



How to Predict and Prevent Side Branch Occlusion?

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Provisional approach and SB occlusion



- ▶ The provisional approach is now regarded as the standard technique for most coronary bifurcation percutaneous coronary intervention (PCI).
- ▶ However, one of the serious procedural complications of the provisional approach is side branch (SB) occlusion after main vessel (MV) stenting.
- ▶ Unfortunately, there are limited data on the predictors of the SB occlusion to date.

SB occlusion after MV stenting



- ▶ It is not uncommon (7-20%).
- ▶ Risk factors
 - Severity and length of SB ostial stenosis, plaque burden in SB ostium, narrow bifurcation angle, size and/or pressure of MV stent
- ▶ Limitations of previous studies
 - Small sample size
 - Small SB (with a diameter of >1 mm)
 - Mostly non-true bifurcation lesions
 - No data on left main lesions
 - No information of procedure for the SB
 - Limited data on long-term clinical outcomes



COronary Bifurcation Stent Registry II

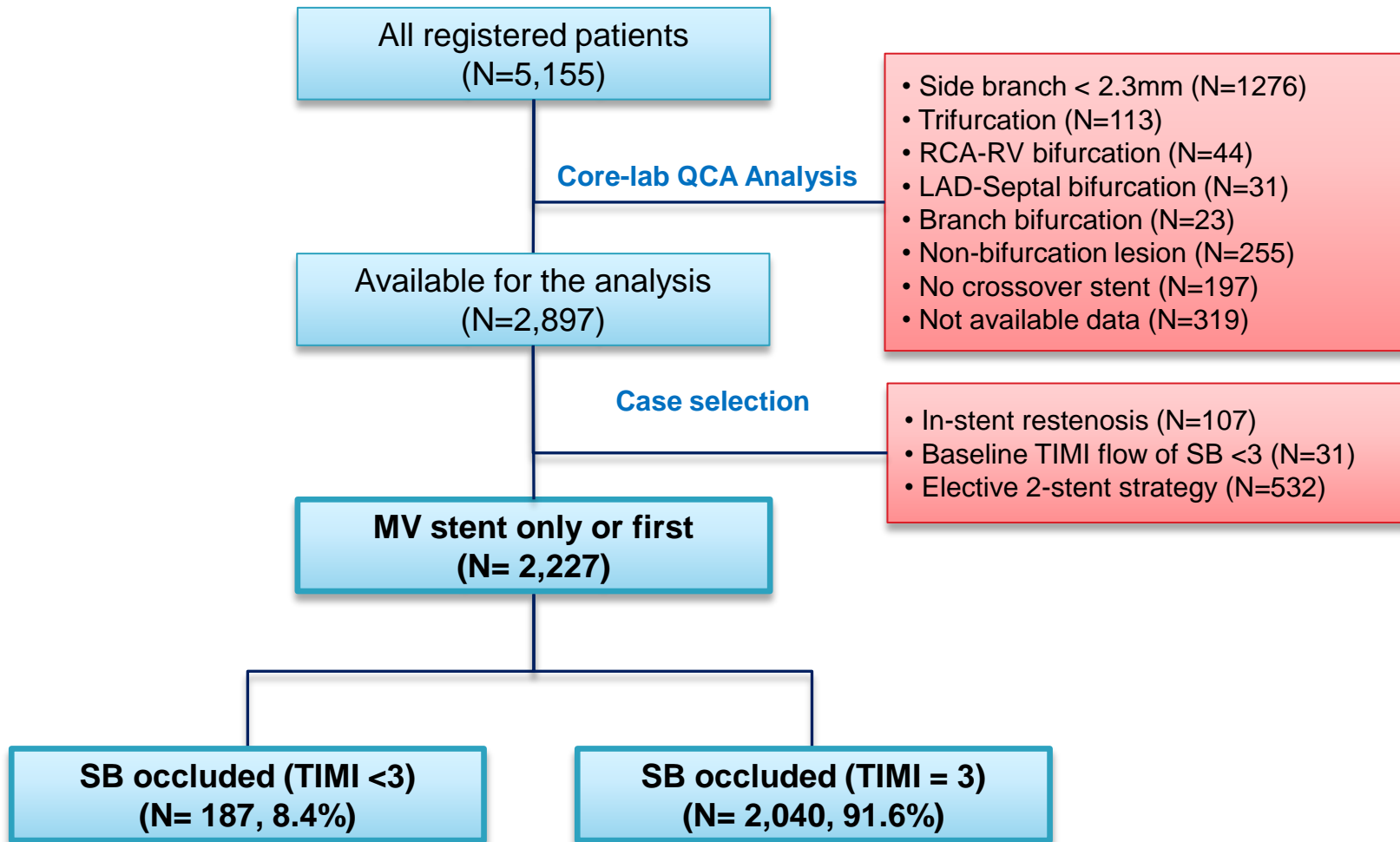


- ▶ Multi-center retrospective real-world registry of contemporary PCI with drug-eluting stent (DES) in coronary bifurcation lesions with minimal exclusion criteria
- ▶ Treated with DES from Jan 2003 to Dec 2009 from 18 centers in Korea

- ▶ Inclusion criteria
 - Coronary bifurcation lesion in major epicardial artery
 - MV diameter of ≥ 2.5 mm and SB diameter of ≥ 2.3 mm (amenable to stent)

- ▶ Exclusion criteria
 - Cardiogenic shock or experience of CPR
 - Protected left main lesions

Patients selection



Baseline Clinical Characteristics



	SB occlusion (n=187)	No SB occlusion (n=2040)	p Value
Age (yrs)	61.9±10.7	62.2±10.3	0.74
Male	133 (71.1)	1485 (83.1)	0.62
Hypertension	99 (52.9)	1203 (59.0)	0.11
Diabetes mellitus	42 (22.5)	591 (29.0)	0.06
Dyslipidemia	69 (36.9)	640 (31.4)	0.12
Current smoker	57 (30.5)	527 (25.8)	0.17
Previous myocardial infarction	12 (6.4)	96 (4.7)	0.30
Previous revascularization	24 (12.8)	228 (11.2)	0.49
Clinical presentation			0.001
Stable coronary artery disease	49 (26.2)	788 (38.6)	
Acute coronary syndromes	138 (73.8)	1252 (61.4)	

Angiographic and Procedural Characteristics



	SB occlusion (n=187)	No SB occlusion (n=2040)	p Value
Bifurcation location			<0.001
Left main bifurcation	14 (7.5)	556 (27.3)	
LAD/diagonal	124 (66.3)	1124 (55.1)	
LCX/OM	32 (17.1)	272 (13.3)	
RCA bifurcation	17 (9.1)	88 (4.3)	
True bifurcation	139 (74.3)	901 (44.2)	<0.001
Jailed wire in the SB	123 (65.8)	1237 (60.6)	0.17
SB predilation before MV stenting	61 (32.6)	437 (21.4)	<0.001
IVUS guidance	52 (27.8)	772 (37.8)	0.007
MV stent diameter (mm)	3.0 (3.0-3.5)	3.0 (3.0-3.5)	0.04
MV stent length (mm)	24.0 (20.0-30.0)	24.0 (18.0-30.0)	0.21
MV stent maximal pressure (atm)	12.0 (10.0-14.0)	14.0 (10.0-16.0)	<0.001
MV stent to artery ratio	1.2 (1.1-1.3)	1.2 (1.1-1.3)	0.63

Quantitative Coronary Angiographic Analysis

	SB occlusion (n=187)	No SB occlusion (n=2040)	p Value
MV proximal RD (mm)*	3.3±0.5	3.4±0.6	<0.001
MV distal RD (mm)	2.7±0.5	2.7±0.5	0.13
SB distal RD (mm)	2.4±0.3	2.6±0.4	<0.001
MV proximal MLD (mm)	1.2±0.7	1.7±0.9	<0.001
MV distal MLD (mm)	1.2±0.6	1.4±0.7	0.01
SB ostial MLD (mm)	1.1±0.6	1.7±0.7	<0.001
MV proximal diameter stenosis (%)*	62.8±21.9	49.8±25.8	<0.001
MV distal diameter stenosis (%)	54.4±22.9	50.1±24.6	0.02
SB diameter stenosis (%)	55.3±22.0	37.2±23.7	<0.001
MV lesion length (mm)	20.6±11.4	18.3±11.6	0.01
SB lesion length (mm)	6.5±7.1	3.7±6.1	<0.001
Angle between the MV and SB (degree)	61.0±21.6	64.6±25.5	0.03

Independent predictors of SB occlusion



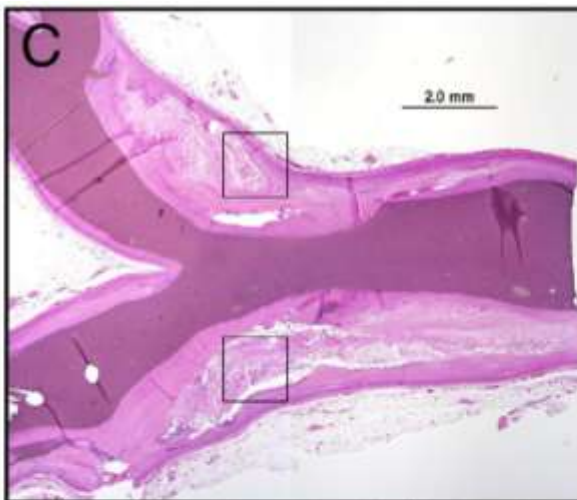
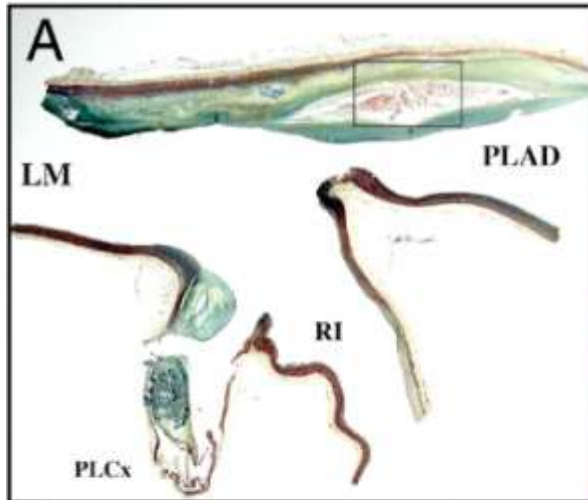
* SB occlusion after MV stenting was defined as TIMI flow <3 (N=187, 8.4%)

Variables	Odds ratio [95% CI]	p Value
Pre-procedural SB DS \geq 50%	2.34 [1.59-3.43]	<0.001
SB lesion length (by 1 mm)	1.03 [1.003-1.06]	<0.001
Pre-procedural proximal MV DS \geq50%	2.34 [1.57-3.50]	0.03
Acute coronary syndrome	1.53 [1.06-2.19]	0.02
Left main lesions (vs. non-left main lesions)	0.34 [0.16-0.72]	0.005

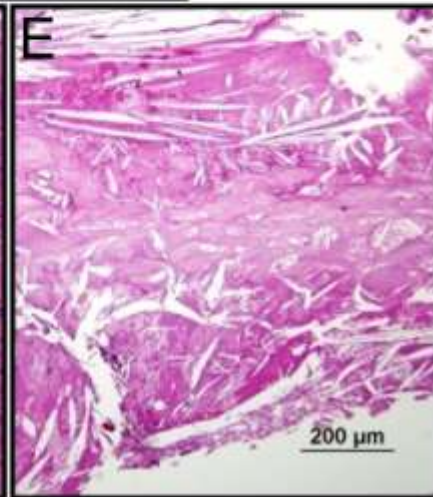
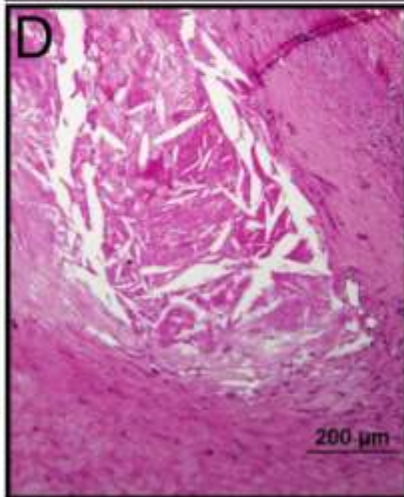
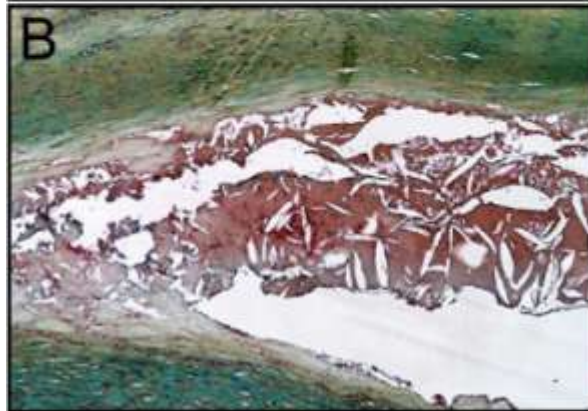
* DS = diameter stenosis, SB = side branch, MV = main vessel

jailed wire technique, SB predilation, IVUS guidance: not associated with SB occlusion

Plaque Distribution



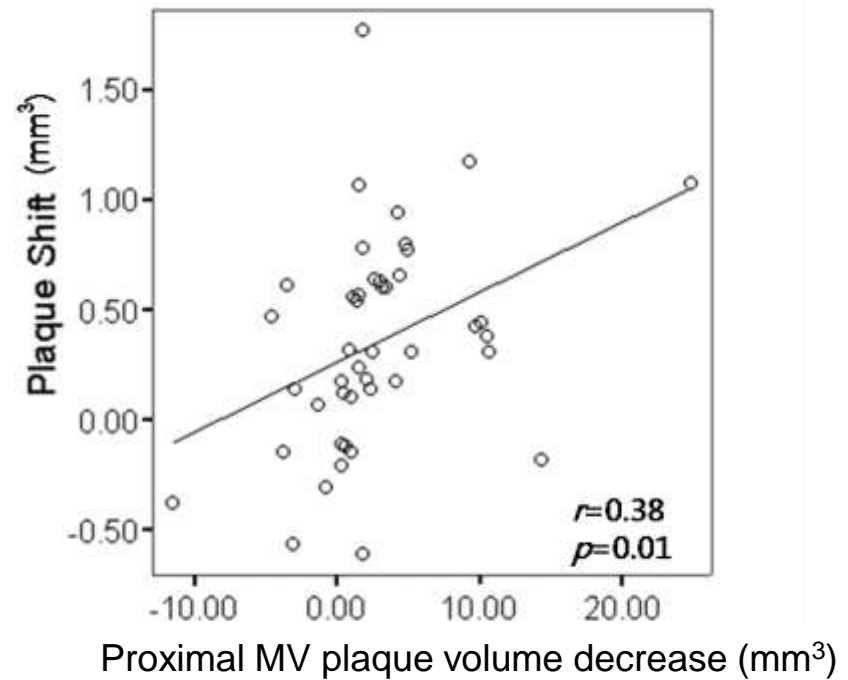
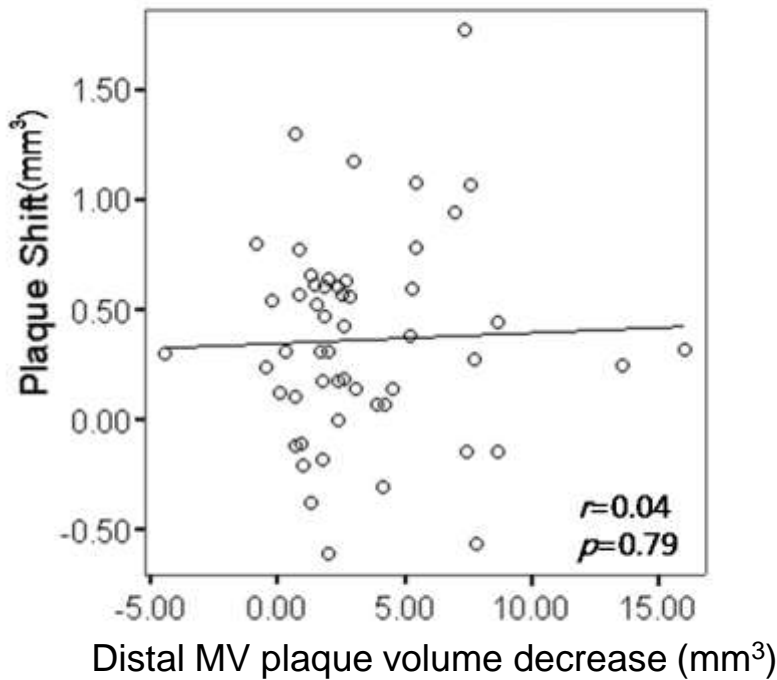
- 1) Carina is spared.
- 2) Abcarinal zone is most diseased, and also lipid-rich.



Plaque shift comes from proximal MV



- ▶ Pre- and post-stenting IVUS for MV and SB (N=44)



SB compromise = Δ SB os lumen volume
Carina shift = Δ SB os vessel volume
Plaque shift = Δ SB os plaque volume

Clinical Impact of SB Occlusion



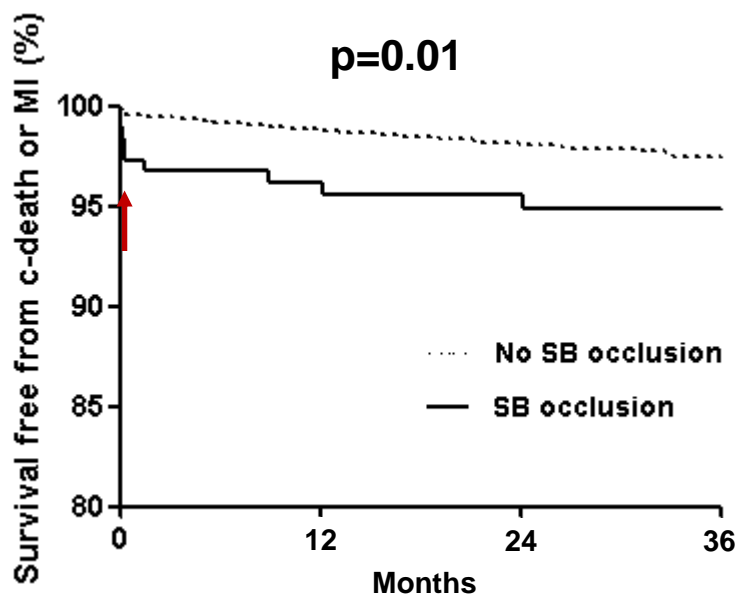
	SB occlusion (n=187)	No SB occlusion (n=2040)	Unadjusted HR (95% CI)	p Value	Adjusted HR* (95% CI)	p Value
Death	10 (5.3)	74 (3.6)	1.6 (0.8-3.0)	0.20	1.5 (0.8-3.0)	0.24
Cardiac death	7 (3.7)	20 (1.0)	4.0 (1.7-9.4)	0.002	4.2 (1.7-10.6)	0.002
MI	4 (2.1)	32 (1.6)	1.4 (0.6-4.1)	0.49	1.5 (0.5-4.4)	0.46
Cardiac death or MI	10 (5.3)	50 (2.5)	2.3 (1.2-4.5)	0.02	2.3 (1.2-4.8)	0.02
Stent thrombosis	6 (3.2)	9 (0.4)	7.7 (2.7-21.6)	<0.001	6.2 (2.0-19.1)	0.002
TLR	14 (7.5)	129 (6.3)	1.3 (0.73-2.2)	0.41	1.3 (0.7-2.3)	0.36
MACE	23 (12.3)	164 (8.0)	1.6 (1.1-2.5)	0.03	1.62 (1.1-2.6)	0.03

*Adjusted covariates included diabetes, acute coronary syndromes, true bifurcation, left main lesion, use of intravascular ultrasound, SB predilatation, MV stent diameter, and MV stent maximal pressure

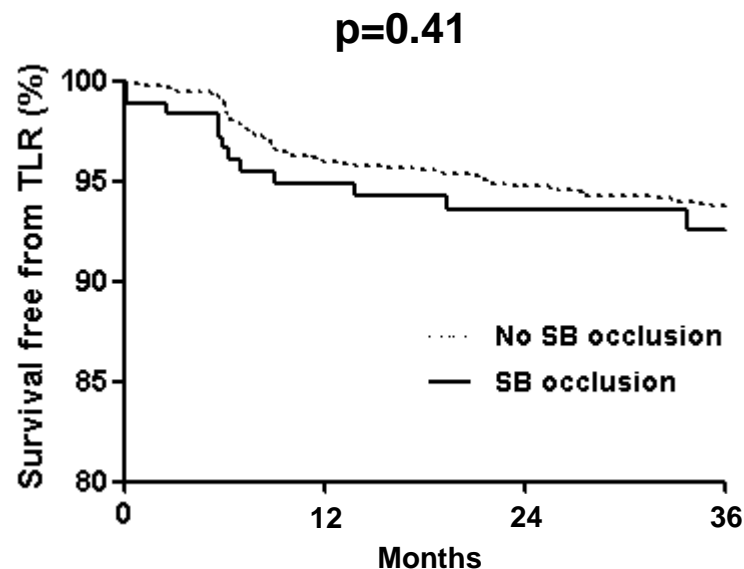
Clinical Impact of SB Occlusion



Cardiac Death / MI



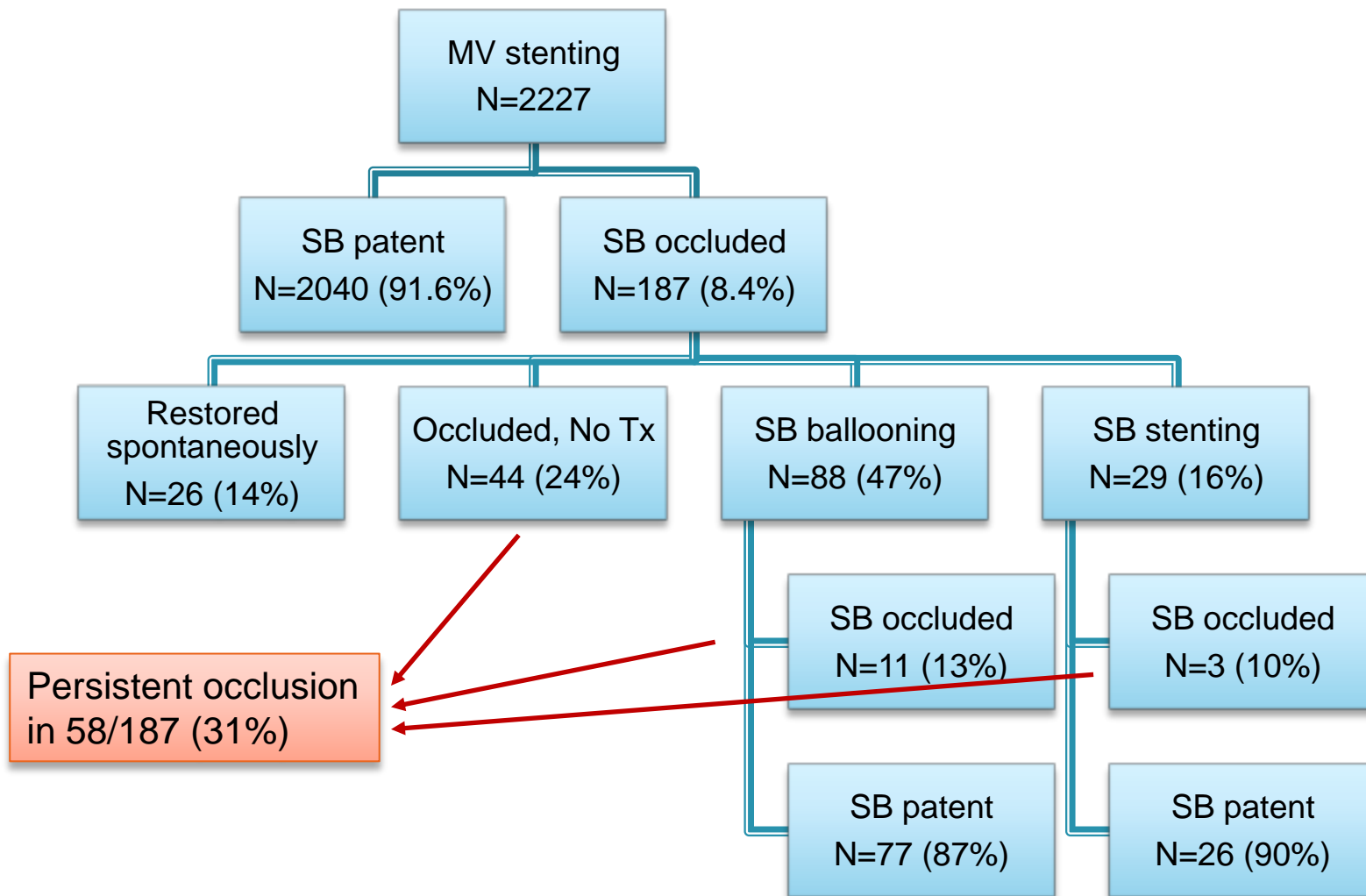
TLR



SB occlusion	187	163	128	83
No SB occlusion	2040	1851	1542	991

SB occlusion	187	156	121	80
No SB occlusion	2040	1790	1478	950

Fate of Occluded SB



Predictors of SB recovery



	SB recovery (n=129)	No SB recovery (n=58)	p Value
Bifurcation location			0.65
Left main bifurcation	9 (7.0)	5 (8.6)	
LAD/diagonal	84 (65.1)	40 (69.0)	
LCX/OM	25 (19.4)	7 (12.1)	
RCA bifurcation	11 (8.5)	6 (10.3)	
True bifurcation	94 (72.9)	45 (77.6)	0.49
Jailed wire in the SB	92 (71.3)	31 (53.4)	0.02
SB predilation before MV stenting	45 (34.9)	16 (27.6)	0.33
Guidance of intravascular ultrasound	39 (30.2)	13 (22.4)	0.27
MV stent diameter (mm)	3.0 (3.0-3.5)	3.0 (2.9-3.5)	0.62
MV stent length (mm)	24.0 (20.0-30.0)	24.0 (20.0-32.0)	0.91
MV stent maximal pressure (atm)	12.0 (10.0-15.5)	12.0 (10.0-14.0)	0.57
MV stent to artery ratio	1.2 (1.1-1.3)	1.2 (1.1-1.4)	0.25

How to prevent SB occlusion?



Unfortunately, we did not find any preventive procedure for the SB occlusion.

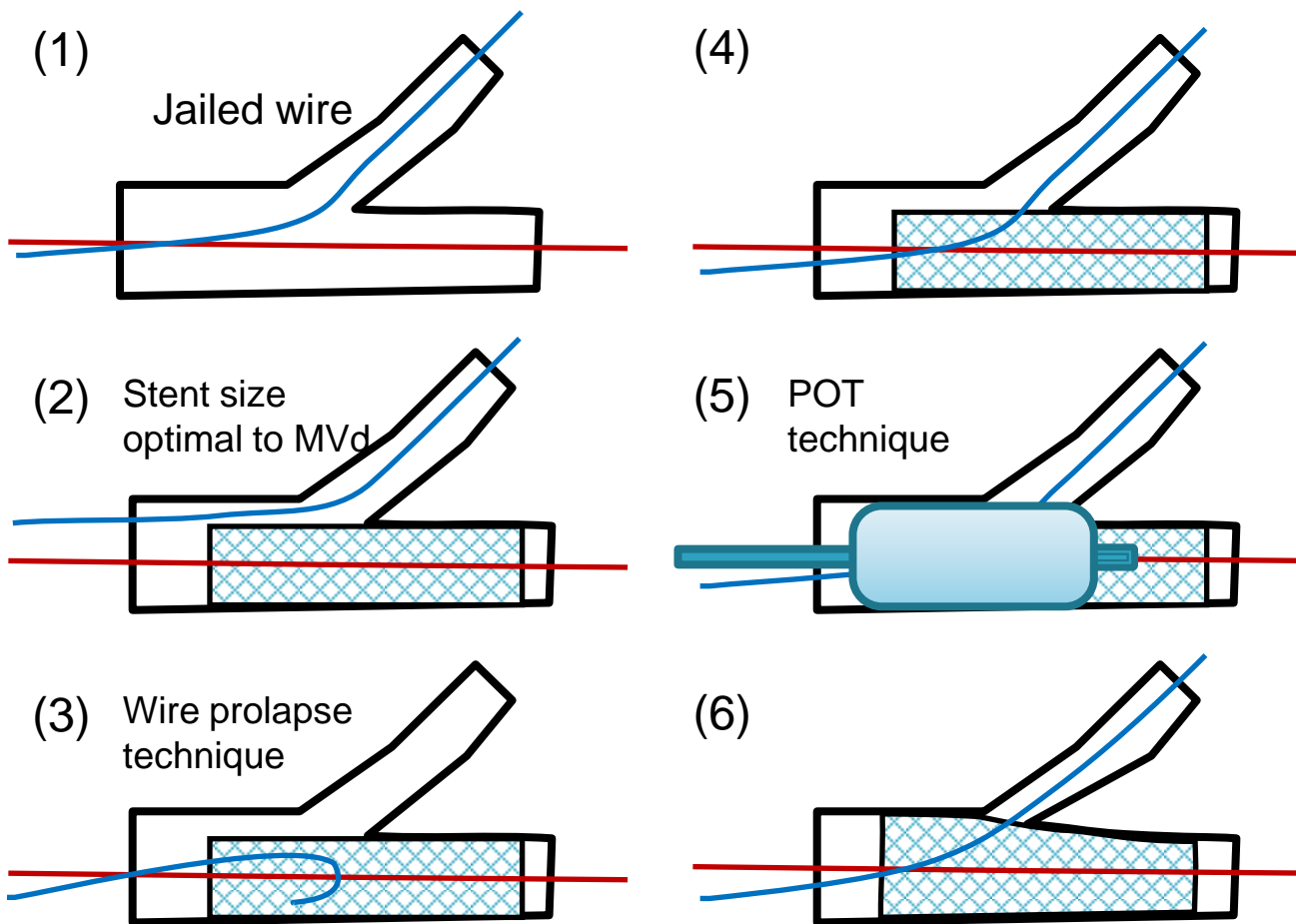


Dissection

Avoid SB pre-dilatation, if you would like to finish the procedure with 1-stent technique. If unavoidable, under-sized ballooning is recommended.

Predilatation was not protective for SB occlusion.

Selection of stent with appropriate size



POT = proximal optimization technique

Try NG and wait for a while.



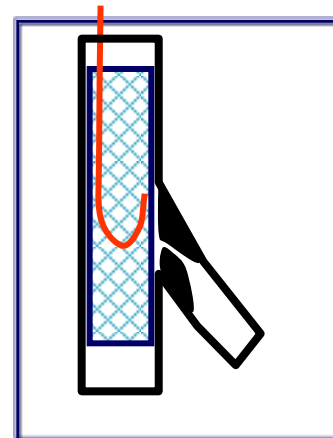
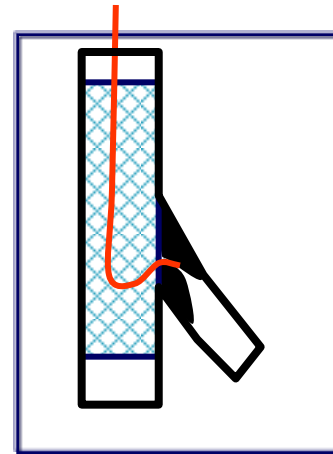
Spasm

When SB is compromised or occluded, the first thing you can do is to wait after intracoronary nitroglycerin injection.

Wire recross into side branch



- ▶ Preferred wire
 - Good curve retention (Runthrough®)
 - Hydrophilic intermediate wire (Pilot 150®)
- ▶ To avoid undermining the stent strut
 - Use wire in the main branch
 - Wire prolapse technique
- ▶ Microcatheter support
 - Better torque control
 - Easy to reshape the wire
- ▶ IVUS guidance for occluded side branch



Summary



- ▶ SB occlusion after MV stenting occurred in 8.4% of bifurcation lesions treated with provisional approach.
- ▶ Angiographic findings of the SB, proximal MV stenosis and clinical presentation are associated with occlusion of SB after MV stenting.
- ▶ Occlusion of sizable SB is associated with adverse clinical outcomes.
- ▶ Jailed wire in the SB may be helpful for recovery of the occluded SB.
- ▶ Careful selection of stent size followed by POT may help avoid SB compromise or occlusion during the procedure.



Thank you for your attention!
감사합니다!



I consider an elective 2-stent strategy when ...



- ▶ True bifurcation lesions with sizable SB
 - Especially, Medina (1,X,1)

And

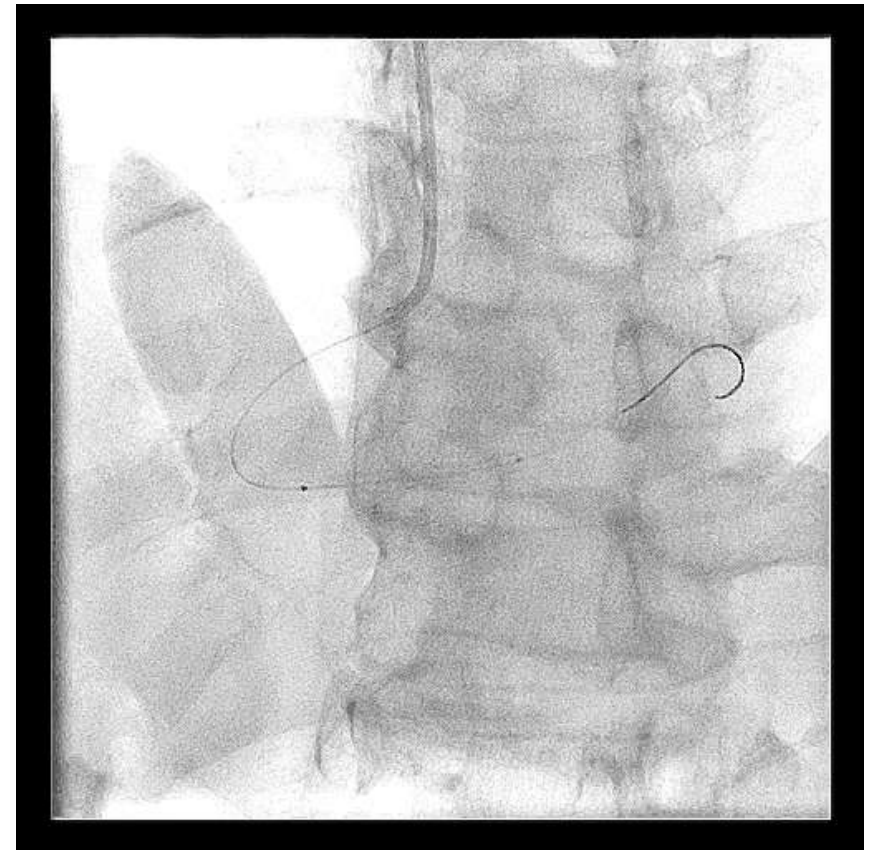
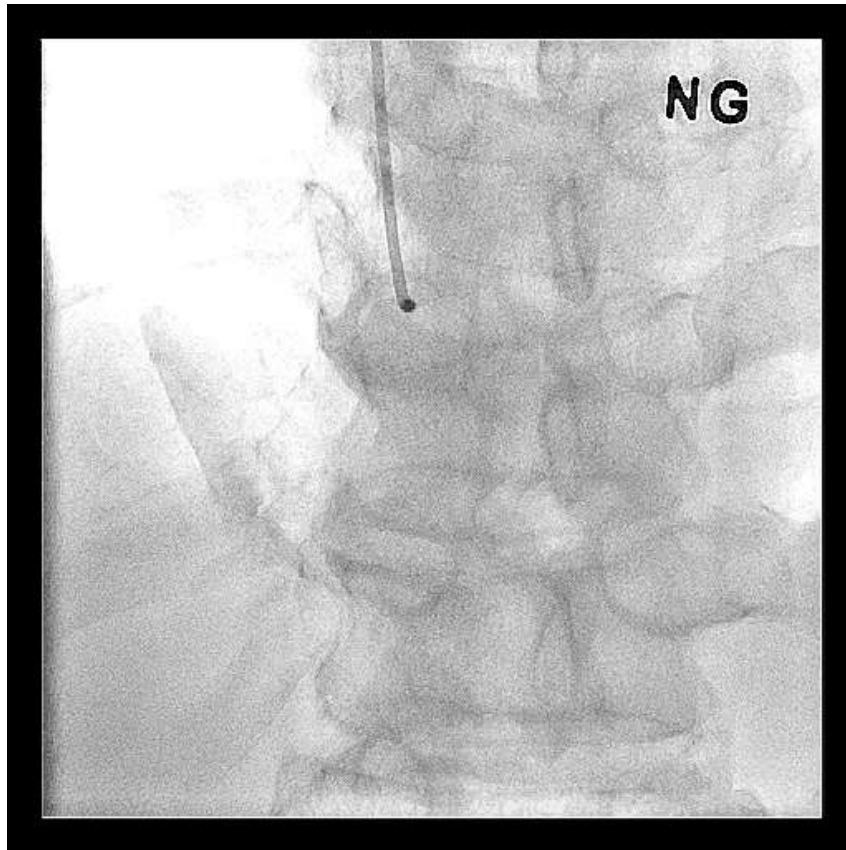
- ▶ Hemodynamic instability or LV dysfunction
- ▶ Emergent PCI

Case

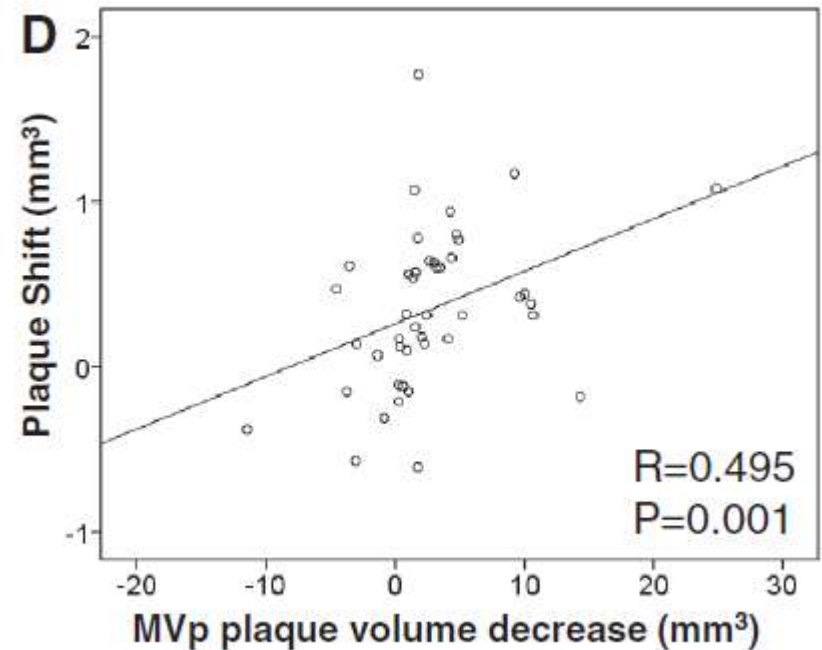
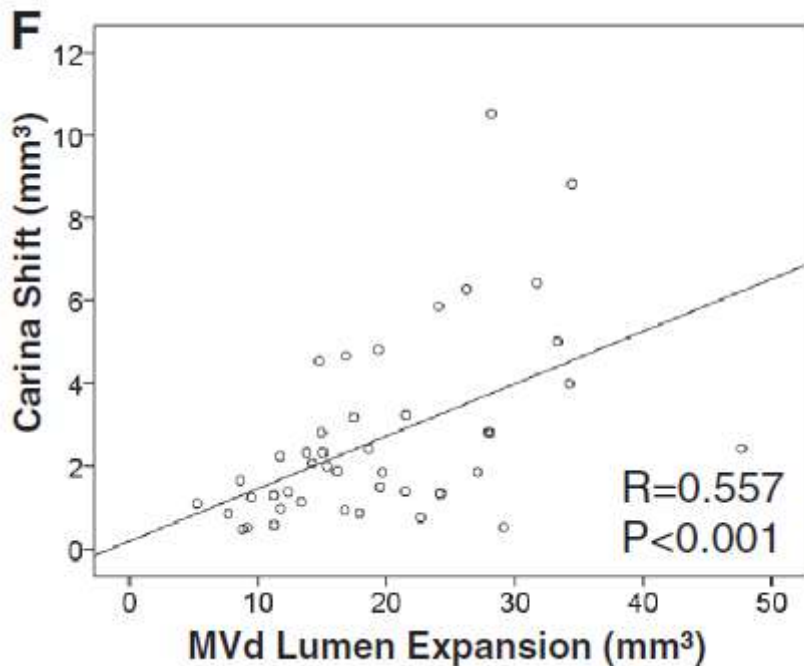


The risk of SB compromise in this case?

After MV stenting



Volume change in MV and carina or plaque shift



Objective



- ▶ To investigate predictors of SB occlusion after MV stenting in coronary bifurcation lesions treated with provisional approach
 - Clinical characteristics, angiographic findings other than SB otial disease, and procedural factors

- ▶ To investigate the fate of occluded SB after MV

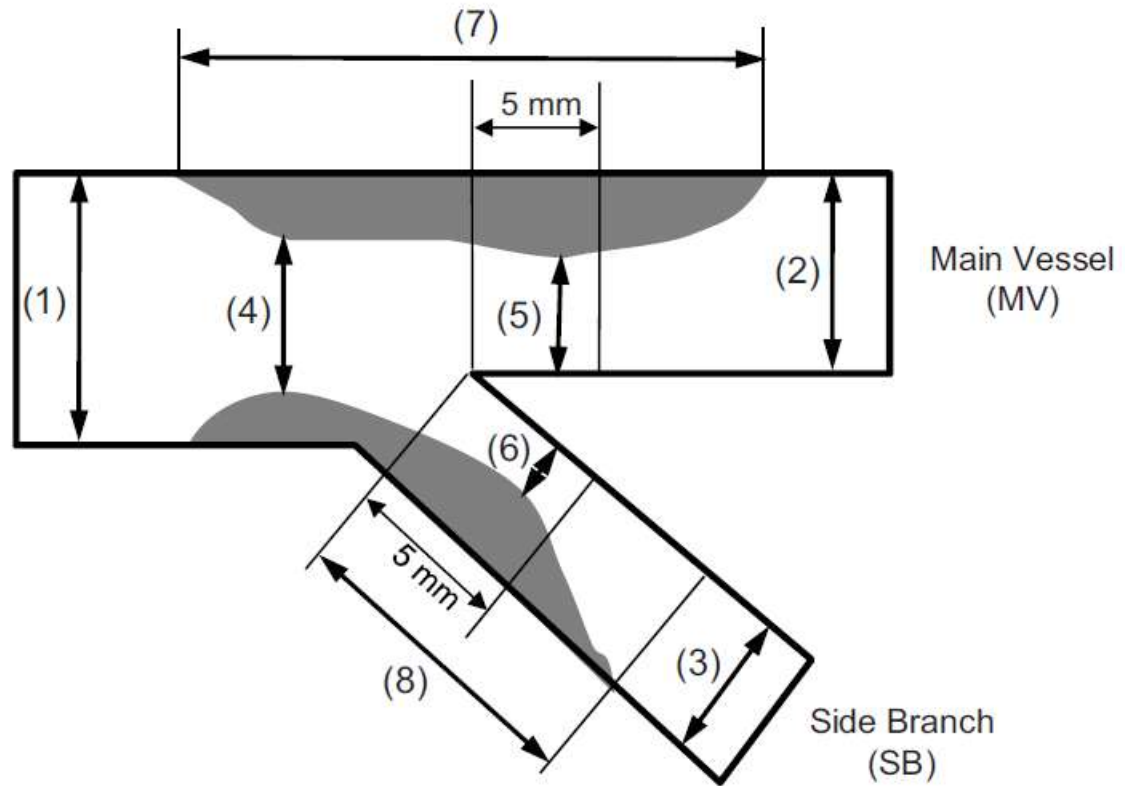
- ▶ To investigate impact of SB occlusion on clinical outcomes

Quantitative Coronary Angiographic Analysis



- ▶ At the angiographic core laboratory in the Cardiac and Vascular Center, Samsung Medical Center, Seoul, Korea.

- 1) MV proximal RD
- 2) MV distal RD
- 3) SB distal RD
- 4) MV proximal MLD
- 5) MV distal MLD
- 6) SB ostial MLD
- 7) MV lesion length
- 8) SB lesion length





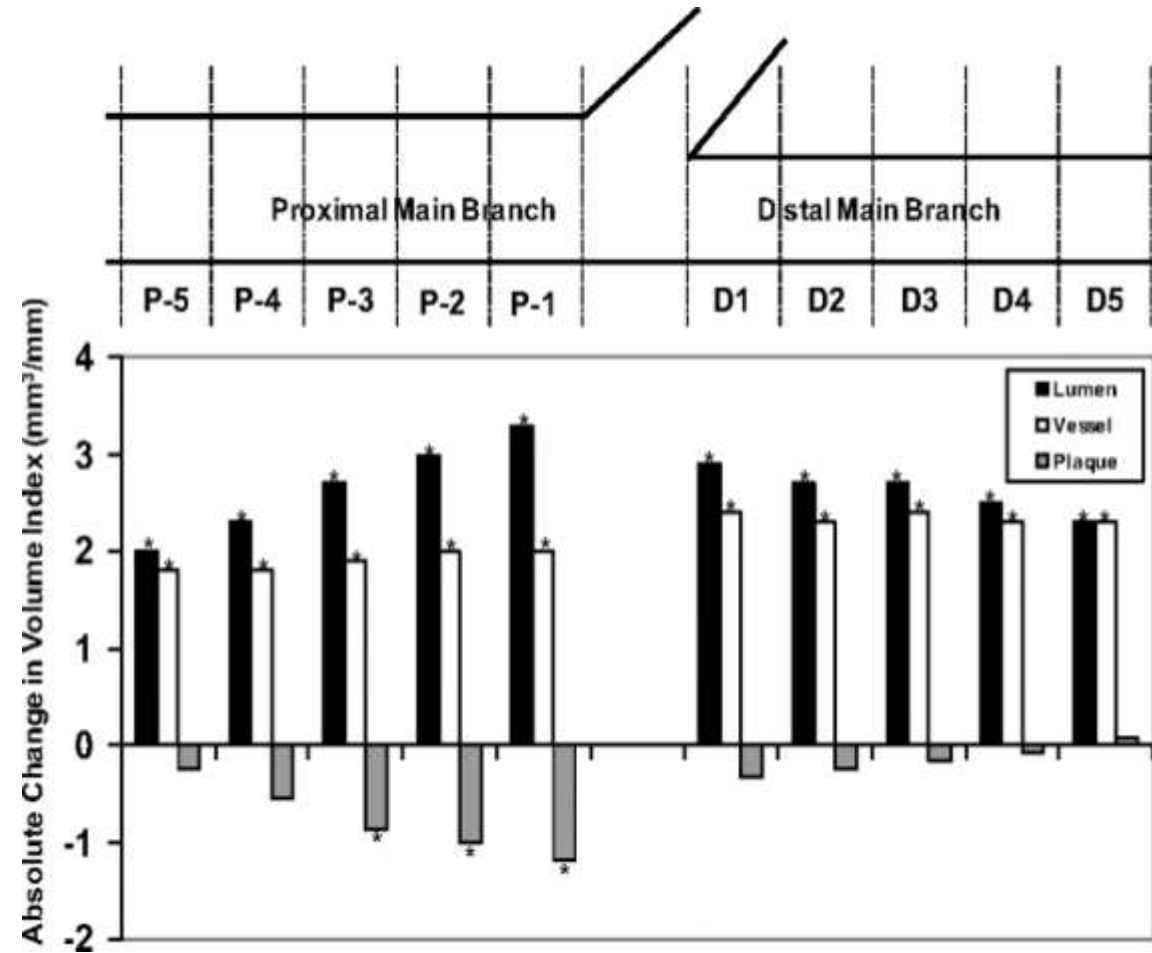
Lesion and Procedural Characteristics (I)

	SB occlusion (n=187)	No SB occlusion (n=2040)	p Value
Bifurcation location			<0.001
Left main bifurcation	14 (7.5)	556 (27.3)	
LAD/diagonal	124 (66.3)	1124 (55.1)	
LCX/OM	32 (17.1)	272 (13.3)	
RCA bifurcation	17 (9.1)	88 (4.3)	
Medina classification			<0.001
1.1.1	97 (51.9)	567 (27.8)	
1.0.1	21 (11.2)	136 (6.7)	
0.1.1	21 (11.2)	198 (9.7)	
1.0.0	19 (10.2)	297 (14.6)	
1.1.0	25 (13.4)	355 (17.4)	
0.1.0	4 (2.1)	462 (22.6)	
0.0.1	0 (0.0)	25 (1.2)	
True bifurcation	139 (74.3)	901 (44.2)	<0.001

Lesion and Procedural Characteristics (II)

	SB occlusion (n=187)	No SB occlusion (n=2040)	p Value
Type of stent used			0.831
Sirolimus-eluting stent	82 (43.9)	966 (47.4)	
Paclitaxel-eluting stent	50 (26.7)	545 (26.7)	
Zotarolimus-eluting stent	23 (12.3)	234 (11.5)	
Everolimus-eluting stent	26 (13.9)	246 (12.1)	
Other drug-eluting stents	6 (3.2)	49 (2.4)	
Jailed wire in the SB	123 (65.8)	1237 (60.6)	0.17
SB predilatation before MV stenting	61 (32.6)	437 (21.4)	<0.001
Guidance of IVUS	52 (27.8)	772 (37.8)	0.007
Stent diameter (mm)	3.1±0.4	3.2±0.4	0.06
Stent length (mm)	25.5±6.2	24.8±6.4	0.20
Stent maximum pressure (atm)	12.3±4.4	13.4±4.3	<0.001
Stent to artery ratio	1.2±0.2	1.2±0.2	0.72

IVUS study in MV



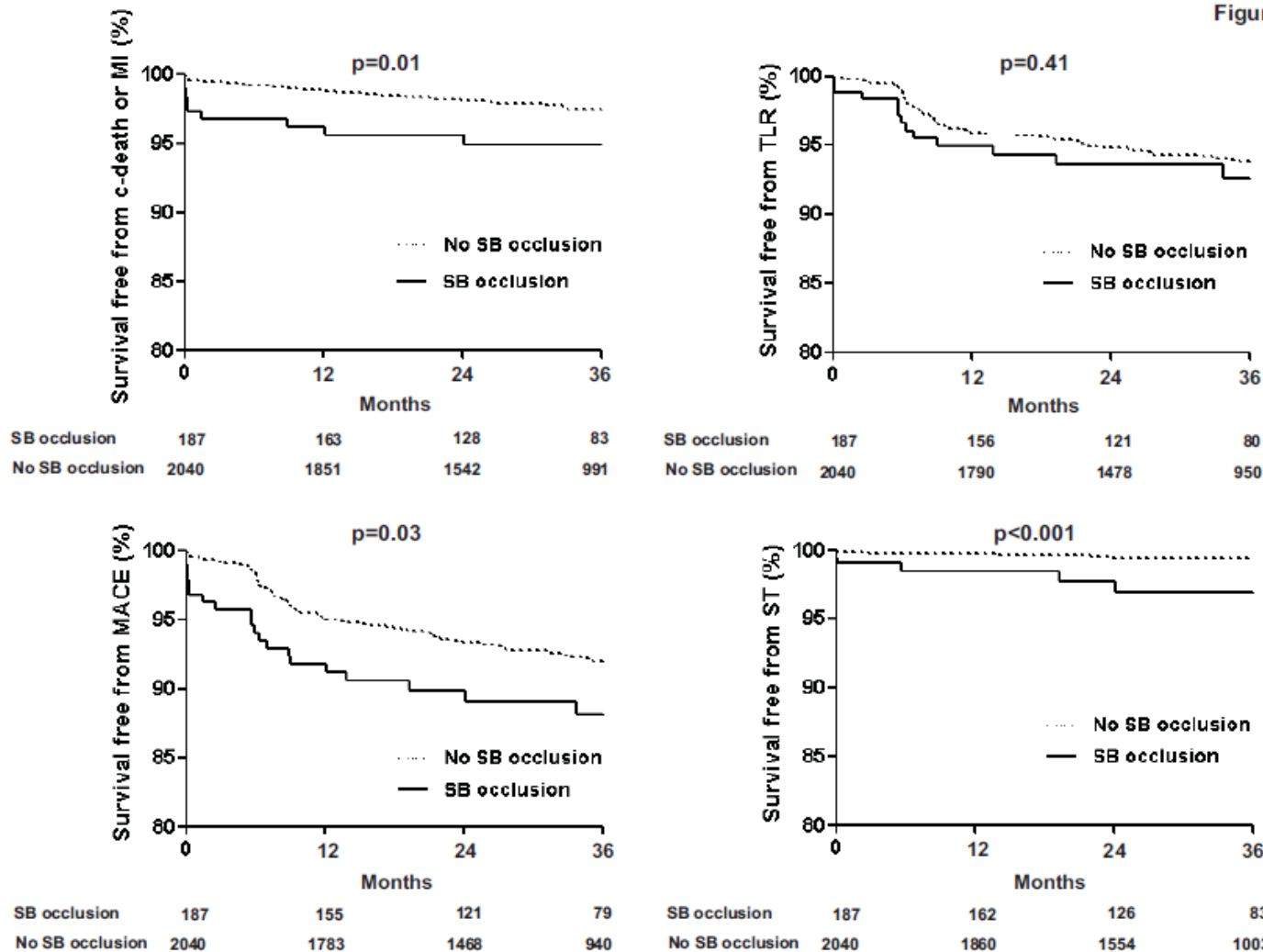
After MV stenting:

- Vessel and lumen volume ↑ in distal MV and proximal MV
- Plaque volume ↓ only in proximal MV
- Plaque volume of the distal MV (-)

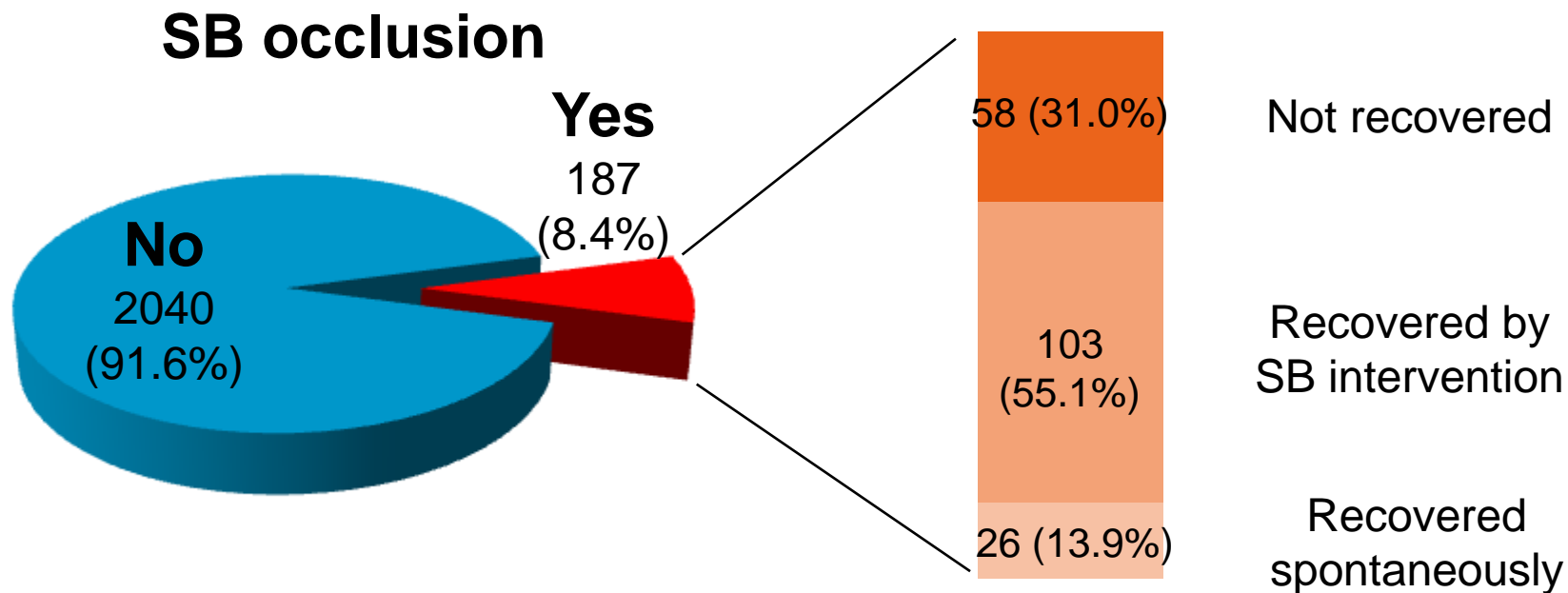
Clinical outcomes of SB occlusion



Figure 2



Fate of occluded SB after MV stenting



Jailed wire in the SB was associated with flow recovery (74.8% versus 57.8%, $p = 0.02$).

Fate of persistent SB occlusion



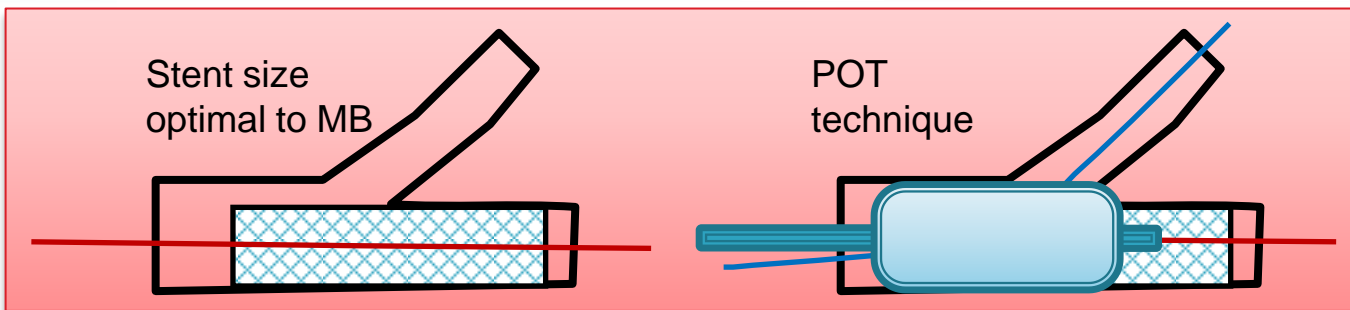
	SB recovery (n=129)	No SB recovery (n=58)	Unadjusted HR (95% CI)	p Value
Death	2 (1.6)	8 (13.8)	9.18 (1.95-43.29)	0.005
Cardiac death	2 (1.6)	5 (8.6)	5.63 (1.09-29.09)	0.04
MI	2 (1.6)	2 (3.4)	2.33 (0.59-4.07)	0.40
Cardiac death or MI	4 (3.1)	6 (10.3)	3.47 (0.98-12.31)	0.054
Stent thrombosis*	4 (3.1)	2 (3.4)	1.18 (0.22-6.42)	0.85
TLR	11 (8.5)	3 (5.2)	0.62 (0.17-2.23)	0.47
MACE	14 (10.9)	9 (15.5)	1.48 (0.64-3.41)	0.36

Study Limitations



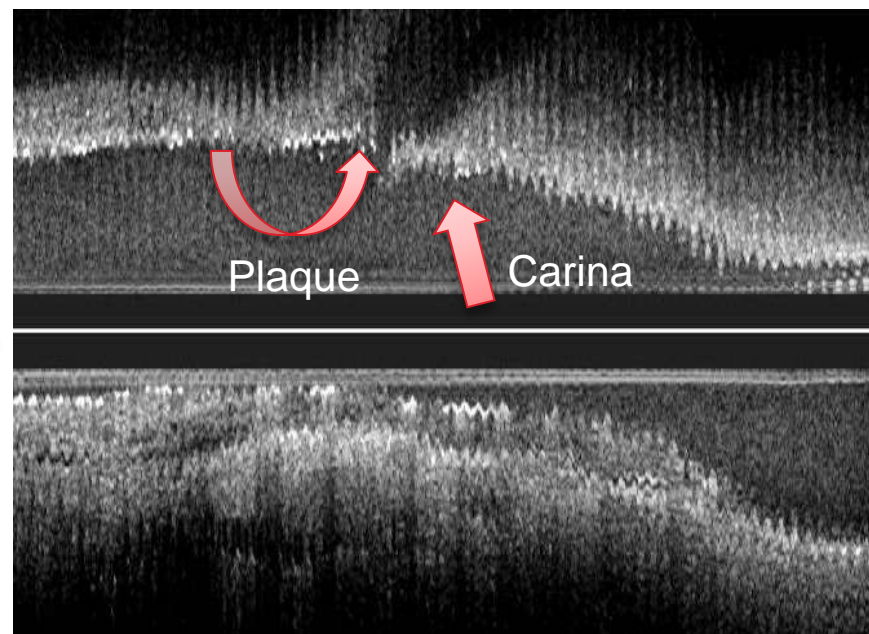
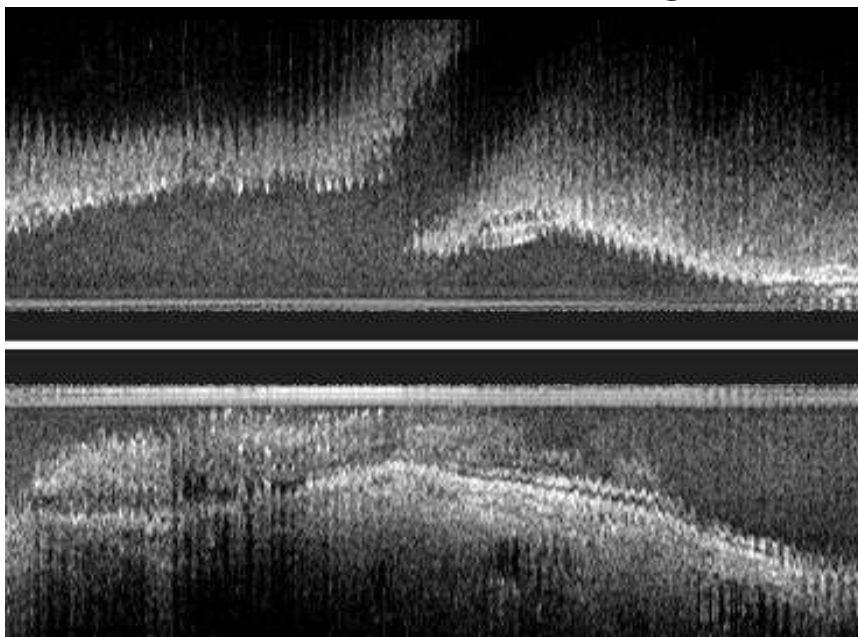
- ▶ Retrospective observational study
- ▶ We cannot completely exclude the protective effects of predilation of the SB or wiring in the SB. Predilation of the SB or wiring in the SB might be performed in SBs with greater jeopardy of occlusion.
- ▶ In patients treated with 2-stent technique, we could not know whether operators planned to implant stents in the SB in advance or had to do so during the procedure
- ▶ The discriminative ability of our multivariate model evaluated by ROC curves was reasonable, but not excellent

Stent overexpansion is a cause of SB compromise

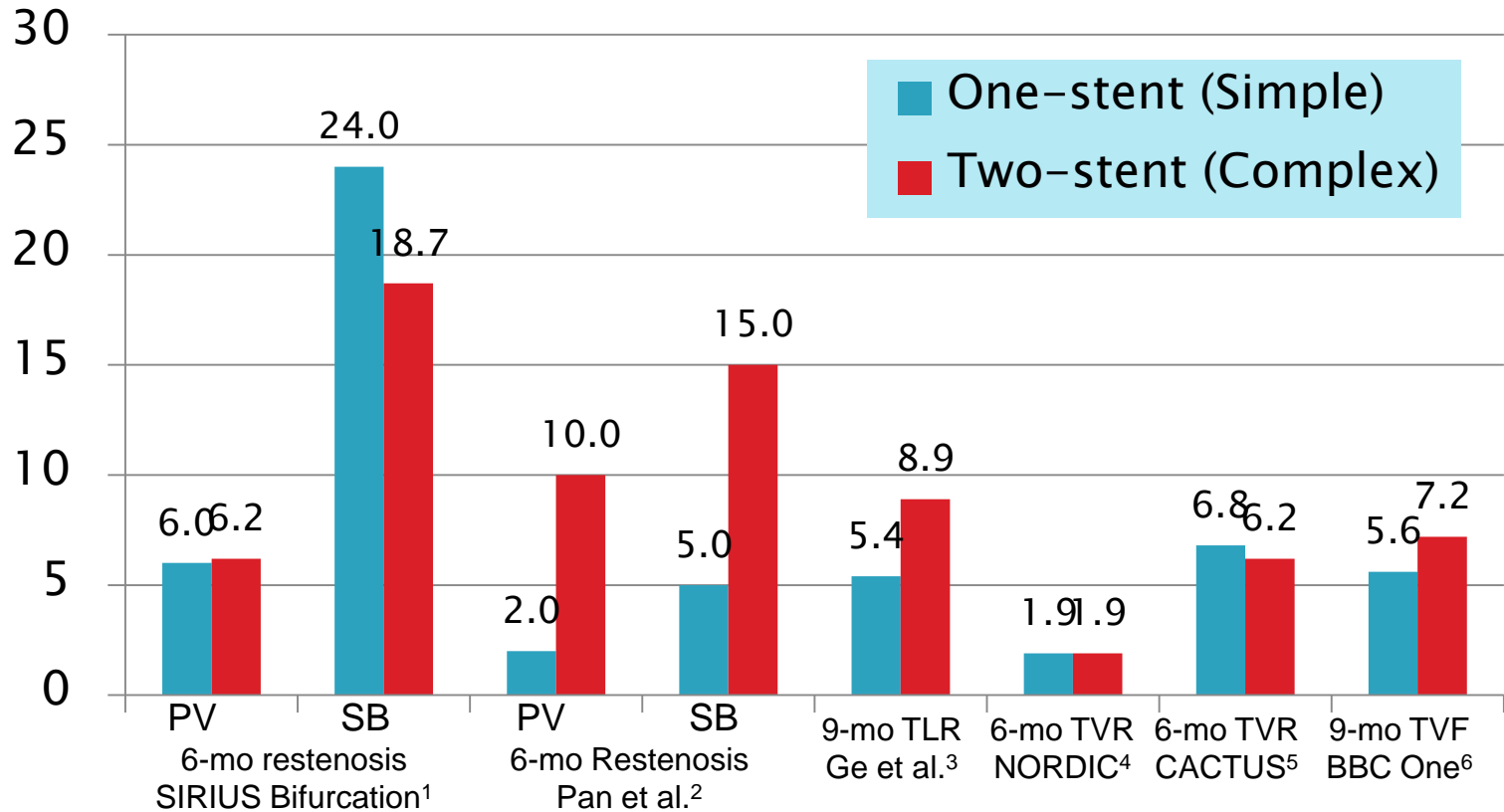


Before stenting

After stenting



Elective 2-stent technique has never been proved to be better than 1-stent technique



1. Colombo A, Circulation 2004

2. Pan M, AHJ 2004

3. Ge, Colombo, Heart 2005

4. Steigen, Circulation 2006

5. Colombo A, EuroPCR 2008

6. Hildick-Smith D. TCT 2008

Most bifurcation lesions can be treated with provisional approach.

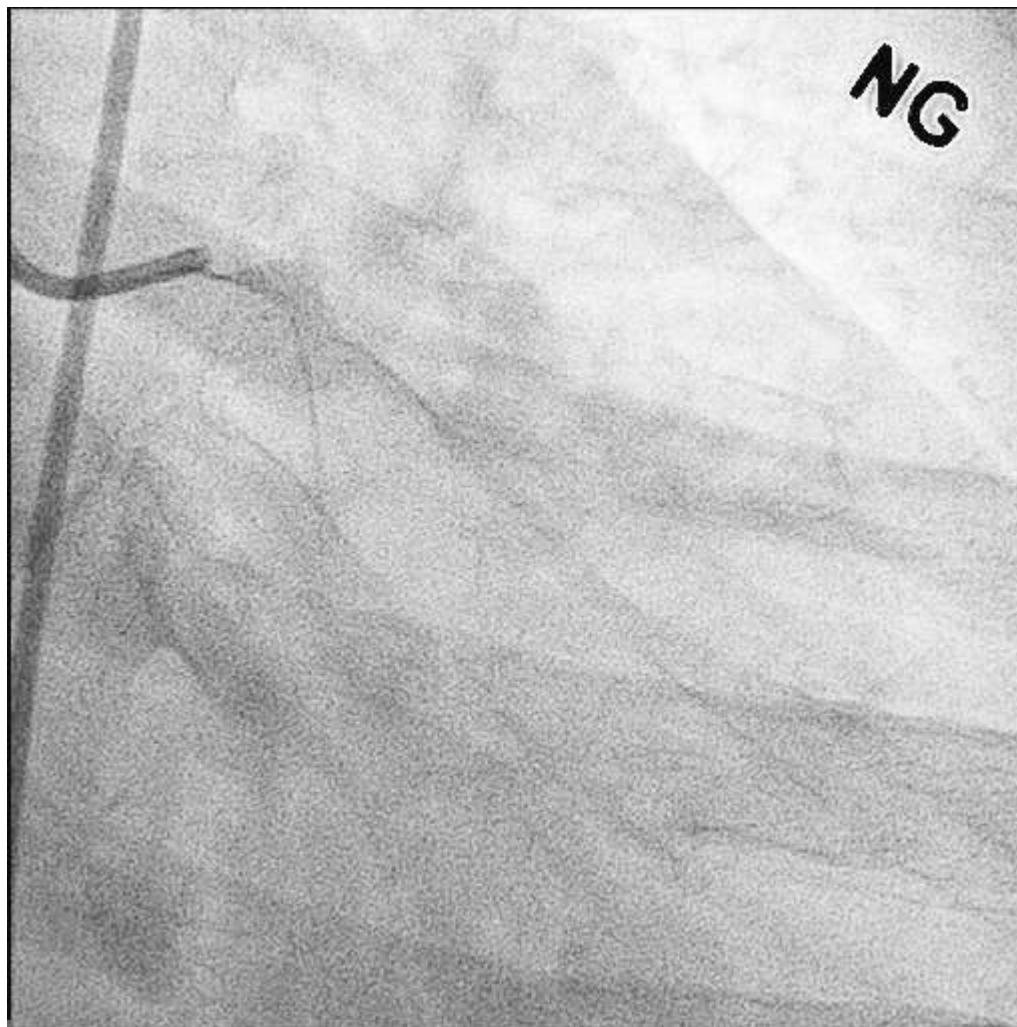


Baseline angiogram

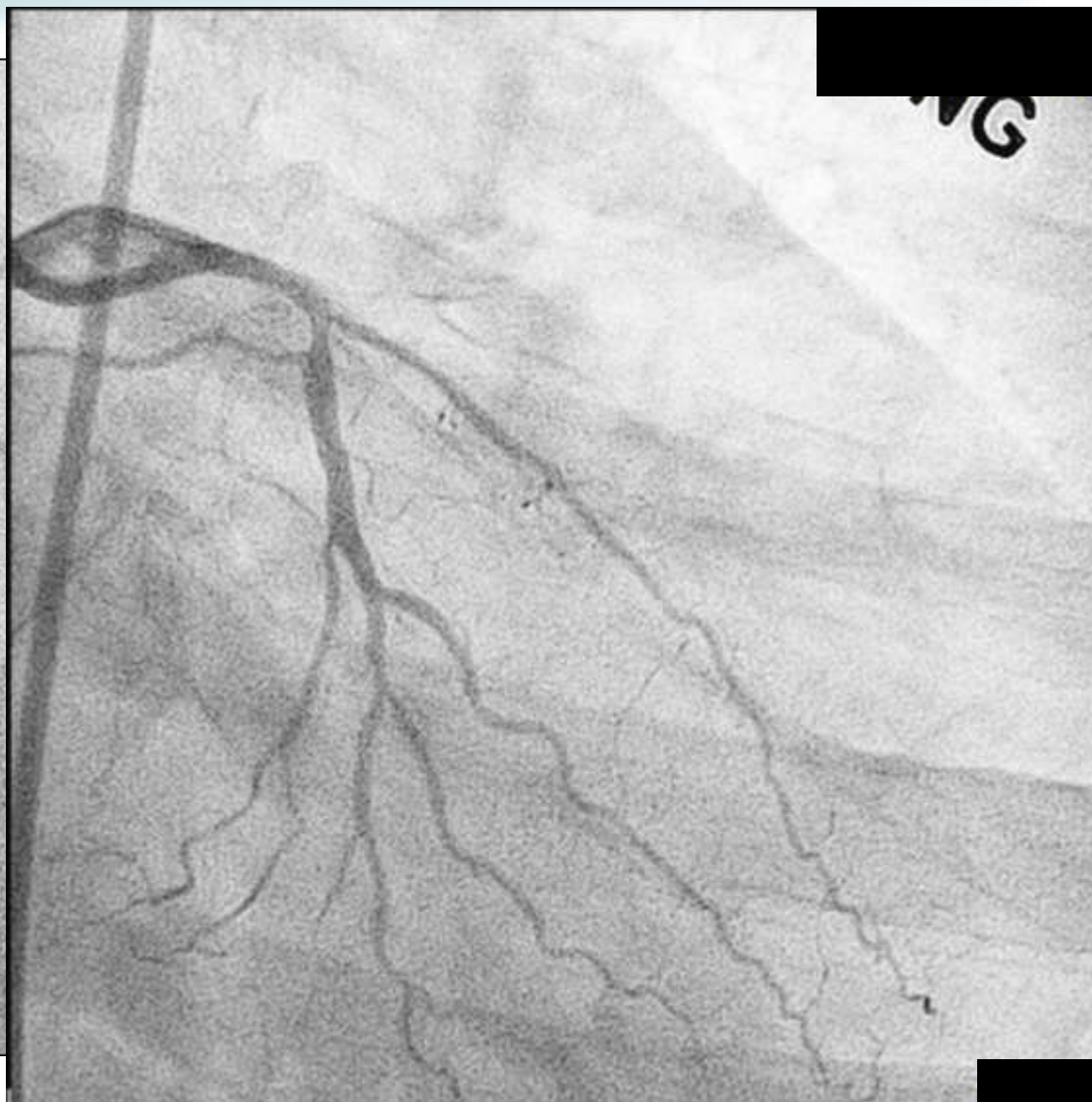
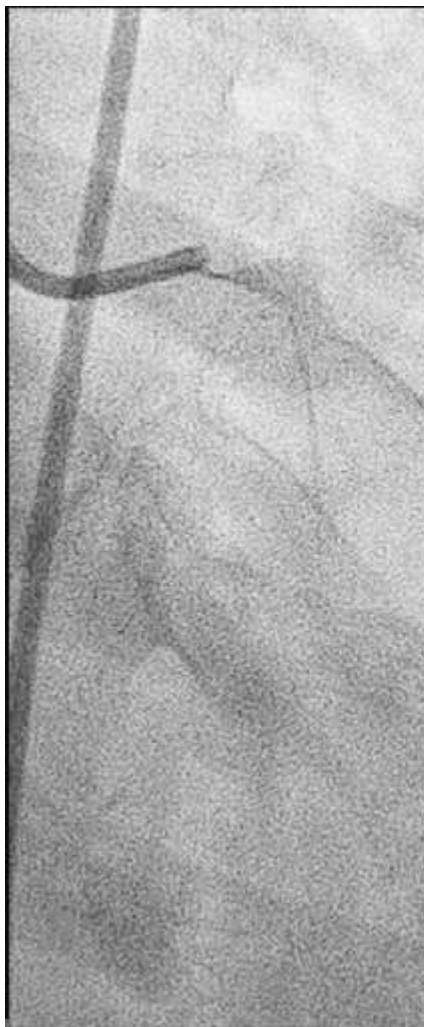


Final angiogram

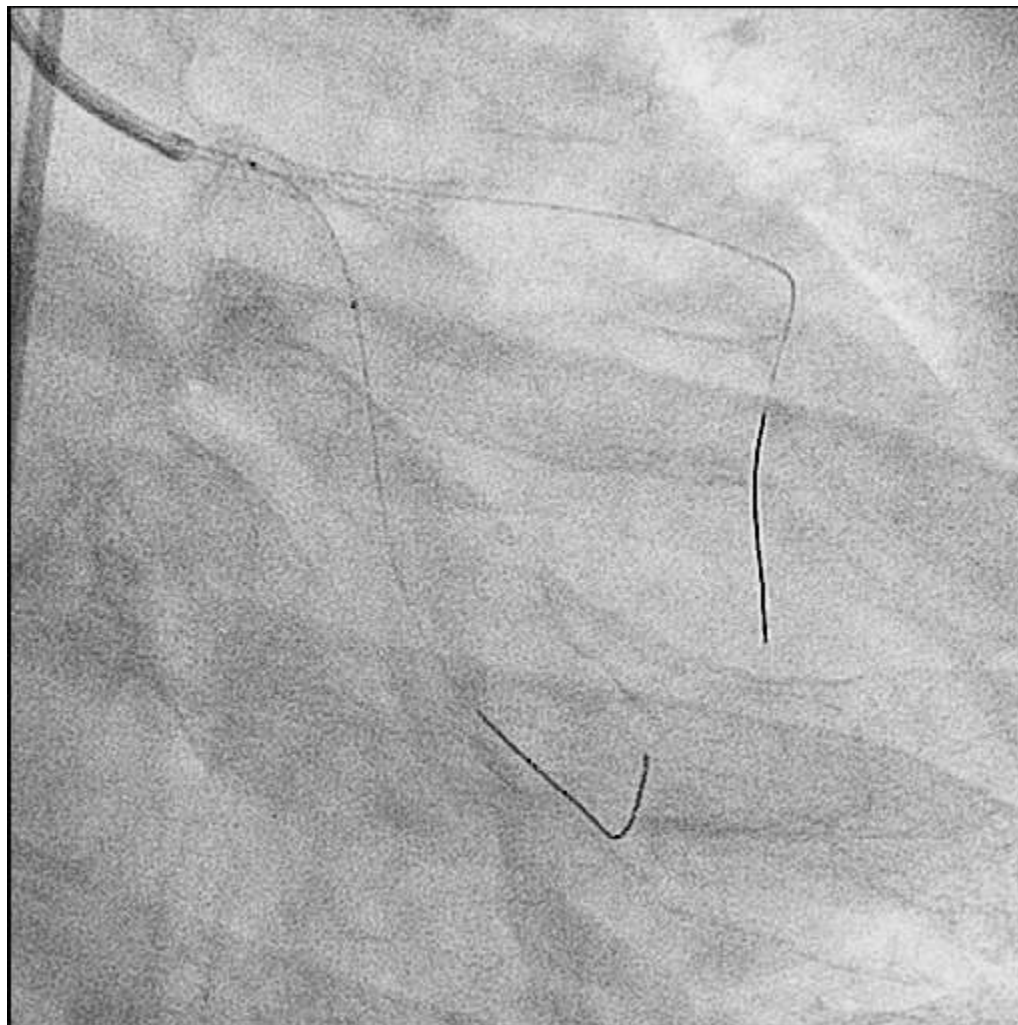
NSTEMI: LAD os lesion



Provisional or elective 2-stent strategy?



SB occlusion is unpredictable.



Participating Center



▶ N=2,897 from 18 centers (After core lab analysis)

Center	Cases	Center	Cases
Seoul National University Hospital	434	Chonnam National University Hospital	85
Korea University Guro Hospital	291	Yonsei University Severance Hospital	104
Sejong General Hospital	297	Chung-ang University Hospital	59
Samsung Medical Center	365	Inje University Ilsan Paik Hospital	66
Yeungnam University Hospital	208	Konyang University Hospital	67
Chungnam National University Hospital	189	National Health Insurance Corporation Ilsan Hospital	48
Samsugn Changwon Hospital	219	Keimyung University Hospital	52
Ajou University Hospital	161	Hallym University Kangdong Sacred Heart Hospital	33
Wonju Christian Hospital	103	Catholic University Seoul St. Mary's Hospital	51