

# Do IVUS-MLA Criteria Need to Be Adjusted ?

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# IVUS-MLA

## Matching with FFR

4 mm<sup>2</sup> for Non-LM,  
6 mm<sup>2</sup> for LM,

Are They Right ?  
Do They Work ?

# IVUS MLA Matched with Functional Significance in Non-LM Disease Old Published Data

	Nishioka T, JACC 1999	Briguori et al AJC 2001	Takaki et al Cir. 1999	Abizaid et al AJC 1998
	70 lesions	53 lesions	42 pts	86 pts
<b>IVUS-MLA (mm<sup>2</sup>)</b>	<b>&lt;4.0 (Thallium +)</b>	<b>&lt; 4.0 (FFR&lt;0.75)</b>	<b>&lt;3.0 (FFR&lt;0.75)</b>	<b>&gt; 4.0 (CFR &gt;2.0)</b>
<b>Sensitivity</b>	80%	92%	83 %	<b>Accuracy</b>
<b>Specificity</b>	90%	54%	92.3 %	92%
<b>QCA VD (mm)</b>		3.08±0.3		
<b>DS (%)</b>		52±11		
<b>MLA (mm<sup>2</sup>)</b>	3.3±2.3	3.9±2.5	3.9±2.0	4.4±2.0
<b>MVA (mm<sup>2</sup>)</b>		12.0±4.6		13.2±4.4
<b>Area stenosis%</b>		65±18	55±24	43±24

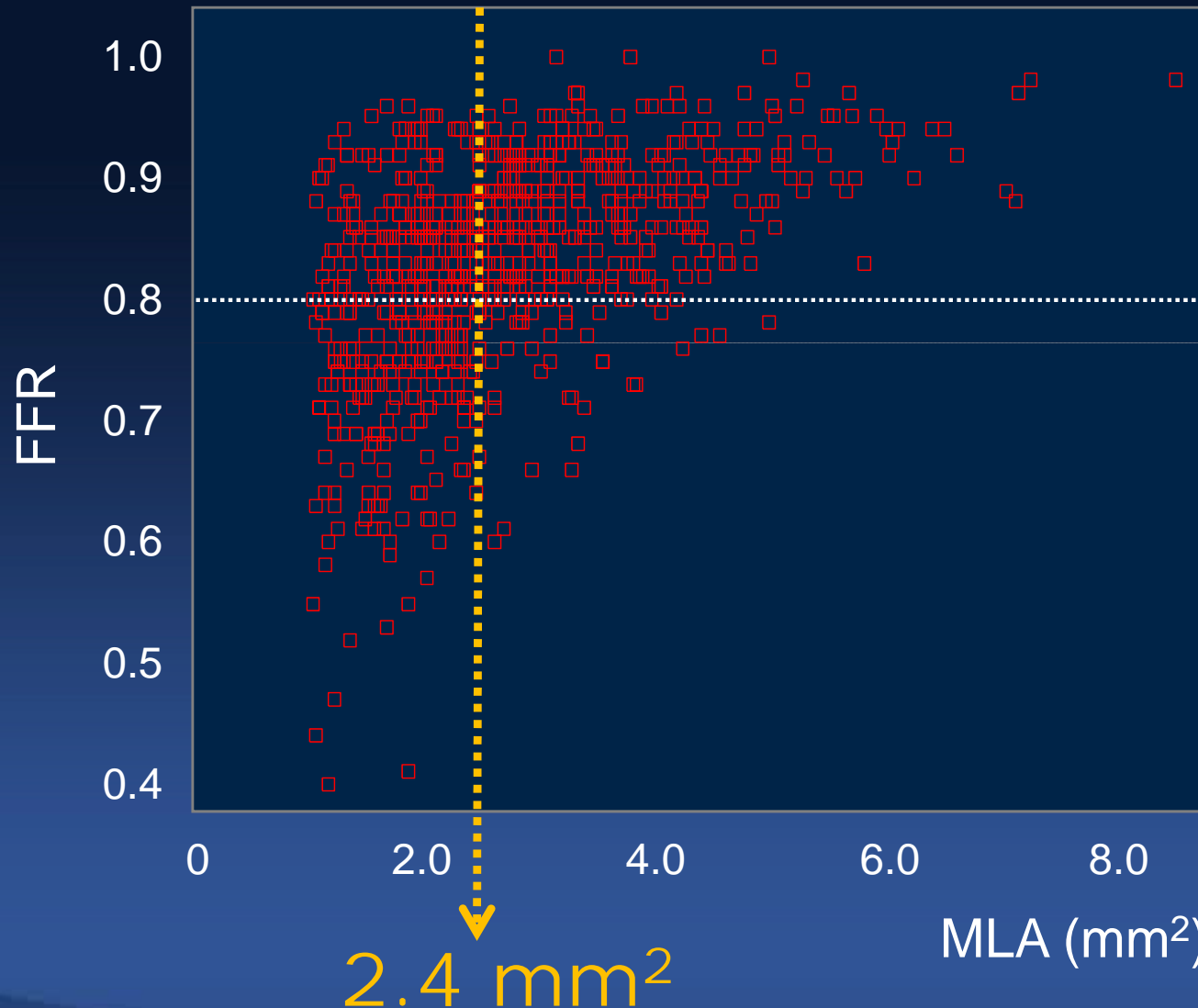
# IVUS MLA Matched with FFR, Non-LM

## New Published Data

	N	FFR	RLA	MLA mm <sup>2</sup>	AUC	Sens	Spec	PPV	NPV	Accu
<b>Briguori</b> (2001, AJC)	53	0.75	7.8	4.0	—	92%	56%	38%	96%	64%
Takaki (1999, Circ)	51	0.75	9.3	3.0	—	83%	92%	—	—	—
Waksman (2013, JACC)	350	0.80	8.6	3.07	0.65	64%	65%	—	—	65%
Kang (2012, AJC)	784	0.80	8.2	2.4	0.77	84%	63%	48%	90%	69%
Kang (2011, Circ int)	236	0.80	7.6	2.4	0.80	90%	60%	37%	96%	68%
Gonzalo (2012, JACC)	47	0.80	7.1	2.36 IVUS	0.63	67%	65%	67%	65%	66%
Gonzalo (2012, JACC)	61	0.80	7.1	1.95 OCT	0.70	82%	63%	66%	80%	72%
Koo (2011, JACC int)	267	0.80	6.8	2.75	0.81	69%	65%	27%	81%	67%
Lee (2010, AJC)	94	0.75	5.9	2.0	0.80	82%	81%	—	—	81%

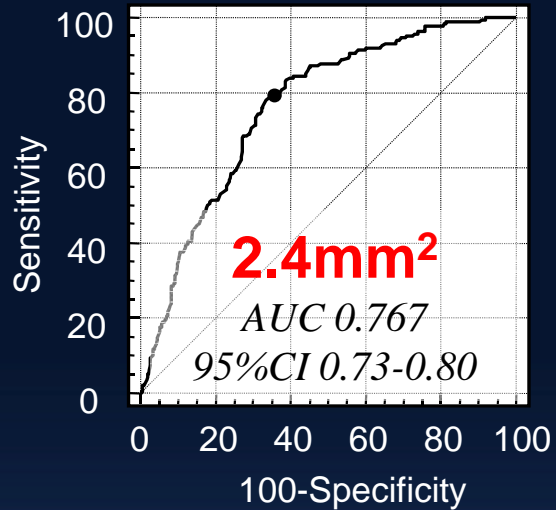
# New IVUS MLA

Matched with FFR <0.80 (AMC data, n=784)



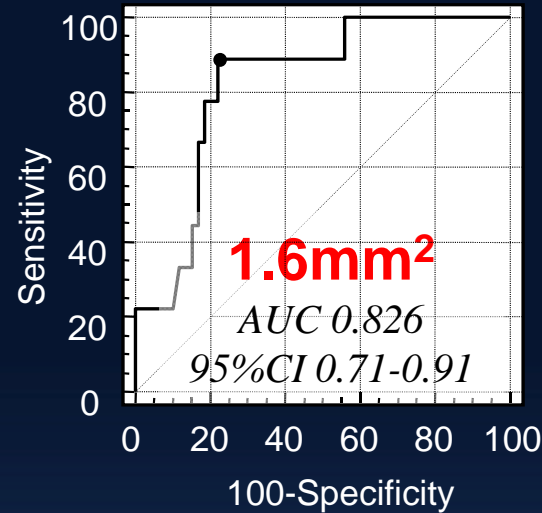
Sensitivity	84%
Specificity	63%
<b>PPV</b>	<b>48%</b>
NPV	90%
Accuracy	69%

## LAD



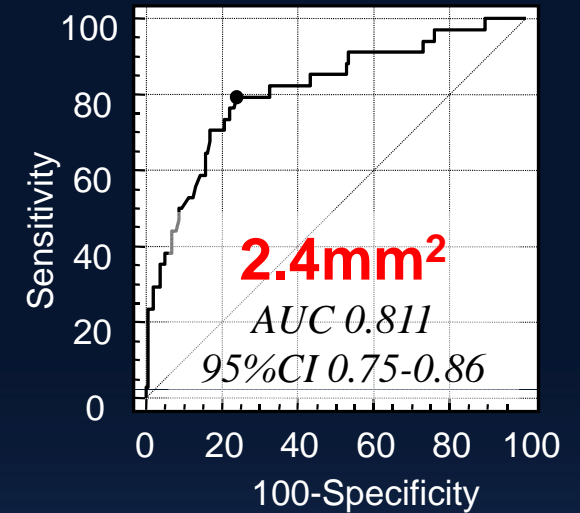
Sens 80%, Spec 64%

## LCX



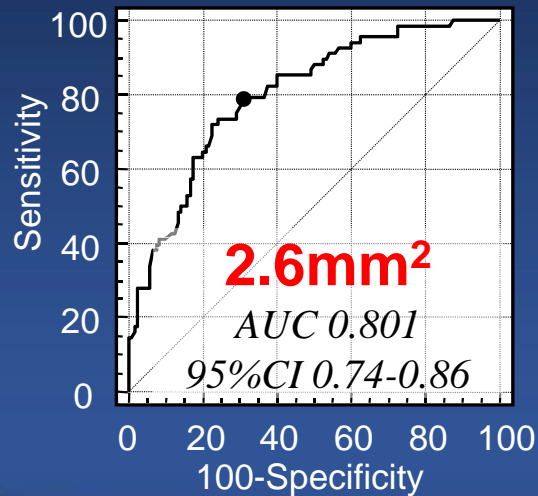
Sens 89%, Spec 77%

## RCA



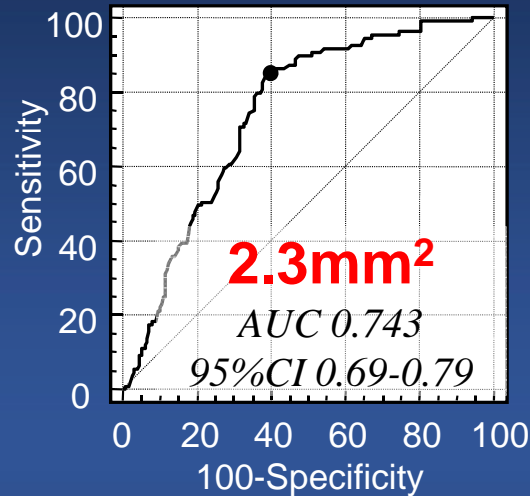
Sens 79%, Spec 77%

## Proximal LAD



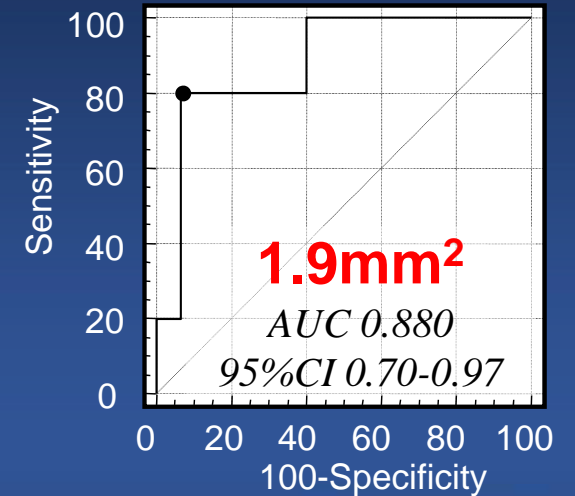
Sens 79%, Spec 70%

## Mid-LAD



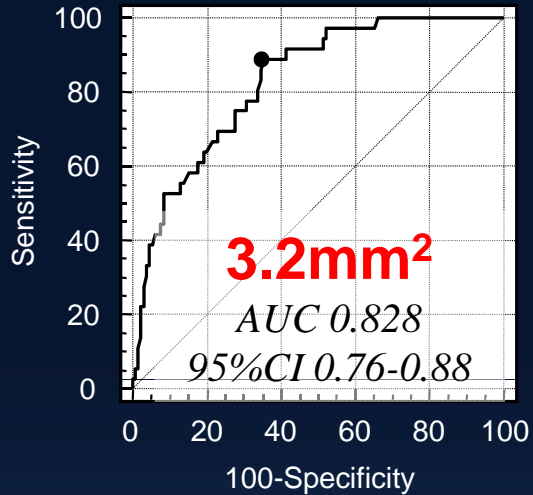
Sens 85%, Spec 61%

## Distal LAD



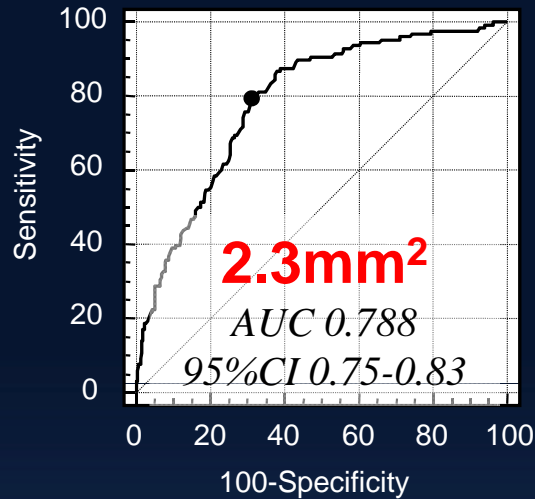
Sens 80%, Spec 93%

## RLD >3.5mm



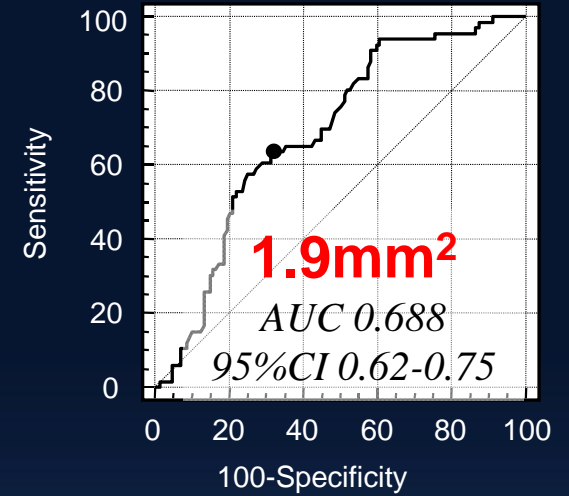
Sens 89%, Spec 65%

## 2.75-3.5mm



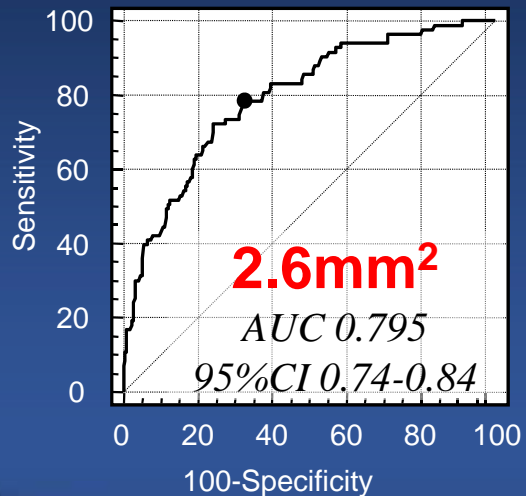
Sens 80%, Spec 68%

## <2.75mm



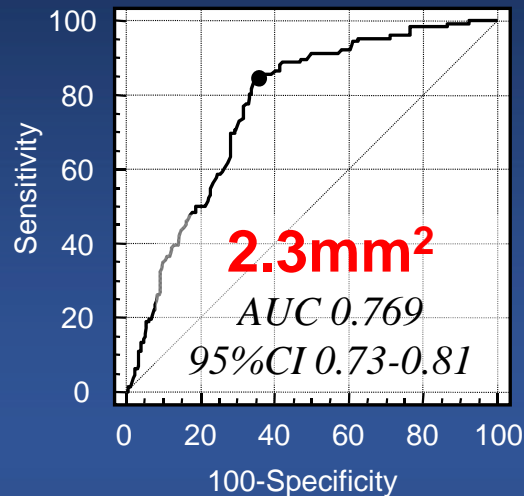
Sens 64%, Spec 69%

## Proximal



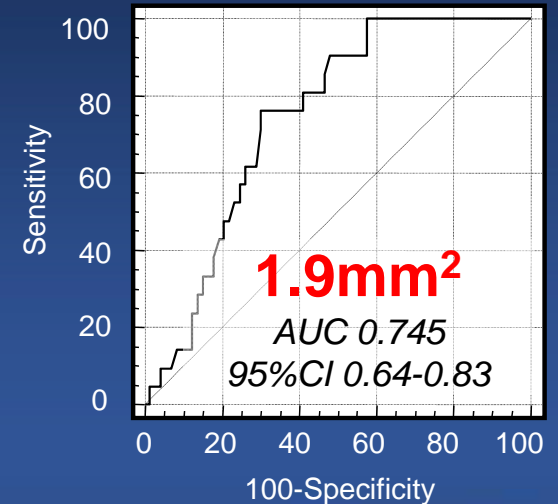
Sens 78%, Spec 68%

## Mid



Sens 84%, Spec 65%

## Distal



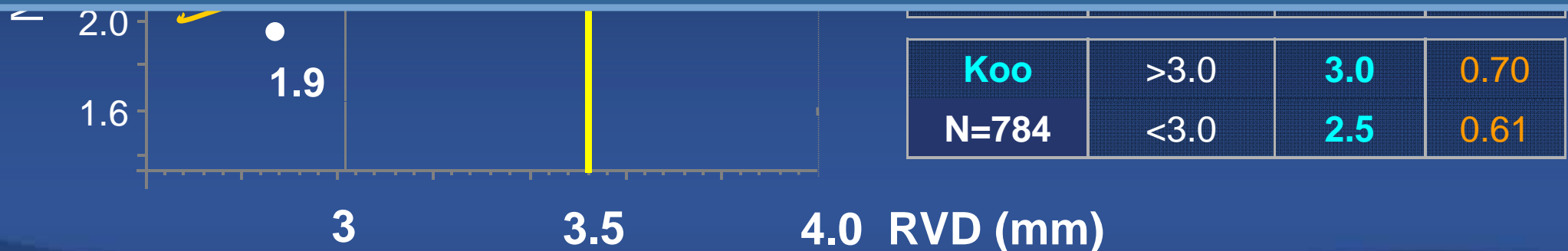
Sens 76%, Spec 70%

Does  
IVUS MLA  $4.0\text{mm}^2$   
Still Work ?

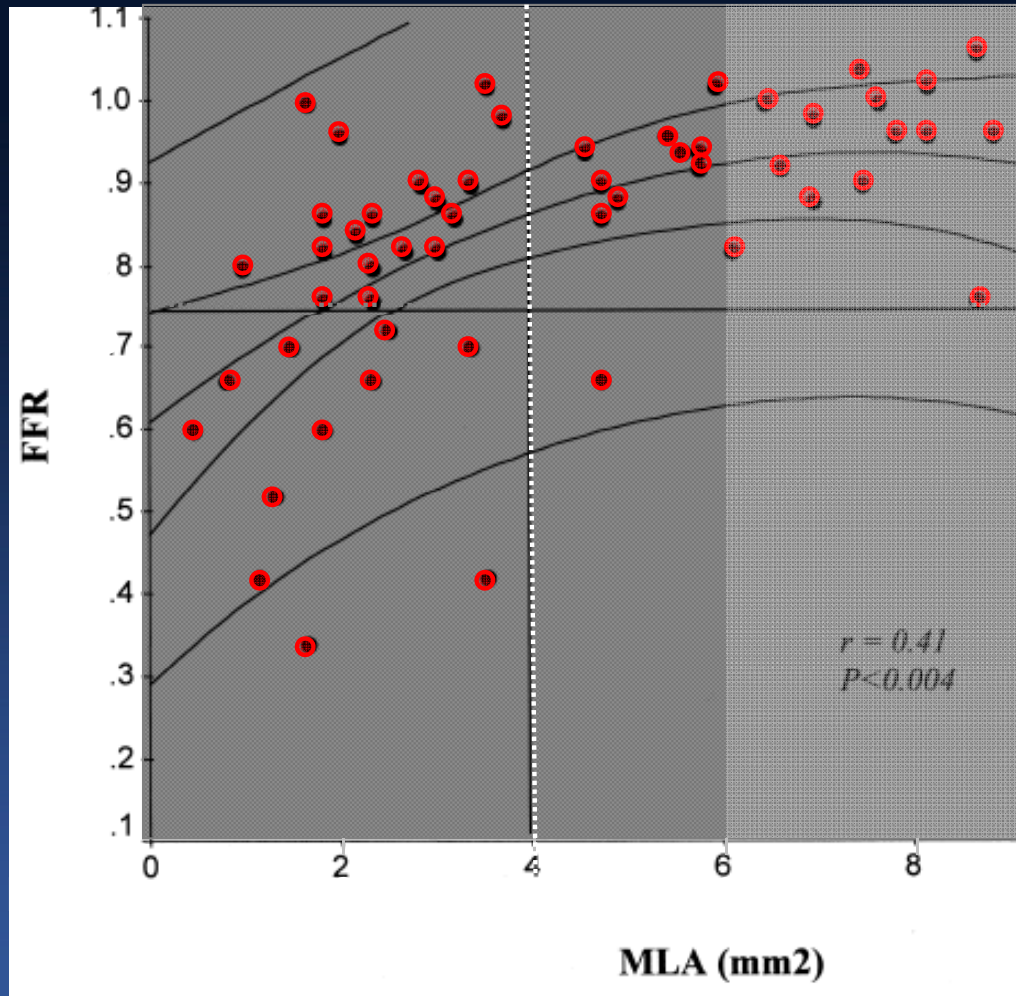


1. The Bigger Reference Vessel, the Bigger IVUS MLA.
2. **IVUS MLA 4 mm<sup>2</sup> Criteria**  
Should Be Matched with Bigger Reference Vessel Diameter  $\geq 4.0$  mm.

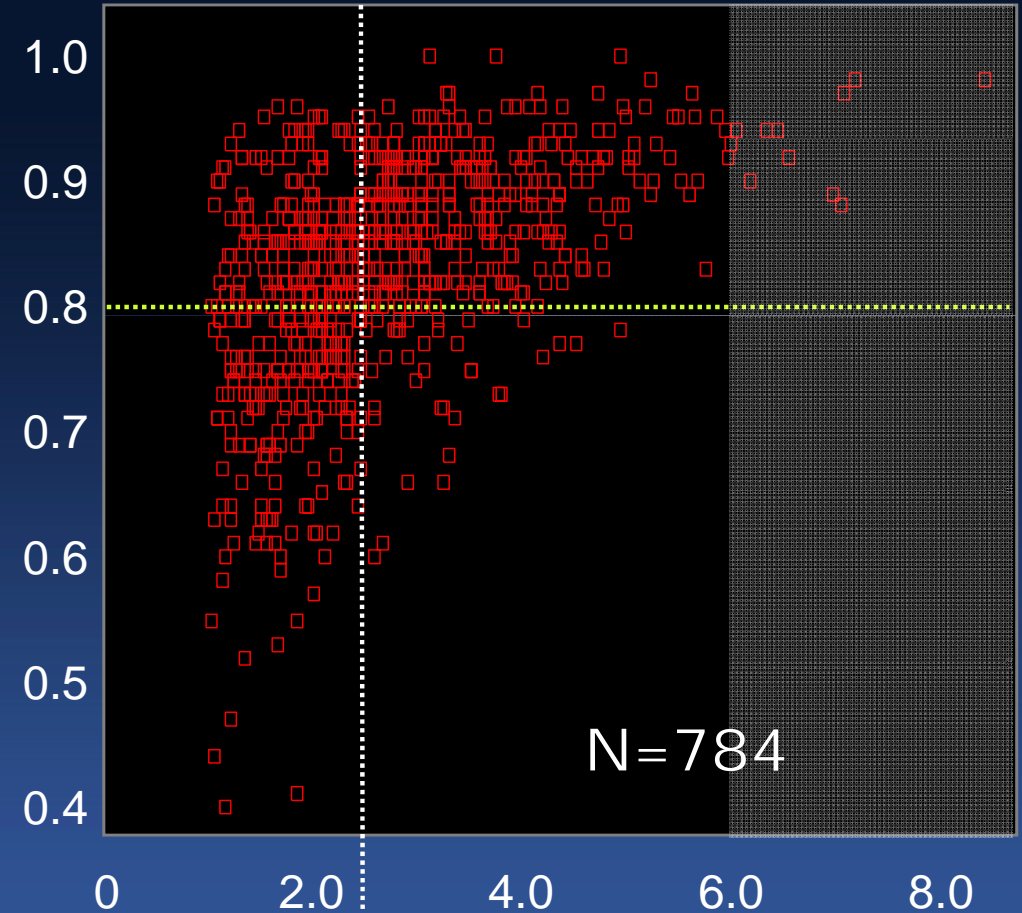
Different IVUS MLA Criteria,  
According to Different Reference Vessel Diameter.  
**The Bigger Reference Vessel, the Bigger IVUS MLA !**



1. Number of Study Patient (n=53) Was Too Small.
2. Too Many Large Vessel with Negative FFR.
3. It Was Not Normal Distribution.



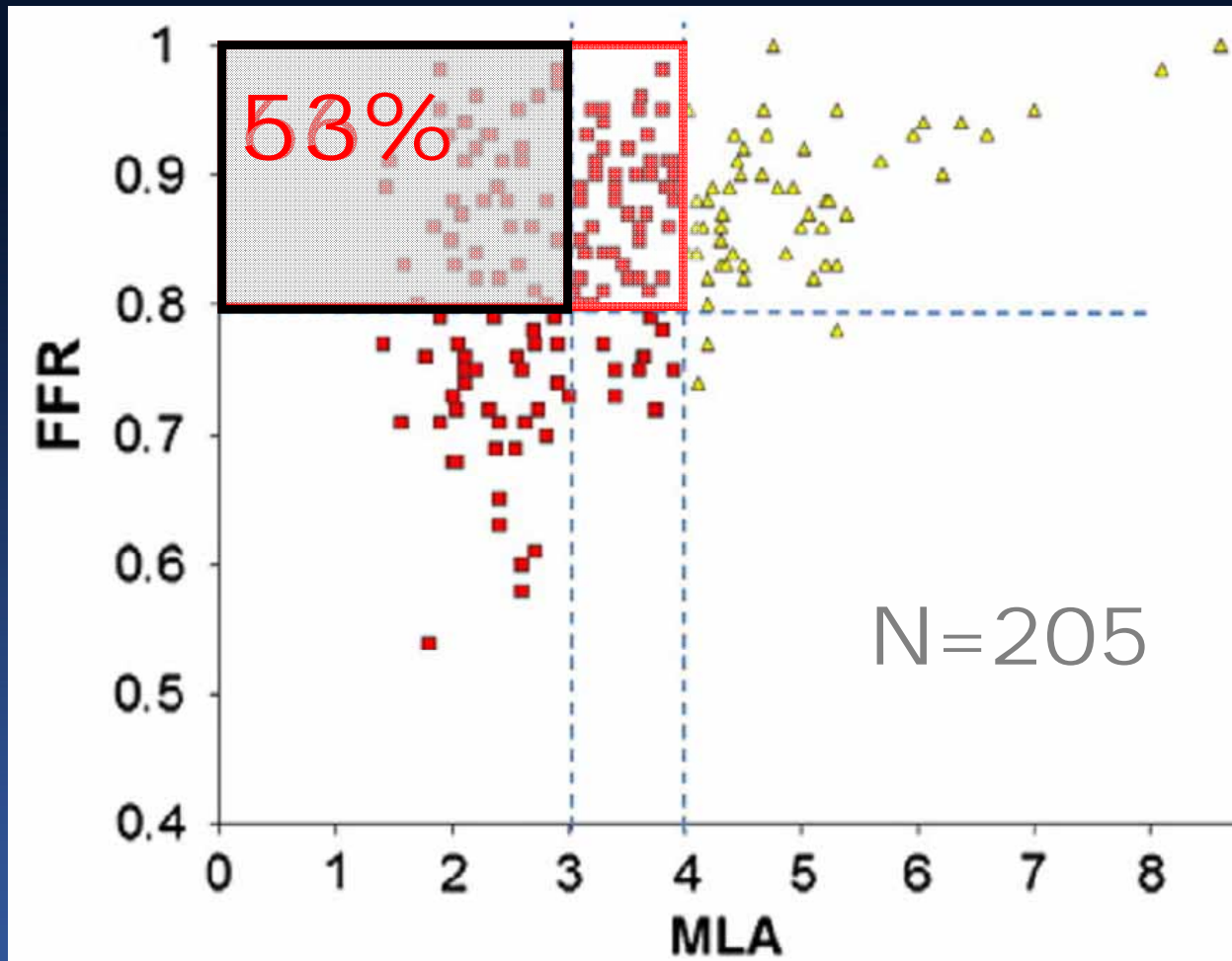
4.0 mm<sup>2</sup>



2.4 mm<sup>2</sup>

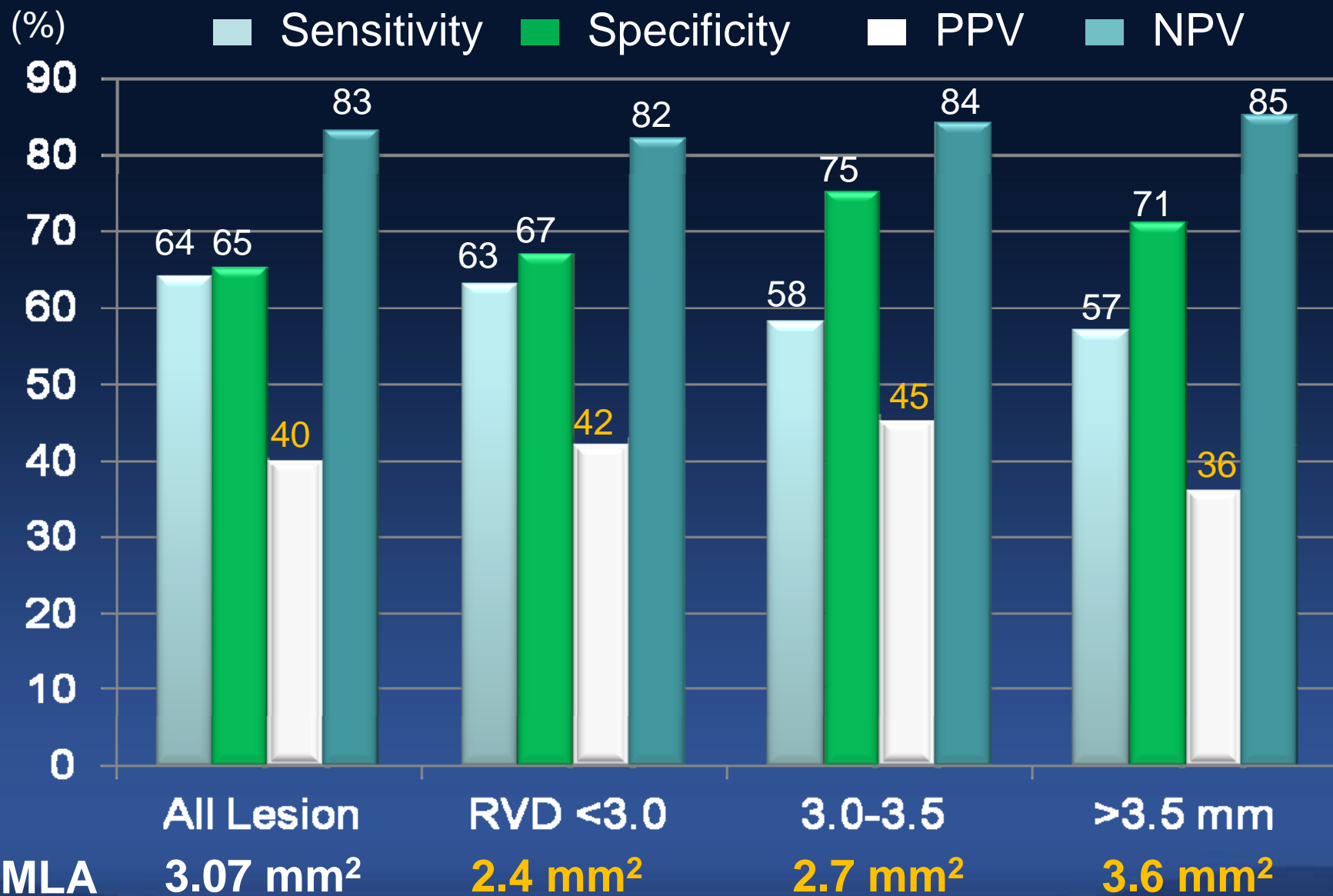
# IVUS MLA Matched with FFR

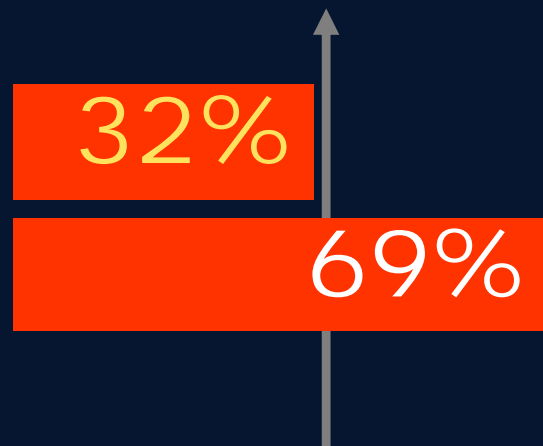
## Lots of Mismatches !



**MLA 3.09mm<sup>2</sup>**  
Sensitivity 69%  
Specificity 72%  
Accuracy 70%

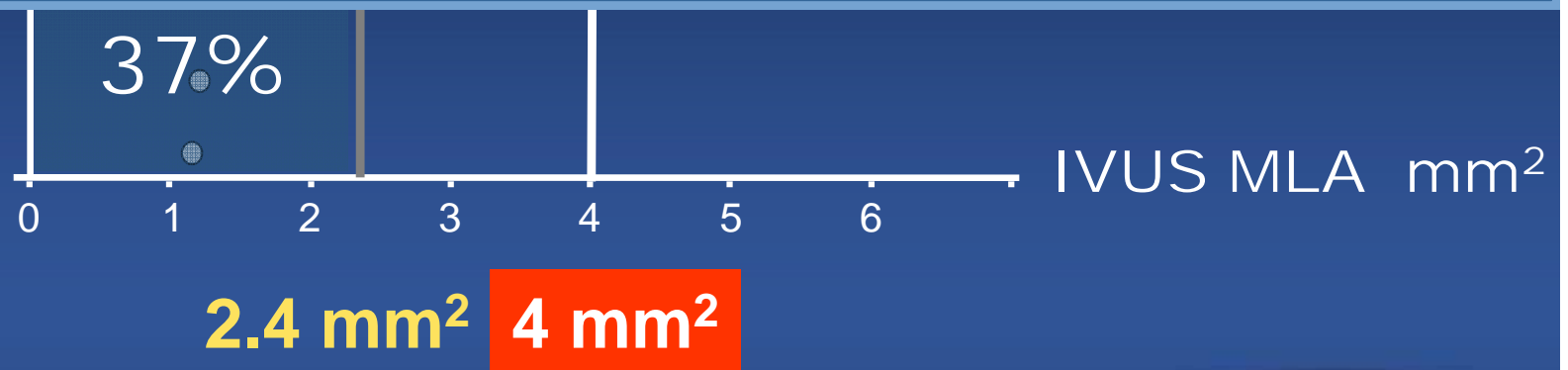
# IVUS MLA Matched with FFR <0.80 (n=350)





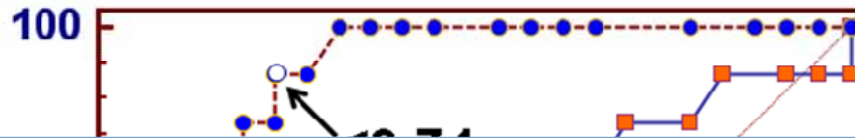
**Negative FFR,  
Mismatches  
Unnecessary PCI**

**3. To treat or Not to Treat Decision Making  
Should be Done by FFR.**



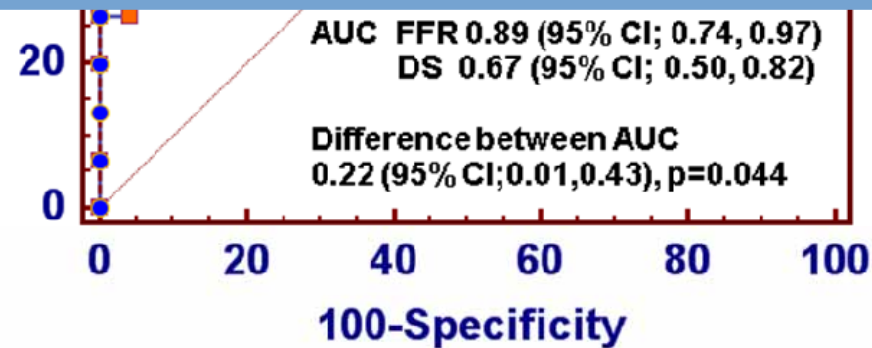
Is  
FFR Cut-Off 0.80,  
Validated in LM Disease  
Too ?

# Validation of FFR Cut-Off for LM Disease; **0.74** (Matched with Thallium Perfusion Scan, n=38)



**0.80 FFR Cut-Off**

Would Be Appropriate for LM Disease Too.



# Multivariable Analysis to Predict FFR <0.80, LM (n=112)

Variables	OR	95%CI	p-value
<b>Model 1</b>			
Plaque rupture	4.51	1.36-14.9	0.014
BMI, kg/m <sup>2</sup>	1.19	1.00-1.40	0.05
Age, year	0.95	0.90-1.00	0.033
MLA, mm <sup>2</sup>	0.37	0.25-0.56	<0.001
<b>Model 2</b>			
LV mass, g	1.01	1.00-1.03	0.03
Age, year	0.94	0.90-0.99	0.022
MLA, mm <sup>2</sup>	0.34	0.21-0.54	<0.001

Model 1 included clinical, QCA, and IVUS variables

Model 2 included Model 1 plus LV mass assessed by **Echocardiography**



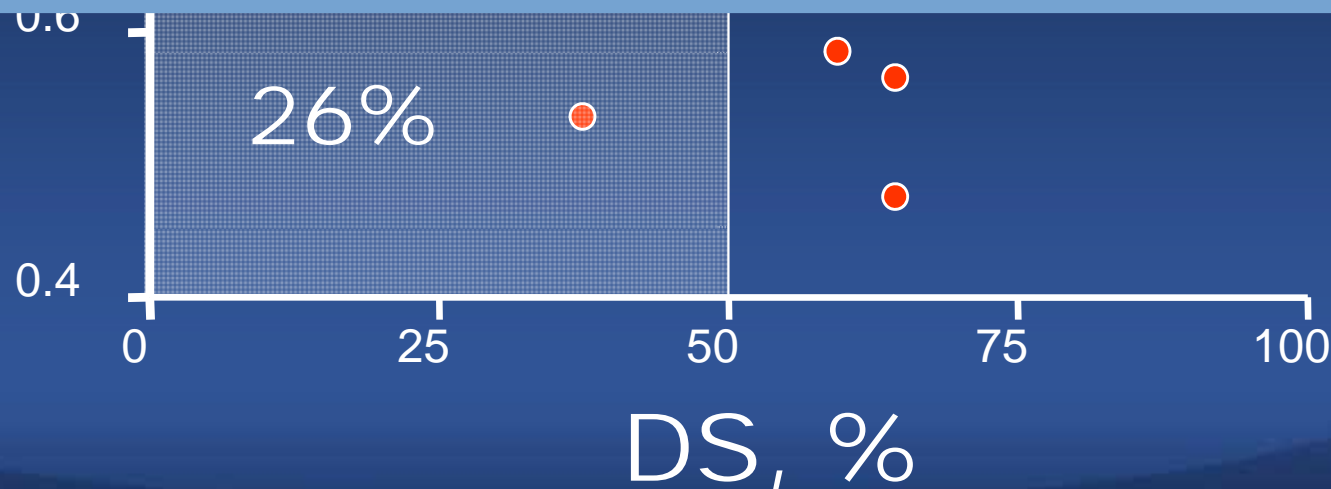


# How Many Mismatches ?

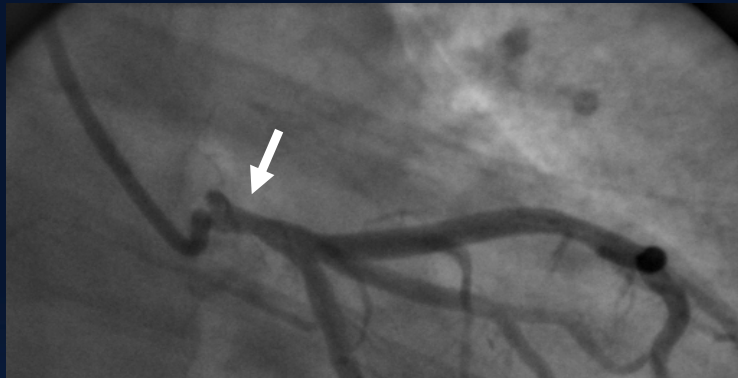
Intermediate LM Ostial and Shaft Disease  
(AMC data, n=112)



Overall 37% of Ostial and Shaft lesions showed Mismatches.  
Relatively Higher Frequency of Reverse Mismatches.



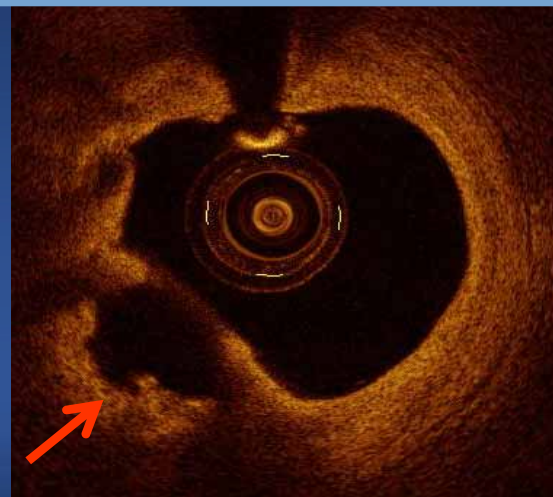
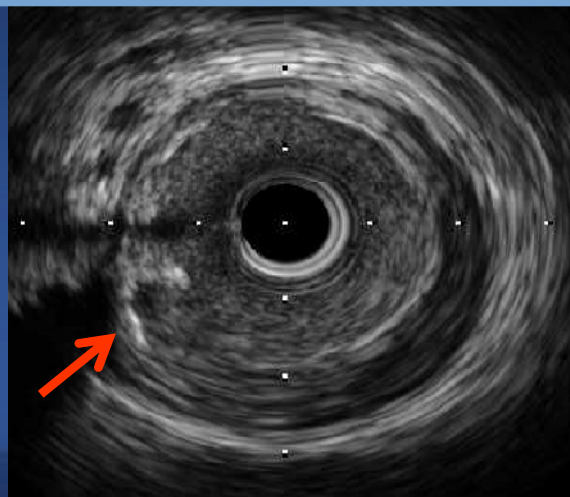
# A Case of Reverse Mismatch



Visual Estimation  
30% DS

FFR : 0.70

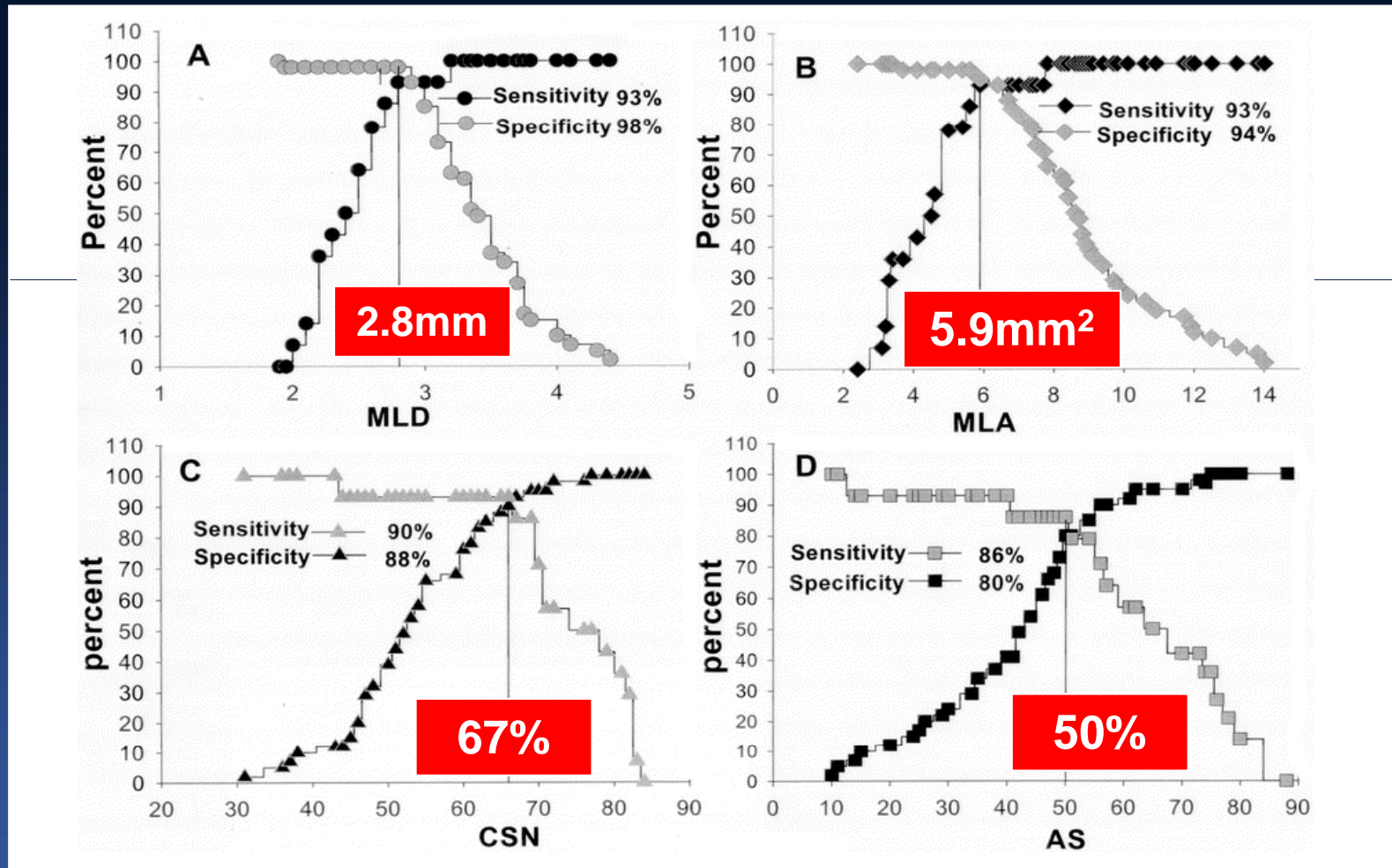
Plaque Rupture, Smaller MLA and Large LV mass (Myocardium) Are Related with Positive FFR.



Plaque rupture,  
MLA 6.2mm<sup>2</sup>

Can **IVUS MLA**  
Predict the Functional  
Significance of Stenosis  
In LM Disease ?

# IVUS MLA $< 6.0 \text{ mm}^2$ is matched with FFR $< 0.75$



# Why 6 mm<sup>2</sup> IVUS MLA Is Not Appropriate ?

# Background, Geometric Abstraction

“The 6-mm<sup>2</sup> value was obtained from **Murray’s law** (considering an MLA of 4 mm<sup>2</sup> as the ischemic threshold of the branches) and has been supported by a study that used IVUS and pressure wire flow fractional reserve (FFR).”

De La Torre Hernandez et al. JACC 2011;58:351-8

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

# IVUS MLA Matched with FFR, Non-LM

## New Published Data

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# Murray's Law, **Finet's Law**, Huo and Kassab (HK)'s Law,

Ischemic Threshold of Branches Would Be  
< 3 mm<sup>2</sup> Based on the Current Data. The 6 mm<sup>2</sup> of IVUS MLA is  
**Not Appropriate Anymore from Geometric Abstraction**  
with Murray's Law, Finet's Law, and HK's Law.





# New IVUS MLA In LM Disease (n=112)

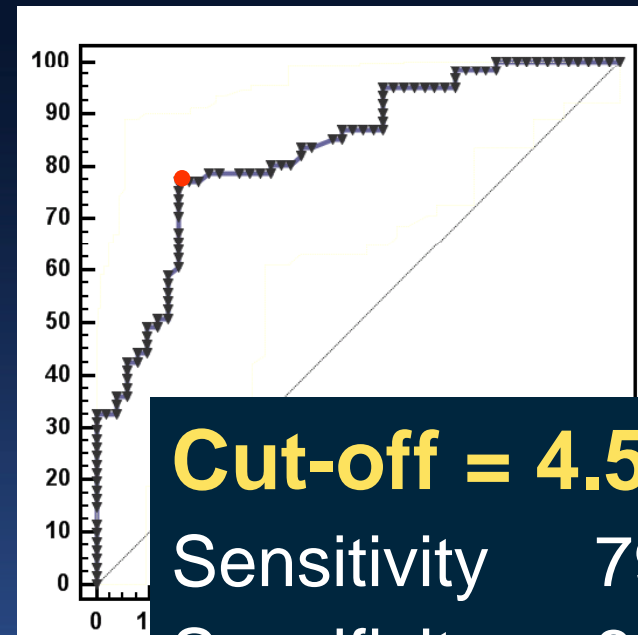
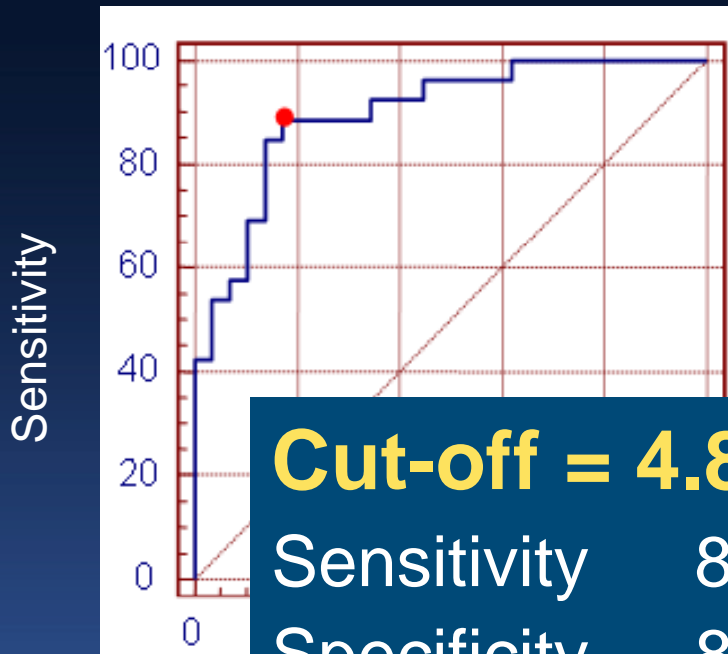
AMC FFR Registry, **New Data**

# New LM IVUS MLA

Matched with FFR <0.80, Ostial and Shaft LM Disease

**(n=55 lesions)**

**(n=112 lesions)**



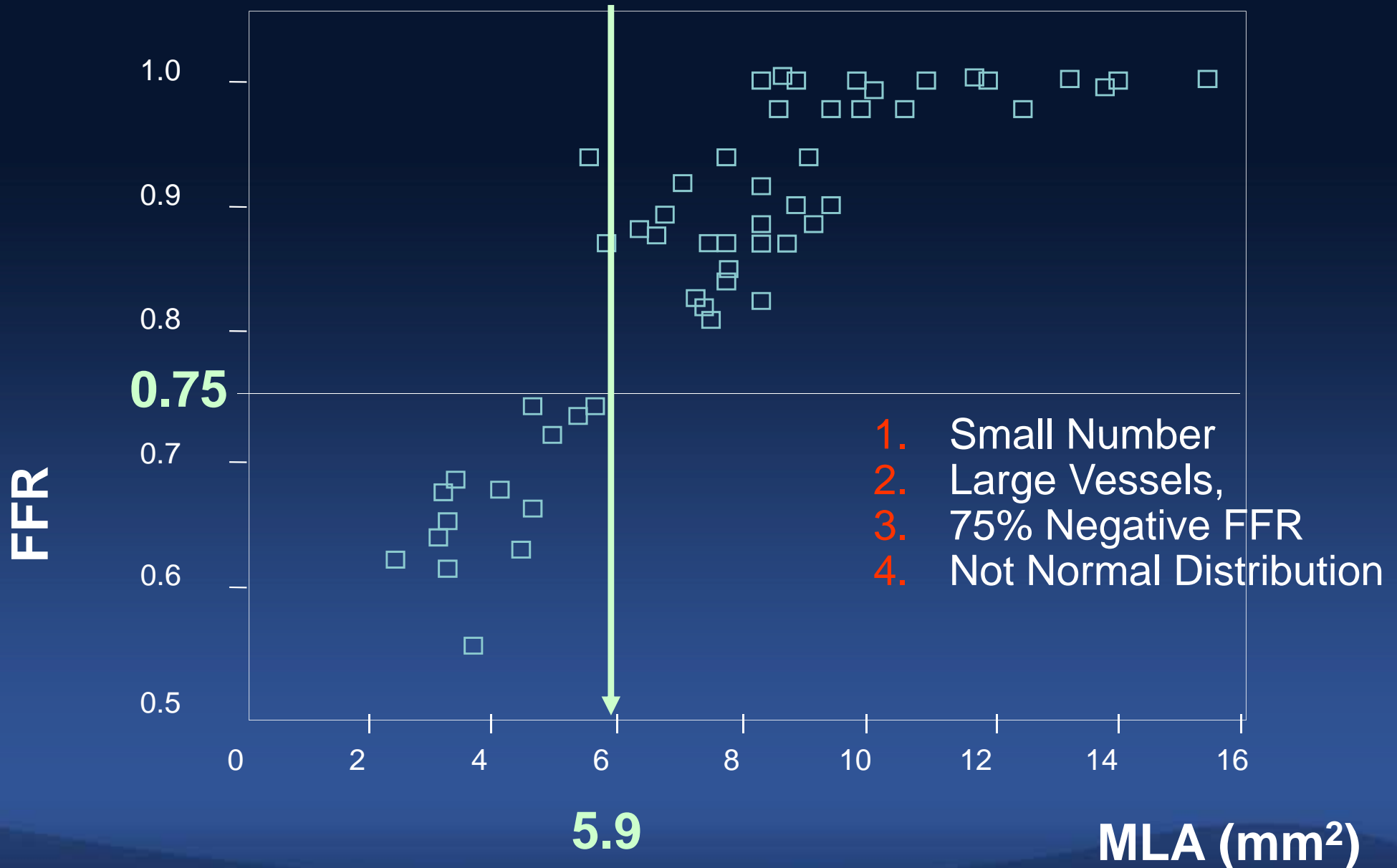
**Cut-off = 4.8 mm<sup>2</sup>**

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

**Cut-off = 4.5 mm<sup>2</sup>**

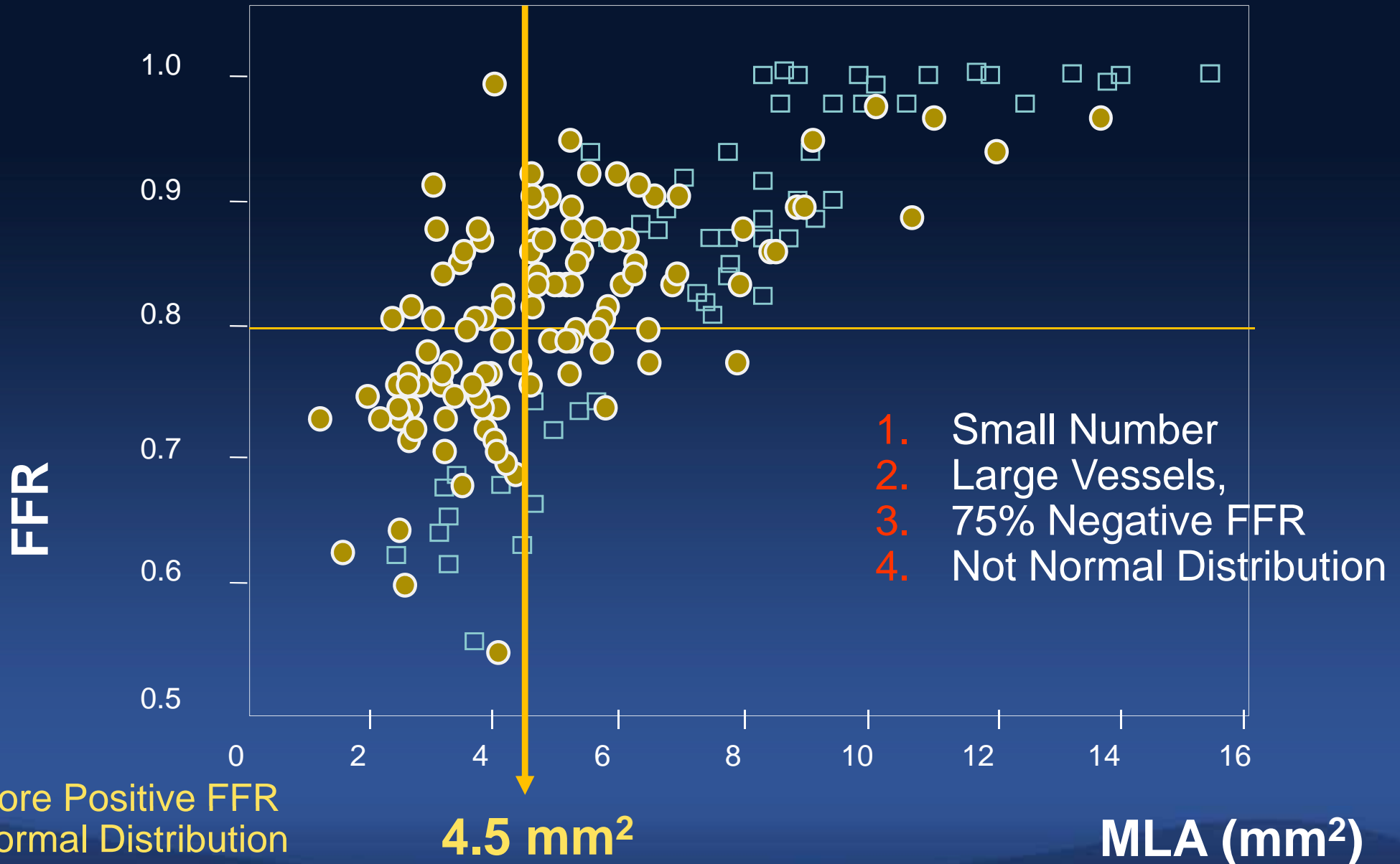
Sensitivity	79%
Specificity	80%
PPV	83%
NPV	76%
Accuracy	80%

# Jasti's data (n=55)

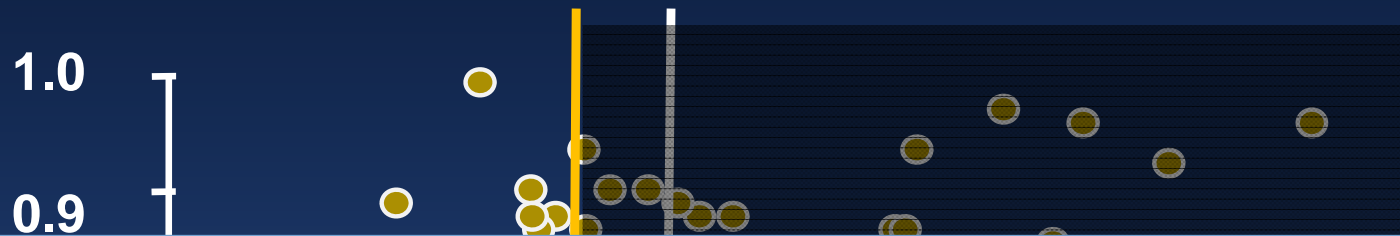


AMC New Data (n=112)

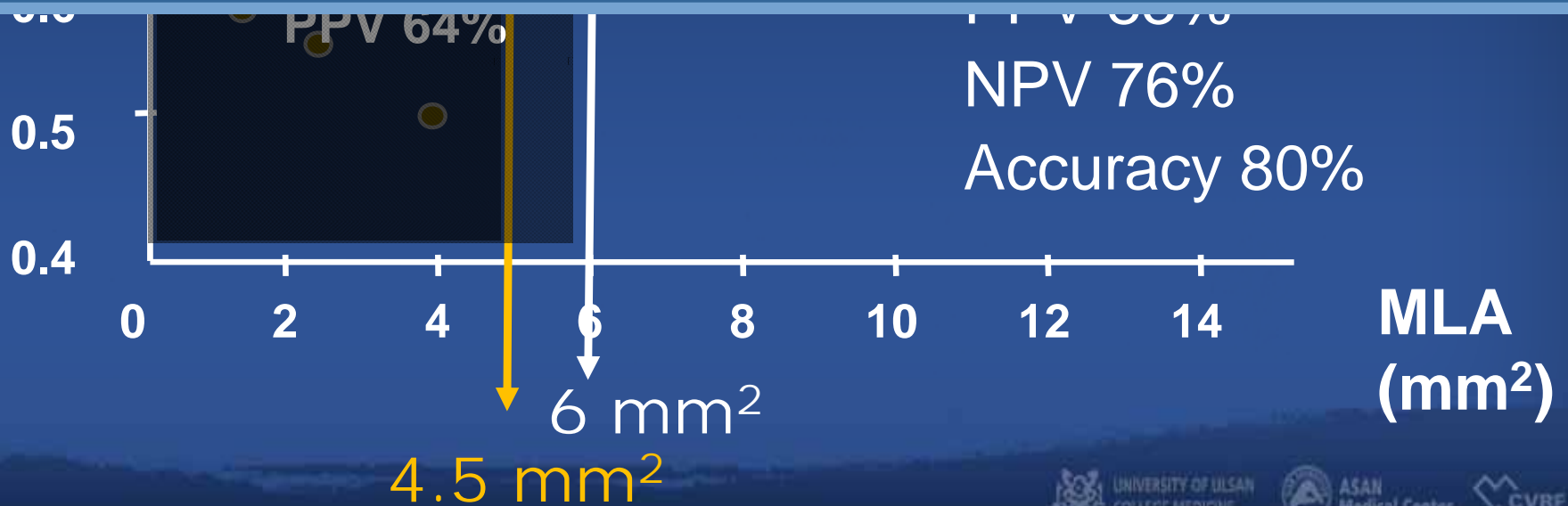
Jasti's data (n=55)



# In Practice,



Smaller LM IVUS MLA of 4.5 mm<sup>2</sup> Can Predict Functional Significance of Stenosis (PPV 83%).



# Still Debate Ethnic Difference ?

Caucasian Is Usually Bigger than Asian.

**The Bigger Body, The Bigger Heart,**

**The Bigger Vessel Diameter,**

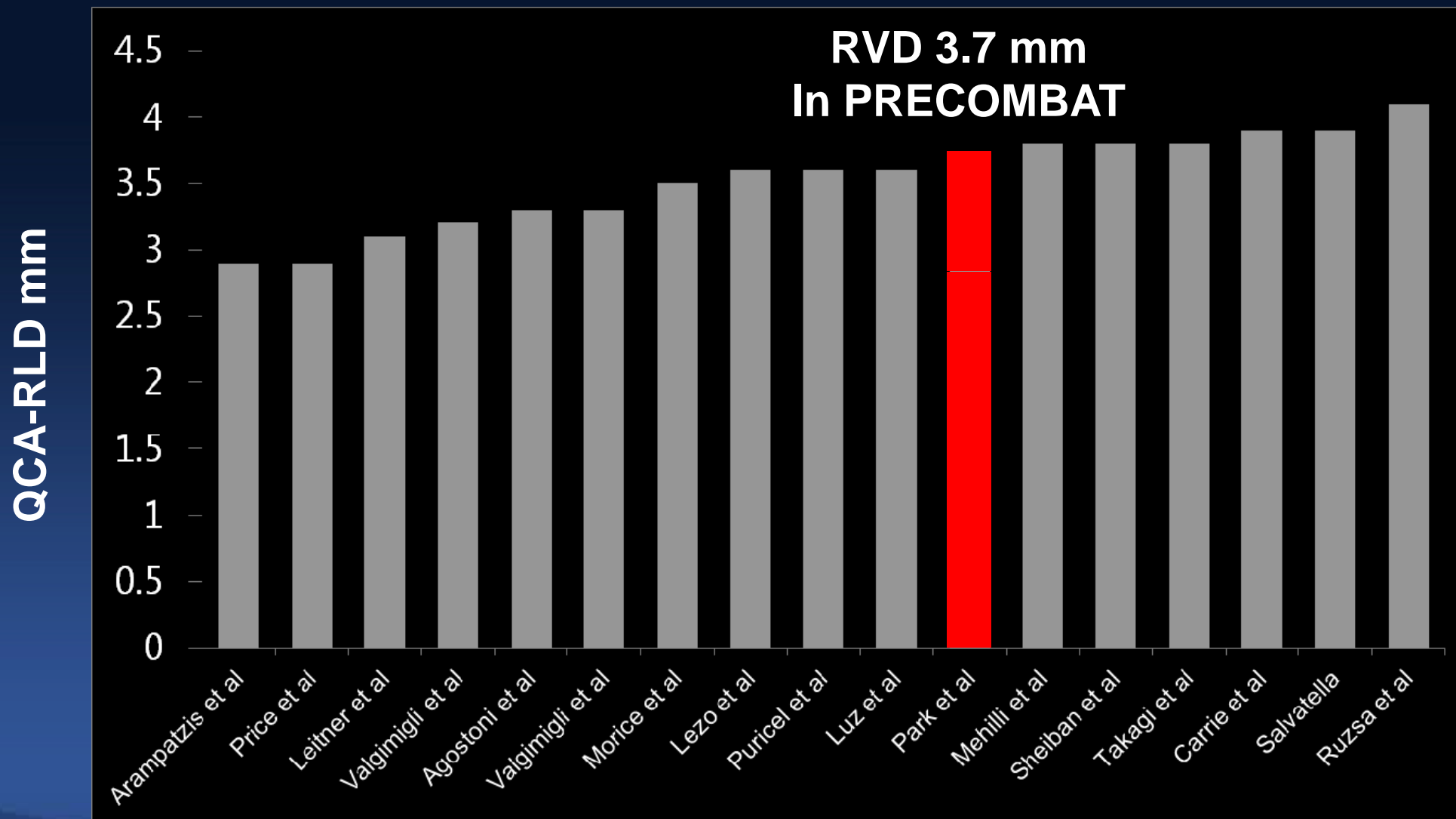
Caucasian Will Possibly Have,

**The Bigger IVUS MLA Threshold ?**

How Much Big ?

# Reference Vessel Size in LM PCI

**2309 USA/EU Patients in 17 Studies**





# Body Mass Index, kg/m<sup>2</sup>

Western Country			Asian Country		
	Male	Female		Male	Female
USA	28.5	28.3	Korea	24.0	23.3
Canada	27.5	26.7	Japan	23.5	21.9

Average Difference is 10~12%. Therefore, **LM IVUS MLA Would Not Be > 5 mm<sup>2</sup>** Based on Our Data and Geometric Abstraction (Murray's Law) Even in the Caucasian People.

	European (N=427)	South Asian (N=325)	P value
LV mass, g	125.4 ± 1.2	109.5 ± 1.4	<0.05
LV mass/height <sup>2.7</sup>	29.8 ± 0.3	28.1 ± 0.4	<0.05
LV mass/BSA	66.1 ± 0.6	61.9 ± 0.7	<0.05

# Do IVUS-MLA Criteria Need to Be Adjusted ?

Yes, They Are.

# Conclusion

1. IVUS MLA 4 mm<sup>2</sup> as Ischemic Threshold for Non-LM Disease is Too Big, Current Data Suggest that < 3mm<sup>2</sup> of IVUS Criteria is Reasonable Value. But, **Any** Subgroup-Specific IVUS MLA Criteria Doesn't Work to Define Clinical Ischemia.
2. IVUS MLA 6 mm<sup>2</sup> as Ischemic Threshold for LM Disease is Too Big, **New IVUS MLA 4.5 mm<sup>2</sup>** is Acceptable Based on Large Number of Data Analysis and Geometric Abstraction. Smaller IVUS MLA Can Predict Functional Significance of Stenosis.