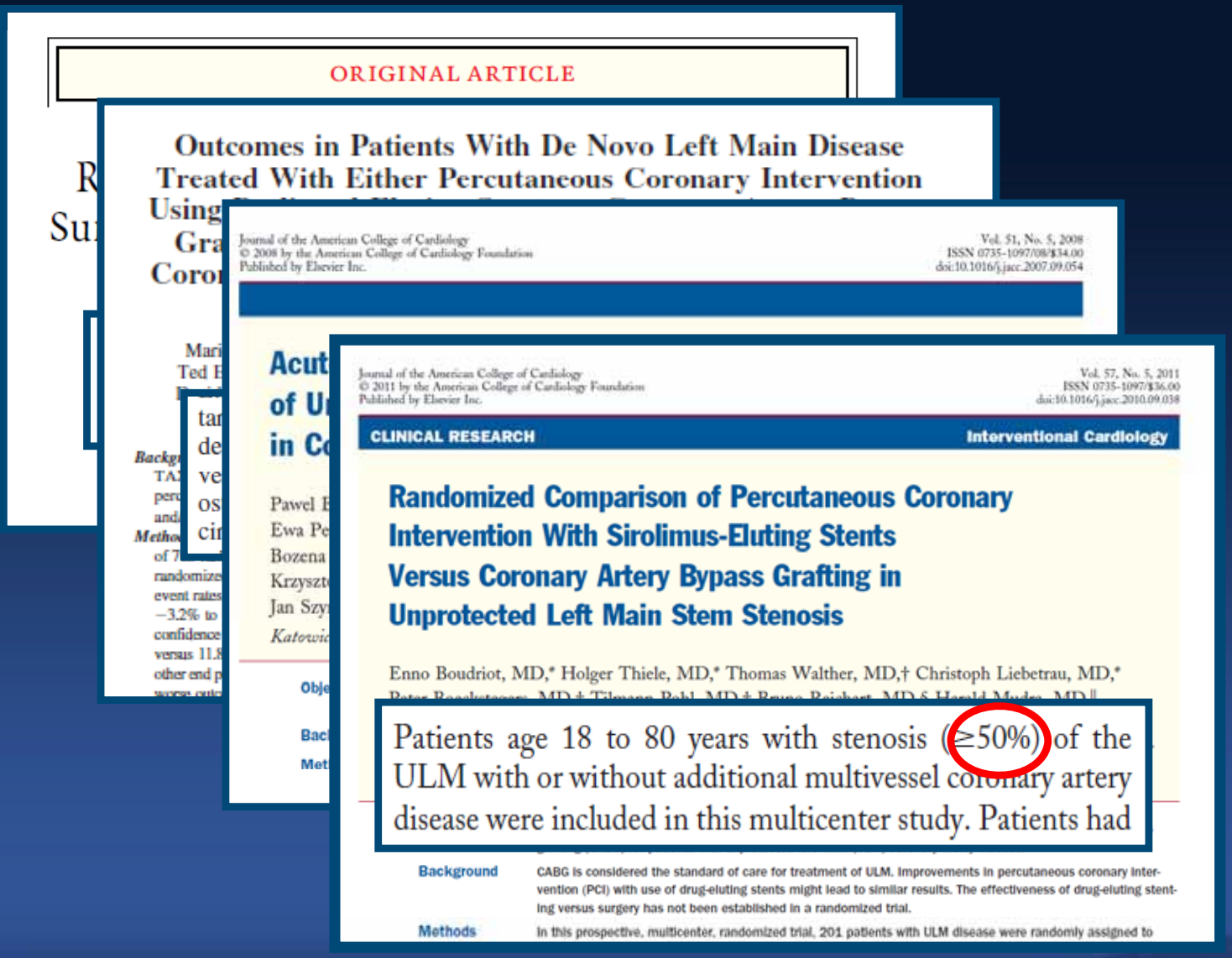
Jung-Min Ahn

Heart Institute, Asan Medical Center

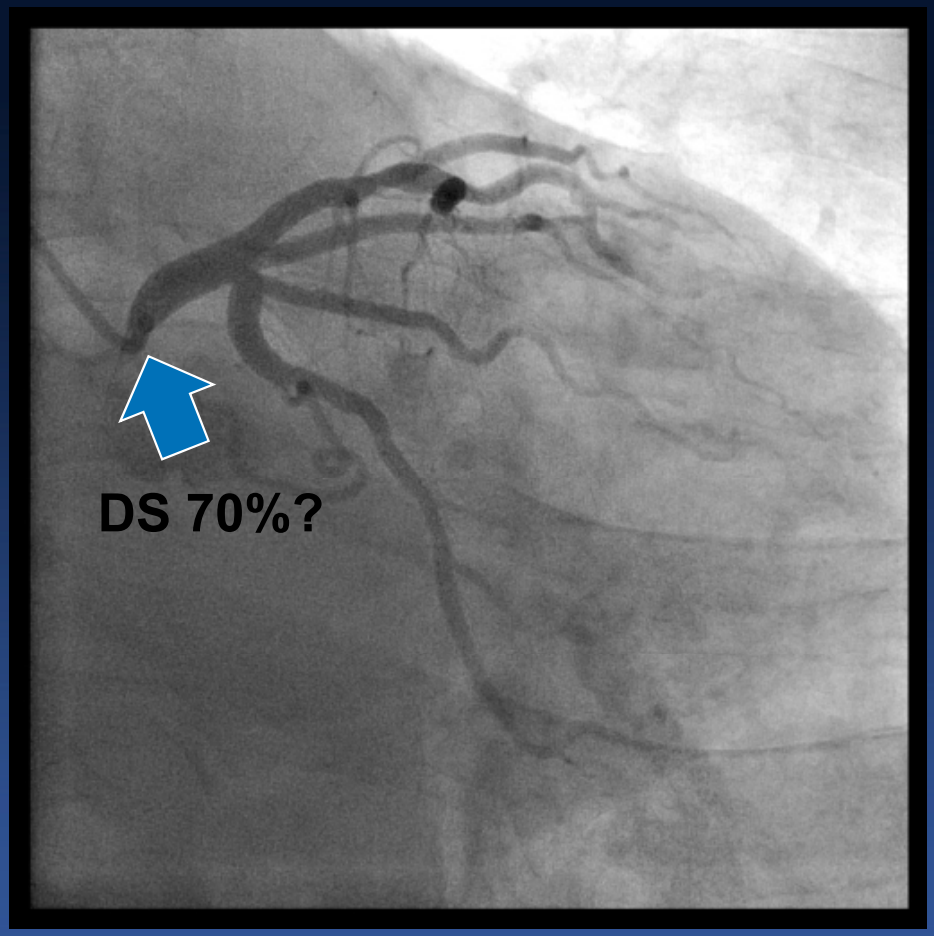
Why We Need FFR in LM Disease?

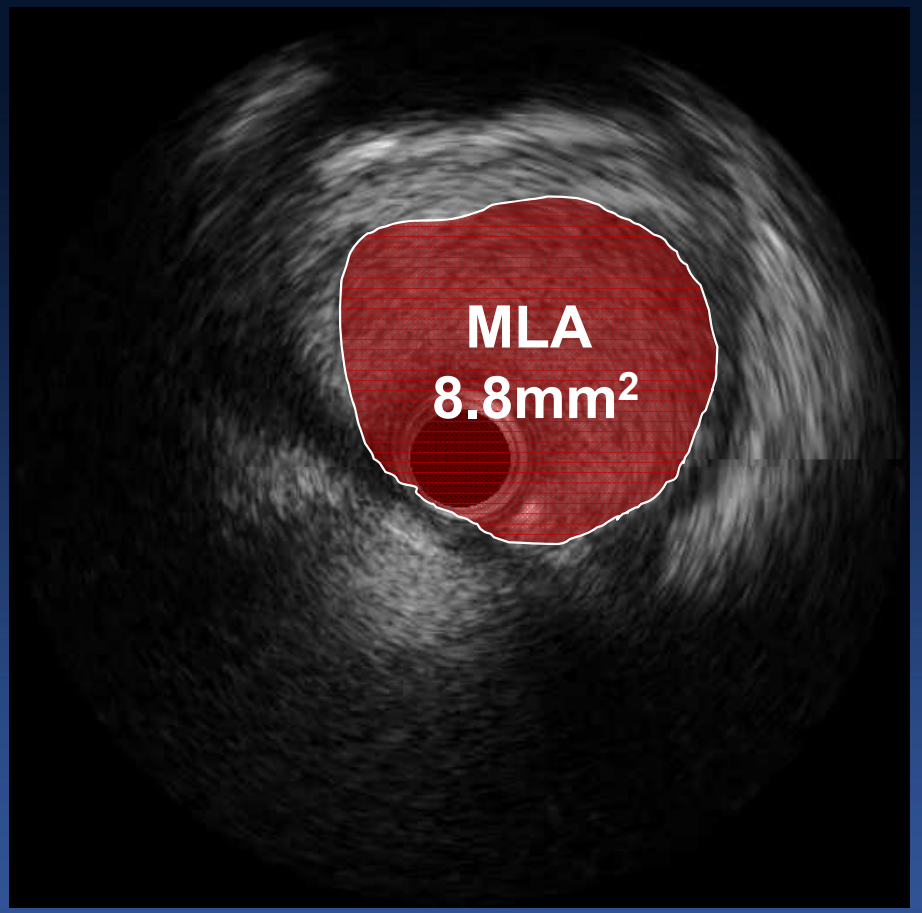
- Inaccuracy of Coronary Angiogram
- Insufficiency of Non-Invasive Functional Study
- FFR guided PCI in LMCA showed favorable outcomes

Major Randomized Studies in LM



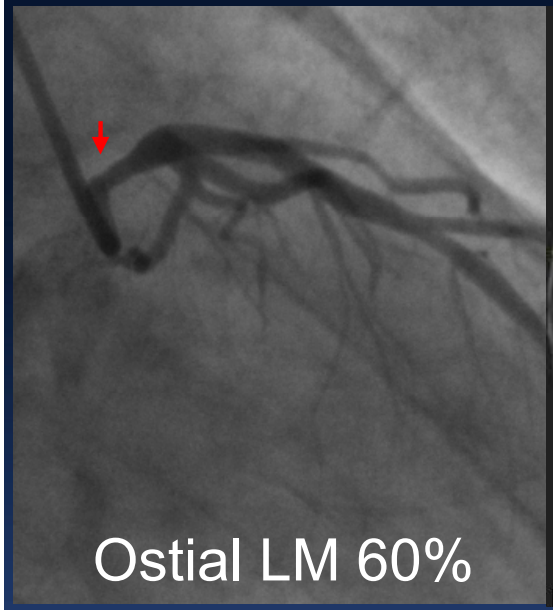
Why We Need FFR?



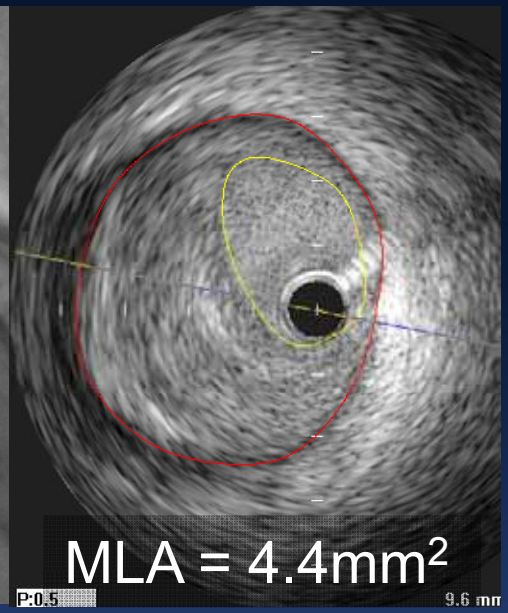


Why We Need FFR in LM?

47/M Stable angina



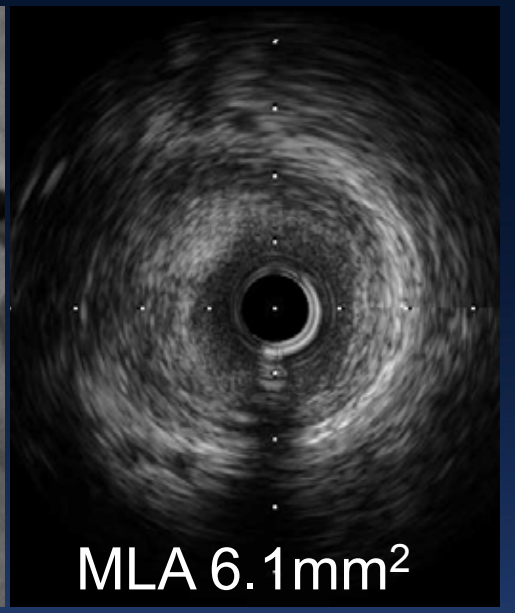
Ostial LM 60%



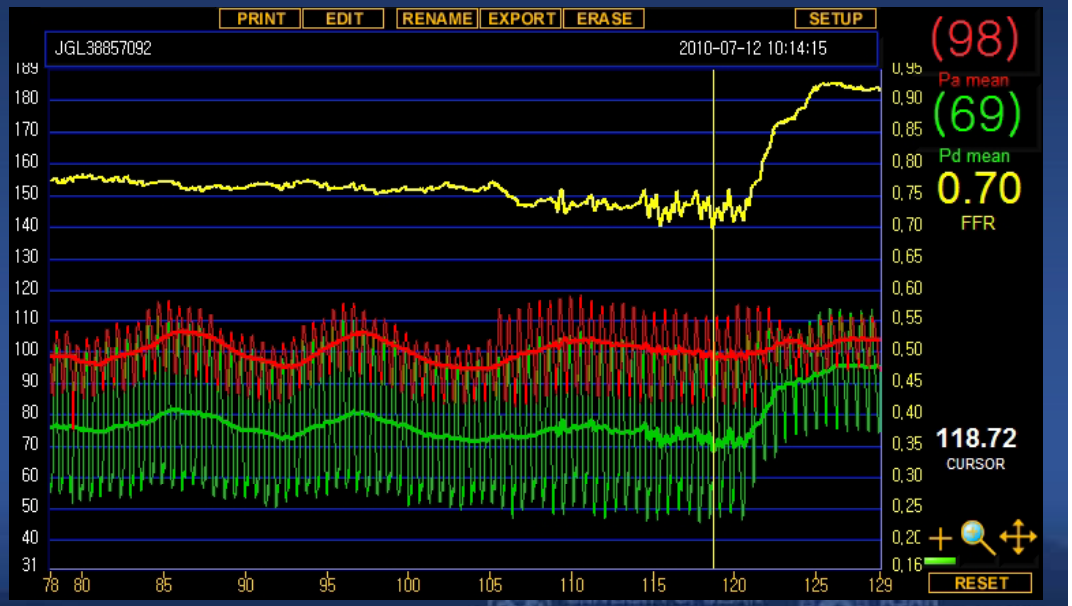
MLA = 4.4mm²

50/M Stable angina

Ostial LM 20%

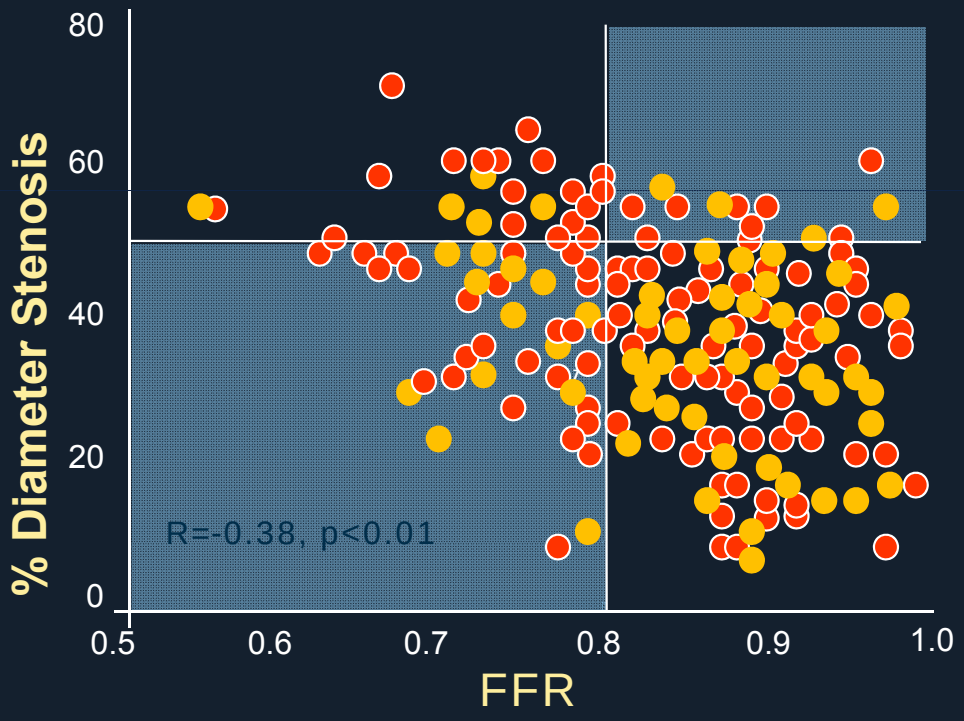


MLA 6.1mm²



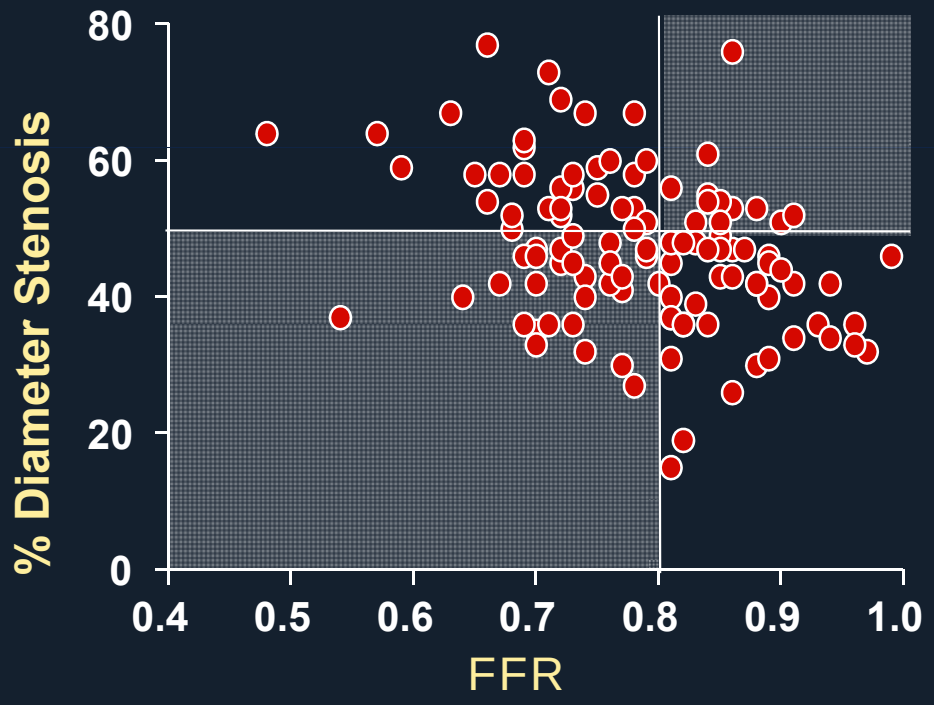
FFR and %DS in Equivocal LMCA

"Mismatch" is 29% in equivocal LMCA



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

"Mismatch" is 37% in equivocal LMCA



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

● **Isolated LMCA disease**

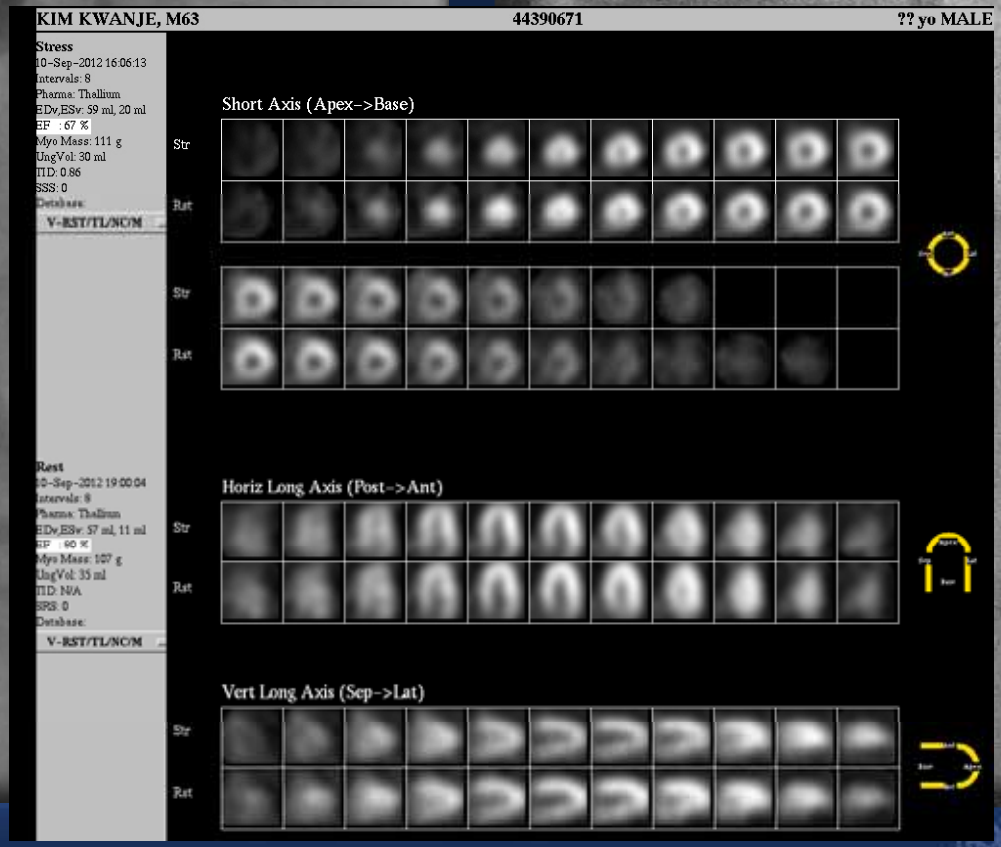
LM with 3VD

65yrs/M, eCP

RCA

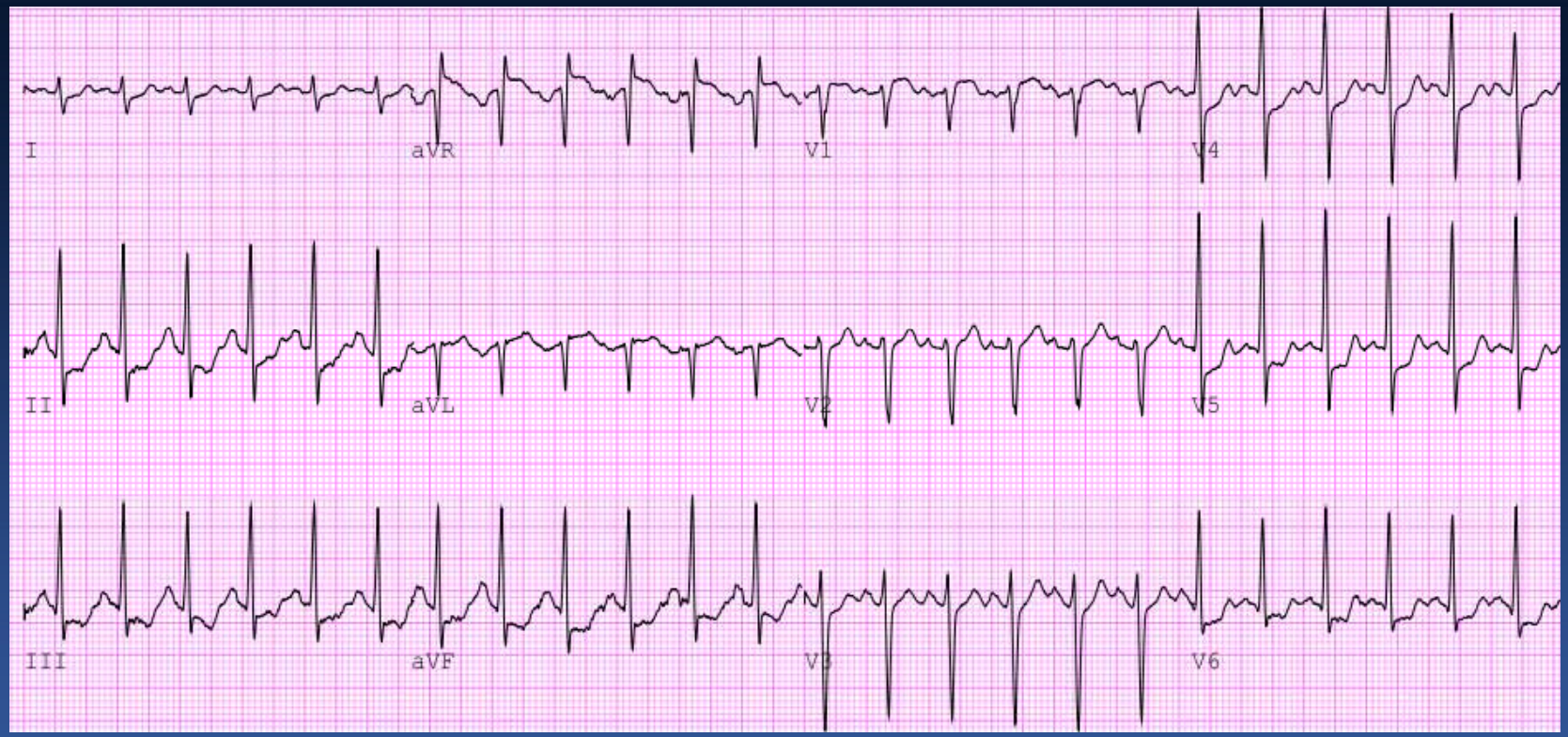
LCA

Normal Perfusion in Thallium SPECT



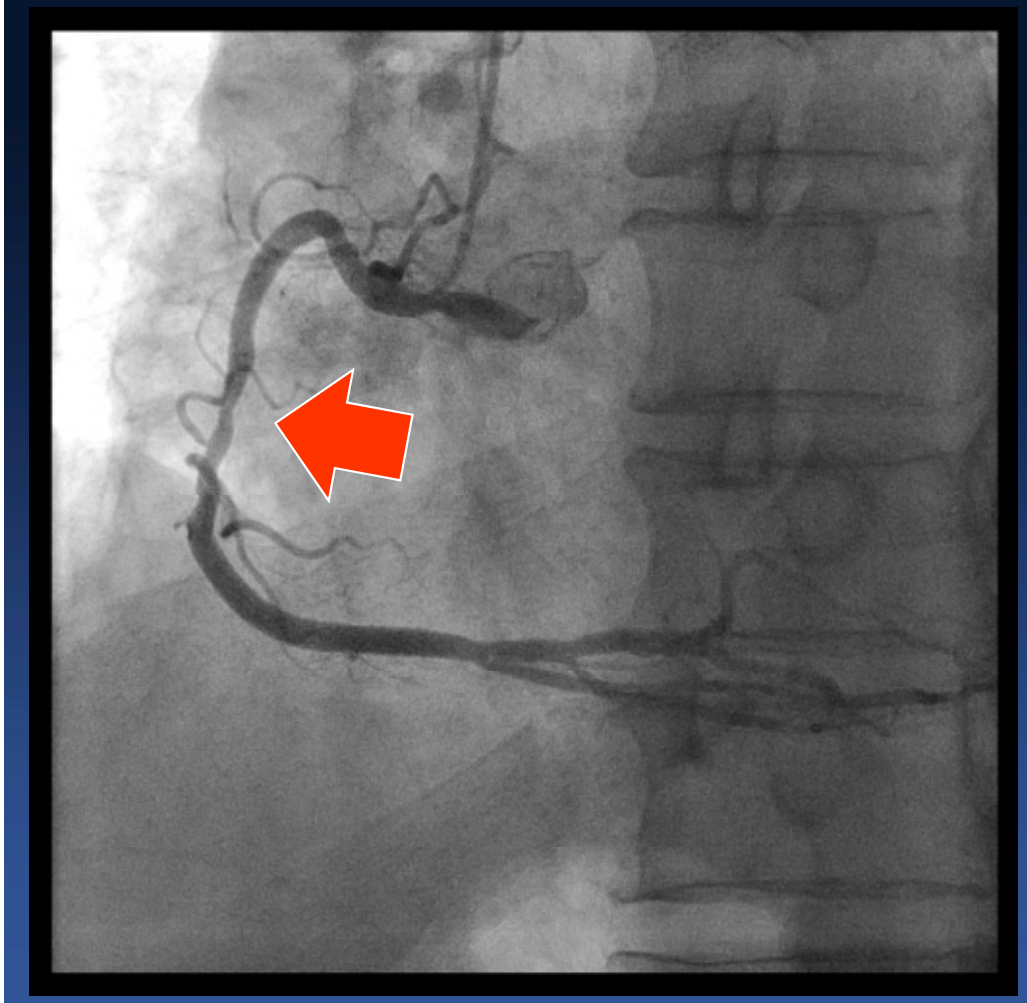
M/76, eCP

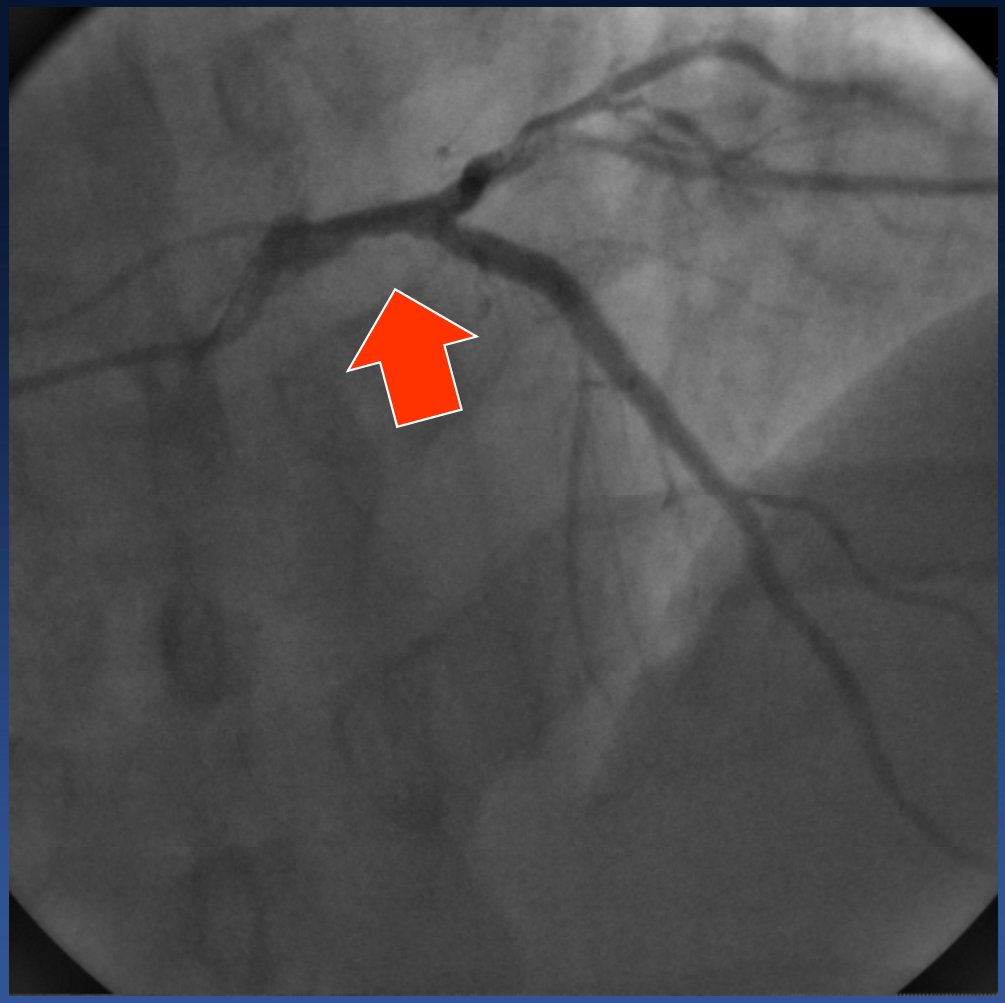
Treadmill Test



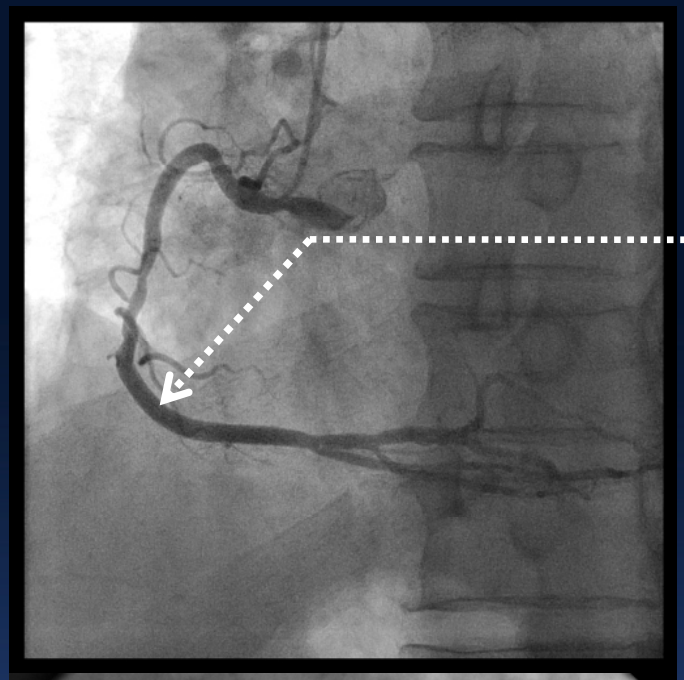
Positive at Stage 4

Coronary Angiography

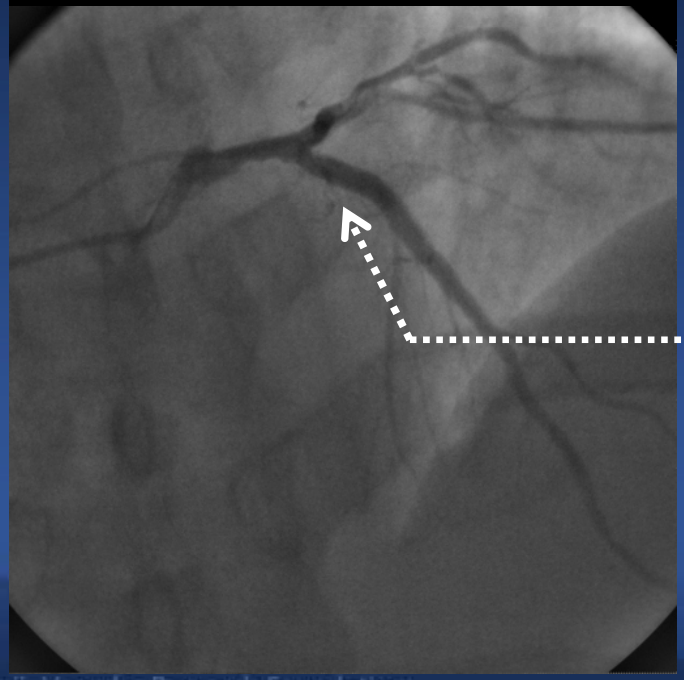




FFR



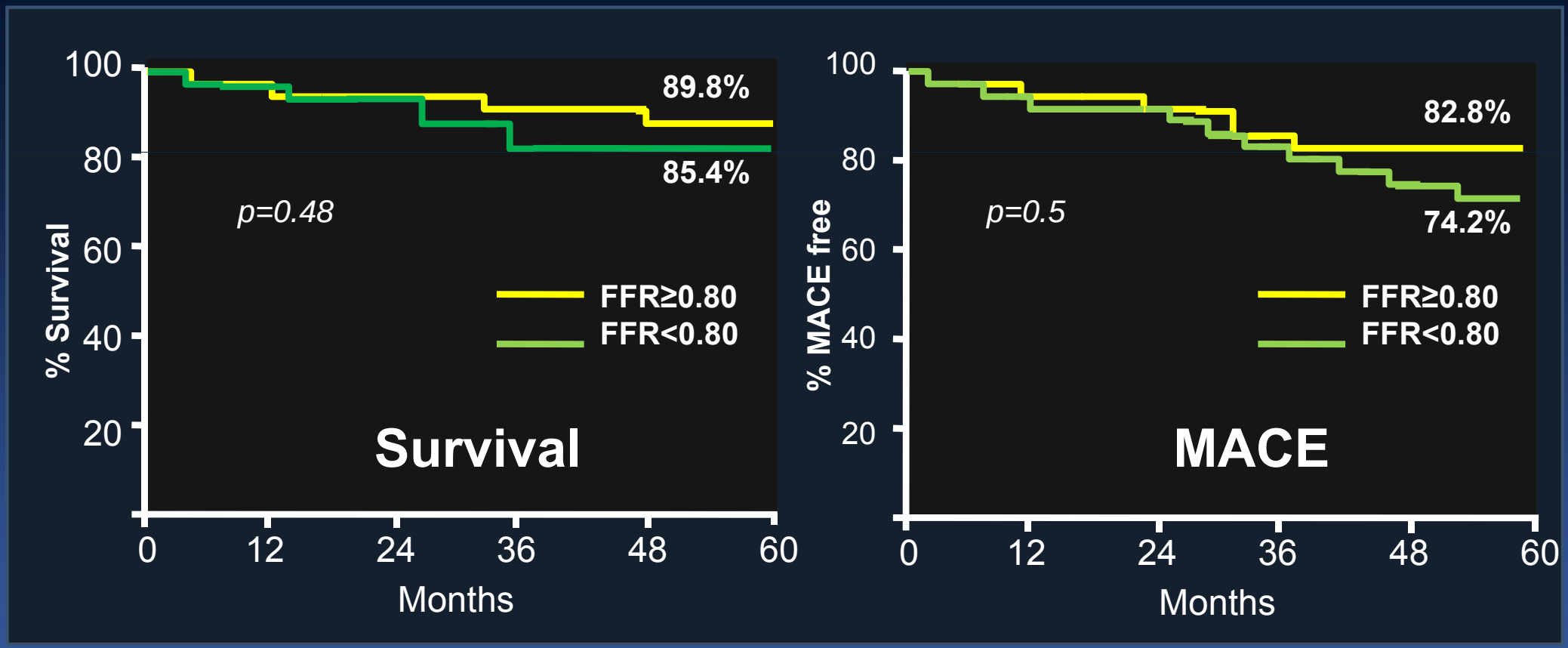

0.72
PressureWire
(77)
(56)
0.72
14.90
AUTOSCALE




0.89
(87)
(77)
0.89
90.66
AUTOSCALE

FFR Guided PCI in Equivocal LMCA

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



An FFR-guided strategy showed the favorable outcome.

Circulation. 2009;120:1505-1512

FFR Guided Decision Making in LM Disease

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

[1]Circulation 2009;120:1505-1512;[2]Heart 2001;86:547-552;[3]Am J Cardiol 2009;103:943-949;
[4]Am Heart J 2006;152:156.e151-156;[5]Circulation 2004;110:2831-2836

Clinical Outcomes After Deferral of LM Disease

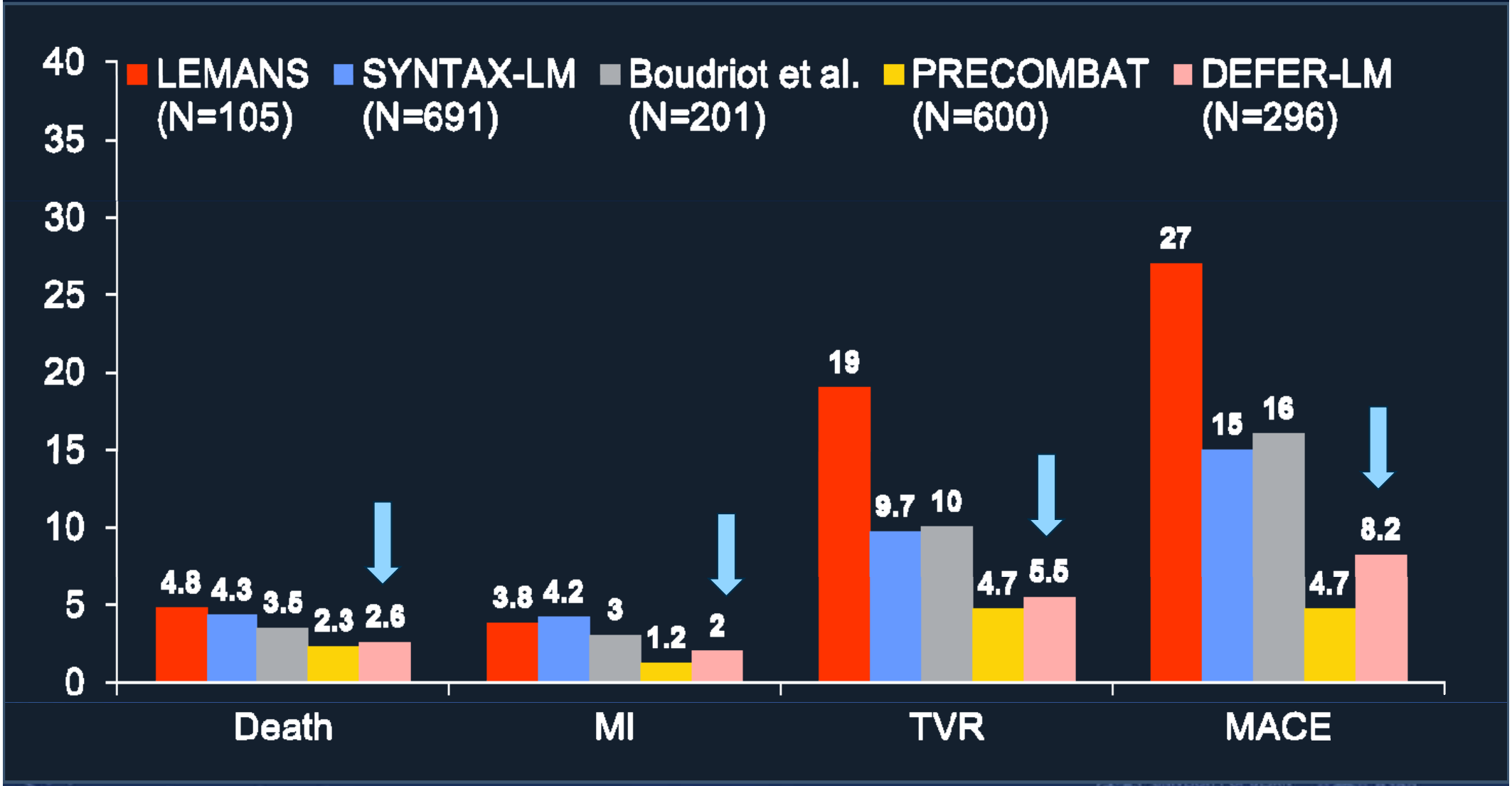
(6 studies, 296 patients)

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

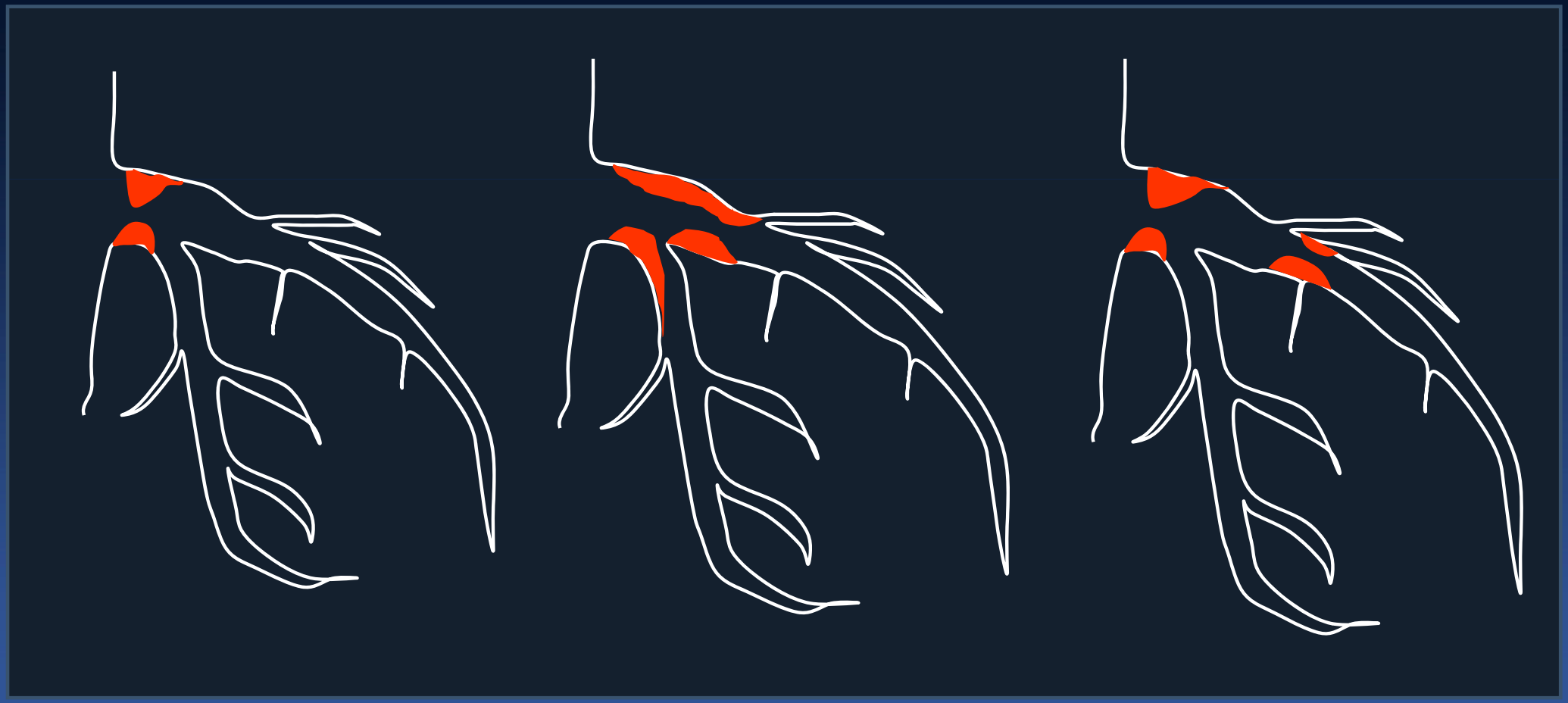
How Can We Implement FFR in Real Practice ?

LMCA Anatomy

(A) Ostial/Shaft

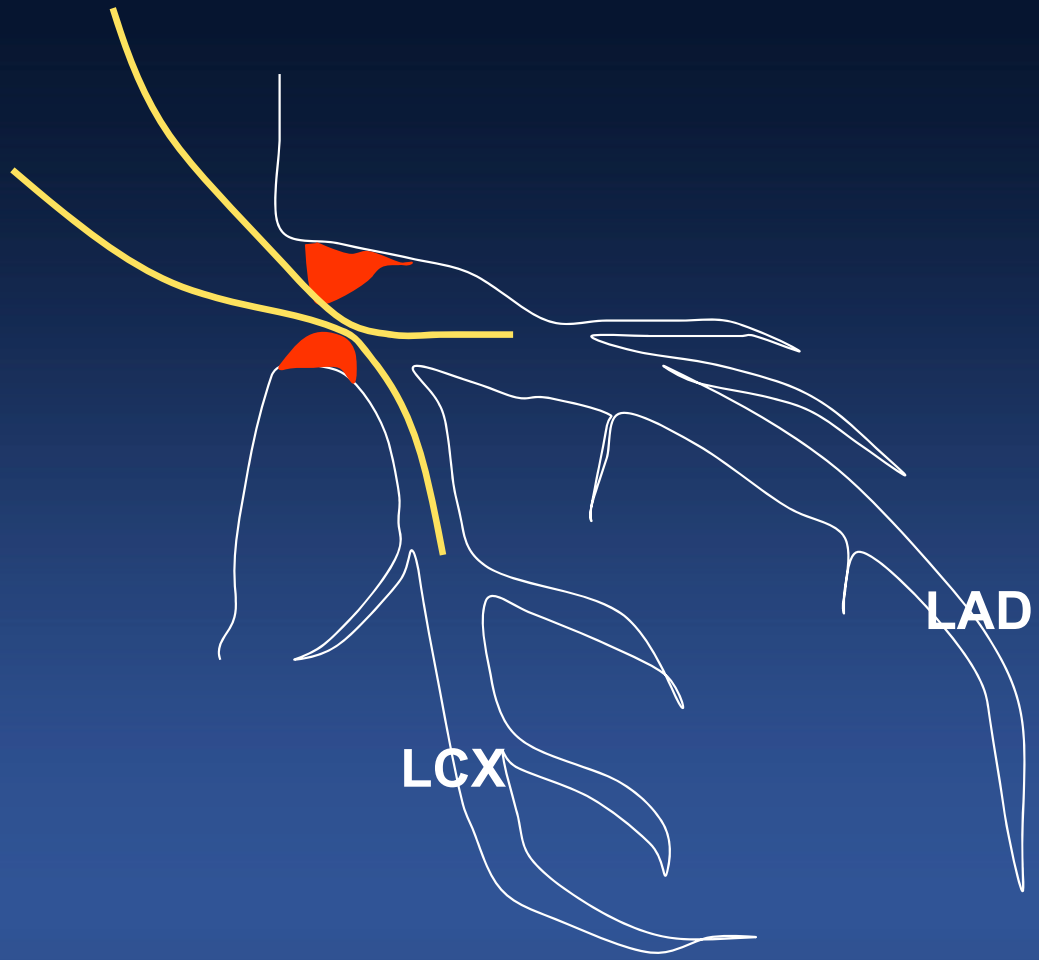
(B) Bifurcation

(C) LM with distal Dz



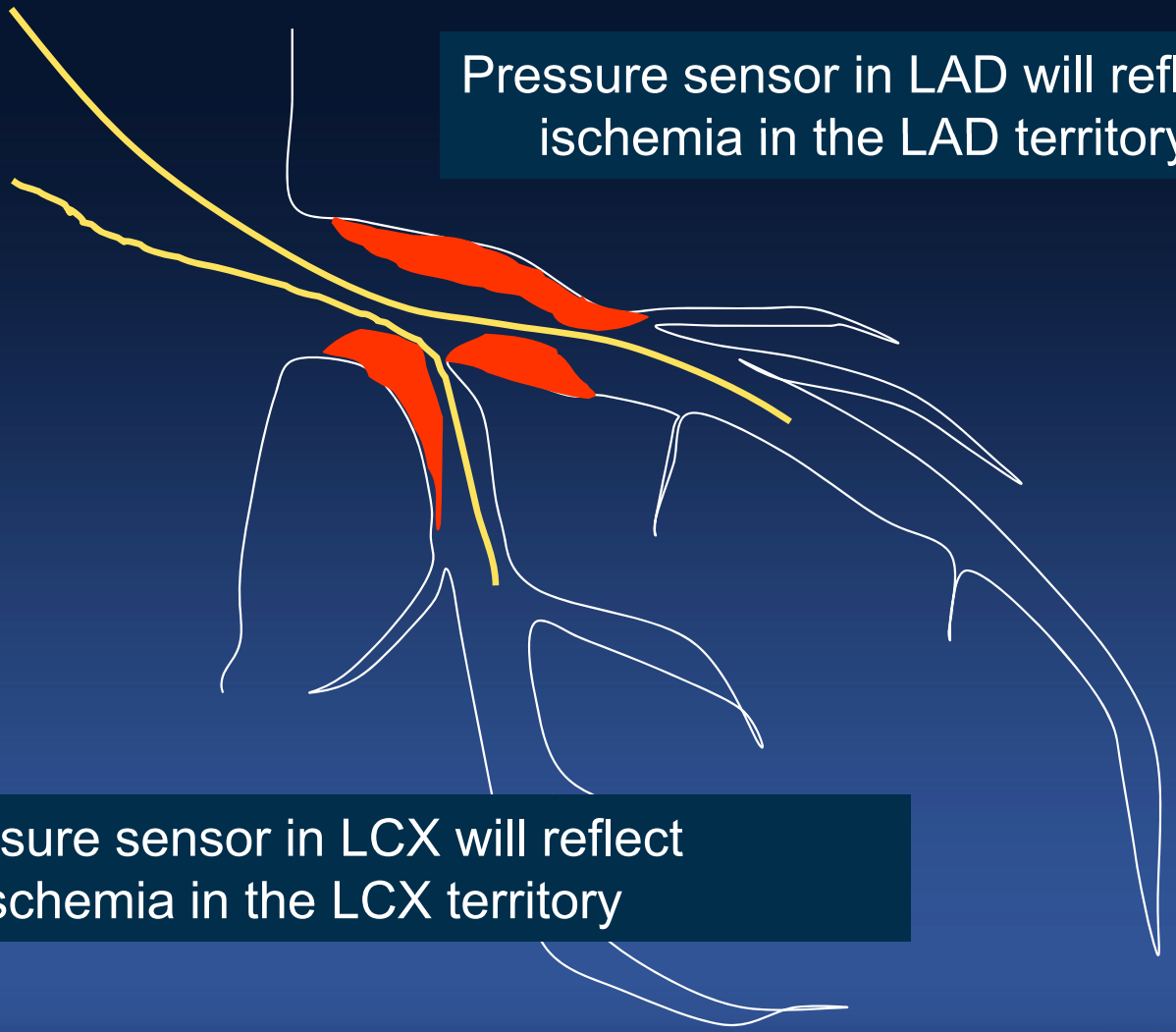
For the Undetermined, Intermediate Ostial and Shaft LM Lesion,

Theoretically, LAD FFR = LCX FFR



For the Intermediate LM Bifurcation Lesion,

LAD FFR = or ≠ LCX FFR



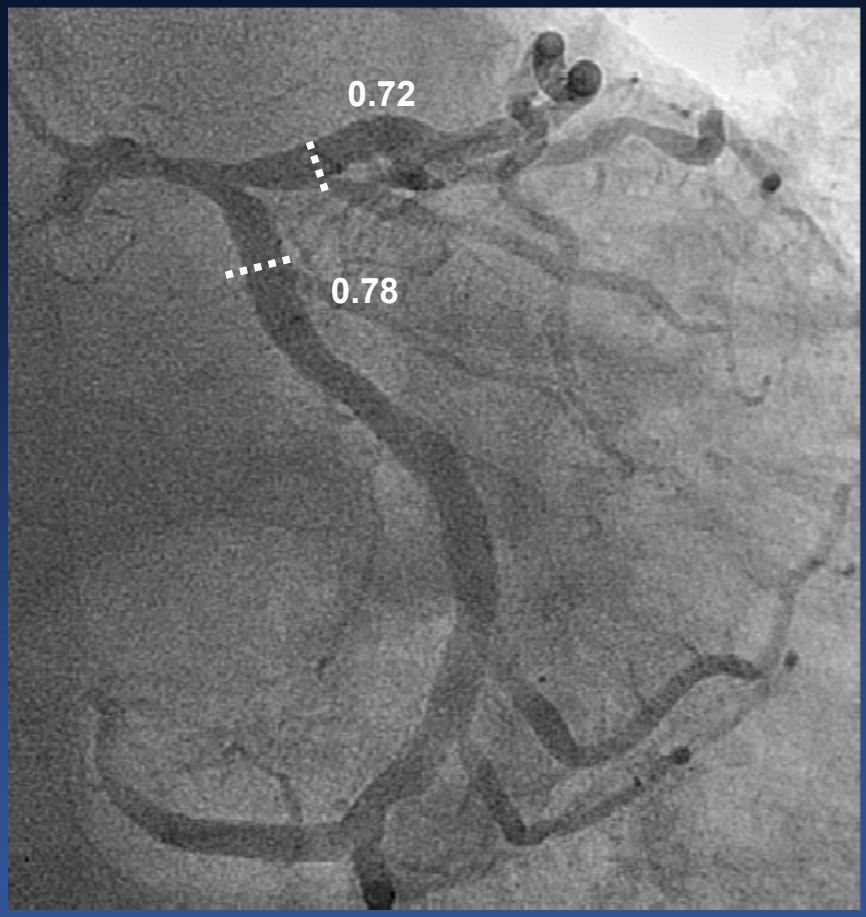
For the Intermediate LM Bifurcation Lesion,
Main Concern is to Determine
Single Stent Cross Over or 2 Stents Technique.

We Can Not Treat Separately

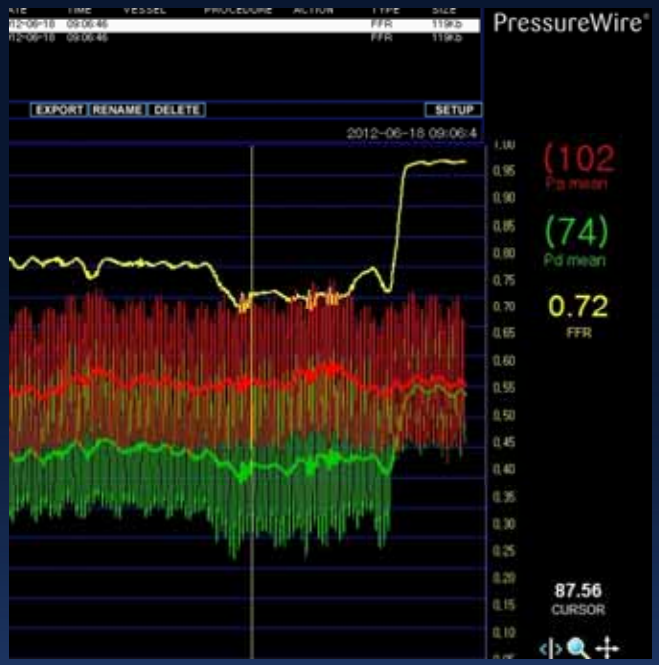
LM Bifurcation Lesion (Medina 1,0,0) with Minimal LCX Disease

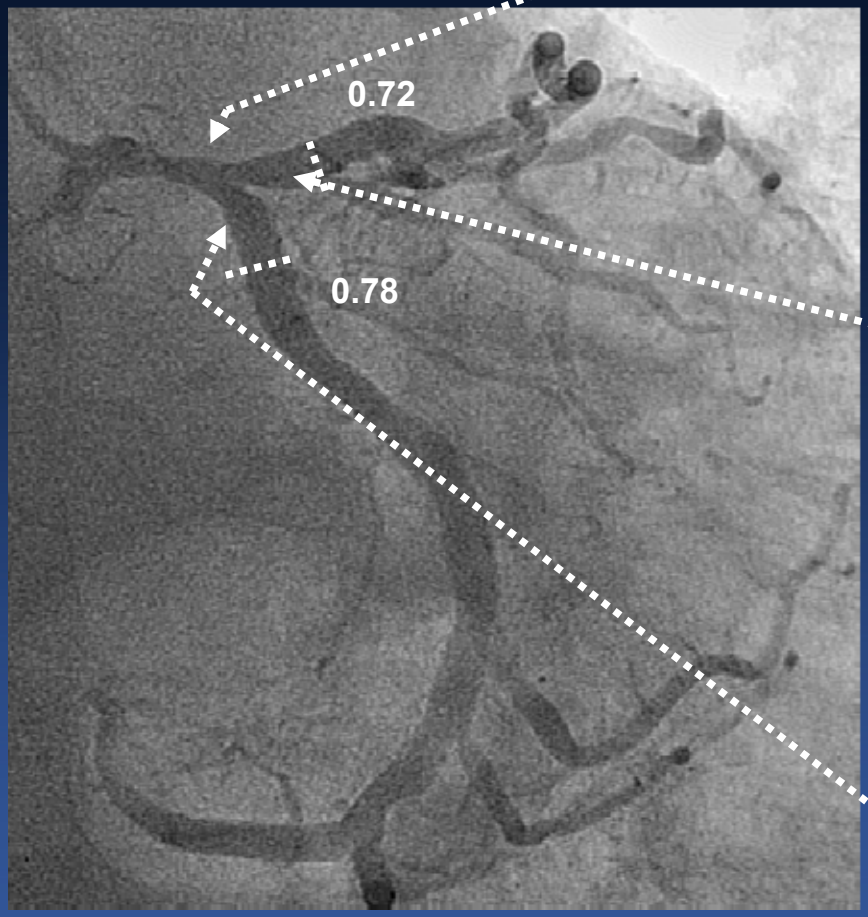
55/M, Stable angina,

FFR in Both LAD and LCX,



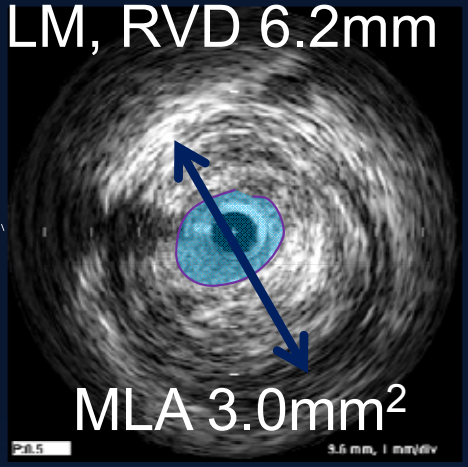
IVUS in Both LAD and LCX,

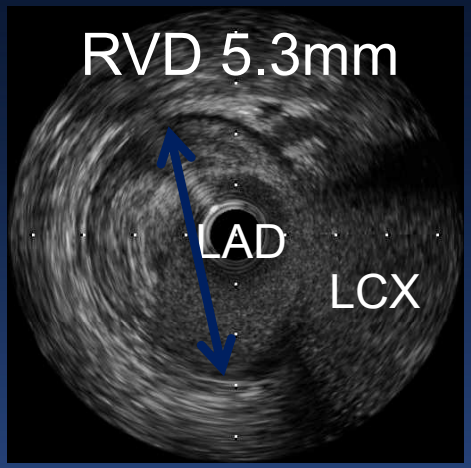


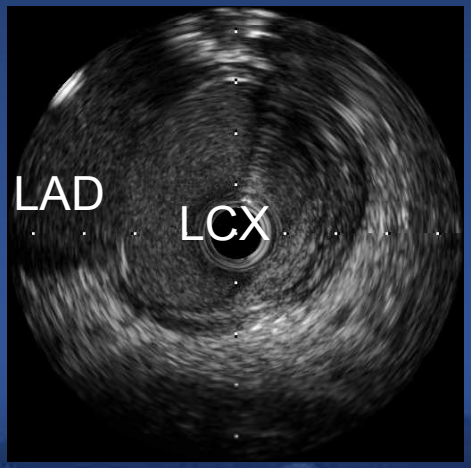


Minimal disease at LCX ostium

Distal LM, RVD 6.2mm

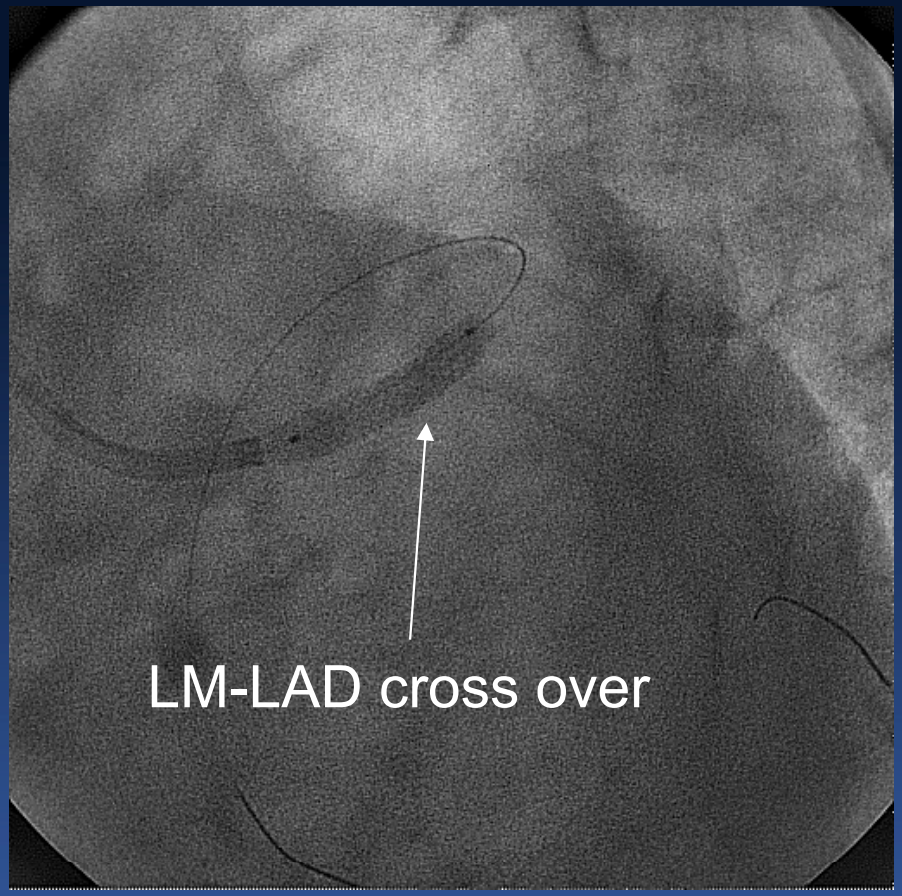




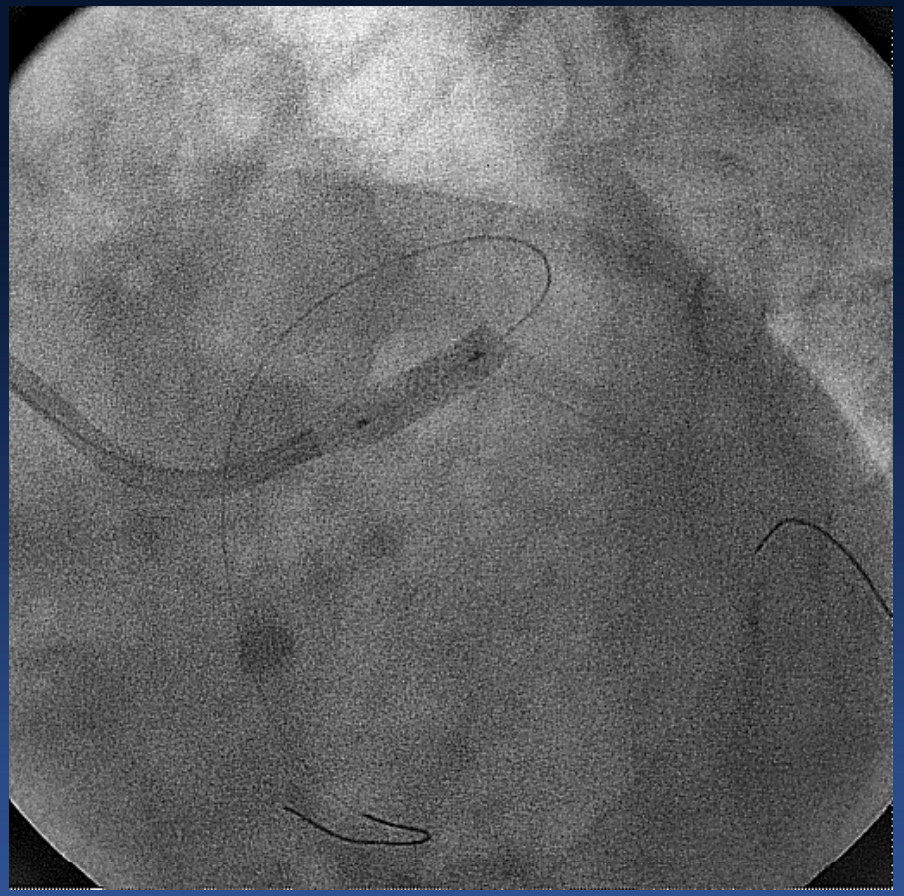


UNIVERSITY OF ULSAN COLLEGE MEDICINE
ASAN Medical Center

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

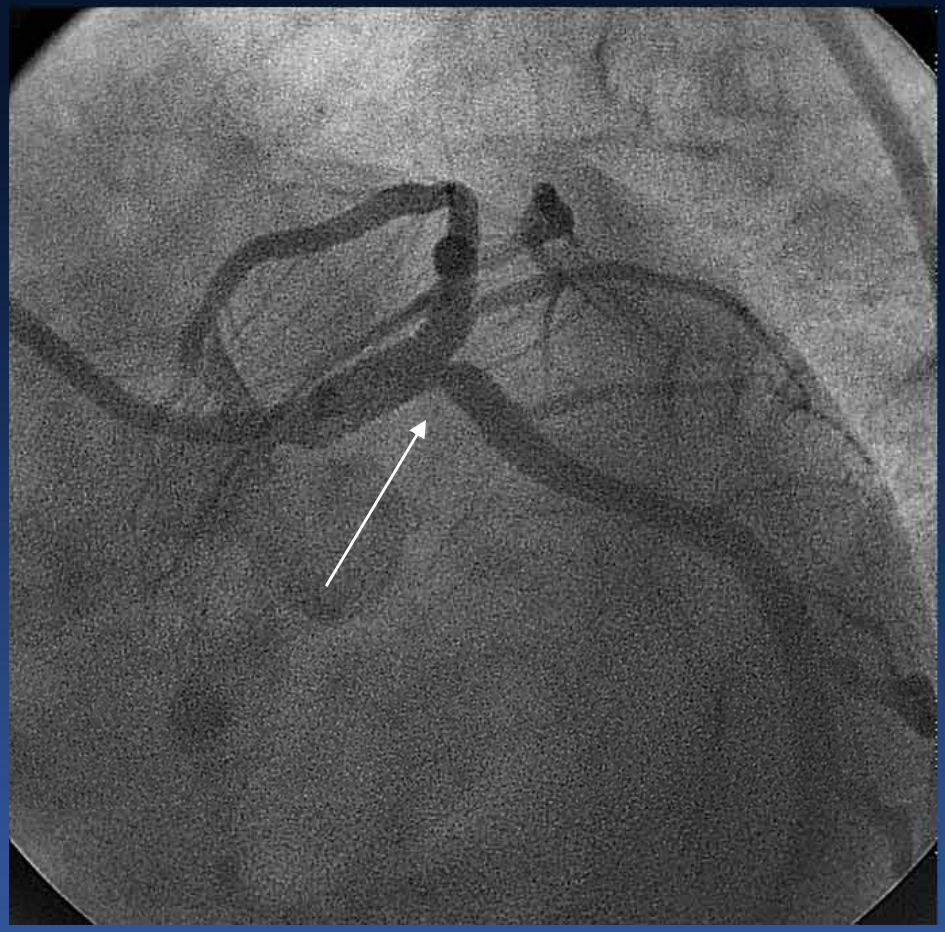


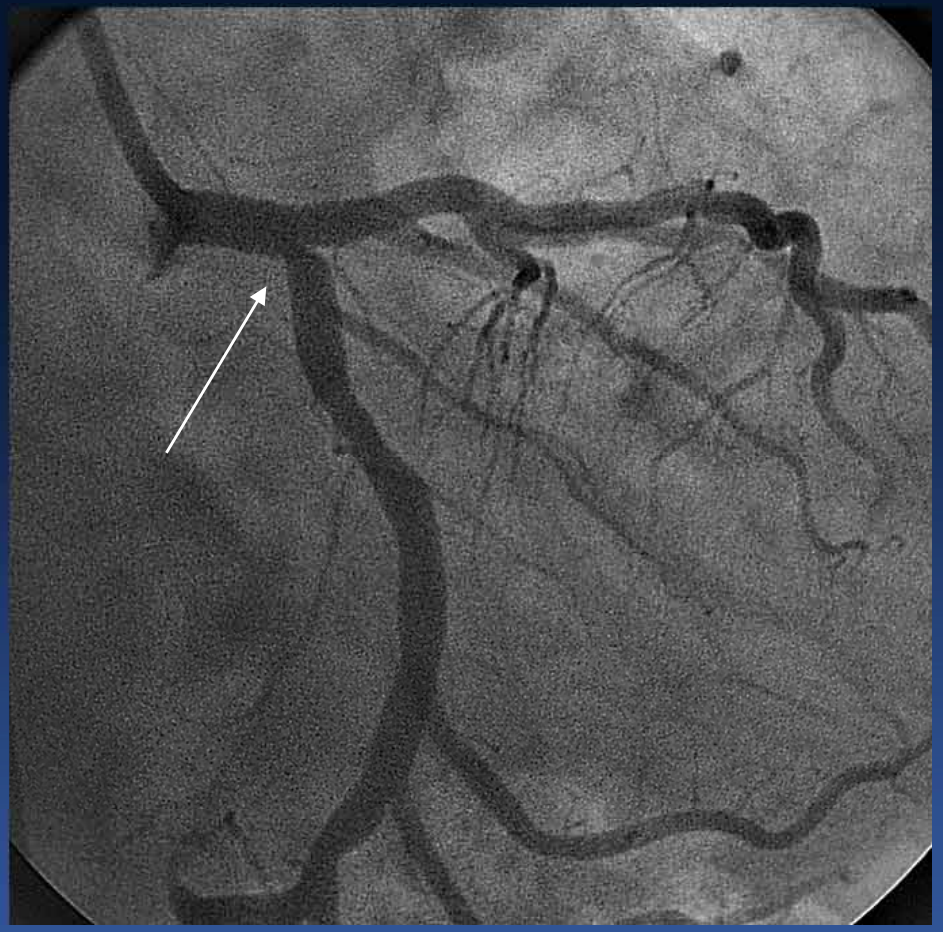
Promus Element
4.0x20



Additional high pressure
Inflation with 4.0 mm
non-compliant balloon

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





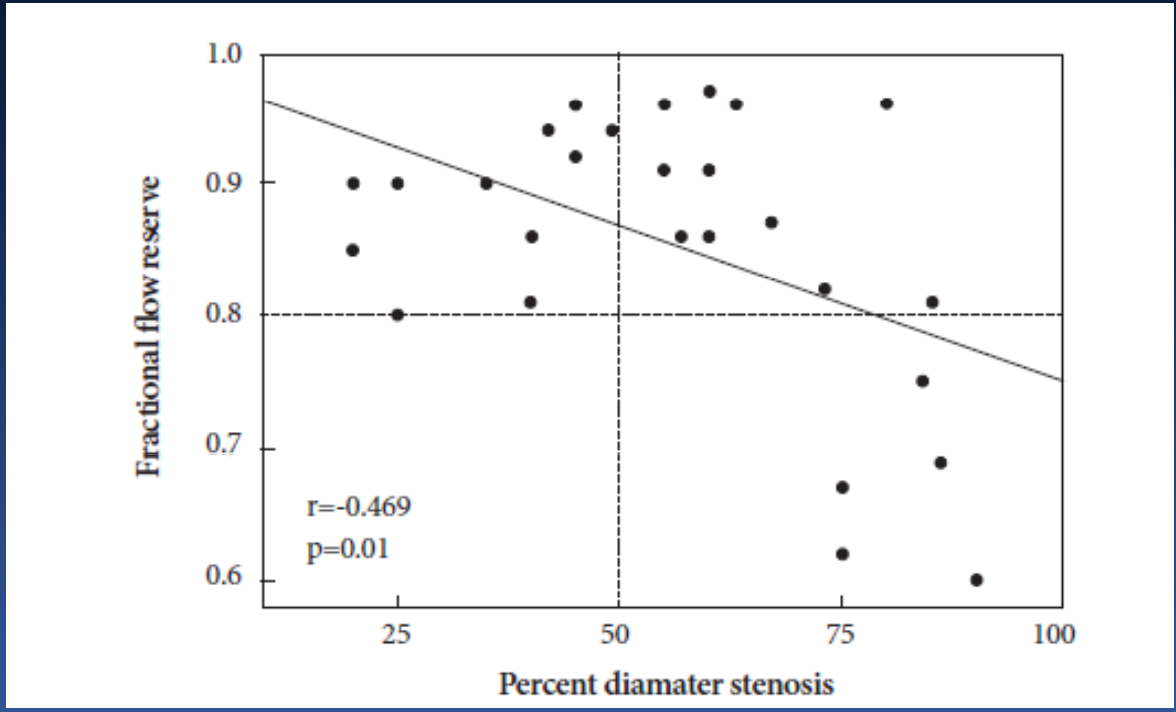
What Would You Do ?
To Treat or Not To Treat

Consider FFR, First !

FFR is 0.92

FFR post LM stenting (1)

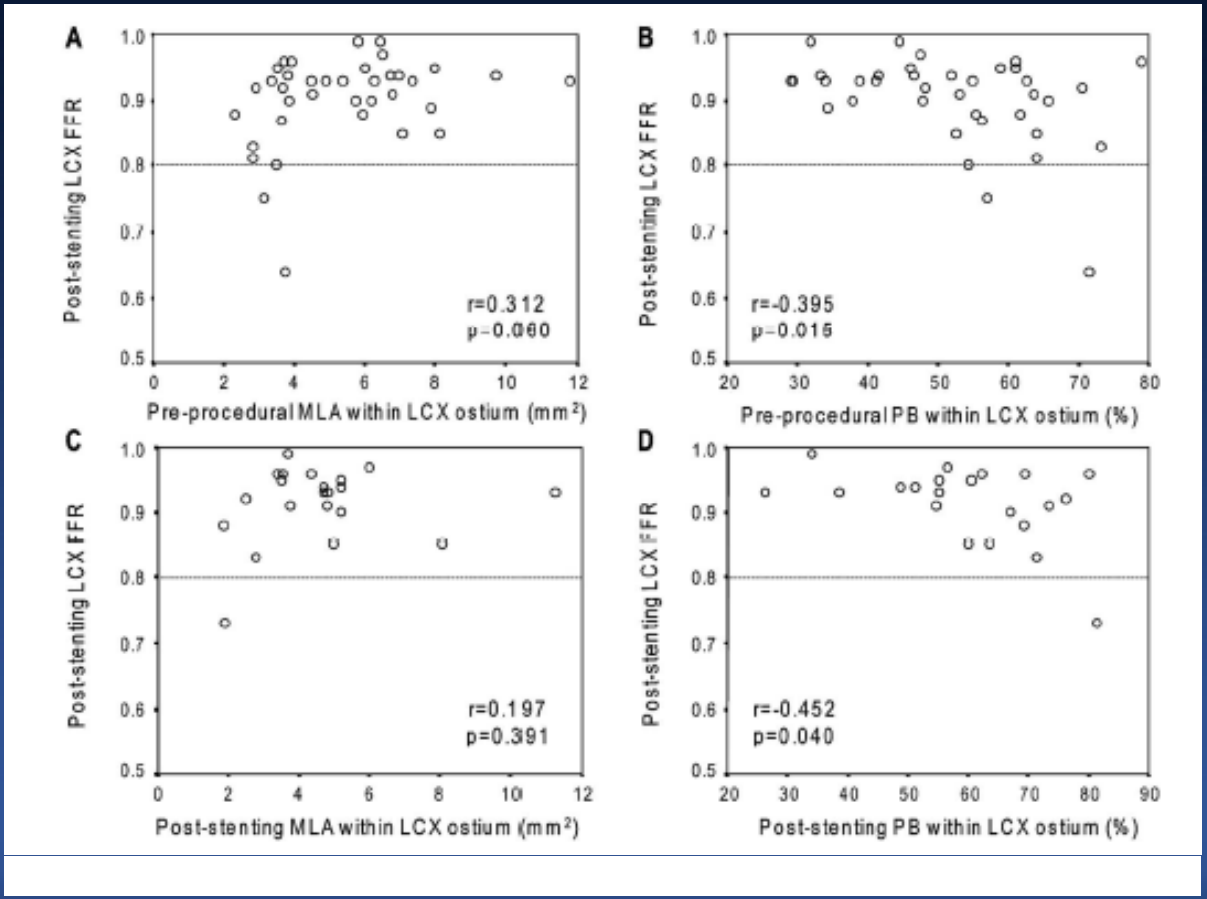
- **29 pts with LM lesion, PCI with 1 stent**
- Post PCI ostial LCx stenosis >50% in 17 (59%) of the cases
- Only 5 (29%) of them functionally significant



Nam et al, Korean Circ J 2011

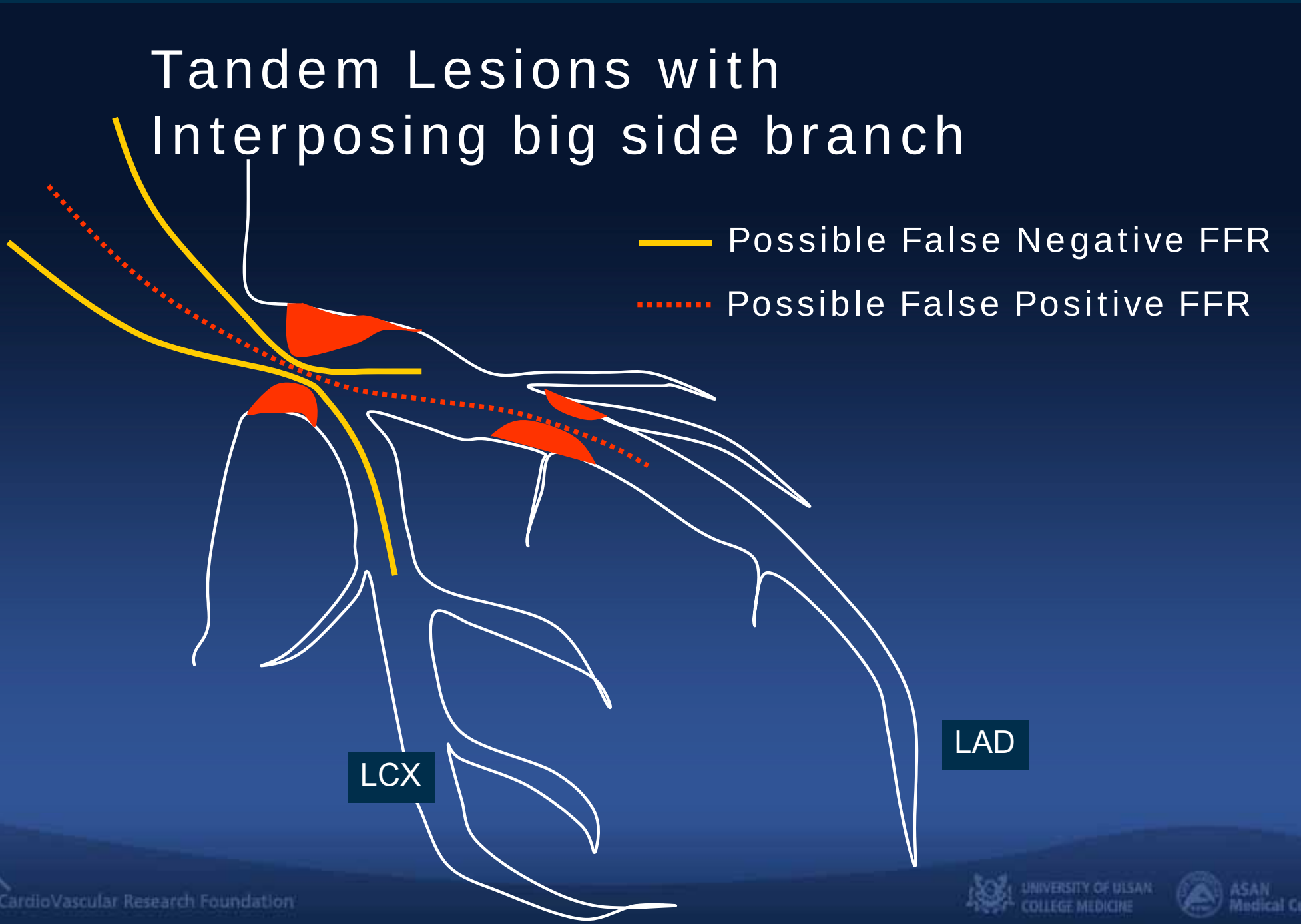
FFR post LM stenting (2)

- **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



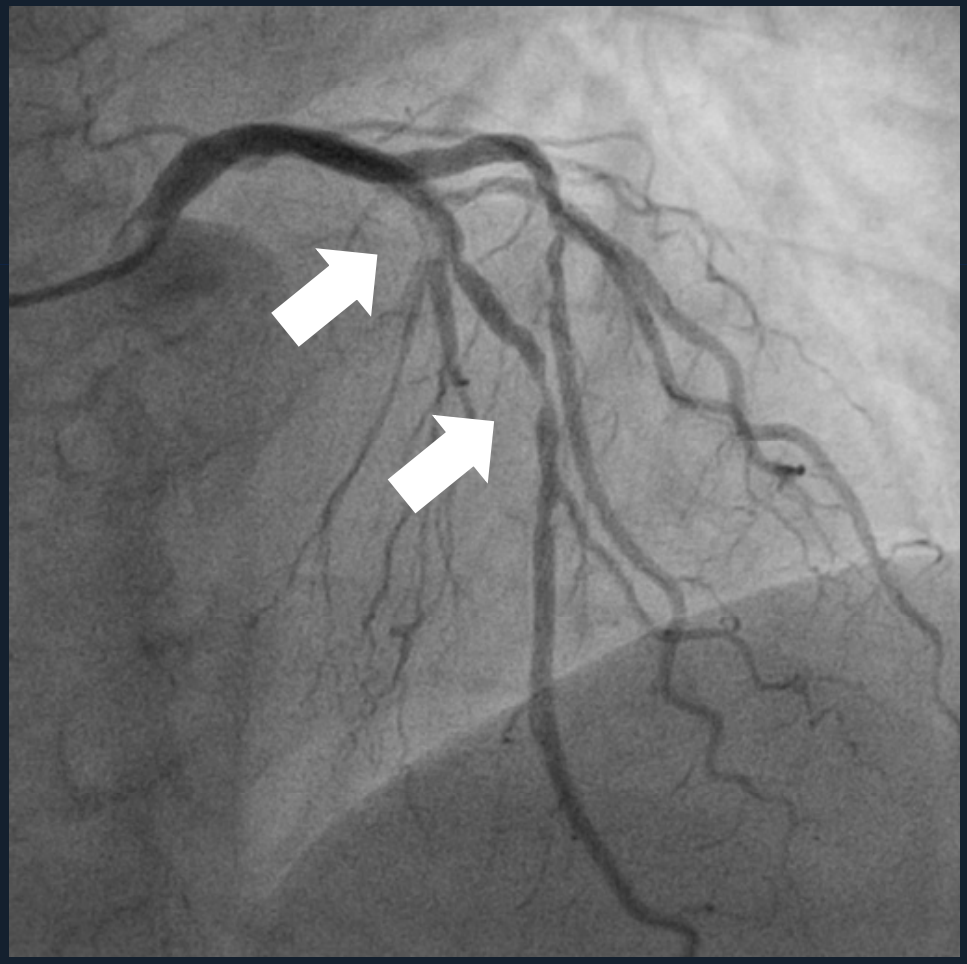
Kang et al. Catheter Cardiovasc Interv. 2013 Jun 13

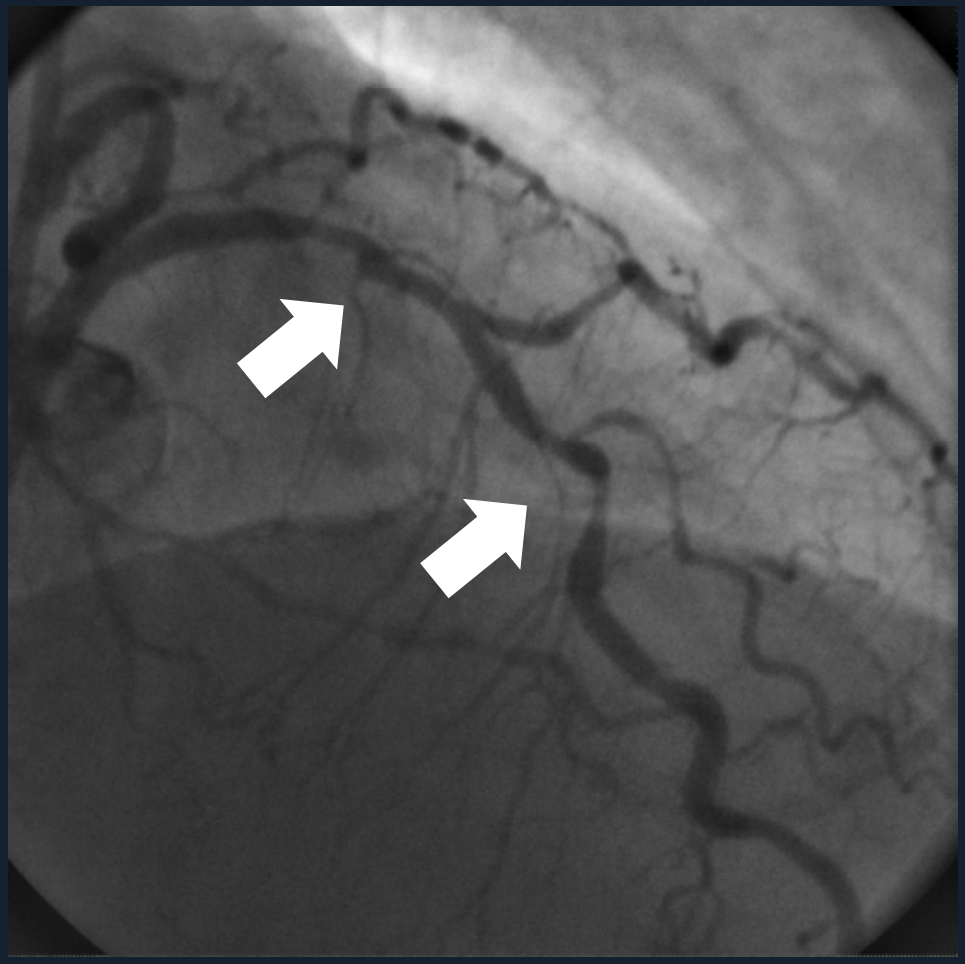
For LMCA stenosis with distal LAD/LCX stenosis



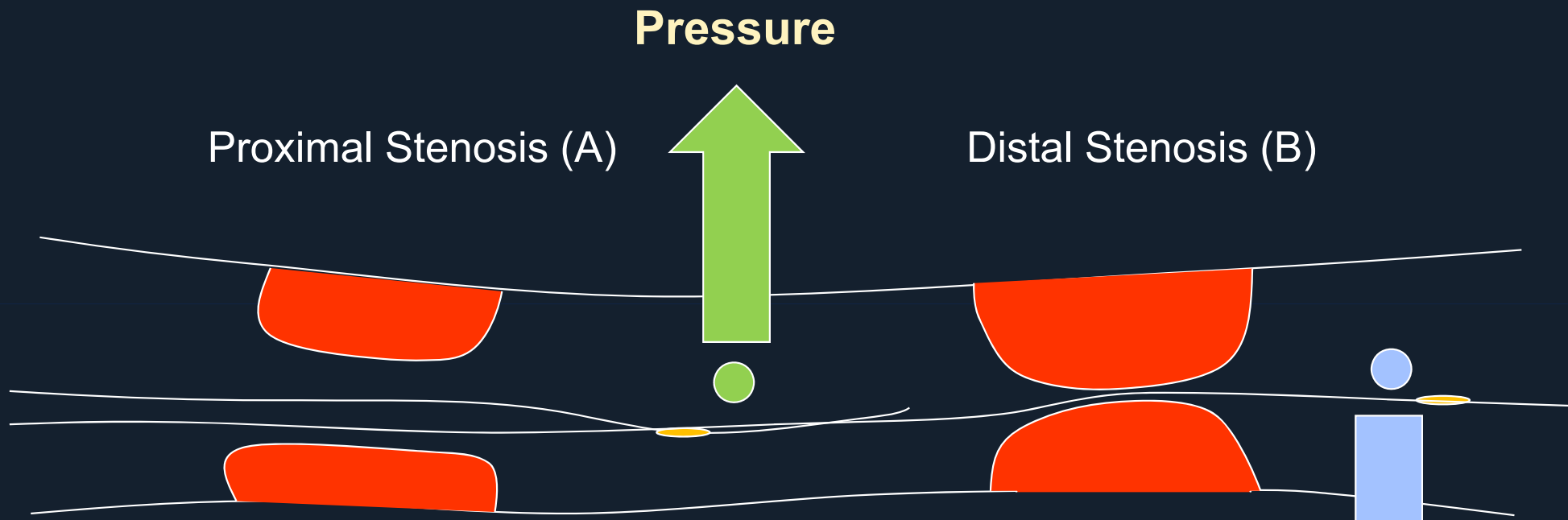
Coronary Tandem Lesions

Multiple stenoses in series along one coronary artery





Hemodynamic Interaction in Tandem Lesion



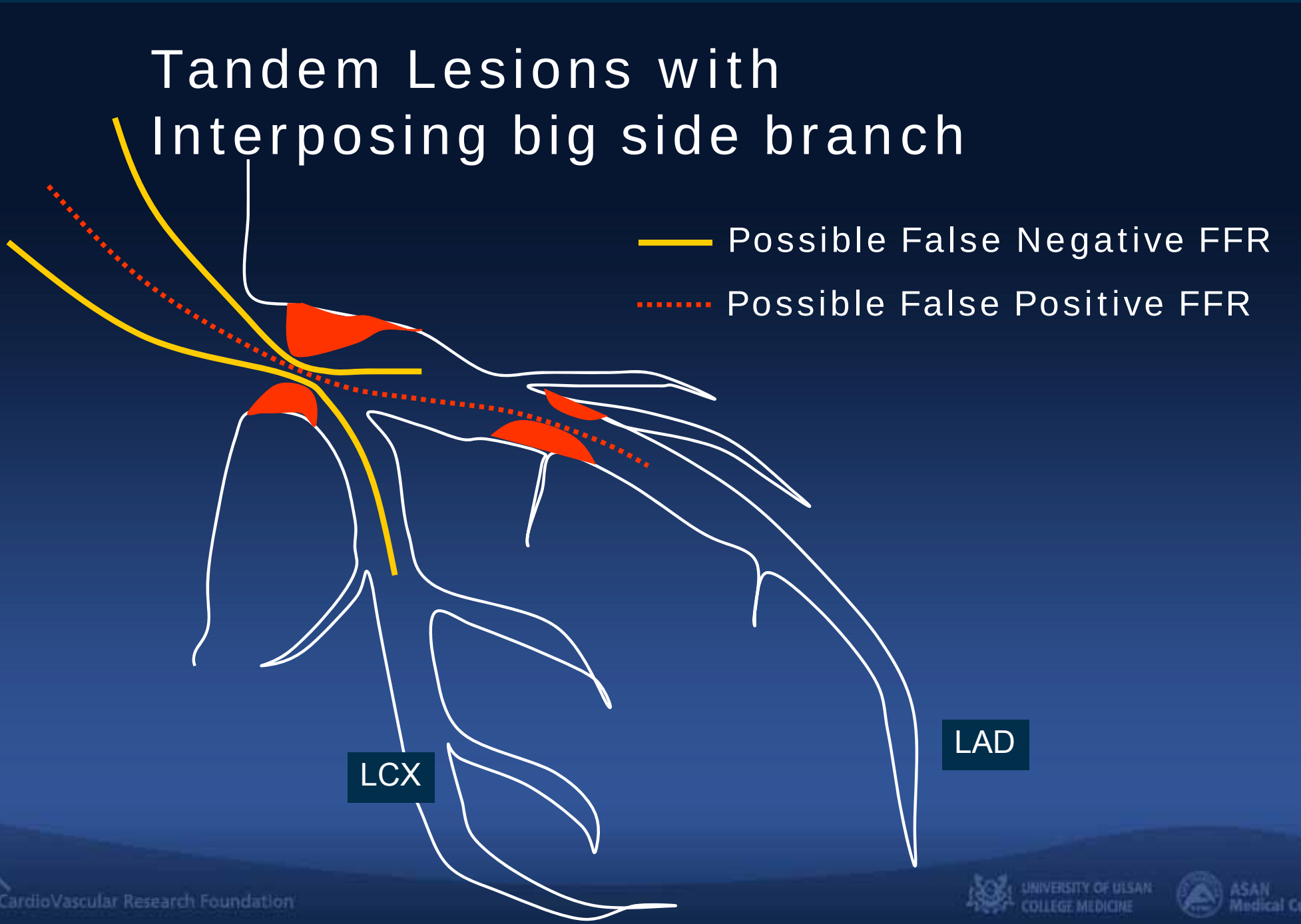
To measure FFR of Proximal Stenosis

$$FFR = \frac{Pd}{Pa}$$

Pressure

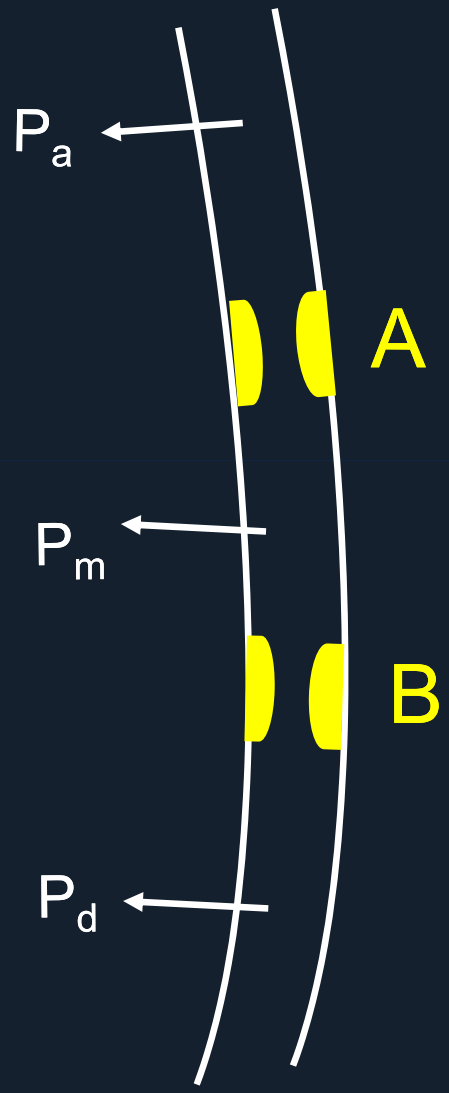
FFR value of proximal stenosis should be underestimated

For LMCA stenosis with distal LAD/LCX stenosis



Tandem Lesion

The Separate Functional Significance of Tandem Stenoses



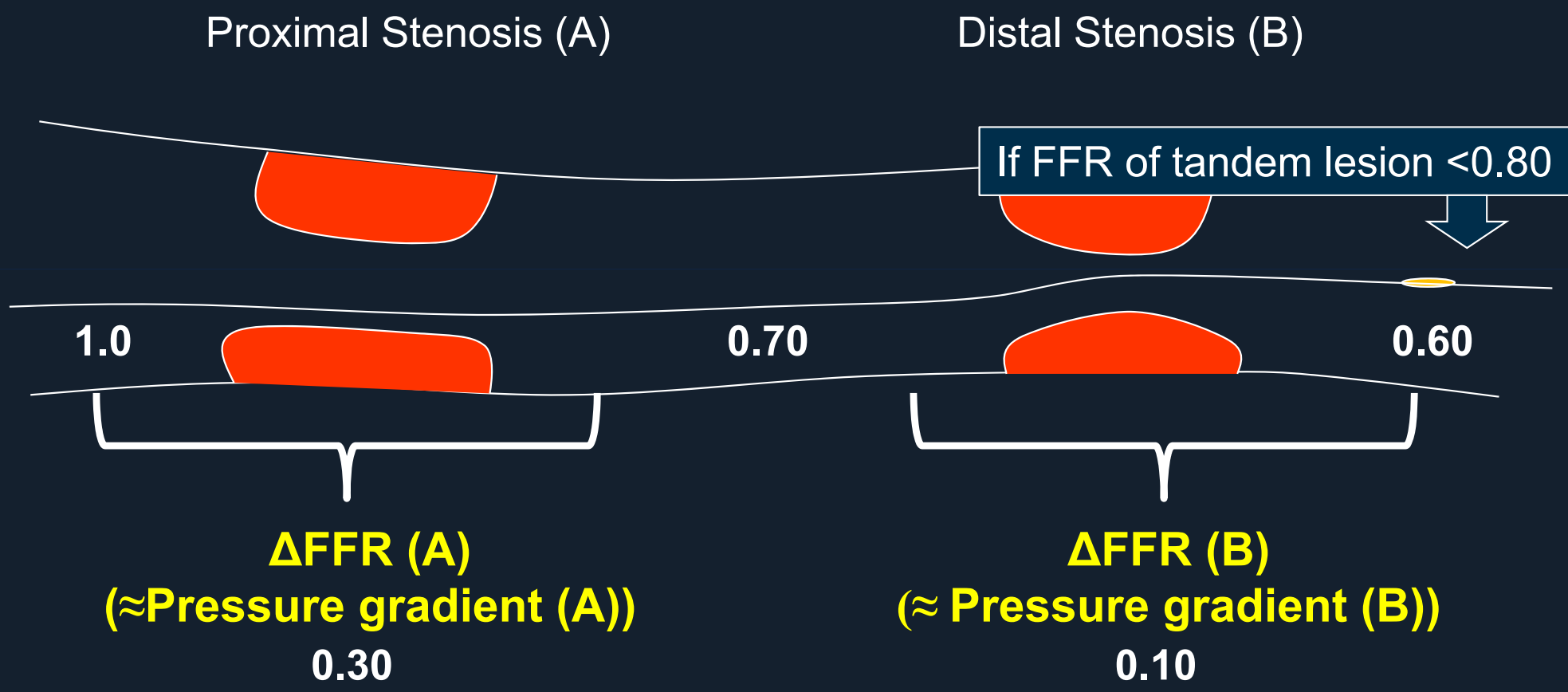
$$FFR(A)_{pred} = \frac{P_d - (P_m/P_a)\,P_w}{P_a - P_m + P_d - P_w}$$

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

P_w = Coronary occlusive pressure

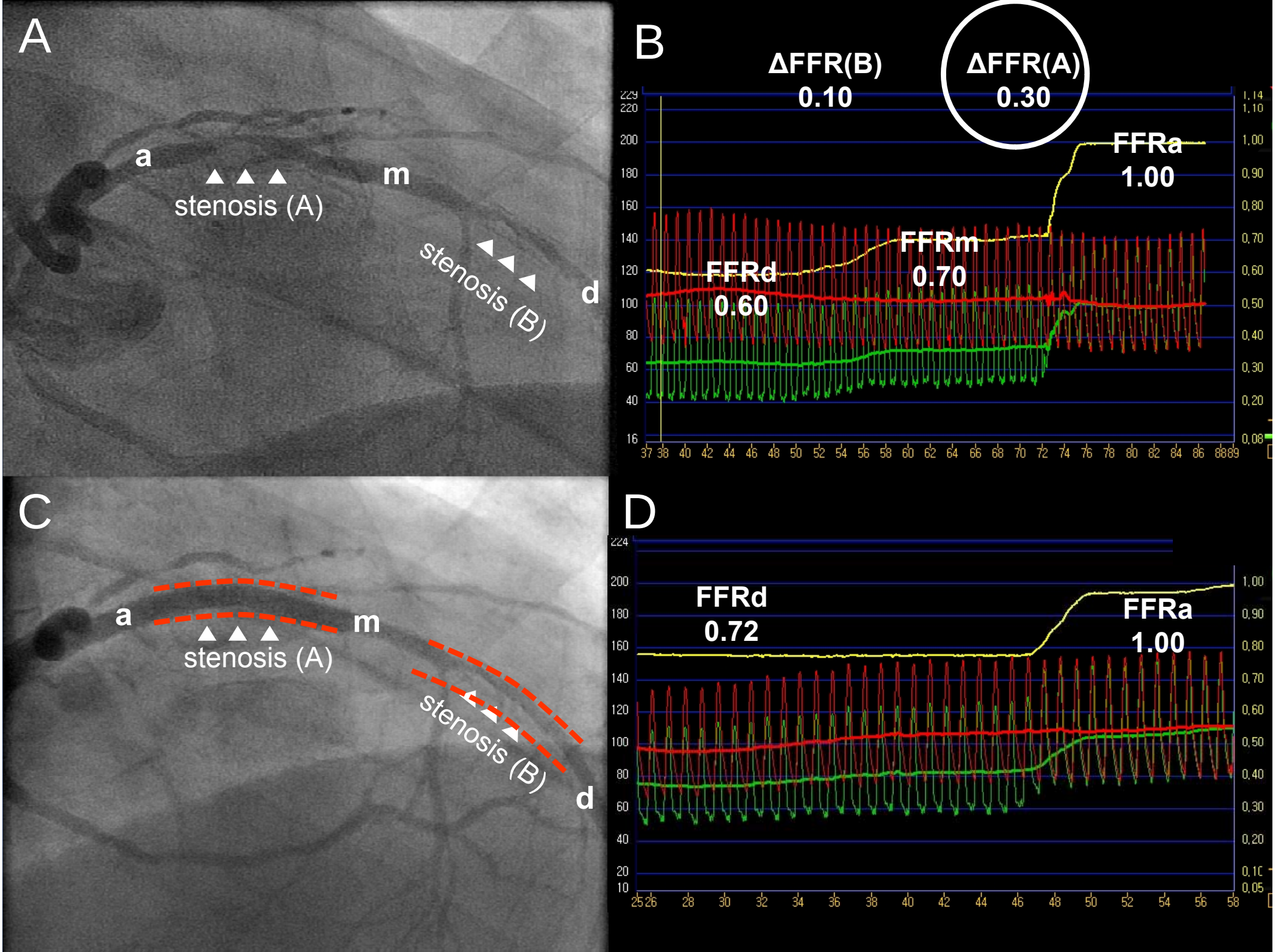
Nico H.J. Pijls and Bernard De Bruyne et al. Circulation 2000;102:2371-2377

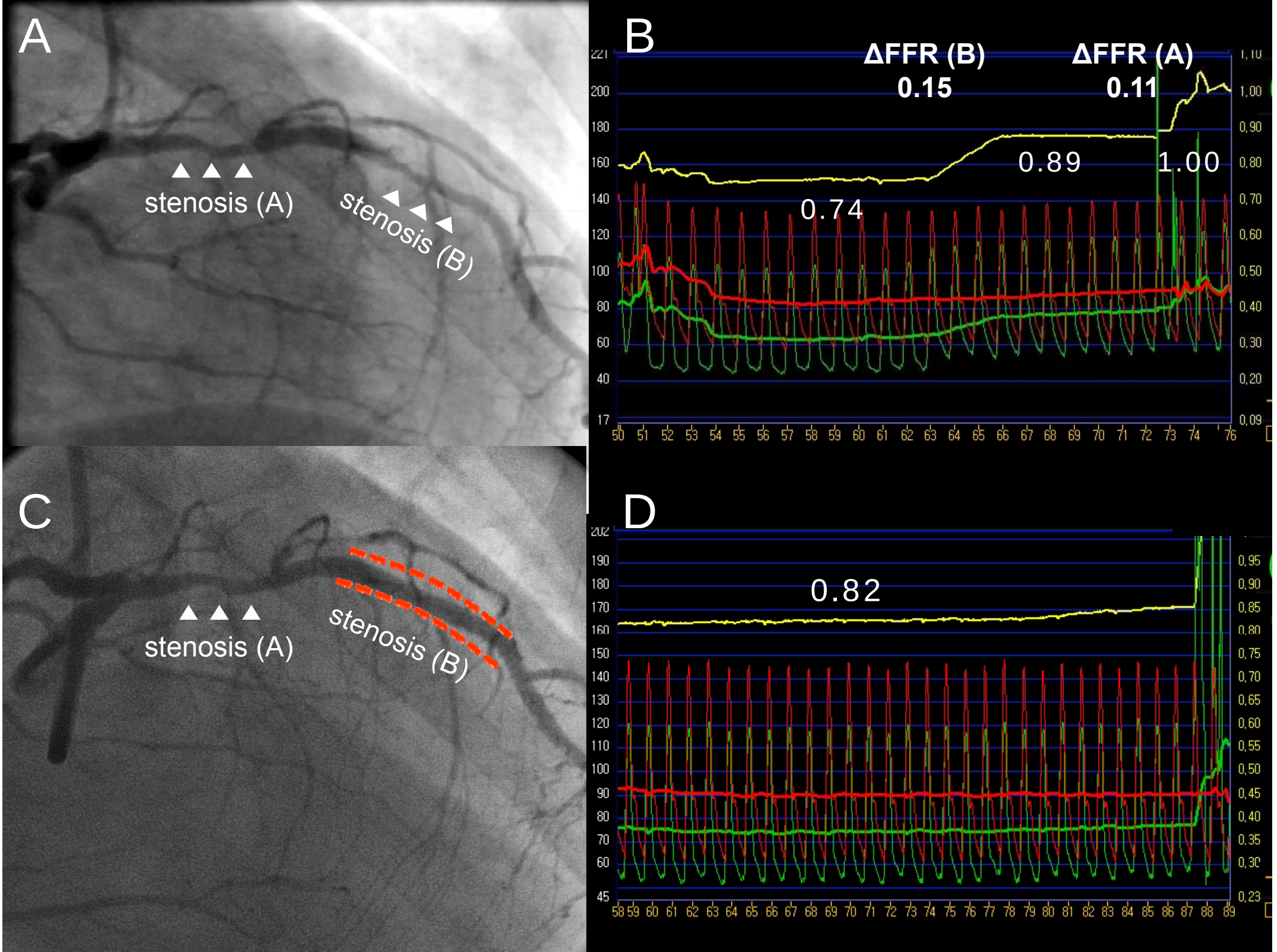
Practical Approach: Rule of Big Δ



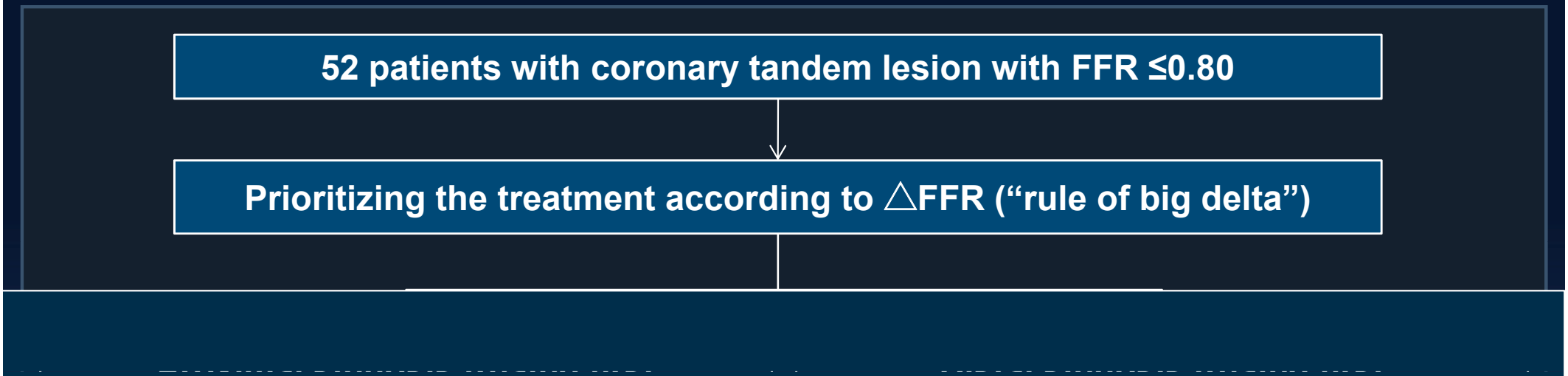
1. ΔFFR corresponds to relative functional severity
2. Performing revascularization first for lesions with more functional severity could increase the chance of deferring PCI for the remaining lesions.

Am J Cardiol. 2012 Dec 1;110(11):1578-84.


A
a
stenosis (A)
m
stenosis (B)
d
B
ΔFFR(B)
0.10
ΔFFR(A)
0.30
FFRa
1.00
FFRm
0.70
FFRd
0.60
C
a
stenosis (A)
m
stenosis (B)
d
D
FFRd
0.72
FFRa
1.00


A
stenosis (A)
stenosis (B)
B
ΔFFR (B)
0.15
ΔFFR (A)
0.11
0.89
1.00
0.74
C
stenosis (A)
stenosis (B)
D
0.82

According to the Rule of "Big Delta"

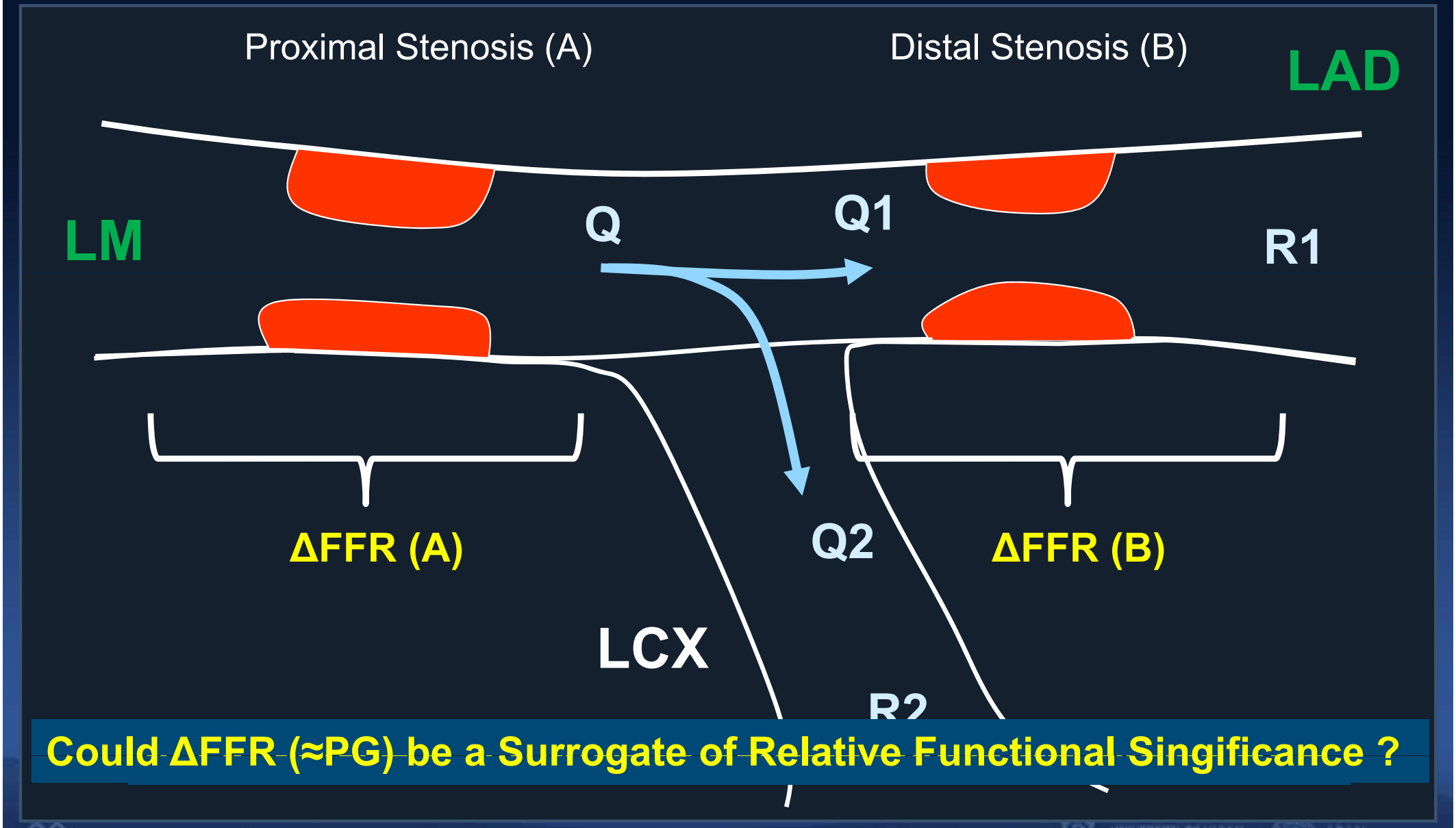


- 28 (53.8%) patients had only single-lesion Tx
- 28 (26.9%) lesions were deferred

Proximal stenosis treated only N=16	Both stenoses treated N=16	Distal stenosis treated only N=12	Both stenoses treated N=8

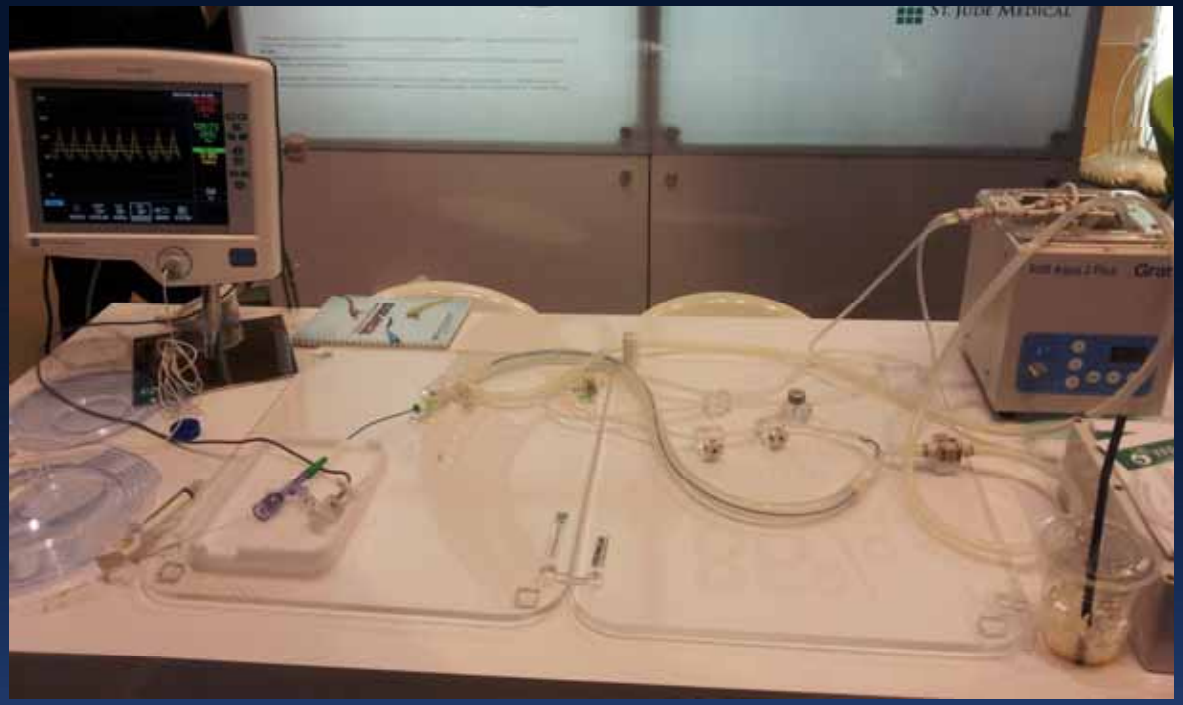
Am J Cardiol. 2012 Dec 1;110(11):1578-84.

Tandem Lesion with Interposing Side Branch like LM

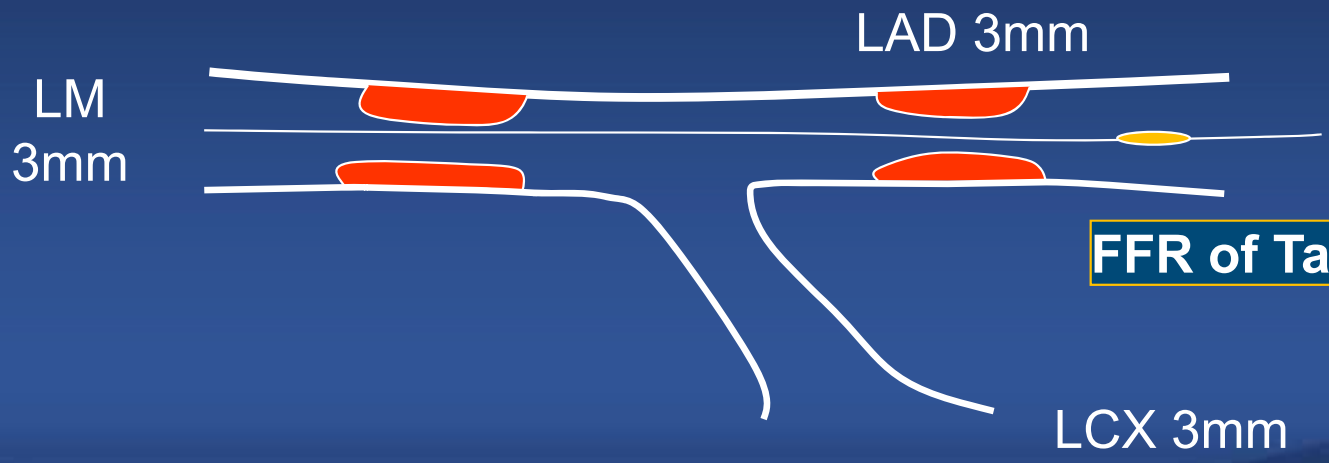


Could ΔFFR (≈PG) be a Surrogate of Relative Functional Singificance ?

In Vitro Simulation

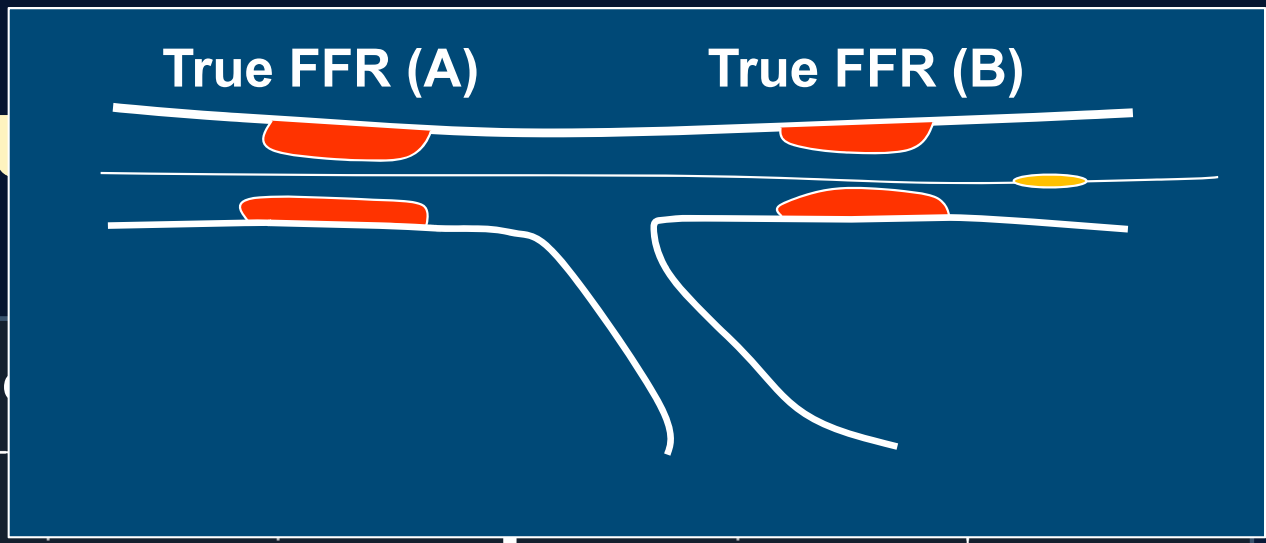


Assumption

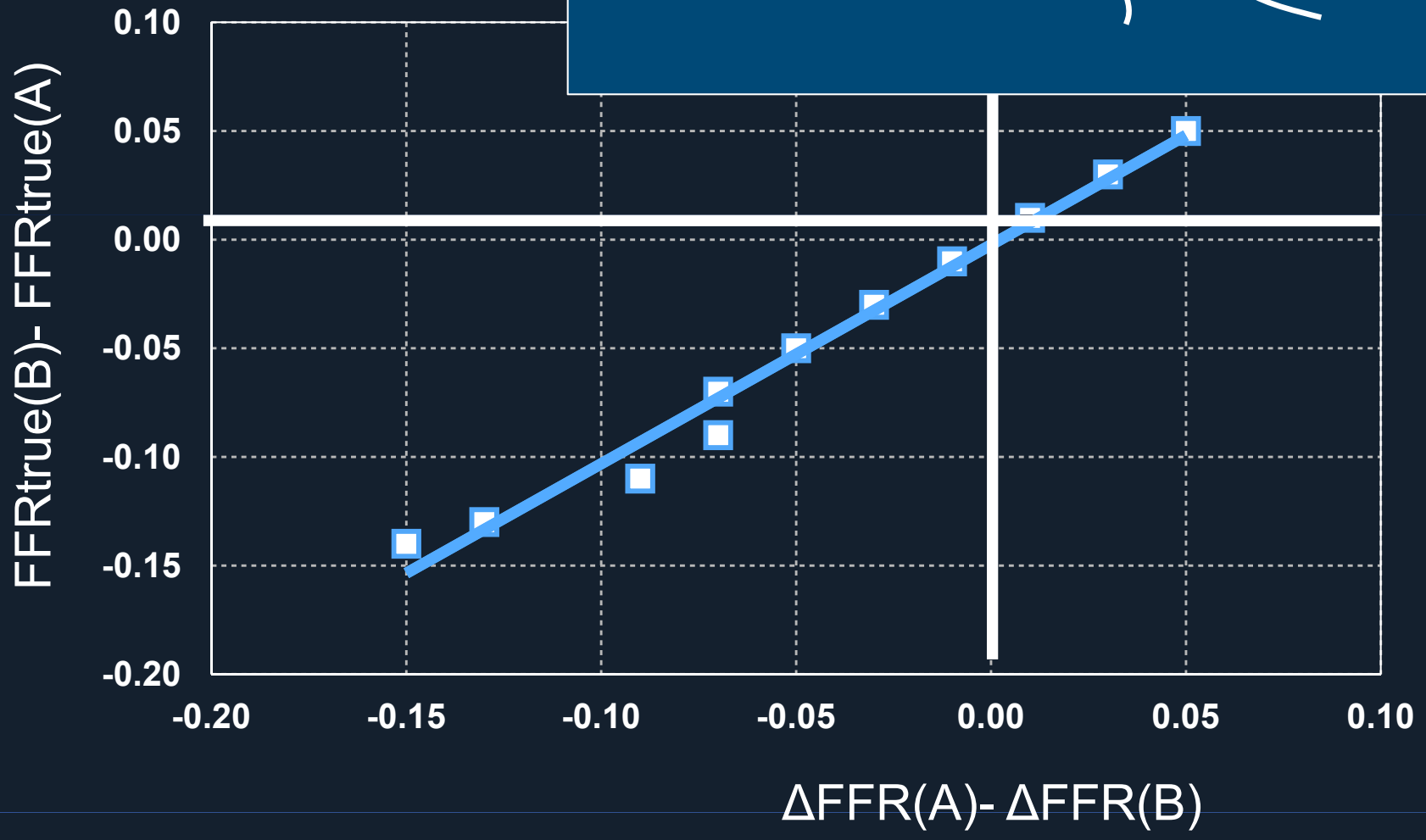


FFR of Tandem Lesions

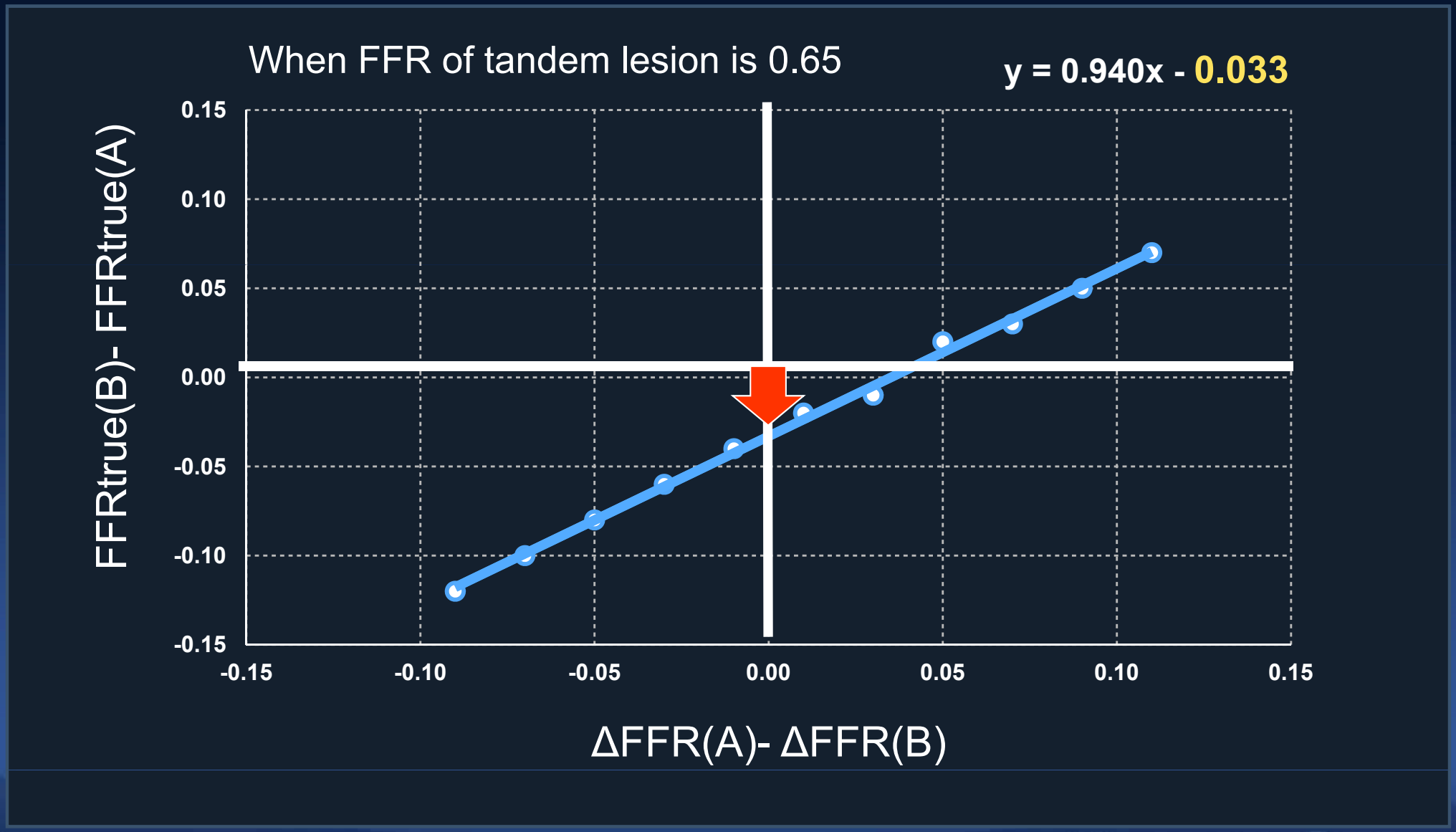
Witho



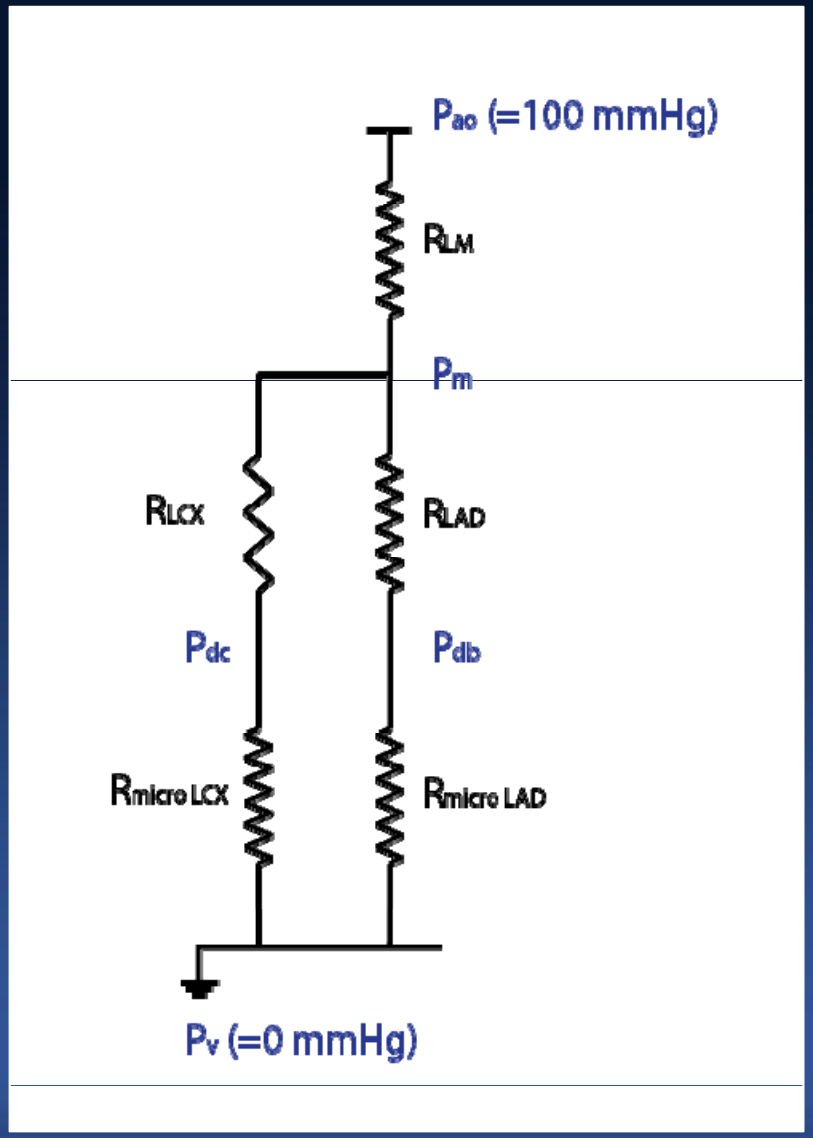
When FFR of tan



With Side Branch

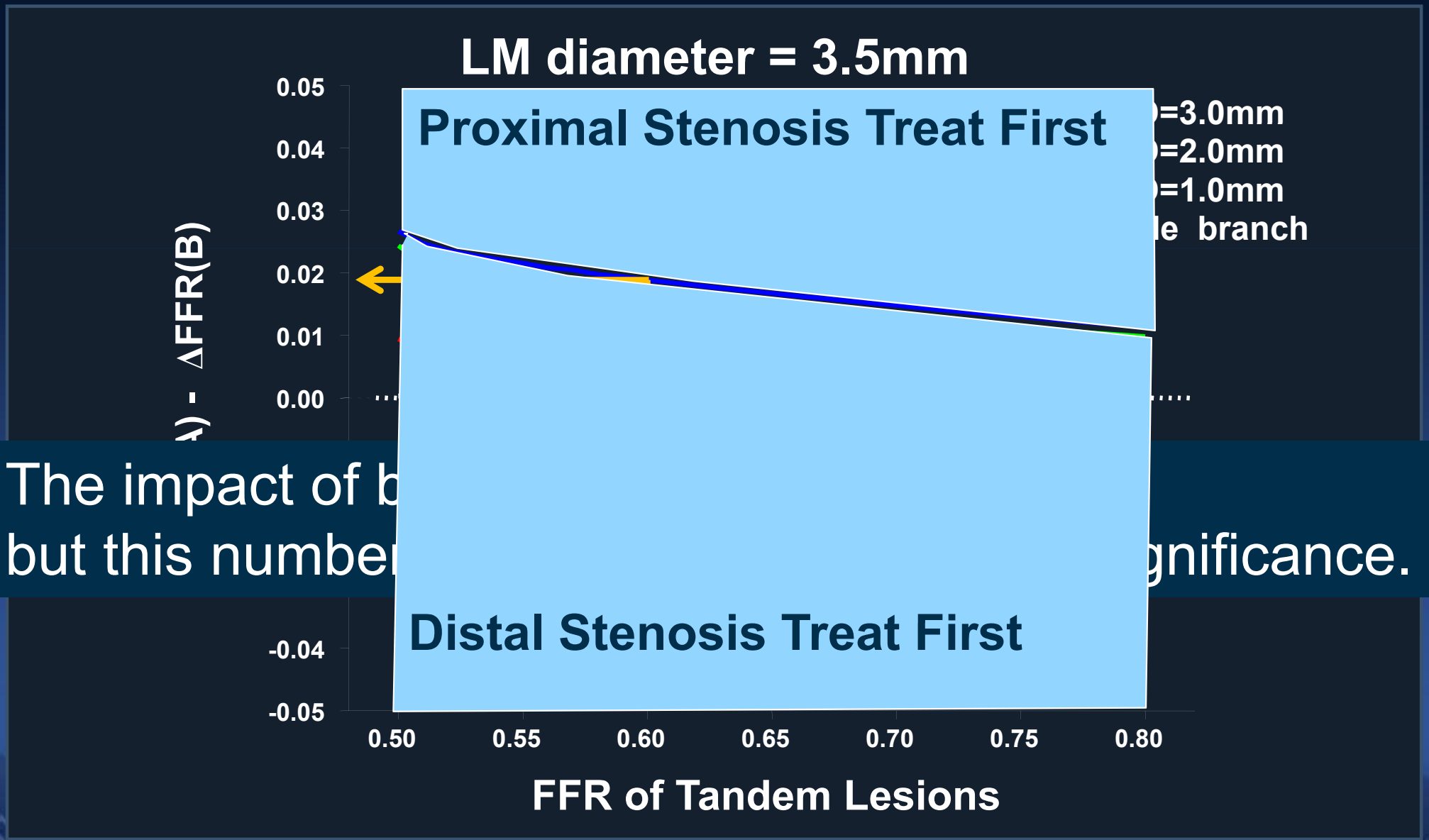


Simulation Study



When Two lesions are functionally equal,

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



The impact of b
but this numbe
gnificance.

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, ΔFFR may be useful index for prioritizing the treatment sequence and optimizing stent outcome with or without interposing side branches.