

# **How would you define stentable long lesion?**

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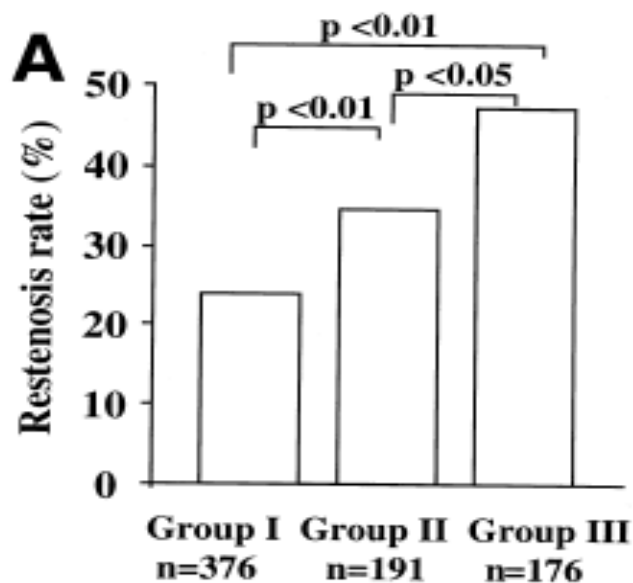
# Long coronary lesions

- Risk of restenosis
- Impact of intracoronary imaging

# Long coronary lesions

- **Risk of restenosis – BMS era**
- **Impact of intracoronary imaging**

# Restenosis-BMS (1)



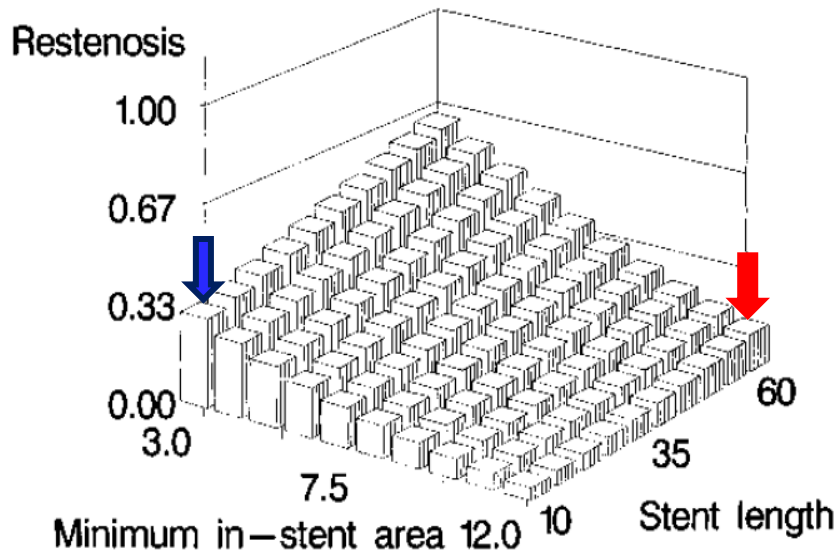
## Predictors of restenosis

	No restenosis	Restenosis	P-value
Stented segment length (mm)	25.1 ± 14.8	32.8 ± 19.9	<0.001
Baseline reference diameter (mm)	3.09 ± 0.52	2.79 ± 0.51	<0.001
Final percent stenosis	4 ± 10	6 ± 11	<0.05

In 725 patients with 1,090 lesions stratified by the length of stented segment (Group I: ≤20 mm, **Group II: 20-35mm**, **Group III: >35 mm**), the length of stented segment was an independent predictor of restenosis

*Kobayashi. et al. J Am Coll Cardiol 1999;34:651-659*

# Restenosis-BMS (2)



IVUS parameters predicting in-stent restenosis	
	P-value
<b>Model 1</b>	
Minimum in-stent area	<0.001
<b>Stent length</b>	<b>&lt;0.001</b>
<b>Model 2</b>	
Mean in-stent area	<0.001
<b>Stent length</b>	<b>&lt;0.001</b>

From 858 patients with BMS implantation from 3 registry data and 2 randomized data, **minimum in-stent area and stent length** were major IVUS parameters for predicting 6-month in-stent restenosis

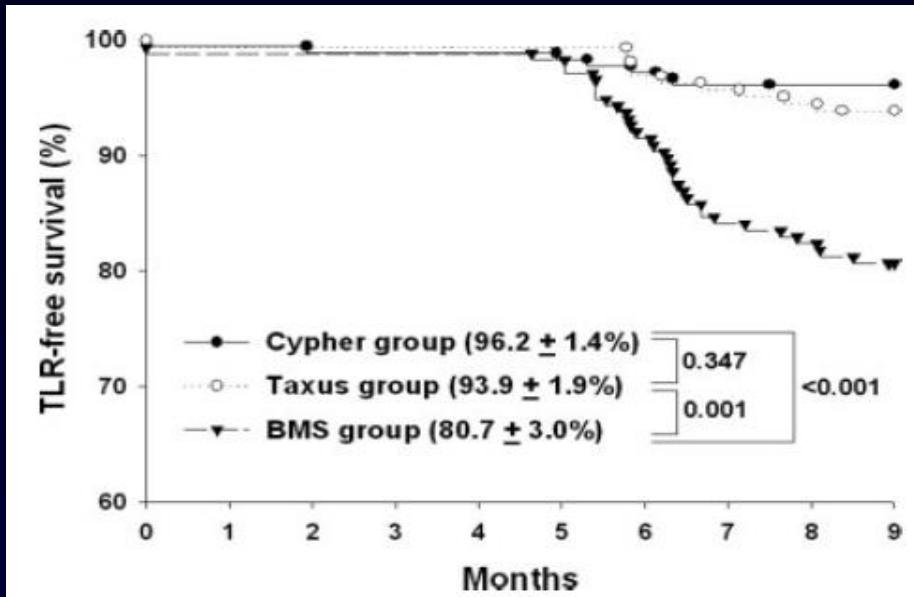
Feyter. et al. Circulation 1999;100:1777-1783

# Long coronary lesions

- **Risk of restenosis – DES era**
- **Impact of intracoronary imaging**

# DES versus BMS (1)

## LONG-DES I study



Independent predictors of in-segment restenosis		
	RR (95% CI)	P-value
DES implantation	0.20 (0.12-0.32)	<0.001
Among DES group		
PES implantation	3.08 (1.57-6.07)	0.001
In-stent MLD	0.31 (0.14-0.67)	0.003
Lesion length per 10 mm	1.29 (1.05-1.58)	0.014

In 527 patients with de novo long coronary **lesions** ( $\geq 24$  mm) treated with long **stents** ( $\geq 28$  mm), the rate of MACE and TLR was lower in DES group (SES: 3.8%, PES: 6.0%) than BMS group (19.2%).

Lesion length was an independent predictor of restenosis among DES group.

Kim. et al. Cathet Cardiovasc Interv 2006;67:181-187

# Restenosis-DES

IVUS parameters predicting angiographic restenosis				
	Univariate analysis		Multivariate analysis	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Reference vessel diameter	0.230 (0.069-0.769)	0.017		
Pre-intervention QCA MLD	0.416 (0.178-0.970)	0.042		
Post-intervention QCA MLD	0.209 (0.065-0.667)	0.008		
Lesion length	1.053 (1.026-1.081)	<0.001		
Stent:Lesion length ratio	0.162 (0.012-2.147)	0.167		
Number of stent	3.325 (1.978-5.592)	<0.001		
<b>IVUS stent length</b>	<b>1.046 (1.026-1.067)</b>	<b>&lt;0.001</b>	<b>1.029 (1.002-1.056)</b>	<b>0.035</b>
Stent under-expansion	4.843 (1.969-11.914)	0.001		
<b>Final minimum stent CSA</b>	<b>0.569 (0.407-0.795)</b>	<b>0.001</b>	<b>0.586 (0.387-0.888)</b>	<b>0.012</b>
Distal reference segment EEM CSA	0.838 (0.708-0.993)	0.041		
Distal reference segment lumen CSA	0.766 (0.590-0.996)	0.047		

In 550 patients with 670 lesions treated with IVUS-guided SES implantation, **minimum stent area** and **stent length** were independent predictors of angiographic restenosis.

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

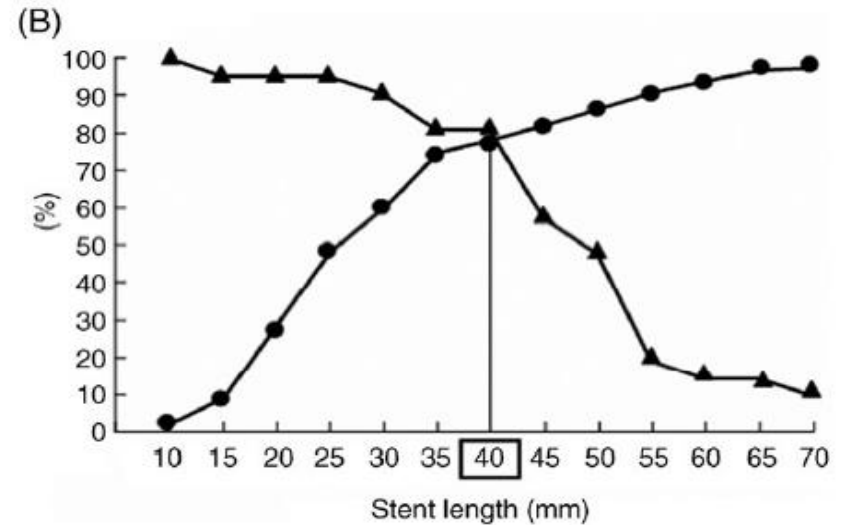
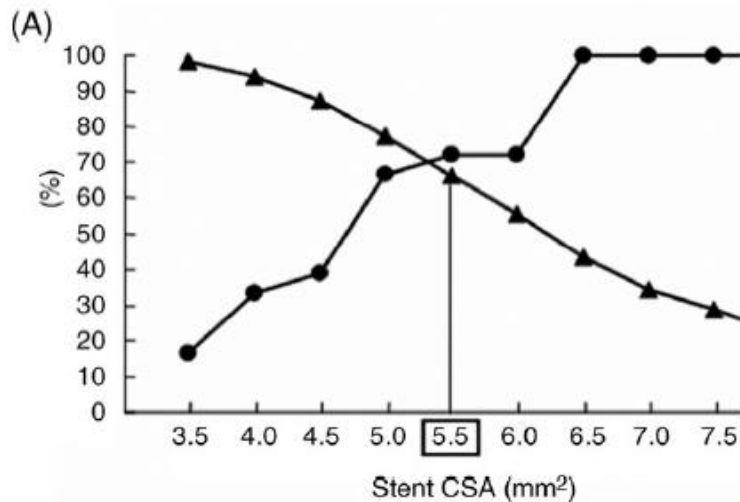


# Restenosis-DES

IVUS parameters predicting angiographic restenosis

Univariate analysis

Multivariate analysis



Distal reference segment EEM CSA

0.838 (0.708-0.993)

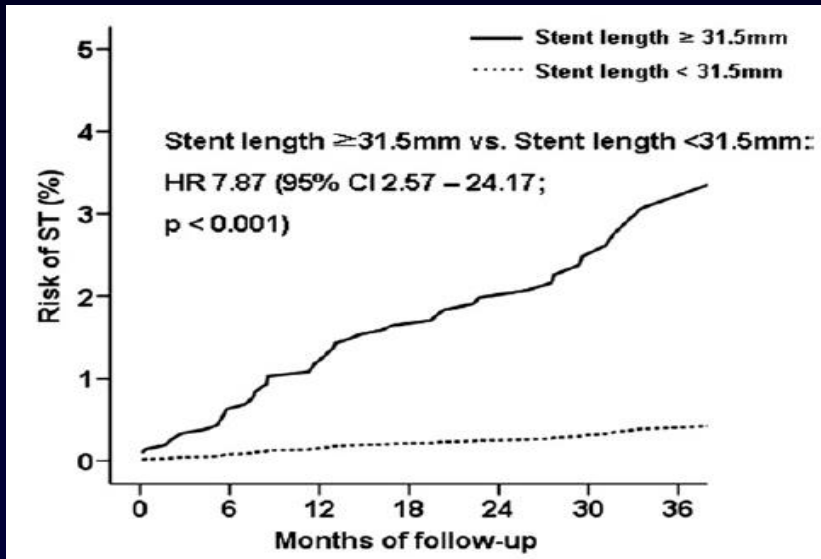
0.041

The optimal cut-off values:

**Final minimum stent area – 5.5 mm<sup>2</sup>**

**Stent length – 40 mm**

# Stent thrombosis



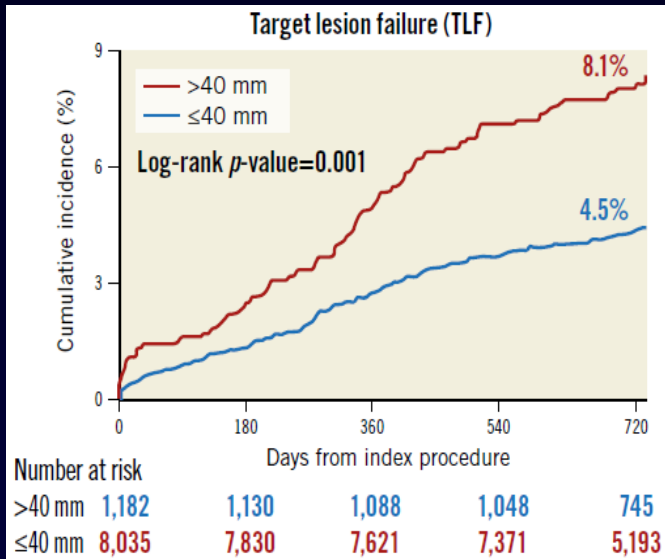
Independent predictors of overall stent thrombosis		
	HR (95% CI)	P-value
Renal failure	7.97 (2.24-28.36)	0.001
Discontinuation of antiplatelet $\leq 6$ months	2.77 (1.12-6.88)	0.028
Total stent length per lesion	1.11 (1.06-1.15)	<0.001

In 3,145 patients treated with SES or PES, the length of stented segment was independently associated with the incidence of ST.

The value of stent length  $\geq 31.5$  mm was a threshold for the prediction of ST.

# Second-generation DES

## GRAND-DES registry



## Clinical outcomes

	Total stent length		HR (95% CI)	P-value
	≤40 mm	>40 mm		
<b>Target lesion failure</b>	369 (4.6)	102 (8.6)	1.88 (1.67-2.13)	<0.001
<b>Cardiac death</b>	207 (2.6)	54 (4.6)	1.43 (1.20-1.70)	<0.001
<b>Target vessel MI</b>	32 (0.4)	9 (0.8)	2.10 (1.38-3.22)	<0.001
<b>Clinically driven TLR</b>	171 (2.1)	52 (4.4)	2.54 (2.14-3.01)	<0.001

In 9,217 patients with second-generation DES at a single target lesion from 5 multicenter registries

**Primary endpoint:** Target lesion failure (TLF), a composite of cardiac death, target vessel MI, clinically driven TLR

**Long total stent length >40 mm** was associated with unfavorable outcome

*Kong et al. Eurointervention 2021;16:1318-1325*

# Second-generation DES

GRAND-DES registry

Target Lesion Failure (TLF)

1. Stent length is a strong predictor of restenosis after PCI even in DES era
2. **Stent length >40 mm** could be a cut-off value for predicting restenosis

9,217 patients with second-generation DES at a single target lesion from 5 multicenter registries

Primary endpoint: Target lesion failure (TLF), a composite of cardiac death, target vessel MI, clinically driven TLR

*Long total stent length >40 mm* was associated with unfavorable outcome

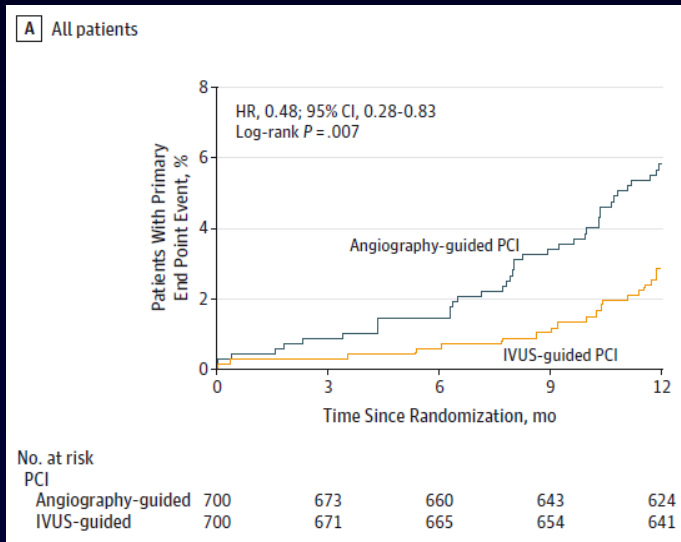
Kong et al. Eurointervention 2021;16:1318-1325

# Long coronary lesions

- Risk of restenosis
- Impact of intracoronary imaging

# Intracoronary imaging

## IVUS-XPL trial



### Clinical outcomes at 1 year

	IVUS-guided	Angiography-guided	HR (95% CI)	P-value
<b>MACE</b>	<b>19 (2.9)</b>	<b>39 (5.8)</b>	0.48 (0.28-0.83)	0.007
<b>Cardiac death</b>	<b>3 (0.4)</b>	<b>5 (0.7)</b>	0.60 (0.14-2.52)	0.48
<b>Target lesion-related MI</b>	<b>0</b>	<b>1 (0.1)</b>	-	0.32
<b>Ischemia-driven TLR</b>	<b>17 (2.5)</b>	<b>33 (5.0)</b>	0.51 (0.28-0.91)	0.02

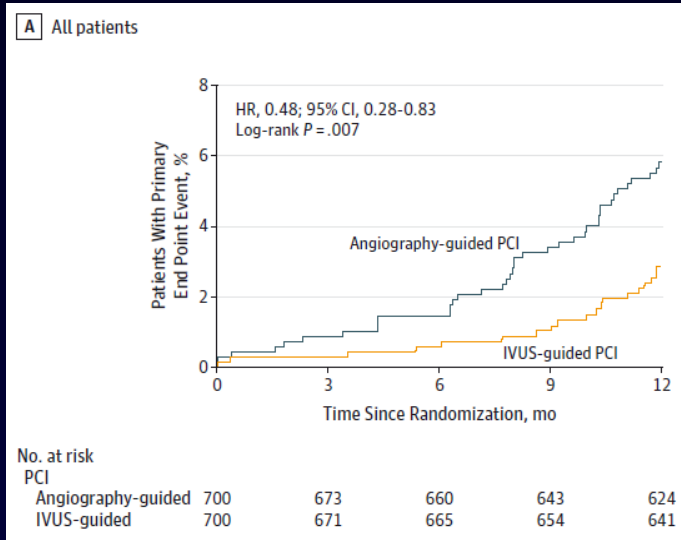
In 1,400 patients with long coronary lesions (**stent length  $\geq 28$  mm**) randomly assigned to either IVUS-guided or angiography-guided EES implantation

**Primary endpoint:** Cardiac death, target lesion-related MI, ischemia-driven TLR  
IVUS-guidance resulted in a significantly lower rate of the primary endpoint at 1 year.

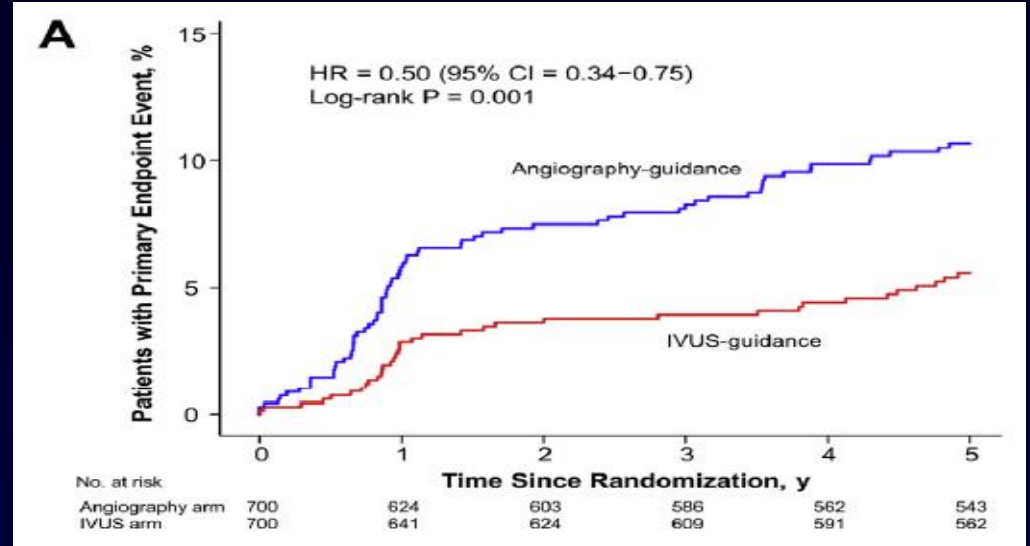
Hong. et al. JAMA 2015;314:2155-2163

# Intracoronary imaging

## IVUS-XPL trial



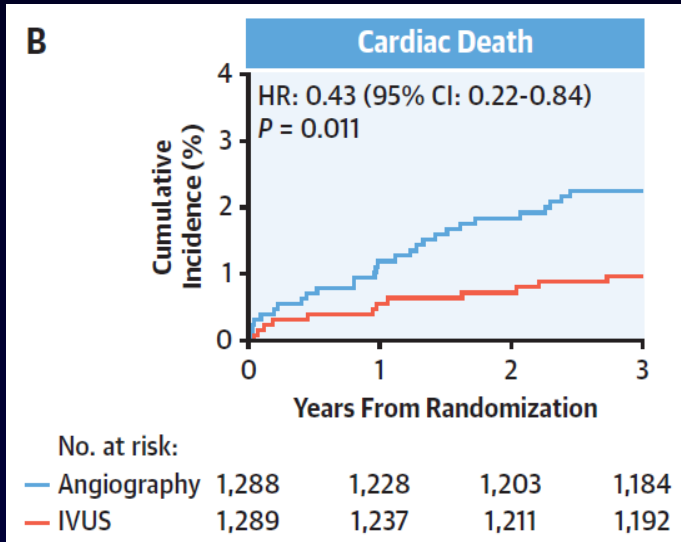
## 5-Year Follow-up of the IVUS-XPL trial



**IVUS-guided stent implantation resulted in a significantly lower rate of MACE up to 5 years.**

# Intracoronary imaging

## IVUS-XPL trial + ULTIMATE trial



Incidence of cardiac death at 3 year

	IVUS -guided	Angiography -guided	HR (95% CI)	P- value
<b>Overall</b>	12 (1.0)	28 (2.2)	0.43 (0.22-0.84)	0.011
<b>IVUS-XPL trial</b>	3 (0.4)	9 (2.0)	0.34 (0.09-1.24)	
<b>ULTIMATE trial</b>	9 (1.4)	19 (3.3)	0.47 (0.21-1.03)	

Patient-level analysis of 2,577 patients with **DES length  $\geq 28$  mm**

Primary endpoint: **Cardiac death**

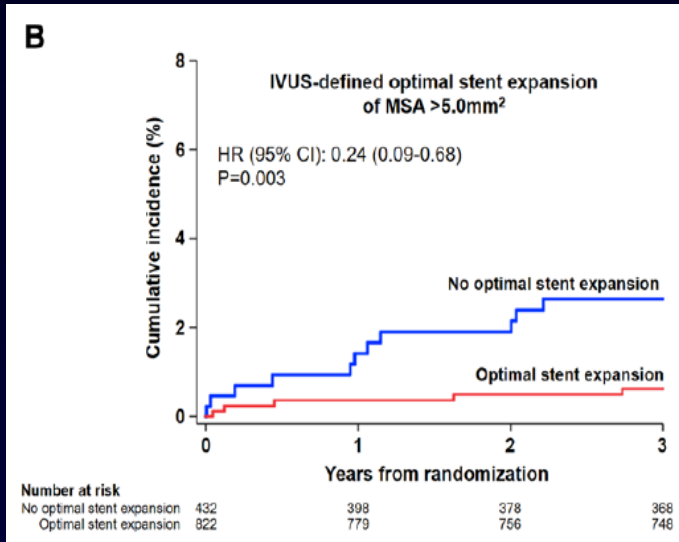
IVUS-guided long DES implantation improved long-term cardiac survival compared with angiography-guided implantation.

Hong. et al. JACC Cardiovasc Interv 2022;15:208-216



# Intracoronary imaging

## IVUS-XPL trial + ULTIMATE trial



### Primary endpoint at 3 year according to IVUS-defined optimal stent expansion

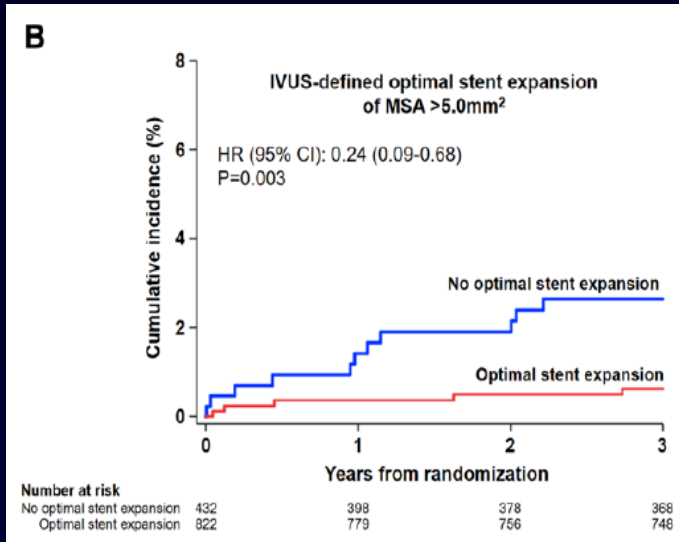
	Optimal expansion	No optimal expansion	HR (95% CI)	P-value
MSA >5.5 mm <sup>2</sup>	3 (0.5)	13 (2.2)	0.21 (0.06-0.75)	0.008
MSA > 5.0 mm <sup>2</sup>	5 (0.6)	11 (2.6)	0.24 (0.09-0.68)	0.003
MSA/distal reference lumen area >90%	6 (0.5)	10 (2.4)	0.32 (0.12-0.88)	0.019

1,254 patients with **DES length ≥28 mm** and available IVUS data  
Primary endpoint: Cardiac death, target lesion-related MI, stent thrombosis

**Optimal stent expansion** was associated with improved long-term clinical outcomes **even among long DES implantation**

# Intracoronary imaging

## IVUS-XPL trial + ULTIMATE trial



Multivariate analysis for achieving ABSOLUTE stent expansion		
	HR (95% CI)	P-value
Achieving MSA >5.5 mm <sup>2</sup>		
Reference vessel diameter	3.89 (2.79-5.42)	<0.001
Achieving MSA > 5.0 mm <sup>2</sup>		
Reference vessel diameter	4.05 (2.87-5.73)	<0.001

Reference vessel diameter was independent determinants for achieving absolute stent expansion.

# Intracoronary imaging

IVUS-XPL trial + ULTIMATE trial

1. **Intracoronary imaging** could improve clinical outcome for patients underwent PCI for long lesion
2. **Optimal stent expansion** is also associated with favorable clinical outcome
  1. Absolute expansion achieving  $MSA > 5.0 \text{mm}^2$  is considerable
  2. Relative expansion achieving  $MSA/\text{distal reference lumen area} > 90\%$  may be considered for long lesions within **small coronary vessels**
3. **Small reference vessel diameter** may hinder optimal stent expansion.

*Optimal stent expansion* was associated with improved long-term clinical outcomes *even among long DES implantation*

Lee. et al. Circ Cardiovasc Interv 2021;14:e011124

# Conclusion

- PCI for long coronary lesion (DES length between 30 and 40 mm) is challenging even in DES era.
- Long stent length is associated with higher rates of **restenosis and repeat revascularization**.
- **Intracoronary imaging** could improve clinical outcome for patients with long coronary stents.
- Achievement of **optimal stent expansion** is important for favorable outcome after PCI for long coronary lesion.