LM and MVD PCI:

Imaging and Functional Guidance

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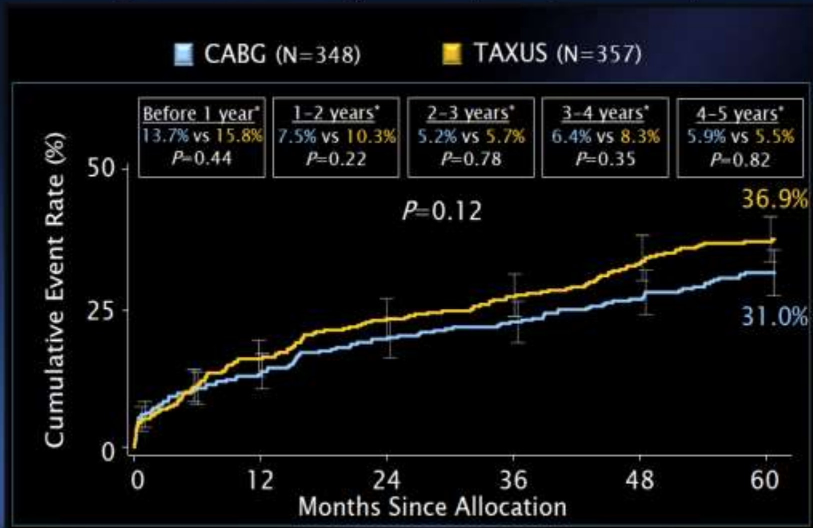
College of Medicine, Seoul, Korea

LM Subgroup From SYNTAX (TAXUS)

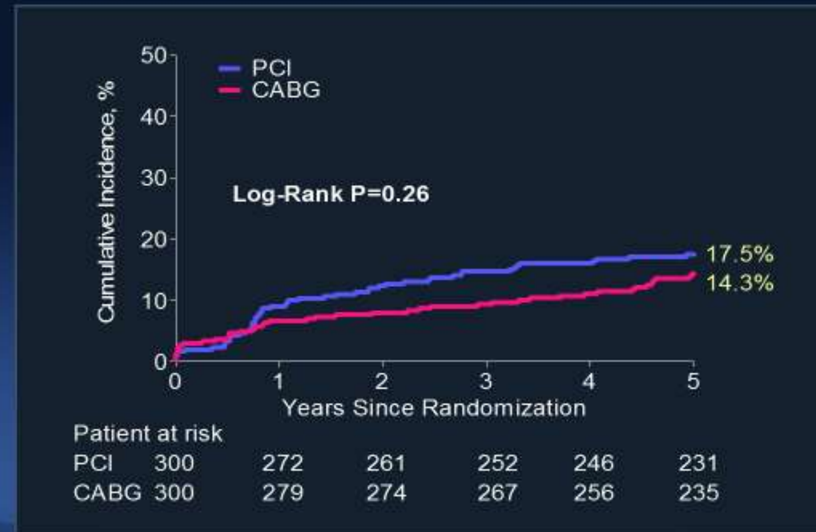
Primary End Point (Death, MI, Stroke, or RR)



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

PRECOMBAT (CYPHER)

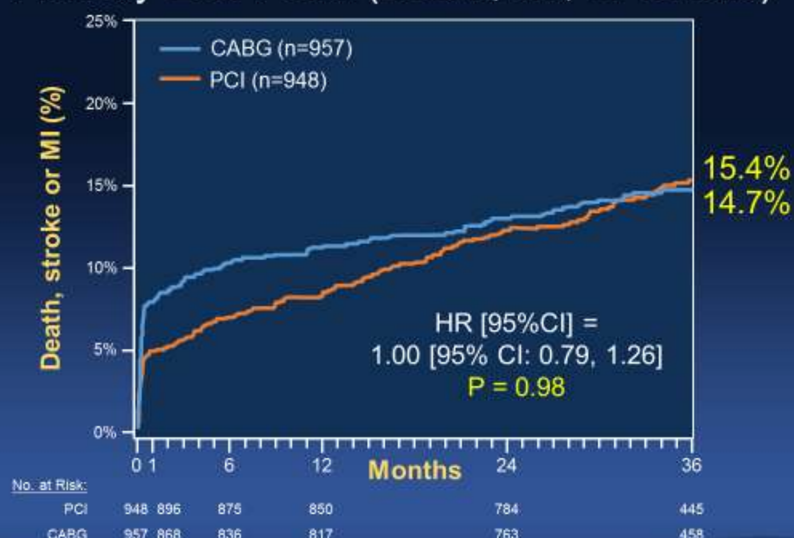
Primary End Point (Death, MI, Stroke, or iTVR)



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

EXCEL (XIENCE)

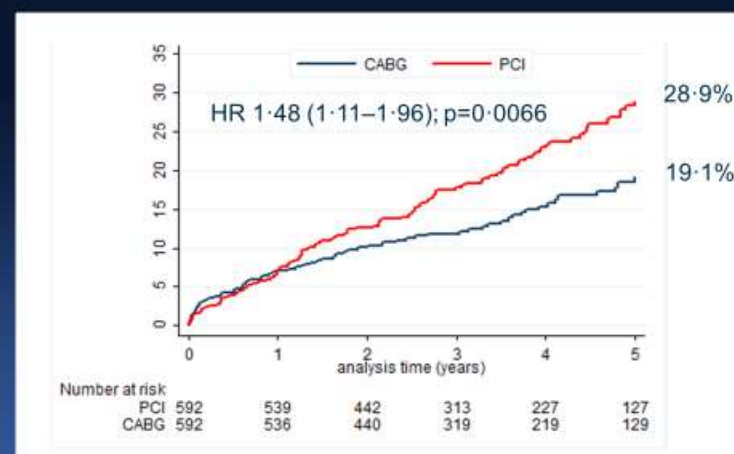
Primary End Point (Death, MI, or Stroke)



Stone GW et al. N Eng J Med 2016 ePub

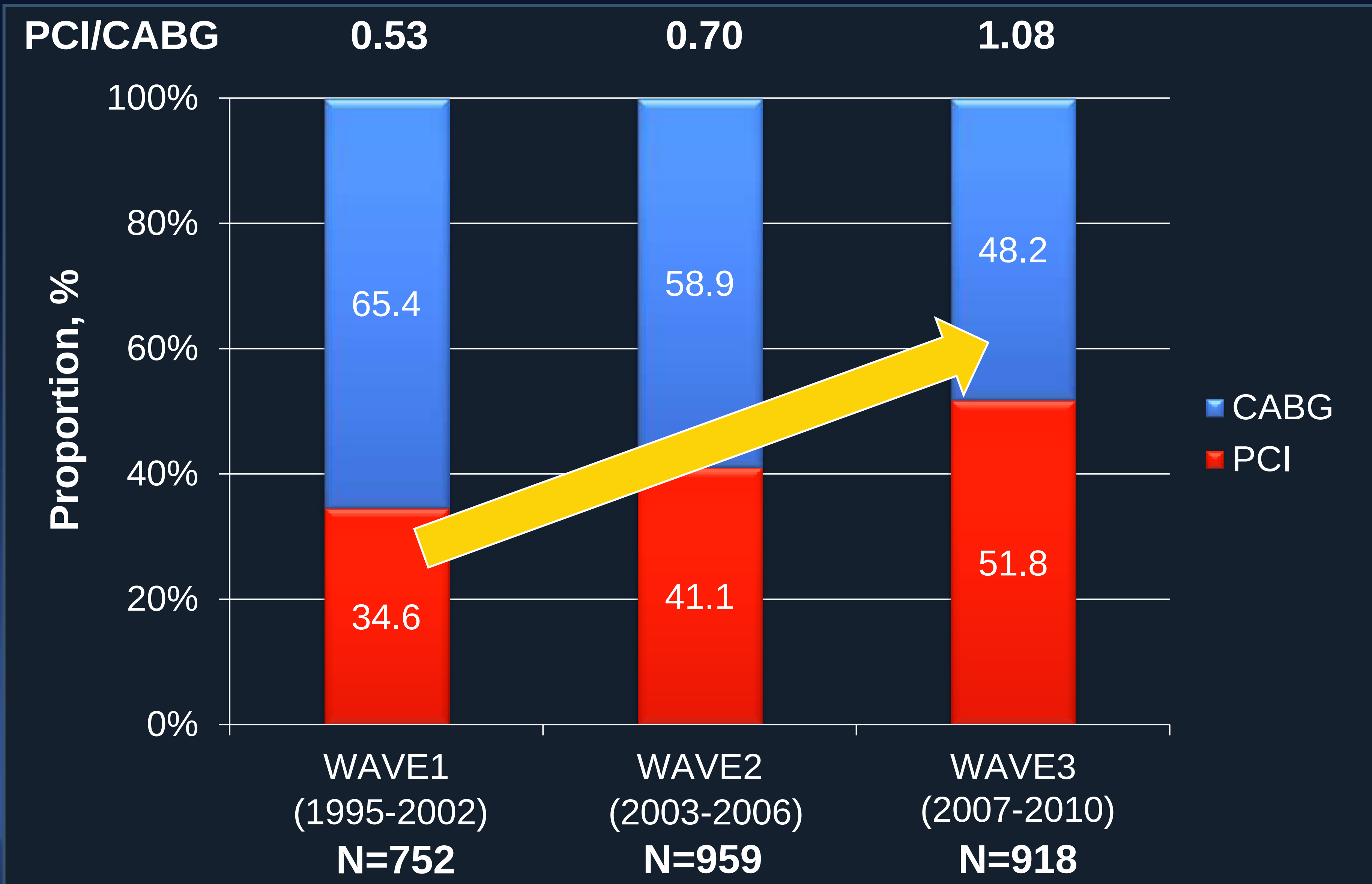
NOBLE Trial

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



Makikallio T et al. Lancet 2016 ePub

Revascularization Strategy



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

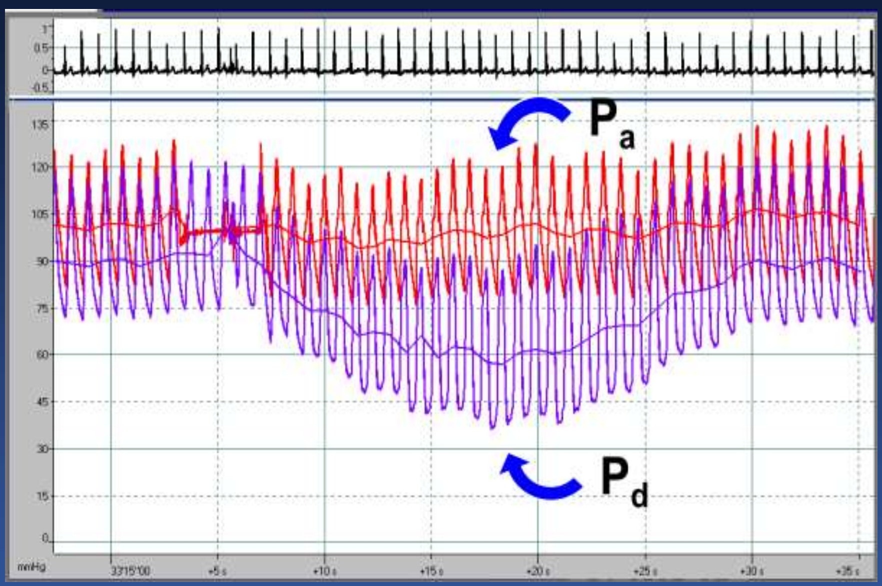
LM PCI 2017

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 $\leq$ 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

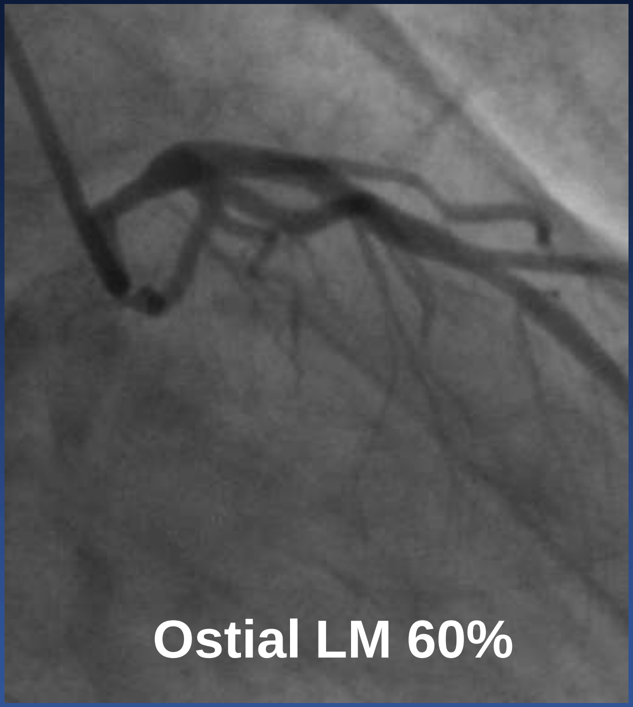
How to Do Optimal LM Stenting?

Integrated Use of FFR and IVUS



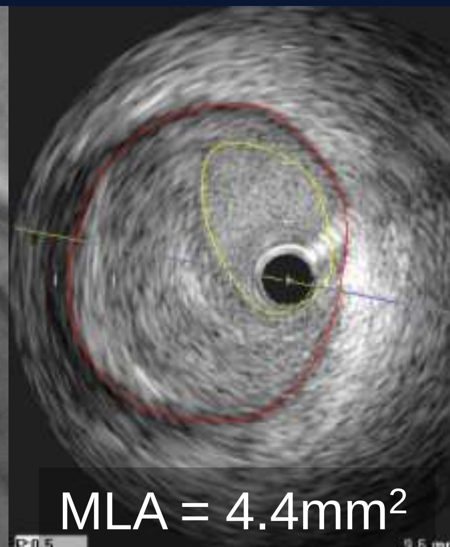
Diagnosis for Significant LM

Which One is Significant LM stenosis?

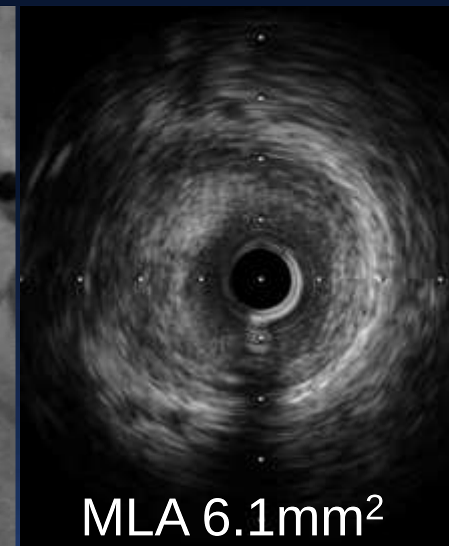


Which one is Significant LM stenosis?

47/M Stable angina

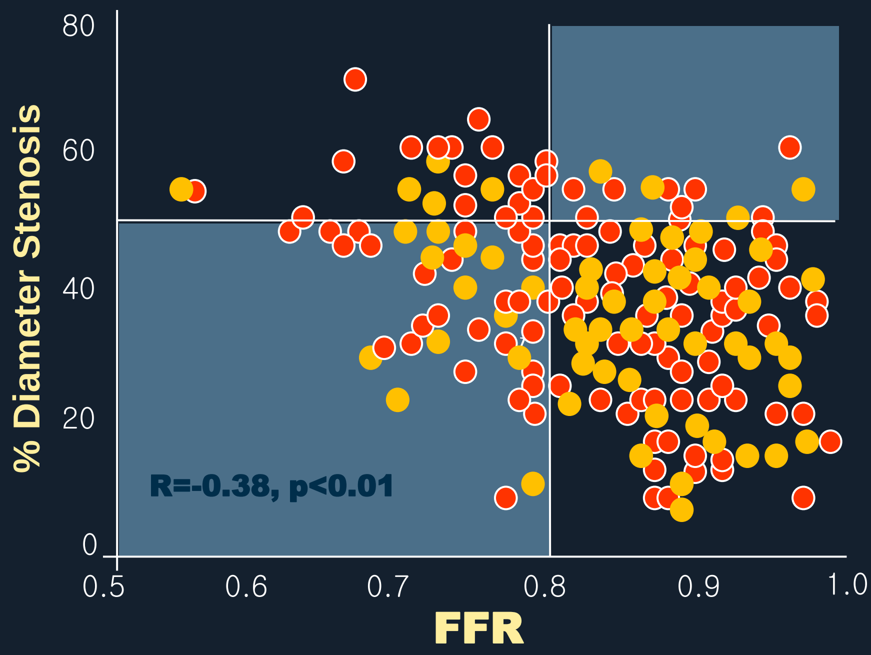


50/M Stable angina



The Limitation of CAG

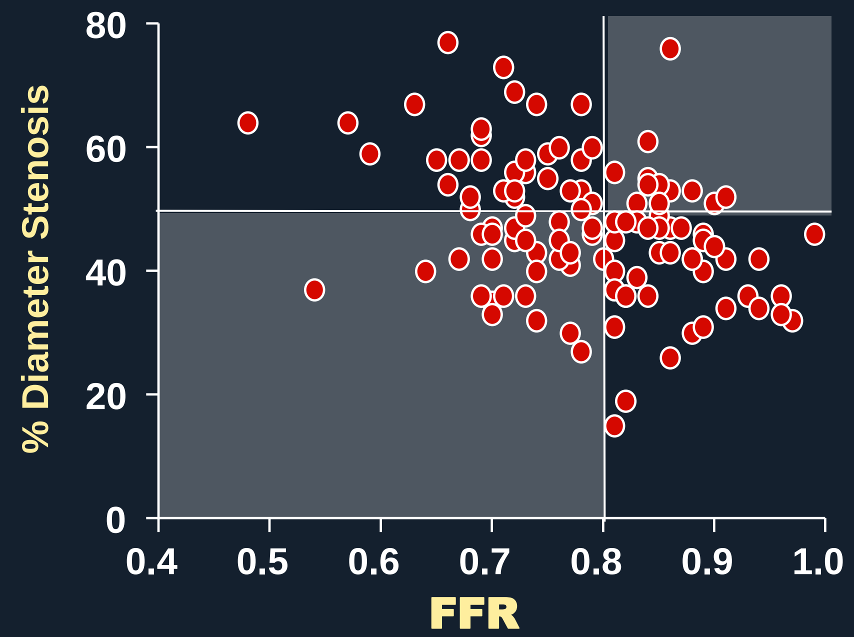
"Mismatch" is 29% in equivocal LMCA



Hamilos et al
Circulation 2009;120:1505-1512

Isolated LMCA disease

"Mismatch" is 37% in equivocal LMCA

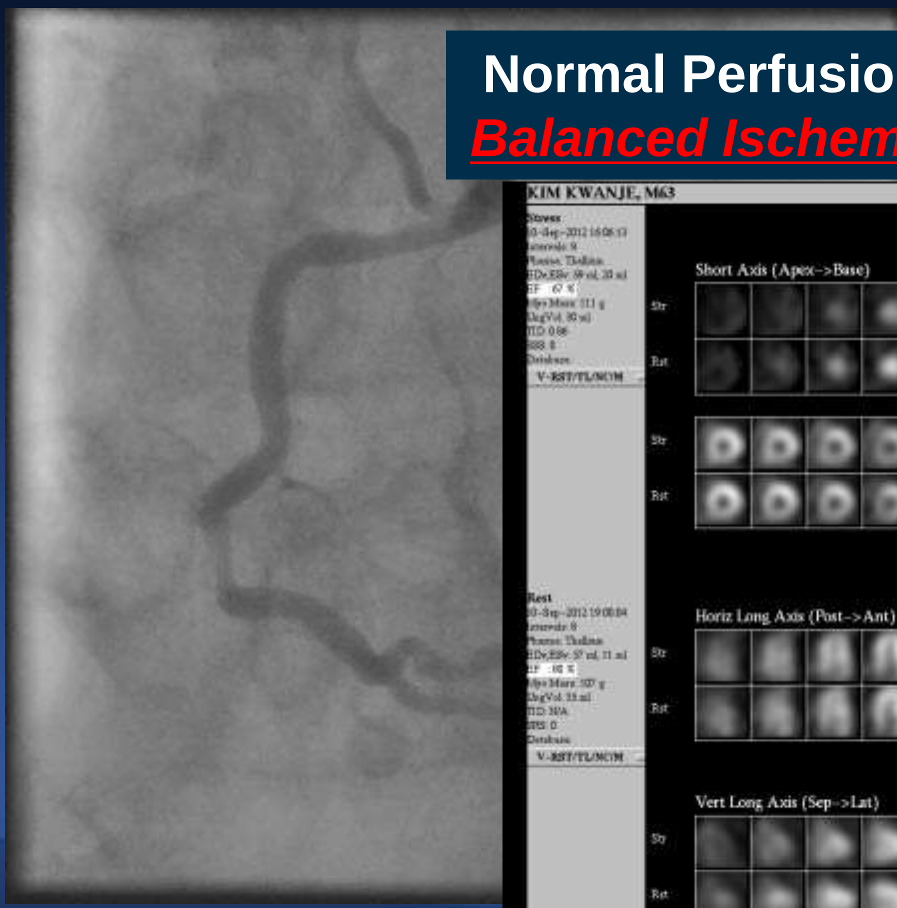


Park SJ, Ahn JM et al
JACC Cardiovasc Interv. 2014 ;7(8):868-74)

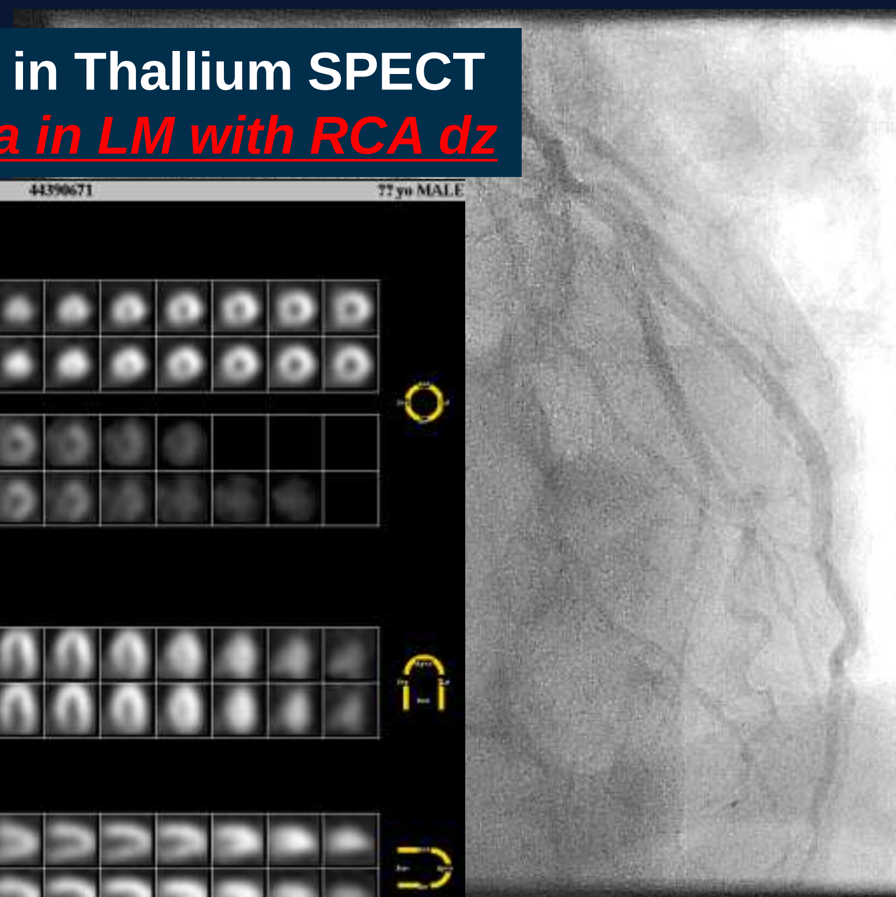
LM Stenosis with RCA disease

65yrs/M, eCP

RCA

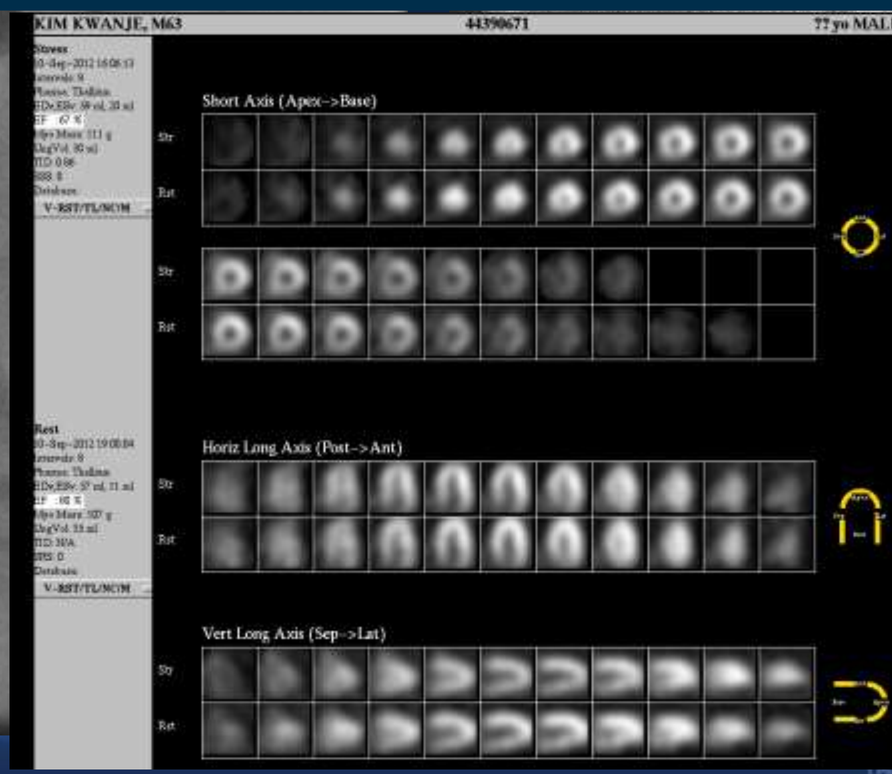


LCA



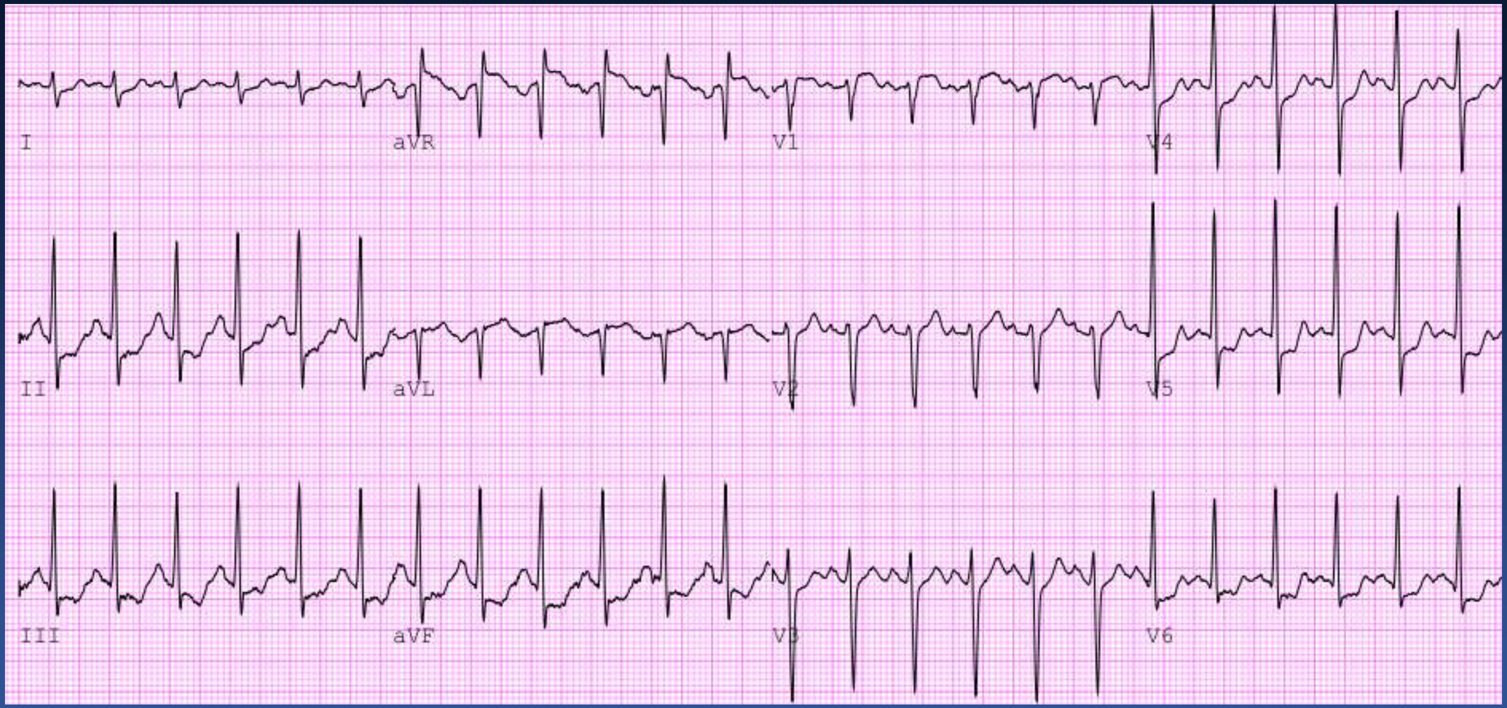
Normal Perfusion in Thallium SPECT

Balanced Ischemia in LM with RCA dz



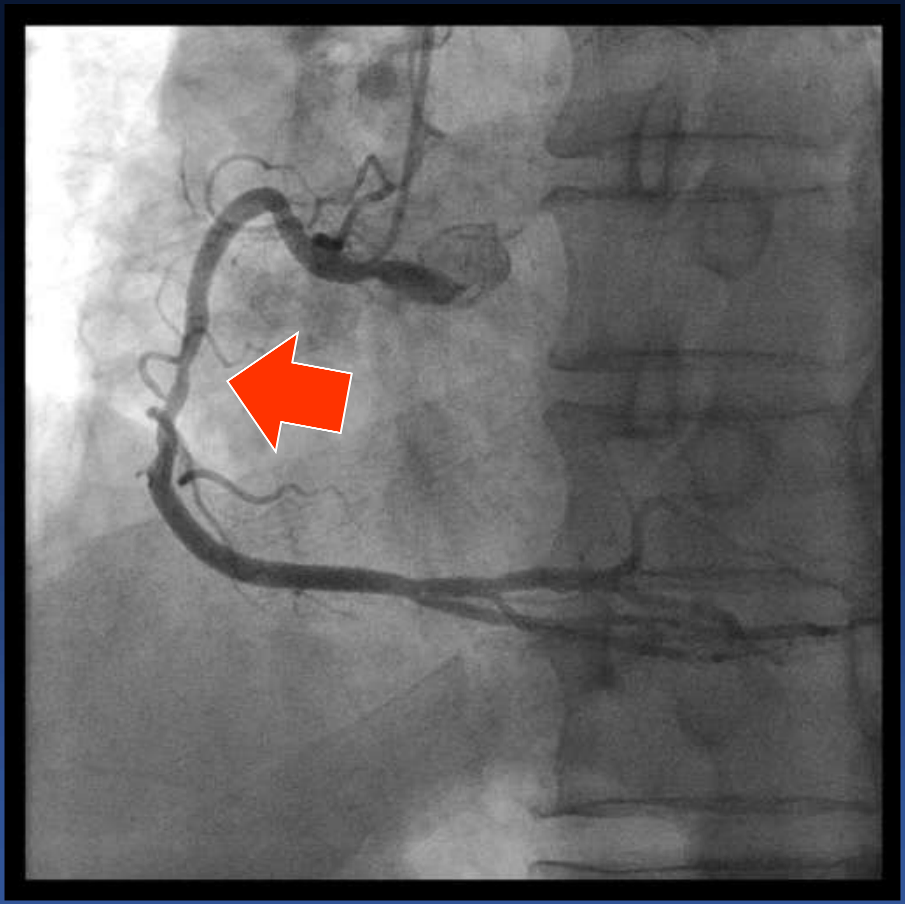
M/76, eCP

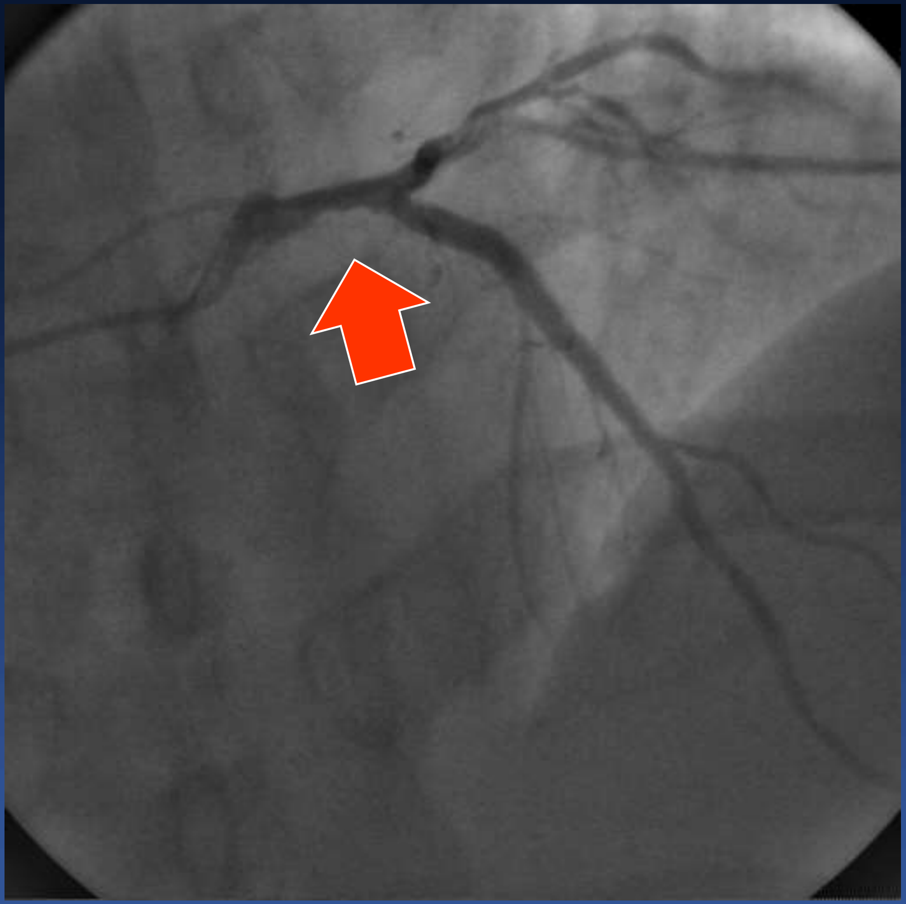
Treadmill Test



Positive at Stage 4

Coronary Angiography



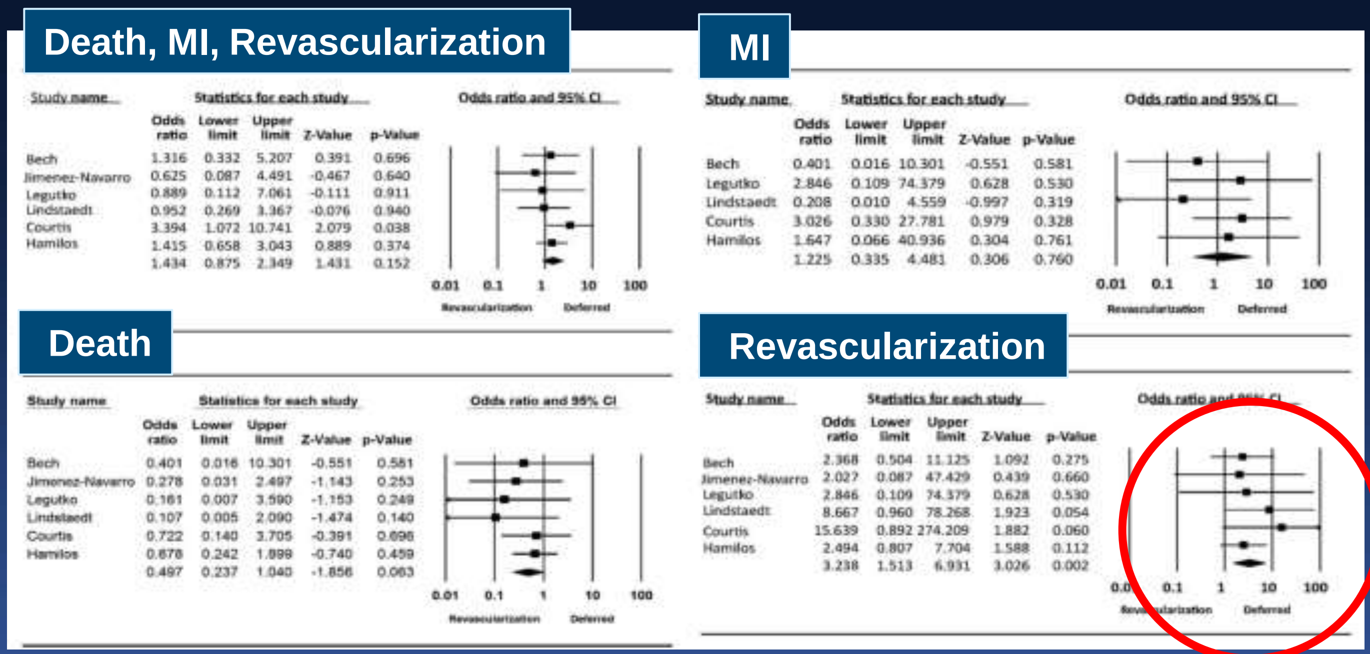


FFR


0.72
PressureWire
(77)
(56)
Pd mean
0.72
14.90
AUTOSCALE
0.89
(87)
(77)
Pd mean
0.89
90.66
AUTOSCALE

Meta-analysis
FFR Guided Treatment of LM:

6 prospective cohort studies involving 525 patients met the inclusion criteria



Death, MI, Revascularization

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Bech	1.316	0.332	5.207	0.391	0.696
Jimenez-Navarro	0.625	0.087	4.491	-0.467	0.640
Legutko	0.889	0.112	7.061	-0.111	0.911
Lindstaedt	0.952	0.269	3.367	-0.076	0.940
Courtis	3.394	1.072	10.741	2.079	0.038
Hamilos	1.415	0.658	3.043	0.889	0.374
	1.434	0.875	2.349	1.431	0.152

MI

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Bech	0.401	0.016	10.301	-0.551	0.581
Legutko	2.846	0.109	74.379	0.628	0.530
Lindstaedt	0.208	0.010	4.559	-0.997	0.319
Courtis	3.026	0.330	27.781	0.979	0.328
Hamilos	1.647	0.066	40.936	0.304	0.761
	1.225	0.335	4.481	0.306	0.760

Death

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Bech	0.401	0.016	10.301	-0.551	0.581
Jimenez-Navarro	0.278	0.031	2.497	-1.143	0.253
Legutko	0.161	0.007	3.590	-1.153	0.249
Lindstaedt	0.107	0.005	2.090	-1.474	0.140
Courtis	0.722	0.140	3.705	-0.391	0.696
Hamilos	0.678	0.242	1.899	-0.740	0.459
	0.497	0.237	1.040	-1.856	0.063

Revascularization

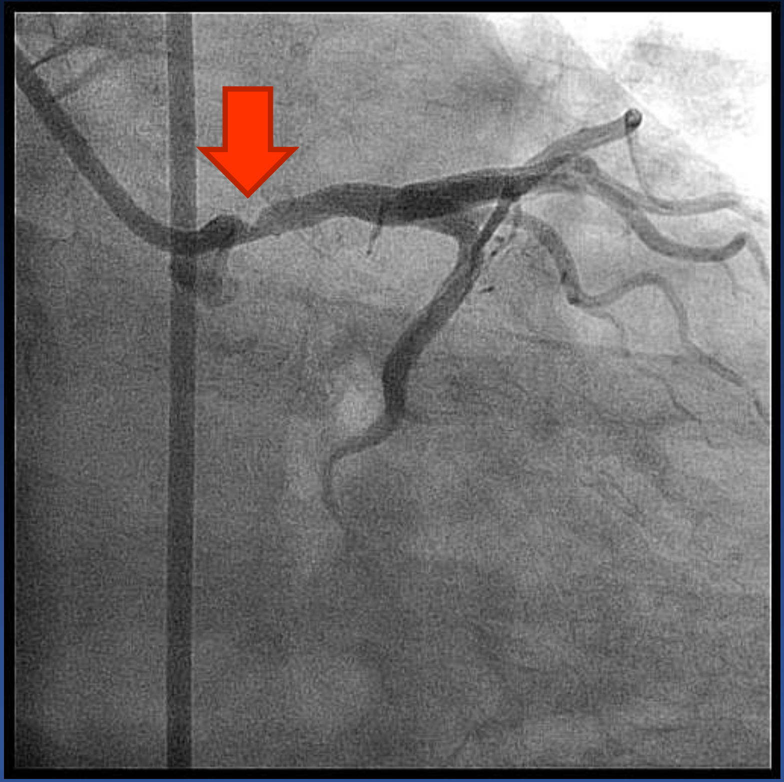
Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Bech	2.368	0.504	11.125	1.092	0.275
Jimenez-Navarro	2.027	0.087	47.429	0.439	0.660
Legutko	2.846	0.109	74.379	0.628	0.530
Lindstaedt	8.667	0.960	78.268	1.923	0.054
Courtis	15.639	0.892	274.209	1.882	0.060
Hamilos	2.494	0.807	7.704	1.588	0.112
	3.238	1.513	6.931	3.026	0.002

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

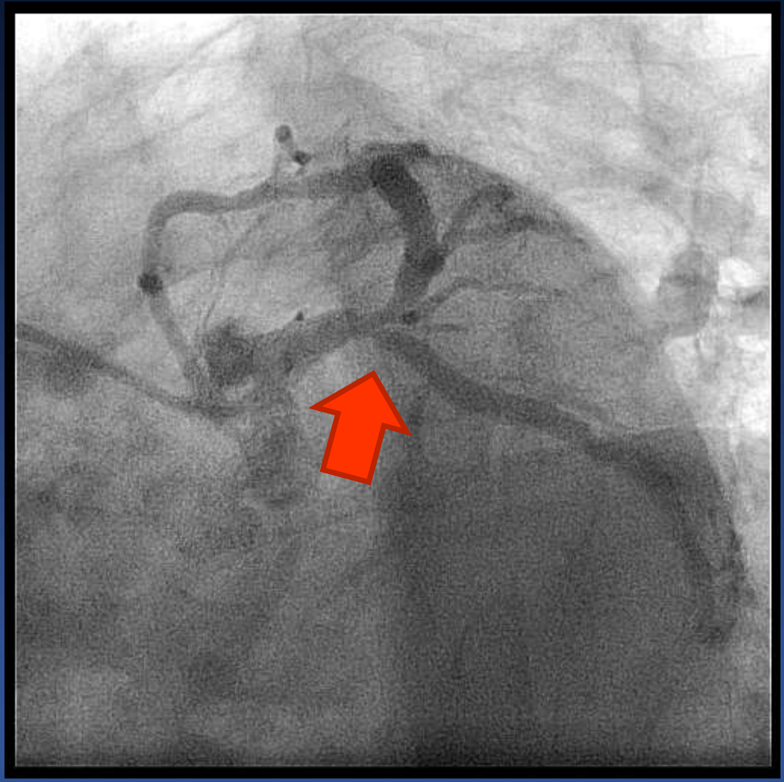
Catheterization and Cardiovascular Interventions 86:12–18 (2015)

How to Treat: PCI Strategy

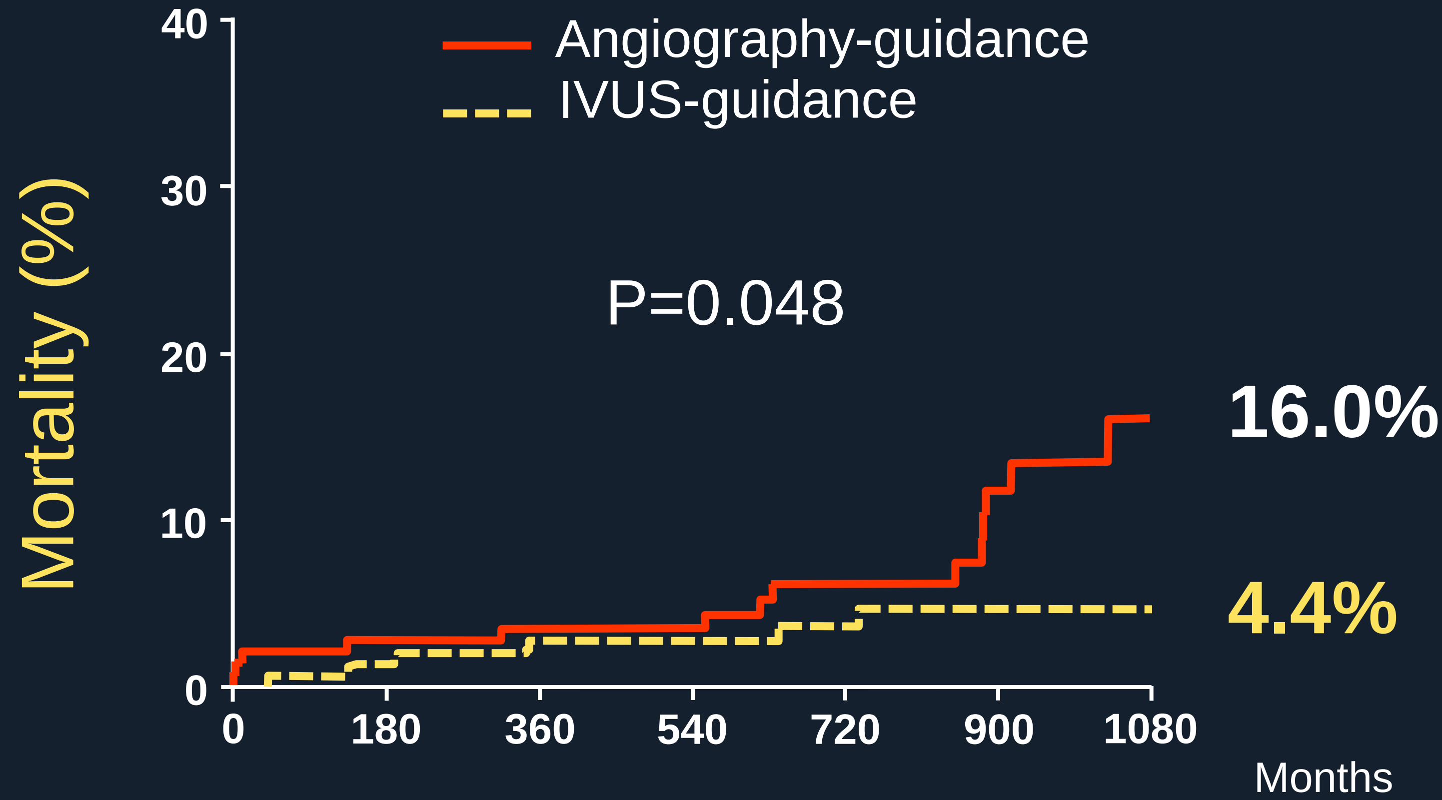
Ostial and Shaft Disease



Bifurcation Disease



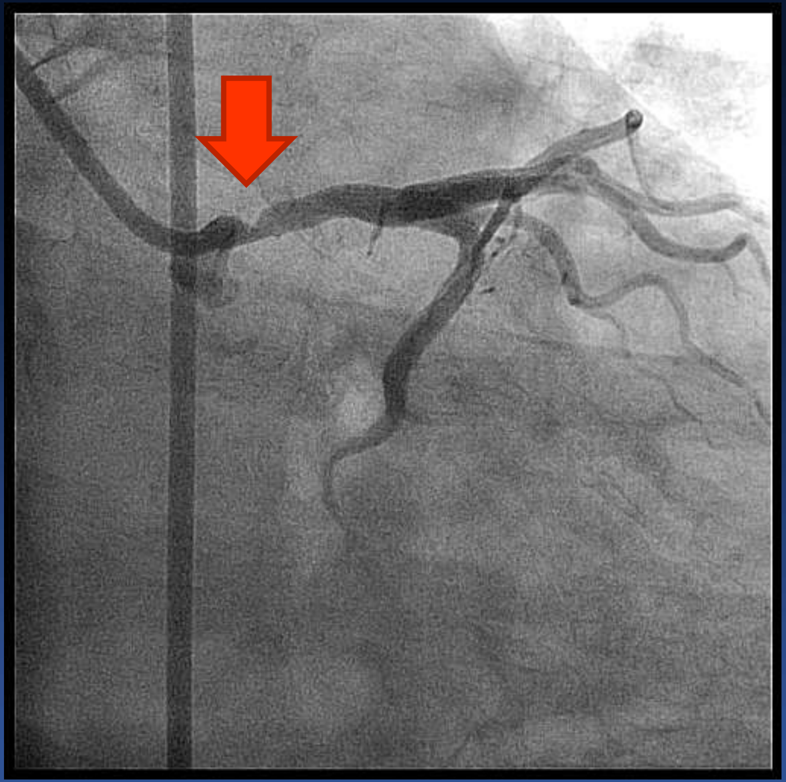
IVUS Guidance Saved Lives !



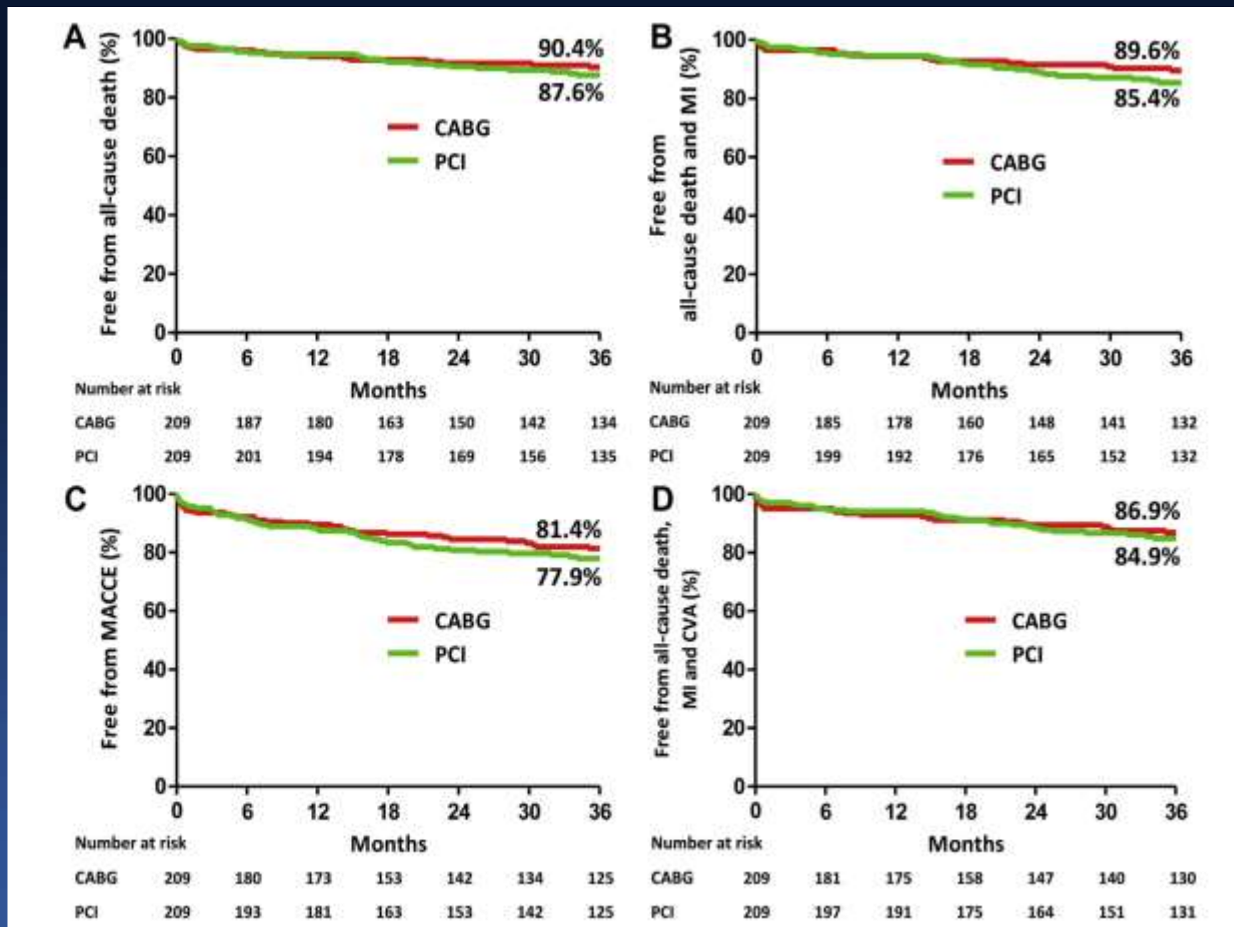
Patients after risk				
IVUS-guidance	145	140	98	37
Angiography-guidance	145	137	88	29

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

Left Main Ostial or Shaft Disease

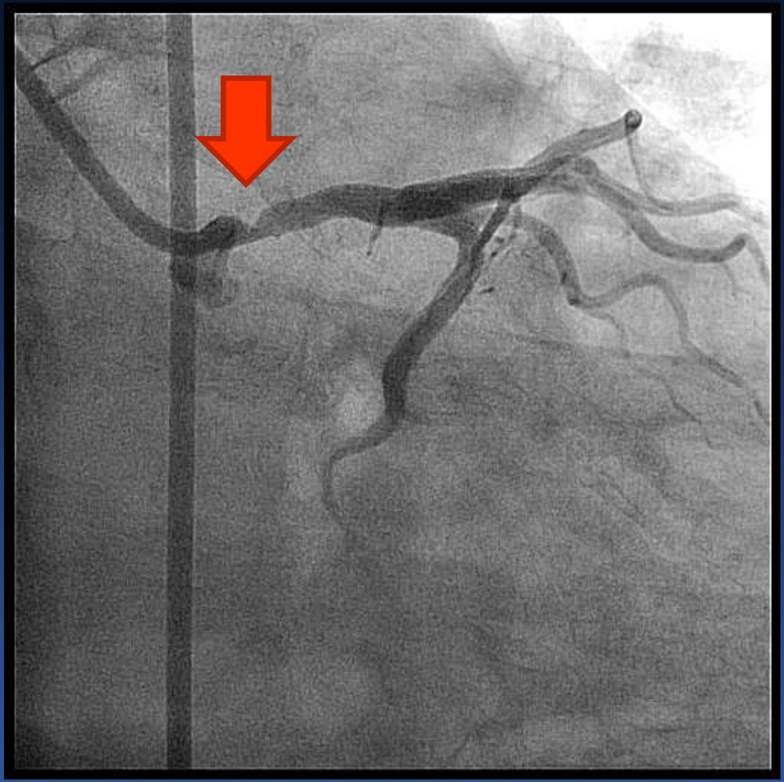


Left Main Ostial or Shaft Disease

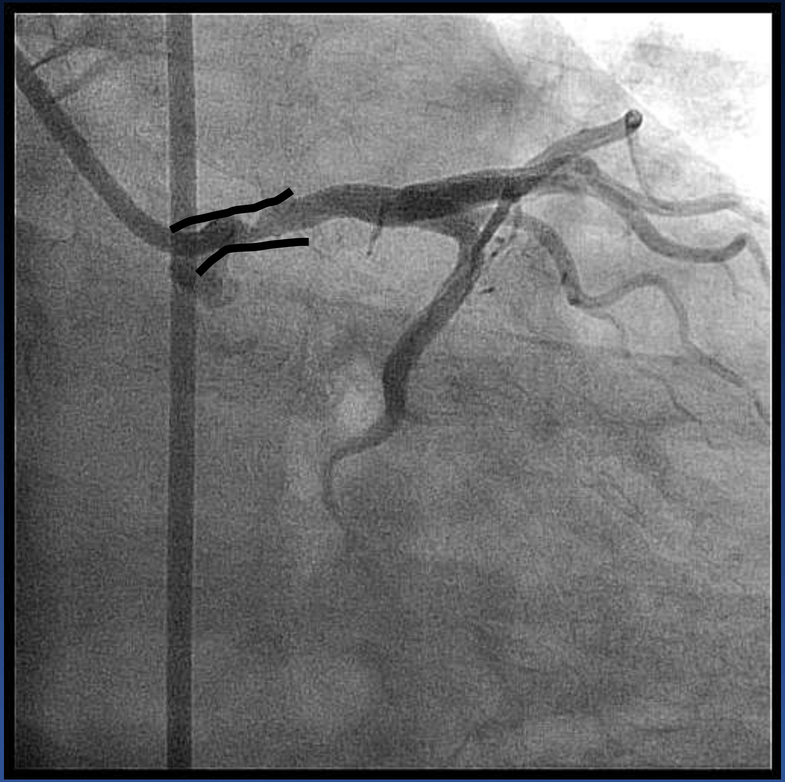


DELTA Registry J Am Coll Cardiol Intv 2014;7:354–61

Left Main Ostial or Shaft Disease

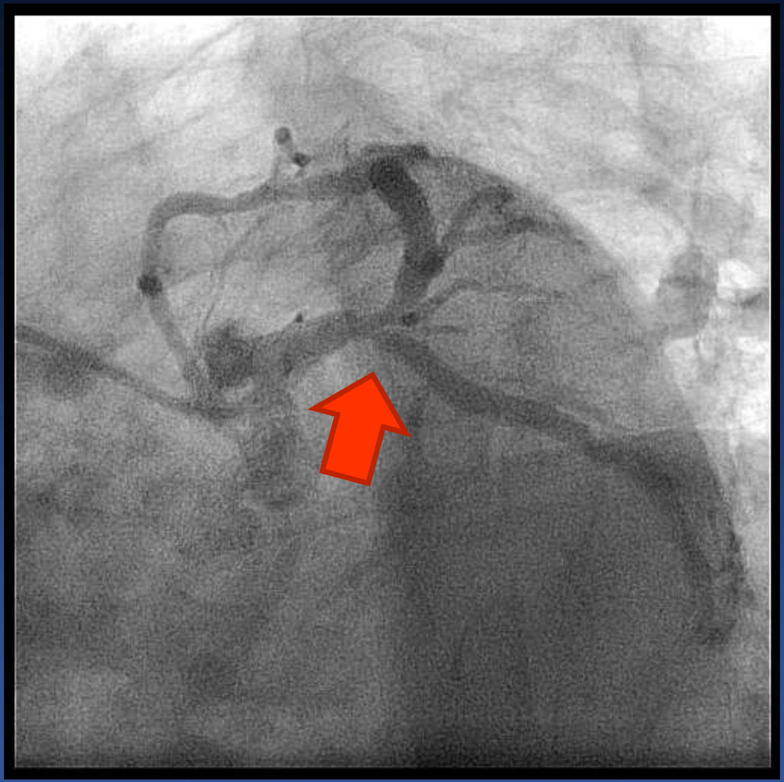


Just Stent it



How to Treat: PCI Strategy

Bifurcation Disease



One Stent Better Than Two Stent For LM Bifurcation

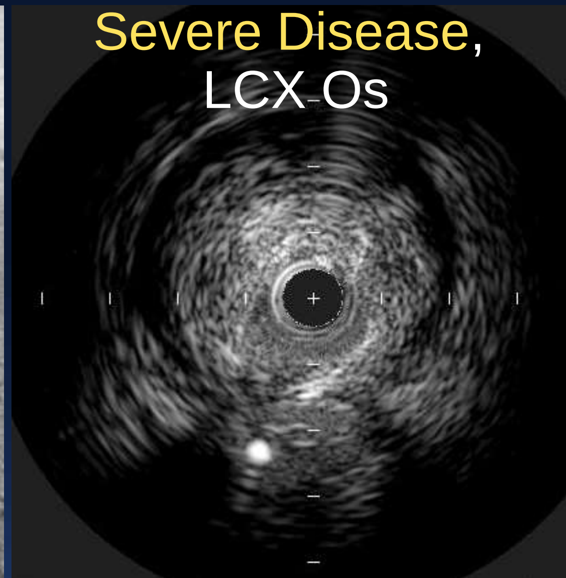
	Patients N		FU	Hazard Ratio			
	1 Stent	2 Stent	(M)	MACE	Death	MI	TVR
Palmerini[1]	456	317	24	0.48 P=0.001	-	-	-
Toyofuku[2]	261	119	36	-	0.61 P=0.09	-	0.32 P<0.01
Kim[3]	234	158	36	0.89 P<0.001	0.77 P=0.62	0.38 P<0.01	0.16 P=0.005
Song[4]	509	344	36	0.42 P<0.001	0.30 P=0.02	0.41 P=0.04	0.47 P<0.01

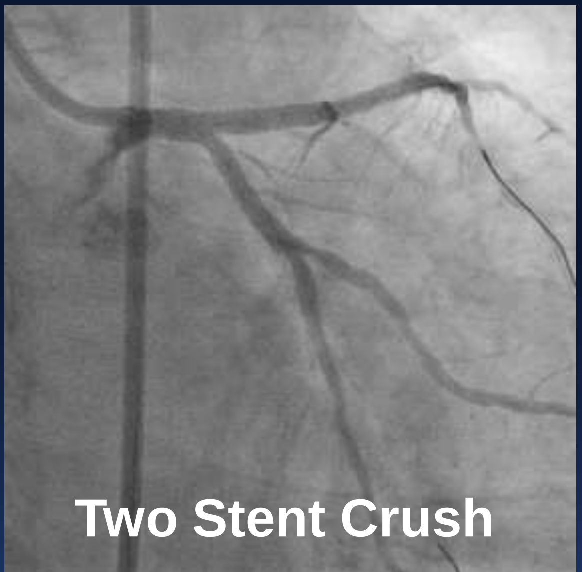
[1]Circ Cardiovasc Interv. 2008;1:185-92
[2]JACC Cardiovasc Interv. 2014;7:255-63
[3]Catheter Cardiovasc Interv. 2011;77:775-82
[4]Circulation. 2009;120:1866-74

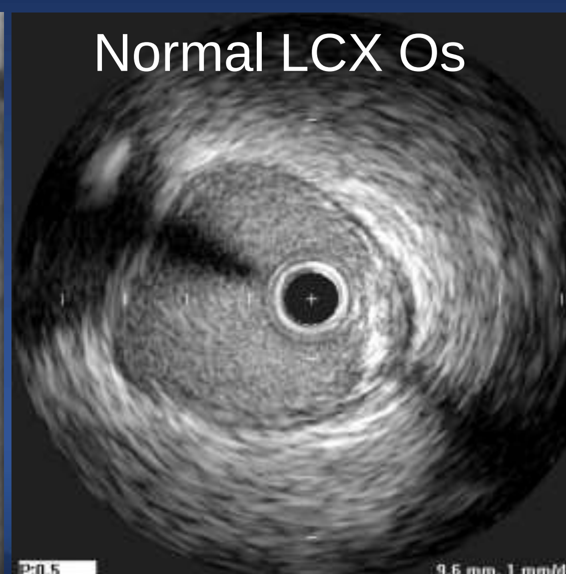
LM Bifurcation

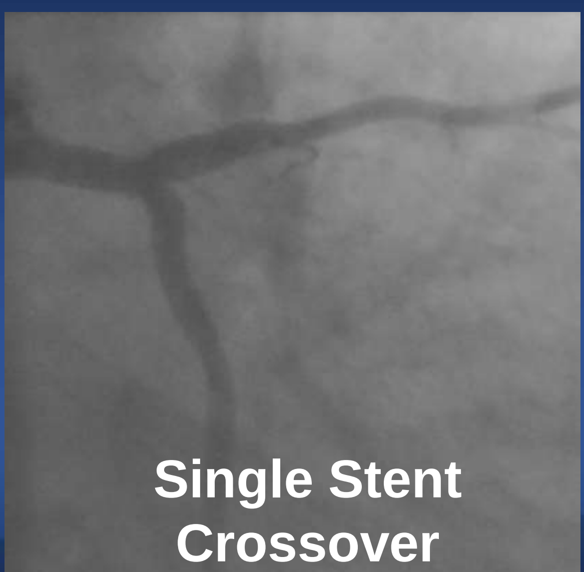
Stent Cross Over	***Normal Ostial LCX (Medina 1.1.0., 1.0.0)*** Normal or Diminutive LCX Small LCX with < 2.5 mm in diameter Focal disease in distal LCX
Two Stent	***Diseased LCX (Medina 1.1.1., 1.0.1)*** Large LCX with ≥ 2.5 mm in diameter Diseased left dominant coronary system Concomitant diffuse disease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

Direct LCX pullback IVUS
LAD pullback overestimates LCX ostial MLA

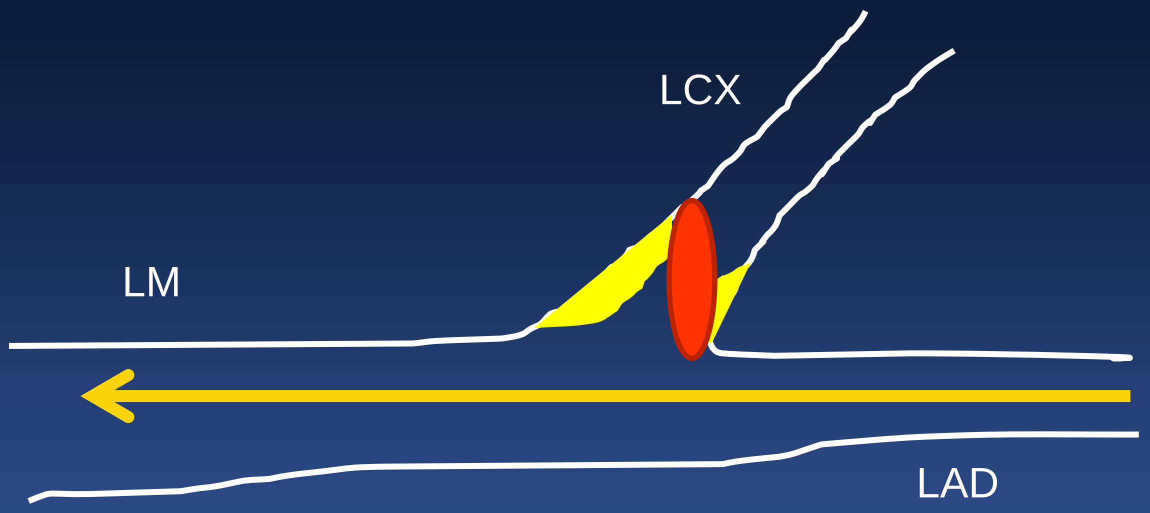




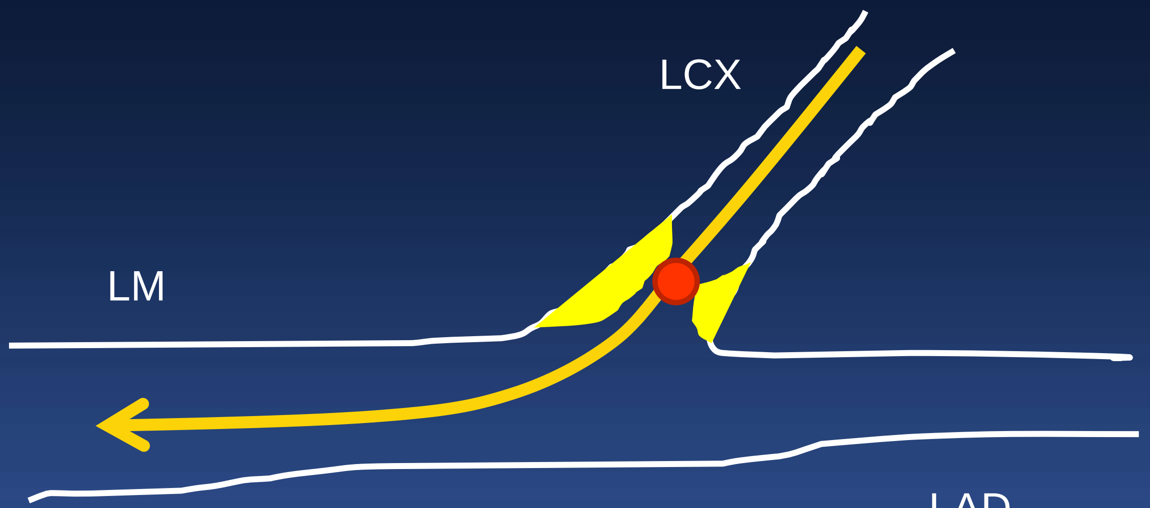




Direct LCX pullback IVUS
LAD pullback overestimates LCX ostial MLA



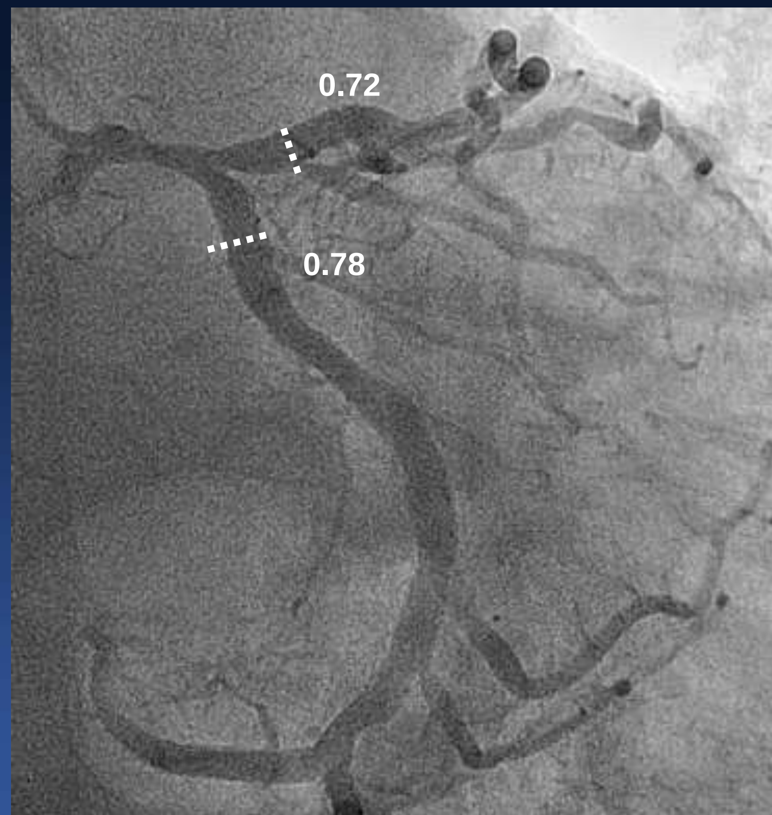
Direct LCX pullback IVUS
LAD pullback overestimates LCX ostial MLA



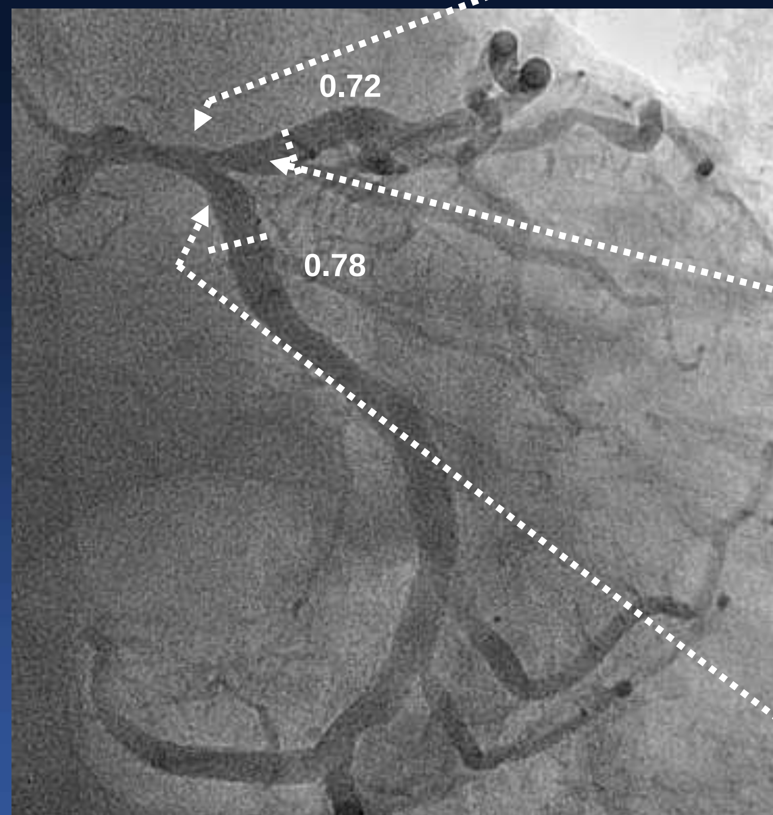
LM Bifurcation Lesion (Medina 1,0,0) with **Minimal LCX Disease**

55/M, Stable angina,

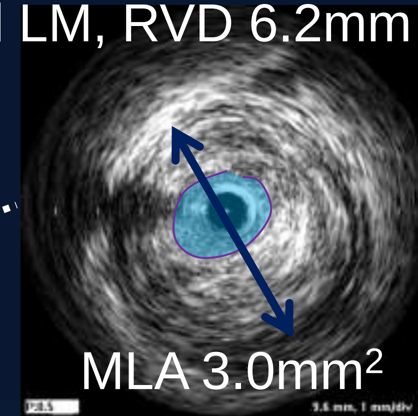
FFR in Both LAD and LCX,

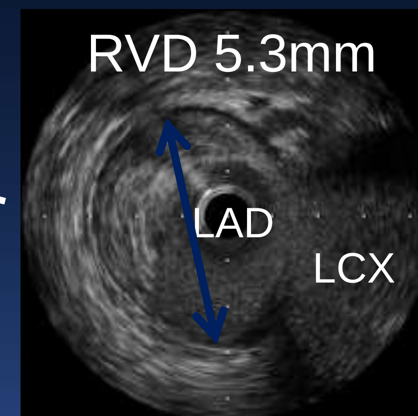


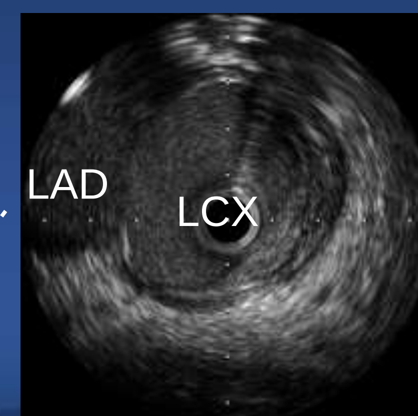
IVUS in Both LAD and LCX,



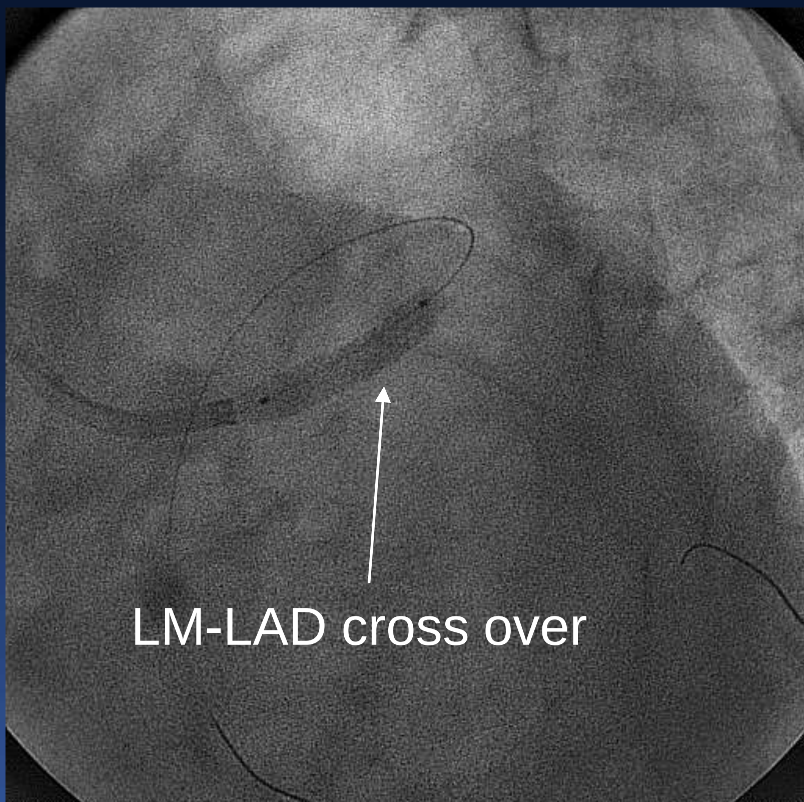
Minimal disease at LCX ostium



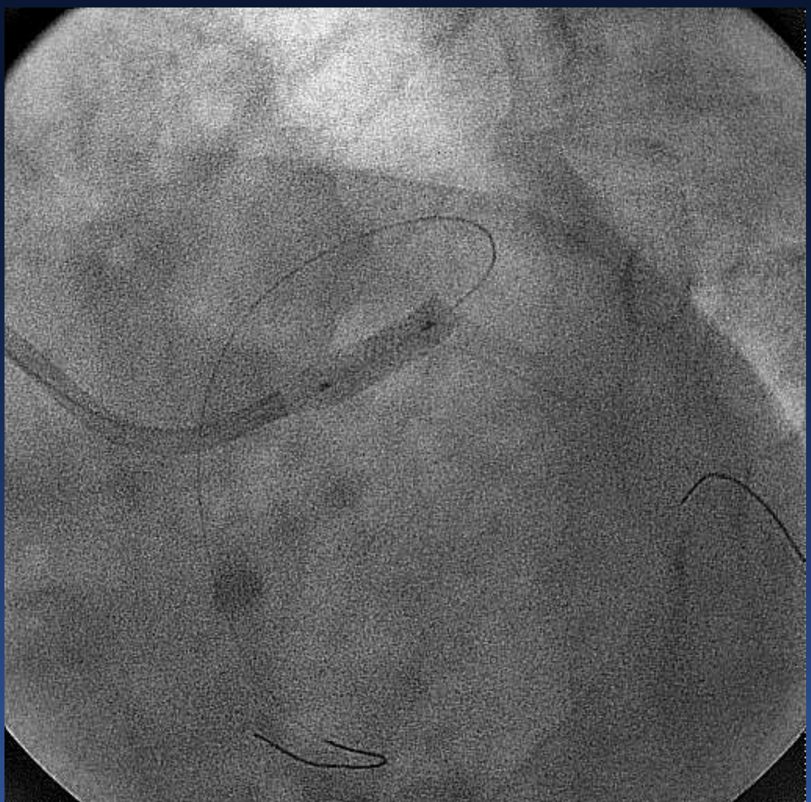




Single Stent Cross-Over
with minimal-disease at LCX OS

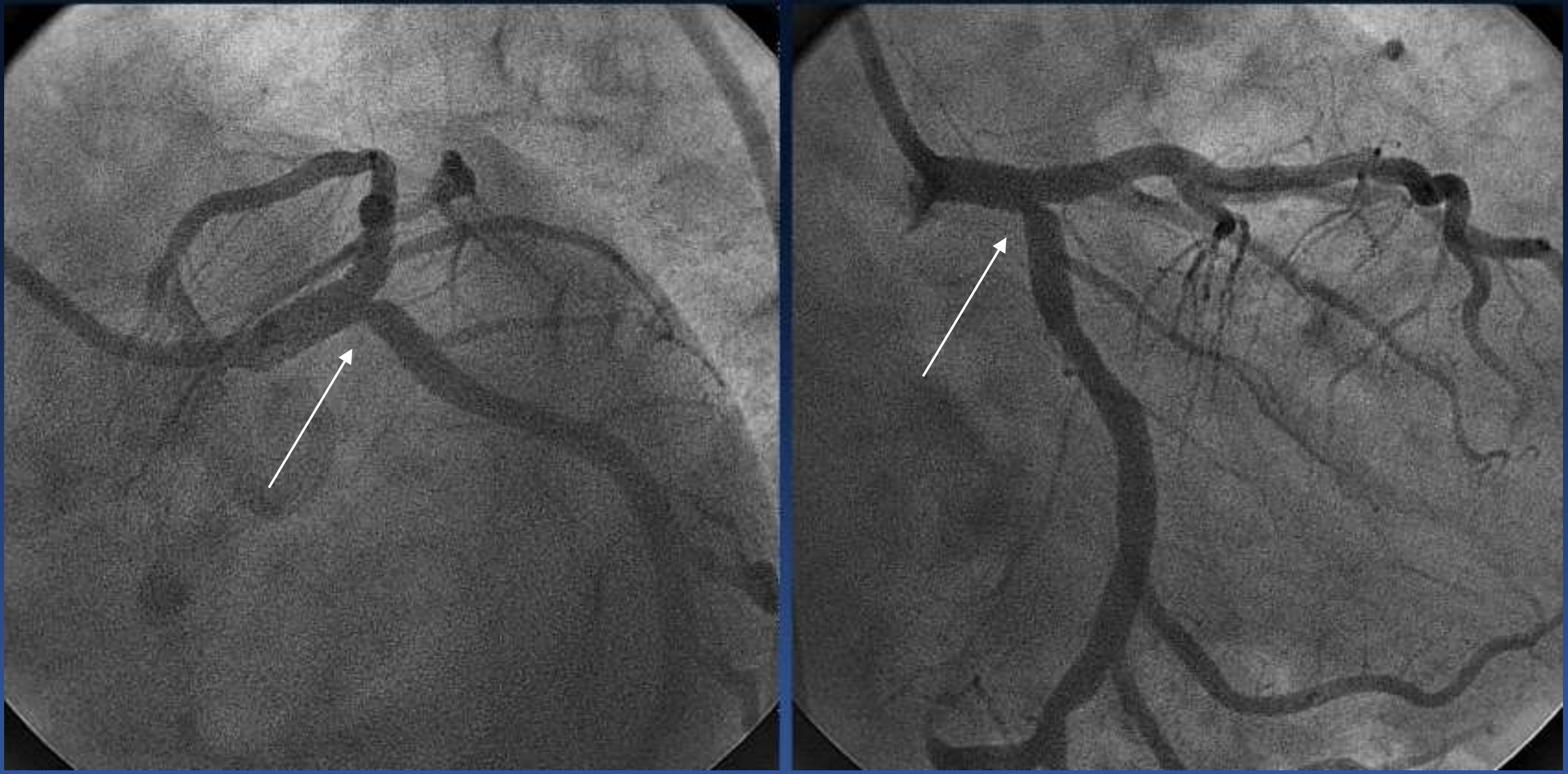


Promus Element
4.0x20



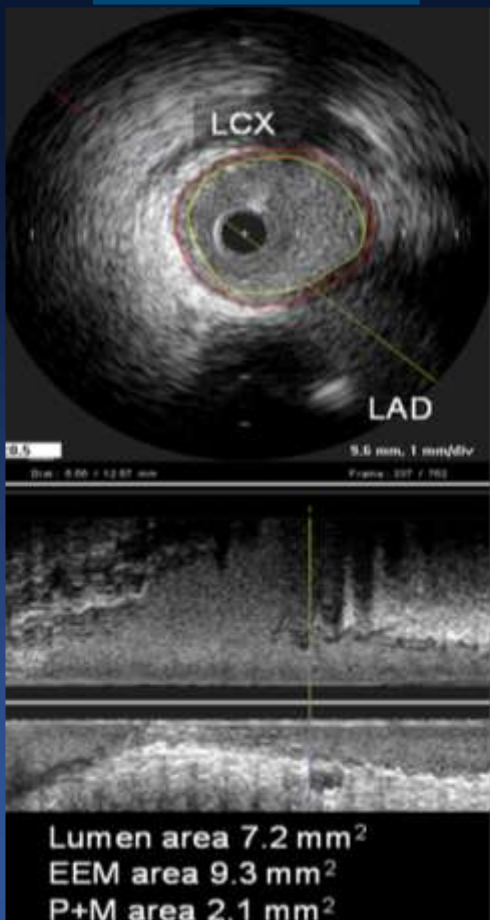
Additional high pressure
Inflation with 4.0 mm
non-compliant balloon

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

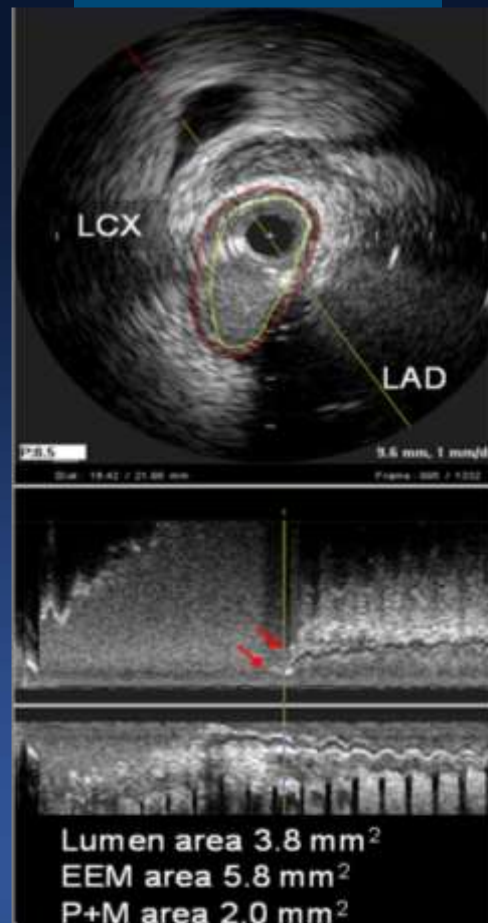


Geometric Change in LCX Ostium After Stent Cross Over

Pre-Stenting



Post-Stenting

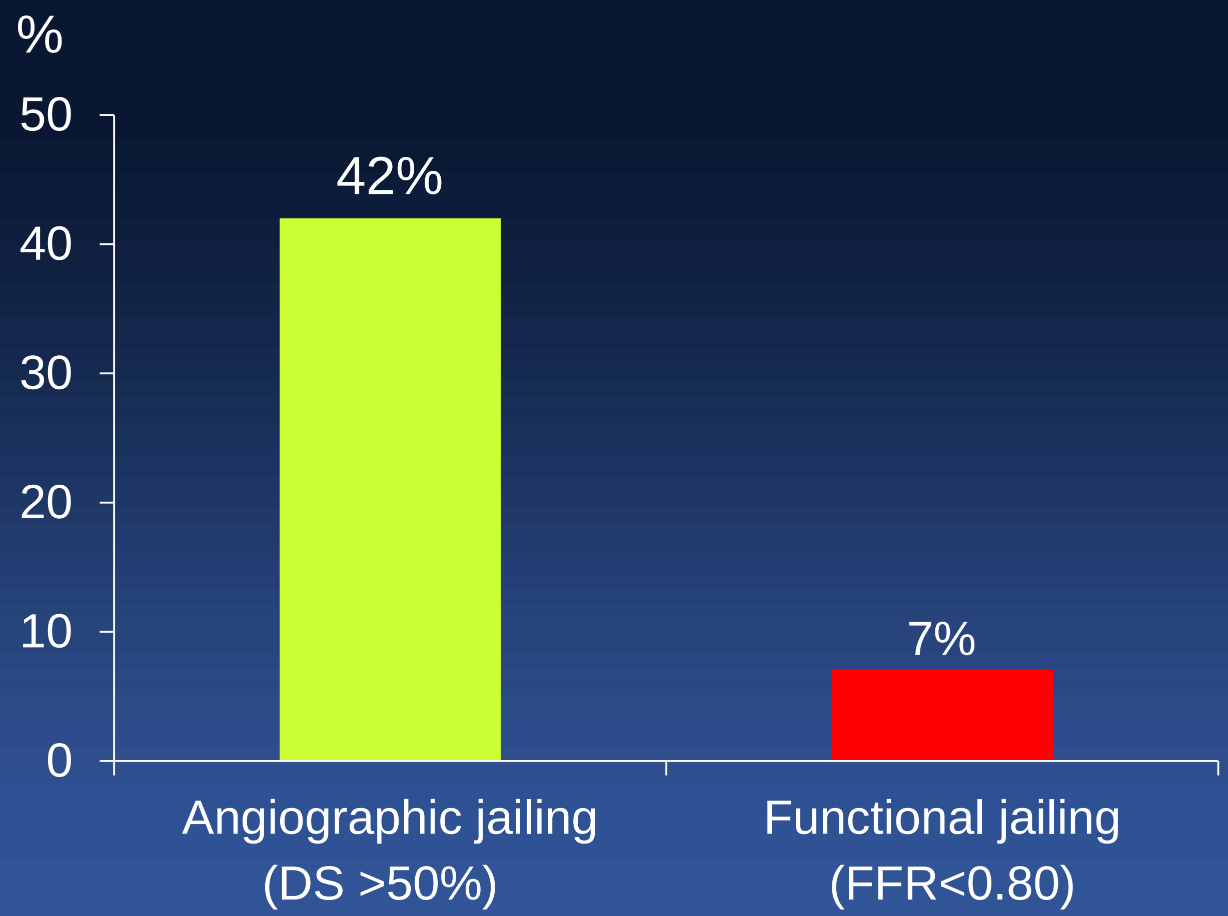


1) Carina shift
2) MLA ↓
3) Eccentricity ↑

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

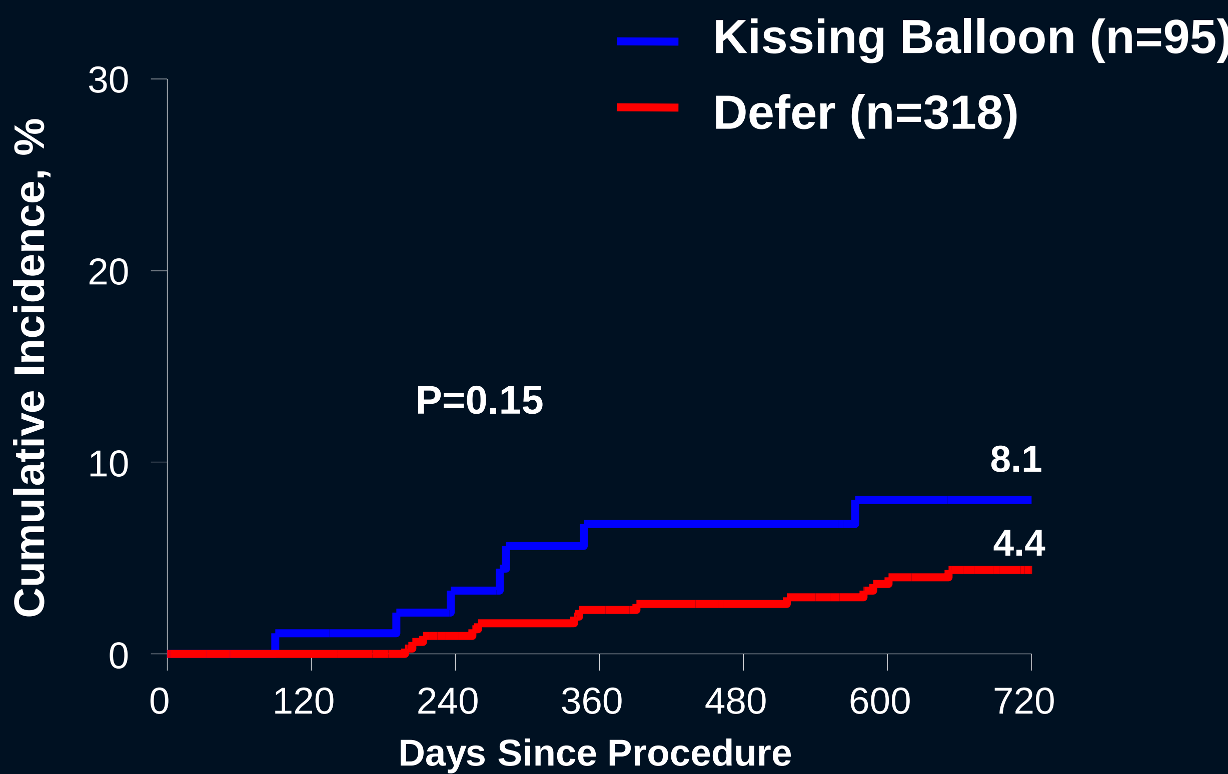
Functionally Significant LCX Jailing

After Stent Crossover (LCX ostial DS<50%)



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

Left Main-TLR *at 2 Years*



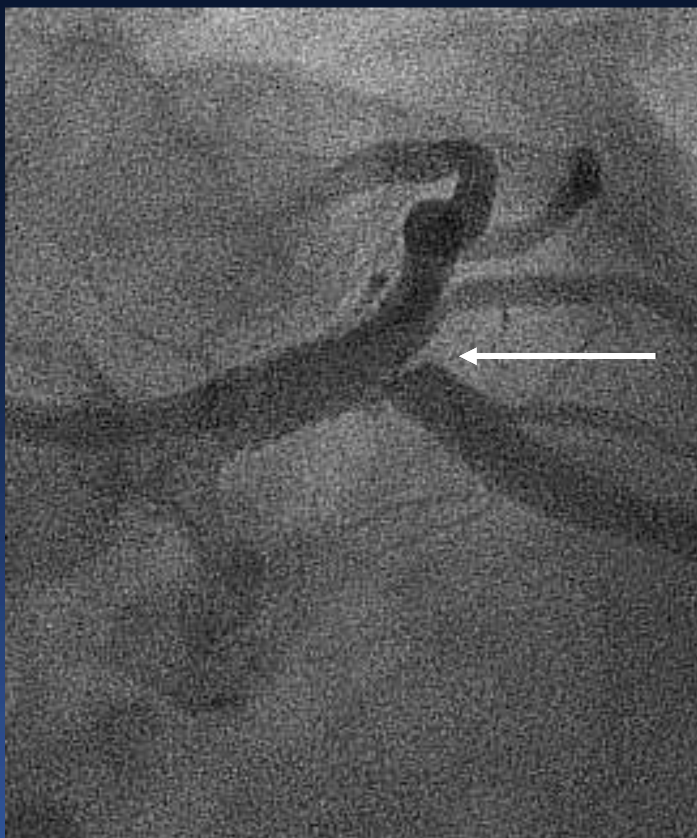
No. at Risk

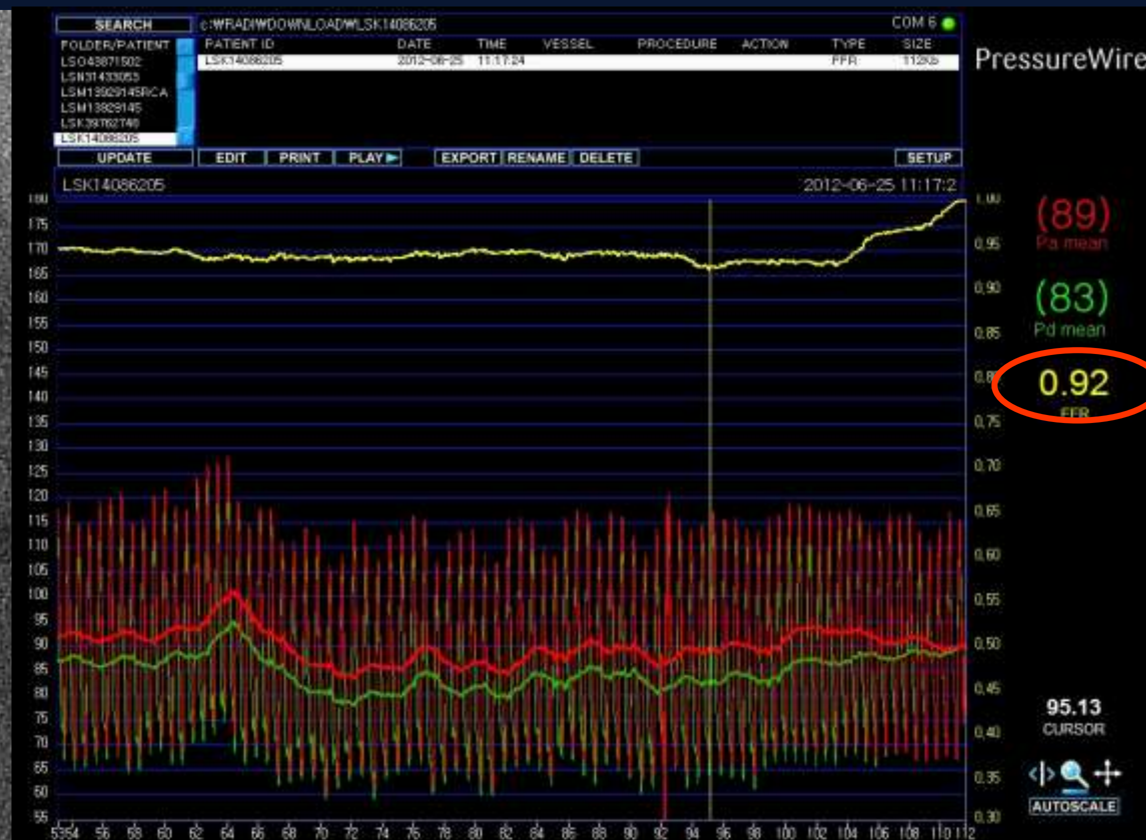
FKB	95	79	74
No-FKB	318	293	265

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

Do You Want to Treat It ?

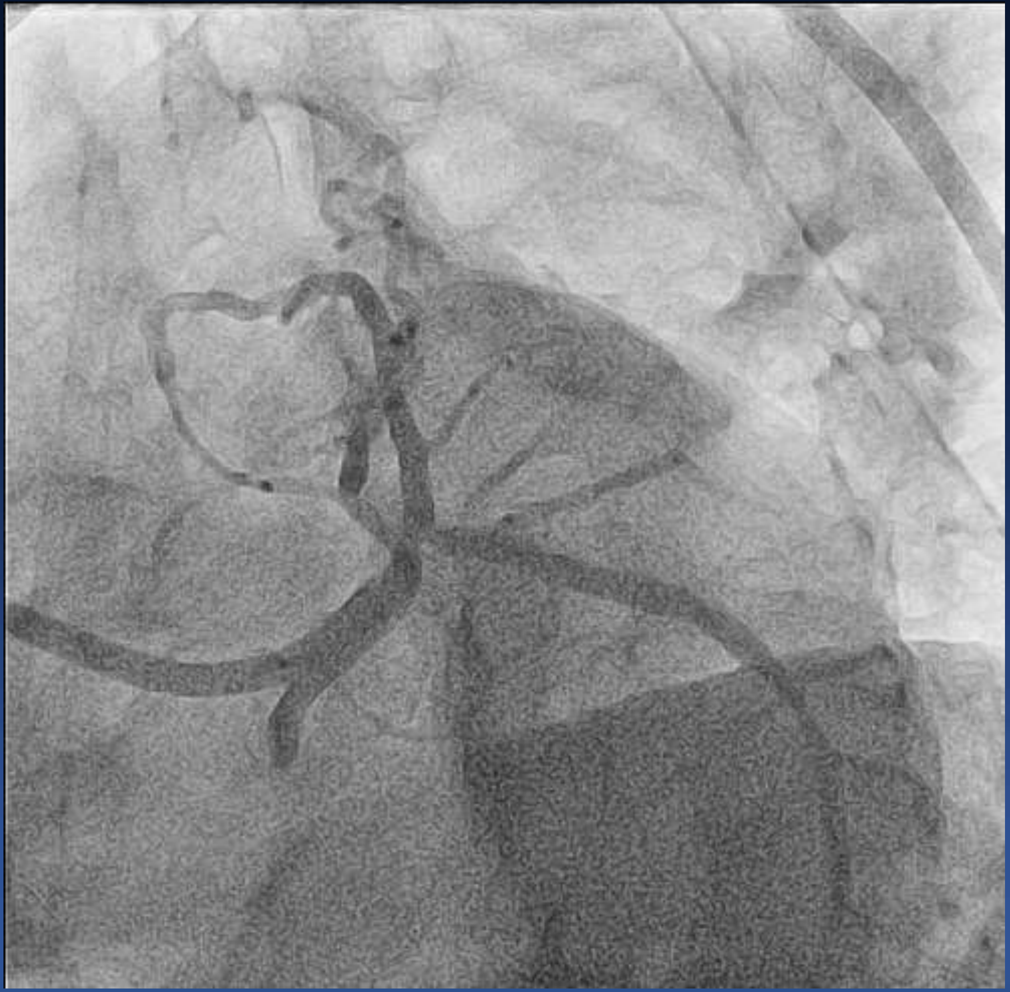
Consider FFR, First !





Just Defer !

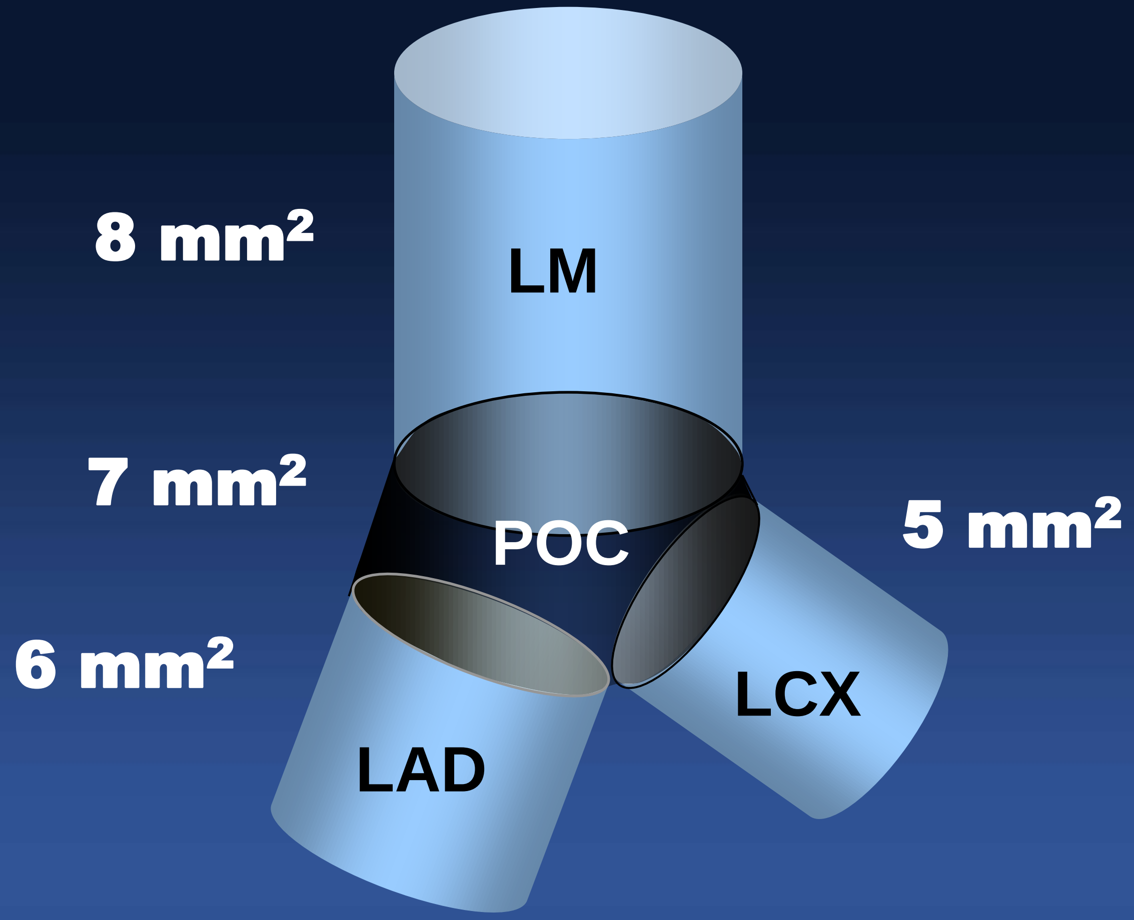
True Bifurcation



Is There Difference in Outcomes?

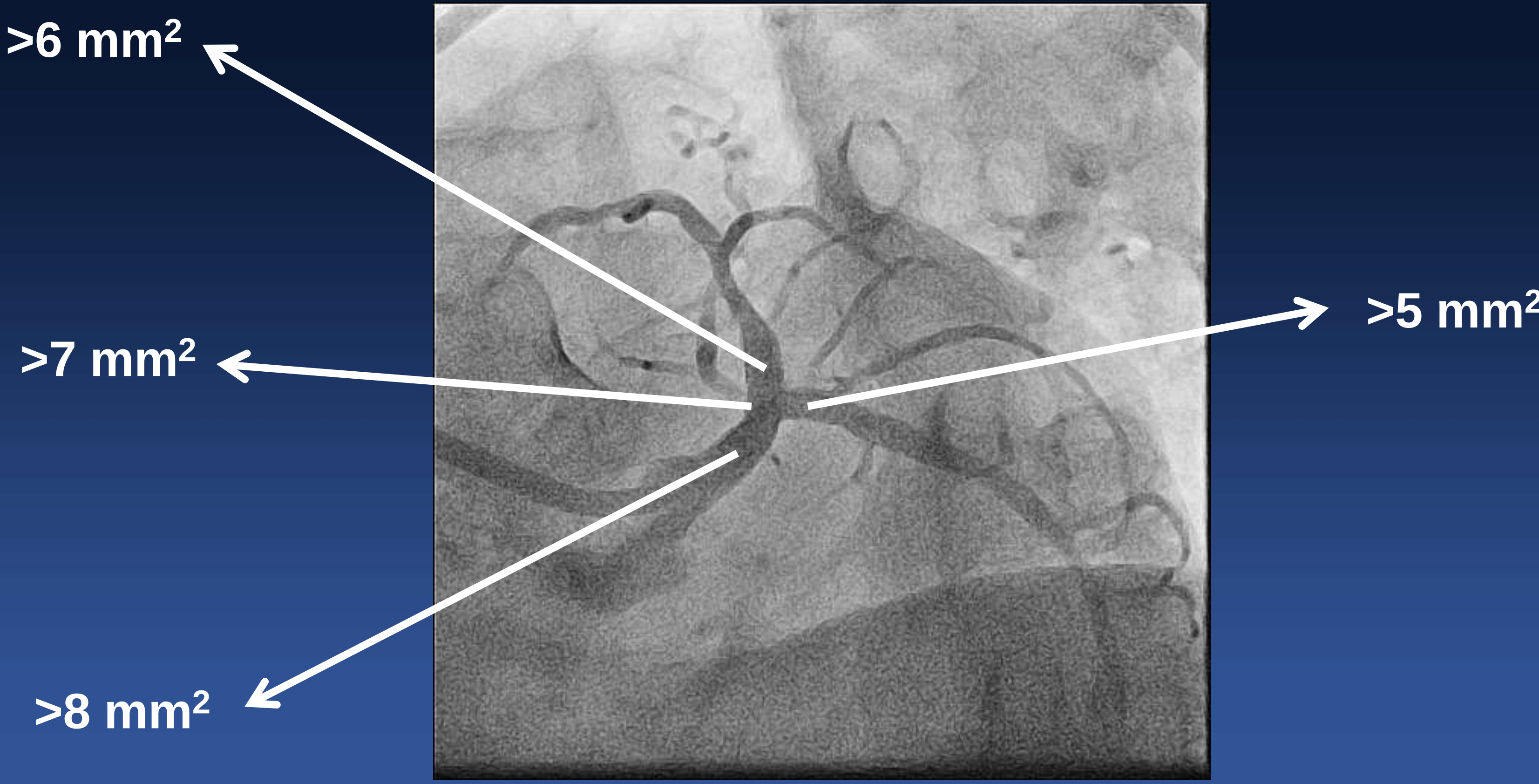
- Crush Technique
- Mini-Crush Technique
- T stent Technique
- Kissing Stent Technique
- Culotte Technique
- Double-Kiss Crush Technique

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

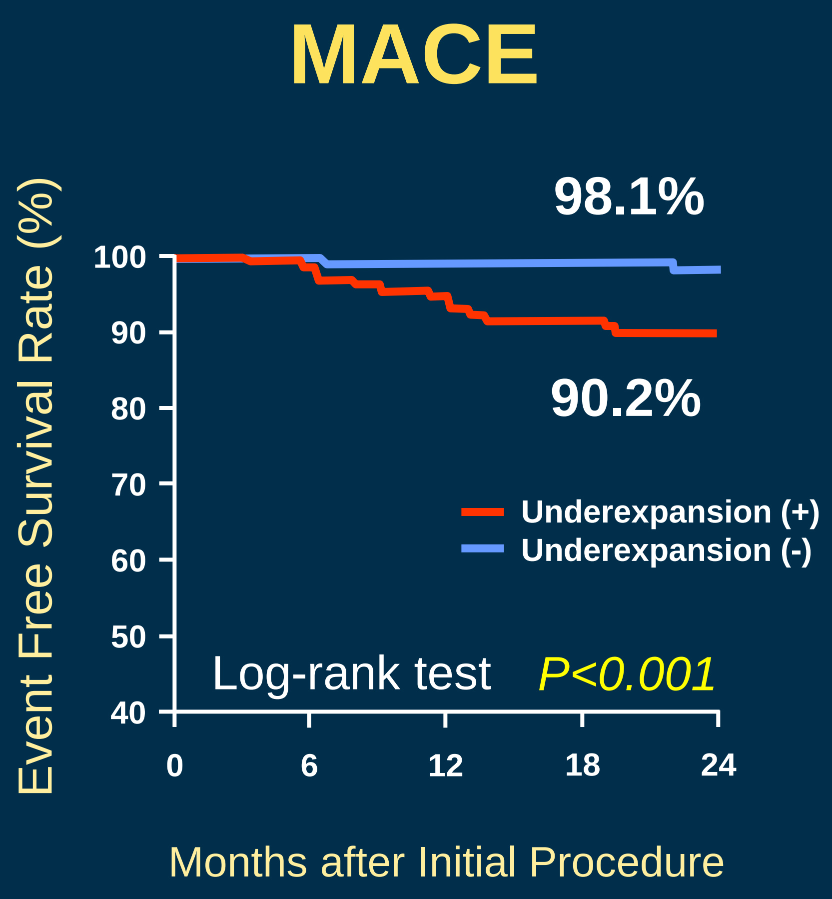


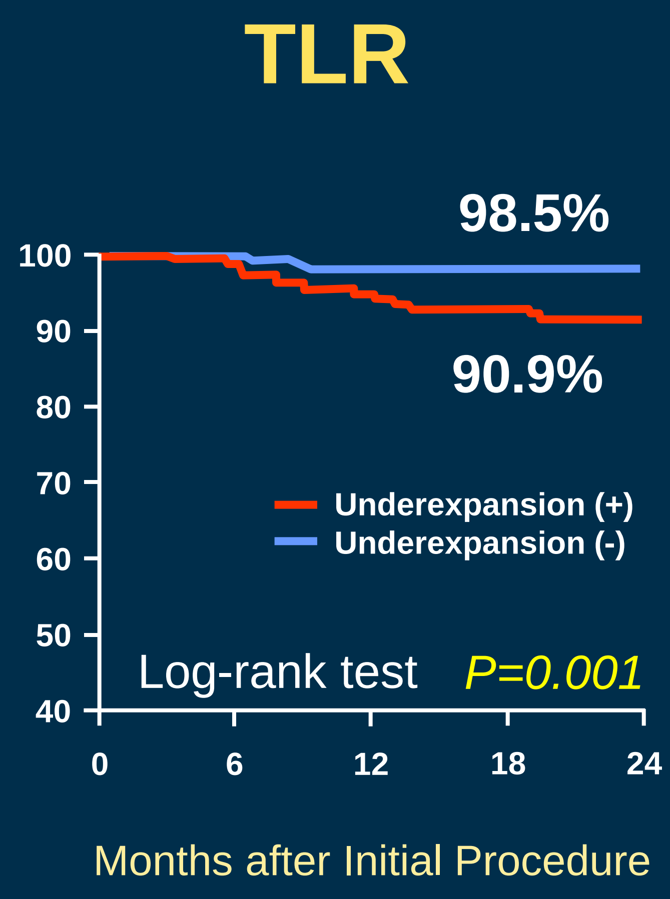
Kang et al. Circ Cardiovasc Interv 2011;4:1168-74

Post Stent IVUS Surveillance For Further High Pressure Ballooning



MACE-free and TLR-free Survival





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

Integrated Use of FFR and IVUS

Ostial or Shaft LM Stenosis

↓

FFR evaluation if necessary

↓

IVUS evaluation

↓

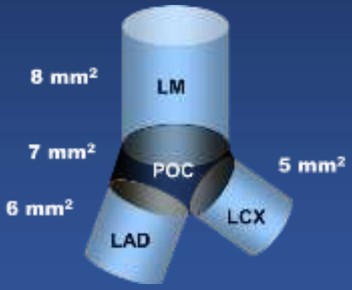
PCI

↓

IVUS Optimization

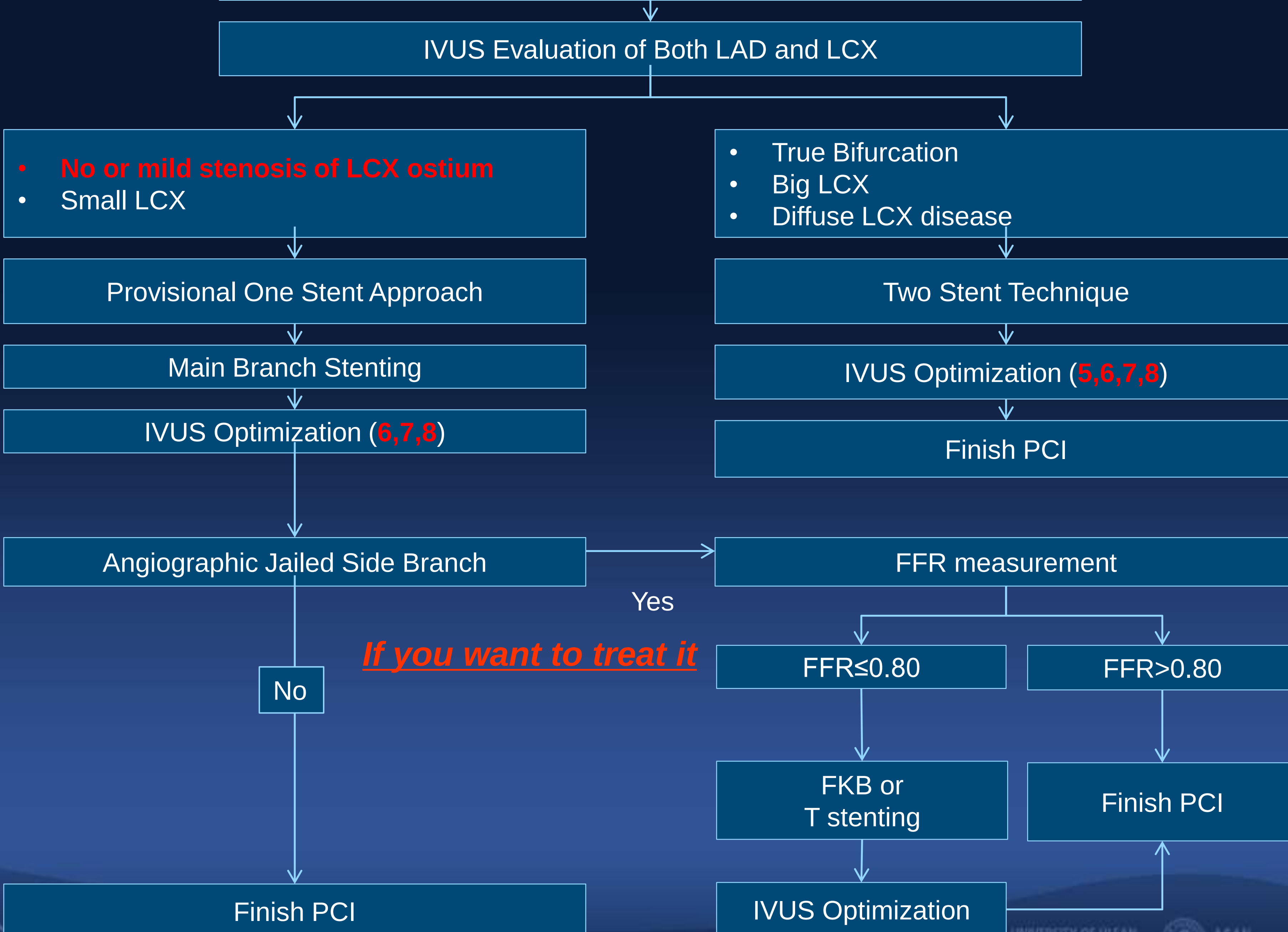
↓

Finish PCI



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

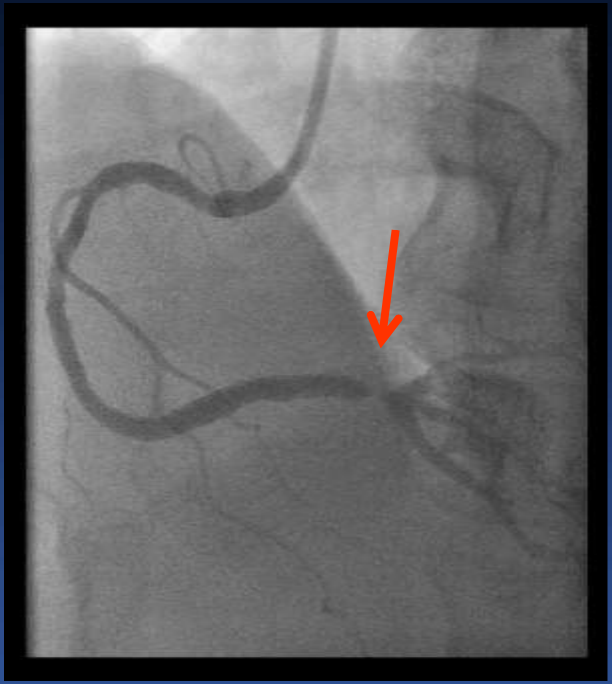
Distal LM Bifurcation Stenosis



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

Coronary Angiogram

Angiographically 3 VD

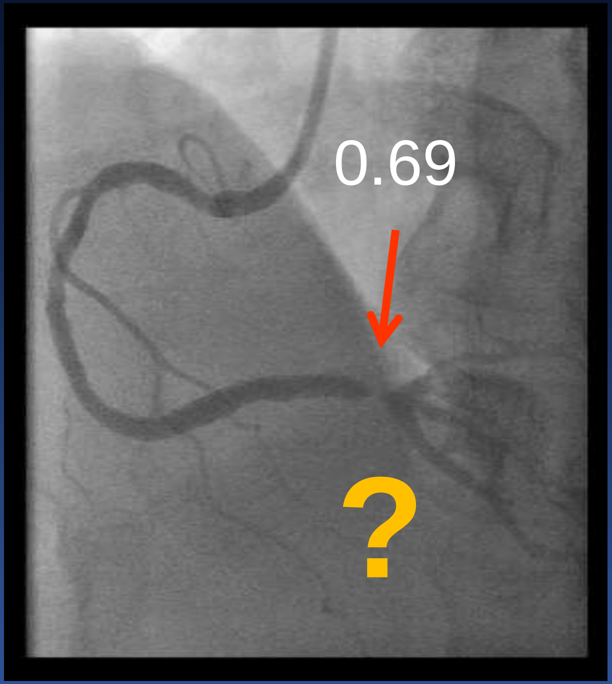


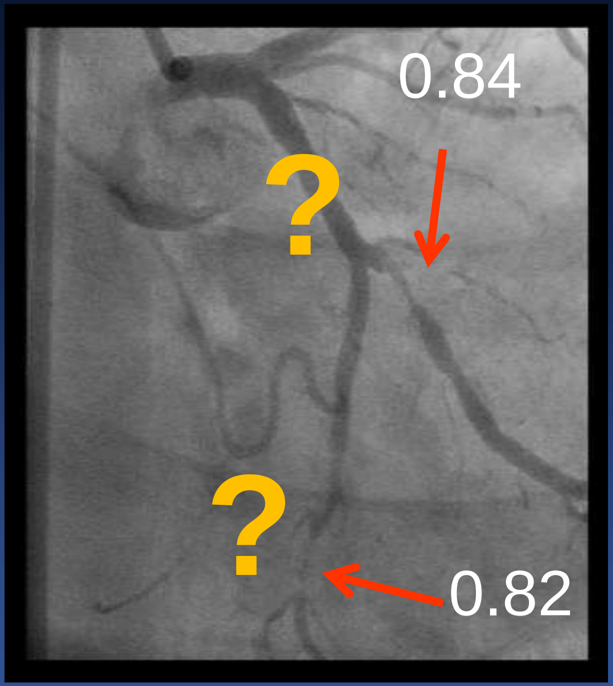
Thallium: large perfusion defect at LAD territory

Fractional Flow Reserve

Functionally 2 VD

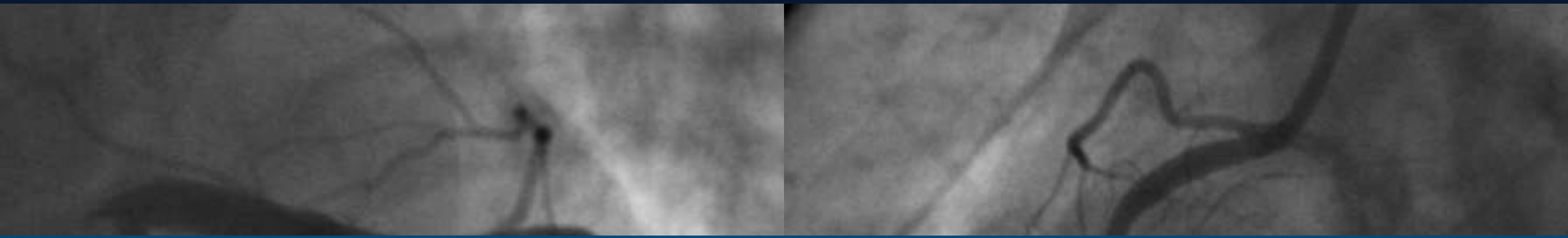
Not Done



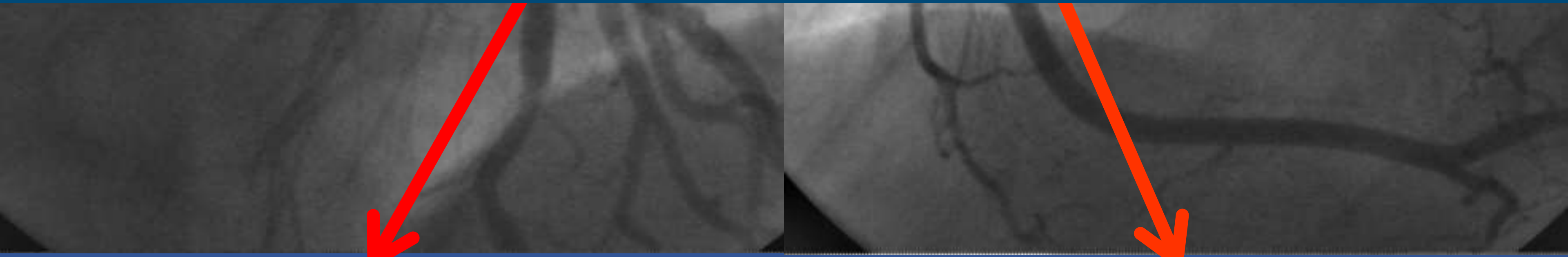


Thallium: large perfusion defect at LAD territory

Multivessel Disease



Angiographic 2 Vessel Disease
But, Functionally Normal Cornary



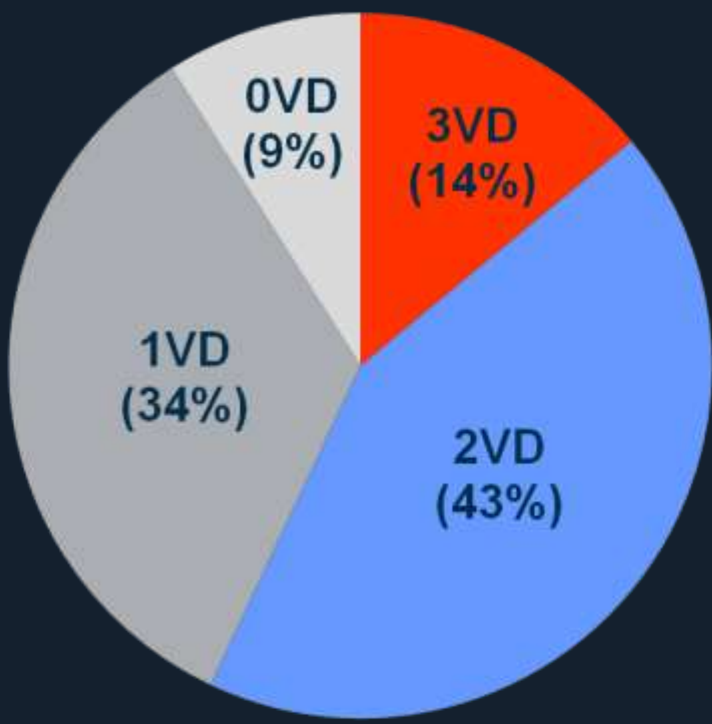
FFR : 0.84

FFR : 0.86

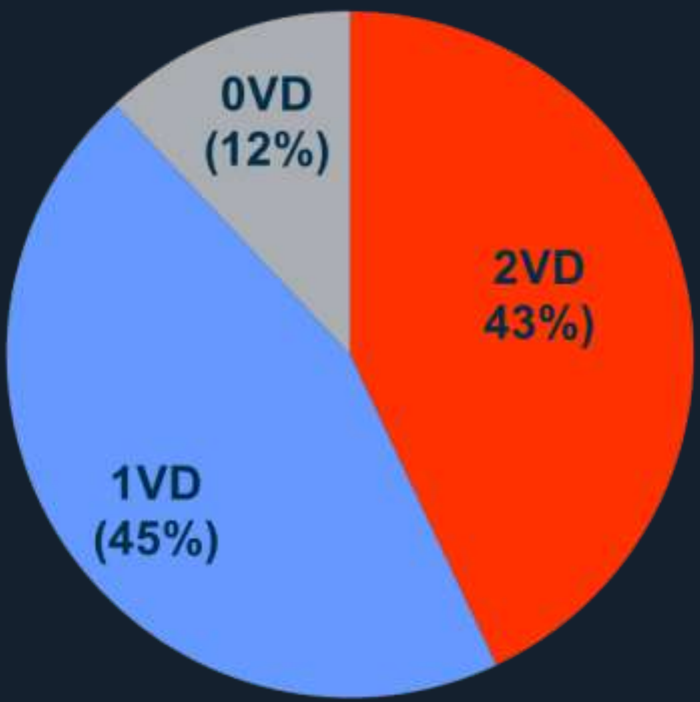
Visual-Functional Mismatch

From FAME Study

Functionally Diseased Coronary Arteries



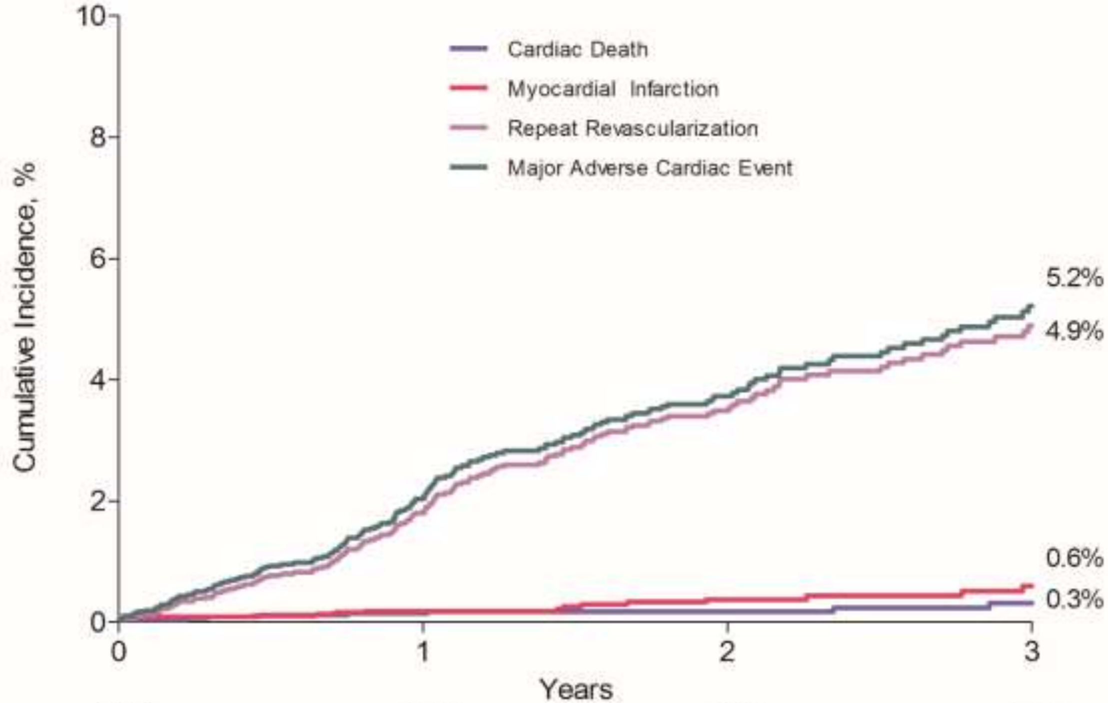
Angiographic 3VD



Angiographic 2VD

J Am Coll Cardiol 2010;55:2816–21

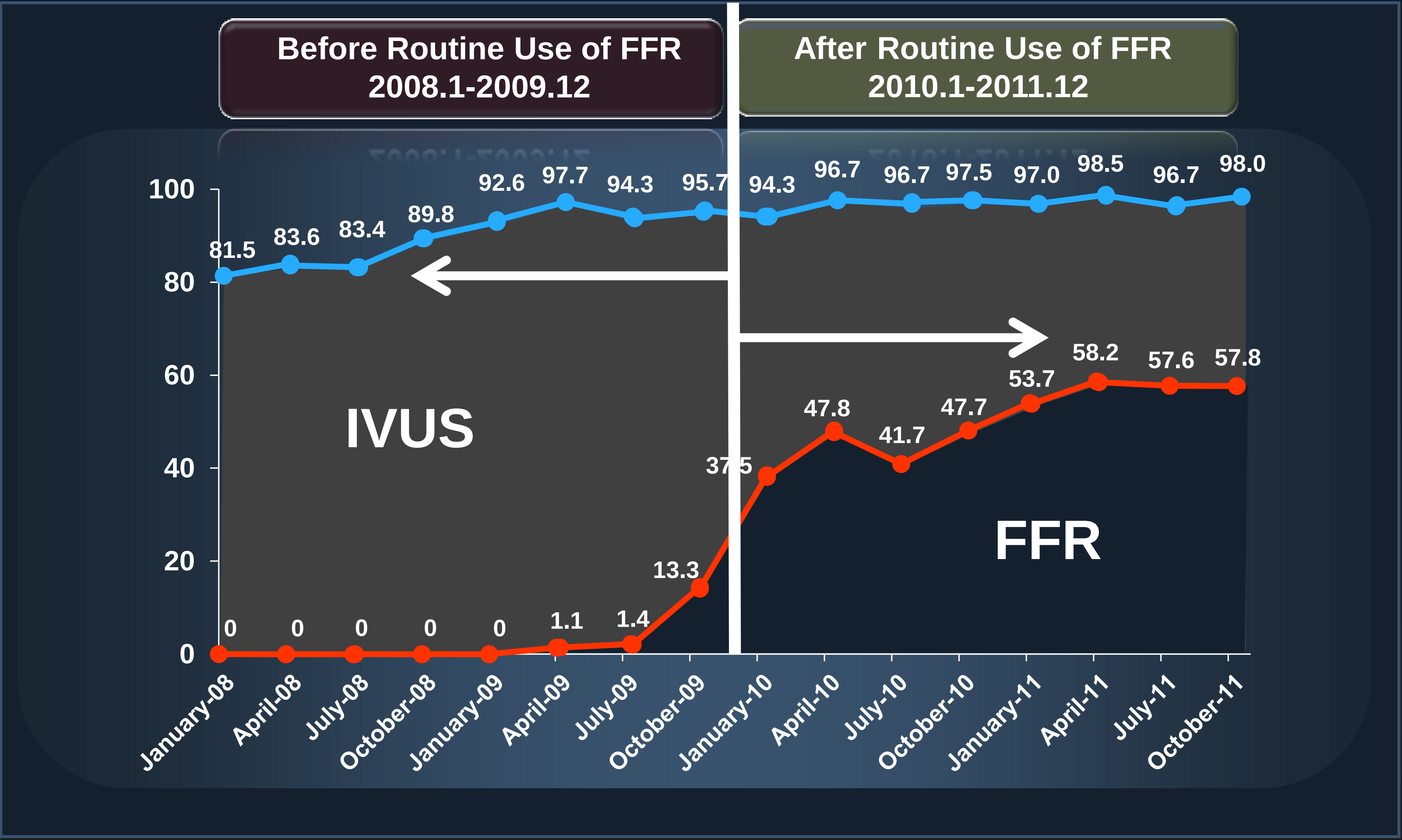
Deferred Lesion Outcome (1)



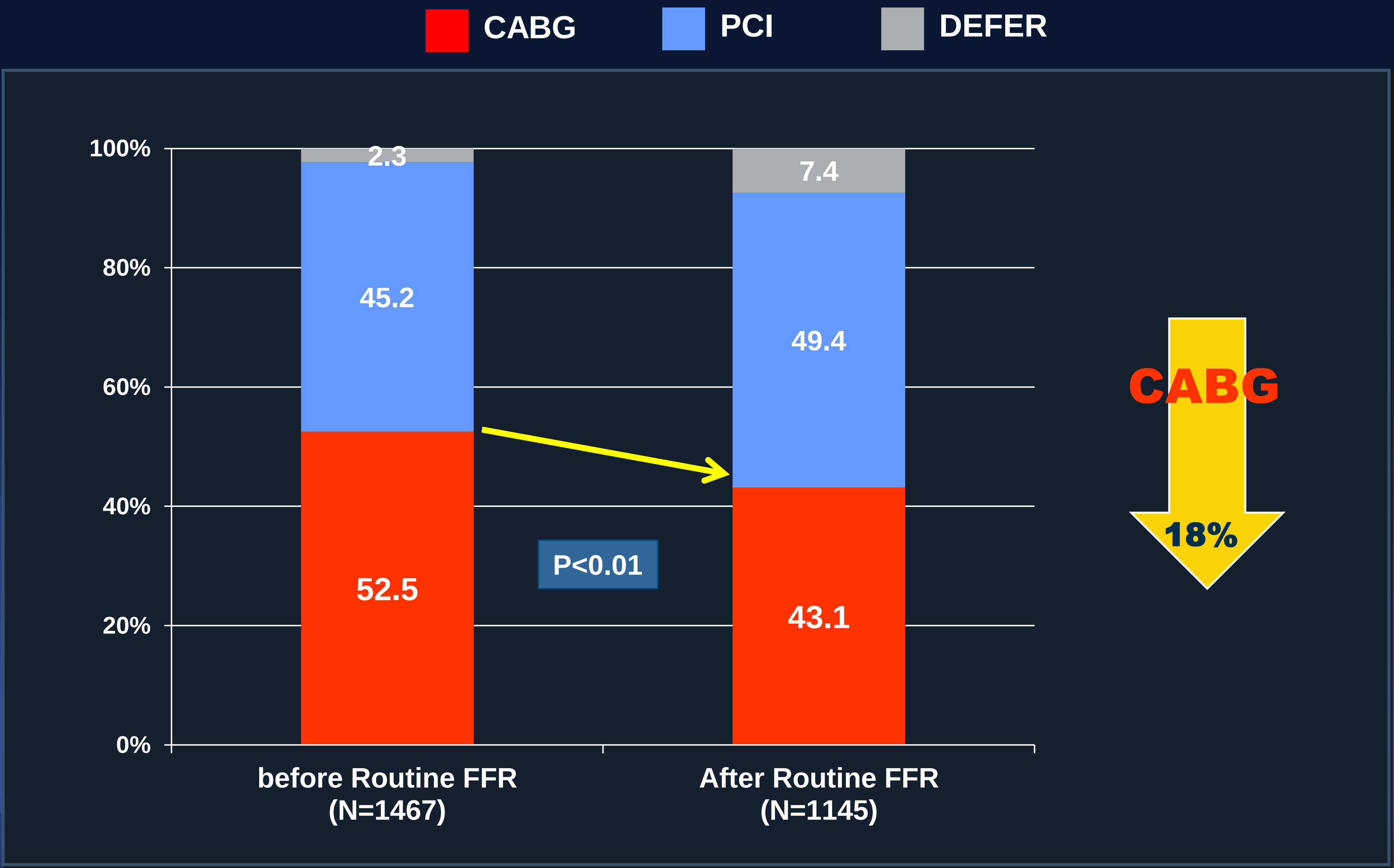
	0	1	2	3
Cardiac Death	4608	3393	2069	1036
Myocardial Infarction	4608	3445	2107	1059
Repeat Revascularization	4608	3337	1998	987
Major Adverse Cardiac Event	4608	3333	1996	987

Ahn JM, Park SJ et al. Circulation. 2017 Mar 29

PCI vs. CABG in LM + 3VD



Treatment Strategy



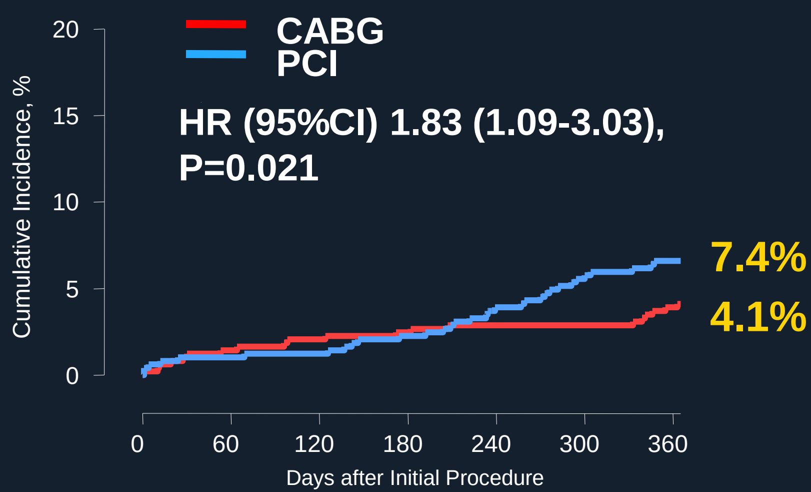
Ahn JM, Park SJ et al. Am J Cardiol 2015;116:1163-1171

Propensity Score Matched Population

Primary End Point

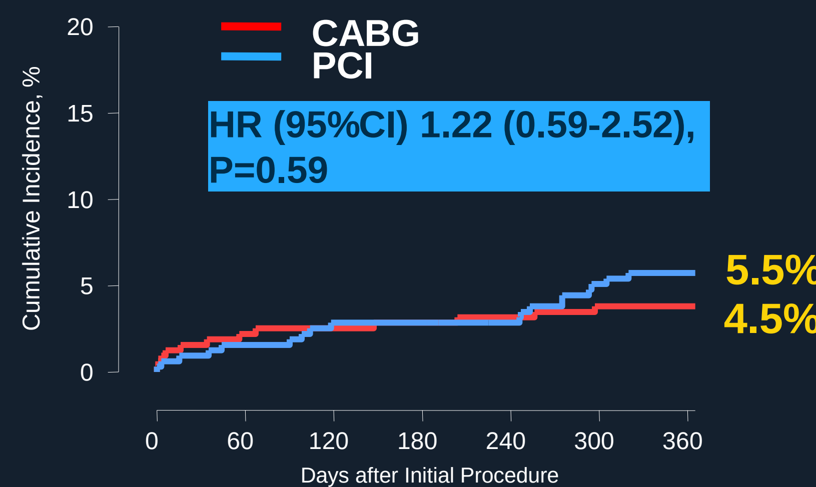
(Death, MI, Stroke or Repeat Revascularization)

Before Routine FFR (2008-2009)



CABG	488	480	472	466
PCI	488	483	465	450

After Routine FFR (2010-2011)



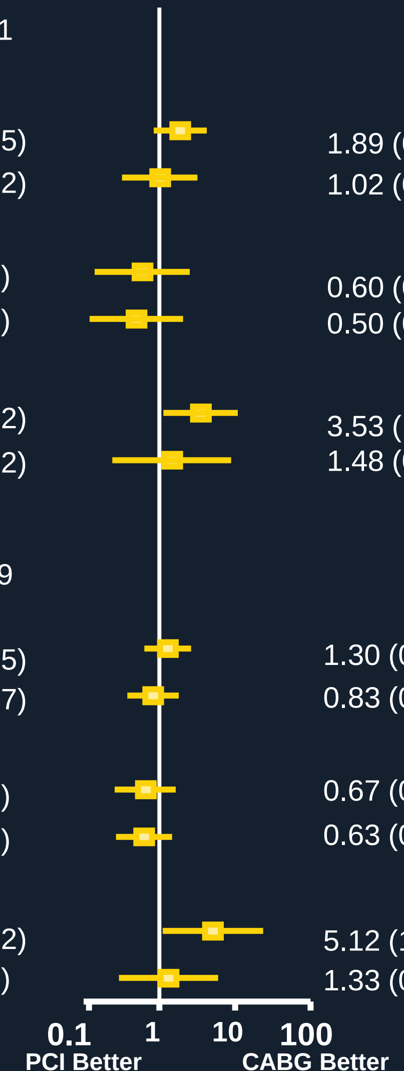
CABG	314	308	303	301
PCI	314	306	300	292

Ahn JM, Park SJ et al. Am J Cardiol 2015;116:1163-1171

Propensity Score Matched Population

Subgroup Analysis

	1 Year Event Rate (%) CABG	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
Triple 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



Ahn JM, Park SJ et al. Am J Cardiol 2015;116:1163-1171

Conclusion

1. The routine incorporation of FFR in the decision making for revascularization has extended role of PCI, while it reduced role of CABG as the primary revascularization strategies.

2. PCI with second generation DES, guided by FFR showed similar clinical outcomes with concurrent CABG at 1 year in patients with left main or three vessel disease.