FFR basics for bifurcation

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EBC

1. FFR basics for bifurcation

Recommendations for specific percutaneous coronary intervention devices

	Class[a]	Level[b]
FFR-guided PCI is recommended for detection of ischaemia-related lesion(s) when objective evidence of vessel-related ischaemia is not available.	I	A
DES[d] are recommended for reduction of restenosis/re-occlusion, if no contraindication to extended DAPT.	I	A
Distal embolic protection is recommended during PCI of SVG disease to avoid distal embolization of debris and prevent MI.	I	B
Rotablation is recommended for preparation of heavily calcified or severely fibrotic lesions that cannot be crossed by a balloon or adequately dilated before planned stenting.	I	C
Manual catheter thrombus aspiration should be considered during PCI of the culprit lesion in STEMI.	IIa	A
For PCI of unstable lesions, i.v. abciximab should be considered for pharmacological treatment of no-reflow.	IIa	B
Drug-eluting balloons[d] should be considered for the treatment of in-stent restenosis after prior BMS.	IIa	B
Proximal embolic protection may be considered for preparation before PCI of SVG disease.	IIb	B
For PCI of unstable lesions, intracoronary or i.v. adenosine may be considered for pharmacological treatment of no-reflow.	IIb	B
Tornus catheter may be used for preparation of heavily calcified or severely fibrotic lesions that cannot be crossed by a balloon or adequately dilated before planned stenting.	IIb	C
Cutting or scoring balloons may be considered for dilatation of in-stent restenosis, to avoid slipping-induced vessel trauma of adjacent segments.	IIb	C
IVUS-guided stent implantation may be considered for unprotected left main PCI.	IIb	C
Mesh-based protection may be considered for PCI of highly thrombotic or SVG lesions.	IIb	C
For PCI of unstable lesions, intracoronary nitroprusside or other vasodilators may be considered for pharmacological treatment of no-reflow.	IIb	C

Wijns, European Heart Journal 2010

2. FFR basics for bifurcation

1. Fractional flow reserve is the ratio of hyperaemic myocardial flow in the stenotic territory (Q_S^{max}) to normal hyperaemic myocardial flow (Q_N^{max})

$$FFR = \frac{Q_S^{max}}{Q_N^{max}} \quad \text{(Empiric definition)}$$

2. Since the flow (Q) is the ratio of the pressure (P) difference across the coronary system divided by its resistance (R), Q can be substituted as following:

$$FFR = \frac{(P_d - P_v)/R_S^{max}}{(P_a - P_v)/R_N^{max}}$$

3. Since the measurements are obtained under maximal hyperaemia, resistances are minimal and therefore equal, and thus they cancel out;

$$FFR = \frac{(P_d - P_v)}{(P_a - P_v)}$$

4. In addition P_v is negligible as compared to P_a or P_d, therefore,

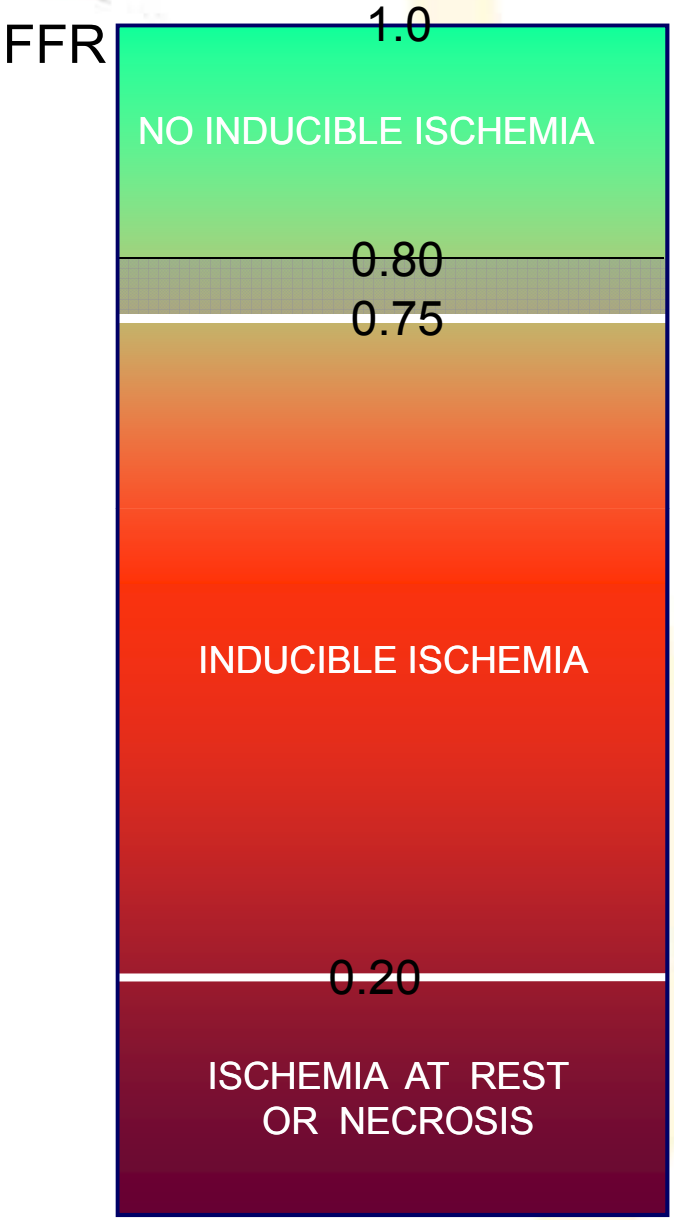
$$FFR = \frac{P_d}{P_a} \quad \text{(Practical measurement)}$$

During maximal hyperemia

(i.e. during maximal transstenotic flow)

Pijls NHJ et al Circulation 1993
De Bruyne et al JACC 1993
De Bruyne et al Circulation 1994

3. Cut-Off Values of FFR



Lesions do not cause symptoms
Favorable clinical outcome

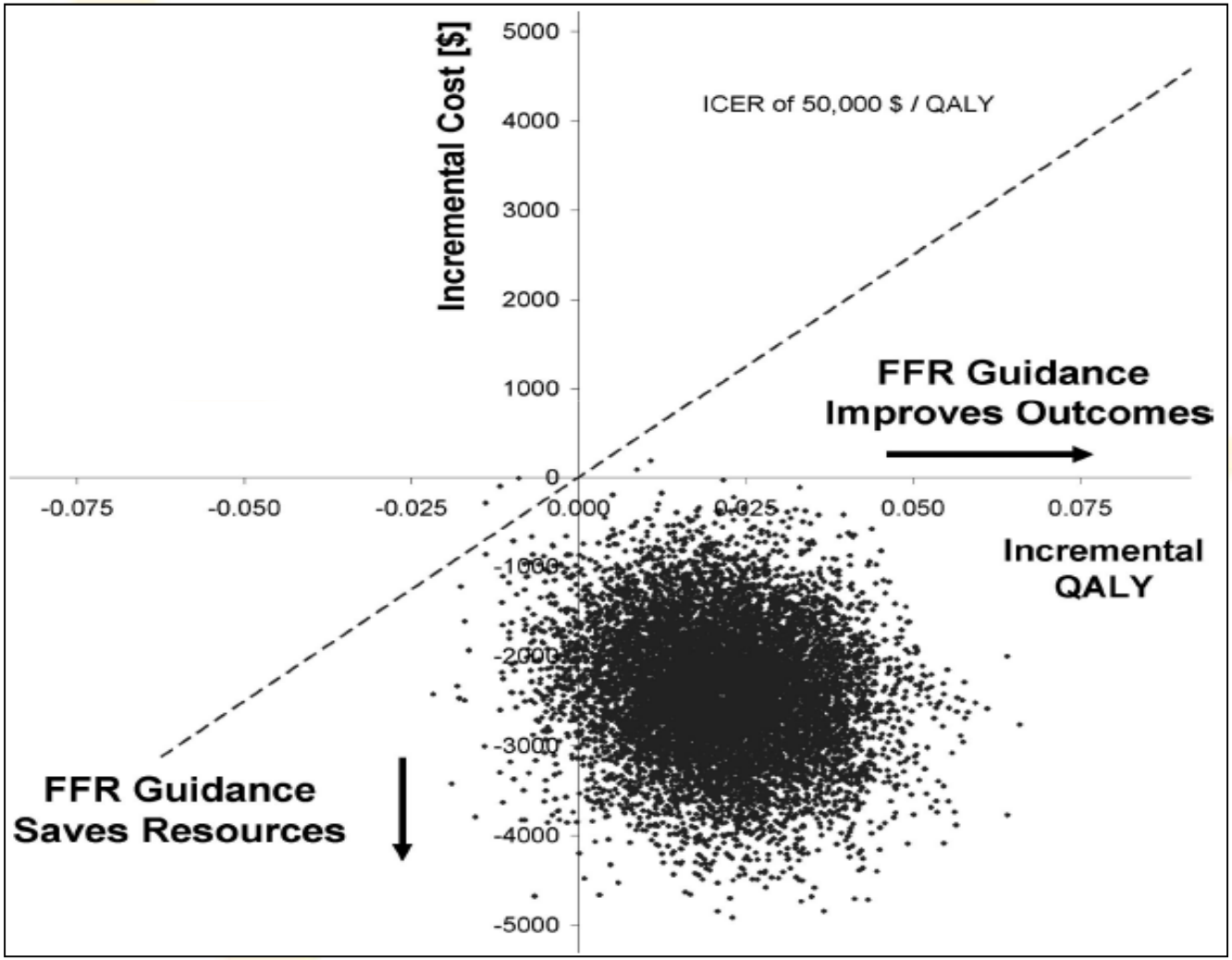
➔ Medical treatment

Lesions cause symptoms
Poor clinical outcome

➔Medical treatment
+
➔Revascularization

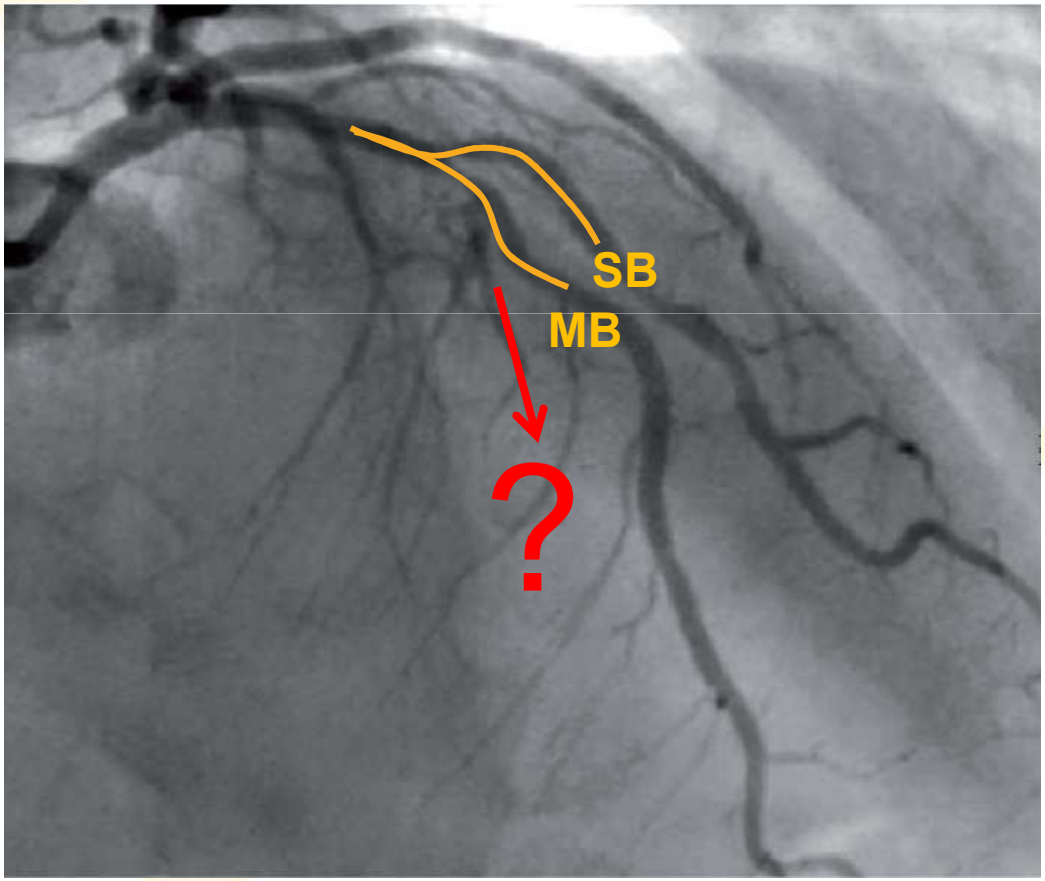
De Bruyne et al.	*Circ 1995*
Pijls et al.	*Circ 1995*
Pijls&De Bruyne	*NEJM 1996*
Bartunek et al.	*JACC 1996*
Chamuleau et al.	*JACC 2000*
Abe et al.	*Circ 2000*
De Bruyne et al	*Circ 2001*

4. FAME Trial



Fearon et al Circulation 2010

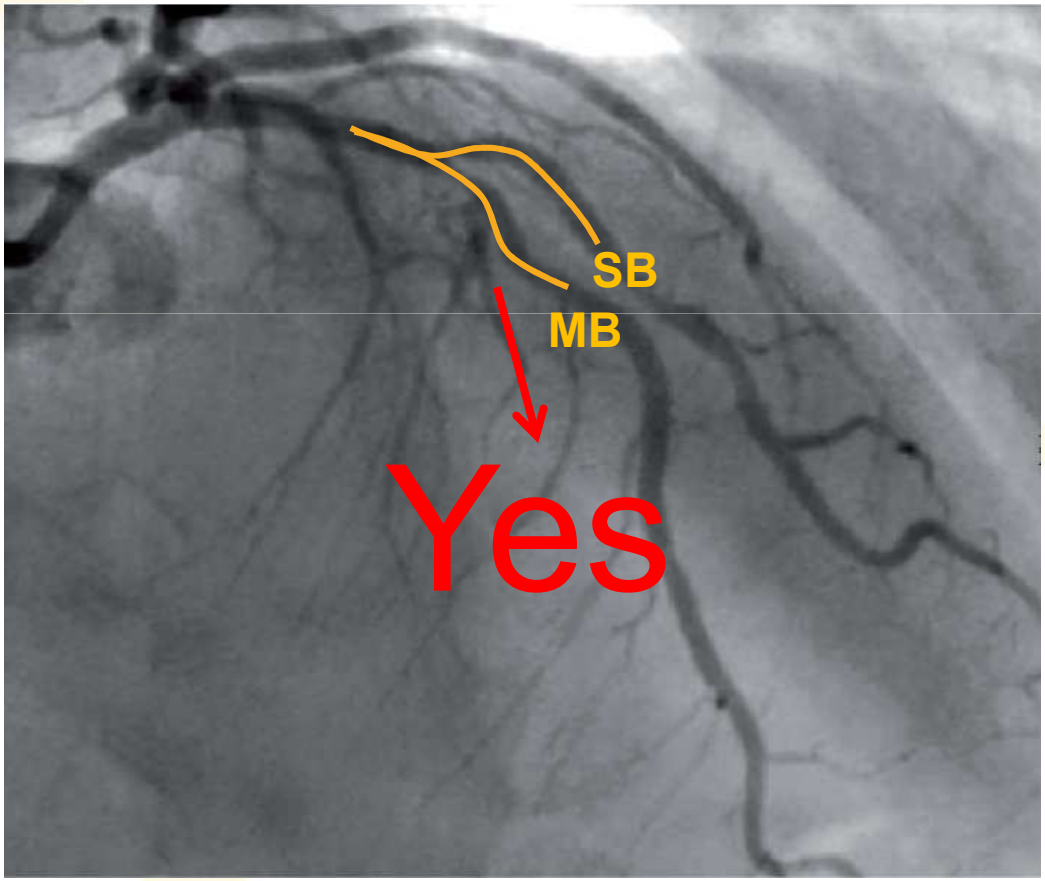
FFR and MB before PCI



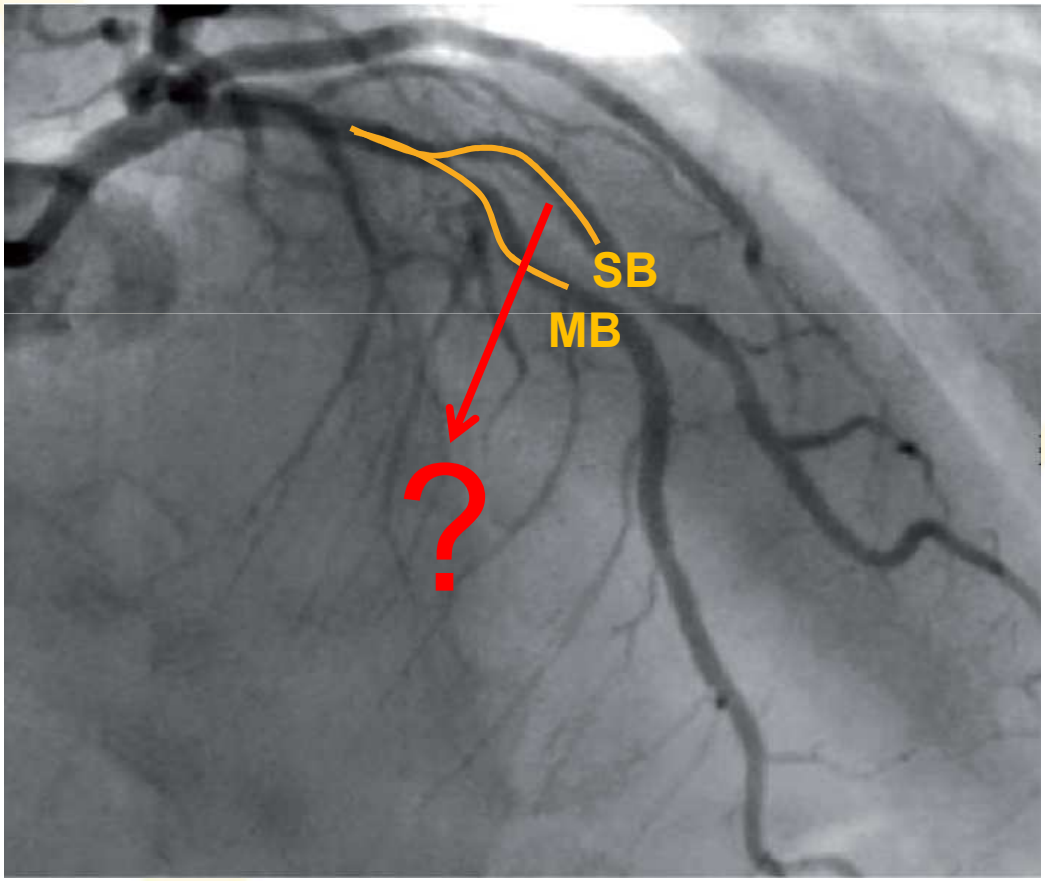
The Value of FFR in terms of Clinical Outcome Has Been Validated in patients with

1. Intermediate stenoses (*Pijls et al. New Engl J Med 1996*) (*Pijls et al. JACC 2010*)
2. Post-myocardial setting (*De Bruyne et al Circulation 2001*) (*Ntalianis et al. JACCInterv 2010*)
3. Multivessel Disease (*Tonino et al. New Engl J Med 2009*)
4. Left main stenosis (*Hamilos, Muller et al. Circulation 2009*)
5. Proximal LAD stenosis (*Muller et al. JACCInterv 2011*)

FFR and MB before PCI



FFR and SB before PCI



Read the Guidelines

11.2 Specific lesion subsets

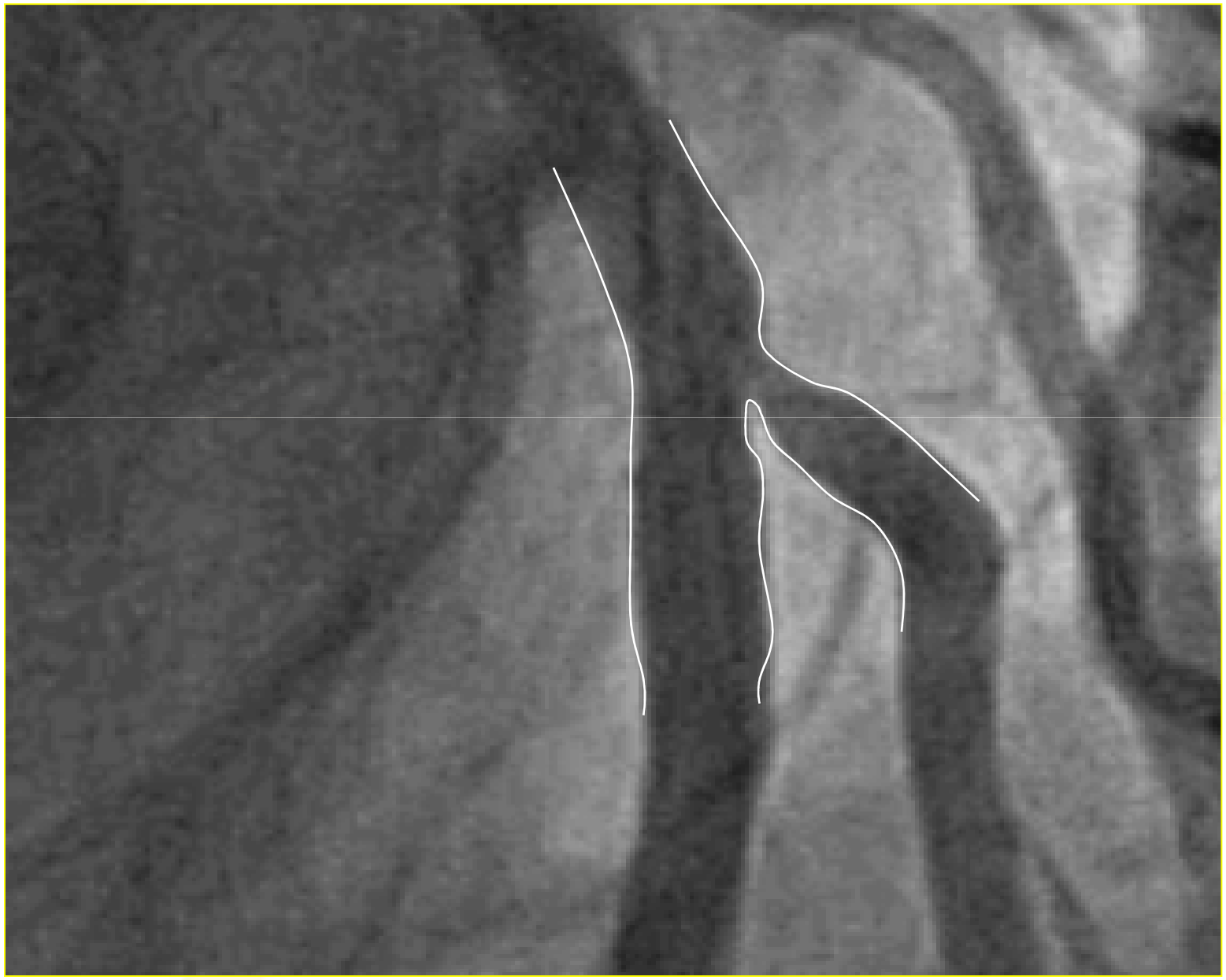
Bifurcation stenosis

Coronary stenoses are frequently located at bifurcations and bifurcation lesions still represent a major challenge for PCI, in terms of both procedural technique and clinical outcome. Bifurcation lesions are best described according to the Medina classification. Despite many attempts with a variety of different stenting has not yet been established. Variables to be considered are plaque distribution, size and downstream territory of each vessel (main and side branch), and the bifurcation angle. Stent implantation with or without stenting of the side branch, seems preferable compared with routine stenting of both vessels. FFR data from side branches suggest that angiography overestimates the functional severity of side branch stenosis. Final kissing balloon dilatation is recommended when two stents are eventually required. Several stents designed specifically for treatment of bifurcation lesions have undergone extensive evaluation with good angiographic and clinical results, especially with side branch size >2.5 mm. Comparative RCTs vs. provisional stenting are lacking.

The above comments apply to PCI of (unprotected) LM lesions, when indicated (Section 6). For bifurcation and LM lesions, DES are preferred with special attention to adequate sizing and deployment. For treatment of small vessels (<2.5 mm), DES with strong antiproliferative properties (late lumen loss ≤0.2 mm) are preferred to reduce restenosis rates.[210]

Wijns, European Heart Journal 2010

Mach band in bifurcation

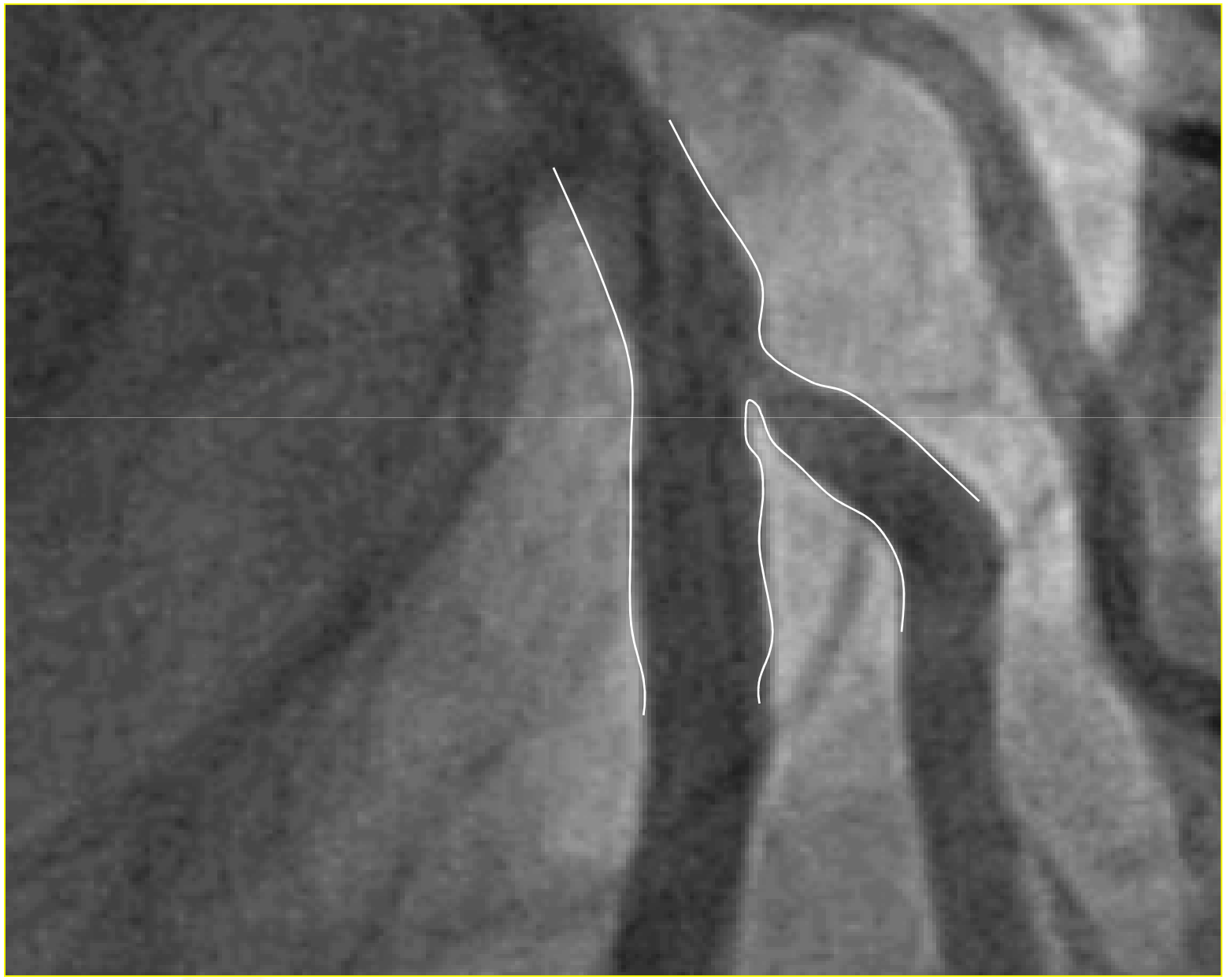


Lateral Inhibition
(or Mach band visual effect)

"Mach bands are an optical illusion consisting of an image of two wide bands, one light and one dark, separated by a narrow strip with a light-to-dark gradient. The human eye perceives two narrow bands of different *brightnesses* either side of the gradient that are not present in the original image."

http://en.wikipedia.org/wiki/Lateral_inhibition

Mach band in bifurcation



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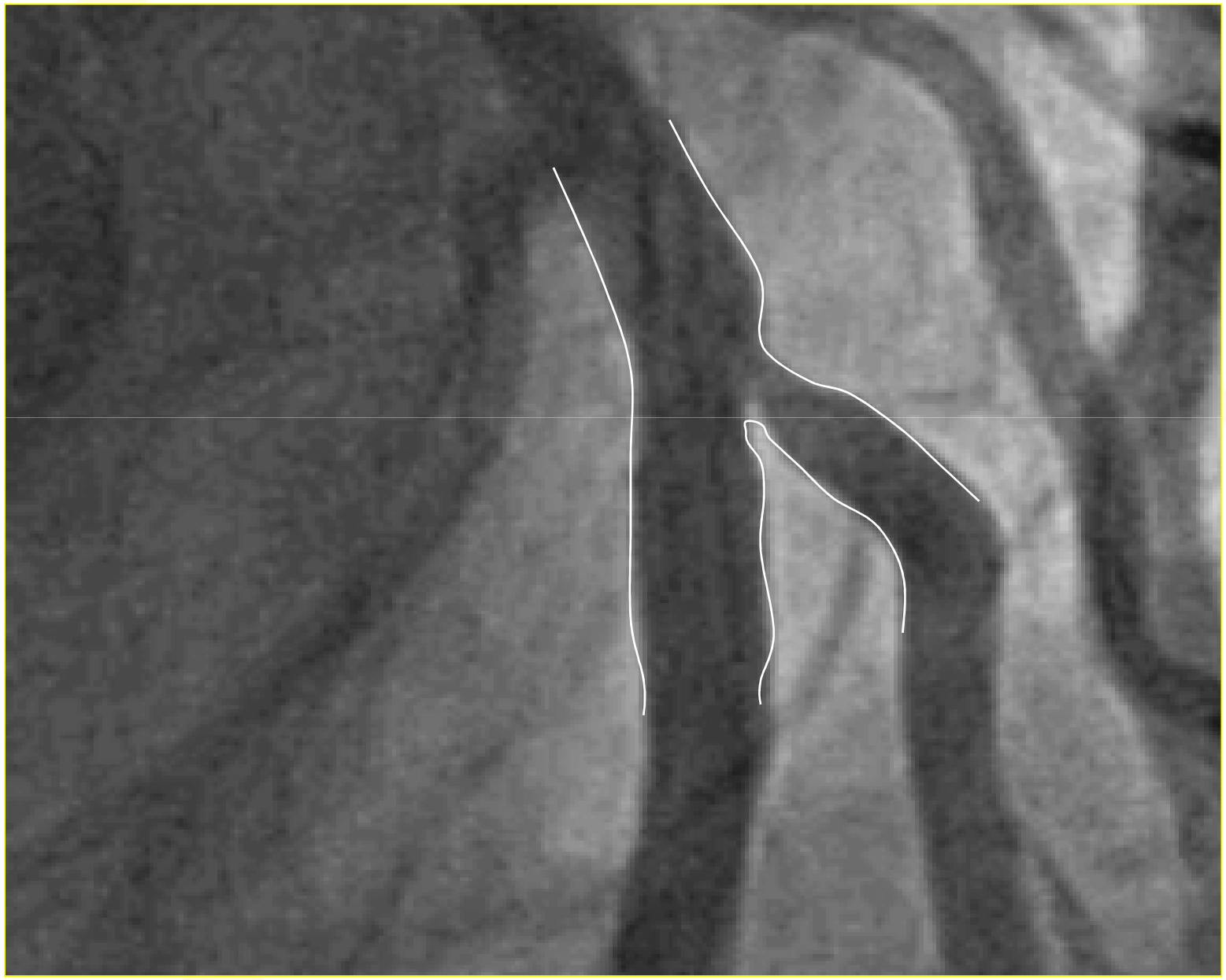
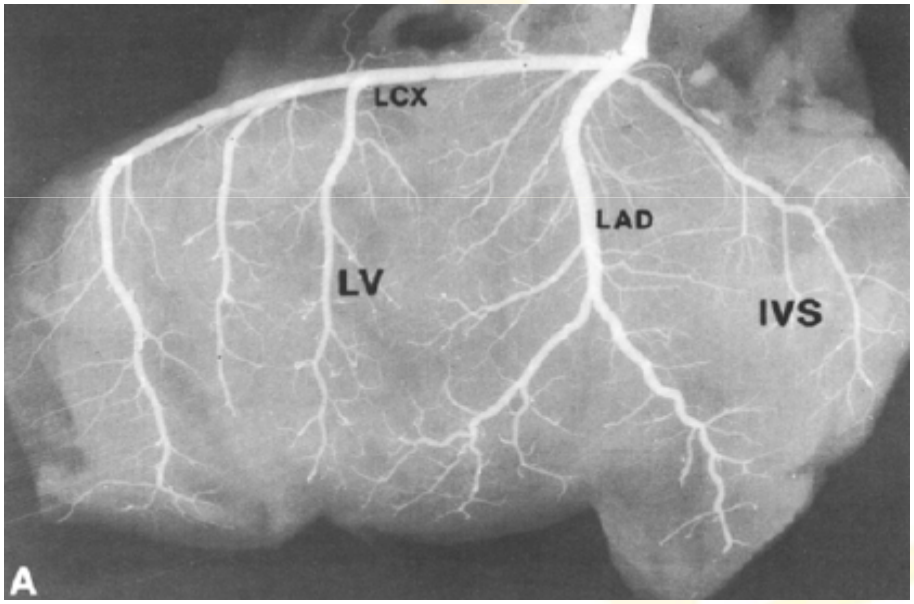
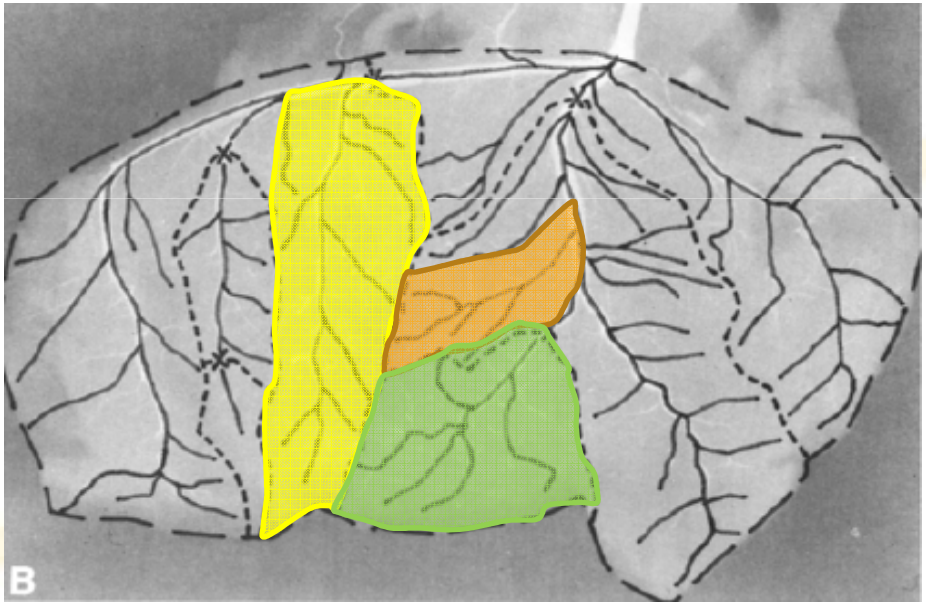


Mass of myocardium at risk

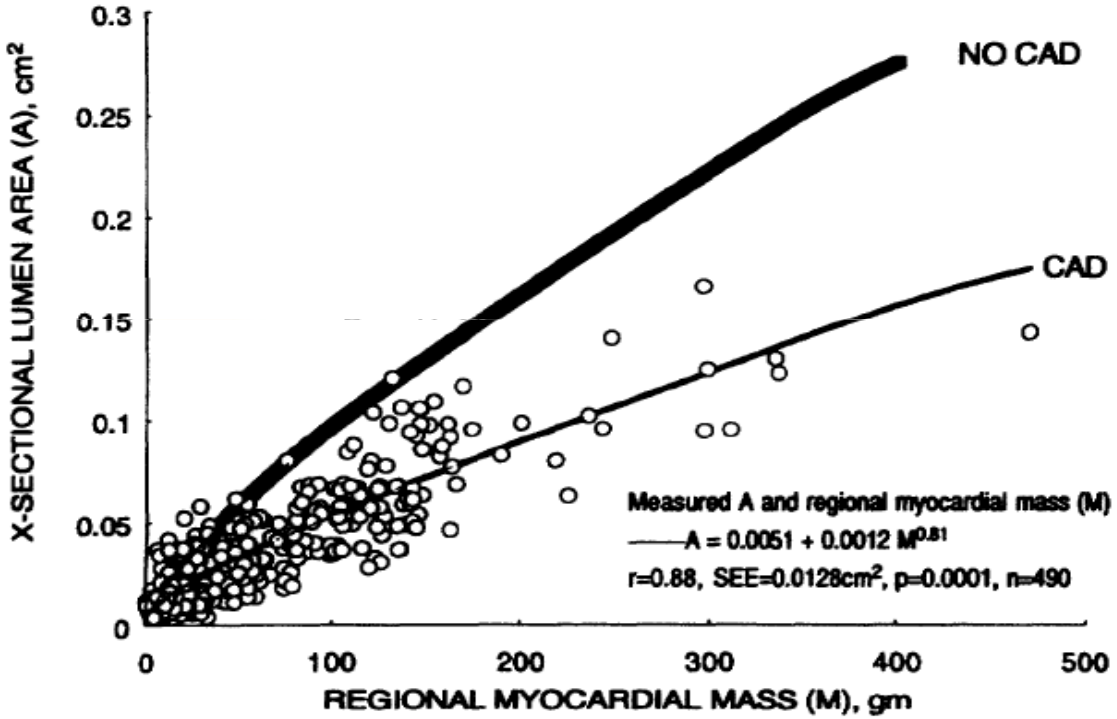




The amount of myocardium supplied by side branch is relatively small and highly variable

Seiler Am Coll Cardiol. 1993

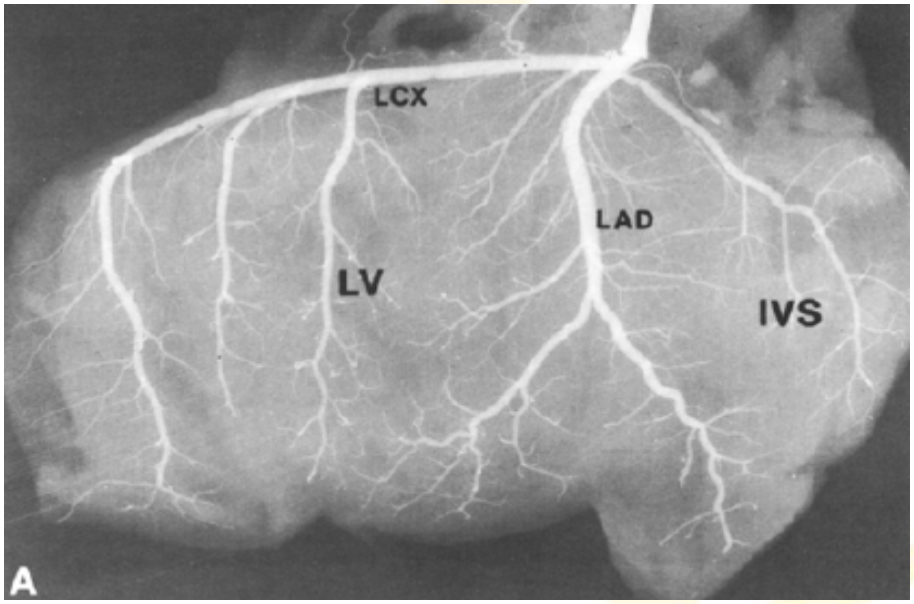
Relation between Vessel Size and Myocardial Mass

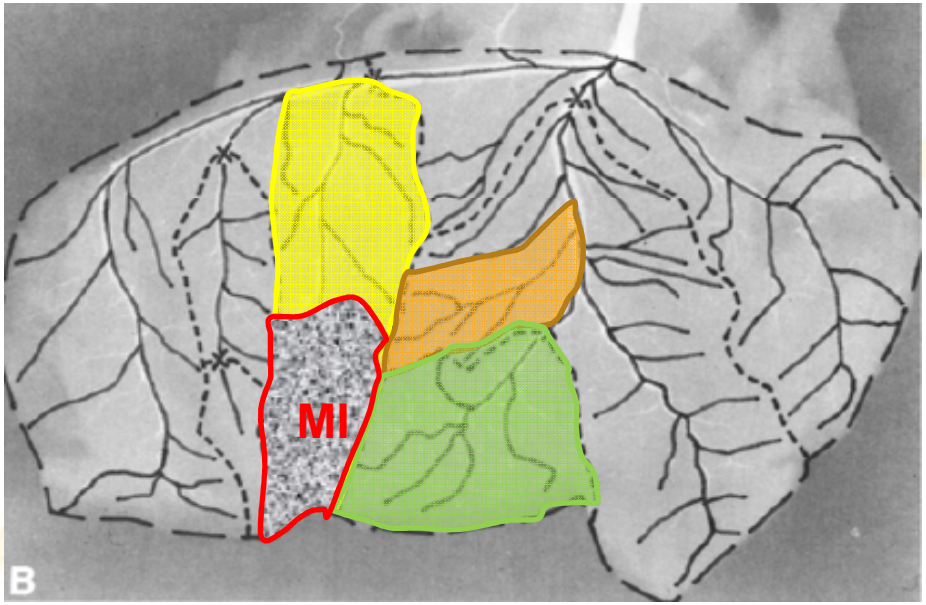


The relation vessel size – myocardial mass in CAD patients can be misleading

Seiler, Circulation 1992

Mass of myocardium at risk





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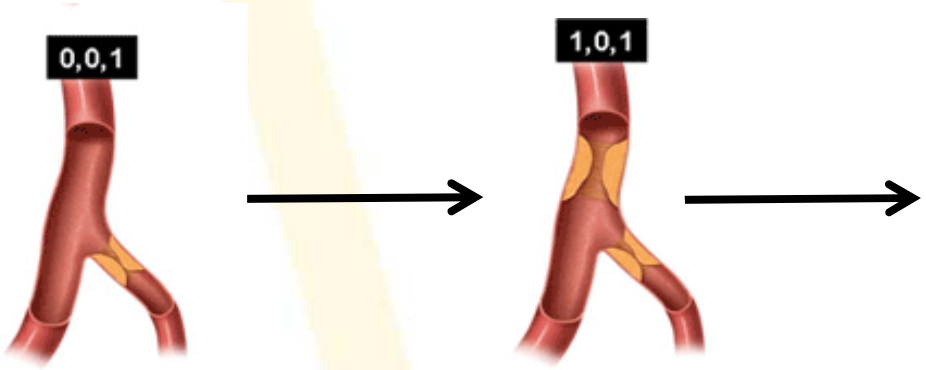
FFR and SB before PCI

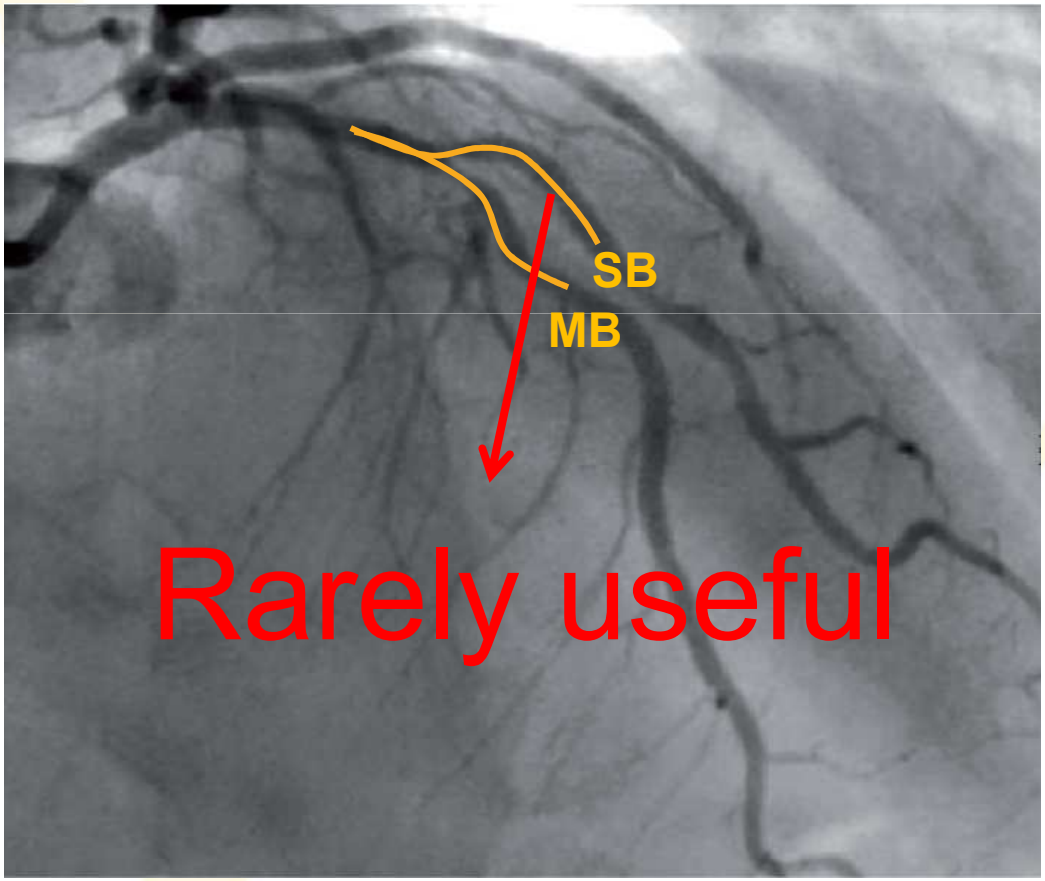
1. 

FFR overestimates the severity

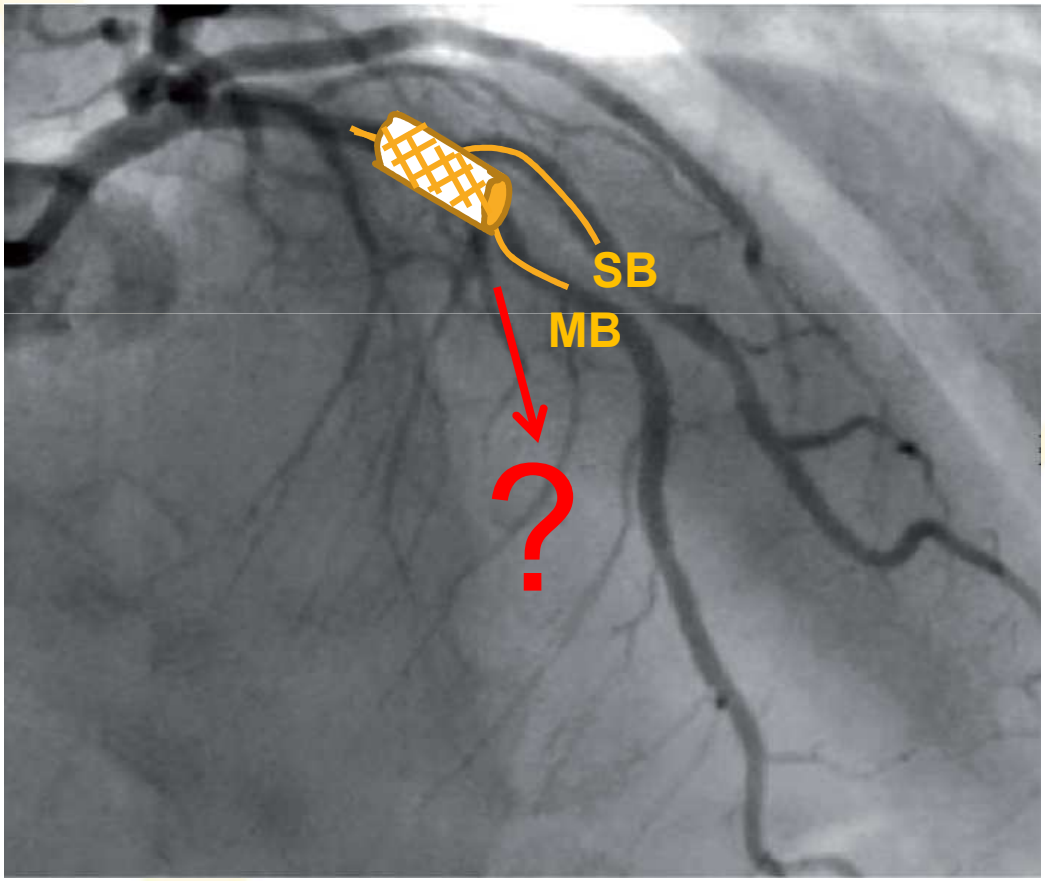
2. Jailing of a pressure wire between the stent and the vessel wall is not recommended

3. Anatomical changes after MB stenting: carina shift, stent struts

FFR and SB before PCI



FFR and MB after PCI



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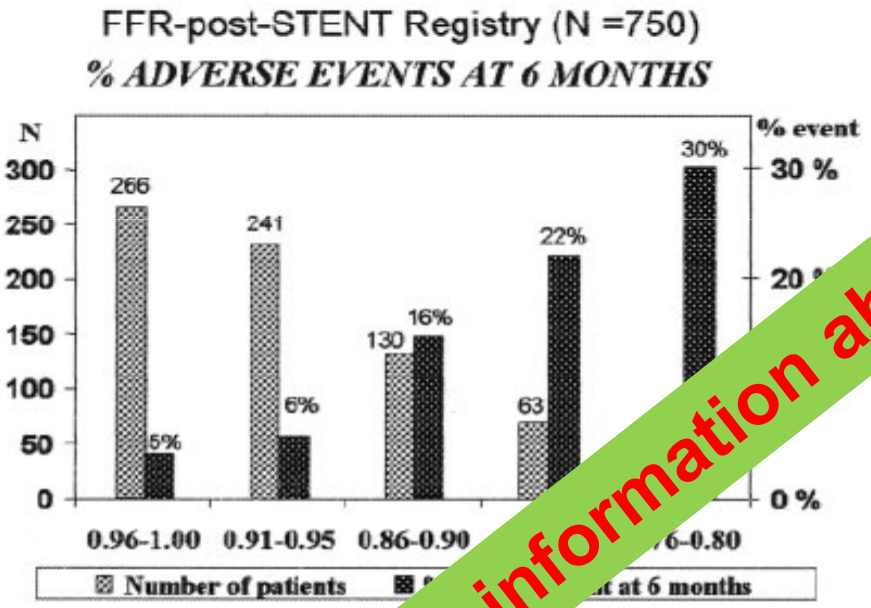


No information about bifurcation lesion

According to Whether a Post-Stent FFR ≤0.90 or <0.90

	Post-Stent FFR >0.90 (n = 424)	Post-Stent FFR <0.90 (n = 162)	p Value
Death	3 (0.7%)	1 (0.6%)	NS
Myocardial infarction	4 (0.9%)	8 (4.9%)	<0.001
Revascularization	21 (4.9%)	24 (14.8%)	<0.001
CABG	4 (0.9%)	9 (5.5%)	<0.001
PCI	17 (4.0%)	15 (9.3%)	0.01
Any MACE	24 (5.7%)	31 (19.1%)	<0.001

Pijls, Circulation 2002

Samady, JACCinterv 2009

FFR and MB after PCI

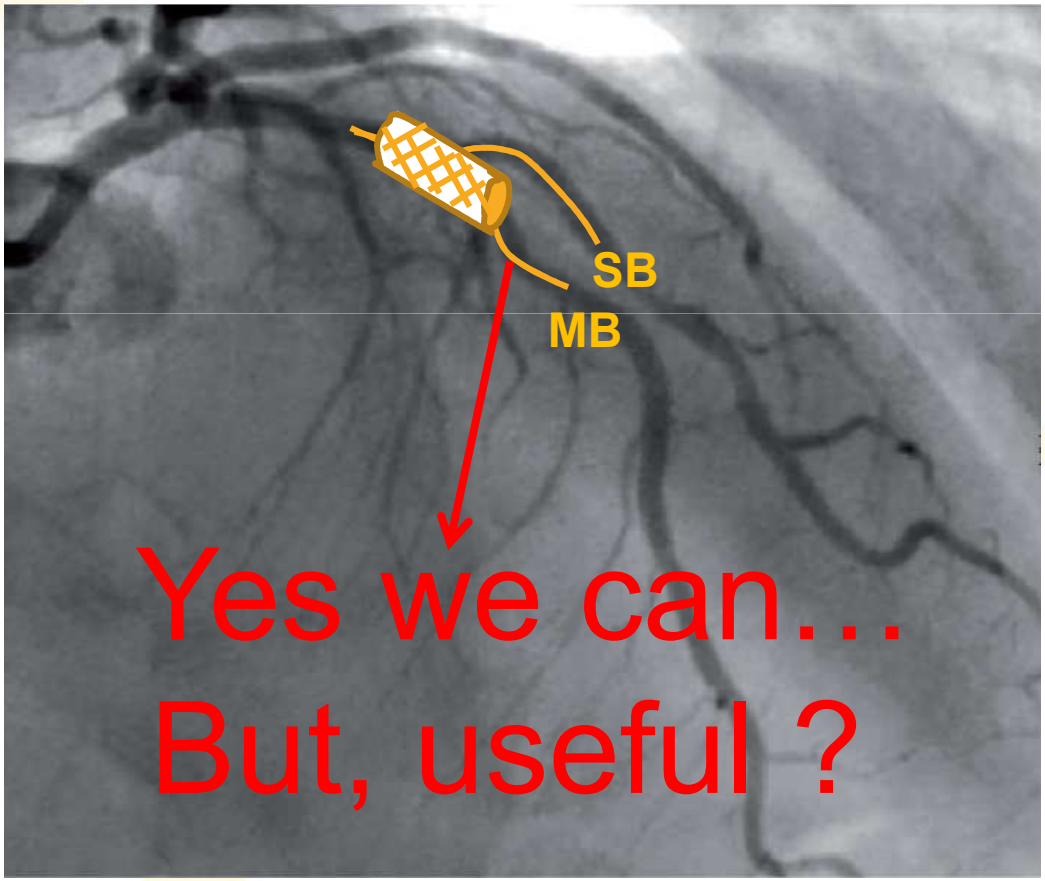
Table 2 Serial changes in fractional flow reserve during 6-month follow-up

	Post-intervention	Follow-up	*P*-value[a]
Main branch	0.96 ± 0.04	0.96 ± 0.04	0.9
Jailed side branch	0.87 ± 0.06	0.87 ± 0.09	0.7
KB group	0.86 ± 0.05	0.84 ± 0.11	0.4
Non-KB group	0.87 ± 0.06	0.89 ± 0.07	0.1

KB, kissing balloon inflation.
[a]Not adjusted for multiple comparisons.

Koo, European Heart Journal (2008)

FFR and MB after PCI



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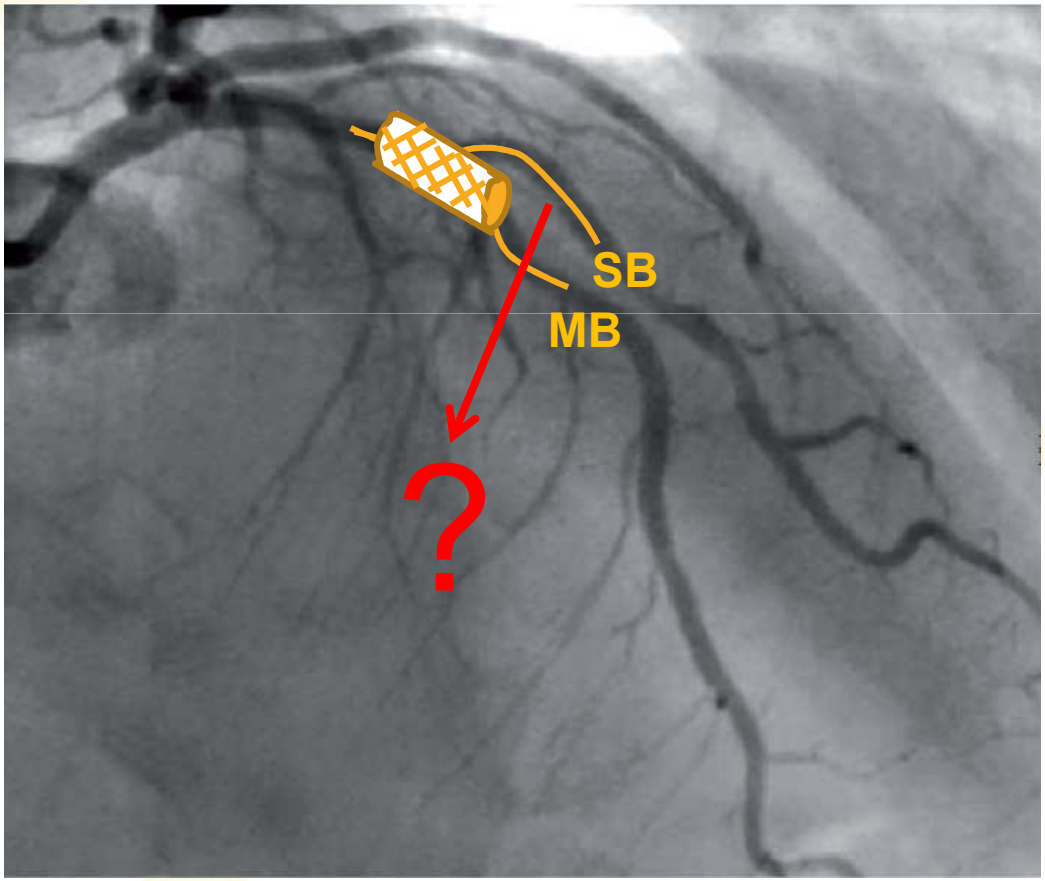

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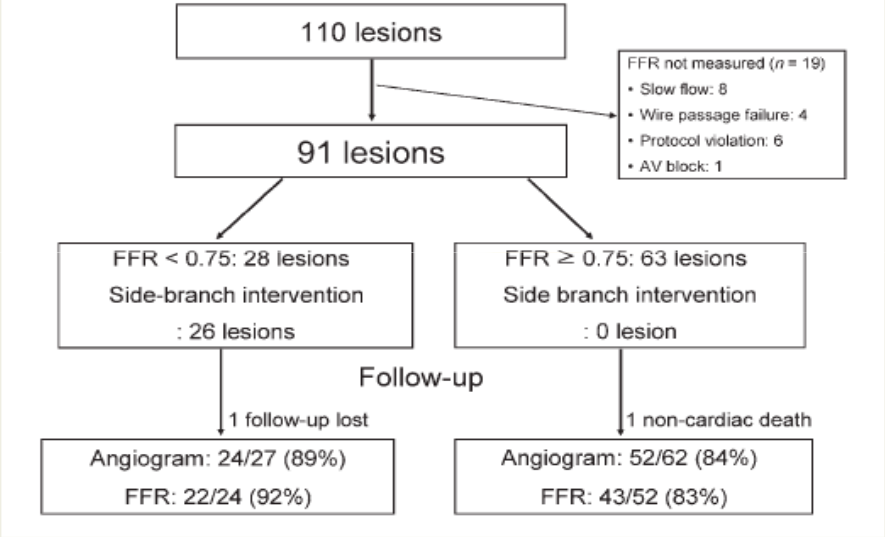

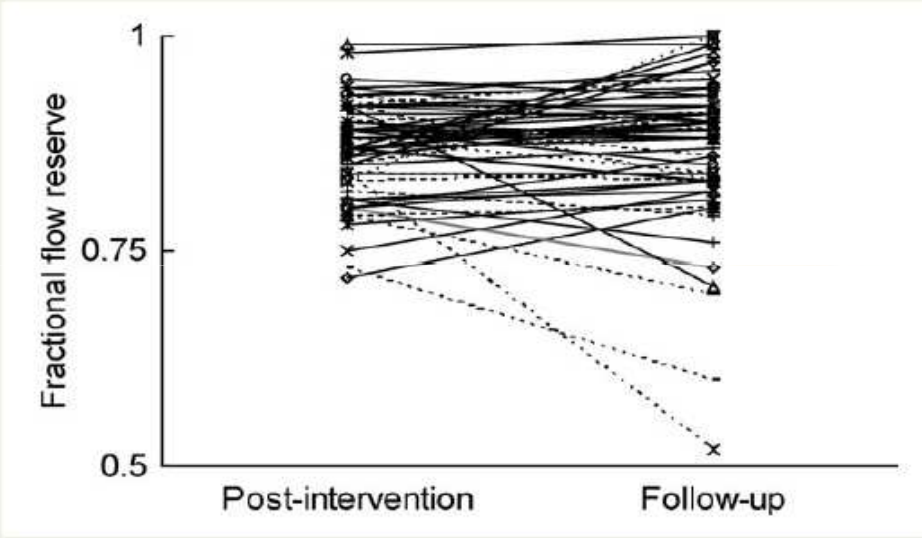

1. FFR-guided provisional SB intervention strategy is feasible and effective

2. Functional status of jailed SB lesions after DES implantation does not change significantly during follow-up

Koo, European Heart Journal (2008)

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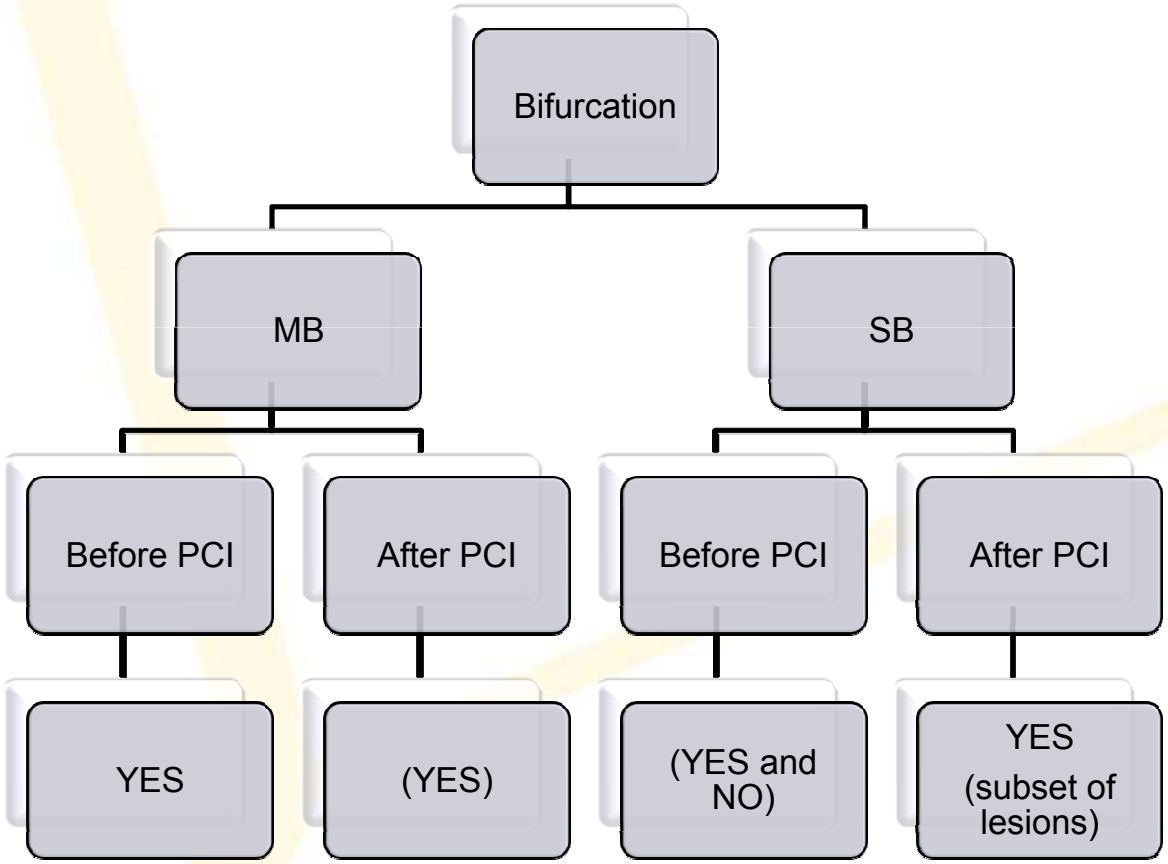

FFR →

Thanks

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