

Role of IVUS in Era of Drug-Eluting Stent

2017.12.08

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Professor of Medicine

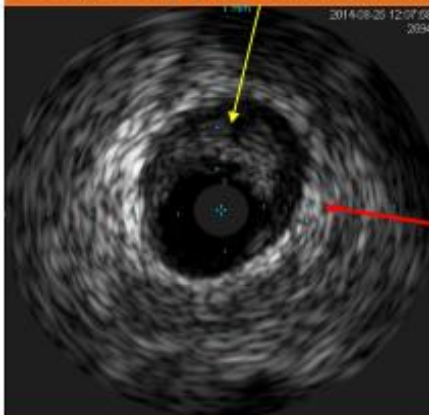
Inje University Ilsan Paik Hospital, Goyang, Korea

How much IVUS helps our clinical practice?

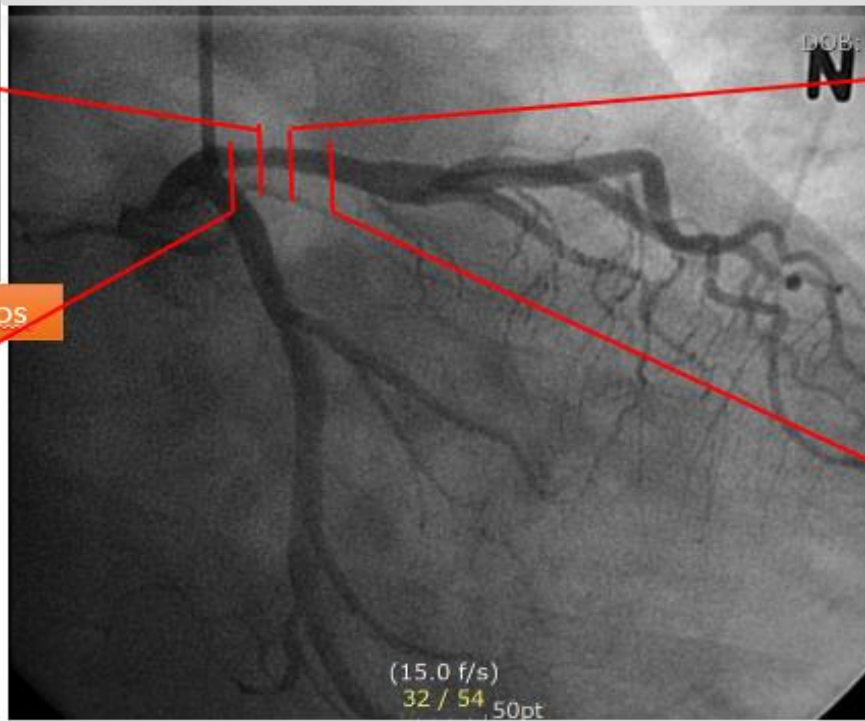
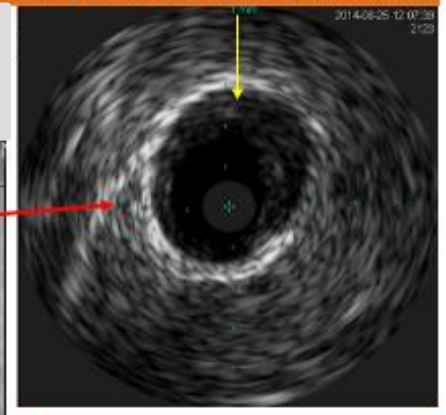
- Typical IVUS Findings with Cases -

Case #M/55, Acute chest pain, cardiac enzyme elevation (-)

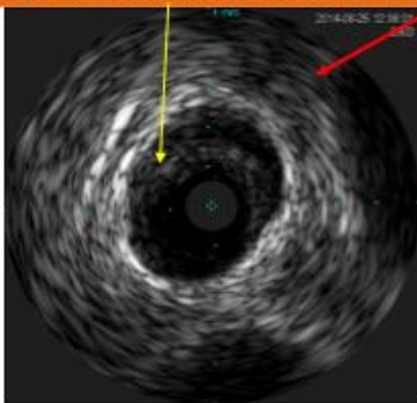
Plaque rupture with thrombus : pLAD



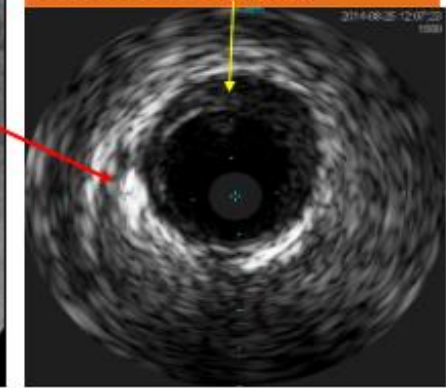
Another plaque rupture: pLAD



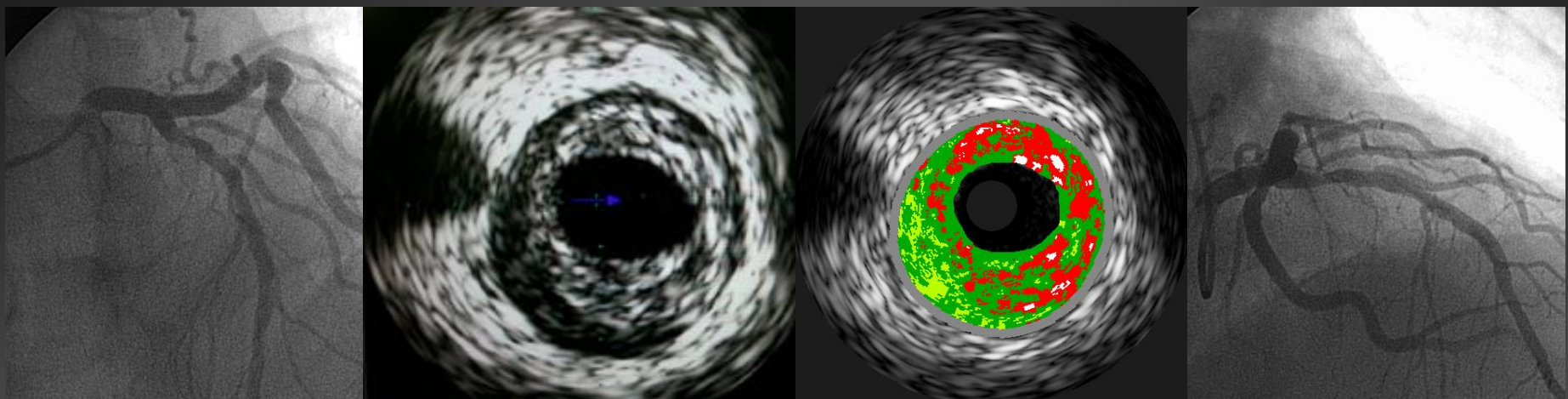
Irregular thrombus near LAD os



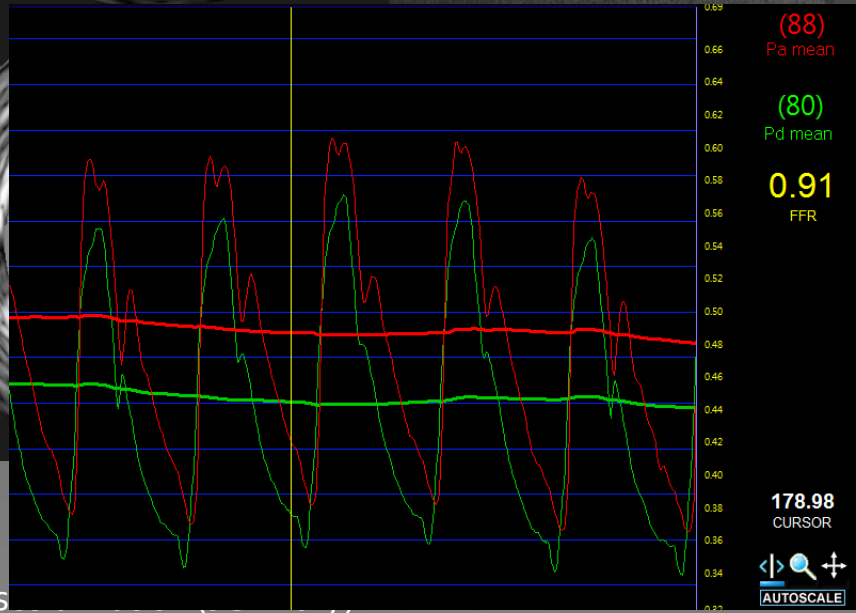
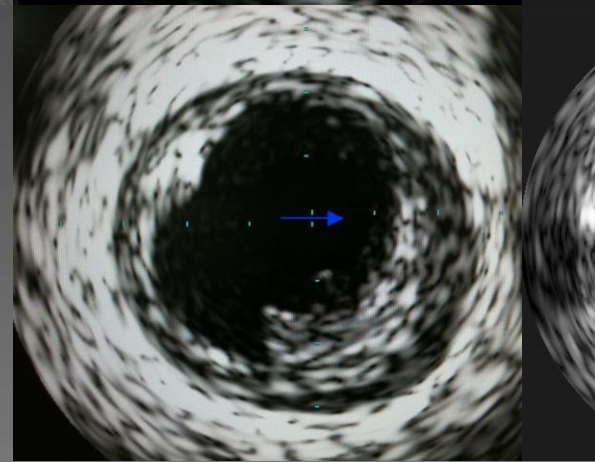
thrombus : pLAD



CASE #M/62, ACS



Troponin +
CK-MB 12.5



IVUS vs. Angio-guided PCI, which one is better?

7 RCT in DES era: IVUS-guided PCI vs Angiography-guided PCI

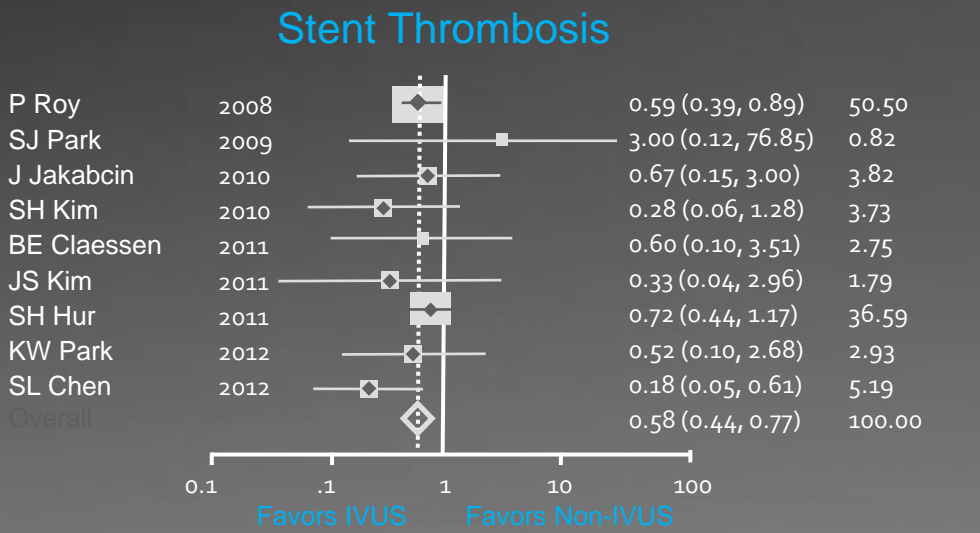
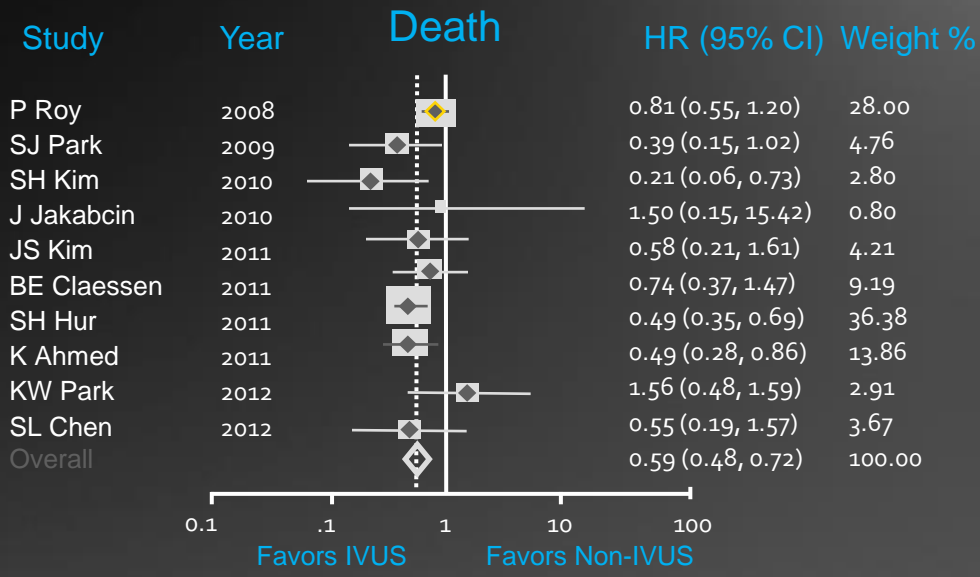
Characteristic	IVUS-XPL ¹⁴	CTO-IVUS ¹⁵	AIR-CTO ¹⁶	Tan et al ²⁶	Kim et al ²⁷	AVIO ²⁸	HOME DES IVUS ²⁹
Year	2015	2015	2015	2015	2013	2013	2010
Patients, n	700/700	201/201	115/115	61/62	269/274	142/142	105/105
Drug-eluting stent type	Second generation	Second generation	First/second generation*	First generation	Second generation	First generation	First generation
Age, years, mean	64/64	61/61	67/66	77/76	63/64	64/64	59/60
Male, %	69/69	81/81	89/80	62/69	66/55	82/77	73/71
DM, %	36/37	35/34	30/27	34/30	32/30	24/27	42/45
Clinical presentation							
Stable angina, %	51/51	100/100	71/76	30/34	53/51	70/64	38/40
Unstable angina, %	35/32	0/0	9/10	70/66	38/39	30/26	43/39†
ST-elevation MI, %	14/17	0/0	20/15‡	0/0	9/10	0/0	29/21
LVEF, %	63/62	57/57	55/56	55/53	55/54	55/56	NR
Follow-up duration, mo	12	12	24	24	12	24	18

Circ Cardiovasc Interv. 2016;9:e003700.

Meta-Analysis of 11 Studies (n=19,619 patients)

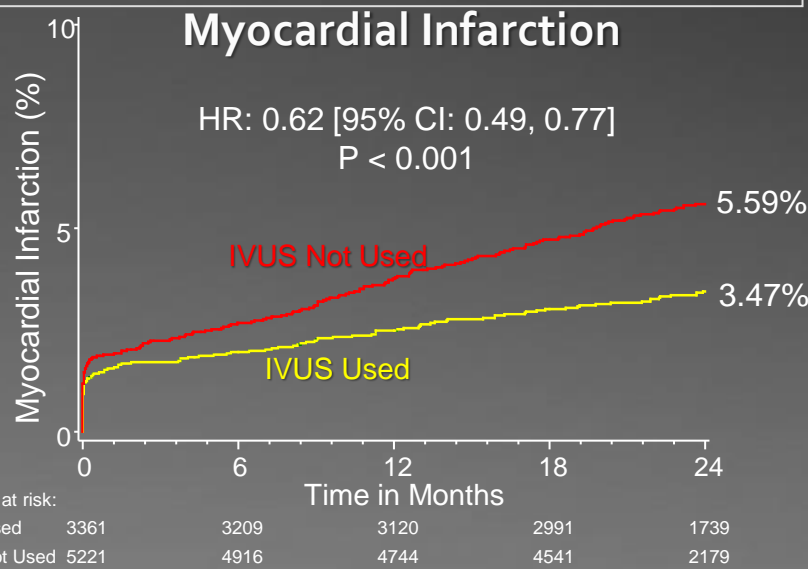
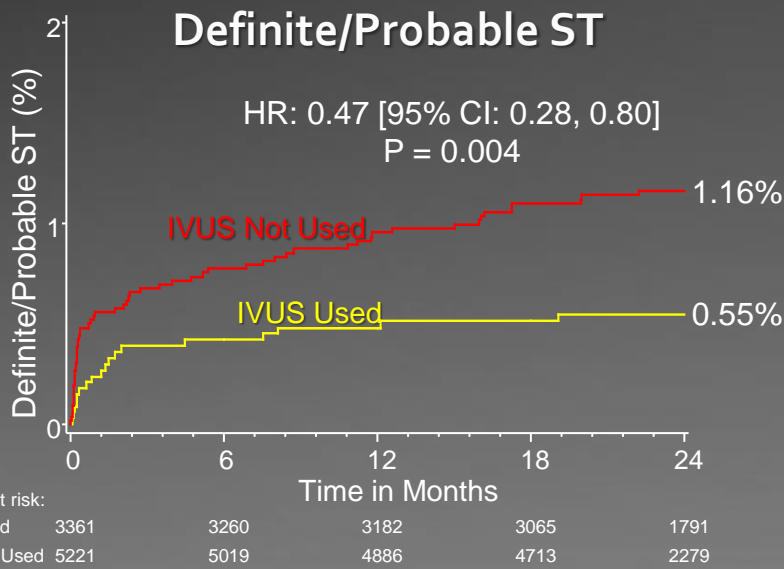
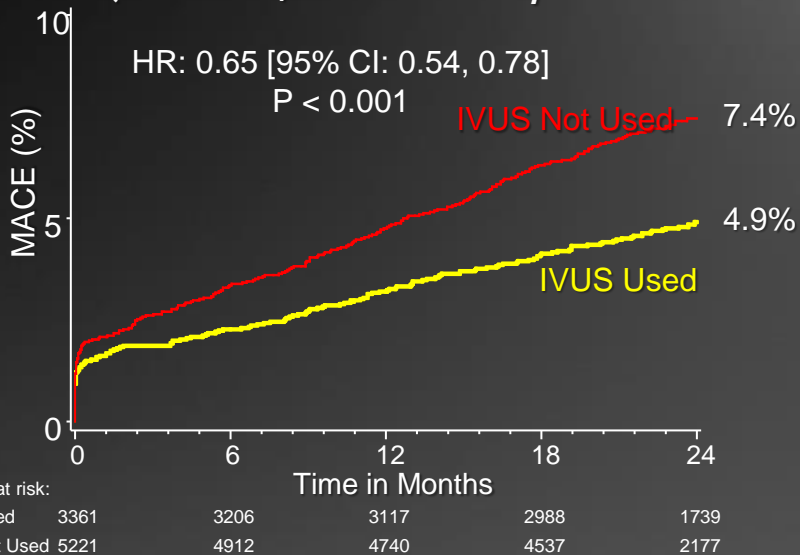
Compared with angiography-guidance, IVUS-guided DES implantation was associated with a reduced incidence of

- Death (HR: 0.59, 95% CI: 0.48-0.73, $p < 0.001$)
- Stent thrombosis (HR: 0.58, 95% CI: 0.44-0.77, $p < 0.0001$)
- Major adverse cardiac events (HR: 0.87, 95% CI: 0.78-0.96, $p = 0.008$)



MACE (Definite/Probable ST, Cardiac Death, MI)

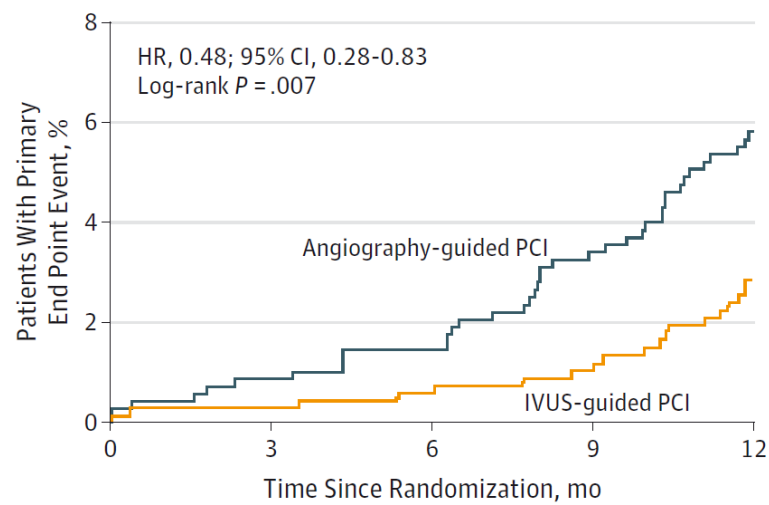
Two year follow-up data from ADAPT-DES (3361 pts treated with IVUS-guidance vs 5221 pts treated with angiographic guidance)



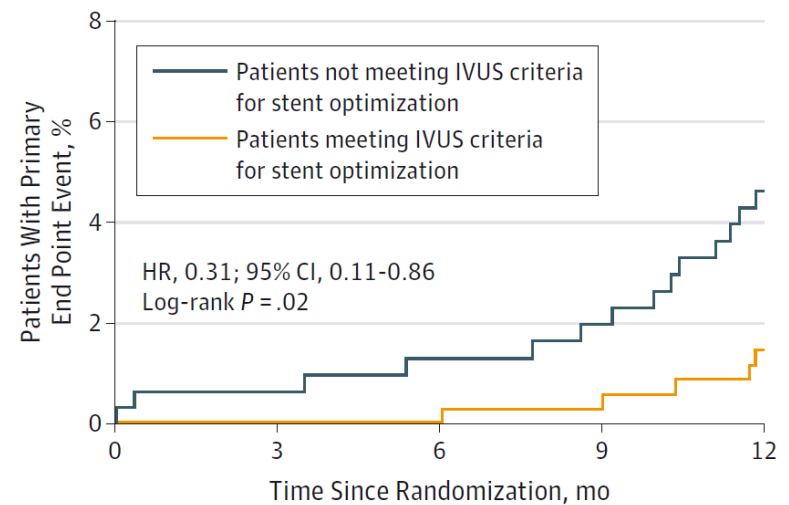
Effect of IVUS-guided vs Angiography-guided EES implantation

IVUS-XPL RCT (n=1400)

All patients (ITT)



Patients who underwent IVUS-guided stent implantation



No. at risk
PCI

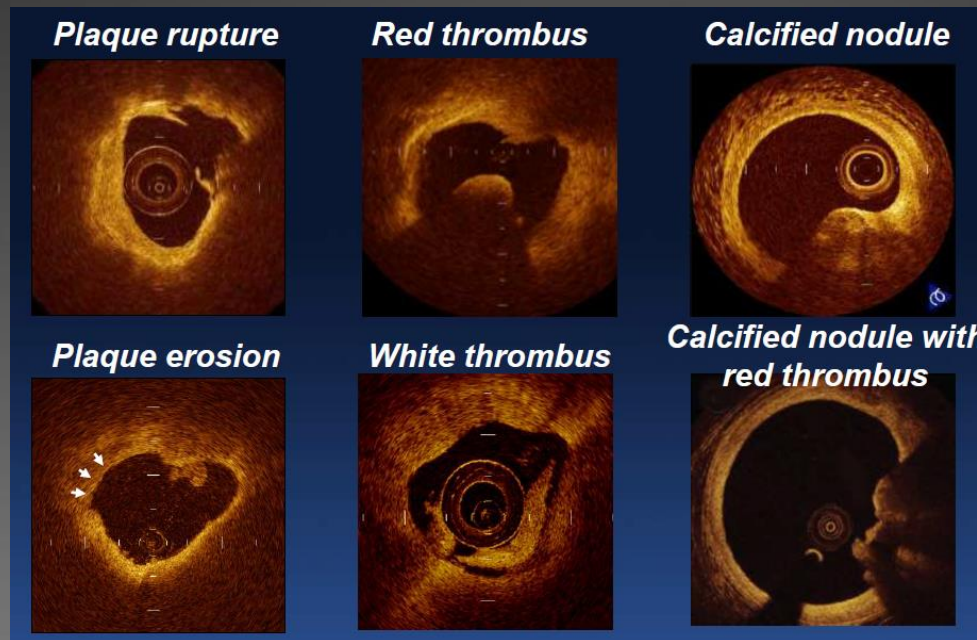
Angiography-guided	700	673	660	643	624
IVUS-guided	700	671	665	654	641

No. at risk
IVUS criteria

Not meeting	315	299	297	394	285
Meeting	363	362	345	338	334

JAMA. 2015;314(20):2155-2163.

IVUS vs. OCT-guided PCI



Kubo et al. J Am Coll Cardiol 2007;50:933-9

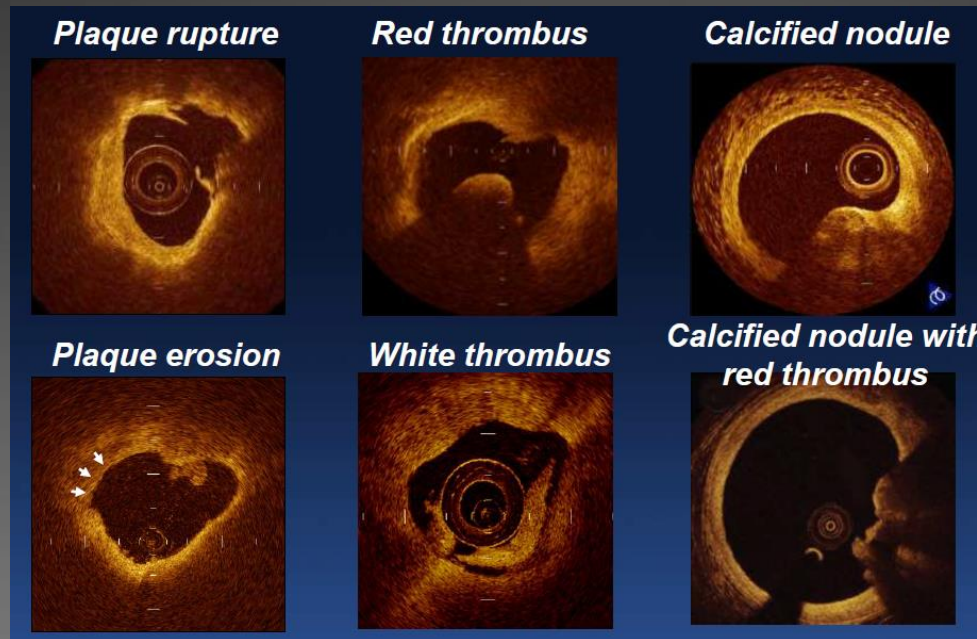
Kume et al. Am J Cardiol 2006;97:1713-7

Otsuka et al. Nature Reviews Cardiol 2014;11

IVUS vs OCT

	IVUS	OCT
Assessing lesion severity		
Non-LMCA		
LMCA	+	
Identifying the culprit lesion		+
Predicting distal embolization	+ (high NPV, but low PPV)	
Optimizing stent implantation	+ (Although the current data favors IVUS, IMHO eventually this will be a matter of preference)	
CTO	+	
LMCA	+	
Chronic renal insufficiency	+	
BRS		
Jailed sidebranch		
Assessing stent failure	Early/Late	Early, Late, or Very Late

IVUS vs. OCT-guided PCI in LM disease



Kubo et al. J Am Coll Cardiol 2007;50:933-9

Kume et al. Am J Cardiol 2006;97:1713-7

Otsuka et al. Nature Reviews Cardiol 2014;11

IVUS vs OCT

IVUS vs OCT assessing LMCA severity (n=35)

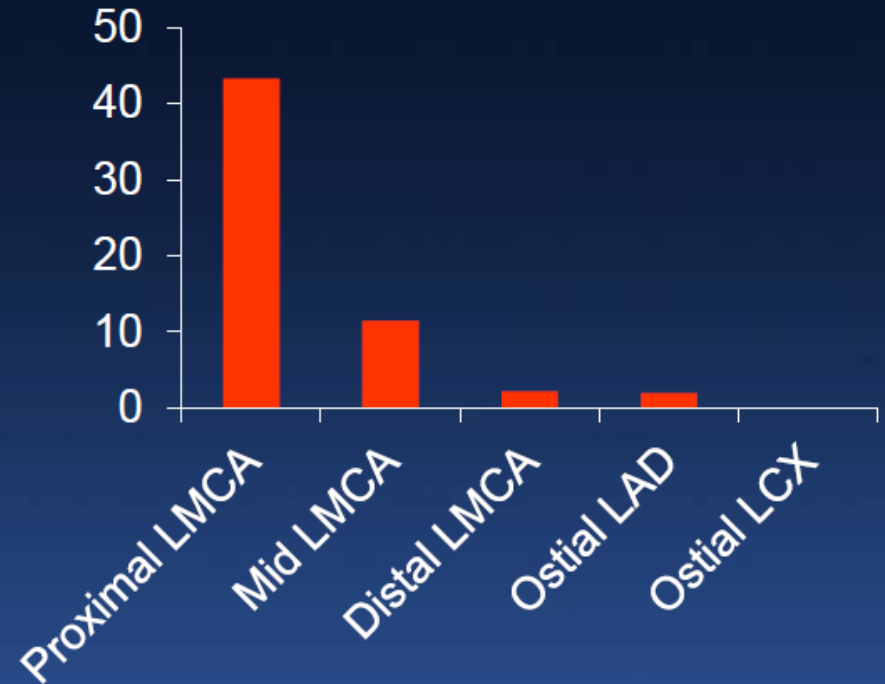
	IVUS	OCT	p
Unable to cross	5.7%	8.6%	0.3
Pullbacks per lesion	1	1.25*	0.003
Pts with repeat pullbacks	0	25%*	0.004
Inadequate assessment of LMCA ostium	6.1%	87.5%	<0.001
MLA (mm ²)	3.46	2.94	0.002

***repeat pullbacks in 8 pts were mostly due to insufficient blood clearance**

Fujino et al. Cathet Cardiovasc Interv 2013;82:E173-83

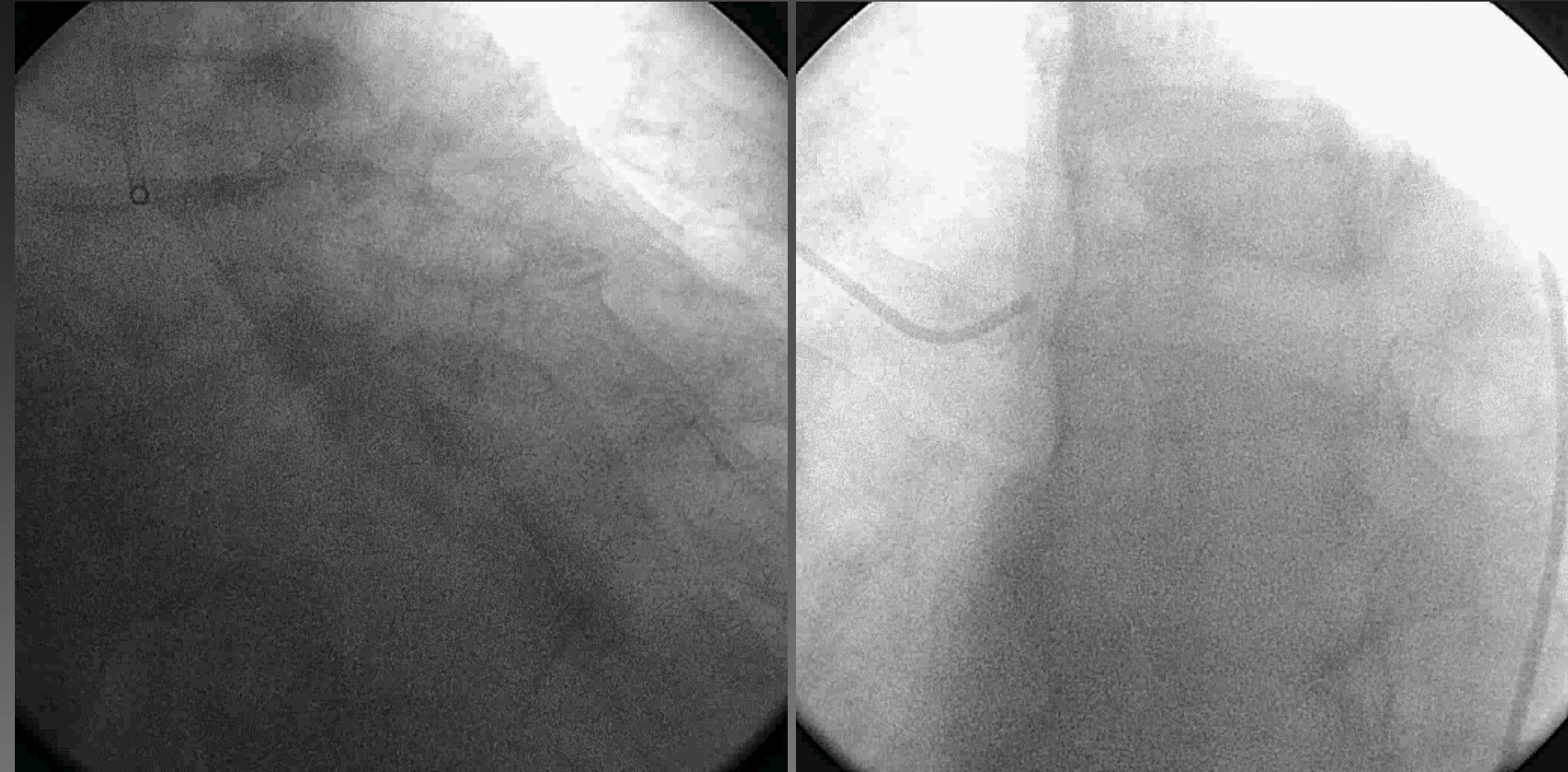
OFDI assessment of LMCA (38 LAD to LMCA, 11 LCX to LMCA, and 5 both LAD and LCX to LMCA)

Percent Artifact Frames

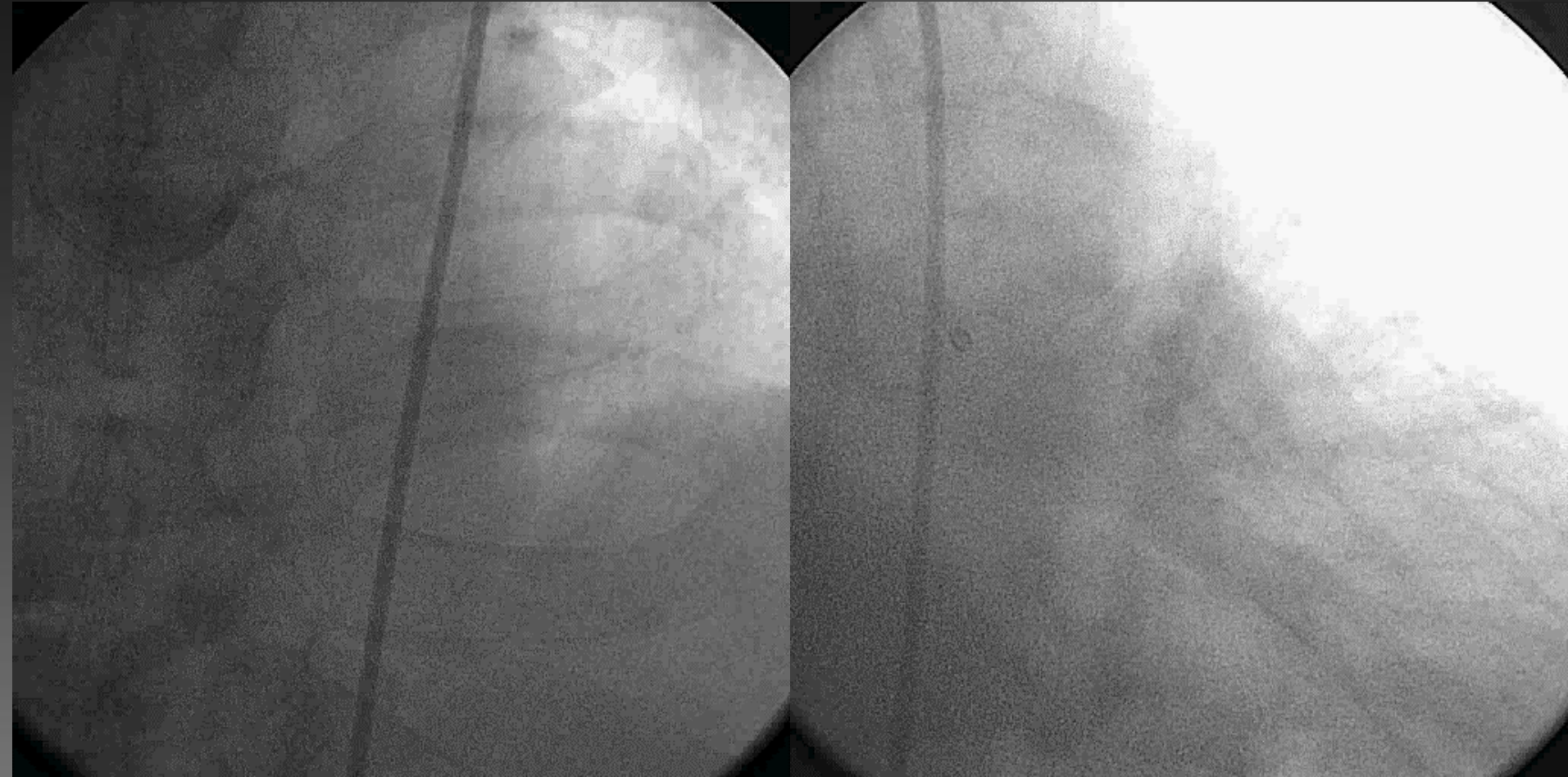


Burzotta et al. EuroIntervention 2015;10:e1-8

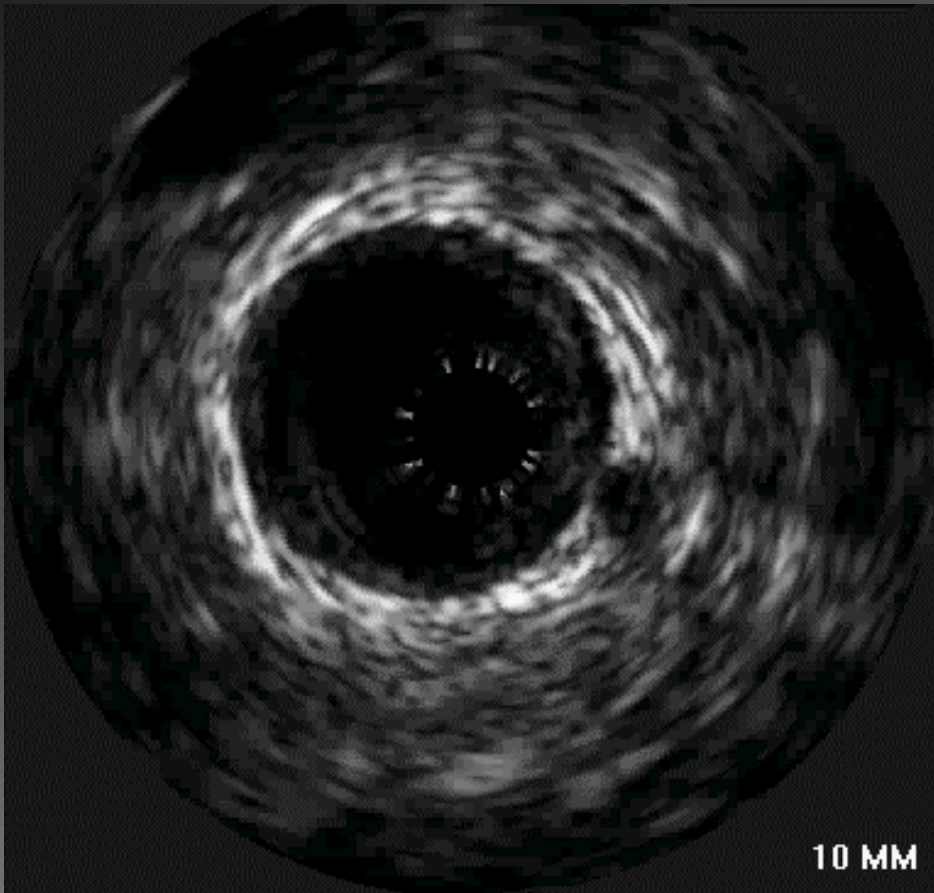
Case #M/67, SA, tricky LM



CAG-LCA



IVUS



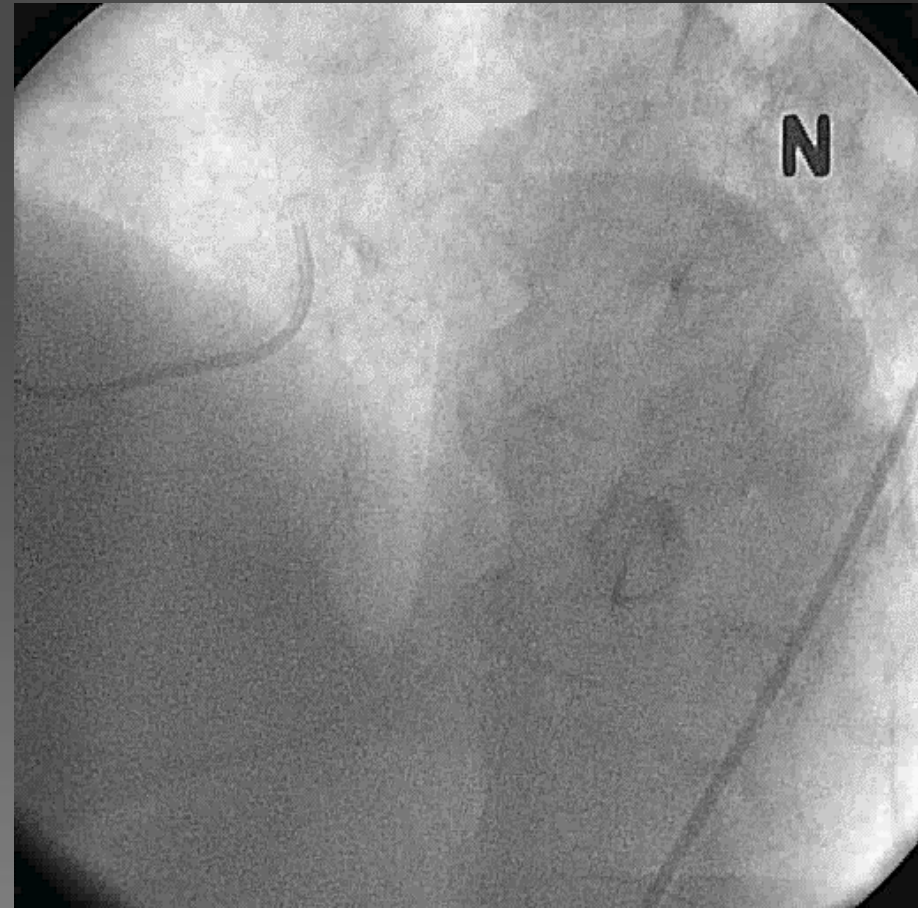
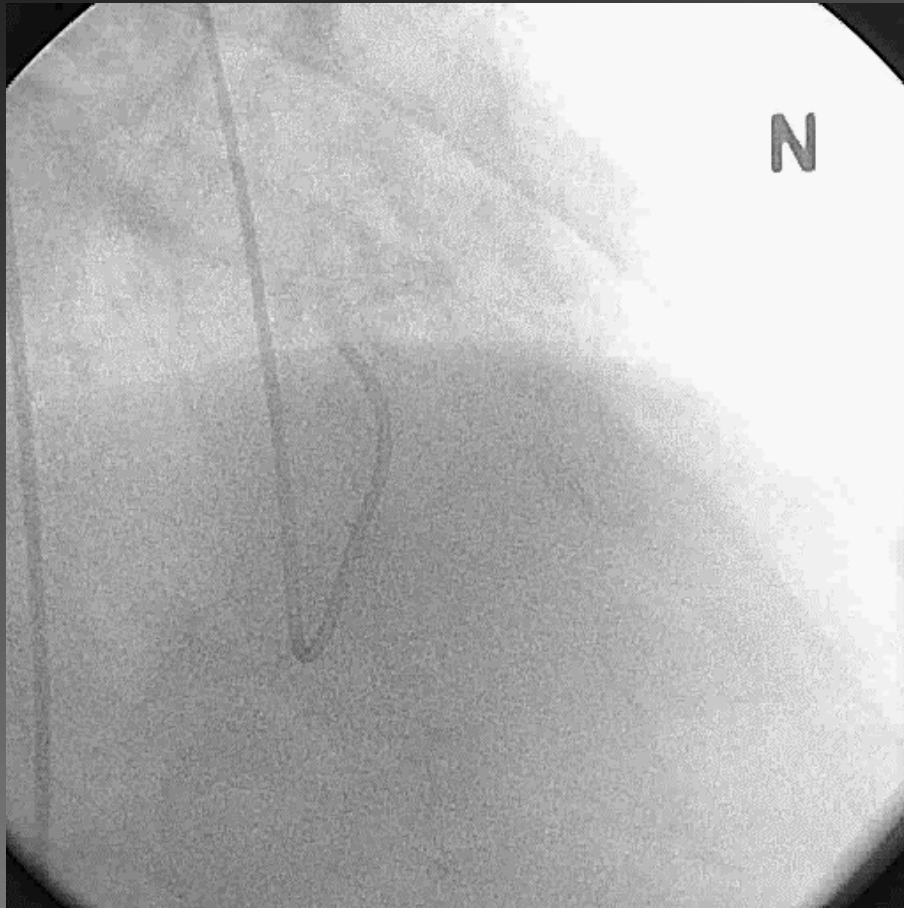
IVUS

LMCA os MLA 4.4mm²

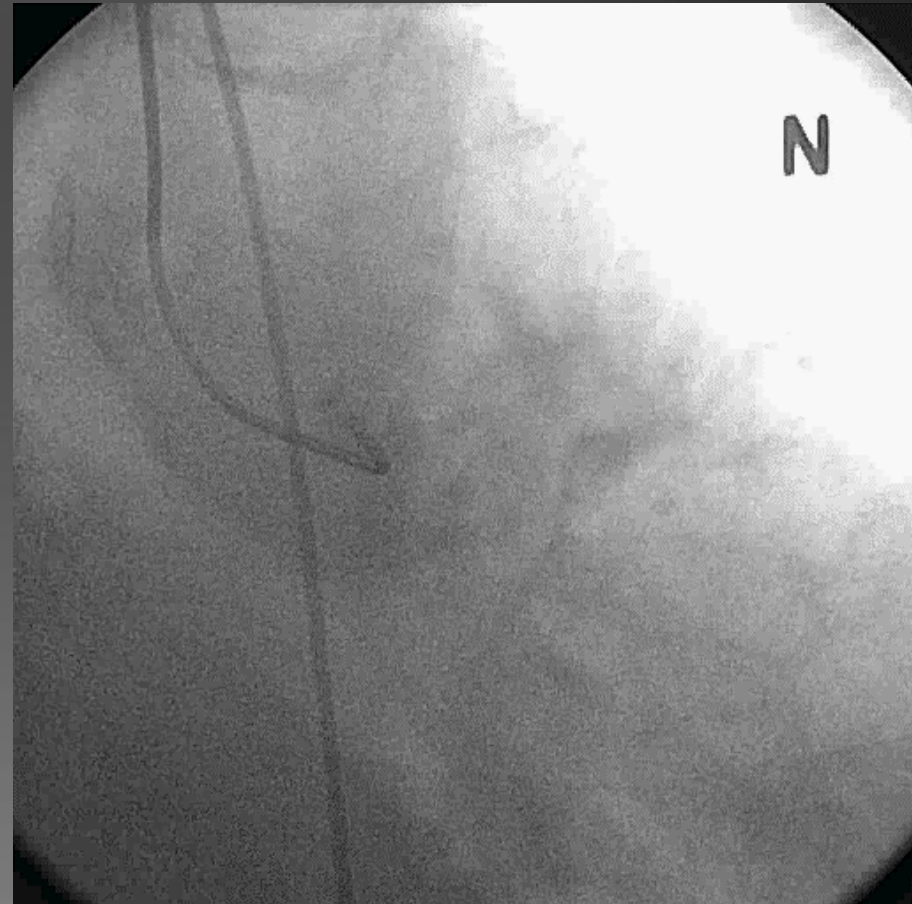
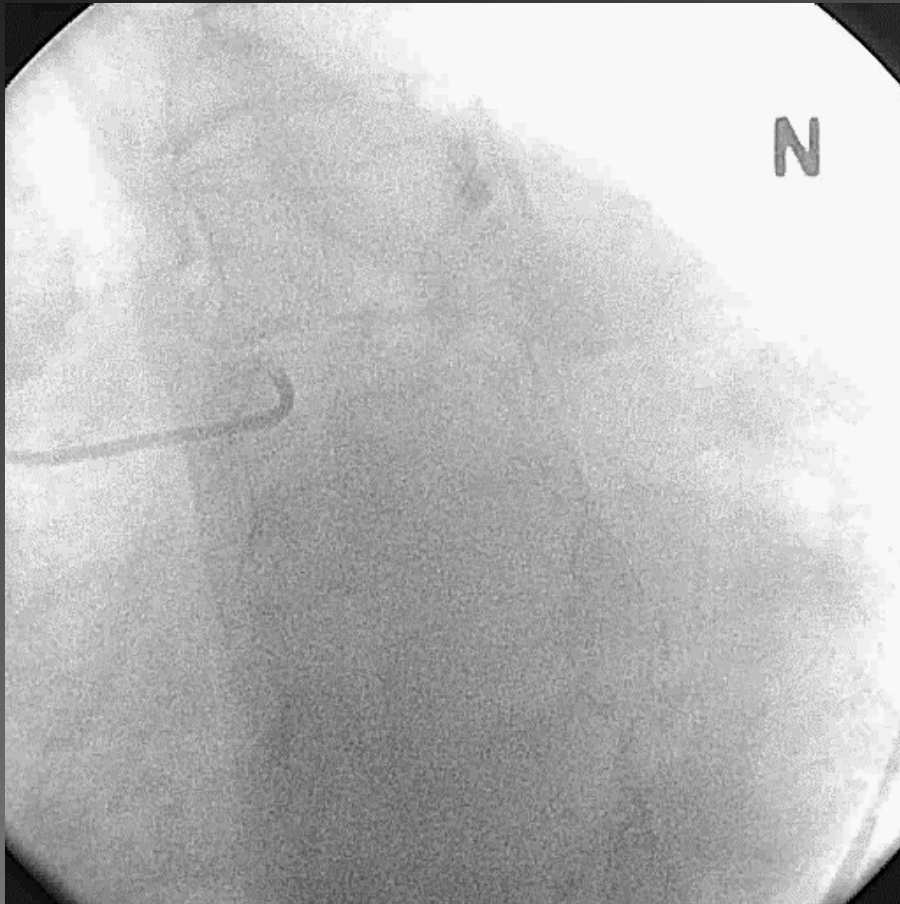
MLD 2.1mm

FFR 0.85

Case #, M/78, SA, tricky LM disease



CAG-LCA

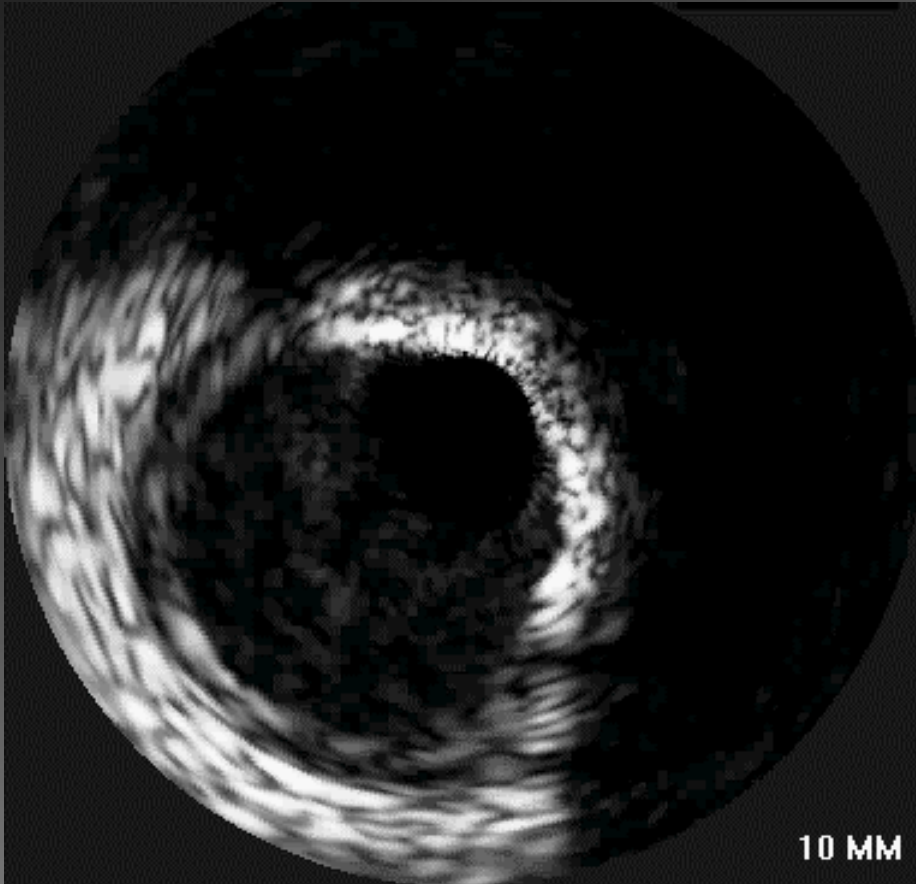


IVUS

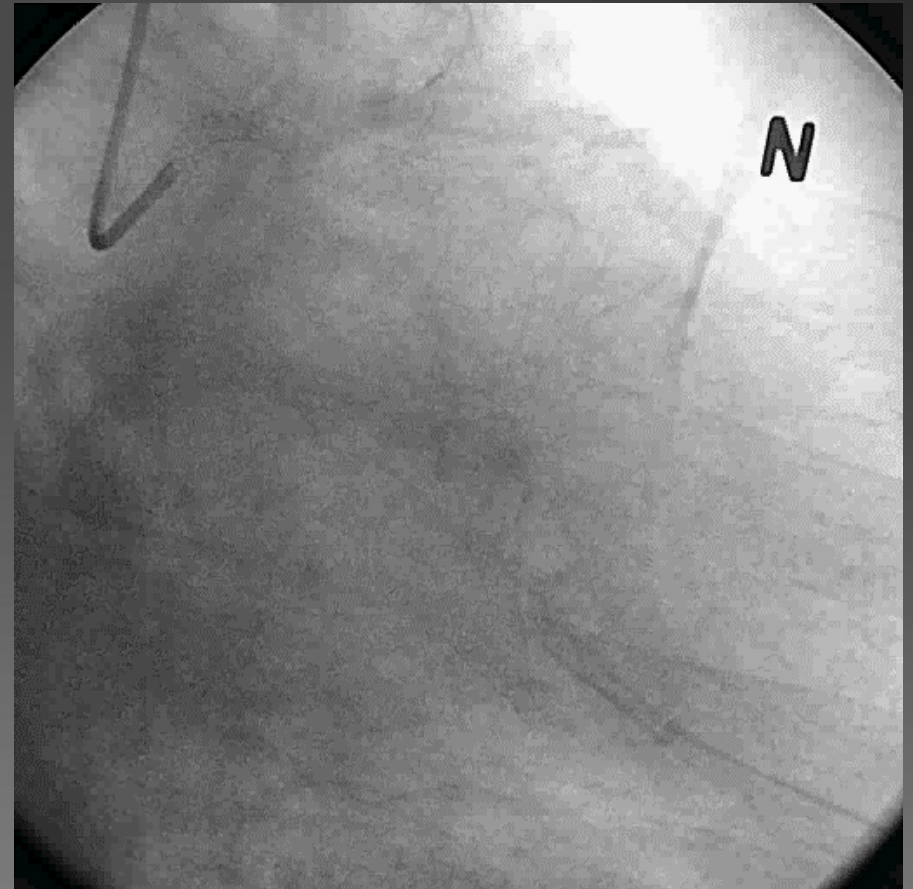
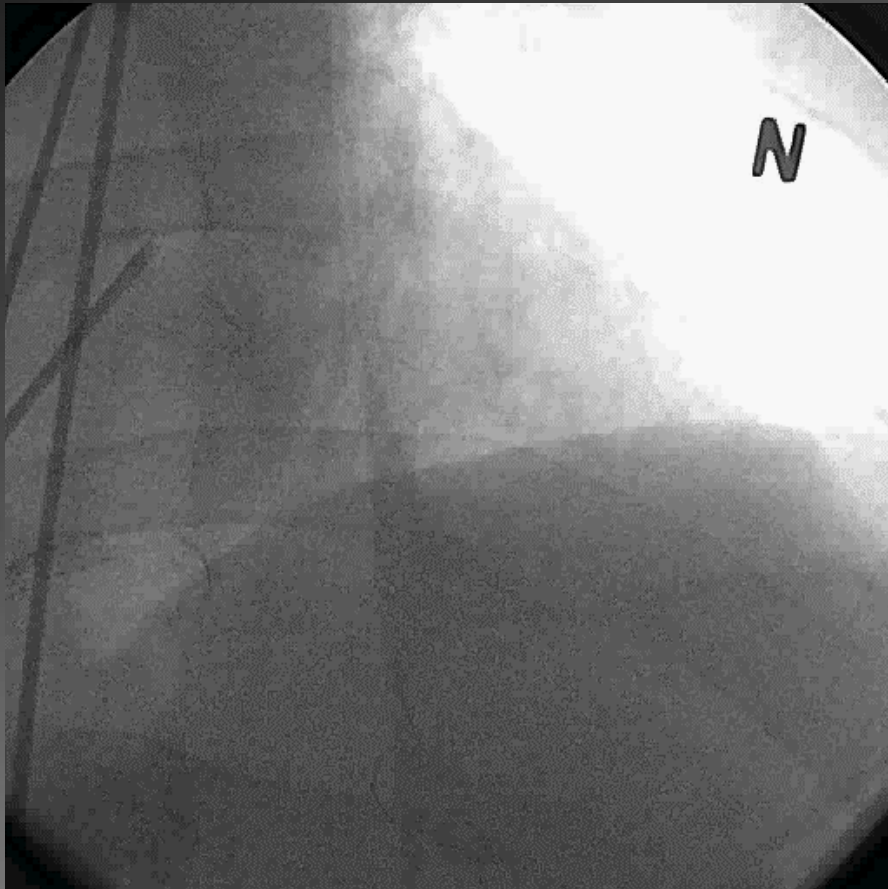
IVUS

LMCA distal MLA 8.0mm²

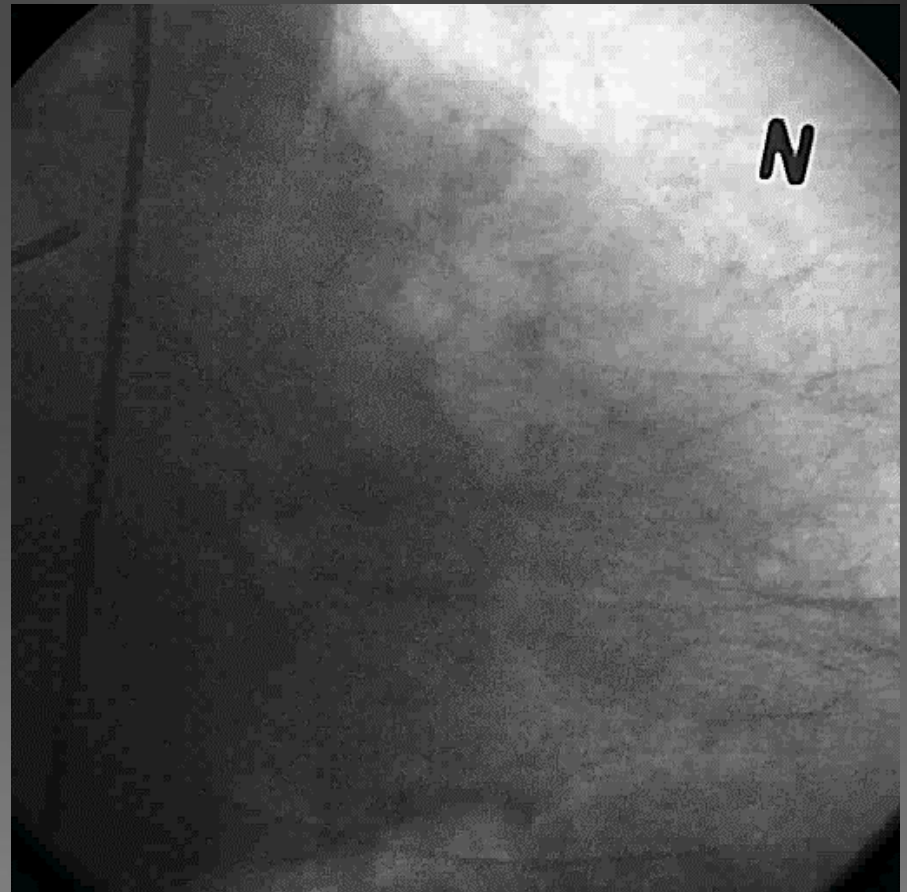
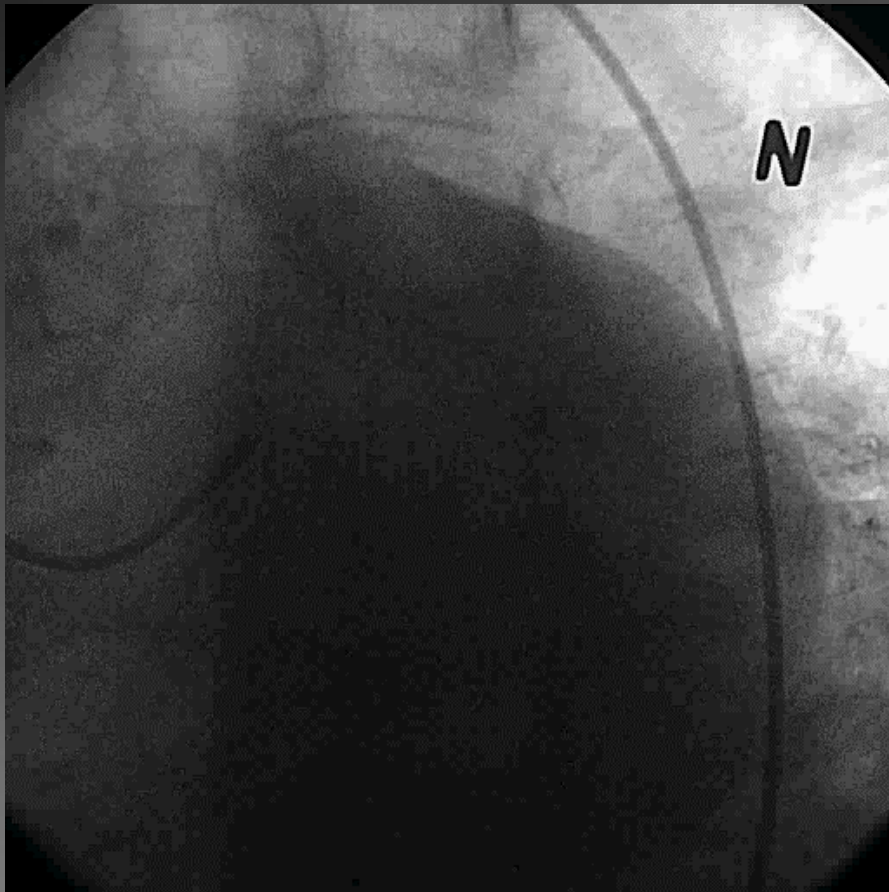
FFR: LMCA 0.88



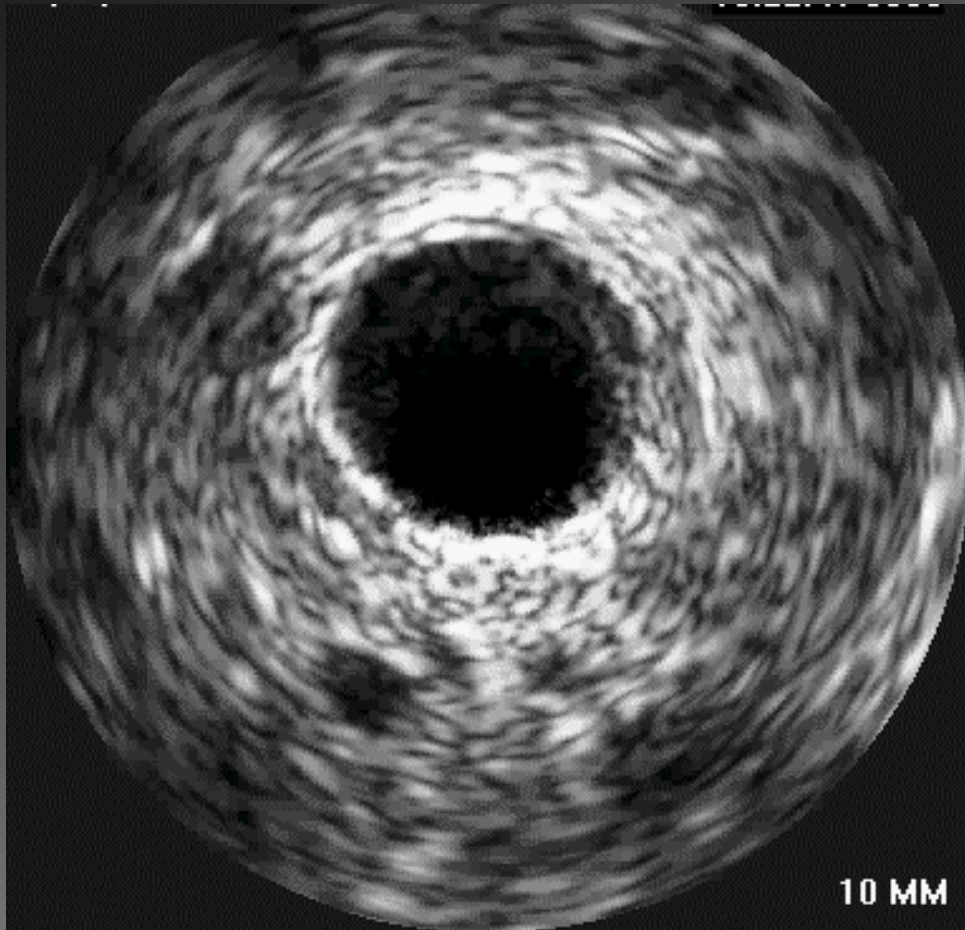
Case#, M/65, SA, tricky LM disease



CAG-LCA



IVUS



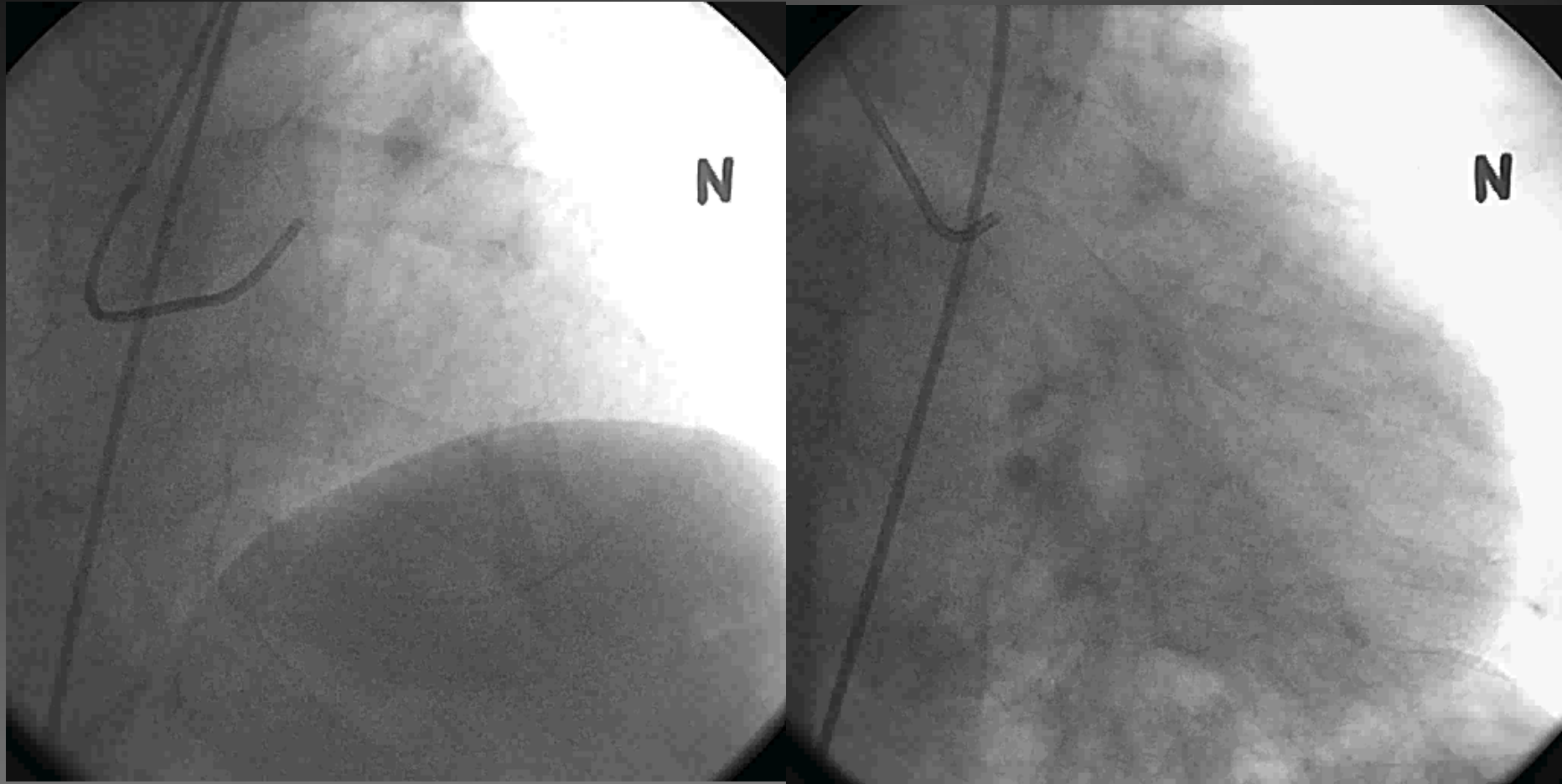
IVUS

LMCA distal MLA 3.0mm²

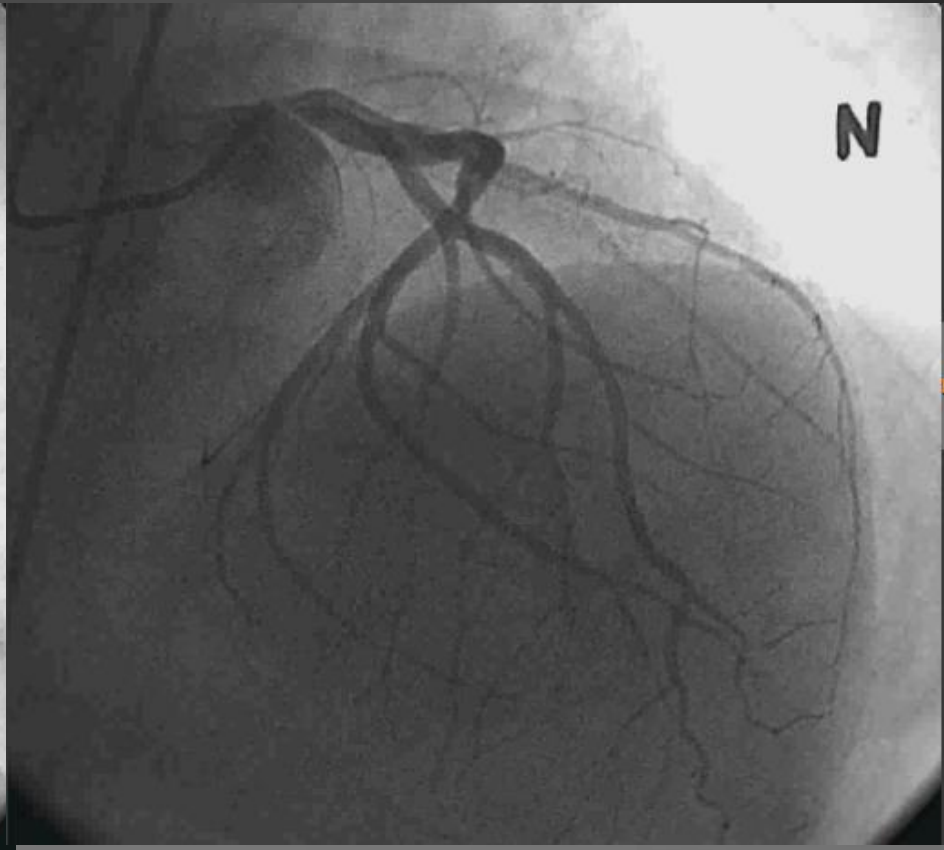
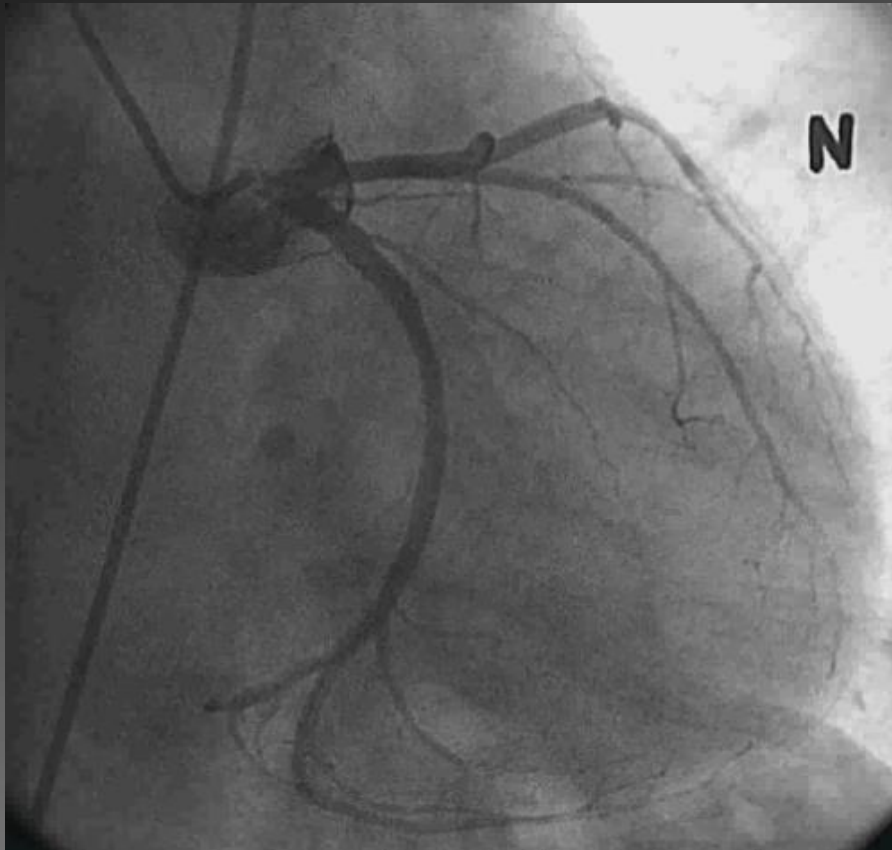
FFR: LMCA 0.73

LAD 0.60

Case# M/81, UA, tricky LMOS



CAG

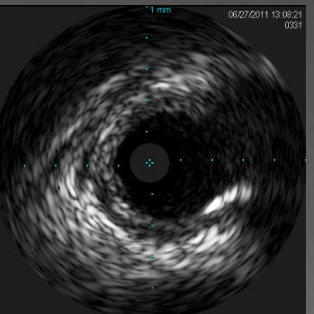
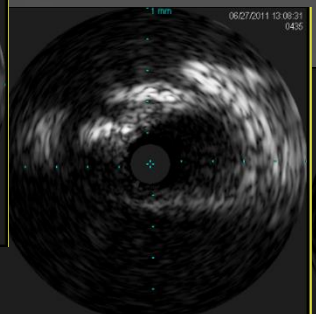
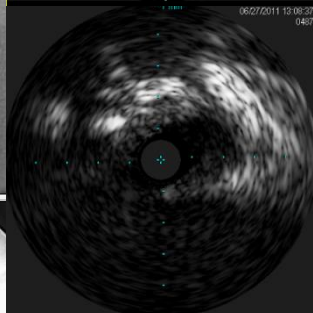
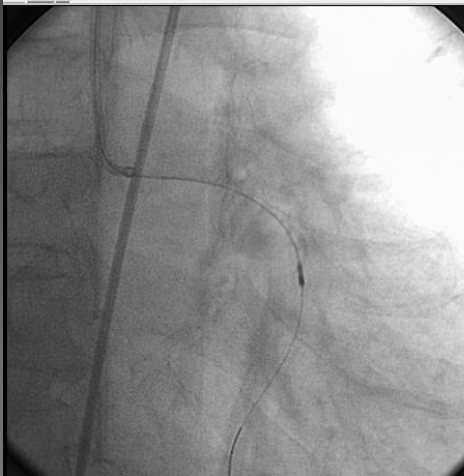
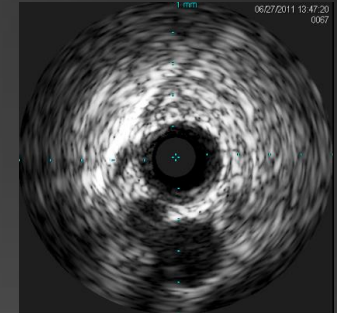
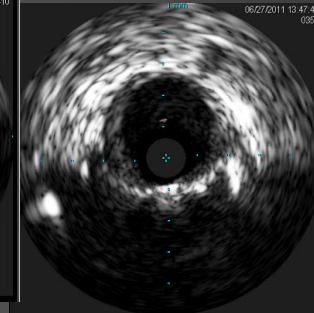
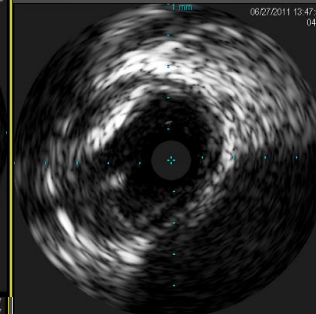
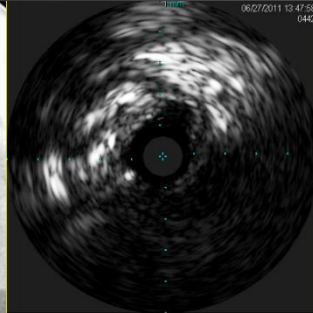
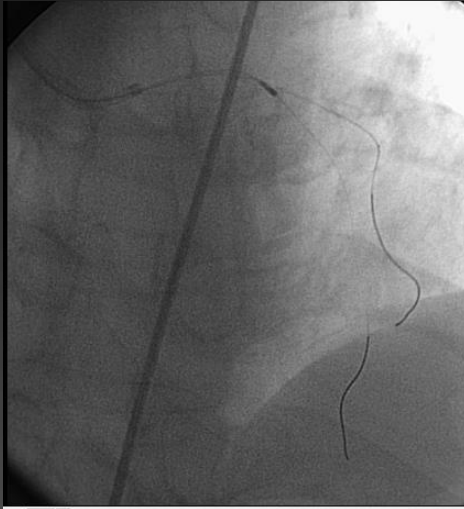


Intravascular Ultrasound

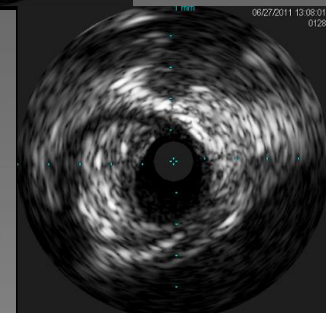
LMCA os : 4.2mm^2

LMCA bifurcation

dLAD

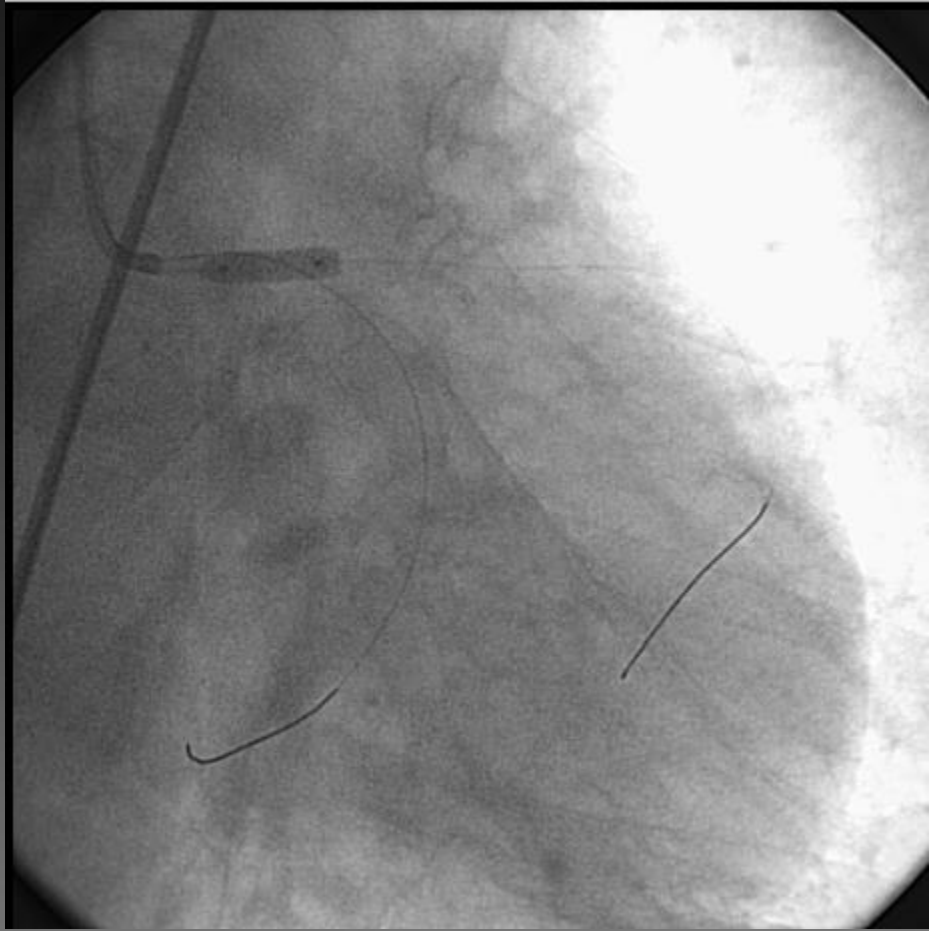


LMCA os : 4.2mm^2

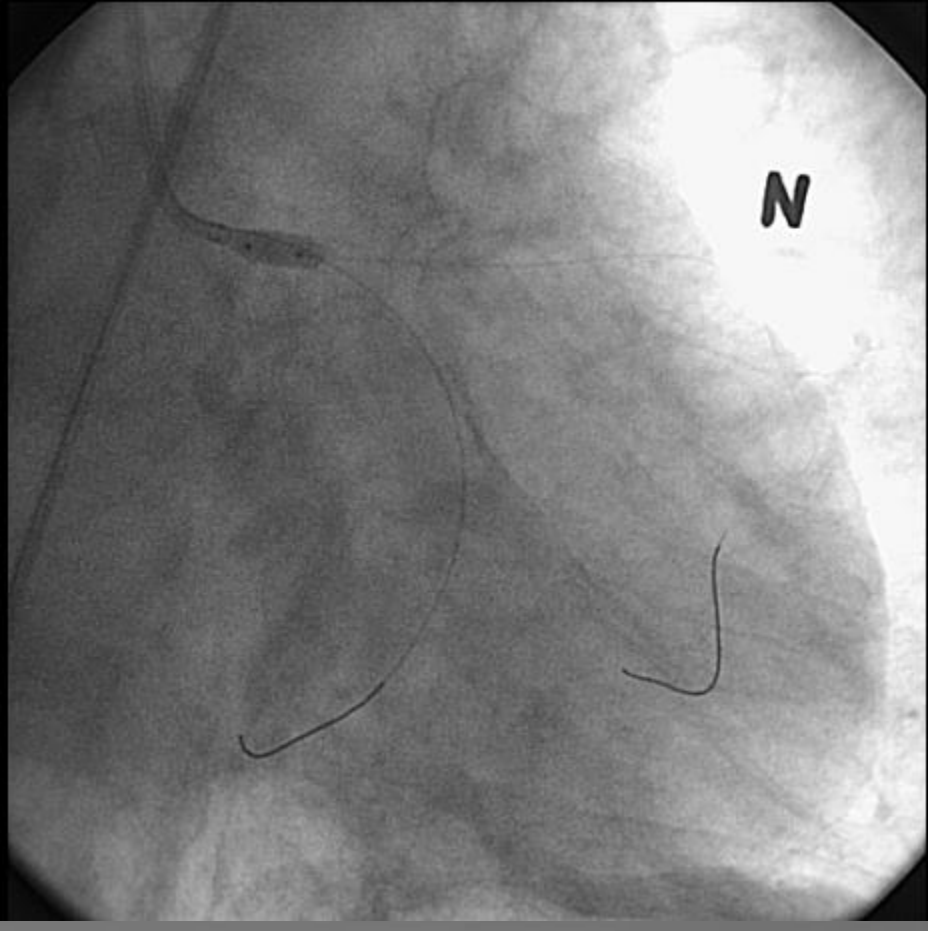


pLCX

PCI for LMCA

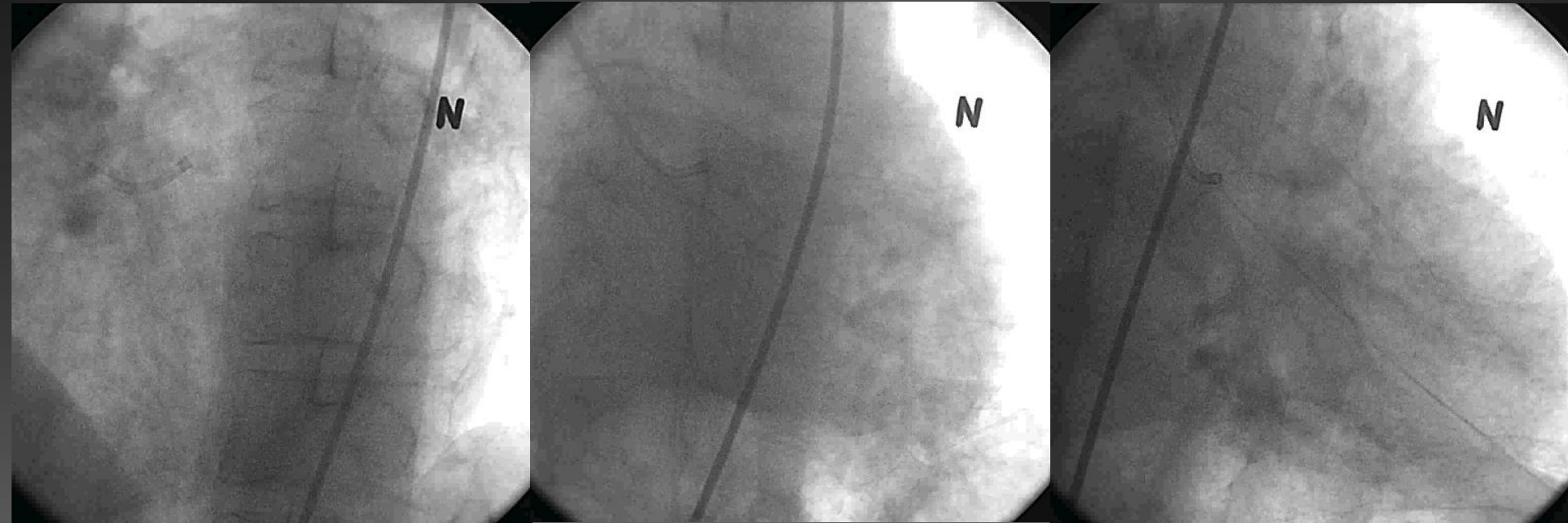


Xience 3.5*12mm

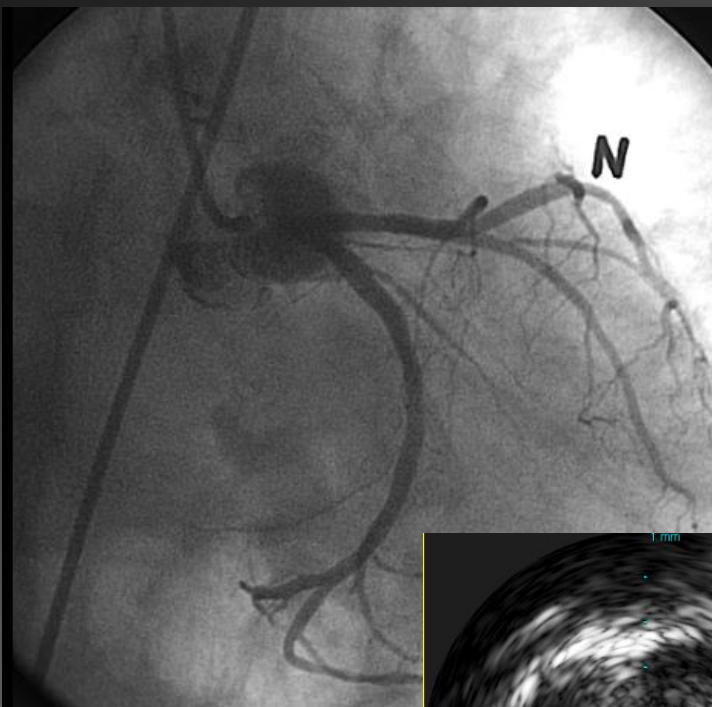


Fortis 4.0*8mm

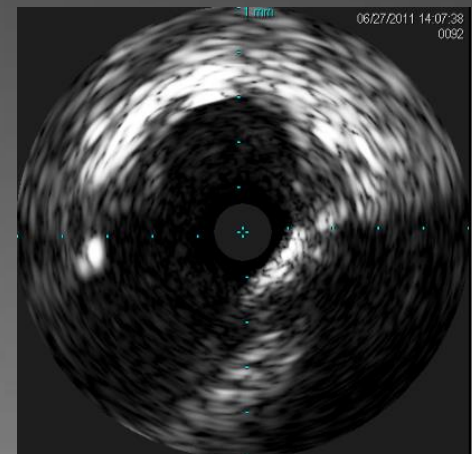
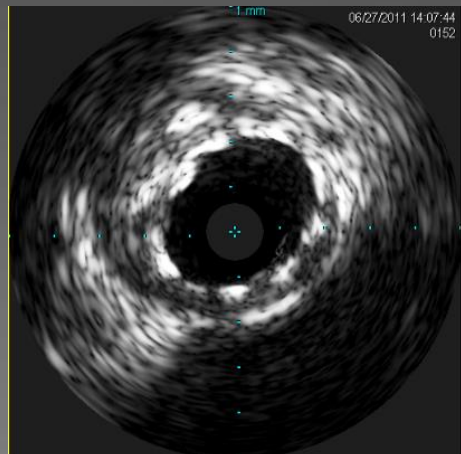
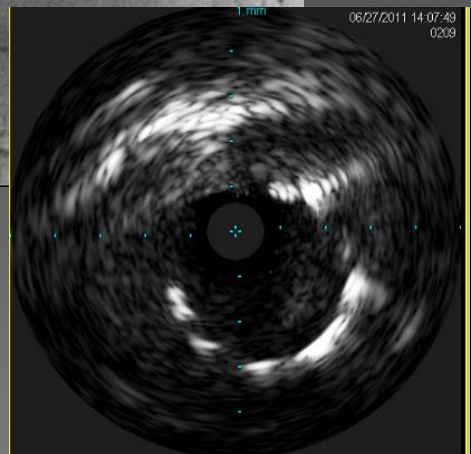
Final Results



Final post stent IVUS



FFR

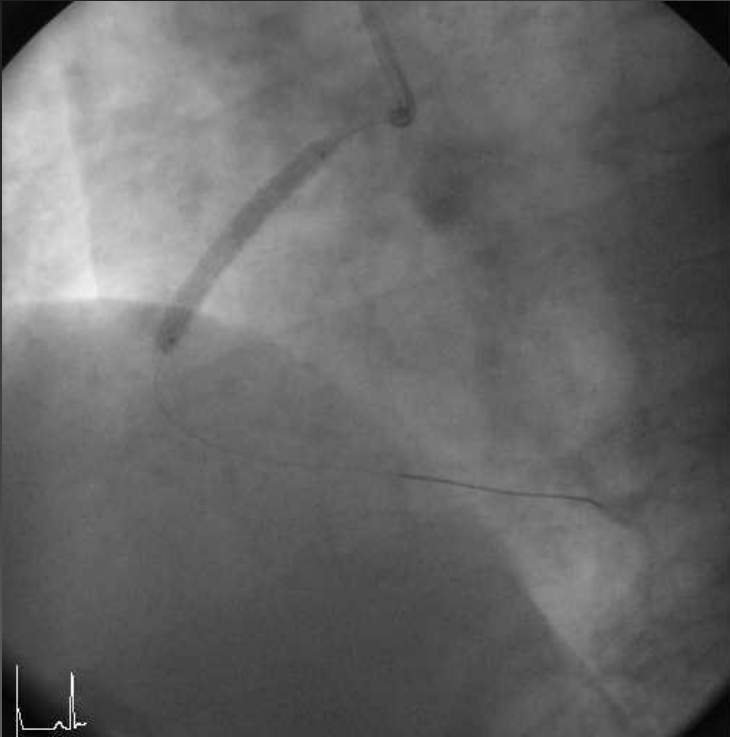


LMCA os LMCA post stent MLA : 9.8mm² LMCA bifurcation
17th Joint Meeting of Coronary Revascularization (JCR 2017)

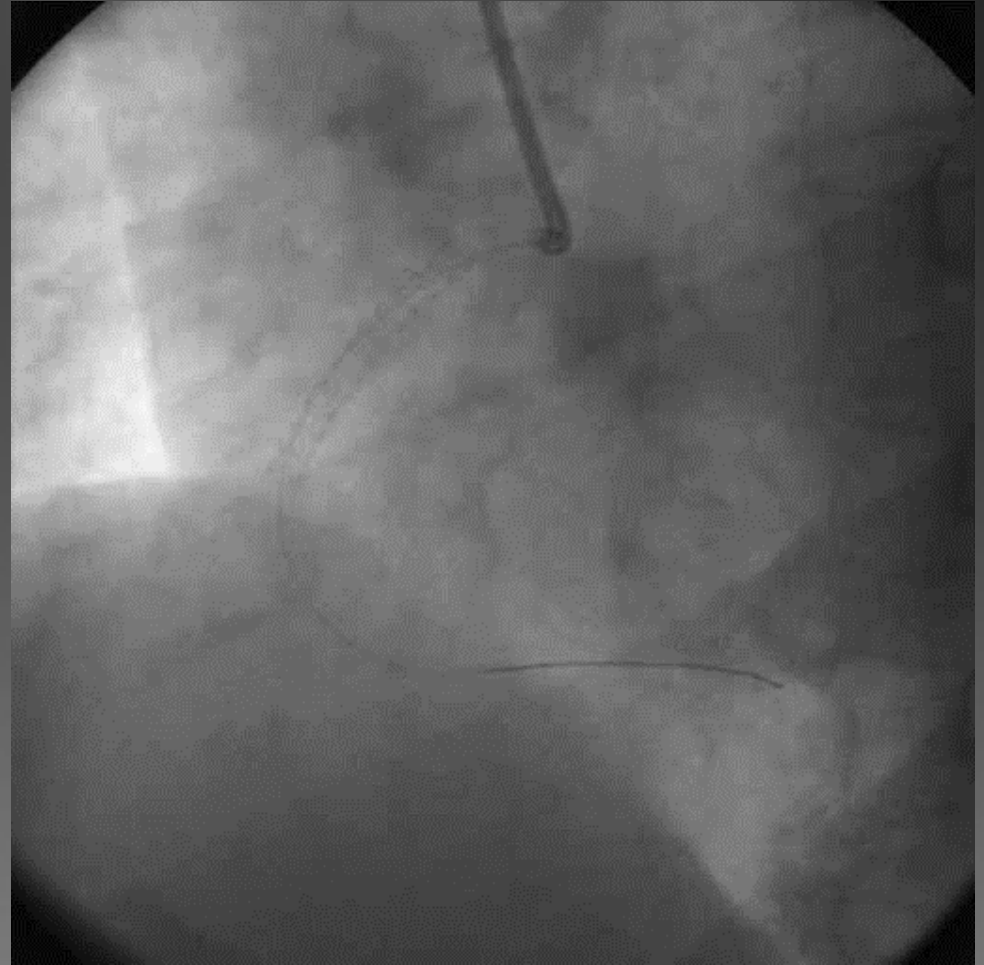
IVUS Predicts DES Early Thrombosis & Restenosis

	Early Thrombosis	Restenosis
Small MSA or underexpansion in stable lesions Small MLA in ACS/MI lesions	<ul style="list-style-type: none"> • Fujii et al. <i>J Am Coll Cardiol</i> 2005;45:995-8 • Okabe et al. <i>Am J Cardiol.</i> 2007;100:615-20 • Liu et al. <i>JACC Cardiovasc Interv.</i> 2009;2:428-34 • Choi et al. <i>Circ Cardiovasc Interv</i> 2011;4:239-47 	<ul style="list-style-type: none"> • Sonoda et al. <i>J Am Coll Cardiol</i> 2004;43:1959-63 • Hong et al. <i>Eur Heart J</i> 2006;27:1305-10 • Doi et al <i>JACC Cardiovasc Interv.</i> 2009;2:1269-75 • Fujii et al. <i>Circulation</i> 2004;109:1085-1088 • Kang et al. <i>Circ Cardiovasc Interv</i> 2011;4:9-14 • Choi et al. <i>Am J Cardiol</i> 2012;109:455-60 • Song et al. <i>Catheter Cardiovasc Interv</i> 2014;83:873-8
Edge problems (geographic miss, secondary lesions, large plaque burden, dissections, etc)	<ul style="list-style-type: none"> • Fujii et al. <i>J Am Coll Cardiol</i> 2005;45:995-8 • Okabe et al., <i>Am J Cardiol.</i> 2007;100:615-20 • Liu et al. <i>JACC Cardiovasc Interv.</i> 2009;2:428-34 • Choi et al. <i>Circ Cardiovasc Interv</i> 2011;4:239-47 	<ul style="list-style-type: none"> • Sakurai et al. <i>Am J Cardiol</i> 2005;96:1251-3 • Liu et al. <i>Am J Cardiol</i> 2009;103:501-6 • Costa et al, <i>Am J Cardiol</i>, 2008;101:1704-11 • Kang et al. <i>Am J Cardiol</i> 2013;111:1408-14 • Kobayashi et al. <i>ACC2014</i>
Stent length (>40mm)		<ul style="list-style-type: none"> • Hong et al. <i>Eur Heart J</i> 2006;27:1305-10

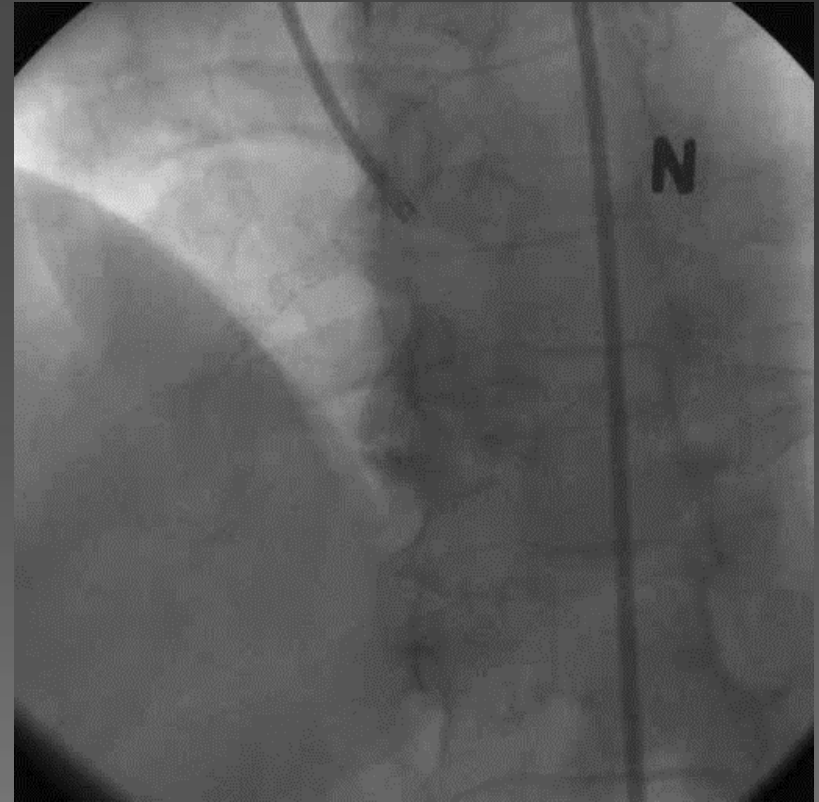
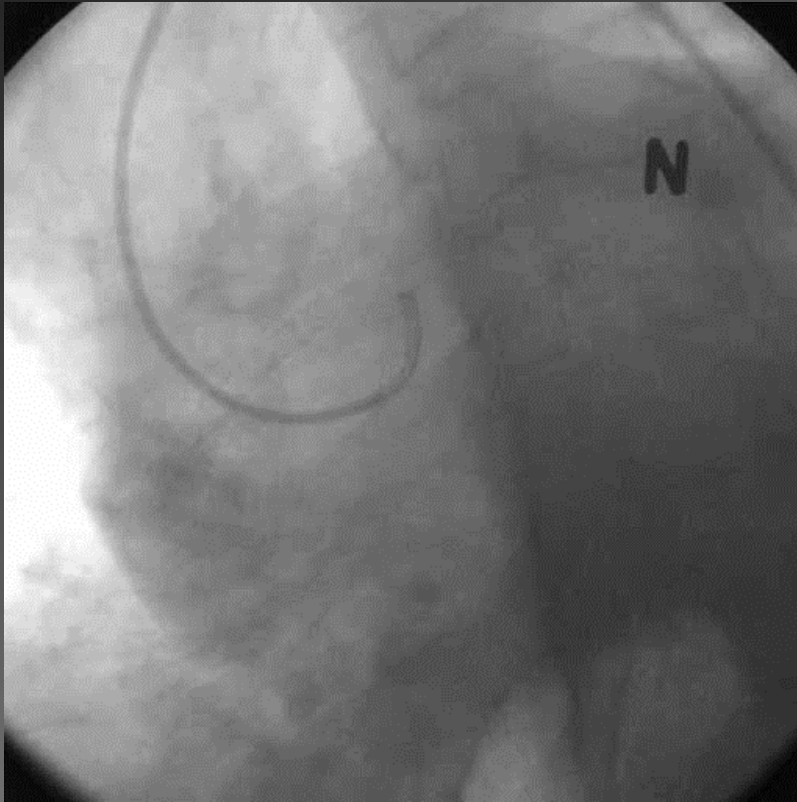
Case# F/69, Post PCI assessment PCI for RCA



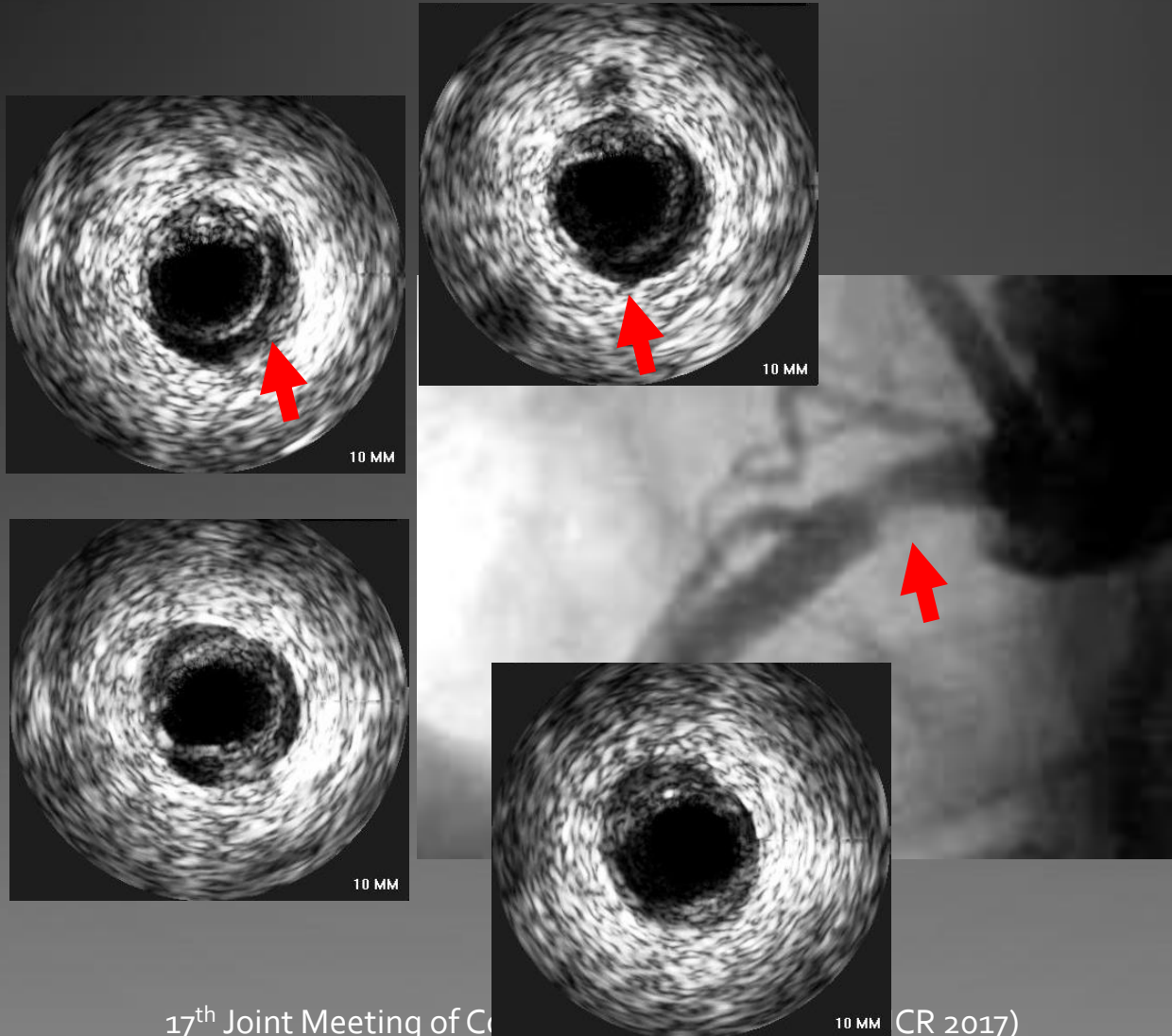
Cypher 3.5x33mm



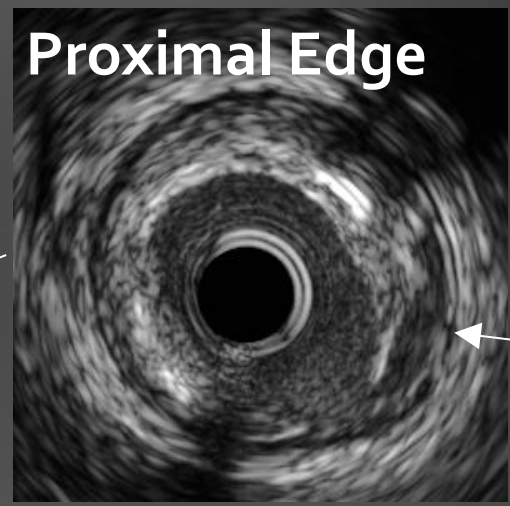
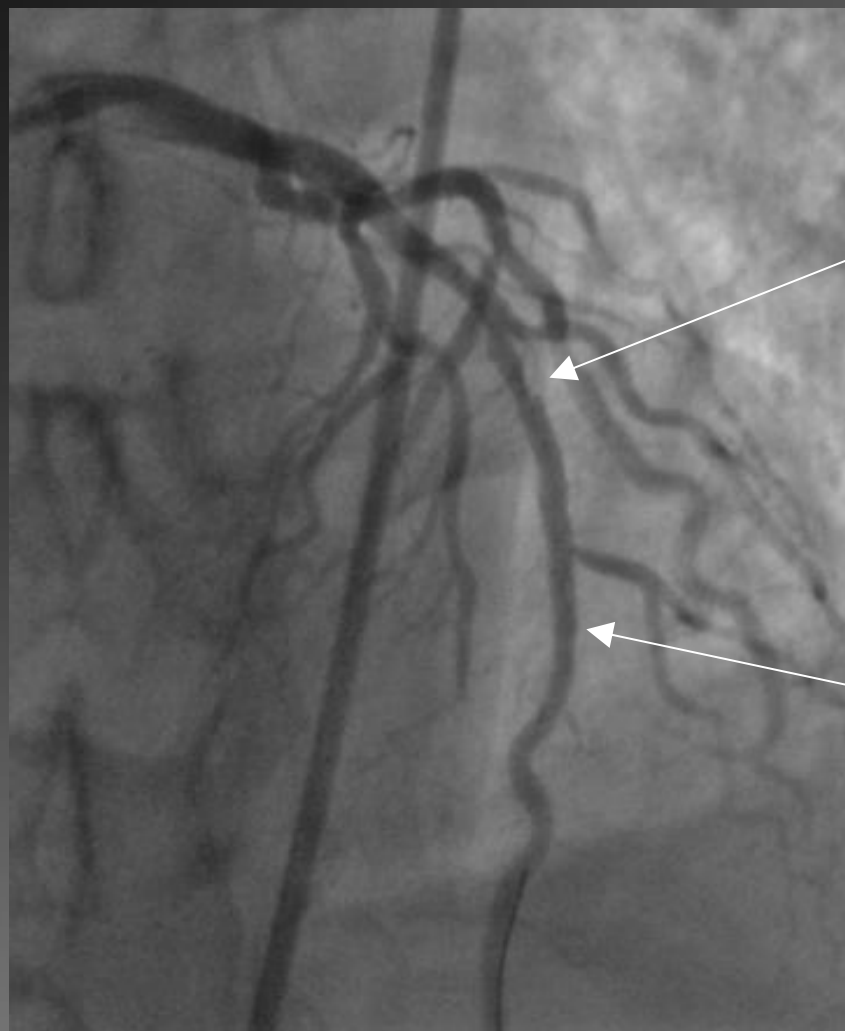
After RCA stent...



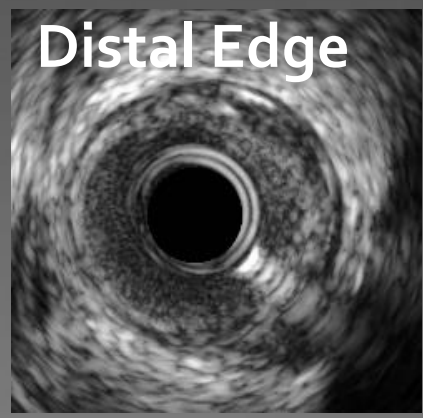
pRCA dissection



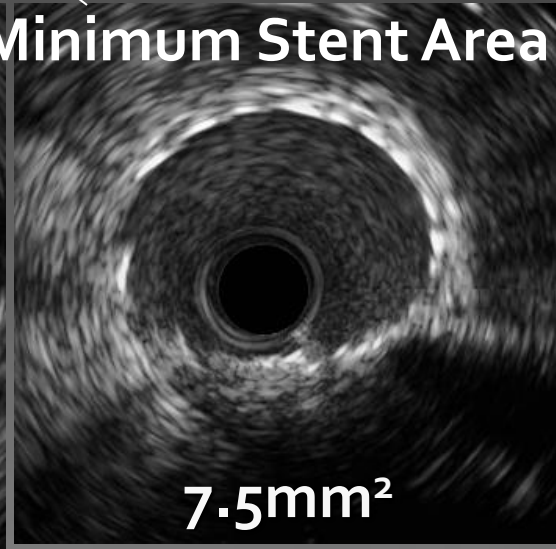
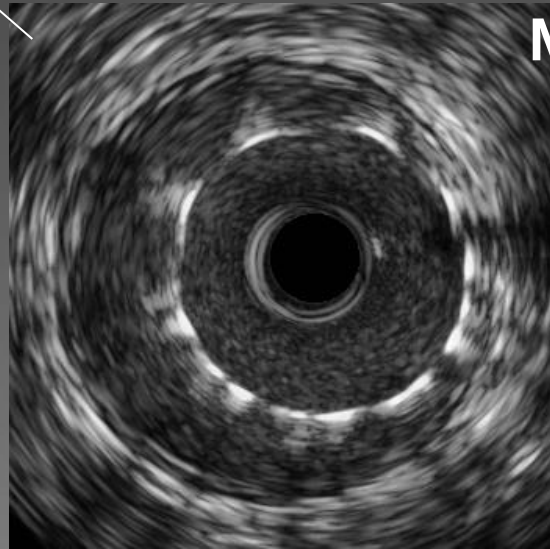
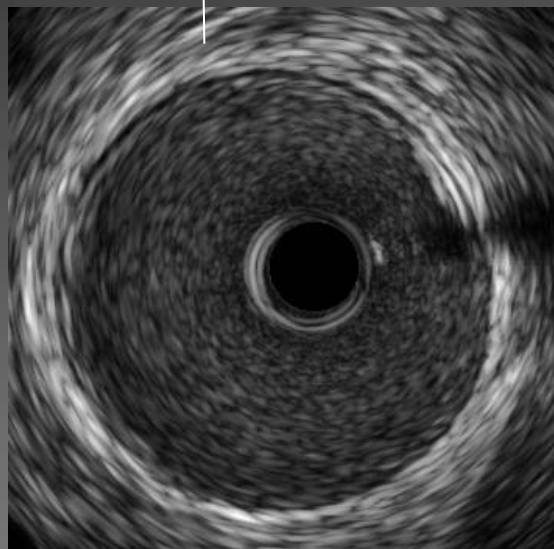
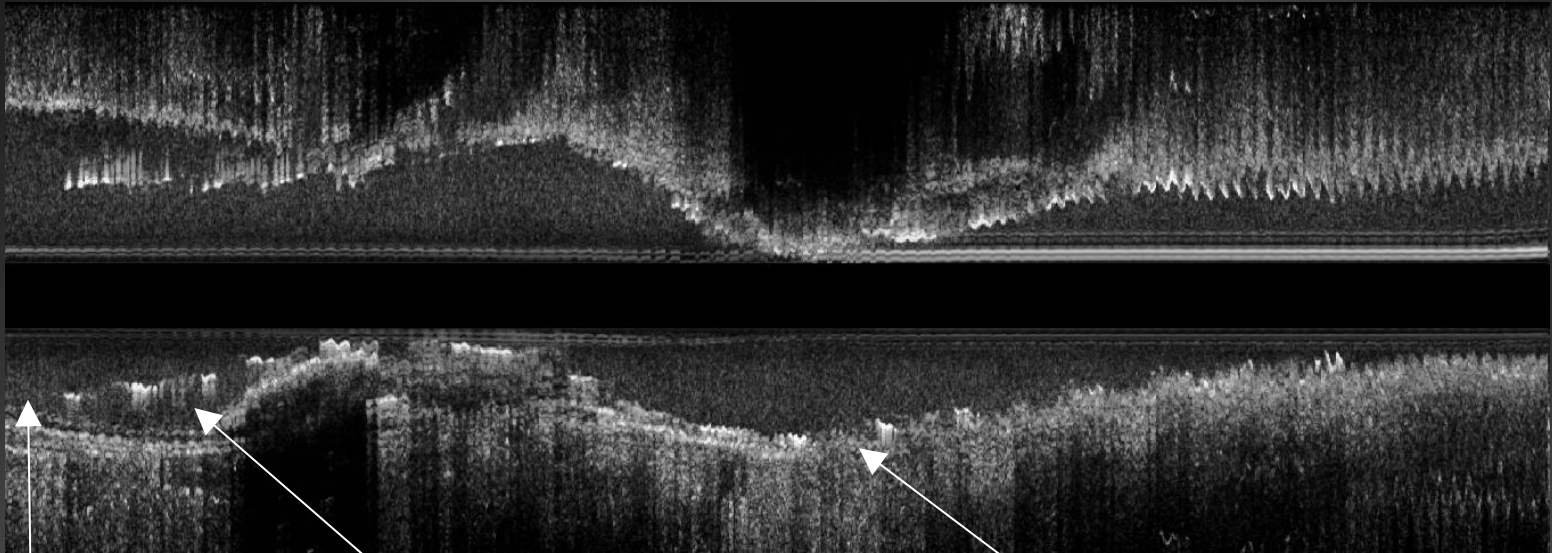
Stent Edge Dissection



dissection



Acute Stent Malapposition



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

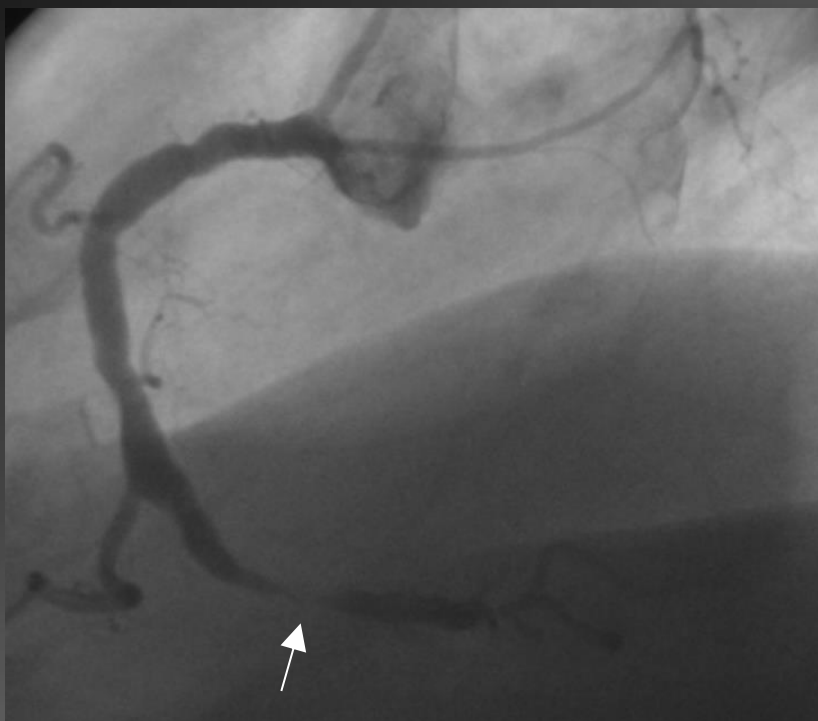
²Steinberg et al. JACC interv 2010;3:486-94

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

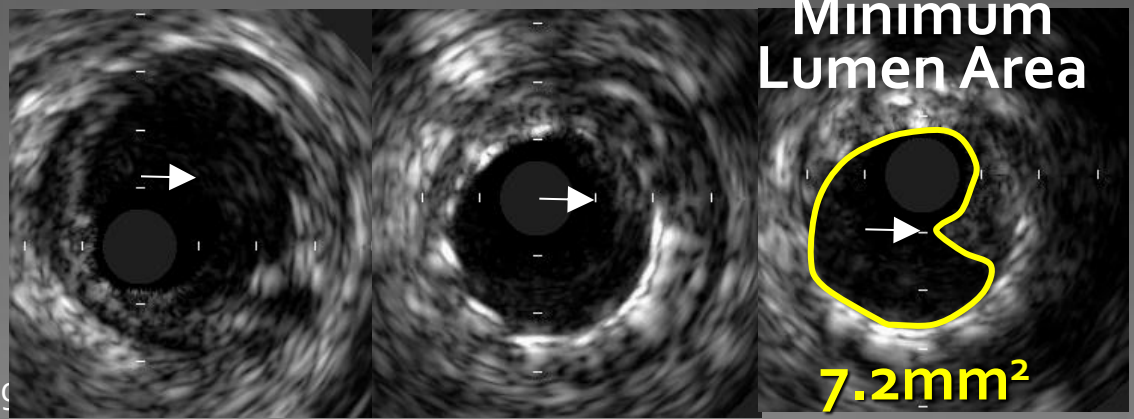
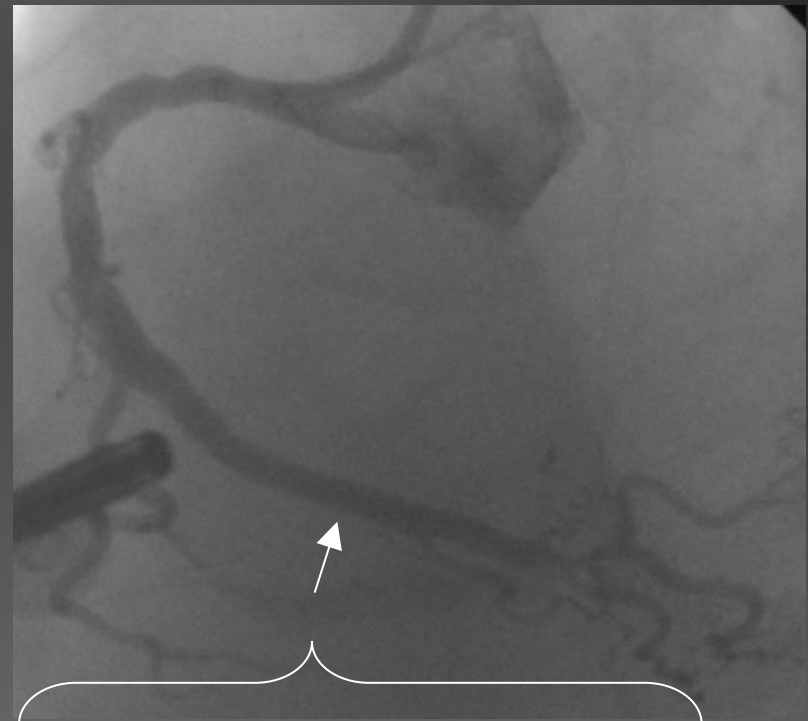
⁴Kimura et al. Am J Cardiol 2006;98:36-42

Thrombus Protrusion

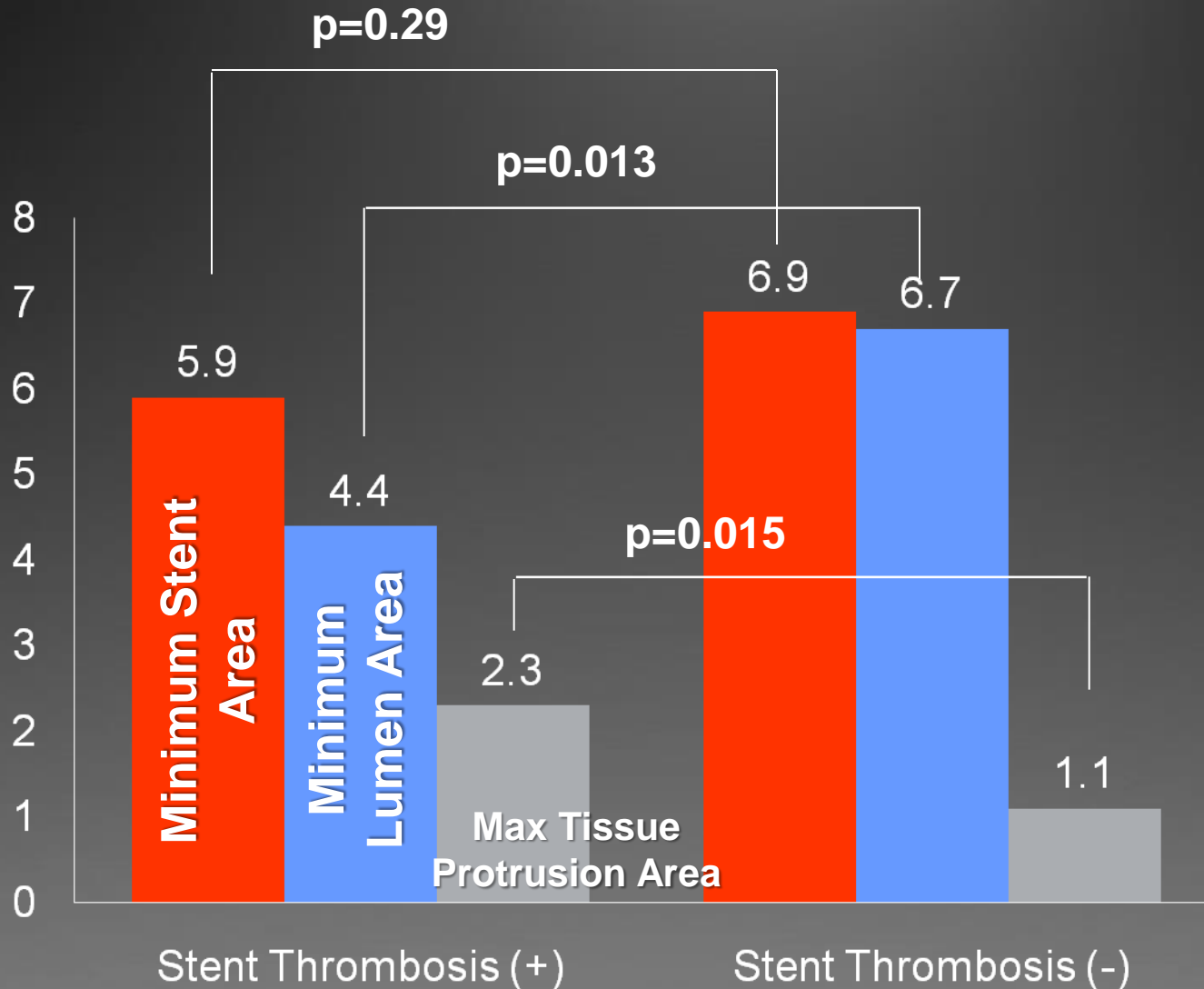
Pre-Intervention



Post-Stent



HORIZONS-AMI Early Stent Thrombosis



Multivariable Cox PHR Models of 2-year Definite/Probable Stent Thrombosis

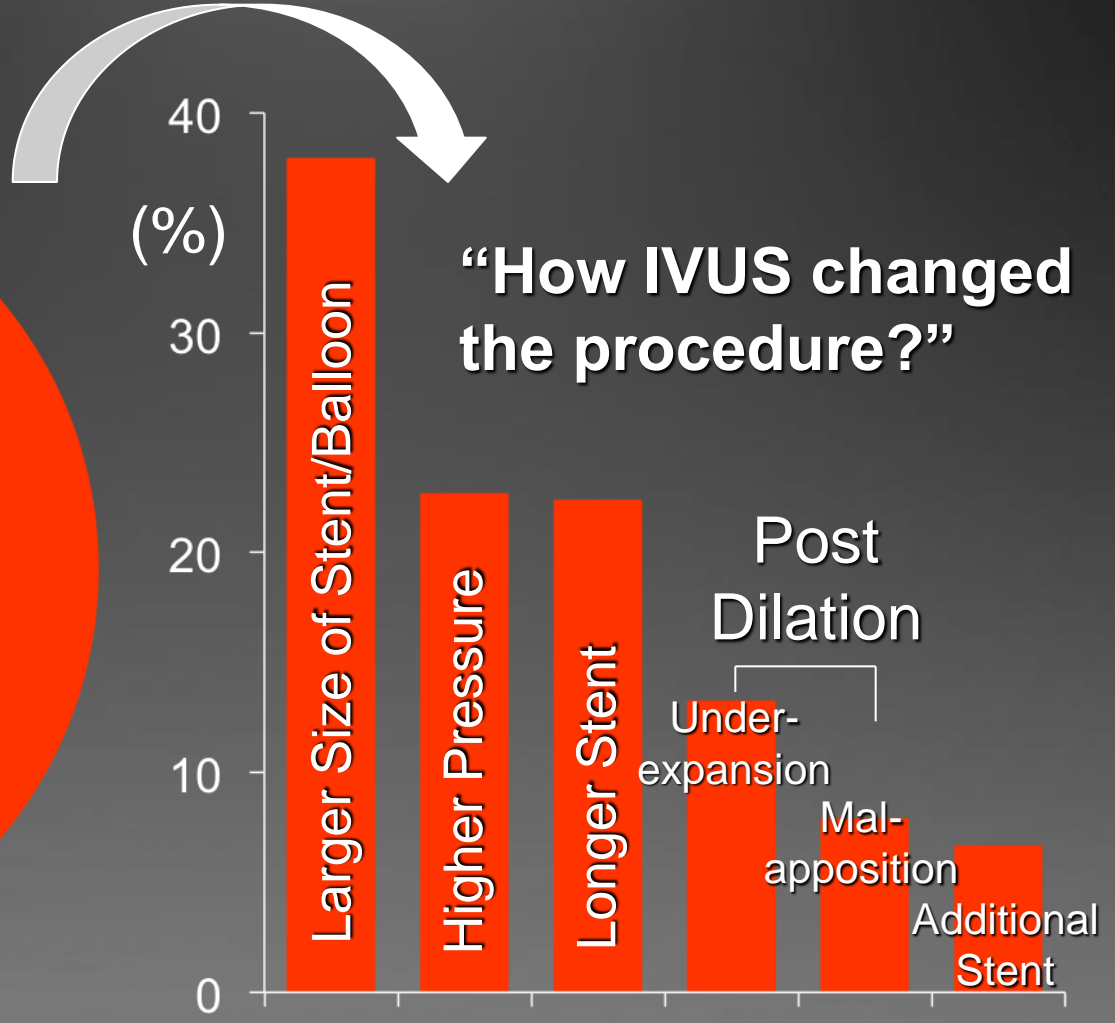
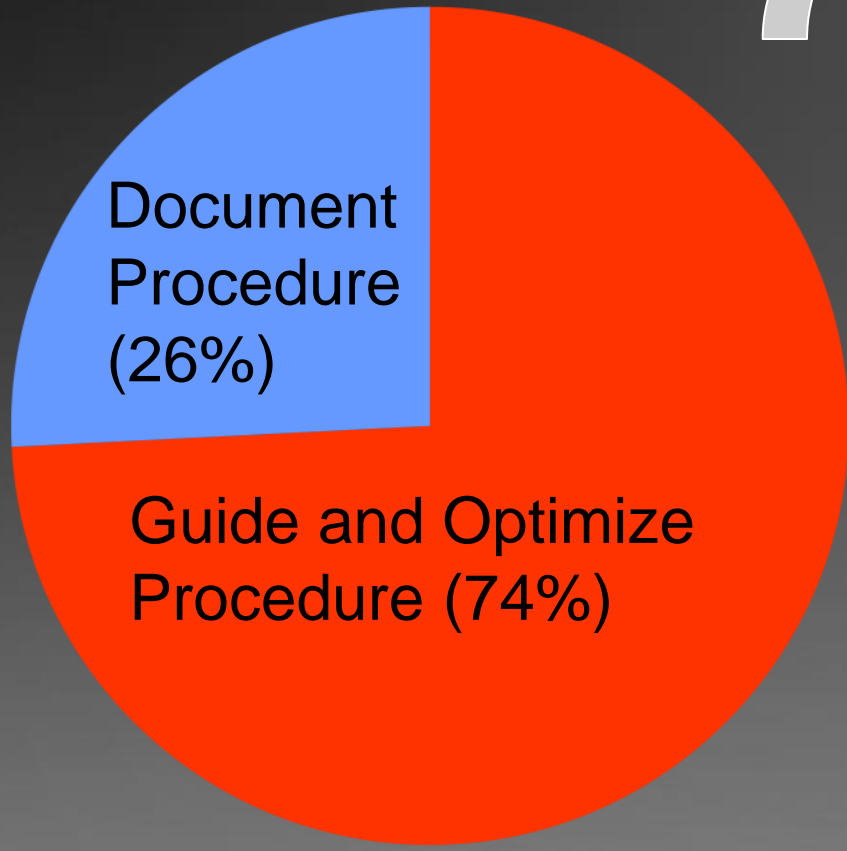
Number events=92, Total at risk=8582

	HR [95%CI]	P value
IVUS use	0.45 [0.24, 0.81]	0.008
Maximum device diameter (mm)	0.57 [0.34, 0.96]	0.03
STEMI Presentation	3.09 [1.74, 5.51]	0.0001
Premature DAPT discontinuation	2.27 [1.30, 3.97]	0.004
PRU >208	2.07 [1.28, 3.35]	0.003
Diabetes	1.68 [1.05, 2.68]	0.014
Total stent length (mm)	1.01 [1.00, 1.02]	0.02

IVUS Guidance to Minimize the Use of Iodine Contrast in PCI

- MOZART - Mariani et al. JACC Cardiovasc Interv 2014;7:1287-93
 - 83 pts randomized to IVUS vs angiographic guidance with a pre-specified PCI strategy designed to reduce contrast usage in both groups
 - **Reduction in contrast use (primary endpoint) from 64.5ml (IQR 42.8-97ml, range 19-170ml) to 20.0ml (IQR 12.5-30.0ml, range 3-54ml): p<0.0001**
 - No difference in 4-month outcomes although there was a trend toward a less common increase in serum Cr >0.5mg/dl (7.3% vs 19.0%, p=0.2)
- Ali et al. Eur Heart J, in press
 - 31 pts with median creatinine of 4.2mg/dL (IQR 3.1-4.8)
 - Successful **zero contrast PCI** was performed at least 1 week after diagnostic angiography using real-time IVUS guidance and pre- and post-PCI FFR and CRF to confirm physiologic improvement
 - No MACE and preservation of renal function in all pts at a median follow-up of 79 days (IQR 33-107).

How was IVUS used?



Take Home Message

1. IVUS can delineate...
 1. Ambiguous angiographic morphology
 2. Vessel size
 3. Stent expansion
 4. Mechanical complication and mechanism
 5. Mechanism of stent failure
2. IVUS can evaluate better than OCT in LM lesion,
3. IVUS can improve outcome, when used correctly.
4. IVUS may become one of best friend of interventional cardiologist as it used routine manner with DES.