Function-guided Bifurcation PCI

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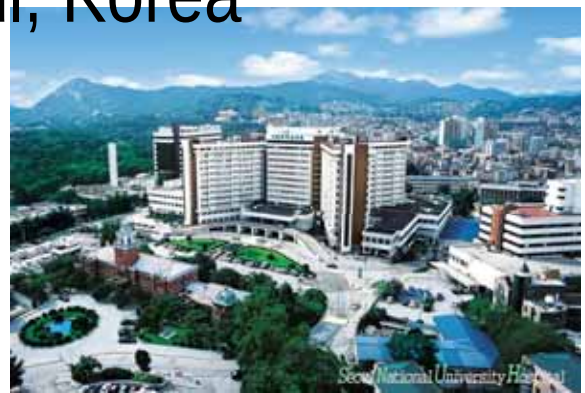
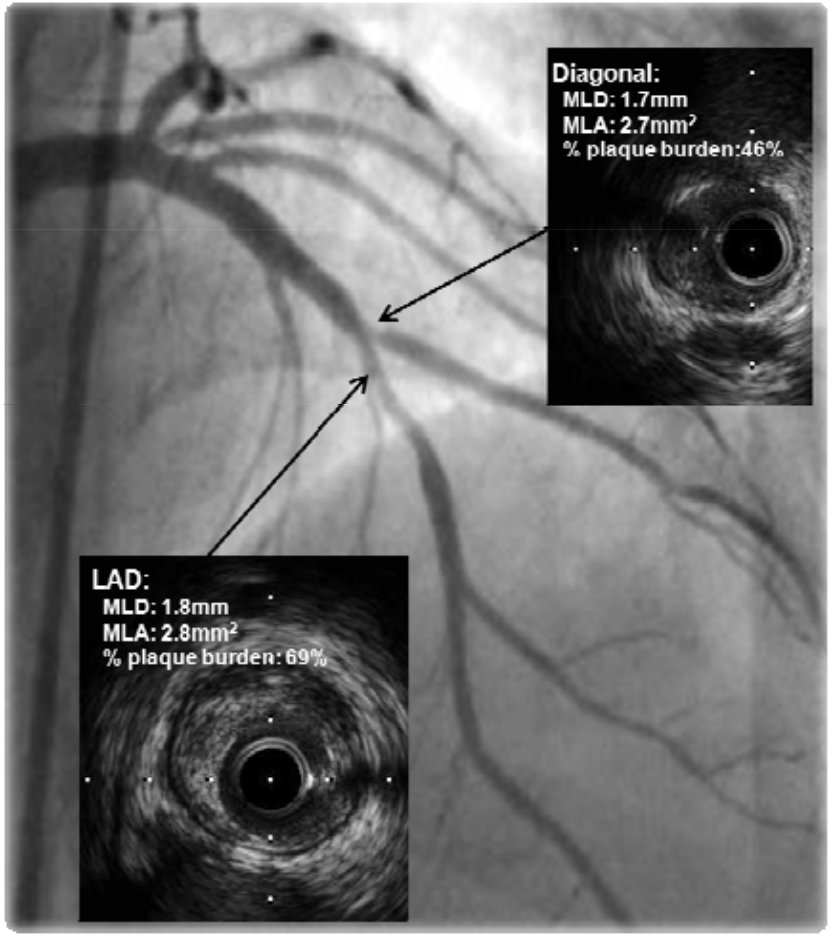
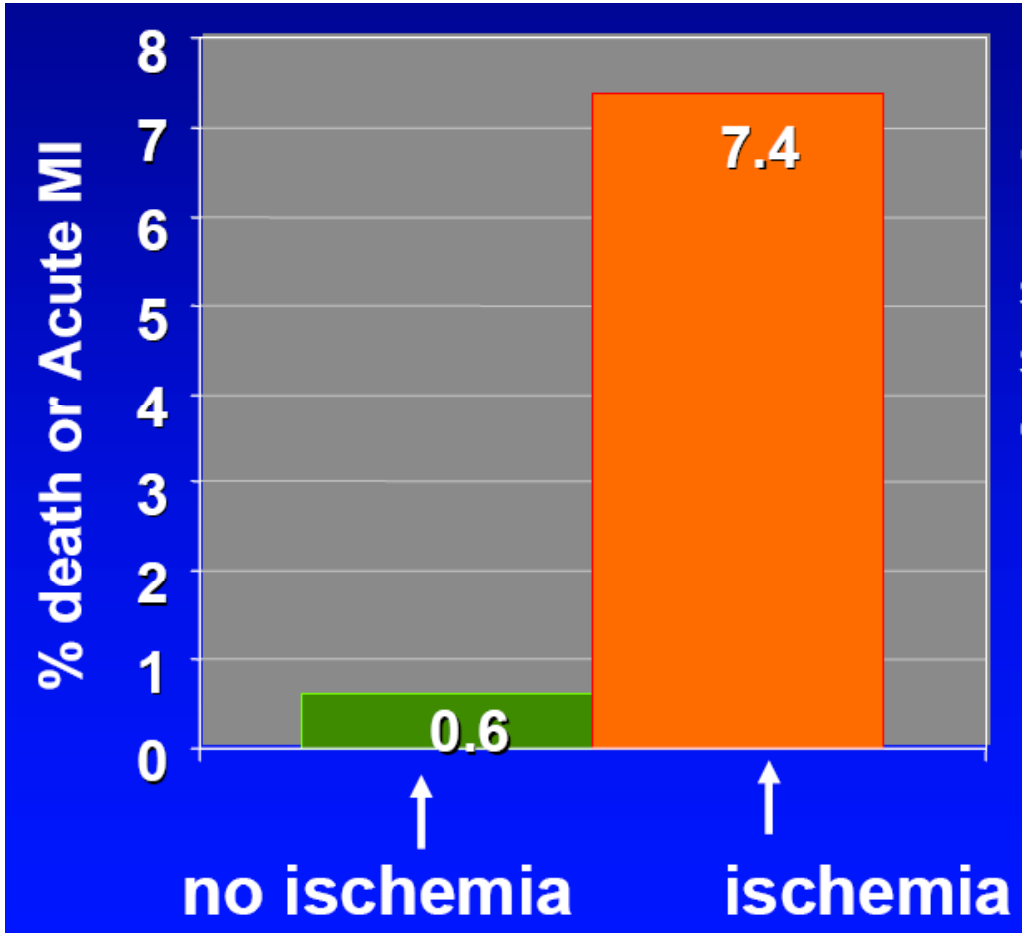


The most important prognostic factor is "Presence of Ischemia"!





Iskander, et al. JACC 1998

Determinants of Myocardial ischemia

: Anatomy ***vs. Ischemia***

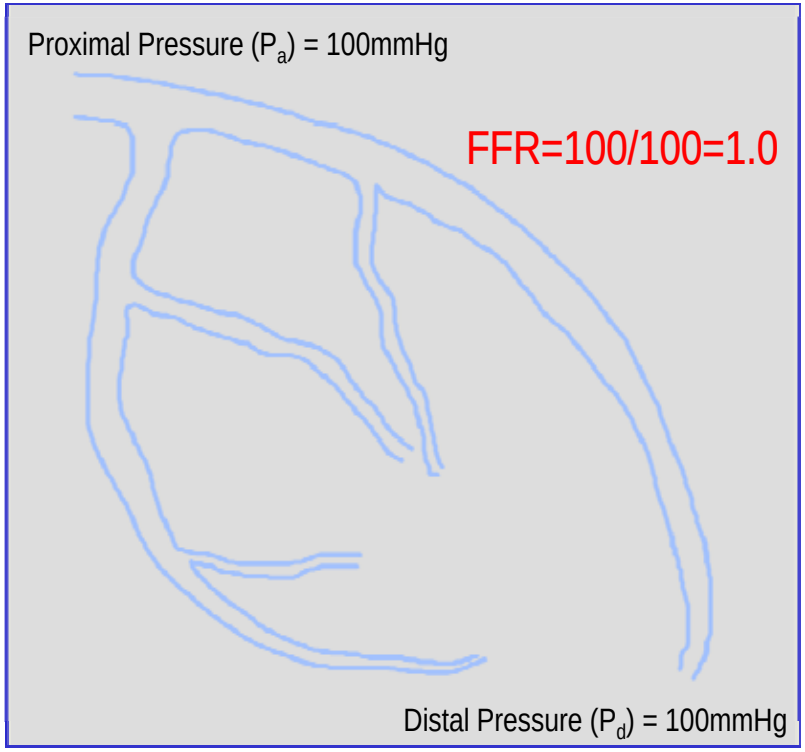
- Stenosis severity by CT, angiography, intravascular US, ...
- Extent of the perfusion territory
- Presence of myocardial infarction
- Myocardial blood flow including collaterals
- Microvascular function

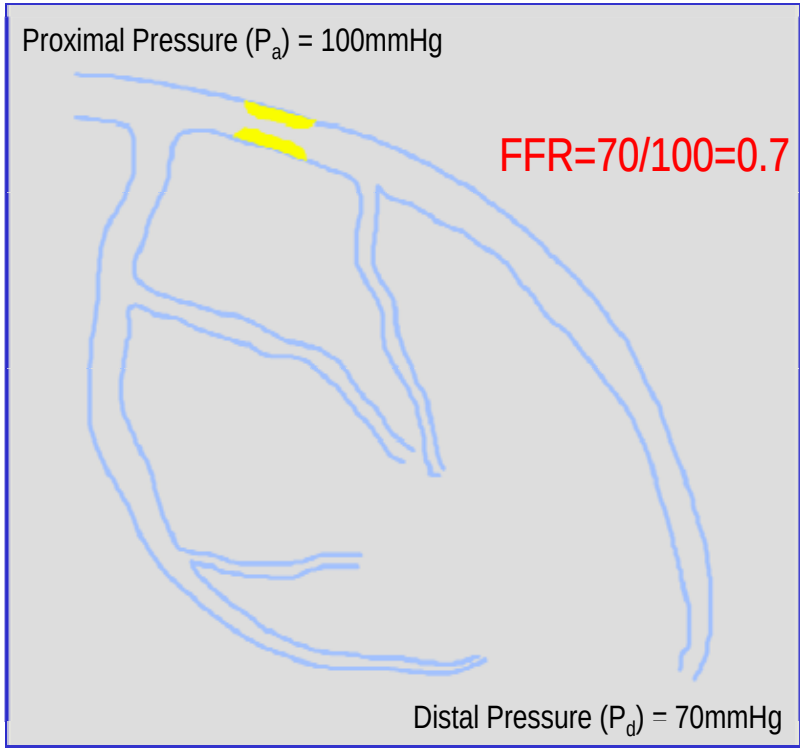
→ ***Functional or Physiologic evaluation***

- Invasive functional test in a cath lab with very high spatial resolution

"Fractional Flow Reserve (FFR)"

$$FFR = \frac{\text{Maximum flow in presence of stenosis}}{\text{Normal maximum flow}} = \frac{Q^{S}_{max}}{Q^{N}_{max}} = \frac{(Pd-Pv)/R}{(Pa-Pv)/R} = \frac{\text{Distal Pr } (P_d)}{\text{Proximal Pr } (P_a)}$$





Why "functional evaluation" in bifurcation PCI?

Pitfalls of anatomical evaluation

- **Angiography**
  - Single directional assessment
  - Variability in stenosis assessment
  - No validated criteria for intervention
  - Not physiologic
- **IVUS/OCT**
  - Difficult to perform in tight stenosis
  - No validated criteria for intervention
  - Not physiologic

Uniqueness of side branch lesions

- Various size, various amount of myocardium
- Side branch stenosis is **unique and complex**
  - Underlying plaque → **Eccentric**
  - Remodeling → **Negative remodeling**
  - Complex mechanisms of side branch jailing

    Carina shift, plaque shift, stent struts, thrombus.....

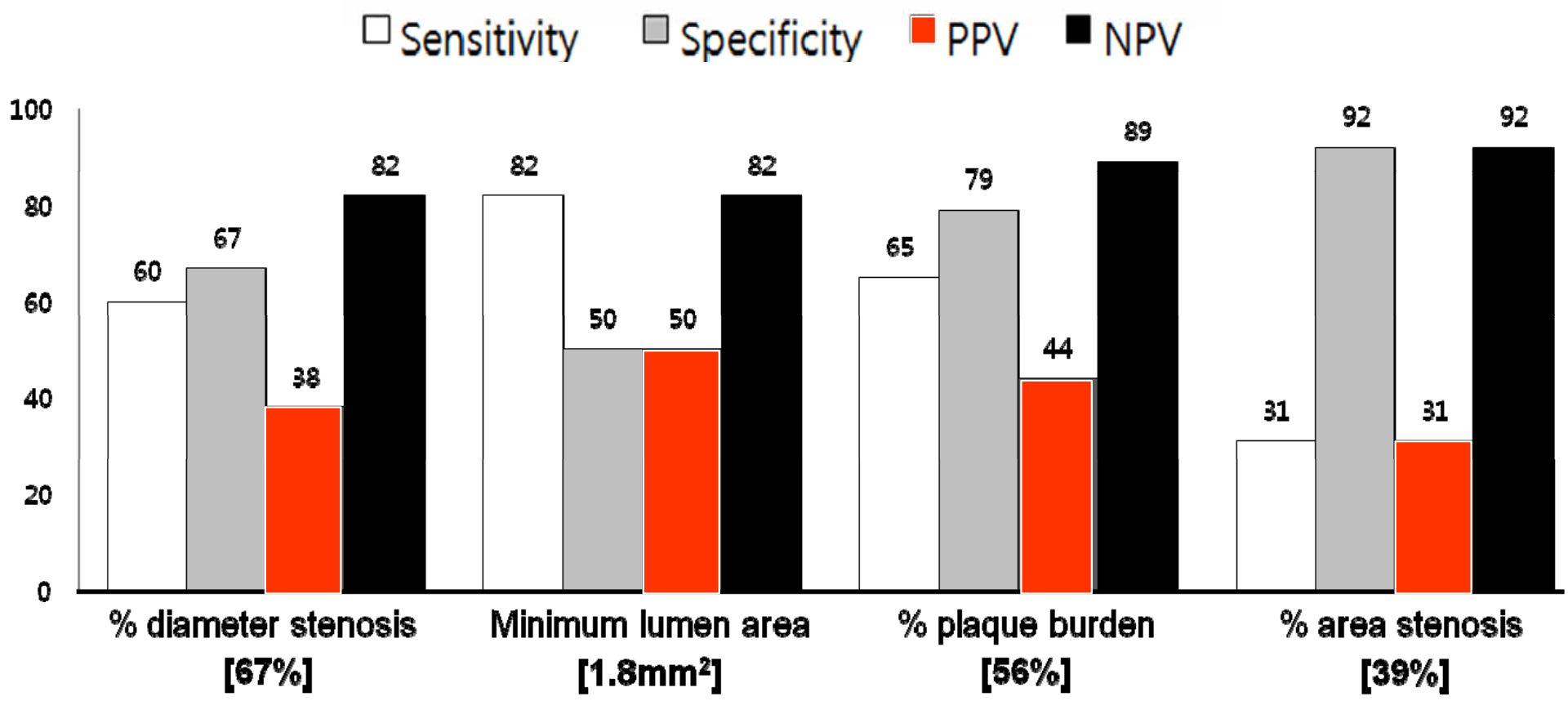
Koo BK & de Bruyne B, Eurointervention 2010

FFR: When and How in Bifurcation PCI?

- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting

Why FFR?

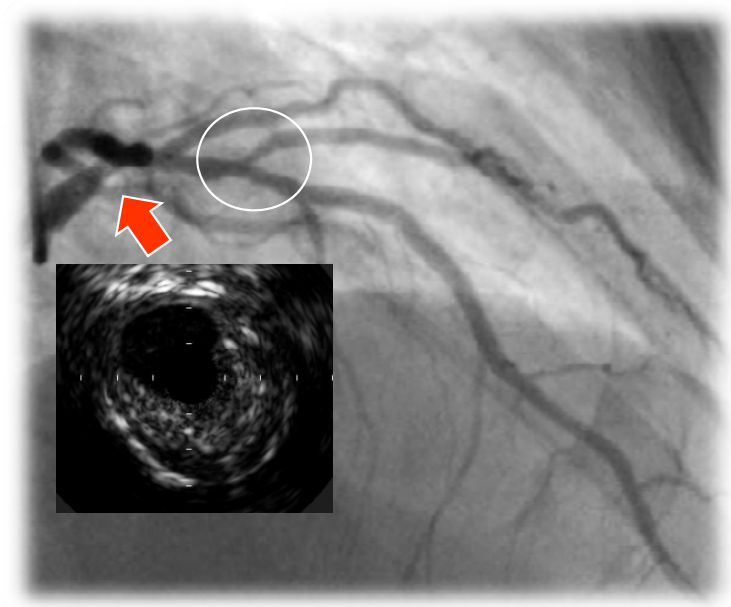
Diagnostic accuracy of anatomic parameters in pure SB ostial lesions

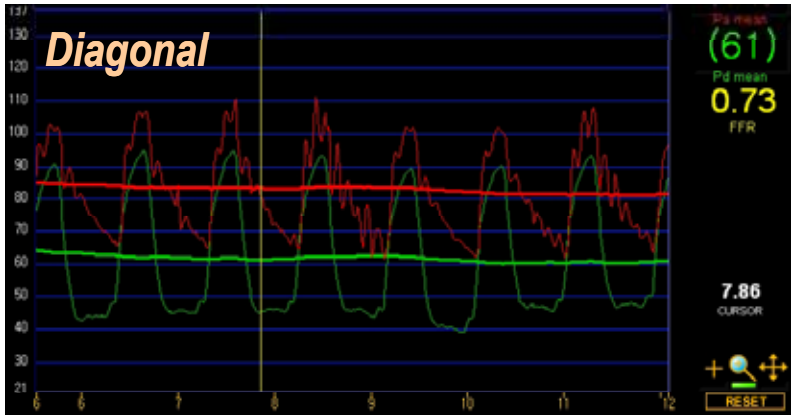


Koh JS, Koo BK, et al., JACC Intv, 2012

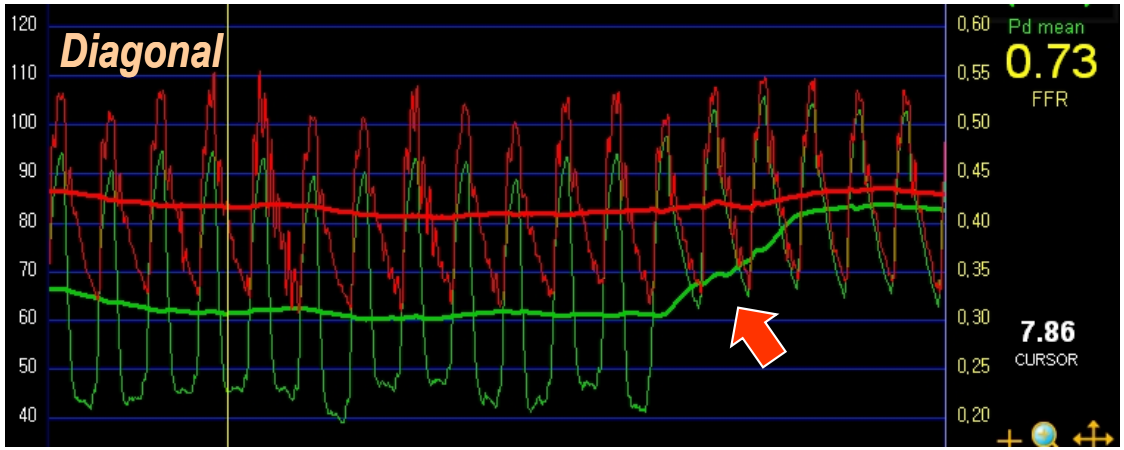
Pitfalls of Side branch FFR: Influence of MB stenosis

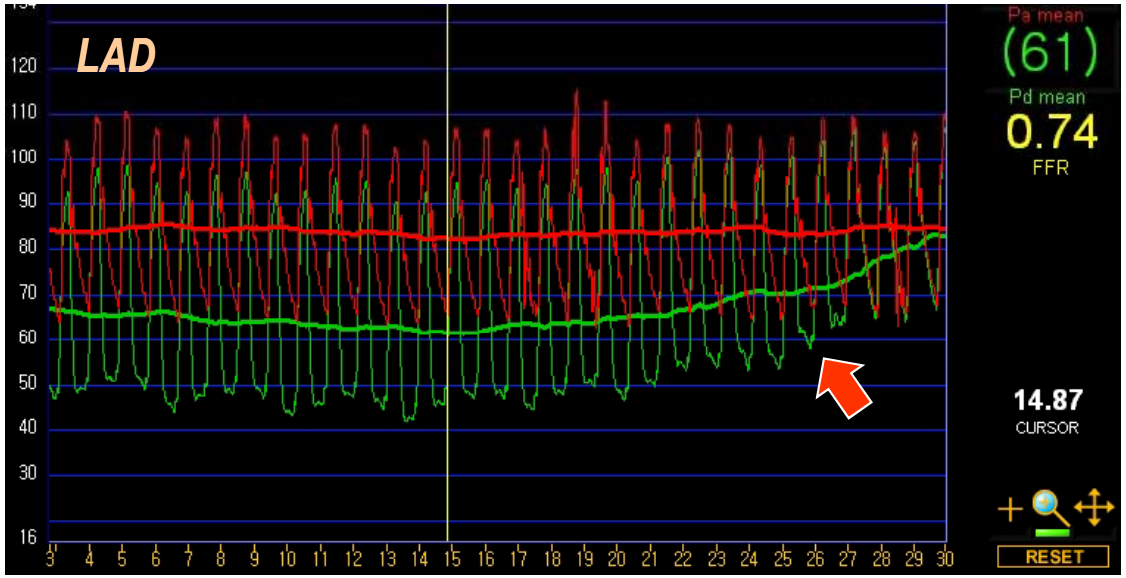
Anatomical & functional Medina 0,0,1 lesion?





Pullback pressure tracing

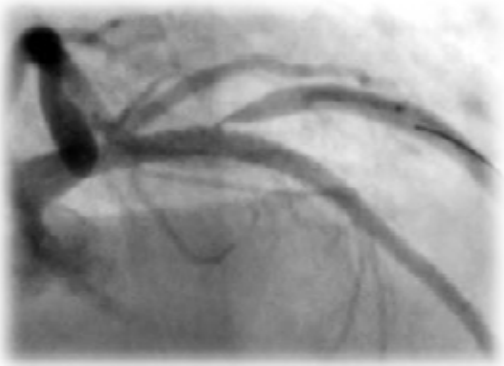




Pre-intervention

- FFR <0.75 does not always mean the clinical relevance of that SB stenosis. FFR should be measured in large SB.
- When SB FFR is measured, the influence of main branch stenosis should always be considered (Don’t forget the pullback pressure tracing!).
- Pre-intervention SB FFR is usually not helpful to predict the jailed SB FFR.

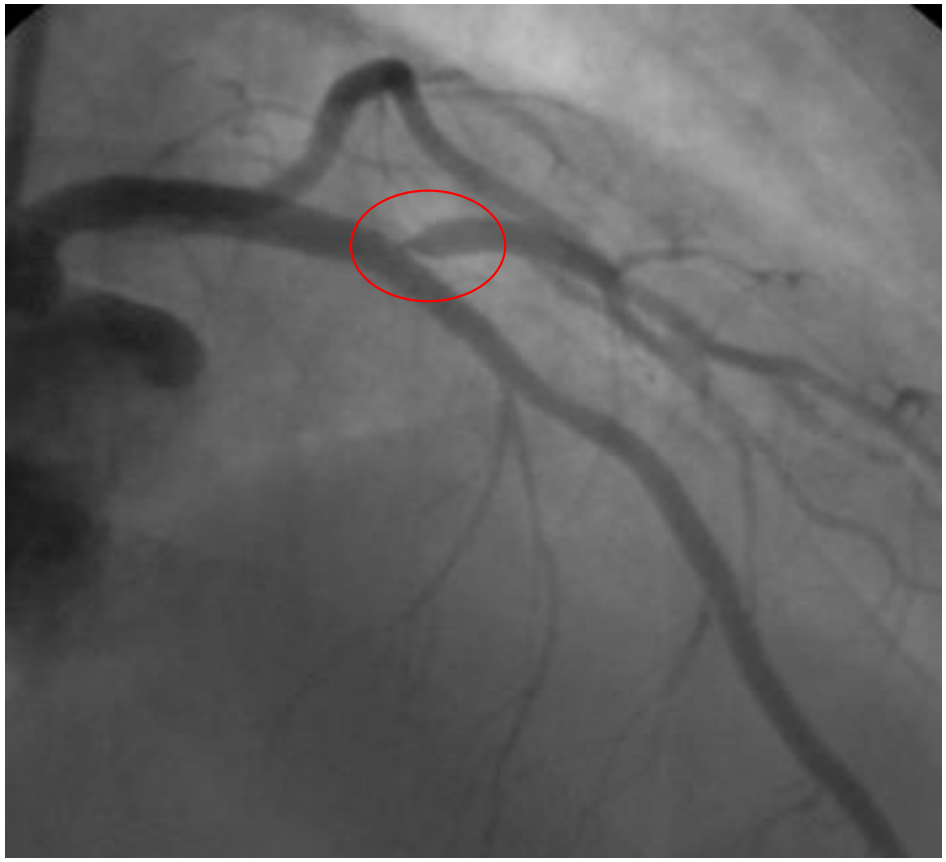
FFR: When and How in Bifurcation PCI?

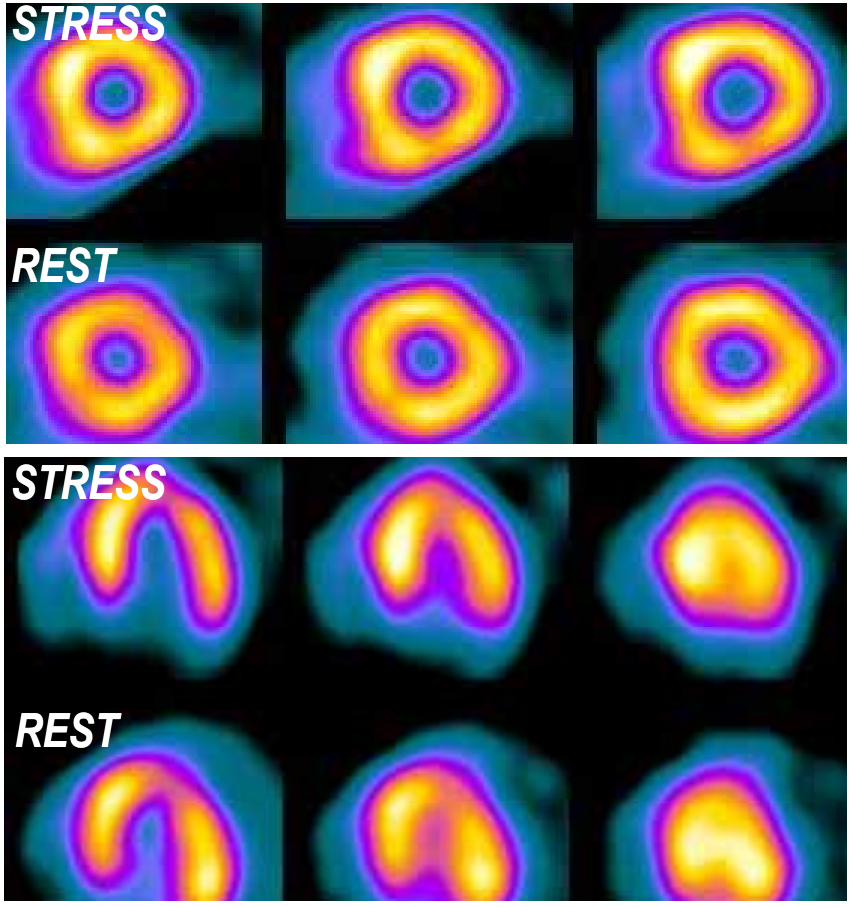


- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting

In Jailed side branch lesions,

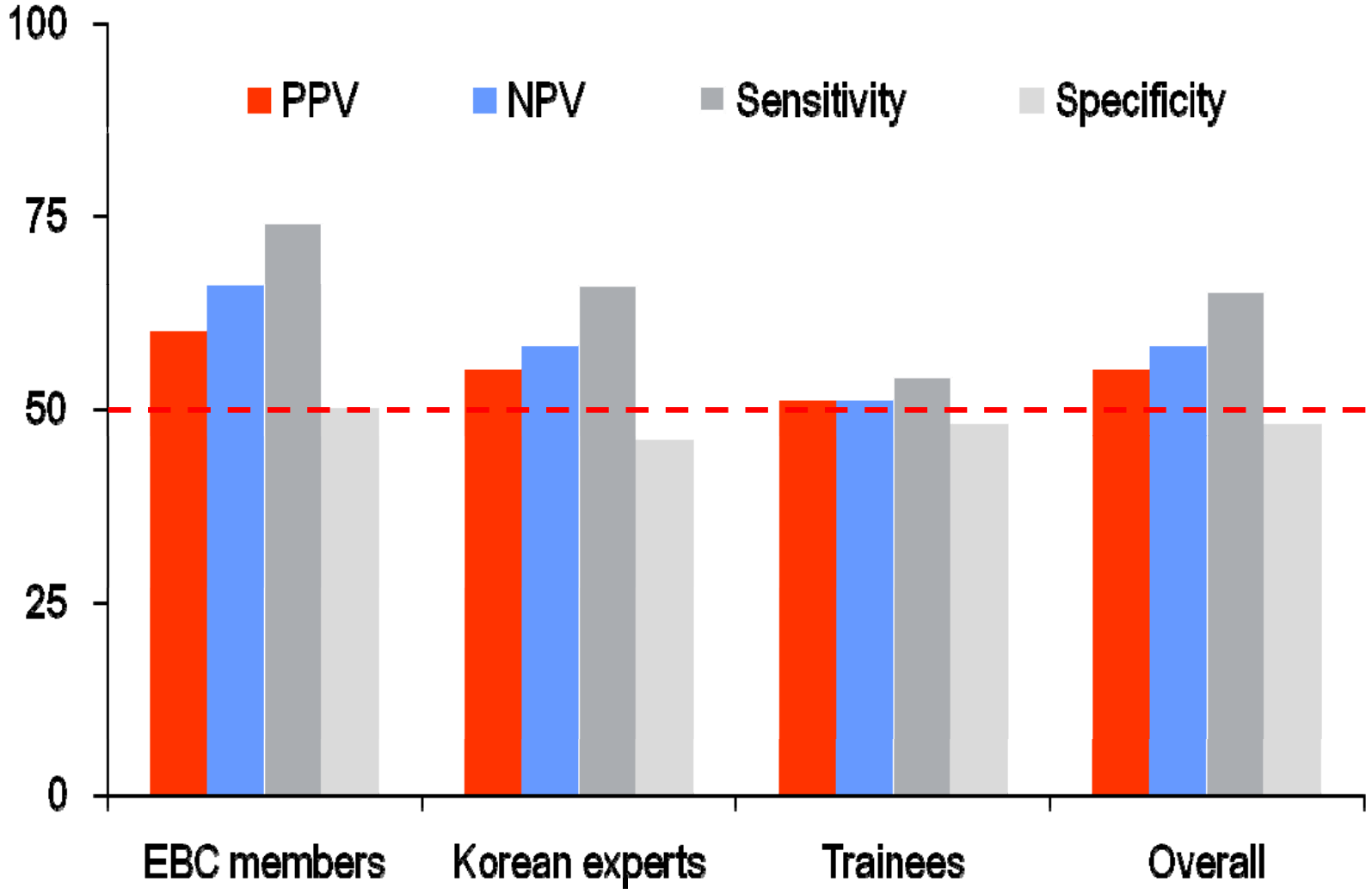
Angiographic severity ≠ Presence of ischemia





Anatomical severity ≠ Functional significance

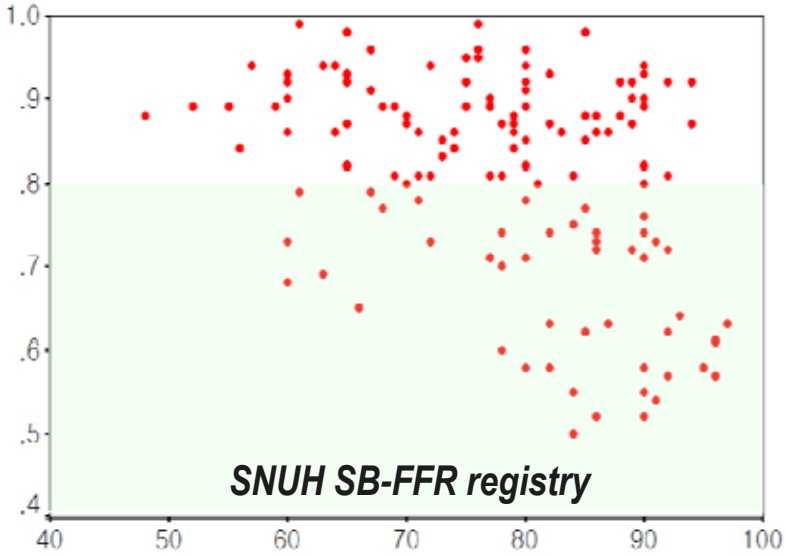
Estimation of "functional significance" in jailed SB lesions

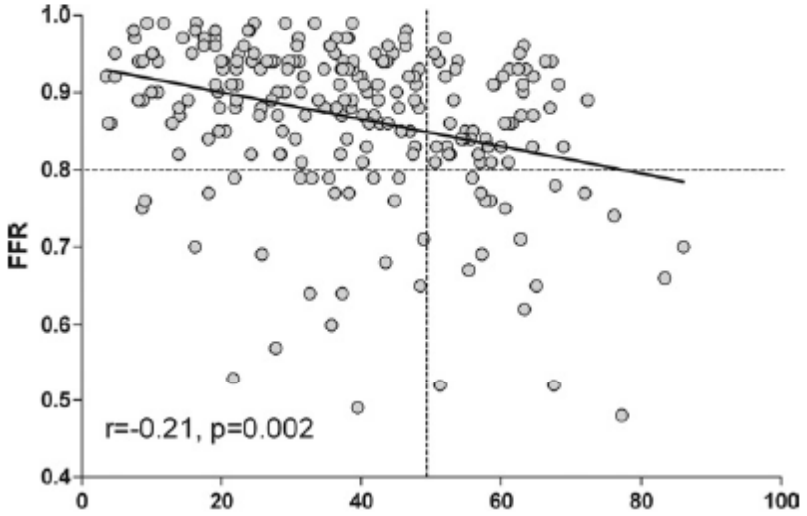


Shin DH, Koo BK, et al. Cath Cardiovasc Interv 2011

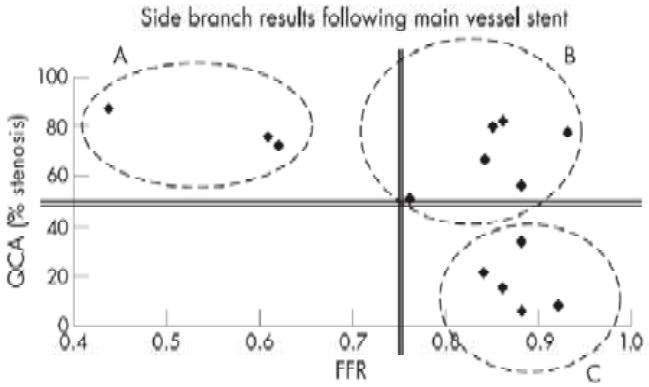
Anatomical severity ≠ Functional significance

FFR vs. % diameter stenosis in Jailed side branches

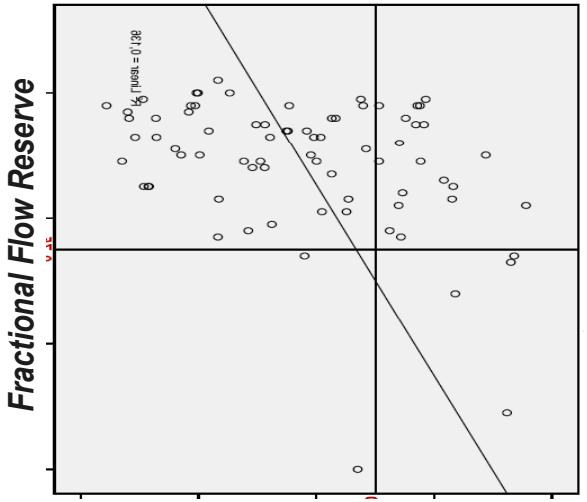




Ahn JM, et al. JACC intv 2012



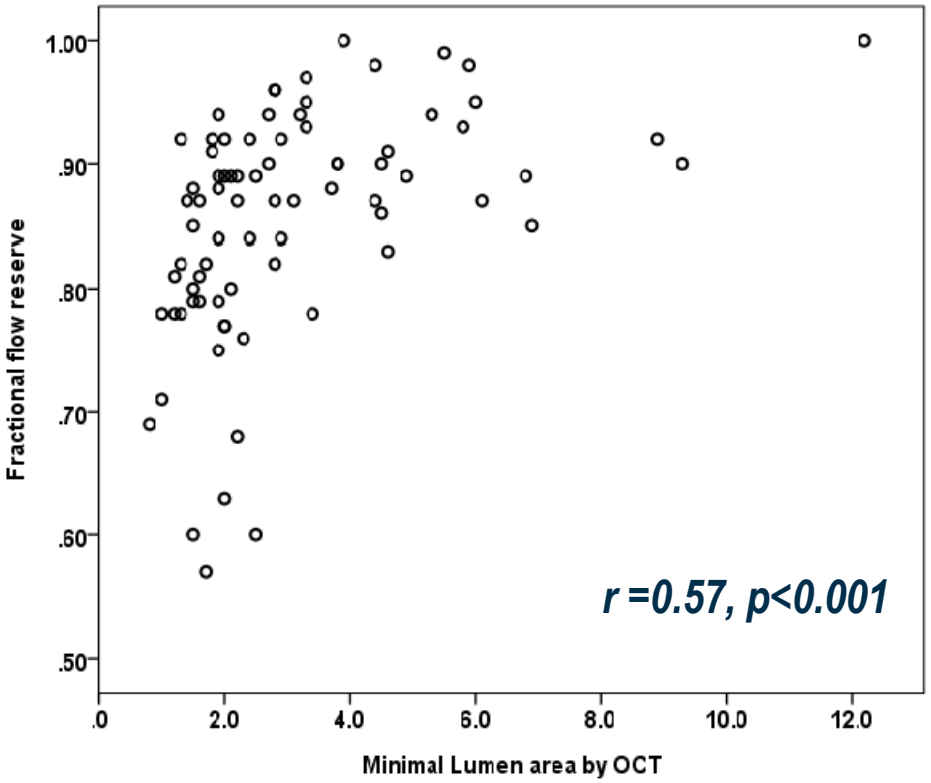
Bellenger, et al. Heart 2007



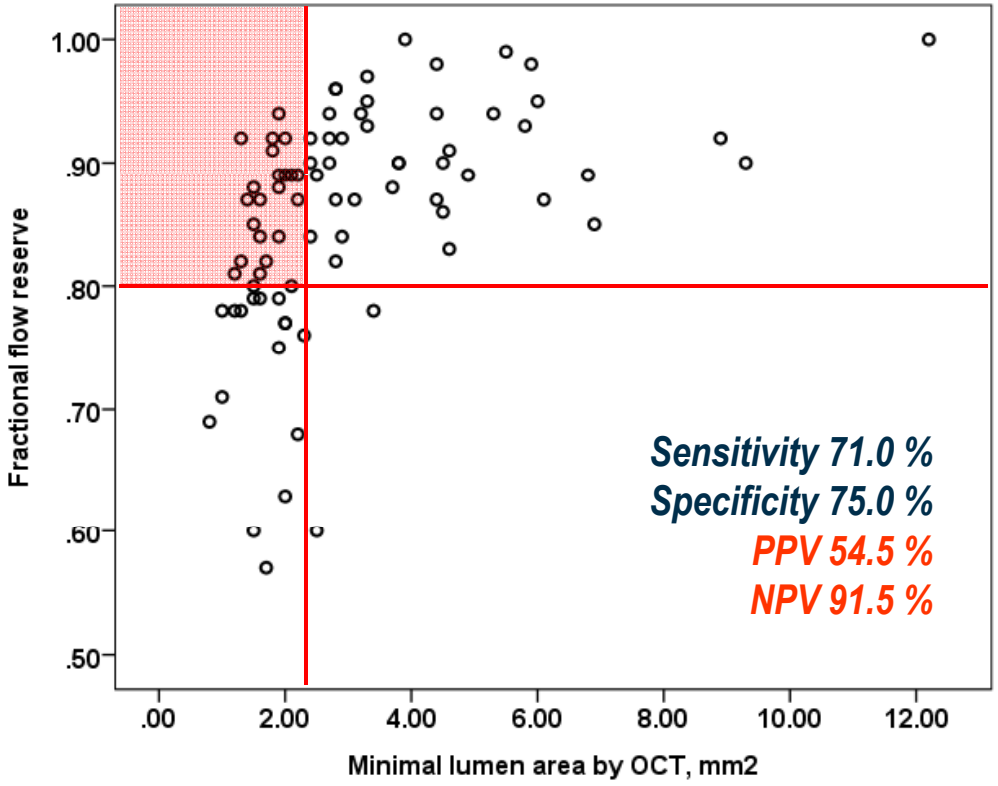
Kumsars I, et al. Eurointervention 2011

Anatomical severity ≠ Functional significance

FFR vs. OCT lumen area in Jailed side branches

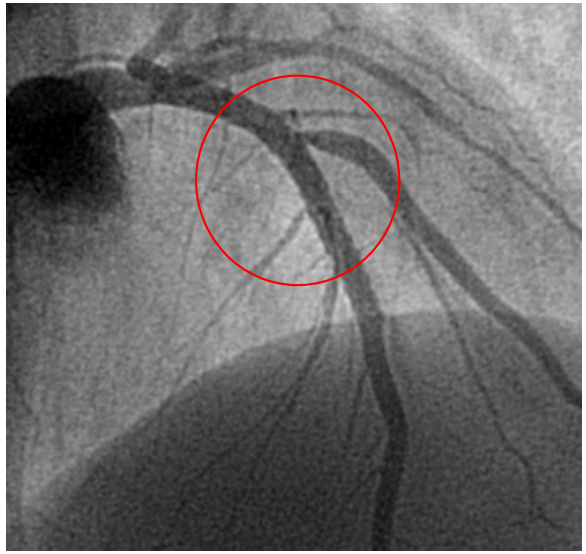


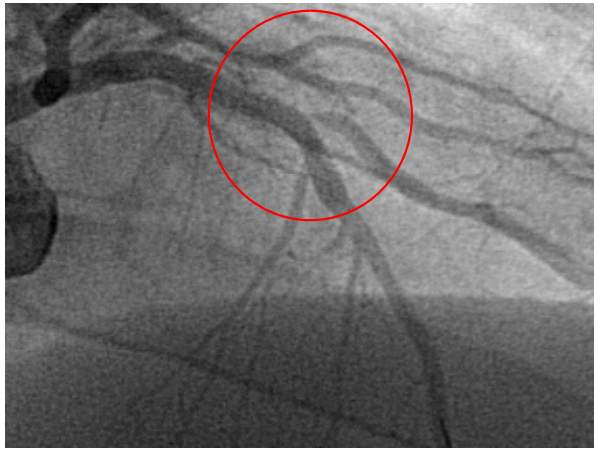
OCT 2.05mm² Vs. FFR 0.80

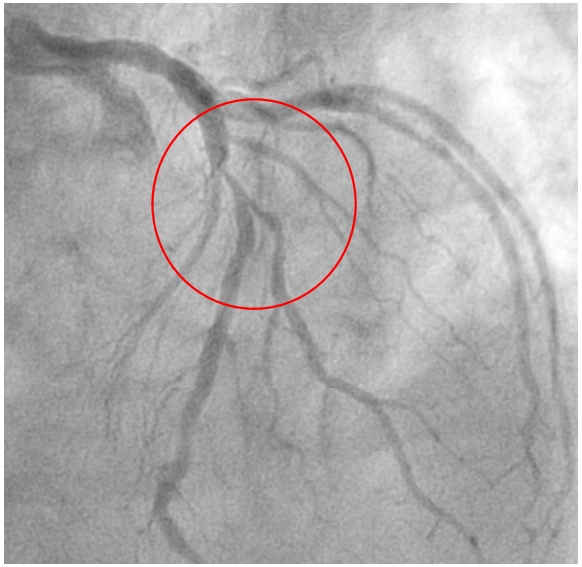


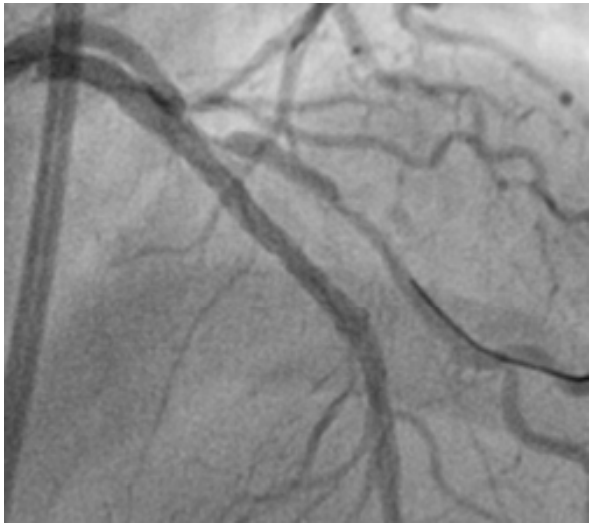
Ha J, Kim JS, et al. JACC Img 2013, in press

FFR in all jailed side branches?







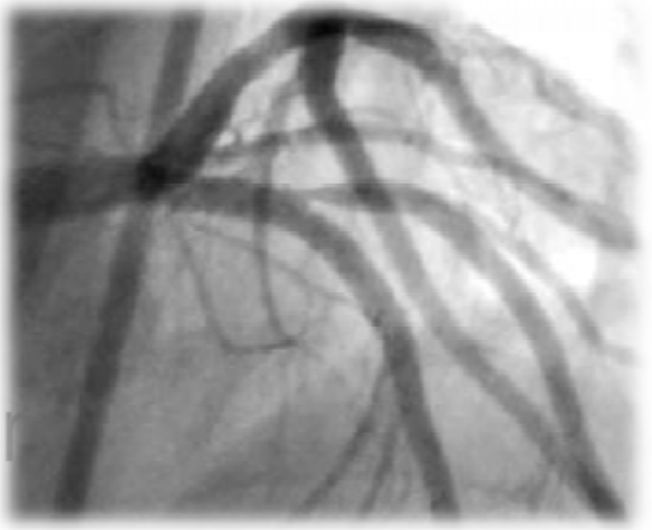


After main branch stent implantation

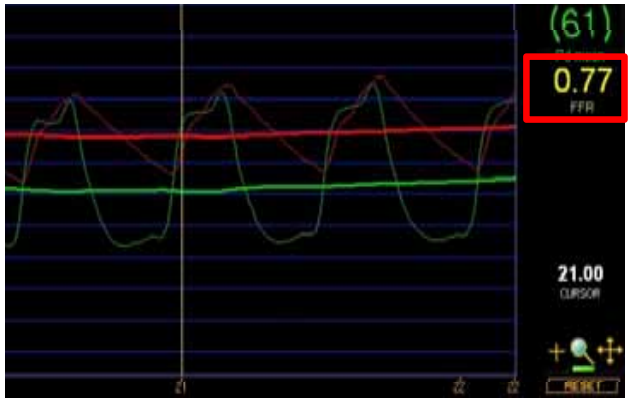
- SB FFR is useful in short ostial SB lesions.
- SB FFR is generally not recommended in very complex SB lesions (severe tortuosity, heavy calcification, diffuse multiple stenosis…..).
- The pressure wire should not be jailed by a MB stent.
- FFR 0.75 seems to be an appropriate criteria for jailed SB intervention considering the clinical relevance of SB and complexity of procedures.

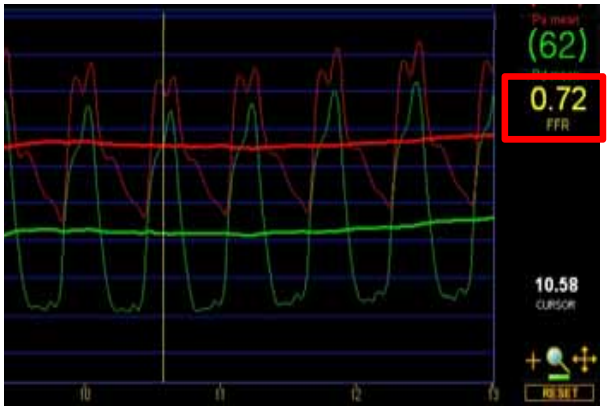
FFR: When and How in Bifurcation PCI?

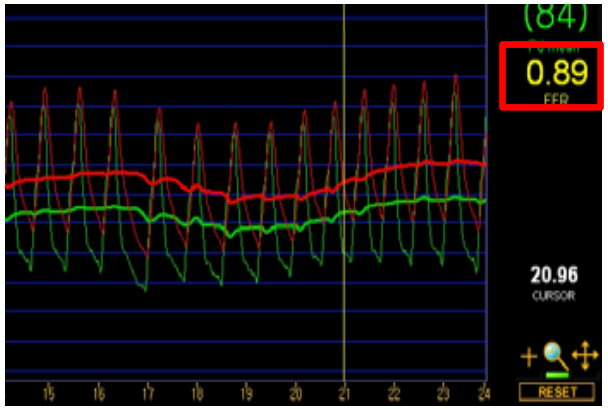
- Pre-intervention
- After main branch stent i
- After side branch balloon angioplasty
- After side branch stenting



Angiographic vs. FFR changes during PCI

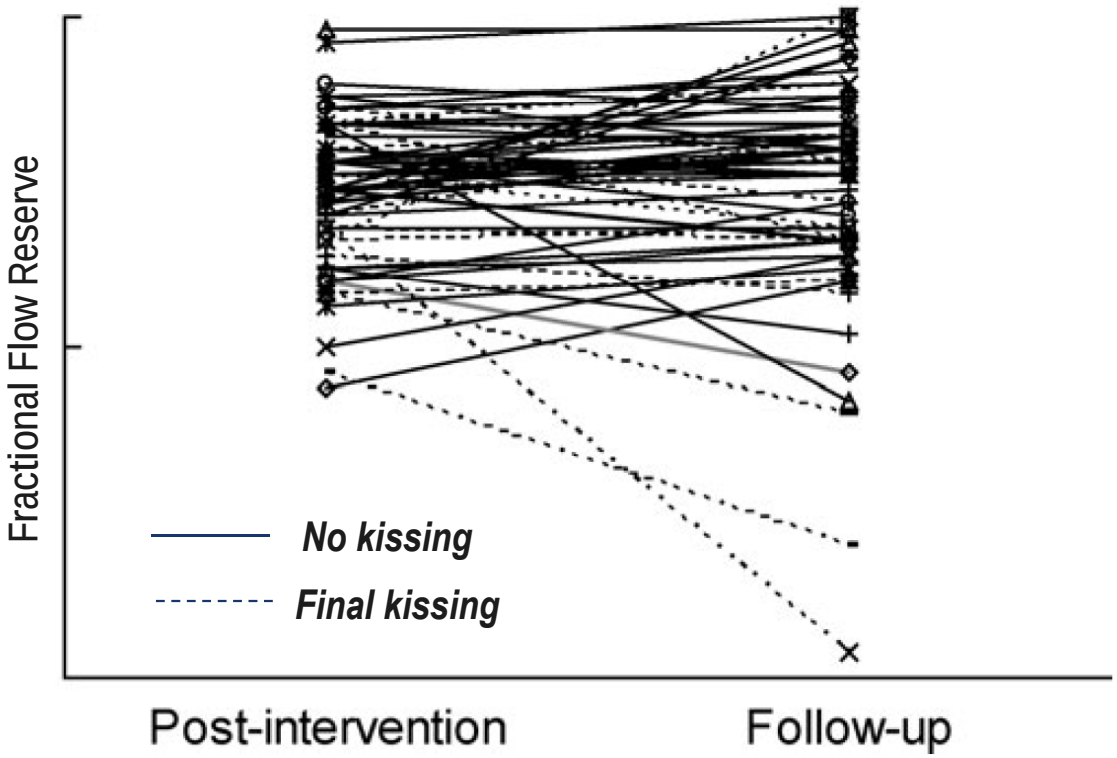






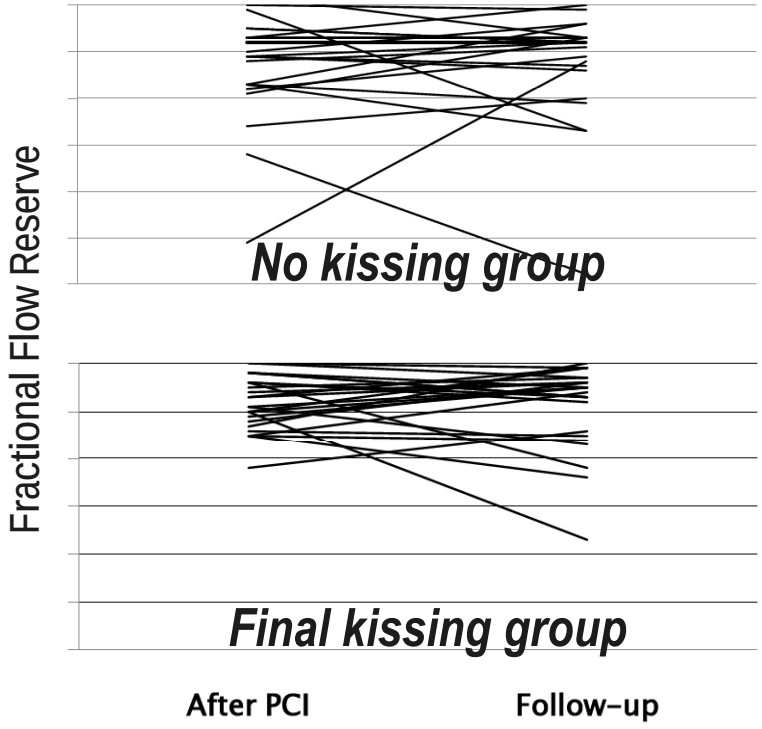
Functional outcome of Jailed side branches

SNUH SB FFR registry



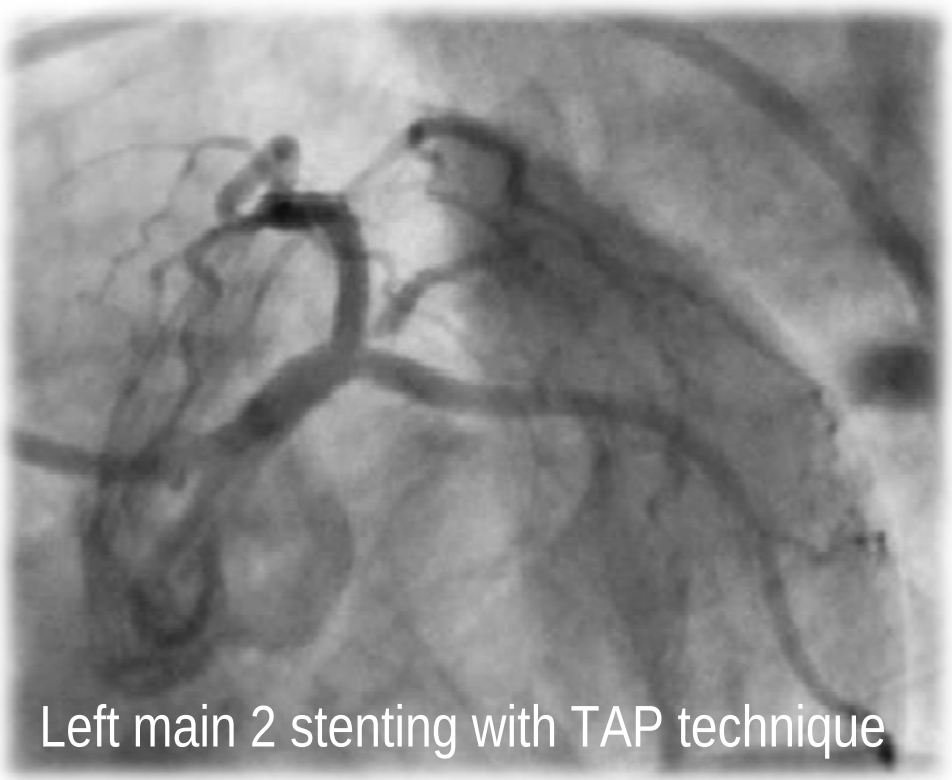
Koo BK, et al Eur Heart J 2009

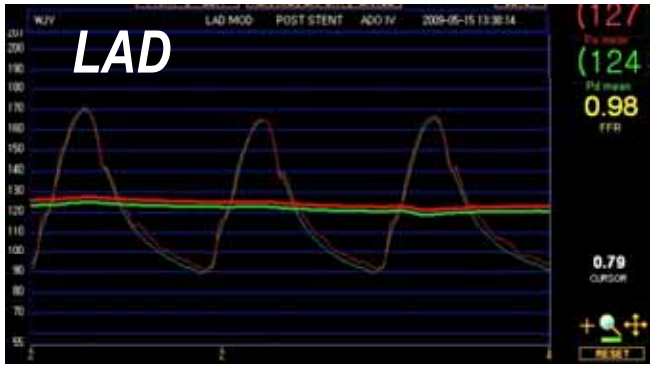
Nordic Baltic Bifurcation III
: SB FFR substudy

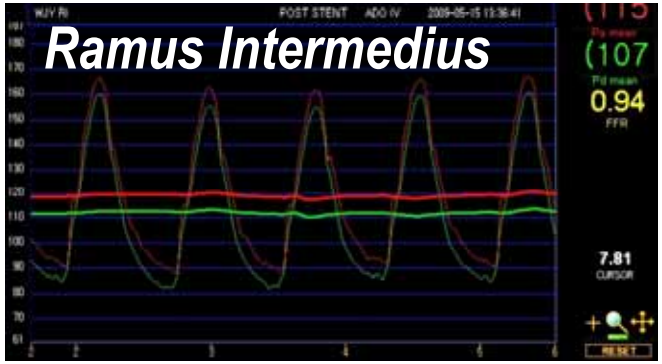


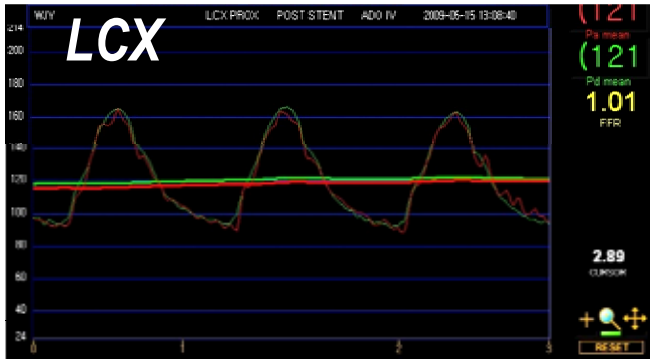
Kumsars I, et al. Eurointervention 2011

FFR after complex Left main stenting









Functionally complete revascularization

FFR after complex side branch stenting

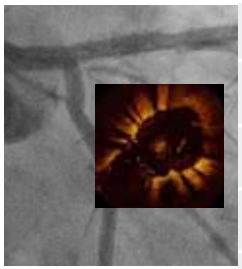
DK crush vs. Provisional

	DK Group	1-Stent Group	P Value
FFR preprocedure			
MB FFR at baseline	0.83 ± 0.15	0.89 ± 0.13	0.109
SB FFR at baseline	0.84 ± 0.15	0.91 ± 0.12	0.100
MB FFR at hyperemia	0.76 ± 0.15	0.83 ± 0.10	0.029
SB FFR at hyperemia	0.76 ± 0.15	0.83 ± 0.16	0.103
FFR postprocedure			
MB FFR at baseline	0.96 ± 0.02	0.95 ± 0.03	0.376
SB FFR at baseline	0.97 ± 0.02	0.96 ± 0.03	0.043
MB FFR at hyperemia	0.92 ± 0.04	0.92 ± 0.05	0.581
SB FFR at hyperemia	0.94 ± 0.03	0.90 ± 0.08	0.028

Ye F, et al. J Interven Cardiol 2010

In cases of crush stenting

Pre- and Post- final kissing balloon



Pre-KBA FFR
0.90
0.96
0.95
0.96
0.92
0.95
0.94
1.00
0.94
0.88
0.88
0.97

0.94 ±0.04

Post-KBA FFR
0.96
1.00
0.95
0.96
1.00
0.98
0.96
1.00
0.94
0.94
0.94
1.00

0.97 ±0.03

Lee BK, et al. Clinical Cardiol 2010

After side branch angioplasty

- Functional outcomes of FFR-guided SB intervention is good regardless of residual stenosis.
- SB FFR is not recommended in case of slow flow or severe dissection.

After side branch stenting

- FFR is useful to detect the residual ischemia.
- However, high FFR does not always guarantee the excellent outcomes of complex intervention for bifurcation lesions.

FFR during Bifurcation PCI: When and How?

	FFR is useful	FFR is not recommended
Pre-intervention	• To assess the functional significance of main branch • To assess the functional significance in pure ostial SB stenosis	• Small side branch • Complex bifurcation (long diffuse, calcified, total occlusion) • To determine functional significance of SB when there is significant MB stenosis • SB FFR to predict the functional significance of jailed SB
Post-MB stenting	• To assess the functional significance of jailed SB and to predict their outcomes	• Small SB • Long diffuse, calcified side branch • SB slow flow
Post-SB angioplasty	• To assess SB procedural success and to predict the outcomes after KBI (non-left main)	• SB slow flow • SB dissection
Post-SB stenting	• To evaluate residual ischemia	• To predict procedural outcomes of complex two stenting