Clinical Significance of post-stent intravascular ultrasound for chronic total occlusion percutaneous coronary intervention with drug-eluting stents

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Disclosure

- I have nothing to disclosure.

Introduction

62/M with chest pain

2 years later

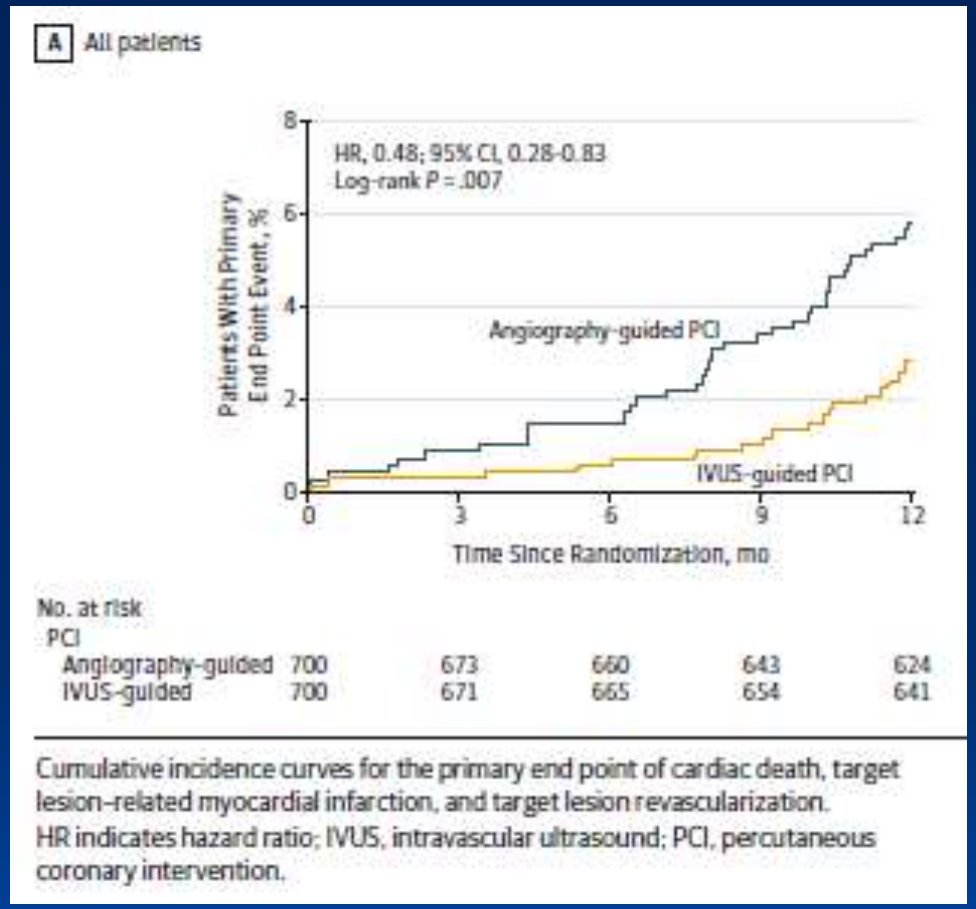
Introduction

62/M with chest pain

2 years later

Despite advancement and the increased success rate of CTO-PCI, still, it has been associated with poorer clinical outcomes especially a higher revascularization rate, compared with other stenotic lesions.

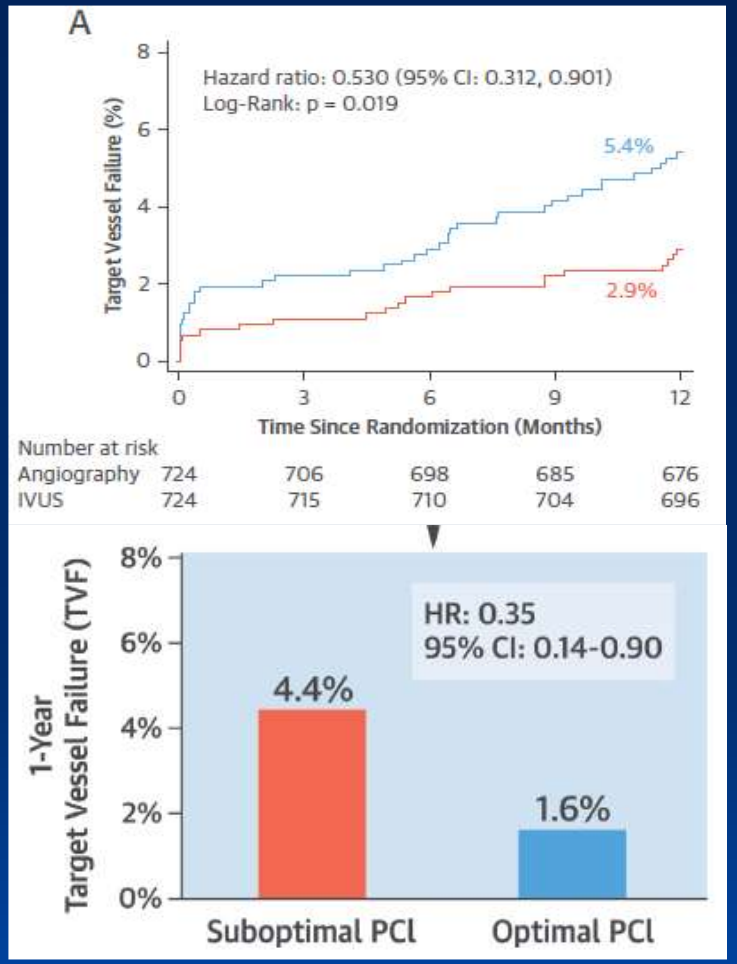
The IVUS-XPL Trial



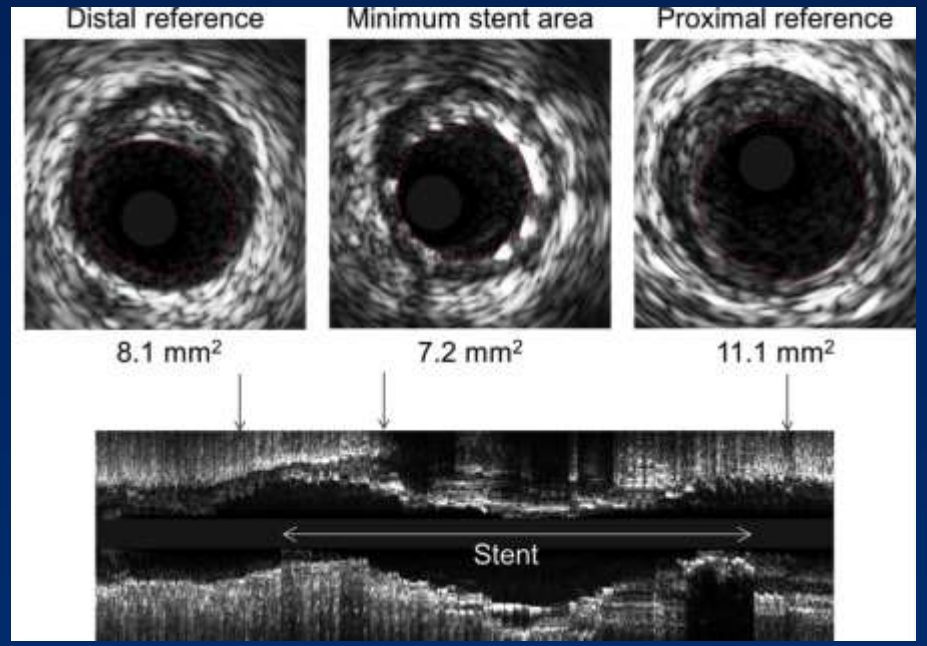
Cumulative incidence curves for the primary end point of cardiac death, target lesion–related myocardial infarction, and target lesion revascularization. HR indicates hazard ratio; IVUS, intravascular ultrasound; PCI, percutaneous coronary intervention.

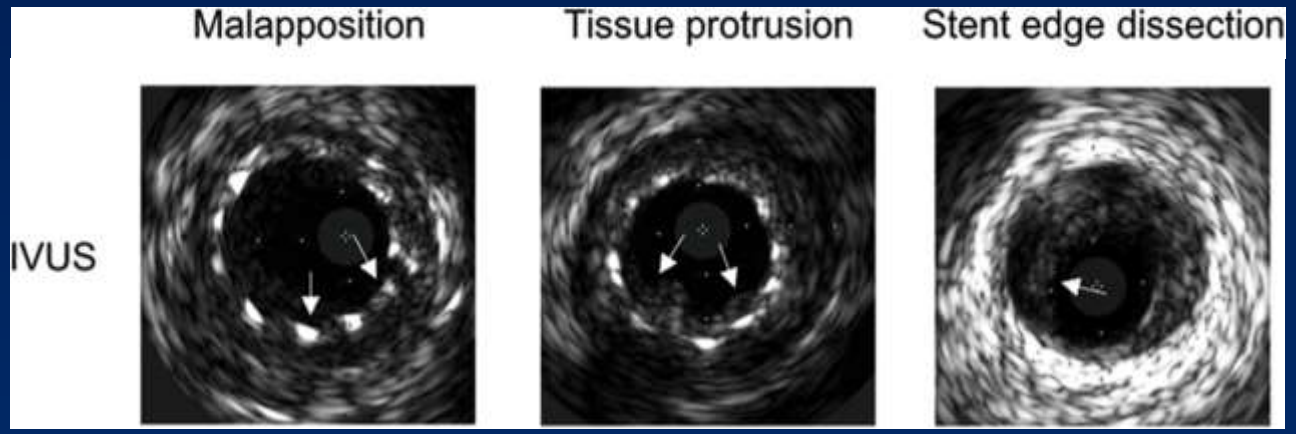
JAMA. 2015;314(20):2155-2163.

The ULTIMATE Trial



J Am Coll Cardiol 2018;72:3126–37





J Am Coll Cardiol Intv 2015;8:1704–14

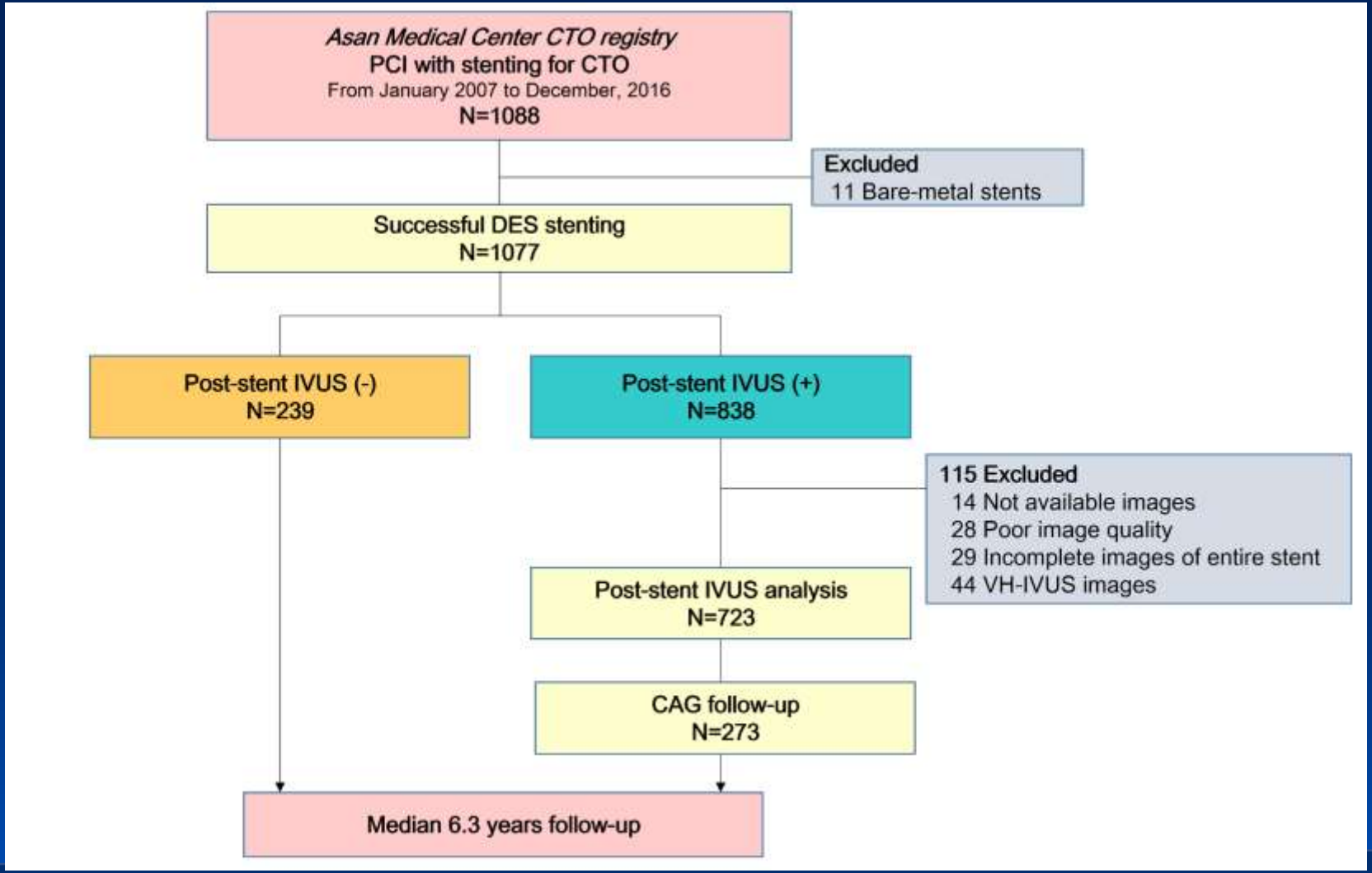
IVUS is a useful tool for planning PCI by informing the operators of lesion severity, reference vessel size, lesion length, and extent of calcification. With validated criteria for stent underexpansion and edge problems, post-stent IVUS has been used to optimize stent deployment to prevent stent failure (restenosis and early thrombosis).

Study objectives

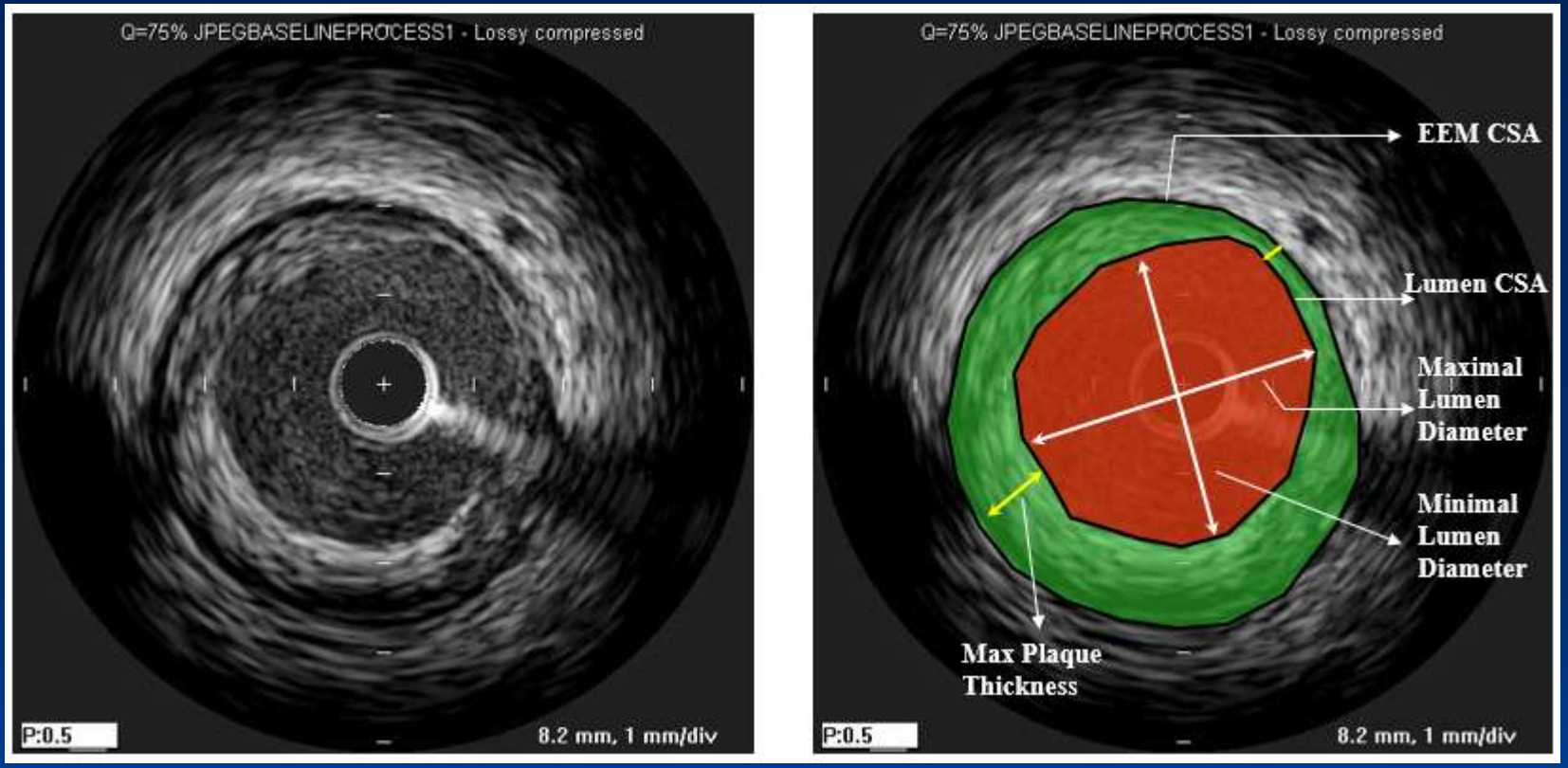
- However, few studies have evaluated its use for CTO intervention and data is limited regarding the definite role and cutoff value for optimal stent expansion in CTO intervention using DESs.

- Thus, this study aimed (1) to evaluate benefits of performing post-stent IVUS for preventing stent failure (target-lesion revascularization) (2) to identify IVUS parameters for predicting target-lesion revascularization and (3) to assess the cut-off values of the IVUS parameters.

Study population



IVUS measurement



Mintz GS, JACC 2001

Sripal Bangalore, circulation 2013

Statistical analysis

- Inverse probability weighting method based on the propensity score

  Propensity score: Age, sex, hypertension, diabetes, hyperlipidemia, current smoker, prior percutaneous coronary intervention, prior coronary artery bypass grafting, renal dysfunction, left ventricular ejection fraction, clinical presentation, target-CTO lesions, in-stent restenosis, stent type generation, stent length per lesion, stent number per lesion, average stent diameter.
- Kaplan-Meier method and compared by the log-rank test
- Cox proportional hazard regression analyses
- A receiver-operating curve
- A sensitivity and specific curve

Baseline characteristics- Unweighted population

	All population (N=1077)	Post-IVUS not performed (n=239)	Post-IVUS performed (N=838)	P value
Age	60.2 ± 10.5	60.5 ± 10.8	60.1 ± 10.4	0.59
Male sex	910 (84.5)	207 (86.6)	703 (83.9)	0.31
Body mass index, kg/m^2	25.5 ± 3.1	25.4 ± 3.4	25.5 ± 3.1	0.73
Hypertension	650 (60.4)	155 (64.9)	495 (59.1)	0.11
Diabetes mellitus	330 (30.6)	76 (31.8)	254 (30.3)	0.66
Insulin use	56 (5.2)	15 (6.3)	41 (4.9)	0.40
Hyperlipidemia	783 (72.7)	164 (68.6)	619 (73.9)	0.11
Current smoker	285 (26.5)	53 (22.2)	232 (27.7)	0.09
History of MI	111 (10.3)	26 (10.9)	85 (10.1)	0.74
Prior PCI	300 (27.9)	71 (29.7)	229 (27.3)	0.47
Prior CABG	32 (3.0)	13 (5.4)	19 (2.3)	0.01
Renal dysfunction	26 (2.4)	10 (4.2)	16 (1.9)	0.04
History of stroke	76 (7.1)	22 (9.2)	54 (6.4)	0.14
PAD	30 (2.8)	7 (2.9)	23 (2.7)	0.88
Atrial fibrillation	24 (2.2)	5 (2.1)	19 (2.3)	0.87
LVEF, %	57.6 ± 8.3	57.2 ± 8.4	57.8 ± 8.3	0.35
Clinical diagnosis				0.69
Silent/stable angina	857 (79.6)	188 (78.7)	669 (79.8)	
ACS	220 (20.4)	51 (21.3)	169 (20.2)	

	All population (N=1077)	Post-IVUS not performed (n=239)	Post-IVUS Performed (N=838)	P value
Target CTO location*				<0.001
LAD	468 (43.5)	75 (31.4)	393 (46.9)	
Left circumflex	140 (13.0)	41 (17.2)	99 (11.8)	
Right coronary	466 (43.3)	121 (50.6)	345 (41.2)	
Graft	3 (0.3)	2 (0.8)	1 (0.1)	
In stent restenosis*	95 (8.8)	12 (5.0)	83 (9.9)	0.02
Multi-vessel disease	615 (57.1)	140 (58.6)	475 (56.7)	0.60
Japanese-CTO score*	1.9 ± 1.1	1.9 ± 1.1	1.9 ± 1.1	0.41
Retrograde attempt	228 (21.2)	58 (24.3)	170 (20.3)	0.18
Total CTO length, mm	14.6 ± 9.4	13.8 ± 8.1	14.9 ± 9.8	0.11
Total lesion length*, mm	41.8 ± 20.4	40.8 ± 20.8	42.1 ± 20.2	0.42
Stent type generation				<0.001
1st generation DES	232 (21.5)	85 (35.6)	147 (17.5)	
2nd generation DES	845 (78.5)	154 (64.4)	691 (82.5)	
Number of stent*	1.8 ± 0.8	1.9 ± 0.9	1.8 ± 0.8	0.14
Stent length*, mm	53.2 ± 24.1	52.5 ± 25.0	53.4 ± 23.8	0.61
Stent diameter*†, mm	3.2 ± 0.4	3.1 ± 0.3	3.2 ± 0.4	<0.001

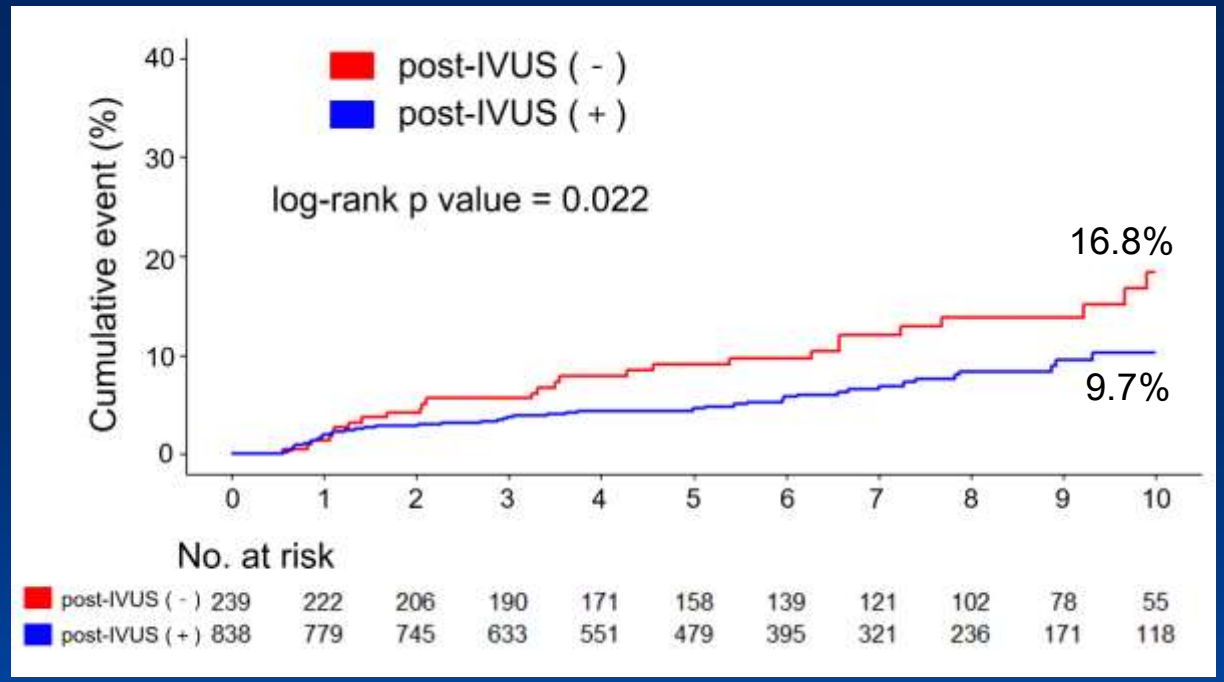
Baseline characteristics- Weighted population

	All population (N=1081)	Post-IVUS not performed (n=241)	Post-IVUS performed (N=840)	P value
Age	60.3 ± 10.6	60.8 ± 10.9	60.2 ± 10.4	0.44
Male sex	908 (84.1)	199 (82.9)	709 (84.4)	0.58
Body mass index, kg/m^2	25.4 ± 3.1	25.2 ± 3.3	25.5 ± 3.1	0.21
Hypertension	657 (60.8)	151 (62.7)	506 (60.2)	0.50
Diabetes mellitus	332 (30.7)	75 (31.3)	257 (30.6)	0.85
Insulin use	60 (5.6)	18 (7.5)	42 (5.0)	0.14
Hyperlipidemia	791 (73.2)	179 (74.3)	612 (72.9)	0.66
Current smoker	277 (25.6)	57 (23.7)	220 (26.2)	0.43
History of MI	105 (9.7)	20 (8.3)	85 (10.1)	0.41
Prior PCI	310 (28.7)	75 (31.1)	235 (28.0)	0.35
Prior CABG	36 (3.3)	8 (3.3)	28 (3.3)	0.99
Renal dysfunction	26 (2.4)	6 (2.5)	20 (2.4)	0.92
History of stroke	76 (7.0)	22 (9.1)	54 (6.4)	0.15
PAD	28 (2.6)	5 (2.1)	23 (2.7)	0.57
Atrial fibrillation	25 (2.3)	5 (2.1)	20 (2.4)	0.78
LVEF, %	57.7 ± 8.2	57.7 ± 7.9	57.7 ± 8.3	0.97
Clinical diagnosis				0.61
Silent/stable angina	862 (79.7)	195 (80.9)	667 (79.4)	
ACS	219 (20.3)	46 (19.1)	173 (20.6)	

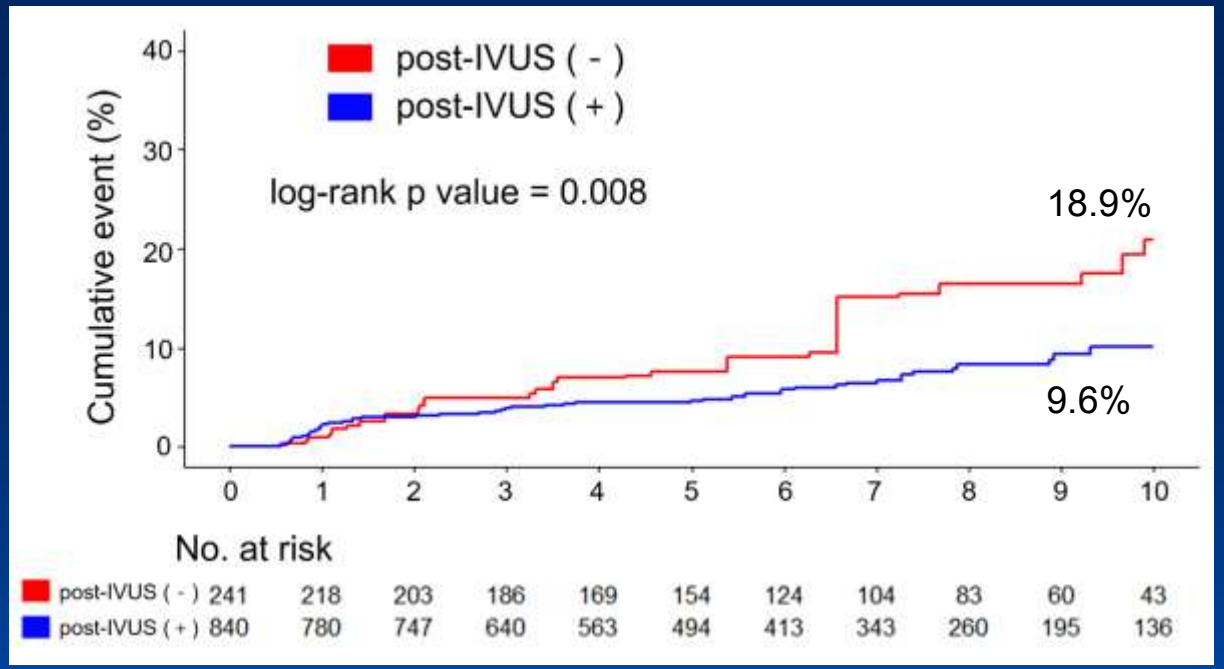
	All population (N=1081)	Post-IVUS not performed (n=241)	Post-IVUS performed (N=840)	P value
Target CTO location*				0.97
LAD	467 (43.2)	104 (43.3)	363 (43.2)	
Left circumflex	139 (12.9)	30 (12.5)	109 (13.0)	
Right coronary	471 (43.6)	105 (43.8)	366 (43.6)	
Graft	3 (0.3)	1 (0.4)	2 (0.2)	
In stent restenosis*	97 (9.0)	23 (9.6)	74 (8.8)	0.71
Multi-vessel disease	624 (57.7)	142 (58.9)	482 (57.4)	0.67
Japanese-CTO score*	1.9 ± 1.1	2.0 ± 1.1	1.9 ± 1.0	0.22
Retrograde attempt	220 (20.4)	57 (23.7)	163 (19.4)	0.15
Total CTO length, mm	14.6 ± 9.3	13.9 ± 7.9	14.8 ± 9.7	0.21
Total lesion length*, mm	42.0 ± 20.1	41.9 ± 19.7	42.1 ± 20.2	0.91
Stent type generation				0.72
1st generation DES	233 (21.6)	50 (20.7)	183 (21.8)	
2nd generation DES	847 (78.4)	191 (79.3)	656 (78.2)	
Number of stents*	1.8 ± 0.8	1.9 ± 0.8	1.8 ± 0.8	0.60
Stent length*, mm	53.5 ± 24.0	54.2 ± 24.6	53.3 ± 23.8	0.63
Stent diameter*†, mm	3.2 ± 0.4	3.2 ± 0.4	3.2 ± 0.4	0.40

Target-lesion revascularization/reocclusion

(A) Unweighted population



(B) Weighted population

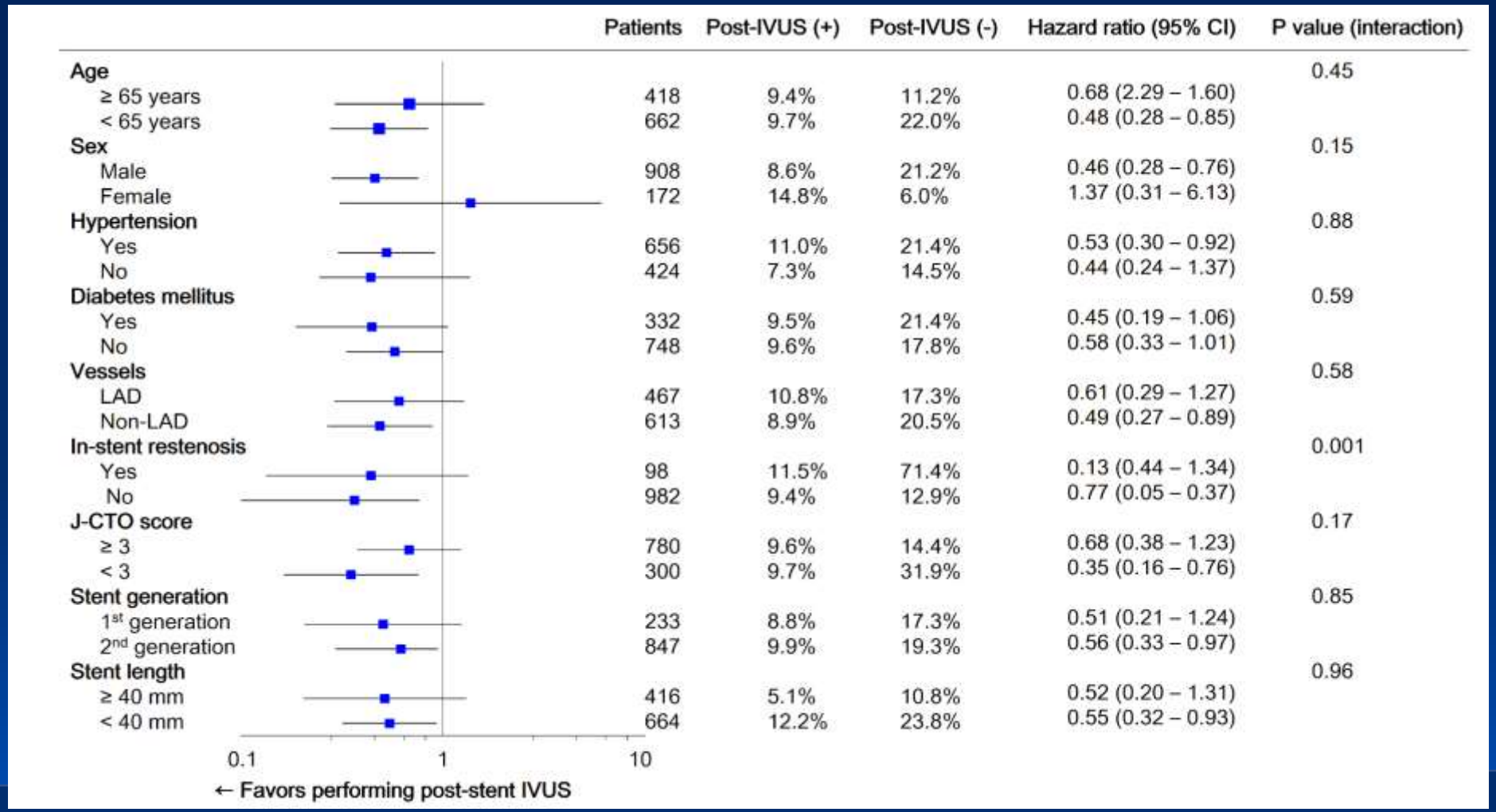


Clinical Outcomes according to post-stent IVUS

	Event number (%)			Unweighted population			Weighted population		
	Post-stent IVUS (+) (n=838)	Post-stent IVUS (-) (n=239)	p value	HR	95% CI	p value	HR	95% CI	p value
All-cause mortality	77 (14.9)	38 (21.1)	0.05	0.67	0.45-0.98	0.04	0.72	0.48-1.06	0.09
Non-CV death	24 (4.2)	5 (2.4)	0.43	1.47	0.56-3.86	0.43	0.78	0.38-1.63	0.51
CV death	53 (11.2)	33 (19.2)	0.01	0.55	0.35-0.85	0.01	0.69	0.43-1.11	0.13
Target-vessel MI	25 (3.5)	12 (6.7)	0.17	0.62	0.31-1.24	0.18	0.79	0.37-1.69	0.54
Periprocedural MI	16 (1.9)	6 (2.5)	0.56	0.76	0.60-1.94	0.56	1.05	0.36-3.07	0.92
Spontaneous MI	9 (1.6)	6 (4.1)	0.16	0.49	0.17-1.37	0.17	0.55	0.18-1.69	0.30
Target-vessel revascularization/reocclusion	53 (10.4)	28 (17.2)	0.03	0.60	0.38-0.96	**0.03**	**0.56**	**0.36-0.89**	**0.01**
Target-lesion revascularization/reocclusion	49 (9.7)	27 (16.8)	0.02	0.58	0.36-0.93	**0.02**	**0.54**	**0.34-0.86**	**0.01**
Stent thrombosis, definite	10 (1.8)	5 (2.5)	0.37	0.62	0.21-1.80	0.38	0.60	0.21-1.71	0.34
Target-lesion failure	116 (21.5)	62 (34.7)	0.0.1	0.60	0.44-0.81	**0.001**	**0.66**	**0.48-0.92**	**0.01**

Target-lesion failure; CV death, target-vessel MI, and target-lesion revascularization/reocclusion

Subgroup analyses of TLR according to post-stent IVUS in weighted population



	Patients	Post-IVUS (+)	Post-IVUS (-)	Hazard ratio (95% CI)	P value (interaction)
Age					0.45
≥ 65 years	418	9.4%	11.2%	0.68 (2.29 – 1.60)	
< 65 years	662	9.7%	22.0%	0.48 (0.28 – 0.85)	
Sex					0.15
Male	908	8.6%	21.2%	0.46 (0.28 – 0.76)	
Female	172	14.8%	6.0%	1.37 (0.31 – 6.13)	
Hypertension					0.88
Yes	656	11.0%	21.4%	0.53 (0.30 – 0.92)	
No	424	7.3%	14.5%	0.44 (0.24 – 1.37)	
Diabetes mellitus					0.59
Yes	332	9.5%	21.4%	0.45 (0.19 – 1.06)	
No	748	9.6%	17.8%	0.58 (0.33 – 1.01)	
Vessels					0.58
LAD	467	10.8%	17.3%	0.61 (0.29 – 1.27)	
Non-LAD	613	8.9%	20.5%	0.49 (0.27 – 0.89)	
In-stent restenosis					0.001
Yes	98	11.5%	71.4%	0.13 (0.44 – 1.34)	
No	982	9.4%	12.9%	0.77 (0.05 – 0.37)	
J-CTO score					0.17
≥ 3	780	9.6%	14.4%	0.68 (0.38 – 1.23)	
< 3	300	9.7%	31.9%	0.35 (0.16 – 0.76)	
Stent generation					0.85
1st generation	233	8.8%	17.3%	0.51 (0.21 – 1.24)	
2nd generation	847	9.9%	19.3%	0.56 (0.33 – 0.97)	
Stent length					0.96
≥ 40 mm	416	5.1%	10.8%	0.52 (0.20 – 1.31)	
< 40 mm	664	12.2%	23.8%	0.55 (0.32 – 0.93)	

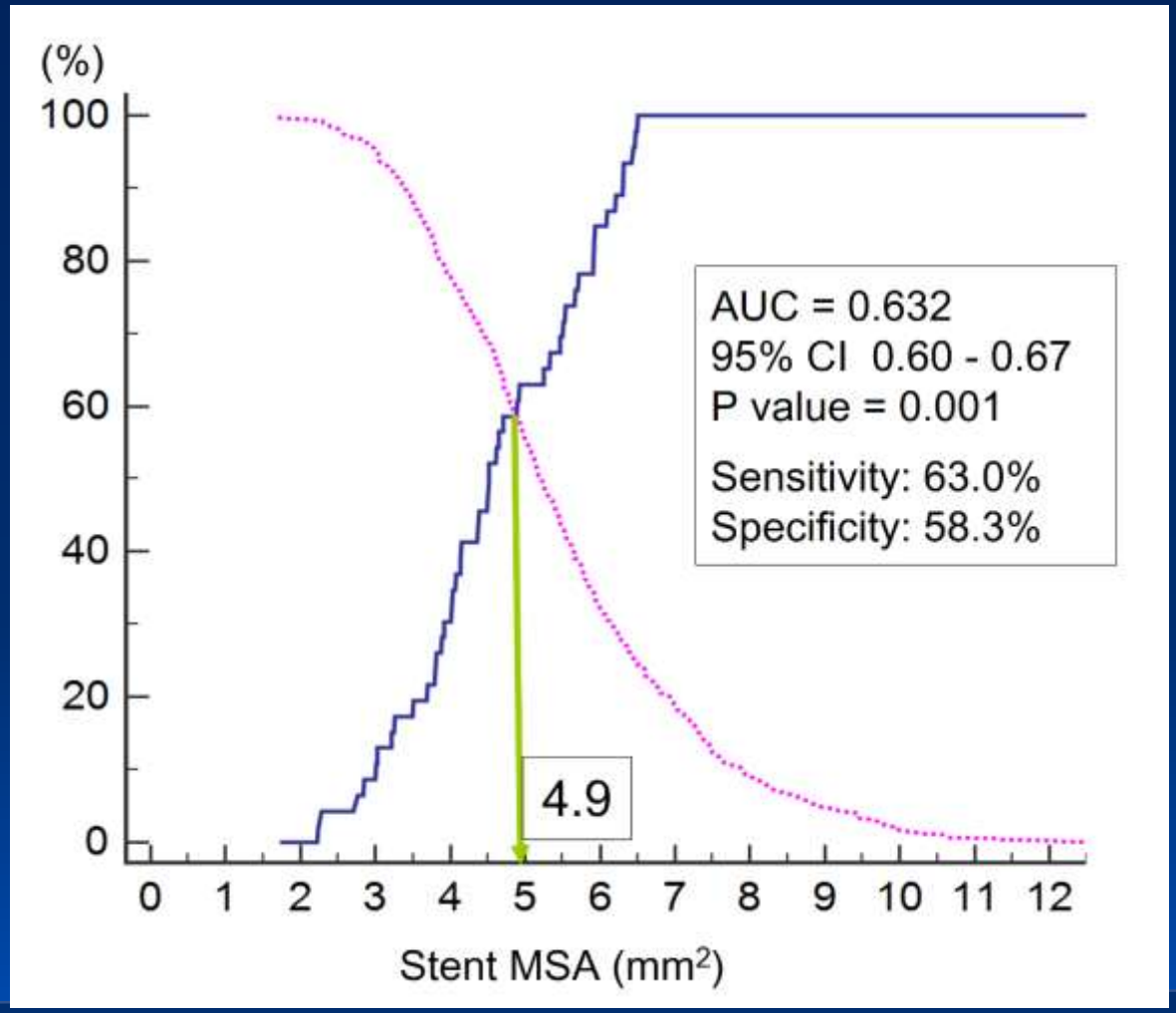
Post-stenting IVUS findings

	All-population (N=723)	TLR (-) (N=677)	TLR (+) (N=46)	P value
Proximal reference segments				
MLA	9.5 ± 3.6	9.5 ± 3.6	8.7 ± 3.2	0.11
EEM area at MLA site (mm^2)	19.7 ± 5.8	19.7 ± 5.8	19.0 ± 5.5	0.40
Maximum plaque burden	51.9 ± 10.9	51.7 ± 11.0	55.1 ± 11.1	0.06
In-stent segments				
MSA		**5.5 ± 1.8**	**4.6 ± 1.2**	**0.001**
EEM area at MLA site (mm^2)		11.8 ± 4.9	10.7 ± 4.7	0.13
Plaque burden at MSA		50.4 ± 11.7	51.0 ± 15.0	0.78
Distal reference segments				
MLA	4.5 ± 2.5	4.5 ± 2.4	4.7 ± 3.3	0.78
EEM area at MLA site (mm^2)	9.0 ± 4.7	9.2 ± 4.7	8.2 ± 5.3	0.34
Maximum plaque burden	47.4 ± 15.1	47.7 ± 15.0	43.7 ± 17.0	0.14
Edge dissection	78 (7.2)	75 (11.1)	3 (6.5)	0.34
Malapposition	105 (9.7)	98 (14.5)	7 (15.2)	0.89
Hematoma	21 (1.9)	19 (2.8)	2 (4.3)	0.64
False lumen involvement	5 (0.5)	**3 (0.4)**	**2 (4.3)**	**0.04**
MSA greater than MLA at the distal reference segment	568 (52.7)	536 (79.2)	32 (69.6)	0.12

Univariate and multivariable predictors of target-lesion revascularization

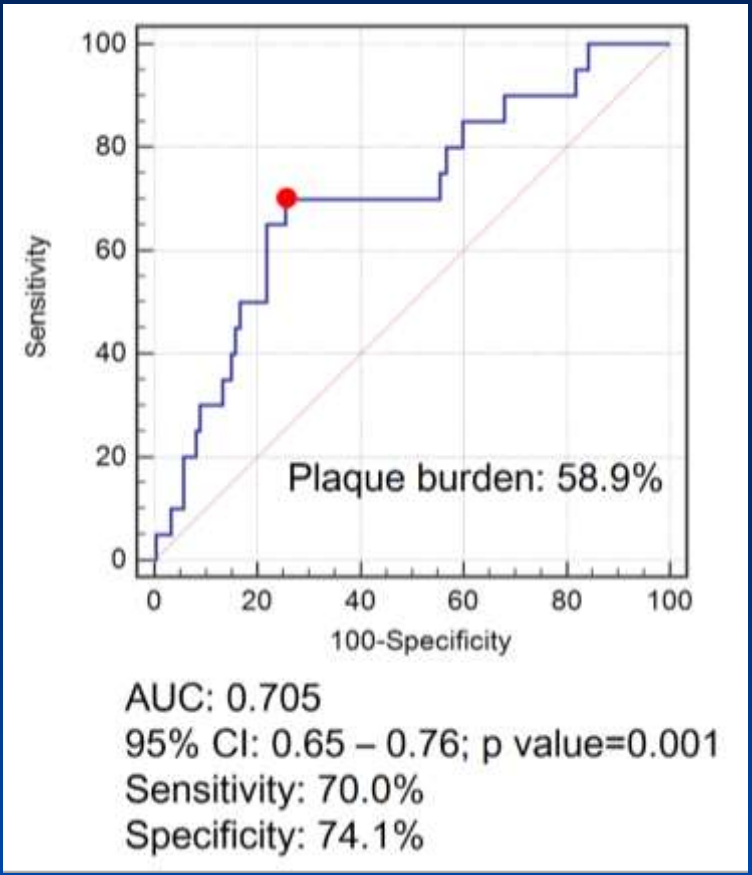
	Univariate			Multivariate		
	HR	95% CI	P	HR	95% CI	P
Age	0.98	0.96-1.01	0.13			
Hypertension	1.46	0.89-2.38	0.13			
In-stent restenosis	1.56	0.82-2.96	0.17			
J-CTO score	1.26	1.02-1.55	0.03			
Stent lengths	1.01	1.00-1.02	0.01			
Stent numbers	1.53	1.18-1.98	0.001			
IVUS parameters						
Proximal segments						
Maximal plaque burden	1.03	1.00-1.06	0.05			
In-stent segments						
MSA	0.75	0.62-0.91	0.004	**0.78**	**0.64-0.95**	**0.01**
EEM at MSA	0.96	0.90-1.02	0.20			
Maximal plaque burden	0.99	0.97-1.01	0.17			
False lumen involvement	8.15	1.97-33.72	0.004			

Optimal cut-off value of final MSA for predicting TLR

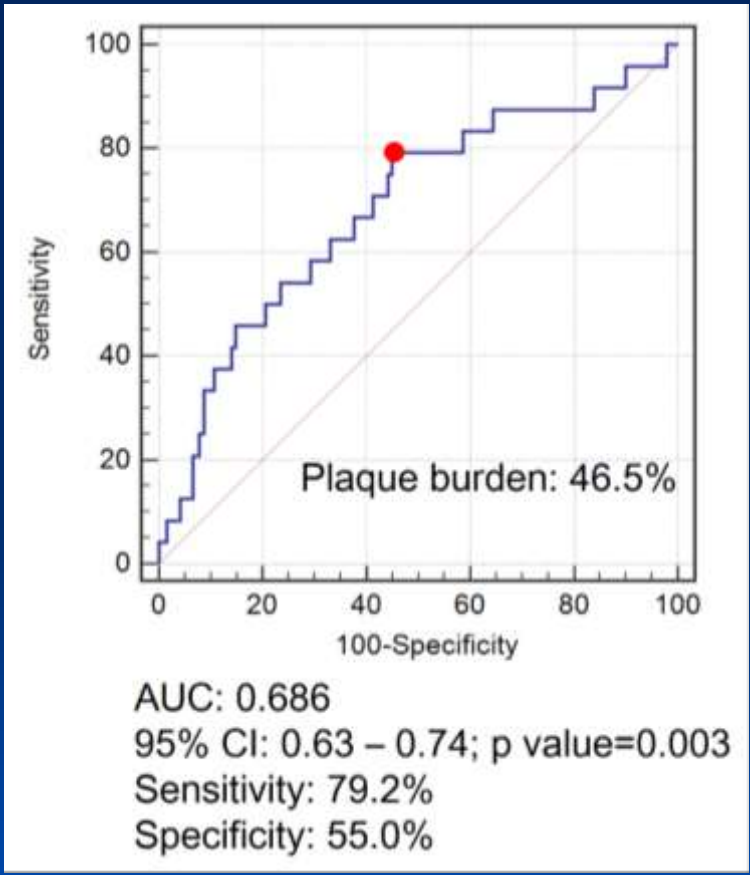


IVUS criteria of edge restenosis (DS≥50%)

(A) **Proximal** reference segments



(B) **Distal** reference segments



Summary

- In CTO-PCI with DESs, subjects with post-stent IVUS evaluation was associated with a low risk of target-lesion revascularization, compared with those without post-stent IVUS.
- A significant interaction between performing post-stent IVUS and ISR lesions may suggest more benefits of IVUS-optimization for ISR–CTO lesions.
- MSA was identified as a strong, independent predictor of TLR and the cut-off value of MSA was 4.9 mm^2
- For prediction of edge restenosis (DS≥50%), the cutoffs for the reference plaque burden were 58.9% in the proximal segments and 46.5% in the distal segments, respectively.

Conclusions

- In CTO-PCI with DESs, post-stent IVUS evaluation and optimization would confer substantial long-term clinical benefits.
- MSA may be the most important optimization criteria for preventing stent failure with the cut-off value of 4.9 mm^2 for CTO lesions.
- The role and optimization criteria of IVUS for CTOs require further study in large-scale prospective trials.

24th CARDIOVASCULAR SUMMIT
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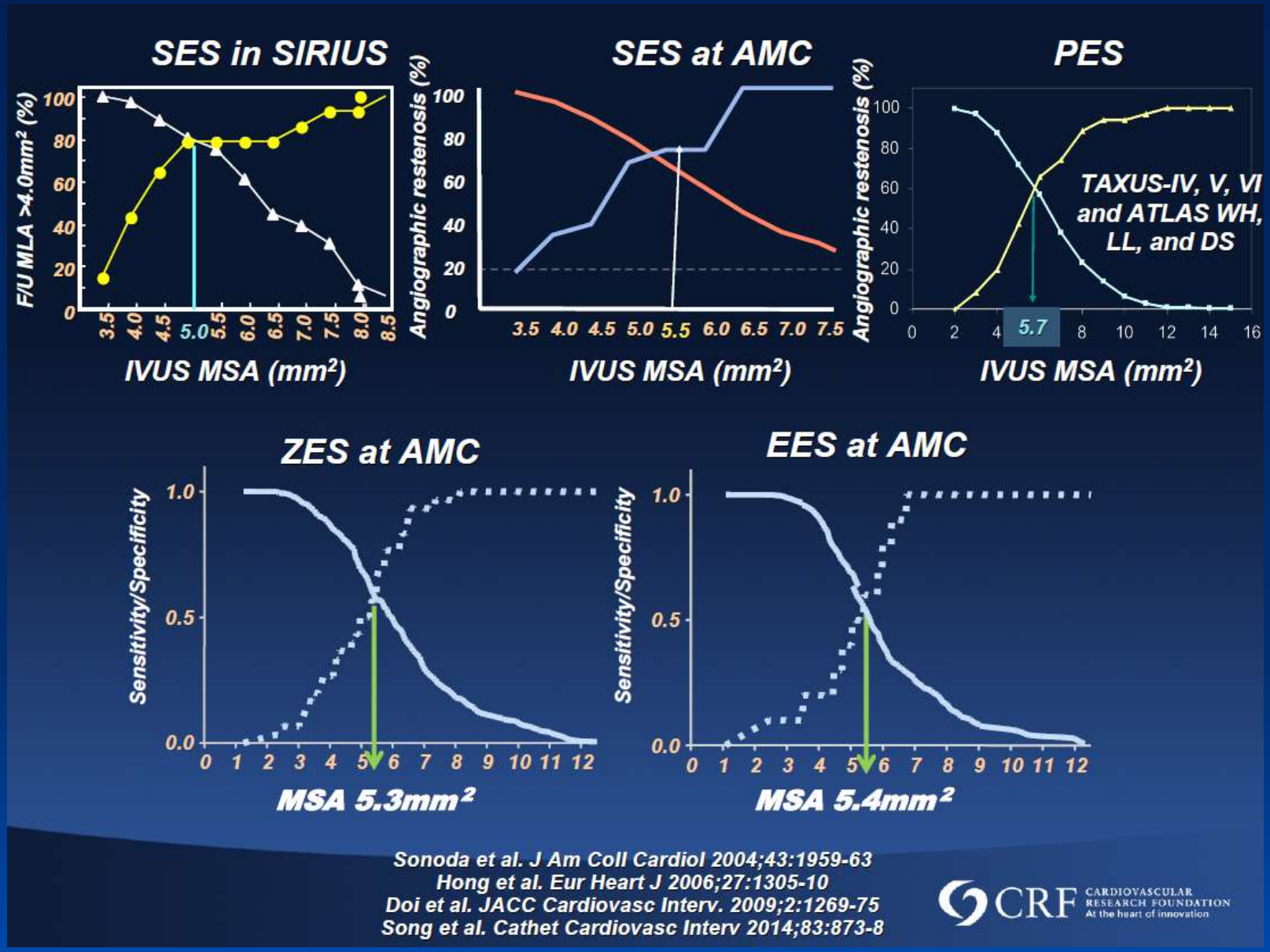
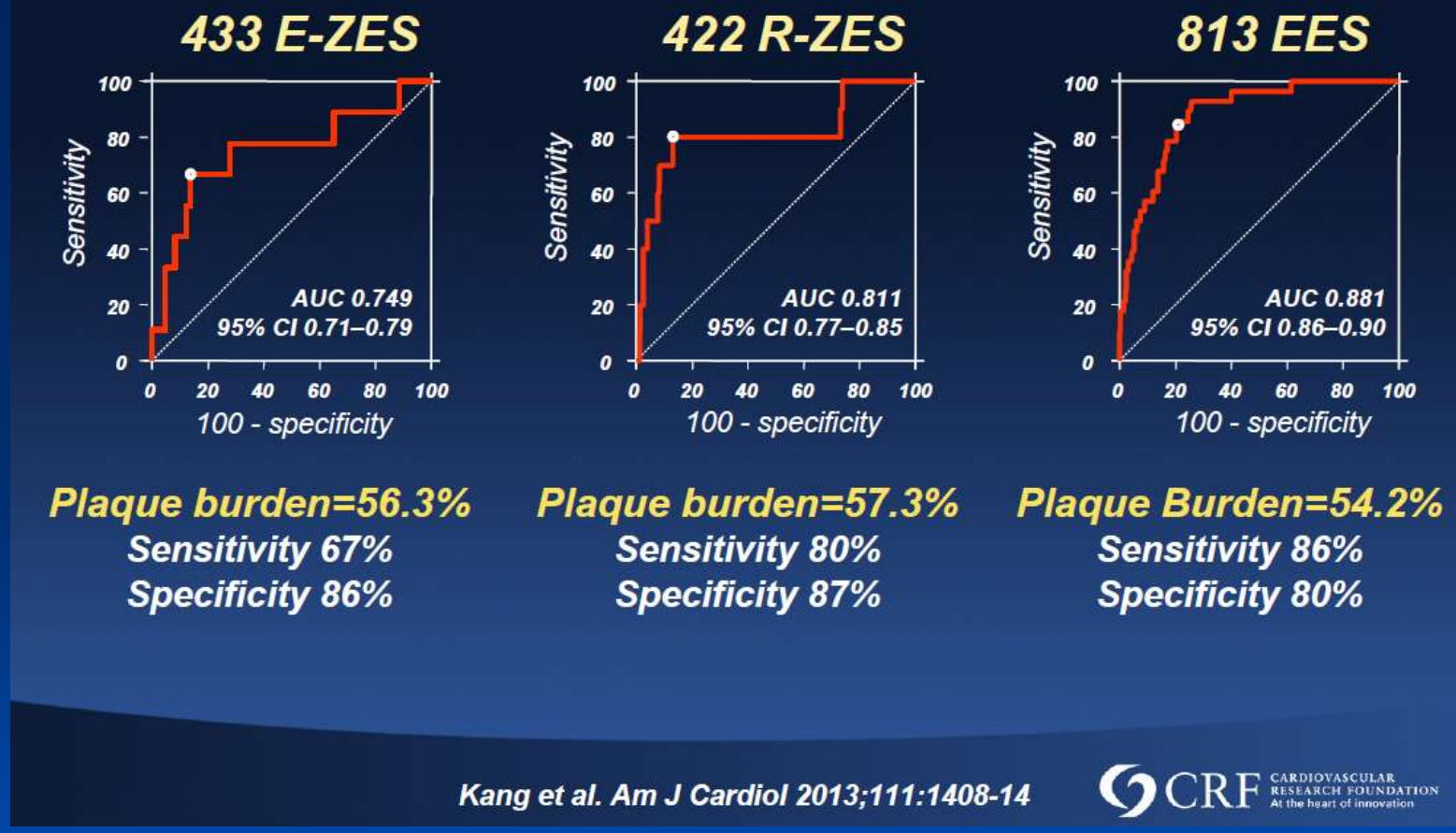
Thank you for your attention



(GS Mintz TCT2015)

IVUS Predictors of Edge Restenosis after Second Generation DES



Plaque burden=56.3%
Sensitivity 67%
Specificity 86%

Plaque burden=57.3%
Sensitivity 80%
Specificity 87%

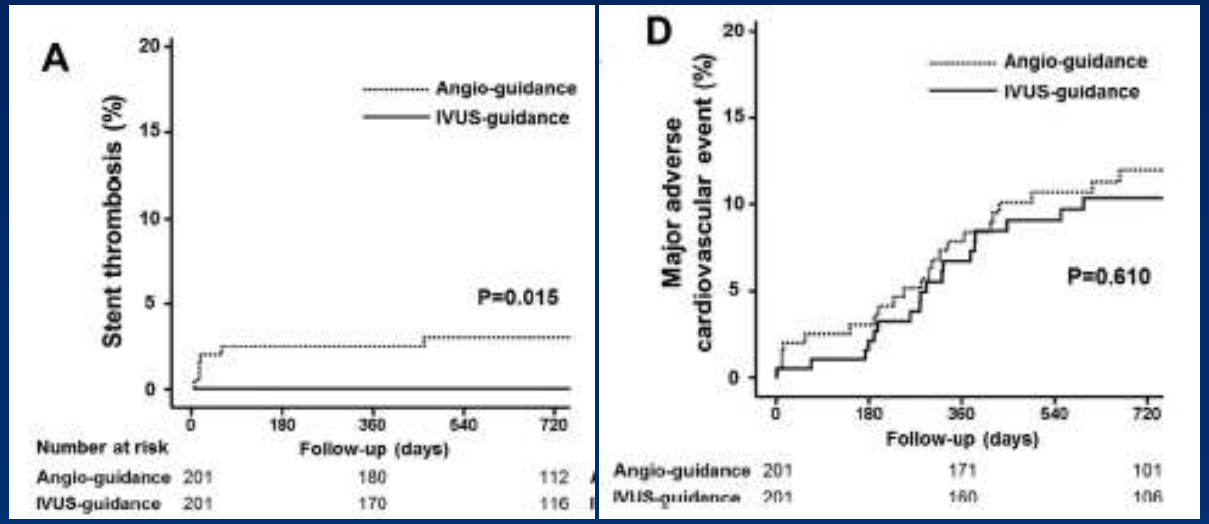
Plaque Burden=54.2%
Sensitivity 86%
Specificity 80%

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

CRF CARDIOVASCULAR RESEARCH FOUNDATION At the heart of innovation

(GS Mintz TCT2015)

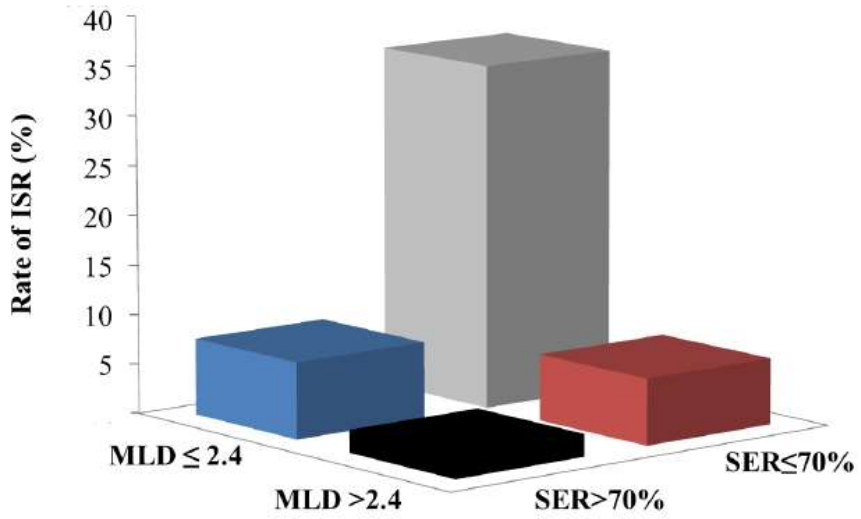
Usefulness of Intravascular Ultrasound Guidance in Percutaneous Coronary Intervention With Second-Generation Drug-Eluting Stents for Chronic Total Occlusions (from the Multicenter Korean-Chronic Total Occlusion Registry)



Am J Cardiol 2014;114:534e540

RESEARCH ARTICLE

Intravascular Ultrasound and Angiographic Predictors of In-Stent Restenosis of Chronic Total Occlusion Lesions

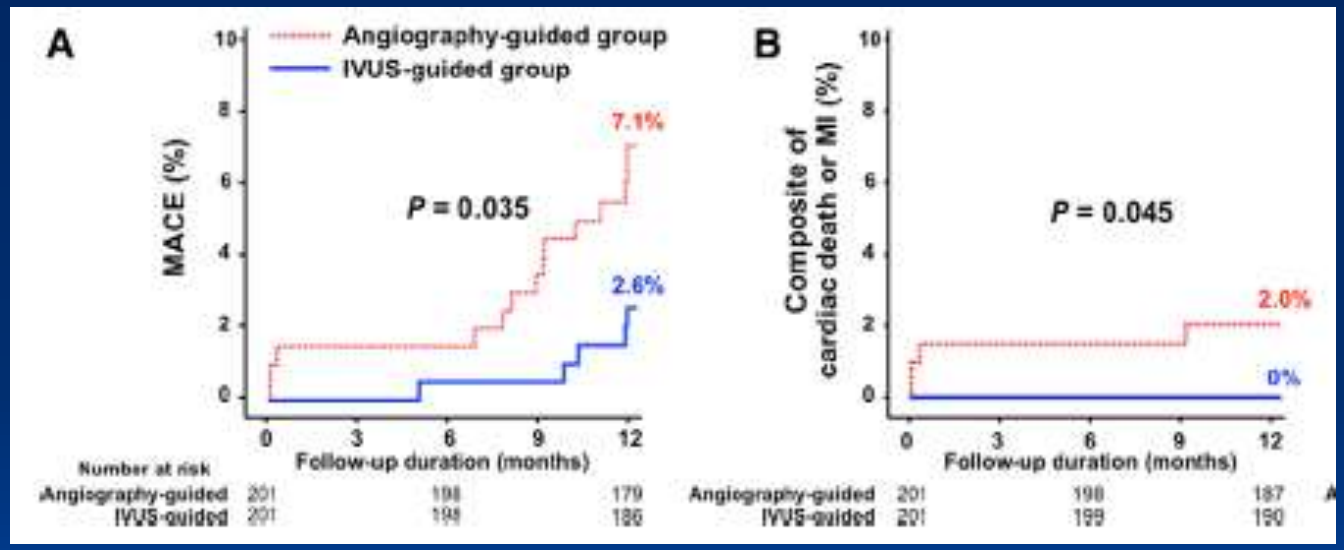


		MLD by QCA		Overall P by χ^2	Interaction P value
		≤2.4mm	>2.4mm		
SER by IVUS	≤70%	34.62% (9/26)	6.67% (2/30)	0.004	0.038
	>70%	7.69% (2/26)	2.27% (1/44)		

PLoS ONE 2015 10(10): e0140421. doi:10

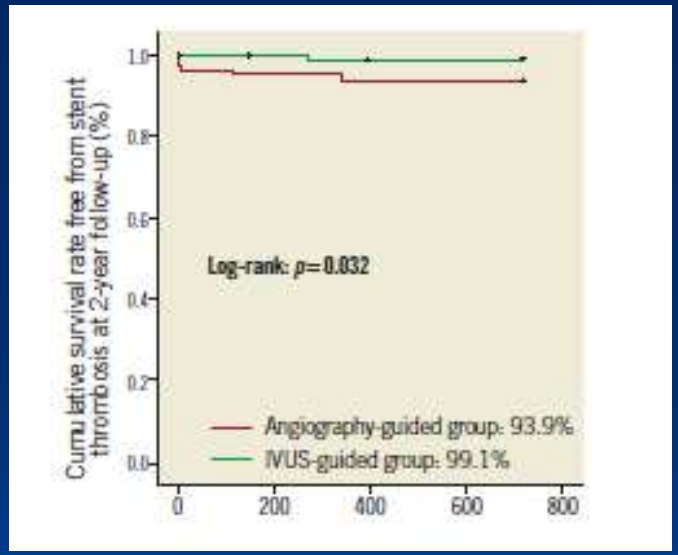
Clinical Impact of Intravascular Ultrasound–Guided Chronic Total Occlusion Intervention With Zotarolimus-Eluting Versus Biolimus-Eluting Stent Implantation

Randomized Study



Circ Cardiovasc Interv. 2015;8:e002592.

Angiographic and clinical comparisons of intravascular ultrasound- versus angiography-guided drug-eluting stent implantation for patients with chronic total occlusion lesions: two-year results from a randomised AIR-CTO study



EuroIntervention 2015;10:1409-1417