# Integrated Use of FFR and IVUS for LM PCI

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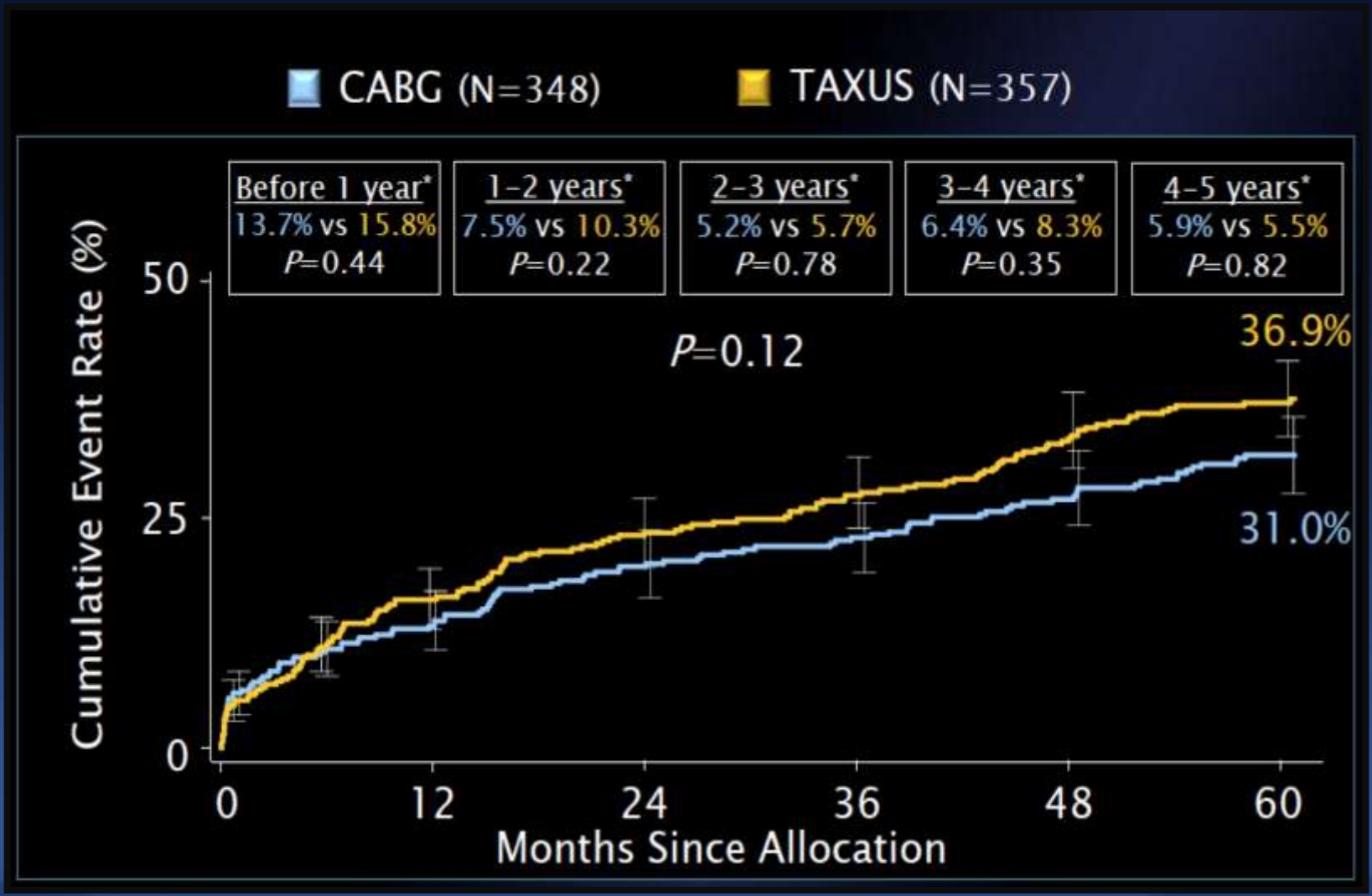
# LM PCI 2017

## ESC Guidelines 2014
## Elective PCI for LM Stenosis

| | CABG | | PCI | |
|---|---|---|---|---|
| Recommendation according to extent of CAD | Class | Level | Class | Level |
| LM disease a SYNTAX score ≤ 22 | I | B | I | B |
| LM disease a SYNTAX score 23 -32 | I | B | IIa | B |
| LM disease a SYNTAX score > 32 | I | B | III | B |

# LM Subgroup From SYNTAX (TAXUS)

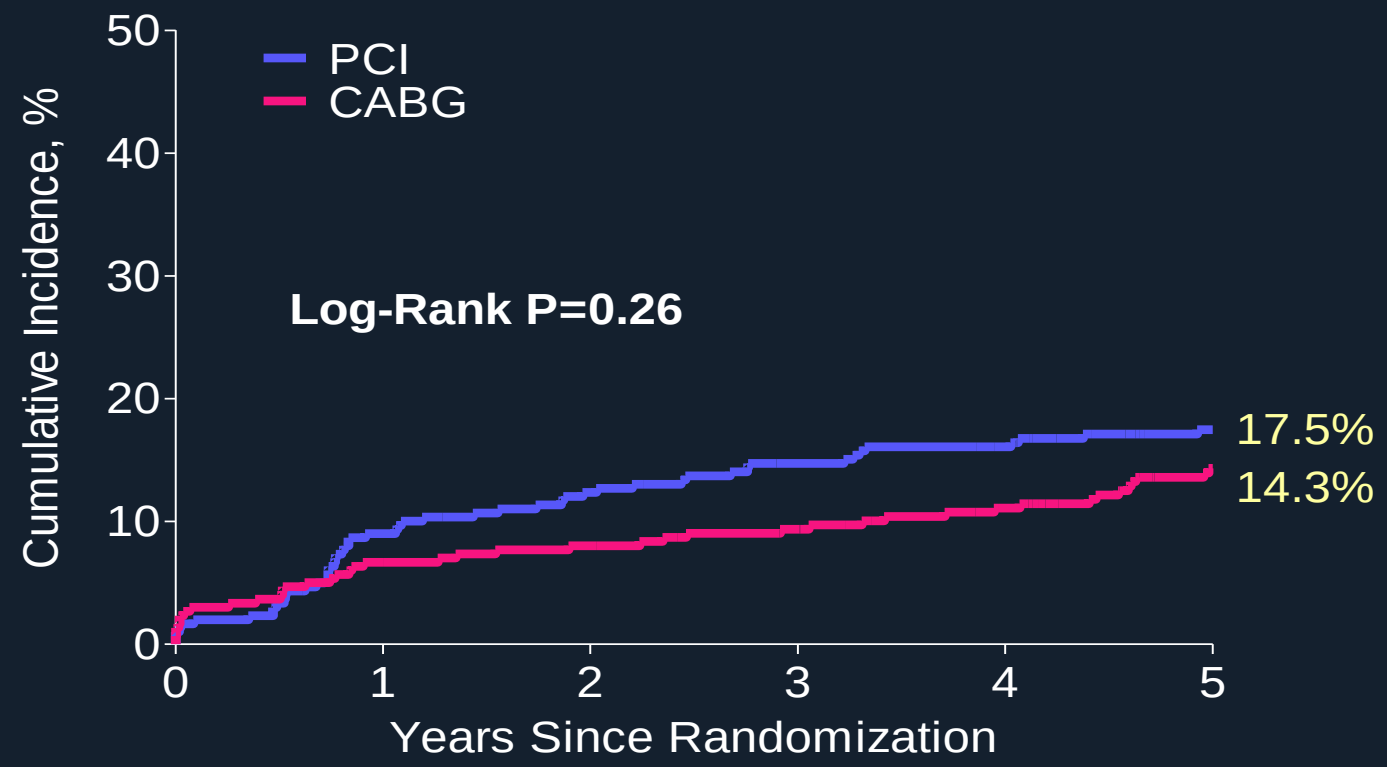
## Primary End Point (Death, MI, Stroke, or RR)




Circulation. 2014 Jun 10;129(23):2388-94

# PRECOMBAT (CYPHER)

## Primary End Point (Death, MI, Stroke, or iTVR)




Patient at risk

| | | | | | | |
|---|---|---|---|---|---|---|
| PCI | 300 | 272 | 261 | 252 | 246 | 231 |
| CABG | 300 | 279 | 274 | 267 | 256 | 235 |

Ahn JM, Roh JH, Park SJ et al. J Am Coll Cardiol. 2015;65(20):2198-206

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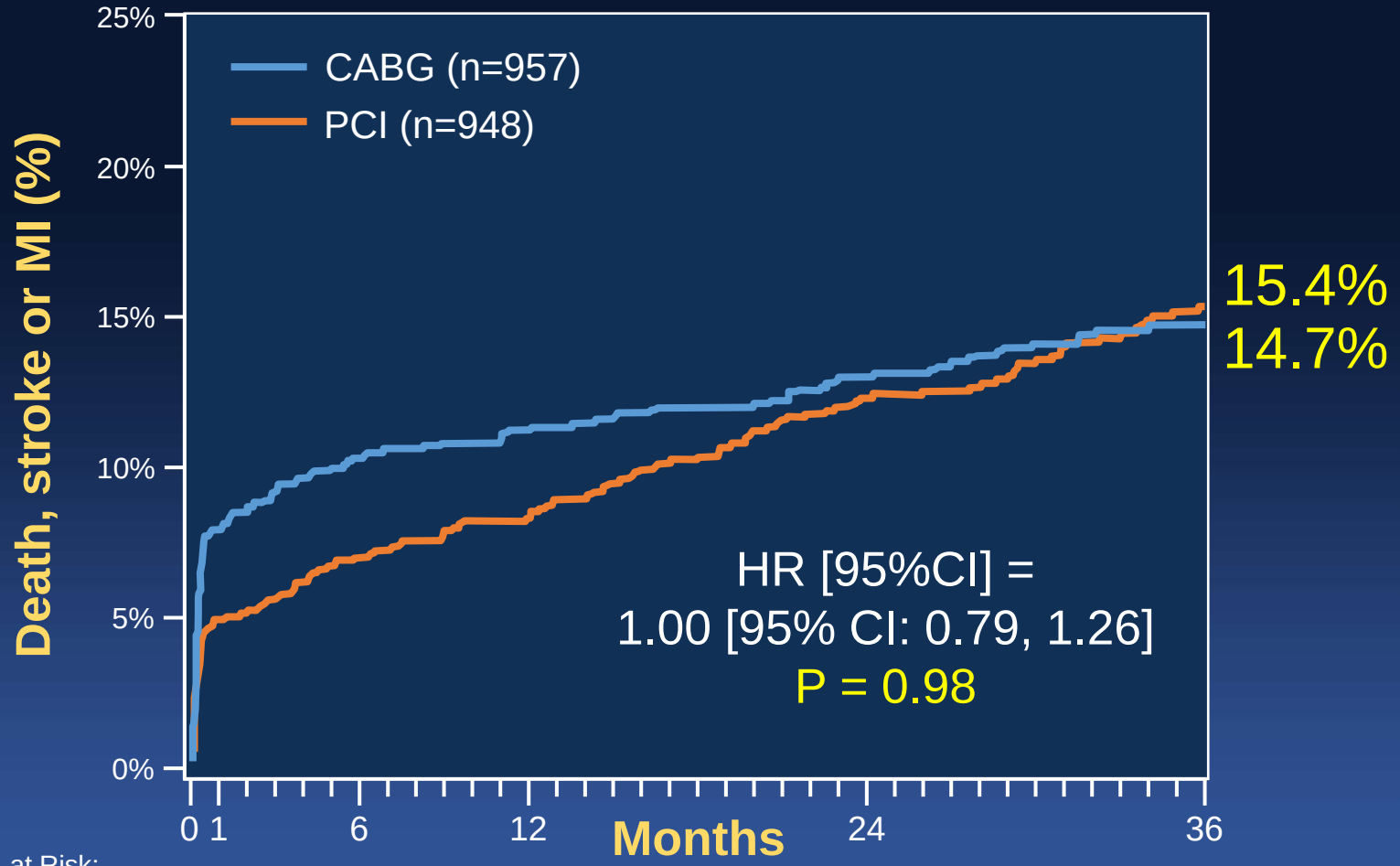
NEWS | TCT 2016

# EXCEL and NOBLE: Opposing Results Pose Quandary for PCI/CABG Choice in Left Main Disease

EXCEL found PCI to be comparable to CABG in left main coronary disease, while the NOBLE trial suggested CABG might have the edge.

# EXCEL (XIENCE)

## Primary End Point (Death, MI, or Stroke)




No. at Risk:

| | | | | | | |
|---|---|---|---|---|---|---|
| PCI | 948 | 896 | 875 | 850 | 784 | 445 |
| CABG | 957 | 868 | 836 | 817 | 763 | 458 |

Stone GW et al. N Eng J Med 2016 ePub

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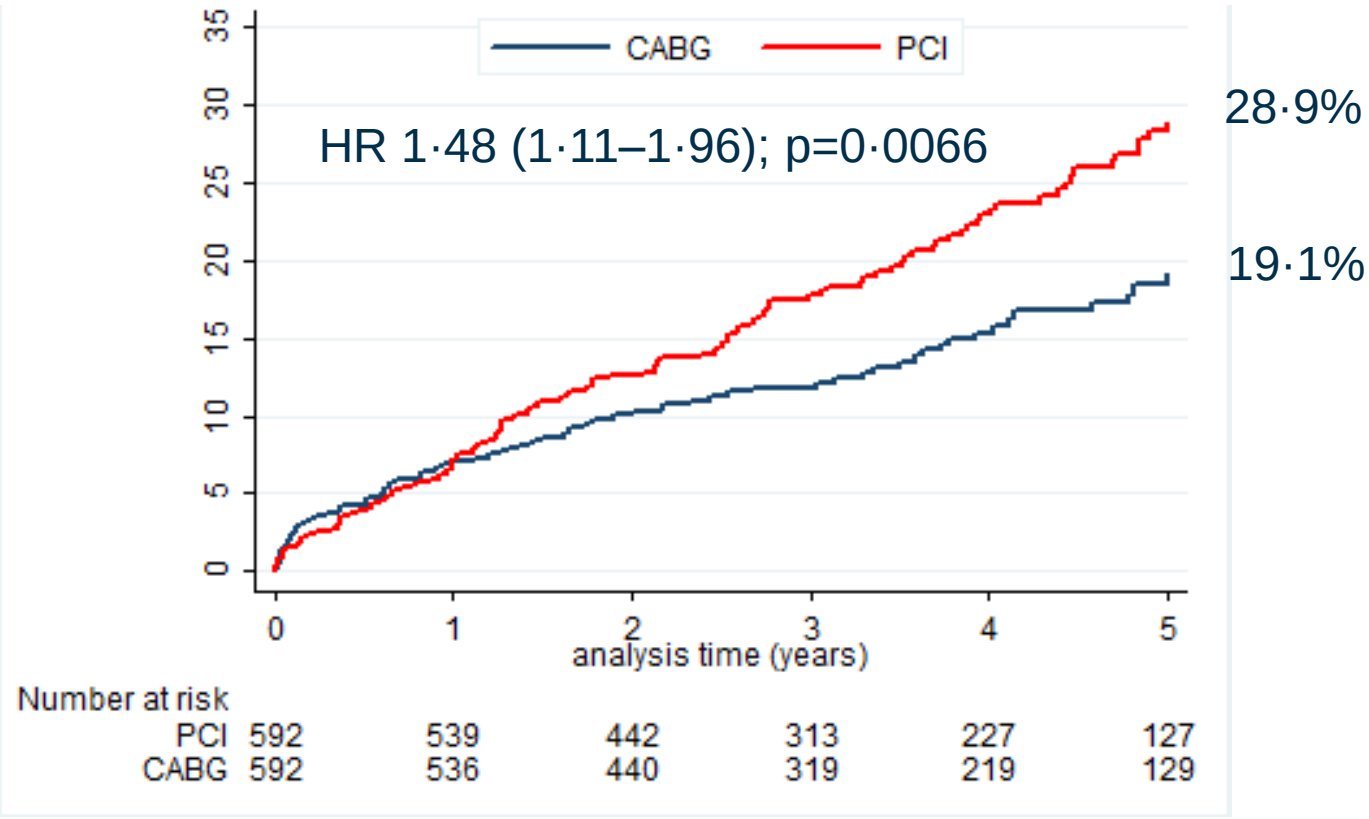
# NOBLE Trial

## Primary End Point (Death, MI, Stroke, or RR)




Makikallio T et al. Lancet 2016 ePub

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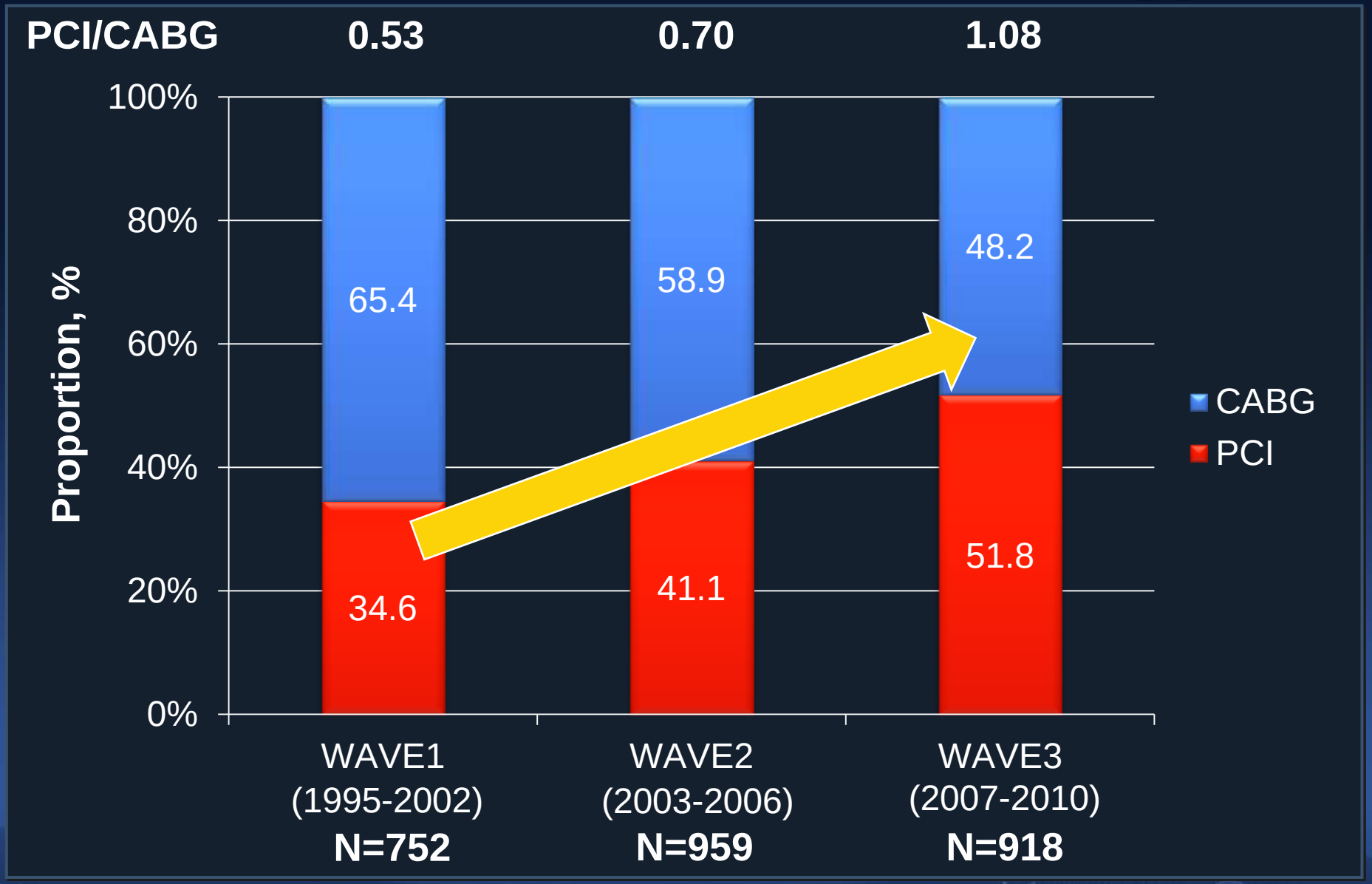
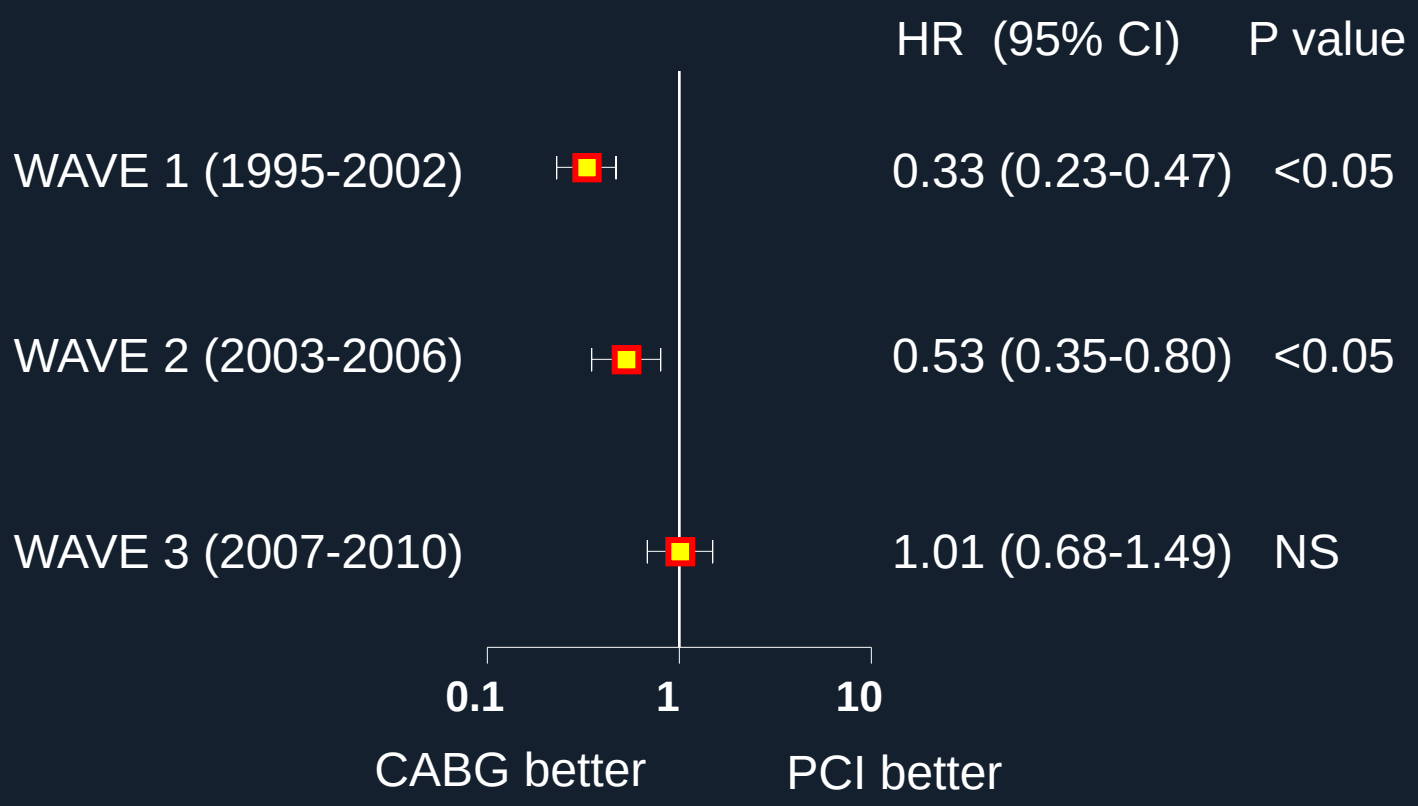
# Revascularization Strategy




Park SJ, Ahn JM et al. Circ Cardiovasc Interv. 2015 Mar;8(3):e001846

# Risk Adjusted Hazard Ratio

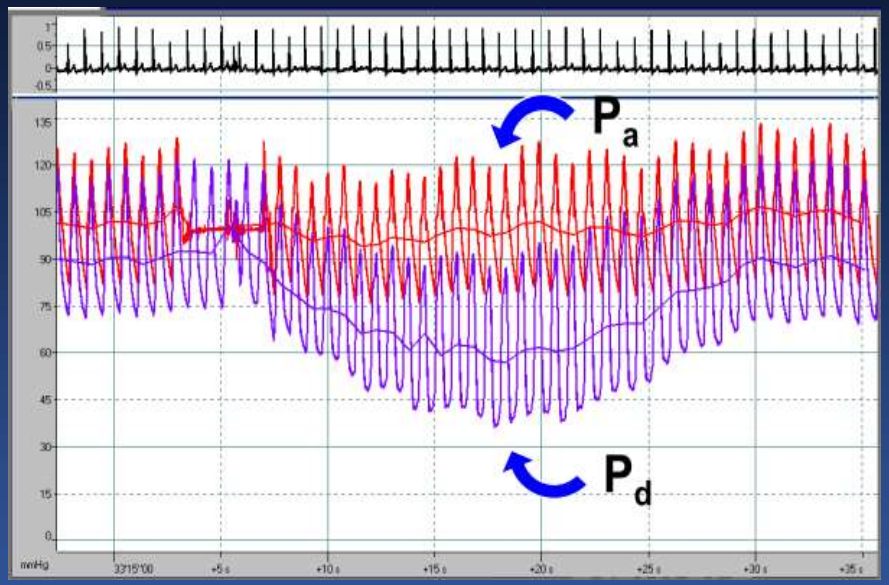
## *Death, MI, Stroke, or RR*




Park SJ, Ahn JM et al. Circ Cardiovasc Interv. 2015 Mar;8(3):e001846

# How to Do Optimal LM Stenting?

## Integrated Use of FFR and IVUS

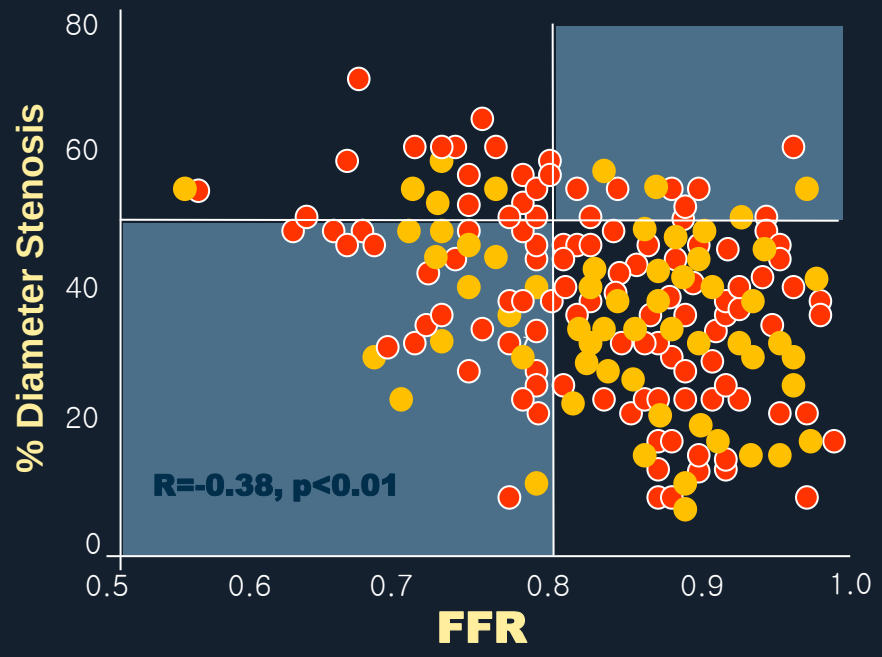


# Diagnosis for Significant LM

Which One is Significant LM stenosis?

# The Limitation of CAG

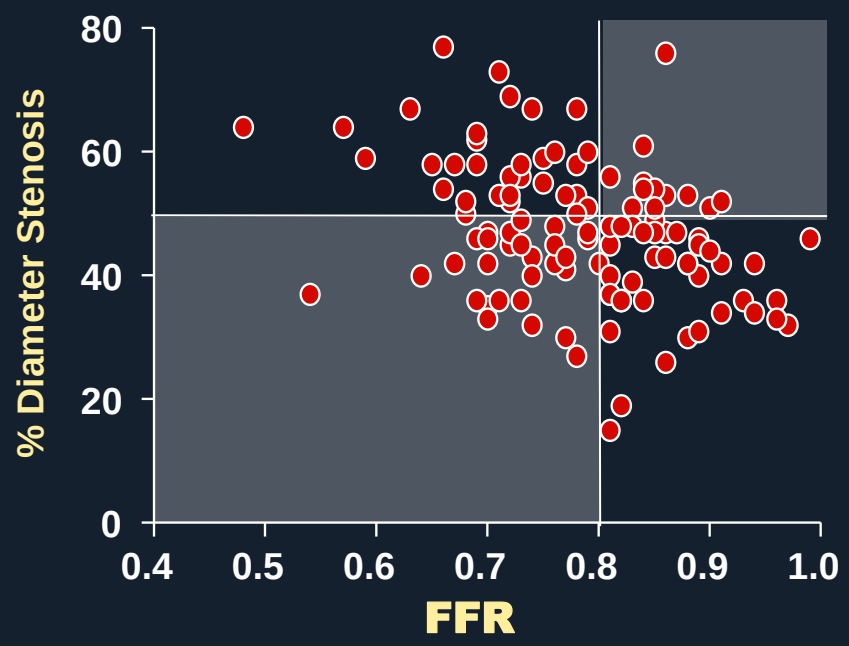
**"Mismatch" is 29% in equivocal LMCA**




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

● Isolated LMCA disease

**"Mismatch" is 37% in equivocal LMCA**

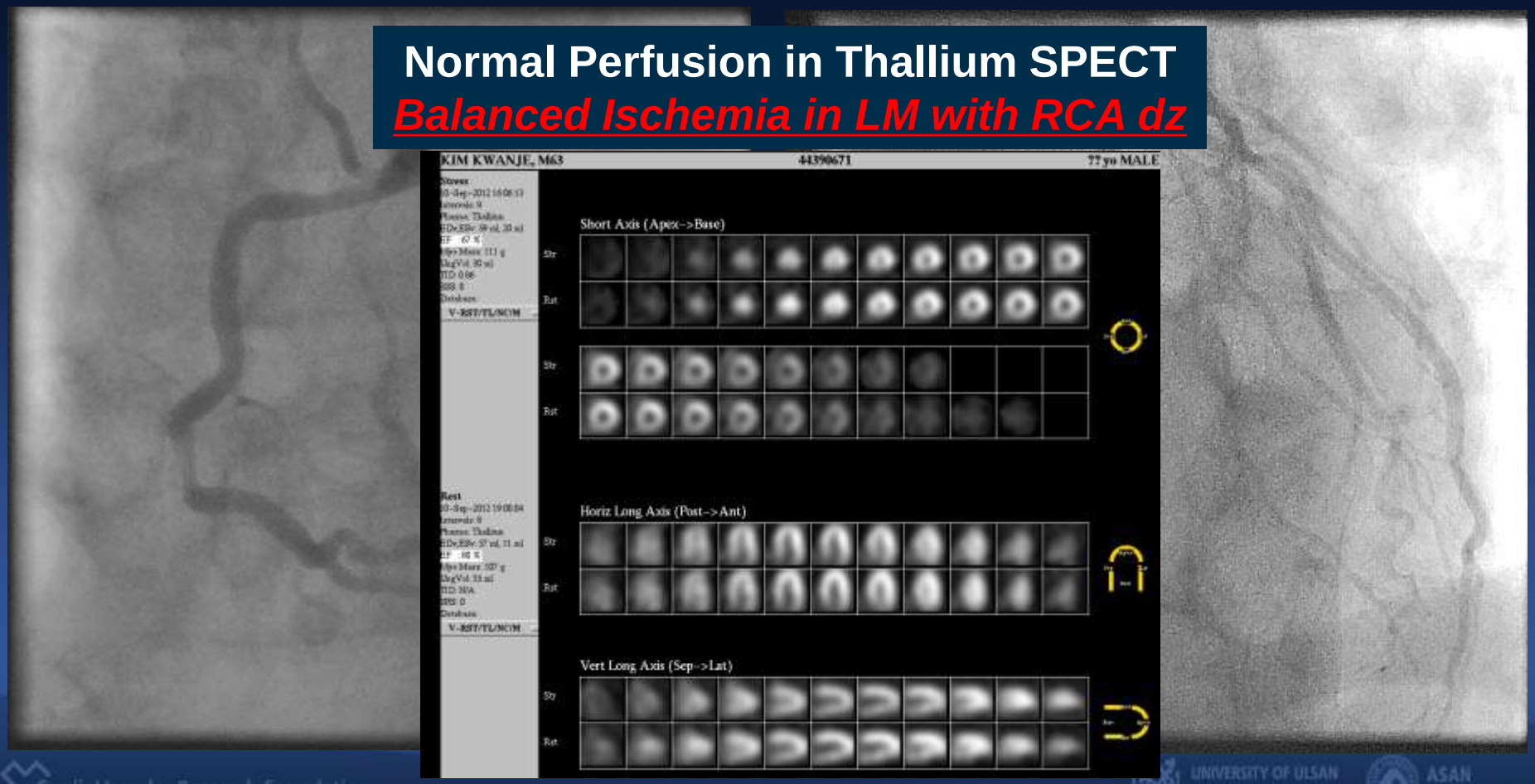



Park SJ, Ahn JM et al
JACC Cardiovasc Interv. 2014 ;7(8):868-74)

# LM Stenosis with RCA disease

**65yrs/M, eCP**

**RCA** **LCA**

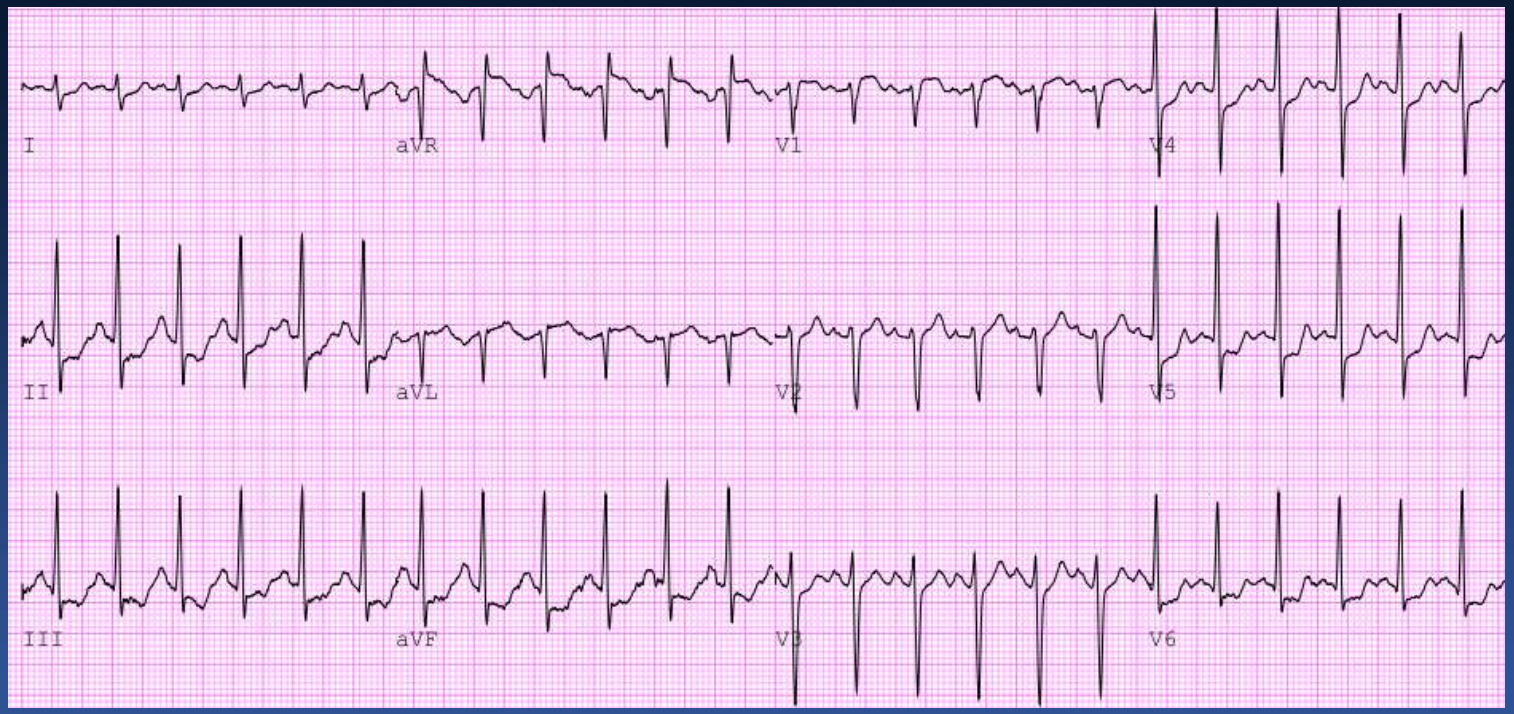



**Normal Perfusion in Thallium SPECT**

***Balanced Ischemia in LM with RCA dz***

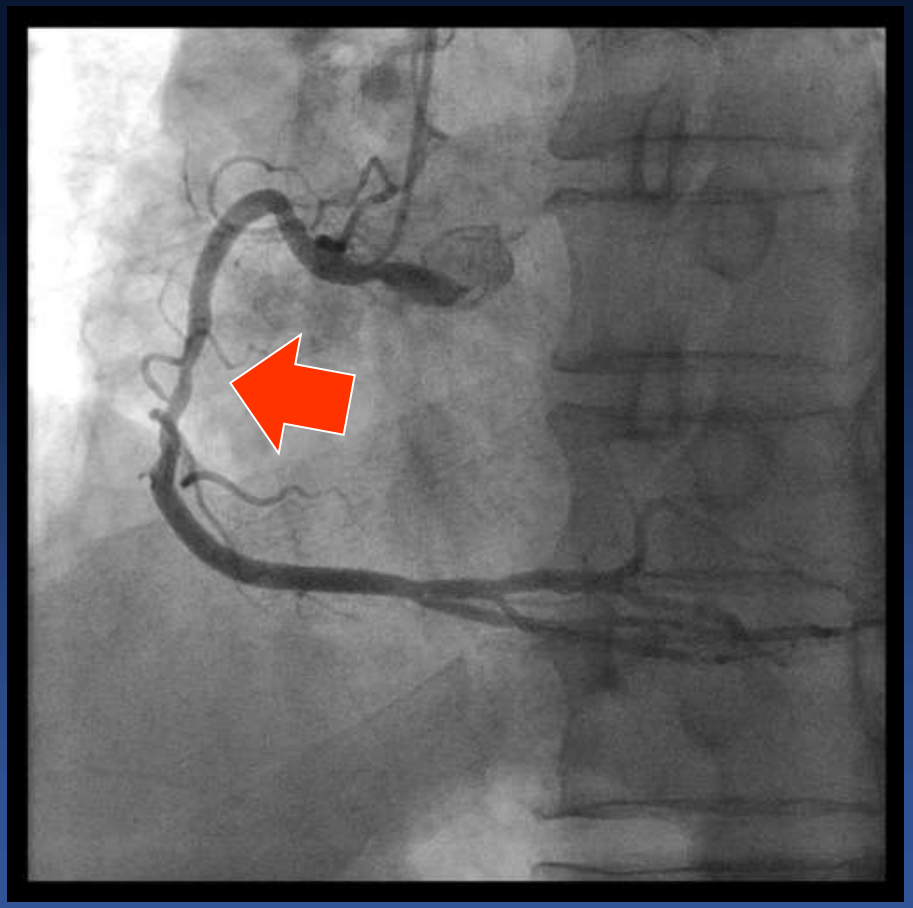
# M/76, eCP

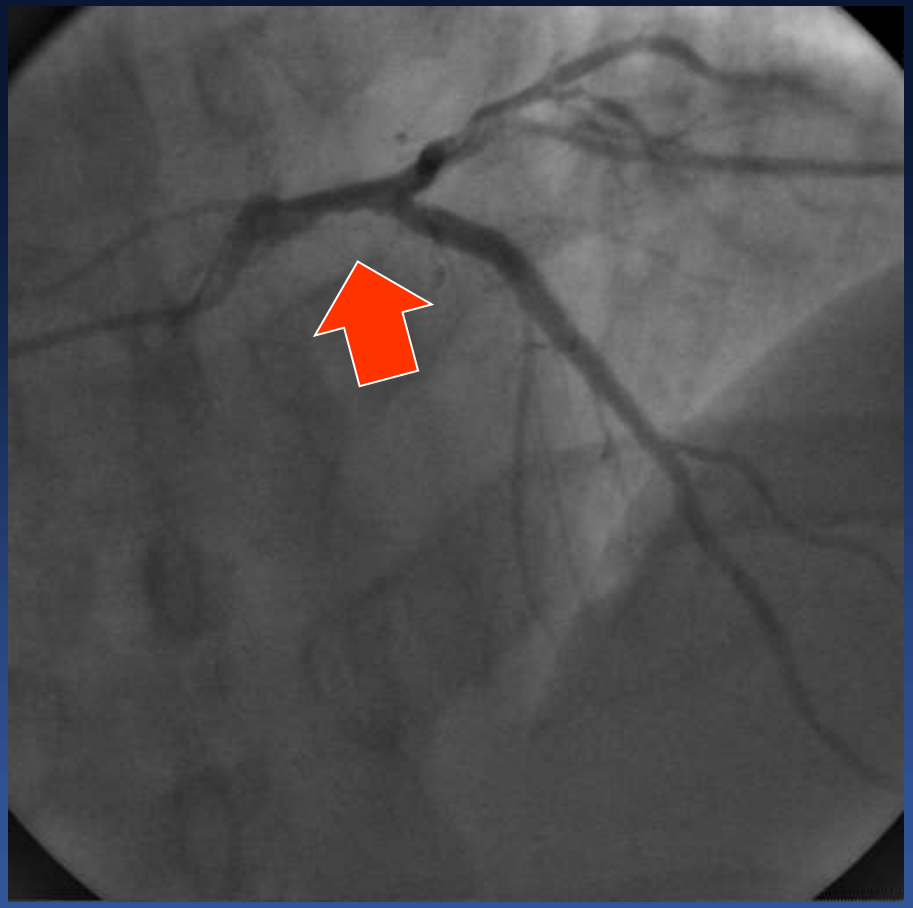
## Treadmill Test



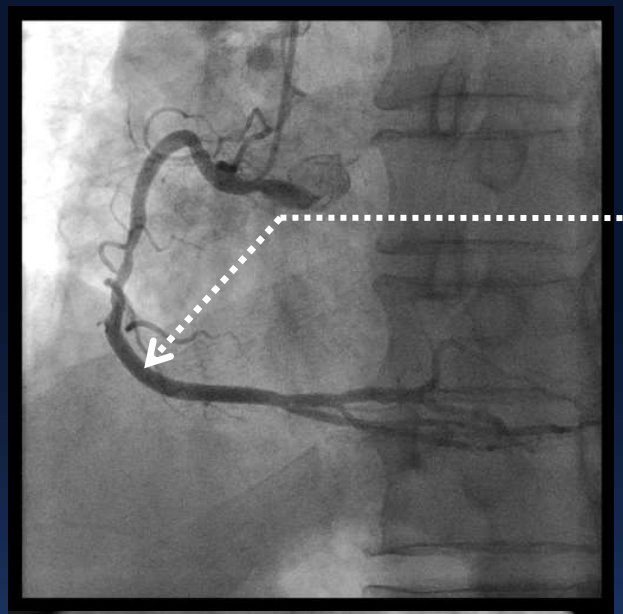

**Positive at Stage 4**

# Coronary Angiography

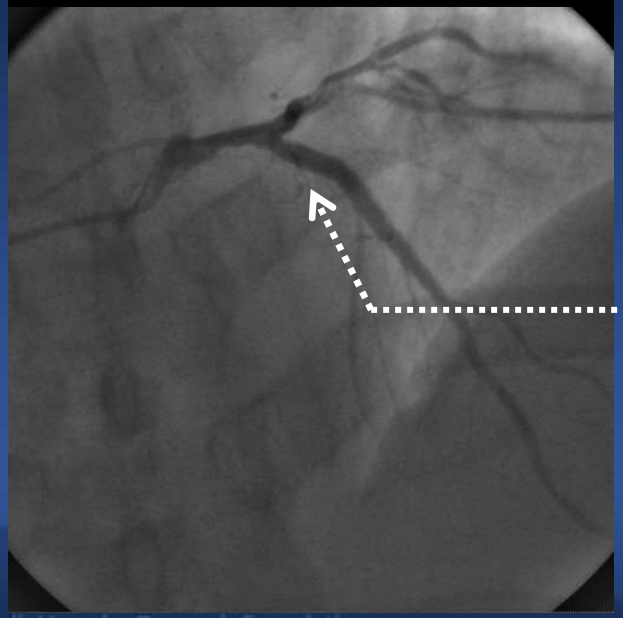




# FFR



0.72
PressureWire
(77)
(56)
0.72
14.90
AUTOSCALE

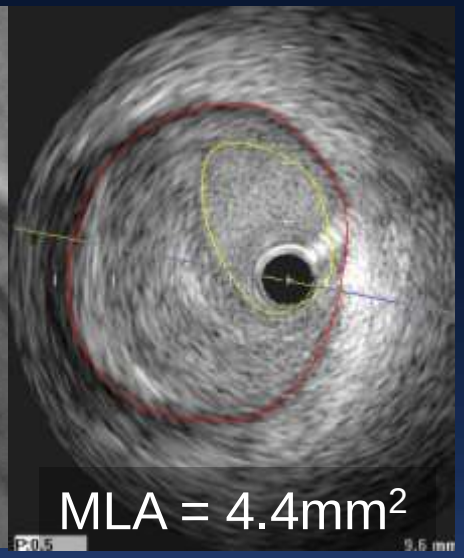


0.89
(87)
(77)
0.89
90.66
AUTOSCALE

# Which one is Significant LM stenosis?

**47/M Stable angina**

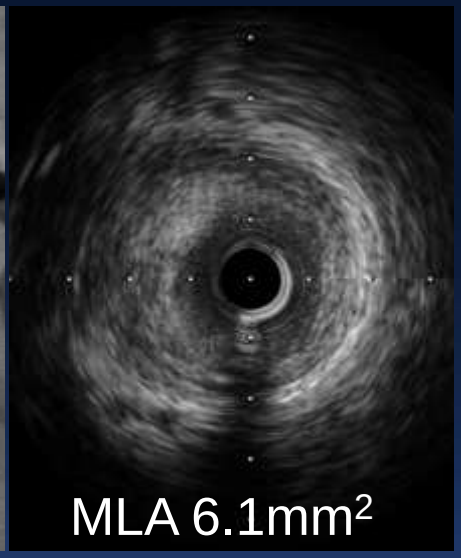
Ostial LM 60%



MLA = 4.4mm$^2$

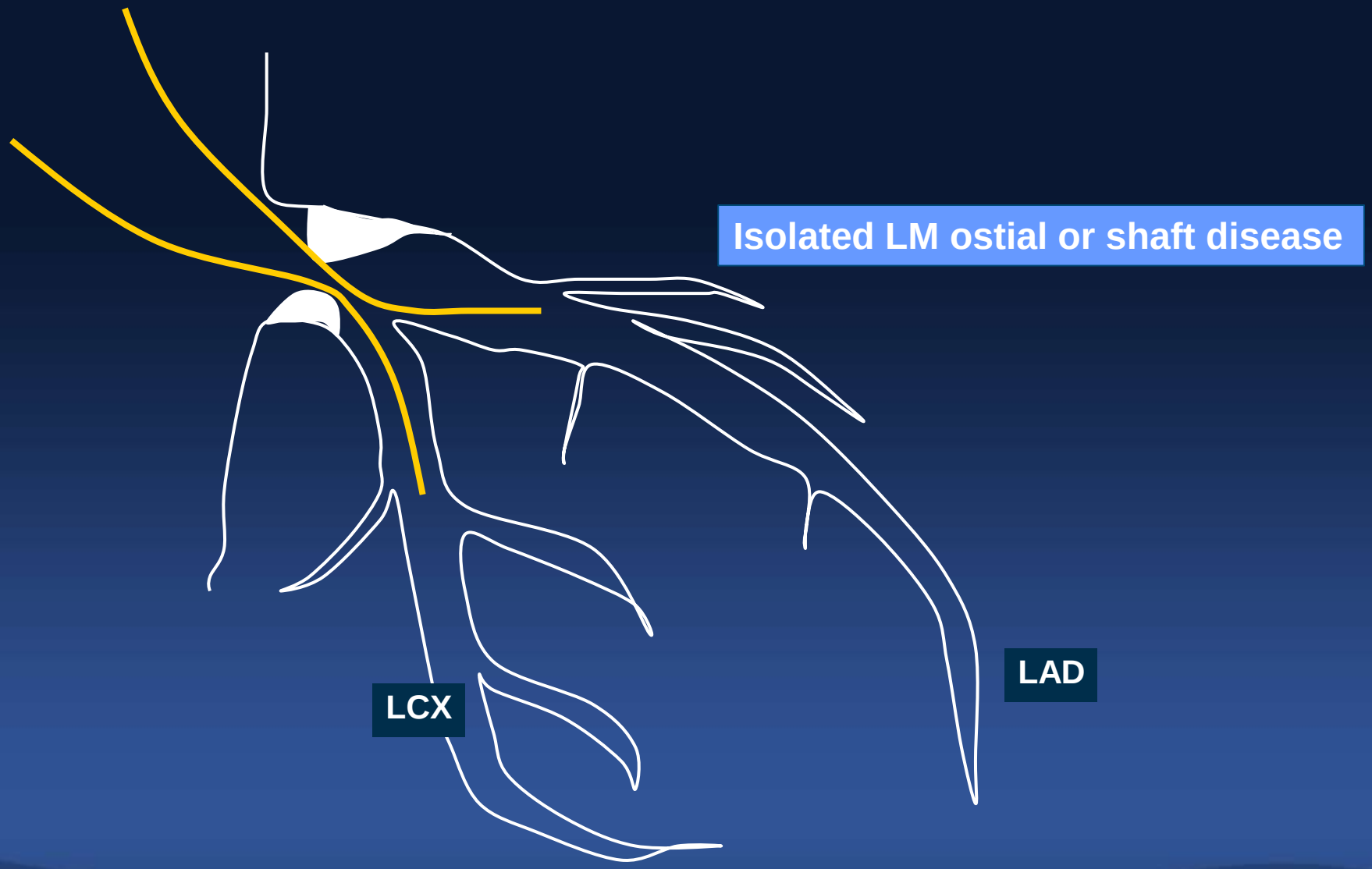
**50/M Stable angina**

Ostial LM 20%

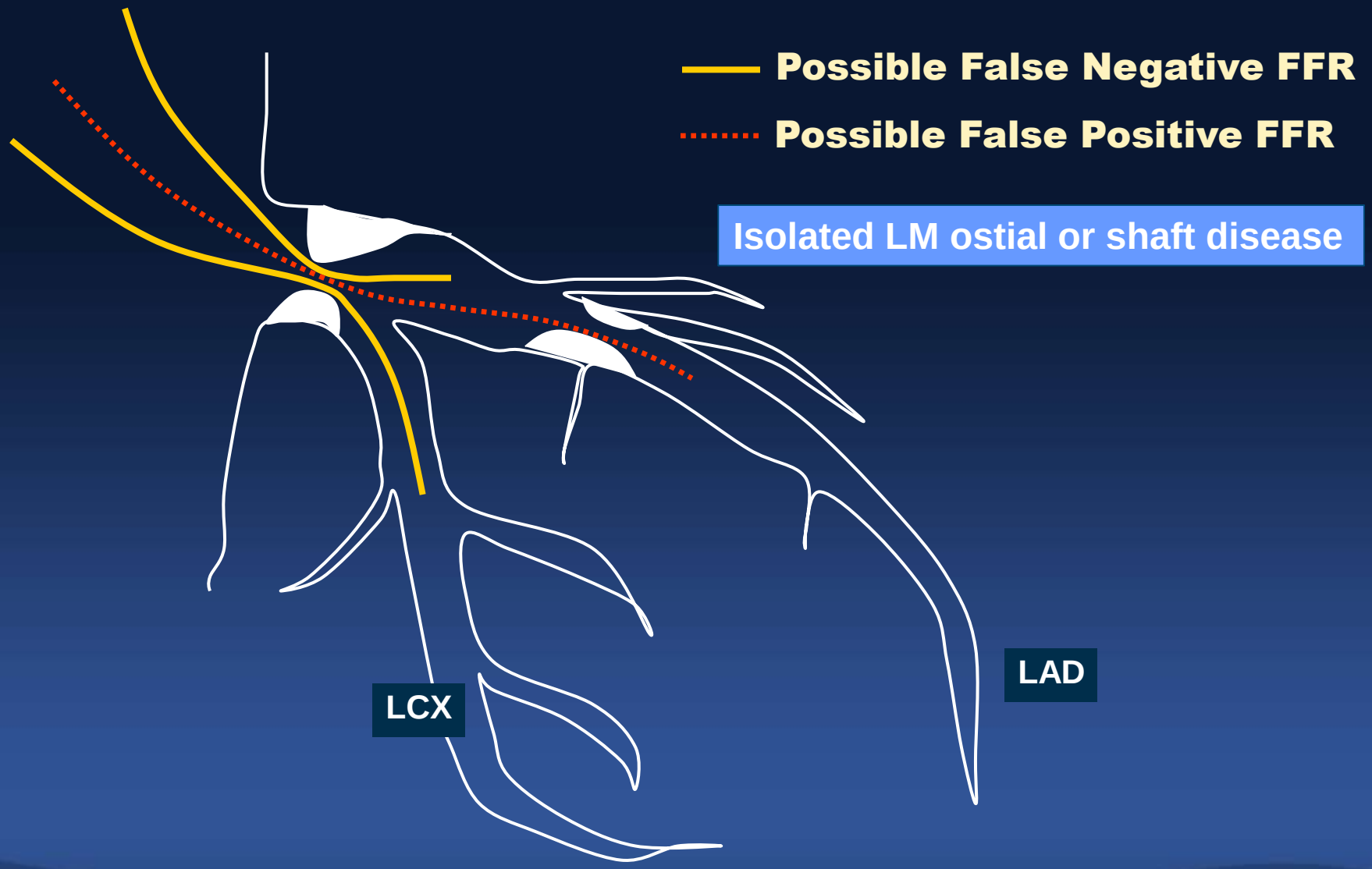


MLA 6.1mm$^2$

# Conceptual Limitations of FFR for LM Disease

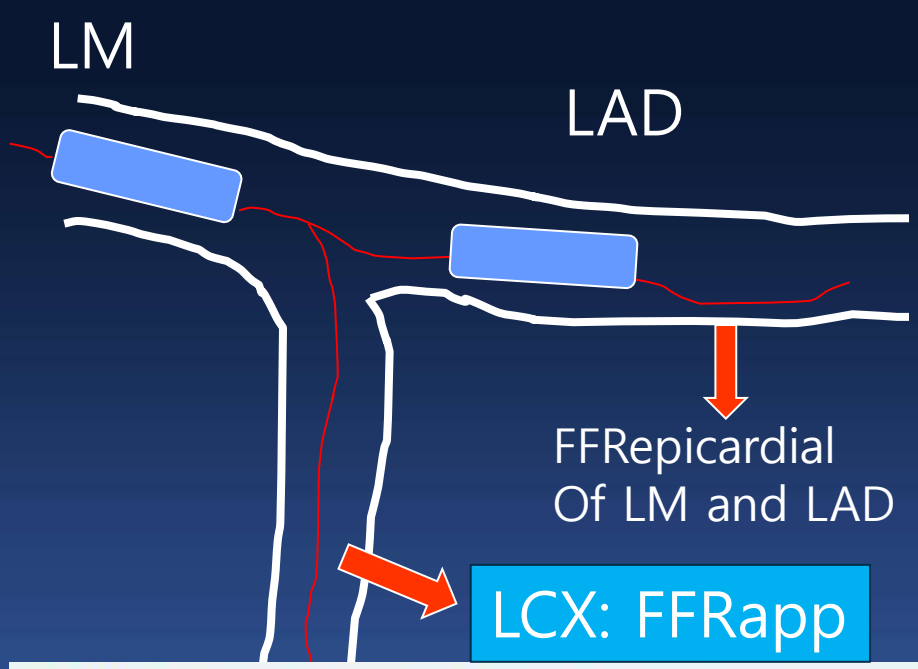


# Conceptual Limitations of FFR for LM Disease

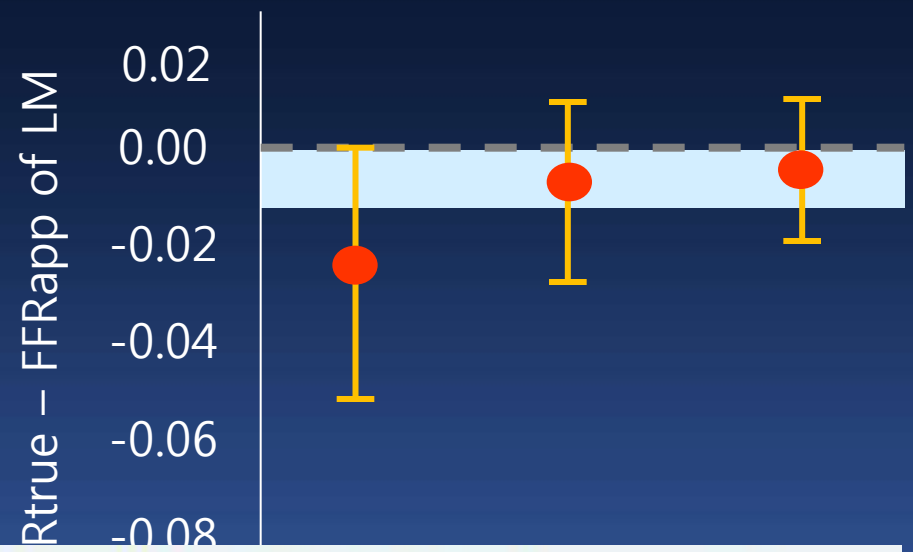


# LM and Downstream Disease

## Define Absolute Number of LM FFR




**Human Validation**

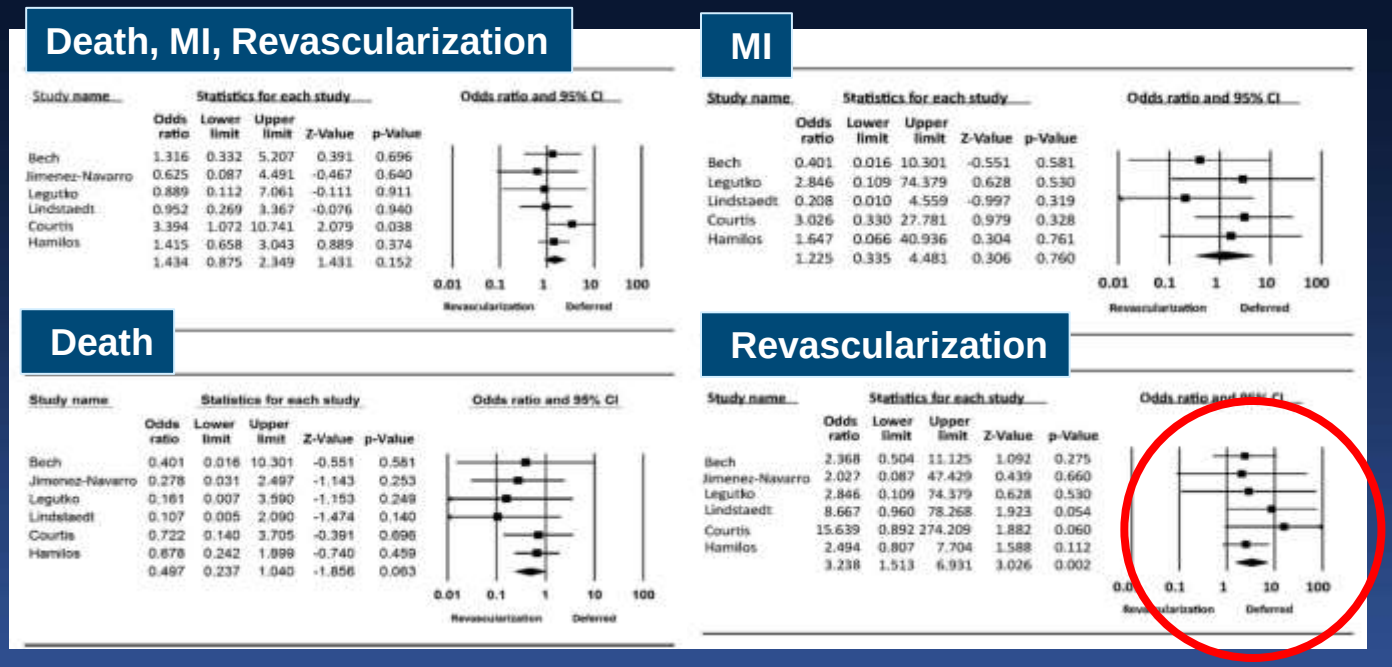



**RESULTS** In 25 patients, 91 pairs of measurements were made, 71 with LAD stenosis and 20 with LCx stenosis. $FFR_{true}$ of the LMCA was significantly lower than $FFR_{app}$ (0.81 ± 0.08 vs. 0.83 ± 0.08, $p < 0.001$), although the numerical difference was small. This difference correlated with the severity of the downstream disease ($r = 0.35$, $p < 0.001$). In all cases in which $FFR_{app}$ was >0.85, $FFR_{true}$ was >0.80.

Fearon WF, et al JACC Cardiovasc Interv. 2015 Mar;8(3):398-403

# Meta-analysis
# FFR Guided Treatment of LM:

6 prospective cohort studies involving 525 patients met the inclusion criteria




The long term clinical outcomes in patients with ambiguous LMCA stenosis for whom revascularization is deferred based on FFR are favorable and similar to the revascularized group in terms of overall mortality and MI

Catheterization and Cardiovascular Interventions 86:12–18 (2015)

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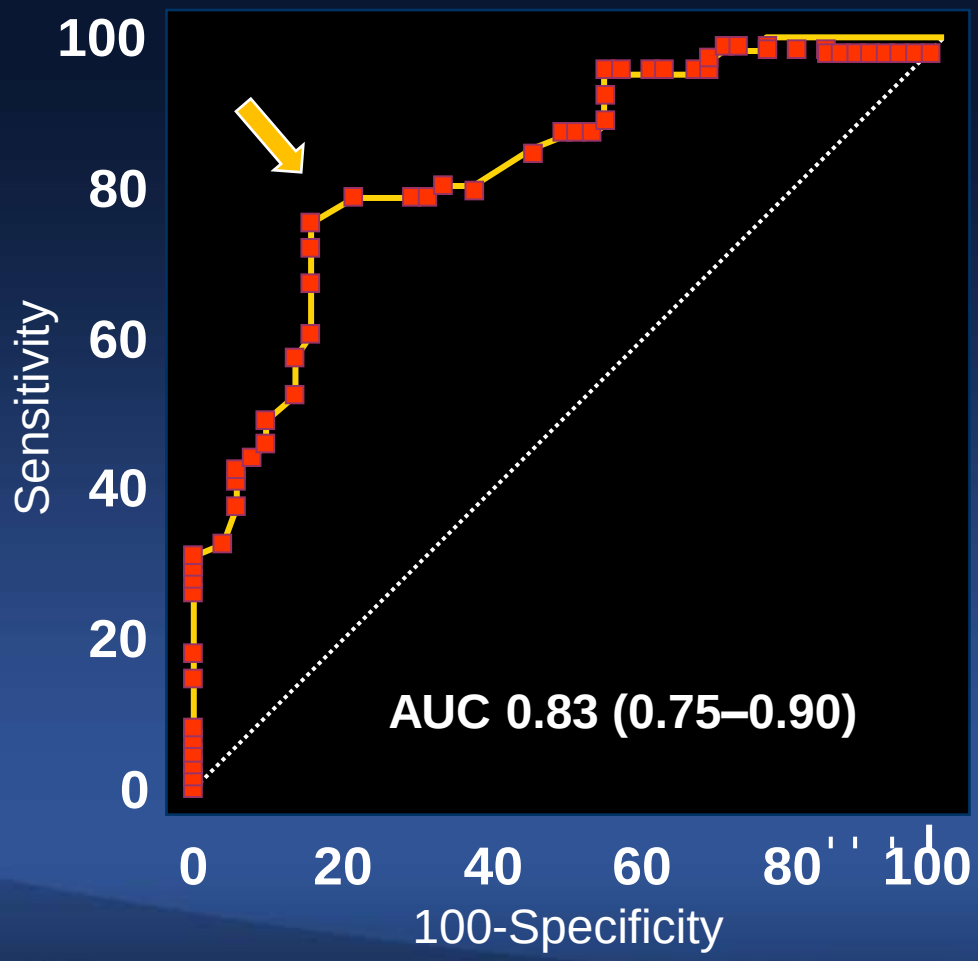
# IVUS MLA

## Matched with FFR <0.80 (N=112)




**Cut-off = 4.5 mm²**

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

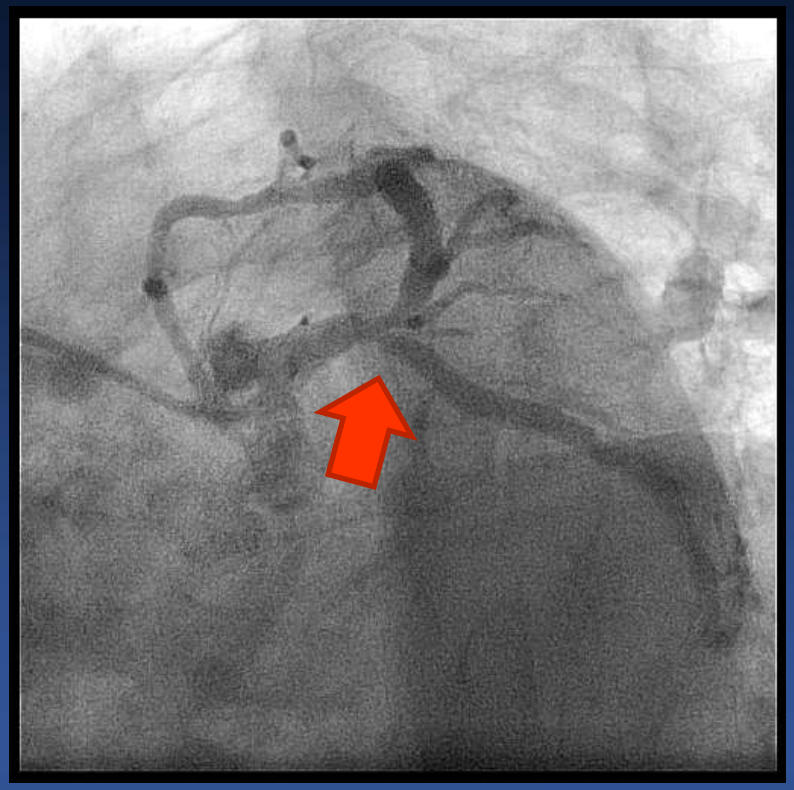


Park SJ, Ahn JM et al. *JACC Interv, 2014;7(8):868-874*

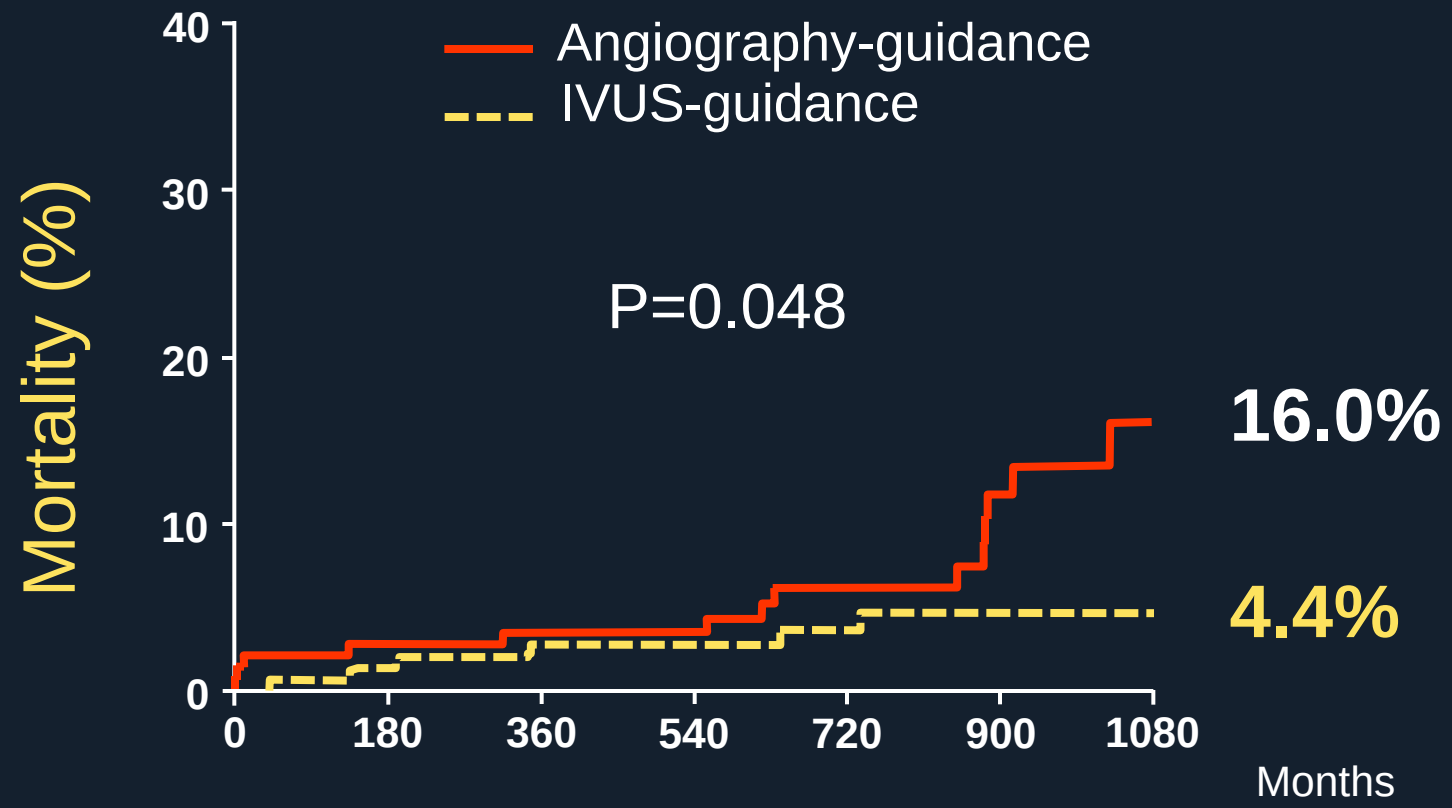
# How to Treat: PCI Strategy

Ostial and Shaft Disease

Bifurcation Disease



# *IVUS Guidance Saved Lives !*




| Patients after risk | | | | |
|---|---|---|---|---|
| IVUS-guidance | 145 | 140 | 98 | 37 |
| Angiography-guidance | 145 | 137 | 88 | 29 |

Park SJ et al, Circulation. Cardiovasc Interv. 2009;2(3):167-77.

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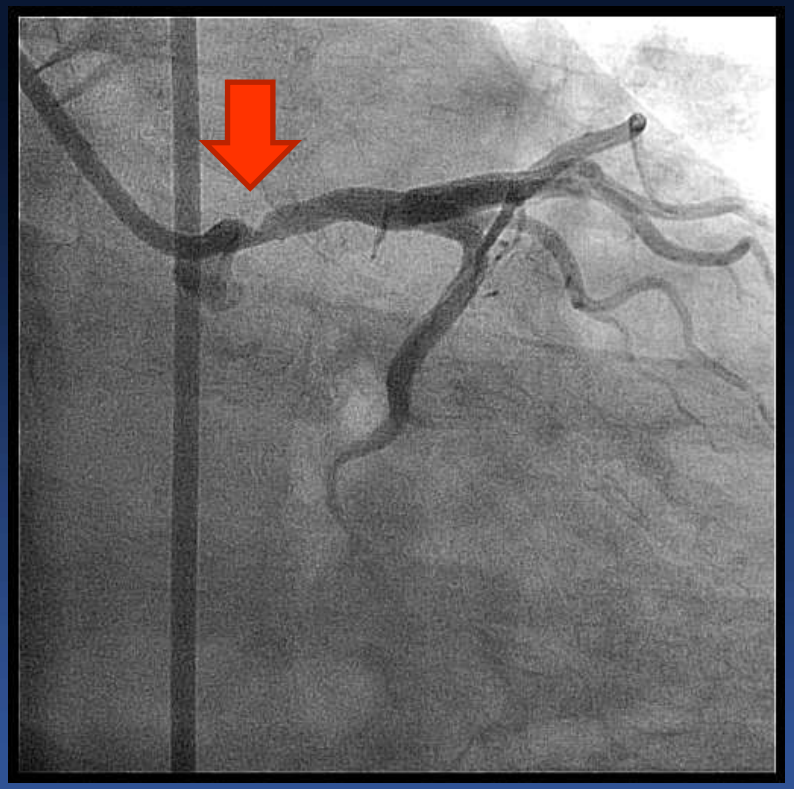
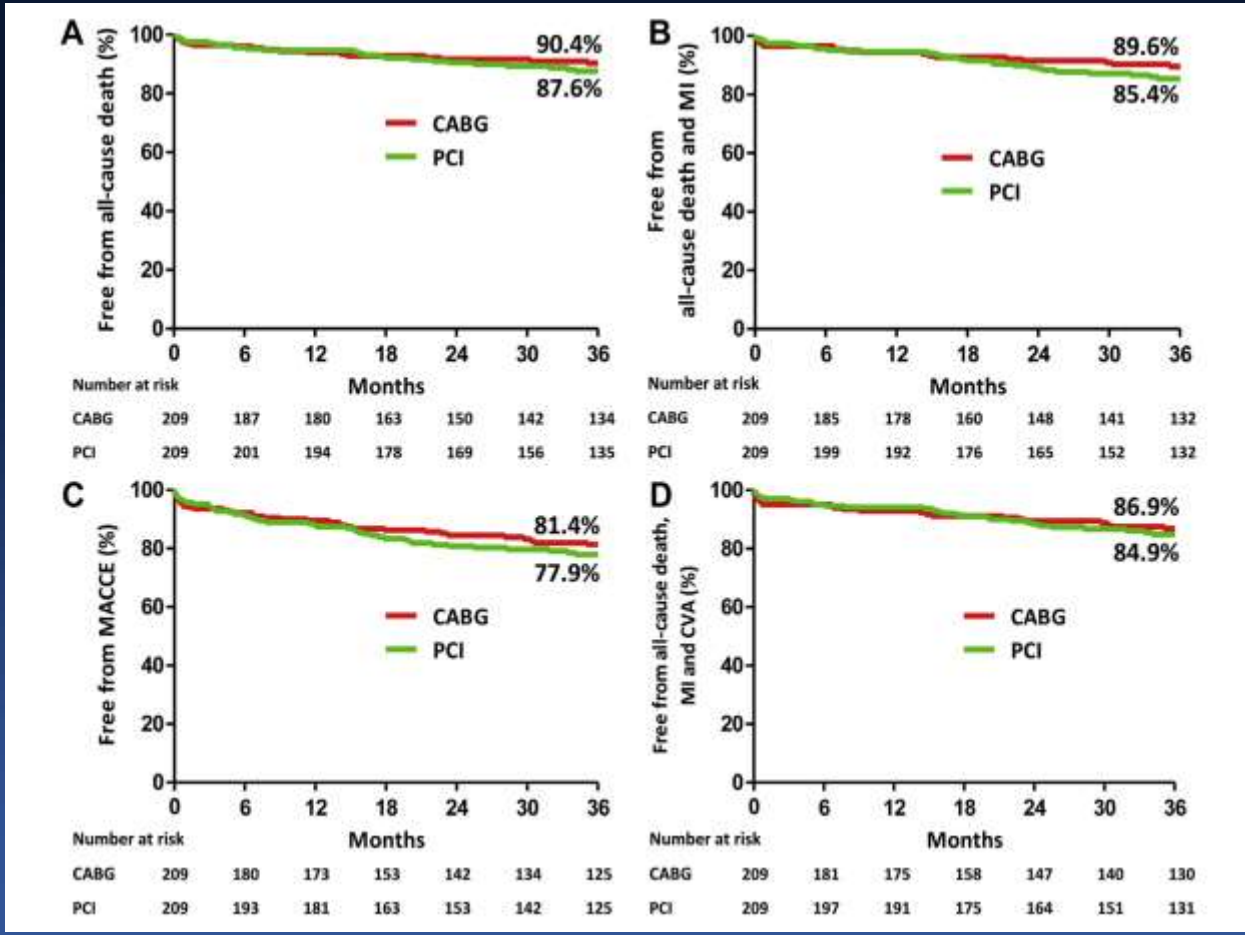
# Left Main Ostial or Shaft Disease



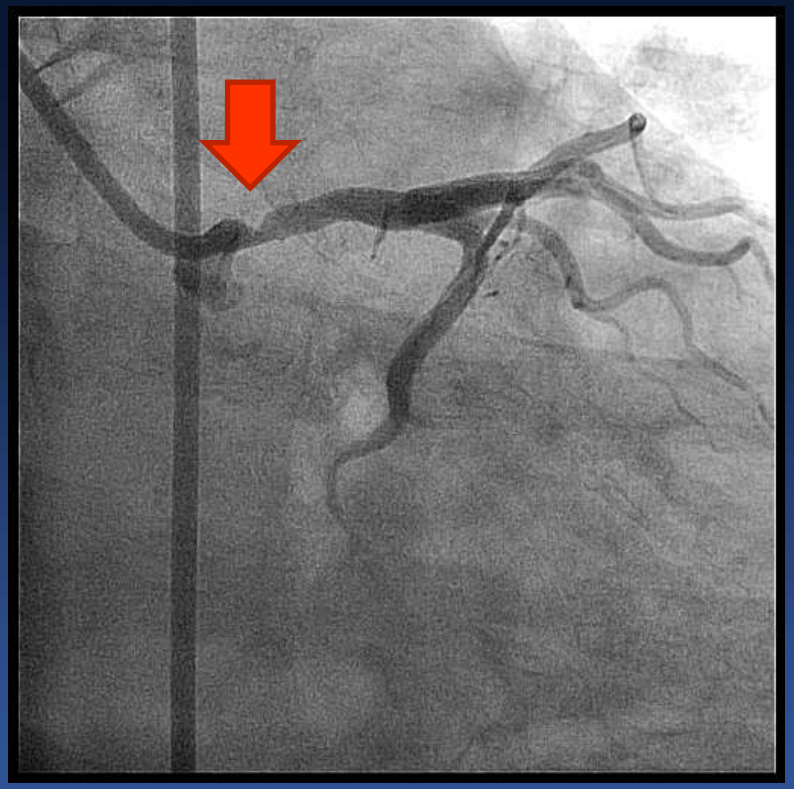
# Left Main Ostial or Shaft Disease




DELTA Registry J Am Coll Cardiol Intv 2014;7:354–61

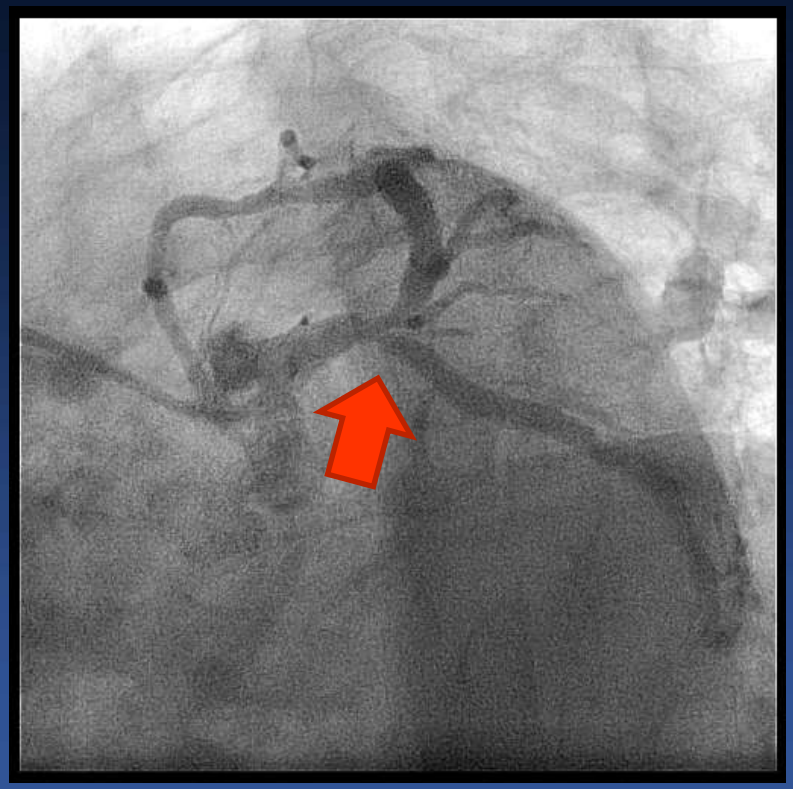
# Left Main Ostial or Shaft Disease

Just Stent it



# How to Treat: PCI Strategy

Bifurcation Disease



# One Stent Better Than Two Stent For LM Bifurcation

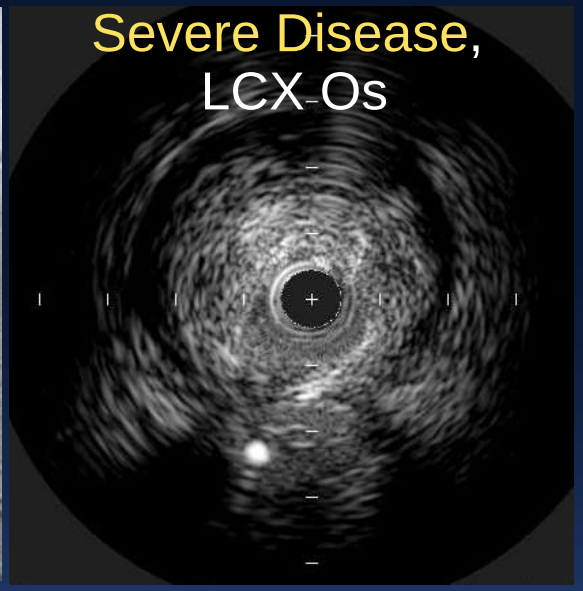
| | Patients N | | FU | Hazard Ratio | | | |
|---|---|---|---|---|---|---|---|
| | 1 Stent | 2 Stent | (M) | MACE | Death | MI | TVR |
| Palmerini[1] | 456 | 317 | 24 | 0.48 P=0.001 | - | - | - |
| Toyofuku[2] | 261 | 119 | 36 | - | 0.61 P=0.09 | - | 0.32 P<0.01 |
| Kim[3] | 234 | 158 | 36 | 0.89 P<0.001 | 0.77 P=0.62 | 0.38 P<0.01 | 0.16 P=0.005 |
| Song[4] | 509 | 344 | 36 | 0.42 P<0.001 | 0.30 P=0.02 | 0.41 P=0.04 | 0.47 P<0.01 |

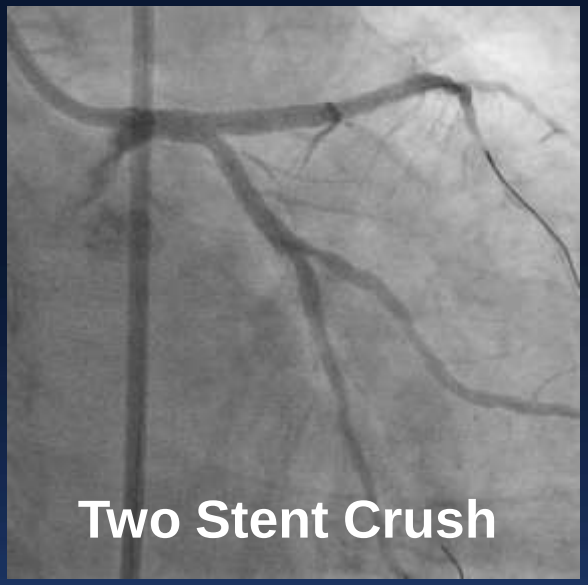
[1]Circ Cardiovasc Interv. 2008;1:185-92
[2]JACC Cardiovasc Interv. 2014;7:255-63
[3]Catheter Cardiovasc Interv. 2011;77:775-82
[4]Circulation. 2009;120:1866-74

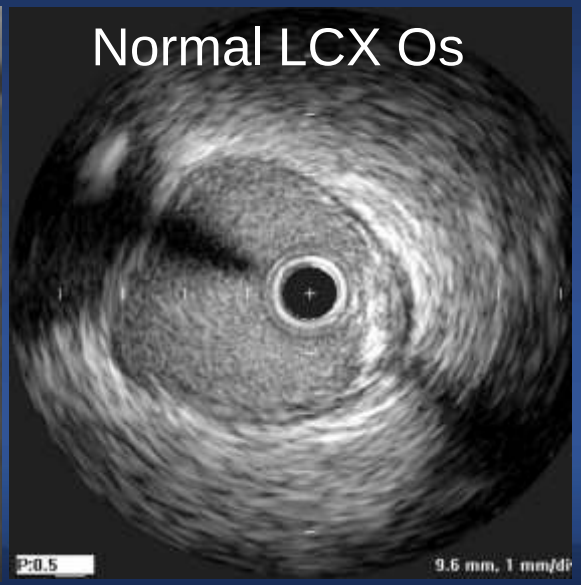
# LM Bifurcation

| | |
|---|---|
| **Stent Cross Over** | ***Normal Ostial LCX (Medina 1.1.0., 1.0.0)***<br>Normal or Diminutive LCX<br>Small LCX with < 2.5 mm in diameter<br>Focal disease in distal LCX |
| **Two Stent** | ***Diseased LCX (Medina 1.1.1., 1.0.1)***<br>Large LCX with ≥ 2.5 mm in diameter<br>Diseased left dominant coronary system<br>Concomitant diffuse disease in distal LCX |

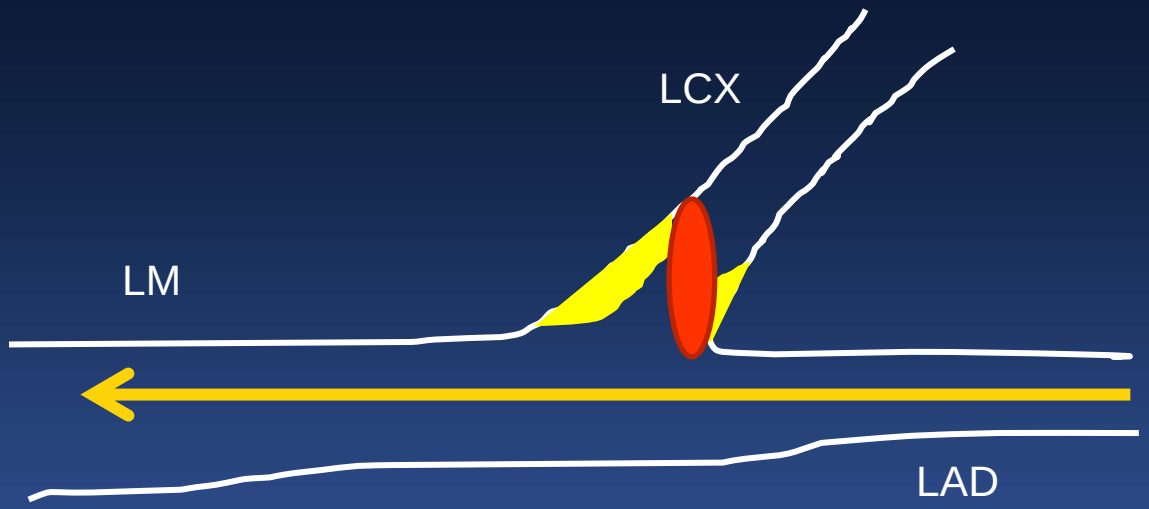
# Direct LCX pullback IVUS
# LAD pullback overestimates LCX ostial MLA



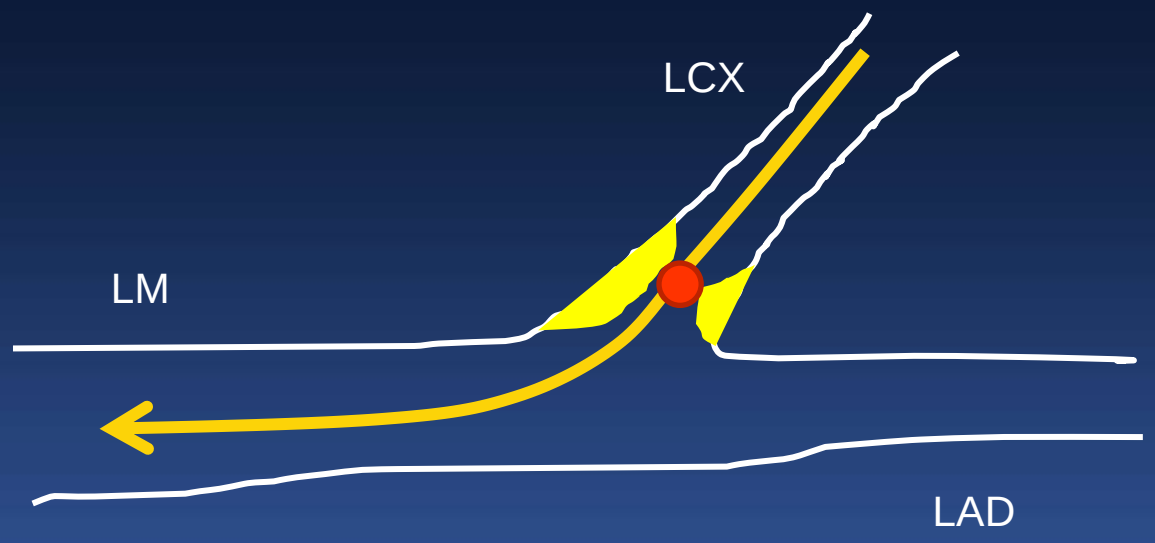





# *Direct LCX pullback IVUS*
# *LAD pullback overestimates LCX ostial MLA*



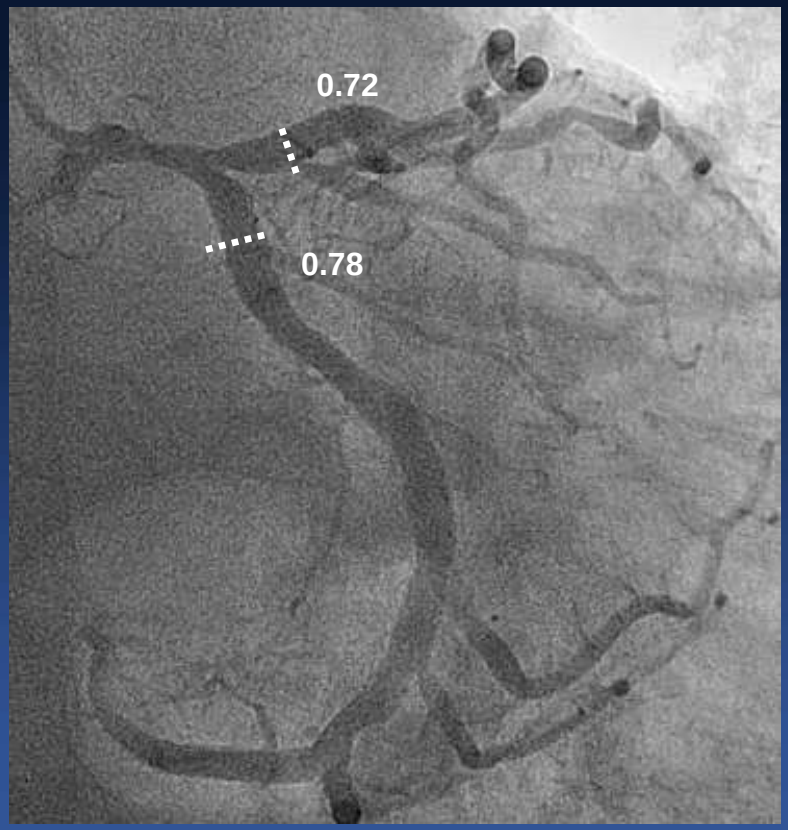
# *Direct LCX pullback IVUS*
# *LAD pullback overestimates LCX ostial MLA*



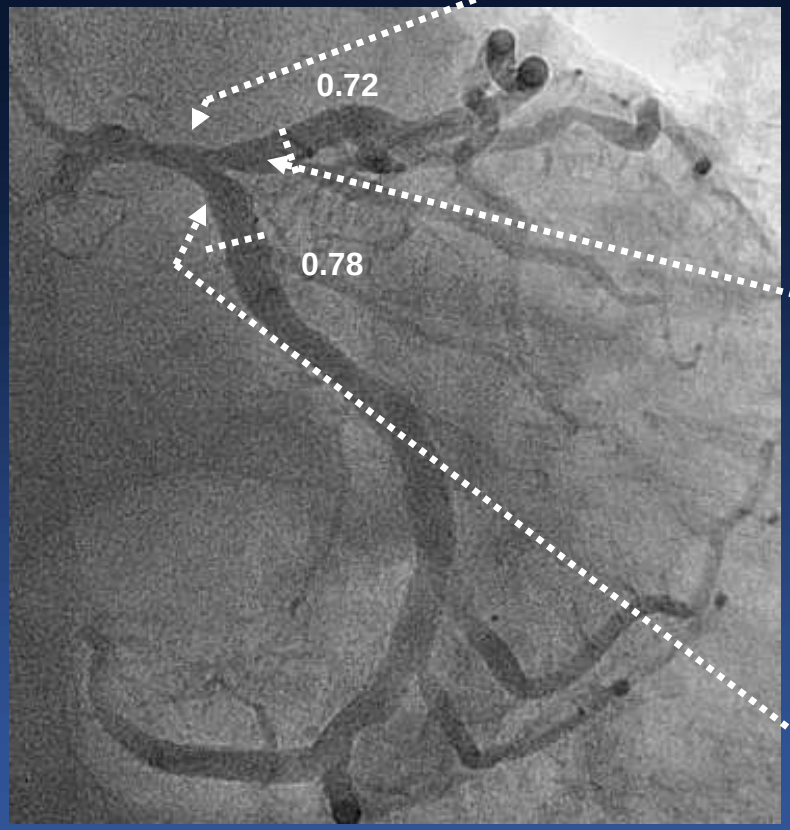
# LM Bifurcation Lesion (Medina 1,0,0) with Minimal LCX Disease

55/M, Stable angina,

# FFR in Both LAD and LCX,

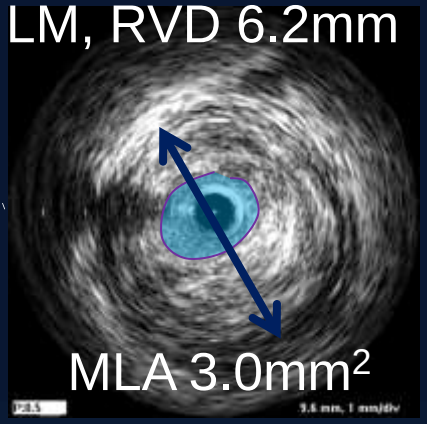


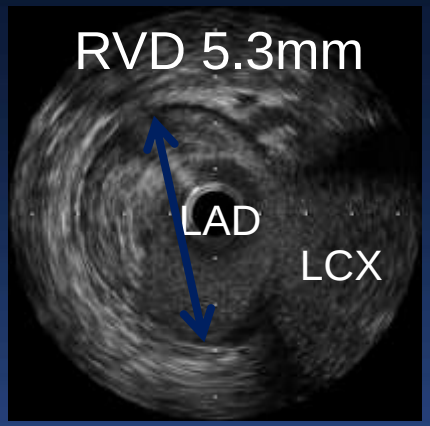
# **IVUS** in Both LAD and LCX,

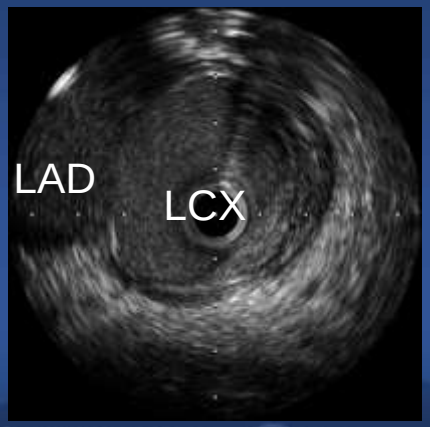



Minimal disease at LCX ostium

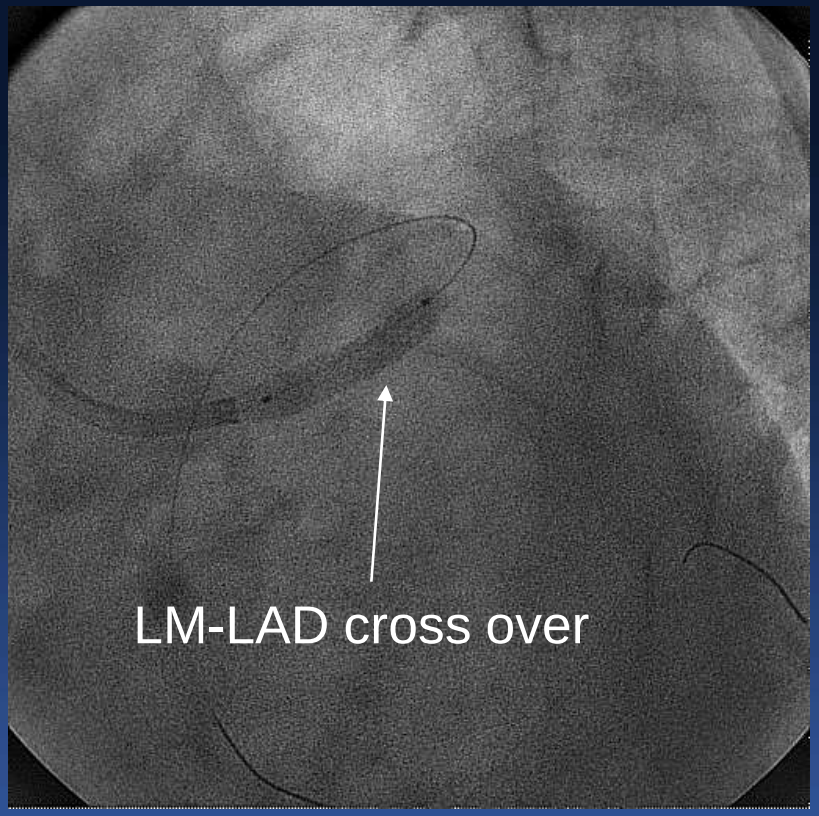
Distal LM, RVD 6.2mm



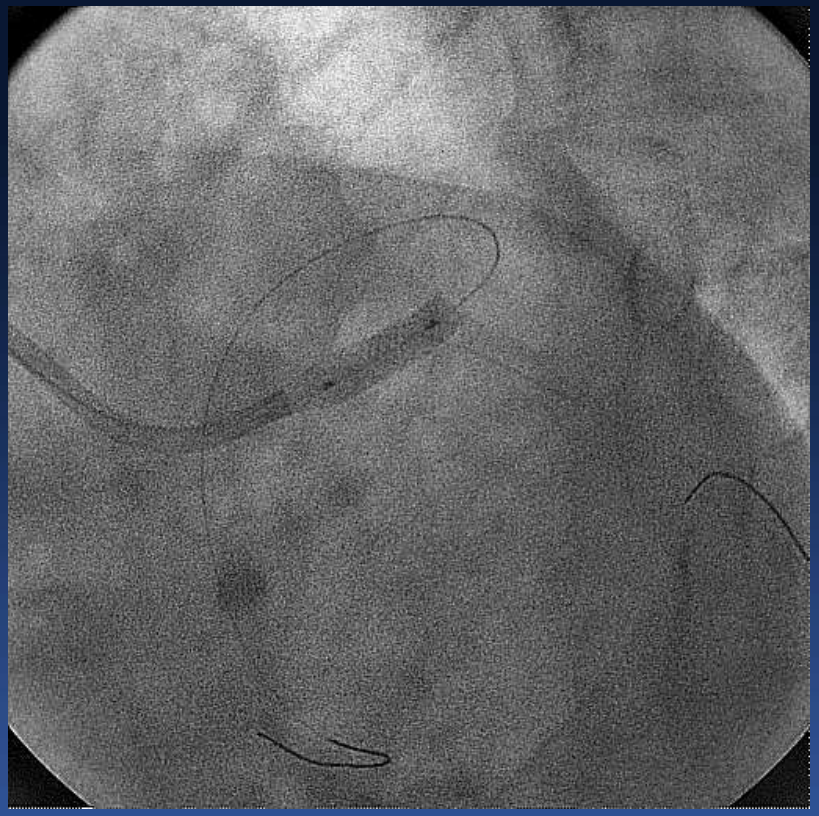



# Single Stent Cross-Over
## with minimal-disease at LCX OS

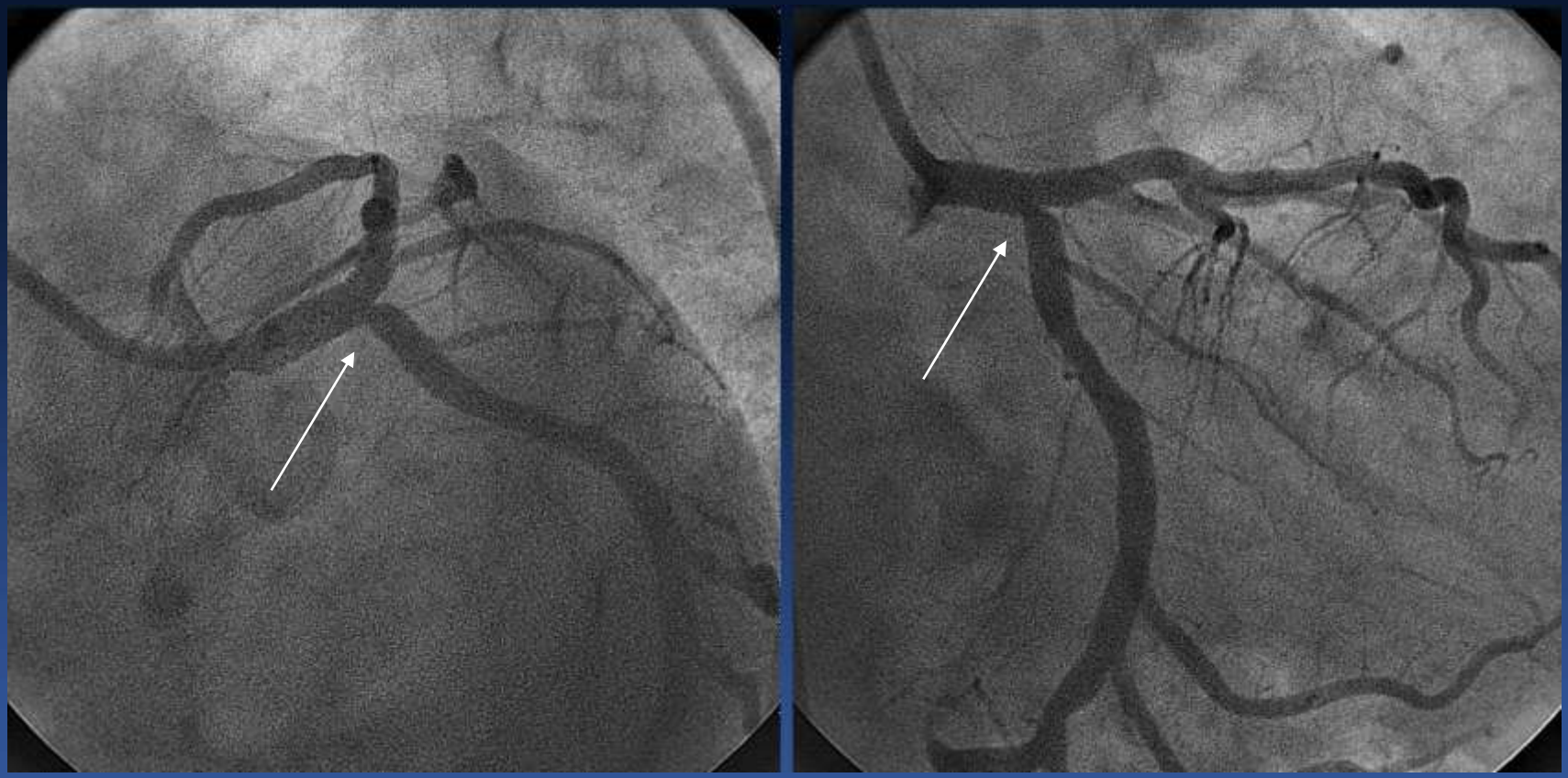



Promus Element
4.0x20



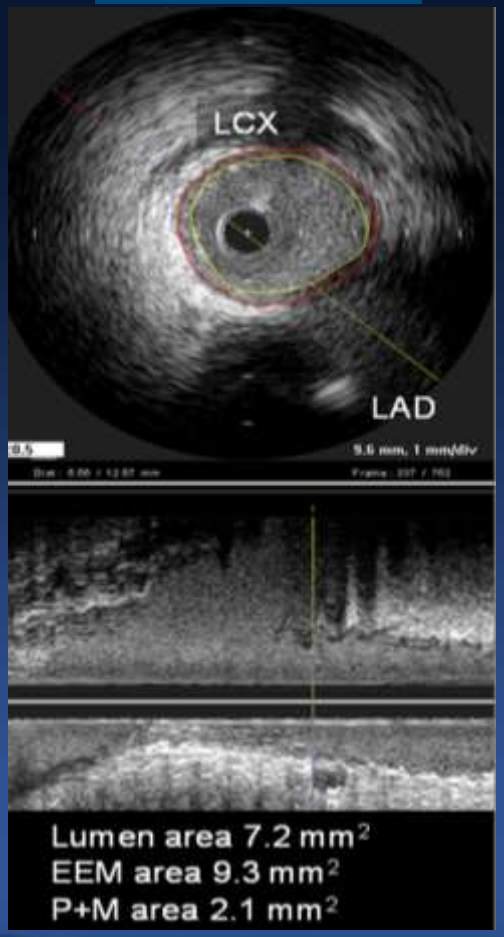
Additional high pressure
Inflation with 4.0 mm
non-compliant balloon

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

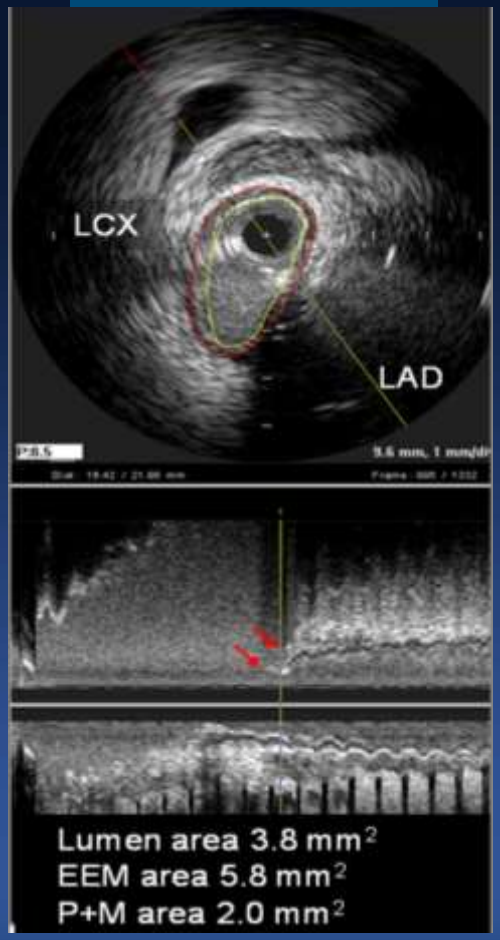


# Geometric Change in LCX Ostium After Stent Cross Over

**Pre-Stenting**




**Post-Stenting**




1)Carina shift
2)MLA ↓
3)Eccentricity ↑

Kang SJ et al. Circ Cardiovasc Interv. 2011;4:355-361.

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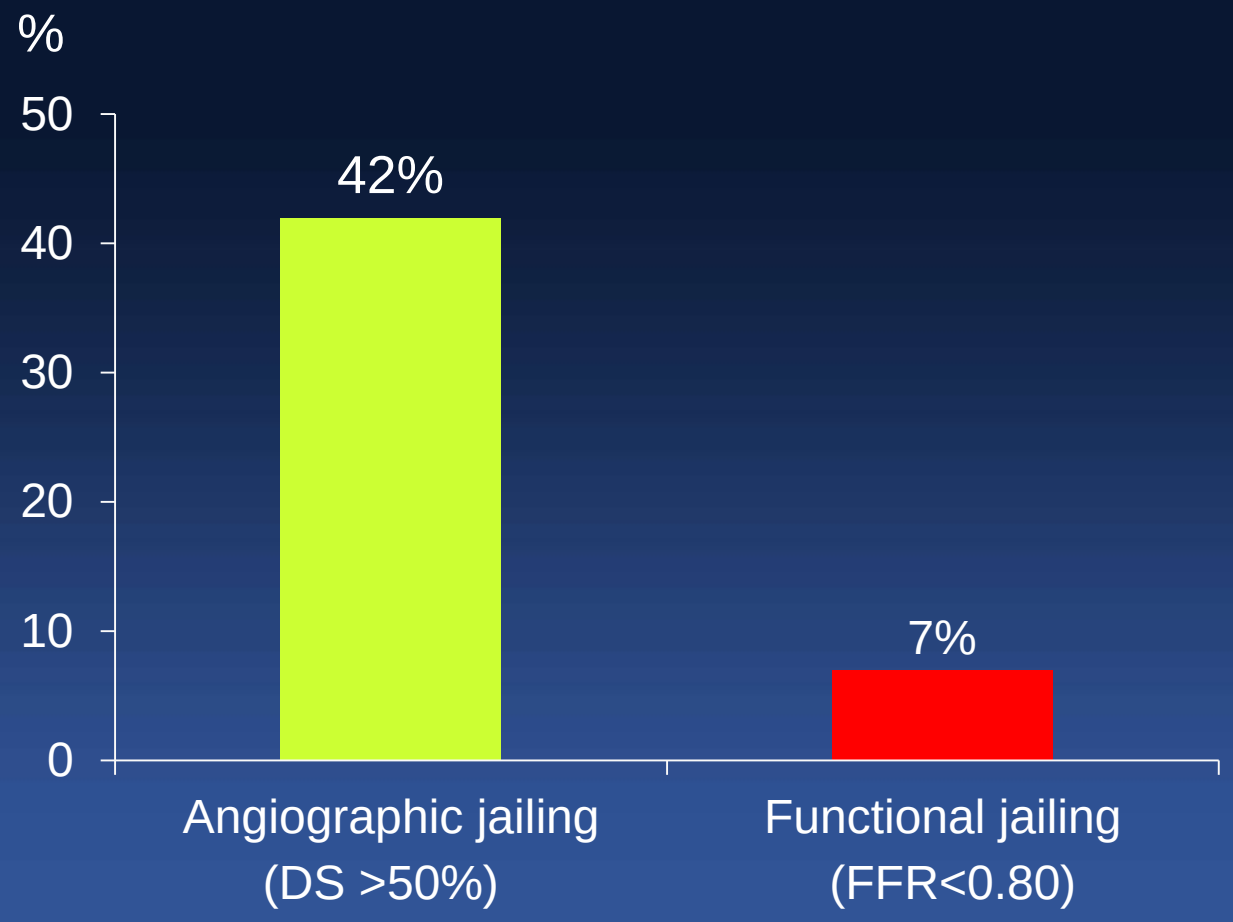
# *Functionally Significant LCX Jailing*
## After Stent Crossover (LCX ostial DS<50%)




Kang SJ, Catheterization and Cardiovascular Interventions. 2014;83(4):545-52.

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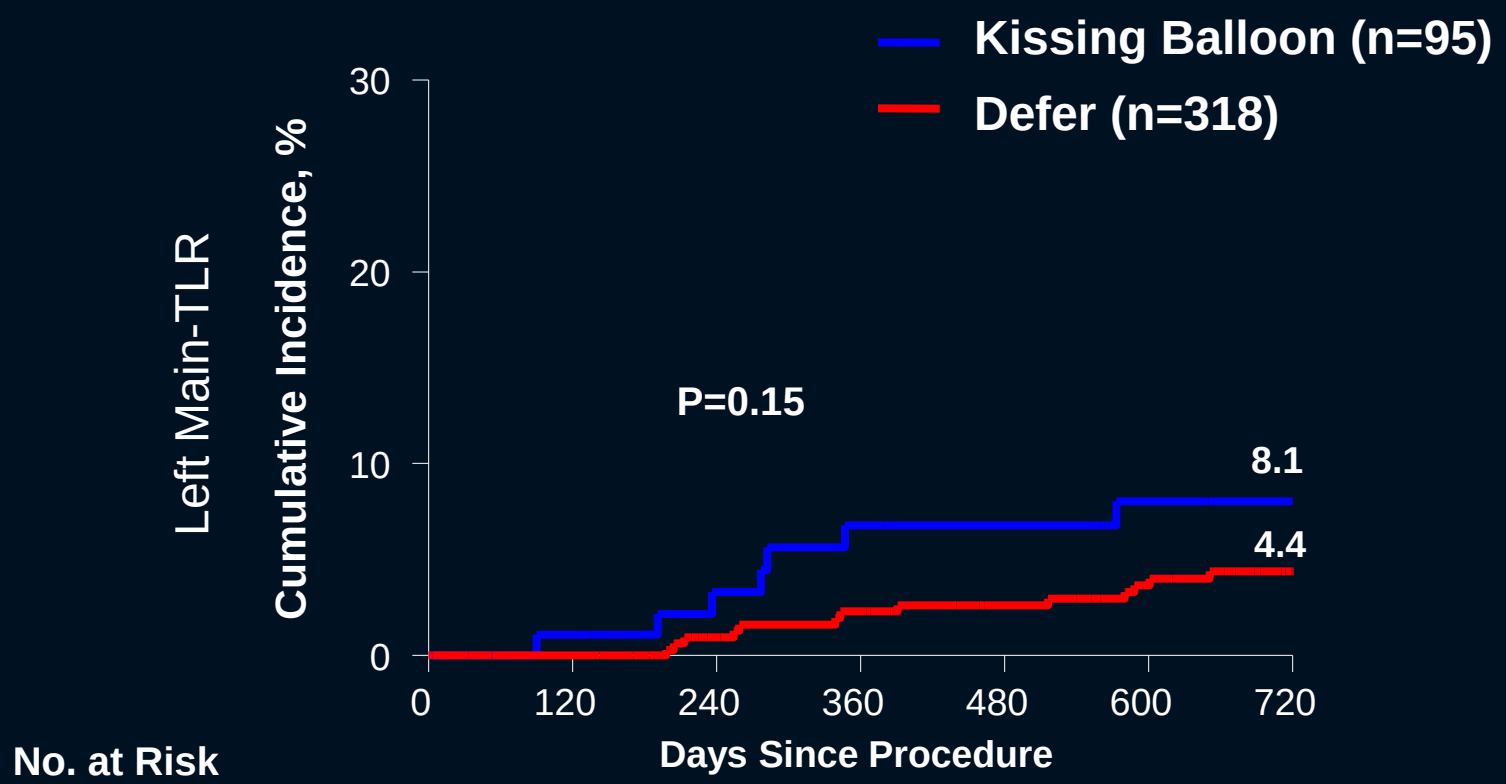
# Final Kissing Balloon

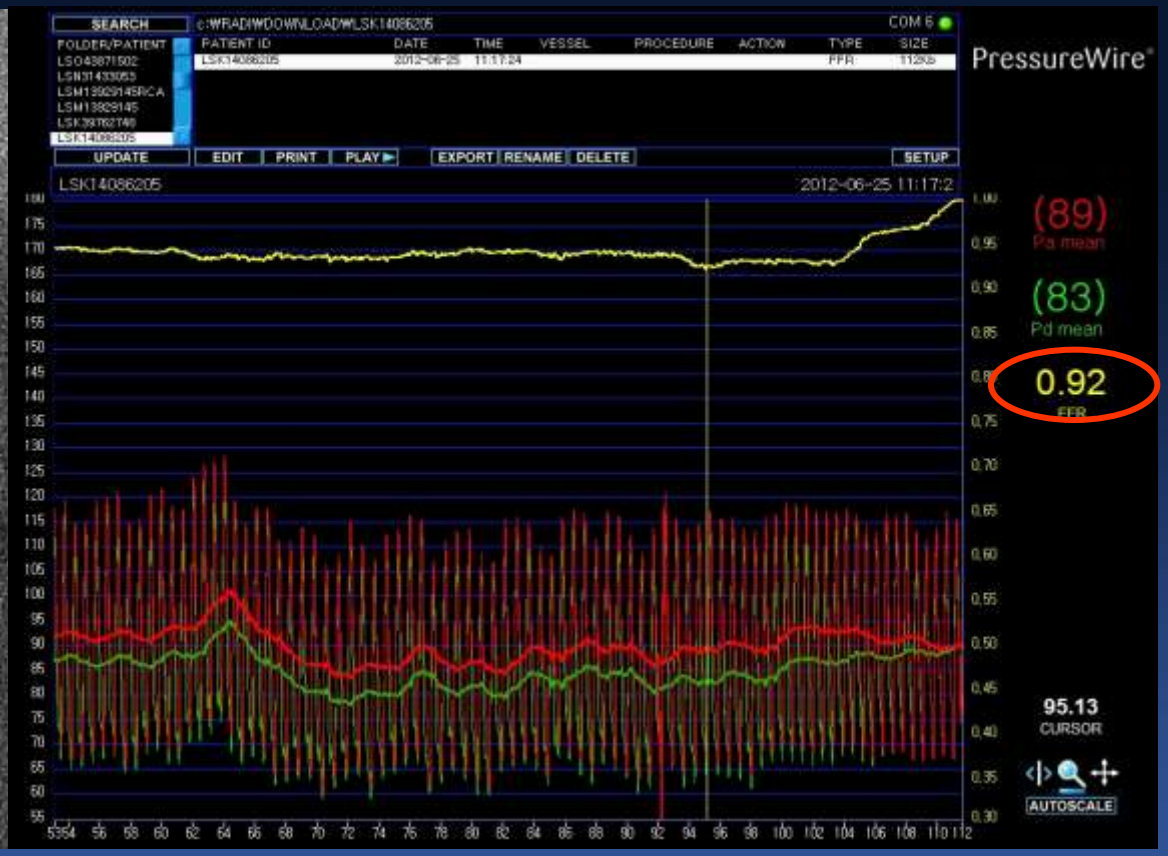



| No. at Risk | | | |
|---|---|---|---|
| FKB | 95 | 79 | 74 |
| No-FKB | 318 | 293 | 265 |

*Ahn JM, Park SJ, et al. Am J Cardiol. 2017 Feb 15;119(4):528-534*

# Do You Want to Treat It ?

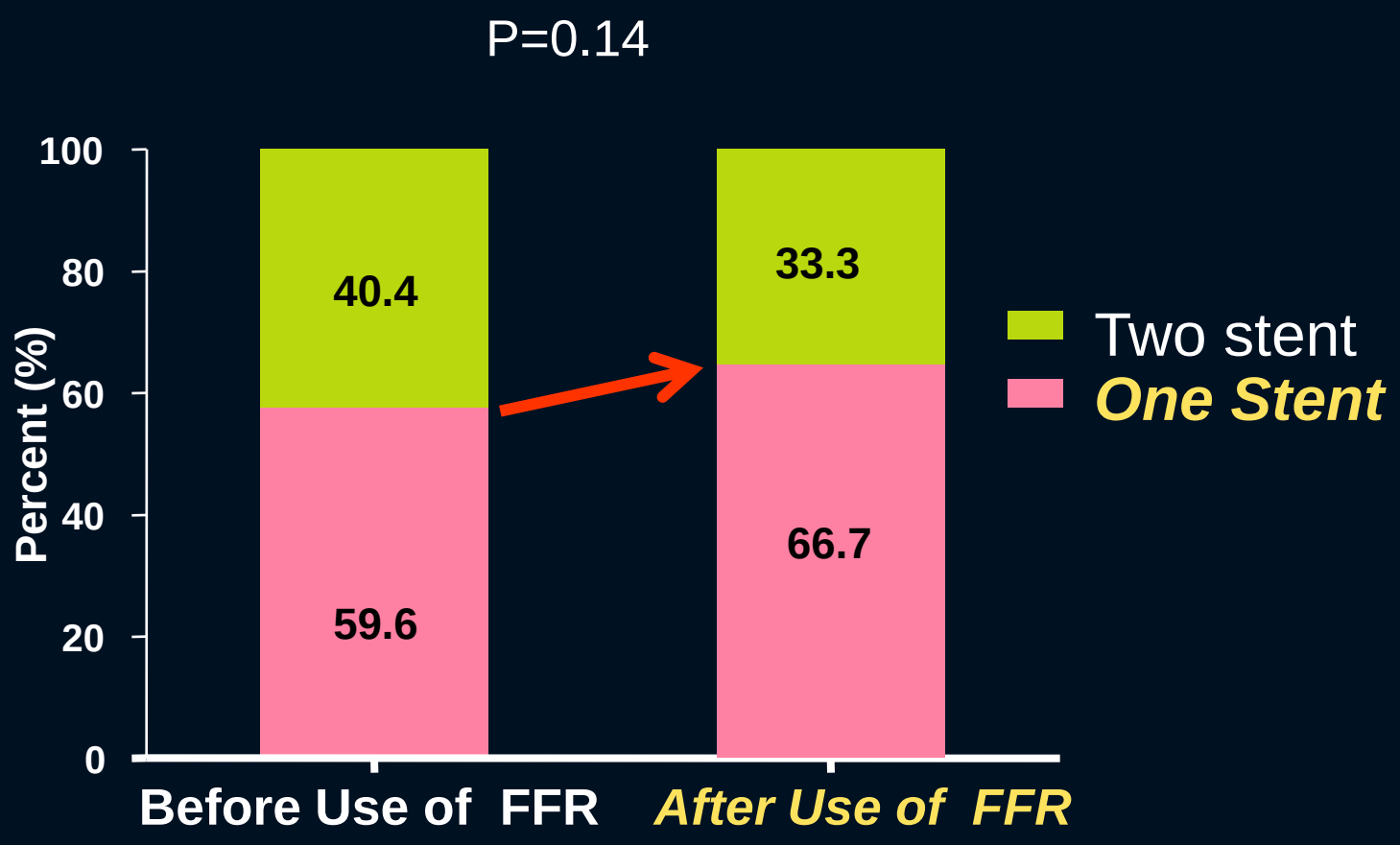
## *Consider FFR, First !*




***Just Defer !***

# Distal LM Stent Technique

## More One-Stent Technique




Ahn JM Park SJ et al. Am J Cardiol. 2015 Oct 15;116(8):1163-71.

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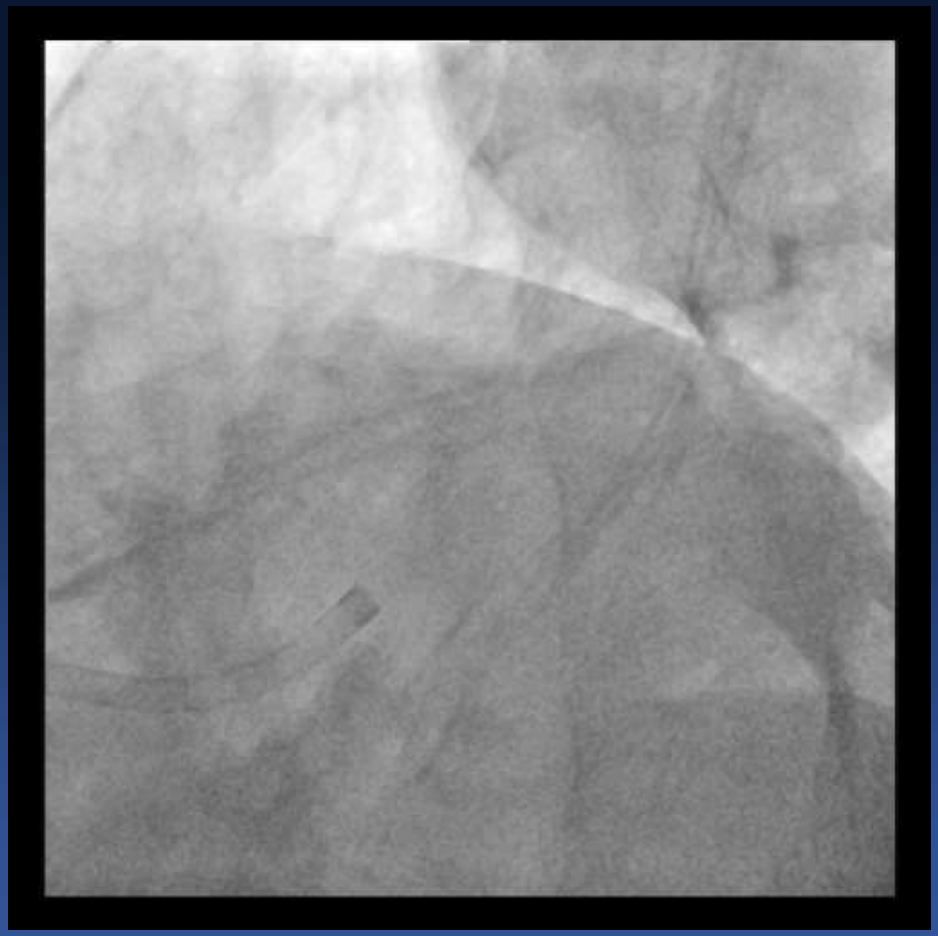
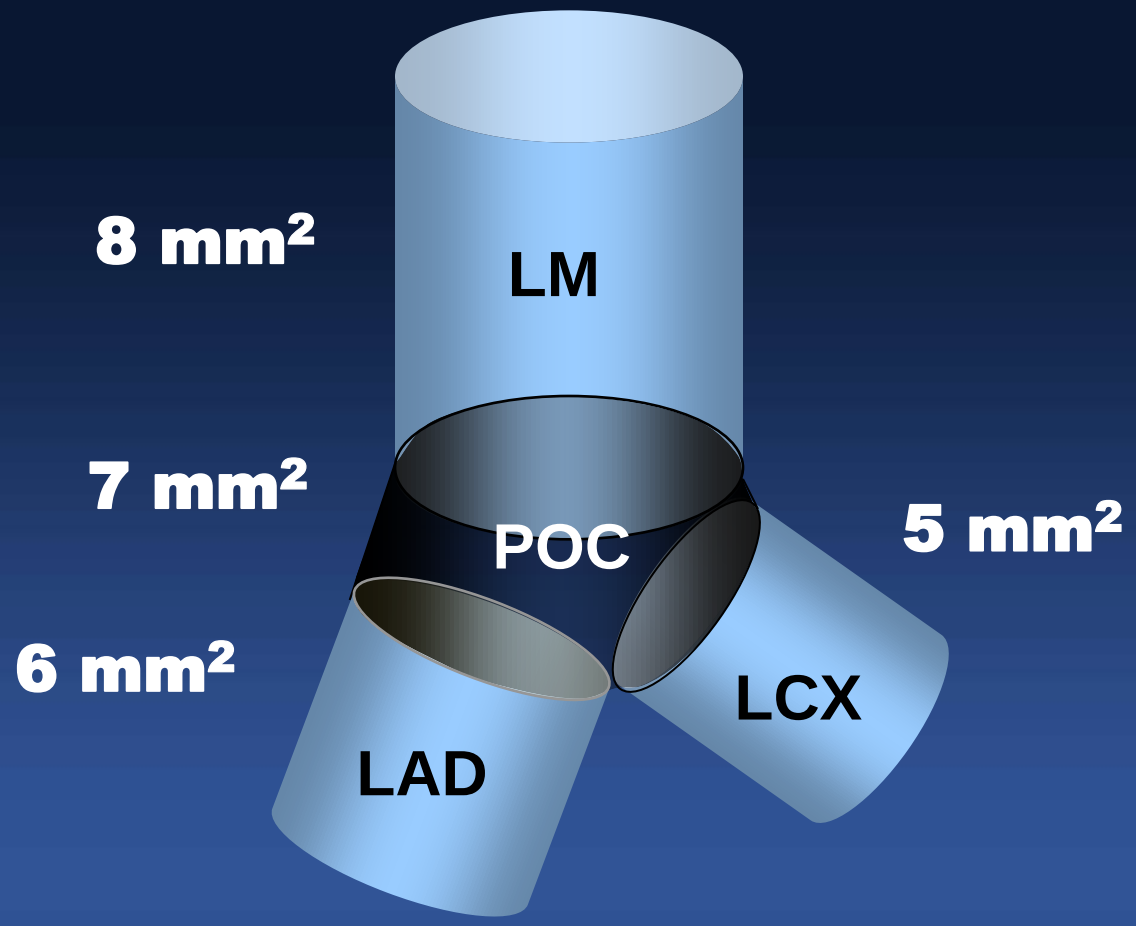
# True LM Bifurcation Disease



# Is There Difference in Outcomes?

- Crush Technique
- Mini-Crush Technique
- T stent Technique
- Kissing Stent Technique
- Culotte Technique
- Double-Kiss Crush Technique

# *Effective IVUS Stent Area* (Rule of 5,6,7,8) Can Reduce Restenosis Rate




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

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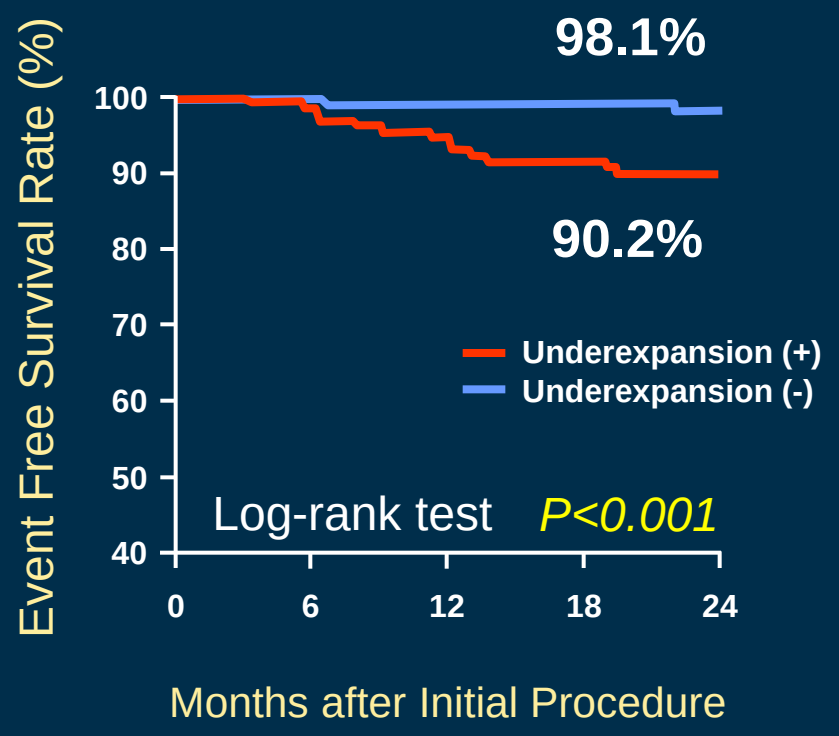
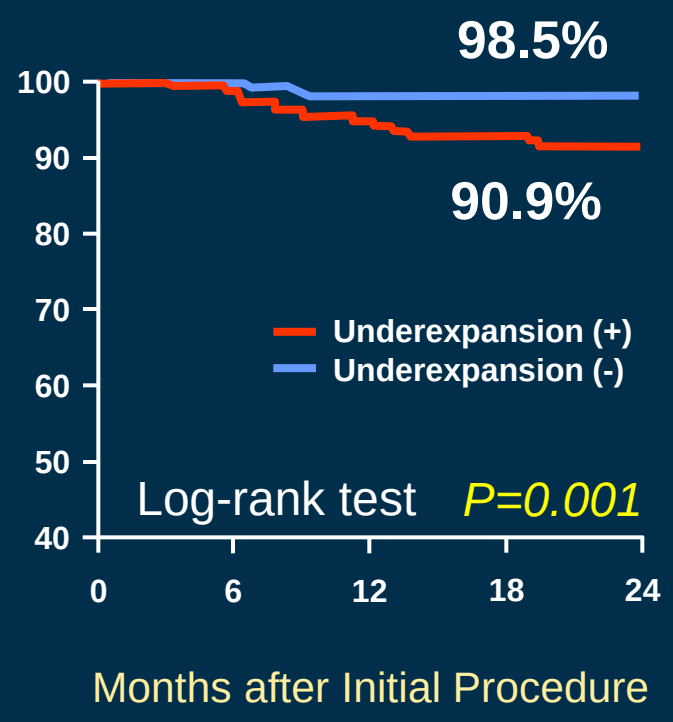
# MACE-free and TLR-free Survival




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

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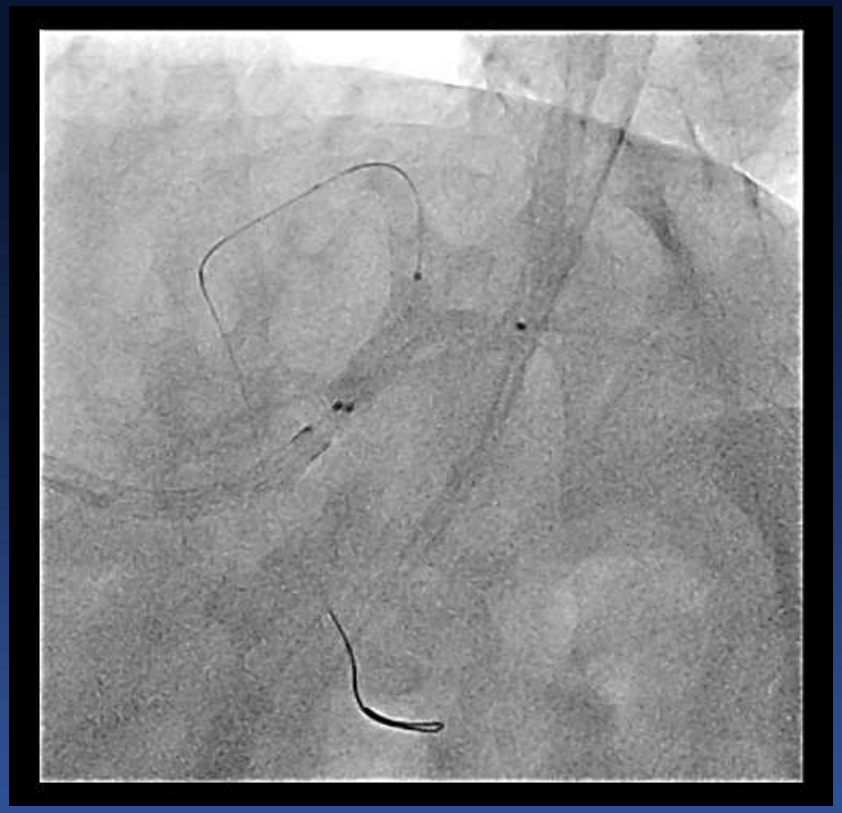
# Balloon Crush Technique

Balloon Crush
LCX : Xience Alpine 3.0 x 28 mm upto 18 atm
LAD : Emerge NC 3.0 x 20 mm upto 16 atm

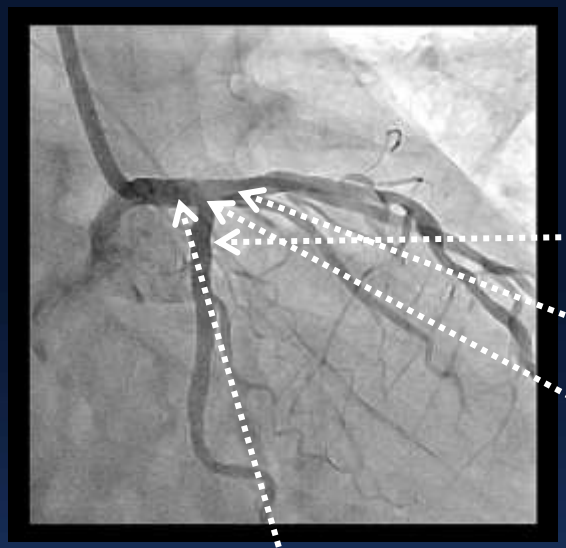
# Stent Optimization With High Pressure Balloon and Final Kissing Balloon: **Mandatory !!**

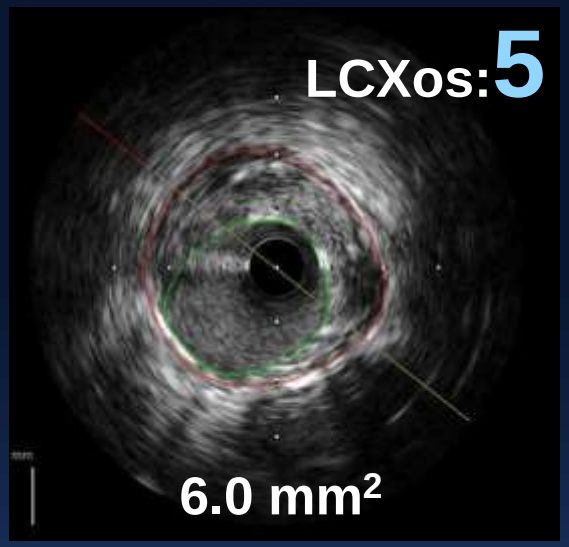


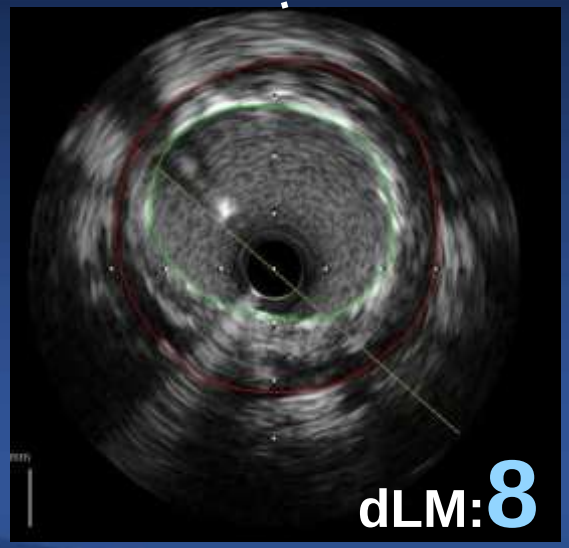
Kissing balloon
LCX : Emerge balloon 3.0 x 20 mm upto 8 atm
LM-LAD : Xience Alpine 3.5 x 23 mm upto 18 atm
NC TREK 4.0 x 15 mm upto 6 atm

# Final Angiography

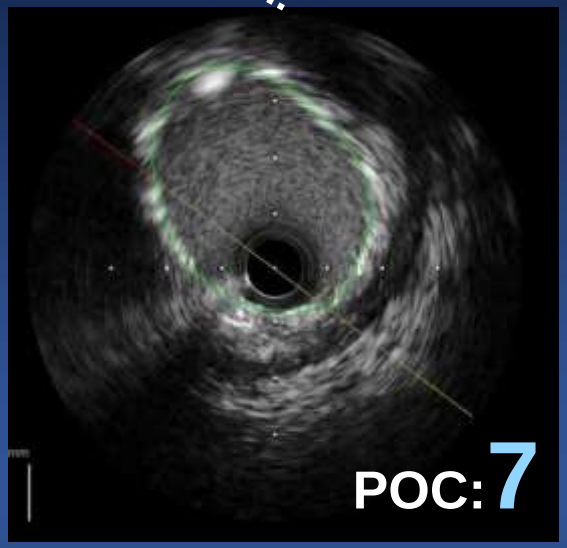
# Post-PCI IVUS



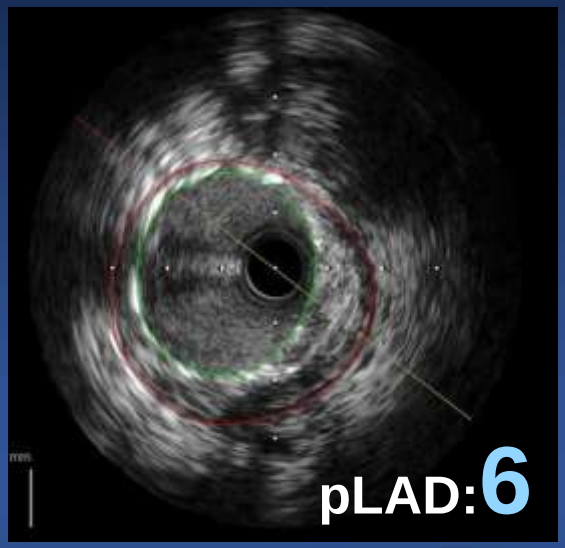



13.1 mm²




12.8 mm²




8.9 mm²

# Integrated Use of FFR and IVUS

**Ostial or Shaft LM Stenosis**

↓

FFR evaluation if necessary

↓

IVUS evaluation

↓

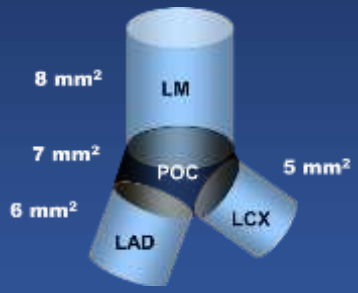
PCI

↓

IVUS Optimization

↓

Finish PCI




Ahn JM, Park SJ et al BMC Cardiovasc Disord 2016;16:49

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# Distal LM Bifurcation Stenosis

IVUS Evaluation of Both LAD and LCX

- **No or mild stenosis of LCX ostium**
- Small LCX

Provisional One Stent Approach

Main Branch Stenting

IVUS Optimization (**6,7,8**)

Angiographic Jailed Side Branch

No

Finish PCI

Yes

***If you want to treat it***

- True Bifurcation
- Big LCX
- Diffuse LCX disease

Two Stent Technique

IVUS Optimization (**5,6,7,8**)

Finish PCI

FFR measurement

FFR≤0.80

FKB or
T stenting

IVUS Optimization

FFR>0.80

Finish PCI

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Ahn JM, Park SJ et al BMC Cardiovasc Disord 2016;16:49