Imaging DIY
Imaging-trained Operator Can Make a Good Clinical Decision

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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.

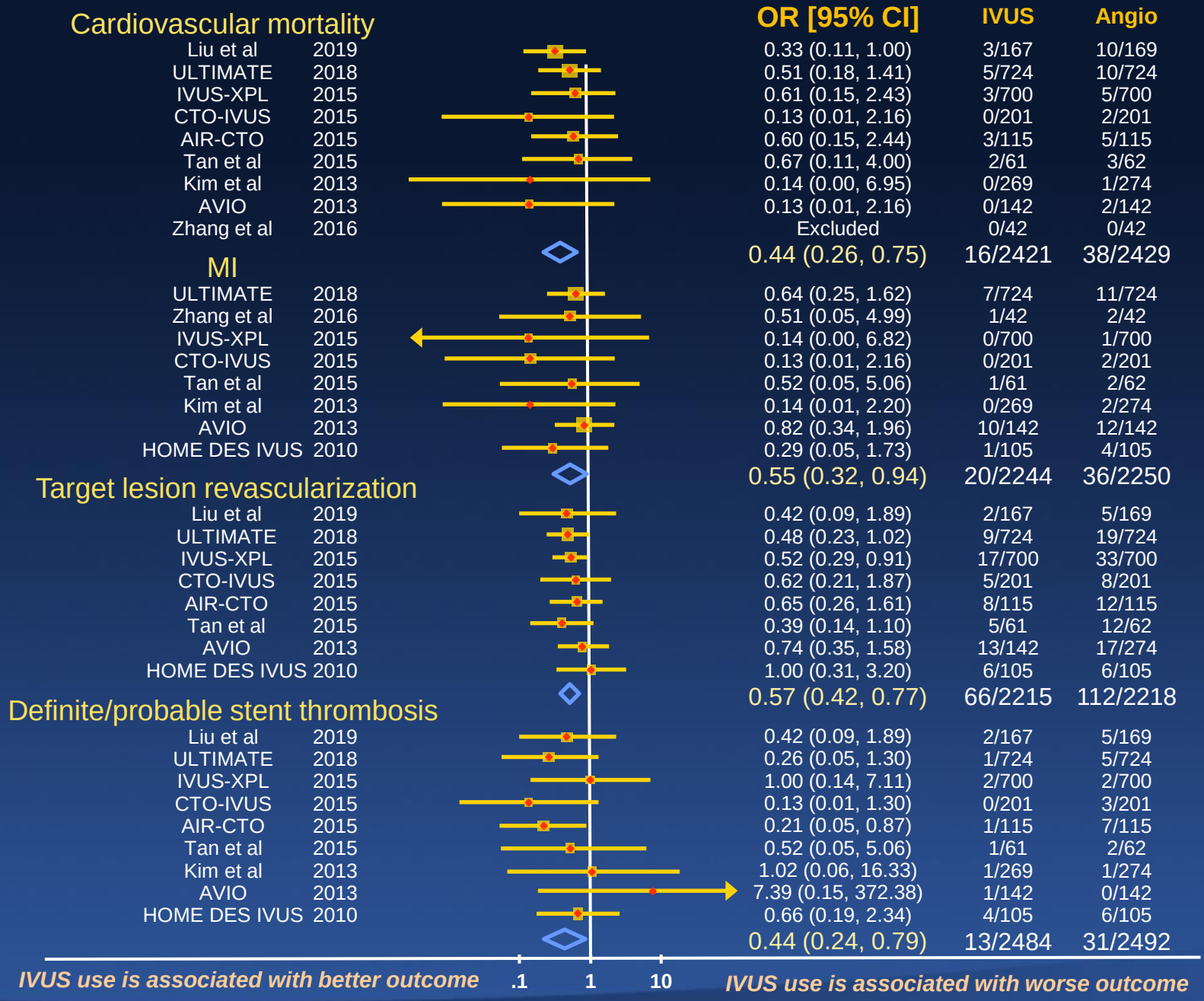
Affiliation/Financial Relationship	Company
• *Consulting Fees/Honoraria*	• *Boston Scientific, Philips*

Updated meta-analysis of 10 randomized trials (5160 pts)

(weighted mean follow up time 13.8±1.4 mos)

IVUS-guided PCI was associated with a lower incidence of

- ***Cardiac mortality (0.3% vs 1.1%, OR 0.44, 95% CI 0.26-0.75, P=0.003)***
- ***MI (0.2% vs 0.9%, OR 0.55, 95% CI 0.32-0.94, P=0.03)***
- ***TLR (2.4% vs 4.5%, OR 0.57, 95% CI 0.42-0.77, P<0.001)***
- ***Stent thrombosis (0.3% vs 0.8%, OR 0.44, 95% CI 0.24-0.79, P=0.006).***



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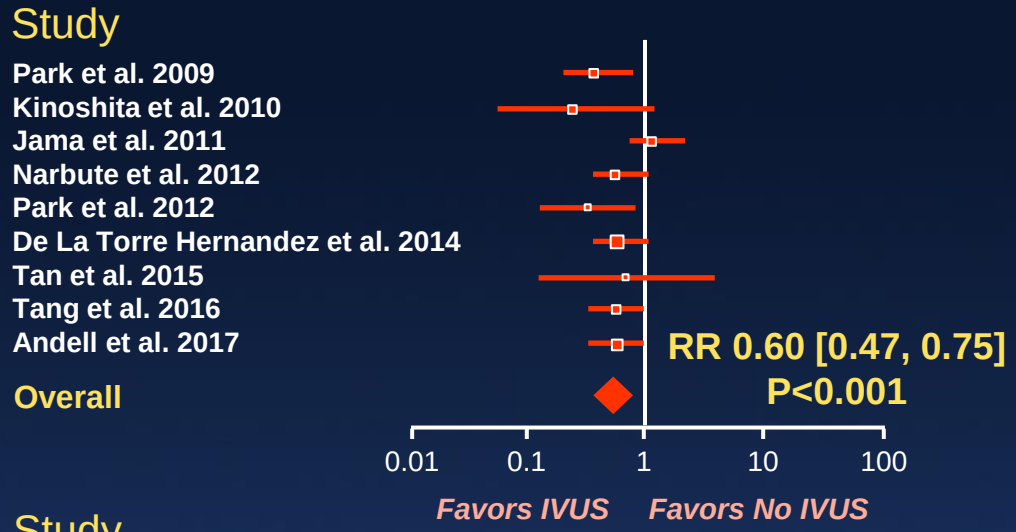
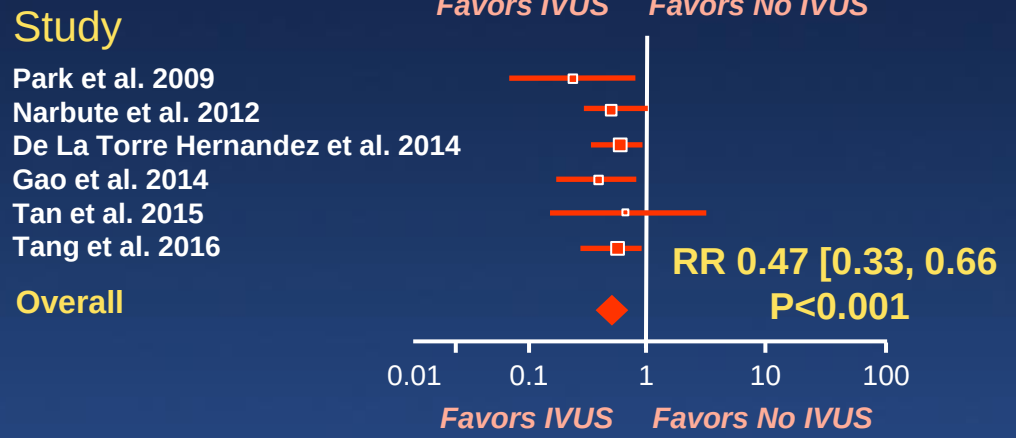
Elgendy et al. Circulation J, in press

Meta-Analysis of 10 LMCA DES Studies

All cause mortality



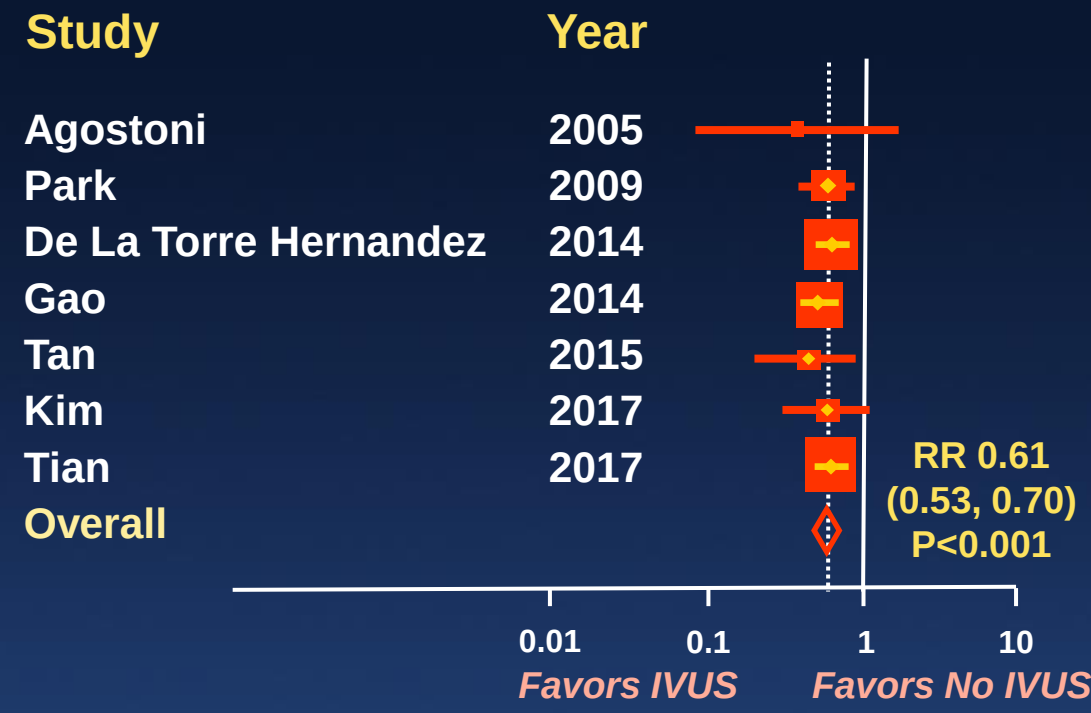
Cardiac mortality



2° Outcome	# Studies	RR	95% CI	P-value
MI	7	0.80	0.61–1.06	0.12
TVR	6	0.89	0.66–1.20	0.44
TLR	3	0.43	0.25–0.73	0.002
ST	4	0.28	0.12–0.67	0.004

Meta-Analysis of 7 LMCA DES Studies

MACE



2° Outcome	# Studies	RR	95% CI	P-value
All cause mortality	4	0.55	0.42–0.71	<0.001
Cardiac mortality	5	0.45	0.32–0.62	<0.001
MI	6	0.66	0.55–0.80	<0.001
ST	4	0.48	0.27–0.84	0.001
TLR	6	0.60	0.31–1.18	0.099
TVR	3	0.64	0.26–1.56	0.3

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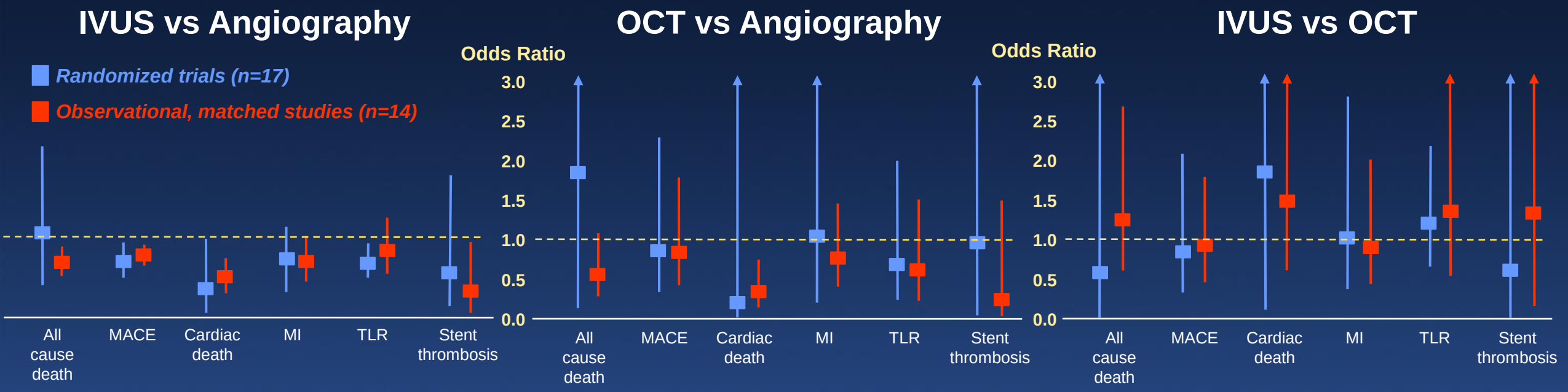
Ye et al. PLoS ONE 2017;12: e0179756
Wang et al. BMC Cardiovascular Disorders 2018;18:115

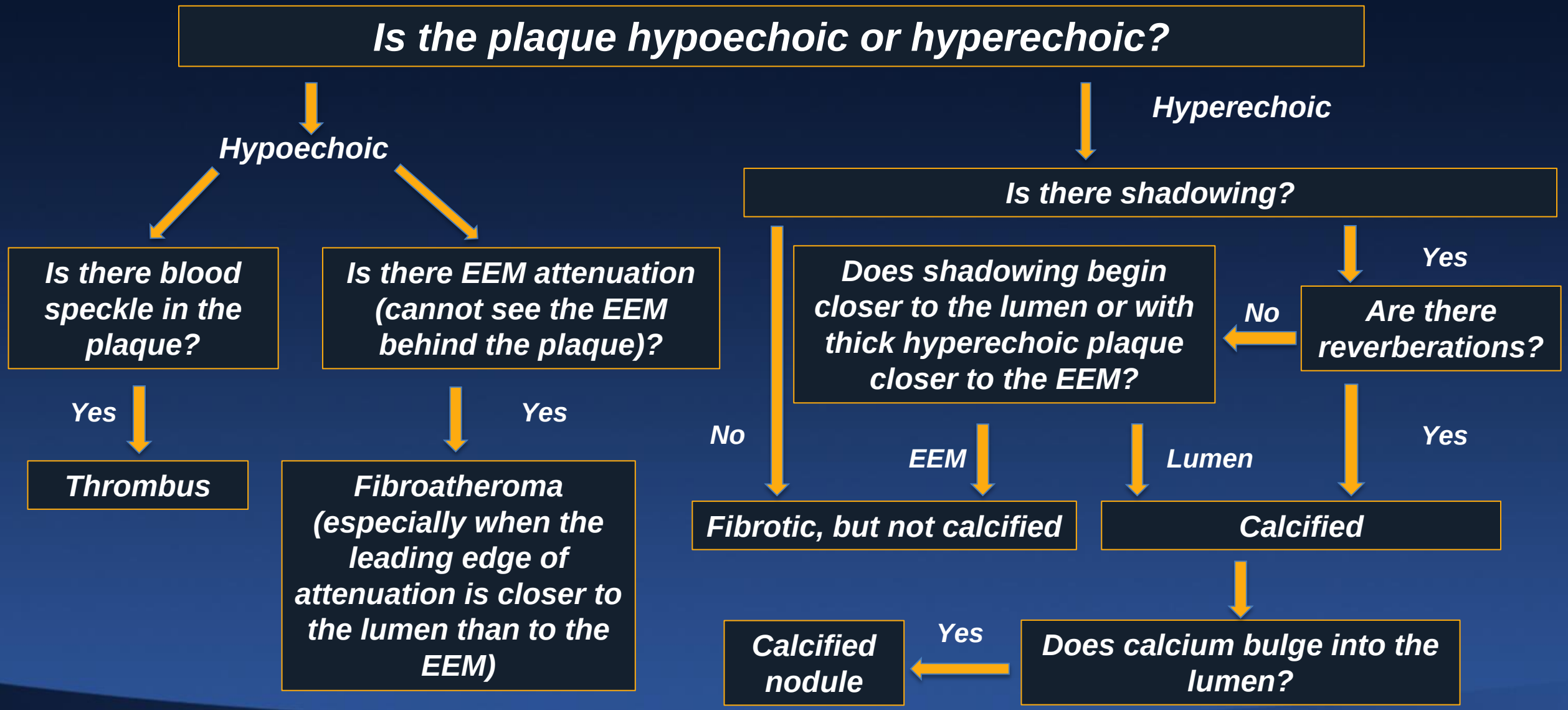
Bayesian network meta-analysis of 31 studies and 17,882 pts comparing clinical outcomes of PCI with BMS and/or DES implantation guided by angiography, IVUS, or OCT



- Angiography (29 studies; 8434 pts), IVUS (17 studies; 7825 pts), OCT (7 studies; 1623 pts)
- Angiography vs IVUS (24 studies; 14295 pts), Angiography vs OCT (4 studies; 2092 pts), IVUS vs OCT (2 studies; 1045 pts), Angiography vs IVUS vs OCT (1 study; 450 pts)

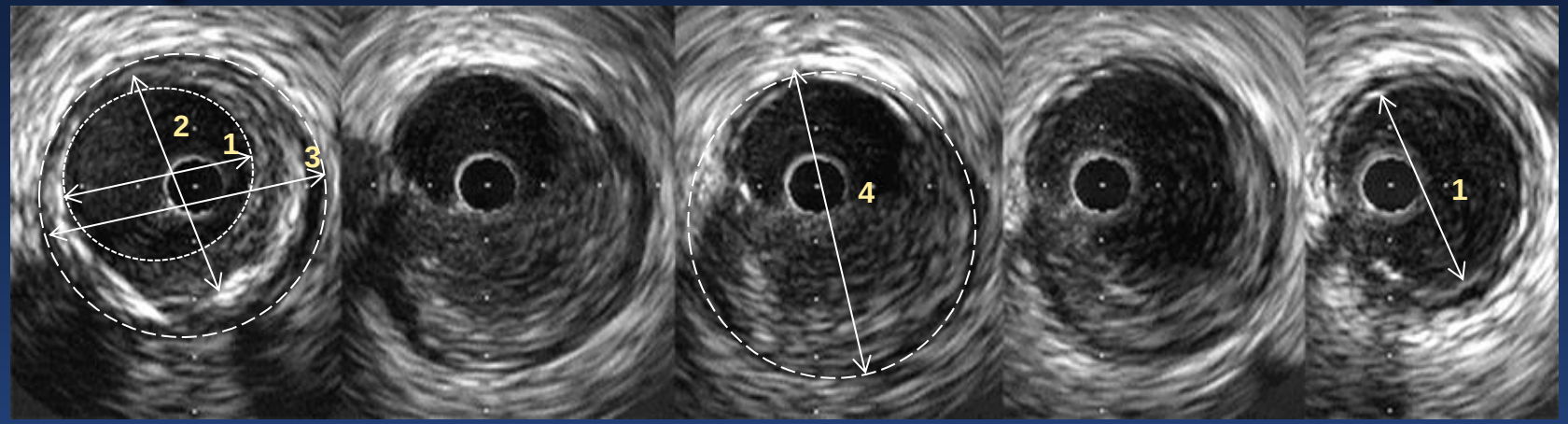
Buccheri et al. J Am Coll Cardiol Intv 2017;10:2488-98.

IVUS Image Interpretation



Stent length determined by landing zones (largest lumen with least plaque burden)

Proximal landing zone | **Lesion Site** | **Distal landing zone**

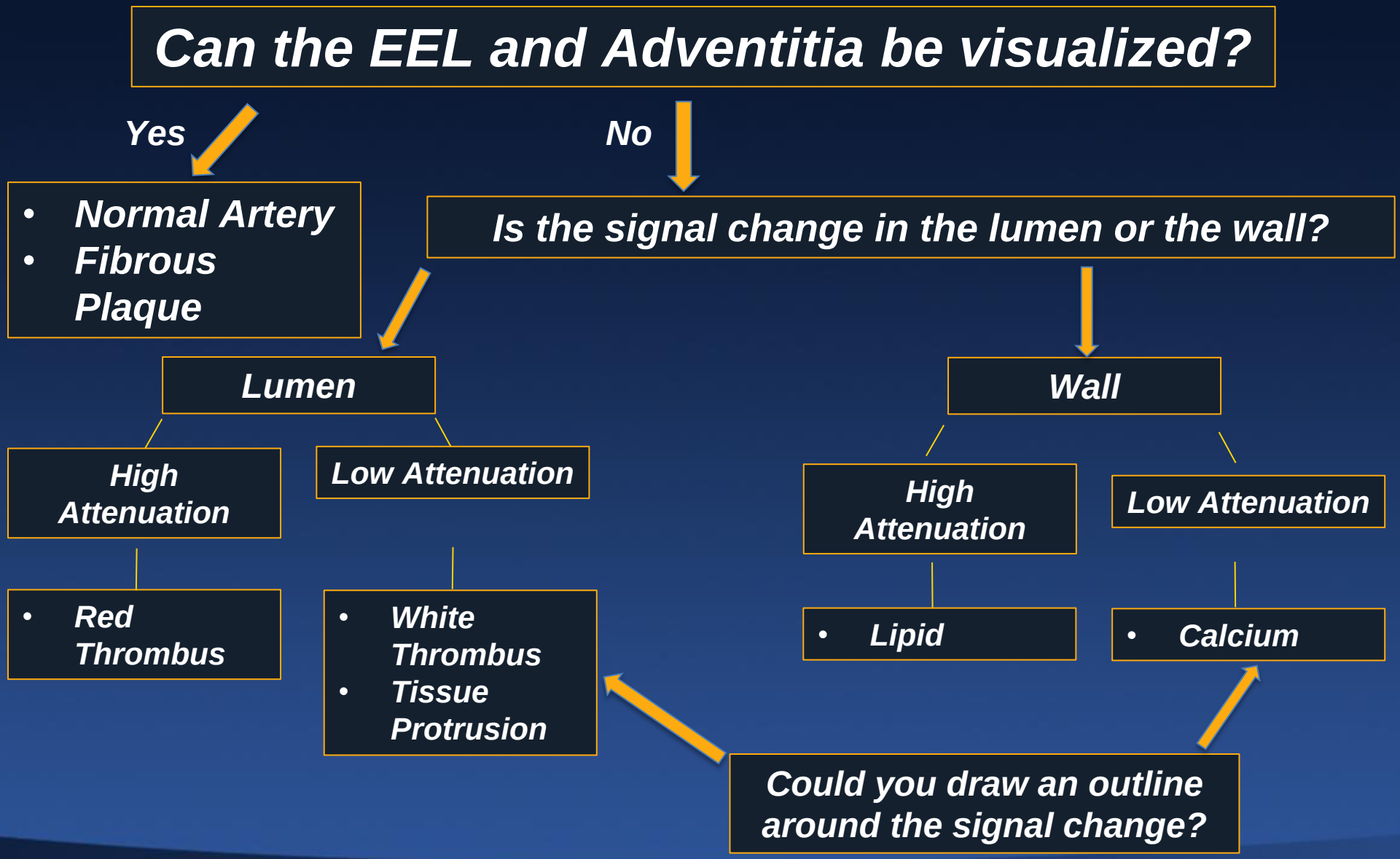


0 → 3mm → 12mm

Increasingly aggressive

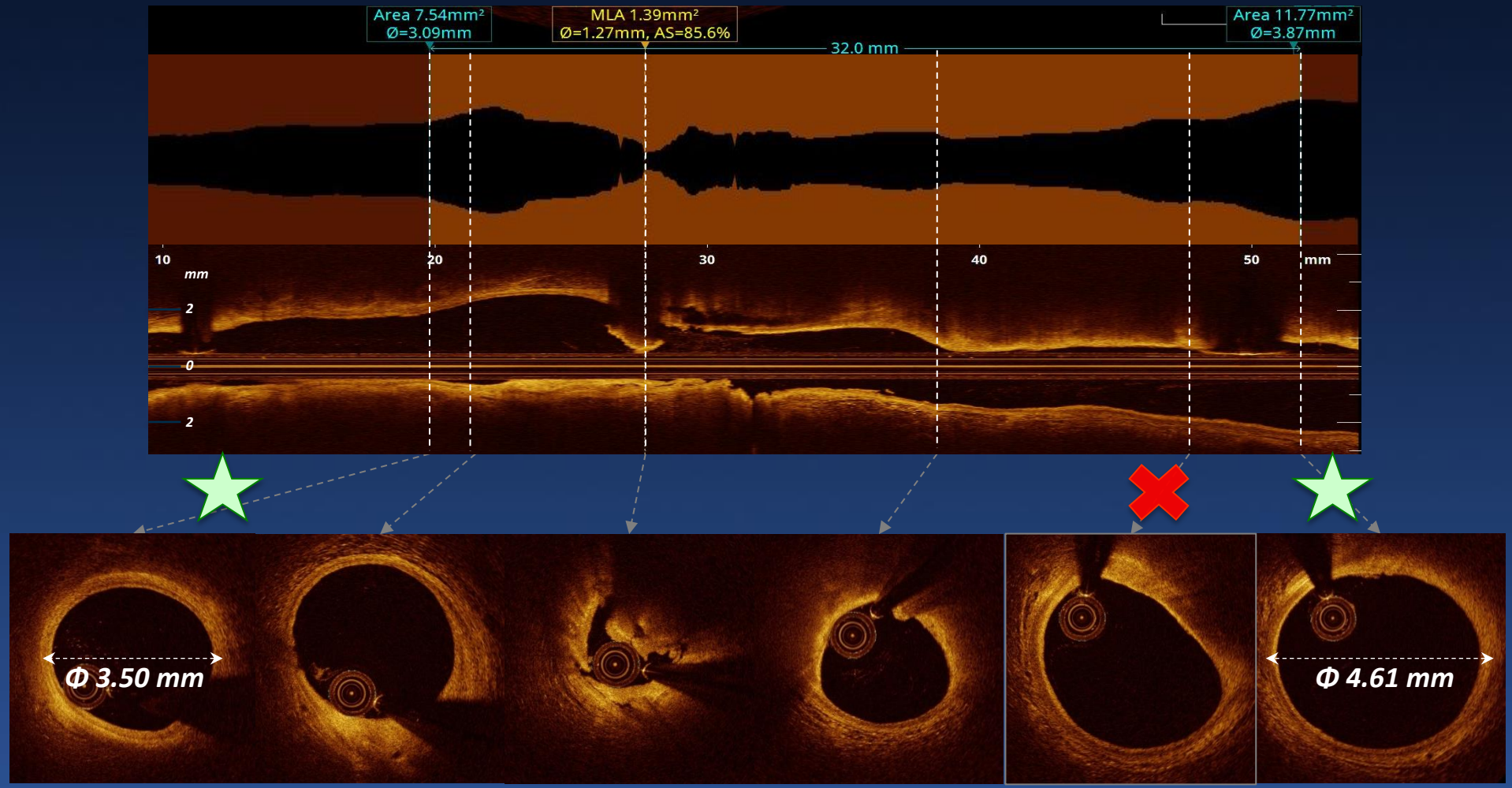
1) *Largest reference lumen whether proximal or distal*
2) *Reference midwall*
3) *Reference media-to-media (although this is often "discounted" by approximately 0.5mm)*
4) *Lesion media-to-media (although this is often discounted by 1mm)*

OCT Image Interpretation



c/o Ziad Ali

How to decide on lesion severity, lesion length, stent sizing, landing zone?

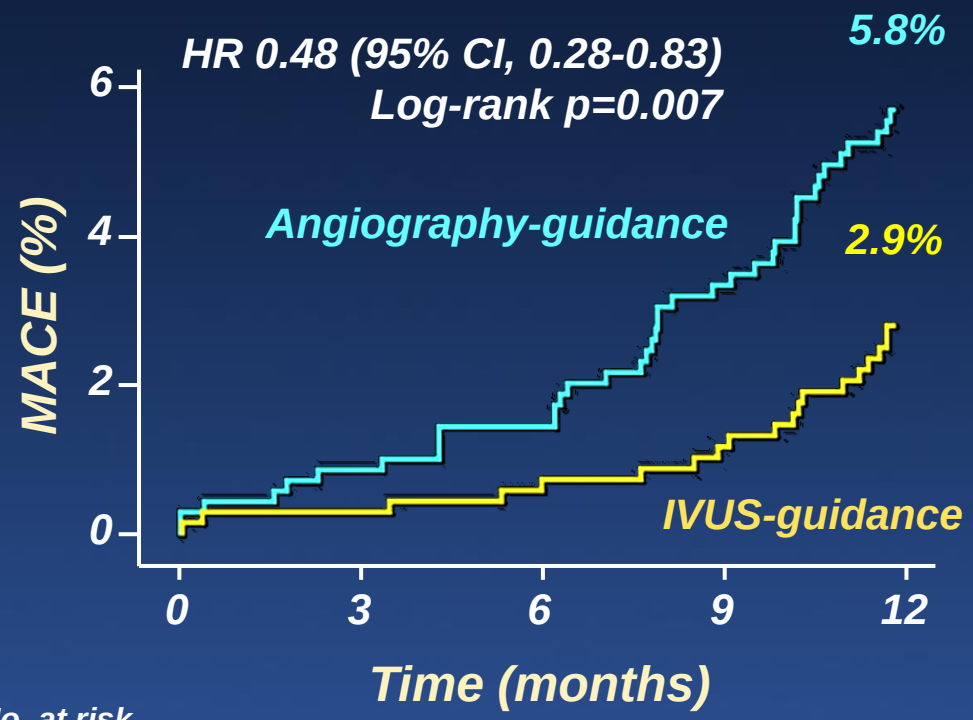


Guagliumi TCT2015

Predictors of DES Early ST, Restenosis, MACE, or DoCE

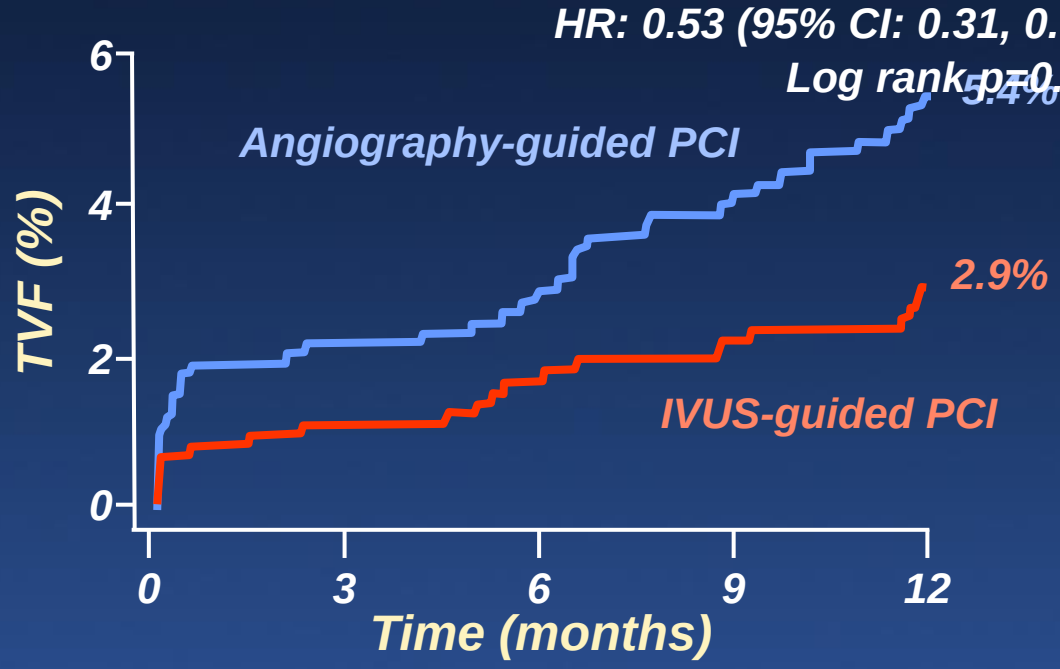
	IVUS		OCT
	Early ST	**Restenosis/MACE**	**Restenosis/MACE/DoCE**
Small MSA or underexpansion in stable lesions **Small MLA in ACS/MI lesions**	•*Fujii et al. J Am Coll Cardiol 2005;45:995-8* •*Okabe et al. Am J Cardiol. 2007;100:615-20* •*Liu et al. JACC Cardiovasc Interv. 2009;2:428-34* •*Choi et al. 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 2014;83:873-8* •*Kang et al. PLoS One 2015;10(10):e0140421* •*Hong et al. JAMA 2015;314(:2155-63.* •*Lee et al. Rev Esp Cardiol 2017;70:88-95* •*Kang et al. PLoS One. 2015 Oct 14;10(10):e0140421* •*Katagiri et al. Catheter Cardiovasc Interv. 2019 Jan 31. doi: 10.1002/ccd.28105.*	•Prati et al. JACC Cardiovasc Imaging 2015;8:1297-305 •Prati et al. Circ Cardiovasc Interv. 2016;9. pii: e003726. •Soeda et al. Circulation 2015;132:1020-9 •Matsuo et al. Cathet Cardiovasc Interv 2015;87:E9-14 •Prati et al. EuroIntervention 2018, in press
Protrusion in ACS/MI **Irregular Protrusion**	•*Choi et al. Circ Cardiovasc Interv 2011;4:239-47* •*Hong et al. Int J Cardiol 2013;168:1674-5*		•Prati et al. Circ Cardiovasc Interv. 2016;9. pii: e003726. •Soeda et al. Circulation 2015;132:1020-9
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. Circ Cardiovasc Interv. 2016;9:e003553* •*Calvert et al. Catheter Cardiovasc Interv 2016;88:340-7*	•Prati et al. JACC Cardiovasc Imaging 2015;8:1297-305 •Prati et al. Circ Cardiovasc Interv. 2016;9. pii: e003726. •Ino et al. Circ Cardiovasc Interv. 2016;9:e004231 •Prati et al. EuroIntervention 2018, in press
Stent length (>40mm)		•*Hong et al. Eur Heart J 2006;27:1305-10*	
Asymmetry/Eccentricity		•*Suwannasom et al. JACC Cardiovasc Interv 2016;9:1231-42*	

Effect of IVUS-Guided vs. Angiography-Guided Everolimus-Eluting Stent Implantation: The 1400 patient IVUS-XPL Randomized Clinical Trial



No. at risk					
Angiography	700	673	660	643	624
IVUS	700	671	665	654	641

ULTIMATE: Multicenter, Prospective, Randomized Trial Comparing IVUS-guided versus Angiography-guided Implantation of DES in All-comers (n=1448)



No. at risk					
Angiography	724	706	698	685	676
IVUS	724	715	710	704	696

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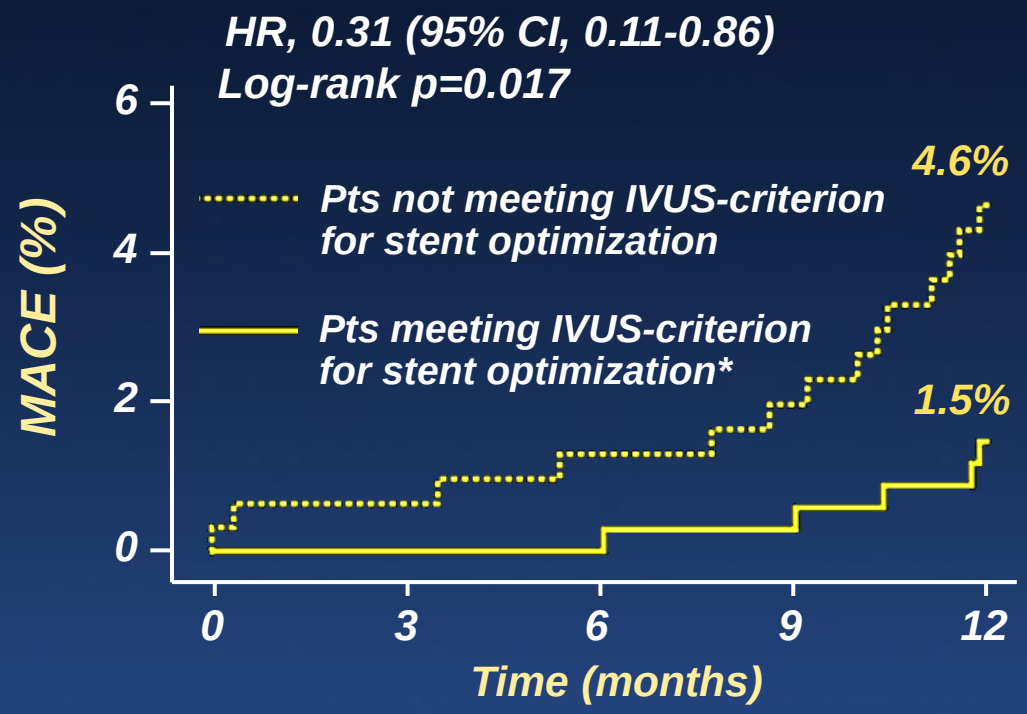
Hong et al. JAMA 2015;314:2155-63
Zhang et al. J Am Coll Cardiol 2018;72:3126-27

Effect of IVUS Optimization

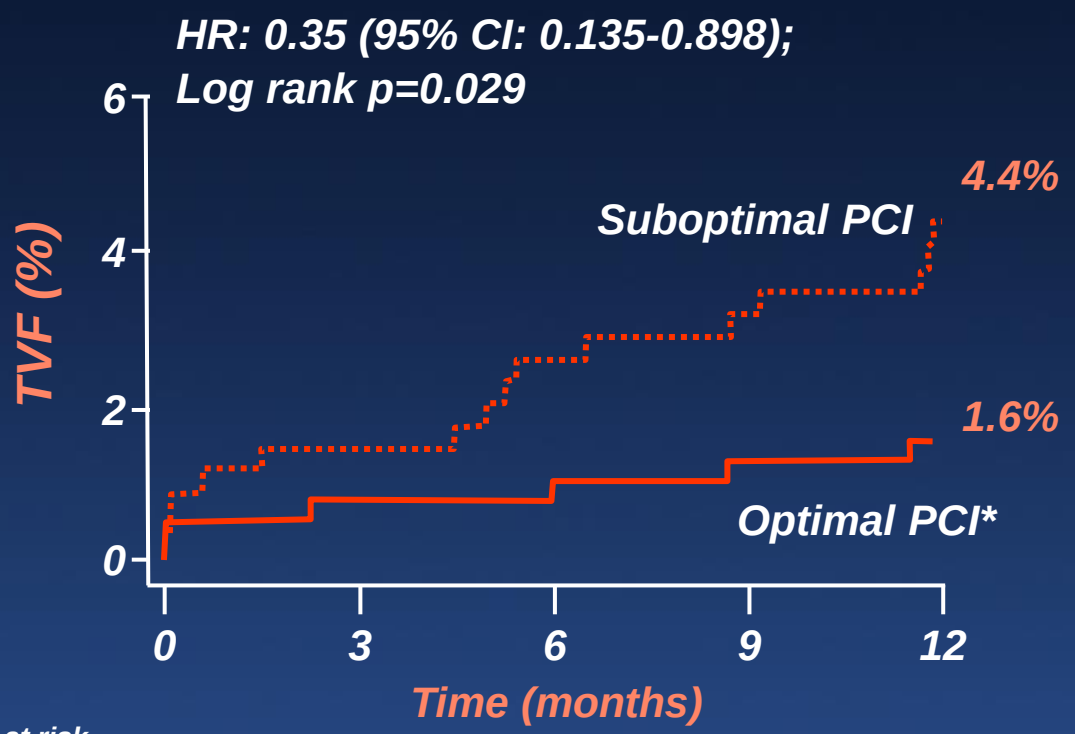
IVUS-XPL



No. at risk					
No stent optimization	315	299	297	394	285
Stent optimization	363	362	345	338	334

*In-stent MLA >distal reference

ULTIMATE



No. at risk					
Suboptimal PCI	340	334	329	326	320
Optimal PCI	384	381	381	378	376

*In-stent MLA >5.0 mm^2 or >90% of distal reference lumen
Edge plaque burden <50% with no medial dissection

Hong et al. JAMA 2015;314:2155-63
Zhang et al. J Am Coll Cardiol 2018;72:3126-27

EXCEL Trial

Evaluation of Xience versus Coronary Artery Bypass Surgery for Effectiveness of Left Main Revascularization

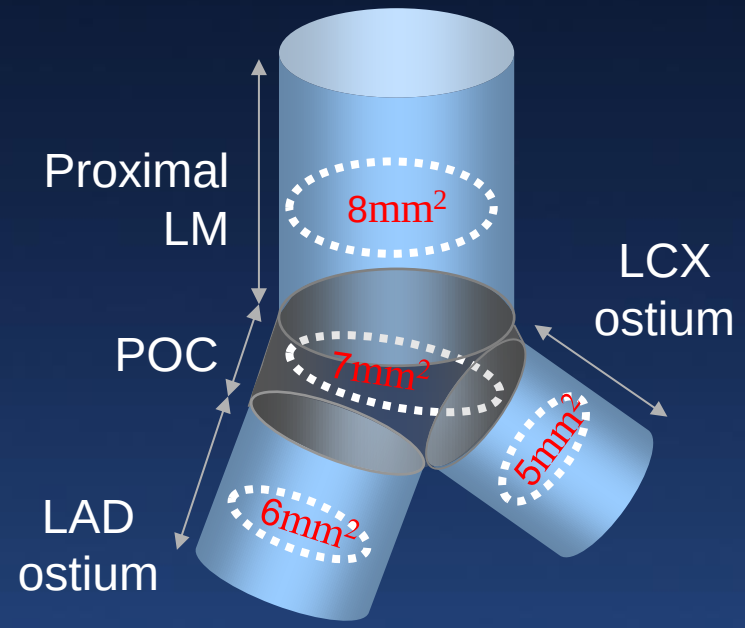
1,905 pts with unprotected LMCAD at 126 sites in 17 countries were prospectively enrolled

R 1:1

- CABG (n=957)
- PCI with CCr-EES (n=948)
  - IVUS guided (n=690)
  - Angio guided (n=245)
    - IVUS Substudy (n=504)

Clinical FU at 30 days, 1 year, 2 years, 3 years

Recommendations for Stent Expansion



Add 0.5 mm² to each location for non-Asian (or larger BSA) pts

Kang et al. *Circulation Cardiovasc Interv.* 2011;4:562-9

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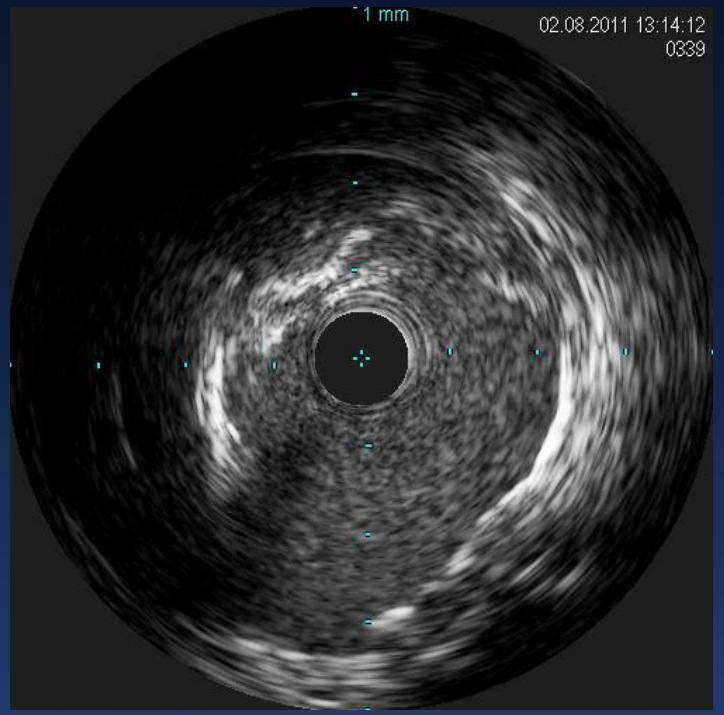
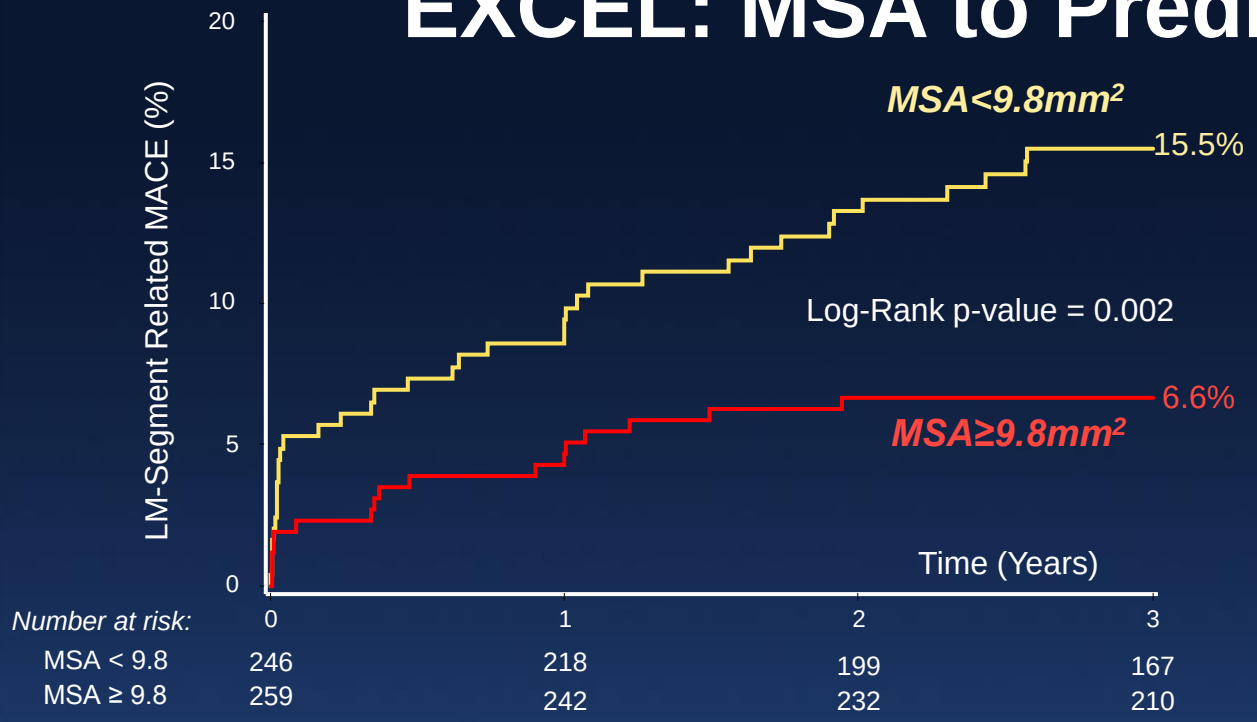
Analysis According to MSA Tertiles

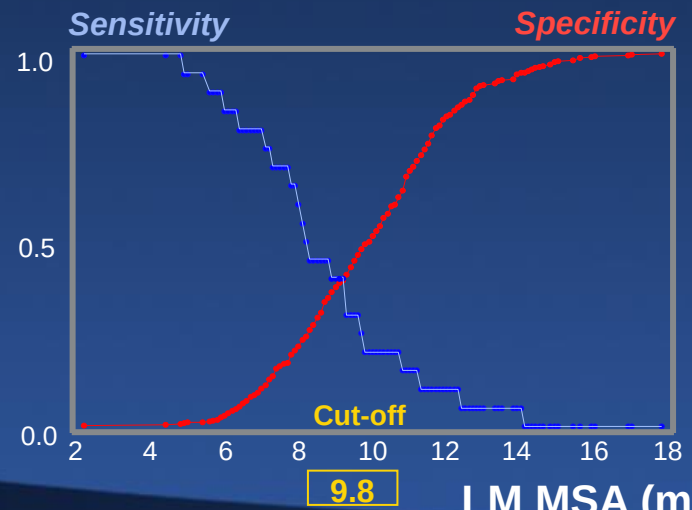
	IVUS MSA tertiles		
	Low	Middle	High
#	172	169	163
MSA mm^2 (range)	4.4-8.7	8.8-10.9	11.0-17.8

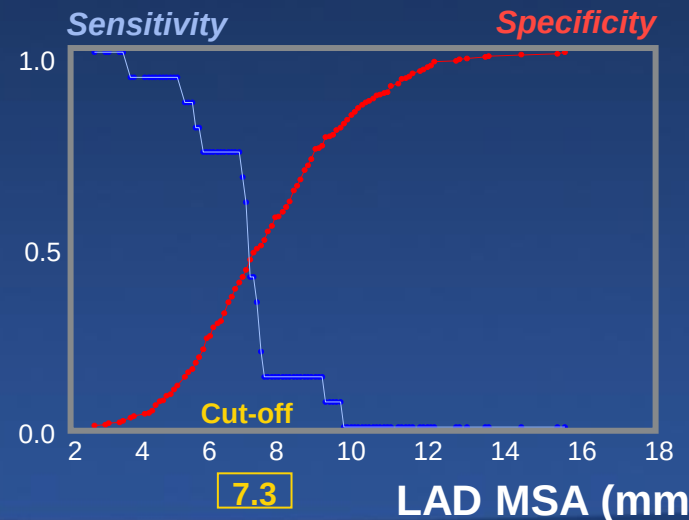


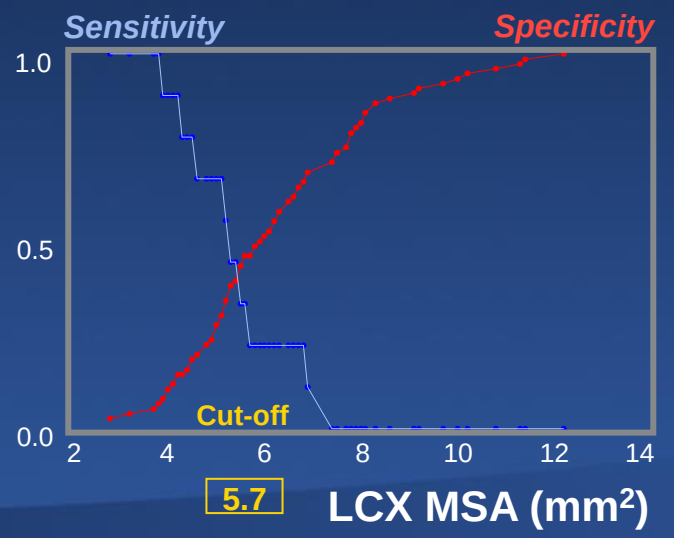
EXCEL: MSA to Predict LMCA-Related Events



	Adjusted Hazard Ratio (95% CI)	P-value
Final IVUS LM MSA (mm^2)	0.84 (0.75-0.94)	0.003
Distal LM lesion location	2.10 (1.0-5.33)	0.05
Diabetes mellitus	1.63 (1.0-2.64)	0.049
ACS presentation	0.60 (0.36-0.99)	0.045







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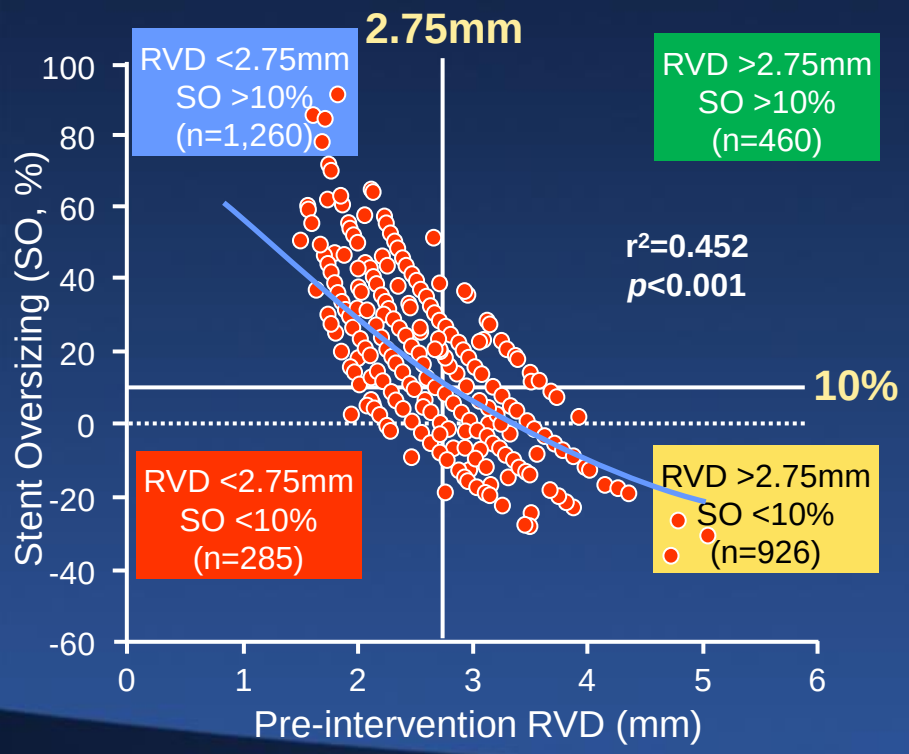
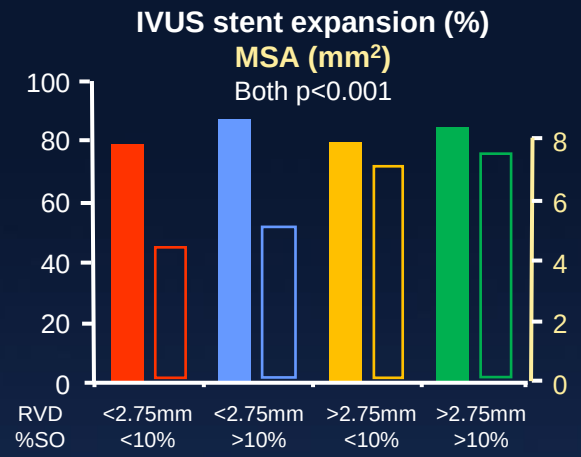
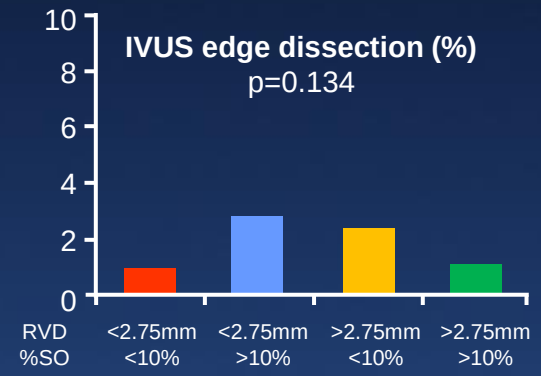
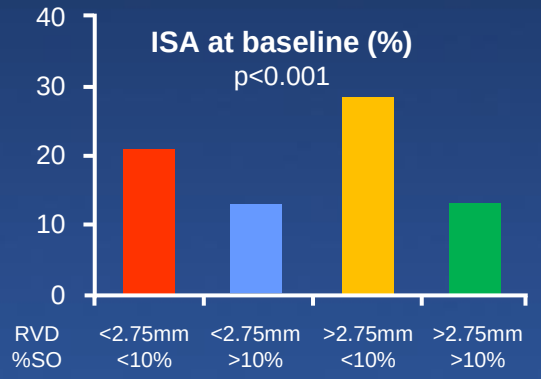
Impact of stent oversizing (SO)

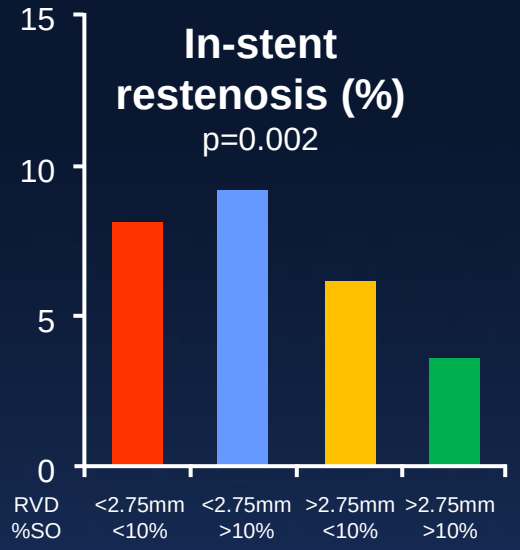
Baseline and 6-12 mos QCA and IVUS in 2931 lesions treated with DES (355 SES, 846 PES, 1387 ZES, and 343 EES)

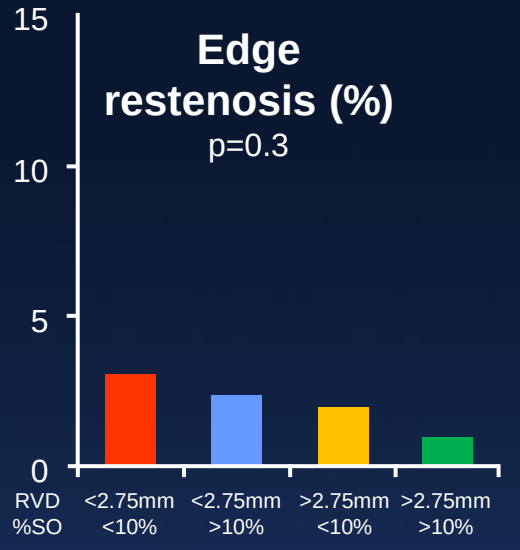


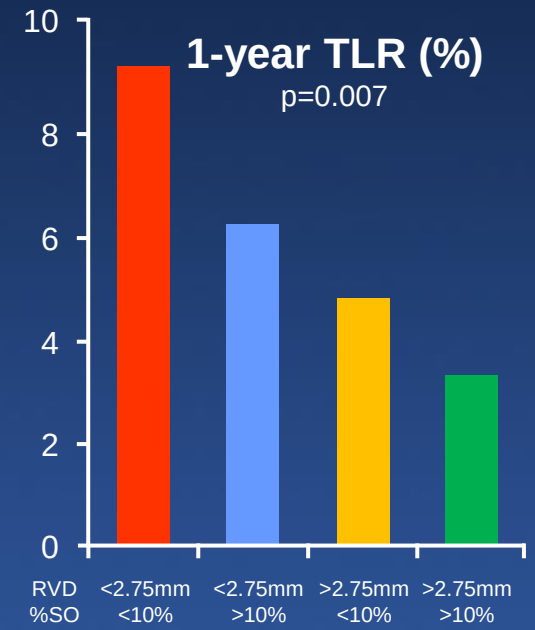


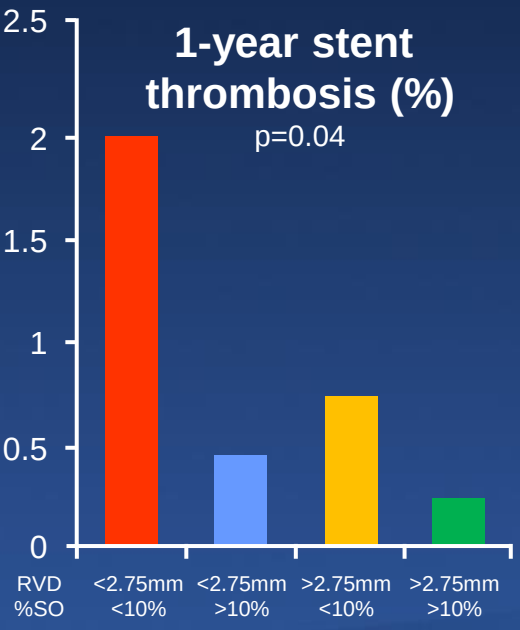












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Kitahara et al. Circ Cardiovasc Interv. 2017;10:e004795

Underexpansion is often lumped with malapposition - even by people who should know better. "Underdeployment" can mean anything.

Stent Thrombosis – No single set of predictors

	JEREMIAS (registry)	IAKOVOU (registry)	MORENO (RCT's)	e-CYPHER (registry)	ARRIVE 1 (registry)	Cheneau et al. (registry)
Advanced age				Yes		
Plux Non-compliance	Yes	Yes				
Diabetes		Yes		Yes	Yes	
ACS/AMI				Yes		
Renal failure		Yes				
Low LVEF		Yes				
Bifurcation		Yes				
Calcifications				Yes		
Total occlusion				Yes		
MVD				Yes		
Total stent length			Yes			
Malapposition						Yes
Number of stents			Yes			

AMI = acute myocardial infarction; LVEF = left ventricular ejection fraction; RCT = randomized clinical trial; MVD = multivessel disease.

Modified from Urban. EuroPCR, 2006. Oral presentation; Cheneau et al. *Circulation*. 2003; 108:43.

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Summary

- **Stent thrombosis is multifactorial**
  - Anatomic, clinical, pharmacologic
- ***Early* stent thrombosis (~ 0.6%) is related to:**
  - Lesion complexity
  - Stent malapposition
  - Variable anti-platelet agent responsiveness
  - Early discontinuation of anti-platelet therapy (strongest risk factor)
- **LST and VLST are rare but serious complications of DES**
  - It was not seen in patients who remain on dual anti-platelet therapy in the RESEARCH/TSEARCH analysis by Ong et al, or the TAXUS meta-analysis (1 patient only)
- **Current ESC PCI guidelines now recommend 6-12 months of dual anti-platelet therapy after DES**
  - The TAXUS® Express²™ DFU recommends 6 months of dual anti-platelet therapy

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Events related to acute stent malapposition

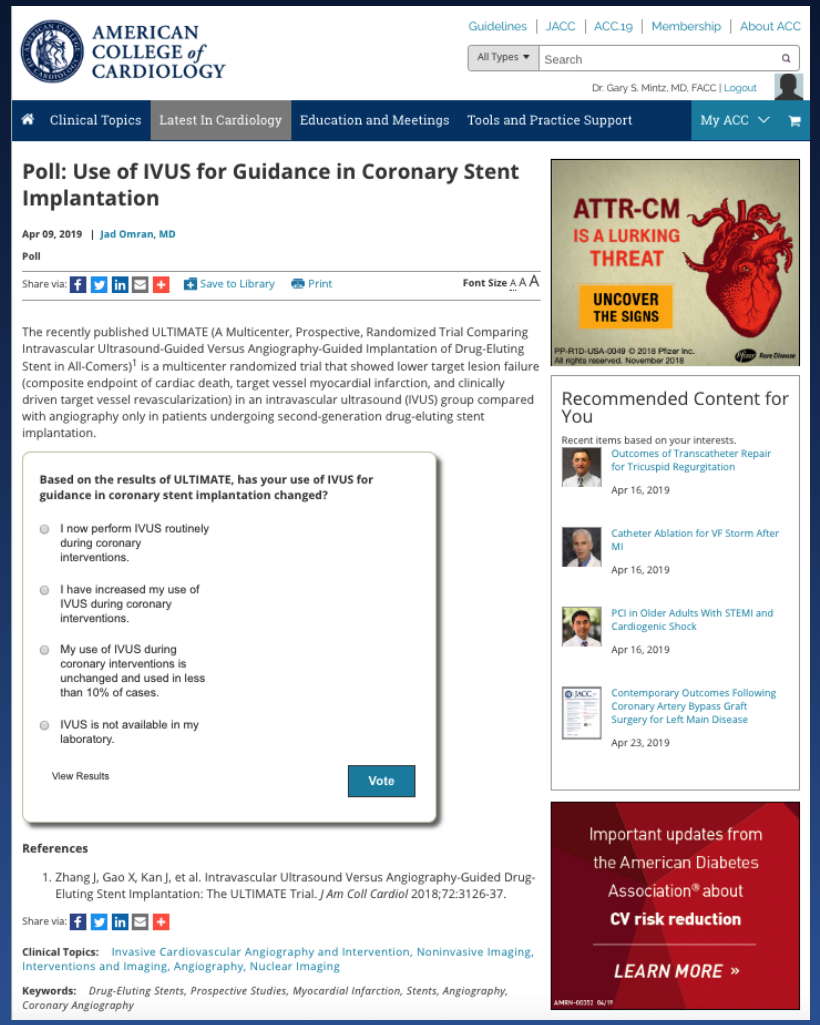
	Study		Follow-up	Acute malapposition	No acute malapposition
Steinberg et al. JACC Cardiovasc Interv 2010;3:486-94	**Combined TAXUS**	**IVUS**	**9 mos**	8.2% MACE	10.7% MACE
Van der Hoeven et al. JACC Cardiovasc Interv 2008;1:192-201	**MISSION-AMI**	**IVUS**	**9 mos**	0% ST	0% ST
Guo et al. Circulation 2010;122:10-77-84	**HORIZONS-AMI**	**IVUS**	**13 mos**	0% ST	0% ST
Soeda et al. Circulation 2015;132:1020-9		**OCT**	**1 yr**	4.4% DoCE	4.8% DoCE
Prati et al. JACC Cardiovasc Imaging 2015;8:1297-305	**CLI-OPCI-II**	**OCT**	**1 yr**	13% MACE	10% MACE
Wang et al. J Am Heart Assoc. 2016;5. pii: e004438. doi: 10.1161	**ADAPT-DES**	**IVUS**	**2 yrs**	5.2% MACE (0.65% ST)	4.5% MACE (0.43% ST)
Prati et al. Circ Cardiovasc Interv. 2016;9. pii: e003726.	**CLI-OPCI-ACS**	**OCT**	**9 mos**	12.8% MACE	12.4% MACE

CLI-OPCI: In 864 pts undergoing PCI, post-procedural OCT revealed a variable grade of acute stent malapposition in 72.3% without correlation between maximal strut-vessel distance vs longitudinal extension.

Acute Malapposition >0.2 mm thickness and >2.2mm length			
	Yes (371/1020)	No (649/1020)	P-value
MACE at 302 (IQR 127-567) days	11.0%	13.0%	**0.4**
Death	3.1%	2.7%	**0.8**
Myocardial infarction	5.3%	8.6%	**0.08**
Periprocedure	1.9%	2.9%	**0.4**
Follow-up	3.5%	5.7%	**0.19**
TLR	5.7%	6.8%	**0.4**
Stent thrombosis	2.4%	3.7%	**0.6**
Increasing severity of malapposition length and distance			
Malapposition distance <0.2mm	227/1020 (22.3%)	HR: 0.97	**1.0**
Malapposition distance 0.2-0.4mm	324/1020 (31.8%)	HR: 0.88	**0.5**
Malapposition distance >0.4mm	186/1020 (18.2%)	HR: 1.24	**0.3**
Malapposition length <2mm	224/1020 (22.4%)	HR: 1.19	**0.4**
Malapposition length 2-4mm	184/1020 (18.0%)	HR: 1.17	**0.5**
Malapposition length 4-6mm	123/1020 (12.1%)	HR: 0.81	**0.5**
Malapposition length 6-8mm	89/1020 (8.7%)	HR: 0.69	**0.3**
Malapposition length 8-10mm	50/1020 (4.9%)	HR: 0.71	**0.5**
Malapposition length >10mm	67/1020 (6.6%)	HR: 1.03	**0.9**

Romagnoli et al. Catheter Cardiovasc Interv 2017, in press

Poll on ACC.ORG (April 9, 2019)



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Poll: Use of IVUS for Guidance in Coronary Stent Implantation

Apr 09, 2019 | Jad Omran, MD

Poll

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The recently published ULTIMATE (A Multicenter, Prospective, Randomized Trial Comparing Intravascular Ultrasound-Guided Versus Angiography-Guided Implantation of Drug-Eluting Stent in All-Comers)[1] is a multicenter randomized trial that showed lower target lesion failure (composite endpoint of cardiac death, target vessel myocardial infarction, and clinically driven target vessel revascularization) in an intravascular ultrasound (IVUS) group compared with angiography only in patients undergoing second-generation drug-eluting stent implantation.

Based on the results of ULTIMATE, has your use of IVUS for guidance in coronary stent implantation changed?

- I now perform IVUS routinely during coronary interventions.
- I have increased my use of IVUS during coronary interventions.
- My use of IVUS during coronary interventions is unchanged and used in less than 10% of cases.
- IVUS is not available in my laboratory.

View Results | Vote

References

1. Zhang J, Gao X, Kan J, et al. Intravascular Ultrasound Versus Angiography-Guided Drug-Eluting Stent Implantation: The ULTIMATE Trial. *J Am Coll Cardiol* 2018;72:3126-37.

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Clinical Topics: Invasive Cardiovascular Angiography and Intervention, Noninvasive Imaging, Interventions and Imaging, Angiography, Nuclear Imaging

Keywords: *Drug-Eluting Stents, Prospective Studies, Myocardial Infarction, Stents, Angiography, Coronary Angiography*

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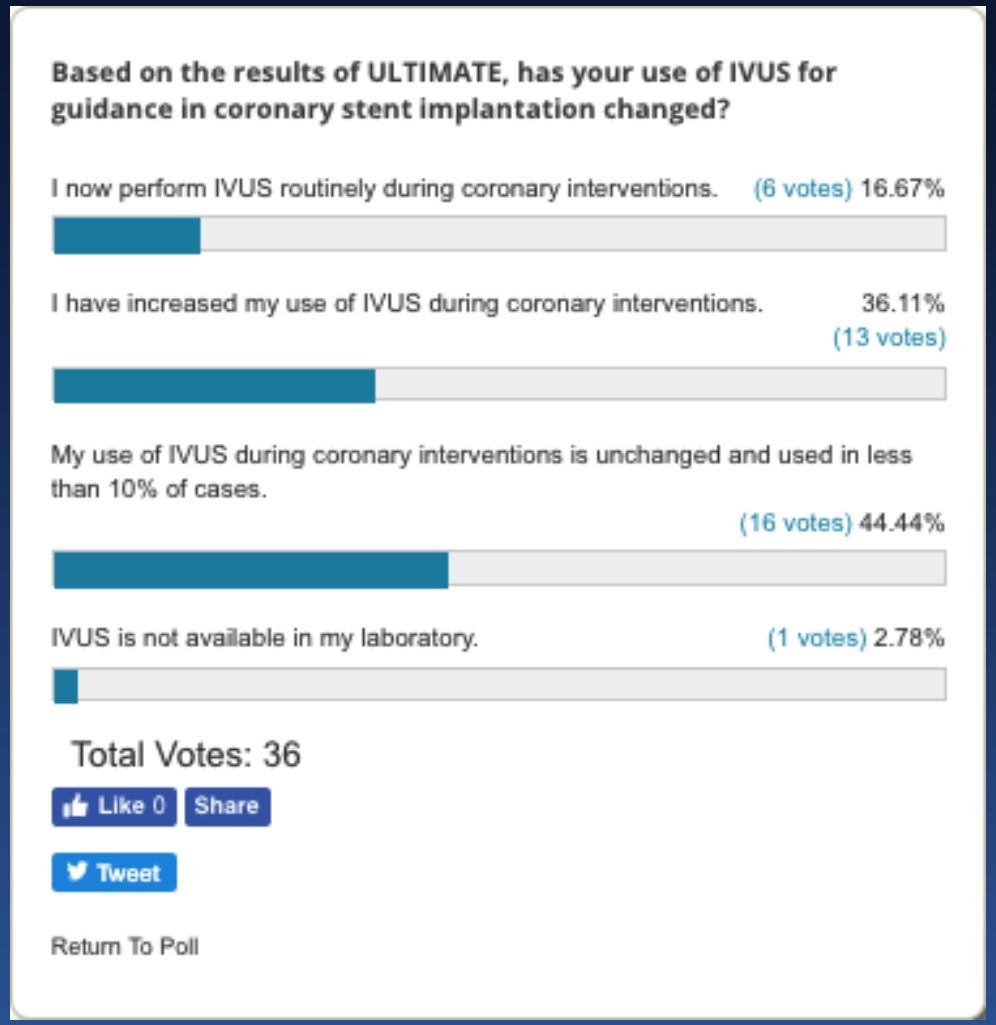

Based on the results of ULTIMATE, has your use of IVUS for guidance in coronary stent implantation changed?

I now perform IVUS routinely during coronary interventions. (6 votes) 16.67%

I have increased my use of IVUS during coronary interventions. 36.11% (13 votes)

My use of IVUS during coronary interventions is unchanged and used in less than 10% of cases. (16 votes) 44.44%

IVUS is not available in my laboratory. (1 votes) 2.78%

Total Votes: 36

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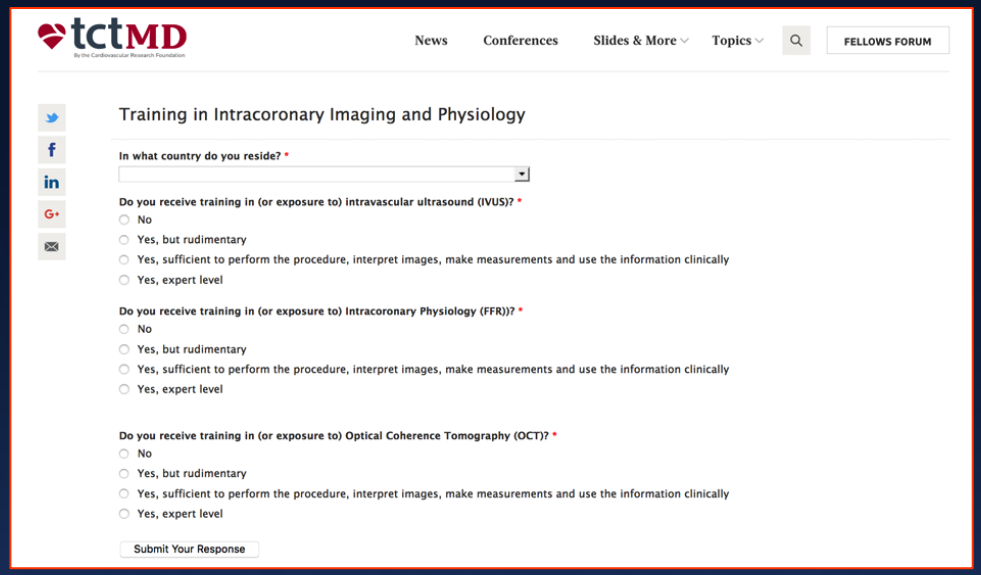

	No	Rudimentary	Sufficient*	Expert
FFR	12%	24%	42%	22%
IVUS	15%	37%	31%	18%
OCT	38%	28%	23%	10%

perform the procedure, interpret images, make measurements, and use information clinically

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