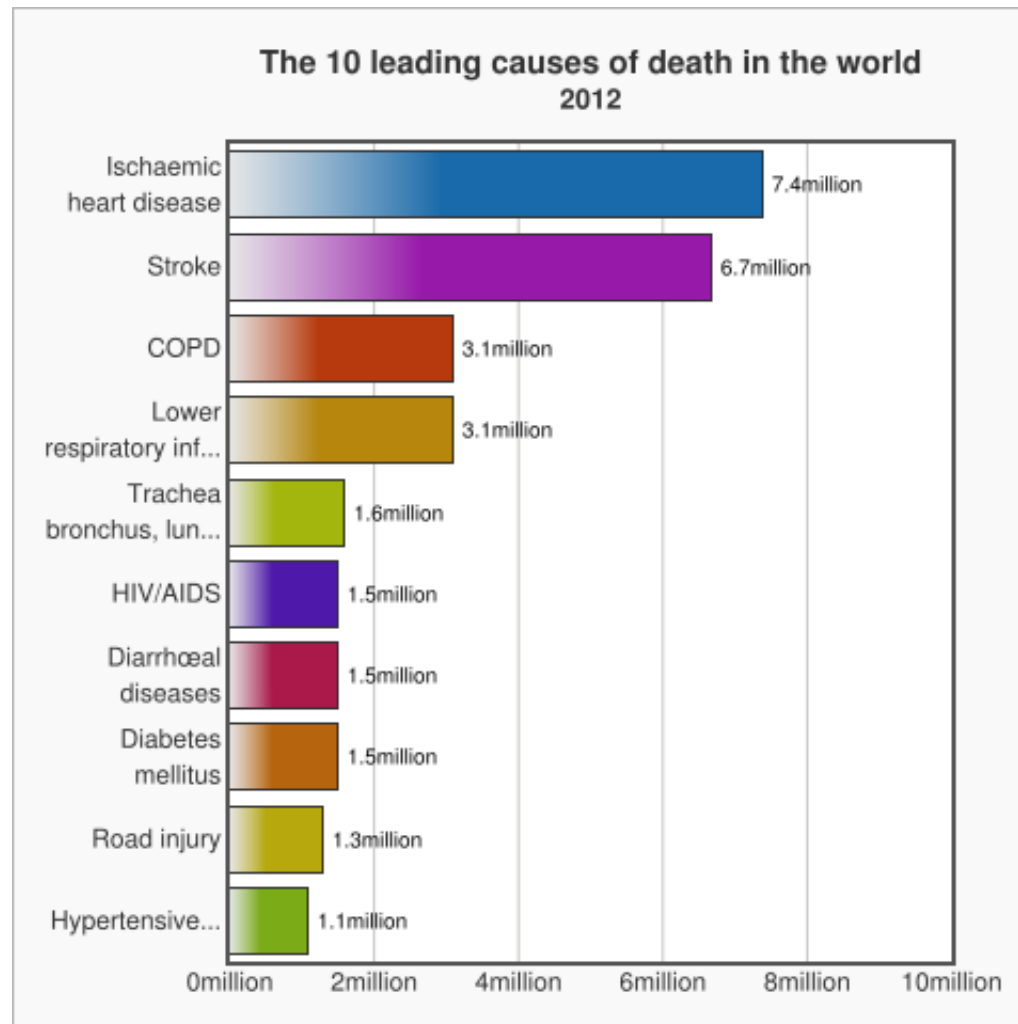


# ROLE OF PHYSIOLOGY AND IMAGING TO OPTIMISE CORONARY INTERVENTIONS

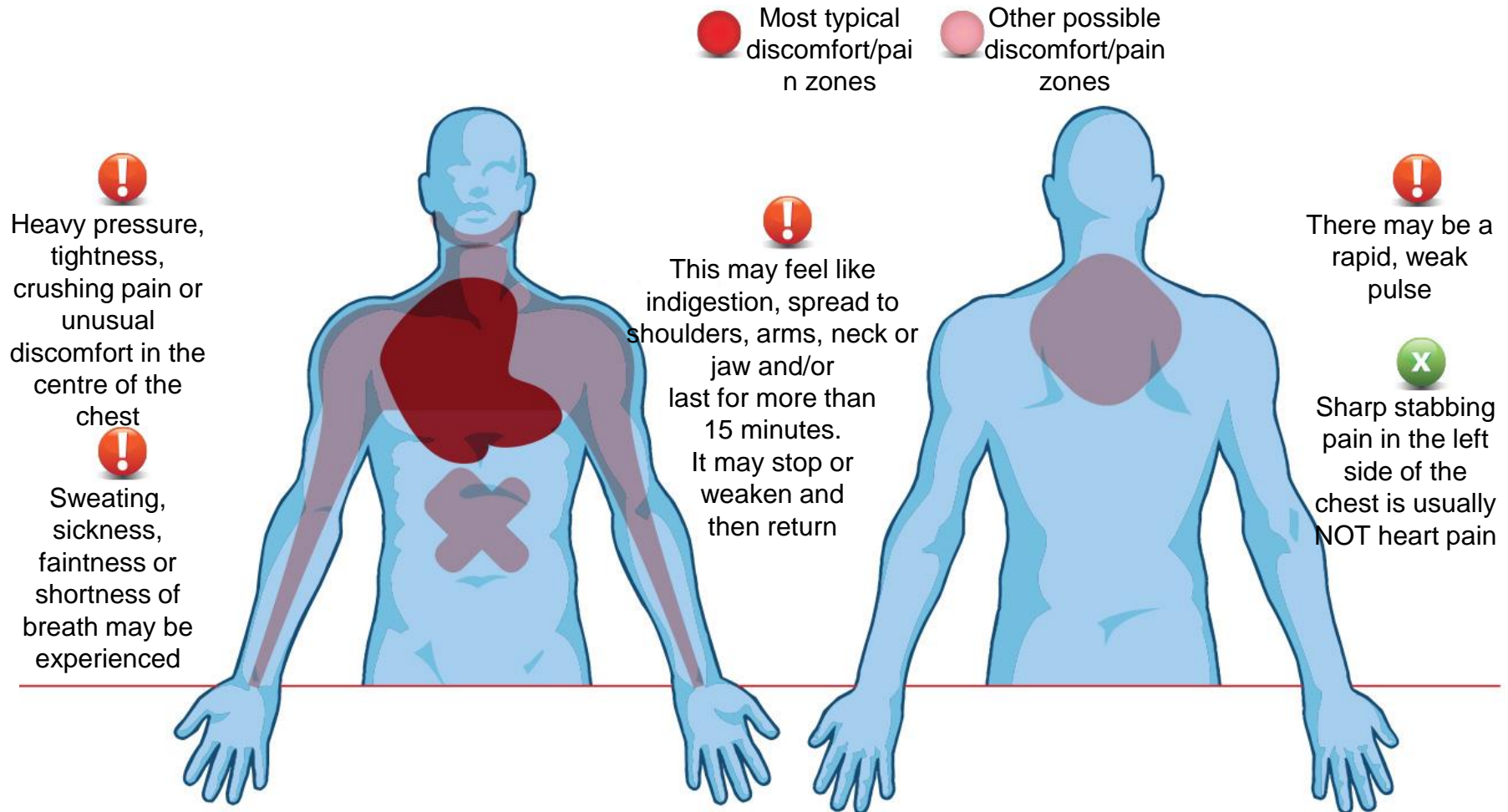
WEDNESDAY 23 JANUARY 2019

DR. ANIFF YEAROO  
INTERVENTIONAL CARDIOLOGIST

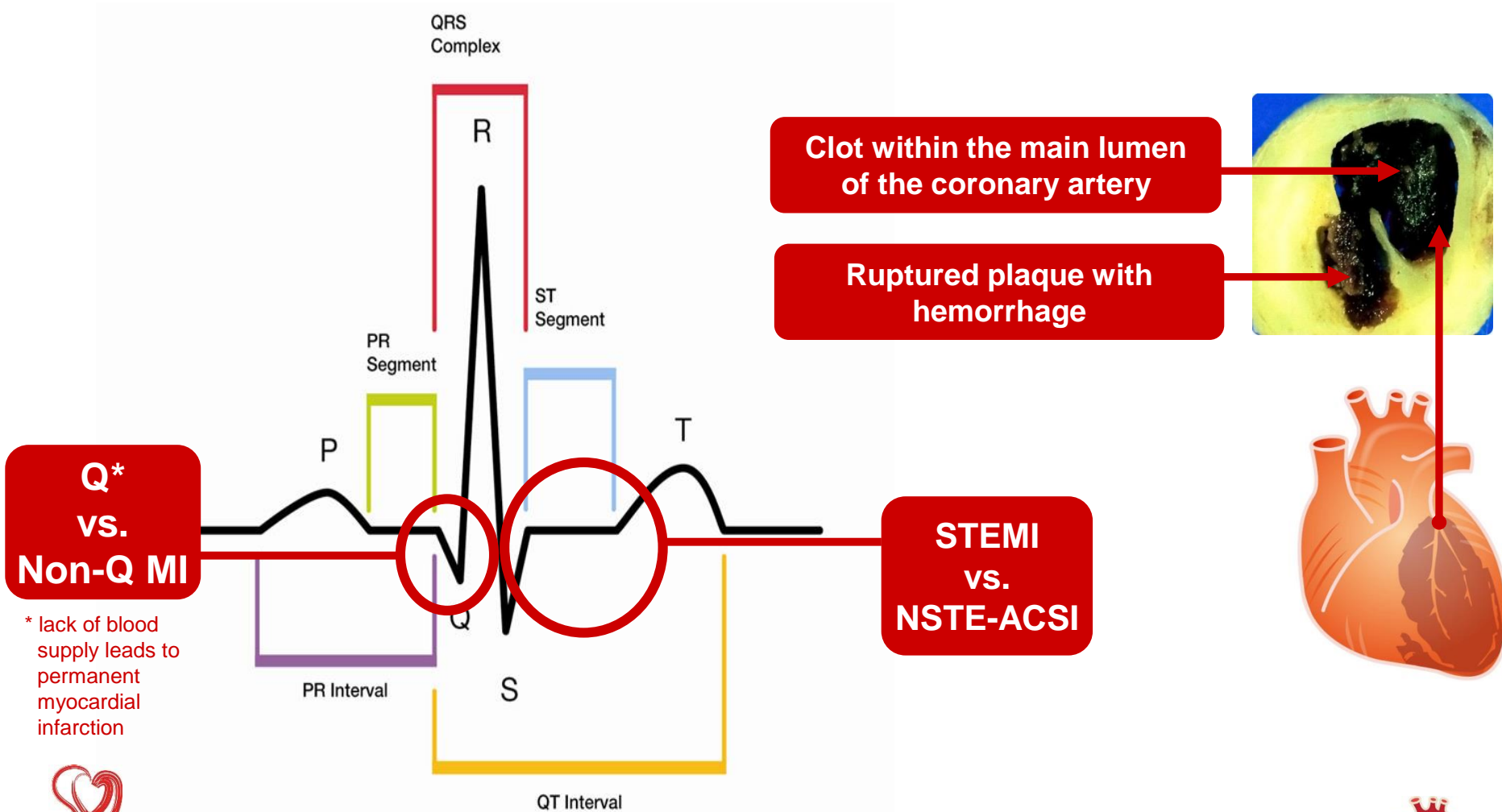
# IHD leading cause of death globally



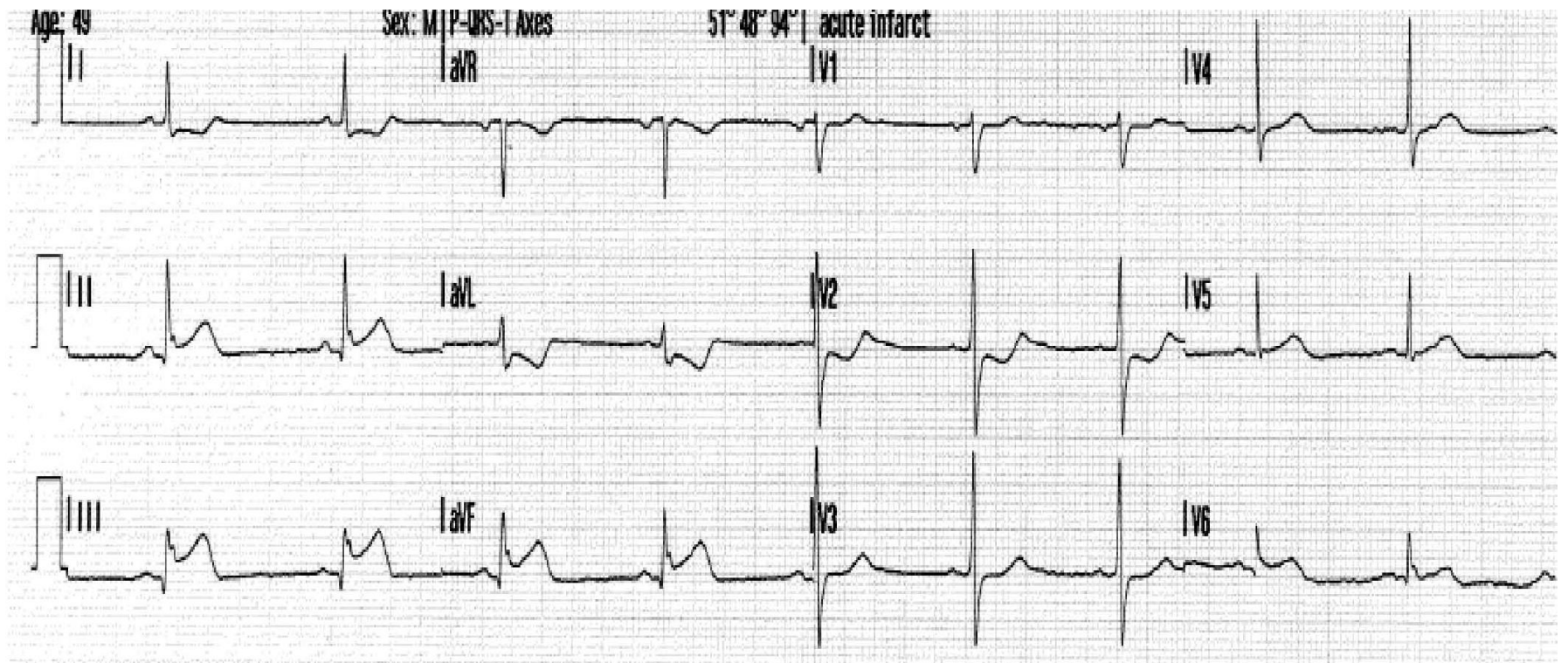
# Symptoms of a heart attack



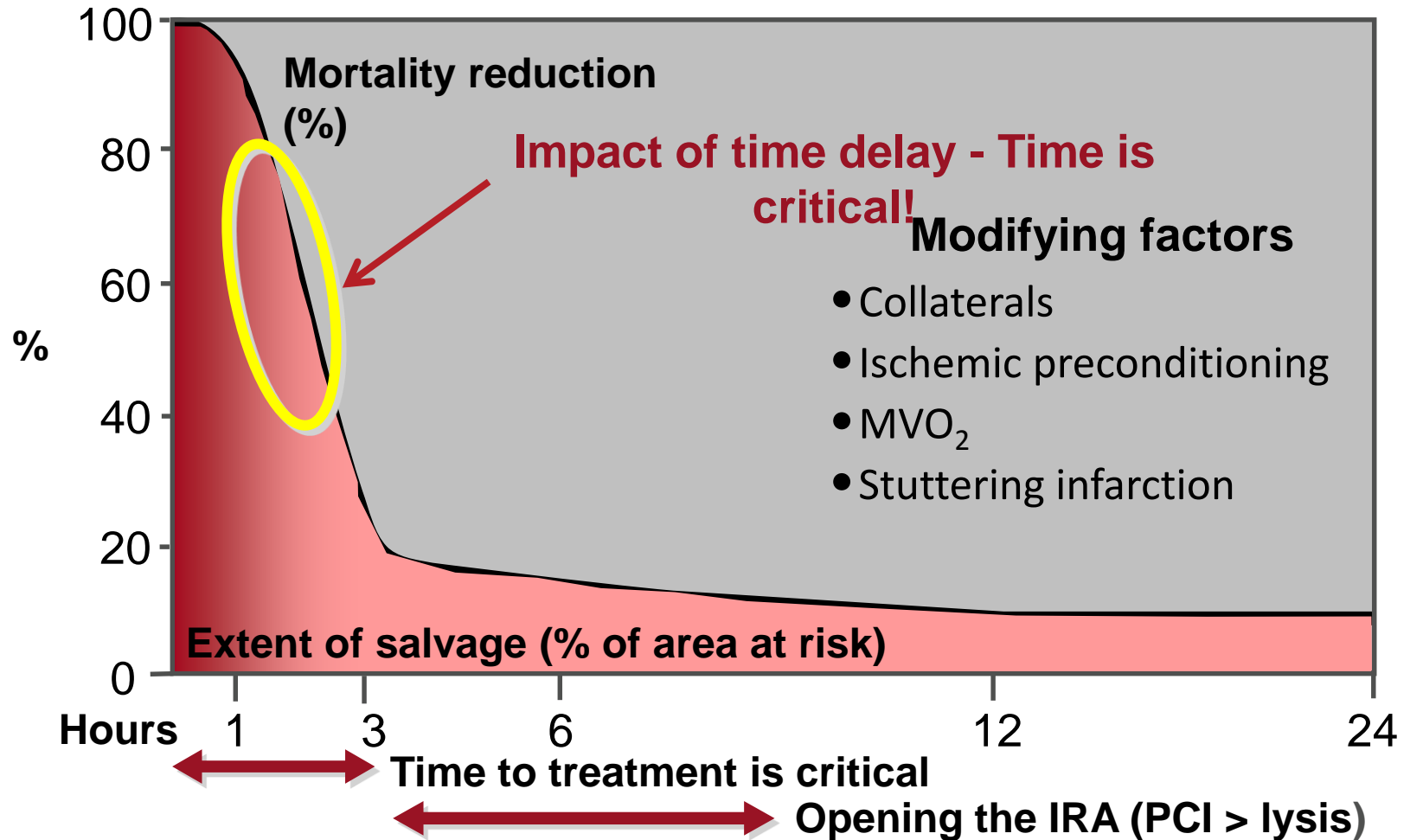
# STEMI: ECG Diagnosis



# STEMI ECG

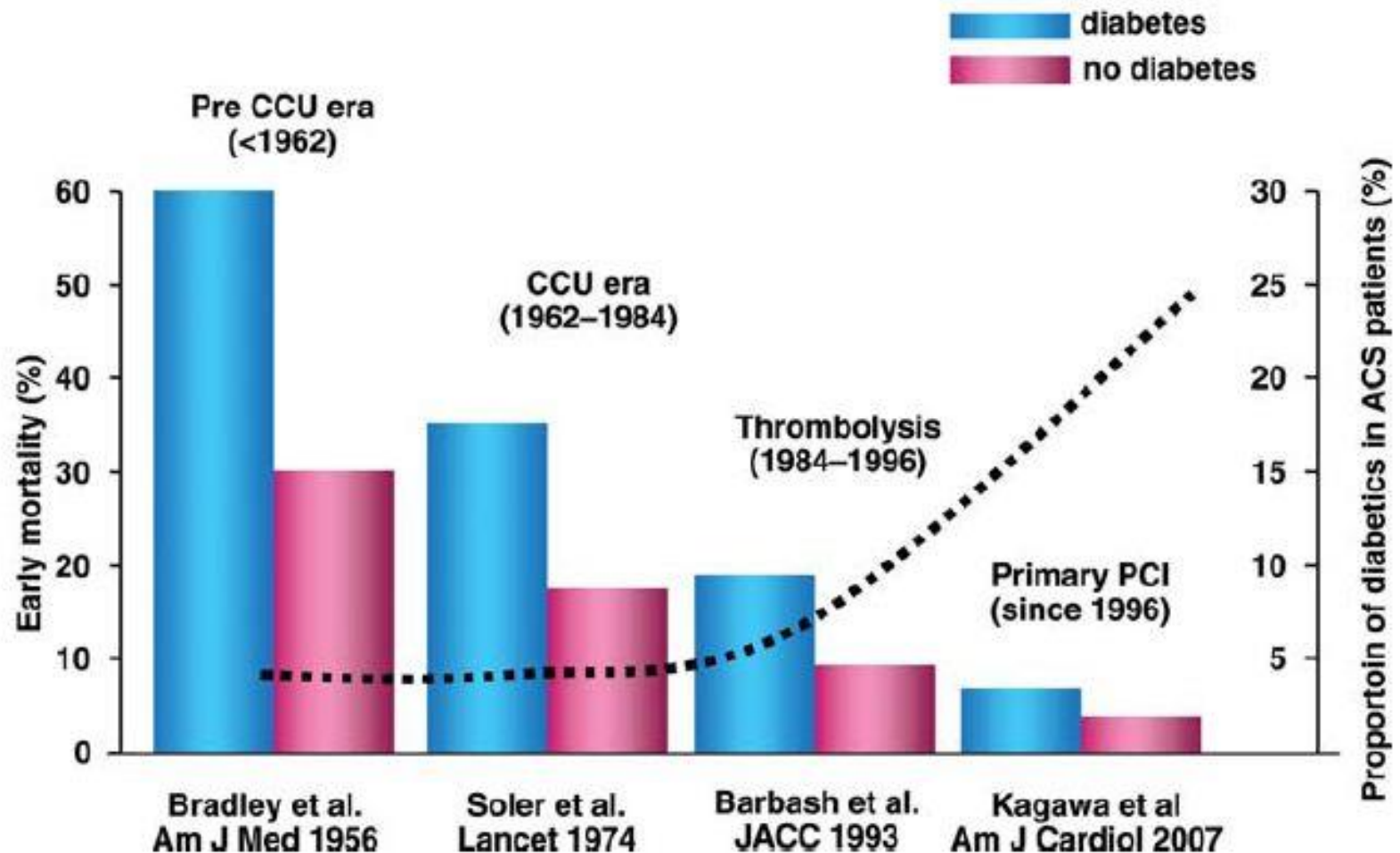


# Relationship Between Mortality Reduction and Extent of Salvage



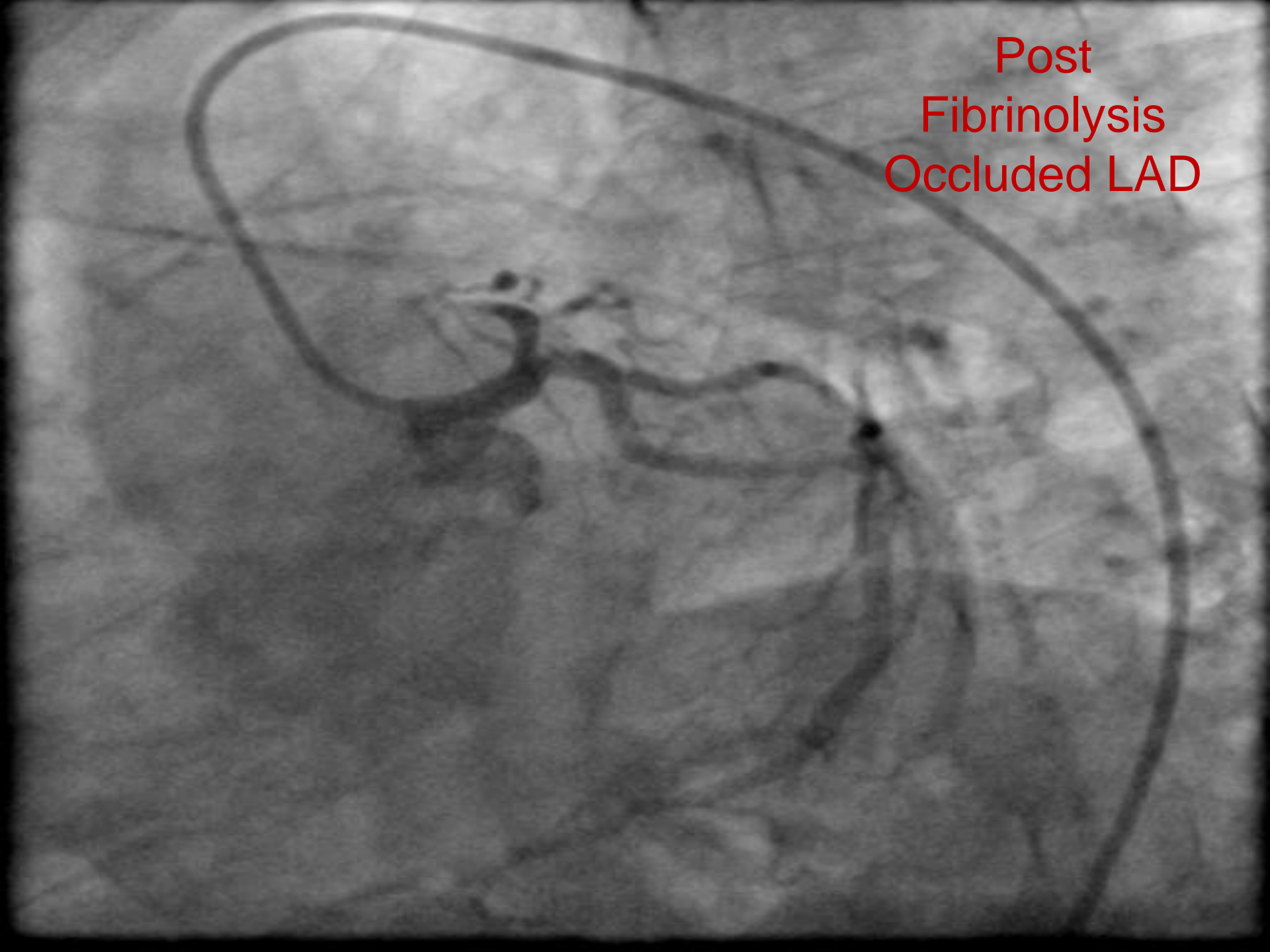
# Reperfusion has changed the management of STEMI

Early mortality of diabetic and non-diabetic patients with acute myocardial infarction: Historical perspective





Post  
Fibrinolysis  
Occluded LAD



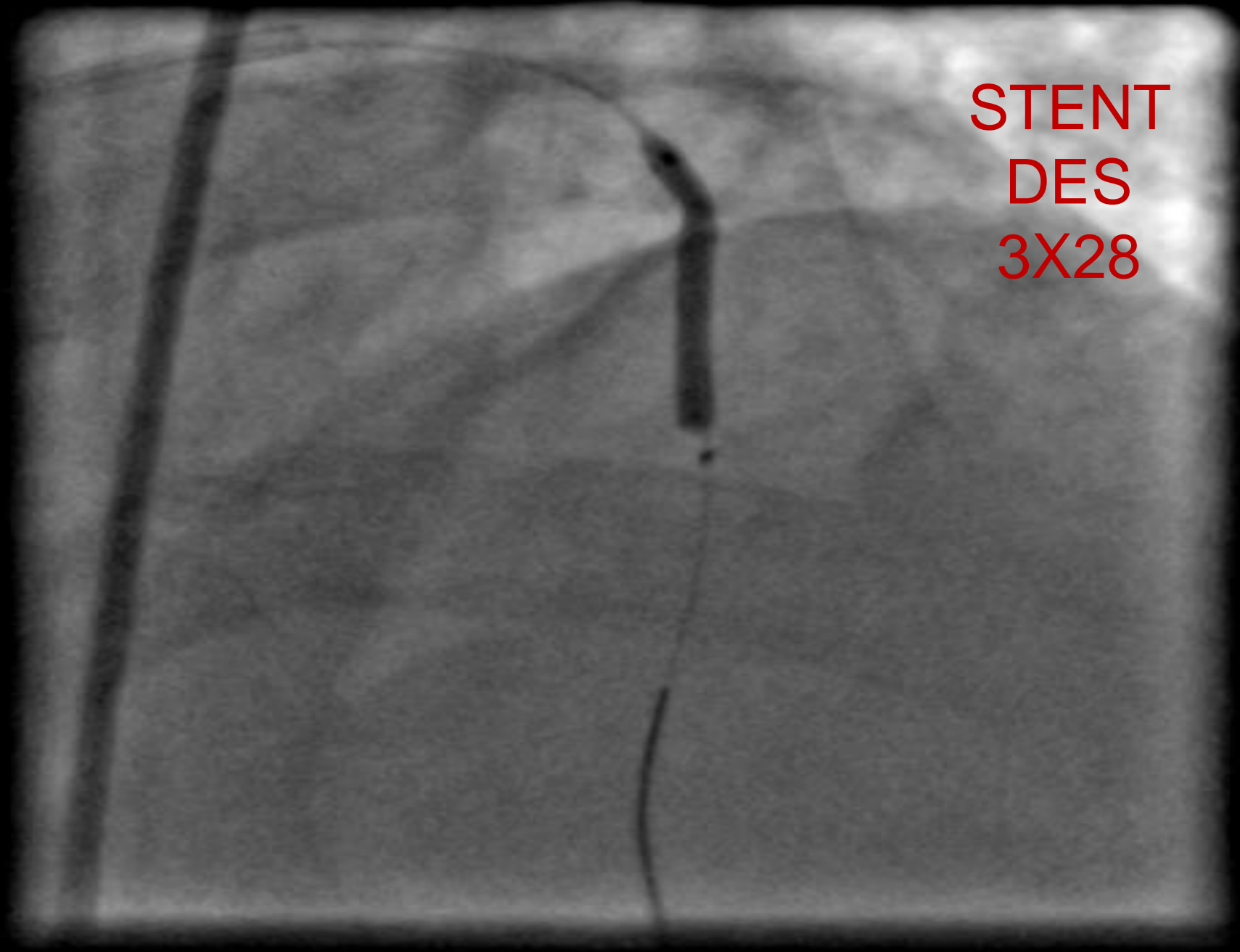




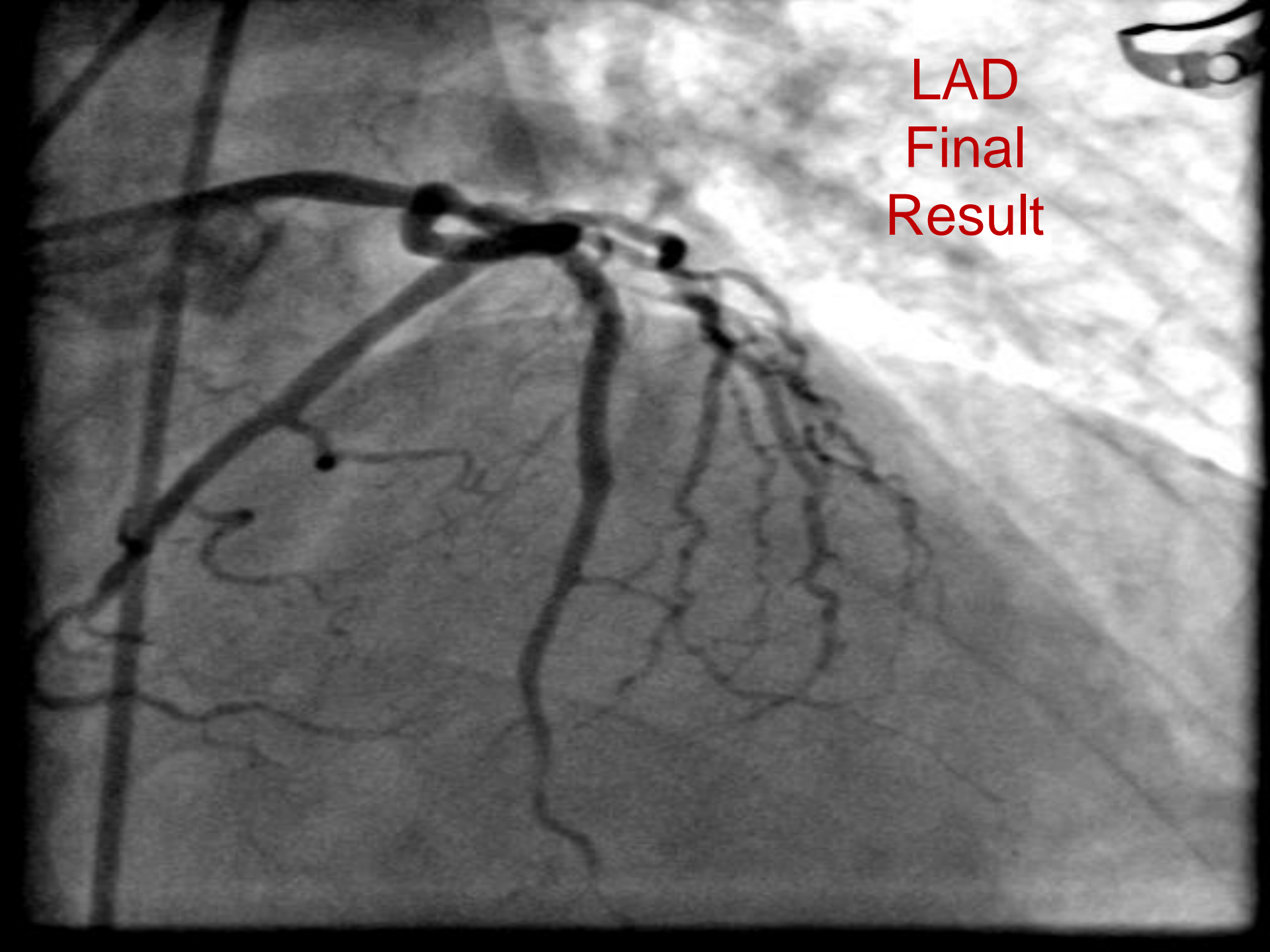
LAD II  
100%

This is a catheter angiogram of the Left Anterior Descending Artery (LAD II). The image shows a significant stenosis (narrowing) of the artery, indicated by the red text 'LAD II 100%'. The stenosis is located in the proximal portion of the artery, where it branches into several smaller vessels. The background is a grayscale image of the coronary artery system, with the LAD II being the most prominent vessel.

STENT  
DES  
3X28



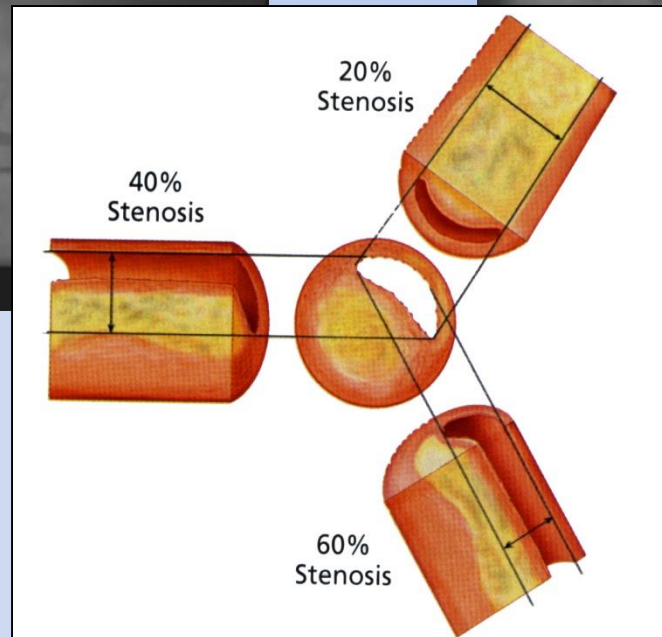
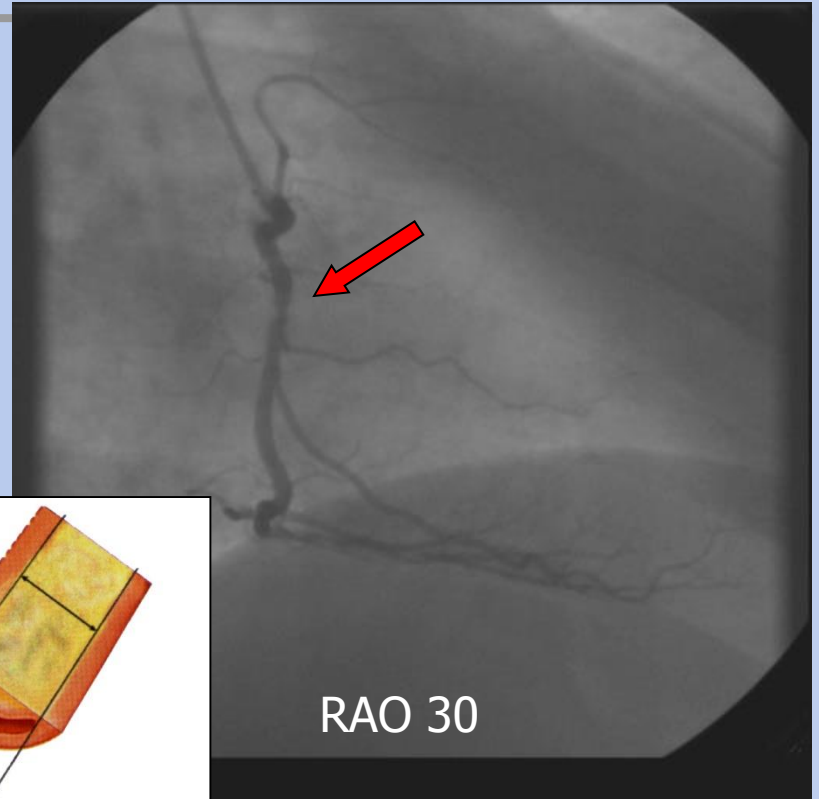
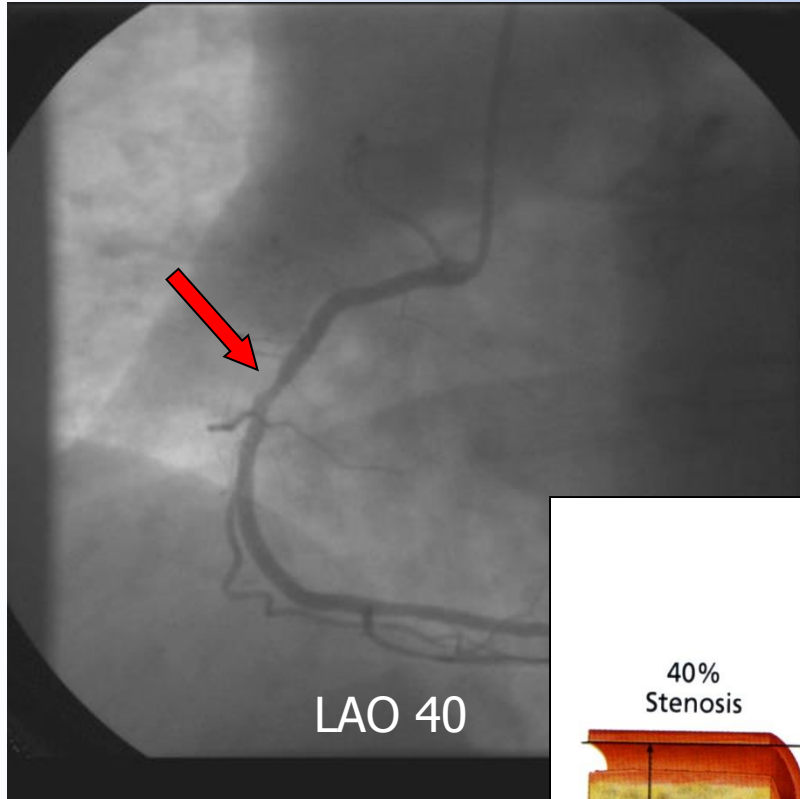
LAD  
Final  
Result



**ANGIOGRAPHY ALONE IS  
NOT ENOUGH IN DIFFUSE  
AND MULTIPLE VESSEL  
DISEASE**

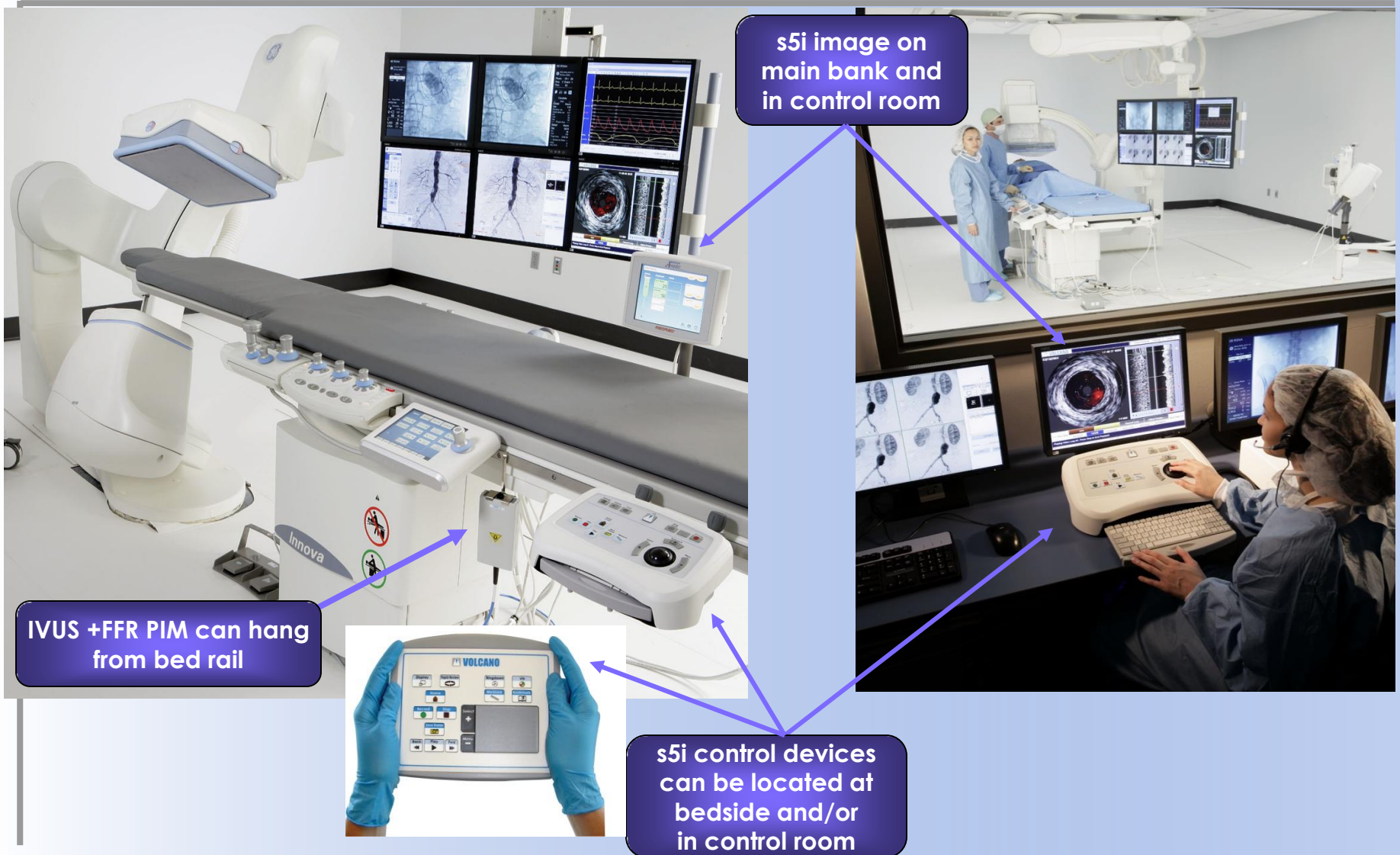
**INDICATION OF IVUS, OCT  
AND FFR**

# RCA Angiogram





# IVUS – Intravascular Ultrasound





# The Value of IVUS, OCT & FFR

## Five questions in the cath lab...

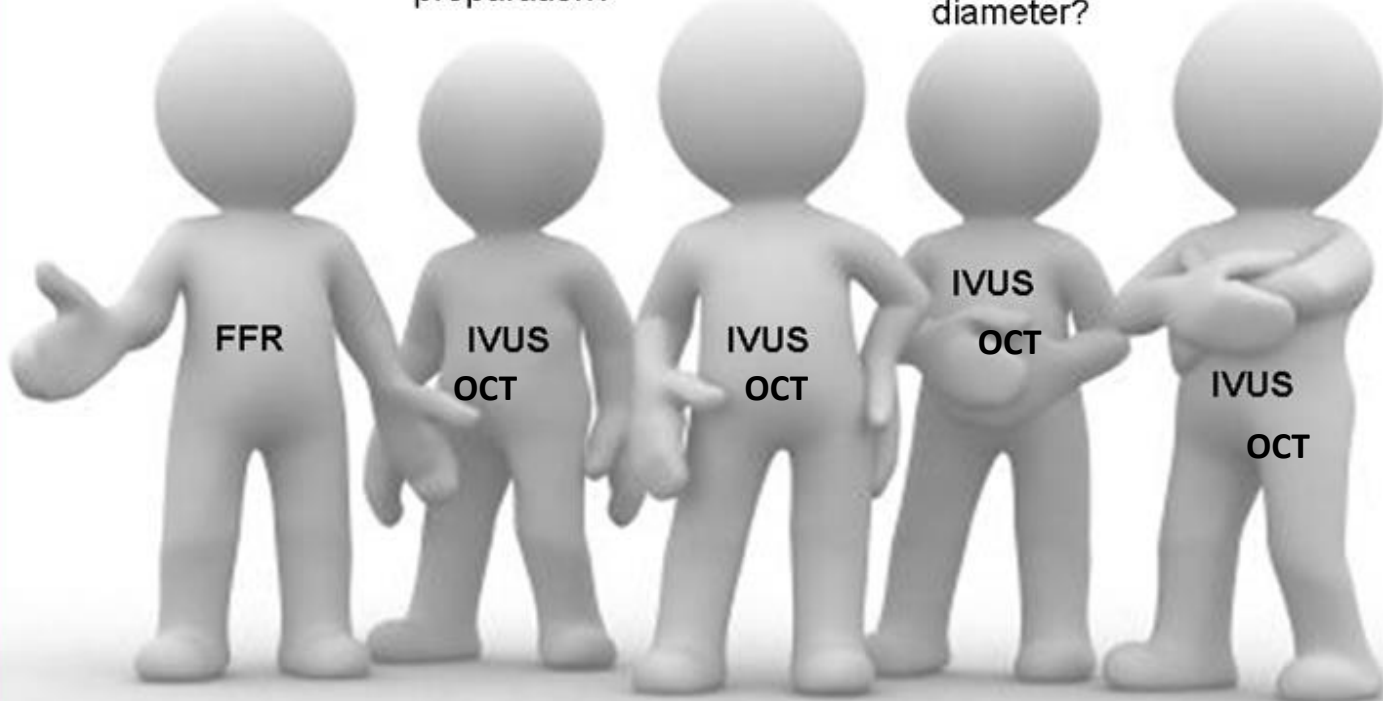
The right lesion?

Lesion preparation?

Which stent length?

Which stent diameter?

Need to optimise stent result?



# Fractional Flow Reserve



# Pressure-sensored guidewires

0.014" – PCI-capable

30 mm radiopaque tip

Sensor located at the junction of radiopaque/non-radiopaque portions

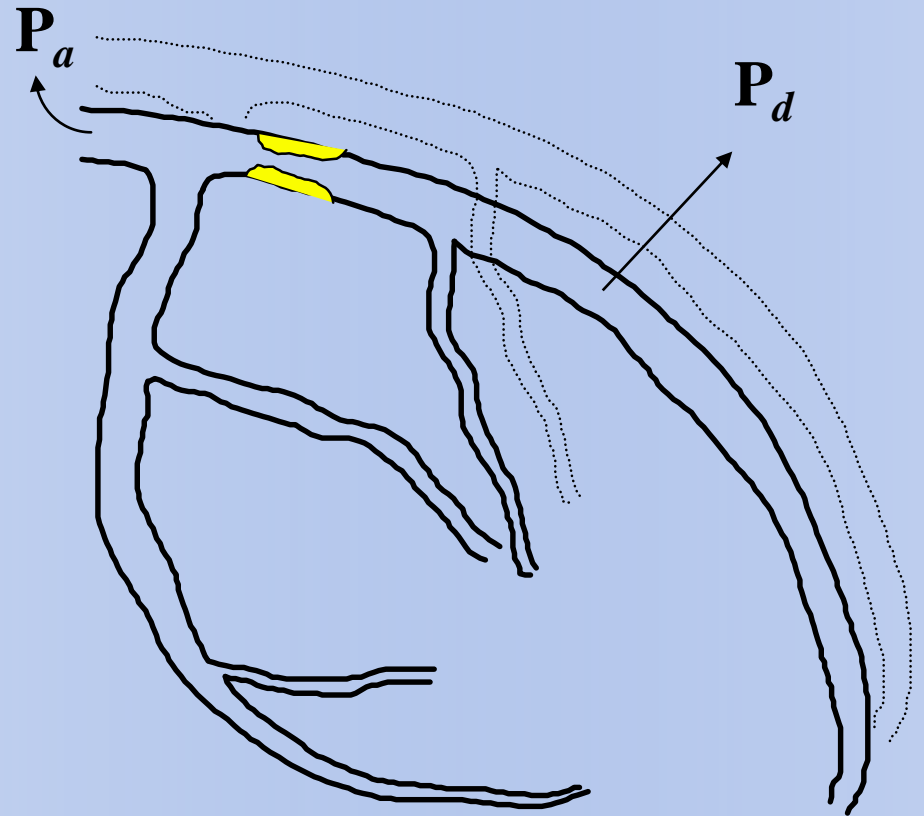


# What is Fractional Flow Reserve (FFR) ?

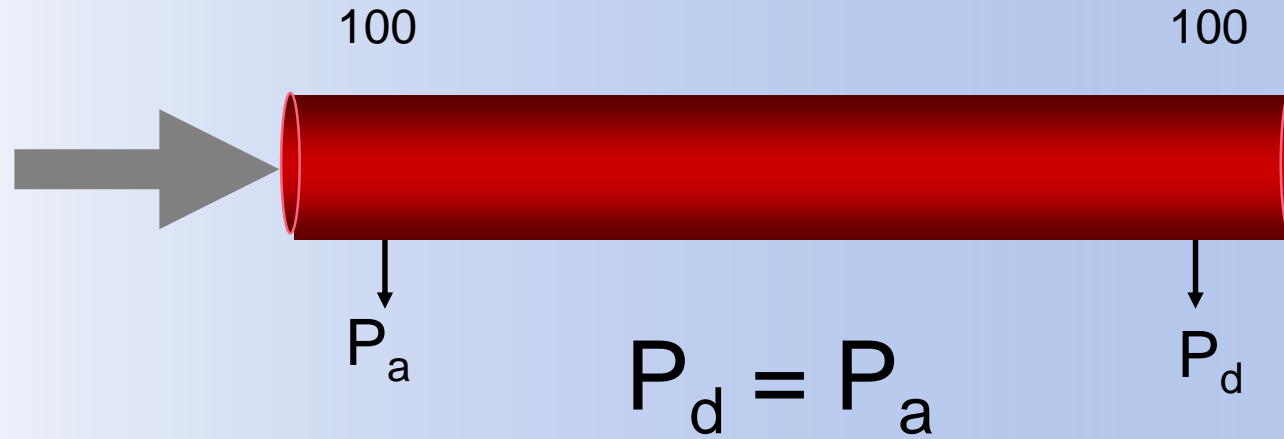
$$FFR = P_d / P_a$$

Ratio of distal mean coronary pressure to mean aortic pressure in the stenotic vessel during maximum hyperemia

Represents the fraction of blood flow preserved despite the stenosis

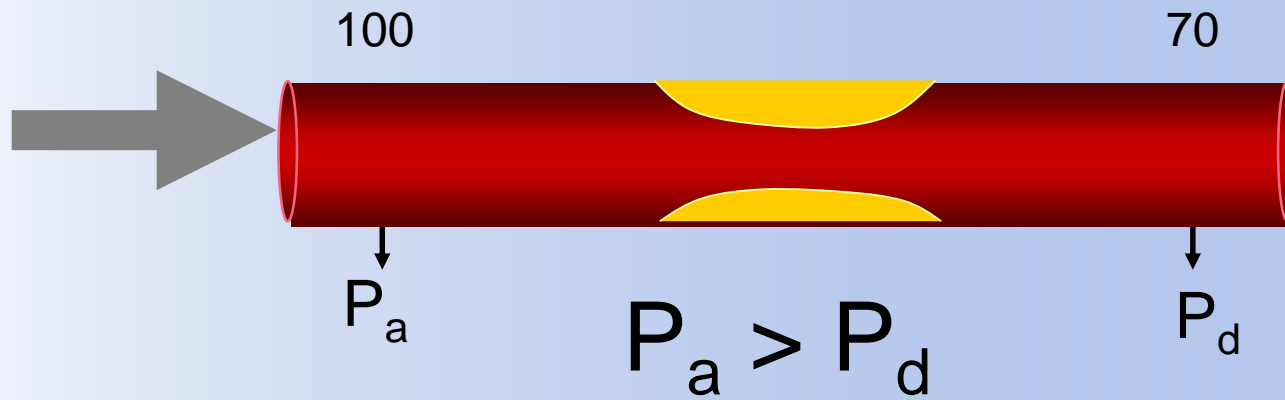


# Normal FFR = 1.0



$$FFR_{\text{myo}} = \frac{P_d}{P_a} = 1$$

## FFR in the presence of a stenosis



$$FFR_{\text{myo}} = \frac{P_d}{P_a} < 1$$



# The updated ESC guidelines classified FFR as IA for the detection of ischemic lesions!

**Table 33** Recommendations for specific percutaneous coronary intervention devices and pharmacotherapy

	Class <sup>a</sup>	Level <sup>b</sup>	Refs <sup>c</sup>
FFR-guided PCI is recommended for detection of ischaemia-related lesion(s) when objective evidence of vessel-related ischaemia is not available.	I	A	15, 28
DES <sup>d</sup> are recommended for reduction of restenosis/re-occlusion, if no contraindication to extended DAPT.	I	A	45, 46, 55, 215
Distal embolic protection is recommended during PCI of SVG disease to avoid distal embolization of debris and prevent MI.	I	B	171, 213
Rotablation is recommended for preparation of heavily calcified or severely fibrotic lesions that cannot be crossed by a balloon or adequately dilated before planned stenting.	I	C	—
Manual catheter thrombus aspiration should be considered during PCI of the culprit lesion in STEMI.	IIa	A	204–208
For PCI of unstable lesions, i.v. abciximab should be considered for pharmacological treatment of no-reflow.	IIa	B	55, 209, 212
Drug-eluting balloons <sup>d</sup> should be considered for the treatment of in-stent restenosis after prior BMS.	IIa	B	174, 175
Proximal embolic protection may be considered for preparation before PCI of SVG disease.	IIb	B	214
For PCI of unstable lesions, intracoronary or i.v. adenosine may be considered for pharmacological treatment of no-reflow.	IIb	B	209
Tornus catheter may be used for preparation of heavily calcified or severely fibrotic lesions that cannot be crossed by a balloon or adequately dilated before planned stenting.	IIb	C	—
Cutting or scoring balloons may be considered for dilatation of in-stent restenosis, to avoid slipping-induced vessel trauma of adjacent segments.	IIb	C	—
IVUS-guided stent implantation may be considered for unprotected left main PCI.	IIb	C	—
Mesh-based protection may be considered for PCI of highly thrombotic or SVG lesions.	IIb	C	—
For PCI of unstable lesions, intracoronary nitroprusside or other vasodilators may be considered for pharmacological treatment of no-reflow.	IIb	C	—

<sup>a</sup>Class of recommendation.

<sup>b</sup>Level of evidence.

<sup>c</sup>References.

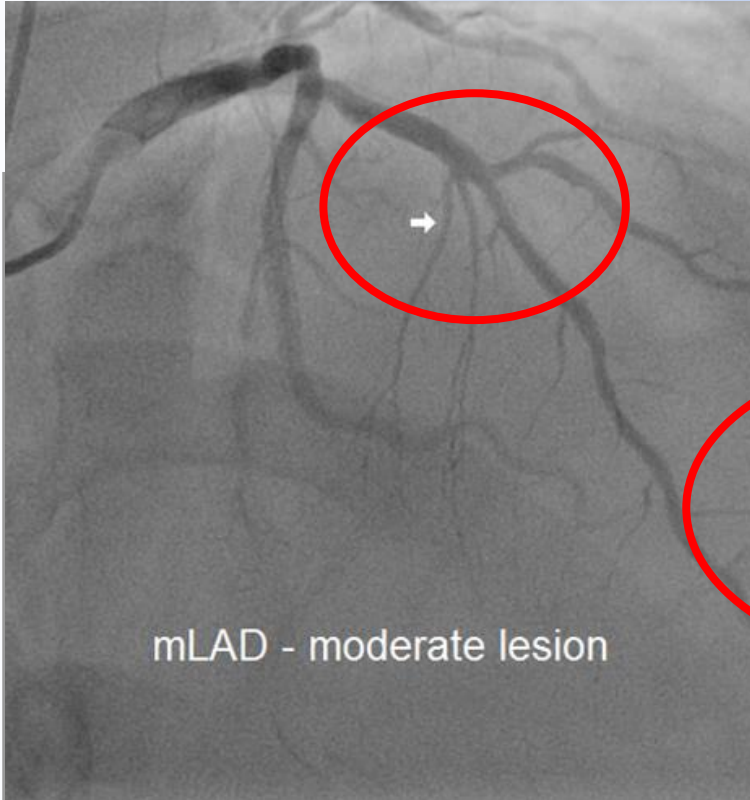
<sup>d</sup>Recommendation is only valid for specific devices with proven efficacy/safety profile, according to the respective lesion characteristics of the studies.

DAPT = dual antiplatelet therapy; DES = drug-eluting stent; FFR = fractional flow reserve; IVUS = intravascular ultrasound; MI = myocardial infarction; PCI = percutaneous coronary intervention; STEMI = ST-segment elevation myocardial infarction; SVG = saphenous vein graft.

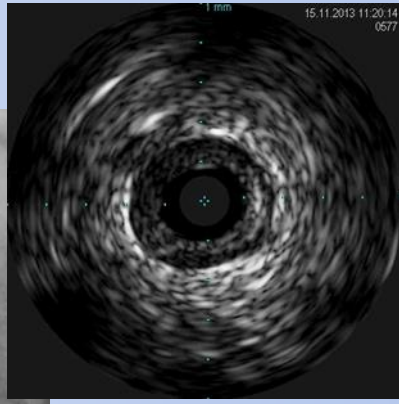
# What is i- FR ?

- "The instant wave-Free Ratio (iFR) is calculated during a period in the cardiac cycle when intra-coronary resistance is **naturally constant and minimized**, similar to what is achieved during hyperemia with vasodilators such as adenosine over the entire cardiac cycle --the 'wave-free period,' as forward- and backward-traveling wave activity has ceased
- iFR was developed by physician-scientists at Imperial College London in partnership with Volcano Corporation.  
PI : Dr. Justin E. Davies

- $> 0.93$  : **NOT** functionally significant
- $0.86 - 0.93$  : GREY Zone – Need FFR with Maximal hyperemia
- $< 0.86$  : Functionally severe lesions



mLAD - moderate lesion



***i-FR***  
Min CSA 3.5 mm sq

**NO MAXIMAL  
HYPEREMIA**

0:05  
**iFR™**  
**0.99**

Time	FFR
11:31:53 AM	0.93
11:32:08 AM	0.93
11:32:22 AM	0.93
LAD Distal	
11:33:04 AM	0.85
LAD Distal	
11:42:25 AM	0.99



Live

Options

Save Frame

# Hybrid iFR<sup>®</sup>/FFR Approach

94.0% match to FFR<sup>1</sup>

65.1% of patients may be free of hyperemic agents<sup>2</sup>



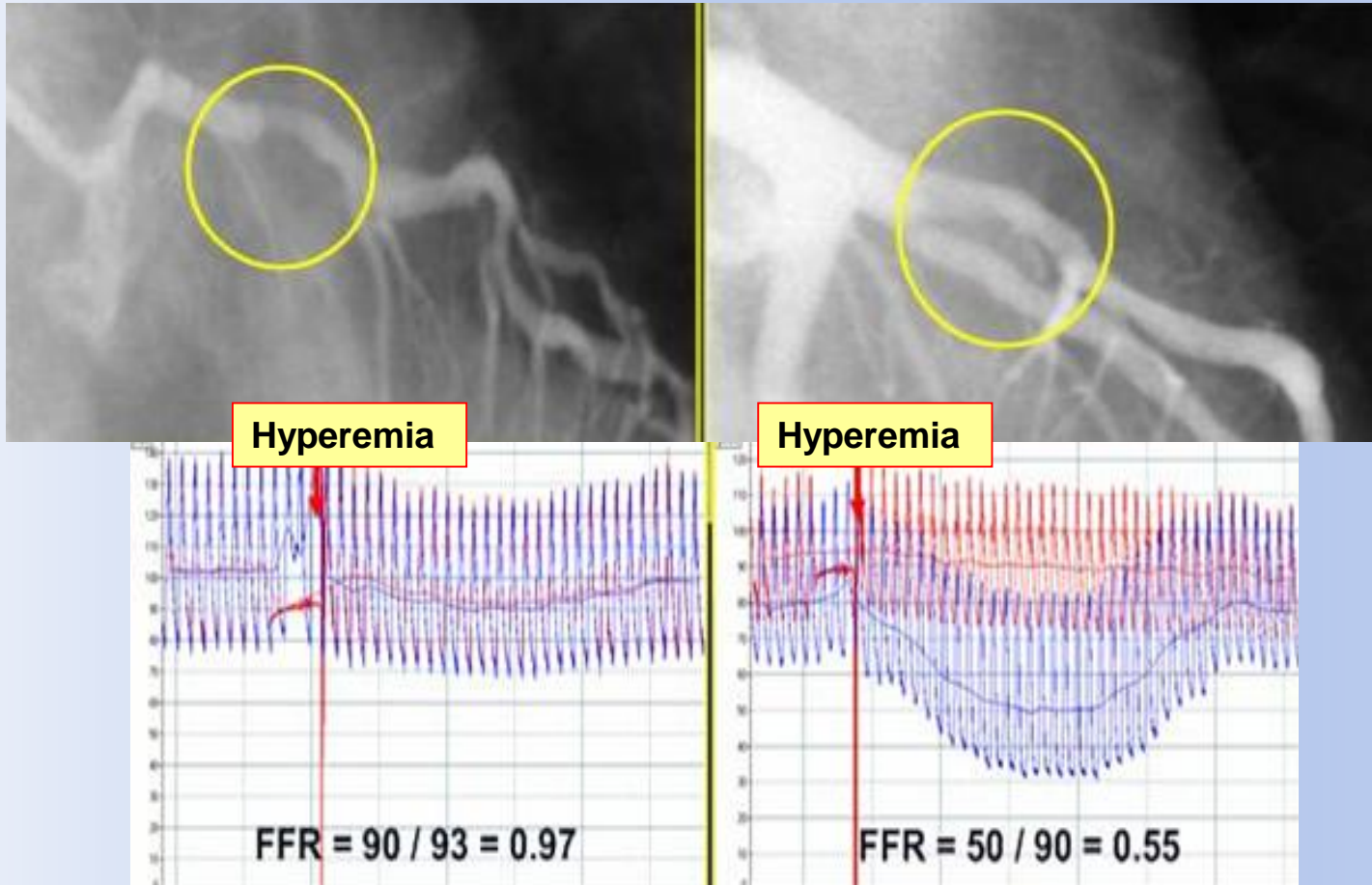
An iFR<sup>®</sup> cut point of 0.89 approximates an FFR cut point of 0.80<sup>3</sup>

1. Using the iFR cut points of 0.85 and 0.94 matches best with an FFR ischemic cut-point of 0.80 with a specificity of 90.7% and sensitivity of 96.2%.
2. The ADVISE II study illustrated a 5.8%, i.e. (17+23)/690, classification discordance between the iFR Hybrid Approach and FFR. Among 477 lesions that would be assessed without hyperemia by the iFR Hybrid Approach, 40 (17+23) were due to classification discordance.
3. An iFR cut-point of 0.89 matches best with an FFR ischemic cut-point of 0.80 with a specificity of 87.8% and sensitivity of 73.0%. (iFR Operator's Manual 505-0101.23)

# Significant or non-significant lesion?

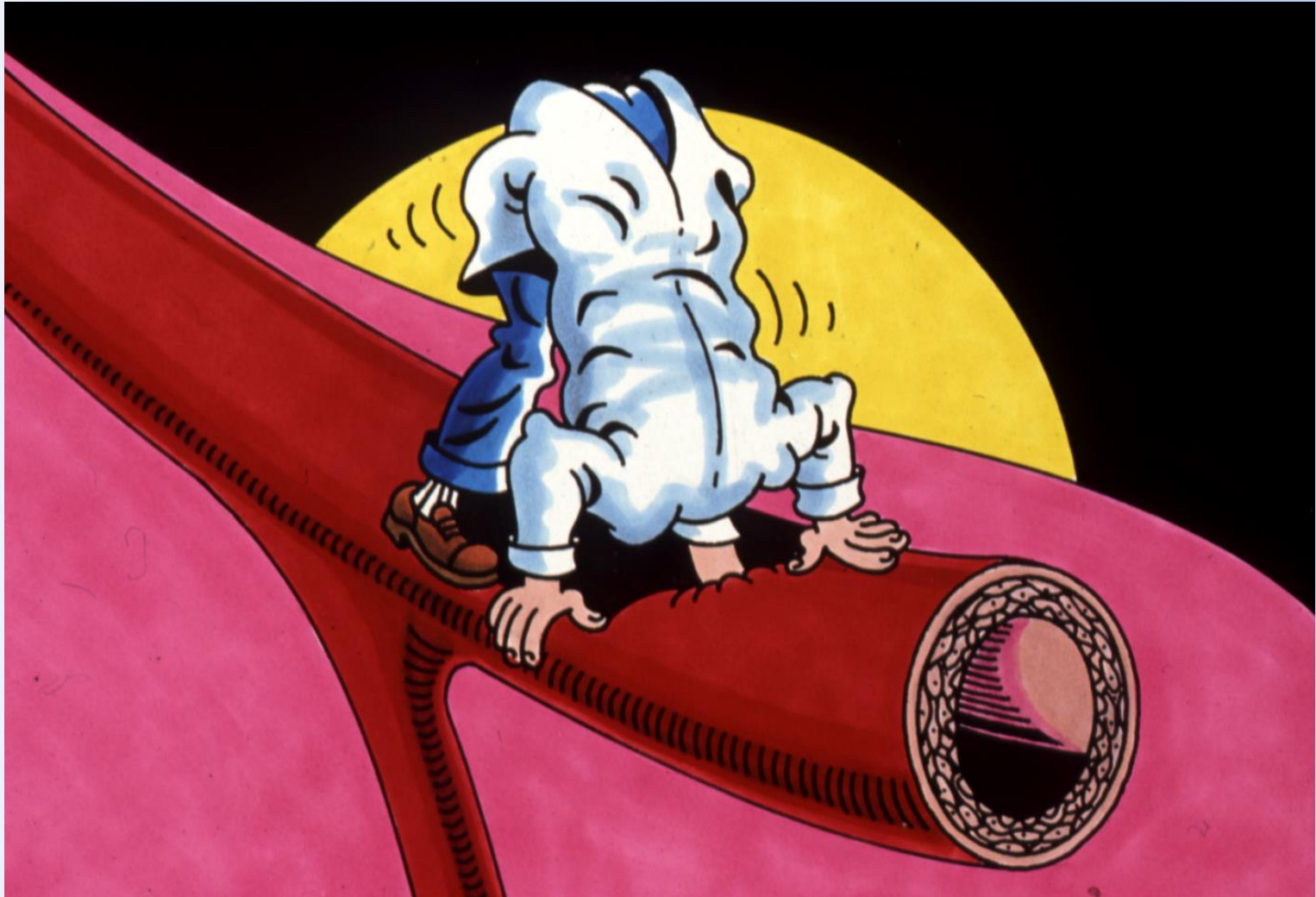


# Significant or non-significant lesion?





**With IVUS you have a different  
view of the vessel**

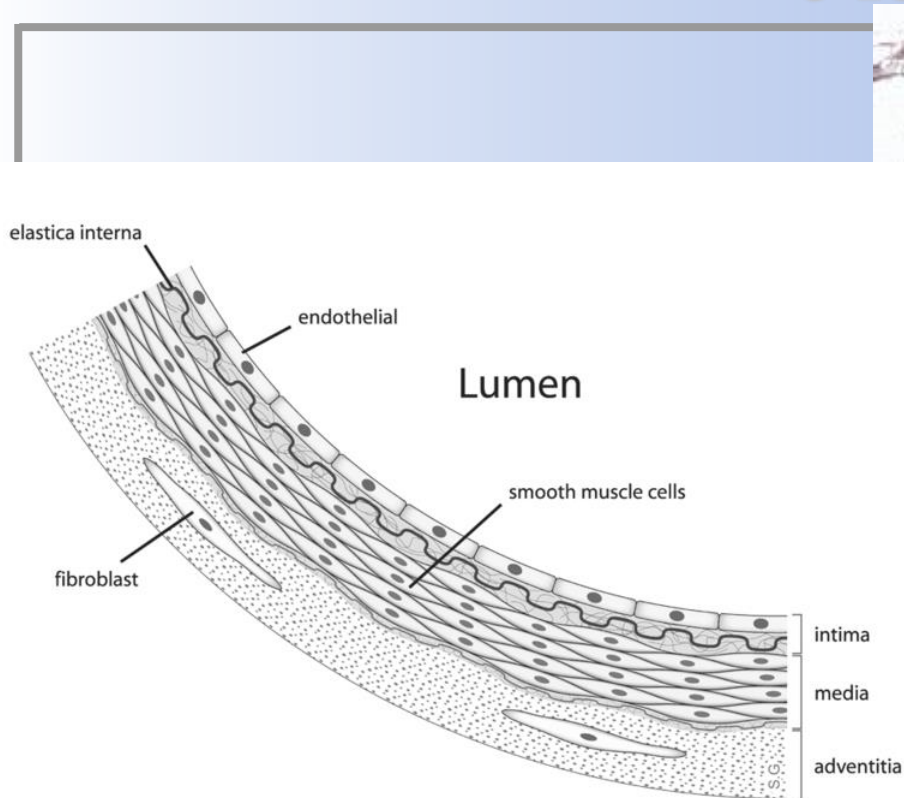


# IVUS

- **Vessel and lumen diameter measurement**
- **Vessel and Lumen Area**
- **Length of the lesion**
- **Type of Plaque**
- **Pre and post PTCA strategy**
- **Precise stent placement (location and apposition)**

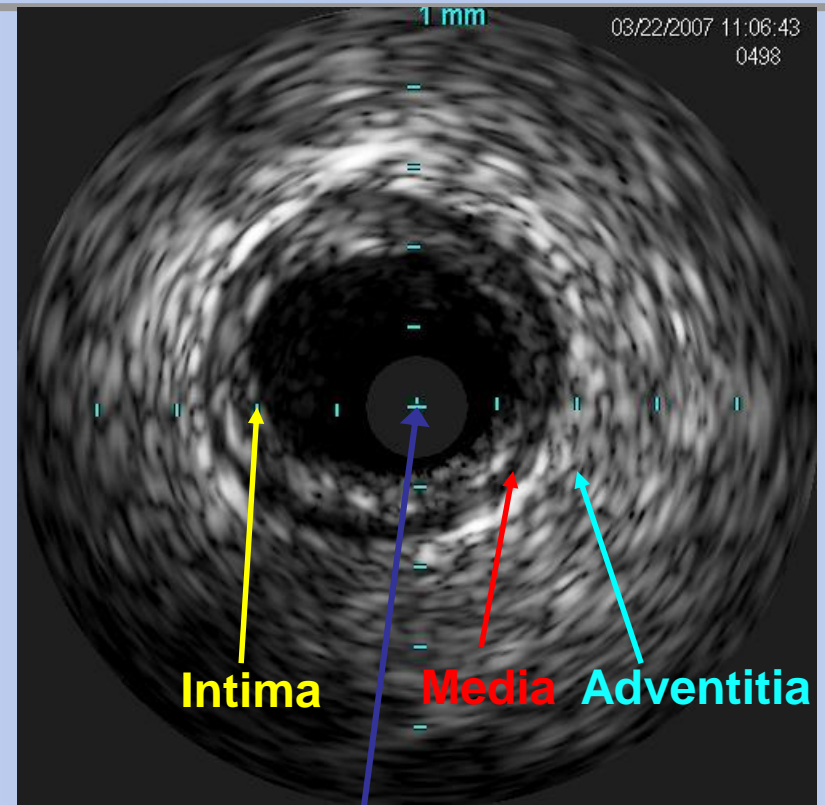
# Normal Artery Wall

## 3 Layers



# Three layers in IVUS image

<b>Intima</b>	- <i>white ring</i>
<b>Media</b>	- <i>black band</i>
<b>Adventitia</b>	- <i>white ring</i>

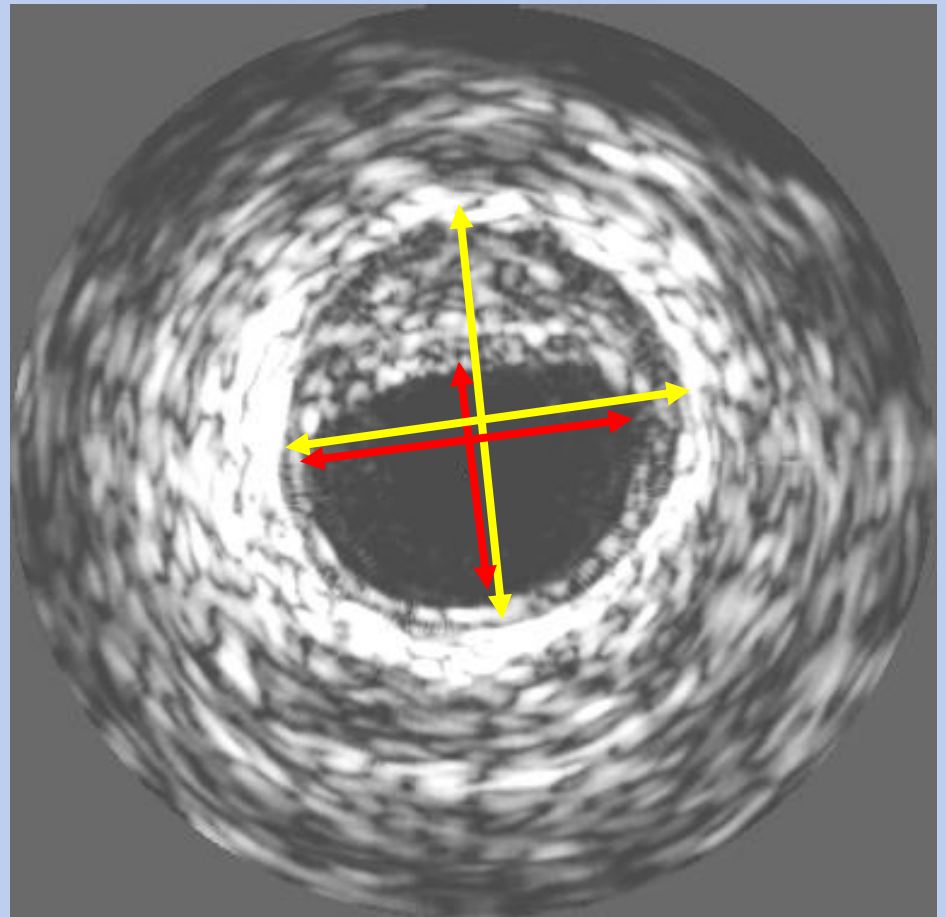


# How can we measure the lesion?

- **Lumen Diameter and Lumen Area**
- **Vessel Diameter and Vessel Area**
- **Lesion length**

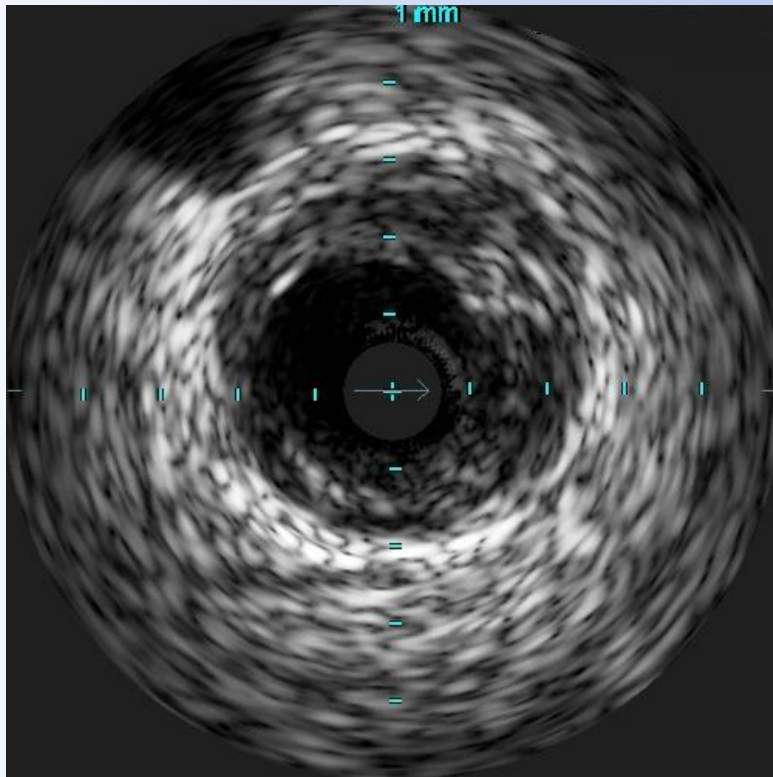
# Diameter measurement

- **Vessel diameter adventitia to adventitia**
- **Lumen diameter intima to intima**

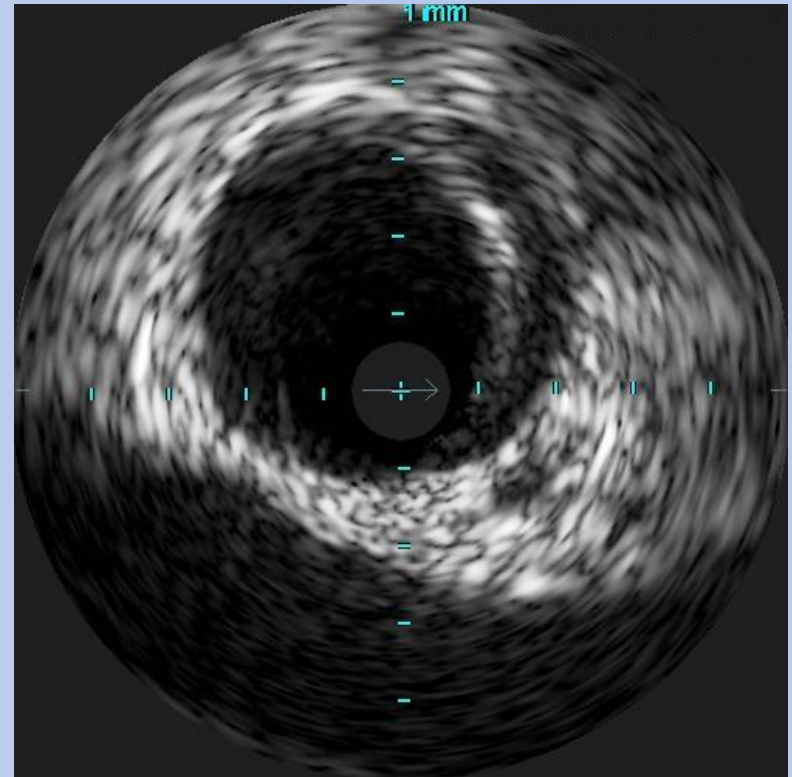




# Diseased vessel: Plaque Geometry



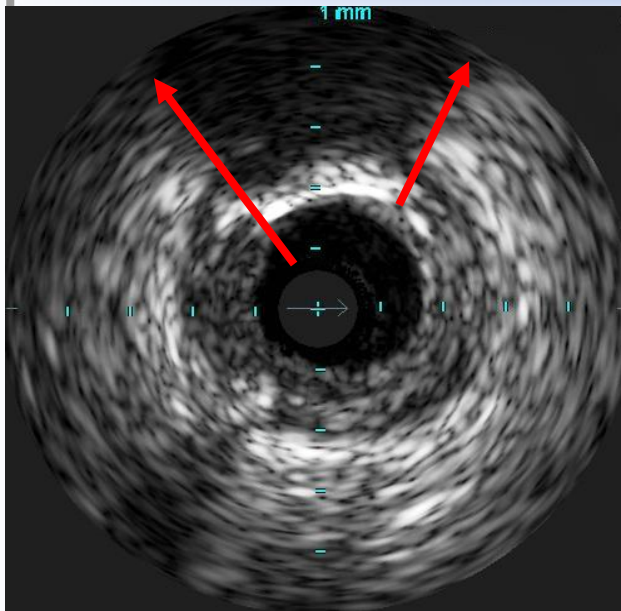
**Concentric Plaque**



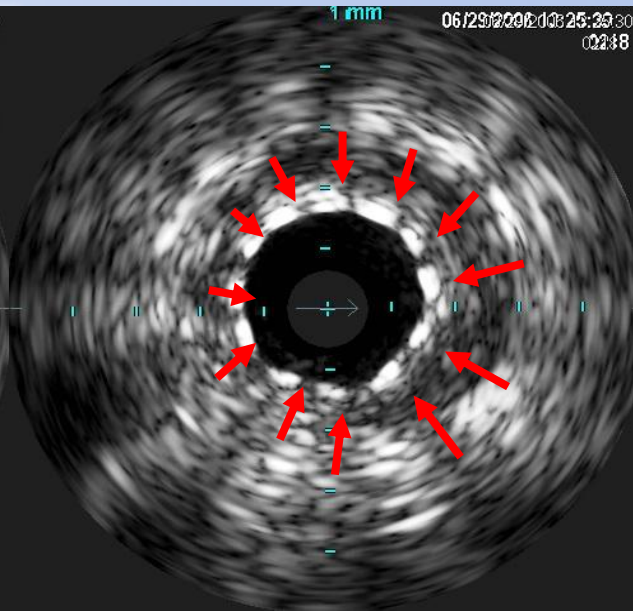
**Eccentric Plaque**

# IVUS Images

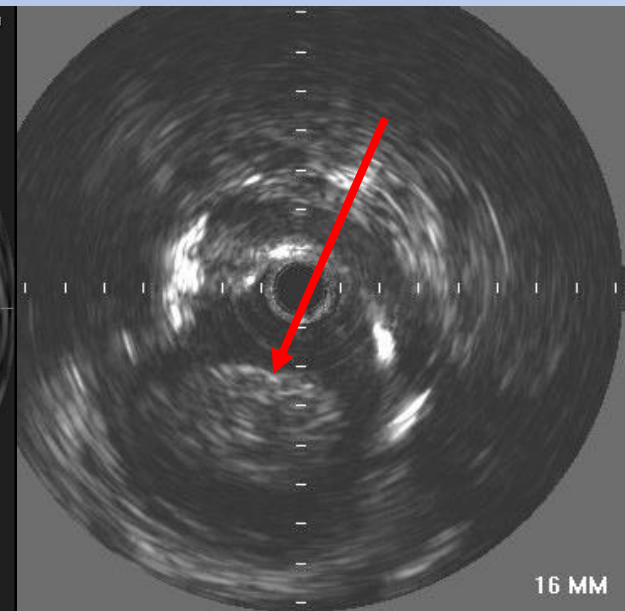
**Calcium  
with shadow**

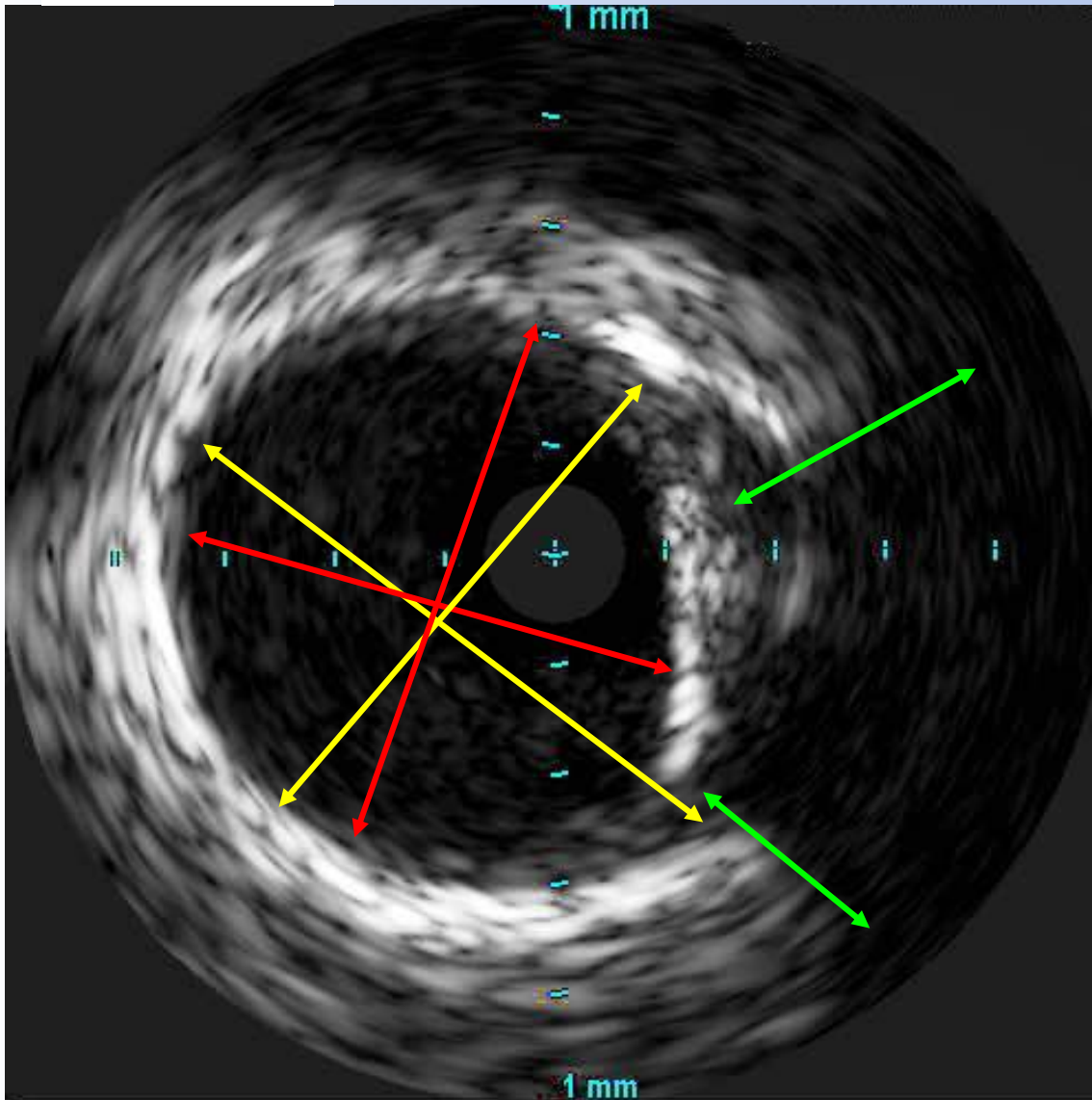


**Stent**



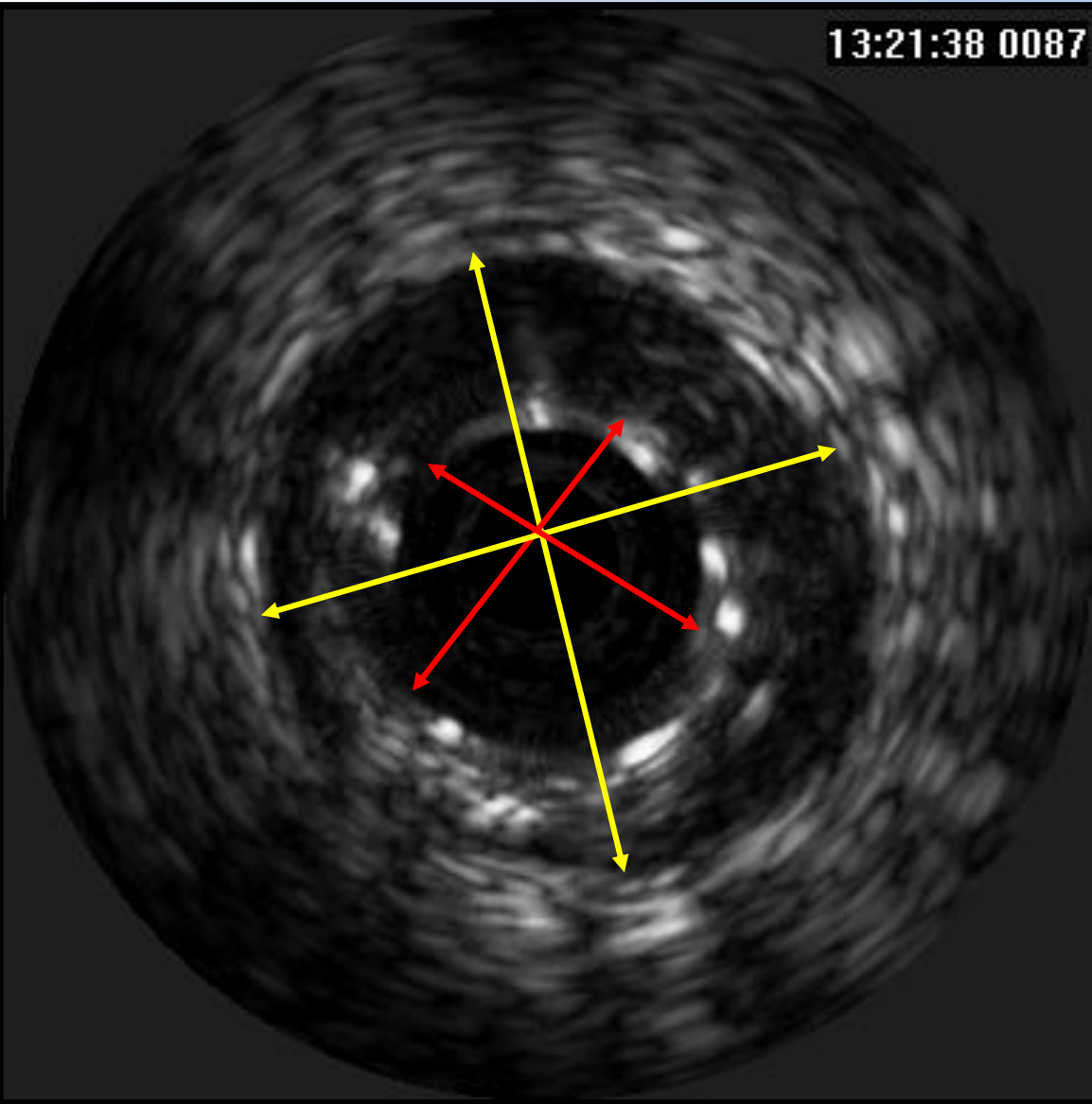
**Thrombus**





- Normal
  - Diseased ✓
- 
- Concentric Plaque
  - Eccentric Plaque ✓
- Soft
  - Fibrous
  - Mixt plaque
  - Calcified ✓
  - Stent ?
- 
- Vessel diameter
  - Lumen diameter
  - Calcified Plaque? where

13:21:38 0087



- Normal
  - Diseased ✓
- 
- Concentric Plaque ✓
  - Eccentric Plaque
- Soft ✓
  - Fibrous
  - Mixt plaque
  - Calcified? **No**
  - Stent ? **Yes**
- 
- Vessel diameter
  - Lumen diameter

## Widely established cut off values:

- **4 mm<sup>2</sup> for proximal major coronaries (LAD, LCX, RCA)**
  - **6 mm<sup>2</sup> - 8 mm<sup>2</sup> for left mains**
- ➔ it correlates with FFR<0.75**

## Table 1: Features of OCT and IVUS

Parameter	OCT	IVUS
Axial resolution	12-15mm	100-200 mm
Frame rate	100 frames/s	30 frames/s
Pullback speed	20mm/s	0.5-1mm/s
Tissue penetration	1.0-2.0mm	10mm
Blood clearing	Required	Not required
technology	Infrared light waves (1,250-1350nm)	Ultrasound 30-40MHz
Catheter equipment	Single rotating lens	Single rotating and multi array transducers



## Table 2: Features of OCT and IVUS

Parameter	OCT	IVUS
Physics applied	Interferometer used – high light speed	Direct measurement of back-scattered waves
Image interpretation	Grey scale and golden scale	Grey scale display
Renal dysfunction	Adds up contrast load	No issues
Complete visualization of Large vessel	Not possible	possible
Assessment thin cap Fibroatheroma, thrombus, dissection	superior	Can be imaged
BVS assessment	superior	inferior
Aorto ostial visualization	Not possible	possible

## Table 3: Features of OCT and IVUS

Parameter	OCT	IVUS
Luminal visualization	Excellent	Limited by resolution
Positive remodeling	Usually missed	Easily picked-up
Distal vessel visualization	Not possible	Not possible
Coregistration	Available	In pipeline
3D Stent enhancement and SB crossing	Available	NA
Acquisition of image	Based on contrast injection	Easy
Interpretation	Easy	Difficult
Data	Up coming	Extensive

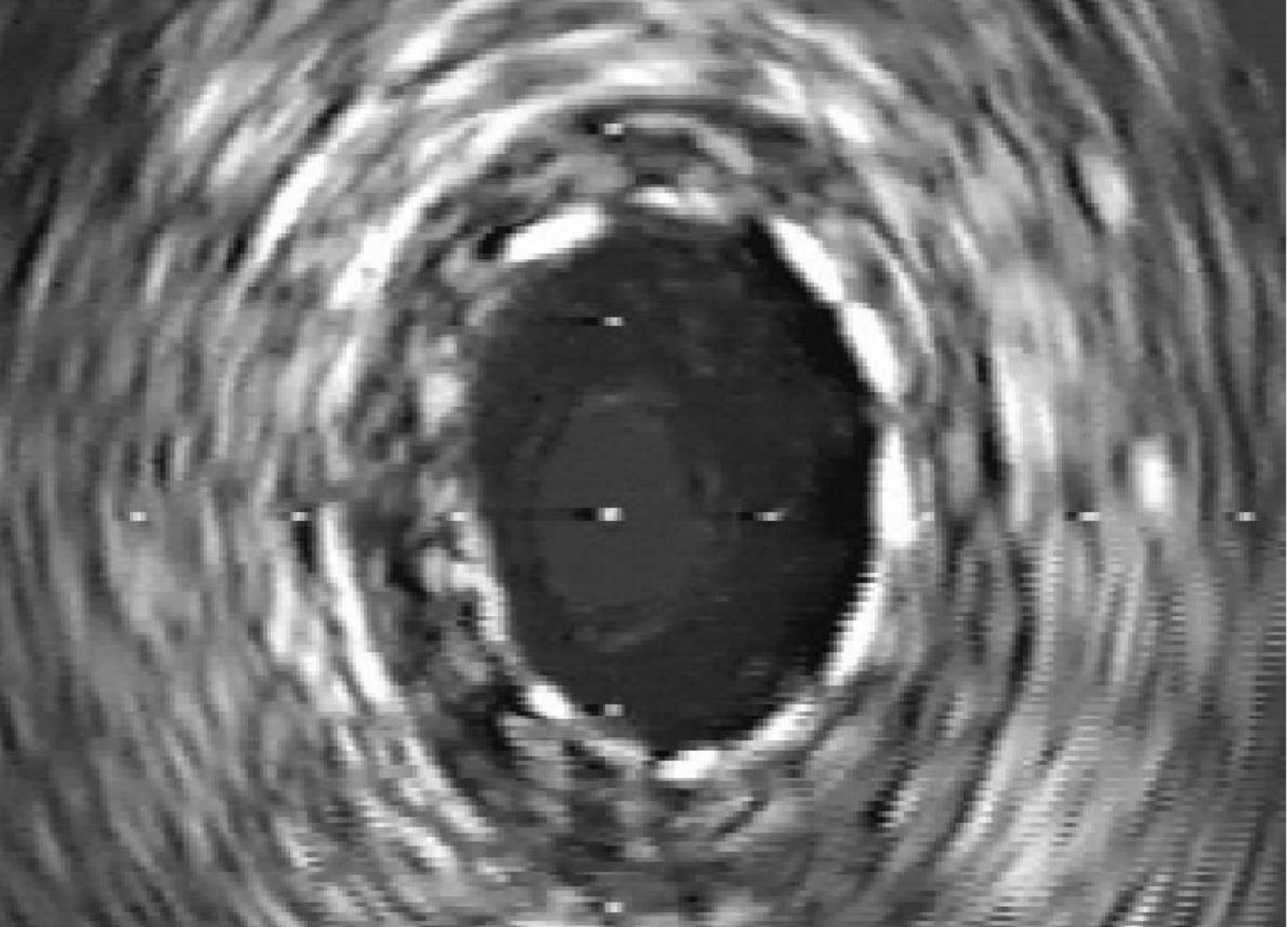
UNLOCK ENHANCED STRATEGIES

OCT

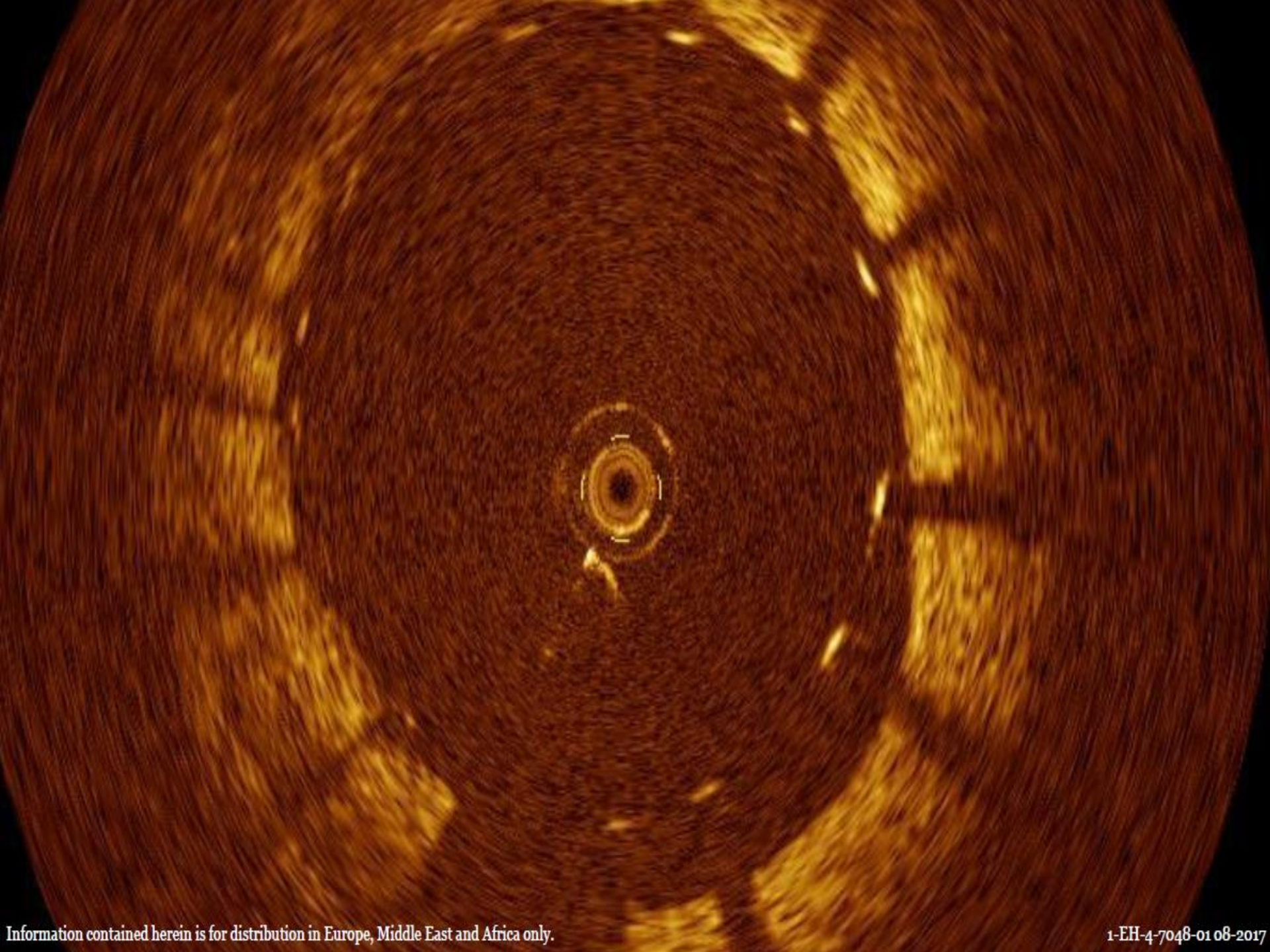


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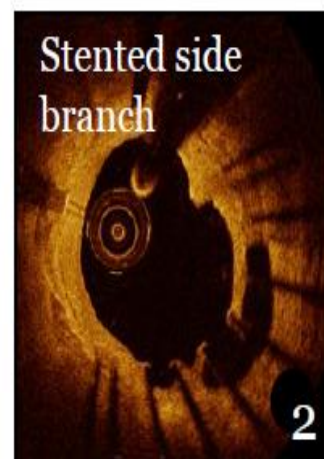
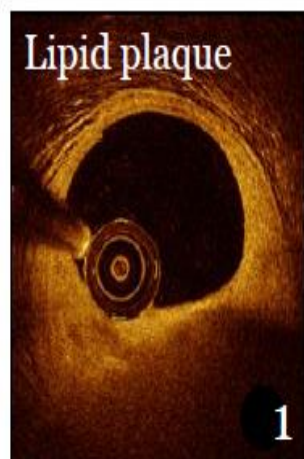
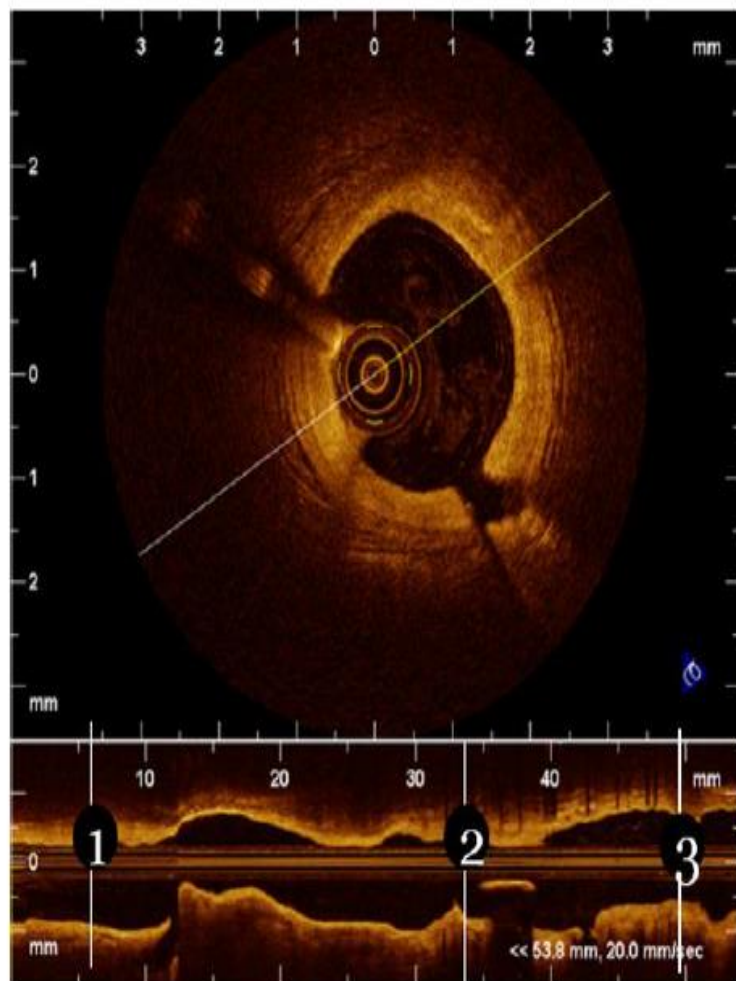






# OCT: Optical Coherence Tomography

## Unique insight into the pathophysiology of the vessel



With courtesy of ThoraxCentre, Netherlands



# TAKE AWAY MESSAGES

- Fluoroscopy alone is often insufficient in the correct evaluation of intermediate severity stenosis.
- Fractional Flow Reserve provides functional evaluation but does not provide information about plaque characteristics.
- IVUS and Optical Coherence Tomography allows assessment of plaque characteristics and stability and can complement both Fluoroscopy and FFR.
- IN CASE OF DOUBT ALWAYS DIG DEEPER!

**THANK YOU FOR YOUR  
ATTENTION**