

# **Limitations of IVUS**

## **“Why we need newer Imaging Techniques?”**

**Akiko Maehara, MD**

**Director of Intravascular Imaging & Physiology Core Laboratories  
Associate Director of MRI/MDCT Core Laboratory**

**Cardiovascular Research Foundation, NY**



## **IVUS Strong points**

**Quantitative measurement**

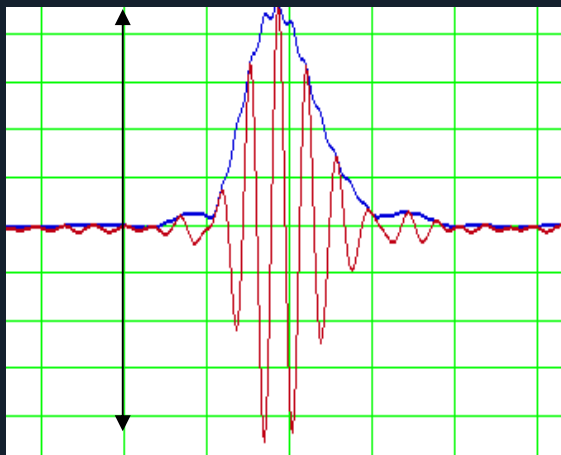
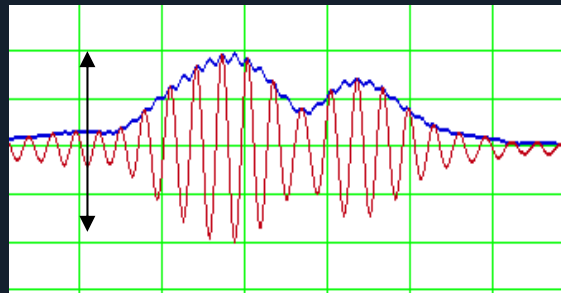
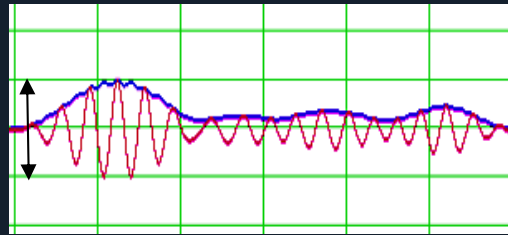
## **IVUS Weak points**

**Vulnerable Plaque (lipid rich plaque), Thrombus**

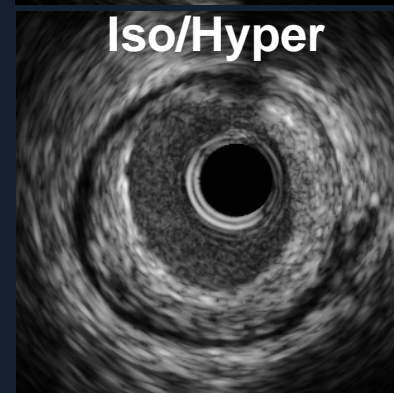
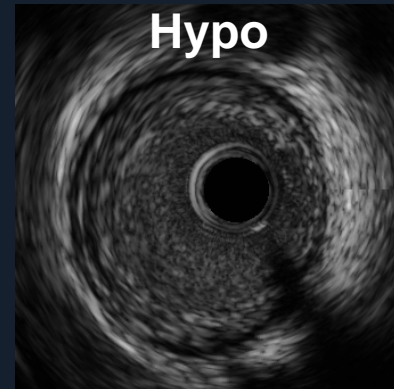


# Grey Scale IVUS Tissue Characterization

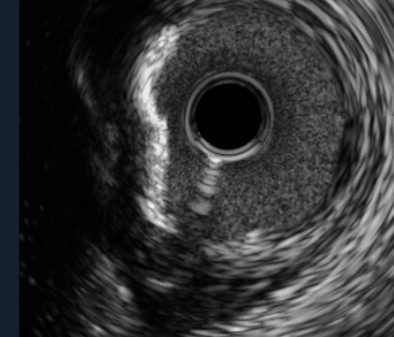
## Ultrasound Wave



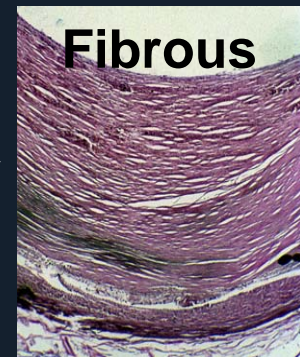
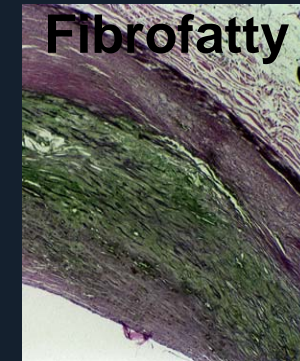
## Grey Scale



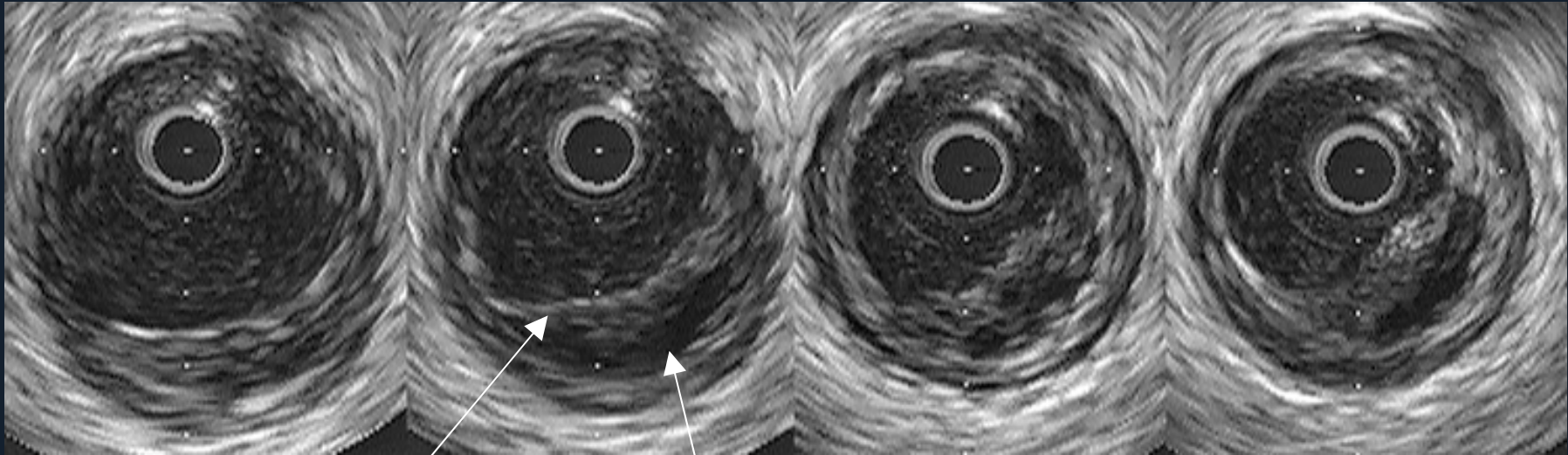
## Hyper with Shadow



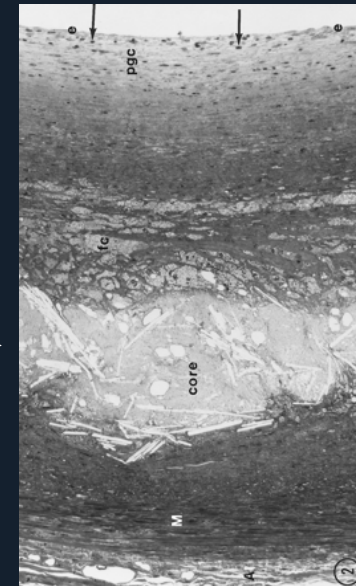
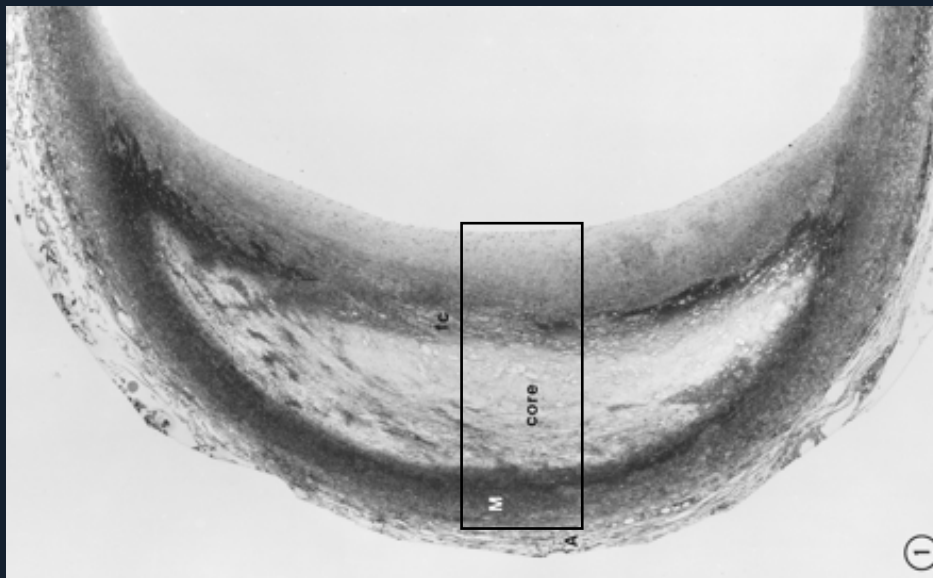
## Pathology



# Vulnerable Plaque?

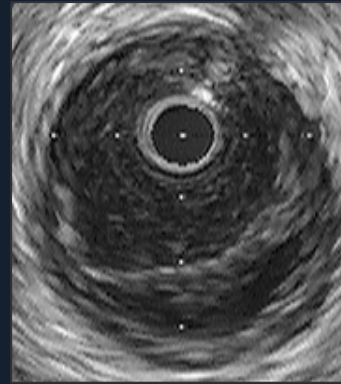


**Fibrous Cap    Necrotic Core**



# Detection of Necrotic Core

- Lipid necrotic area



- 40MHz IVUS

- Human 10 coronary & 2 carotid arteries, in vitro

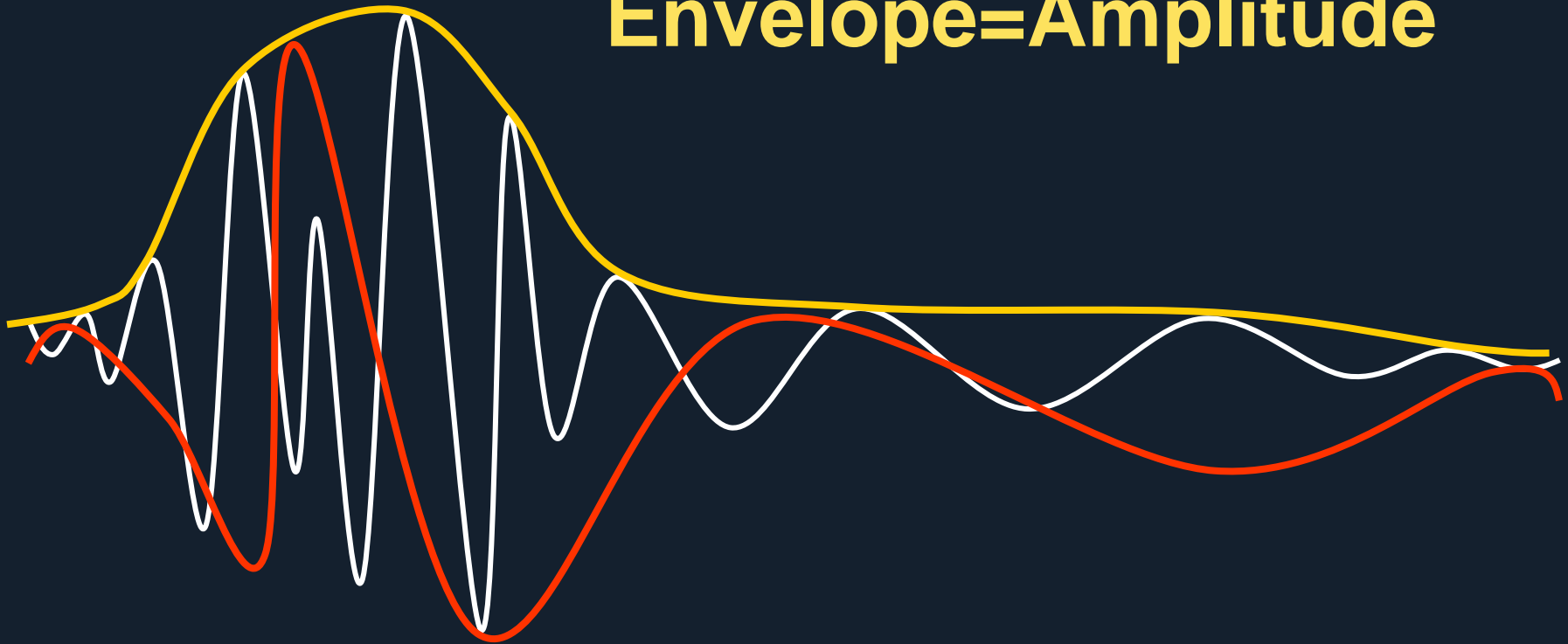
30 /122 (25%): histological lipid pool

19/122 (16%): IVUS lipid pool

**Sensitivity: 67%**

**Specificity: 94%**

**Envelope=Amplitude**



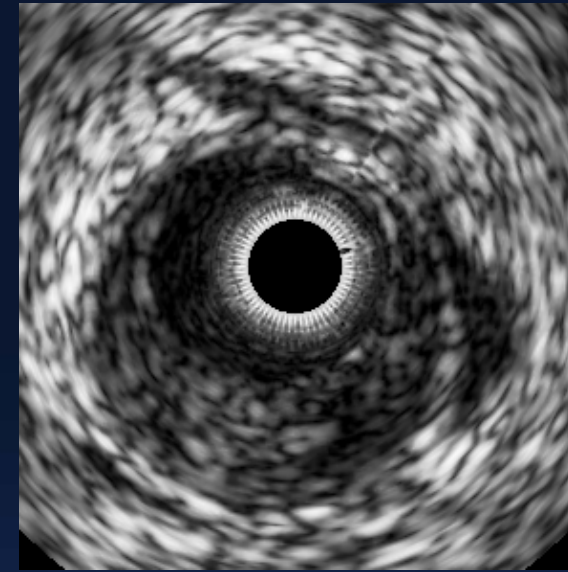
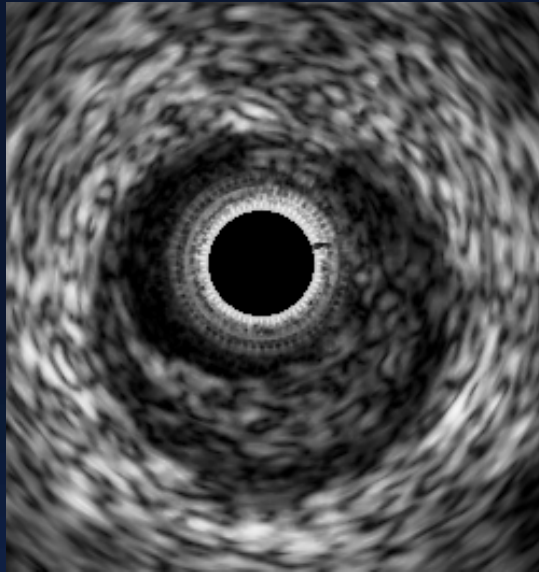
+

**Frequency**

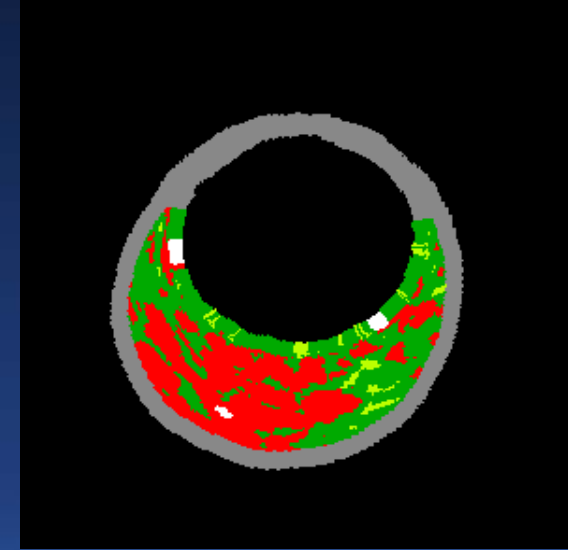
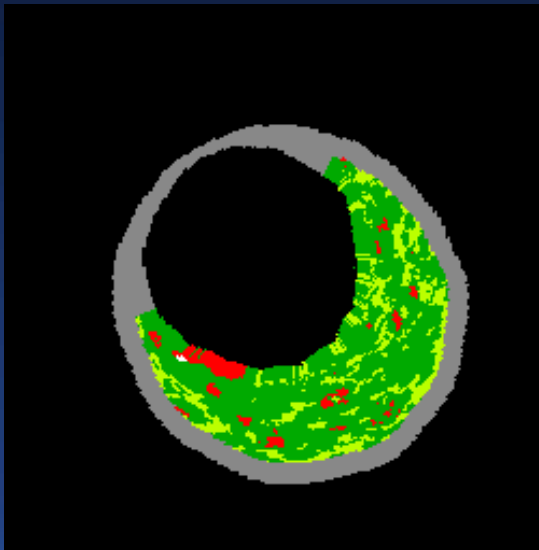


**= VH-IVUS**

# Grey Scale IVUS



# VH-IVUS



Pathological Intimal  
Thickening (PIT)

Thick Cap  
Fibroatheroma

# VH-IVUS Classification

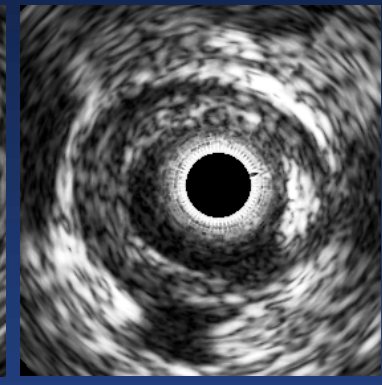
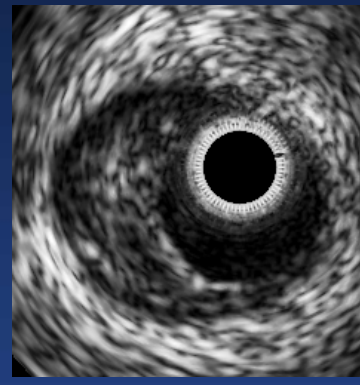
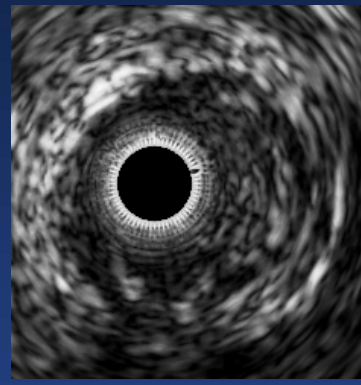
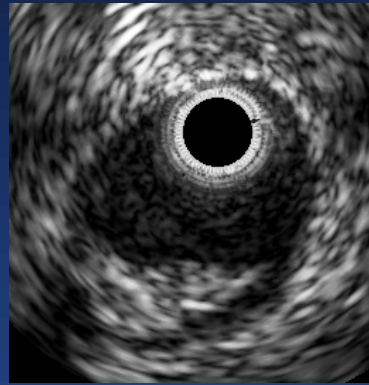
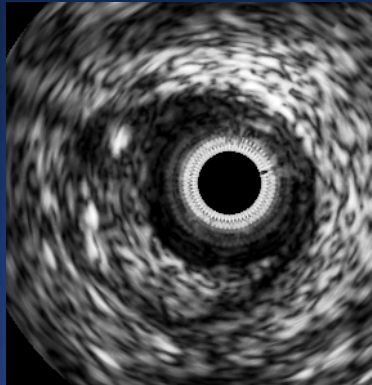
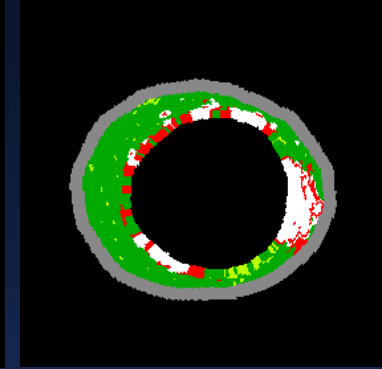
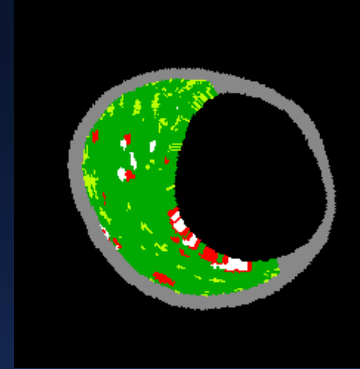
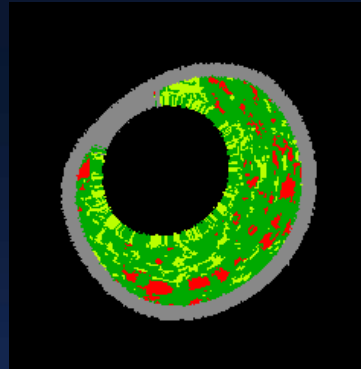
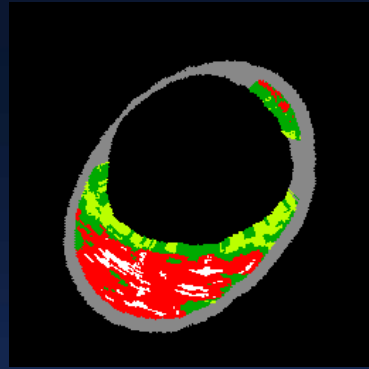
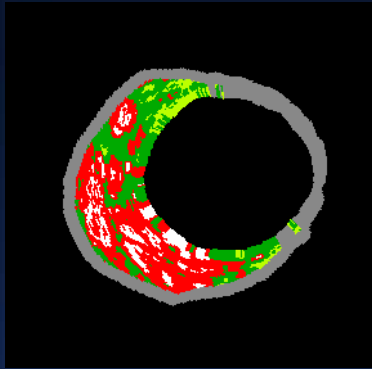
Thin-cap FA

Thick-cap FA

PIT

Fibrous

Fibrocalcific



More than 10%  
Confluent  
Necrotic Core

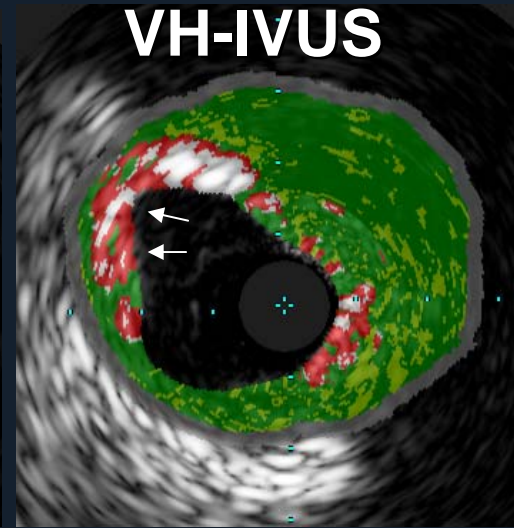
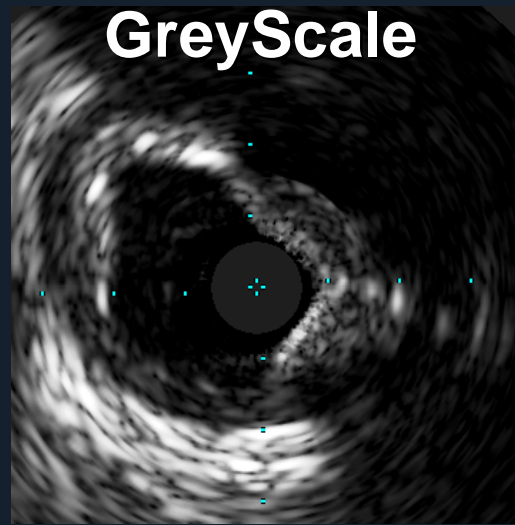
↑  
More than 15%  
Fibrofatty

NO more than 10%  
Confluent Necrotic  
Core

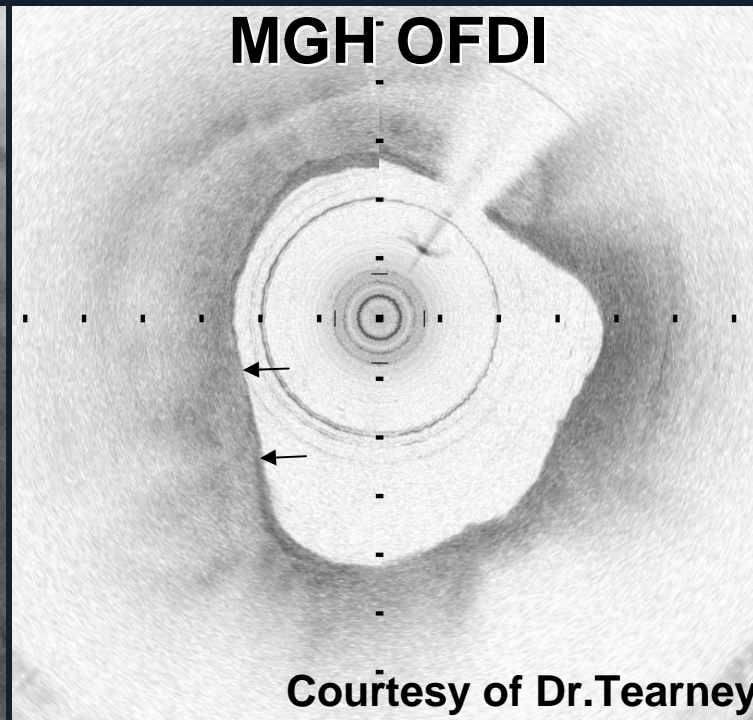
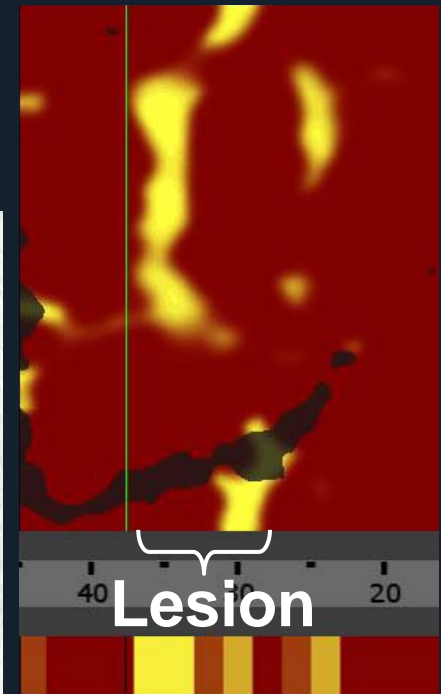
More than 10%  
confluent  
calcium



# Thin Cap Fibroatheroma



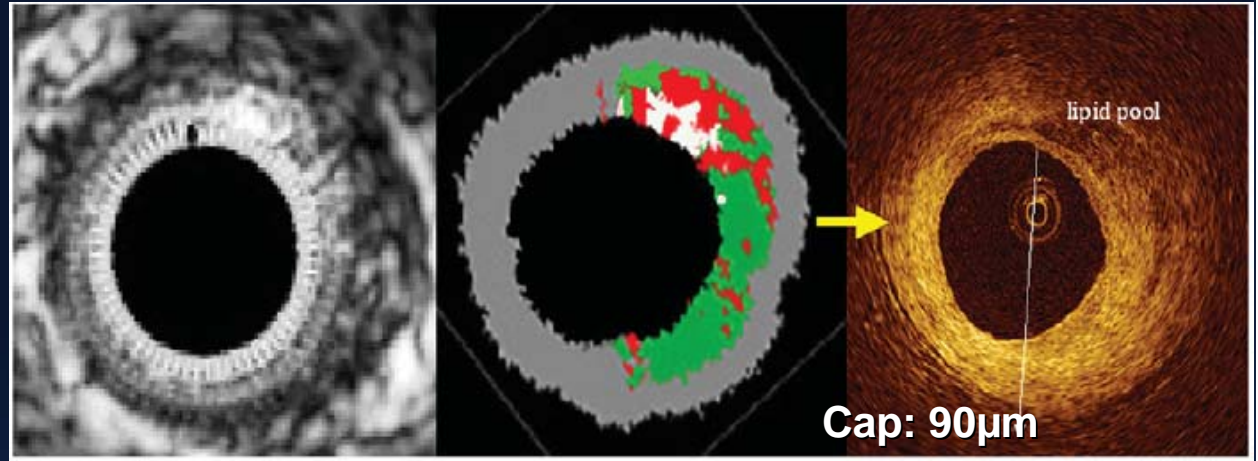
**NIR Spectroscopy**



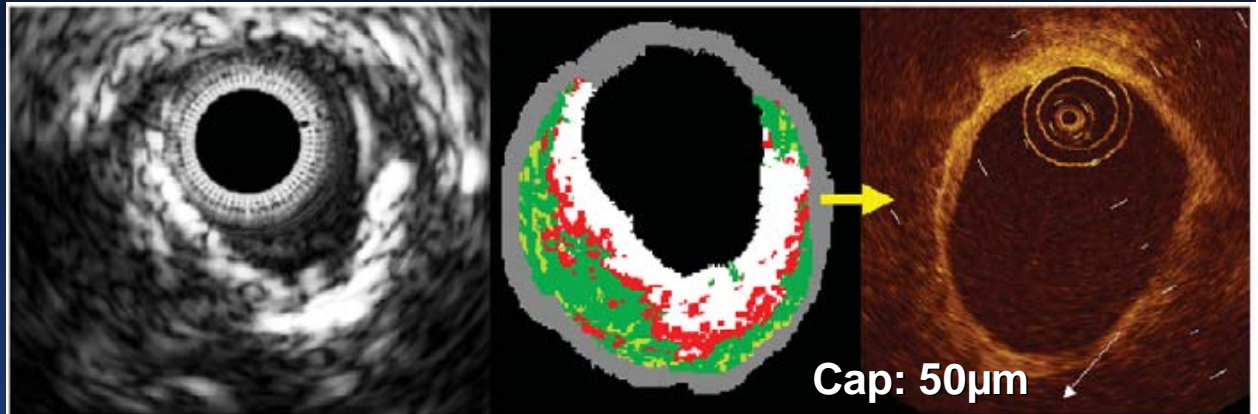
# Comparison OCT&VH

PPV: VH=46%  
PPV:OCT=78%

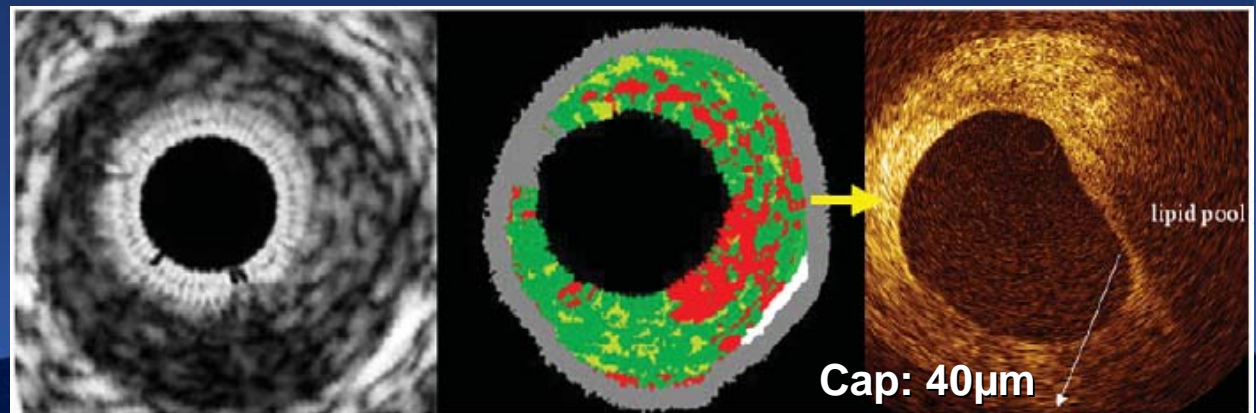
False Positive by VH



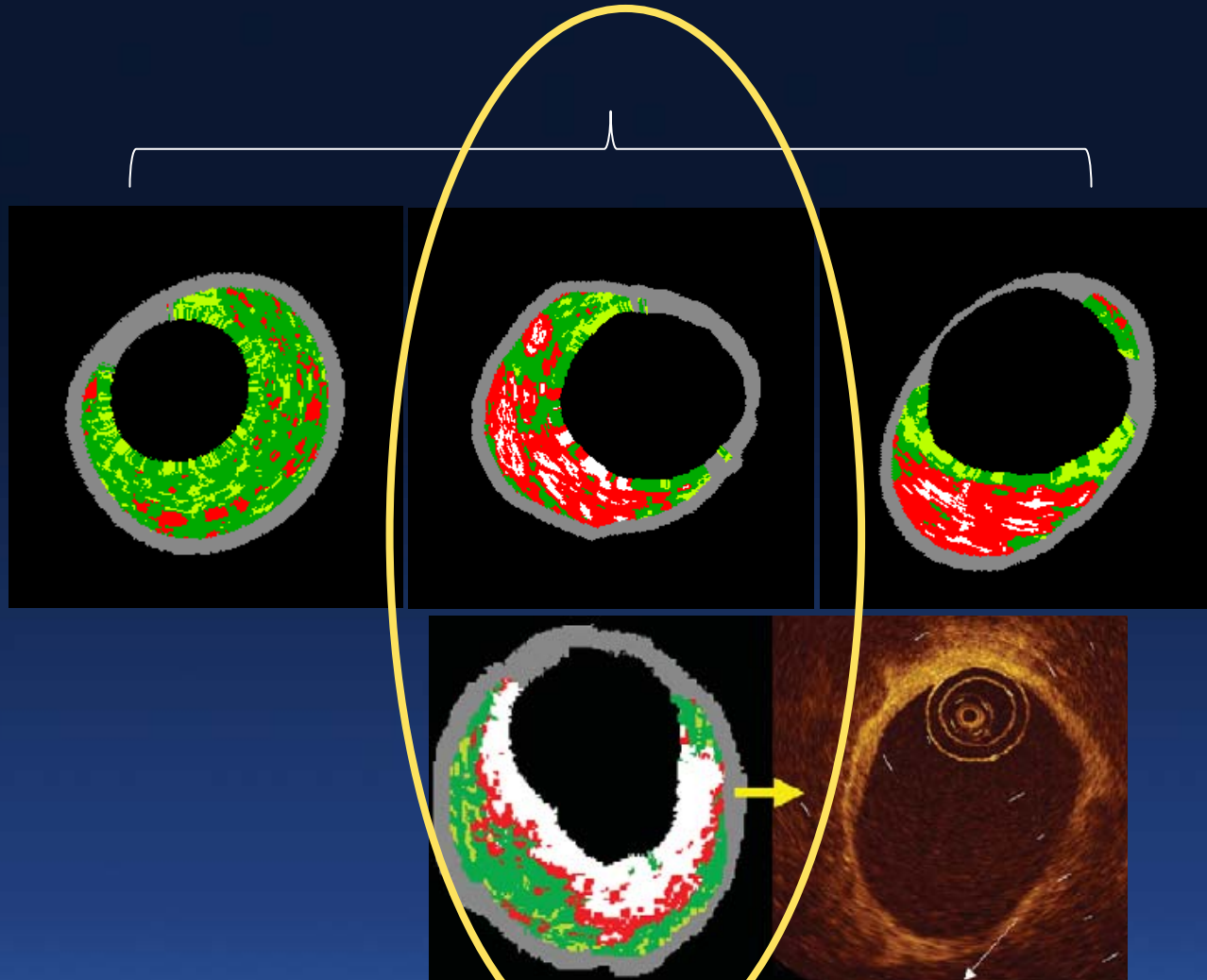
False Positive by OCT



Consensus TCFA

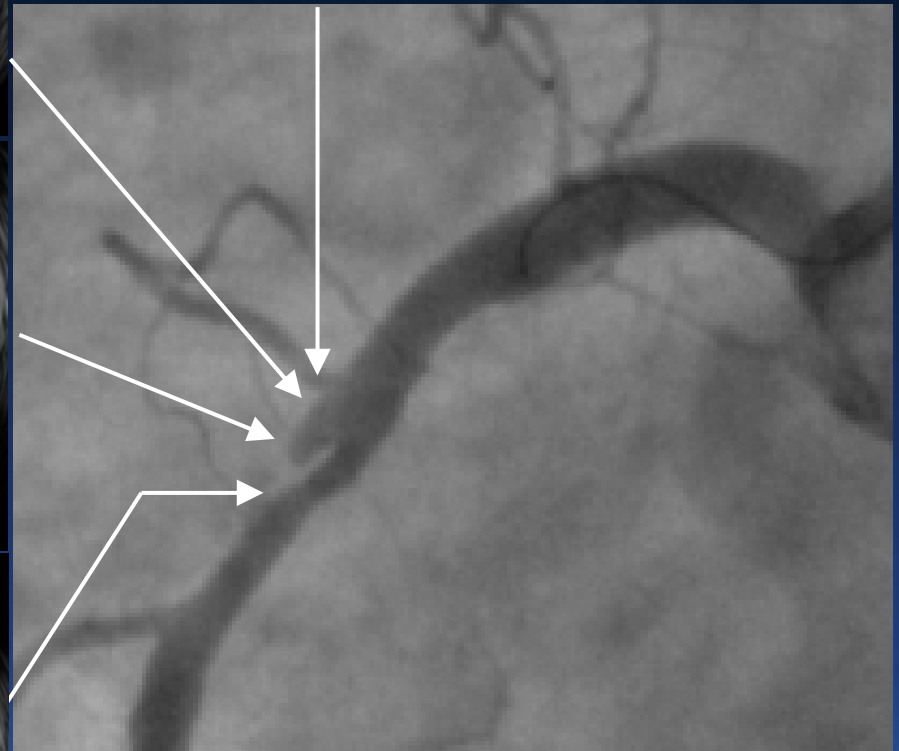
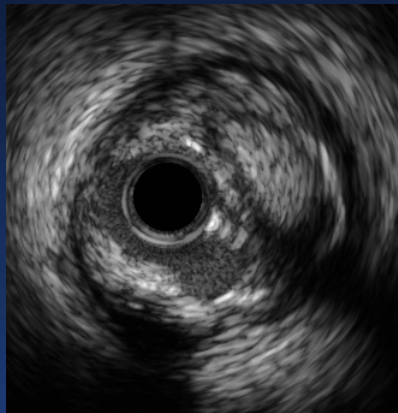
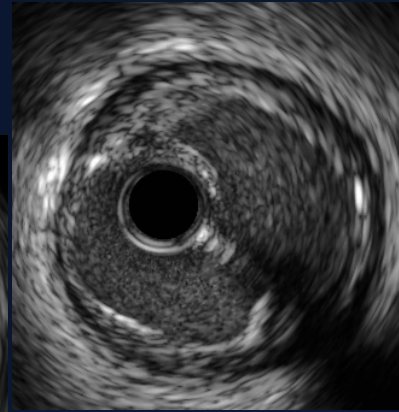
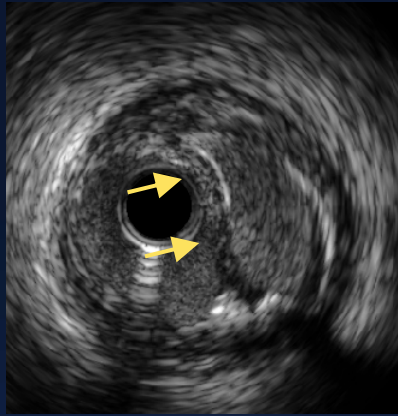


# OCT Fibroatheroma



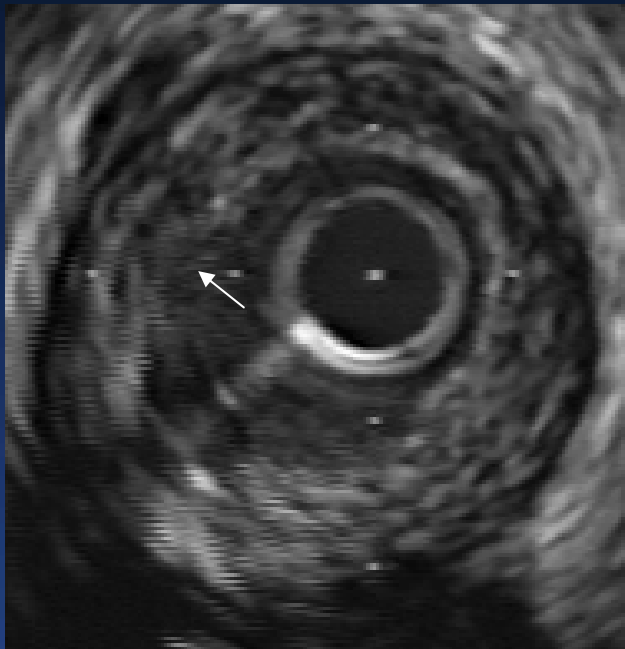
# Plaque Rupture

Fibrous cap

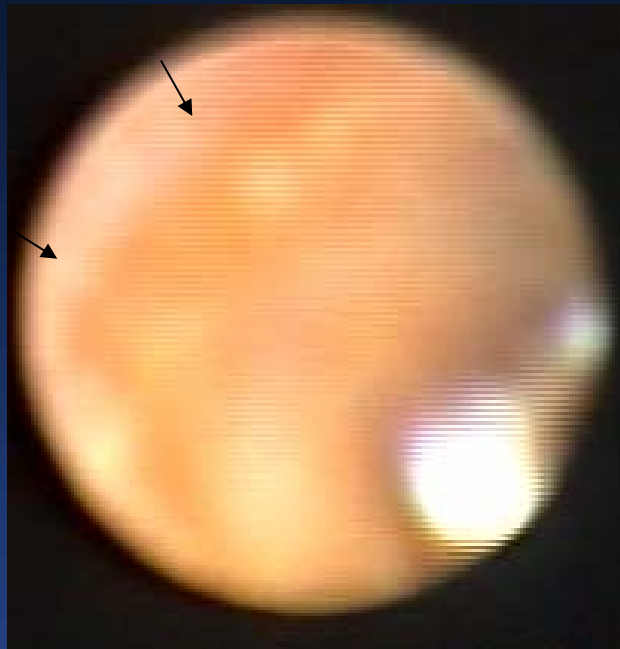


# Erosion

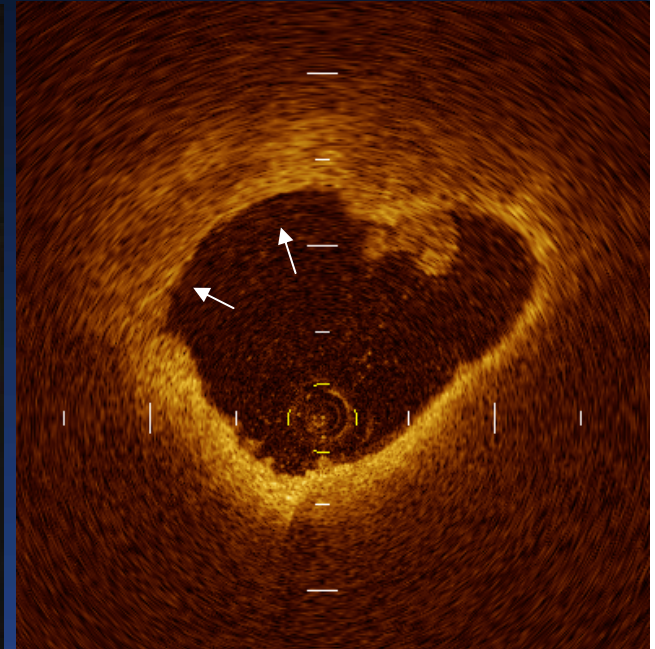
IVUS



Angioscopy



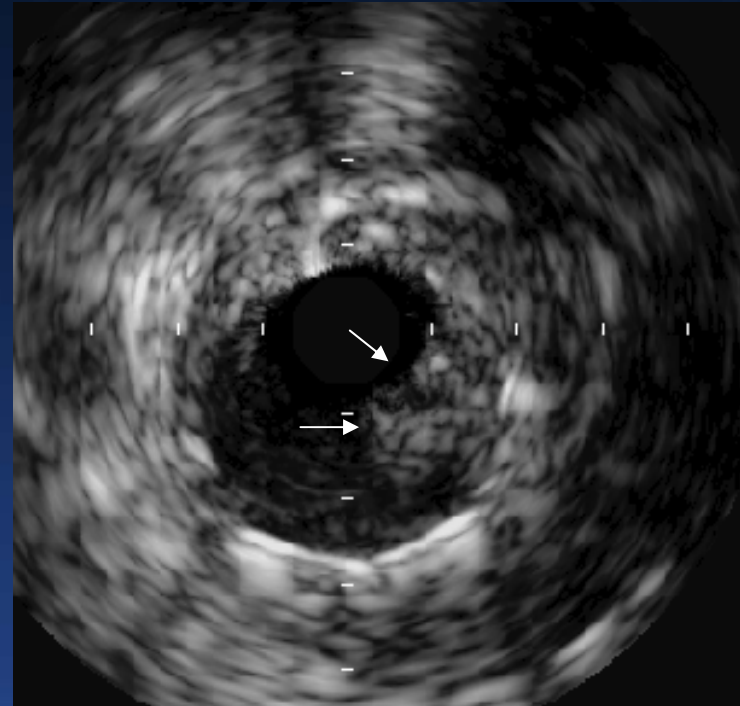
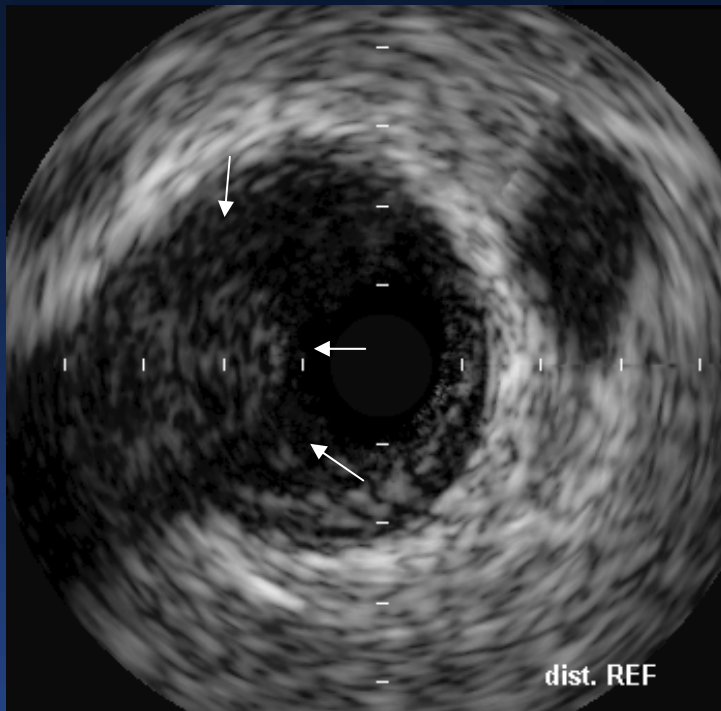
OCT



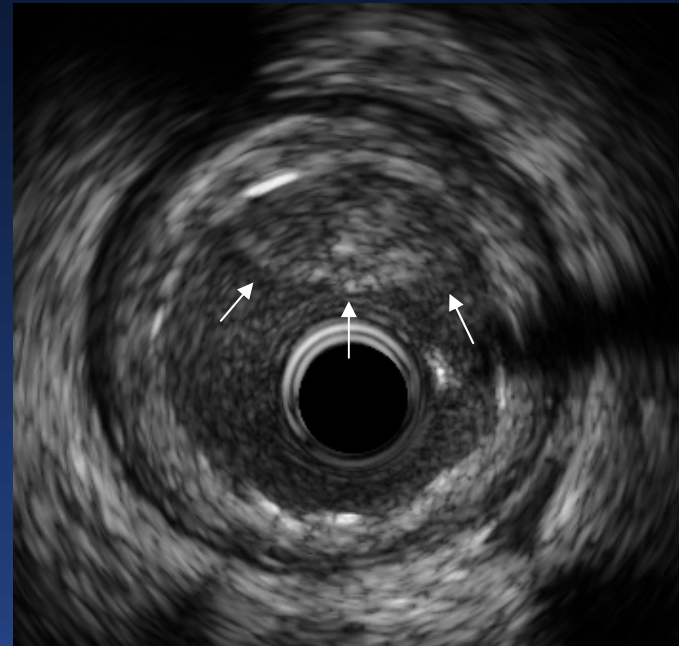
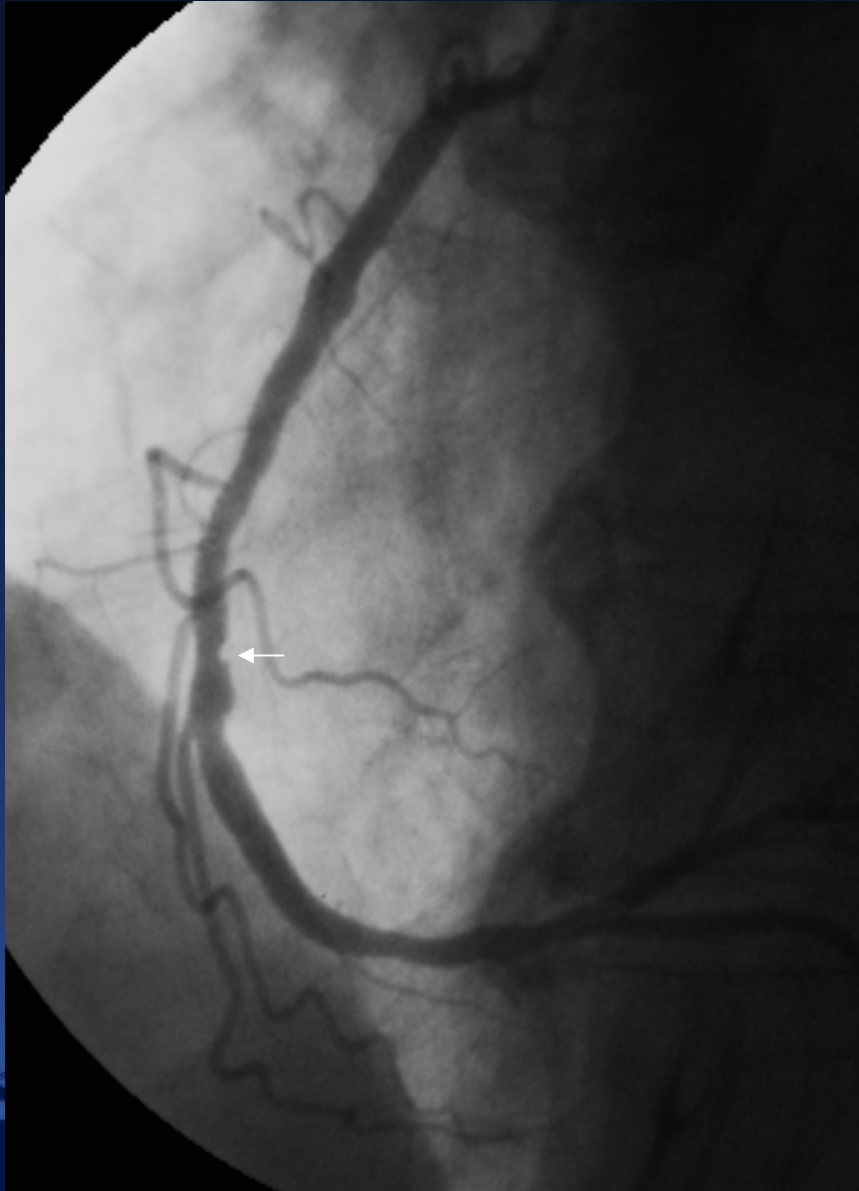
Kubo T, et al JACC 2007

# Thrombus

- Acute Thrombus -

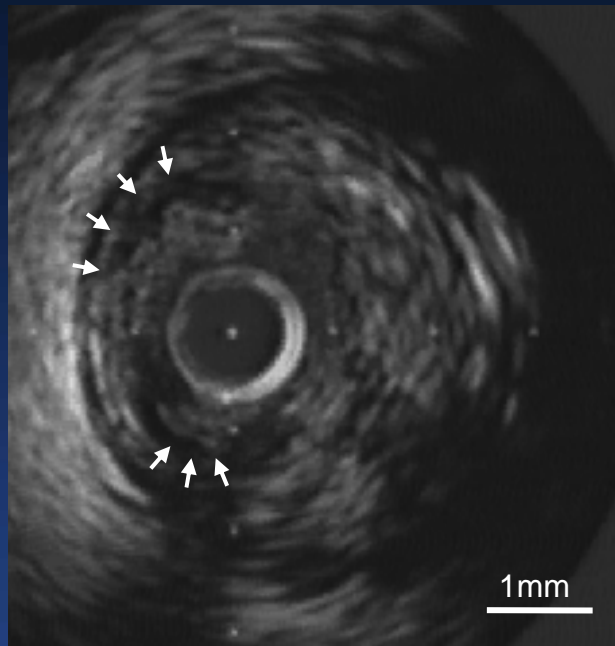


# Organized Thrombus

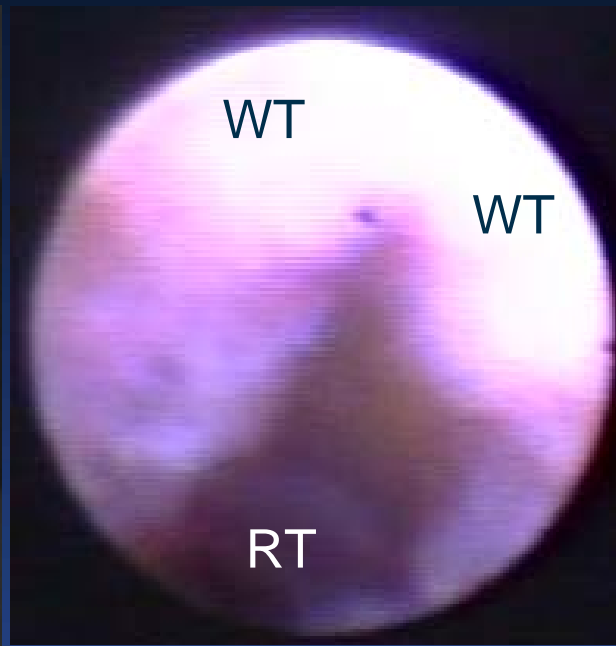


# Acute thrombus

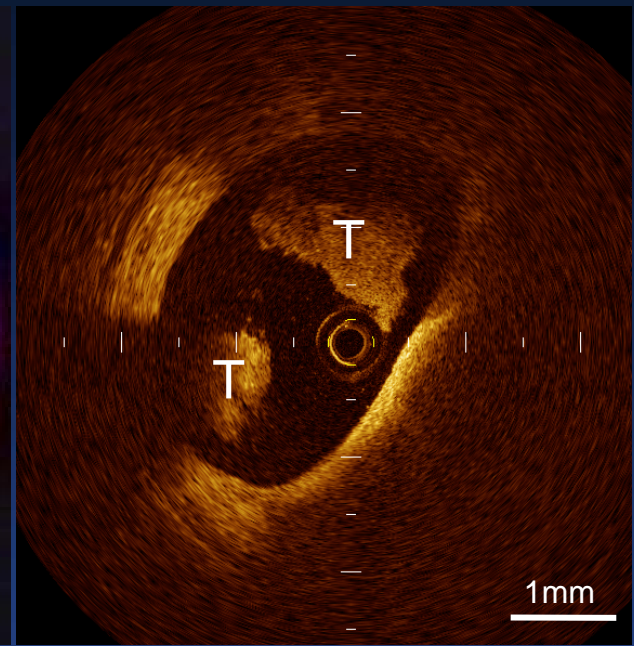
IVUS



Angioscopy



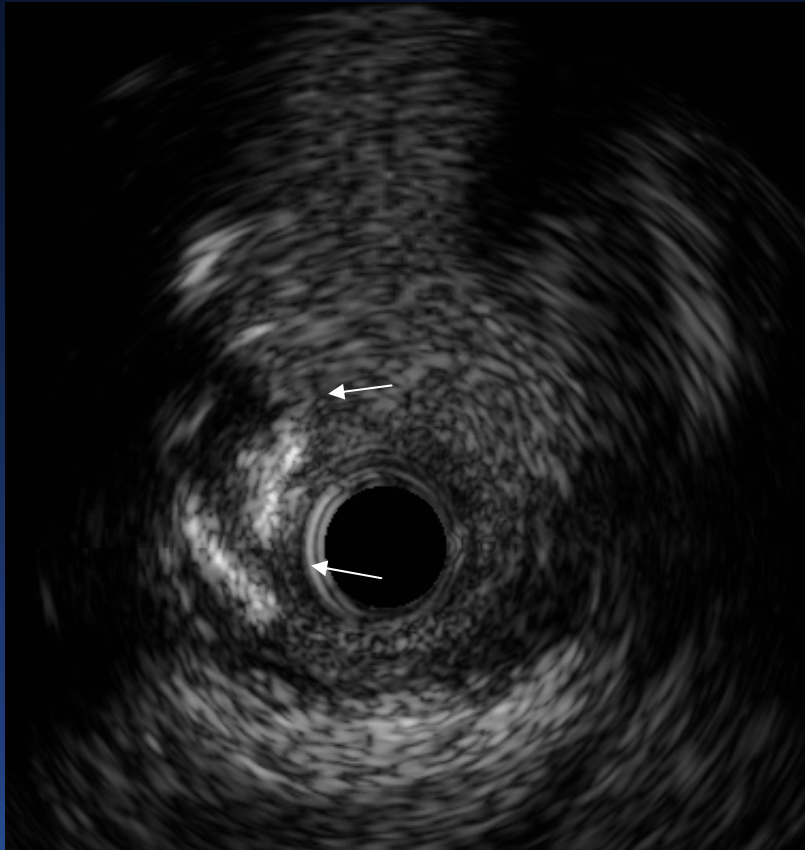
OCT



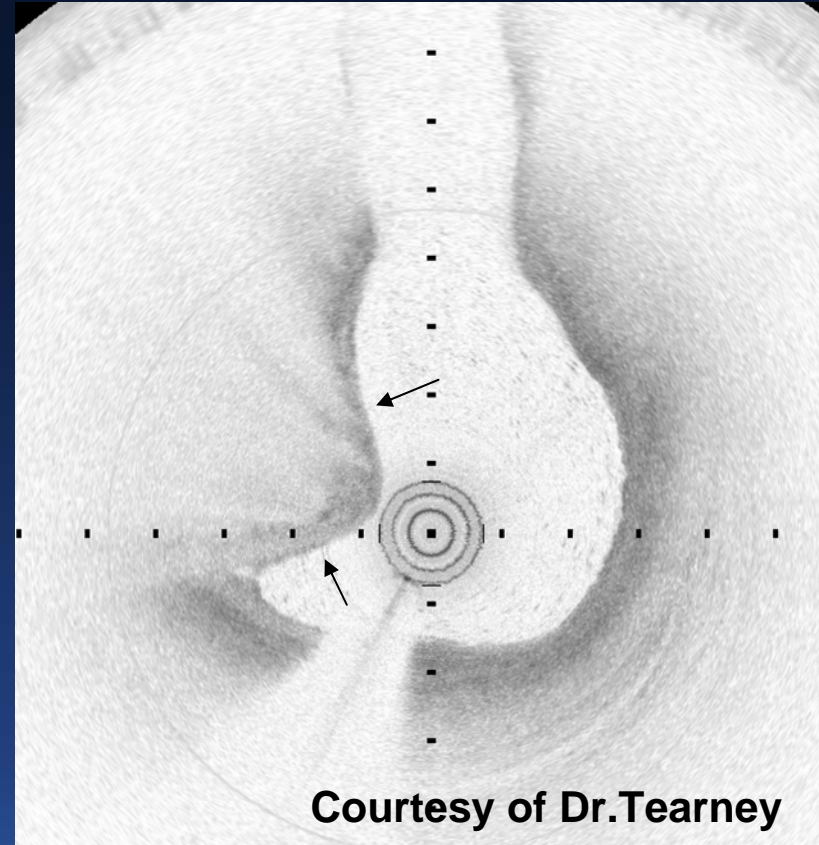


# Organized Thrombus

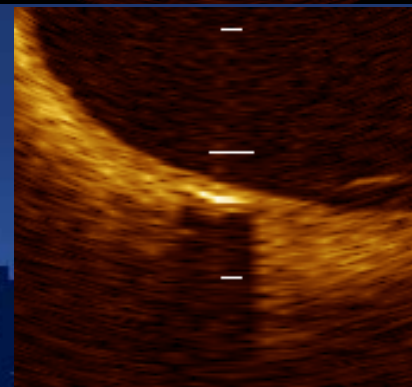
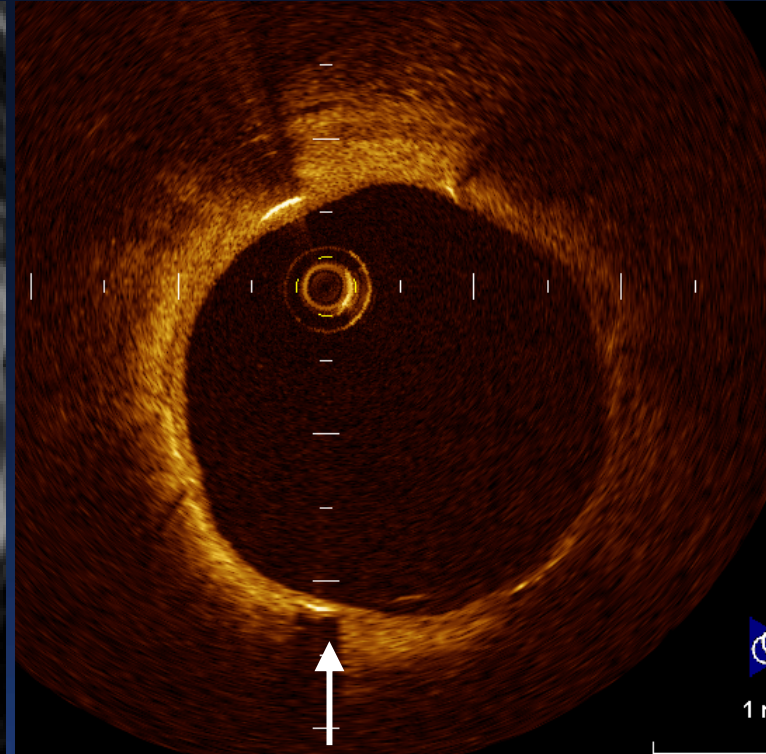
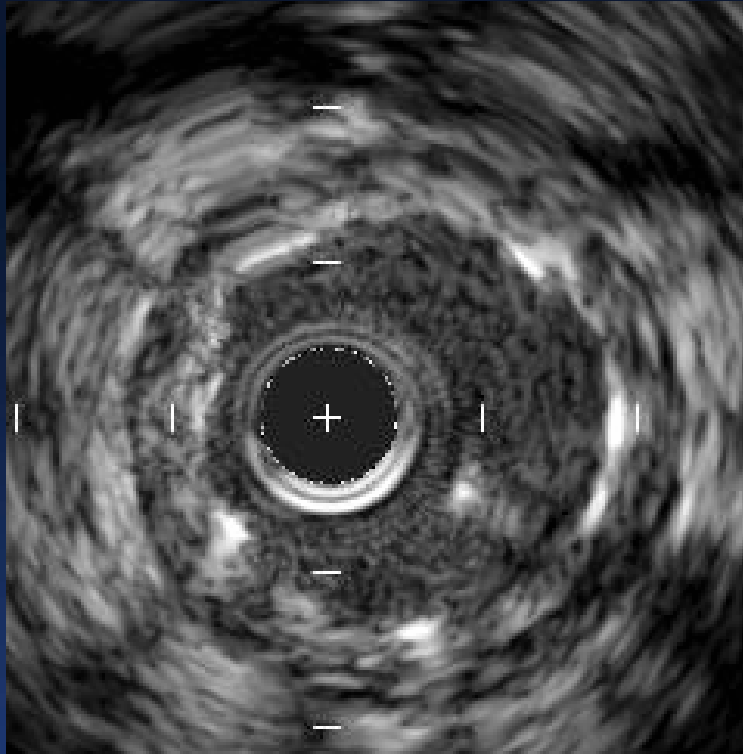
IVUS



MGH OFDI



# Neointimal Coverage

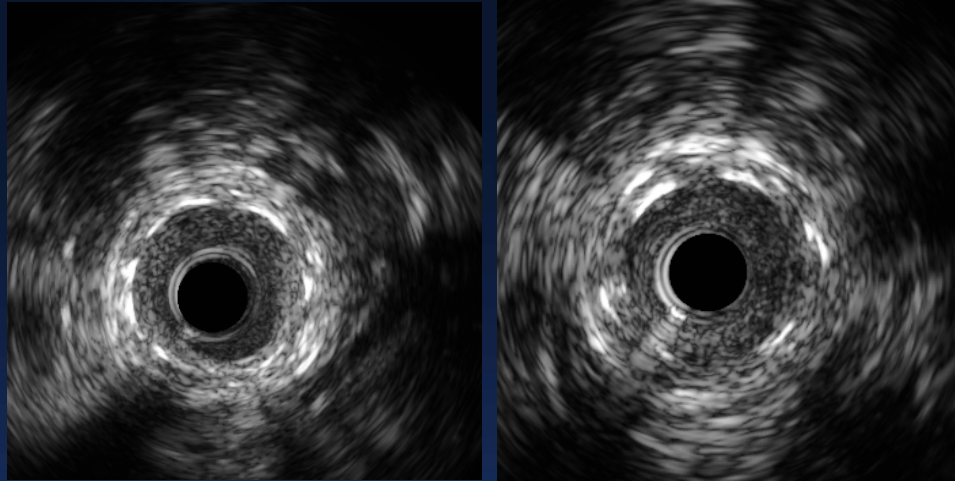


## **“0” neointima by IVUS**

- **ODESSA (OCT for DES Safety)**
- **Cypher/Taxus/Endeavor/BMS in 75 pts**
- **6 months follow-up**
- **20/250 (8%) segment were “0” neointima by IVUS, 16 Cypher, 4 Taxus**
- **92.7% struts were covered by OCT**

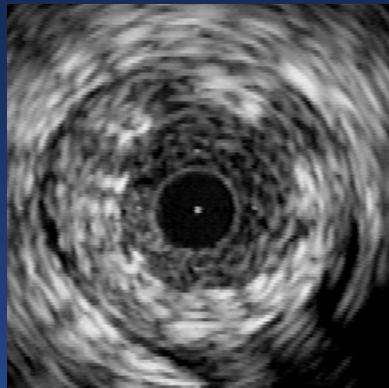
# *Difference between DES and BMS?*

DES

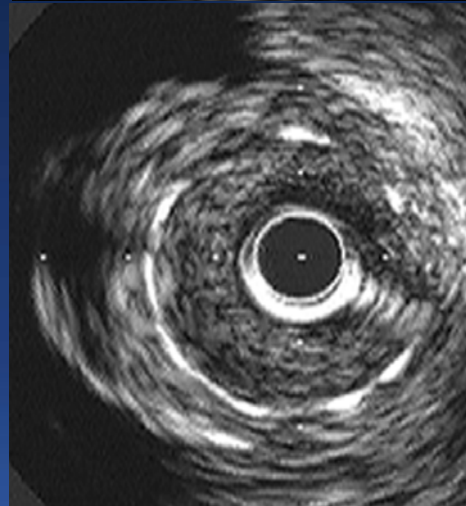


Heterogeneous

BMS

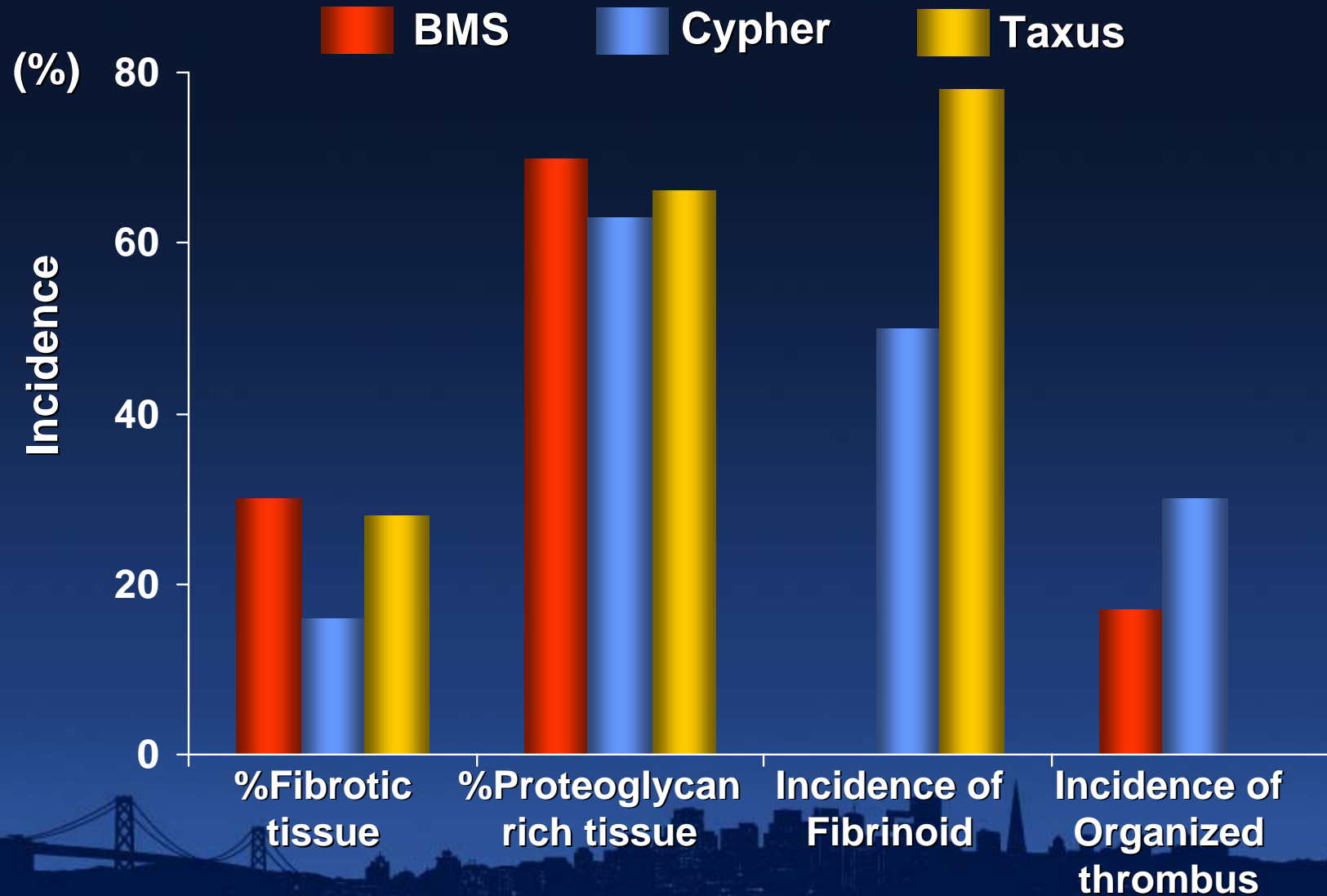


Homogeneous,  
Concentric



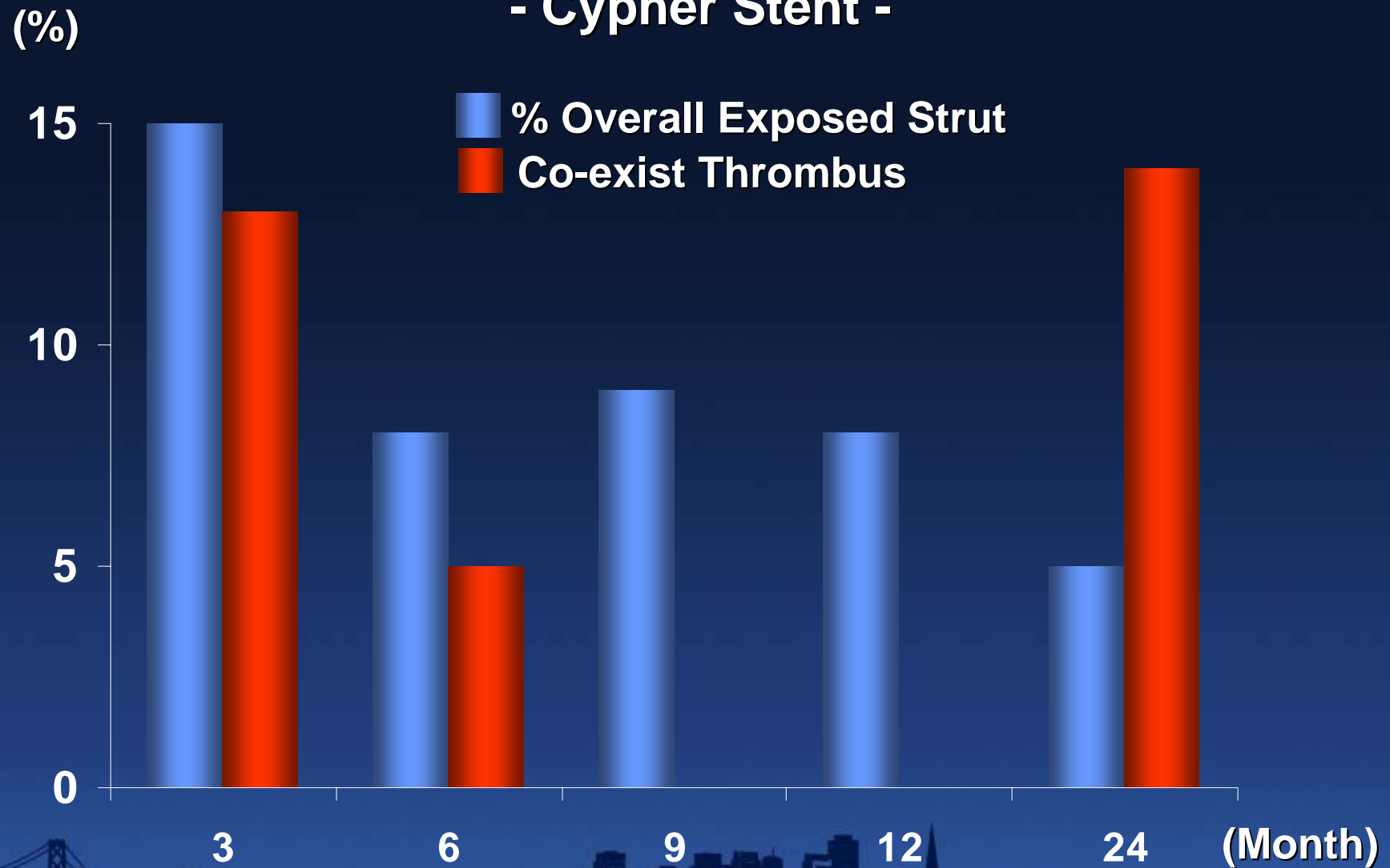
# *In-stent restenosis tissue shows “delayed healing”*

Tissue by DCA (10 Cypher, 9 Taxus, 6 BMS), 103-1472 days old



# OCT: Neointimal Coverage and Thrombus

- Cypher Stent -



Xie Y, AJC 2008, Matsumoto D, Eur Heart J 2007, Kubo T JACC  
Img 2008, Zhu-hua Y, Chin Med J 2008, Takano M, JACC 2008

# Angioscopy: Co-Exist Thrombus

- Cypher Stent -

(%)

40

30

20

10

0

4-Awata

6-Takano

6-Oyabu

11-Awata

21-Awata

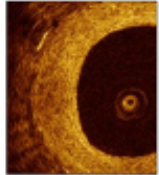
24-Takano

(Month)

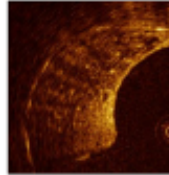
Awata, Circulation 2007, Takano, Eur Heart J 2006, Takano Heart 2007, Oyabu AHJ 2006

# Pattern of restenotic tissue

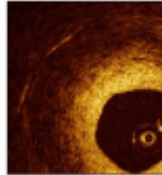
## Restenotic tissue structure



**Homogeneous:** restenotic tissue has uniform optical properties and does not show focal variations in backscattering pattern.

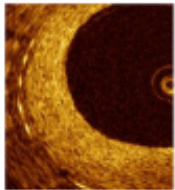


**Heterogeneous:** restenotic tissue has focally changing optical properties and shows various backscattering patterns.

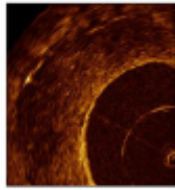


**Layered:** restenotic tissue consists of concentric layers with different optical properties: an adluminal high scattering layer and an abluminal low scattering layer.

## Restenotic tissue backscatter

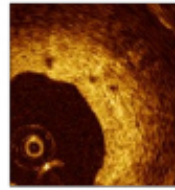


**High:** the majority of the tissue shows high backscatter and appears bright.

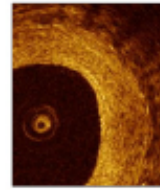


**Low:** the majority of the tissue shows low backscatter and appears dark or black.

## Microvessels visible

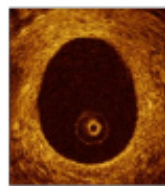


**Yes:** microvessels appear as well delineated low backscattering structures less than 200 micron in diameter that show a trajectory within the vessel.

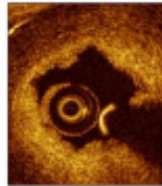


**No**

## Lumen shape

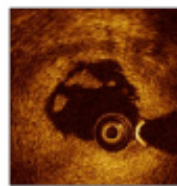


**Regular:** lumen border is sharply delineated, smooth and circular.

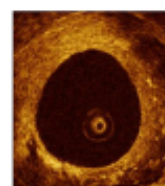


**Irregular:** lumen border irregular with tissue protrusions from the vessel wall into the lumen.

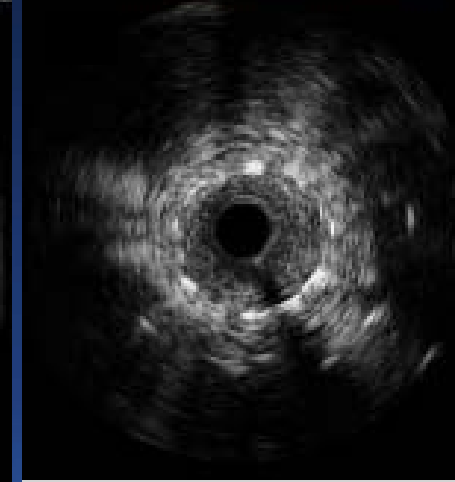
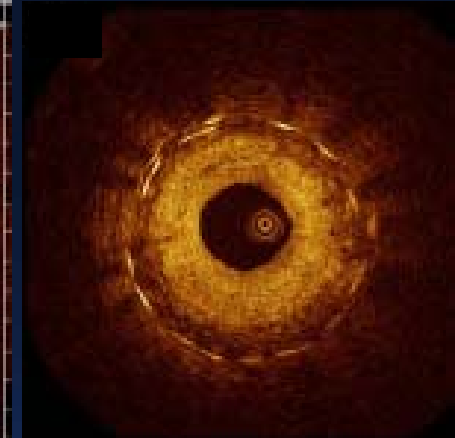
## Presence of intraluminal material



**Yes:** there is visible material inside the vessel lumen.



**No**





# Summary

	<b>Grey Scale IVUS</b>	<b>VH</b>	<b>OCT</b>	<b>NIR Spectroscopy</b>	<b>Angioscopy</b>
<b>Axial Resolution (<math>\mu\text{m}</math>)</b>	<b>100</b>	<b>200</b>	<b>20</b>	<b>NA</b>	<b>10-50</b>
<b>PCI</b>	<b>++</b>	<b>+/-</b>	<b>+</b>	<b>-</b>	<b>+/-</b>
<b>TCFA</b>	<b>+/-</b>	<b>+</b>	<b>++</b>	<b>+/-</b>	<b>+</b>
<b>Necrotic Core</b>	<b>+/-</b>	<b>+</b>	<b>+</b>	<b>++</b>	<b>+</b>
<b>Thrombus</b>	<b>+/-</b>	<b>-</b>	<b>++</b>	<b>+/-</b>	<b>++</b>
<b>Stent Coverage</b>	<b>+</b>	<b>+</b>	<b>++</b>	<b>-</b>	<b>++</b>

