# Understanding About Visual-Functional Mismatch


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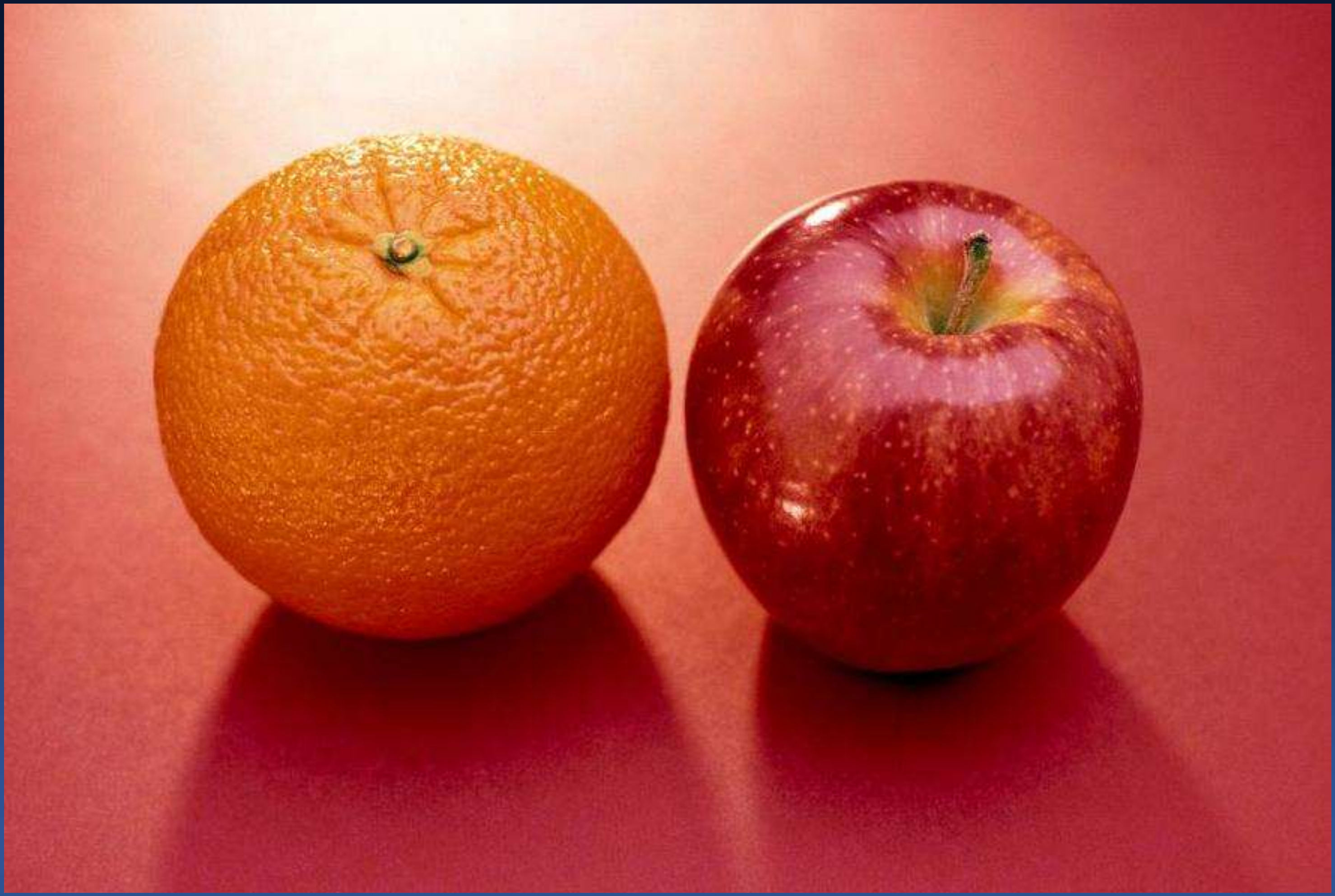
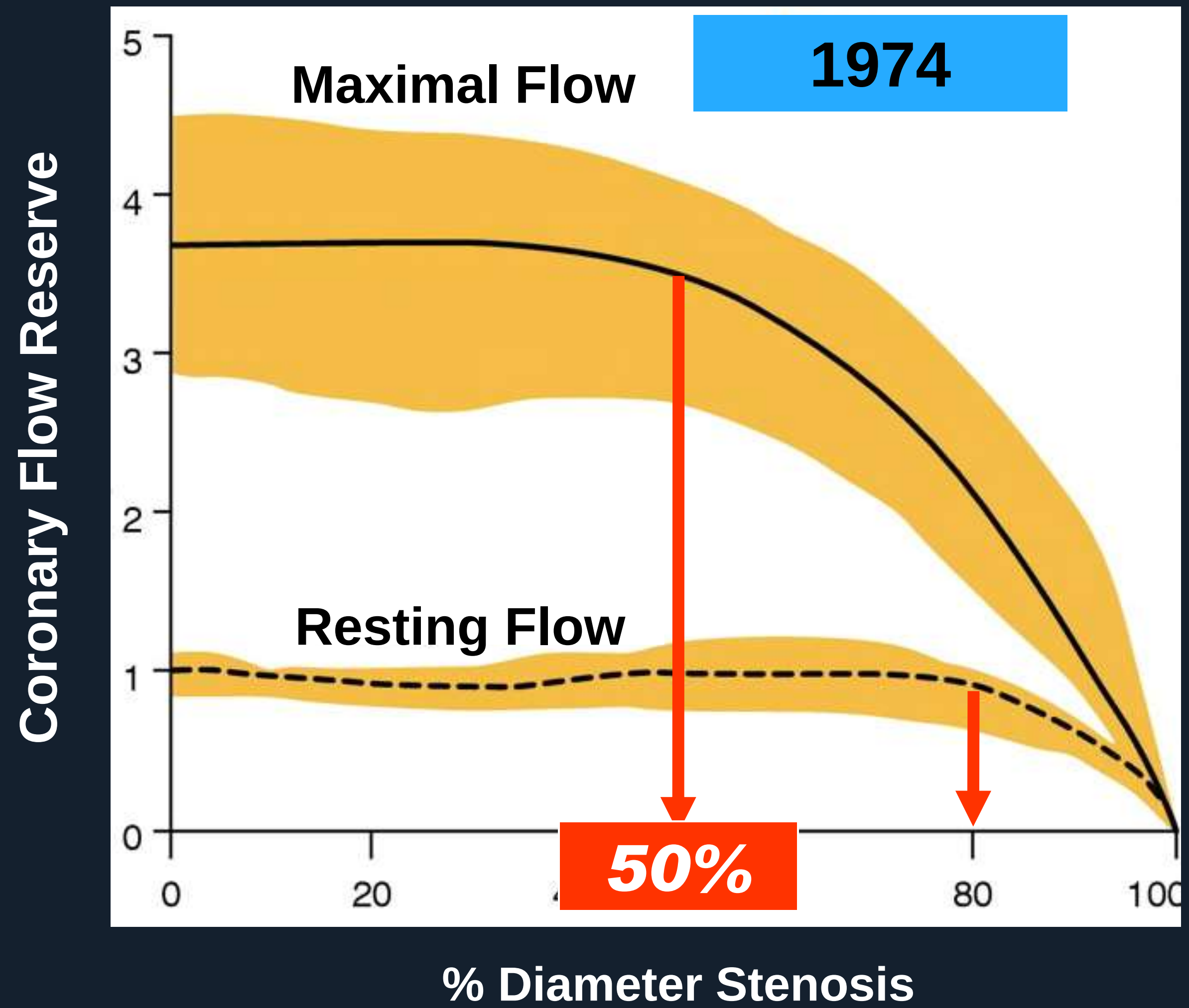
# Anatomy and Function

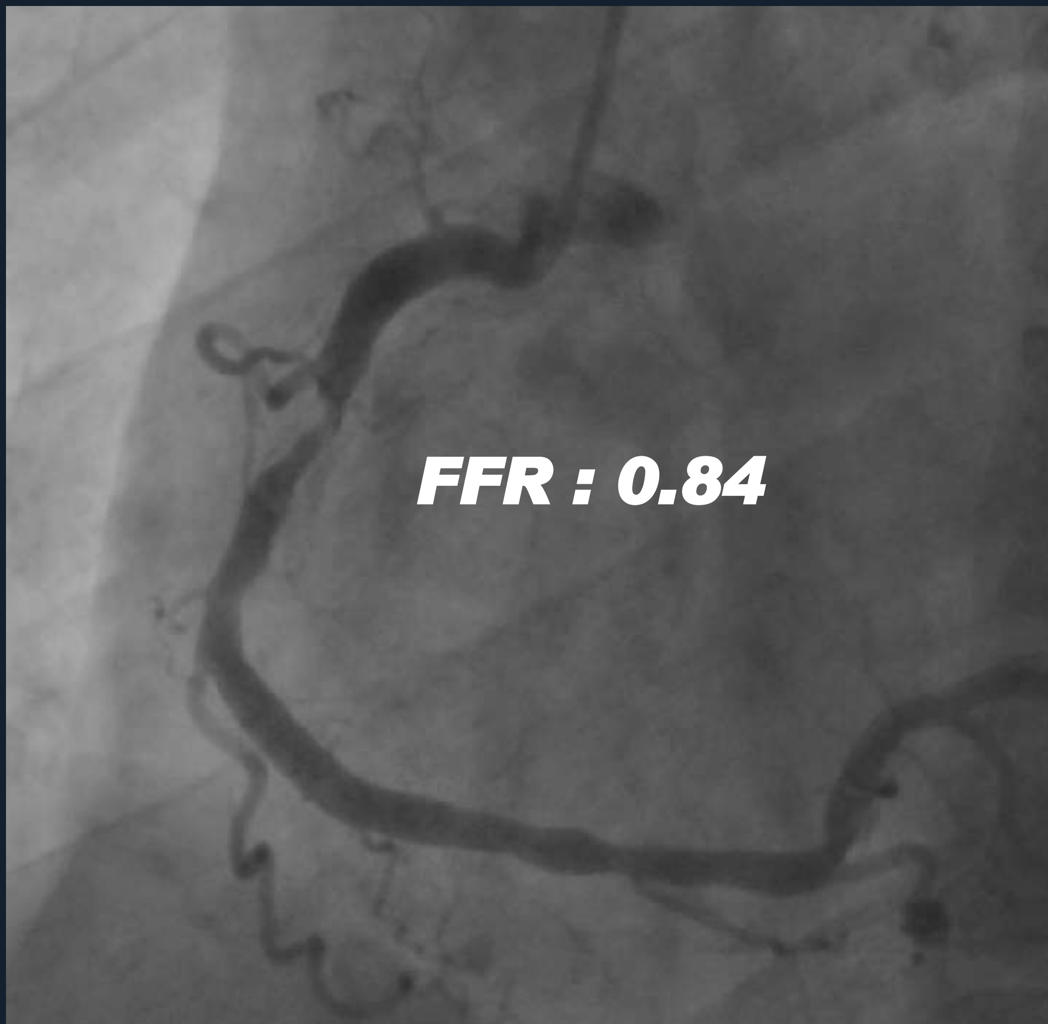


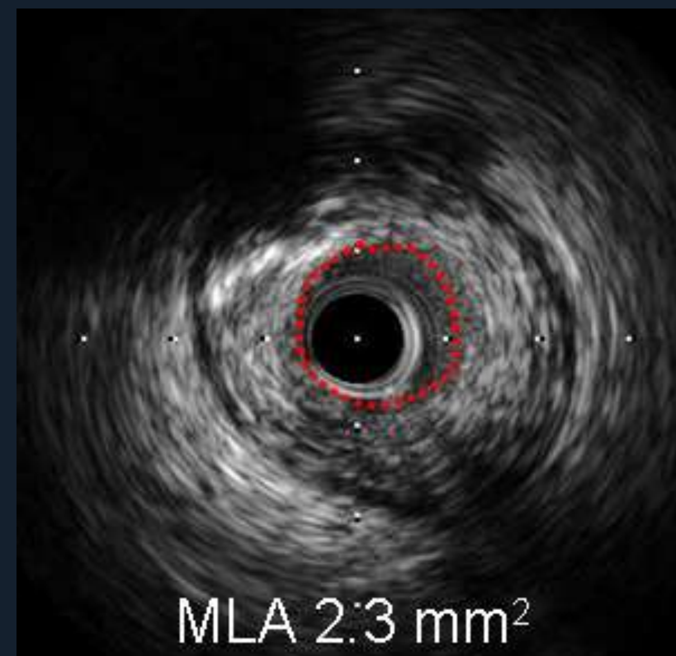
# Coronary Blood Flow and Stenosis




Gould, K. L. J Am Coll Cardiol Img 2009;2:1009-1023

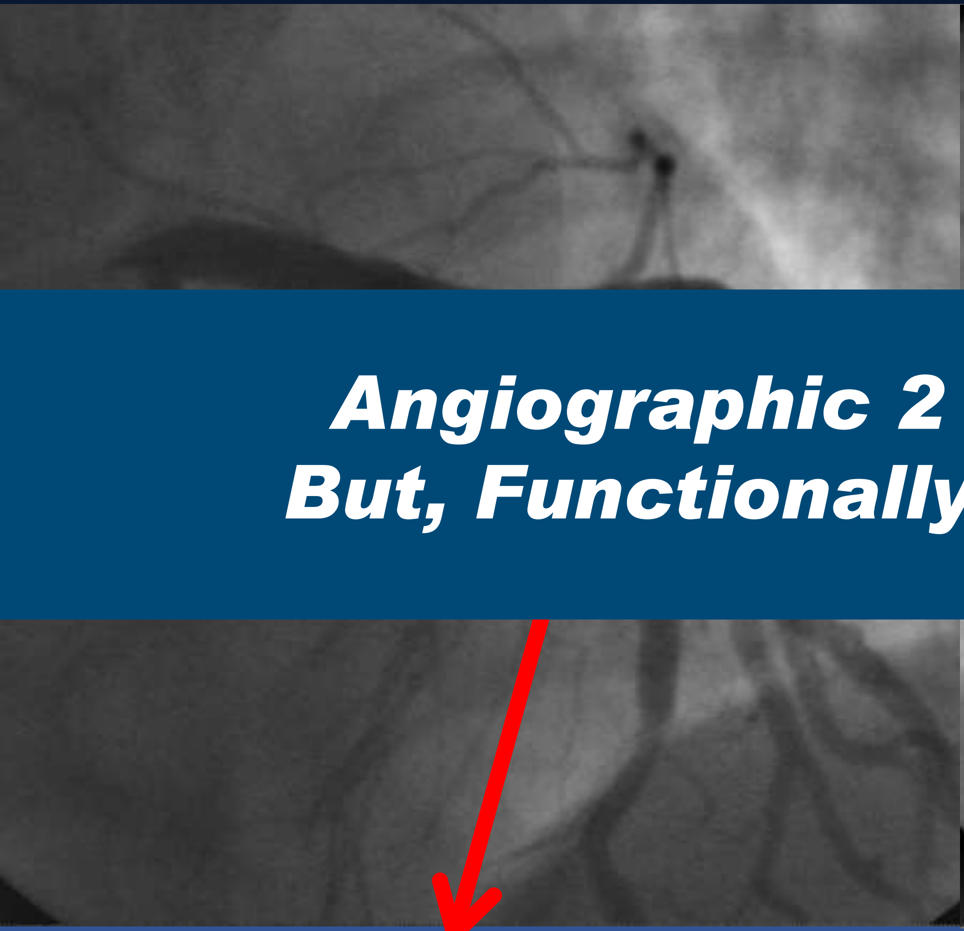
# Visual-Functional Mismatch (1)
## Coronary Angiography and FFR

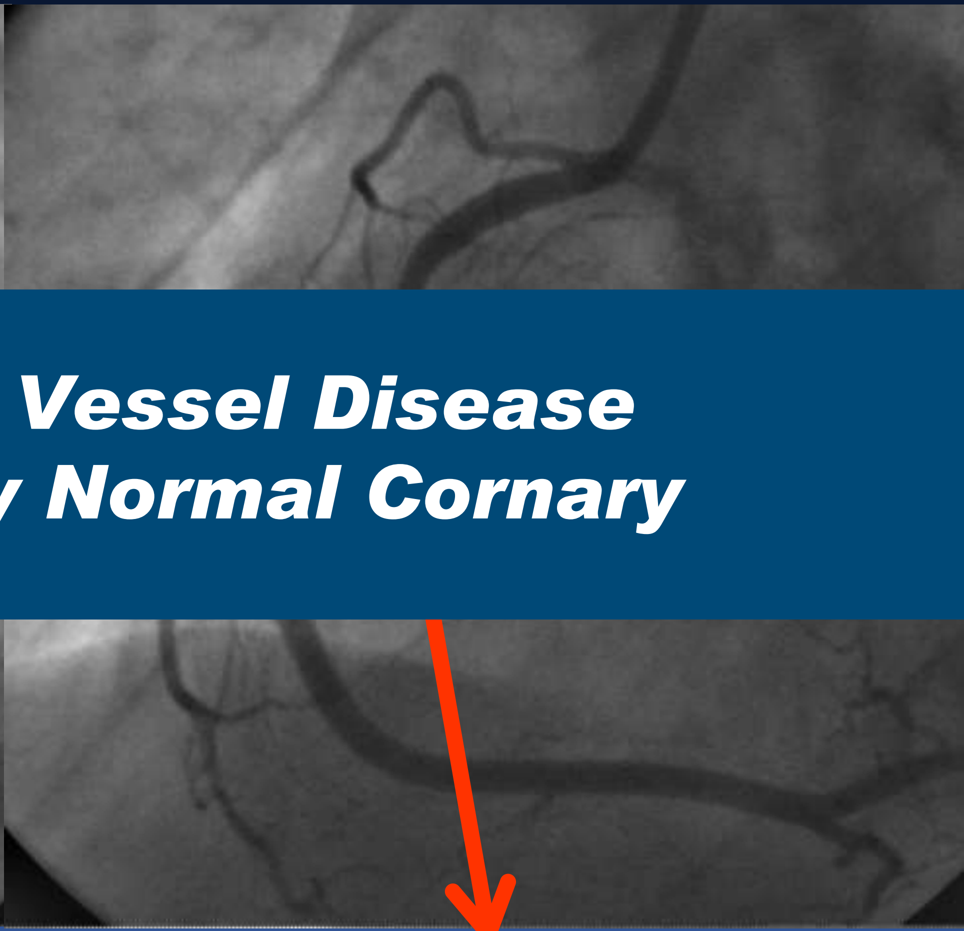


# Visual-Functional Mismatch

## Multivessel Disease





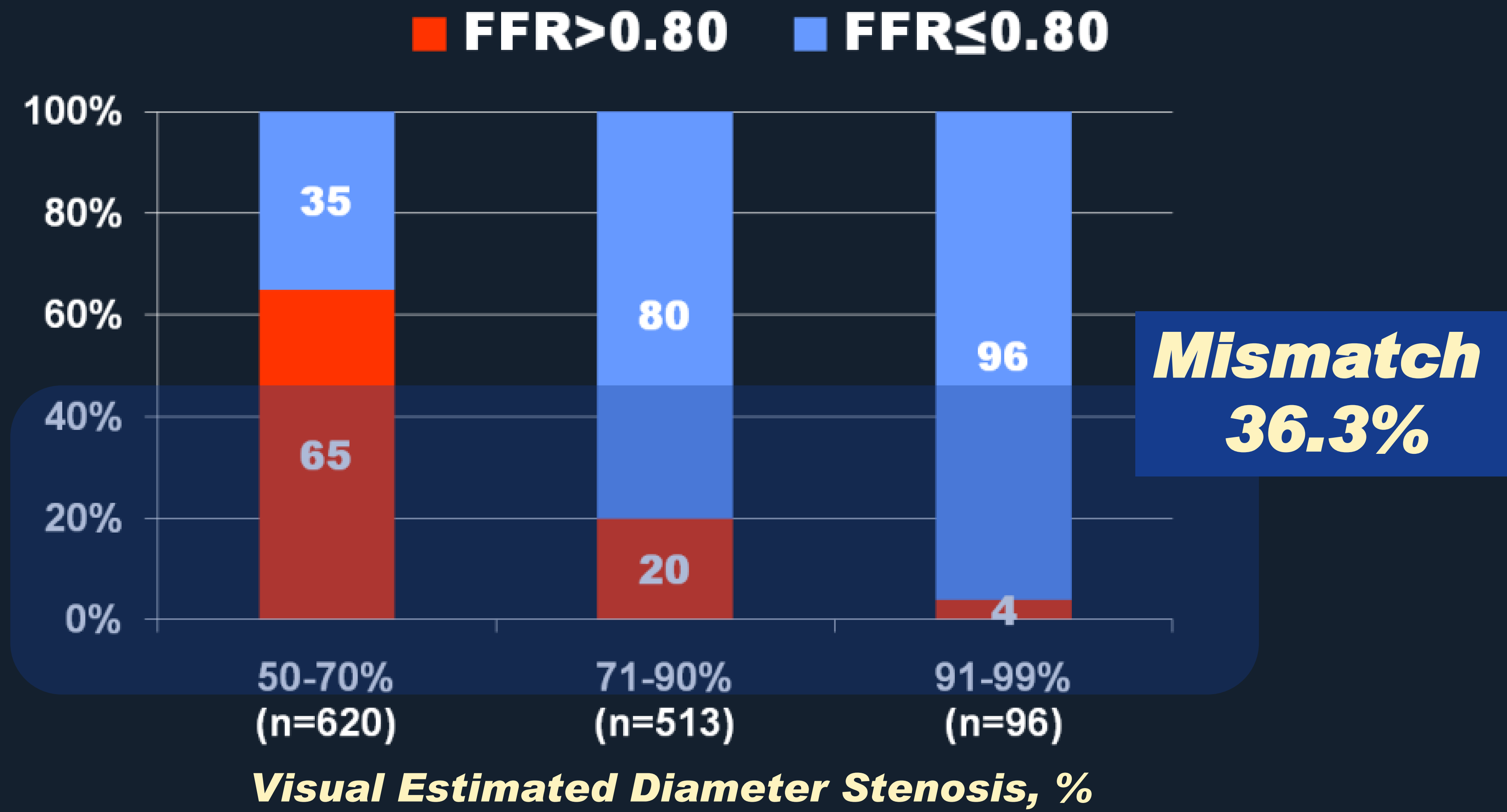
**Angiographic 2 Vessel Disease**
**But, Functionally Normal Cornary**

**FFR : 0.84**

**FFR : 0.86**

# Visual-Functional Mismatch

## From FAME Study



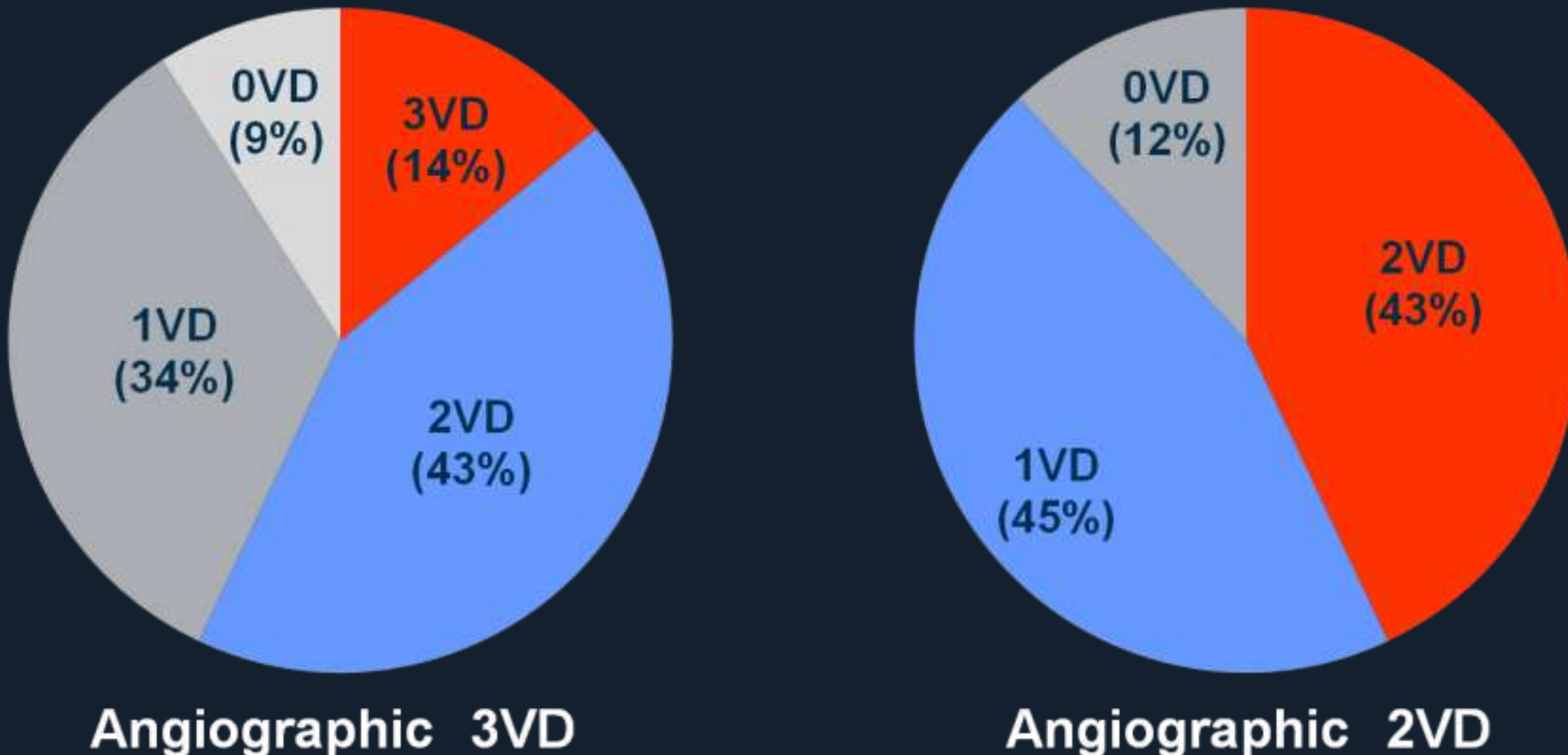



J Am Coll Cardiol 2010;55:2816–21

# Visual-Functional Mismatch

## From FAME Study

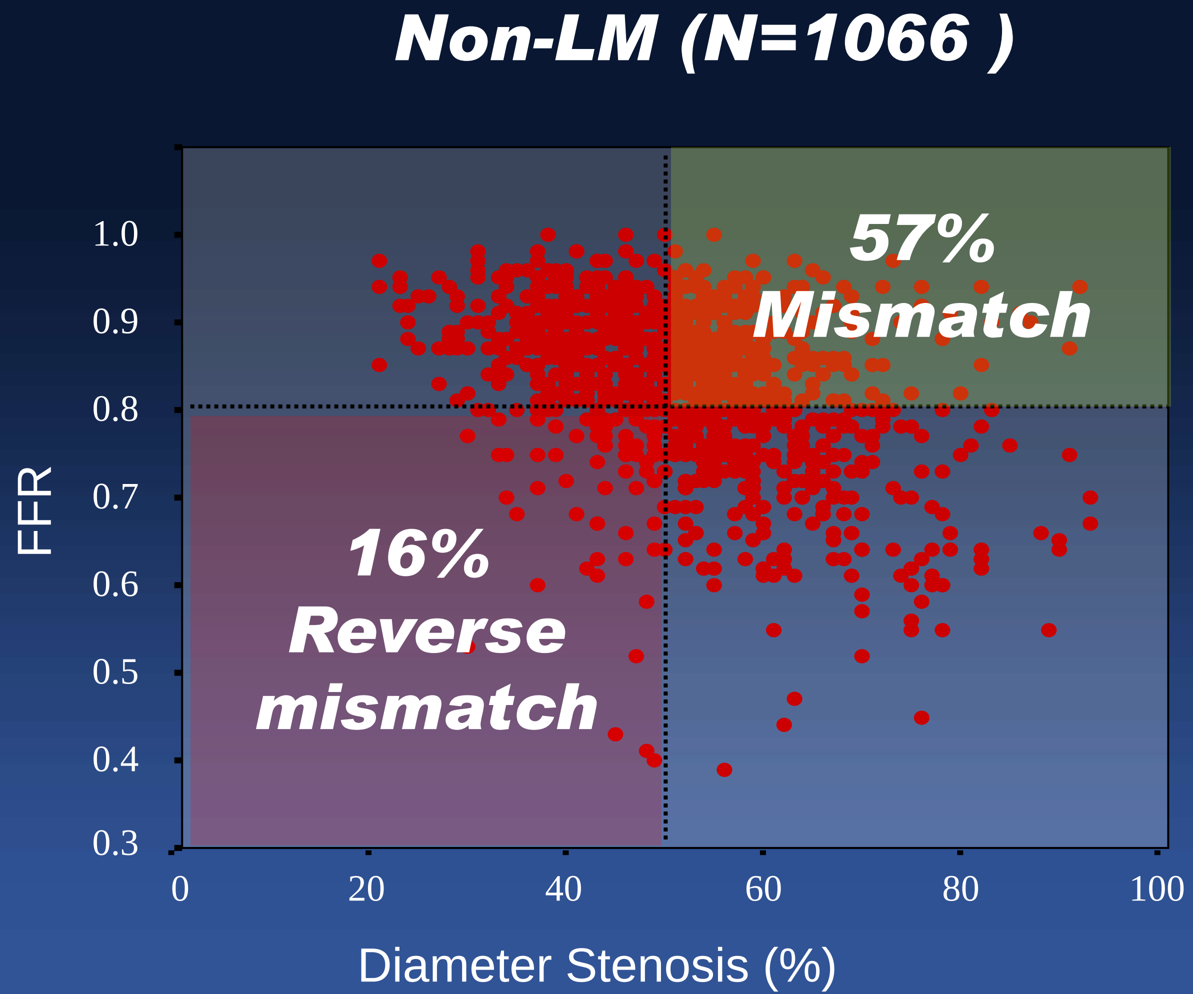
### Functionally Diseased Coronary Arteries





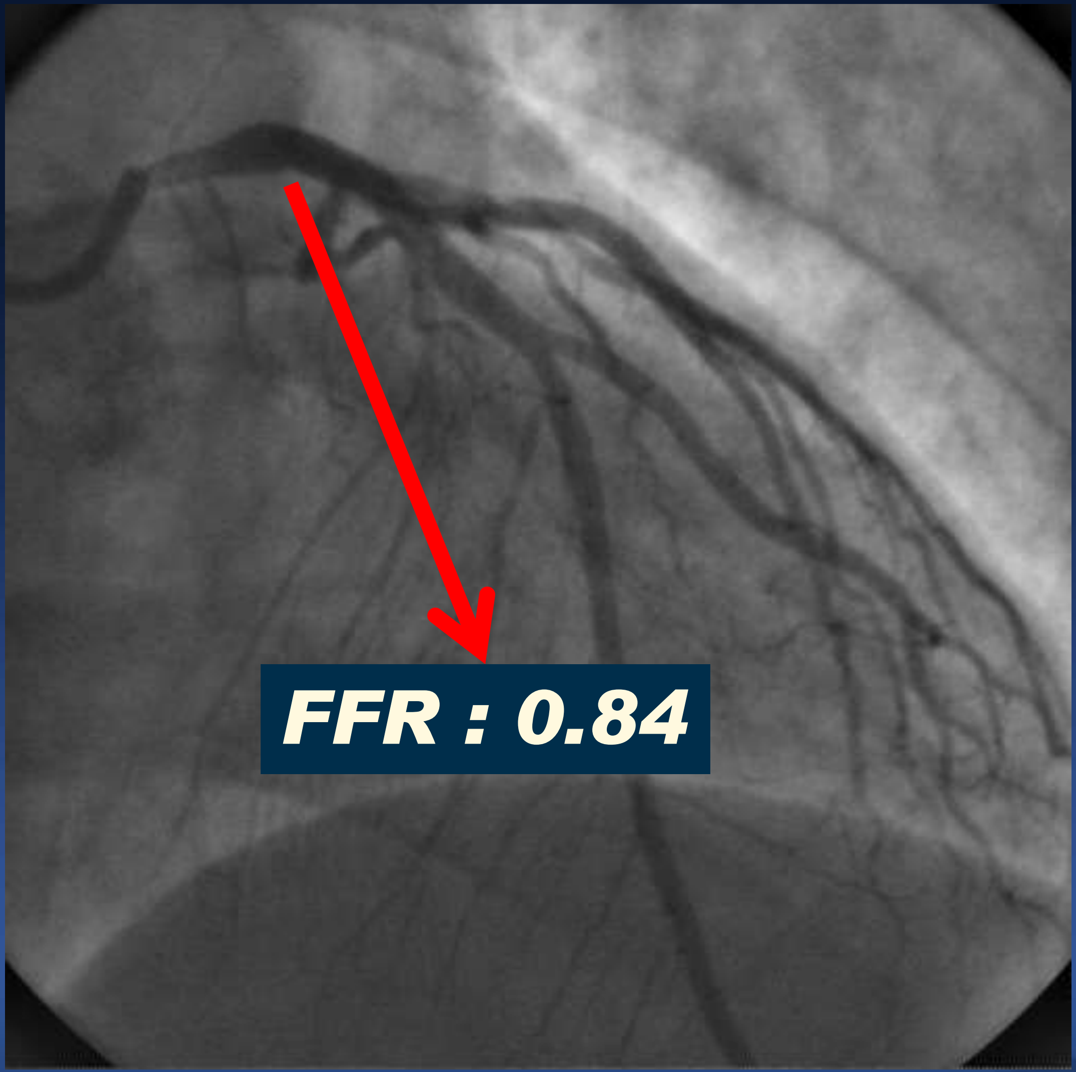

*J Am Coll Cardiol 2010;55:2816–21*

# Visual-Functional Mismatch

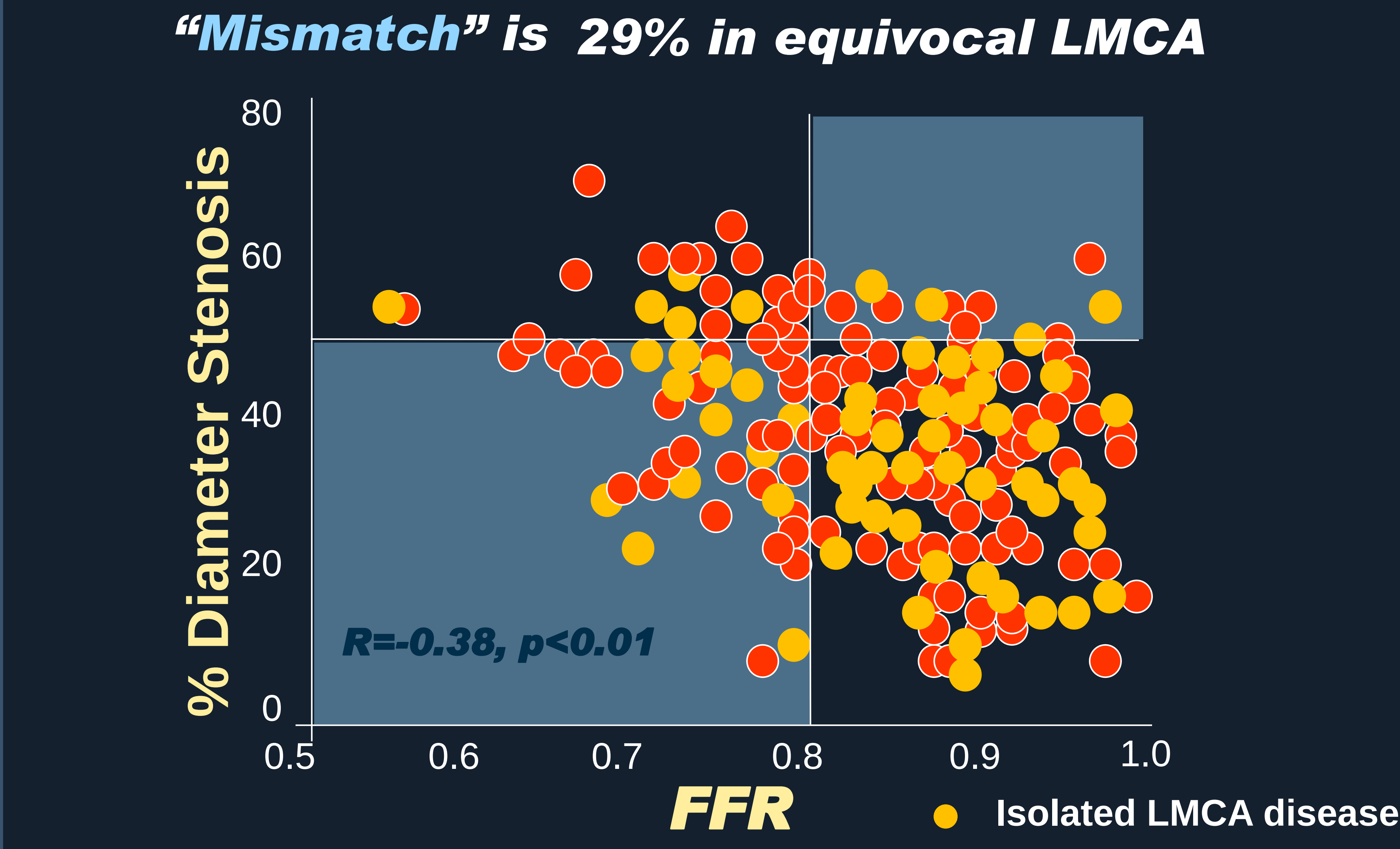



Park SJ, Kang SJ et al. JACC Cardiovasc Interv. 2012 Oct;5(10):1029-36

# Left Main Coronary Artery Stenosis



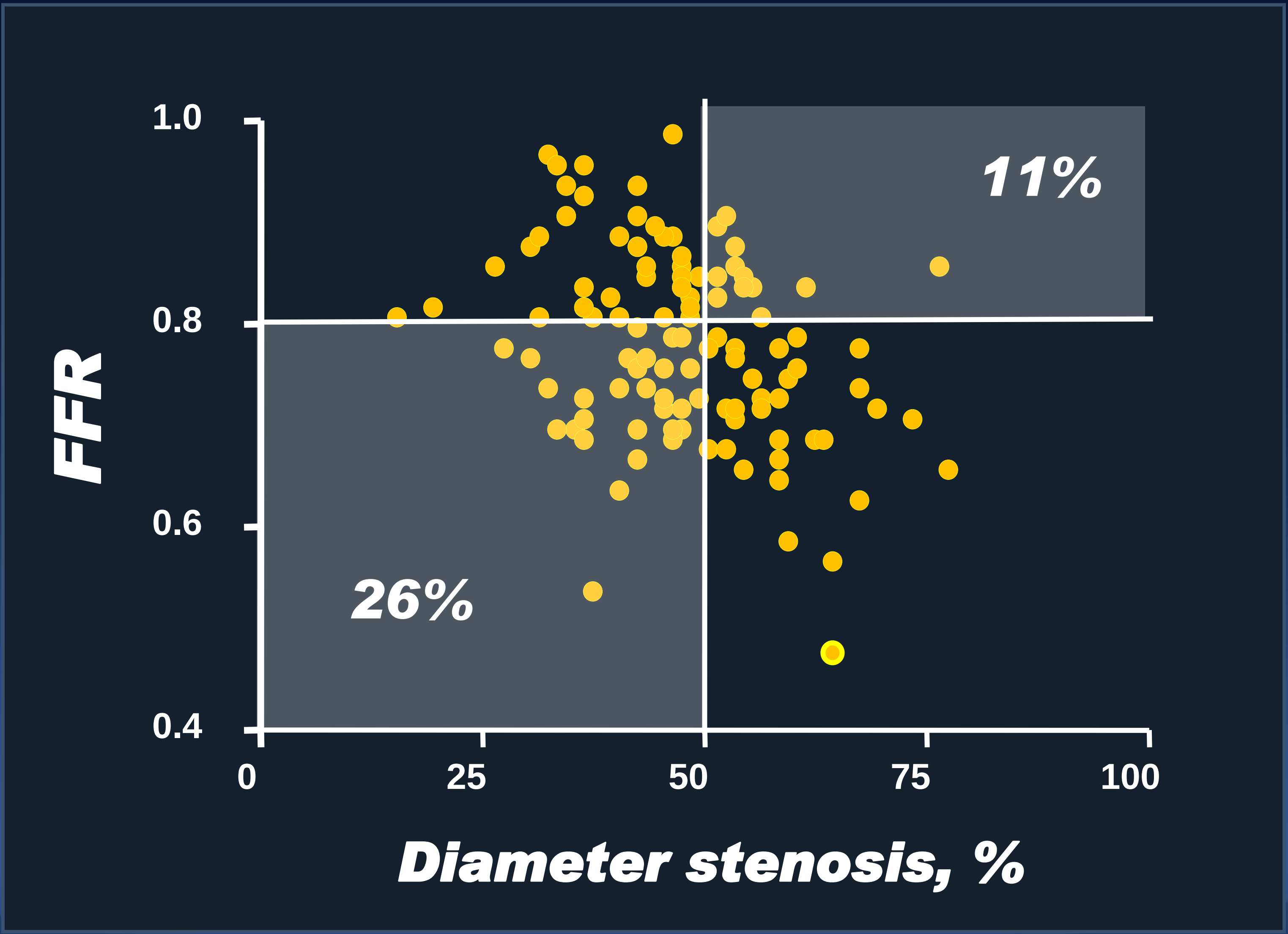
# FFR of the Equivocal LMCA



AMC data

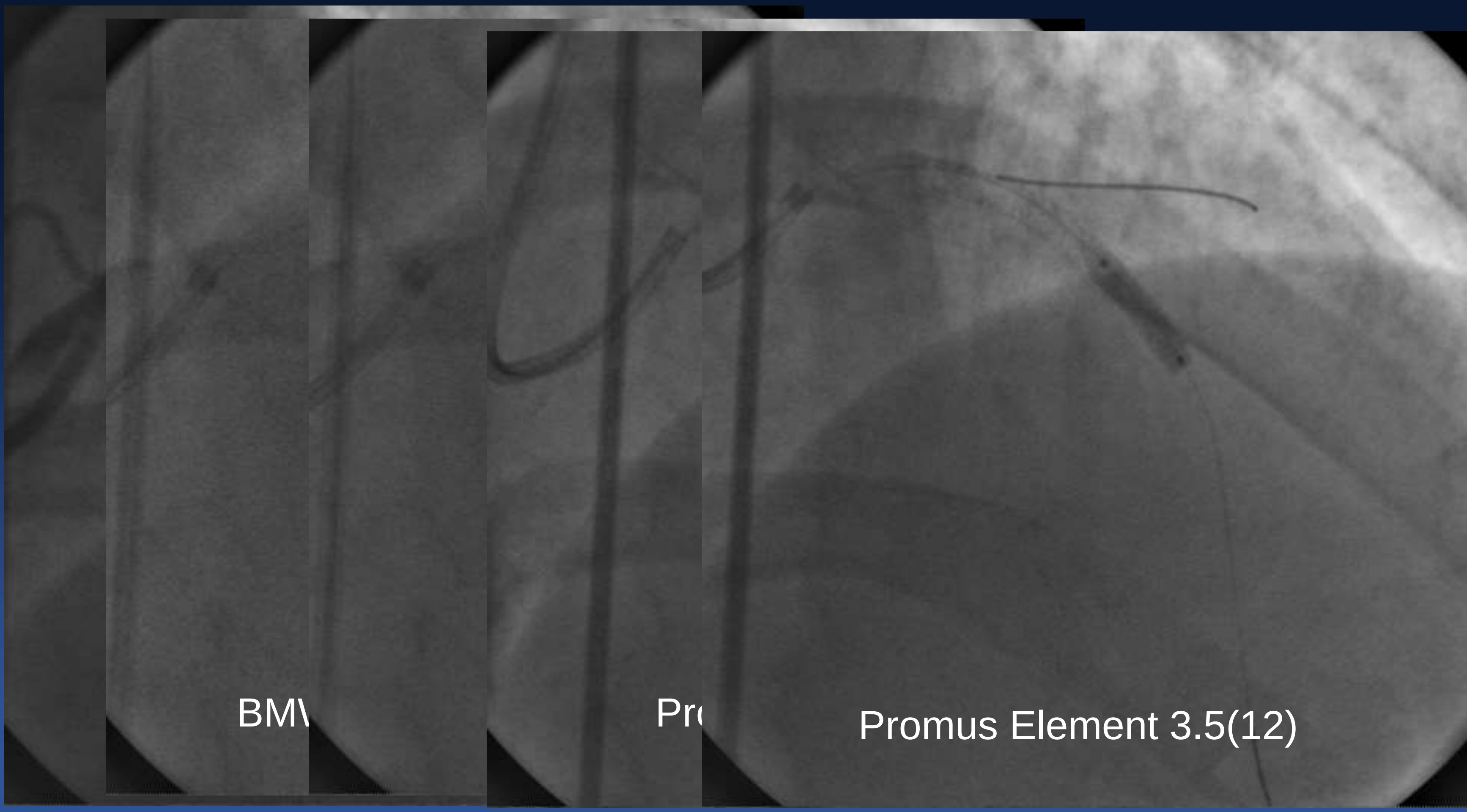
# *Mismatch*

## *in Isolated intermediate LM Disease (n=112)*

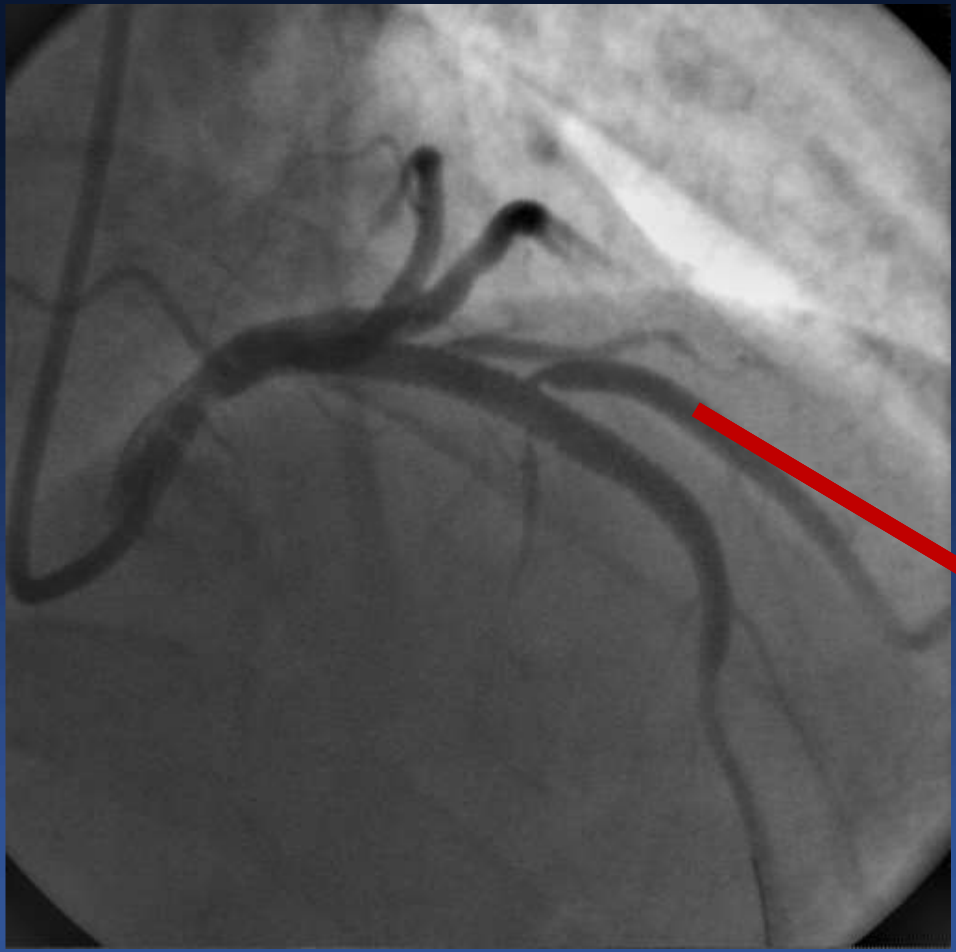


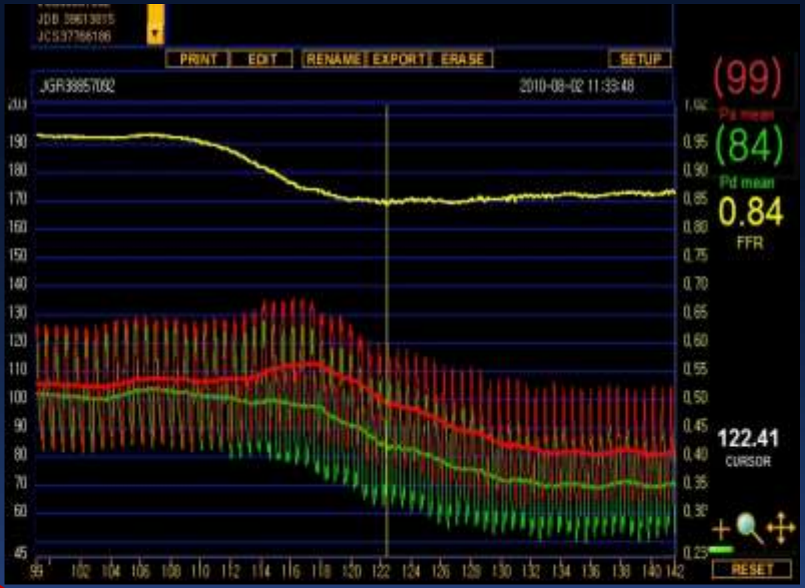

Park SJ, Ahn JM JACC Cardiovasc Interv. 2014 Aug;7(8):868-74

# Bifurcation Lesions



# After Stenting at Main Vessel



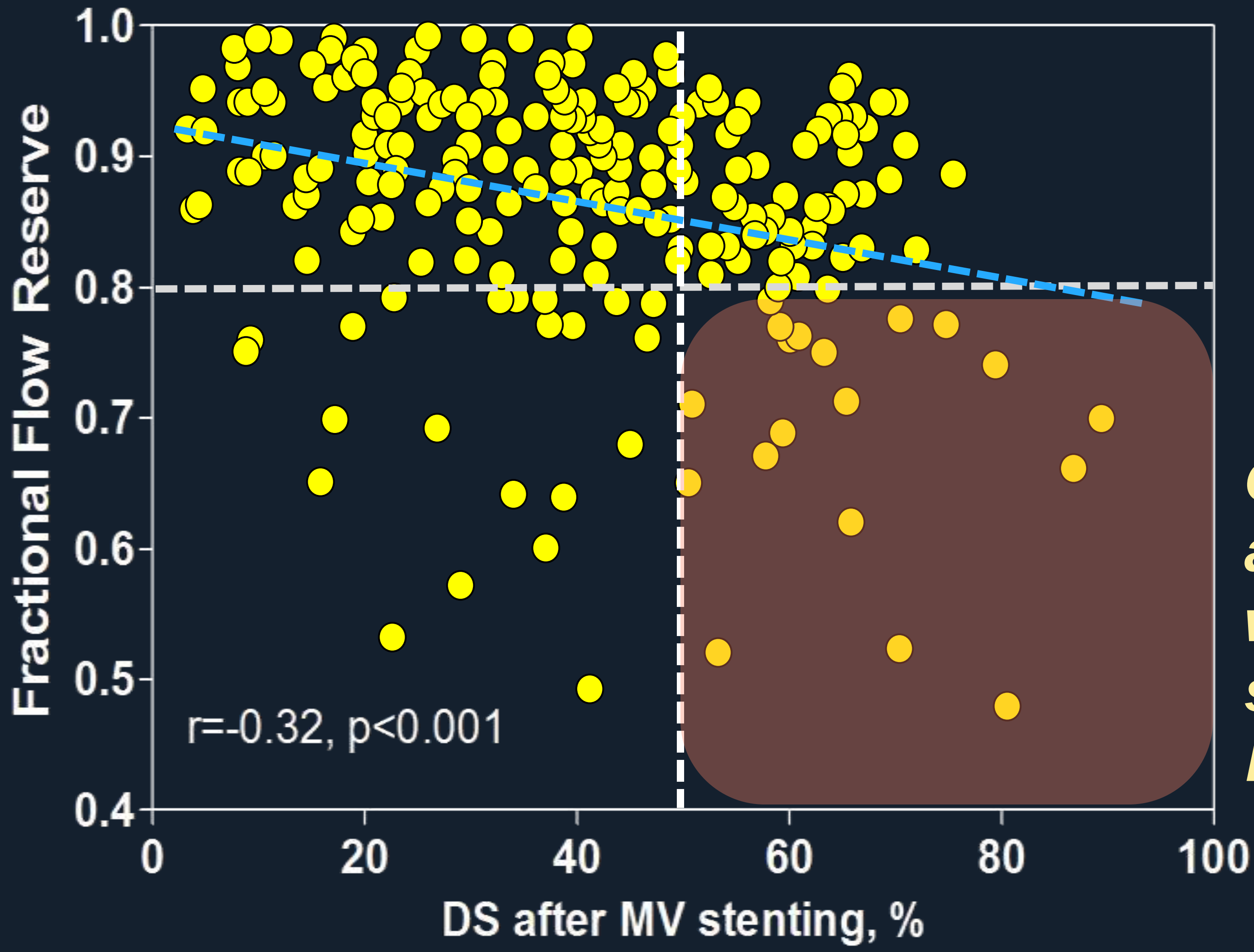



FFR 0.84

Leave it alone.

# FFR of the Jailed Side Branch

## By Using Dedicated Bifurcation QCA




- N=230 SBs

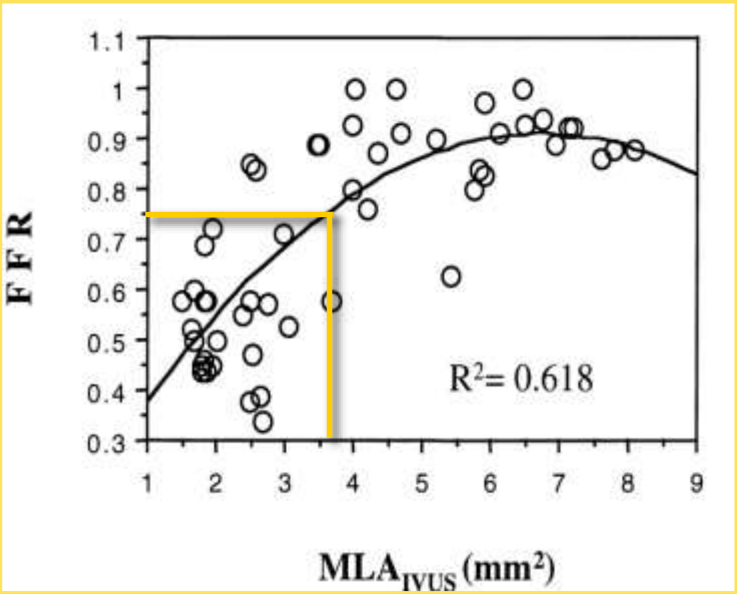
***Only 26.2% among SBs with >50% stenosis had FFR≤0.80***



Ahn JM et al. JACC Cardiovasc Interv. 2012 Feb;5(2):155-61

# Visual-Functional Mismatch (2)
# IVUS and FFR

## MLA 4.0mm²

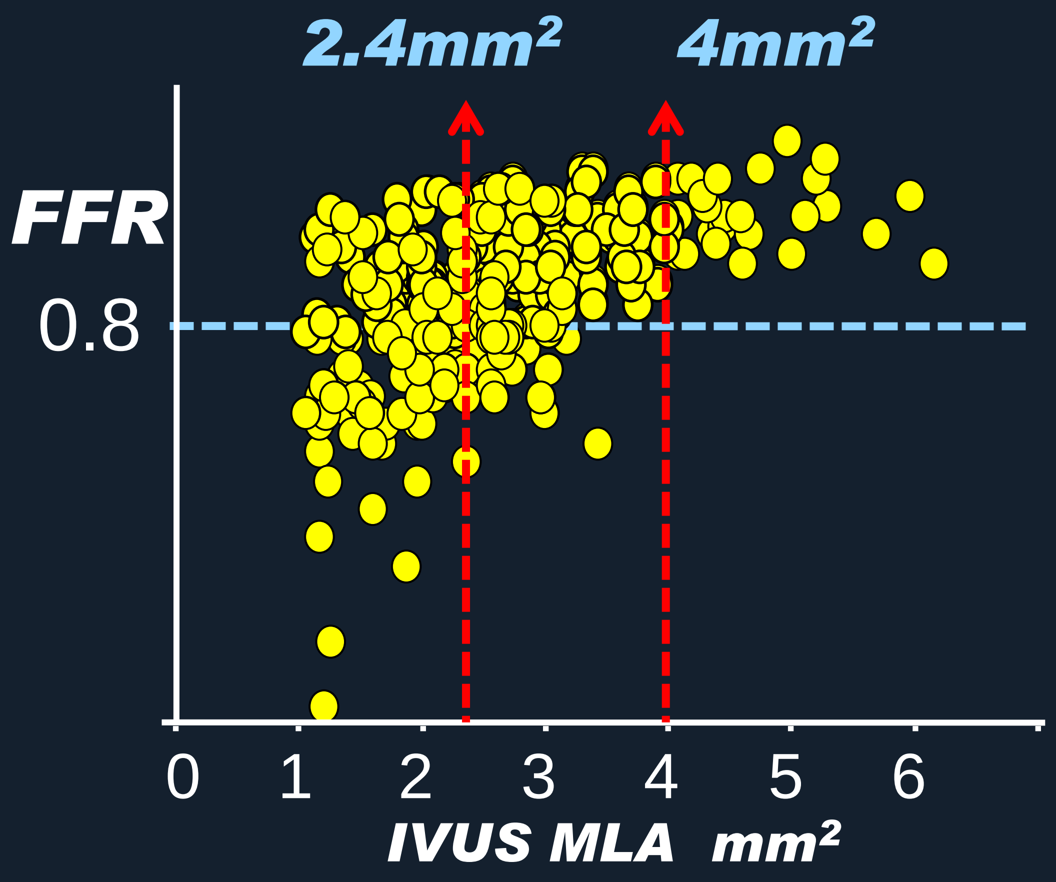



| | Sensitivity | Specificity |
|---|---|---|
| AS > 70% | 100% | 68% |
| MLD < 1.8 mm | 100% | 66% |
| MLA < 4.0 $mm^2$ | 82% | 56% |
| Length > 10 mm | 41% | 80% |

Takagi et al. Circulation 1999;100:250-5

Briguori et al. AJC 2001;87:136-41

# New IVUS MLA for FFR <0.80
# In Epicardial Coronary Artery




- 66% of analyzed lesions have MLA<4 $mm^2$ but FFR >0.80
- 30% of analyzed lesions had MLA <2.4$mm^2$ but FFR >0.80.
- Regardless of cutoff values, use of IVUS MLA criteria alone could not predict the result of FFR measurement

Kang SJ, Park SJ, Circ Cardiovasc Interv. 2011;4: 65-71

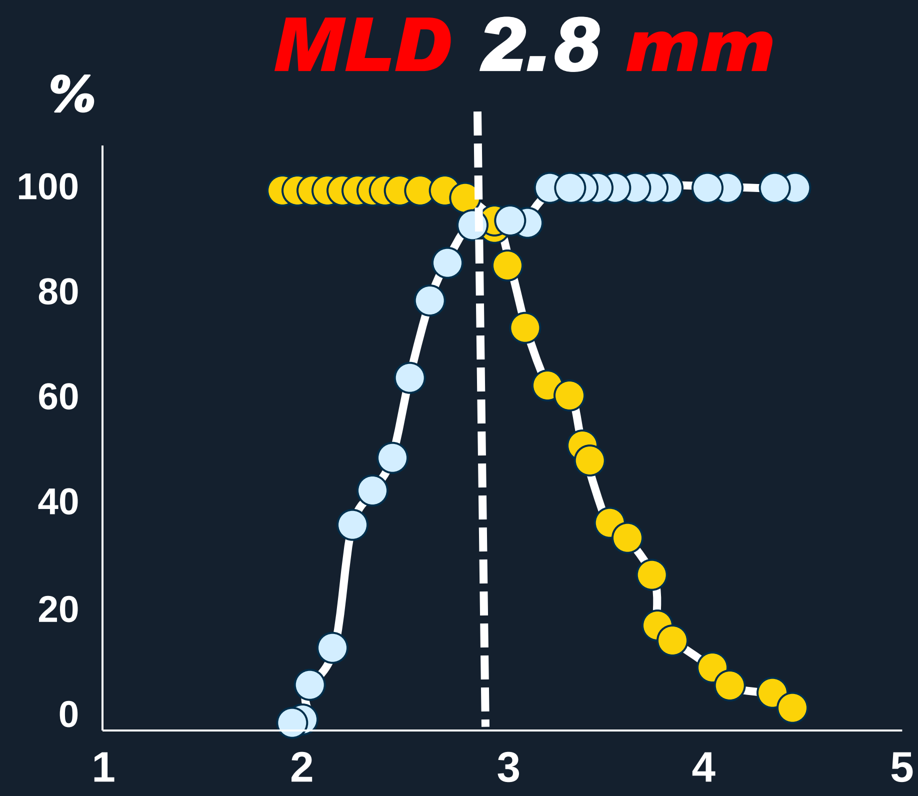
# IVUS Minimal Lumen Area

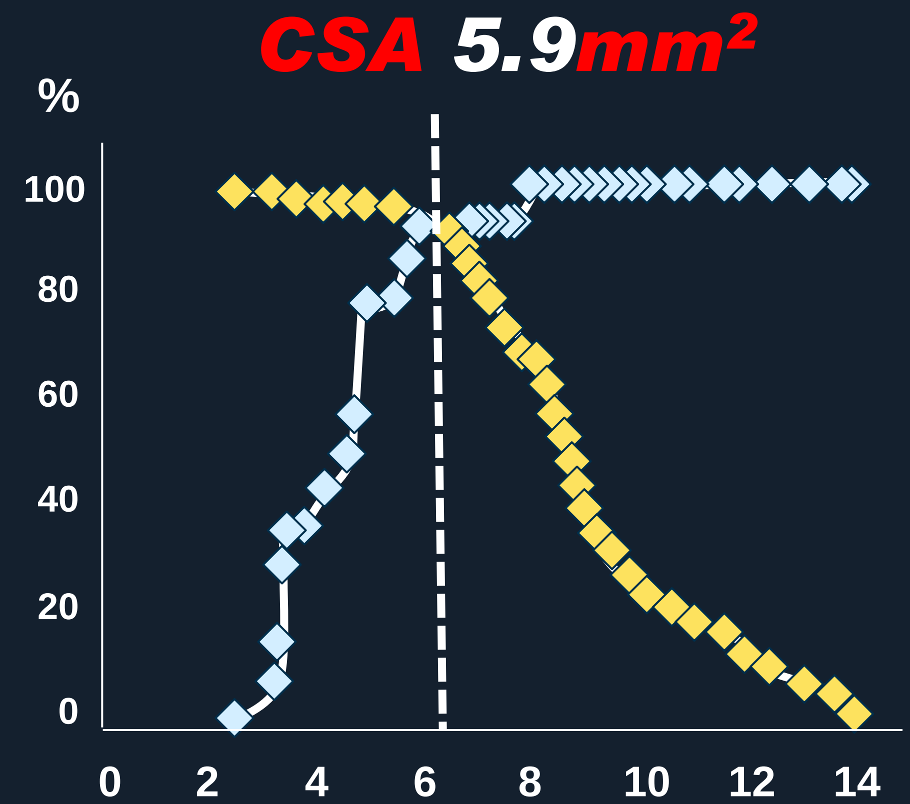
| | N | FFR | RLA | MLA | AUC | Sens | Spec | PPV | NPV | Accu |
|---|---|---|---|---|---|---|---|---|---|---|
| Takaki (1999 Circ) | 51 | 0.75 | 9.3 | **3.0** | – | 83% | 92% | – | – | – |
| Briguori (2001 AJC) | 53 | 0.75 | 7.8 | **4.0** | – | 92% | 56% | 38% | 96% | 64% |
| Kang (2011 Circ int) | 236 | 0.80 | 7.6 | **2.4** | 0.80 | 90% | 60% | 37% | 96% | 68% |
| (2011 JACC int) | 267 | 0.80 | 6.8 | **2.75** | 0.81 | 69% | 65% | 27% | 81% | 67% |
| Gonzalo (2012 JACC) | 47 | 0.80 | 7.1 | **2.36 IVUS** | 0.63 | 67% | 65% | 67% | 65% | 66% |
| Gonzalo (2012 JACC) | 61 | 0.80 | 7.1 | **1.95 OCT** | 0.70 | 82% | 63% | 66% | 80% | 72% |
| Waksman (2013 JACC) | 367 | 0.80 | 6.9 | **3.07** | 0.65 | 64% | 65% | 40% | 83% | - |

Furthermore, the accuracies of specific MLA criteria optimized by vessel size still remain poor

# Significant LM Stenosis

## CSA <6.0mm$^2$ ≈ LM FFR<0.75



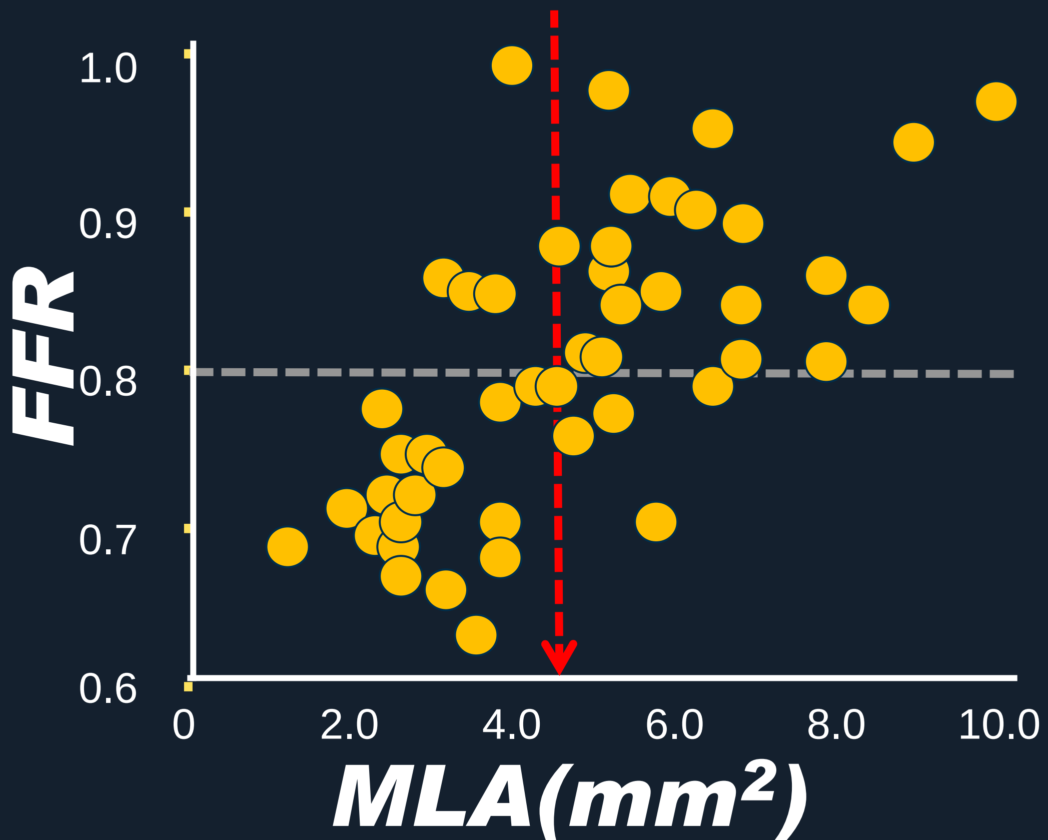






Jasti et al. Circulation 2004;110:2831-6

# Significant LM Stenosis

## MLA 4.8mm² New IVUS Criteria

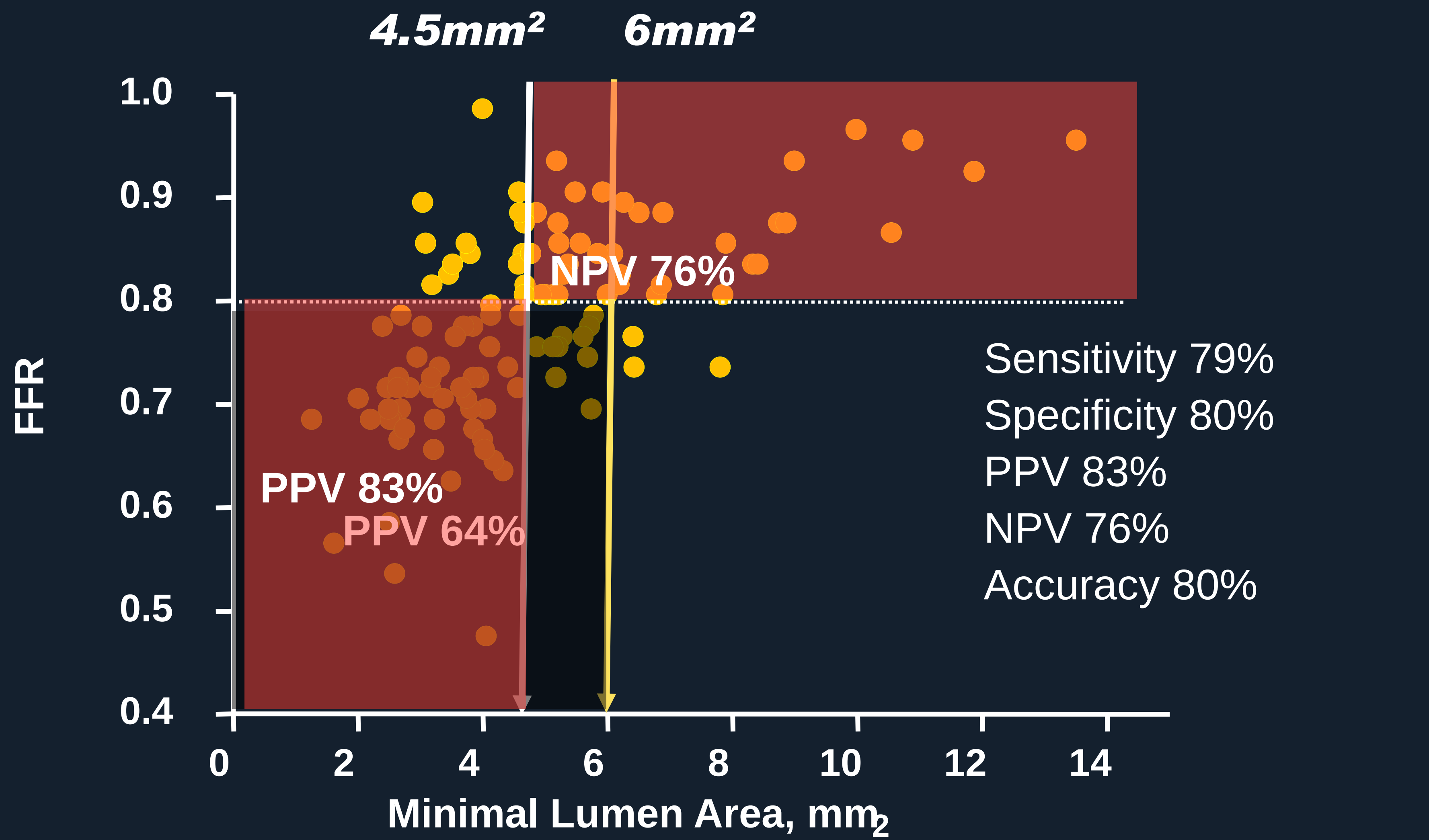



Sensitivity 83%
Specificity 83%
PPV 83%
NPV 83%
Accuracy 83%

47 isolated LM disease
With 30-80% stenosis

*Kang et al. Circ Cardiovasc Interv 2011;4:65-71*

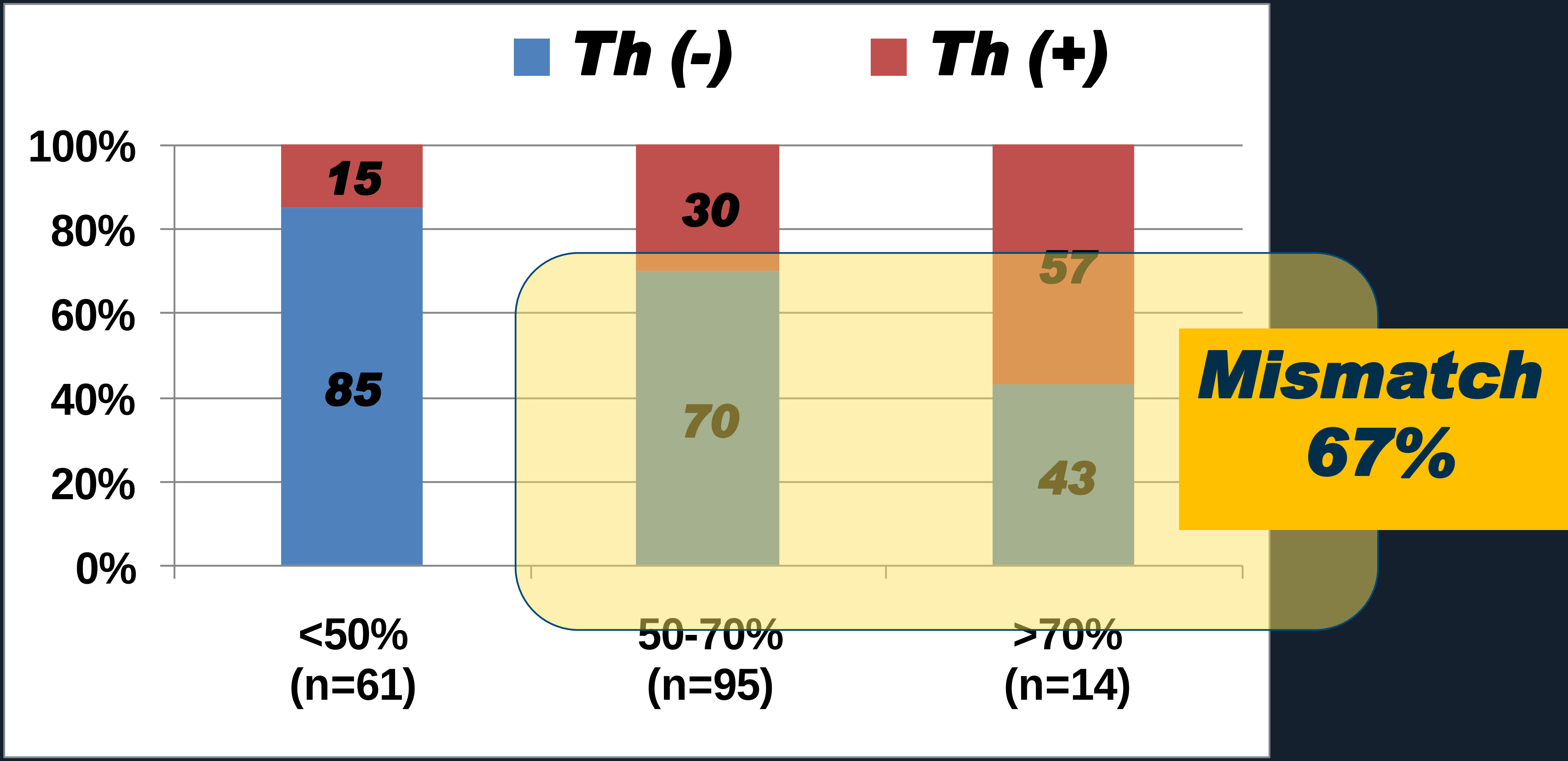
# *IVUS and FFR*
## *Isolated intermediate LM Disease (n=112)*




Park SJ, Ahn JM JACC Cardiovasc Interv. 2014 Aug;7(8):868-74

# Visual-Functional Mismatch (3)
# Coronary angiography and Thallium SPECT

A total of 170 coronary lesions in 150 patients who underwent Thallium SPECT




**QCA Diameter Stenosis, %**

Ahn JM et al. JACC Cardiovasc Interv. 2011 Jun;4(6):665-71

# Thallium SPECT and IVUS/QCA

| | AUC | BCV | Sensitivity | Specificity | PPV | NPV | K |
|---|---|---|---|---|---|---|---|
| ***QCA parameters*** | | | | | | | |
| MLD, mm | 0.670 | **≤1.26** | 57.8 | 76.8 | **47.3** | 83.5 | 0.32 |
| DS, % | 0.692 | **>58.2** | 62.2 | 70.4 | **43.1** | 83.8 | 0.28 |
| LL, mm | 0.582 | **>26.2** | 43.2 | 79.2 | **42.2** | 79.8 | 0.21 |
| ***IVUS parameters*** | | | | | | | |
| MLA, $mm^2$ | 0.690 | **≤2.1** | 86.7 | 50.4 | **38.6** | 91.3 | 0.27 |
| PB, % | 0.730 | **>83.4** | 73.3 | 64.8 | **42.9** | 87.1 | 0.31 |

Ahn JM et al. JACC Cardiovasc Interv. 2011 Jun;4(6):665-71

# Determinants for Functional State of Coronary Narrowing

## Preliminary analysis from IRIS FFR registry

- 1756 lesions in 1470 patients
- Clinical, Angiographic, and Hemodynamic variables

# Determinants for Functional State of Coronary Narrowing

## FFR as continuous variables

$R^2$=0.73

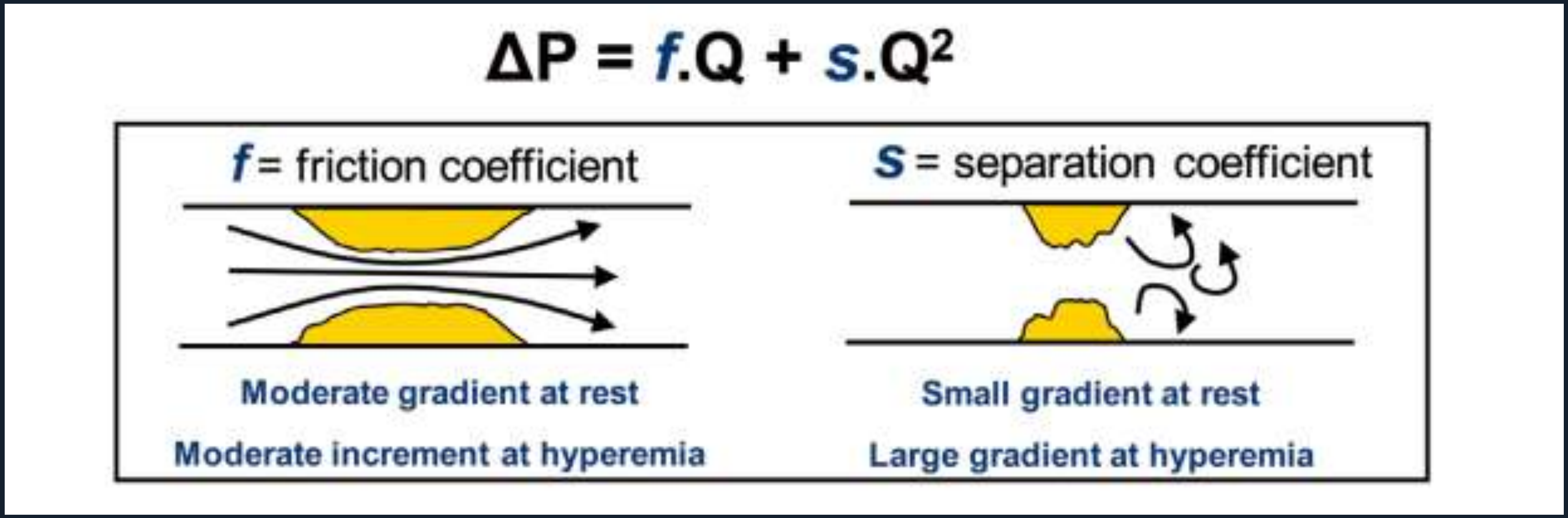
| | Beta coefficient | 95% CI | p-value |
|---|---|---|---|
| Lesion location* | 0.012 | 0.008-0.016 | <0.001 |
| Reference vessel diameter | -0.01 | -0.017- -0.003 | 0.006 |
| Minimal lumen diameter | 0.025 | 0.015-0.035 | <0.001 |
| Diameter stenosis | -0.001 | -0.001- -0.001 | <0.001 |
| Resting Pd/Pa | 1.077 | 1.021-1.132 | <0.001 |
| Sex | 0.011 | 0.001 – 0.020 | 0.027 |
| Age | 0.001 | 0.001 – 0.001 | <0.001 |
| Body surface area | -0.044 | -0.07 - -0.018 | 0.001 |

*Lesion location: LM(1)-LAD(2)-RCA(3)-LCX(4)-SB(5)

# Anatomical factor

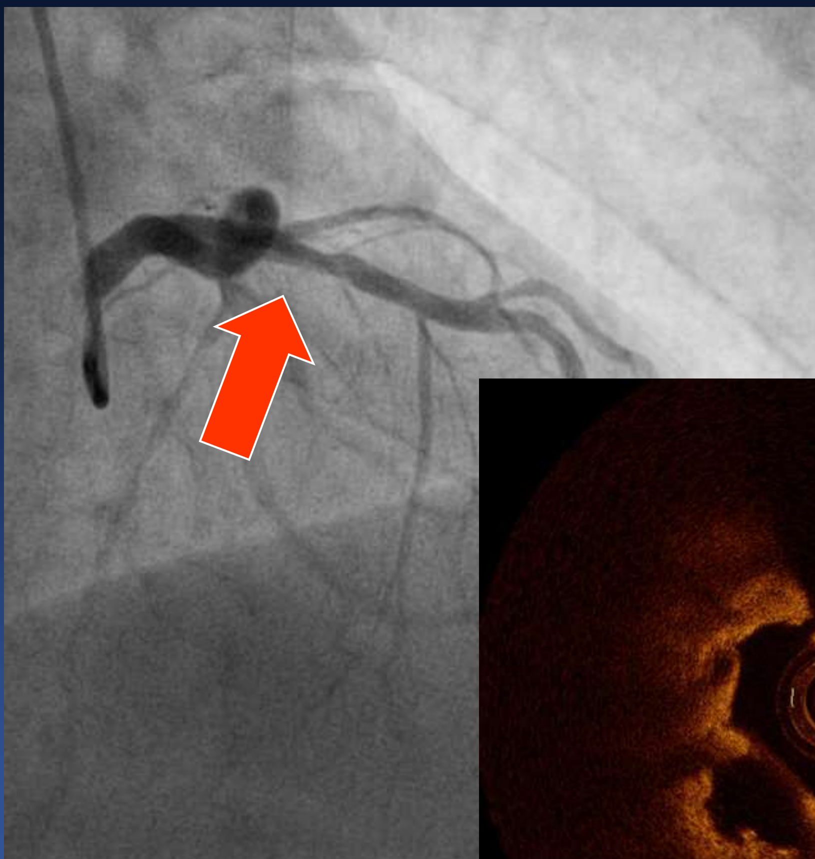
- Degree of diameter stenosis
- Reference vessel diameter (myocardium)
- Lesion morphology
- Eccentricity
- Lesion length
- Plaque burden, Plaque rupture
- Surface roughness
- Viscous friction, flow separation, turbulence, and eddies

# Fluid-dynamics equation
# Cause of Energy Loss




Pijls et al. Circ J. 2013 Feb 25;77(3):561-9

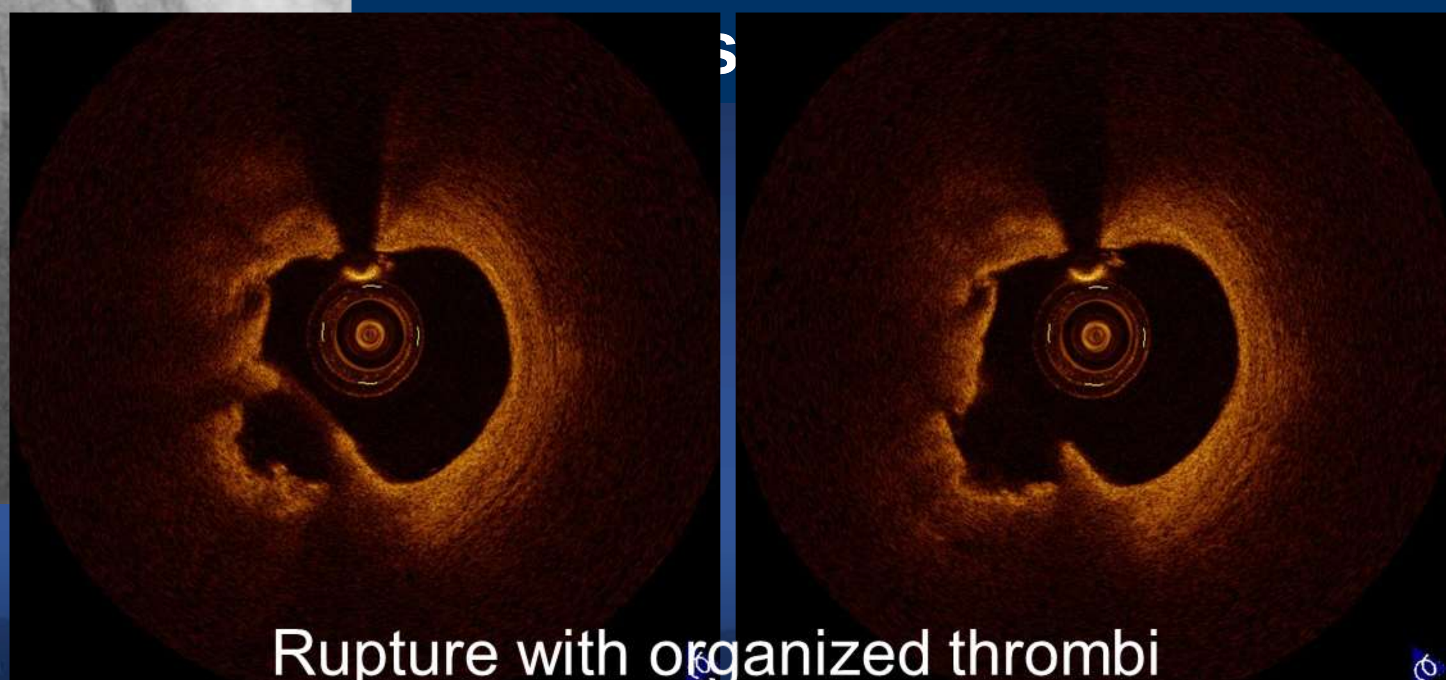
# Plaque Rupture



QCA DS(%) : 32%

FFR : 0.73

Treadmill test : stage 3 +

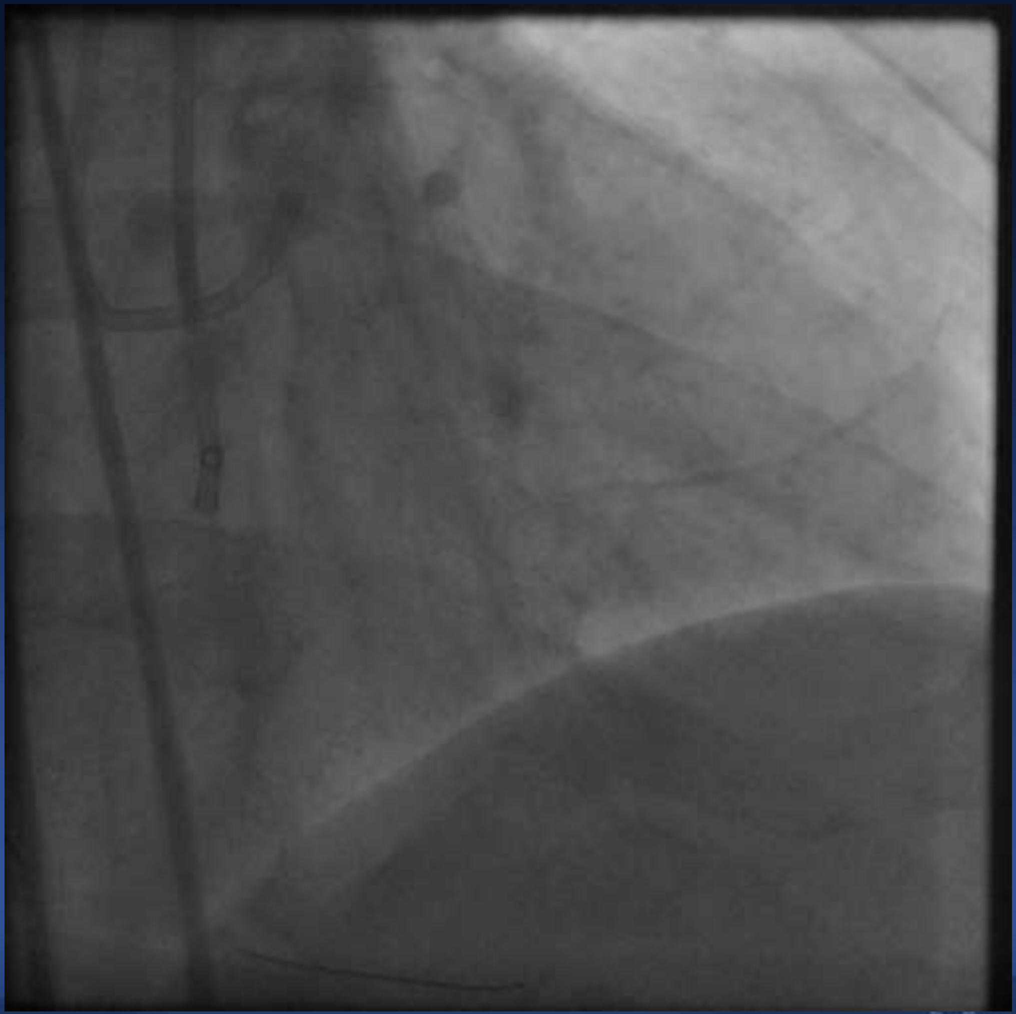


**If we can perfectly simulate the luminal configuration of the coronary stenosis, Can we predict the real FFR?**

# My Opinion is No…

# Supplying Myocardial Burden

## FFR in RCA

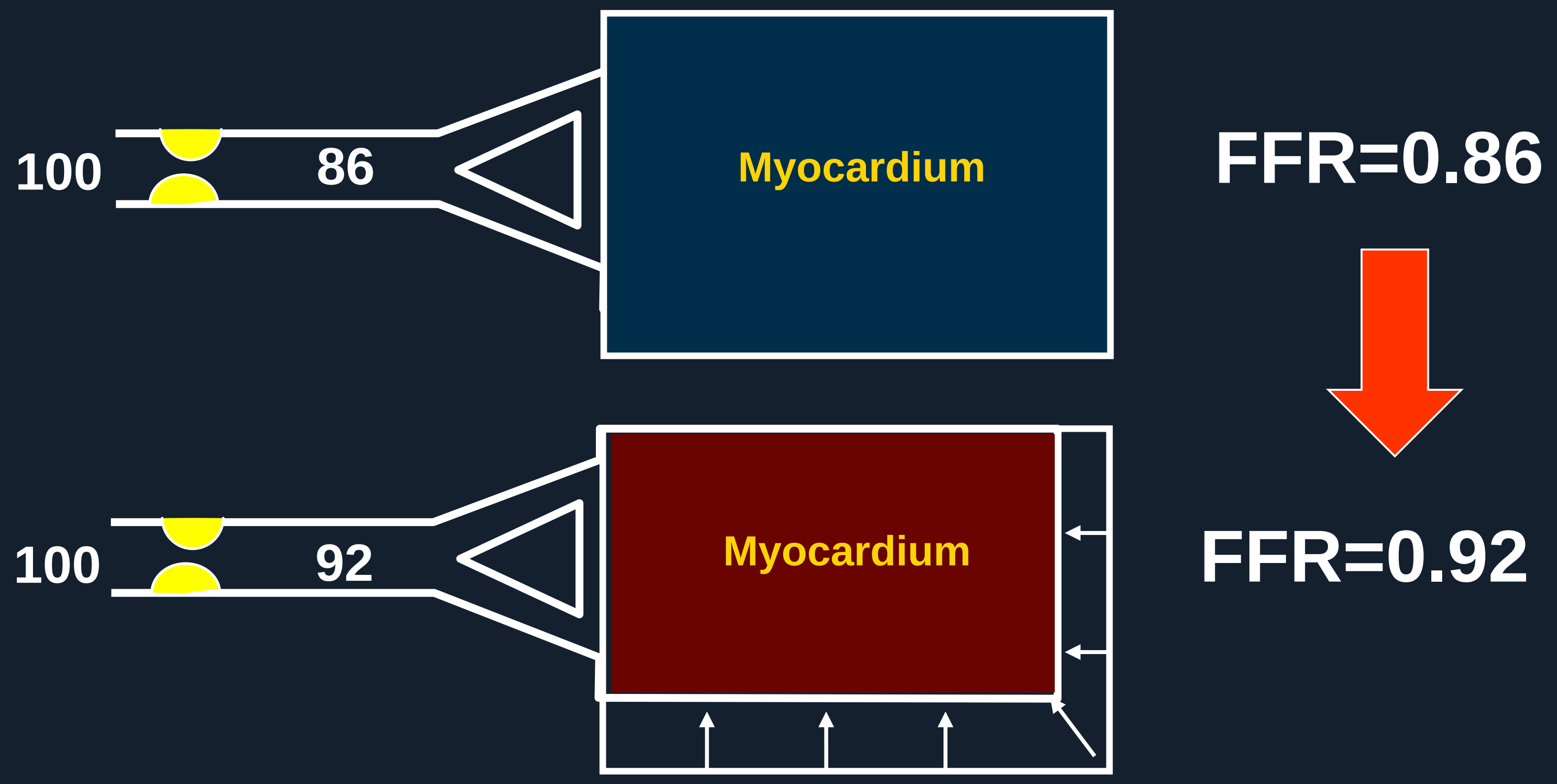


# FFR in RCA

## Before
## Recanalization of LAD

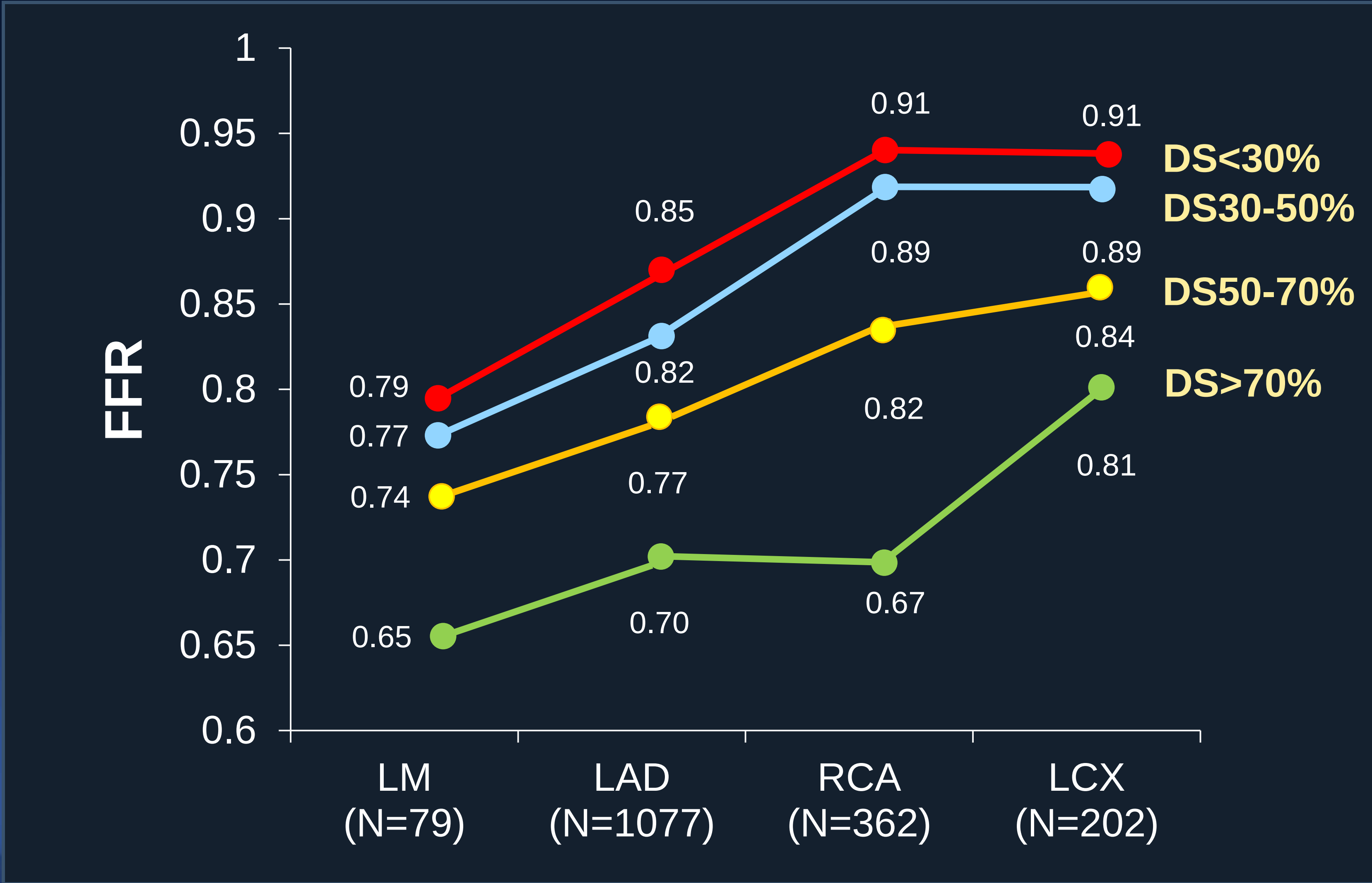

## After
## Recanalization of LAD

# Supplying Myocardial Burden

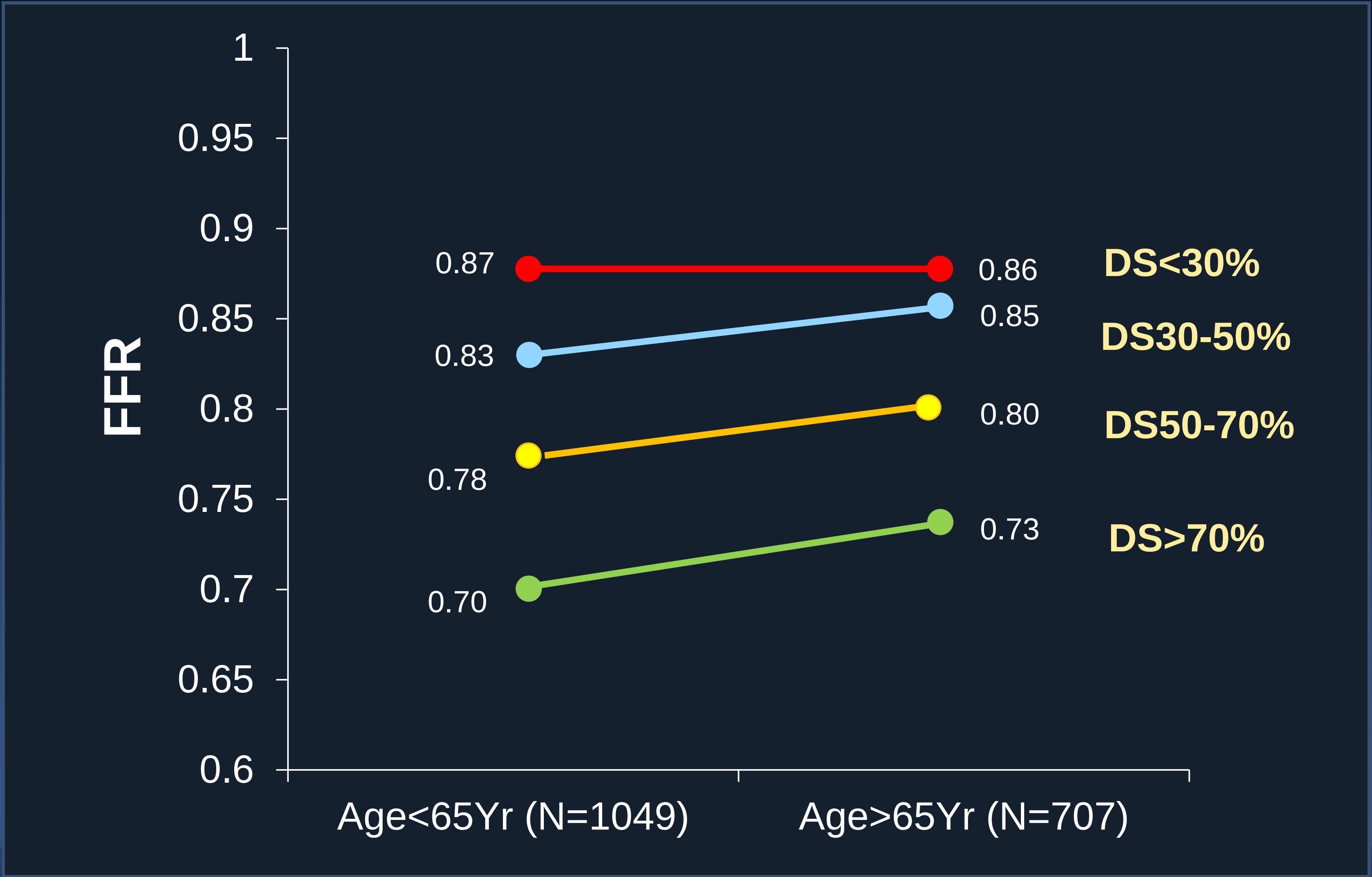


Data from IRIS FFR

# Location of Stenosis



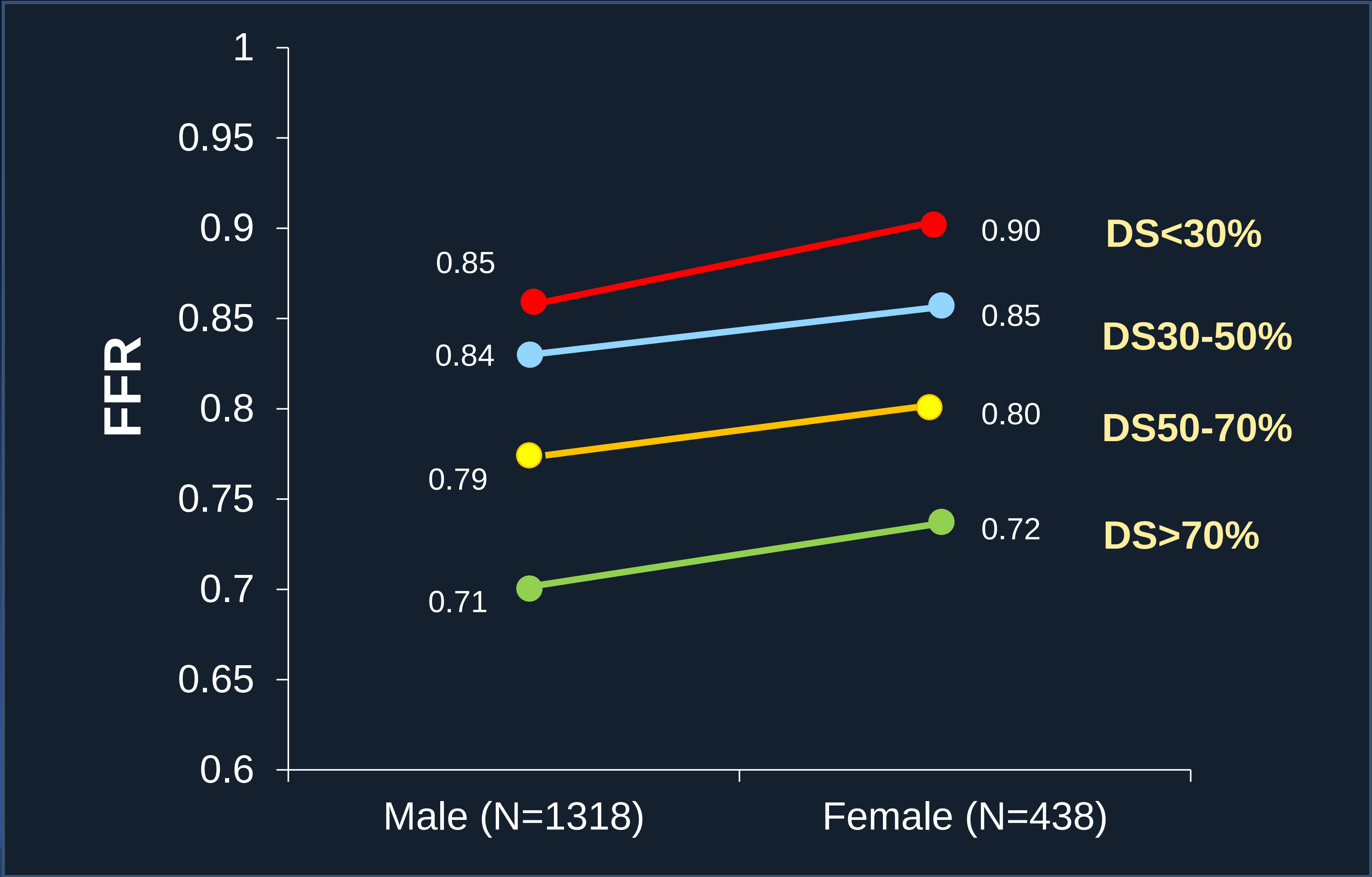
# Age



FFR
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.87
0.86
0.83
0.85
0.78
0.80
0.70
0.73
DS<30%
DS30-50%
DS50-70%
DS>70%
Age<65Yr (N=1049)
Age>65Yr (N=707)

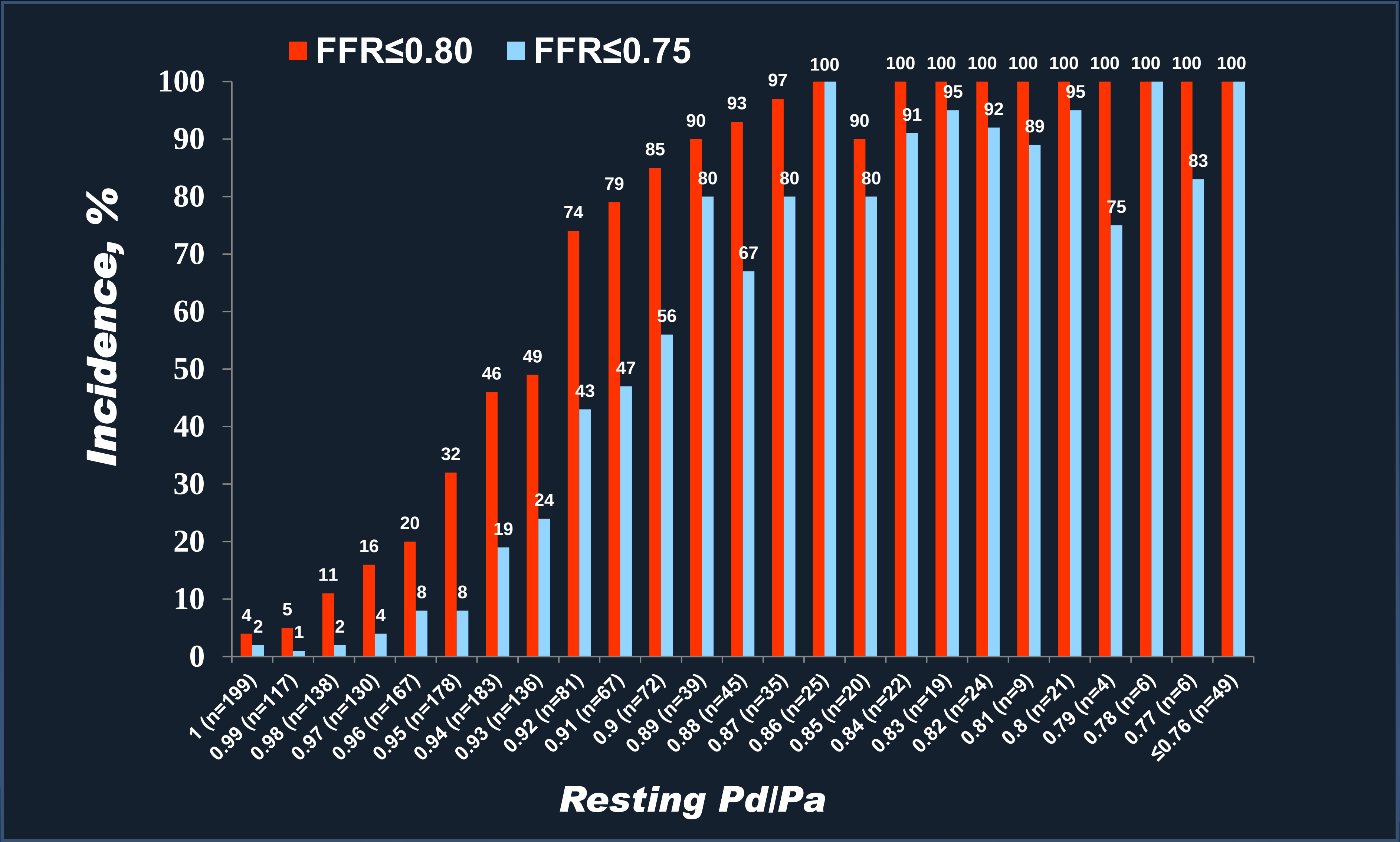
Data from IRIS FFR

# Sex



Data from IRIS FFR

# Resting Pd/Pa and FFR



# Summary

- Because many anatomical and non-anatomical factors affected the functional severity of coronary stenosis, discordant between anatomical and functional assessment was very frequent.
- Therefore, every physicians should understand it and overcome their visual (anatomical) bias and decide the treatment strategy based on the functional evaluation.