Physiological Assessment and Intra-Coronary Imaging in the Cath Lab

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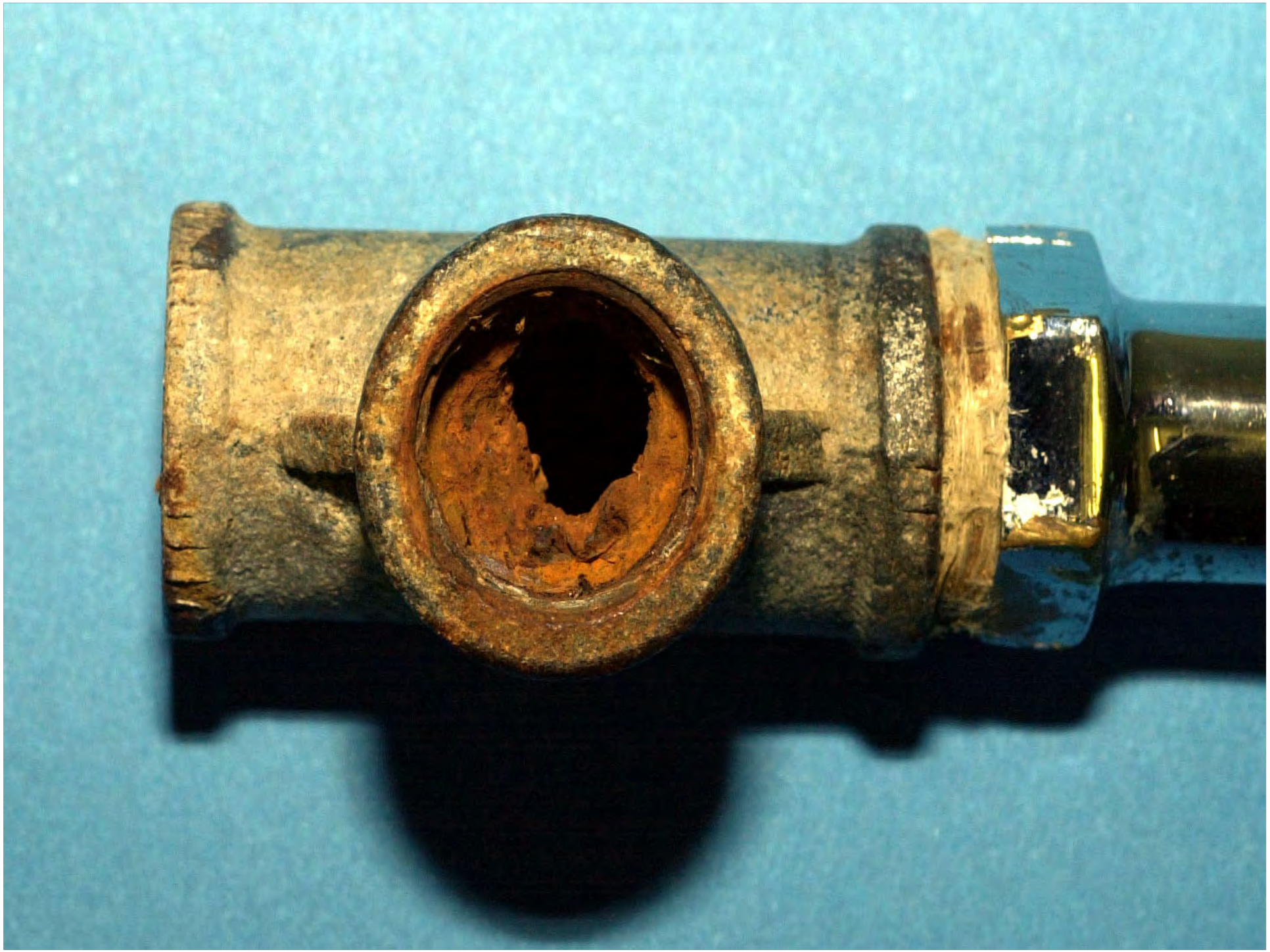
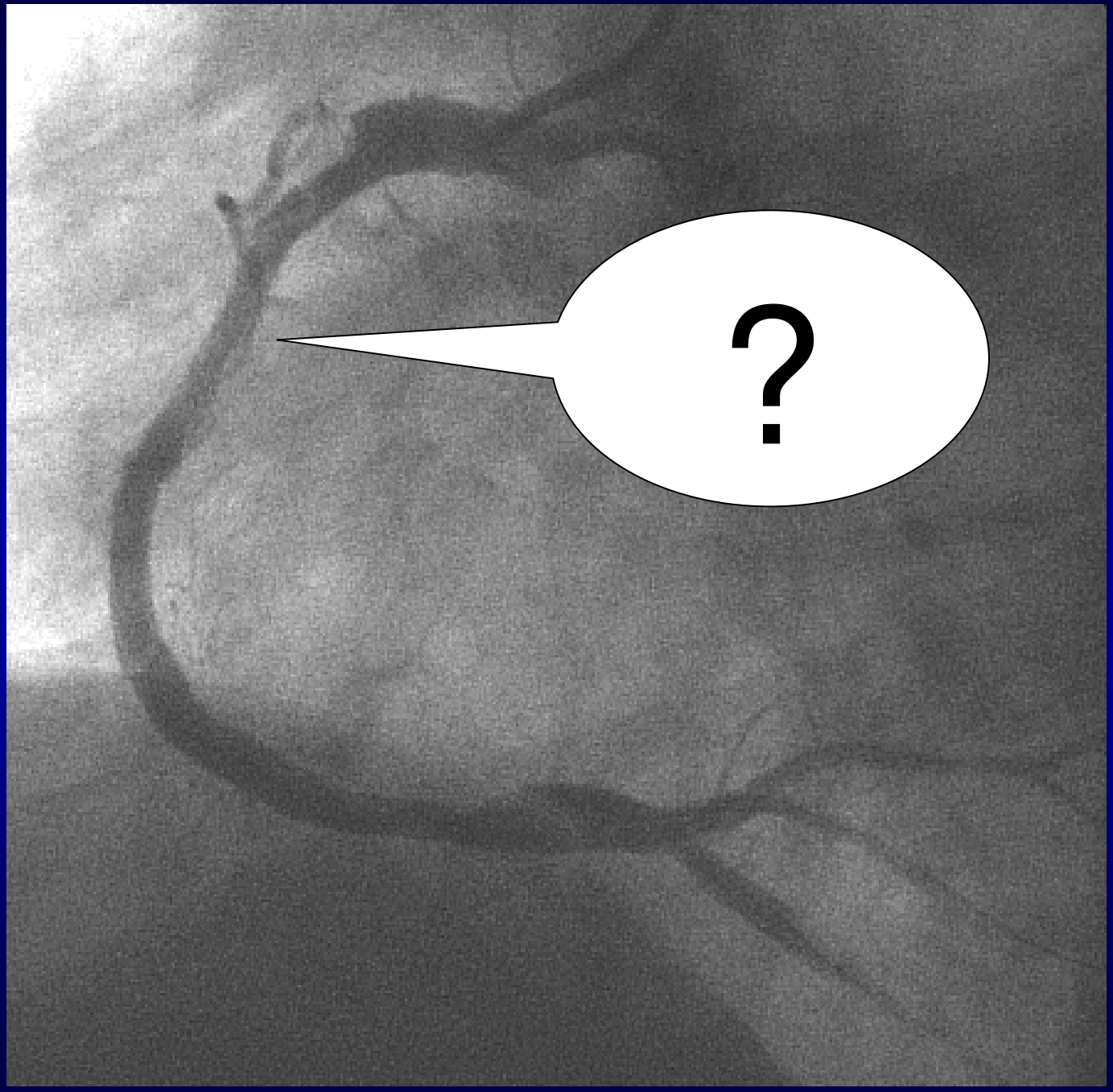
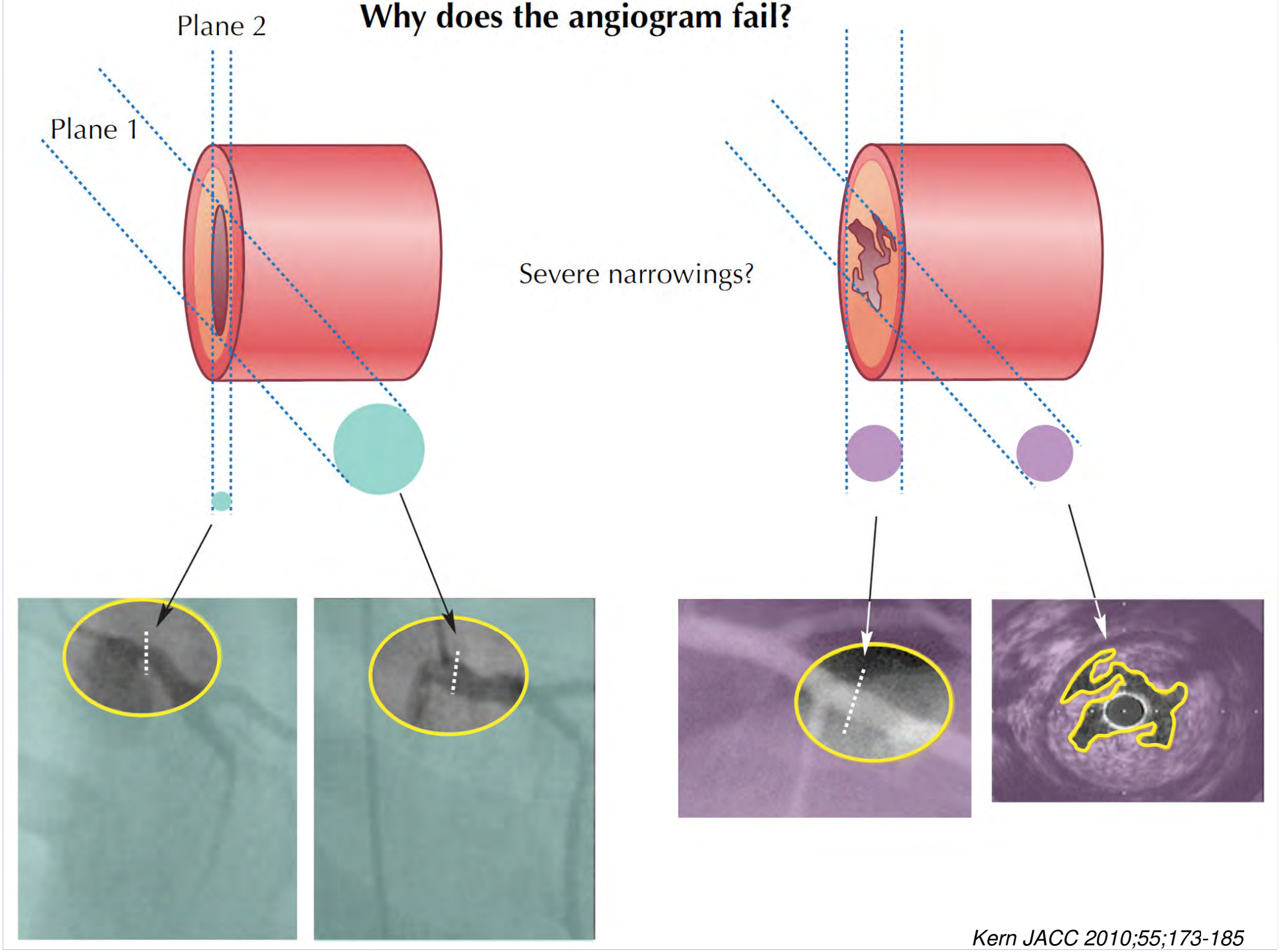


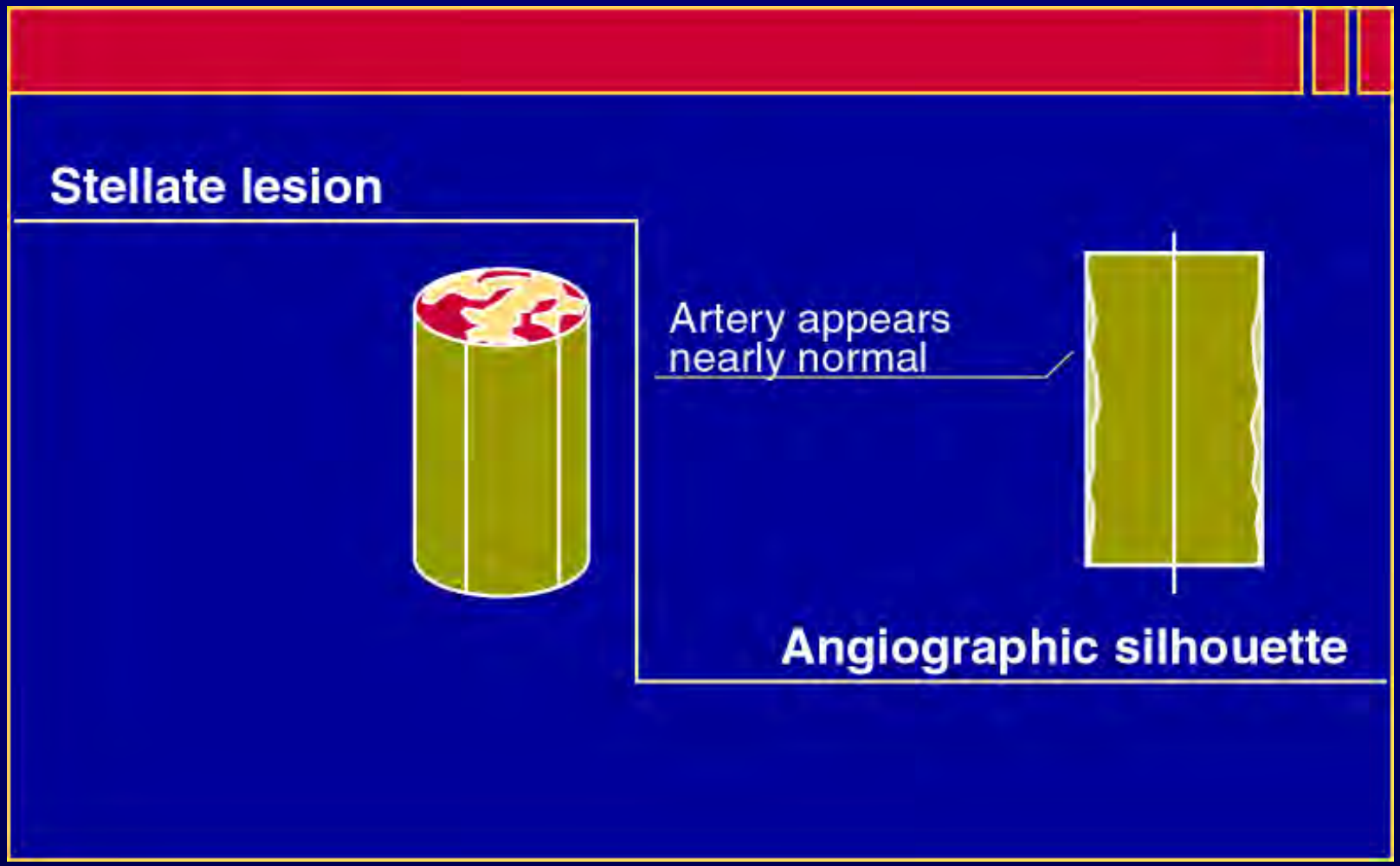


Why does the angiogram fail?

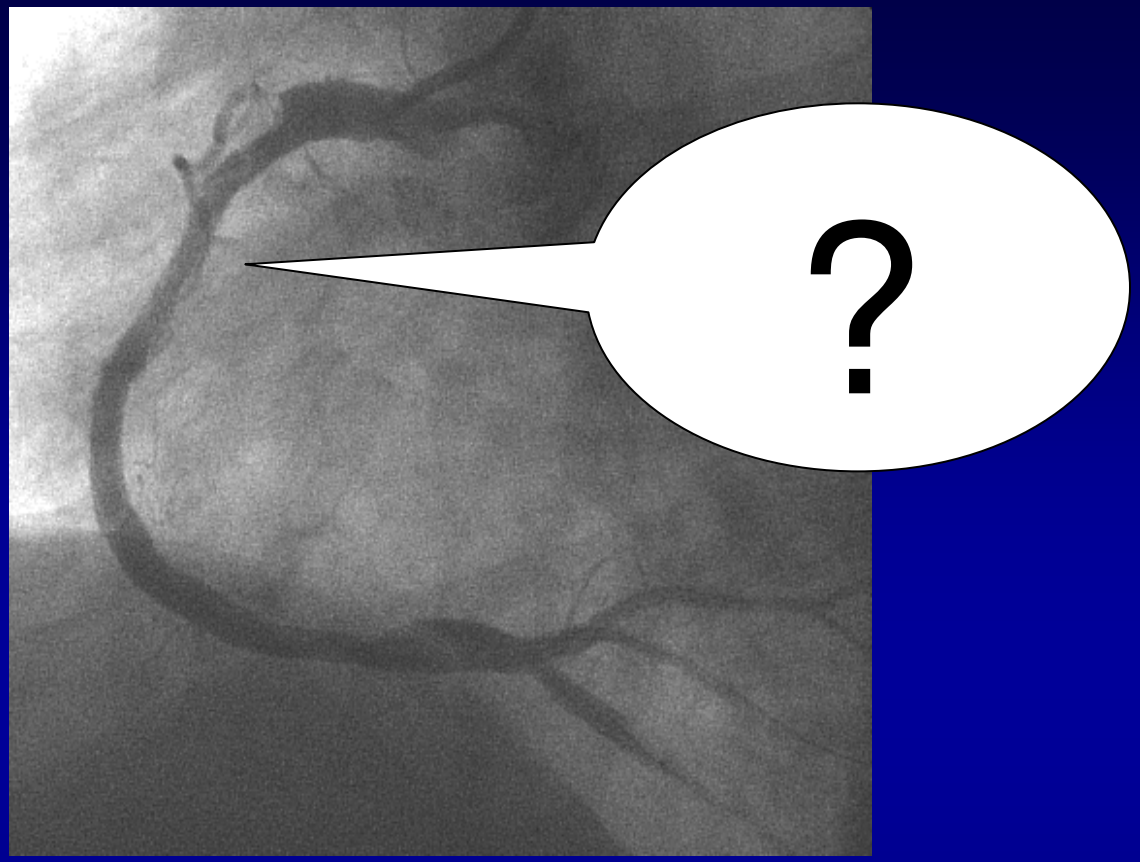


Kern JACC 2010;55;173-185

Angiography Has Major Limitations in Assessing Complicated Lesions



Nissen SE et al in *Textbook of Cardiovascular Medicine,* 1998; Topol EJ et al, *Circulation*, 1995.



IC Imaging:
ANATOMY

Functional assessment:
PHYSIOLOGY

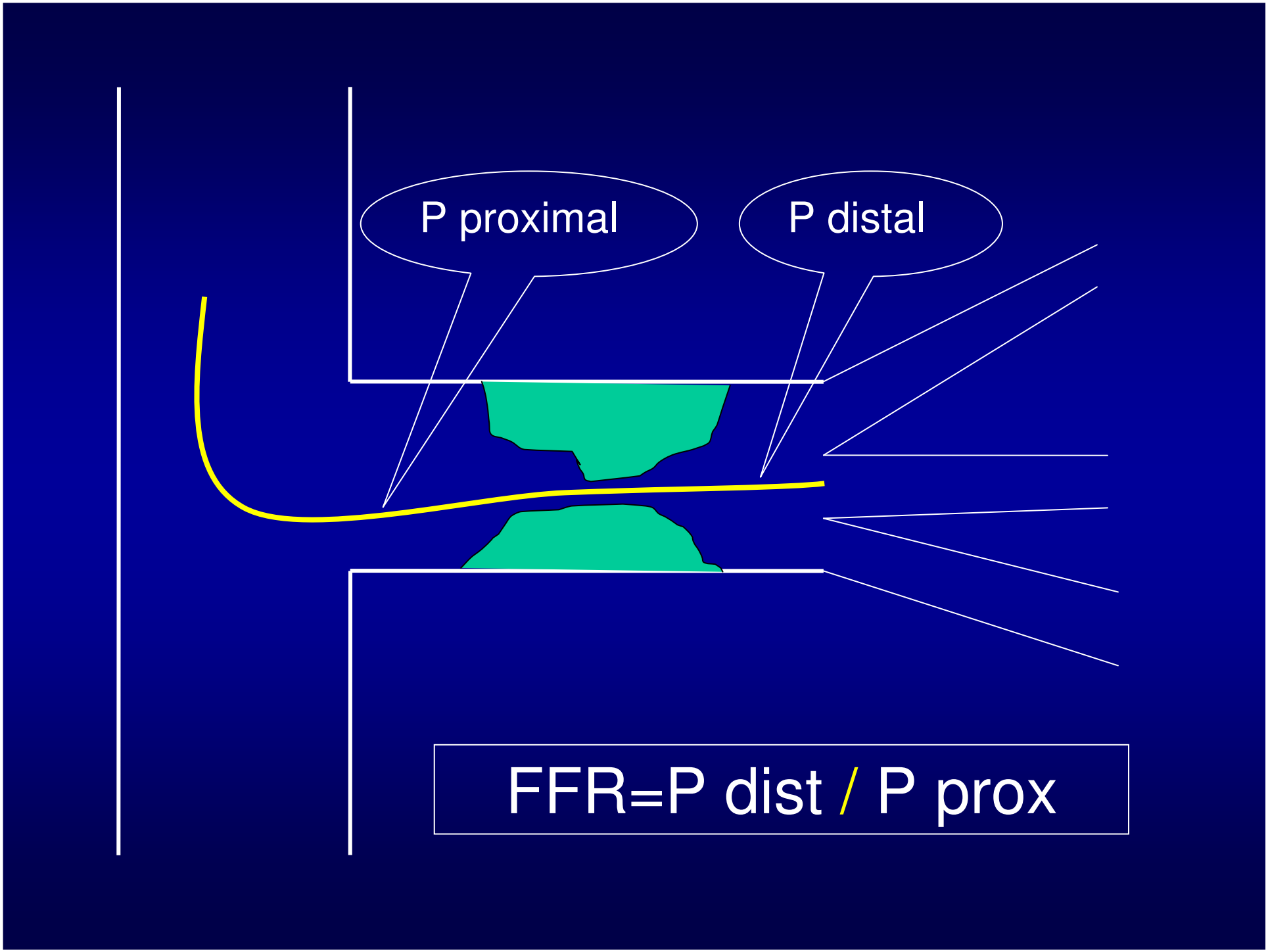
Improved Assessment of Coronary Lesions

- Fractional Flow Reserve (FFR):
  - Accurate assessment of hemodynamic significance
- Intravascular imaging (IVUS/OCT):
  - Precise visualization of intra-coronary anatomy

Anatomy Vs. Physiology

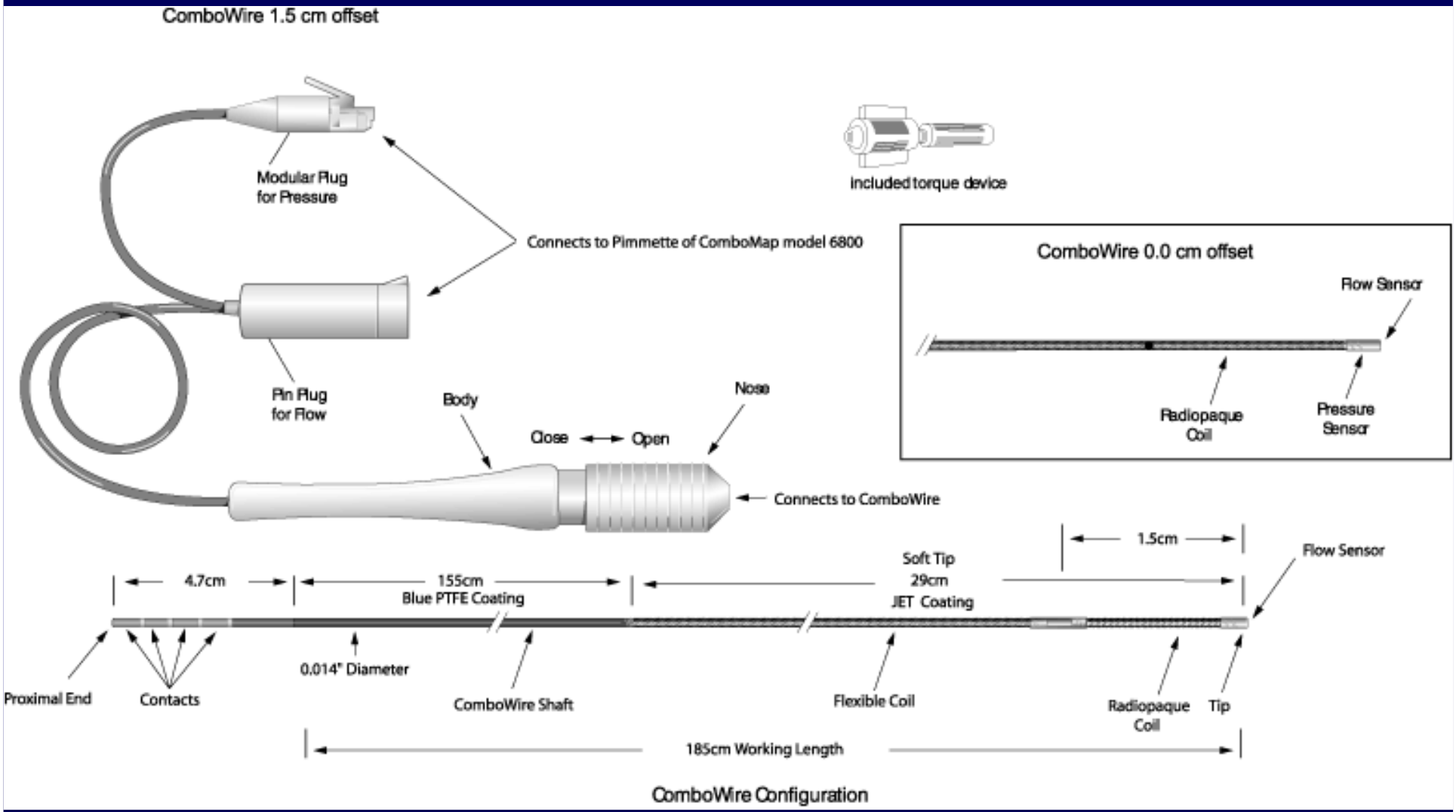
Two clinical settings:

1. Is PCI indicated?
2. Technical aspects of PCI:
   - Characterization of lesion
   - Is the PCI result optimal?
   - ….


P proximal
P distal
FFR=P dist / P prox

Fractional Flow Reserve (FFR)

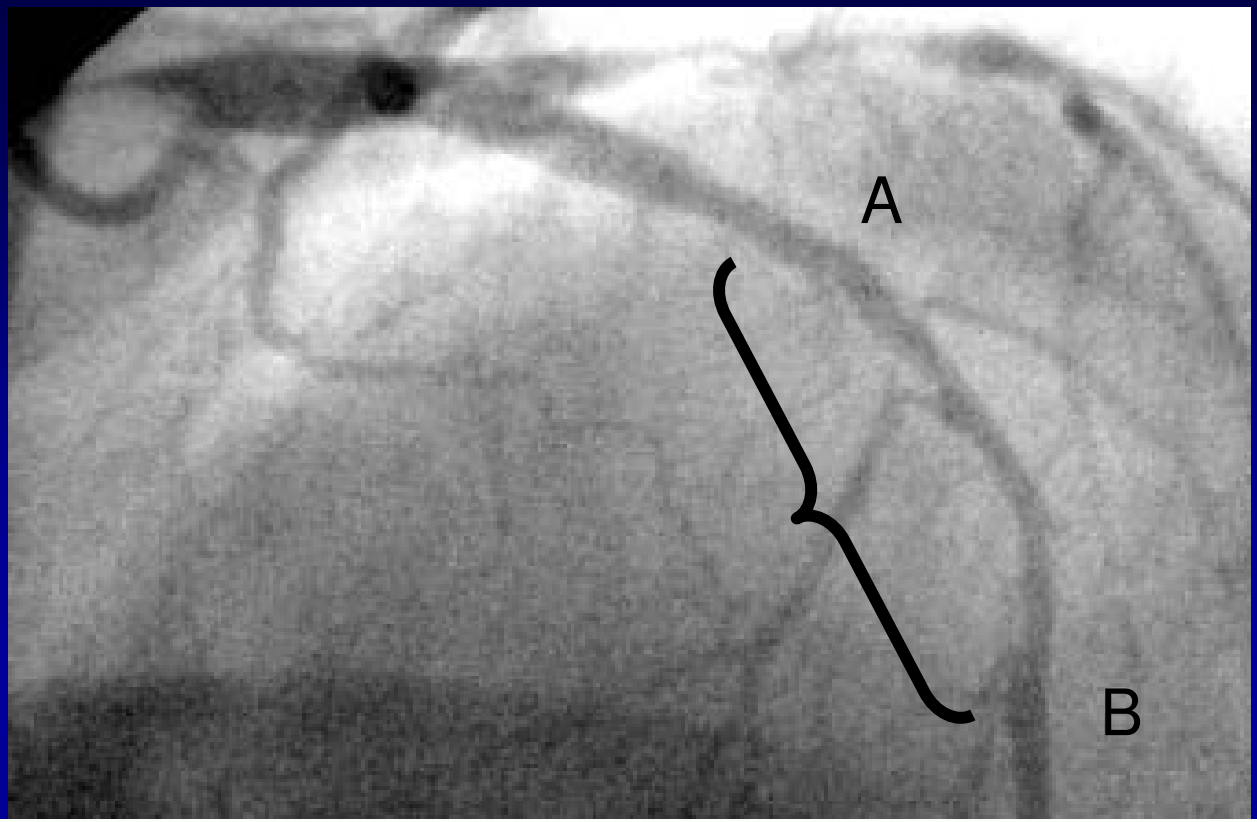
FFR > 0.8	Normal
FFR: 0.75-0.8	?
FFR < 0.75	Ischemia



ComboWire Configuration

Microvascular hyperemia: Adenosine

- Adenosine: 6mg/500cc NS (12mcg/cc)
- IC boluses:
  - 60 mcg (5 cc)
  - 96 mcg (8 cc)
  - 120 mcg (10 cc)
- IV drip 140 mcg/Kg/Min

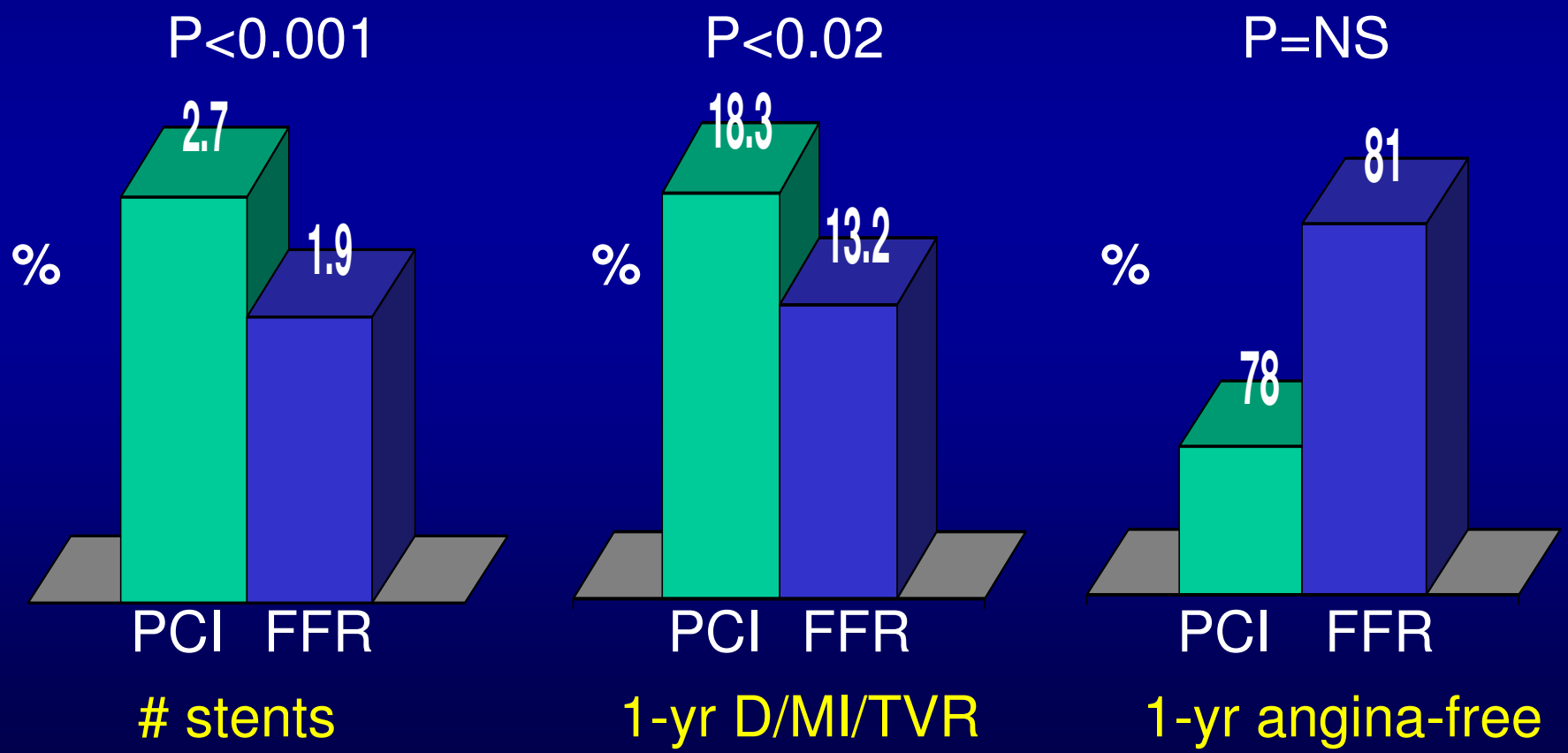


B: FFR=0.65

A: FFR=1.00

FAME study

1005 patients with stenosis >50% randomized:
PCI or FFR (PCI if FFR<0.8)

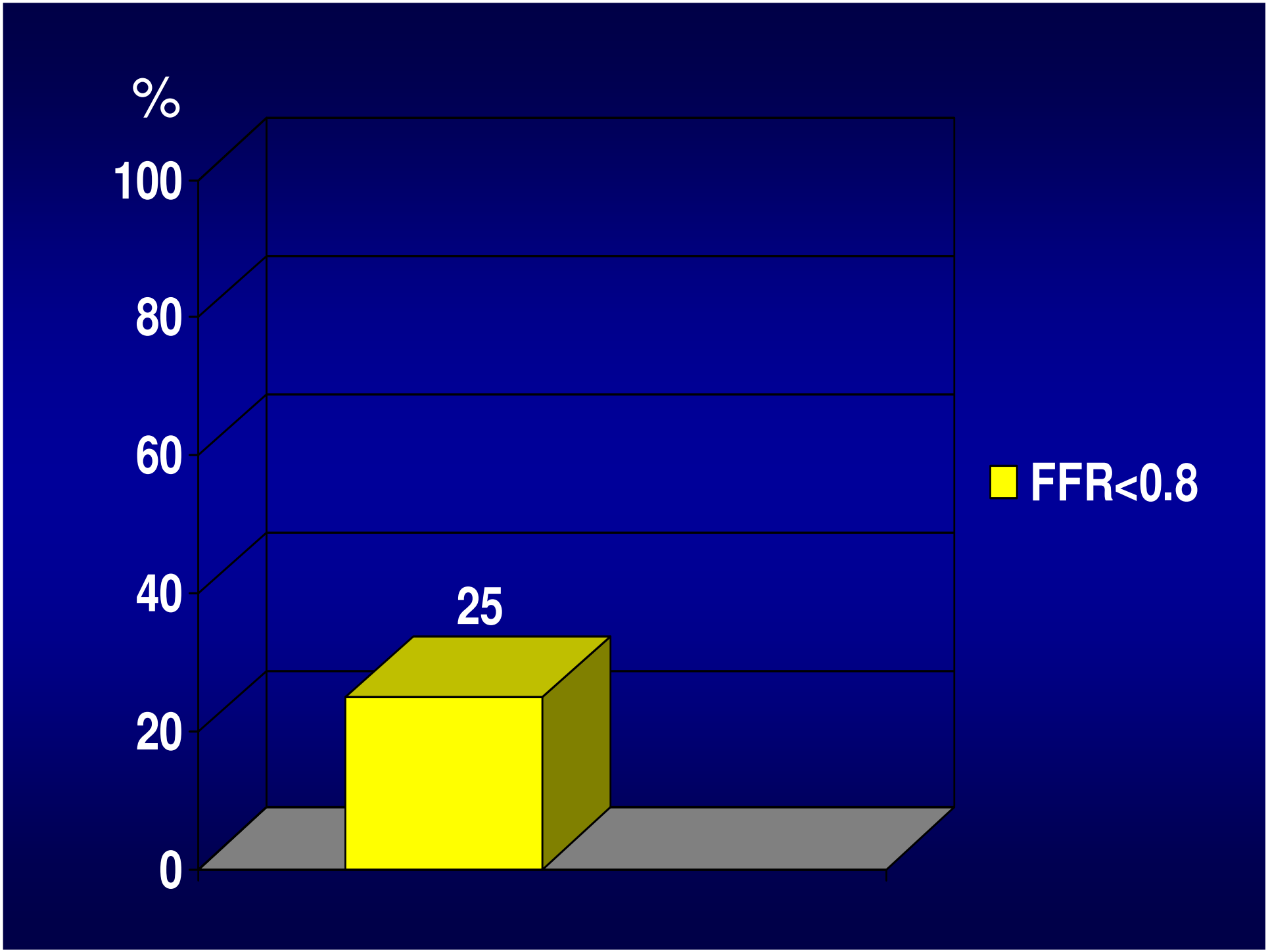


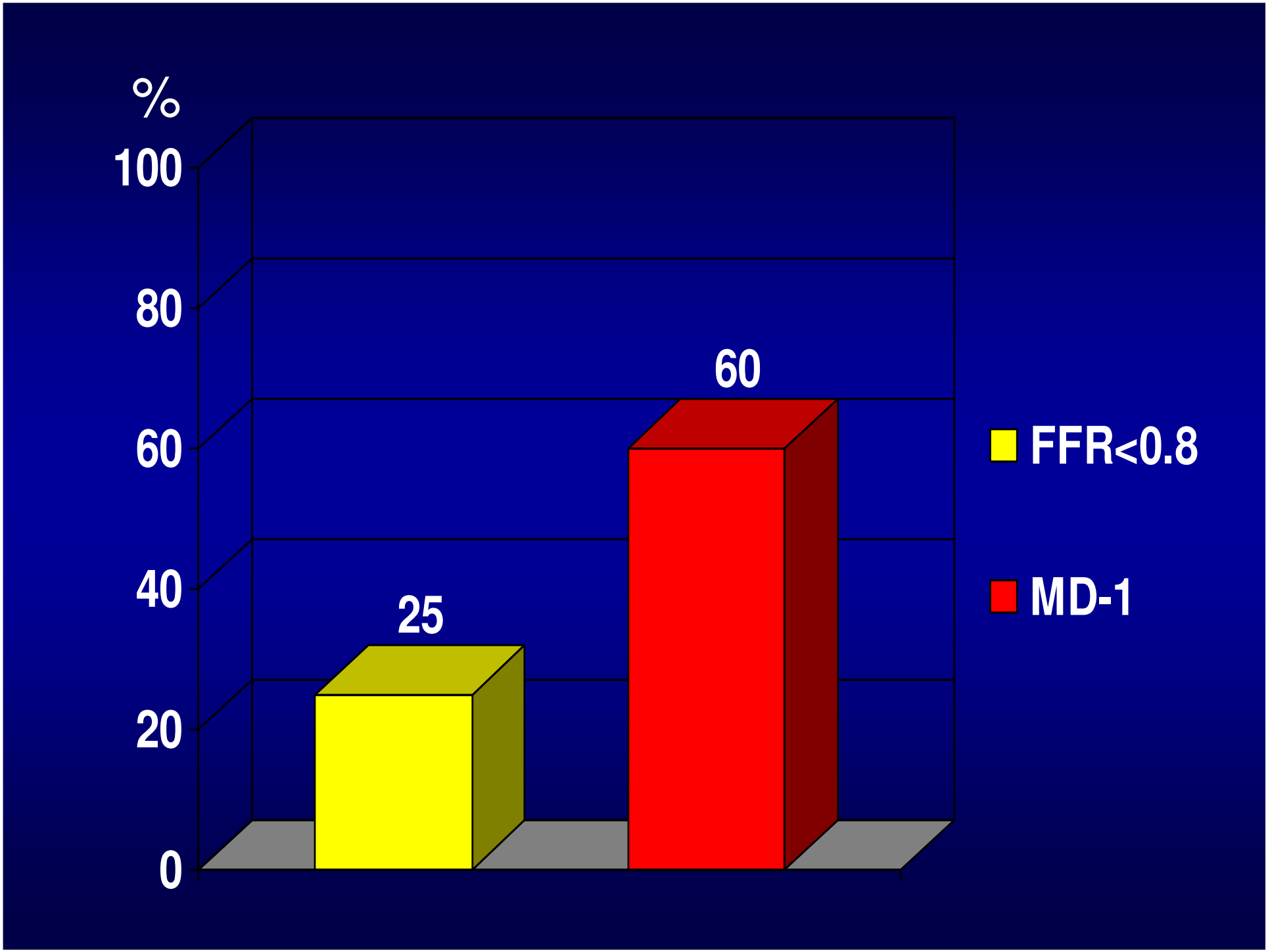
FAME NEJM 2009;360:213-24

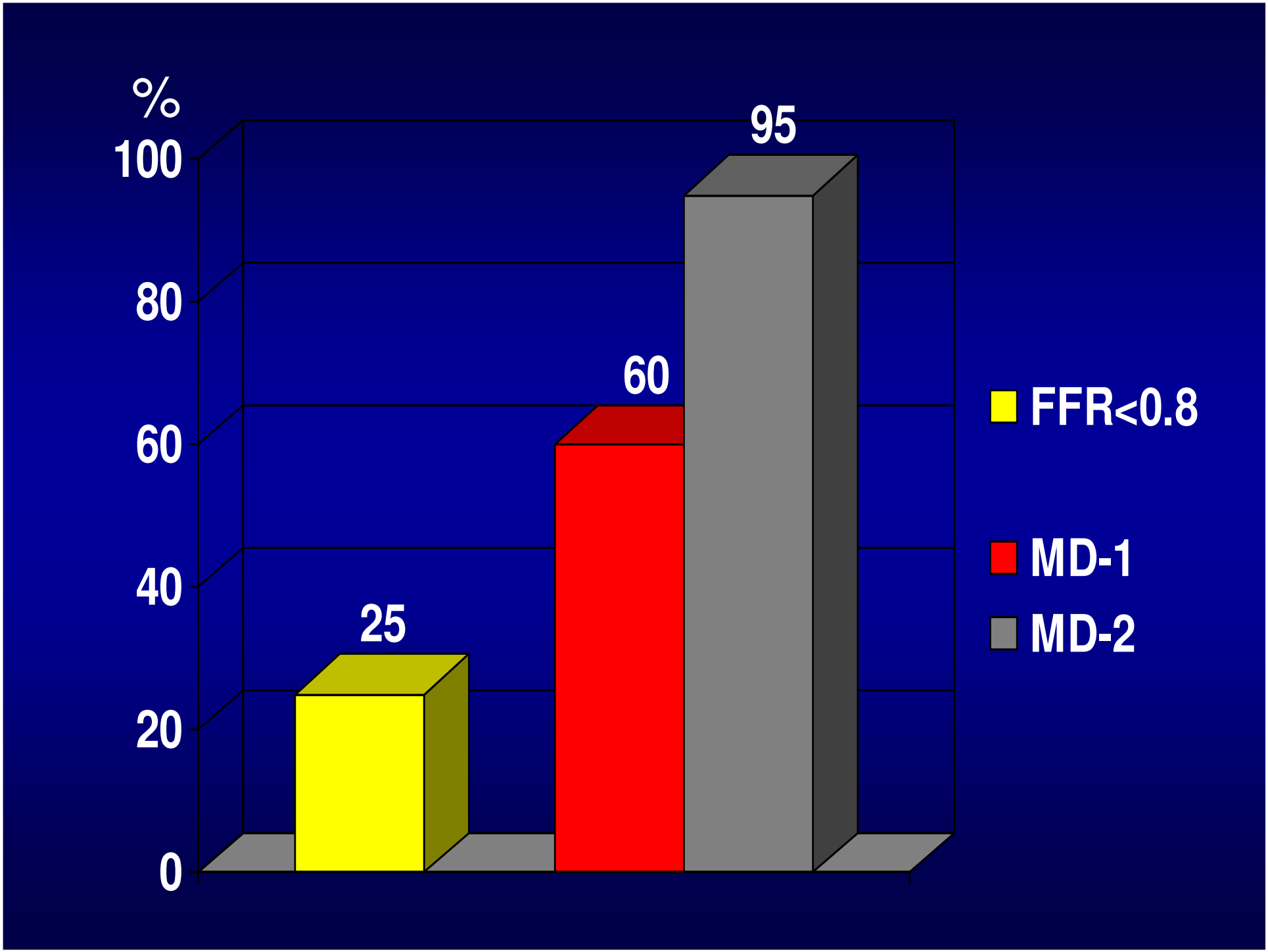
LDCMC Analysis: First 20 FFR Cases in Intermediate Lesions

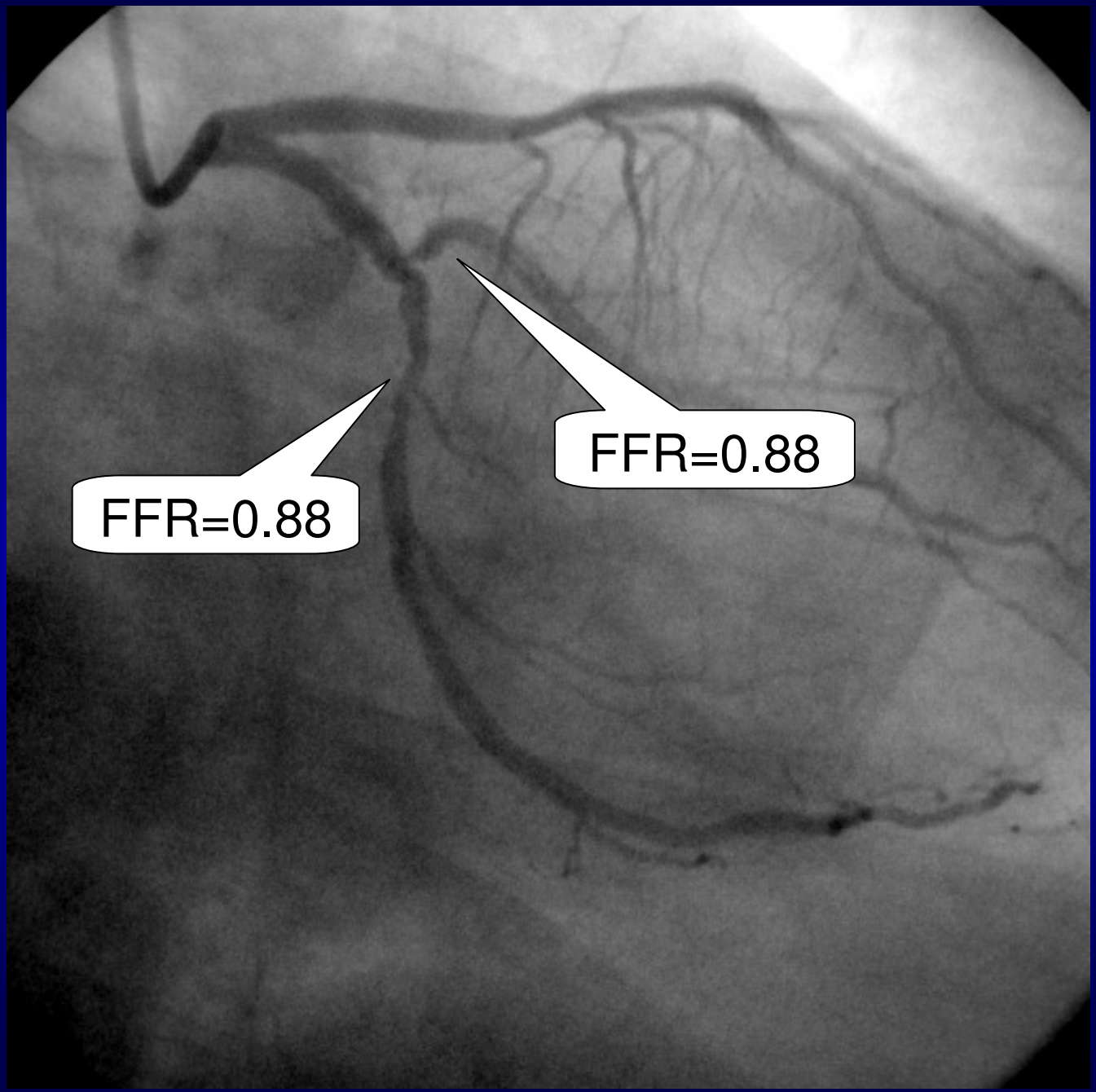
- Mean FFR = 0.85±0.08

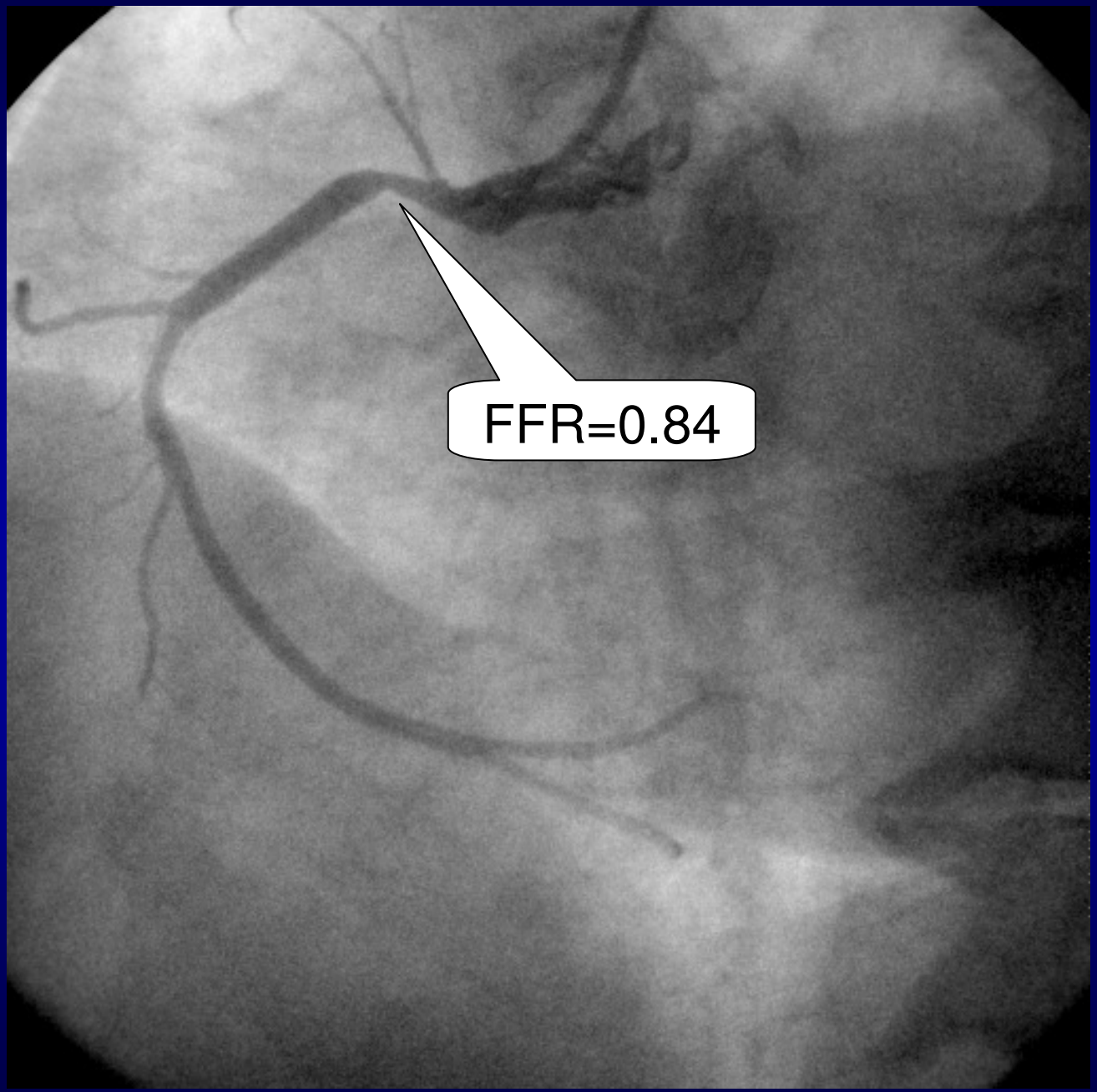
  (range: 0.71-1.00)
- FFR<0.80 was measured in only 5 stenoses (25%)
- Comparison of FFR to opinion of 2 experienced cardiologists

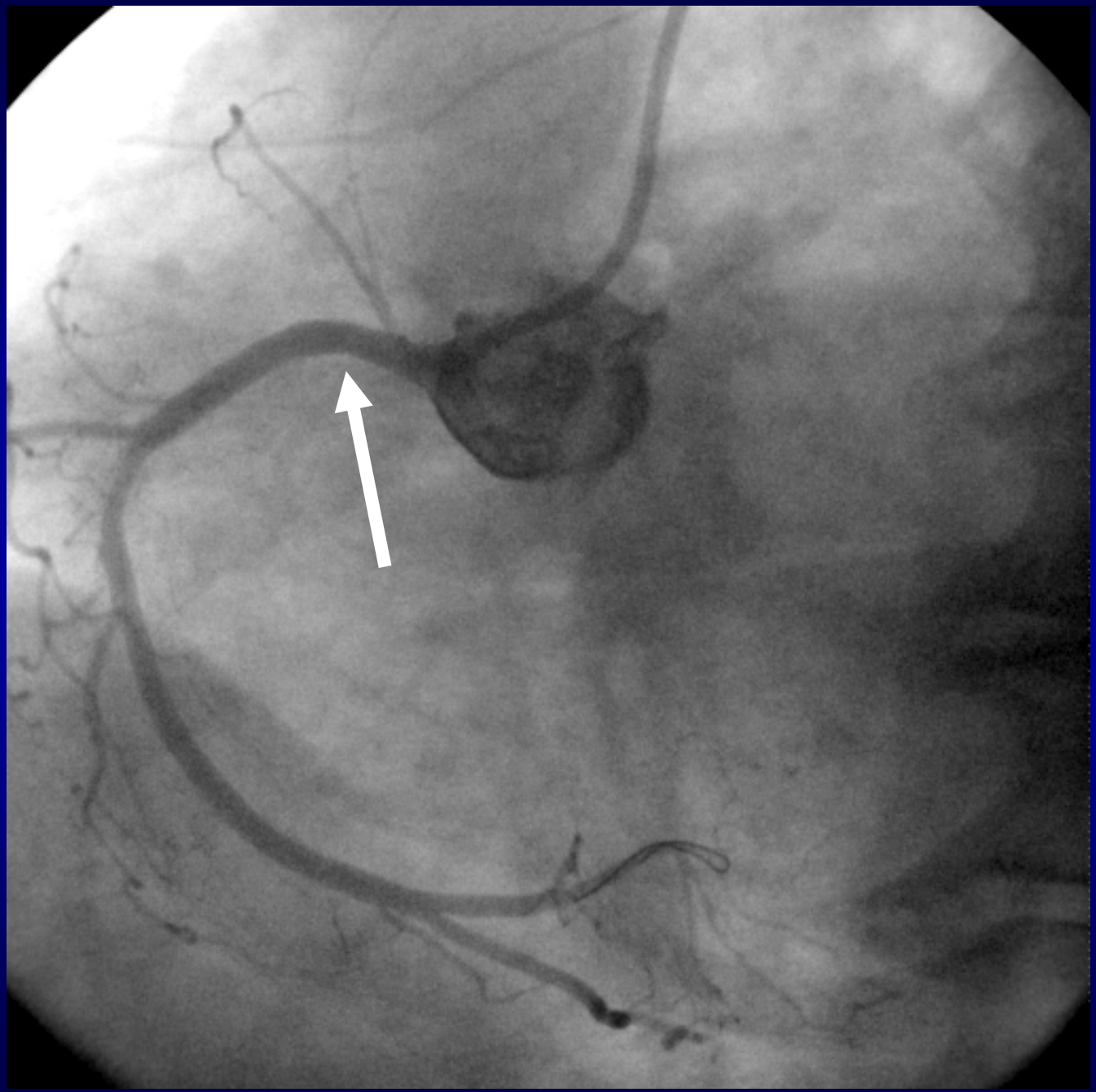

%
100
80
60
40
20
0
25
FFR<0.8

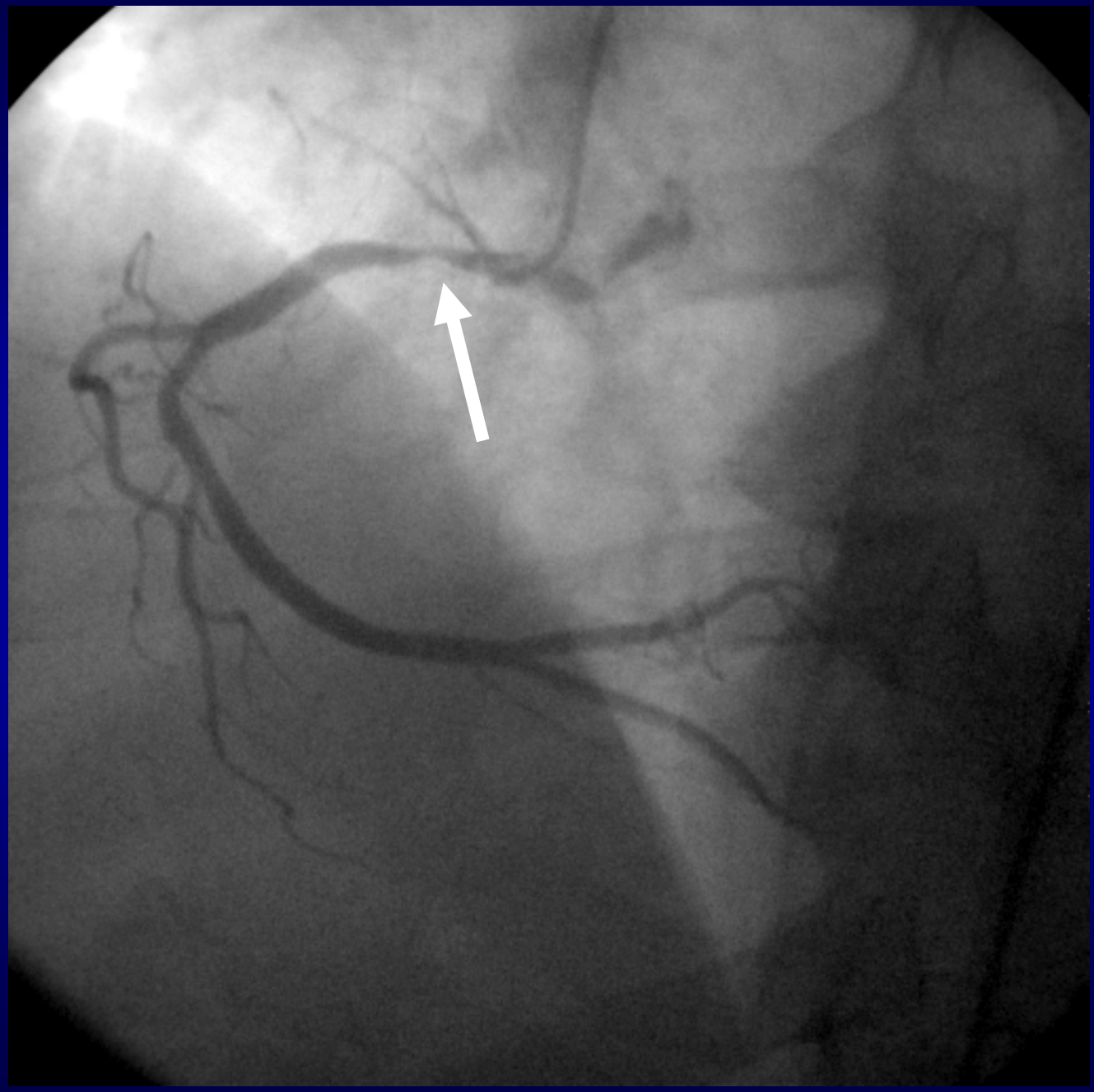

%
100
80
60
40
20
0
25
60
FFR<0.8
MD-1


%
100
80
60
40
20
0
25
60
95
FFR<0.8
MD-1
MD-2


FFR=0.88
FFR=0.88


FFR=0.84





Potential Limitations of FFR

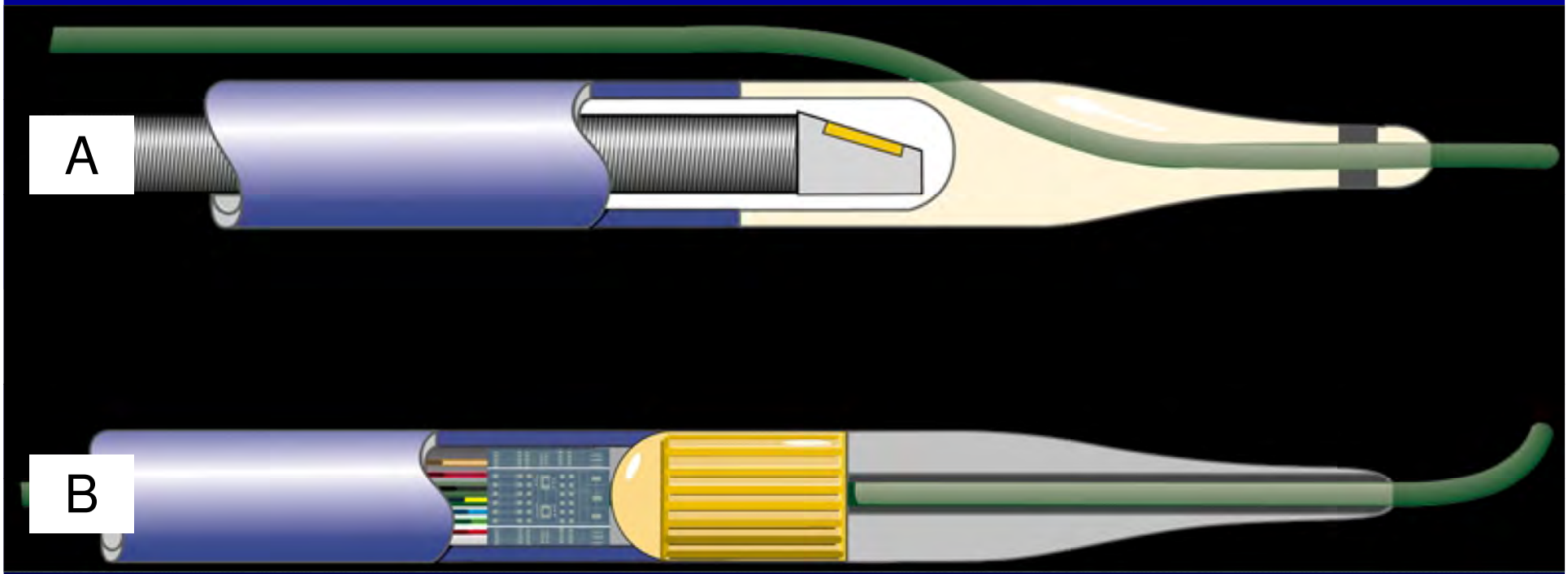
- False negative: ACS, Microvascular disease, Elevated RAP
- LMCA / CABG graft lesions- excluded from FAME
- Assessment of optimal PCI result

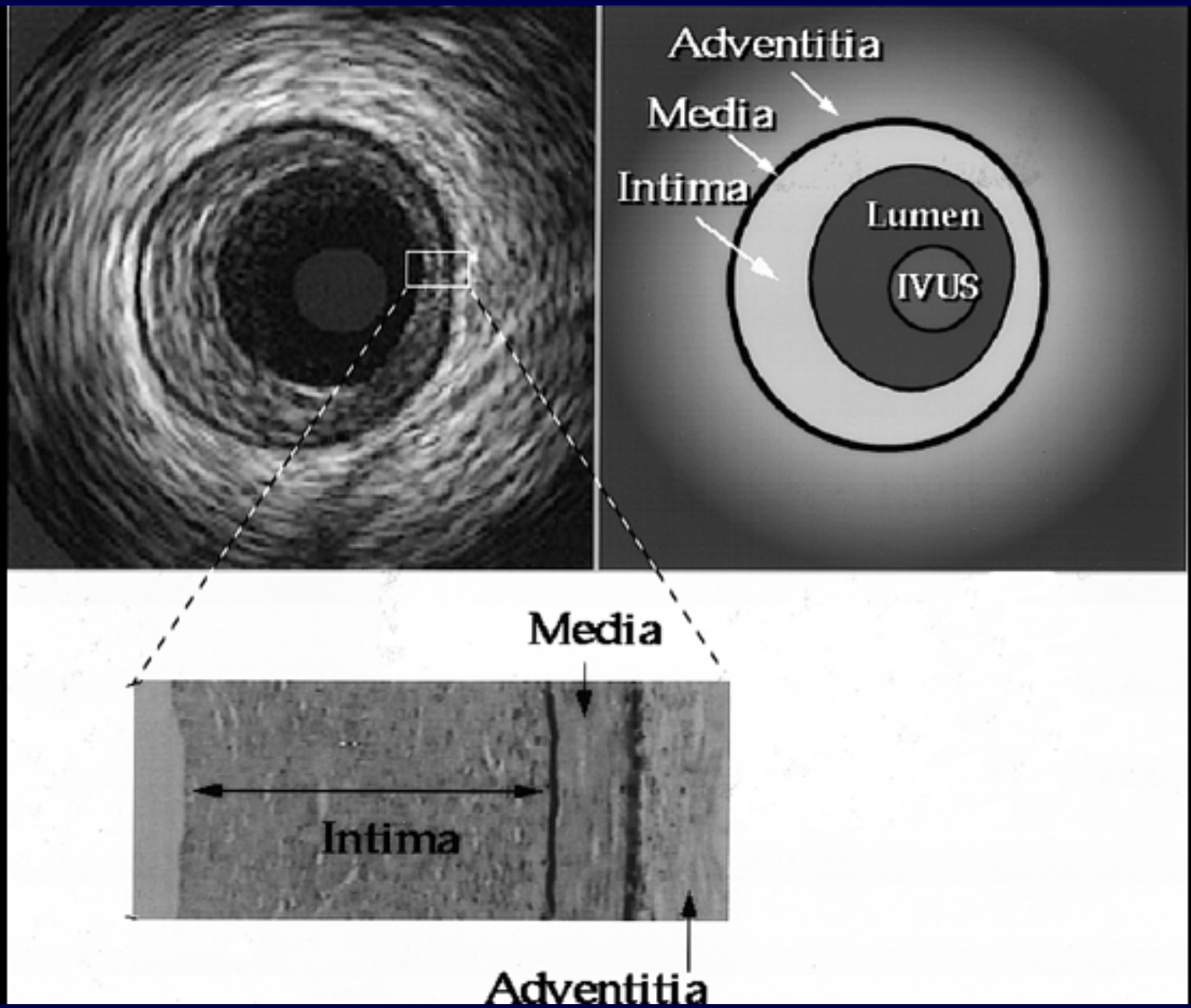
IVUS / OCT

- Accurate visualization of coronary anatomy
- Analysis of plaque composition & distribution, vessel and lumen geometry
- Identify dissections, stent apposition etc…
- Virtual histology

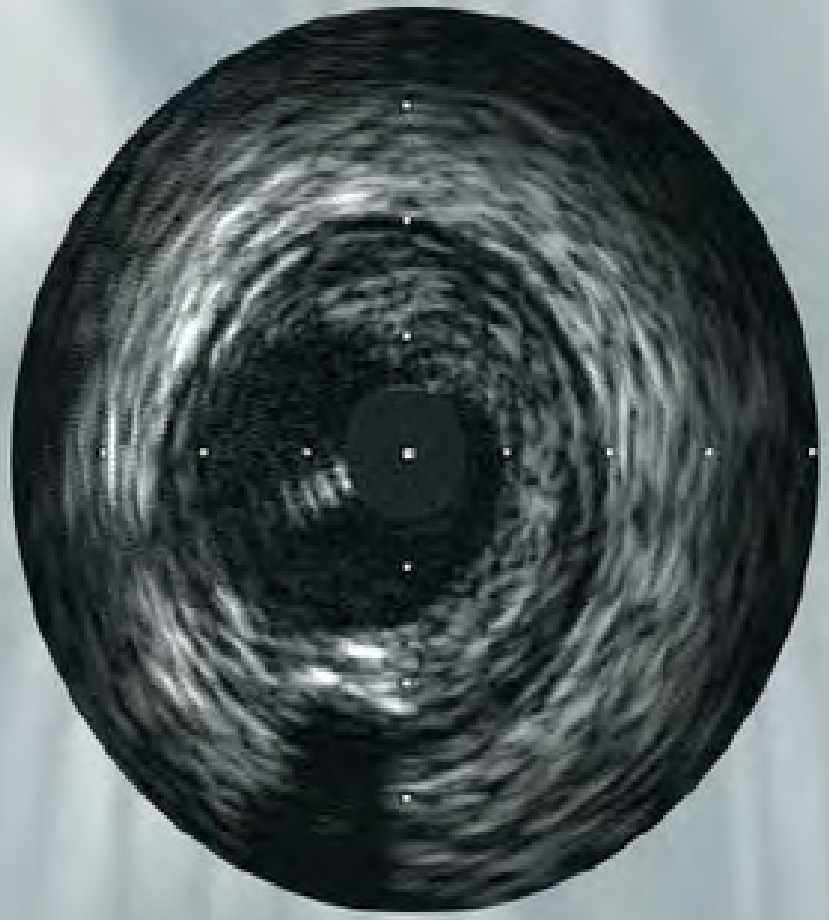
IVUS Transducers

A: Mechanical rotating transducer
B: Electronic phased array



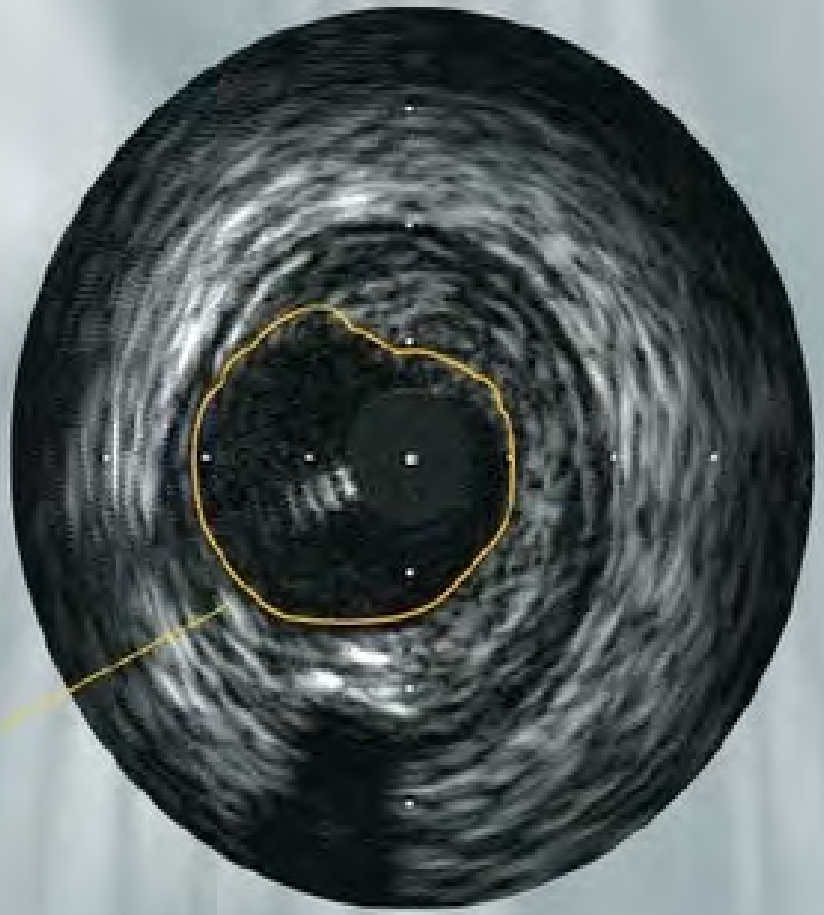

Adventitia
Media
Intima
Lumen
IVUS
Media
Intima
Adventitia

Measurement and Analysis



Boston Scientific
SCIMED

Calculating - Area and % Stenosis



Boston Scientific
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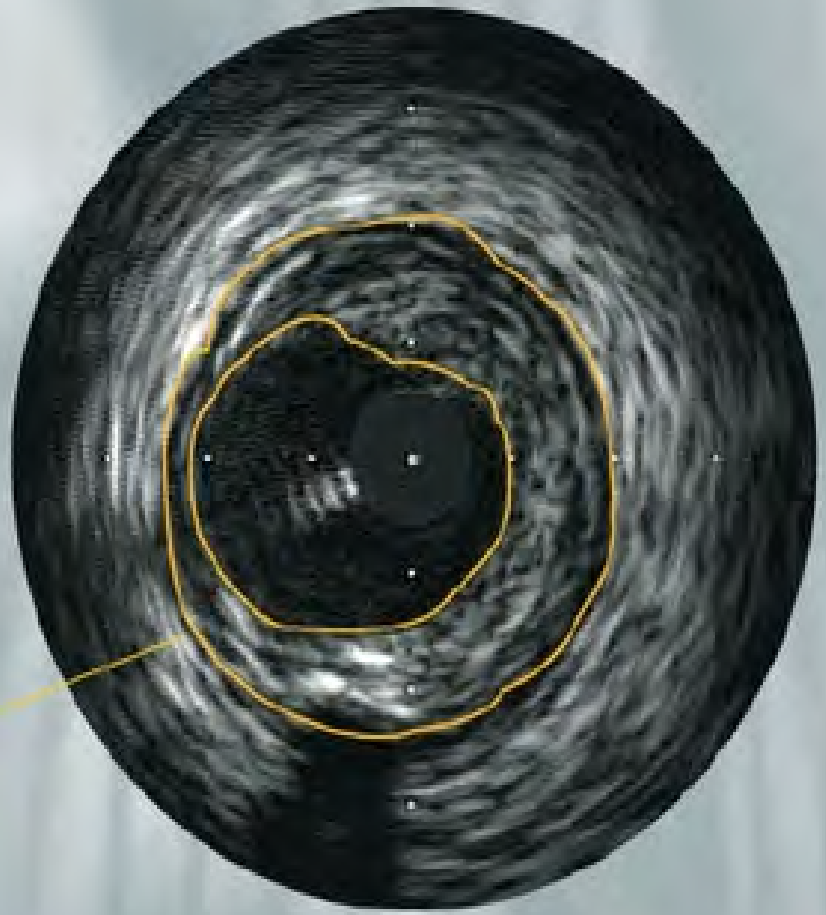
Calculating - Area and % Stenosis



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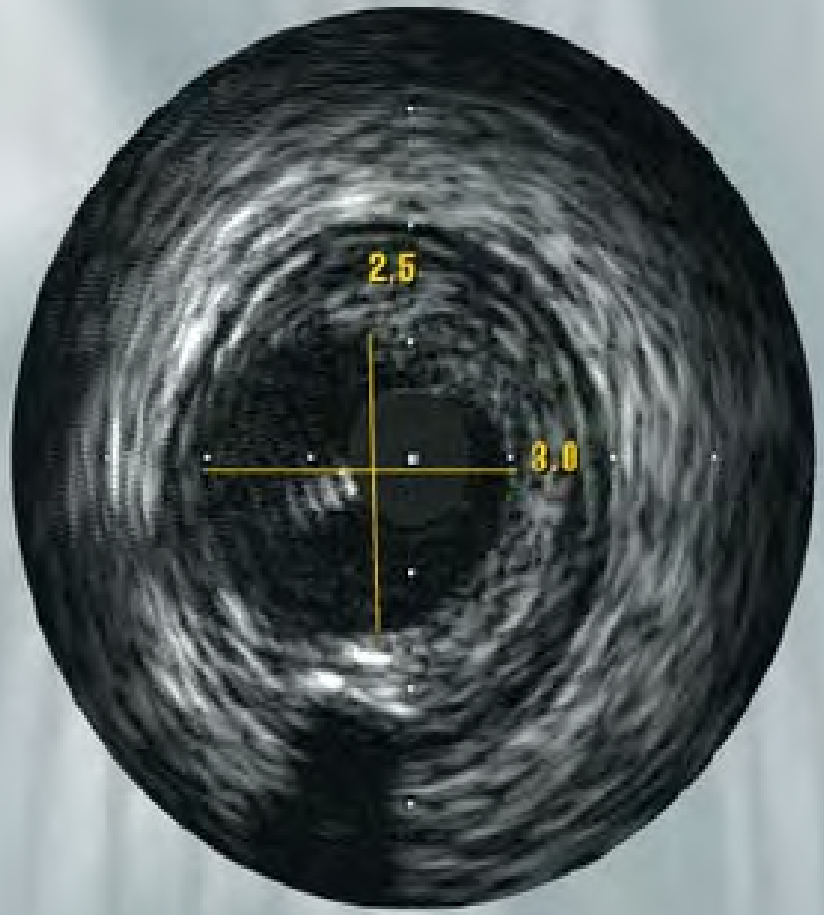
Lumen Diameter Measurements



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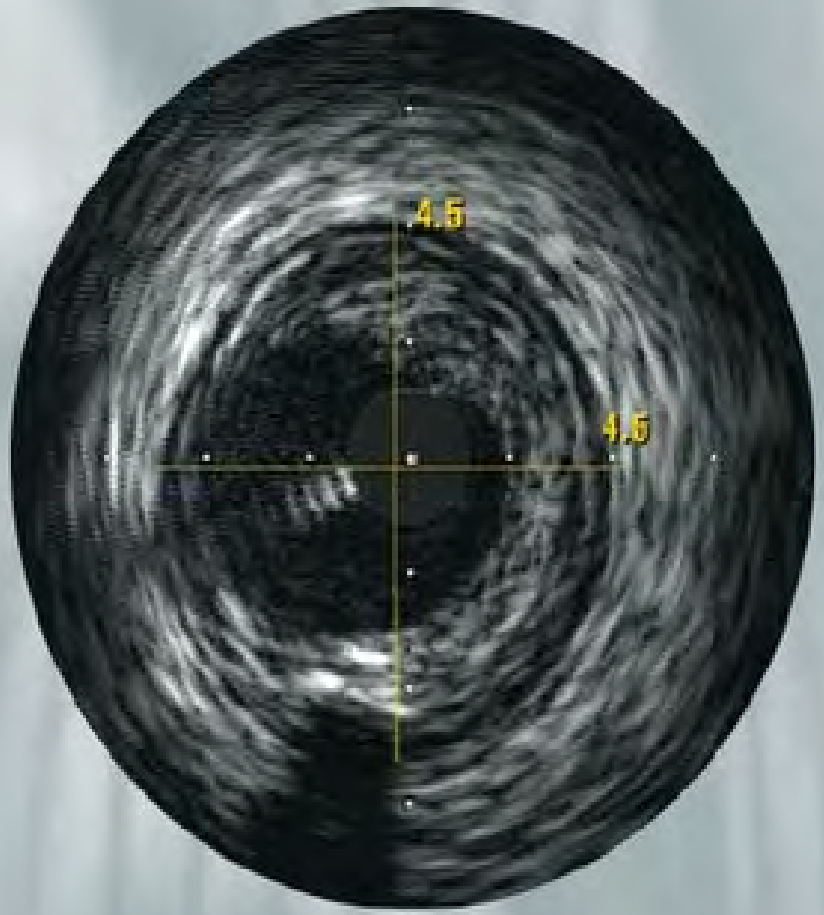
Vessel Diameter Measurements



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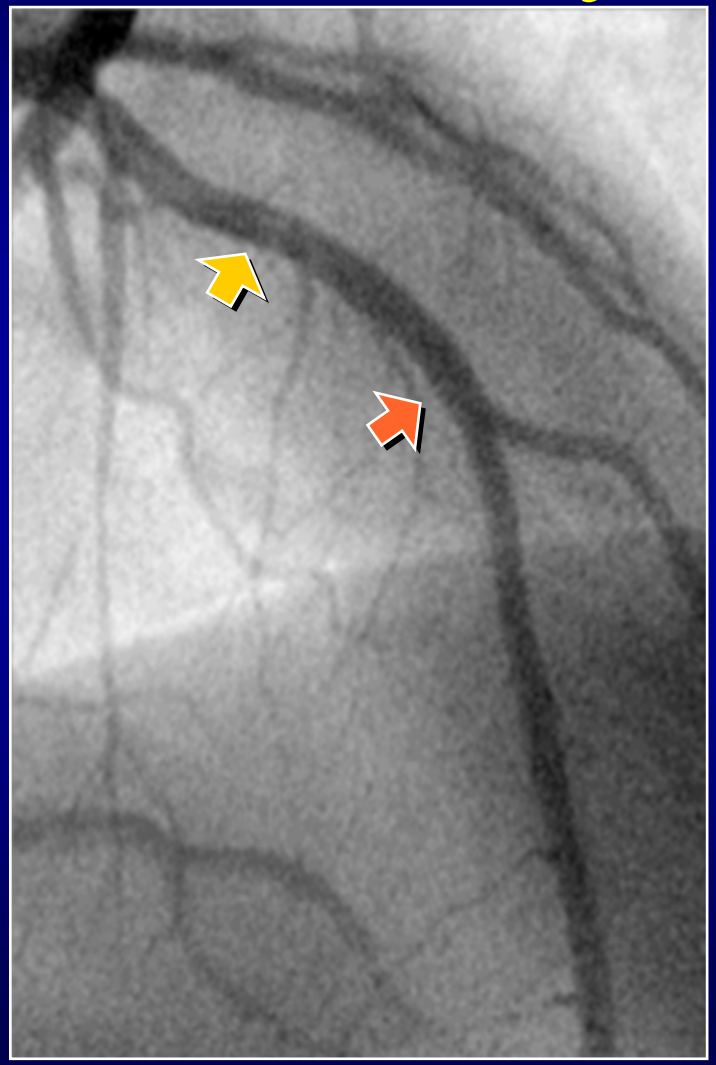
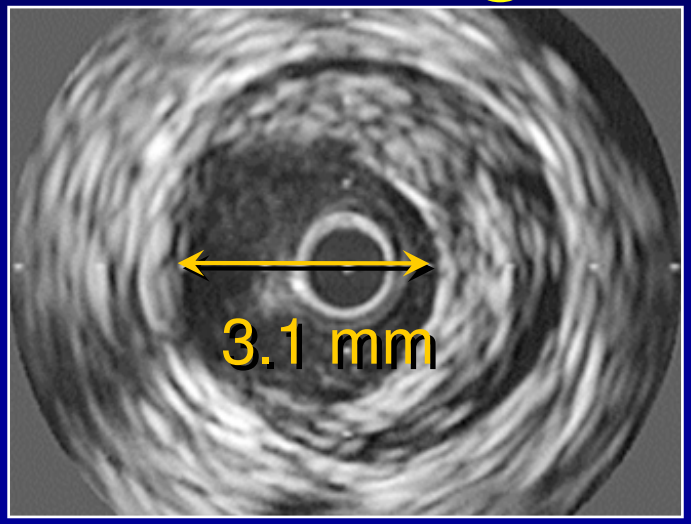
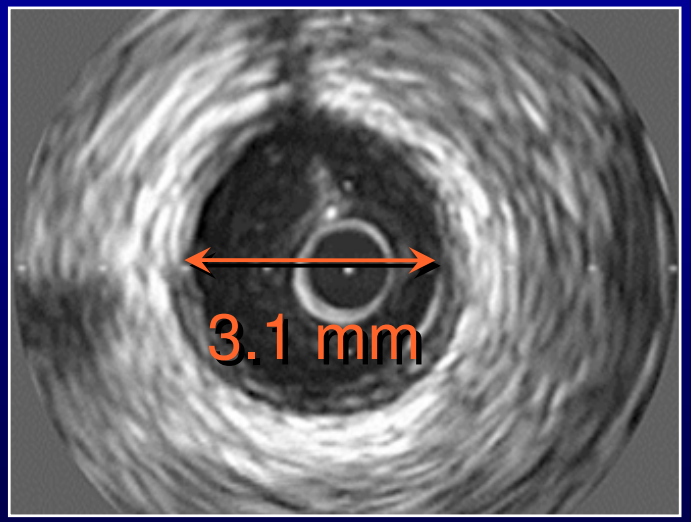
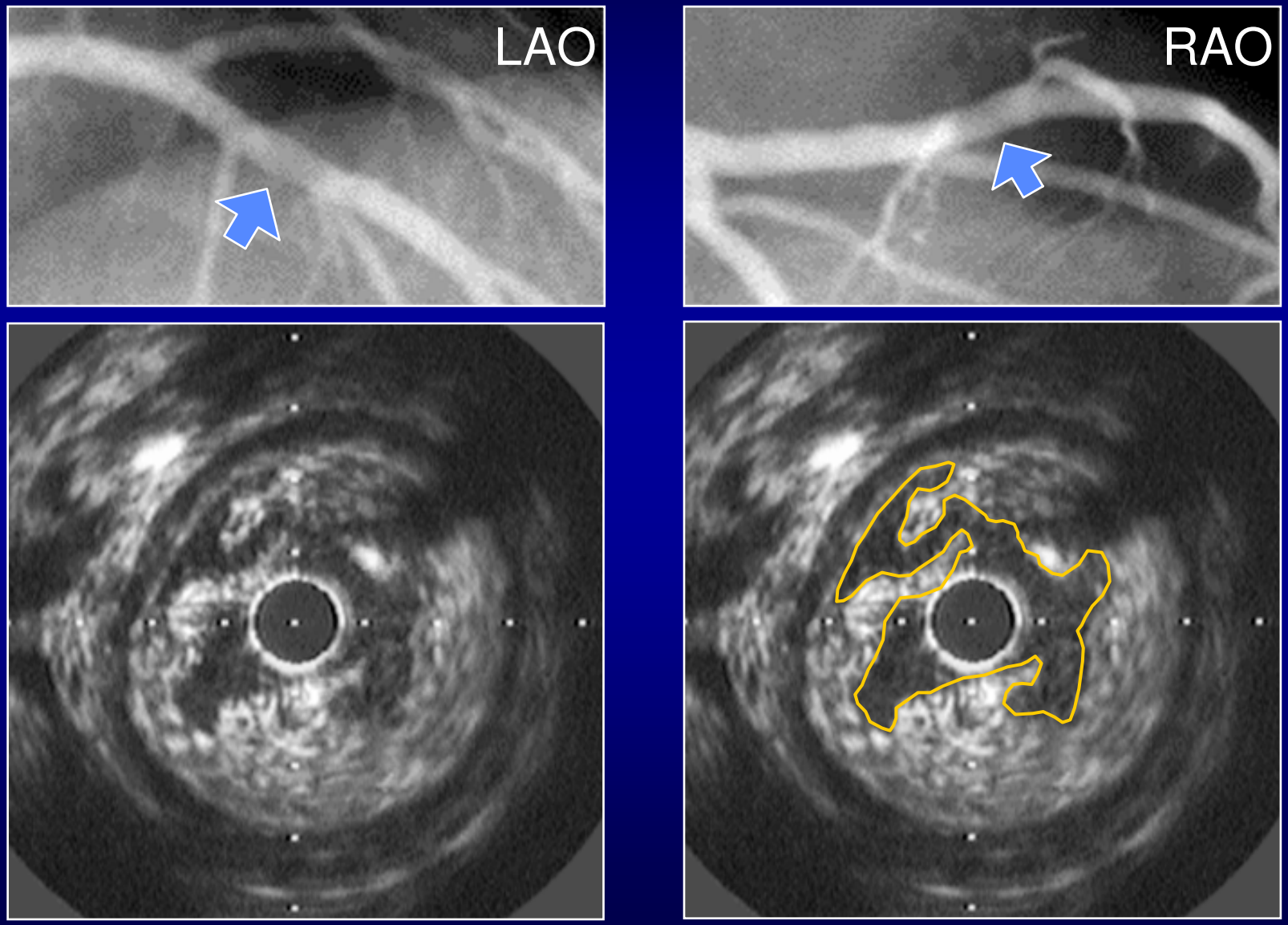
Angiography Cannot Account for Coronary Remodeling



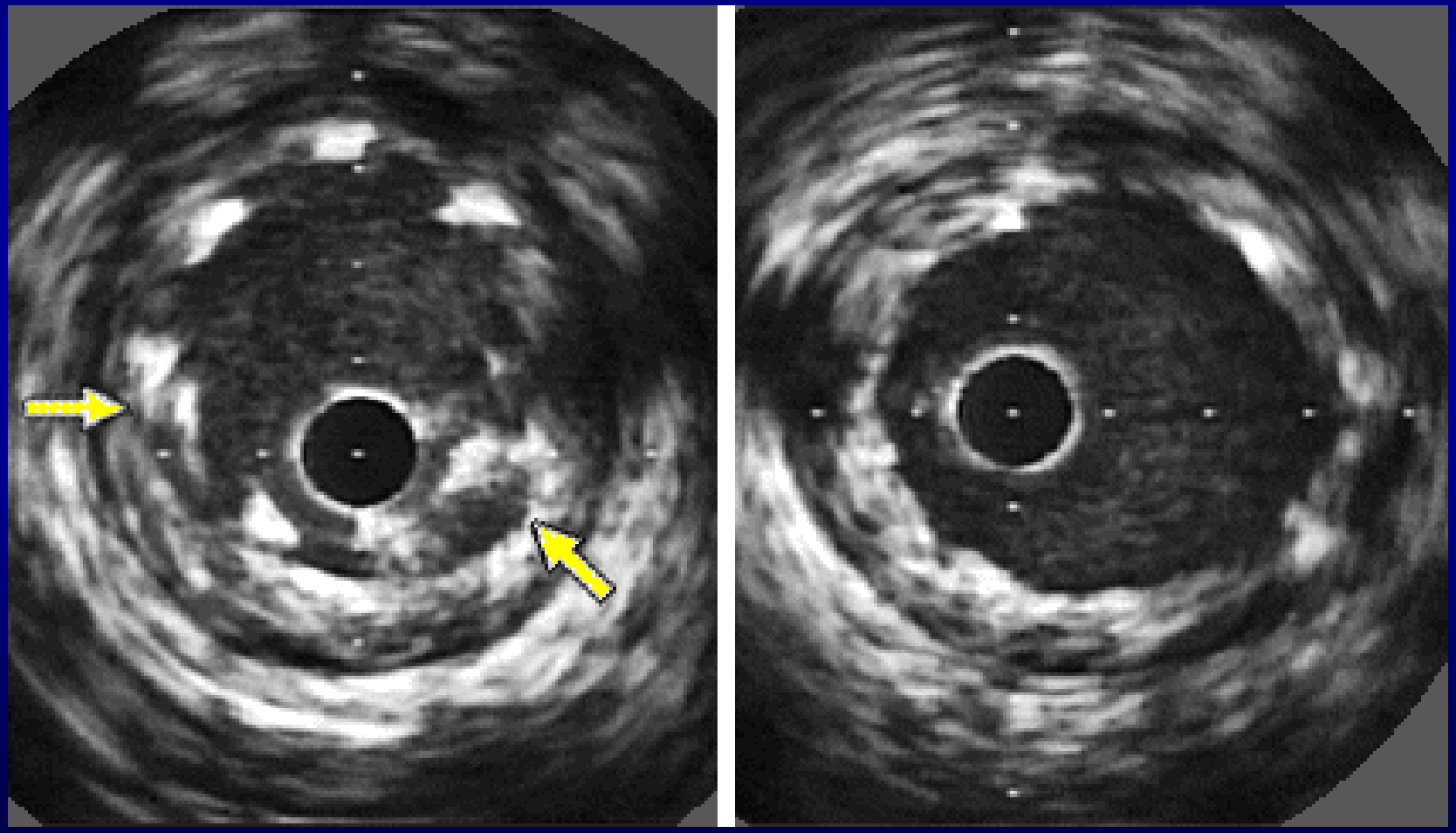




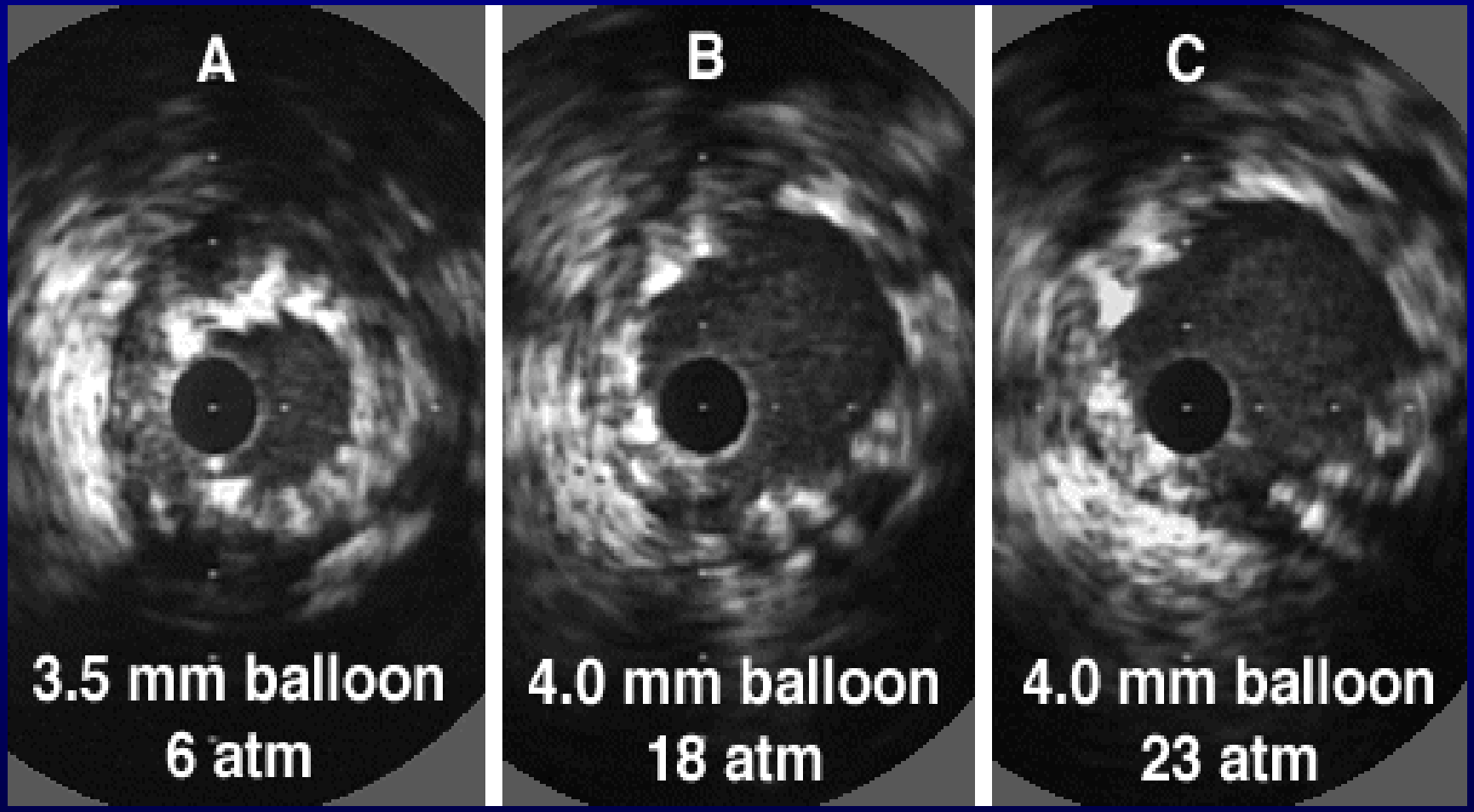
Angiography Masks Complicated Lesions



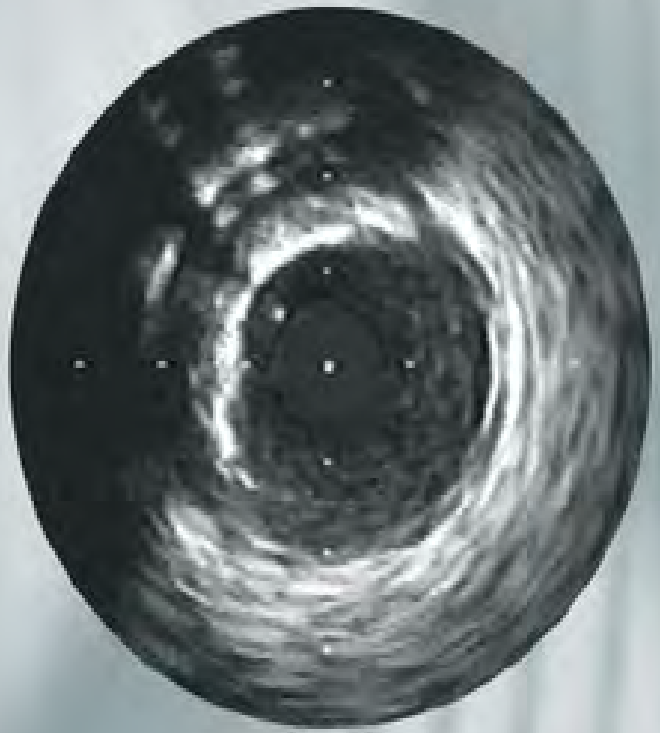
IVUS GUIDED STENT DEPLOYMENT



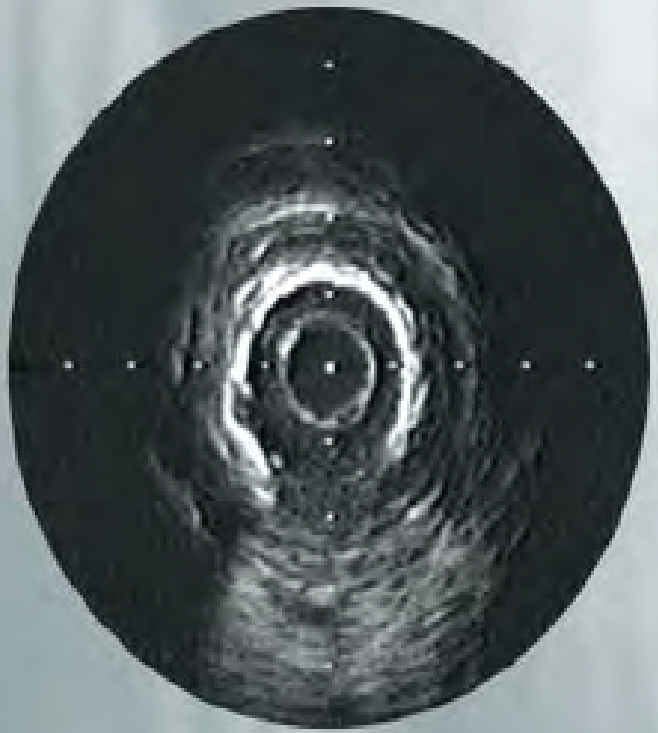
IVUS GUIDED STENT DEPLOYMENT



Calcified plaque (continued)

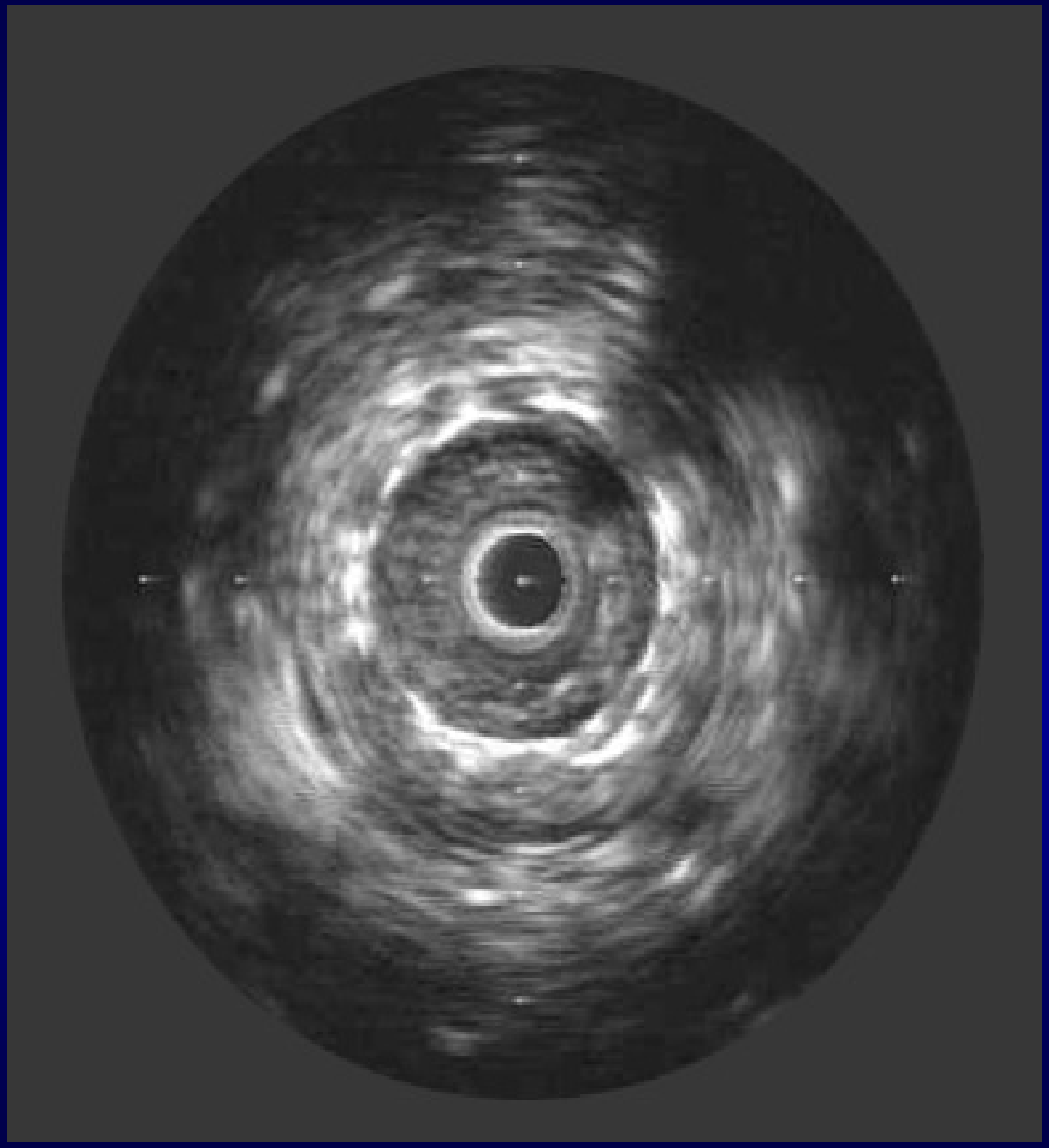


180° arc of eccentric superficial calcified plaque



270° arc of superficial calcified plaque

Boston Scientific
SCIMED



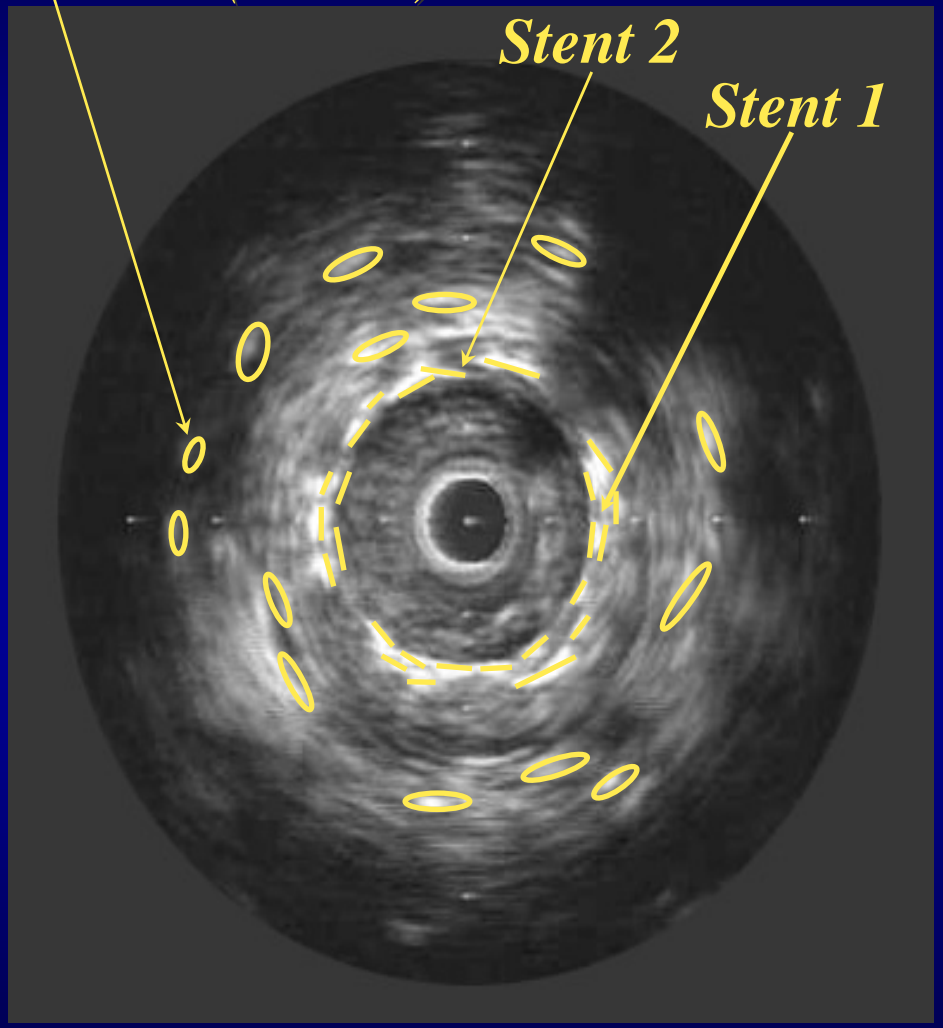
How many previous stents have been placed in this lesion?

1) 1

2) 2

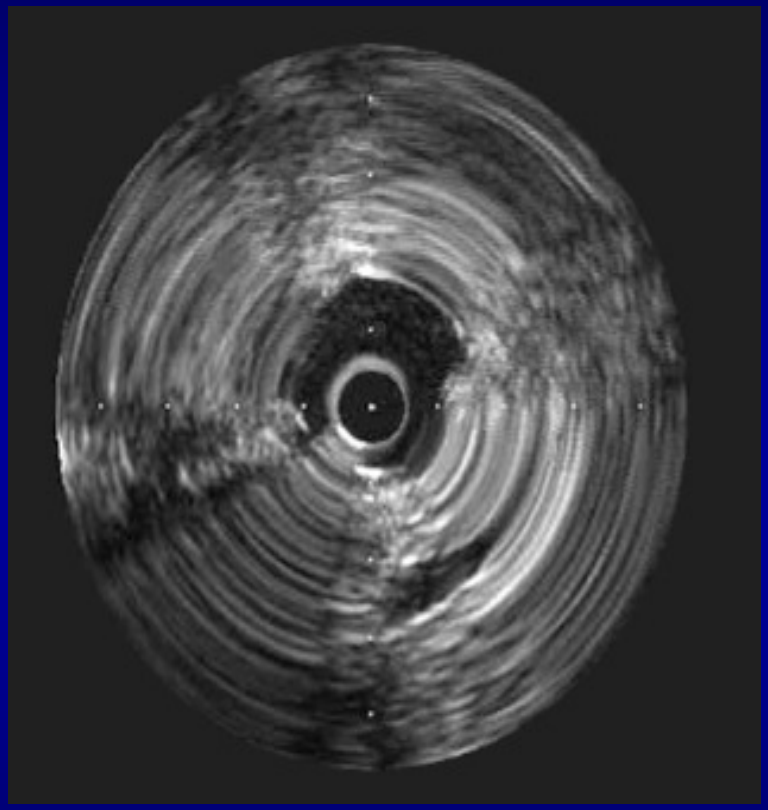
3) 3

Reflection of the stent as the sound wave bounces between stent and catheter (reverb)



How many previous stents have been placed in this lesion?

2) 2



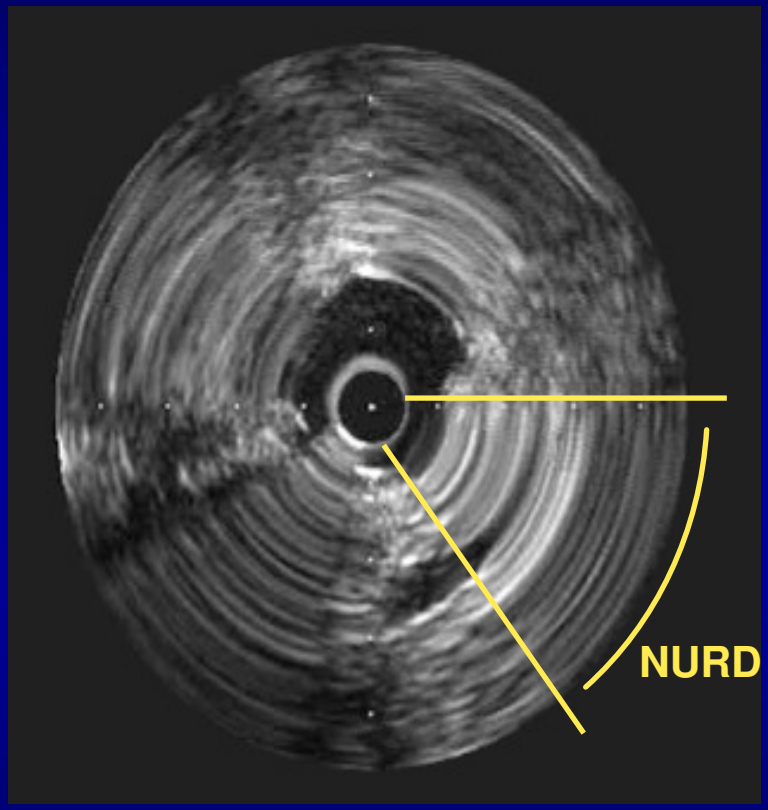
The most likely cause of this image is:

1) Inadequate flushing

2) Bend in catheter

3) Calcified Plaque

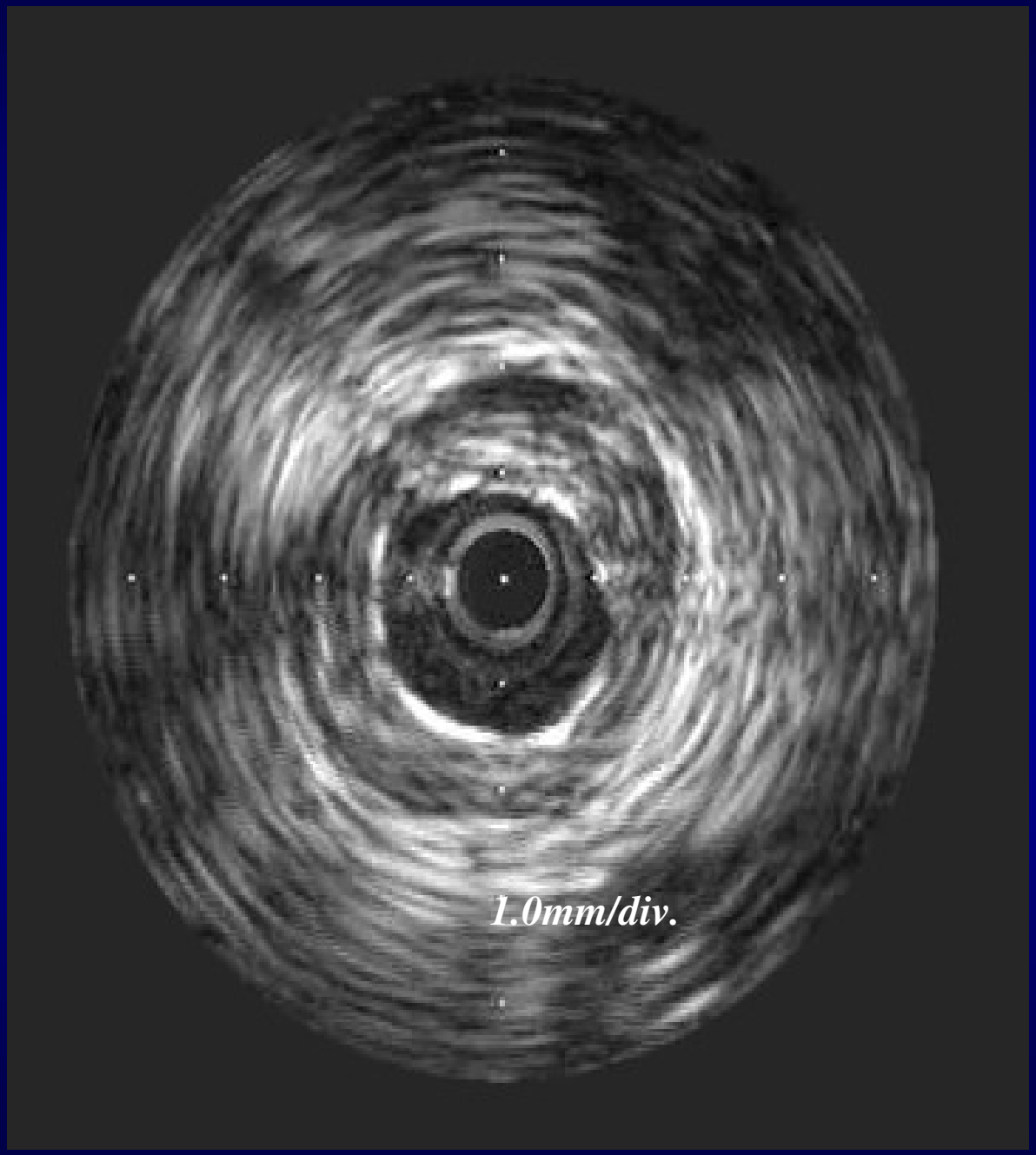
4) Wrong Frequency



The most likely cause of this image is:

2) Bend in catheter

A bend in a mechanical IVUS catheter may cause unnecessary friction and generate Non-Uniform Rotational Distortion (NURD), which results in a smeared image. This affect can be minimized by removing bends in the catheter and checking the tension on the Y-adaptor. NURD can also occur when imaging in torturous anatomy.



What is the present diameter of the stent?

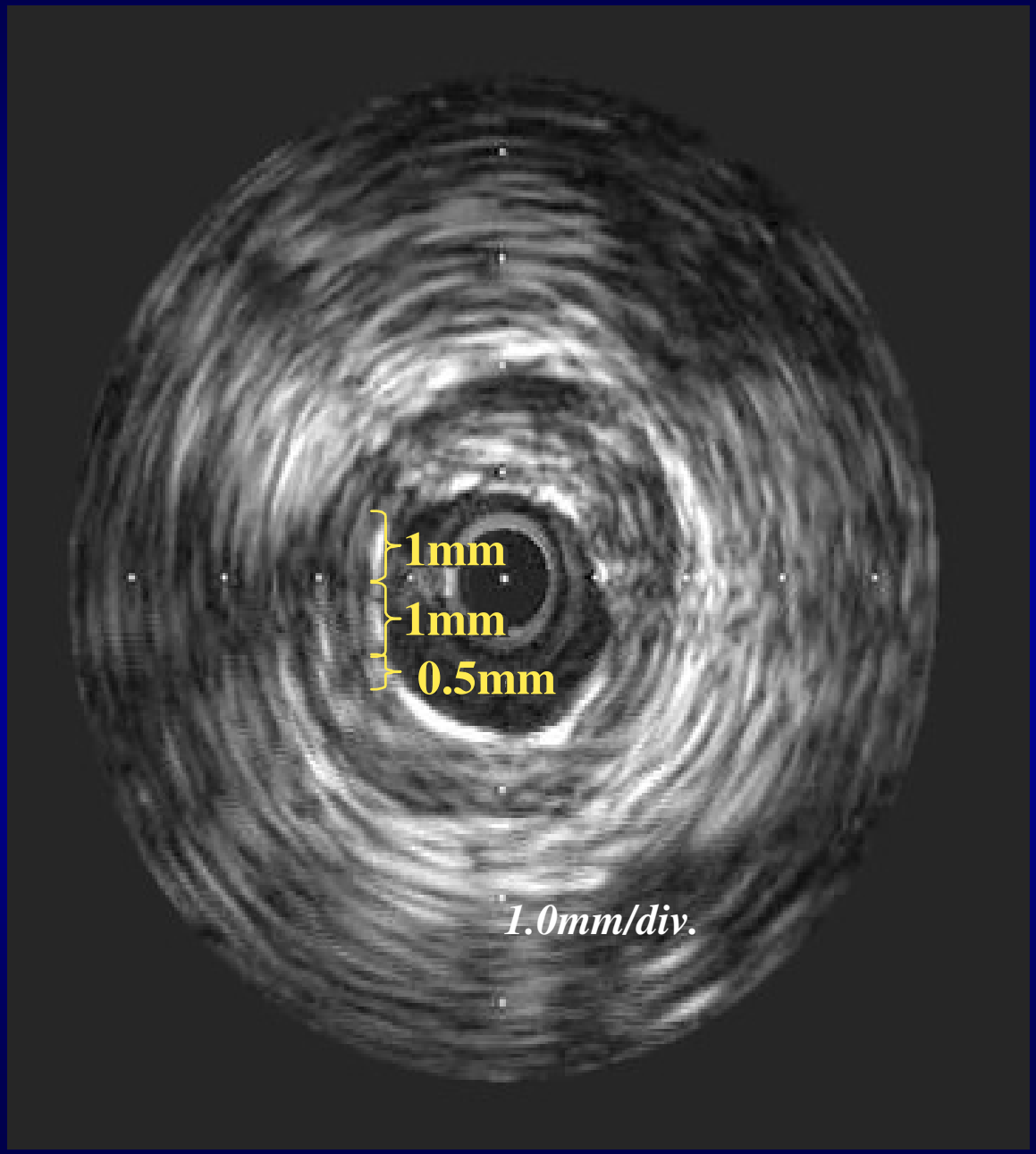
1) 2.0mm

2) 2.5mm

3) 3.0mm

4) 4.5mm

5) 4.0mm



What is the present diameter of the stent?

2) 2.5 mm

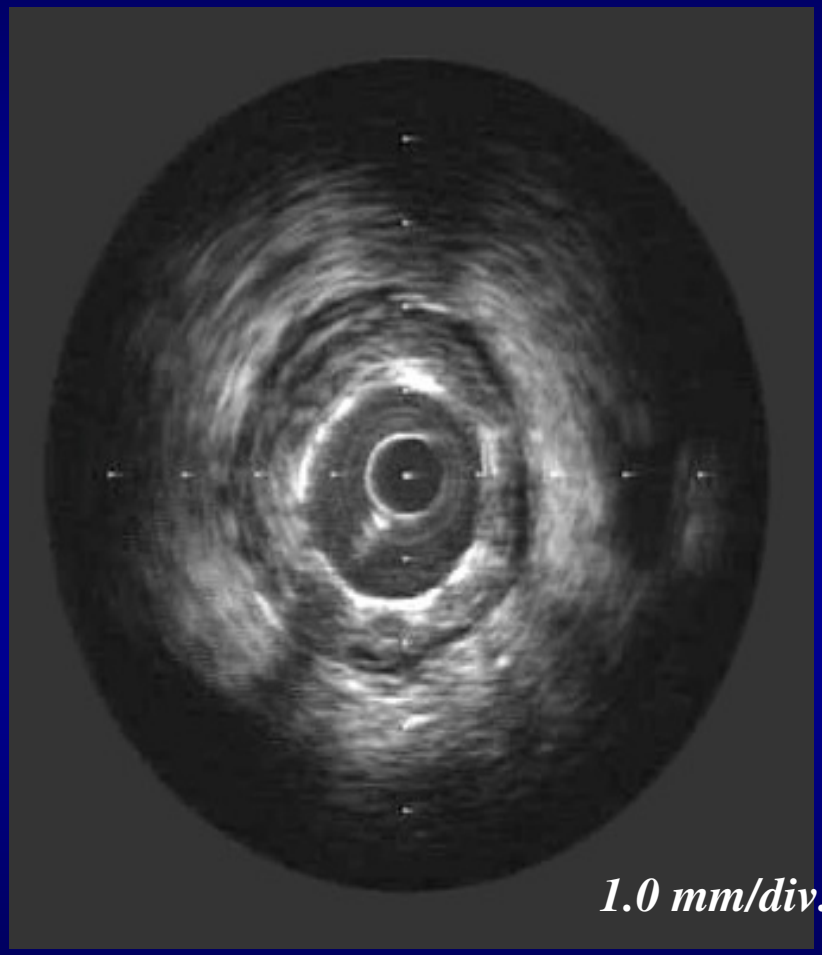
Since each division is 1 mm, the diameter is approximately 2.5 mm.

What size balloon should be used to adequately deploy this stent?

1) 3.0 mm

2) 4.0 mm

3) 5.0 mm



What size balloon should be used to adequately deploy this stent?

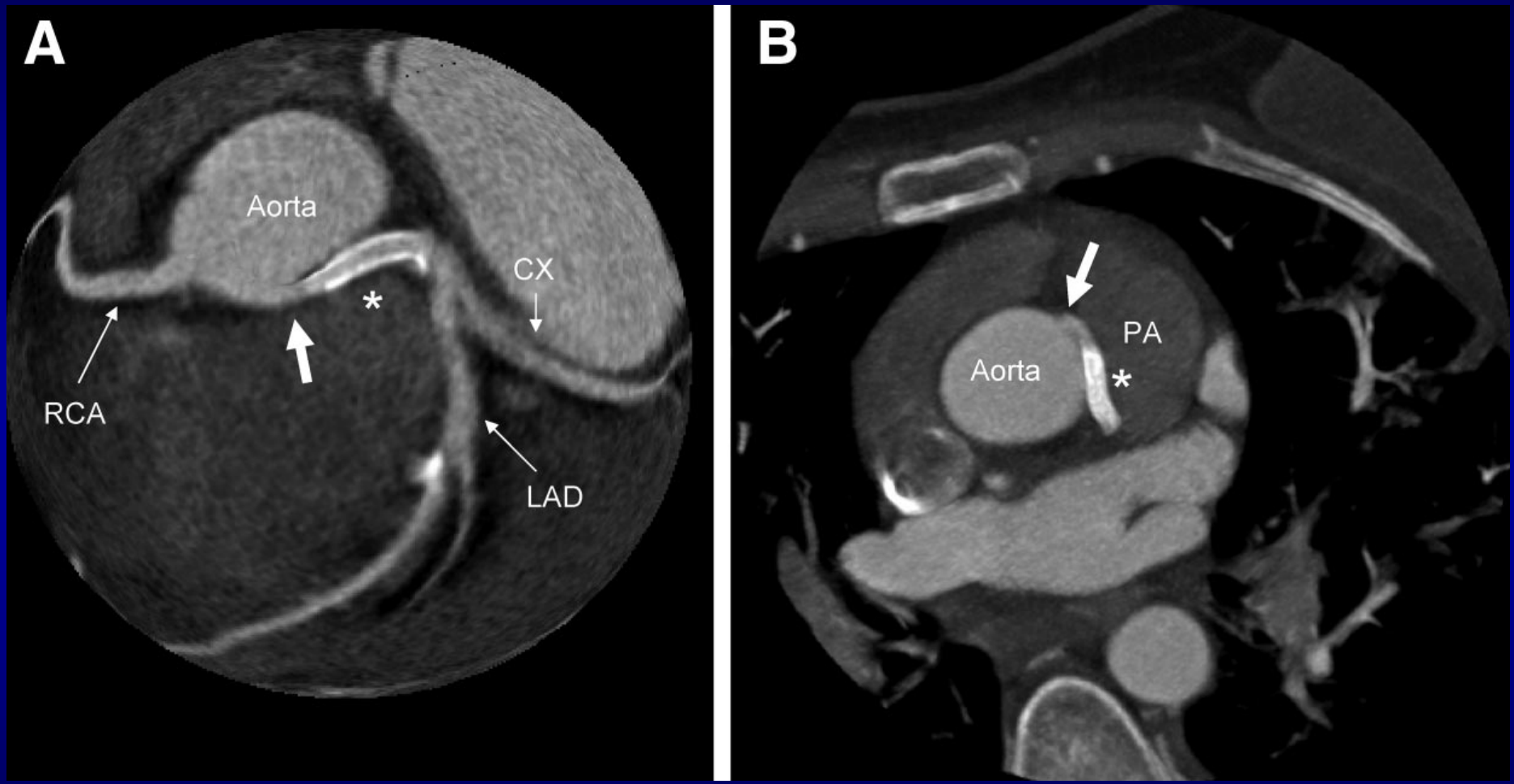
2) 4.0mm

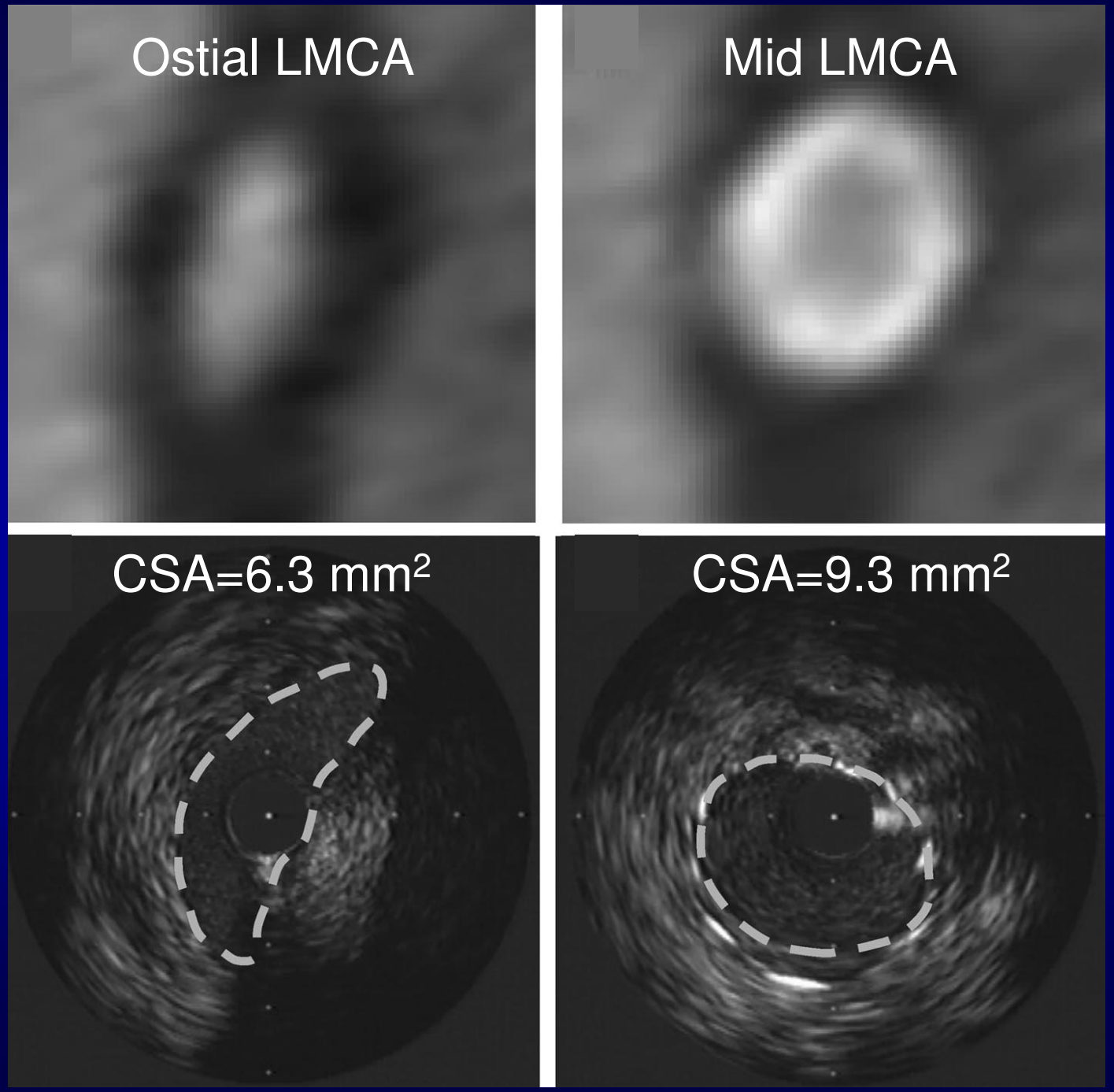
The external elastic lamina (EEL) appears to be 4.0 mm and the lesion is primarily fibrofatty plaque. Therefore, a 4.0 mm balloon should produce the desired result.

IVUS

- Threshold for PCI (vs FFR/CFR)
  - LMCA: CSA=6 mm^2
  - Prox vessels: CSA=4 mm^2
- Missing: Robust outcome data
- IVUS less specific than FFR for ischemia
- “If you want PCI then IVUS, if not-then FFR”

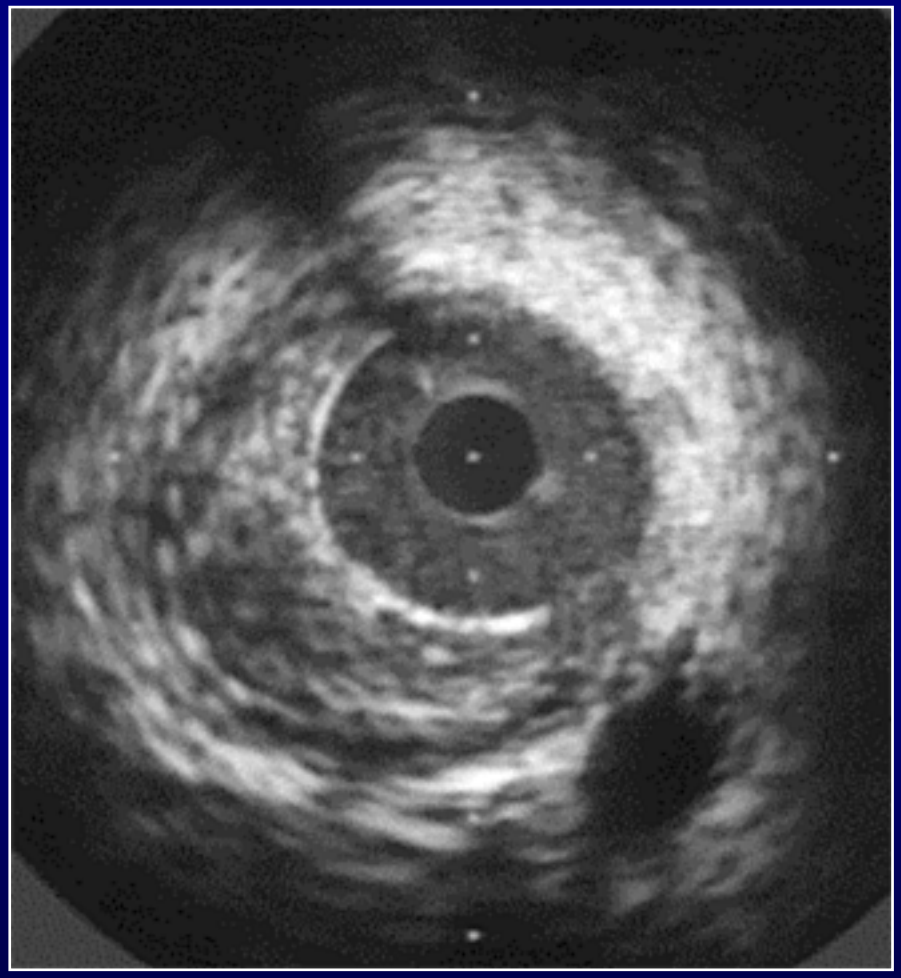
- 48-year old woman
- Extensive anterior STEMI with RBBB
- Cardiogenic shock
- Cardiac arrest-2.5 hours CPR with 20 DC shock
- Finally located and stented an anomalous origin LMCA


A
Aorta
CX
*
RCA
LAD
B
PA
Aorta
*

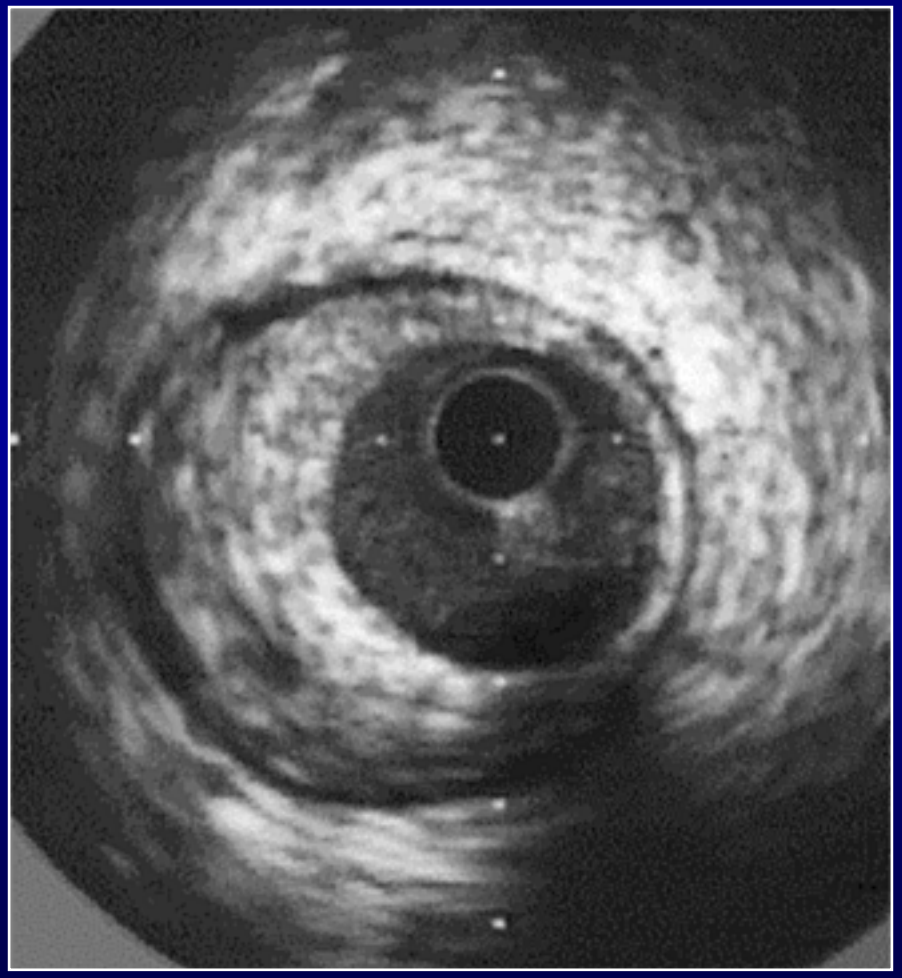

Ostial LMCA
Mid LMCA
CSA=6.3 mm²
CSA=9.3 mm²

Same Lumen Size: Different Atheromas

Thin Cap With Lipid Core

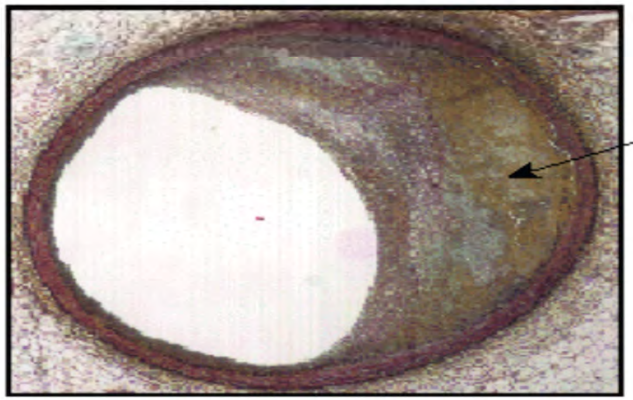


Thick Stable Fibrotic Cap



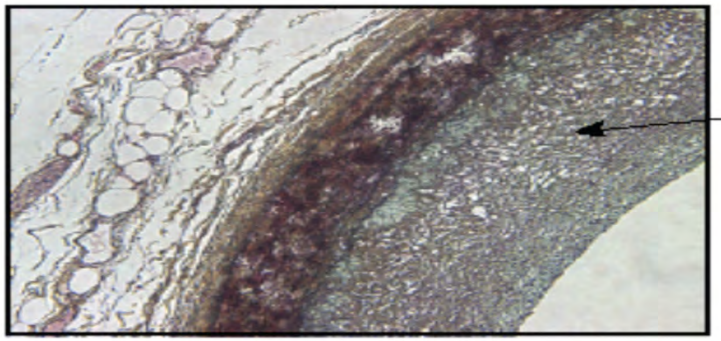
Fibrous

Densely packed bundles of collagen fibers with no evidence of intra-fiber lipid accumulation. No evidence of macrophage infiltration. Appears dark yellow on Movat stained section.



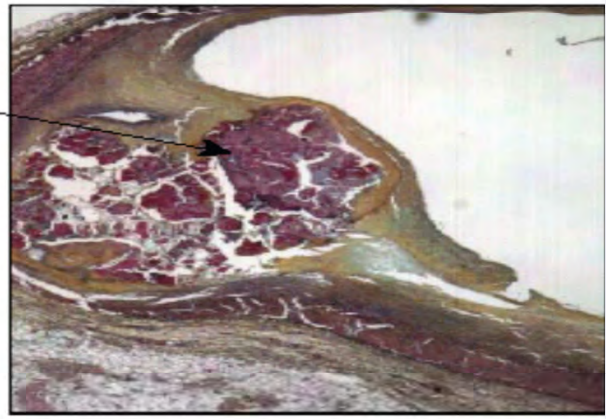
Fibro-lipidic

Loosely packed bundles of collagen fibers with regions of lipid deposition present. These areas are cellular and no cholesterol clefts or necrosis are present. Some macrophage infiltration. Increase in extracellular matrix. Appears turquoise on Movat stained section.



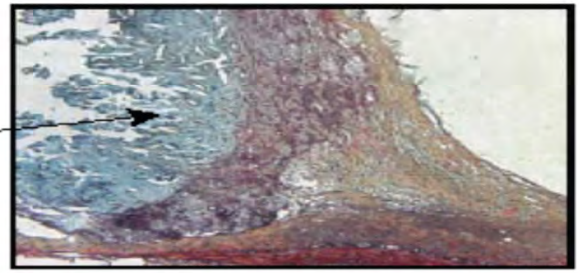
Lipid Core

Highly lipidic necrotic region with remnants of foam cells and dead lymphocytes present. No collagen fibers are visible and mechanical integrity is poor. Cholesterol clefts and micro calcifications are visible.

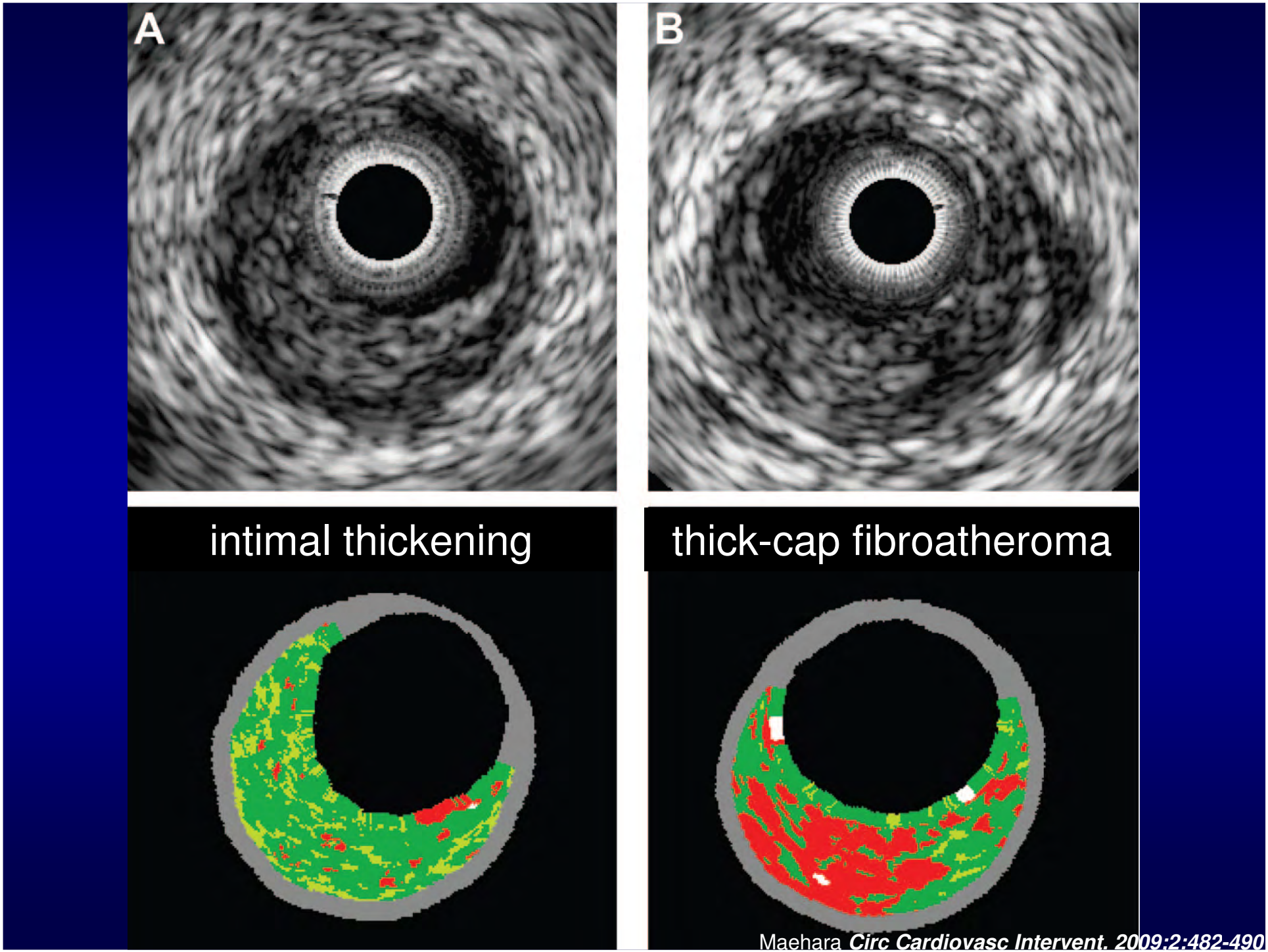


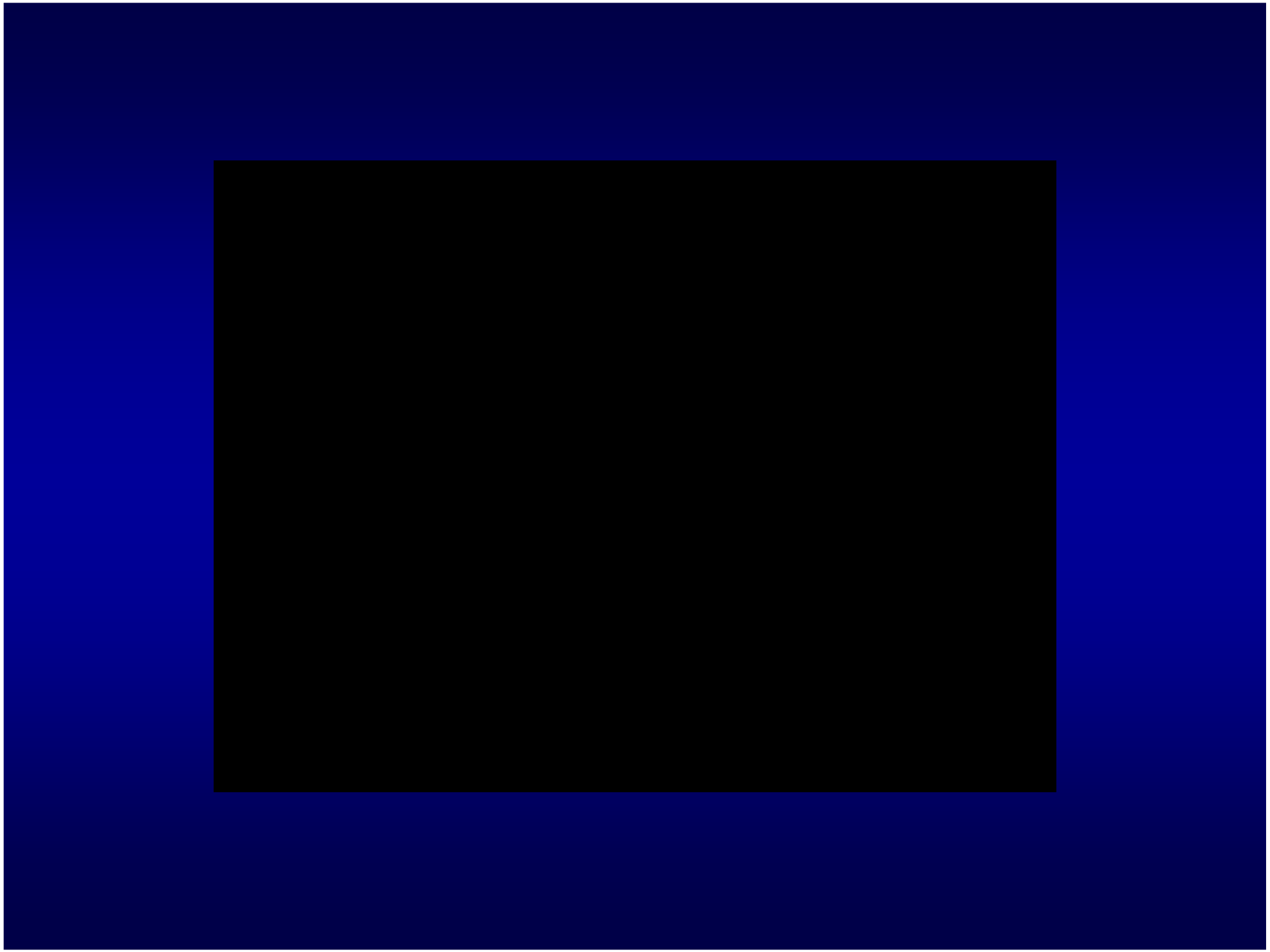
Calcium

Focal area of dense calcium. Appears purple on Movat. Usually falls out section, but calcium crystals are evident at borders.

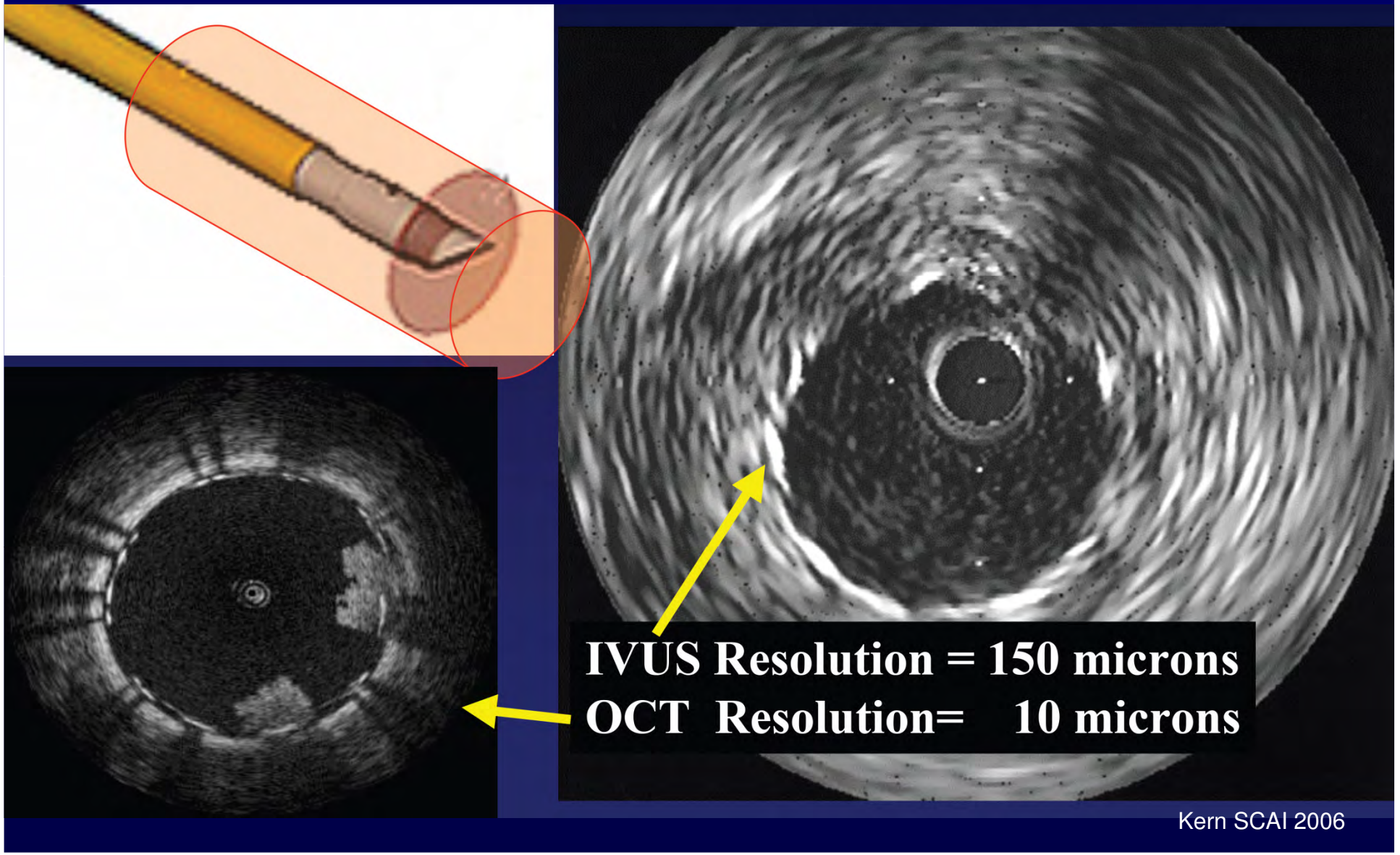


Kern SCAI 2006


A
B
intimal thickening
thick-cap fibroatheroma
Maehara *Circ Cardiovasc Intervent. 2009:2:482-490*

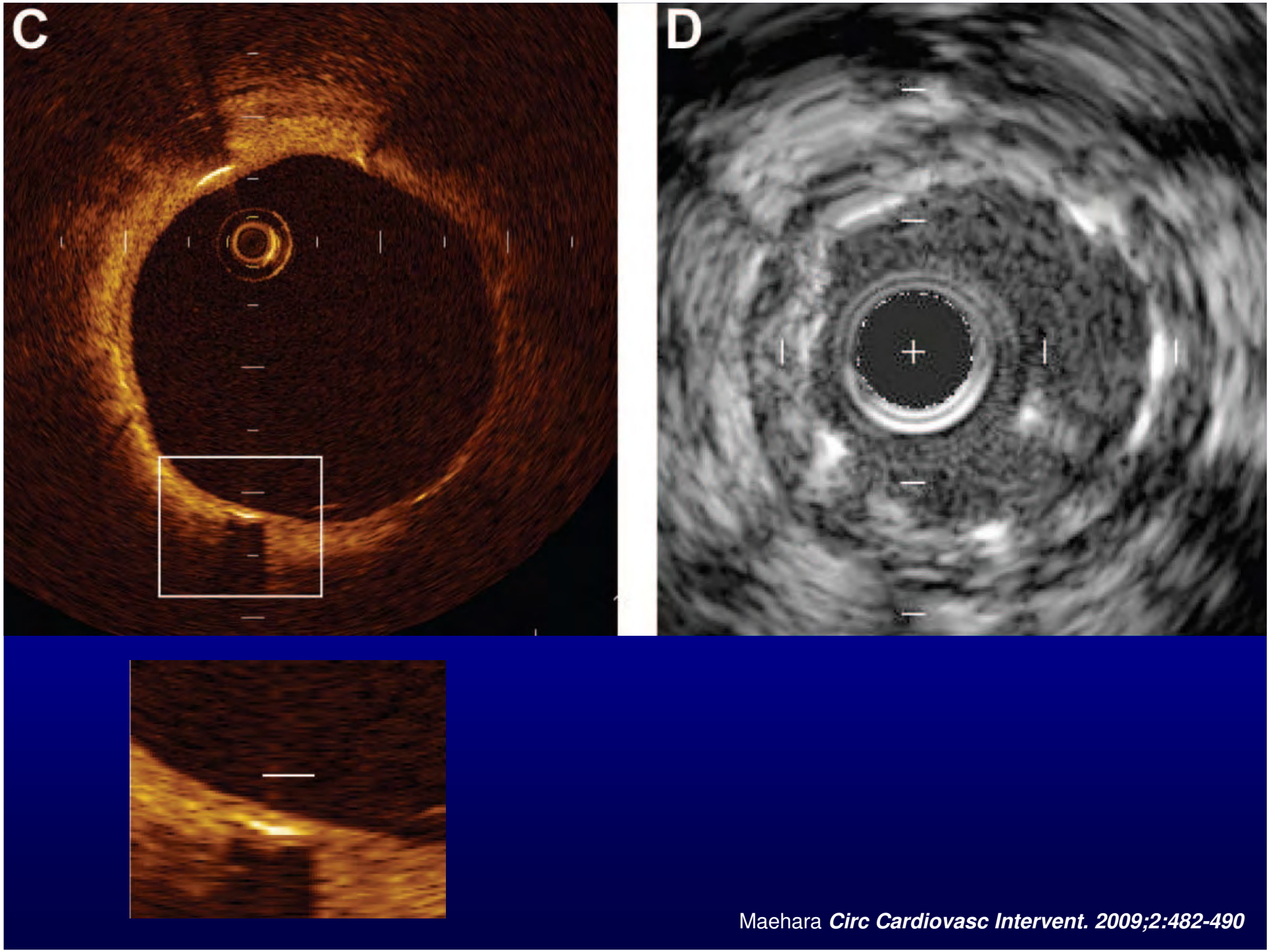


IVUS vs. OCT



	OCT	IVUS
Resolution	15 µm	100 µm
Penetration*	2 mm	10 mm
Penetration requires blood clearance	Yes	No


© KURT JONES 2003

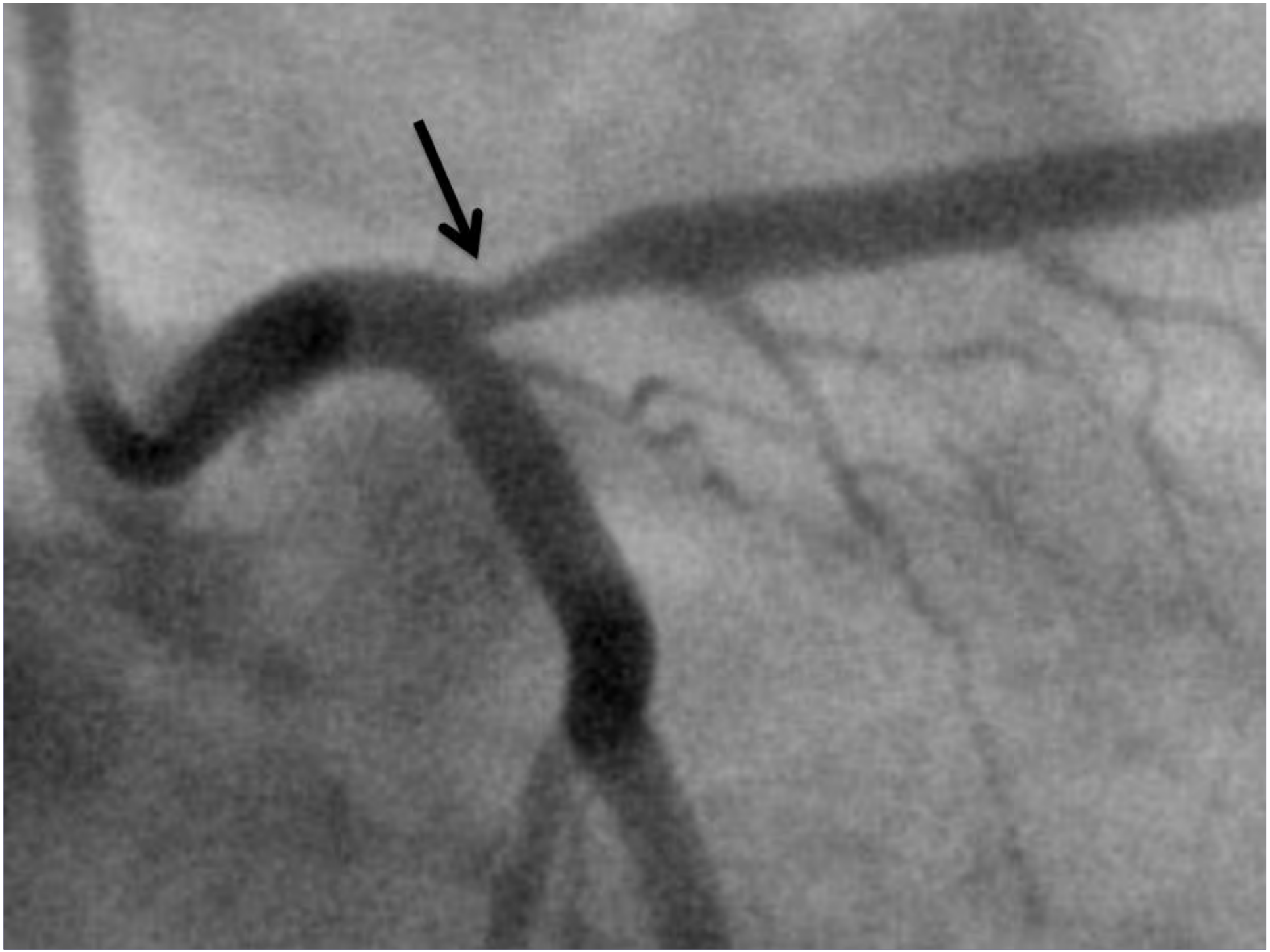


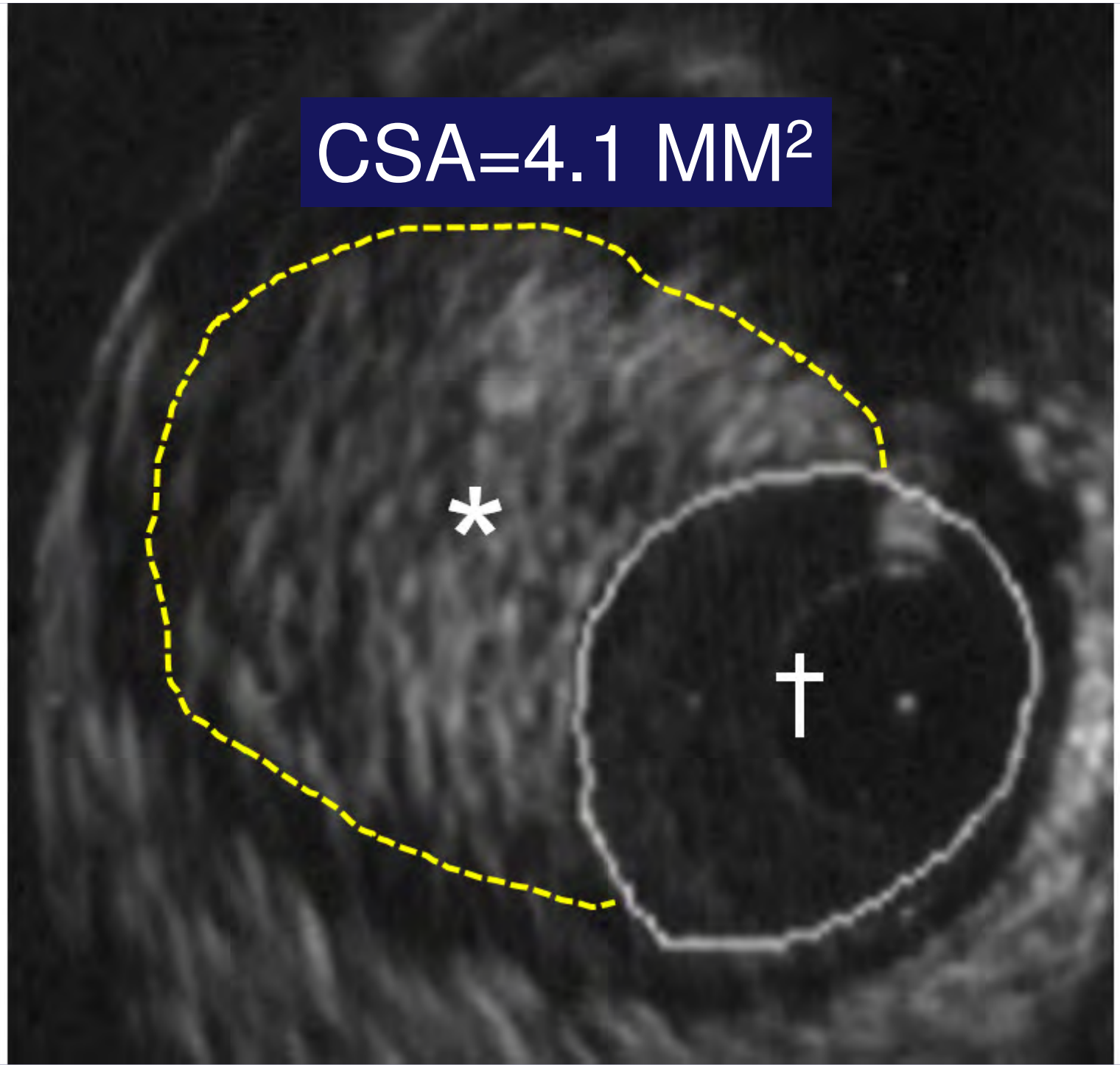
Maehara ***Circ Cardiovasc Intervent. 2009;2:482-490***

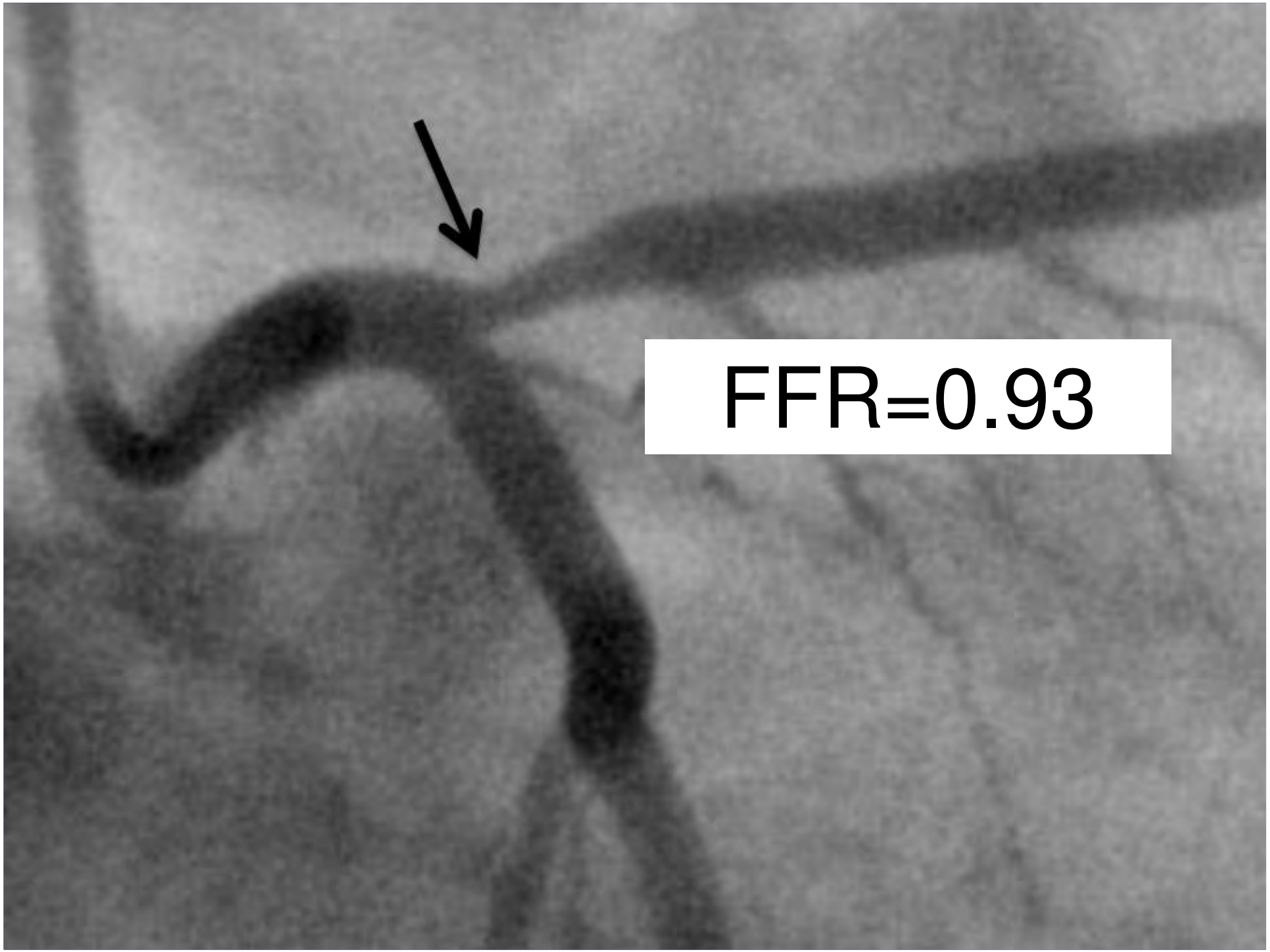
The Future?

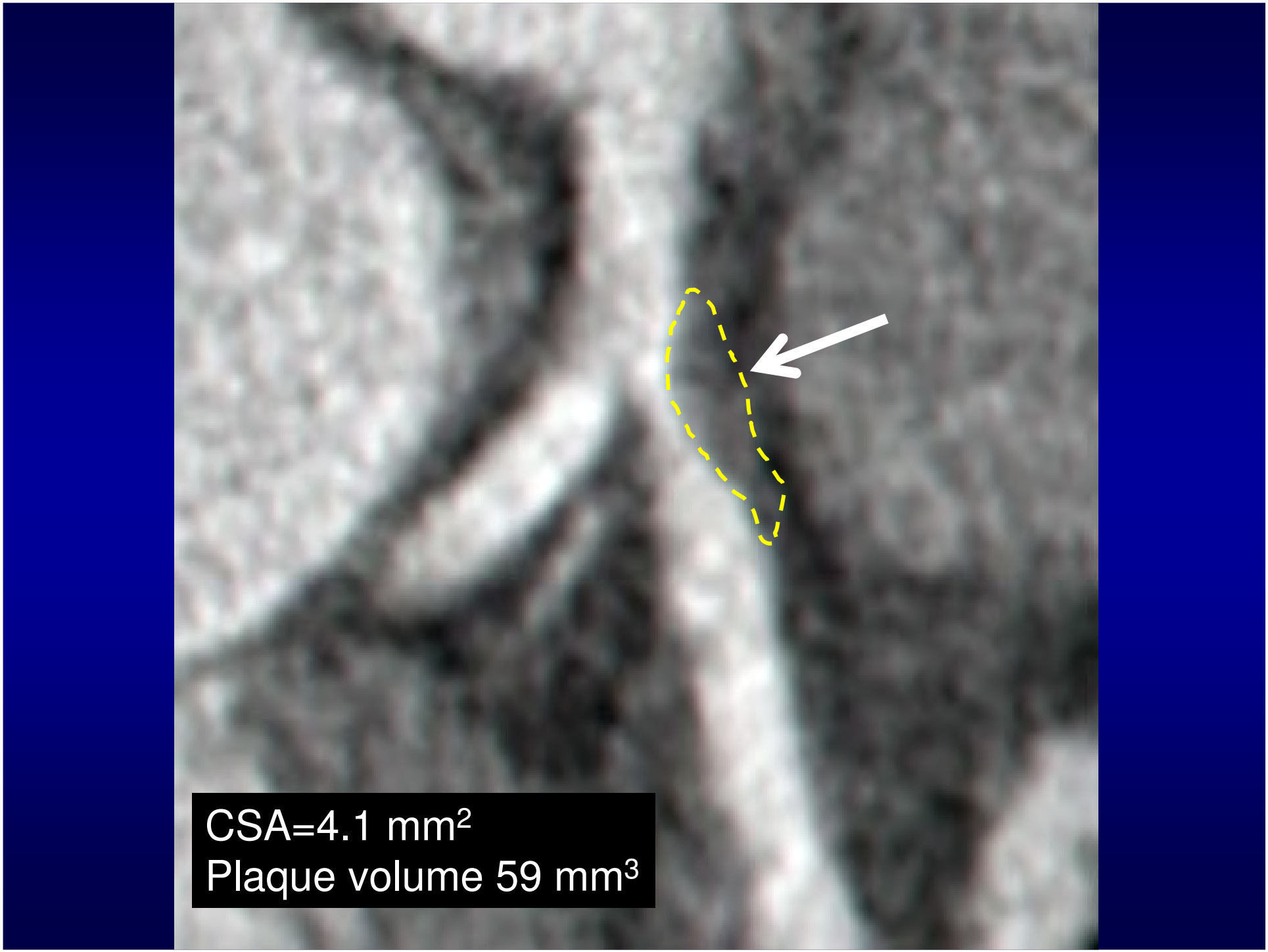
- 51 year-old diabetic woman
- Atypical angina
- ? Positive exercise test

Angiography:
≈ 50% stenosis in ostial LAD

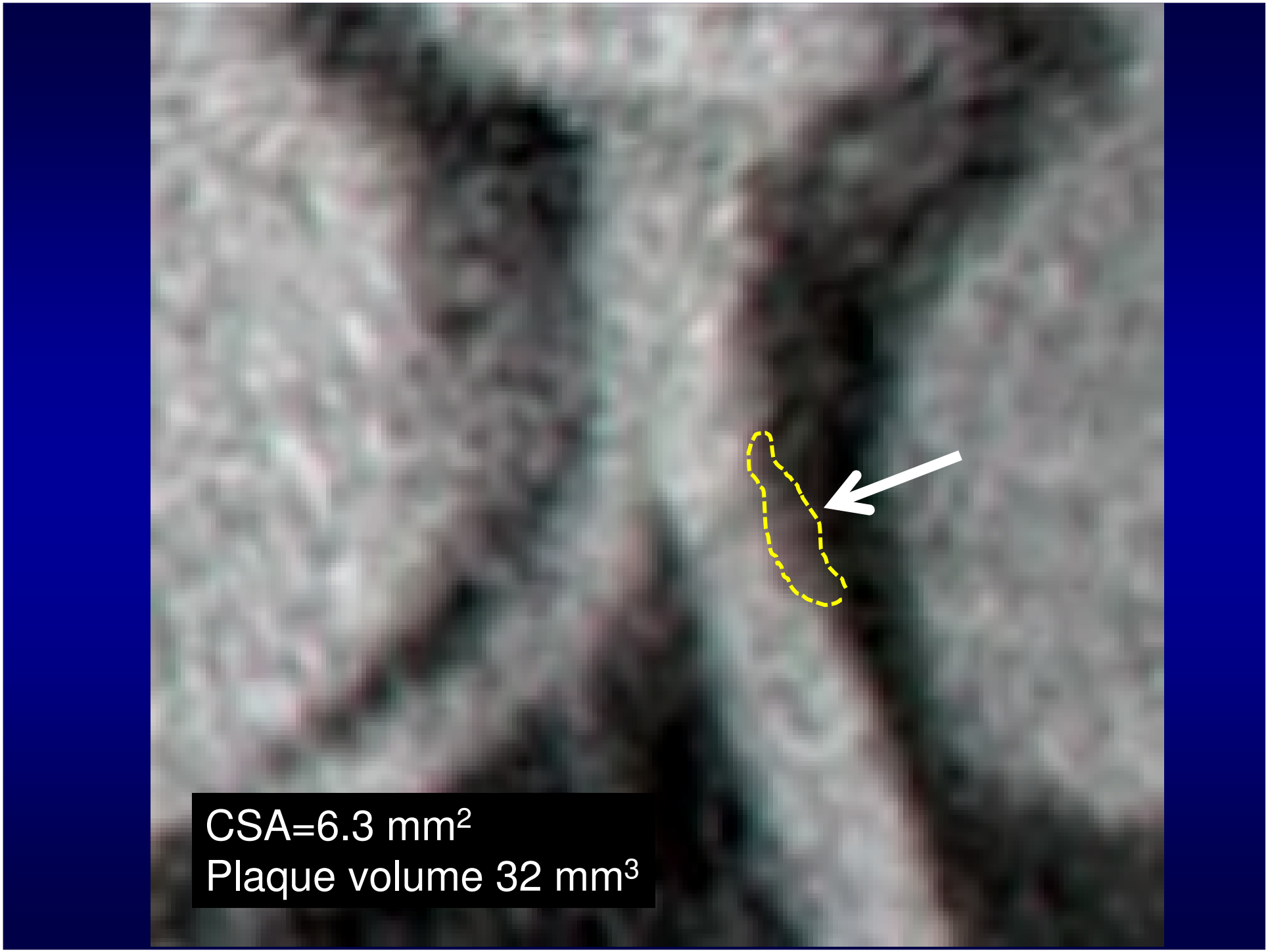



CSA=4.1 MM2
*
†

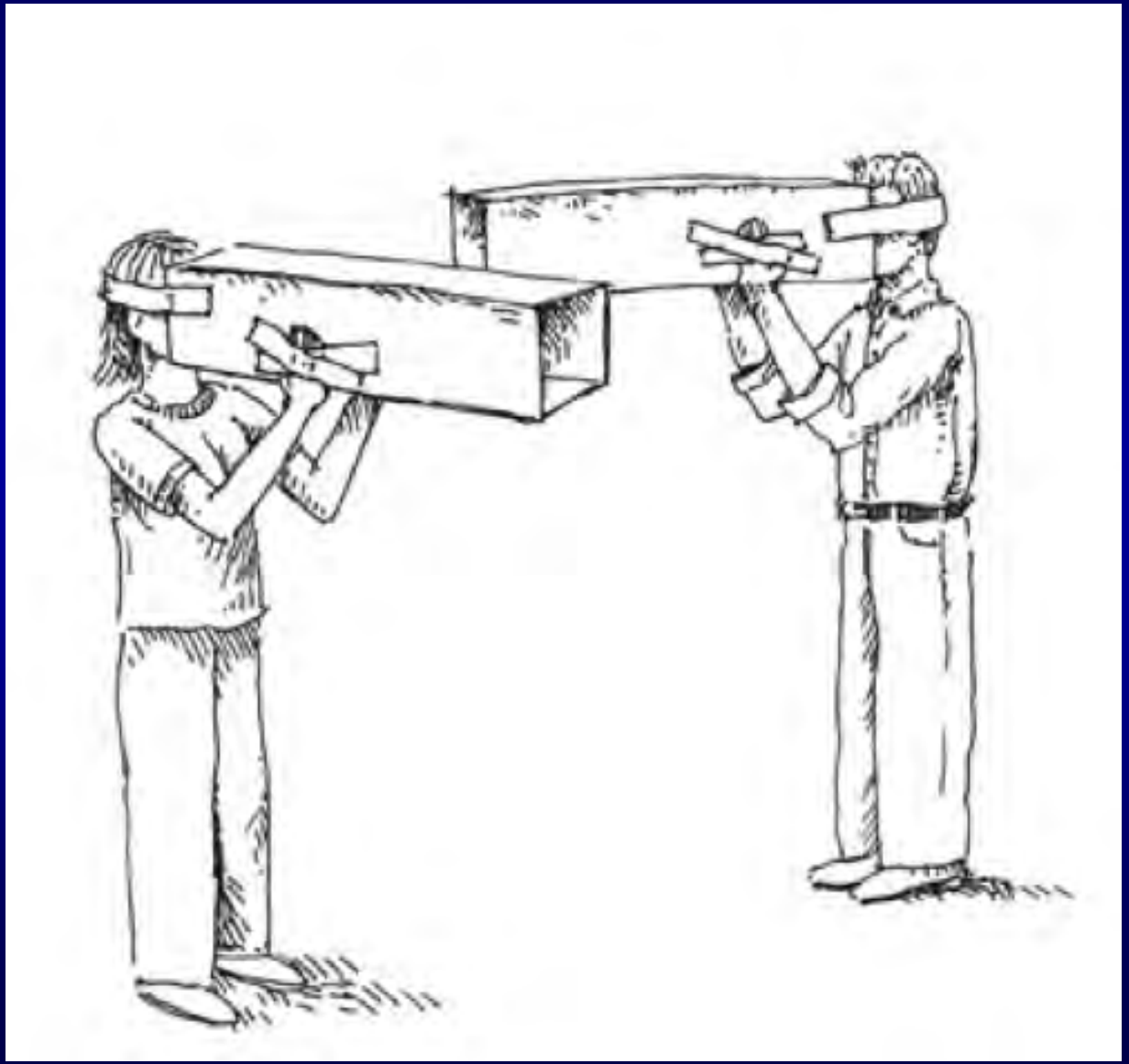

FFR=0.93


CSA=4.1 mm²
Plaque volume 59 mm³

- Decision not to perform PCI
- Medical therapy:
  Lipitor and Aspirin
- Follow-up CTA after 1 year

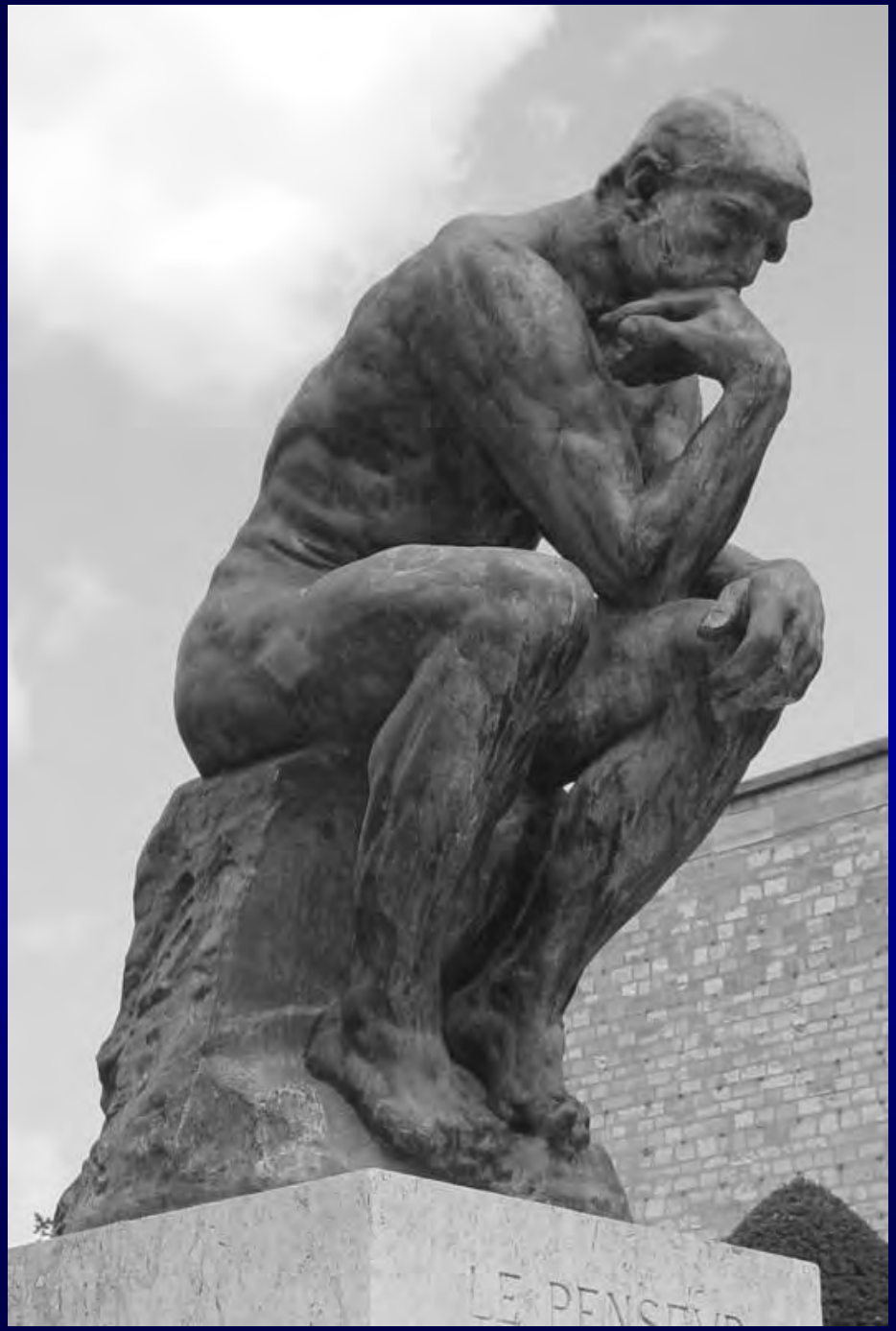

CSA=6.3 mm²
Plaque volume 32 mm³

Conclusions



Conclusions

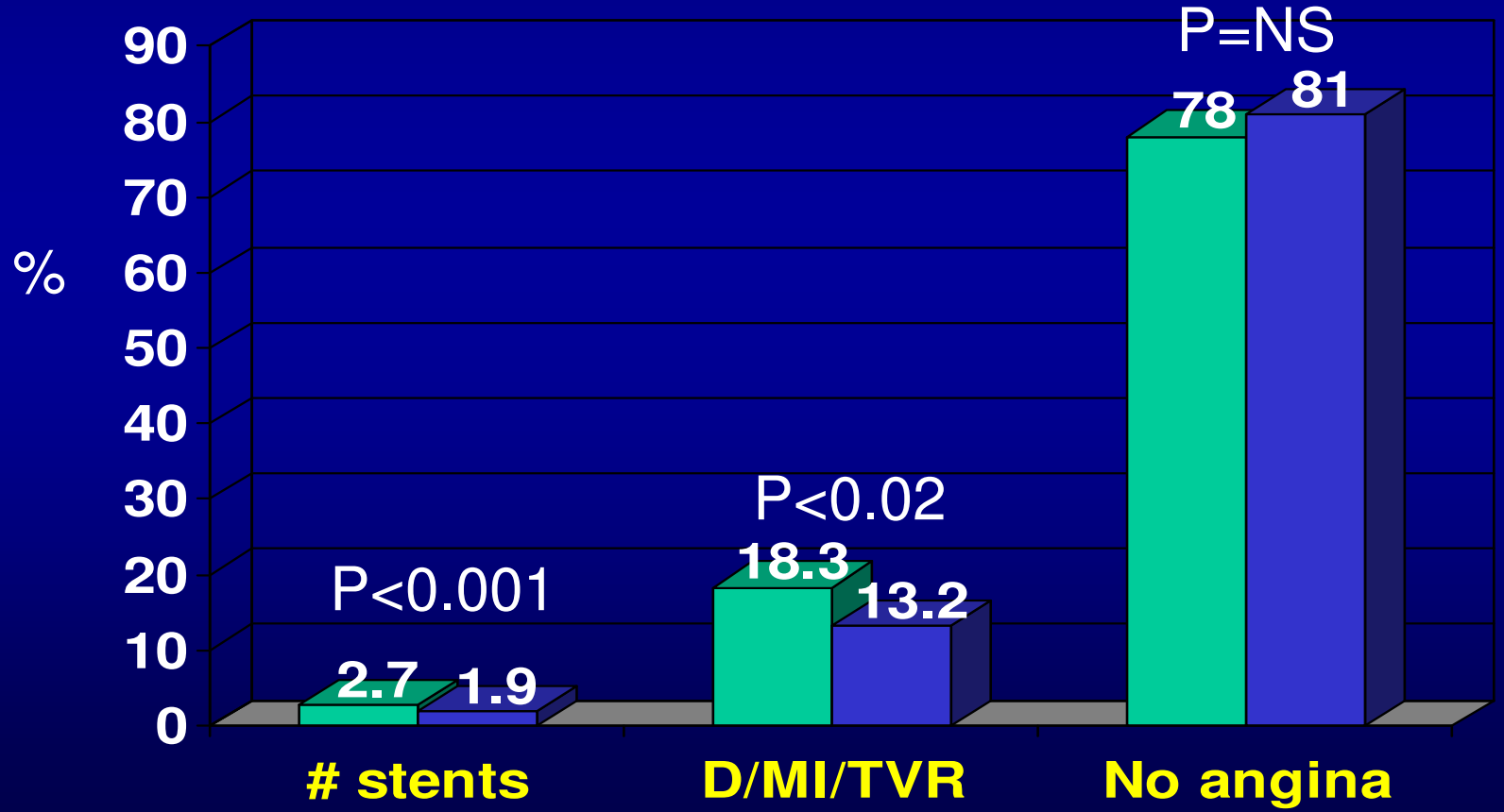
- IVUS/OCT and FFR are complementary techniques
- "Is PCI indicated?"
  - Shift from anatomic revasc to physiological revasc-FFR more applicable
  - IVUS has a role in LMCA and prox LAD
- "Is PCI result optimal?"
  - IVUS preferred


LE PENSEUR

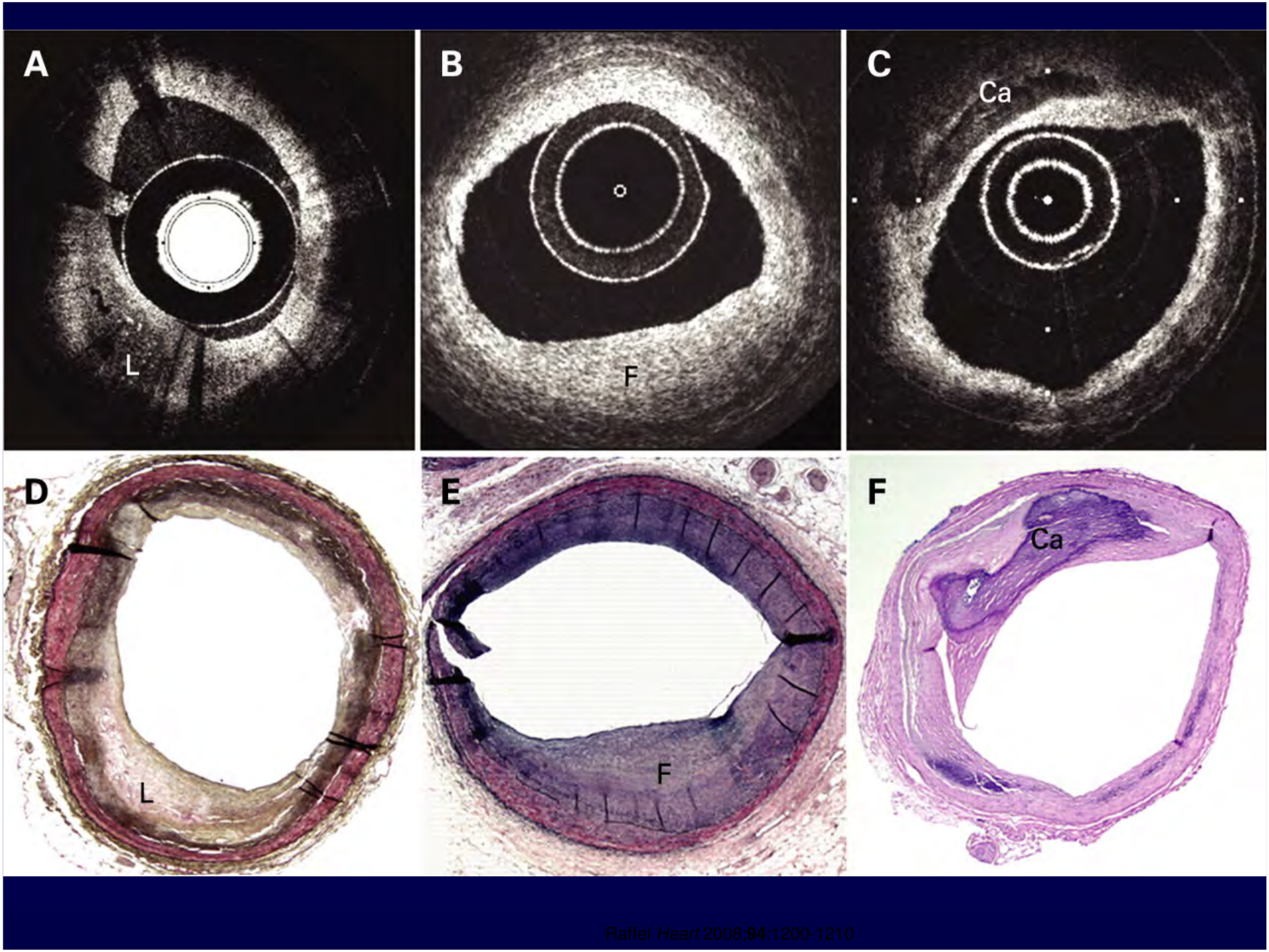
Thank-you

FAME study

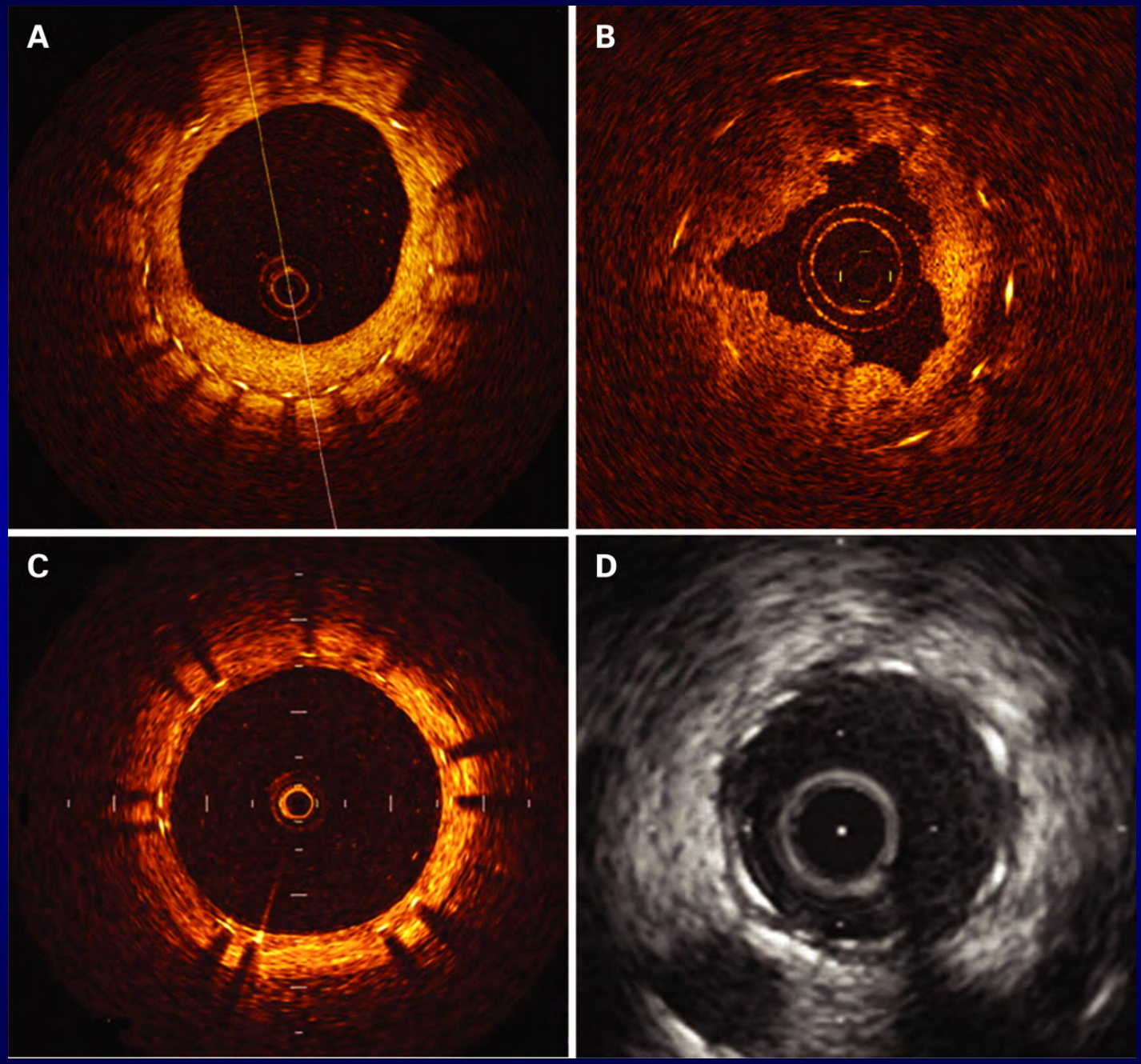
1005 patients with stenosis > 50% randomized:
PCI or FFR (PCI if FFR<0.8)



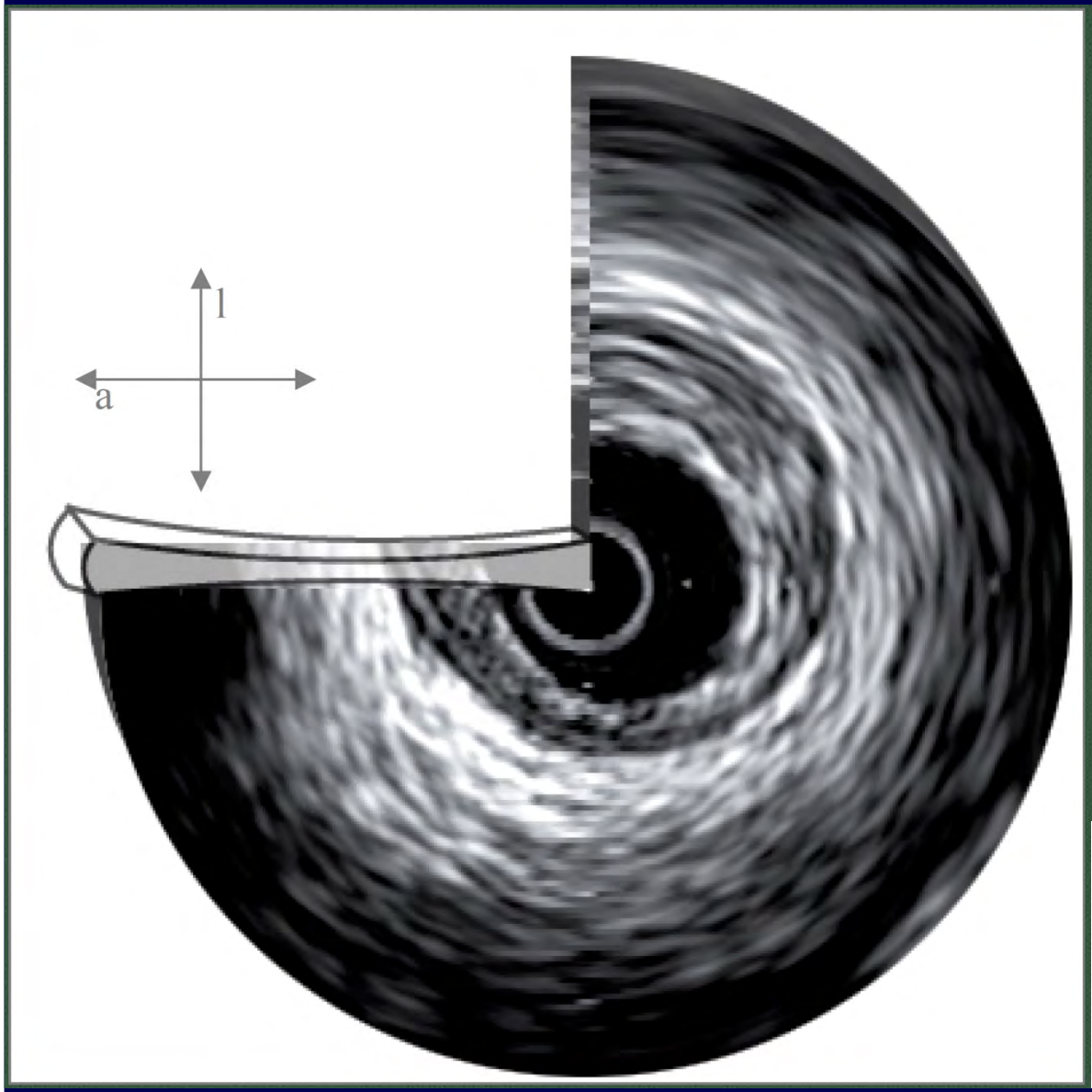
FAME NEJM 2009;360:213-24



Raffel *Heart* 2008;**94**:1200-1210



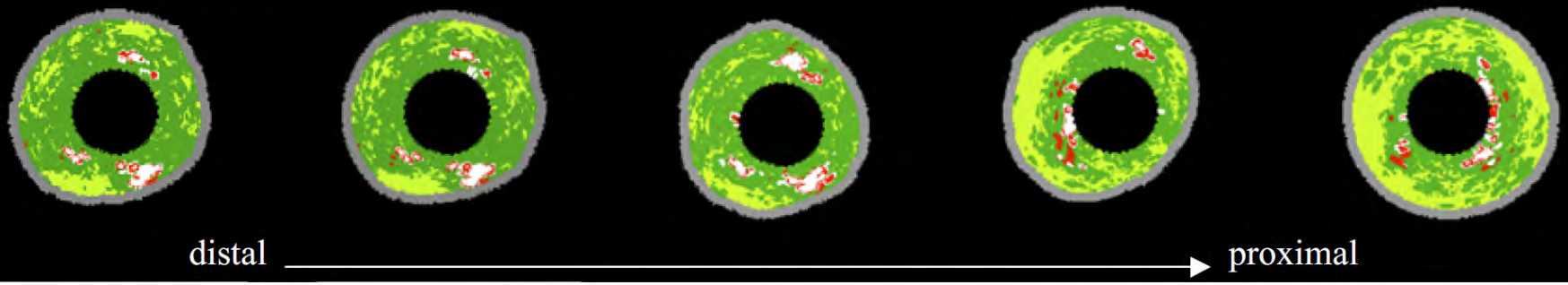
Raffel *Heart* 2008;**94**:1200-1210



a = Axial Resolution
l = Lateral Resolution

For a 30-40 MHz IVUS transducer:
Axial resolution=80-100 μ
Lateral resolution=200-250 μ

Case A: non-STR case



Percentage of each plaque component at the MLA site

Plaque area: 12.2 mm^2 Lumen area: 3.7 mm^2

- fibrous: 73.8 %
- fibro-lipid: 14.8 %
- necrotic core: 3.5 %
- dense-calcium: 7.8 %

Each plaque component volume

Total volume 131.1 mm^3

- fibrous: 79.2 mm^3
- fibro-lipid: 41.8 mm^3
- necrotic core: 3.9 mm^3
- dense-calcium: 6.2 mm^3

Case B: STR case

Percentage of each plaque component at the MLA site

Plaque area: 9.8 mm^2 Lumen area: 3.7 mm^2

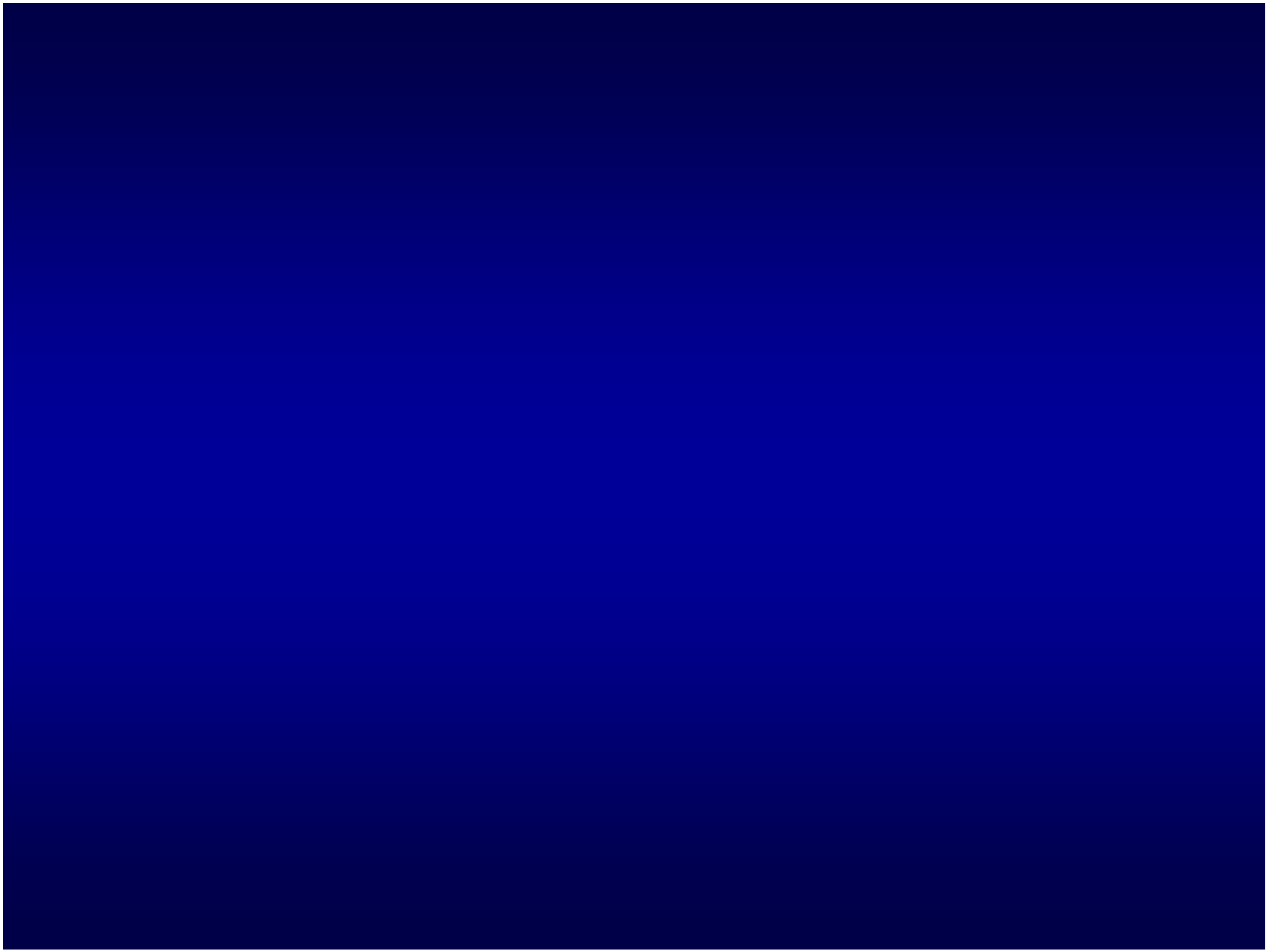
- fibrous: 46.0 %
- fibro-lipid: 5.1 %
- necrotic core: 36.7 %
- dense-calcium: 12.2 %

Each plaque component volume

Total volume 112.8 mm^3

- fibrous: 59.4 mm^3
- fibro-lipid: 7.1 mm^3
- necrotic core: 37.1 mm^3
- dense-calcium: 9.2 mm^3

Kawaguchi JACC 2007 50:1641



Fractional Flow Reserve (FFR)

- FFR=Distal coronary/Aortic pressure during maximal hyperemia
- Normal FFR=1.0
- FFR<0.75 accurately identifies stenosis associated with inducible ischemia
- FFR 0.75-0.80: Grey zone