EBC

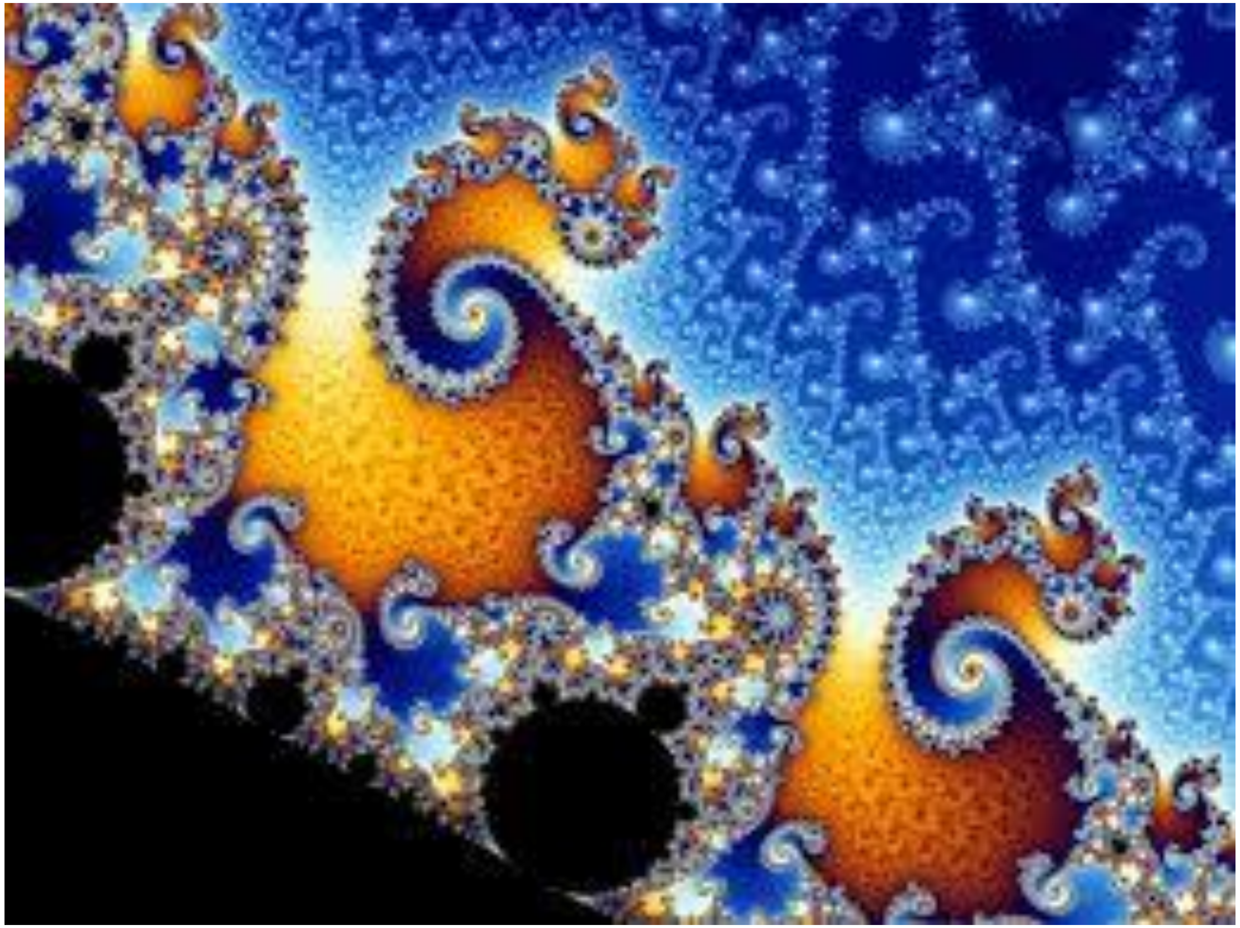
LM stenting: diameters, prevention of SB occlusion, and stent choice

Yves louvard, ICPS Massy, Générale de Santé – Ramsay, France

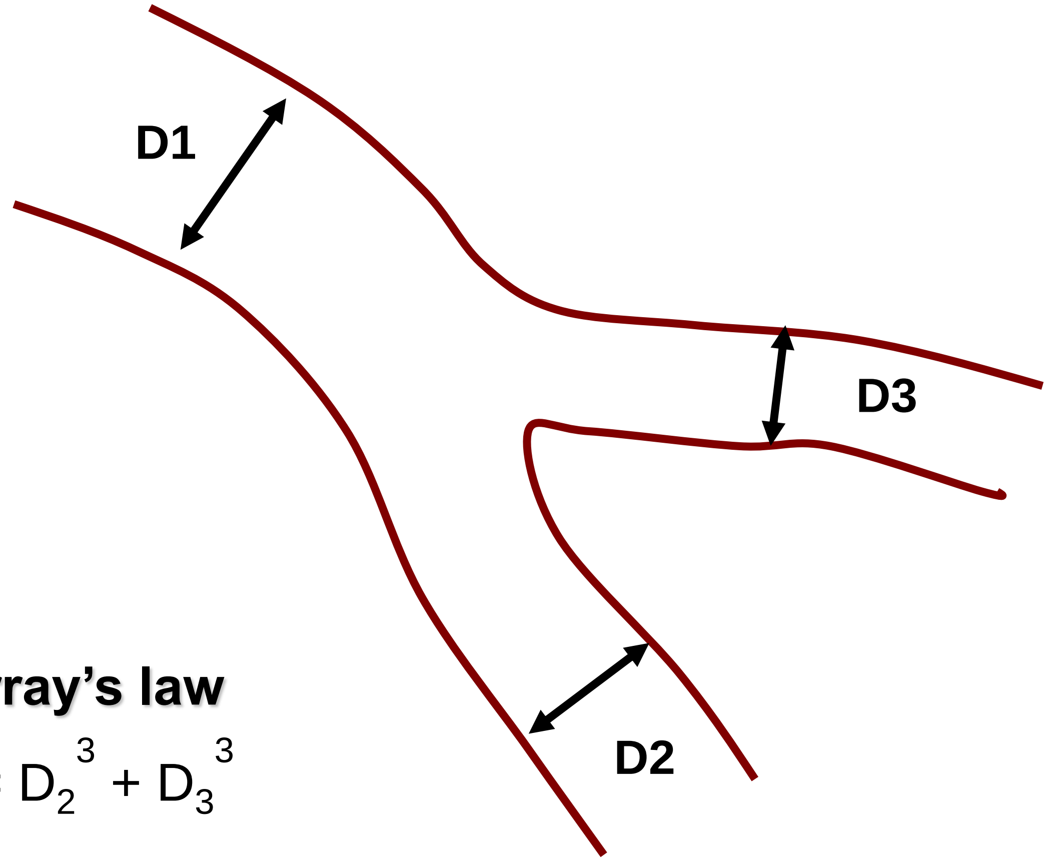
RAMSAY GÉNÉRALE DE SANTÉ

No conflict of interest to declare

Benoit Mandelbrot (1924-2010): fractals



Structure-function scaling laws of vascular trees

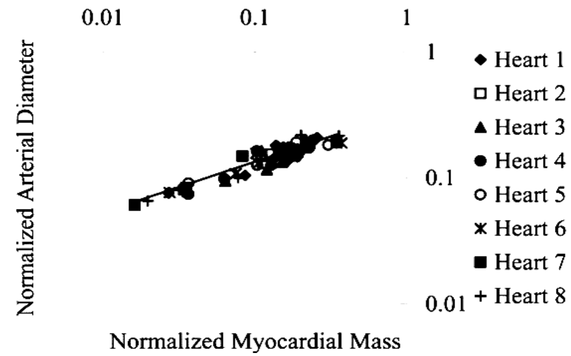


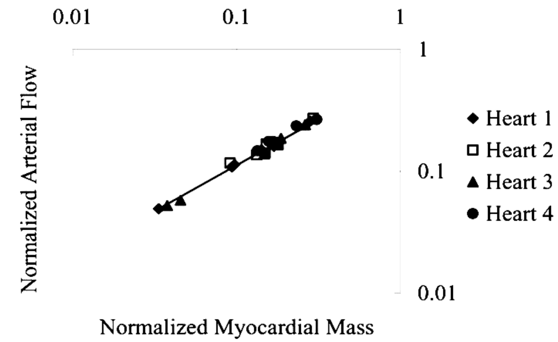
Murray's law

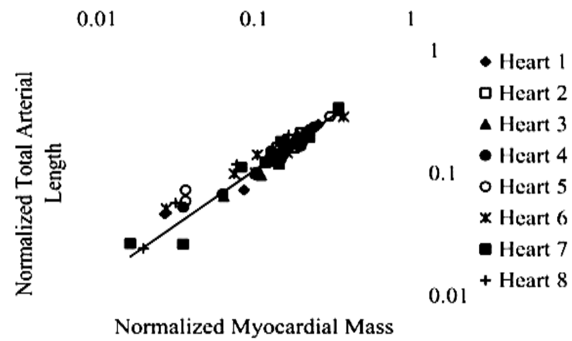
$$D_1^3 = D_2^3 + D_3^3$$

Finet's law

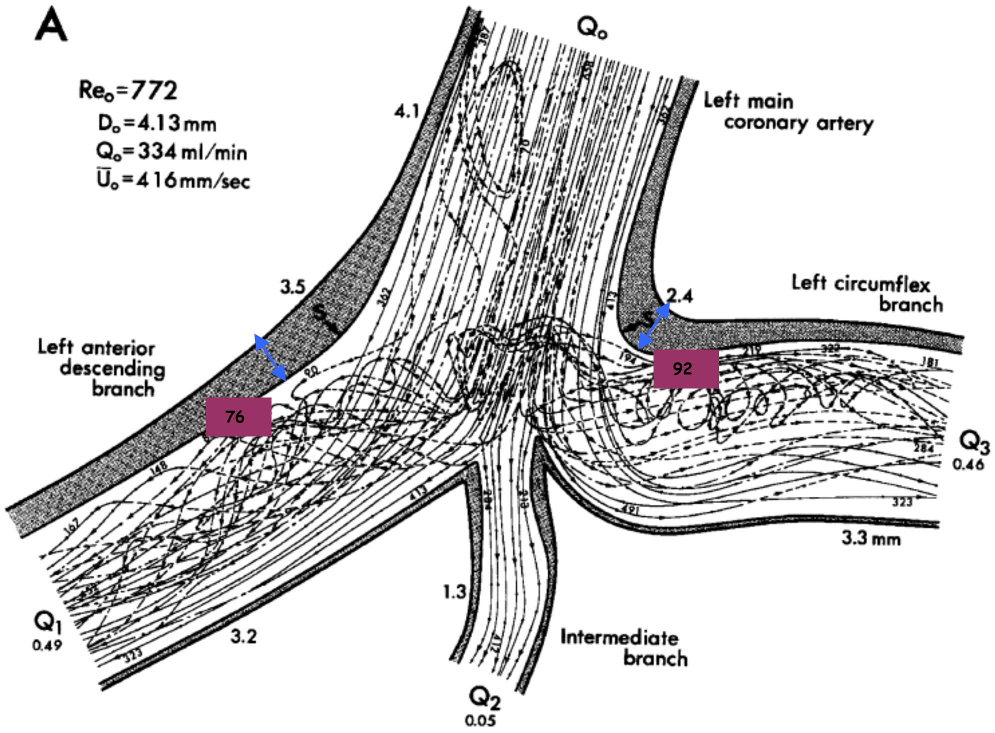
$$D_1 = 0.67(D_2 + D3)$$

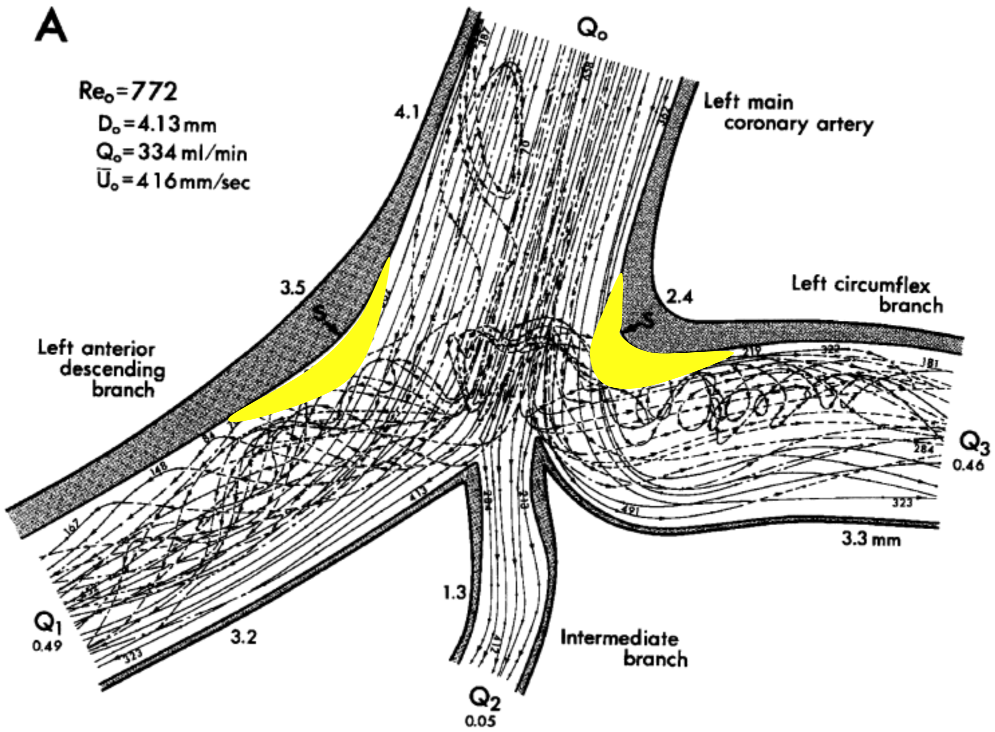






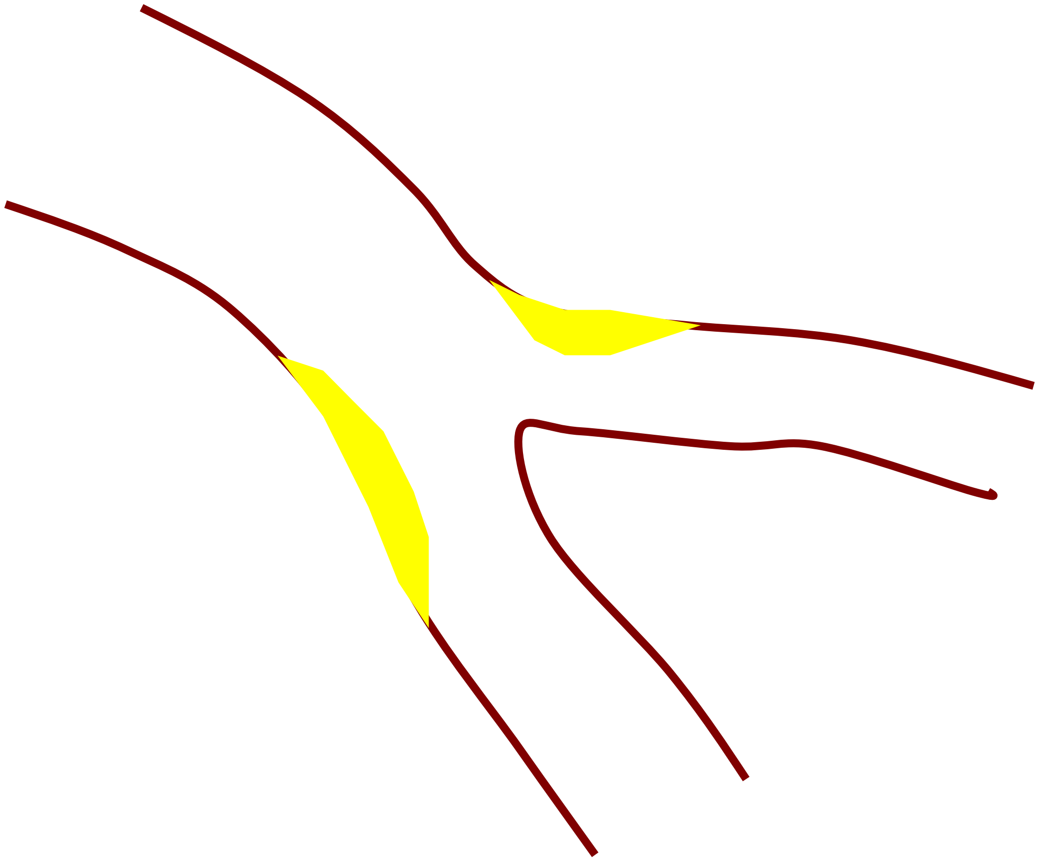
Flow Patterns and Spatial Distribution of Atherosclerotic Lesions in Human Coronary Arteries

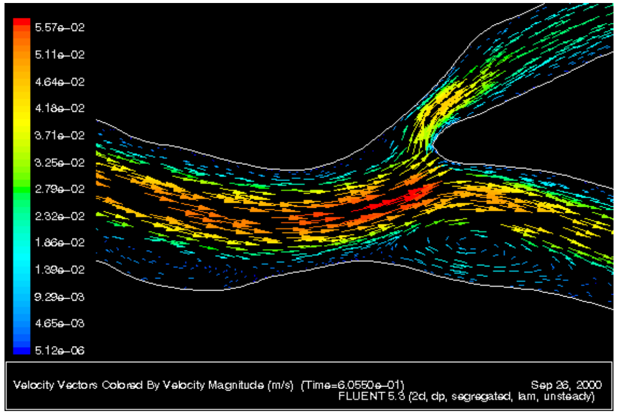


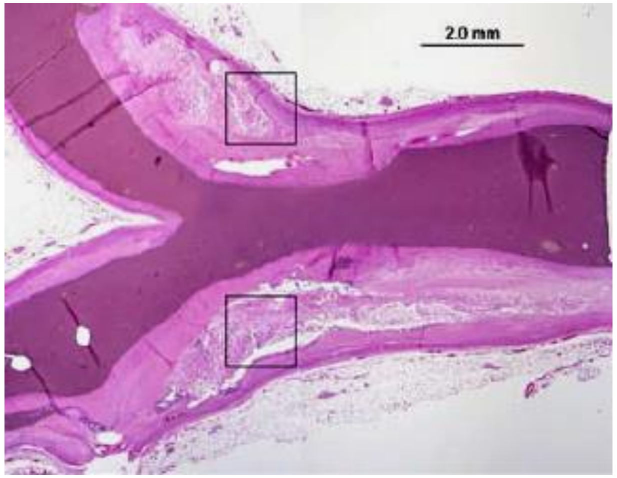


Asakura, Circulation Research 1990; 66:1045-1066

Low wall shear stress and atheroma in bifurcation







Virmani, Chatzizisis

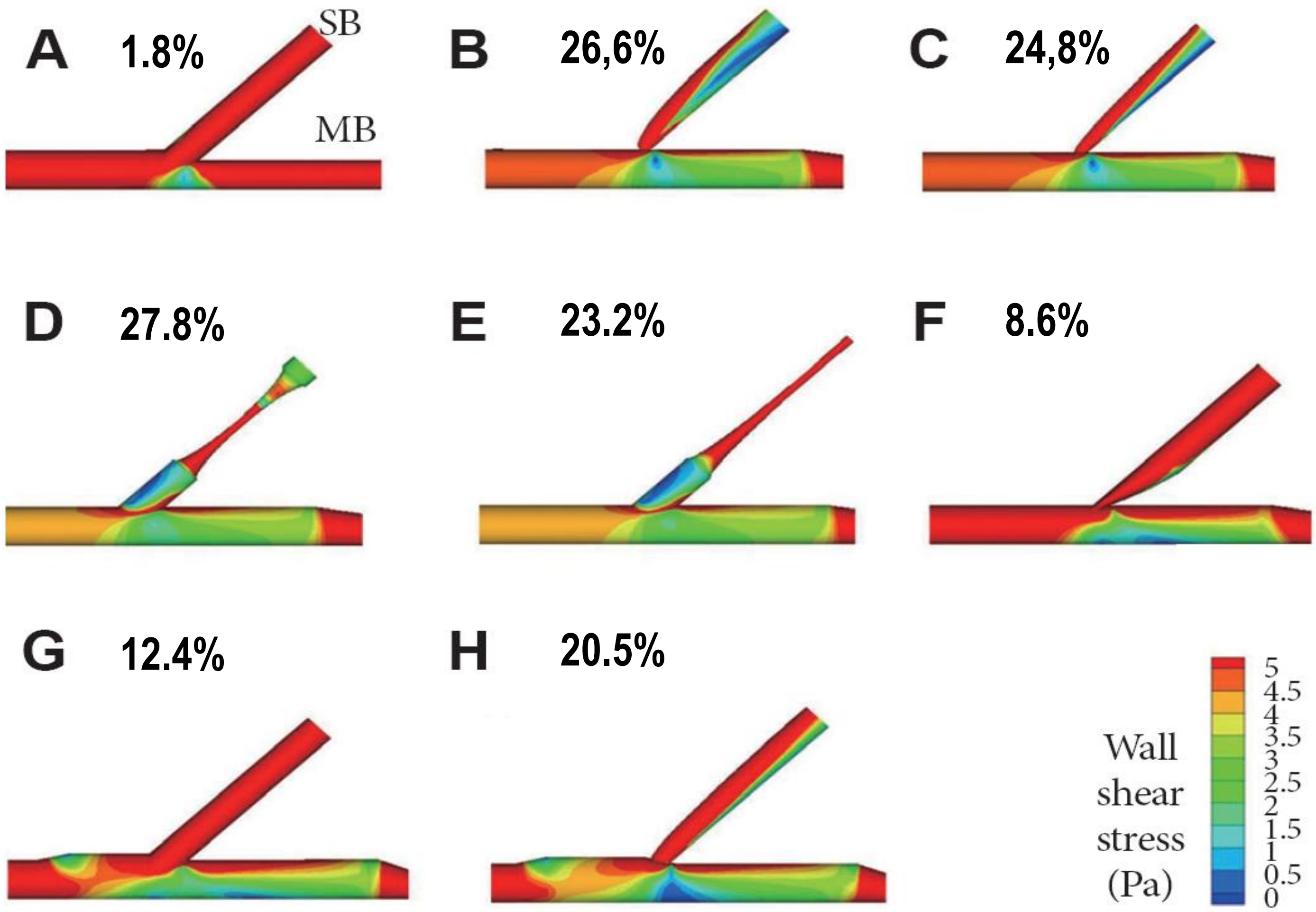
Pathological Findings at Bifurcation Lesions: Impact of Flow Distribution on Atherosclerosis and Arterial Healing After Stent Implantation

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

Local flow conditions in jailed SB lesions using computational fluid dynamics

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



SH. Na, BK. Koo, Korean Circ J 2011;41:91-96

Distal LM stenosis is a bifurcation stenosis

- Same branching laws
- Same distribution of plaques (opposite to the carena)

But:

- Big bifurcation
- Take off from the aorta
- Larger B angle
- Bigger myocardial mass at risk (MMAR)
- Technically more difficult ?: No ! But not forgiving mistakes

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

EuroIntervention. 2010 Jan;5(6):709-15.

Diffuse atherosclerotic left main coronary artery disease unmasked by fractal geometric law applied to quantitative coronary angiography: an angiographic and intravascular ultrasound study.

Motreff P[1], Rioufol G, Gilard M, Caussin C, Ouchchane L, Souteyrand G, Finet G.

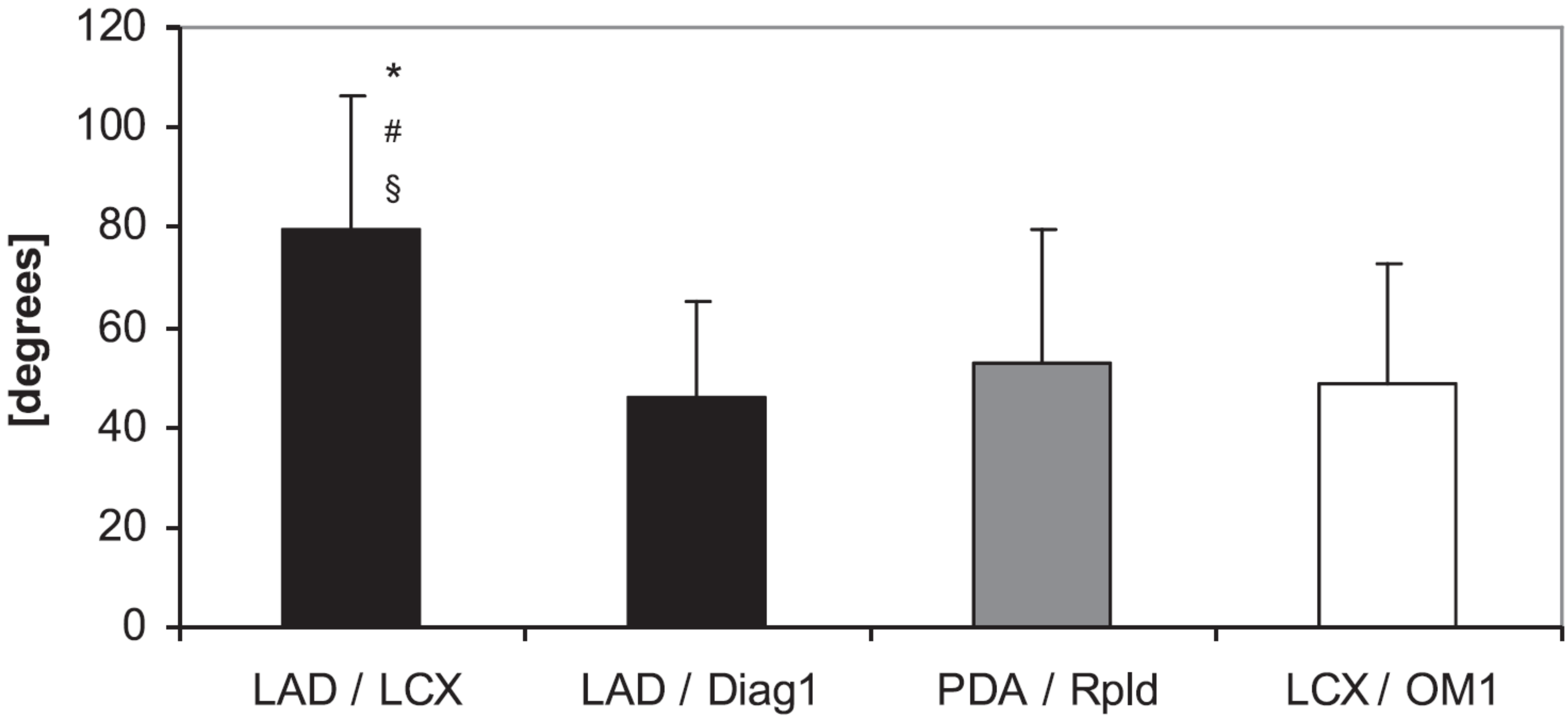
Author information

Abstract

AIMS: Angiographic analysis of left main coronary artery (LMCA) stenosis can be hindered by the lack of any reference segment when the LMCA is short or there is diffuse atheroma. Fractal geometric law (FGL) enables the theoretic diameter of one bifurcation vessel to be calculated from those of the other two (Dmother=0.678*(Ddaughter1+Ddaughter2). Applied to the LMCA, the FGL can help the quantification of stenoses.

METHODS AND RESULTS: Fifty-two patients with angiographically mild focal LMCA disease (n=14) or normal to nearly normal LMCA (n=38) who had undergone intravascular ultrasound (IVUS) were included. IVUS analysis confirmed all 14 focal stenoses (group C); of the 38 angiographically normal patients, however, 10 were found to present diffuse LMCA disease (group B), the remaining 28 showing a truly healthy LMCA (group A). LMCA stenosis in groups A,B and C was respectively 3%,4% and 42% on usual quantitative coronary angiography (QCA) and 5%, 31% and 43% on QCAfractal applying the FGL. In cases of diffuse atheroma, the FGL corrected the underestimation of LMCA diameter, which averaged 1.2 mm. conclusions: Angiographic underestimation of LMCA stenosis can be corrected by applying the FGL to obtain a theoretic LMCA diameter, thereby unmasking any diffuse atherosclerotic LMCA disease, or to quantify focal stenosis more precisely where the adjacent segments are also pathological.

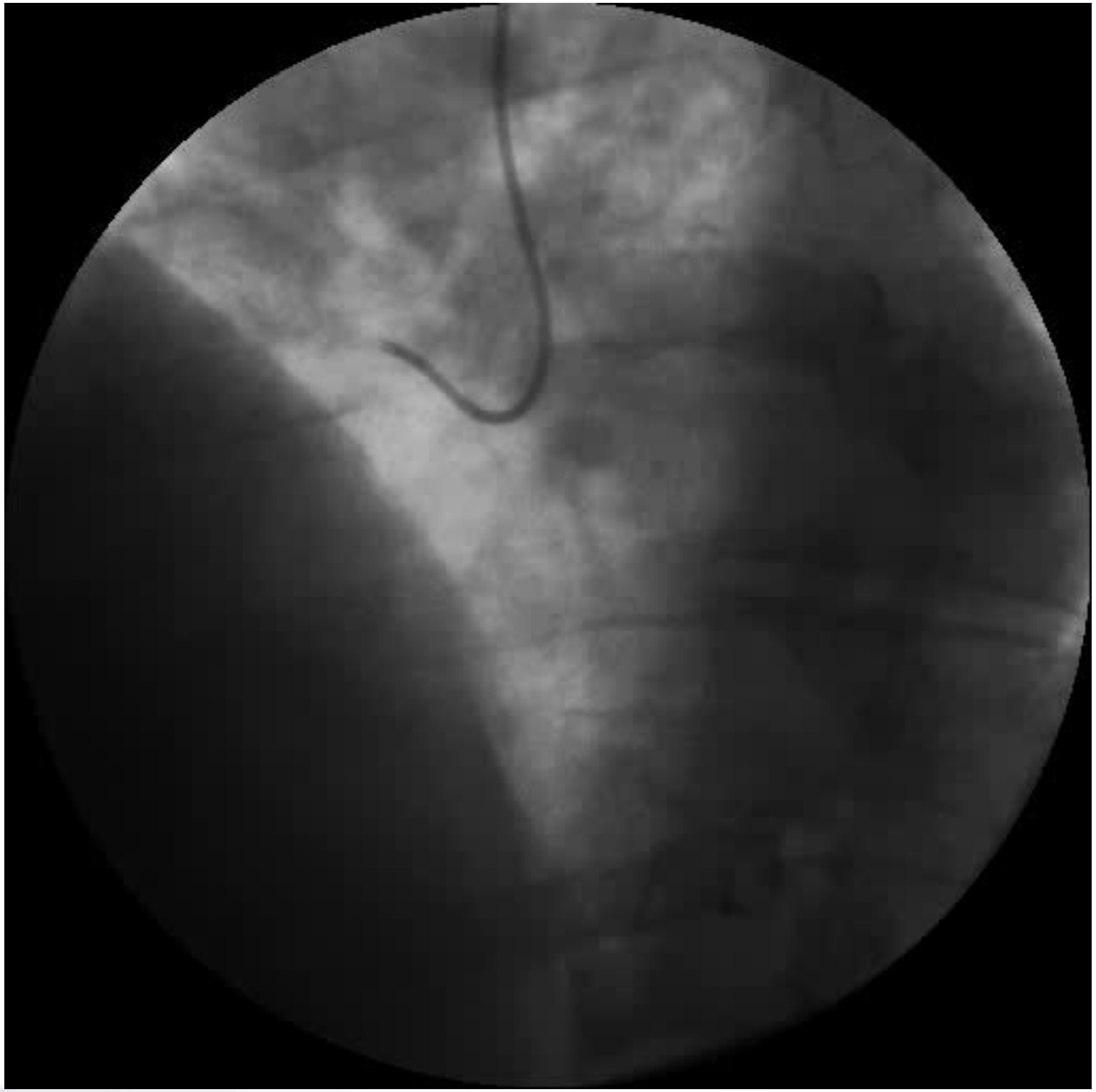
Measurement of Coronary Artery Bifurcation Angles by Multidetector Computed Tomography



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

High risk

High risk ? = No



Risk assessment

3 VD ?

Occluded RCA (dominant ?)

Dominant LCA ?

Collaterals ? LCA to RCA / RCA to LCA

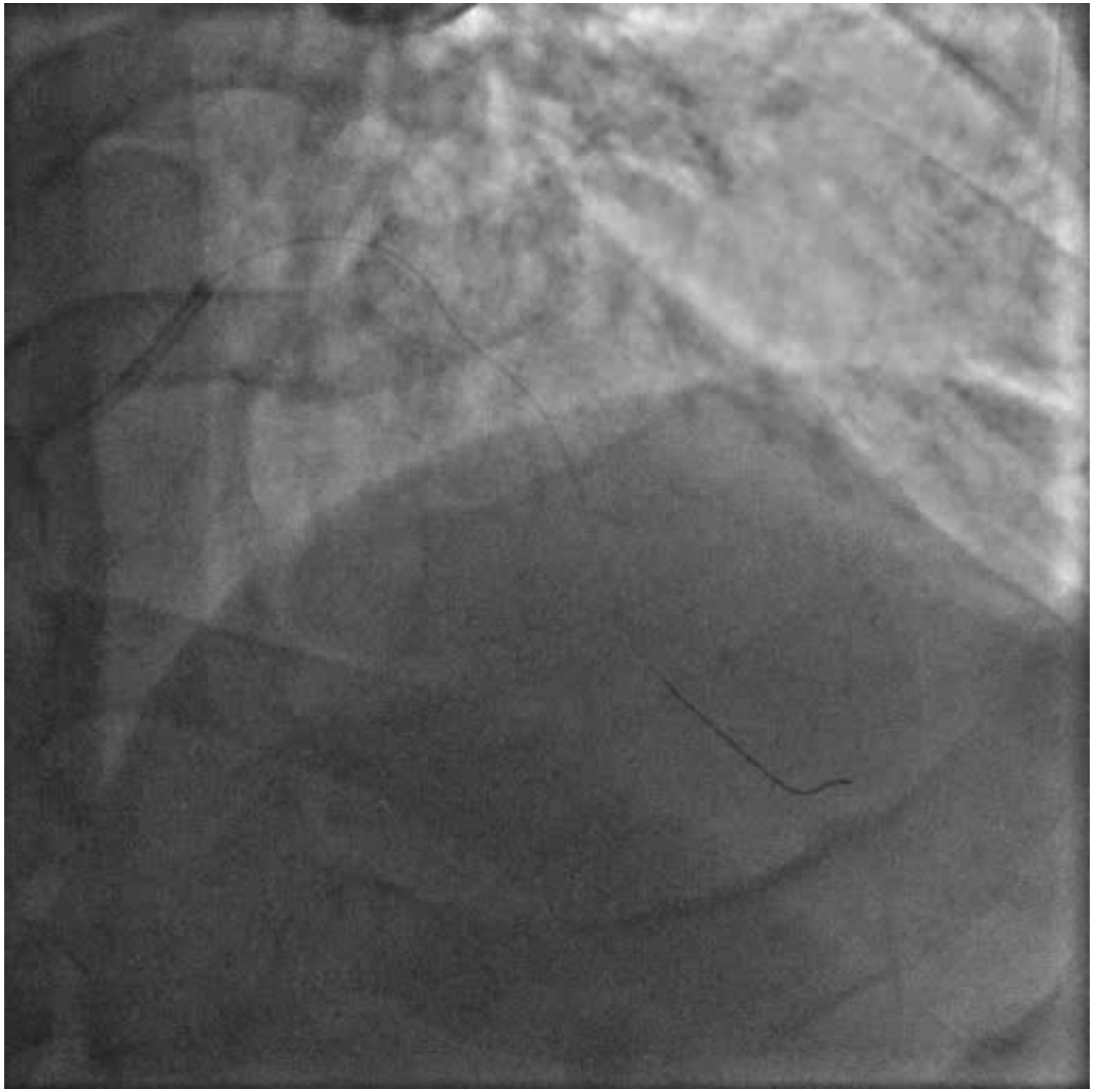
LVEF ?

Lesion complexity (handling time) ?

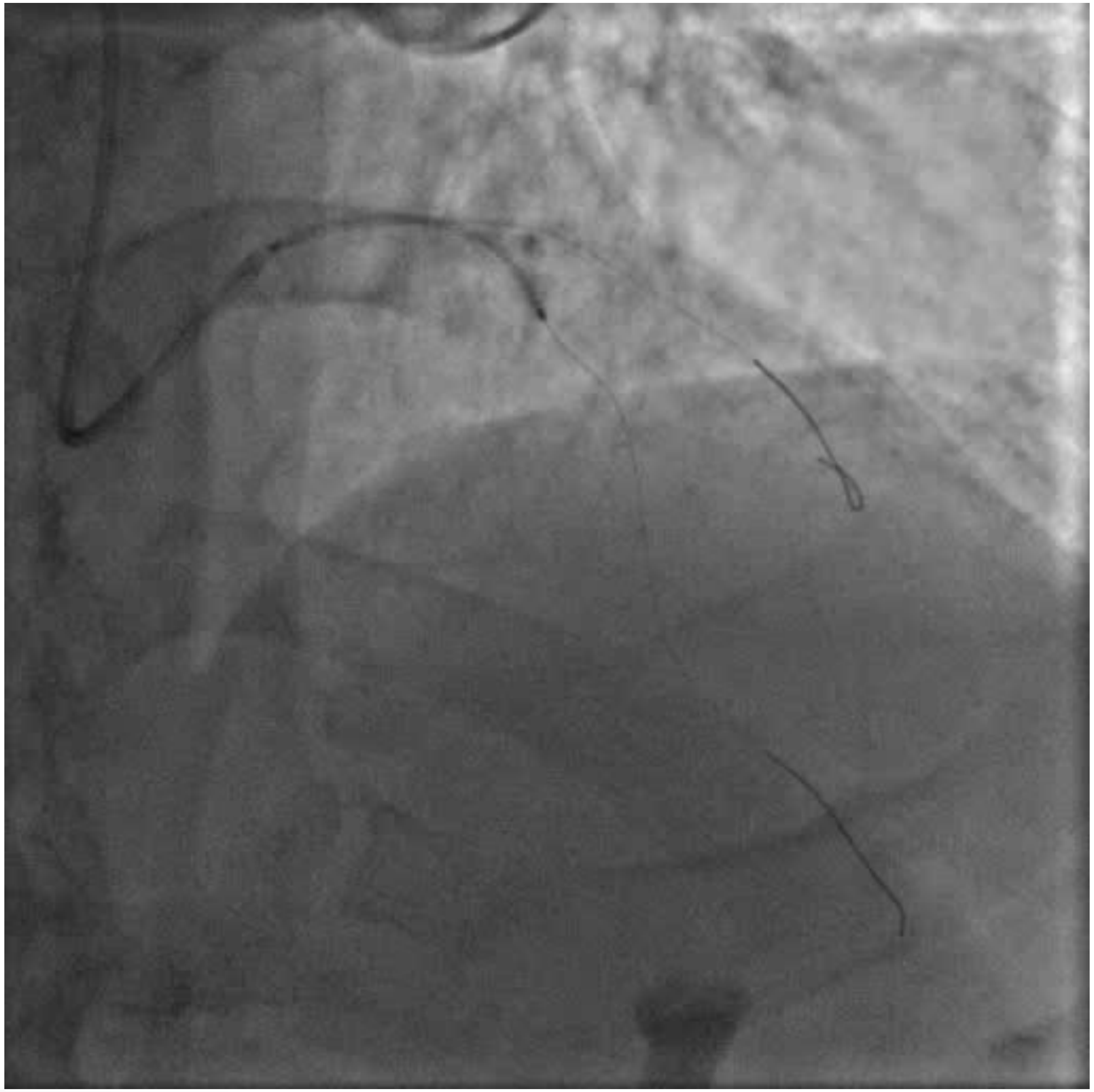
Syntax score II, Euroscore ….

→ PCI/CABG ?, hemodynamic support ?

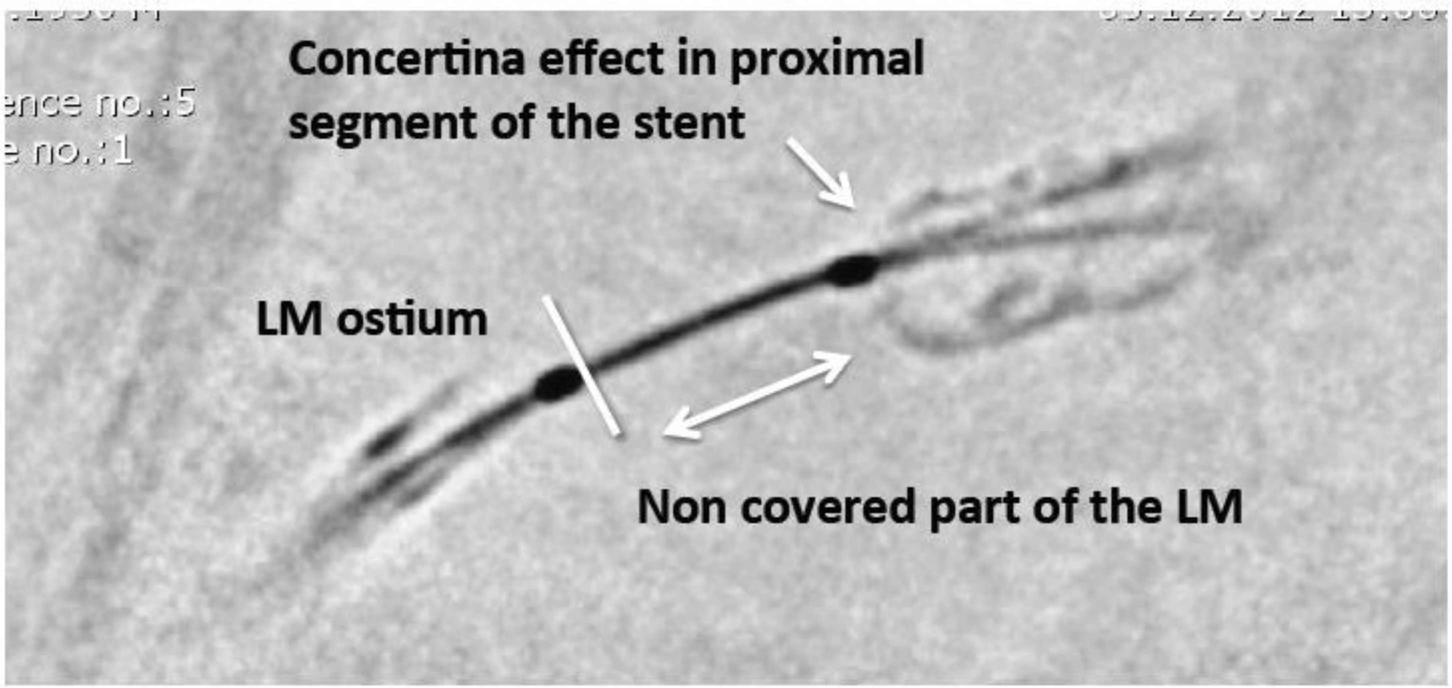
LM longitudinal stent distorsion: guiding / stent proximity



LM longitudinal stent distorsion: guiding / stent proximity

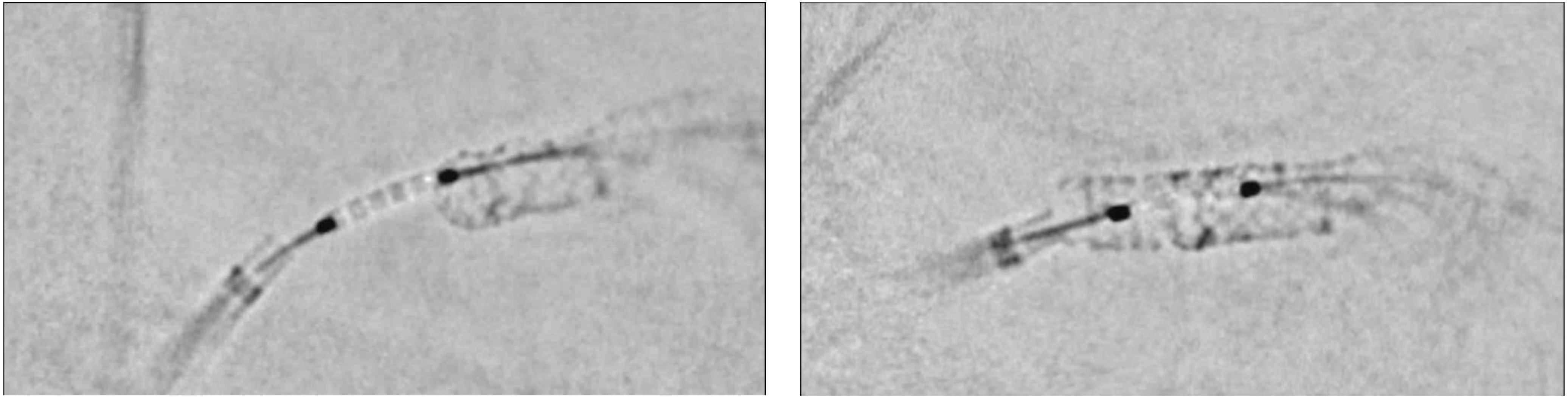


LM longitudinal stent distorsion: guiding / stent proximity



- Stent Viz (General Electrics) evidenced a shortening of the stent with a disrupted portion in its proximal edge.

LM longitudinal stent distorsion: guiding / stent proximity



Avoid SB occlusion

Predictors and outcomes of SB occlusion after main vessel stenting in coronary bifurcation lesions

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

Hahn, J Am Coll Cardiol 2013;62:1654–9

Predictors and Outcomes of SB Occlusion After Main Vessel Stenting in Coronary Bifurcation Lesions Results From the COBIS II Registry

Lesion and Procedural Characteristics

Characteristic	SB Occlusion (n = 187)	No SB Occlusion (n = 2,040)	p Value
Bifurcation location			<0.001
Left main bifurcation	14 (7.5)	556 (27.3)	
LAD/diagonal	124 (66.3)	1,124 (55.1)	
LCX/OM	32 (17.1)	272 (13.3)	
RCA bifurcation	17 (9.1)	88 (4.3)	
Medina classification			<0.001
1,1,1	97 (51.9)	567 (27.8)	
True bifurcation	139 (74.3)	901 (44.2)	<0.001
Type of stent used			0.83
Sirolimus-eluting stent	82 (43.9)	966 (47.4)	
Paclitaxel-eluting stent	50 (26.7)	545 (26.7)	
Zotarolimus-eluting stent	23 (12.3)	234 (11.5)	
Everolimus-eluting stent	26 (13.9)	246 (12.1)	
Other drug-eluting stents	6 (3.2)	49 (2.4)	
Jailed wire in the SB	123 (65.8)	1,237 (60.6)	0.17
SB pre-dilation before MV stenting	61 (32.6)	437 (21.4)	<0.001
Guidance of intravascular ultrasound	52 (27.8)	772 (37.8)	0.007
MV stent diameter, mm (range)	3.0 (3.0–3.5)	3.0 (3.0–3.5)	0.04
MV stent length, mm (range)	24.0 (20.0–30.0)	24.0 (18.0–30.0)	0.21
MV stent maximal pressure, atm (range)	12.0 (10.0–14.0)	14.0 (10.0–16.0)	<0.001
MV stent/artery ratio (range)	1.2 (1.1–1.3)	1.2 (1.1–1.3)	0.63

Patients with recovery of the occluded SB had jailed wire in the SB more frequently than those without recovery of the occluded SB (74.8% vs. 57.8%, p < 0.02)

SB occlusion
wo JW = 7%
w JW = 9%

Hahn, J Am Coll Cardiol 2013;62:1654–9

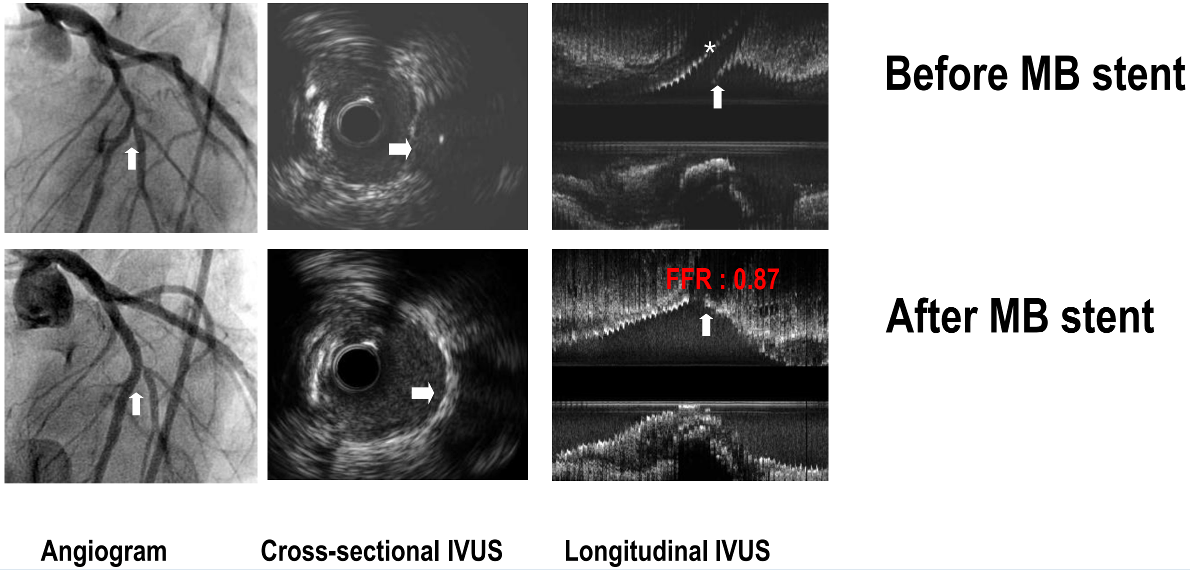
Independant predictors of SB occlusion

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

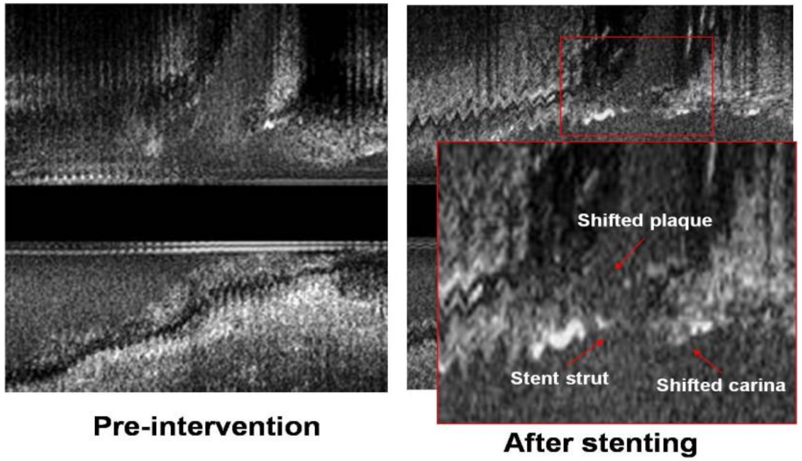
Hahn, J Am Coll Cardiol 2013;62:1654–9)

IVUS findings of Carina shift vs. Plaque shift

carina shift

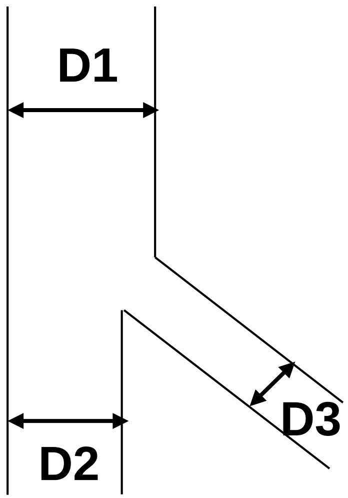


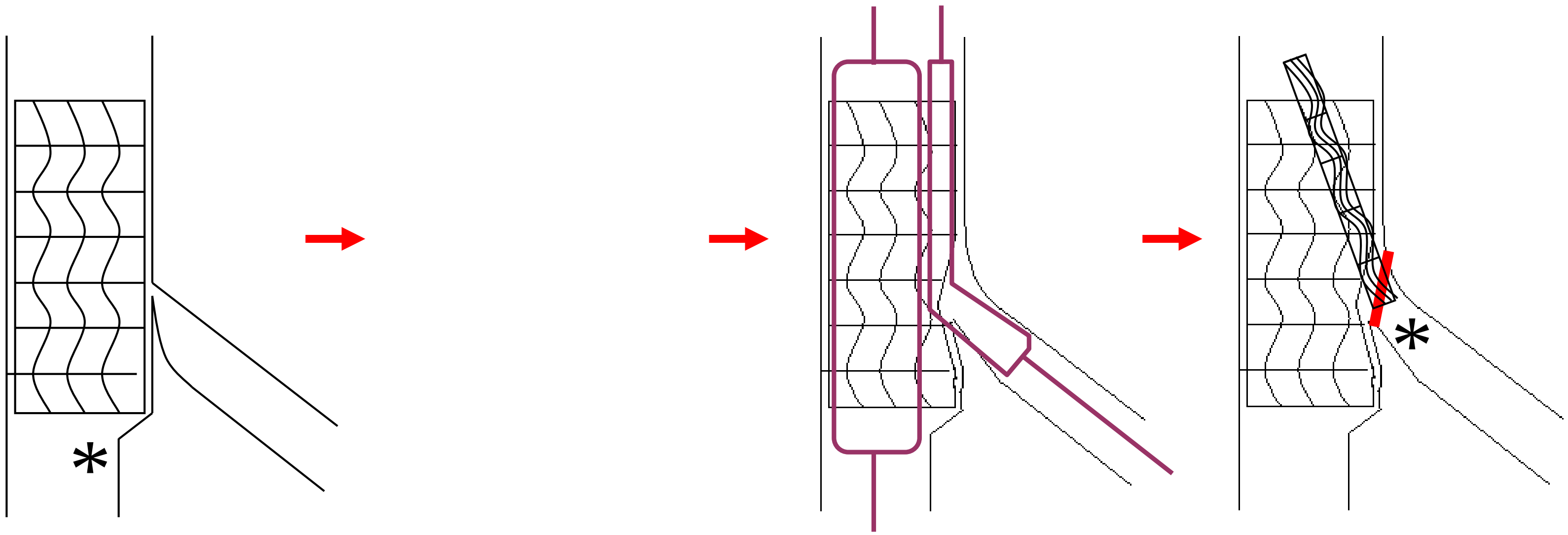
Both plaque shift and carina shift → Aggravation of SB luminal narrowing after MB stent implantation



Koo, Circ Cardiovasc Interv 2010;3;113-119

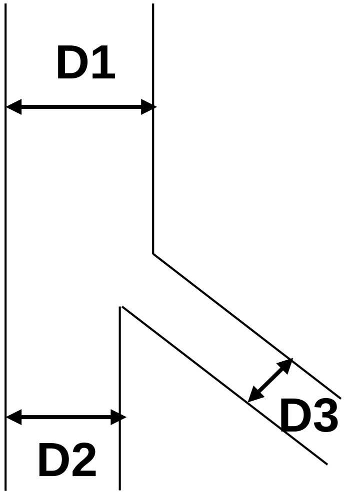
Stent diameter



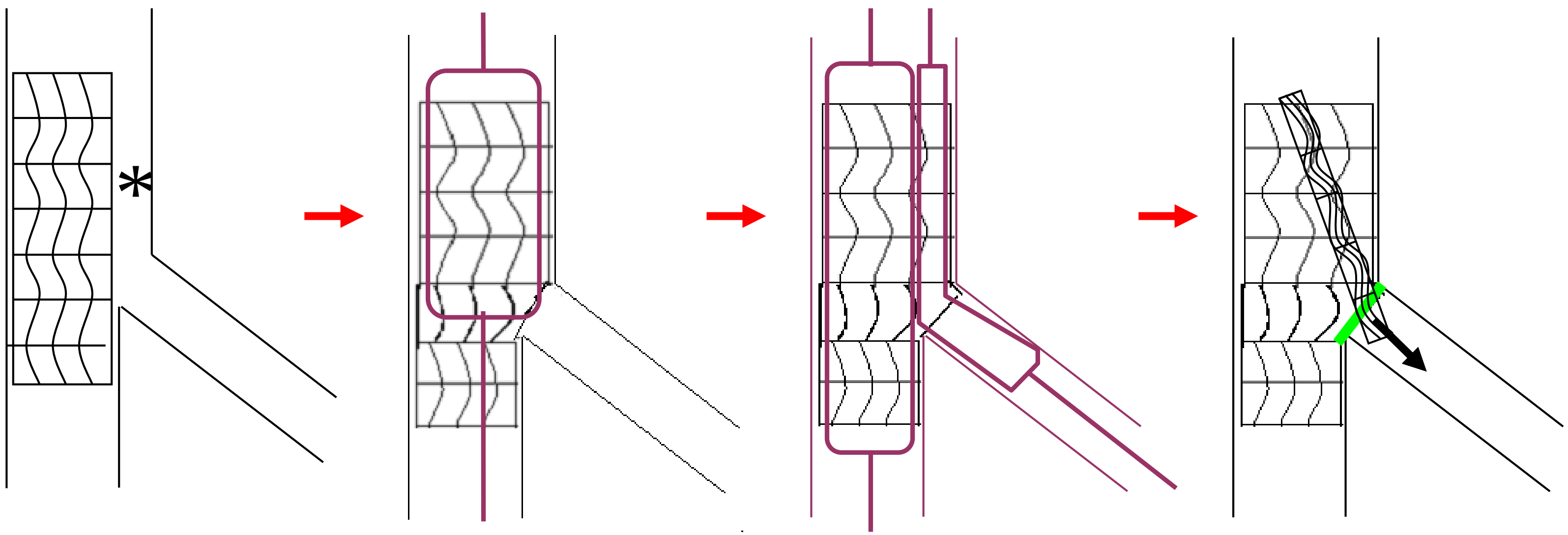


Optimal Provisional SB Stenting

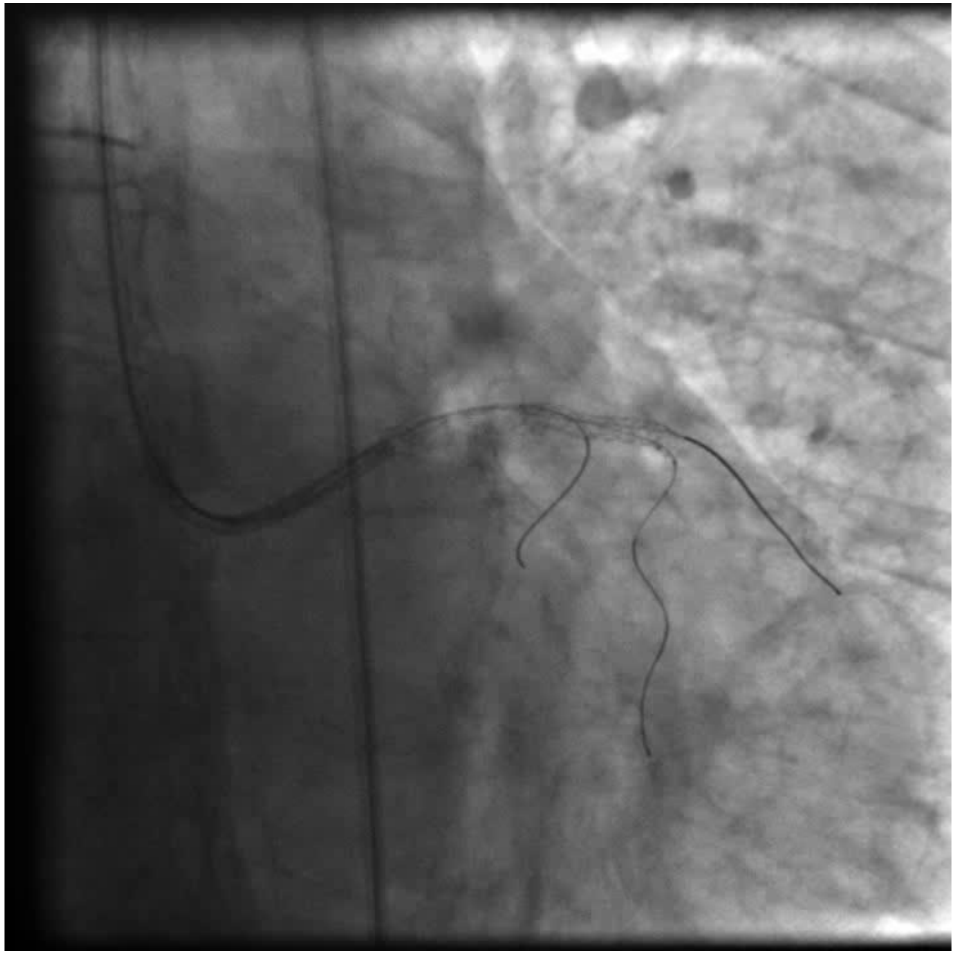
Stent diameter

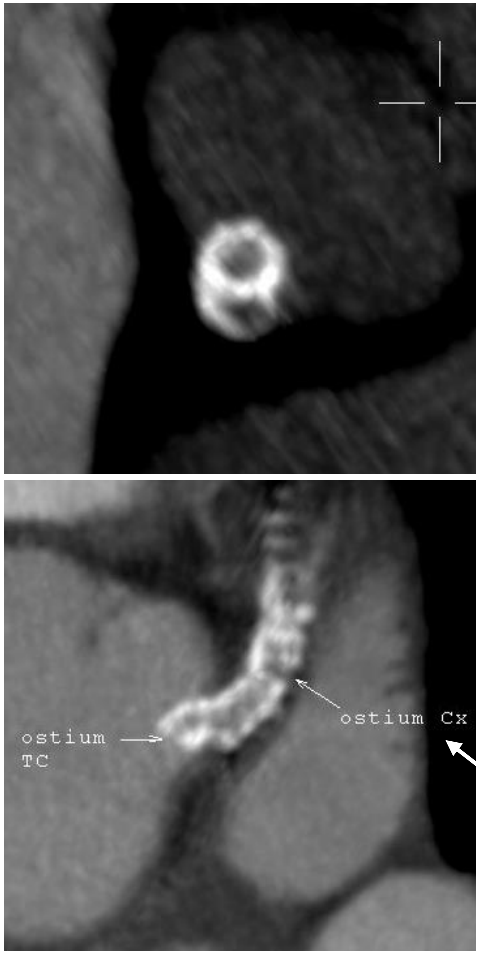


Optimal
Provisional SB
Stenting



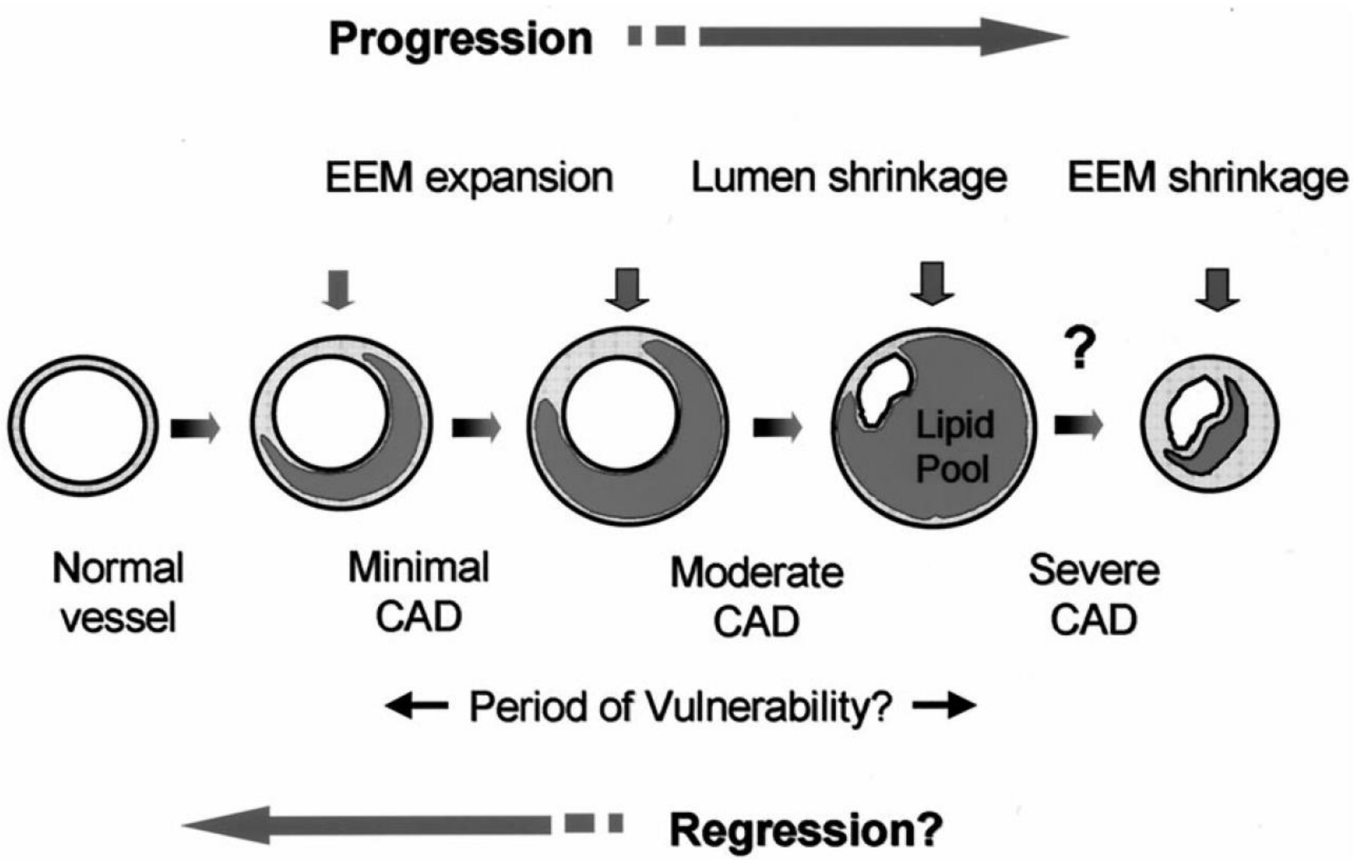
Left Main Stenting Acute Result, 6 Month CTCA





One stent, two diameters … but which ones ?

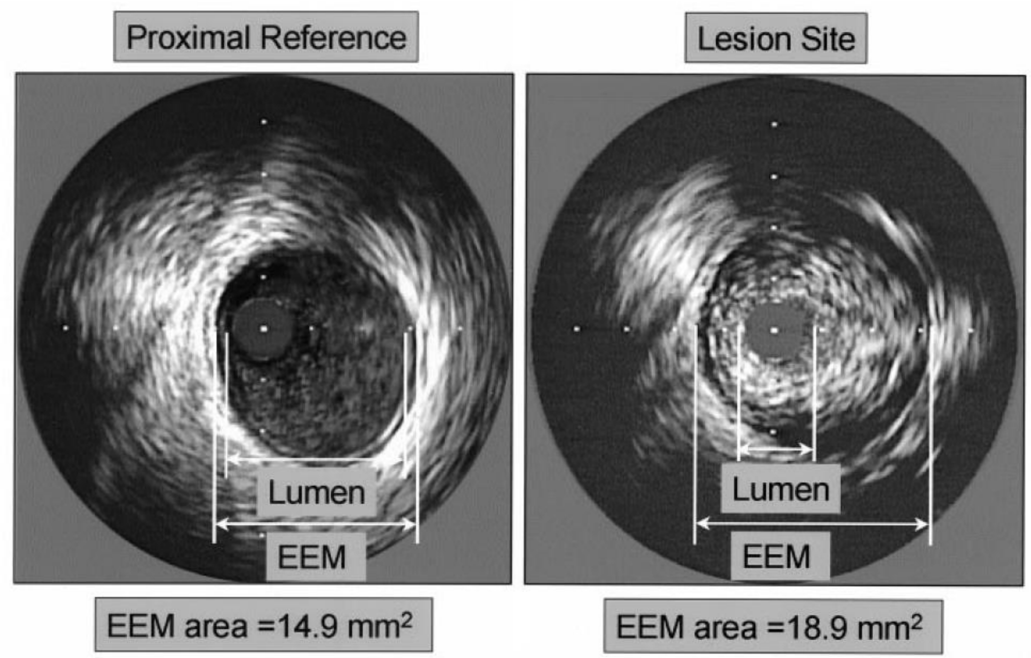
Arterial remodeling and CAD: the concept of "dilated" vs "obstructive" coronary atherosclerosis

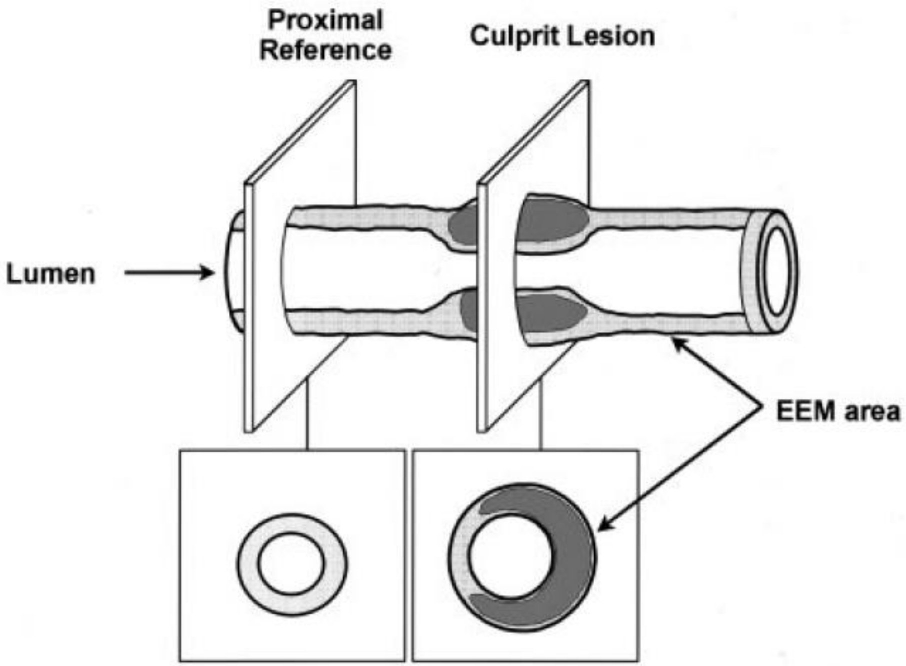


Early plaque accumulation in human coronary arteries is associated with compensatory enlargement of vessel size (positive remodeling). Therefore, luminal size is initially not affected by plaque growth. These complex changes of lumen, plaque and external elastic membrane (EEM) may also affect plaque regression.

adapted from Glagov, N Engl J Med 1987;316:1371–53.

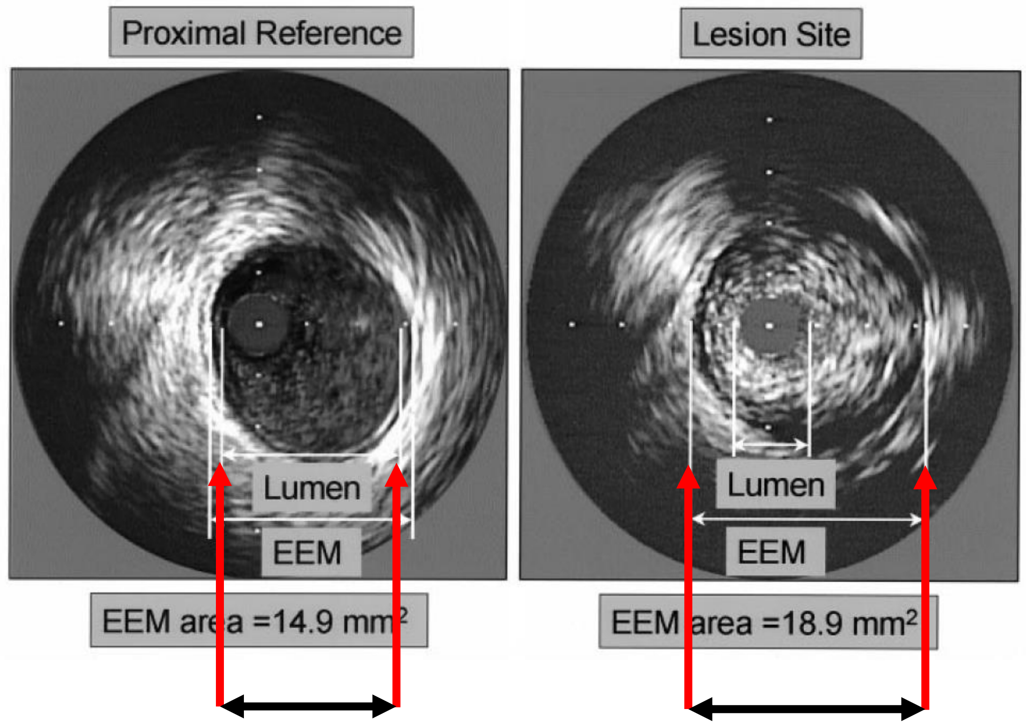
Positive remodeling and vessel diameter

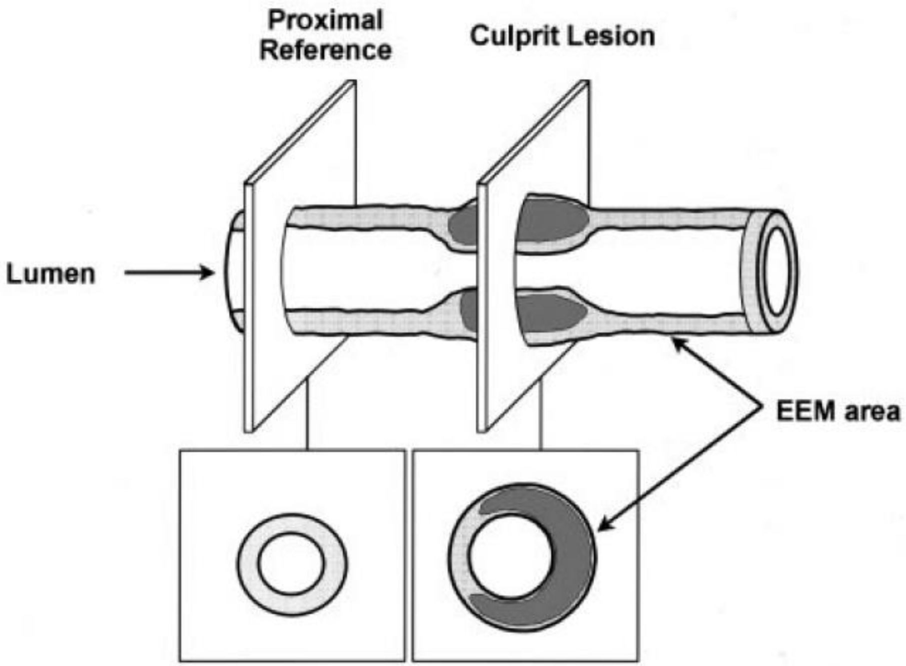




adapted from Schoenhagen, JACC 2001;38:297–306

Positive remodeling and vessel diameter





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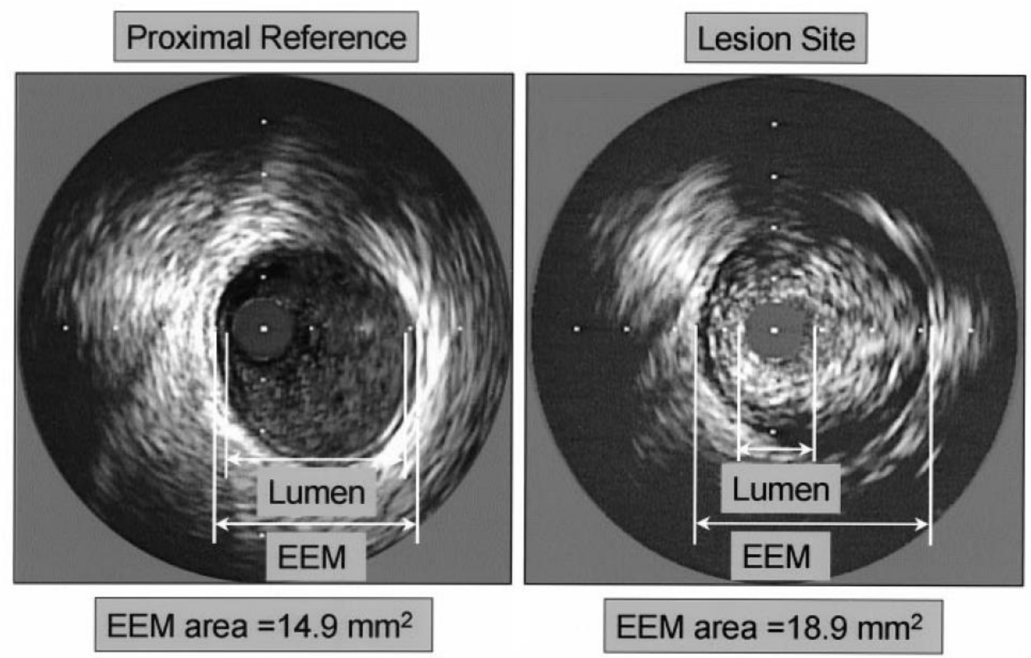
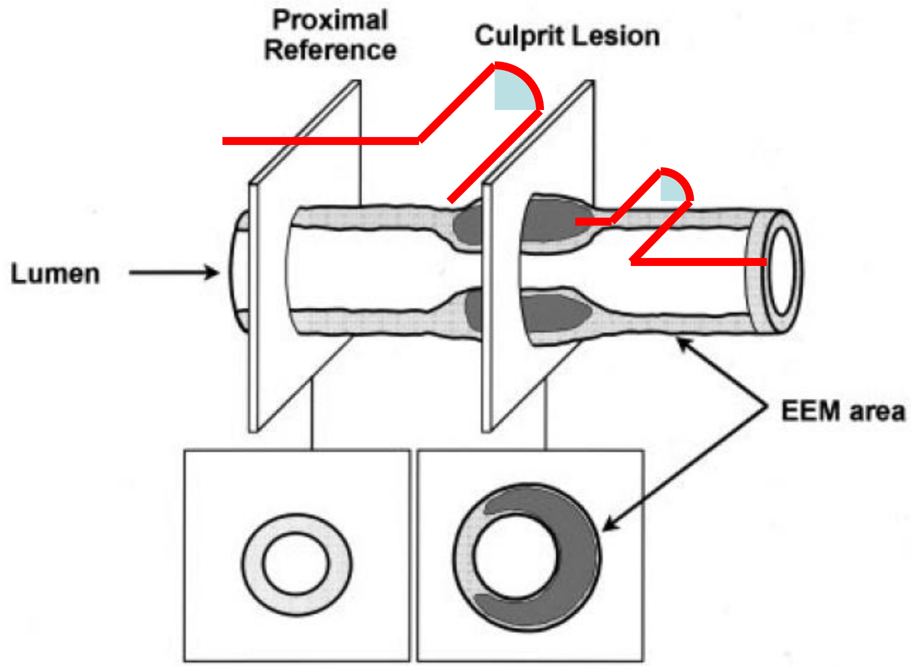
Positive remodeling and vessel diameter

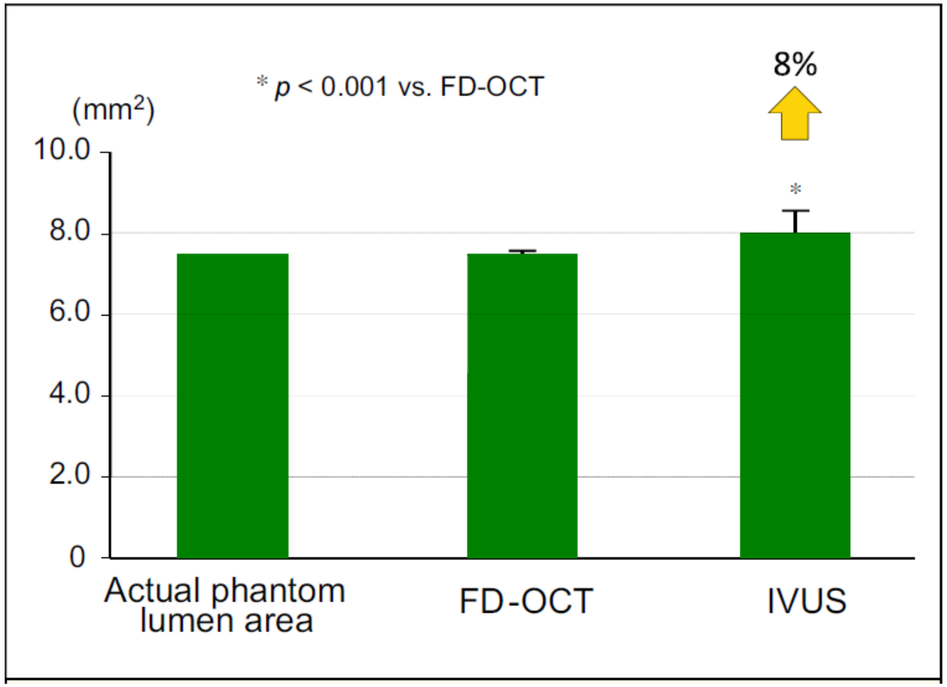




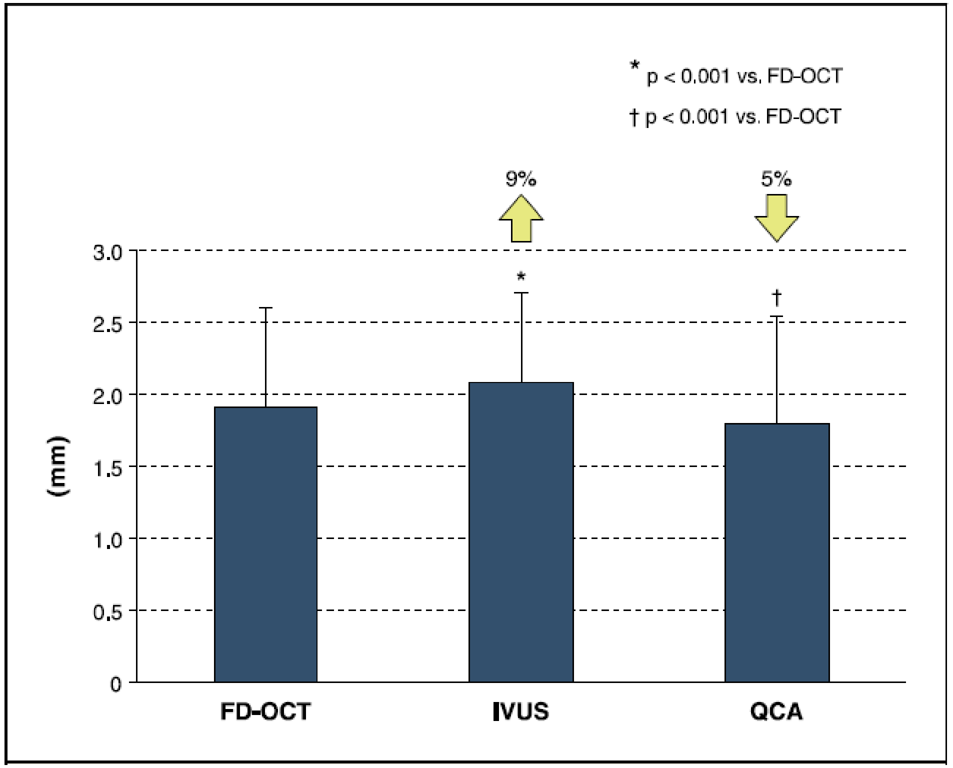
adapted from Schoenhagen, JACC 2001;38:297–306

OCT compared with IVUS in a coronary lesion assessment
The OPUS-CLASS study

MLA in Phantom Models: FD-OCT / IVUS

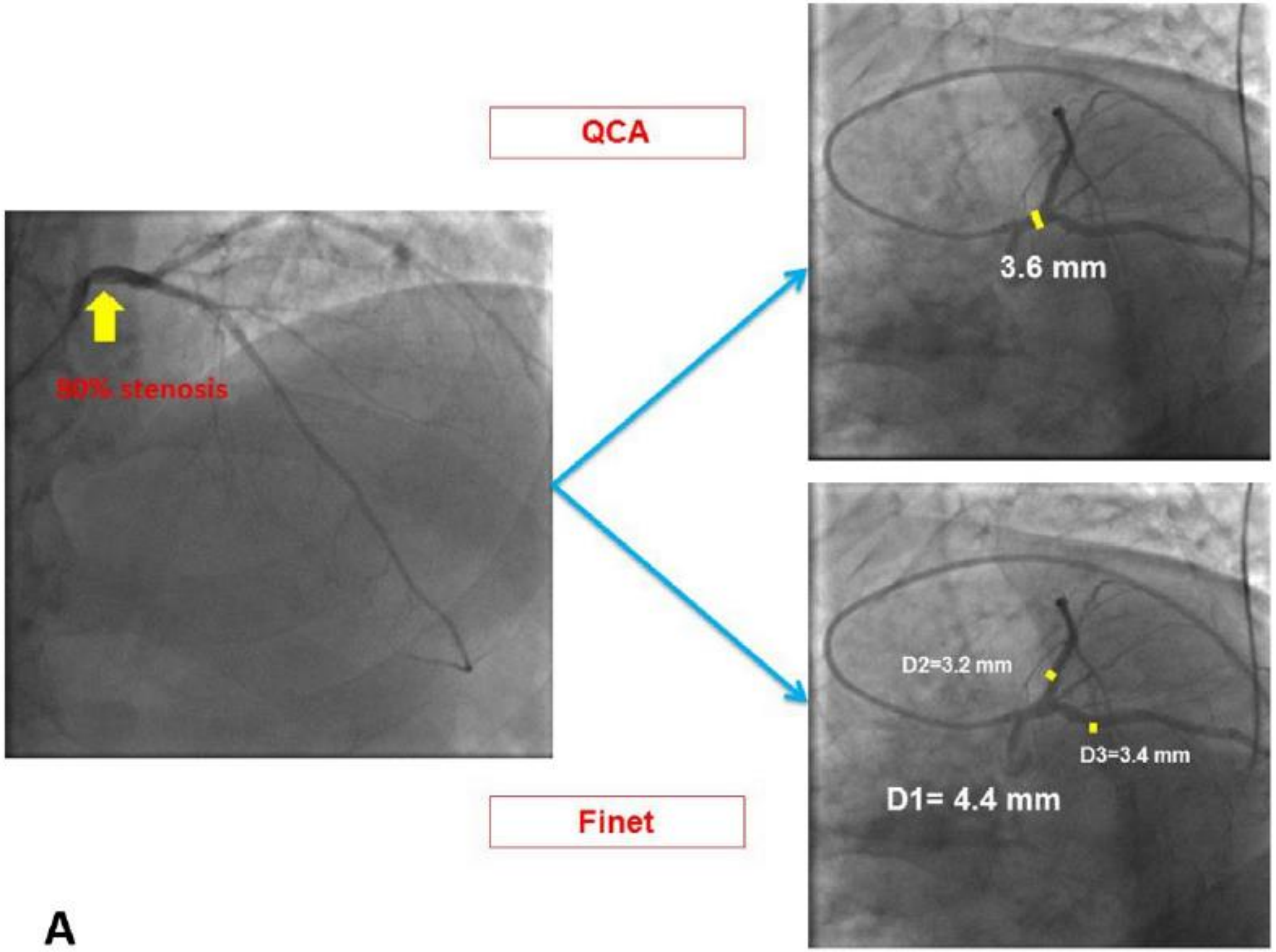


MLD in patients: FD-OCT, IVUS, and QCA



Kubo, J Am Coll Cardiol Img 2013;6:1095–104

Usefulness of the Finet law to guide stent size selection in ostial LM stenting: Comparison with standard angiographic estimation



Rigatelli, Cardiovascular Revascularization Medicine 19 (2018) 751–754

DES Designs Overexpansion

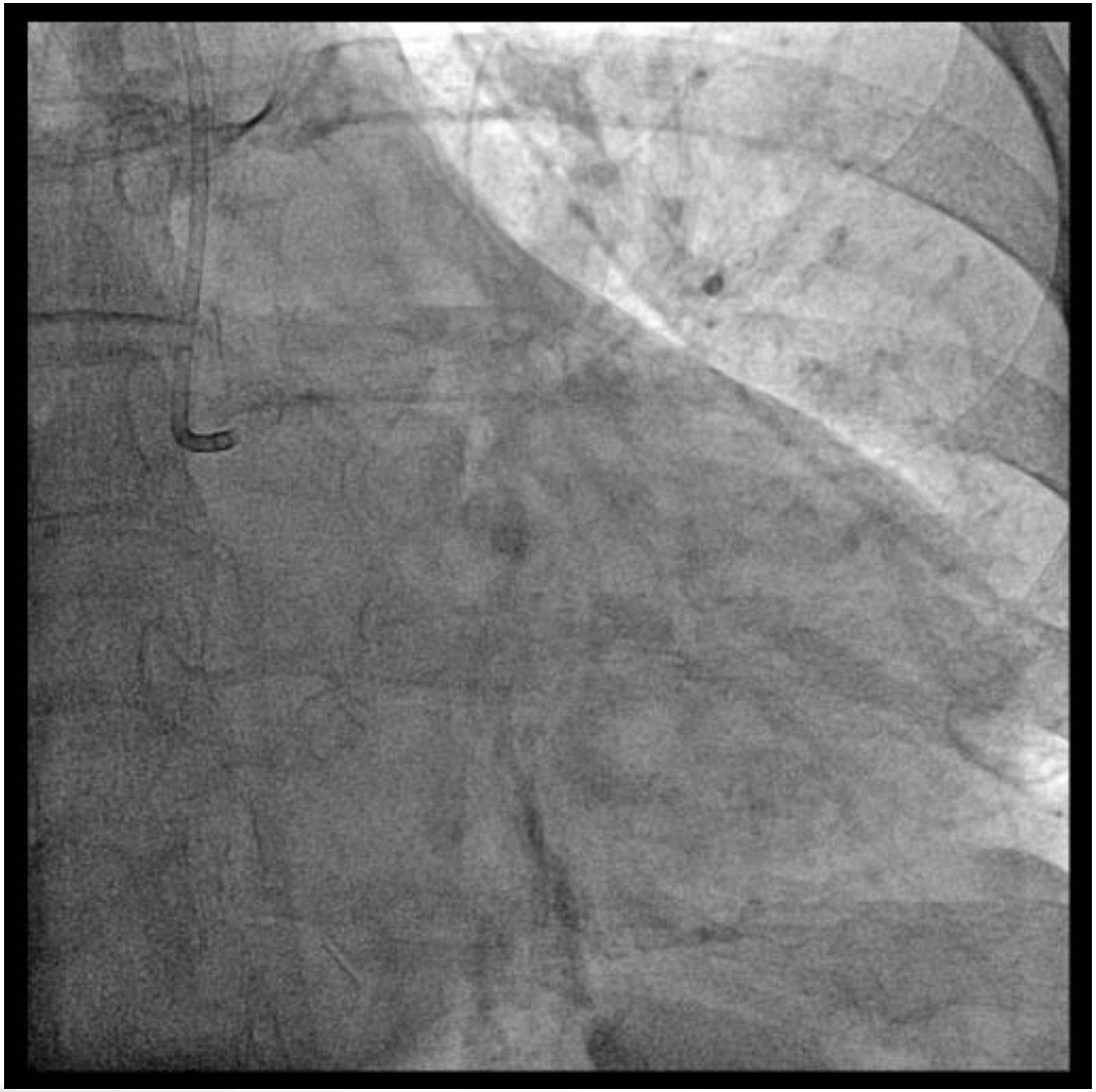
Balloon Max Size		Synergy	Xpedition	Res. Onyx	Ultimaster	BioMatrix A	Orsiro
4.0	2.25	Small vessel (8 crowns, 2-4 connectors) *Expansion: 3.6mm*	Small vessel (6 crowns, 3 connectors) *Expansion: 4.1mm*	Small vessel workhorse (6.5 crowns, 2 connectors) *Expan: 3.3mm*	Small vessel (8 crowns, 2 connectors) *Expansion: 4.3mm*	Small vessel (6 crowns, 2 connectors) *Expansion: 4.1mm*	Small vessel (6 crowns, 3 connectors) *Expansion: 4.0mm*
	2.50						
5.0	2.75			Medium vessel workhorse (8.5 crowns, 2 connectors) *Expansion: 4.4mm*			
	3.00	Workhorse (8 crowns, 2-4 connectors) *Expansion: 4.2mm*					
	3.50		Large vessel (9 crowns, 3 connectors) *Expansion: 5.6mm*	Large vessel (9.5 crowns, 2.5 connectors) *Expansion: 5.6mm*	Large vessel (8 crowns, 2 connectors) *Expansion: 5.8mm*	Large vessel (9 crowns, 3 connectors) *Expansion: 5.9mm*	Large vessel (6 crowns, 3 connectors) *Expansion: 5.3mm*
6.0	4.00	Large vessel (10 crowns, 2-5 connectors) *Exp: 5.7mm*					
	4.50			Extra-Large vessel (10.5 crowns, 2.5 connectors) *Expansion: 6.0mm*			
	5.00						

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

Foin, Ng, 2016

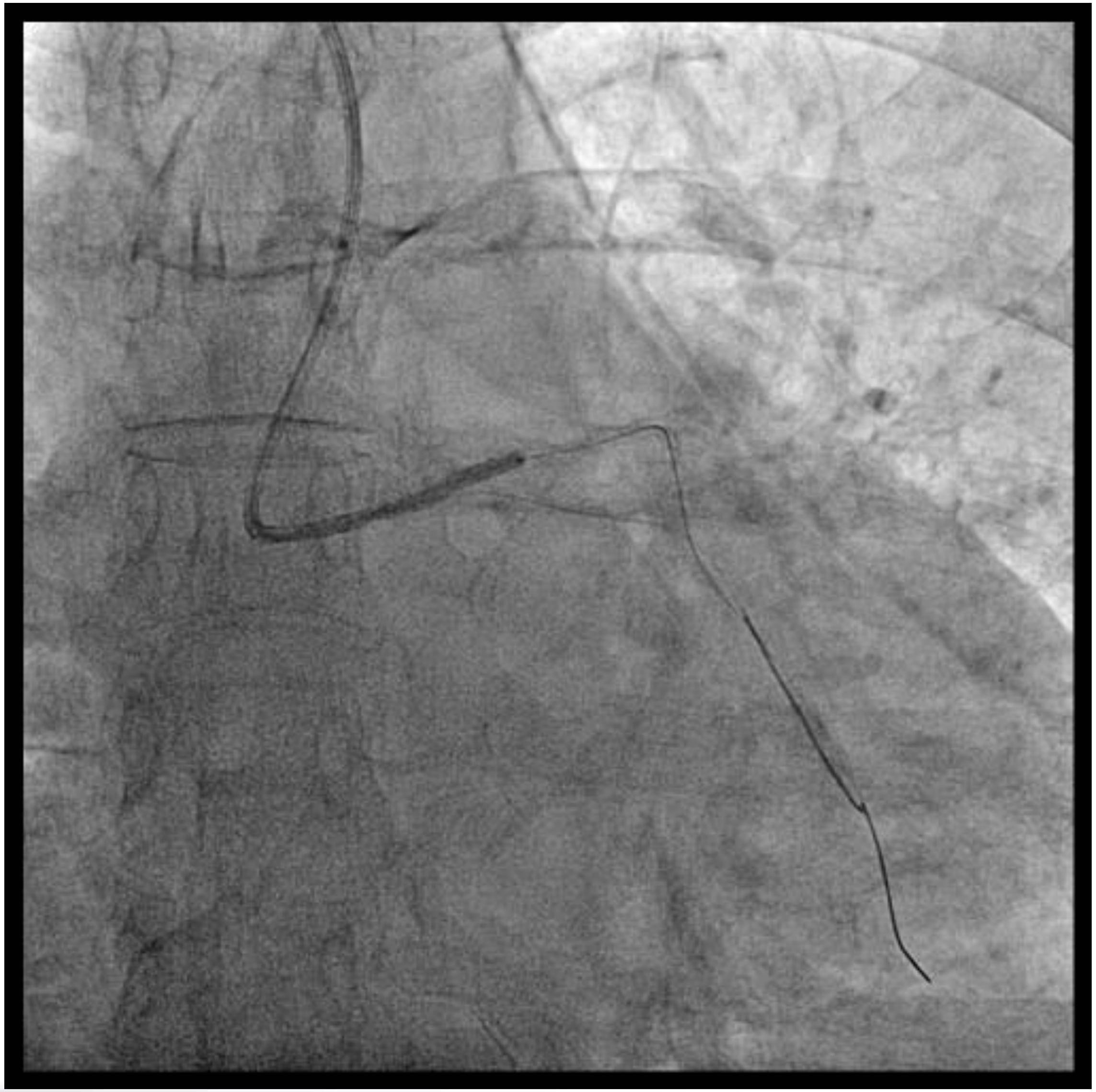
A « SB » occlusion…

Female patient, 70 yo



Live in Euro-PCR

Runthrough ns X 2, Trek 2.5X20



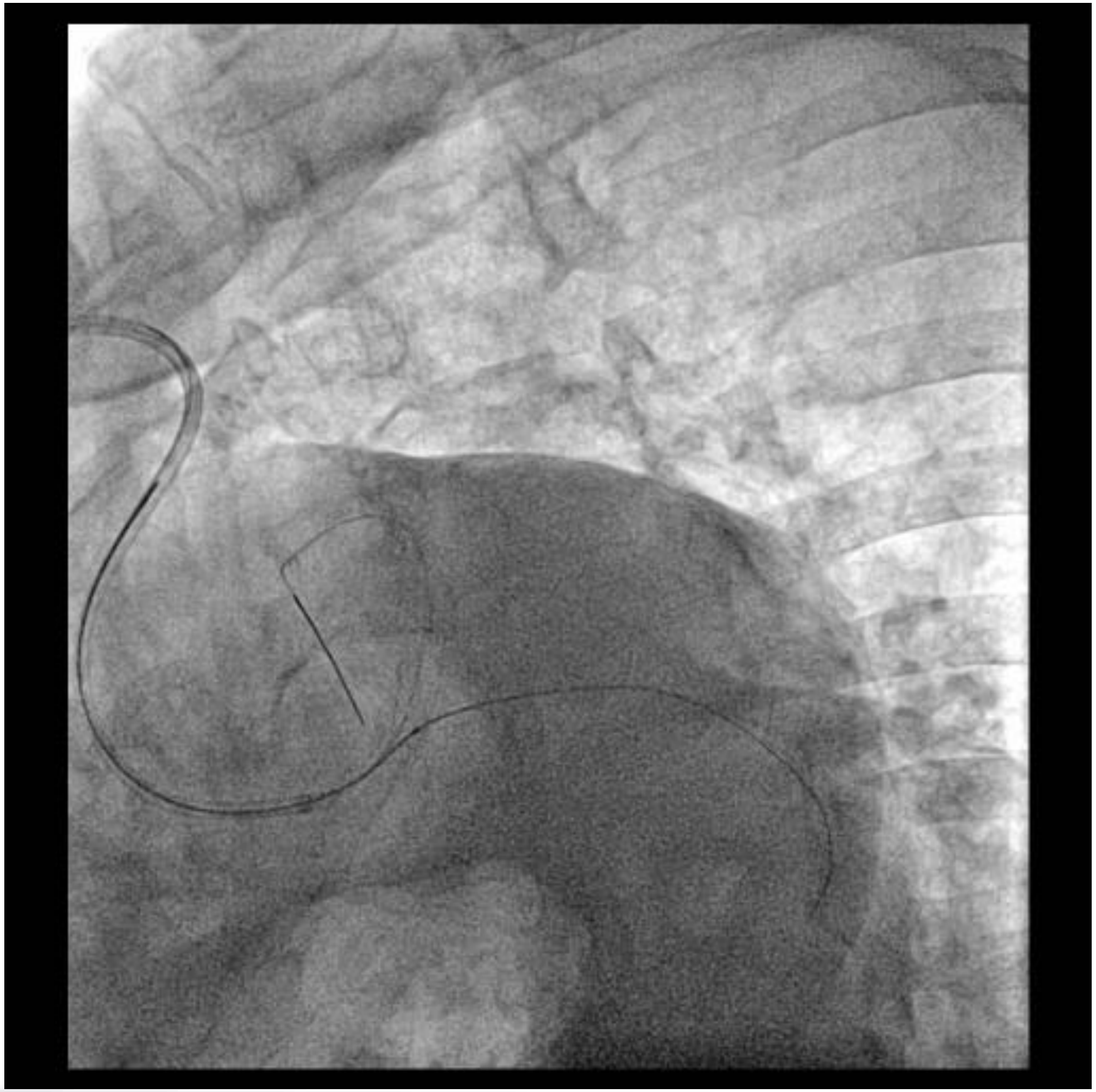
Synergy 3X24

Cx occlusion

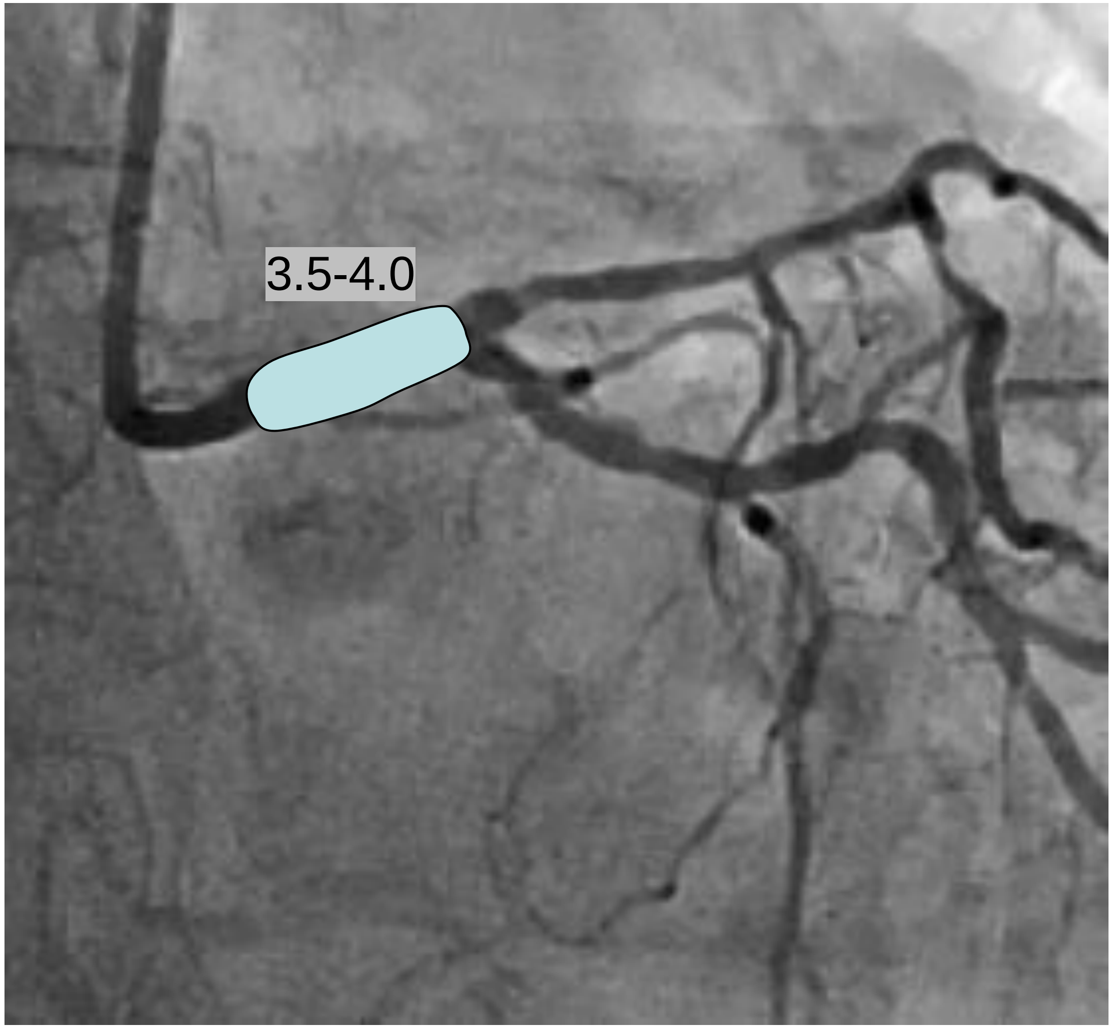
POT 3.5X10

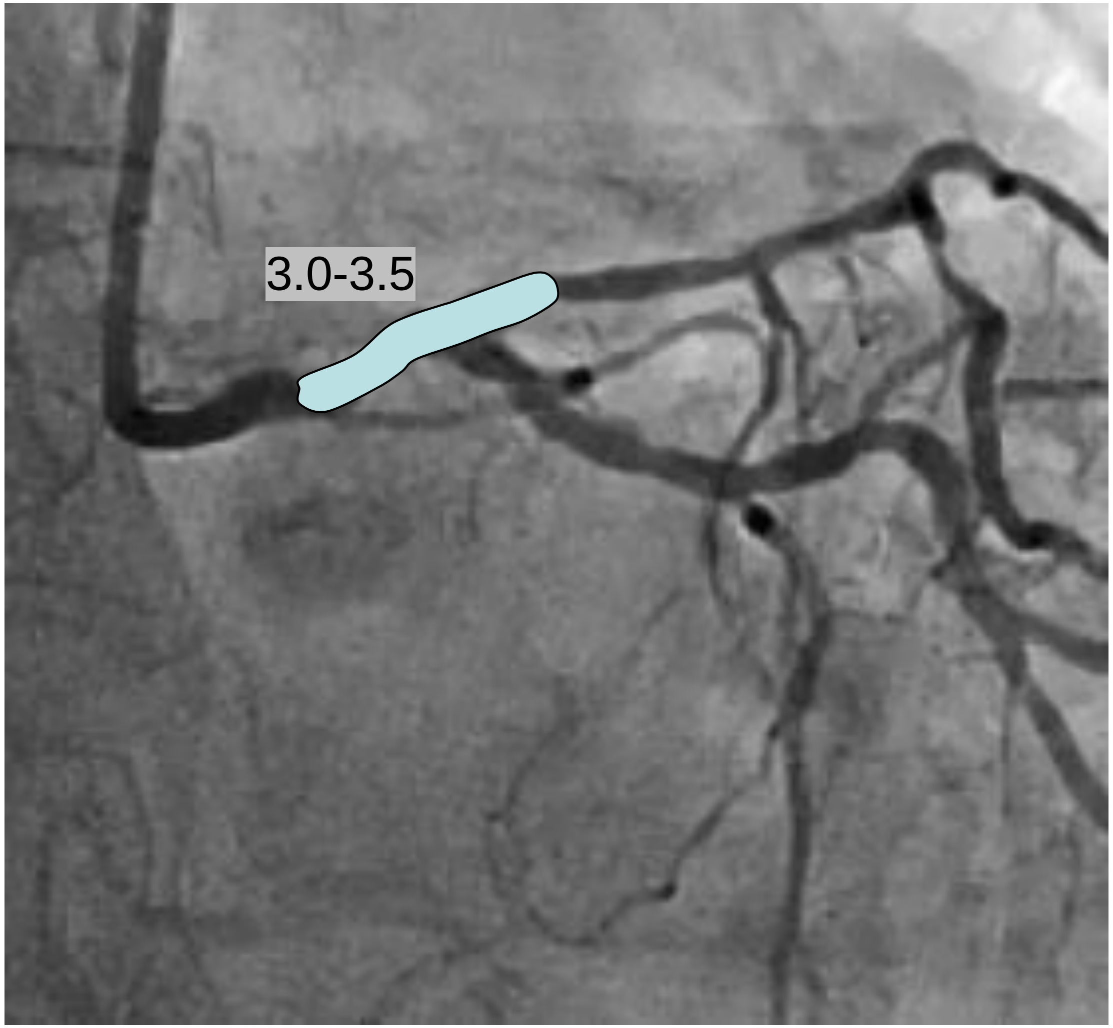
Cx wire failure: Fielder FC, Asahi medium,

Finecross + Fielder XT-A



Result


3.5-4.0


3.0-3.5

Conclusions (1)

- Coronary trees have « pseudo » fractal anatomy
- This anatomy has a distributive fonction in epicardic arteries
- In pathologic conditions it explain development of plaques opposite to the carena
- But this anatomy remains the most effective and has to be respected by treatment
- Particularly important in LM stenting regarding the lethal risk

Conclusions (2)

- Respect the anatomy but how to choose the stent diameters ?
- IVUS is oversizing and QCA undersizing the luminal diameter
- Media to media diameter choice is a provider of SB occlusion ?
- After diameter choice, stent choice using independant maximal expansion measurements is important
- We need bench evaluation of stents in severe curves