Optimal Minimal Stent Area and Impact of Stent Underexpansion in Left Main Up-Front 2-Stent Strategy

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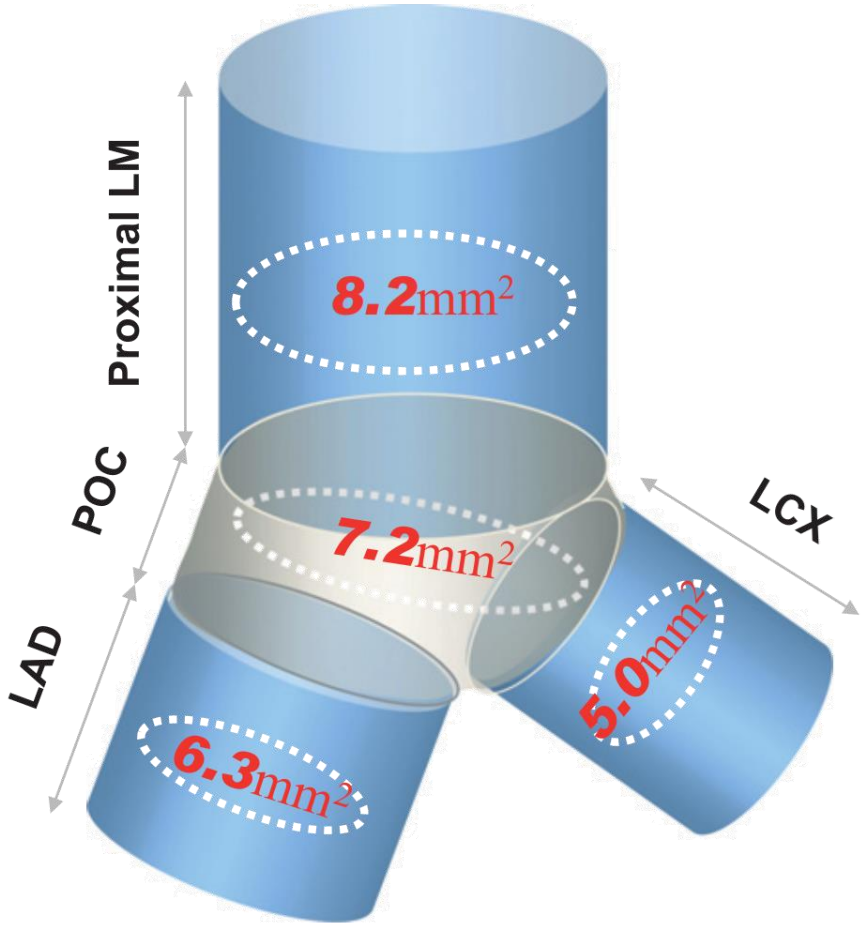
Background

- Current guidelines recommend the use of intracoronary imaging during left-main (LM) stenting because intravascular ultrasound (IVUS) guidance can improve clinical outcomes by ensuring well-apposed and adequately expanded stents.

- Previously proposed criteria for optimal stent expansion were based on IVUS-measured minimal stent area (MSA) in patients undergoing LM stenting to predict angiographic restenosis.

Kang SJ, et al. *Circ Cardiovasc Interv.* 2011;4:562-569

“5-6-7-8” MSA criteria



- Between March 2003 and May 2009
- Heterogeneous population (n=403)
  a single-stent (n=289, 72%)
  an upfront two-stent (28%)
- Predicted the risk of angiographic restenosis at 9-month follow-up

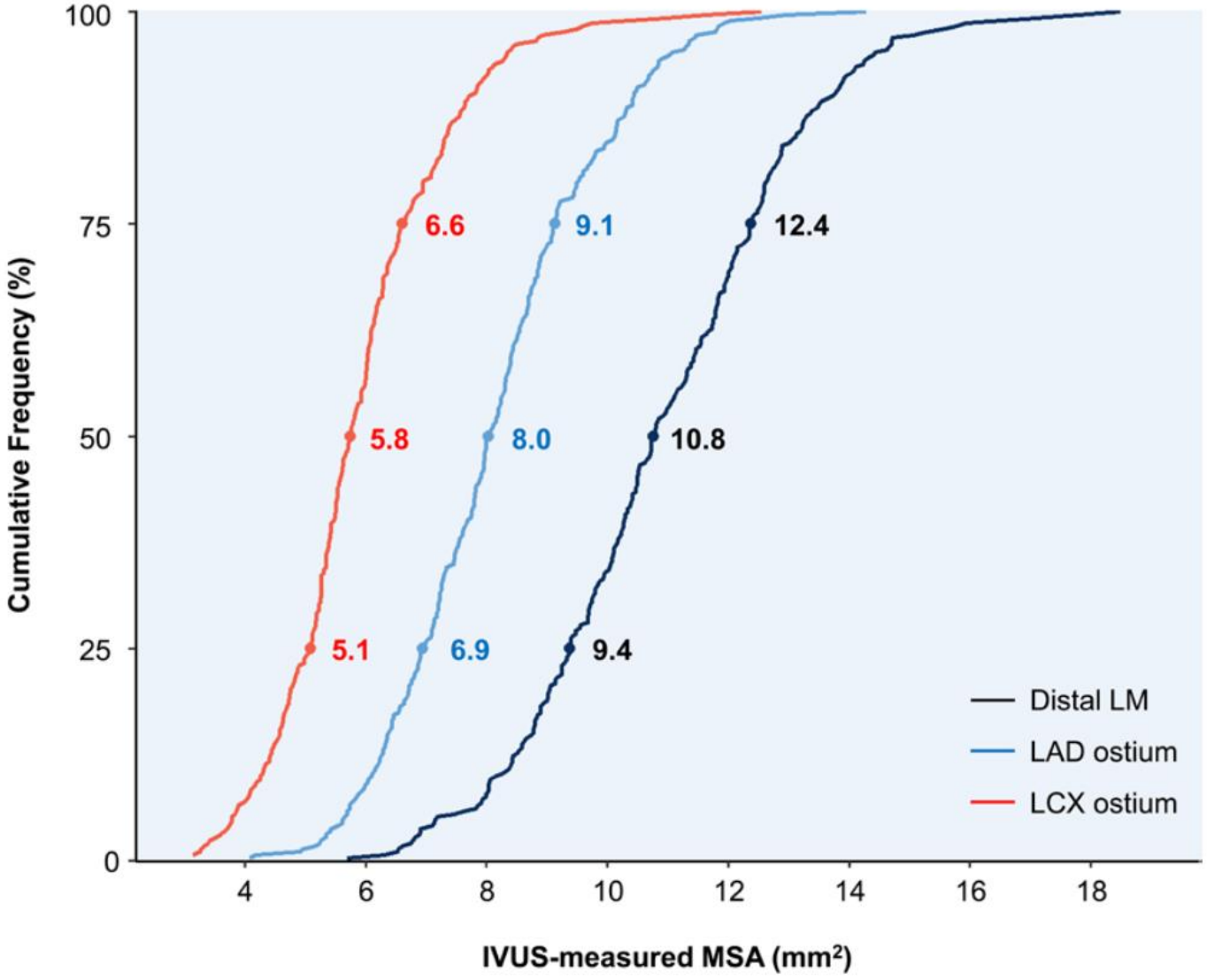
Objective

- To revise the MSA criteria for optimal stent expansion in patients undergoing an up-front 2-stent strategy using the crush technique for LM bifurcation lesions to predict the 5-year clinical outcomes.

Methods

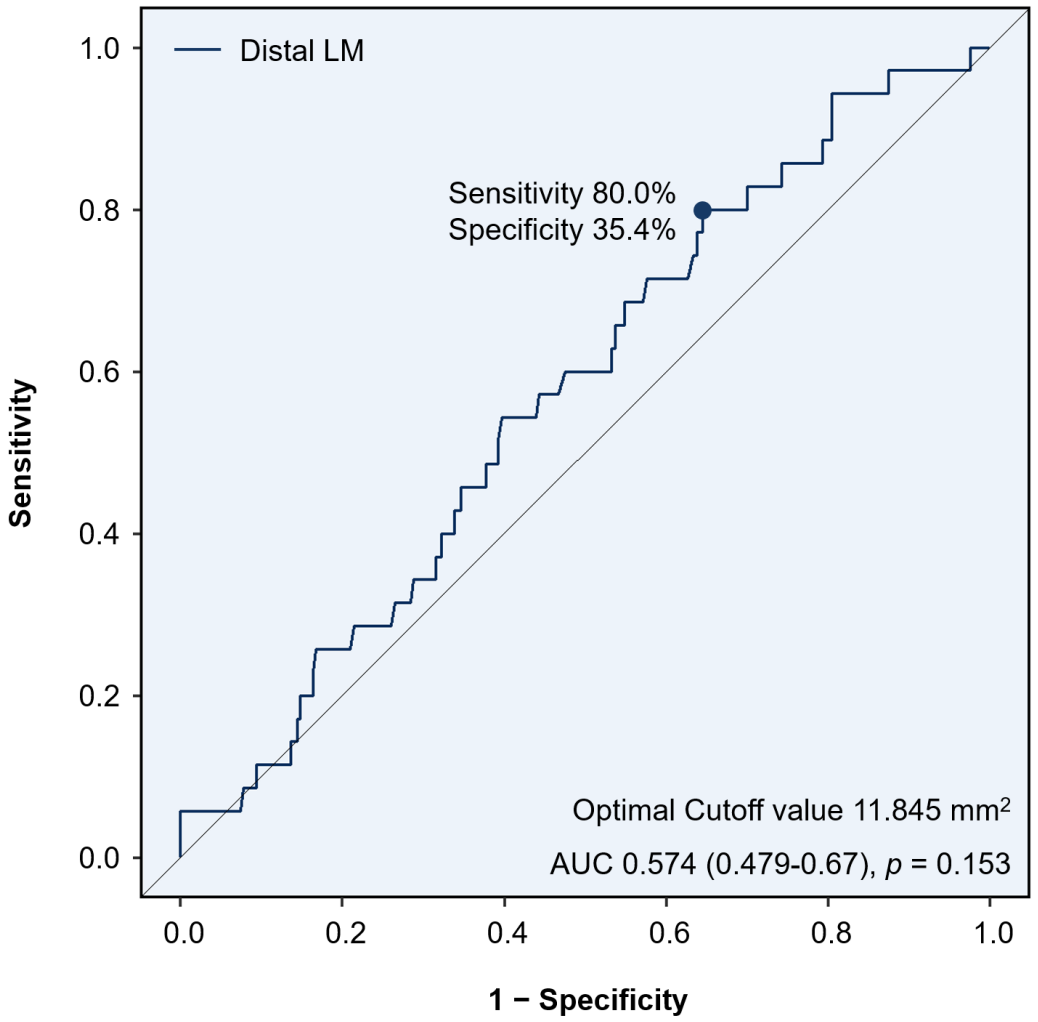
- We identified 292 consecutive patients with LM bifurcation stenosis who were treated using the crush technique from March 2005 to December 2019.
- MSA within the ostial LAD, ostial LCX, and distal LM
- 5-year MACE, including all-cause death, myocardial infarction, and target lesion revascularization related to LM stenosis.

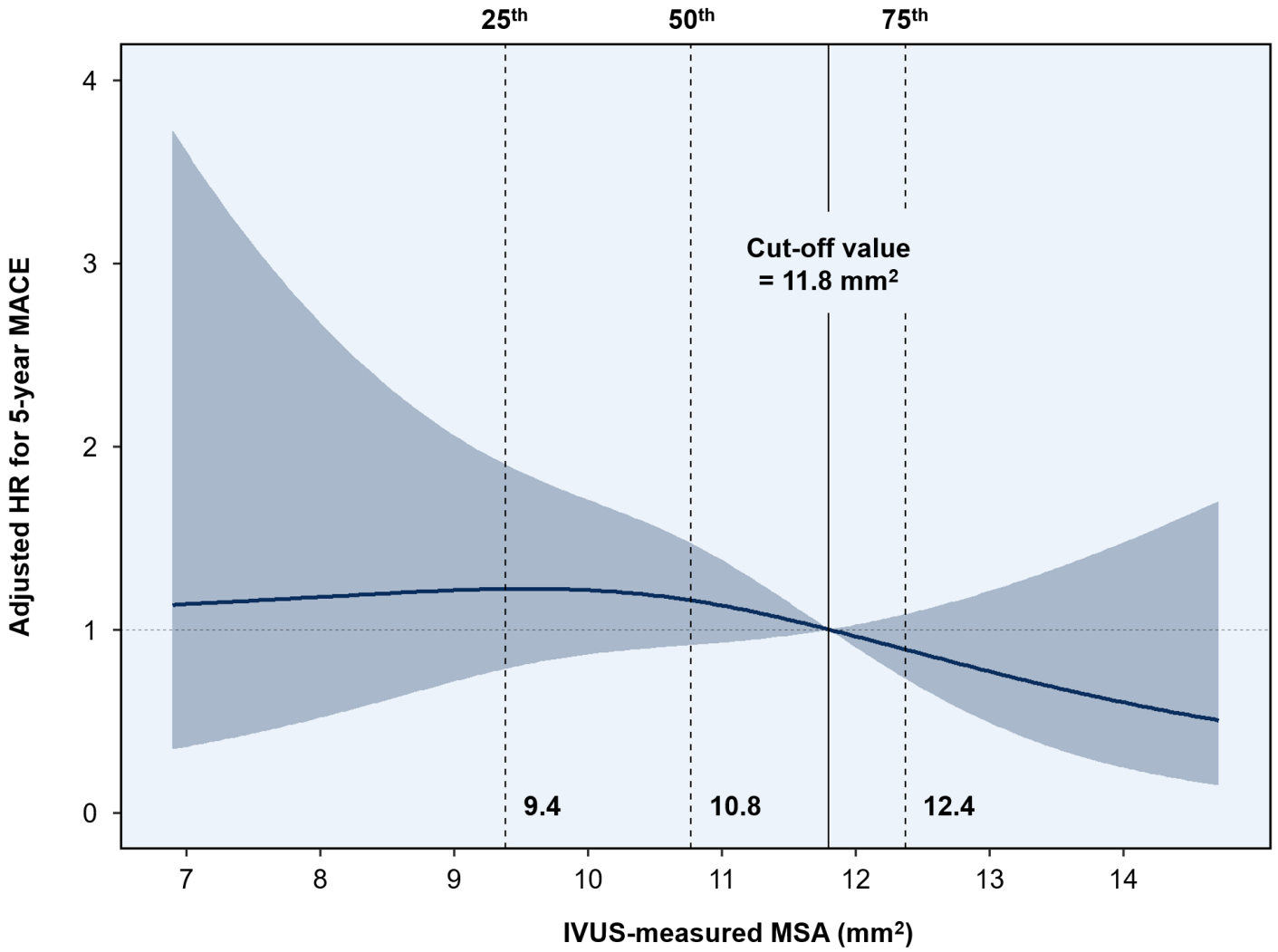
IVUS-measured Minimal Stent Area



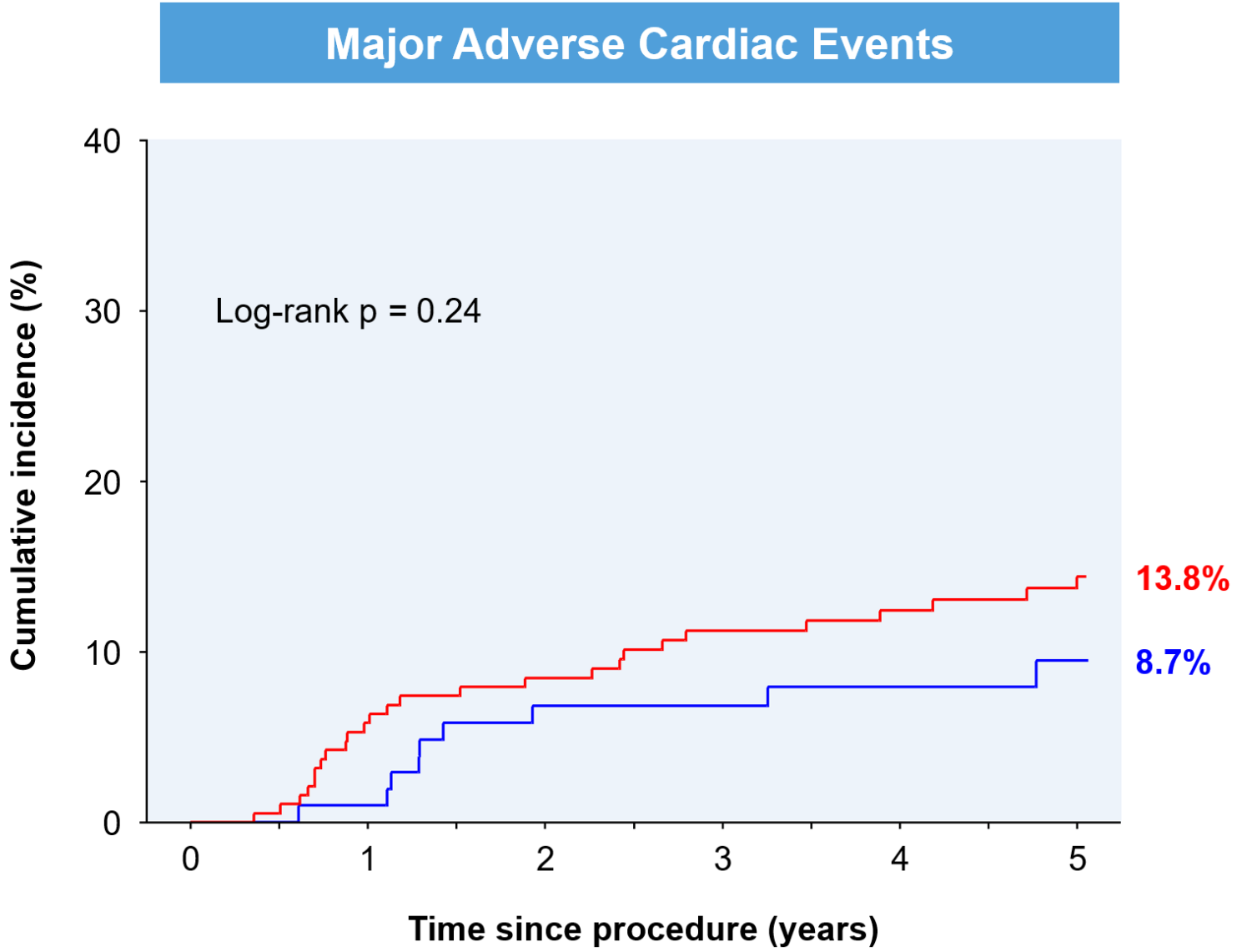
- N = 292
- 64.0 ± 9.9 years
- Male, 224 (76.7%)
- Diabetes, 98 (33.6%)
- 1st DES, 52 (17.8%)

Distal LM


Distal LM
Sensitivity 80.0%
Specificity 35.4%
Optimal Cutoff value 11.845 mm²
AUC 0.574 (0.479-0.67), p = 0.153
Sensitivity
1 − Specificity
0.0
0.2
0.4
0.6
0.8
1.0


25th
50th
75th
Cut-off value
= 11.8 mm²
9.4
10.8
12.4
Adjusted HR for 5-year MACE
IVUS-measured MSA (mm²)
0
1
2
3
4
7
8
9
10
11
12
13
14

A

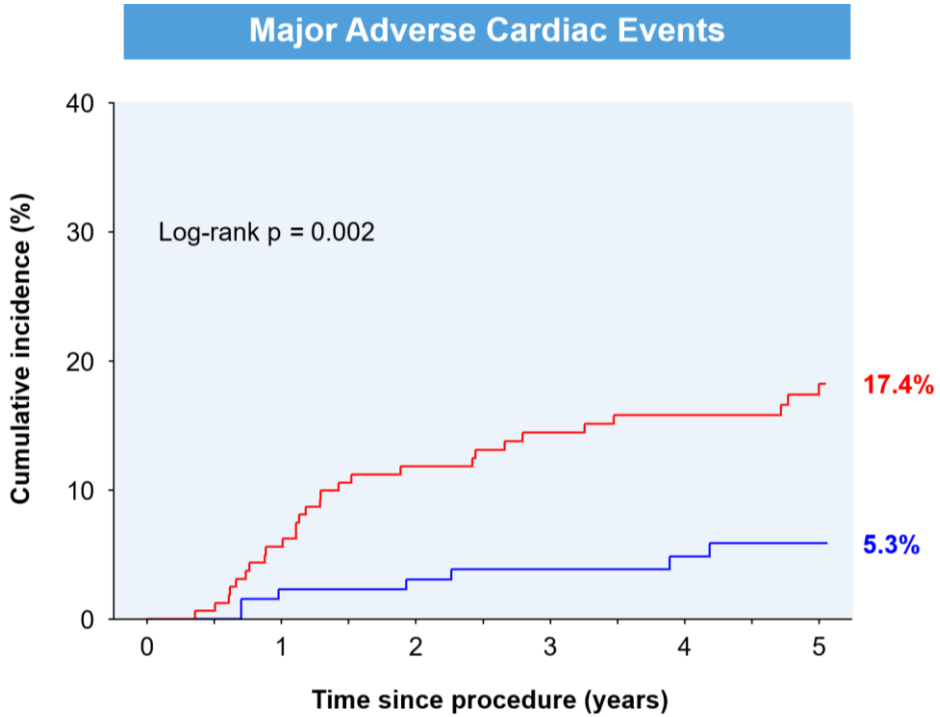


No. at risk

LM MSA < 11.8 mm^2	189	178	173	155	141	125
LM MSA ≥ 11.8 mm^2	103	102	94	87	67	56

LAD AUROC = 0.62

B

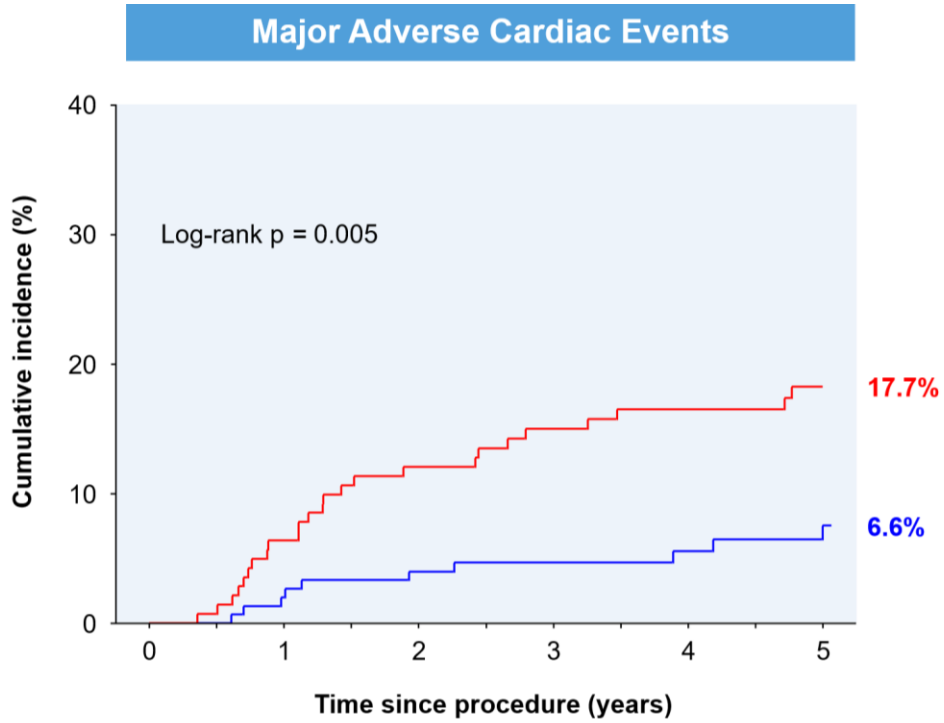


No. at risk

LAD MSA < 8.3 mm²	161	152	142	128	114	98
LAD MSA ≥ 8.3 mm²	131	128	125	114	94	83

LCX AUROC = 0.64

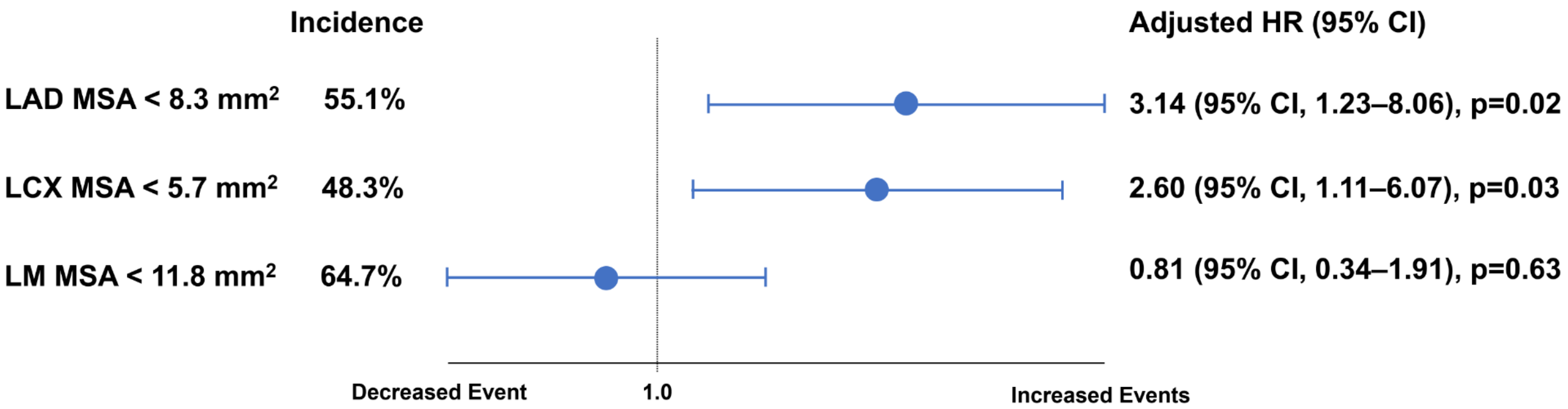
C



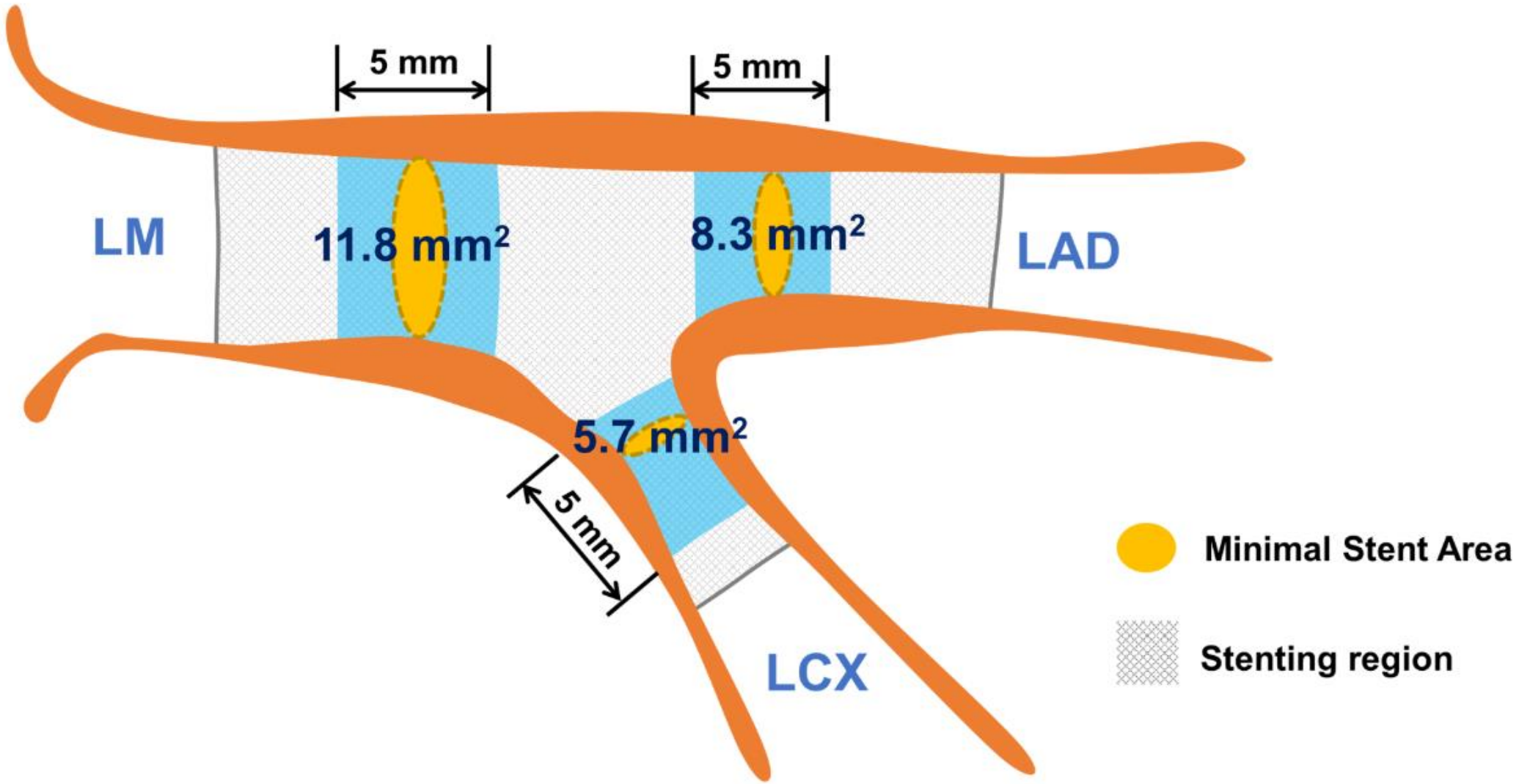
No. at risk

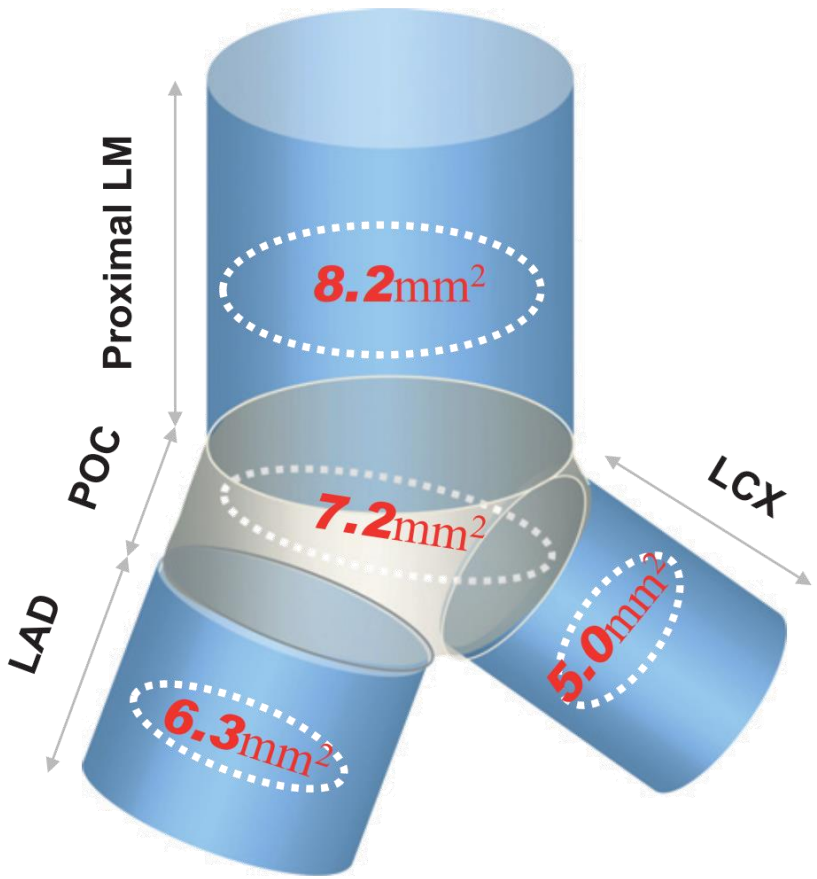
LCX MSA < 5.7 mm²	141	132	124	114	103	93
LCX MSA ≥ 5.7 mm²	151	148	143	128	105	88

Stent Under-Expansion Criteria in LM Two-Stenting With the Crush Technique

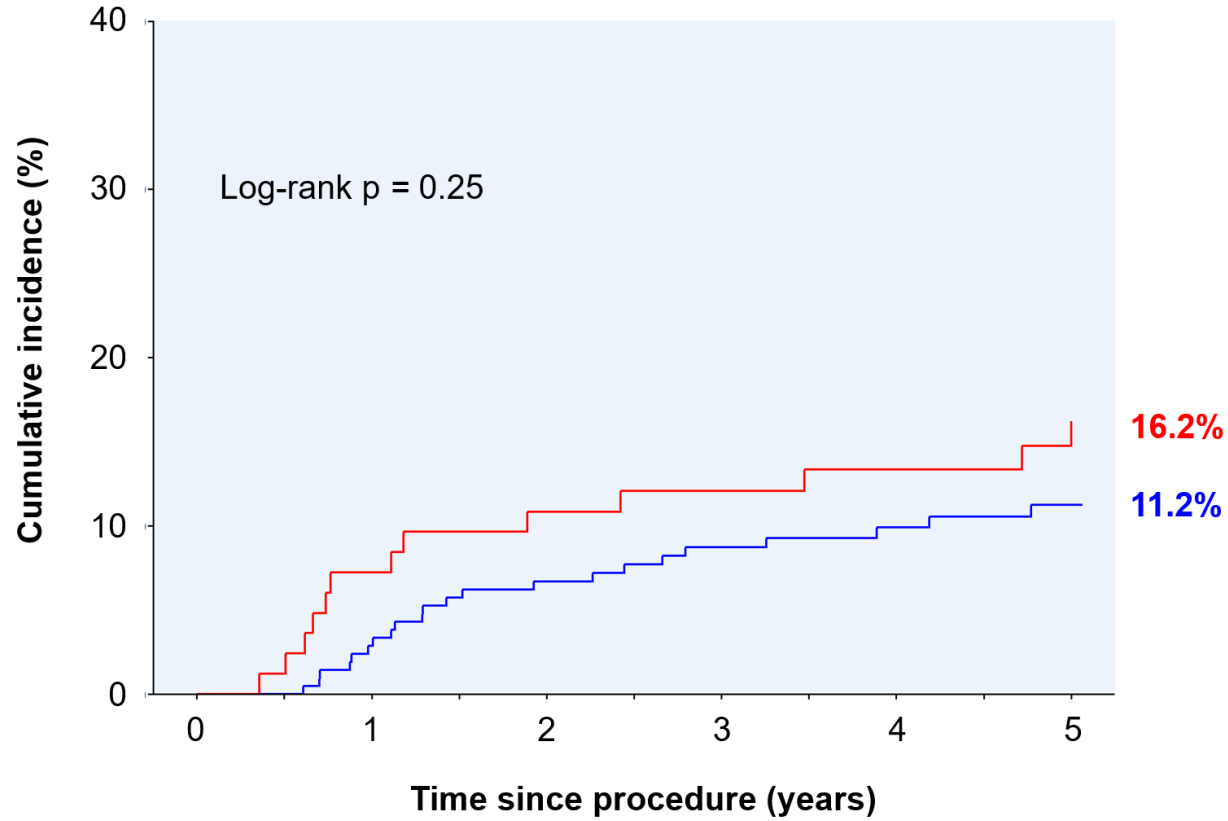


The Optimal Minimal Stent Area within Each Left Main Segment





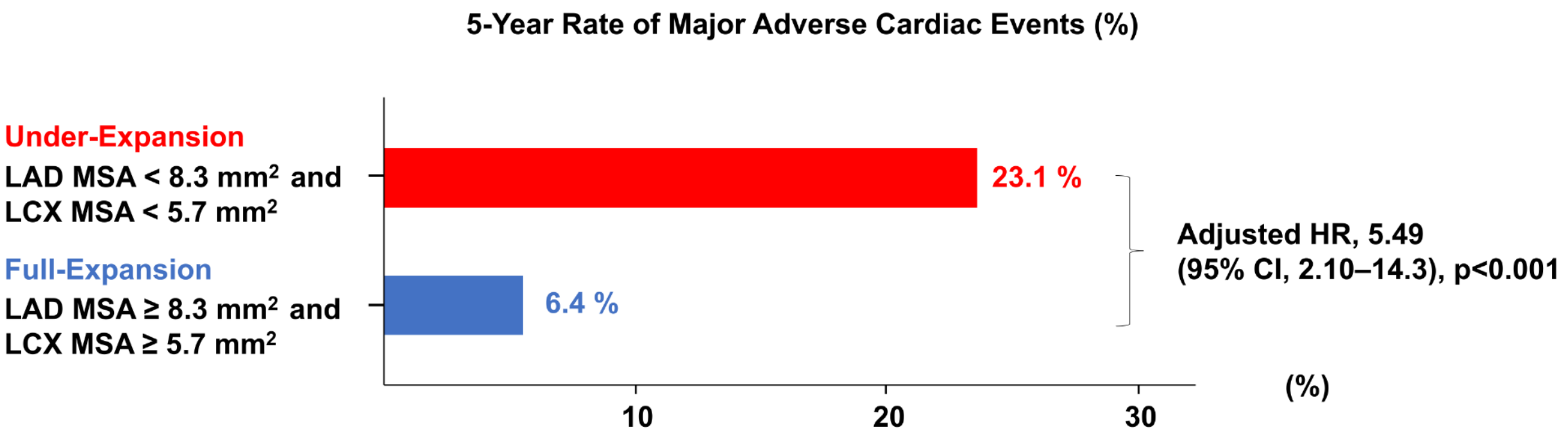
"5 – 6 – 7 – 8" Criteria

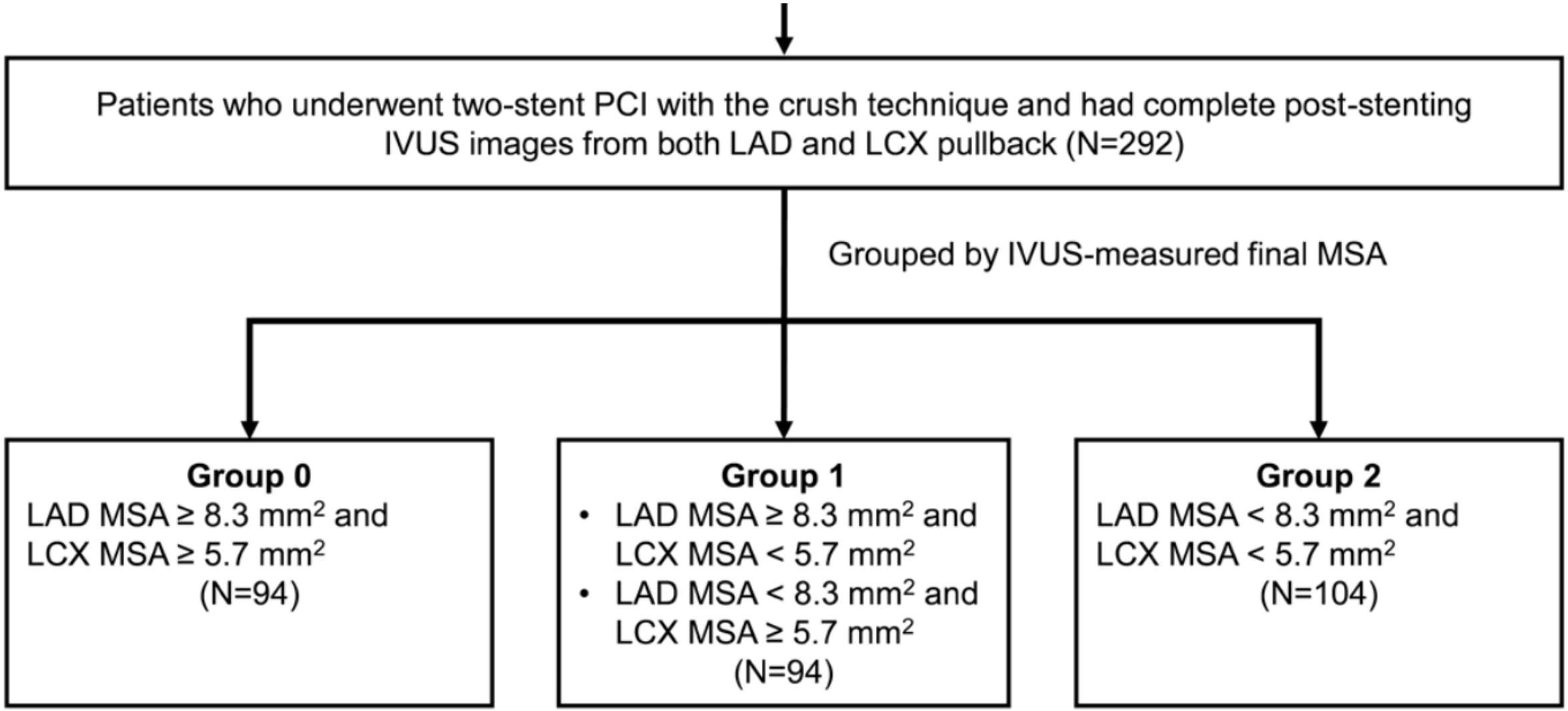


No. at risk

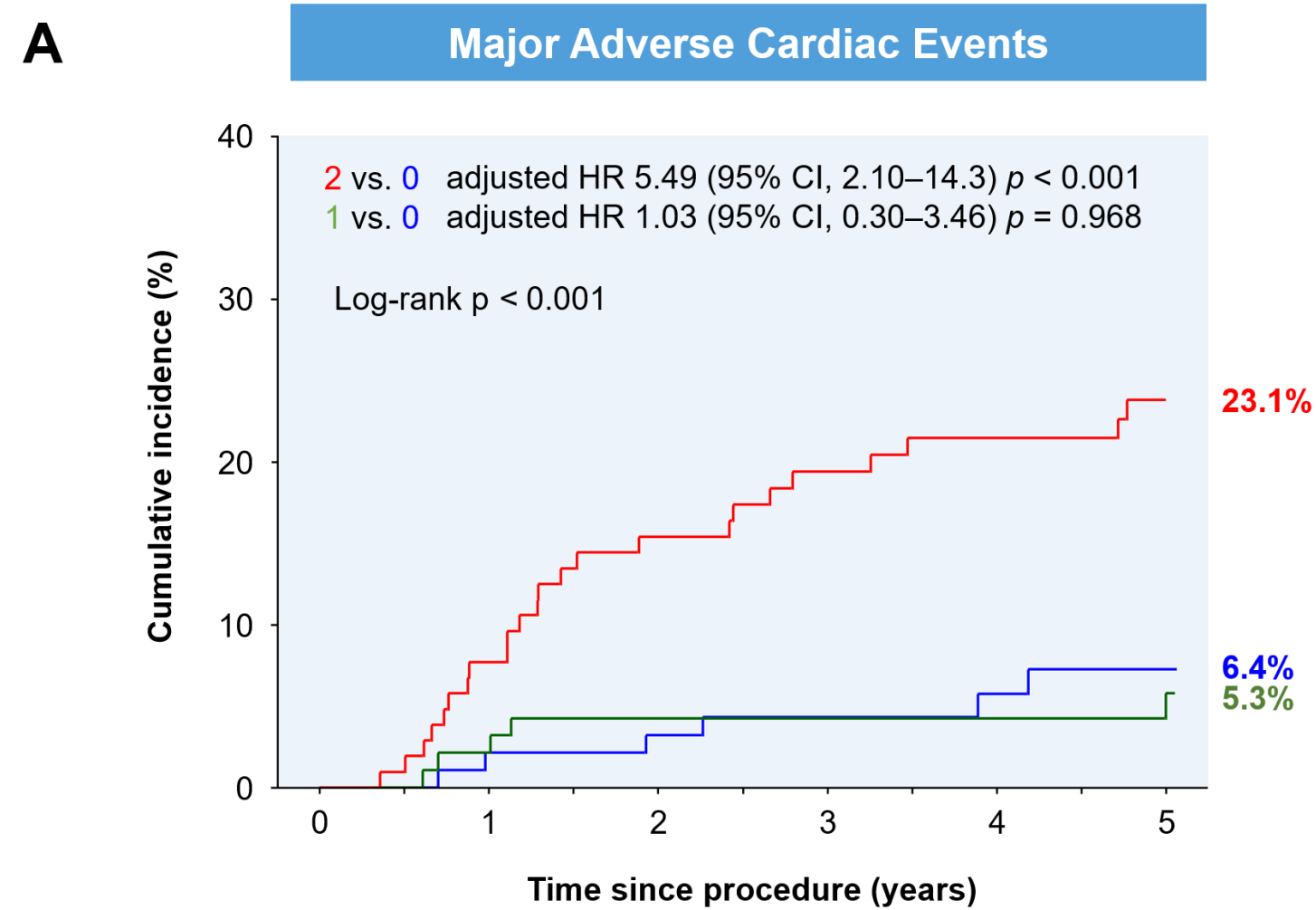
Under-expansion (+)	83	77	74	69	66	59
Under-expansion (−)	209	203	193	173	142	122

Major Adverse Cardiac Events at 5 Years according to Stent Under-Expansion




Patients who underwent two-stent PCI with the crush technique and had complete post-stenting IVUS images from both LAD and LCX pullback (N=292)
Grouped by IVUS-measured final MSA
Group 0
LAD MSA ≥ 8.3 mm2 and
LCX MSA ≥ 5.7 mm2
(N=94)
Group 1
• LAD MSA ≥ 8.3 mm2 and LCX MSA < 5.7 mm2
• LAD MSA < 8.3 mm2 and LCX MSA ≥ 5.7 mm2
(N=94)
Group 2
LAD MSA < 8.3 mm2 and
LCX MSA < 5.7 mm2
(N=104)

A



No. at risk

Group 2	104	96	88	79	73	64
Group 1	94	92	90	84	71	63
Group 0	94	92	89	79	64	54

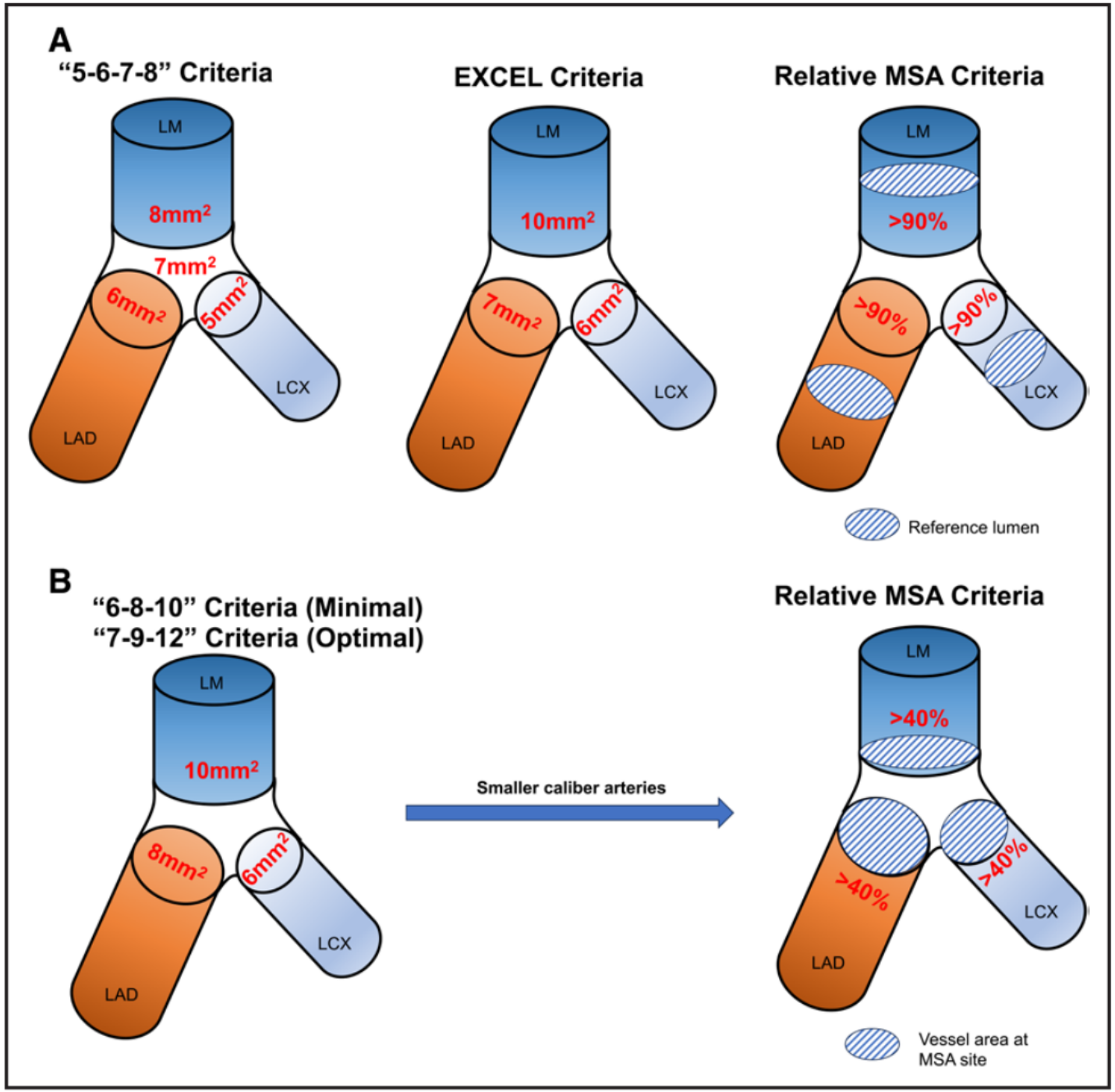


Figure. Expansion criteria.
A, Existing stent expansion criteria for distal left main (LM) bifurcation stenting. **B**, Proposed stent expansion criteria for LM stenting. LAD indicates left anterior descending; LCX, left circumflex; and MSA, minimal stent area.

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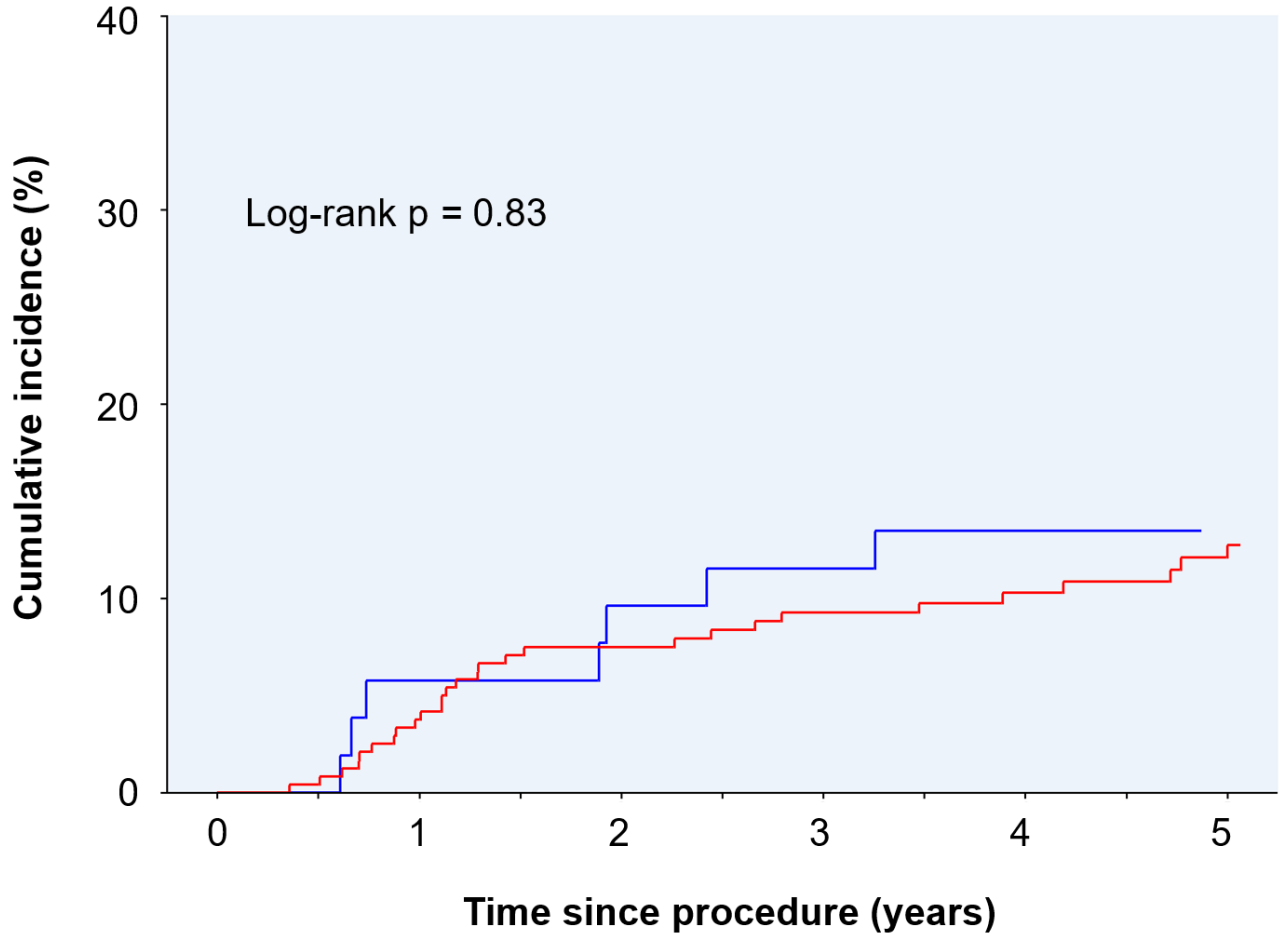
Major Adverse Cardiac Events



No. at risk

Newer-generation DES	240	231	220	196	163	137
First-generation DES	52	49	47	46	45	44

	Total	Single Stent	Two-Stent	*P* Value
LAD ostium, n†	336	222	114	
MSA, mm^2	8.1±1.8	8.3±1.8	7.8±1.7	0.015
EEM area at the MSA, mm^2	16.6±3.7	16.8±3.8	16.3±3.4	0.172
Peristent plaque burden, %	50.6±8.0	50.0±8.2	51.7±7.4	0.067
MSA <6.3 mm^2	58 (17%)	29 (13%)	29 (25%)	0.004
POC, n†	336	222	114	
MSA, mm^2	8.7±1.9	9.1±1.9	8.1±1.8	<0.001
MSA <7.2 mm^2	77 (23%)	40 (18%)	37 (33%)	0.003
Proximal LM above the POC, n	403	289	114	
MSA, mm^2	10.2±2.4	10.0±2.2	10.5±2.8	0.055
EEM area at the MSA, mm^2	21.8±5.1	21.8±5.2	21.8±4.7	0.936
Peristent plaque burden, %	52.2±9.2	53.0±9.0	50.2±9.3	0.007
MSA <8.2 mm^2	83 (21%)	60 (21%)	23 (20%)	0.896
LCX ostium, by LCX pullback,* n			104	
MSA, mm^2			5.6±1.4	
EEM area at the MSA, mm^2			11.8±2.8	
Peristent plaque burden, %			51.7±9.3	
MSA <5.0 mm^2			38 (37%)	

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Characteristics	Overall population (N=292)	MACEs		*P* value
		No (n=257)	Yes (n=35)	
Distal LM				
MSA, mm^2	10.9±2.2	11.0±2.2	10.4±2.0	0.135
EEM area at the MSA site, mm^2	23.8±4.1	23.9±4.2	22.9±4.1	0.180
MSA <11.8 mm^2	189 (64.7%)	163 (63.4%)	26 (74.3%)	0.283
Stent expansion index	46.4±7.2	46.4±7.3	46.0±7.0	0.730
LAD ostium				
MSA, mm^2	8.2±1.7	8.2±1.7	7.6±1.2	0.004
EEM area at the MSA site, mm^2	17.3±3.4	17.4±3.4	16.5±3.2	0.114
MSA <8.3 mm^2	161 (55.1%)	133 (51.8%)	28 (80.0%)	0.003
Stent expansion index	47.7±7.6	47.8±7.9	46.7±5.7	0.274
LCX ostium, by LCX pullback				
MSA, mm^2	5.9±1.4	6.0±1.5	5.3±1.1	0.007
EEM area at the MSA site, mm^2	13.2±3.2	13.3±3.0	12.8±4.0	0.529
MSA <5.7 mm^2	141 (48.3%)	116 (45.1%)	25 (71.4%)	0.006
Stent expansion index	45.7±8.6	46.0±8.5	43.4±8.6	0.082

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Summary

- Stent under-expansion was significantly associated with long-term clinical outcomes in patients who underwent two-stenting for LM bifurcation stenosis.

- This study advocated the imaging-guided stent optimization to achieve maximal MSA for better clinical outcome.