PLACE 2026
PLATFORM OF LABORATORIES FOR ADVANCES IN CARDIAC EXPERIENCE

CONGRESSO
ROMA, 25 - 27 Giugno 2026

COMPLICATIONS 1: COMPLICATION ACADEMY

Occlusione del side branch: predittori e trattamento

Gregory A. Sgueglia

Predictors and consequences of SB occlusion

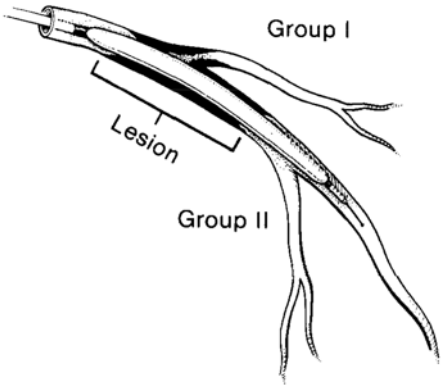
Risk of Side Branch Occlusion During Coronary Angioplasty

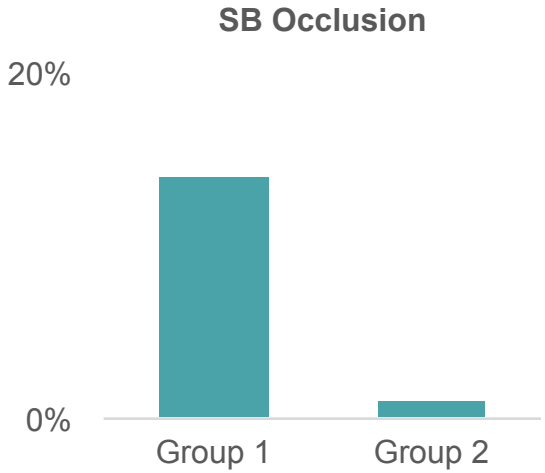
BERNHARD MEIER, MD, ANDREAS R. GRUENTZIG, MD, SPENCER B. KING III, MD,
JOHN S. DOUGLAS, Jr., MD, JAY HOLLMAN, MD, THOMAS ISCHINGER, MD,
FRED AUERON, MD, and KATHY GALAN, RN

Meier B et al. Am J Cardiol . 1984;53:10-4

Emory University PTCA Registry

- 302 patients with 365 SB involved during angioplasty between October 1982 and May 1983
- 122 SB in 102 patients were in Group 1; 243 SB in 214 patients were in Group 2
- 20 SB occlusion (5%)





- **Chest pain:** 5 patients
- **CK increase**: 6 patients
- **Decrease in exercise tolerance:** 0 patients

Meier B et al. Am J Cardiol 1984;53:10-4

Palmaz-Schatz Multicenter Registry

- 153 patients at eight centers between December 1987 and November 1990
- Thomas Jefferson University Core Lab

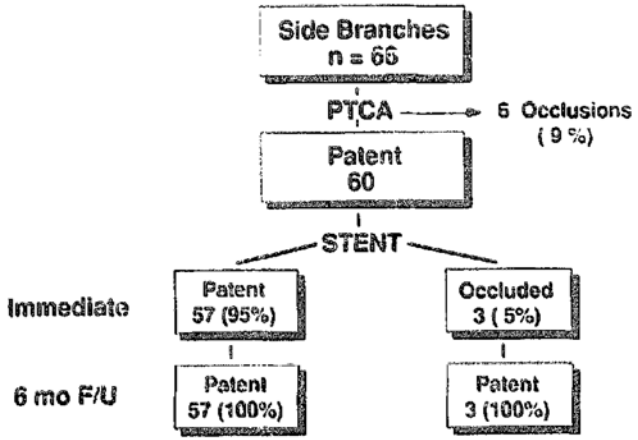
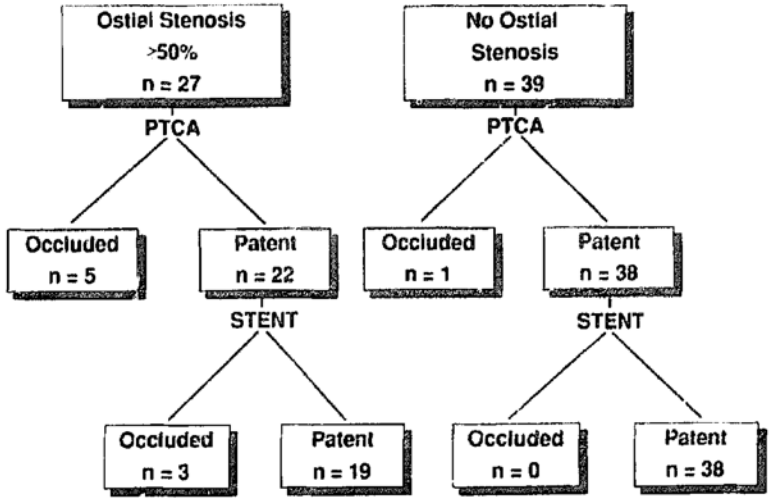


Figure 2. Outcome of side branches after stenting. F/U = follow-up; PTCA = percutaneous transluminal coronary angioplasty.

Figure 3. Effect of ostial disease on the outcome of side branches after stenting. PTCA = percutaneous transluminal coronary angioplasty.



Fischman DL et al. J Am Coll Cardiol 1993;22:1641-1646

William Beaumont Hospital Registry

- 175 patients with 224 SB involved during high-pressure stenting between November 1994 and June 1995
- 189 SB were considered non-threatened morphology; 35 SB were considered threatened morphology
- 43 SB occlusion (19%)

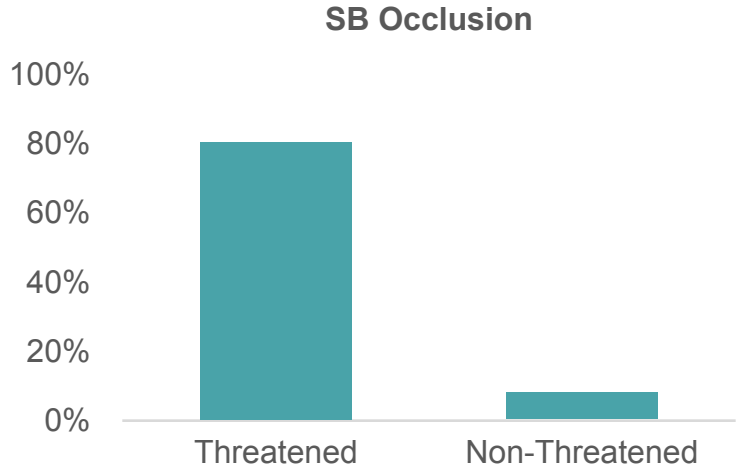


TABLE IV Summary of Nine-Month Clinical Follow-Up of the 175 Patients With Major Side Branches Covered by Stents

	With SBO (n = 43)	Without SBO (n = 132)
Death	1(2.3)	3(2.3)
Myocardial infarction	0	3(2.3)
Target vessel revascularization	9(21)	25(19)
Any	10(23)	30(23)

Data presented are number (%).

Aliabadi D et al. Am J Cardiol 1997;80:994-997

COBIS II Registry (COronary BIfurcation Stenting)

- 2,897 consecutive patients enrolled from 18 centers in Korea between January 2003 and December 2009
- 2,227 patients included in the analysis; SB occlusion in 187 bifurcation lesions (8.4%)

Table 5 Clinical Outcomes at 12-Month Follow-Up

Outcome	SB Occlusion (n = 187)	No SB Occlusion (n = 2,040)	Unadjusted HR (95% CI)	p Value	Adjusted HR* (95% CI)	p Value
Death	10 (5.3)	74 (3.6)	1.55 (0.80–2.99)	0.20	1.50 (0.76–2.97)	0.24
Cardiac death	7 (3.7)	20 (1.0)	3.95 (1.67–9.35)	0.002	4.19 (1.66–10.59)	0.002
MI	4 (2.1)	32 (1.6)	1.44 (0.59–4.07)	0.49	1.50 (0.51–4.41)	0.46
Cardiac death or MI	10 (5.3)	50 (2.5)	2.29 (1.16–4.52)	0.02	2.34 (1.15–4.77)	0.02
Stent thrombosis†	6 (3.2)	9 (0.4)	7.68 (2.73–21.59)	<0.001	6.19 (2.00–19.13)	0.002
TLR	14 (7.5)	129 (6.3)	1.26 (0.73–2.19)	0.41	1.31 (0.74–2.30)	0.36
MACE	23 (12.3)	164 (8.0)	1.63 (1.06–2.53)	0.03	1.64 (1.05–2.58)	0.03

Values are n (%). *Adjusted covariates included diabetes, acute coronary syndromes, true bifurcation, left main lesion, use of intravascular ultrasound, SB pre-dilation, MV stent diameter, and MV stent maximal pressure. †Definite or probable stent thrombosis.

CI = confidence interval; HR = hazard ratio; MACE = major adverse cardiac events; MI = myocardial infarction; TLR = target lesion revascularization.

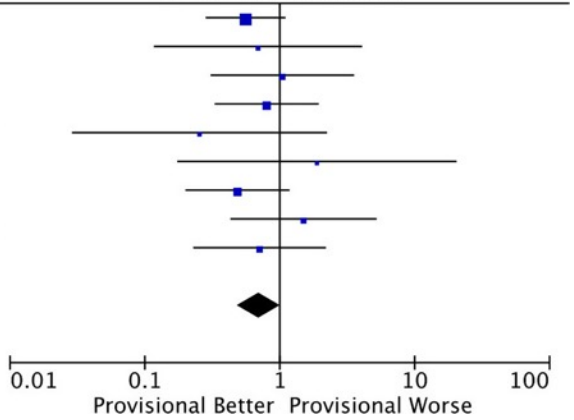
Hahn JY et al. J Am Coll Cardiol 2013;62:1654-1659

Meta-analysis single- versus two-stent strategy for bifurcation PCI

- 9 RCTs, 3,265 patients

Study or Subgroup	Provisional One Stent Events	Total	Two-Stent Events	Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
NORDIC 2013	12	207	21	202	28.8%	0.56 [0.28, 1.10]	2013
PERFECT 2015	2	206	3	213	4.2%	0.69 [0.12, 4.08]	2015
Nordi-Baltic Bifurcation IV 2015	5	218	5	228	8.9%	1.05 [0.31, 3.56]	2015
BBK1 2015	8	101	10	101	17.0%	0.80 [0.33, 1.94]	2015
SMART-STRATEGY 2016	1	128	4	130	2.8%	0.25 [0.03, 2.24]	2016
EBC Two	2	103	1	97	2.4%	1.88 [0.17, 20.44]	2016
BBC 1	7	245	14	238	16.9%	0.49 [0.20, 1.18]	2016
DK Crush II 5 year follow up 2017	6	183	4	183	8.6%	1.50 [0.43, 5.23]	2017
DK Crush V 2017	5	242	7	240	10.4%	0.71 [0.23, 2.20]	2017
Total (95% CI)		**1633**		**1632**	**100.0%**	**0.69 [0.48, 1.00]**	
Total events	48		69				

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 4.50$, df = 8 (P = 0.81); $I^2 = 0\%$
Test for overall effect: Z = 1.95 (P = 0.05)



Ford TJ et al. J Am Heart Assoc 2018;7:e008730

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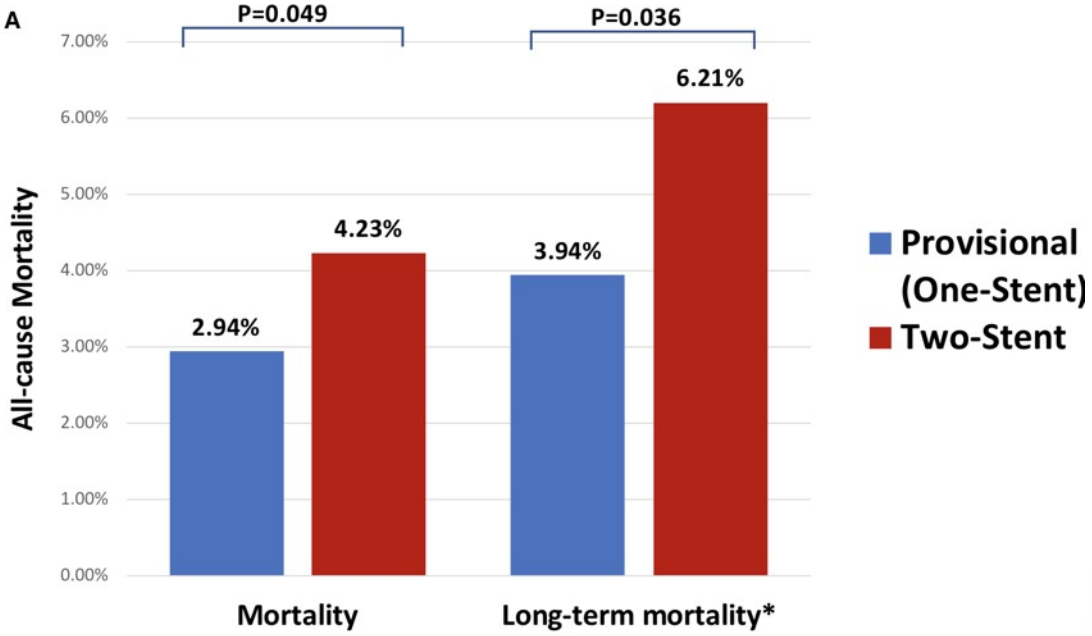

Kini AS et al. JACC Cardiovasc Interv 2016;9:862-865

COBIS II Registry (COronary BIfurcation Stenting)

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Table 4 Independent Predictors of SB Occlusion

Variable	Odds Ratio (95% CI) (range)	p Value
Pre-procedural %DS of the SB ≥50%	2.34 (1.59–3.43)	<0.001
Pre-procedural %DS of the proximal MV ≥50%	2.34 (1.57–3.50)	0.03
SB lesion length	1.03 (1.003–1.06)	<0.001
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

Table 5. Influence of bifurcation angle on interventional procedures in side branches

	Low-angle group (n = 724)	High-angle group (n = 708)	p value
Guide wiring of SB	423 (58.4)	367 (51.8)	0.015
Initial protection	348 (48.1)	310 (43.8)	
Protection after MV ballooning	75 (10.3)	57 (8.0)	
Predilatation of SB	172 (23.8)	148 (20.9)	0.195
Acute closure of SB after MV stenting	34 (4.7)	33 (4.7)	0.975
SB ballooning after MV stenting	298 (41.2)	240 (33.9)	0.005
Final kissing ballooning	305 (42.1)	251 (35.5)	0.010
SB stenting	147 (20.3)	75 (10.6)	<0.001
Final TIMI <3 flow of SB	36 (5.0)	32 (4.5)	0.124

Values are n (%).

Hahn JY et al. J Am Coll Cardiol 2013;62:1654-1659 | Yang JH et al. Cardiology 2012;122:216-224

PRESSURE Trial

- 77 patients undergoing MV stenting enrolled from 8 international centers
- IVUS before and after MV stenting (also FFR in jailed side branch)

Table 3. Changes in IVUS Volume Indices (mm^3/mm) After Stent Implantation

	Proximal Segment			Distal Segment		
	Pre	Post	*P*	Pre	Post	*P*
LVI	4.0±2.0	6.7±2.0	<0.0001	3.5±1.5	6.1±2.1	<0.0001
PVI	9.1±3.0	8.4±2.4	0.001	5.4±1.8	5.3±1.7	0.227
VVI	13.2±3.6	15.1±3.5	<0.0001	9.0±2.5	11.3±3.1	<0.0001

LVI indicates lumen volume index; PVI, plaque volume index; VVI, vessel volume index.

Plaque shift

Carina shift

Koo BK et al. Circ Cardiovasc Interv 2010;3:113-119

RESOLVE Score System (Risk prEdiction of Side branch OccLusion in coronary bifurcation interVEntion)

- 7,007 patients undergoing PCI at a single Chinese institution between January 2012 and July 2021
- 1,545 patients with 1,602 bifurcation lesions; SB occlusion in 118 bifurcation lesions (7.37%)

TABLE 4 Scores Attributed to Each Variable

Risk Factor	Level	Point
Plaque distribution	At the opposite side of SB	0
	At the same side of SB	1
MV TIMI flow grade before stenting	TIMI 3	0
	TIMI 2	6
	TIMI 1	11
	TIMI 0	17
Pre-procedural diameter stenosis of bifurcation core (%)	<50	0
	50-<70	2
	≥70	3
Bifurcation angle (°)	<70	0
	70-<90	4
	≥90	6
Diameter ratio between MV/SB	<1.0	0
	1.0-<1.5	2
	1.5-<2.0	6
	≥2.0	9
Diameter stenosis of SB before MV stenting (%)	<50	0
	50-<70	4
	70-<90	6
	≥90	7

TABLE 5 Frequency Distribution of SB Occlusion Across Different Risk Groups

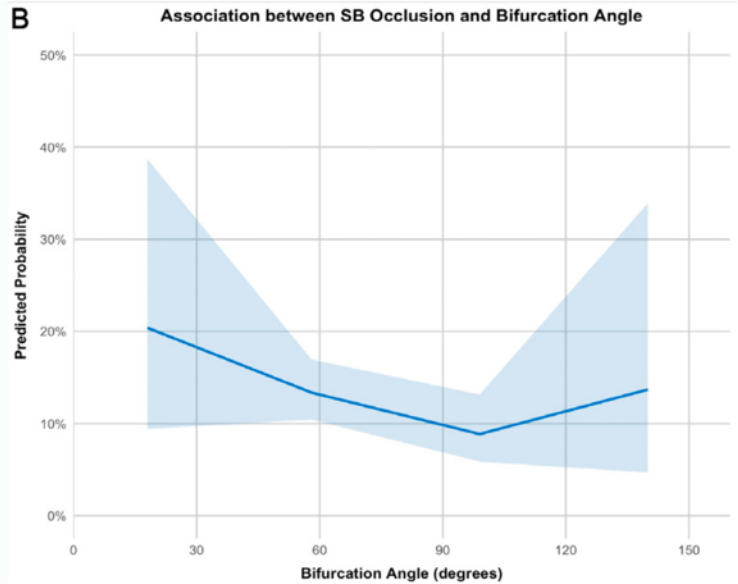
	Low-Risk Group (Quartile I)	Intermediate-Risk Group (Quartile II + III)	High-Risk Group (Quartile IV)	p Value
Range	0-2	3-9	≥10	
SB occlusion rate in training dataset (n = 1,200)	1/98 (1.0)	29/770 (3.8)	58/332 (17.5)	<0.001
SB occlusion rate in validation dataset (n = 401)	0/47 (0)	9/239 (3.8)	21/85 (19.8)	<0.001

Values are n/N (%).
SB = side branch.

Dou K et al. JACC Cardiovasc Interv 2015;8(1 Pt A):39-46

PROGRESS-BIFURCATION Registry

- 855 patients with 1015 bifurcations lesions at five international sites 2014 and 2023; 124 SB occlusions (13%)
- Assessment of the association between bifurcation angle and SB occlusion



Mutlu D et al. Am J Cardiol 2025:253:41-48

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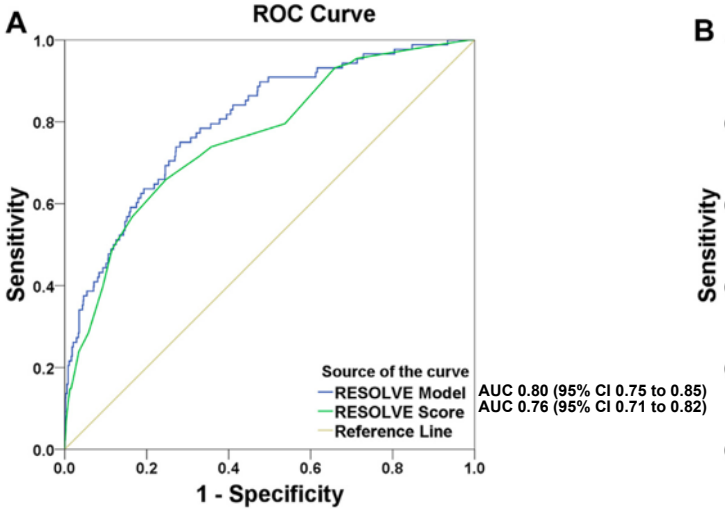
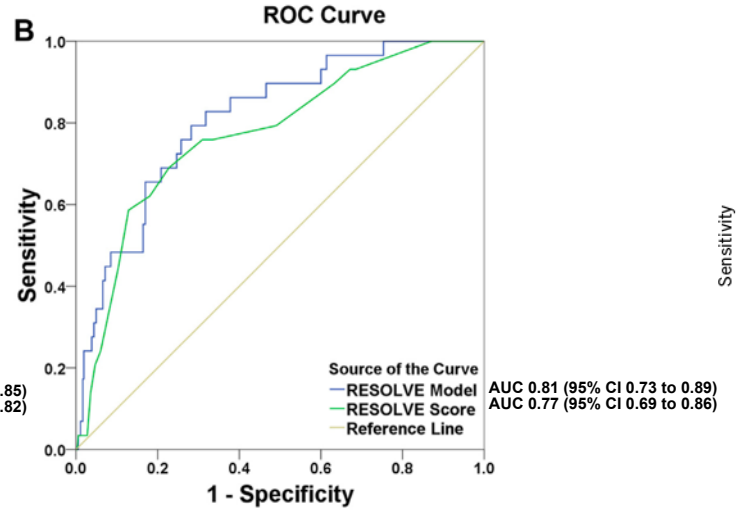
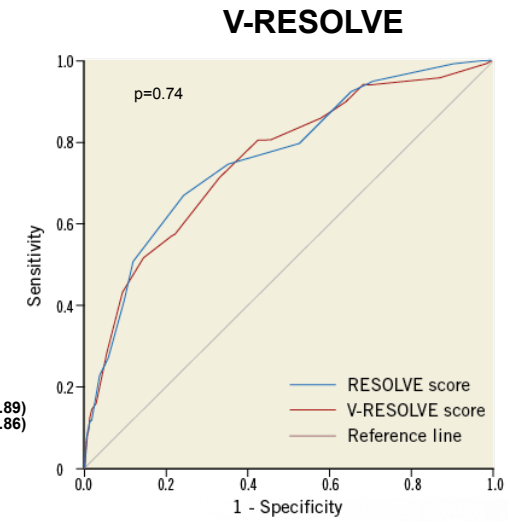


Derivation cohort



Validation cohort



Dou K et al. JACC Cardiovasc Interv 2015;8(1 Pt A):39-46 | Dou K et al. EuroIntervention 2016;11:e1604-11

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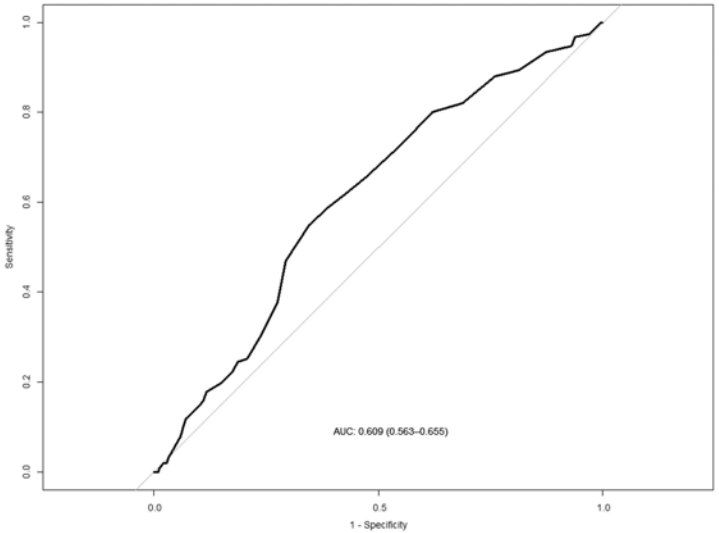
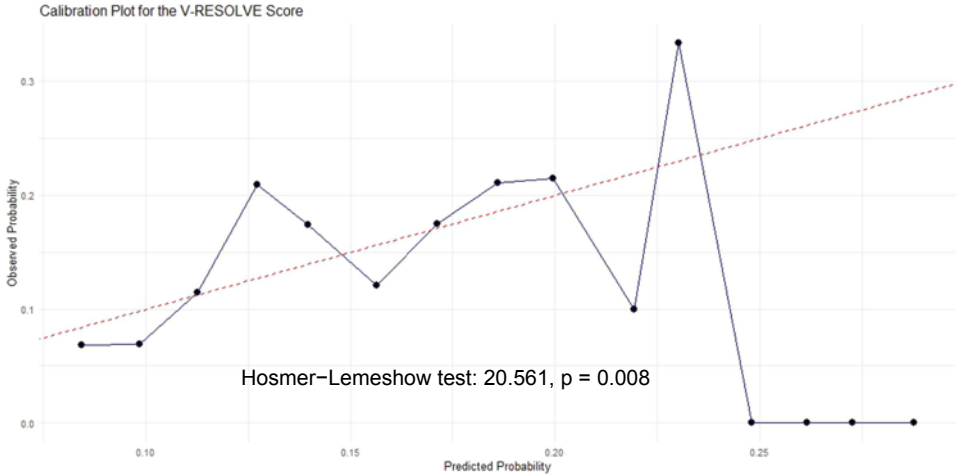


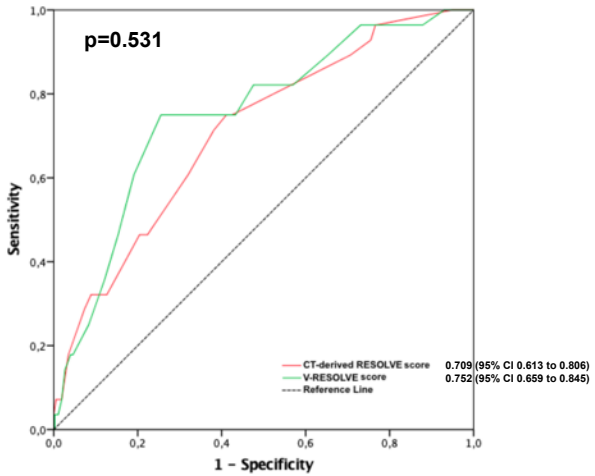


Strepkos D et al. Catheter Cardiovasc Interv 2025;106:1958-1965

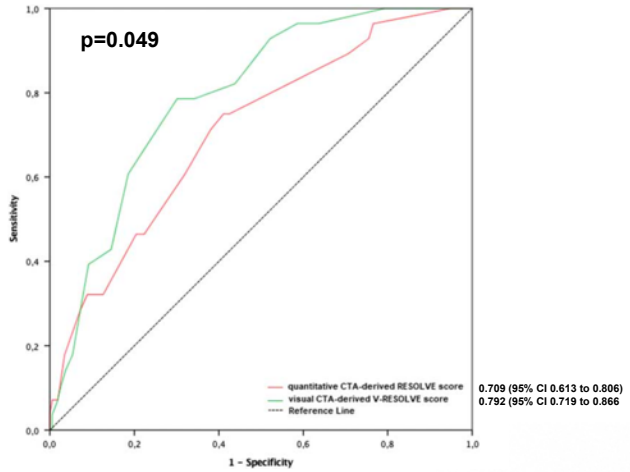
CTA-RESOLVE Study

- 363 patients with 400 bifurcations lesions with coronary CTA; 28 SB occlusions (7%)
- Assessment of CTA-derived RESOLVE Score and CTA-derived V-RESOLVED Score

CTA-derived RESOLVE Score



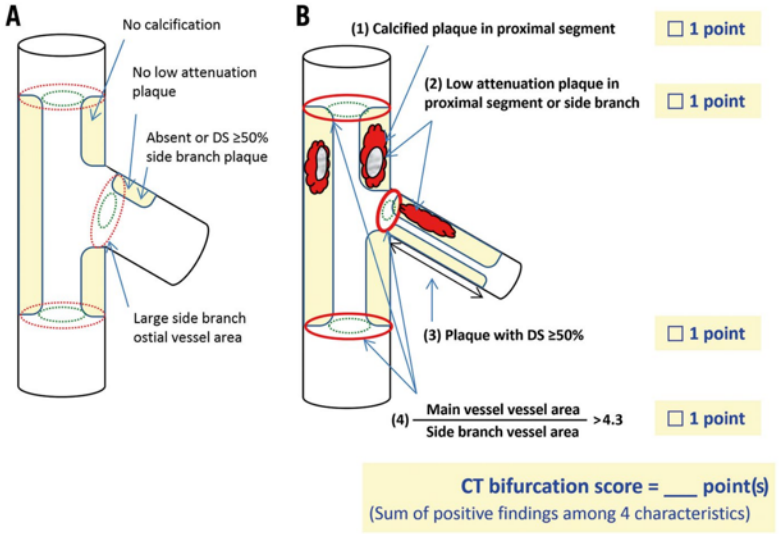
CTA-derived V-RESOLVE Score

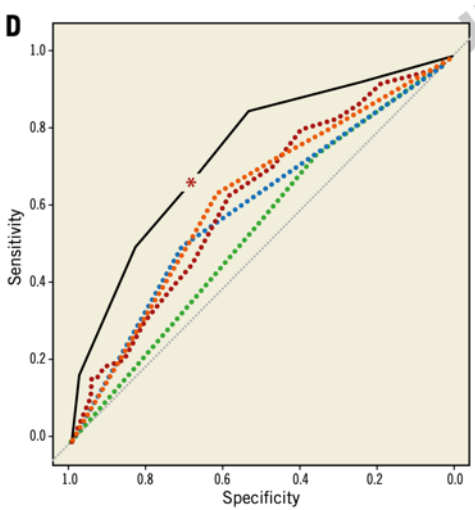


Opolski MP et al. J Cardiovasc Comput Tomogr. 2020;14:258-265| Michalowska AM et al. J Thorac Imaging 2021;36:189-196

CT Bifurcation Study

- 246 patients; 260 bifurcations lesions; 42 SB occlusions (16%)





	c-statistics (95% CI)
CT bifurcation score	0.749 (0.672-0.827)
RESOLVE score	0.627 (0.537-0.717)
Medina classification with any SB plaque (type 1,1,1, 1,0,1, 0,1,1, 0,0,1)	0.631 (0.551-0.711)
Medina classification with MV proximal and SB plaque (type 1,1,1 or 1,0,1)	0.608 (0.526-0.690)
Medina classification with any MV proximal plaque (type 1,1,1, 1,1,0, 1,0,1, or 1,0,0)	0.551 (0.478-0.623)

Lee SH et al. EuroIntervention 2019;15:e788-e795

Fukushima IVUS Study

- 174 patients, 272 bifurcations lesions between December 2009 and May 2013

TABLE IV. Univariable and Multivariable Logistic Analyses to Predict SB Occlusion

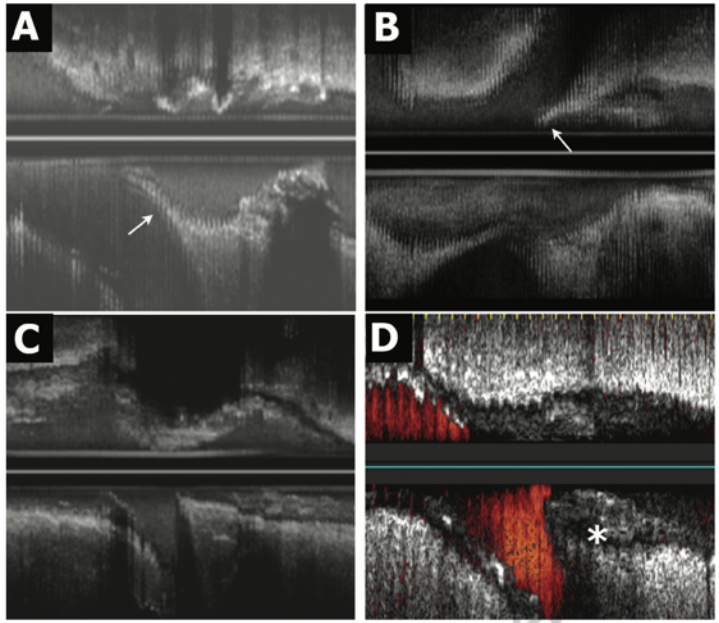
	Univariable analysis		Multivariable analysis	
Risk factor	OR (95% CI)	*P*	OR (95% CI)	*P*
MLD	0.522 (0.360–0.756)	0.001	1.924 (0.539–6.867)	0.314
MVD	1.266 (0.937–1.709)	0.124		
Lumen CSA	0.422 (0.270–0.660)	0.0001	0.521 (0.131–2.074)	0.355
EEM CSA	1.225 (0.912–1.651)	0.175		
Plaque area	1.675 (1.239–2.267)	0.001	0.988 (0.611–1.602)	0.966
The thinner MV plaque on the sides of SB	6.796 (4.010–11.520)	0.0001	4.956 (2.655–9.252)	<0.0001
SB total diameter	1.198 (0.894–1.603)	0.226		
SB luminal diameter	0.280 (0.175–0.451)	0.0001	1.092 (0.557–2.142)	0.799
The SB diameter ratio	7.730 (4.280–13.953)	0.0001	4.226 (1.788–9.990)	<0.0001

Data reported are per one SD increase.
SB, side branch; OR, odds ratio; CI, confidence interval; MV, major vessel; IVUS, intravascular ultrasound; MLD, minimum lumen diameter; MVD, minimum vessel diameter; CSA, cross-sectional area; EEM, external elastic membrane.

Sakamoto N et al. Catheter Cardiovasc Interv 2016;87:243-50

Cordoba IVUS Study

- 99 patients, 110 bifurcations lesions Medina 1,0,0 - 1,1,0 – 0,1,0
- The “eyebrow” sign



Suárez de Lezo J et al. EuroIntervention 2012;7:1147-1154

Mount Sinai OCT Study

- 134 bifurcations lesions; 17 SB occlusions (12.7%)

TABLE 1 OCT Image Analysis of Main Vessel Before MV Stenting

	Proximal MV		Distal MV	
	SB Occlusion n = 17	No SB Occlusion n = 117	SB Occlusion n = 17	No SB Occlusion n = 117
Reference lumen area, mm^2	6.7 (5.4-8.4)	6.8 (5.6-8.9)	4.4 (3.7-8.3)	4.9 (3.7-6.0)
Minimal lumen area, mm^2	2.0 (1.4-3.1)	3.2 (2.1-5.0)†	2.1 (1.7-3.0)	2.4 (1.8-3.5)
Area stenosis, %	68.4 (55.4-73.4)	55.2 (33.9-65.7)†	55.7 (28.9-70.8)	42.9 (25.9-64.6)
Lipid plaque	15 (88.2)	53 (45.3)‡	14 (82.4)	49 (41.9)†
Maximal lipid arc, °	227.2 (194.0-273.0)	129.0 (99.1-186.5)‡	138.0 (104.3-209.3)	123.5 (100.6-164.5)
Maximal lipid arc distance to bifurcation, mm	0.5 (0.1-3.6)	1.2 (0.0-2.5)	2.0 (0.5-3.3)	1.6 (0.6-2.4)
Averaged lipid arc, °	163.0 (137.0-219.0)	112.8 (89.6-138.7)‡	121.3 (103.1-157.5)	107.1 (90.6-137.4)
Lipid length, mm	5.0 (3.0-6.0)	3.0 (2.0-4.0)†	2.0 (1.0-4.3)	3.0 (1.0-4.0)
Lipid volume index	866.1 (507.0-1,006.0)	316.1 (184.0-481.5)‡	238.0 (127.4-626.0)	284.0 (124.1-433.9)
Minimum cap thickness, µm	70.0 (60.0-110.0)	120.0 (80.0-150.0)†	120.0 (67.5-235.0)	120.0 (105.0-170.0)
TCFA	5 (33.3)	7 (13.2)	3 (21.4)	1 (2.0)*
Calcified plaque	14 (82.4)	90 (76.9)	11 (64.7)	64 (54.7)
Maximal calcium arc, °	96.2 (72.1-147.6)	110.5 (62.4-203.1)	78.0 (54.0-120.0)	90.2 (61.2-131.5)
Averaged calcium arc, °	77.7 (46.4-92.3)	79.0 (47.1-130.8)	67.5 (46.8-92.3)	70.9 (49.3-99.5)
Calcium length, mm	3.0 (2.0-5.0)	4.0 (2.0-6.0)	2.0 (1.0-3.0)	3.0 (2.0-5.0)
Calcium volume index	240.5 (157.0-400.7)	271.1 (91.4-599.5)	175.0 (78.0-270.0)	232.1 (110.8-414.6)
Spotty calcification	11 (64.7)	29 (24.8)‡	6 (35.3)	14 (12.0)*

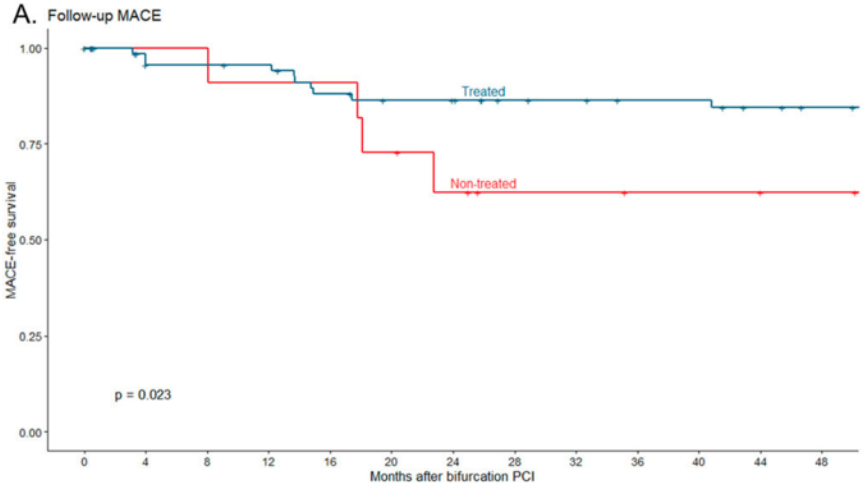
Values are median (interquartile range), n (%), or mean ± SD. *p ≤ 0.05 versus SB occlusion. †p ≤ 0.01 versus SB occlusion. ‡p ≤ 0.001 versus SB occlusion.
MV = main vessel; OCT = optical coherence tomography; SB = side branch; TCFA = thin-cap fibroatheroma.

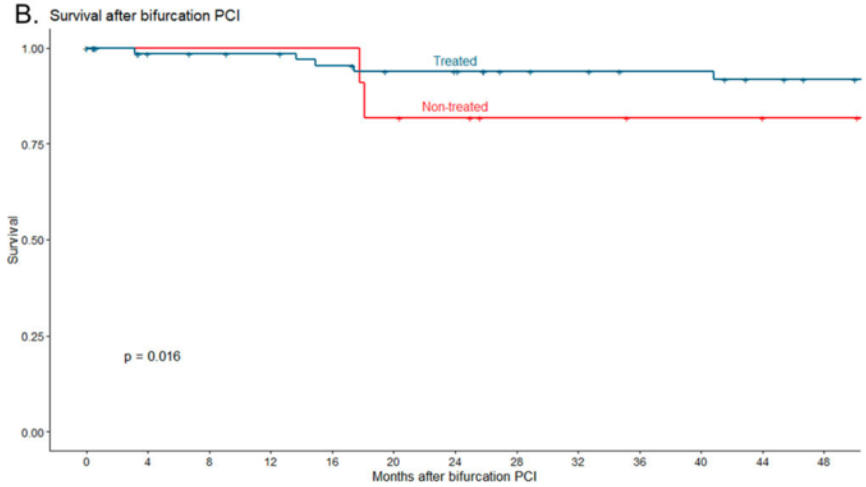
Kini AS et al. JACC Cardiovasc Interv 2016;9:862-865

Prevention and treatment of SB occlusion

PROGRESS-BIFURCATION Registry

- 791 patients with 937 bifurcations lesions at five international sites 2014 and 2024; 124 SB occlusions (13%)
- Assessment of the V-RESOLVE score in an independent registry





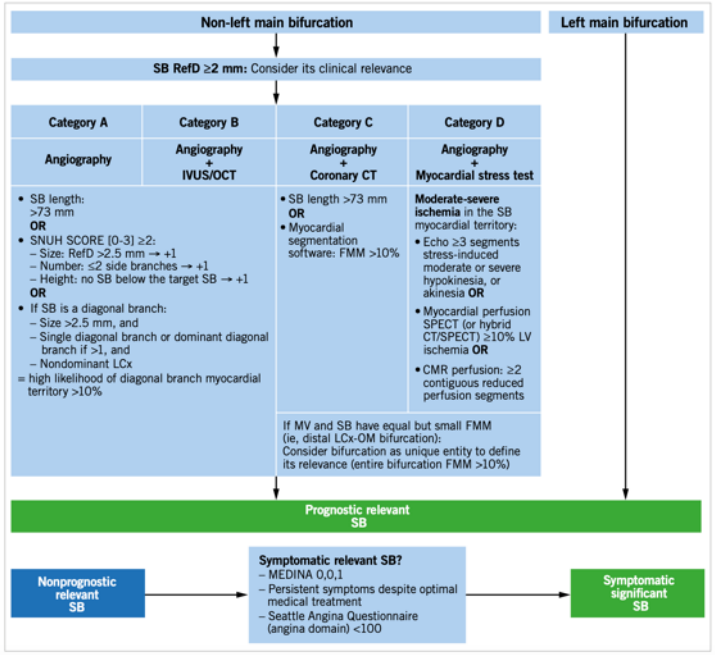
Strepkos D et al. Catheter Cardiovasc Interv 2025;106:1958-1965

The 17th expert consensus document of the European Bifurcation Club – techniques to preserve access to the side branch during stepwise provisional stenting

Pan M et al. EuroIntervention 2023;19:26-36

Relevant SB Concept

- Definitions and Standardized Endpoints for Treatment of Coronary Bifurcations
- Bifurcation Academic Research Consortium and European Bifurcation Club



Lunardi M et al. EuroIntervention 2022;18:e807-e831

TULIPE Study

- 186 consecutive enrolled by 14 high-volume French centers between February and December 2002
- Assessment of a provisional T-stenting strategy with final kissing balloon

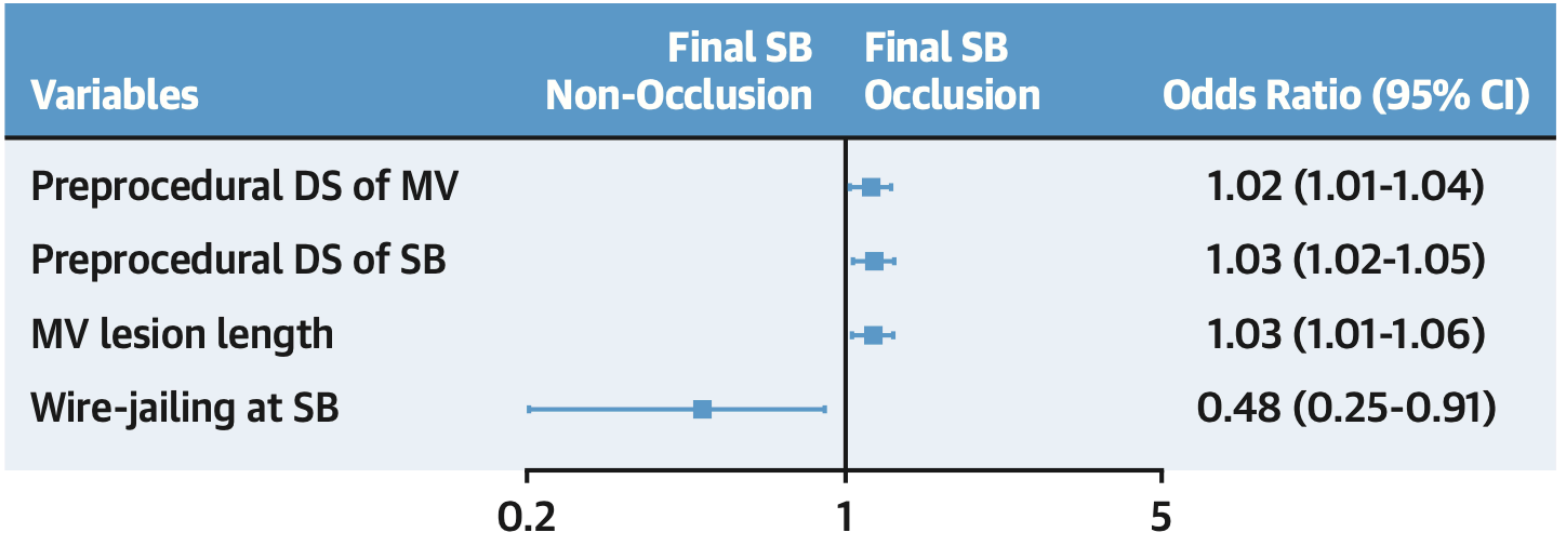
Predictors of TLR at 7-month FU

	OR (95% CI)
Left ventricle ejection fraction	0.93 (0.89-0.98)
SB calcification	7.86 (2.07-29.77)
Non-use of jailed wire	**4.26 (1.27-14.35)**

Brunel P et al. Catheter Cardiovasc Interv . 2006;68:67-73

COBIS III Registry (COronary BIfurcation Stenting)

- 1,890 patients with with bifurcation lesions treated with 1-stent
- 819 patients made the wire-jailing group; 1,071 patients made the non-wire-jailing group



Choi YJ et al. J Am Coll Cardiol Intv 2022;15:443–455

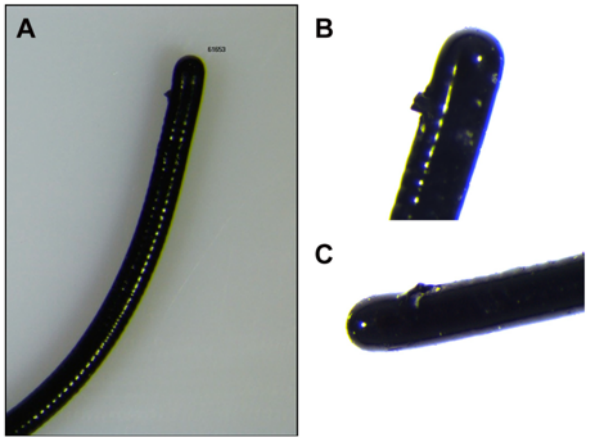
EDITORIAL COMMENT

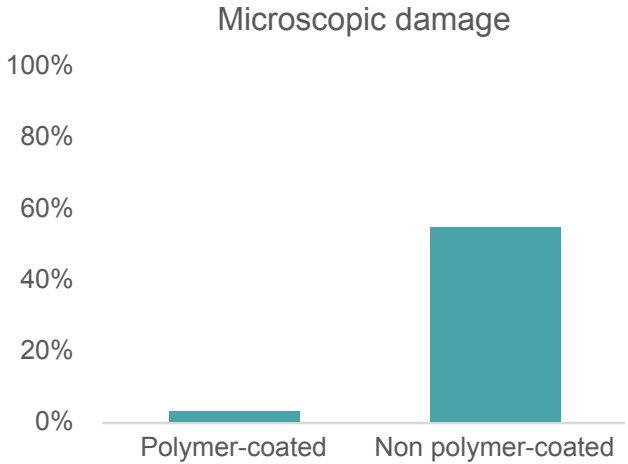
When You Ask Yourself the Question "Should I Protect the Side Branch?": The Answer Is "Yes"*

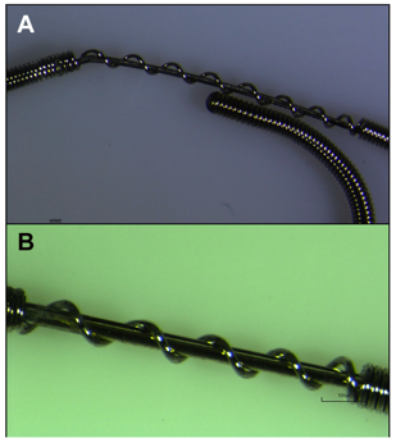
Colombo A, Ruparelia N. JACC Cardiovasc Interv 2015;8(1 Pt A):47-8

Microscopic Randomized Trial

- 235 patients with bifurcation lesions treated with provisional stenting with jail-wire
- Randomization to polymer-coated wire (n=115) or non polymer coated (n=120)







Pan M et al. J Am Coll Cardiol Intv 2016;9:1917-1924

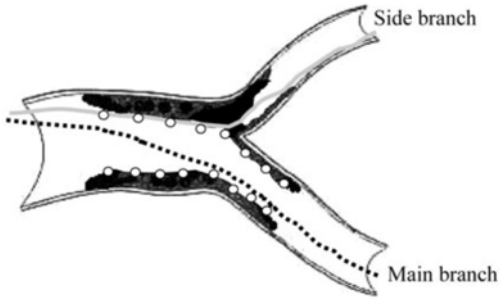
Advantages of the jailed-wire

- Helps to keep the SB open by favorably changing the angle of the bifurcation
- In case of occlusion, the guidewire is the only marker of the SB ostium
- Provide anchoring of the guide catheter which facilitate balloon crossing through the stent struts to the SB
- Case of SB occlusion, the jailed wire can be used to pass a low-profile balloon (or penetrative microcatheter) between the stent and the vessel wall to restore SB flow

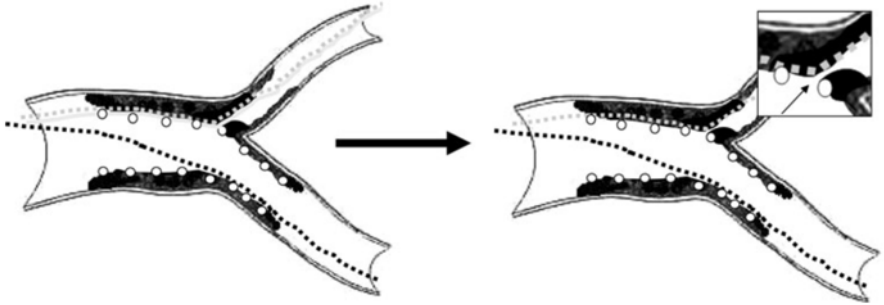
Choi YJ et al. J Am Coll Cardiol Intv 2022;15:443–455

Two-wire protection of side branches to prevent side branch occlusion during stent implantation for bifurcational lesions

One-wire

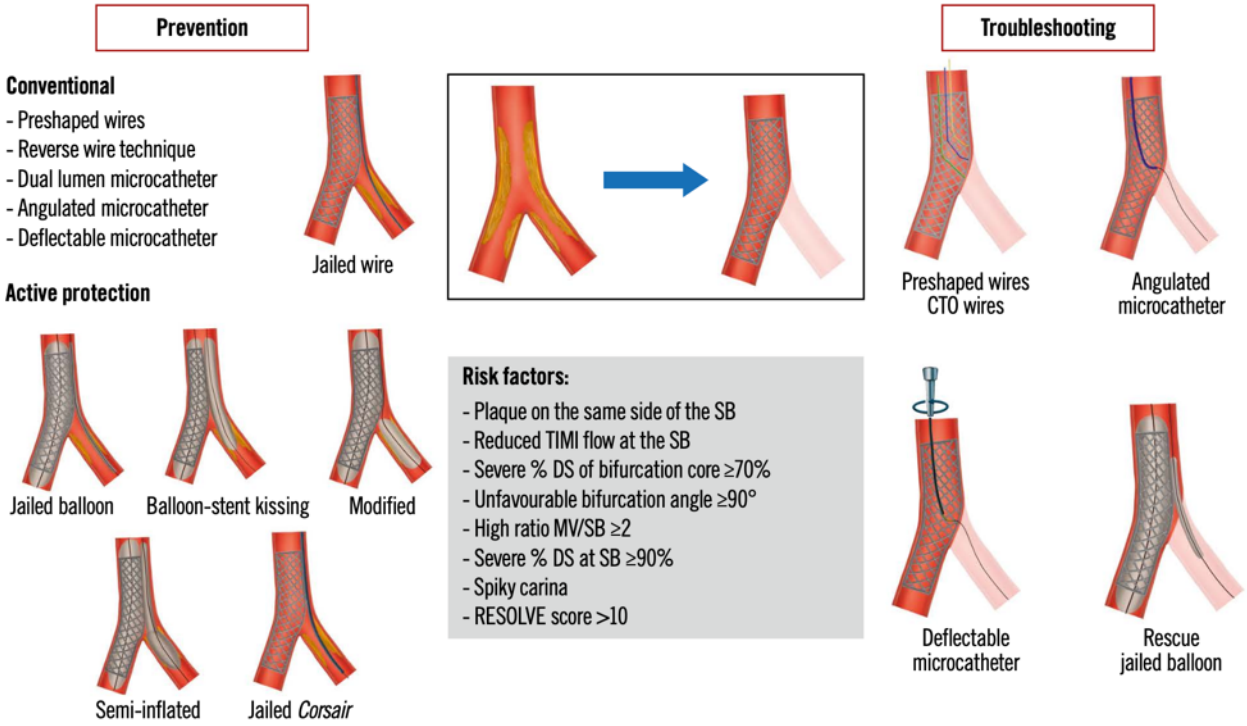


Two-wire



Oda H et al. Cardiovasc Interv Ther 2010;25:112-6

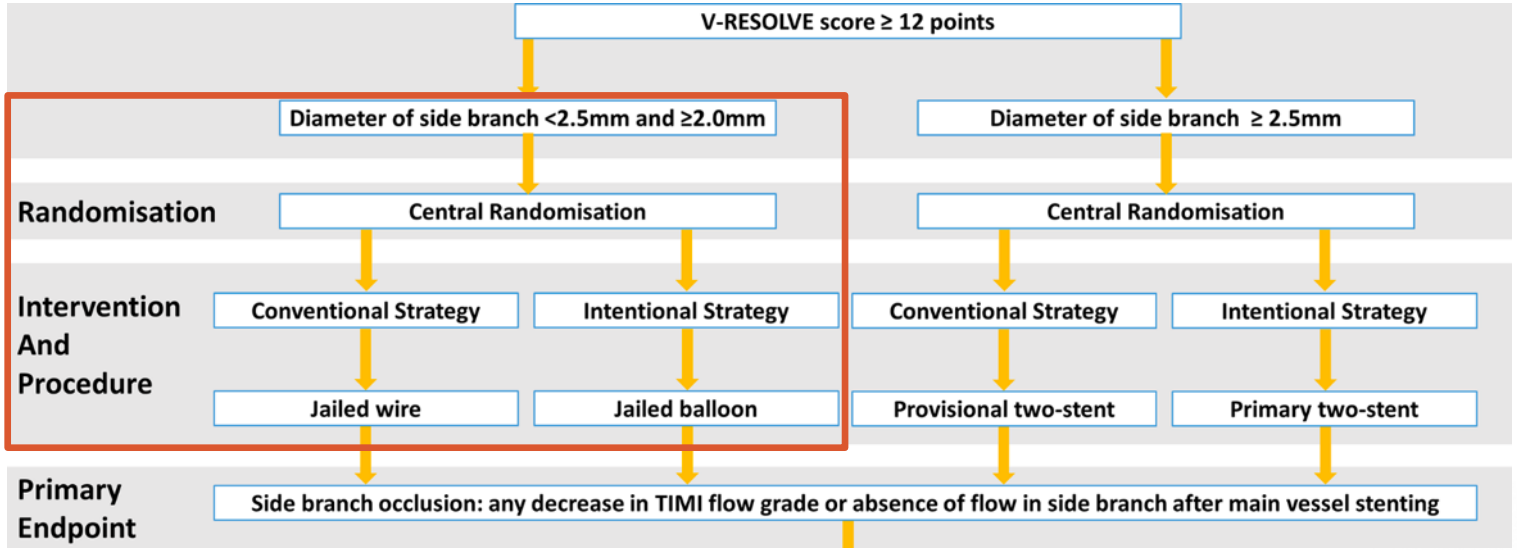
Preserving SB access during provisional stenting



Pan M et al. EuroIntervention 2023;19:26-36

The CIT-RESOLVE Trial

- 335 patients at 16 sites randomized to active SB protection (168 patients) or conventional strategy (167 pateients)



Zhang D et al. BMJ Open 2017;7:e016044

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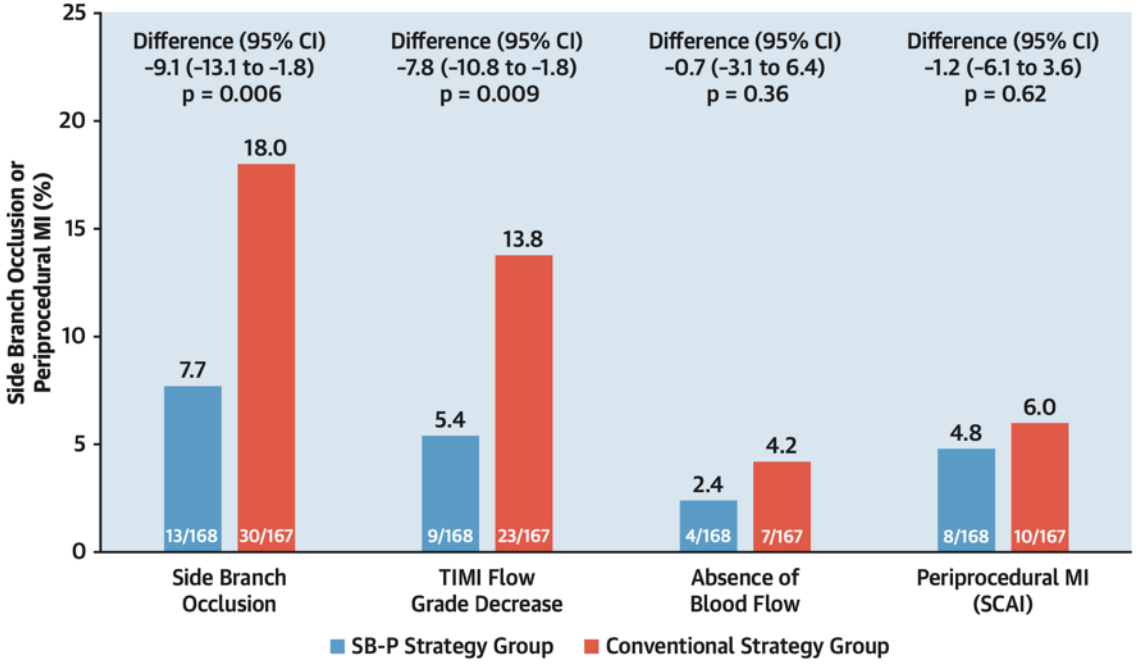


Dou K et al. J Am Coll Cardiol Intv 2020;13:1112–1122

Preserving and rescuing SB access during provisional stenting

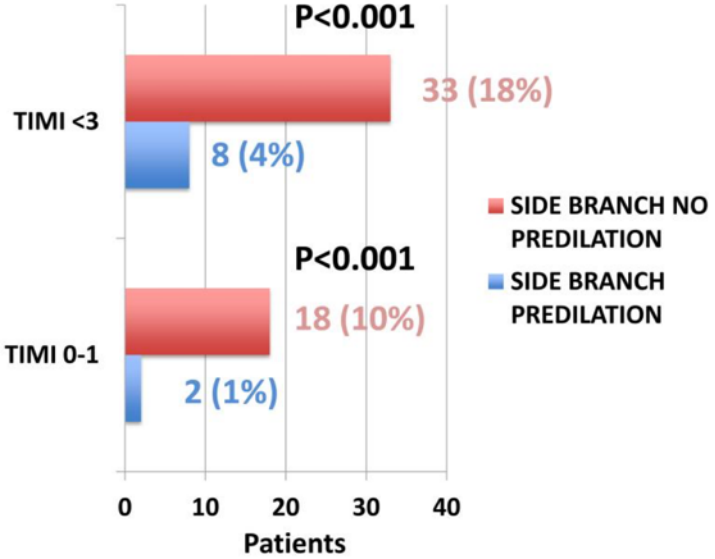
Table 2. Side branch protection and rescue techniques.

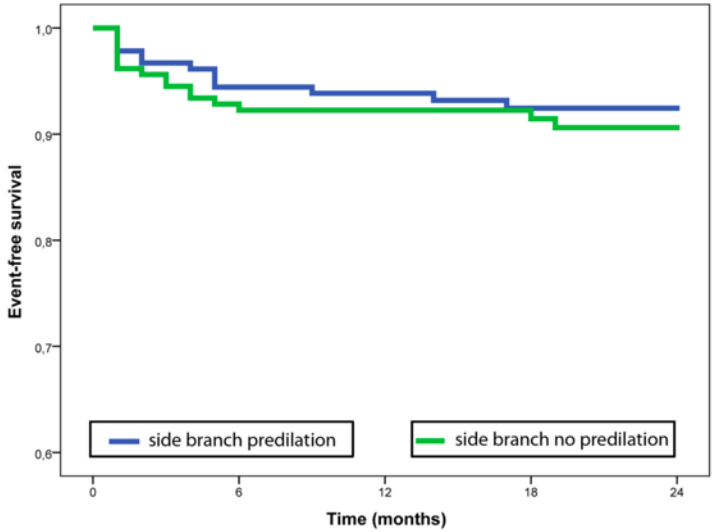
TECHNIQUE	WHEN TO APPLY	DESCRIPTION
Jailed wire	Before MV stenting	Wire placement in the SB
Jailed balloon protection	Before MV stenting	Small-diameter balloon placed in the SB and kept uninflated during MV stent deployment
Jailed microcatheter (including jailed Corsair)	Before MV stenting	Microcatheter placed in the SB and kept uninflated during MV stent deployment
Inflated jailed balloon protection (including modified jailed balloon and balloon-stent kissing)	Before MV stenting	Small-diameter balloon (with different degrees of protrusion in the MV) placed in the SB and kept inflated during MV stent deployment
Semi-inflated jailed balloon protection	Before MV stenting	Small-diameter balloon placed in the SB and inflated at low atmospheres during MV stent deployment
Rescue balloon jailing	After MV stenting, in the case of SB occlusion (or jailed wire entrapment)	Small-diameter balloon advancement and inflation over the jailed wire
Rescue microcatheter jailing	After MV stenting, in the case of SB occlusion (or jailed wire entrapment)	High-penetration microcatheter advancement over the jailed wire
MV: main vessel; SB: side branch		

Pan M et al. EuroIntervention 2023;19:26-36

SB predilation trial

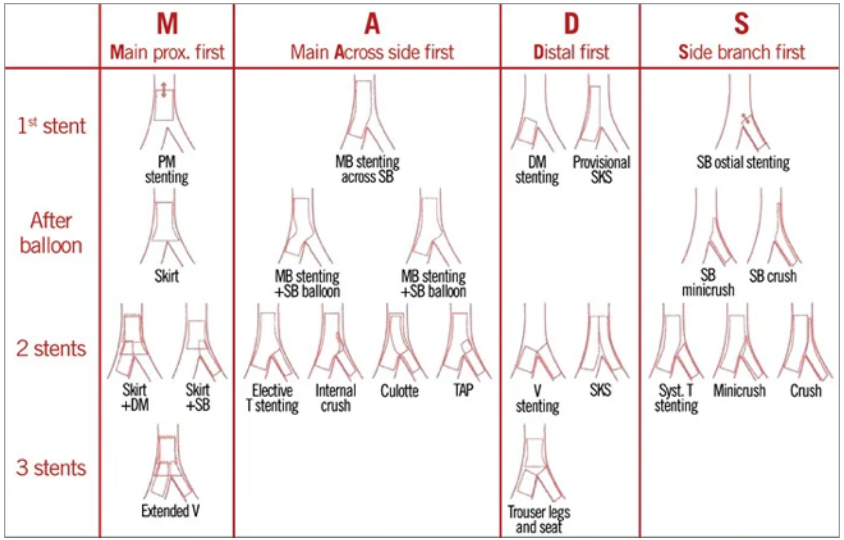
- 232 patients with true bifurcation lesion
- Randomization to SB pre-dilation (n=187) or no pre-dilation (n=185)

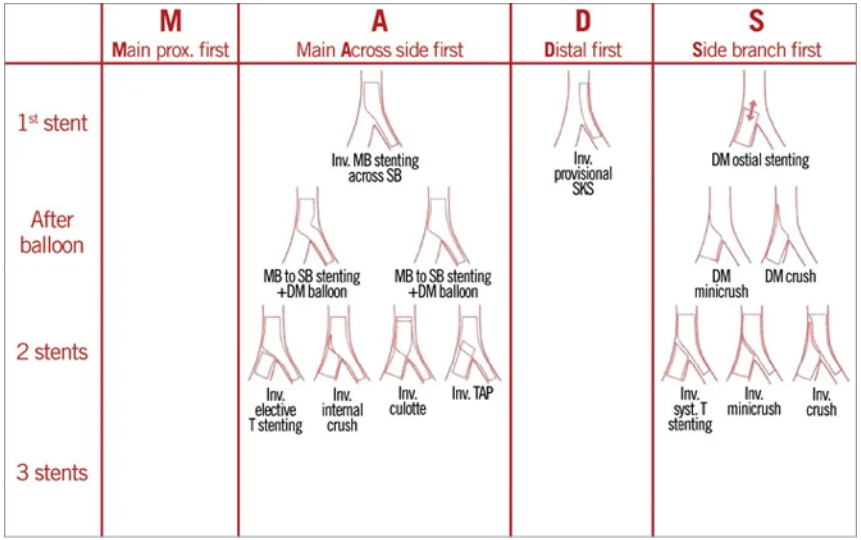




Pan M et al. Am Heart J 2014;168:374-380

Systematic description of bifurcation stenting techniques





Lassen JF et al. EuroIntervention 2014;10:545-560

TAKE HOME MESSAGE

Side branch occlusion is a common complication of bifurcation PCI

Loss of a significant side branch may lead to myocardial injury and worse clinical outcomes

The risk can often be predicted from lesion anatomy, side branch characteristics, and procedural factors

Careful planning, appropriate bifurcation strategy, and side branch protection are key to prevention

Familiarity with a broad range of bifurcation techniques provides multiple opportunities to prevent, manage, and resolve side branch compromise throughout the procedure