

Long Journey of Imaging-guided PCI, Why We Need It

Myeong-Ki Hong, MD. PhD

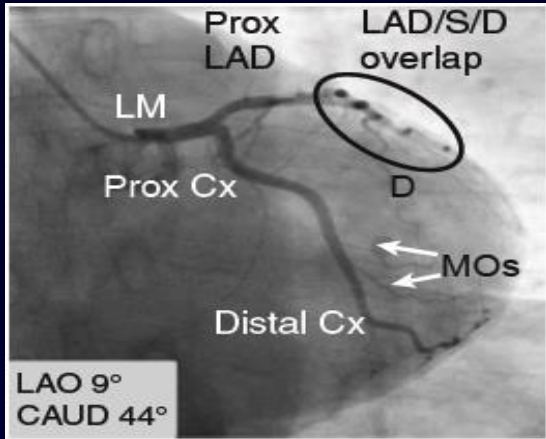
Professor of Medicine

**Cardiology Division, Severance Cardiovascular Hospital
Yonsei University College of Medicine, Seoul, Korea**

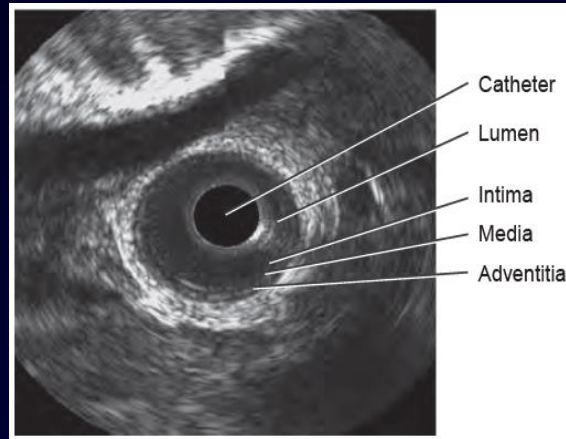
Conflict of Interest

- I have nothing to disclose

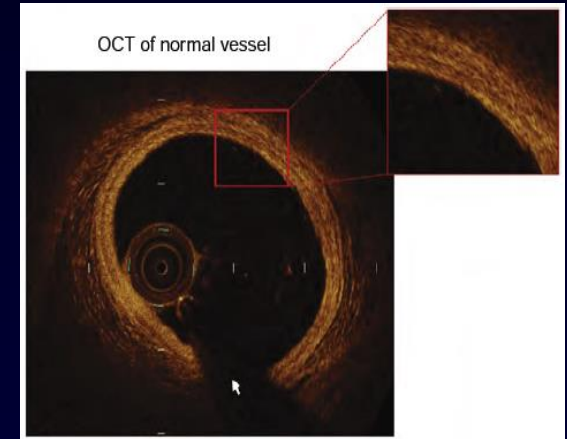
Angiography vs. Intravascular imaging



Coronary angiography



Intravascular ultrasound



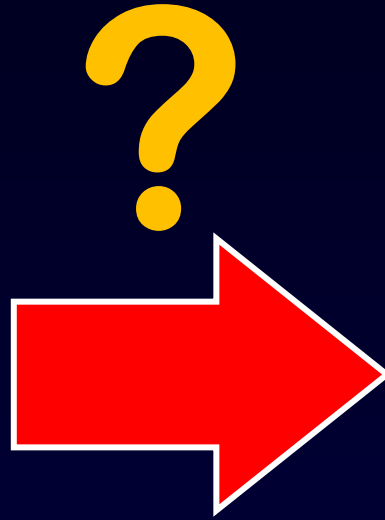
Optical coherent tomography

Coronary angiography is **luminogram** and is unable to visualize the atherosclerotic involvement of the arterial wall.

Intravascular imaging allows a **real-time, tomographic assessment** of lumen area, plaque composition, size, and distribution.

Clinical usefulness of IVUS

IVUS usage
during PCI



Improved
clinical
outcomes

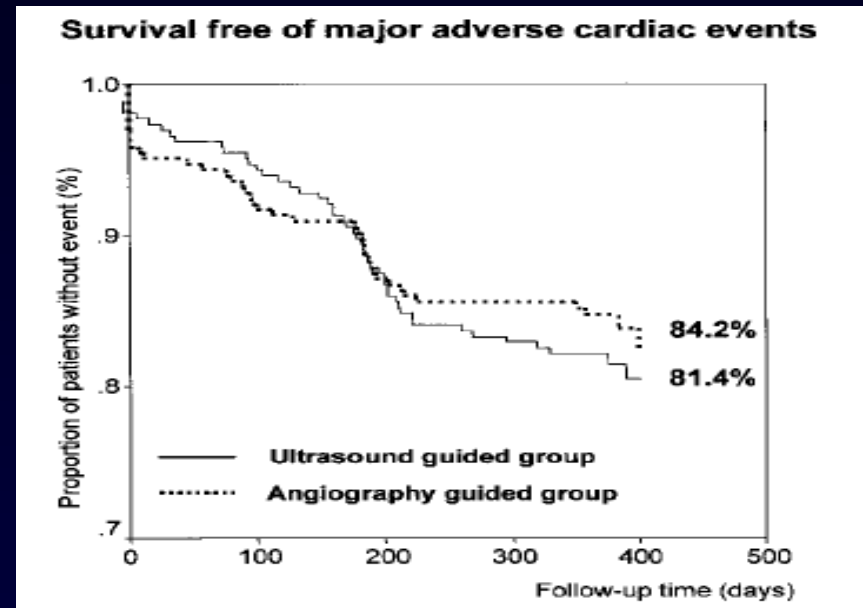
Randomized data to demonstrate
clinical usefulness of IVUS is limited
in lesions with BMS or DES

In BMS era

RESIST

Predictors of angiographic restenosis at 6 months		
	OR (95% CI)	P-value
IVUS guidance	0.94 (0.38-2.30)	0.89
Age	1.03 (0.99-1.07)	0.15
Average reference diameter	0.82 (0.40-1.70)	0.59
MLD after stent	0.79 (0.19-3.19)	0.73
Stent lumen CSA	0.70 (0.47-0.93)	0.007

OPTICUS



Late 1990 ~ Early 2000

Randomized trials comparing IVUS-guided and angiography-guided PCI demonstrated **no difference in binary restenosis and clinical outcomes after BMS implantation.**

Schiele et al. J Am Coll Cardiol 1998;32:320-328
Mudra et al. Circulation 2001;104:1343-1349

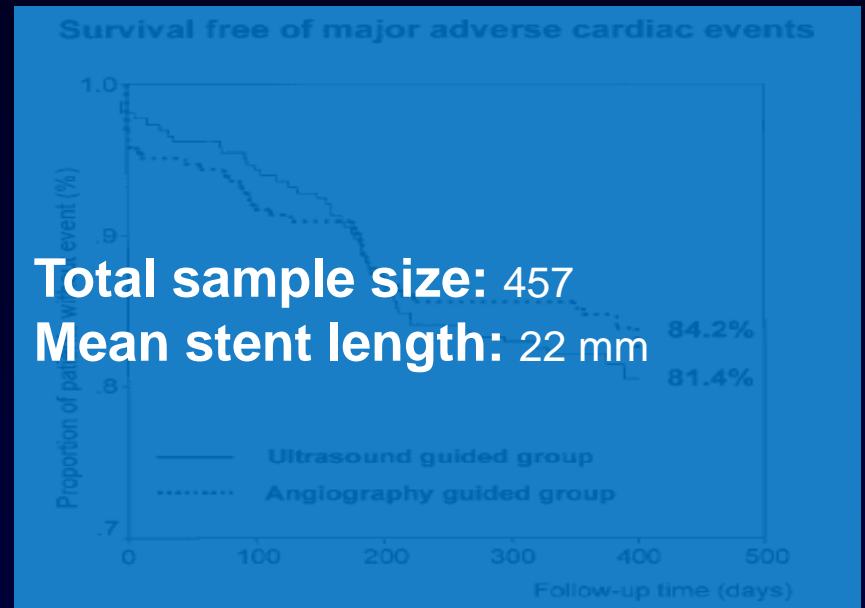
In BMS era

RESIST

Predictors of angiographic restenosis at 6 months

	OR (95% CI)	P-value
Total sample size: 155		
IVUS guidance	0.94 (0.38-2.30)	0.89
Mean stent length: 15.5 mm		
Stent lumen CSA:	0.92 (0.99-1.07)	0.15
7.16 mm ² (IVUS group) vs. 6.89 mm ² (Angio group); P=0.35	0.92 (0.48-1.75)	0.59
MLD after stent	0.79 (0.19-3.19)	0.73
Stent lumen CSA	0.70 (0.47-0.93)	0.007

OPTICUS



Late 1990 ~ Early 2000

The result may be resulted from **small sample size** of the trials and **short length of coronary artery lesion and stent (simple lesions)**.

Schiele et al. *J Am Coll Cardiol* 1998;32:320-328
 Mudra et al. *Circulation* 2001;104:1343-1349

In 1st- generation DES era

HOME DES IVUS: Taxus 62.5%, Cypher 37.5%

Clinical outcome at 18-month follow-up			
	DES (N=105)	DES+IVUS (N=105)	P- value
MACE	12	11	NS
Death	2	3	NS
MI	4	1	NS
TLR	6	6	NS
Stent thrombosis	6	4	NS

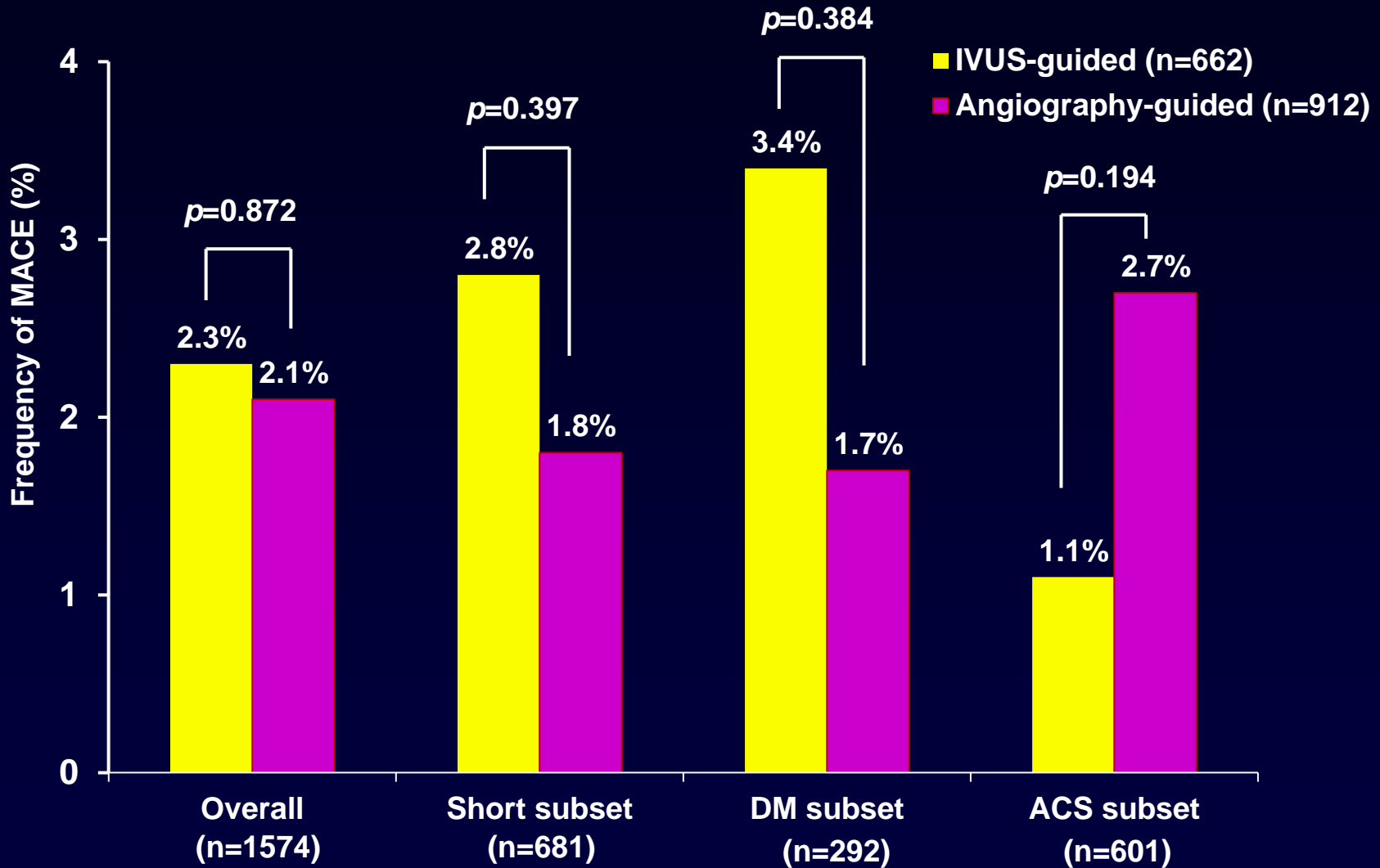
Total sample size: 210
Mean lesion length: 17.9 mm
Mean stent length: 22.9 mm

Late 2000 ~ Early 2010

Also in the **1st-generation DES era**, IVUS guidance was **not** associated with favorable clinical outcome. However, lesion and stent length were still short to elucidate the benefit of IVUS during PCI.

Jakabcin et al. Catheter Cardiovasc Interv 2010;75:578-583

Usefulness of IVUS in short-length narrowings (DES length ≤ 24 mm) in RESET trials



Yoon YW, Hong MK (corresponding author). *Am J Cardiol* 2013;112:642-646

IVUS predictors of angiographic restenosis after SES.

(N=543 lesions)

Angiographic restenosis rate

Stent CSA

Stent length	Total	< 5.5 mm ²	≥ 5.5 mm ²	p
Total	21/543 (3.9%)	14/189 (7.4%)	7/354 (2.0%)	0.002
< 40 mm	4/411 (1.0%)	3/127 (2.4%)	1/284 (0.4%)	0.090
≥ 40 mm	17/132 (12.9%)	11/62 (17.7%)	6/70 (8.6%)	0.116
p	<0.001	<0.001	<0.001	

Hong MK, et al. Eur Heart J 2006; 27: 1305-1310

Practice guidelines

2011 American guideline

Recommendations on intravascular imaging		
COR	LOE	Recommendation
IIb	B	IVUS may be considered for guidance of coronary stent implantation, particularly in cases of LM stenting

2014 European guideline

Recommendations on intravascular imaging		
COR	LOE	Recommendation
IIa	B	IVUS in selected patients to optimize stent implantation

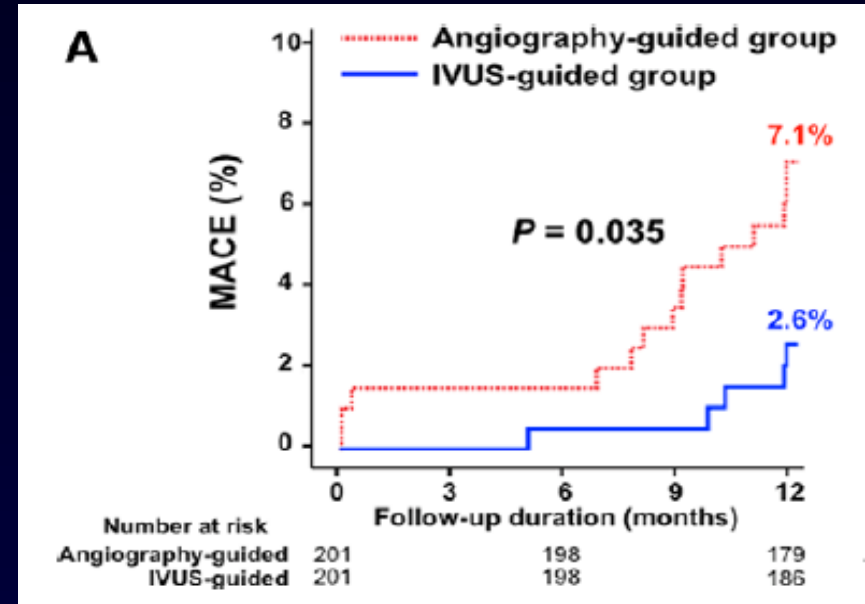
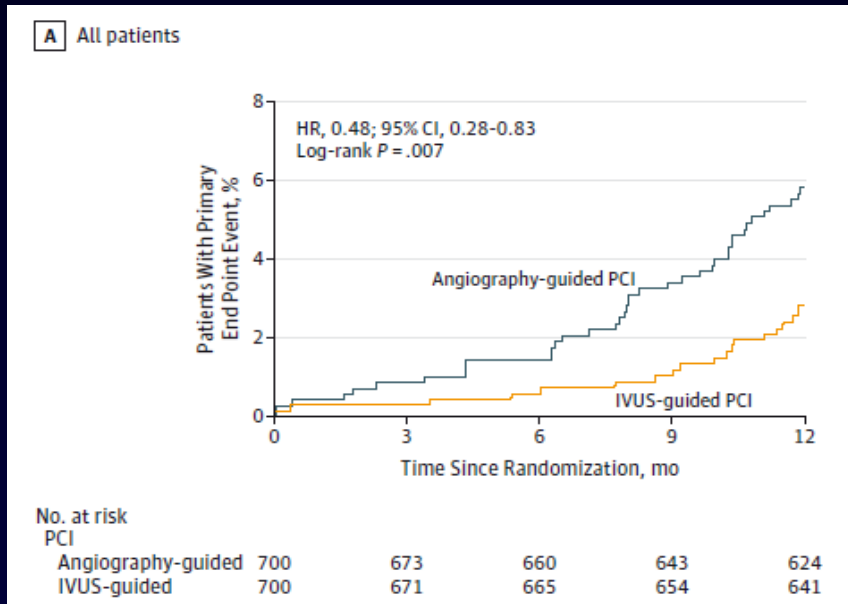
Until the early 2010', due to lack of evidence, recommendation for use of IVUS was limited in selected patients with **low class of recommendation**.

ACCF/AHA/SCAI guideline for PCI. *Circulation* 2011;124:e574-e651
ESC/EACTS guideline on myocardial revascularization. *Eur Heart J* 2014;35:2541-2619

In current-generation DES era, 2015

IVUS-XPL: 1400 patients with long lesion

CTO-IVUS: 402 CTO patients



Total stent length: 39.3 mm

As **next-generation DES era** began, PCI for complex coronary lesion, such as long lesion and CTO lesion, has compared between angiography-guided and IVUS-guided procedures. **In these trials, clinical benefit of IVUS-guided PCI has firstly elucidated.**

Hong et al. JAMA 2015;314:2155-2163

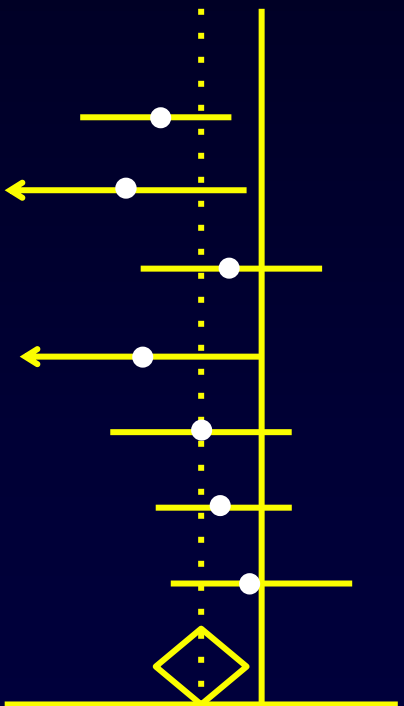
Kim et al. Circ Cardiovasc Interv 2015;8:e002592

Meta-analysis of 7 randomized trials: IVUS vs. angio-guided (first and next-generation) DES implantation

Event: cardiac death, MI, TLR

Study-level meta-analysis

Study	Year
IVUS-XPL	2015
CTO-IVUS	2015
AIR-CTO	2015
Tan et al	2015
Kim et al (RESET)	2013
AVIO	2013
HOME DES IVUS	2010
Overall	



OR	Events: IVUS	Events: Angio
0.49	19/700	39/700
0.37	5/201	14/201
0.82	25/115	29/115
0.42	8/61	17/62
0.60	12/269	20/274
0.67	24/142	33/142
0.91	11/105	12/105
0.60	104/1593	164/1599

IVUS better Angio better

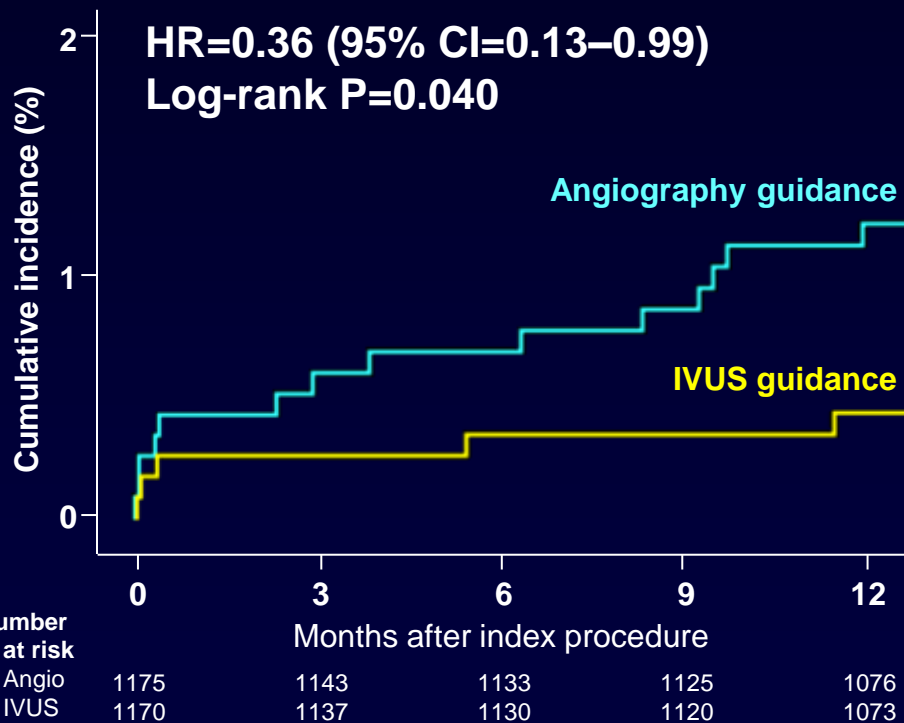
Islam Y. Elgendy et al. *Circ Cardiovasc Interv.* 2016;9:e003700



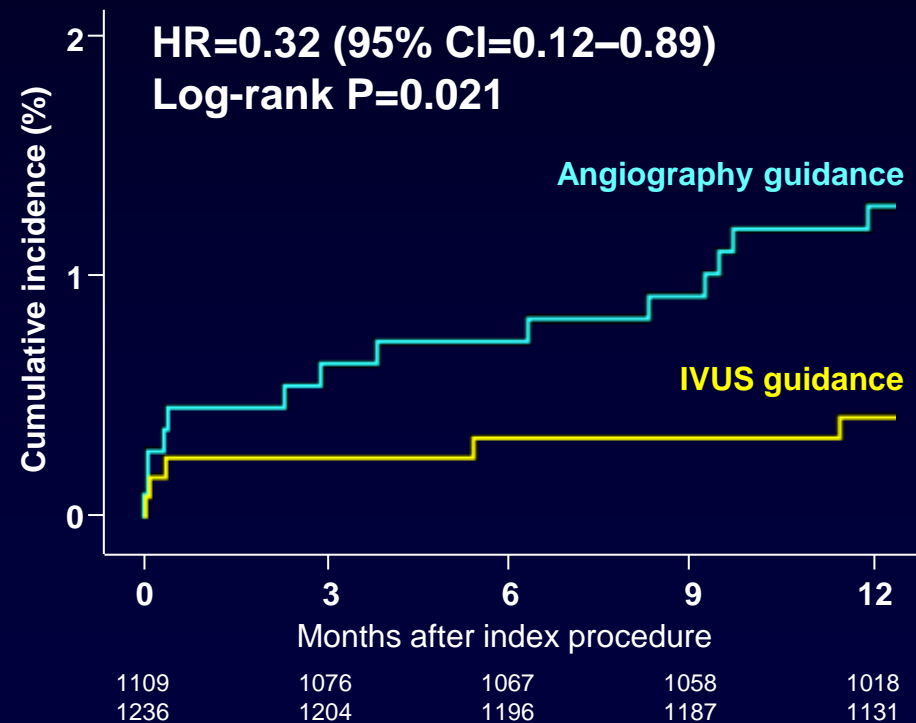
Meta-analysis with Individual Patient-Level Data from 2,345 Randomized Patients with second-generation DES (RESET Long, CTO IVUS and IVUS XPL)

Hard events of MACE (cardiac death, MI, or stent thrombosis)

Intention-to treat analysis



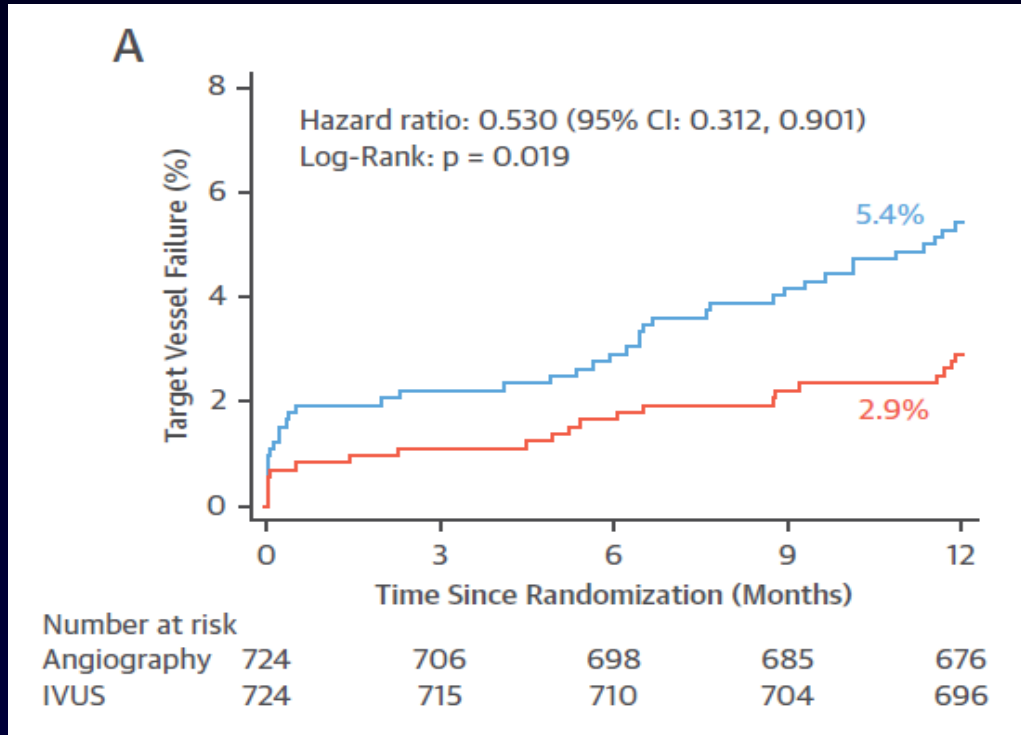
Per-protocol analysis



Shin DH, Hong MK (corresponding author), et al. *JACC Intv* 2016;9:2232-2239

In next-generation DES era, 2018

ULTIMATE, 2018: 1978 “all-comer” patients



Target-vessel failure

In randomized studies for “all-comer”, **IVUS-guided PCI significantly improved clinical outcome** compared to angiography-guided PCI.

Zhang et al. *J Am Coll Cardiol* 2018;72:3126-3137

Practice guidelines

2021 American guideline

Recommendations on intravascular imaging		
COR	LOE	Recommendation
<u>IIb → IIa</u>	B-R	In patients undergoind coronary stent implantation, <u>IVUS can be useful for procedural guidance</u> , particularly in cases of <i>left main or complex coronary artery stenting</i> , to reduce ischemic events.

2018 European guideline

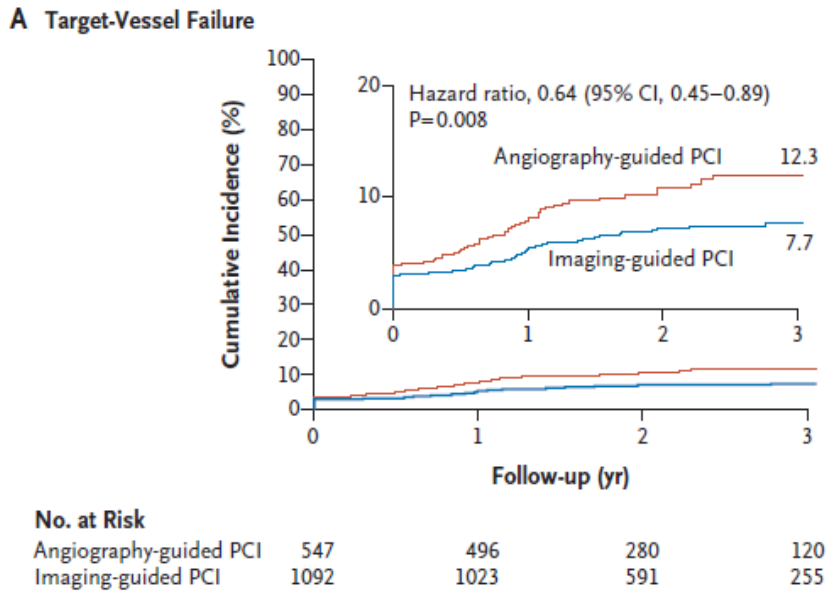
Recommendations on intravascular imaging		
COR	LOE	Recommendation
IIa	B	<u>IVUS or OCT should be considered</u> in selected patients to optimize stent implantation

The recommendations for intravascular imaging have been adjusted upward, however, **still limited IIa recommendation.**

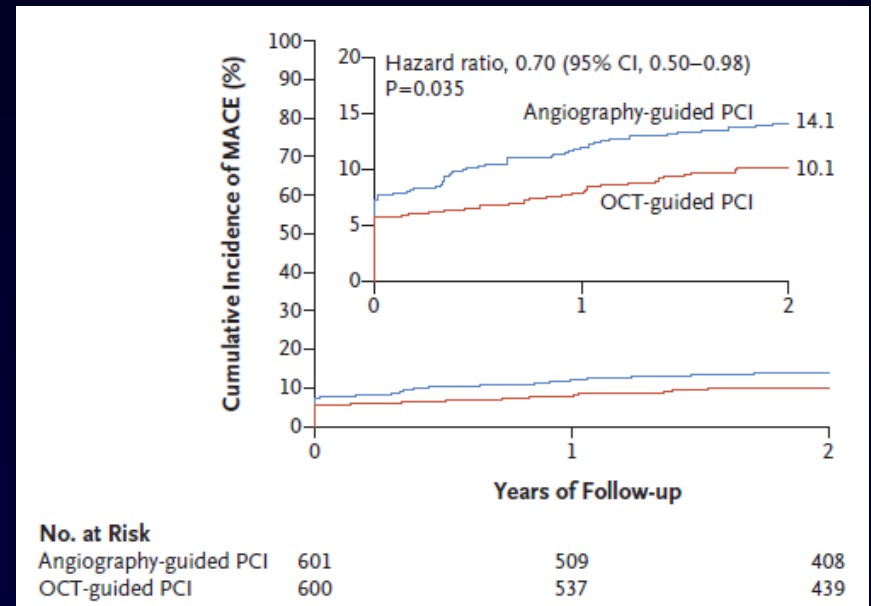
ACCF/AHA/SCAI guideline for coronary artery revascularization. *Circulation* 2022;145:e18-e114
ESC/EACTS guideline on myocardial revascularization. *Eur Heart J* 2019;40:87-165

Intravascular imaging for complex PCI

RENOVATE-COMPLEX-PCI trial



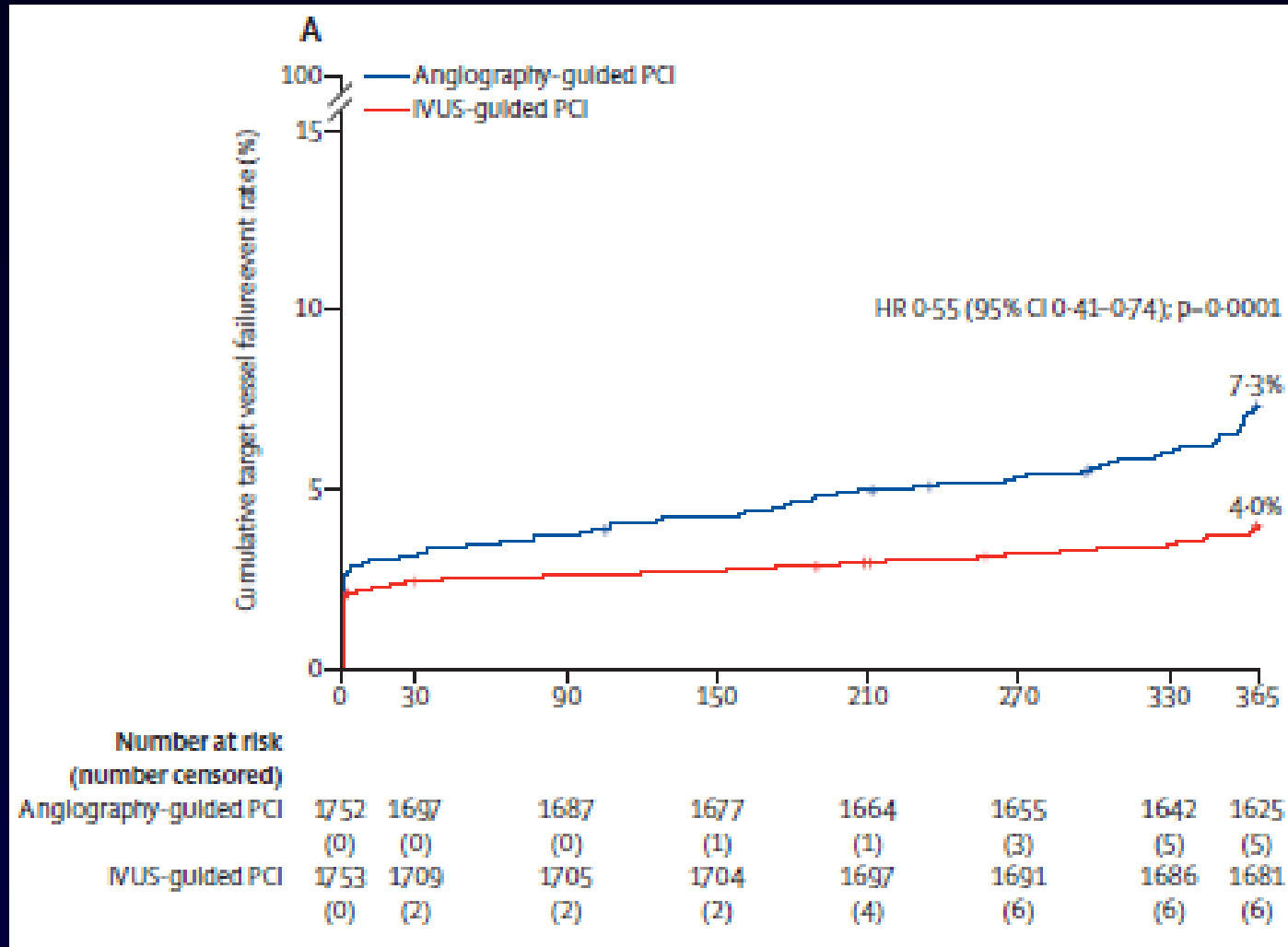
OCTOBER trial



Recent randomized trials regarding the benefit of OCT demonstrated that **OCT improved clinical outcome in patients undergoing complex PCI**, such as long lesion and bifurcation PCI.

Lee et al. *N Eng J Med* 2023;388:1668-1679
Holm et al. *N Eng J Med* 2023;389:1477-1487

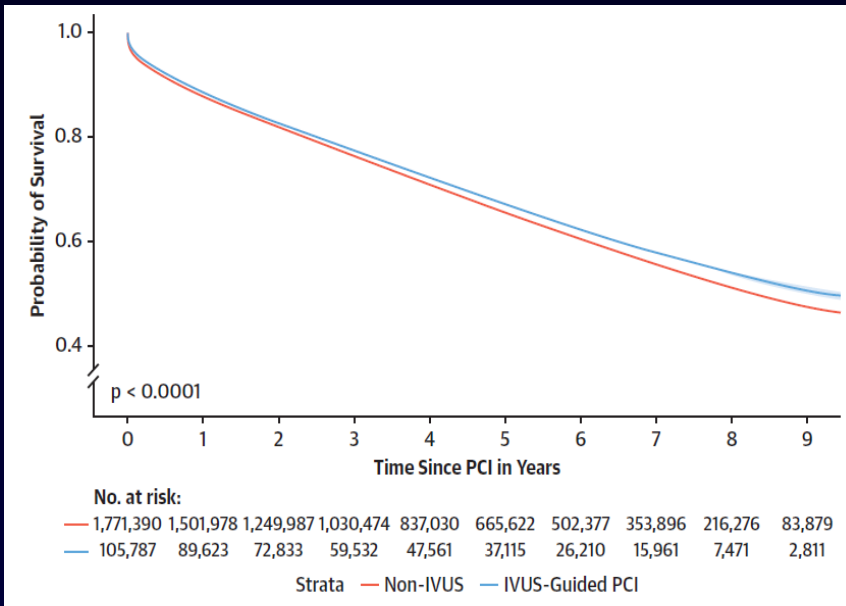
Intravascular imaging for ACS patients (IVUS-ACS)



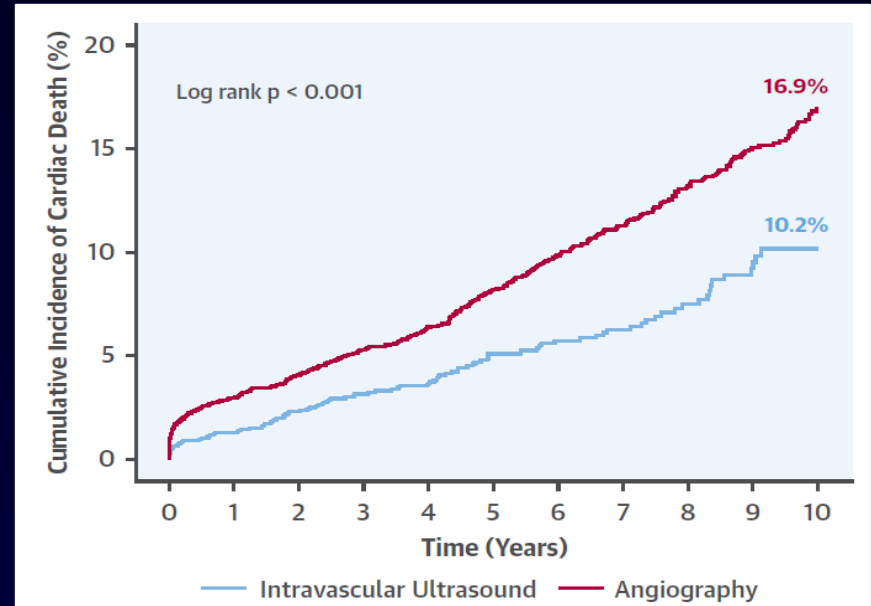
Li X, *Lancet* 2024 (in press)

Long-term clinical benefits

US Medicare source



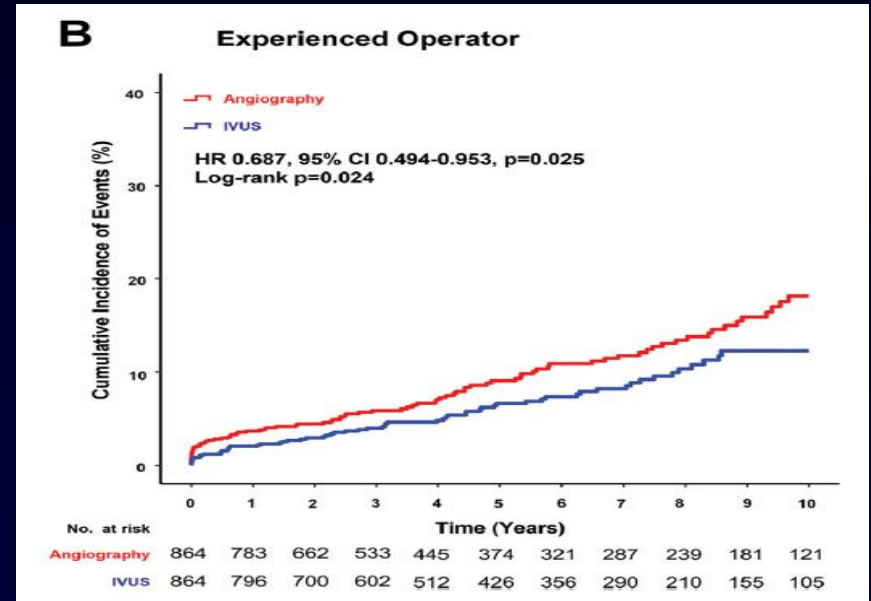
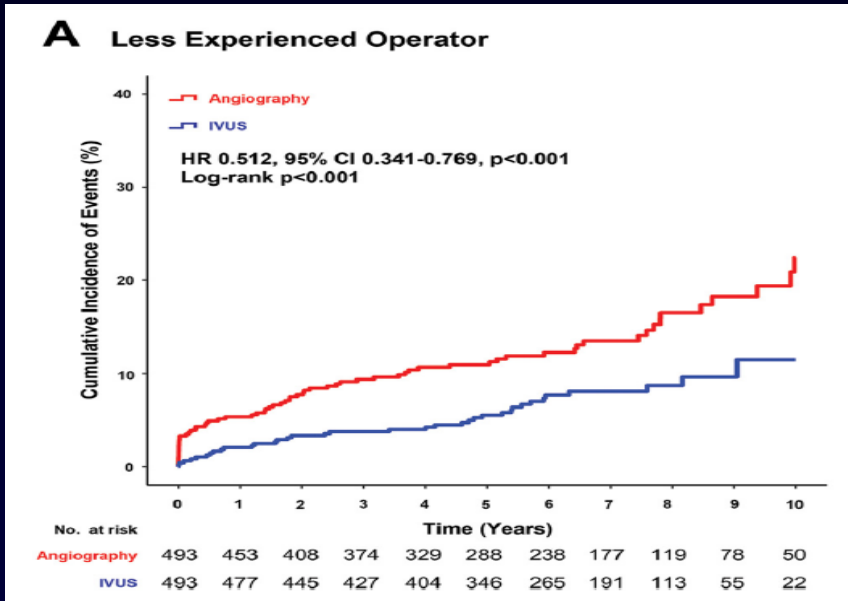
Korean single-center



In the **long-term analysis**, IVUS-guided PCI was associated with a lower risk of adverse event including cardiac death compared with angiography-guided PCI.

Mentias et al. *J Am Coll Cardiol Interv* 2020;13:1880-1890
Choi et al. *J Am Coll Cardiol Interv* 2019;12:607-620

Impact of IVUS according to operator's experience



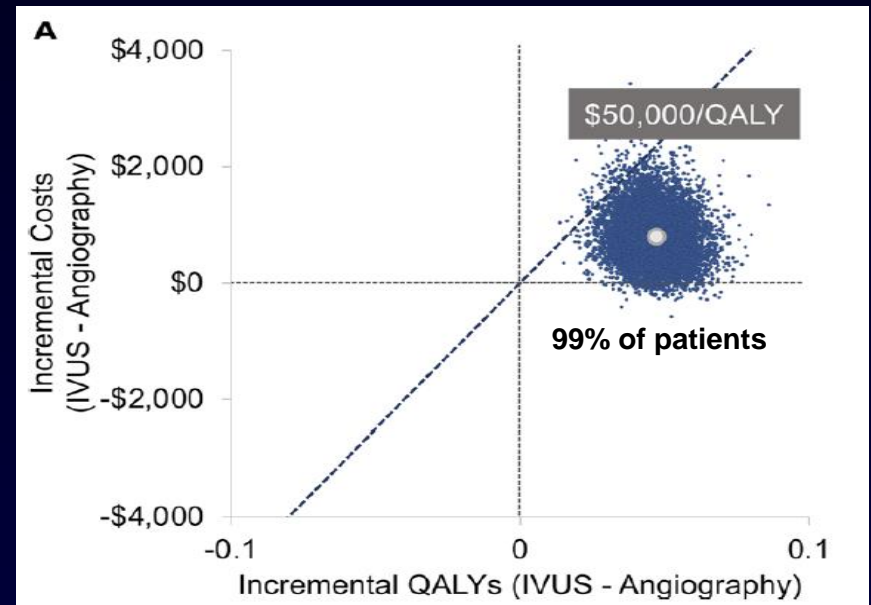
IVUS use was associated with a significantly lower risk of cardiac death or target-vessel MI regardless of operator's experience. Furthermore, **the beneficial effects of IVUS were more prominent for less experienced operators.** (P for interaction = 0.037)

Cost-effectiveness of Intravascular Imaging

Lifetime horizon (Cost as Australian dollar)			
	IVUS	Angiography	Incremental
Total cost	\$21,738	\$20,915	\$823
Life years	11.43	11.39	0.04
QALYs	9.40	9.35	0.05
ICER	$\Delta \text{Cost} / \Delta \text{QALY} = \$17,539$		

QALY: Quality-adjusted Life Years

Cost-effectiveness analysis from the Australian healthcare system sources demonstrated that **use of IVUS guidance is likely to be cost-effective** compared with angiography guidance **in 99% of patients** undergoing PCI.



Zhou et al. *Circ Cardiovasc Qual Outcomes* 2021;14:e006789

Conclusion

I would like to claim as follows.

Next American and European guideline

Recommendations on intravascular imaging		
COR	LOE	Recommendation
IIa→Ia	B→A	<u>IVUS or OCT should be considered</u> in patients for complex PCI

**Dreams will
come true**

