How IVUS imaging can reduce the number and length of stent?

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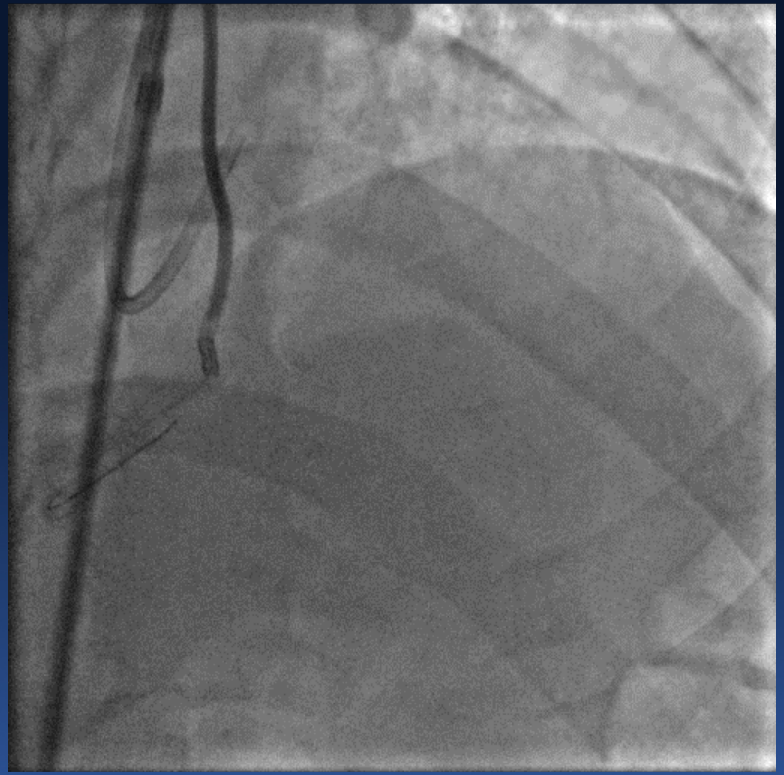
Disclosure Statement of Financial Interest

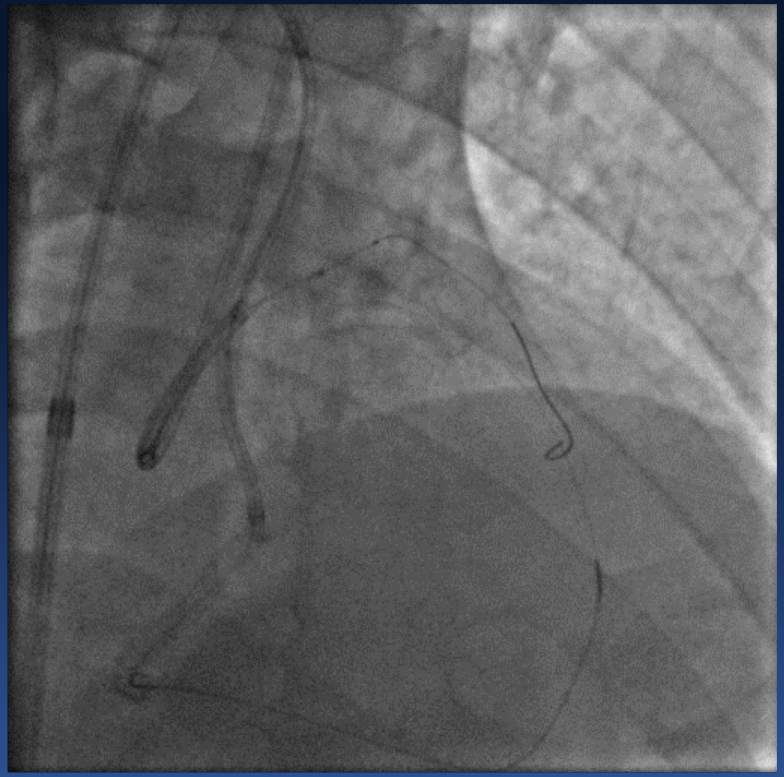
Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

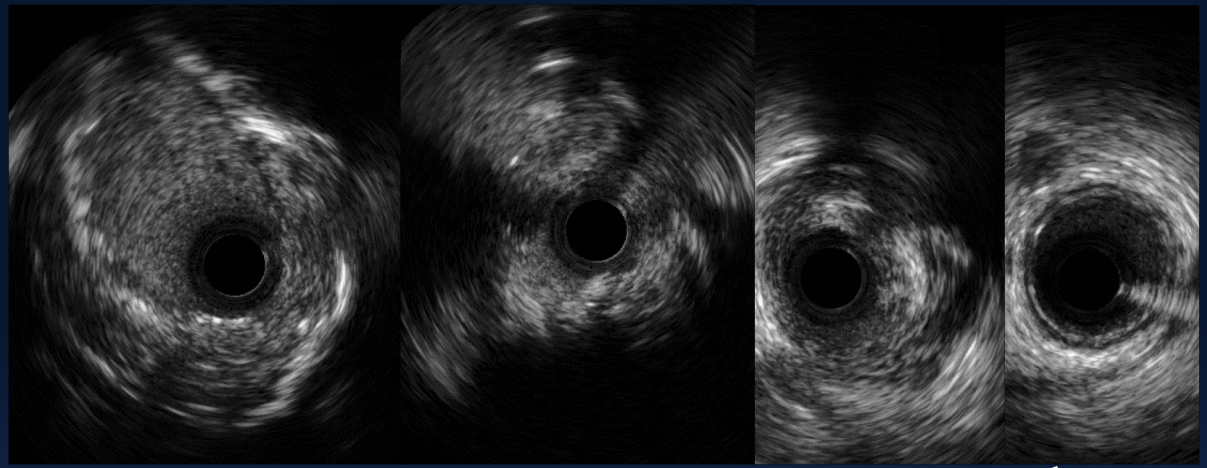
Affiliation/Financial Relationship	Company
• Grant/Research Support	Boston Scientific, Abbott Vascular
• Consulting Fees/Honoraria	Abbott Vascular

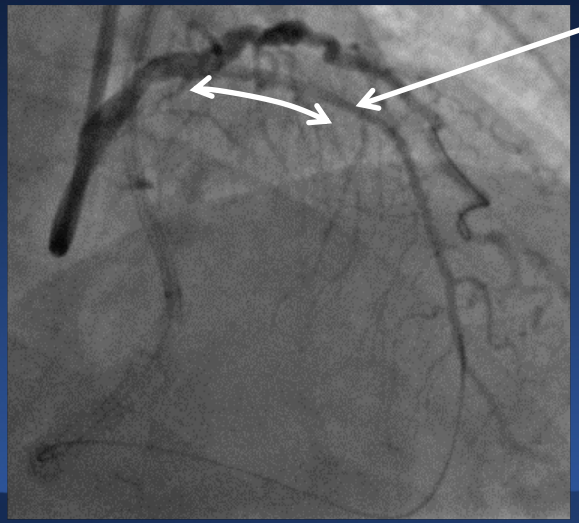
How IVUS imaging can reduce the length of stent?



Post-Ballooning

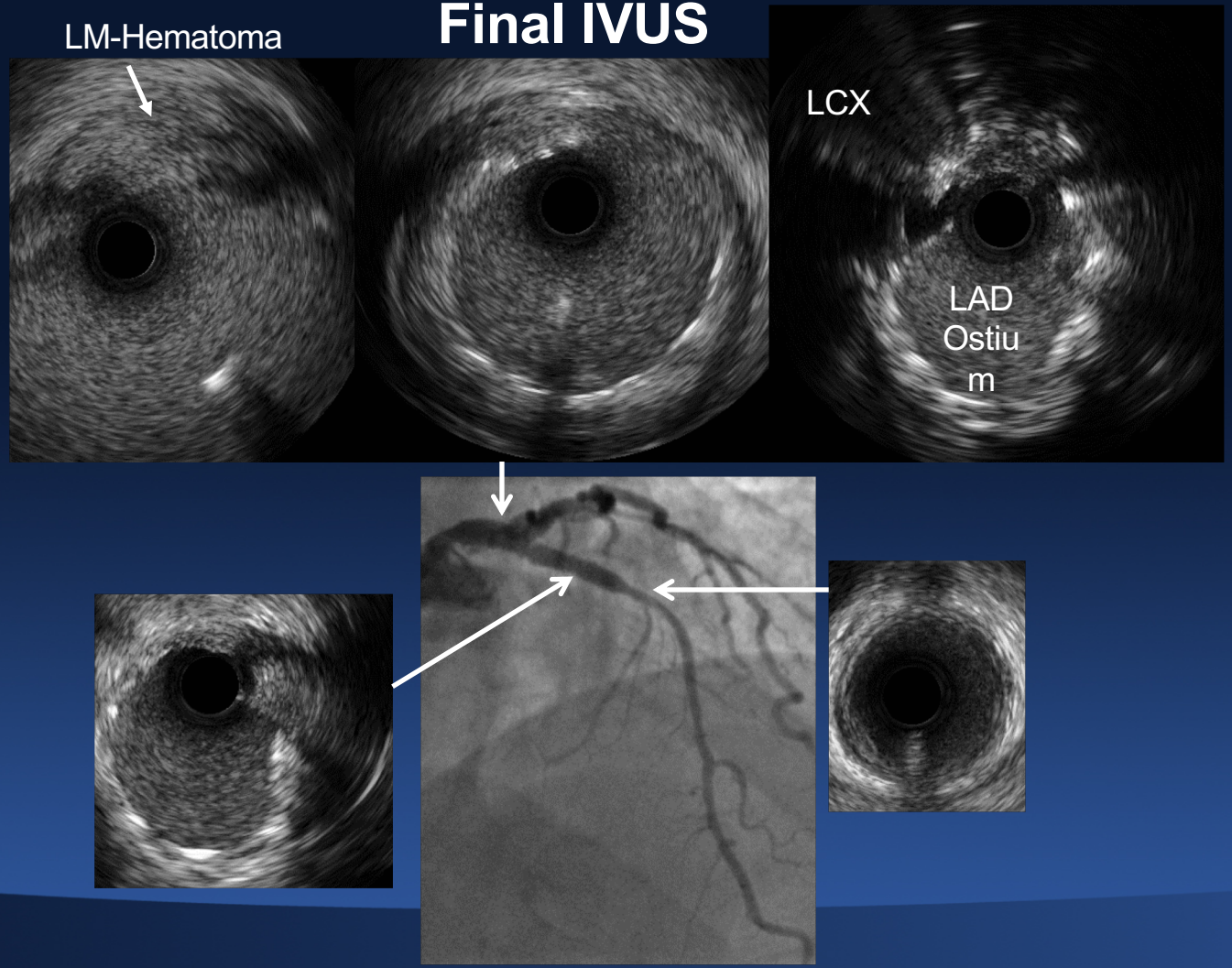






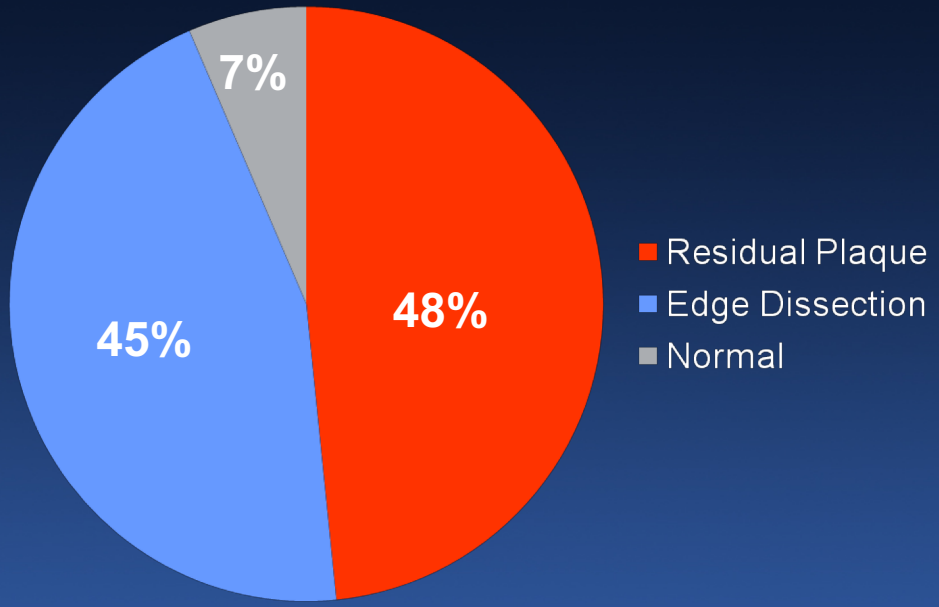
3.5×32 mm Stent

Final IVUS



IVUS Assessment for Angiographic "Haziness"

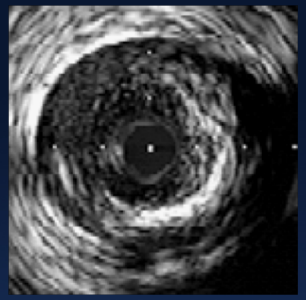
Angiographical Haziness : 31/201 segments (15%)



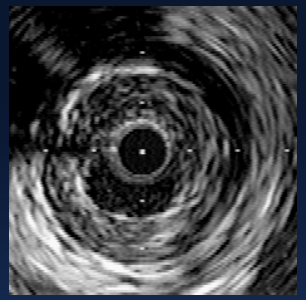
Ziada et al. Am J Cardiol 1997

Residual Issue Following Stenting

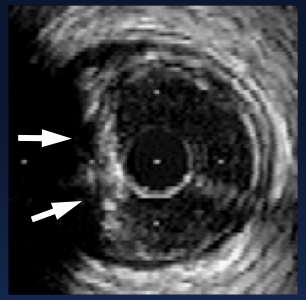
1. Edge Dissection



2. Residual Plaque Burden

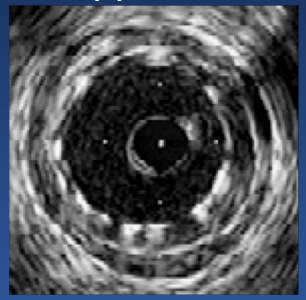


3. Calcified Plaque

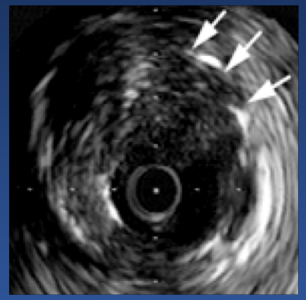


4. Incomplete Expansion

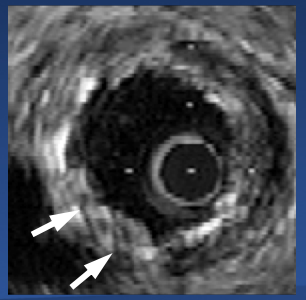
5. Incomplete Apposition



6. Thrombus



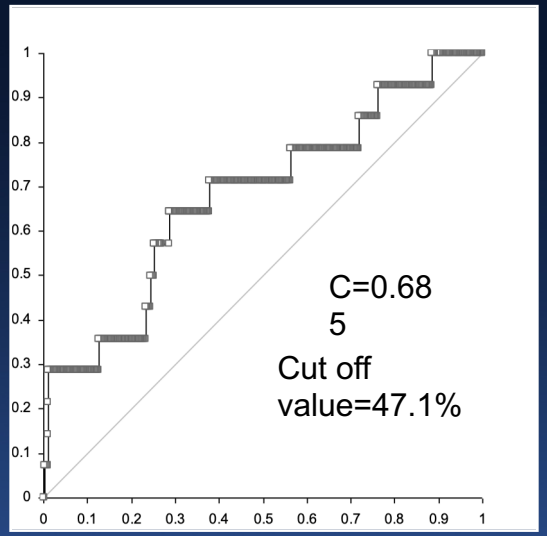
7. Plaque Protrusion



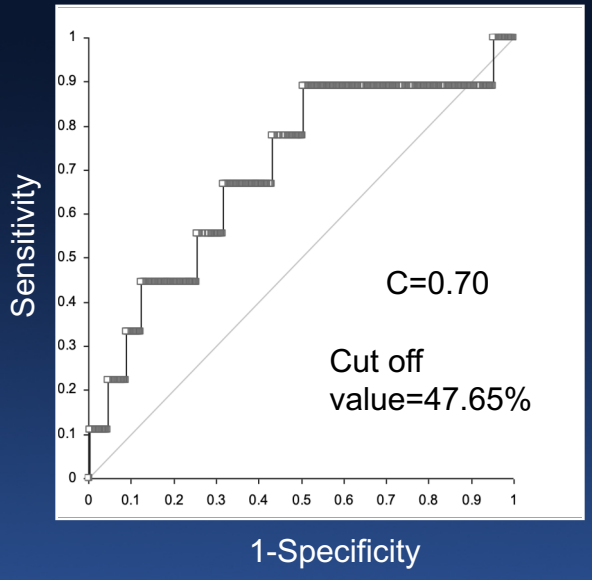
Plaque burden as a predictor for stent edge restenosis from TAXUS IV, V, VI (n=531)

Edge restenosis; TAXUS 5.6%, BMS 4.9%

TAXUS



BMS

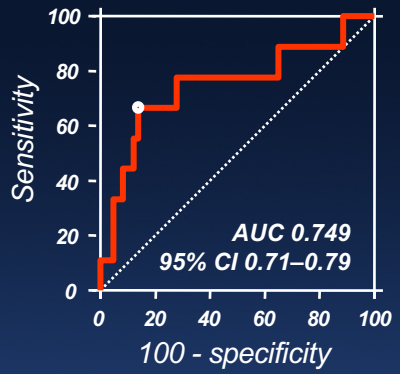


Plaque Burden 47%≅50%

Liu AJC 2008

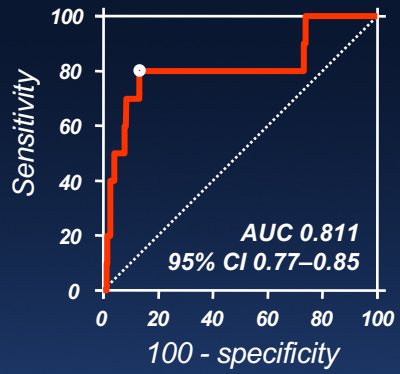
IVUS Predictors of Edge Restenosis after Second Generation DES

433 E-ZES



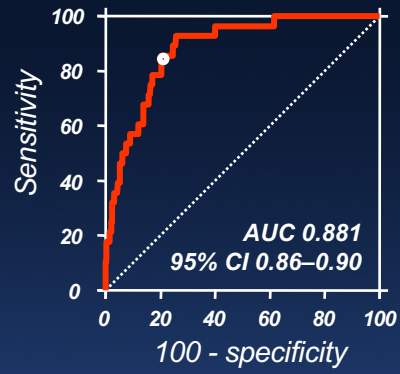
Plaque burden=56.3%
Sensitivity 67%
Specificity 86%

422 R-ZES



Plaque burden=57.3%
Sensitivity 80%
Specificity 87%

813 EES

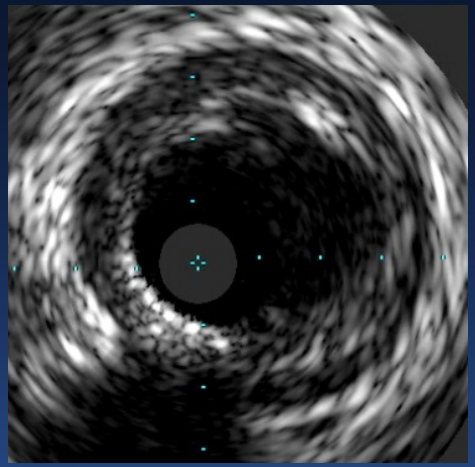


Plaque Burden=54.2%
Sensitivity 86%
Specificity 80%

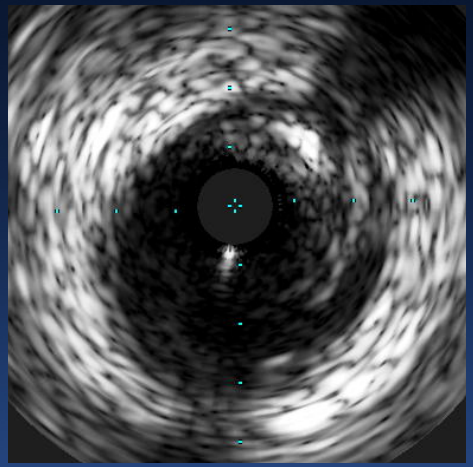
Kang et al. Am J Cardiol 2013;111:1408-14

Stent Edge Dissection

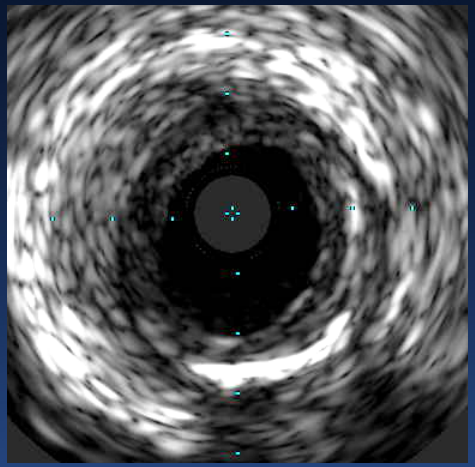
Intimal



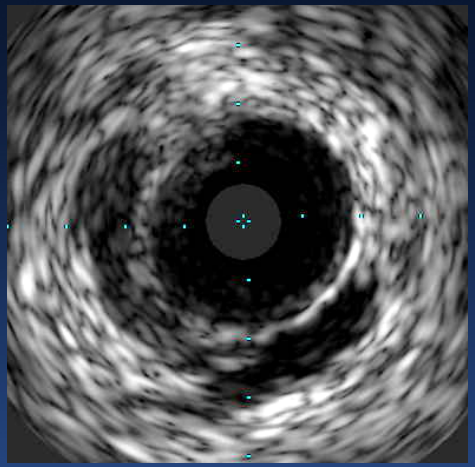
Media



Hematoma



Extra-media



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

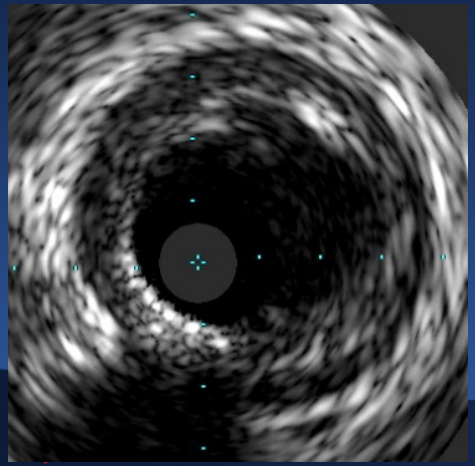
Time–to–event Kaplan-Meier estimated data.
MACE = cardiac death, re-myocardial infarction or target lesion revascularization.
Target vessel failure = death, re-myocardial infarction or target vessel revascularization

Kobayashi, et al. 2016; DOI: 10.1161/CIRCINTERVENTIONS.115.003553.

Stent Edge Dissection

- **Morphological predictor**
  - Proximal edge dissection: stent expansion,1.2 (1.1-1.3) per 10%; calcified plaque, 1.7 (1.03-2.9)
  - Distal edge dissection: stent expansion, 1.1 (1.01-1.2) per 10%; plaque burden, 1.6 (1.4-1.8) per 10%; attenuated plaque, 3.5 (1.5, 8.2)
- **Predictor of dissection with MACE**
  - lumen area cut off=5.1mm^2, dissection flap angle >60°, length>3mm

Intimal



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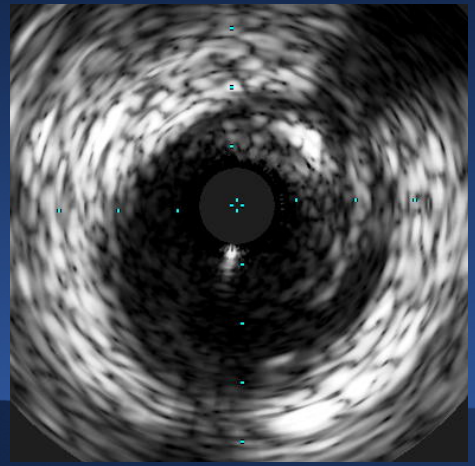
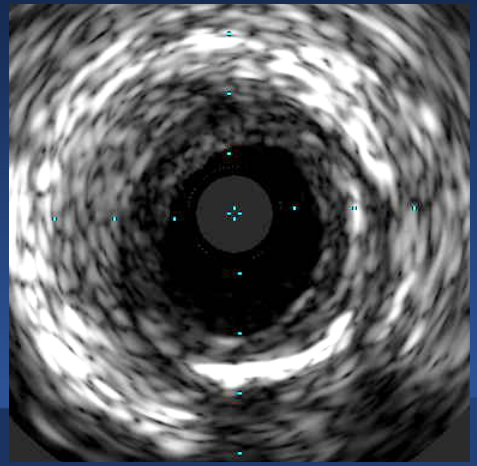
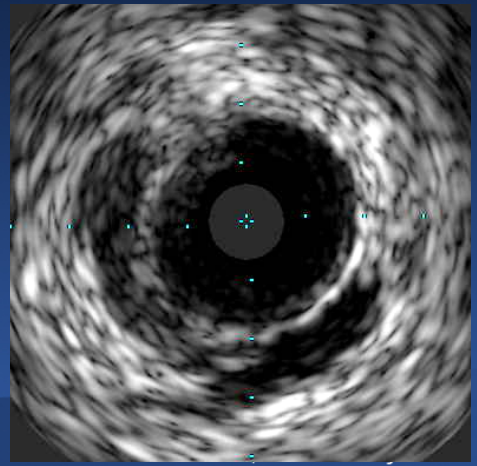


Hematoma



Extra-media



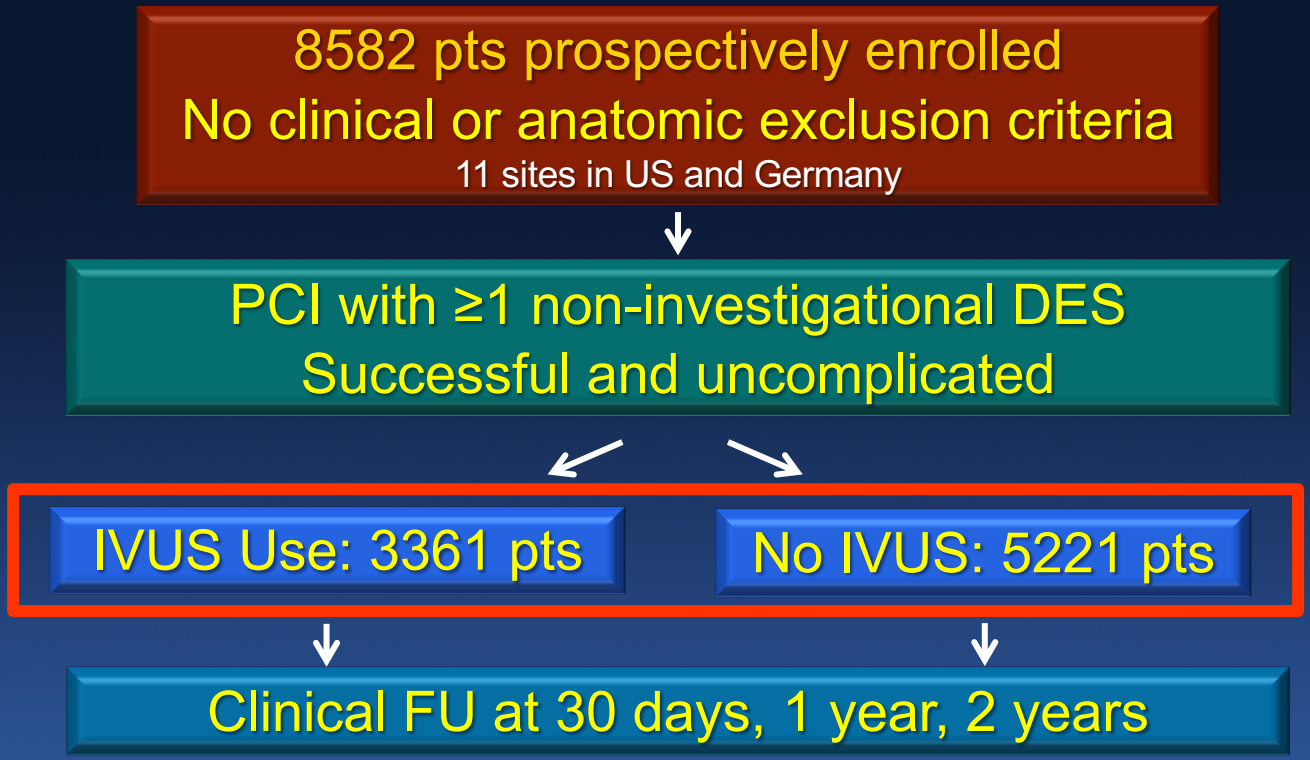
Early ST in STEMI
- HORIZONS-AMI trial -

	Early ST (n=13)	No Early ST (n=389)
Minimum lumen area in stent, mm^2	4.4 (3.6, 6.9)	6.7 (5.3, 8.0)
Minimum stent area in stent, mm^2	6.3 (4.8, 8.3)	7.1 (5.5, 8.5)
Minimum lumen area in ref, mm^2	3.5 (2.8, 4.0)	5.9 (4.4, 7.6)
Max plaque burden in ref, %	67.5 (58.5, 76.3)	49.5 (37.6, 59.2)
Malapposition	58%	67%
Thrombus/tissue protrusion	83%	73%
Edge dissection (≥Medial dissection)	42%	7%

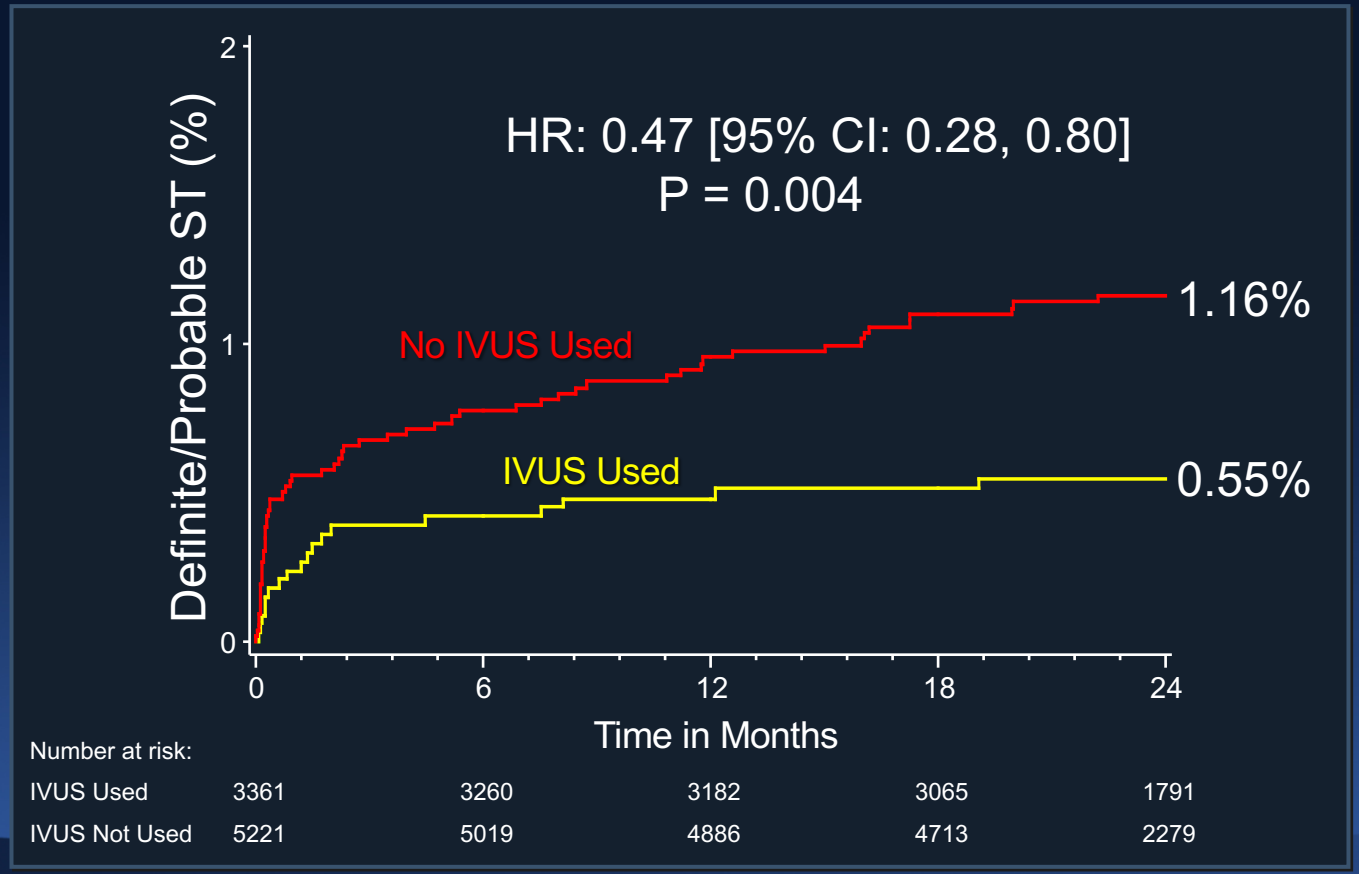
Choi S, et al. Circ Interv 2011; 4:239-247.

ADAPT-DES - Current Cohort -

Assessment of Dual AntiPlatelet Therapy with Drug-Eluting Stents



Relationship Between IVUS Use and Definite/Probable Stent Thrombosis Within 2 Years



Lesion and Procedural Characteristics

	IVUS n = 3361	No IVUS n = 5221	P Value
# of lesions treated	1.48±0.75	1.52±0.81	0.024
Bifurcation lesion	14.2%	16.2%	0.012
In-stent restenosis lesion	11.6%	9.6%	0.003
Bypass graft lesion	2.9%	6.3%	<0.0001
# of DES implanted	1.71±0.96	1.69±1.03	0.31
Total stent length (mm)	33.6±21.9	31.8±22.6	0.0002
Max device diameter (mm)	3.44±0.56	3.14±0.50	<0.0001
Max balloon pressure (atm)	16.9±3.7	16.7±3.5	0.070

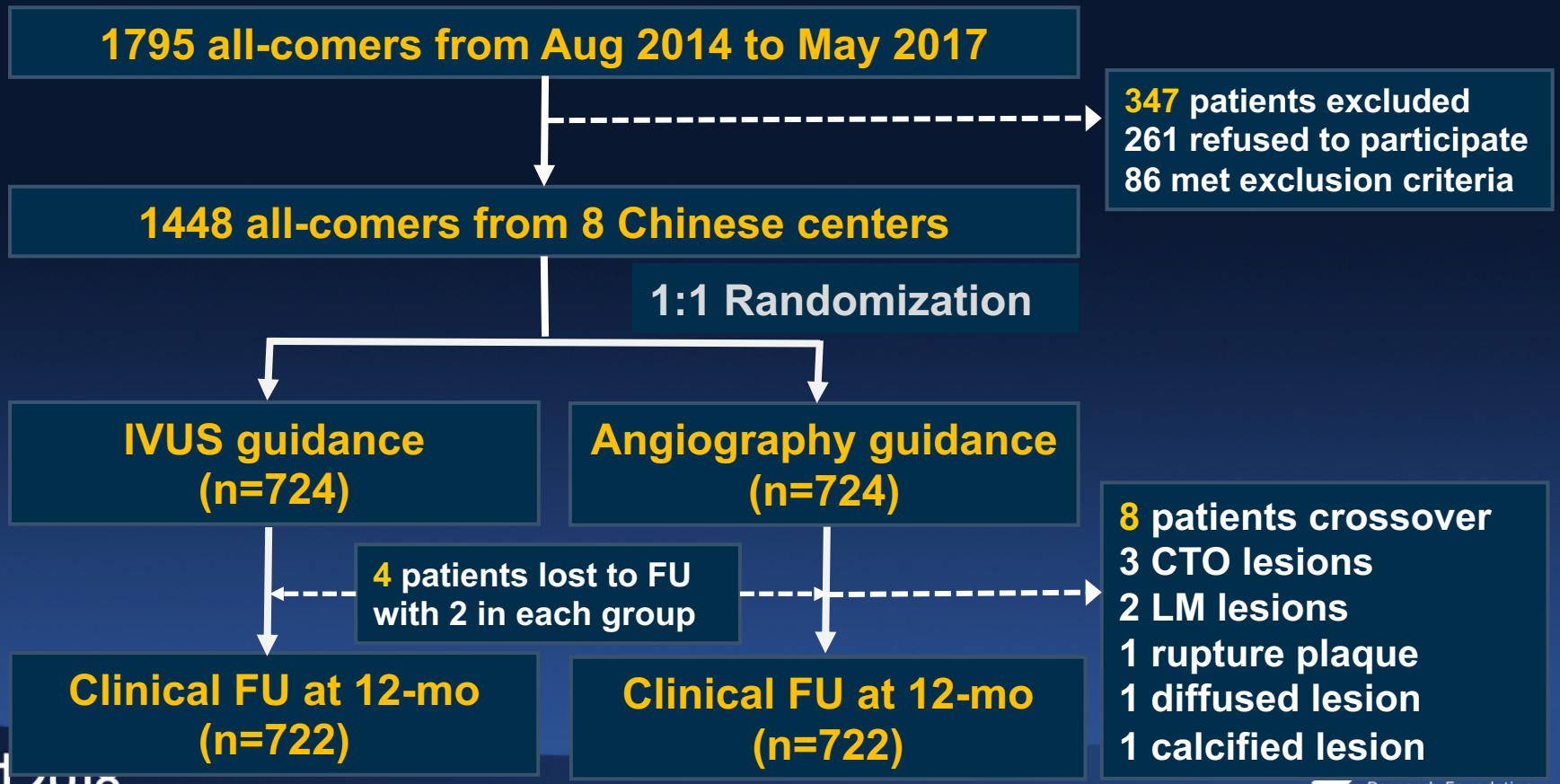
ULTIMATE

A Multicenter, Prospective, Randomized Trial Comparing Intravascular Ultrasound-guided versus Angiography-guided Implantation of Drug-Eluting Stent in All-comers

Jun-Jie Zhang, MD, PhD

Xiaofei Gao, Jing Kan, Zhen Ge, Leng Han, Shu Lu, Nailiang Tian, Song Lin, Qinghua Lu Xueming Wu, Qihua Li, Zhizhong Liu, Yan Chen, Xuesong Qian, Juan Wang, Dayang Chai, Chonghao Chen, Xiaolong Li, Bill D. Gogas, Tao Pan, Shoujie Shan, Fei Ye, Shao-Liang Chen

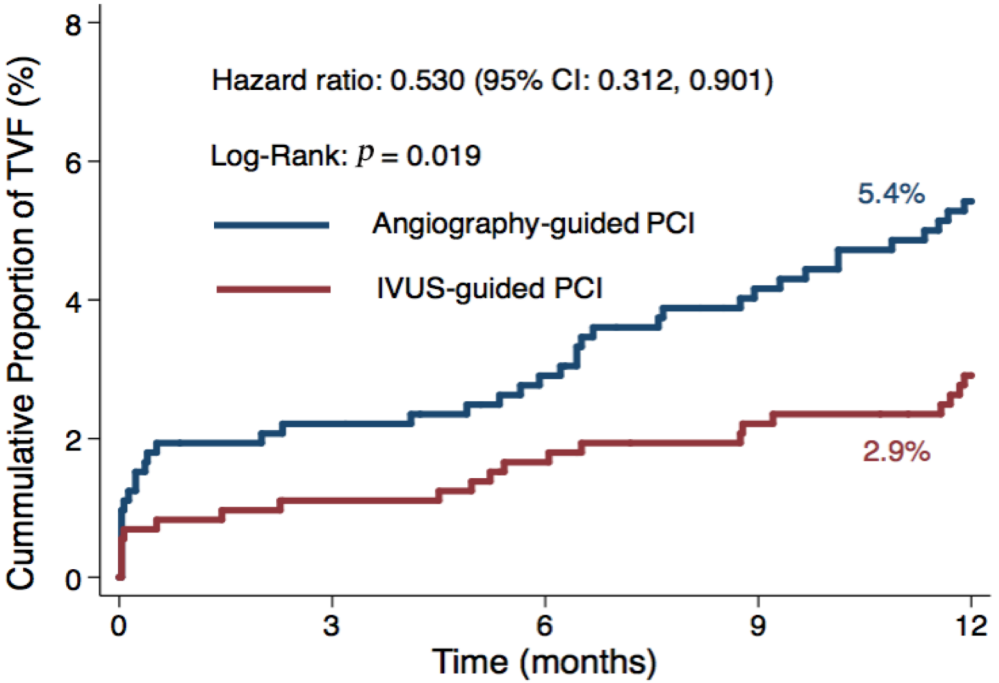
Enrollment


1795 all-comers from Aug 2014 to May 2017
347 patients excluded
261 refused to participate
86 met exclusion criteria
1448 all-comers from 8 Chinese centers
1:1 Randomization
IVUS guidance (n=724)
Angiography guidance (n=724)
4 patients lost to FU with 2 in each group
8 patients crossover
3 CTO lesions
2 LM lesions
1 rupture plaque
1 diffused lesion
1 calcified lesion
Clinical FU at 12-mo (n=722)
Clinical FU at 12-mo (n=722)

ULTIMATE

Primary Endpoint

TVF at 12 months

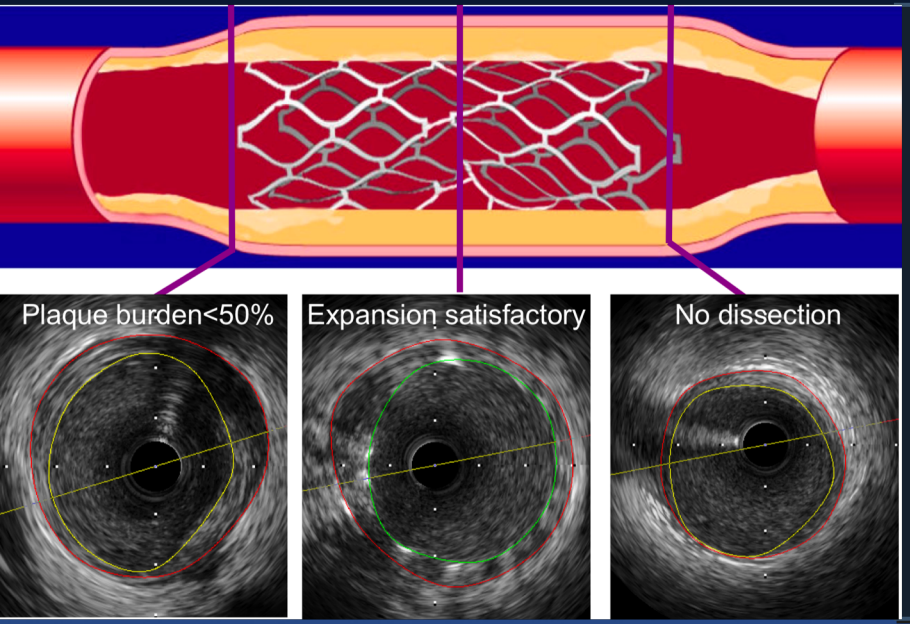


Number at risk					
Angiography	724	706	698	685	676
IVUS	724	715	710	704	696

tct2018

Cardiovascular Research Foundation

IVUS-defined Criteria for The Optimal Stent Deployment



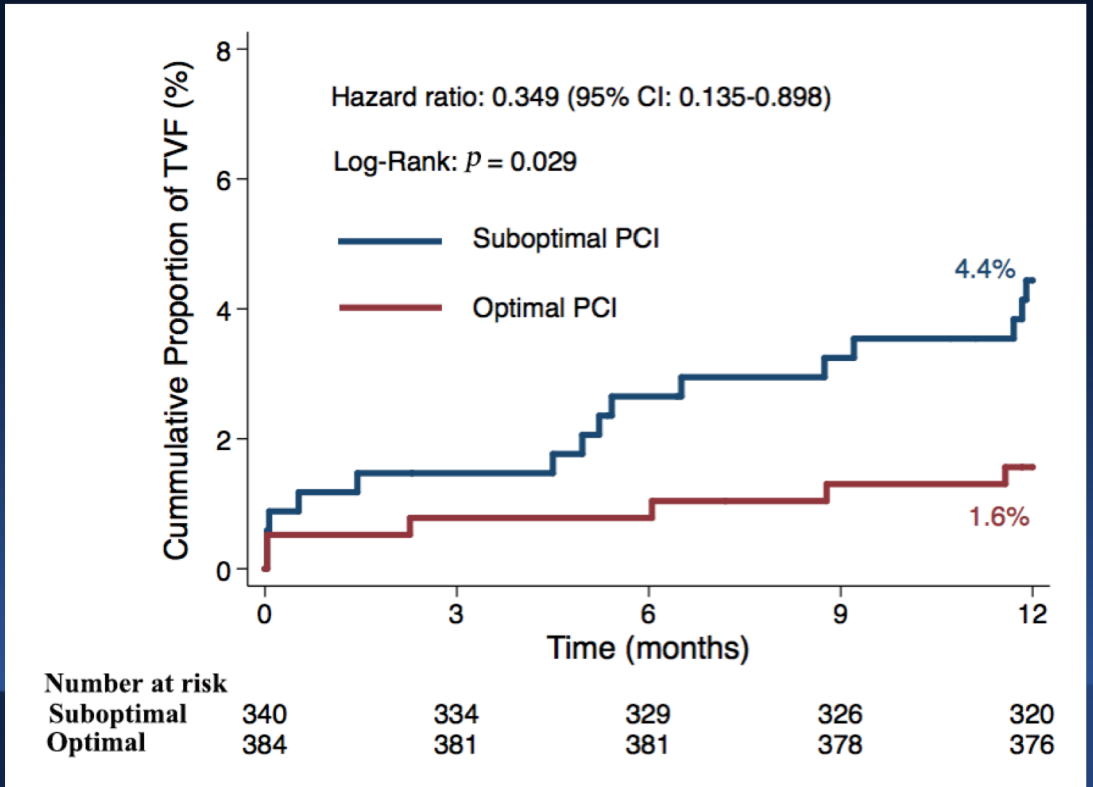
1. Minimal lumen CSA in stented segment >5.0 mm^2, or 90% of distal reference lumen CSA;
2. Plaque burden at the 5-mm proximal or distal to the stent edge <50%;
3. no edge dissection involving media with length >3mm.

On-site Post-procedure IVUS Assessment

	Optimal group	Suboptimal group	*P*
Number of patients, n (%)	384 (53.0)	340 (47.0)	
Number of lesions, n (%)	578 (60.1)	384 (39.9)	
MSA, mm^2	6.09	5.45	<0.001
Prox. edge plaque burden	37.2%	51.2%	<0.001
Dist. edge plaque burden	24.2%	35.1%	<0.001

Optimal vs. Suboptimal IVUS-guided PCI

TVF at 12 months



Procedural Data (II)

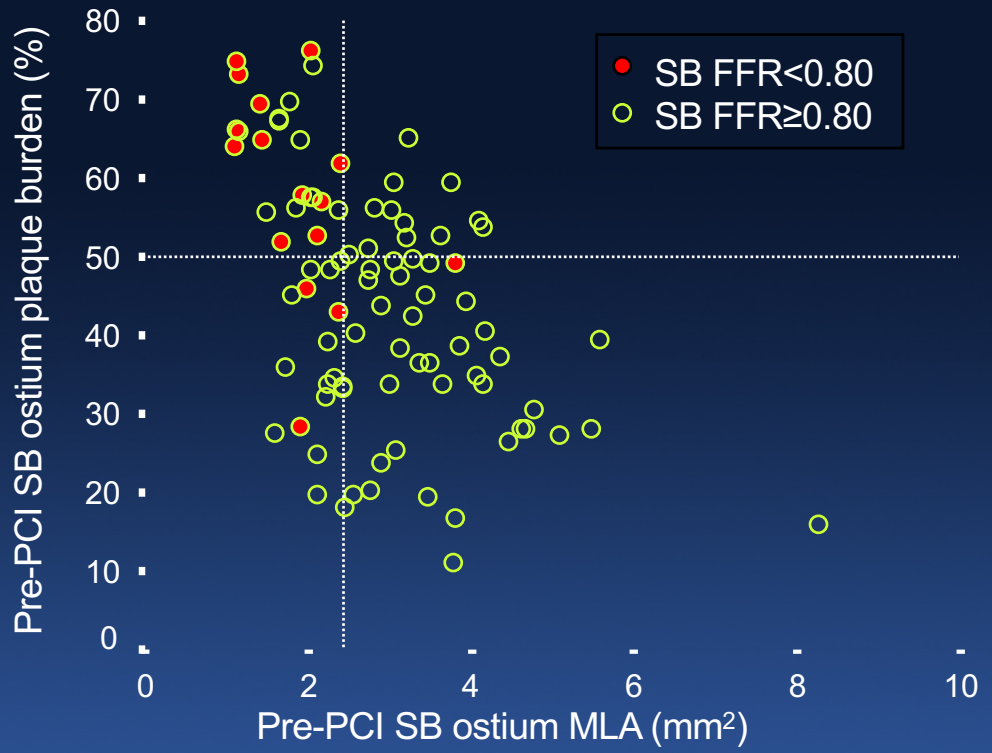
	IVUS guidance (n=962)	Angiography guidance (n=1016)	*P*
Per lesion, n (%)			
Stent number	1.81±0.80	1.76±0.77	0.16
Mean stent length, mm	49.99±25.10	47.38±22.42	0.02
Mean stent diameter, mm	3.14±0.51	2.97±0.48	<0.001
Max balloon diameter, mm	3.73±0.56	3.51±0.53	<0.001
Max post-dilation pressure, atm	19.7±3.7	19.0±3.7	<0.001

Special 2 comments for Bifurcation…

Negative remodeling at the ostium of the sidebranch

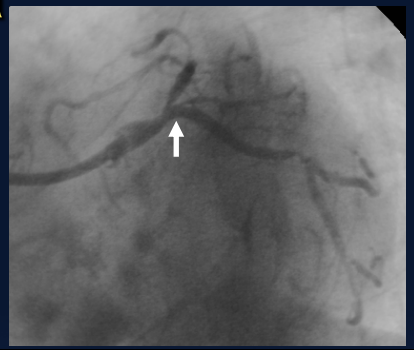
- Present in 70%-90%
  - Fujii et al. Am J Cardiol 2003;92:59-61
  - Kang et al. Am J Cardiol 2011;107;1787-93
  - Costa et al. Int J Cardiovasc Imaging. 2013;29:1657-66.
  - Kang et al. Catheter Cardiovasc Interv 2012;81:1150-5
- Although negative remodeling contributes to a smaller MLA of SB ostium, it rarely affects SB FFR without a significant plaque burden
  - Kang et al. Am J Cardiol 2011;107;1787-93

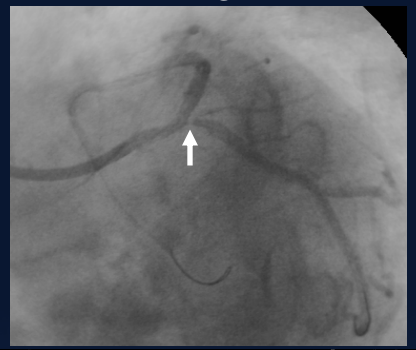
If MLA is reduced not by significant plaque, but by a small vessel or negative remodeling, 80% show normal FFR

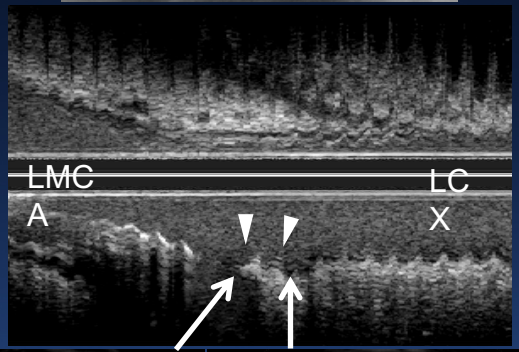


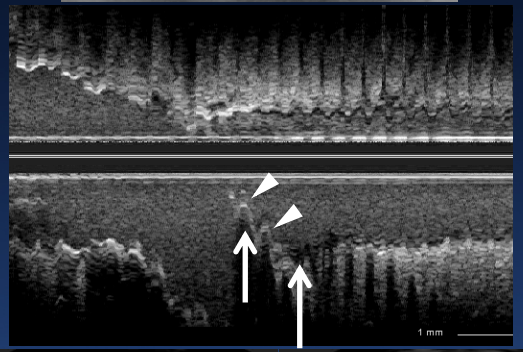
Kang et al. Am J Cardiol 2011;107:1787-93

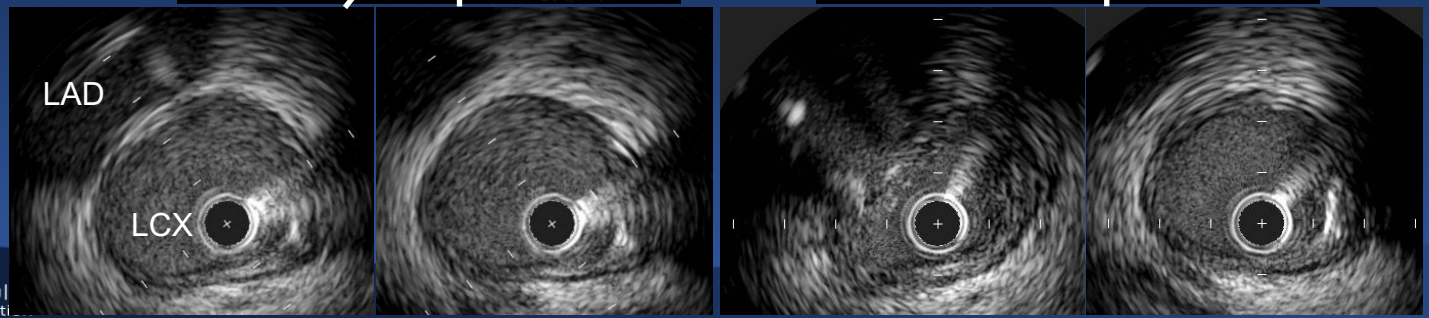
Carina Shift











Take Home Message

1. IVUS can inform you appropriate landing zone of stent. ≈50% of plaque burden is recommended.
2. The presence of calcified lesion, attenuated plaque (lipidic plaque), and overstretch at landing zone predict stent edge dissection.
3. When dissection occur, long (>3mm), large (>60°), deep (>=media), and small lumen (<5mm^2) cause edge restenosis.
4. **IVUS guidance did not decrease the actual stent length compared to PCI without IVUS by appropriate coverage, and reduced future events.**
5. Side branch of bifurcation lesions are usually negative remodeling (~70-80%) and cause carina shift after cross-over stenting.