FFR and Ostial/Bifurcation Lesions

William F. Fearon, MD
Associate Professor
Stanford University Medical Center

Why do we need FFR for ostial/bifurcation lesions?

- Angiographic evaluation is difficult due to vessel overlap, angulation, foreshortening, and stent strut artifact
- IVUS/OCT criteria for a significant sidebranch lesion are unknown and it is technically difficult to perform in some cases (particularly after stenting)
- The amount of myocardium supplied by a sidebranch is relatively small and highly variable
- PCI outcomes of ostial/bifurcation lesions are historically poor

Koo and De Bruyne. Eurointervention 2010;6:J94-J98.

Ostial/Bifurcation Lesions and FFR

Even with DES Ostial Lesions have Worse Outcome

TABLE 4. Clinical, Procedural, and Angiographic Multivariate Predictors of In-Segment Restenosis After SES Restenosis*

	OR	95% CI	*P*
Treatment of in-stent restenosis	4.16	1.63–11.01	<0.01
Ostial location	4.84	1.81–12.07	<0.01
Diabetes mellitus	2.63	1.14–6.31	0.02
Total stented length (per 10-mm increase)	1.42	1.21–1.68	<0.01
Reference diameter (per 1.0-mm increase)	0.46	0.24–0.87	0.03
Left anterior descending artery	0.30	0.10–0.69	<0.01

Circulation 2004;109:1366-1370

Ostial/Bifurcation Lesions and FFR

Comparison of Medical Rx and PCI for Ostial Lesions

TABLE 3 Type and Distribution of Events in the 2 Groups

Event	Group I No Angioplasty (n = 233)	Group II Angioplasty (n = 69)	p Value
In-hospital events			
Acute stent thrombosis	—	0	—
Acute myocardial infarction	0	0	1.0
Emergent coronary bypass	0	0	1.0
Death	0	0	1.0
12-mo follow-up			
Rehospitalization for cardiac indication	51 (22%)	38 (55%)	<0.001
Recatheterization	45 (19%)	32 (46%)	<0.001
PCI or repeat PCI	19 (8%)	16 (23%)	0.001
Acute myocardial infarction	9 (4%)	3 (4%)	0.865
Death	0	0	1.0
Free of angina	130 (56%)	28 (41%)	0.255

Data are presented as numbers of patients (percentages).

Brueck et al. Am J Cardiol 2004;93:1162-1164

Ostial/Bifurcation Lesions and FFR

Comparison of Angiography and FFR in Ostial Lesions

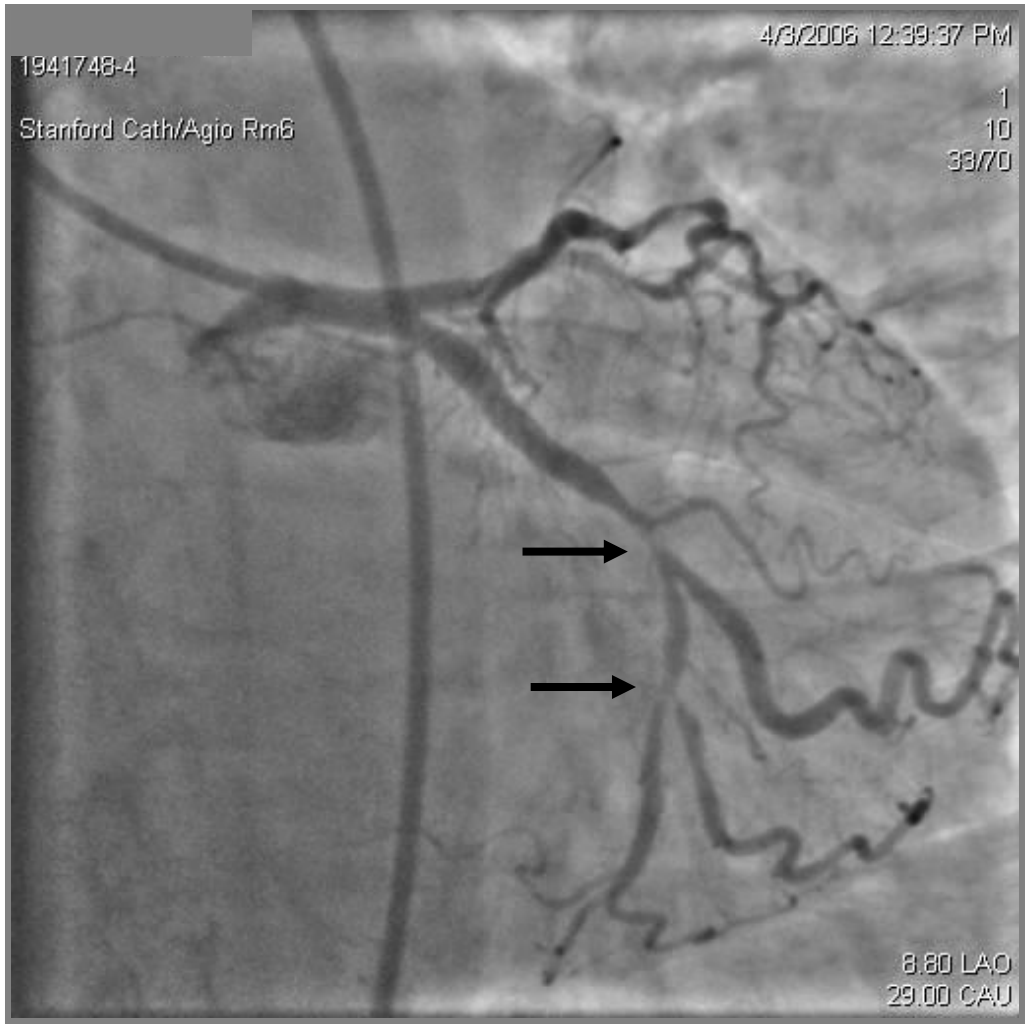
TABLE 2 Ostial Lesions: Angiography Versus Fractional Flow Reserve

FFR	≥70% Angiographic Stenosis	50%–70% Angiographic Stenosis
≥0.75	20	30
<0.75	5	0

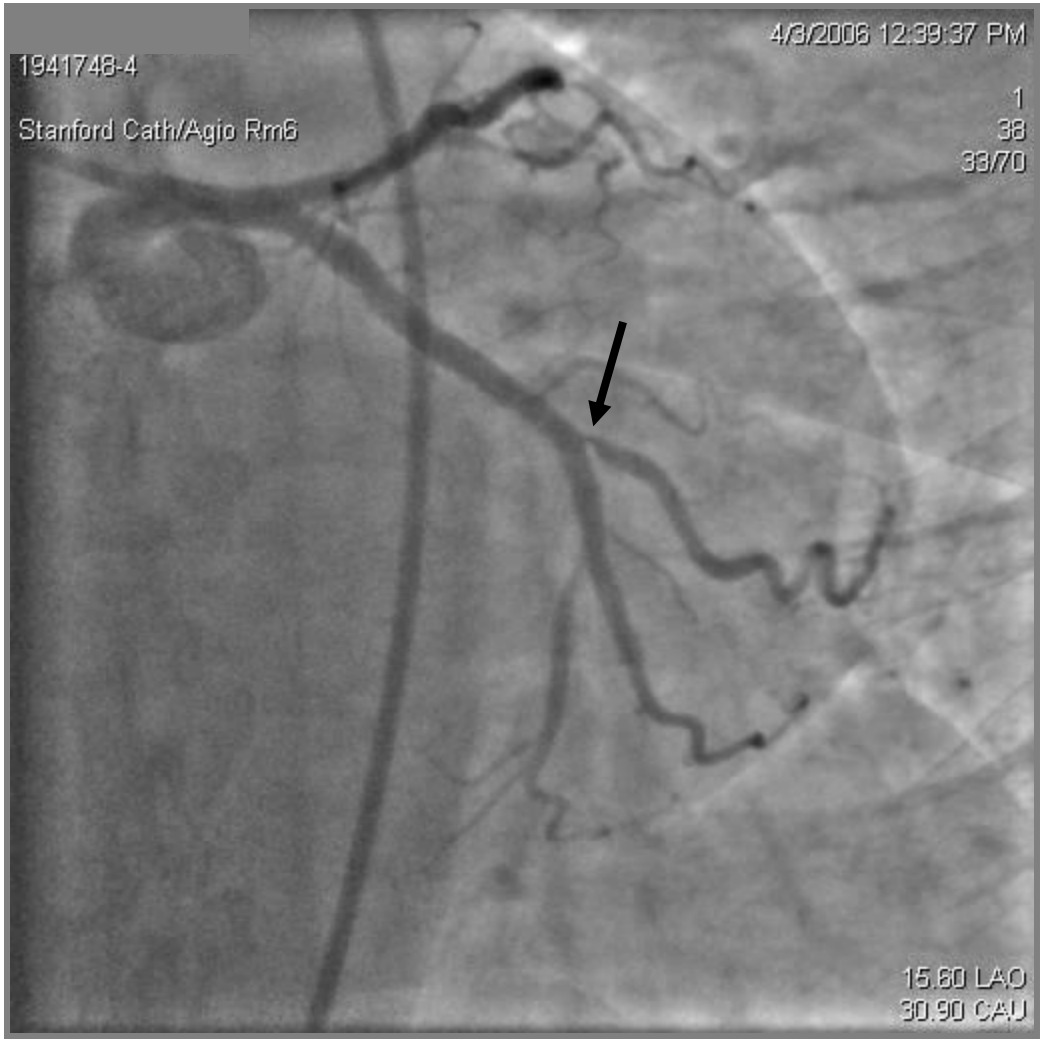
Sensitivity 100%, specificity 55%, and test accuracy 60%.

Ziaee et al. Am J Cardiol 2004;93:1404-1407

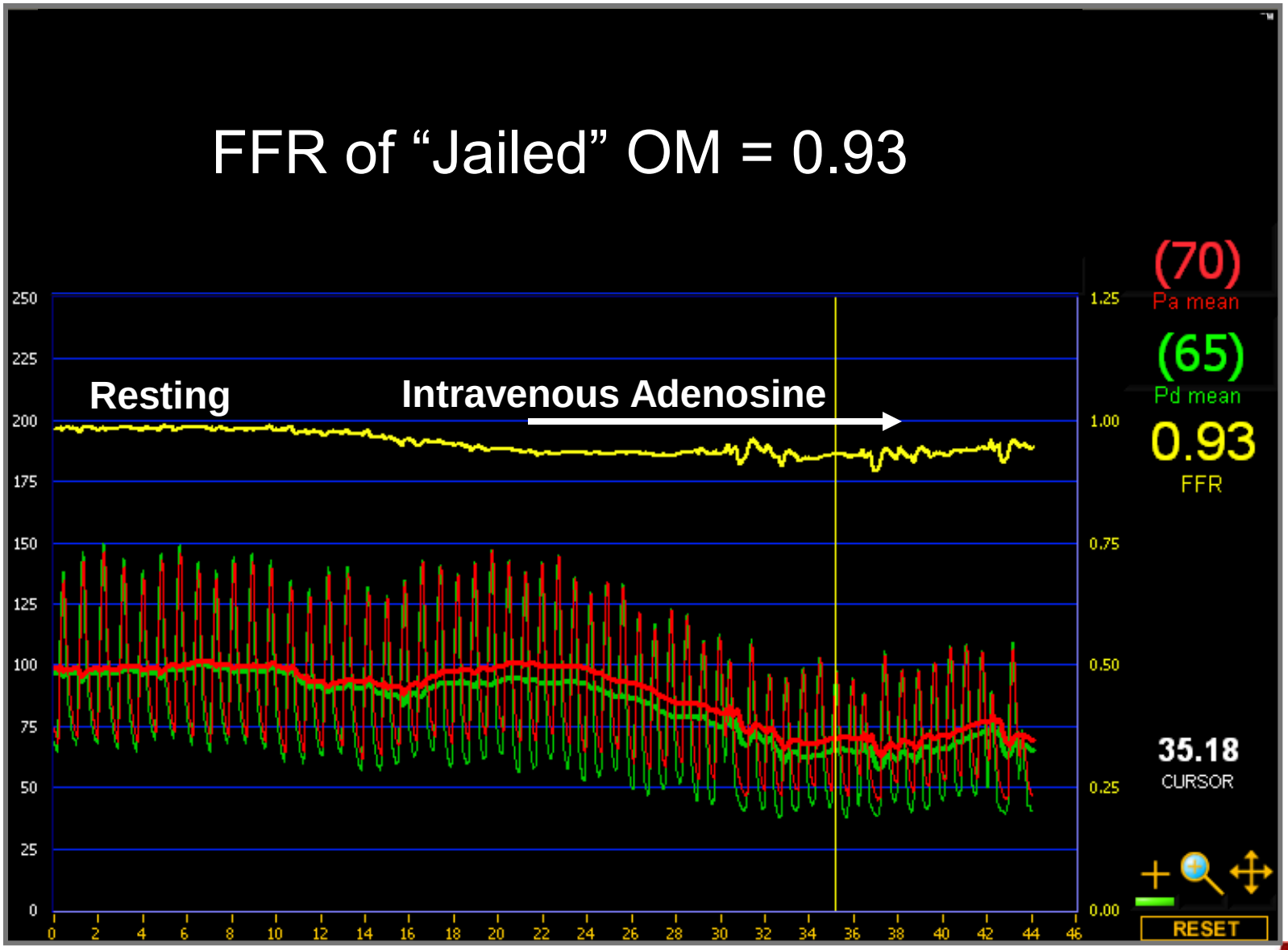
“Jailed” Side Branches



“Jailed” Side Branches

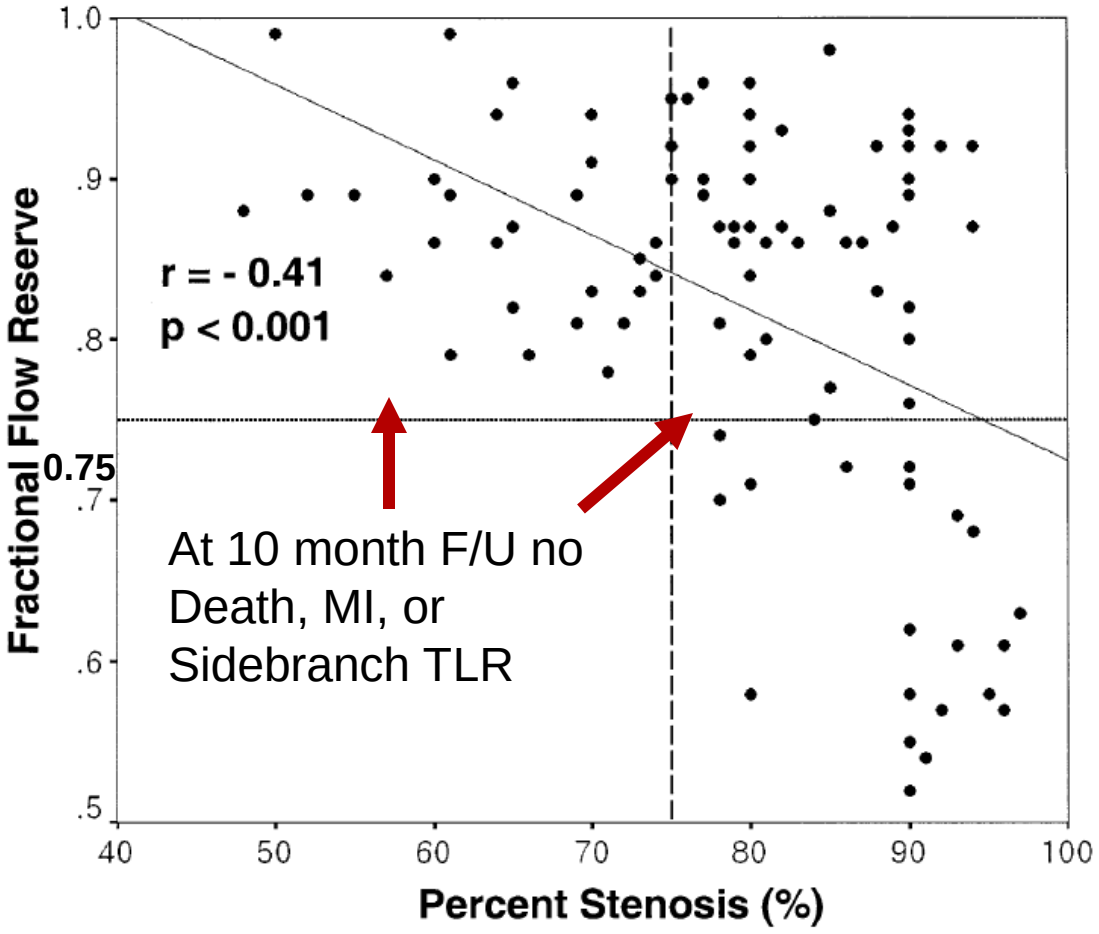


FFR of “Jailed” OM = 0.93



Jailed Side Branches and FFR

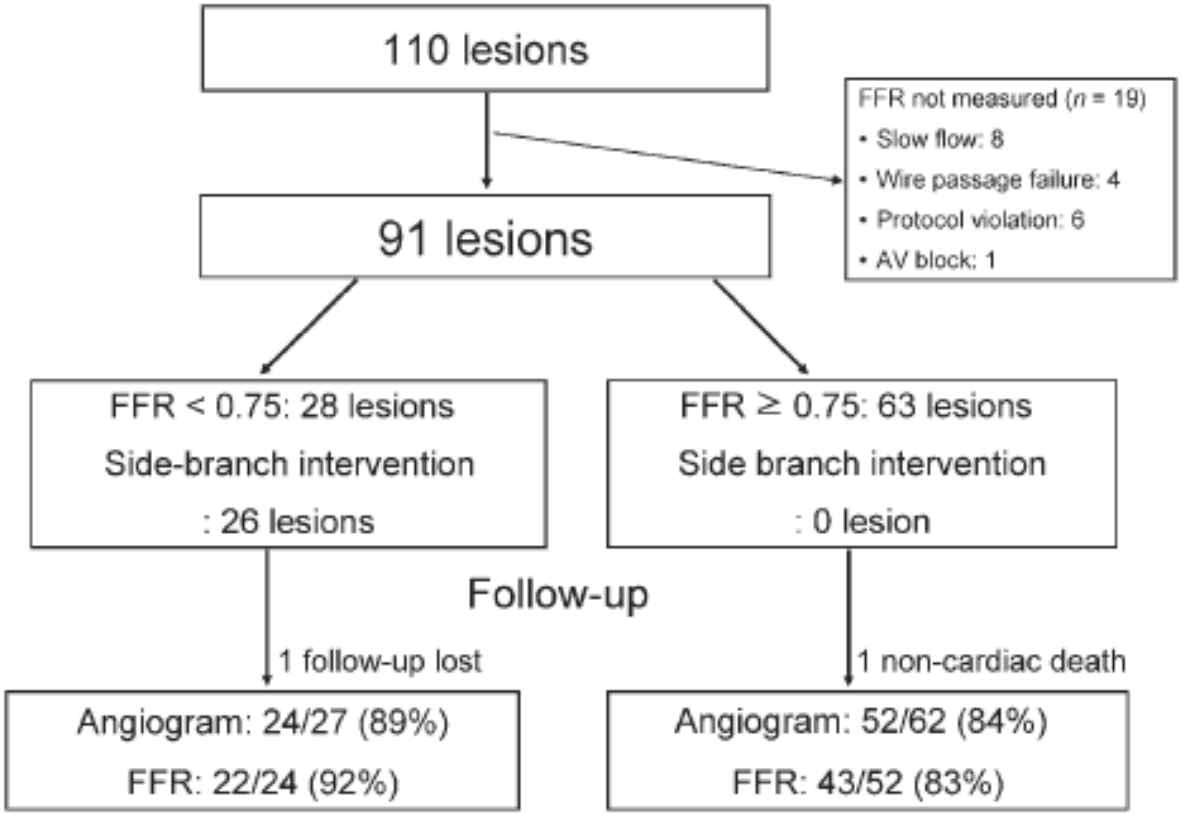
FFR in 97 "Jailed" Side Branches



Koo et al. J Am Coll Cardiol 2005;46:633-7.

Jailed Side Branches and FFR

FFR-Guided Bifurcation Strategy in 91 Patients



Koo et al. Eur Heart J 2008;29:726-32.

Jailed Side Branches and FFR

FFR in 91 "Jailed" Side Branches, Repeated at 6 Months

	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

Koo et al. Eur Heart J 2008;29:726-32.

Jailed Side Branches and FFR

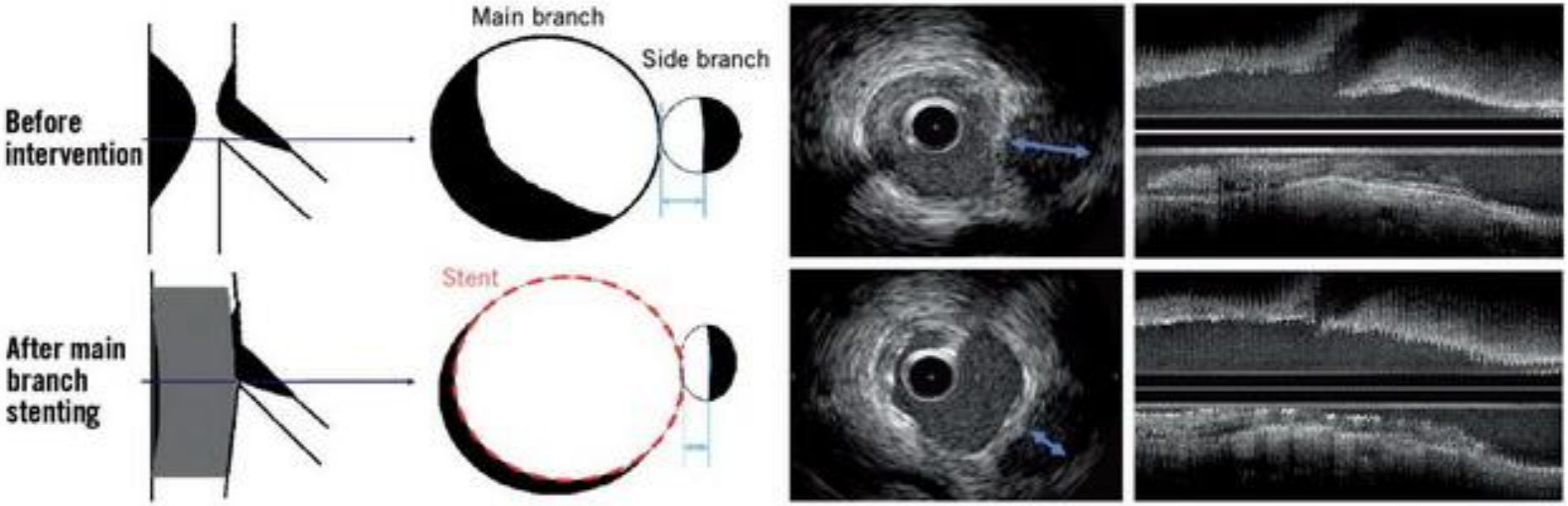
Comparison of FFR-Guided and Conventional Strategies

	FFR group, $n = 108$[a]	Conventional group, $n = 108$[b]	*P*-value[c]
Cardiac death	0	0	1
Myocardial infarction	0	0	1
Target vessel revascularization, *n* (%)	5 (4.6)	4 (3.7)	0.7

Koo et al. Eur Heart J 2008;29:726-32.

Mechanism of Side Branch "Jailing"

Carina Shifting and Plaque Shifting



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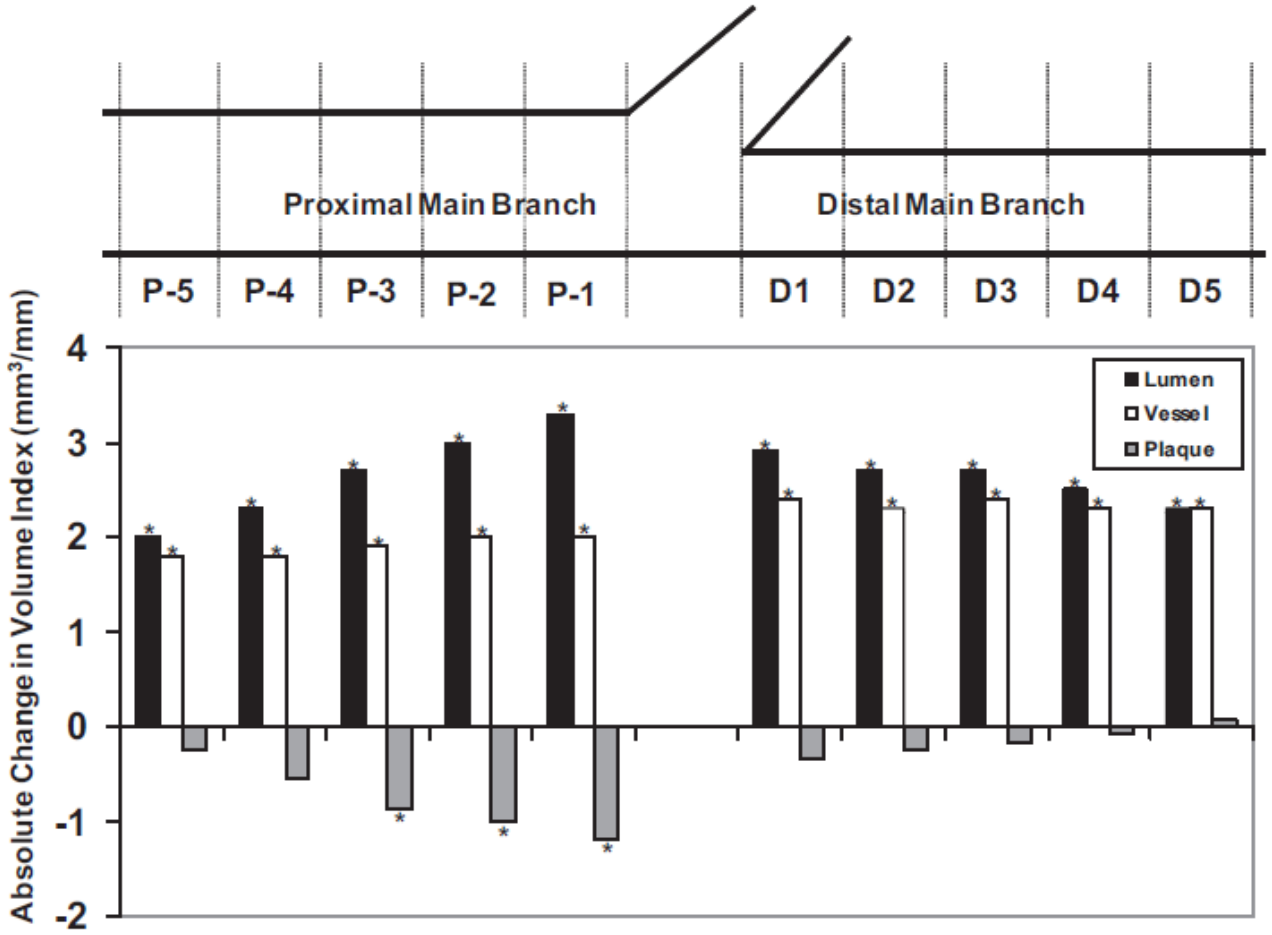


Circ Cardiovasc Intervent 2010;3:113-9.

Can we predict which side branches will have an abnormal FFR after MB stenting?

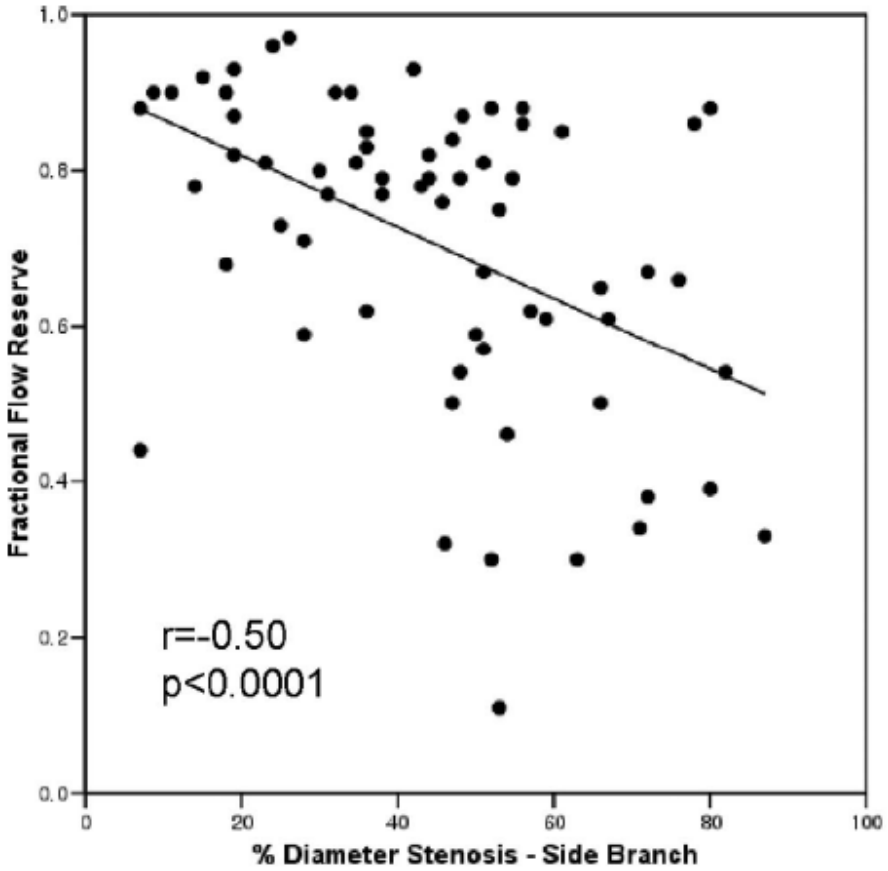
Pre-Intervention Angiographic Parameters

Angiographic Parameters	FFR<0.75 (N=28)	FFR≥0.75 (N=39)	*P*
Main branch			
Reference diameter, mm	3.0±0.6	3.0±0.4	1
Minimal lumen diameter, mm	1.0±0.4	1.2±0.4	0.15
% diameter stenosis	65±13	61±14	0.27
Side branch			
Reference diameter, mm	2.1±0.5	2.2±0.4	0.33
Minimal lumen diameter, mm	0.9±0.4	1.4±0.4	<0.001
% diameter stenosis	54±20	37±18	<0.001
Type B lesion	19 (56)	15 (44)	0.04
Bifurcation angle, degrees	44±19	46±11	0.62

Circ Cardiovasc Intervent 2010;3:113-9.

Can we predict which side branches will have an abnormal FFR after MB stenting?

Correlation between Pre PCI Angiographic DS and Post PCI SB FFR



Circ Cardiovasc Intervent 2010;3:113-9.

Can we predict which side branches will have an abnormal FFR after MB stenting?

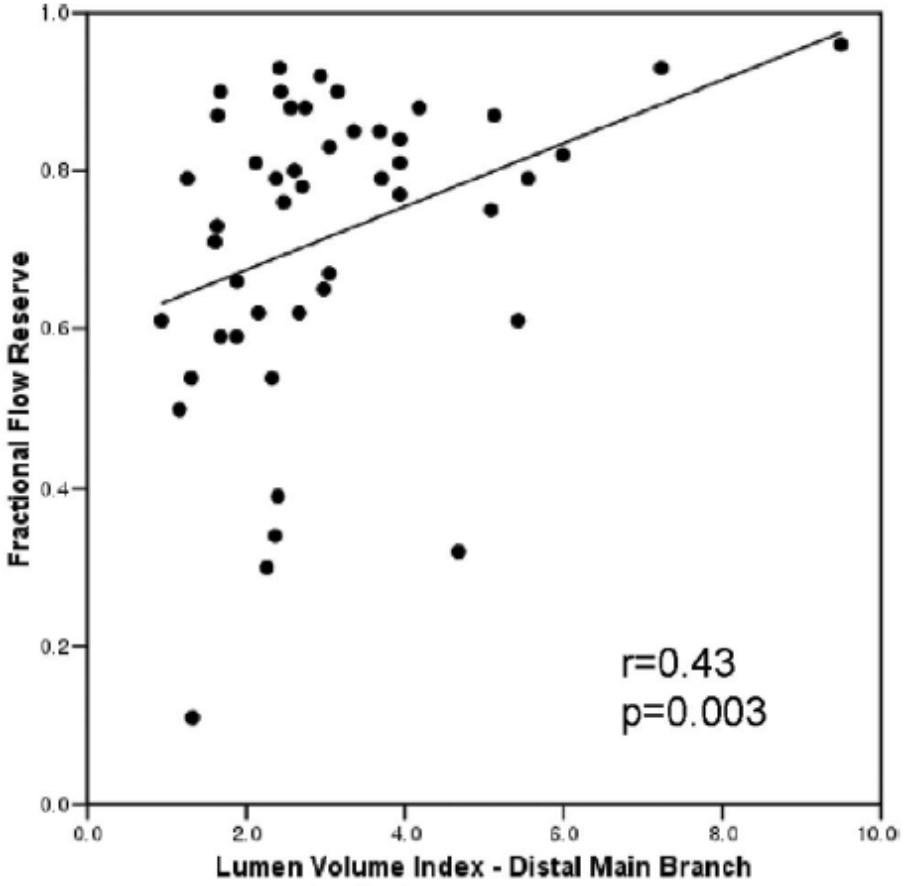
Pre-Intervention IVUS Parameters

IVUS parameters	FFR<0.75 (N=22)	FFR≥0.75 (N=30)	*P*
Proximal MB			
Lumen volume index, mm^3/mm	2.6±1.1	3.4±1.5	0.08
Vessel volume index, mm^3/mm	13.2±3.5	12.7±3.5	0.67
Plaque volume index, mm^3/mm	10.6±3.1	9.4±3.1	0.21
Plaque burden, %	80±8	73±10	0.03
Distal MB			
Lumen volume index, mm^3/mm	2.3±1.1	3.6±1.8	0.01
Vessel volume index, mm^3/mm	8.3±2.0	9.4±2.7	0.14
Plaque volume index, mm^3/mm	6.0±1.5	5.8±2.0	0.69
Plaque burden, %	73±10	61±12	0.002

Circ Cardiovasc Intervent 2010;3:113-9.

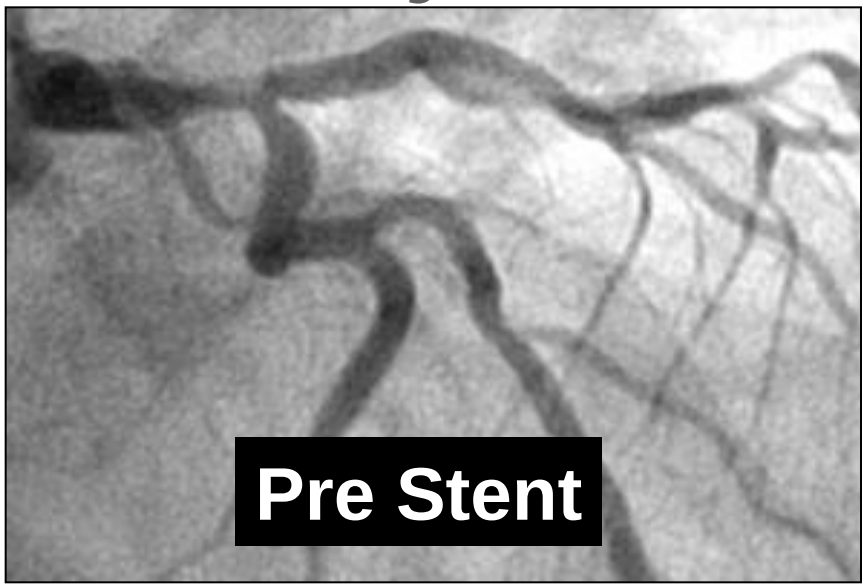
Can we predict which side branches will have an abnormal FFR after MB stenting?

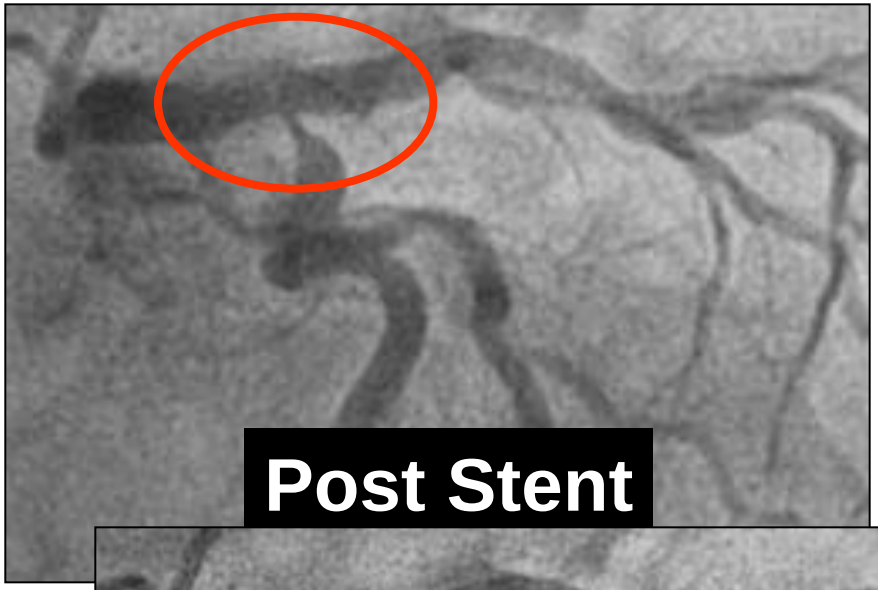
Correlation between Pre PCI MB IVUS and Post PCI SB FFR

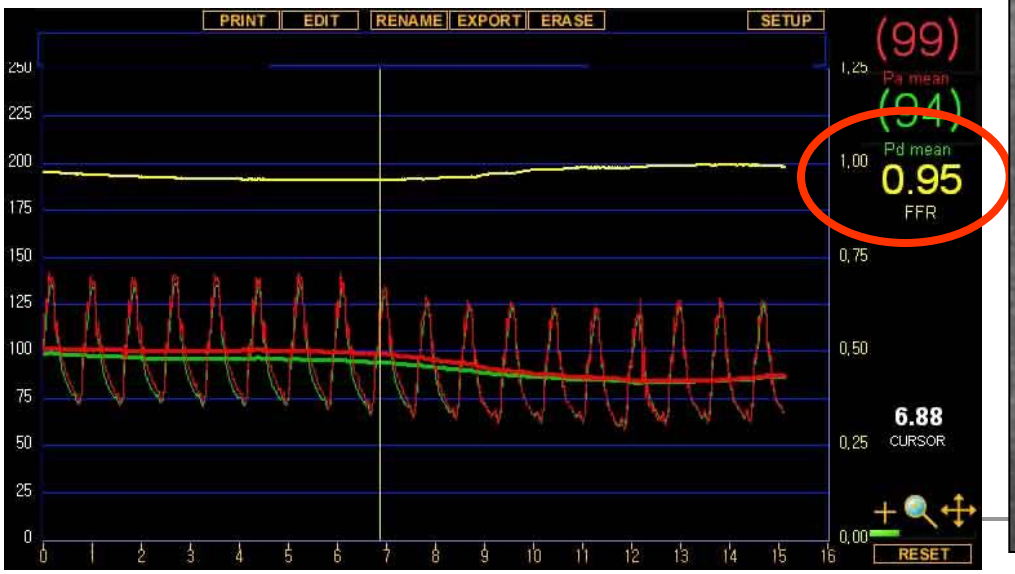


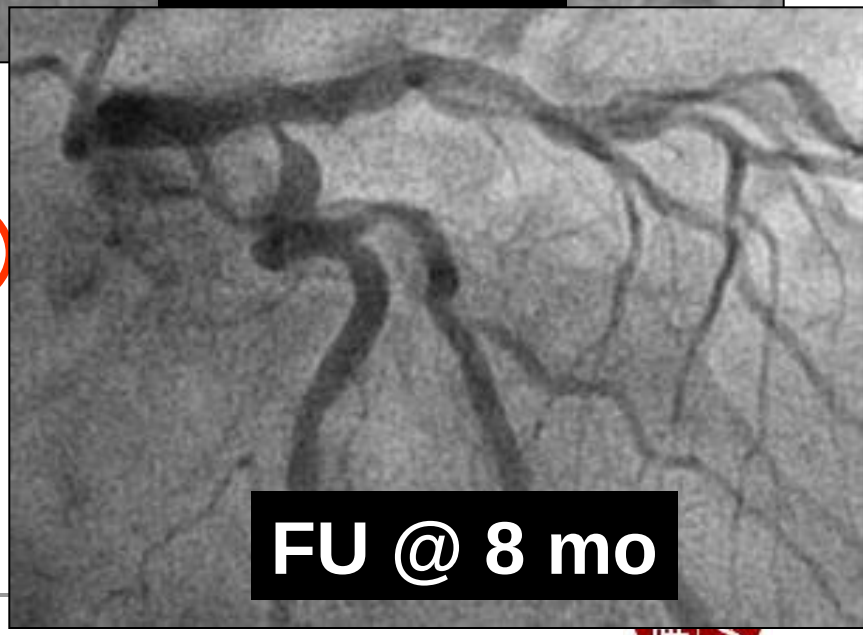
Circ Cardiovasc Intervent 2010;3:113-9.

FFR of “jailed” Circumflex



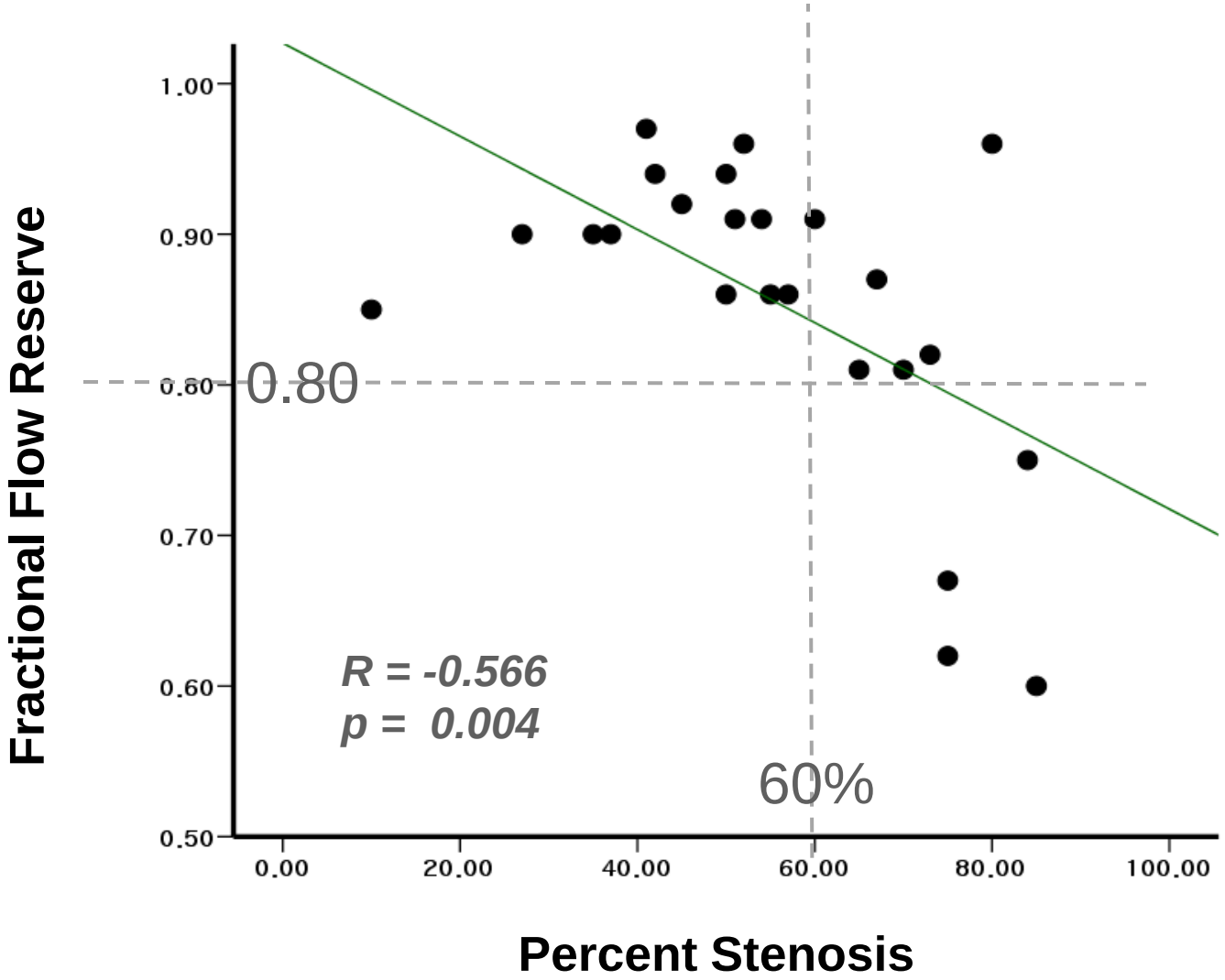






Courtesy of Chang-Wook Nam, MD

FFR of “jailed” Circumflex



Nam CW, AHA 2008

FFR of “jailed” Circumflex

	Defer group n = 20	PCI group n = 4
Death, n	0	1
Myocardial Infarction, n	0	0
TLR, n	3	1
Stent Thrombosis, n	0	0
Total Events, n	3	2

Nam CW, AHA 2008

Practical Considerations:

- Do not “jail” the pressure wire behind a stent
- Remember to consider distal side branch disease or proximal main branch disease when assessing FFR of a sidebranch ostium
- If you are intent on measuring the FFR of a “jailed” side branch, but cannot wire the vessel with a pressure wire, can wire with another wire and exchange over a transit catheter

Ostial/Bifurcation Lesions and FFR

Take Home Messages:

- Angiographic evaluation of ostial/bifurcation lesions overestimates their functional significance.
- Functionally significant “jailing” of side branches is caused by both plaque shift and carina shift.
- Anatomic parameters (angiography/IVUS) cannot predict which side branches are going to become significantly “jailed” after main branch stenting.
- FFR measurement is feasible and safe in ostial and bifurcation lesions, and can help guide the decision regarding the need for PCI