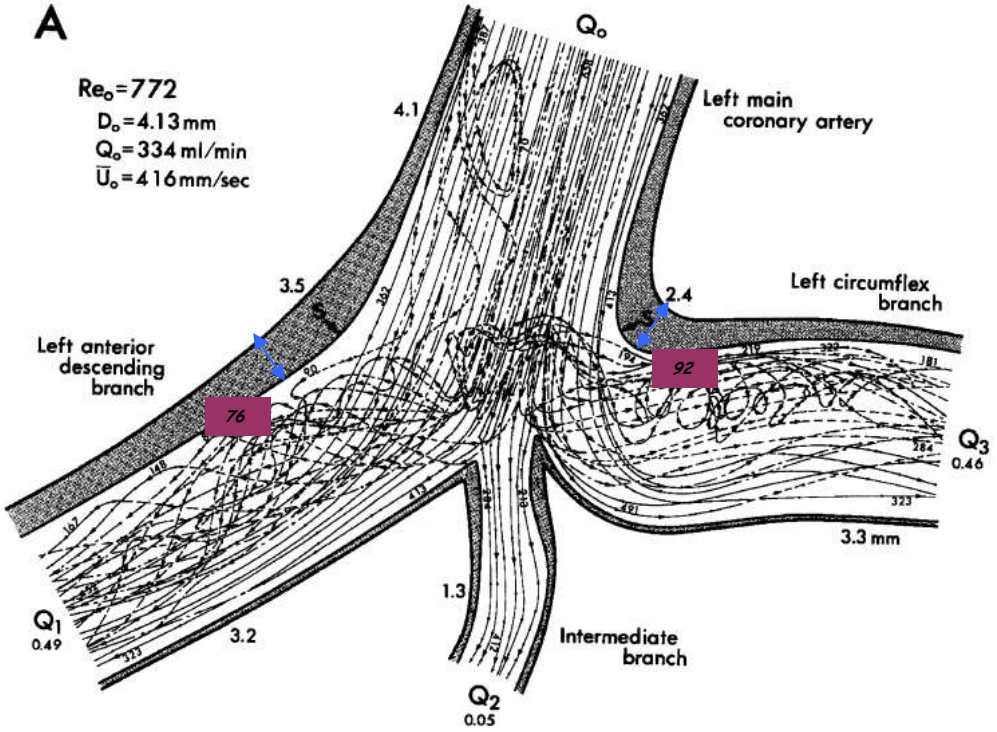
EBC

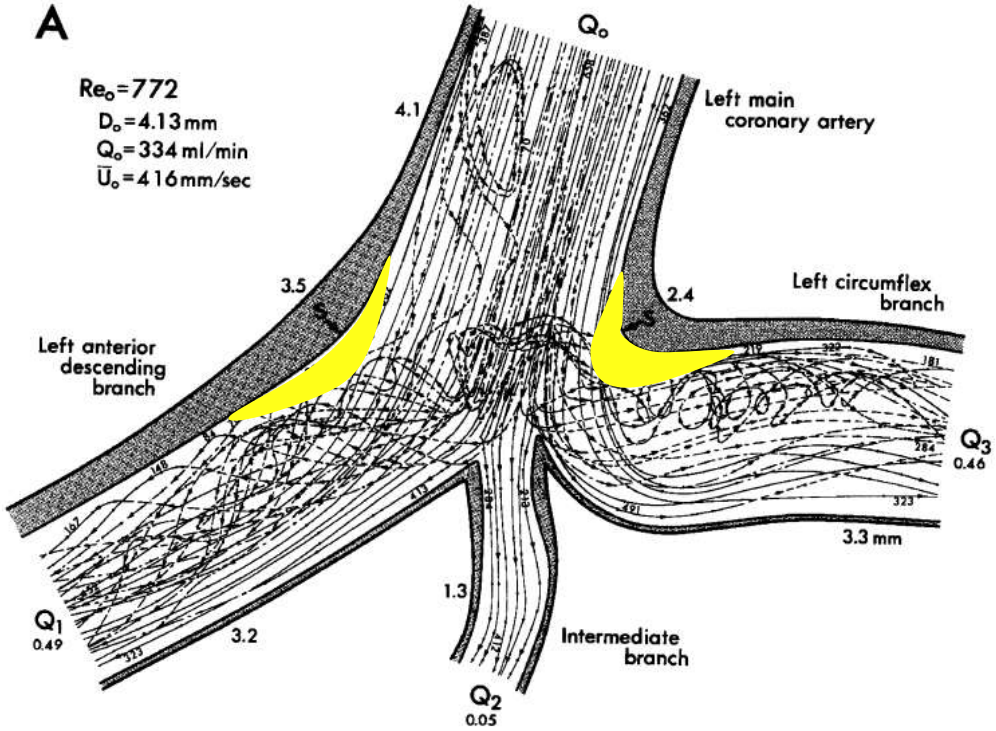
Morning Roundtable Forum: Meet the Experts over Breakfast.

Bifurcation PCI.
Consensus from European Bifurcation Club

Y. Louvard, ICPS, Massy, Quincy
Générale de Santé, France

Flow Patterns and Spatial Distribution of Atherosclerotic Lesions in Human Coronary Arteries





Asakura, Circulation Research 1990; 66:1045-1066

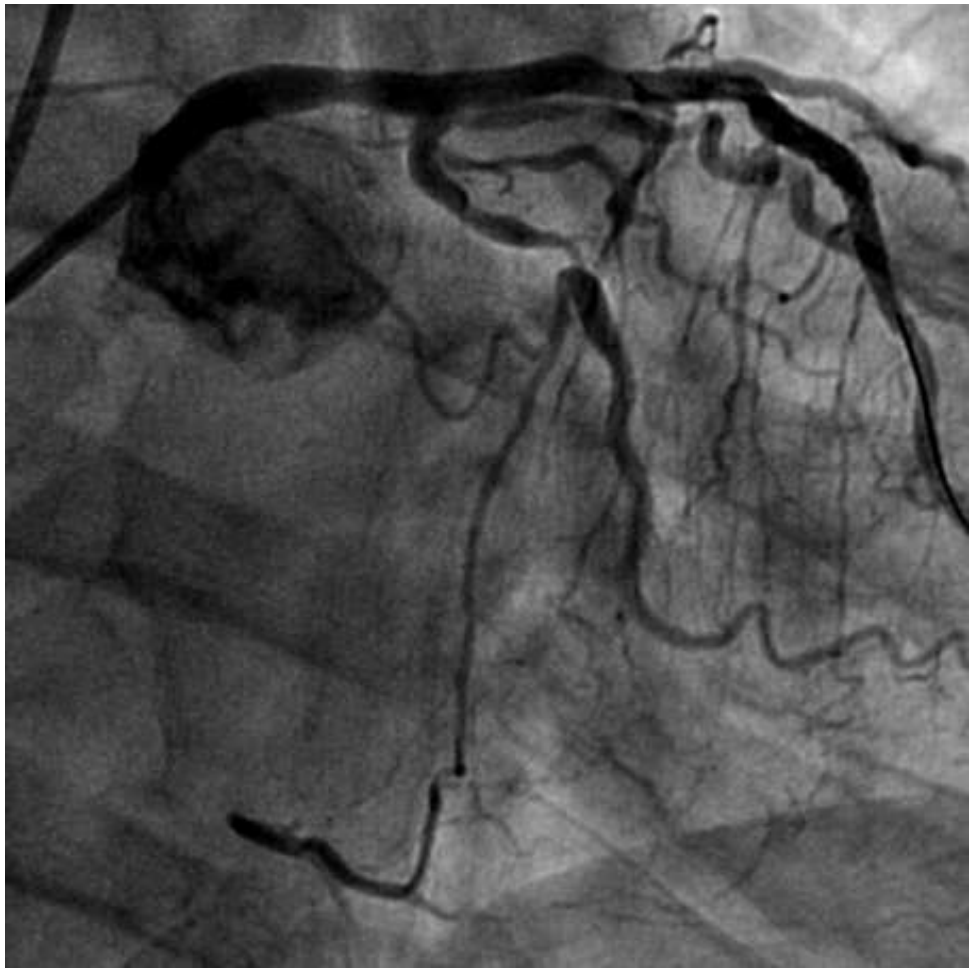
How to define a bifurcation lesion ?

- "A coronary artery narrowing occuring adjacent to, and/or involving, the origin of a significant side branch".

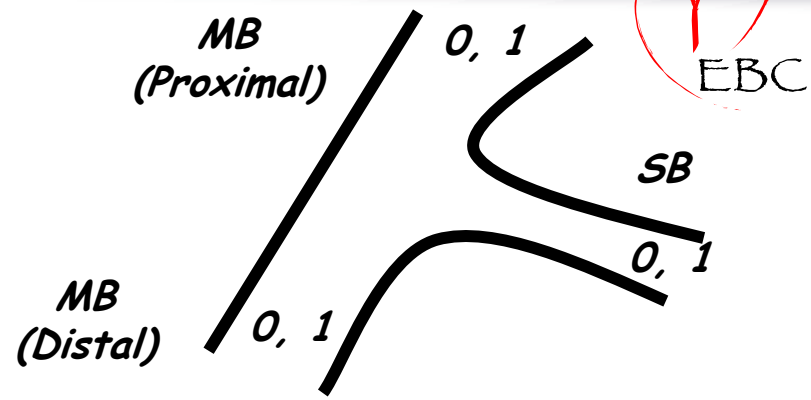
- A significant SB is a branch that you don't want to loose in the global context of a particular patient

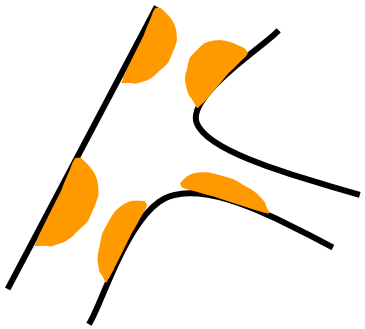
Y. Louvard Catheter Cardiovasc Interv. 2008 Feb 1;71:175-83

Bifurcation or not ?

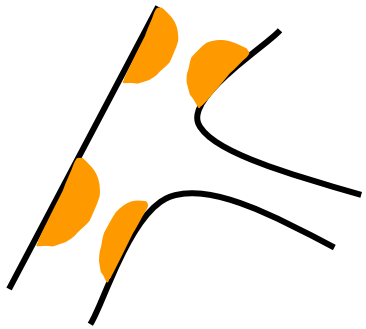


Medina Classification





1,1,1



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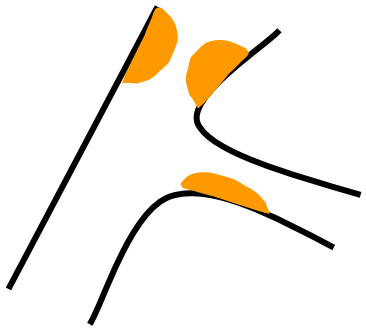

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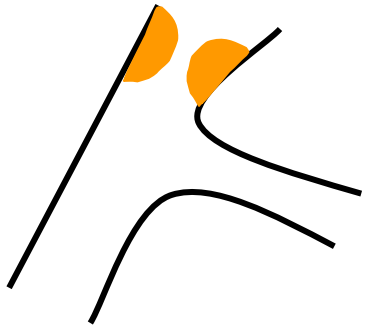
0,1,1



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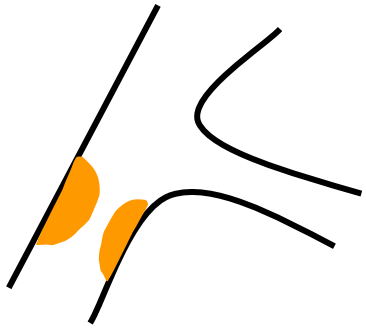
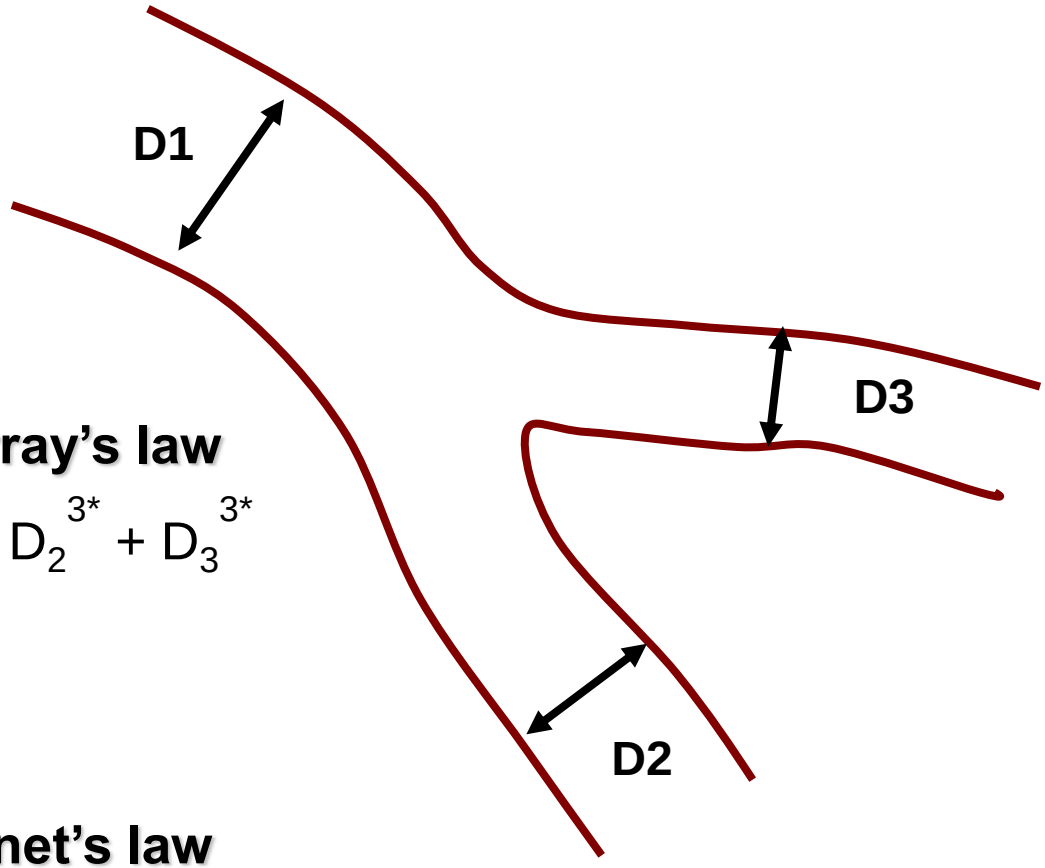


0,1,0

0,0,1

Medina et al. Rev. Esp. Cardiol 2006; 59(2): 183-4

Structure-function scaling laws of vascular trees

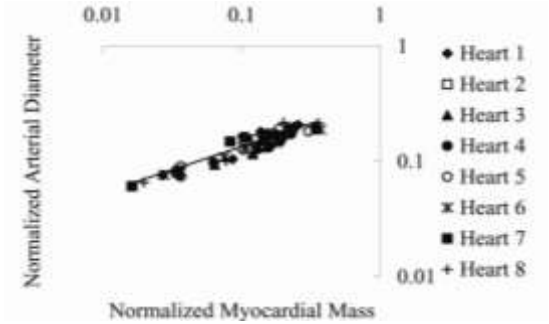


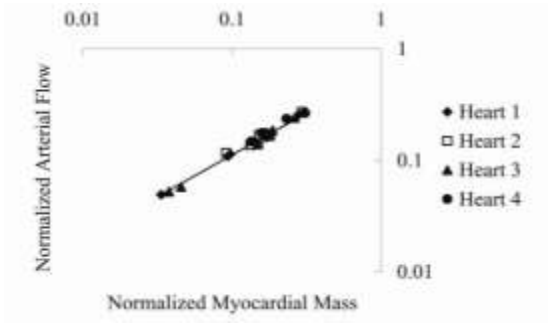
Murray's law

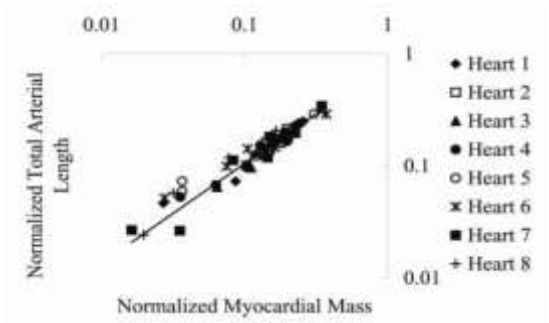
$$D_1^{3*} = D_2^{3*} + D_3^{3*}$$

Finet's law

$$D_1 = 0.67(D_2 + D3)$$

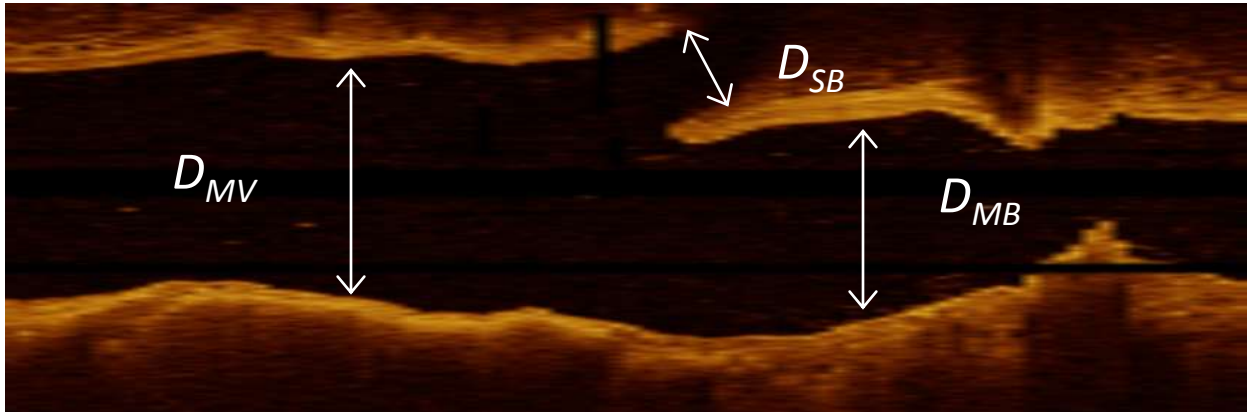


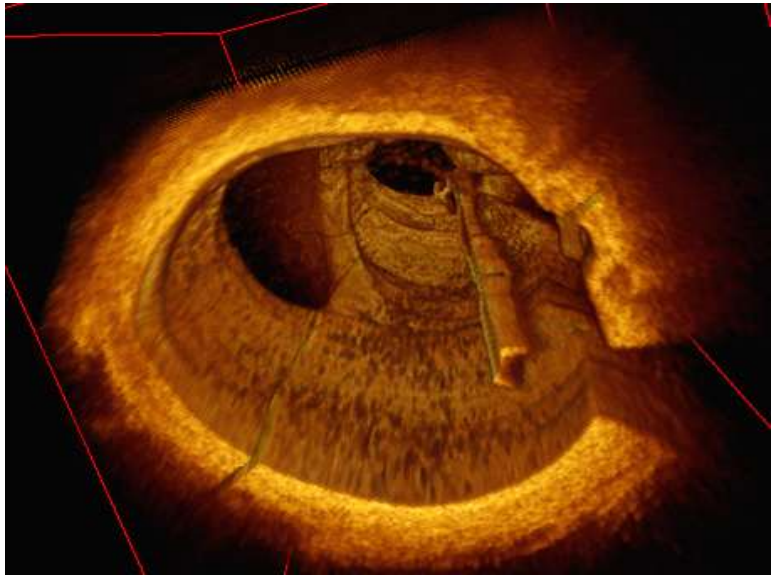




Kassab

Anatomy of Bifurcations



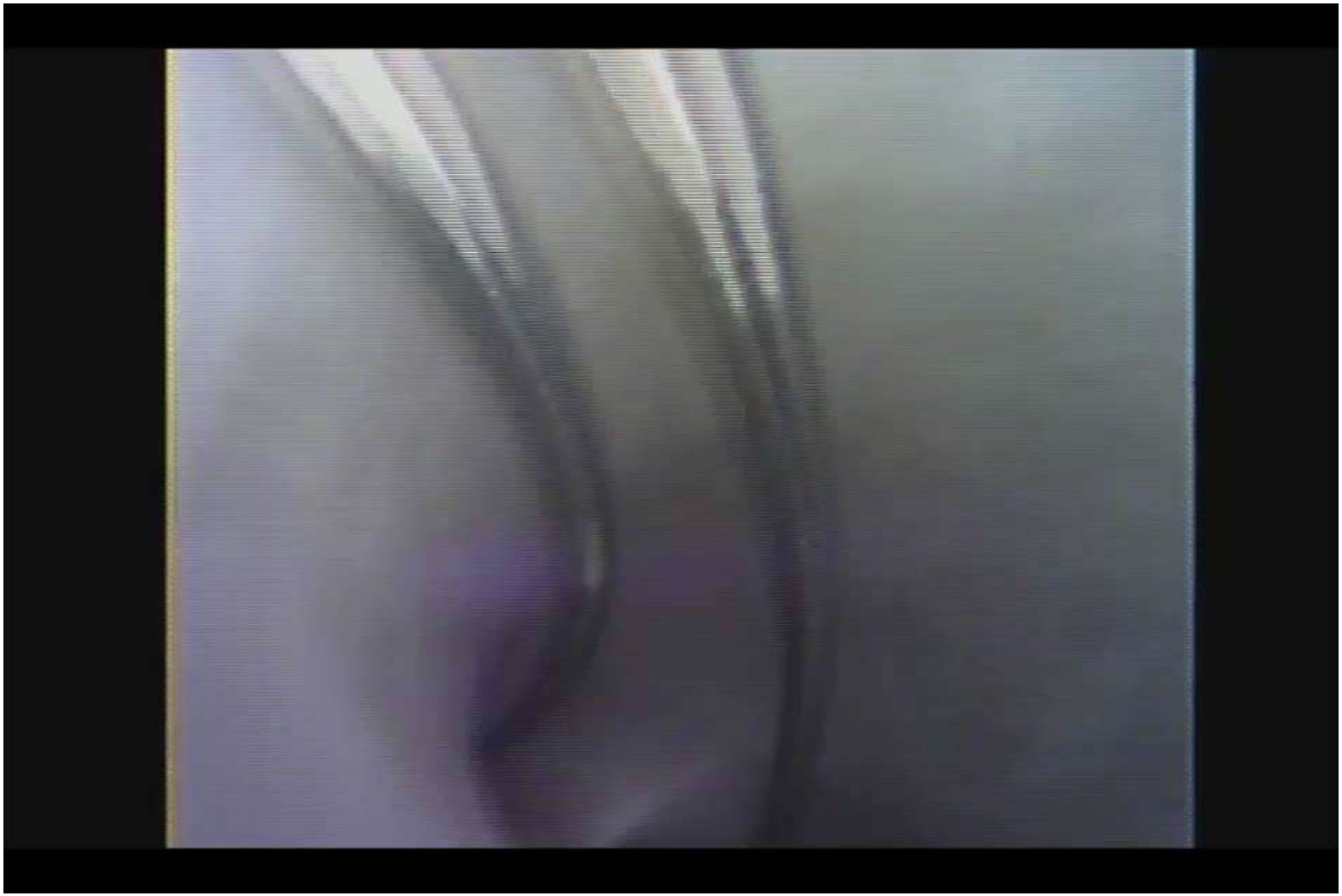


	Principle	Relation	*Ratio Dm/Dd for D_{d1}~ D_{d2}*
Murray's law	Minimum Work	$D_m3 = D_{d1}3 + D_{d2}3$	*1.26*
HK: Huo-Kassab	Minimum Energy	$D_m7/3 = D_{d1}7/3 + D_{d2}7/3$	*1.35*
Flow conservation	$Q_m = Q_{d1} + Q_{d2}$	$D_m2 = D_{d1}2 + D_{d2}2$	*1.4*
Finet	Measurement	$D_m = \underline{0.678}\ (D_{d1} + D_{d2})$	*1.36*

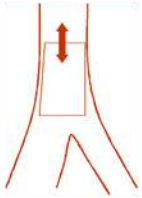
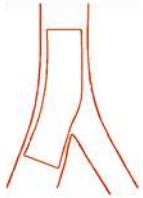
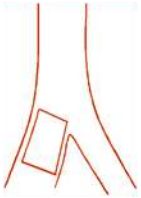
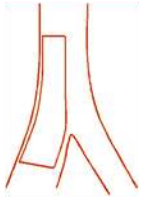
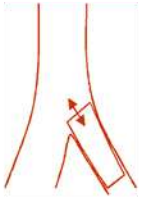
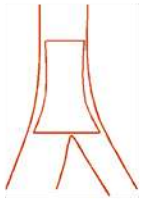
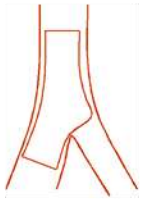
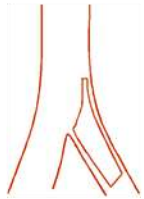
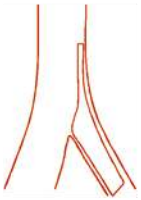
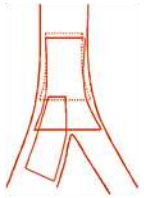
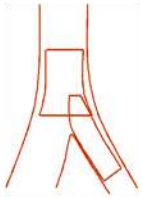
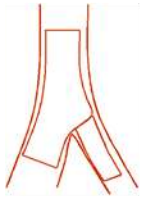
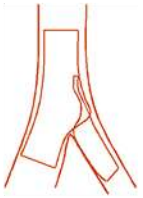
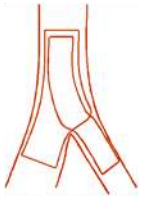
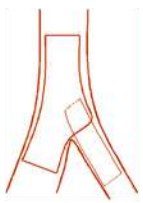
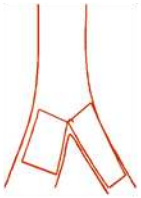
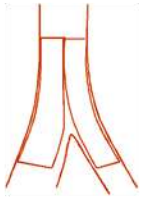
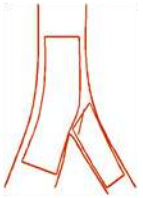
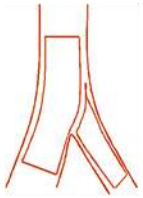
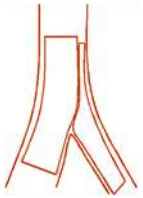
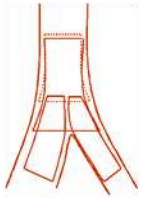
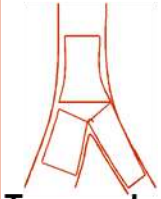
- The larger the SB, the larger the change in MV diameter throughout the bifurcation

Courtesy of N Foin

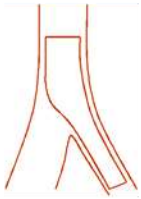
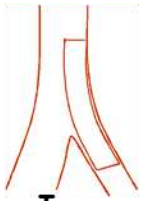
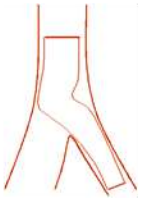
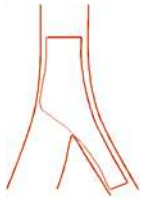
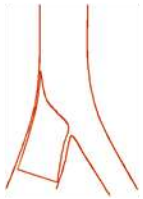
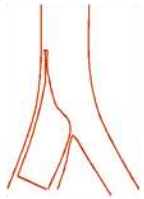
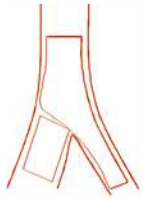
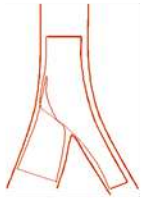
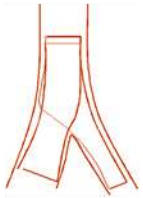
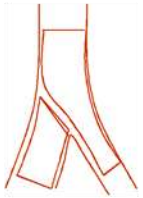
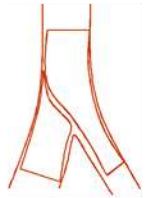
Choose the stent from the distal MB diameter



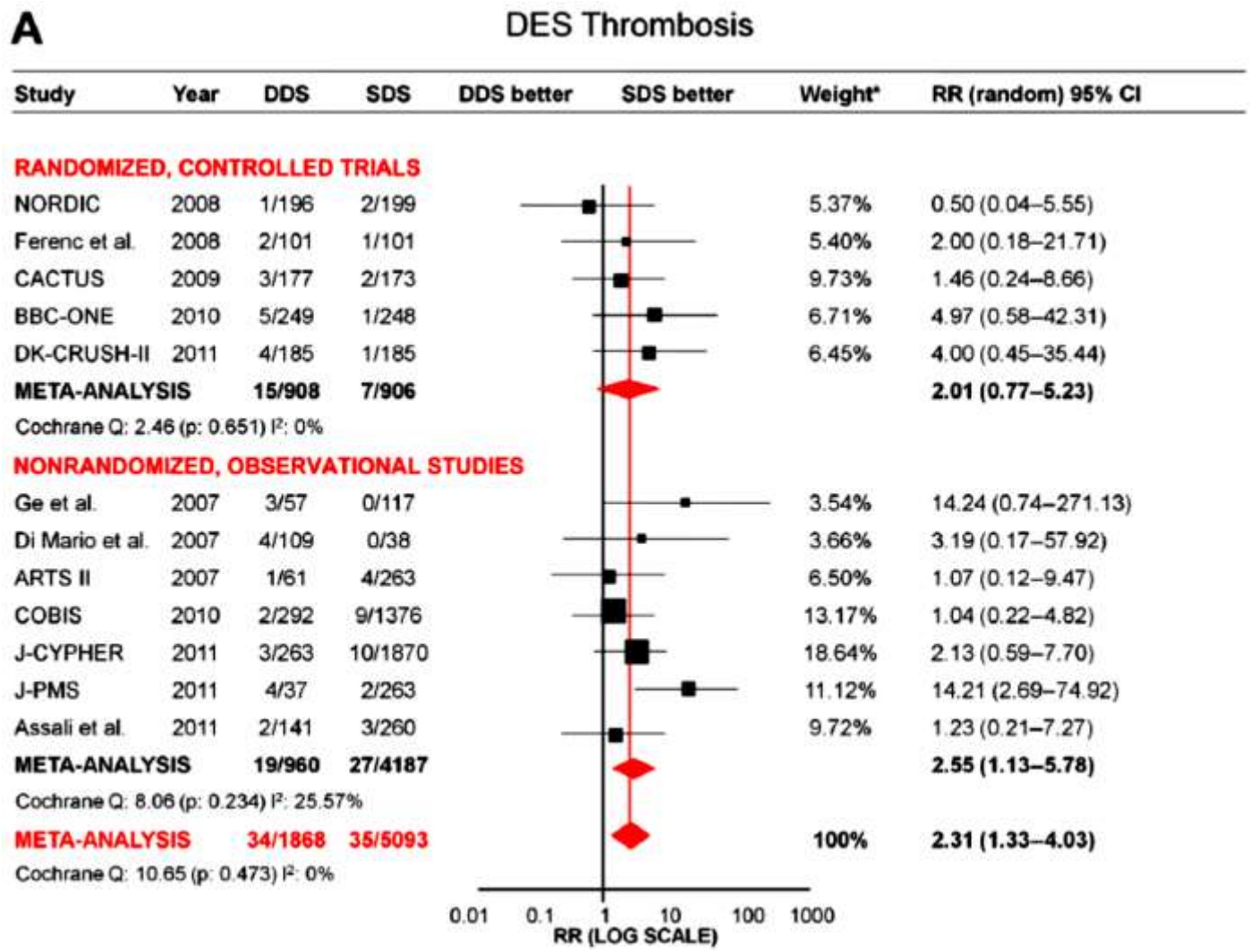
EBC

	M **M**ain prox. first	**A** Main **A**ccross side first	**D** **D**ouble	**S** **S**ide branch first
1st stent	 PM stenting	 MB stenting across SB	 DM stenting  Provisional SKS	 SB ostial stenting
After balloon	 Skirt	 MB stenting + SB balloon  MB stenting + kissing		 SB minicrush  SB crush
2 stents	 Skirt + DM  Skirt + SB	 Elective T stenting  Internal crush  Culotte  TAP	 V stenting  SKS	 Syst. T Stenting  Minicrush  Crush
3 stents	 Extended V		 Trouser legs and seat	

EBC

	M **M**ain prox. first	**A** Main **A**ccross side first	**D** **D**istal first	**S** **S**ide branch first
1st stent		 Inv. MB stenting across SB	 Inv. Provisional SKS	 DM ostial stenting
After balloon		 MB to SB stenting + DM balloon  MB to SB stenting + kissing		 DM minicrush  DM crush
2 stents		 Inv. Elective T stenting  Inv. Internal crush  Inv. Culotte  Inv. TAP		 Inv. Syst. T Stenting  Inv. Minicrush  Inv. Crush
3 stents				

Late Thrombosis After 2 Versus 1 DES in the Treatment of Coronary Bifurcations. Meta-analysis of Randomized and Observational Studies



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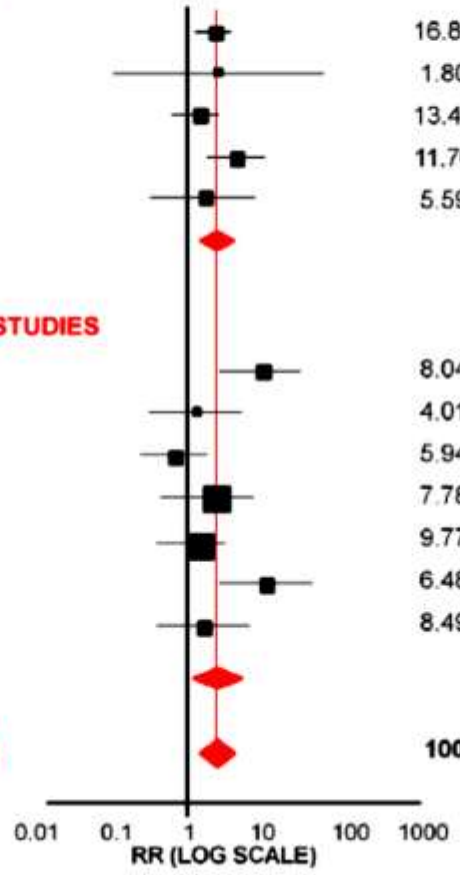
Late Thrombosis After 2 Versus 1 DES in the Treatment of Coronary Bifurcations. Meta-analysis of Randomized and Observational Studies

C Myocardial Infarction

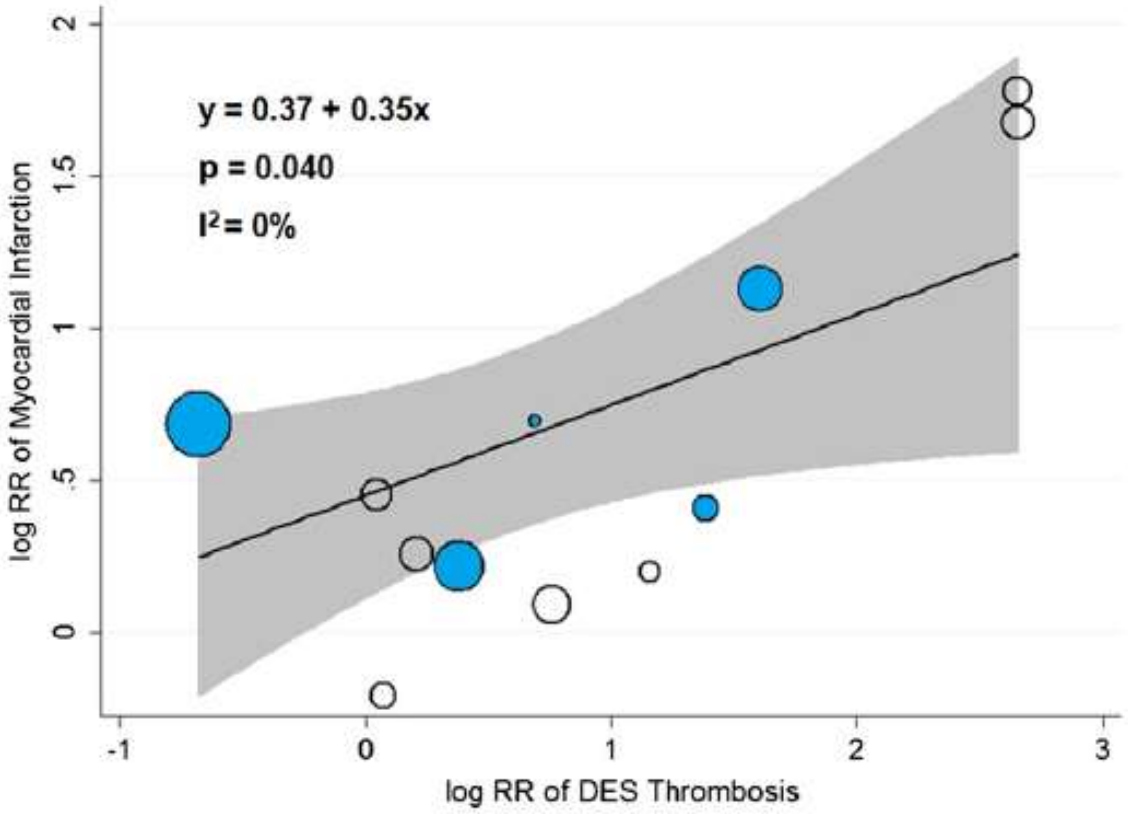
Study	Year	DDS	SDS	Weight*	RR (random) 95% CI
RANDOMIZED, CONTROLLED TRIALS					
NORDIC	2008	39/196	20/199	16.86%	1.97 (1.19–3.26)
Ferenc et al.	2008	2/101	1/101	1.80%	2.00 (0.18–21.71)
CACTUS	2009	19/177	15/173	13.48%	1.28 (0.65–2.35)
BBC-ONE	2010	28/249	9/248	11.76%	3.09 (1.49–6.43)
DK-CRUSH-II	2011	6/185	4/185	5.59%	1.50 (0.43–5.22)
META-ANALYSIS		**94/908**	**49/906**		**1.88 (1.35–2.62)**
Cochrane Q: 3.59 (p: 0.453) I^2: 0%					
NONRANDOMIZED, OBSERVATIONAL STUDIES					
Ge et al.	2007	13/57	5/117	8.04%	5.33 (1.99–14.24)
Di Mario et al.	2007	7/109	2/38	4.01%	1.22 (0.26–5.62)
ARTS II	2007	3/61	16/263	5.94%	0.80 (0.24–2.68)
COBIS	2010	5/292	15/1376	7.78%	1.57 (0.57–4.28)
J-CYPHER	2011	6/263	39/1870	9.77%	1.09 (0.46–2.55)
J-PMS	2011	5/37	6/263	6.48%	5.92 (1.90–18.44)
Assali et al.	2011	7/141	10/260	8.49%	1.29 (0.50–3.32)
META-ANALYSIS		**43/960**	**93/4187**		**1.85 (1.03–3.32)**
Cochrane Q: 12.79 (p: 0.041) I^2: 53.11%					
META-ANALYSIS		**140/1727**	**142/5093**	**100%**	**1.86 (1.34–2.60)**
Cochrane Q: 16.34 (p: 0.129) I^2: 32.69%					



Zimarino J Am Coll Cardiol Intv 2013

Late Thrombosis After 2 Versus 1 DES in the Treatment of Coronary Bifurcations. Meta-analysis of Randomized and Observational Studies

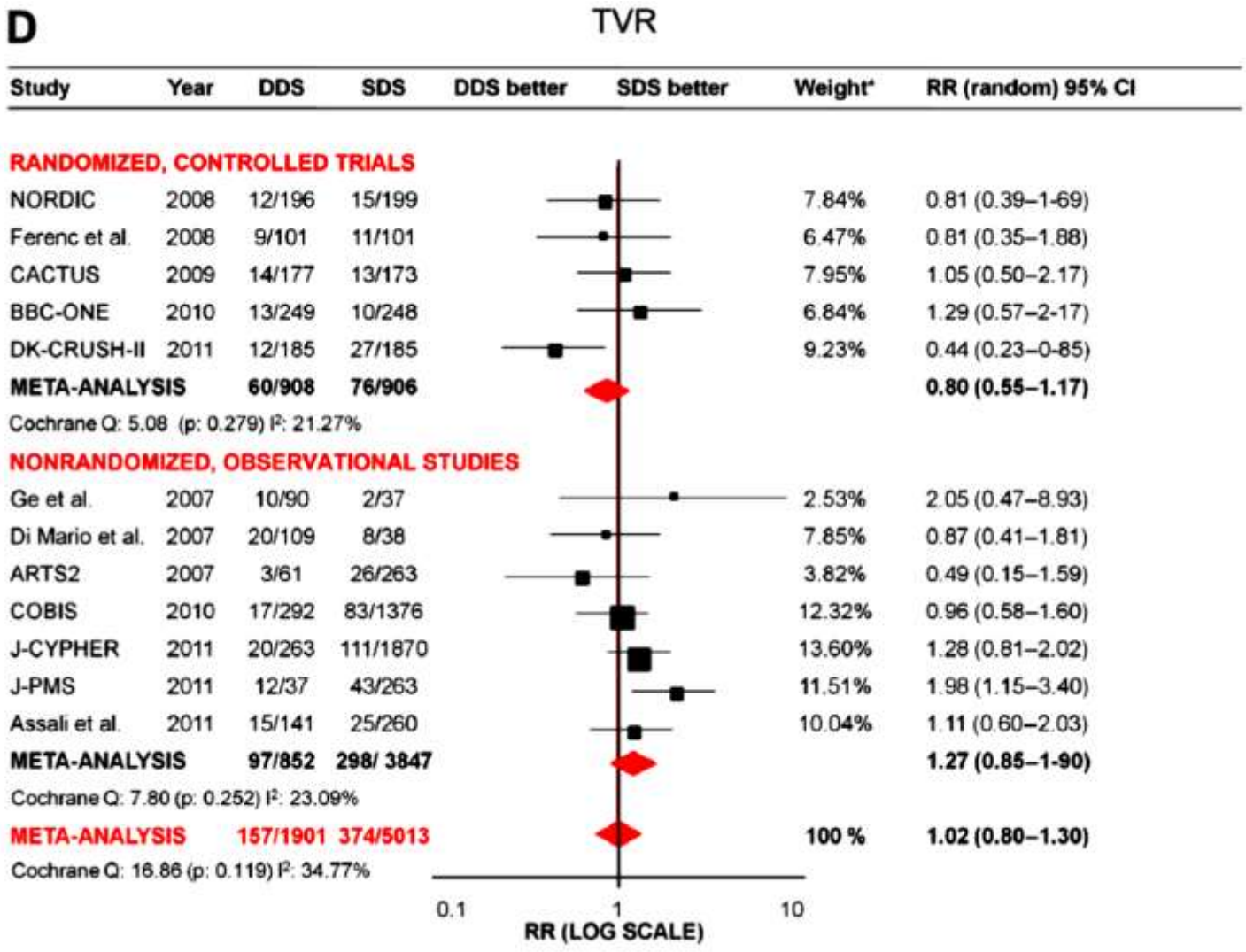
Association Between Log-Transformed Risk of DES Thrombosis and Myocardial Infarction



The size of each circle represents the precision of each estimate (the inverse variance of the log RR in the trial), and the line is the best fit for the meta-regression model. Randomized, controlled trials (filled circles); nonrandomized observational studies (open circles).

Zimarino J Am Coll Cardiol Intv 2013

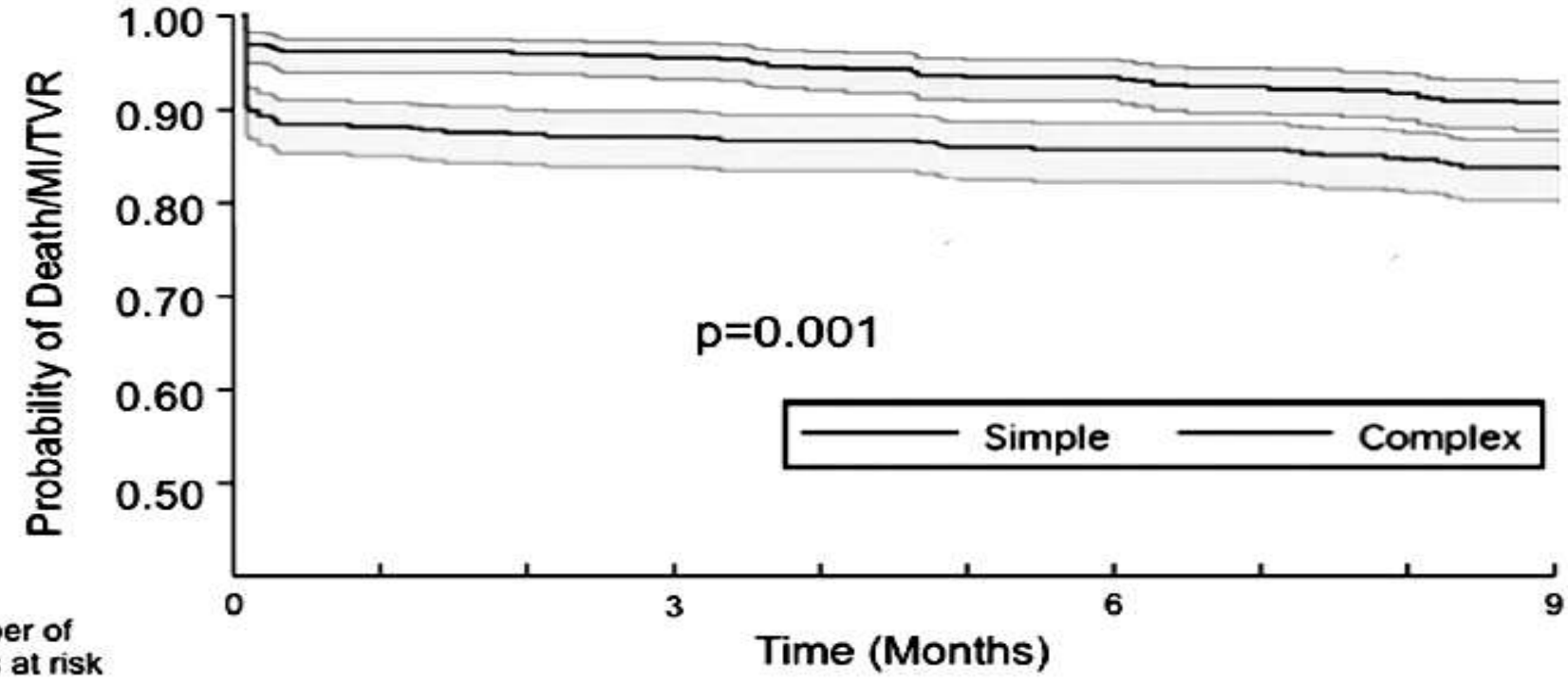
Late Thrombosis After 2 Versus 1 DES in the Treatment of Coronary Bifurcations. Meta-analysis of Randomized and Observational Studies



Zimarino J Am Coll Cardiol Intv 2013

Simple or Complex Stenting for Bifurcation Coronary Lesions: A Patient-Level Pooled-Analysis of Nordic 1 and BBC

Kaplan-Meier freedom from the composite event

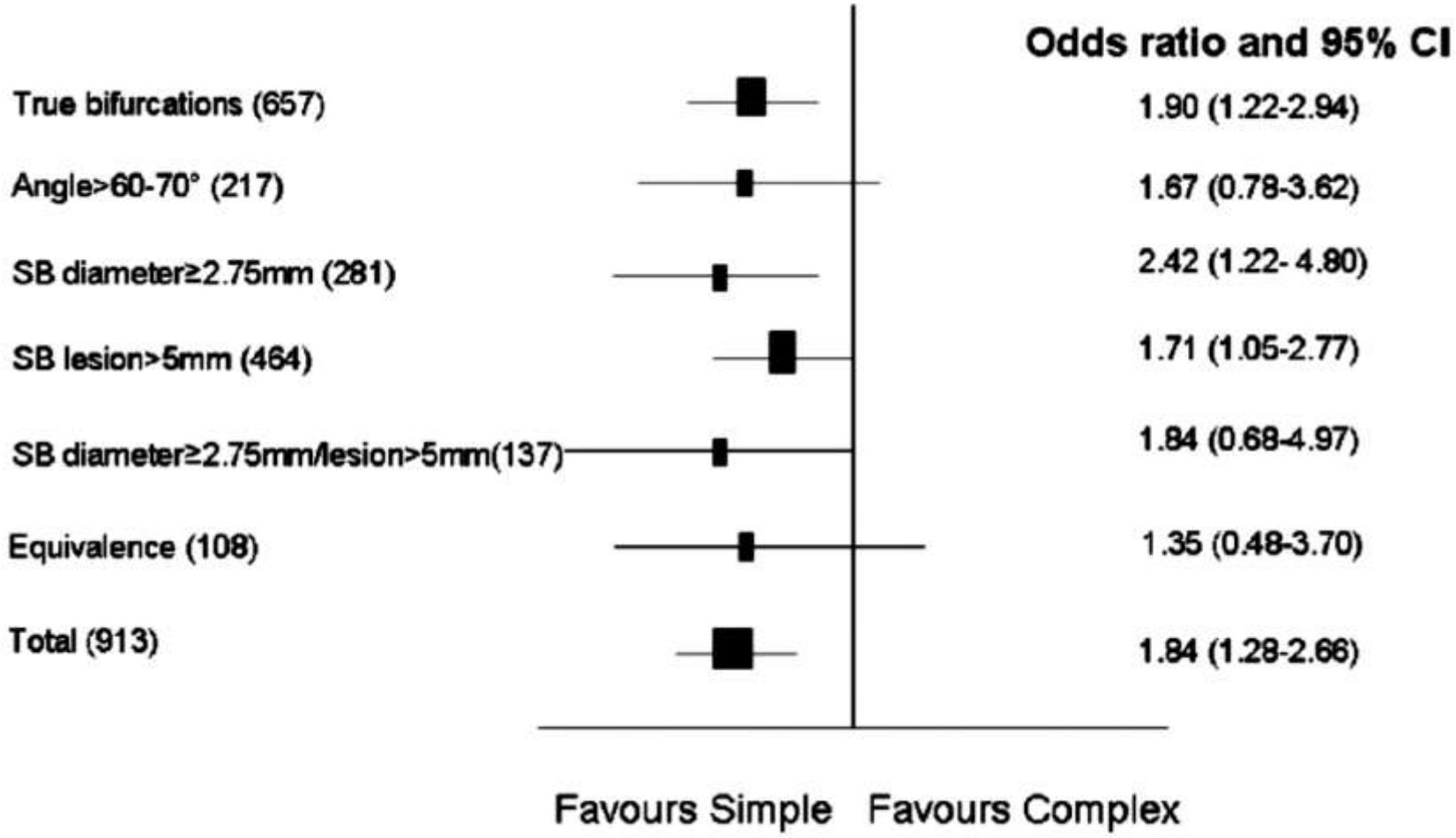


Number of patients at risk				
Complex	456	396	389	377
Simple	457	433	422	411

Behan Circ Cardiovasc Interv. 2011;4:57-64

Simple or Complex Stenting for Bifurcation Coronary Lesions : A Patient-Level Pooled-Analysis of Nordic 1 and BBC

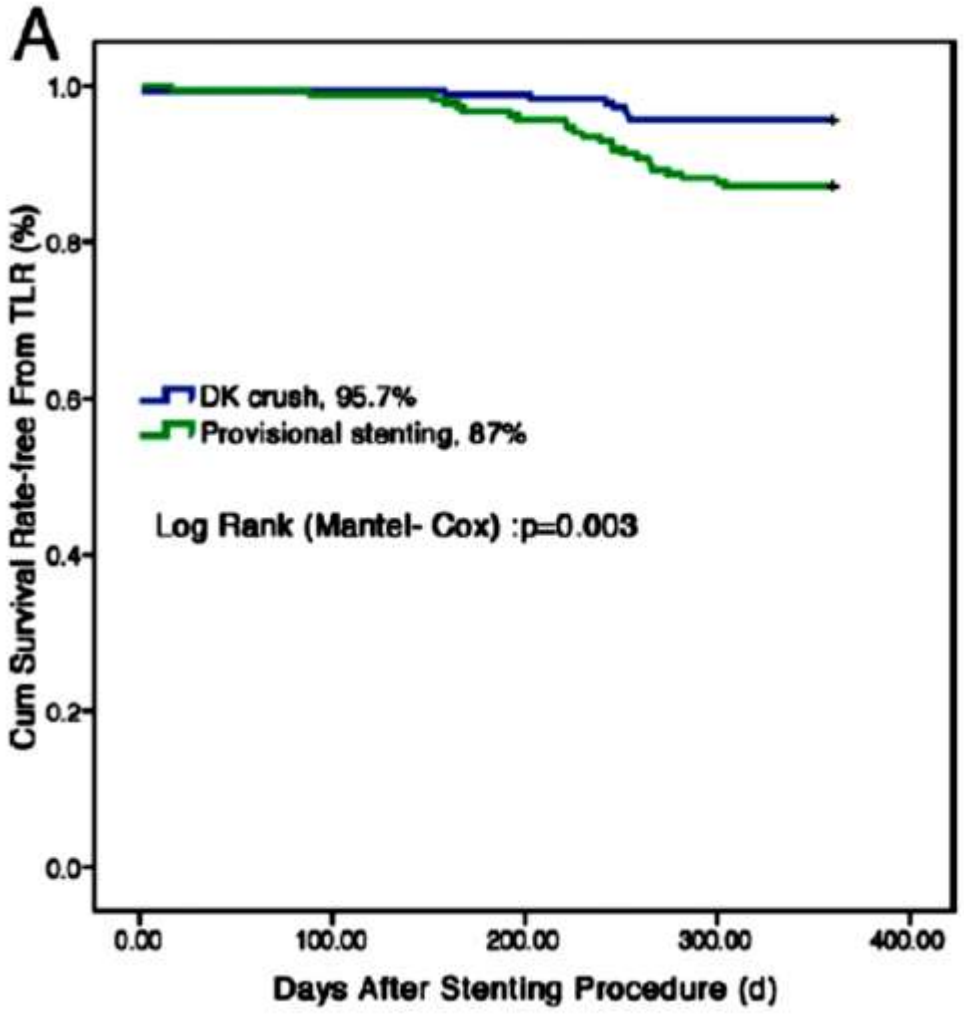
Primary outcome for individual subgroups



Behan Circ Cardiovasc Interv. 2011;4:57-64

Randomized study comparing Double Kissing Crush with Provisional Stenting for treatment of coronary bifurcation lesions: DK-CRUSH-II

Comparison of Survival Rate Free From TLR Between DK Crush and PS Groups



SL Chen J. Am. Coll. Cardiol. 2011;57;914-920

Randomized study comparing Double Kissing Crush with Provisional Stenting for treatment of coronary bifurcation lesions: DK-CRUSH-II

Clinical outcome (2)

	DK Group (n = 185)	PS Group (n =185)	p Value
Procedural success	179 (96.8)	173 (93.5)	0.217
At 6-month			
Cardiac death	1 (0.5)	2 (1.1)	1.000
MI	6 (3.2)	4 (2.2)	0.751
CABG	0 (0)	1 (0.5)	0.500
TLR	2 (1.1)	6 (3.2)	0.284
TVR	3 (1.6)	8 (4.3)	0.220
MACE	6 (3.2)	11 (5.9)	0.321
Stent thrombosis definite	4 (2.2)	1 (0.5)	0.372
At 12-month			
Cardiac death	2 (1.1)	2 (1.1)	1.000
MI	6 (3.2)	4 (2.2)	0.751
CABG	0 (0)	1 (0.5)	0.500
TLR	8 (4.3)	24 (13.0)	0.005
TVR	12 (6.5)	27 (14.6)	0.017
MACE	19 (10.3)	32 (17.3)	0.070
Stent thrombosis	5 (2.7)	2 (1.1)	0.449
Definite	4 (2.2)	1 (0.5)	0.372
Possible	1 (0.5)	1 (0.5)	1.000

Follow-up coronary angiography at 8 months

SL Chen J. Am. Coll. Cardiol. 2011;57;914-920

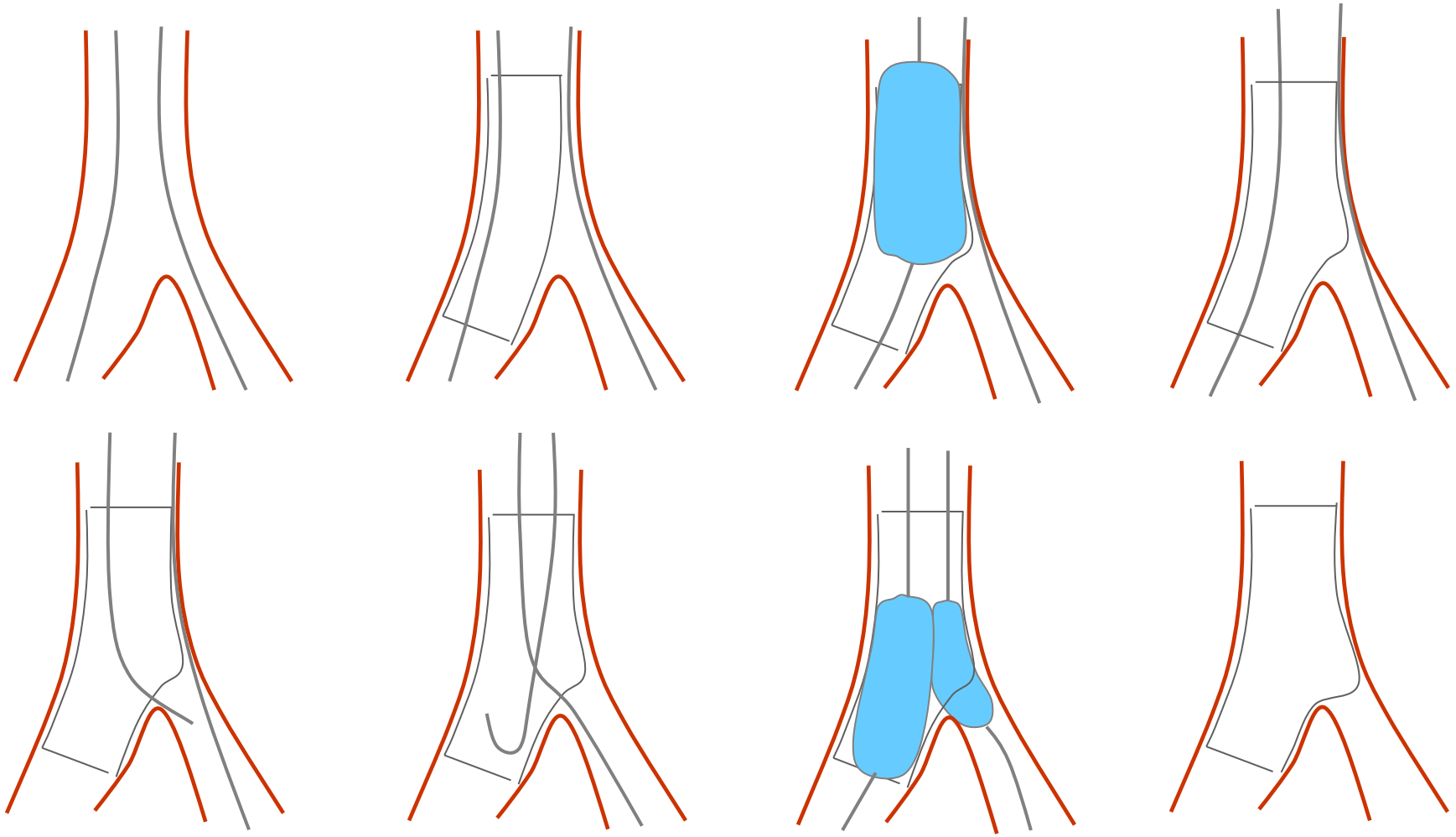
Strategy: EBC consensus

☐ Main vessel (MV) stenting with provisional SB treatment, if needed, is recommended as the preferred technique for the majority of bifurcation lesions.

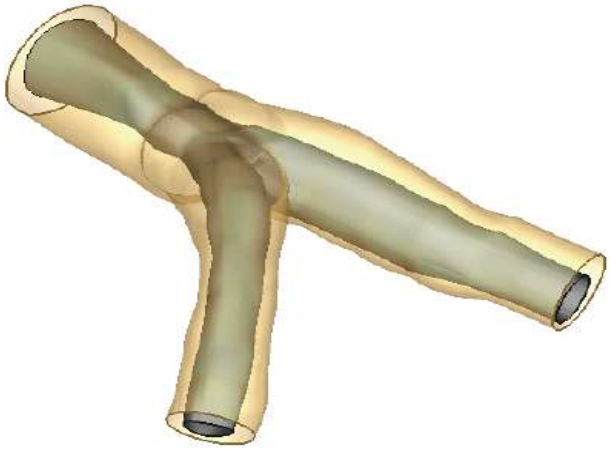
☐ Large SBs with significant ostial disease extending further into the SB are likely to require a two-stent strategy.

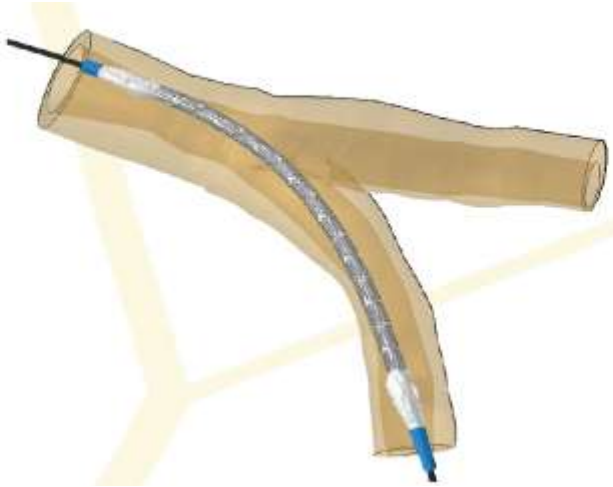
☐ Larger SBs whose access is particularly challenging should be secured by stenting once accessed.

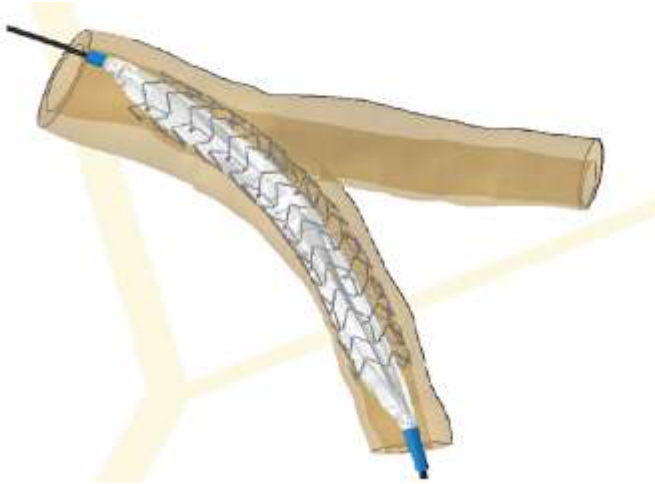
Provisional Side Branch Stenting: Step-by-step procedure

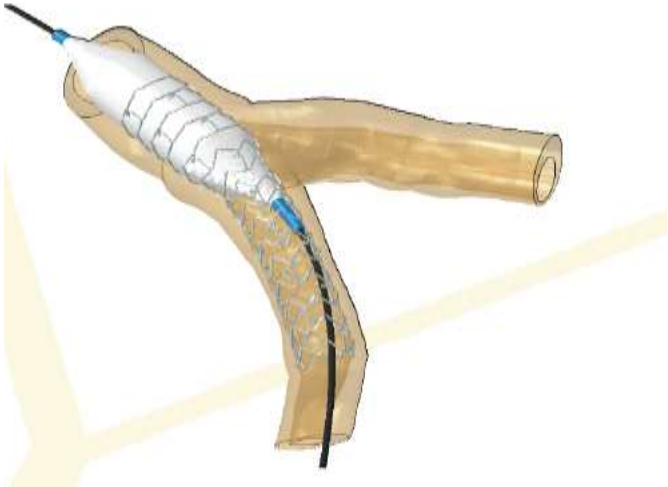


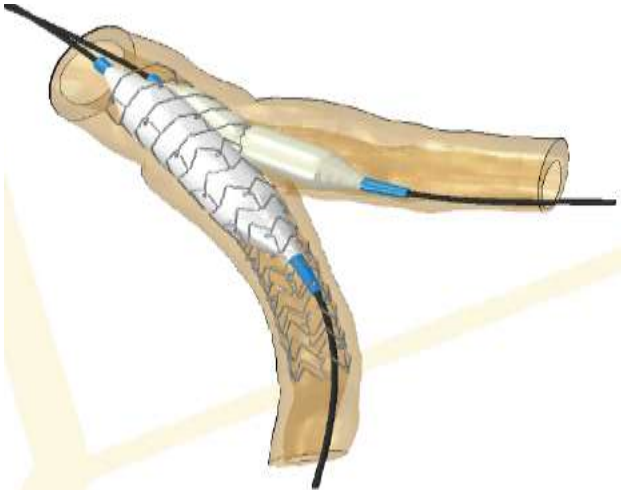
Patient's specific stenting simulation (Xience Prime)

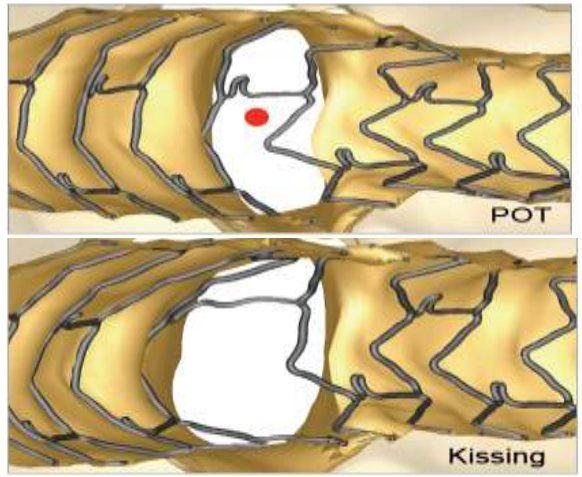












From J. Wentzel, P. Mortier

Balloon Max. size		Element	Xience	Taxus	Integrity	BioMatrix	Cypher
4.0	2.25	Very Small WH (2 cells) *max exp.: 3.0mm*	Medium Workhorse (6 crowns , 3 cells) *max. expansion: 4.4mm*	Small workshorse (6 crowns, 2 cells) *max expansion: 3.4mm*	Small workhorse (7crowns, 2 cells*) *max expansion: 4.9mm* **1.5 cell in Resolute*	Medium workhorse (6 crowns, 2 cells) max expansion: 4.6mm	Medium workhorse (6 crowns, 6 cells) max expansion: 4.7mm
	2.50	Small workshorse (8 crowns, 2 cells) *max expansion : 3.8mm*					
5.0	2.75			Medium Workhorse (9 crowns, 3 cells) *max expansion: 4.8mm*			
	3.00	Medium Workhorse (8 crowns, 2 cells) *max expansion : 4.4mm*			Medium workhorse (10 crowns, 2 cells) *max expansion : 5.4mm*		
	3.50		Large workhorse: (9 crowns , 3 cells) *max expansion : 5.6mm*			Large workhorse (9 crowns, 3 cells) max expansion: 5.9mm	Large workhorse (7 crowns, 7 cells) max expansion: 5.8mm
6.0	4.00	Large workhorse (10 crowns, 2 cells) *max expansion: 5.7mm*		Large workhorse (9 crowns, 3 cells) *max expansion: 6.0mm*			
	4.50						
	5.00						

- *Minimal stent LD excluding struts*
- *Limited to 6.0 mm SC balloon at 14 ATM*

From N. Foin

Randomized Comparison of Final KB Dilatation Versus No Final KB Dilatation in Patients With Coronary Bifurcation Lesions Treated With Main Vessel Stenting. The Nordic-Baltic Bifurcation Study III

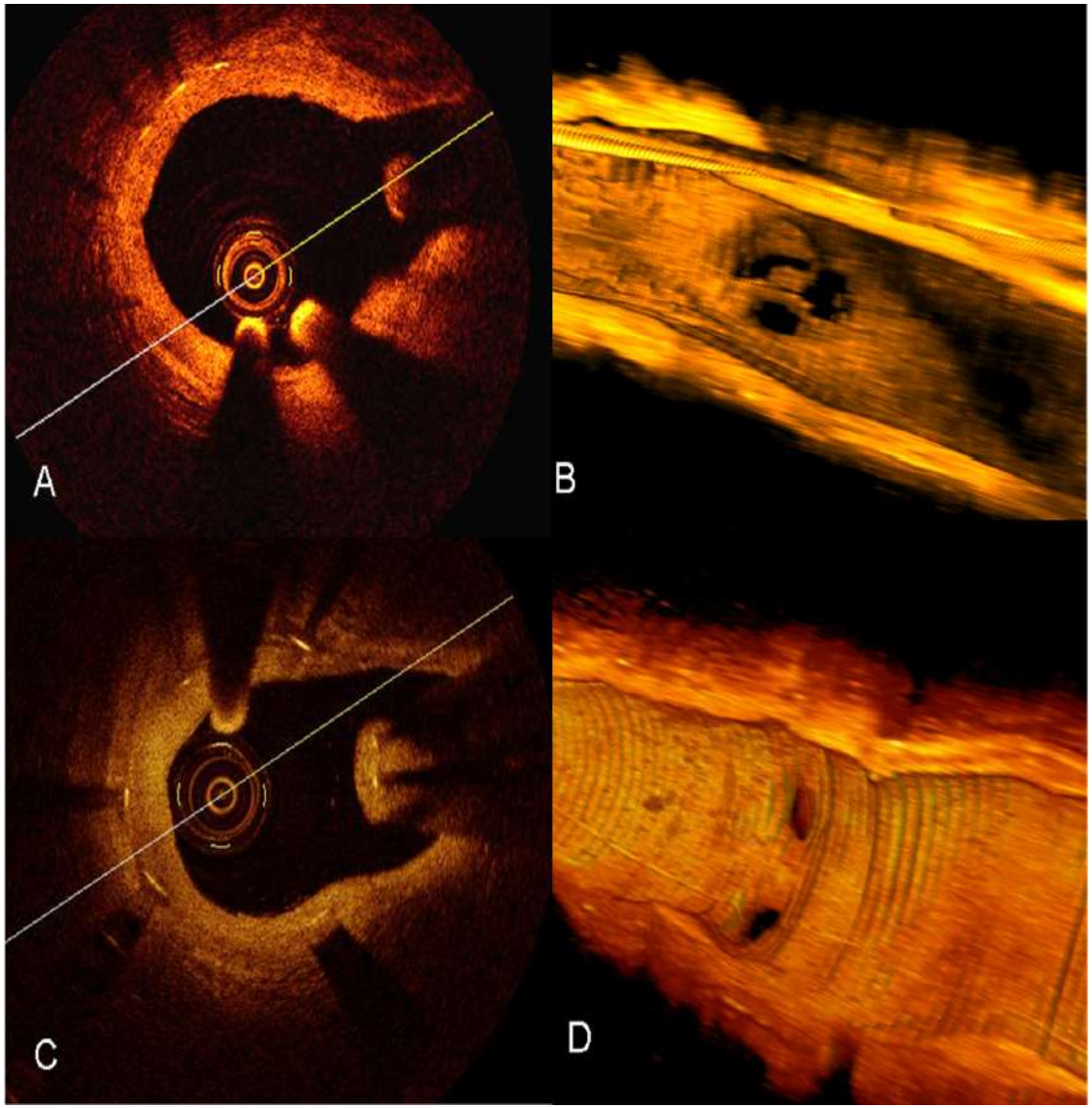
Individual Components of MACEs and Clinical Outcomes at 6 Months

	No FKBD (n=239), n (%)	FKBD (n=238), n (%)	*P*
Noncardiac death	0 (0)	1 (0.4)	0.49
Cardiac death	0 (0)	2 (0.8)	0.24
Index lesion MI*	3 (1.3)	1 (0.4)	0.62
TLR	4 (1.7)	3 (1.3)	1.00
CCS class ≥2 angina	29 (12.0)	28 (11.7)	1.00
Stent thrombosis	1 (0.4)	1 (0.4)	1.00

Niemela, Circulation. 2011;123:79-86

EBC

Why? : to keep the door open…..

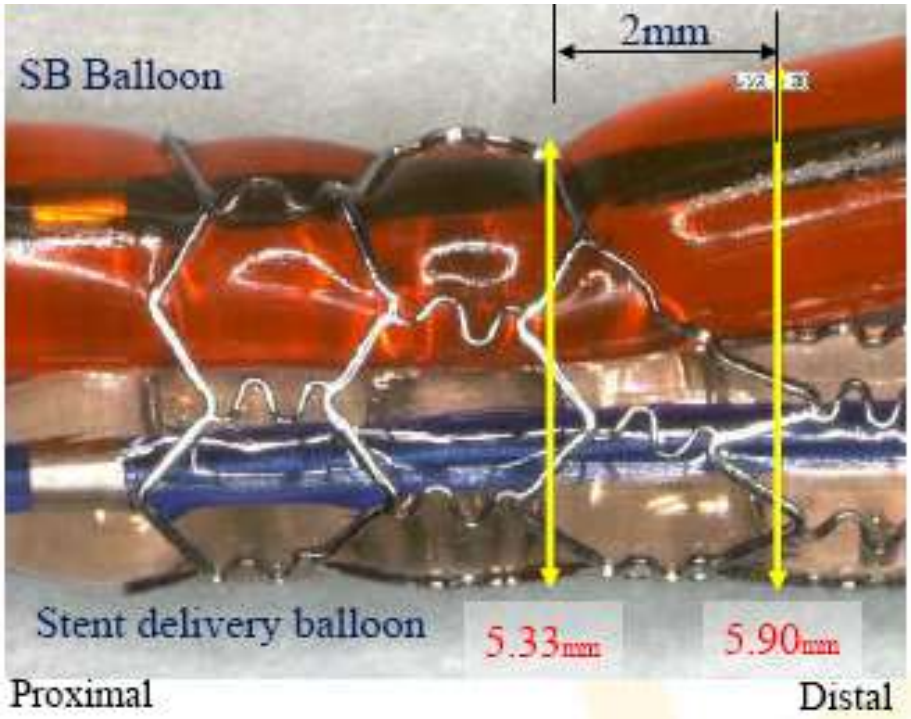


LAD/ SB

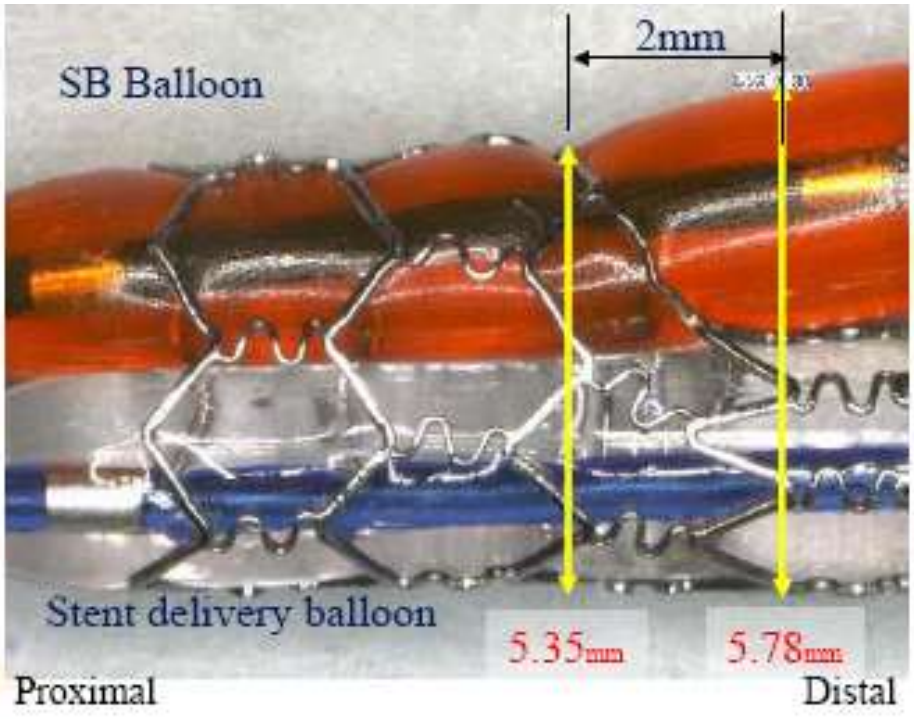
follow-up 7 months

after PCI with BMS

Non compliant high pressure balloons for kissing



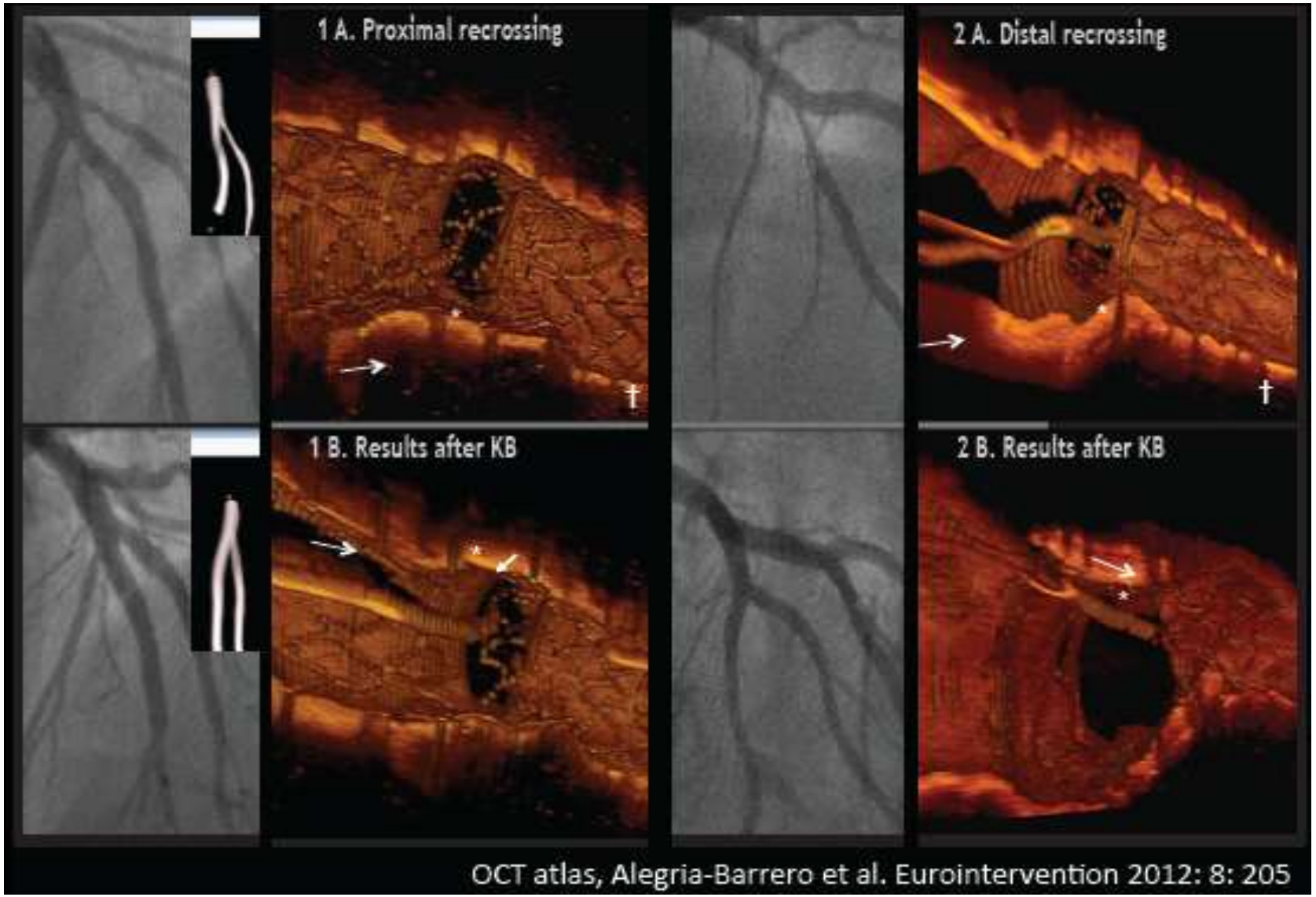
Semi-Compliant Balloon
(Ryujin Plus, Terumo)



Non-Compliant Balloon
(Hiryu, Terumo)

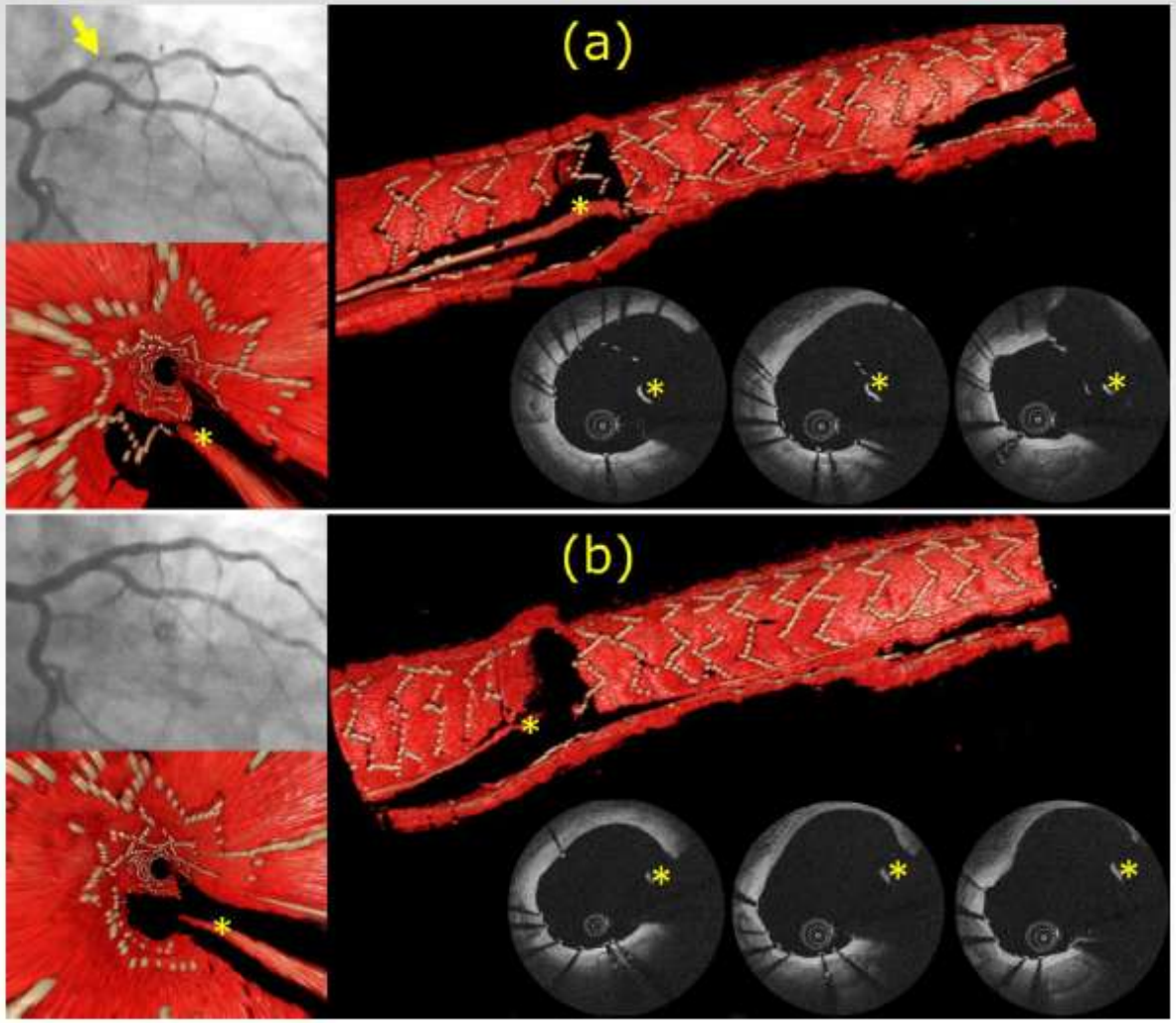
Kinoshita, EBC 2009

Proximal vs distal recrossing



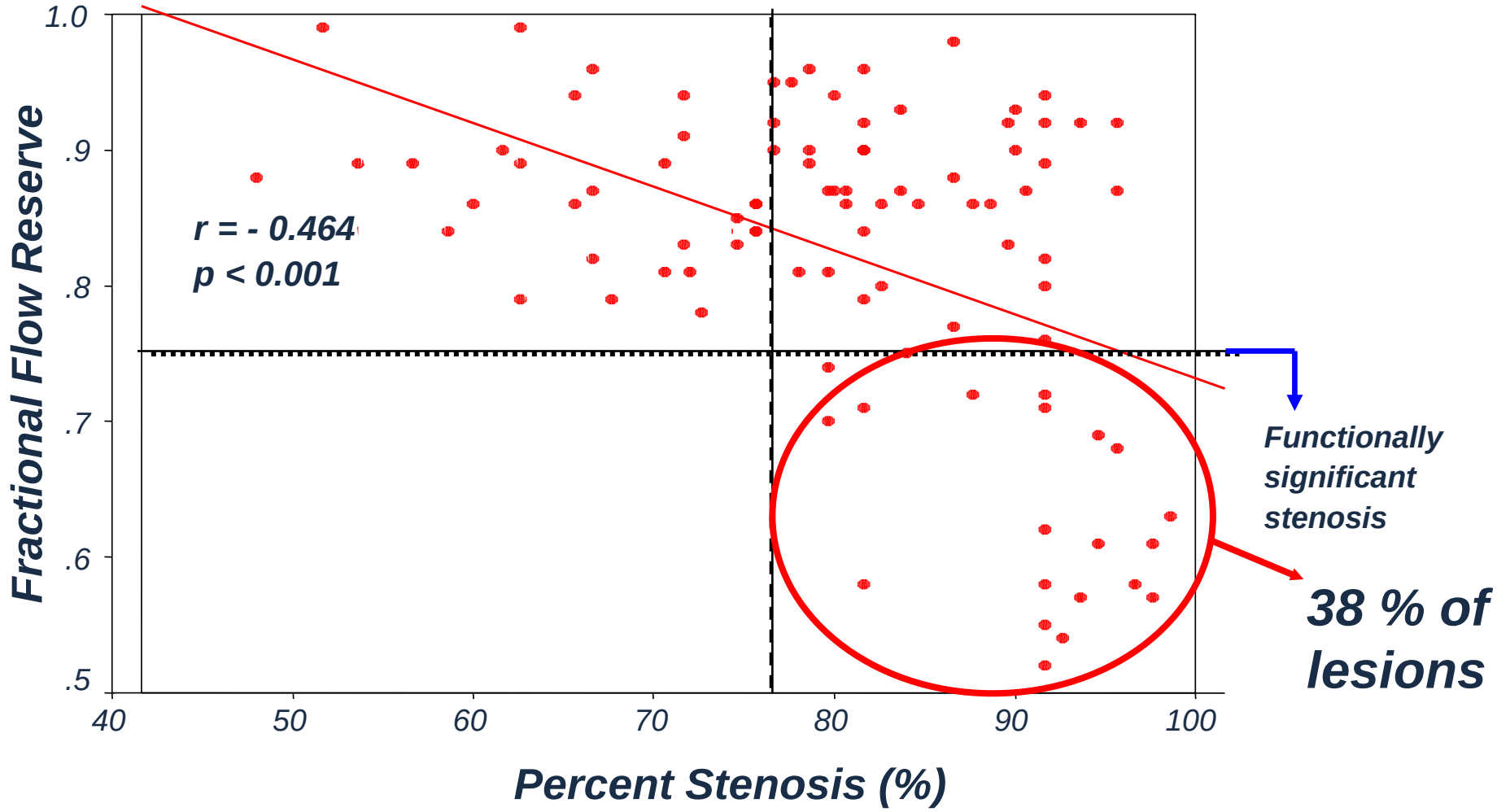
OCT atlas, Alegria-Barrero et al. Eurointervention 2012: 8: 205

2D vs. 3D OCT assessment of wire re-crossing



Ughi et al. Eur Heart J Cardiovasc Img 2013

Significant Post Stenting SB Stenosis:QCA vs FFR (jailed side branch lesions, n=94)



Bon-Kwon Koo et al JACC 2005; 46: 633-7

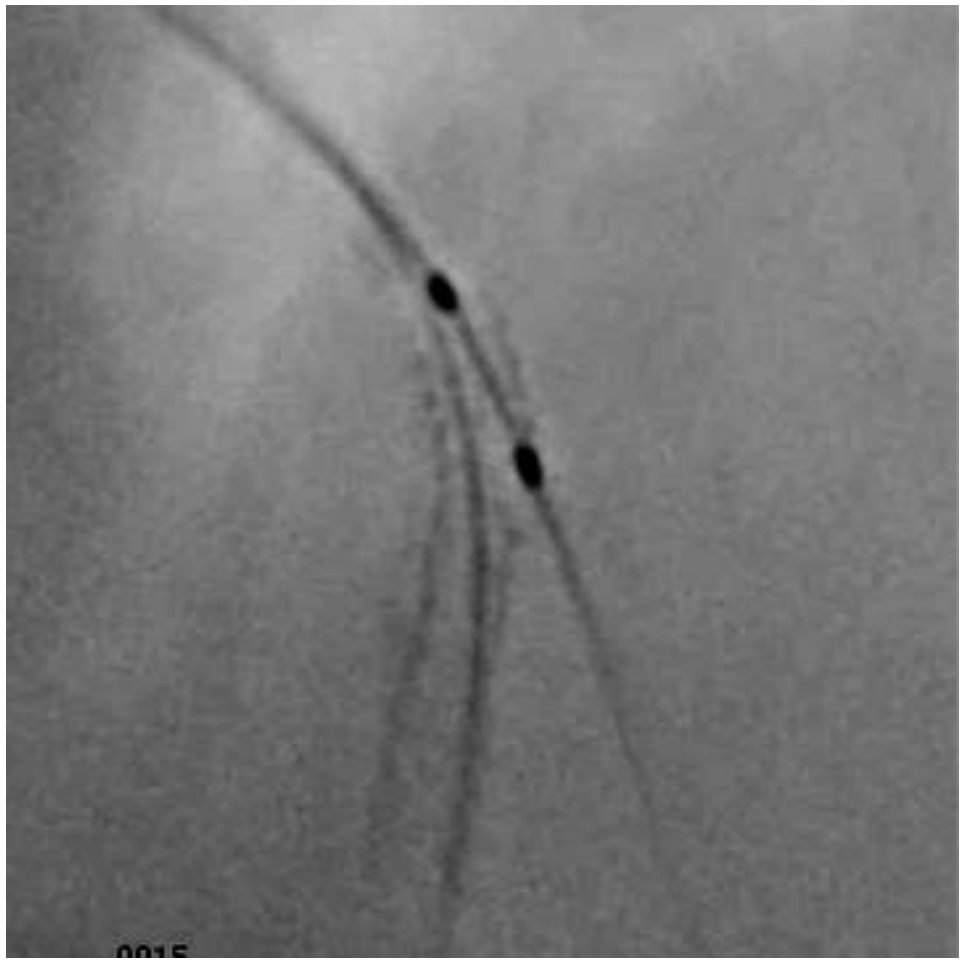
Provisional stenting of the side branch

- ☐ When an SB stent becomes necessary in provisional stenting, T-stenting, TAP-stenting, internal mini-crush and culotte stenting are recommended. Optimal choice depends mainly on angulation.

- ☐ Internal crush and Culotte require a second SB or MV rewiring compared to T and TAP.

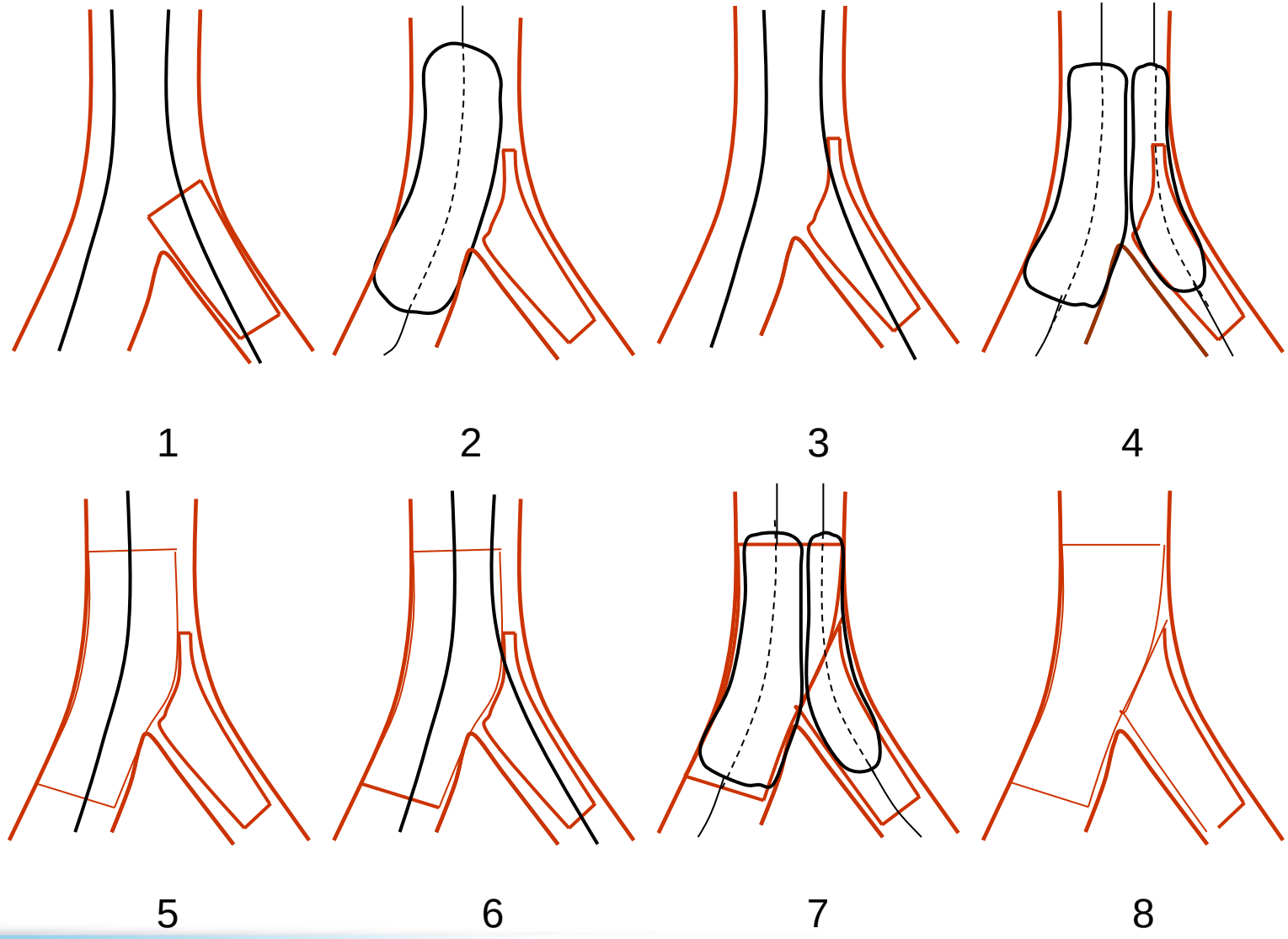
T or TAP ? (stent boost)

T

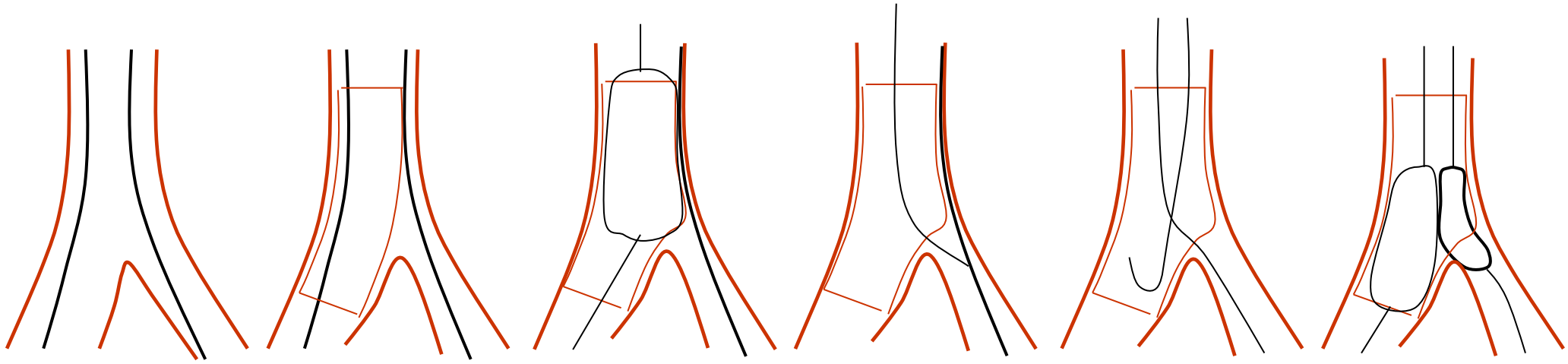


TAP

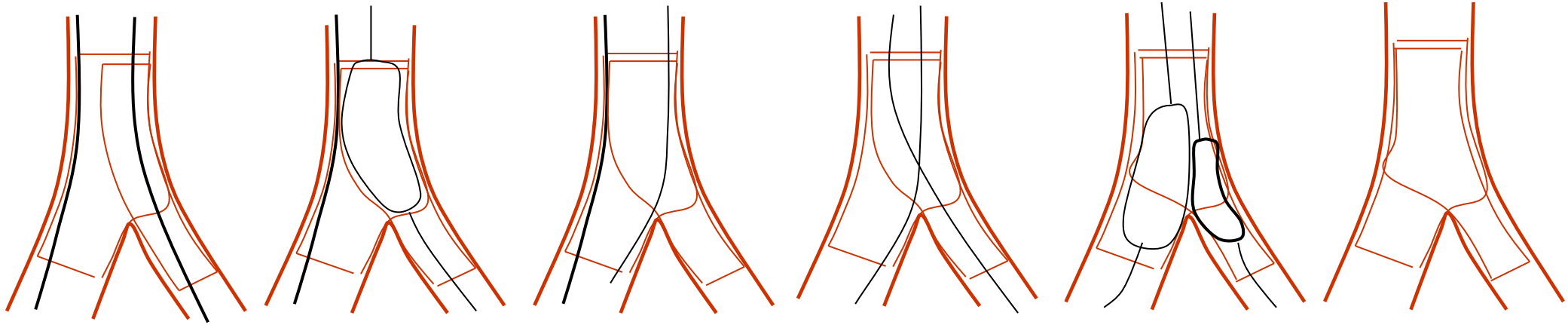
Mini DK Crush technique



Culotte technique



1 2 3 4 5 6



7 8 9 10 11 12

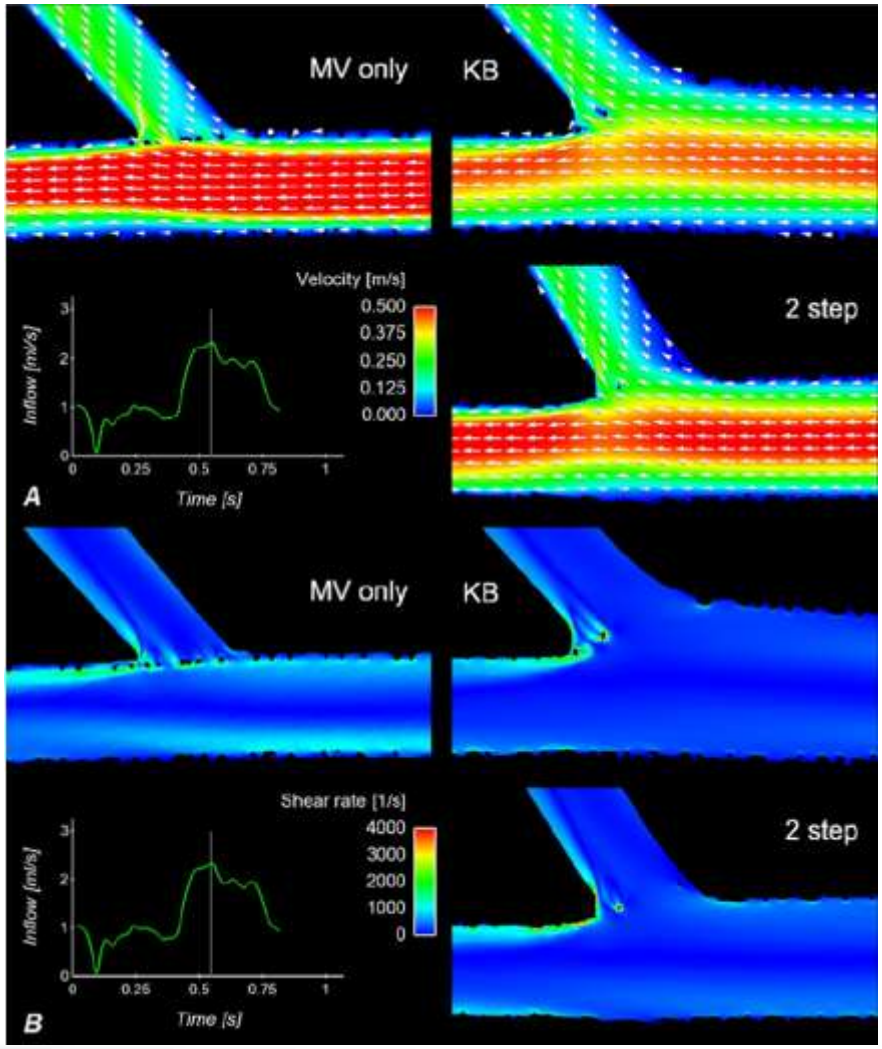
EBC

Definition of complex Bif	Sen (%)	Spe (%)
One Major**+any** two **of** Minor **criteria**	>84 **(78)**	**≥79 (71-72)**

Chen et al. JACC interv 2014, online

Kissing or sequential dilation of the side and main vessel for provisional stenting of bifurcations: Micro-Computed Tomography and Simulations

Computational Flow Simulation

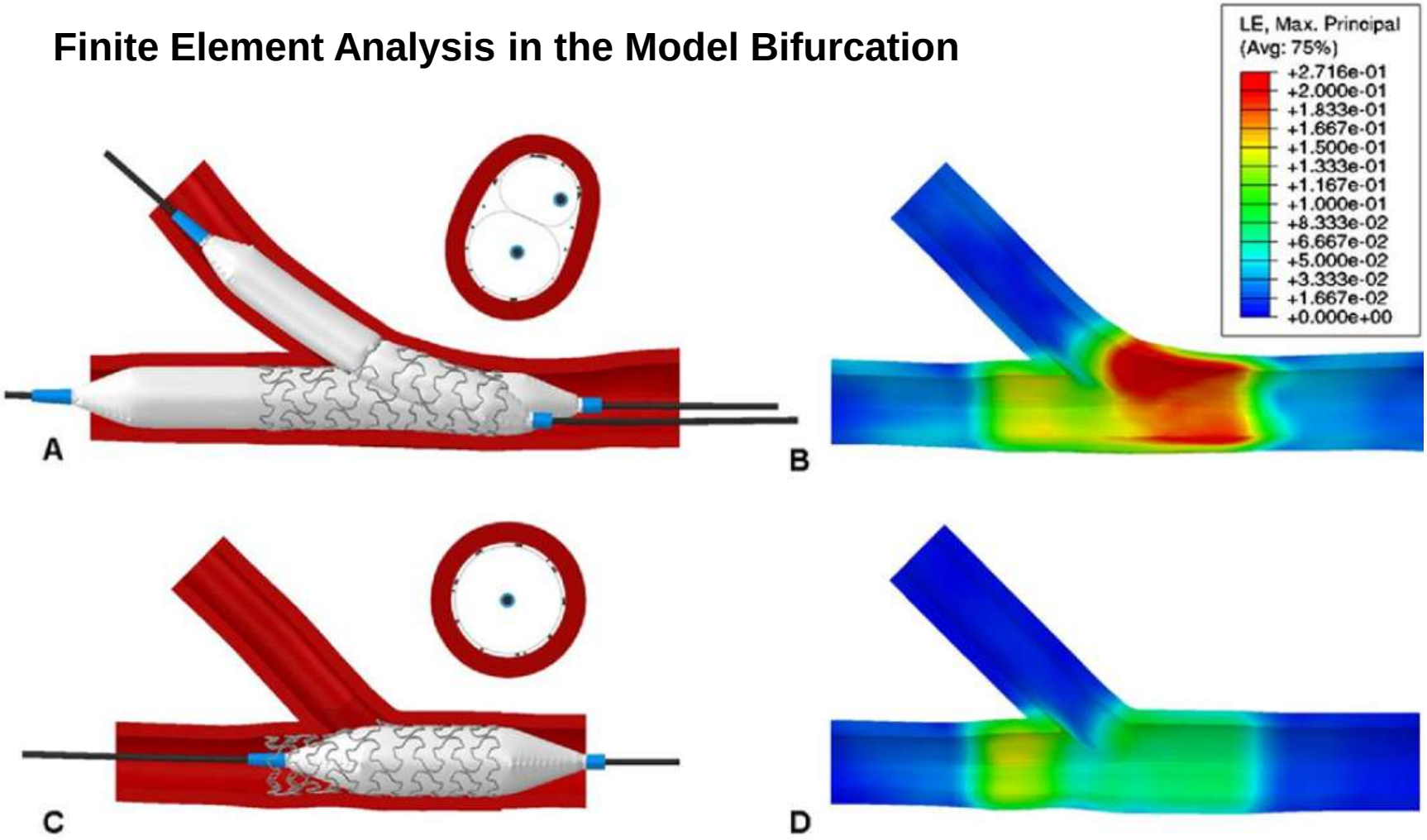


Computational flow simulation of the velocity field **(A)** and shear rate **(B)** in cases representative of provisional technique with MV stenting only and post-dilation with KB or the sequential 2-step SB–MV dilation.

Foin, JACC CVINT 2012, 5: 50-56

Kissing or sequential dilation of the side and main vessel for provisional stenting of bifurcations: Micro-Computed Tomography and Simulations

Finite Element Analysis in the Model Bifurcation

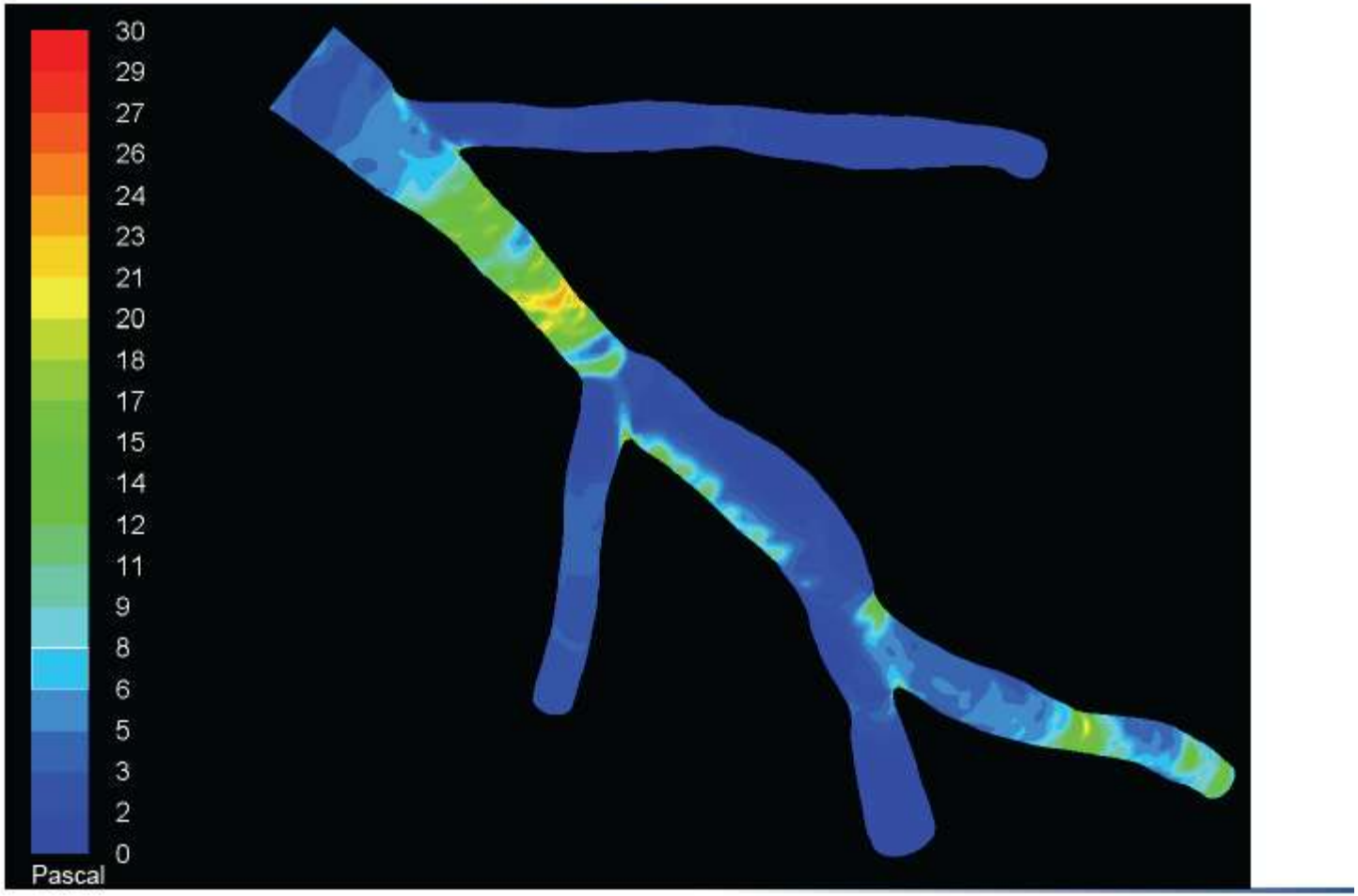


Foin, JACC CVINT 2012, 5: 50-56

EBC

上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

Wall shear stress



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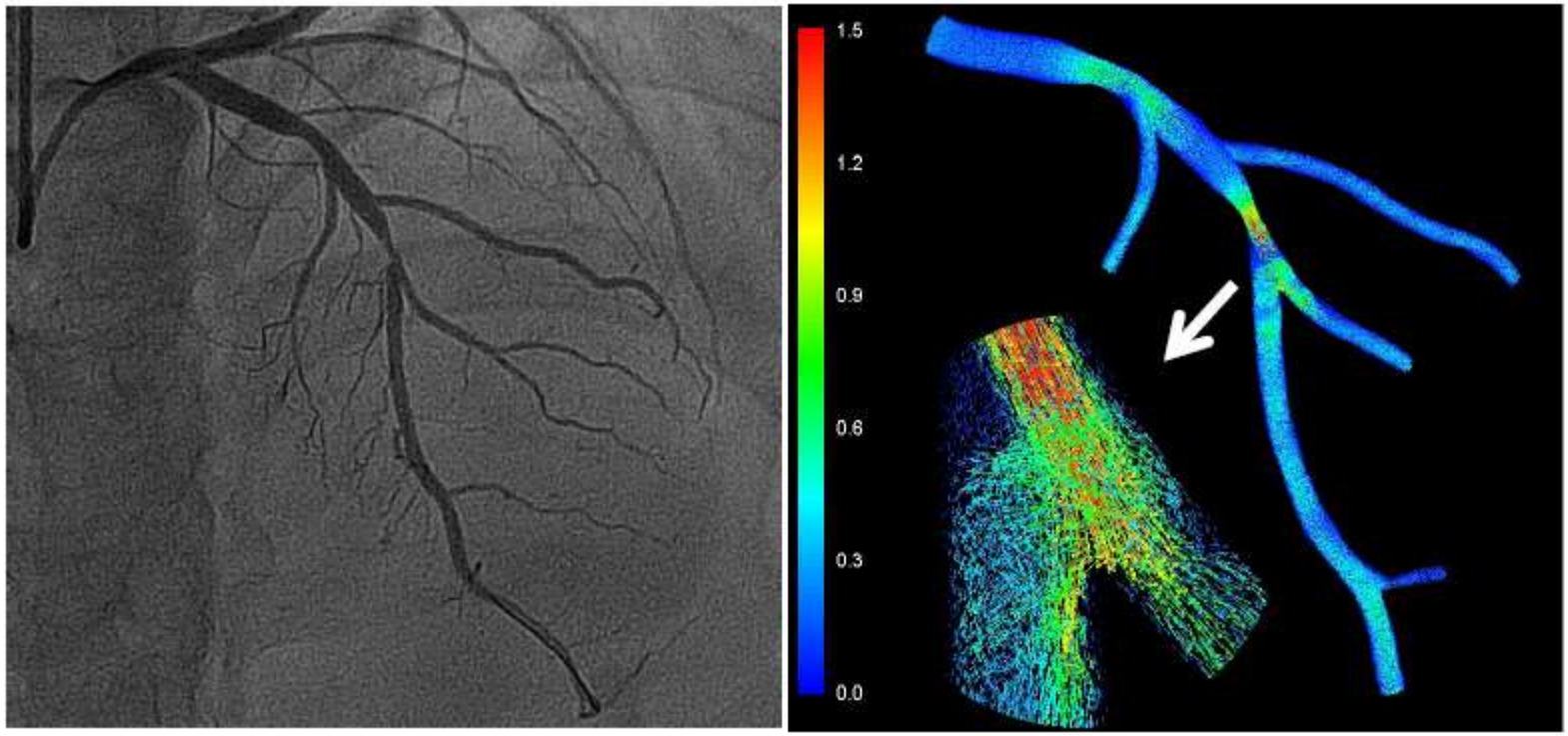
Flow simulation



LM stenting EBC consensus

☐ LMCA treatment by PCI and CABG may have similar safety outcome. PCI has a lower risk of stroke but a higher risk of repeat intervention.

☐ LMCA bifurcation treatment is associated with worse prognosis

☐ Provisional stenting is the preferred strategy in LMCA bifurcation lesions.

☐ POT may be of particular importance in LMCA bifurcation treatment.

Adjunctive intracoronary imaging in bifurcation treatment: EBC consensus

☐ IVUS and OCT may be of particular value in guiding bifurcation treatment and are recommended for left main bifurcation treatment.

☐ Wiring of jailed SBs with imaging wires should be avoided due to the risk of distorting the stent.

☐ Segments overlapping on angiography (often the SB ostium) can be evaluated by intracoronary imaging. OCT may be superior to IVUS in evaluation of the SB ostium by MV pullback.

☐ Evaluation of wire positions may be of importance whenever crossing stents in single and double stenting.

☐ Intracoronary evaluation of optimal vessel and stent expansion is superior to angiographic assessment.

☐ Pullbacks in both SB and MV are recommended in evaluation of two-stent techniques if intracoronary imaging is used.

BVS RUPTURE