

Why and How

We Utilize Imaging and Functional Information in LM PCI

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Why FFR ?

Visual Functional Mismatch



Visual : 80%

FFR : 0.82

Treadmill test : Negative

Thallium spect : Normal

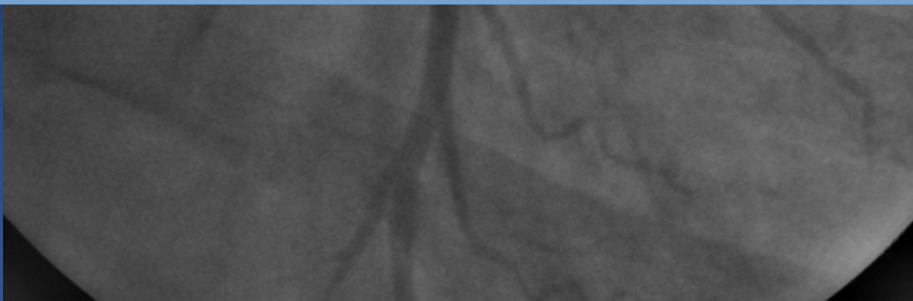
Stress Echo : Negative

Reverse Mismatch



Visual Estimation : 30%

Angiography is **Not Always Enough !**

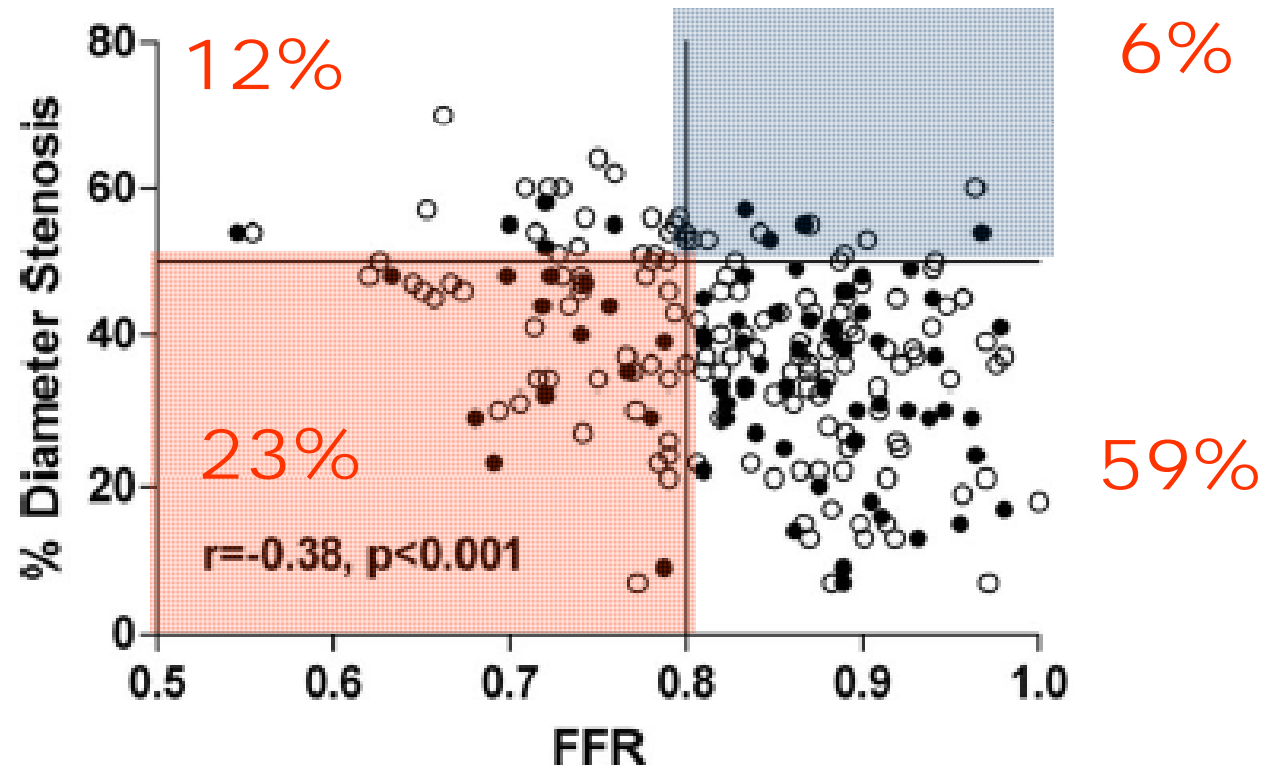


Thallium spect : + large
LAD

How Many Mismatches ?

Mismatch

in intermediate LM Disease



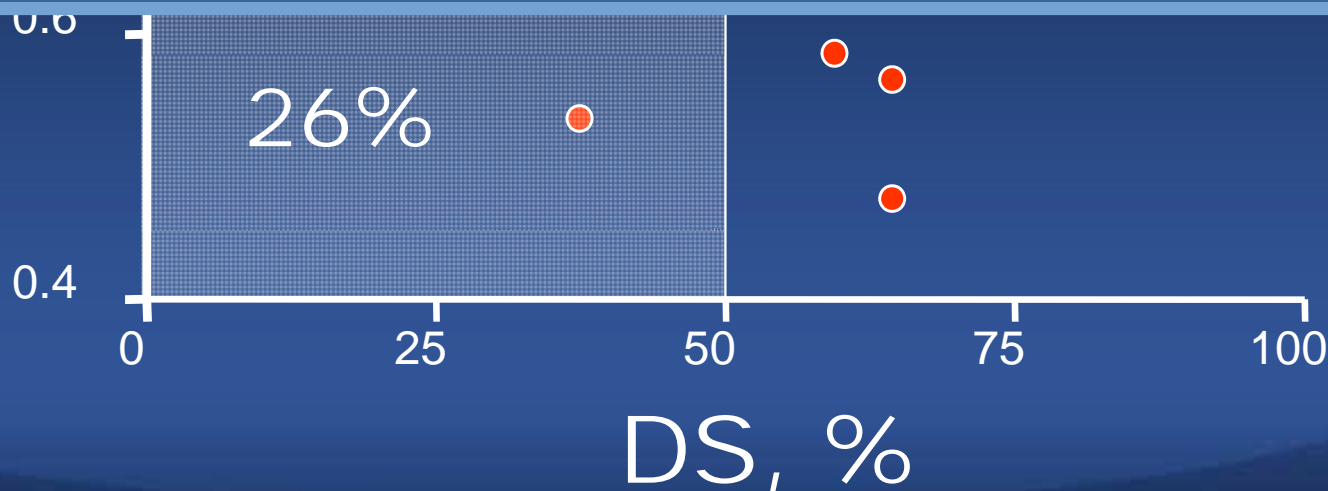
Hamilos M, Circulation 2009; 120: 1505-1512

Mismatch

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.



Why Mismatches ?

Multivariable Analysis to Predict Mismatches, **Non-LM**

IVUS Analysis of Prospective Cohort 1000 Patients

Mismatch

Significant Stenosis (>50%)
Negative FFR (>0.80)

Older Age

Non-LAD location

Shorter lesion length

Larger MLA by IVUS

Larger MLD by QCA

Smaller PB

Reverse Mismatch

Insignificant Stenosis (<50%),
Positive FFR (<0.80)

Younger Age

LAD location

Plaque Rupture

Smaller MLA by IVUS

Larger PB

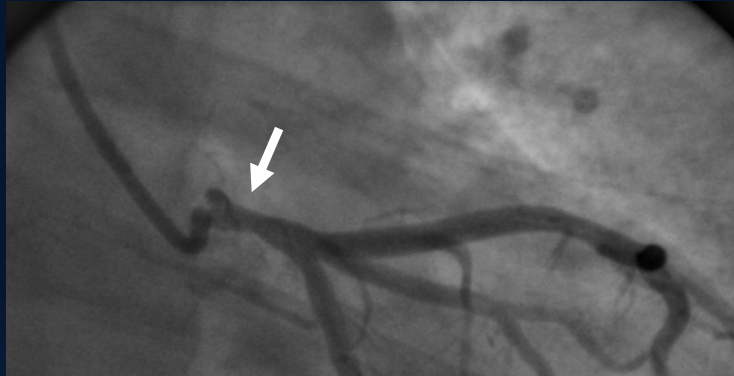
Multivariable Analysis to Predict FFR <0.80, LM (n=112)

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

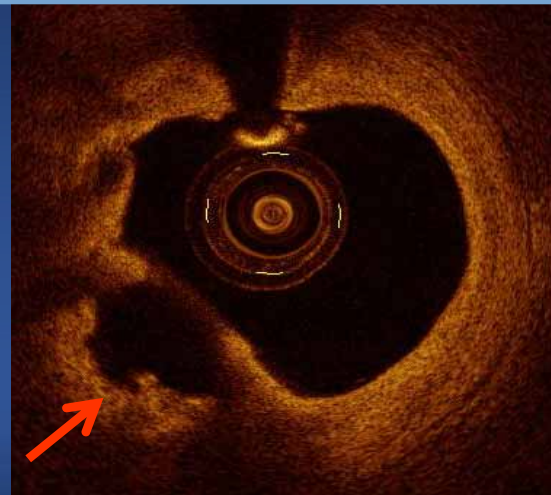
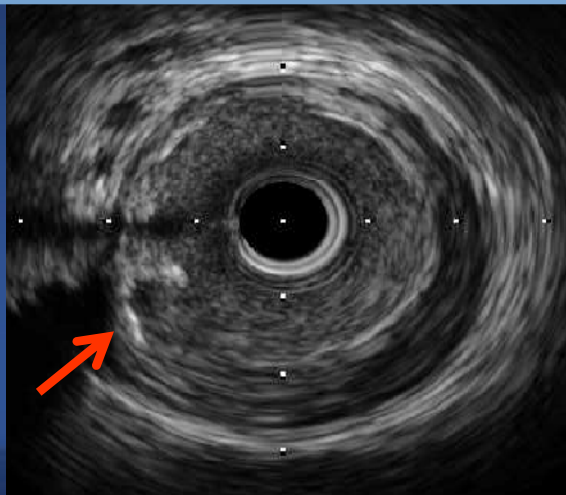
Reverse Mismatch



Visual Estimation
30% DS

FFR : 0.70

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



Plaque rupture,
MLA 6.2mm²

Why FFR ?

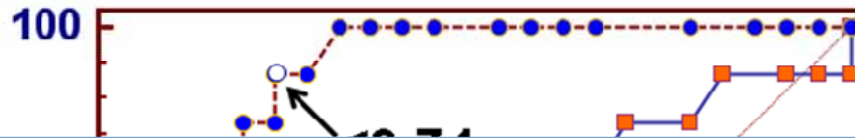
**For the Decision Making ;
To Treat or Not To Treat
Accurate Diagnosis First !**

How FFR ?

**Continuous IV Infusion of Adenosine,
140-280 ug/min/kg.**

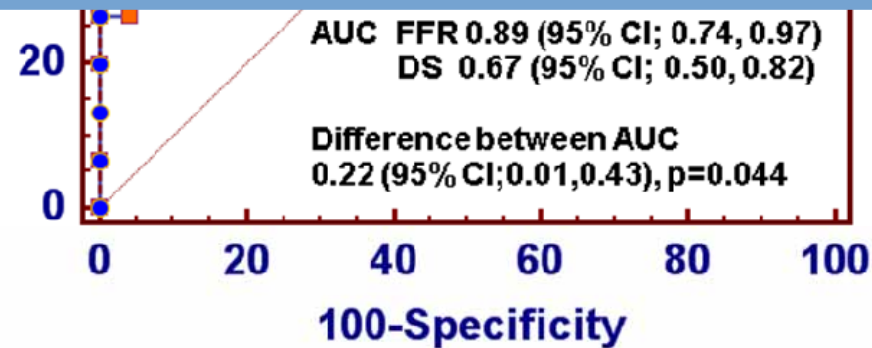
Is
FFR Cut-Off 0.80,
Validated in LM Disease
Too ?

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



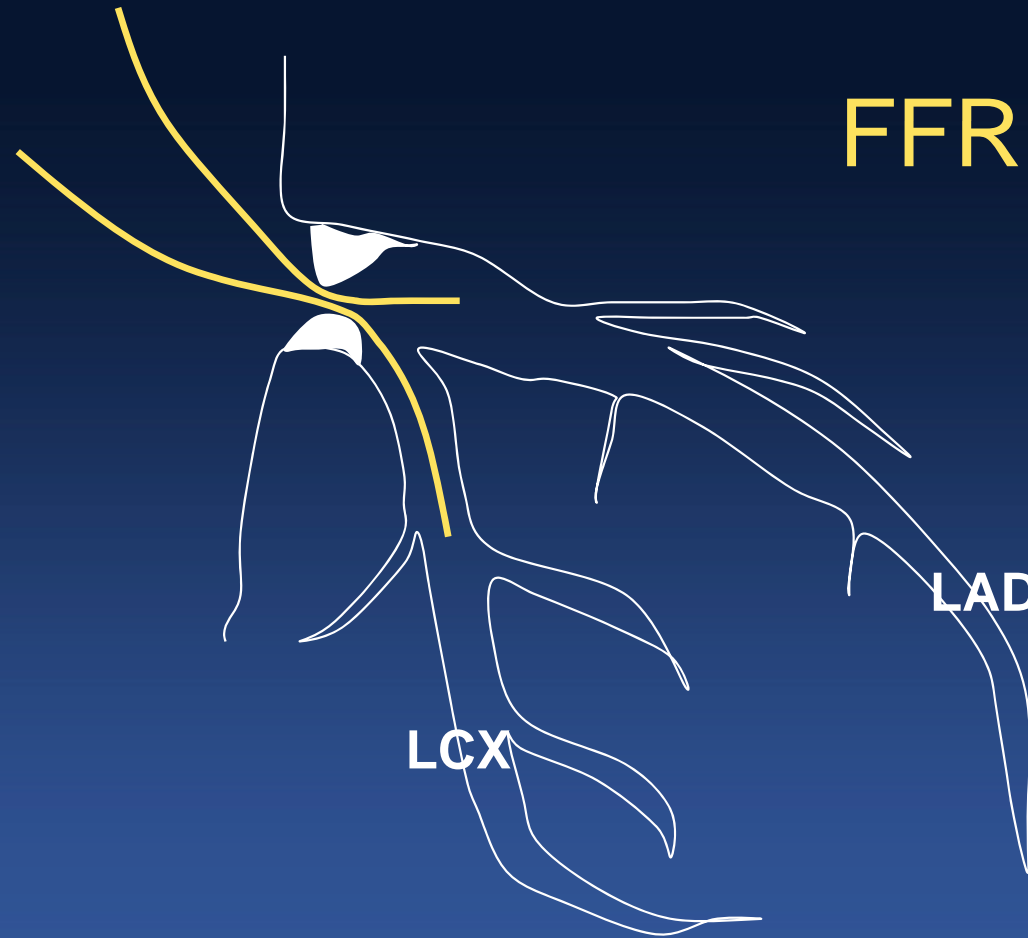
0.80 FFR Cut-Off

Would Be Appropriate for LM Disease Too.



How I **Implement FFR** in Real Practice ?

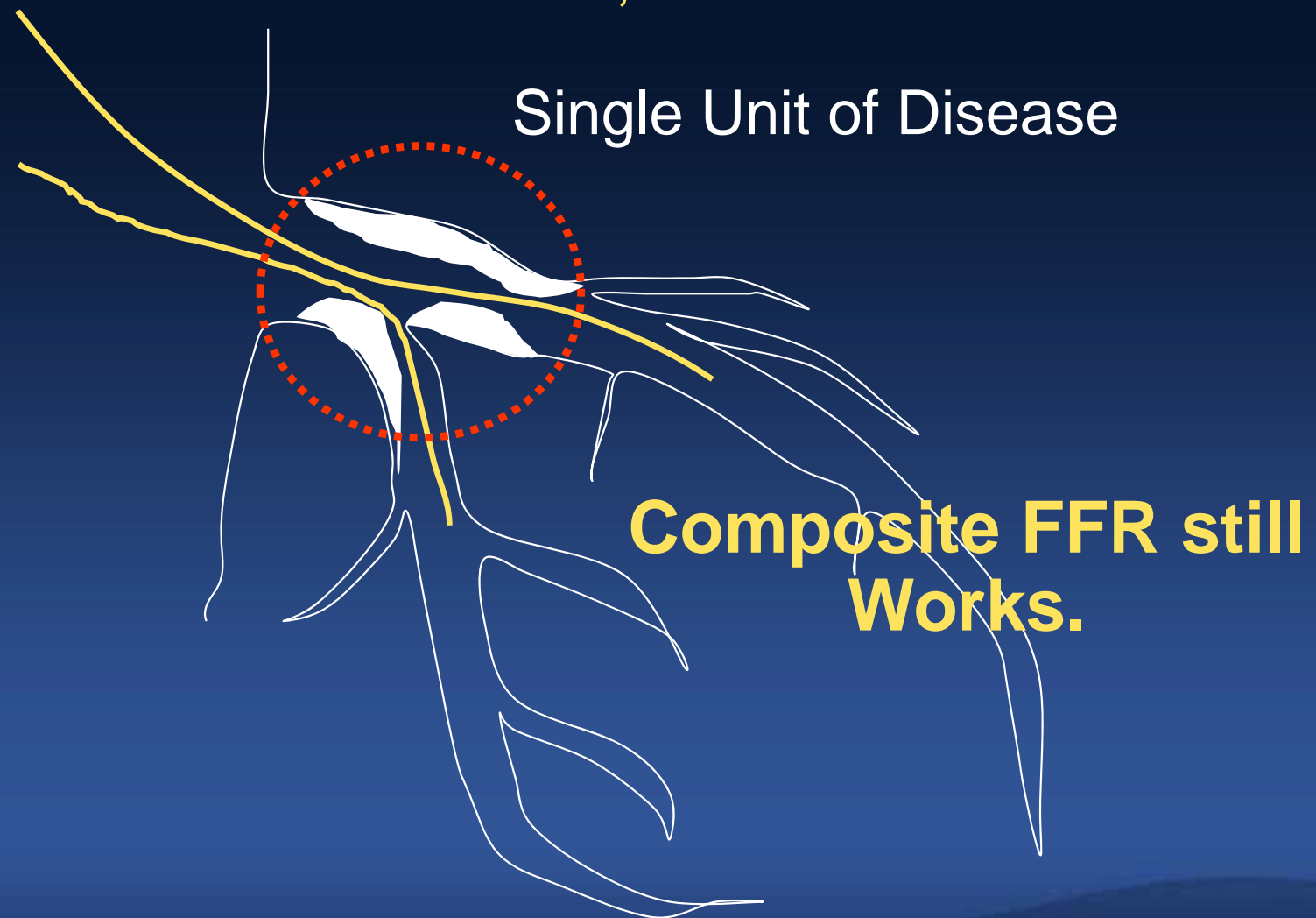
For the Undetermined, Intermediate Ostial and Shaft LM Lesion,



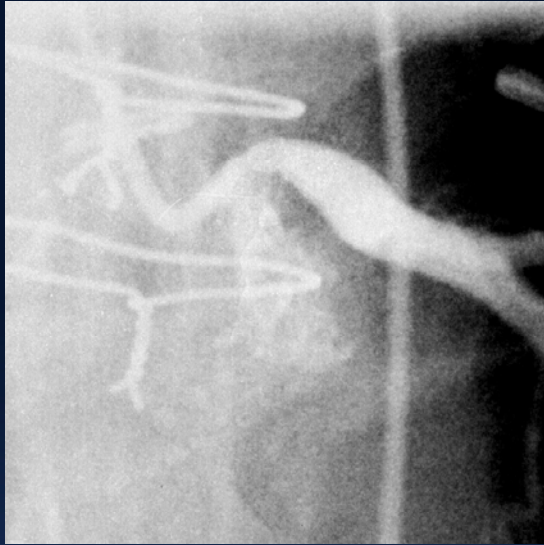
FFR is Crucial

For the Intermediate LM Bifurcation Lesion,

If Transducer Placed Beyond Bifurcation
in both LAD and LCX,

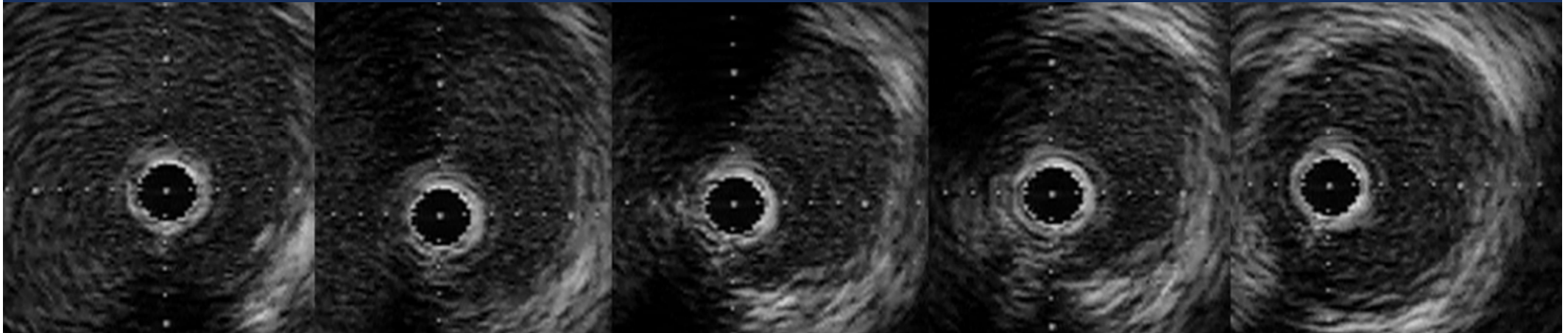


Why IVUS Too?



Angiographic 80% LM Ostial Disease,
And, Patient received CABG,
But, IVUS finding is Free of Disease.

Angiography Is **Not Always Enough**,
To Define Clinical Ischemia.



Why IVUS Too ?

1. Assessment of LM Ostium, Reference Vessel Diameter, Pattern of Remodeling, and Vulnerability of Plaque.
2. Separate IVUS Run of LCX Can Clarify the Disease Status of LCX Ostium and its Reference Vessel Size. Therefore, Treatment Strategy Would be Simplified.

LM Bifurcation Disease with Minimal LCX Disease

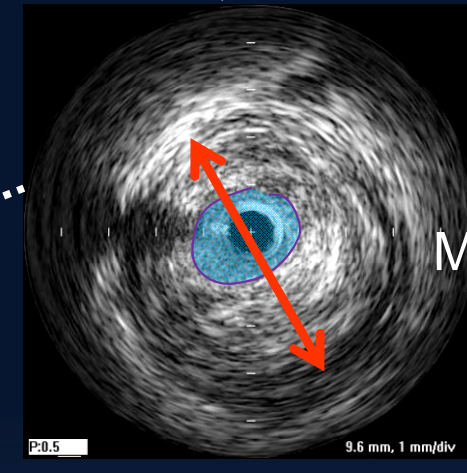
55/M, Stable angina, TMT (+), Thallium scan (-)



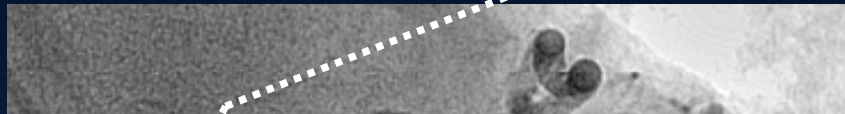
By IVUS

in Both LAD and LCX,

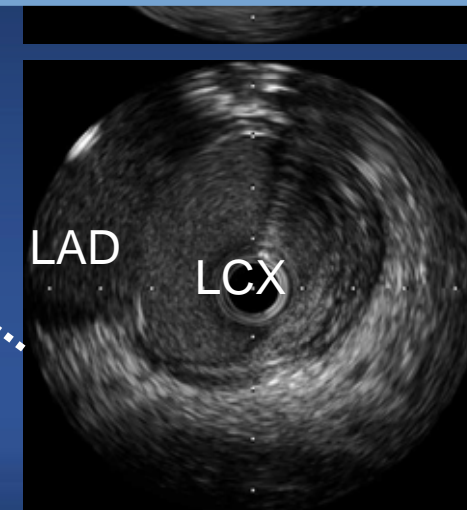
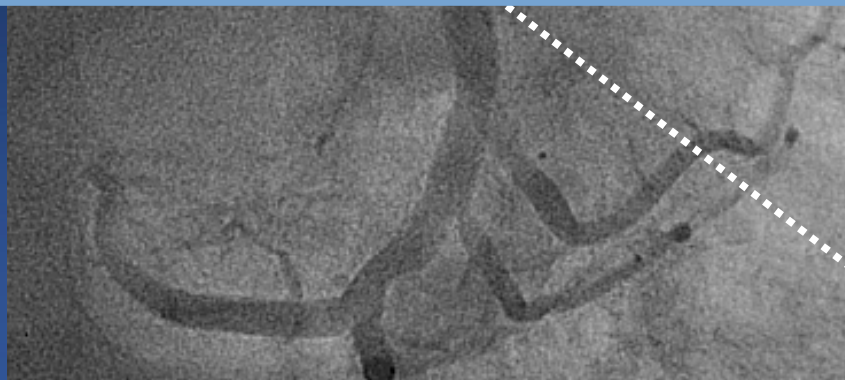
Distal LM, RVD 6.2mm



MLA 3.0mm²

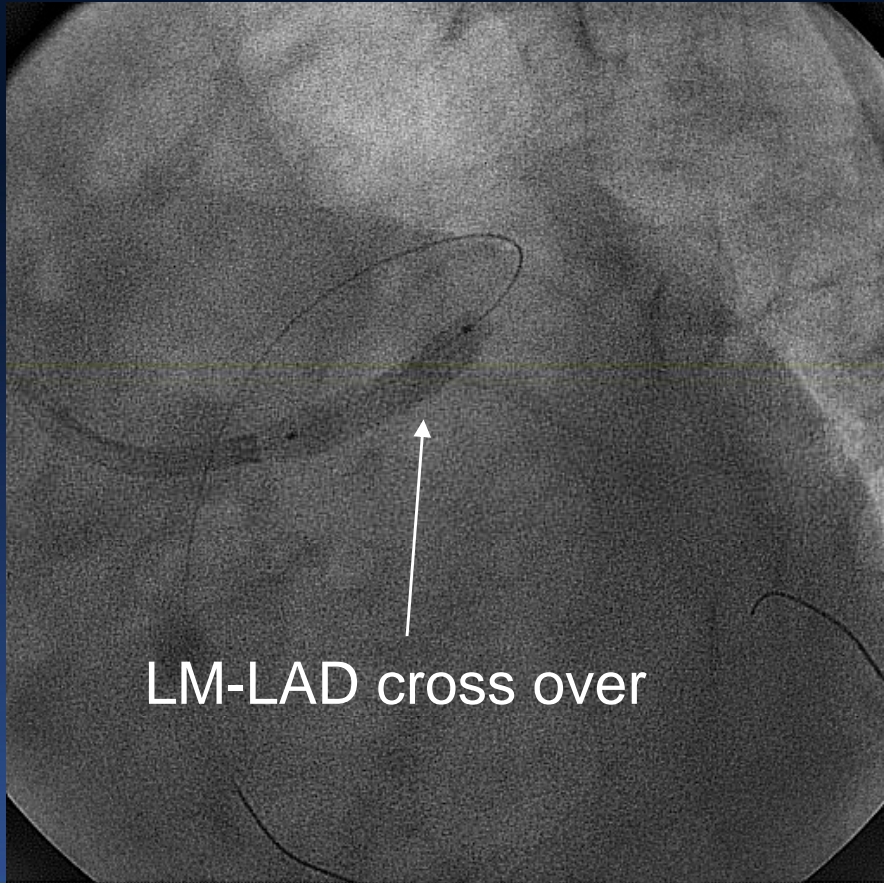


By IVUS, Reference Vessel Diameters of LM and LAD are Bigger than Angiographic Assessment, and the LCX ostium Showed Free of Disease.



Minimal disease at LCX ostium

We Did Just **Single Stent Cross-Over** !



Promus Element 4.0x20



Additional high pressure
Inflation with 4.0 mm
non-compliant balloon

After Stent Cross-Over, LCX Ostium Was Jailed !



What Would You Do ?

Do You Want to Treat Jailed Side Branch ?

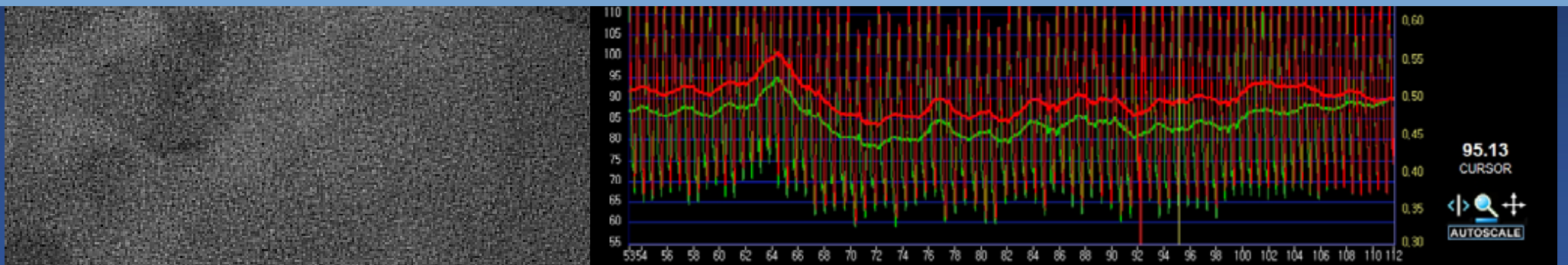
Consider FFR, First !



The screenshot shows a software interface with a search results table on the right and a live angiogram on the left. The table has columns for FOLDER/PATIENT, PATIENT ID, DATE, TIME, VESSEL, PROCEDURE, ACTION, TYPE, and SIZE. The selected row shows patient ID LSK14088205, date 2012-09-25, time 11:17:24, vessel IFR, and size 119KB. The software is labeled 'PressureWire' in the top right corner.

FOLDER/PATIENT	PATIENT ID	DATE	TIME	VESSEL	PROCEDURE	ACTION	TYPE	SIZE
LSO48871502	LSK14088205	2012-09-25	11:17:24				IFR	119KB
LSN81433053								
LSM13929145RCA								
LSM13929145								
LSK39702740								
LSK14088205								

Just Defer !
It's Safe and Effective.

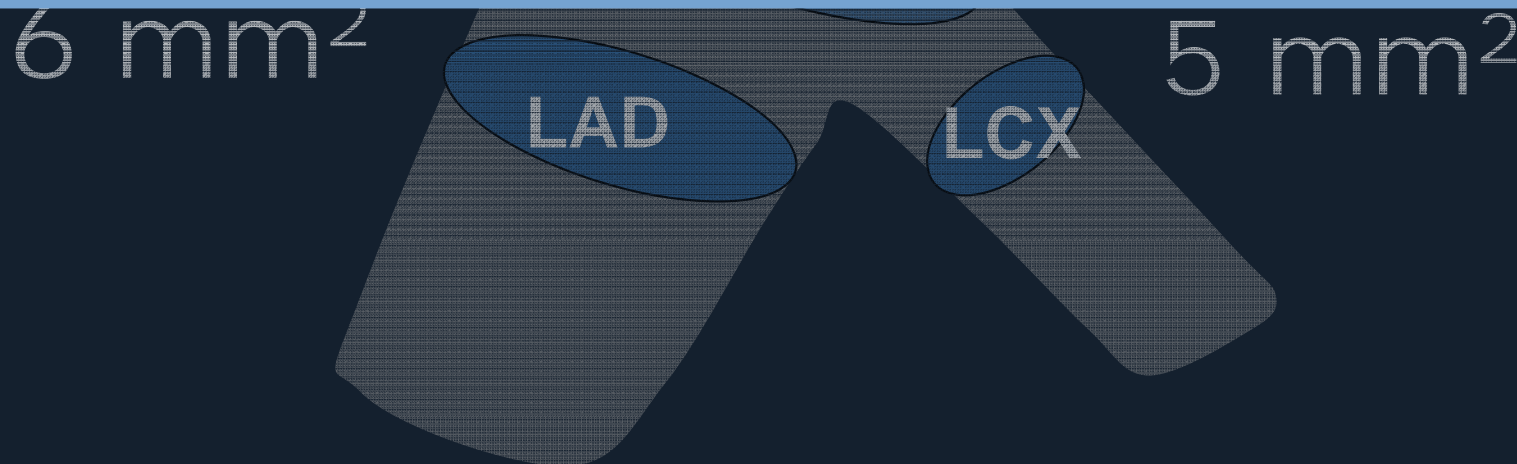


Why IVUS Too ?

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3. IVUS Guided Stent Optimization and Effective Stent CSA Can Make a Good Clinical Outcomes.

IVUS Stent Area to Reduce Restenosis (Rule of 5,6,7,8)

Restenosis Rate < 5%,
TLR < 2%



Overall Efficacy of IVUS Guidance

Meta-Analysis **IVUS vs. CAG Guided PCI**

**A total of 23,392 patients
(2 randomized trial and 12 observational studies)**

Park SJ, Ahn JM, Unpublished Data, 2013

Death from Any Causes

Study name Time point Statistics for each study Odds ratio and 95% CI

		OR	LL	UL	Z-Value	P
Roy	2008	0.79	0.54	1.16	-1.20	0.23
MAIN-COMPARE	2009	0.26	0.11	0.63	-2.98	0.00
Kim	2010	0.03	0.00	0.44	-2.57	0.01
HOME DES IVUS	2010	1.52	0.26	8.87	0.46	0.64
MATRIX	2011	0.53	0.29	0.97	-2.07	0.04
COBIS	2011	0.47	0.26	0.83	-2.62	0.01
Youn	2011	0.21	0.03	1.70	-1.46	0.14
Hur	2012	0.49	0.36	0.66	-4.60	0.00
EXCELLENT	2012	1.84	0.42	7.99	0.82	0.41
Ahn	2012	0.48	0.29	0.79	-2.88	0.00
Patel	2012	0.04	0.01	0.24	-3.66	0.00
Chen	2012	0.09	0.00	1.58	-1.65	0.10
ADAPT-DES	2012	0.88	0.64	1.20	-0.82	0.41
AVIO	2013	0.20	0.01	4.17	-1.04	0.30
Random pooled estimate		0.50	0.36	0.69	-4.10	<0.001

I²=63



IVUS vs. Angio-Guided PCI

(Meta-analysis n=23,392)

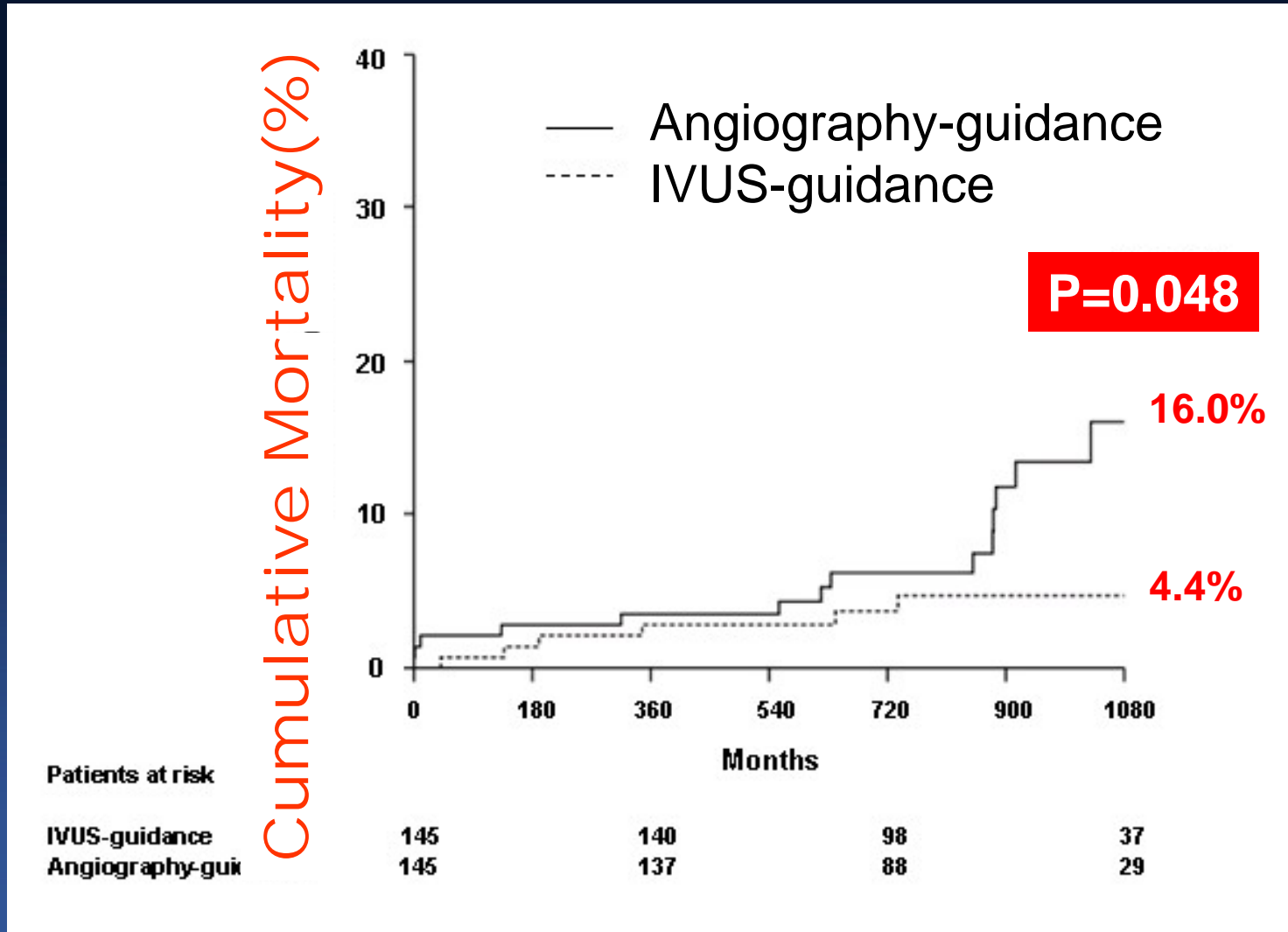
Outcomes	Relative Risk Reduction	P value
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Death / MI, Benefit !

TVR	↓ 22%	0.02
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Stent Thrombosis	↓ 45%	<0.001
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IVUS Guidance Saves Lives in LM PCI

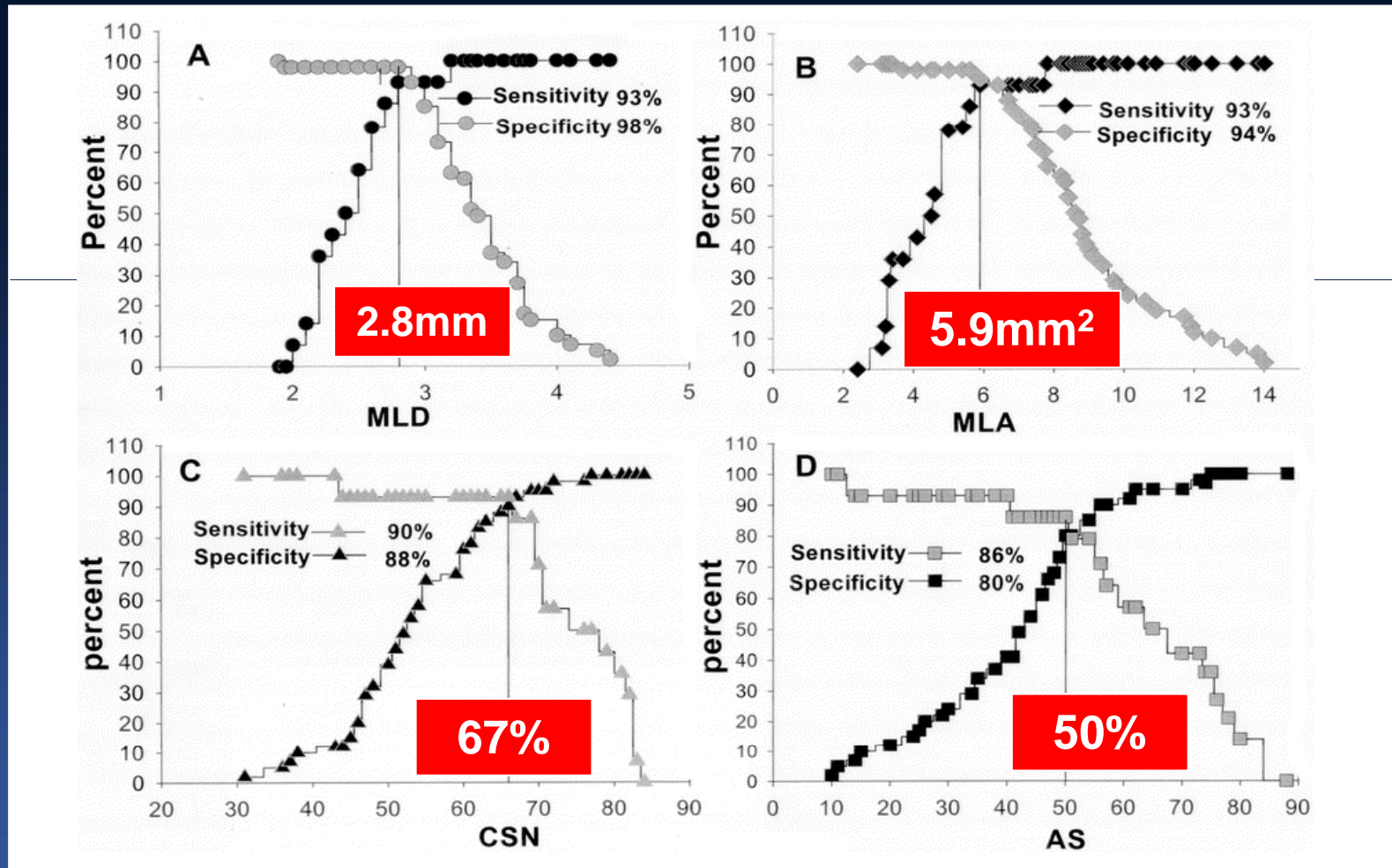


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3. IVUS Guided Stent Optimization and Effective Stent CSA Can Make a Good Clinical Outcomes.
4. IVUS Guidance Reduced Death/MI and Saved Lives.

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 mm² IVUS MLA Is Not Appropriate ?

Background, Geometric Abstraction

“ The 6-mm² value was obtained from **Murray’s law** (considering an MLA of 4 mm² 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

	N	FFR	RLA	MLA mm ²	AUC	Sens	Spec	PPV	NPV	Accu
Briguori (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%

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

Ischemic Threshold of Branches Would Be
< 3 mm² Based on the Current Data. The 6 mm² 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)

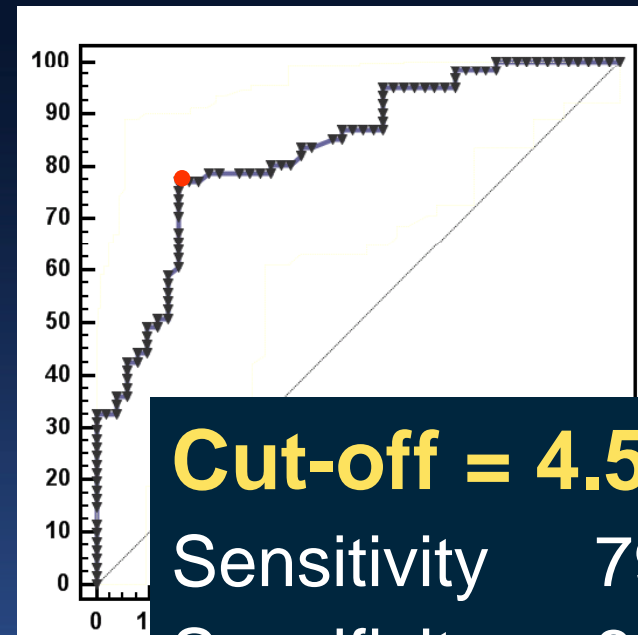
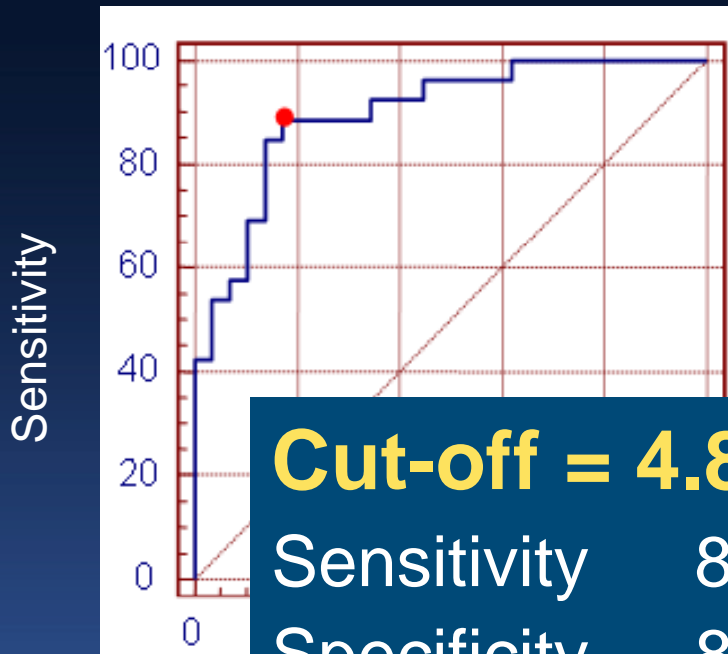
AMC FFR Registry, **New Data**

New LM IVUS MLA

Matched with FFR <0.80, Ostial and Shaft LM Disease

(n=55 lesions)

(n=112 lesions)



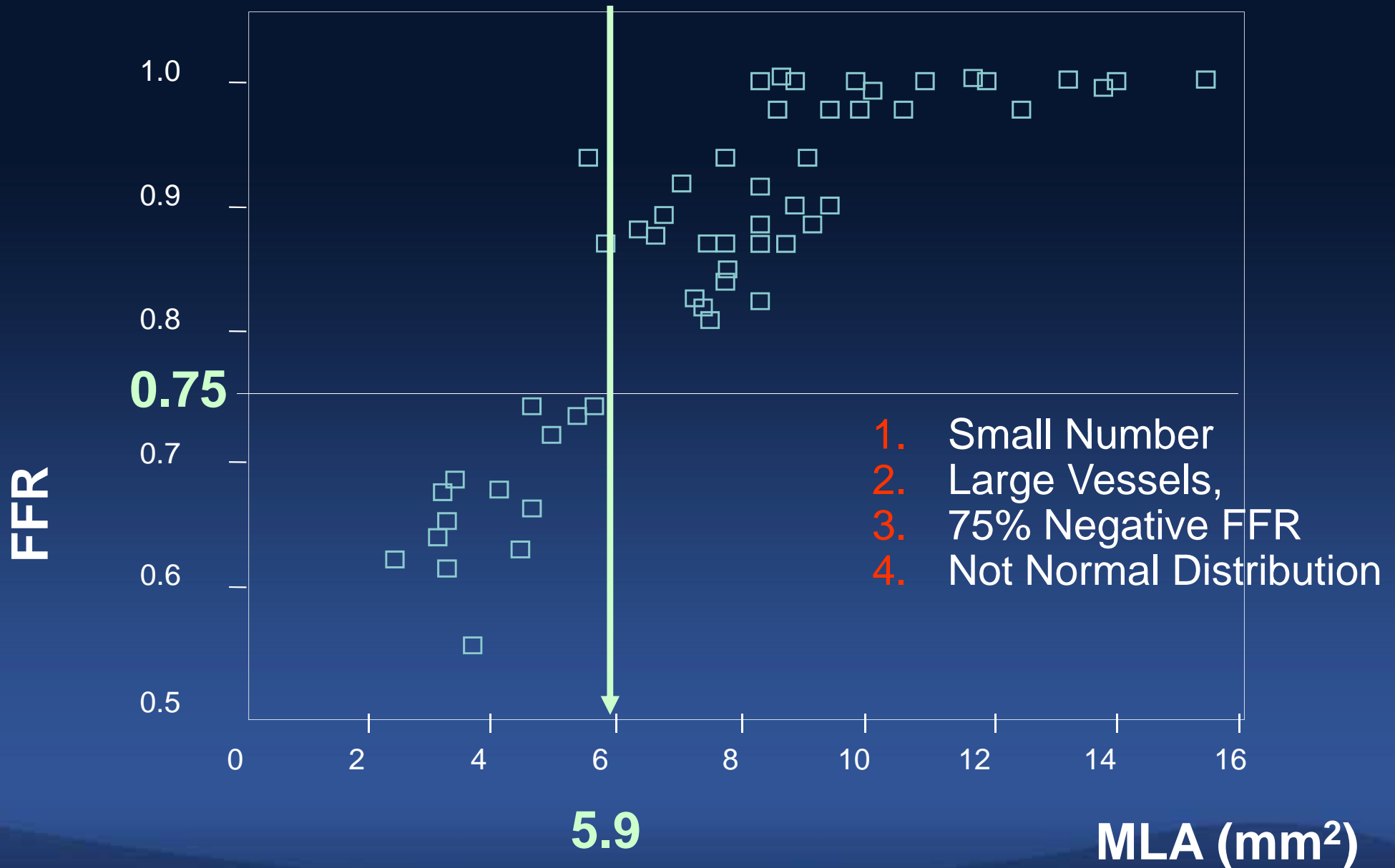
Cut-off = 4.8 mm²

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

Cut-off = 4.5 mm²

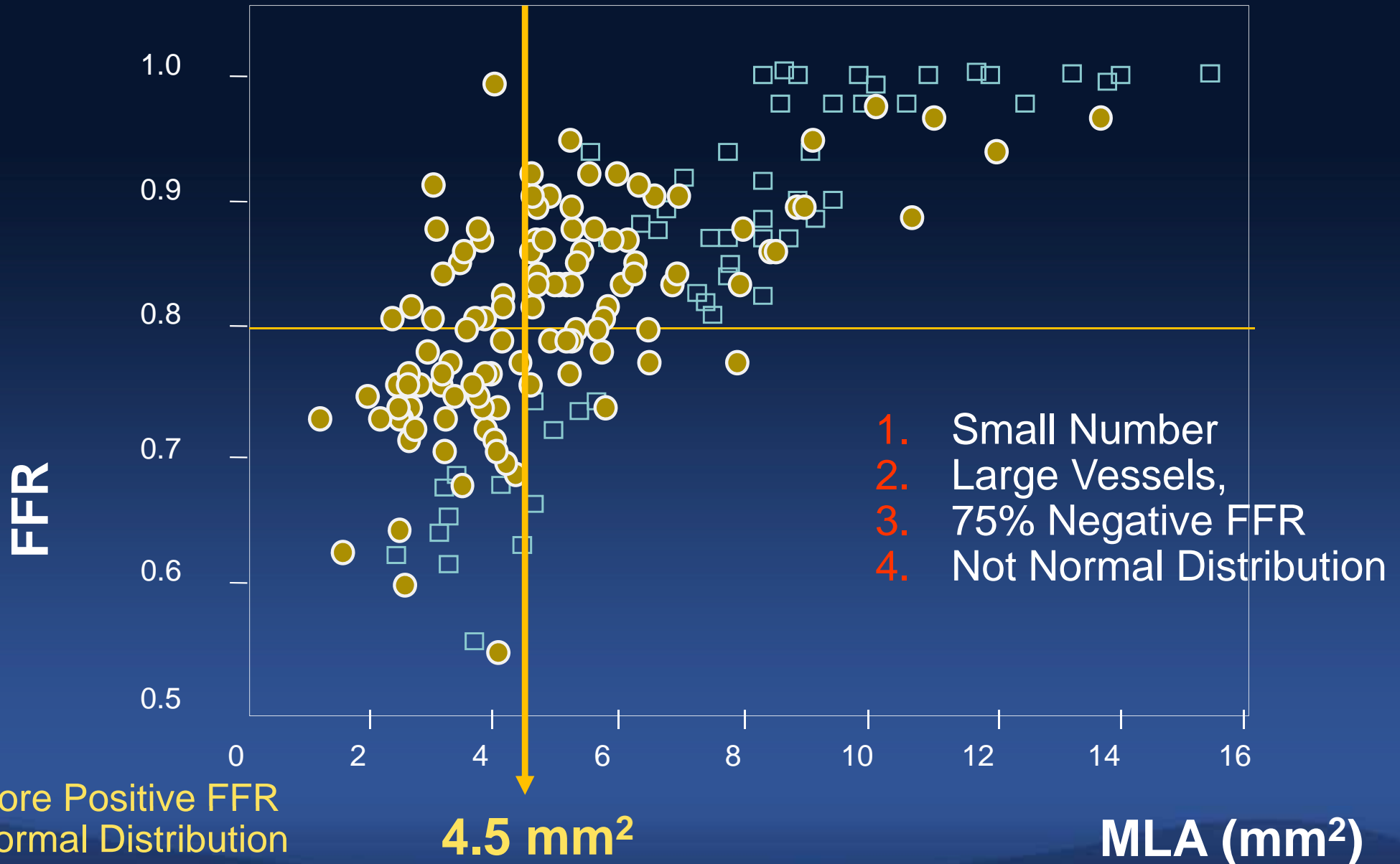
Sensitivity	79%
Specificity	80%
PPV	83%
NPV	76%
Accuracy	80%

Jasti's data (n=55)

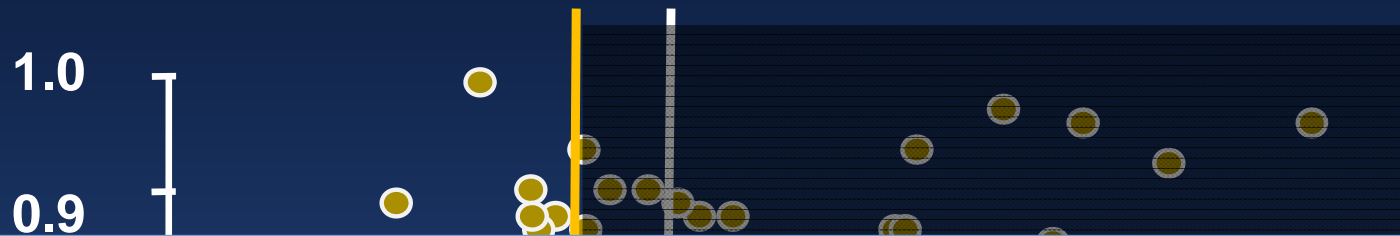


AMC New Data (n=112)

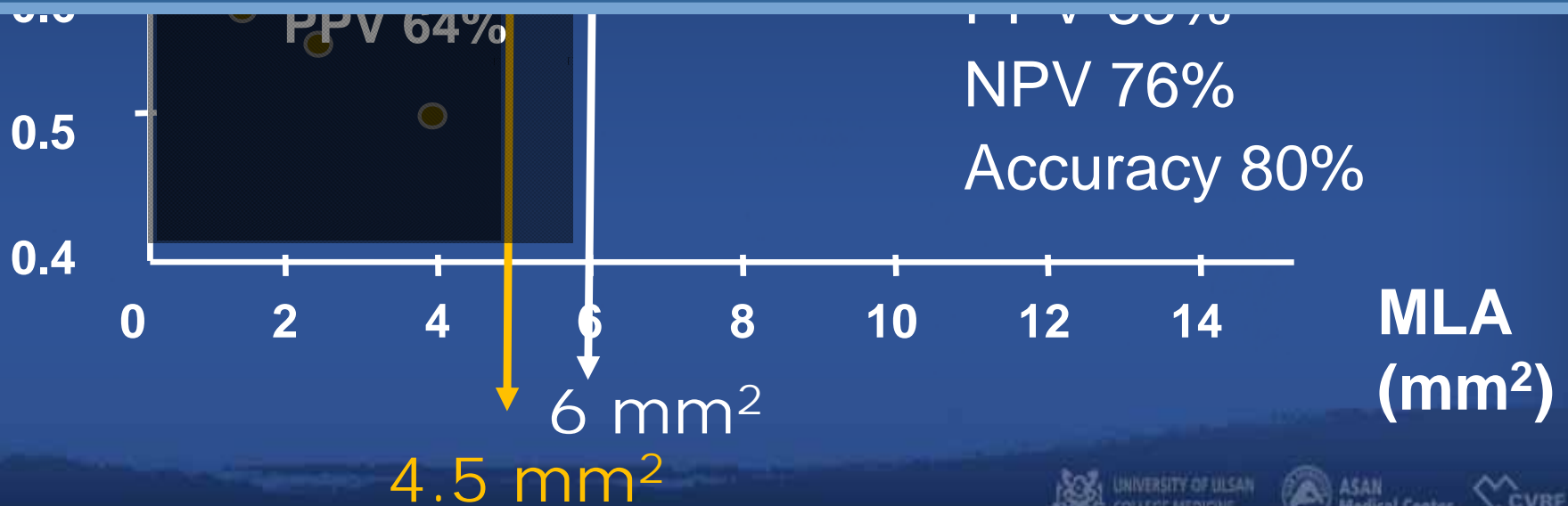
Jasti's data (n=55)



In Practice,



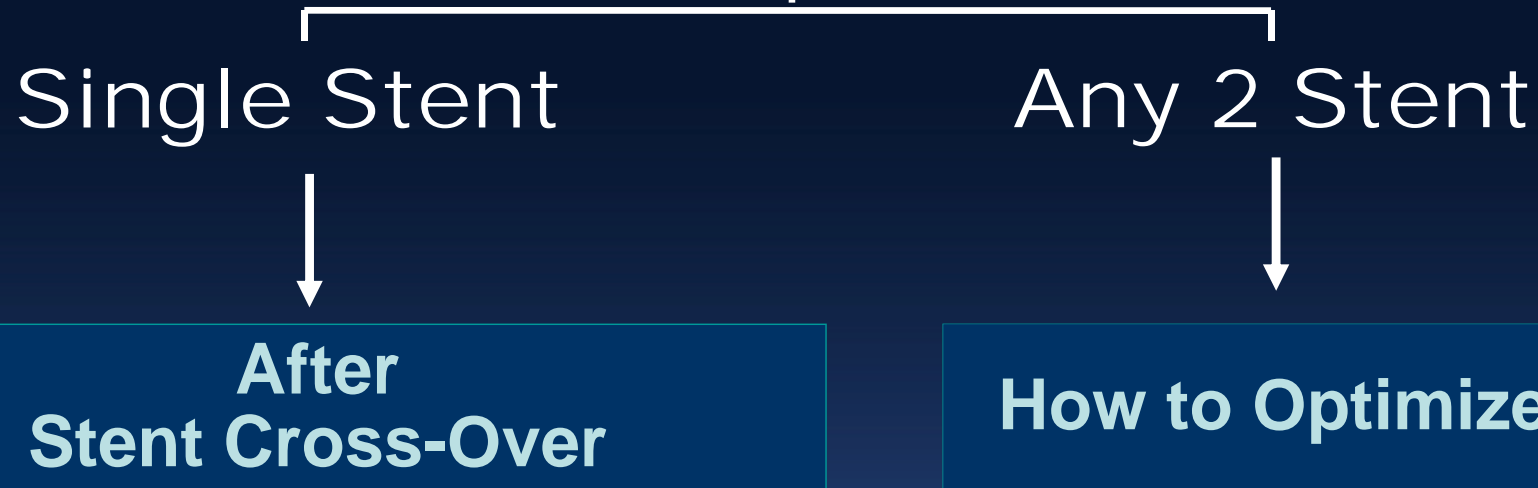
Smaller LM IVUS MLA of 4.5 mm² Can Predict Functional Significance of Stenosis (PPV 83%).



Why IVUS Too ?

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2. Separate IVUS Run of LCX Can Clarify the Disease Status of LCX Ostium and its Reference Vessel Size. Therefore, Treatment Strategy Would be Simplified.
3. IVUS Guided Stent Optimization and Effective Stent CSA Can Make a Good Clinical Outcomes.
4. IVUS Guidance Reduced Death/MI and Saved Lives.
5. Smaller IVUS MLA 4.5 mm^2 Can Predict Functional Significance of LM Stenosis.

LM Bifurcation Stenting



- Do You Want to Treat the Jailed Side Branch ?
- How to Treat ?

IVUS Minimal Stent CSA Criteria 5-6-7-8 mm²
May Improve Long-term Clinical Outcomes.

Why FFR and IVUS ?

1. FFR Guided Decision Making.
2. IVUS Guided Stent Optimization.
3. They are Complementary for the Good Clinical Outcomes.