Is Distal LM Stenosis Really Different from Other Bifurcation Lesions ?

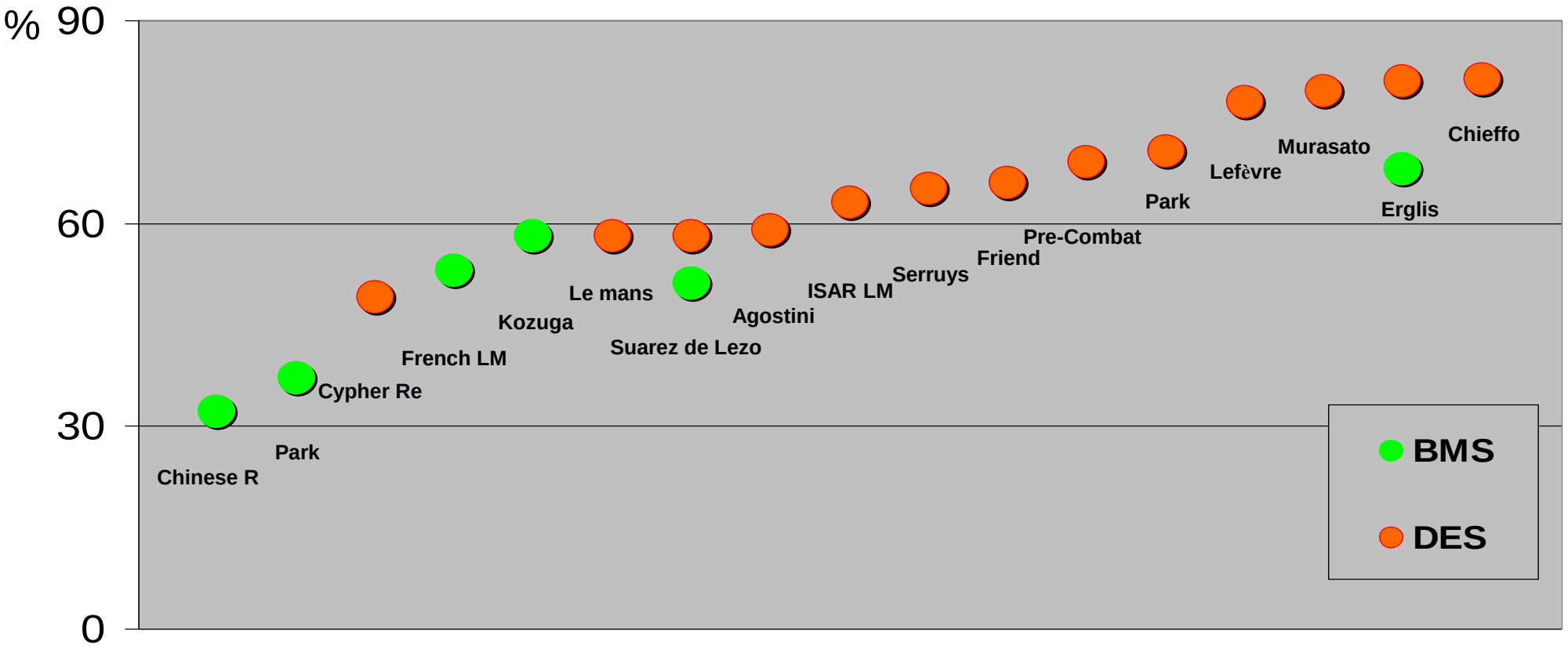
Y. Louvard, ICPS, Massy, Quincy, France

Joint meeting of Coronary Revascularization

Busan, Korea, december 8-9, 2011

1. LM stenosis is near always a bifurcation stenosis

High Frequency of Distal LM Location



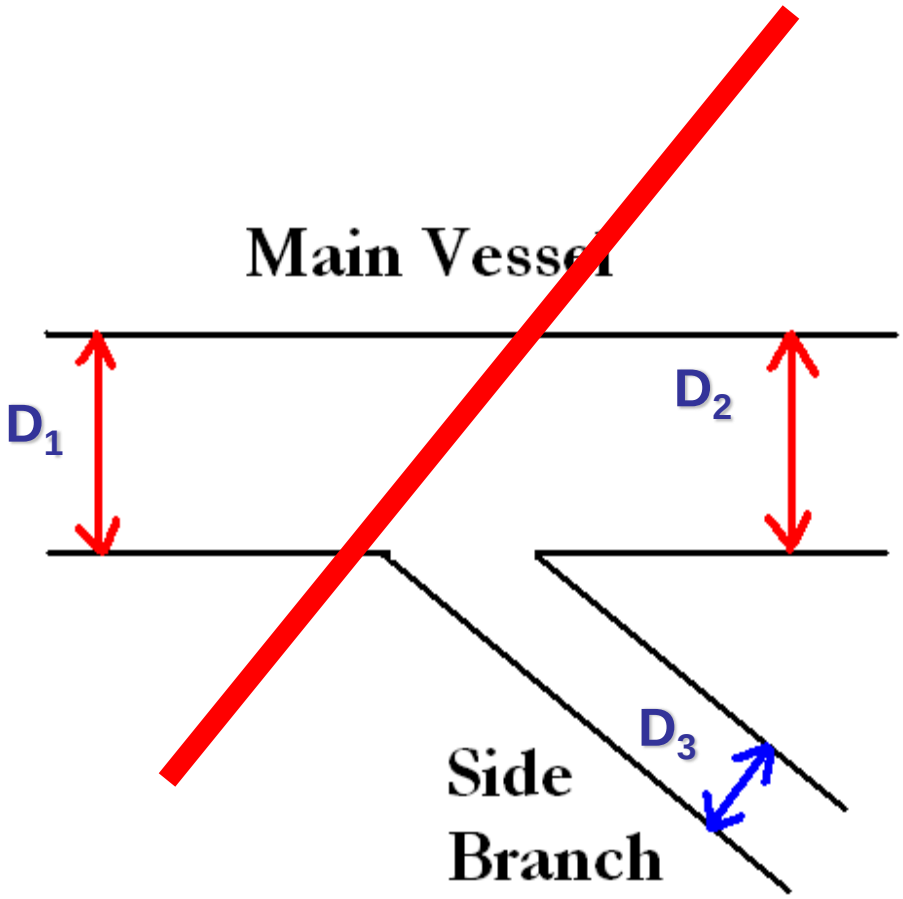
Bifurcation branching laws

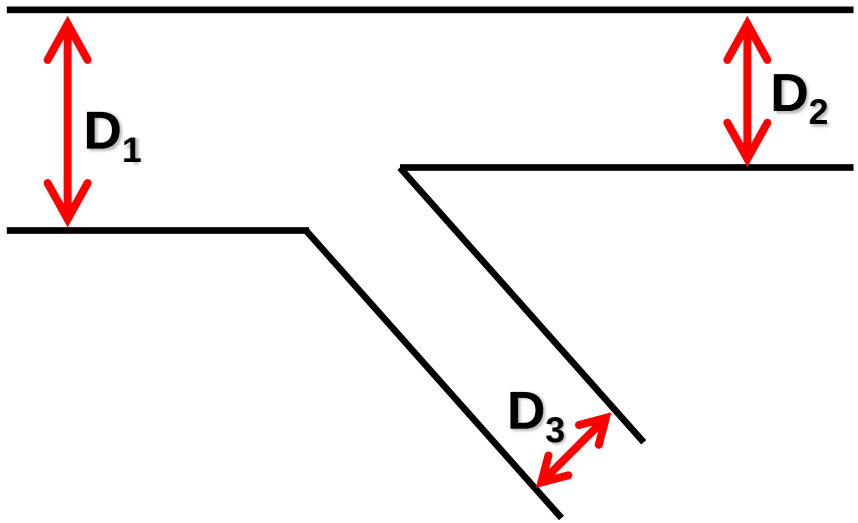
Murray's law

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

Finet's law

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

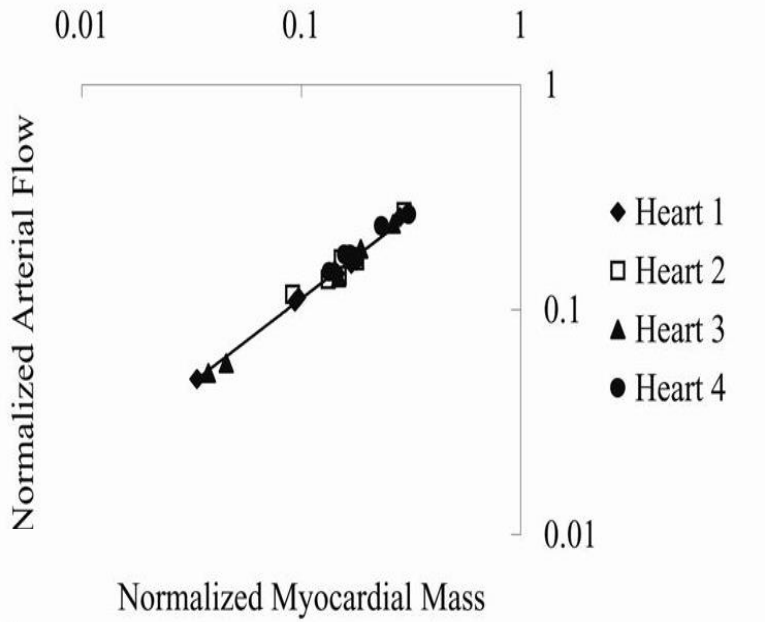




* 2.3

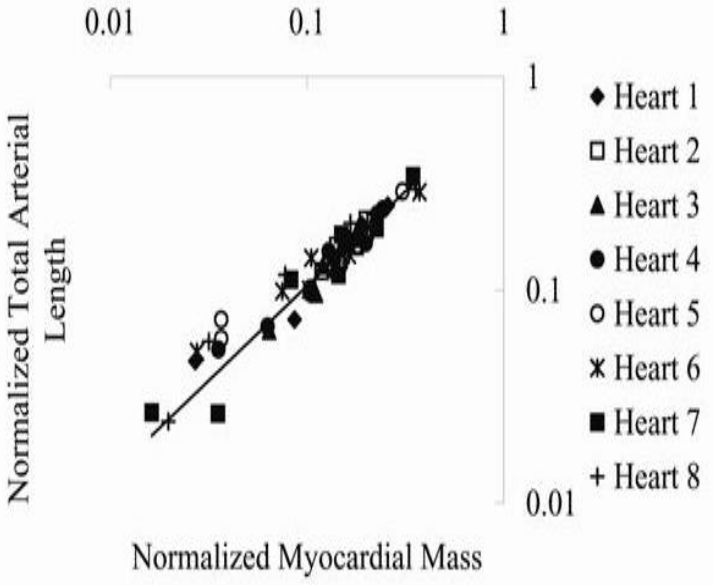
From Koo, EBC, 2008

Structure-function scaling laws of vascular trees

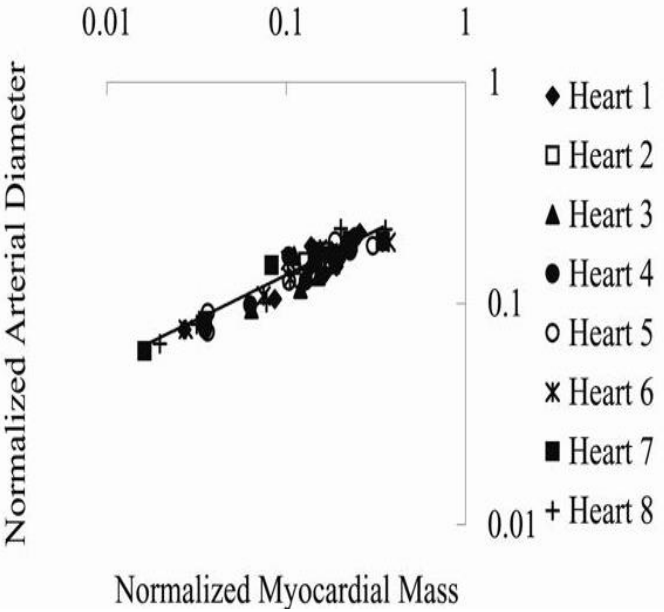


/ Flow

Myocardial mass



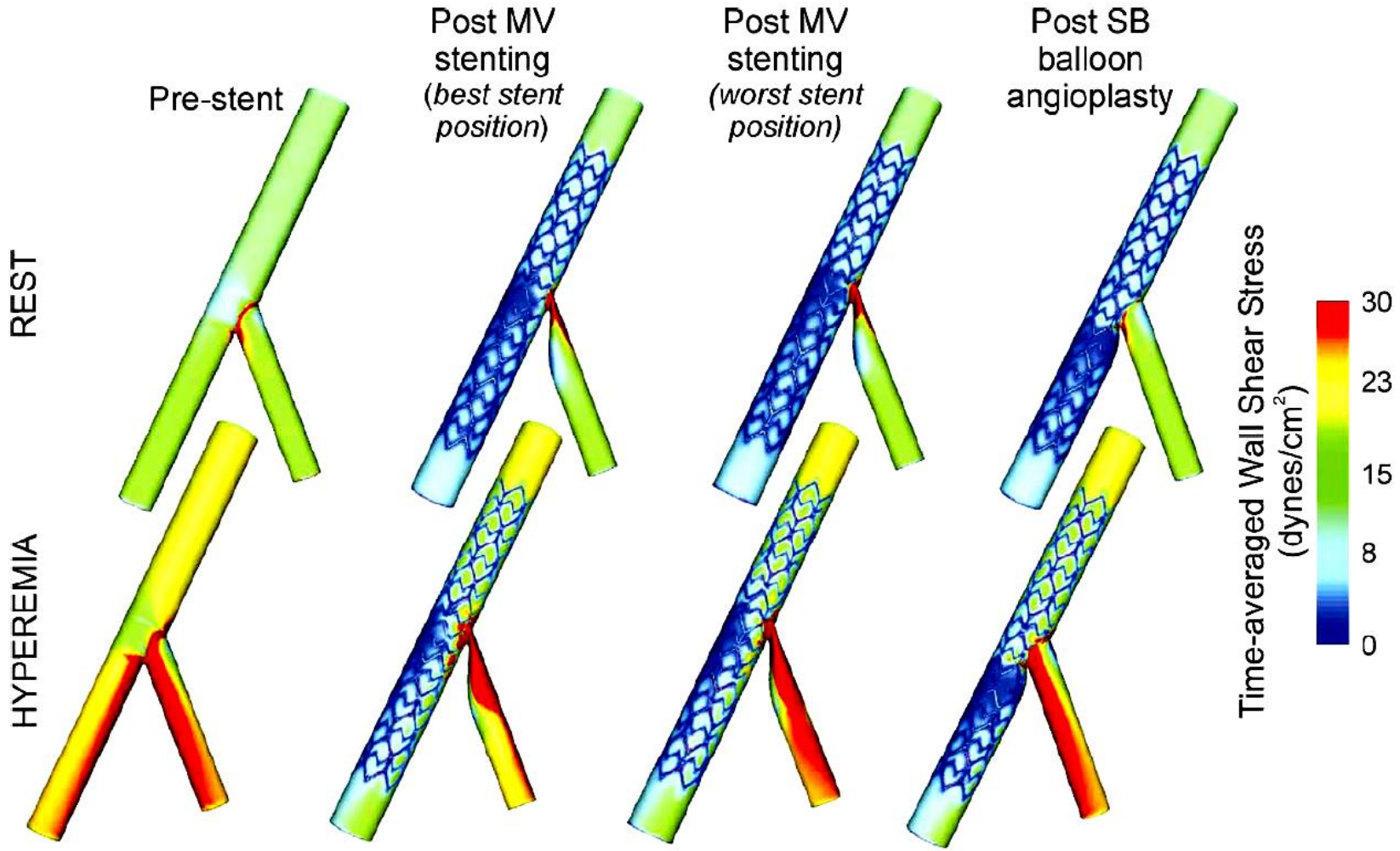
/ Length



/ Diameter

Kassab, EBC 2009

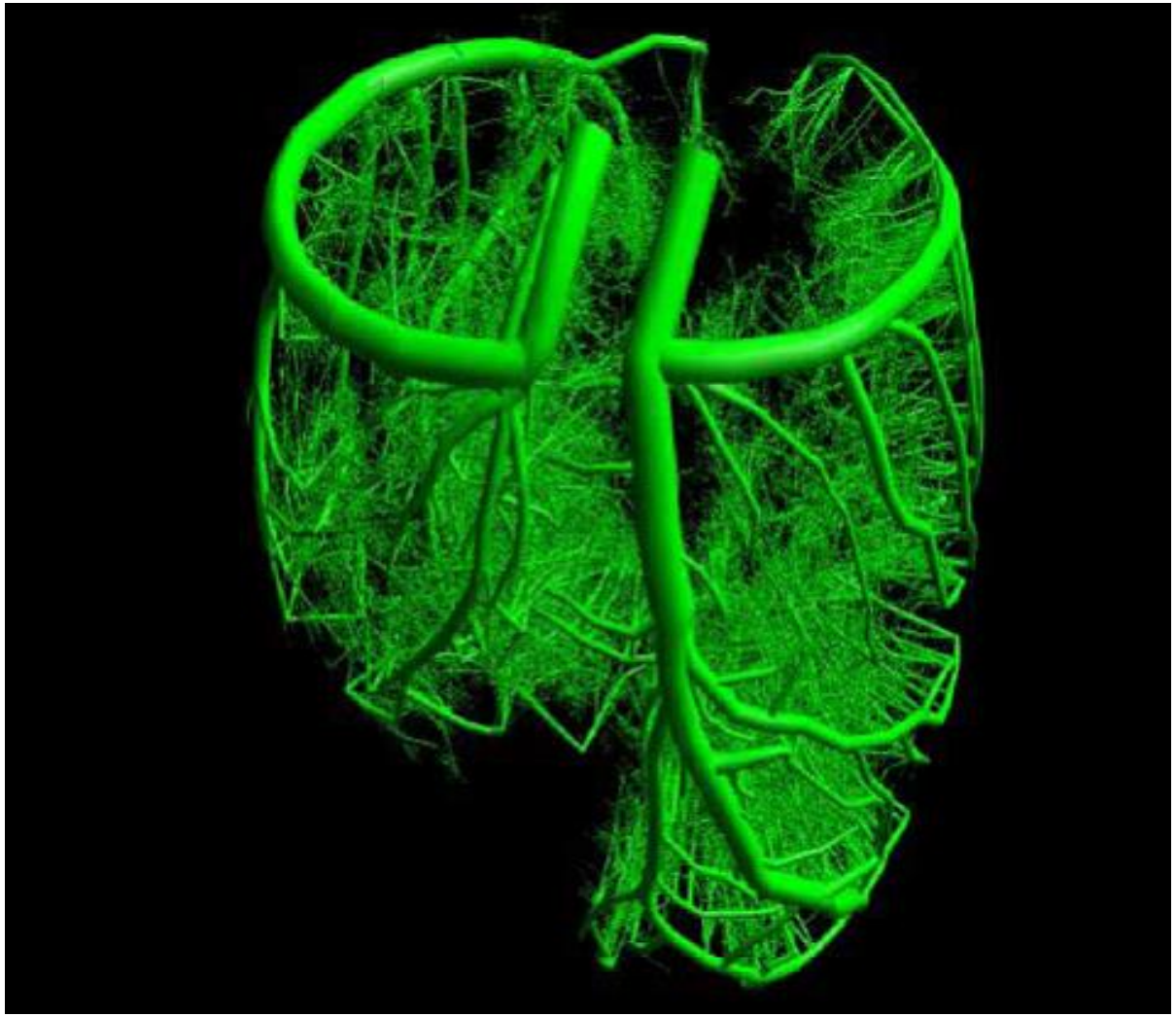
Hemodynamic changes after MB stenting and subsequent SB balloon angioplasty in a representative coronary bifurcation



Changes in time-averaged wall shear stress introduced by bifurcation stenting

Williams J Appl Physiol (May 27, 2010)

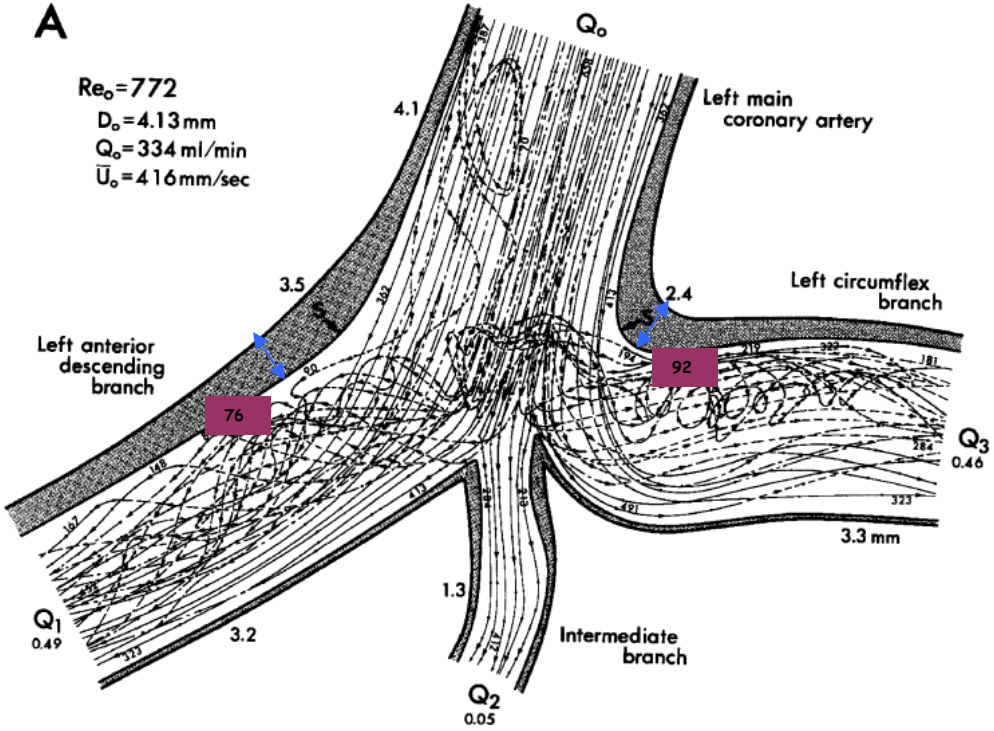
Mathematical model of coronary arterial tree

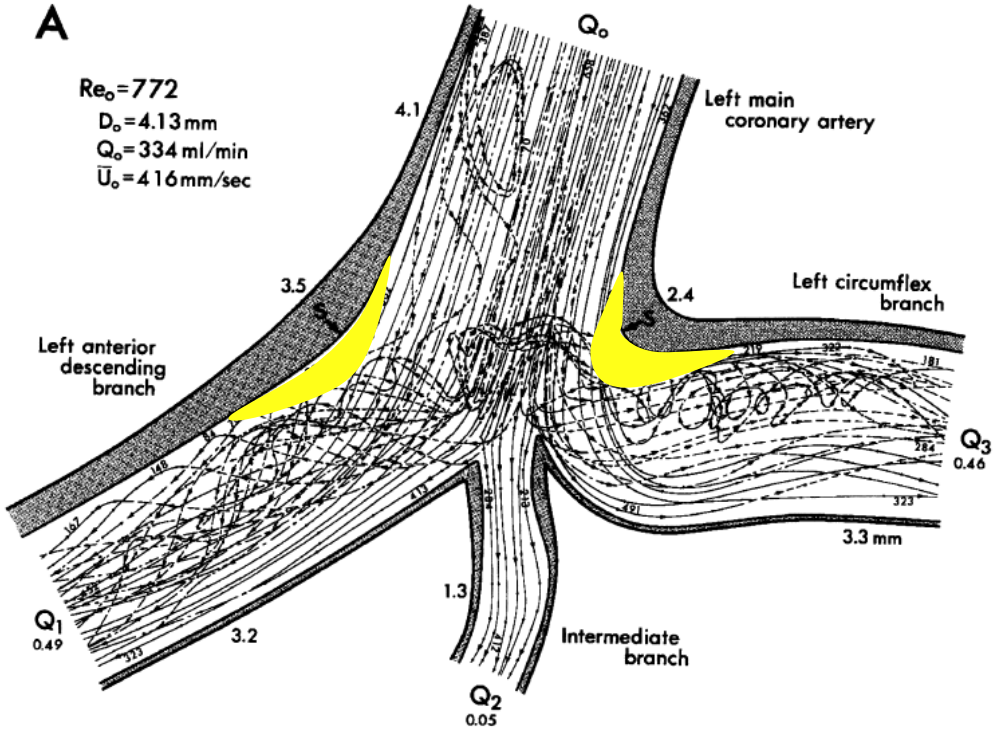


From G. Kassab

2. A bifurcation is a pro-atherogenic anatomy

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





Asakura, Circulation Research 1990; 66:1045-1066

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

Nakazawa, J Am Coll Cardiol 2010;55:1679–87

Compositional characteristics of LM-LAD and non-LM bifurcation sites

Segment	LM-LAD bifurcation (n=41)	Non-LM bifurcation (n=215)	p Value
Proximal			
DC, %	1.89±2.10	4.57±4.67	<0.001
FT, %	29.88±10.66	31.07±10.20	0.50
FF, %	13.81±8.67	9.83±6.93	0.008
NC, %	4.89±4.78	8.08±6.20	<0.001
Media, %	49.54±17.02	46.45±14.60	0.23
At the bifurcation			
DC, %	3.31±2.87	3.38±3.44	0.90
FT, %	31.81±8.87	30.46±9.74	0.41
FF, %	14.60±7.87	12.02±7.44	0.045
NC, %	6.75±5.09	6.47±5.11	0.75
Media, %	43.53±13.85	47.68±14.38	0.90
Distal			
DC, %	3.73±3.28	3.55±3.74	0.78
FT, %	28.58±10.91	26.25±10.94	0.21
FF, %	9.94±6.83	8.22±6.47	0.12
NC, %	7.36±6.01	6.28±5.05	0.22
Media, %	50.38±17.96	55.70±17.00	0.70

Data are expressed as mean±SD. LM: left main artery; LAD: left anterior descending artery; DC: dense calcium; FT: fibrous tissue; FF: fibro-fatty; NC: necrotic core

Han SH, EuroIntervention 2010; 6:313-20

3. At least 2/3 segments are big

LM IVUS: A Large Vessel Underestimated by Angio and Poorly Predicted by Patient Physical Parameters

IVUS and Angiographic blinded evaluation of the LMCA in 82 consecutive pts (age, 62 ± 7; 59 men)

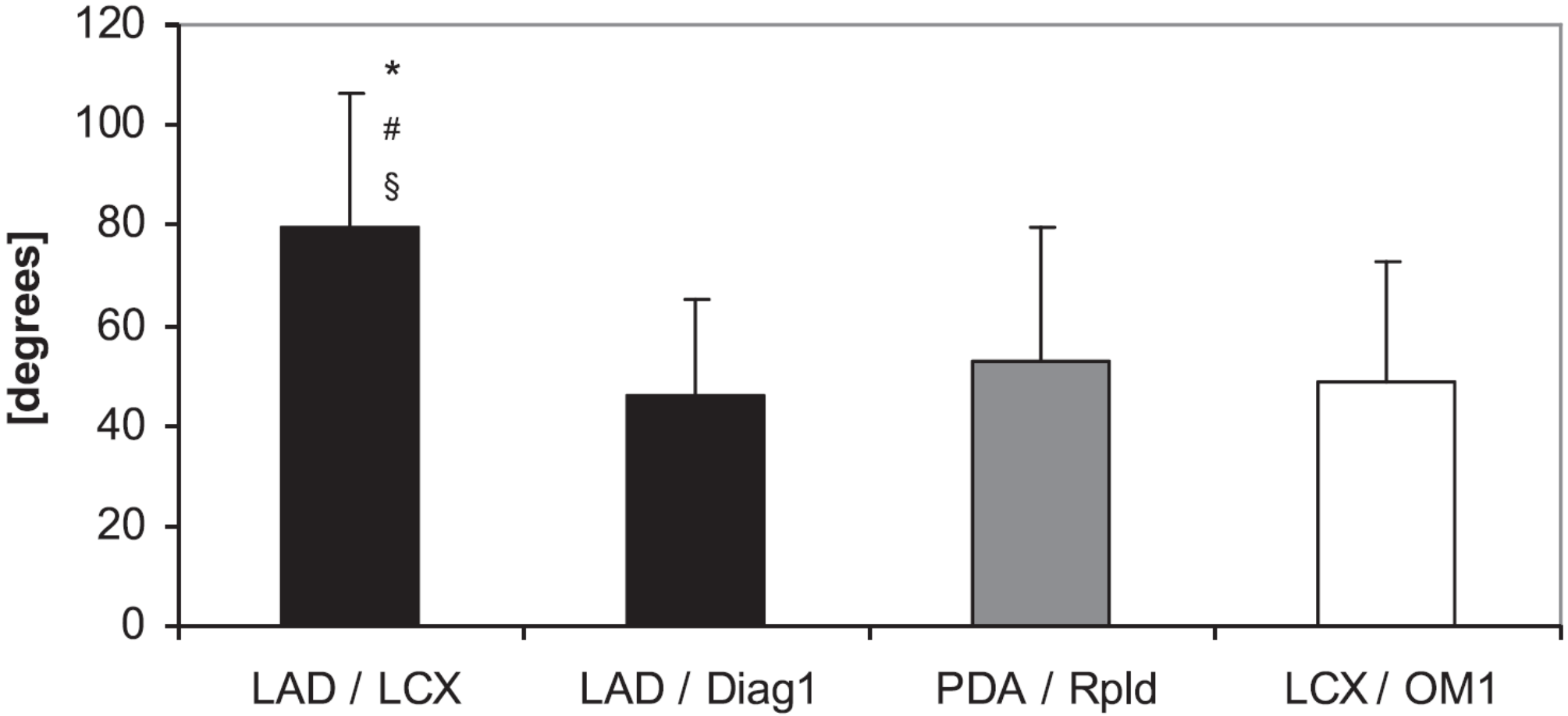
	Angiography	IVUS	p
LM size (mm)	4.01 ± 0.52	4.90 ± 0.51	<0.01

BSA, Age, gender (4.93 ± 0.6 vs 4.88 ± 0.49), height, weight, or ideal body weight did not predict LM size

D.C. Metzger, TCT 2003

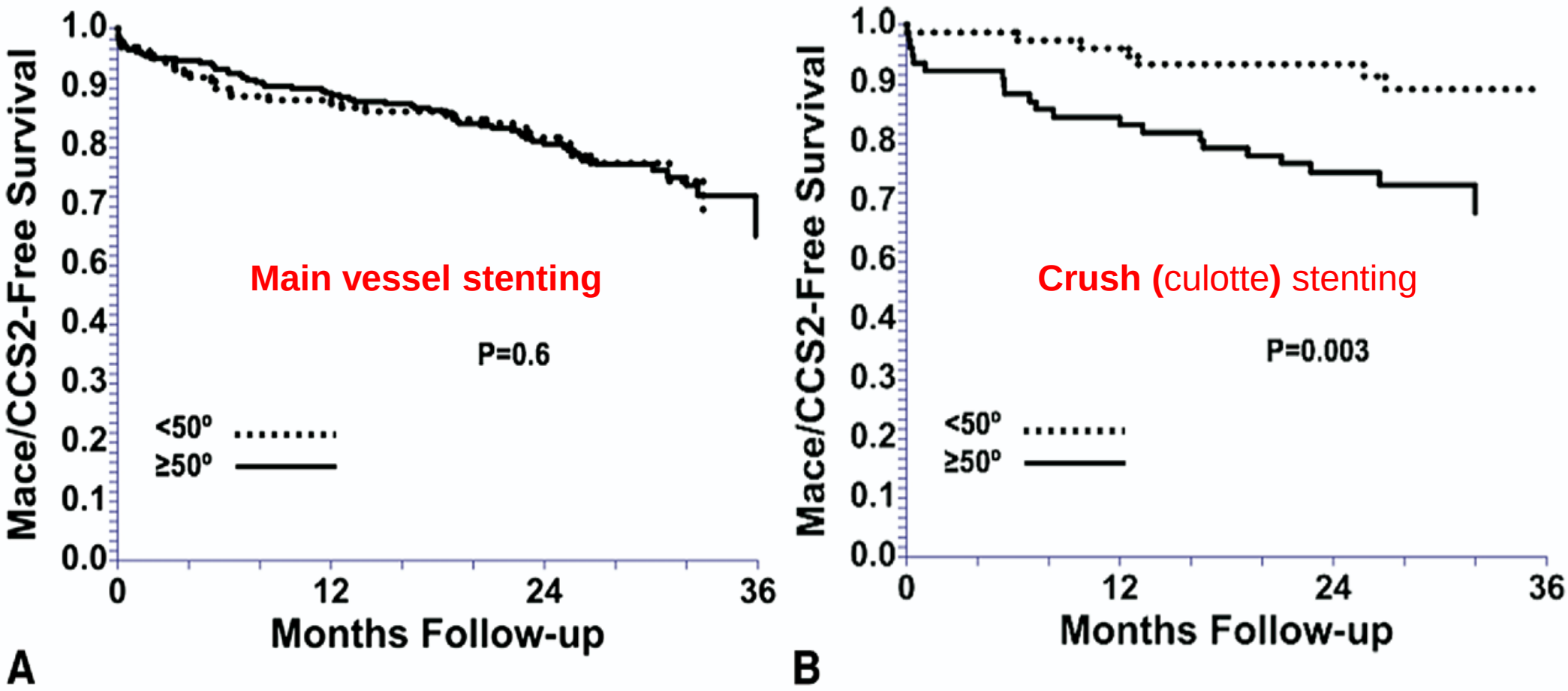
4. B (between) angle is more open

Measurement of Coronary Artery Bifurcation Angles by Multidetector Computed Tomography



Pflederer Invest Radiol. 2006;41(11):793-8

Outcome After Bifurcation PCI: role of angle



Kaplan-Meier curves for MACE or CCS class 2 angina-free survival / bifurcation angle

Collins Am J Cardiol 2008;102:404–410

Culotte stenting : 12m dedicated QCA and clinical outcomes

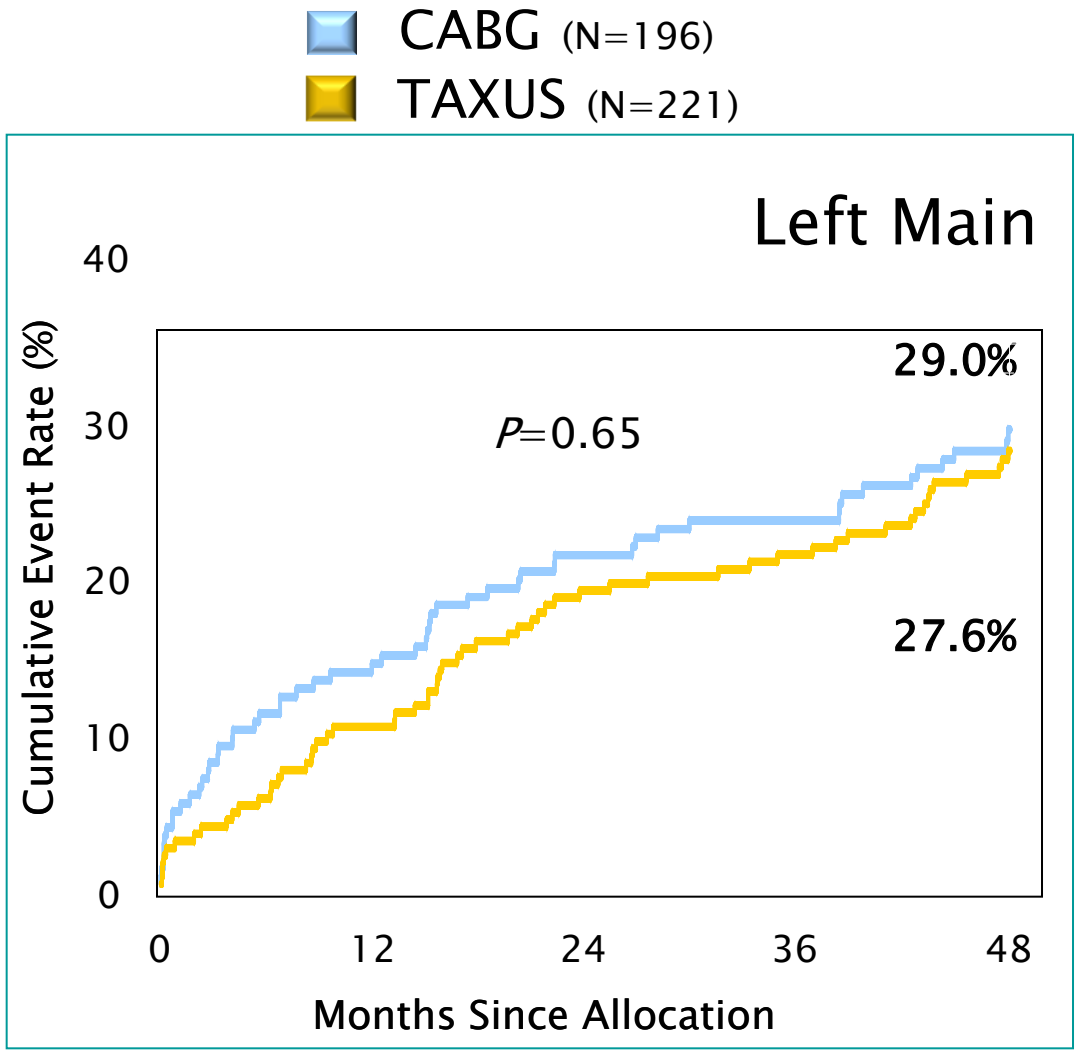
Predictors of binary restenosis

Variable	Odds ratio (95% CI)	*P*-value
Age increase by 10 years	2.38 (1.21–4.96)	0.01
Diabetes	3.43 (0.71–16.60)	0.13
Male sex	0.62 (0.15–2.53)	0.51
Medina classification	0.42 (0.13–1.32)	0.14
Restenotic lesion	0.52 (0.12–2.24)	0.38
Bifurcation angle increase by 10°	1.53 (1.04–2.23)	0.03
Calcified lesion	0.53 (0.12–2.24)	0.39
Proximal main vessel		
Reference vessel diameter decrease by 1 mm	4.55 (0.17–123.36)	0.37
Baseline stenosis increase by 10%	0.91 (0.67–1.23)	0.54
Distal main vessel		
Reference vessel diameter decrease by 1 mm	0.10 (0.00–3.17)	0.19
Baseline stenosis increase by 10%	1.47 (1.03–2.09)	0.03
Side branch vessel		
Reference vessel diameter decrease by 1 mm	31.83 (1.71–592.77)	0.02
Baseline stenosis increase by 10%	0.97 (0.82–1.15)	0.75
Kissing balloon post-dilatation	0.37 (0.13–1.10)	0.07

Adriaenssens EHJ 2008; 29: 2868–2876

5. Is a LM bifurcation stenosis a surgical indication ?

MACCE to 4 Years by SYNTAX Score Tercile Low to Intermediate Scores (0-32)

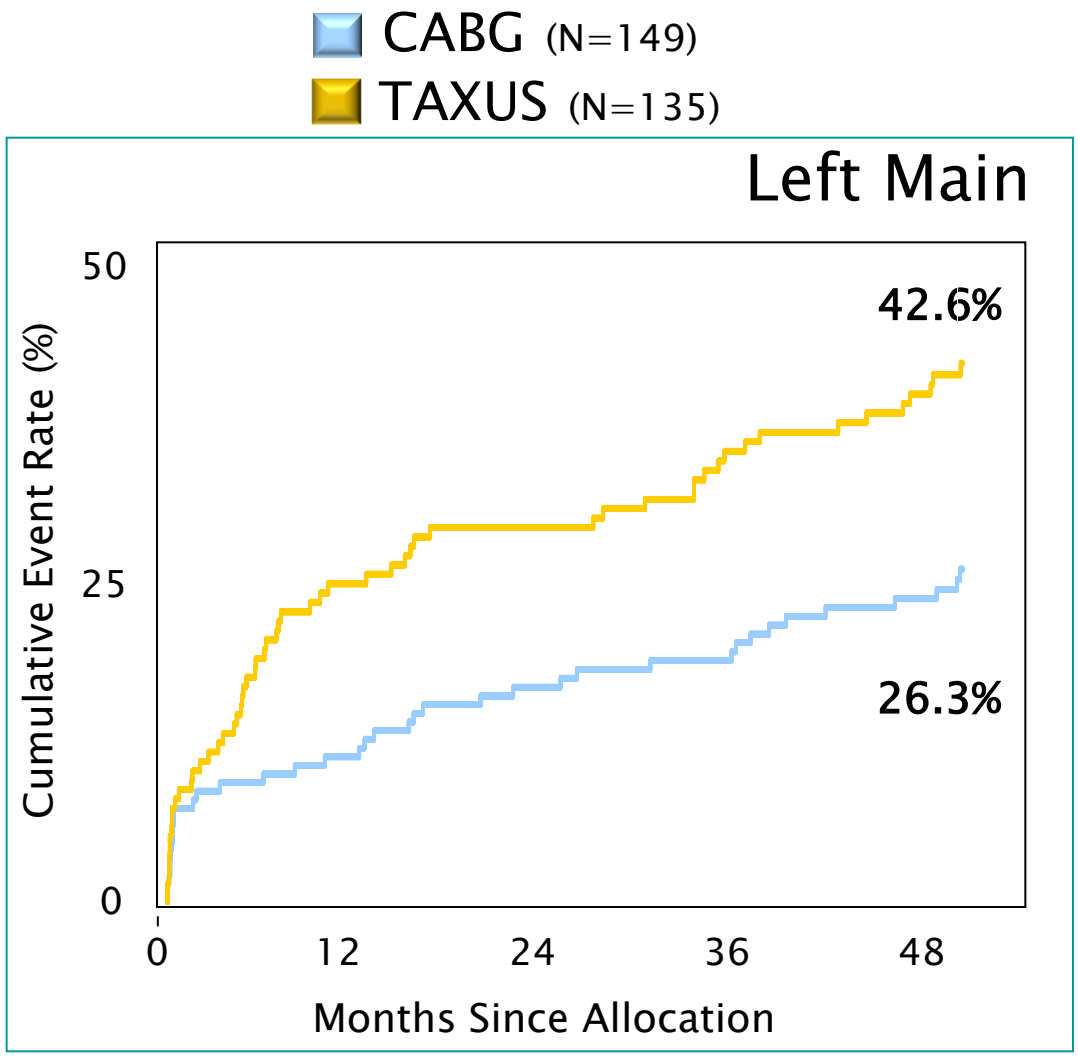


Cumulative KM Event Rate ± 1.5 SE; log-rank *P* value

	CABG		PCI	*P* value
Death	11.8%	>	7.5%	0.12
CVA	3.9%	>	1.4%	0.11
MI	3.8%	<	5.1%	0.55
Death, CVA or MI	17.1%	>	13.5%	0.25
Revasc.	16.9%	<	19.1%	0.57

Site-reported Data; ITT population

MACCE to 4 Years by SYNTAX Score Tercile High Scores (≥33)

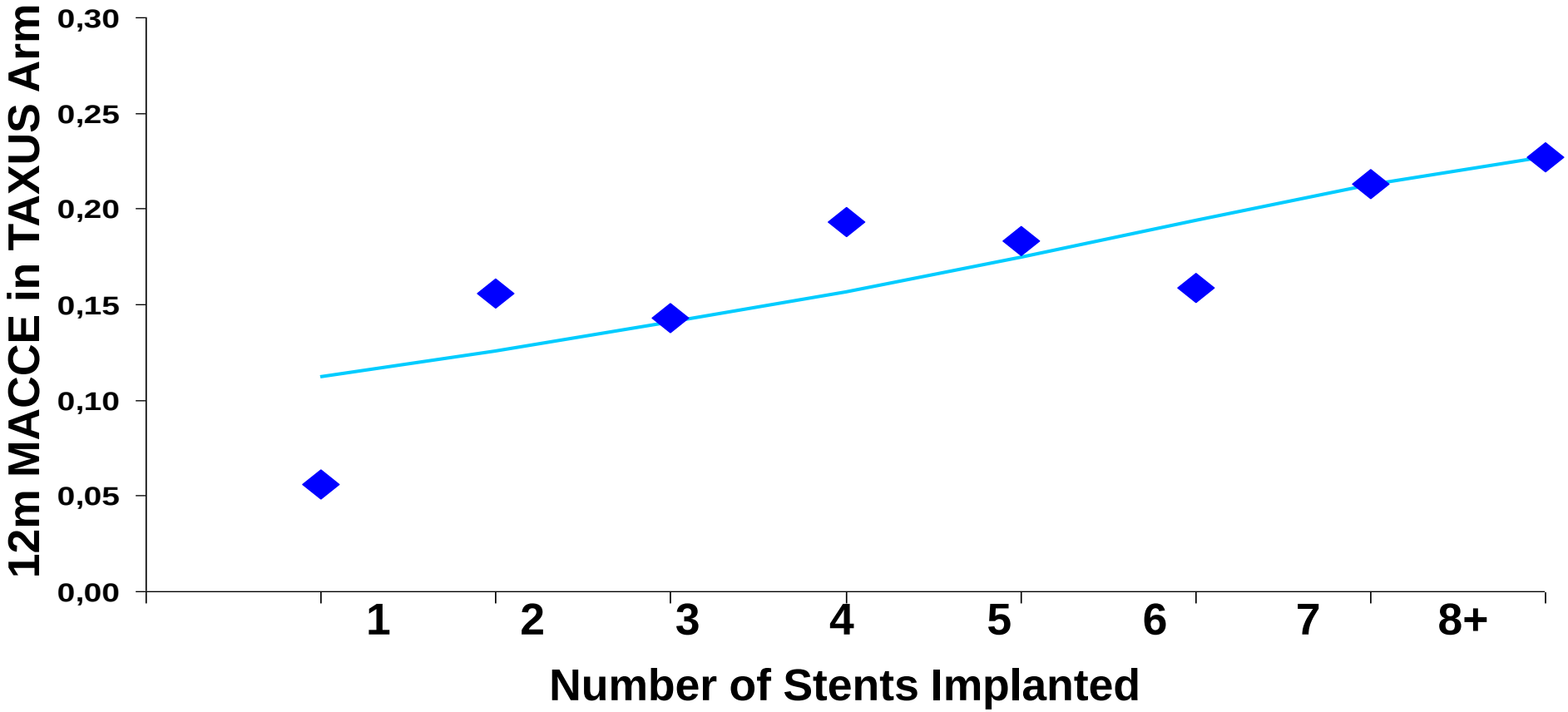


Cumulative KM Event Rate ± 1.5 SE; log-rank *P* value

	CABG	PCI	*P* value
Death	10.5%	17.9%	0.06
CVA	4.9%	1.6%	0.14
MI	6.1%	10.9%	0.18
Death, CVA or MI	18.5%	23.1%	0.33
Revasc.	11.8%	31.3%	<0.001

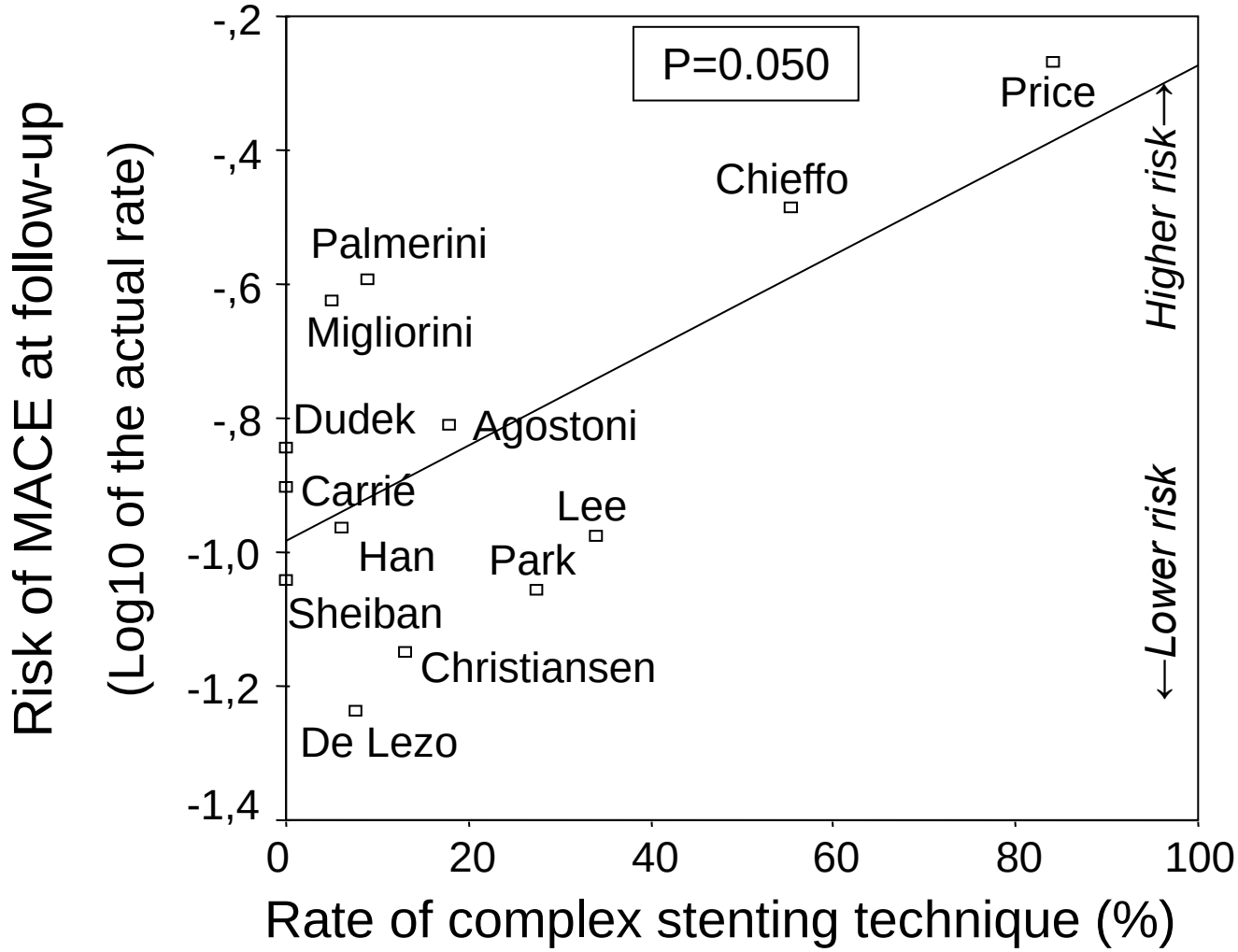
Site-reported Data; ITT population

Linear Increase in 12-month MACCE by Number of Stents in the SYNTAX Trial



6. LM / non LM bifurcation: different techniques ?

A metaanalysis on 1274 patients with DES for ULM disease: Stenting technique and MACE rate

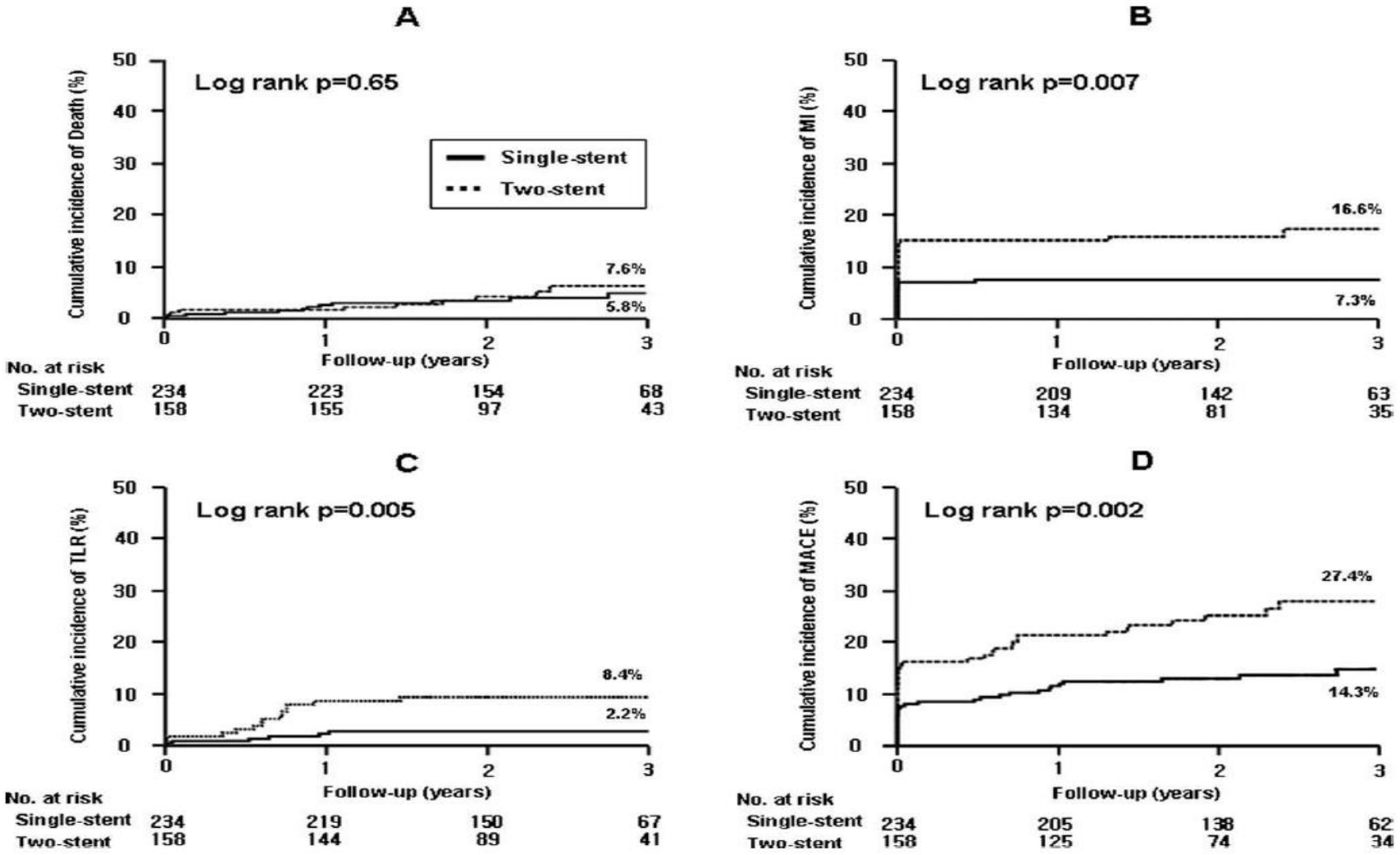


Patients treated with 2 stents are significantly more likely to have MACE

I. Sheiban, EBC 2008

Single- Versus Two-Stent inTreatment of ULMCA

(A) death, (B) MI), (C) TLR, (D) MACE (death/MI/TLR)



Kim WJ, CCI 2011;77:775–782

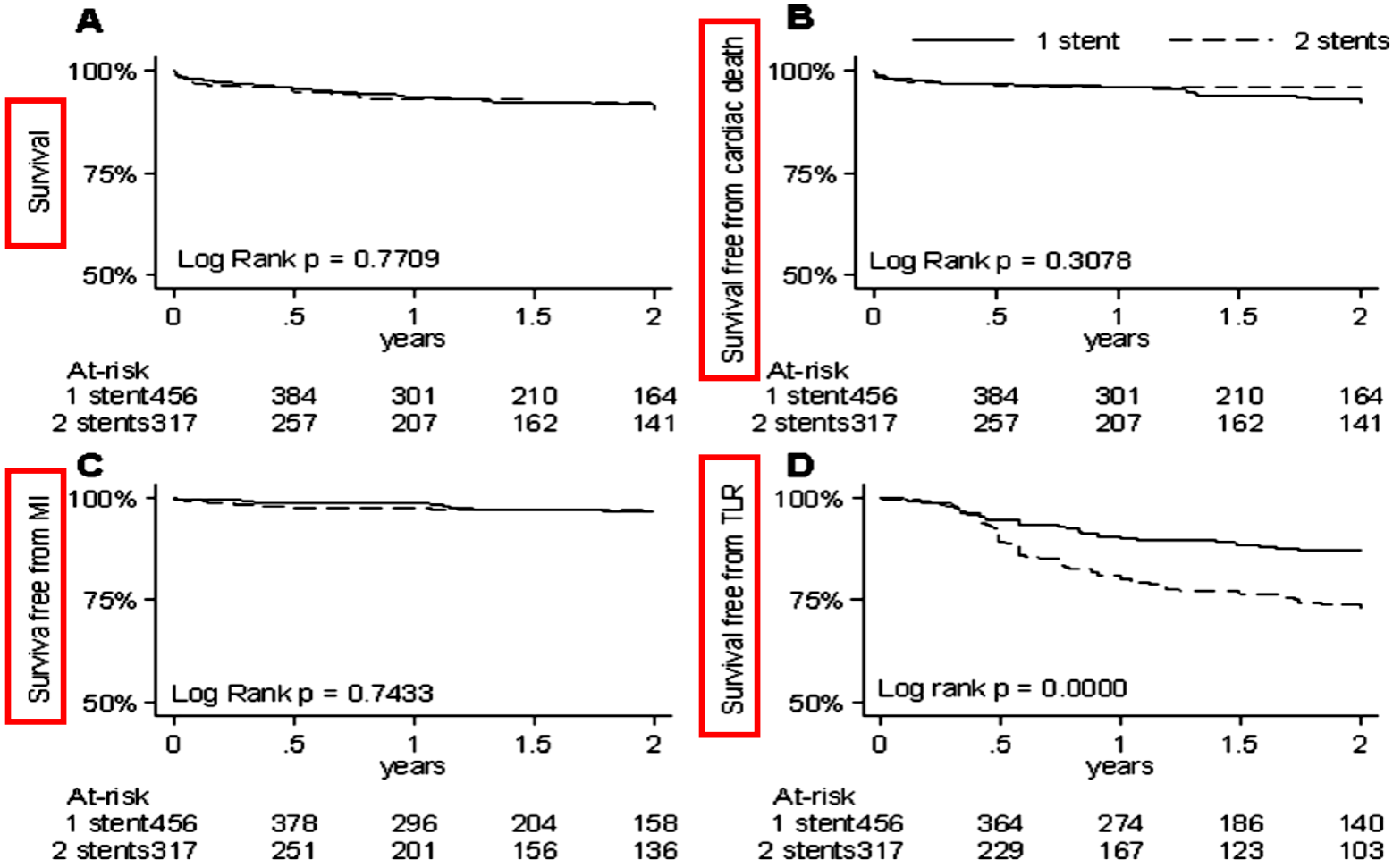
Single- Versus Two-Stent inTreatment of ULMCA

3Y Outcomes in the Unadjusted, Covariate-Adjusted Cox Proportional Analysis, and Adjusted With Inverse Probability Treatment Weight Methods: 1 Vs 2 Stent Technique

	Crude		Multivariate		Adjusted with IPTW	
Outcome	Hazard ratio (95% CI)	*P*	Hazard ratio (95% CI)	*P*	Hazard ratio (95% CI)	*P*
Death	0.818 (0.339–1.972)	0.654	0.874 (0.323–2.364)	0.79†	0.772 (0.280–2.132)	0.62
MI	0.440 (0.237–0.814)	0.009	0.482 (0.260–0.894)	0.021‡	0.379 (0.185–0.777)	0.008
TLR	0.254 (0.091–0.713)	0.009	0.254 (0.091–0.713)	0.009	0.163 (0.046–0.573)	0.005
TVR	0.316 (0.158–0.633)	0.001	0.267 (0.129–0.550)	0.0003§	0.248 (0.111–0.556)	0.0007
MACE	0.485 (0.303–0.776)	0.003	0.518 (0.323–0.831)	0.006‖	0.387 (0.224–0.671)	0.0007

Kim WJ, CCI 2011;77:775–782

Impact of Bifurcation Technique on 2-Year Clinical Outcomes in 773 Pts With Distal ULM Stenosis Treated With DES



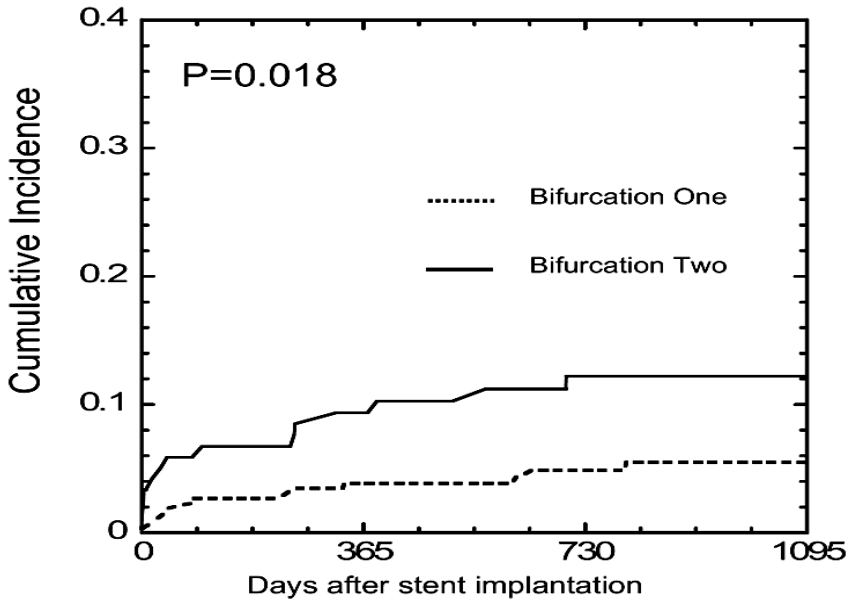
Palmerini Circ Cardiovasc Interv 2008;1;185-192

3Y Outcomes After SES Implantation for ULM Coronary Artery Disease: Insights From the j-Cypher Registry

Cardiac death and TLR in pts treated for ULMCA / distal bifurcation stenting strategy

A

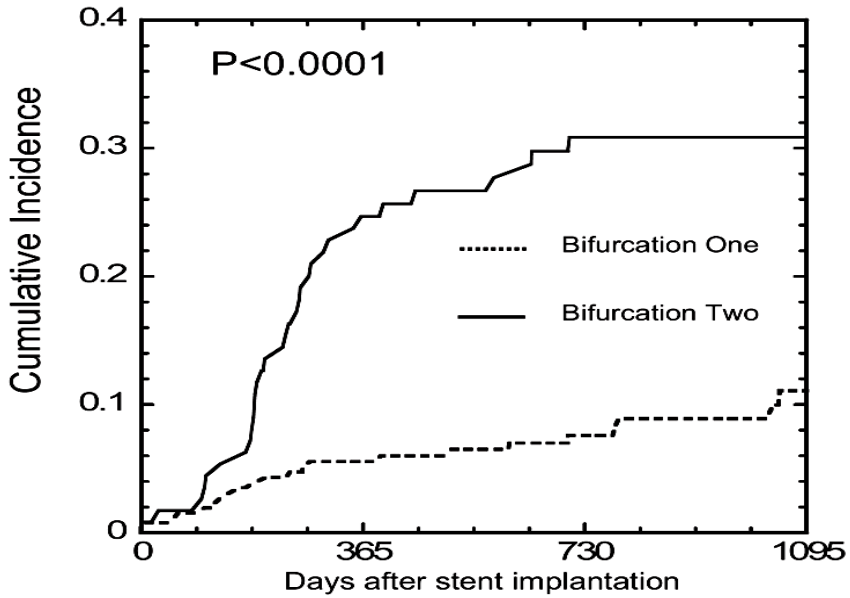
Cardiac Mortality



Day	0	365	730	1095
Bifurcation One				
Incidence (%)		3.9	4.9	5.5
No. at risk	261	242	180	86
Bifurcation Two				
Incidence (%)		9.4	12.2	12.2
No. at risk	119	105	86	52

B

Target Lesion Revascularization



Day	0	365	730	1095
Bifurcation One				
Incidence (%)		5.6	7.6	11.1
No. at risk	261	229	161	76
Bifurcation Two				
Incidence (%)		24.6	30.9	30.9
No. at risk	119	81	62	37

Toyofuku Circulation 2009;120;1866-1874;

French Multi-center Left Main studies with DES

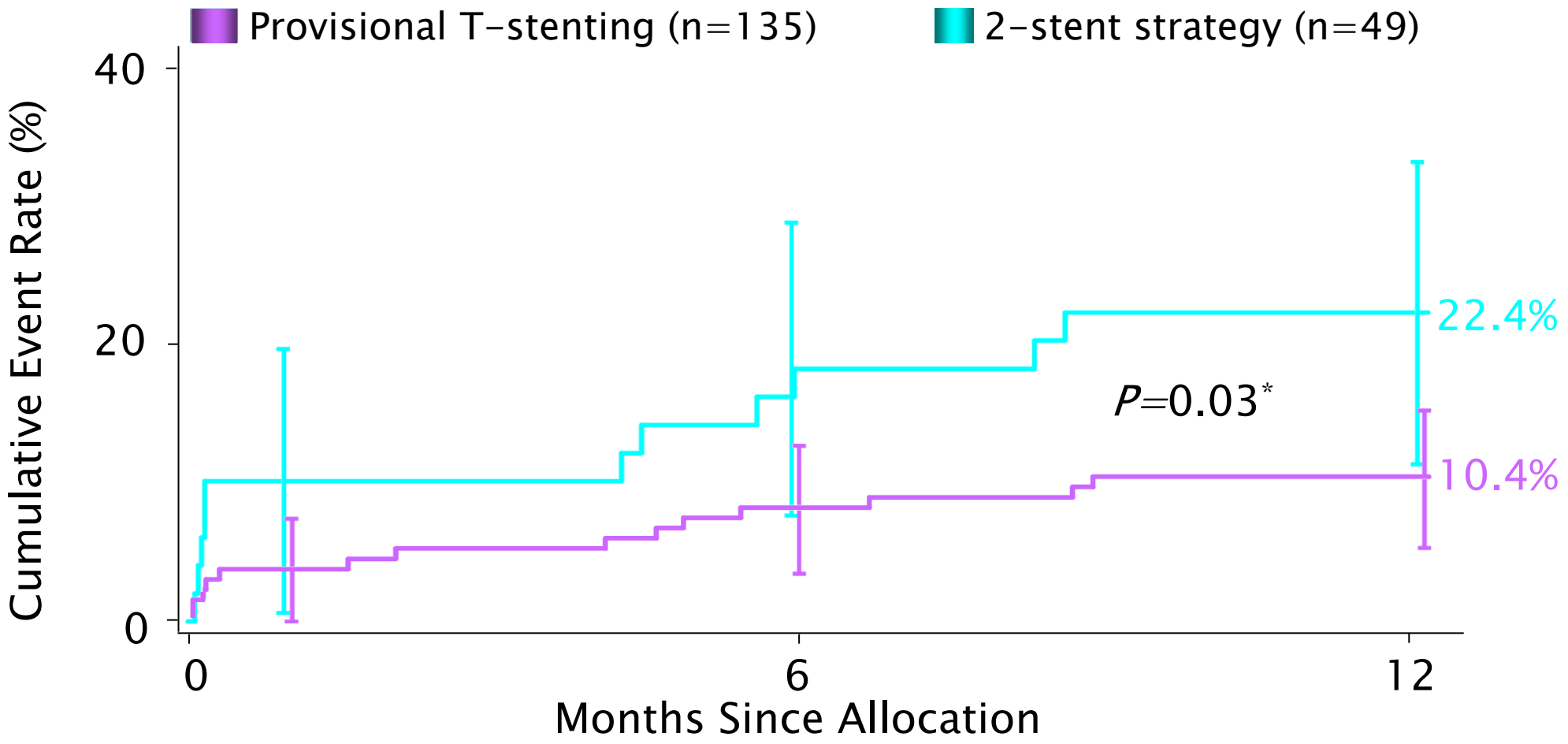
	Pilot Taxus* 2004	FRIEND** 2006	LEMAX 2008	
Nb patients	291	151	174	= 616
% distal lesion	78	69	81	
% 2 stents	42	26	19	
Mean LM stent diameter (mm)	3.44±0.39	3.59±0.49	3.63±0.33	
12 month TLR	5.9%	2.7%	2.3%	

*B. Vaquerizo et al. Circulation 2009;119:2349-56

**D.Carrié et al., Eurointerv 2009;4:449-56

SYNTAX, MACCE to 12 Months

LM PCI Subset

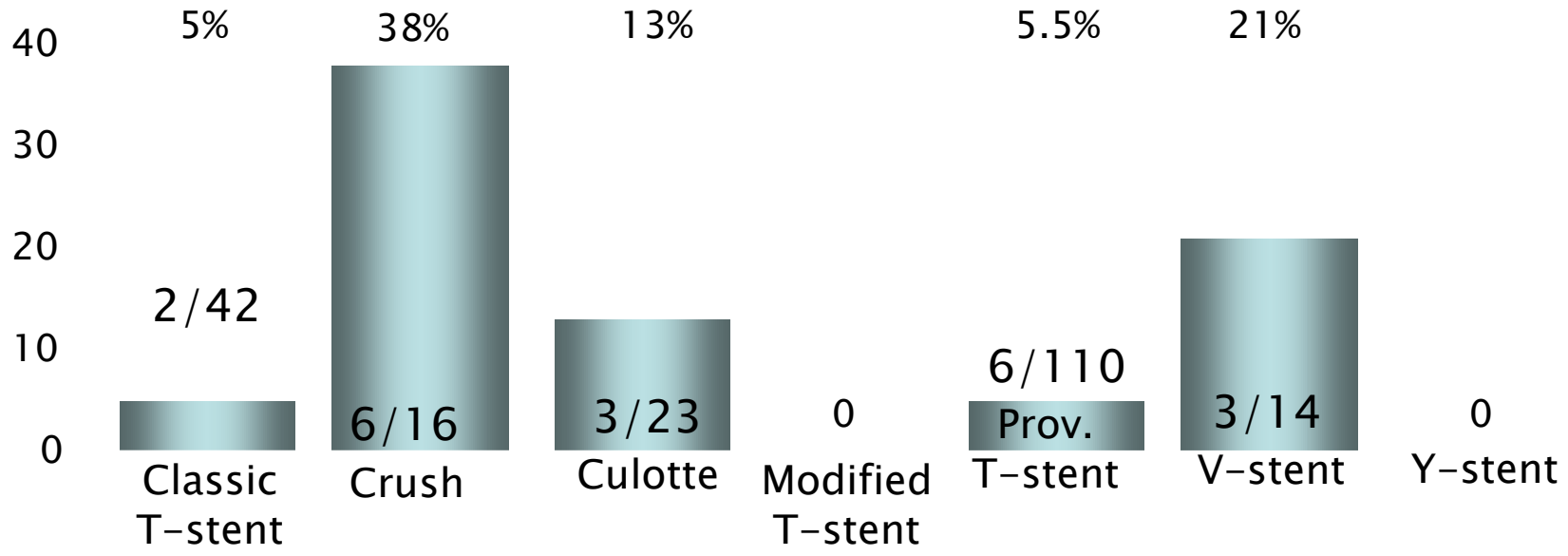


Event Rate ± 1.5 SE, *Fisher exact test

ITT population

SYNTAX: Baseline LM Bifurcation Stenting Techniques Requiring Re-treatment

LM Distal PCI (n=20 lesions)



5/20 (25%) lesions originally treated with 1 stent
15/20 (75%) originally treated with 2 or 3 stents

Bar graphs represent percent of baseline treated lesions

7. More thrombosis ?

3Y Outcomes After SES Implantation for ULM Coronary Artery Disease: Insights From the j-Cypher Registry

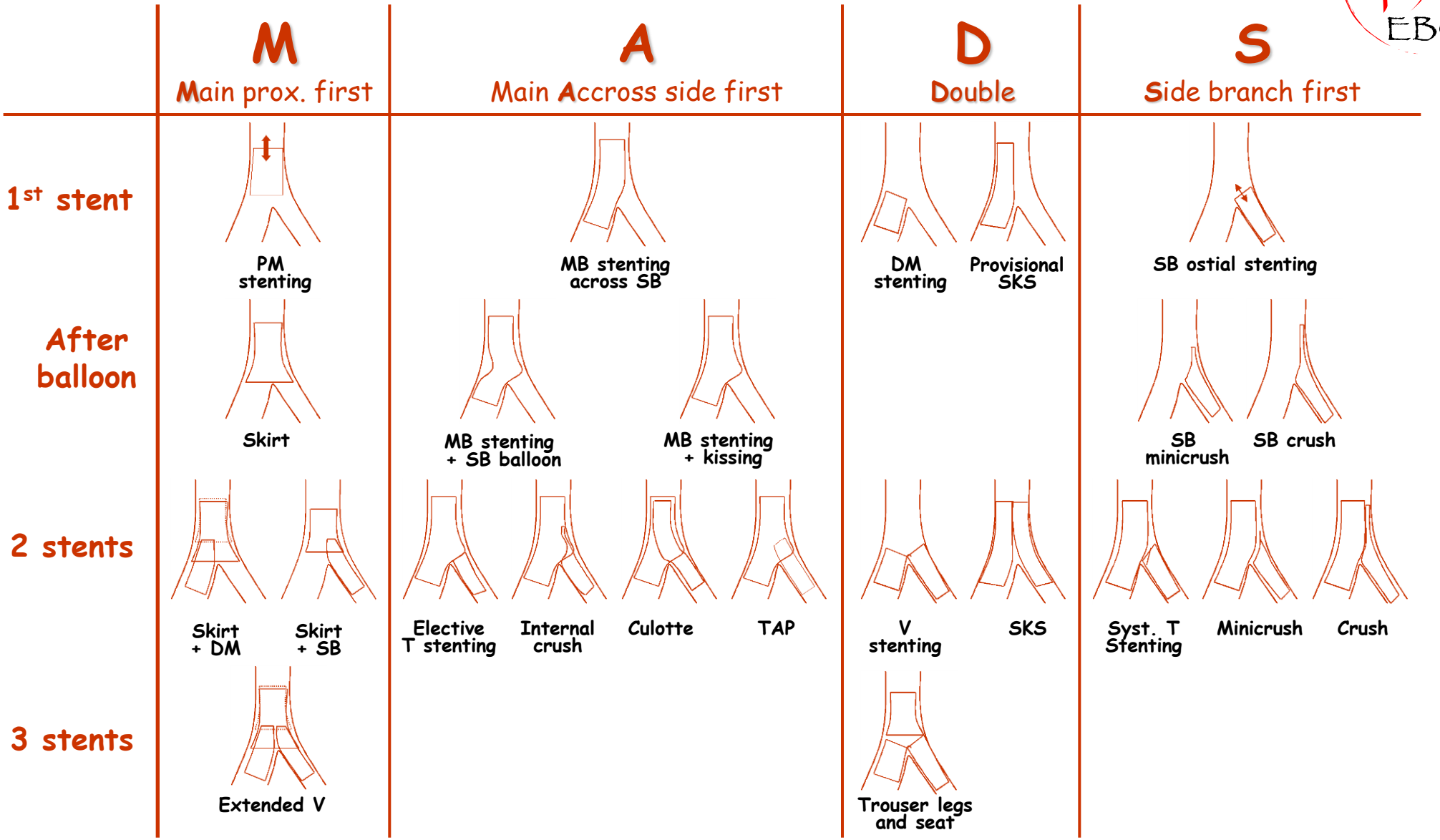
Outcomes After ULMCA Stenting / Bifurcation Stenting Strategies Through 3 Years

	Events, Incidence (%)		
	One-Stent Bifurcation (n=261)	Two-Stent Bifurcation (n=119)	*P*
Total death	30 (13.4)	21 (18.8)	0.12
Cardiac deaths	13 (5.5)	14 (12.2)	0.018
Sudden deaths	2 (0.8)	3 (2.7)	0.15
Myocardial infarction	8 (4.5)	5 (4.7)	0.58
Stroke	10 (4.7)	3 (3.0)	0.53
Definite/probable ST	3 (1.5)	7 (6.3)	0.0076
Definite ST	3 (1.5)	5 (4.7)	0.054
Definite ST (ULMCA)	1 (0.4)	3 (2.8)	0.050
TLR	22 (11.1)	33 (30.9)	<0.0001
CABG	2 (0.9)	3 (0.3)	0.15
Any revascularization	77 (35.5)	47 (44.0)	0.017

Toyofuku Circulation 2009;120;1866-1874;

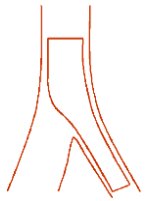
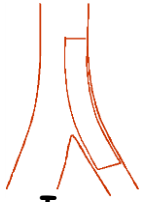
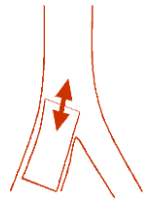
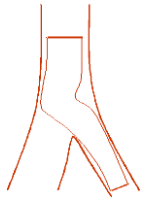
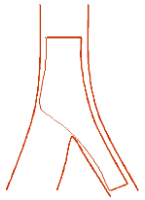
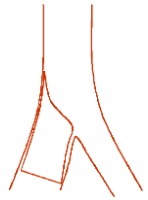
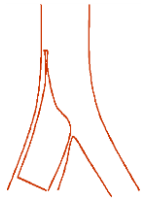
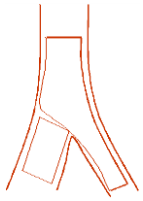
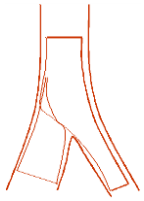
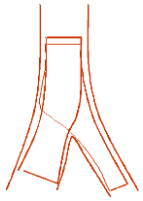
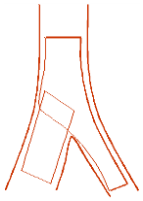
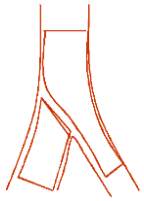
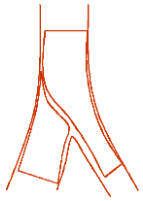
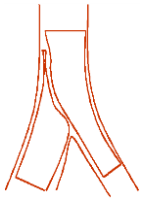
8. Specific tips and tricks ?

EBC



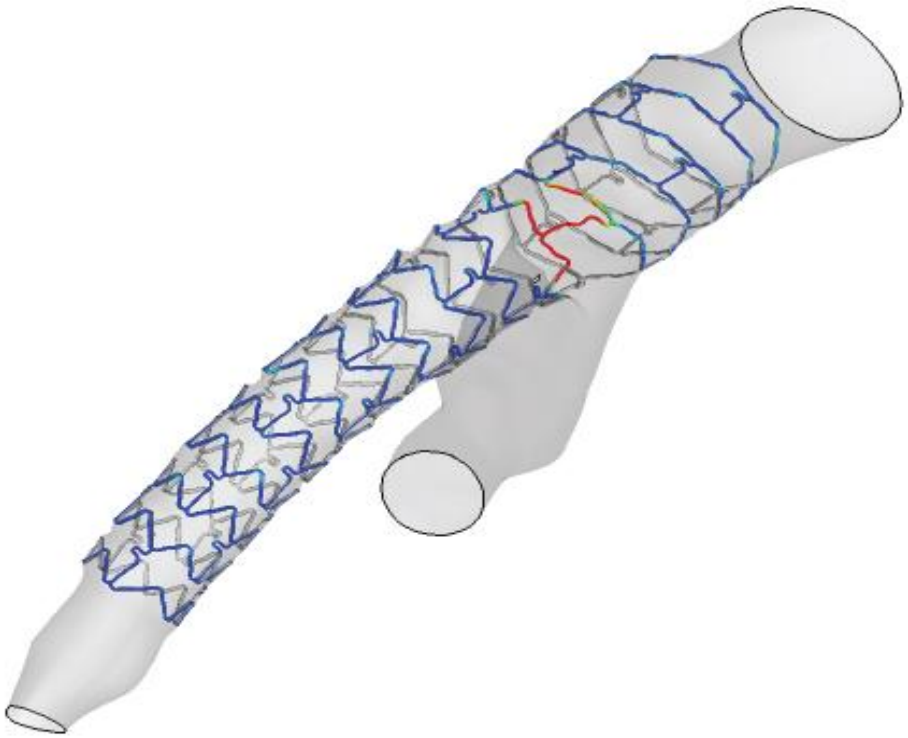
Y. Louvard, CCVI 2008; 71: 175-83

EBC

	M Main prox. first	A Main Accross Main first	D Double	S DM 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				

Y. Louvard, CCI 2008 Feb 1;71(2):175-83.

Strut apposition analysis



Strut-artery distance [mm]

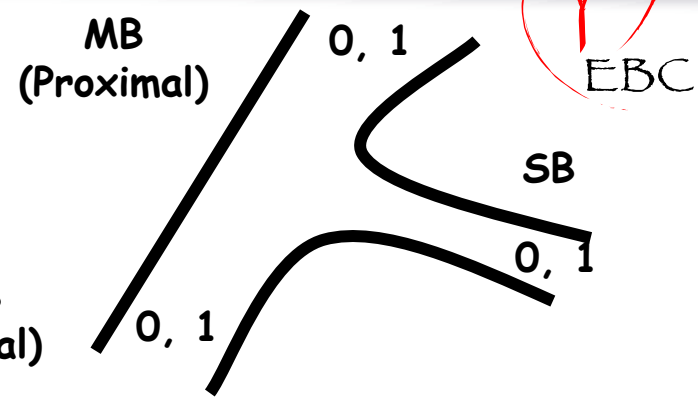
0.2

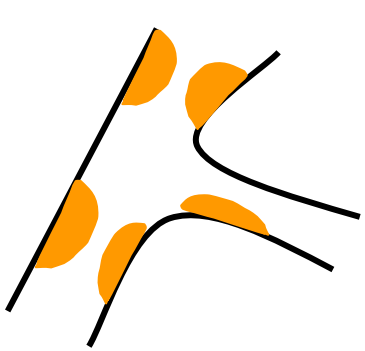
0.1

0.0

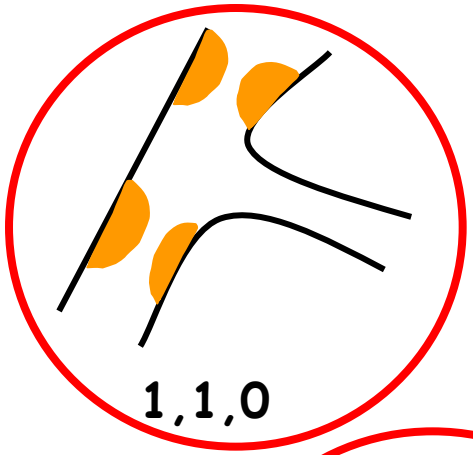
From Peter Mortier

Medina Classification

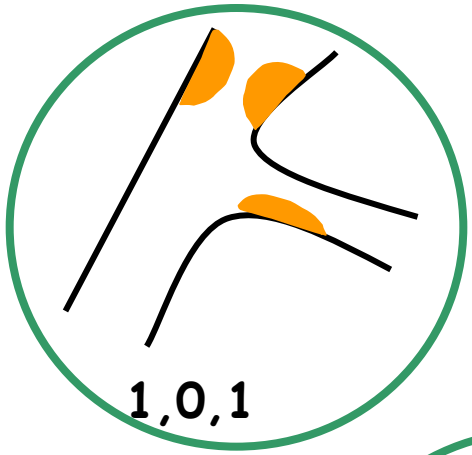




1,1,1

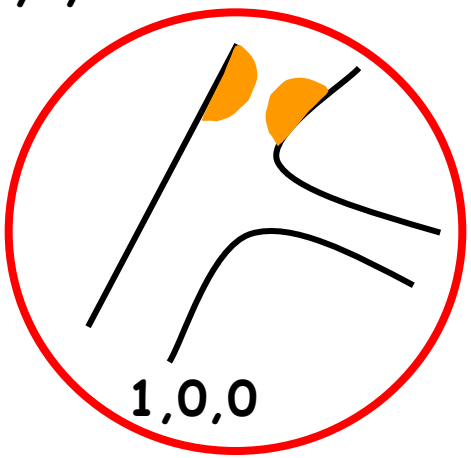


1,1,0



1,0,1

0,1,1



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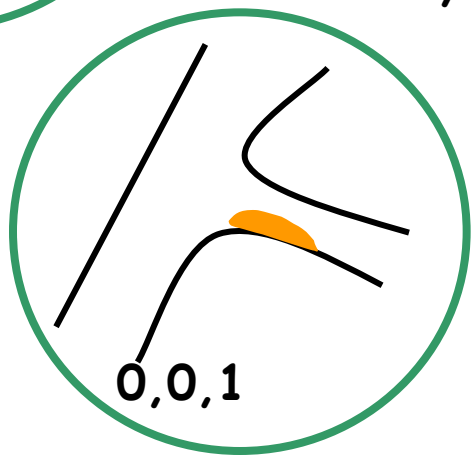
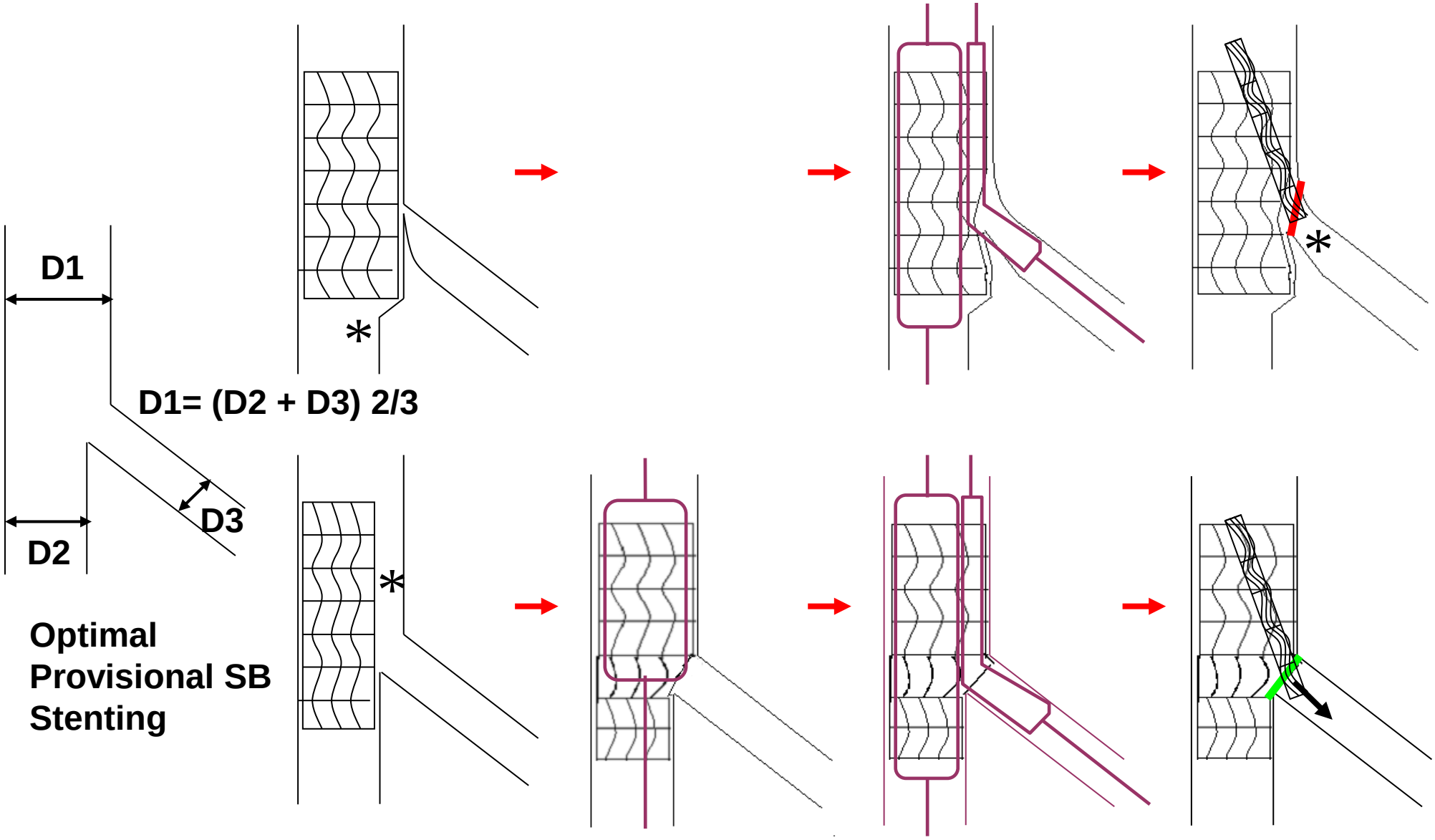


0,0,1

Optimal Provisional SB Stenting



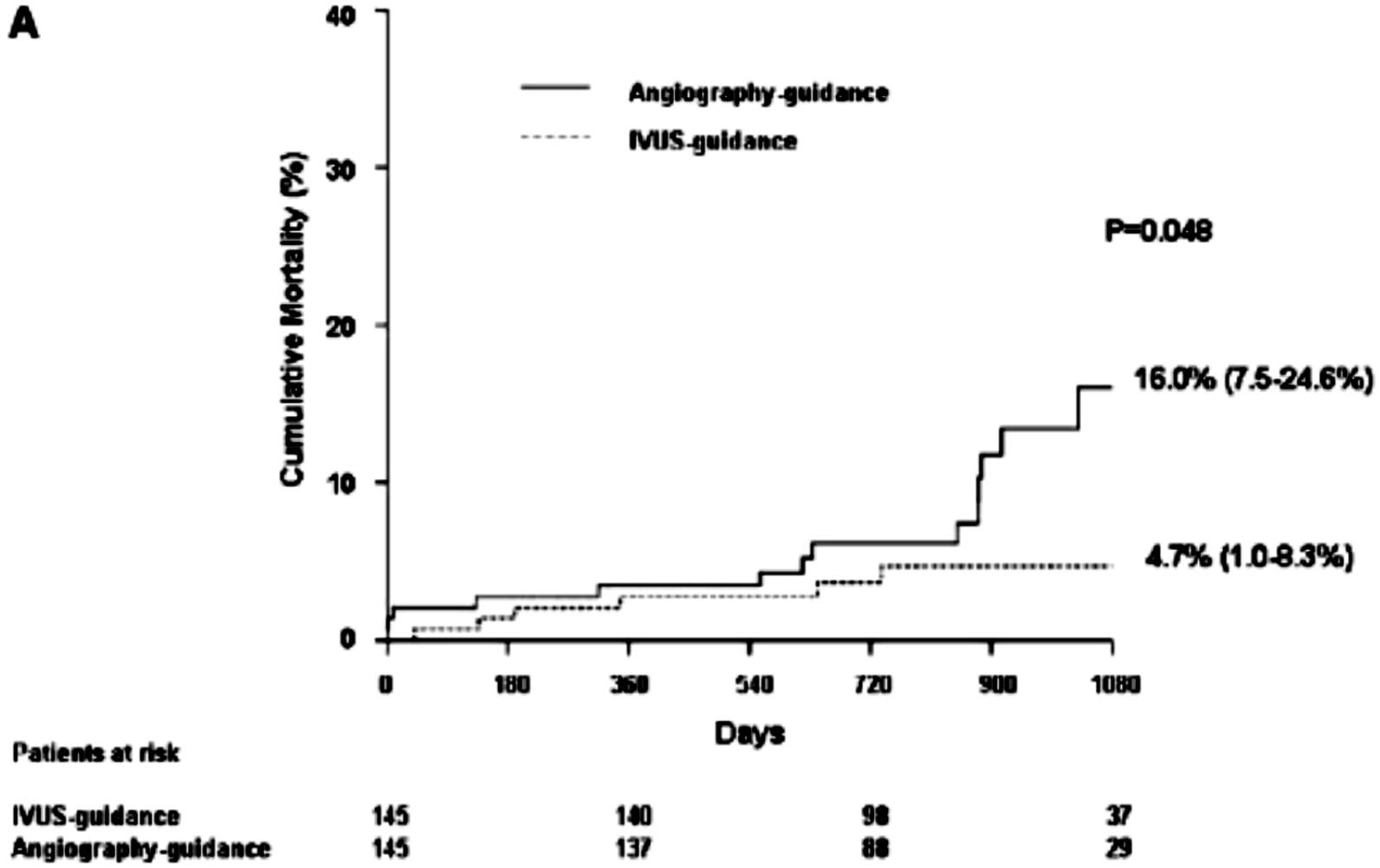
Optimal Provisional SB Stenting

POT

9. Specific guidance ?: Angio, IVUS, FFR, OCT …

Impact of IVUS Guidance on Long-Term Mortality in Stenting for ULM Stenosis

145 propensity matched pairs of patients receiving DES



Park SJ, Circ Cardiovasc Intervent. 2009;2:167-177

ANY IMPACT OF IVUS ON LEFT MAIN

Comparison of Early Outcome of Percutaneous Coronary Intervention for Unprotected Left Main Coronary Artery Disease in the Drug-Eluting Stent Era With Versus Without Intravascular Ultrasonic Guidance

Pierfrancesco Agostoni, MD, Marco Valgimigli, MD, Carlos A.G. Van Mieghem, MD, Gaston A. Rodriguez-Granillo, MD, Jiro Aoki, MD, Andrew T.L. Ong, MBBS, Keiichi Tsuchida, MD, Eugène P. McFadden, MD, Jurgen M. Ligthart, BSc, Pieter C. Smits, MD, PhD, Peter de Jaegere, MD, PhD, George Sianos, MD, PhD, Willem J. Van der Giessen, MD, PhD, Pim De Feyter, MD, PhD, and Patrick W. Serruys, MD, PhD

The aim of this study was to assess the short- and mid-term clinical impact of intravascular ultrasound guidance in 58 patients referred for elective percutaneous treatment of unprotected left main coronary artery disease with drug-eluting stents. The use of intravascular ultrasound, used in 41% of the procedures, was not associated with additional clinical benefit with respect to angiographic-assisted stent deployment. ©2005 by Excerpta Medica Inc.

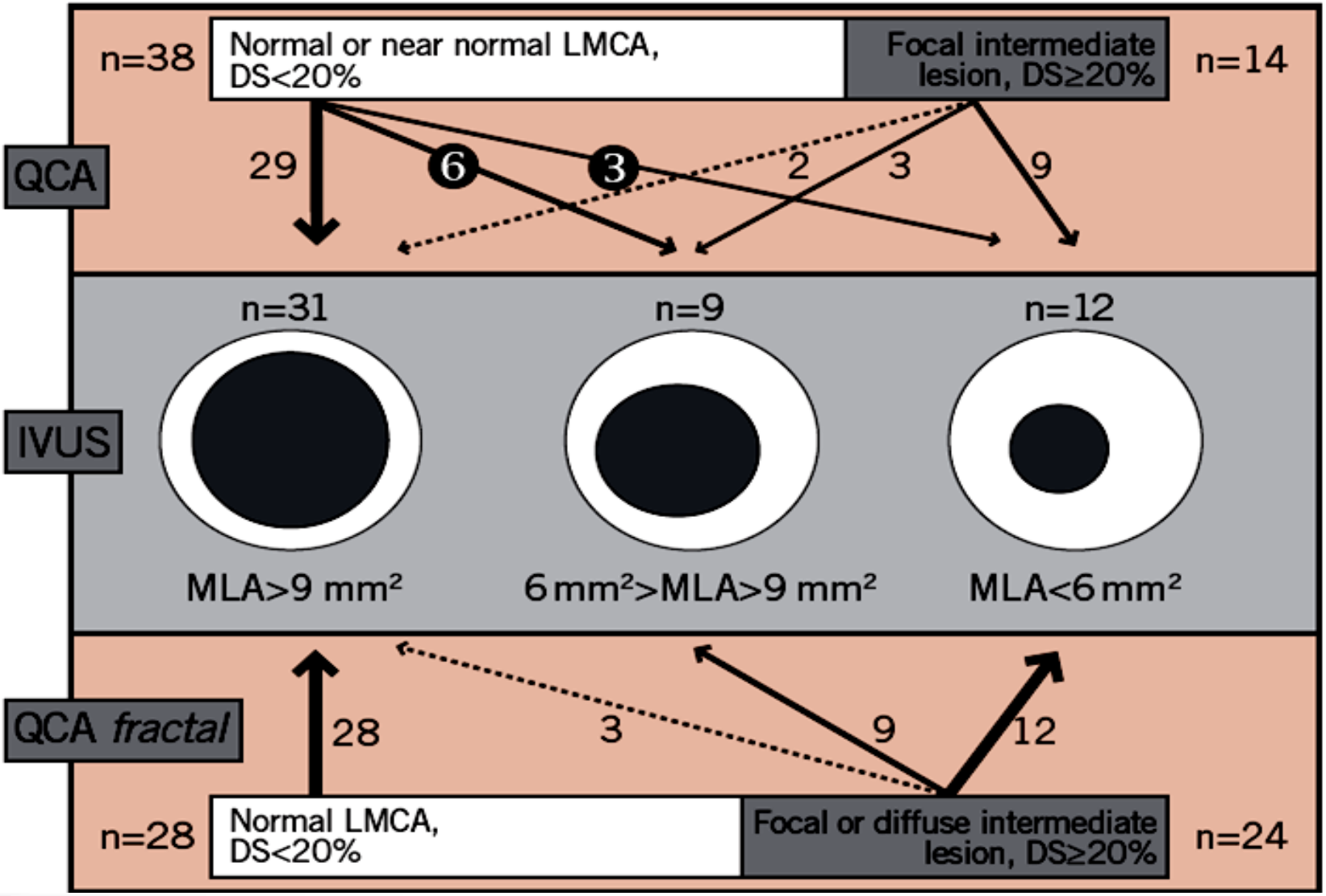
(Am J Cardiol 2005;95:644–647)

Cordis Europa, NV, Roden, The Netherlands) and paclitaxel-eluting stents (Taxus, Boston Scientific Corp., Natick, Massachusetts) have been used as part of the Rapamycin-Eluting Stent Evaluated At Rotterdam Cardiology Hospital and the Taxus-Stent Evaluated At Rotterdam Cardiology Hospital registries, respectively. These protocols were approved by the hospital ethics committee and are in accordance with the Declaration of Helsinki. Written informed consent was obtained from every patient.

Angiographic success was defined as residual ste-

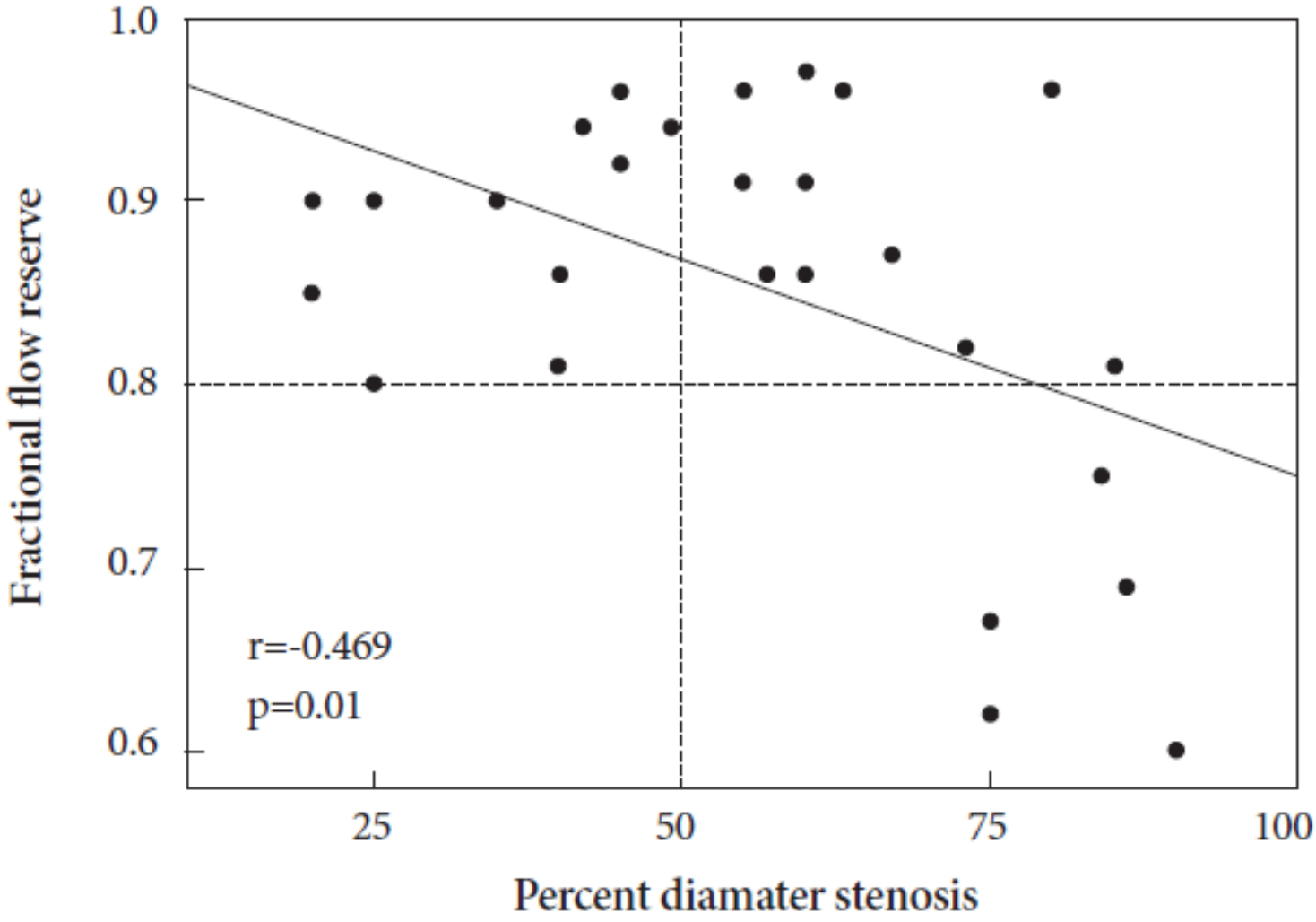
Agostoni Am J Cardiol. 2005 Mar 1;95(5):644-7

Diffuse atherosclerotic LMCA disease unmasked by fractal geometric law applied to QCA: an angiographic and IVUS study



Motreff EuroIntervention 2010; 5: 709-715

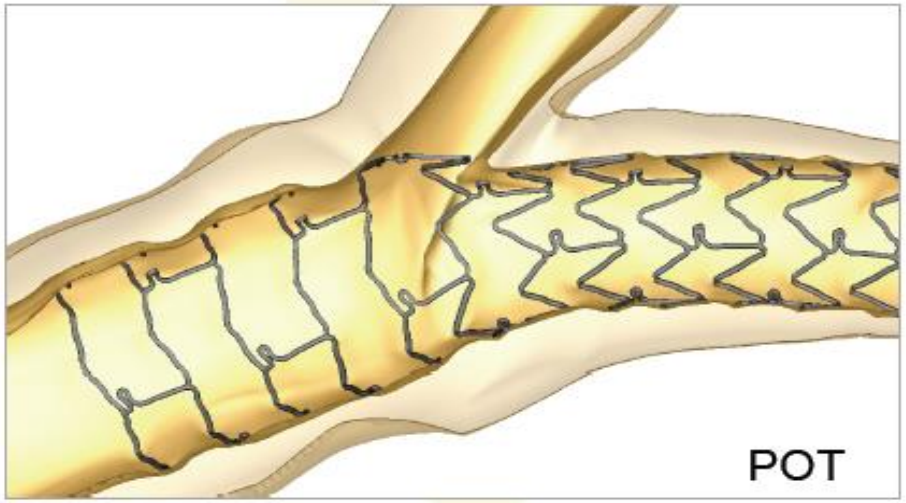
Correlation between FFR and % diameter stenosis of ostial Circ. after LM to LAD stenting

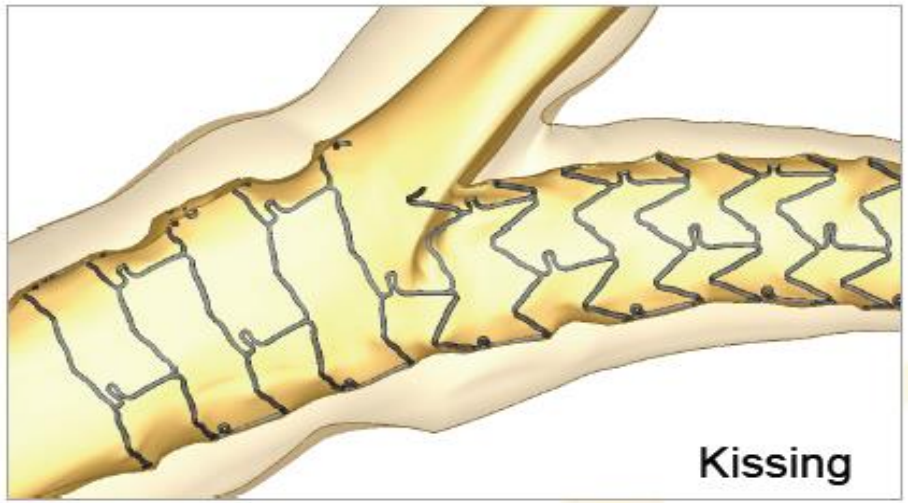


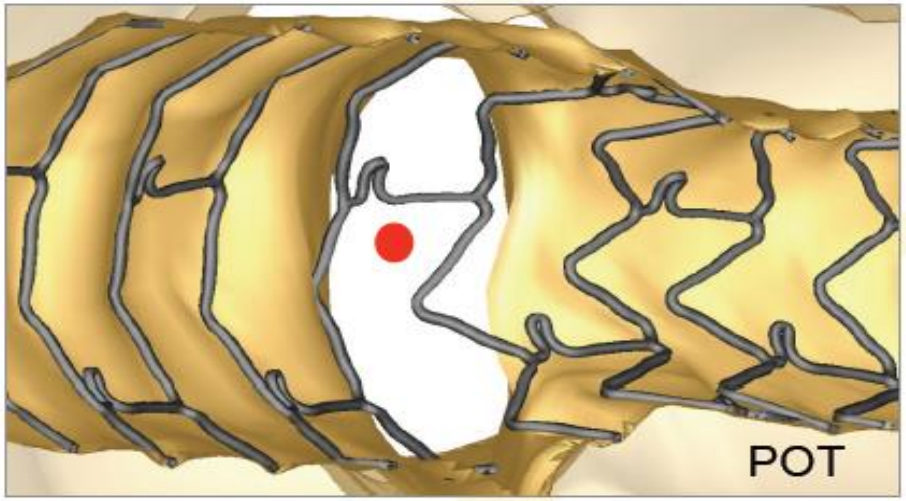
Nam CW, Korean Circ J 2011;41:304-30

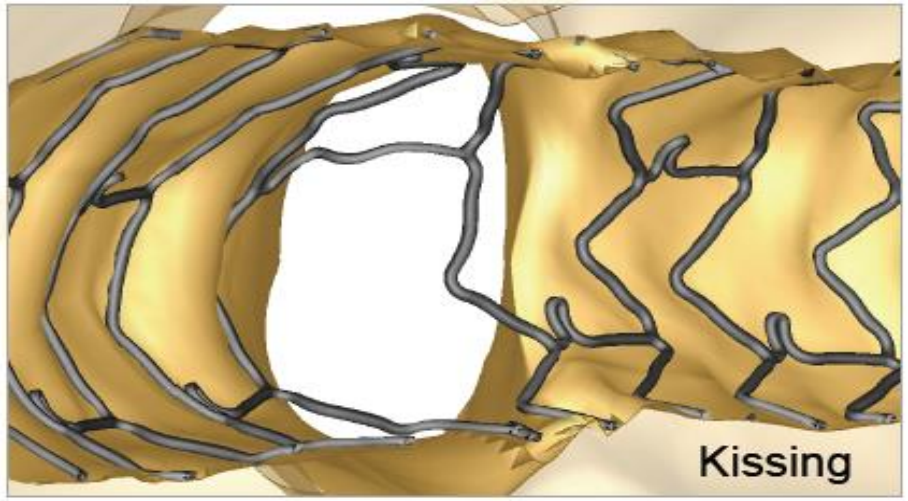
10. Available stents are inadapted !

Xience Prime maximal expansion with a 4.5 ballon and a 3 + 3.5 kissing balloon









From Peter Mortier

Conclusions (1)

- Same branching laws for LM and non LM bifurcations, same flow dynamics, same atheroma distribution
- Different atheroma ? Consequences ?
- Some quantitative differences between LM and non LM bifurcation: bigger vessels, bigger flow, more myocardium, more procedural risk, different angles…
- Can be treated safely with PCI with same recommended provisional strategy, tips and tricks, guidance, same TLR results, same thrombosis rate …
- **Standard stents are not adapted to LM stenting: bigger stents ? dedicated stents ?**

Distal LM POT