

IVUS: Pre-Intervention and Post-Intervention

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Disclosure Statement of Financial Interest

Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

Affiliation/Financial Relationship

- Grant/Research Support
- Consulting Fees/Honoraria
- Speaker Fee

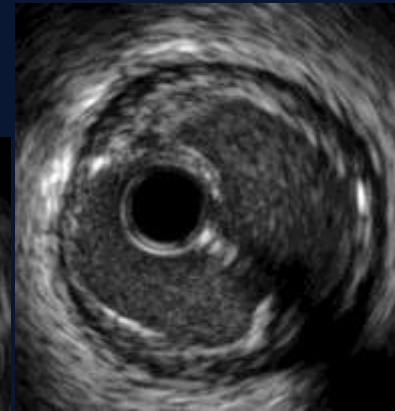
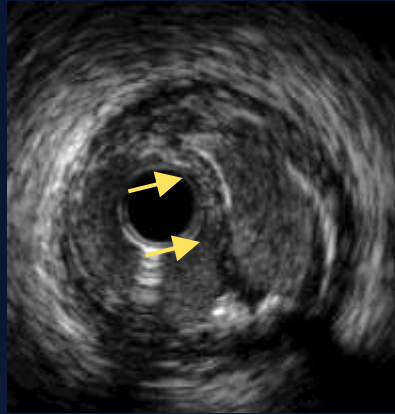
Company

- Boston Scientific Corporation
- Boston Scientific Corporation, ACIST
- Volcano Corporation, St Jude Medical

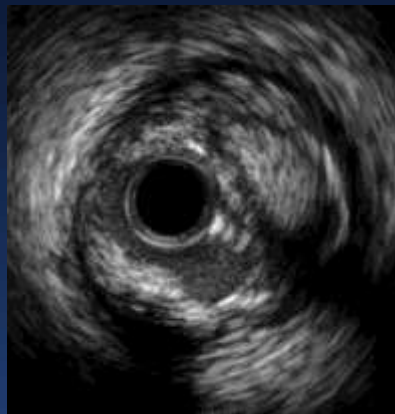
Pre-Intervention Qualitative Evaluation

Plaque Rupture

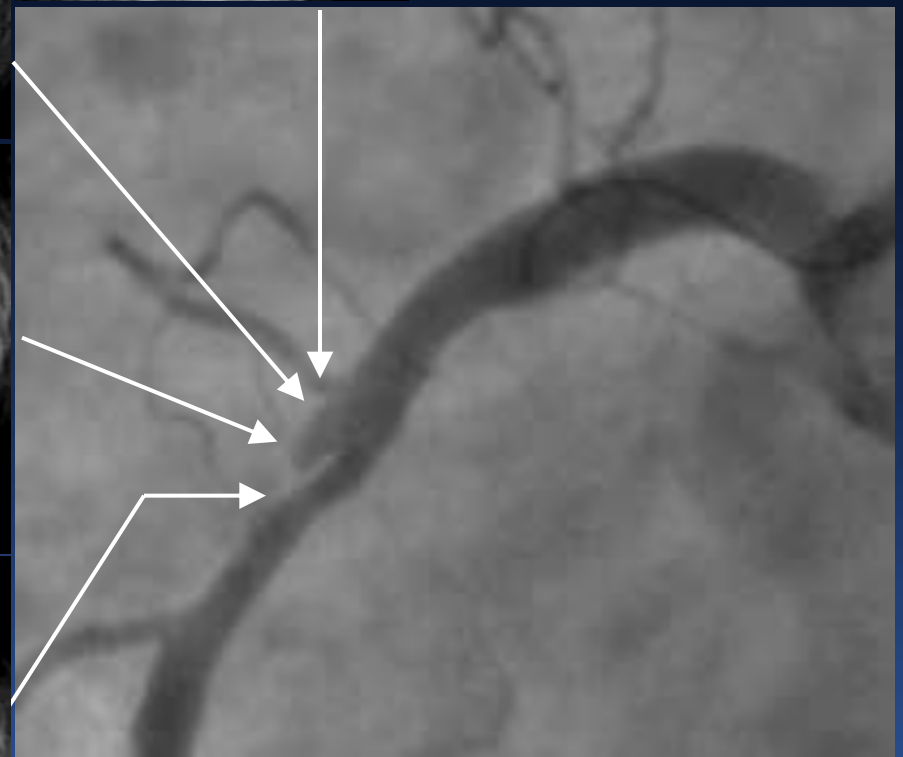
Fibrous cap



End of rupture



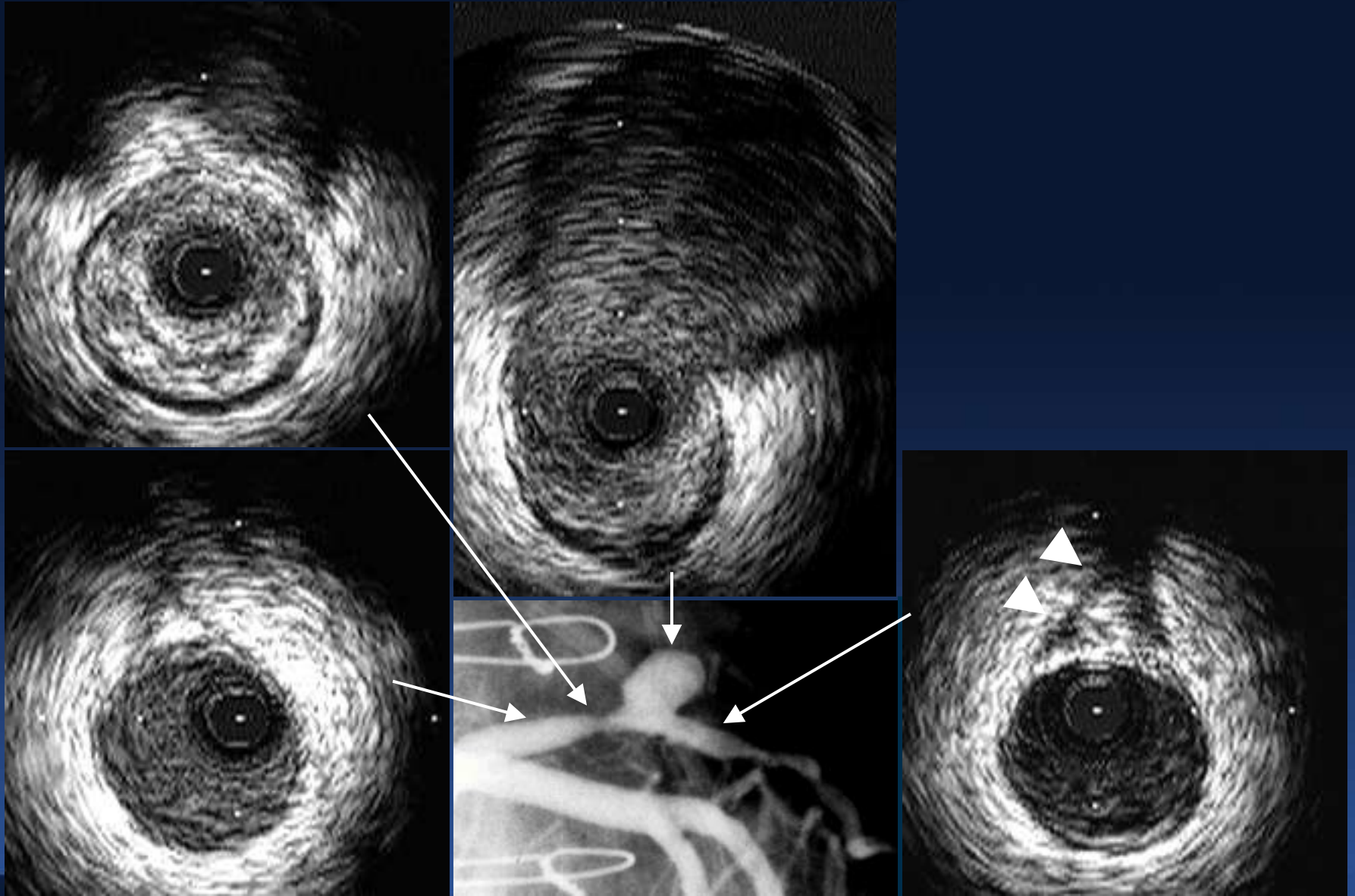
MLA



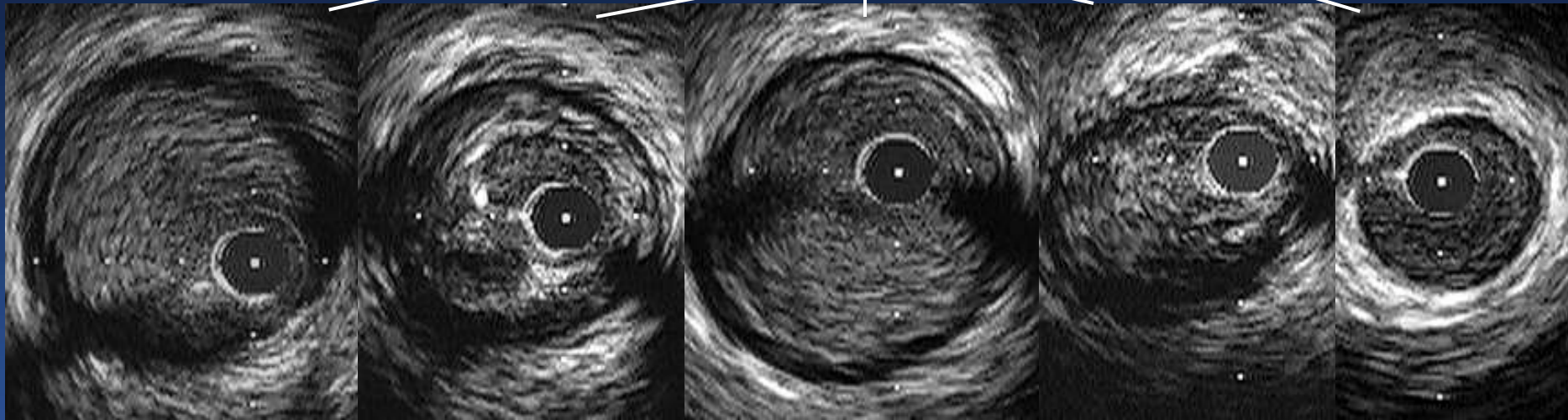
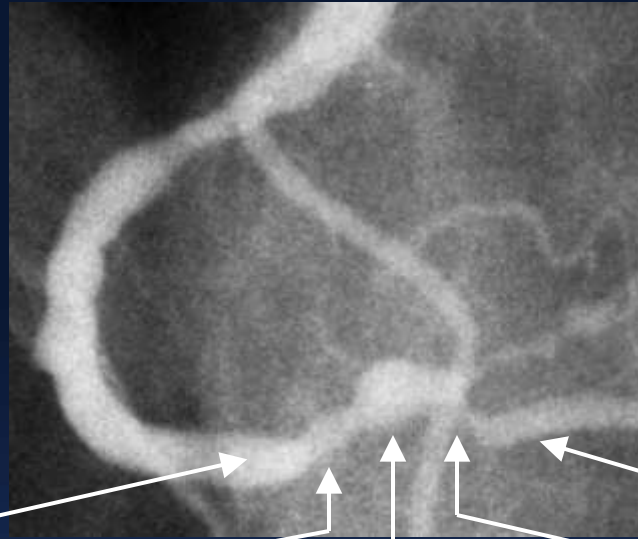
Angiographical Coronary Aneurysm



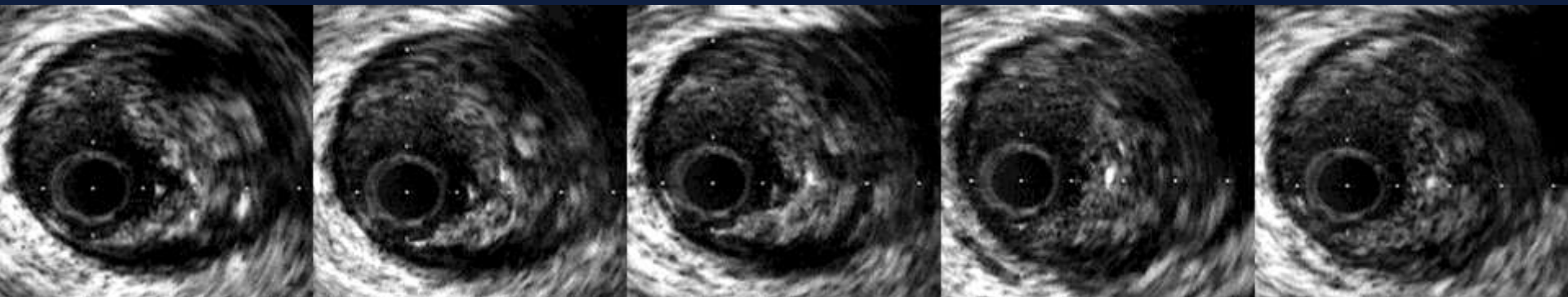
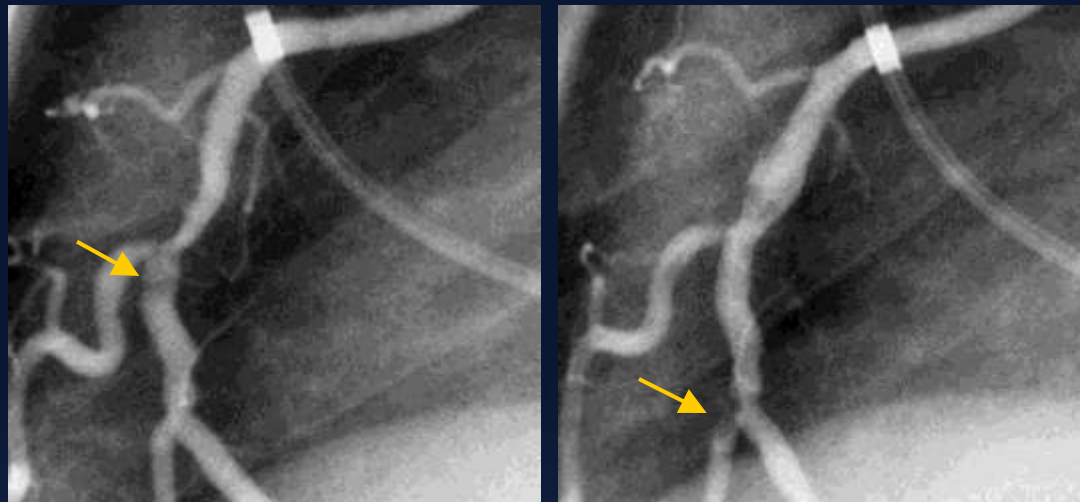
Pseudo Aneurysm



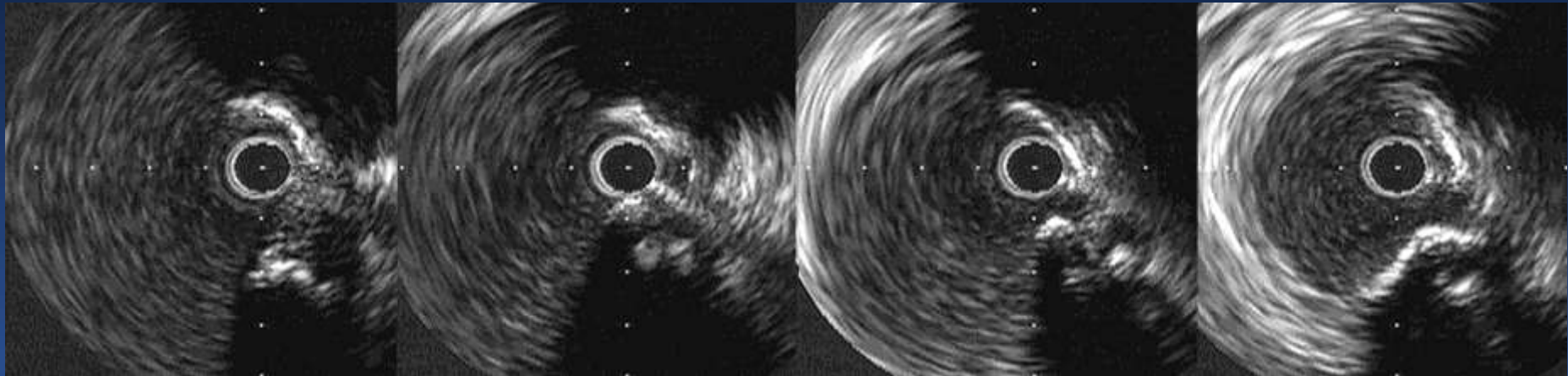
Normal Site with Adjacent Stenoses



Thrombus in Both Main & Branch



Filling Defect - Calcium Nodule -



0



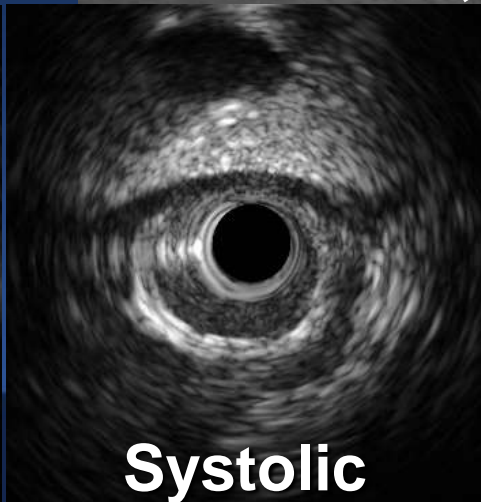
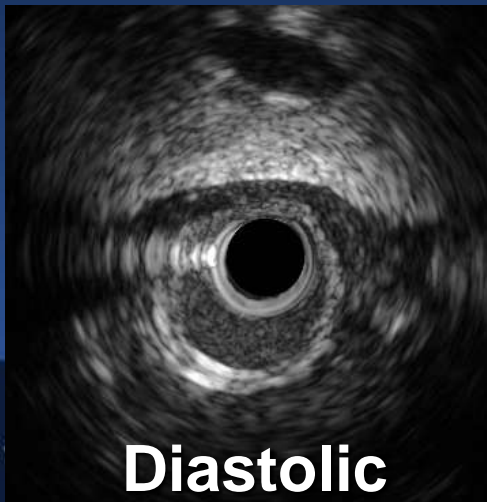
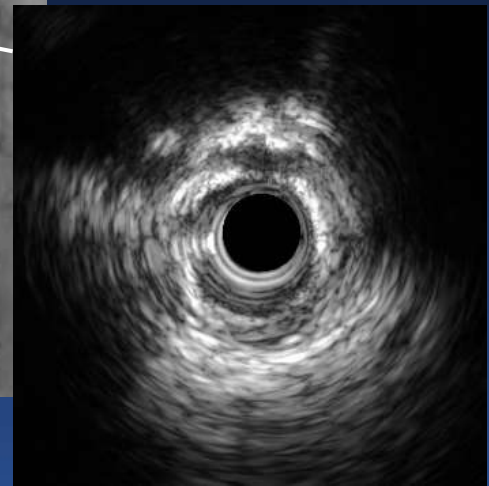
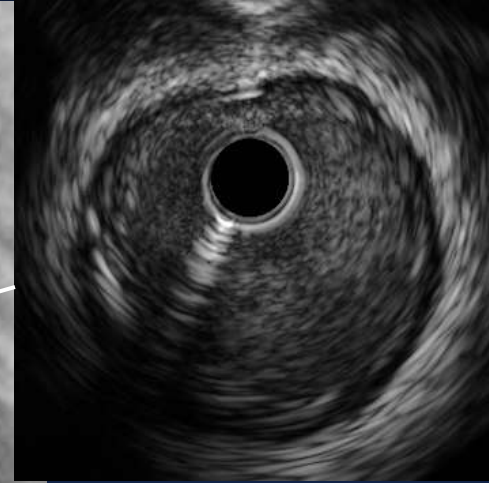
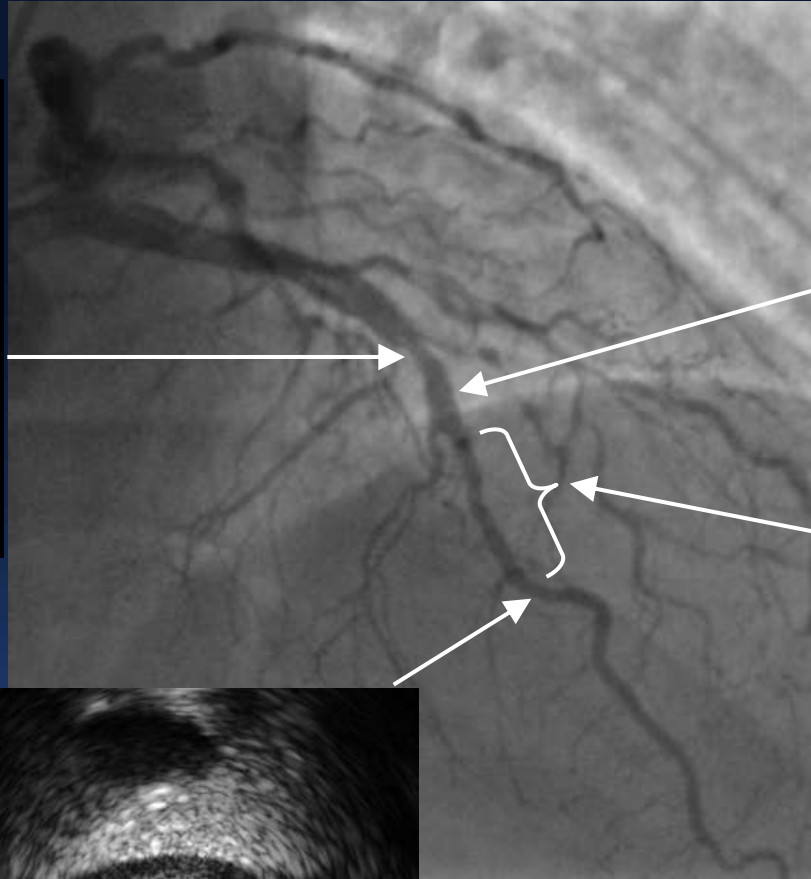
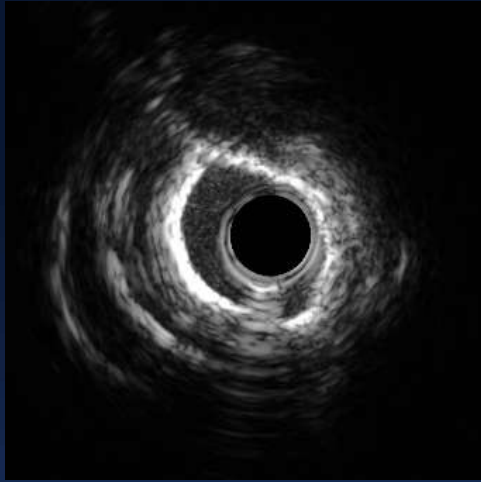
2.0



6.0mm

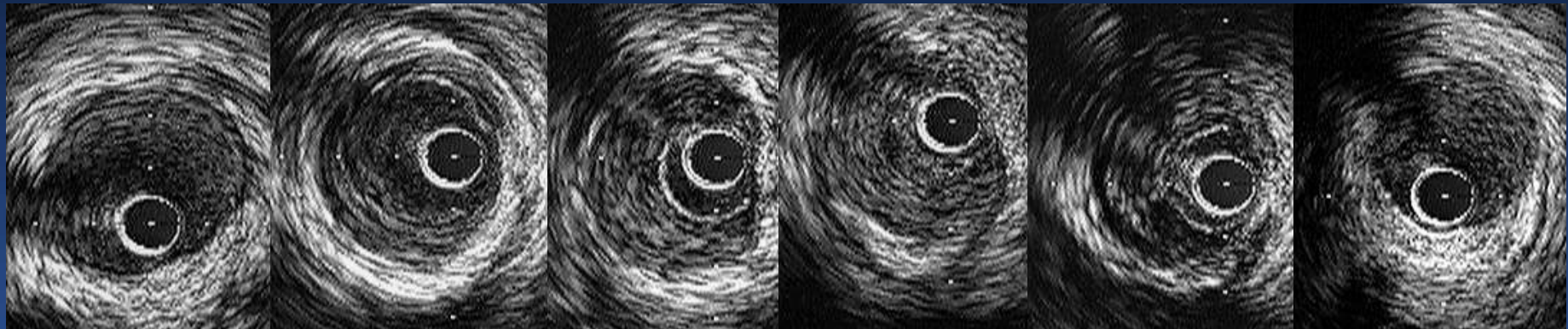
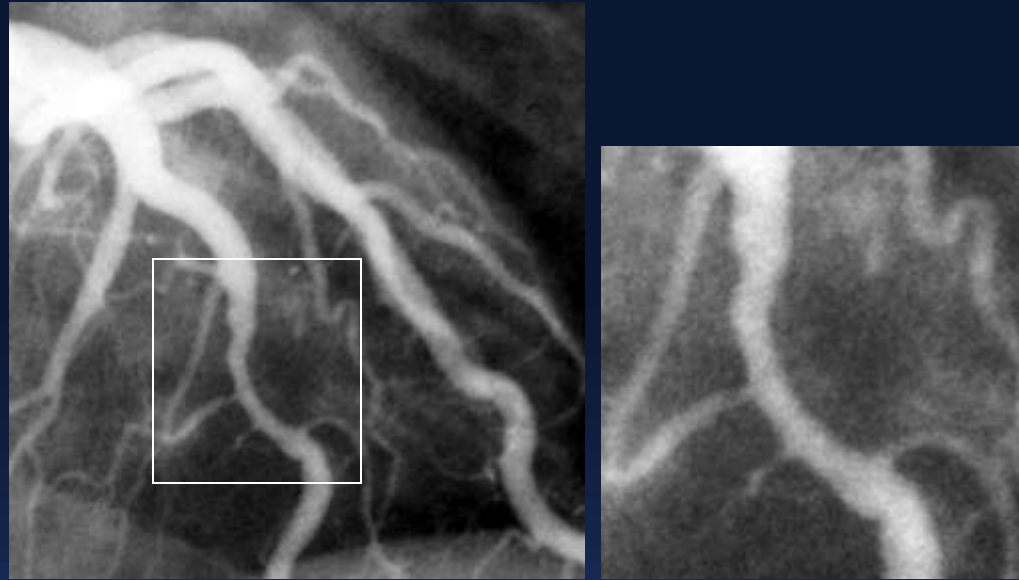
Haziness in the mid LAD

“Muscle Bridge”



**Inside the muscle bridge,
no plaque at all!**

55y.o. Female, AMI



Proximal

“Spontaneous Dissection”

Summary Pre-Qualitative Assessment

Angio

Filling Defect

Haziness

Aneurysm

Ulceration

Dissection

IVUS

Thrombus

Aneurysm

Plaque Rupture

Normal Site

Calcium Nodule

Calcified Plaque

Spontaneous dissection

Muscle Bridge

Once a Day

Once a Week

Once a Month-Year

Pre-Intervention Quantitative Evaluation

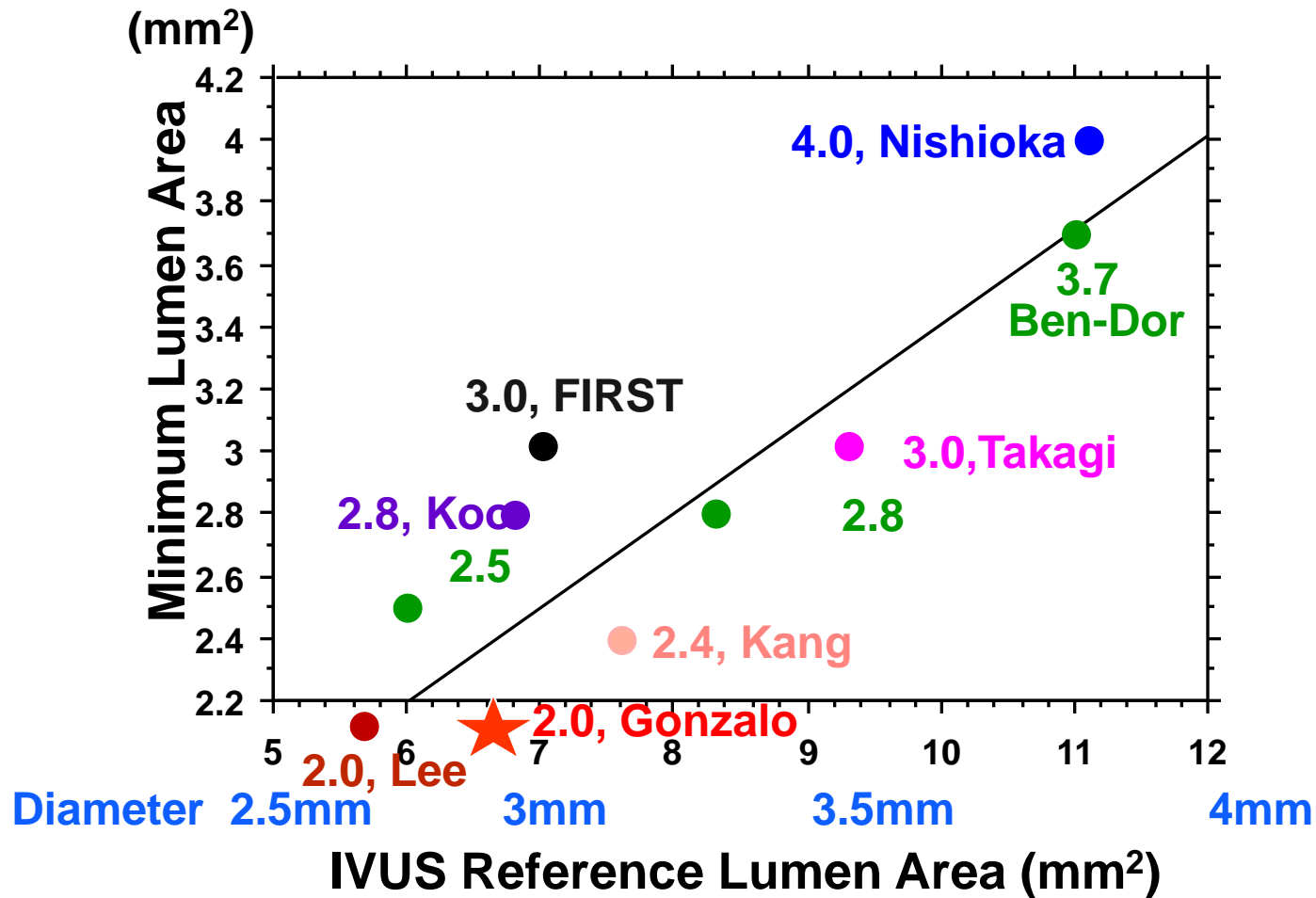
Can IVUS determine the
ischemic lesion?

	N	FFR	MLA	AUC	Sens	Spec	PPV	NPV	Accura
Takaki (1999 Circ)	51	0.75	3.0	—	83%	92%	—	—	—
Briguori (2001 AJC)	53	0.75	4.0	—	92%	56%	38%	96%	64%

Ben-Dor (2012 *)	205	0.80	3.09	0.73	69%	72%	—	—	70%
Kang (2011 Circ int)	236	0.80	2.4	0.80	90%	60%	37%	96%	68%
Kang (2012 AJC)	784	0.80	2.4	0.77	84%	63%	48%	90%	69%
Koo (2011 JACC int)	267	0.80	2.75	0.81	69%	65%	27%	81%	67%
Gonzalo (2012 JACC)	47	0.80	2.36 IVUS	0.63	67%	65%	67%	65%	66%
Gonzalo (2012 JACC)	61	0.80	1.95 OCT	0.70	82%	63%	66%	80%	72%

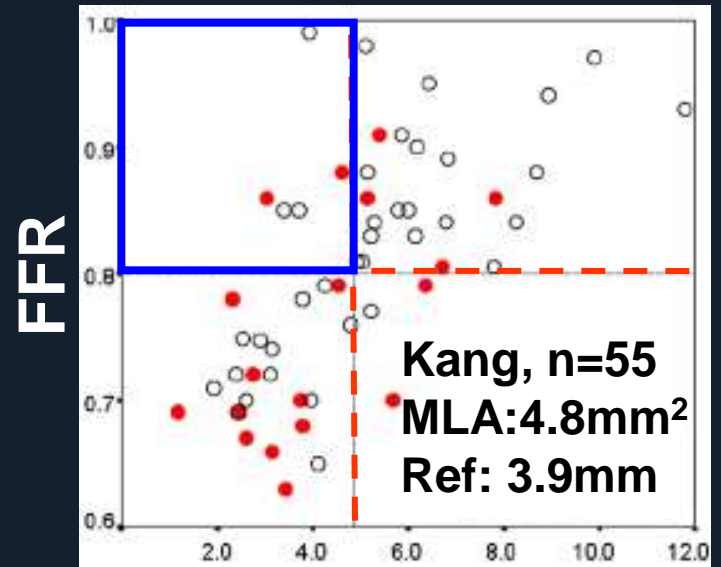
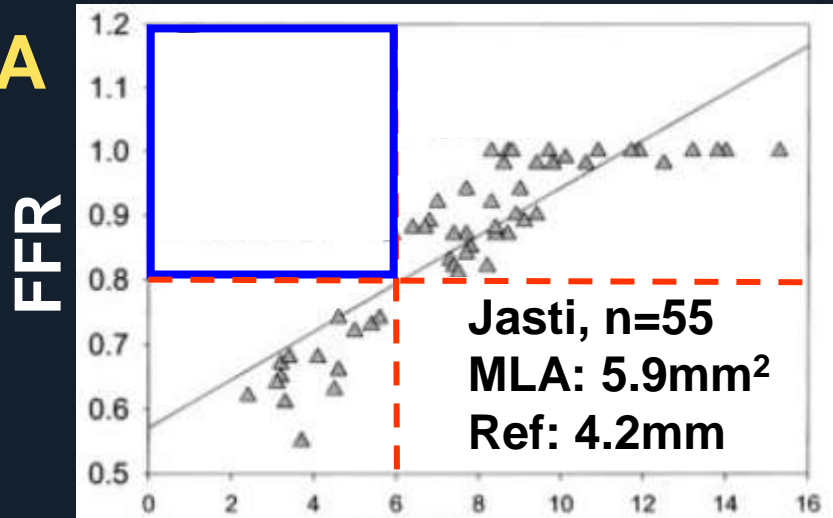
Cut-off MLA and Reference Area

FFR Cut-off: 0.75 by Takagi, Lee, 0.80 by Kang, Ben-Dor, Koo, FIRST, Gonzalo

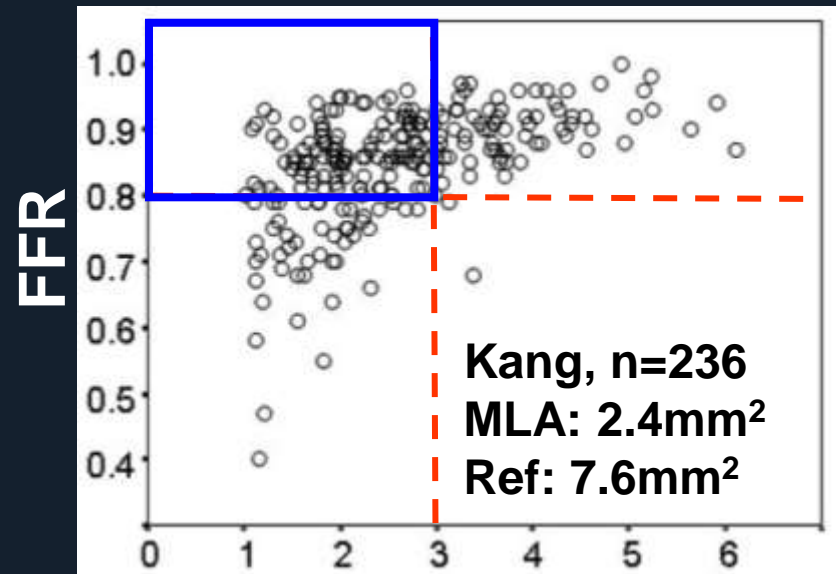
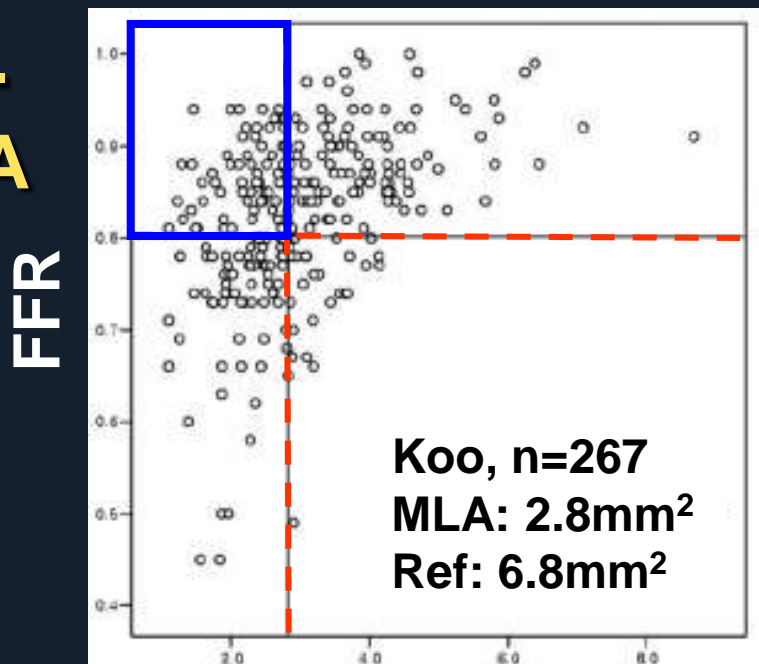


LMCA vs non-LMCA

LMCA



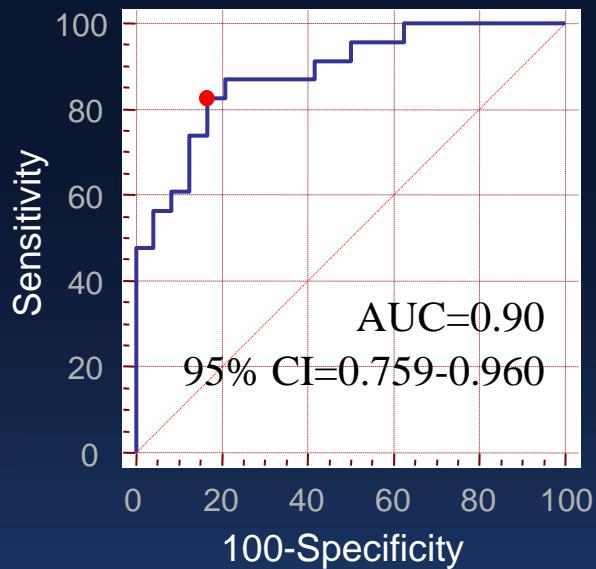
Non-LMCA



Minimum Lumen Area (mm²)

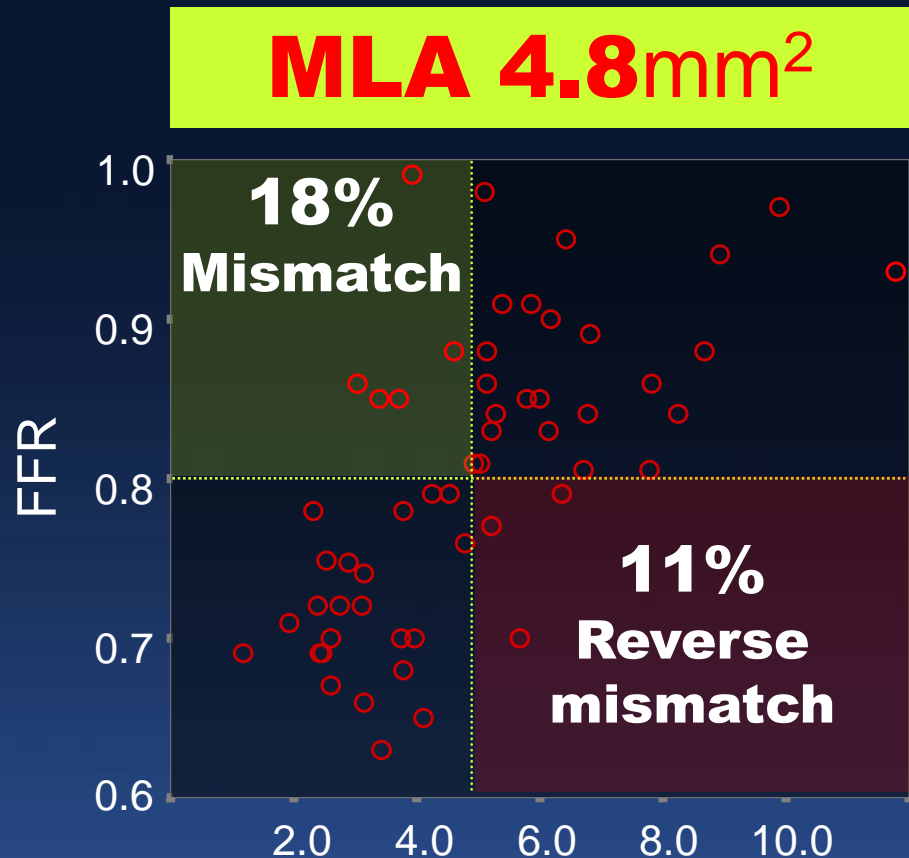
IVUS-MLA Predicts LM FFR<0.80

Pure LM lesion of DS 30-80%, exclude distal stream disease



Sens 89%, Spec 83%

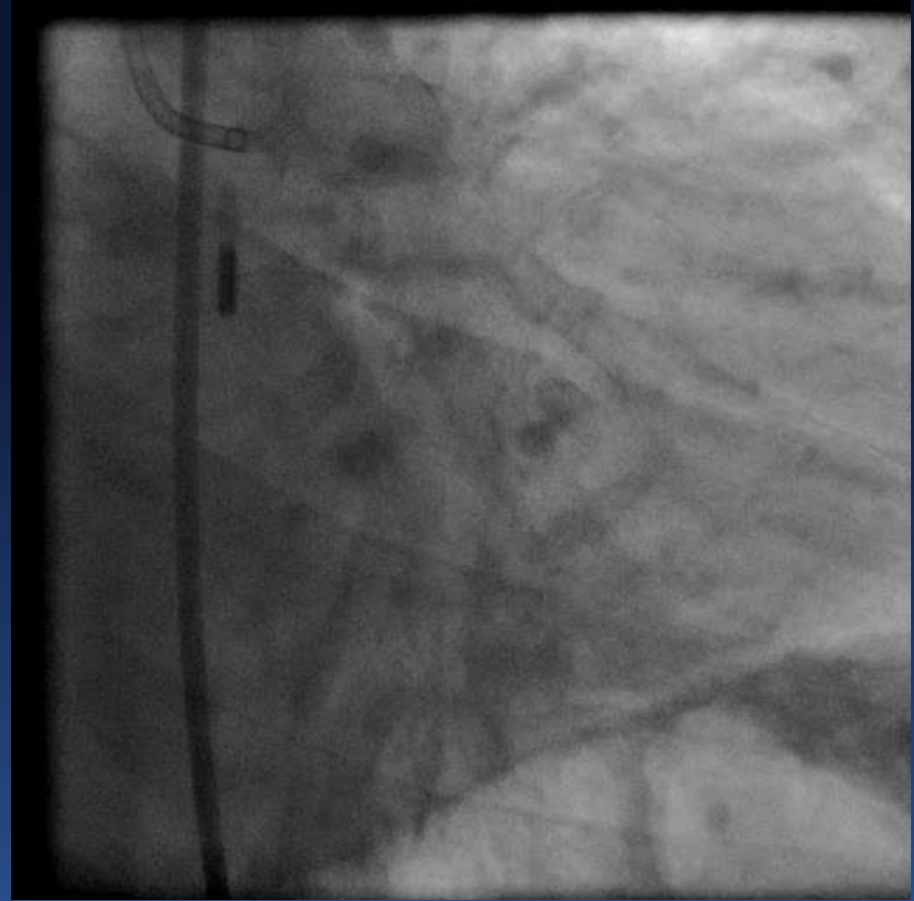
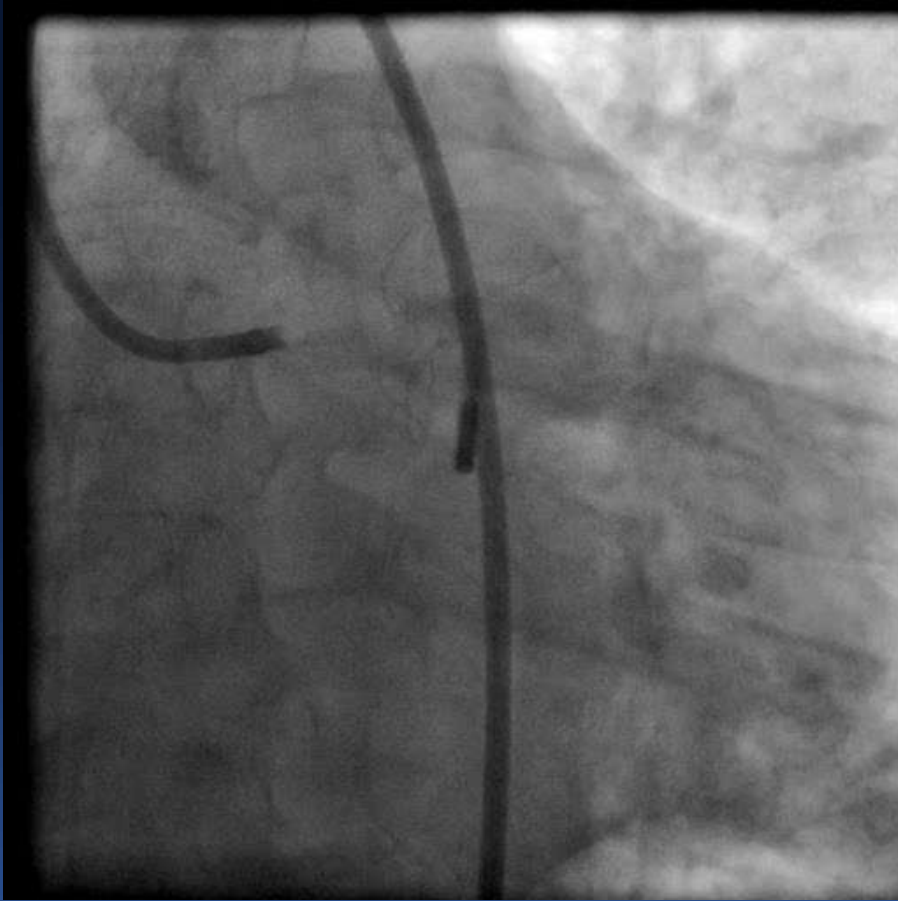
Accuracy 86%

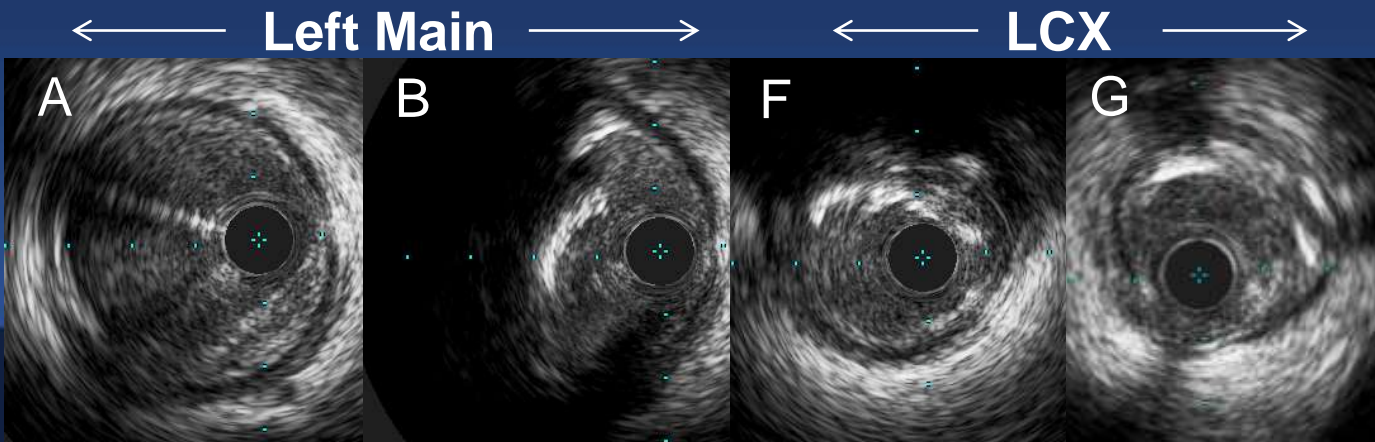
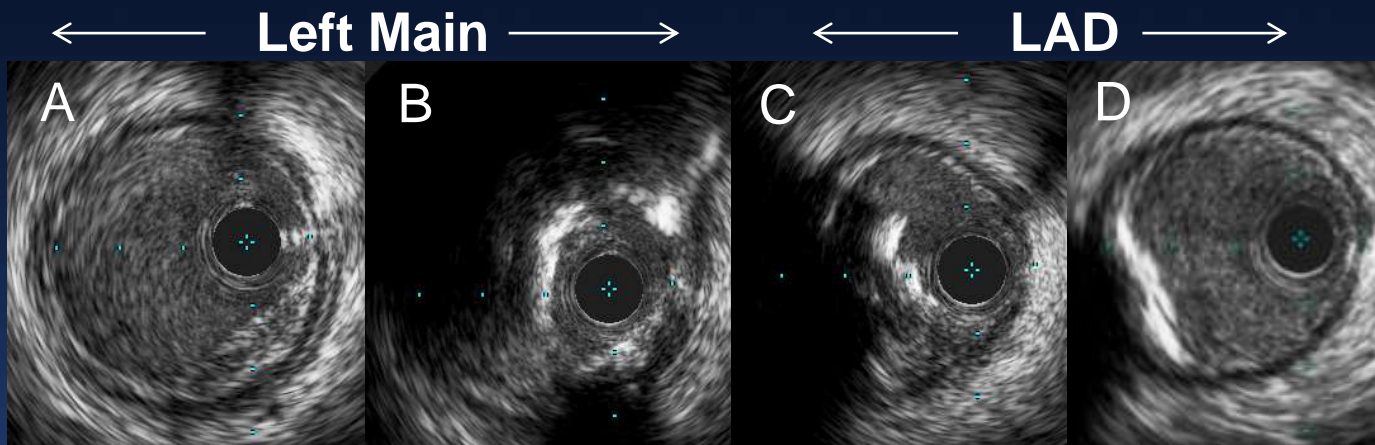
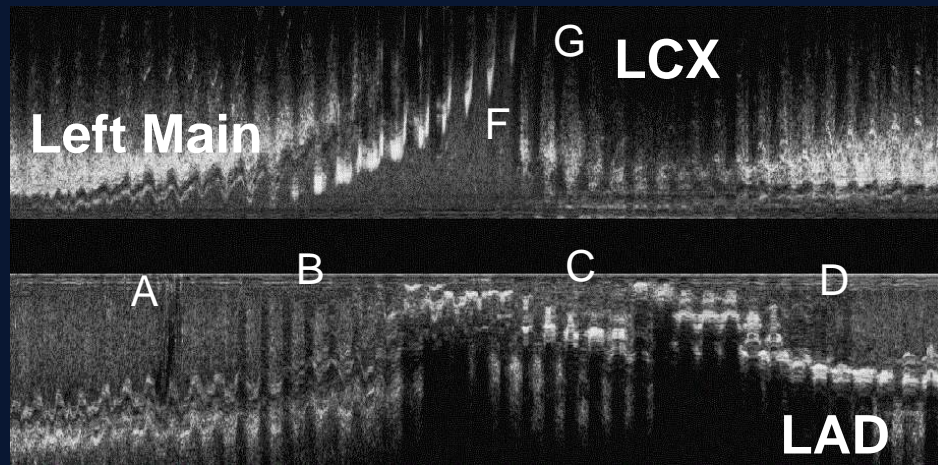
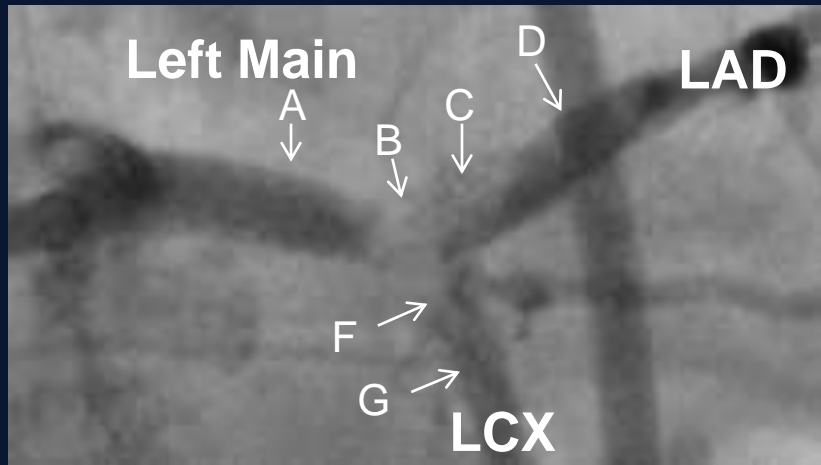


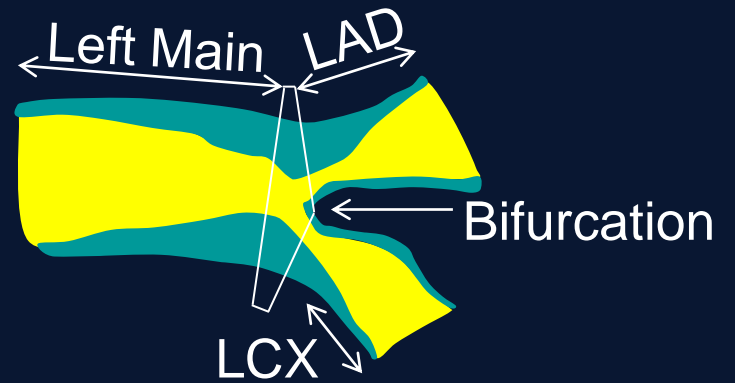
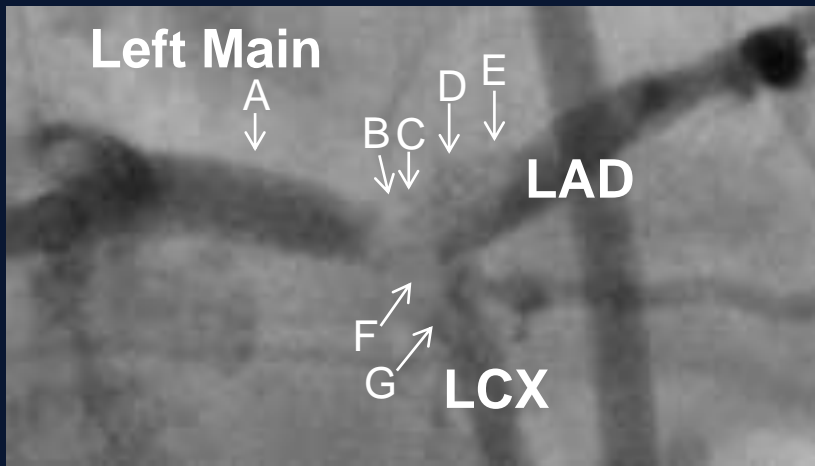
Kang et al. JACC Interv 2011;4:1168-74

Stent Optimization - Pre Intervention -

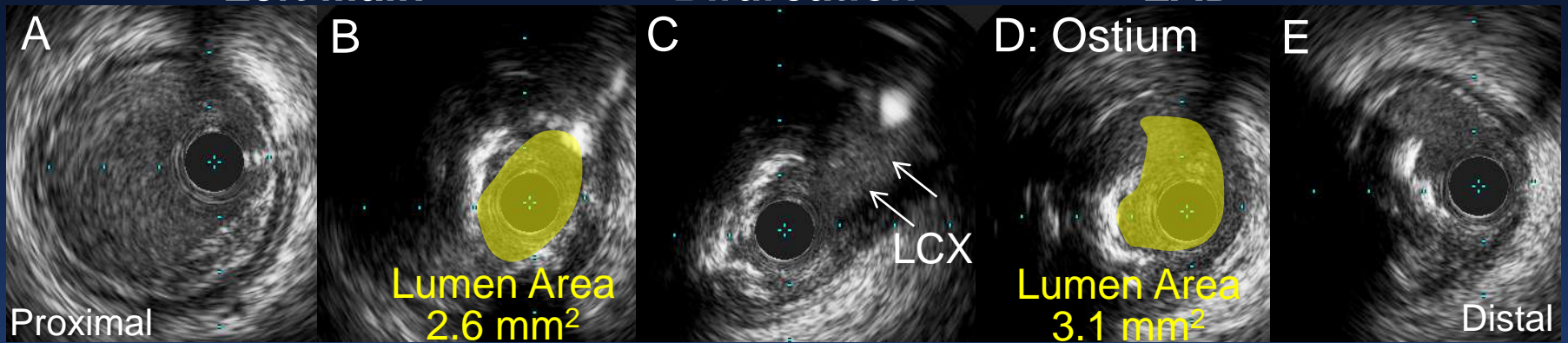
Optimal Stent Expansion



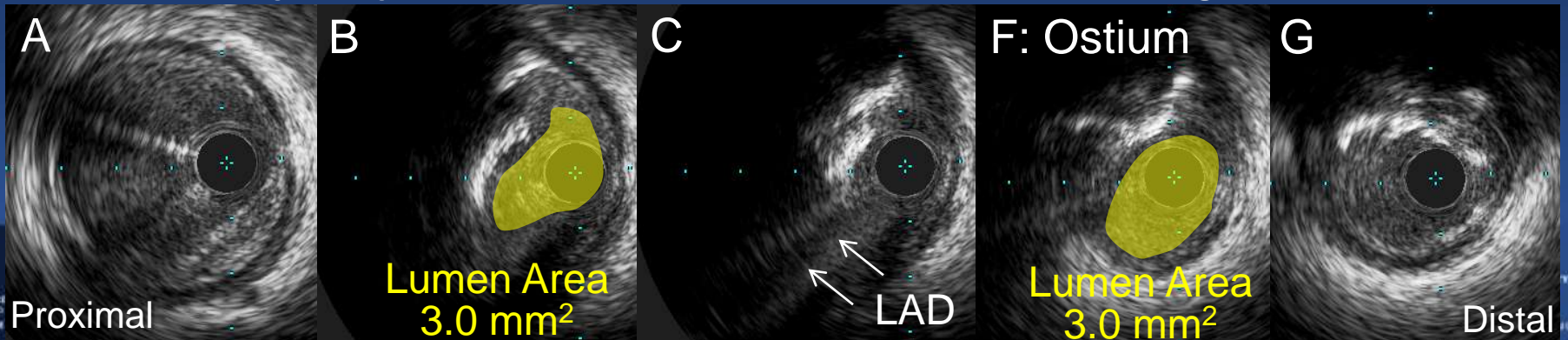


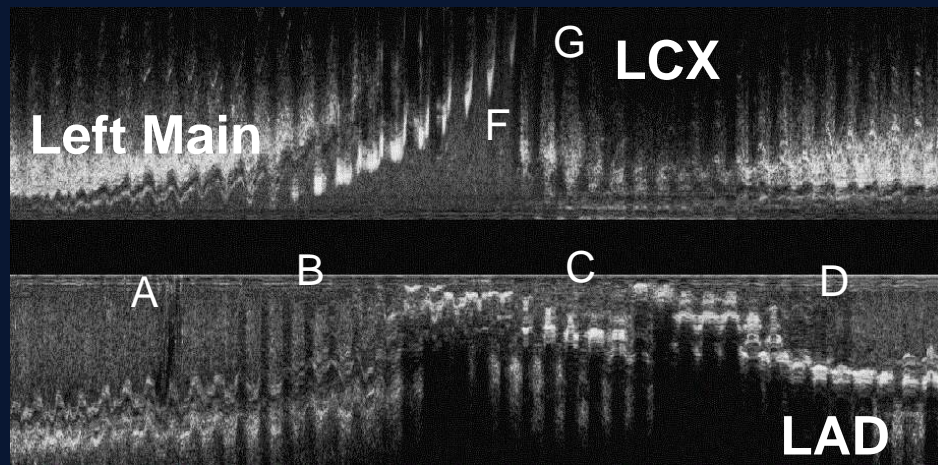
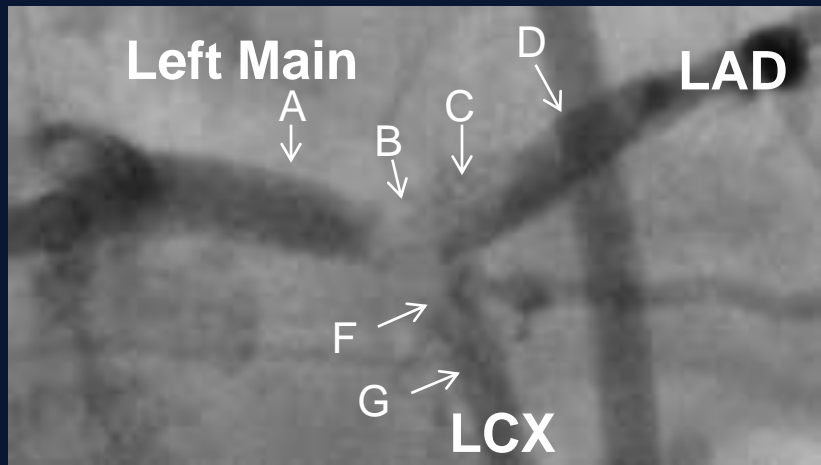


← Left Main → ← Bifurcation → ← LAD →



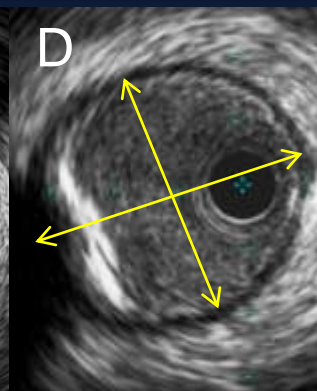
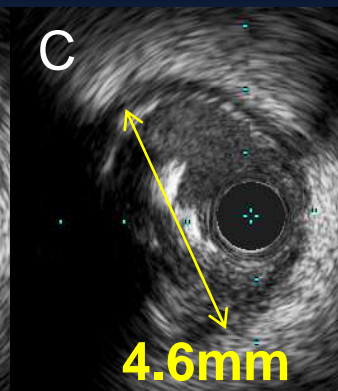
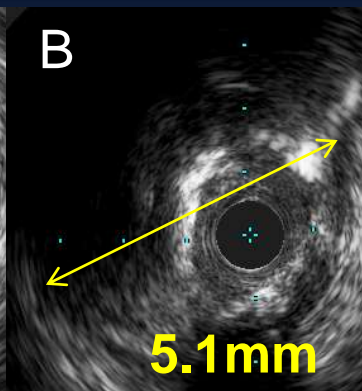
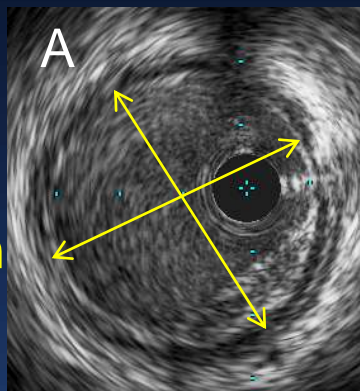
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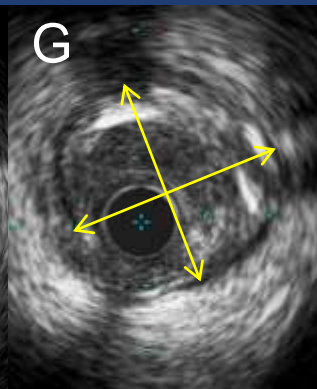
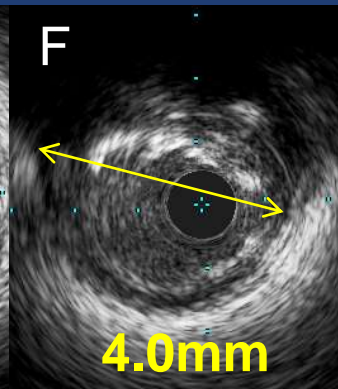
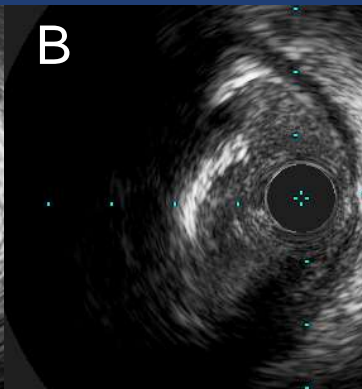
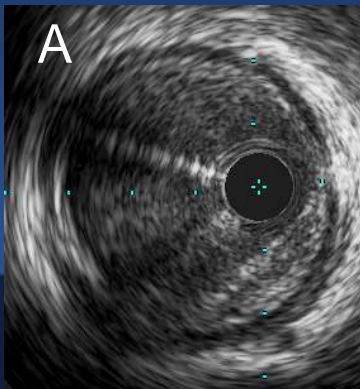
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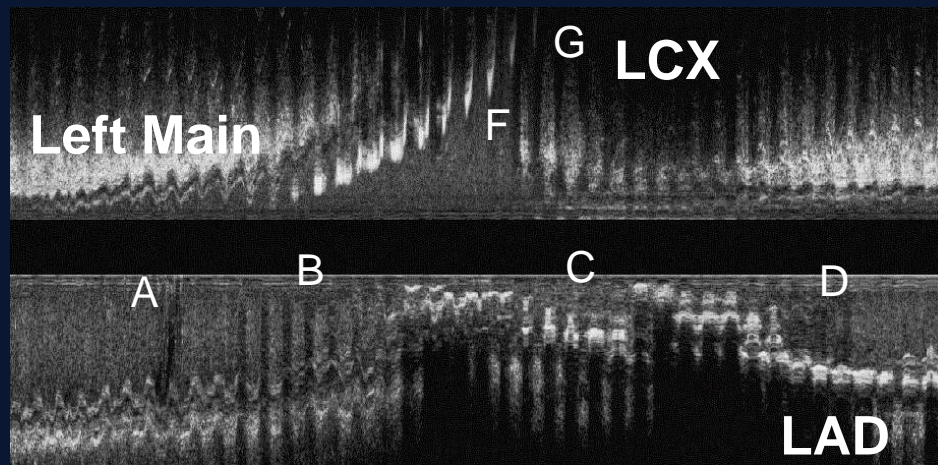
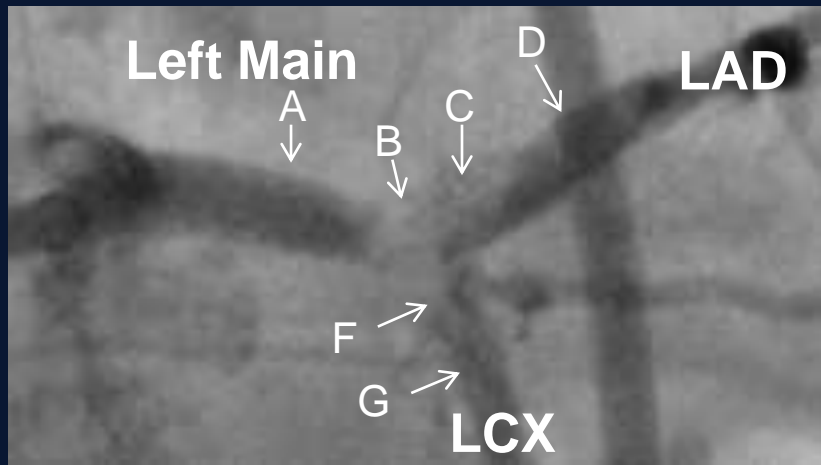
← LAD →



← Left Main →

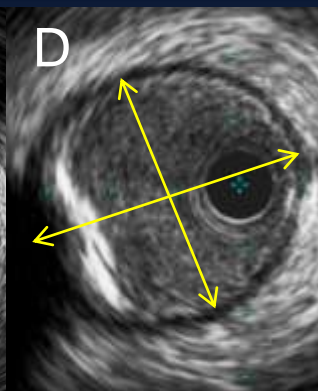
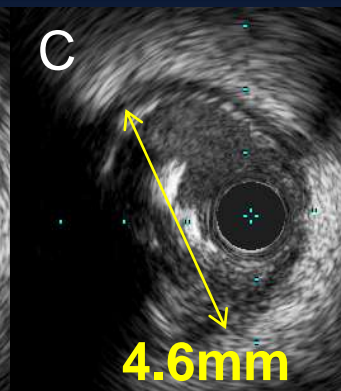
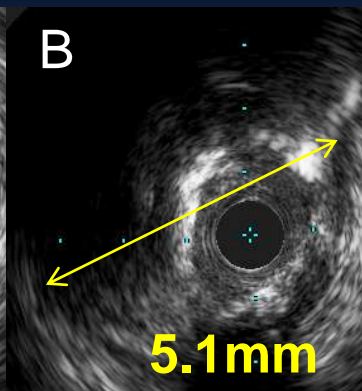
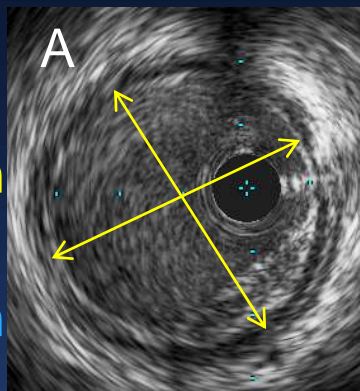
← LCX →





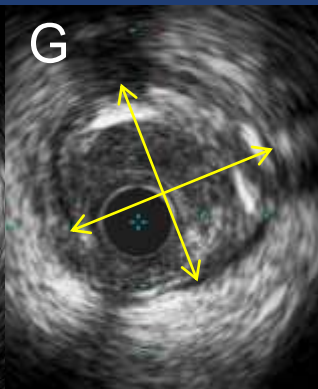
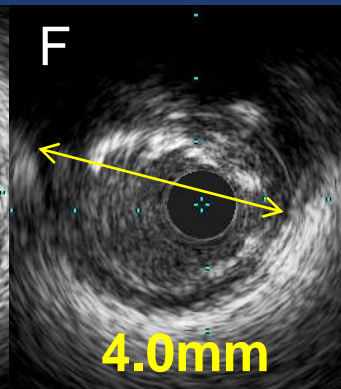
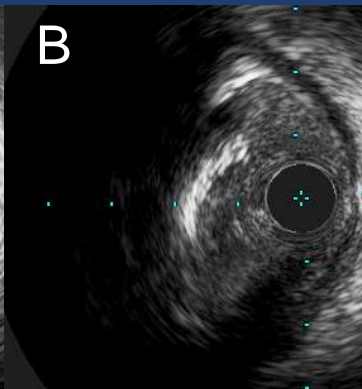
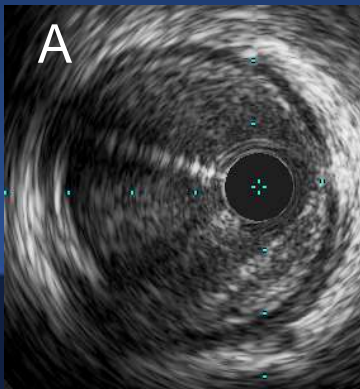
← Left Main →

← LAD →



← Left Main →

← LCX →



4.6mm × 4.0mm

3.4mm × 3.2mm

3.5mm × 3.4mm

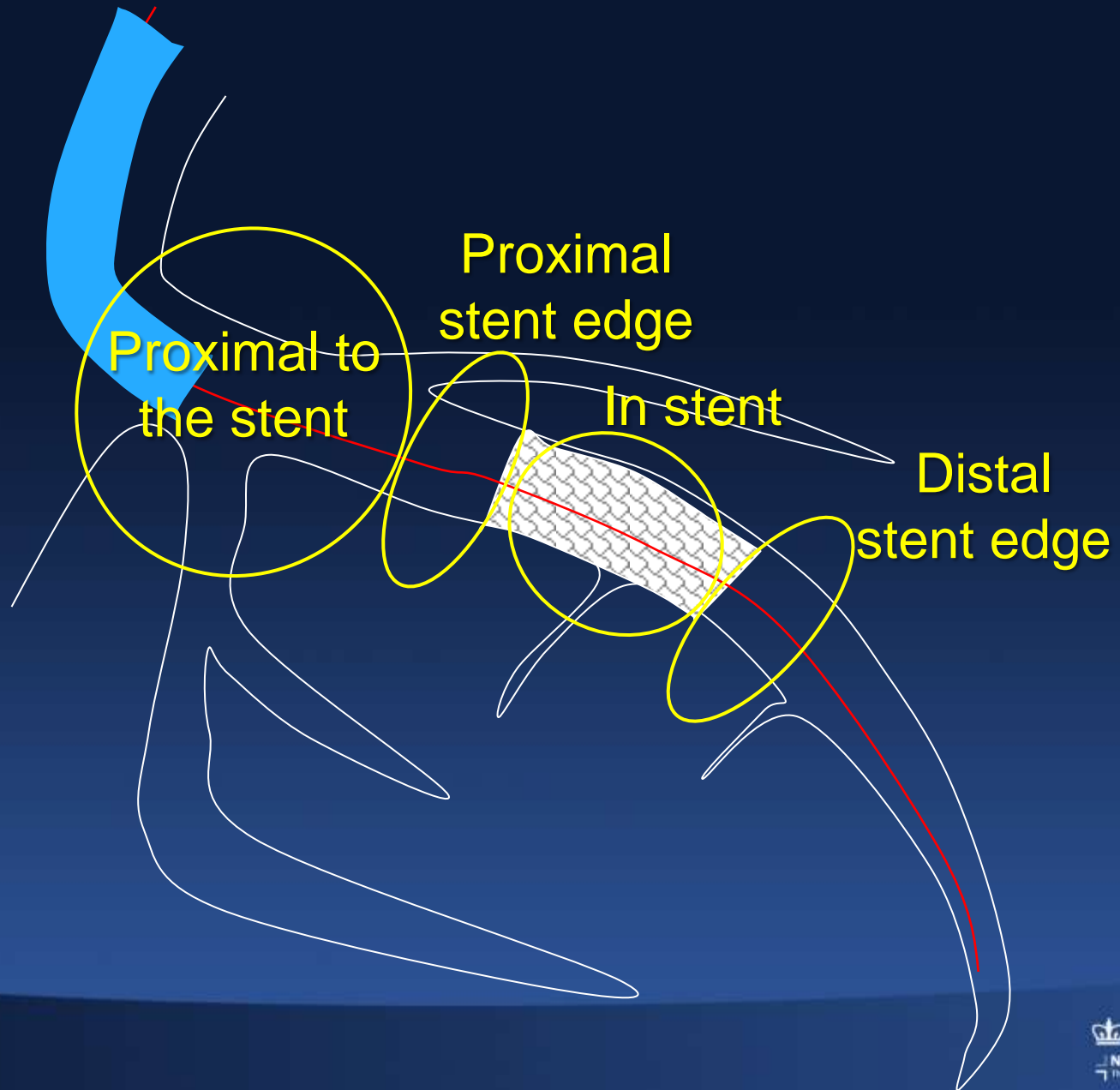
2.3mm × 2.4mm

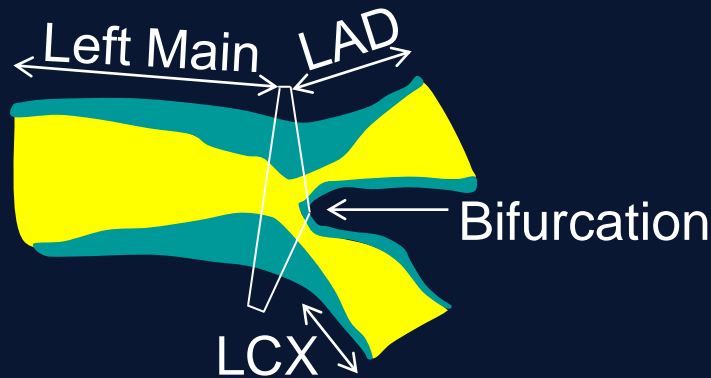
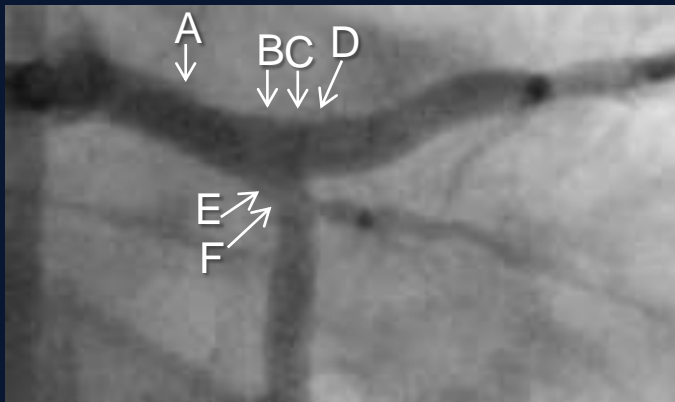
4.5mm × 4.6mm

4.1mm × 3.8mm

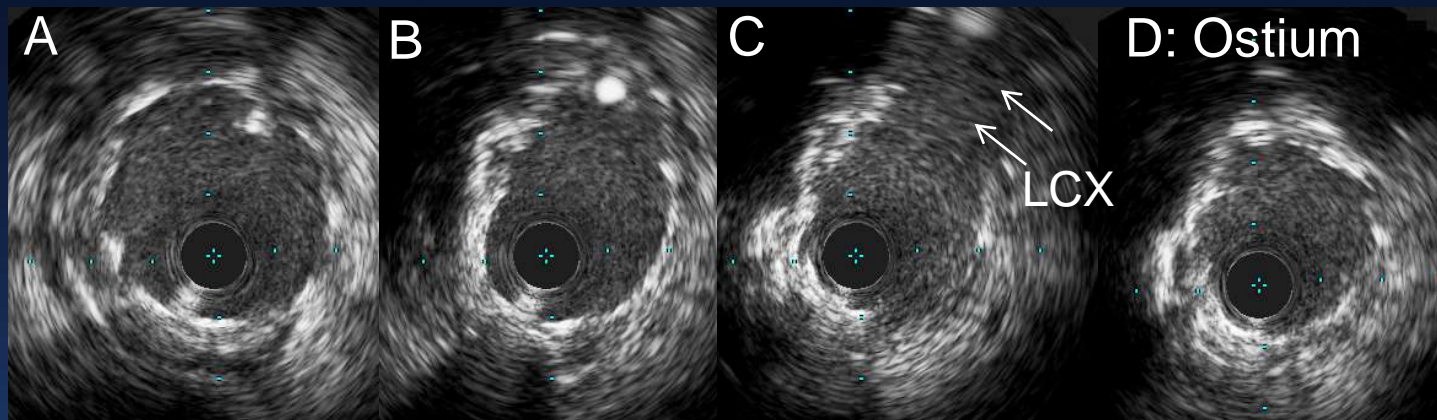
Stent Optimization - Post-Intervention -

Post Stent Evaluation



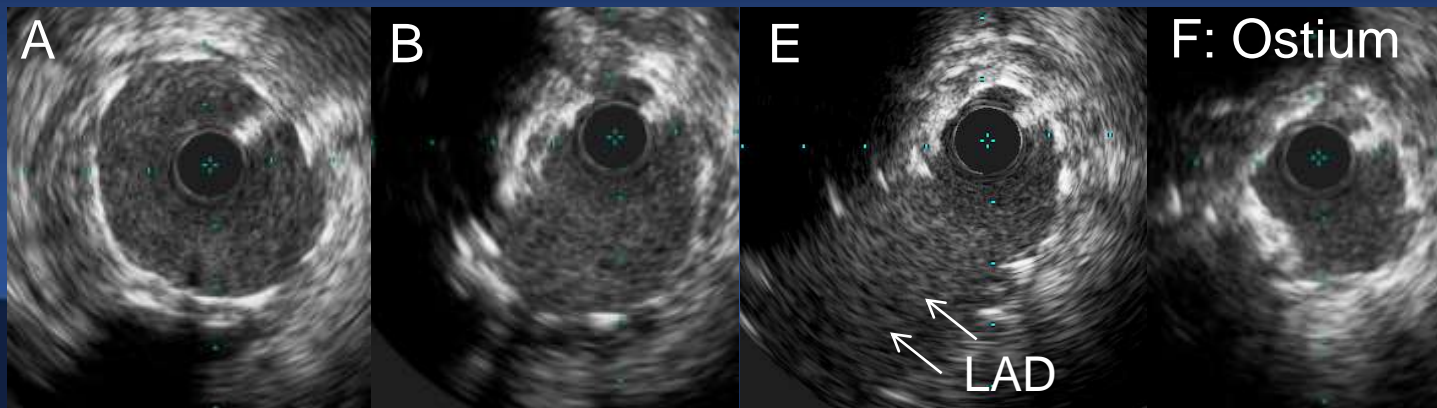


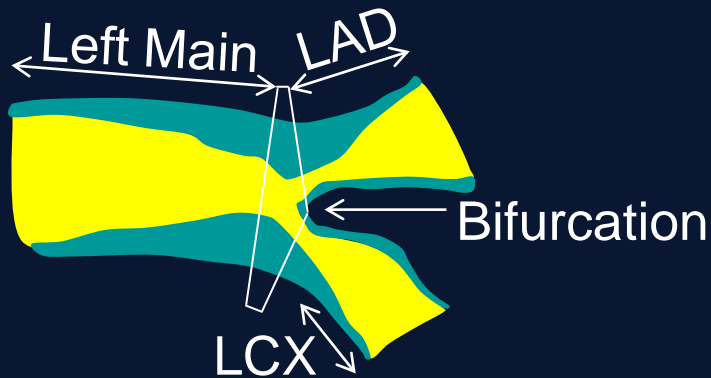
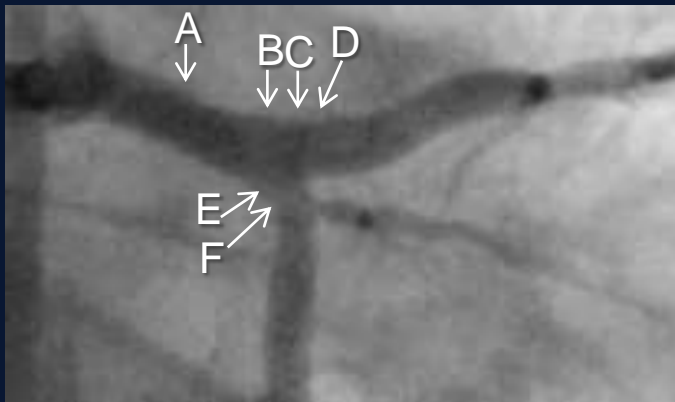
← Left Main → Bifurcation ← LAD →



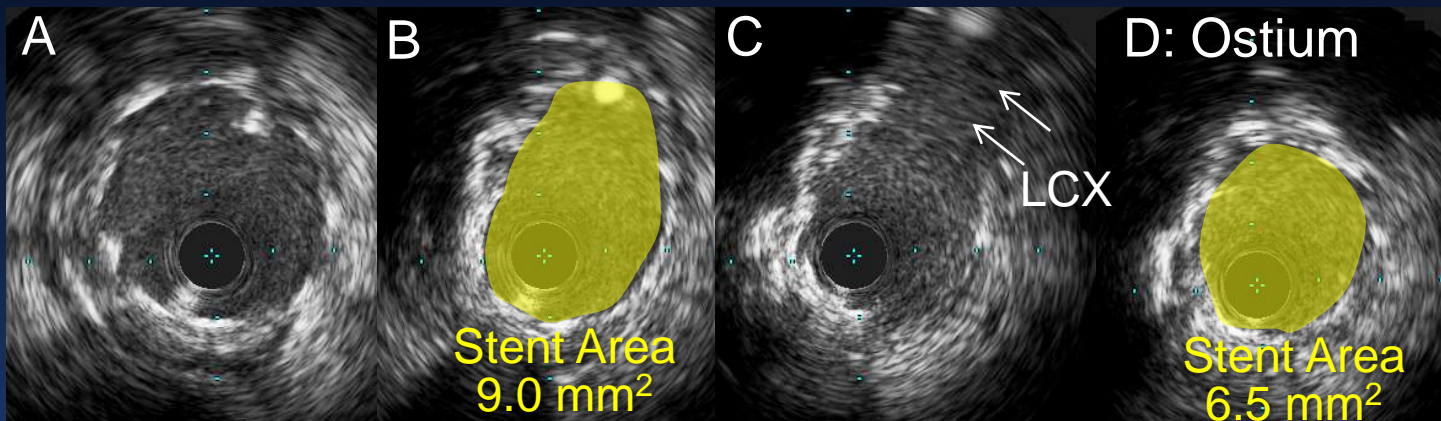
Proximal Distal

← Left Main → Bifurcation ← LCX →



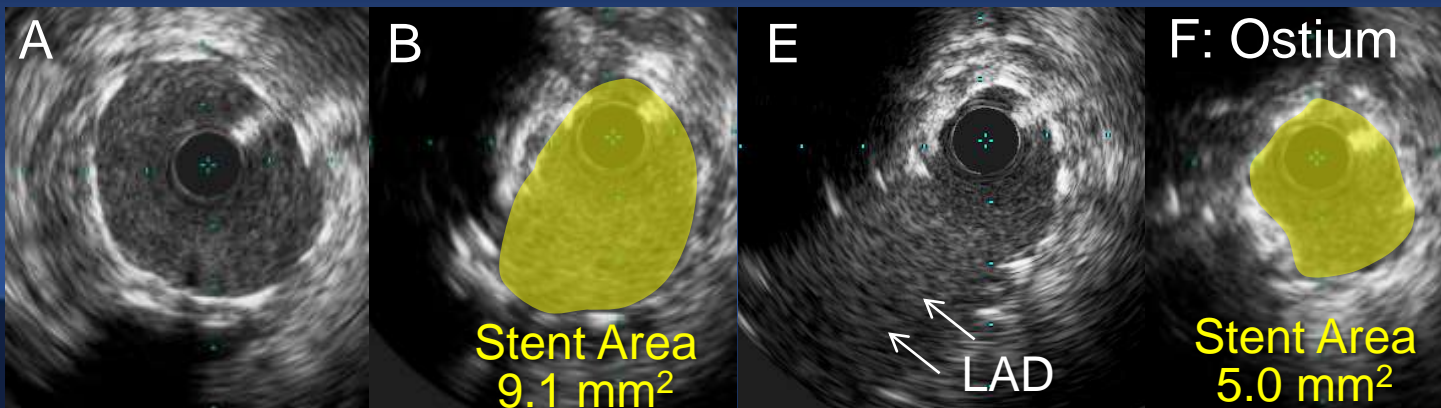


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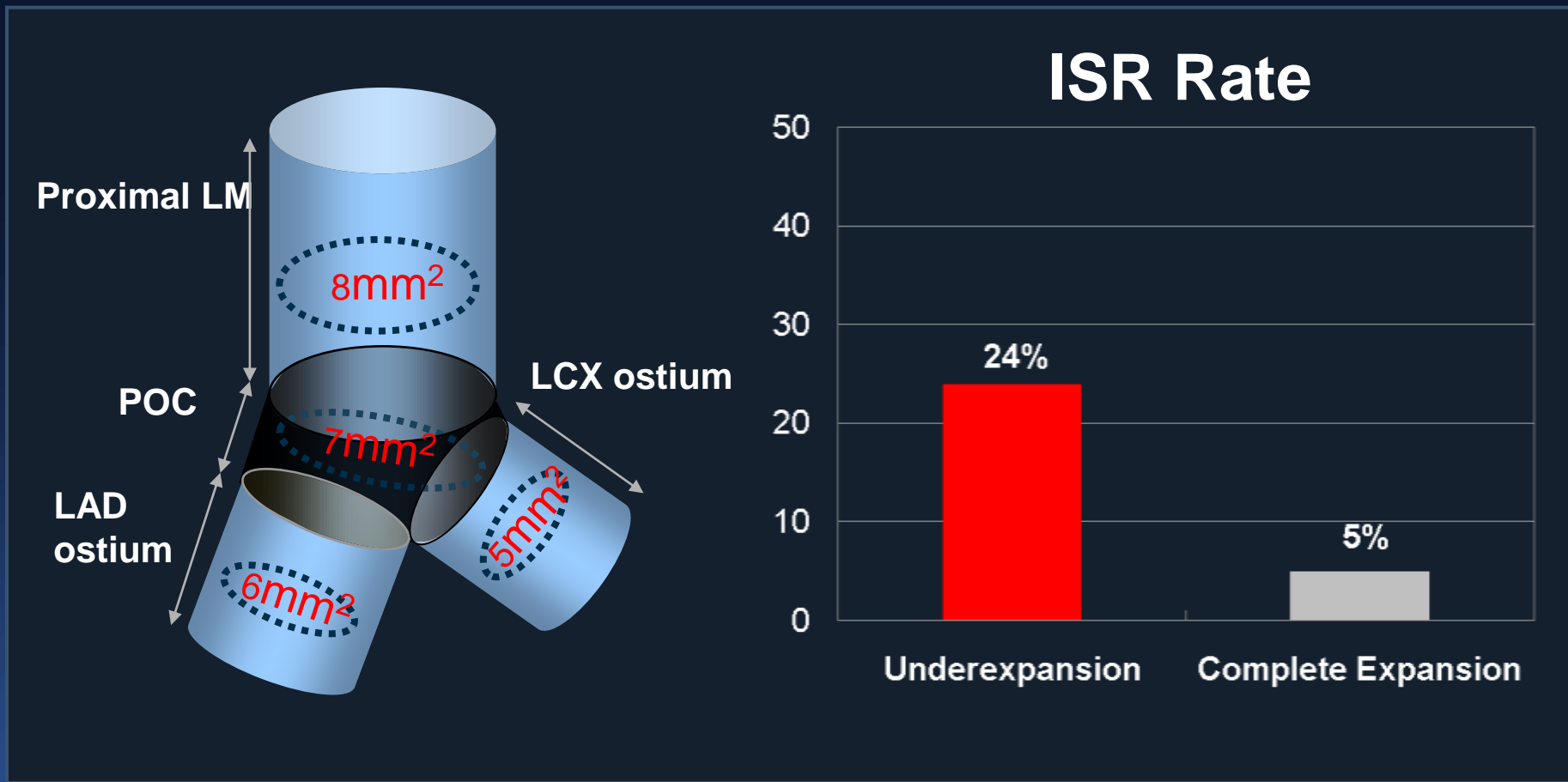


Proximal Distal

← Left Main → Bifurcation ← LCX →

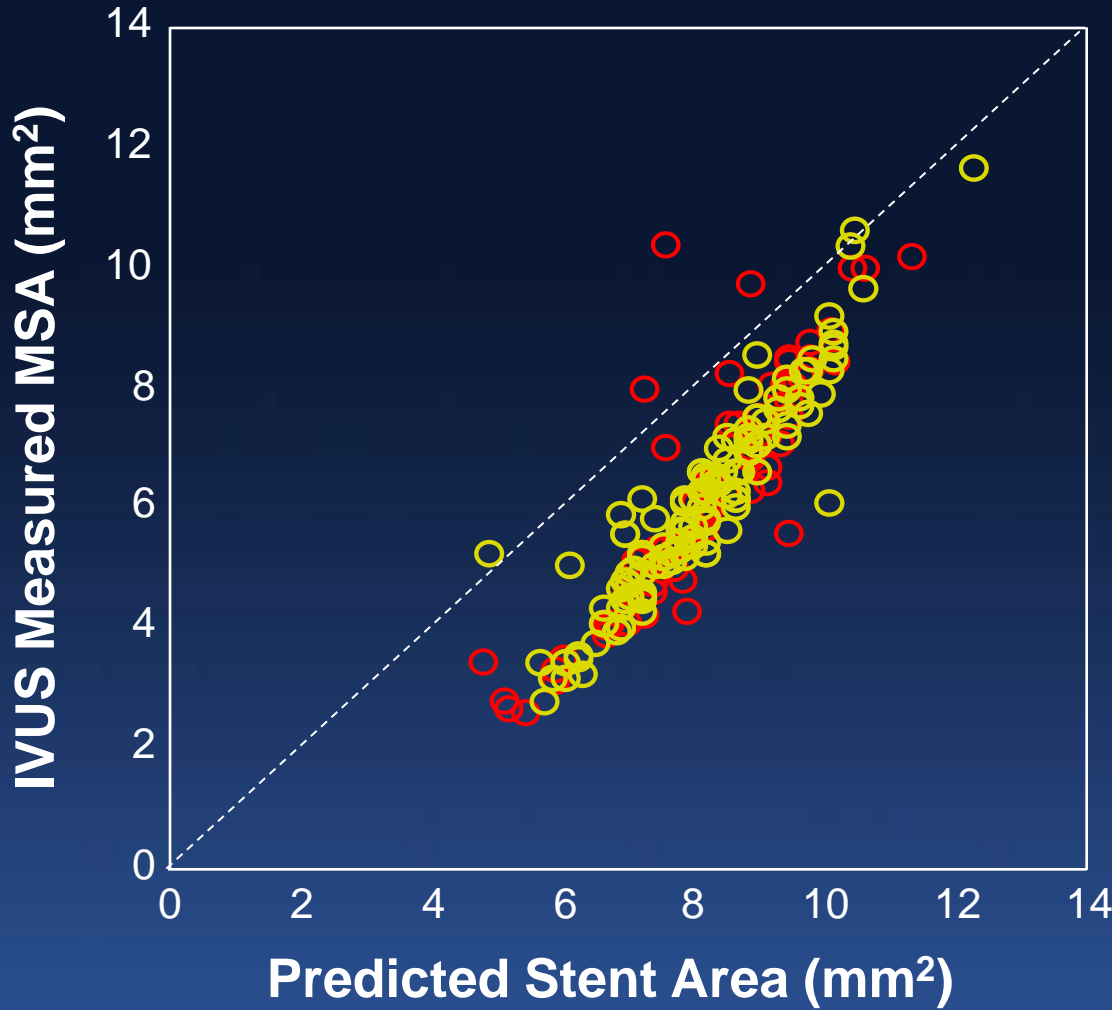


Optimal Stent Cross Sectional Area After LM Stenting



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

Compliance Charts and the Actual Expansion



- CYPHER (n=133)
- TAXUS (n=67)

66%

3mm Stent = 7mm²

66% Expansion = 4.6mm²

Underexpansion Predicts DES Restenosis

	Population	DES	Endpoint	MSA Cut-off
SIRIUS ¹	72	SES	8 mo, MLA<4.0mm ²	5.0mm²
Hong ²	550	SES	6 mo, Angio-ISR	5.5mm²
TAXUS-Meta ³	1098	PES	9 mo, Angio-ISR	5.7mm²

¹J Am Coll Cardiol 2004;43:1959-63 ² Eur Heart J 2006;27:1305-10 ³ JACC Interv 2009;2:1269-75

BMS

100%

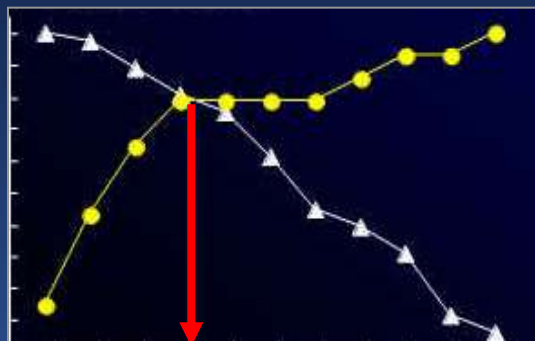


MSA 6.5mm²

Predictive value 56%

SES

100%



MSA 5.0mm²

Predictive value 90%

PES

100%



MSA 5.7mm²

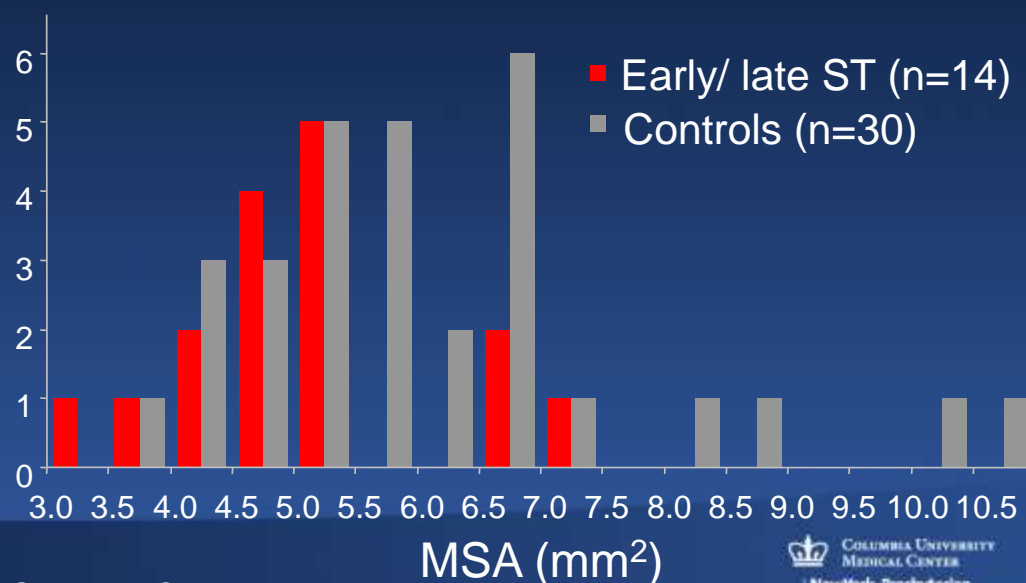
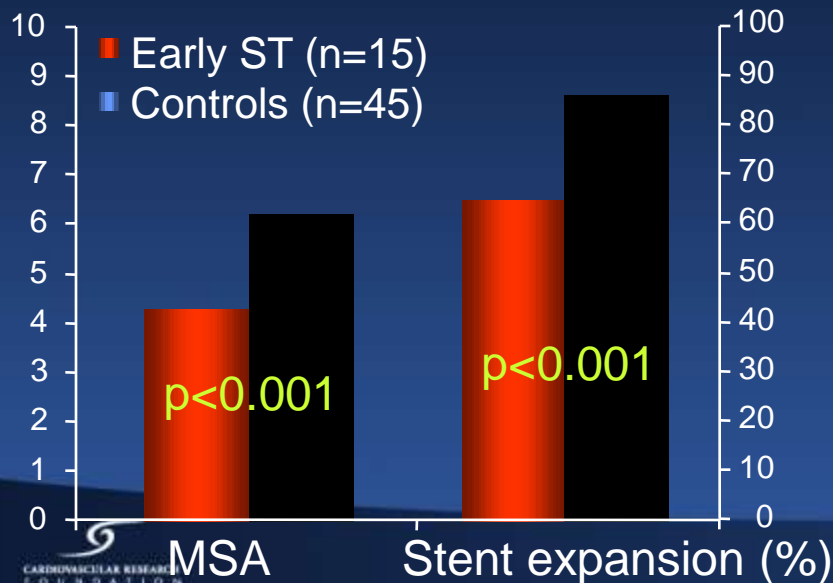
Underexpansion Predicts DES Thrombosis

	Population	DES	Endpoint	Rate of Underexpansion
Fujii ¹	15 ST vs. 45 controls	SES	ST <1 month	<5.0mm ² in 80% vs. 29%
Okabe ²	13 ST vs. 27 controls	DES	ST <1 year	<5.0mm ² in 79% vs. 40%
Liu ³	20 ST vs. 50 controls	DES	ST <1 year	<5.0mm ² in 85% vs. 26%

¹ J Am Coll Cardiol 2005;45:995-8

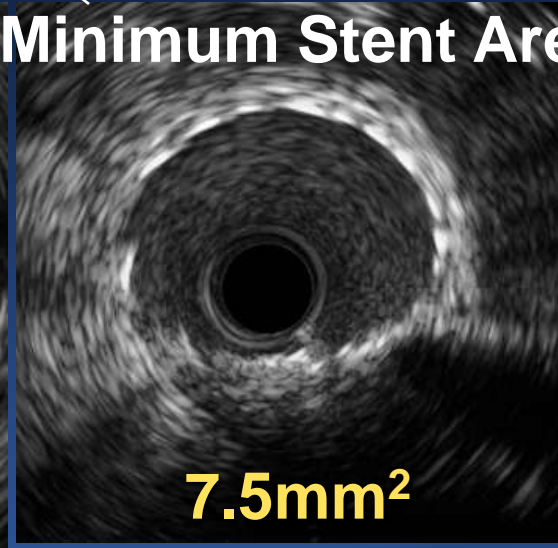
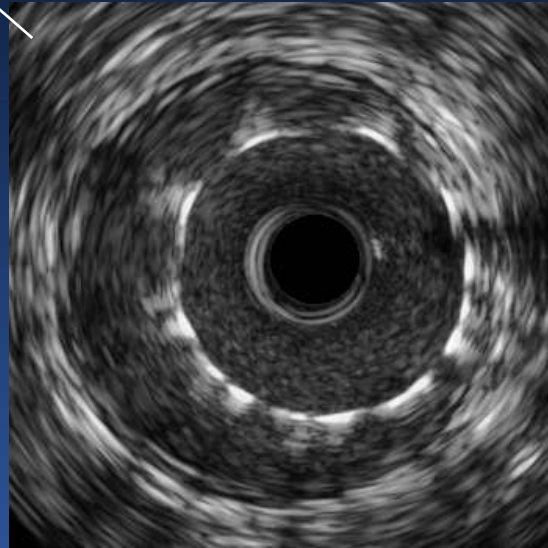
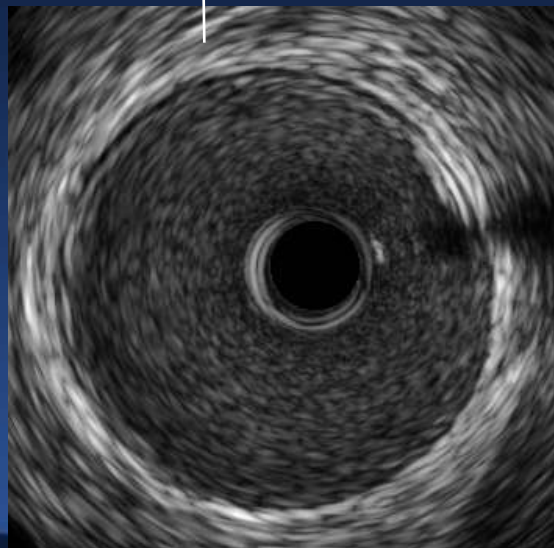
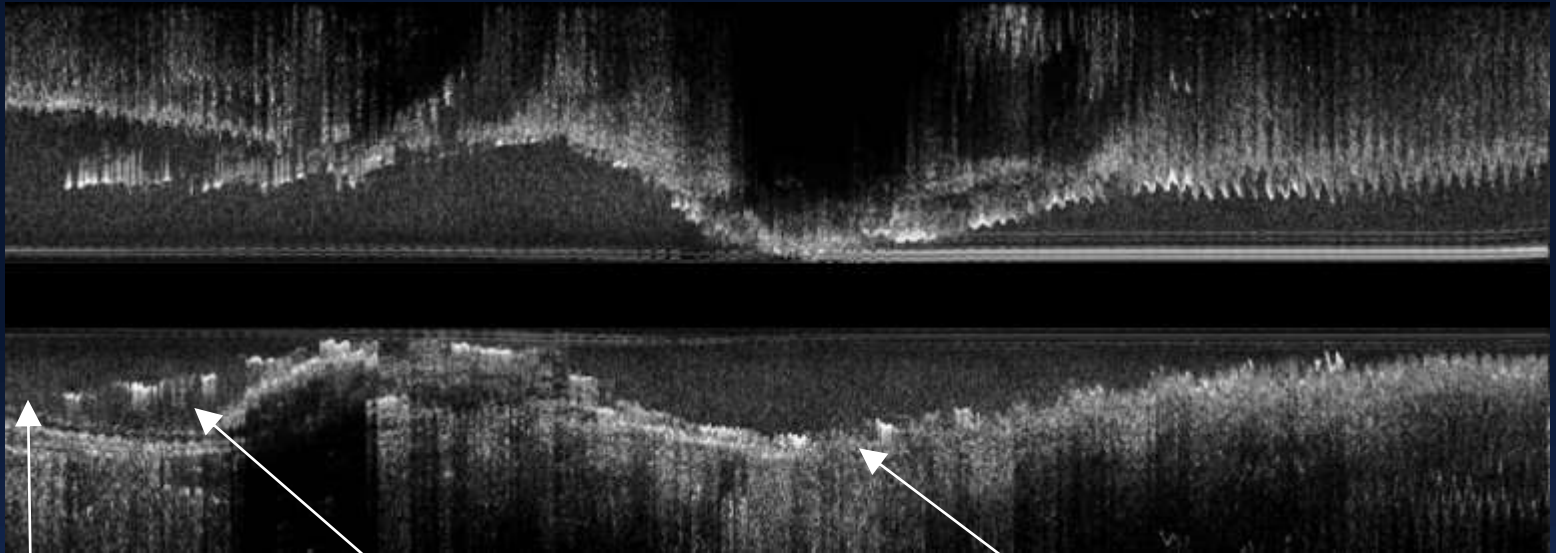
² Am J Cardiol 2007;100:615-20

³ JACC interv 2009;2:428-34



Stent Optimization - Complication -

Acute Stent Malapposition



Minimum Stent Area

7.5mm²

Malapposition

Acute Stent Malapposition (ASM)

Little Evidence Linking ASM to MACE

Study	ASM frequency	Clinical outcomes
HORIZON-AMI¹	34% of PES 39% of BMS	39% resolved by negative remodeling No difference in 13-month MACE
TAXUS IV,V,VI²	9.7% of PES 7.2% of BMS	No difference in 9-mo MACE between ASM vs. control (12% vs. 9%, p=0.45)
Hong et al.³	7.2% of DES	No MACE or TLR at 6 months
Kimura et al.⁴	18% of SES	25% of ASM resolved at 6 months No ISR or ST

¹Guo et al. Circulation 2010;122:1077-84

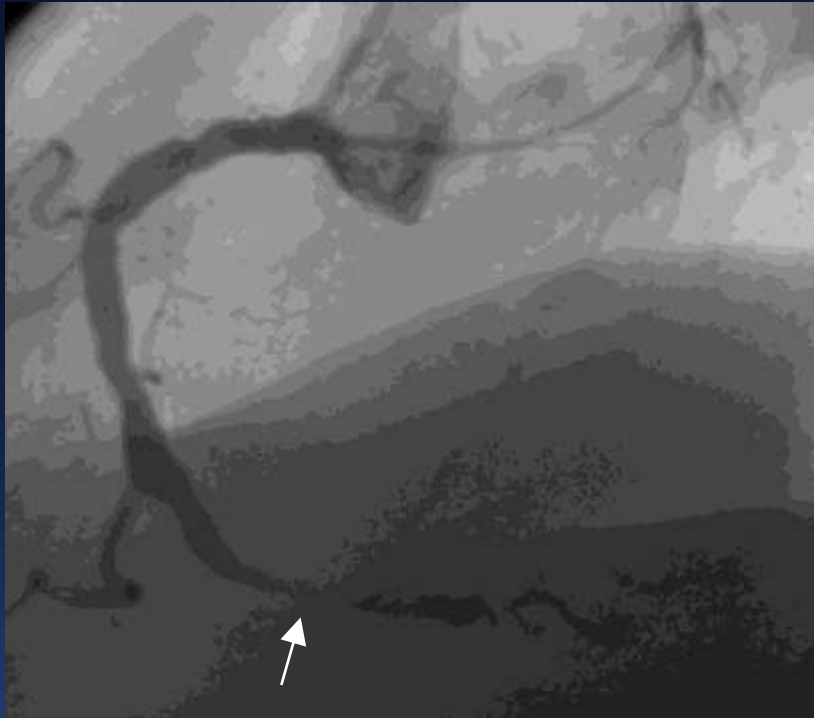
²Steinberg et al. JACC interv 2010;3:486-94

³Hong et al. Circulation 2006;113:414-9

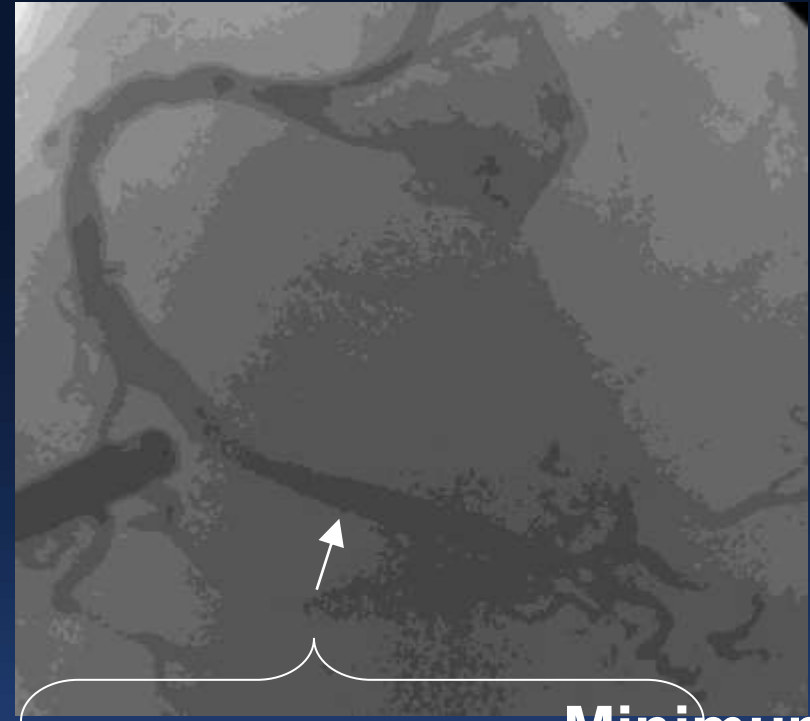
⁴Kimura et al. Am J Cardiol 2006;98:36-42

Thrombus Protrusion

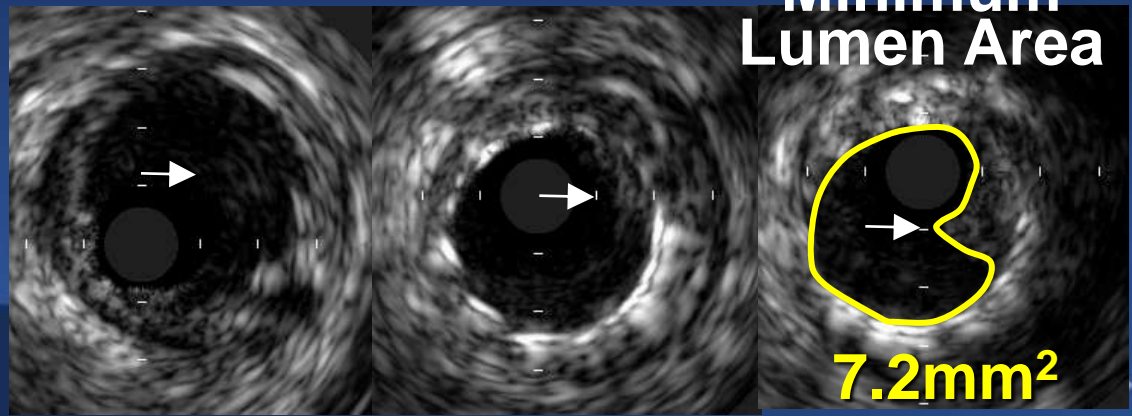
Pre-Intervention



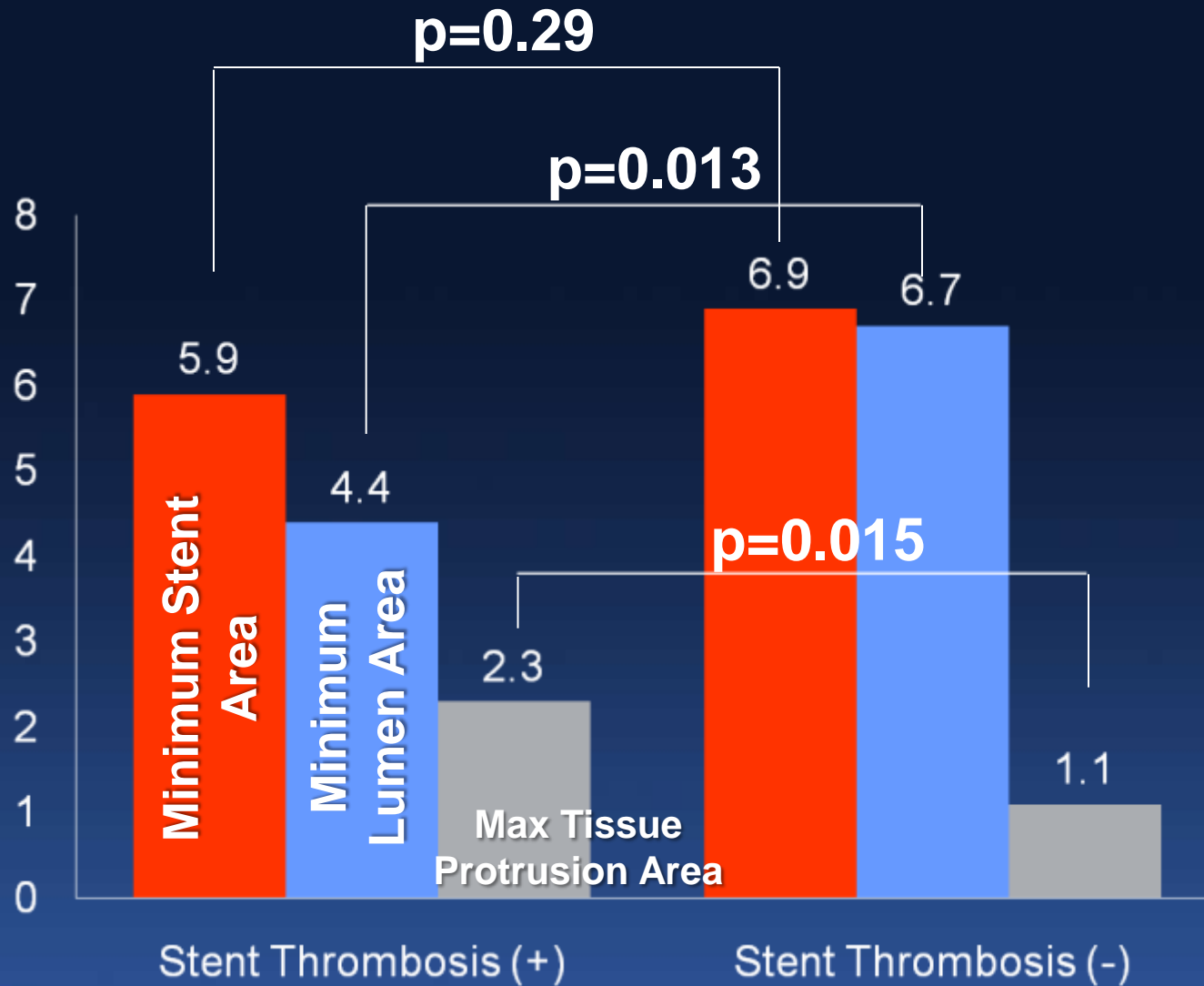
Post-Stent



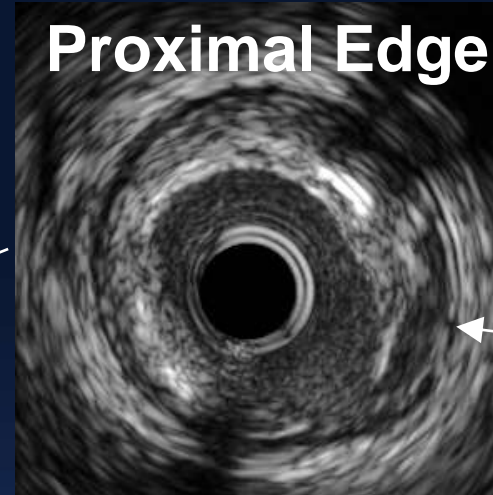
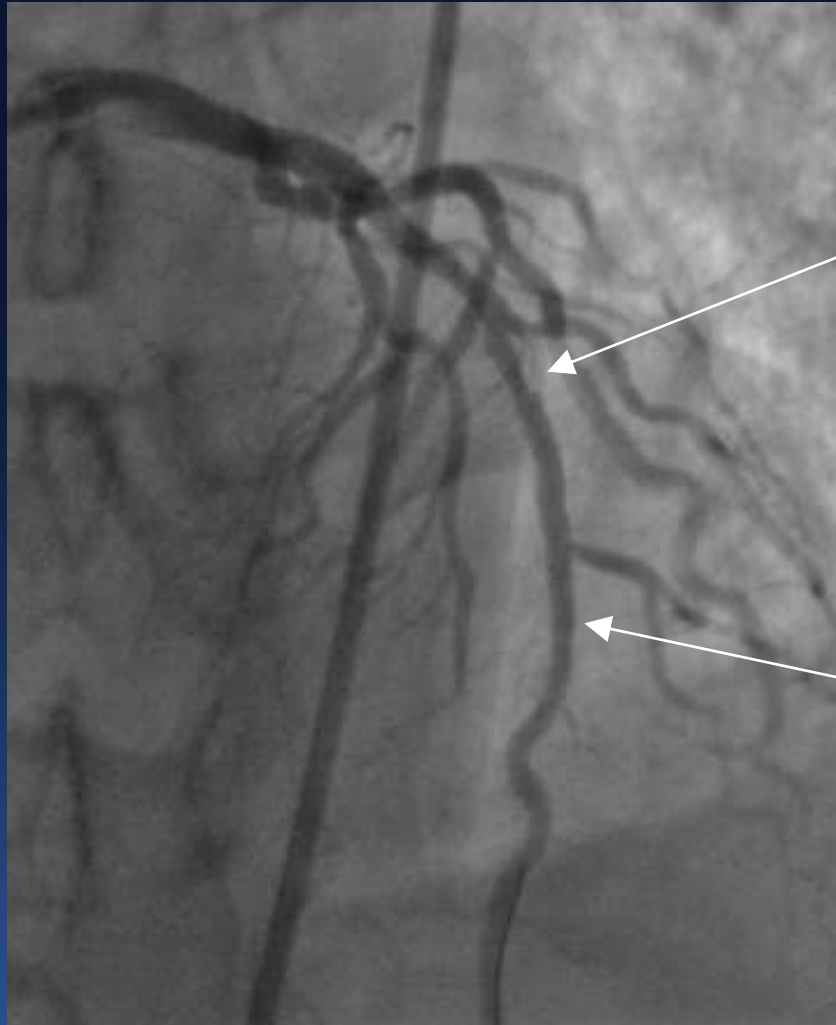
Minimum
Lumen Area



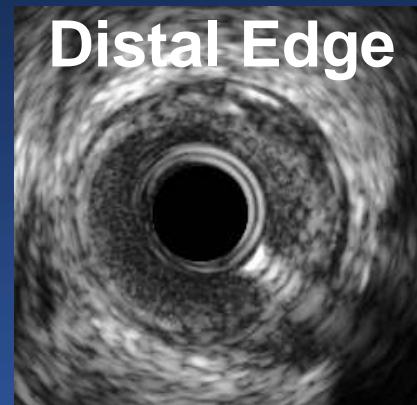
HORIZONS-AMI Early Stent Thrombosis



Stent Edge Dissection

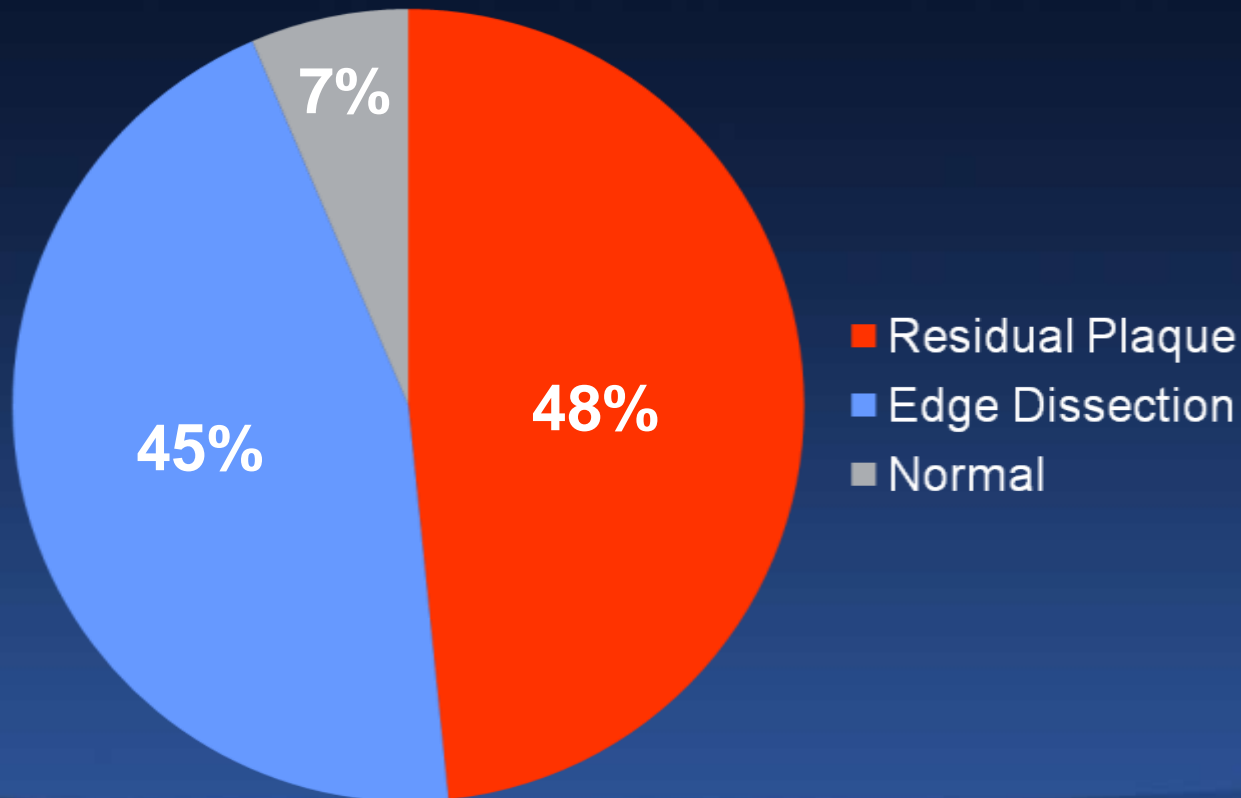


dissection



IVUS Assessment for Angiographic “Haziness”

Angiographical Haziness : 31/201 segments (15%)



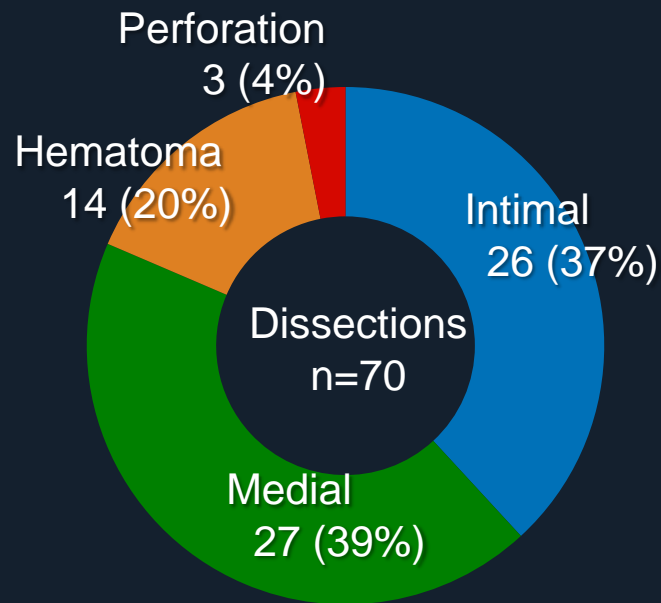
Ziada et al. Am J Cardiol 1997

Incidence of Stent Edge Dissection ADAPT-DES IVUS Substudy

Proximal Edge

(n=2,215 segments)

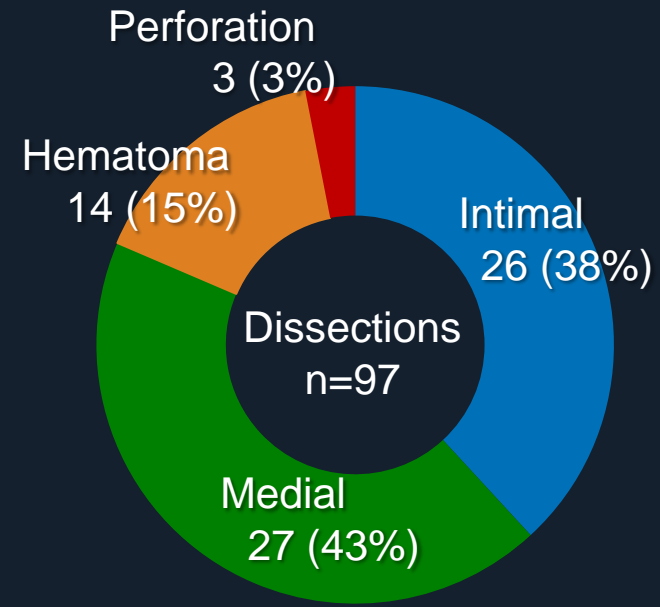
70 (3.2%) dissections



Distal Edge

(n=2,376 segments)

97 (4.1%) dissections



N Kobayashi, ACC2014

Clinical Outcomes (at 1 year)

	Dissection (159 patients)	No dissection (1903 patients)	HR [95% CI]	P Value
MACE	10.2% (16)	5.4% (101)	1.95 [1.15,3.30]	0.0116
Target vessel failure	14.0% (22)	8.6% (163)	1.67 [1.07,2.61]	0.022
Death	1.9% (3)	1.5% (28)	1.30 [0.39,4.26]	0.67
Myocardial infarction	5.1% (8)	2.0% (38)	2.55 [1.19,5.46]	0.013
Stent thrombosis (definite/probable)	1.3% (2)	0.5% (9)	2.67 [0.58,12.36]	0.19

Time-to-event Kaplan-Meier estimated data.

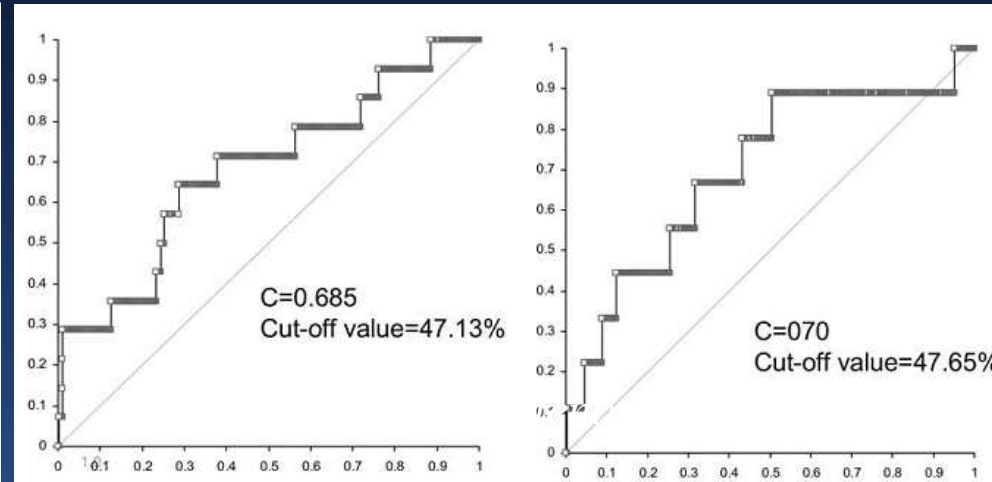
MACE = cardiac death, re-myocardial infarction or target lesion revascularization.

Target vessel failure = death, re-myocardial infarction or target vessel revascularization

Residual Plaque Predicts DES Restenosis

	Population	DES	F/U time	Predictor
SIRIUS¹	6 edge restenosis vs. 162 controls	SES	8 mo	Ref segment PB 60% vs. 41% (p<0.01)
TAXUS²	276 edge stenosis	PES	9 mo	Ref segment PB 47%

	Edge restenosis		p
	Yes	No	
Ref MLA, mm ²	4.7±2.3	6.4±2.3	0.05
Ref EEM, mm ²	10.7±3.8	14.0±4.8	0.16
Max PB, %	61 ±9	41±12	0.03
Edge dissec	0	2 (1%)	1.00



Plaque Burden 47%≈50%

¹Am J Cardiol 2005;96:1251-3

²Liu et al. Am J Cardiol 2009;103:501-6

Pre-Intervention



Ballooning



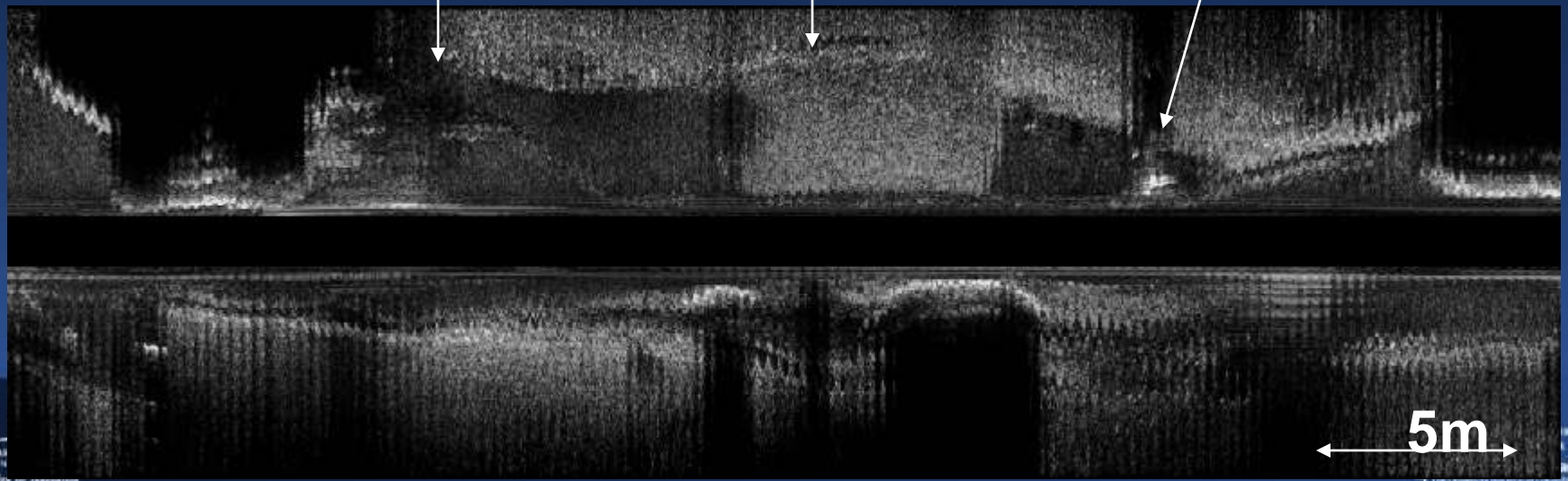
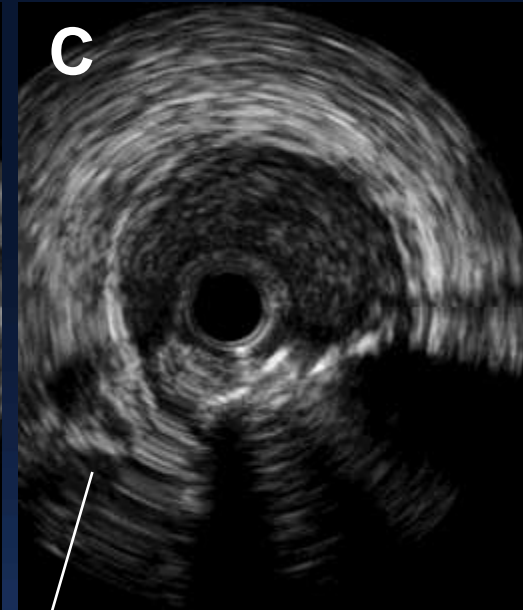
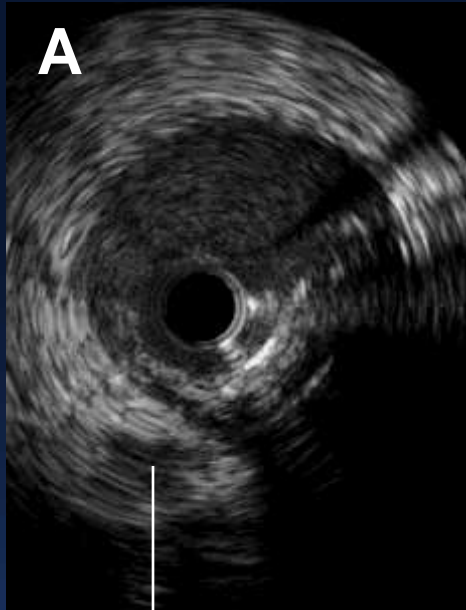
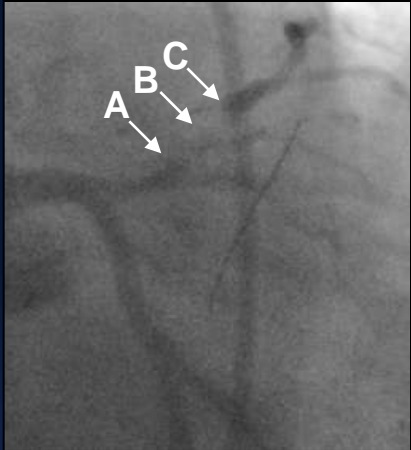
Post-Balloon



Intramural Hematoma

Entry site of hematoma

Distal End of
hematoma space

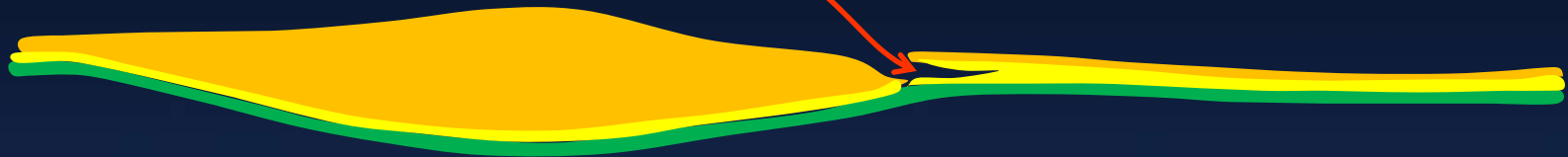


Mechanism of Intra-Medial Hematoma

Post-Balloon



Blood



New Stenosis

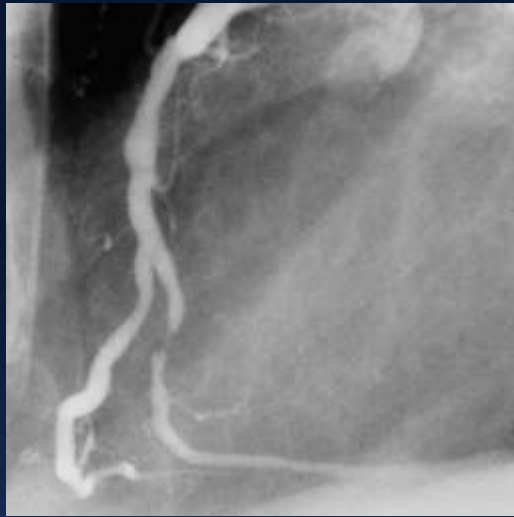


- Intima
- Media
- Adventitia

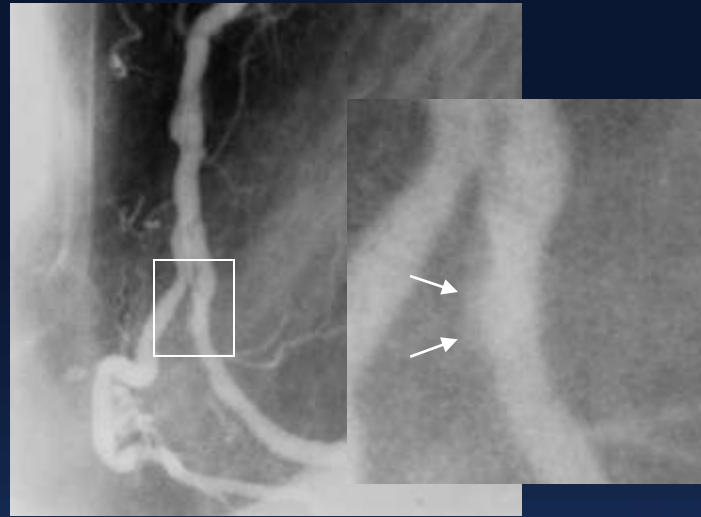


Perforation - angiographically unclear -

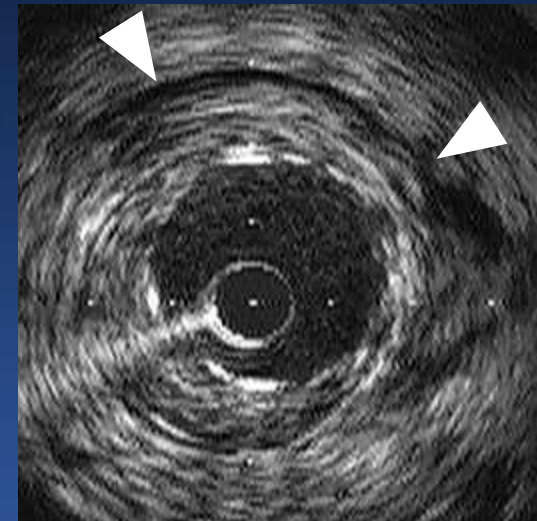
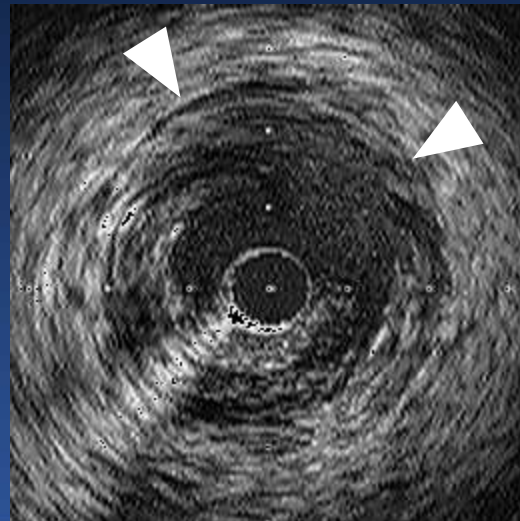
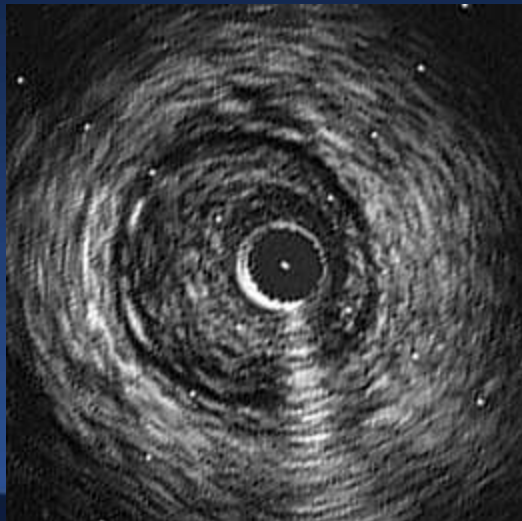
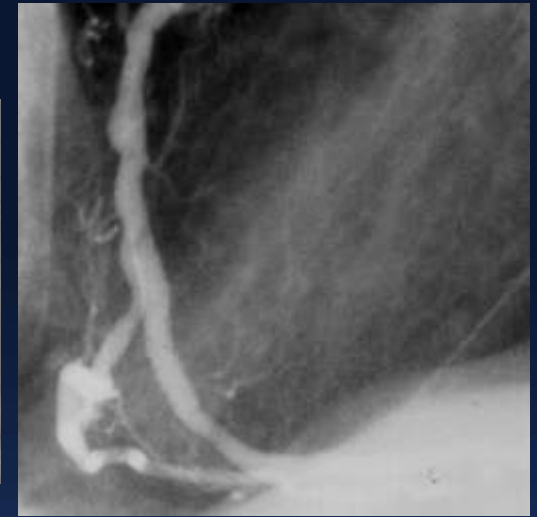
Pre



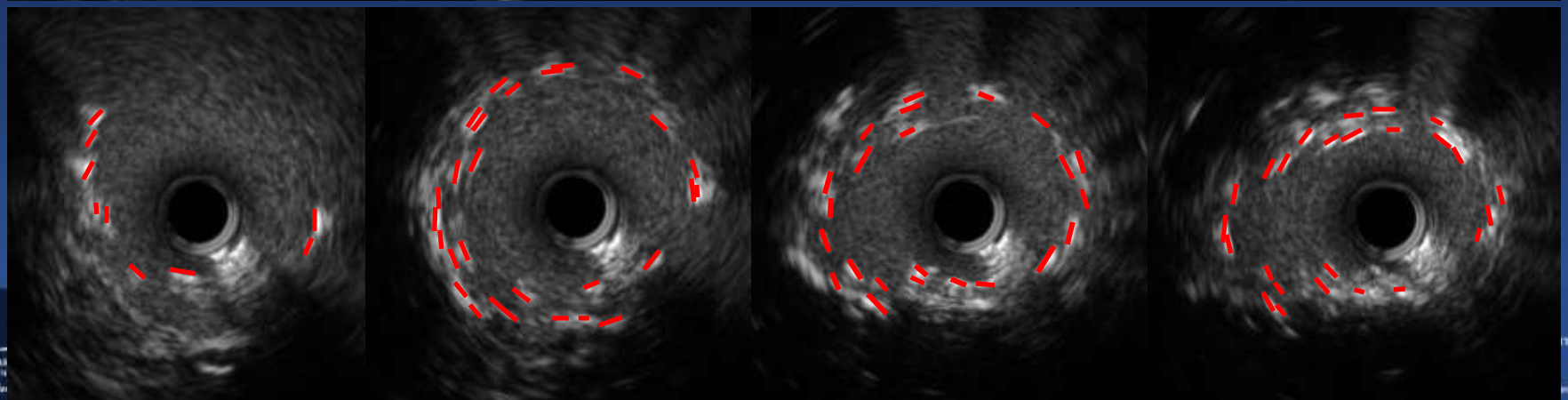
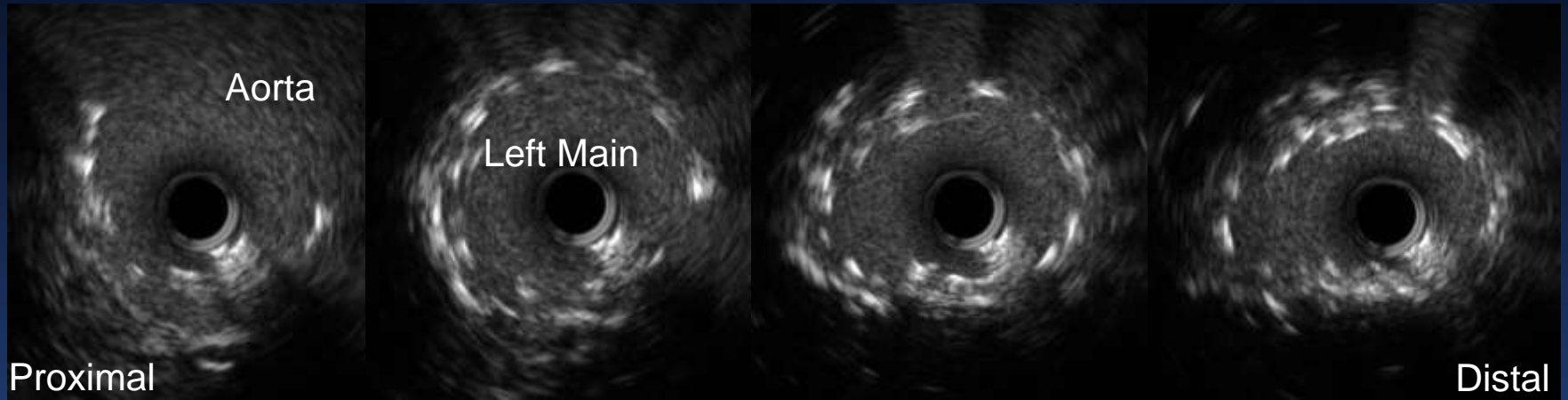
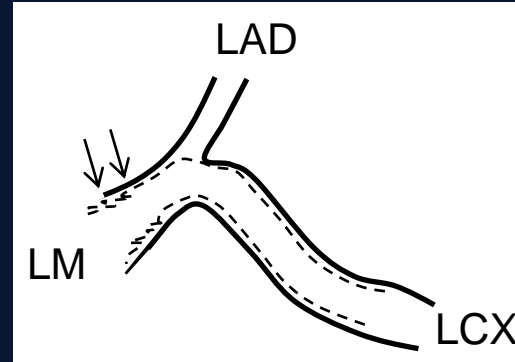
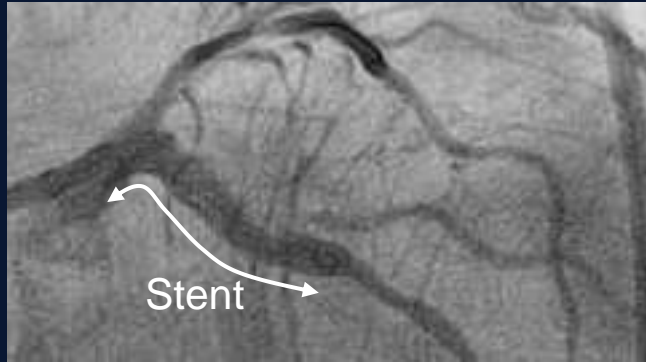
Post-Balloon



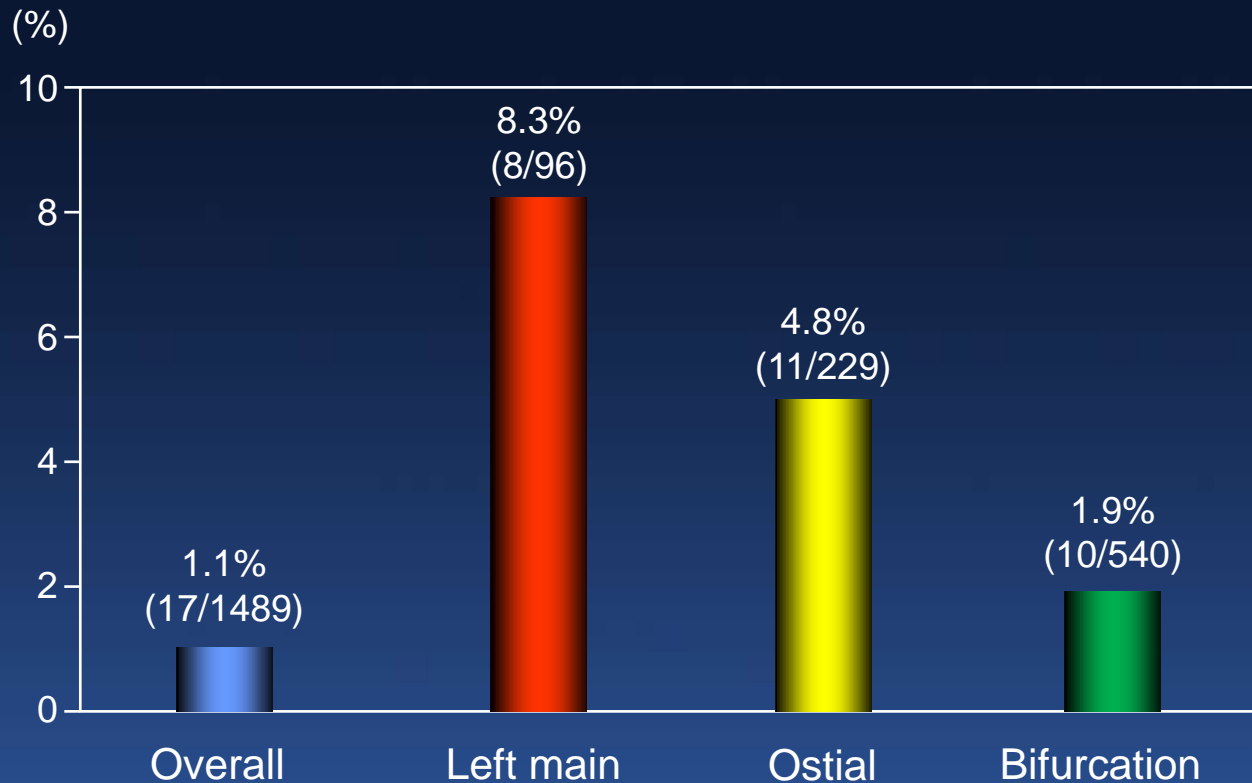
Post-Stent



Stent Deformation



Incidence of Stent Deformation



Take Home Message

1. IVUS can delineate...

1. Ambiguous angiographic morphology
2. Vessel size
3. Stent expansion
4. Mechanical complication and mechanism

2. IVUS cannot evaluate ischemic lesion except left main.