# Left Main PCI

## Integrated Use of IVUS and FFR

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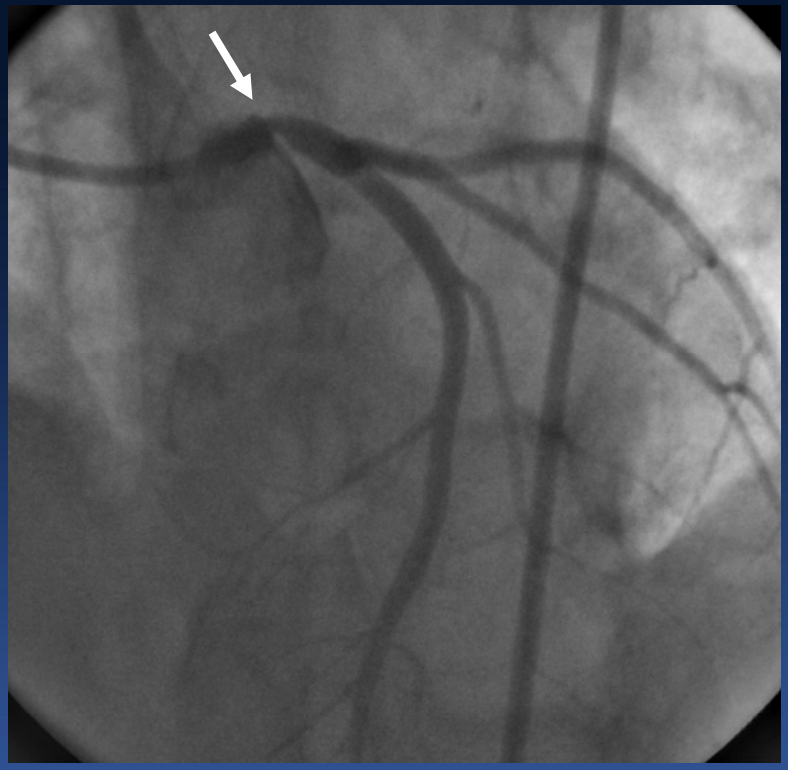
# How To Do ?

## Functional Angioplasty ;
## **Integrated Use of IVUS and FFR**

# Visual Functional Mismatch



**Visual : 80%**

**IVUS MLA : 6.2mm$^2$**

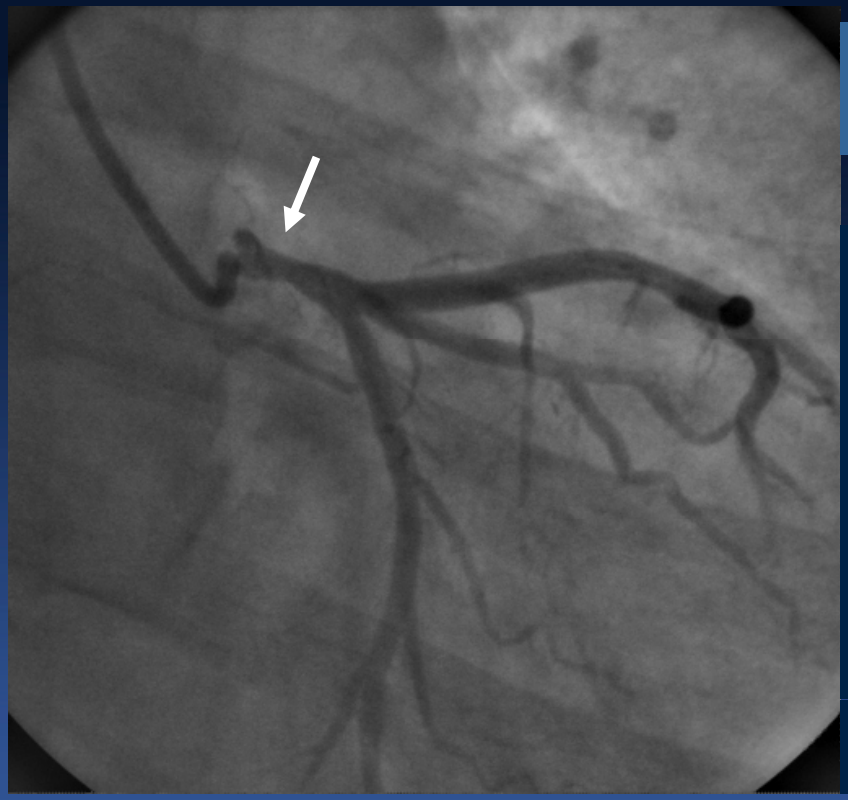
**FFR : 0.82**

**Treadmill test : Negative**

**Thallium spect : Normal**

**Stress Echo : Negative**

# Reverse Mismatch



**Visual Estimation : 30%**

**FFR : 0.70**

**IVUS MLA: 4.5 mm2**

**Treadmill test: + stage 2**

**Thallium spect : + large LAD**

## Mismatches ;

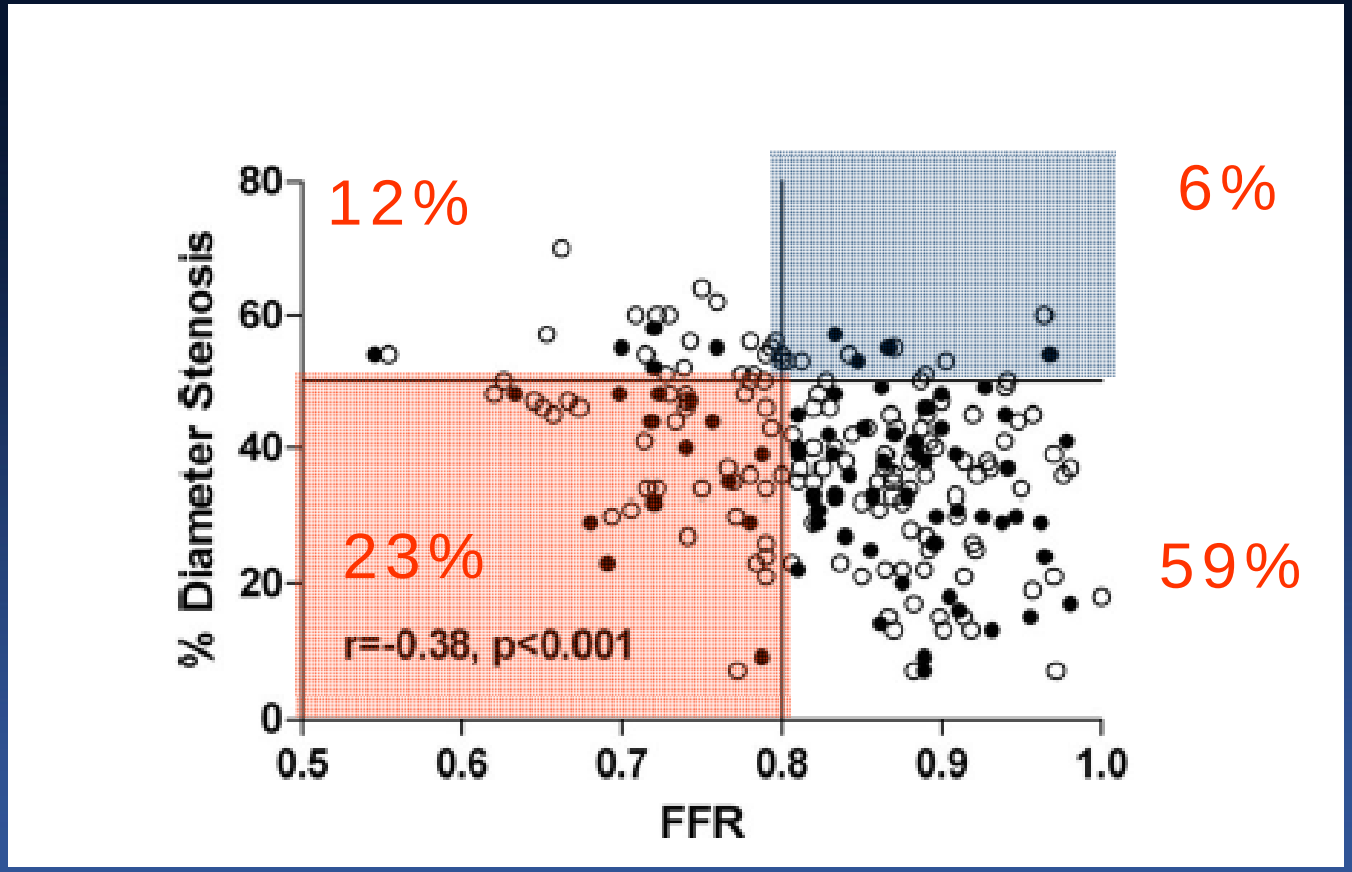
**Significant Stenosis (>50%) with Negative FFR**

## Reverse Mismatches ;

**Insignificant Stenosis (<50%) with Positive FFR**

# How Many Mismatches ?

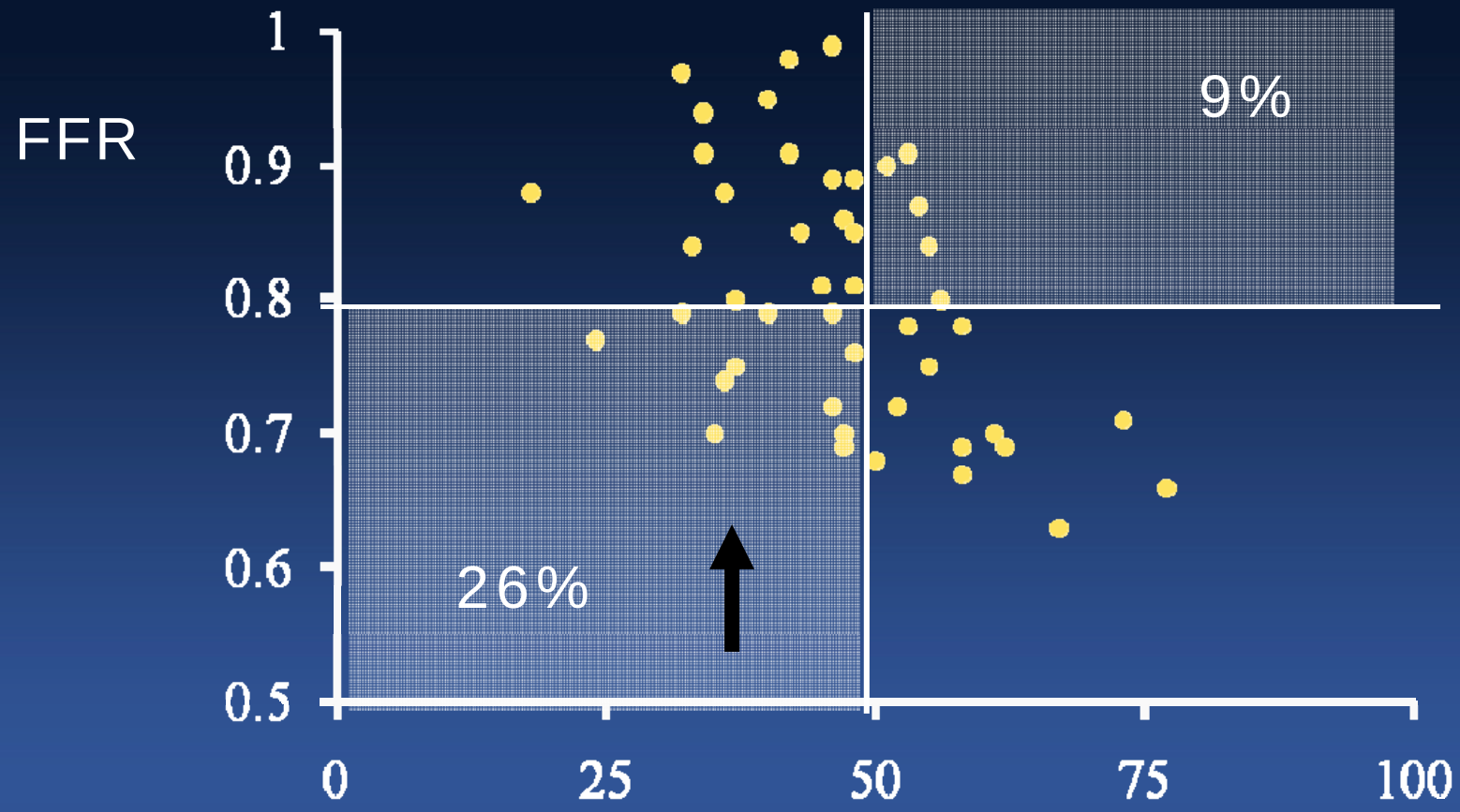
# Mismatch
## in intermediate LM Disease




Hamilos M, Circulation 2009; 120: 1505-1512

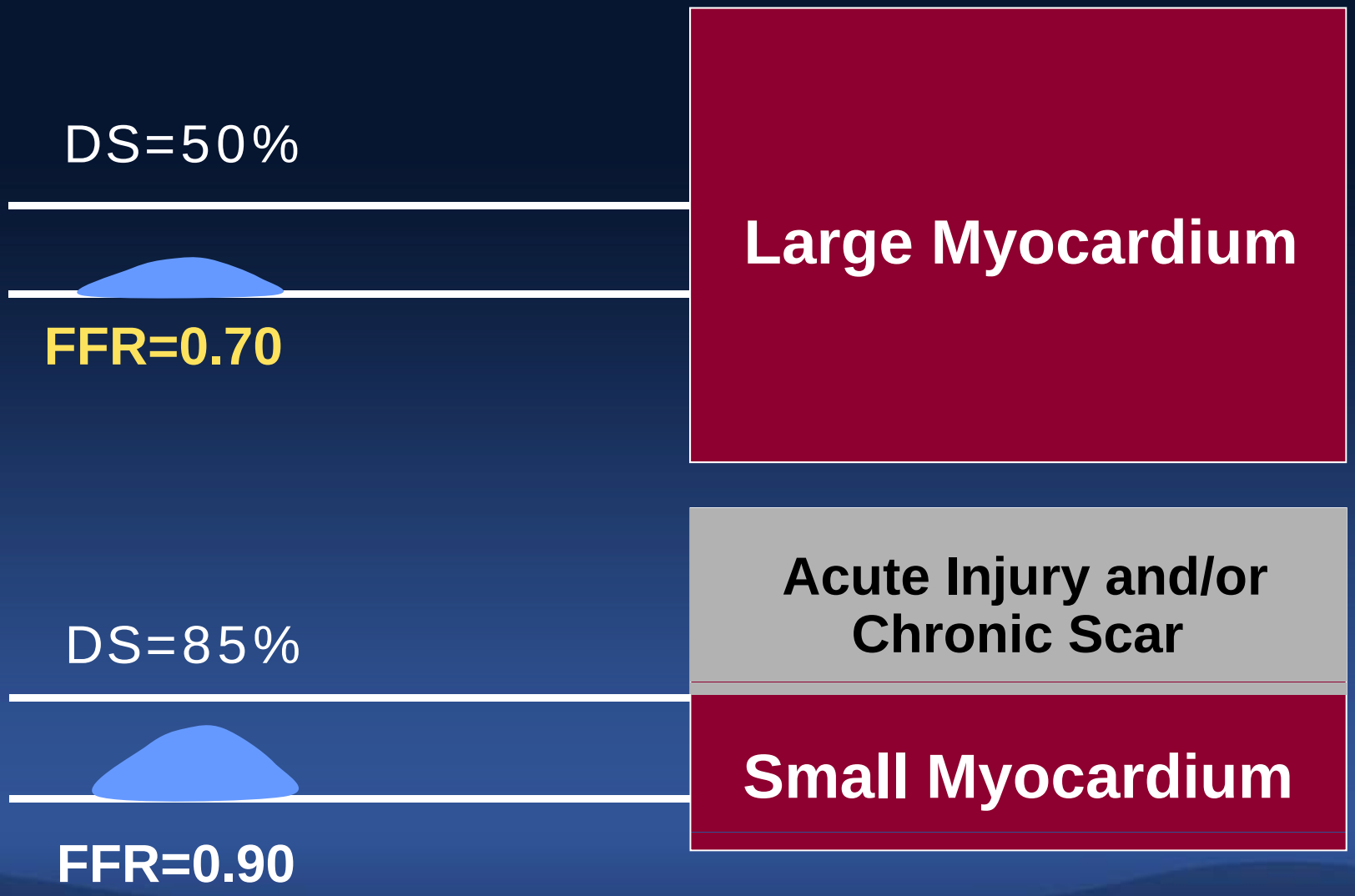
# Mismatch

## in Isolated intermediate LM Disease (n=55)



# Why Relatively Higher Reverse Mismatches in LM disease?

# LM supplied Large Myocardium



# Univariable Analysis to Predict FFR <0.8

| Variables | C-OR | 95%CI | p-value |
|---|---|---|---|
| MLA within LM | 0.312 | 0.164-0.593 | <0.001 |
| Plaque burden | 1.095 | 1.031-1.164 | 0.003 |
| Lesion length | 1.192 | 1.038-1.368 | 0.013 |
| Rupture | 3.273 | 0.953-11.243 | 0.060 |
| Angiographic DS | 1.049 | 0.993 – 1.108 | 0.088 |
| Lesion location | 2.081 | 1.070 – 4.046 | 0.031 |
| Male | 0.511 | 0.127-2.057 | 0.345 |
| Age | 0.965 | 0.917-1.016 | 0.172 |
| Diabetes melitus | 1.062 | 0.304-3.710 | 0.924 |
| Hypertension | 1.3 | 0.412-4.101 | 0.654 |
| Smoker | 2.701 | 0.816-0.8945 | 0.104 |
| Hyperlipidemia | 1.167 | 0.324-4.200 | 0.814 |
| Stable presentation | 0.476 | 0.078-2.894 | 0.42 |

# Multivariable Analysis to Predict FFR

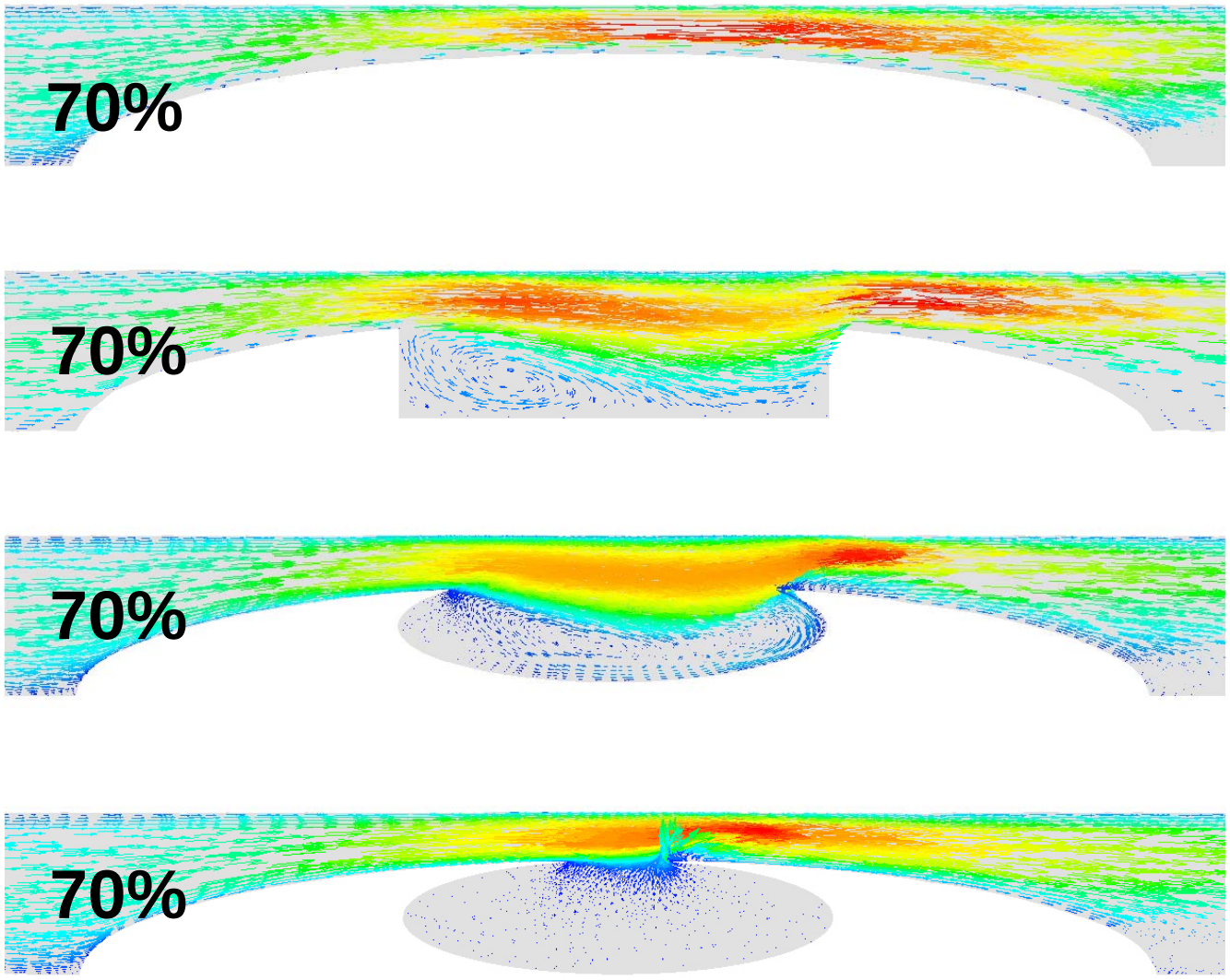
**Independent predictors for FFR as continuous variable**

MLA (β=0.58, 95% CI=0.02 - 0.04, p<0.001)

Plaque rupture (β=-0.24, 95% CI= -0.09-0.01, p=0.036)

Kang SJ et al, JACC. Cardiovascular Interventions. 2011 Nov;4(11):1168-74.

# Presence of Plaque Rupture




FFR : 0.62

0.68

0.66

0.58

**Steady-state 3D Computed Simulation under Hyperemic Condition, AMC data**

# FFR theory

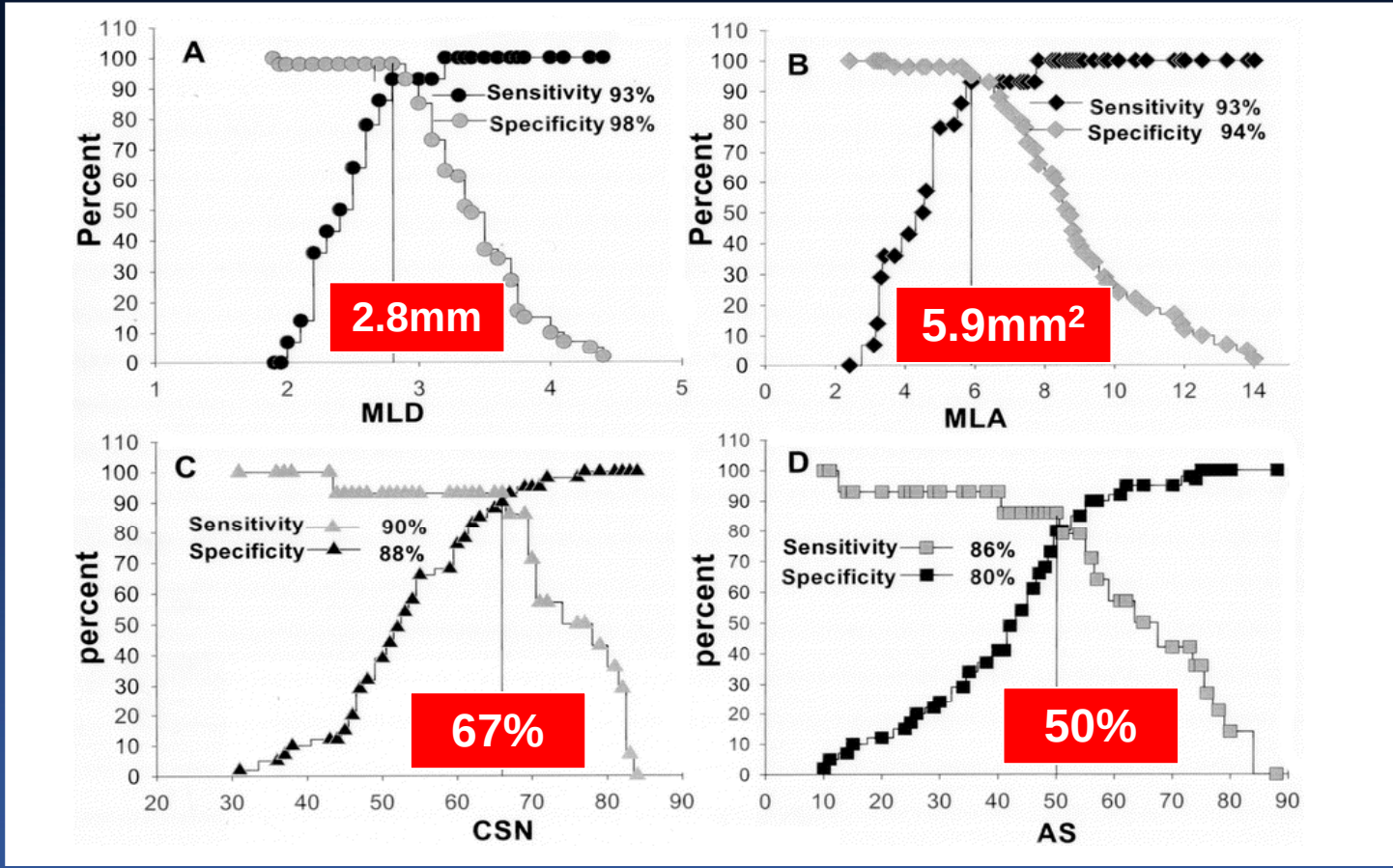
FFR is more sensitive and integrated summation of physiological and anatomical aspects (total morphology) of a stenosis rather than 2-dimensional angiographic diameter stenosis.

# Why FFR ?

1. Angiography is not always enough !
2. FFR is the only matched index with objective ischemia even in the Left main disease.

# IVUS MLA vs. FFR

# IVUS MLA < 6.0 $mm^2$ is matched with FFR <0.75






Jasti V et al. Circulation 2004;110:2831-6

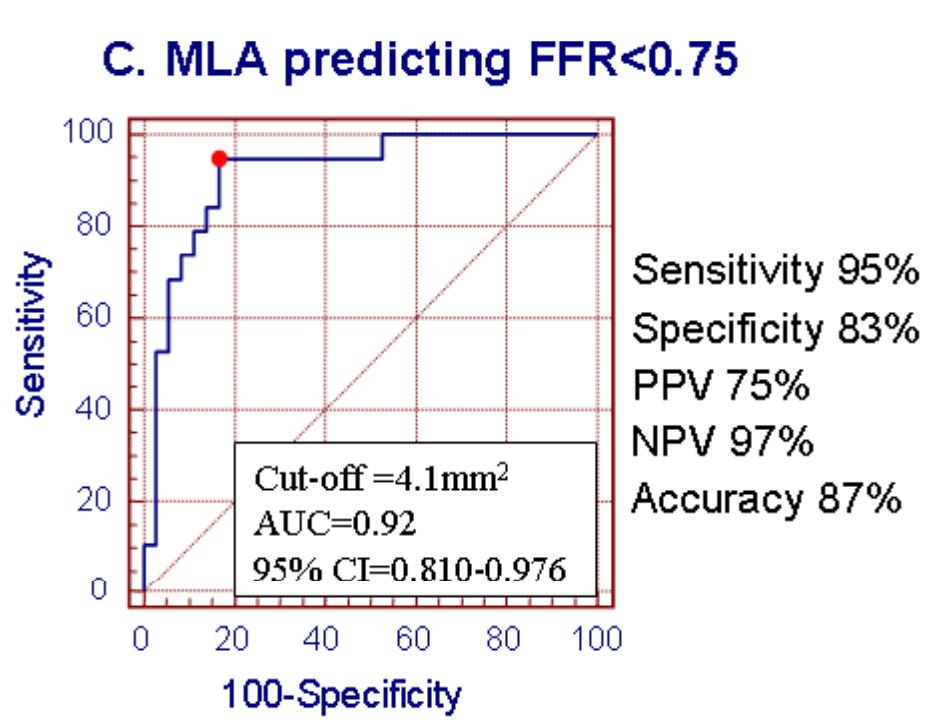
# New Comparison

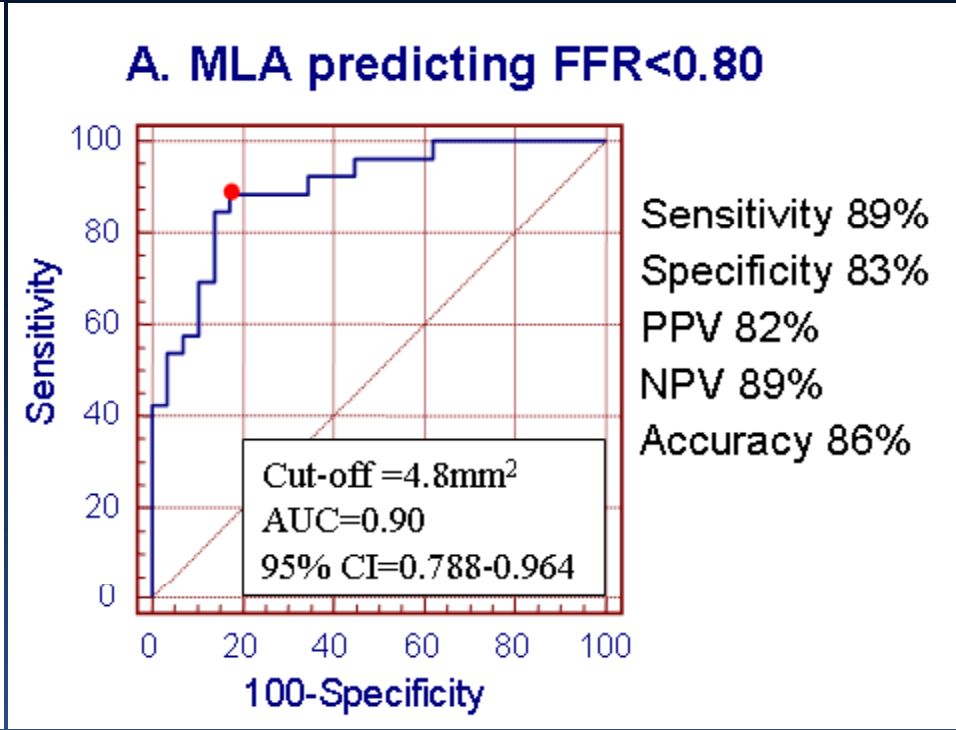
**AMC prospective cohort registry (n=55 lesions), 2011**

## FFR vs. IVUS MLA

JACC Cardiovasc Interv, 2011 (in press)

# New IVUS MLA




4.1 mm²

4.8 mm²

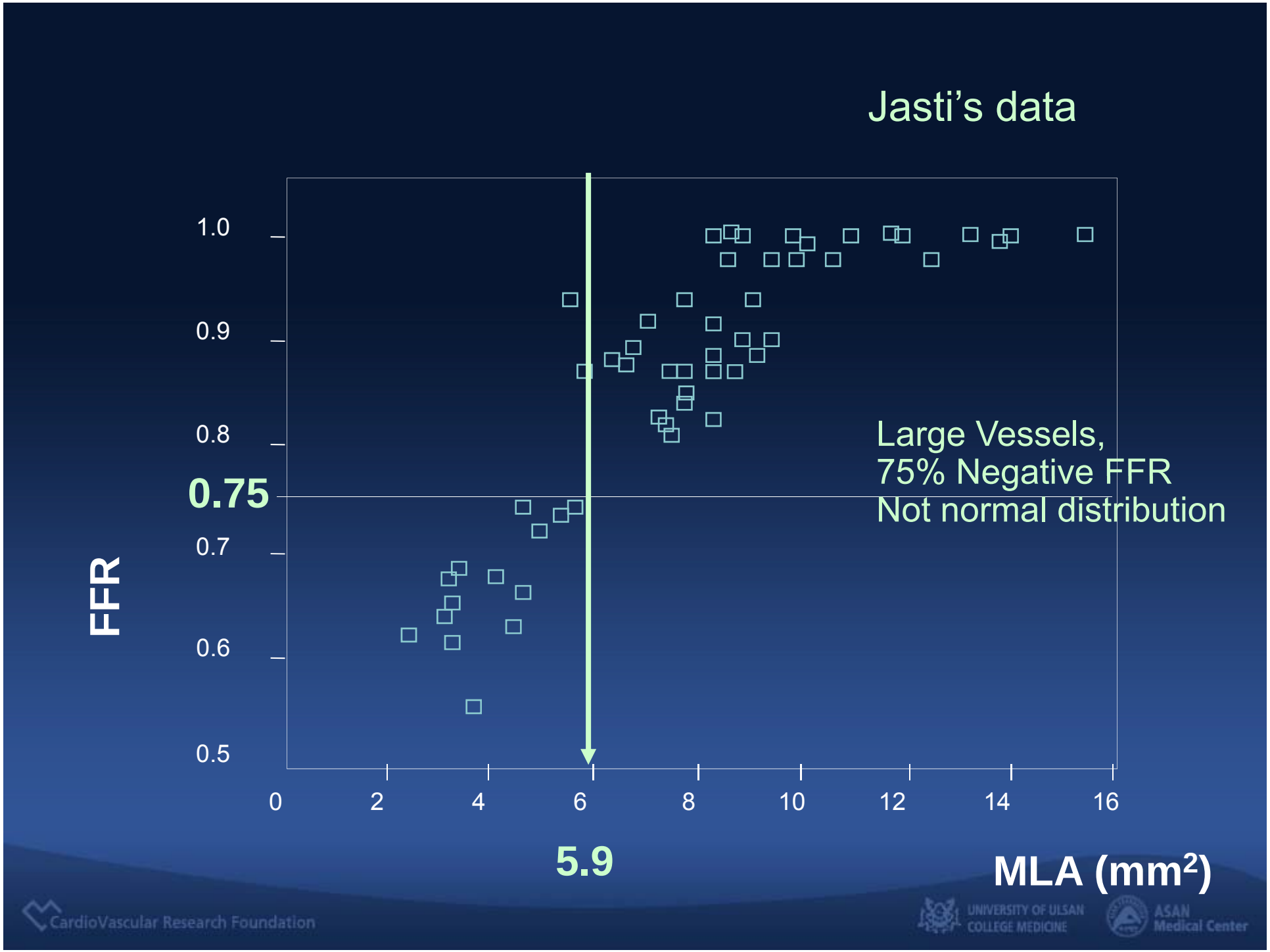
Kang SJ, Park SJ et al, JACC. Cardiovascular Interventions. 2011 Nov;4(11):1168-74.

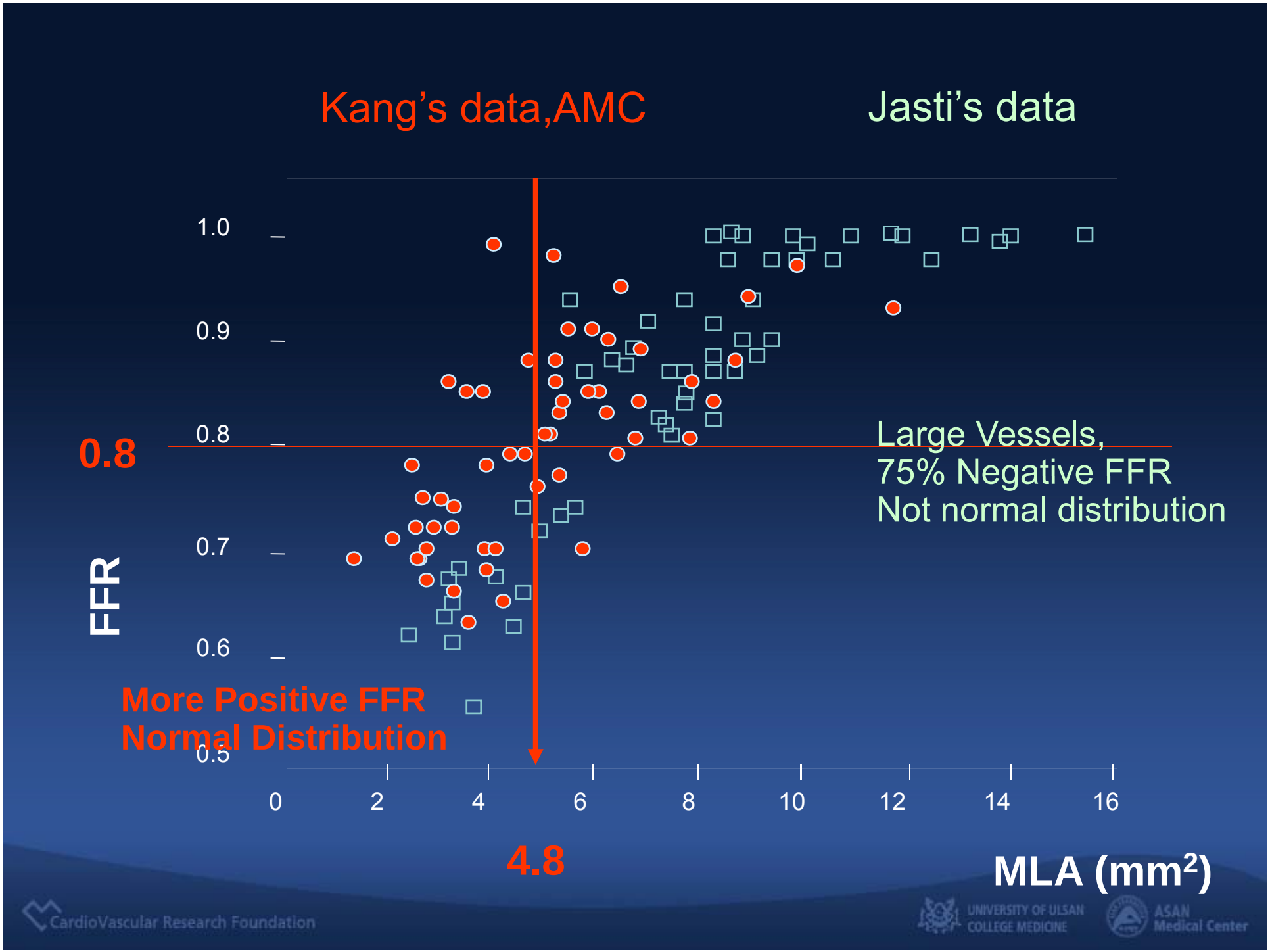
# New IVUS MLA

## Matched with FFR <0.80 in LM Disease

$4.8\ mm^2$

Kang SJ, Park SJ et al, JACC. Cardiovascular Interventions. 2011 Nov;4(11):1168-74.


Jasti's data
1.0
0.9
0.8
0.75
0.7
0.6
0.5
FFR
0
2
4
6
8
10
12
14
16
5.9
MLA (mm²)
Large Vessels,
75% Negative FFR
Not normal distribution
CardioVascular Research Foundation
UNIVERSITY OF ULSAN COLLEGE MEDICINE
ASAN Medical Center


Kang's data,AMC
Jasti's data
1.0
0.9
0.8
0.7
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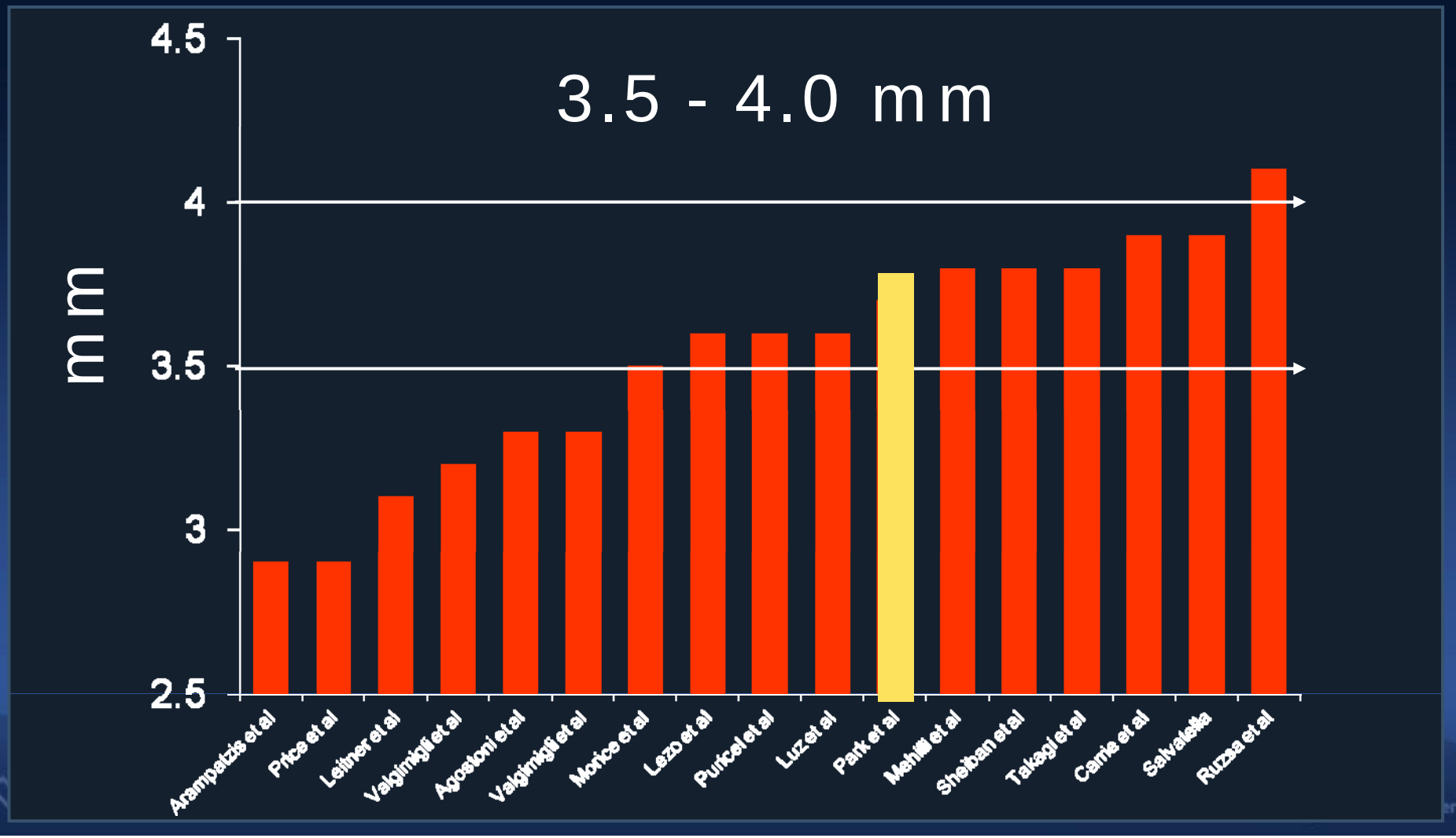
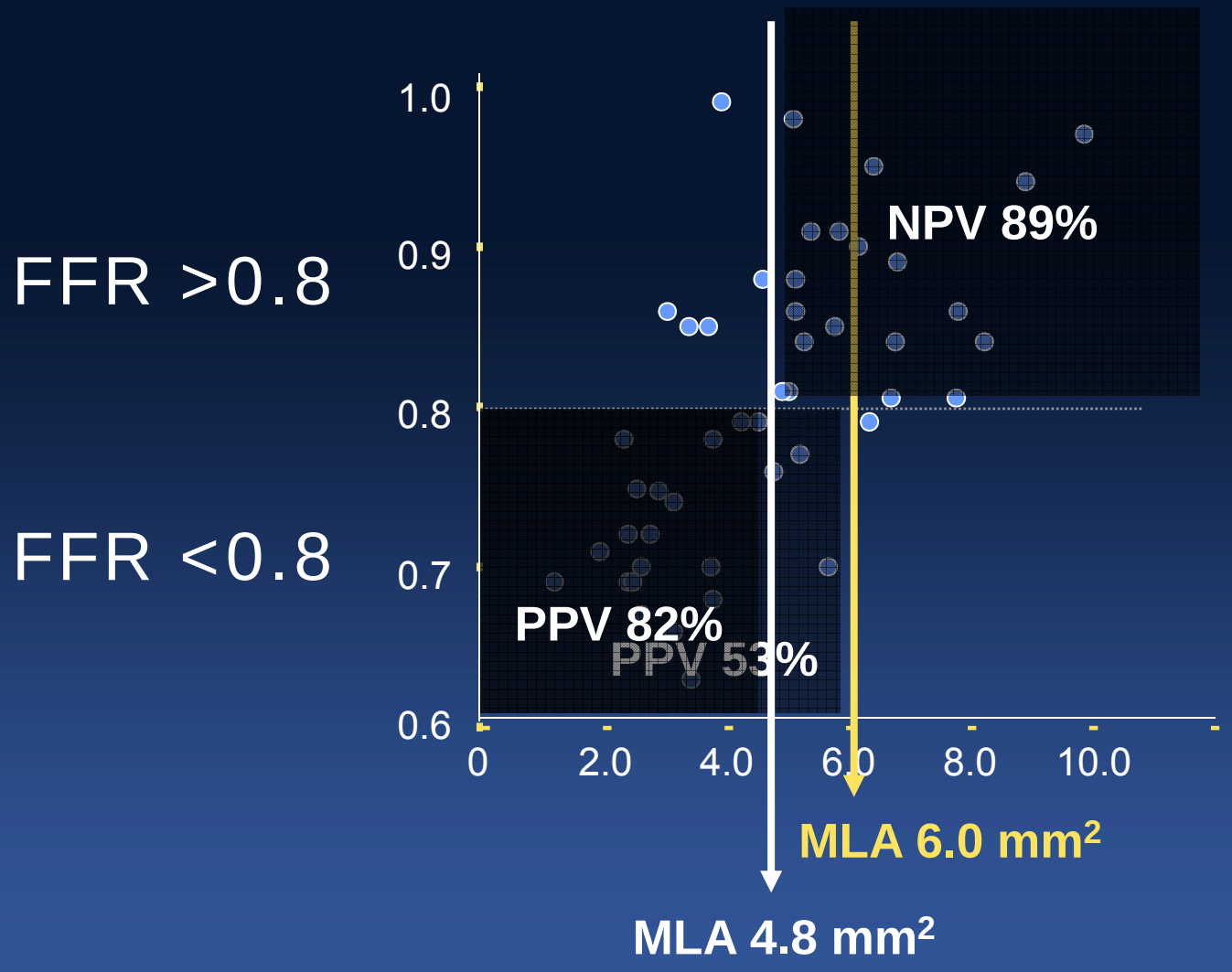
FFR
0.8
Large Vessels,
75% Negative FFR
Not normal distribution
More Positive FFR
Normal Distribution
0
2
4
6
8
10
12
14
16
4.8
MLA (mm²)
CardioVascular Research Foundation
UNIVERSITY OF ULSAN COLLEGE MEDICINE
ASAN Medical Center

# Ethnic Difference ?

# Reference Vessel Size of Left Main Coronary Artery by QCA

## 2309 USA/EU Patients in 17 Studies






Sensitivity 89%
Specificity 83%
PPV 82%
NPV 89%
Accuracy 86%

# Why FFR ?

1. Angiography is not always enough !
2. FFR is the only matched index with objective ischemia even in the Left main disease.

# Why IVUS ?

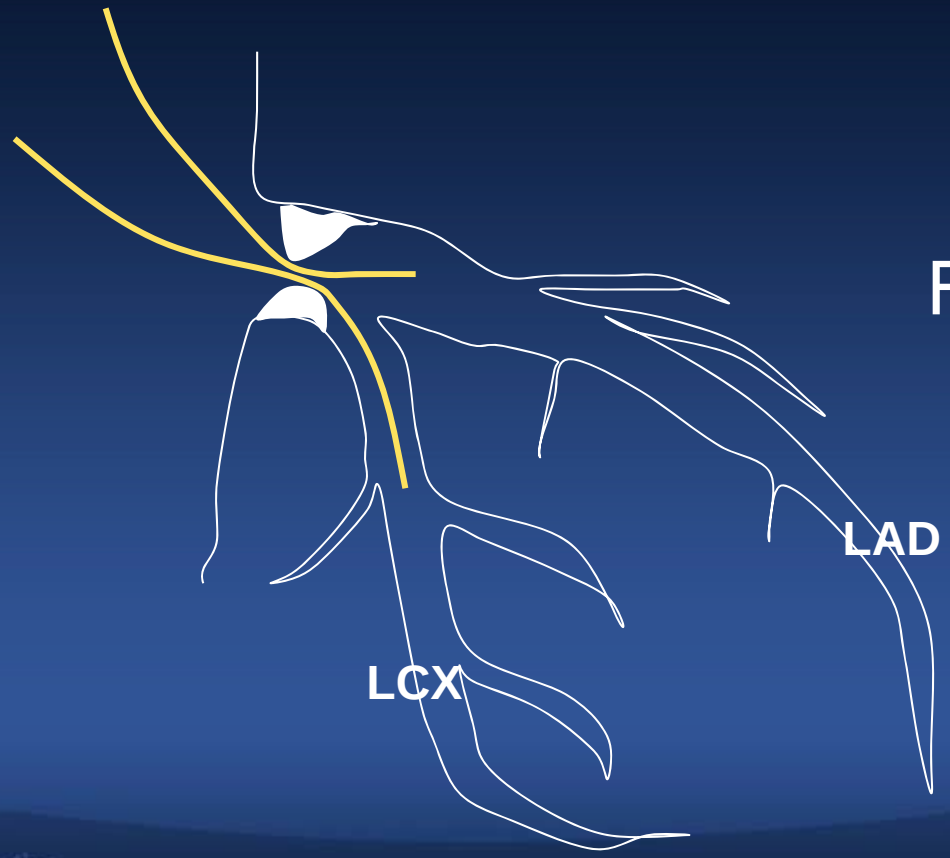
1. The IVUS-guidance will reduce 3-year mortality from MAIN COMPARE registry data.
   (Park SJ, et al. Circulation Cardiovasc Interv. 2009 Jun;2(3):167-77)
2. Treat or not treat decision could be made by IVUS MLA 4.8 $mm^2$ (PPV:82%).
3. IVUS guidance have more understanding about the inside of the vessel (negative remodeling, true reference vessel size and ostial lesion assessment). We can decide the treatment strategy based on IVUS guidance.

# Ostial and Shaft LM PCI

## How to Do ?

# Ostial and Shaft LM PCI

- Functional Assessment (FFR) is Crucial.




FFR works



Courtesy of Akiko Maehara, MD

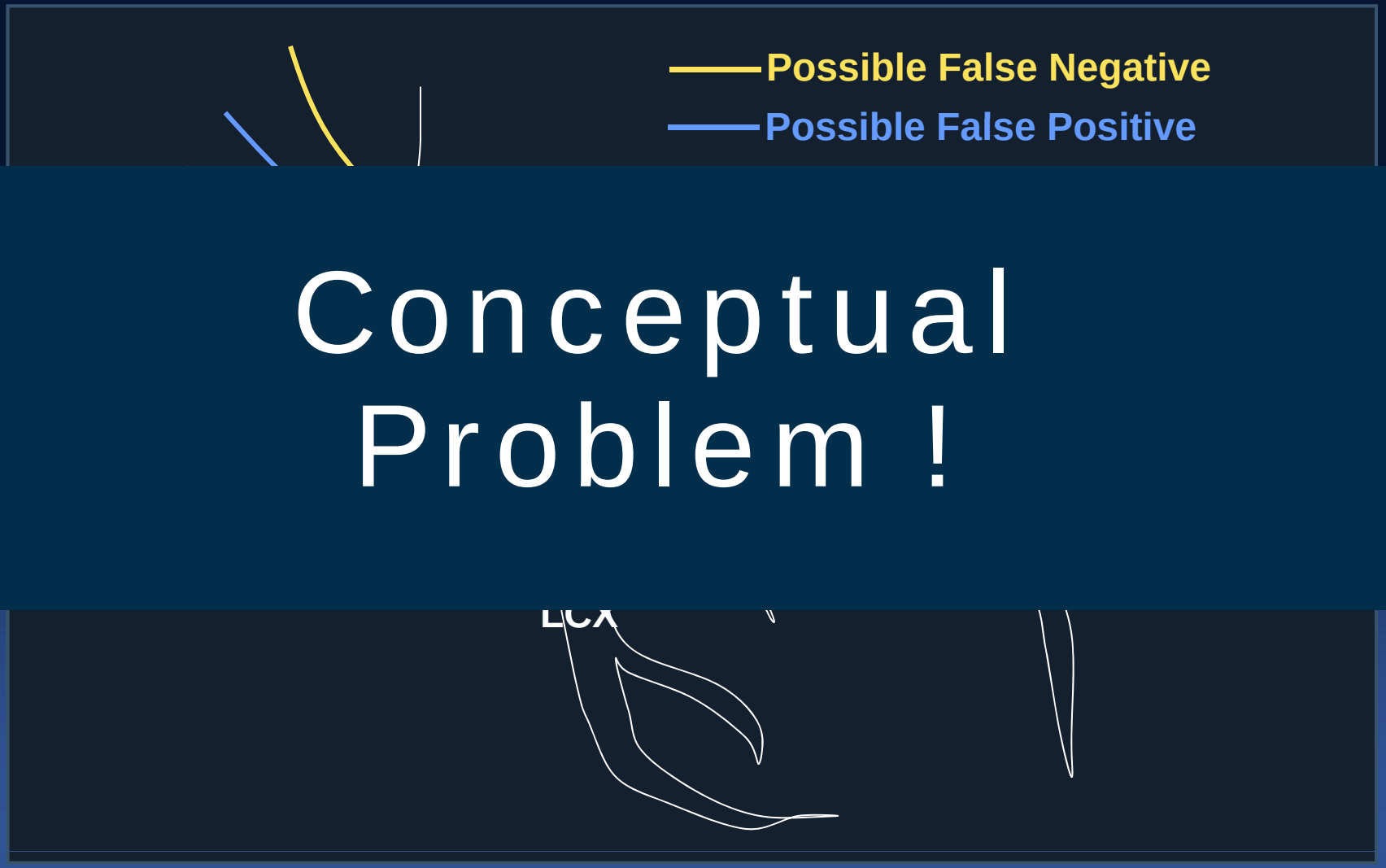
# Ostial and Shaft LM PCI

- Functional Assessment (FFR) is Crucial.
- IVUS MLA (4.8 $mm^2$) can predict functional significance of stenosis of LM disease.
- Just Stent it ! It takes just 5 minutes !
- We have more than 5 -10 year long-term data.
- No difference of death and MI compared with surgery (even better).
- Long-term clinical outcomes should be comparable to 100% of arterial grafts.

# Distal Bifurcation
# LM PCI

## How to Do ?

# Problem of FFR for LMCA Lesions



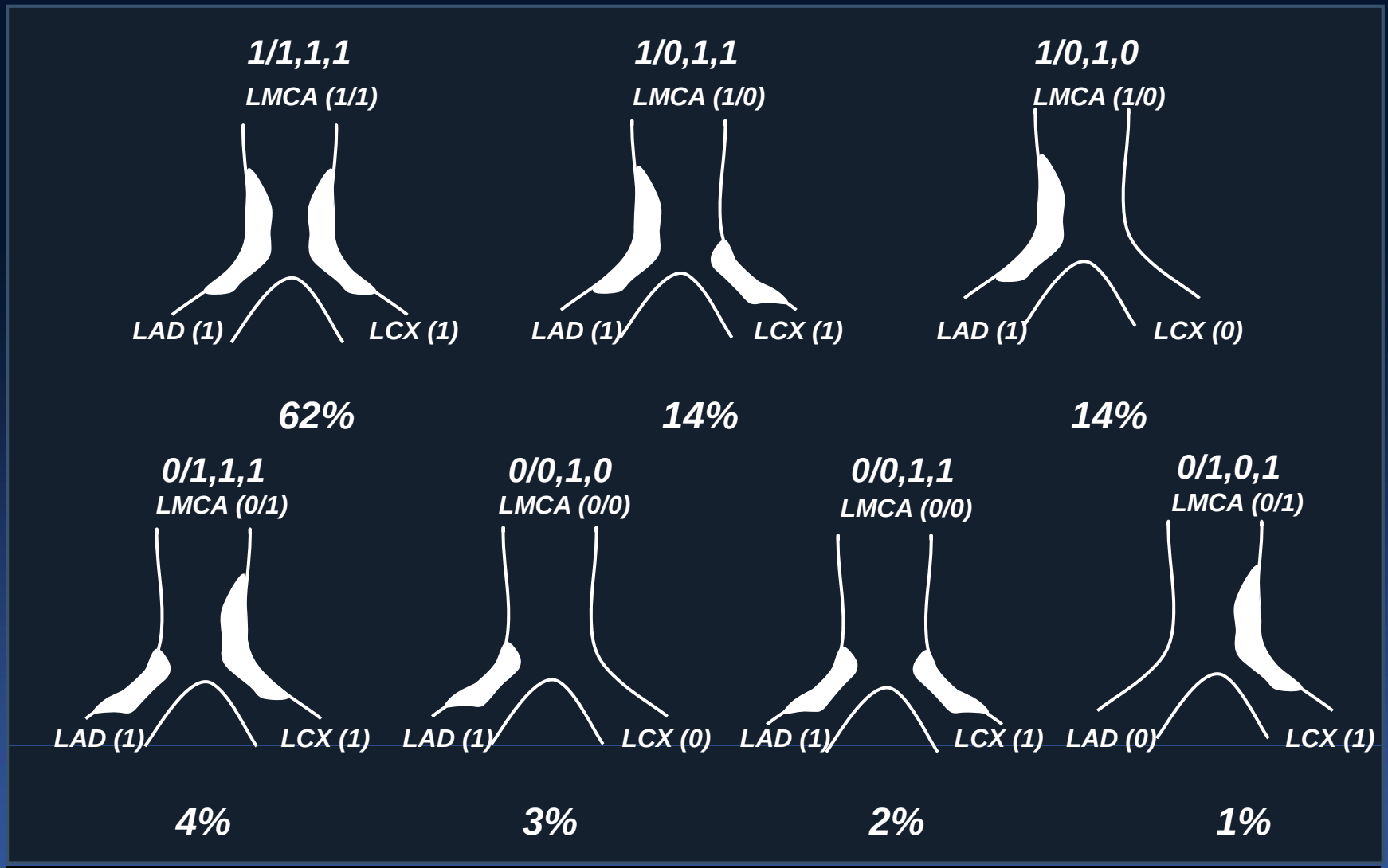

Conceptual Problem !



Courtesy of Akiko Maehara, MD

# In Reality,

# Plaque Distribution by IVUS (n=140)

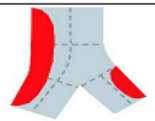
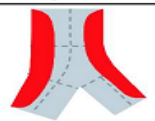
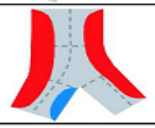
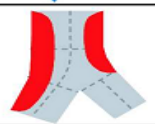
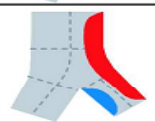
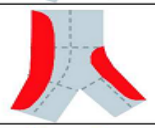
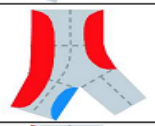



***In 90% plaque extends from LMCA-LAD***



Oviedo C et al. Circ Cardiovasc Interv 2010;3:105-12.

# Plaque Distribution by IVUS (n=82)

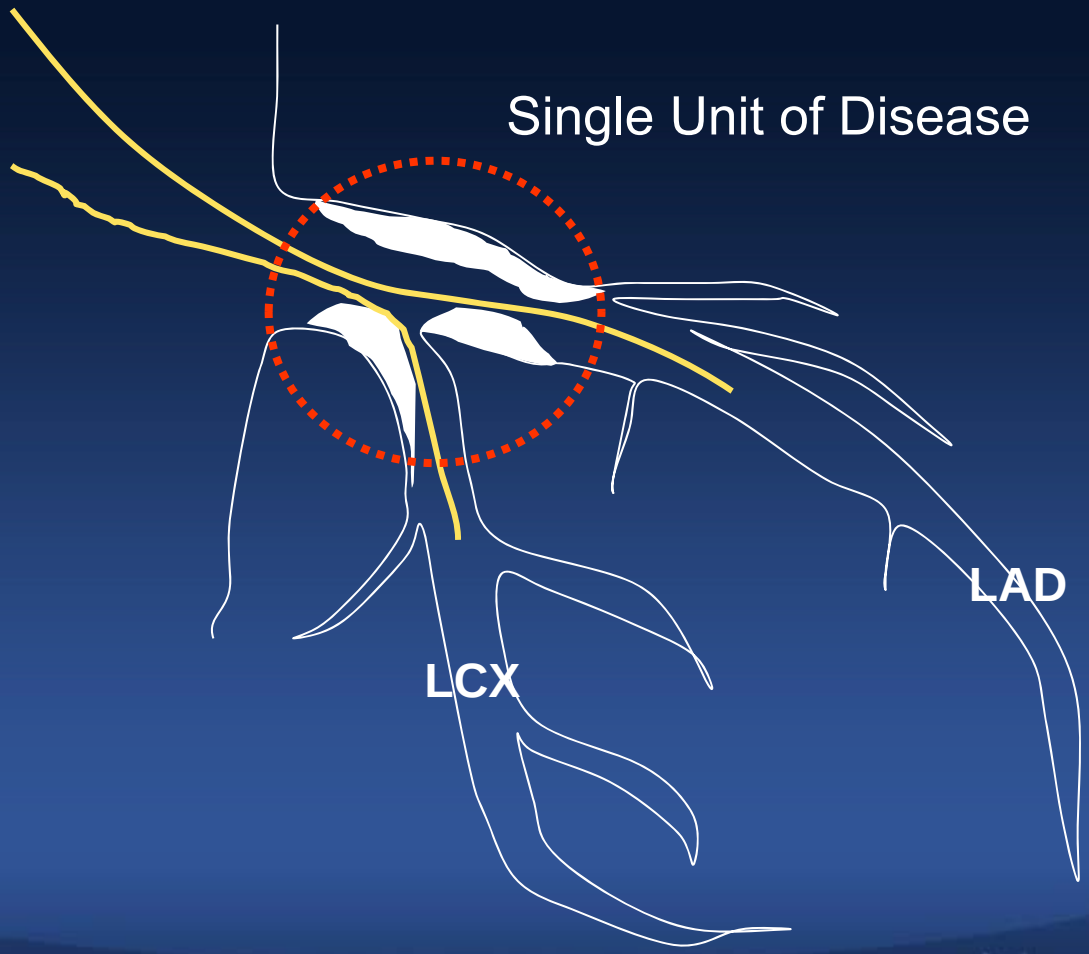
| DLM / POC / LAD / LCX | N. (%) | LAD ostium, MLA ($mm^2$) | POC, MLA ($mm^2$) | DLM, MLA ($mm^2$) | LCX ostium, MLA ($mm^2$) |
|---|---|---|---|---|---|
|  | 5 (6%) | 4.4±2.0 | 9.6±4.4 | 8.1±4.7 | 3.4±1.6 |
|  | 26 (32%) | 4.2±2.8 | 5.3±2.6 | 4.6±1.5 | 3.9±2.1 |
|  | 12 (15%) | 2.6±1.3 | 4.5±1.6 | 4.5±2.1 | 3.3±2.0 |
|  | 9 (11%) | 4.3±2.5 | 5.6±3.3 | 5.7±3.8 | 7.6±3.6 |
|  | 9 (11%) | 3.2±1.4 | 6.1±2.0 | 4.8±2.5 | 3.9±1.4 |
|  | 4 (5%) | 3.4±1.9 | 5.2±1.9 | 5.8±4.7 | 3.9±2.0 |
|  | 4 (5%) | 2.8±0.7 | 5.1±2.1 | 5.1±2.2 | 6.6±1.7 |
|  | 5 (6%) | 3.4±1.9 | 5.2±2.6 | 5.1±3.8 | 4.6±2.1 |

**In all cases, the LM disease extended into LAD and LCX continuously.**

Kang et al, Catheterization and Cardiovascular Interventions. 2011 Jul 29.

# Placed Transducer Beyond Bifurcation in both LAD and LCX

## FFR still works.



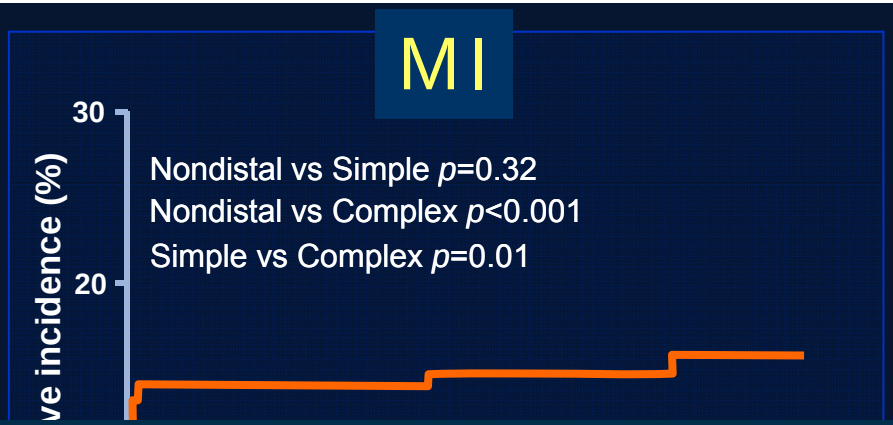
# Distal LM Bifurcation PCI

- Single Stent Cross Over
- 2 Stents Procedures

# When, 1 vs. 2 stents

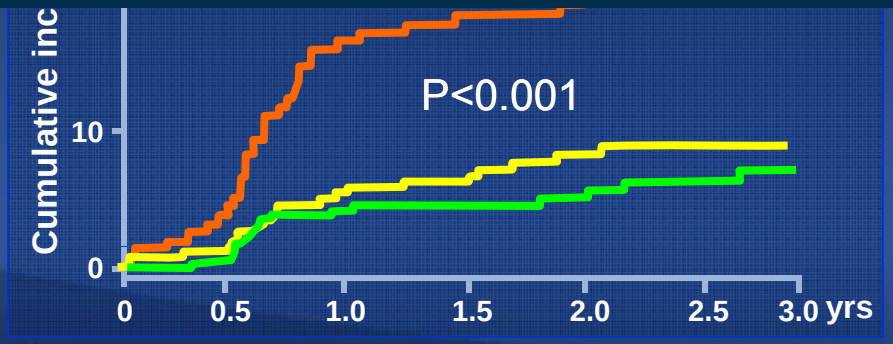
| | |
|---|---|
| **Single stent** | • **Normal ostial LCX with MEDINA 1.1.0. or 1.0.0.**<br>• **Small LCX with < 2.5 mm in diameter**<br>• **Diminutive LCX**<br>• **Normal or focal disease in distal LCX** |
| **Two stent** | • **Diseased LCX with MEDINA 1.1.1., 1.0.1., or 0.1.1**<br>• **Large LCX with ≥ 2.5 mm in diameter**<br>• **Diseased left dominant coronary system**<br>• **Concomitant diffuse disease in distal LCX** |

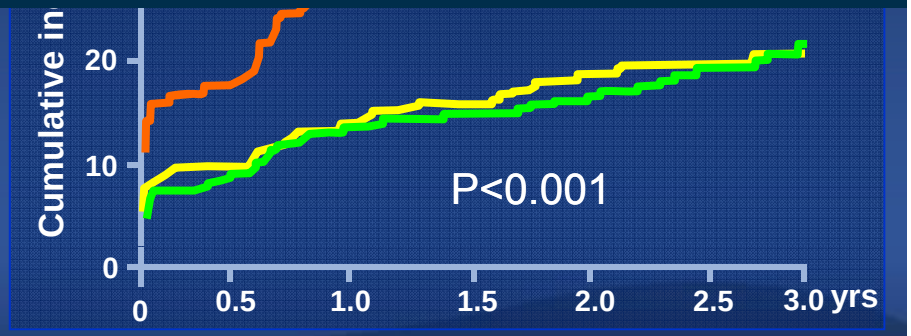
Park SJ, Kim YH. Colombo A, Issam D. Moussa et al. Textbook of Bifurcation Stenting




- Complex 2 stents
- Non-distal (Ostial and Shaft)
- **Simple (single stent cross over) In LM bifurcation lesions**

# Single Stent Cross Over is Clearly better !

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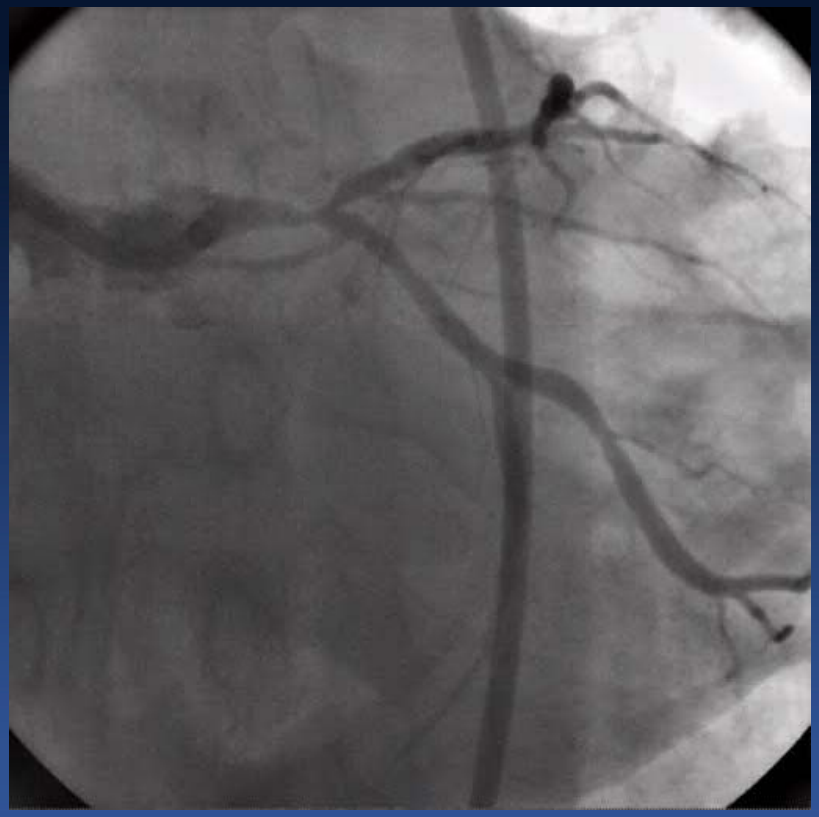
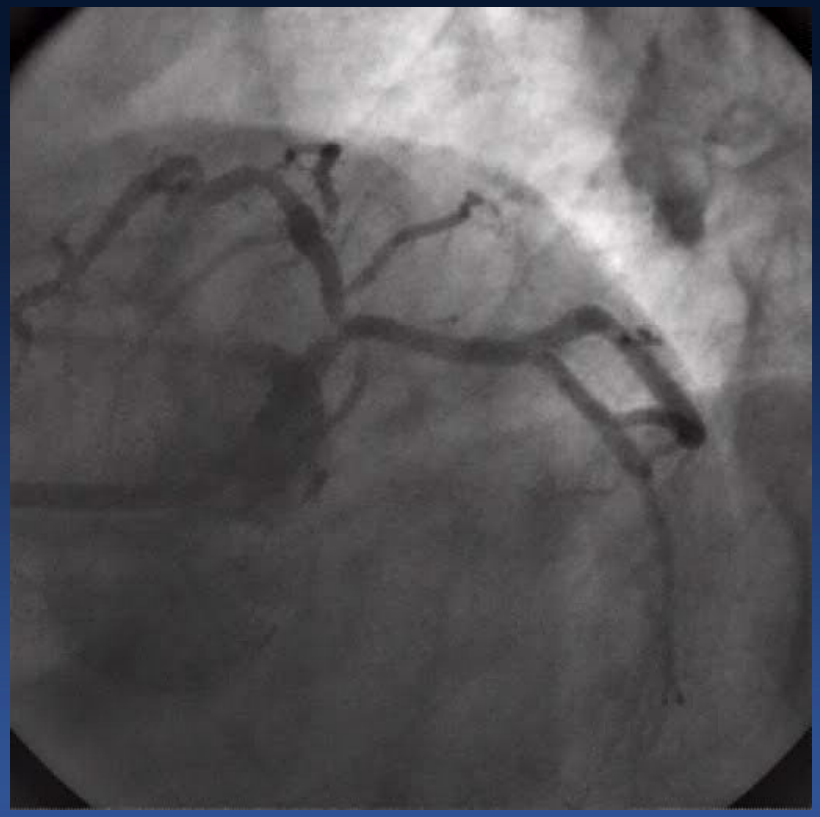
ASAN Medical Center

Kim WJ, et al. Catheter Cardiovasc Interv. 2011 May 1;77(6):775-82

# Stent Cross Over
# for LM Bifurcation Lesions

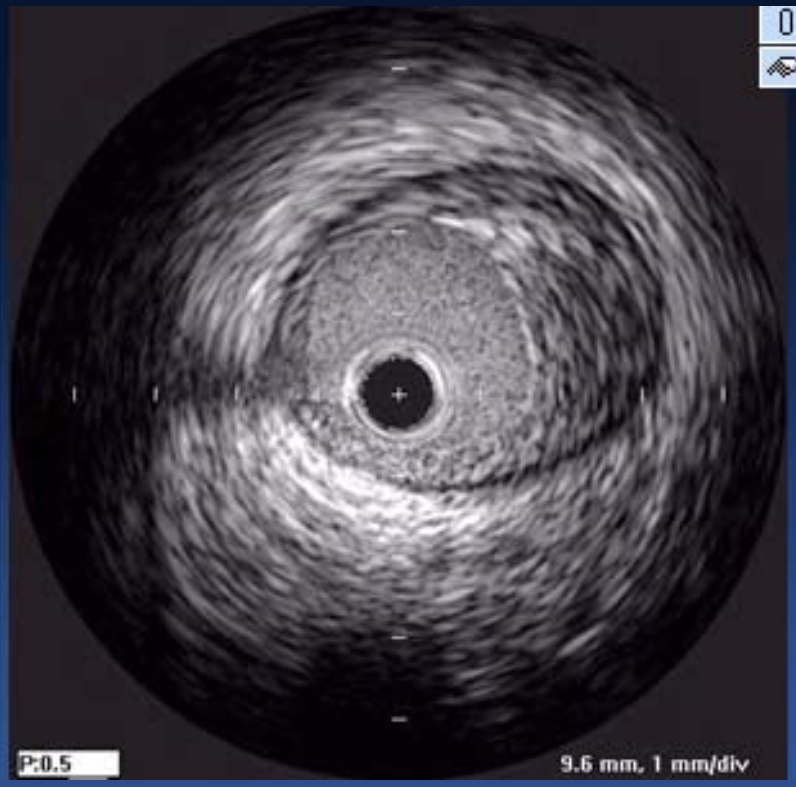
# LM Bifurcation Lesion with minimal-disease of LCX



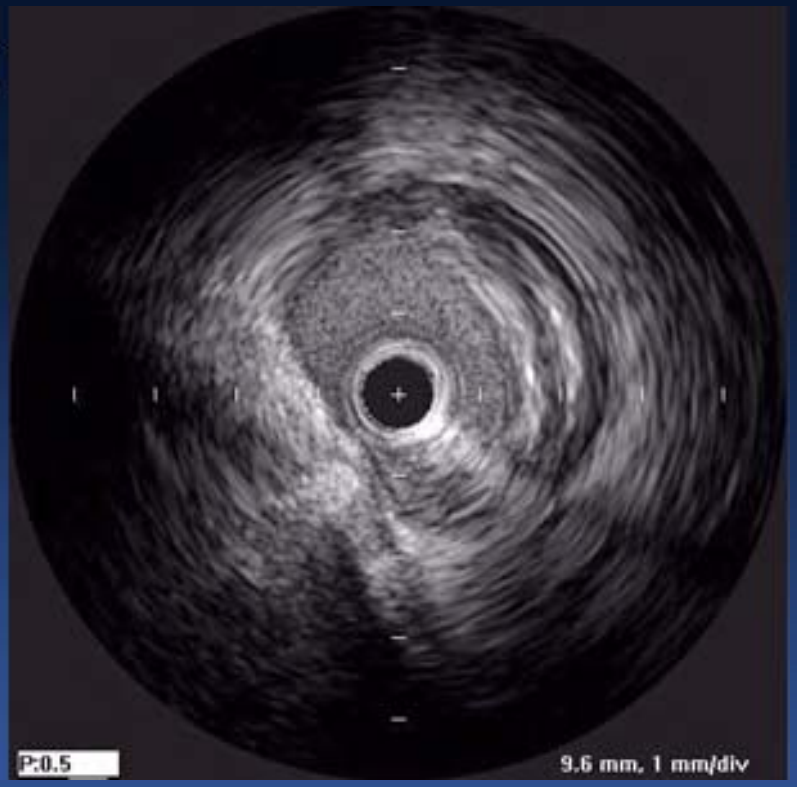


72/M, Unstable angina,

# IVUS

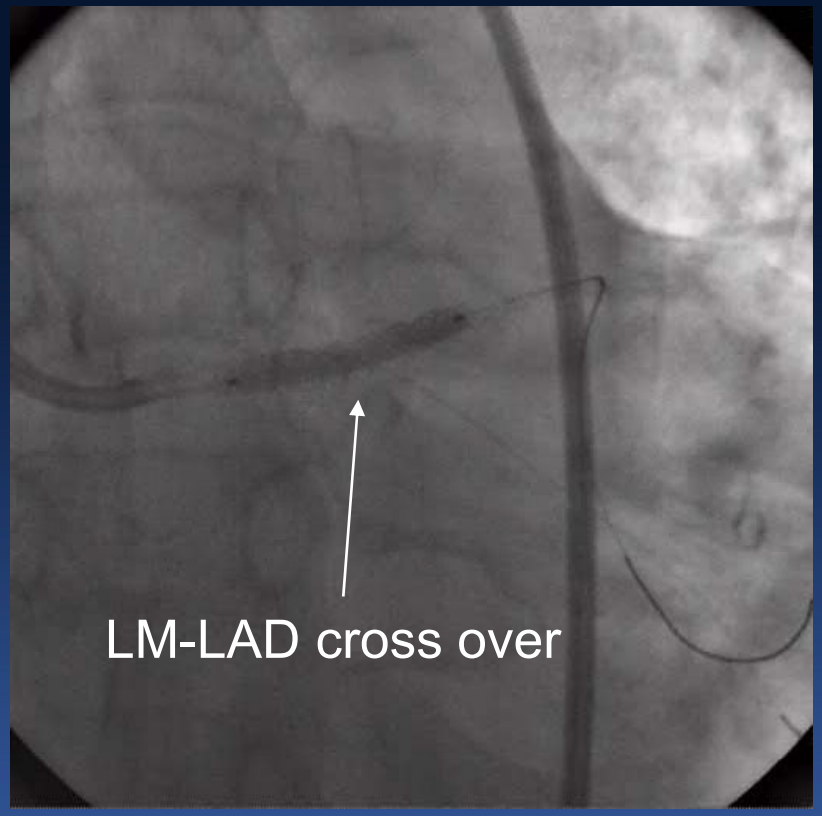


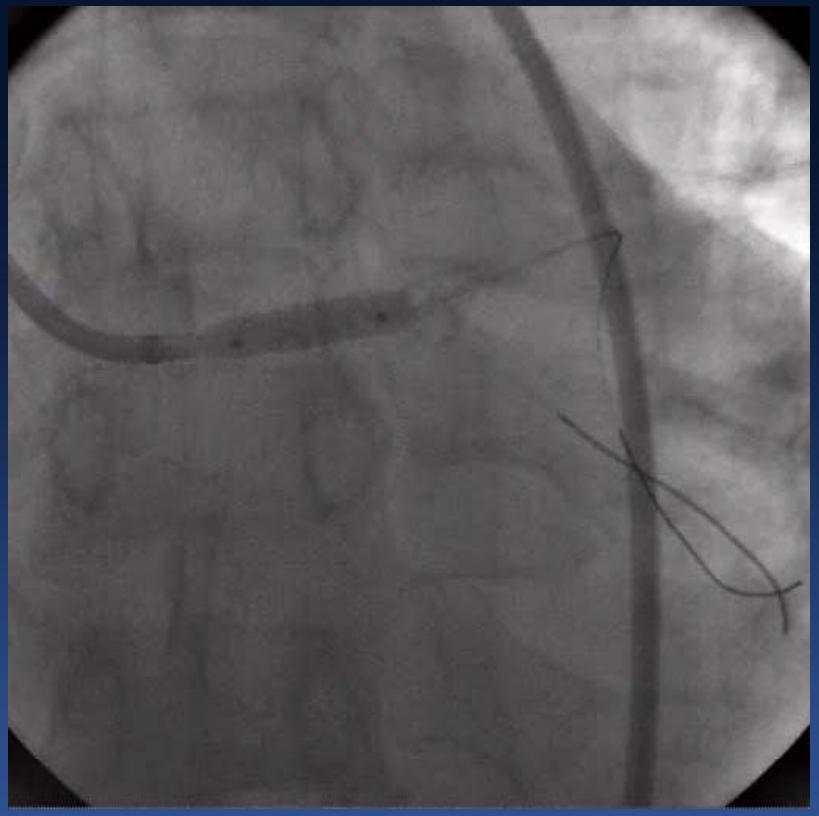

**LAD Ostium**




**LCX Ostium**
**Minimal-disease**
**MLA 5.4 mm²**

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

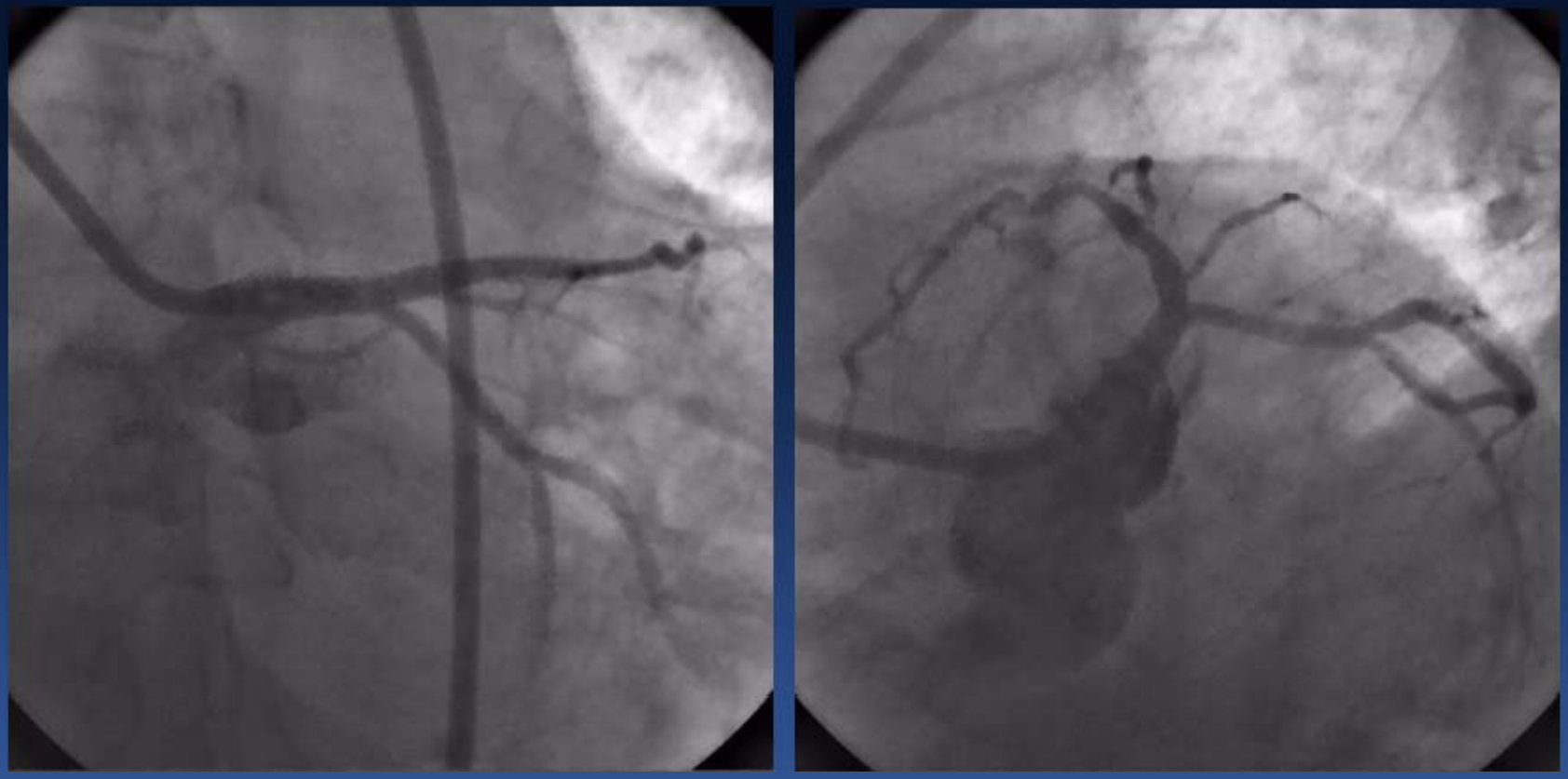


Cypher 3.5 × 23 mm

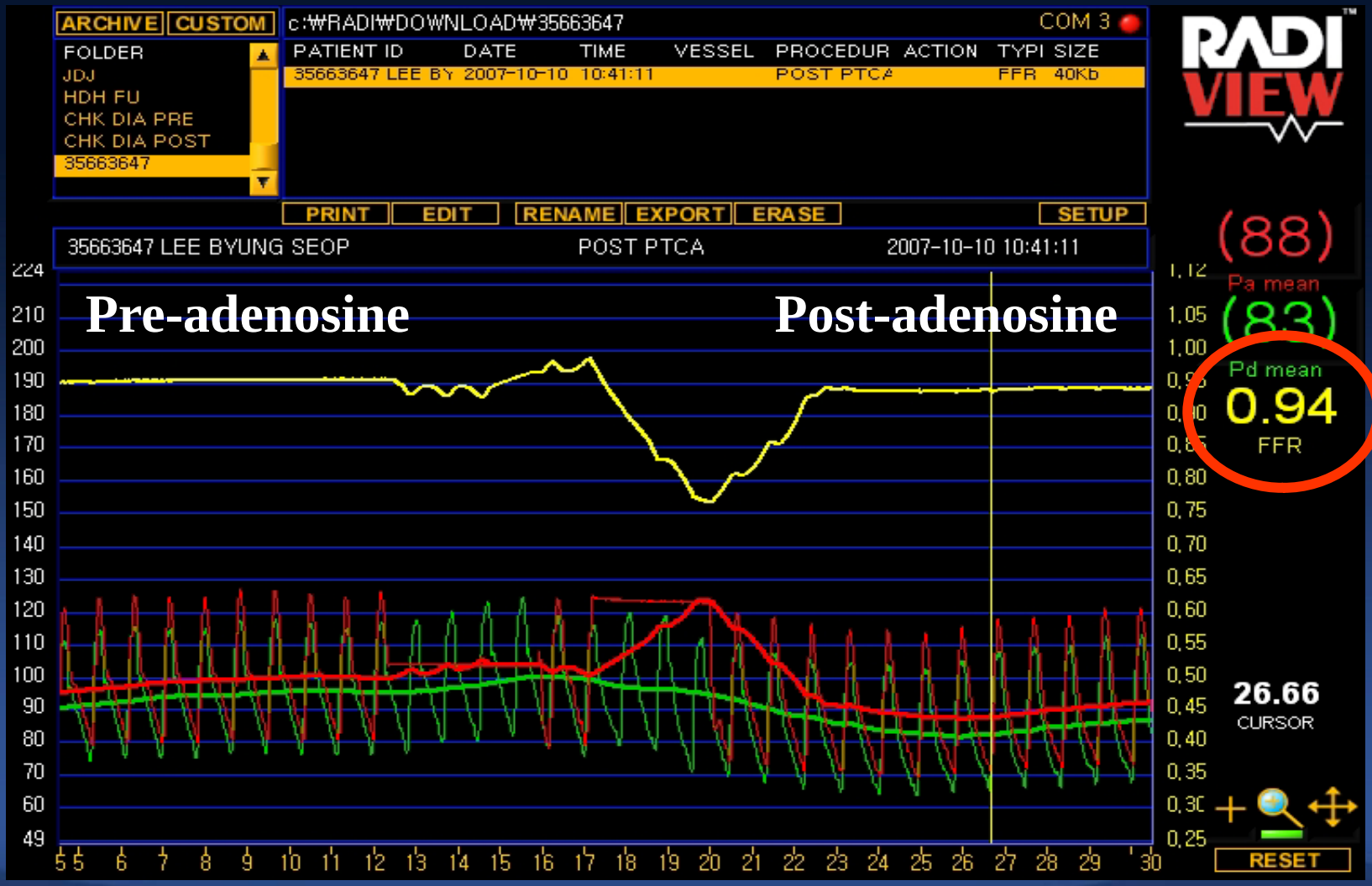
Additional high pressure Inflation with 4.0 mm non-compliant balloon

# Final Results
# after Single Stent Cross-Over



Immediate after the procedure, there was no significant compromise of LCX ostium.

# FFR of LCX is 0.94



# Single Stent Cross-Over

**IVUS Guided Stent Cross over depending on LCX disease status by IVUS, stent size selection, stent optimization.**

**FFR Guided decision making for further treatment about the compromised side branch (LCX).**

# 2 stent techniques
# in LM true bifurcation lesions

# 2 stent Techniques

- T-stent, modified T-stent or TAP
- Mini-crush (or step crush)
- Culotte
- V-stent
- Y-stent (SKS-simultaneous kissing stents)

# When to Choose Different 2 stent Techniques

| Technique | When to choose |
| --- | --- |
| T, modified T, TAP: | 75-90’ angled LCX |
| Culotte: | Y bif with matched LAD/LCX dia. |
| Mini-crush (or step crush): | Y bif with LAD/LCX dia mismatch. |
| V-stent: | Medina 0,1,1 (true LMEQ ds) |
| SKS: | Short LM, unstable pt |

**End with a FKB inflation with all 2-stent techniques**

*Whatever*

**you choose 2 stent techniques,**

**You have to consider IVUS guided Stent Optimization !**

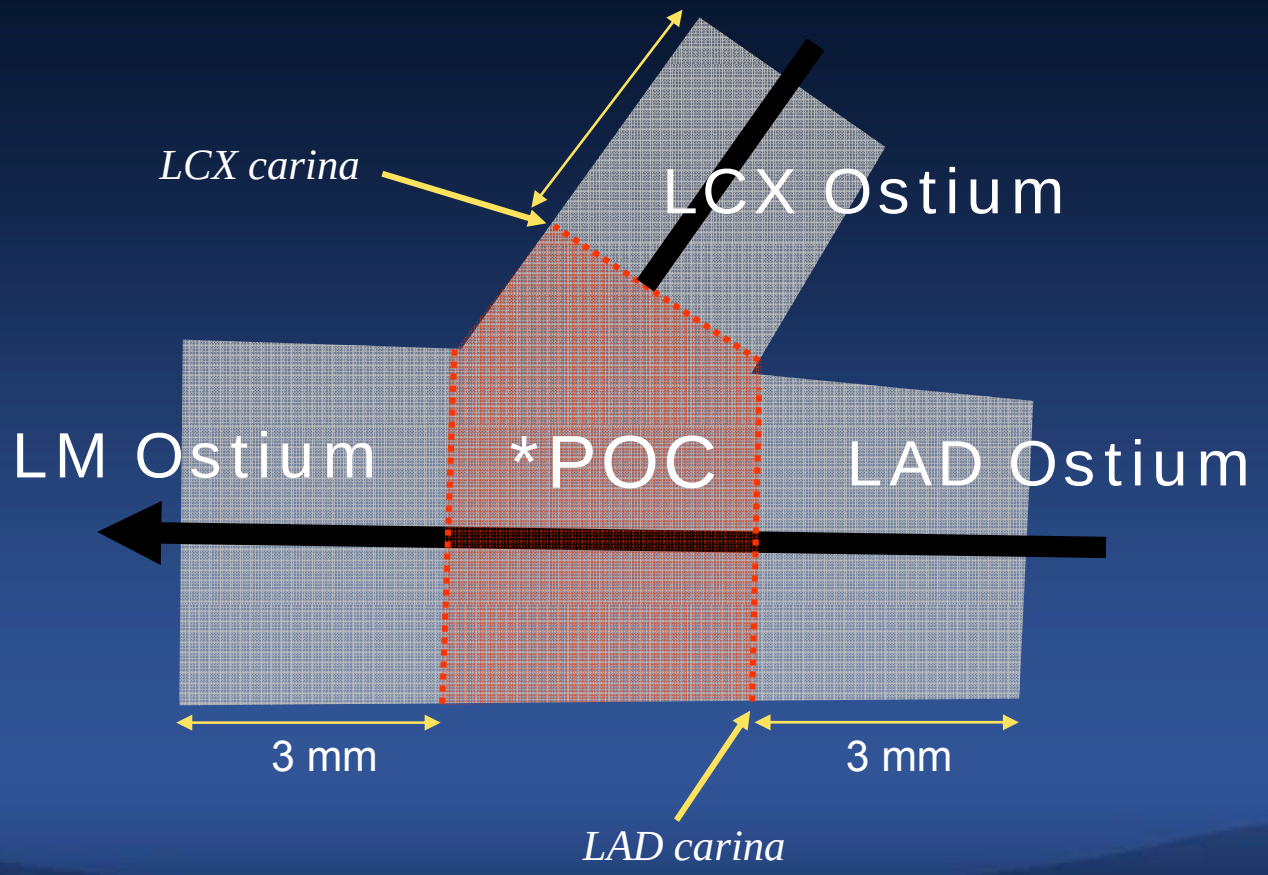
# IVUS Stent Area and its Impact for restenosis

in 403 Patients with Unprotected Left Main Disease

All patients treated with SES
100% Post-stent IVUS,
100% Angiography F/U at 9 months and
2 years clinical F/U

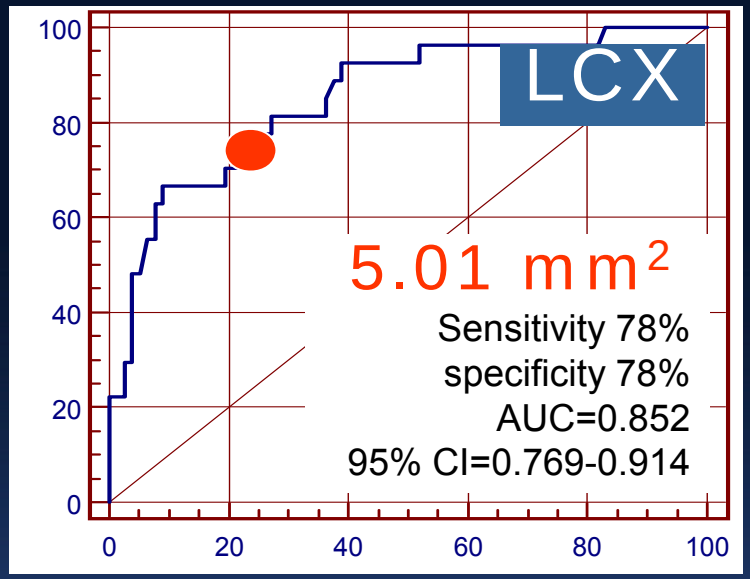
Kang SJ, et al. Circulation. Cardiovascular Interventions. 2011 Dec 1;4(6):562-9.

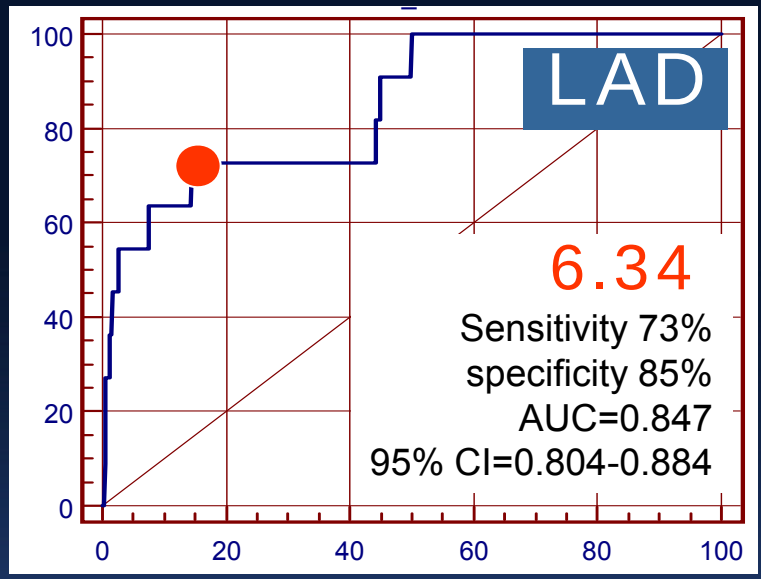
# IVUS Measurement for LM Bifurcation Stents

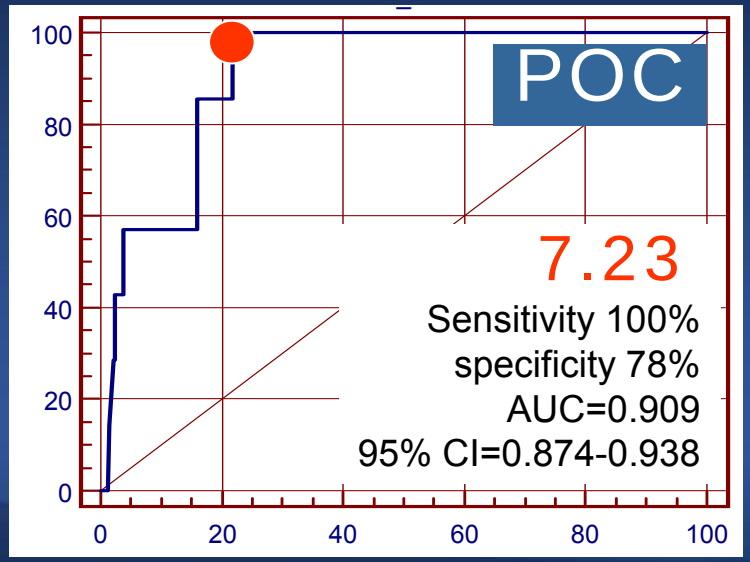


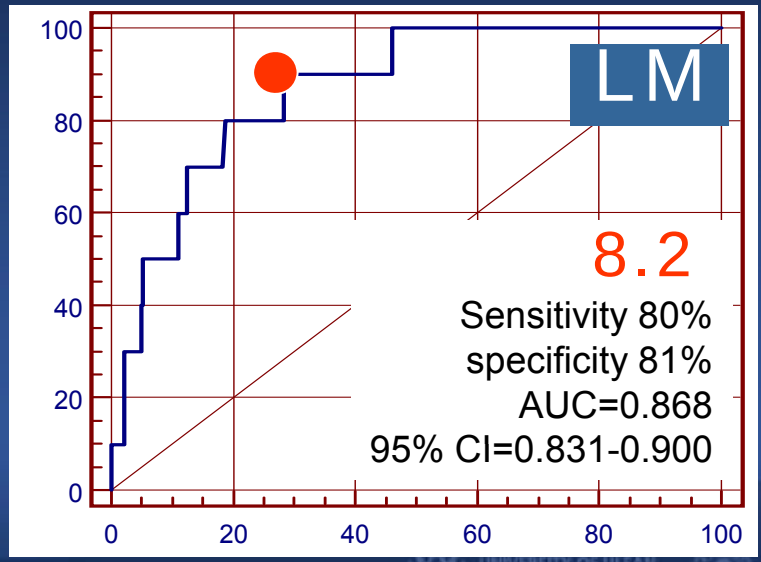

*POC : Polygon Of Confluence

# Minimal Stent Area ($mm^2$)
## to predict ISR




Sensitivity

Specificity

# IVUS Stent Optimization
## (Stent Cross-sectional Area)

**5,6,7,8 $mm^2$ of Stent CSA Can Make a Good Clinical Outcomes in 2 stents technique in LM bifurcation PCI. (Restenosis Rate < 5% and TLR < 2%)**

Kang SJ et al. Circulation. Cardiovascular Interventions. 2011 Dec 1;4(6):562-9.

# Distal LM Bifurcation Treatment

- For the intermediate LM bifurcation disease, FFR still works. IVUS guidance give us more understanding about the inside of vessel. And also MLA of LM <4.8 $mm^2$ can predict functional significance of stenosis (PPV 83%).
- When we used single stent cross over, FFR guided side branch optimization is reasonable approach.
- When we used 2 stents technique, IVUS guided optimization of stent (IVUS stent CSA 5,6,7,8 $mm^2$) can make a good clinical outcomes.

# Functional Angioplasty
## Integrated Use of FFR and IVUS

- Avoid unnecessary PCI
- Avoid unnecessary Surgery
- Minimize MACE
- Maximize clinical outcomes
- Save money
- Save lives