

# IVUS-guided Decision Making for PCI



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Kyung Jin Park RT

# BSC IVUS Pipeline



ClearView®  
Ultra™ System

1999년

Galaxy™ System

2001년

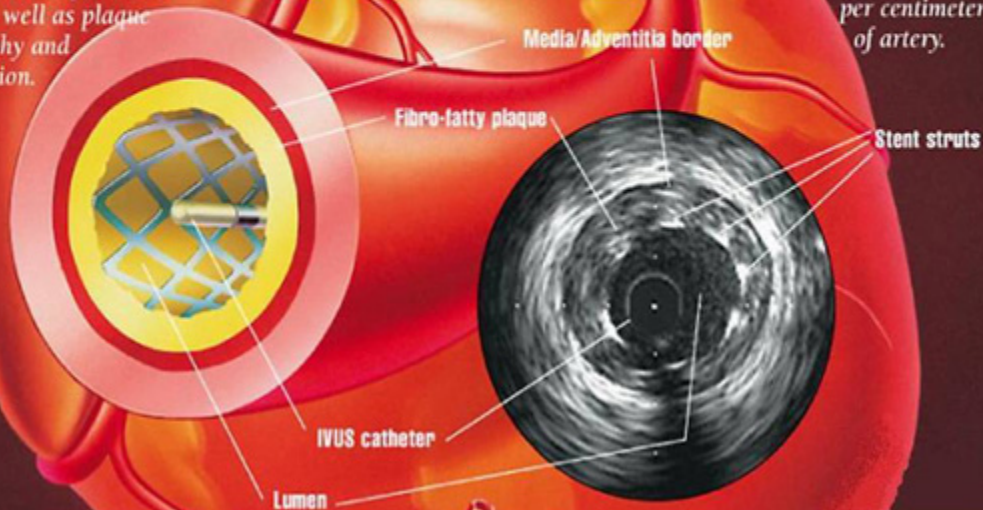
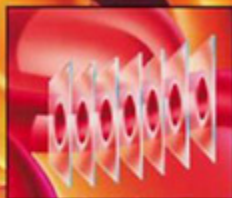
iLab® System

2006년

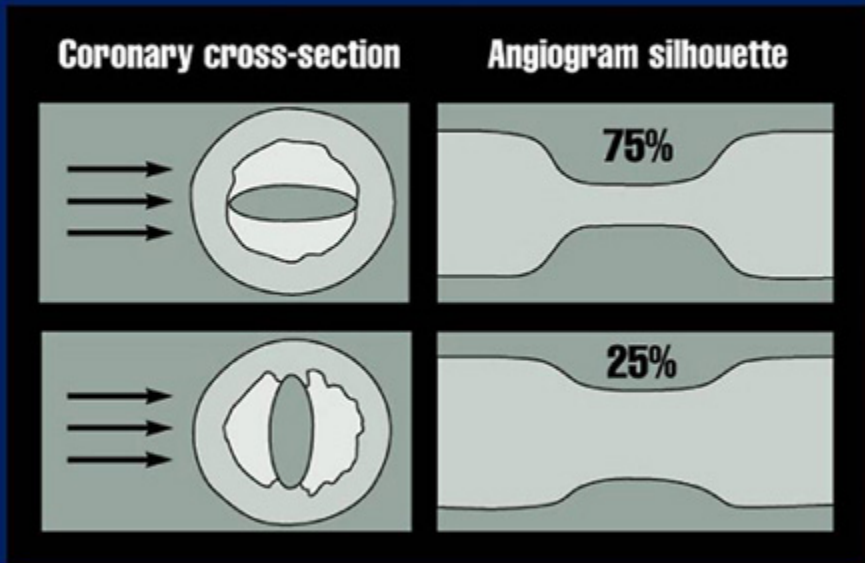
## What are we seeing when we look at an IVUS image?

An IVUS image shows us a 360° cross-sectional view of an artery. We see lumen size and shape as well as plaque topography and composition.

The IVUS image is an extremely thin slice of the artery. The IVUS technology is capable of producing 500-600 images per centimeter of artery.



# Comparing Angiography and IVUS



In angiography, angle of view determines what we see.

# Clinical Utility for IVUS

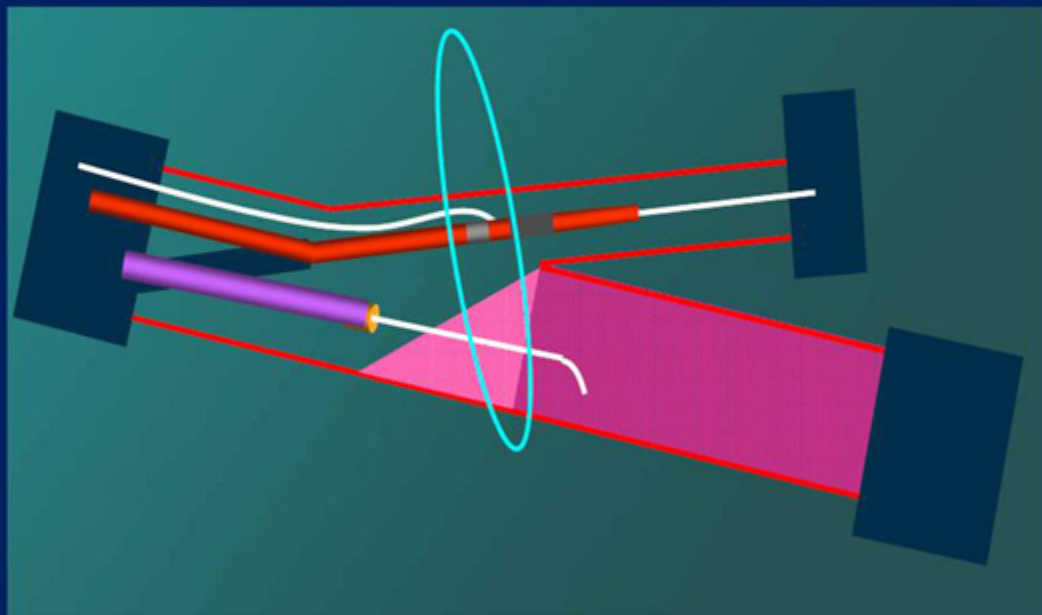
- Stenting of smaller vessels
  - Vessels  $\leq$  3mm
- Intra-stent restenosis
  - Visualize the stent
- Difficult to assess lesions
  - More sensitive plaque detection

# Clinical Utility for IVUS

## **Dynamic visualization in cross-sectional fashion In Vivo**

- . Tomographic assessment of plaque
- . Qualitative information about plaque composition
- . Quantitative detail about lumen & vessel dimension

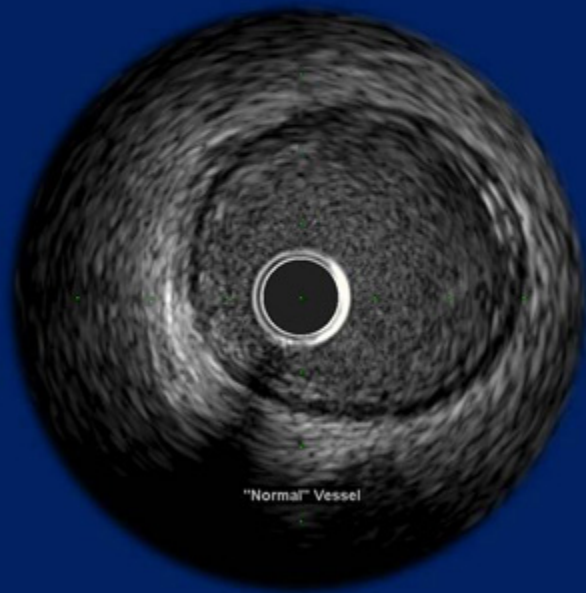
# Utility CTO of IVUS



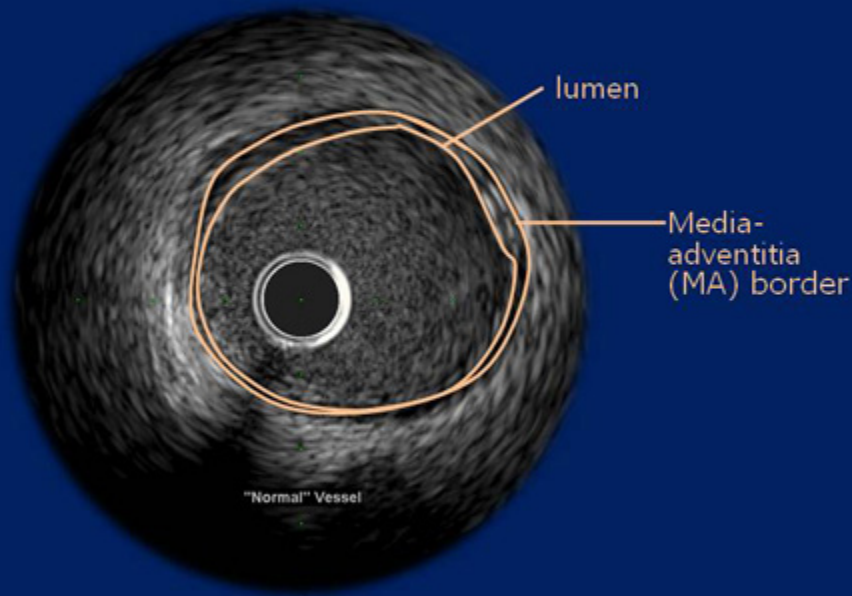
# Image Interpretation



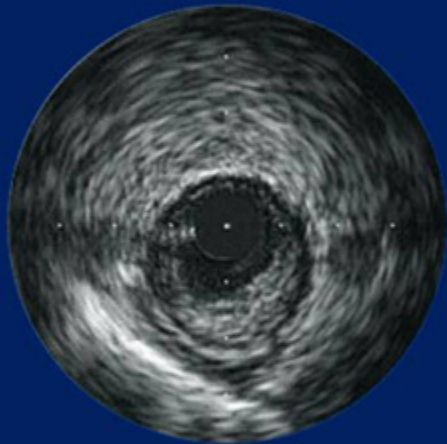
# Normal or "Healthy" Vessels



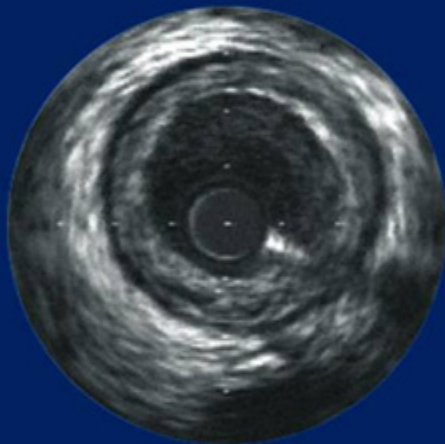
# Normal or "Healthy" Vessels



# Lower Density Plaques

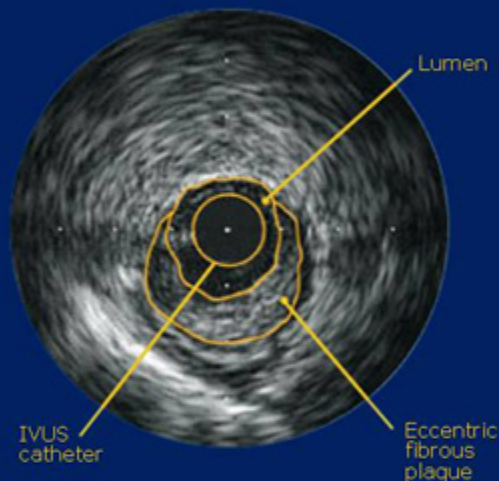


Eccentric fibrous plaque

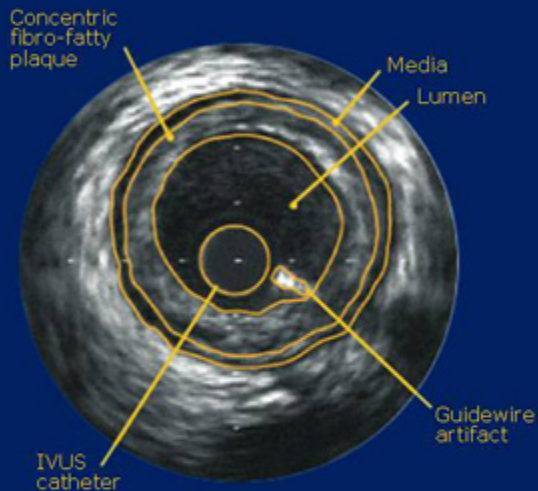


Concentric fibro-fatty plaque

# Lower Density Plaques

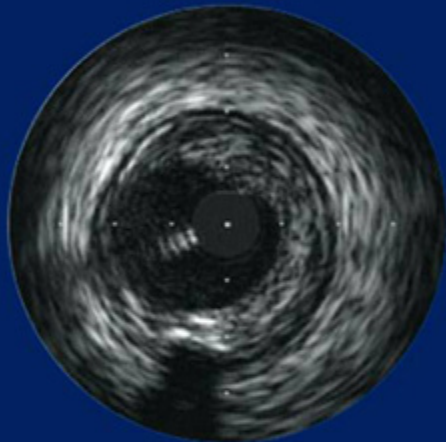


Eccentric fibrous plaque

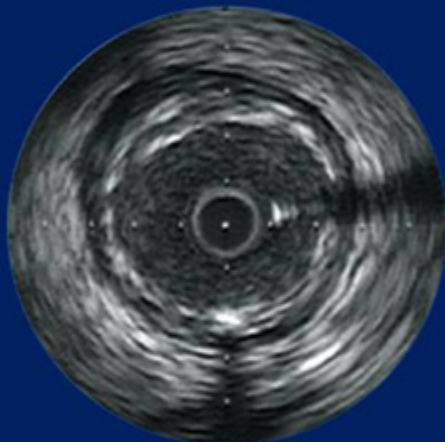


Concentric fibro-fatty plaque

# Mixed Plaque

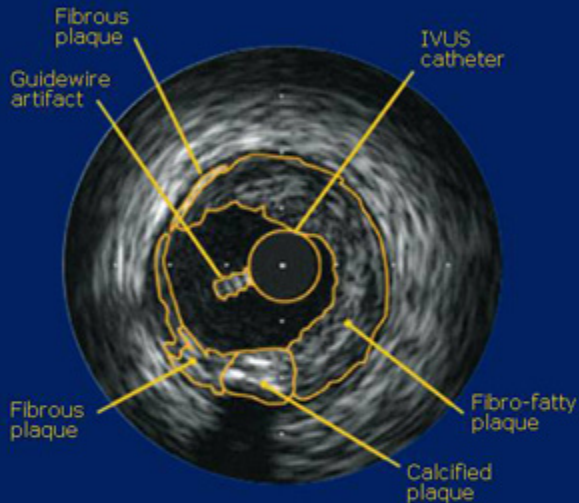


Mixed eccentric plaque  
(fibrous, fibro-fatty, and calcified)

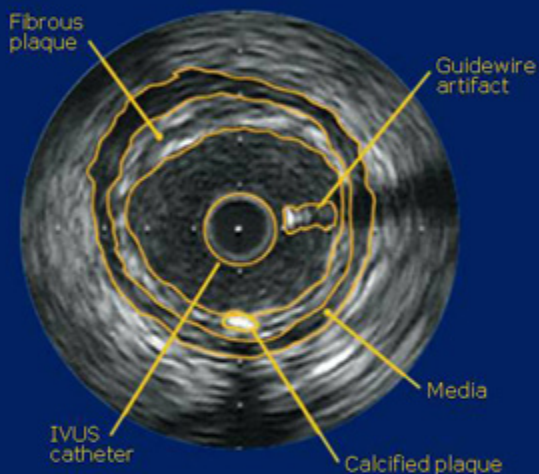


Thin concentric fibrous plaque  
mixed with calcium

# Mixed Plaque

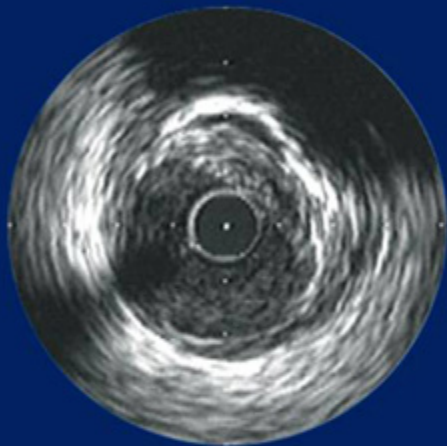


Mixed eccentric plaque  
(fibrous, fibro-fatty, and calcified)

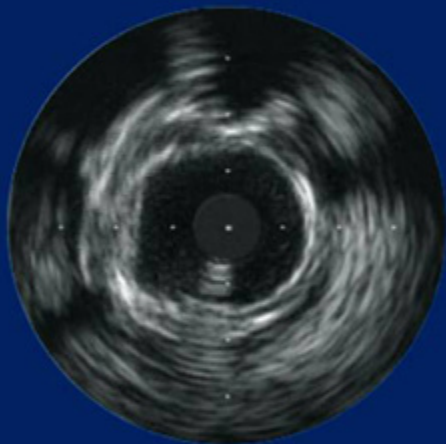


Thin concentric fibrous plaque  
mixed with calcium

# Calcified Plaque

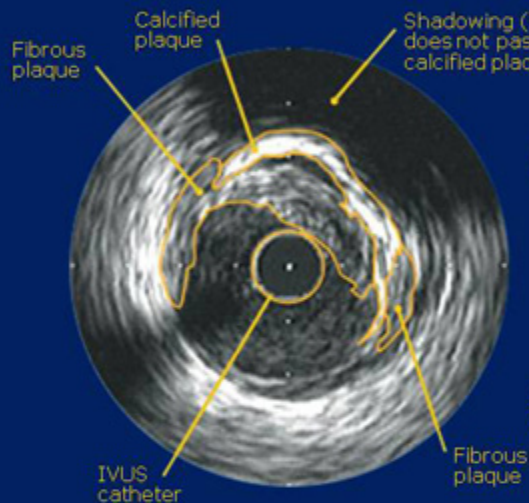


90° arc (one quadrant)  
of deep calcium

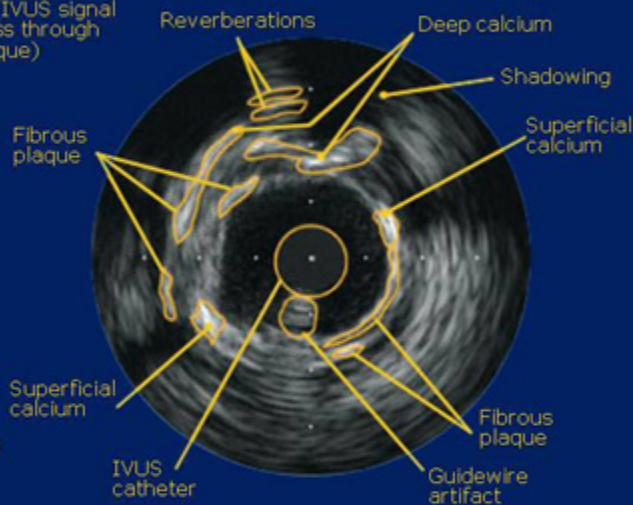


Mixed deep and superficial  
calcified plaque

# Calcified Plaque



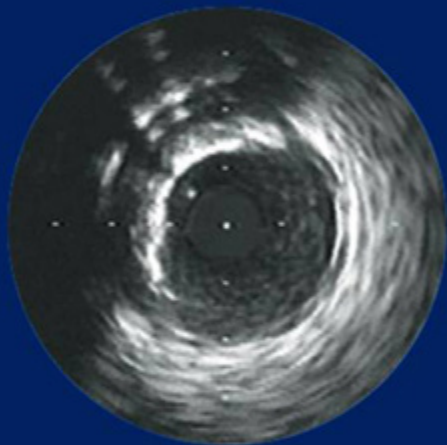
90° arc (one quadrant)  
of deep calcium



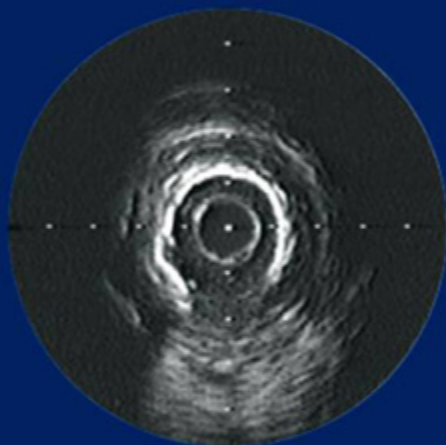
Mixed deep and superficial  
calcified plaque



## Calcified Plaque (continued)

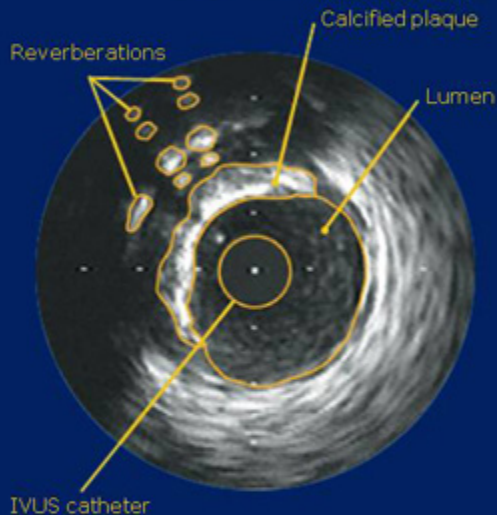


180° arc of eccentric superficial calcified plaque

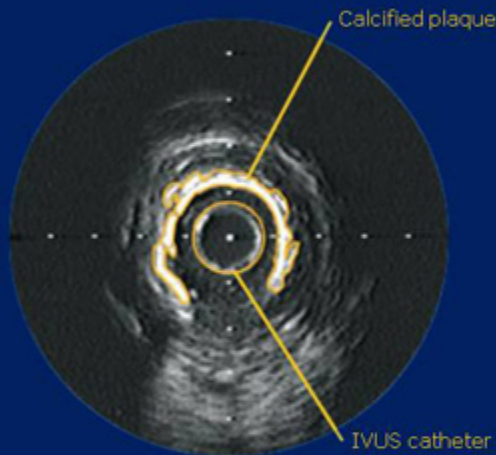


270° arc of superficial calcified plaque

# Calcified Plaque (continued)

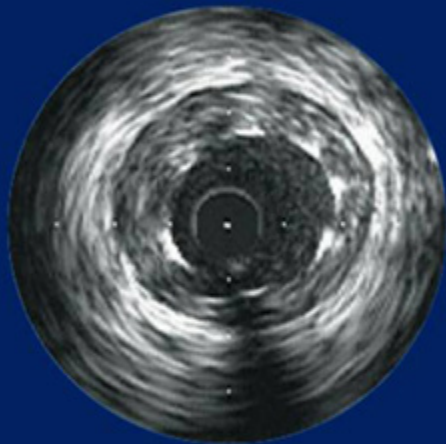


180° arc of eccentric superficial calcified plaque

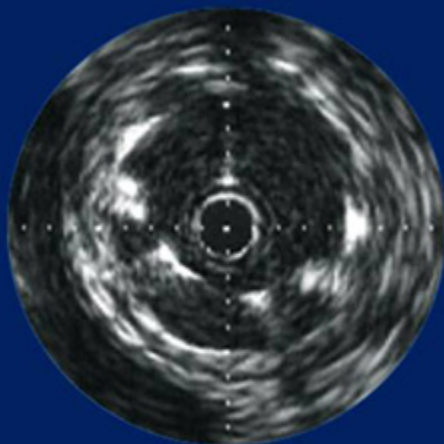


270° arc of superficial calcified plaque

# Stents

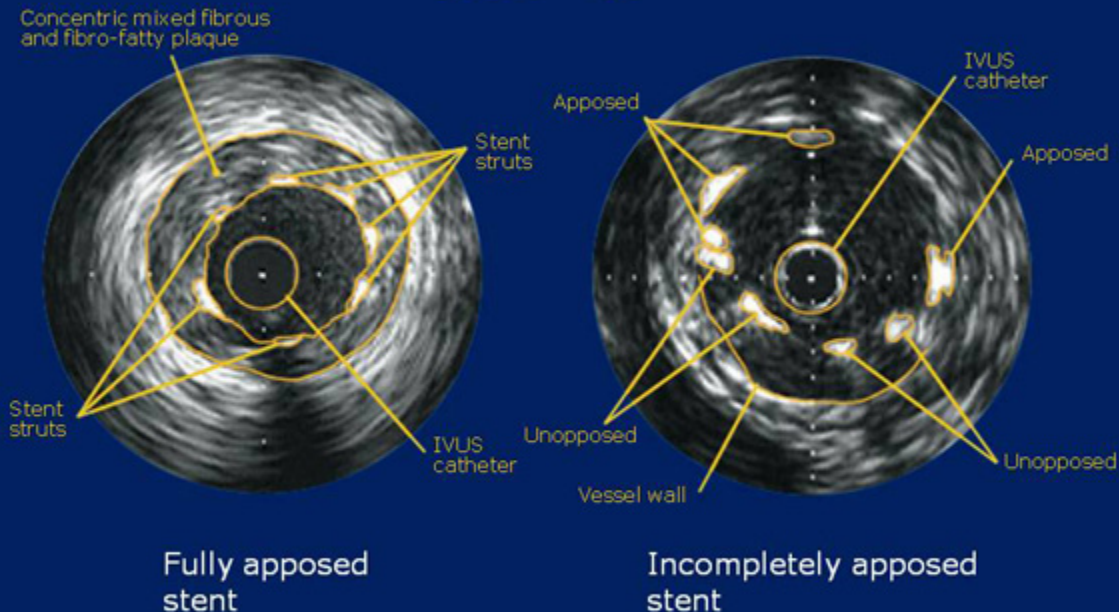


Fully apposed stent

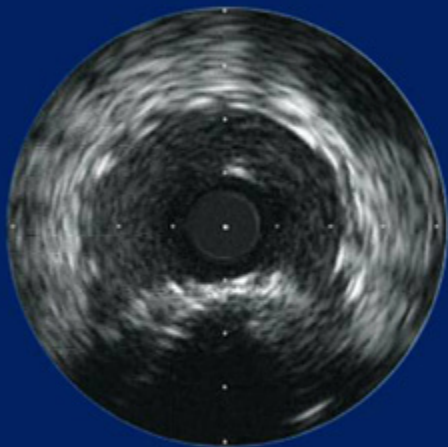


Incompletely apposed stent

# Stents

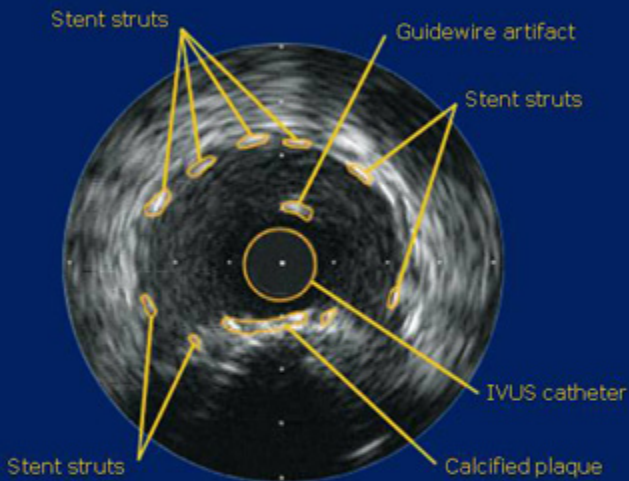


## Stents (continued)



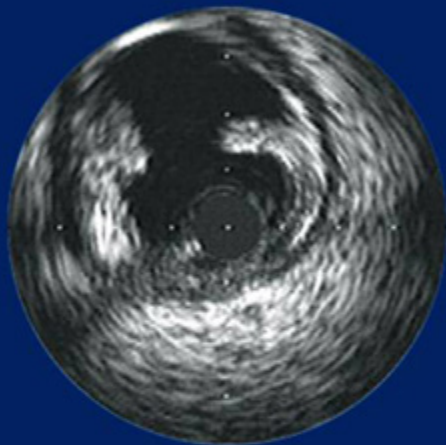
Stent deployment in a heavily calcified vessel

# Stents (continued)

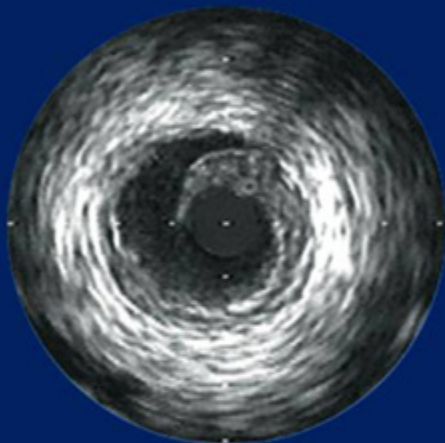


Stent deployment in a heavily calcified vessel

# Dissections

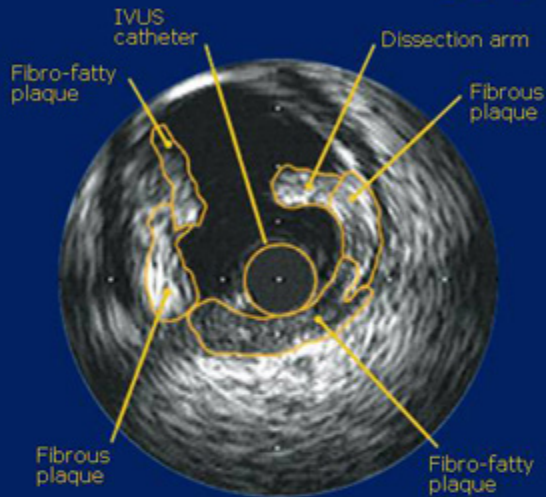


Fibrous plaque dissection  
extending into the intima

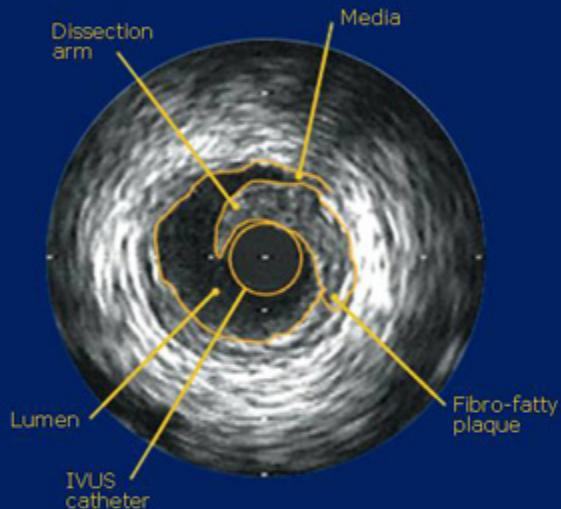


Deep fibro-fatty plaque dissection  
extending into the media

# Dissections



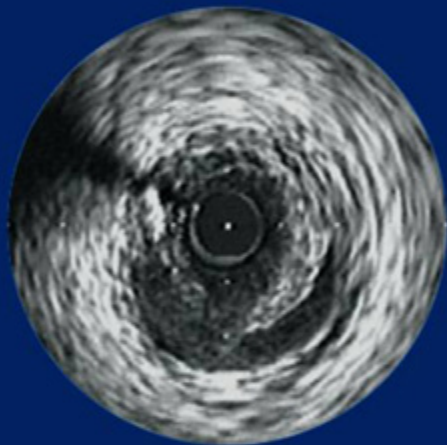
Fibrous plaque dissection  
extending into the intima



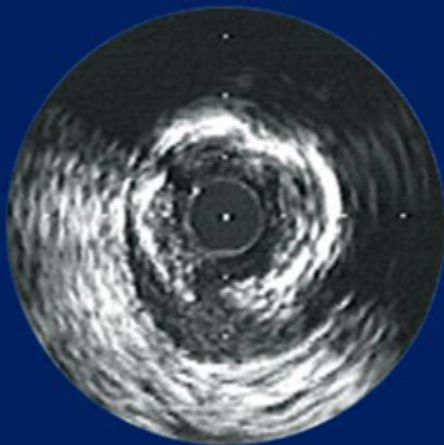
Deep fibro-fatty plaque dissection  
extending into the media



## Dissections (continued)

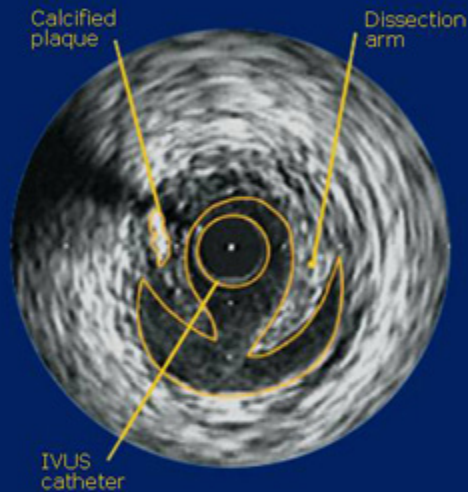


Horseshoe dissection of fibrous plaque extending into the media

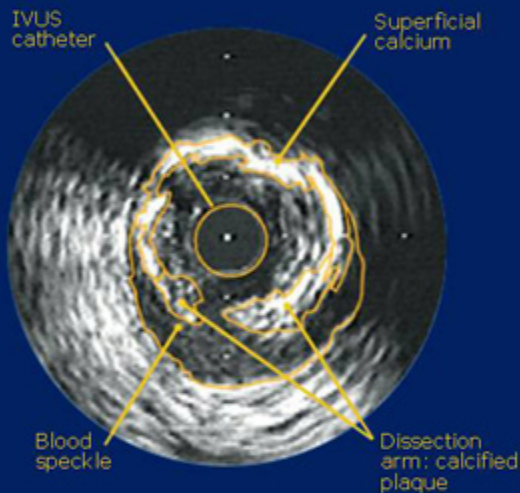


Horseshoe dissection of calcified plaque

# Dissections (continued)

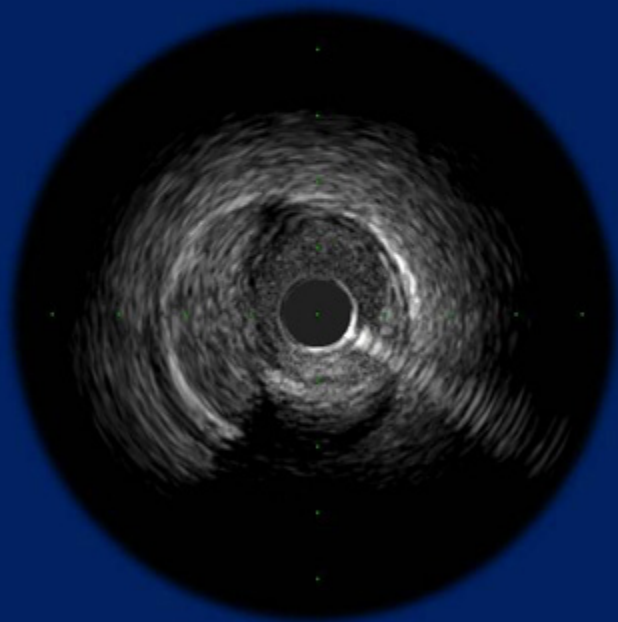


Horseshoe dissection of fibrous plaque extending into the media

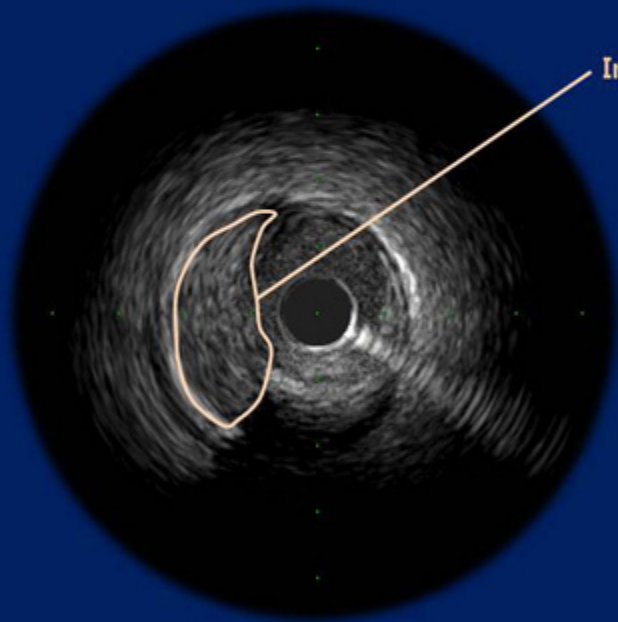


Horseshoe dissection of calcified plaque

# Intramural Hematoma

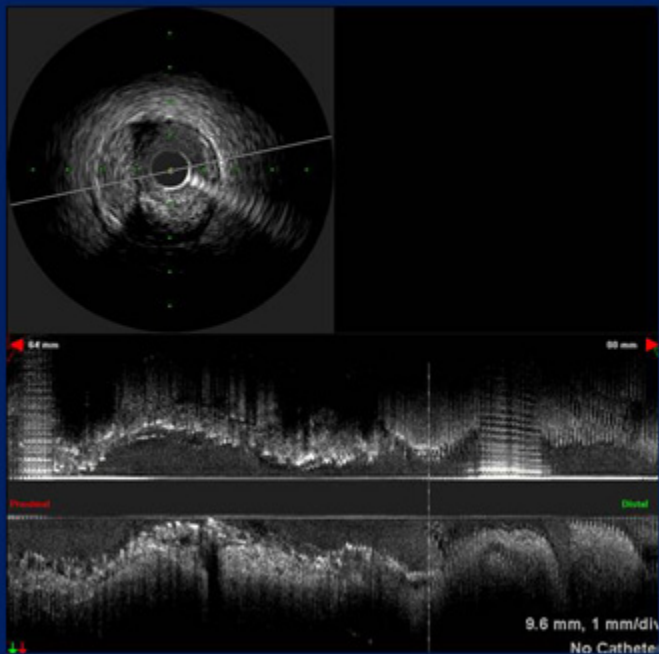


# Intramural Hematoma

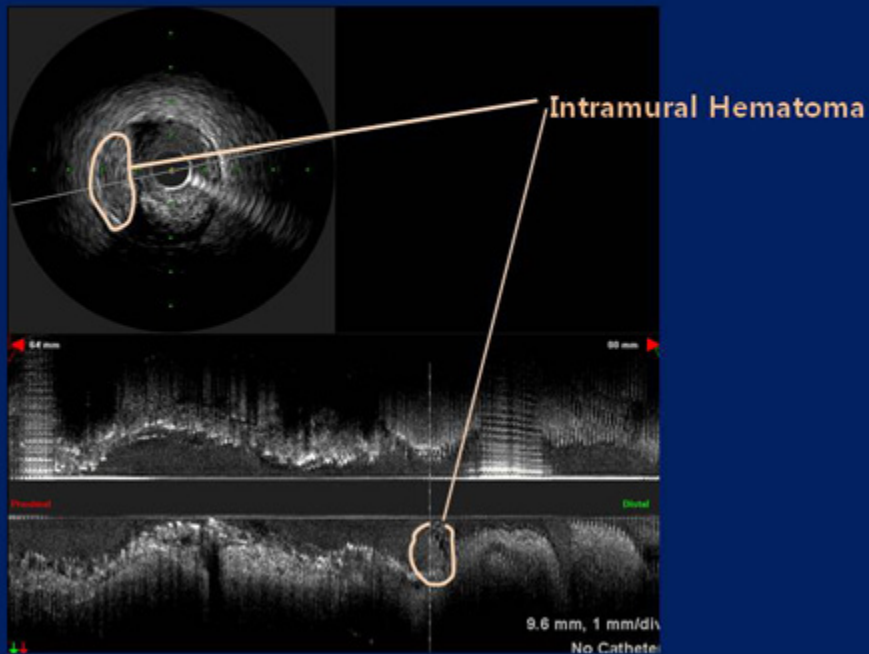


Intramural Hematoma

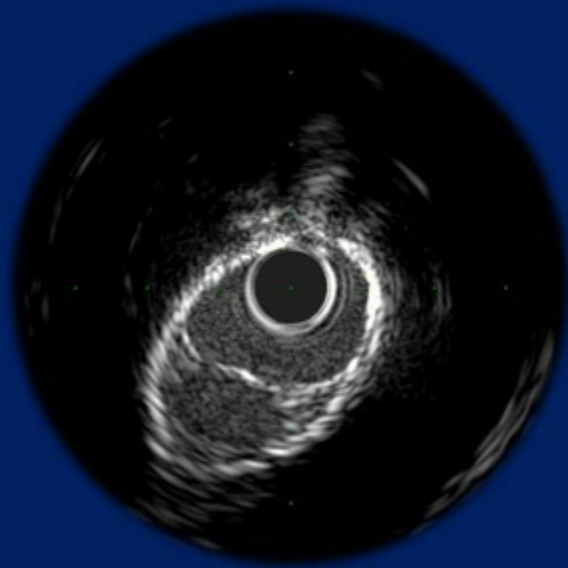
# Intramural Hematoma



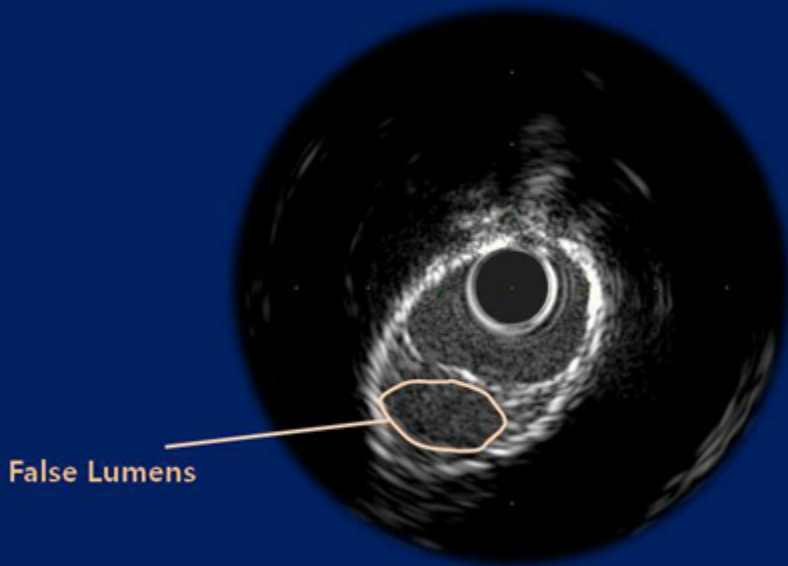
# Intramural Hematoma



# False Lumens

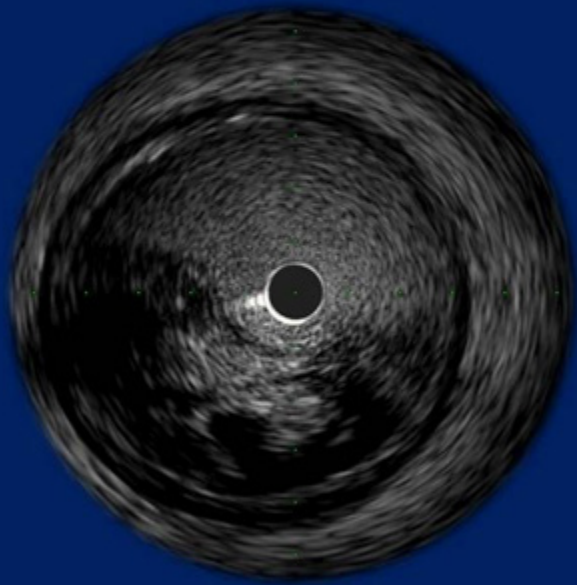


# False Lumens

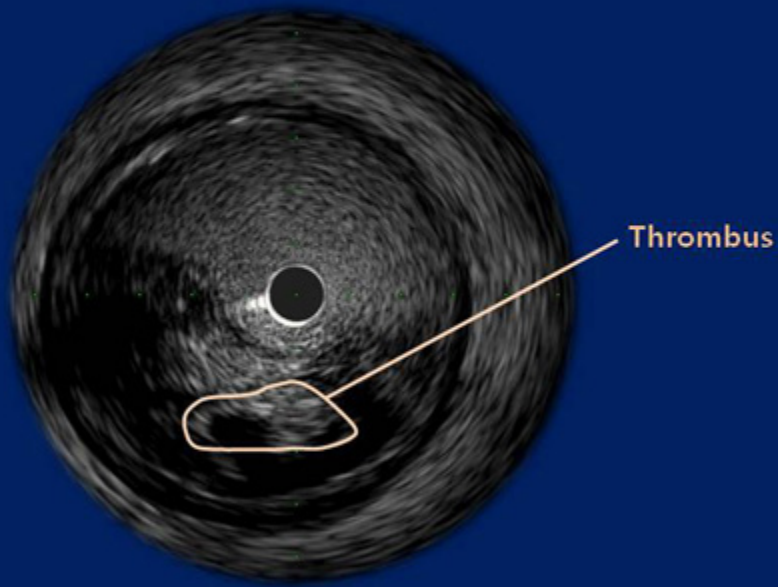




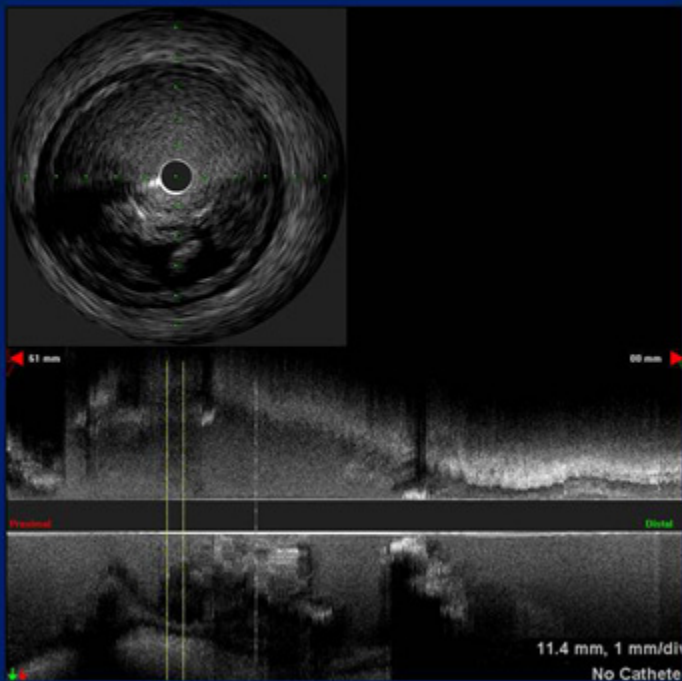
# Thrombus



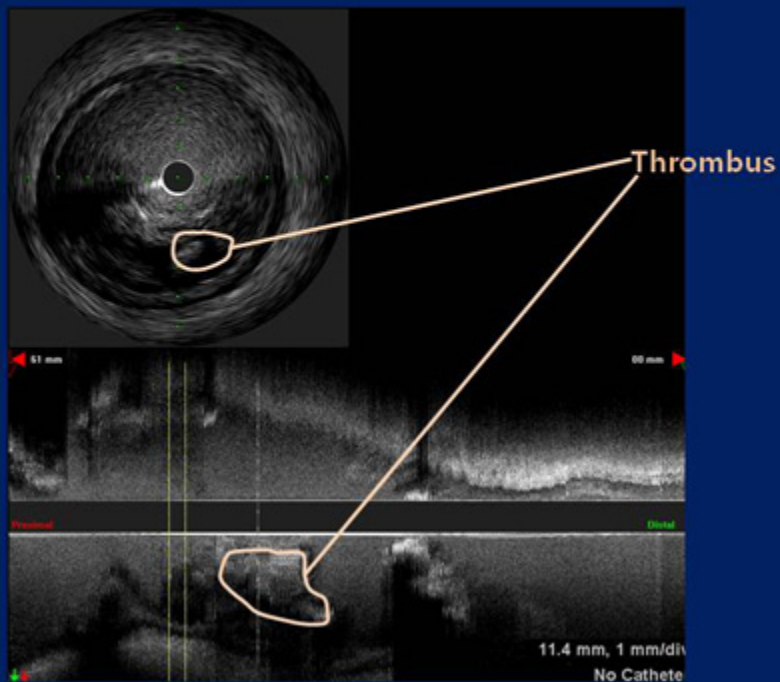
# Thrombus



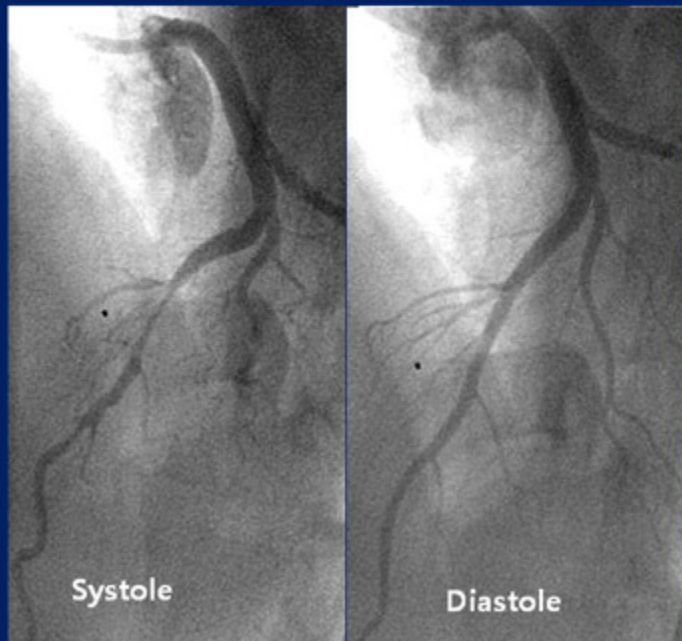
# Thrombus



# Thrombus



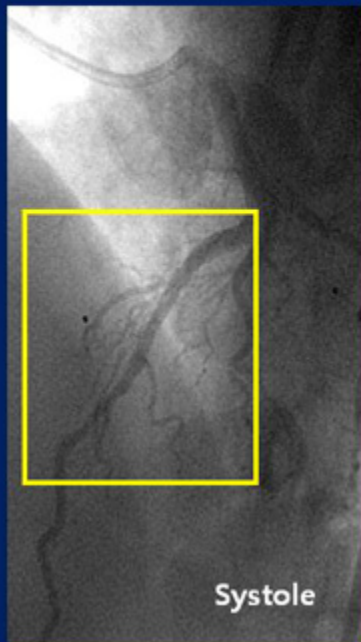
# Initial IVUS of LAD Milking



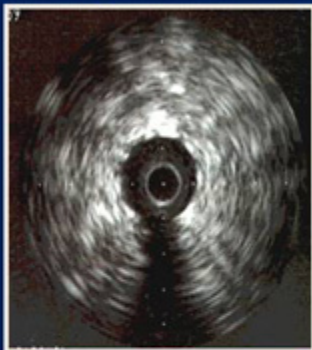
# Post Stent

## Stenting for LAD Milking

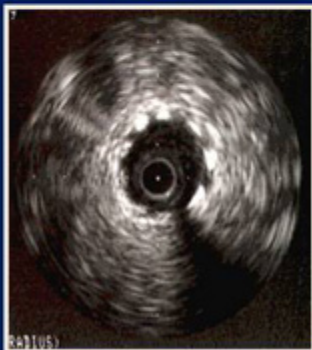
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Systolic

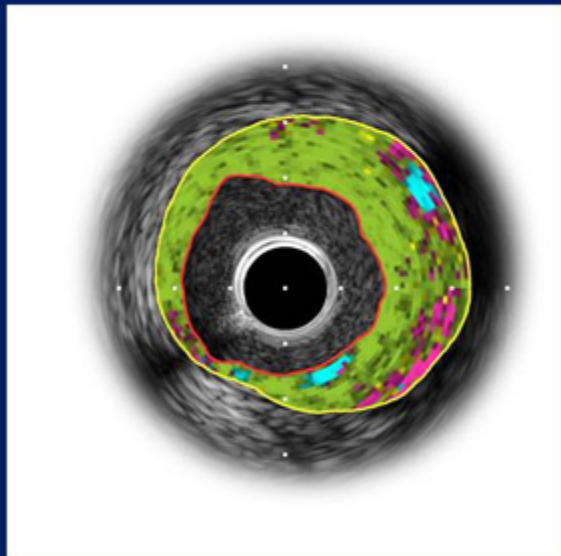


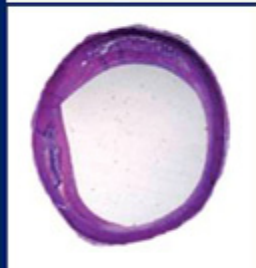
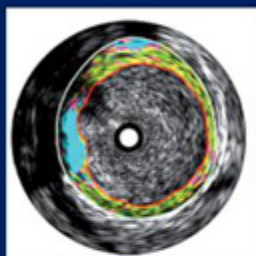
Diastolic



## Characterization of plaque composition between the lumen and media.

- Fibrotic Tissue
- Lipidic Tissue
- Necrotic Tissue
- Calcified Tissue





**Fibrotic** Densely packed collagen fibers, no intra-fiber lipid no microphage



**Lipid Pool** Lipid pools are areas of extracellular lipid accumulation in a proteoglycan-rich matrix without necrosis. Lipid pool areas should have a relatively well-demarcated area of homogeneous clearing (these areas often have a "fluffy" appearance) with apoptotic smooth muscle cells and/or barely-perceptible cholesterol crystals.



**Necrotic Core** Early: The core of an early fibroatheroma typically contains evidence of smooth muscle cell apoptosis, with microscopic calcifications in many cases, and small (usually less than 20 microns) cholesterol clefts. There is a small amount of macrophage infiltration around the edges of the core, but no significant macrophage breakdown or loss of extracellular matrix.

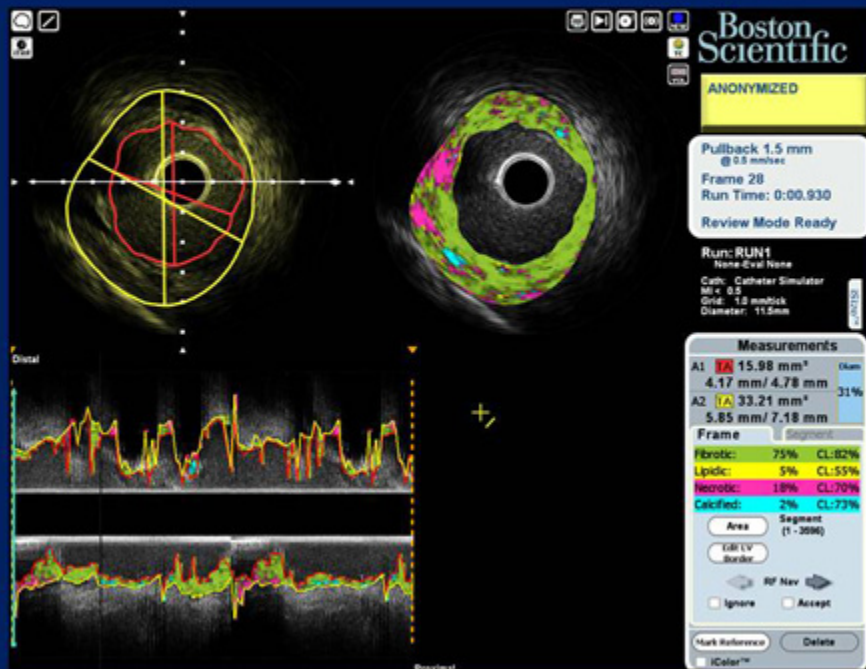
Late: The core of a late fibroatheroma may contain hemorrhage and has cholesterol crystals greater than 20 microns in size. There is evidence of extensive or complete extracellular matrix degradation.



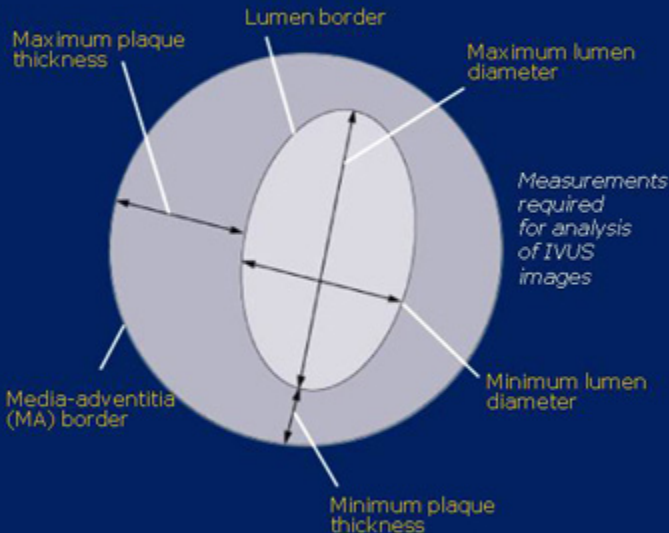
**Calcified** Focal area of dense calcium



# iLab™ System Software 2.2



# Measurement and Analysis



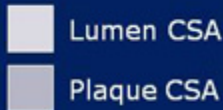
$$\text{Eccentricity} = \frac{\text{Maximum plaque thickness}}{\text{Minimum plaque thickness}}$$

$$\text{Plaque CSA}^* = \text{MA CSA} - \text{Lumen CSA}$$

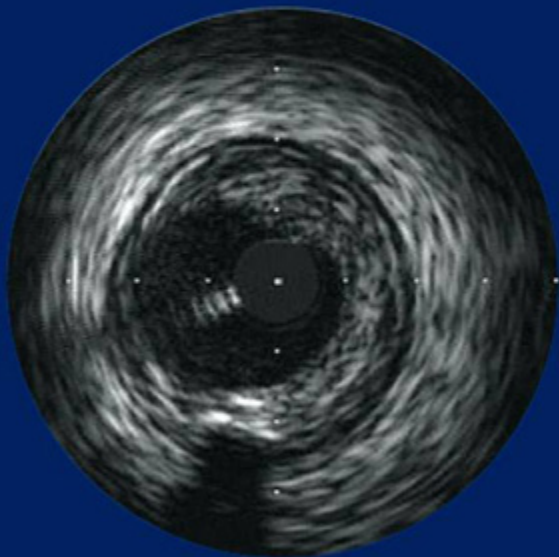
$$\% \text{ Plaque area} = \frac{\text{Plaque CSA}}{\text{MA CSA}}$$

$$\% \text{ Area stenosis} = \frac{\text{Reference lumen CSA} - \text{Lesion lumen CSA}}{\text{Reference lumen CSA}}$$

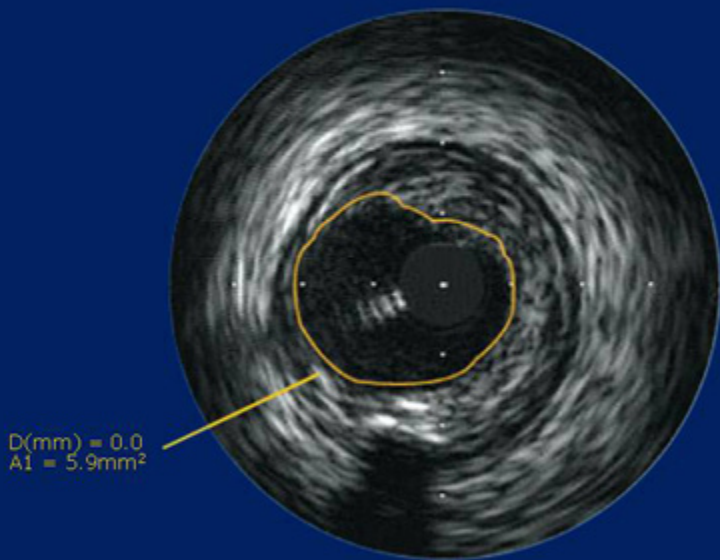
\* Plaque CSA includes variable amounts of smooth muscle from media



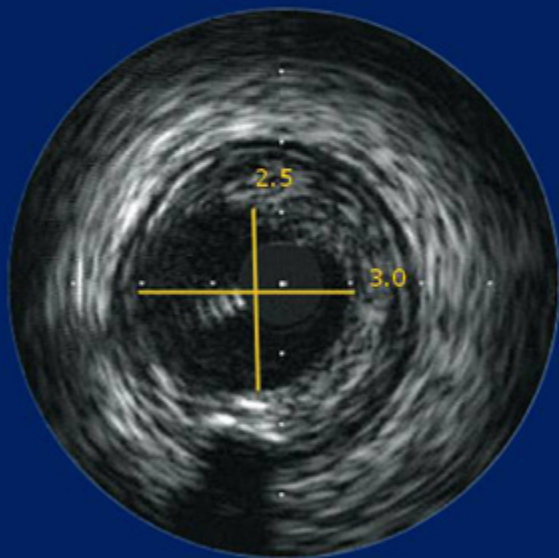
# Measurement and Analysis



# Calculating – Area



# Lumen Diameter Measurements



# IVUS-Guided Stenting

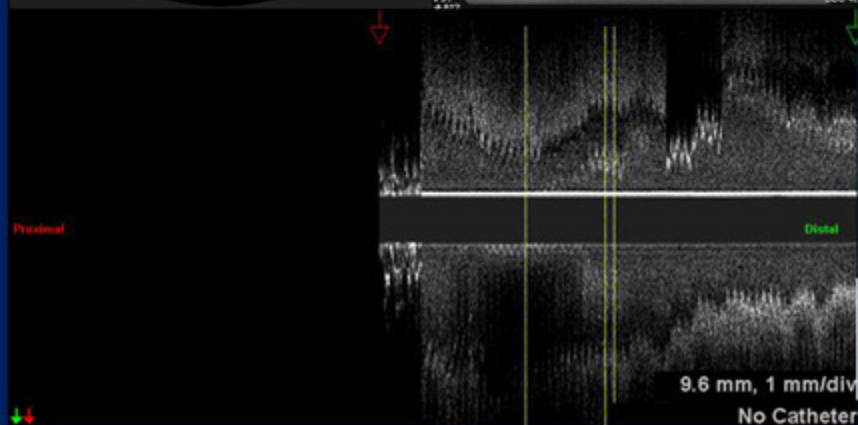
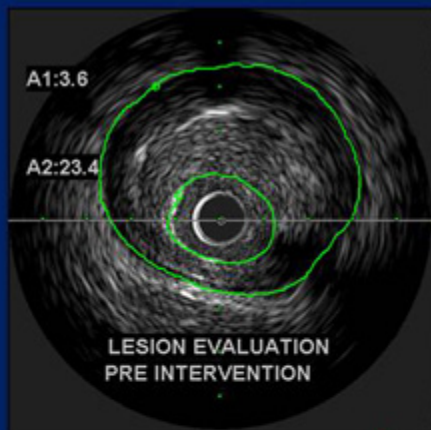
- Measurement and Analysis

Lumen Diameters vs. Cross Sectional Areas (CSA)			
Lumen Diameter (mm)	Lumen CSA (mm <sup>2</sup> )	90% of Lumen CSA (mm <sup>2</sup> )	Lumen Diameter at 90% of CSA (mm)
2.5	4.9	4.4	2.4
3.0	7.0	6.4	2.8
3.2	8.0	7.2	3.0
3.4	9.0	8.2	3.2

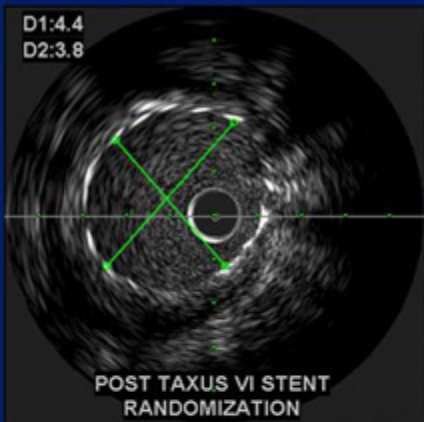
"The Predictive Value of Different Intravascular Ultrasound Criteria for Restenosis After Coronary Stenting"<sup>1</sup>

	Minimum Lumen Cross Sectional Area	Potential Restenosis Rate
The incidence of restenosis has an inverse relationship to post-procedure absolute IVUS lumen CSA.	< 5mm <sup>2</sup>	46%
	5.0-5.9mm <sup>2</sup>	33%
	6.0-7.9mm <sup>2</sup>	27%
	8.0-8.9mm <sup>2</sup>	21%
	≥9mm <sup>2</sup>	8%

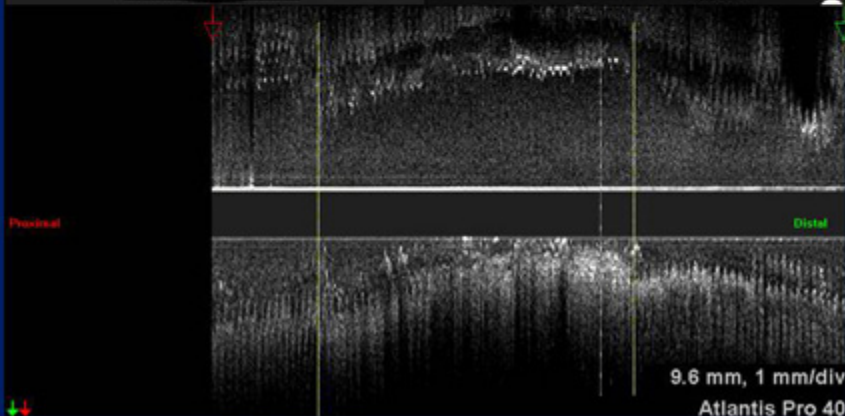
<sup>1</sup> Moussa et al., ACC 97: 707-6. Data did not include DES.



D1:4.4  
D2:3.8

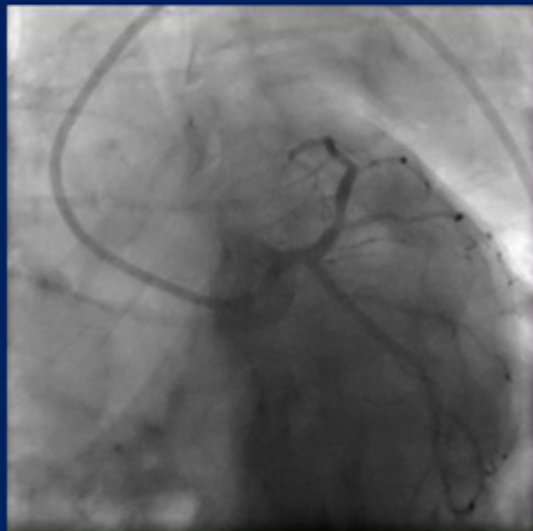


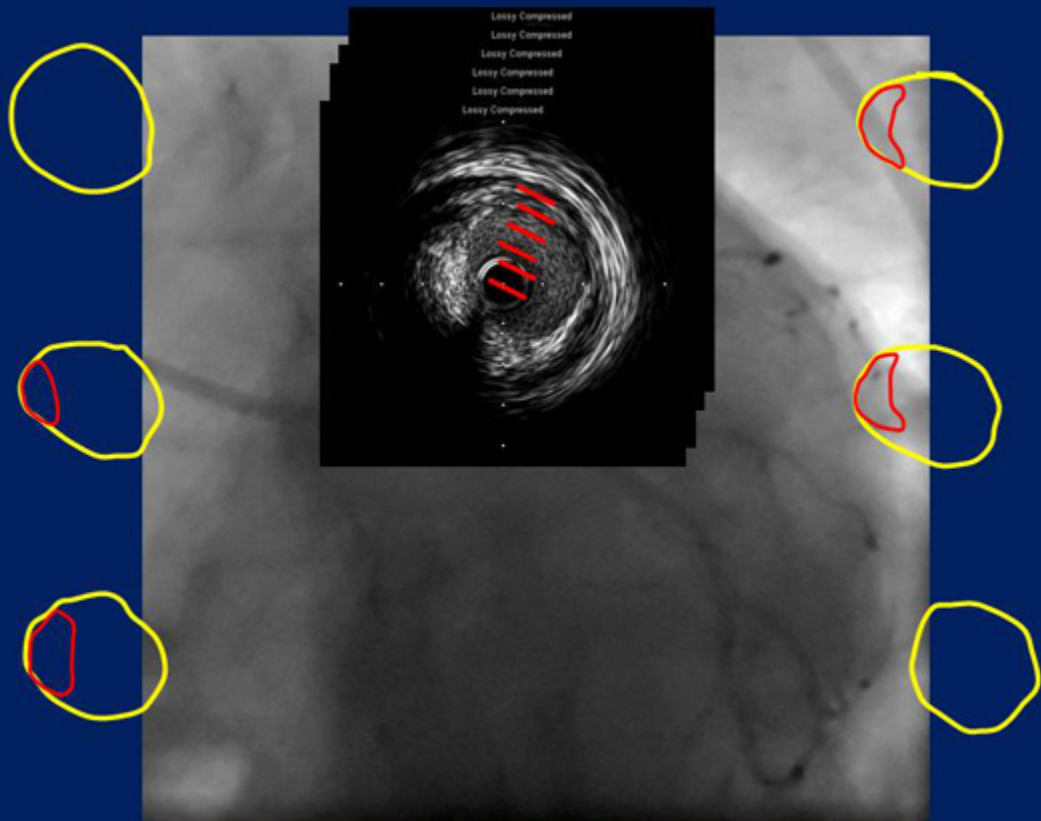
POST TAXUS VI STENT  
RANDOMIZATION



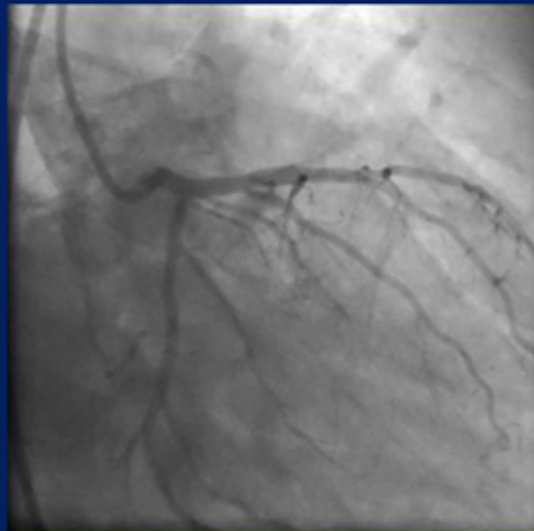
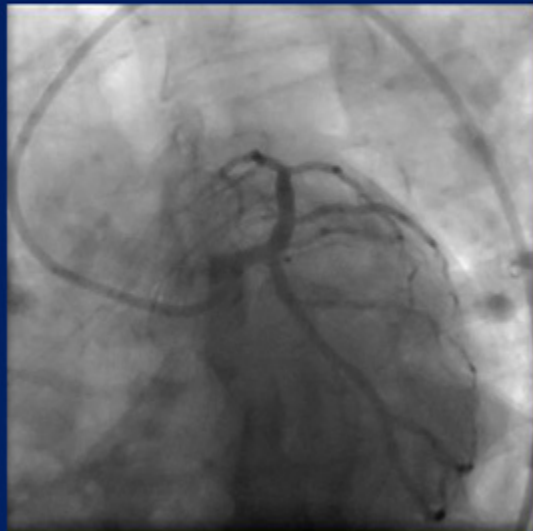


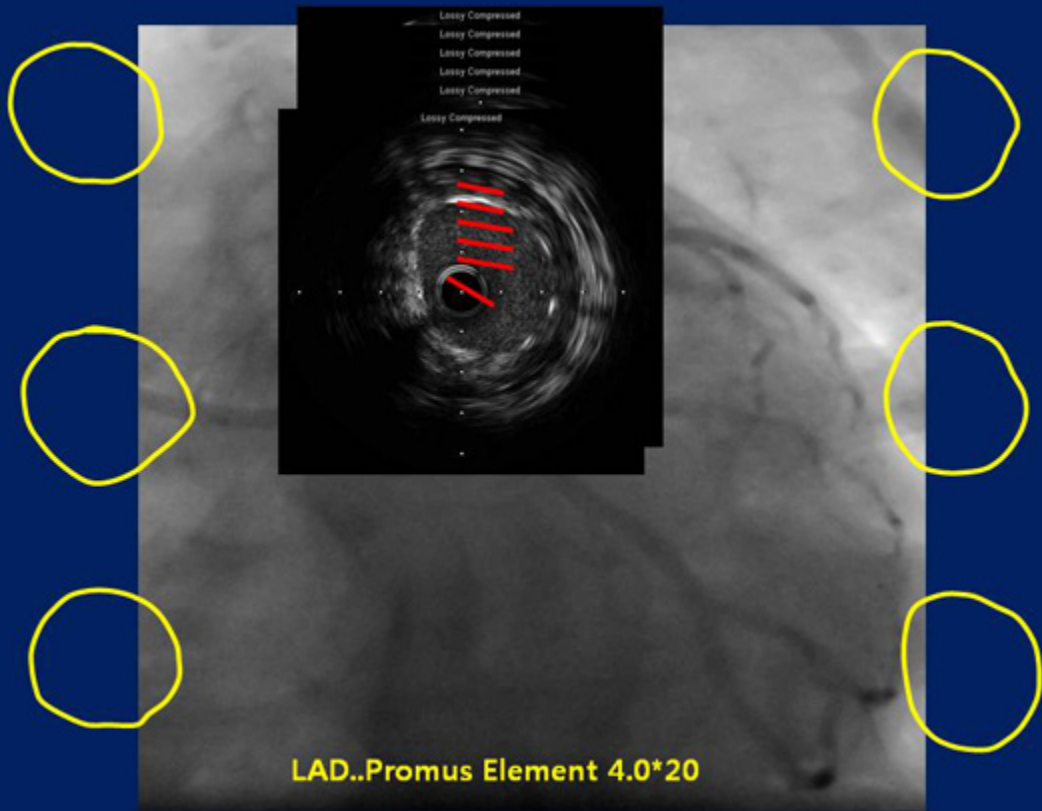
# Pre(Lipid pool)



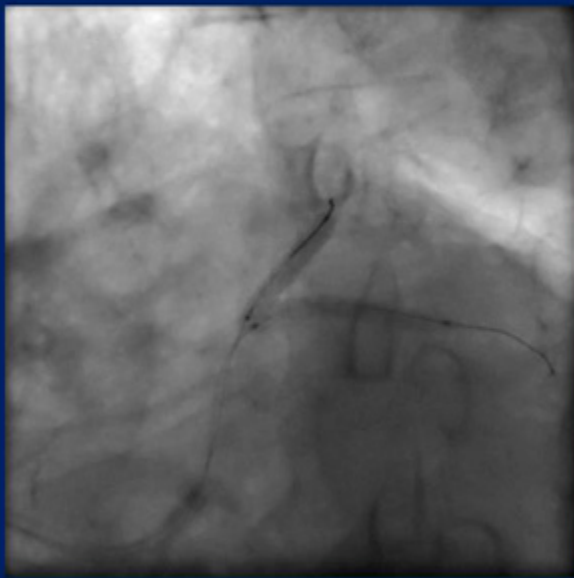
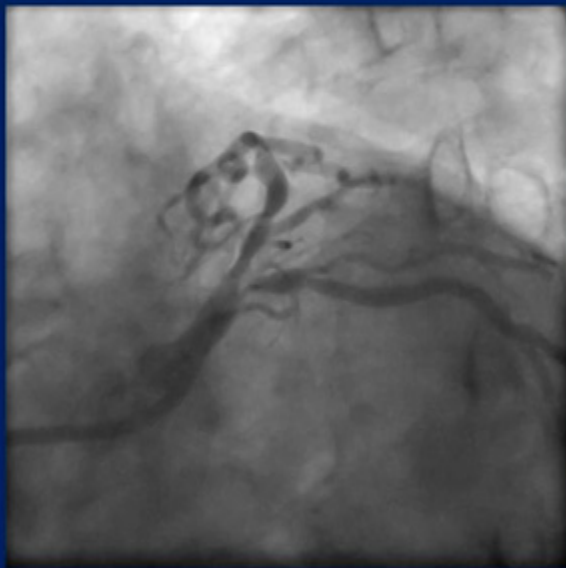


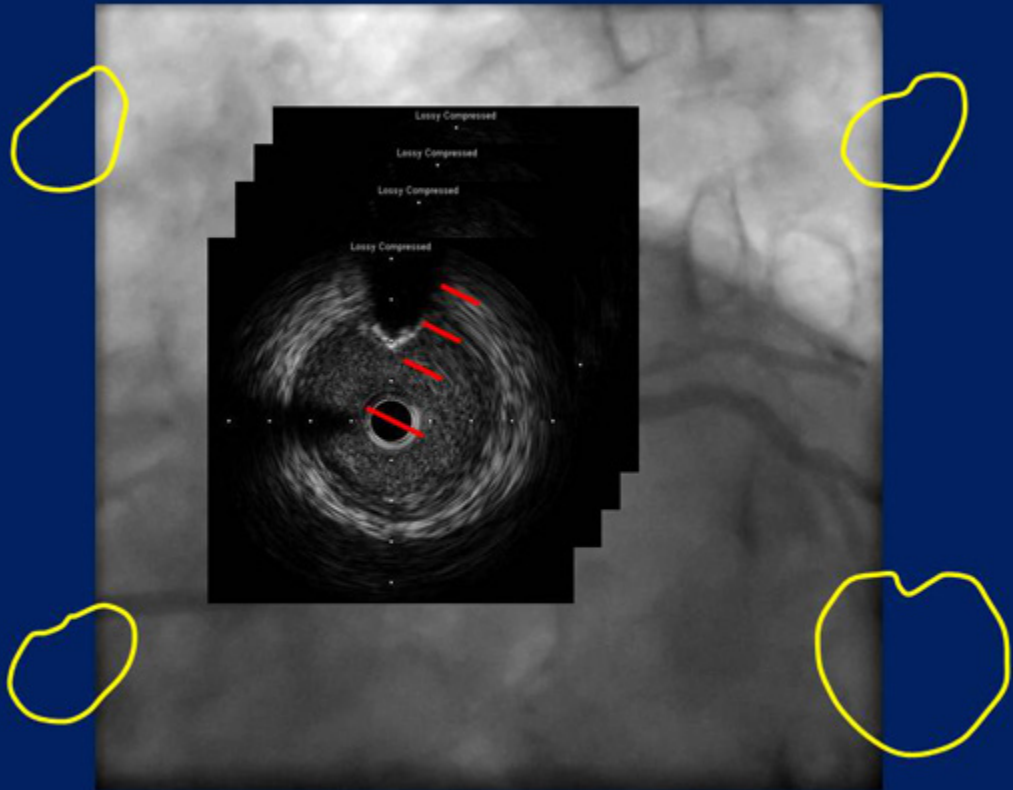
## Post(Lipid pool)

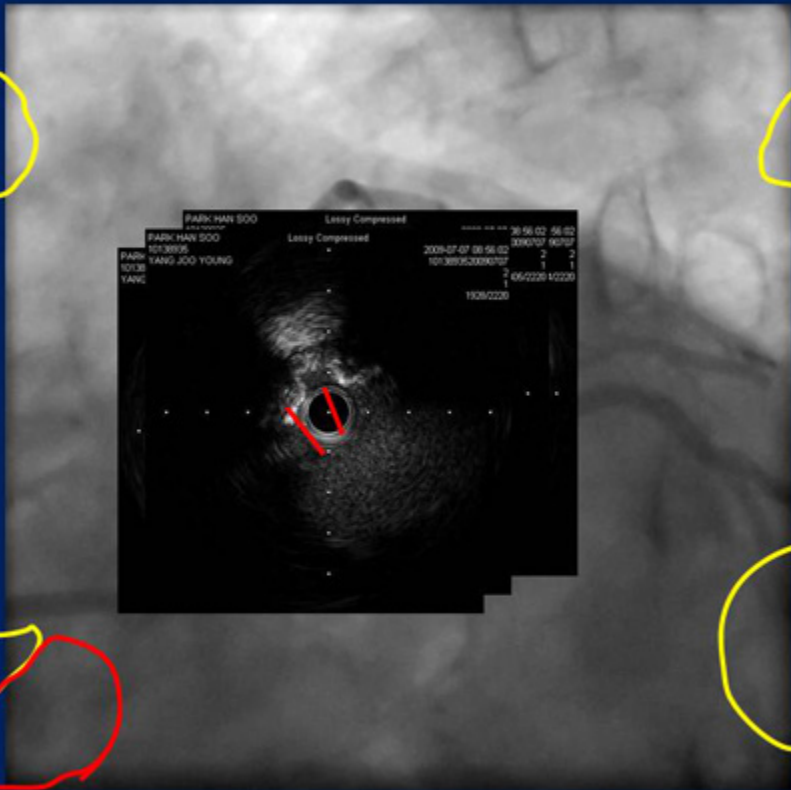


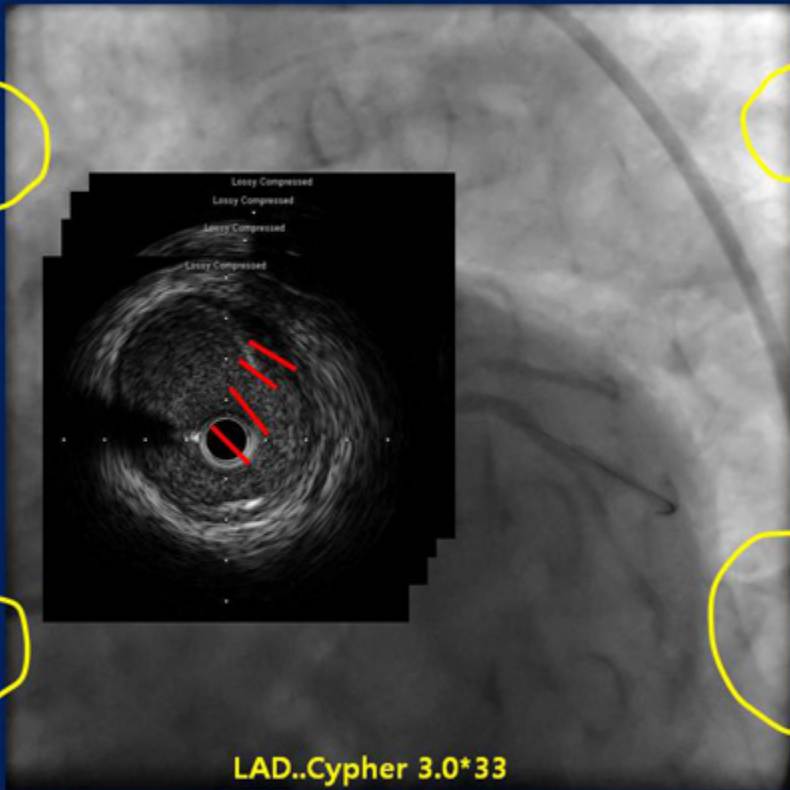


# kissing stent(pre)

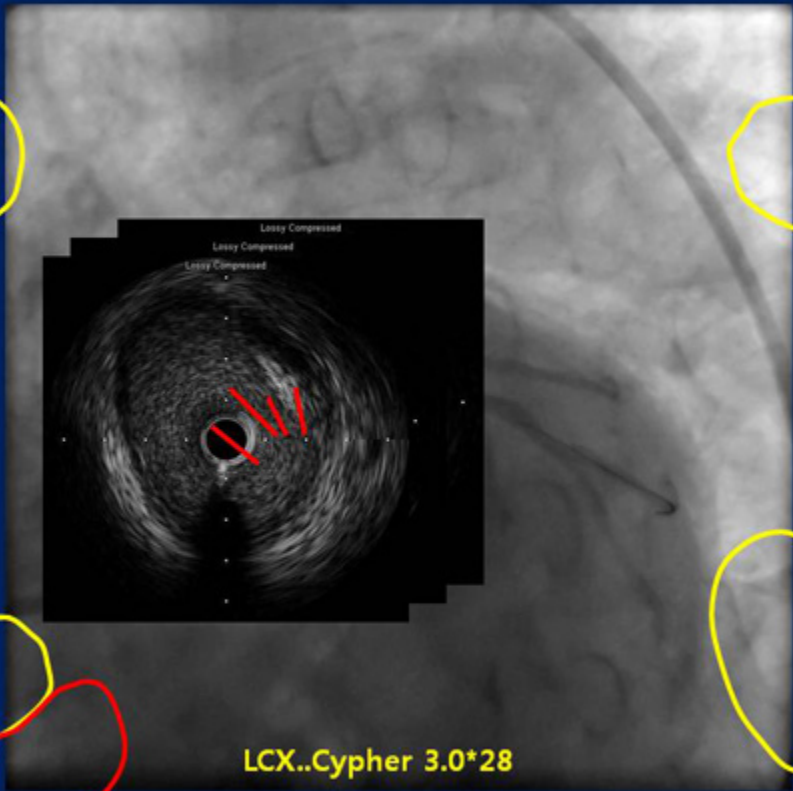








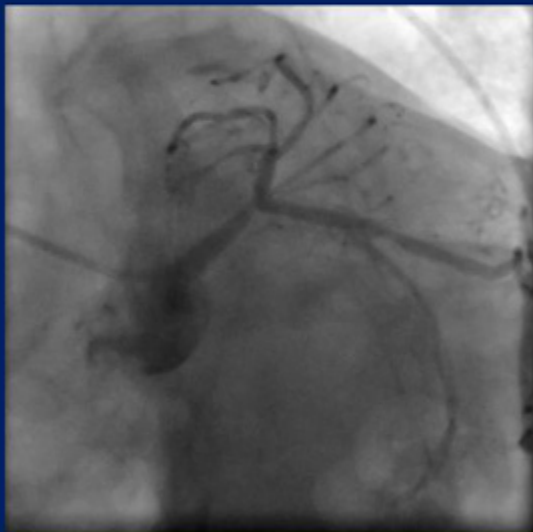
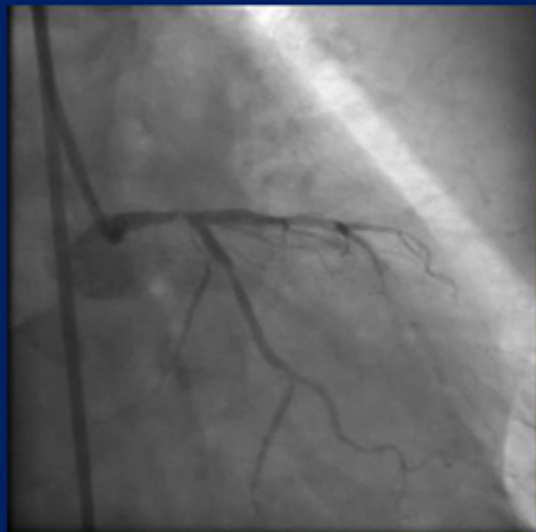


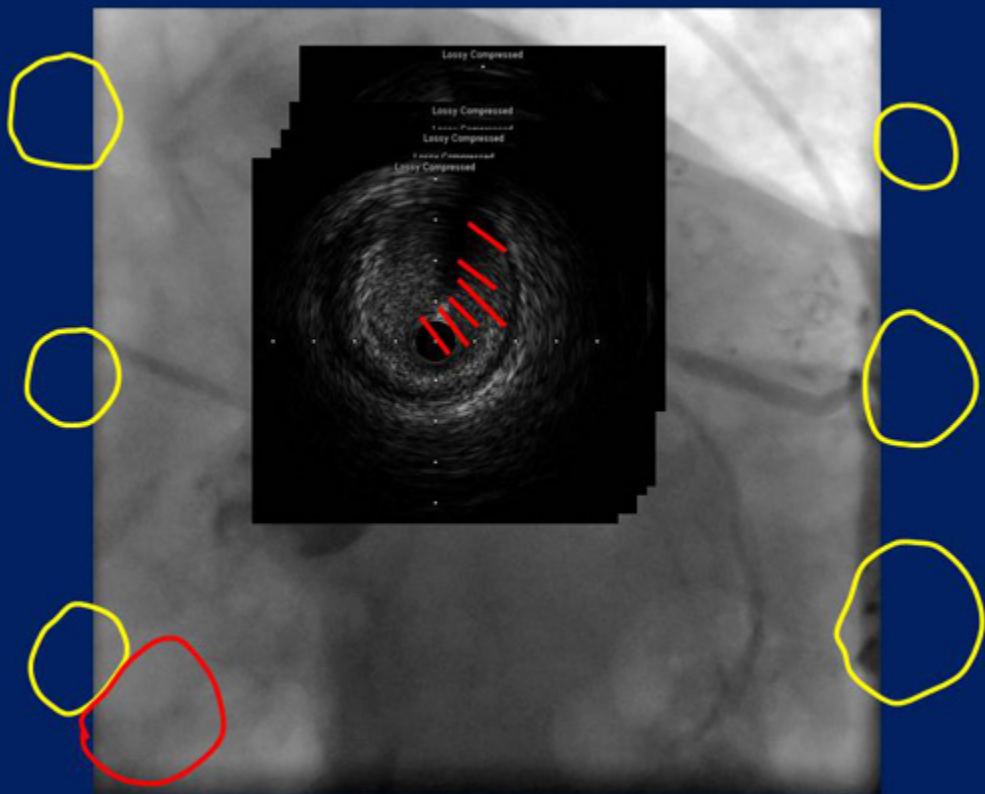


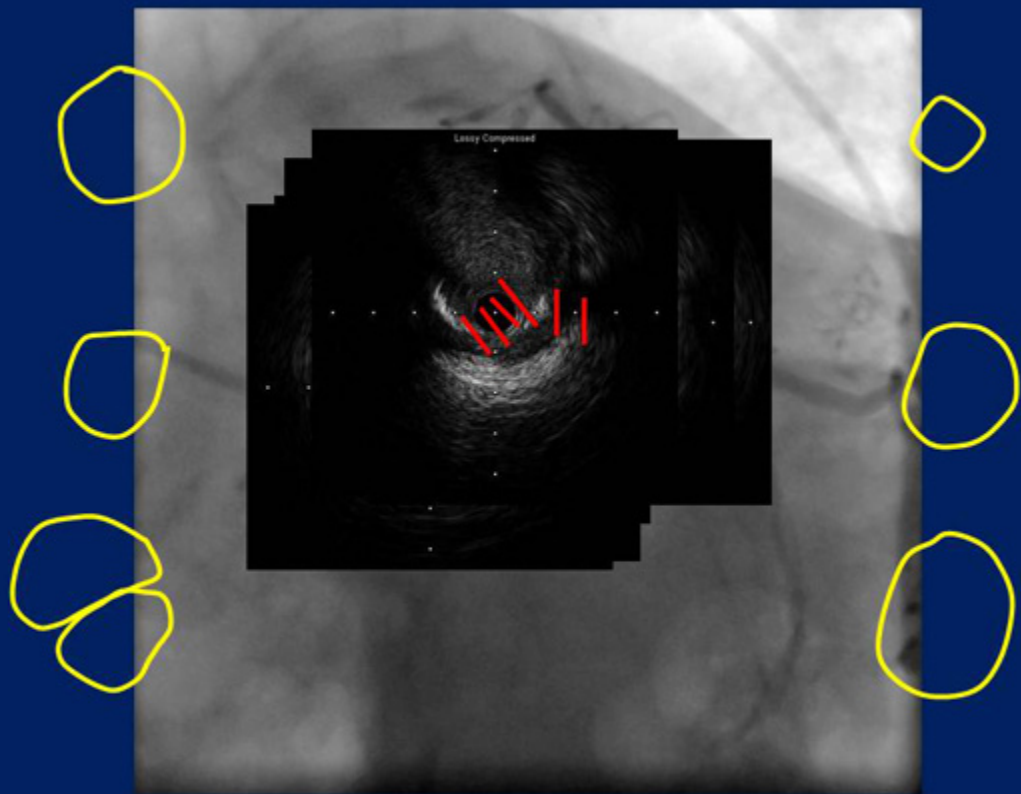
LCX..Cypher 3.0\*28

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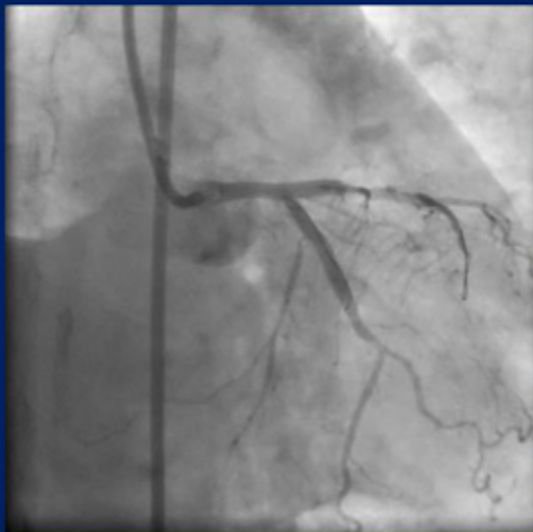
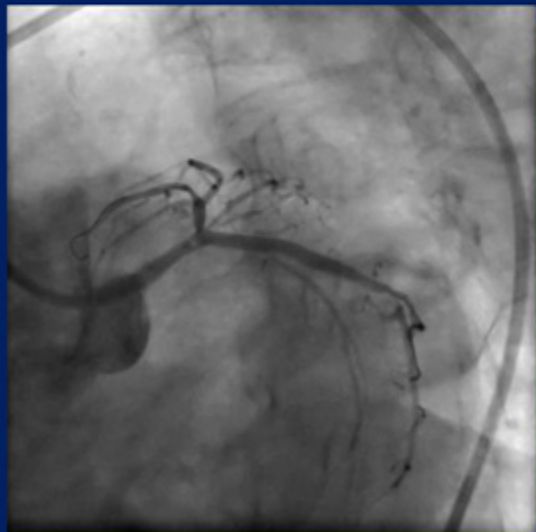
# Crush(pre)

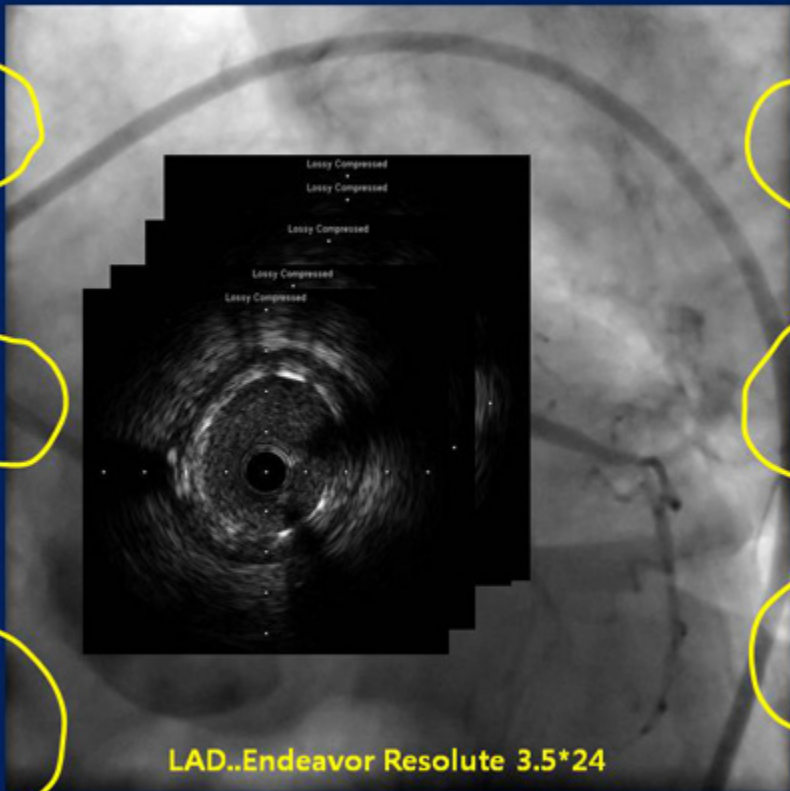




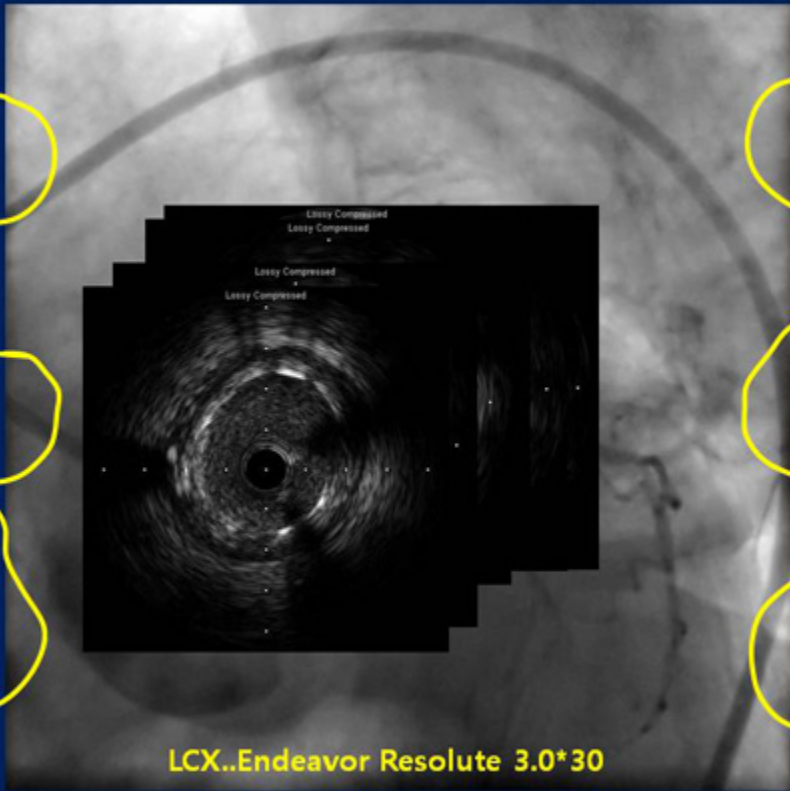


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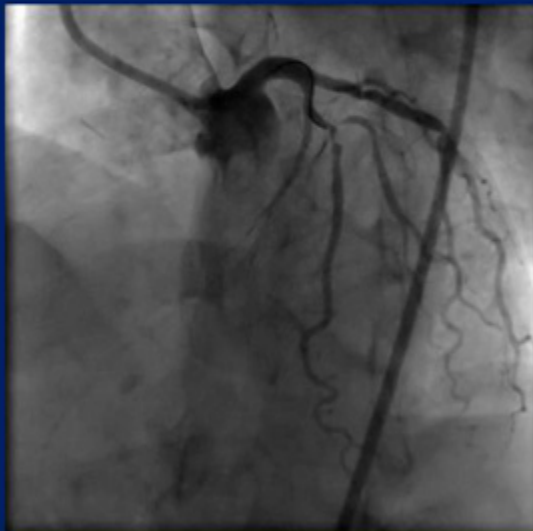
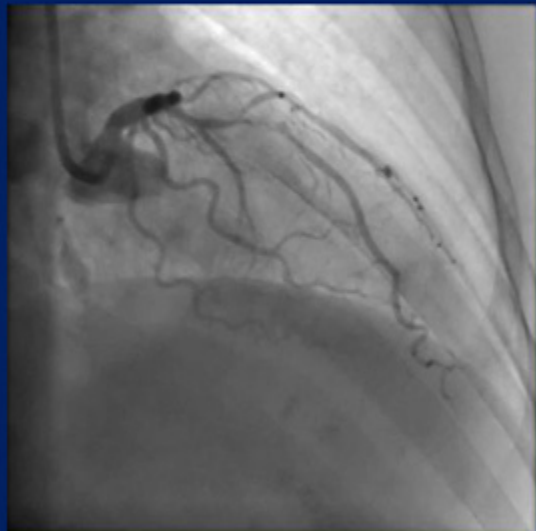


LAD..Endeavor Resolute 3.5\*24

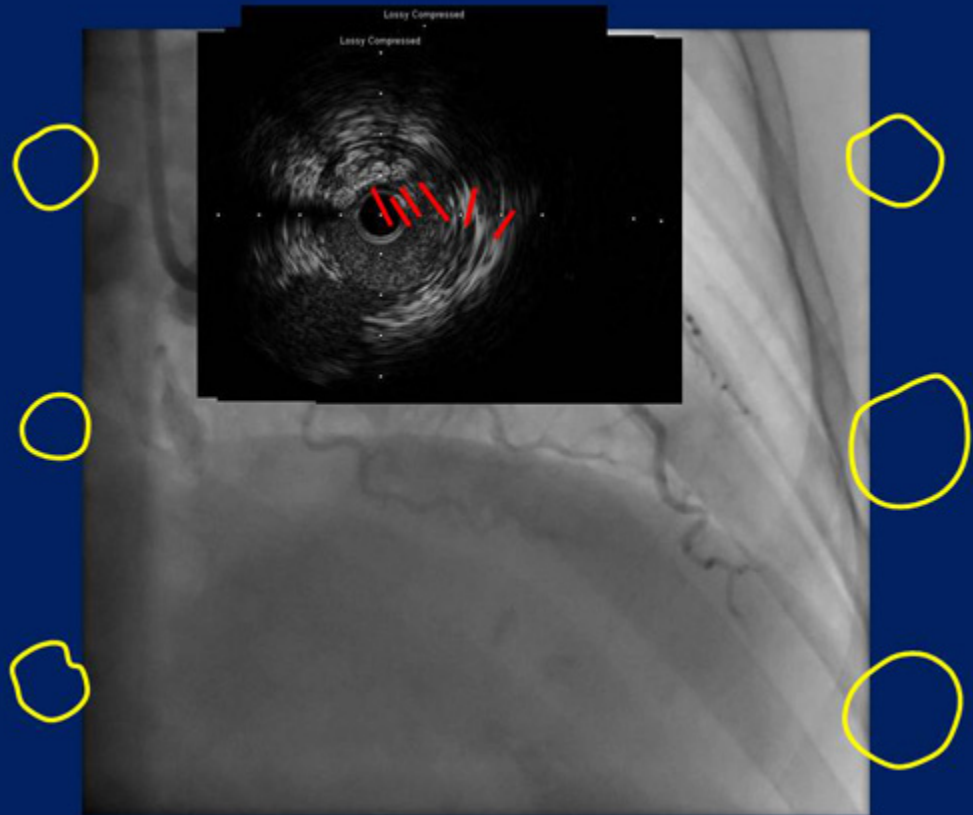


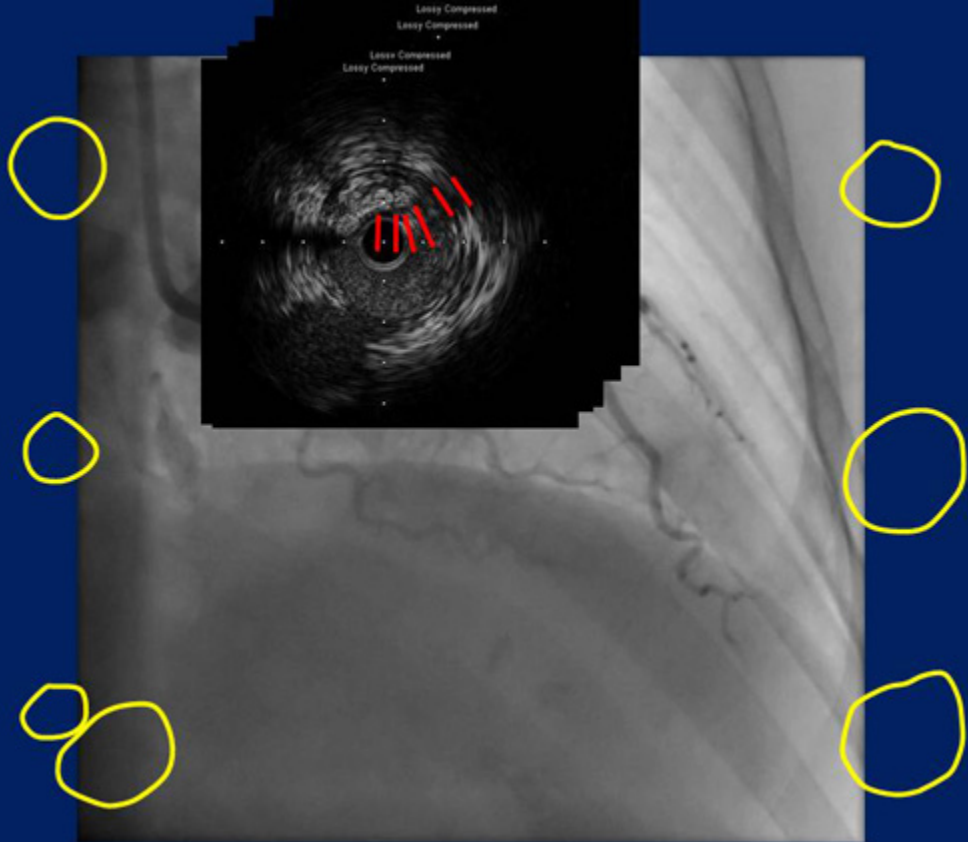
LCX..Endeavor Resolute 3.0\*30

## T-stent(pre)

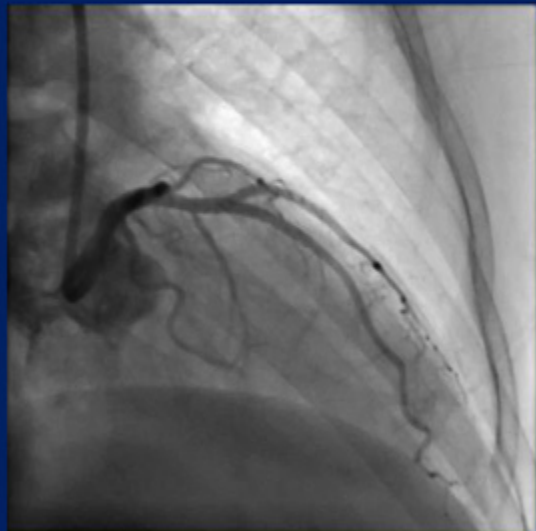


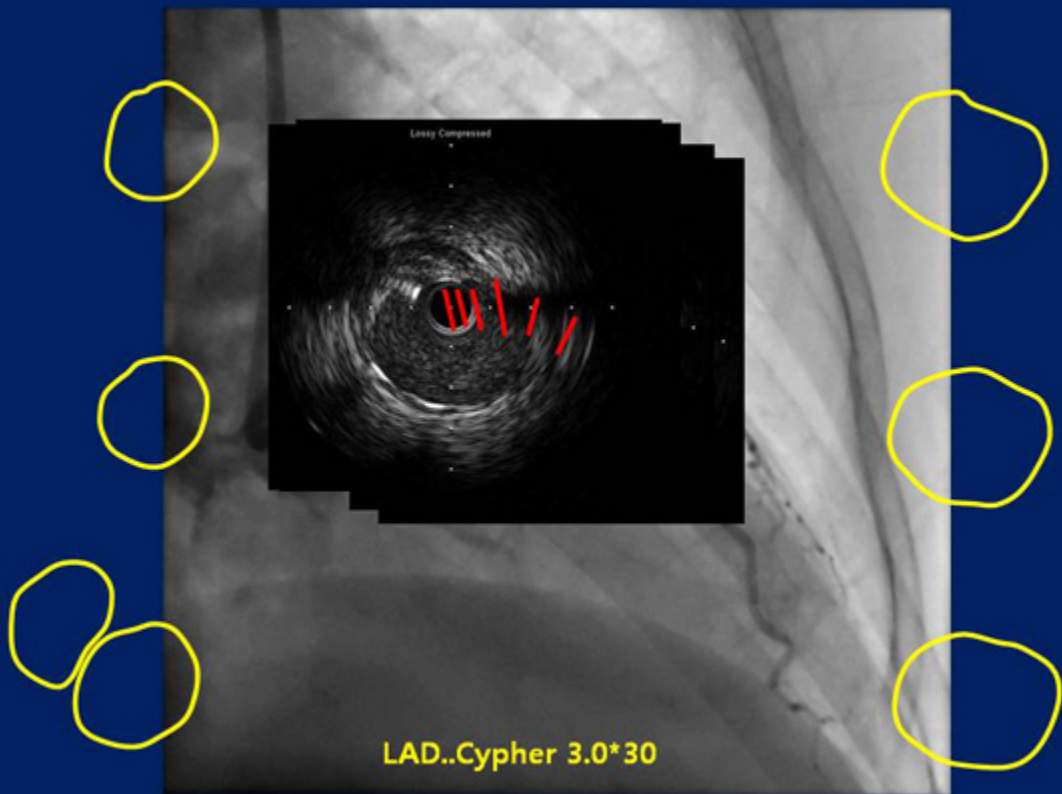


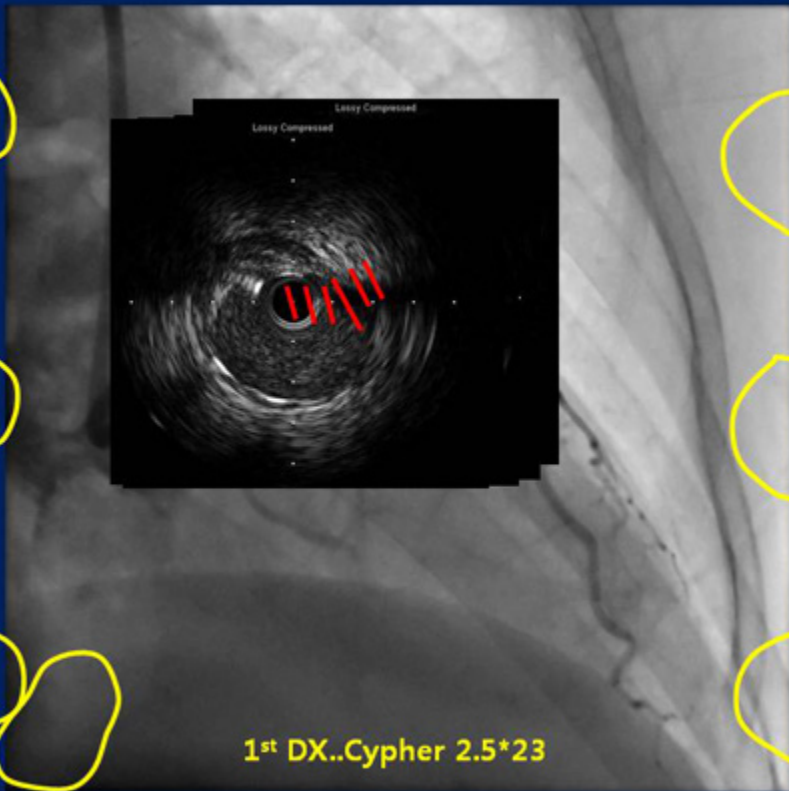




# T-stent(post)

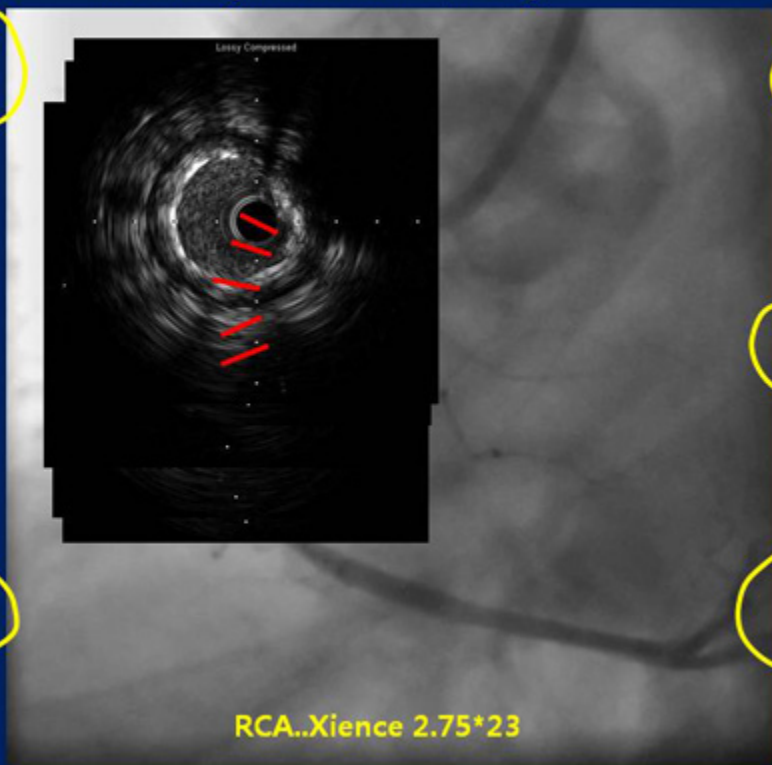




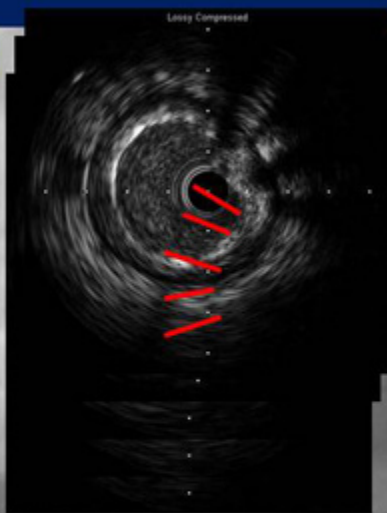


1st DX..Cypher 2.5\*23

# ISR(9mo F/U)

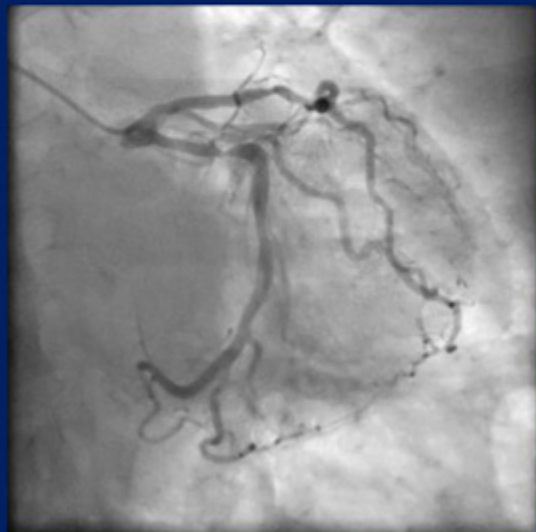


# ISR



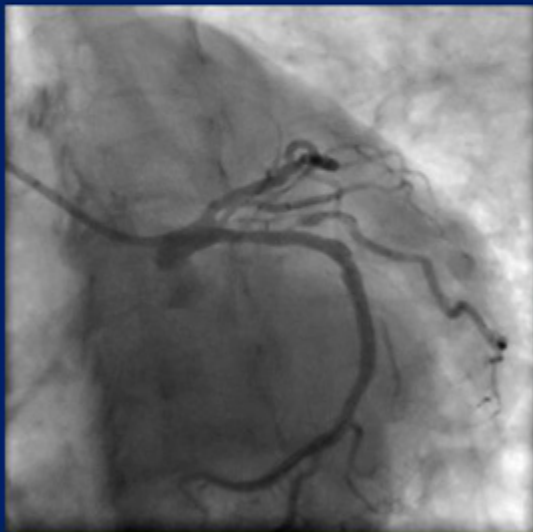
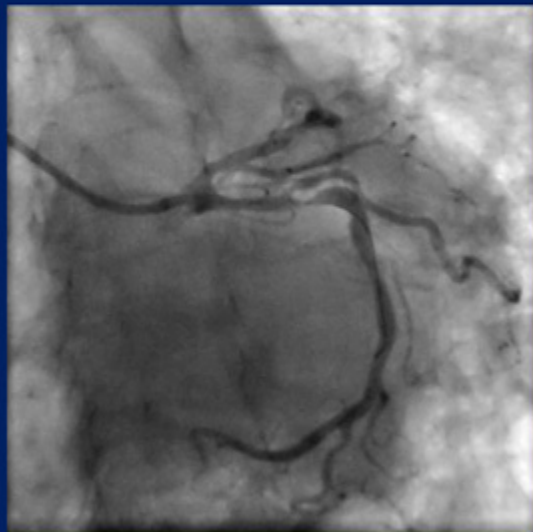
RCA..Cutting 3.0

# Dissection

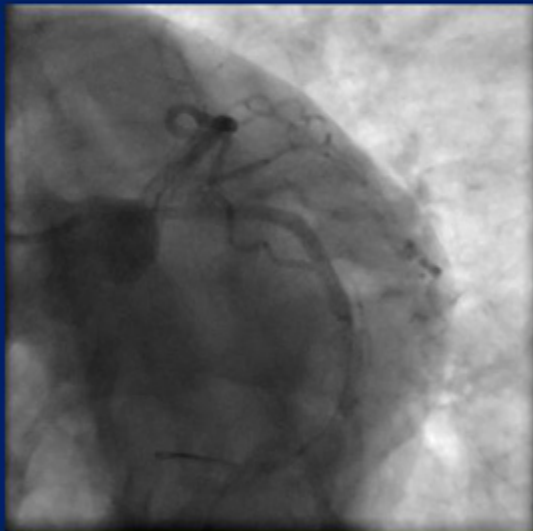


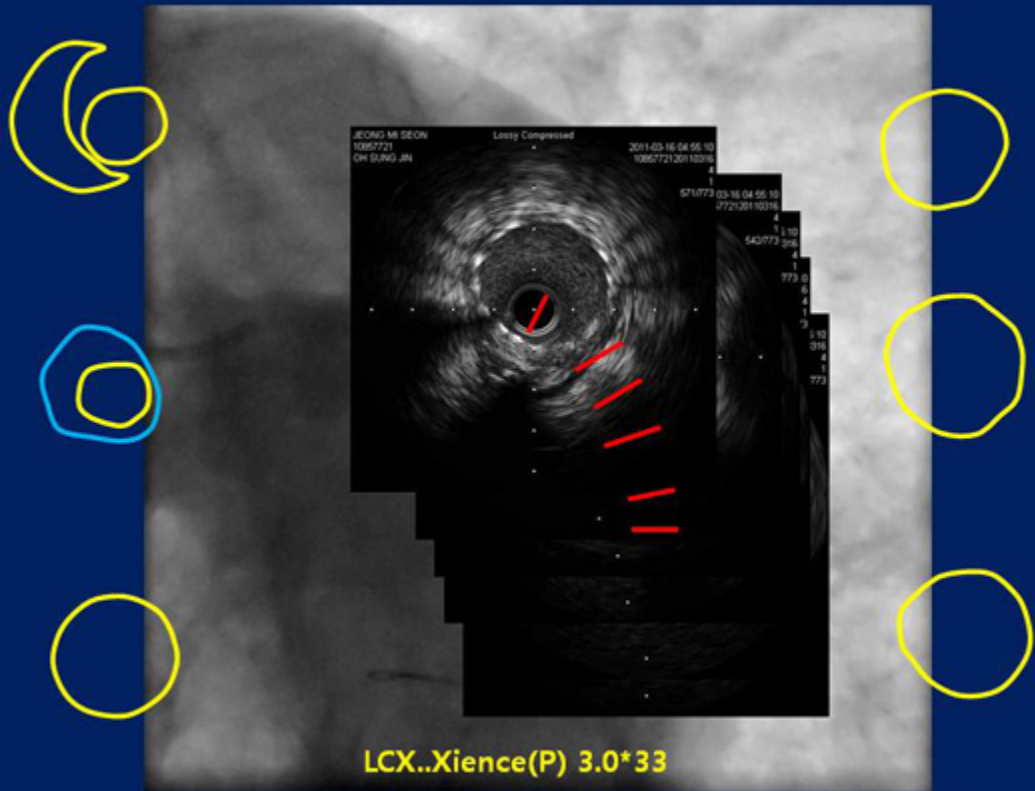


# Dissection



# Dissection





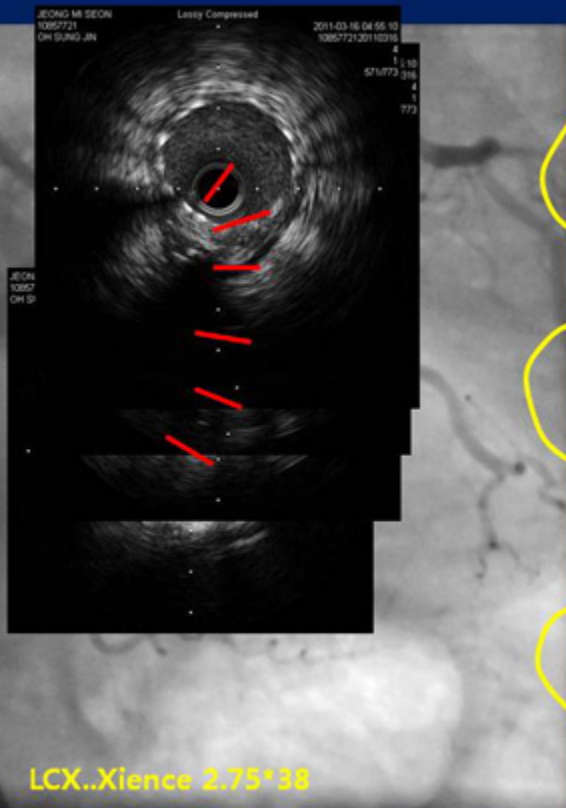
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LCX..Xience 2.75\*38

# PCI IVUS Role !!!

- How to determine lesion length morphology
- How to identify dissections
- Determining appropriate stent placement
- Determining lesion size
- Understanding the shortfalls of angiography
- Understanding the clinical indications for IVUS utilization

# Long-Term Outcomes of Intravascular Ultrasound-Guided Stenting in Coronary Bifurcation Lesions

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Stenting for bifurcation lesions is still challenging, and the effect of intravascular ultrasound (IVUS) guidance on long-term outcomes has not been evaluated. We assessed the long-term outcomes of IVUS-guided stenting in bifurcation lesions. We evaluated 758 patients with de novo nonleft main coronary bifurcation lesions who underwent stent implantation from January 1998 to February 2006. We compared the adverse outcomes (i.e., death, stent thrombosis, and target lesion revascularization) within 4 years, after adjustment using a multivariate Cox proportional hazards model and propensity scoring. IVUS-guided stenting significantly reduced the long-term all-cause mortality (hazard ratio [HR] 0.31, 95% confidence interval [CI] 0.13 to 0.74,  $p = 0.008$ ) in the total population and in the patients receiving drug-eluting stents (DESs) (HR 0.24, 95% CI 0.06 to 0.86,  $p = 0.03$ ), but not in the patients receiving bare metal stents (HR 0.41, 95% CI 0.13 to 1.26,  $p = 0.12$ ). IVUS-guided stenting had no effect on the rate of stent thrombosis (HR 0.48, 95% CI 0.16 to 1.43,  $p = 0.19$ ) or target lesion revascularization (HR 1.47, 95% CI 0.79 to 2.71,  $p = 0.21$ ). In patients receiving DESs, however, IVUS guidance reduced the development of very late stent thrombosis (0.3% vs 0.8%,  $p = 0.03$ , log-rank test). In conclusion, in patients receiving DESs, IVUS-guided stenting for treatment of bifurcation lesions significantly reduced the 4-year mortality compared to conventional angiographically guided stenting. In addition, IVUS guidance reduced the development of very late stent thrombosis in patients receiving DESs. © 2010 Elsevier Inc. All rights reserved. (Am J Cardiol 2010;106:612–618)

Intravascular ultrasonography provides useful information on vessel anatomy and can result in optimal stent deployment. A large cohort study reported that intravascular ultrasound (IVUS) guidance during drug-eluting stent (DES) implantation significantly reduced the thrombosis rate and showed a favorable trend for repeat revascularization.<sup>1</sup> IVUS guidance might be even more useful in complex

stenting at the Asan Medical Center (Seoul and Gangneung, Korea).<sup>2</sup> Of these, 758 consecutive patients underwent stenting for de novo nonleft main coronary bifurcation lesions with a side branch  $>2.0$  mm in diameter, by visual estimation. The performance of IVUS-guided stenting was left to the physician's discretion. Patients were classified as having undergone IVUS-guided stenting if an IVUS exam-

# Is there still a role for intravascular ultrasound in the current practice era?

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*The authors have no conflict of interest to declare.*

## KEYWORDS

*Intravascular  
ultrasound,  
percutaneous coronary  
intervention*

## Abstract

Although coronary angiogram is considered the gold standard for coronary assessment, it consistently underestimates vessel size/lesion severity, and usually misses heavy calcified plaques. Intravascular ultrasound (IVUS) technology accurately determines vessel size/lesion severity and allows a detailed plaque

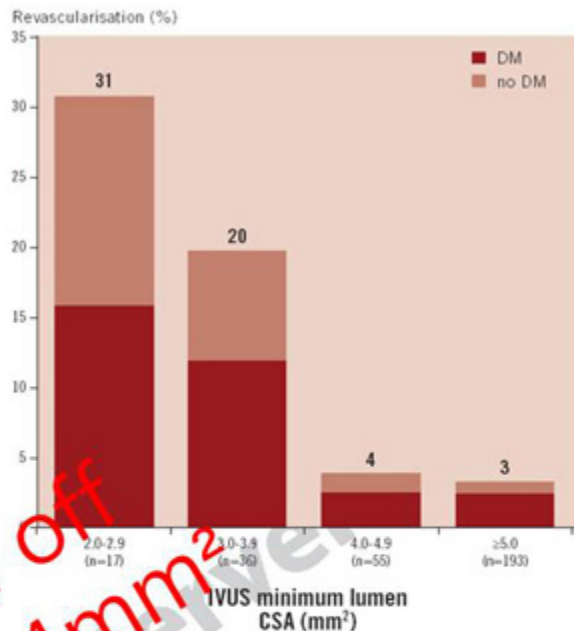
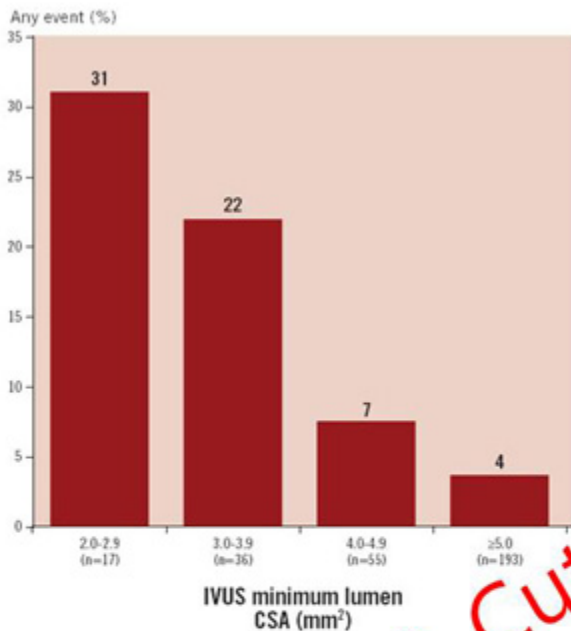


Figure 2. The occurrence of any event (death, MI, or revascularisation) decreased with increasing minimum lumen CSA and was similar in diabetics and nondiabetics. Target lesion revascularisation increased with increasing minimum lumen CSA, but it was lower in nondiabetic than diabetic patients. DM indicates diabetes mellitus.

subsequent decrease in the rate of in-stent restenosis (ISR), it has been suggested that the benefit related to IVUS guidance may be minimised. However, DES underexpansion is an important predictor for further stent failure and stent thrombosis (ST),<sup>11,12</sup> an issue of

quantitative coronary angiography on the LMCA is worse than on any other coronary territories.<sup>15</sup> Therefore, IVUS appears to be a very useful tool for accurate assessment of the LMCA when the angiographic interpretation is ambiguous (Figure 3). Indeed, the



# SVMI HD-IVUS



# SVMI HD-IVUS



# SVMI HD-IVUS

## Product Comparison

Feature	SVMI HD-IVUS	BSC iLab / Atlantis	Volcano s5/Revolutions	LLI/SJM C7-XR/C7-Dragonfly
Frequency/wavelength	40 & 60MHz	40MHz	45MHz	1300nm
Energy	Ultrasound	Ultrasound	Ultrasound	NIR Light
Axial Resolution	<50 $\mu$ m	~150 $\mu$ m	~200 $\mu$ m	~15 $\mu$ m
Max. Frame Rate	100 fps	30 fps	30 fps	100 fps
Max. Pullback Speed	20 mm/sec	1.0 mm/sec	1.0 mm/sec	20 mm/sec
Frame Spacing	200 $\mu$ m	33 $\mu$ m	33 $\mu$ m	200 $\mu$ m
Elevational Resolution	~200 $\mu$ m	~400 $\mu$ m	~600 $\mu$ m	~40 $\mu$ m
Pullback Length	120 mm	100 mm	100 mm	50 mm
Tissue Penetration	>4 mm	>5 mm	>5 mm	0.8-1.5 mm
Imaging in Blood	Yes	Yes	Yes	No

*Thank you for attention !*

