Clinical Implementation of IVUS

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Disclosure Statement of Financial Interest

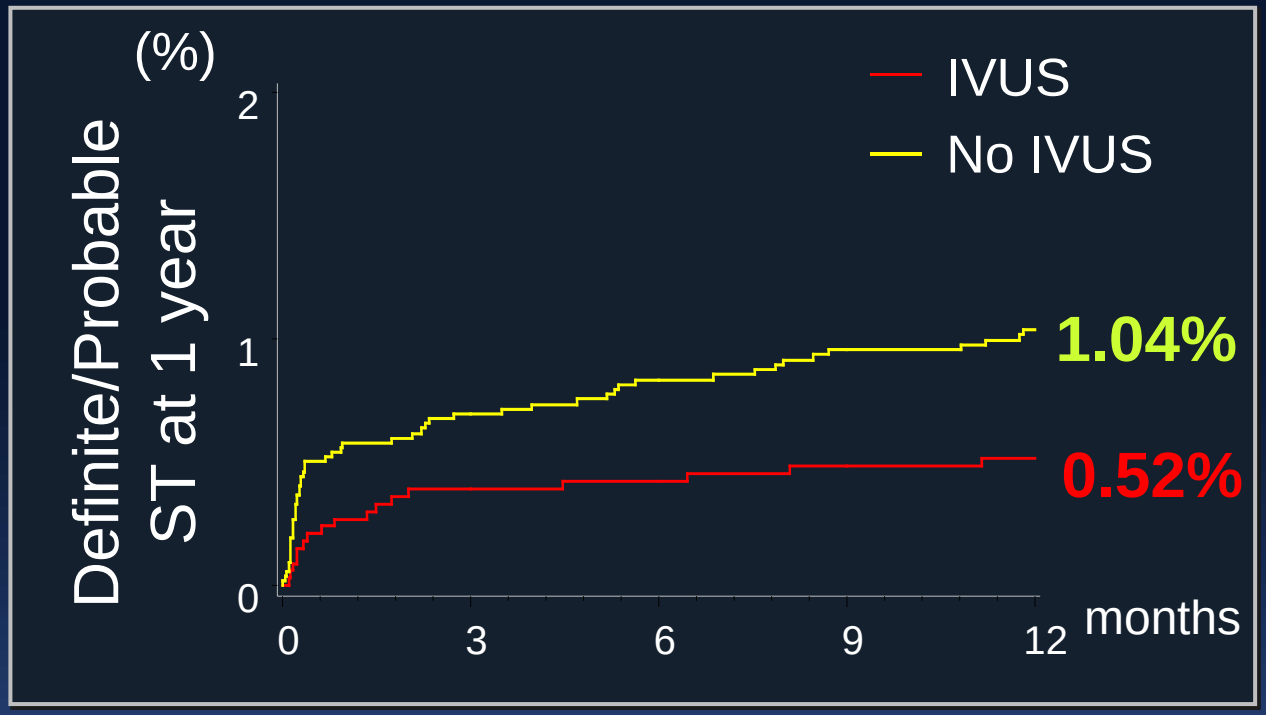
I, Soo-Jin Kang DO NOT have a financial interest /arrangement or affiliation with organizations that could be perceived as a real or apparent conflict of interest in the context of the subject

Meta-analysis: Impact of IVUS on Clinical Outcomes

IVUS- vs. Angio-guided PCI

	Year	RCT	Non-RCT	Pt. No.	HR (p value)				
					MACE	Death	MI	ST	TLR
Zhang et al Eurointerv	2012	1	10	19,619	**0.87 (0.008)**	**0.59 (<0.001)**	0.82 (NS)	**0.58 (<0.001)**	0.90 (NS)
Klersy et al. Int J Cardiol	2013	3	9	18,707	**0.80 (<0.001)**	**0.60 (<0.001)**	**0.59 (0.001)**	**0.58 (0.007)**	0.95 (NS)
Jang et al. JACC interv	2014	3	12	24,869	**0.79 (0.001)**	**0.64 (<0.001)**	**0.57 (<0.001)**	**0.59 (0.002)**	**0.76 (0.01)**
Ahn et al. Am J Cardiol	2014	3	14	26,503	**0.74 (<0.001)**	**0.61 (<0.001)**	**0.57 (<0.001)**	**0.59 (<0.001)**	**0.81 (0.046)**

ADAPT-DES 1-year Outcomes



p=0.01
HR 0.50
95%CI 0.29-0.86

	IVUS n = 3349	No IVUS n = 5234	p Value
Definite/probable ST	0.52% (17)	1.04% (53)	0.011
All myocardial infarction	2.46% (81)	3.68% (188)	0.0022
Ischemic driven TVR*	2.42% (81)	3.95% (207)	0.0001

Witzenbichler et al. Circulation 2014;129:463-70

Clinical Implementation of IVUS

- **Treat or Not?**
- **PCI Optimization**
- **IVUS- vs. OCT-guided PCI**

Meta-analysis of 11 Clinical Trials

1759 patients with 1953 lesions

Predict FFR<0.80

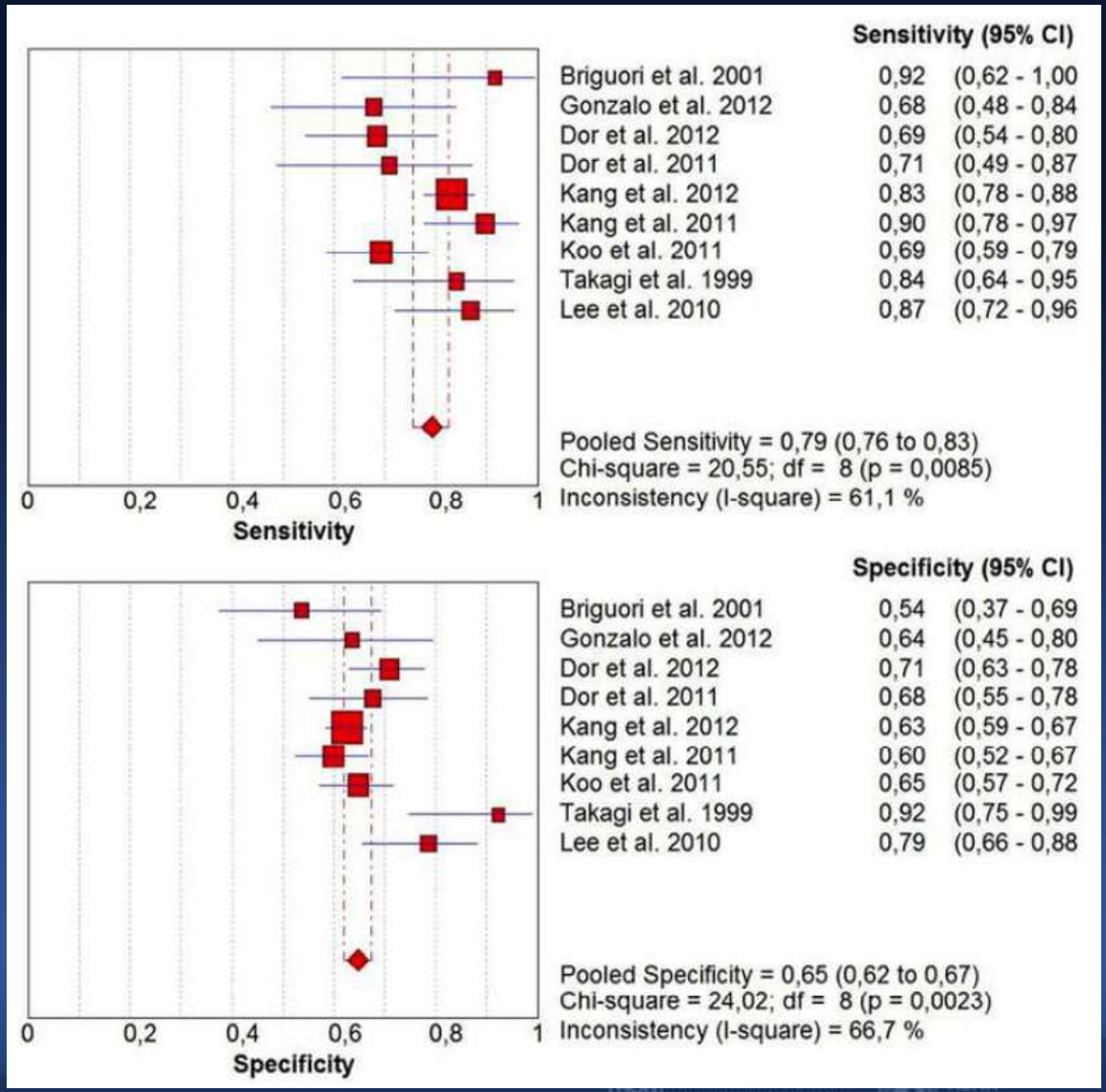
Weighted **MLA 2.61**mm^2

Pooled sensitivity **79%**

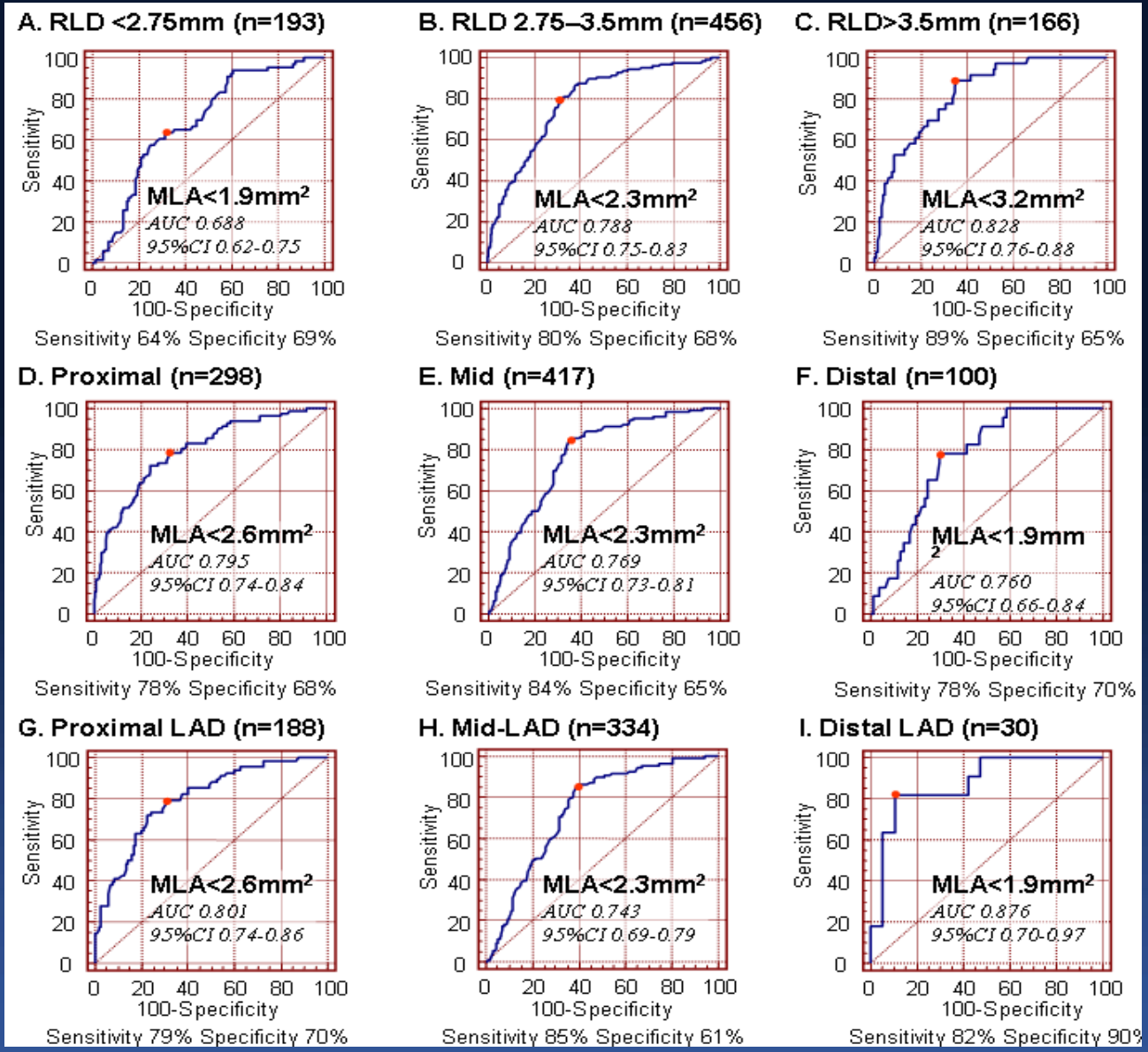
Pooled specificity **65%**

Smaller Cut-off than Used

Poor Accuracy



Nascimento et al. Catheter Cardiovasc Interv 2013 (in press)



All Subgroup-specific MLA, Accuracies <70-75%

Kang et al. Am J Cardiol 2012;109:947-5

Why Mismatch

Nov 2009-Jun 2011, 1000 consecutive patients (1129 lesions with DS >30%) who underwent pre-PCI IVUS and FFR *(ClinicalTrials.gov NCT01366404)*

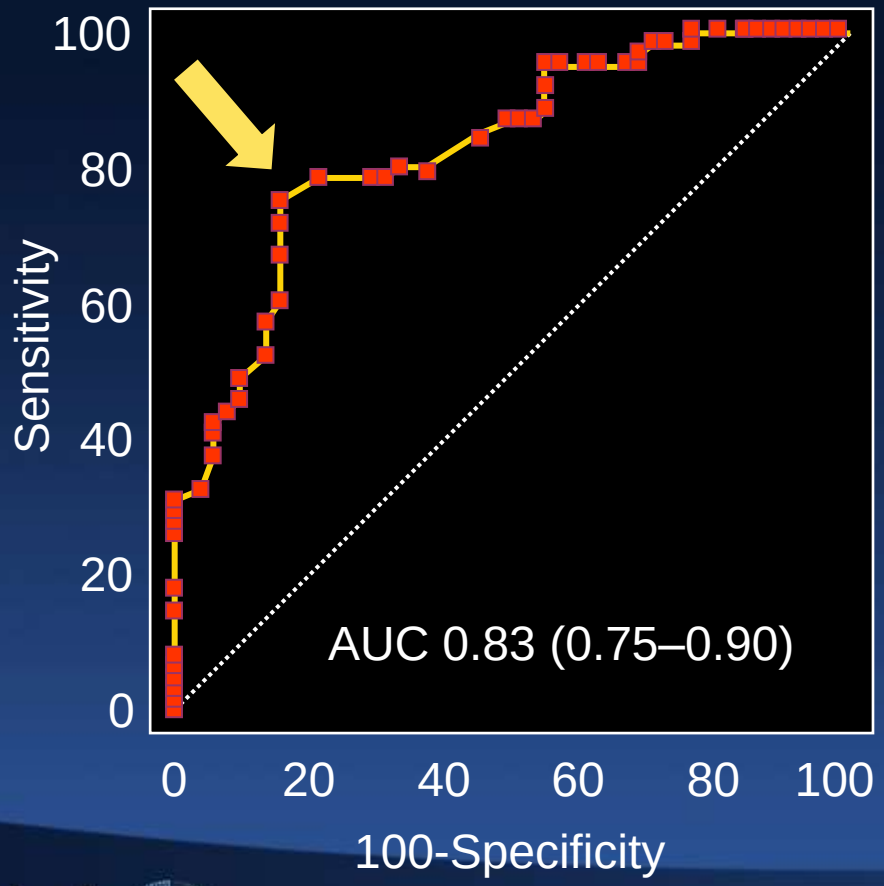
Factors Affecting FFR

	Beta	p-value	95% CI
Age	0.008	<0.001	0.004 - 0.011
LAD location	-0.386	<0.001	-0.462 - 0.311
Lesion length	-0.006	<0.001	-0.009 - 0.003
Minimal lumen area	0.185	<0.001	0.149 - 0.222
Plaque burden	-0.006	<0.004	-0.009 - 0.003
Plaque rupture	-0.165	0.020	-0.302 - 0.027

Park et al. JACC interv 2012;5:1029-36

New LM MLA 4.5 mm^2

Matched with FFR <0.80
Ostial and Shaft LM Disease (N=112)

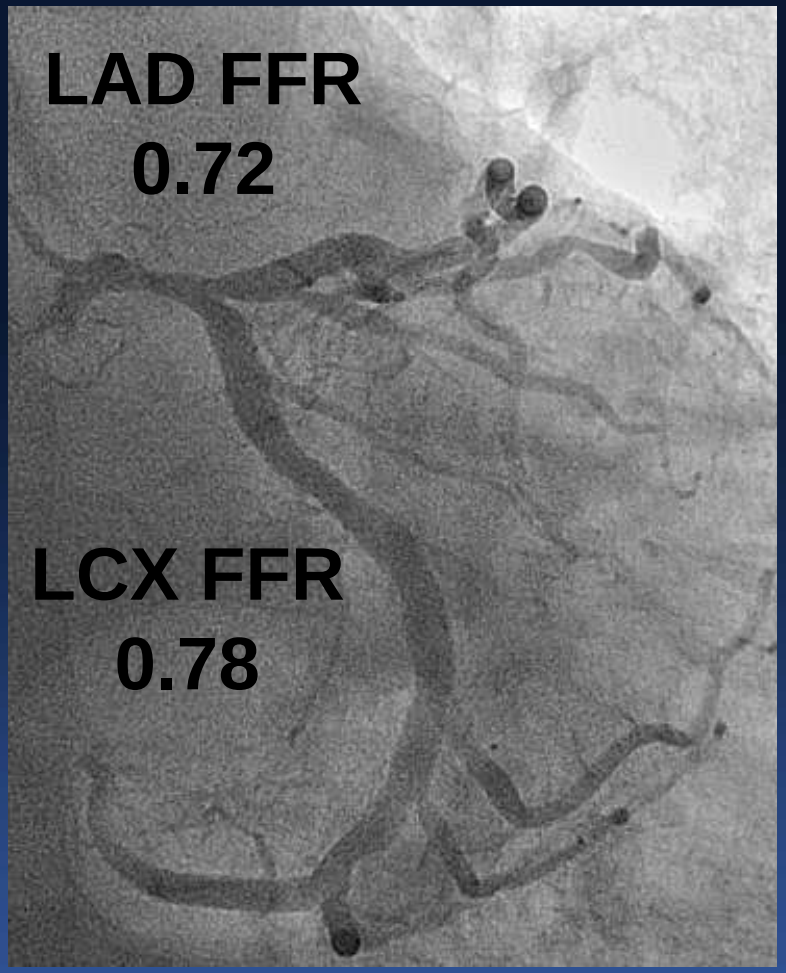


Sensitivity	79%
Specificity	80%
PPV	83%
NPV	76%

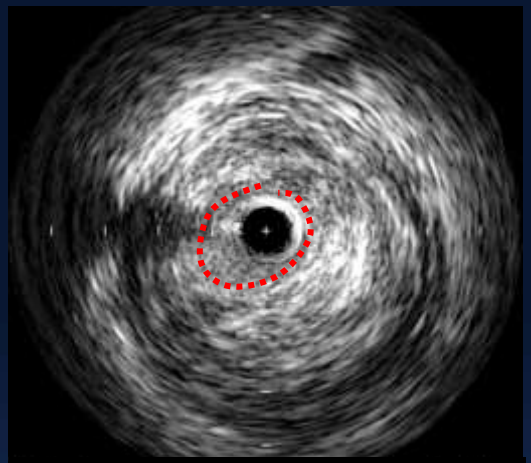
IVUS-MLA can be alternatively used in pure LM lesions

Park SJ, Ahn JM et al. JACC Interv (in press)

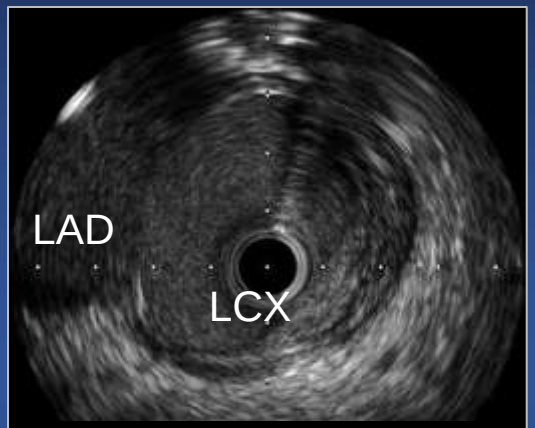
Stent Strategy for LMCA Bifurcation



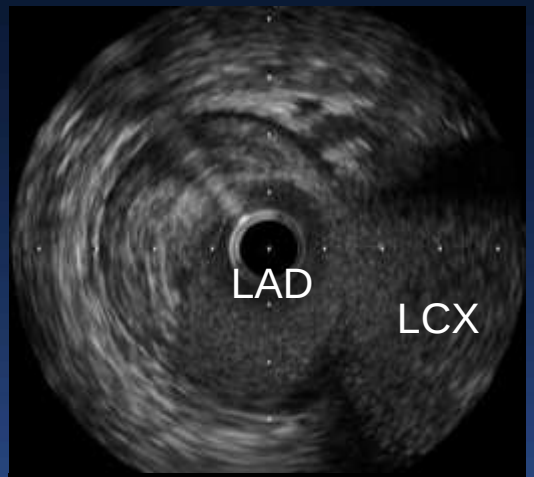
How big?
How severe?



Distal LM
EEMφ 6.2mm
MLA 3.0mm^2

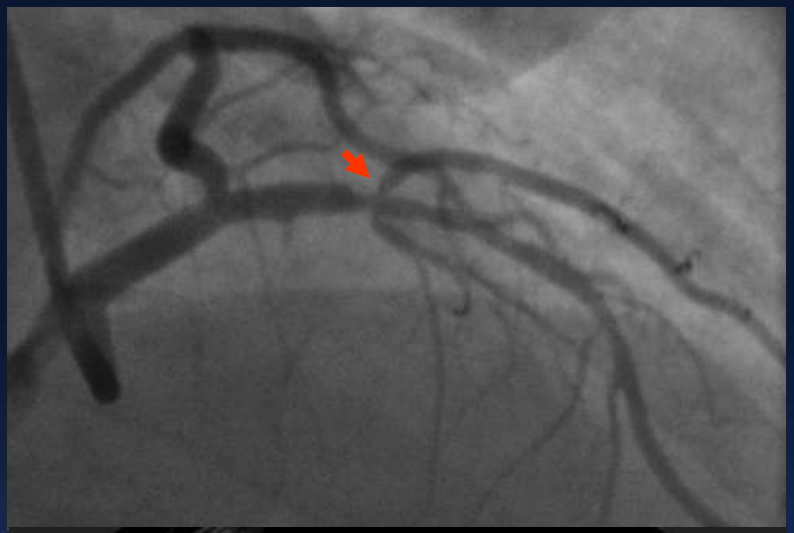


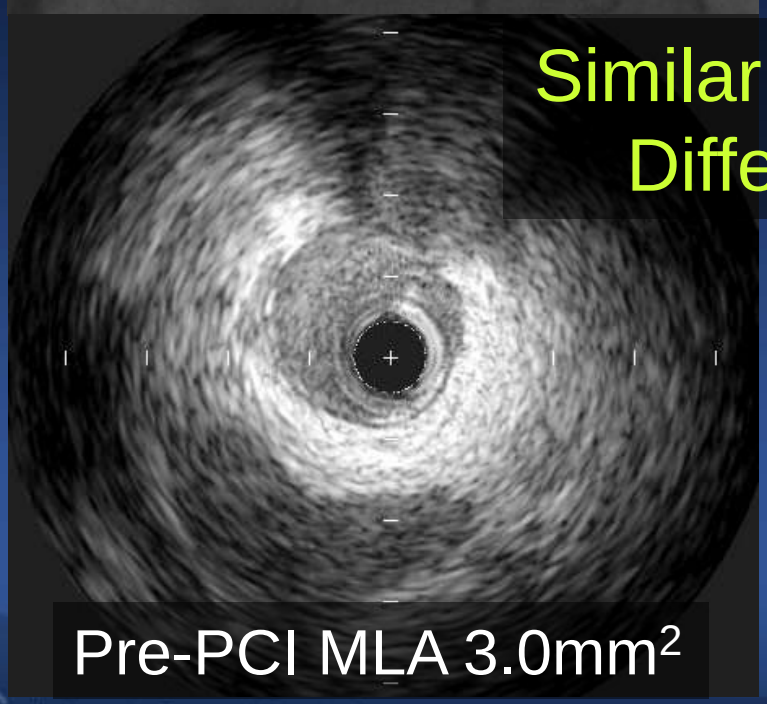
LCX os minimal



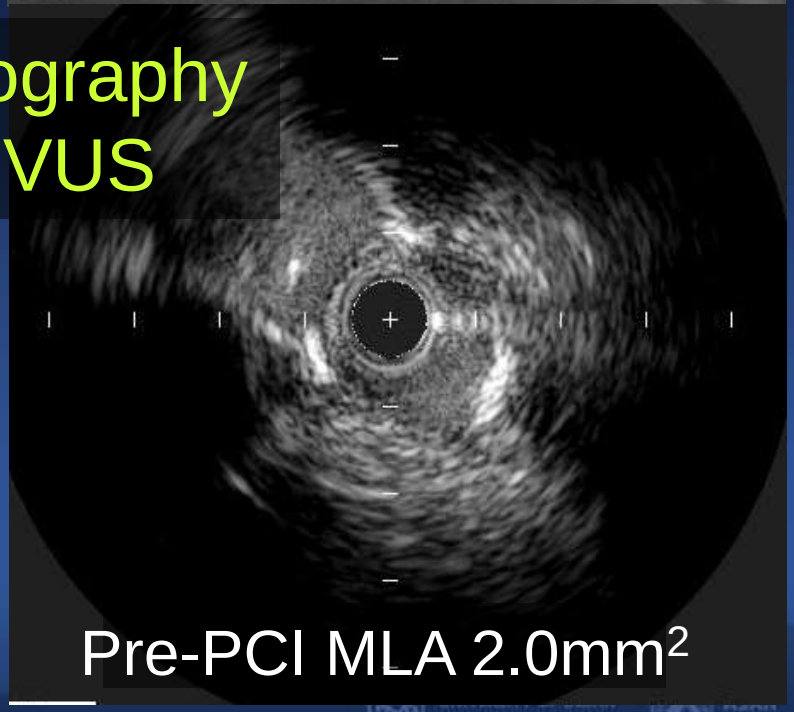
LAD os
EEMφ 5.2mm
MLA 6.0mm^2

SB-IVUS in Non-LMCA Bifurcation





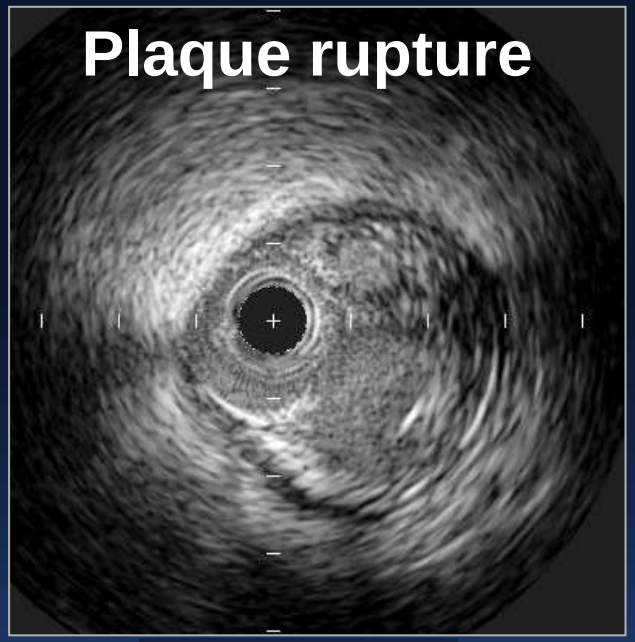
Similar angiography
Different IVUS

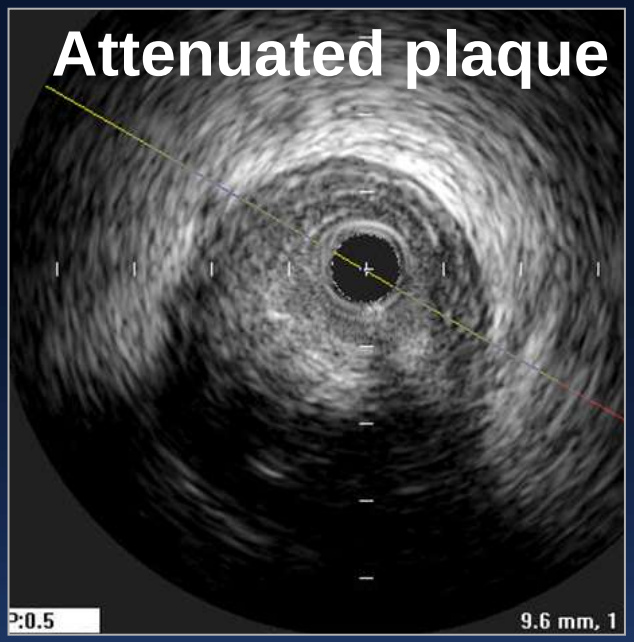


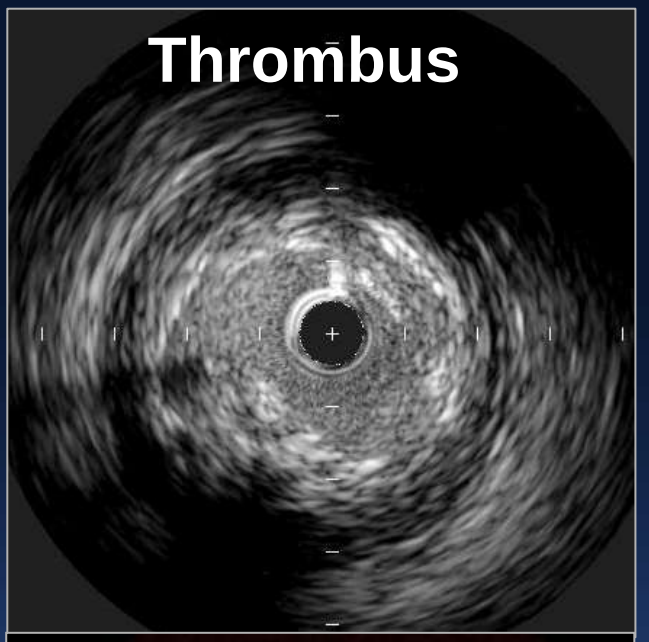
Pre-PCI MLA 3.0mm^2

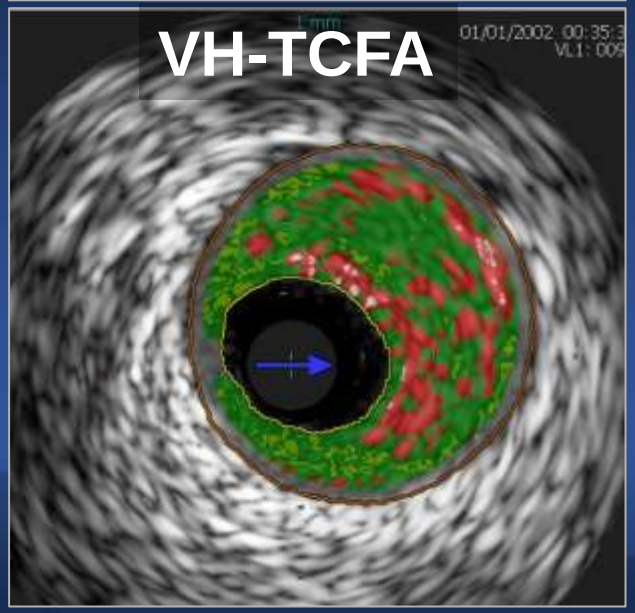
Pre-PCI MLA 2.0mm^2

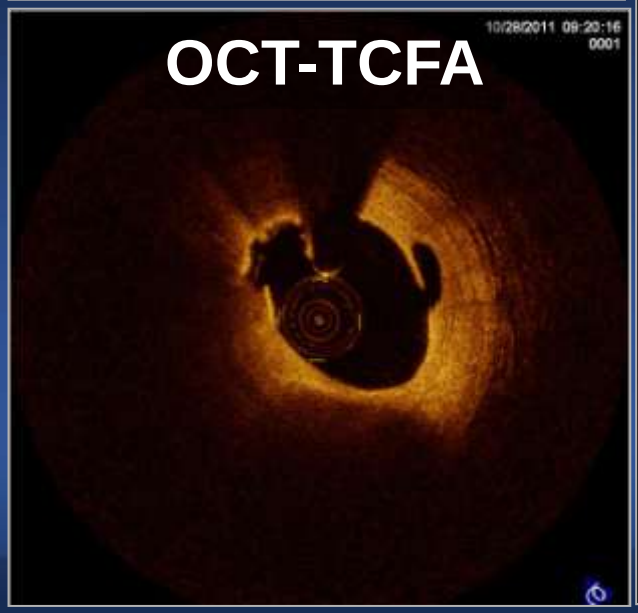
Predictor for Distal Embolization



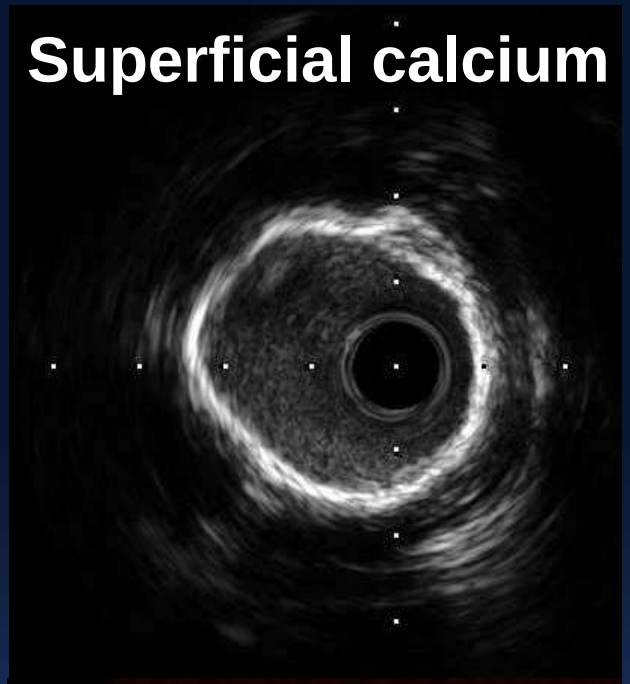






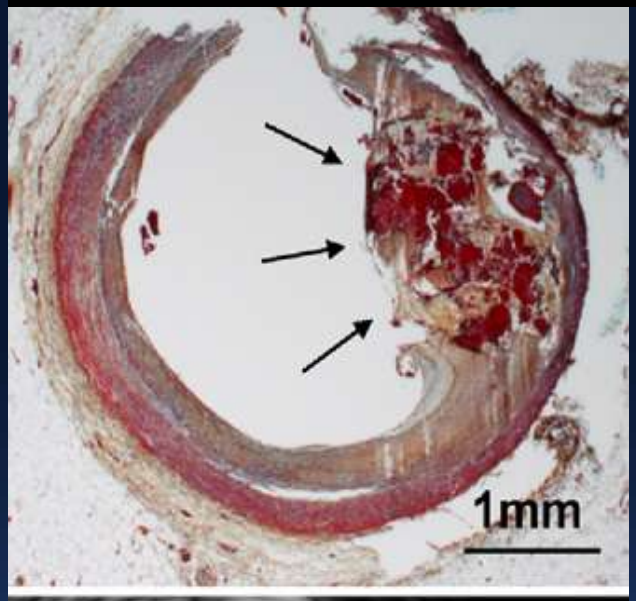


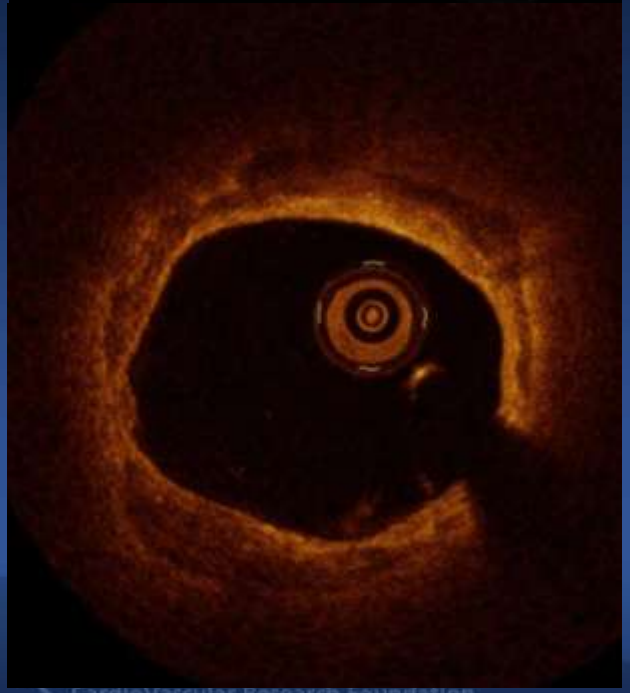
Superficial calcium



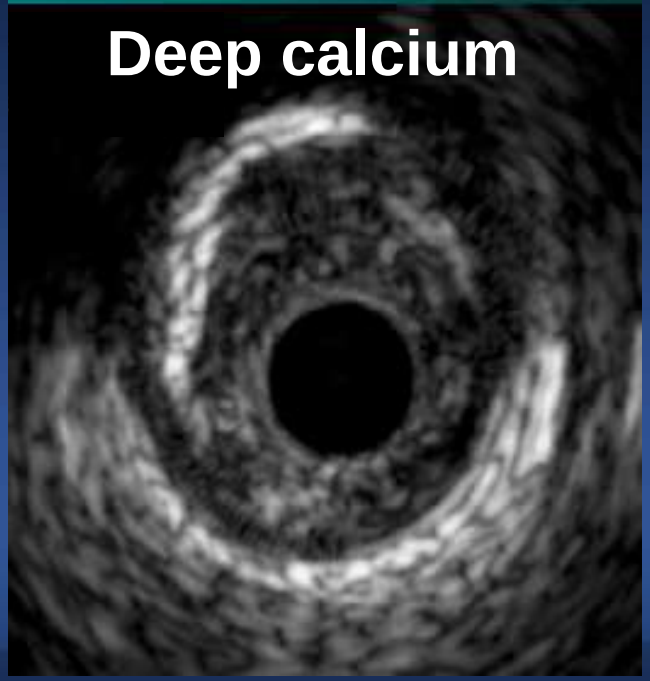
Superficial calcium

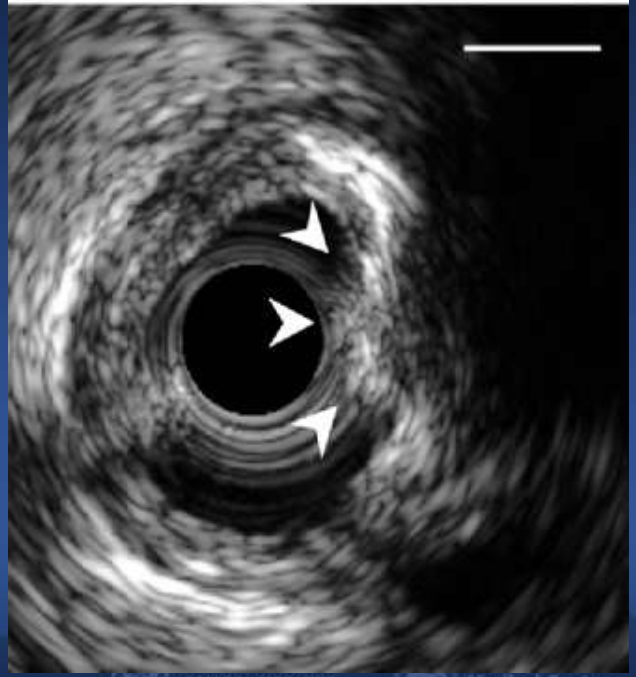
Calcified nodule





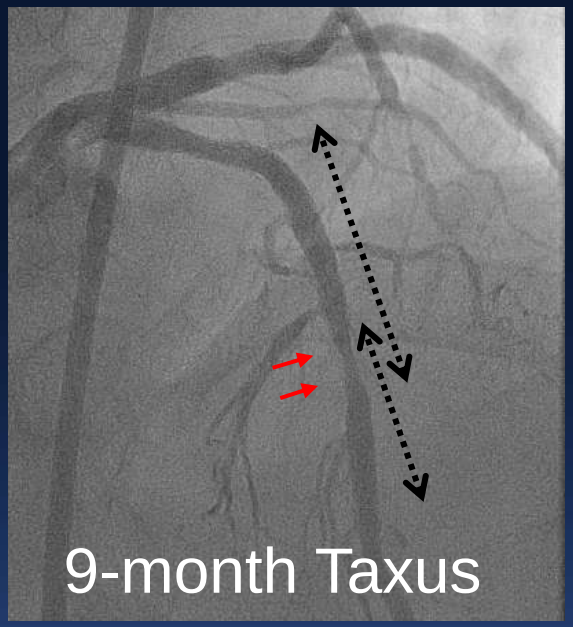
Deep calcium



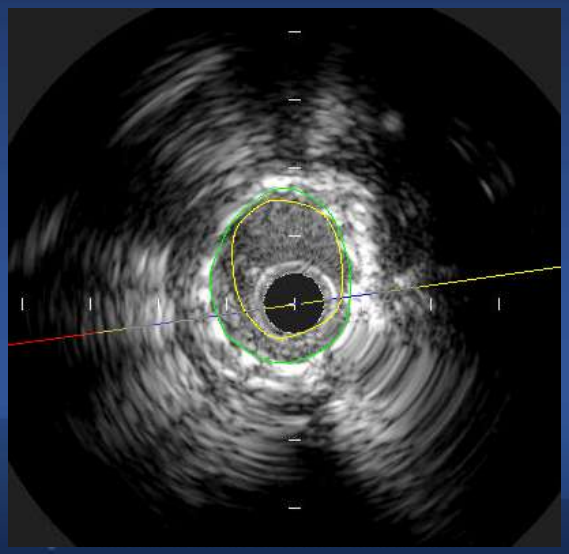


Mechanism of In-stent Restenosis

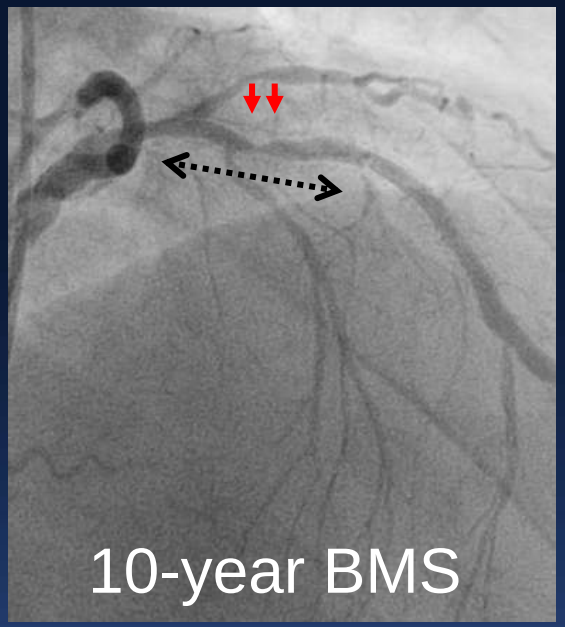
Underexpansion



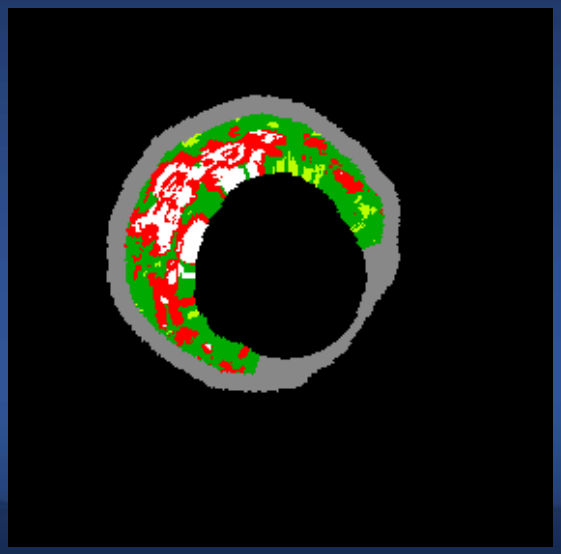
9-month Taxus



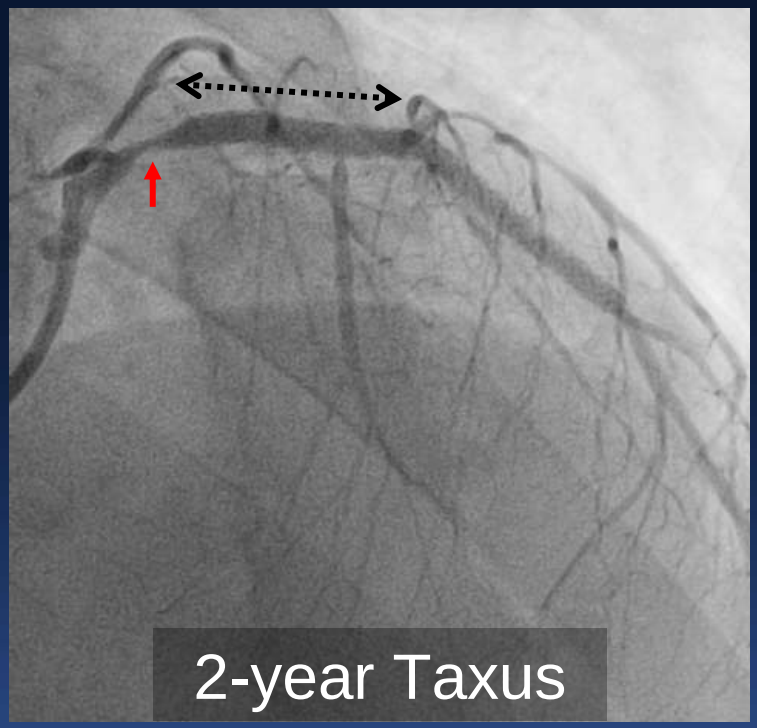
Intimal HP



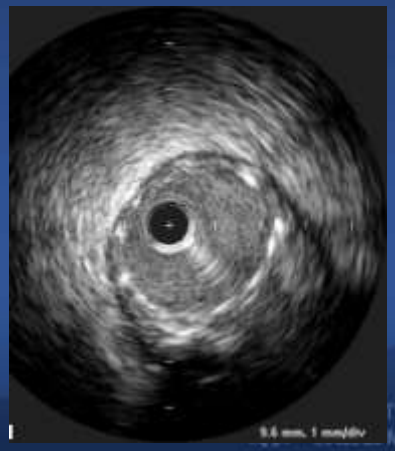
10-year BMS

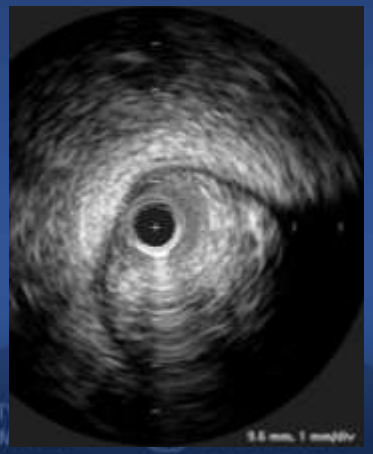


Edge Restenosis



2-year Taxus

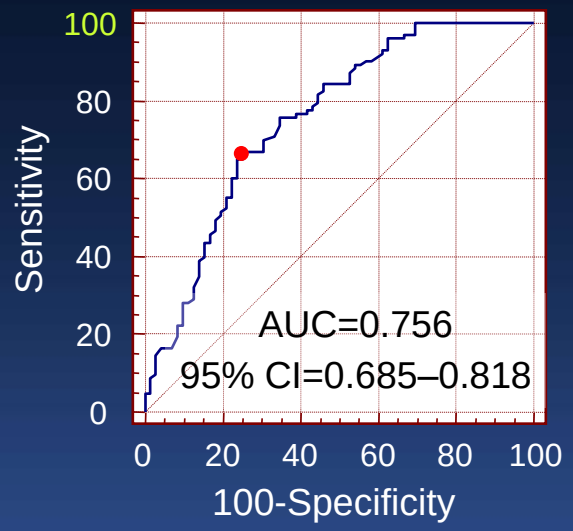




Predictors for Functionally Significant In-stent Restenosis (Positive SPECT)

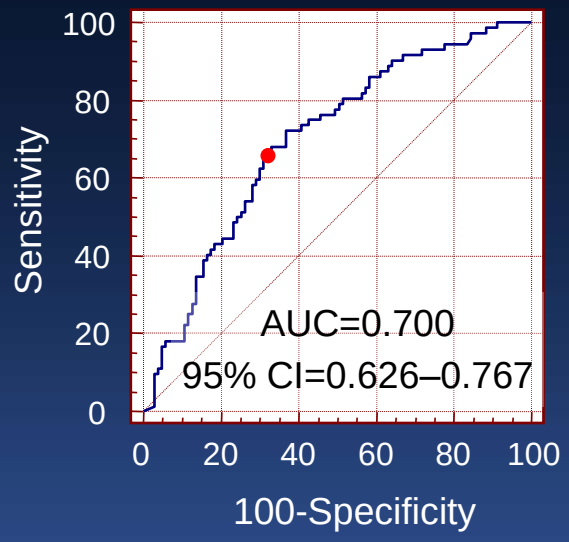
175 patients with ISR of single coronary artery

In-seg MLA≤1.9mm^2



sensitivity 67%
specificity 75%
accuracy 70%

%IH>68%



sensitivity 67%
specificity 69%
accuracy 68%

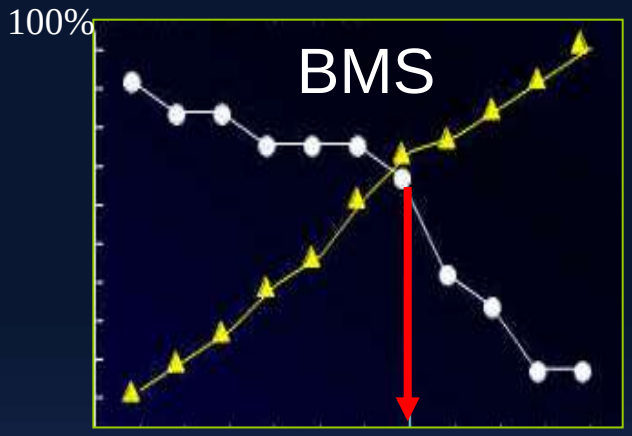
Kang et al. JACC Cardiovasc Imaging 2013 in press

PCI Optimization

IVUS Predictors of DES Early Thrombosis & Restenosis

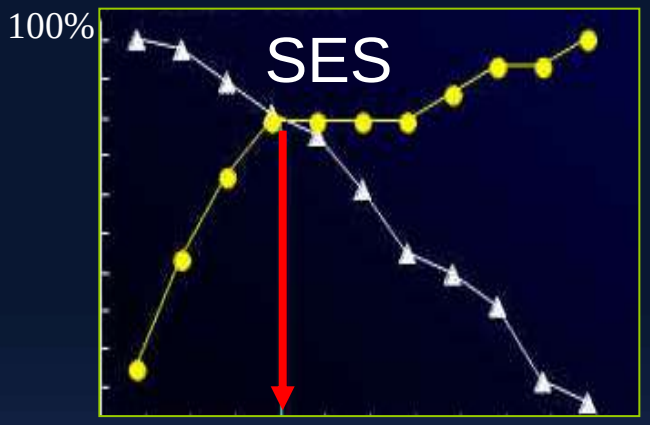
	Early Thrombosis	Restenosis
Small MSA or MLA or underexpansion	•*Fujii et al. J Am Coll Cardiol 2005;45:995-8* •*Okabe et al. Am J Cardiol. 2007;100:615-20* •*Liu et al. JACC Cardiovasc Interv. 2009;2:428-34* •*Choi et al. Circ Cardiovasc Interv 2011;4:239-47*	•*Sonoda et al. J Am Coll Cardiol 2004;43:1959-63* •*Hong et al. Eur Heart J 2006;27:1305-10* •*Doi et al JACC Cardiovasc Interv. 2009;2:1269-75* •*Fujii et al. Circulation 2004;109:1085-1088* •*Kang et al. Circ Cardiovasc Interv 2011;4:9-14* •*Choi et al. Am J Cardiol 2012;109:455-60* •*Song et al. Catheter Cardiovasc Interv, in press*
Edge problems (geographic miss, secondary lesions, large plaque burden, dissections, etc)	•*Fujii et al. J Am Coll Cardiol 2005;45:995-8* •*Okabe et al., Am J Cardiol. 2007;100:615-20* •*Liu et al. JACC Cardiovasc Interv. 2009;2:428-34* •*Choi et al. Circ Cardiovasc Interv 2011;4:239-47*	•*Sakurai et al. Am J Cardiol 2005;96:1251-3* •*Liu et al. Am J Cardiol 2009;103:501-6* •*Costa et al, Am J Cardiol, 2008;101:1704-11* •*Kang et al. Am J Cardiol 2013;111:1408-14* •*Kobayashi et al. ACC2014*

Underexpansion Predicts DES Restenosis



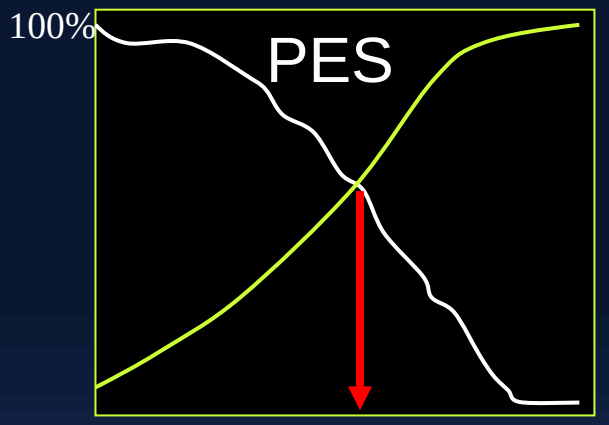
MSA 6.5mm²

Predictive value 56%



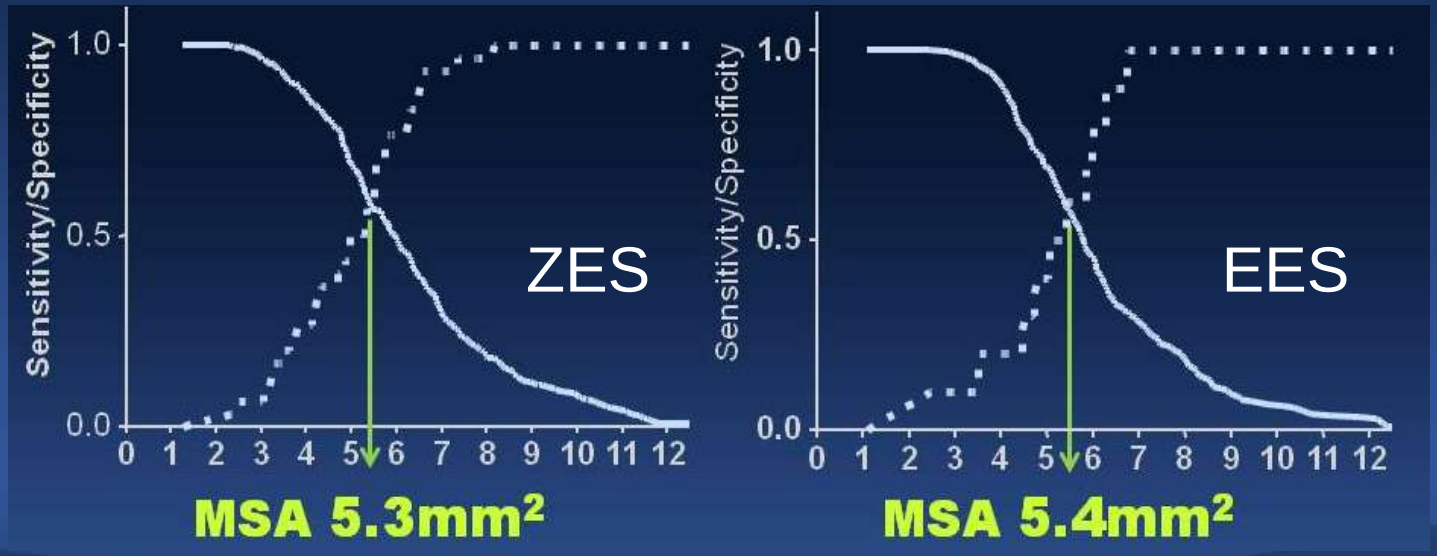
MSA 5.0mm²

Predictive value 90%



MSA 5.7mm²

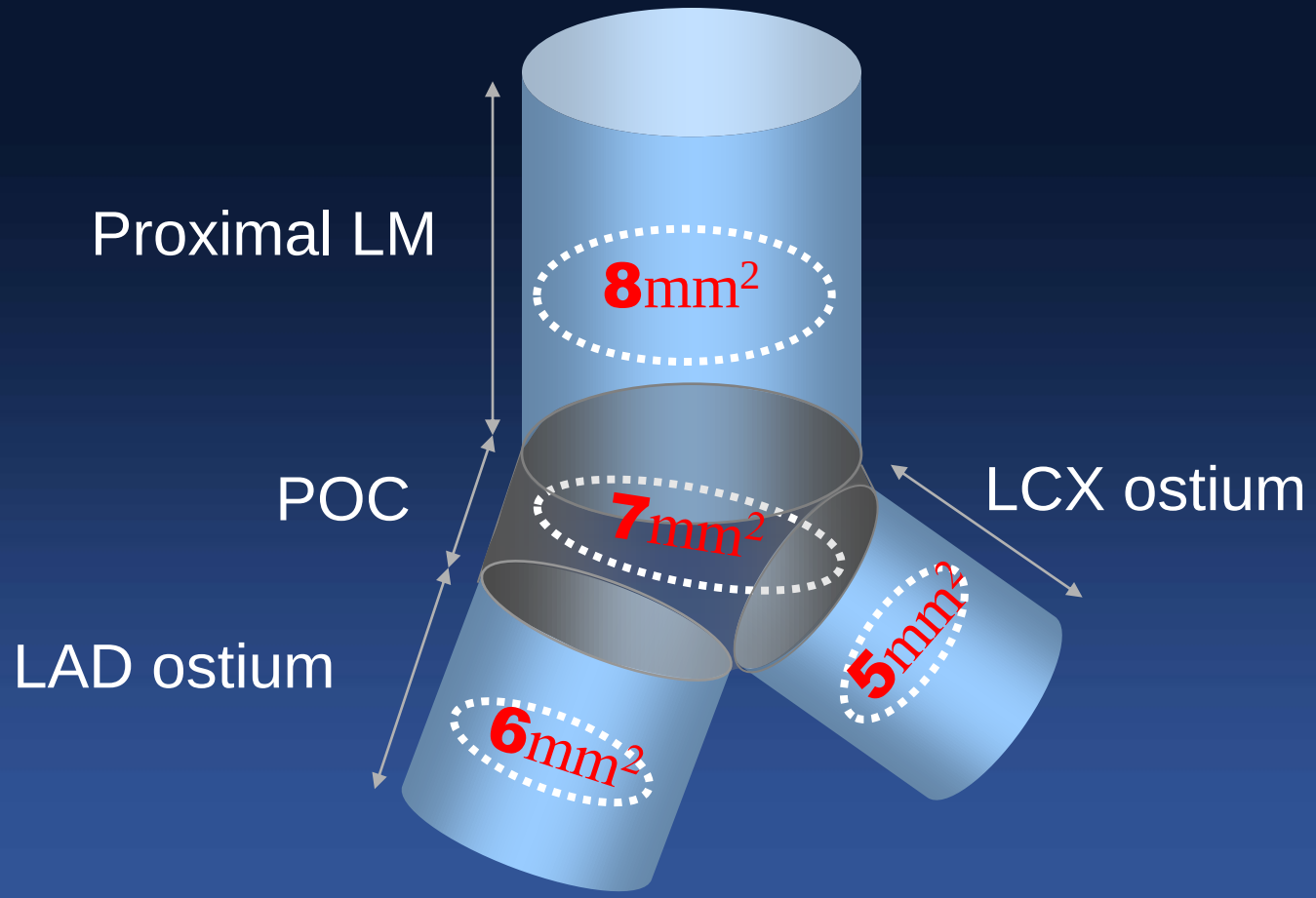
Eur Heart J 2006;27:1305-10
JACC Interv 2009;2:1269-75



Song et al. Catheter Cardiovasc Interv 2012 (in press)

LM Stent Optimization

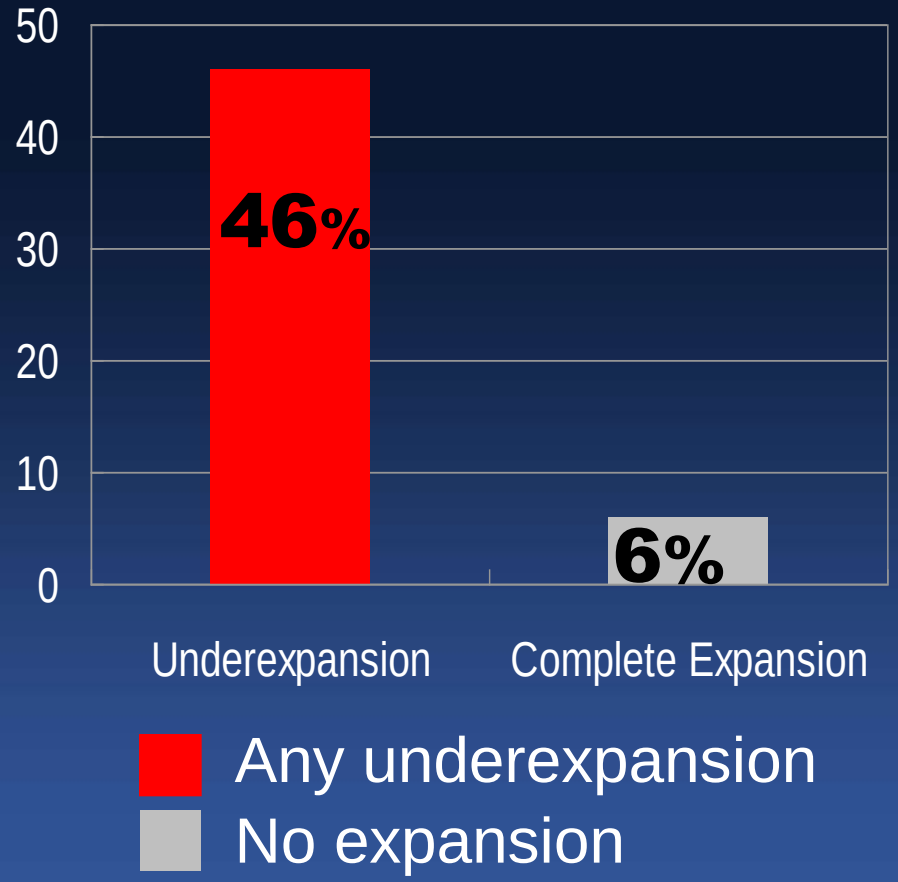
on a segmental basis



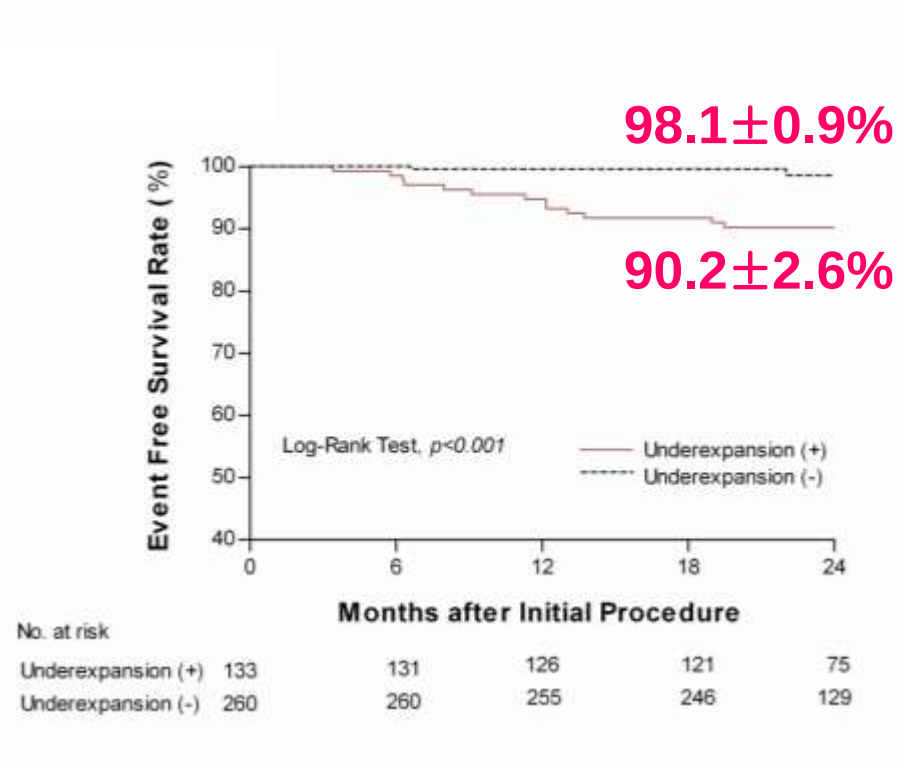
Kang et al. Circ Cardiovasc Interv 2011 2011;4:1168-74

Two-Stent in LMCA Bifurcation

9-month ISR



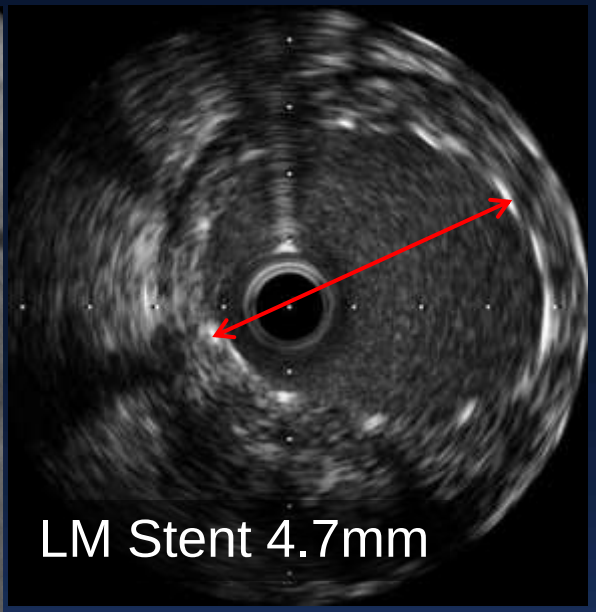
2-yr MACE-free Survival



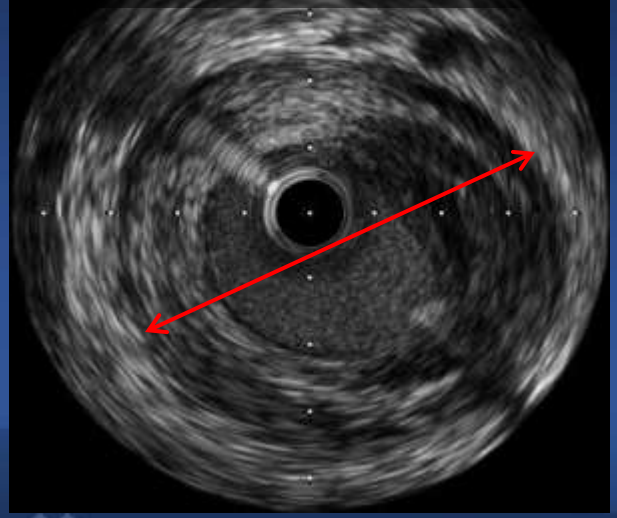
Kang et al. Circ Cardiovasc Interv 2011 2011;4:1168-74

Pre-procedure

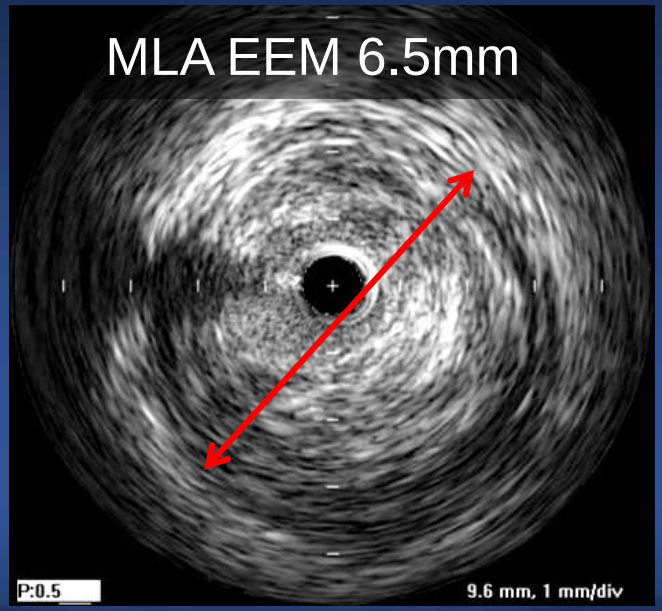
Promus-E 4.0x20mm, high pressure balloon



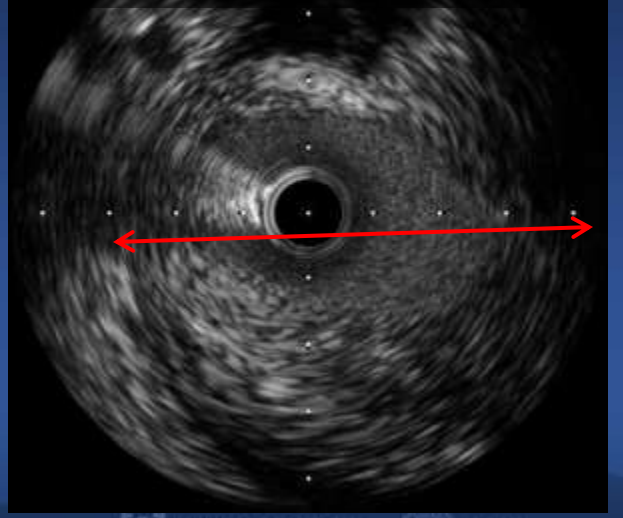
Distal LM EEM 7.0mm



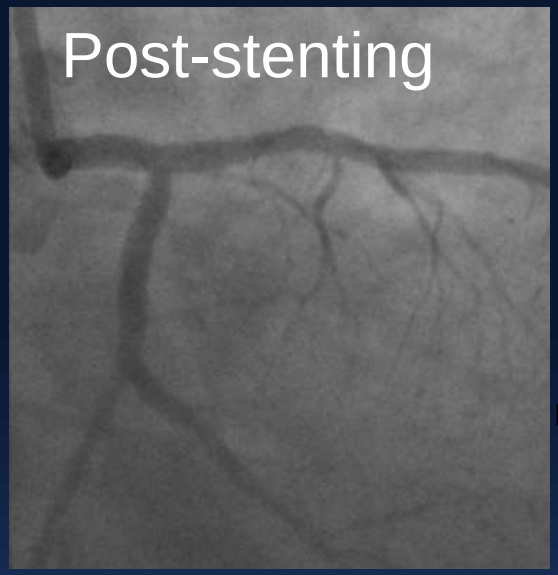
MLA EEM 6.5mm

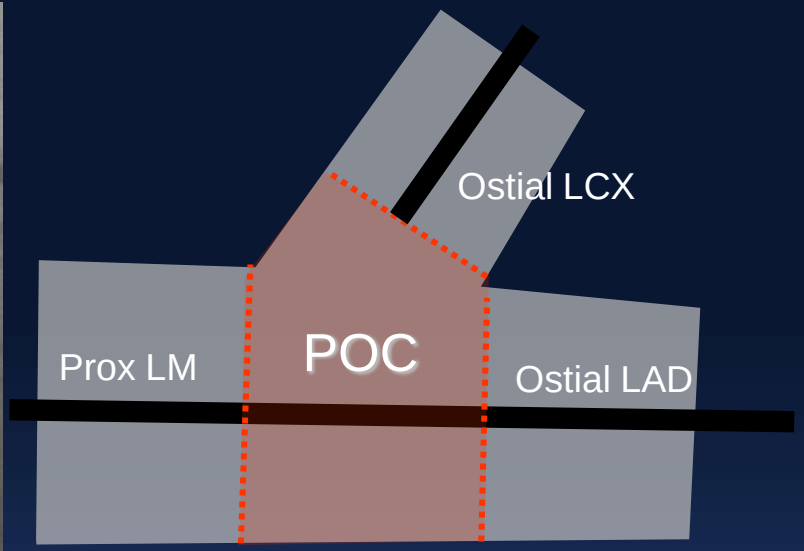


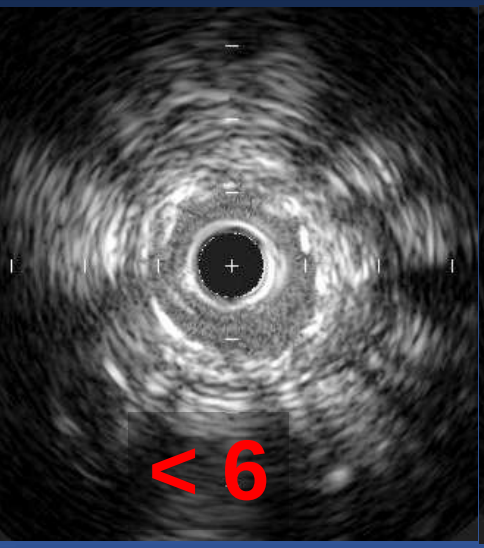
LM ostium EEM>8.0mm

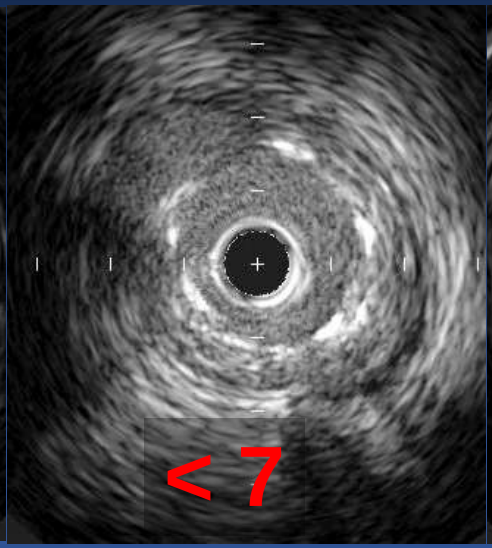


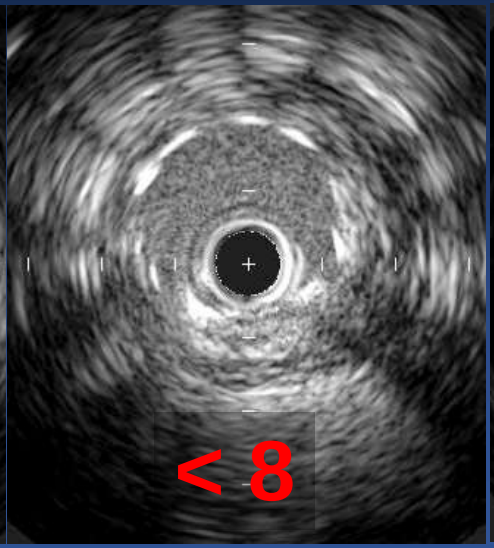
Angiography Poorly Predicts Underexpansion

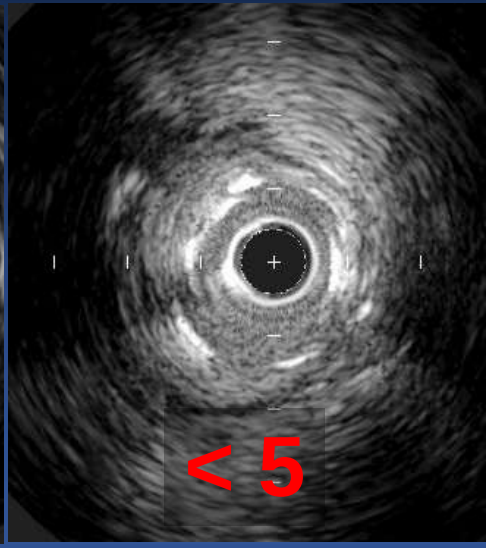










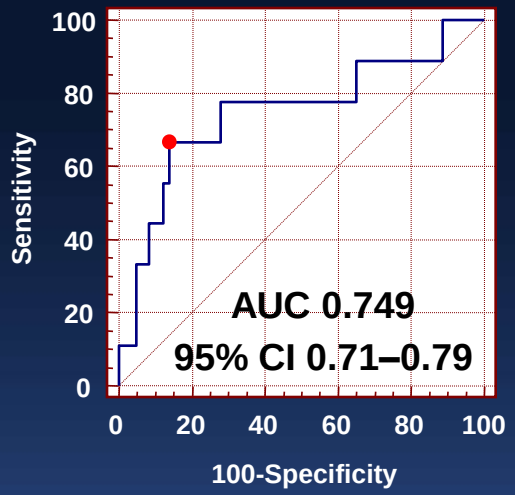


LAD 5.0mm^2 POC 6.3mm^2 Prox LM 6.8mm^2 LCX 4.0mm^2

Kang et al. Am J Cardiol 2011;107:367-73

Intravascular Ultrasound Predictors for Edge Restenosis After Newer Generation Drug-Eluting Stent Implantation

433 E-ZES

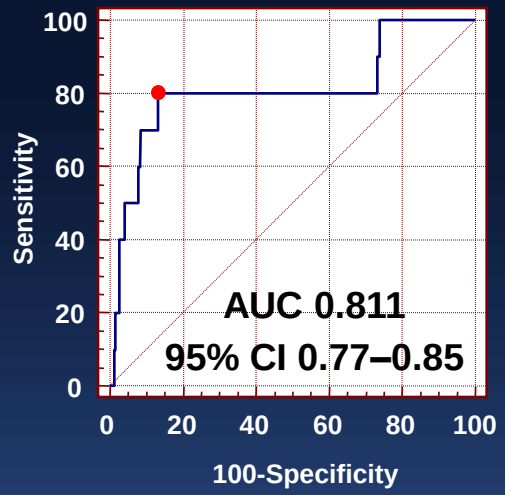


PB 56.3%

Sensitivity 67%

Specificity 86%

422 R-ZES

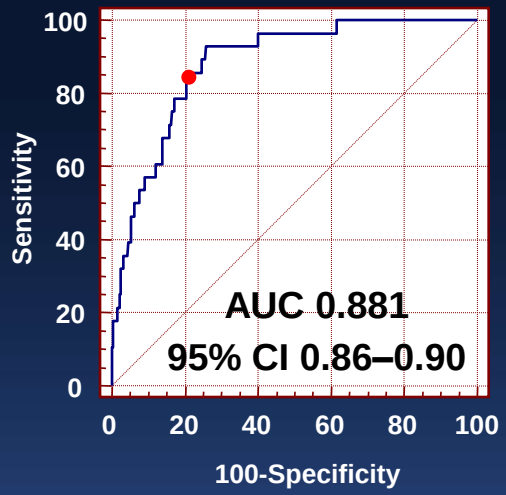


PB 57.3%

Sensitivity 80%

Specificity 87%

813 EES



PB 54.2%

Sensitivity 86%

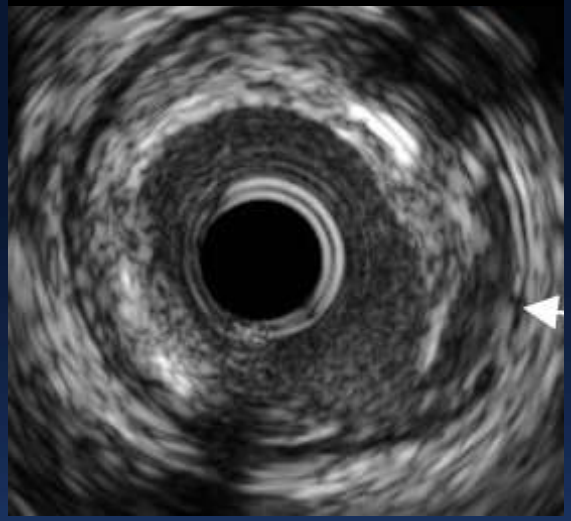
Specificity 80%

Reference segment residual PB<55% is useful to determine the optimal landing site of stent deployment

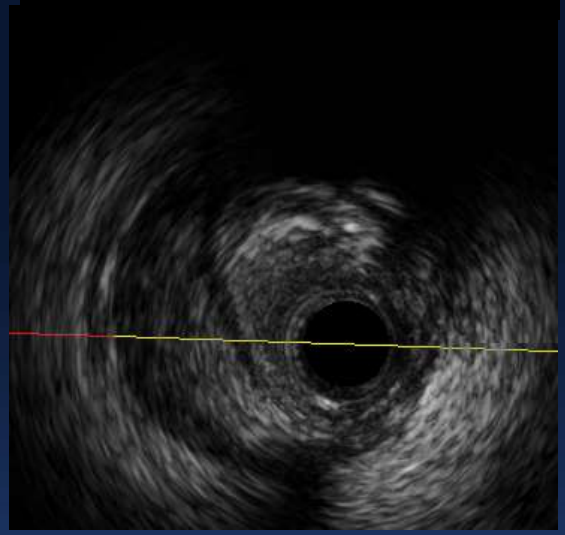
Kang et al. Am J Cardiol 2013 in press

IVUS-detected PCI Complication

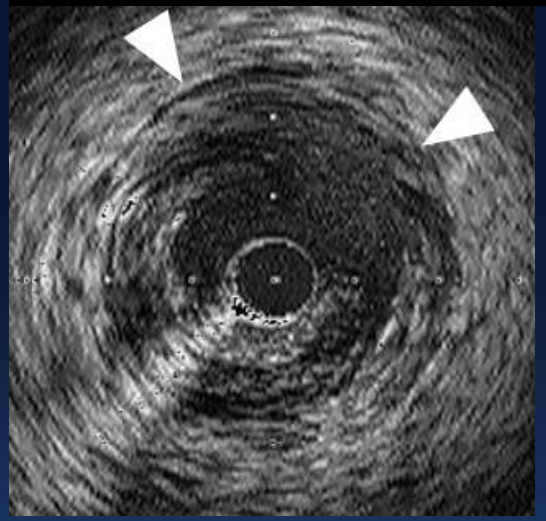
Dissection



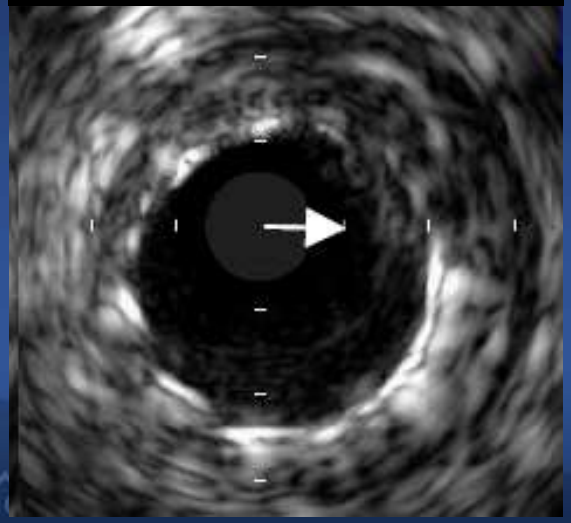
Hematoma



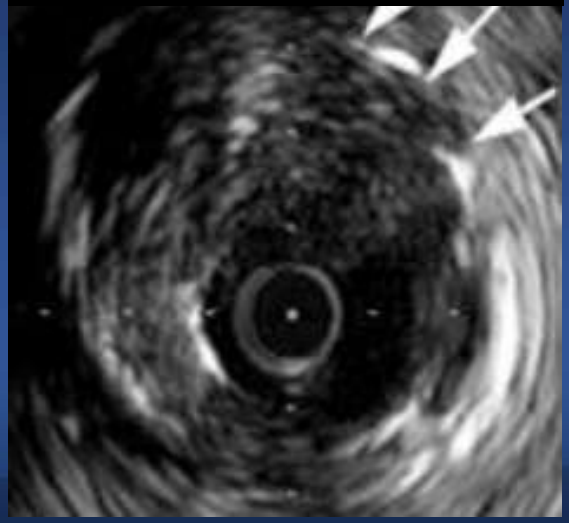
Perforation



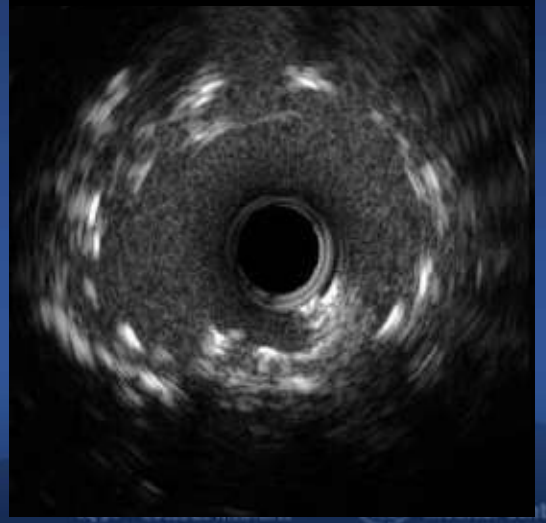
Plaque prolapse



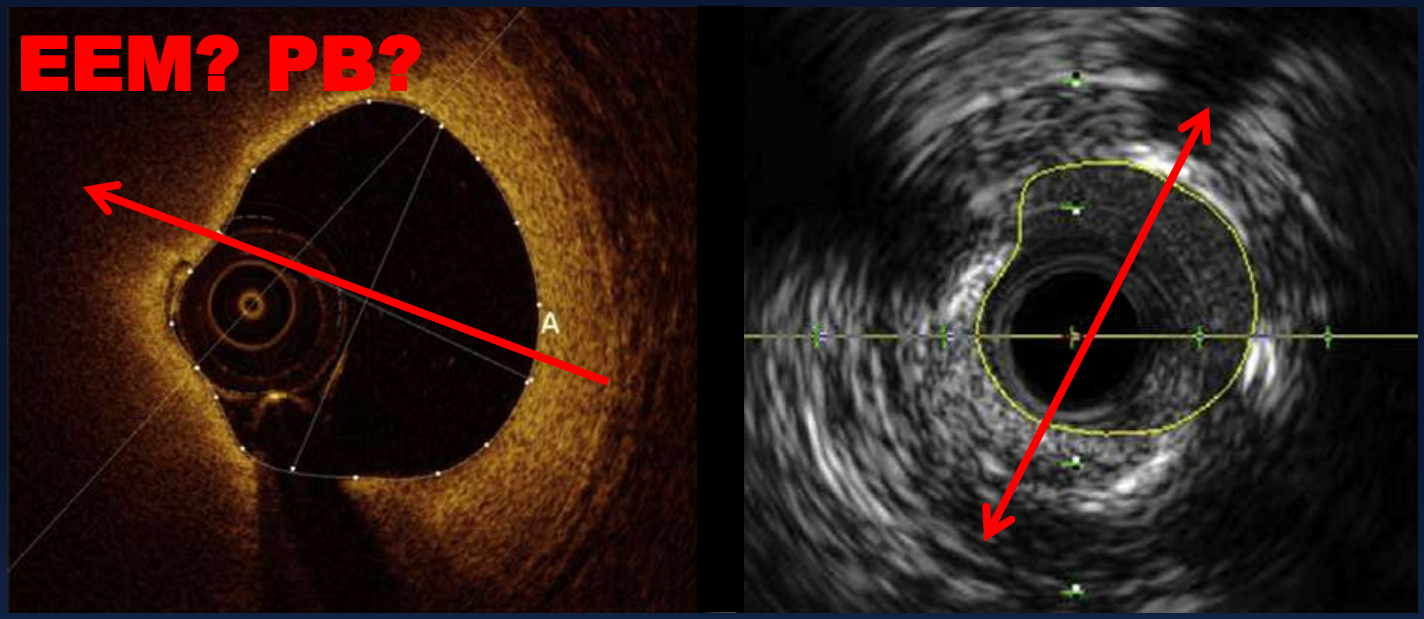
Thrombosis



Deformation



IVUS- vs. OCT-Guided PCI



Ability to Detect Suboptimal Findings (OPUS-CLASS)

Post-PCI	IVUS	OCT	p
Malapposition	14%	39%	<0.001
Tissue protrusion	18%	95%	<0.001
Dissection	0%	13%	0.013
Thrombus	0%	13%	0.013

Kubo et al. JACC imaging 2013;6:1095-104

IVUS- vs. OCT-guided PCI

Prospective Randomized study

	OCT-guided	IVUS-guided	p
Total procedural time, min	40±16.4	47.0±17.6	0.09
Total fluroscopy time, min	20.4±8.4	24.8±10.4	0.05
Contrast media volume, ml	130.0±57.9	146.9±60.0	0.24
Good visibility of EEM			
at proximal reference	22 (63%)	35 (100%)	<0.001
at MLA site	3 (9%)	33 (94%)	<0.001
at distal reference	22 (63%)	35 (100%)	<0.001

Poor visibility of EEM may affect device size, deployment pressure and post-balloon dilation

Habara et al. Circ Cardiovasc Interv 2012;5:193-201

IVUS- vs. OCT-guided PCI

Post-stenting Data

	OCT-guided	IVUS-guided	p
Angiographic DS,%	7.7±5.8	5.0±4.5	0.03
Post-stenting IVUS			
Min. stent area,mm^2	6.1±2.2	7.1±2.1	0.04
Mean stent area, mm^2	7.5±2.5	8.7±2.4	0.04
Residual PB (prox) >50%	42.2±11.6	36.5±8.6	0.02
Residual PB >50%, prox	8 (23%)	1 (3%)	0.03
Post-stenting OCT			
Min stent area, mm^2	7.2±2.8	8.4±2.4	0.03
Incomplete apposition,%	0.4±0.7	0.6±0.8	0.34

Habara et al. Circ Cardiovasc Interv 2012;5:193-201

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Intravascular Ultrasound Versus Optical Coherence Tomography Guidance

Ron Waksman, MD, Hironori Kitabata, MD, Francesco Prati, MD, Mario Albertucci, MD,

Stent optimization criteria	Standardized by IVUS
Penetration *(EEM visualization)*	IVUS better
Need for contrast media	OCT requires
Resolution *(additional information)*	OCT better

IVUS remains the more trusted modality for stent sizing and optimization until OCT own criteria are validated with clinical outcomes

Summary

- IVUS-MLA poorly matched with FFR. In pure LM lesions, IVUS-MLA can be alternatively used
- IVUS is useful to assess plaque vulnerability and risk of peri-procedural MI
- Underexpansion and inflow/outflow tract disease are predictors of stent failure, thus they should be treated during PCI by IVUS-guidance
- With sufficient data and solid optimization criteria, IVUS-guided PCI improves patient outcomes