Coronary Physiology in Left Main Disease

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Disclosure Statement of Financial Interest

Within the past 12 months, I or my spouse/partner have had a financial interest /arrangement or affiliation with the organization(s) listed below

Affiliation/Financial Relationship	Company
Grant/ Research Support:	**Abbott, Medtronic, NIH: 5R33HL139929**
Consulting Fees/Honoraria:	**CathWorks, Siemens**
Major Stock Shareholder/Equity Interest:	
Royalty Income:	
Ownership/Founder:	
Salary:	
Intellectual Property Rights:	
Other Financial Benefit:	**Minor Stock Options: HeartFlow**

Coronary Physiology for LM

- Why should we use coronary physiology to evaluate intermediate left main coronary disease?
- Are FFR/iFR reliable for evaluating intermediate left main coronary disease?
- What are some of the issues related to using coronary physiology to evaluate left main disease?

IVUS for Assessing LM Disease

One-Year Follow-up After Intravascular Ultrasound Assessment of Moderate Left Main Coronary Artery Disease in Patients With Ambiguous Angiograms

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Washington, DC

OBJECTIVES The purpose of this study was to correlate angiographic and intravascular ultrasound (IVUS) findings in left main coronary artery (LMCA) disease and identify the predictors of coronary events at one year in patients with LMCA stenoses.

BACKGROUND Significant (≥50% diameter stenosis [DS]) LMCA disease has a poor long-term prognosis.

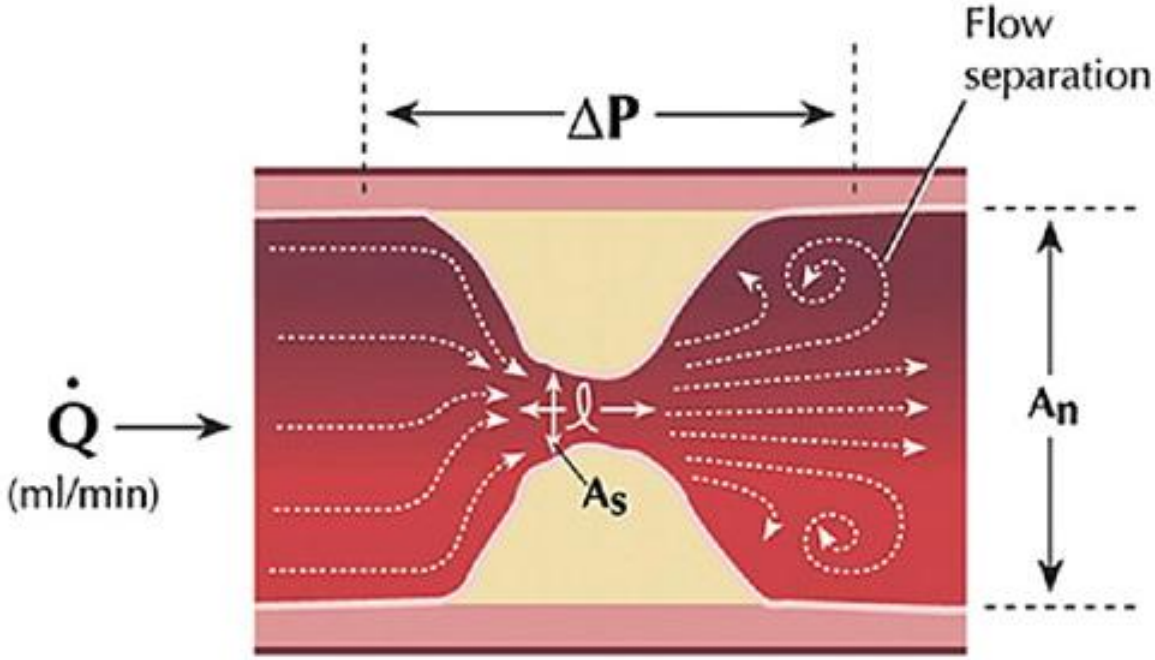
METHODS One hundred twenty-two patients who underwent angiographic and IVUS assessment of the severity of LMCA disease and who did not have subsequent catheter or surgical intervention were followed for one year. Standard clinical, angiographic and IVUS parameters were collected.

RESULTS The quantitative coronary angiography (QCA) reference diameter (3.91 ± 0.76 mm, mean ± 1 SD) correlated moderately with IVUS (4.25 ± 0.78 mm, r = 0.492, p = 0.0001). The lesion site minimum lumen diameter (MLD) (2.26 ± 0.82 mm) by QCA correlated less well . . .

CONCLUSIONS In selected patients assessed by IVUS, moderate LMCA disease had a one-year event rate of only 14%. Intravascular ultrasound MLD was the most important quantitative predictor of cardiac events. For any given MLD, the event rate was exaggerated in the presence of diabetes or another untreated lesion (>50% DS). (J Am Coll Cardiol 1999;34:707–15)

Why should we use coronary physiology?

Factors contributing to a lesion's ischemic potential

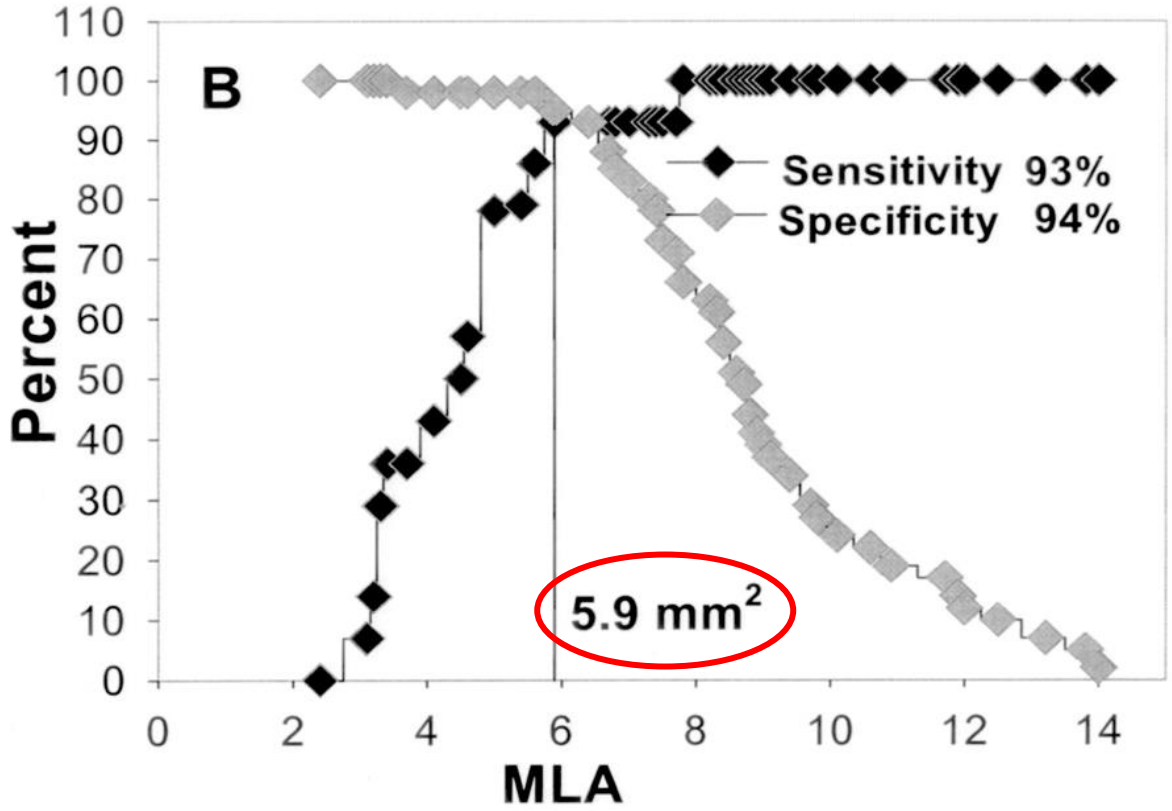


$$\Delta P = \underbrace{f_1(1/A_s^2, \ell, \dot{Q})}_{\text{Viscous}} + \underbrace{f_2(1/A_s^2, 1/A_n^2, \dot{Q}^2)}_{\text{Separation}}$$

Kern MJ, et al. J Am Coll Cardiol 2010;55:173-85

IVUS Cutoff Value For Significant LM

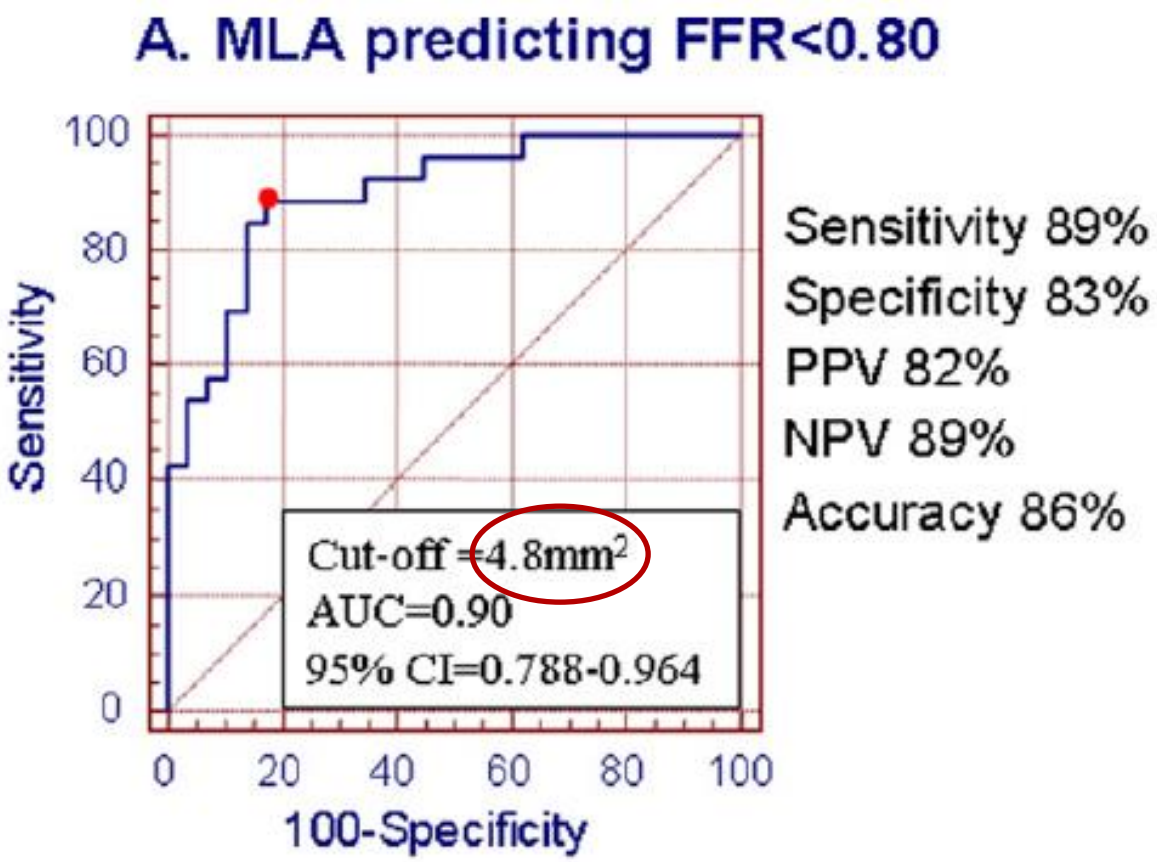
55 patients with ambiguous left main disease had IVUS and FFR performed



Jasti, et al. Circulation 2004;110:2831-6

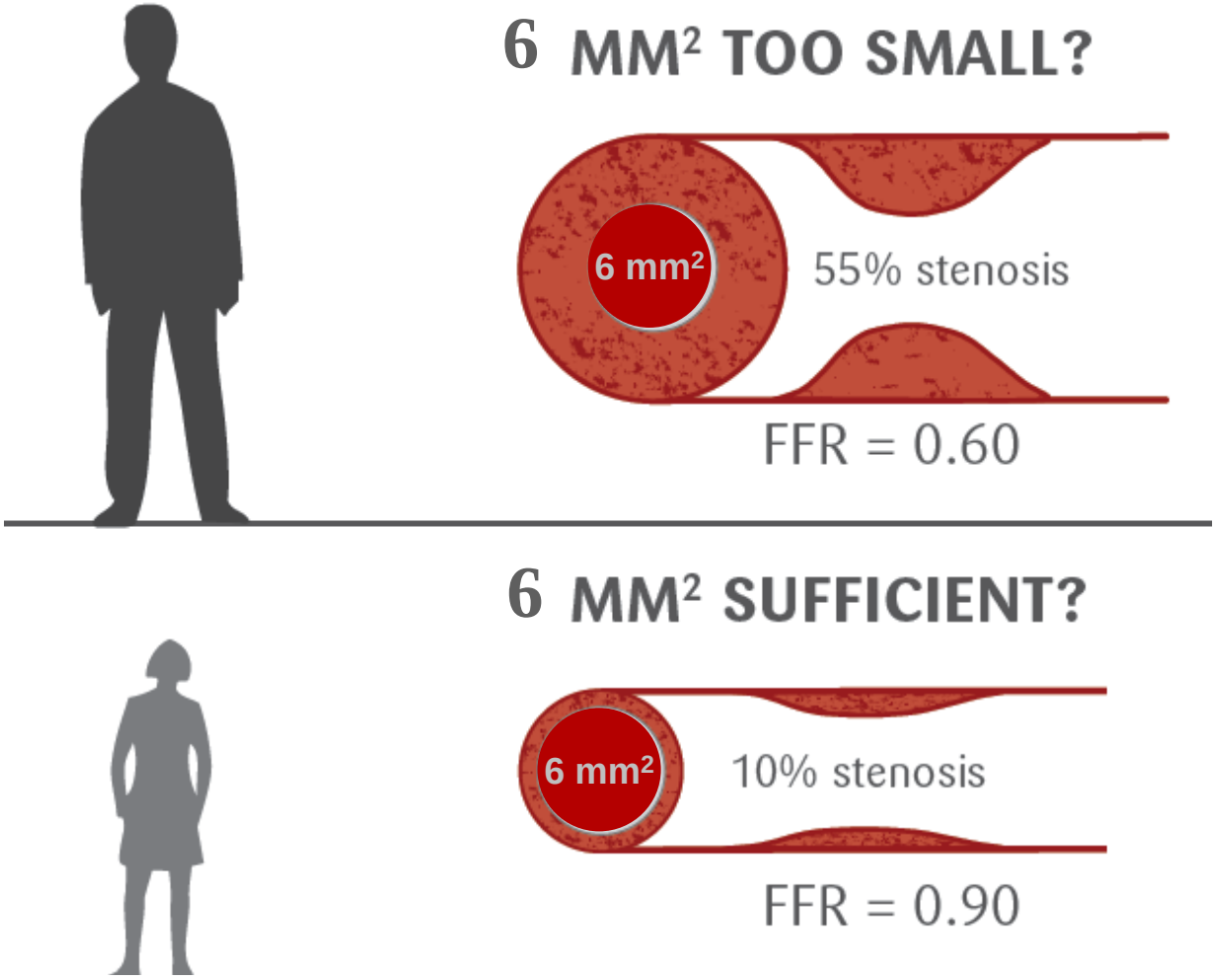
Variability of IVUS Cutoff Values

55 patients with 30-80% LM and FFR and IVUS



Kang, et al. J Am Coll Cardiol Intv 2011;4:1168-74

Limitation of Absolute MLA Cutoff



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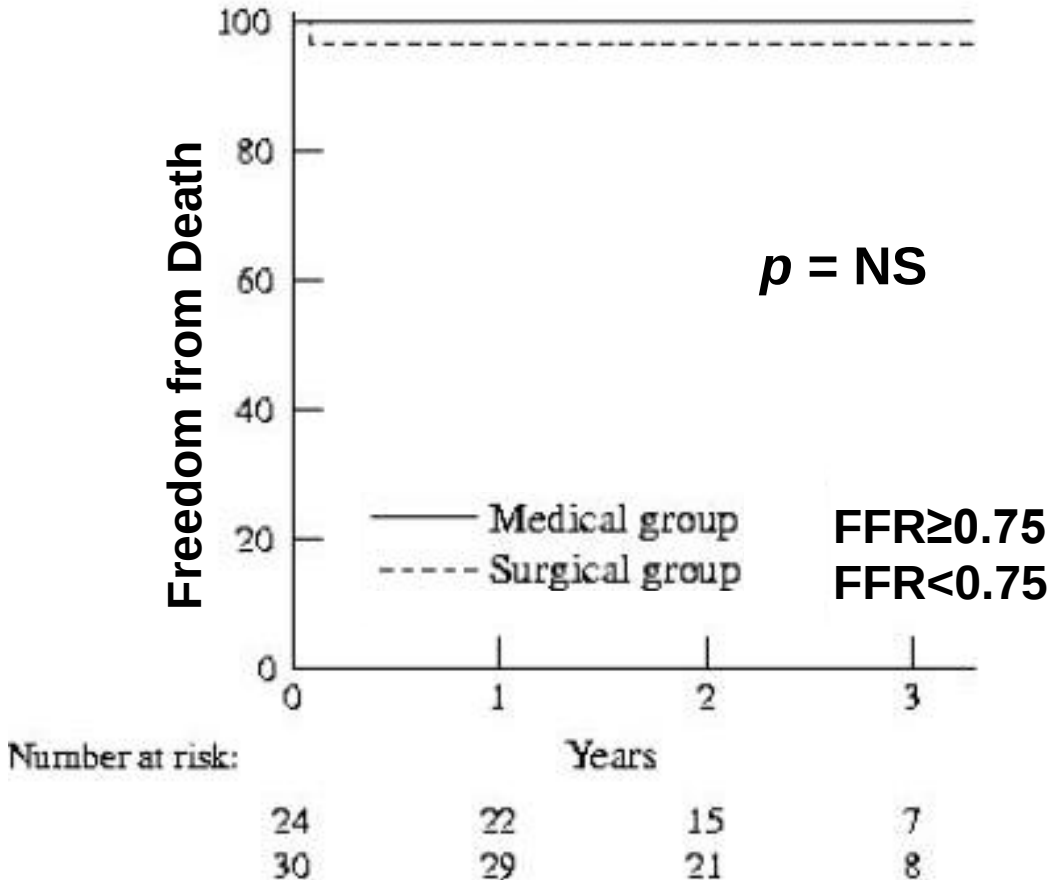
Safety of Deferring LM Revascularization

FFR measured in 54 patients with equivocal left main



Bech, et al. Heart 2001;86:547-552

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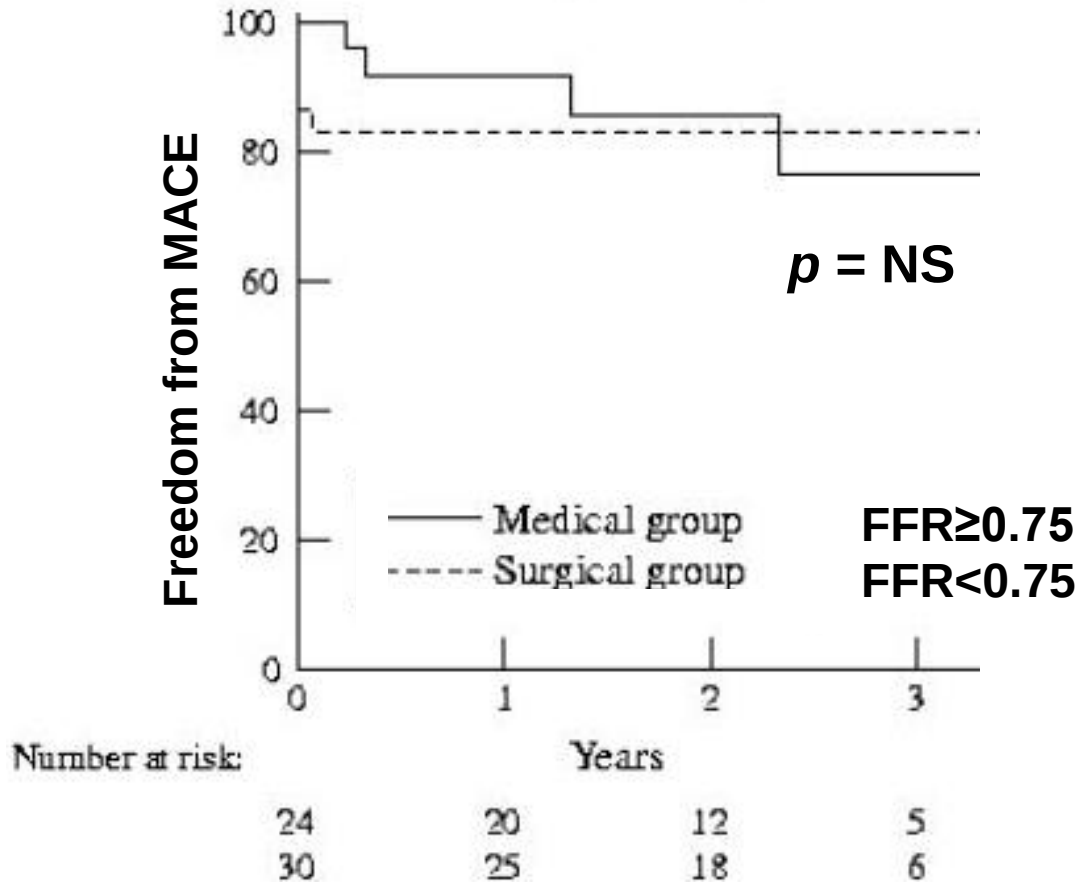
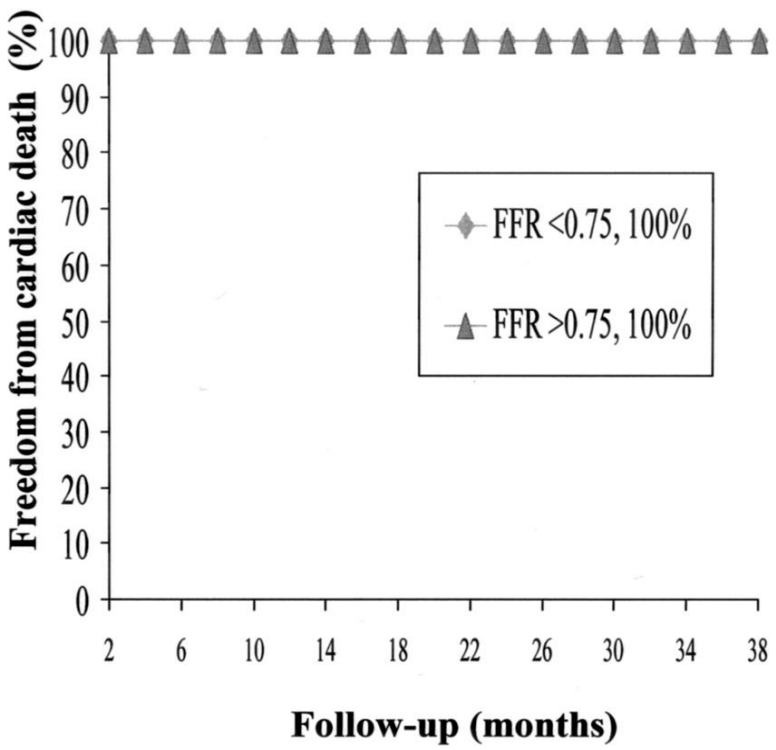
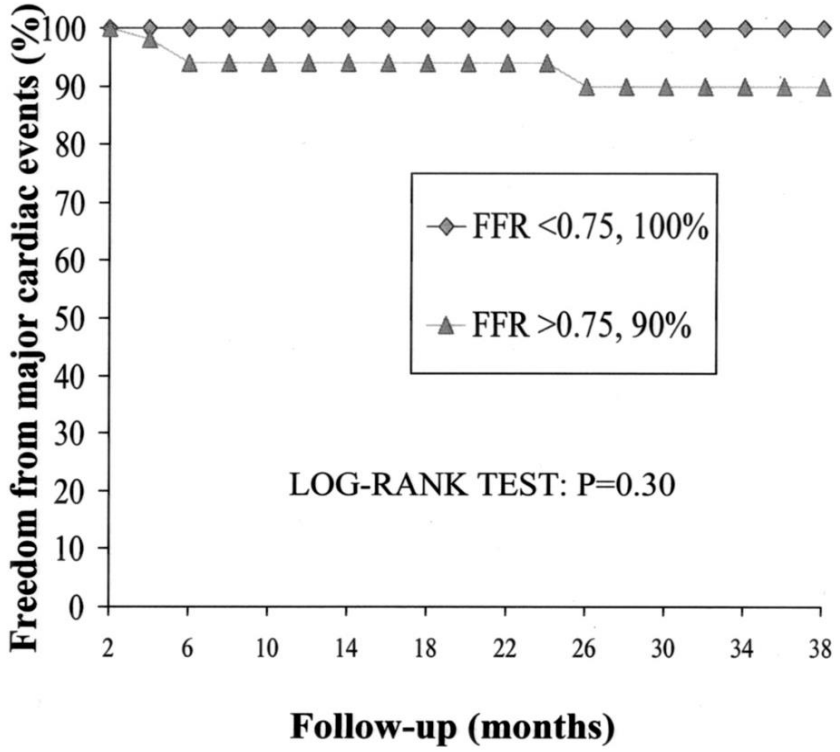


Bech, et al. Heart 2001;86:547-552

Safety of Deferring LM Revascularization

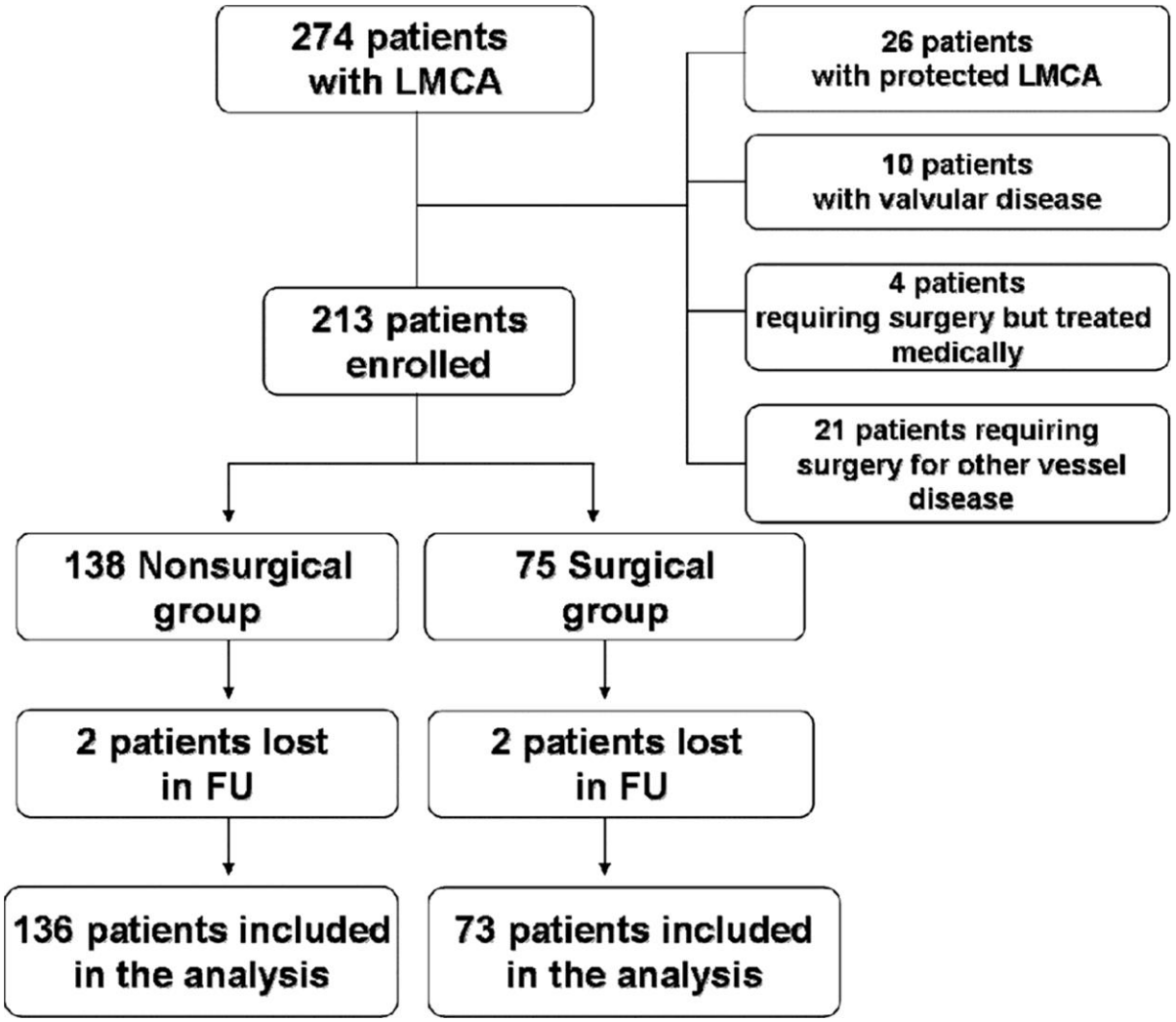
55 patients with ambiguous left main disease





Jasti, et al. Circulation 2004;110:2831-6

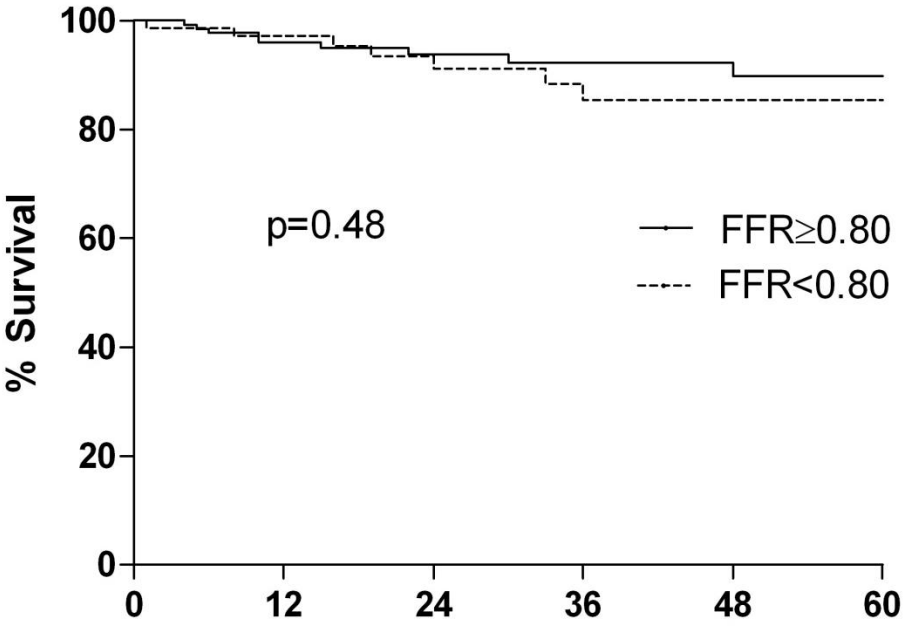
FFR of LM to Guide Revascularization



Hamilos, et al. Circulation 2009;120:1505

FFR of LM to Guide Revascularization

Survival Rate

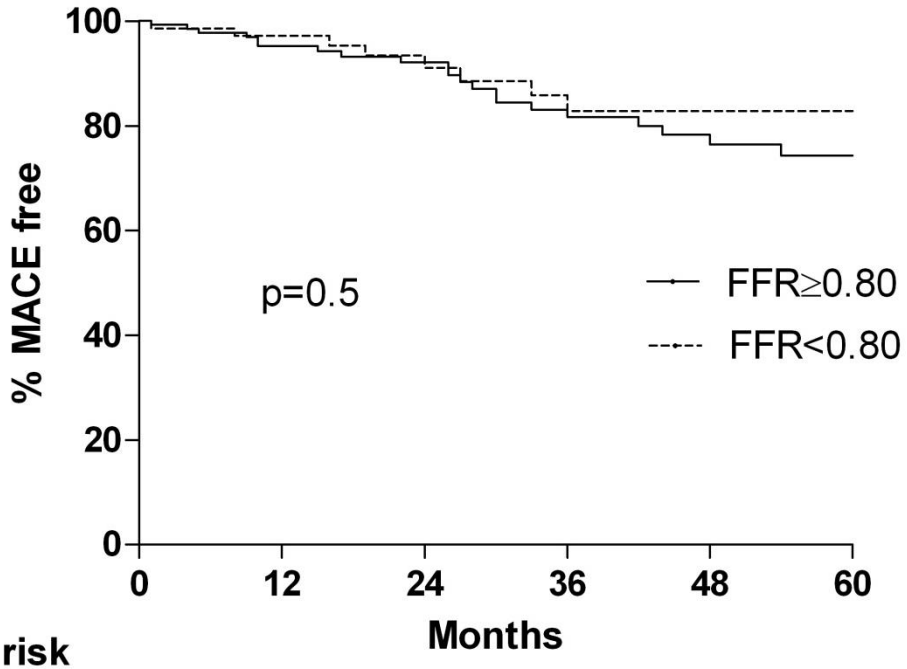


No at risk						
FFR≥0.80	136	103	72	52	38	26
FFR<0.80	73	56	41	30	14	10

Hamilos, et al. Circulation 2009;120:1505

FFR of LM to Guide Revascularization

MACE Rate

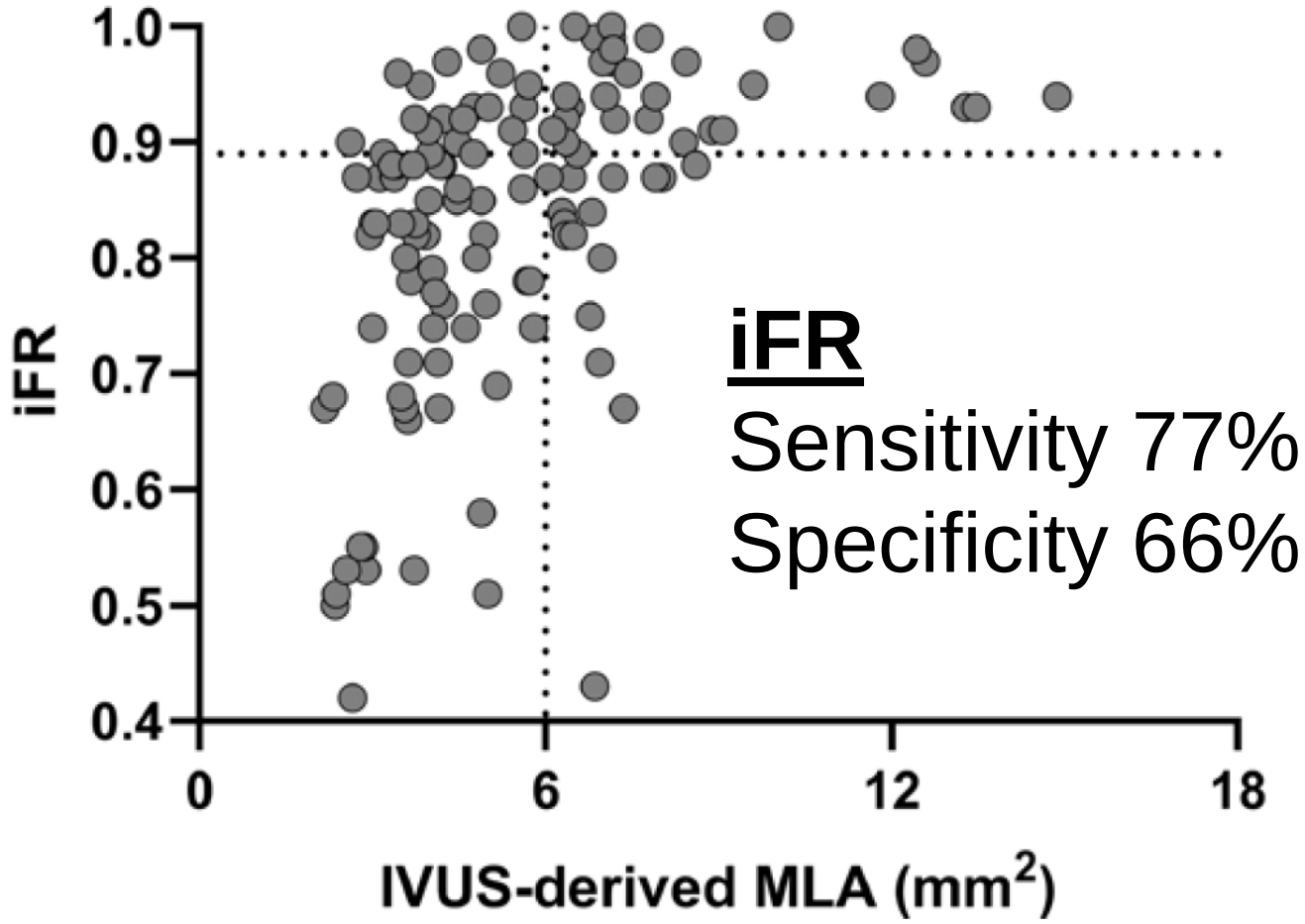


No at risk						
FFR≥0.80	136	106	77	57	42	30
FFR<0.80	73	56	40	29	15	10

Hamilos, et al. Circulation 2009;120:1505

iFR Compared with IVUS of the Left Main

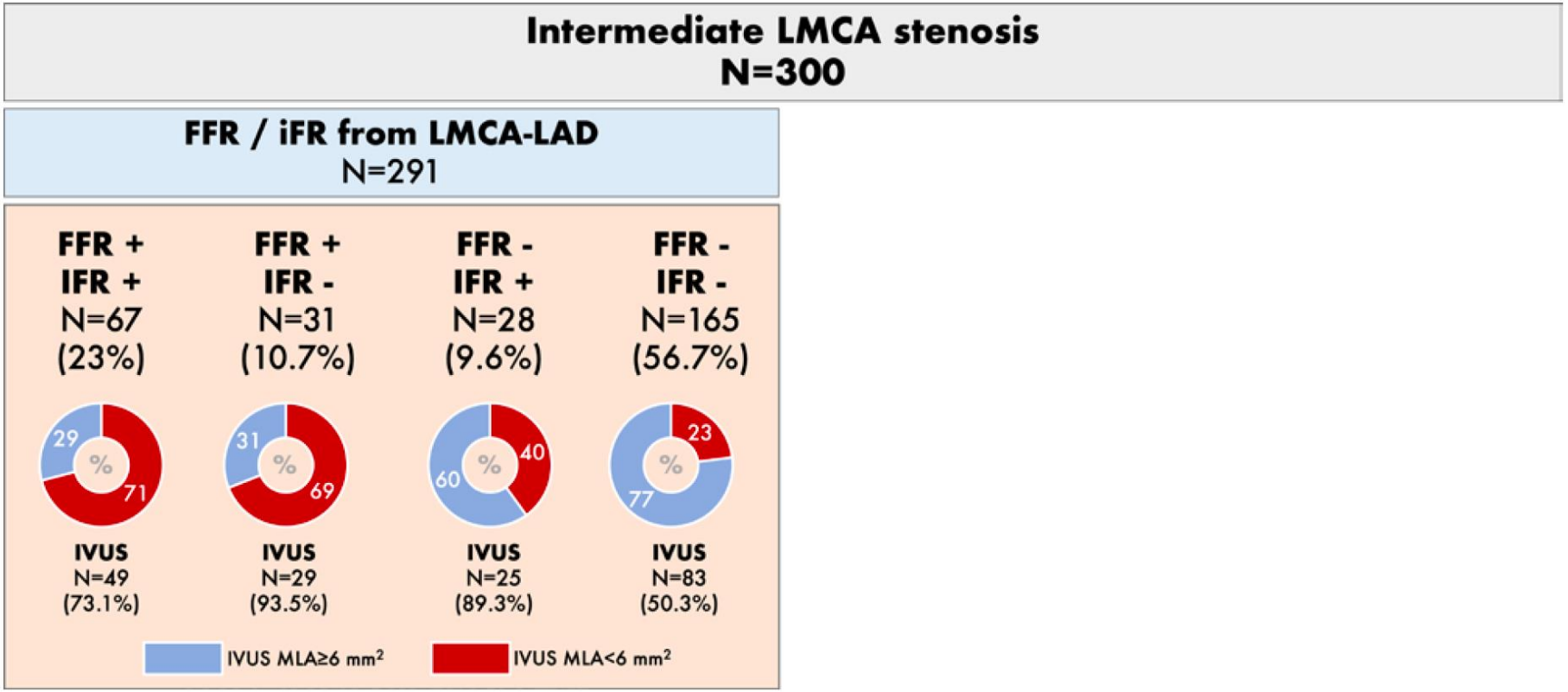
125 patients with intermediate LM underwent iFR and IVUS



El Hajj, et al. Circ Cardiovasc Interv 2021;14:e009830

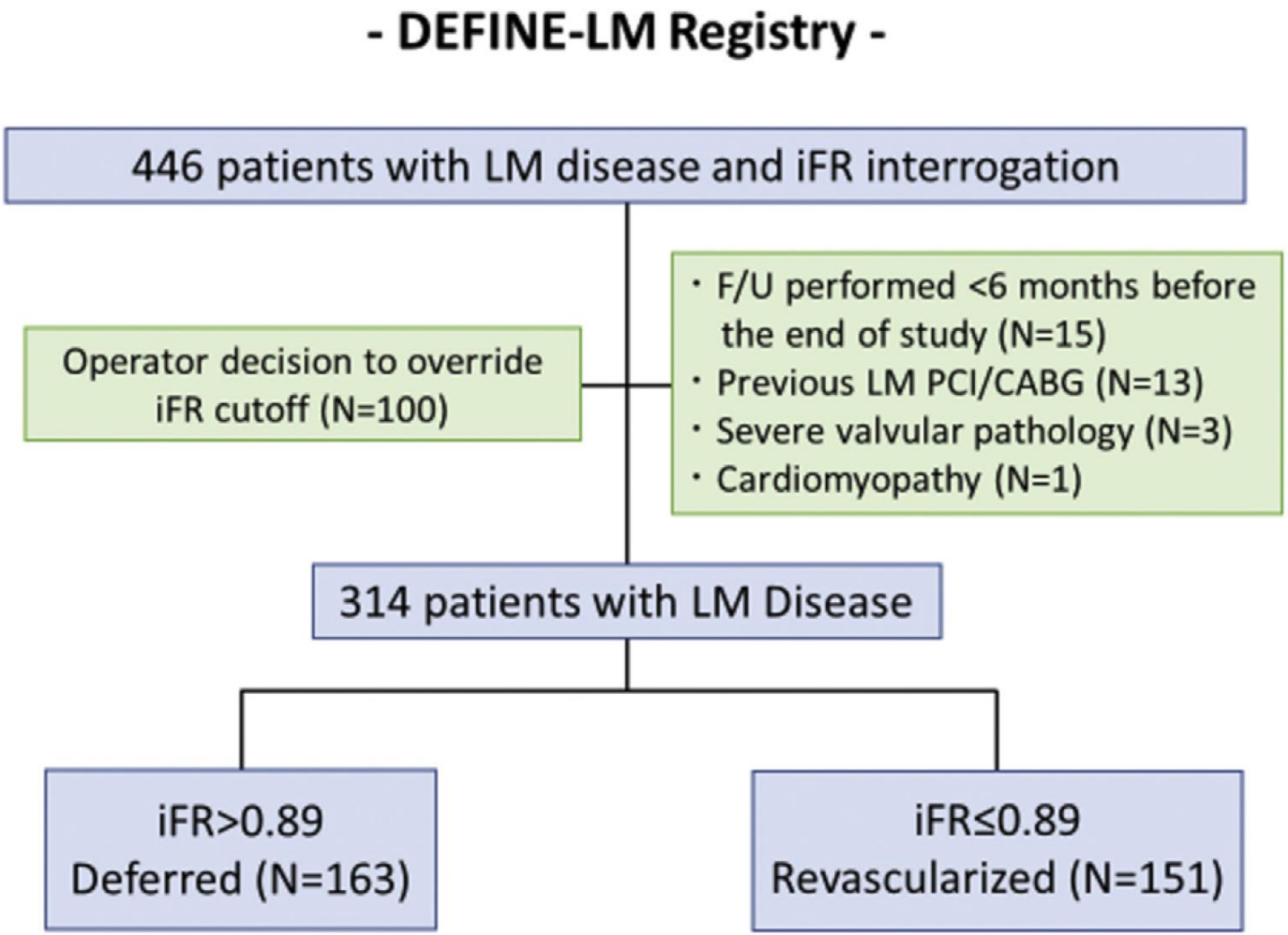
FFR, iFR and IVUS Assessment of LM

300 patients with intermediate LM had iFR, FFR and IVUS



Rodriguez-Leor, et al. Circ Cardiovasc Interv. 2022;15:e012328.

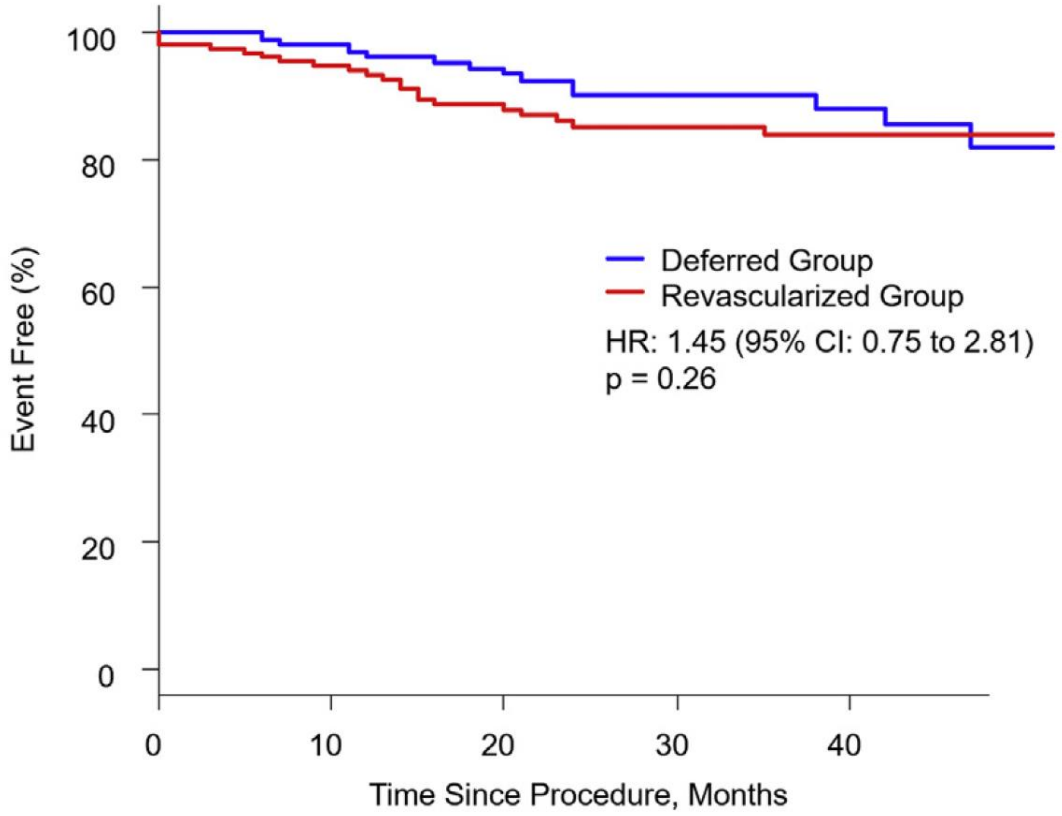
iFR of LM to Guide Revascularization



Warisawa, et al. J Am Coll Cardiol Intv 2020;13:1655-64

iFR of LM to Guide Revascularization

DEFINE LM Registry



Death, MI, TLR

Number at risk

Deferred Group	163	143	99	59	41
Revascularized Group	151	135	102	78	54

Warisawa, et al. J Am Coll Cardiol Intv 2020;13:1655-64

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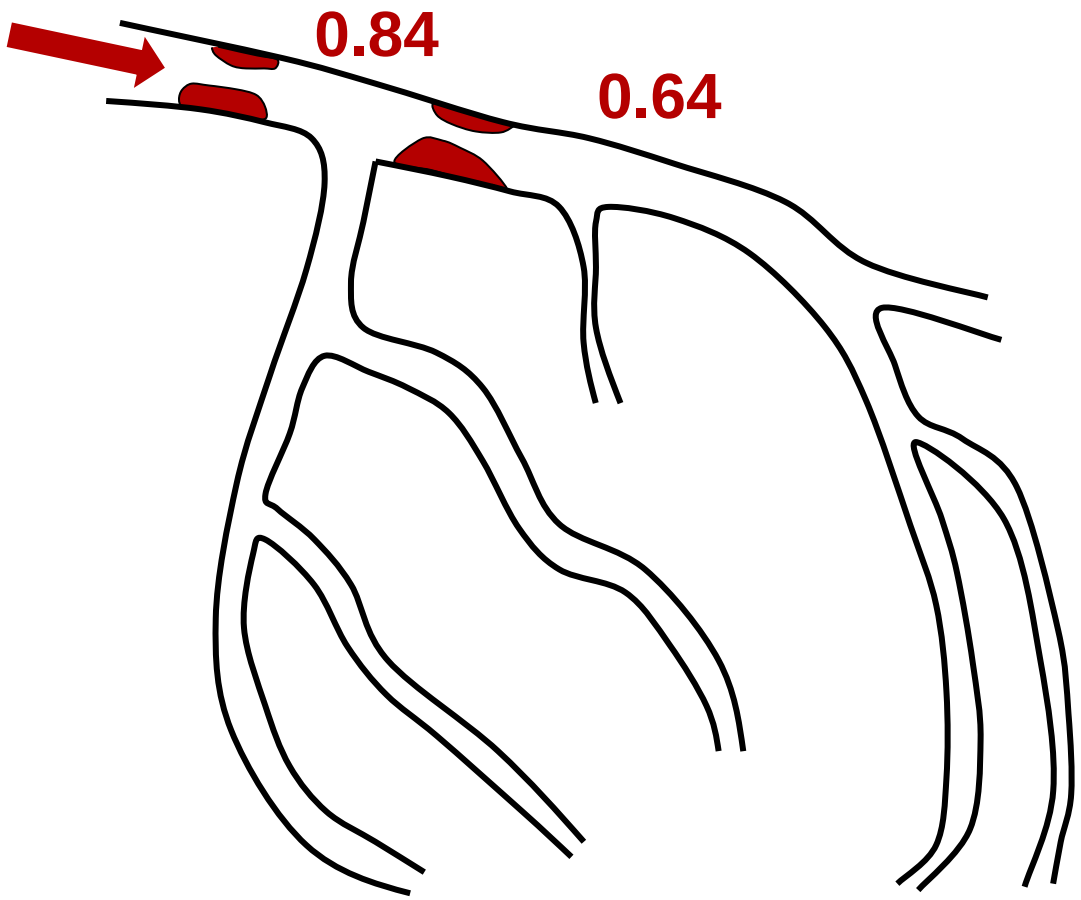
FFR of LM with Downstream Disease



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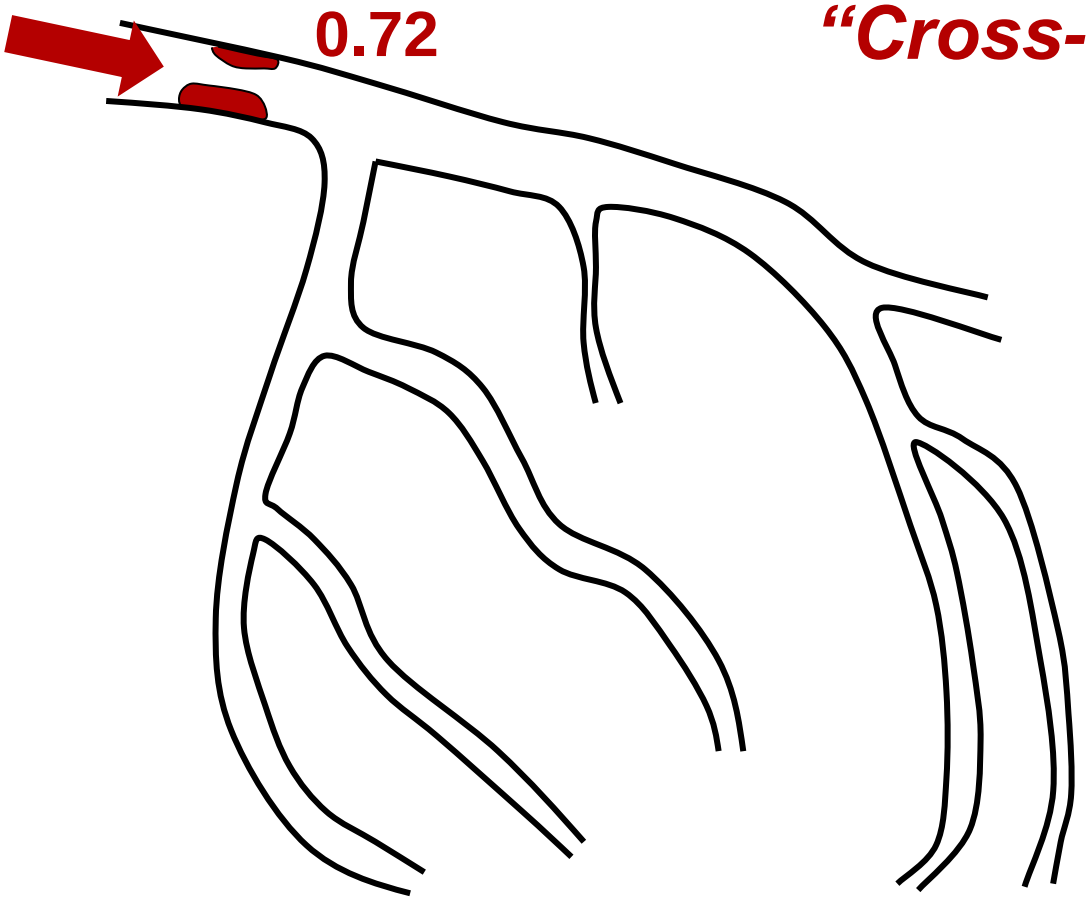


Are NHPRs (iFR, Pd/Pa) Prone to "Cross-Talk" like FFR?

Impact of Serial Coronary Stenoses on Various Coronary Physiologic Indices

Jung-Min Ahn, MD; Takaharu Nakayoshi, MD; Takehiro Hashikata, MD; Kuninobu Kashiyama, MD; Hiroyuki Arashi, MD; Jihoon Kweon, PhD; Marcel van't Veer, MSc, PhD; Jennifer Lyons, RVT; William F. Fearon, MD

BACKGROUND: Determining the functional significance of each individual coronary lesion in patients with serial coronary stenoses is challenging. It has been proposed that nonhyperemic pressure ratios, such as the instantaneous wave free ratio (iFR) and the ratio of resting distal to proximal coronary pressure (Pd/Pa) are more accurate than fractional flow reserve (FFR) because autoregulation should maintain stable resting coronary flow and avoid hemodynamic interdependence (cross-talk) that occurs during hyperemia. This study aimed to measure the degree of hemodynamic interdependence of iFR, resting Pd/Pa, and FFR in a porcine model of serial coronary stenosis.

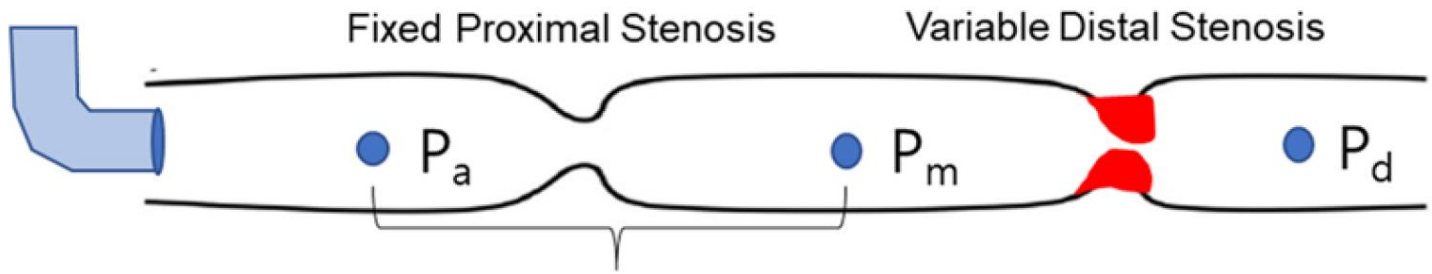
METHODS: In 6 anesthetized female swine, 381 serial coronary stenoses were created in the left anterior descending artery using 2 balloon catheters. The degree of hemodynamic interdependence was calculated by measuring the absolute changes in iFR, resting Pd/Pa, and FFR across the fixed stenosis as the severity of the other stenosis varied.

RESULTS: The hemodynamic interdependence of iFR, resting Pd/Pa, and FFR was 0.039±0.048, 0.021±0.026, and 0.034±0.034, respectively (all $P<0.001$). When the functional significance of serial stenoses was less severe (0.70–0.90 for each index), the hemodynamic interdependence was 0.009±0.020, 0.007±0.013, and 0.017±0.022 for iFR, resting Pd/Pa, and FFR, respectively (all $P<0.001$). However, in more severe serial coronary stenoses (<0.60 for each index), hemodynamic interdependence was 0.060±0.050, 0.037±0.030, and 0.051±0.037 for iFR, resting Pd/Pa, and FFR, respectively (all $P<0.001$).

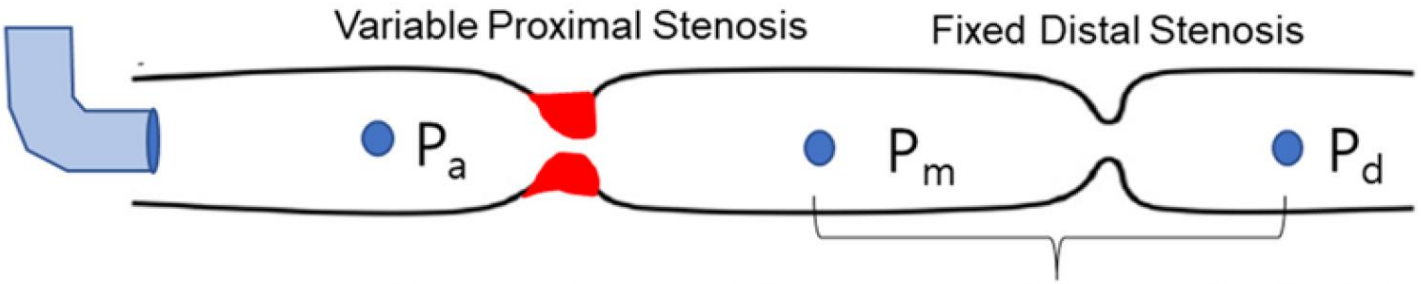
CONCLUSIONS: When assessing serial coronary stenoses, nonhyperemic pressure ratios are affected by hemodynamic interdependence. When the functional significance of serial coronary stenoses is severe, the effect is similar to that which is seen with FFR.

Circ Cardiovasc Interv. 2022;15:e012134.

FFR, iFR, Pd/Pa and “Cross-Talk”



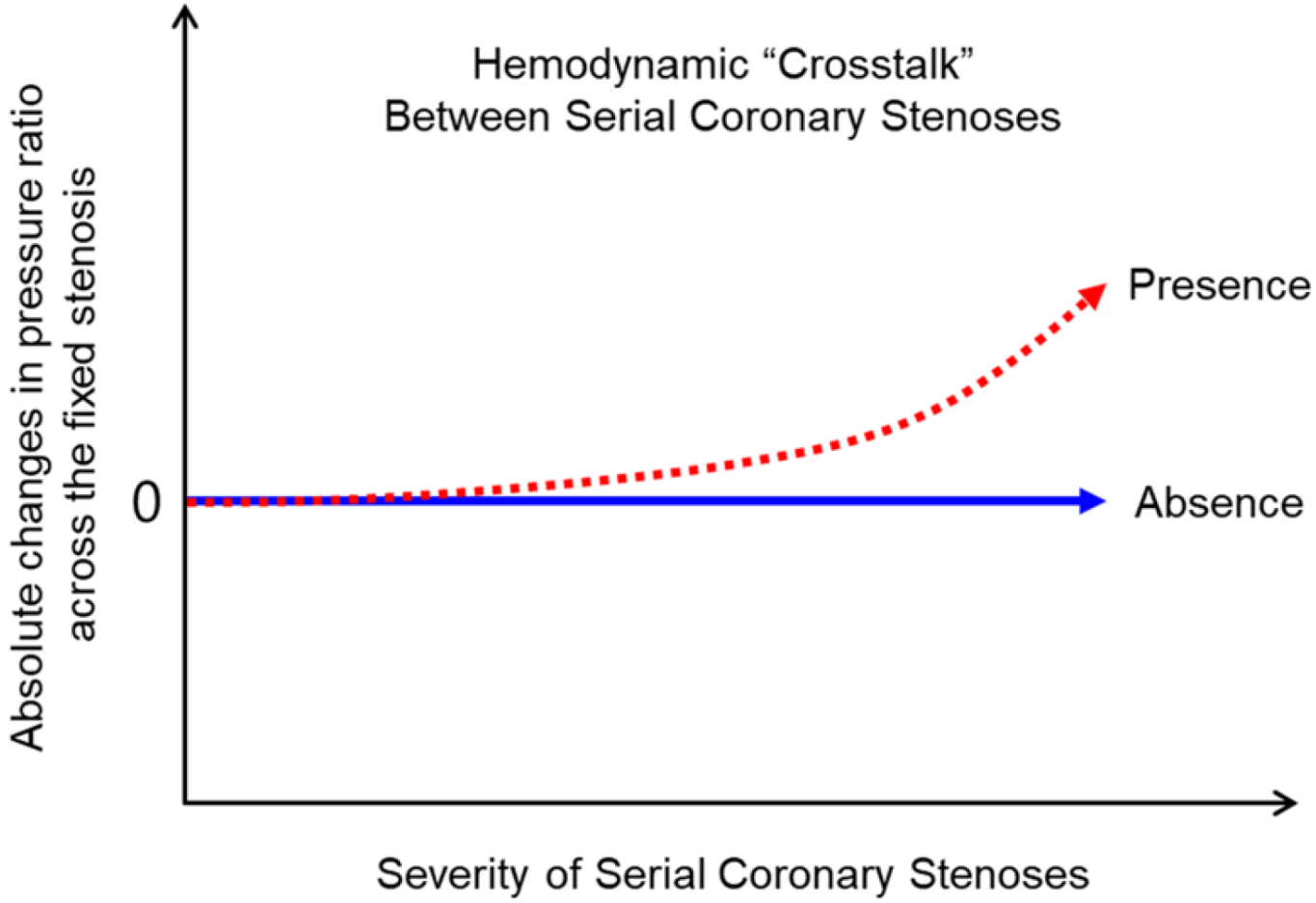
Absolute changes of the pressure ratio across the fixed stenosis according to the variable degree of distal stenosis = “Cross-talk”



“Cross-talk” = Absolute changes of the pressure ratio across the fixed stenosis according to the variable degree of proximal stenosis

Ahn JM, et al. Circ Cardiovasc Interv 2022;15:e012134

FFR, iFR, Pd/Pa and “Cross-Talk”



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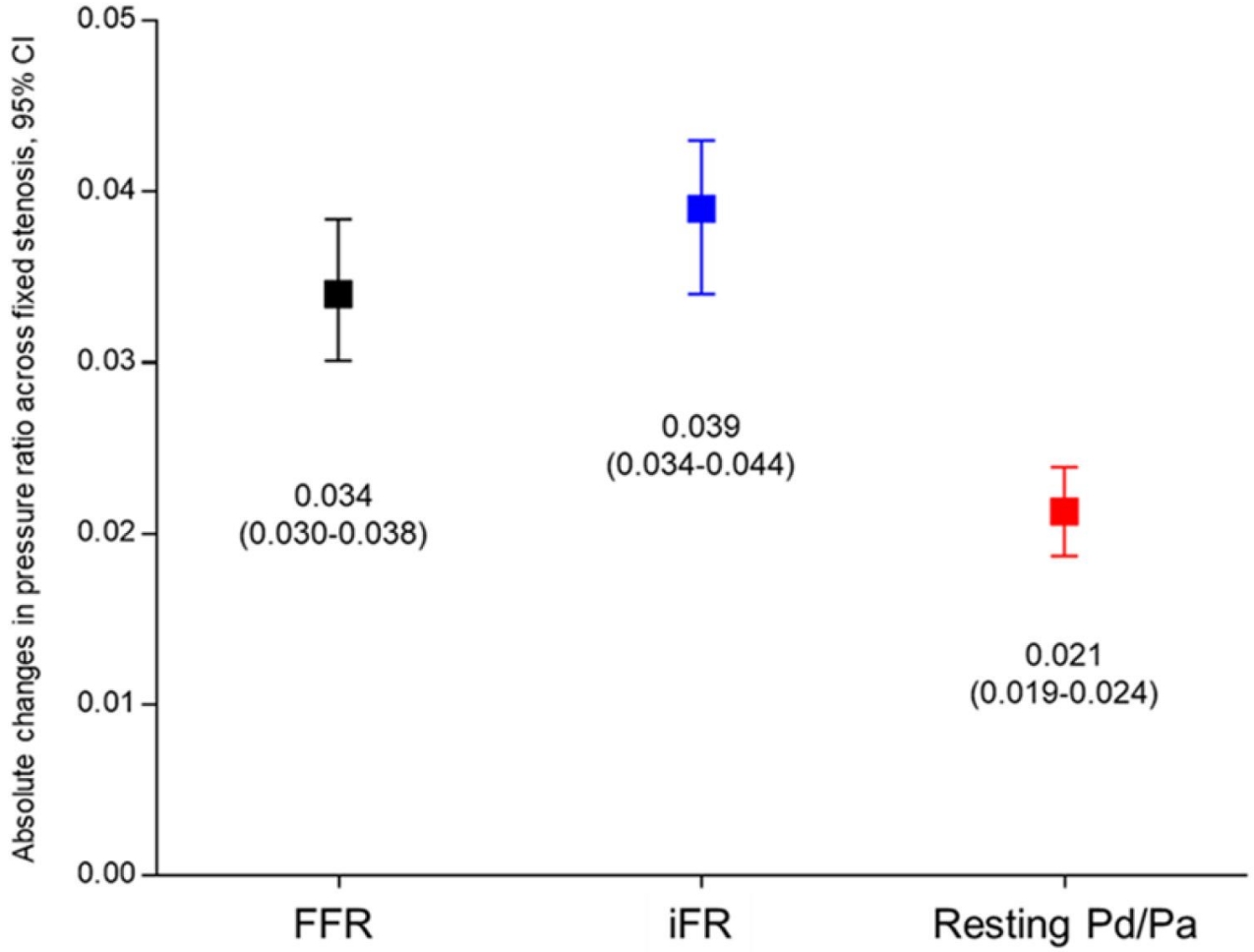
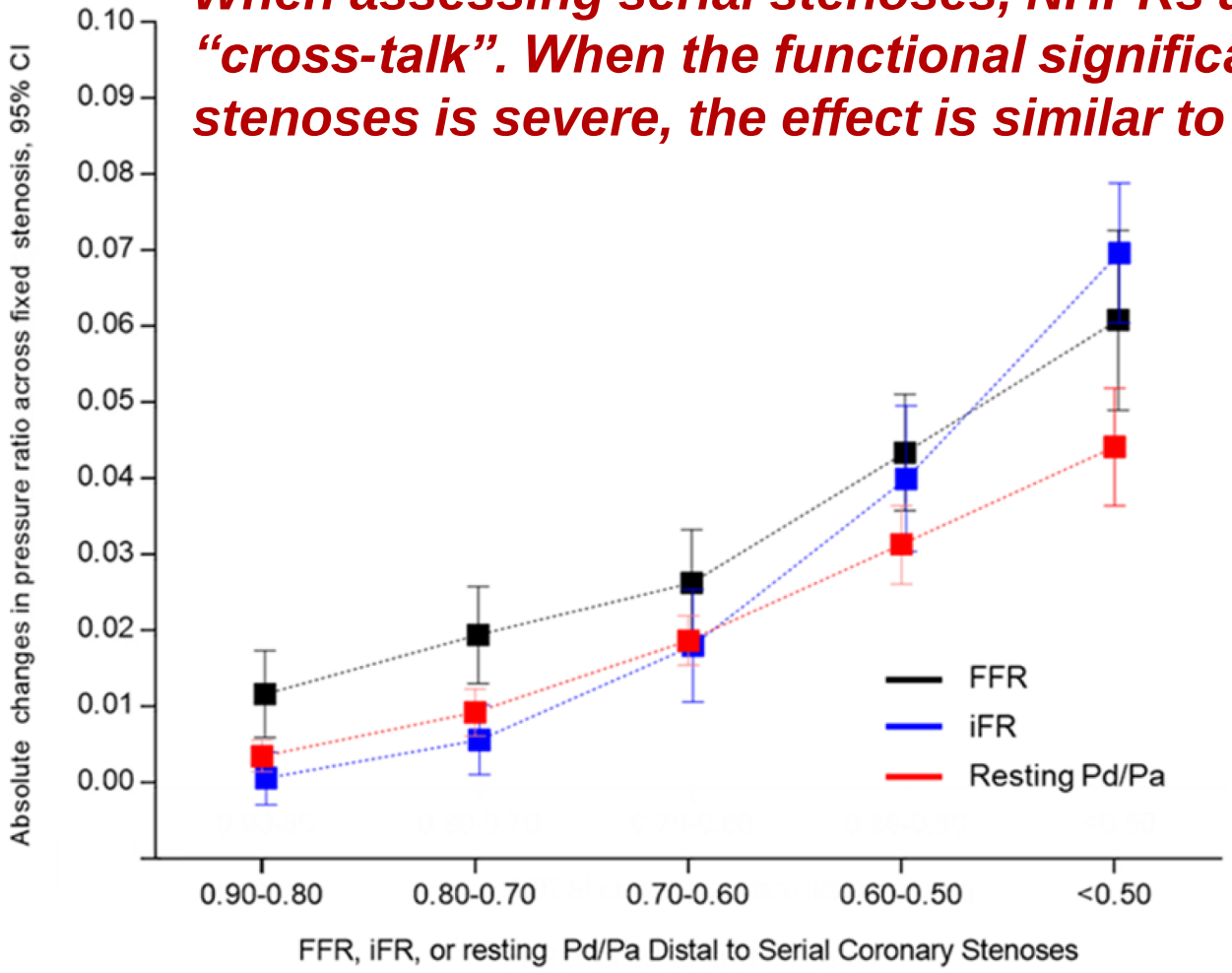
FFR, iFR, Pd/Pa and “Cross-Talk”



Ahn JM, et al. Circ Cardiovasc Interv 2022;15:e012134

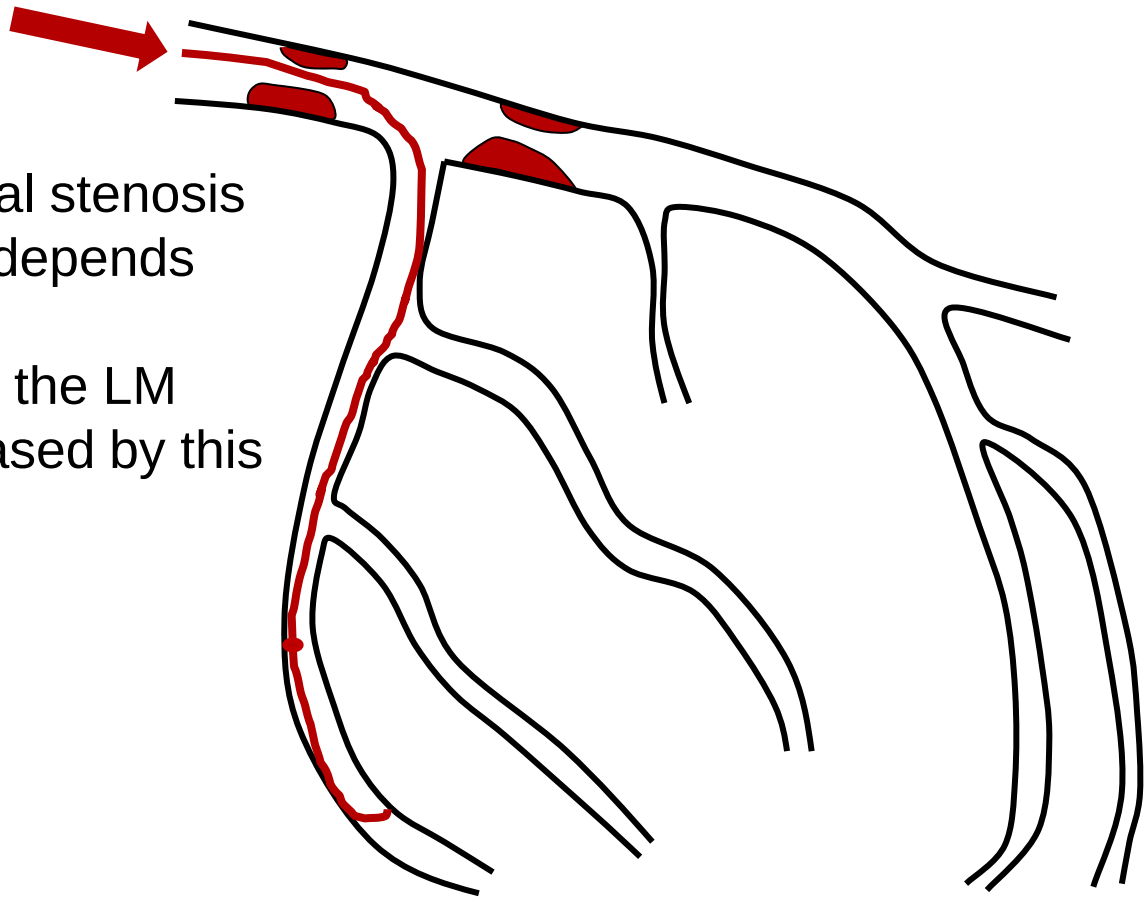
FFR, iFR, Pd/Pa and "Cross-Talk"

When assessing serial stenoses, NHPRs are affected by "cross-talk". When the functional significance of the stenoses is severe, the effect is similar to FFR.



Ahn JM, et al. Circ Cardiovasc Interv 2022;15:e012134

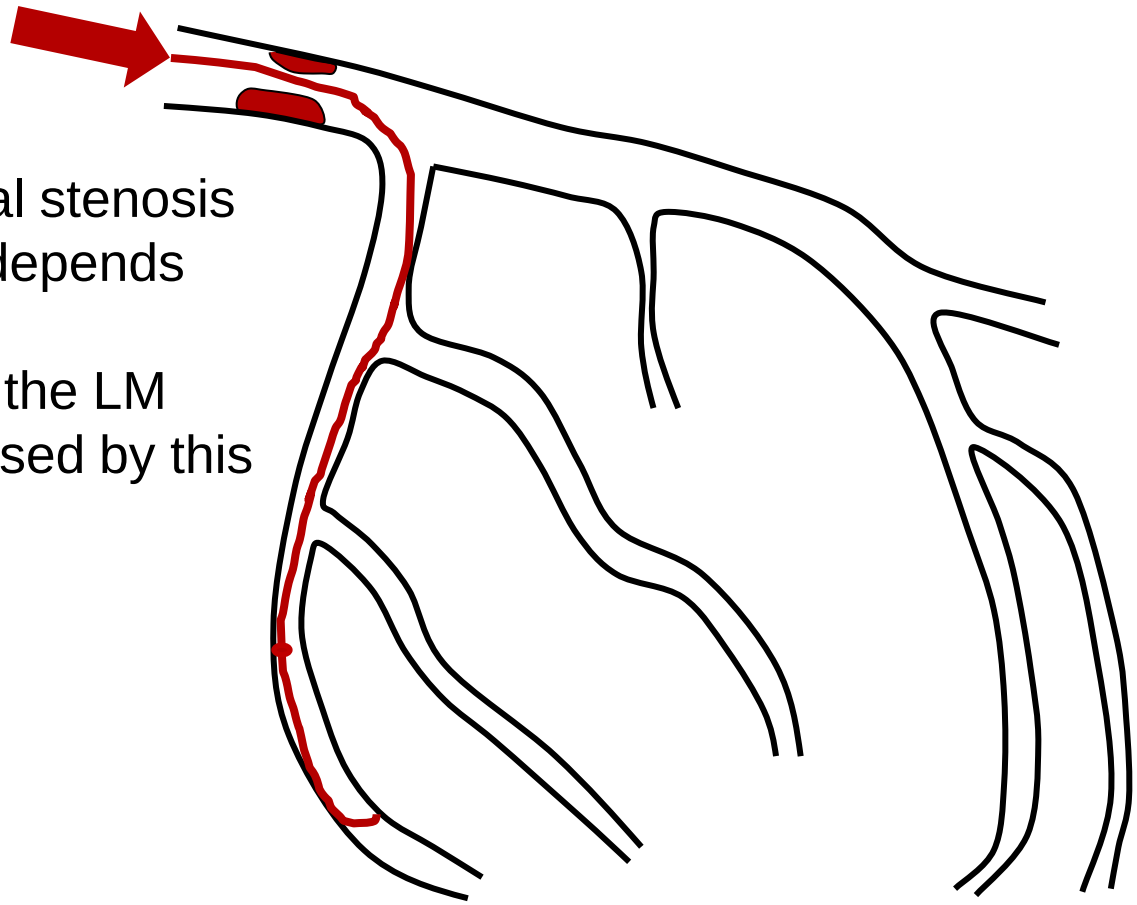
FFR of LM with Downstream Disease



The influence of a distal stenosis on the FFR of the LM depends on the extent to which hyperemic flow across the LM stenosis will be decreased by this distal lesion

- Severity
- Myocardial mass

FFR of LM with Downstream Disease



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The Impact of Downstream Coronary Stenoses on Fractional Flow Reserve Assessment of Intermediate Left Main Disease

Coronary Artery Disease

Fractional Flow Reserve Assessment of Left Main Stenosis in the Presence of Downstream Coronary Stenoses

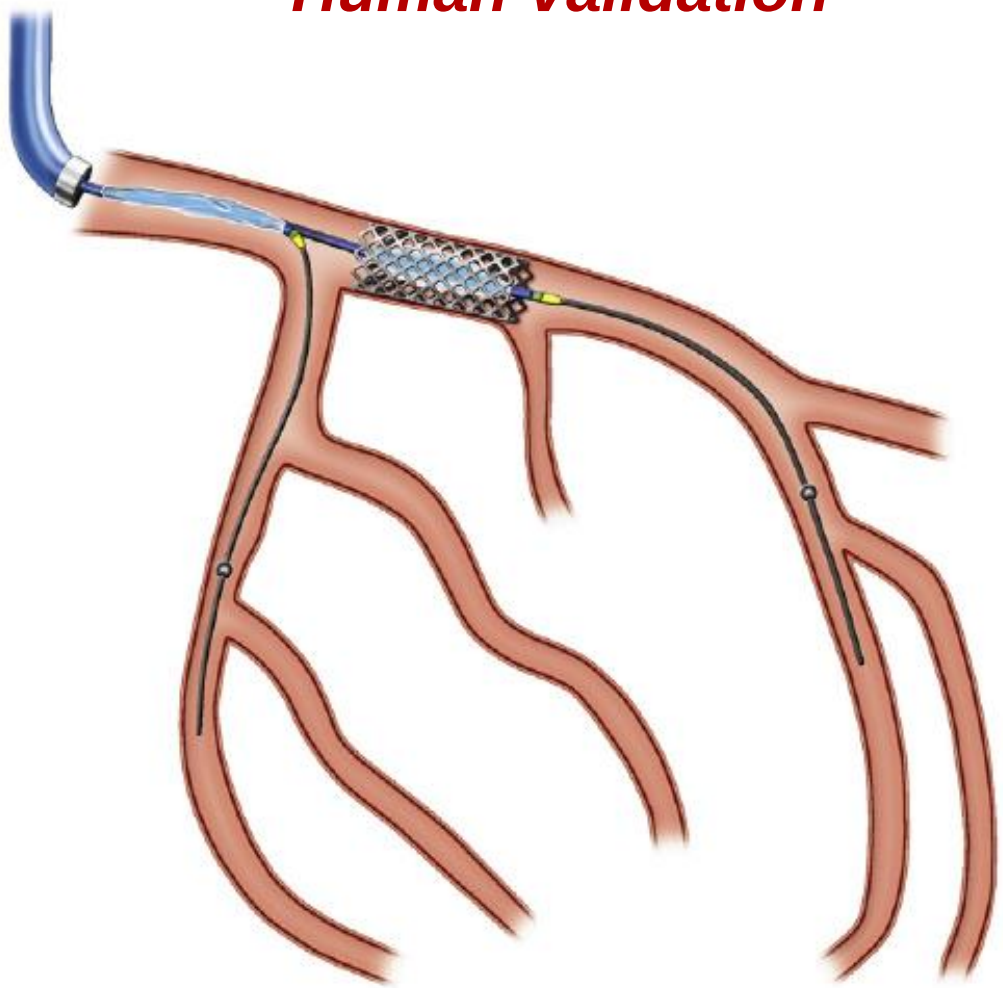
The Impact of Downstream Coronary Stenosis on Fractional Flow Reserve Assessment of Intermediate Left Main Coronary Artery Disease

Human Validation

William F. Fearon, MD,* Andy S. Yong, MBBS, PhD,* Guy Lenders, MD,† Gabor G. Toth, MD,‡ Catherine Dao, MD,* David V. Daniels, MD,* Nico H.J. Pijls, MD, PhD,† Bernard De Bruyne, MD, PhD‡

Effect of Downstream Stenosis on LM FFR:

Human Validation

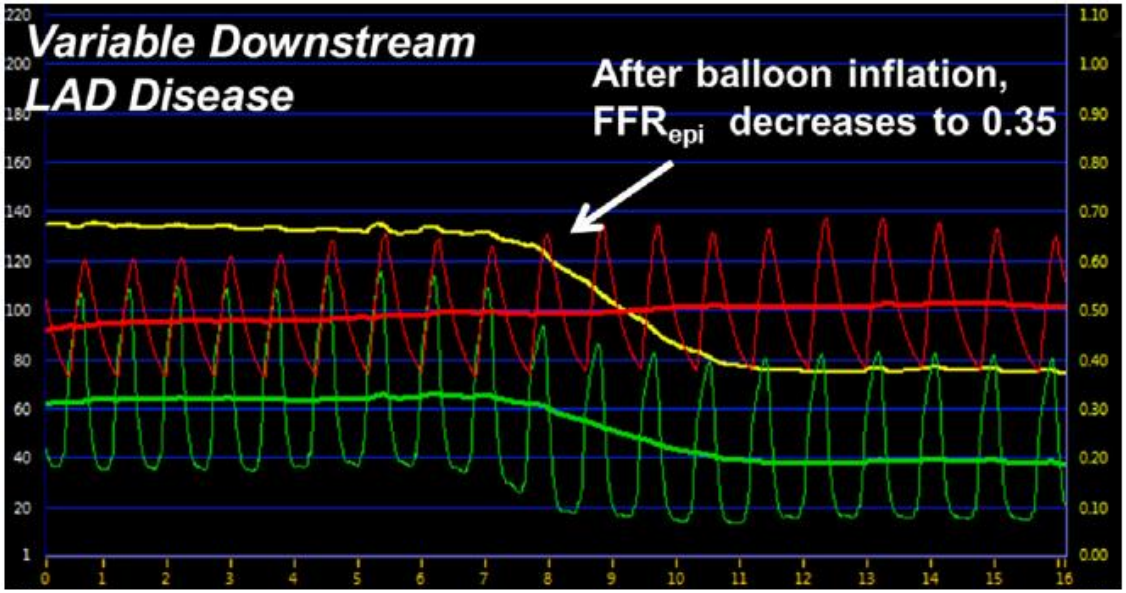


FFR_{app} represents the FFR of the LM and LCx in the presence of LAD balloon inflation

FFR_{true} represents the FFR of the LM and LCx in the absence of LAD balloon inflation

FFR_{epi} represents the FFR of the LM and LAD with the LAD balloon inflated to varying degrees

J Am Coll Cardiol Intv 2015;8:398-403.



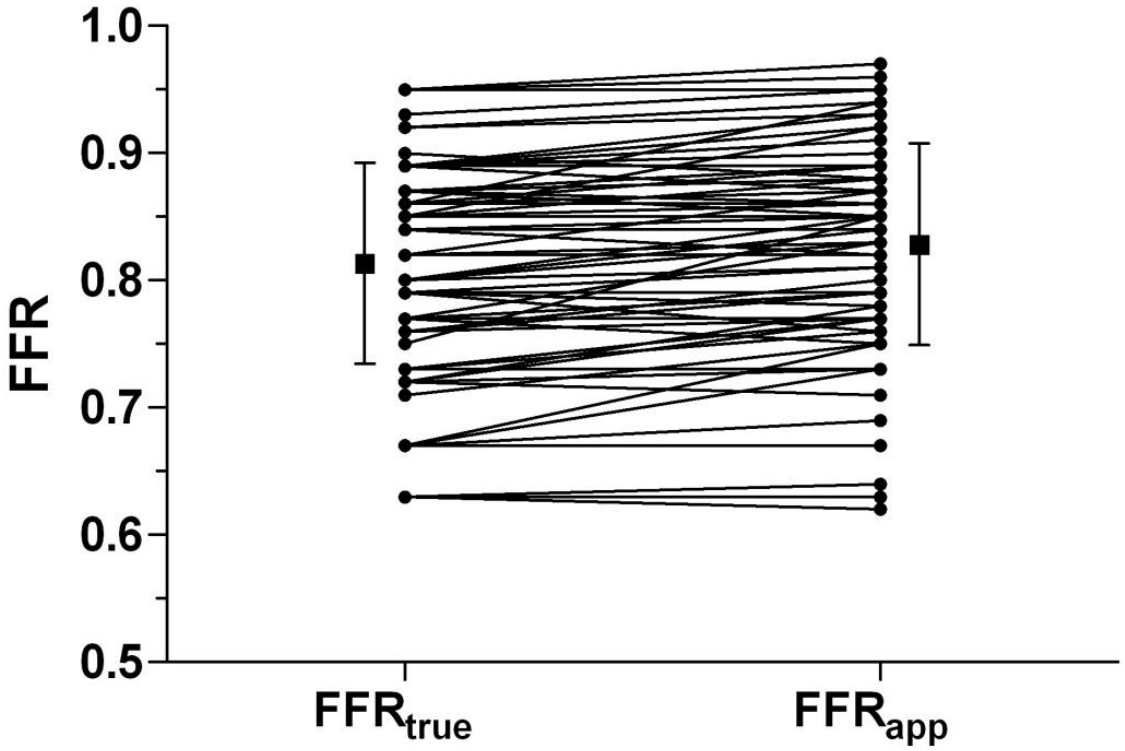
J Am Coll Cardiol Intv 2015;8:398-403.

Effect of Downstream Stenosis on LM FFR:

Human Validation

91 paired measurements obtained in 25 patients

0.81 ± 0.08 vs. 0.83 ± 0.08, $P<0.001$



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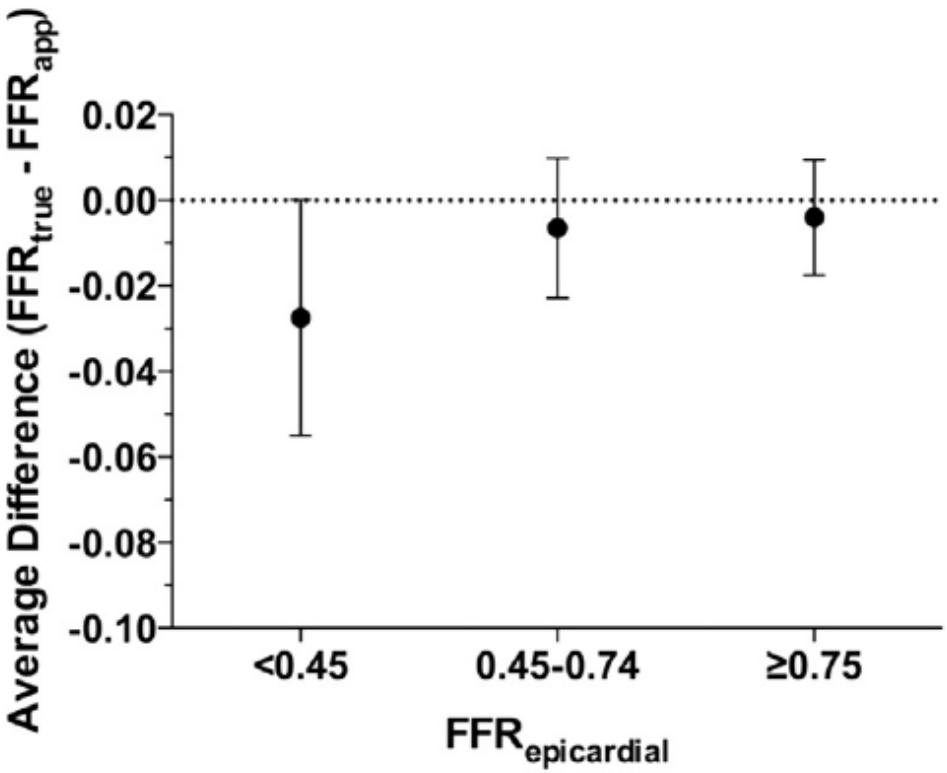

When FFR$_{app}$ >0.85, FFR$_{true}$ >0.80 100% of the time.

JACC CV Intervent 2015;8:398-403.

Coronary Physiology in LM Disease

- Both FFR and iFR correlate with intravascular imaging, but with variable MLA depending on the population studied.

- Deferring LM revascularization based on coronary physiology appears to be safe.

Coronary Physiology in LM Disease

- When performing coronary physiology to assess LM disease, one needs to be aware of downstream disease and the possibility for “cross-talk” between lesions.

- Doing a pressure wire pullback in the least diseased vessel can help to isolate the contribution of the LM disease.