

Why Mismatch ?

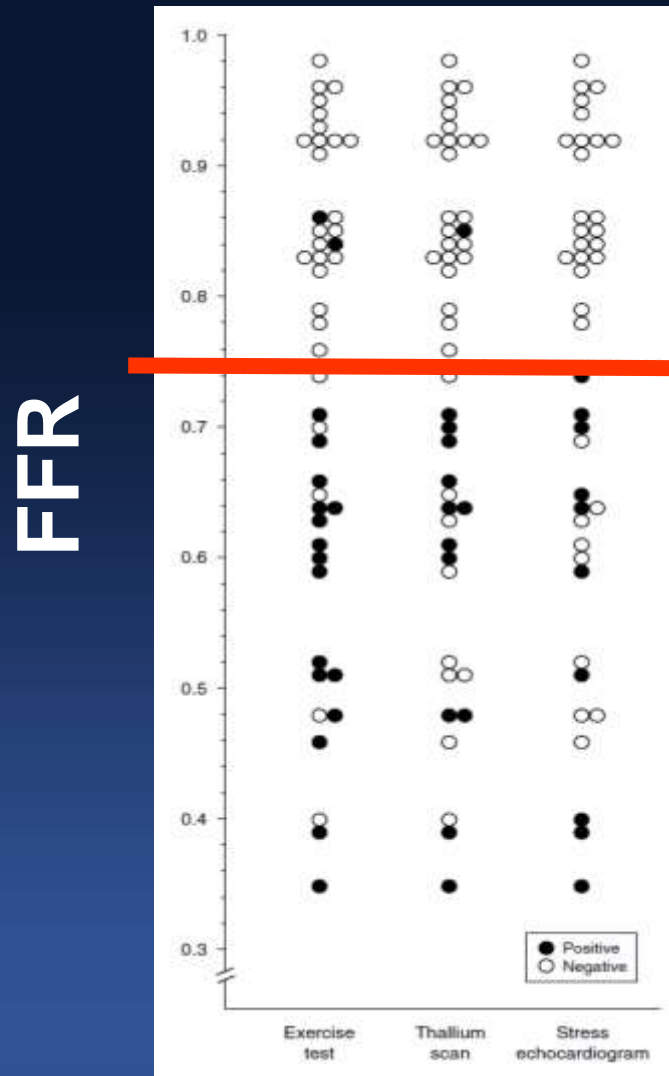
FFR vs. Angiographic %DS

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Heart Institute, Asan Medical Center, Seoul, Korea

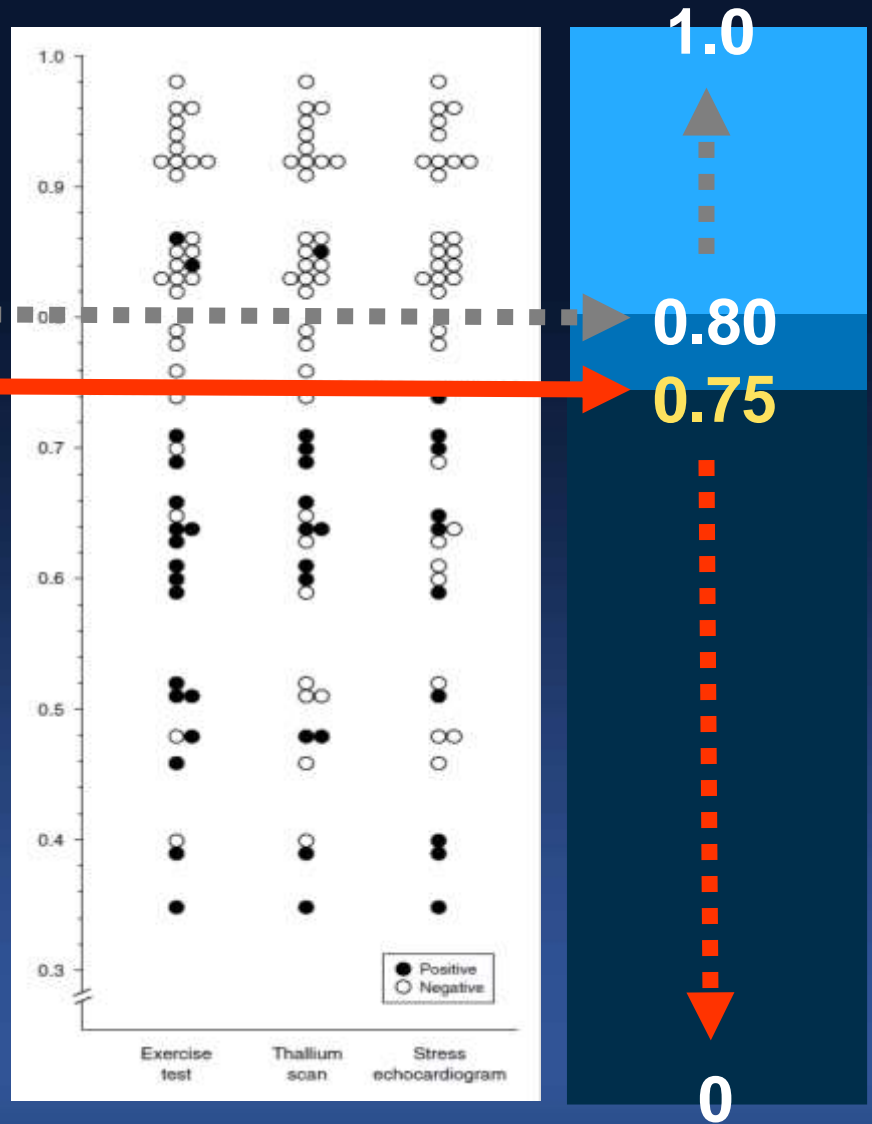
What Does It Mean
FFR <0.80 ?

FFR Cut-Off Value Matched with Non-invasive Stress Test Results (n=45)



FFR < 0.75

Sensitivity	88%
Specificity	100%
Positive PV	100%
Negative PV	88%
Accuracy	93%

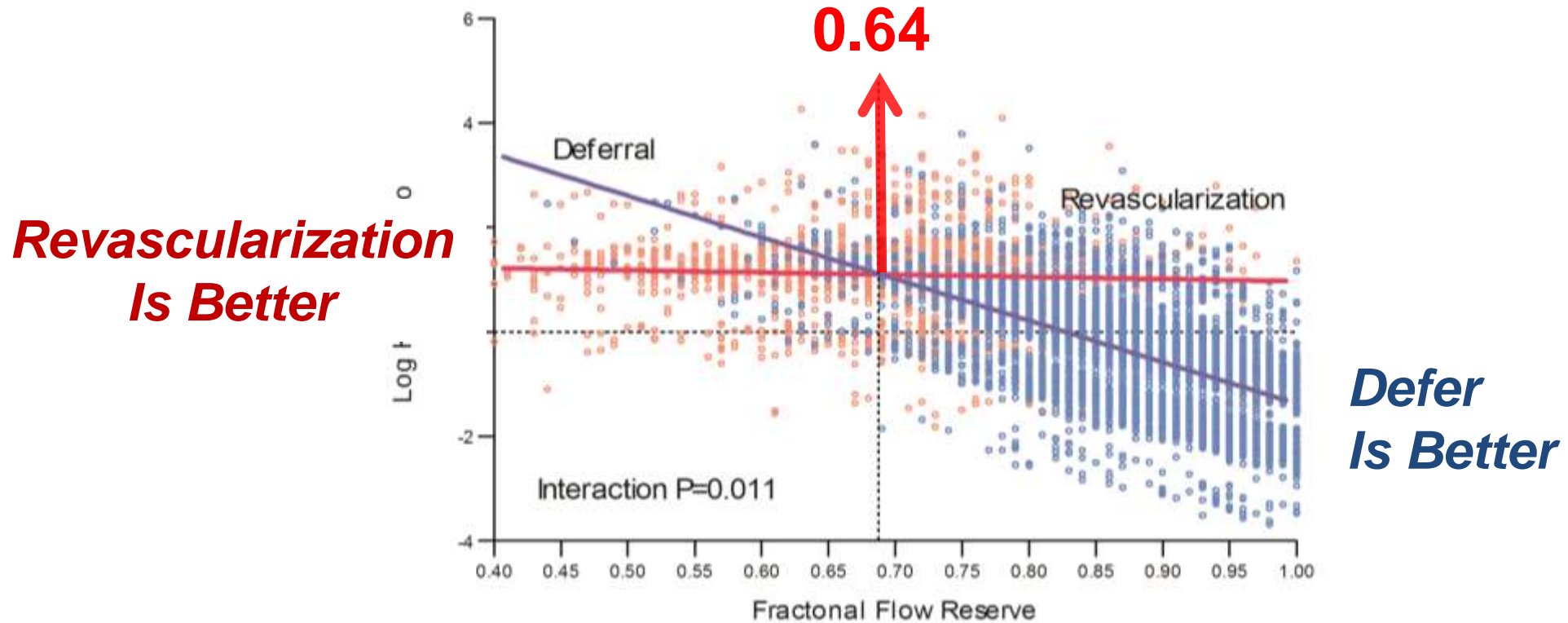


Non-Ischemic

Ischemic

Outcome Derived Optimal Threshold of FFR (IRIS-FFR Registry, n=8,632)

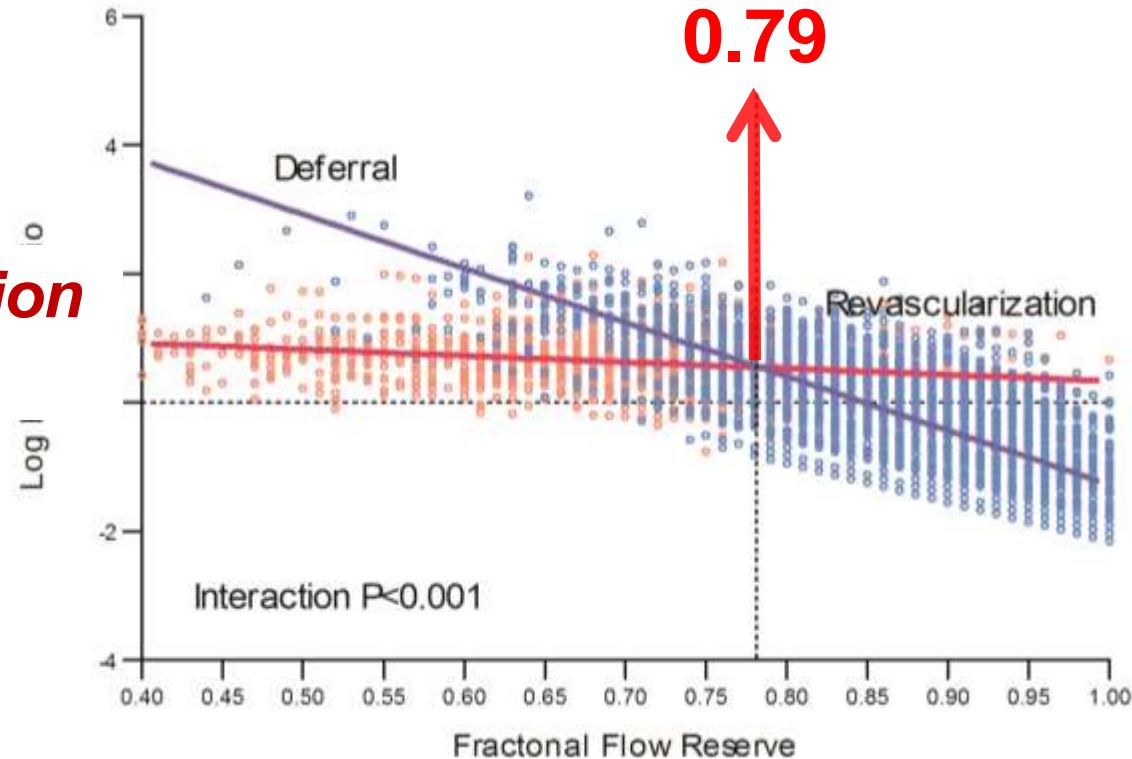
Cardiac Death and MI



Outcome Derived Optimal Threshold of FFR (IRIS-FFR Registry, n=8,632)

MACE

*Revascularization
Is Better*



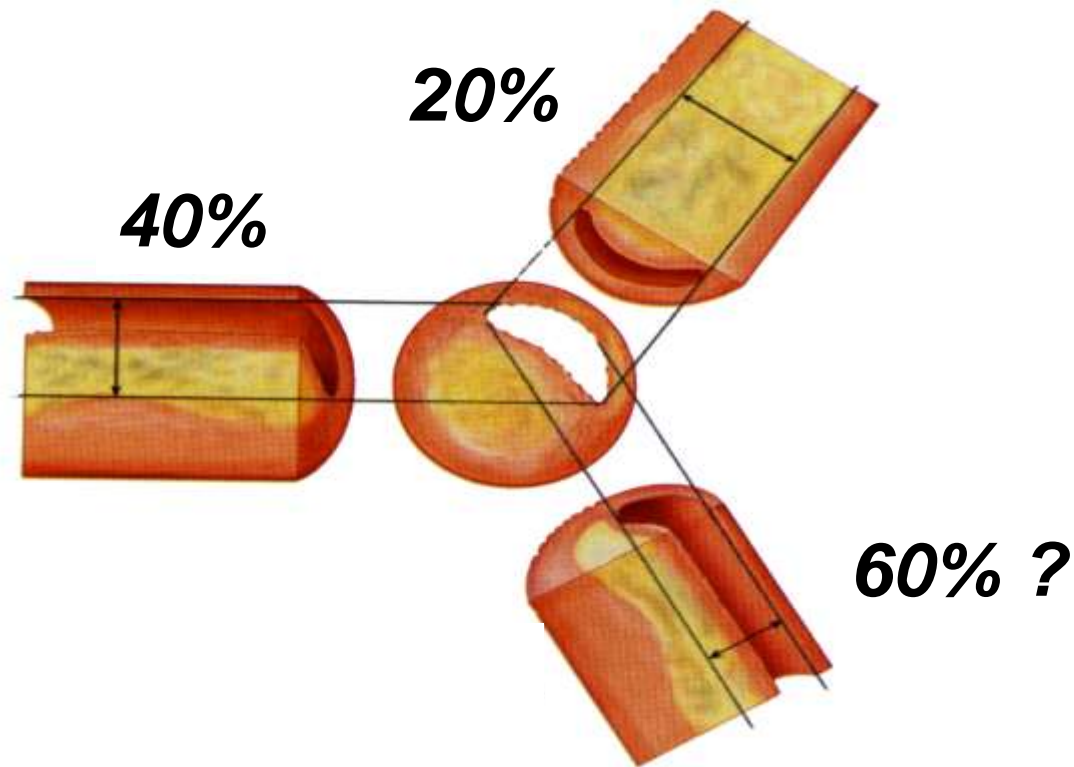
*Defer
Is Better*

FFR 0.80 Means,

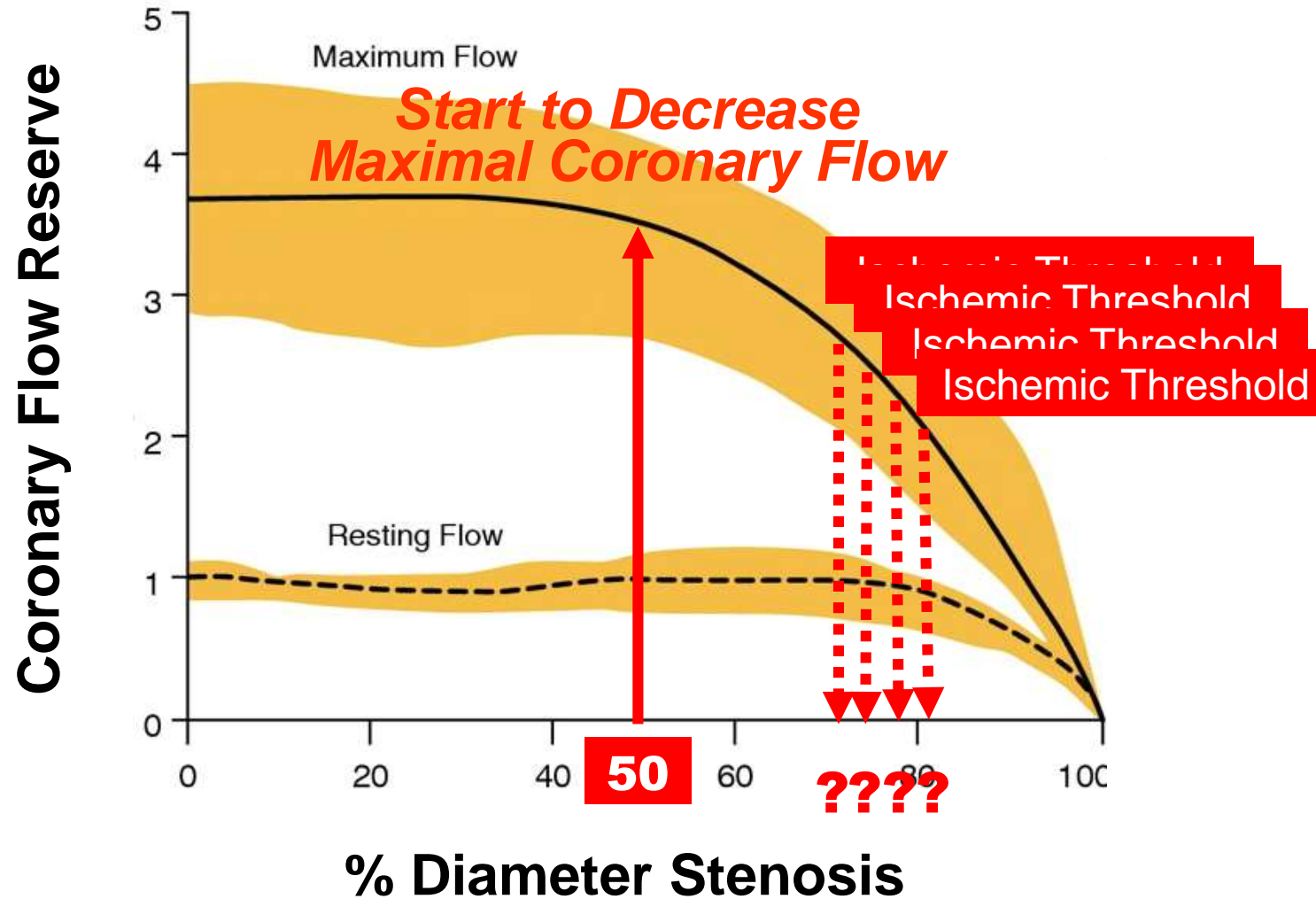
Good Clinical Outcome Threshold !

What Does It Mean Angiographic % DS ?

**Angiographic % DS Is,
2-Dimensional, Single Cut Image.
Different % DS at Different Angle**



What Does It Mean 50% Diameter Stenosis ?



Gould, K. L. 1974, Animal Study

***FFR-Guided Means,
Ischemia Guided !***

***Angio-Guided Means,
No Ischemic threshold !
No Clinical Relevance !***

FFR vs. Angiographic %DS

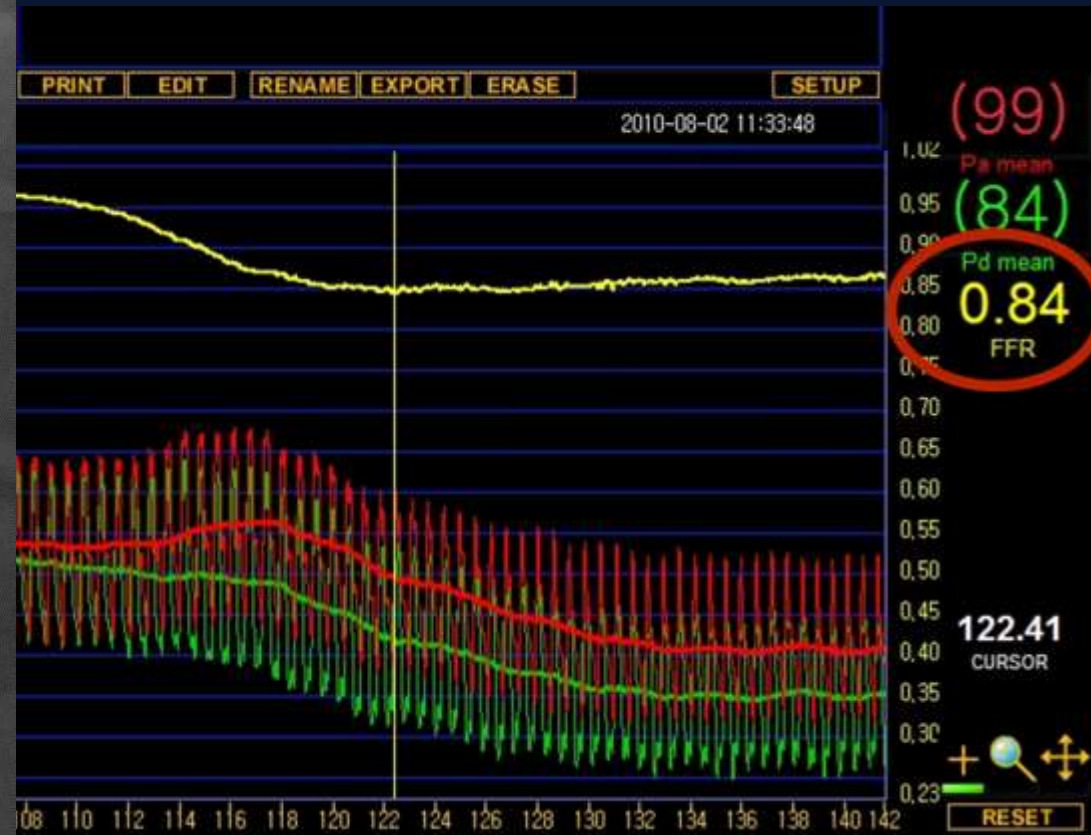
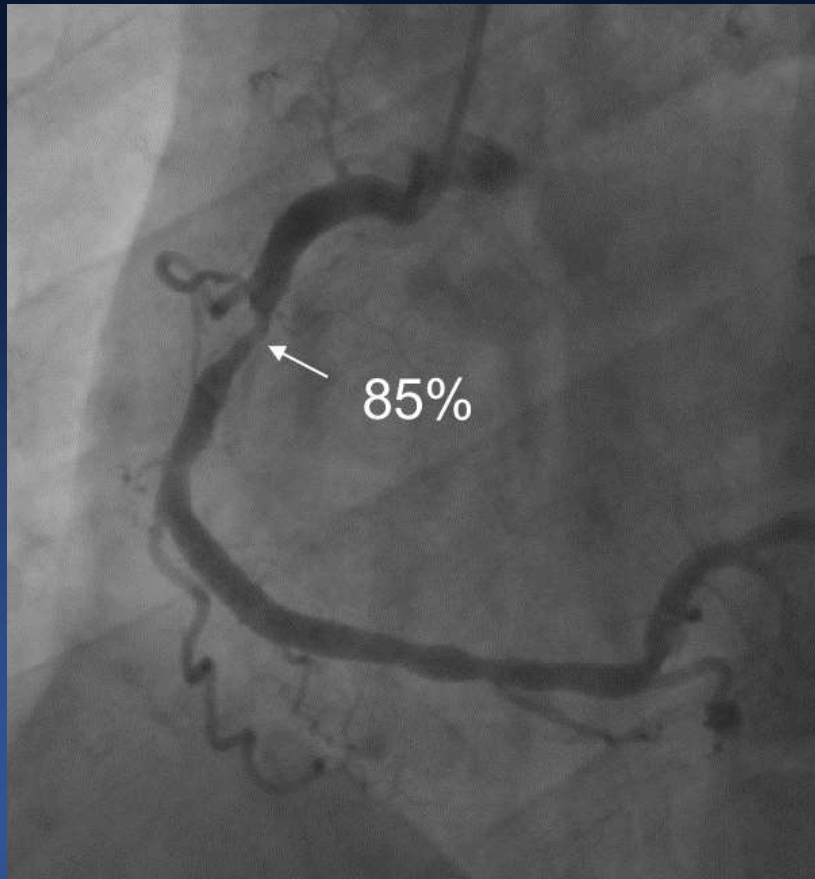
Totally Different !

*There Are Visual **Functional** Mismatches !*

Mismatches !

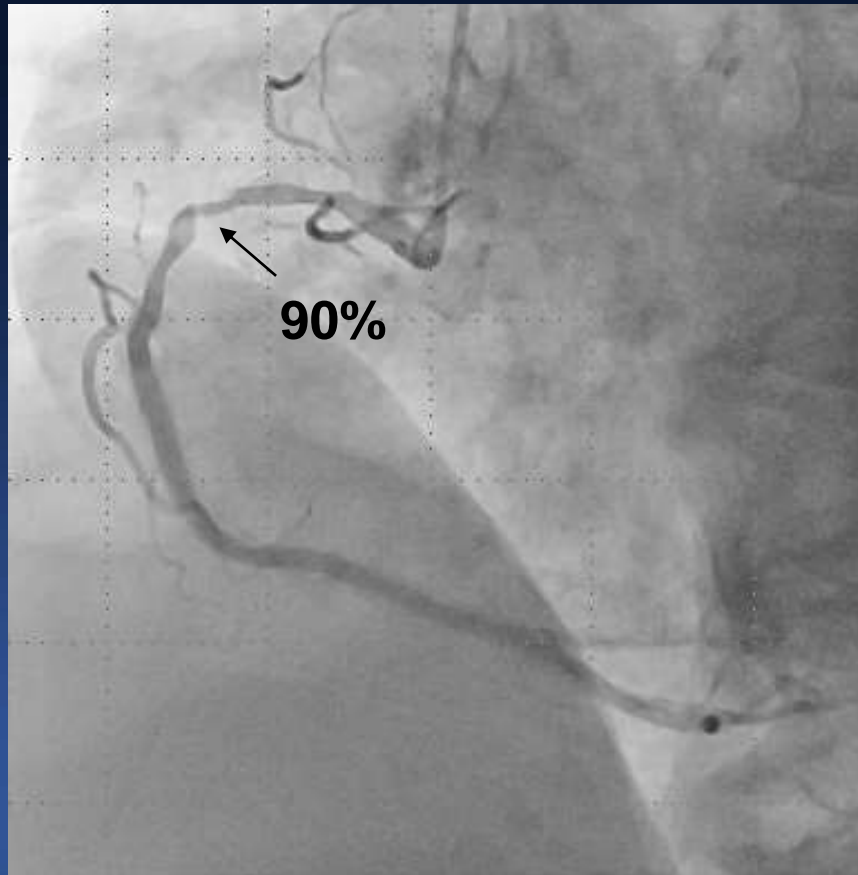
72/M

FFR 0.84



Mismatches !

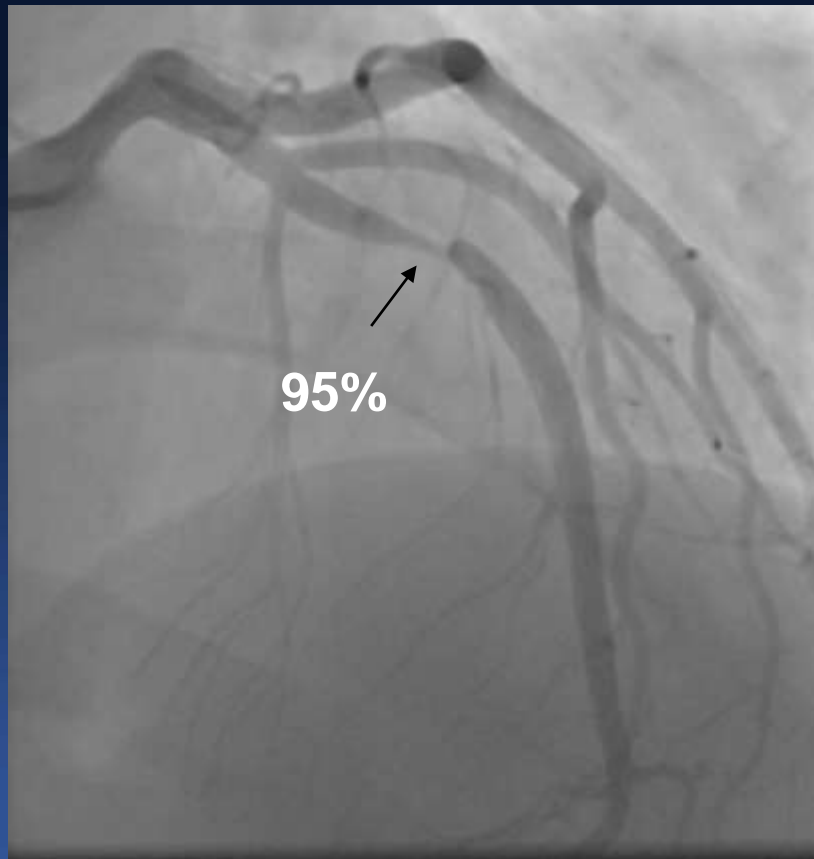
77/F



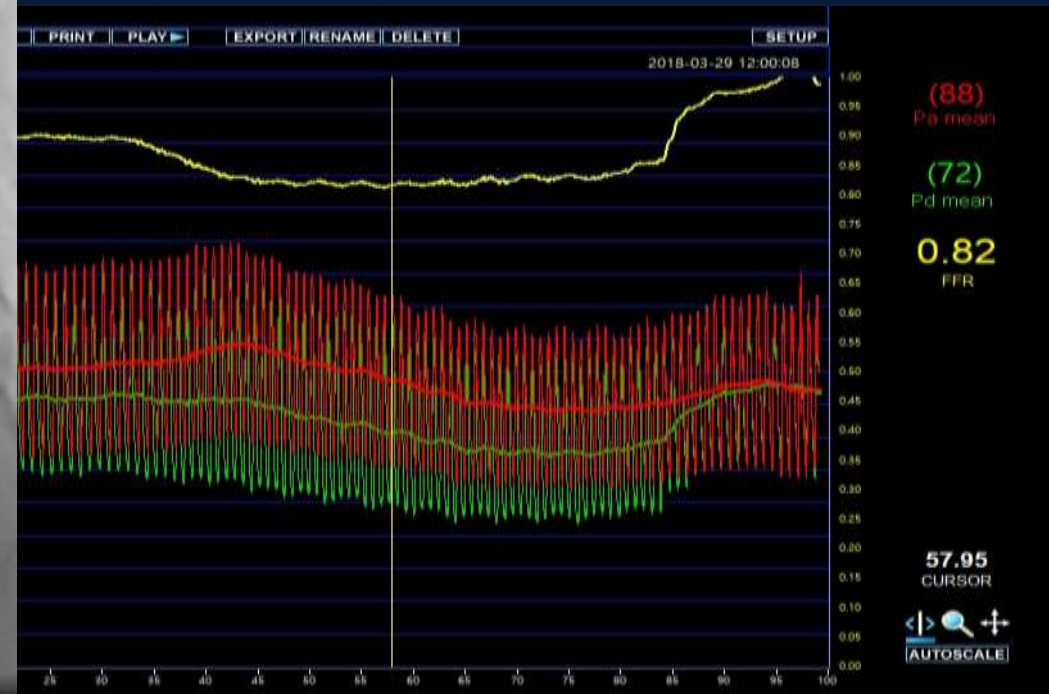
FFR 0.85



Mismatches !

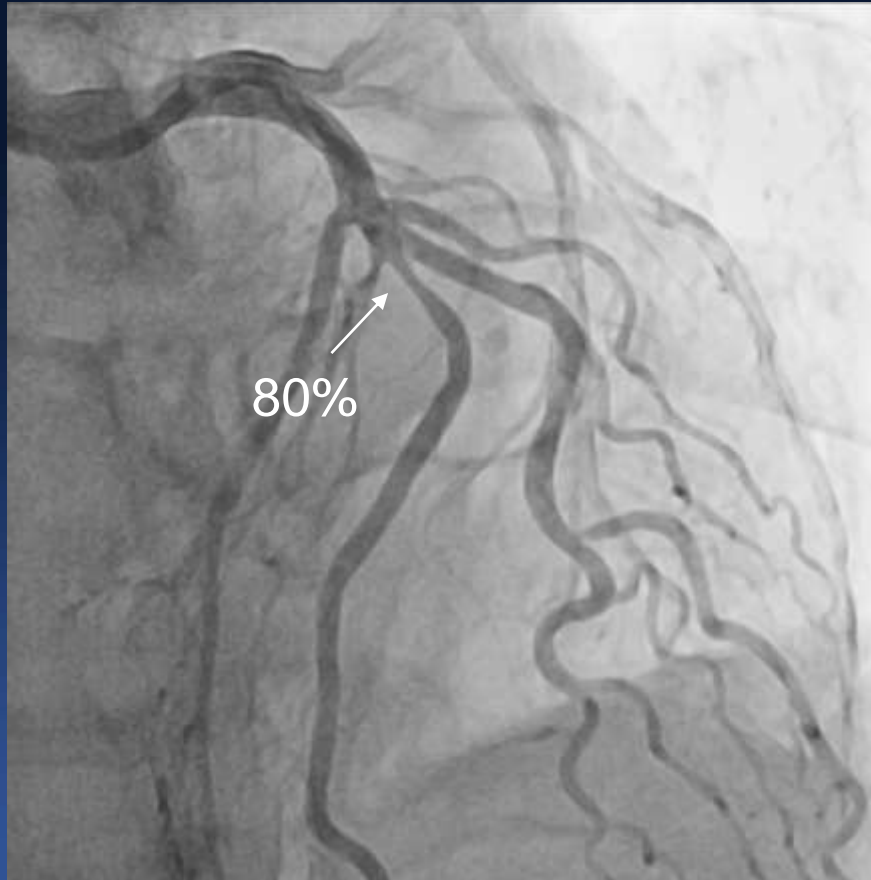


FFR 0.82



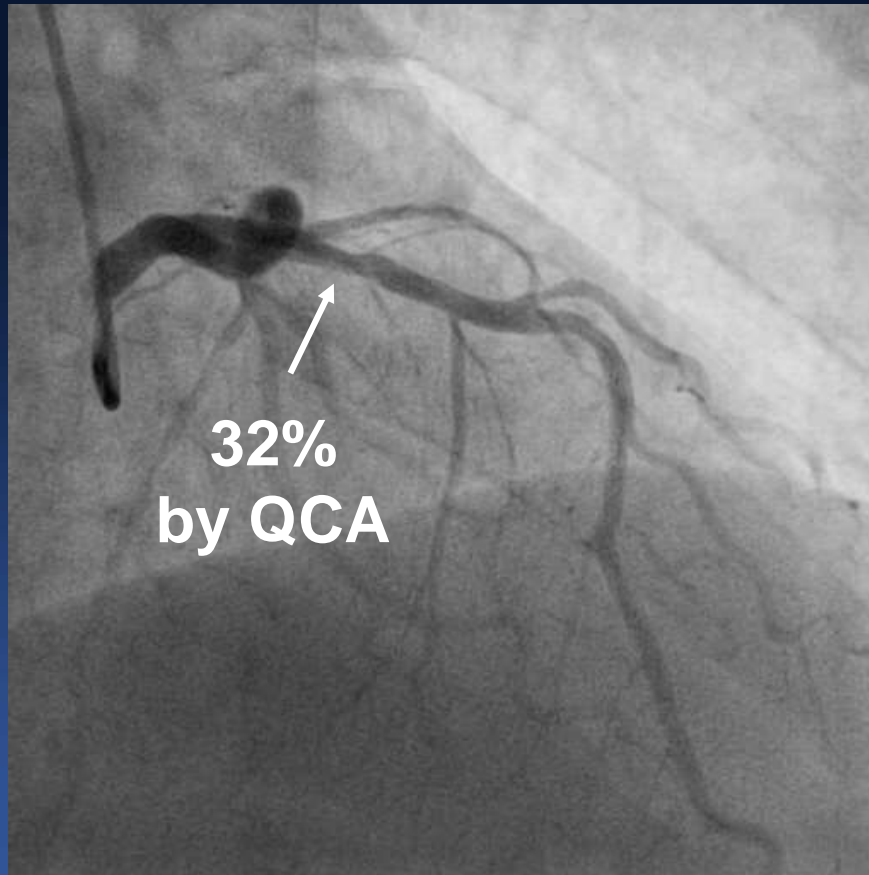
Mismatches !

FFR 0.82

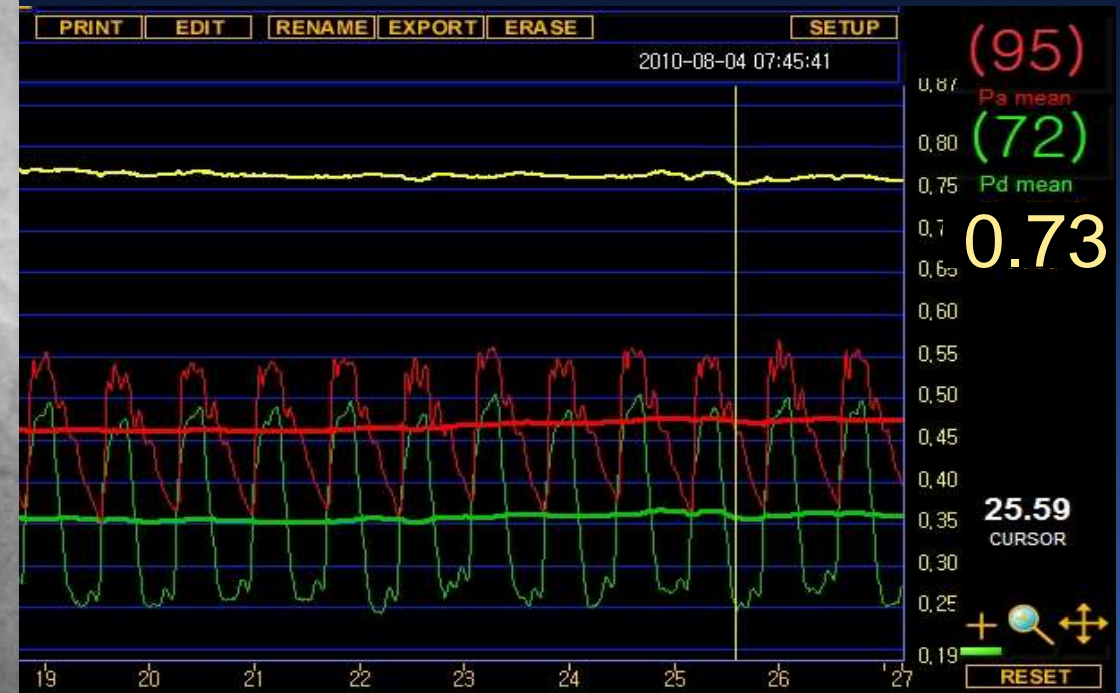


Reverse Mismatches !

44/M Intermittent resting chest pain



FFR 0.73



Mismatches ;

Significant Stenosis (>50%)
with Negative FFR

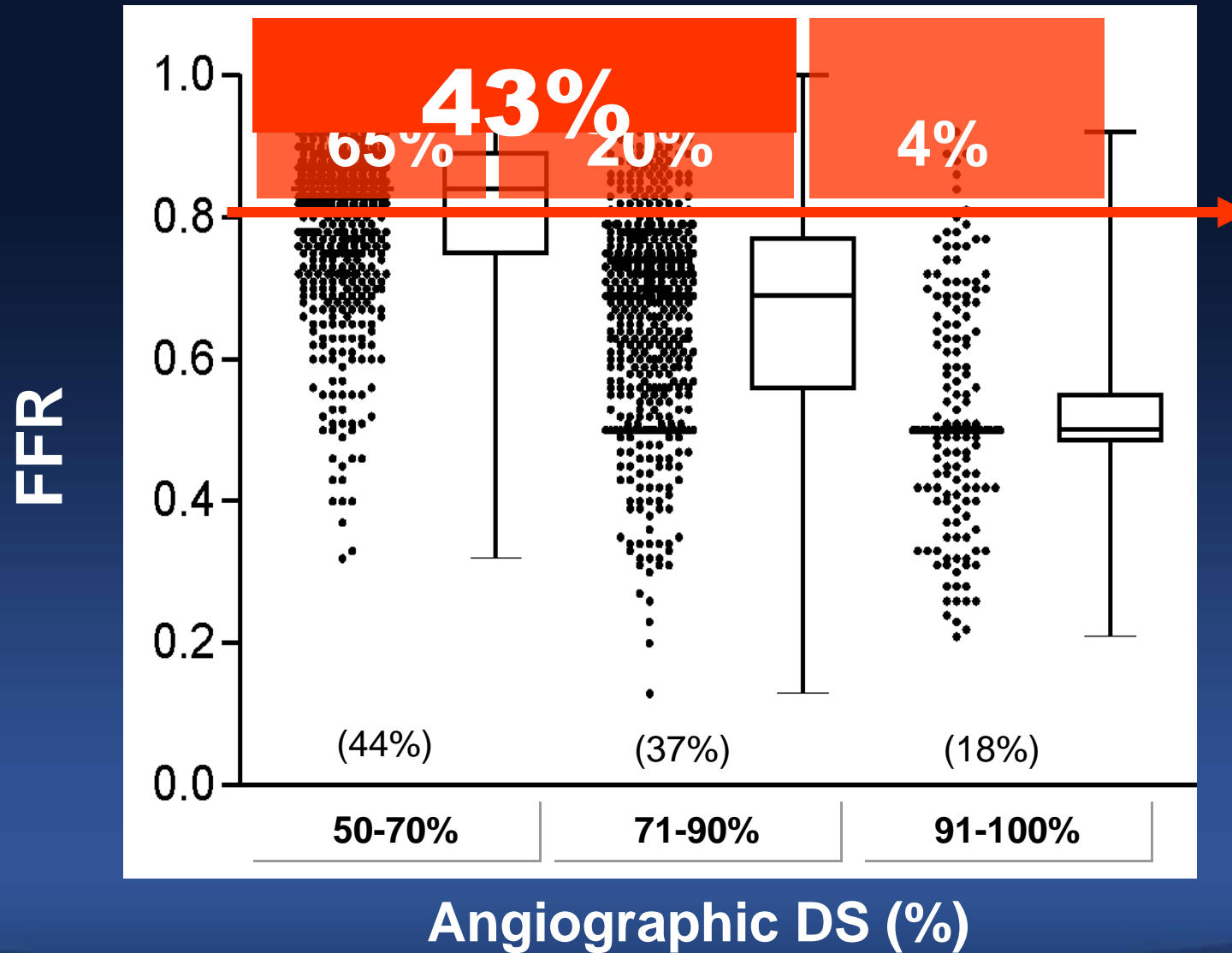
Reverse Mismatches ;

Insignificant Stenosis (<50%)
with Positive FFR

How Many Mismatches ?

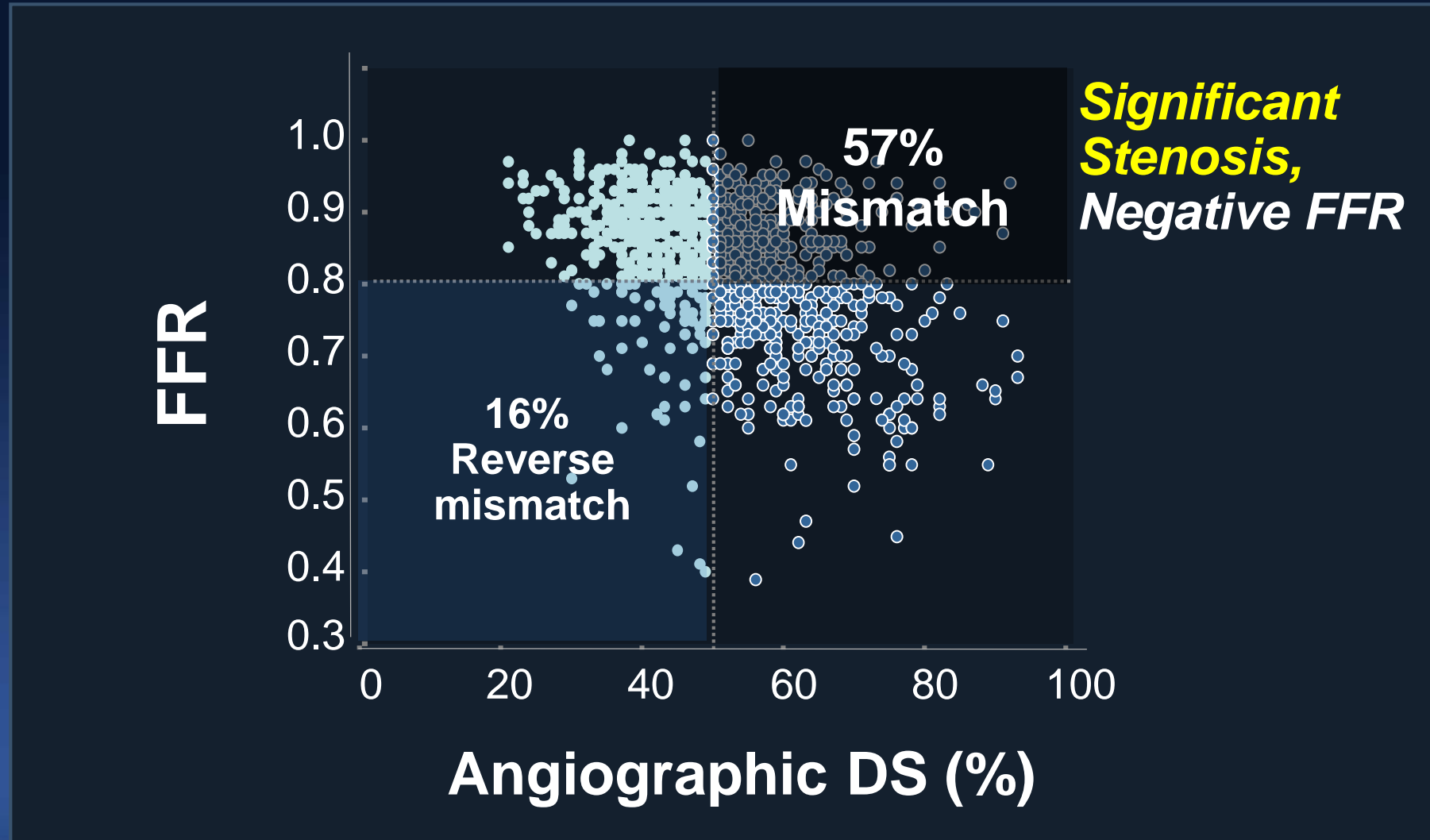
FAME Study

1329 lesions in the FFR-guided arm



Many Mismatches

Non-LM lesions (n=1066)



Why Mismatches ?

FFR

(Fractional Flow Reserve)

$$\text{FFR} = \frac{Q_{\text{Distal}}}{Q_{\text{Normal}}}$$

Hyperemic myocardial flow
in the stenotic territory

Normal hyperemic
Maximal myocardial flow

$$\text{FFR} = \frac{\frac{P_d - P_v}{R}}{\frac{P_a - P_v}{R}}$$

At Maximal Hyperemia
Resistance ≈ 0

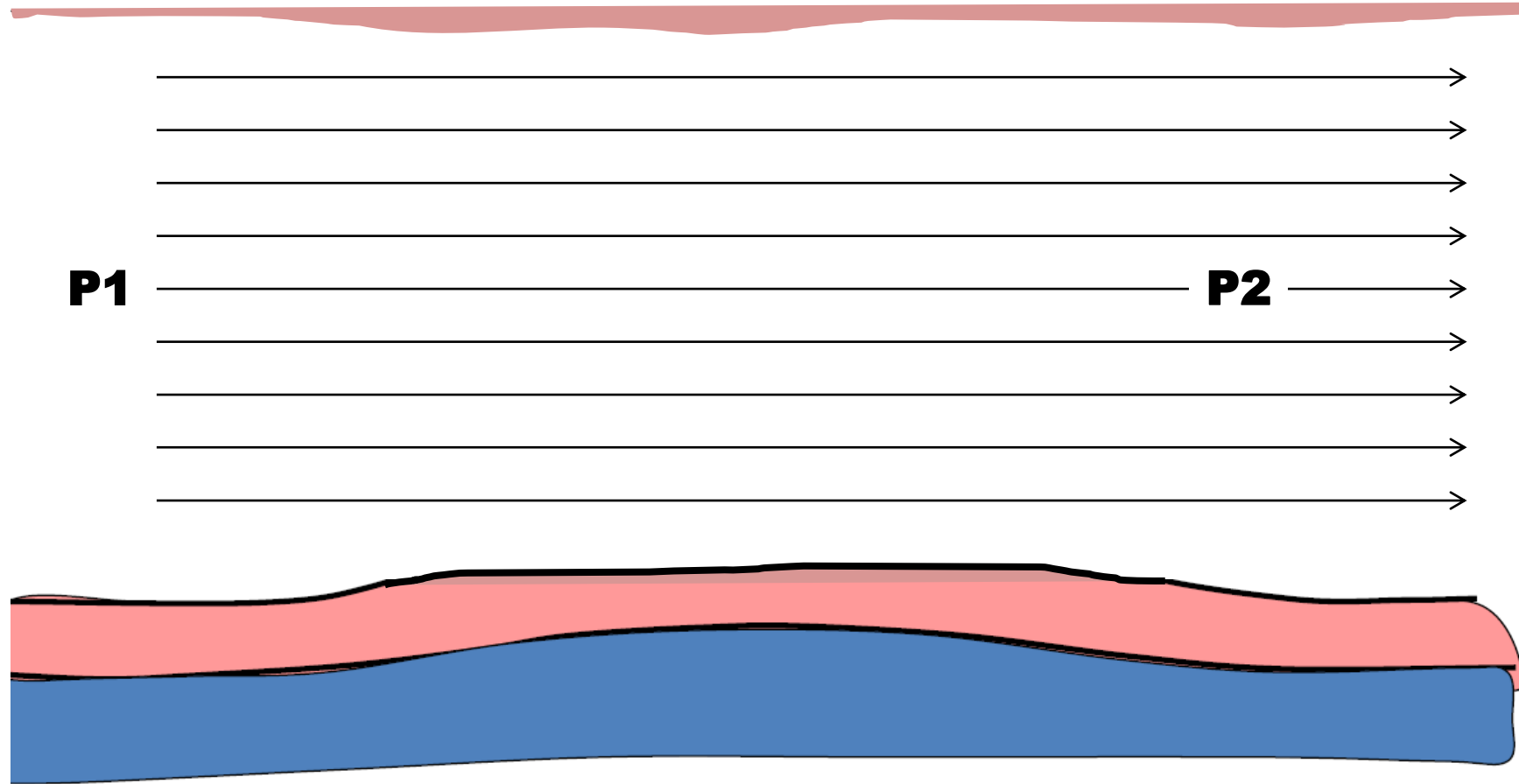
$$\text{FFR} = \frac{P_d \text{ (distal)}}{P_a \text{ (aorta)}}$$

Why

Pressure Drop ?

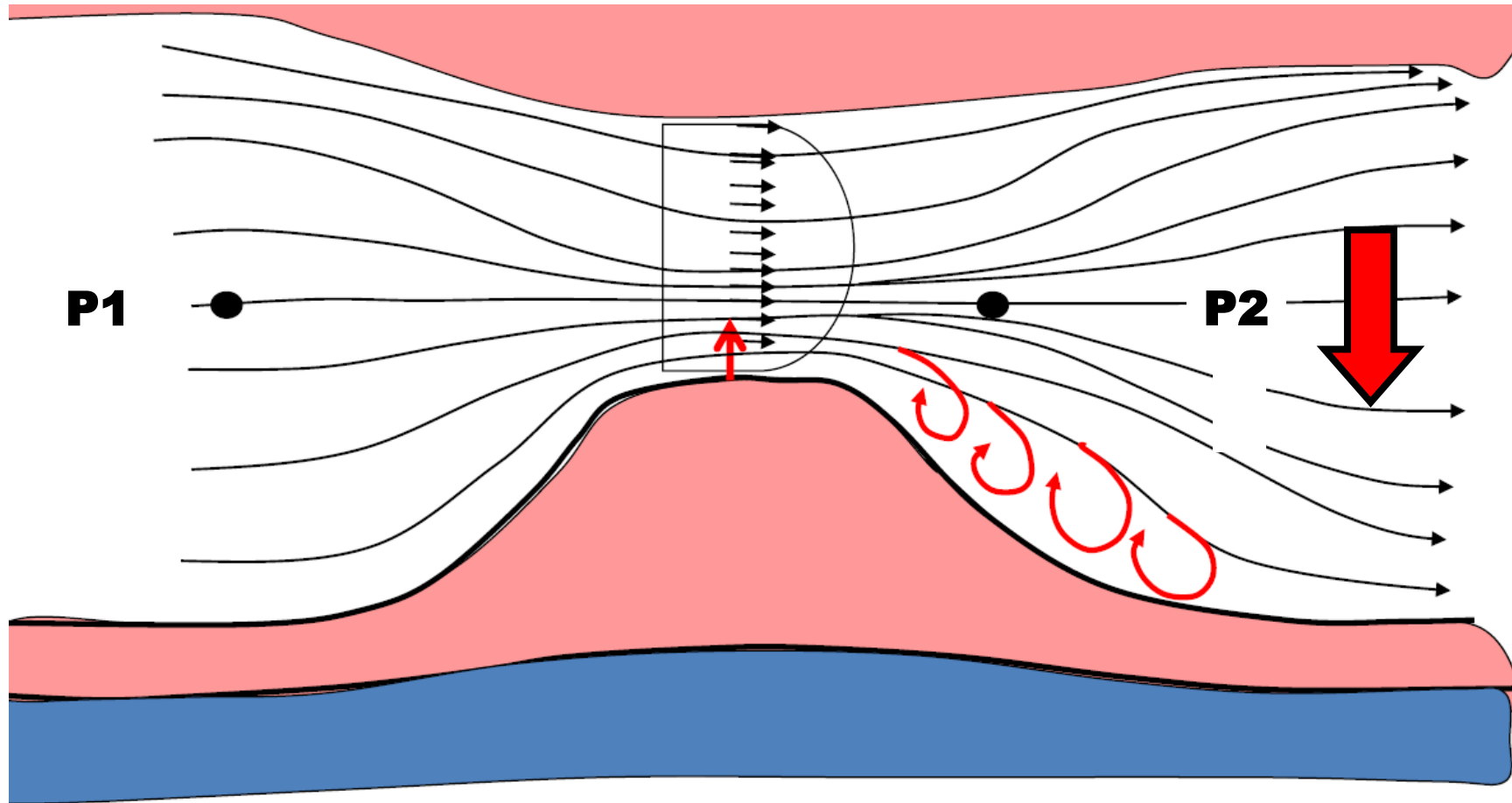
Normal Laminar Flow

$$P1 = P2$$

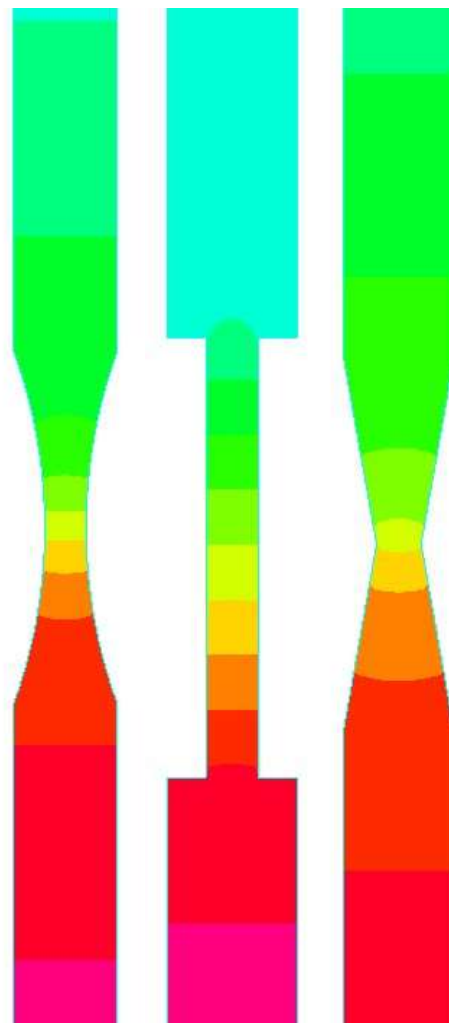
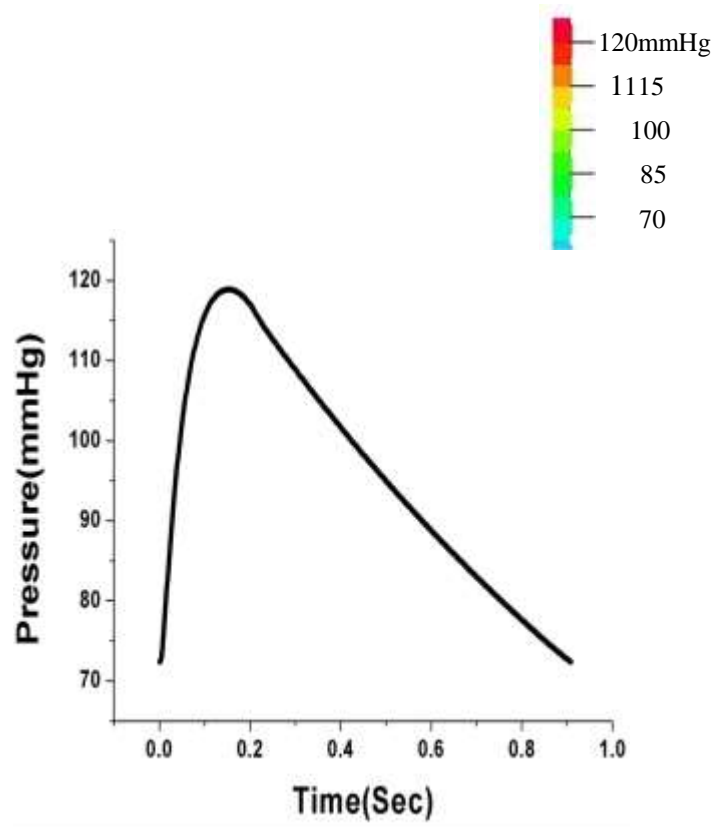


Recirculation (Vortex Flow)

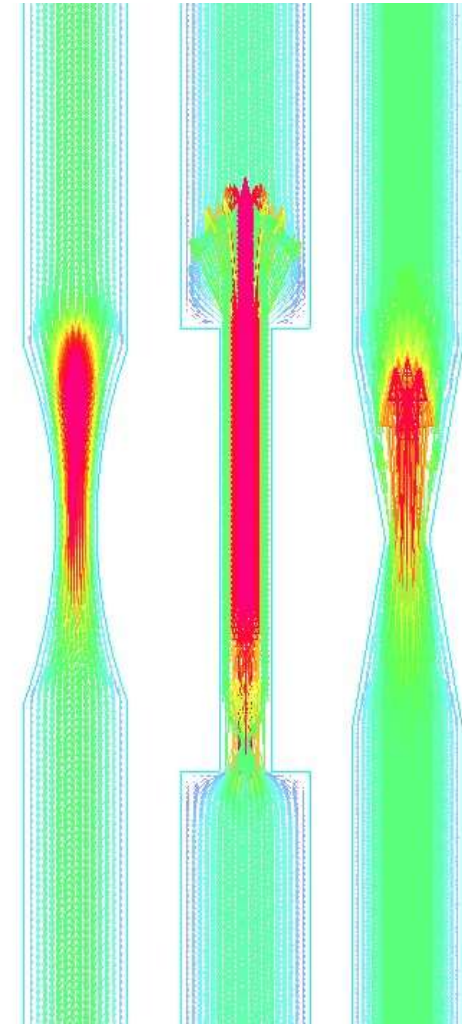
- Energy Loss of Fluid,
- Pressure Drop !



Steady-state 3D Simulation under Hyperemic Condition



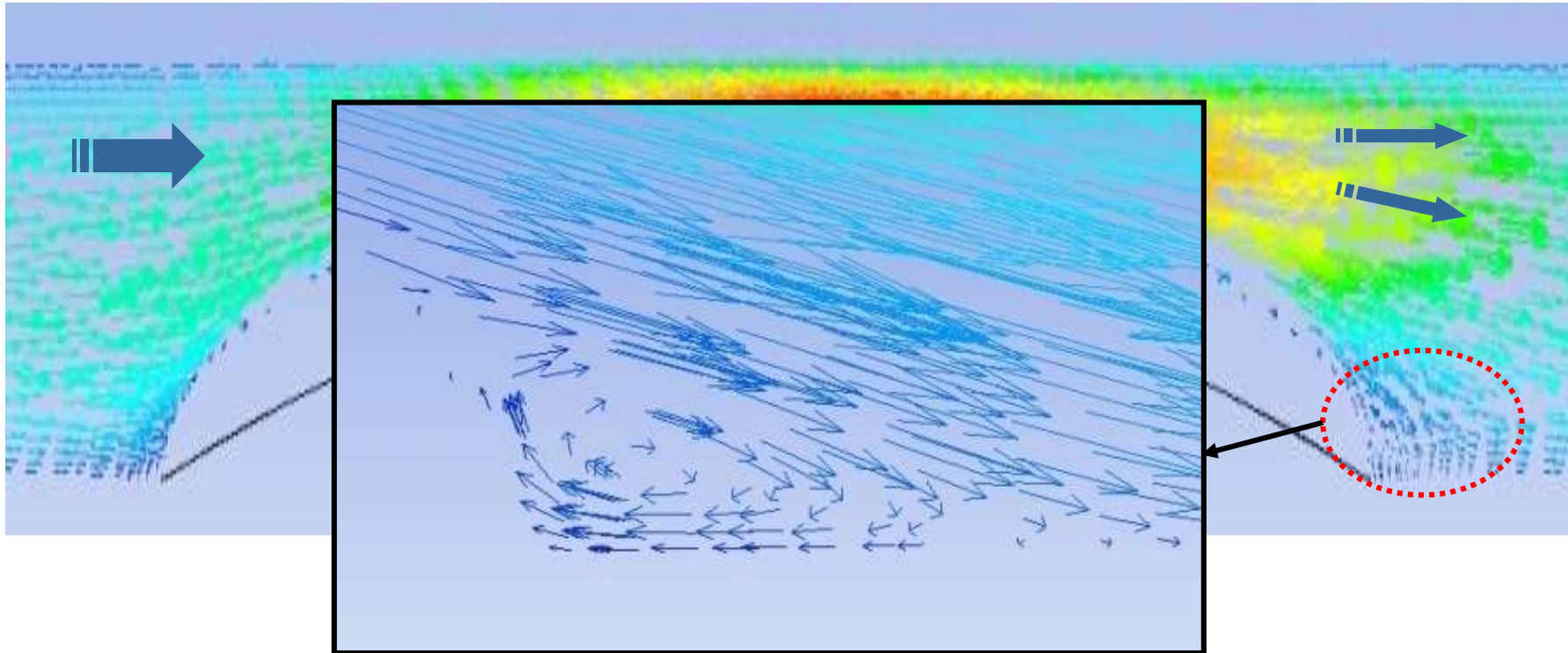
Pressure contours



Velocity vectors

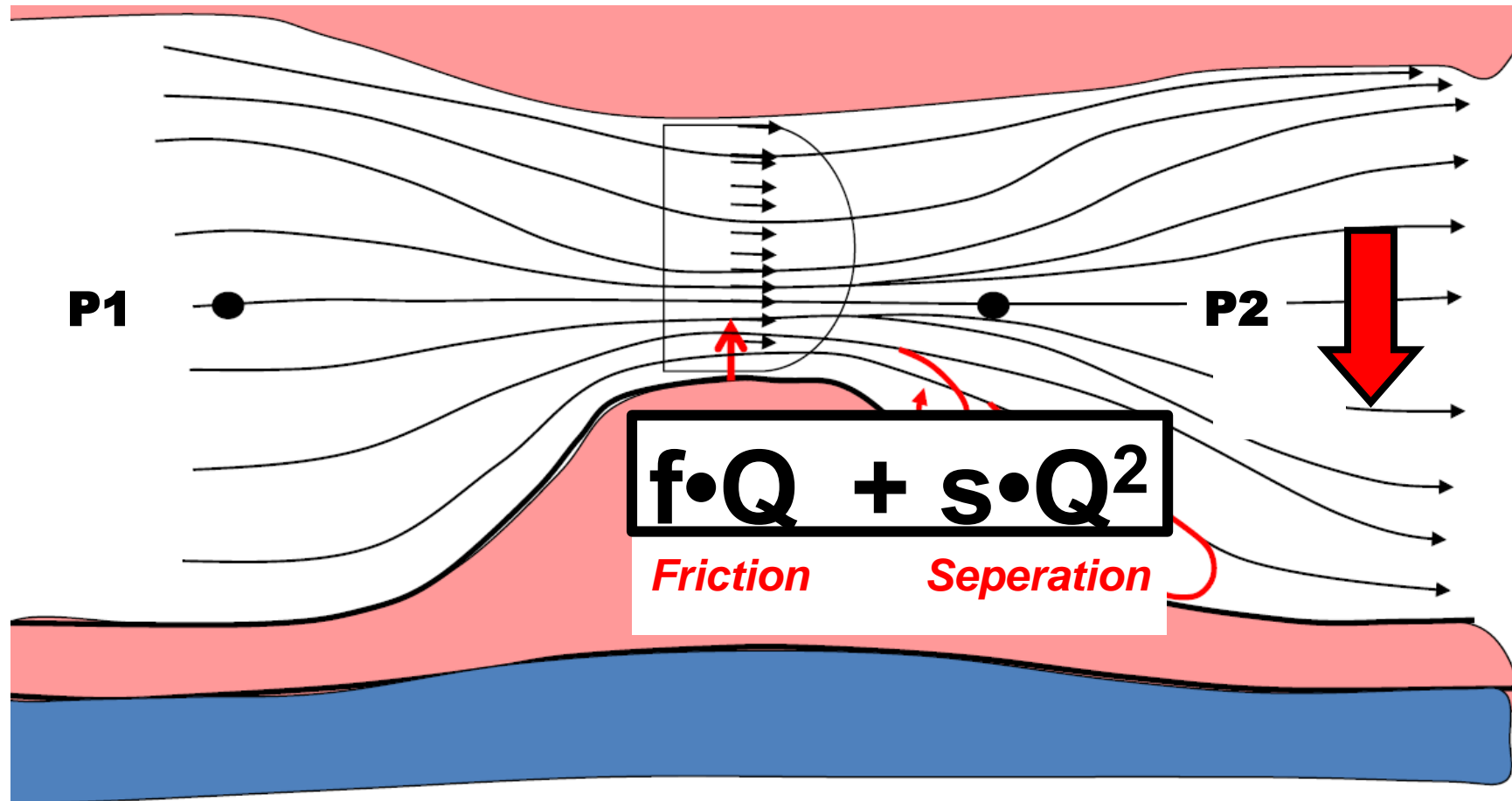
Recirculation (Vortex Flow)

- Energy Loss of Fluid,
- Pressure Drop !



Recirculation

Pressure Drop



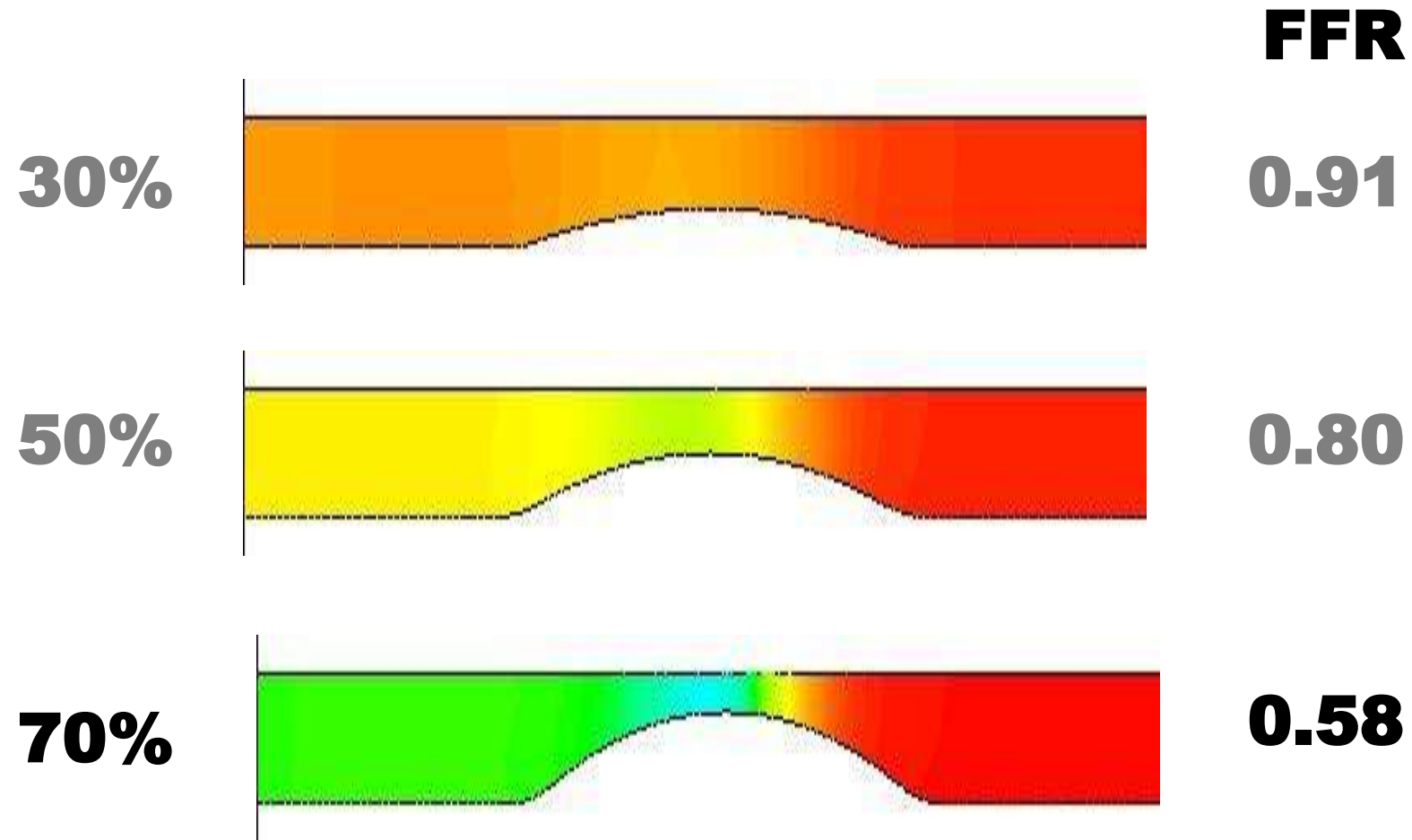
FFR is Mainly Determined by,

- 1.** *Degree of stenosis*
- 2.** *Size of myocardium*
- 3.** *Lesion specific morphologies*

FFR is Mainly Determined by,

- 1.** *Degree of stenosis*

Degree of Stenosis

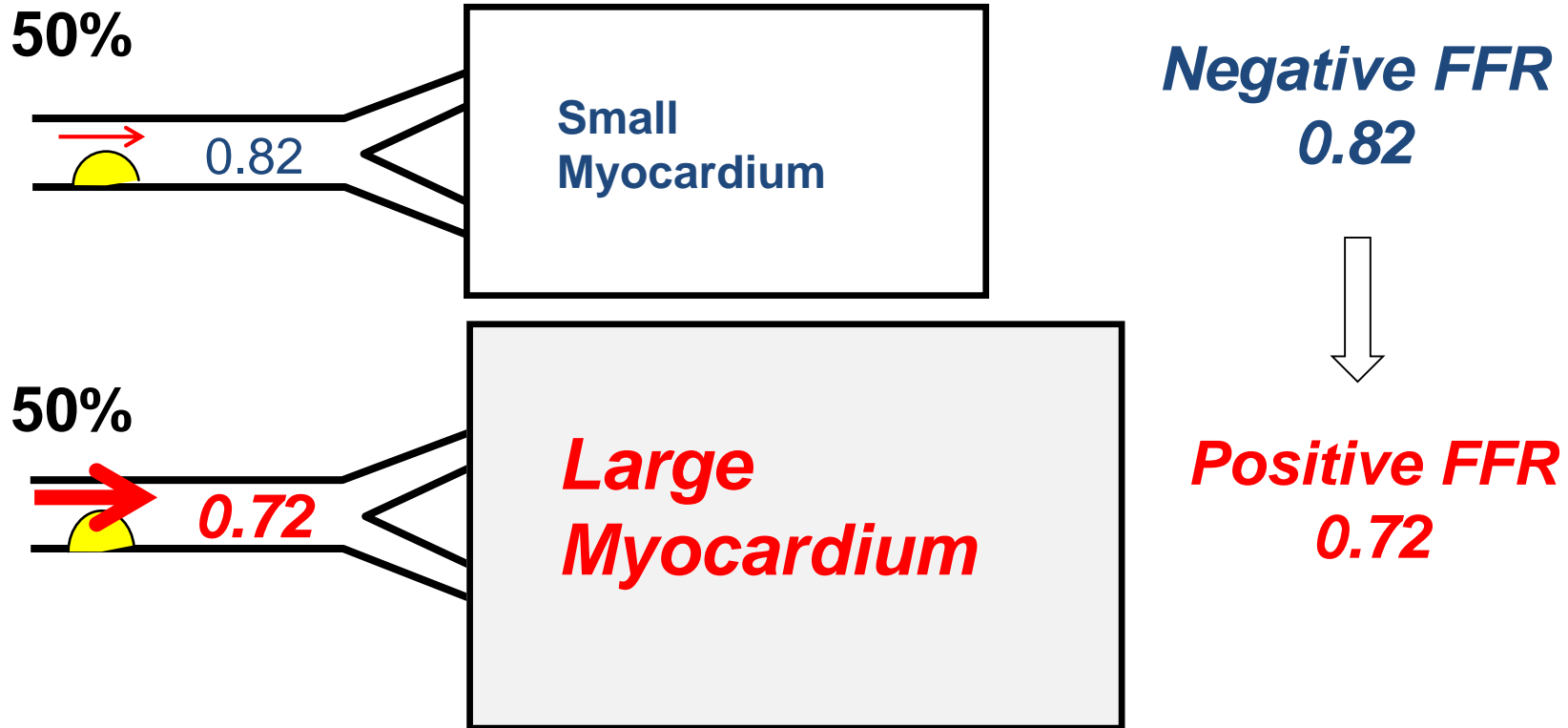


3D Computational Simulation Study

FFR is Mainly Determined by,

- 1.** *Degree of stenosis*
- 2.** *Size of myocardium*

Large Supplied Myocardium Can Make A Positive FFR

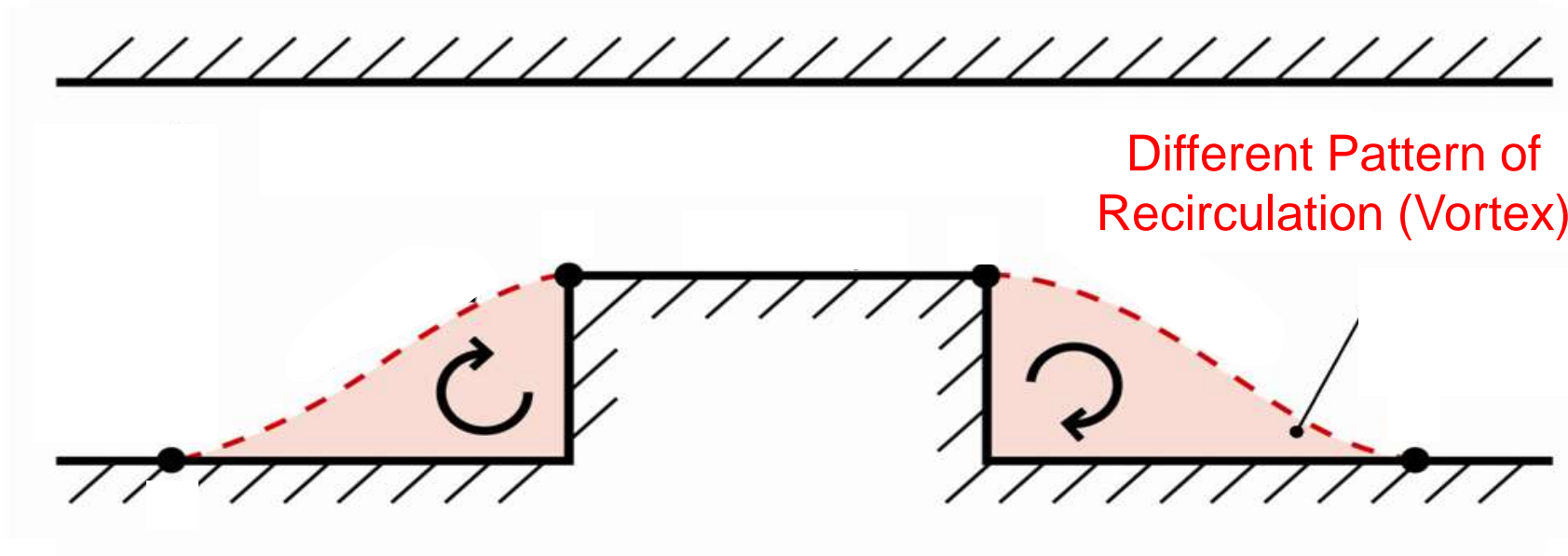


Increased Flow Velocity
Increased Vortex flow (Recirculation),
More energy loss, More pressure drop !

FFR is Mainly Determined by,

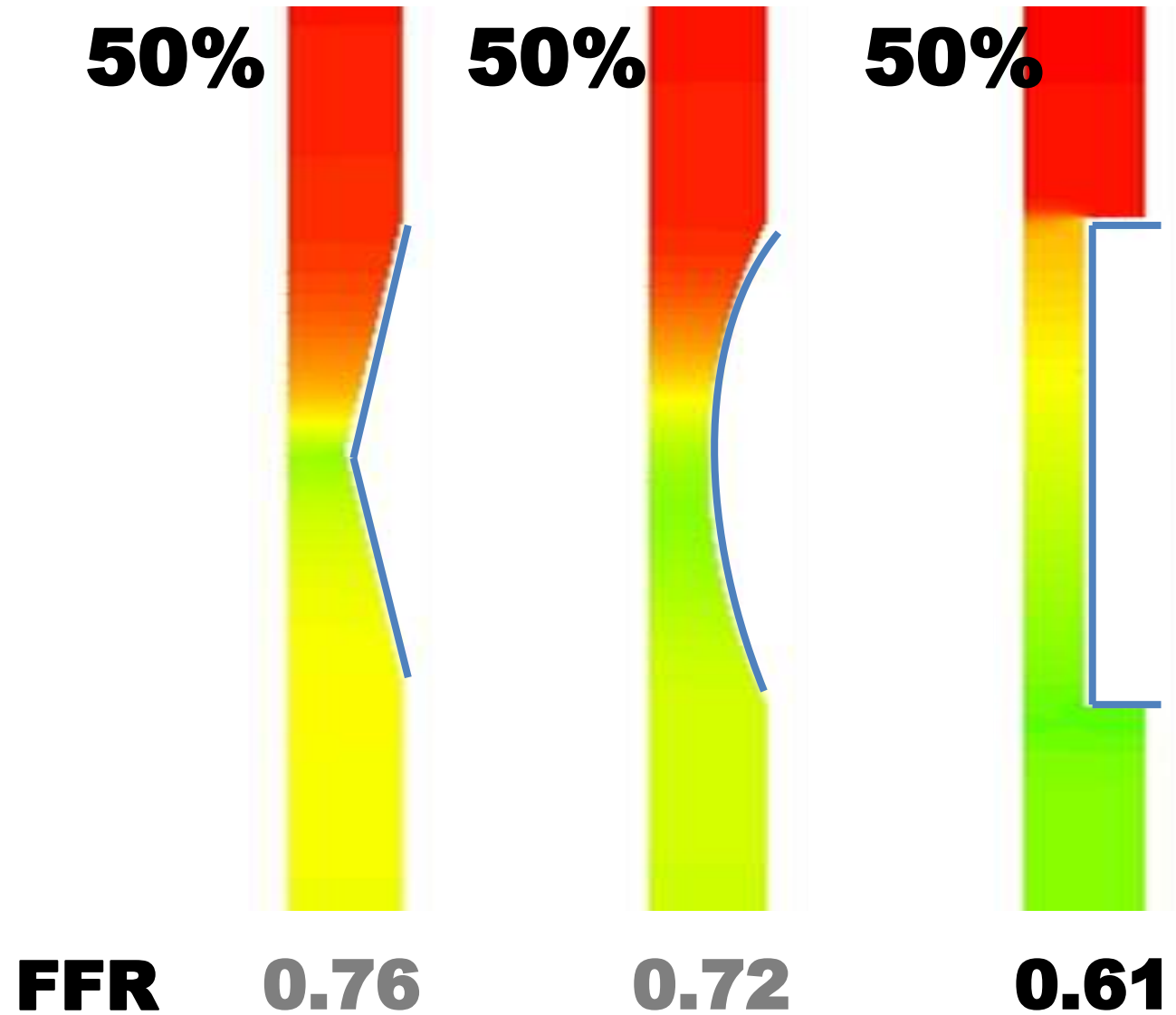
- 1.** *Degree of stenosis*
- 2.** *Size of myocardium*
- 3.** *Lesion specific morphologies*

Different Lesion Morphology

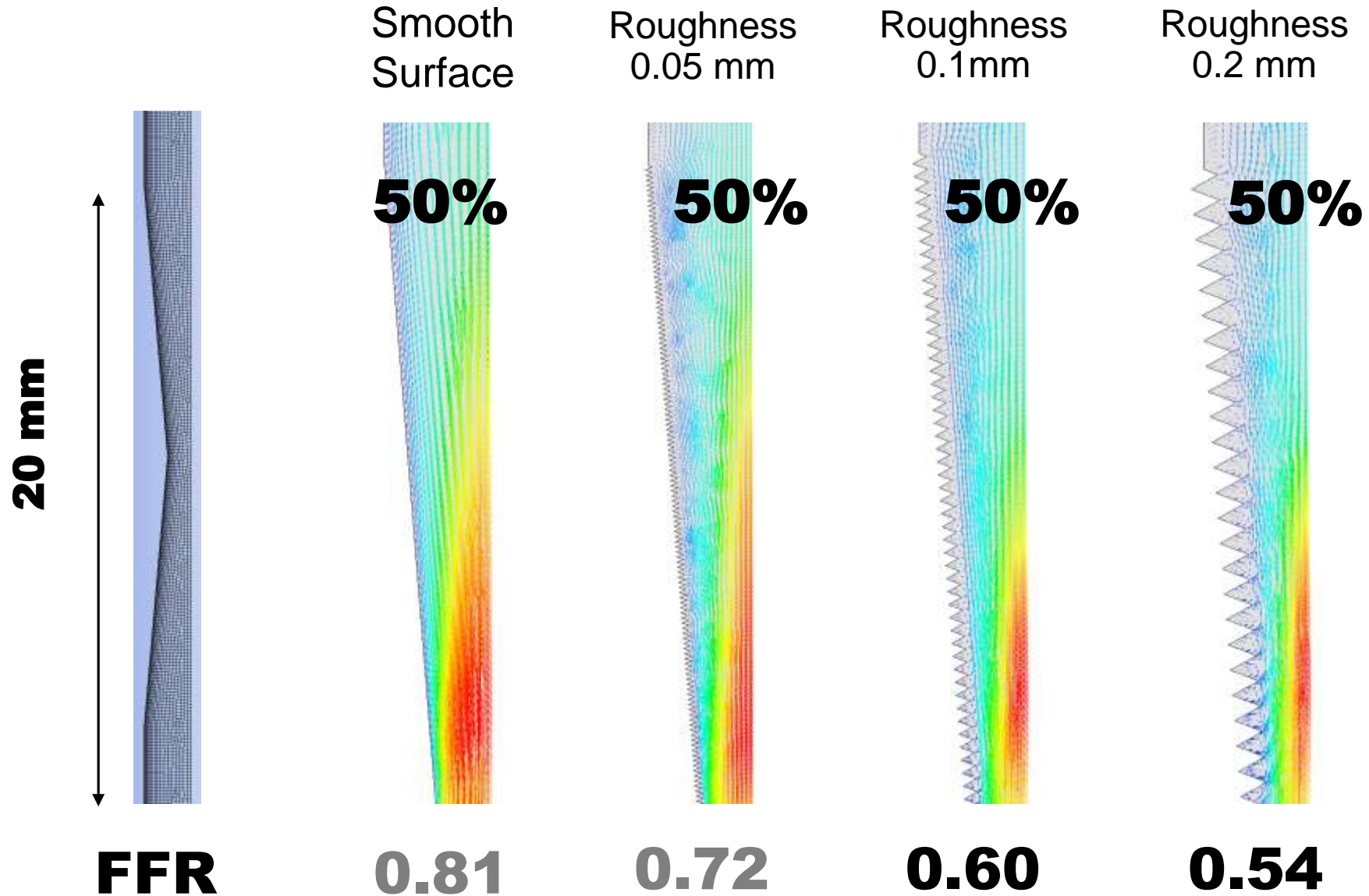


Different Pressure Drop ?

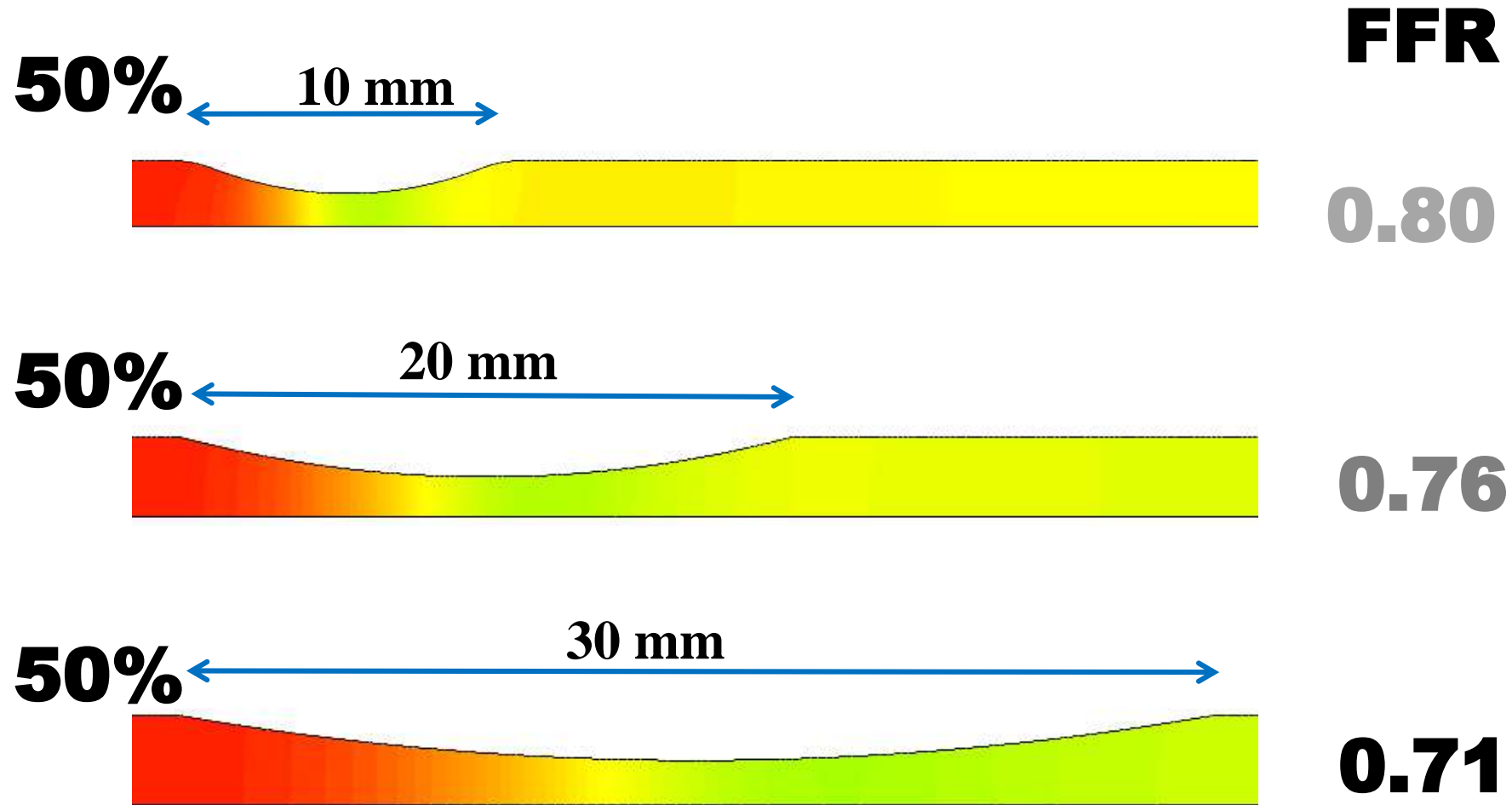
Different Lesion Morphology



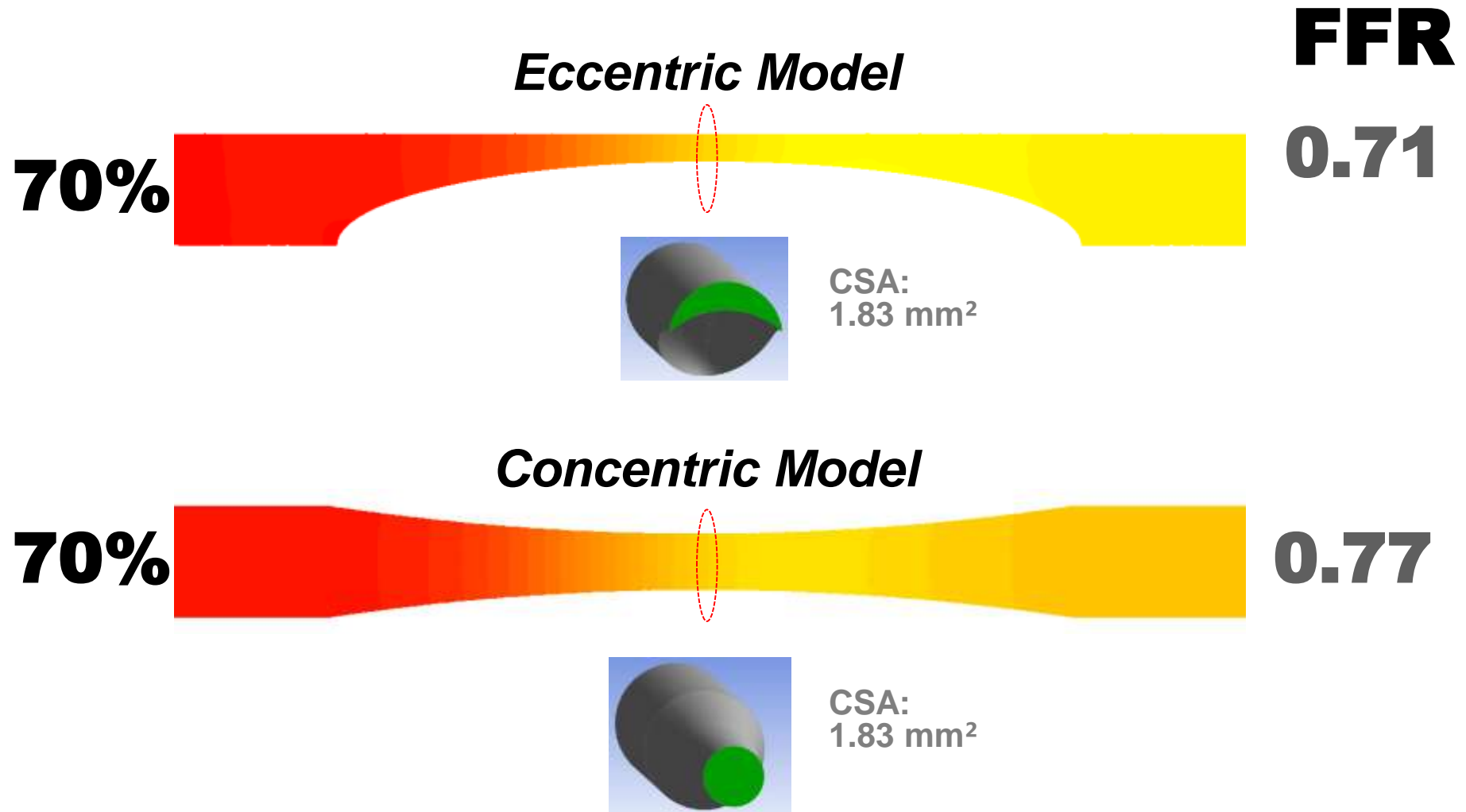
Different Surface Roughness



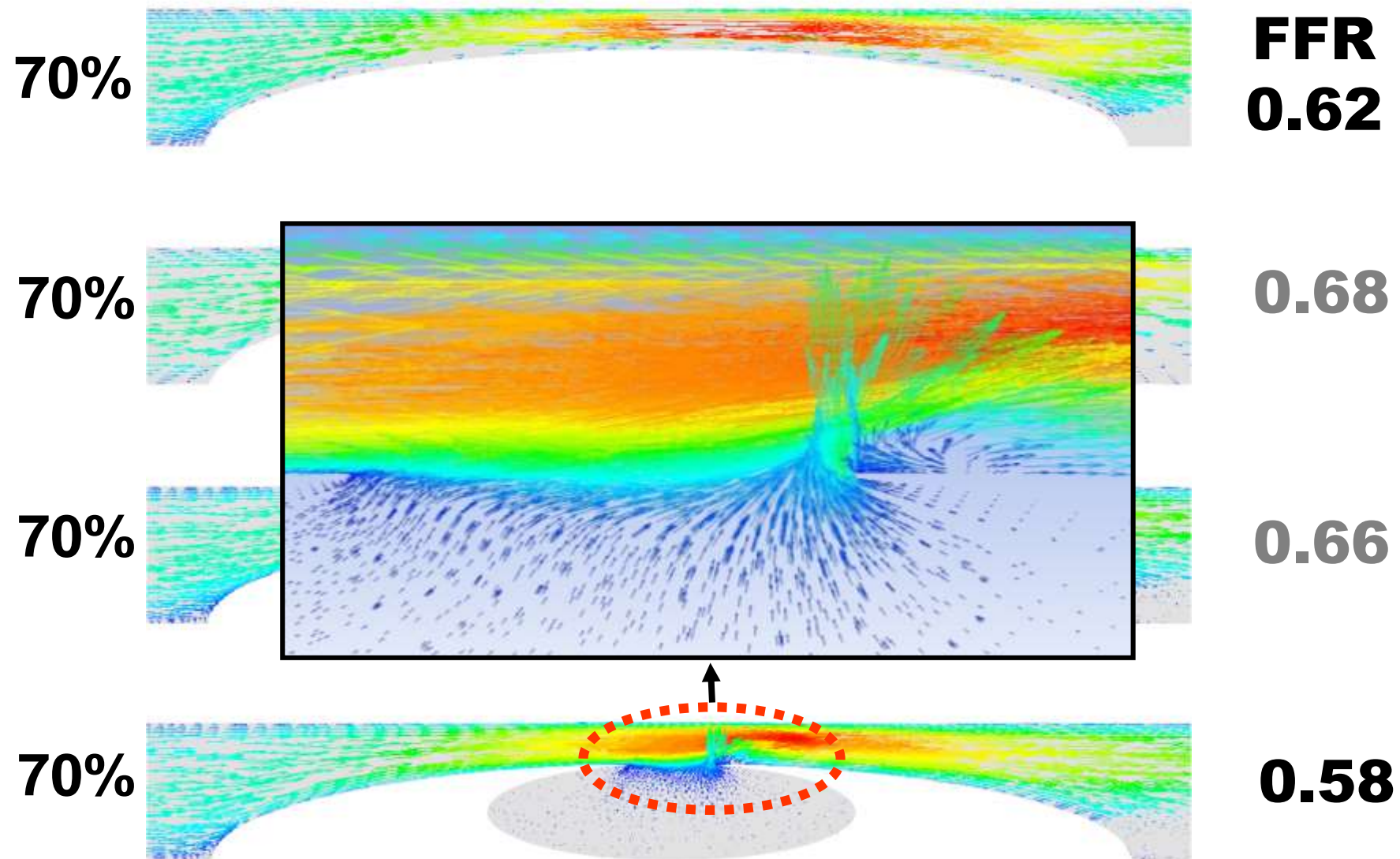
Different Lesion Length



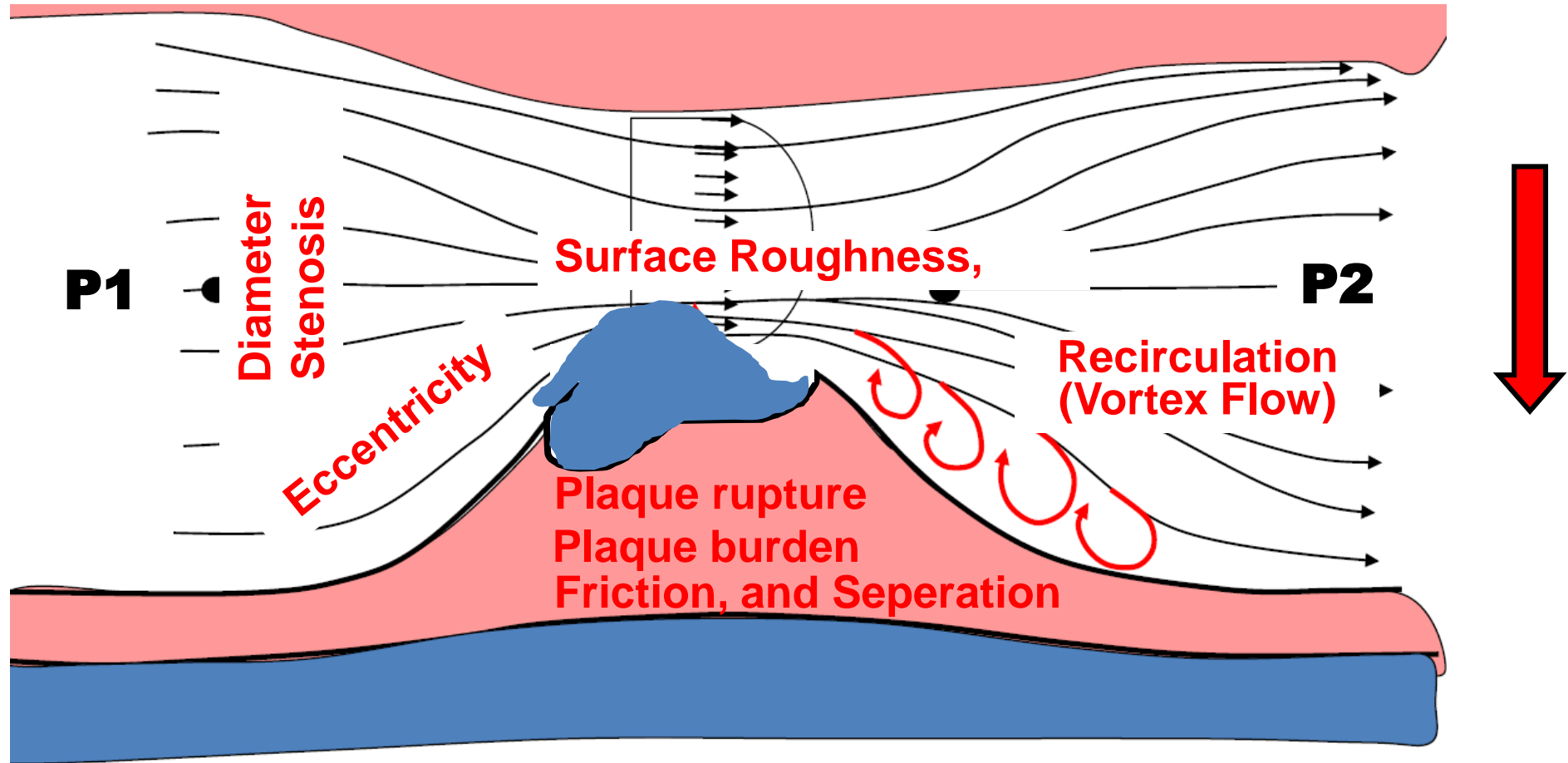
Lesion Eccentricity (cross-sectional)



Presence of Plaque Rupture



***Pressure Drop Due to
Various Lesion Specific Morphologies
Influenced FFR !***



FFR is Mainly Determined by,

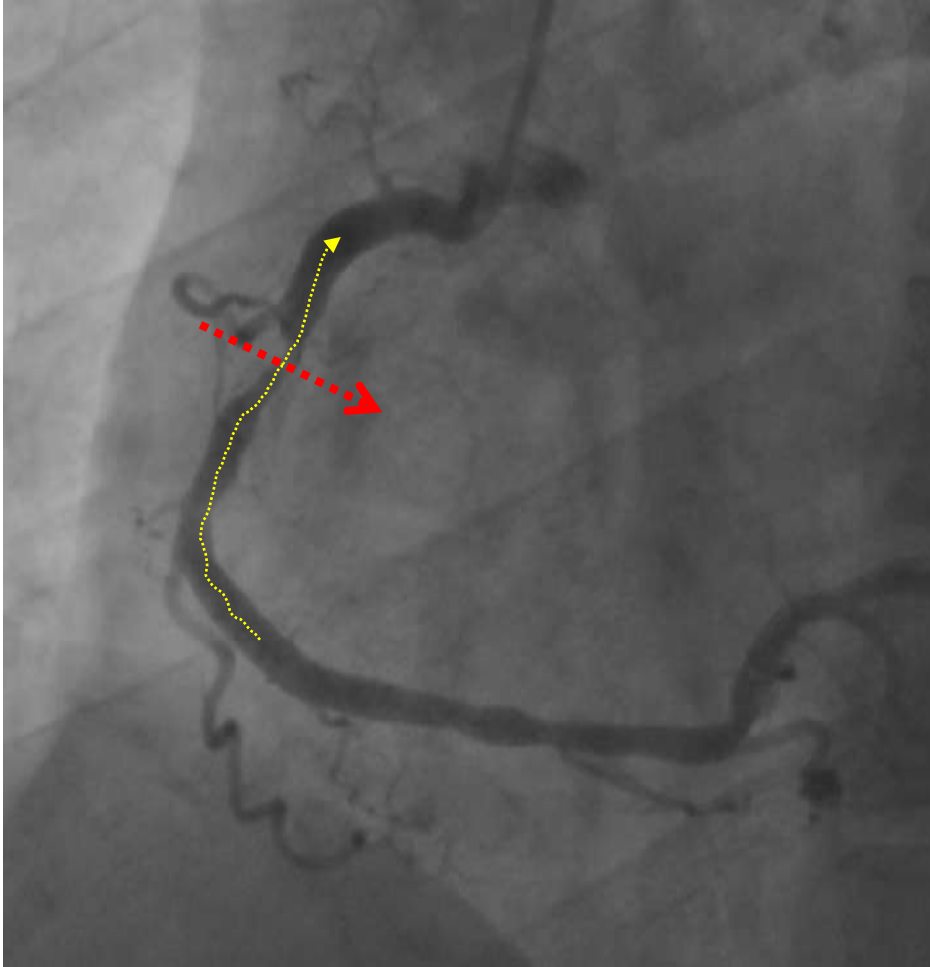
- 1. Degree of stenosis**
- 2. Size of myocardium**
- 3. Lesion specific morphologies**
*surface roughness,
lesion length,
eccentricity,
plaque rupture,
plaque burden,
viscous friction, flow separation,
turbulence and eddies.*

FFR Is,

***Total Lesion Perception ;
Summation of Physiologic and
Morphologic Integration of Stenosis.***

**FFR vs.
Angiographic %DS**

Totally Different One !



FFR Is,
Physiologic and Morphologic
Integration of Stenosis.
(Total Lesion Perception)

Angiographic % DS Is,
Single Cut, 2D Cross-Sectional
Image on Just Narrowest Part
of Lesion.

***Lesion Specific Morphologies
Can Influence the FFR !!
Real Data from AMC***

Multivariate Predictors For Mismatches

IRIS-FFR registry (n=1,000 Non-LM lesions)

Mismatch

Significant Stenosis (>50%)
Negative FFR (>0.80)

Older Age

Non-LAD location

Shorter lesion length

Larger MLA by IVUS

Larger MLD by QCA

Smaller PB

Reverse Mismatch

Insignificant Stenosis (<50%),
Positive FFR (<0.80)

Younger Age

LAD location

Plaque Rupture

Smaller MLA by IVUS

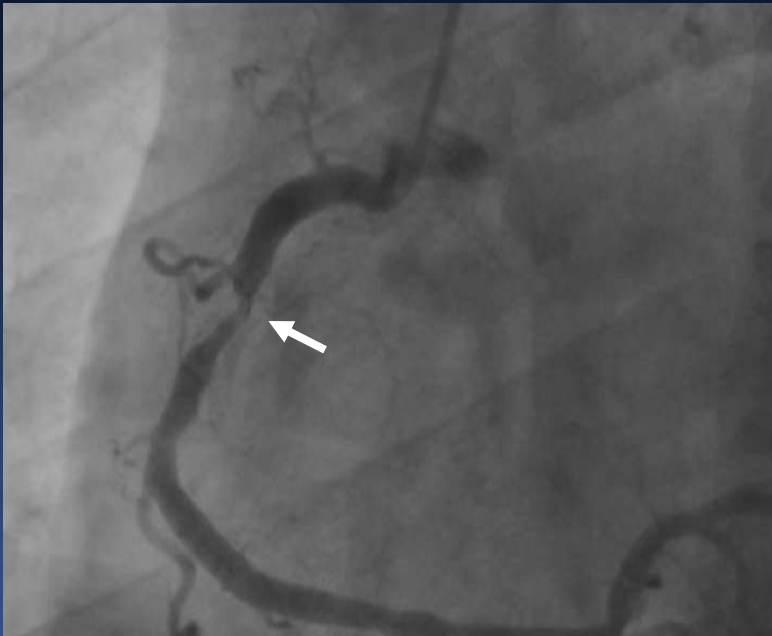
Larger PB

Mismatch

M/72,

Old Age

Recent developed effort chest pain, Hyperlipidemia, Smoker



85%

Negative FFR, 0.84

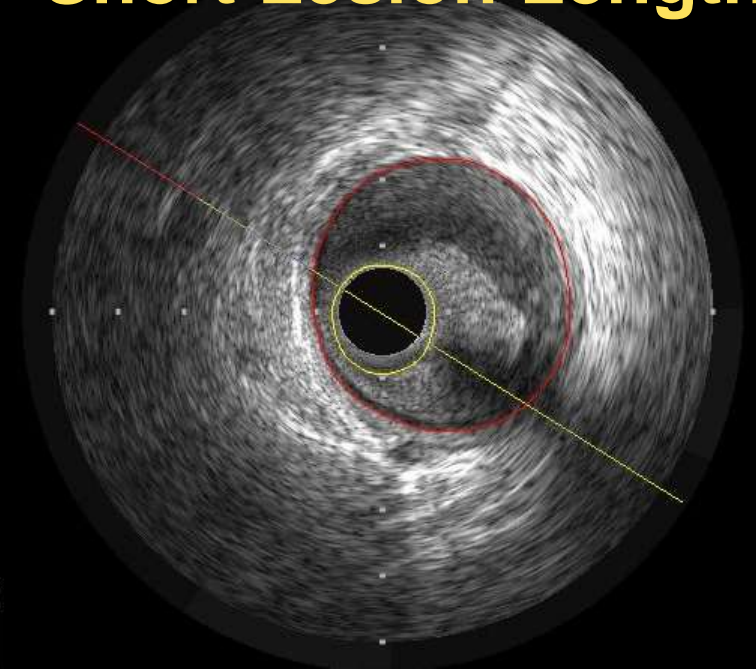
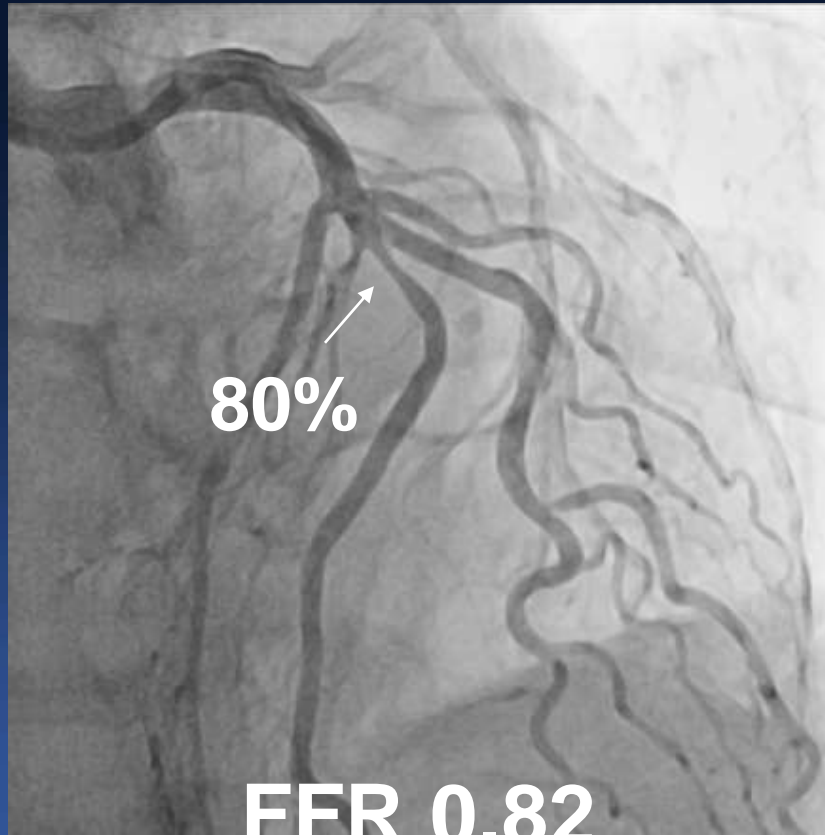
Non-LAD lesion
Discrete Narrowing

Mismatch

MLA 2.0 mm²

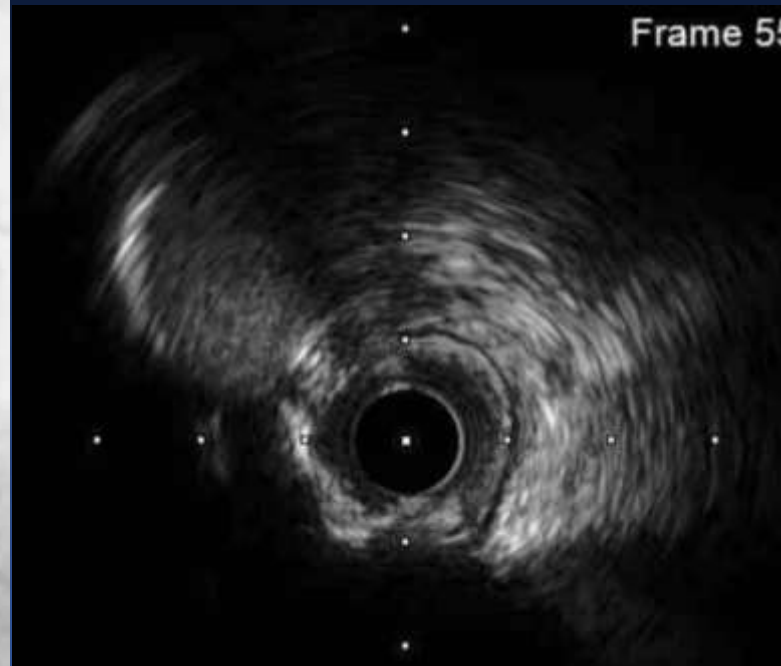
PB 84 %

Short Lesion Length



Mismatch

**Negative Remodeling
Short Lesion Length**

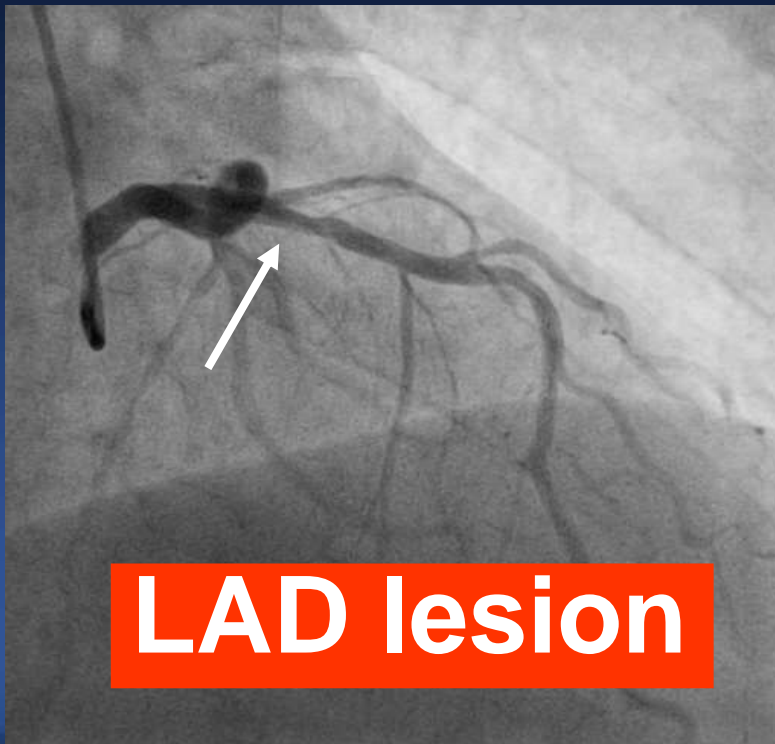


Reverse Mismatch

M/44,

Young Age

Intermittent resting chest pain, Hyperlipidemia, Smoker, Hypertension and Family history of CHD.

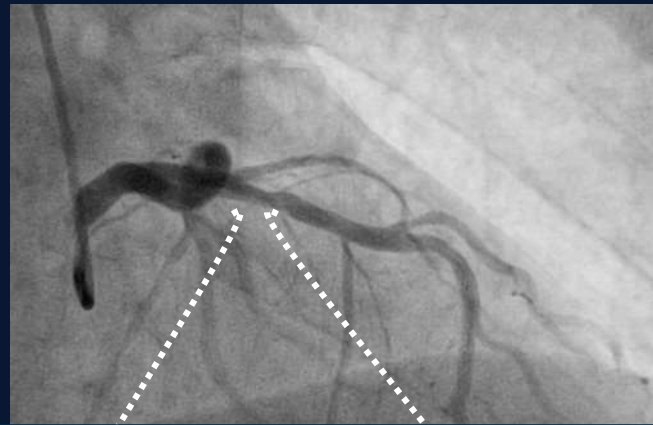


32%

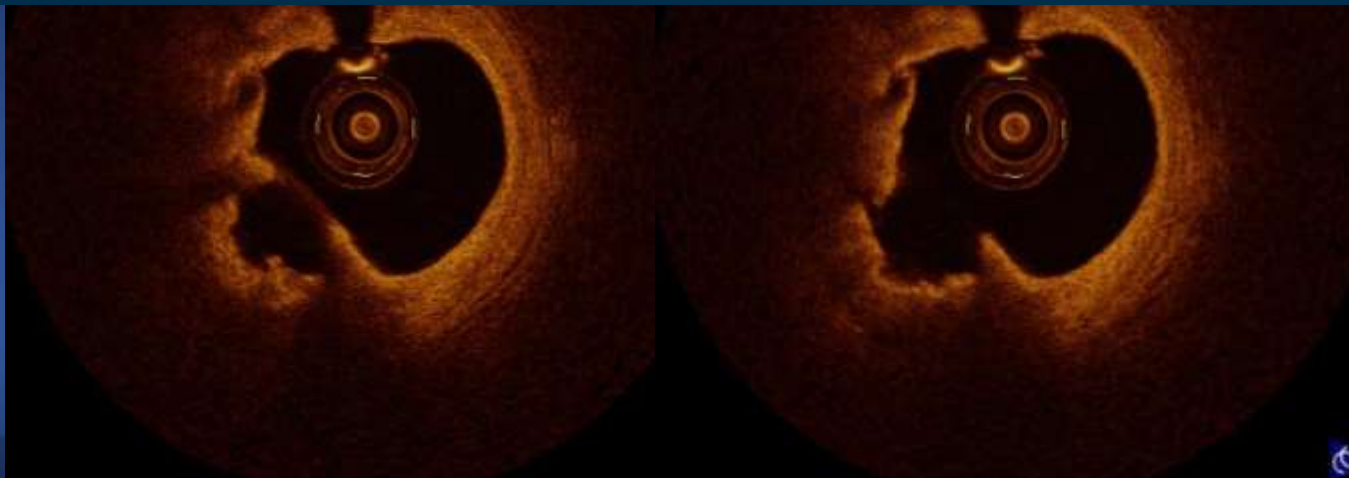
Positive FFR, 0.73

LAD lesion

**IVUS
Insight
for FFR 0.73**



***Don't Believe Your Eyes !
Angiography is Not Always Enough !***



FFR vs. Angiographic %DS

Current Guideline of FFR

Ia **ESC/EACTS**

IIa **ACCF/AHA/SCAI**

Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for CardioThoracic Surgery (EACTS); European Association for Percutaneous Cardiovascular Interventions (EAPCI), Wijns W et al. Guidelines on myocardial revascularization. Eur Heart J. 2010 Oct;31(20):2501-55. Levine GN, et al. 2011 ACCF/AHA/SCAI Guideline for PCI: Executive Summary. Circulation 2011;124:2574-2609

2018 ESC Guidelines for FFR

Recommendations	Class	Level
When evidence of ischemia is not available, FFR or iwFR are recommended to assess the hemodynamic relevance of intermediate-grade stenosis.	I	A
Revascularization of stenosis with FFR <0.80 is recommended in patients with angina symptoms or a positive stress test.	I	B
FFR-guided PCI should be considered in patients with multi-vessel disease undergoing PCI.	Ia	B
<i>Revascularization of an angiographically intermediate stenosis without related ischemia or without FFR <0.80 is not recommended.</i>	III	B

Rule 1

**In Any Lesion
With FFR < 0.80**

**Treat !
(Operator's discretion)**

Rule 2

**In Any Lesion
With FFR > 0.80**

**Don't Touch !
It's Safe !**