OCT Versus IVUS for Complex PCI

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2018 ESC Guideline for Intravascular Imaging

	COR	LOE
➢ IVUS or OCT should be considered in selected patients to **optimize stent implantation**	IIa	B
➢ IVUS should be considered to optimize treatment of **unprotected left main lesions**	IIa	B
➢ IVUS and/or OCT should be considered to detect stent-related mechanical problems leading to **restenosis**	IIa	C

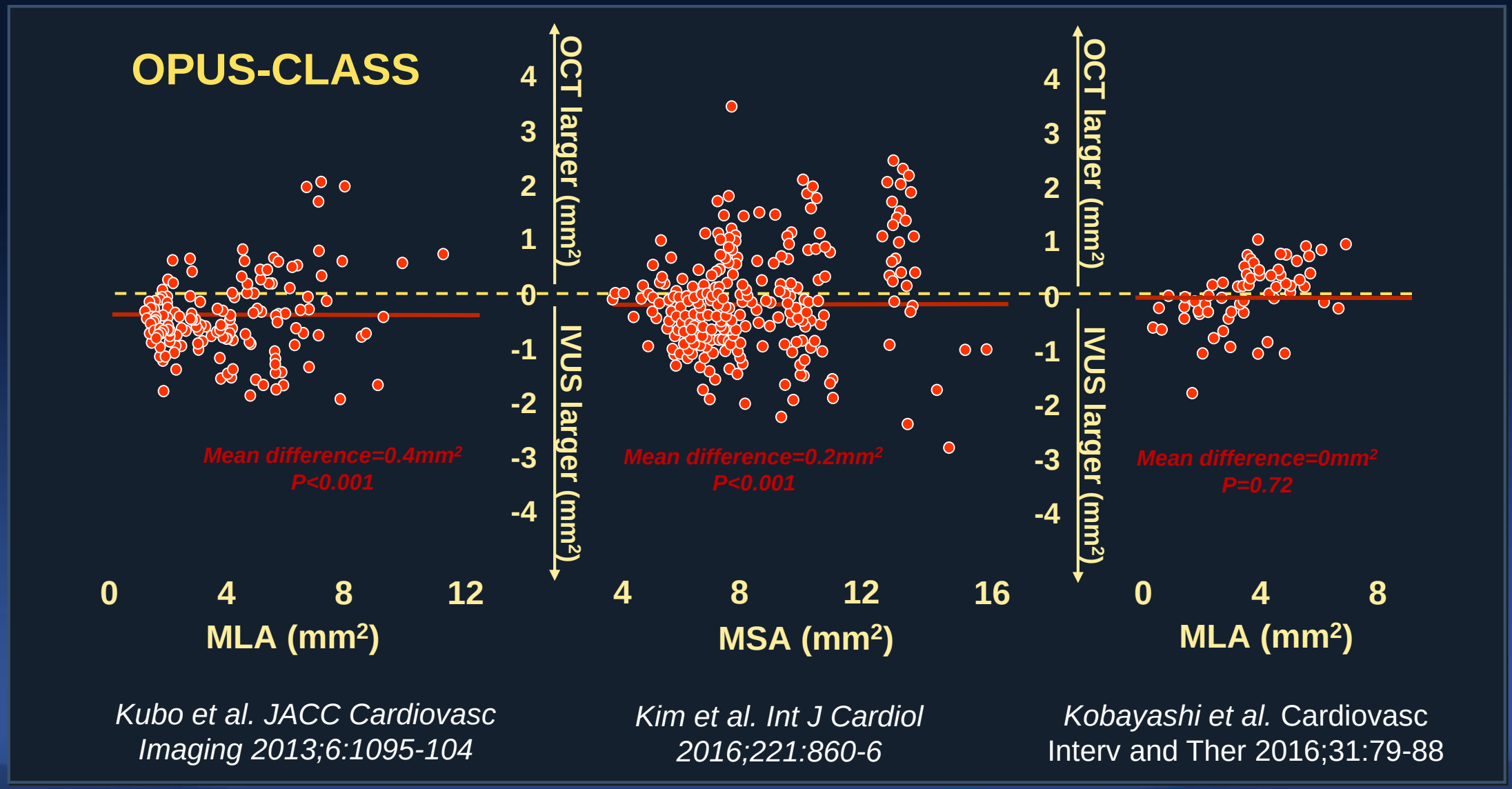
Eur Heart J 2019:40;87-165

OCT vs. IVUS

	OCT	IVUS
Wave source	Near-infrared light	Ultrasound
Axial resolution, μm	15-20	38-46
Penetration depth in soft tissue, mm	1-2	>5
Blood clearance	Needs Contrast	Not required
Plaque burden at lesion	-	+
Aorto-ostial visualization	-	+
Cross-sectional calcium evaluation	Thickness, Angle	Angle only
Lipidic plaque evaluation	Lipidic plaque, Cap thickness	Attenuated plaque

Maehara A et al., J Am Coll Cardiol Img 2017;10:1487-503
Koganti S et al., Interv Cardiol 2016;11:11-16

In vivo comparison of OCT vs IVUS



Kubo et al. JACC Cardiovasc Imaging 2013;6:1095-104

Kim et al. Int J Cardiol 2016;221:860-6

Kobayashi et al. Cardiovasc Interv and Ther 2016;31:79-88

Gary S. Mintz, presented at TCT 2017.

OCT vs. IVUS for Morphologic Evaluation

	Morphologic Evaluation	OCT	IVUS
Pre-PCI	Severity of Calcium	★★★	★★
	Stent Sizing by Vessel Wall	★★	★★★
	Stent length by Normal Vessel	★★★	★★★
Post-PCI	Stent Expansion	★★★	★★★
	Stent Malapposition	★★★	★★
	Stent Deformation at Ostium	★★	★★
	Edge Dissection	★★★	★★
	Residual Disease at Edge	★★★	★★★
At follow-up	Old Stent Expansion	★★★	★★★
	Neointimal Hyperplasia	★★★	★★★
	Neoatherosclerosis	★★★	★★
	Stent Fracture	★★	★★
	Positive Remodeling of Vessel Wall	★	★★★

Maehara A et al., J Am Coll Cardiol Img 2017;10:1487–503

OCT-guided vs. IVUS-guided PCI, Which is better ?

OCT- vs. IVUS- guided PCI

Randomized 70 patients with short, single lesion

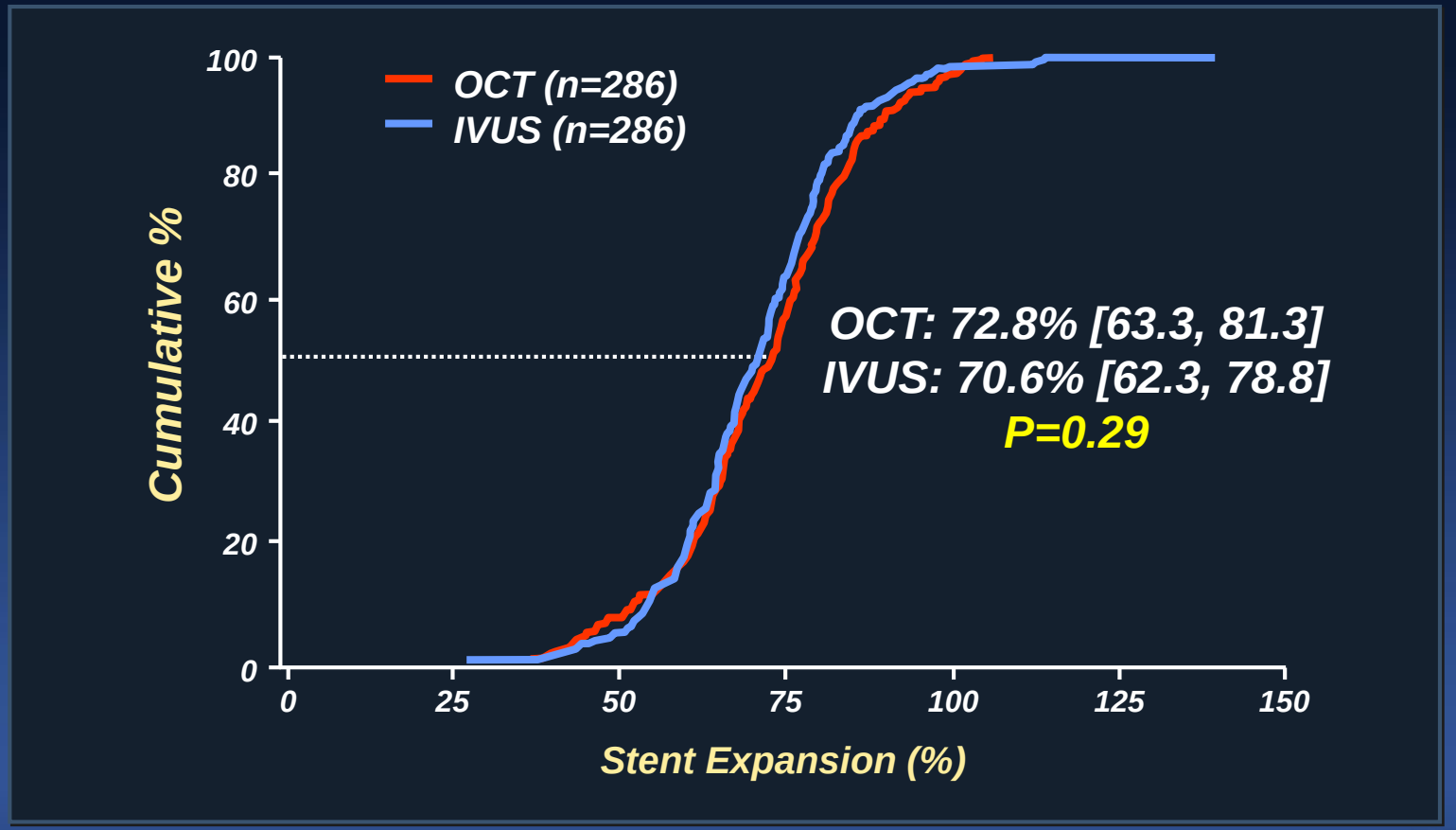
Primary endpoint: stent expansion by IVUS

	OCT (n=35)	IVUS (n=35)	P Value
Stent length, mm	16.5±4.2	17.6±5.4	0.33
Stent diameter, mm	3.1±0.5	3.0±0.4	0.78
Stent deployment pressure, atm	9.8±2.4	14.2±3.4	<0.001
Post-procedure IVUS Analysis			
Minimum stent area, mm^2	6.1±2.2	7.1±2.1	0.04
Mean stent area, mm^2	7.5±2.5	8.7±2.4	0.04
Focal stent expansion, %	64.7±13.7	80.3±13.4	0.002
Diffuse stent expansion, %	84.2±15.8	98.8±16.5	0.003

Habara M et al. Circ Cardiovasc Interv. 2012;5:193-201.

ILUMIEN II

OCT-guided PCI in ILUMIEN I matched to IVUS-guided PCI in ADAPT-DES



Maehara A et al. JACC Cardiovasc Interv 2015;8:1704-14

OCT- vs. IVUS- guided PCI

: in propensity-matched population From 2 Tertiary Hospital in Korea

	OCT (n=114)	IVUS (n=114)	P Value
Age, years	61.5 ± 10.2	61.7 ± 10.2	0.89
Male gender (%)	84 (73.7)	89 (78.1)	0.44
Diabetes (%)	21 (18.4)	21 (18.4)	1.0
Hypertension (%)	50 (43.9)	51 (44.7)	0.89
Stable angina (%)	36 (31.6)	38 (33.3)	0.86
Ejection fraction, %	57.0 ± 10.8	56.2 ± 12.0	0.62
One-Vessel Disease	70 (61.4%)	72 (63.2%)	0.67
LAD target vessel	81 (71.1%)	70 (61.4%)	0.22
Stent size	3.21 ± 0.42	3.18 ± 0.39	0.61
Stent length	25.2 ± 9.3	25.0 ± 11.1	0.90
Overlapped stent (%)	13 (11.4%)	12 (10.5%)	0.83
Contrast dose, mL	297.9 ± 119.6	241.0 ± 105.9	<0.001

Kim IC, Hur SH et al. J Interv Cardiol. 2016;29:216-24

OCT- vs. IVUS- guided PCI

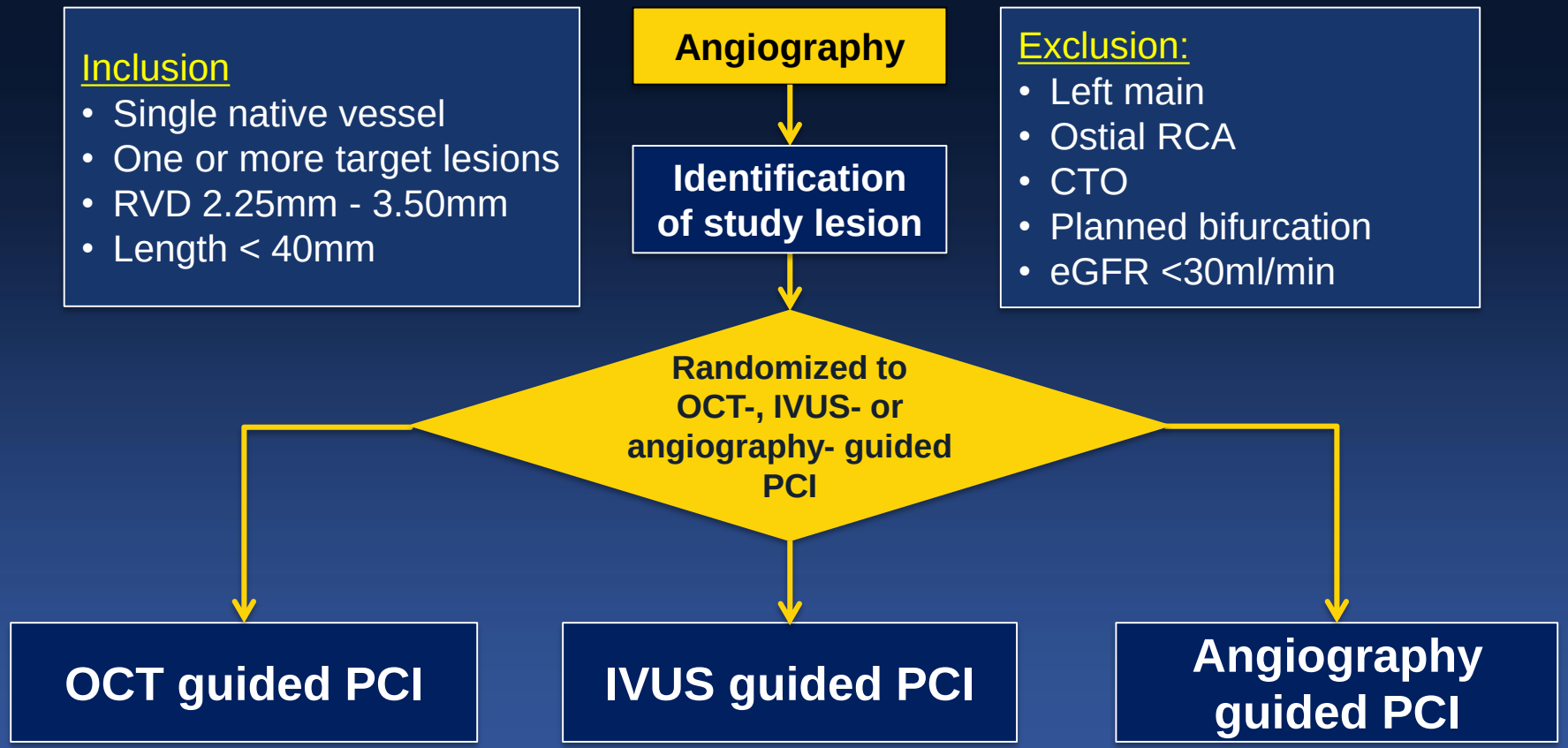
: in propensity-matched population From 2 Tertiary Hospital in Korea

	OCT (n=114)	IVUS (n=114)	P Value
Stent optimization, %	102 (89.5)	105 (92.1)	0.49
Minimum stent area, mm^2	6.32±2.06	6.34±1.88	0.93
1-year clinical outcomes			
Cardiac death, %	2 (1.8)	3 (2.6)	1.00
Myocardial infarction, %	0	1 (0.9)	1.00
TLR, %	2 (1.8)	1 (0.9)	1.00
MACE, %	4 (3.5)	4 (3.5)	1.00
Stent thrombosis, %	0	1 (0.9)	1.00

Kim IC, Hur SH et al. J Interv Cardiol. 2016;29:216-24

ILUMIEN III – OPTIMIZE PCI

Randomized OCT vs. IVUS vs. Angiography



Ali ZA et al. Lancet 2016:388;2618-28

ILUMIEN III – OPTIMIZE PCI

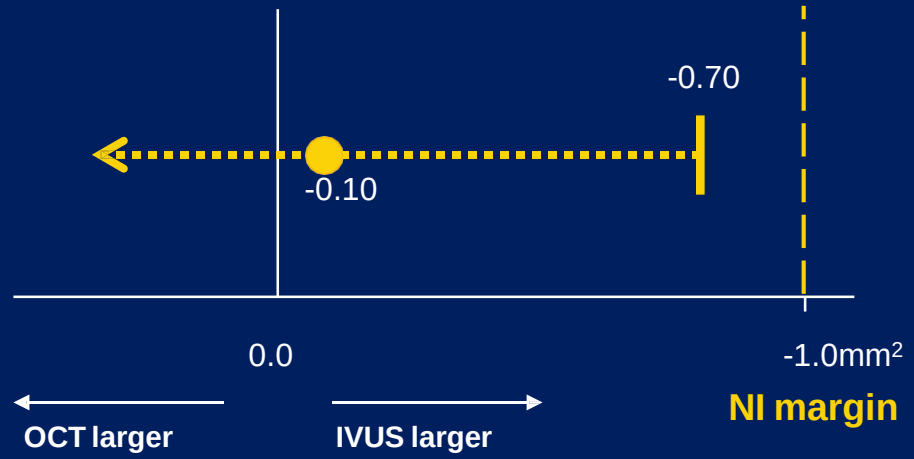
Randomized OCT vs. IVUS vs. Angiography

Primary endpoint: Final post-PCI MSA by OCT

OCT 5.79 mm^2 [4.54, 7.34]

IVUS 5.89 mm^2 [4.67, 7.80]

97.5% one-sided CI: [-0.70, -]



$P_{noninferiority} = 0.001$

Ali ZA et al. Lancet 2016:388;2618-28

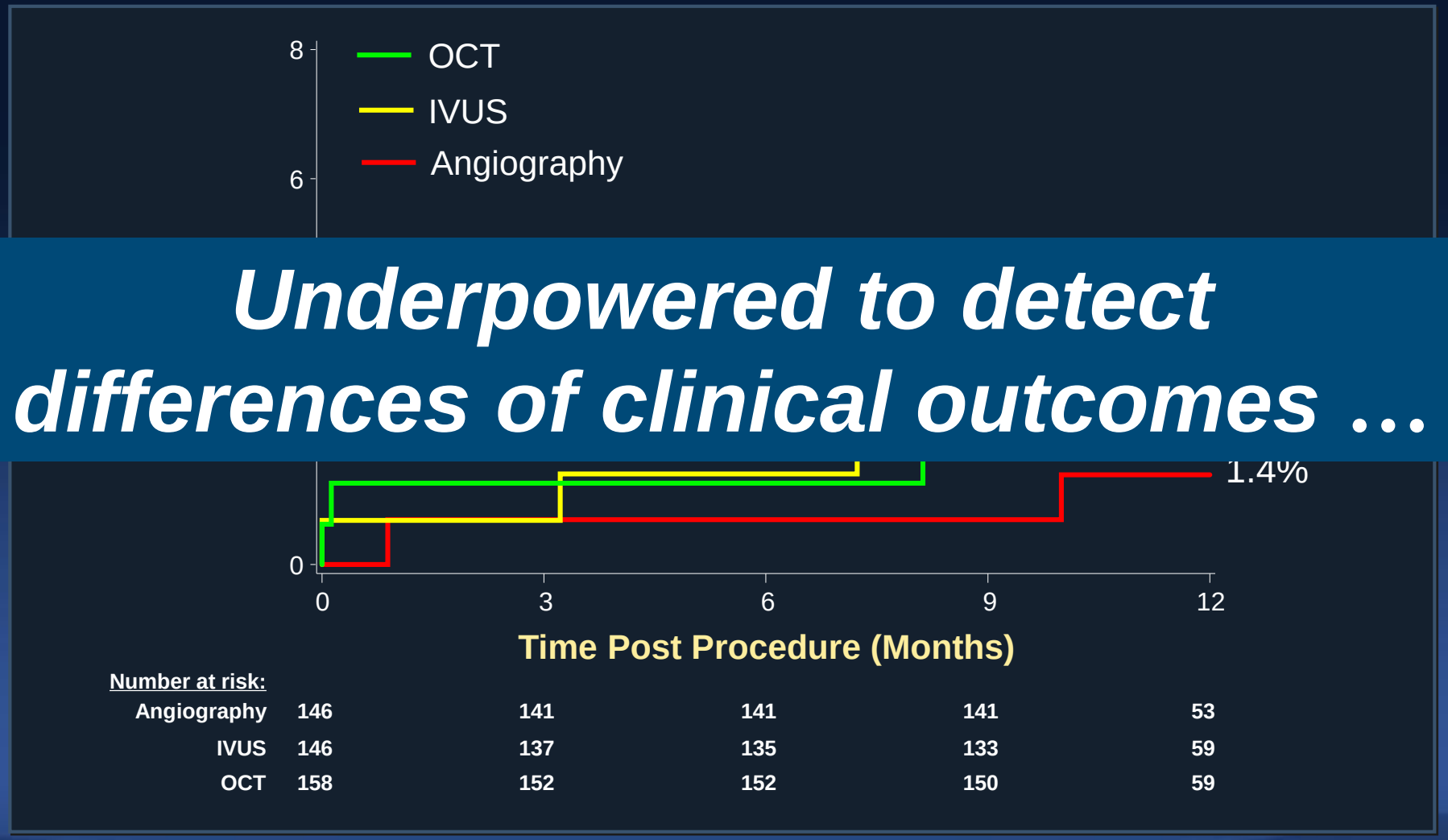
ILUMIEN III: Expansion Endpoints

	OCT (n=140)	IVUS (n=135)	Angio (n=140)	P OCT vs IVUS	P OCT vs Angio
Minimal stent area, mm^2	5.79 [4.54,7.34]	5.89 [4.67,7.80]	5.49 [4.39, 6.59]	0.42	0.12
Min stent expansion, %	88 ± 17	87 ± 16	83 ± 13	0.77	0.02
Mean stent expansion, %	106 [98, 120]	106 [97, 117]	101 [92, 110]	0.63	0.001
Stent expansion					
- Optimal (>95%)	26%	25%	17%	0.84	0.07
- Acceptable (90 - <95%)	16%	12%	3.7%	0.42	0.0008
- Unacceptable (<90%)	59%	63%	79%	0.45	0.0002

Ali ZA et al. Lancet 2016:388;2618-28

ILUMIEN-III: 1-Year TLF

Cardiac Death, TV-MI, or ID-TLR



Underpowered to detect differences of clinical outcomes …

Ali ZA et al. Lancet 2016:388;2618-28

The OPINION RCT: Design

Prospective, multi-center (n=42), randomized (1:1), non-inferiority trial comparing OCT-guided PCI with IVUS-guided PCI

Patients scheduled for PCI using DES*
n = 800

1:1

OCT-guided PCI
n = 400

*DES: NOBORI biolimus-eluting stent

IVUS-guided PCI
n = 400

8 months: Follow-up coronary angiography

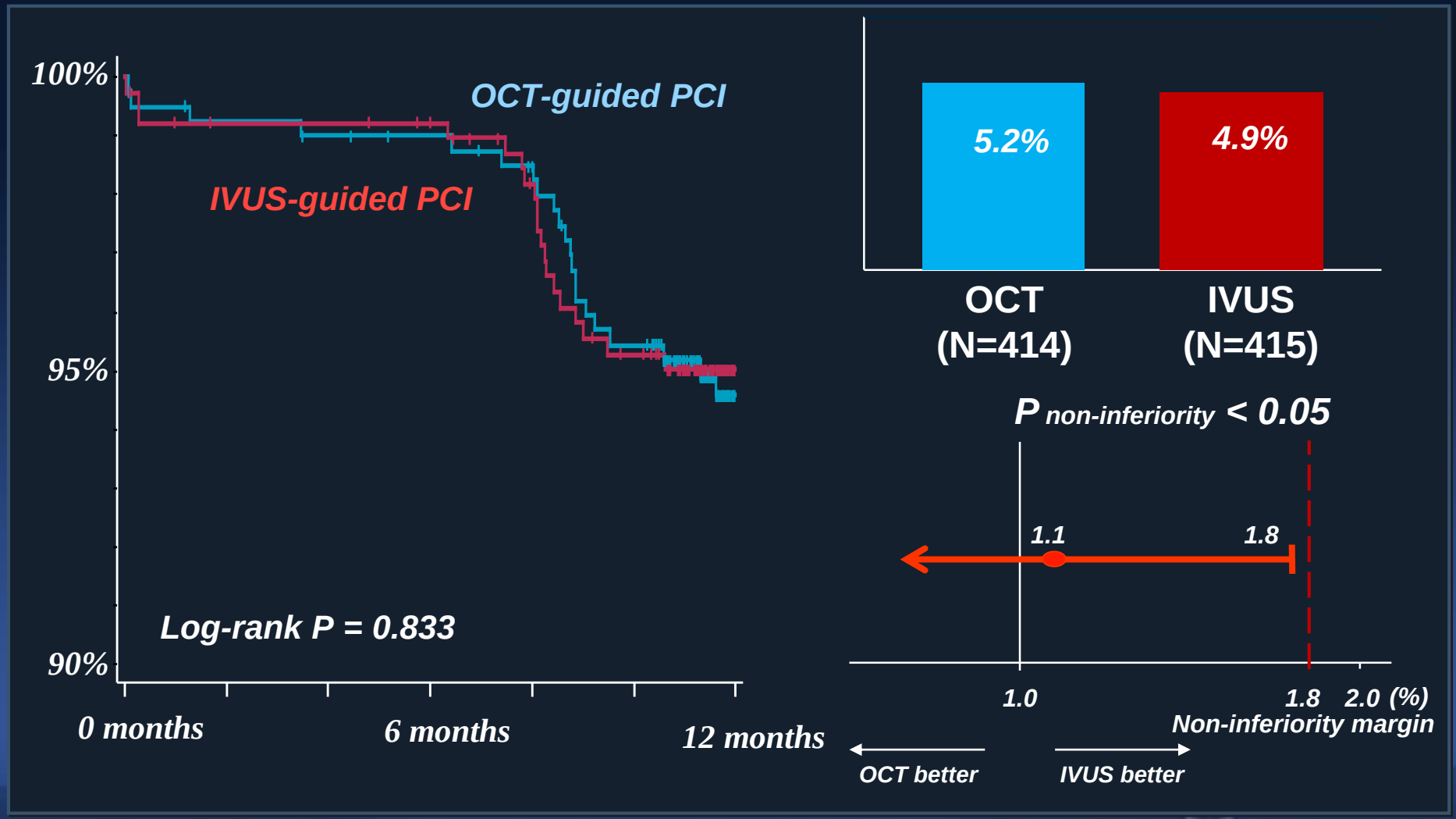
12 months: Clinical follow-up

Primary Endpoint: Target Vessel Failure (TVF) at 12 months after PCI

Exclusion:
- 3VD, LM disease
- Ostial Lesion
- CTO
- Bypass graft
- In-stent restenosis
- CHF
- eGFR <30ml/min

RCT: OPINION Trial: OCT vs. IVUS

1-Year TVF (Cardiac Death, TV-MI, or ID-TVR)



Kubo T, Akasaka T et al., Eur Heart J 2017:38;3139-47

RCT: OPINION Trial: OCT vs. IVUS

Procedure Results

	OCT-guided (412 pts)	IVUS-guided (405 pts)	P value
Stent diameter, mm	2.92 ± 0.39	2.99 ± 0.39	0.005
Total stent length, mm	25.9 ± 13.2	24.8 ± 13.2	0.06
Multiple stenting	16.5%	14.6%	0.50
Pre-dilatation	76.7%	78.0%	0.67
Post-dilatation	76.7%	75.1%	0.62
Max. balloon diameter, mm	3.1 ± 0.8	3.3 ± 1.2	0.06
Max. inflation pressure, atm	16.0 ± 4.2	16.0 ± 4.2	0.06
No. of OCT/IVUS procedure	3.0 ± 1.1	3.0 ± 1.1	0.14
OCT/IVUS related complication	0.7%	0.3%	0.62
Total amount of contrast, mL	164 ± 66	138 ± 56	<0.001

Kubo T, Akasaka T et al., Eur Heart J 2017:38;3139-47

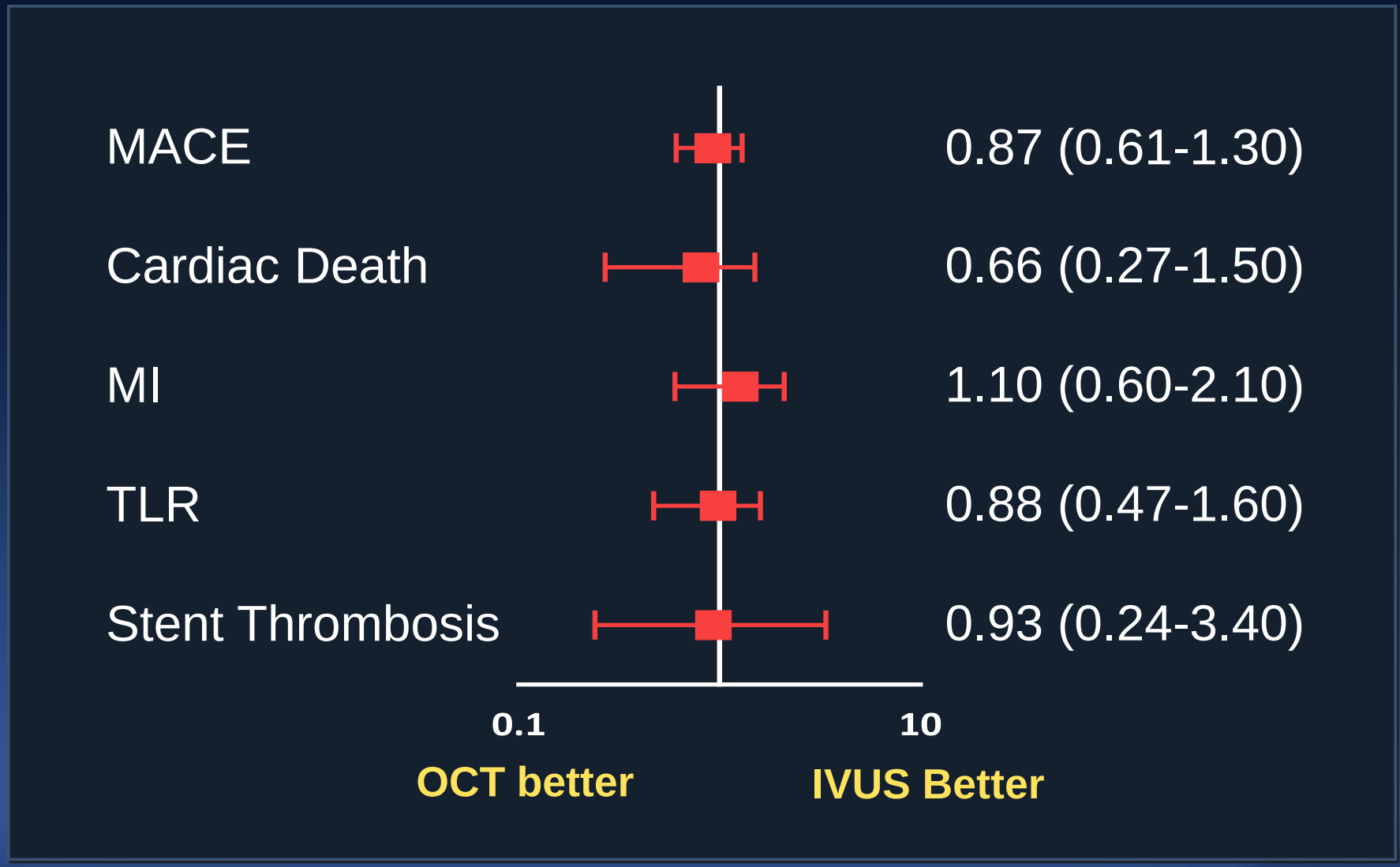
RCT: OPINION Trial: OCT vs. IVUS

QCA Results

	OCT-guided	IVUS-guided	P value
Post-PCI	409 patients	400 patients	
In-segment RVD, mm	2.86 ± 0.56	2.89 ± 0.56	0.63
In-segment MLD, mm	2.25 ± 0.53	2.27 ± 0.52	0.78
In-segment DS, %	22 ± 10	22 ± 9	0.89
In-segment acute gain, mm	1.32 ± 0.54	1.38 ± 0.54	0.15
8-month FU	369 patients	365 patients	
In-segment RVD, mm	2.82 ± 0.53	2.85 ± 0.56	0.59
In-segment MLD, mm	2.16 ± 0.56	2.17 ± 0.55	0.75
In-segment DS, %	24 ± 13	24 ± 12	0.54
In-segment acute gain, mm	0.10 ± 0.46	0.10 ± 0.44	0.72

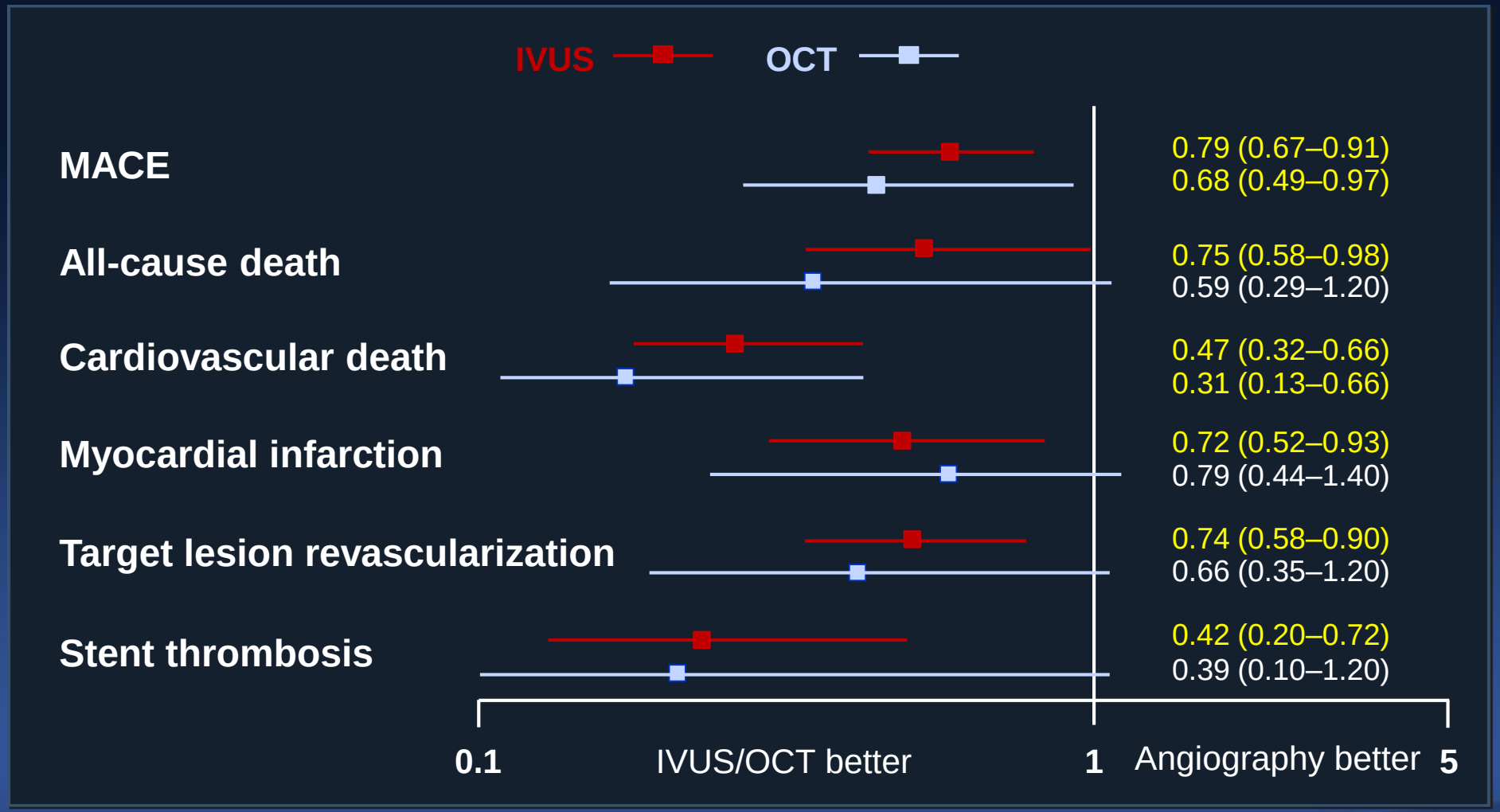
Kubo T, Akasaka T et al., Eur Heart J 2017:38;3139-47

OCT vs. IVUS: Meta-analysis



Buccheri S et al., JACC interv. 2017:10;2488-98.

OCT / IVUS vs. Angiography-guided PCI : Meta-analysis



Buccheri S et al., JACC interv. 2017:10;2488-98.

OCT-guidance vs. IVUS-guidance for Complex PCI, Which is better ?

No Definitive Evidence Yet !!

Prior RCTs Excluded Complex Lesions

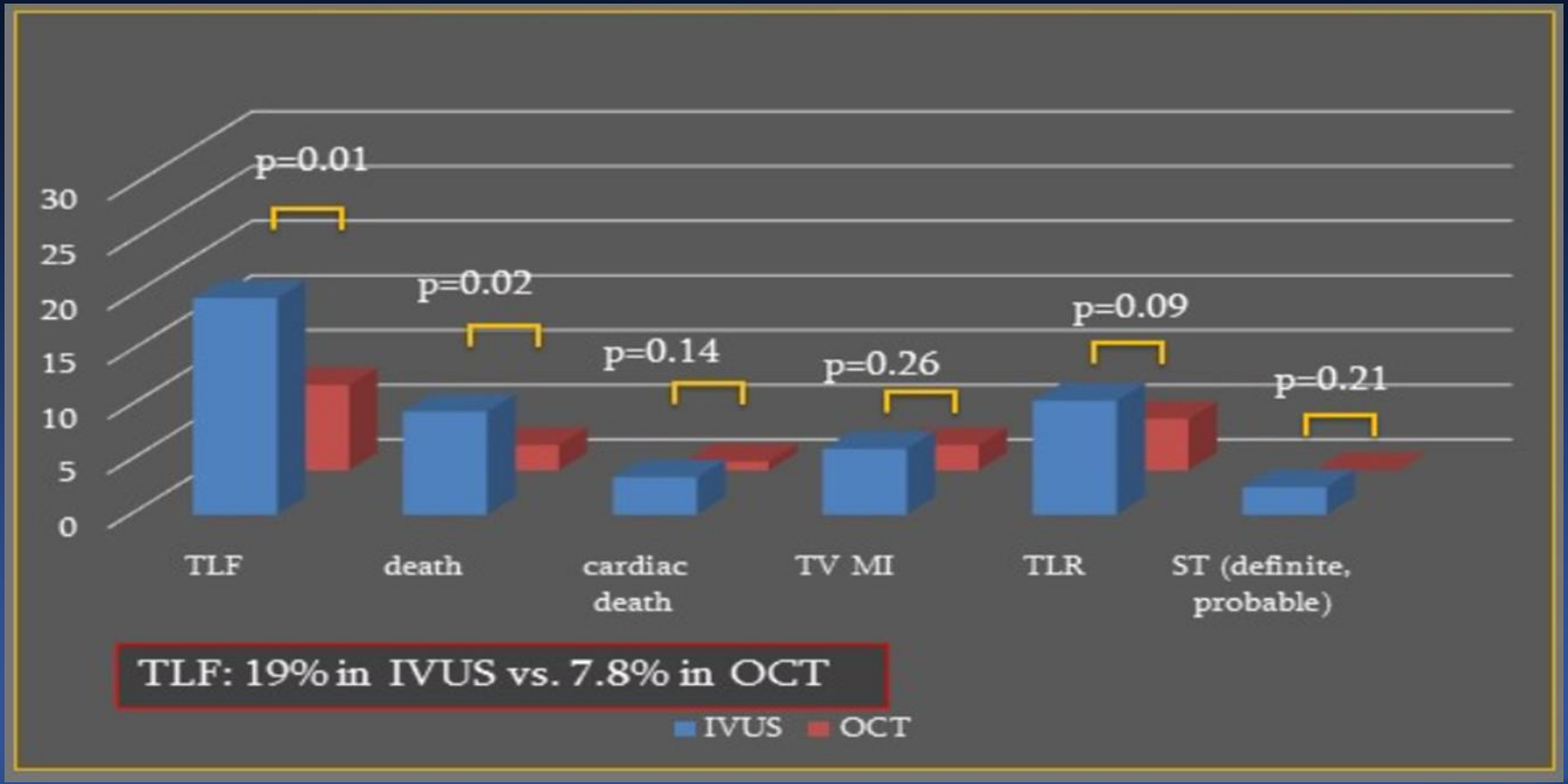
- **ILUMIEN III**
  - Vessel diameter limited to 2.25-3.5 mm, length <40mm
  - Complex lesions excluded
    (LM, RCA os, graft, CTO, ISR, planned 2-stent bifurcation)

- **OPINION**
  - Complex lesions excluded
    (LM or 3VD, ostial lesion, CTO, ISR, bypass graft)

OCT- vs. IVUS- guided PCI in LM PCI

: in Retrospective registry in 13 European centers

246 (41%) of 598 patients used OCT/IVUS, 35 (OCT) 30 (IVUS) Mo FU



Cortese B, presented at EuroPCR 2019

OCT is Better for Complex PCI?

OCT is Better?

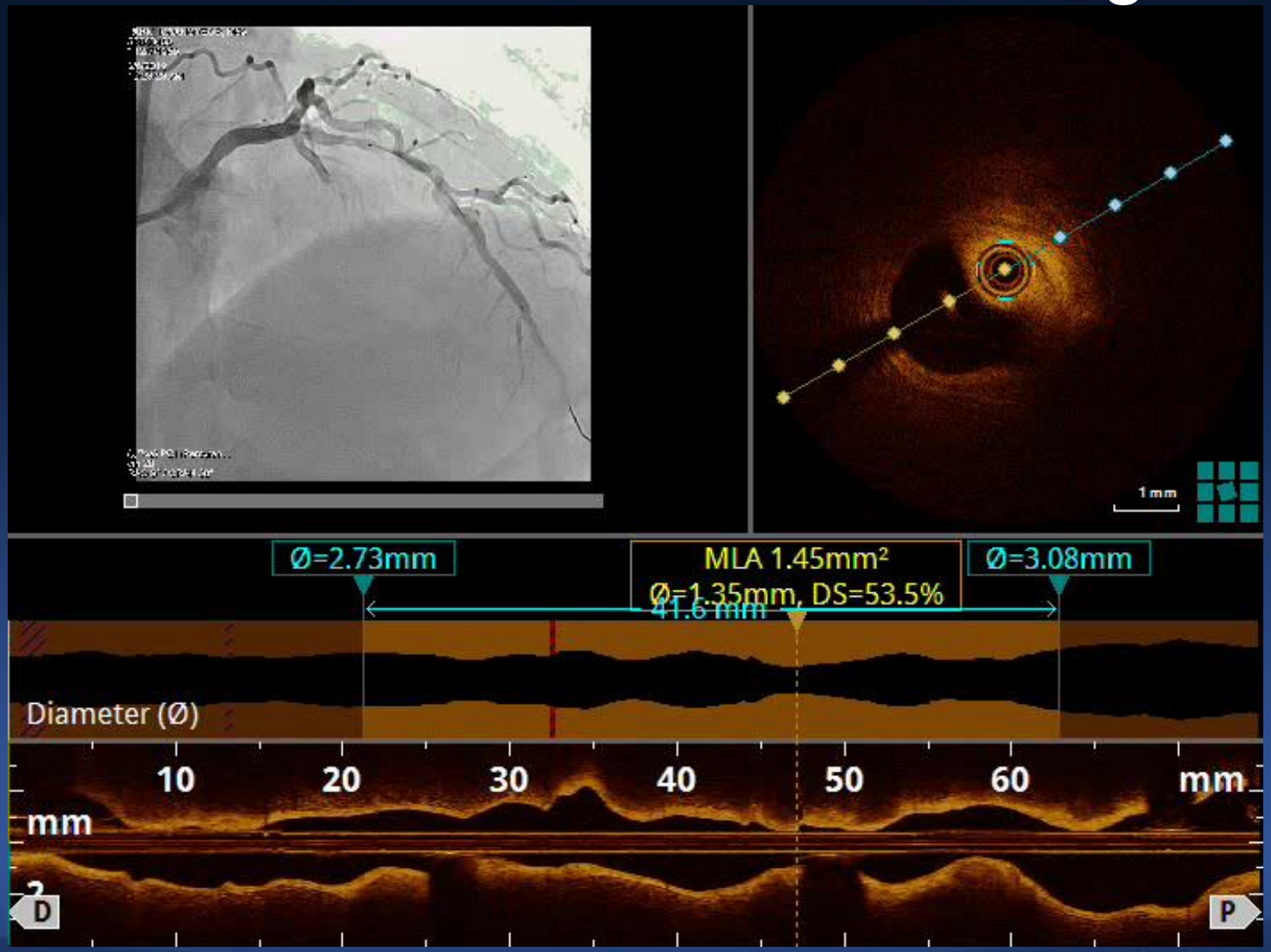
Better Spatial Resolution to Detect Acute Complication (ILUMIEN III)

	OCT (n=140)	IVUS (n=135)	*P Value*
Dissection, any	28%	40%	0.04
Major	14%	26%	0.009
Minor	14%	13%	0.84
Malapposition, any	41%	38%	0.62
Major	11%	21%	0.02
Minor	31%	18%	0.01
Tissue Protrusion, any	67%	74%	0.21
Major	19%	20%	0.88
Minor	48%	54%	0.30

Ali ZA et al. Lancet 2016:388;2618-28

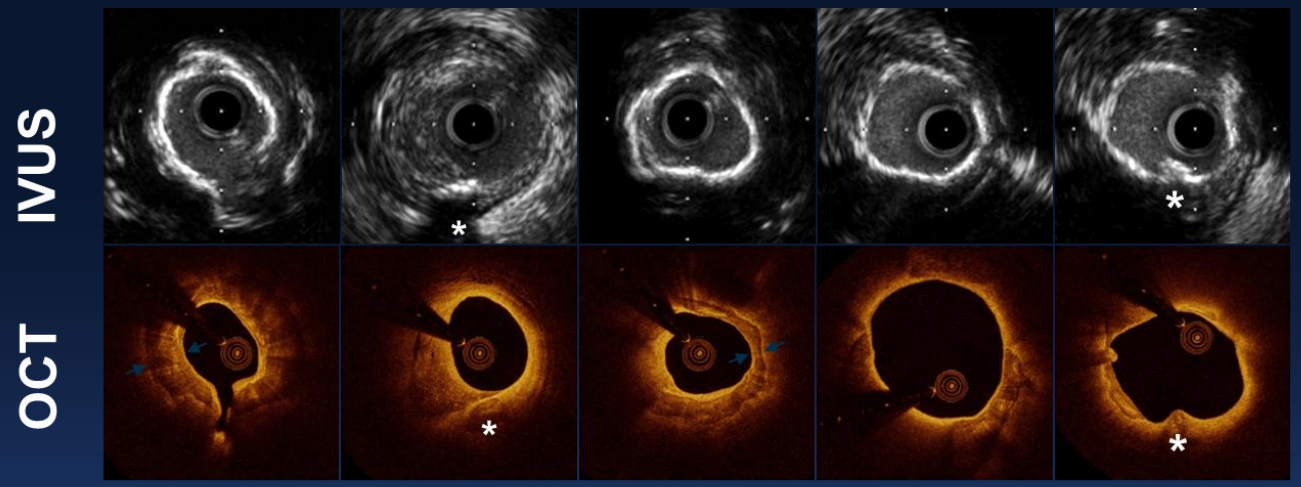
OCT is Better?

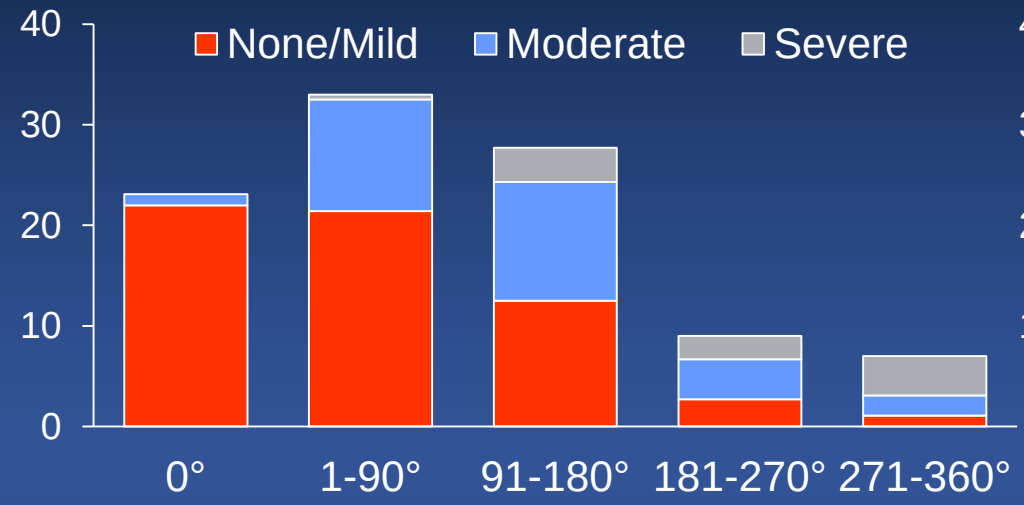
Beautiful, Convenient OCT Co-registration



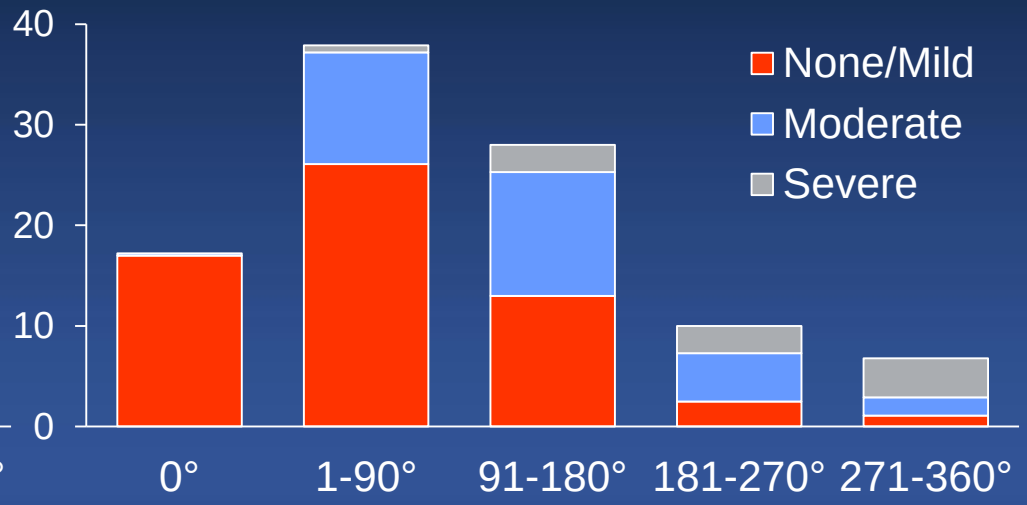
OCT is Better?

Visualization of Calcium with Thickness





OCT Calcium

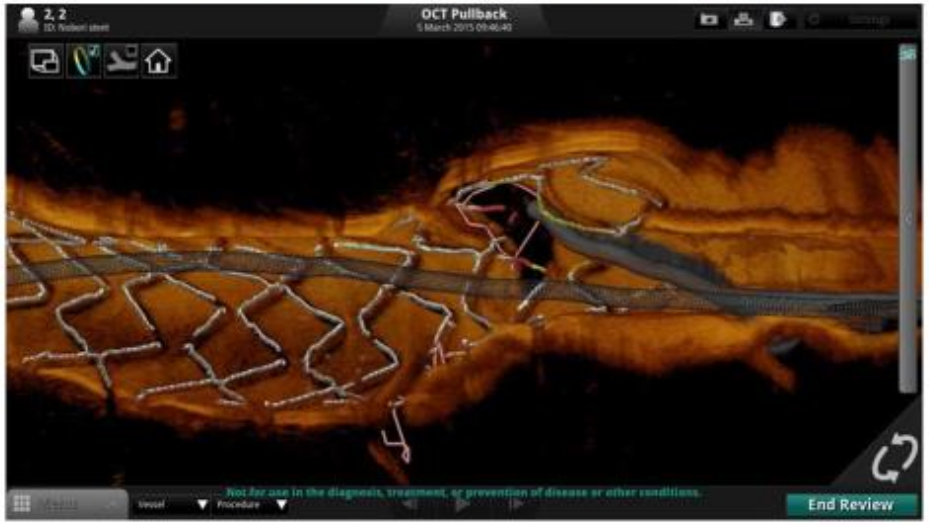


IVUS Calcium

Wang et al. JACC Cardiovasc Imaging 2017;10:869-79
Mintz and Guagliumi. Lancet 2017;390:793-809

OCT is Better?
Delicate Bifurcation PCI with 3D Image

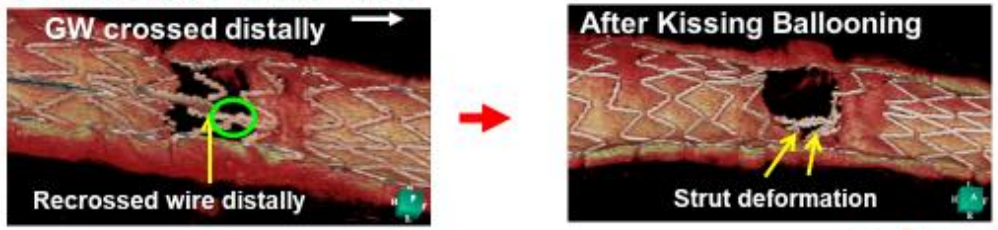
New Development in OCT



Re-crossing wire position in the jailed side branch can be easily identified by newly developed OCT software and improvement of side branch KBT procedure could be expected by the guidance of new OCT.

Link connecting to carina type

GW recross distal cell



GW recross proximal cell

suboptimal

Wakayama Medical University

Akasaka T, Presented at TCTAP 2019

OCT is Better?

- OCT-Angiography Co-registration
- Faster Imaging Acquisition
- Calcium / In-stent Neoatherosclerosis well visualized
- Delicate 3D-view, especially for Bifurcation PCI

But,

- Weaker Catheter Tip
- Often can not Visualize Vessel Size
- No Visualization of Ostium
- Need Contrast (Alternatives: Dextran, Saline)

IVUS Better for Complex PCI?

IVUS is Better?

Greater Number of Scientific Evidence

Randomized Trials

1) Jakabcin J, Spacek R, Bystron M, et al. Long-term health outcome and mortality evaluation after invasive coronary treatment using drug eluting stents with or without the IVUS guidance. Randomized control trial. HOME DES IVUS. Catheter Cardiovasc Interv 2010;75:578-583.
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6) Kim BK, Shin DH, Hong MK, et al; CTO-IVUS Study Investigators. 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.
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9) Mariani J Jr, Guedes C, Soares P, et al. Intravascular ultrasound guidance to minimize the use of iodine contrast in percutaneous coronary intervention: the MOZART (Minimizing cOntrast utiliZation With IVUS Guidance in coRonary angioplasTy) randomized controlled trial. JACC Cardiovasc Interv. 2014;7:1287-93
10) Habara M, Nasu K, Terashima M, et al. Impact of frequency-domain optical coherence tomography guidance for optimal coronary stent implantation in comparison with intravascular ultrasound guidence. Circ Cardiovasc Interv. 2012;5:193-201
11) Ali ZA, Maehara A, Généreux P, et al. Optical coherence tomography compared with intravascular ultrasound and with angiography to guide coronary stent implantation (ILUMIEN III: OPTIMIZE PCI): a randomised controlled trial. Lancet. 2016;388:2618-28.
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13) Kubo T, Shinke T, Okamura T, et al. Optical frequency domain imaging vs. intravascular ultrasound in percutaneous coronary intervention (OPINION trial): one-year angiographic and clinical results. Eur Heart J. 2017;38:3139-47.
14) Kala P, Cervinka P, Jakl M, et al. OCT guidance during stent implantation in primary PCI: A randomized multicenter study with nine months of optical coherence tomography follow-up. Int J Cardiol. 2018;250:98-103

Meta-analyses

1) Zhang Y, Farooq V, Garcia-Garcia HM, et al. Comparison of intravascular ultrasound versus angiography-guided drug-eluting stent implantation: a meta-analysis of one randomised trial and ten observational studies involving 19,619 patients. EuroIntervention. 2012;8:855-65.
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15) Kuku KO, Ekanem E, Azizi V, et al. Optical coherence tomography-guided percutaneous coronary intervention compared with other imaging guidance: a meta-analysis. Int J Cardiovasc Imaging. 2018;34:503-13

Registries

1) Agostoni P, Valgimigli M, Van Mieghem CA, et al. Comparison of early outcome of percutaneous coronary intervention for unprotected left main coronary artery disease in the drug-eluting stent era with versus without intravascular ultrasonic guidance. Am J Cardiol 2005;95:644-647.
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4) Park SJ, Kim YH, Park DW, et al; Investigators M-C. Impact of intravascular ultrasound guidance on long-term mortality in stenting for unprotected left main coronary artery stenosis. Circ Cardiovasc Interv 2009;2:167-177.
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IVUS

OCT

IVUS

IVUS

OCT

OCT

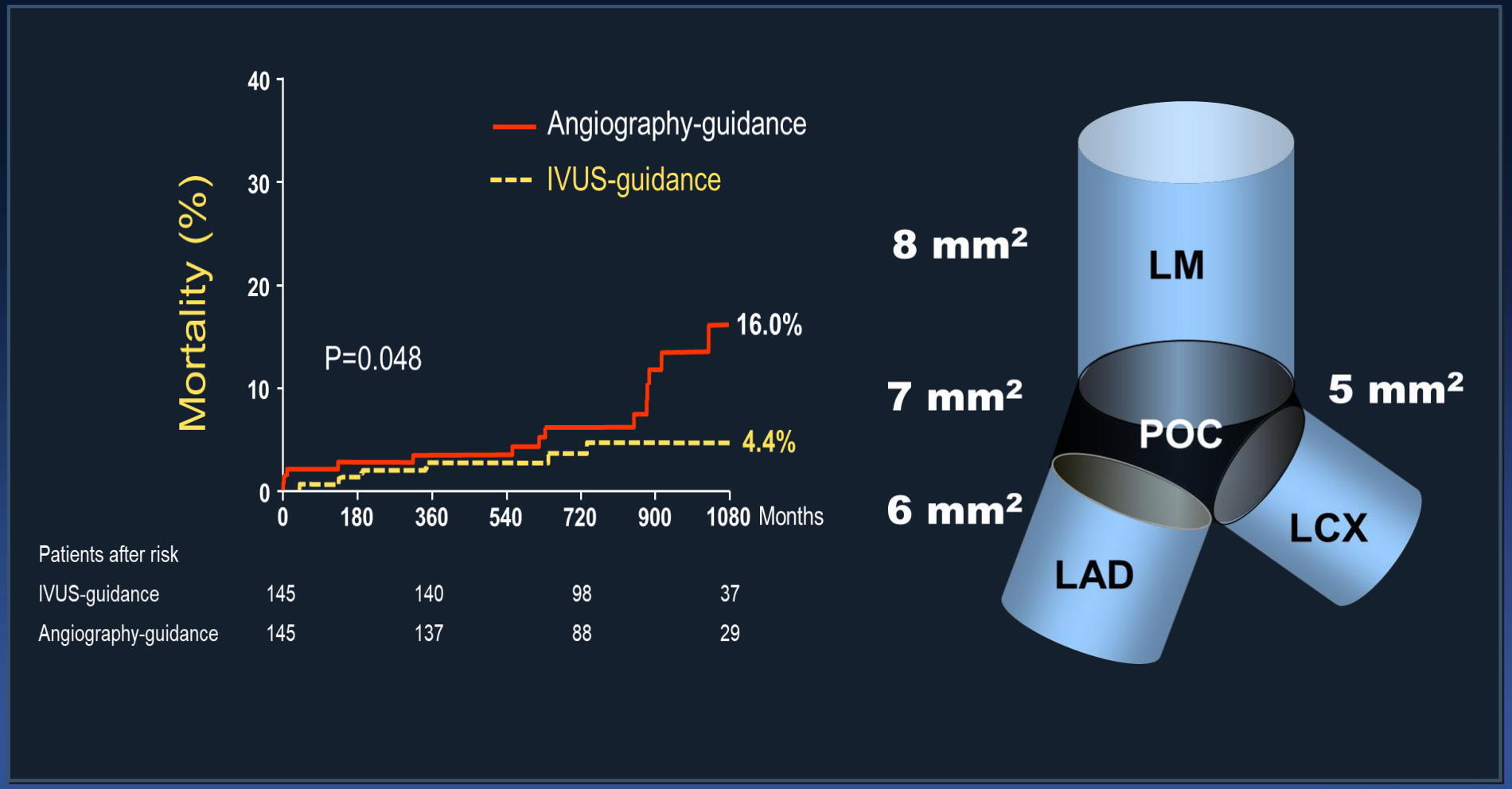
Cardiovascular Research Foundation

Columbia University Medical Center
NewYork-Presbyterian

Courtesy of Mintz GS

IVUS is Better?

Stronger Scientific Evidence Especially in LM PCI



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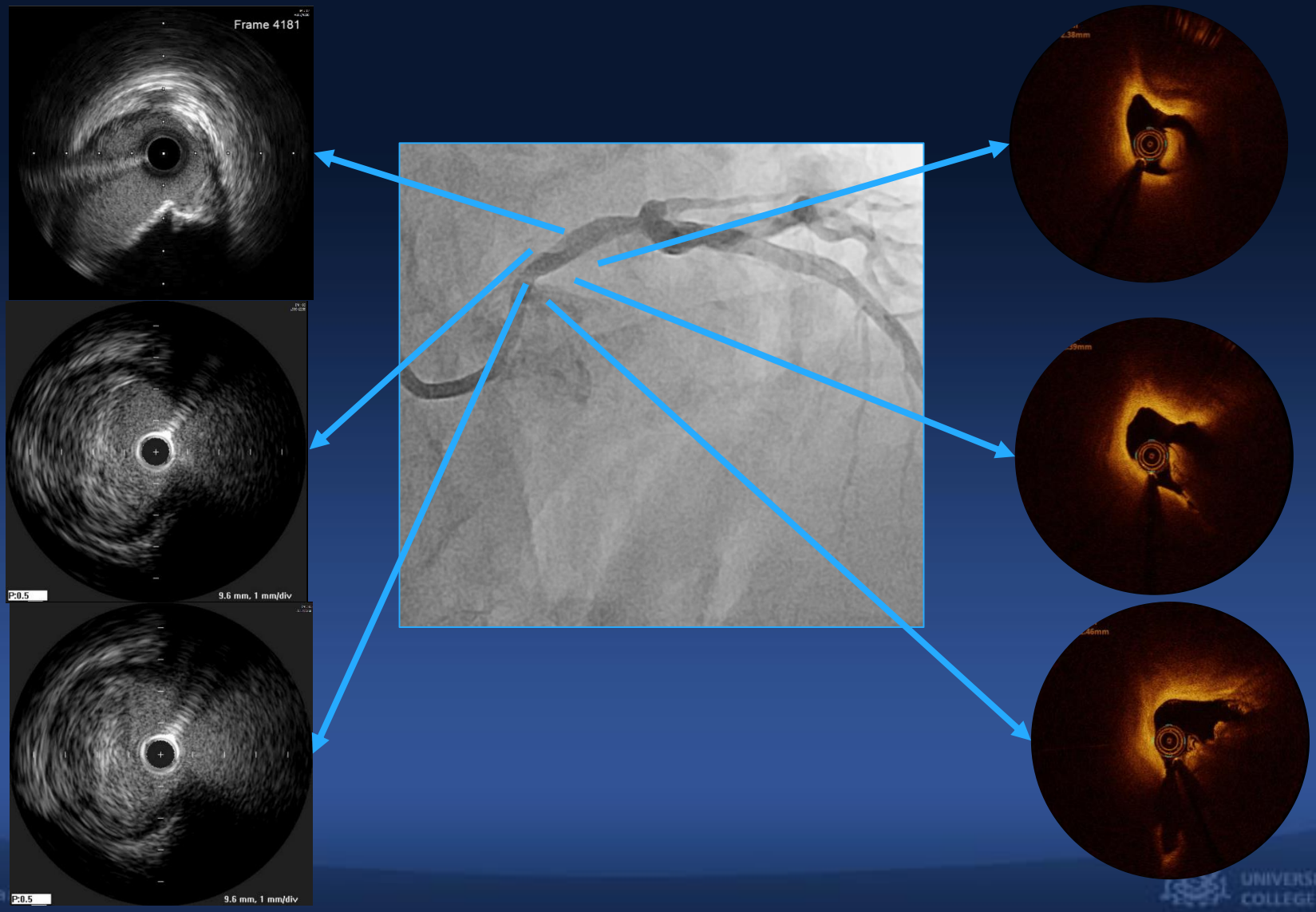
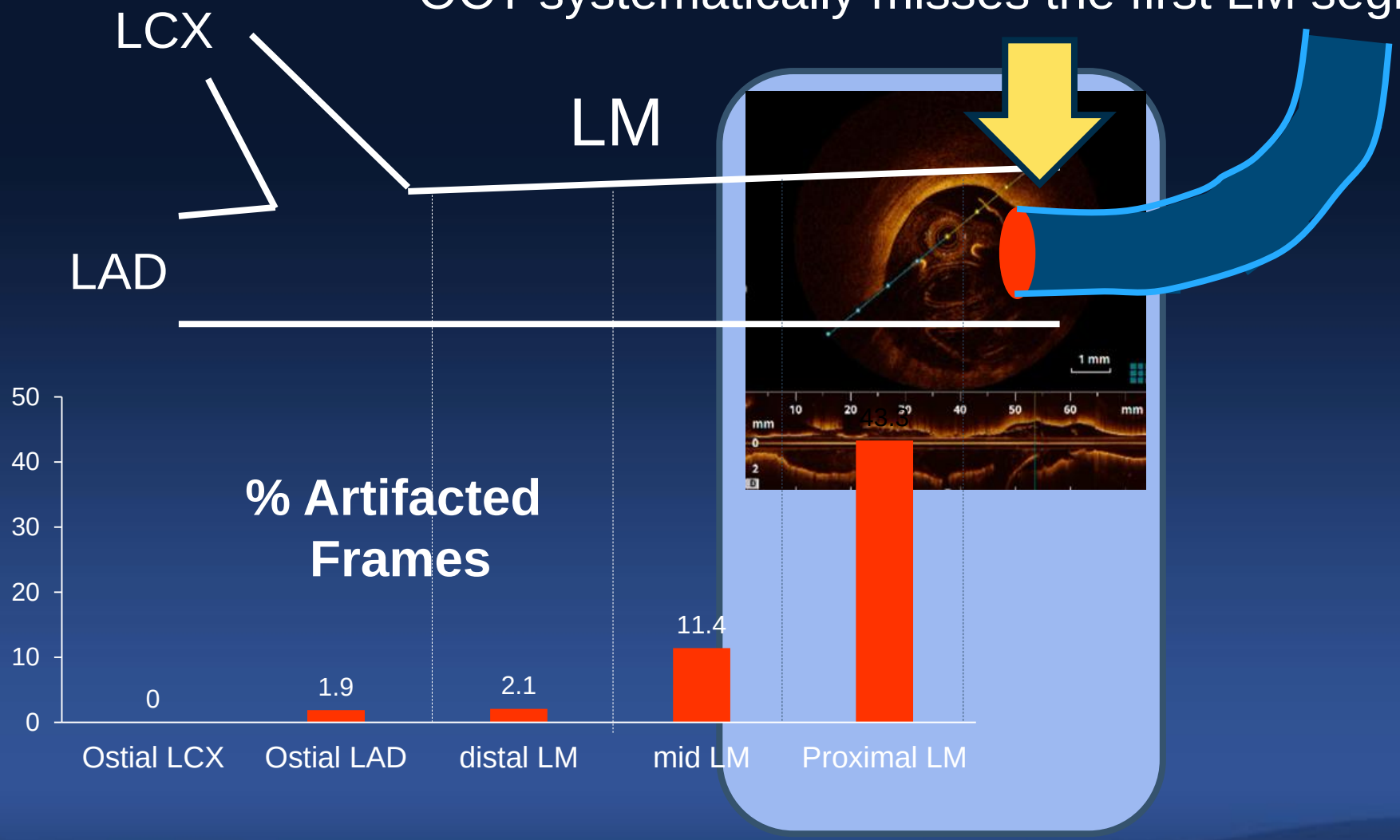
IVUS is Better?
for Left Main Ostium Evaluation



OCT for Left Main

OCT systematically misses the first LM segments



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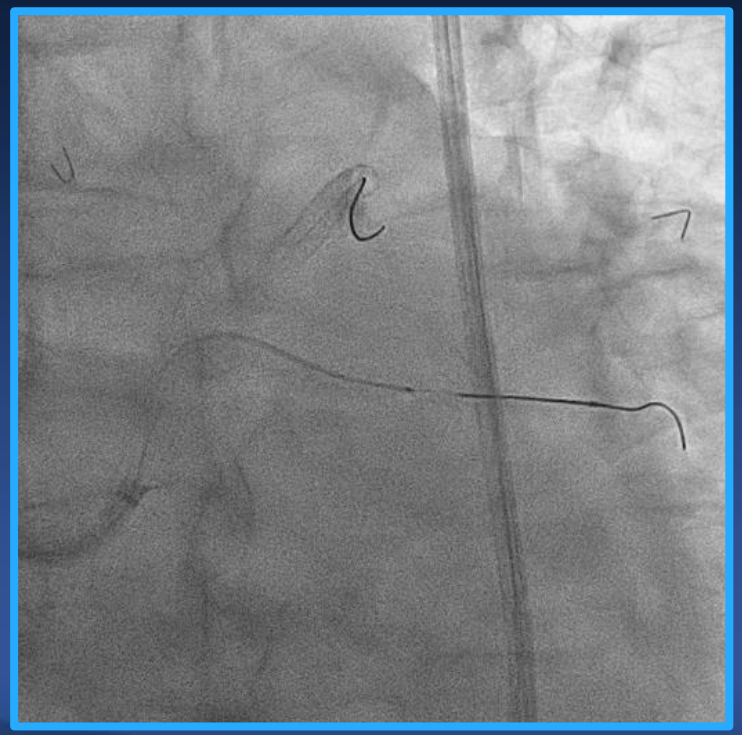
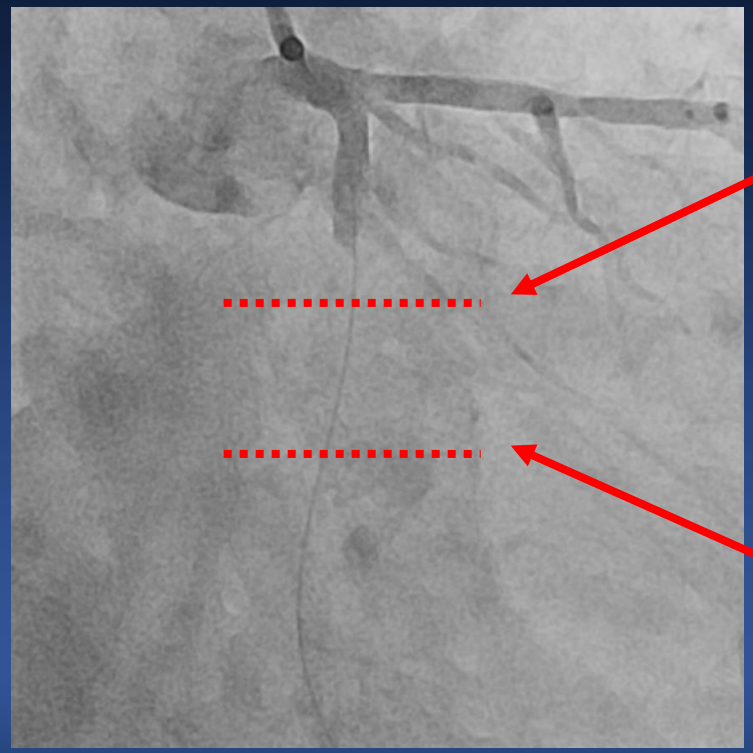
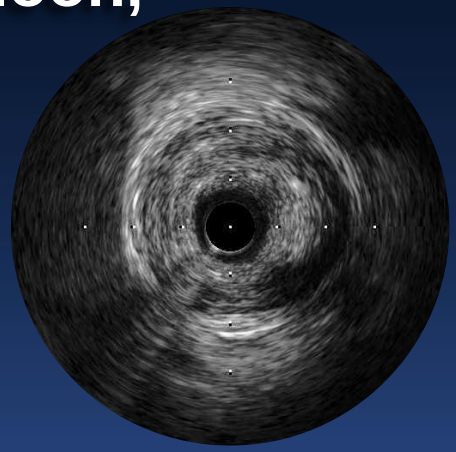
IVUS is Better?

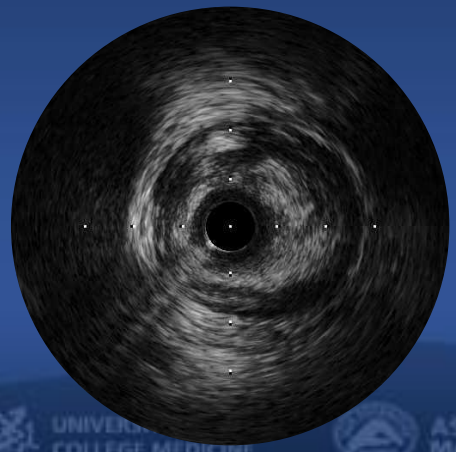
for Non-visualized Vessel
(Tight stenosis, Dissection, No-reflow…)

Even I Can Not See Distal Even After Repeated Balloon,
I Can See Vessel by IVUS



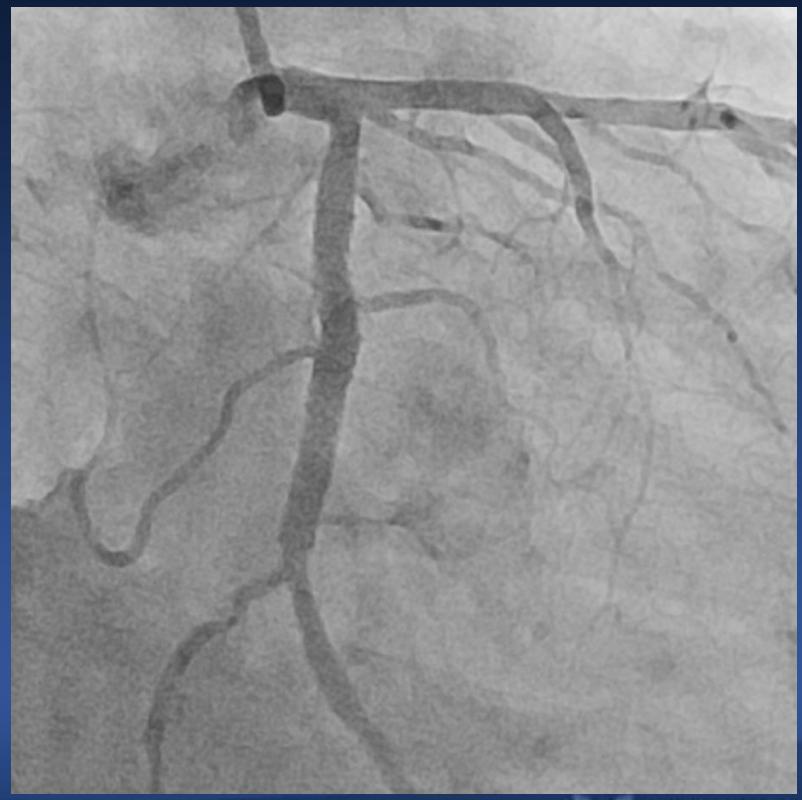




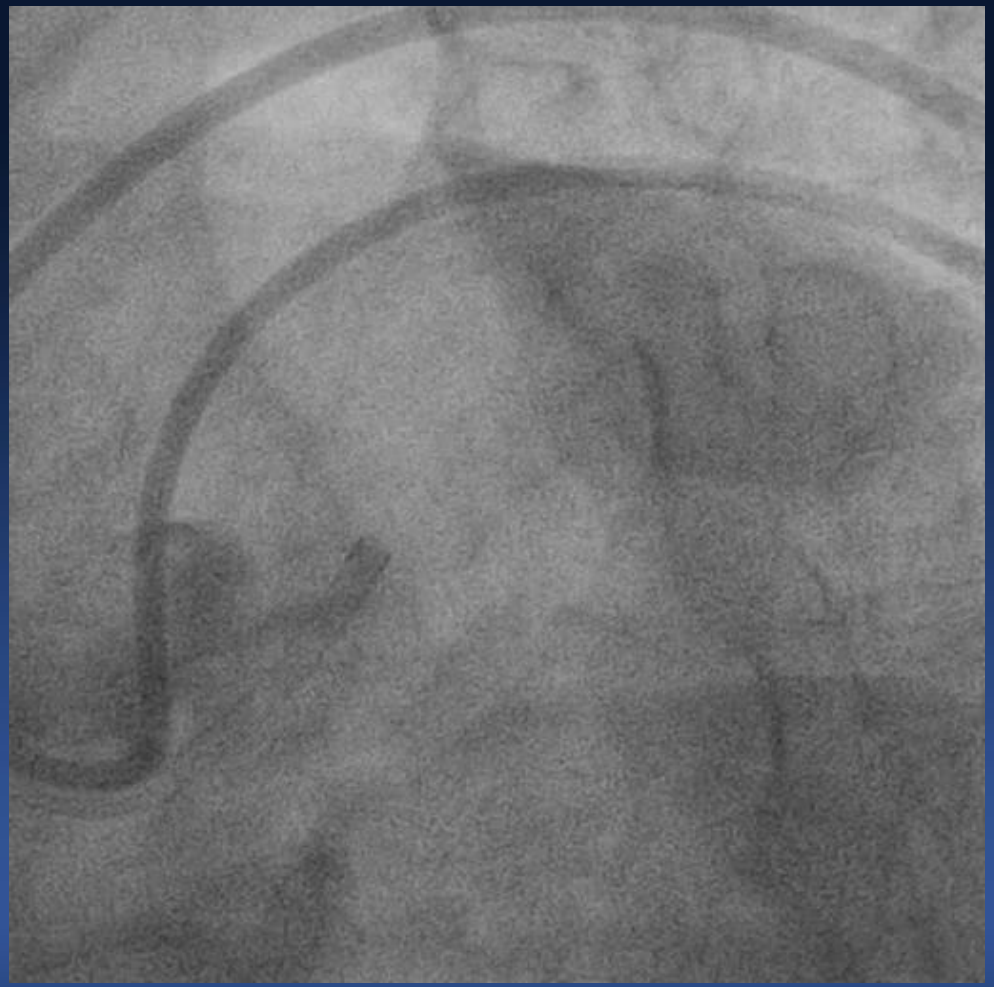


IVUS is Better?
for Non-visualized Vessel

Even I Can Not See Distal Even After Repeated Balloon,
I Can See Vessel by IVUS, and Implant Stent

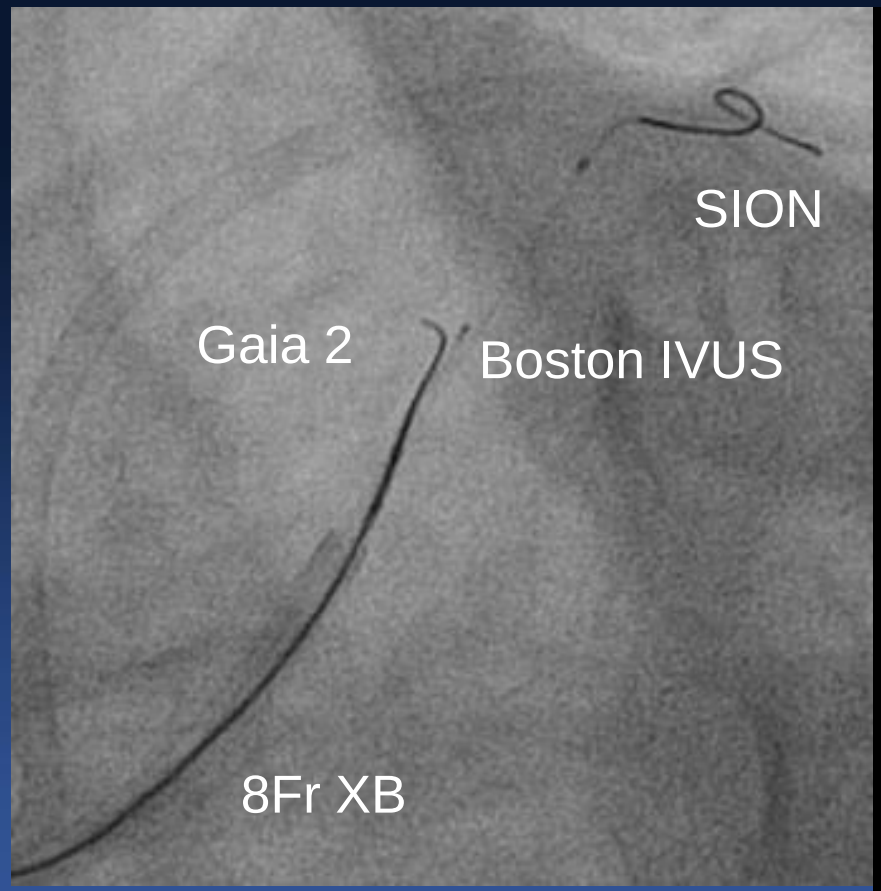


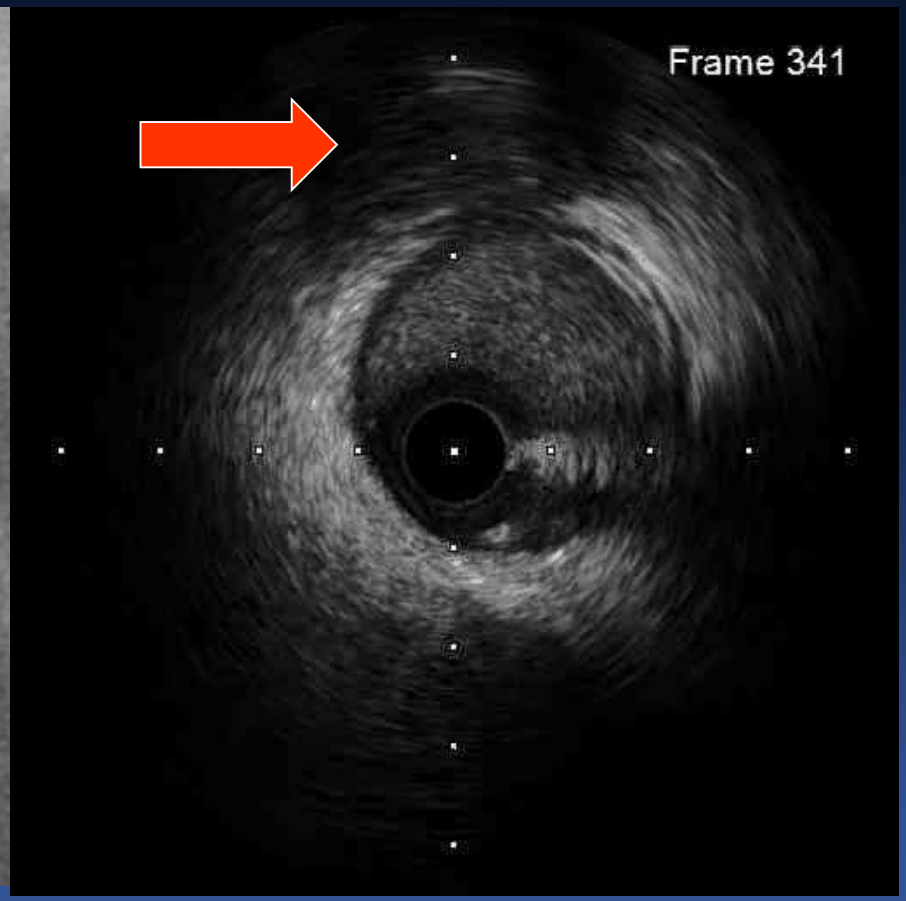
IVUS is Better?
for Real-Time Guidance for CTO PCI



Courtesy of SW Lee

IVUS is Better?
for Real-Time Guidance





Courtesy of SW Lee

IVUS is Better?

Zero Contrast Procedure Available with IVUS

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Imaging- and ph
coronary interv
administration i
a feasibility, safe

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Received 21 December 2015; revised 10 January 2016; accep

Aims The feasibility, safety, a
patients with advance
'zero contrast' PCI wi
(RRT) in patients with

Methods and results A total of 31 patients v
erular filtration rate =
coronary angiogram w
real-time intravascular
coronary flow reserv
adverse cardiovascula
of 79 days (IQR 33–2

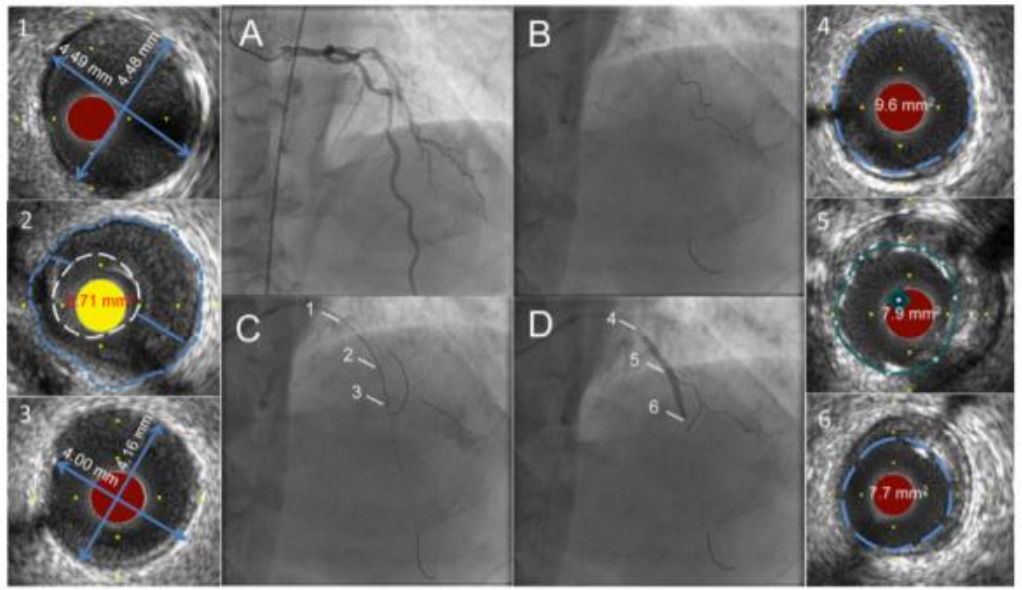
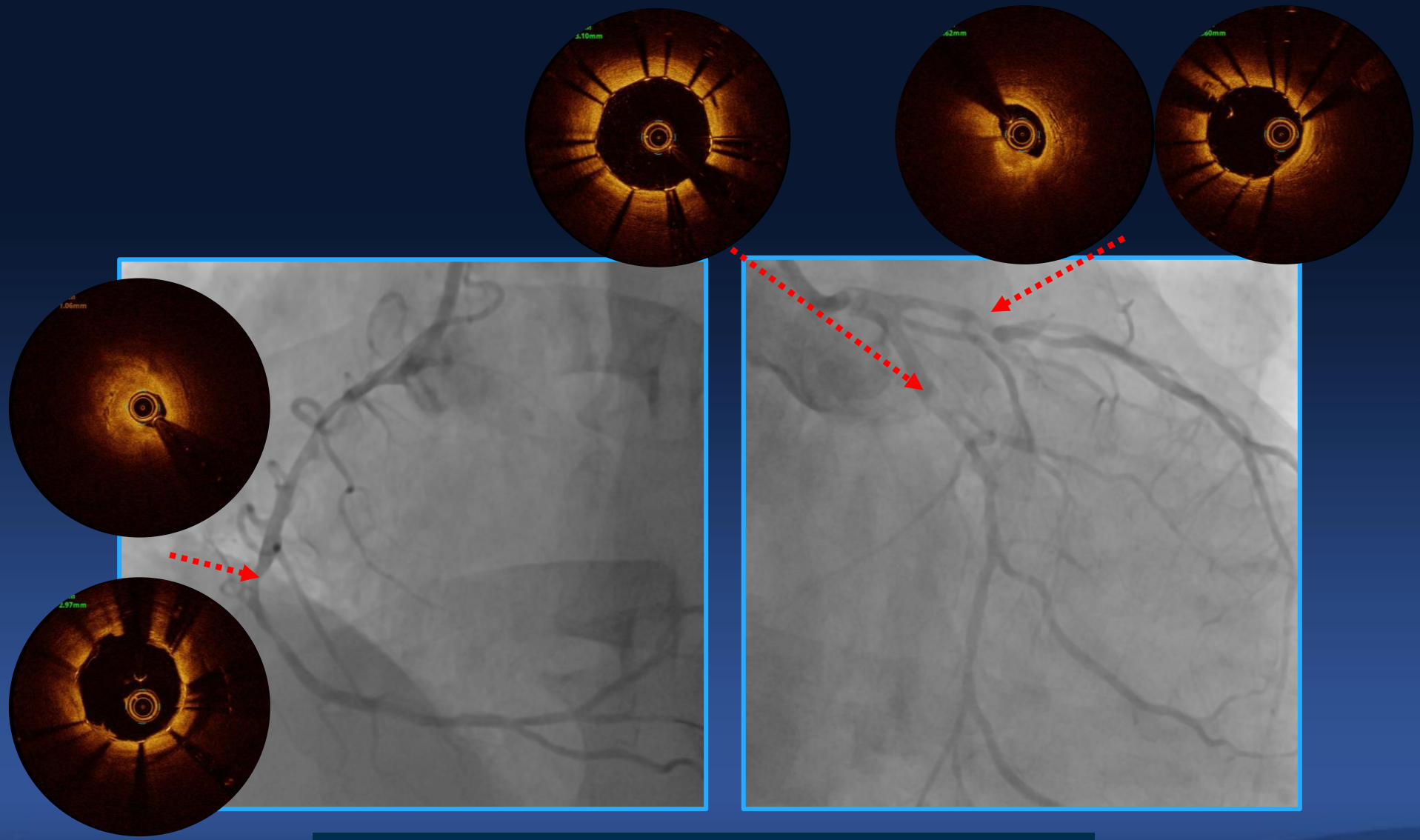


Figure 1 Ultra-low contrast coronary angiography followed by staged percutaneous coronary intervention with zero contrast. Cine images recorded at the initial angiography using ultra-low contrast volume are displayed on adjoining screen during the staged percutaneous coronary intervention (*A*) and used to guide catheter engagement, coronary guide wire placement in the left anterior descending artery, diagonal branch, and the circumflex artery, thus creating a metallic silhouette of the left coronary system (*B*). Intravascular ultrasound imaging of the left anterior descending artery is performed with proximal reference diameter (≈4.5 mm) (1), minimal luminal area (3.71 mm^2) (2), and distal reference diameter (≈4.0 mm) (3) measured for selection of the appropriate pre-dilation balloon and stent sizes. The co-registered dry cine image of intravascular ultrasound transducer placed at the distal reference (*C*) is used to guide the percutaneous coronary intervention. Following preparation of the lesion and deployment of a 3.5 × 38 mm drug-eluting stent (*D*), intravascular ultrasound is repeated to assess the result, to determine the proximal (9.6 mm^2) (4) and distal (7.7 mm^2) (6) reference areas, and to guide post-dilation of under-expanded segments to achieve the pre-determined MSA, defined as >90% of the mean of the proximal and distal reference areas, (7.9 mm^2) (5).

3 vessel PCI with OCT



Total Contrast Volume: 500cc

IVUS is Better?

- Stronger Evidence in Complex Lesions
- Vessel Size, Ostial Visualization
- Visualize Vessel Even without Flow
- Real Time Guidance and Manual Pull-Back
- No Contrast

But,

- Time consuming, No co-registration
- Identification of Thick Calcium or In-Stent neoatherosclerosis is difficult

My Thoughts: OCT vs. IVUS in Complex PCI

	OCT	IVUS
LM disease		Better
Ostial lesion		Better
Bifurcation	Delicate	Convenient
Calcification	Better, as far as it passes the lesion	
Long lesion	It saves time	
CTO		Better
In-stent restenosis	Better	
Renal dysfunction or CHF		Better

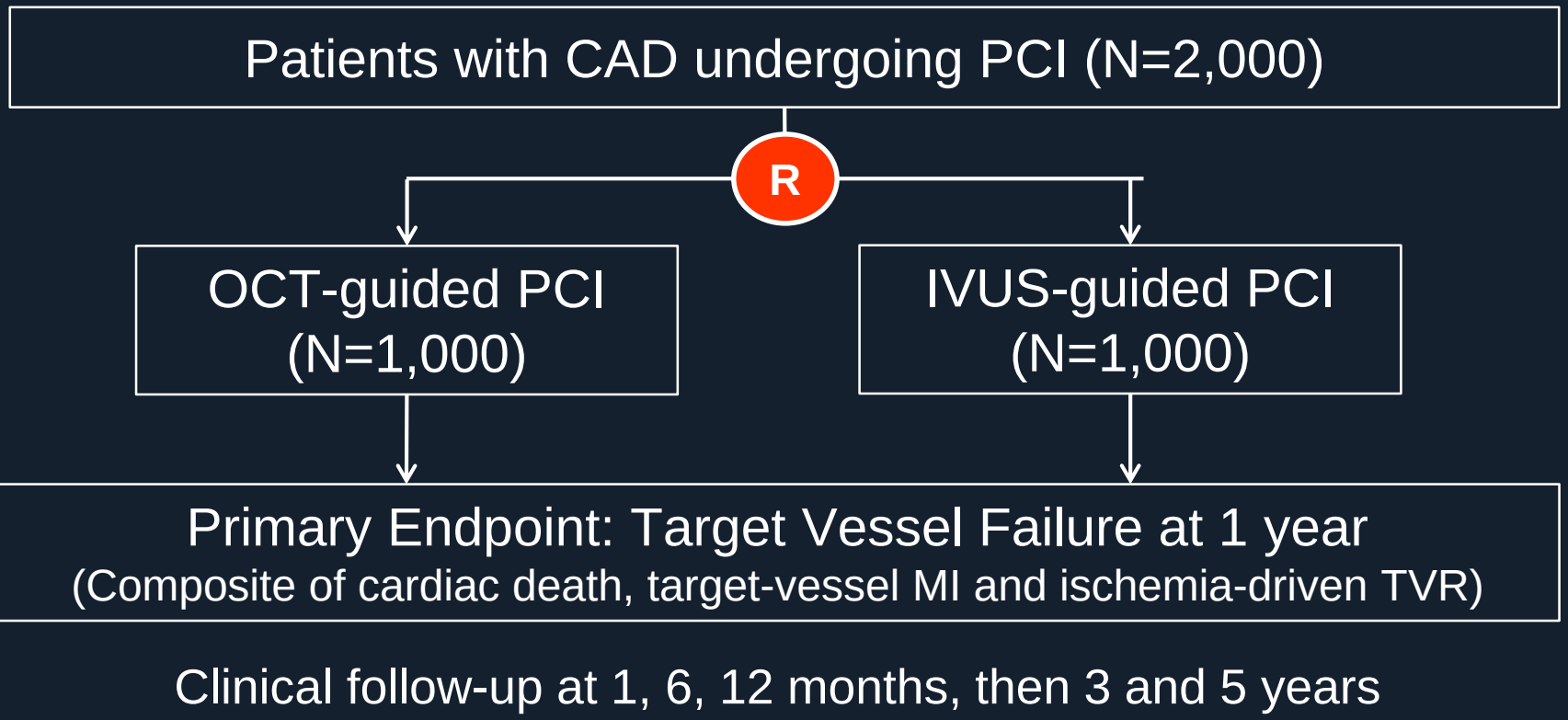
OCTIVUS Trial

Larger-sized, Pragmatic RCT
To detect differences in Clinical Outcomes
For All-Comer, including Complex PCI

Comparing
OCT-guided and IVUS-guided PCI

Optical Coherence Tomography versus Intravascular Ultrasound Guided Percutaneous Coronary Intervention

OCTIVUS Trial



Clinical follow-up at 1, 6, 12 months, then 3 and 5 years

Conclusions

OCT vs. IVUS for Guiding Complex PCI

- OCT-guided and IVUS-guided PCI showed similar procedural benefits.
- Which one is Better for Complex PCI? No Definitive Data yet. They are Different with their own Advantages and Limitations.
- Pragmatic RCT for all-comer PCI, OCTIVUS will provide a relative benefit of OCT- vs. IVUS-guided PCI in contemporary PCI practice.