

# **Assessment of Vulnerable Plaque by IVUS and VH-IVUS**

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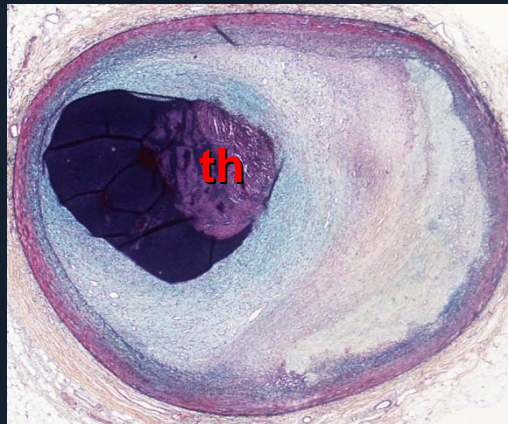


# Plaque Morphology of AMI/SCD w/Thrombi

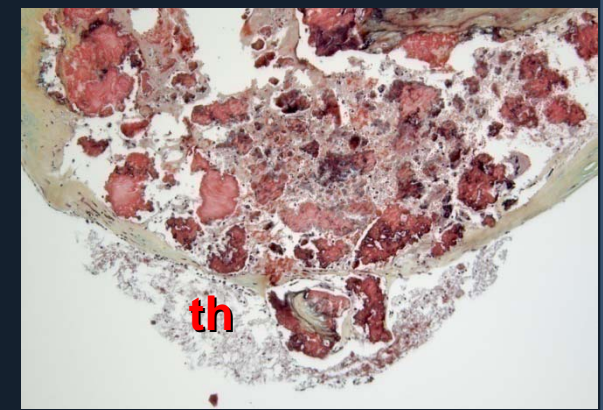
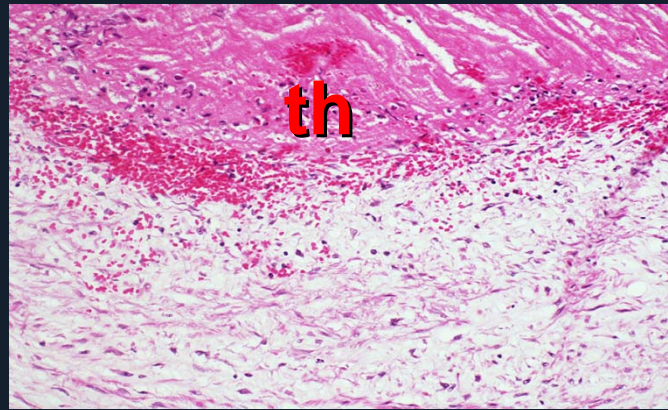
**Plaque Rupture**  
60%(f) – 80%(m)



**Plaque Erosion**  
20%(m) - 40%(f)

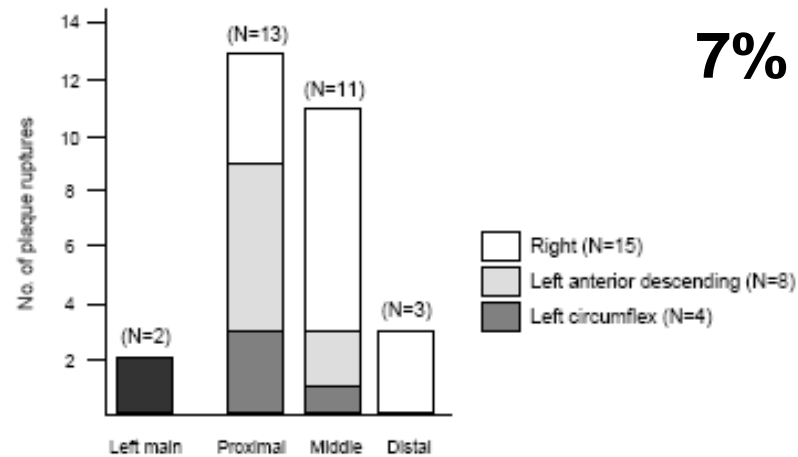


**Calcified Nodule**  
2% - 7%

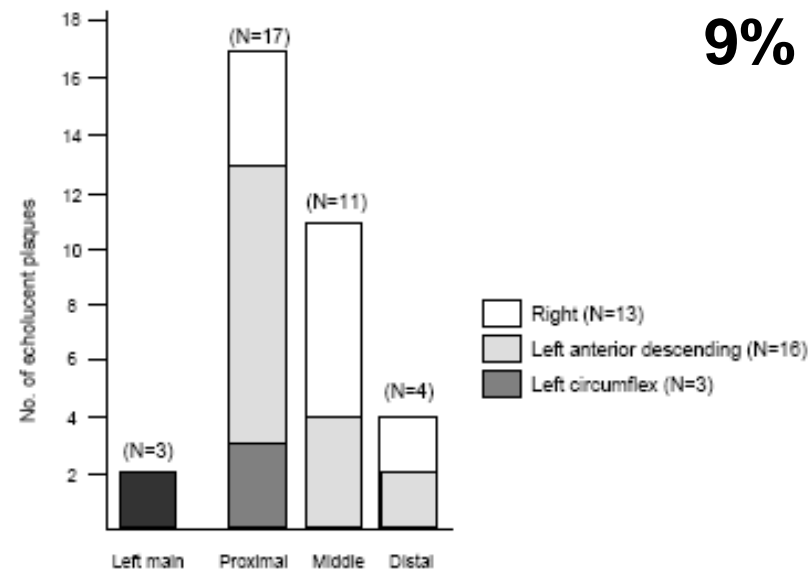


# Plaque Rupture & Echolucent Plaque in non-Culprit lesions HORIZONS-AMI

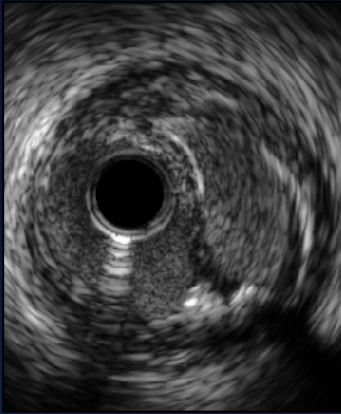
A. Plaque ruptures at baseline (N=29)



B. Echolucent plaques at baseline (N=35)



## Plaque Rupture



29

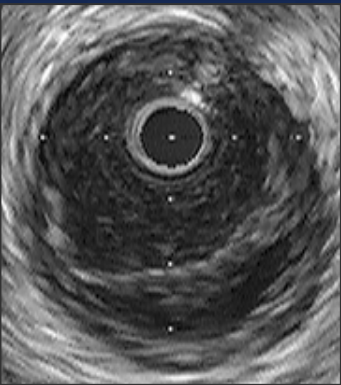
13 Months FU

4/11: Healed

7/11: Persisted

9: New

## Echolucent Plaque



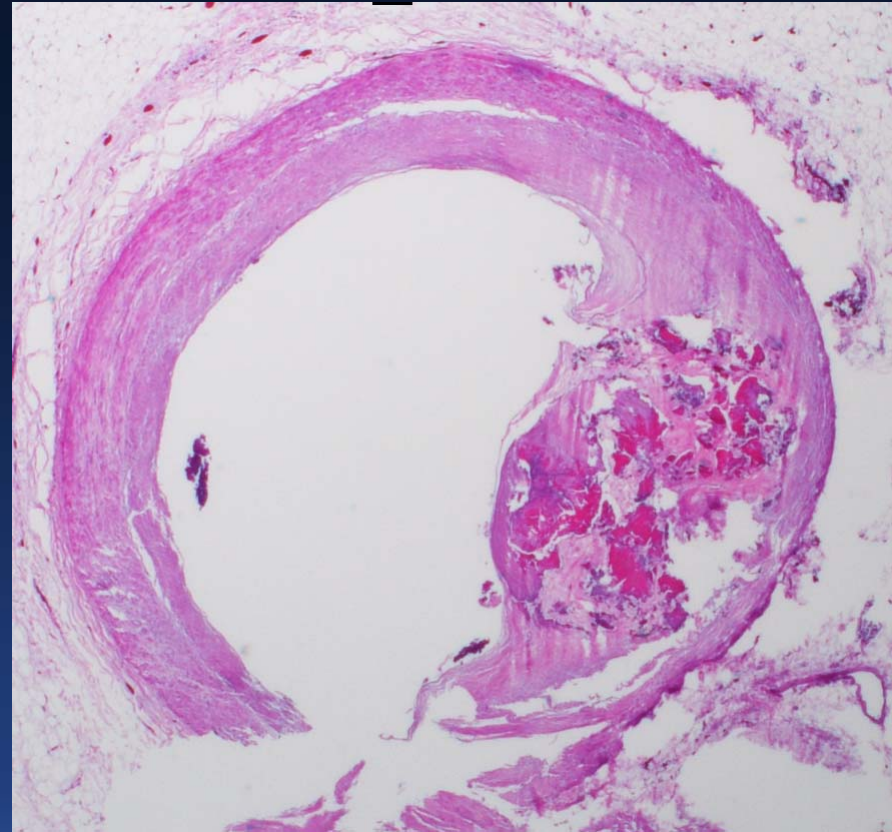
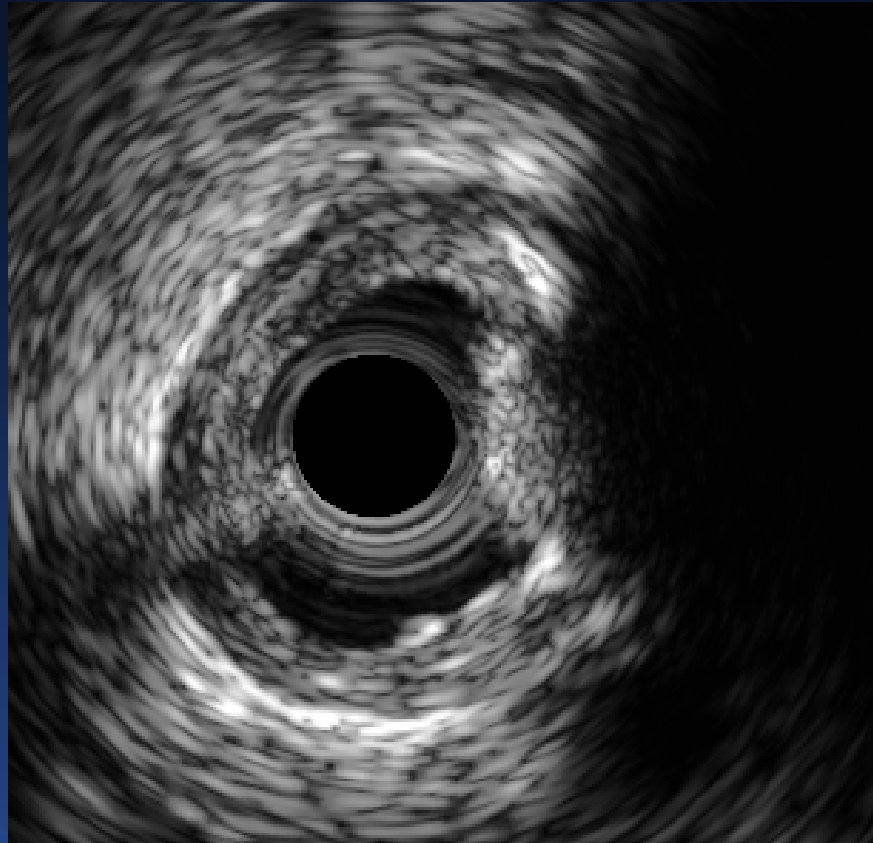
35

11/25: Disappeared

14/25: Persisted

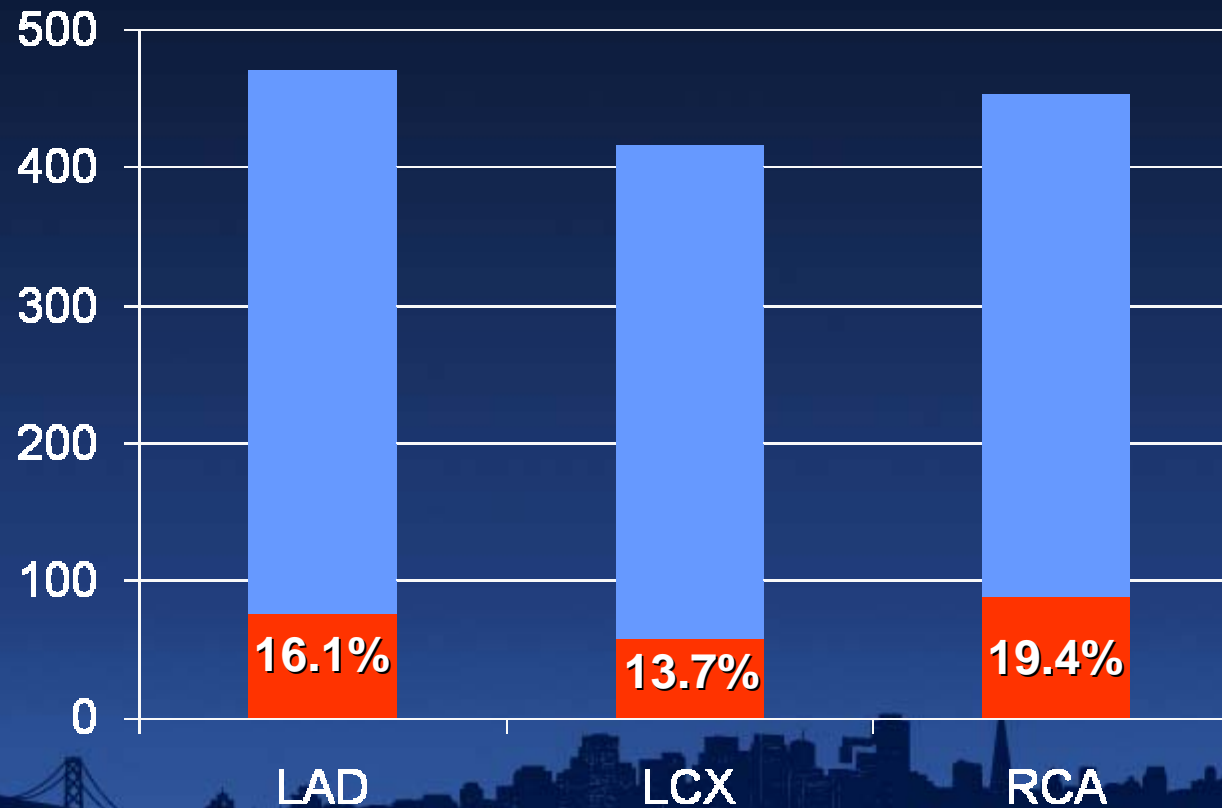
10: New

# Calcium Nodule



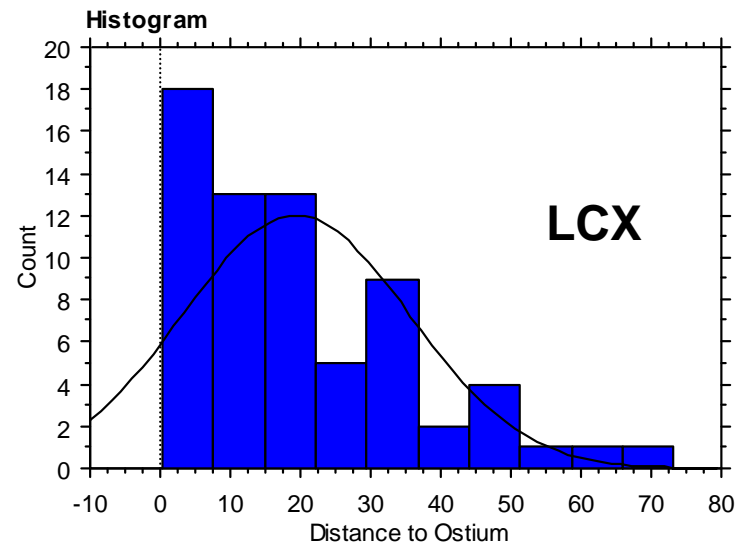
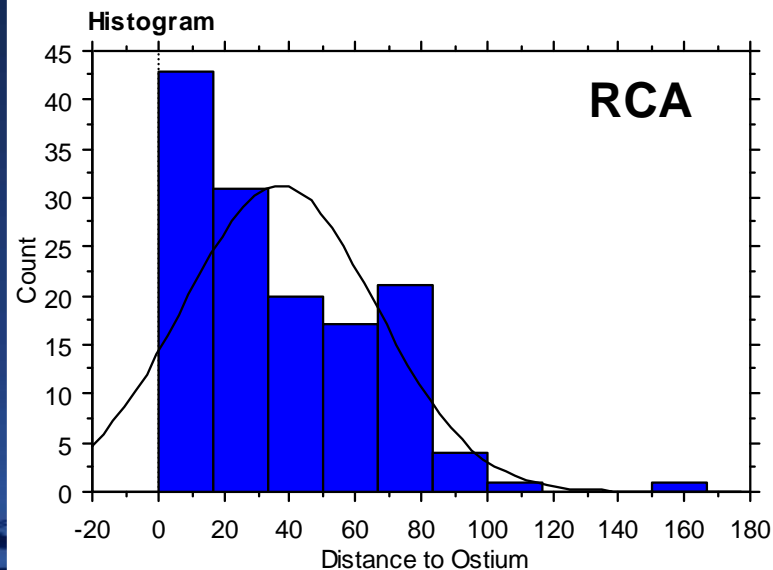
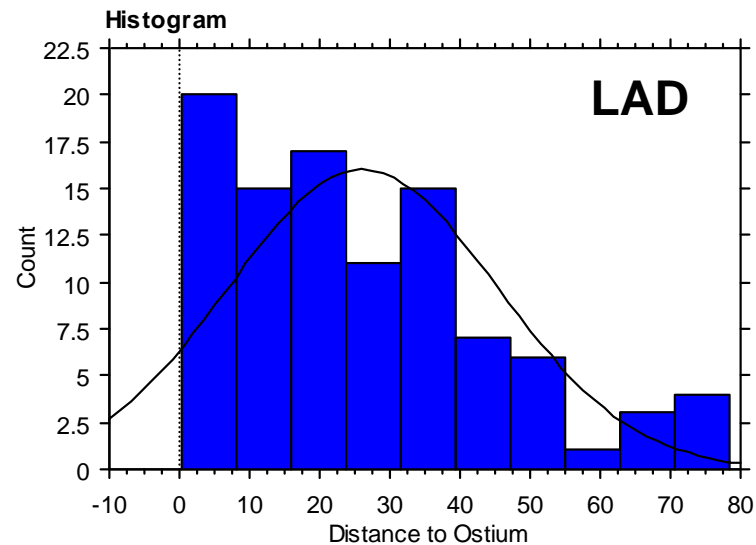
Data obtained in the CDEV3 Study, Gardner et al, JACC Imaging, 2008, sponsored by InfraReDx, Inc.

- 327 Calcified nodule in 1340 vessels in 572 pts
- Incidence: **pt 49.8%** (285/572), **vessel 18%** (241/1340)
- Multiple nodule/vessel 25.3% (61/241)



# Distribution of Calcium Nodule

Similar with the distribution of plaque rupture, TCFA



# VH-IVUS Classification

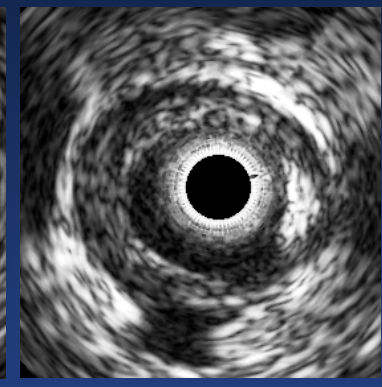
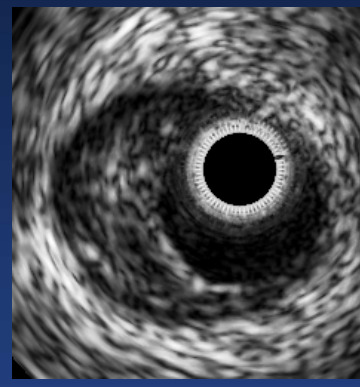
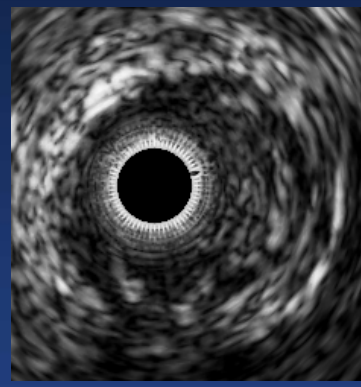
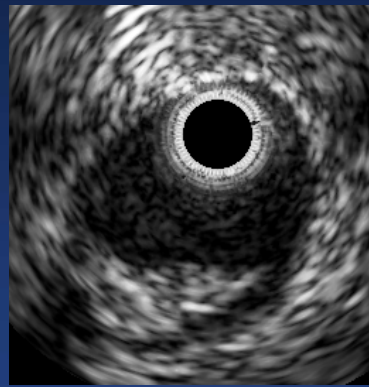
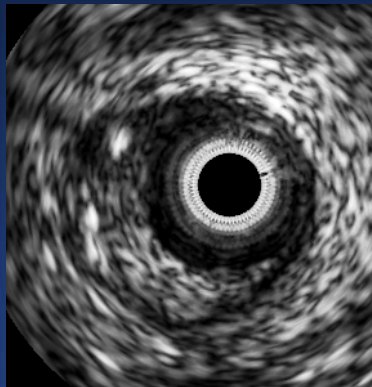
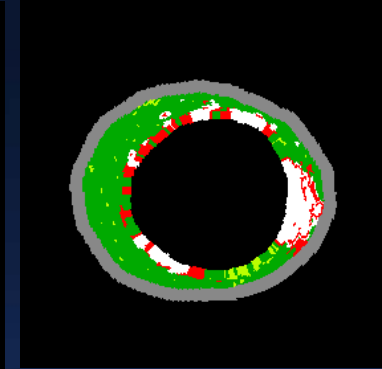
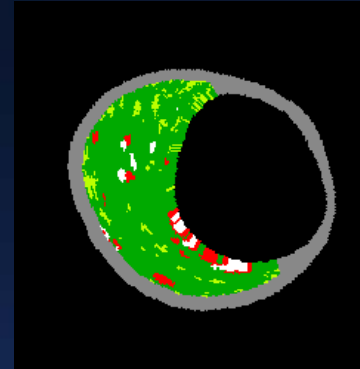
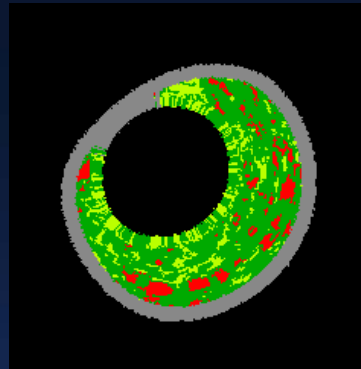
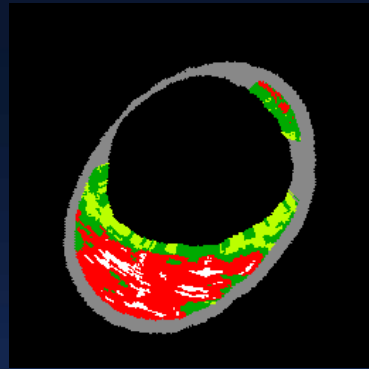
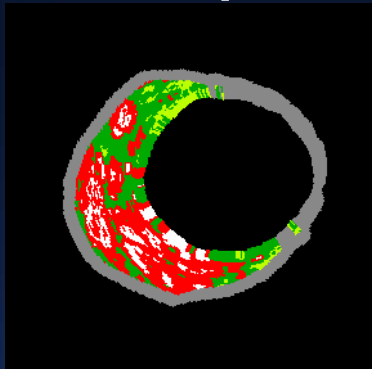
Thin-cap FA

Thick-cap FA

PIT

Fibrous

Fibrocalcific



More than 10%  
**Confluent**  
Necrotic Core

More than 15%  
Fibrofatty

NO more than 10%  
Confluent Necrotic  
Core

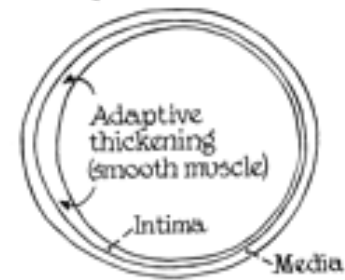
More than 10%  
confluent  
calcium



# Histological Atherosclerosis Classification

Nomenclature and main histology	Sequences in progression	Main growth mechanism	Earliest onset	Clinical correlation
<b>Type I (initial) lesion</b> isolated macrophage foam cells		growth mainly by lipid accumulation	from first decade	clinically silent
<b>Type II (fatty streak) lesion</b> mainly intracellular lipid accumulation			from third decade	
<b>Type III (intermediate) lesion</b> Type II changes & small extracellular lipid pools				
<b>Type IV (atheroma) lesion</b> Type II changes & core of extracellular lipid		accelerated smooth muscle and collagen increase	from fourth decade	clinically silent or overt
<b>Type V (fibroatheroma) lesion</b> lipid core & fibrotic layer, or multiple lipid cores & fibrotic layers, or mainly calcific, or mainly fibrotic		thrombosis, hematoma		
<b>Type VI (complicated) lesion</b> surface defect, hematoma-hemorrhage, thrombus				

Coronary artery at lesion-prone location



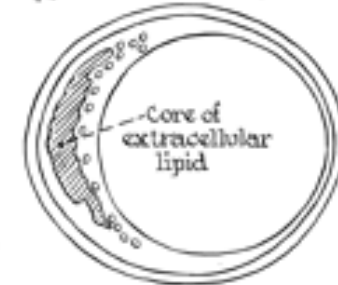
Type II lesion



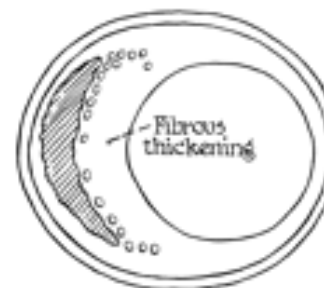
Type III (preatheroma)



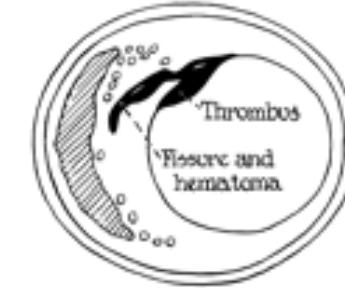
Type IV (atheroma)



Type V (fibroatheroma)



Type VI (complicated lesion)



Terms for Atherosclerotic Lesions in Histological Classification		Other Terms for the Same Lesions Often Based on Appearance to the Unaided Eye	
Type I lesion	Initial lesion	Fatty dot or streak	Early lesion
Type II lesion			
IIa	Progression-prone type II lesion		
IIb	Progression-resistant type II lesion		
Type III lesion	Intermediate lesion (preatheroma)	Atheromatous plaque, fibrolipid plaque, fibrous plaque, plaque	Advanced lesions, raised lesions
Type IV lesion	Atheroma		
Va	Fibroatheroma (type V lesion)		
Vb	Calcific lesion (type VII lesion)		
Vc	Fibrotic lesion (type VIII)		
Type VI lesion	Lesion with surface defect and/or hematoma/hemorrhage and/or thrombotic deposit	Complicated lesion, complicated plaque	

**1. Pathological Intimal Thickening (PIT)**

**2. Thin cap fibroatheroma (TCFA)**

**3. Thick cap Fibroatheroma (ThCFA)**

**4. Fibrous Plaque**

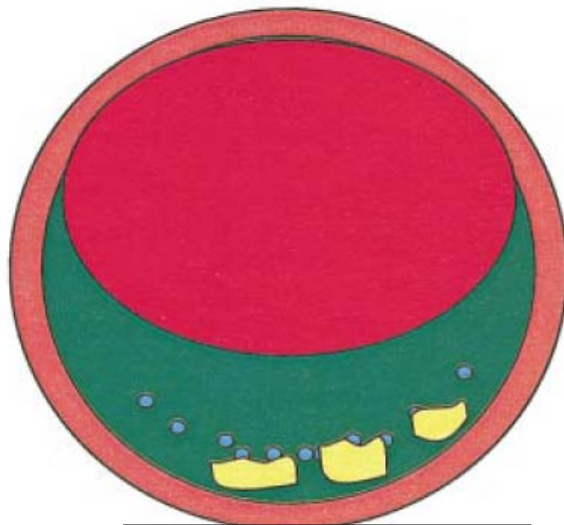
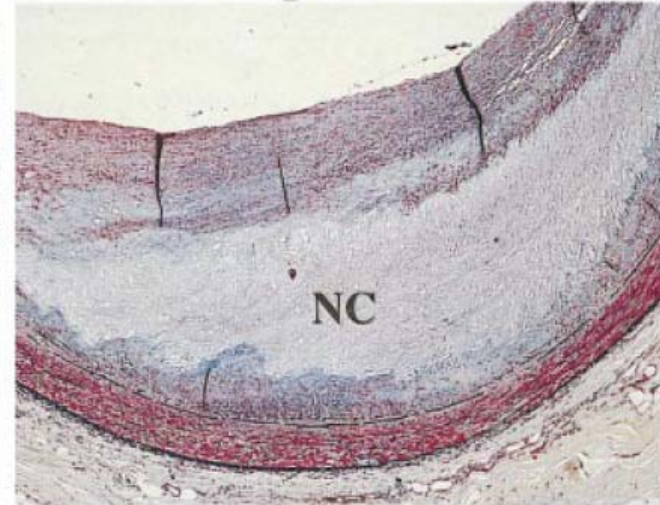
**5. Fibrocalcific**

# Pathological Intimal thickening & Fibroatheroma

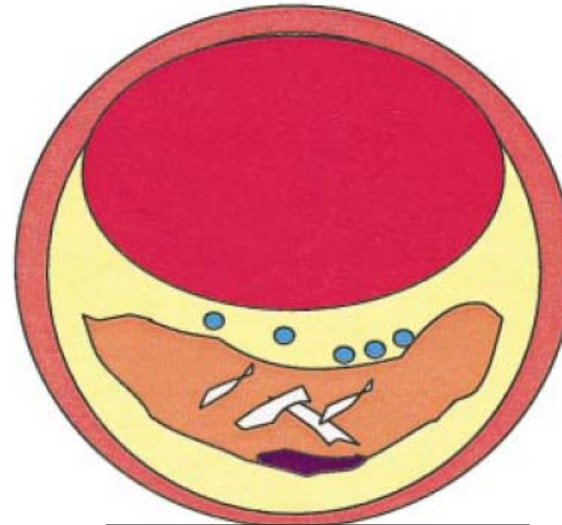
**Pathologic intimal thickening**



**Fibrous cap atheroma**



**Necrosis (-)**



**Necrosis (+)**

# VH-IVUS Classification

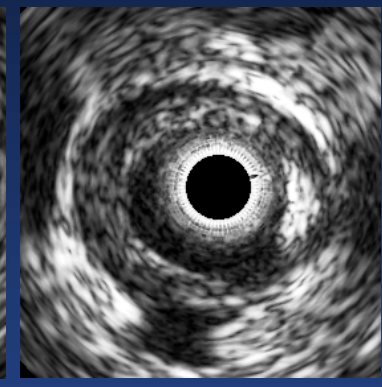
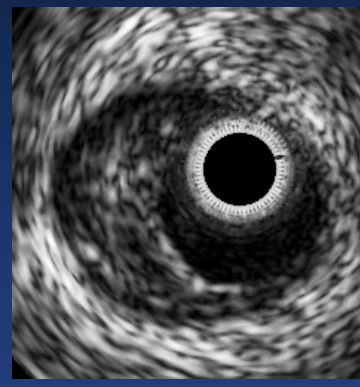
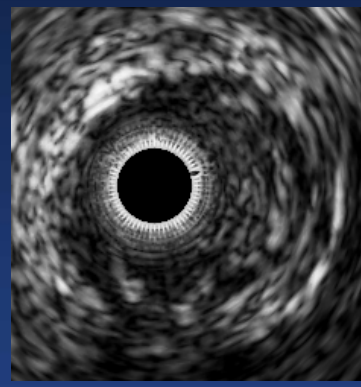
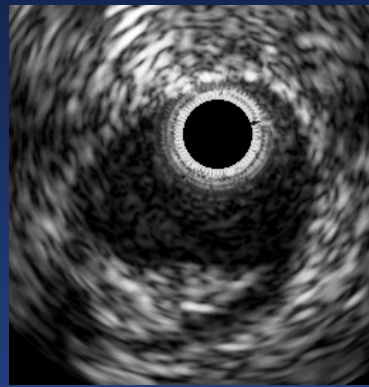
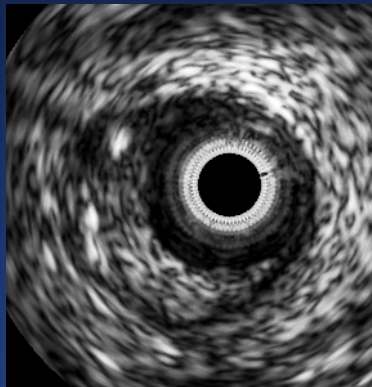
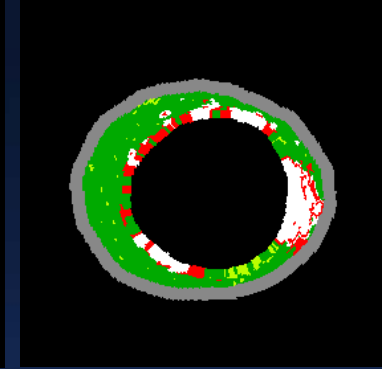
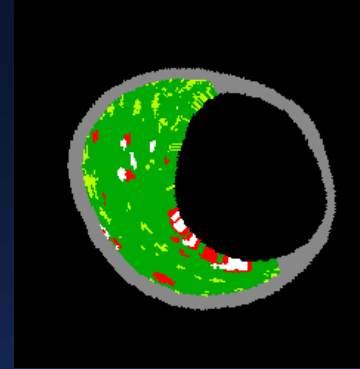
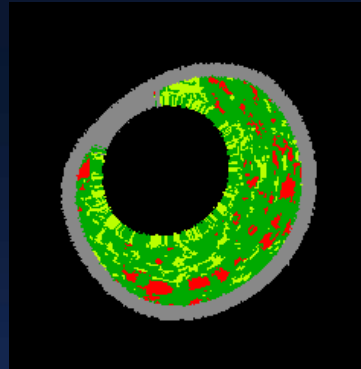
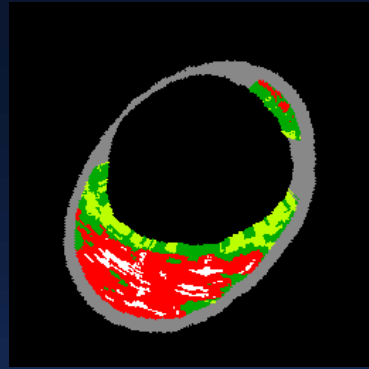
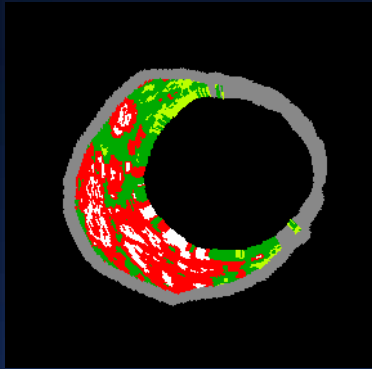
Thin-cap FA

Thick-cap FA

PIT

Fibrous

Fibrocalcific



More than 10%  
**Confluent**  
Necrotic Core

More than 15%  
Fibrofatty

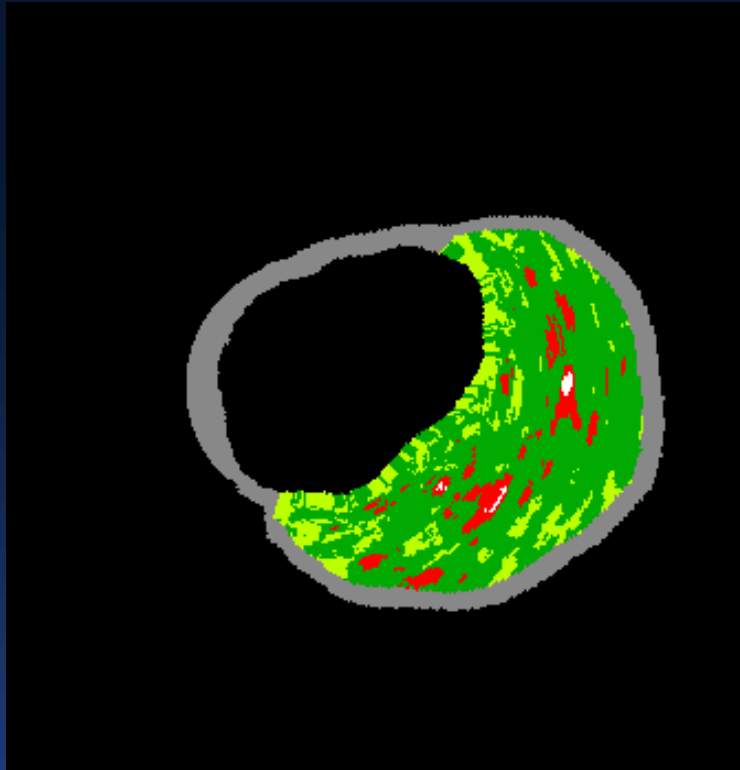
NO more than 10%  
Confluent Necrotic  
Core

More than 10%  
confluent  
calcium

**“Confluent”**



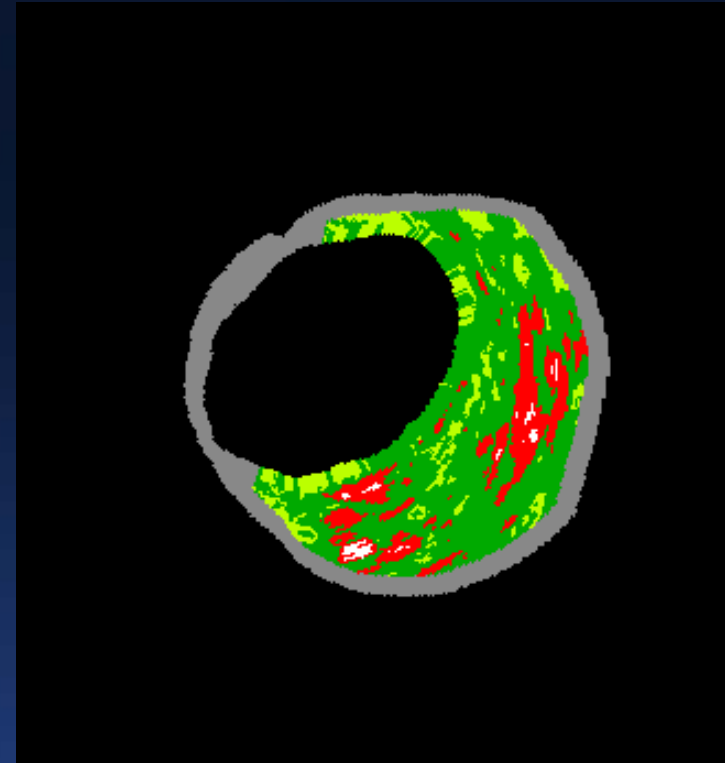
# Confluent Necrotic Core



**Non-Confluent**



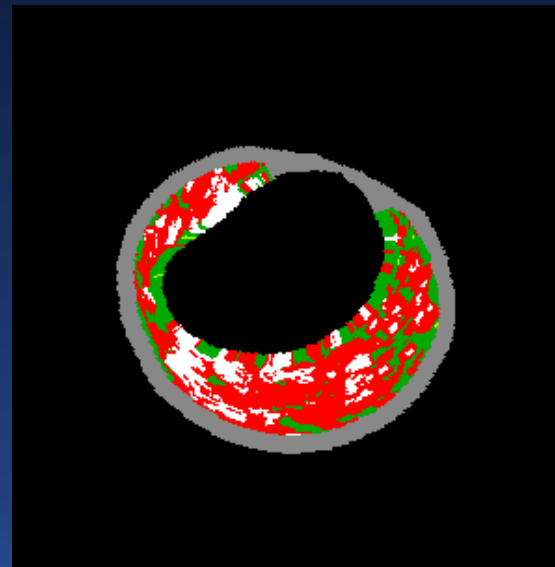
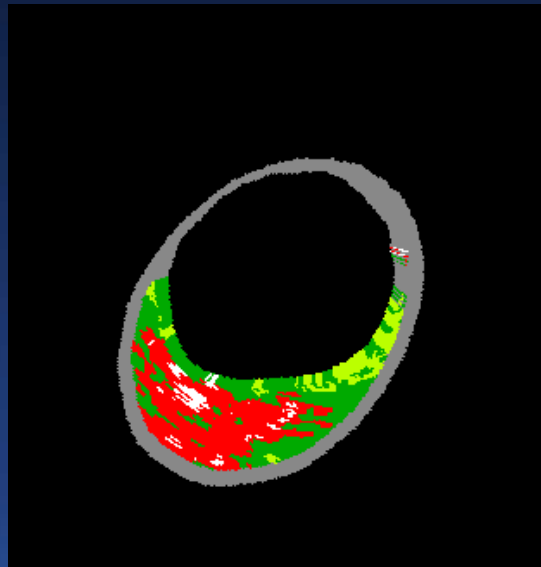
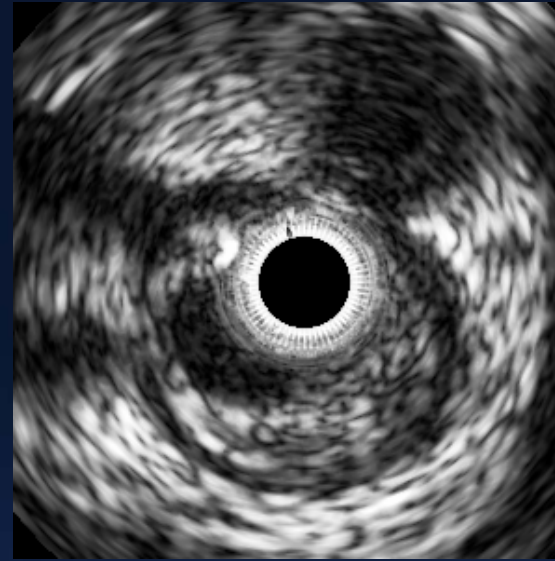
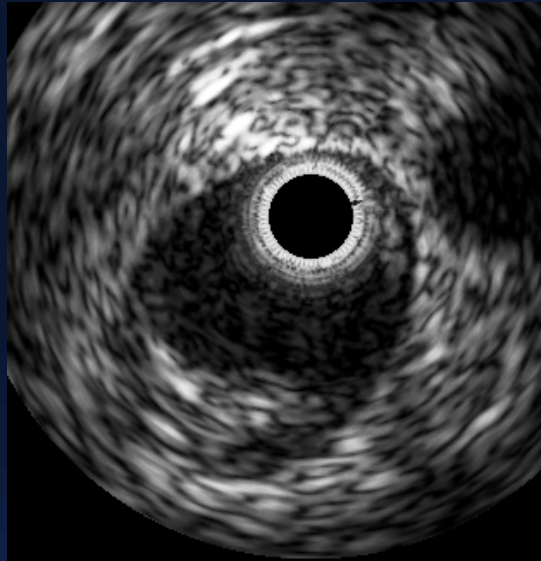
**Pathological Intimal  
Thickening**



**Confluent**



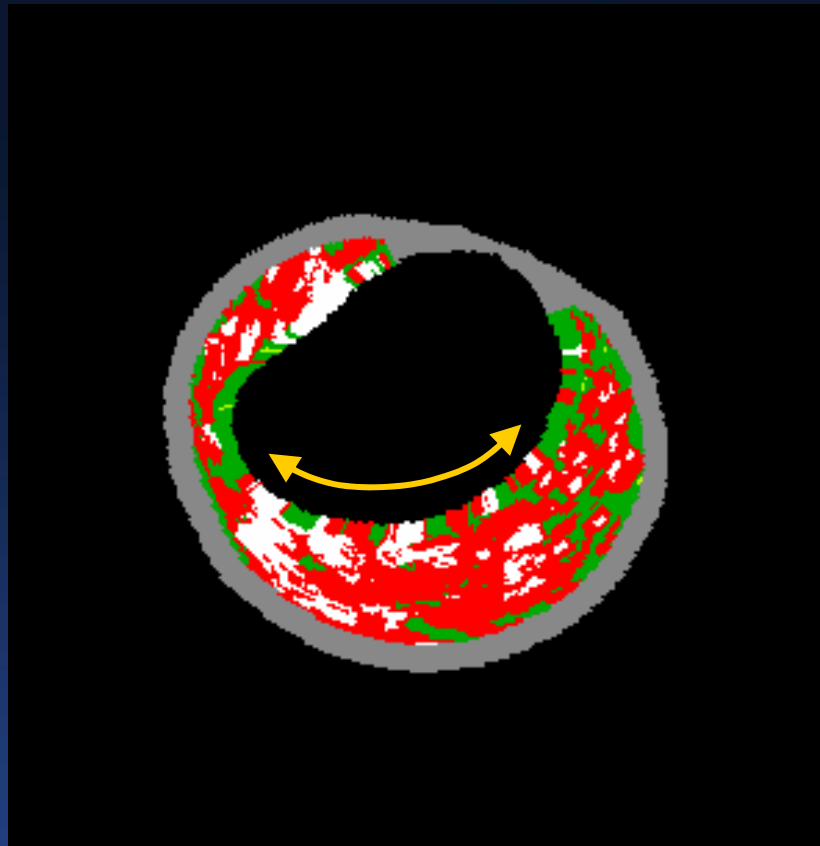
**Thick Cap  
Fibroatheroma**



**Thick cap  
fibroatheroma**

**Thin cap  
fibroatheroma**

## VH Thin cap fibroatheroma (TCFA)



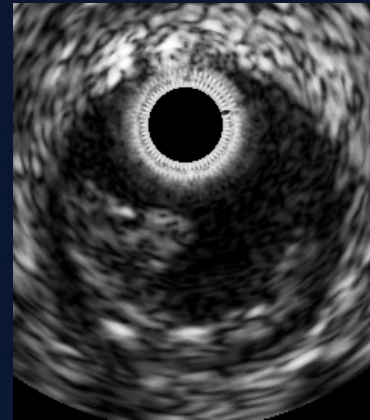
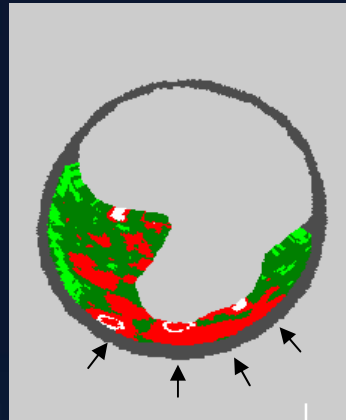
1. Confluent NC > 10%
2. 30° NC abutting the lumen
3. 3 consecutive frames  
(= 1.5 mm in length)

Thin cap < 65  $\mu\text{m}$  (less than the 200  $\mu\text{m}$  resolution of IVUS)



Incidence of NC at the bottom/shoulder of the cavity

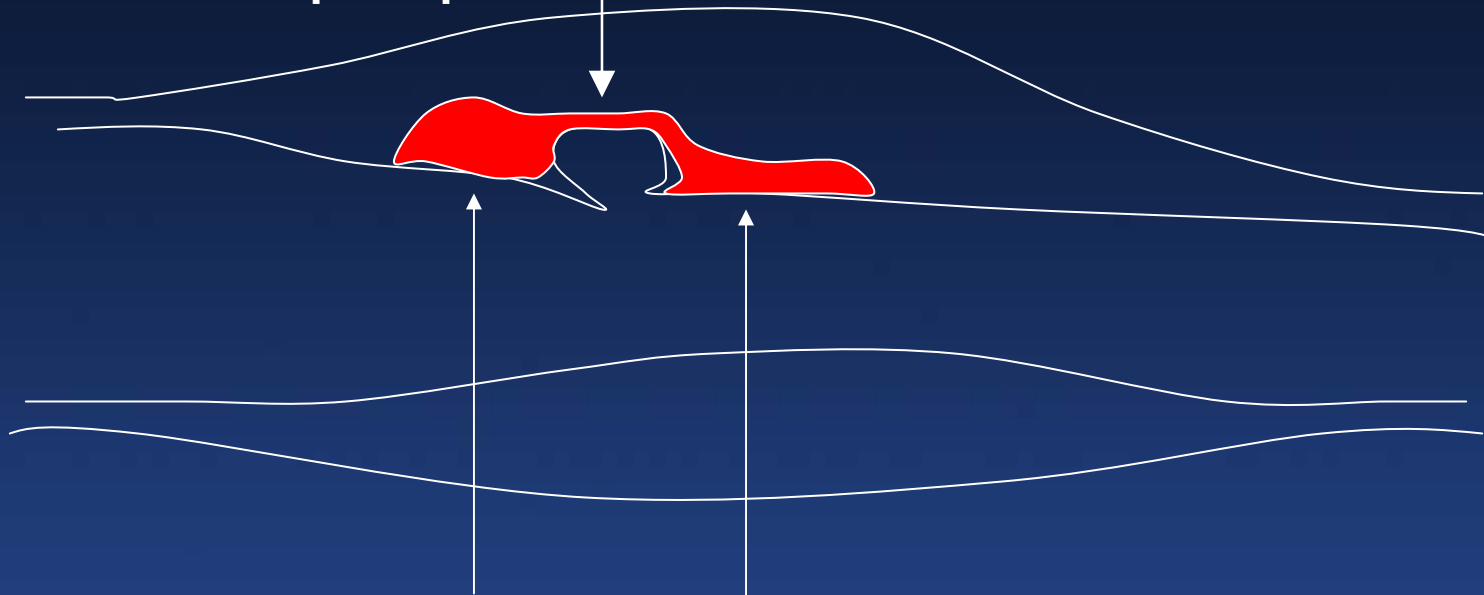
84% (41/49)



1. 129 ruptures in 100 vessels in 97 patients in PROSPECT.

2. Typical plaque rupture=49/129 (38%)

Plaque rupture

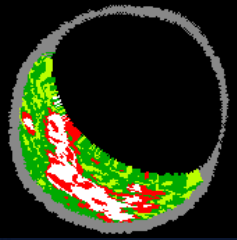


Proximal

57% (28/49)

Distal

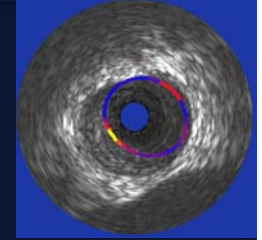
37% (18/49)



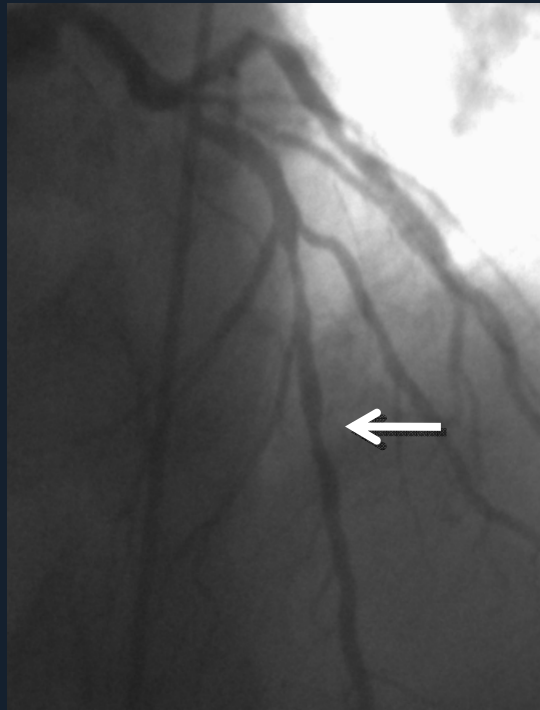
**PROSPECT 27731-003: 58 yo man**

**3/15/05: NSTEMI, PCI of MRCA**

**3/23/06 (1 year): Unstable angina  
attributed to LAD**

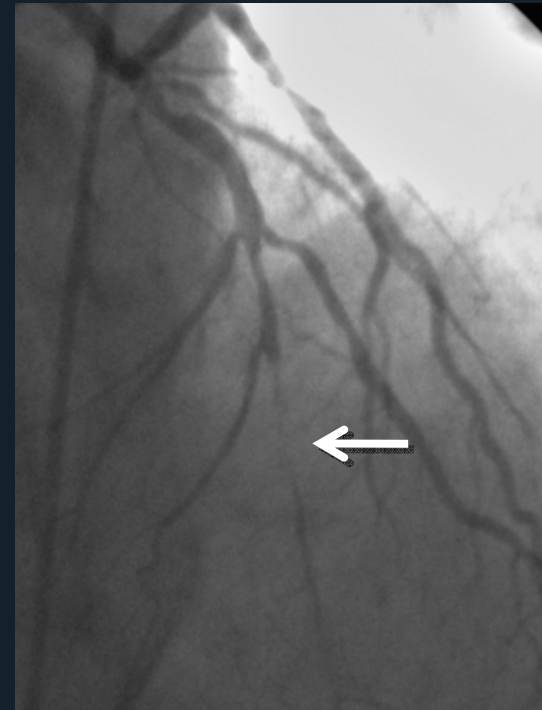


**Index 3/15/05**



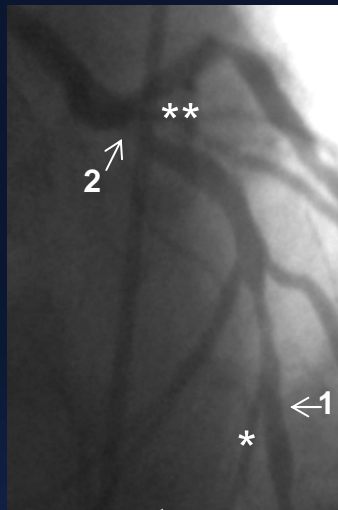
**QCA MLAD DS 31.1%**

**Event 3/23/06**



**QCA MLAD DS 100%**

# PROSPECT 27731-003: Index 3/15/05

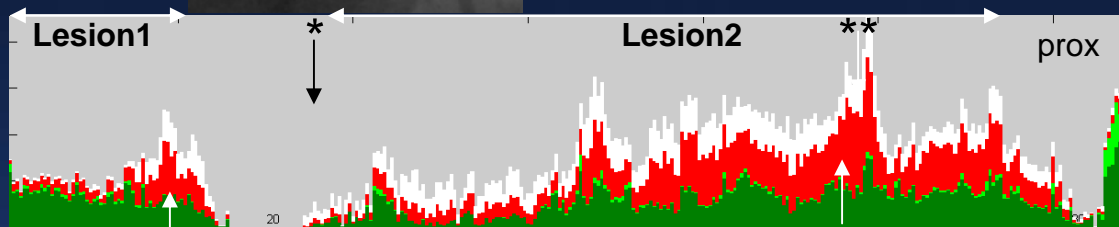


Baseline MLAD

**QCA: DS 31.1%**

**IVUS: MLA 3.6 mm<sup>2</sup>**

**VH: TCFA**

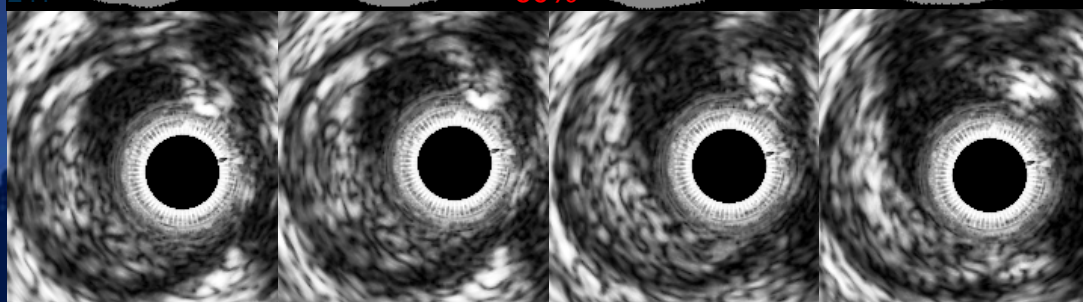
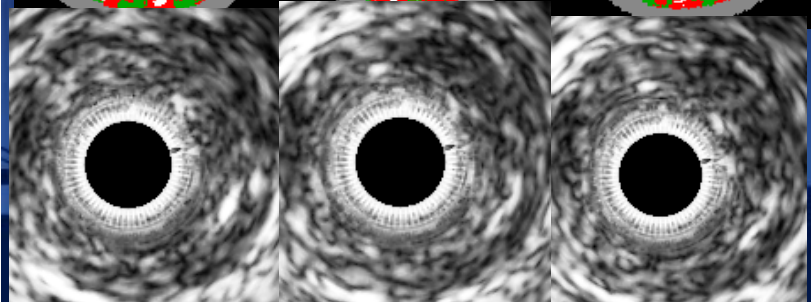
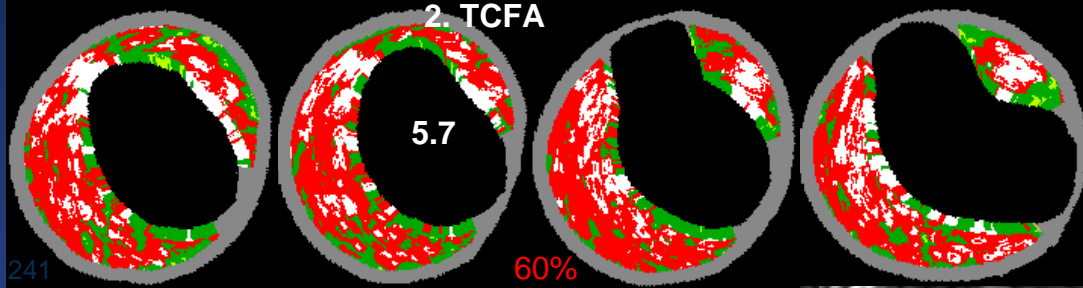
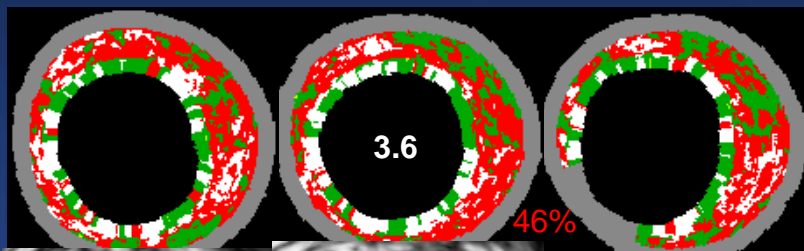


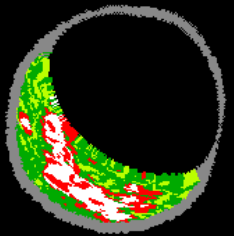
**MLAD**

**PLAD**

1. TCFA

2. TCFA

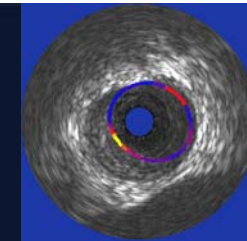




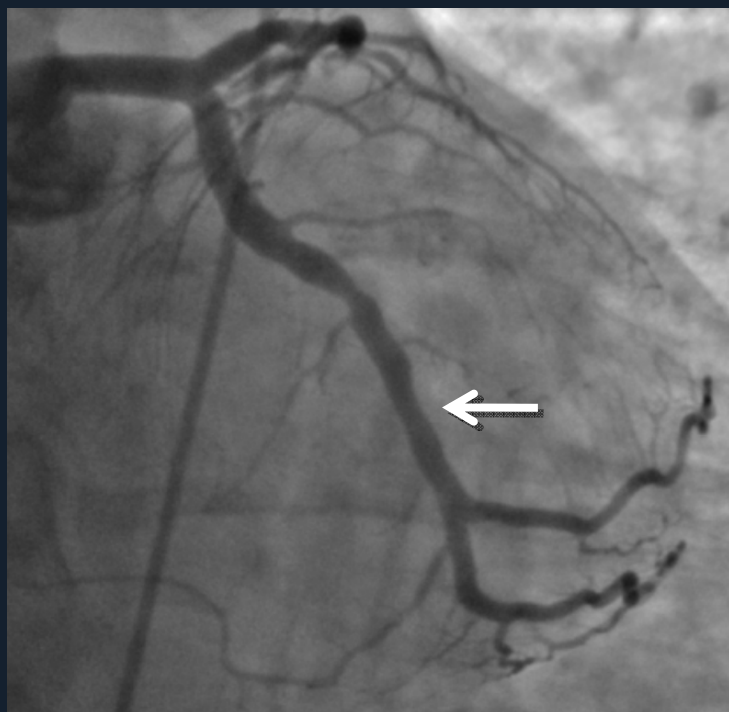
**PROSPECT 82910-012: 52 yo man**

**2/13/06: NSTEMI, PCI of MLAD**

**2/6/07 (1 year): NSTEMI attributed to  
LCX**

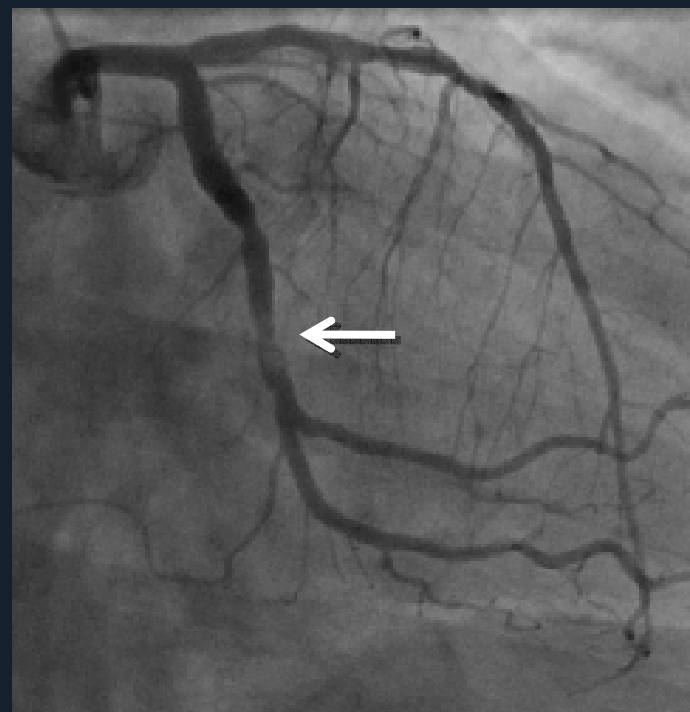


**Index 2/13/06**



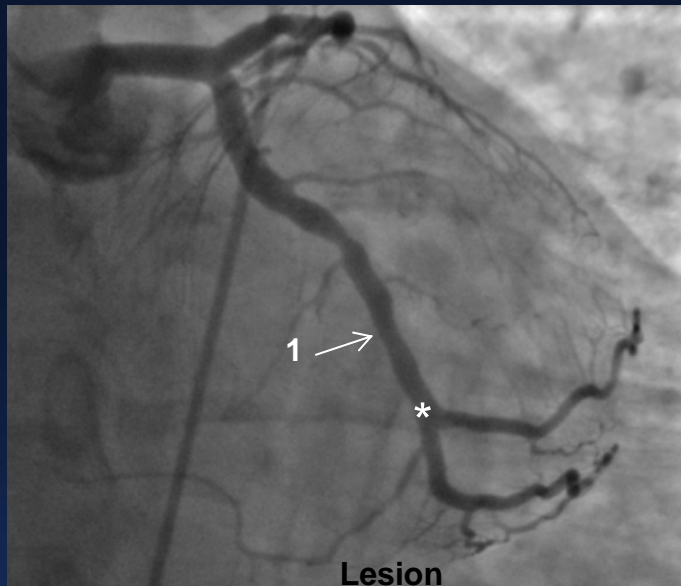
**QCA PLCX DS 38.6%**

**Event 2/6/07**



**QCA PLCX DS 71.3%**

# PROSPECT 82910-012: Index 2/13/06

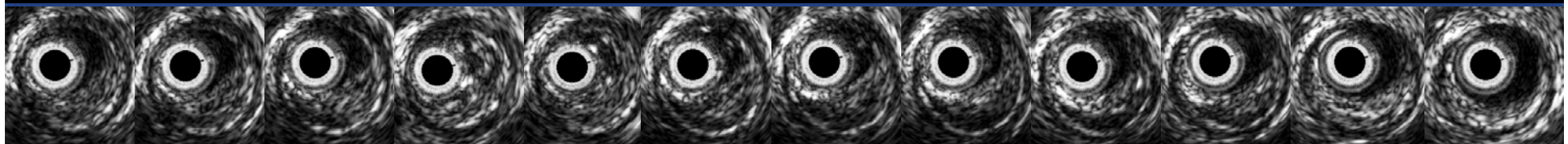
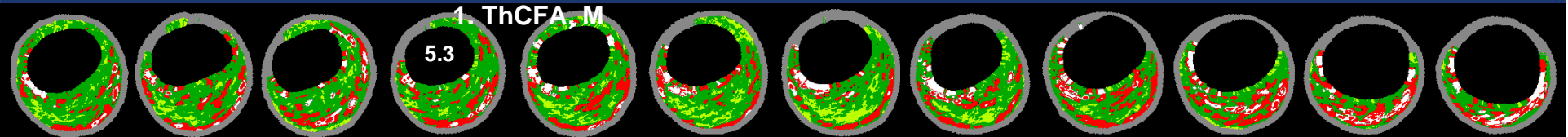
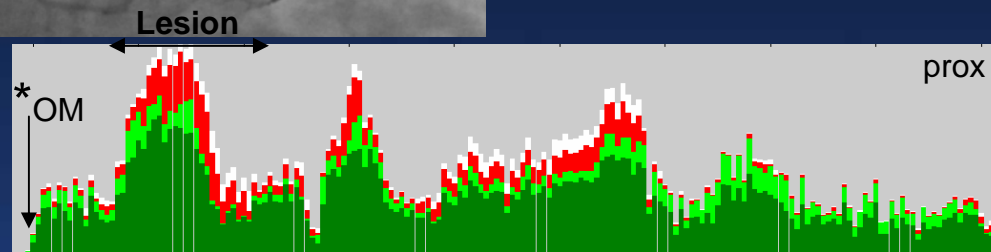


Baseline PLCX

**QCA: DS 38.6%**

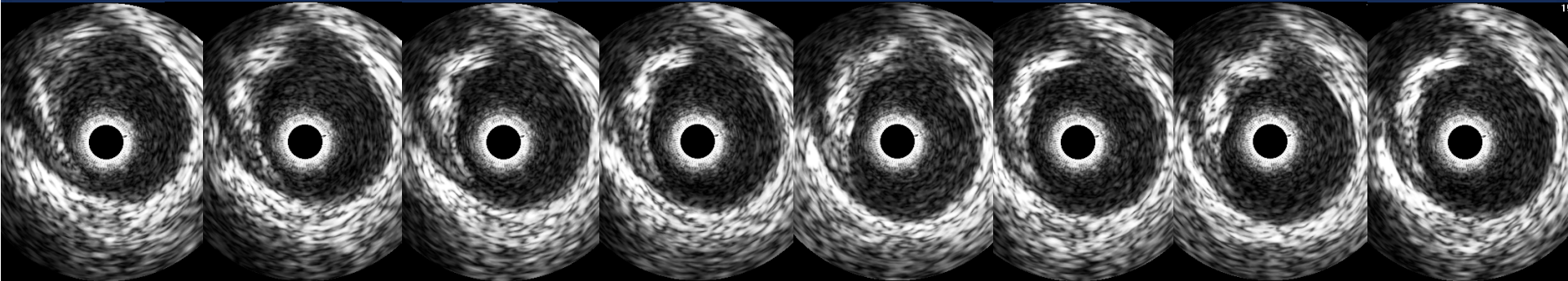
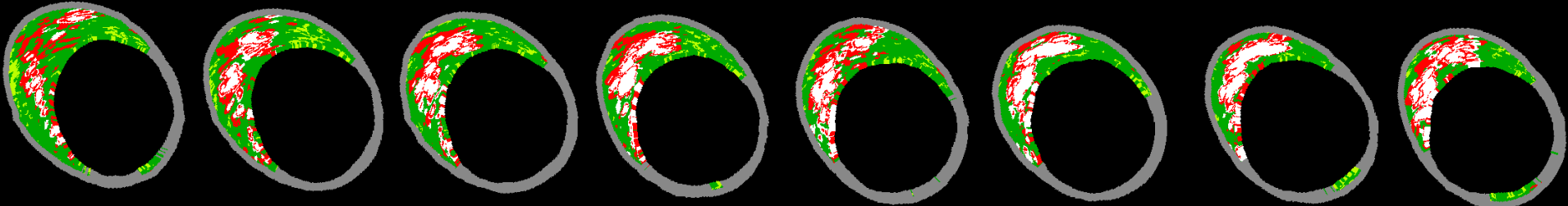
**IVUS: MLA 5.3 mm<sup>2</sup>**

**VH: ThCFA**

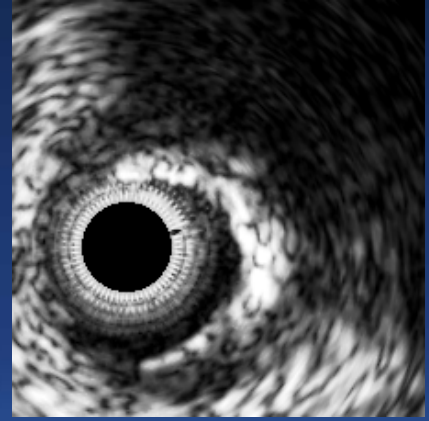
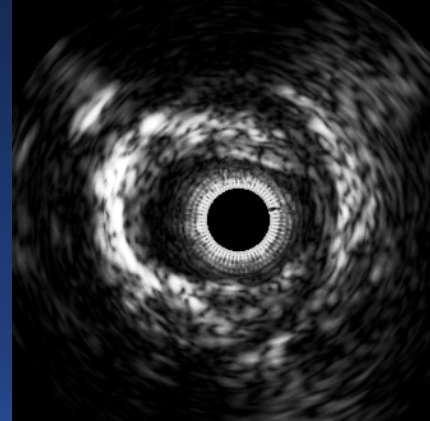
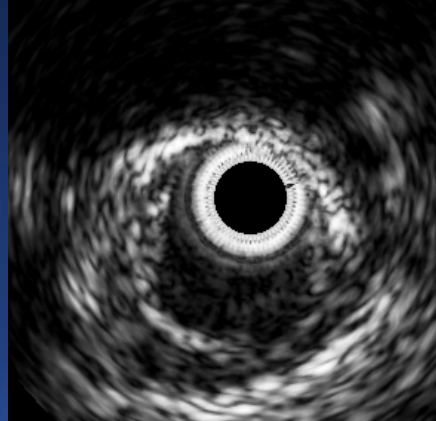
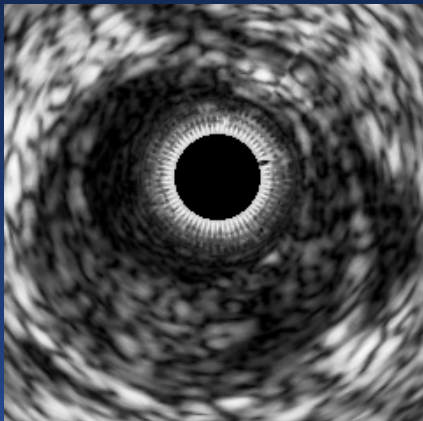
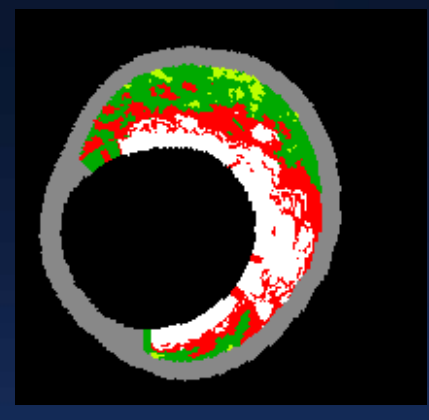
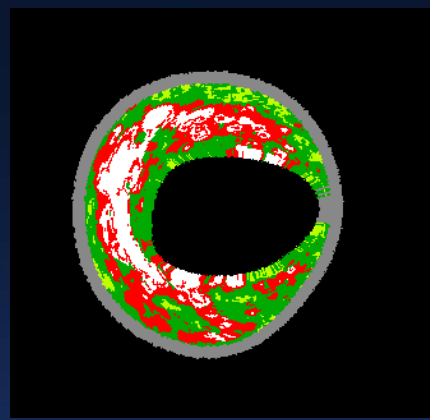
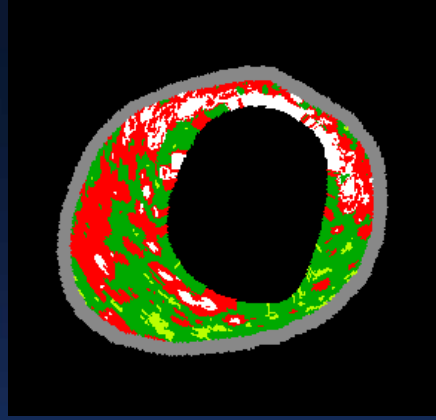
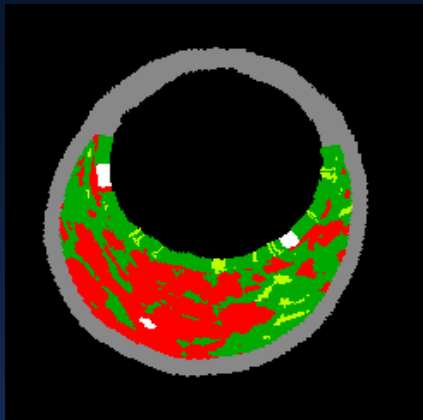


Echolucent Plaque

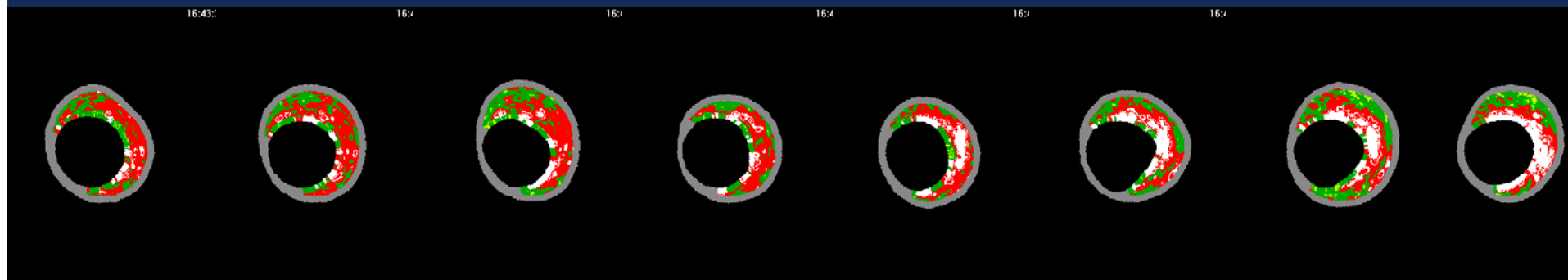
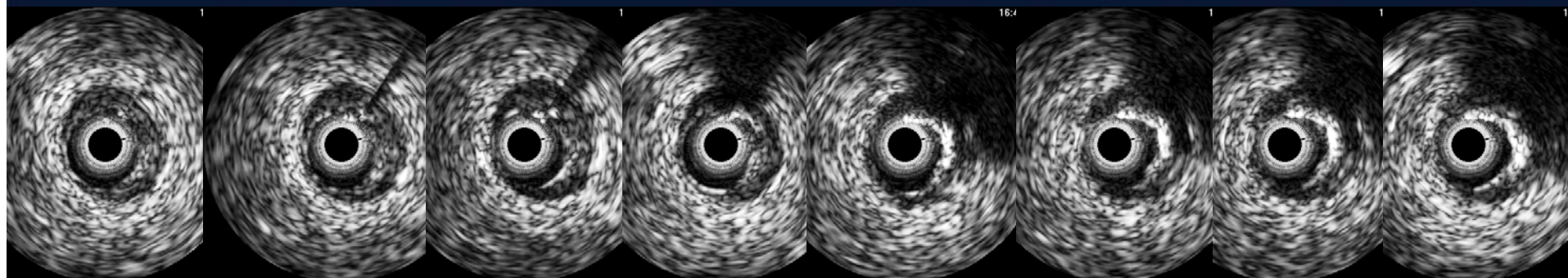
# Consecutive 3 frames



# True or Artificial Necrotic Core?

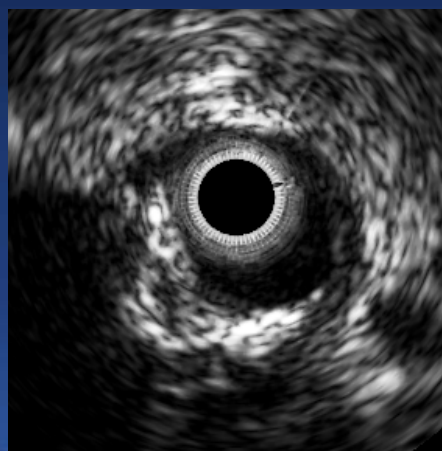
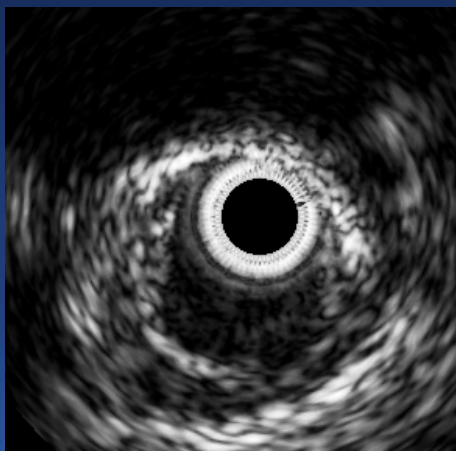
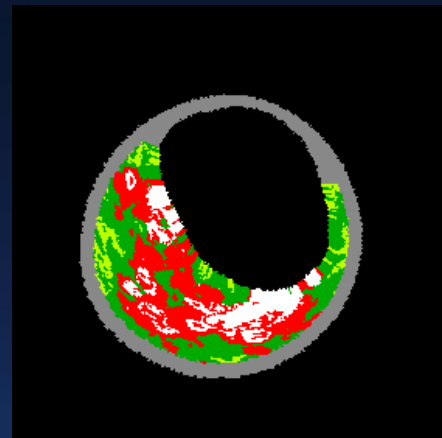
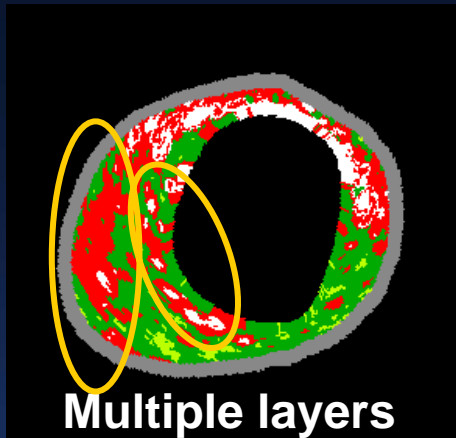


**Necrotic core and Calcium are together longitudinally.**

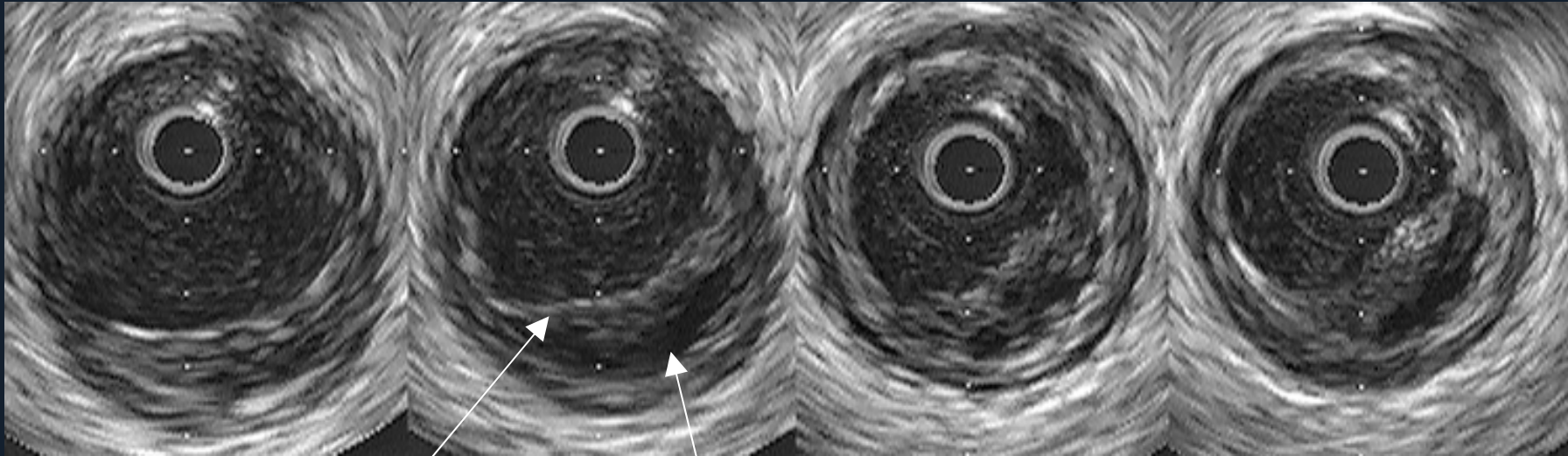




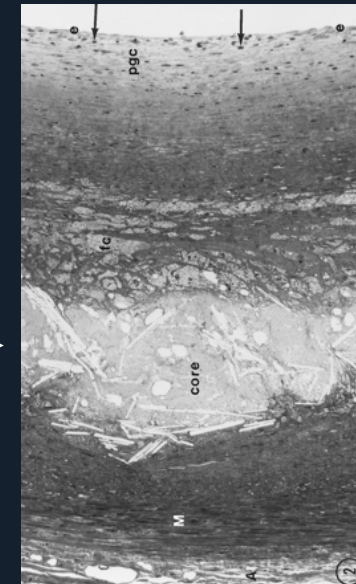
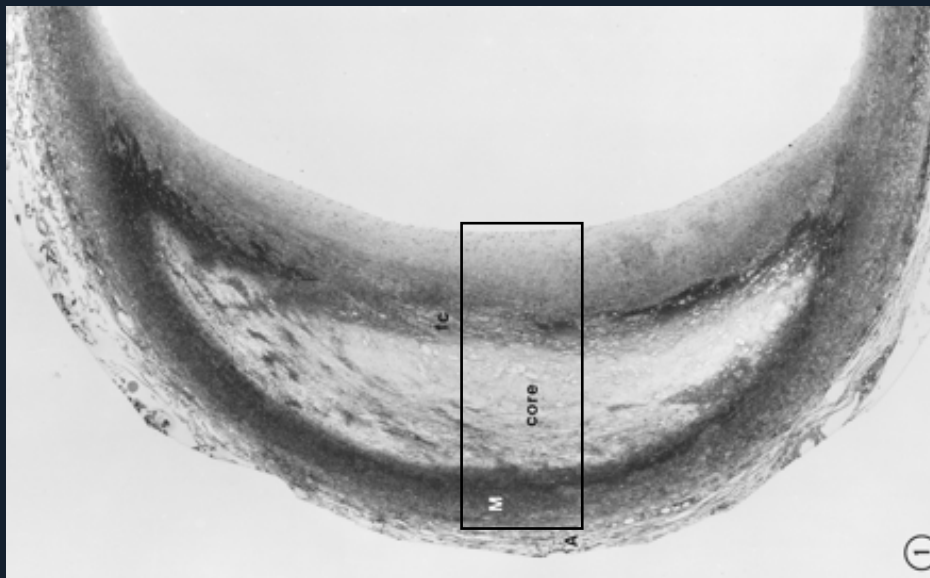
**Necrotic core and Calcium are together circumferentially.**



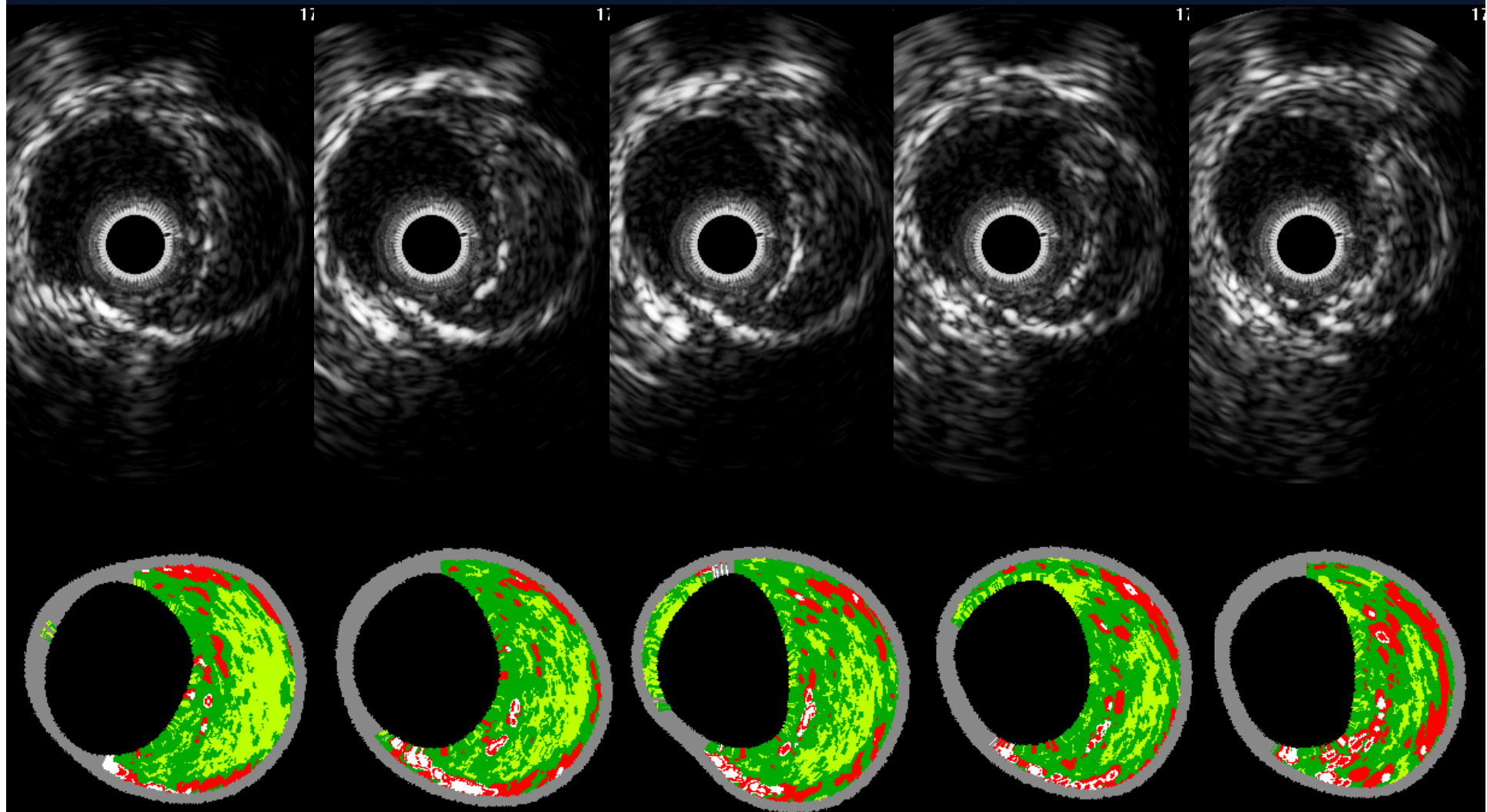
# Echolucent Plaque=Vulnerable Plaque?



Fibrous Cap    Necrotic Core?

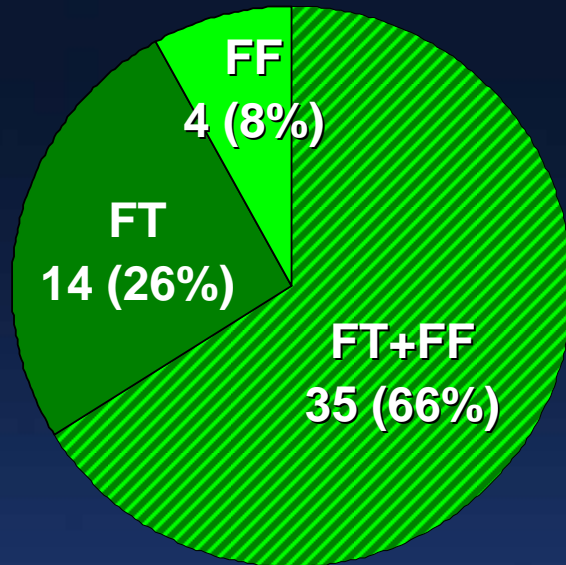


# Echolucent Plaque and VH

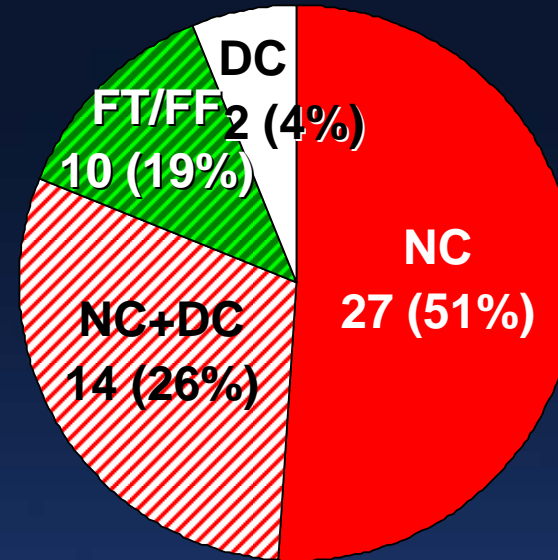


# Echolucent Plaque and VH

## Echolucent Zone

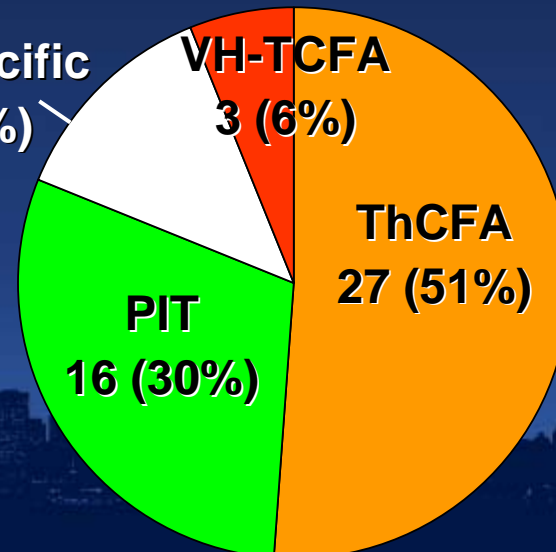


## Adjacent to Echolucent Zone



## VH Phenotype of Echolucent Lesion

Fibrocalcific  
7 (13%)

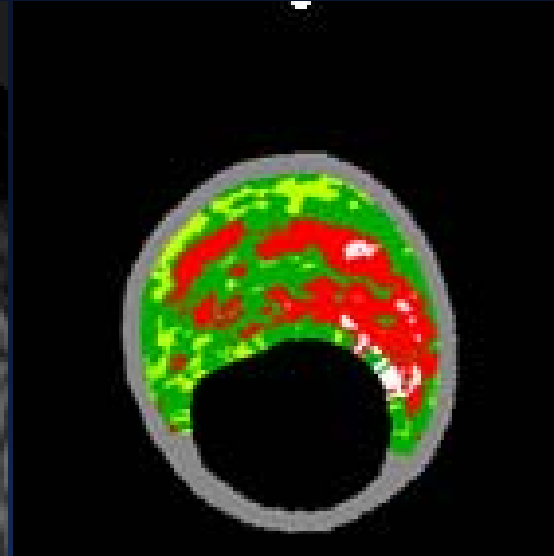
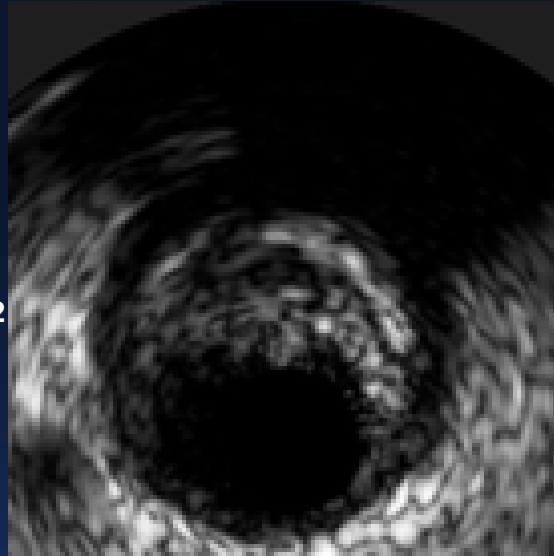


# Attenuated Plaque and VH

## Attenuated plaque

P&M : 9.44 mm<sup>2</sup>

PB: 67.3%



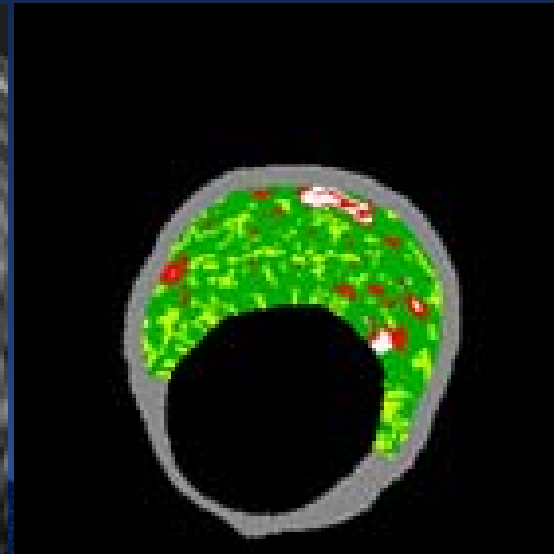
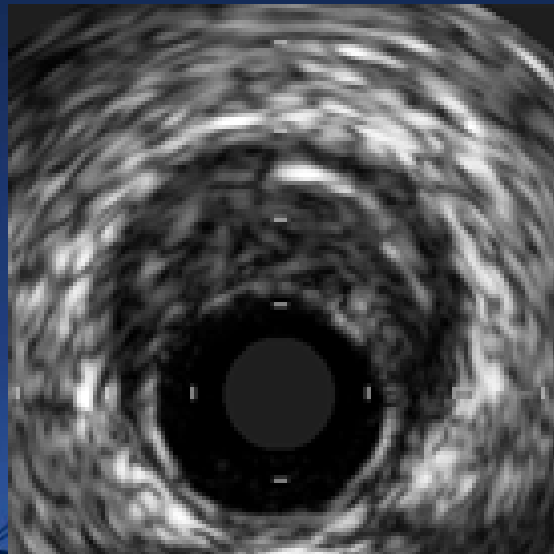
NC area: 1.96 mm<sup>2</sup>

NC%: 20.8%

## Non attenuated plaque

P&M : 8.8 mm<sup>2</sup>

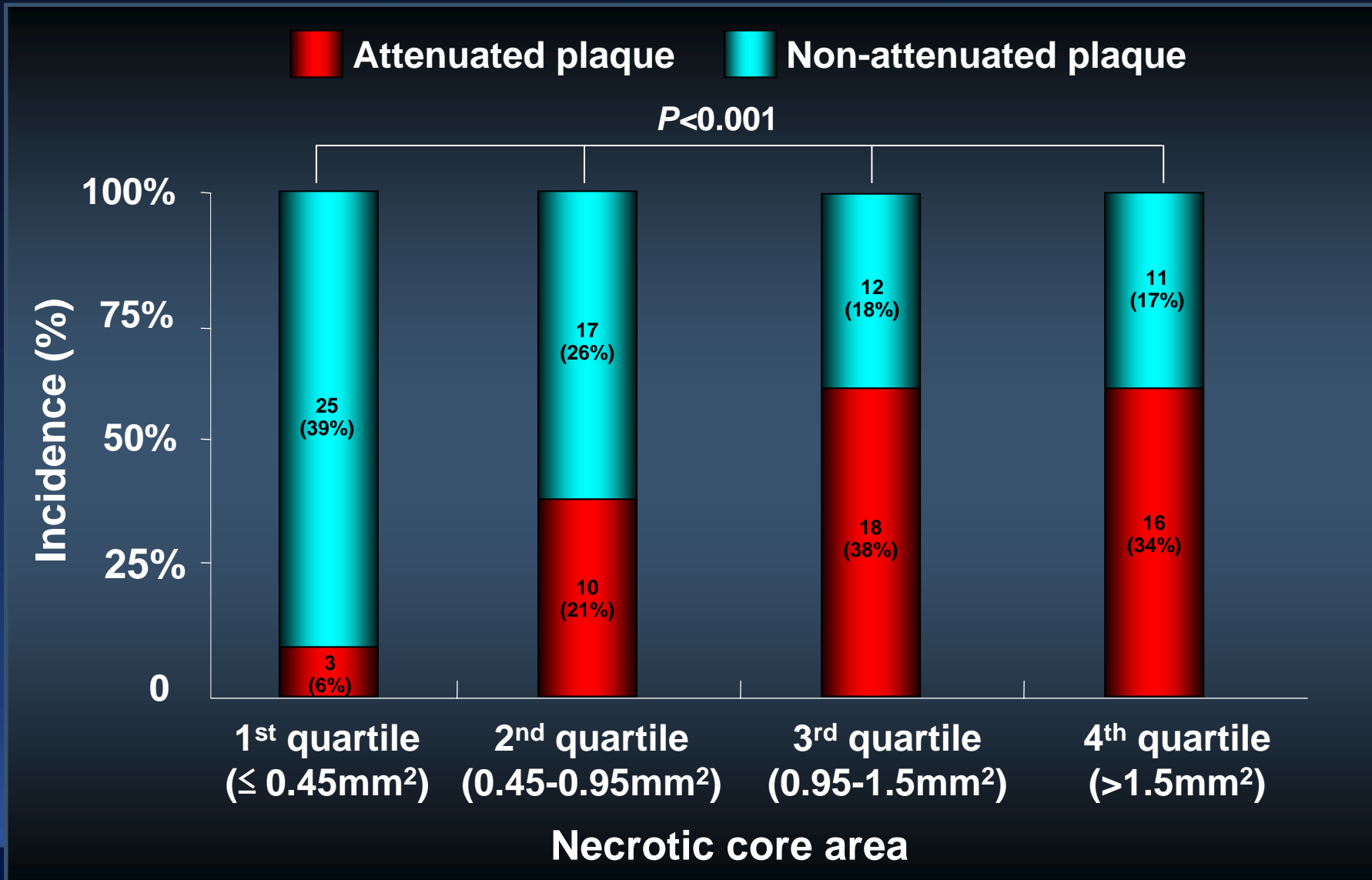
PB: 61.7%



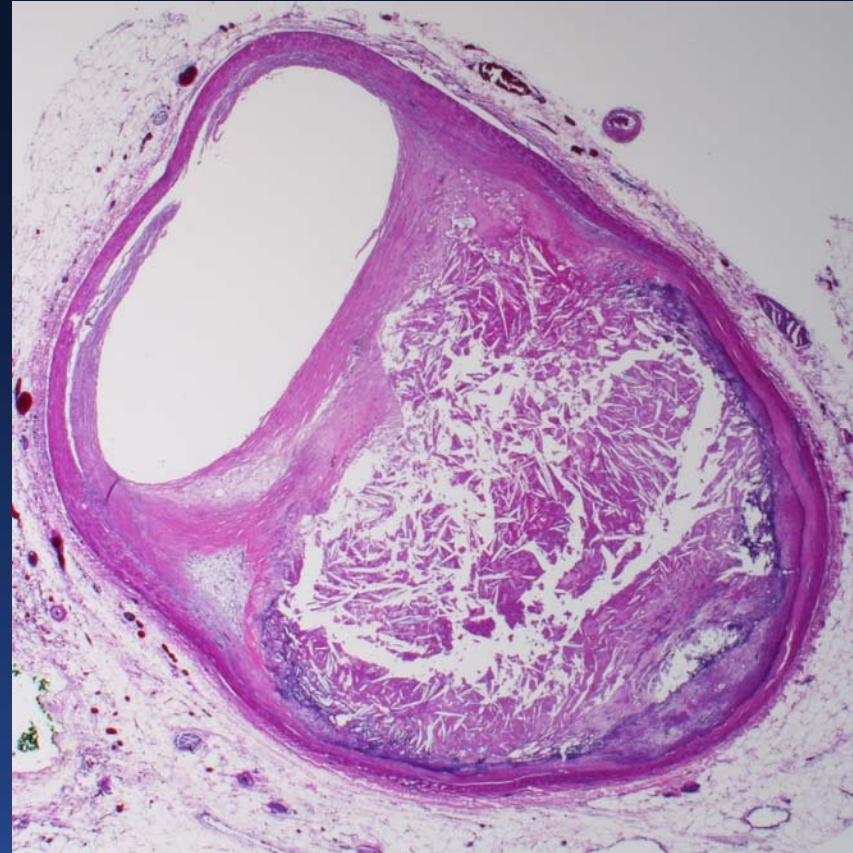
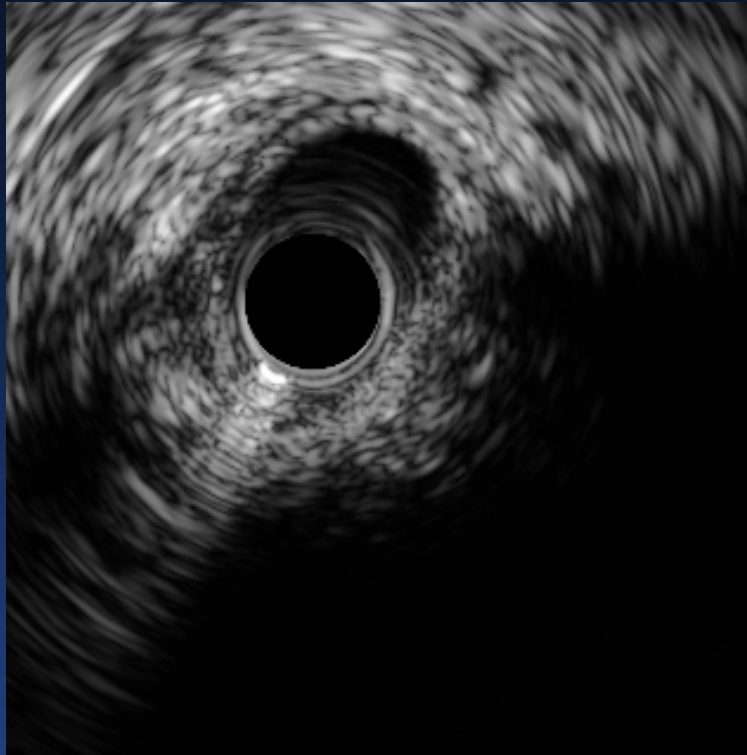
NC area: 0.54 mm<sup>2</sup>

NC%: 6.1%

# Attenuated Plaque & NC

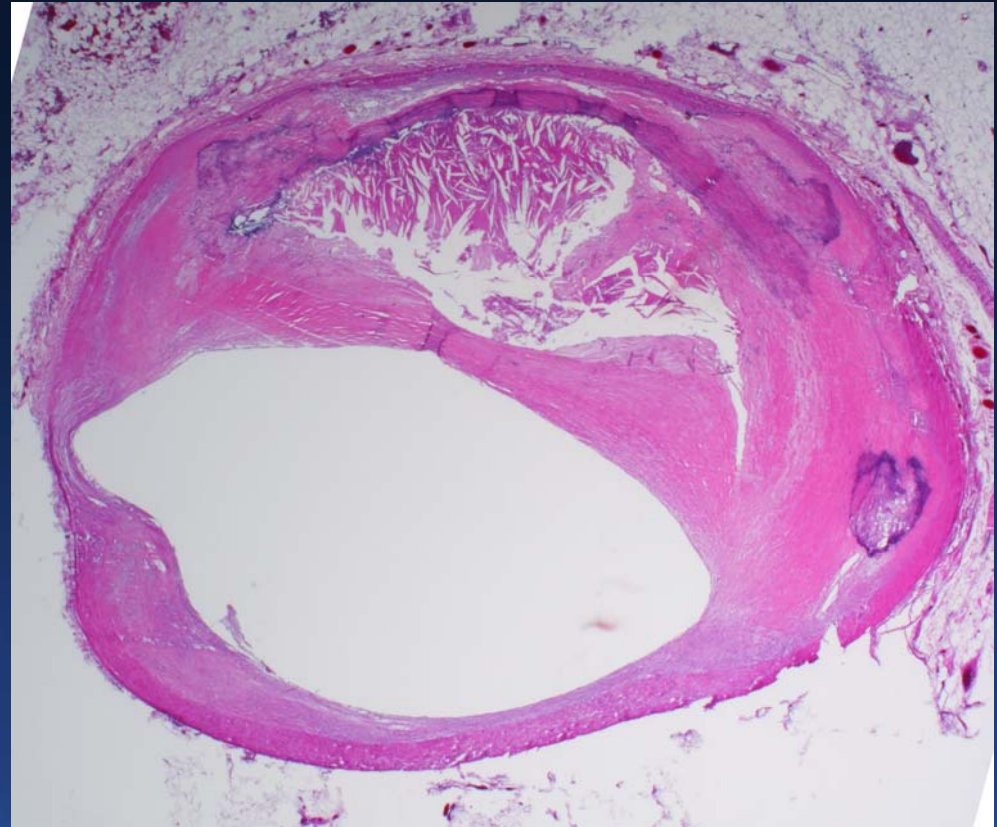
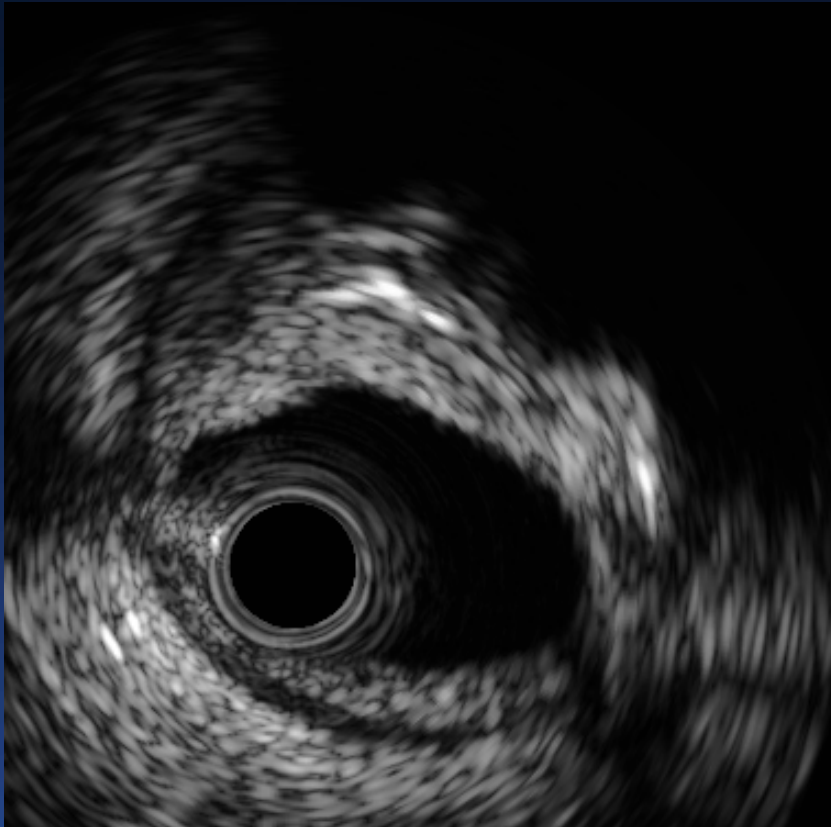


# Attenuated Plaque



Data obtained in the CDEV3 Study, Gardner et al, JACC Imaging, 2008, sponsored by InfraReDx, Inc.

# Attenuated Plaque



Data obtained in the CDEV3 Study, Gardner et al, JACC Imaging, 2008, sponsored by InfraReDx, Inc.

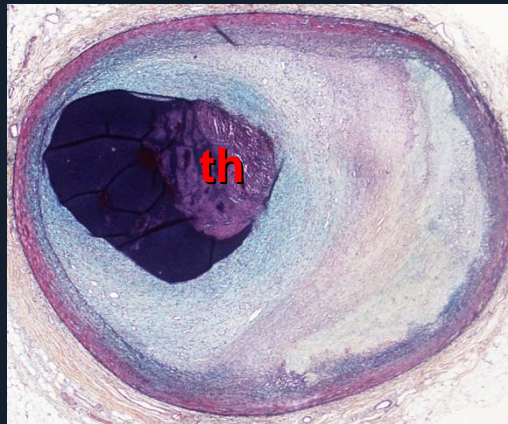


# Plaque Morphology of AMI/SCD w/Thrombi

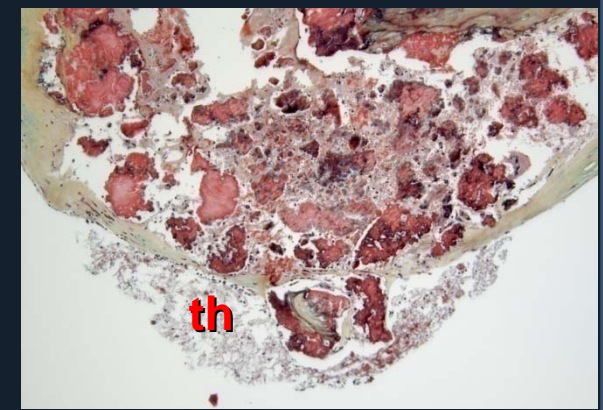
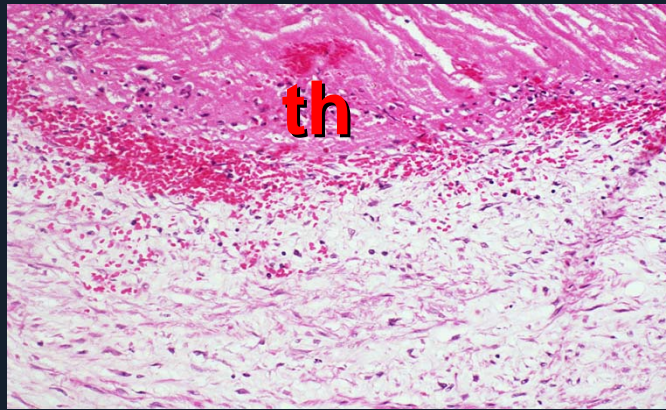
**Plaque Rupture**  
60%(f) – 80%(m)



**Plaque Erosion**  
20%(m) - 40%(f)



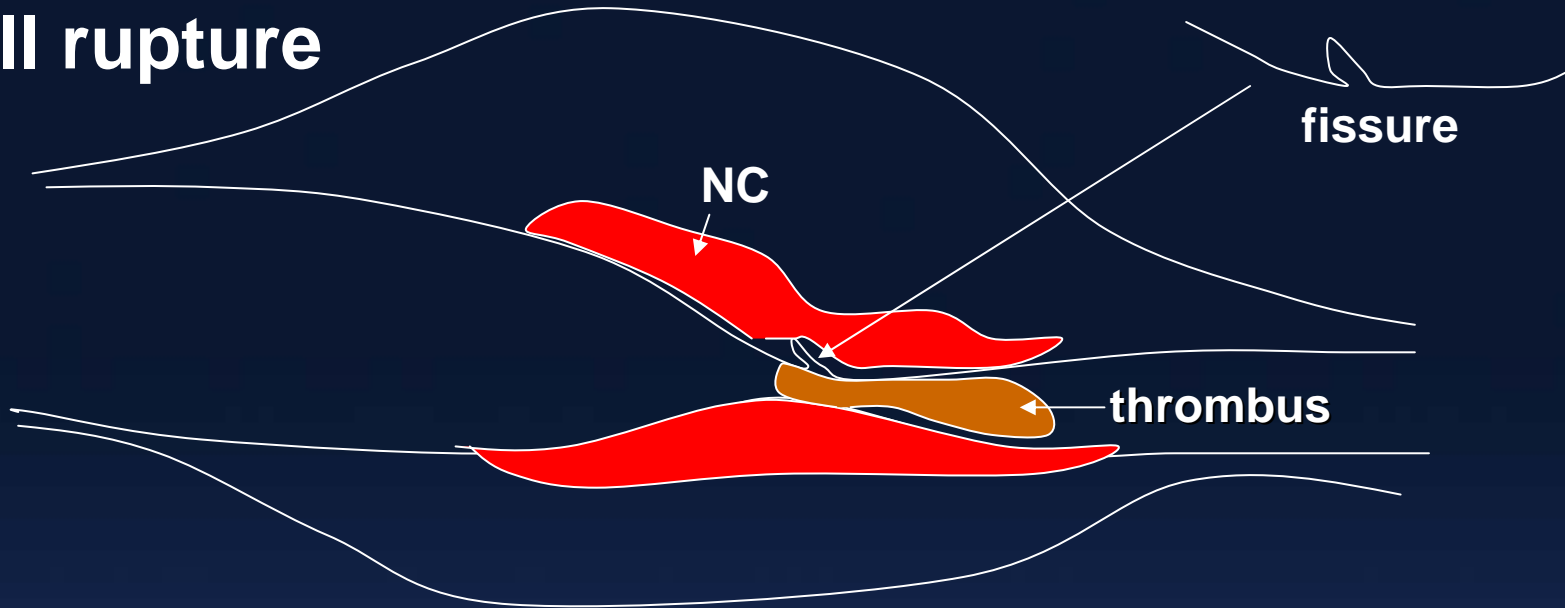
**Calcified Nodule**  
2% - 7%



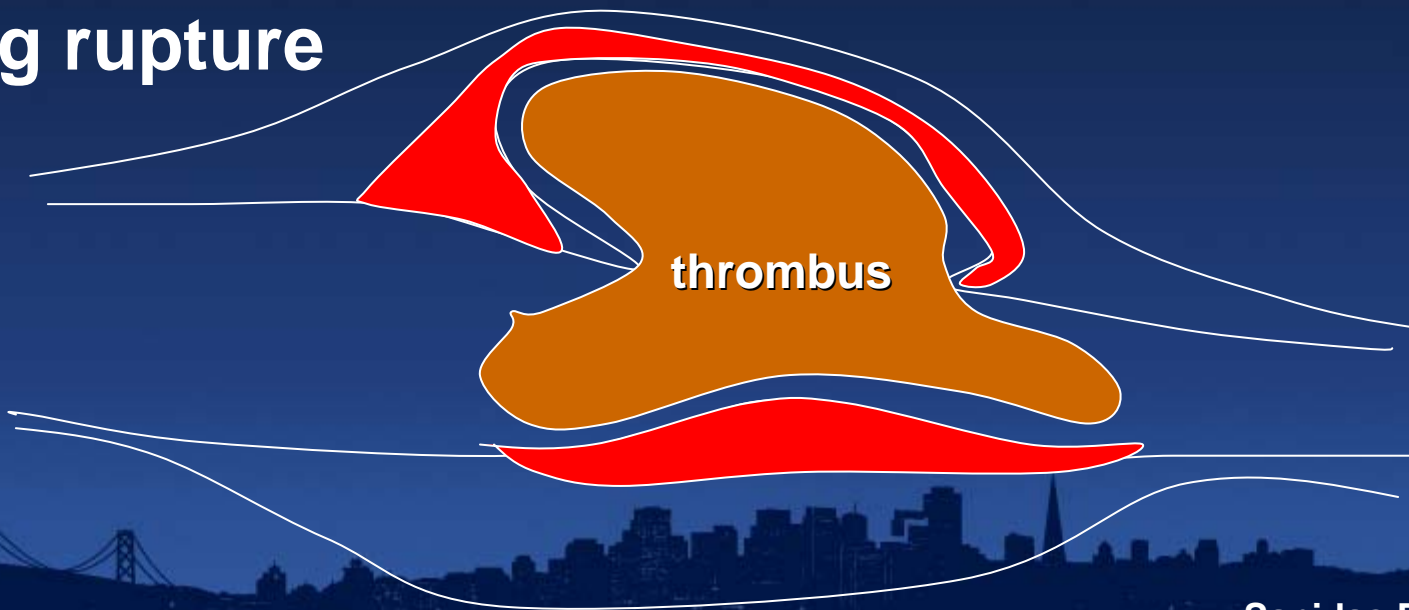
# Comparison between Ruptured thrombosis vs. Erosive thrombosis

	No Plaque Rupture (n=23)	Plaque Rupture (n=17)	p-value
<b>TCFA</b>	<b>73.9%</b>	<b>64.7%</b>	<b>0.53</b>
<b>MLA site</b>			
Lumen Area (mm <sup>2</sup> )	3.5±1.4	3.1±0.6	0.34
Vessel Area (mm <sup>2</sup> )	16.0±4.4	20.3±5.5	0.09
Plaque Burden (%)	78.2±5.5	83.6±4.7	0.002
<b>Necrotic Core (%)</b>	<b>23.1±11.9</b>	<b>19.1±10.1</b>	<b>0.26</b>
<b>Maximum NC site</b>			
Lumen Area (mm <sup>2</sup> )	4.8±2.0	5.4±1.7	0.40
Vessel Area (mm <sup>2</sup> )	16.0±4.3	18.6±5.3	0.11
Plaque Burden (%)	70.3±8.0	70.3±7.9	0.97
<b>Necrotic Core (%)</b>	<b>34.3±12.9</b>	<b>28.7±9.1</b>	<b>0.13</b>

# Small rupture



# Big rupture



# Comparison between Ruptured thrombosis vs. Erosive thrombosis

## - Pathology-

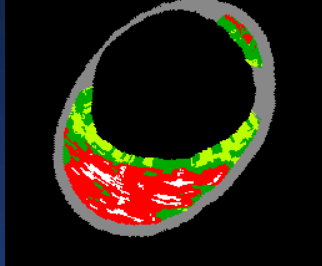
	Erosion (n=50)	Rupture (n=65)	p-value
Age (yrs)	43±9	52±10	<0.0001
Male	74%	89%	0.03
Vessel Area (mm <sup>2</sup> )	9.5±5.2	13.7±6.0	<0.0001
Plaque Burden (%)	77.1±13.8	71.3±14.9	0.02
Plaque Burden (%)	78.2±5.5	83.6±4.7	0.002
<b>Necrotic Core (%)</b>	<b>18.3±24.4</b>	<b>38.3±23.4</b>	<b>&lt;0.0001</b>
Occlusive Thrombus (%)	52%	46%	0.53

# Vulnerable Plaque?

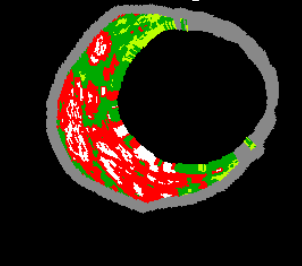
Pathological Intimal  
Thickening



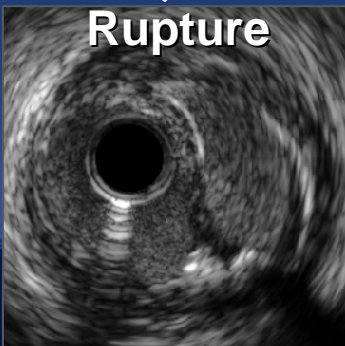
Thick Cap FA



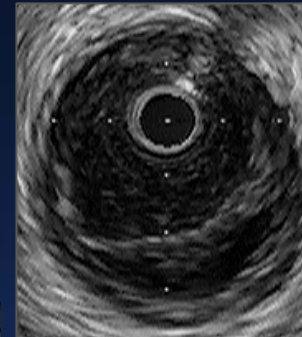
Thin Cap FA



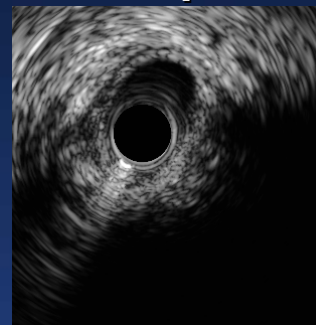
Rupture



Echolucent Plaque

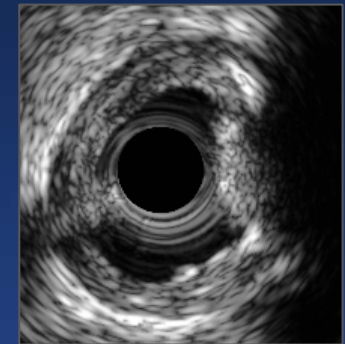


Attenuated  
Plaque



|||

Calcium Nodule



**thrombosis**

