Integrated Use of FFR and IVUS in Real Practice

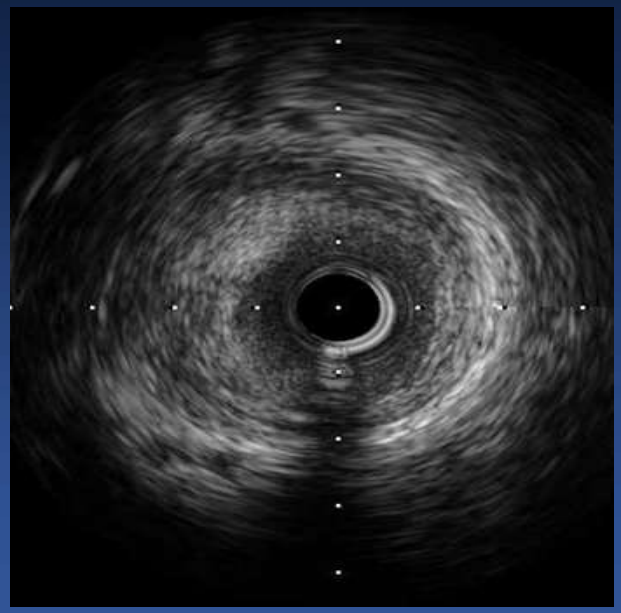
Jung-Min Ahn
Heart Institute, Asan Medical Center
University of Ulsan College of Medicine

IVUS and FFR are Complementary

The FFR value and IVUS measured parameters should not be considered an equivalent comparison as these are ***Complementary*** and not competitive.

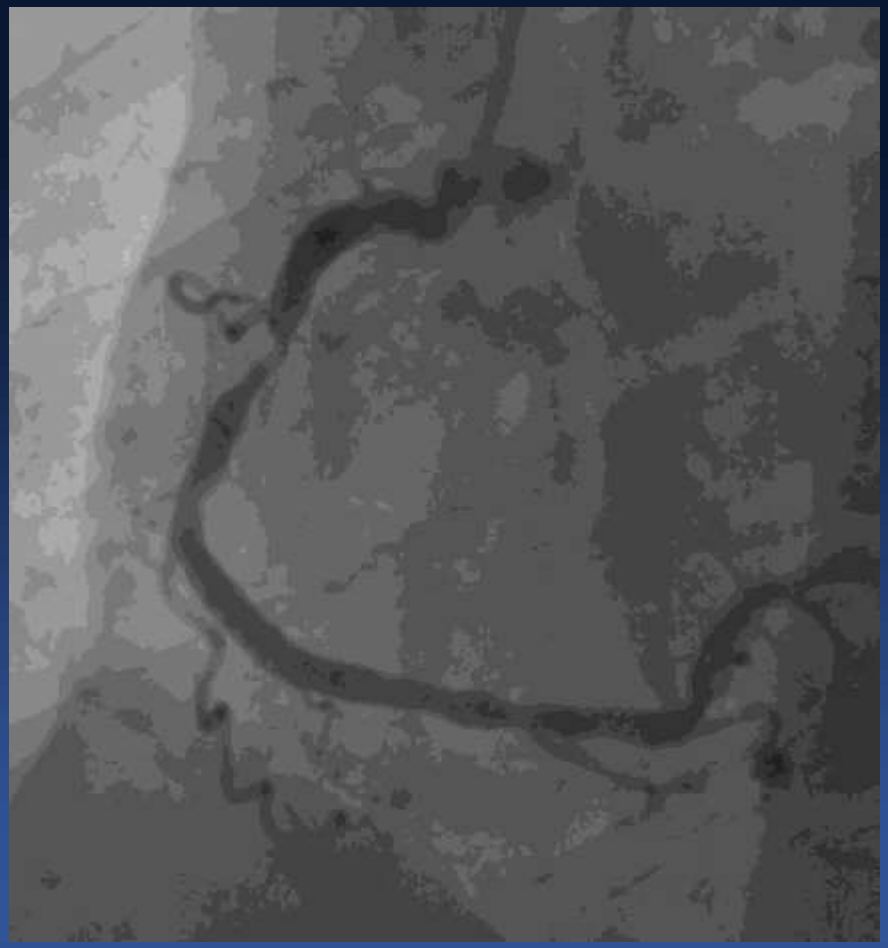
Park SJ, Ahn JM et al *Circulation* 2011:23;124(8):951-7

FFR: Treat or Not Treat



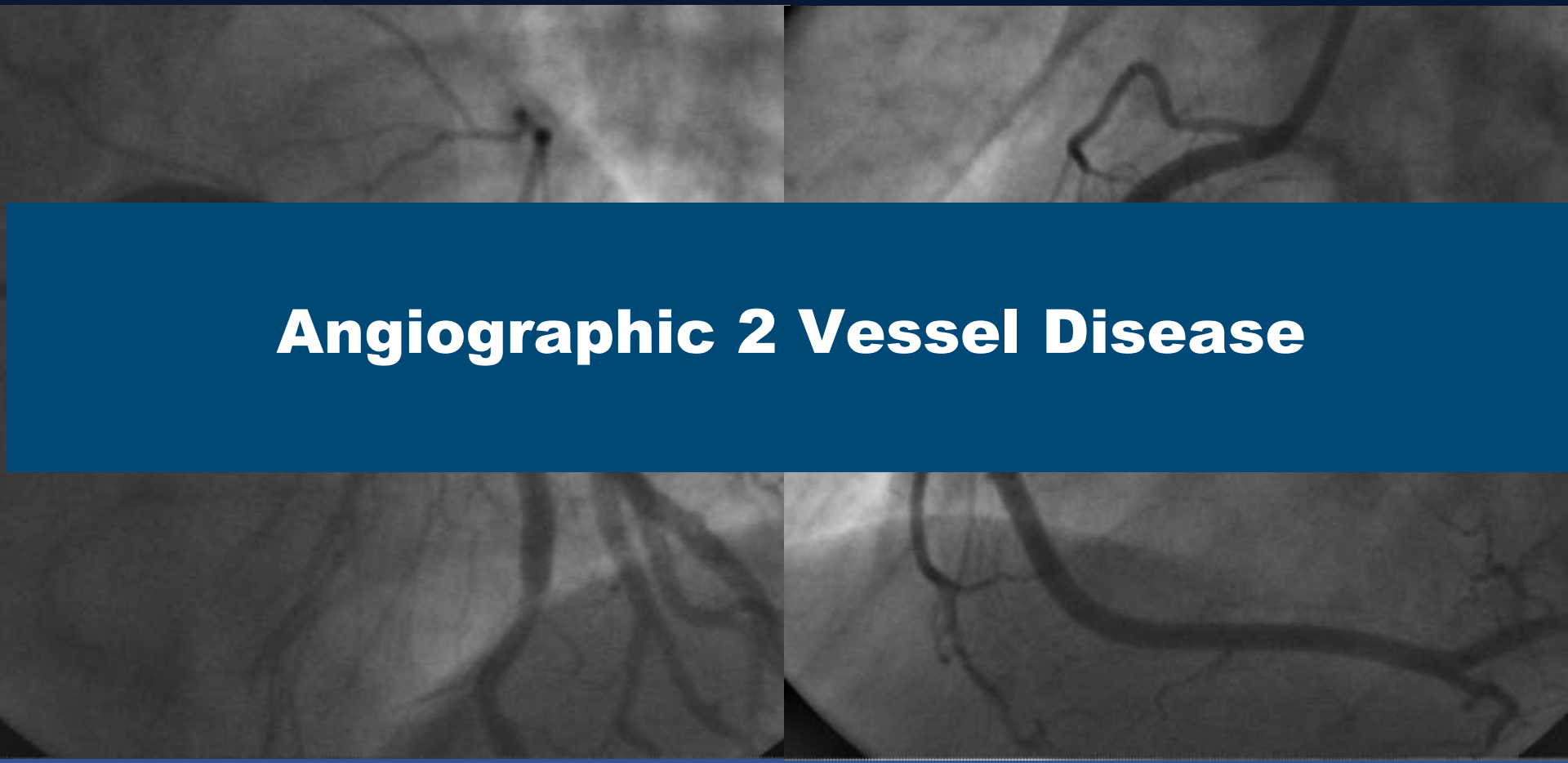
IVUS: Stent Optimization

Single Vessel Disease



Angiographic DS(%) : 85%

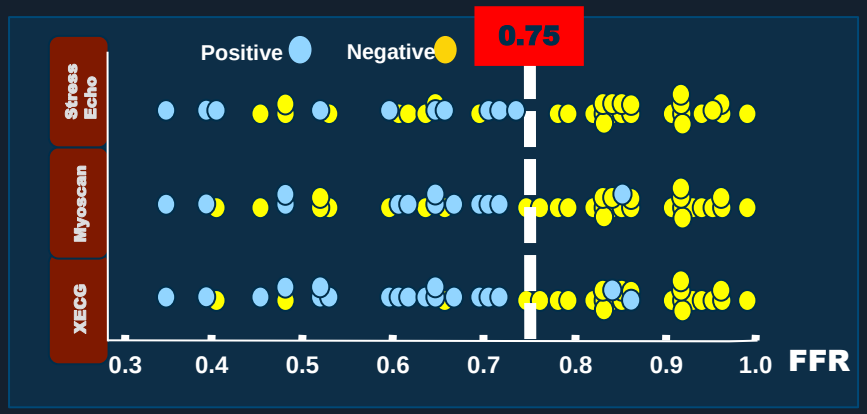
Multivessel Disease



Angiographic 2 Vessel Disease

Single or Multivessel Disease

FFR



- **N = 45 patients**
- **Sensitivity 88%, Specificity 100%, PPV 100%, NPV 88%**

Pijls et al N Engl J Med 1996;334:1703-8

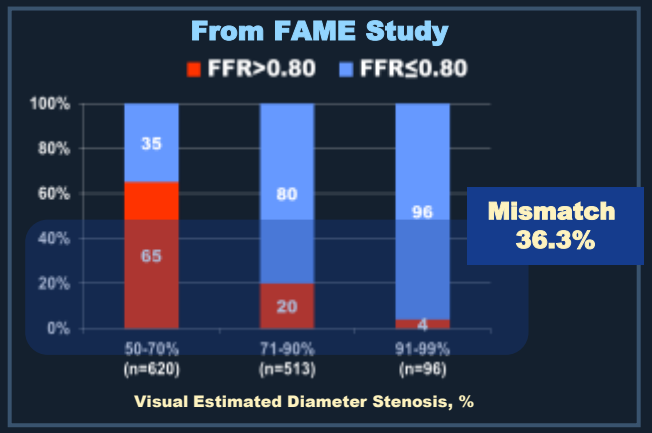
FAME 1	FAME 1	FAME 2
Death/MI At 2 Years	Cost at 1 Year	Urgent RR In sAP
35%	$2400	87%

IVUS

Single or Multivessel Disease

FFR

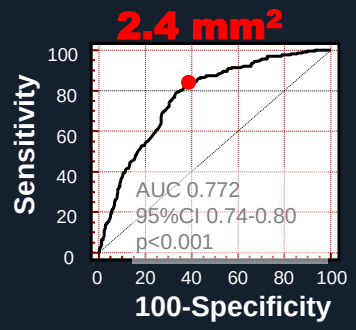
Visual-Functional Mismatch



Tonino et al. J Am Coll Cardiol 2010;55:2816–21

IVUS MLA, Non-LM

Matched with FFR 0.80 (n=784)

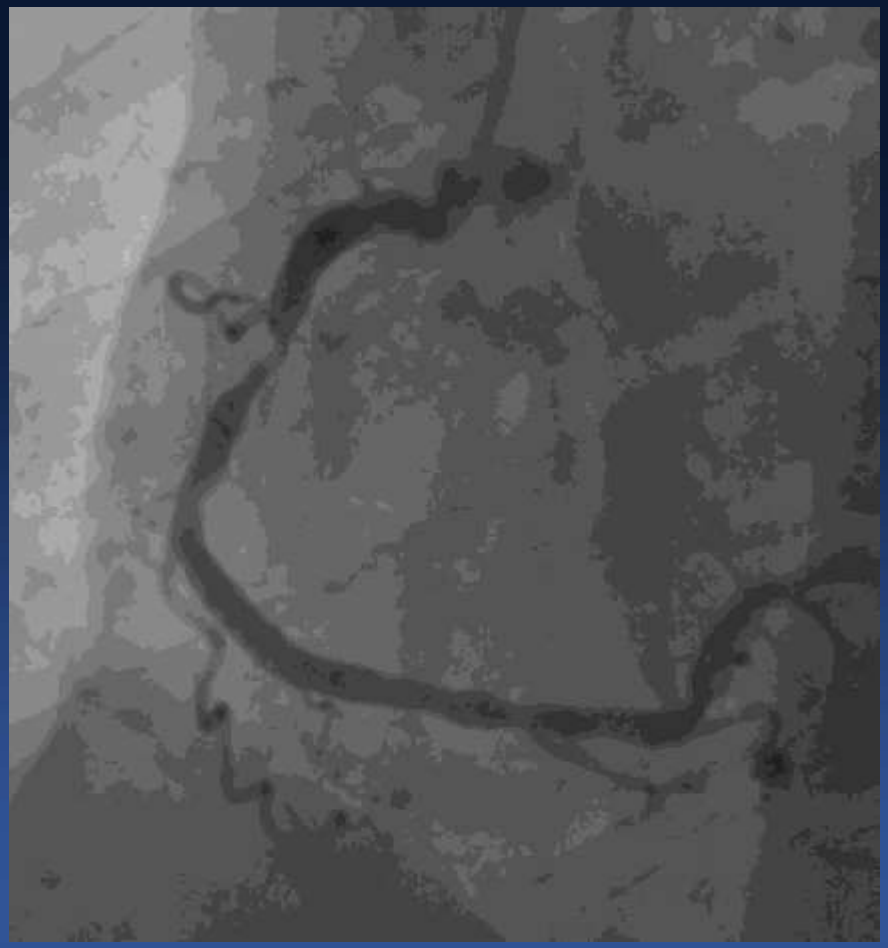


Sens.	84%
Spec.	63%
PPV	48%
NPV	90%
Accuracy	69%

Kang et al. Am J Cardiol 2012;109:947-53

IVUS

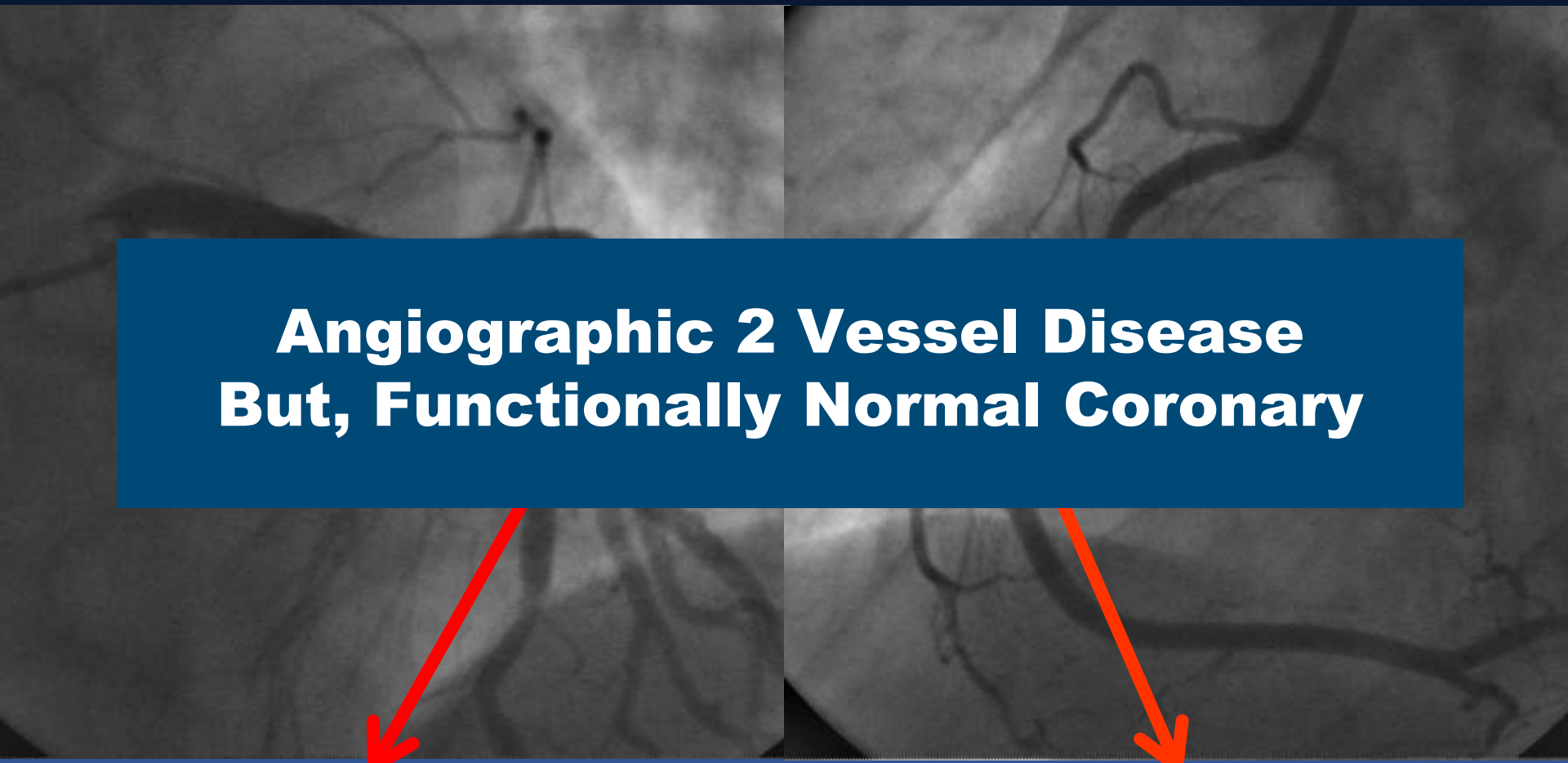
Single Vessel Disease



Angiographic DS(%) : 85%

FFR : 0.84

Multivessel Disease



Angiographic 2 Vessel Disease
But, Functionally Normal Coronary

FFR : 0.84

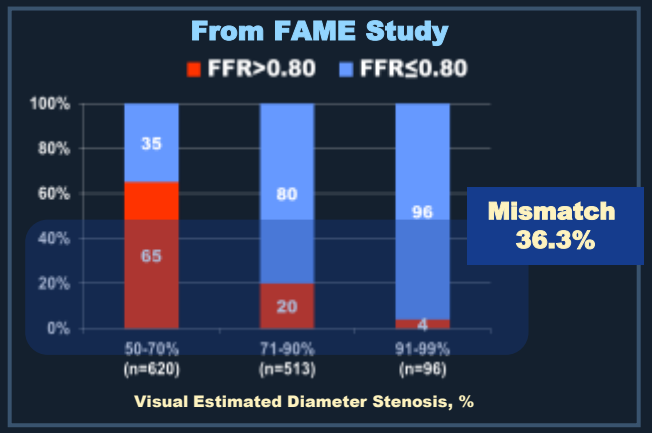
FFR : 0.86

CardioVascular Research Foundation
COLLEGE MEDICINE
ASAN Medical Center

Single or Multivessel Disease

FFR

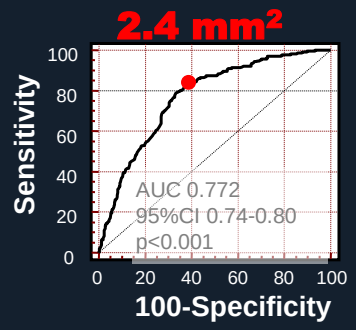
Visual-Functional Mismatch



Tonino et al. J Am Coll Cardiol 2010;55:2816–21

IVUS MLA, Non-LM

Matched with FFR 0.80 (n=784)



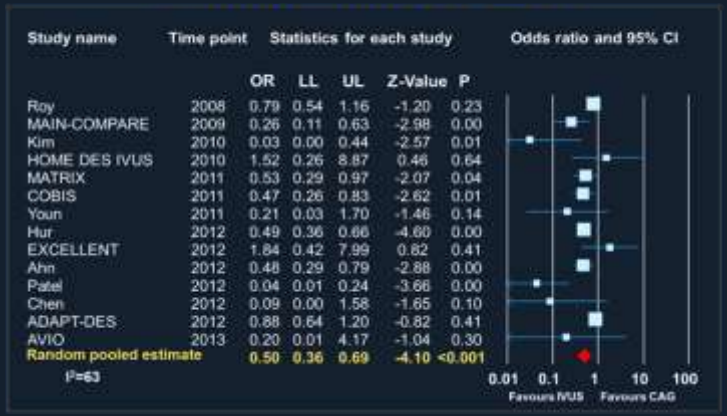
Sens.	84%
Spec.	63%
PPV	48%
NPV	90%
Accuracy	69%

Kang et al. Am J Cardiol 2012;109:947-53

IVUS

IVUS guidance improve PCI outcome

Death from any causes



Study name	Time point	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

Ahn JM, Park SJ, et al Am J Cariol 2014, 113(8):1338-47

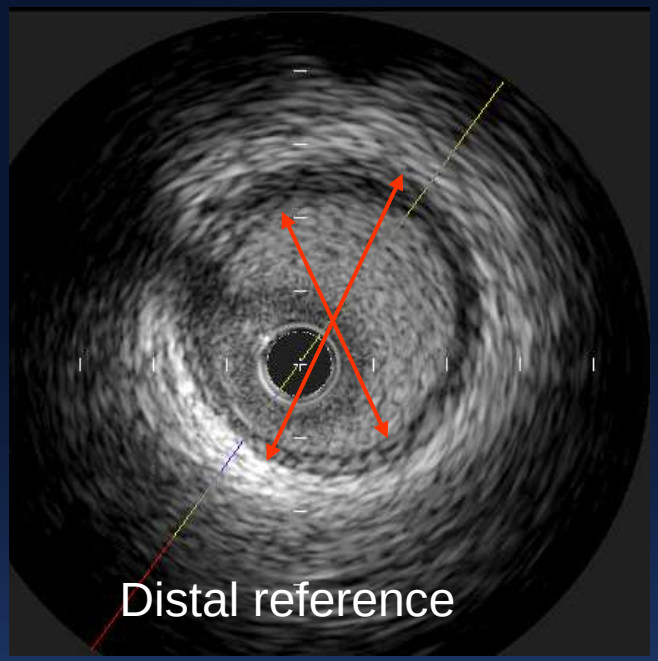
IVUS MSA Criteria

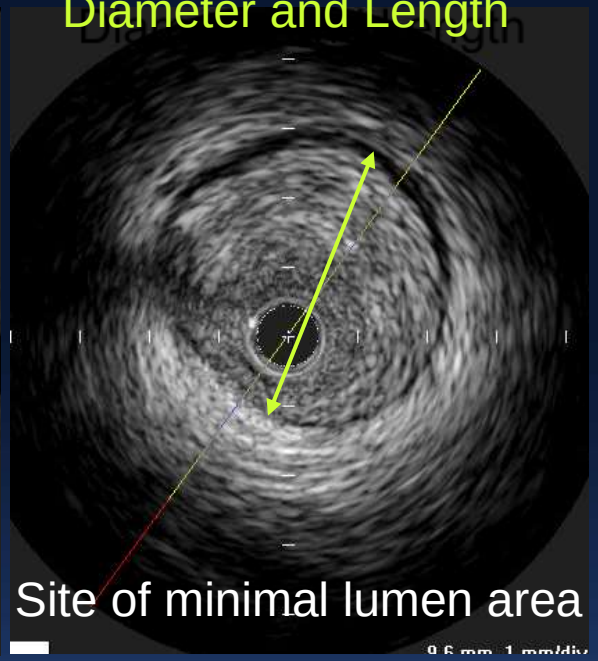
To reduce ISR, MSA 5-5.5mm²

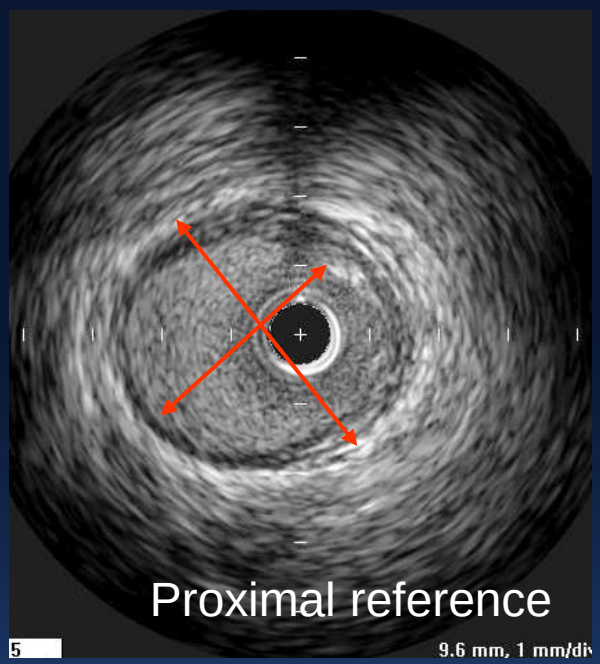
	Size	DES	Endpoint	MSA
SIRIUS	72	SES	8 mo, MLA<4mm²	5.0mm²
Hong et al.	550	SES	6 mo, ISR	5.5mm²
TAXUS-Meta	1098	PES	9 mo, ISR	5.7mm²
Song et al.	220	ZES	9 mo, ISR	5.3mm²
Song et al.	229	EES	9 mo, ISR	5.4mm²

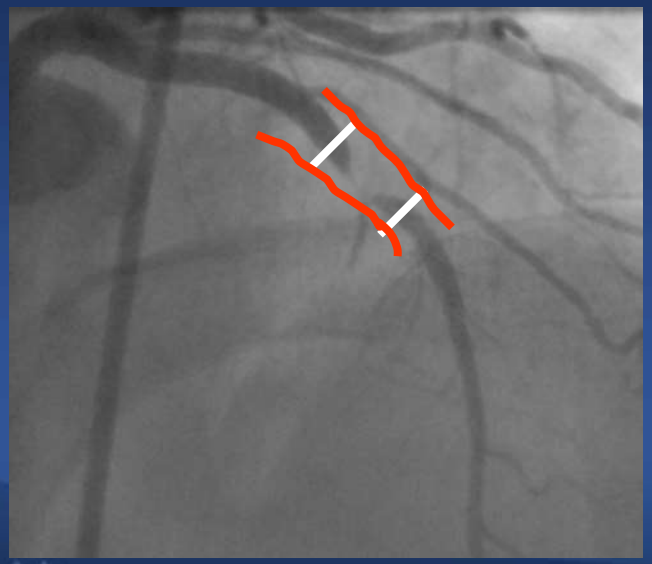
Optimal Sizing of Stent

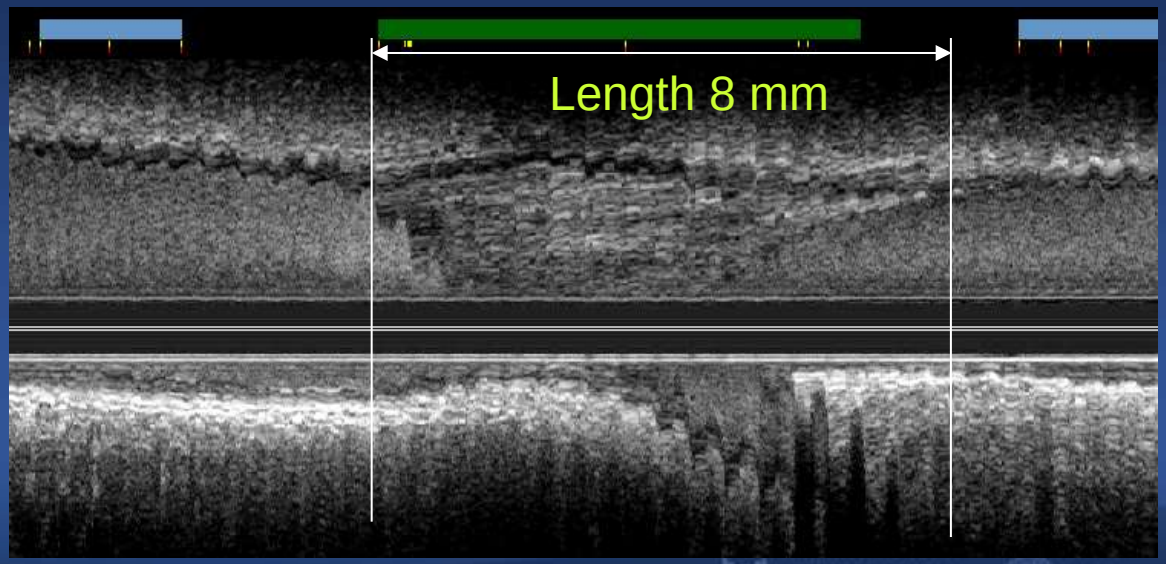
Diameter and Length



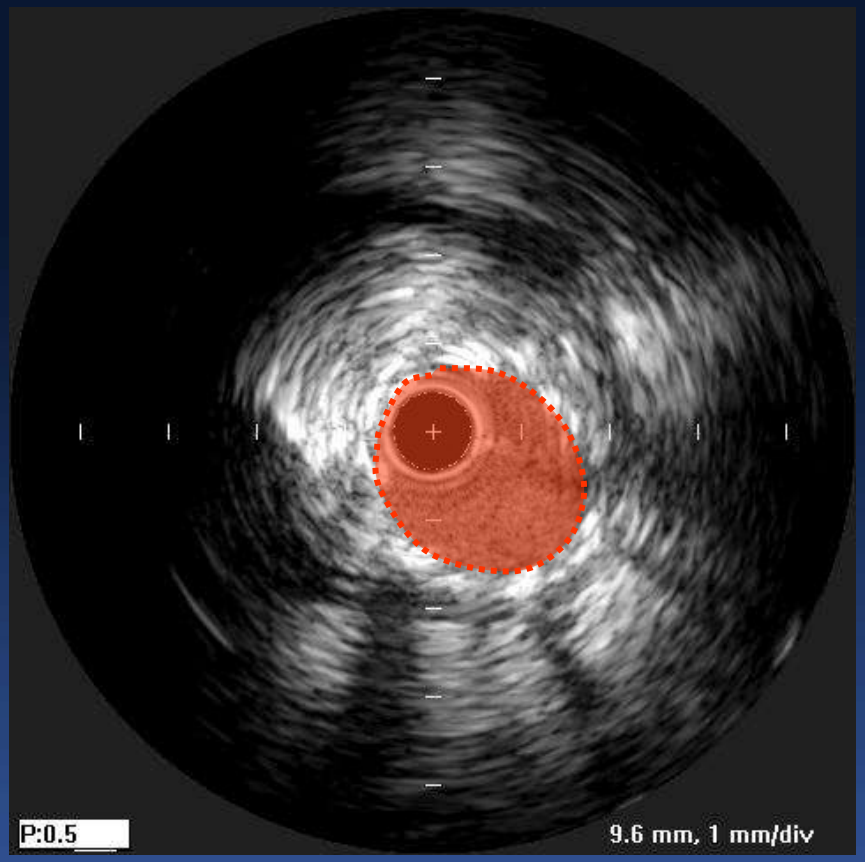






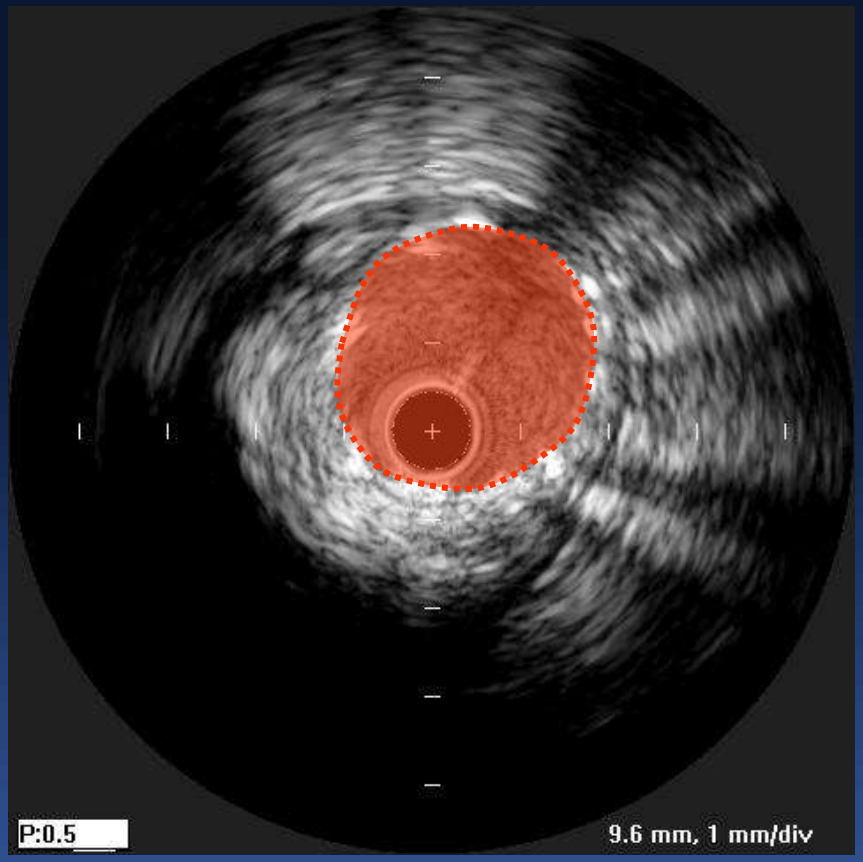


Underexpansion After Cypher 3.5mm Implantation



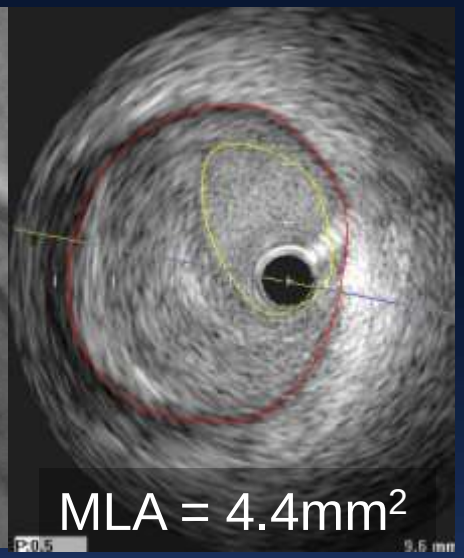
Minimal Stent Area 3.7 mm^2
Mean Sent Diameter 2.2 mm

Well-expanded After Additional HP Balloon

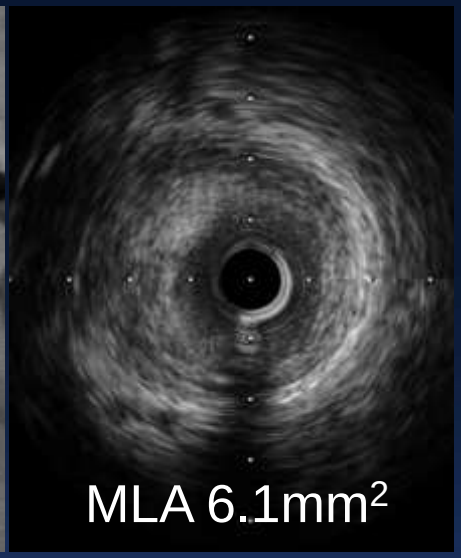


Minimal Stent Area 6.5 mm^2
Mean Stent Diameter 3.0 mm

47/M Stable angina



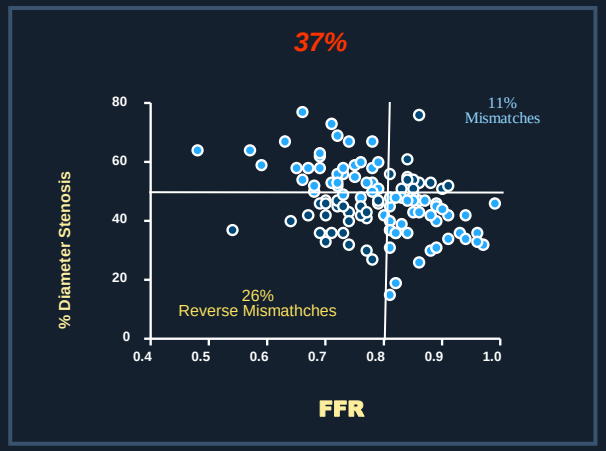
50/M Stable angina



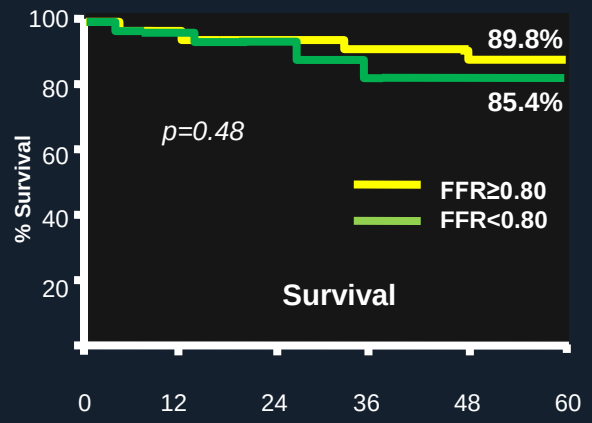
Left Main Disease

FFR

Visual-Functional Mismatch



FFR guided Rev. in Equivocal LMCA

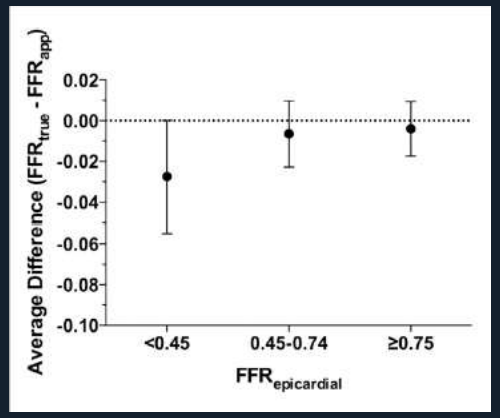


Circulation. 2009;120:1505-1512

IVUS

Left Main Disease

FFR

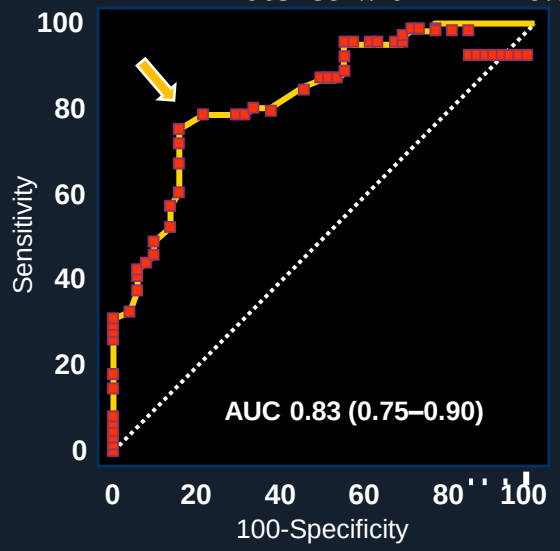


LM and Down stream dz In human

Fearon WF et al JACC CI 2015

IVUS MLA

Matched with FFR <0.80 (N=112)



Cut-off = 4.5 mm^2

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

Park SJ, Ahn JM et al. *JACC Interv, 2014;7(8):868-874*

IVUS

Left Main Disease

FFR

IVUS

Direct evaluation of LCXos:
One stent or Two stent

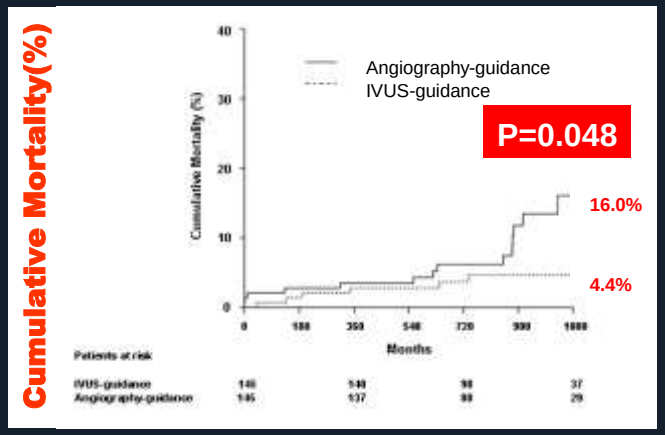
Stent Cross Over	***Normal Ostial LCX (Medina 1.1.0., 1.0.0)*** Normal or Diminutive LCX Small LCX with < 2.5 mm in diameter Focal disease in distal LCX
Two Stent	***Diseased LCX (Medina 1.1.1., 1.0.1)*** Large LCX with ≥ 2.5 mm in diameter Diseased left dominant coronary system Concomitant diffuse disease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

Left Main Disease

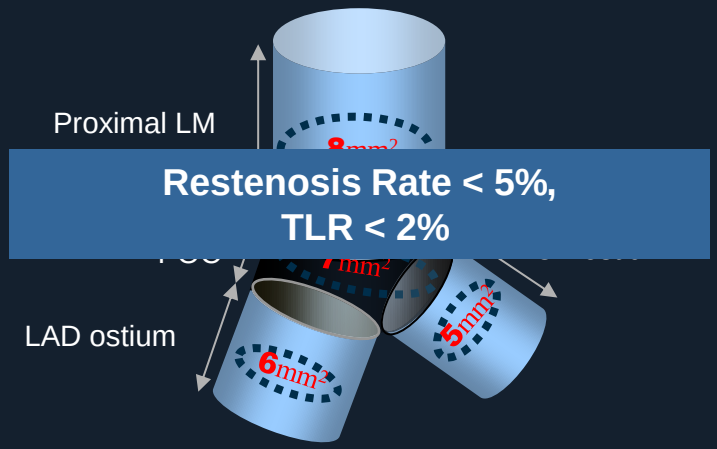
FFR

IVUS

IVUS Guidance Saves Lives



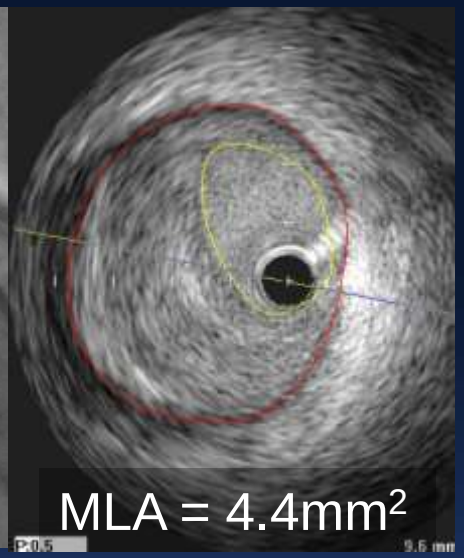
Park SJ et al, Circulation. Cardiovasc Interv. 2009 ;2(3):167-77



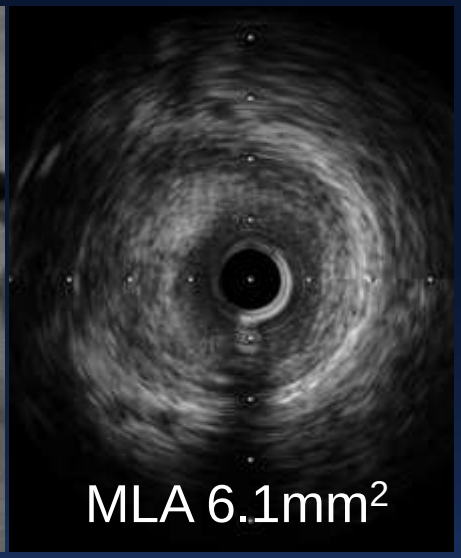
Restenosis Rate < 5%,
TLR < 2%

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

47/M Stable angina



50/M Stable angina

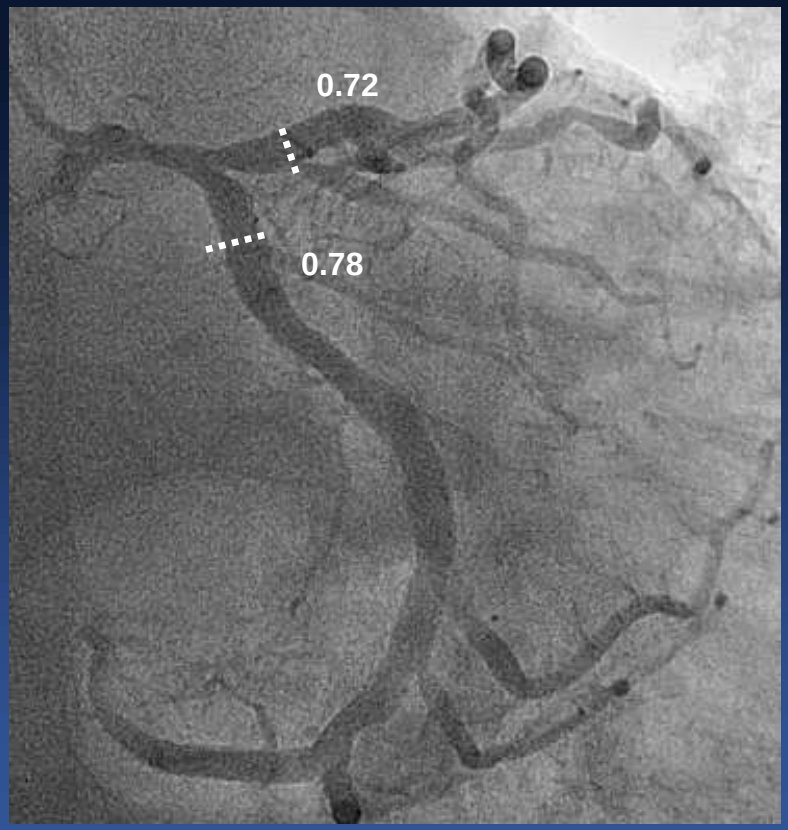


LM Bifurcation Disease

Medina (1,0,0)

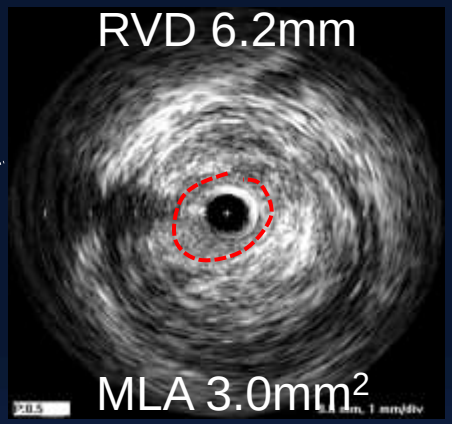
55/M, Stable angina, TMT (+), Thallium scan (-)

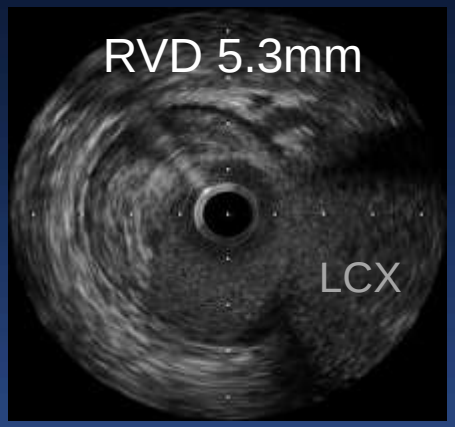
FFR in Both LAD and LCX,



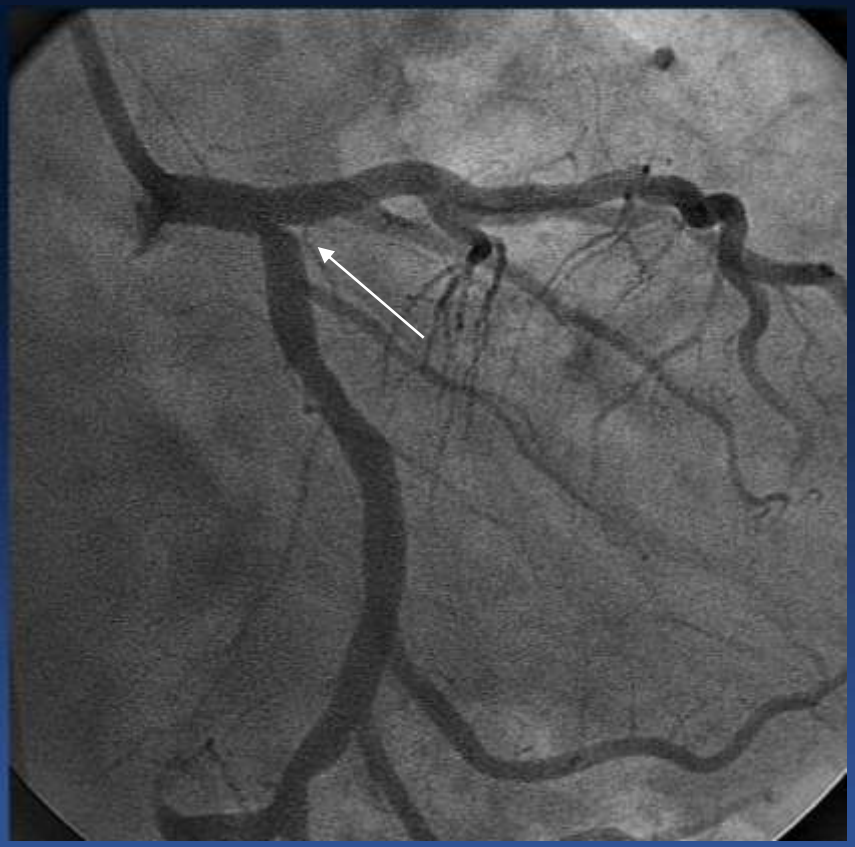
IVUS in Both LAD and LCX,

Distal LM,
RVD 6.2mm





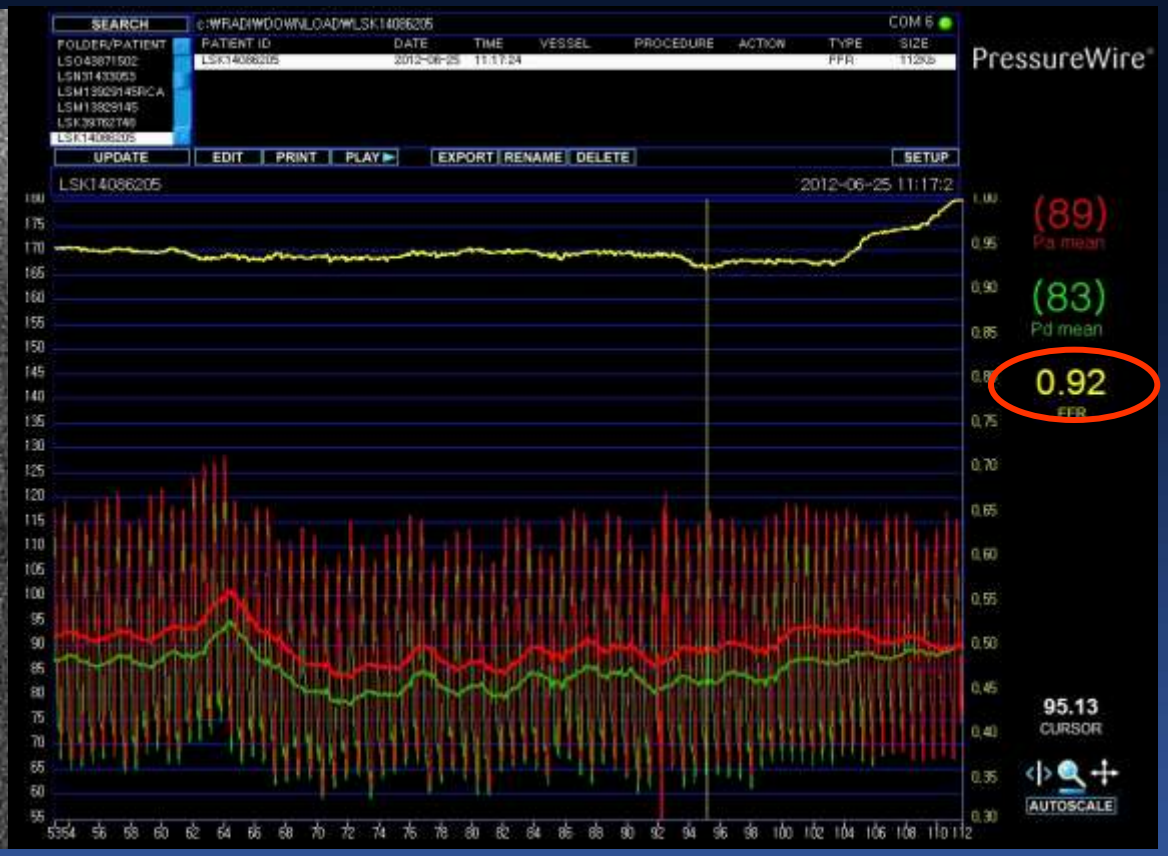
After Stent Crossover, LCX Ostium Was Jailed !



What Would You Do ?

Do You Want to Treat It ?

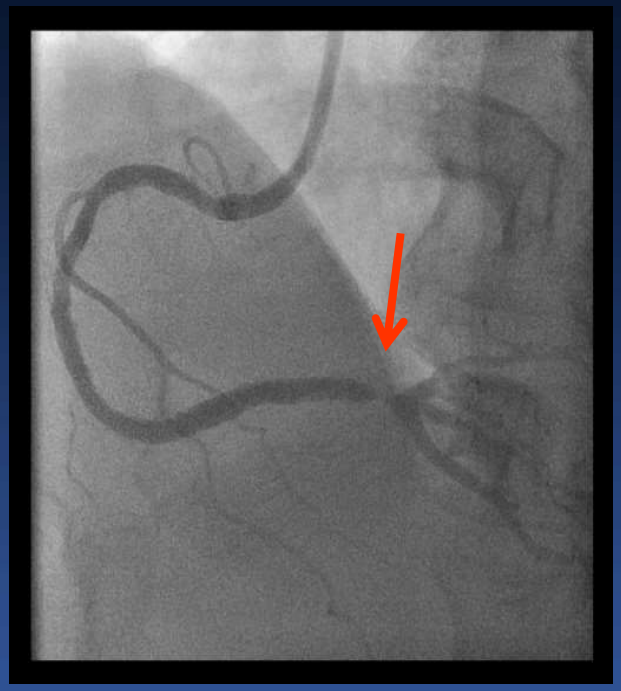
Consider FFR, First !



Just Defer !

Coronary Angiogram

Angiographically 3 VD with 2 Bifurcation



Thallium: Large Perfusion Defect at LAD Territory

Bifurcation

FFR

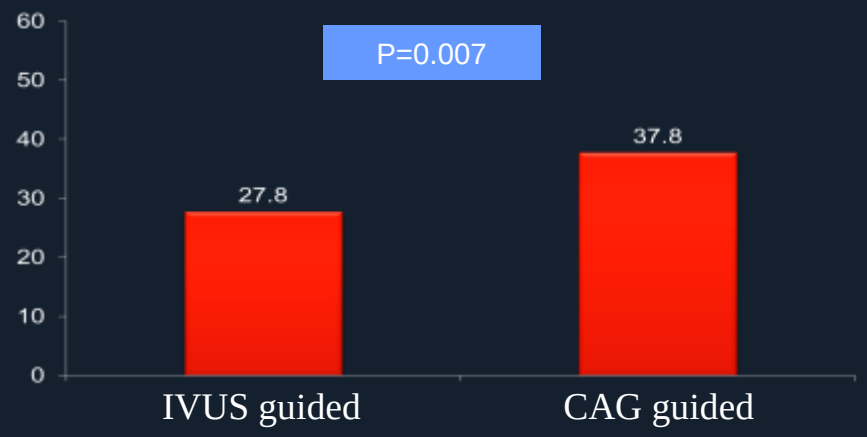
IVUS

IVUS Predictors for FFR (<0.80) of Side Branch

	P value
MLA of SB ostium	0.040
Plaque Burden at SB ostium	0.005

Kang SJ et al, AJC. 2011 Jun 15;107(12):1787-93.

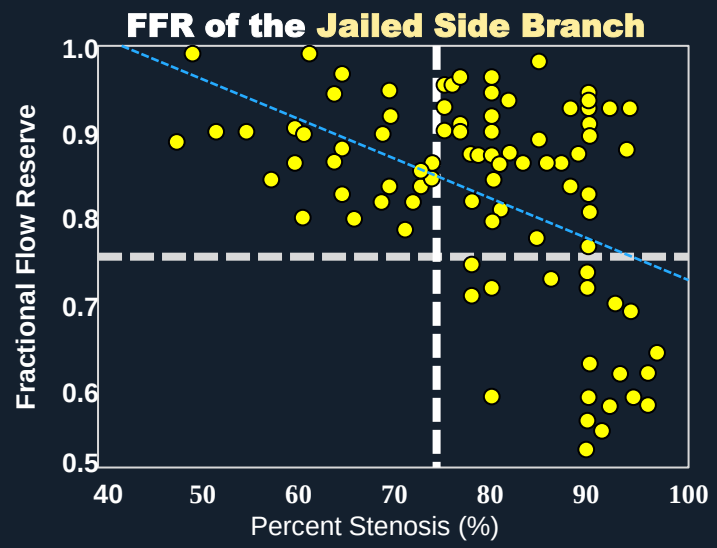
SB Occlusion Rate



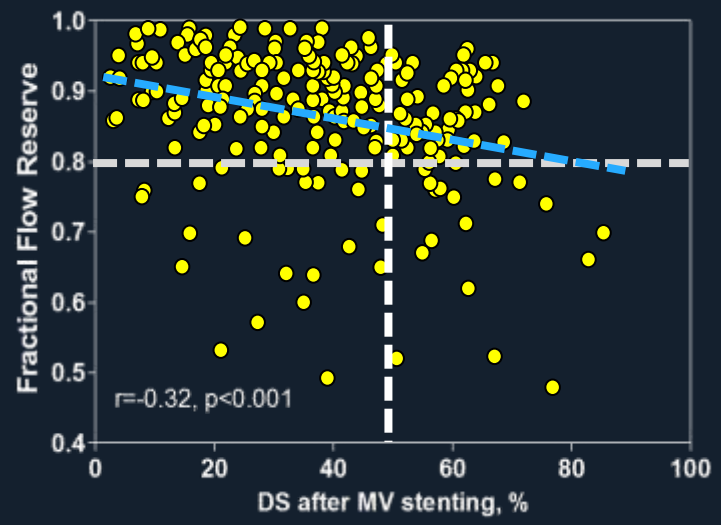
Hahn JY, et al. J Am Coll Cardiol. 2013;62(18):1654-9

Bifurcation

FFR



Koo BK et al JACC 2005; 46: 633



Ahn JM, Park SJ et al. JACC CI. 2012;5(2):155-61

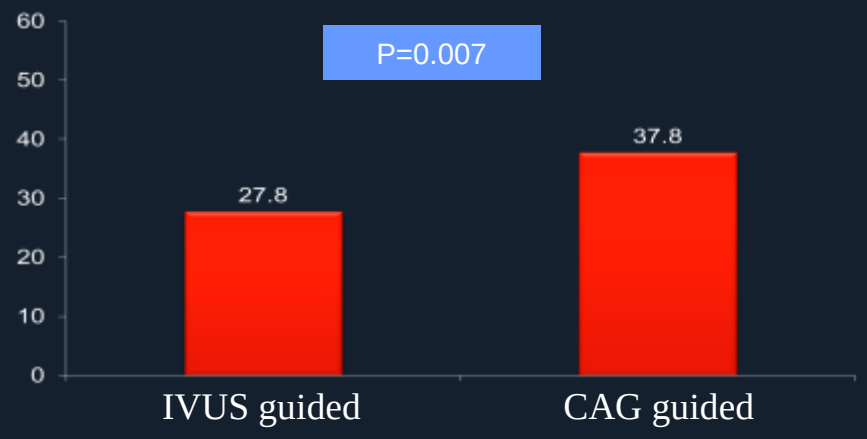
IVUS

IVUS Predictors for FFR (<0.80) of Side Branch

	P value
MLA of SB ostium	0.040
Plaque Burden at SB ostium	0.005

Kang SJ et al, AJC. 2011 Jun 15;107(12):1787-93.

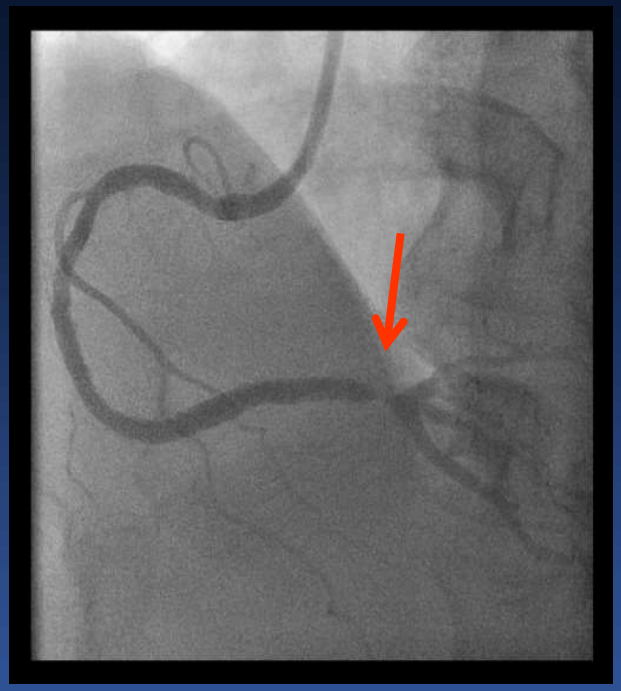
SB Occlusion Rate



Hahn JY, et al. J Am Coll Cardiol. 2013;62(18):1654-9

Coronary Angiogram

Angiographically 3 VD

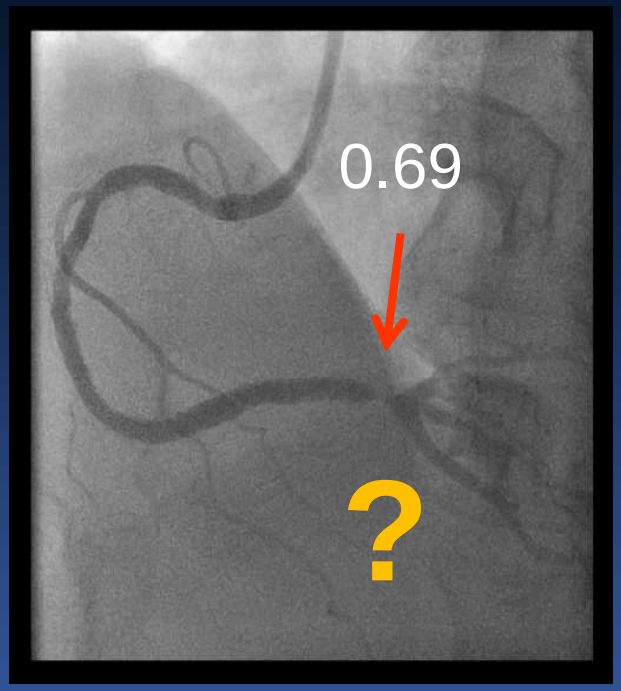


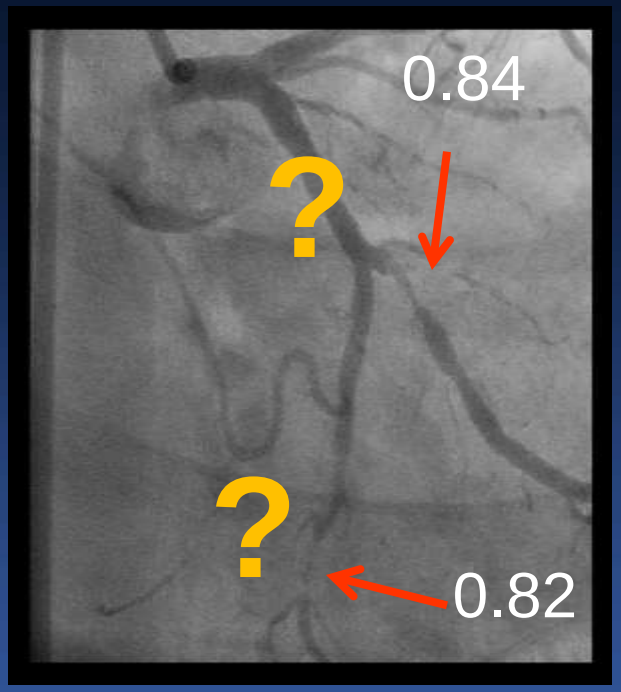
Thallium: Large Perfusion Defect at LAD Territory

Fractional Flow Reserve

Functionally 2 VD

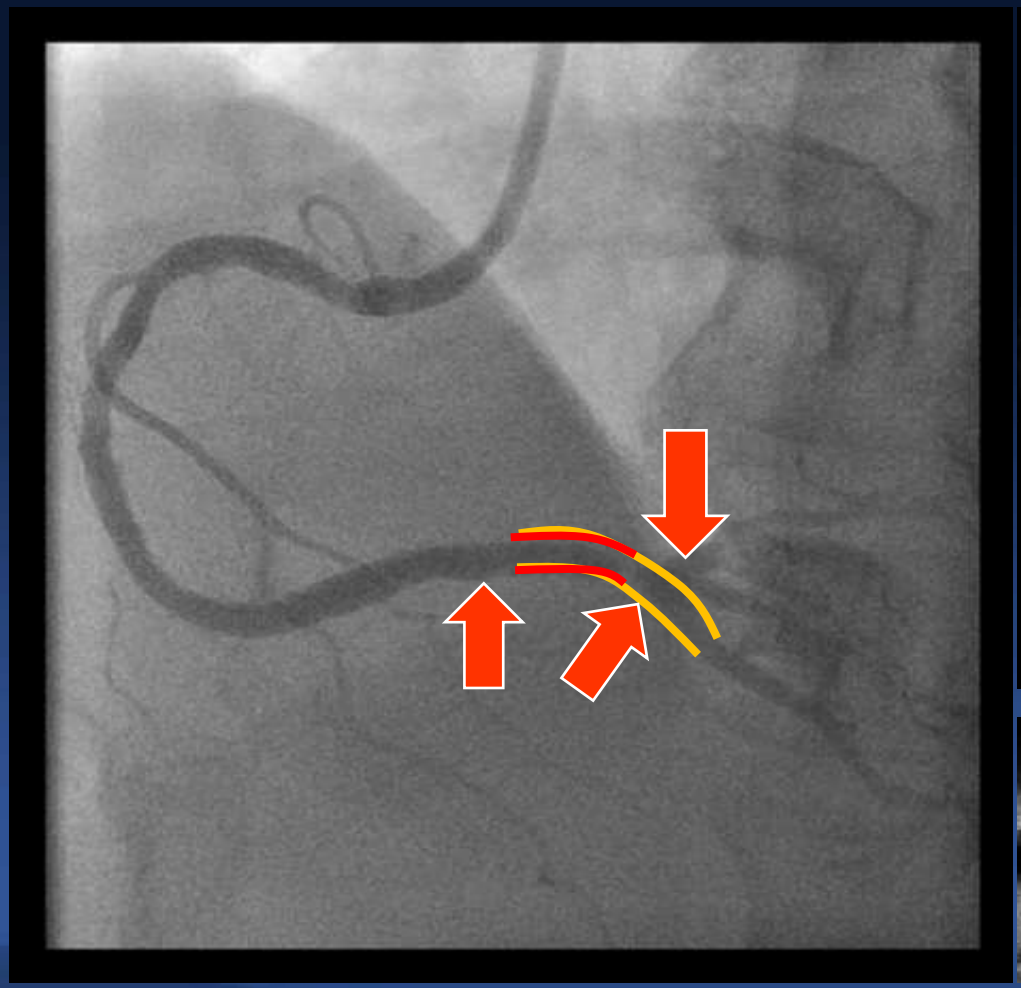
Not Done

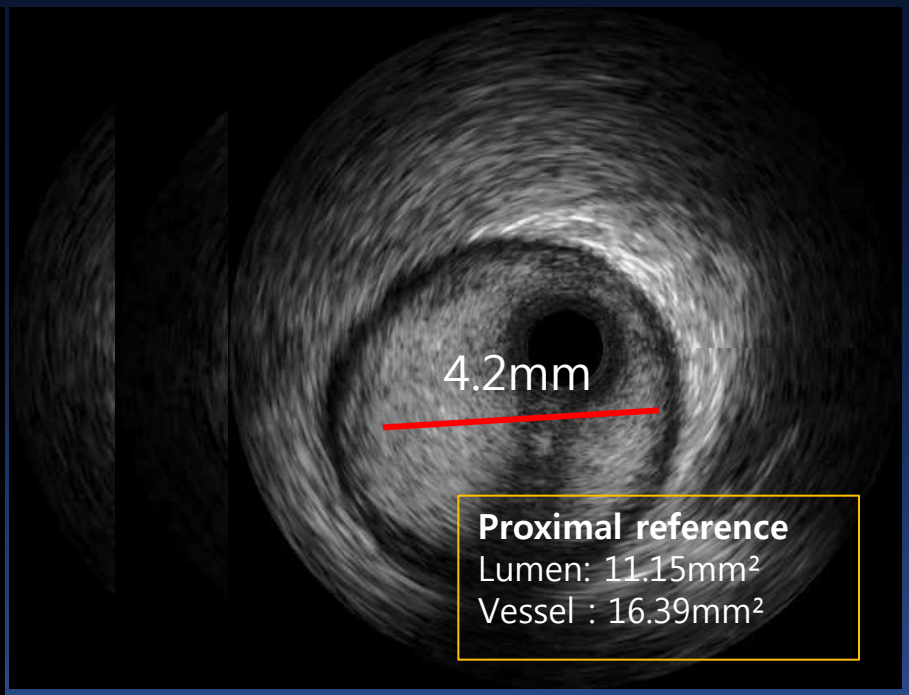


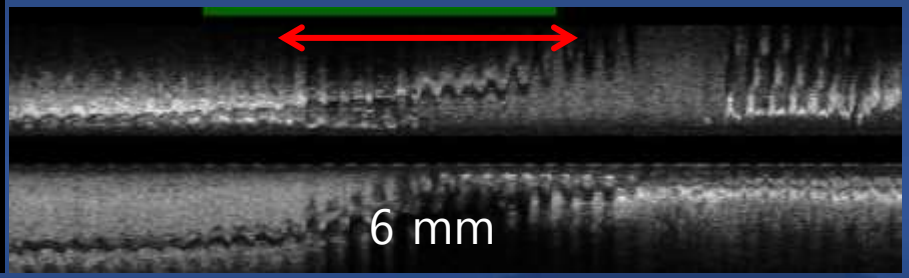


Thallium: large perfusion defect at LAD territory

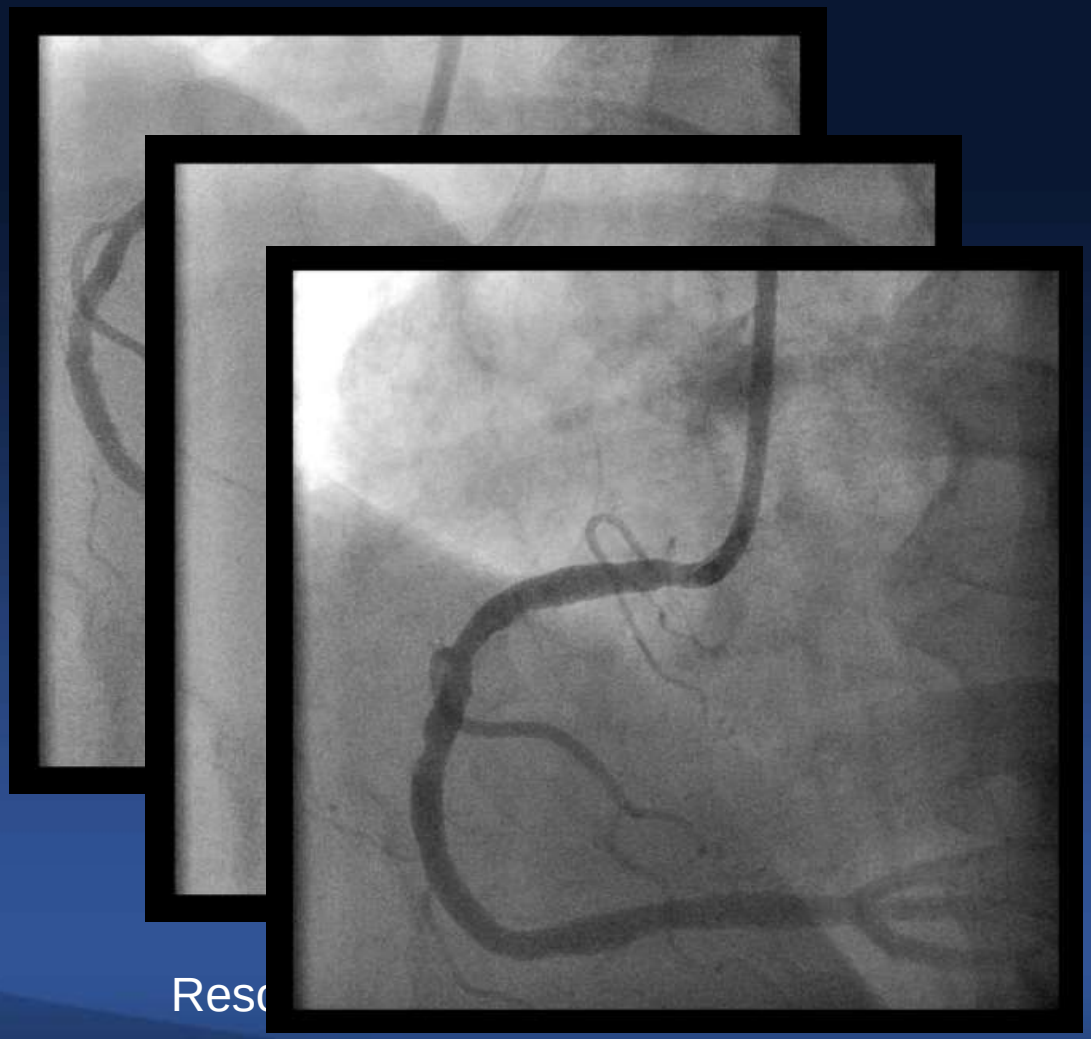
RCA

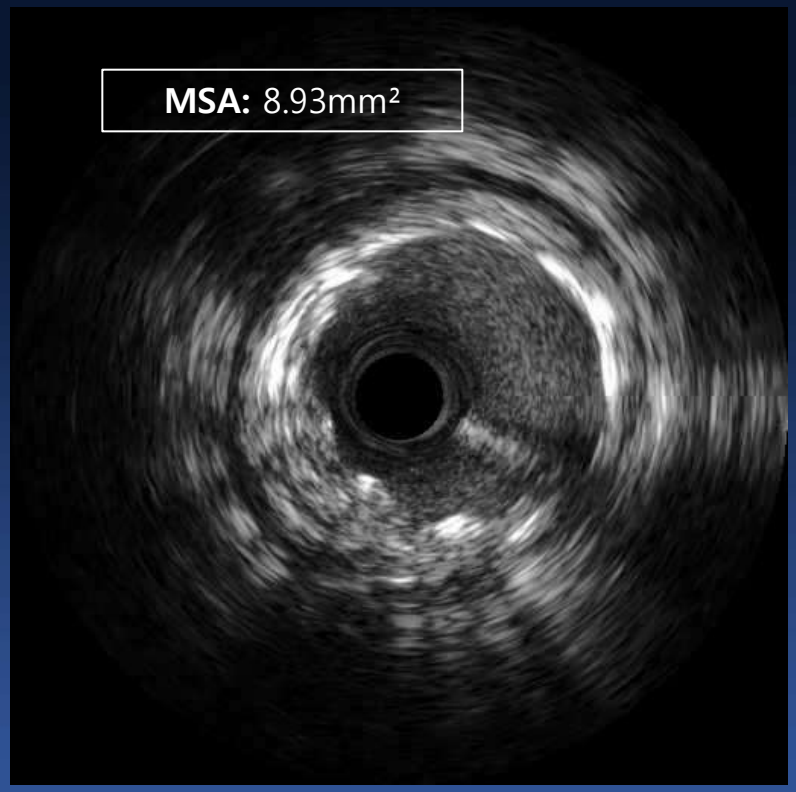






RCA

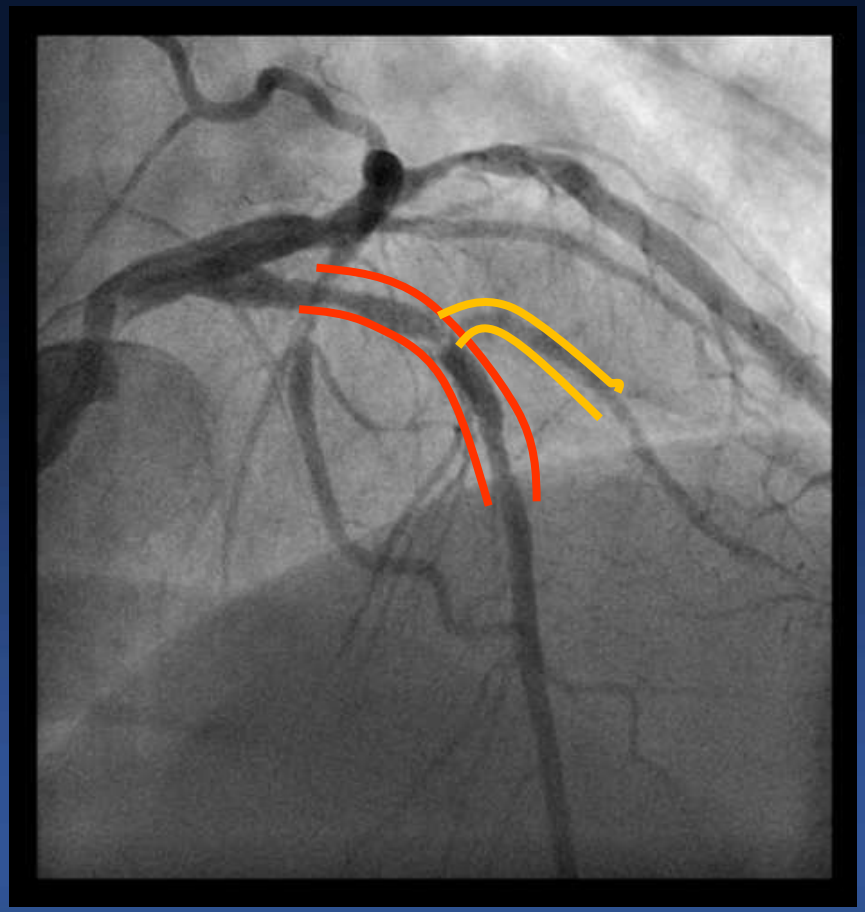




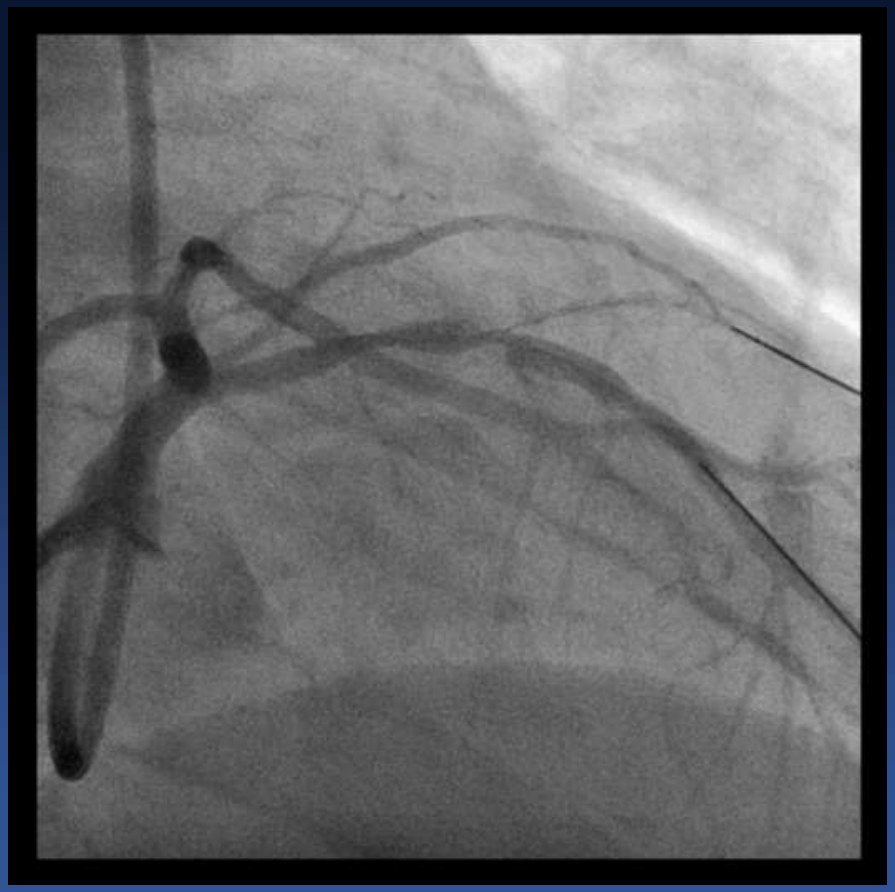
Resc

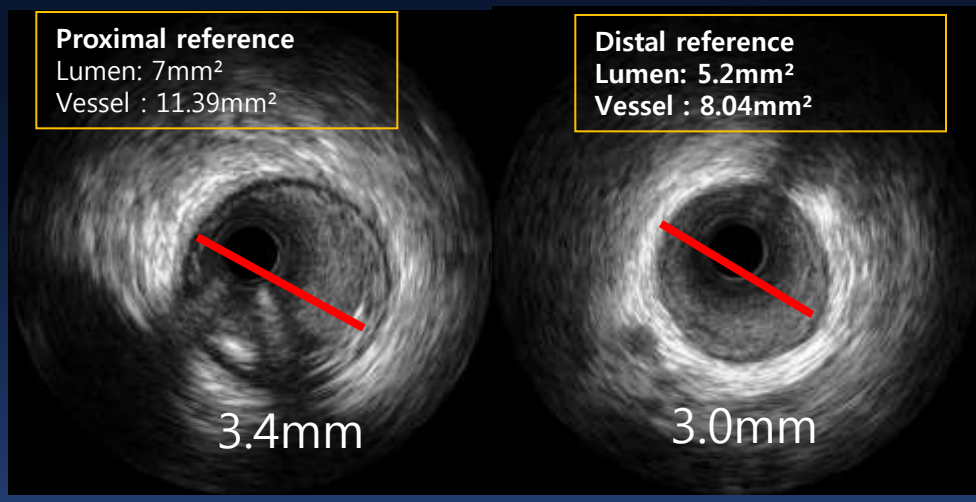
LAD

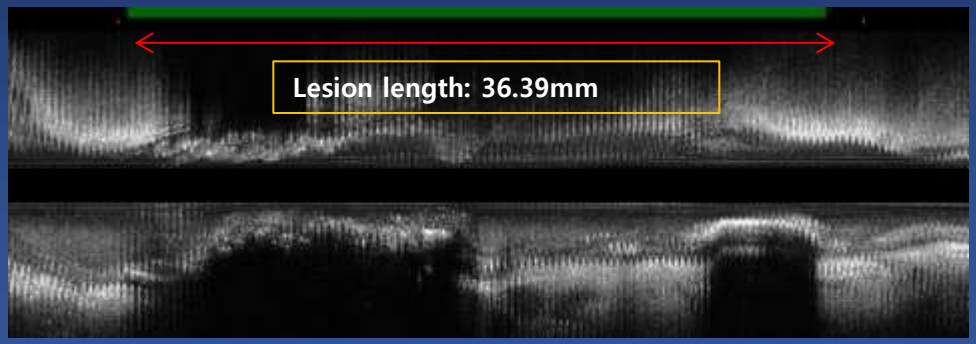
One or Two Stent Technique



Provisional 1 Stent

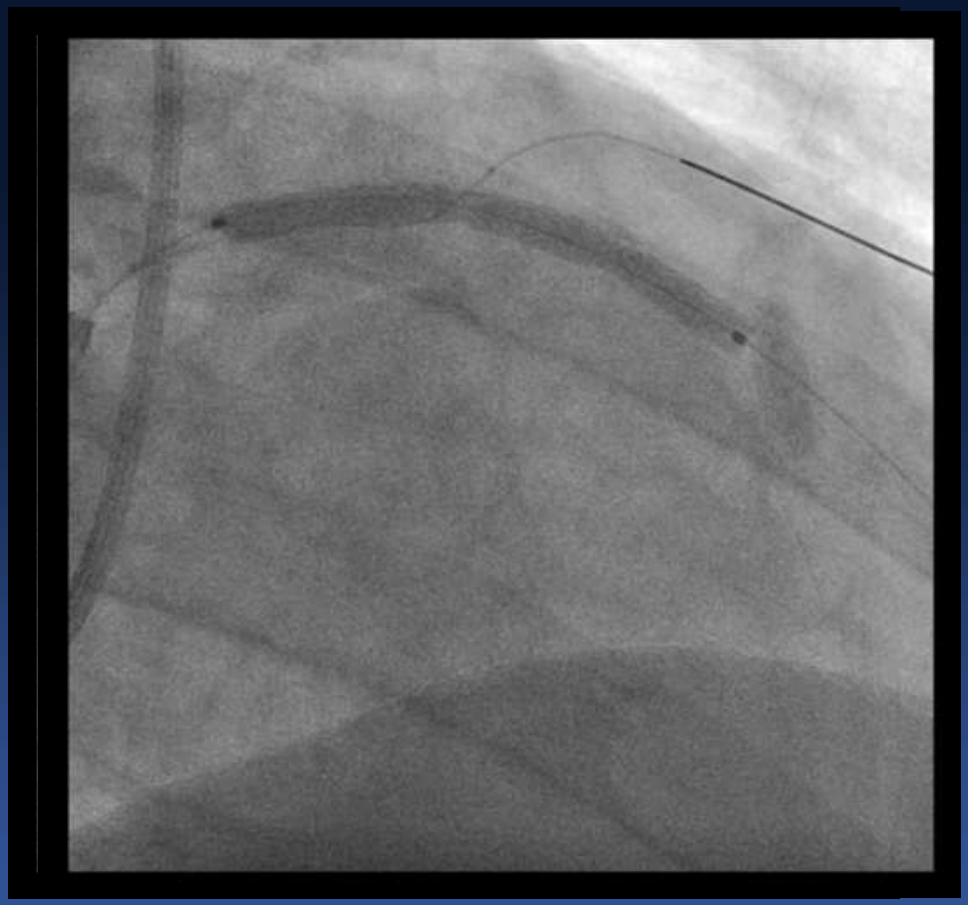






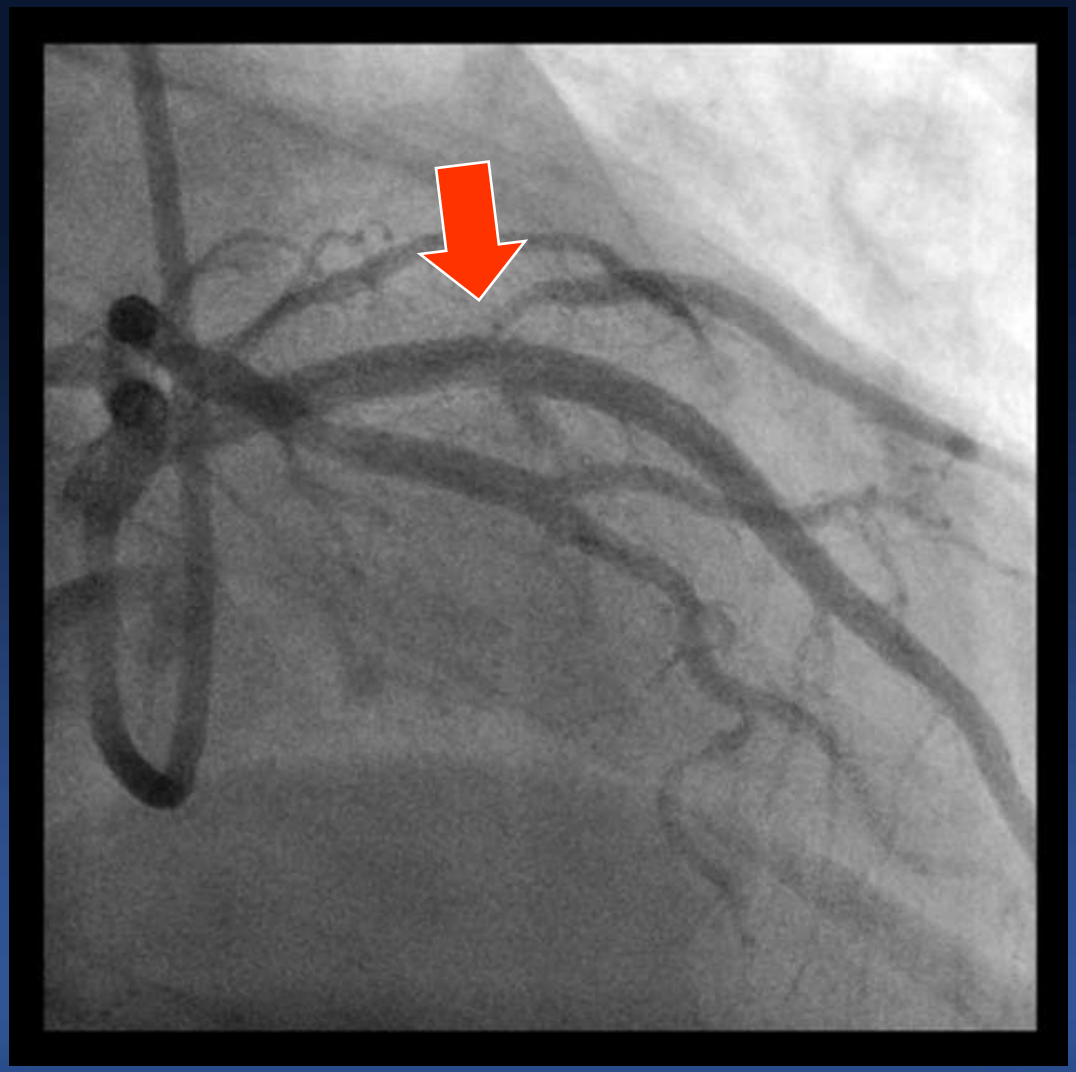
NEO's(Sion) 0.014" Wire at LAD and Di

Stenting

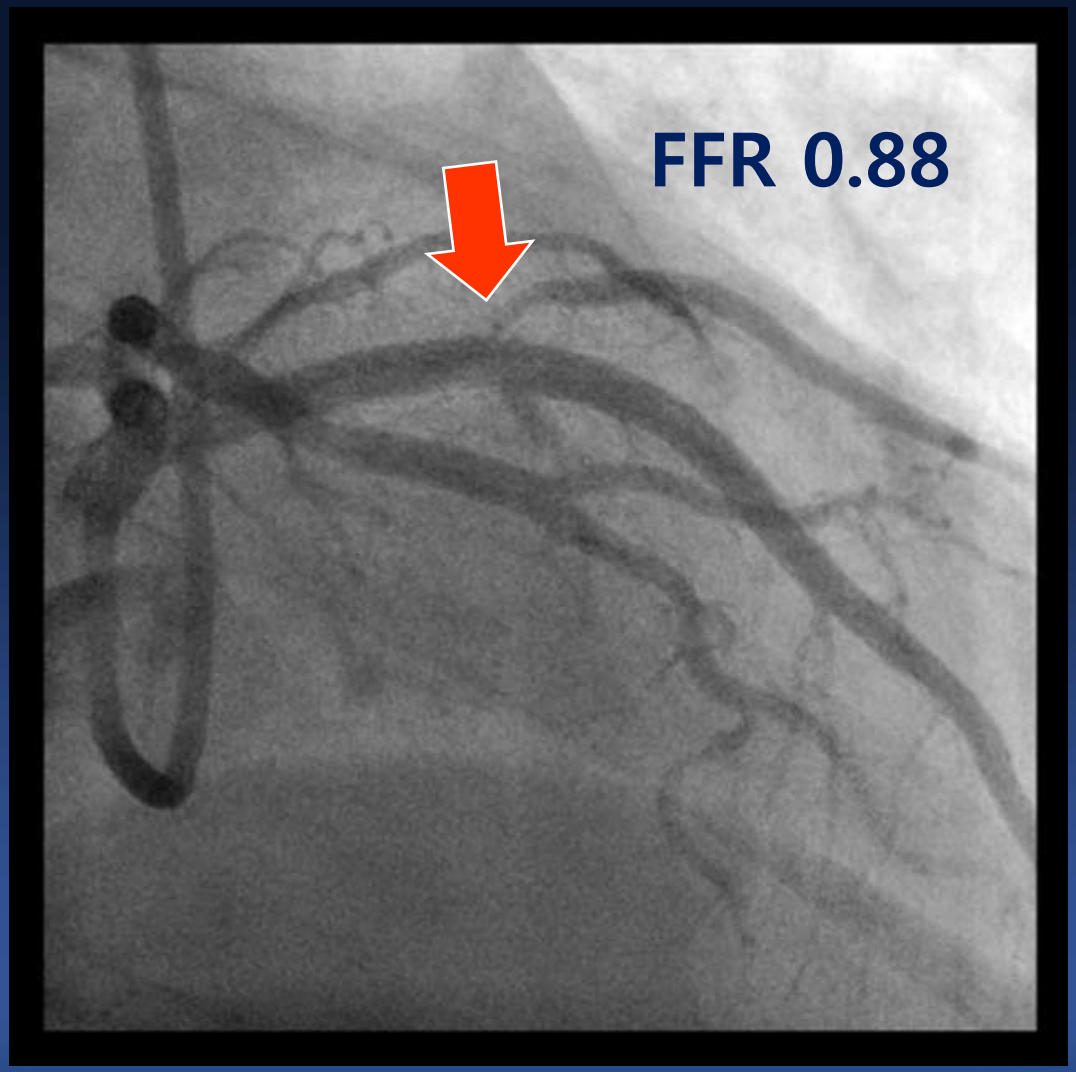


Resolute Intergrity 3.0(38)

After High Pressure Ballooning

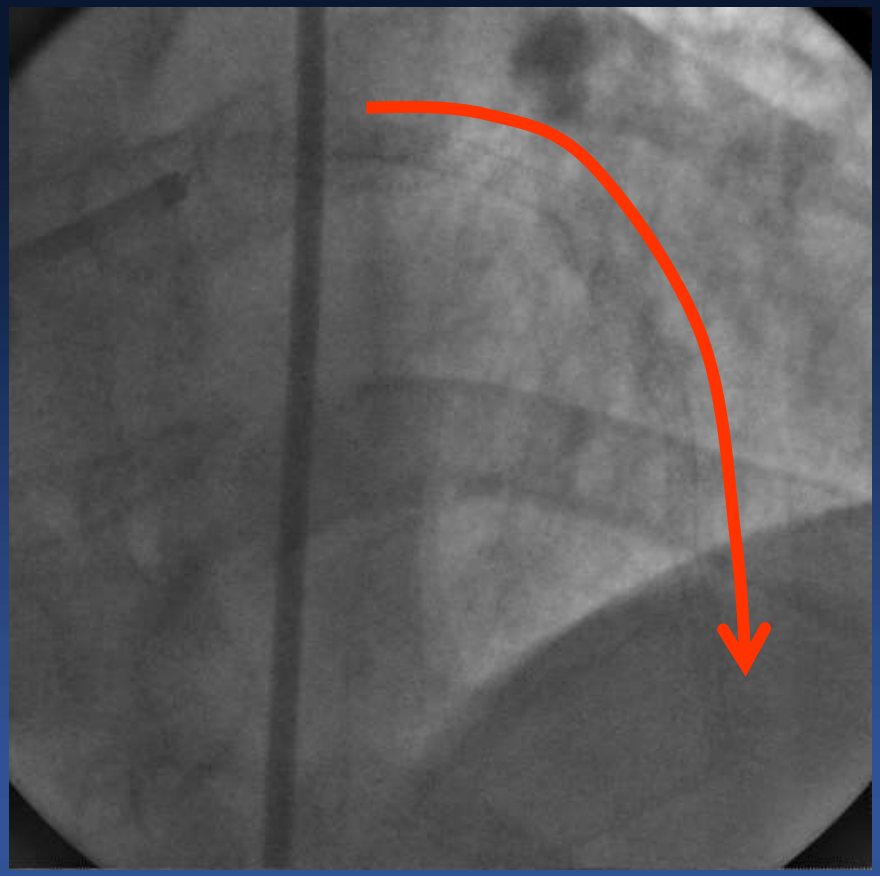


FFR



“Full Metal Jacket”

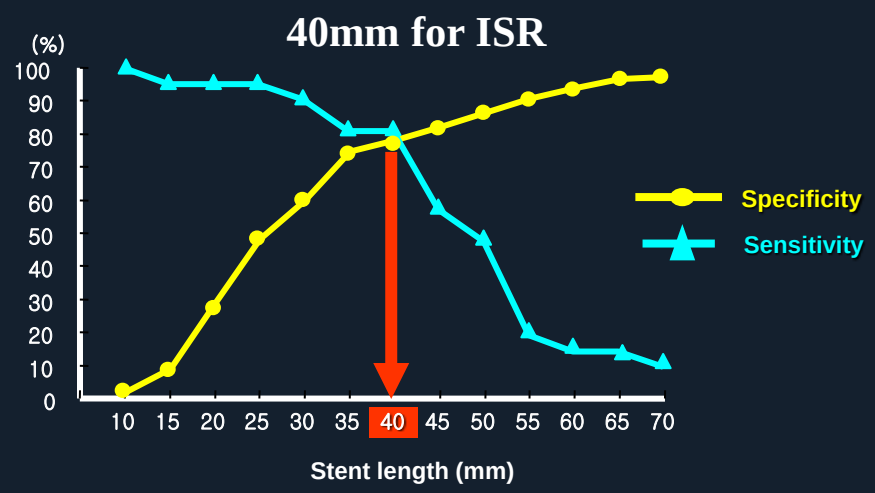
Multiple or overlapping stent implantation



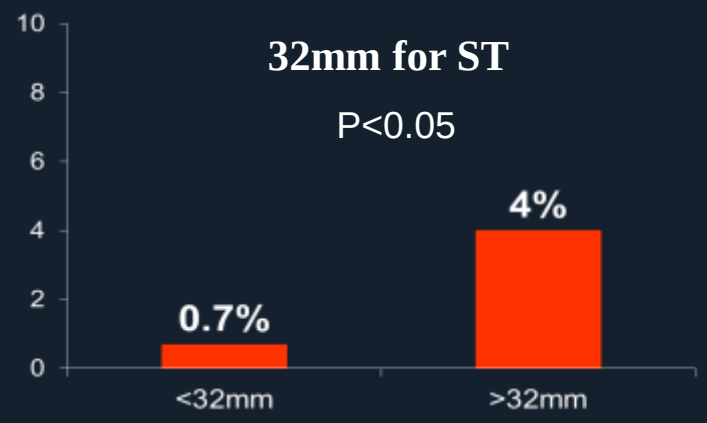
Long & Tandem Lesion

FFR

IVUS



Hong MK, Park SJ, et al. Eur Heart J 2006;27(11):1305-10



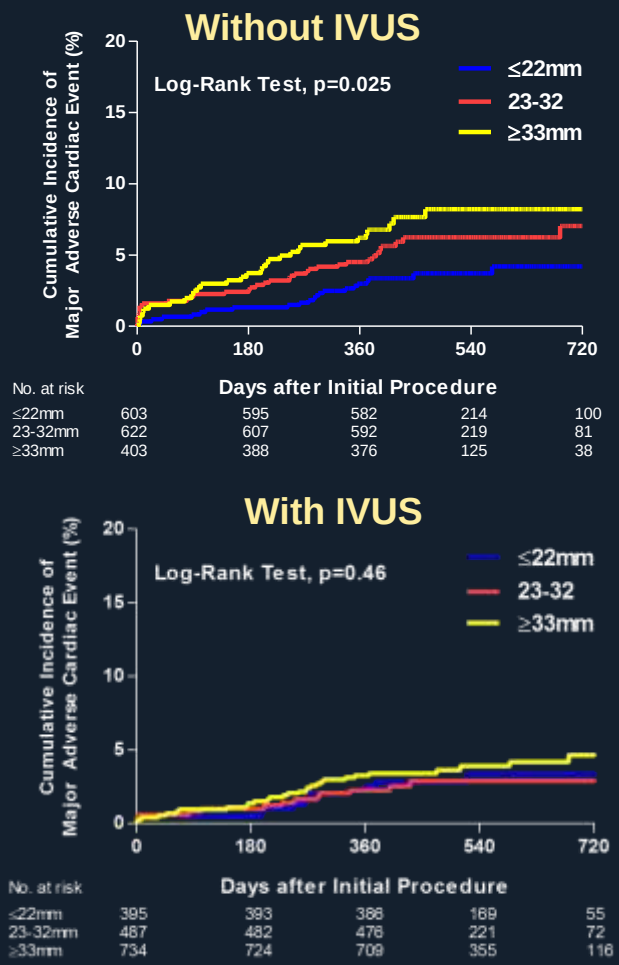
Suh J, Park SJ, et al. JACC CI 2010;3:383-9

Long & Tandem Lesion

FFR

IVUS

IVUS Modify the Stent Length Effect On Clinical Outcomes

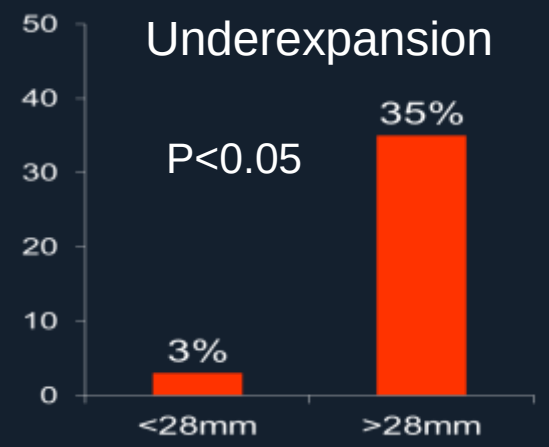


Ahn JM, Park SJ et al. Am J Cardiol 2013;111:829-35

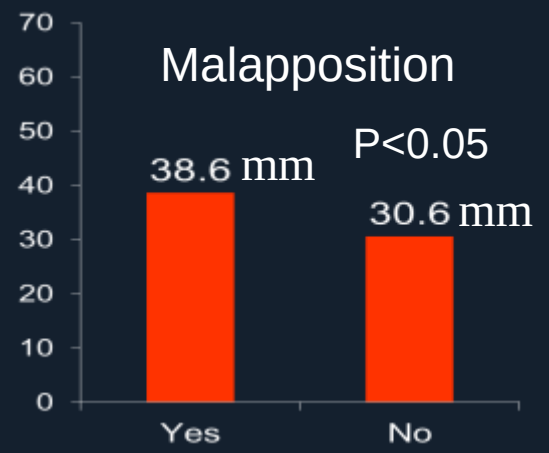
Long & Tandem Lesion

FFR

IVUS



Kang SJ, et al Circ Cardiovasc Interv 2011;4:9-14

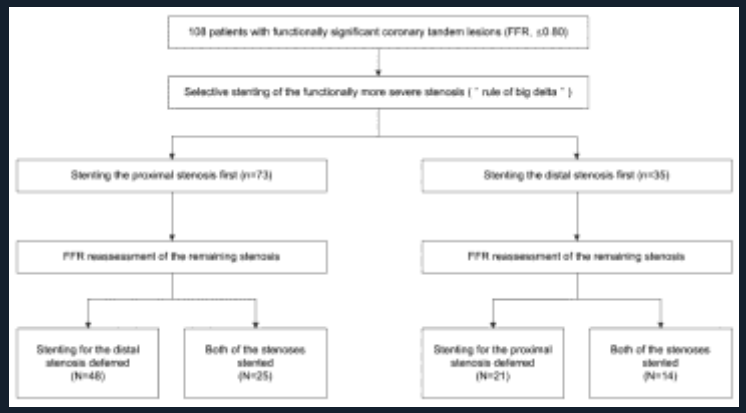


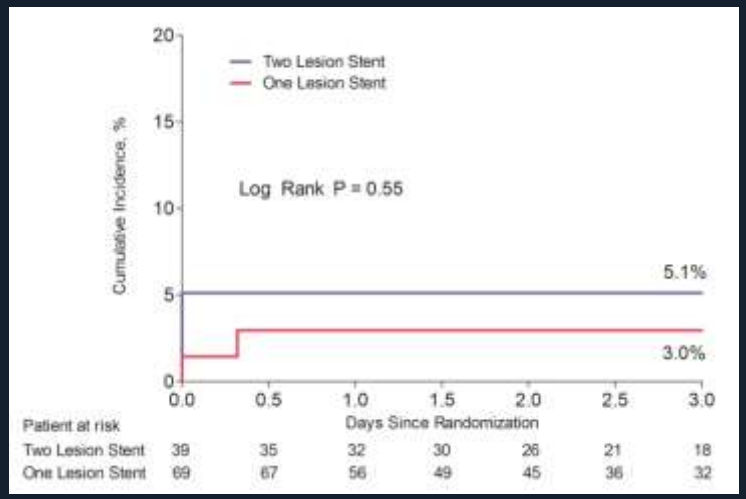
Hong MK, et al Circulation 2006;113:414-419

Long & Tandem Lesion

FFR

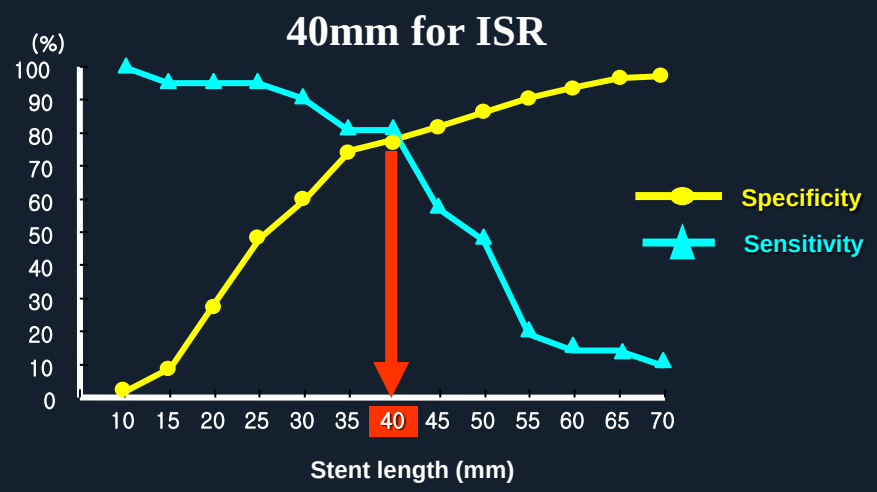
Selective Stenting for Coronary Tandem Lesion According to ΔFFR



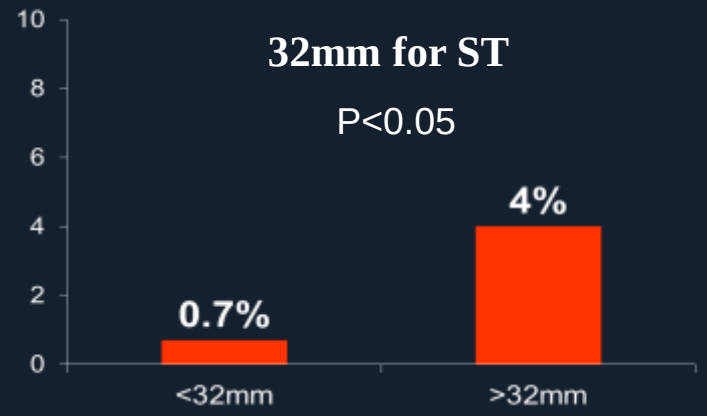


Park SJ, Ahn JM, et al Am J Cardiol. 2012 Dec 1;110(11):1578-84
Ahn JM, Park SJ, et al in Submission

IVUS



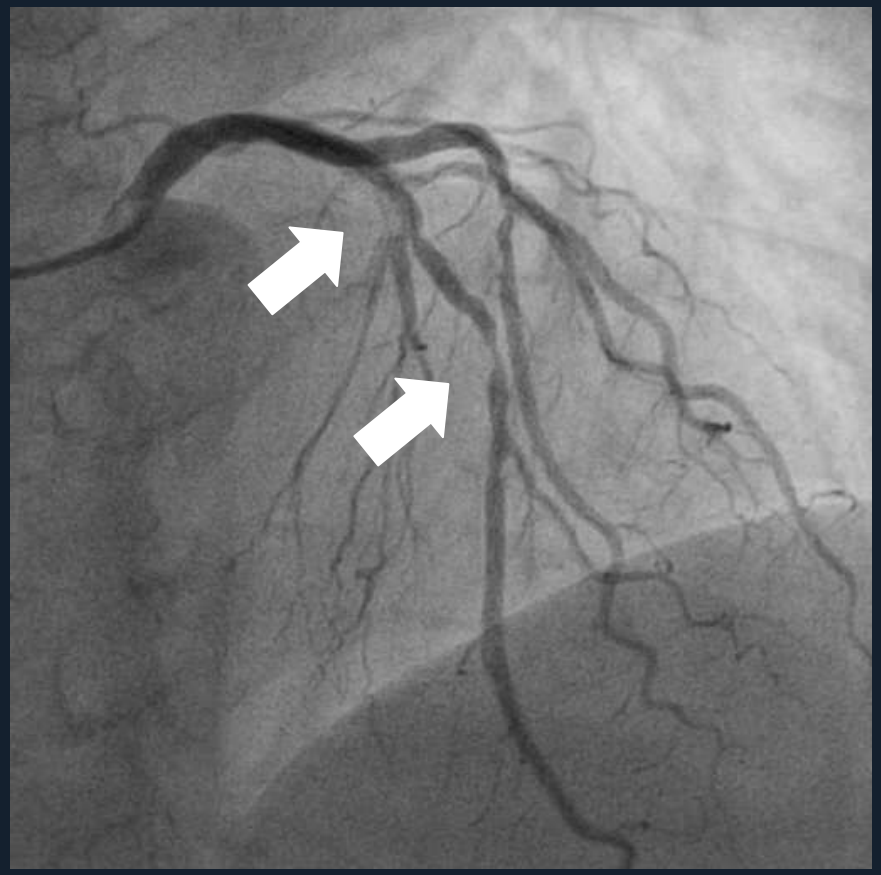
Hong MK, Park SJ, et al. Eur Heart J 2006;27(11):1305-10

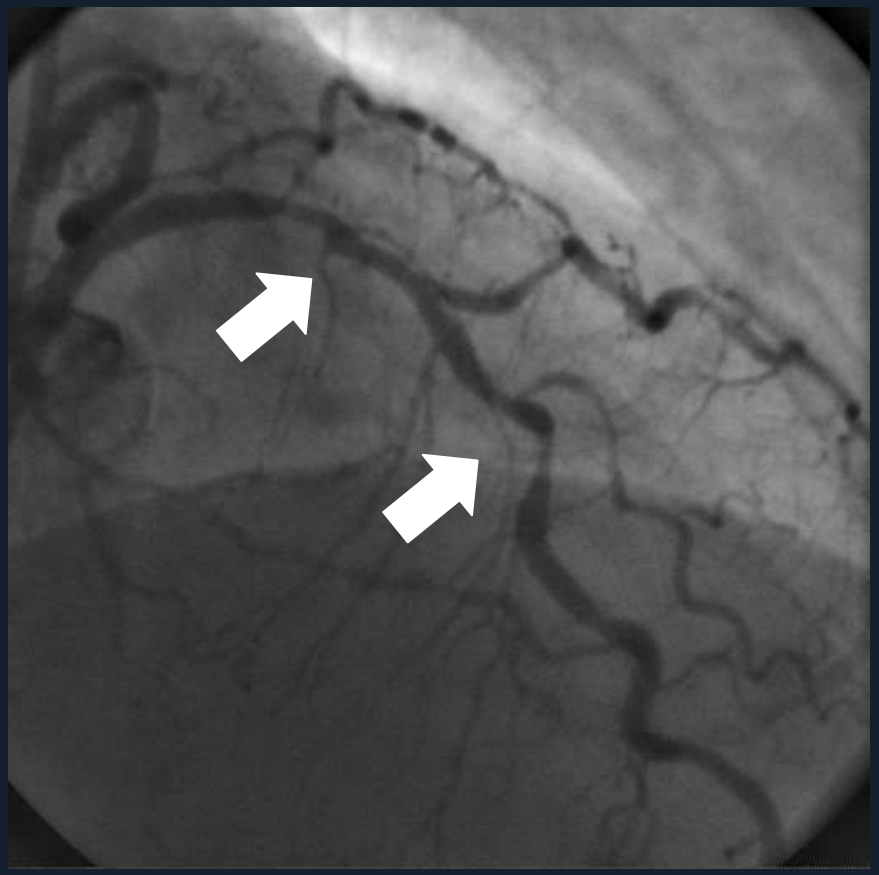


Suh J, Park SJ, et al. JACC CI 2010;3:383-9

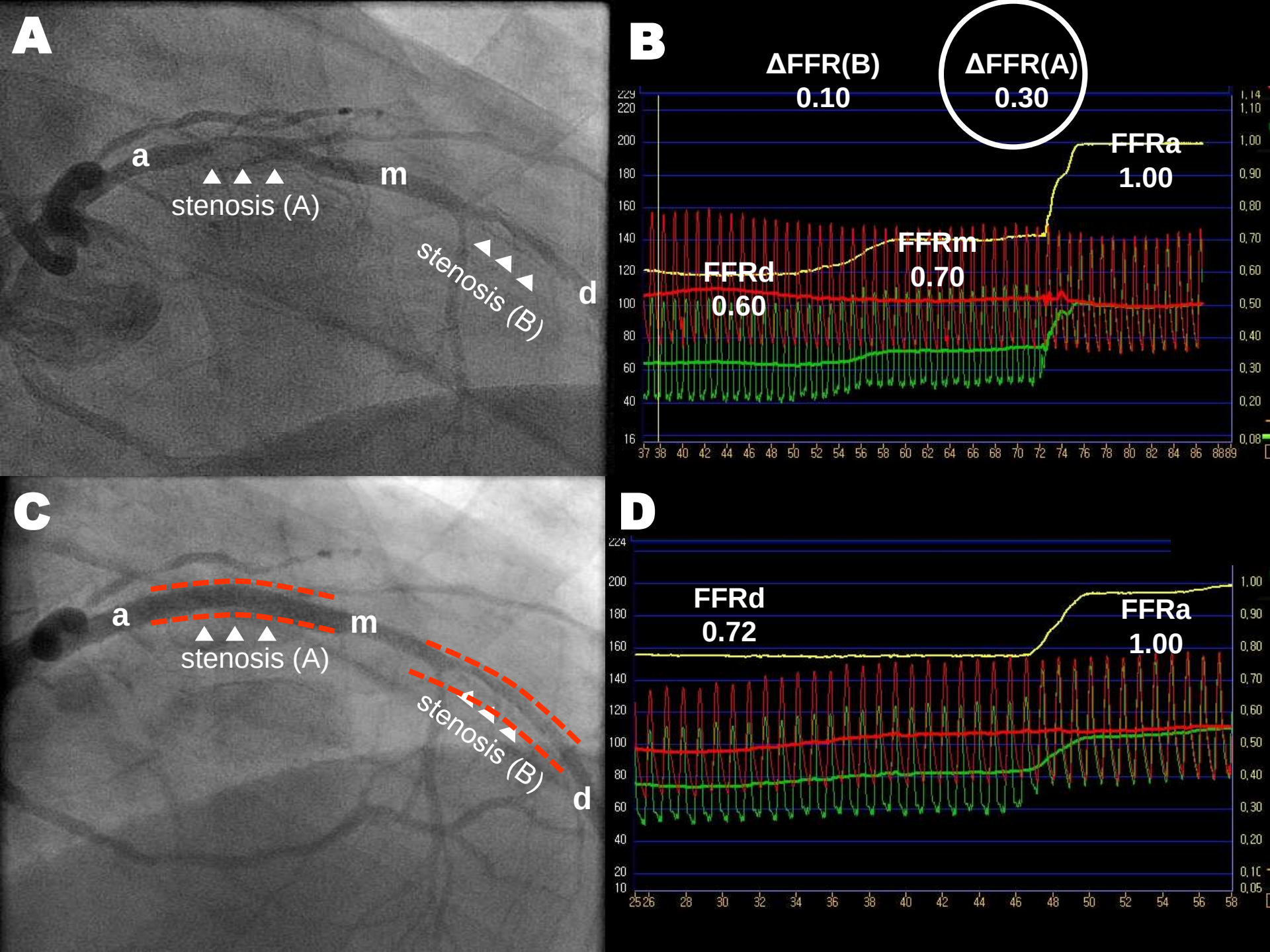
Tandem Lesions

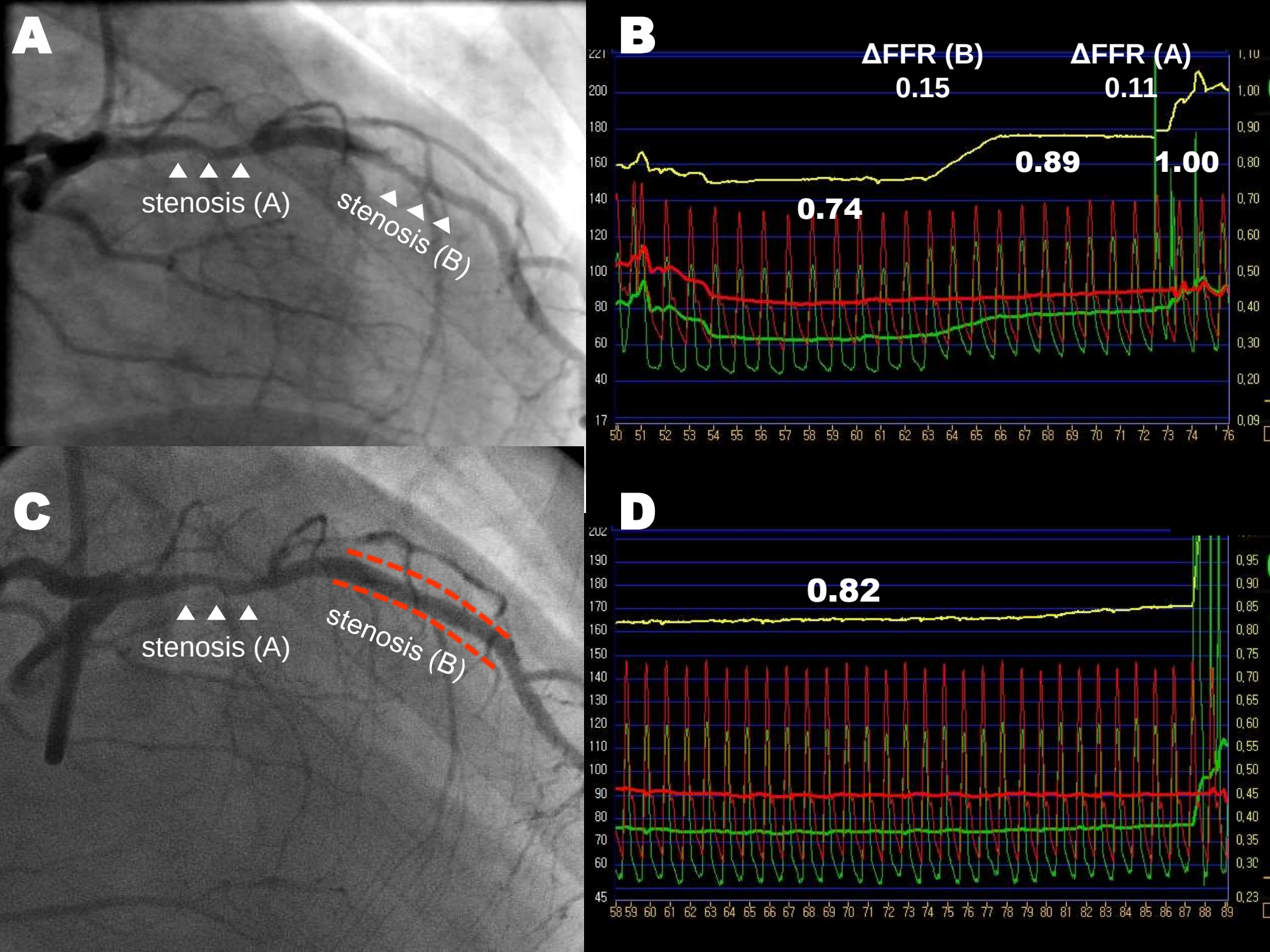
Multiple stenoses in series along one coronary artery



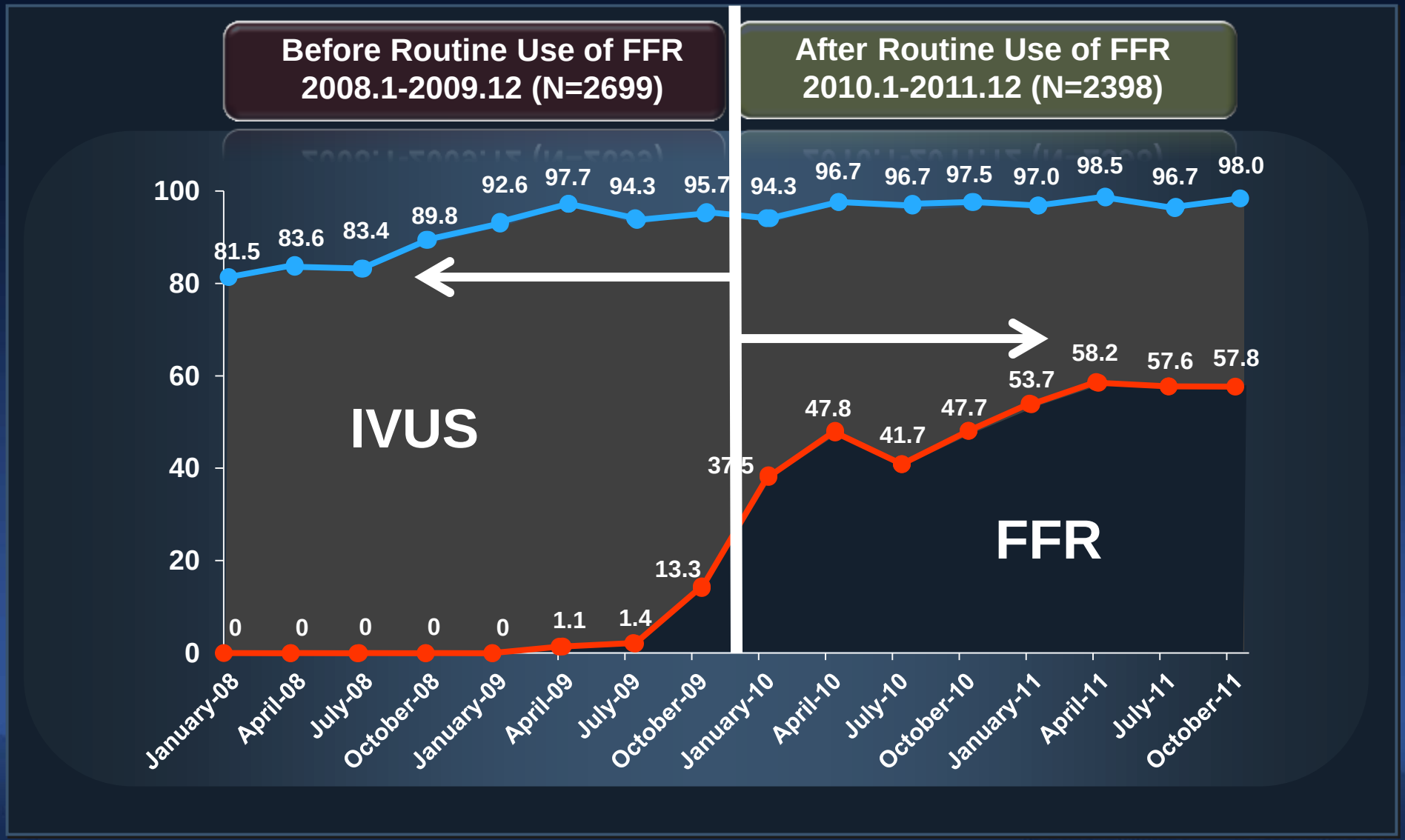


Park SJ, Ahn JM, et al Am J Cardiol. 2012 Dec 1;110(11):1578-84


A
a
m
d
stenosis (A)
stenosis (B)
B
ΔFFR(B)
0.10
ΔFFR(A)
0.30
FFRa
1.00
FFRm
0.70
FFRd
0.60
C
a
m
d
stenosis (A)
stenosis (B)
D
FFRd
0.72
FFRa
1.00

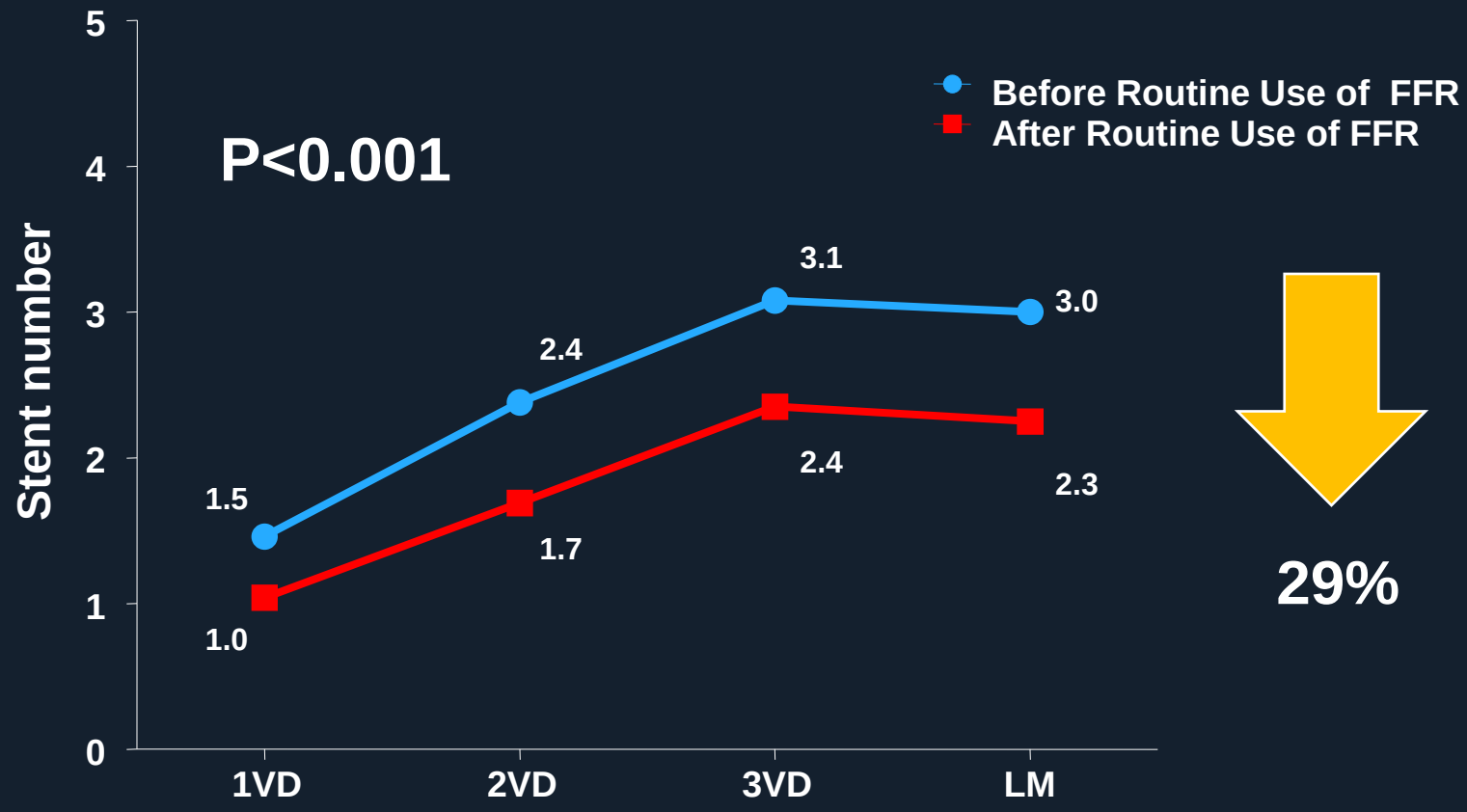

A
stenosis (A)
stenosis (B)
B
ΔFFR (B)
0.15
ΔFFR (A)
0.11
0.89
1.00
0.74
C
stenosis (A)
stenosis (B)
D
0.82

Rate of FFR Use in Asan Medical Center

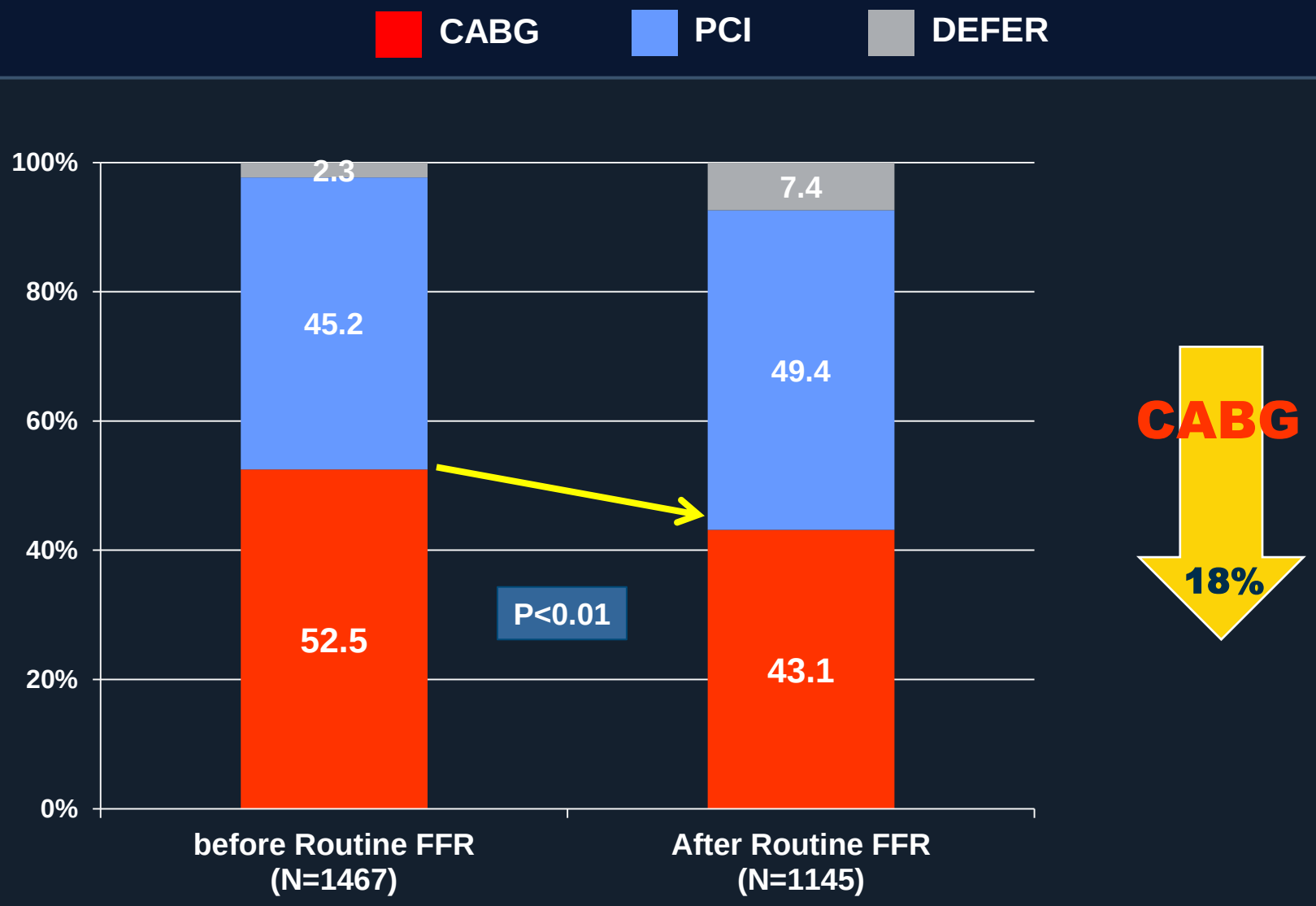


Changes in PCI procedure

Stent Number

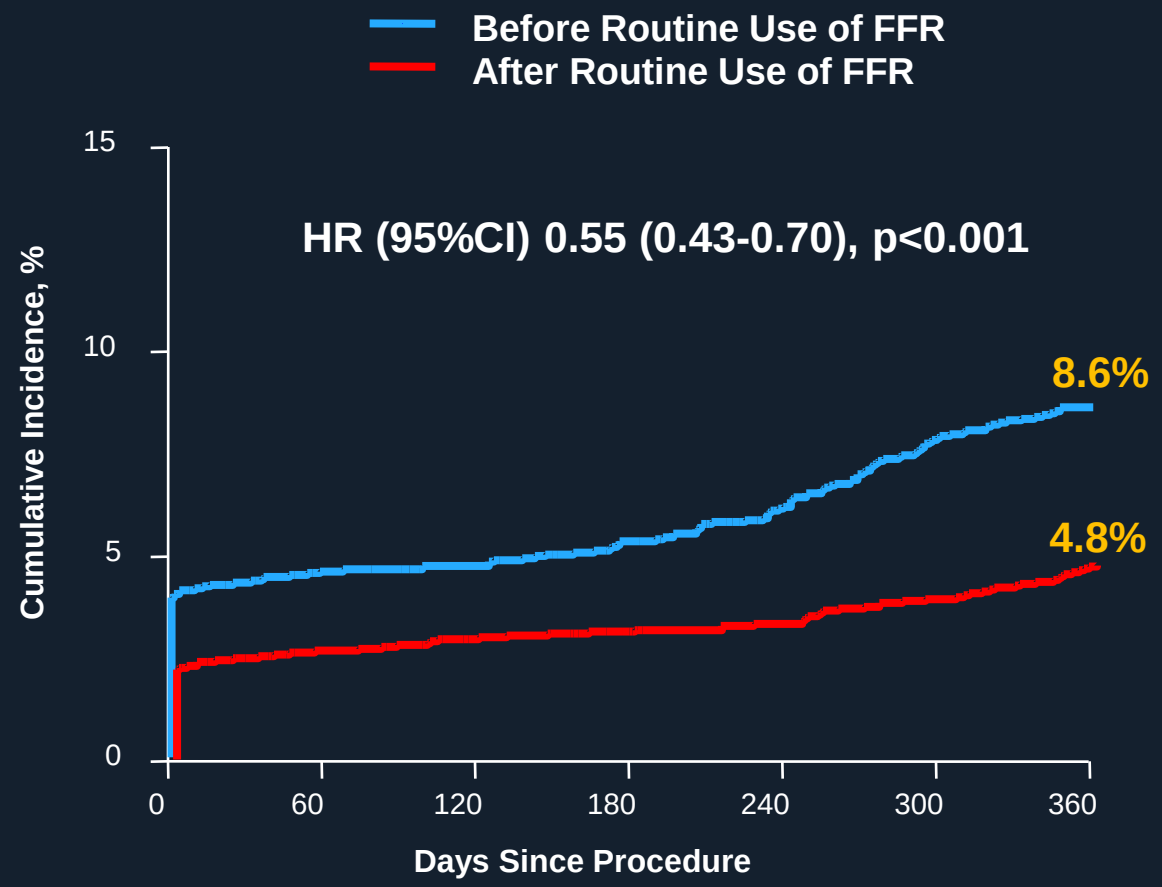


Treatment Strategy



PCI Outcome

(Death, MI, or Repeat Revascularization)



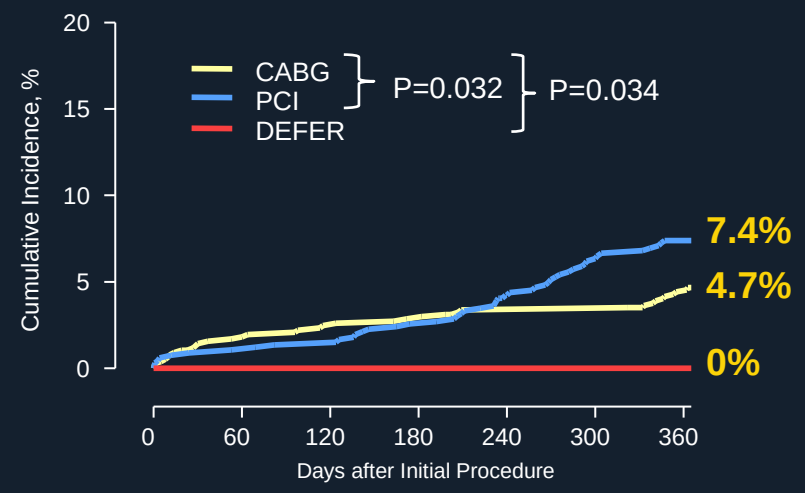
41%

No. at Risk				
Before Routine Use	2178	2066	2011	1960
After Routine Use	2178	2092	2067	2037

Left Main and 3VD

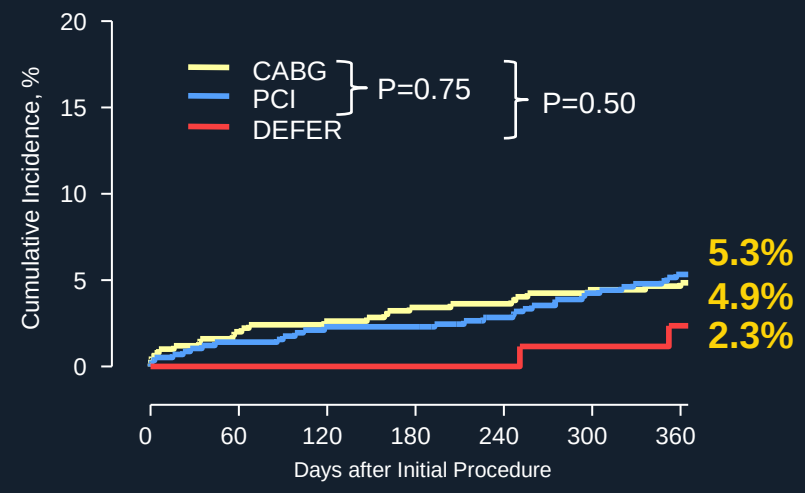
(Death, MI, Stroke or Repeat Revascularization)

Before Routine FFR (2008-2009)



CABG	770	751	743	734
PCI	663	655	634	612
DEFER	34	34	34	34

After Routine FFR (2010-2011)



CABG	494	482	477	471
PCI	566	553	545	531
DEFER	85	85	85	84

Unadjusted K-M curve

Optimal Revascularization Results

Integrated Use of FFR and IVUS

FFR guided Decision Making
IVUS guided Stent Optimization