

Clinical Application of Integrated Use of FFR and IVUS

Left Main PCI

Jung-Min Ahn

Heart Institute, Asan Medical Center

Why We Need FFR in LM Disease?

- Inaccuracy of Coronary Angiography
- Lack or Low Spatial Resolution of Non-Invasive Functional Study
- FFR guided PCI in LMCA Also 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 Drug-Eluting Stents or Coronary Artery Bypass Grafting

Journal of the American College of Cardiology
© 2008 by the American College of Cardiology Foundation
Published by Elsevier Inc.

Vol. 51, No. 5, 2008
ISSN 0735-1097/08/\$34.00
doi:10.1016/j.jacc.2007.09.054

Acute Effects of Unprotected Left Main Coronary Artery Stenosis in Coronary Artery Disease

Journal of the American College of Cardiology
© 2011 by the American College of Cardiology Foundation
Published by Elsevier Inc.

Vol. 57, No. 5, 2011
ISSN 0735-1097/\$36.00
doi:10.1016/j.jacc.2010.09.038

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

Pawel B. Gierula, MD, PhD,† Ewa Pelech, MD, PhD,† Bozena Kozlowska, MD, PhD,† Krzysztof Jan Szymanski, MD, PhD,† Katowice, Poland

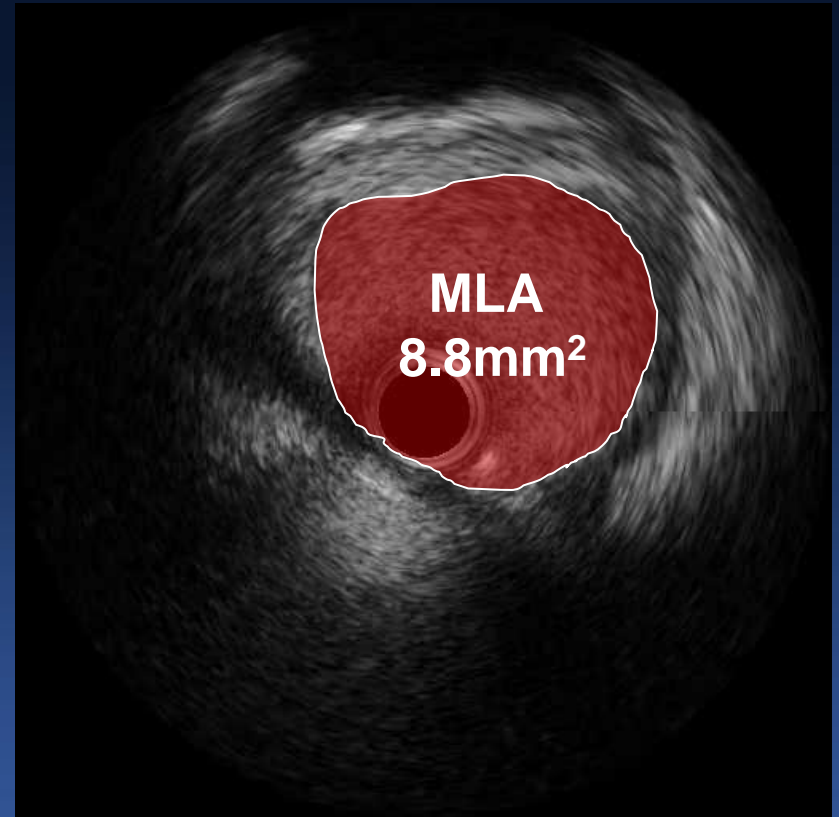
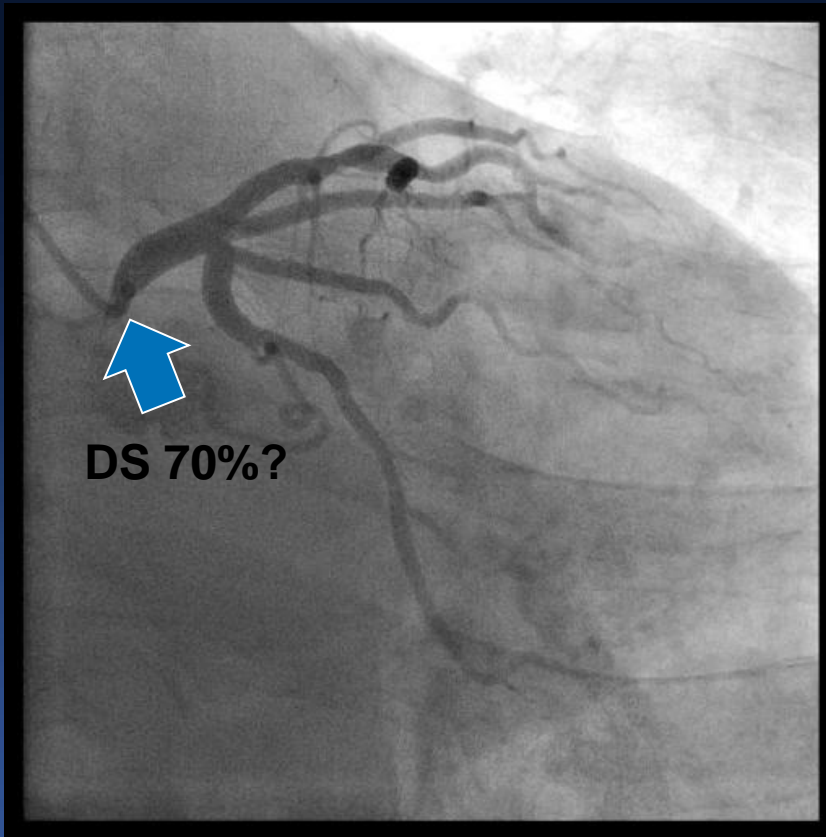
Enno Boudriot, MD,* Holger Thiele, MD,* Thomas Walther, MD,† Christoph Liebetrau, MD,* Peter Bode, MD,† Tobias Reichlin, MD,† Peter Birkhofer, MD,† Harald M. Lüscher, MD,†

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

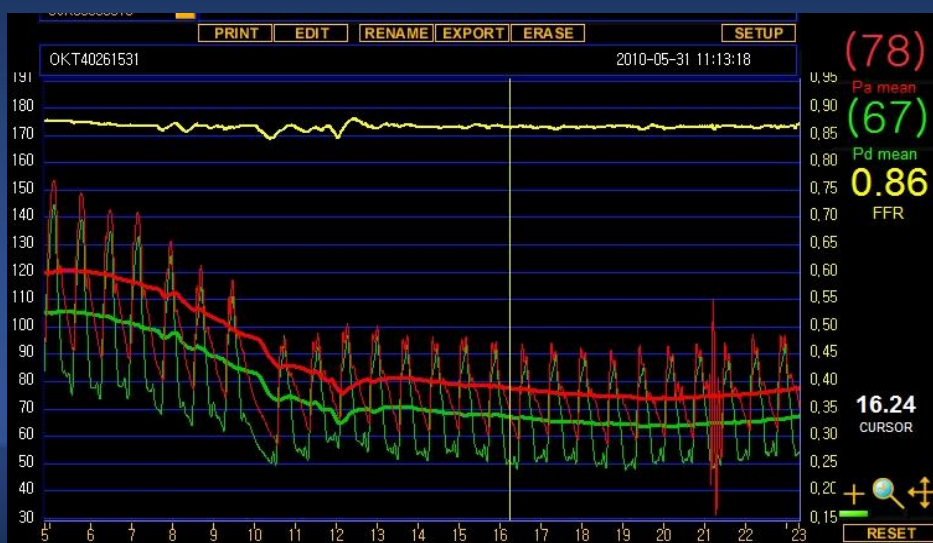
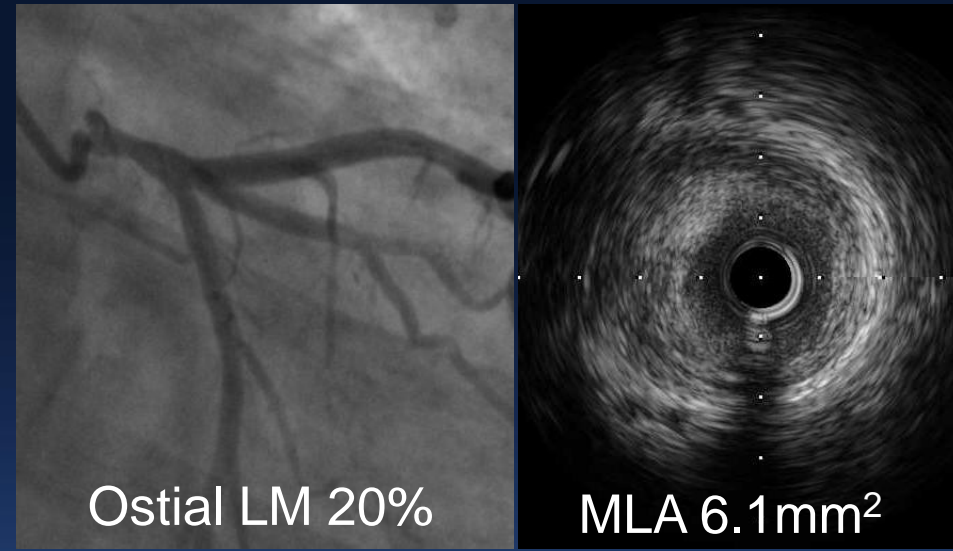
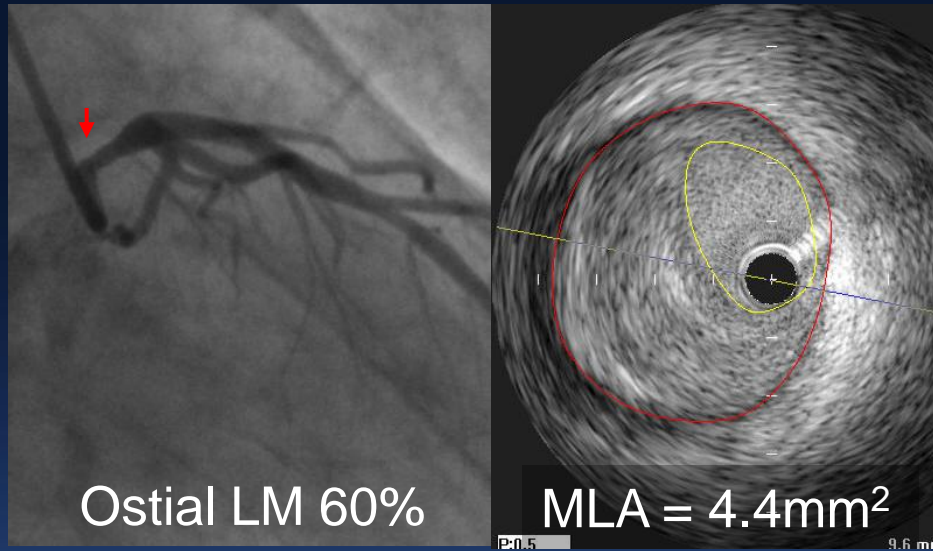
Why We Need FFR?



Why We Need FFR in LM?

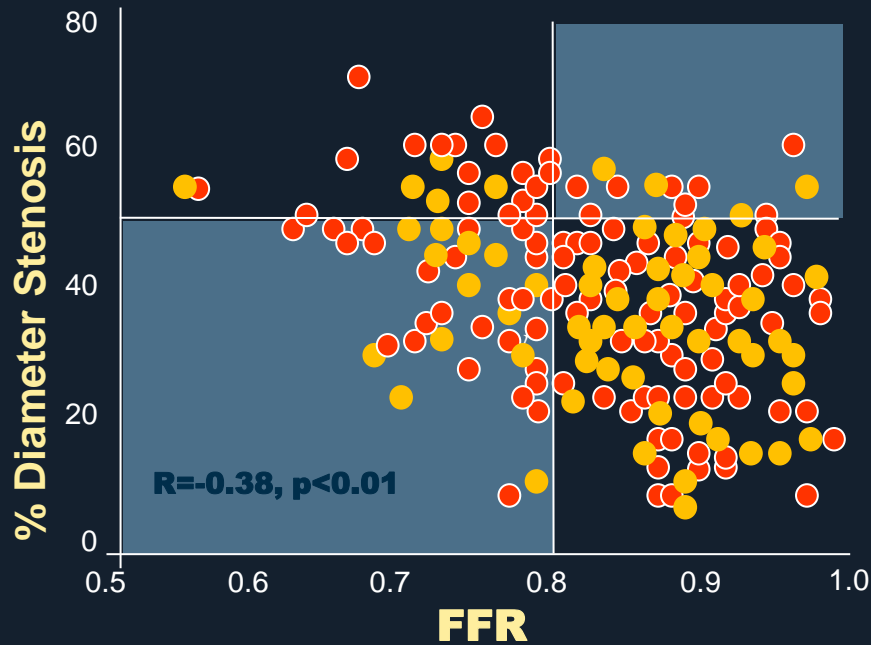
47/M Stable angina

50/M Stable angina



FFR and %DS in Equivocal LMCA

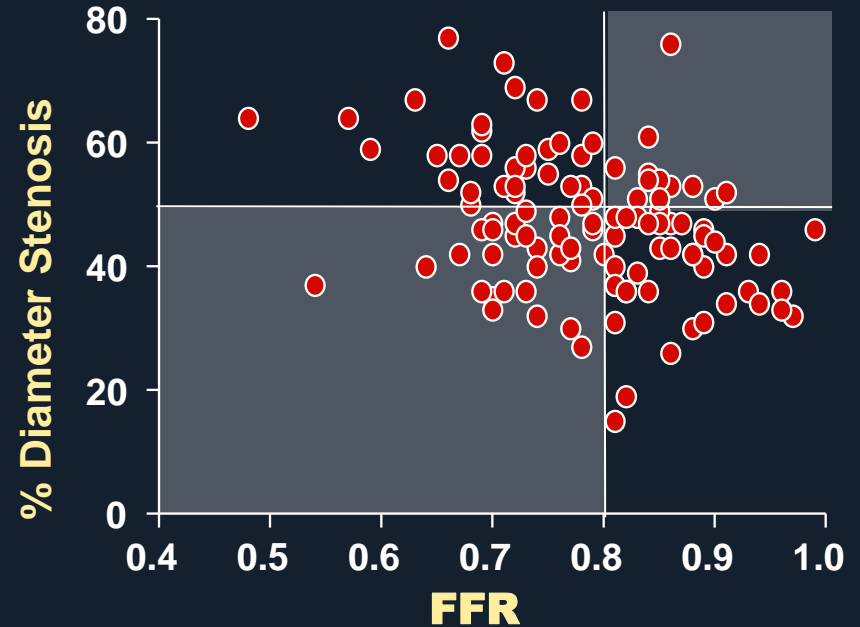
“Mismatch” is **29%** in equivocal LMCA



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

● Isolated LMCA disease

“Mismatch” is **37%** in equivocal LMCA



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

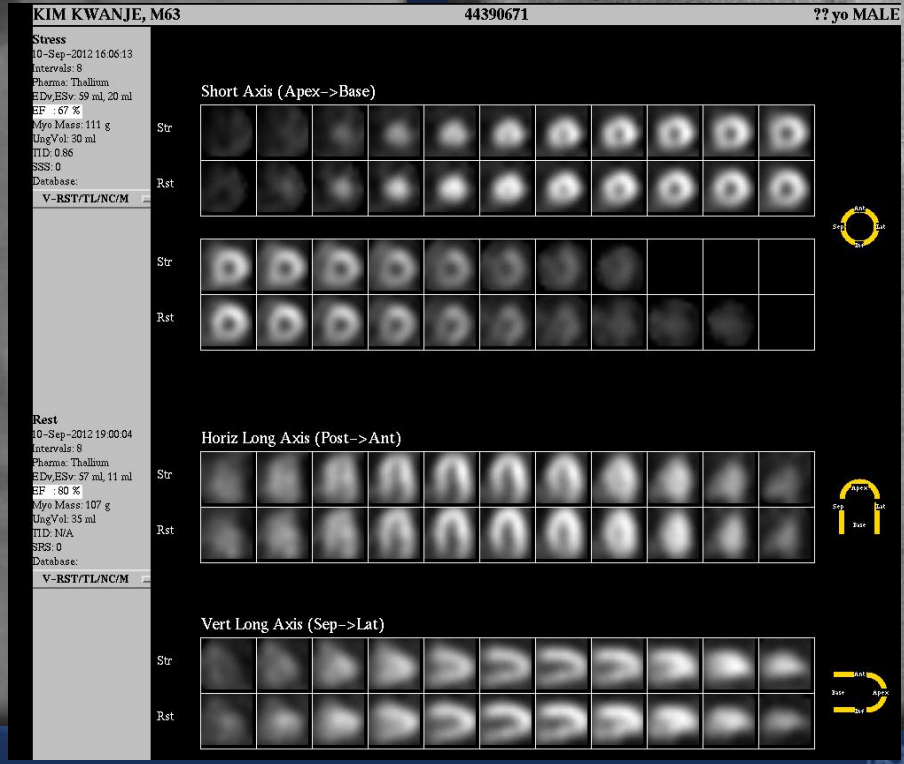
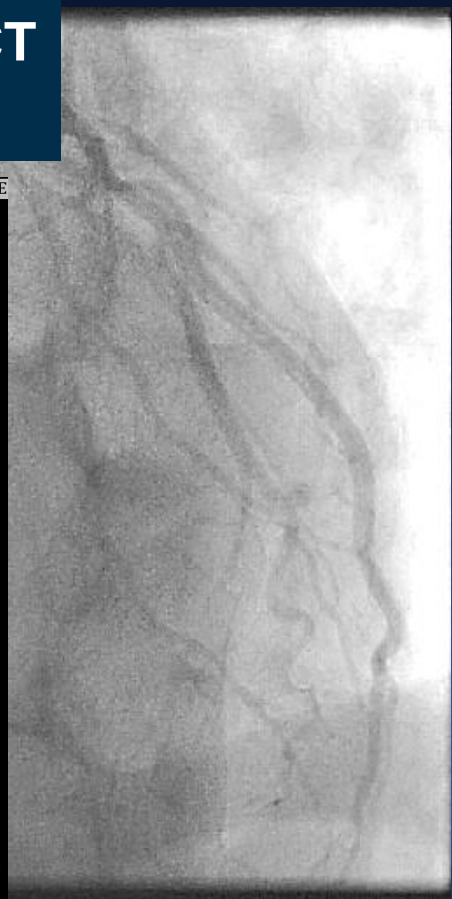
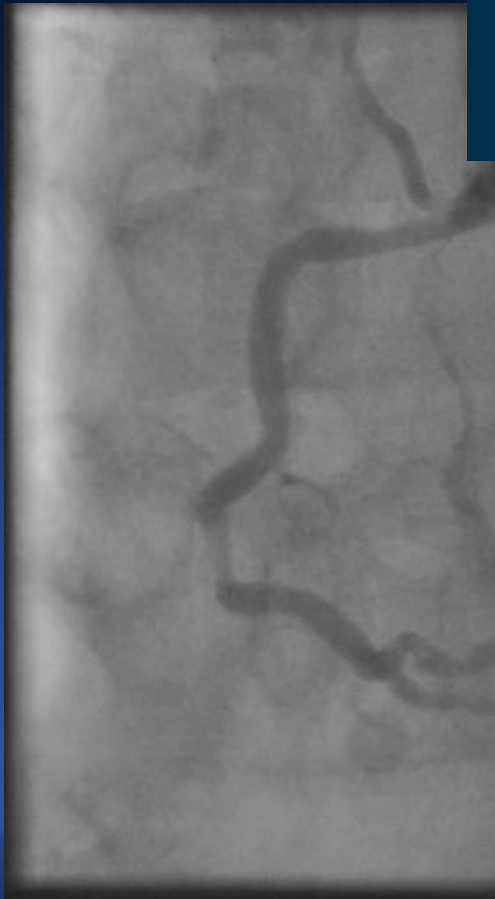
LM with 3VD

65yrs/M, eCP

RCA

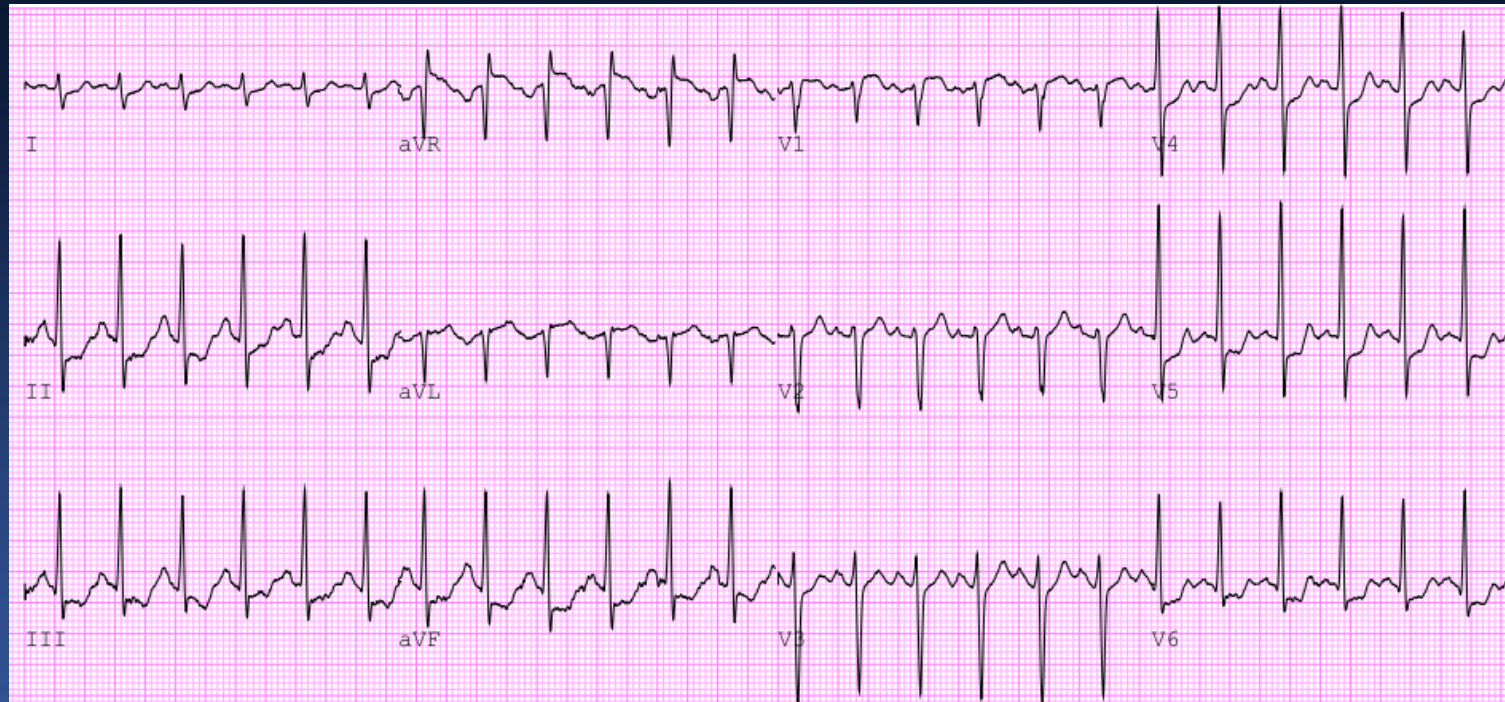
LCA

Normal Perfusion in Thallium SPECT
Balanced Ischemia?



M/76, eCP

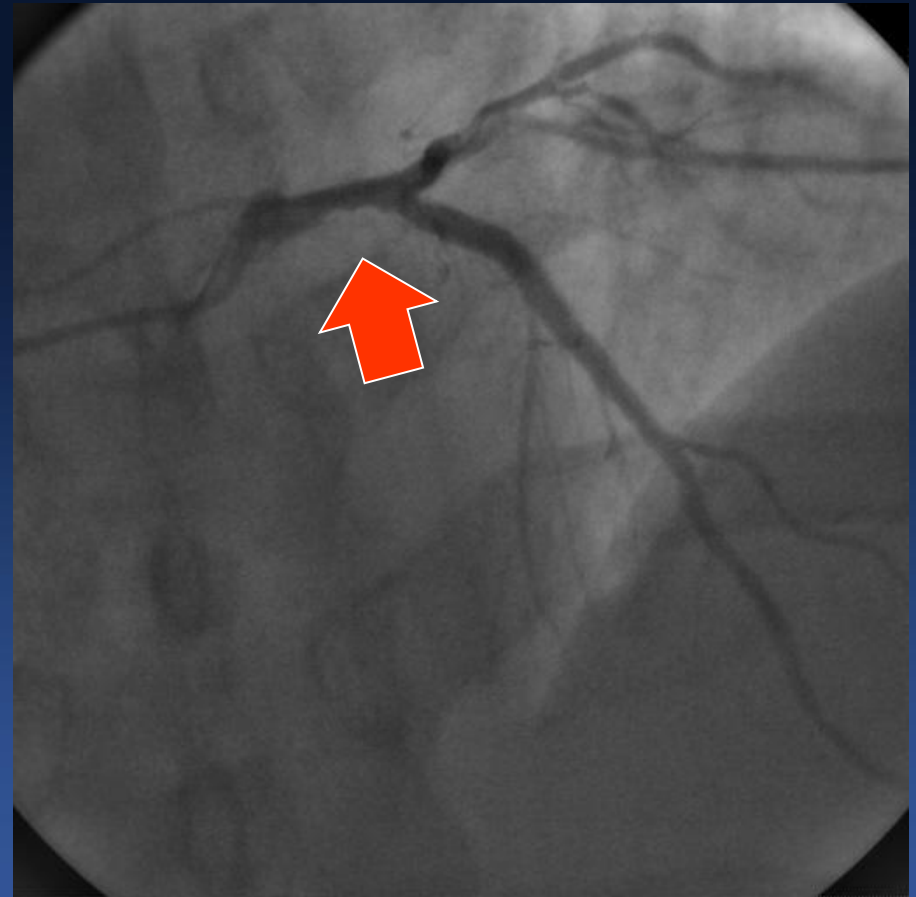
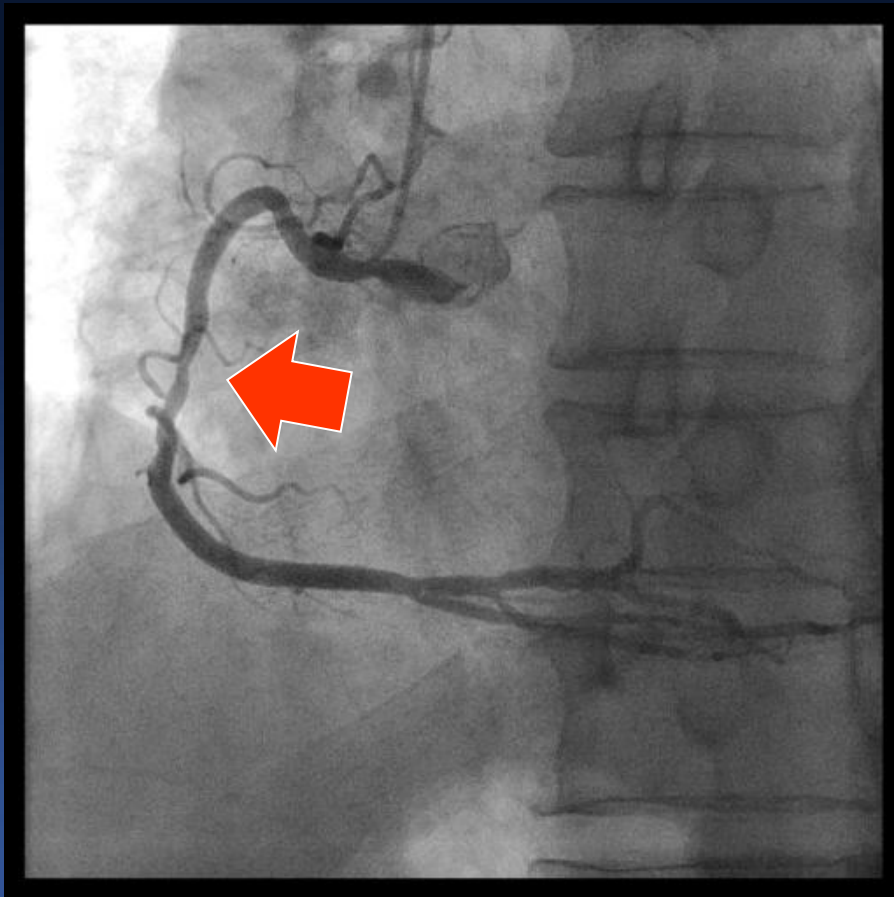
Treadmill Test



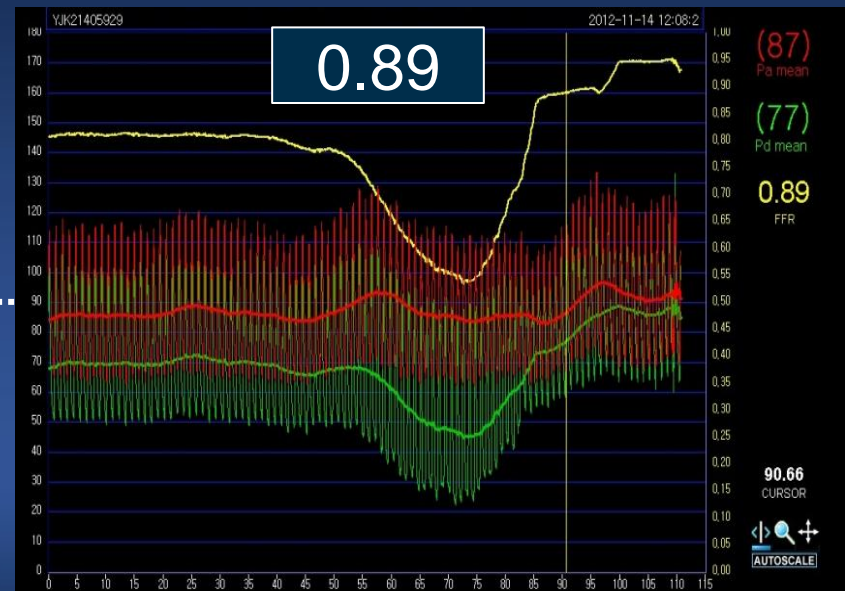
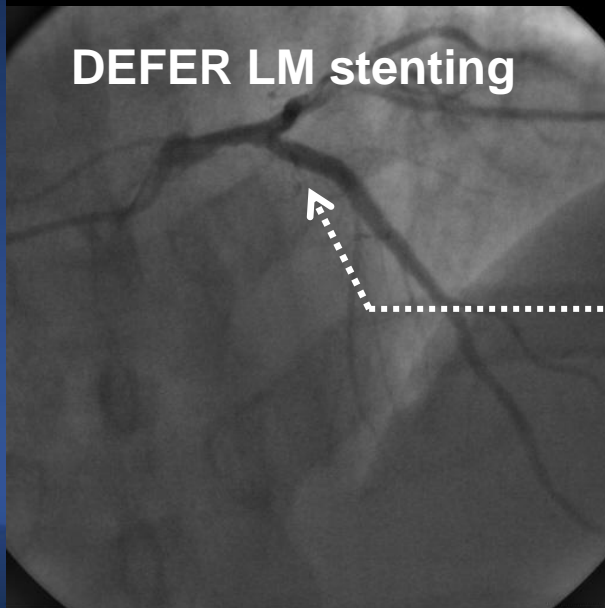
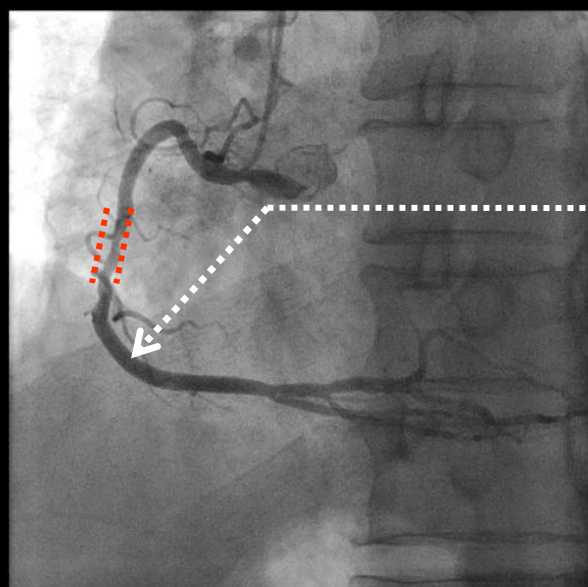
Positive at Stage 4

Coronary Angiography

Intermediate RCA and LM stenosis

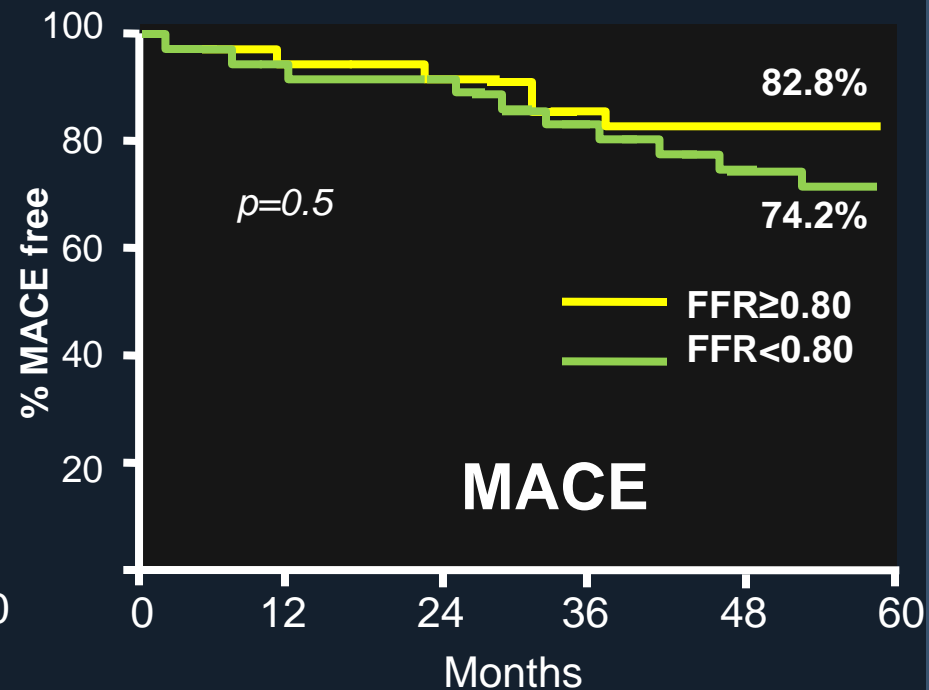
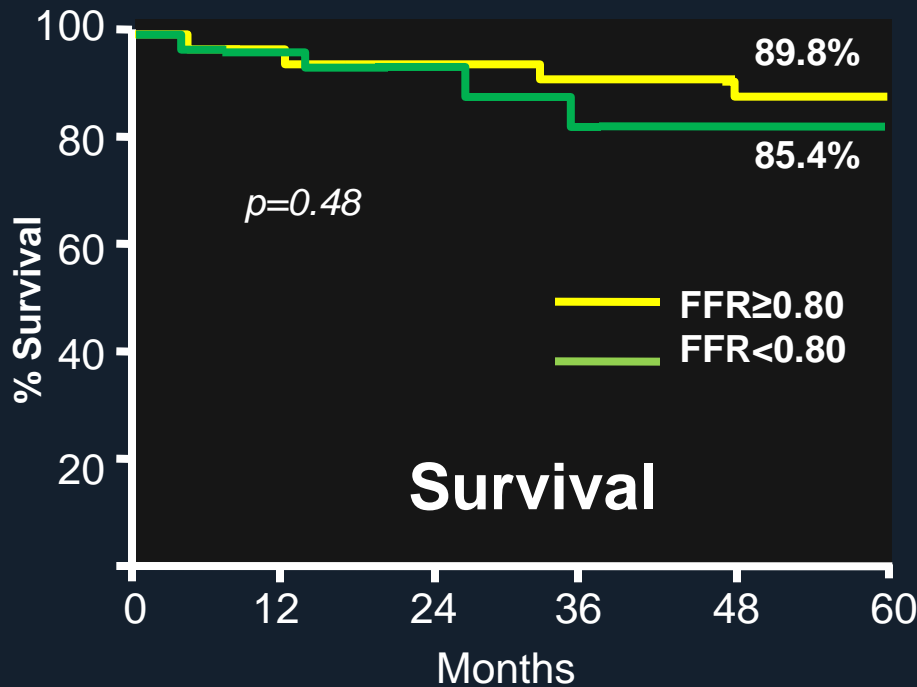


FFR



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.

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

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

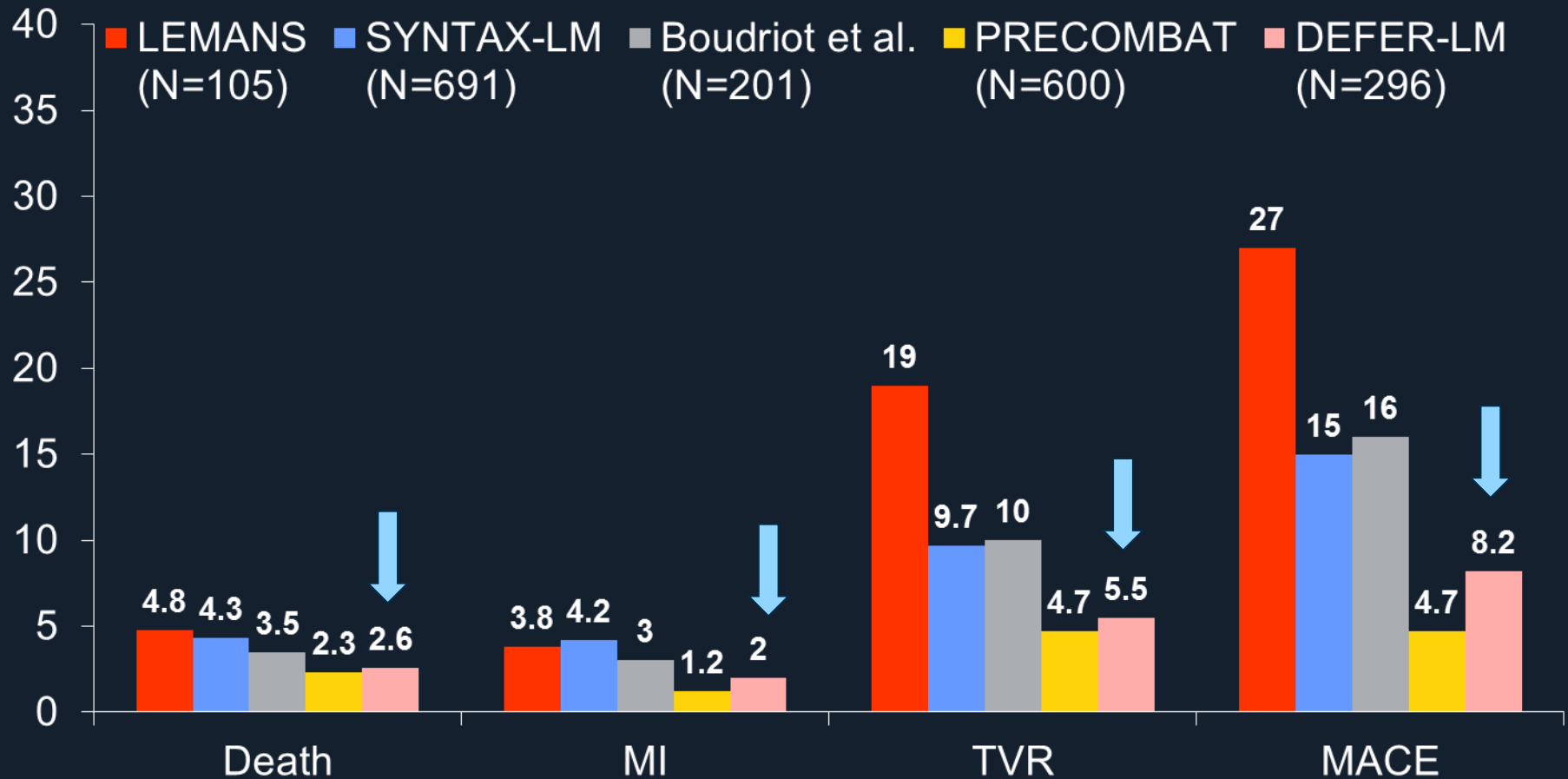
Clinical Outcomes After Deferral of LM Disease (6 studies, 296 patients)

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 Disease?

- Inaccuracy of Coronary Angiography
- Lack or Low Spatial Resolution of Non-Invasive Functional Study
- FFR guided PCI in LMCA Also Showed Favorable Outcomes

Therefore, We Have To Measure LM FFR

How Can We **Implement FFR** in LM stenosis?

LMCA Anatomy

(A) Ostial/Shaft

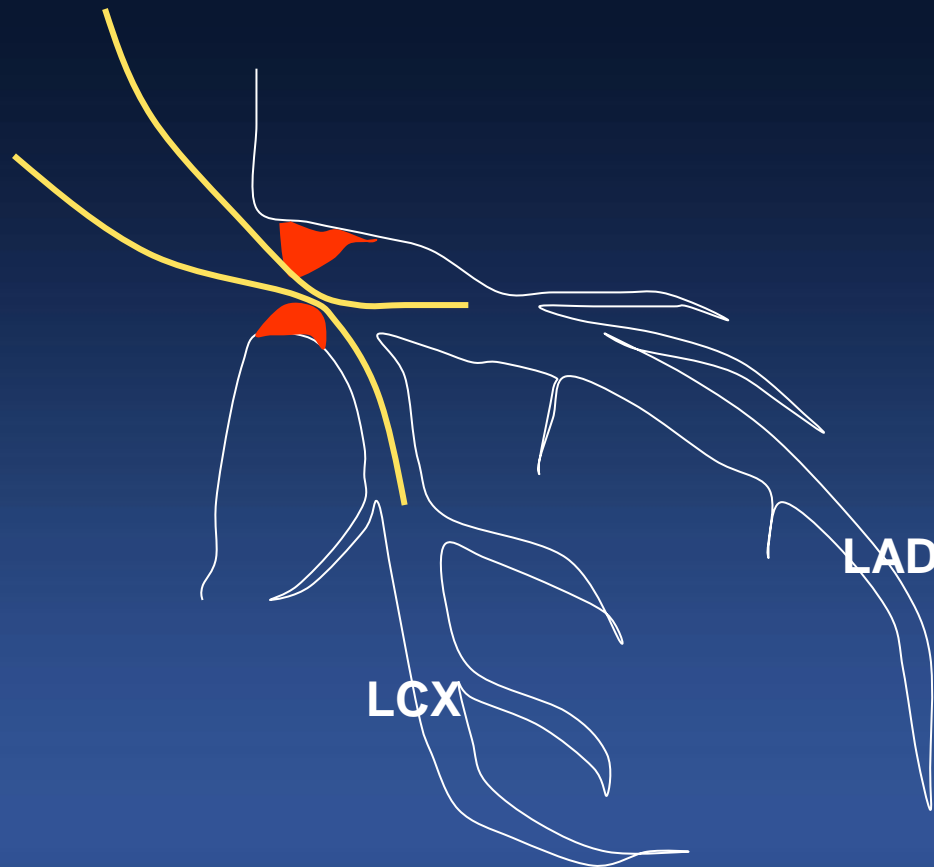
(B) Bifurcation

(C) LM with distal Dz

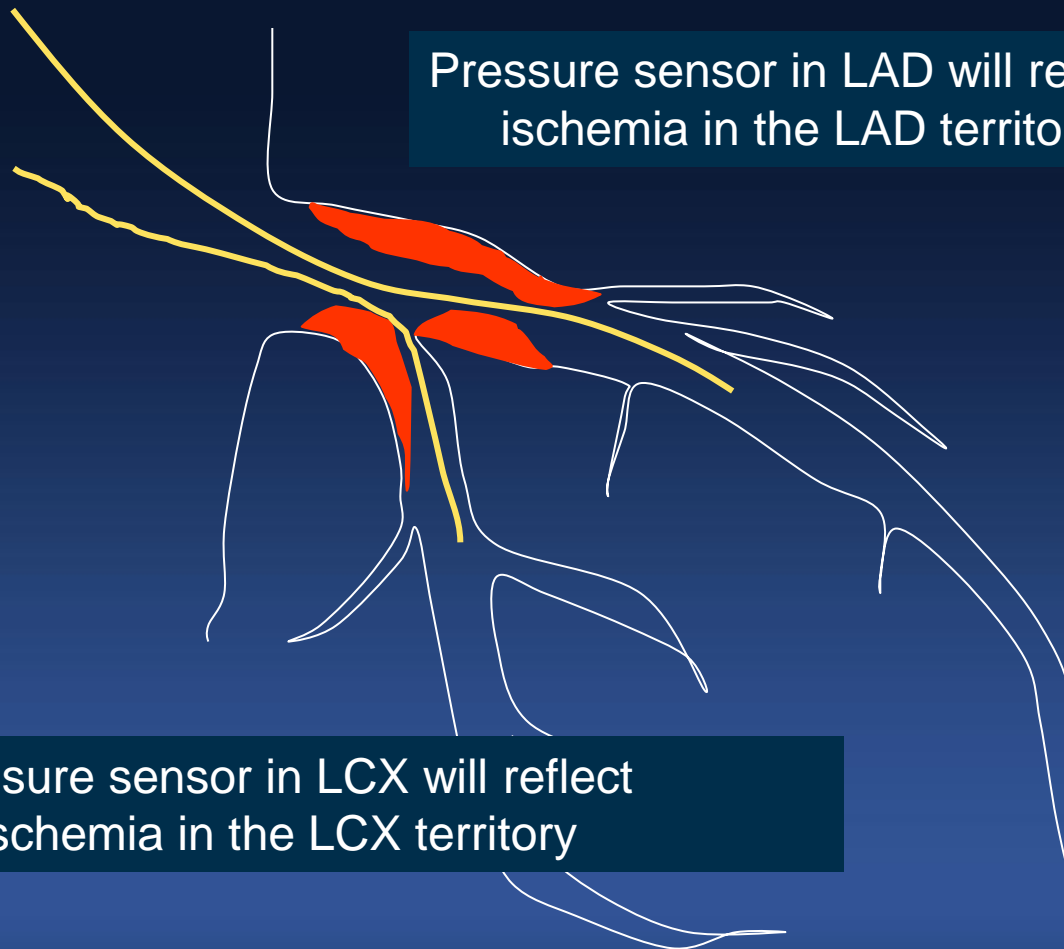


For the Undetermined, Intermediate Ostial and Shaft LM Lesion,

Theoretically, $LAD\ FFR = LCX\ FFR = LM\ FFR$



For the Intermediate **LM Bifurcation Lesion**, **LAD FFR \neq LCX FFR \neq LM FFR**



Pressure sensor in LAD will reflect ischemia in the LAD territory

Pressure sensor in LCX will reflect ischemia in the LCX territory

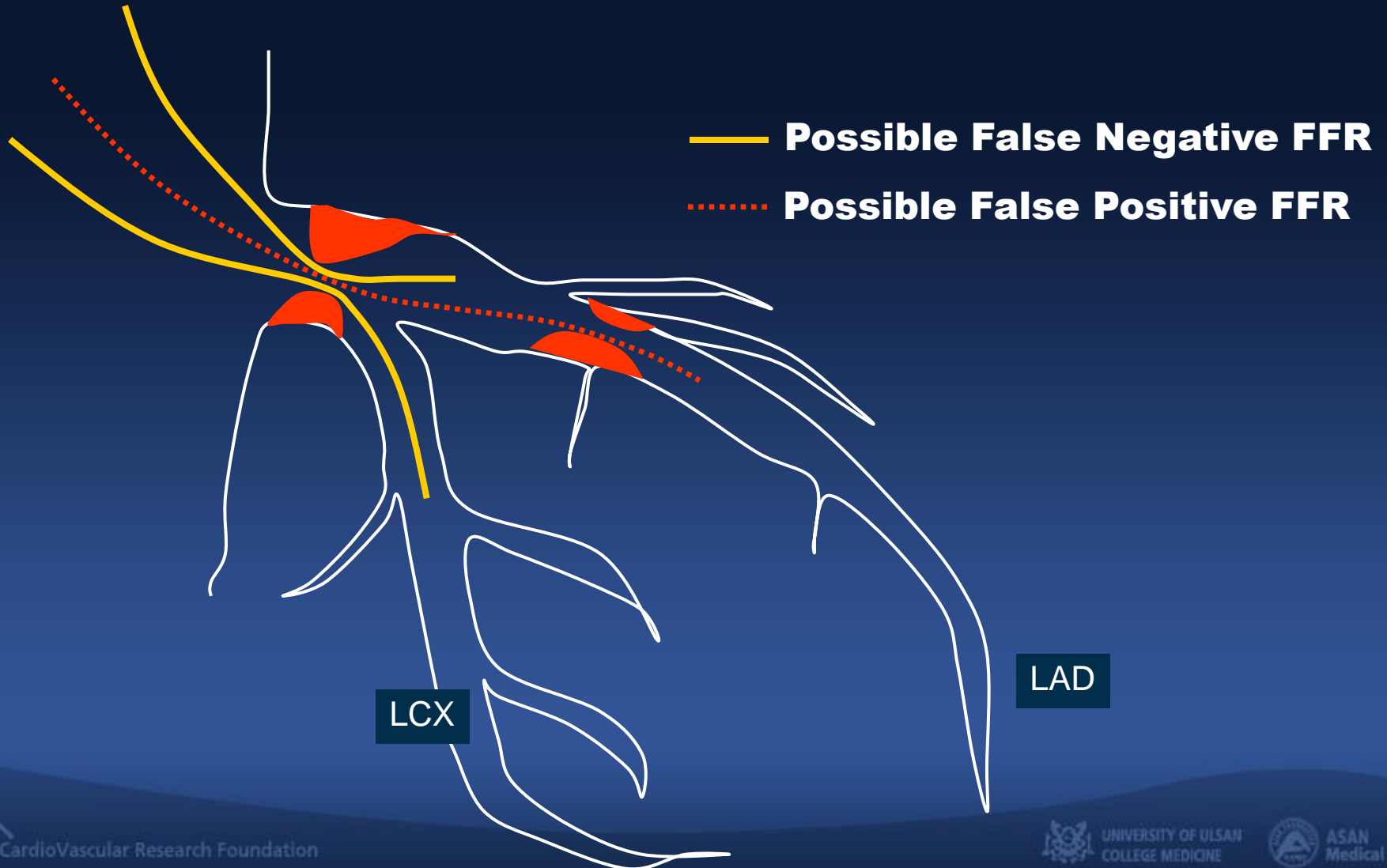
For the Intermediate **LM Bifurcation** Lesion,
If any of **FFR in LAD or LCX** < 0.80
Main Concern is Just to Determine
Single Stent Cross Over or 2 Stents Technique.



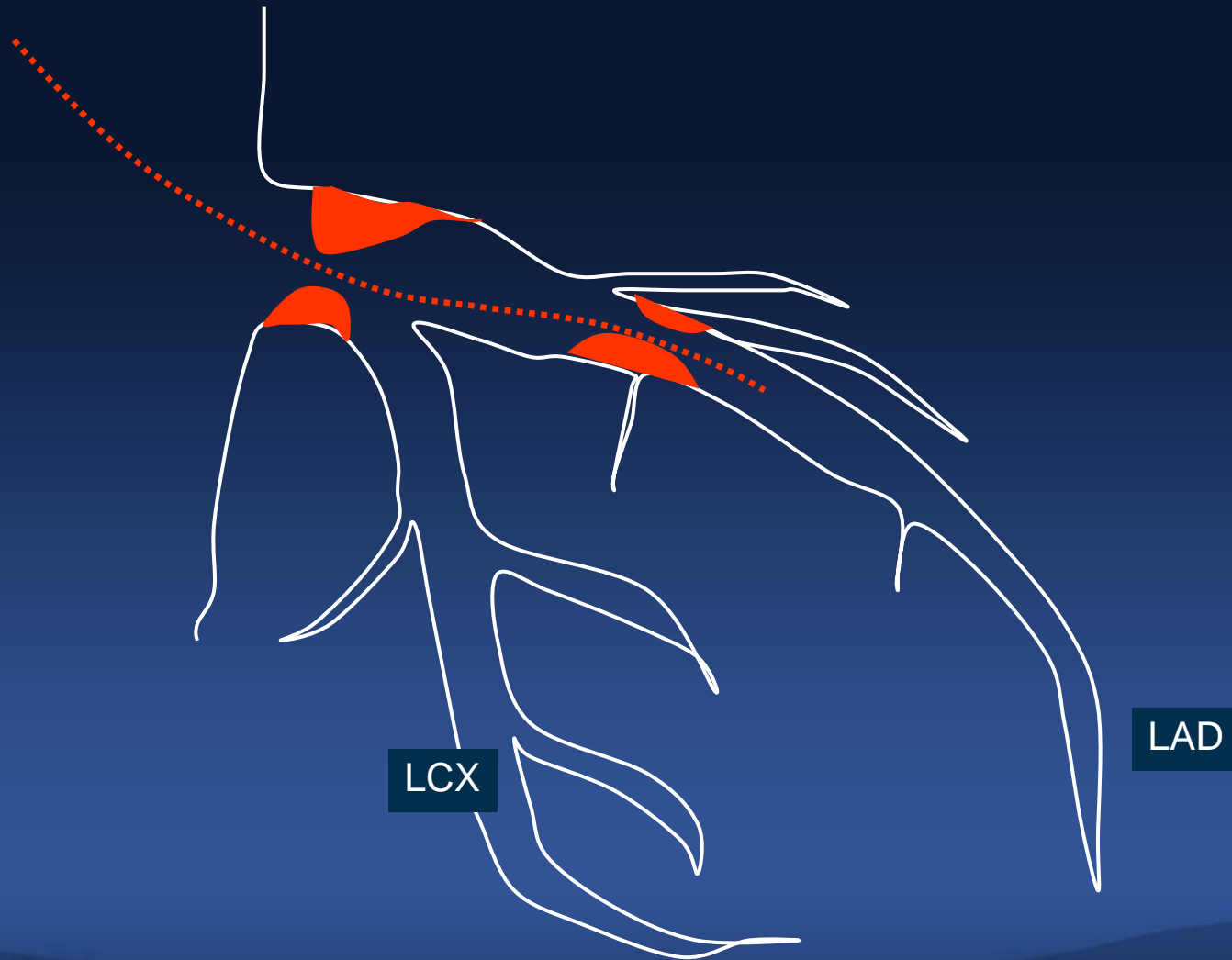
Practically, We Can Not Separately Treat

For LMCA stenosis with distal LAD/LCX stenosis

Tandem Lesions with Interposing side branch

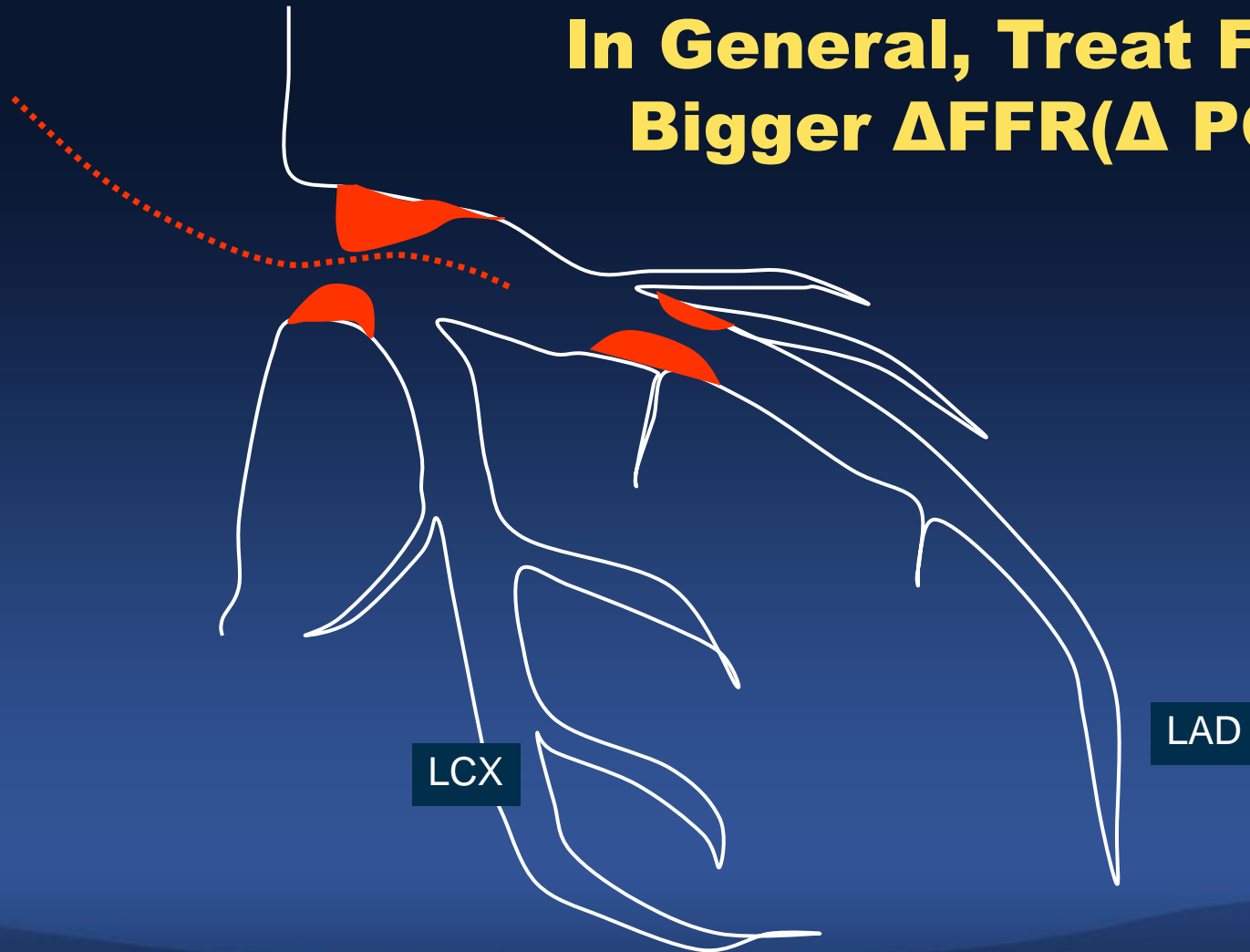


Pressure Wire Pull-Back Help To Decide the Treatment Sequence

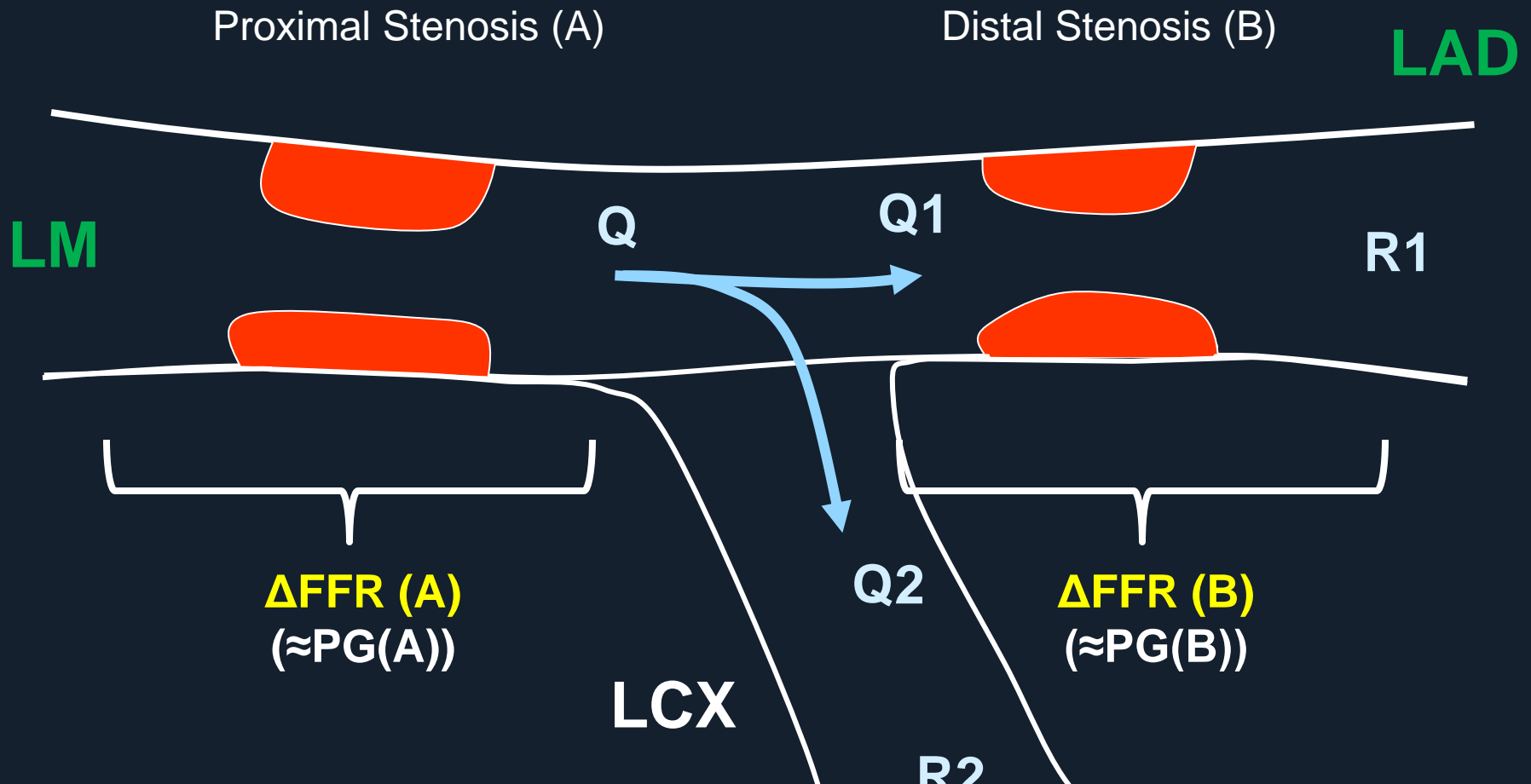


Pressure Wire Pull-Back Help To Decide the Treatment Sequence

In General, Treat First Bigger $\Delta FFR(\Delta PG)$

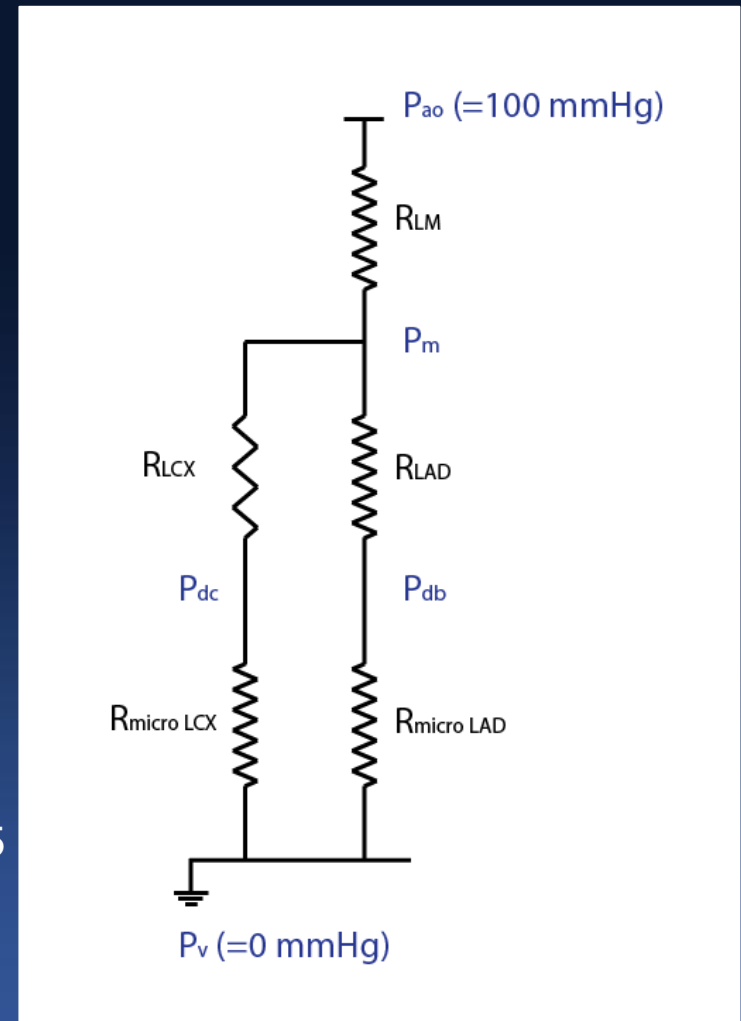
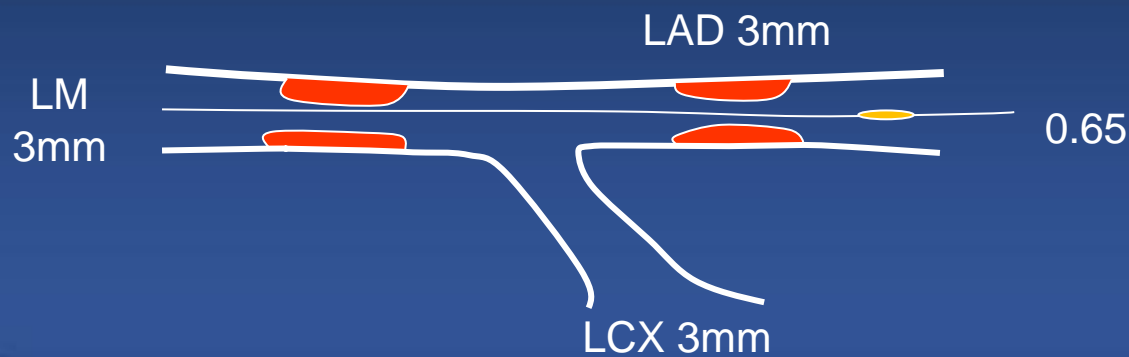
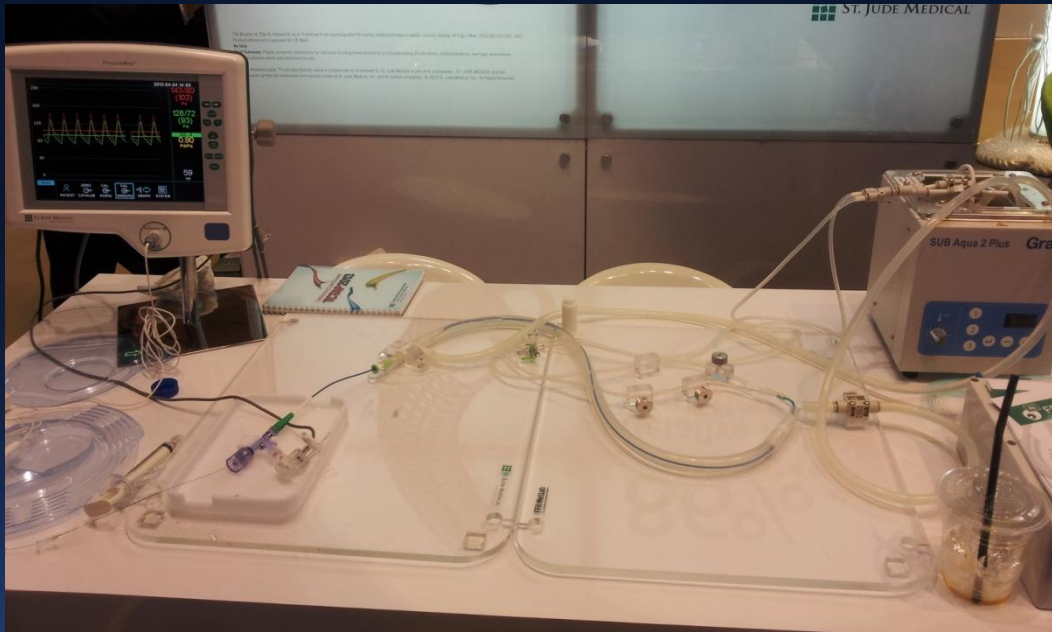


Tandem Lesion



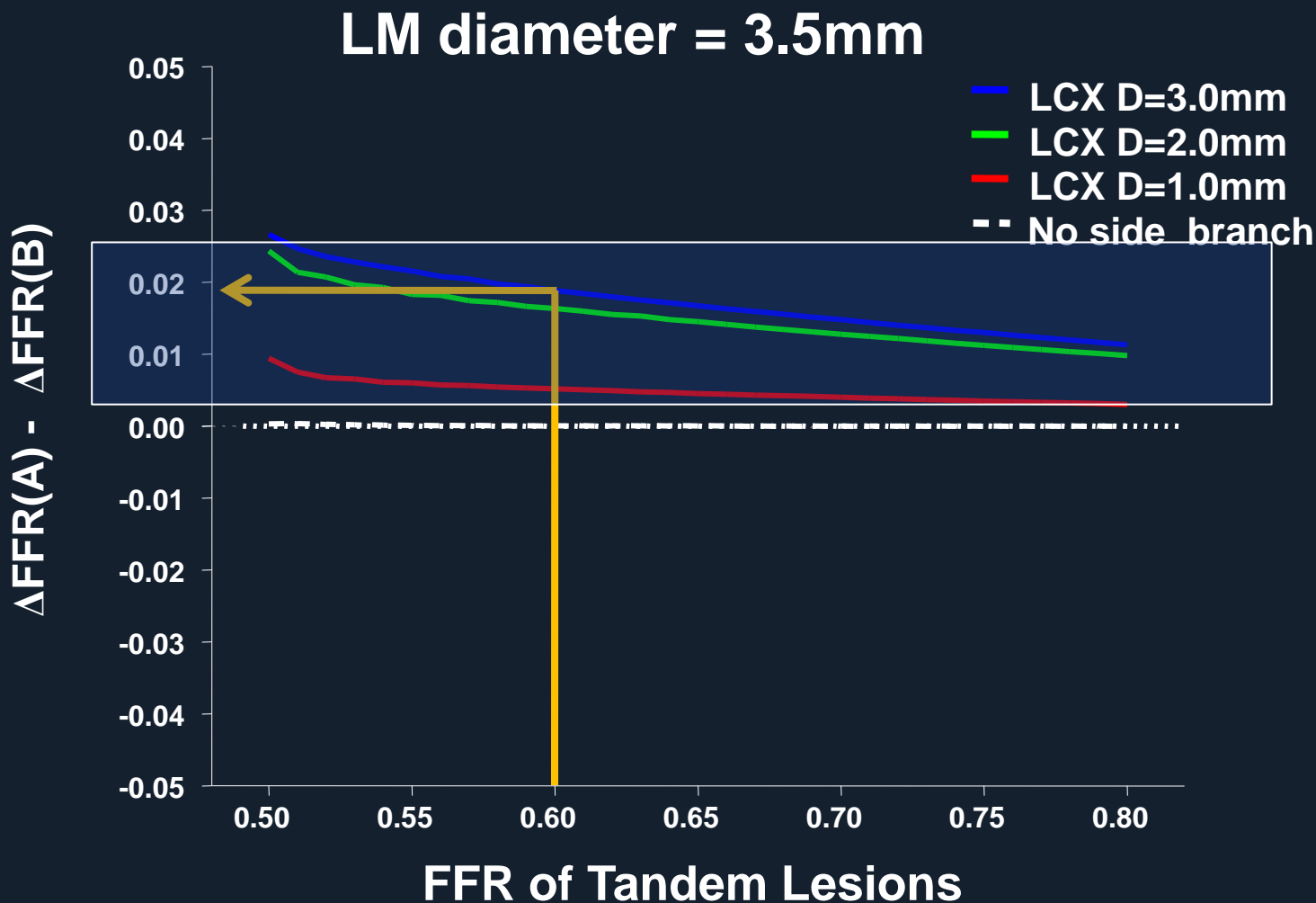
Could $\Delta FFR \approx \Delta PG$ be a Surrogate of Relative Functional Significance ?

In Vitro Simulation



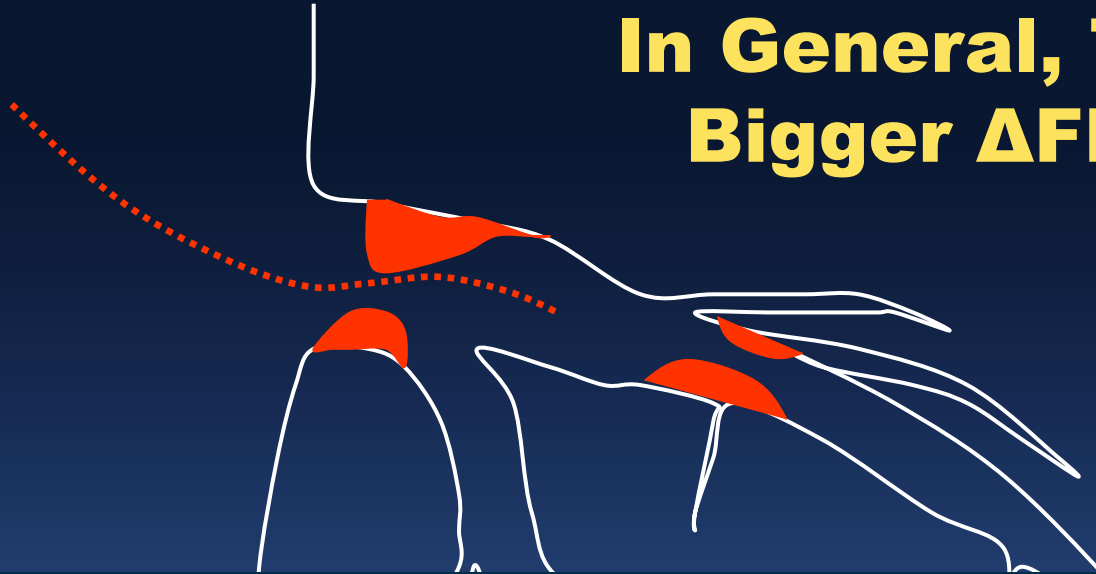
When Two Lesions Are Functionally Equal,

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



Pressure Wire Pull-Back Help To Decide the Treatment Sequence

In General, Treat First Bigger $\Delta FFR(\Delta PG)$



The impact of side branch (≈ 0.02) should be considered, But this number may be below the clinical significance.

LCX

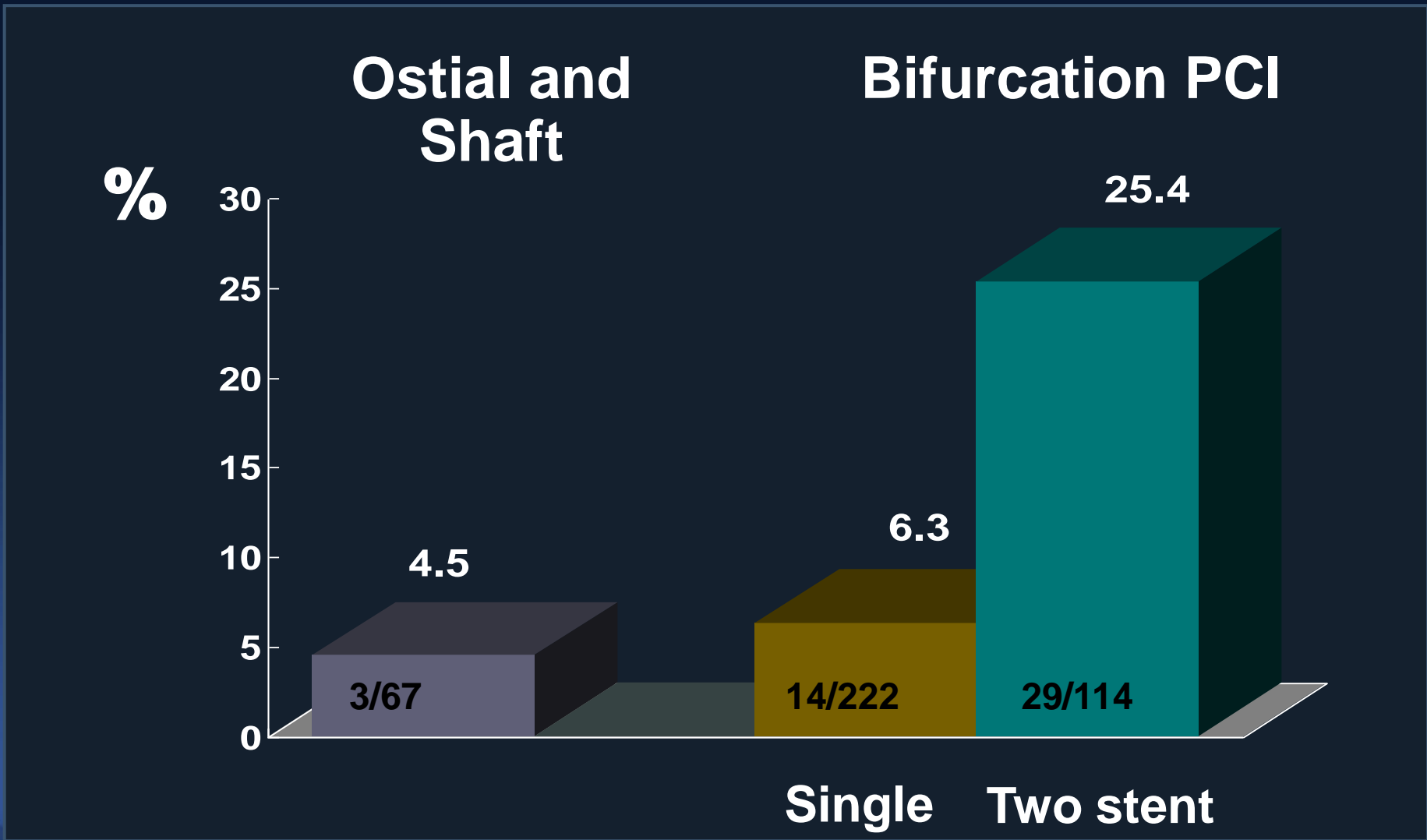
LAD

Why We Need IVUS in LM Stenting?

- Selection of Treatment strategies: 1 stent or 2 stents
- Post-Stent Optimization (5,6,7,8) Reduced ISR
- IVUS guided PCI in LMCA Improved the Survival
- Assist the Functional evaluation of Complex LM disease

Restenosis at 2 year

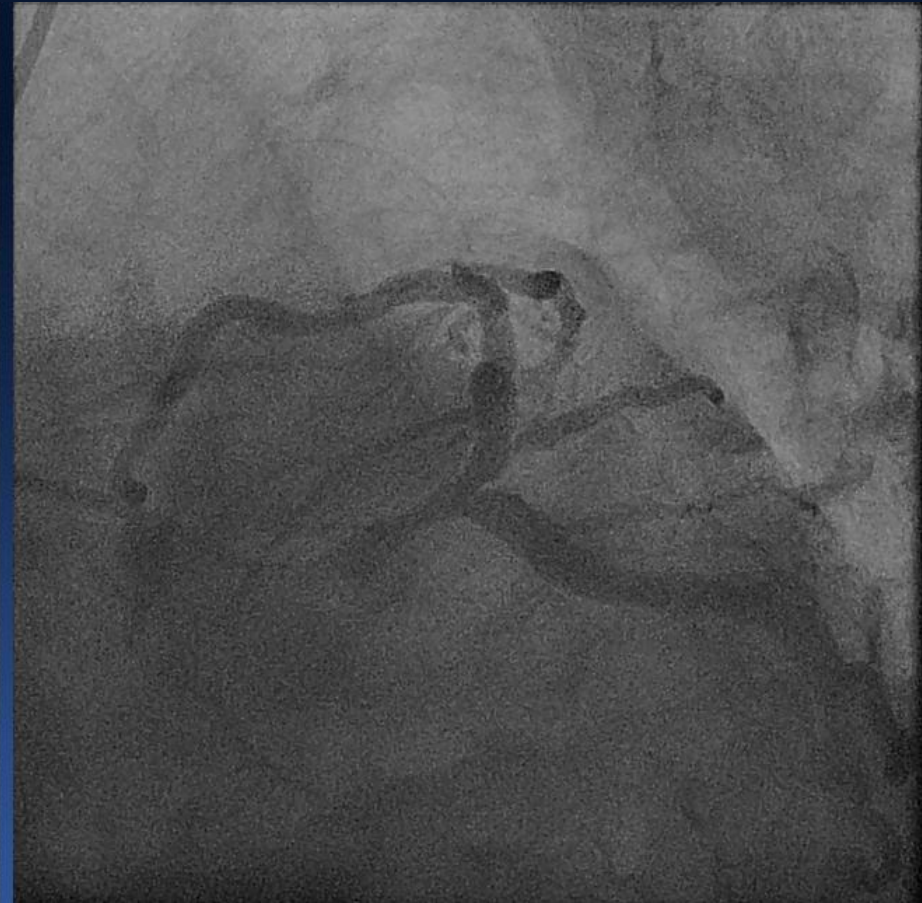
Pooled Analysis in 403 Patients with LM PCI Using SES



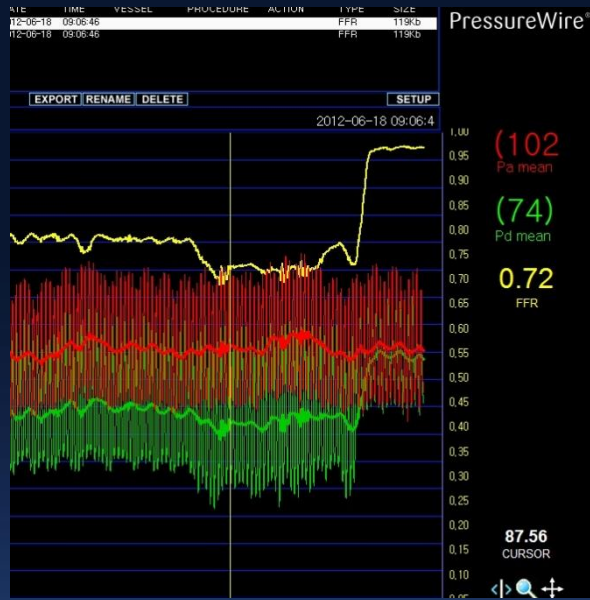
Kang et al. Circ Cardiovasc Interv 2011 2011;4:1168-74

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

55/M, Stable angina,

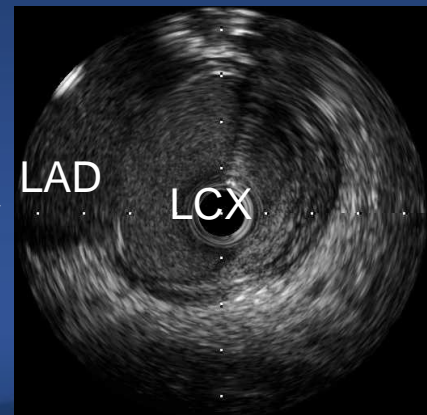
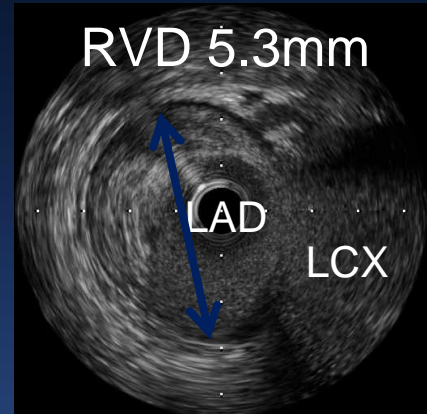
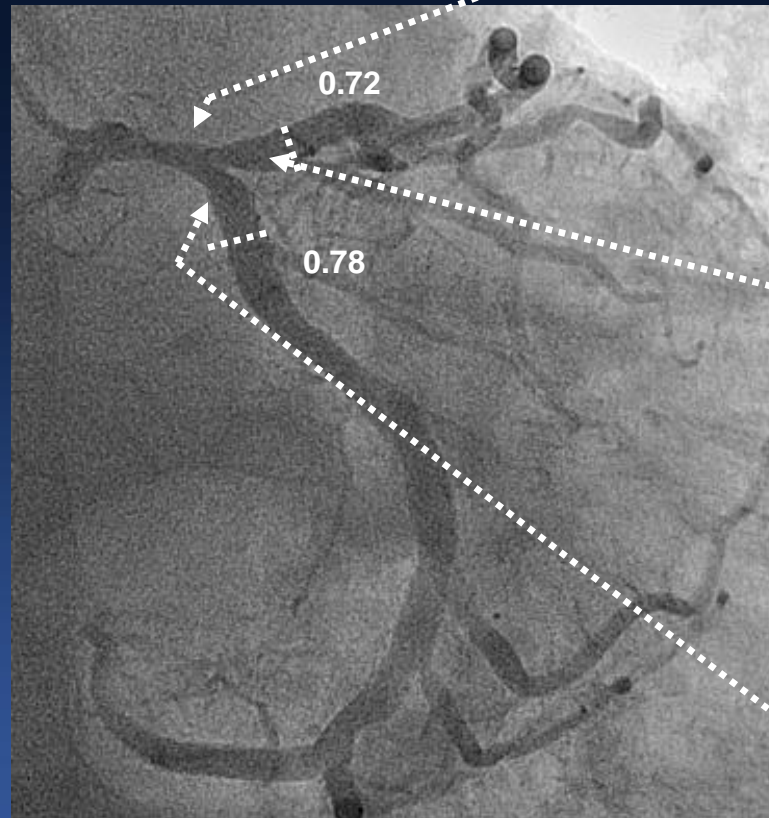
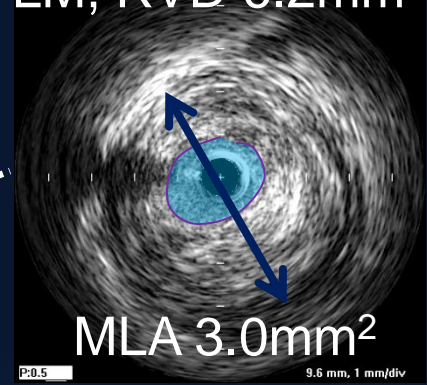
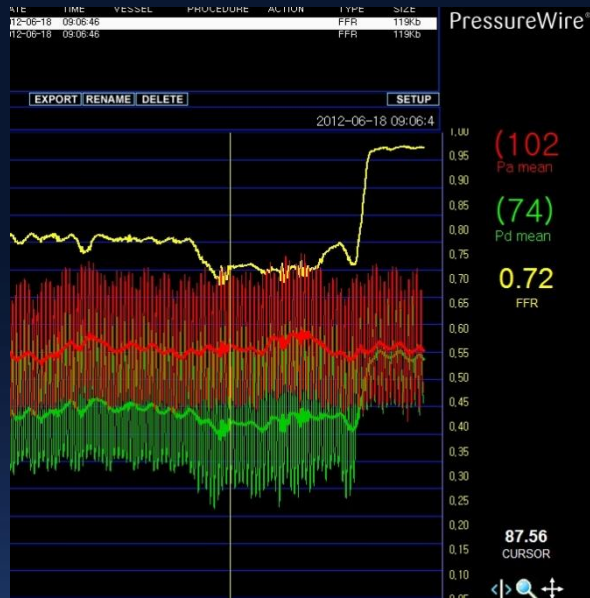


FFR in Both LAD and LCX,



IVUS in Both LAD and LCX,

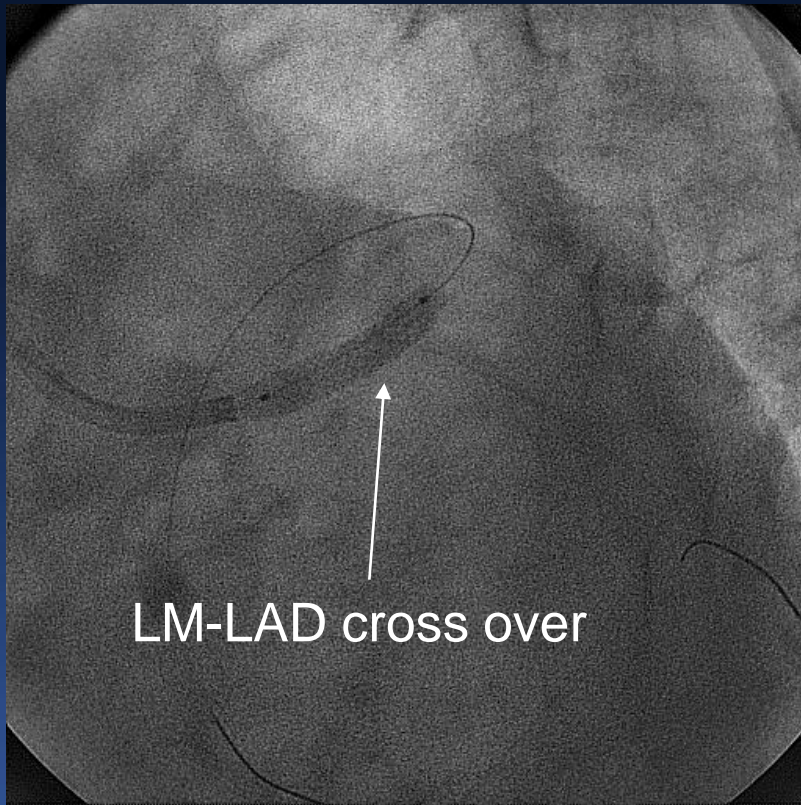
Distal LM, RVD 6.2mm



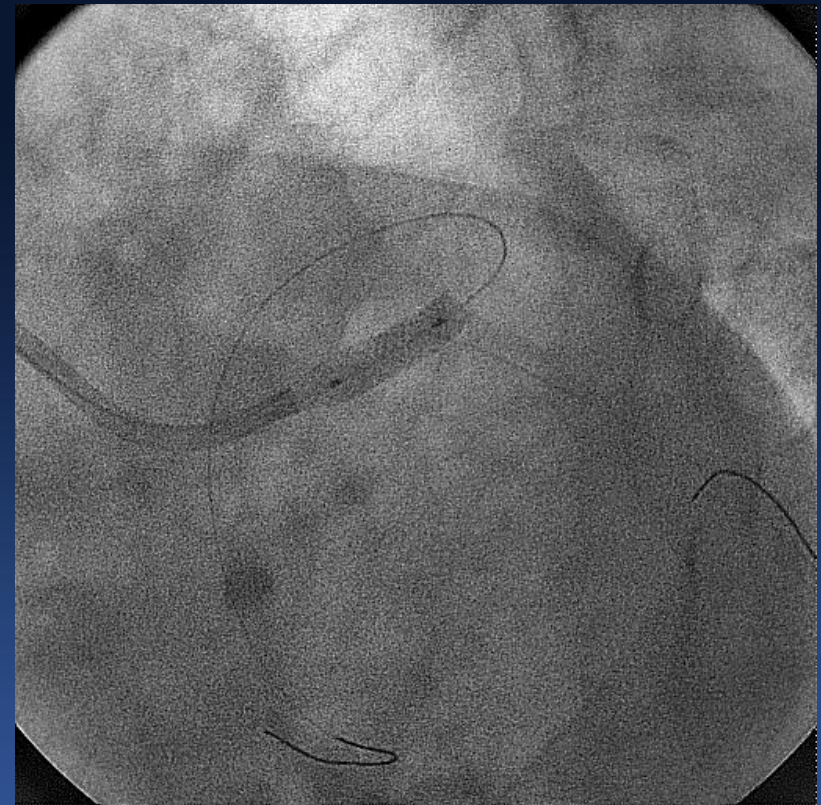
Minimal disease at LCX ostium



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

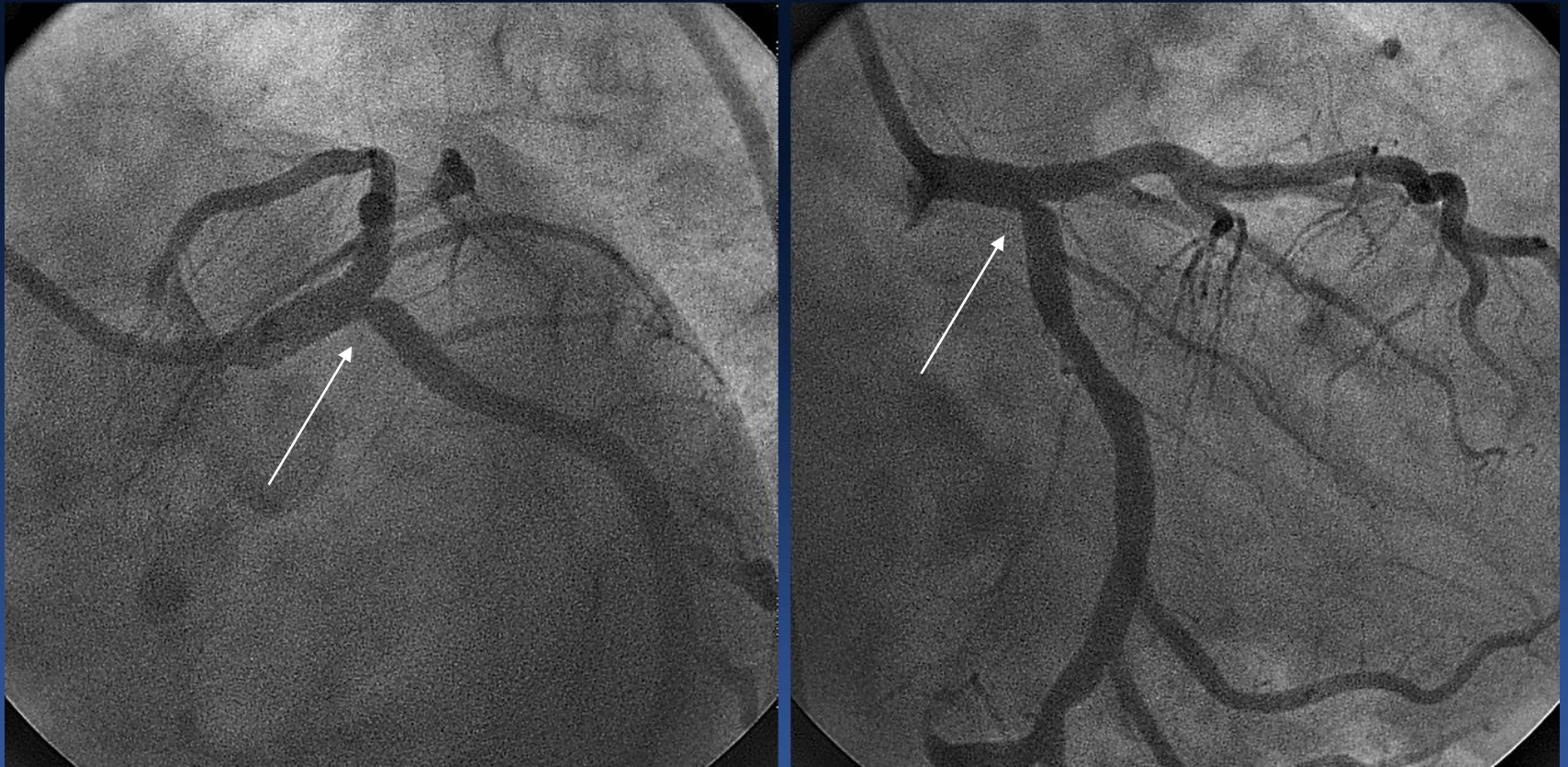


Promus Element
4.0x20



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



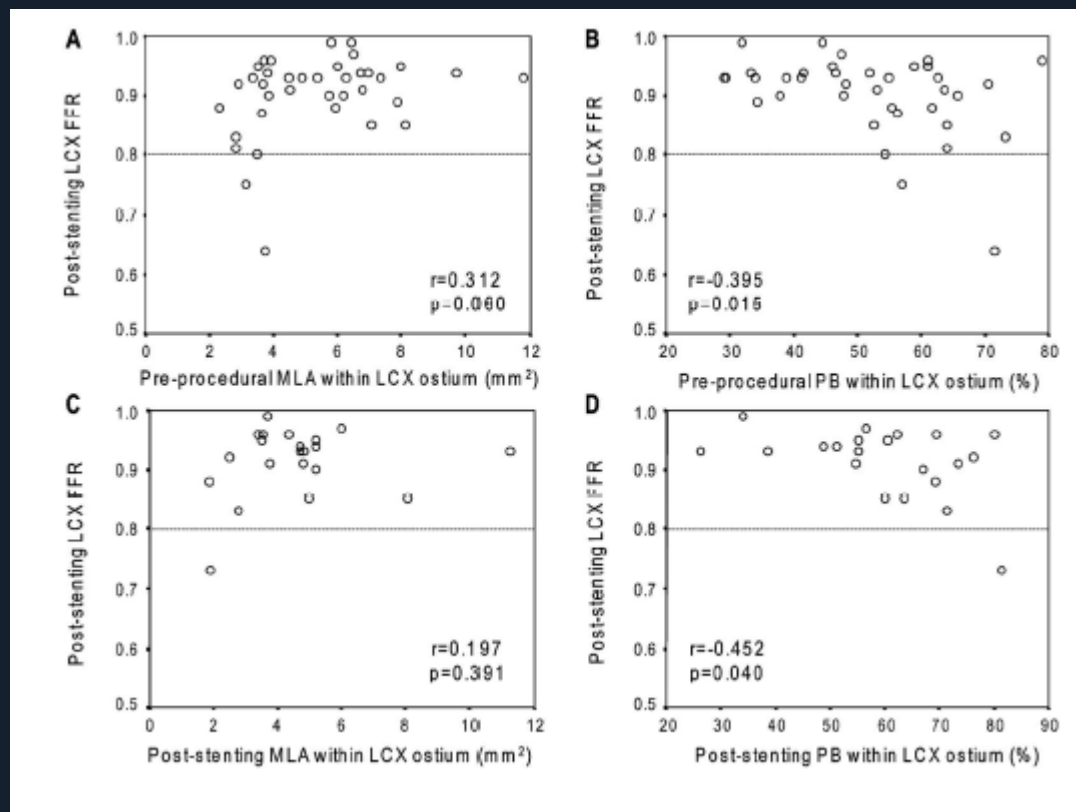
Consider FFR, First !

FFR is 0.92

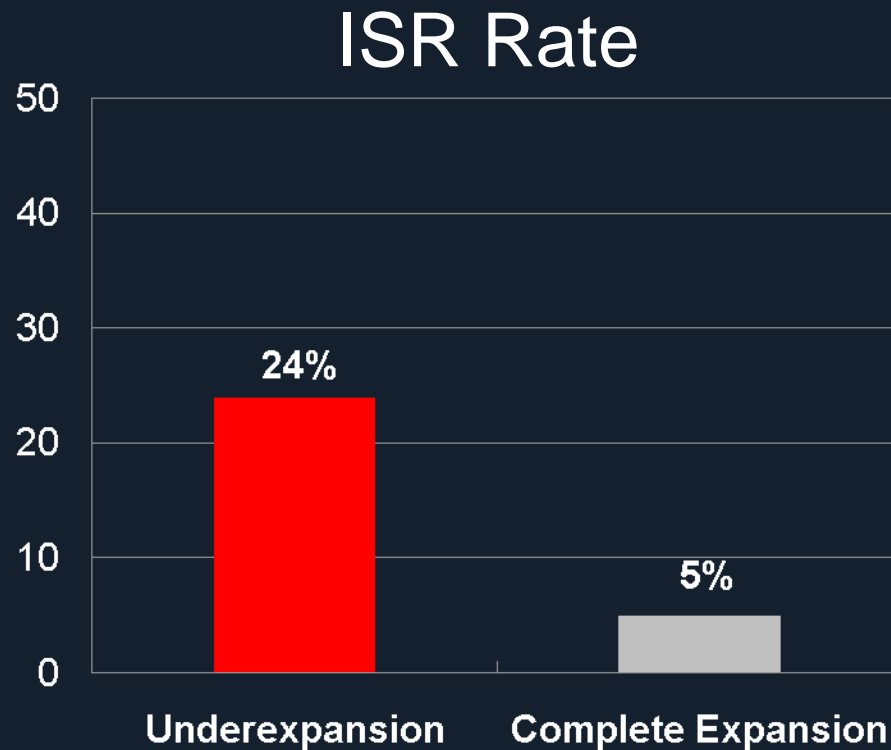
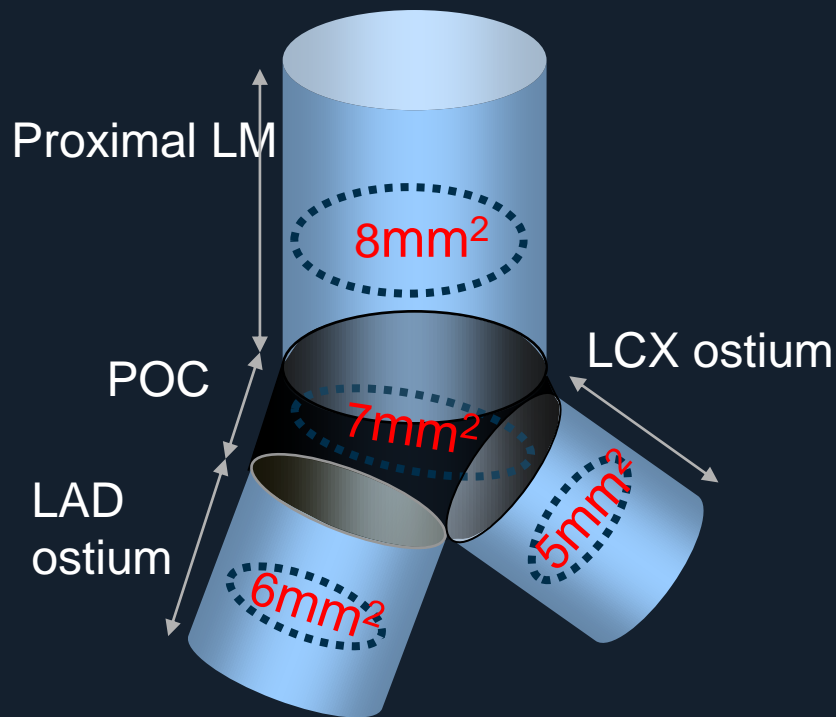


LCX FFR after Cross Over Stenting

- 43 Patients with LM Bifurcation Lesions
- Only in 3 Patients, FFR of LCX ostium after LM Stenting <0.80

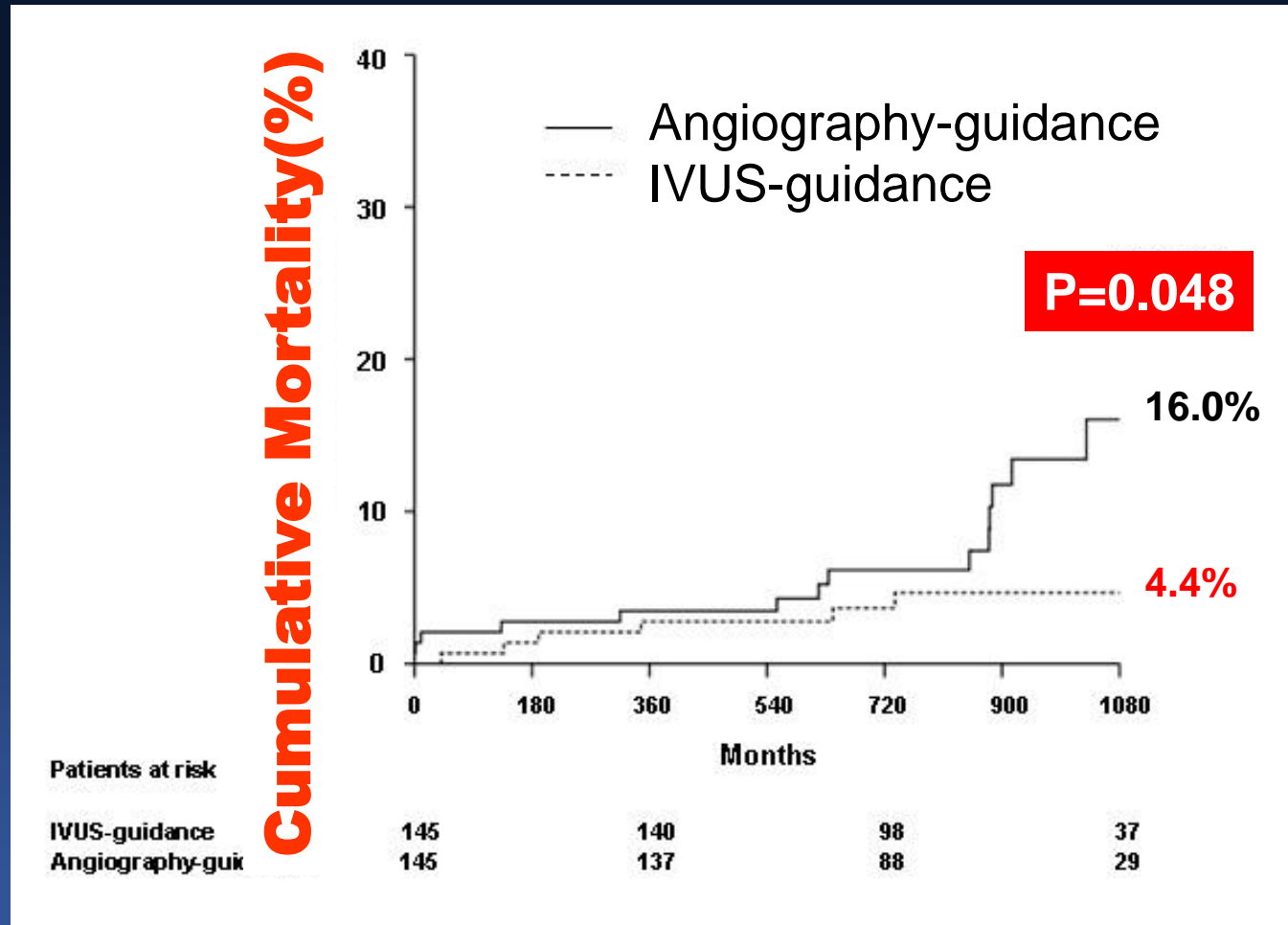


Optimal Stent Cross Sectional Area After LM Stenting



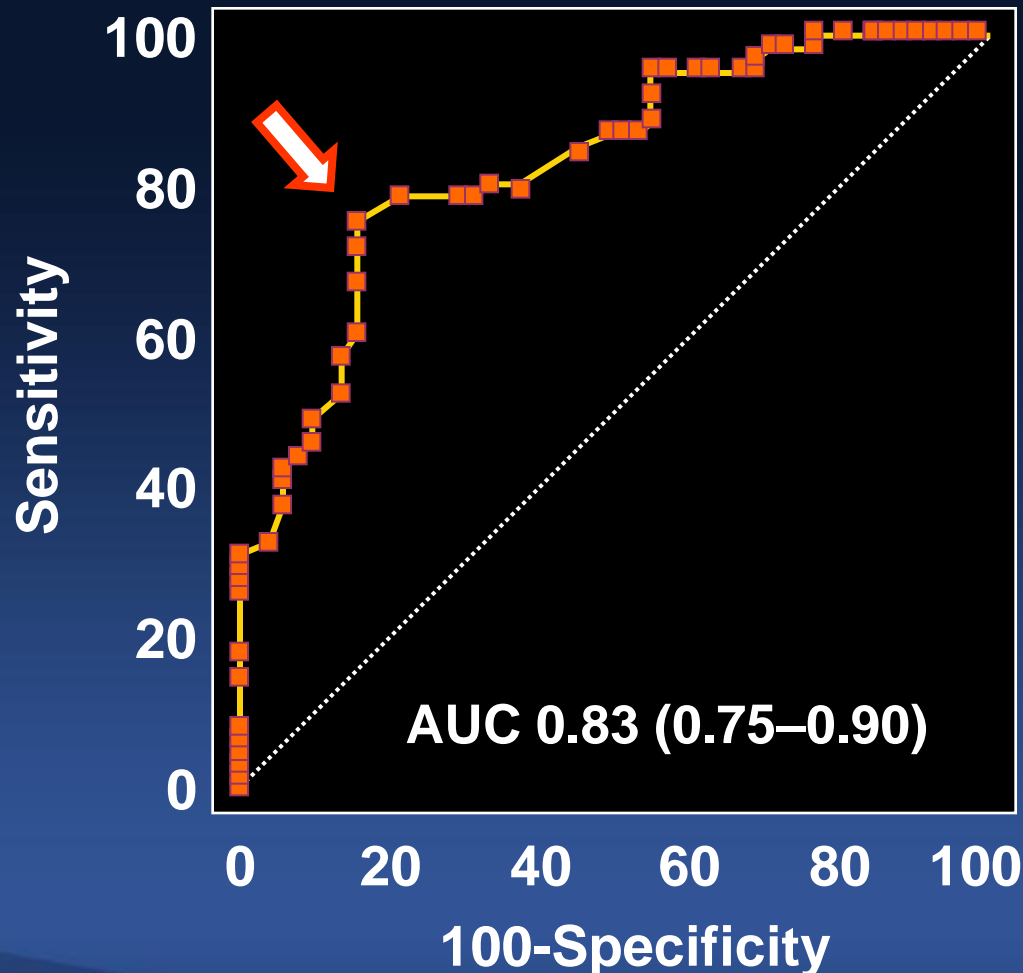
Kang et al. Circ Cardiovasc Interv 2011 2011;4:1168-74

IVUS Guidance reduced the rate of mortality In LM DES stenting



New LM IVUS MLA

Matched with FFR <0.80,
Ostial and Shaft LM Disease (N=112)



Cut-off = 4.5 mm²

Sensitivity	79%
Specificity	80%
PPV	83%
NPV	76%
Accuracy	80%

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

Integrated Use of FFR and IVUS in LM stenting

Ostial or Shaft Stenosis

Whether to Treat or Not: FFR guidance

How to Treat: IVUS guidance

- Preintervention IVUS evaluation
MLA, RVD, LL, Plaque burden etc.
- Postintervention IVUS optimization
MSA > 8mm²

Bifurcation Stenosis

Whether to Treat or Not: FFR guidance

- FFR measurement is important
Consider a bifurcation stenosis as a single unit of disease
- IVUS can assist the functional evaluation of complex LM disease
MLA < 4.5mm²

How to Treat: IVUS guidance

- Preintervention IVUS evaluation
MLA, RVD, LL, Plaque burden etc.
- Postintervention IVUS optimization
Evaluate MSA in every segment (5,6,7,8)