FFR Guided Clinical Practice of Left Main PCI

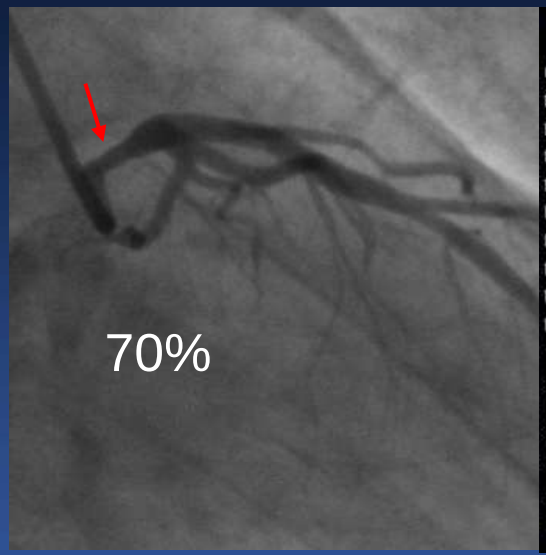
Seung-Jung Park, MD, PhD

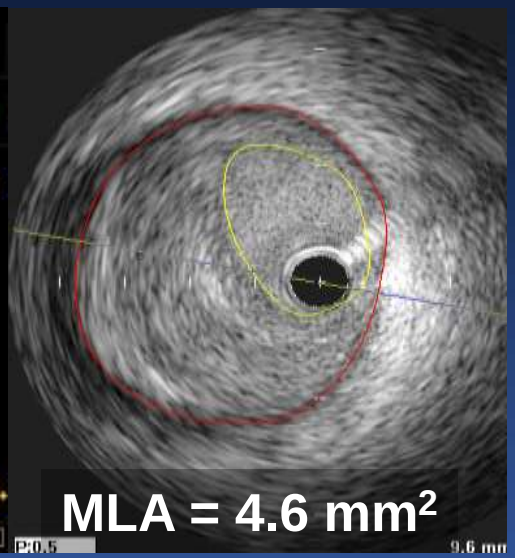
Heart Institute, University of Ulsan College of Medicine
Asan Medical Center, Seoul, Korea

Why FFR ?

Visual Assessment Misleads
Negative FFR

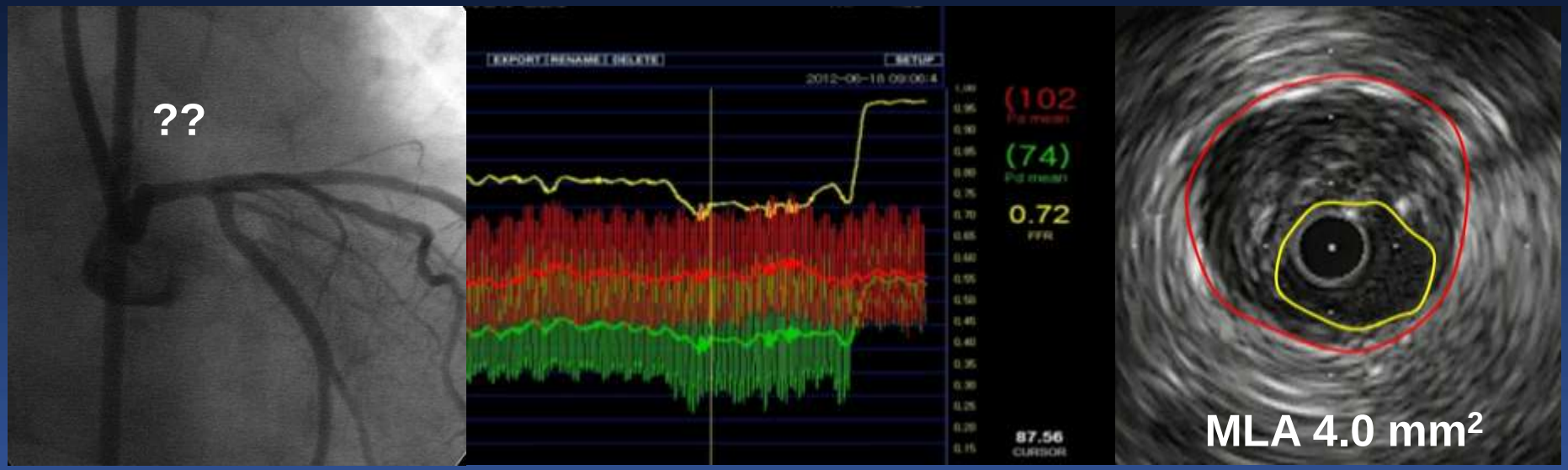
47/M Stable Angina





Insignificant Stenosis Reverse Mismatch Positive FFR

62/F Stable Angina



Why FFR ?

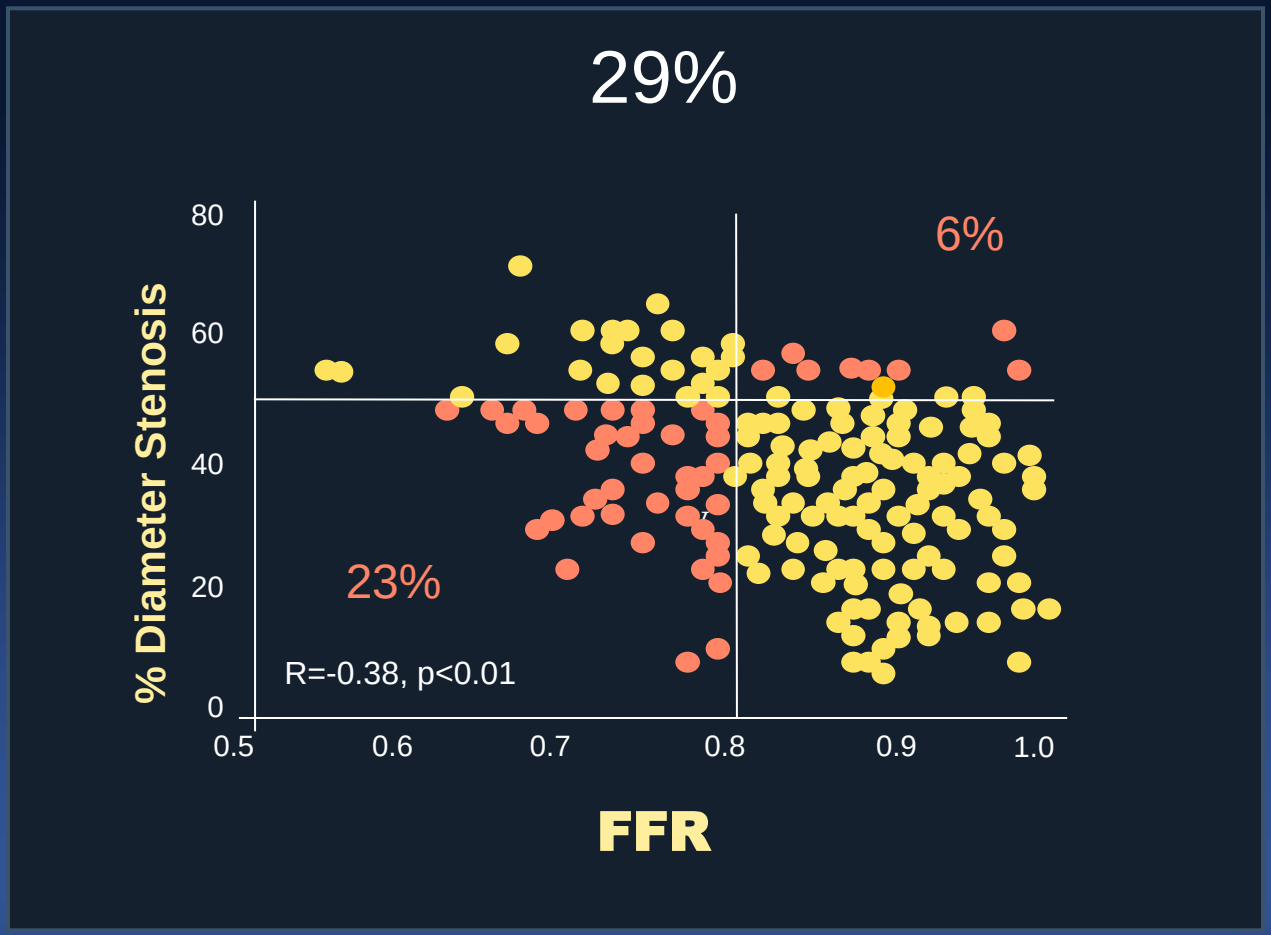
Accurate Diagnosis First !

Many Visual-Functional Mismatches.

How Many Mismatches ?

Many Mismatch

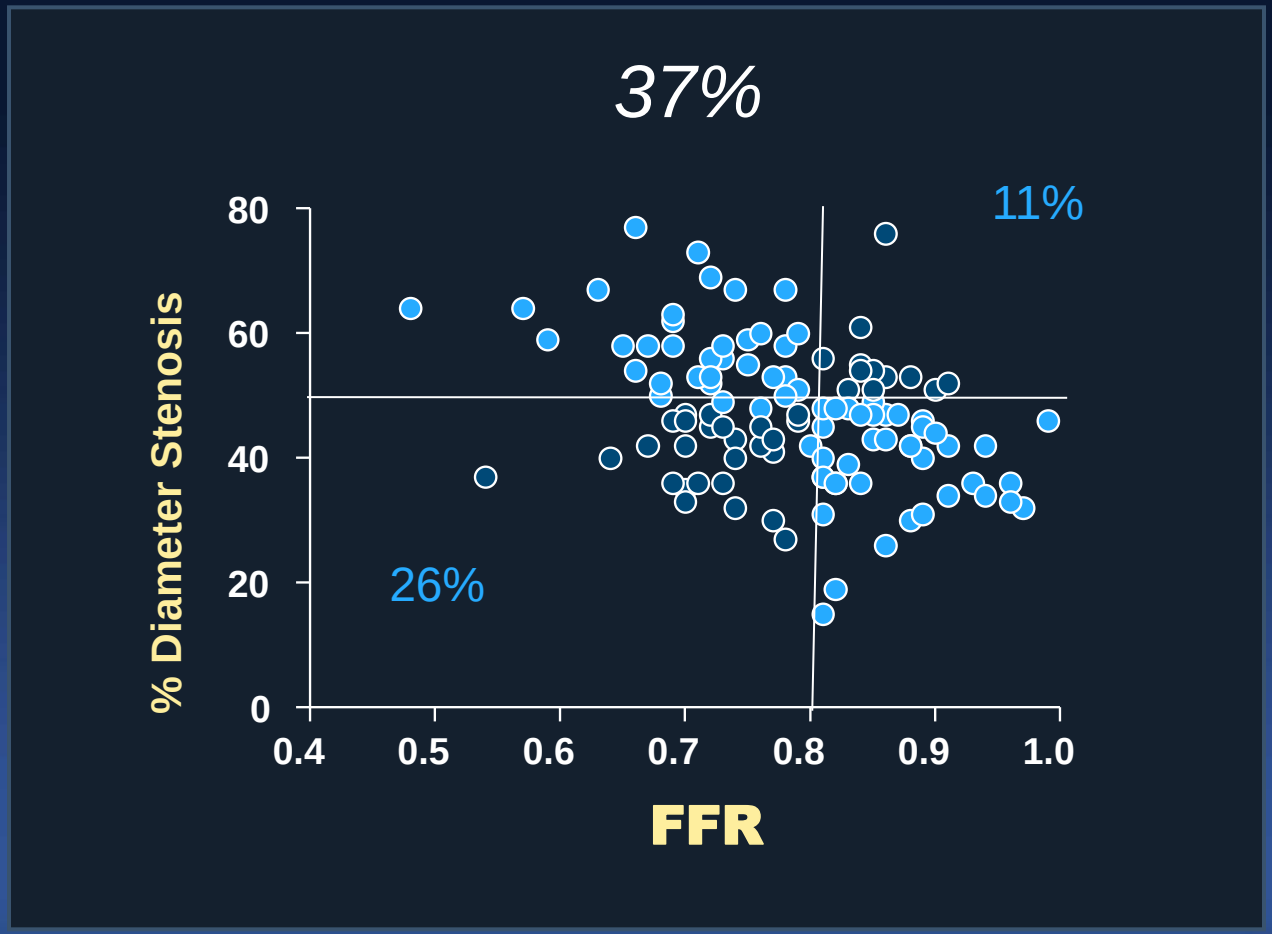
Intermediate LM Disease, Overall



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

Many Mismatch

Intermediate LM Disease, Os/Shaft



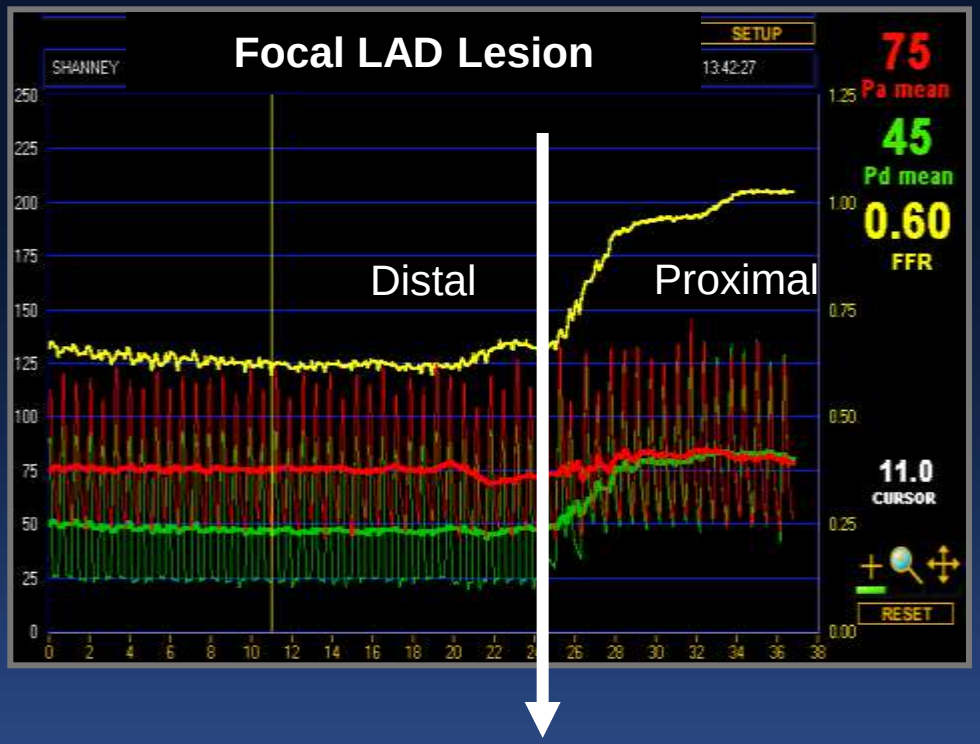
Park SJ et al. *JACC-CI (In Press)*

Why Mismatches ?

FFR vs. Angiographic DS (%)

FFR

- 100-200 ug IC NTG
- Adenosine infusion
- intracoronary bolus 60-70 ug
- intravenous continuous infusion
  140-280ug/kg/min



Measure
the Pressure Drop
at Maximal Hyperemia

FFR Is Mainly Determined By

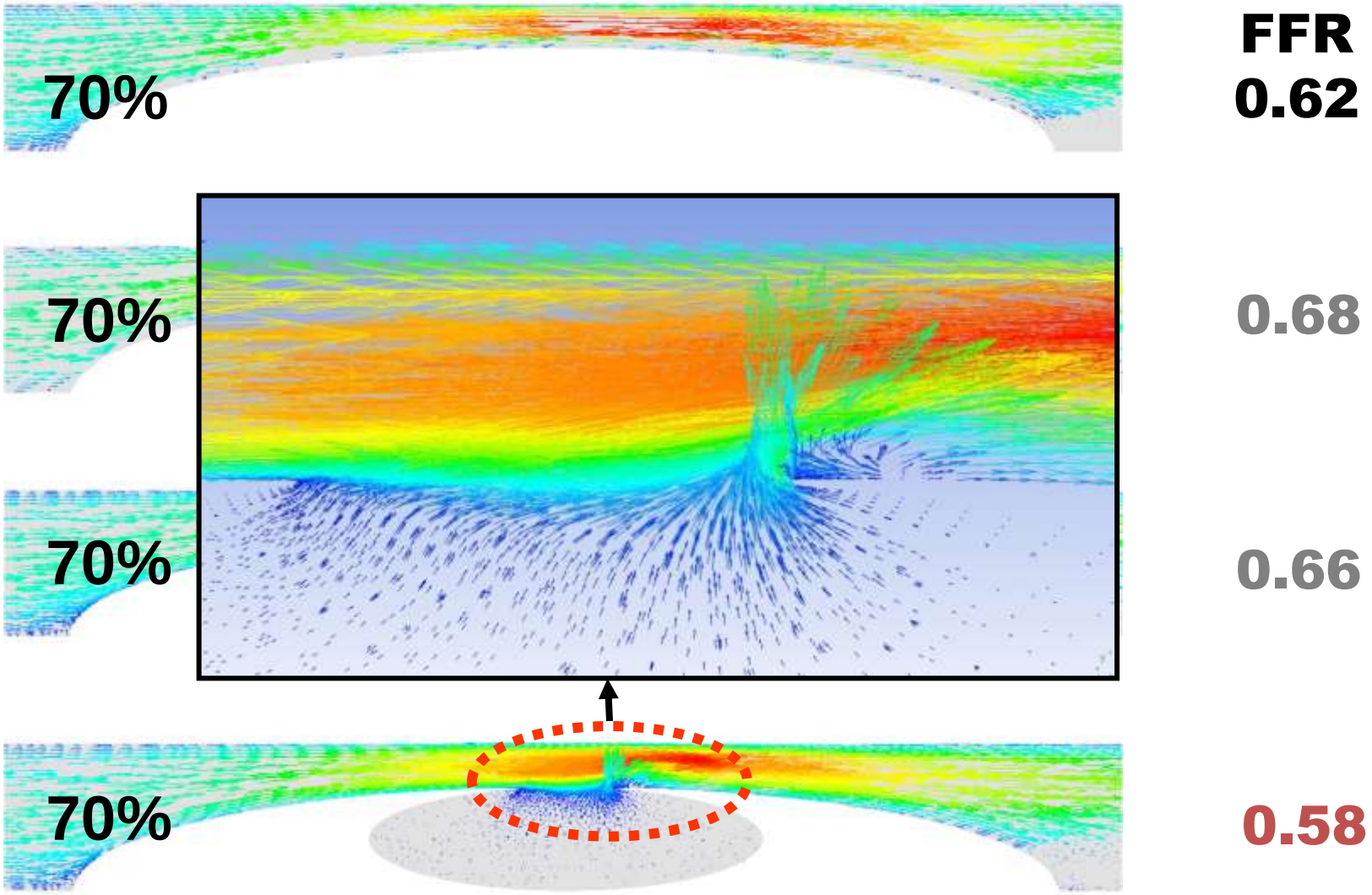
1. Size of Myocardium and
2. Lesion Specific Local Factors.

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

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

Model 1 included clinical, QCA, and IVUS variables
Model 2 included Model 1 plus LV mass assessed by **Echocardiography**

Influence of Plaque Rupture

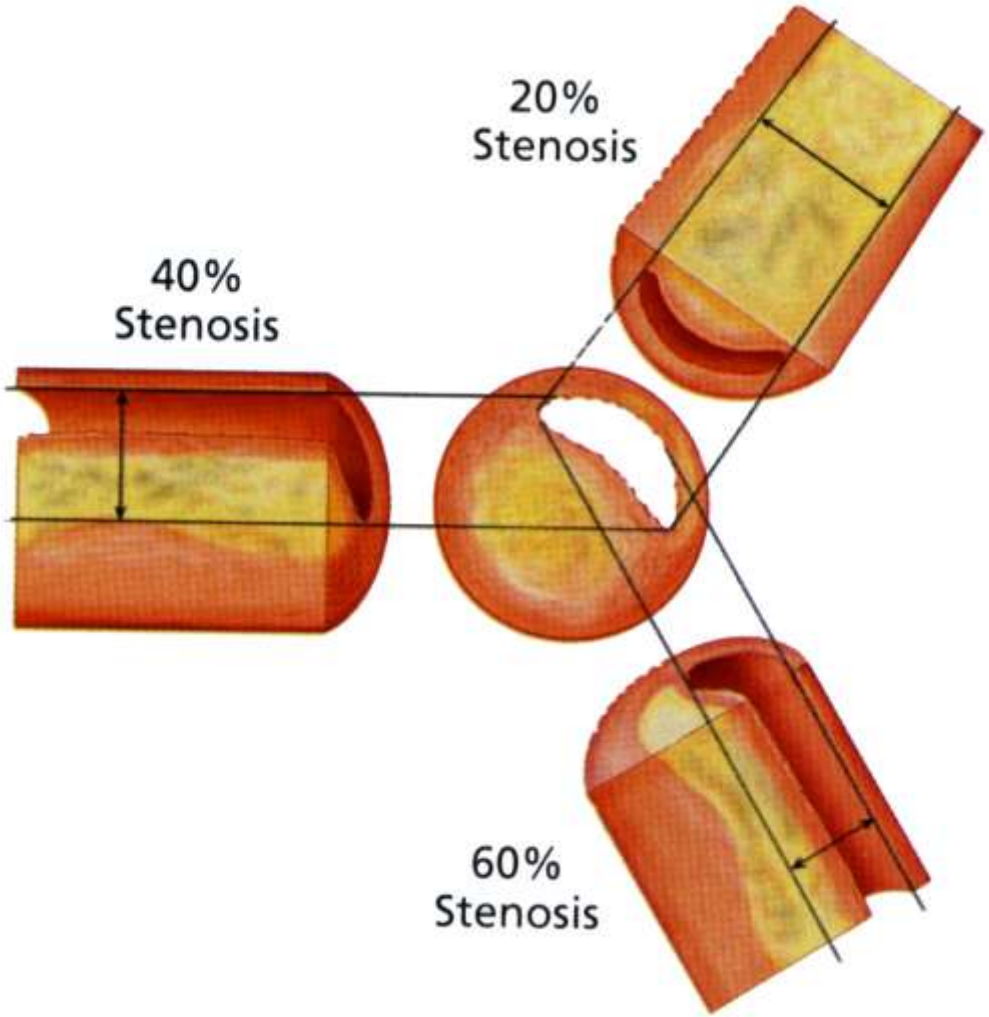


3D Computed Simulation Study, *AMC data*

Angiographic DS (%) Has *Inherent Limitation* to Assess the Functional Significance of Stenosis.

Angiographic %DS

2-Dimensional, Single Cut Image



Why Mismatches ?

1. FFR Is Determined by Size of Myocardium and Many Lesion Specific Local Factors; FFR Is A Summation of Anatomical and Functional Integration of Stenosis. "Total Morphology Perception"
2. Angiographic % DS is Simply, 2-Dimensional, Single Cut Image Measurement.

They are Totally Different !

What Does It Mean, *FFR Guided*?

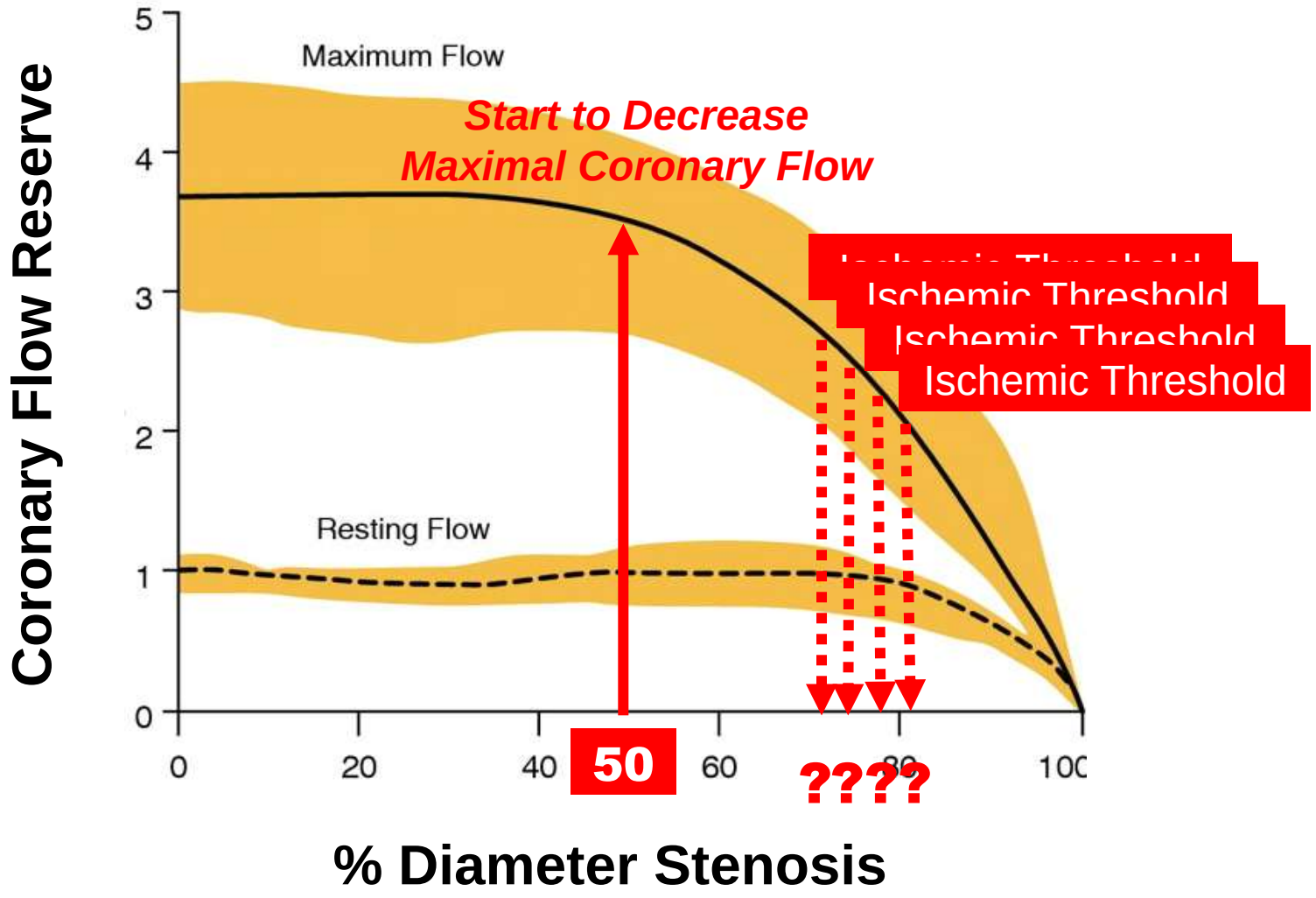
FFR *Matched Non-Invasive Stress Tests,* Cut-off Value (0.72~0.78) Is Extremely Reproducible and Very Solid.

Author	Number	Stress Test	Best Cut-off	Accuracy
Pijls et al.	60	X-ECG	0.74	97
DeBruyne et al.	60	X-ECG/SPECT	0.72	85
Pijls et al.	45	X-ECG/SPECT/pacing/DSE	0.75	93
Bartunek et al.	37	DSE	0.68	90
Abe et al.	46	SPECT	0.75	91
Chamuleau et al.	127	SPECT	0.74	77
Caymaz et al.	40	SPECT	0.76	95
Jimenez-Navarro et al.	21	DSE	0.75	90
Usui et al.	167	SPECT	0.75	79
Yanagisawa et al.	167	SPECT	0.75	76
Meuwissen et al.	151	SPECT	0.74	85
DeBruyne et al.	57	MIBI-SPECT post-MI	0.78	85
Samady et al.	48	MIBI-SPECT post-MI	0.78	85
Ahn JM et al.(2011)	151	SPECT	0.77	89

FFR-Guided Means,
Ischemia Guided !

Physiologic Meaning of 50% DS

Background from Animal Study



Gould, K. L. 1974, Animal Study

FFR-Guided Means,
Ischemia Guided !

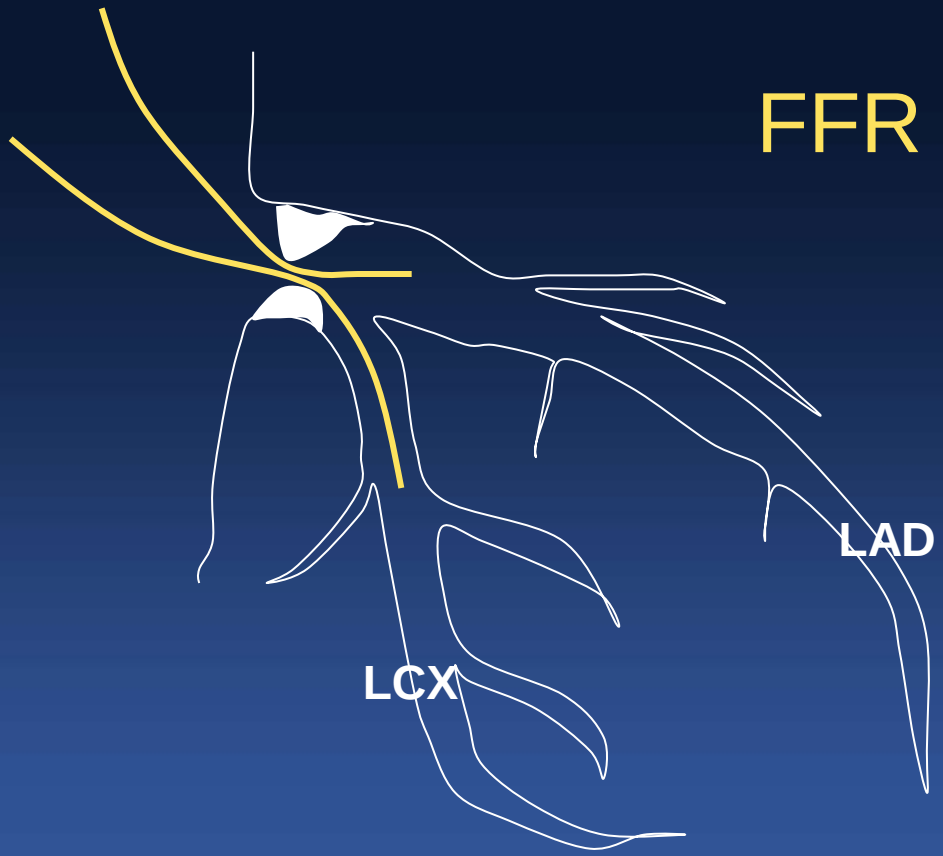
Angio-Guided Means,
No Clinical Relevance !

2013, ESC Guidelines

Recommendations	Class	Level
FFR is recommended to identify hemodynamically relevant coronary lesion(s) when evidence of ischemia is not available.	I	A
Revascularization of stenosis with FFR <0.80 is recommended in patients with angina symptoms or a positive stress test.	I	B
Revascularization of an angiographically intermediate stenosis without related ischemia or without FFR <0.80 is not recommended.	III	B

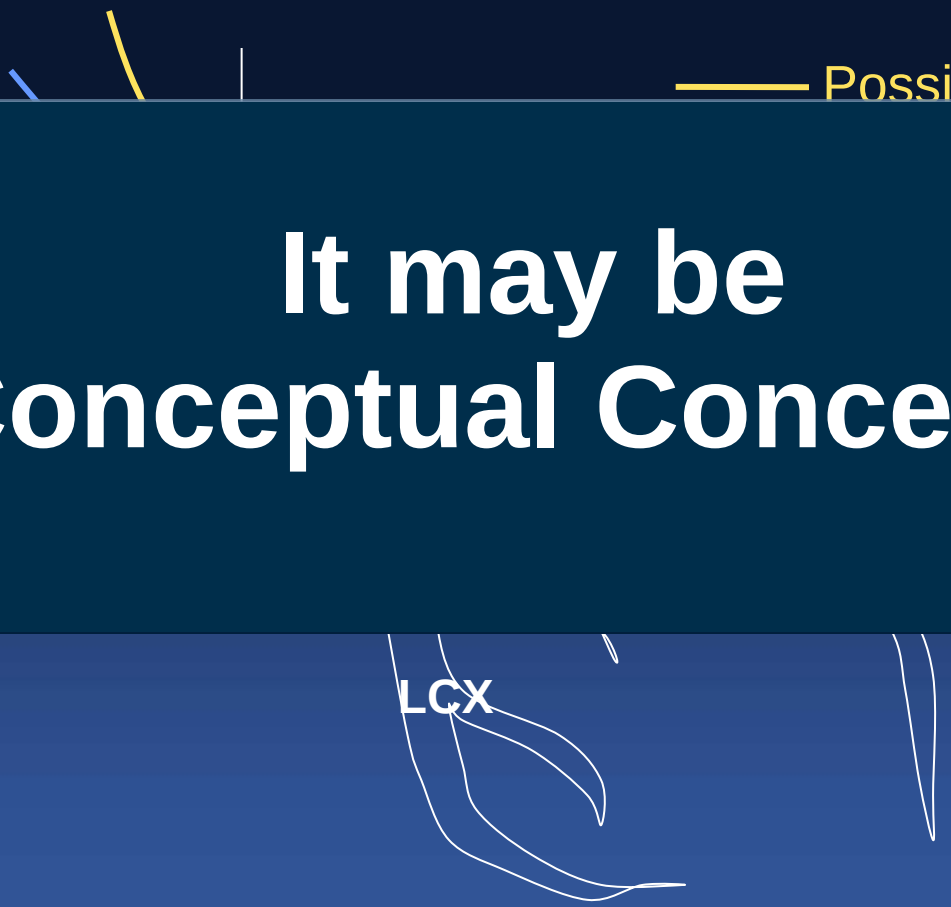
How I Implement FFR in Real Practice ?

For the Undetermined, Intermediate Ostial and Shaft LM Lesion,



FFR is Crucial

For Bifurcation LM Lesion, Have Problem to Measure FFR ??

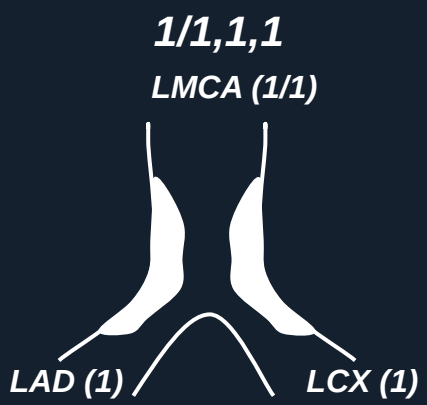


It may be Conceptual Concern !

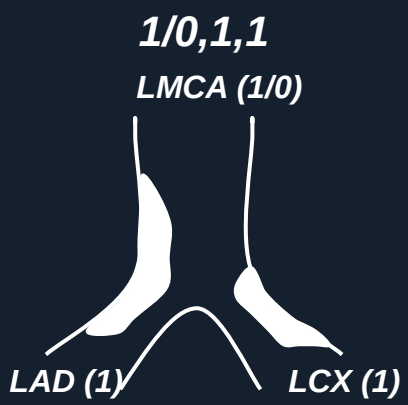
Courtesy of Akiko Maehara, MD

In Reality,

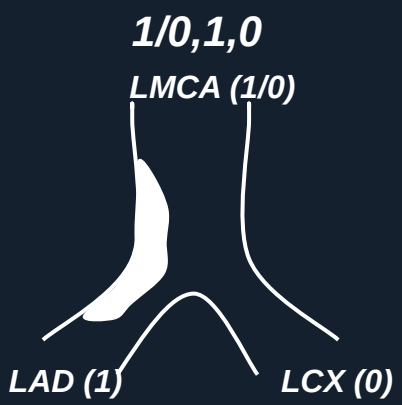
Plaque Distribution by IVUS (n=140)



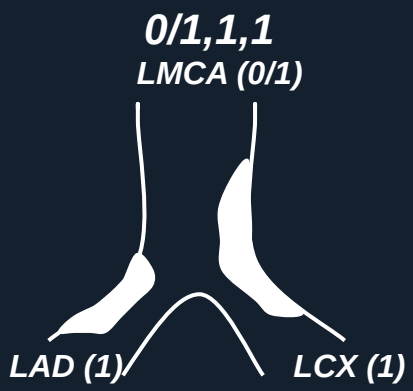
62%



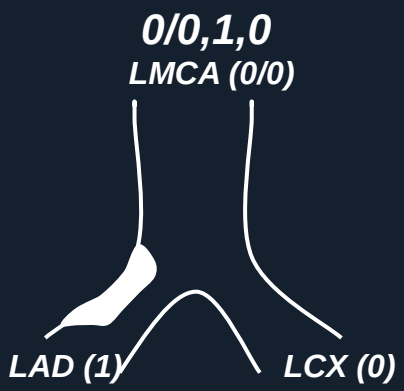
14%



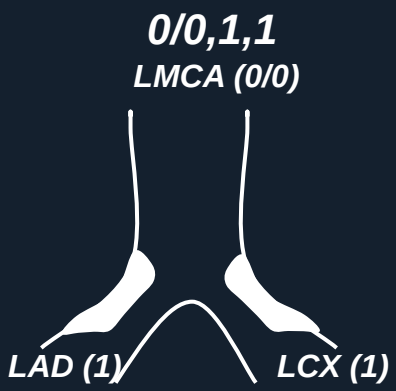
14%



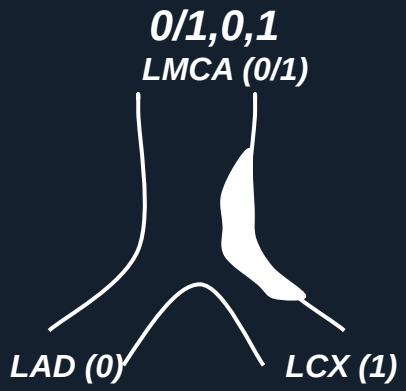
4%



3%



2%

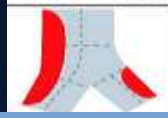
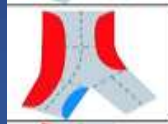


1%

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
	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

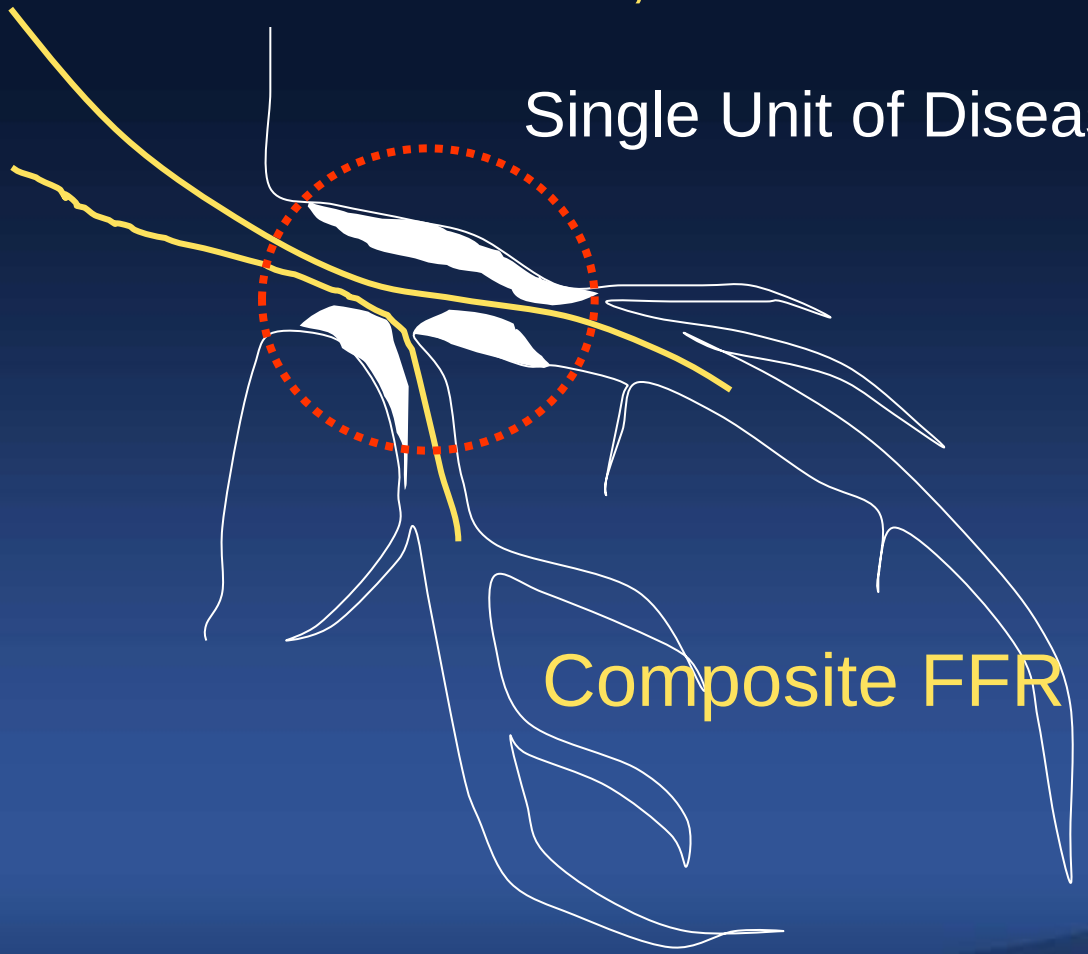
LM Bifurcation Disease Would be Defined
Single Unit of Disease.

continuously.

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

For the Intermediate LM Bifurcation Lesion,

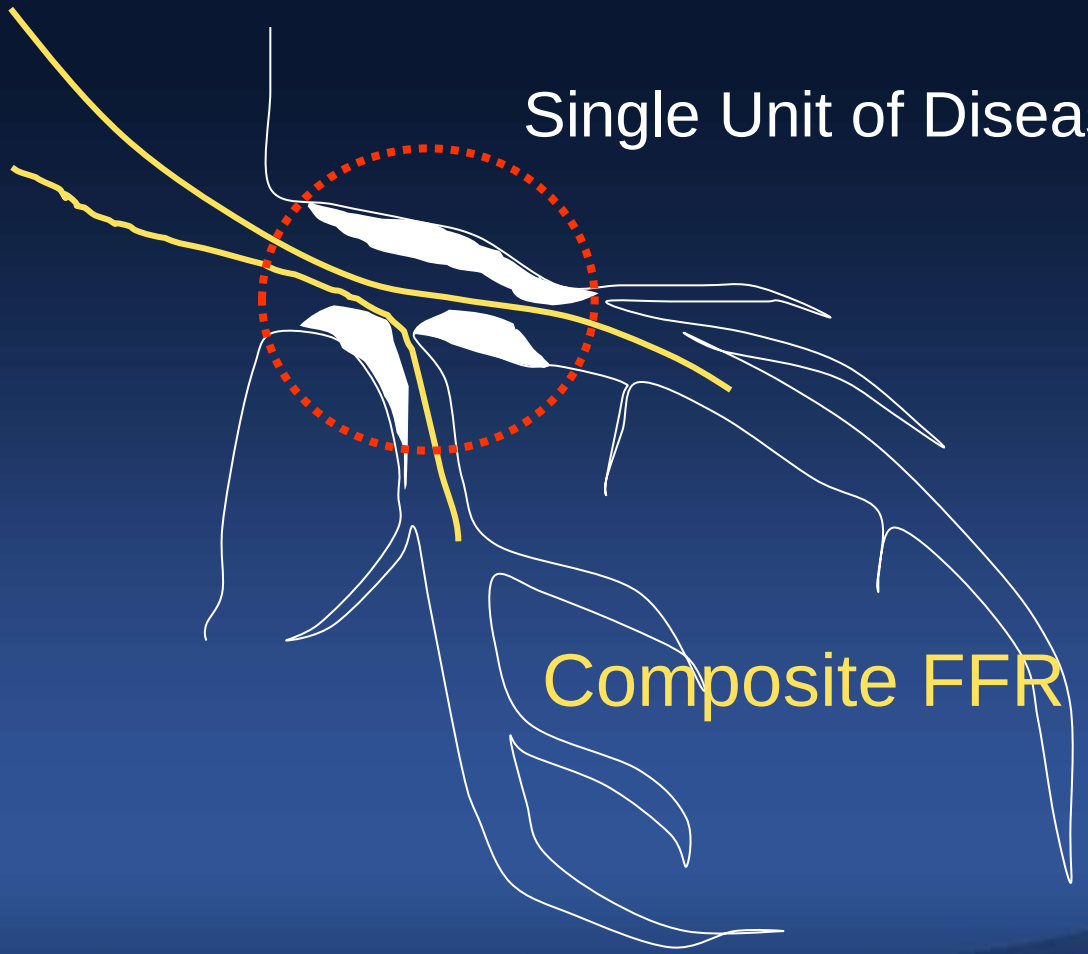
If Transducer Placed Beyond Bifurcation
in both LAD and LCX,



Single Unit of Disease

Composite FFR still Works.

Main Issue is How to Treat,
Single Stent Cross Over or 2 Stents Technique According to the Composite FFR.

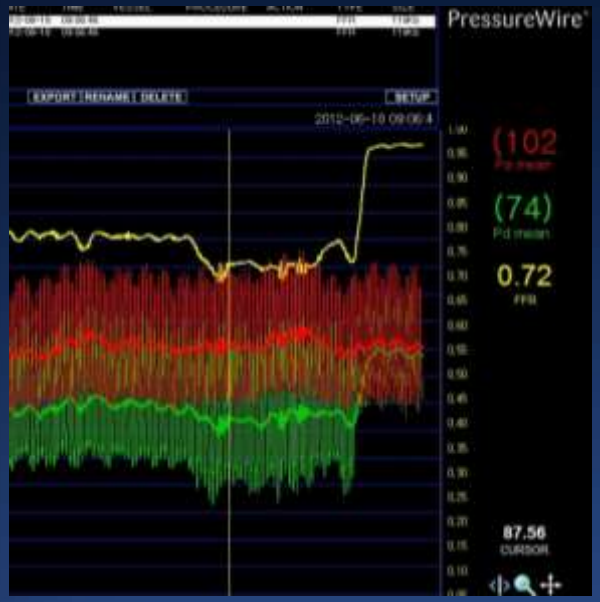


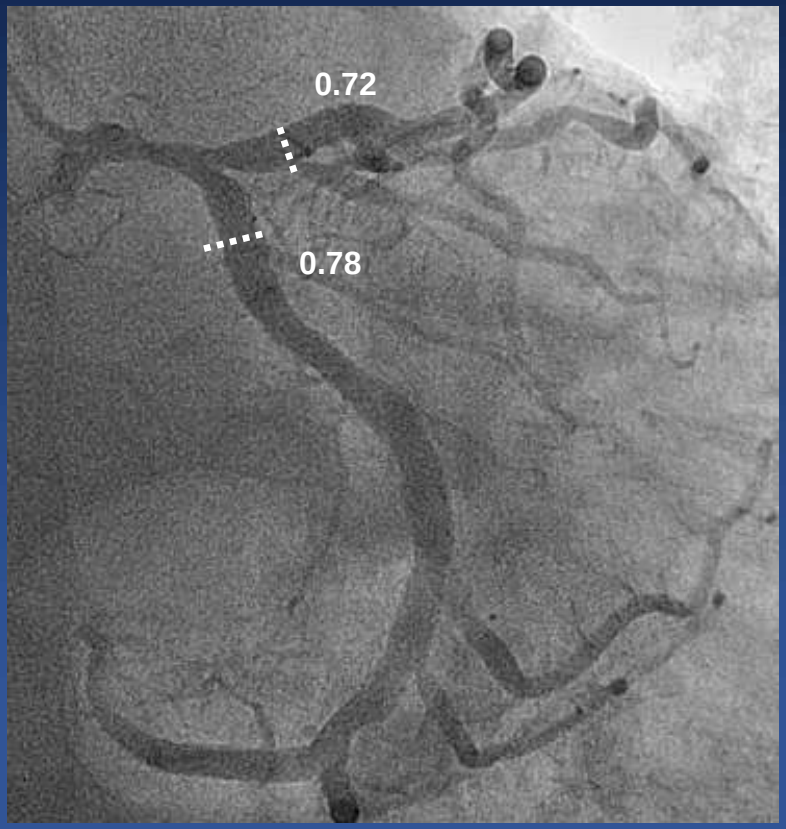
Composite FFR still Works.

LM Bifurcation Disease with Medina (1,1,0)

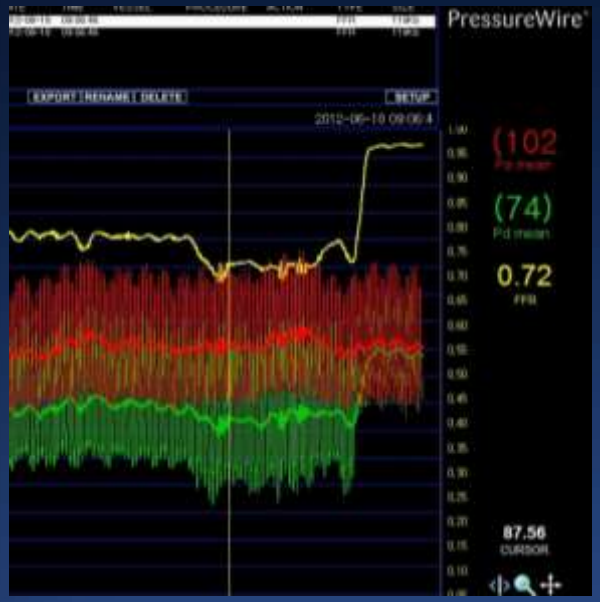
55/M, Stable angina, TMT (+), Thallium scan (-)

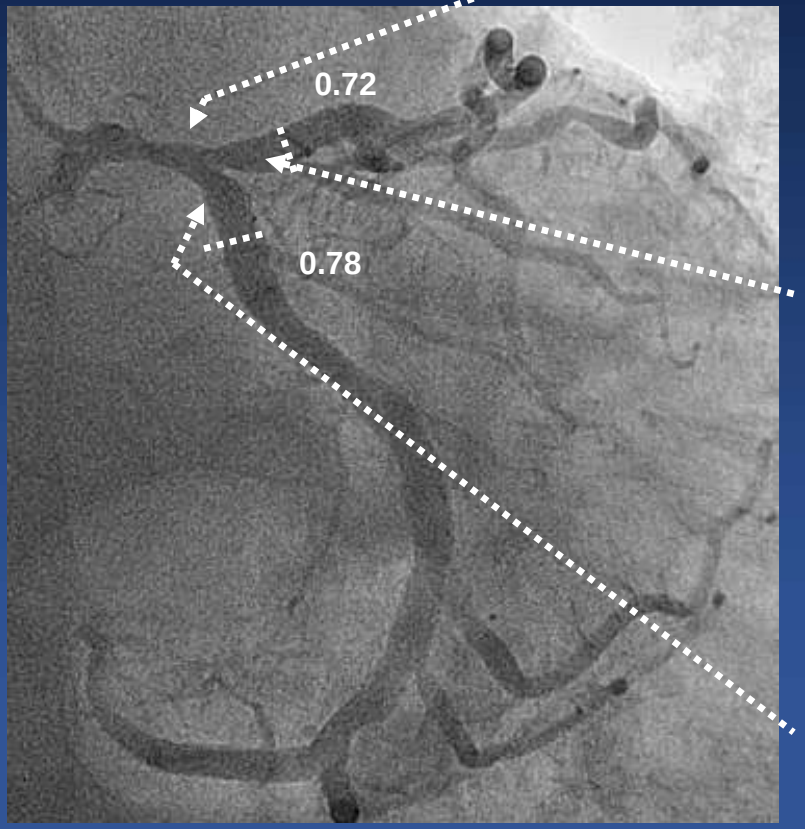
FFR in Both LAD and LCX,





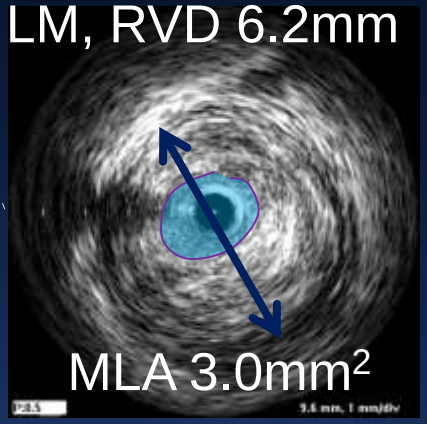
IVUS in Both LAD and LCX,

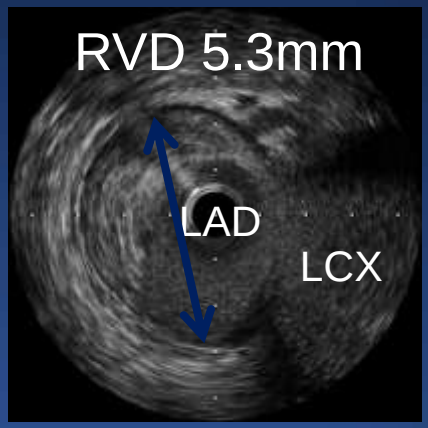


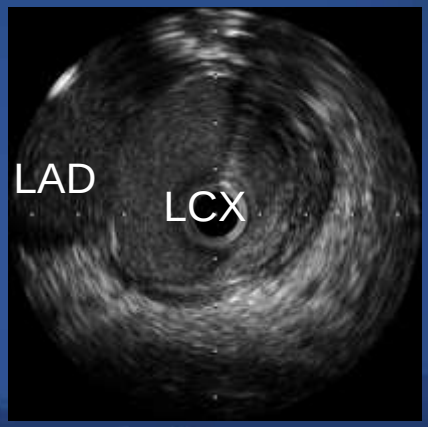


Minimal disease at LCX ostium

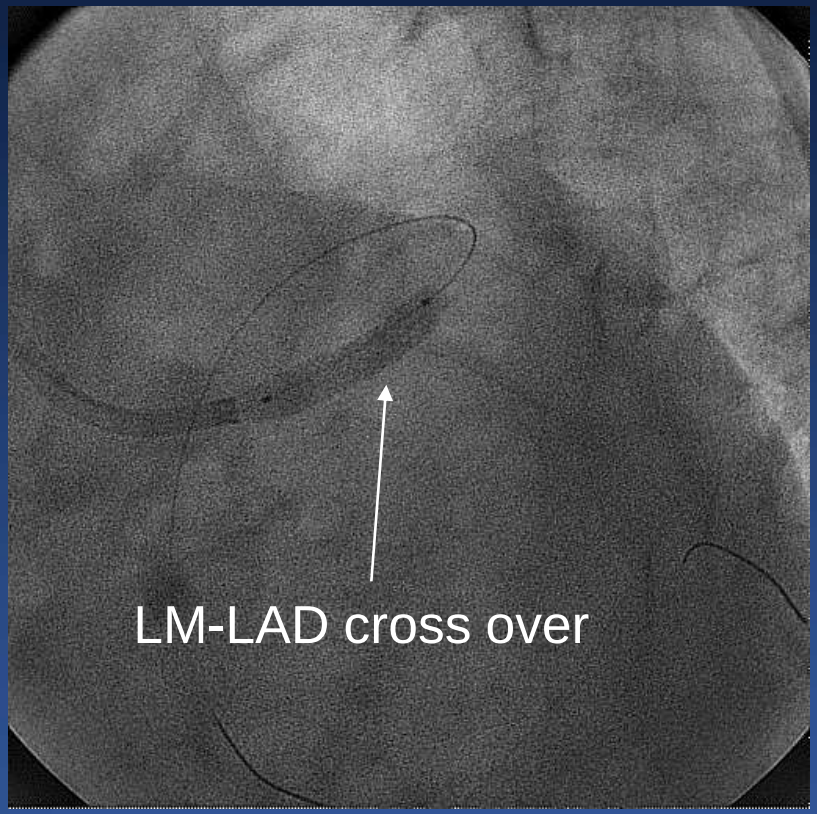
Distal LM, RVD 6.2mm



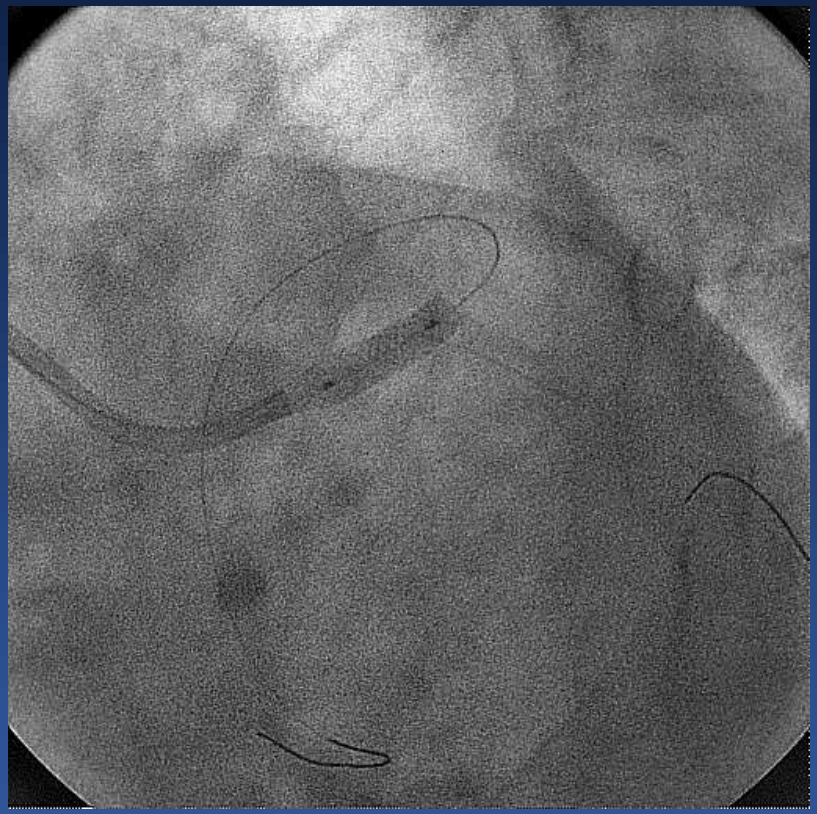




We Decided,
Just Single Stent Cross-Over !

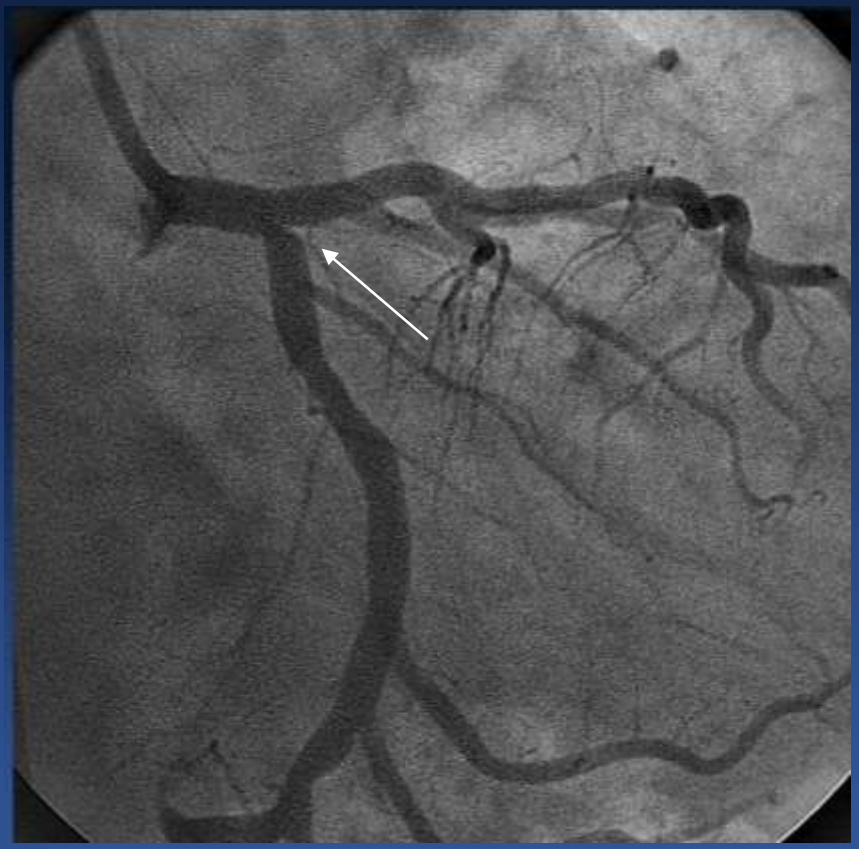


Promus Element 4.0x20



Additional high pressure
Inflation with 4.0 mm
non-compliant balloon

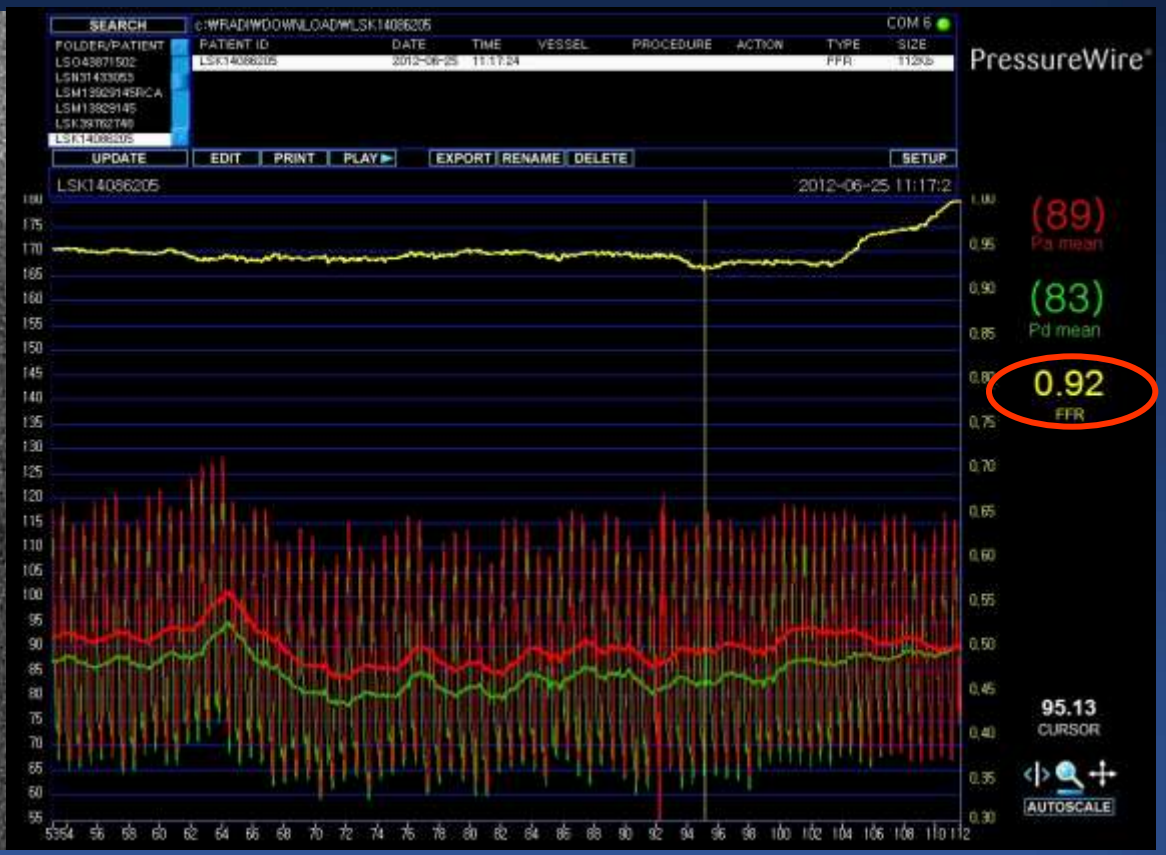
After Stent Cross-Over, LCX Ostium Was Jailed !



What Would You Do ?

Do You Want to Treat Jailed Side Branch ?

Consider FFR, First !



Integrated Use of FFR and IVUS Means,

FFR Guided Decision Making and IVUS Guided Optimization Can Make An Excellent Clinical Outcomes.

Why IVUS Too ?

1. IVUS Guidance Saves Lives.
2. Assessment of LM Ostium, Reference Vessel Diameter, Pattern of Remodeling, and Vulnerability of Plaque.
3. Treatment Strategy Would be Simplified as Single Stent Cross-Over Depending on the Disease Status of LCX Ostium by Separate IVUS Run.
4. IVUS Guided Stent Optimization and Effective Stent CSA Can Make a Good Clinical Outcomes.
5. Smaller IVUS MLA 4.5 mm^2 Can Predict Functional Significance of LM Stenosis.

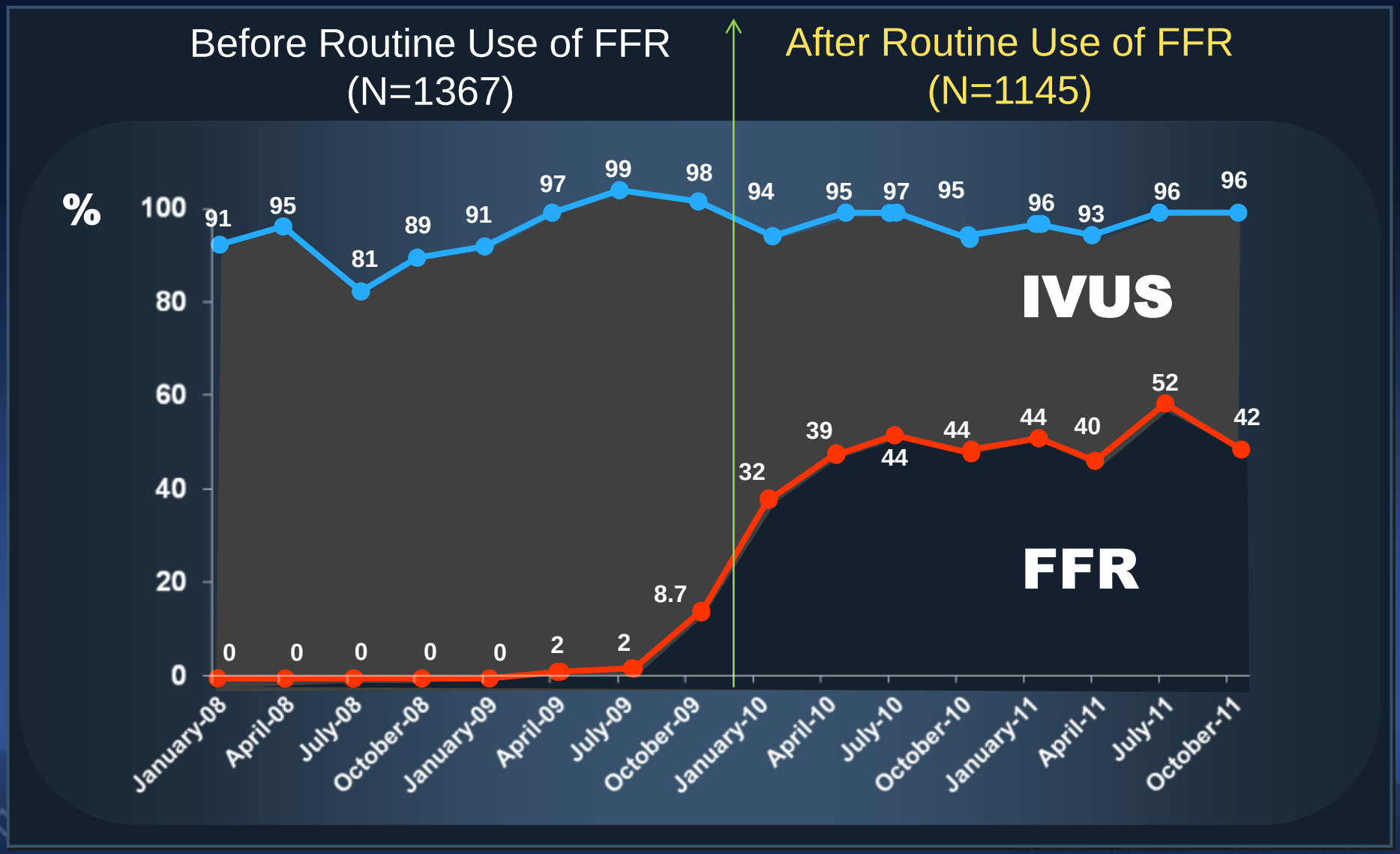
Clinical Data, 2014

Impact of Integrated Use of FFR and IVUS for Left Main and 3-Vessel Disease Revascularization in Real Practice.

2014, Data from ASAN Multi-Vessel and Left Main Disease Registry

Integrated Use of FFR and IVUS

(AMC data, n=2512)



Propensity Matched Population
Overall Clinical Outcomes

Before Routine Use of FFR vs.
After Routine Use of FFR (971 pairs)

Procedural Characteristics of PCI

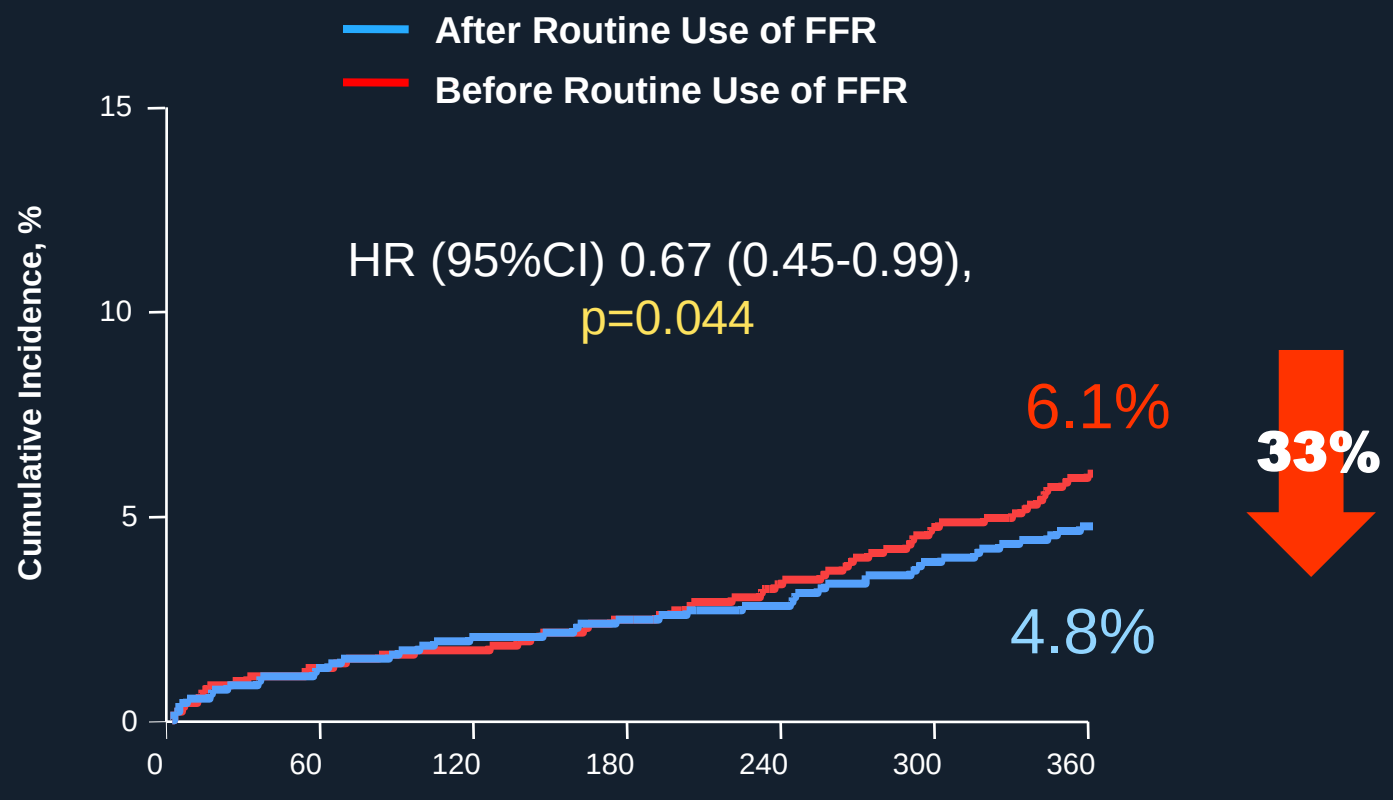
	Before Routine FFR (N=663)	After Routine FFR (N=566)	P value
Fractional flow reserve	13 (2.0)	237 (41.9)	<0.001
Mean	0.87±0.08	0.77±0.12	
>0.80	13 (86.7)	133 (39.8)	
0.75-0.80	0	77 (23.1)	
<0.75	2 (13.3)	124 (37.1)	
N. of Deferred lesions	13 (86.7)	145 (43.4)	
No. of stents	3.04±1.52	2.51±1.39	<0.001
Total stent length, mm	77.7±40.9	65.6±39.0	<0.001
Average stent diameter, mm	3.32±0.28	3.33±0.32	0.63

Procedural Characteristics of CABG

	Before Routine FFR (N=770)	After Routine FFR (N=494)	P value
Number of conduit	2.97±0.94	3.08±0.94	0.038
Number of vein conduit	1.17±0.90	1.30±0.85	0.009
Number of arterial conduit	1.80±0.87	1.78±0.90	0.69
Internal thoracic artery	757 (98.3)	481 (97.4)	0.25
Off-pump	499 (64.8)	433 (87.7)	<0.001

Primary End Point

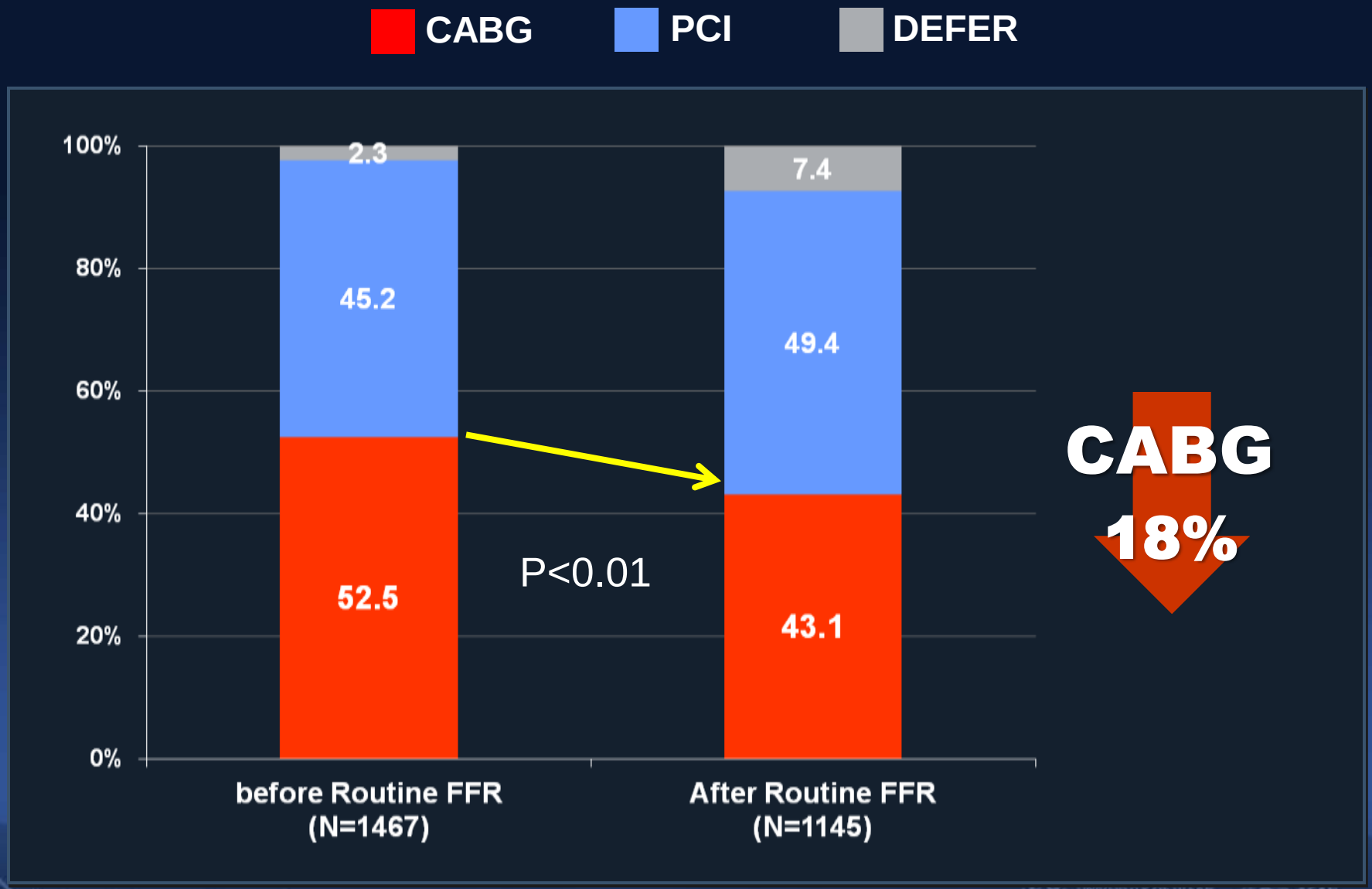
Death, MI, Stroke or Repeat Revascularization



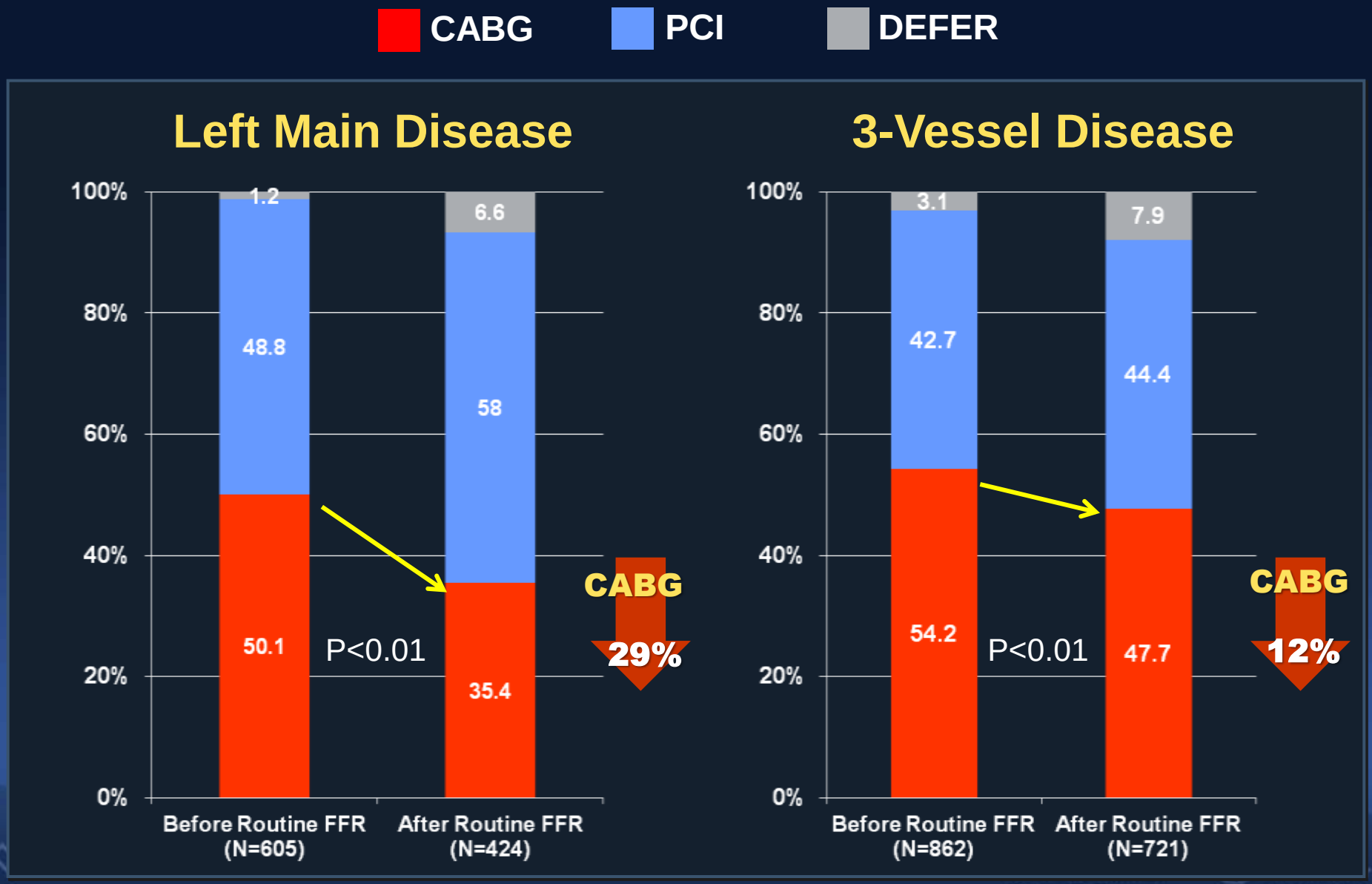
No. at Risk

Before Routine Use	917	901	883	857
After Routine Use	917	898	886	869

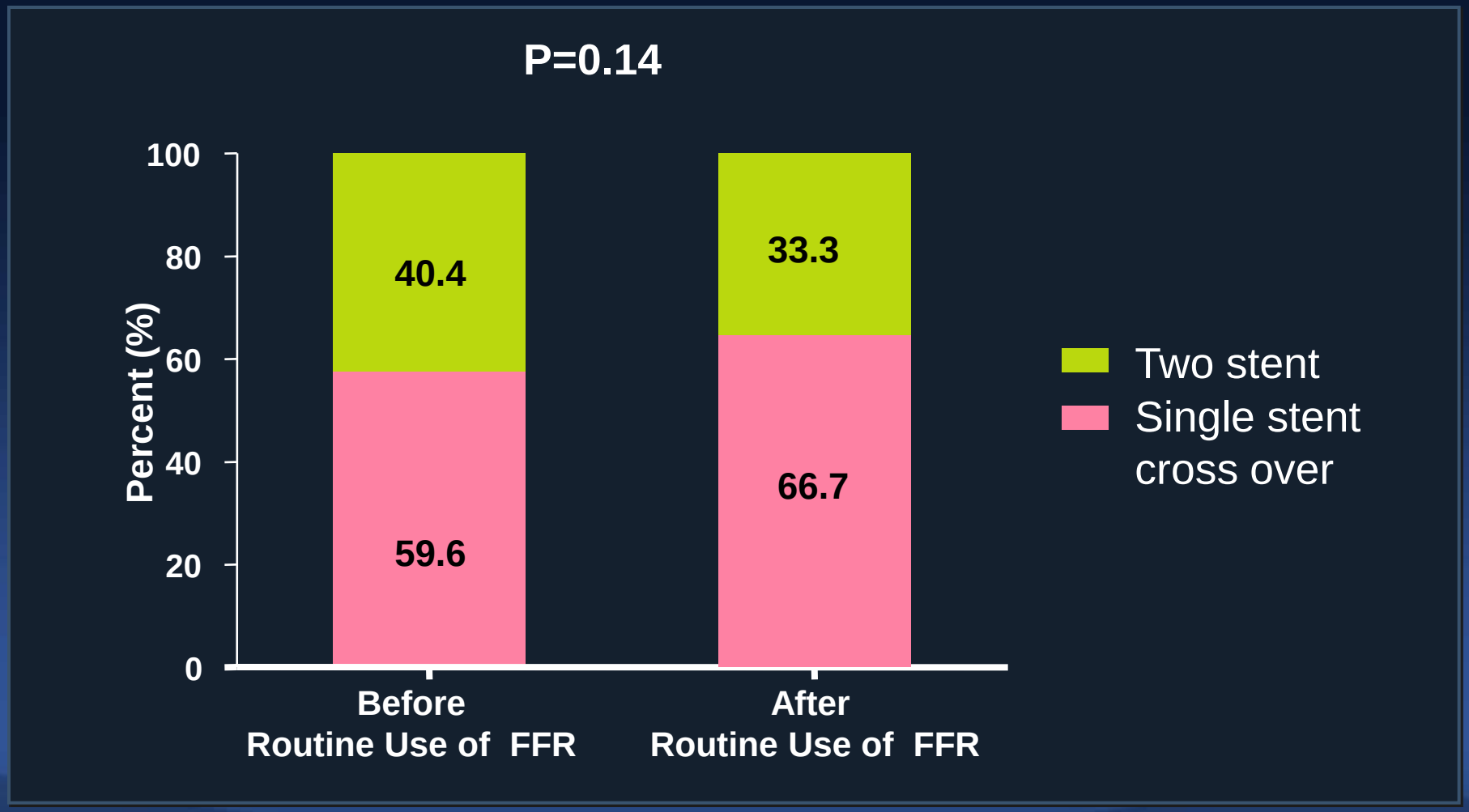
Treatment Strategy *Changes*



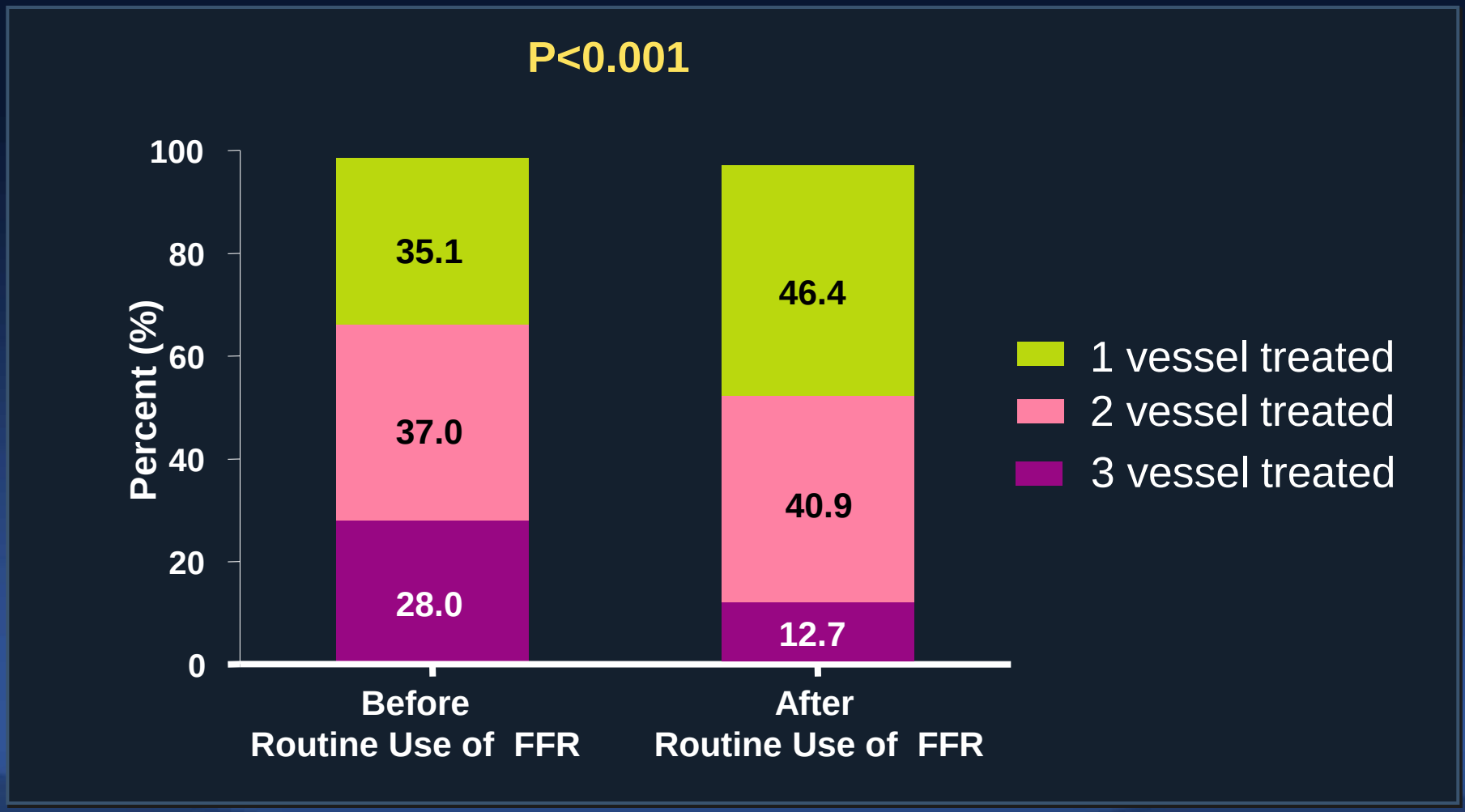
Treatment Strategy *Changes*



Procedural Change in PCI
Distal LM Treatment

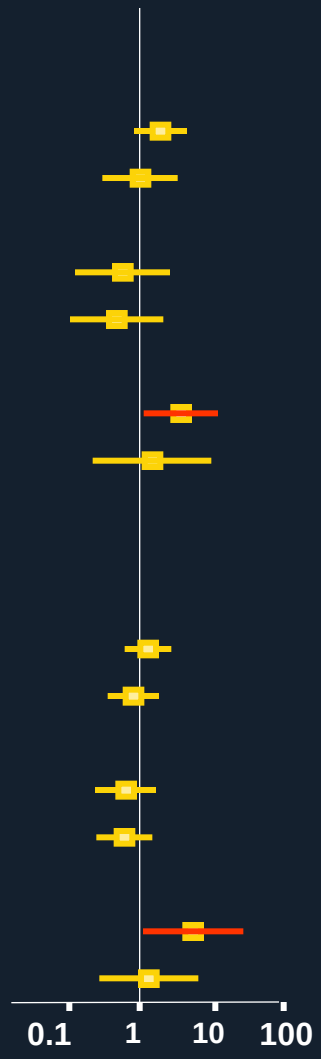


Procedural Change in PCI
3 Vessel Disease, Treatment



LM and 3-Vessel, Subgroup Analysis

	1 Year Event Rate (%) CABG	1 Year Event Rate (%) PCI	Adjusted Hazard Ratio (95% CI)	P value
Left Main Disease	N=231	N=231		
MACCE				
Before Routine FFR	15 (5.0)	25 (8.5)	1.89 (0.84-4.25)	0.12
After Routine FFR	7 (4.6)	15 (6.2)	1.02 (0.32-3.21)	0.97
Death, MI, or stroke				
Before Routine FFR	10 (3.3)	4 (1.4)	0.60 (0.14-2.54)	0.49
After Routine FFR	6 (4.0)	6 (2.5)	0.50 (0.12-2.06)	0.34
Any Repeat Revascularization				
Before Routine FFR	5 (1.7)	21 (7.2)	3.53 (1.14-11.0)	0.029
After Routine FFR	2 (1.3)	10 (4.2)	1.48 (0.24-8.98)	0.67
3 Vessel Disease	N=529	N=529		
MACCE				
Before Routine FFR	21 (4.5)	24 (6.5)	1.30 (0.63-2.65)	0.48
After Routine FFR	18 (5.3)	15 (4.7)	0.83 (0.38-1.81)	0.65
Death, MI, or stroke				
Before Routine FFR	18 (3.9)	9 (2.5)	0.67 (0.27-1.65)	0.38
After Routine FFR	17 (5.0)	9 (2.8)	0.63 (0.27-1.48)	0.29
Any Repeat Revascularization				
Before Routine FFR	3 (0.7)	15 (4.2)	5.12 (1.11-23.7)	0.036
After Routine FFR	3 (0.9)	8 (2.5)	1.33 (0.30-5.97)	0.71



Independent Predictors of Primary End Point

	Hazard Ratio (95% CI)	P value
Chronic renal failure	2.41 (1.61-3.59)	<0.001
Multivessel disease	1.89 (1.45-2.46)	<0.001
Peripheral vascular disease	1.84 (1.07-3.17)	0.027
Bifurcation lesion	1.37 (1.09-1.71)	0.006
Acute coronary syndrome	1.37 (1.10-1.69)	0.004
Total stent length per patient	1.01 (1.00-1.01)	<0.001
Fractional flow reserve	0.72 (0.53-0.98)	0.036
Intravascular ultrasound	0.57 (0.40-0.81)	0.002

FFR Guided Clinical Practice Of Left Main PCI

1. Various Clinical Variables Can Predict MACE, but the Only Two Procedure-Related Variables *Use of FFR and IVUS Can Reduce MACE* Mainly Due to Reduced Rate of Any Repeat Revascularization of PCI.

2. FFR guided PCI Showed Similar Clinical Outcomes with Concurrent CABG at 1 year and It Had Reduced Role of CABG as the Primary Treatment Strategy.

3. *Better Concept of PCI is Important* for Better Outcomes. Less surgery, Less DES and Simplified Procedure Can Improve Clinical Outcomes.

Thank You !!

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