

Contemporary Technical Approach to Bifurcation

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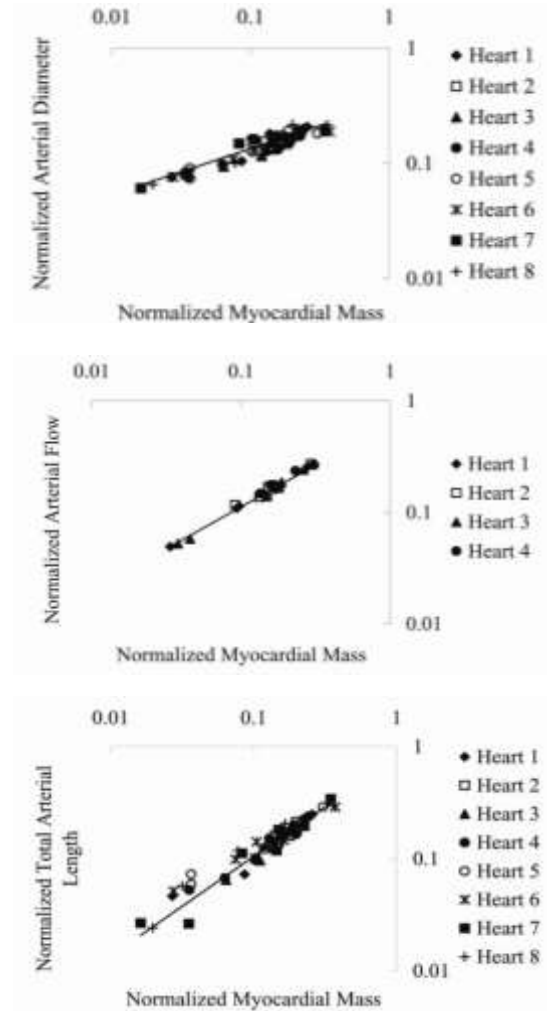
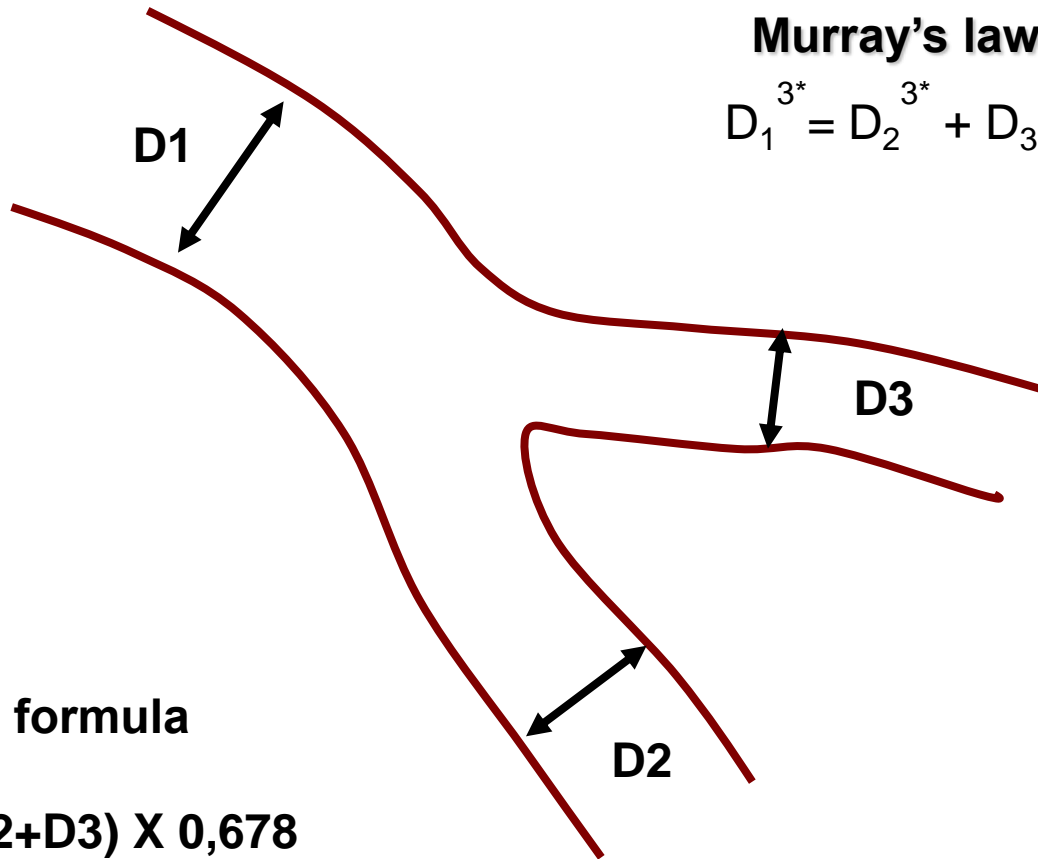
CARDIOVASCULAR SUMMIT
TCTAP 2017

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Coex, Seoul, Korea



Anatomy and fonction of coronary bifurcations

Structure-function scaling laws of vascular trees

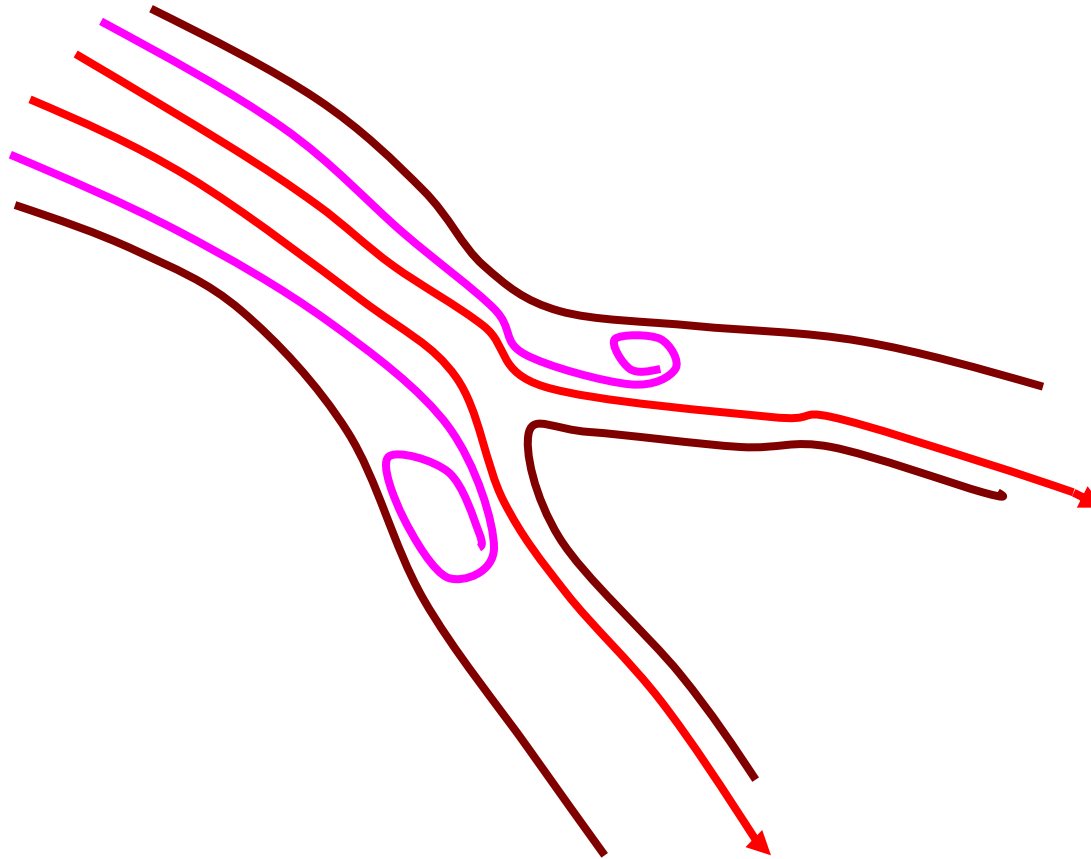


* 2.3 (Huo-Kassab)

Adapted from G. Kassab

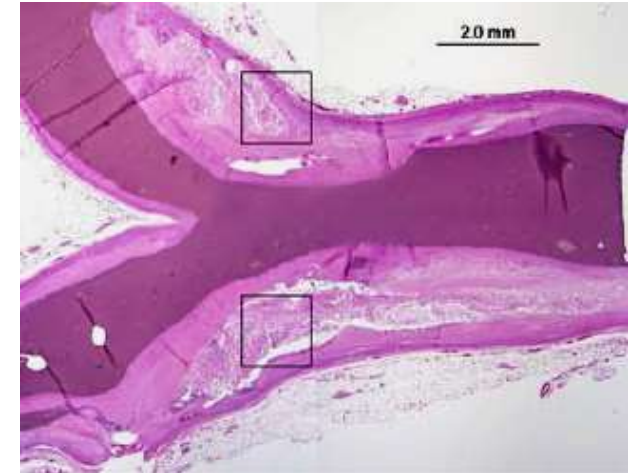
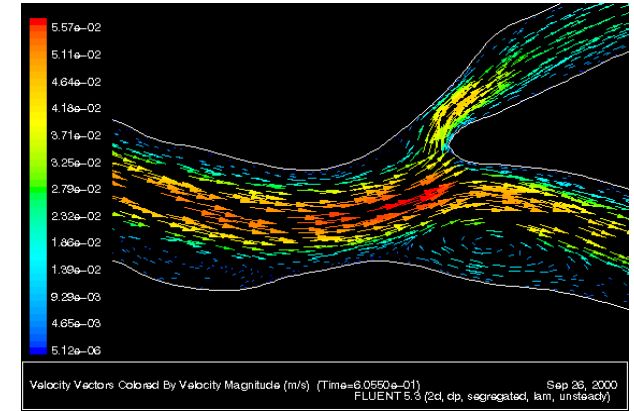
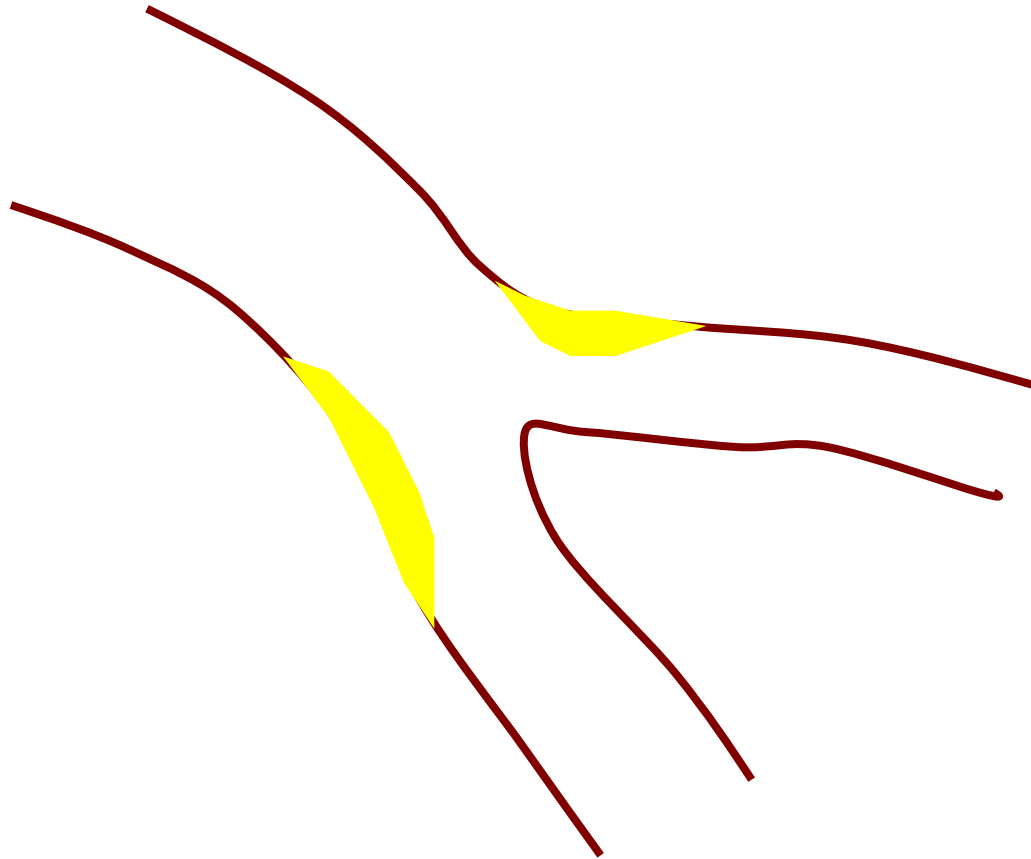
Flow and atheroma

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



**Low wall shear stress =
proatherogenic**

Low wall shear stress and atheroma in bifurcation



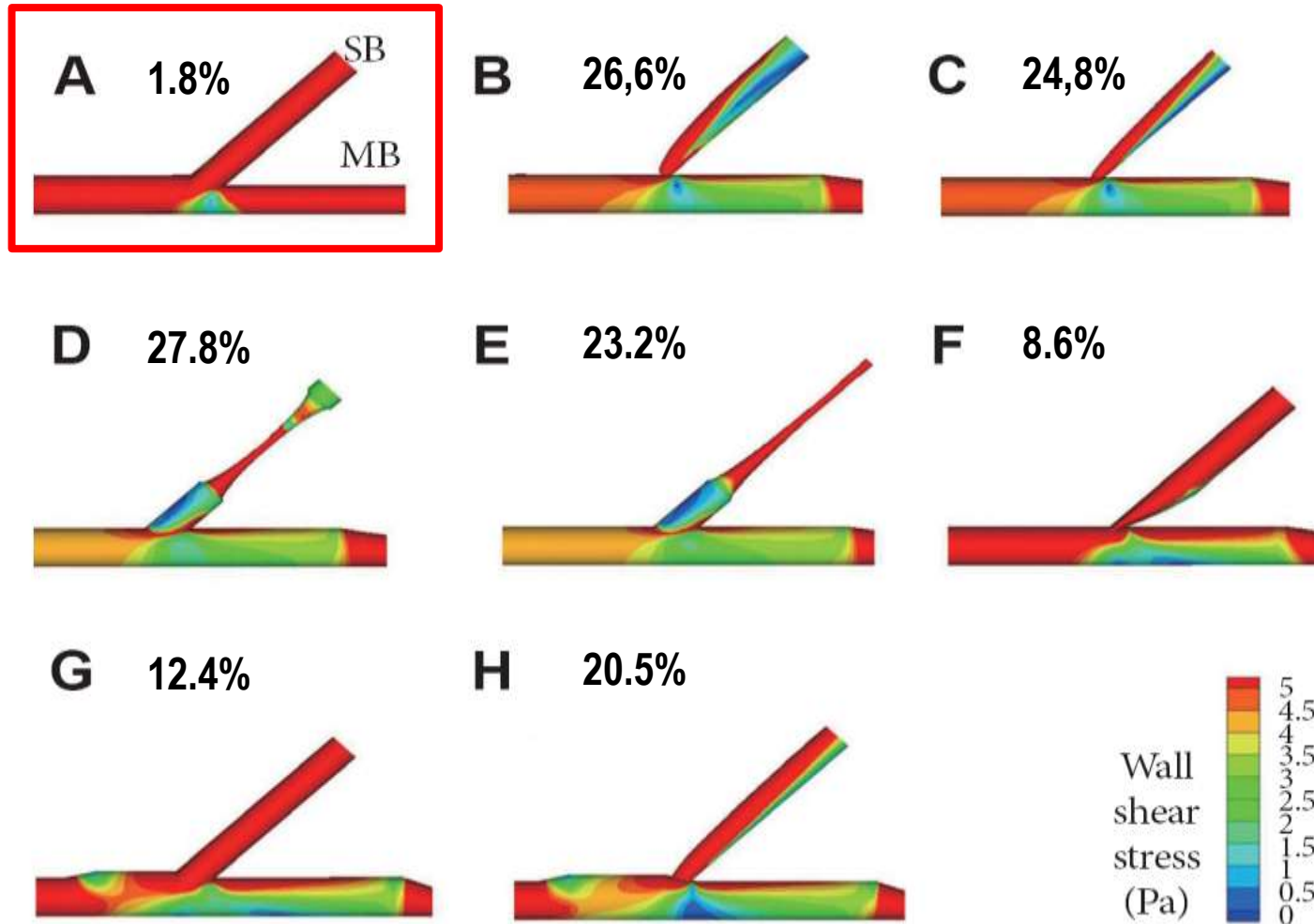
Pathological Findings at Bifurcation Lesions: Impact of Flow Distribution on Atherosclerosis and Arterial Healing After Stent Implantation

	DES (12 Lesions, 17 Stents)			BMS (14 Lesions, 18 Stents)			p Value for DES vs. BMS	
	Flow Divider	Lateral	p Value	Flow Divider	Lateral	p Value	Flow Divider	Lateral
Neointimal thickness (mm)	0.07 (0.03-0.15)	0.17 (0.09-0.23)	0.001	0.26 (0.16-0.73)	0.44 (0.17-0.67)	0.25	0.0002	0.004
Fibrin deposition (% struts)	60 (21-67)	17 (0-55)	0.01	8 (0-33)	3 (0-21)	0.21	0.008	0.19
Uncovered struts (% struts)	40 (16-76)	0 (0-15)	0.001	0 (0-21)	0 (0-0)	0.10	0.004	0.38

Treatment, flow and outcome

Evaluation of Local Flow Conditions in Jailed Side Branch Lesions Using Computational Fluid Dynamics

Area of low WSS (<4 Pa) in 8-computational bifurcation models

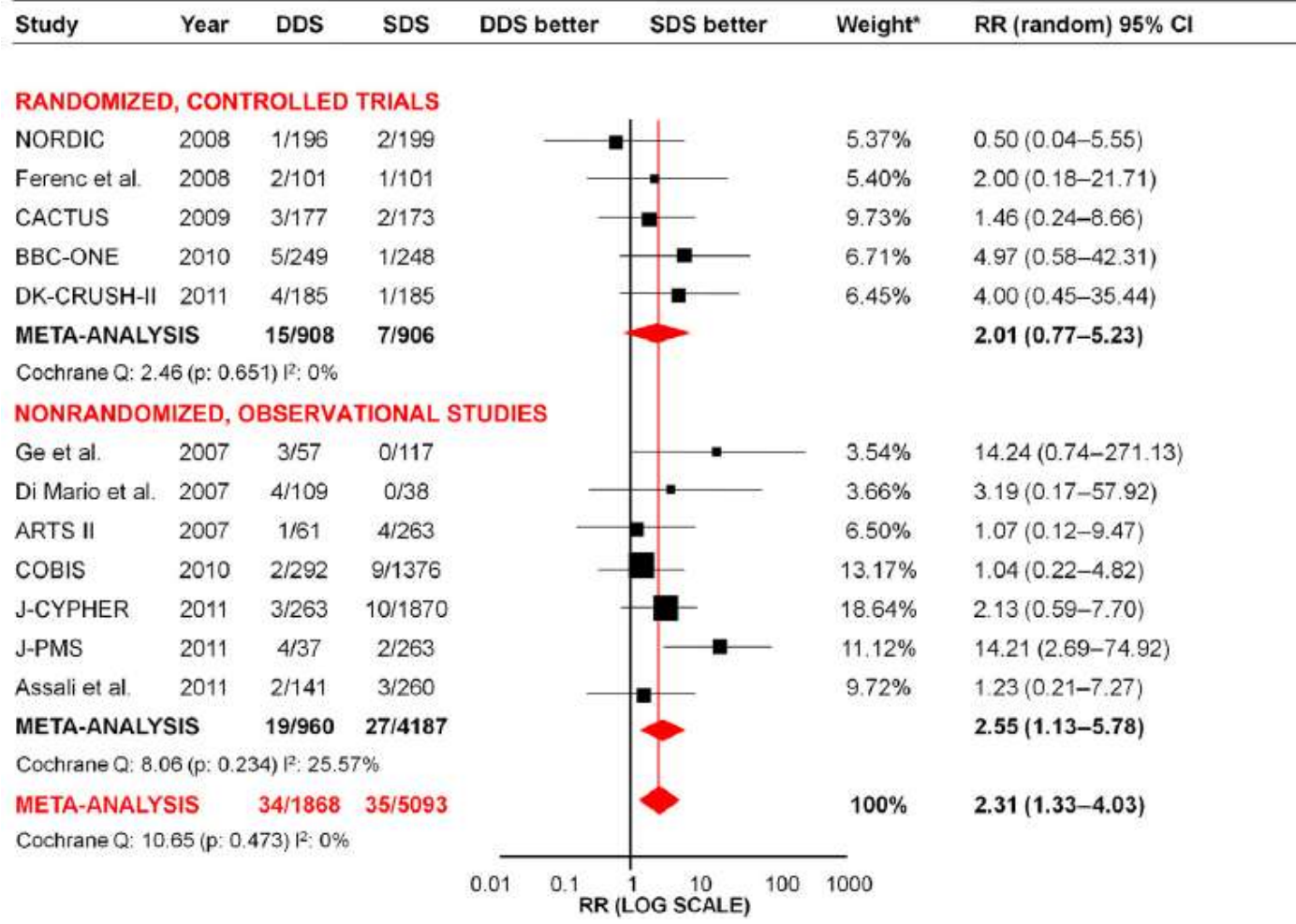


1 versus 2 stents

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

A

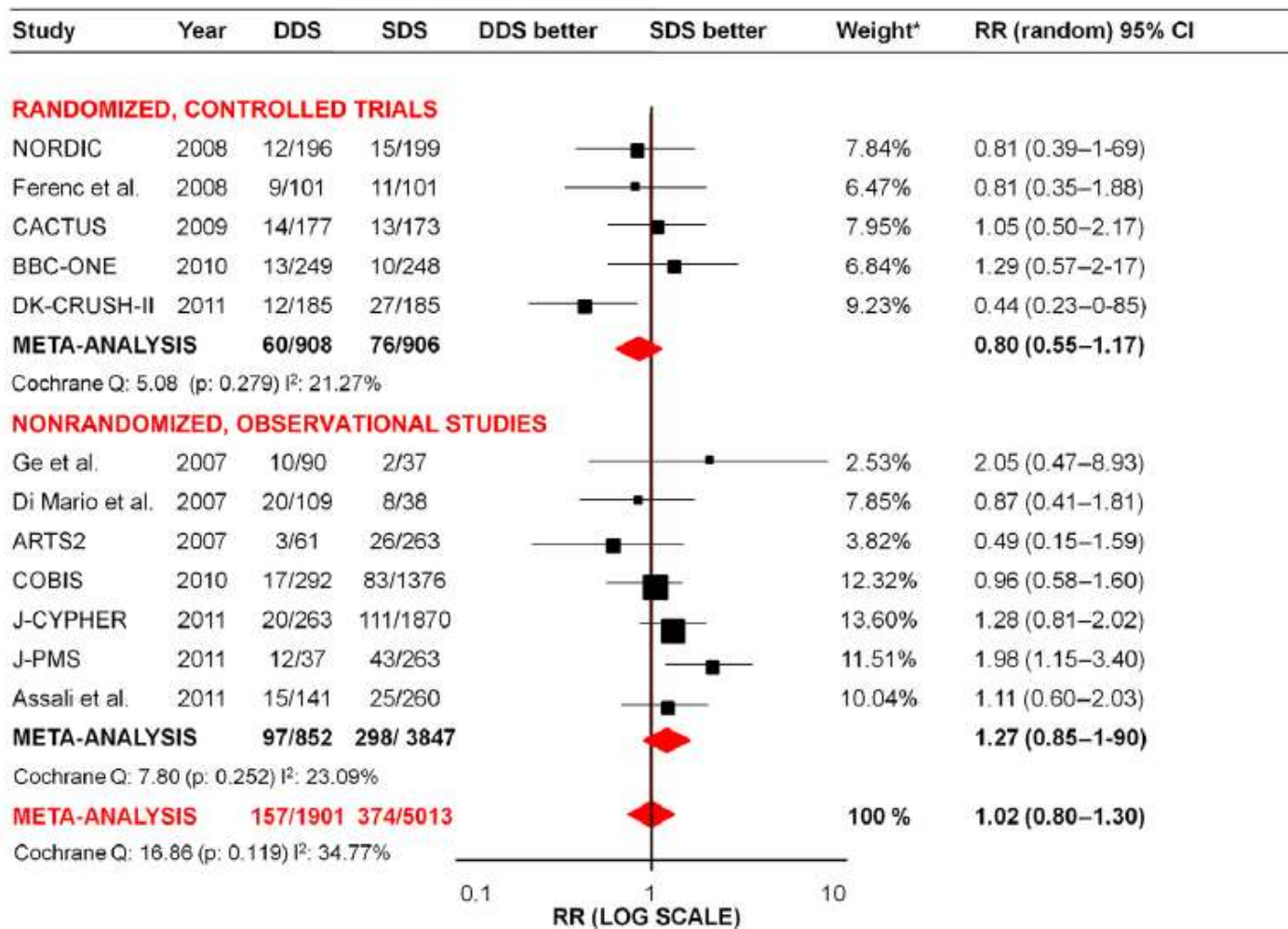
DES Thrombosis



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

D

TVR



Bifurcation lesion treatment principles

- 1. Limit the number of stents (carena)**
- 2. Single stent layer apposition (no overlapping)**
- 3. Respect the original anatomy**

1 versus 2 stent randomized trials

1 versus 2 stents randomized trials (n= 11)

	Centers	Stent	1 / 2	True bif. %	SB	2 stents technique	Crossover 1:2 / 2:1
Pan 2004 AHJ	1	Cypher	47 / 44			Provisional	
Colombo 2004 Circ.	5	Cypher	23 / 63			Crush	51.2%
Nordic 2006 Circ.	28	Cypher	205 / 206		>2	Crush, Culotte...	4.3% / 4.9%
BBK 2008 EHJ	1	Cypher	101 / 101	68.2 / 68.3	>2.25	Provisional	18.8% / 3%
CACTUS 2009 Circ.	12	Cypher	173 / 177	100 / 100	>2.25	Crush	31% / -
BBC 1 2010 Circ.	20	Taxus	250 / 250	81 / 84	>2.25	Culotte, ..	3% / -
Lin 2010 Coron Art Dis	1	Taxus Cypher	54 / 54	100 / 100	>2.2	DK Crush, ...	16.7% / 5.6%
PERFECT 2015 JACCi	14	> 4	206 / 213	100 / 100	> 2	Mini Crush Kiss	25.9% / 1%
DKCRUSH-II 2011 JACC	7	Excel	185 / 185	100 / 100	>2.5, long L.	DK crush	28.6% / -
Nordic-Baltic IV 2013	16	Cypher Xience	221 / 229	100 / 100	>2.75	Culotte, ...	3.7% / 4%
EBC 2 2015	20	Nobori	103 / 97	100 / 100	> 2.5, long L.	Culotte	16% / 3%

Provisional versus 2 stents randomized trials (n= 5)

All comers

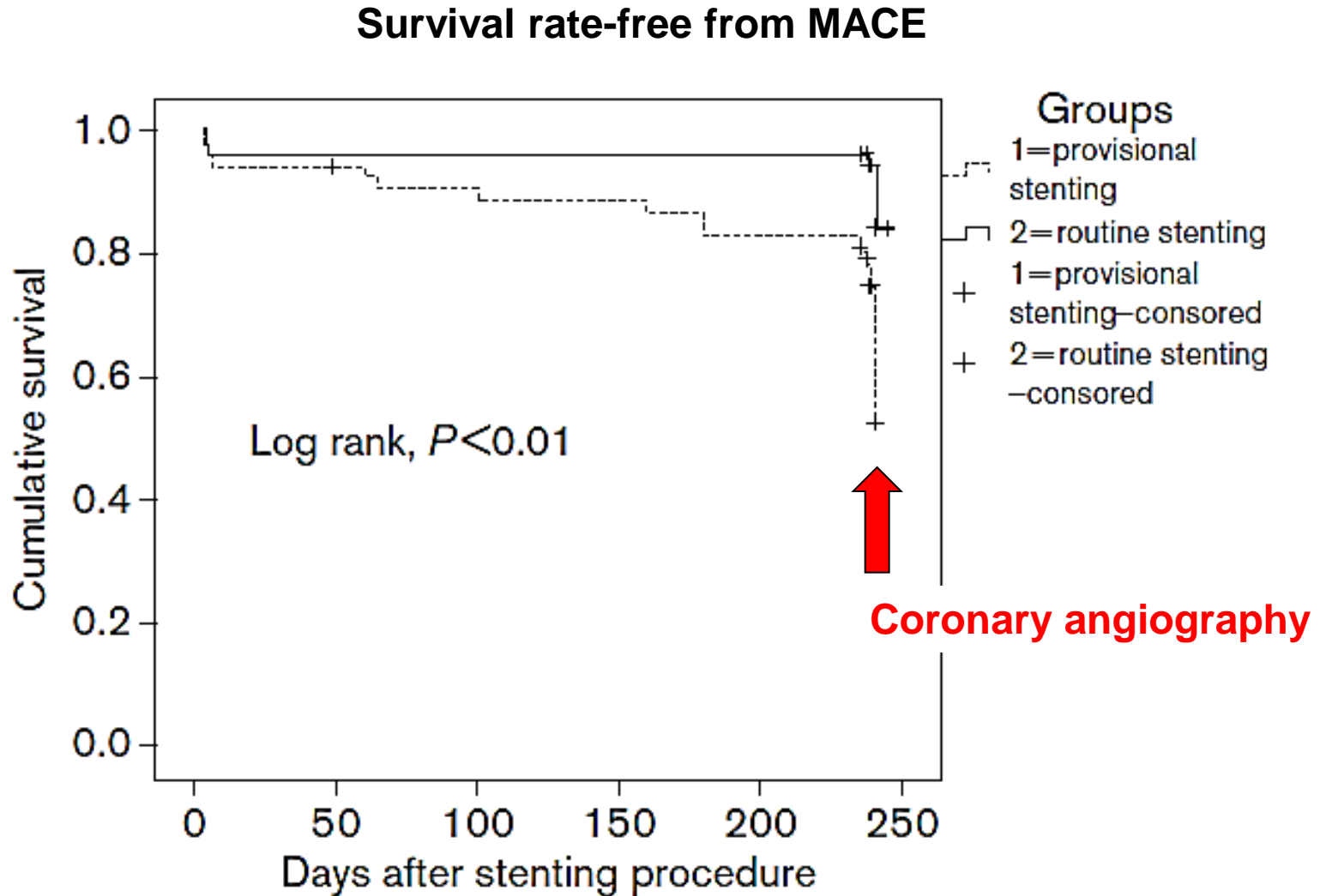
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Provisional versus 2 stents randomized trials (n= 5)

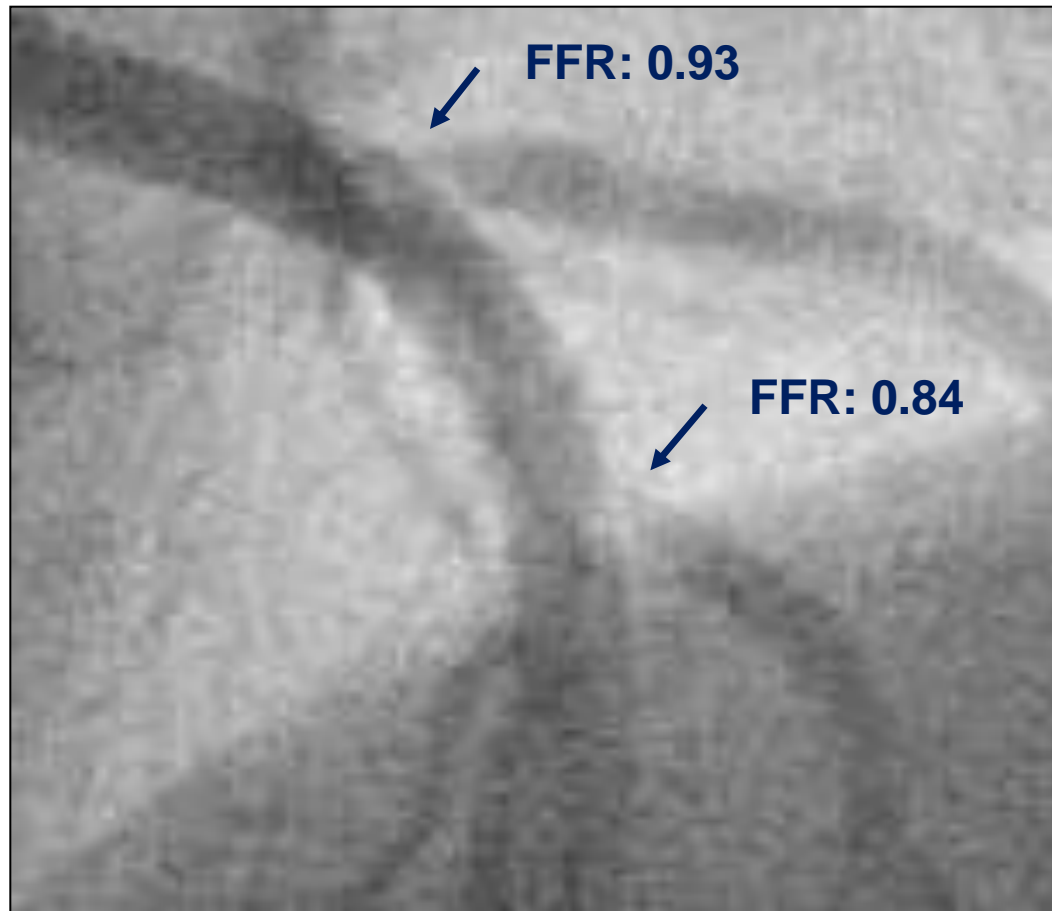
All comers

	1 ary Endpoint	Syst. angio	Endpoint %	(Cardiac) death %	MI %	TVR %	TLR %	Rest.	ST
Nordic 2006 Circ.	C. death MI ST TVR 6 m	6 m	2.9 3.4	1 1	0 0.5	1.9 1.9			0.5 0
CACTUS 2009 Circ.	C. death MI ST TVR 6 m	8 m	15 15.8	0.5 0	8.6 10.7	6.2 6.8			Def 1.1 1.7
BBC 1 2010 Circ.	Death MI TVF 9 m	No	8 15.1	2 1	3.6 11.2	5.5 7.2			1 5
Lin 2010 Coron Art Dis	C. death MI ST TVR 8 m	8 m	38.9 11	0 0	1.9 1.9		26.9 6.4		1.9 0
PERFECT 2015 JACCI	% restenosis 2 branch	8 m	SB 8.3/3.9 MB 4.8/5.2	0.5 0.9	14.1 14.1	3.4 2.9	3.4 1.9	11 8.4	0 0.5

Choice of stenting strategy in true coronary artery bifurcation lesions



SB Ostial Lesions Are Overestimated



SB clinical relevance (Koo)

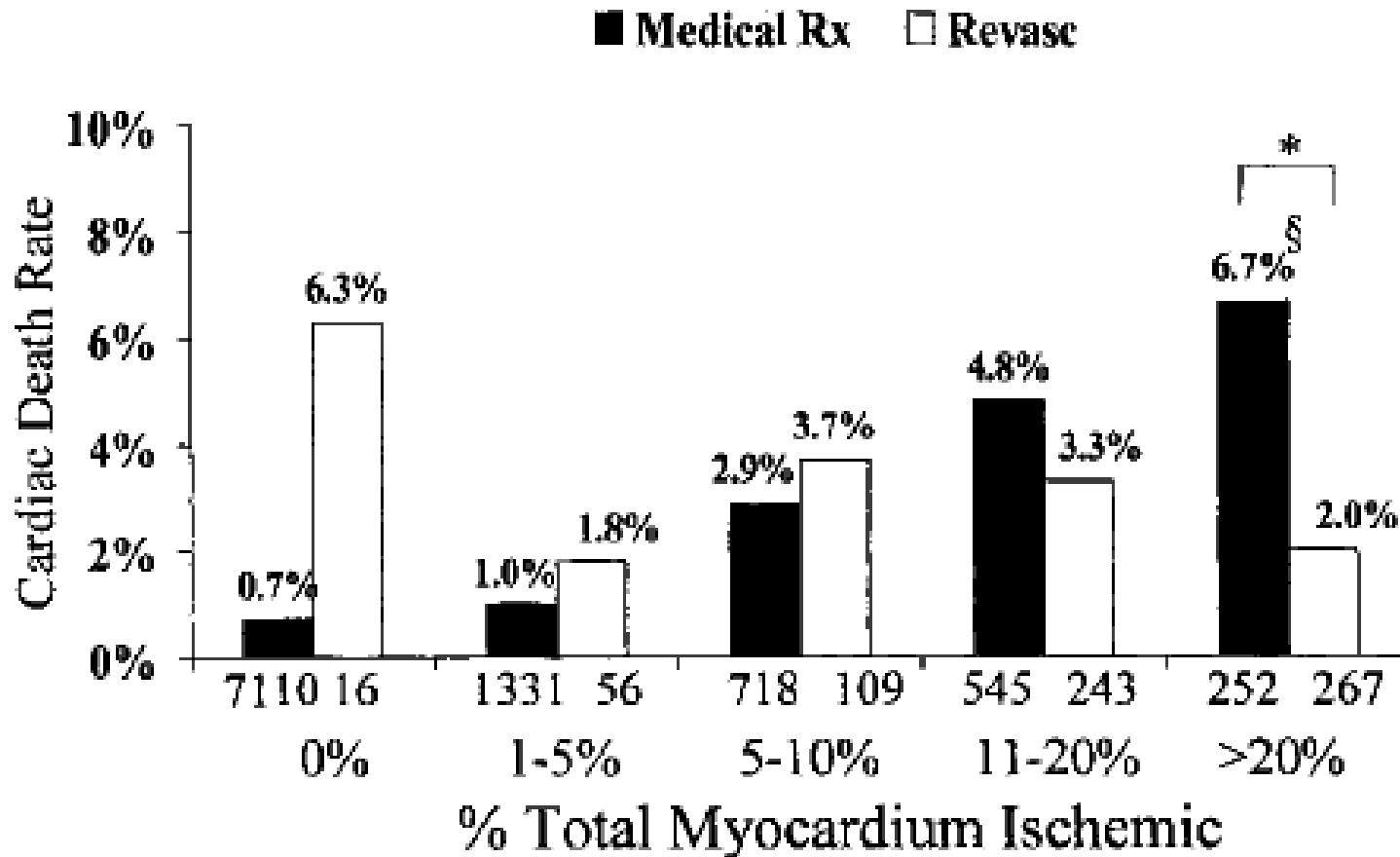
Assessment of Clinical, Electrocardiographic, and Physiological Relevance of Diagonal Branch in Left Anterior Descending Coronary Artery Bifurcation Lesions

Bon-Kwon Koo, MD, PhD,* Seung-Pyo Lee, MD,* Ju-Hee Lee, MD,*
Kyung-Woo Park, MD, PhD,* Jung-Won Suh, MD, PhD,† Young-Seok Cho, MD, PhD,†
Woo-Young Chung, MD, PhD,‡ Joon-Hyung Doh, MD, PhD,§
Chang-Wook Nam, MD, PhD,|| Cheol Woong Yu, MD, PhD,¶ Bong-Ki Lee, MD, PhD,#
Dobrin Vassilev, MD,** Robert Gil, MD,†† Hong-Seok Lim, MD, PhD,‡‡
Seung-Jea Tahk, MD, PhD,‡‡ Hyo-Soo Kim, MD, PhD*

Seoul, Gyeonggi-do, Daegu, Bucheon, and Kangwŏn-do, Korea; Sofia, Bulgaria; and Warsaw, Poland

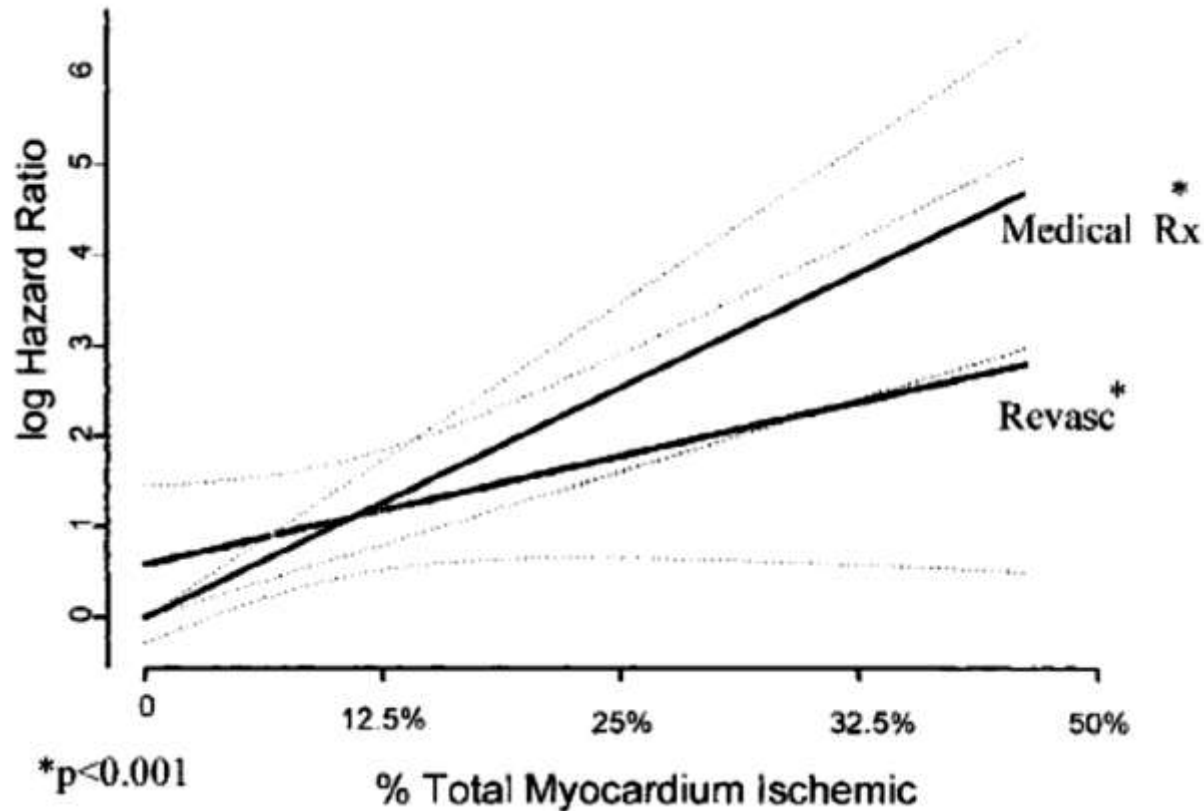
Revascularization for clinically insignificant side branches cannot be translated into clinical benefit and may even be harmful

Short-term benefit associated with revascularization / medical therapy in Pts with no prior CAD undergoing stress myocardial perfusion SPECT



Observed cardiac death rates over the FU period in patients undergoing revascularization vs medical therapy as a function of the amount of inducible ischemia. $P=0.0001$.

Short-term benefit associated with revascularization / medical therapy in Pts with no prior CAD undergoing stress myocardial perfusion SPECT



Log hazard ratio for Revasc vs Medical Rx as a function of % myocardium ischemic based on final Cox proportional hazards model. Model, $P=0.0001$; interaction, $P=0.0305$.

Small SB are an acute concern = protection (bail out stenting)

1 vs 2 stents for bifurcation with big SB (clinically relevant) ...

1 versus 2 stents randomized trials for large SB (n= 3)

	Centers	Stent	1 / 2	True bif. %	SB	2 stents technique	Crossover 1:2 / 2:1
DKCRUSH-II 2011 JACC	7	Excel	185 / 185	100 / 100	>2.5, long L.	DK crush	28.6% / -
Nordic-Baltic IV 2013	16	Cypher Xience	221 / 229	100 / 100	>2.75	Culotte, ...	3.7% / 4%
EBC 2 2015	20	Nobori	103 / 97	100 / 100	> 2.5, long L.	Culotte	16% / 3%

Provisional versus 2 stents randomized trials for large SB

	Centers	Stent	1 / 2	SB stenosis	SB	2 stents technique	Crossover 1:2 / 2:1
DKCRUSH-II 2011 JACC	7	Excel	185 / 185	63% / 63%	>2.5, long L.	DK crush	28.6% / -
Nordic-Baltic IV 2013	16	Cypher Xience	221 / 229	44% / 47%	>2.75	Culotte, ...	3.7% / 4%
EBC 2 2015	20	Nobori	103 / 97	? / ?	> 2.5	Culotte	16% / 3%

Provisional versus 2 stents randomized trials for large SB

	Centers	Stent	1 / 2	True bif. %	SB QCA diameter	2 stents technique	Crossover 1:2 / 2:1
DKCRUSH-II 2011 JACC	7	Excel	185 / 185	100 / 100	2.3 / 2.4	DK crush	28.6% / -
Nordic-Baltic IV 2013	16	Cypher Xience	221 / 229	100 / 100	2.4 / 2.5	Culotte, ...	3.7% / 4%
EBC 2 2015	20	Nobori	103 / 97	100 / 100	? / ?	Culotte	16% / 3%

Provisional versus 2 stents randomized trials for large SB

	1 ary Endpoint	Syst. angio	Endpoint %	(Cardiac) death %	MI %	TVR %	TLR %	Rest.	ST
DKCRUSH-II 2011 JACC	C. death MI TVR 12 m	8 m	17.3 10.3	1.1 1.1	2.2 3.2	14.6 / 6.5	13 4.3		Def 0.5 2.2
Nordic-Baltic IV 2013	C. death non procedure MI TLR Def. ST 6 m	8 m	4.6 1.8	0 0	1.8 0.9		3.2 1.3		0.9 0.4
EBC 2 2015	Death MI TVR 12 m	No	8 10	2 1	5 10	3 1			1 3

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

Clinical outcome (2)

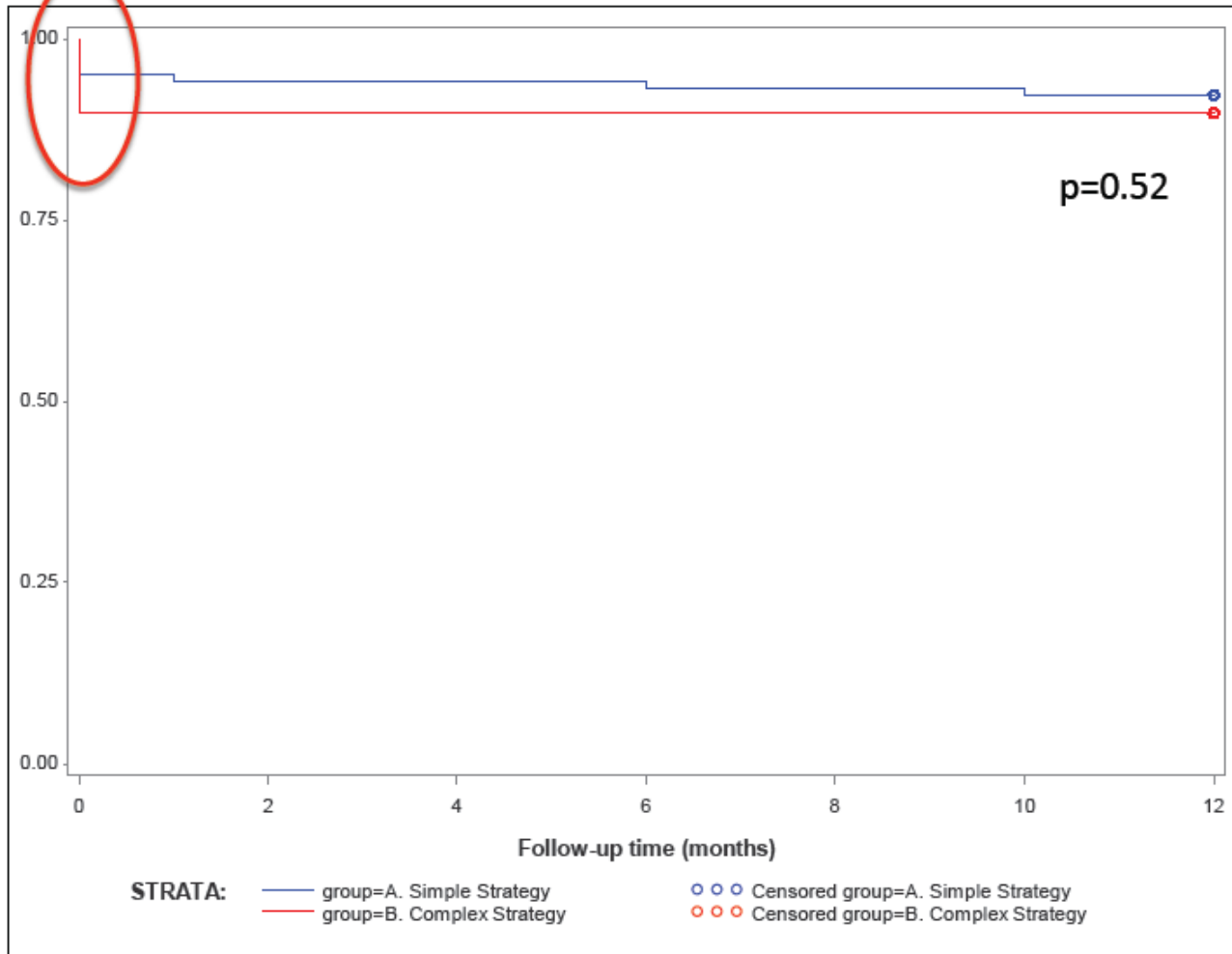
	DK Group (n = 185)	PS Group (n =185)	p Value
Procedural success	179 (96.8)	173 (93.5)	0.217
At 6-month			
Cardiac death	1 (0.5)	2 (1.1)	1.000
MI	6 (3.2)	4 (2.2)	0.751
CABG	0 (0)	1 (0.5)	0.500
TLR	2 (1.1)	6 (3.2)	0.284
TVR	3 (1.6)	8 (4.3)	0.220
MACE	6 (3.2)	11 (5.9)	0.321
Stent thrombosis definite	4 (2.2)	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

euro
PCR
2015

The EBC TWO Trial

12 M Outcome : Death, MI and TVR at 12

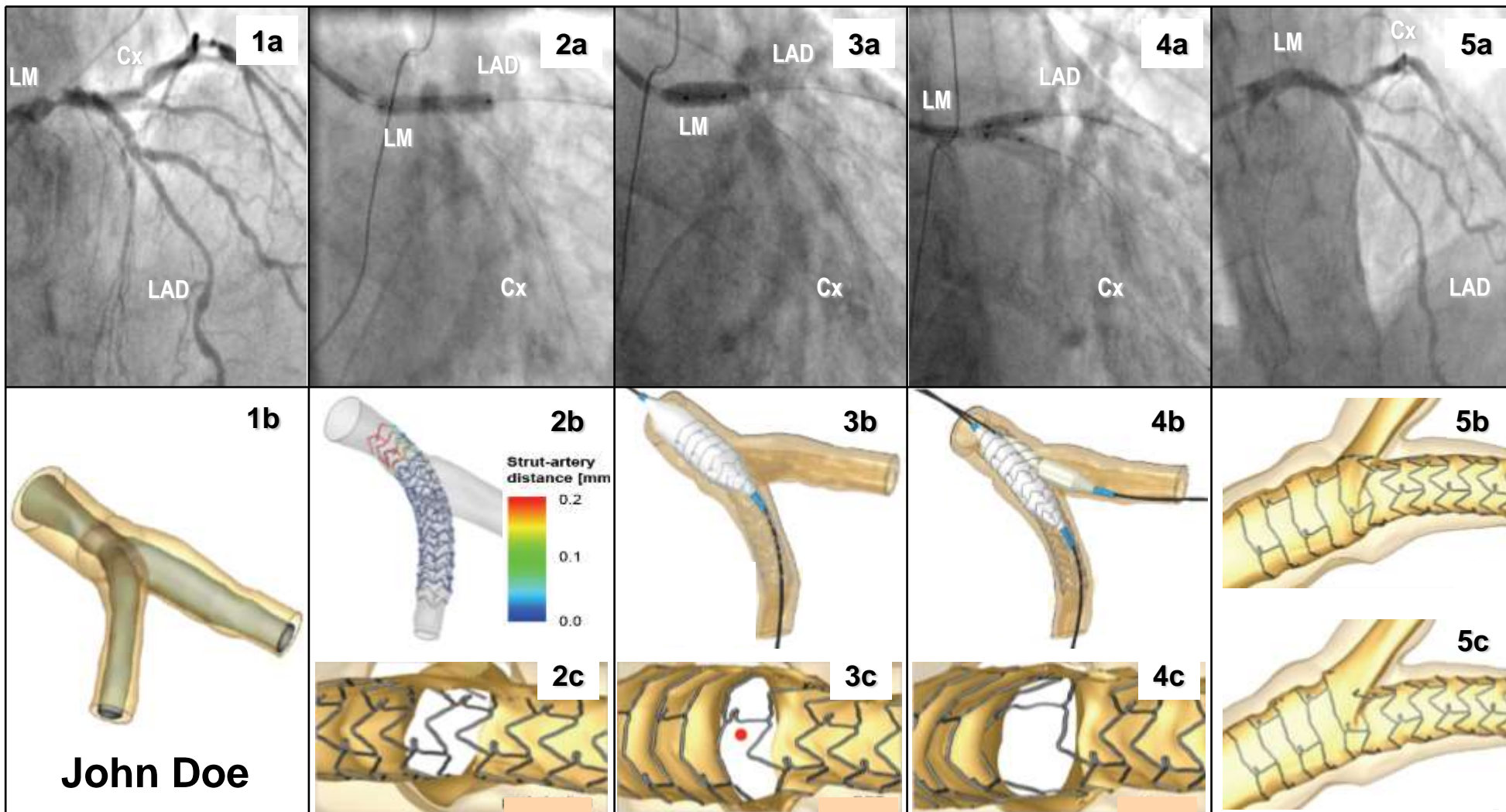


1 vs 2 for big SB and long lesion:









Provisional SB stenting strategy

EBC 2012: patient's specific simulation



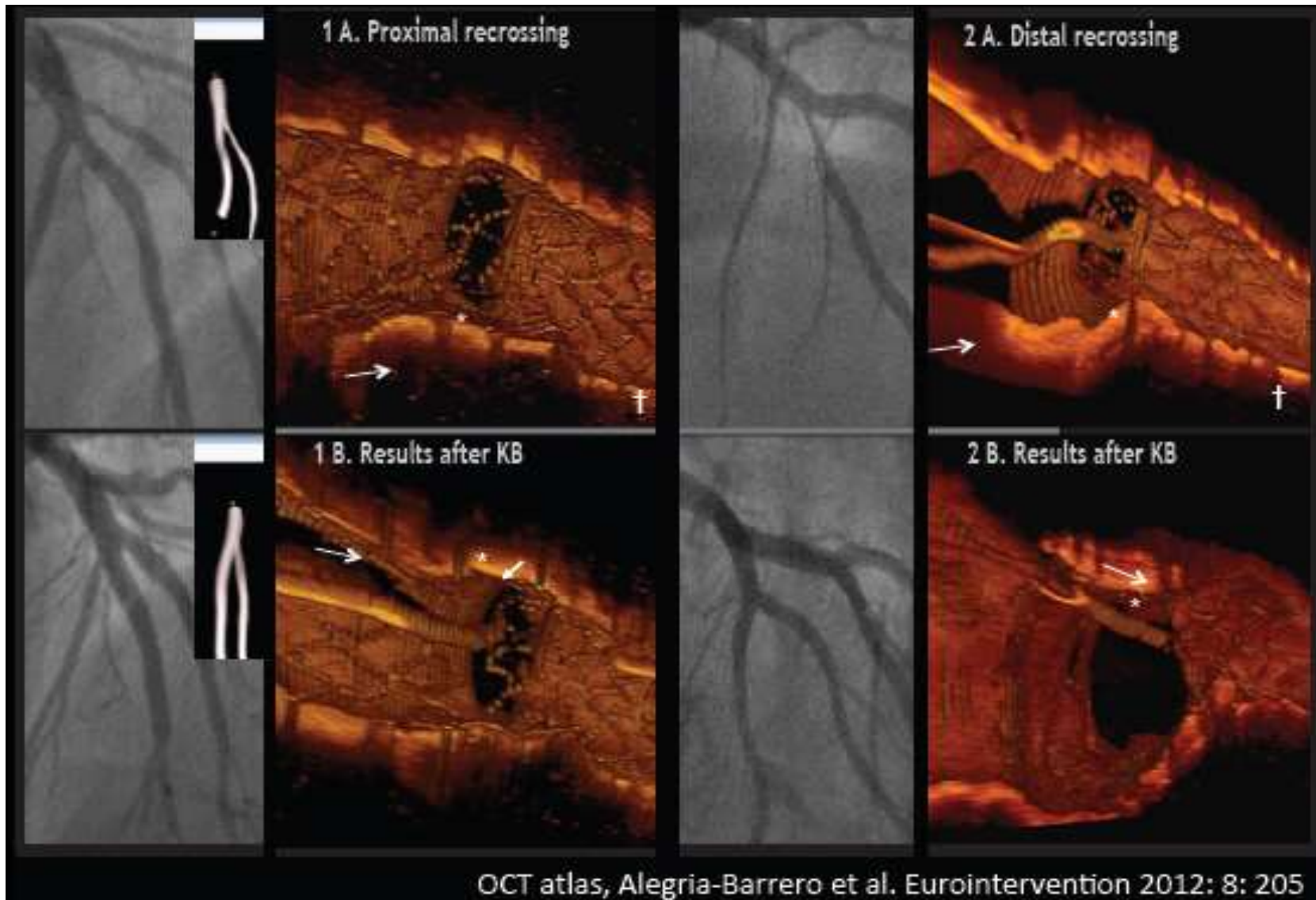
DES Designs Overexpansion

Balloon Max Size						
	Synergy	Xpedition	Res. Onyx	Ultimaster	BioMatrix A	Orsiro
4.0	2.25	Small vessel (8 crowns, 2-4 connectors) <i>Expansion: 3.6mm</i>	Small vessel (6 crowns, 3 connectors) <i>Expansion: 4.1mm</i>	Small vessel (8 crowns, 2 connectors) <i>Expansion: 4.3mm</i>	Small vessel (6 crowns, 2 connectors) <i>Expansion: 4.1mm</i>	Small vessel (6 crowns, 3 connectors) <i>Expansion: 4.0mm</i>
	2.50					
5.0	2.75		Medium vessel (8.5 crowns, 2 connectors) <i>Expansion: 4.4mm</i>			
	3.00	Workhorse (8 crowns, 2-4 connectors) <i>Expansion: 4.2mm</i>				
	3.50		Large vessel (9 crowns, 3 connectors) <i>Expansion: 5.6mm</i>	Large vessel (8 crowns, 2 connectors) <i>Expansion: 5.8mm</i>	Large vessel (9 crowns, 3 connectors) <i>Expansion: 5.9mm</i>	Large vessel (6 crowns, 3 connectors) <i>Expansion: 5.3mm</i>
6.0	4.00	Large vessel (10 crowns, 2-5 connectors) <i>Exp: 5.7mm</i>	Large vessel (9.5 crowns, 2.5 connectors) <i>Expansion: 5.6mm</i>			
	4.50		Extra-Large vessel (10.5 crowns, 2.5 connectors) <i>Expansion: 6.0mm</i>			
	5.00					

- *Expansion : inner stent MLD excluding struts*
- *Max balloon size : Maverick 6.0mm at 14 ATM*

Foin, Ng, 2016

Proximal vs distal recrossing toward side branch



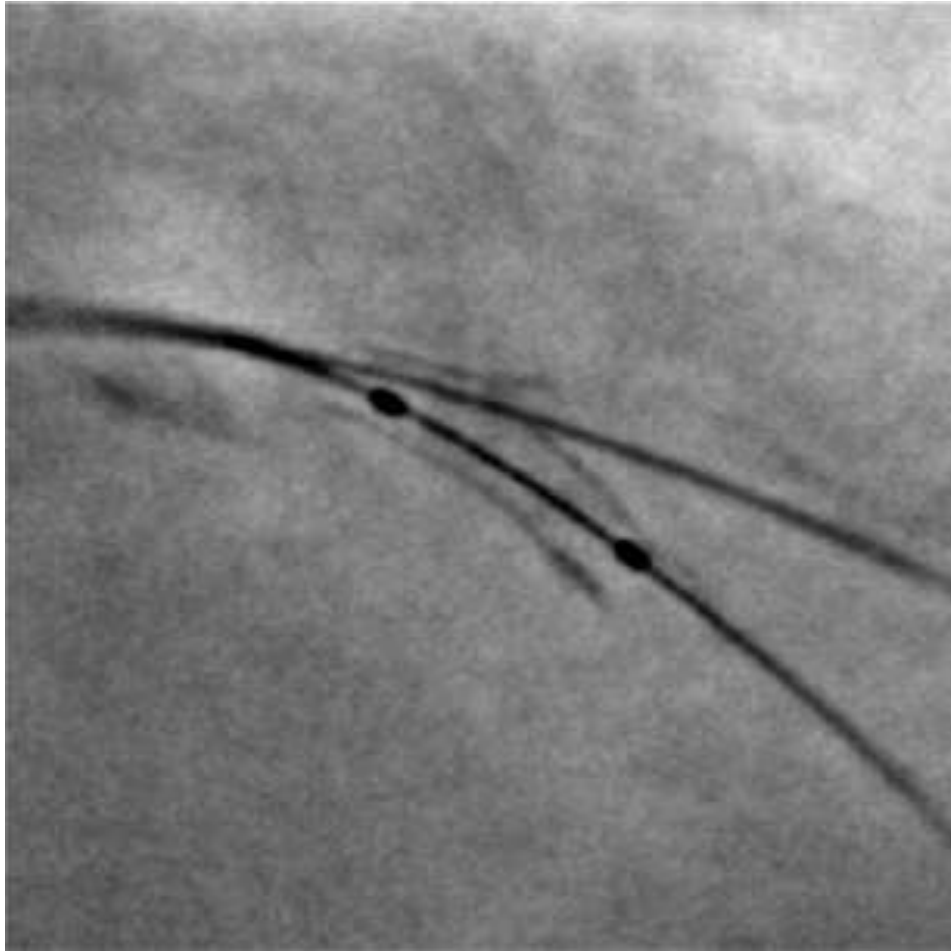
Long-term Clinical outcomes of final KB in coronary bifurcation lesions treated with the 1-stent technique: results from the COBIS II registry

Clinical Outcomes in FKB Group Compared With Non-FKB Group in Propensity-Matched Population During FU Period

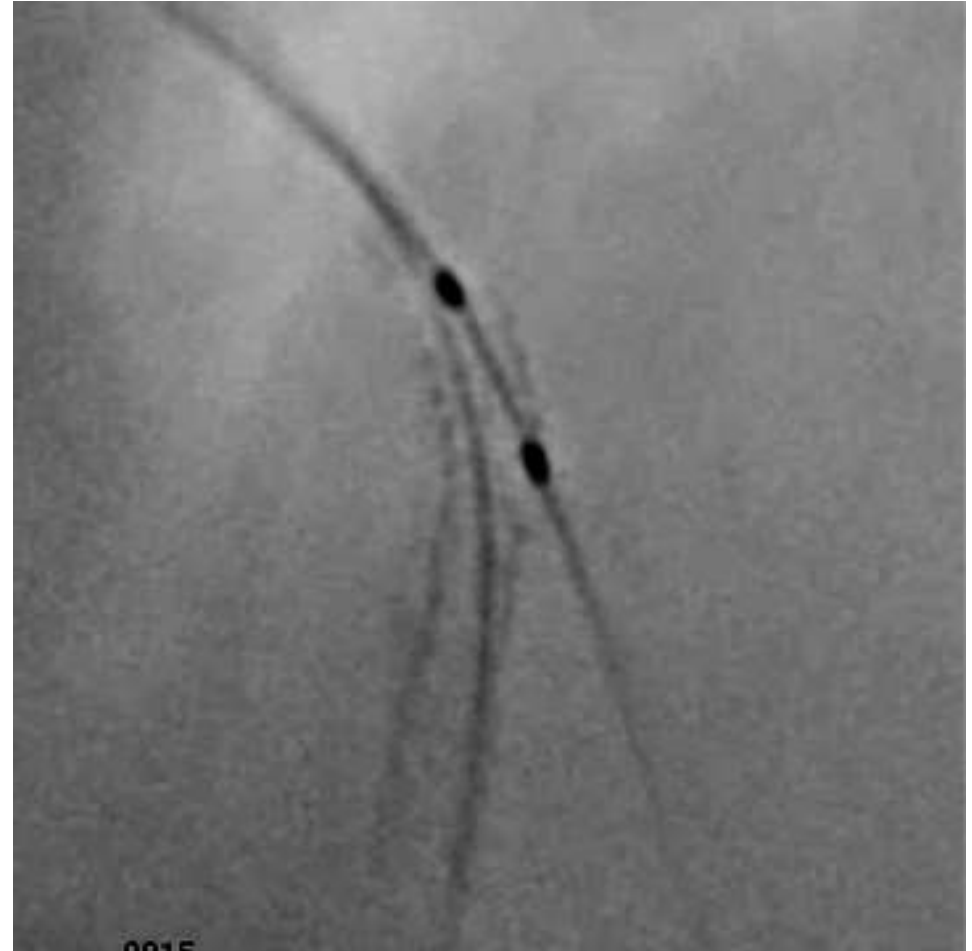
	FKB (n = 545)	Non-FKB (n = 545)	Unadjusted HR (95% CI)	p Value	Adjusted HR* (95% CI)	p Value
All-cause death	17 (3.1)	20 (3.7)	0.67 (0.30-1.48)	0.32	0.68 (0.28-1.63)	0.39
Cardiac death	3 (0.6)	8 (1.5)	0.43 (0.11-1.66)	0.22	0.50 (0.11-2.29)	0.37
MI	4 (0.7)	5 (0.9)	0.50 (0.09-2.73)	0.42	0.18 (0.01-20.36)	0.48
Stent thrombosis†	3 (0.6)	4 (0.7)	0.72 (0.16-3.23)	0.67	0.77 (0.17-3.45)	0.73
Target lesion revascularization	32 (5.9)	43 (7.9)	0.53 (0.30-0.94)	0.03	0.51 (0.28-0.91)	0.02
Main vessel	31 (5.7)	40 (7.3)	0.53 (0.30-0.96)	0.04	0.51 (0.28-0.93)	0.03
Side branch	12 (2.2)	18 (3.3)	0.57 (0.24-1.36)	0.21	0.57 (0.24-1.37)	0.21
Both vessels	23 (4.2)	38 (7.0)	0.47 (0.25-0.88)	0.02	0.47 (0.25-0.90)	0.02
MACE‡	37 (6.8)	53 (9.7)	0.54 (0.32-0.89)	0.02	0.50 (0.30-0.85)	0.01

*Adjusted covariates include hypertension, history of coronary artery bypass graft, and distal RD of SB

T or TAP ? (stent boost)



↓
T



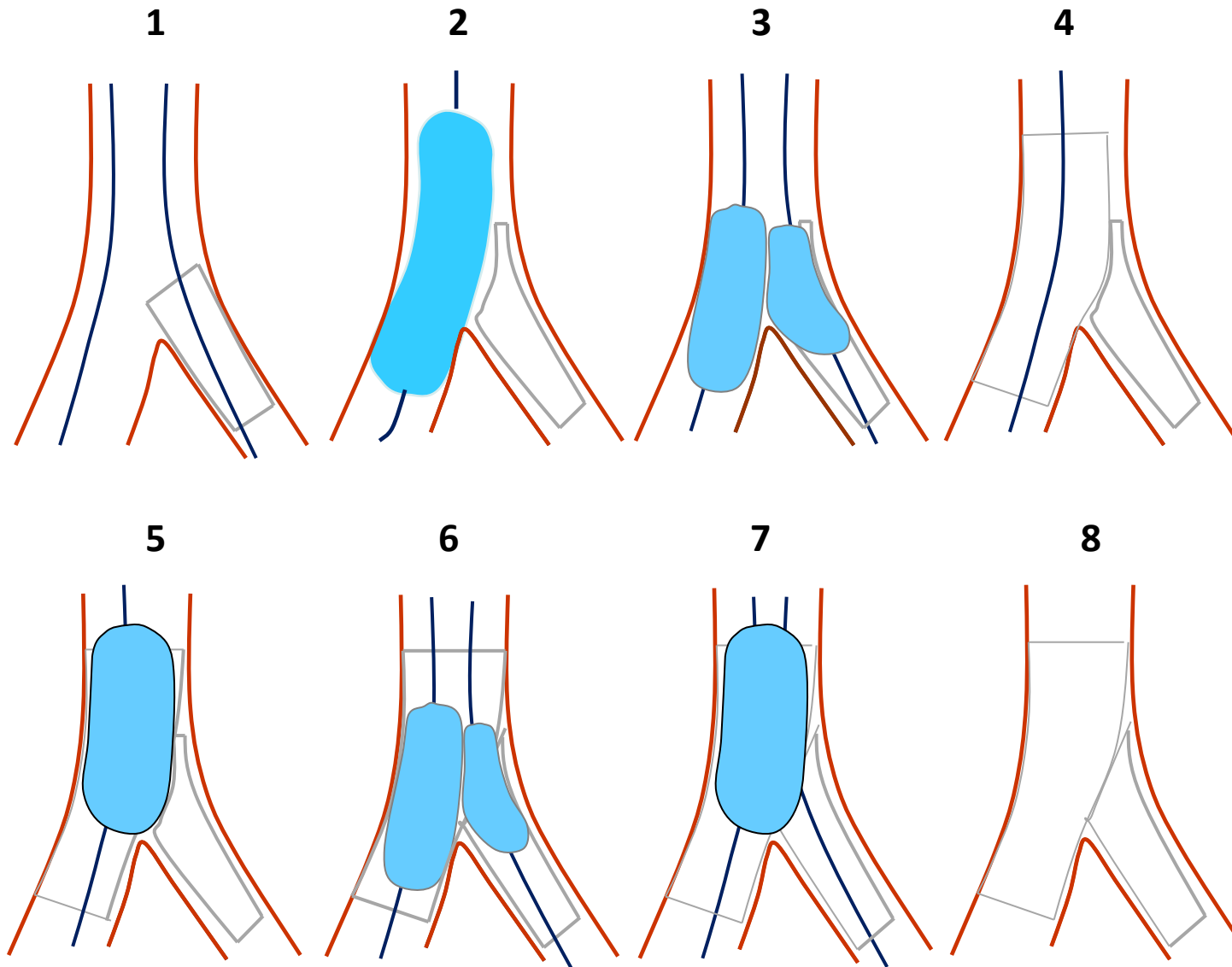
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TAP

Double stenting beginning with SB

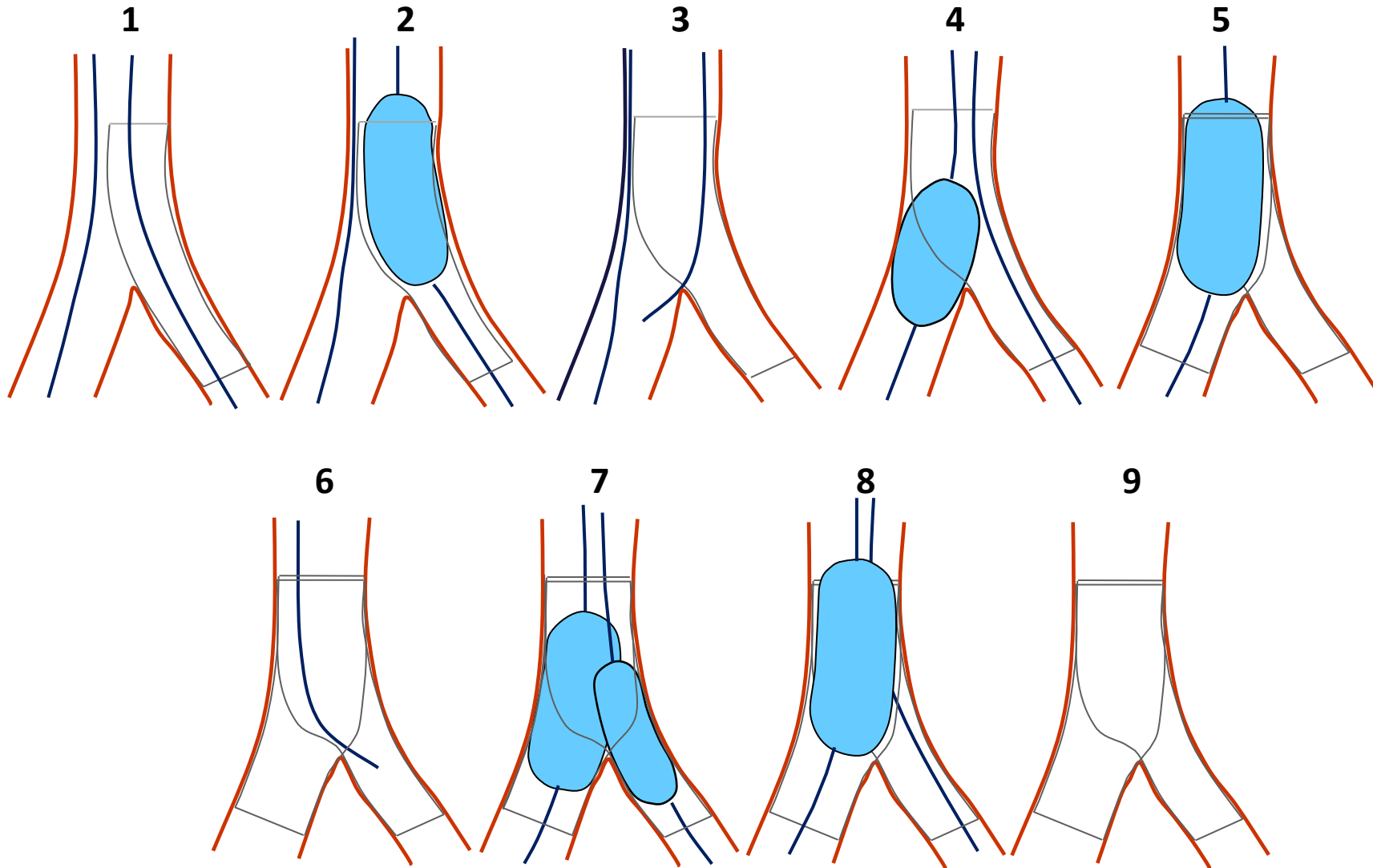
2 stent technique differences

2 stent techniques	DK-Crush	Inverted-Culotte	Provisional SB stenting
Approach	Radial	Radial	Radial
Catheter size	6F	6F	6F (TAP: 7F)
% SB stenting	100%	100%	variable
2 stent decision	Predictors	Predictors	Result
SB stenting failure	None	None	Very low
MB stenting failure	Very low	Very low	None
SB stenting rate	100% of 30% Pts with predictors = 30%*		< 30% of double stenting

Mini DK Crush technique



Inverted Culotte



Bifurcation lesion treatment principles

- 1. Protection only for non clinically relevant SB (non left main, length, diameter ...)**
- 2. Limit the number of stents (provisional, FFR)**
- 3. Single stent layer, well apposed**
- 4. Respect the original anatomy**