

# Histopathologic Insight for CTO-PCI

*G. NAKAZAWA*

*TOKAI Univ.*

*CV-HILLS*

TCTAP2013

# Chronic Total Occlusion

- Pathology of CTO from review of the literature
- Experience from autopsy at CVPath
- Nature of CTO lesions
- Fate of False Lumen Stenting

# Chronic Total Occlusion

- Pathology of CTO from review of the literature
- Experience from autopsy at CVPath
- Nature of CTO lesions
- Fate of False Lumen Stenting

# Chronic Total Occlusion (CTO) Pathology

- Data from 10 autopsy patients with CTO and angiography performed 3 months prior to death and estimated duration >1 year (Katsuragawa M, et al. JACC 1993;21:604)
- CTO in 61 autopsy patients with angiographically documented CTO in 96 arteries (defined as abrupt vessel cut off) (Srivatsa SS, et al. JACC 1997;29:955)
  - 49% of the lesions were <99% stenosis at autopsy despite angiographically documented TO with

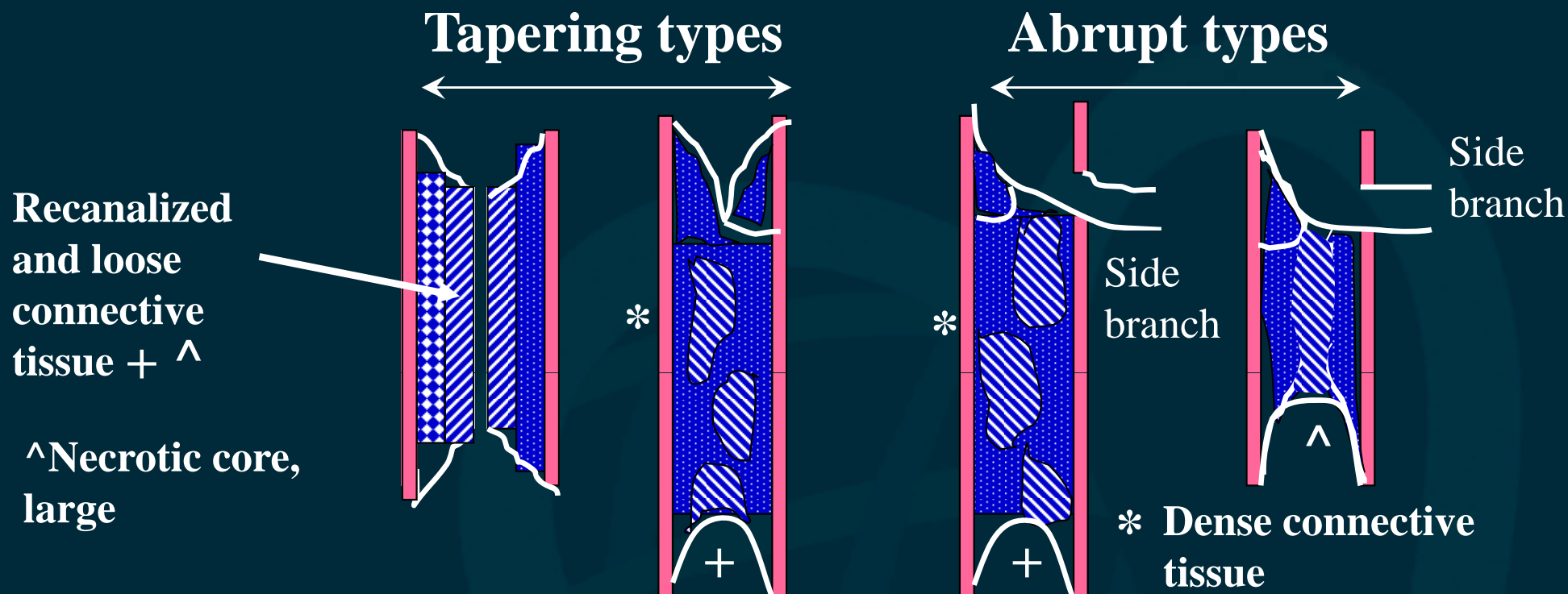
# Chronic Total Occlusion Pathology by Dr. Katsuragawa

- Clinical characteristics of arteries with chronic total occlusion : (n=10)
  - Coronary vessel size is  $3.61 \pm 0.57$  mm
  - Prior MI 67%
  - Interval from prior MI to death 1.5 yrs to 10 years
  - Risk factors; DM 17%, HTN 38%, Smokers 19%, prior stroke/TIA =3%

# Chronic Total Occlusion Pathology by Dr. Katsuragawa

Type of CTO	Tapering	Abrupt
CTO Length, mm	10 ± 9 (4 - 26)	14 ± 12 (3 - 33)
Side branch	20%	80%
Vessel Stump	100%	20%

# Clinical and Histologic Classification of Chronic Total Occlusion



Number of Cases	4	1	2	3
Small recanalization	+	-	-	-
Configuration of Small fibrous tissue	type1	type2*	type2*	type1
Length of the occluded segment	4-8mm (6+2mm)	26mm	20,30mm	3-9mm (6+3mm)

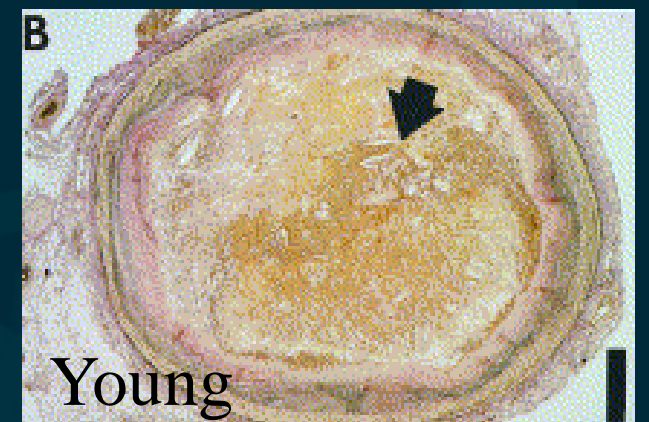
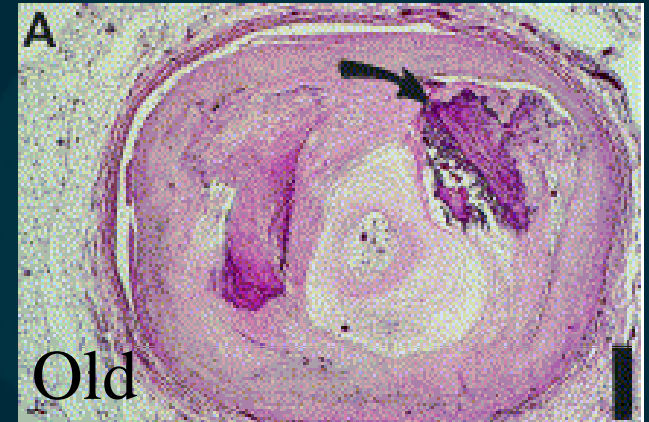
# Chronic Total Occlusion Pathology by Dr. Srivatsa

- Location of CTO in the coronary arteries in 61 patients:  
RCA 43%, LAD 30%, and LCx 27%
- Duration of CTO:  
64% > 1 year (35% > 5 years, 29% 1 to 5 years)  
17% 3 months to 1 year, 19% <3 months
- Mean Patient's age :  
63.4<sub>±</sub>1.3 yrs
- Type of Plaque Morphology:  
64% fibrocalcific plaque  
11% predominantly cholesterol rich  
25% mixed type



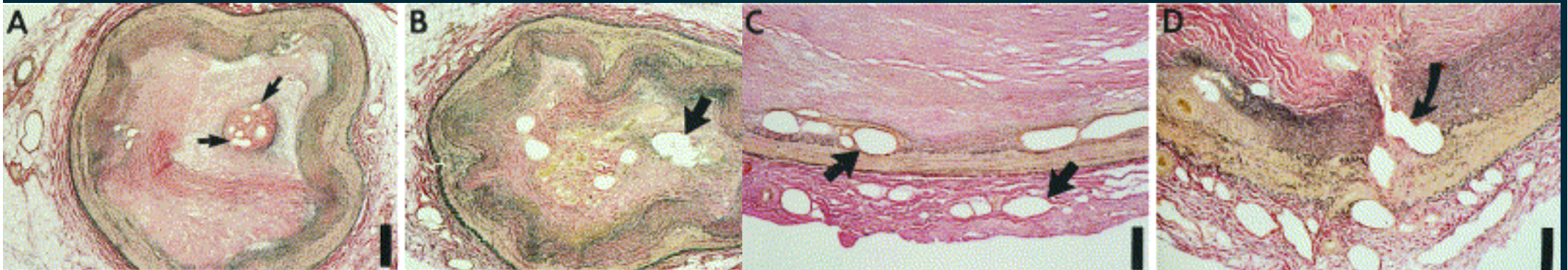
# Plaque Characteristics in CTO

- Angiographic CTO and morphologic correlates:
  - The majority (78%) of angiographic CTOs were  $\leq$  99% occluded by histology. (25% were 90% to 95% occluded, 24% were 96% to 98% occluded, 29% were 99% occluded and 22% were 100% occluded)
- Cholesterol and foam cell plaques were more frequently found in younger lesions than older ones ( $p=0.0007$ ), whereas fibrotic plaques were predominantly seen in the older lesions ( $p=0.008$ )
- Luminal neocapillary channels (NC) were extensive and frequent (59% of CTOs) which were similarly seen in all CTOs irrespective of age.
  - There was a correlation between number and size of NC and increase in cellular inflammation of intimal plaque



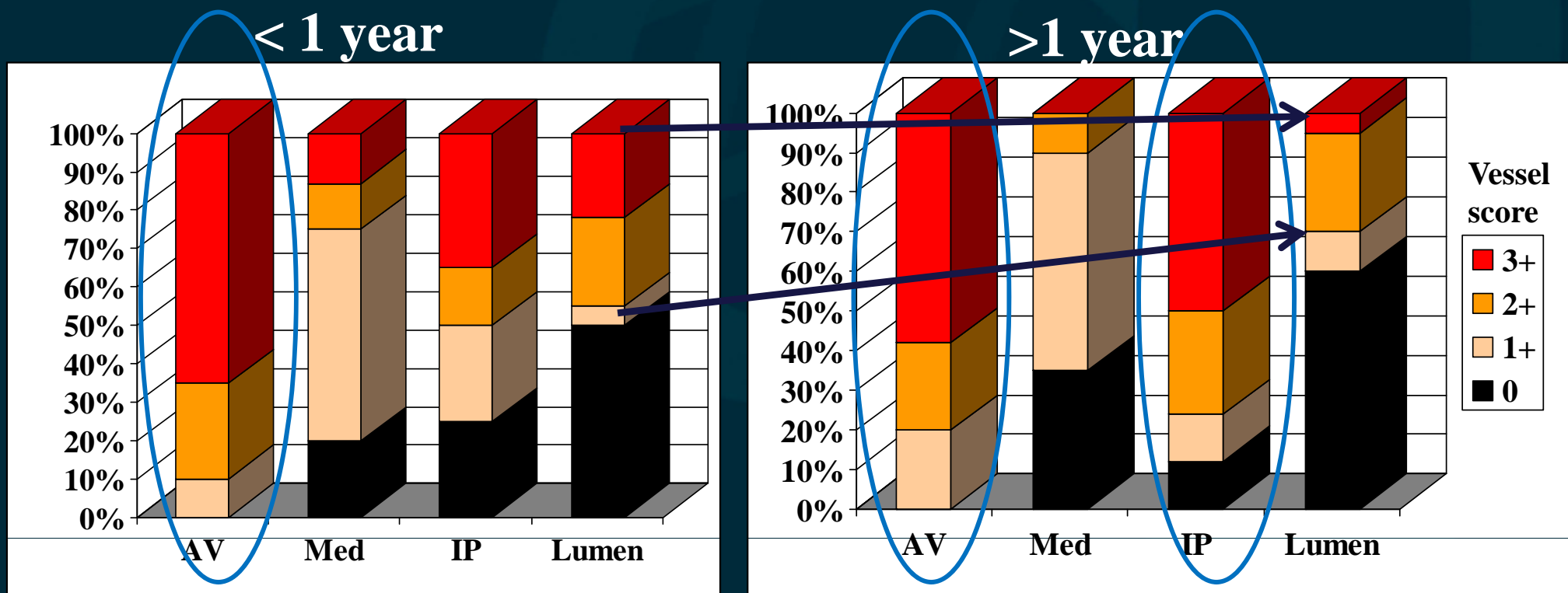
# Plaque Characteristics in CTO

- Communication between lumen recanalization channels and the IP neovasculature was rarely observed!
- Intimal plaque neovascular recanalization was observed in 85% of CTOs > 1 year as compared to 74% of CTO < 1 year (p=0.06).
- In almost all CTO lesions, intimal plaque neocapillary channels were observed directly communicate with the adventitial vasa vasorum



# Neovascular Channel Score According to Vessel wall Location

- ✓ In CTOs < 1 year old, the adventitia had larger number and size of neovascular recanalizations relative to intra plaque (IP), medial and recanalized lumen
- ✓ In CTOs > 1 year old, the adventitial and IP neovascular recanalization number was similar but exceeded neovascular recanalizations number found in the media and lumen



Abbreviations: AV= advential, med = medial, IP = intraplaque  
Vessel Score

Srivastva S, et al. JACC 1997;29:955



# Chronic Total Occlusion

- Pathology of CTO from review of the literature
- Experience from autopsy at CVPath
- Nature of CTO lesions
- Fate of False Lumen Stenting

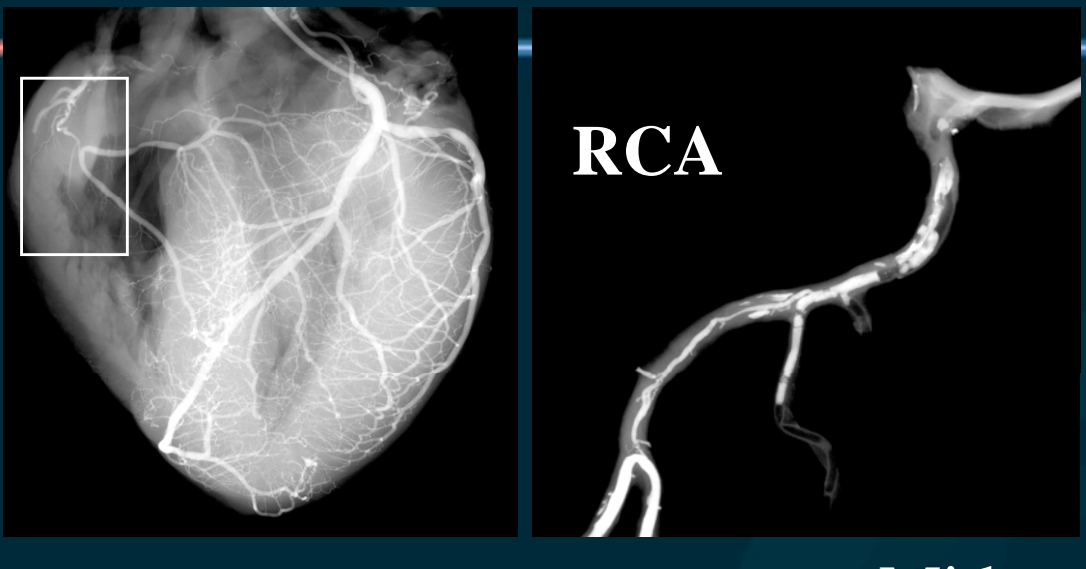
# Chronic Total Occlusion

- Pathology of CTO from review of the literature
- Experience from autopsy at CVPath
- Nature of CTO lesions
- Fate of False Lumen Stenting

# Chronic Total Occlusion of Coronary Arteries Studies at autopsy by Postmortem Angiography and Serial Cross-Sectioning of the Arteries

- 10 SCD patients, mean age  $56 \pm 7$  years (range 43 to 67 years), 7 M and 3 F
- 6 had three vessel disease, 2 had two vessel disease, and 2 had one vessel disease
- Total occlusion involved:
  - LAD - 4, RCA - 4, and LCX - 4
- Length of lesion, mean  $2.2 \pm 1.8$  cm, range 0.5 to 5.7 cm
- 6 had TM, healed MI; and 4 had SE healed MI (1 had LV aneurysm)

# Tapered type



## History

**42-year-old white male, found unresponsive at home; no known risk factors. Total occlusion of the proximal and mid-RCA. Acute, healing, and healed MIs in the LV.**

A



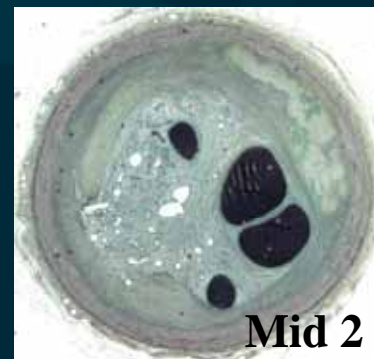
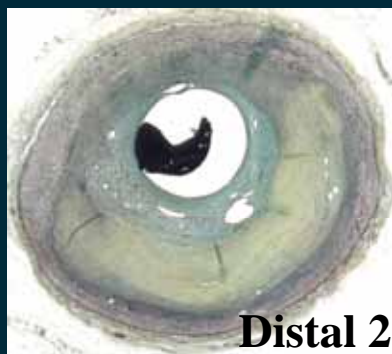
3.7 cm length

Distal

B



Proximal



# Tapered type

# History

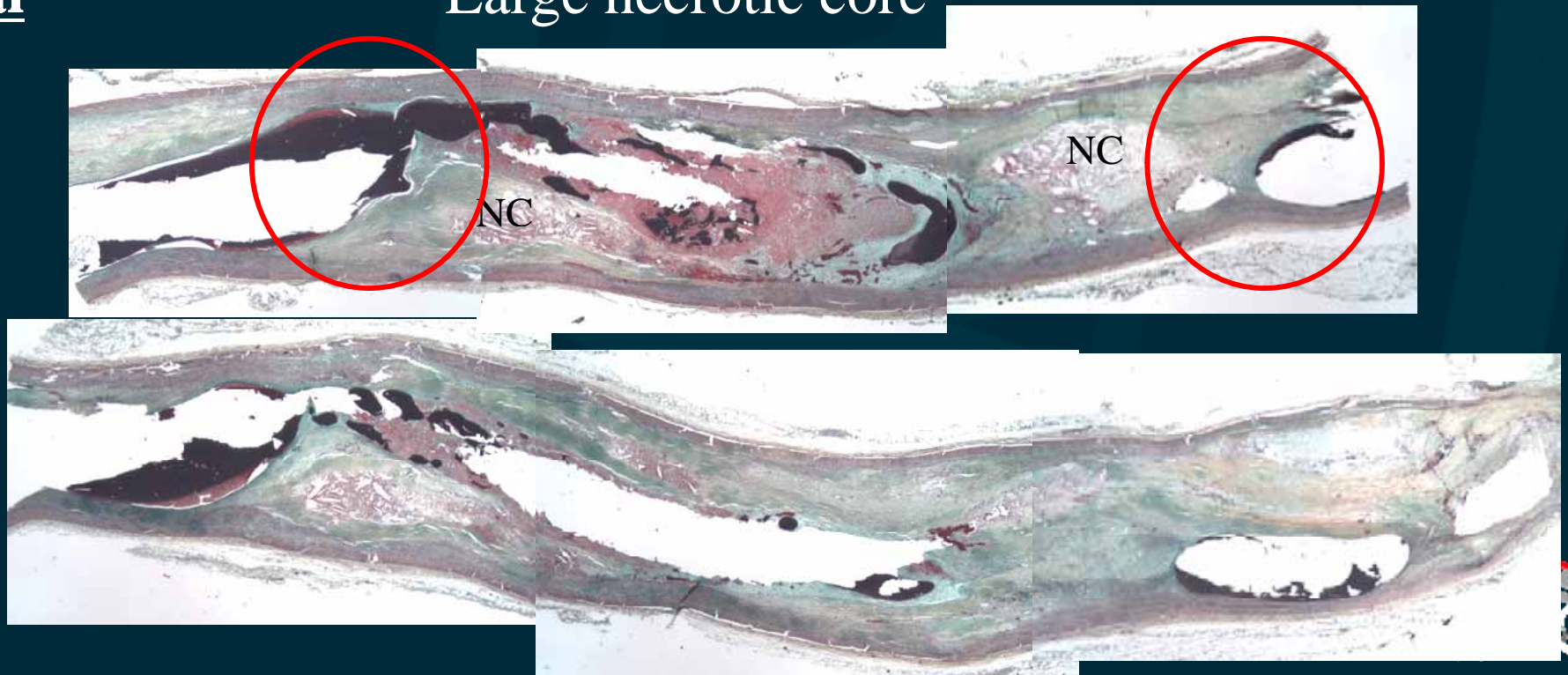
**62 year old black male; sudden death while driving. At autopsy, LCx had 75% narrowing and total occlusion of RCA with a healed MI in the posterior LV**



Distal 2.5 cm, Recanalized

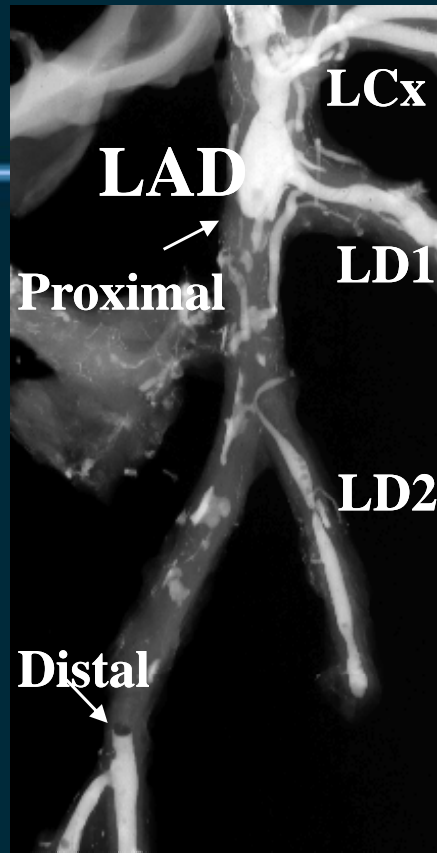
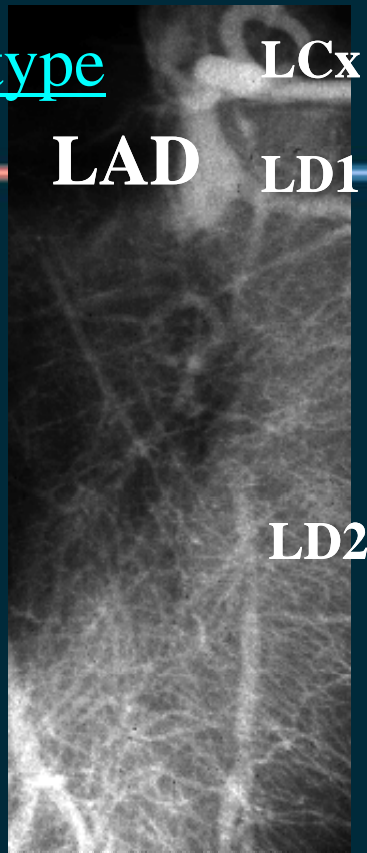
Large necrotic core

Proximal





Blunt type



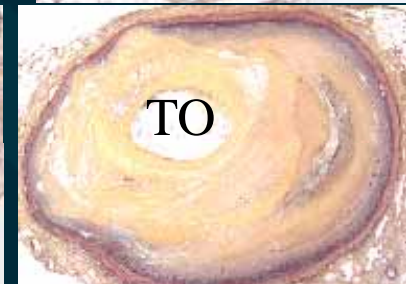
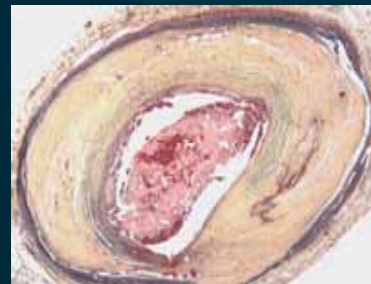
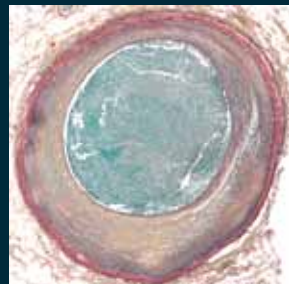
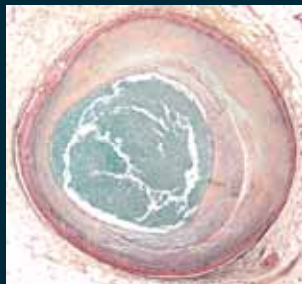
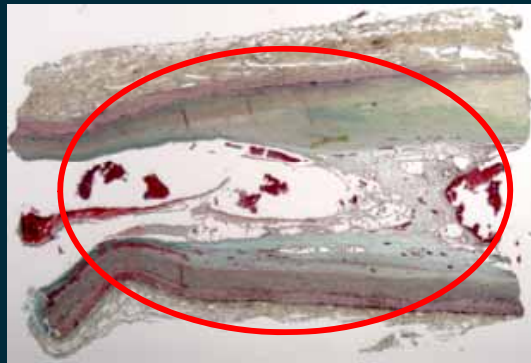
History

**71 year old white male;  
cardiac arrest while  
driving; at autopsy had  
total occlusion of LAD and  
75% of RCA**

Distal

4.5 cm, length

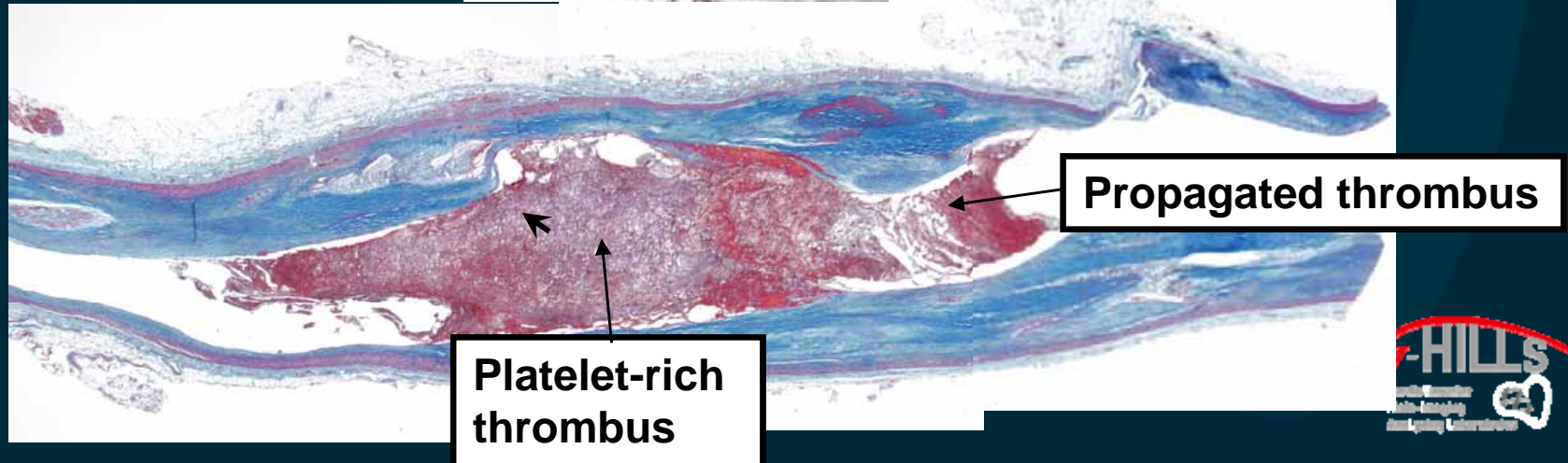
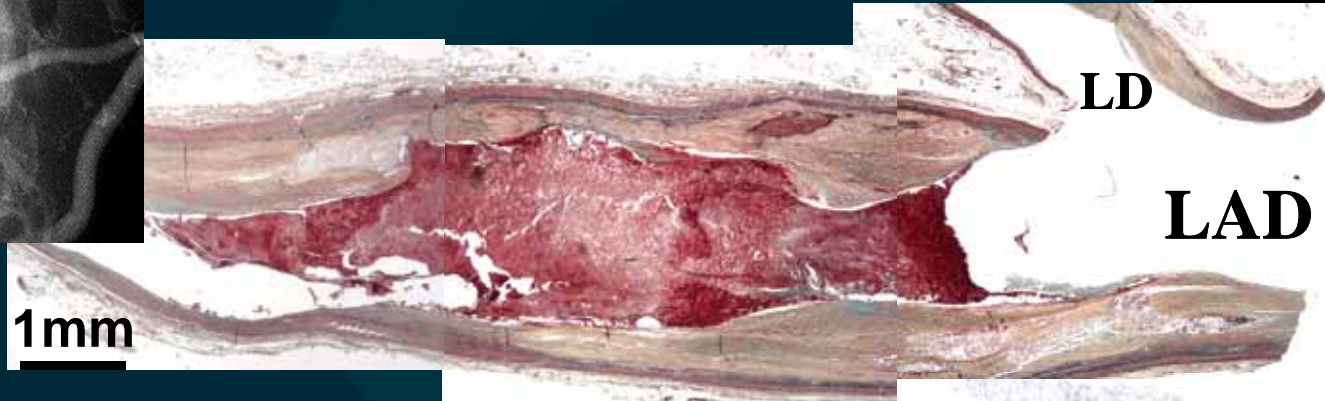
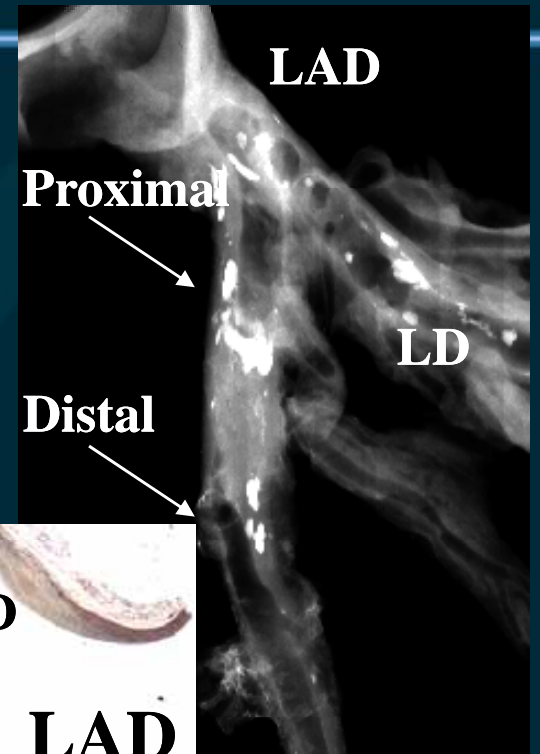
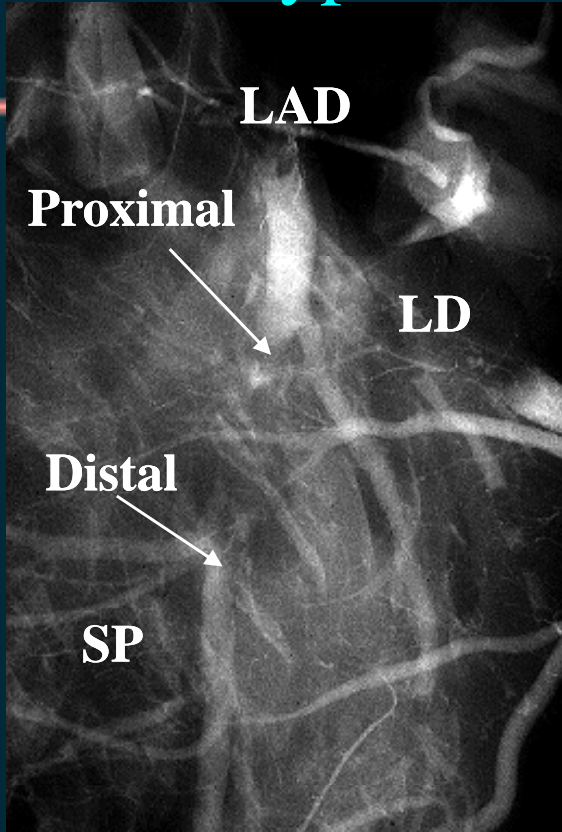
Proximal



# Blunt type

Abrupt occlusion LAD with side branch

**53 year old black male  
found dead, at autopsy  
had total occlusion of  
LAD and RCA,  
and 70% of LOM**



# Chronic Total Occlusion

- Pathology of CTO from review of the literature
- Experience from autopsy at CVPath
- Nature of CTO lesions
- Fate of False Lumen Stenting

# Chronic Total Occlusion

- Pathology of CTO from review of the literature
- Experience from autopsy at CVPath
- Nature of CTO lesions
- Fate of False Lumen Stenting

**MINI-FOCUS ISSUE: CHRONIC TOTAL OCCLUSION**

# In-Hospital Outcomes of Contemporary Percutaneous Coronary Intervention in Patients With Chronic Total Occlusion

Insights From the J-CTO Registry (Multicenter CTO Registry in Japan)

Yoshihiro Morino, MD,\* Takeshi Kimura, MD,† Yasuhiko Hayashi, MD,§ Toshiya Muramatsu, MD,|| Masahiko Ochiai, MD,¶ Yuichi Noguchi, MD,# Kenichi Kato, MD,\*\* Yoshisato Shibata, MD,†† Yoshikazu Hiasa, MD,‡‡ Osamu Doi, MD,§§ Takehiro Yamashita, MD,|||| Takeshi Morimoto, MD,‡ Mitsuru Abe, MD,¶¶ Tomoaki Hinohara, MD,## Kazuaki Mitsudo, MD,\*\*\* for the J-CTO Registry Investigators

*Isehara, Kyoto, Hiroshima, Yokohama, Tsukuba, Miyazaki, Komatsushima, Shizuoka, Sapporo, and Kurashiki, Japan; and Redwood City, California*

## J-CTO SCORE SHEET

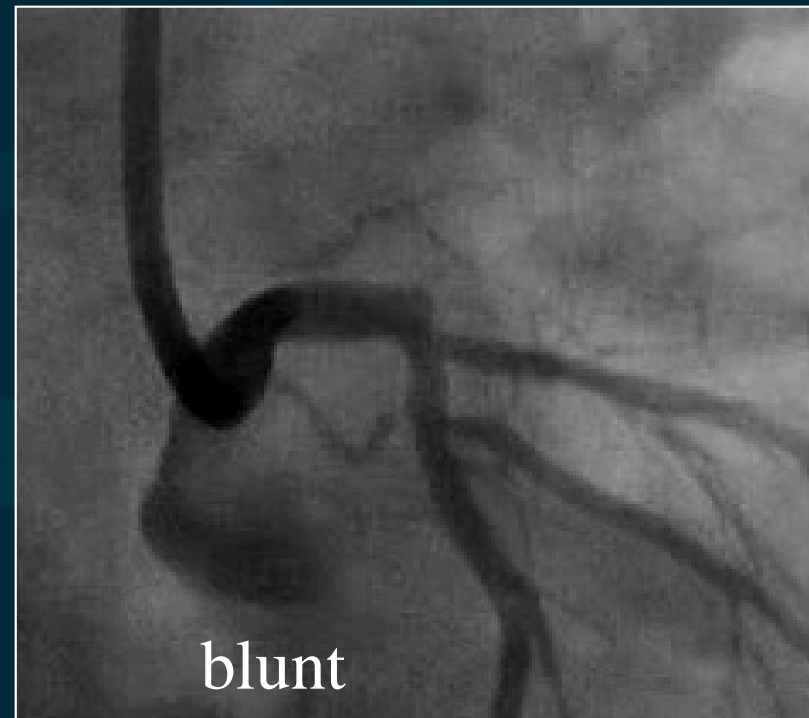
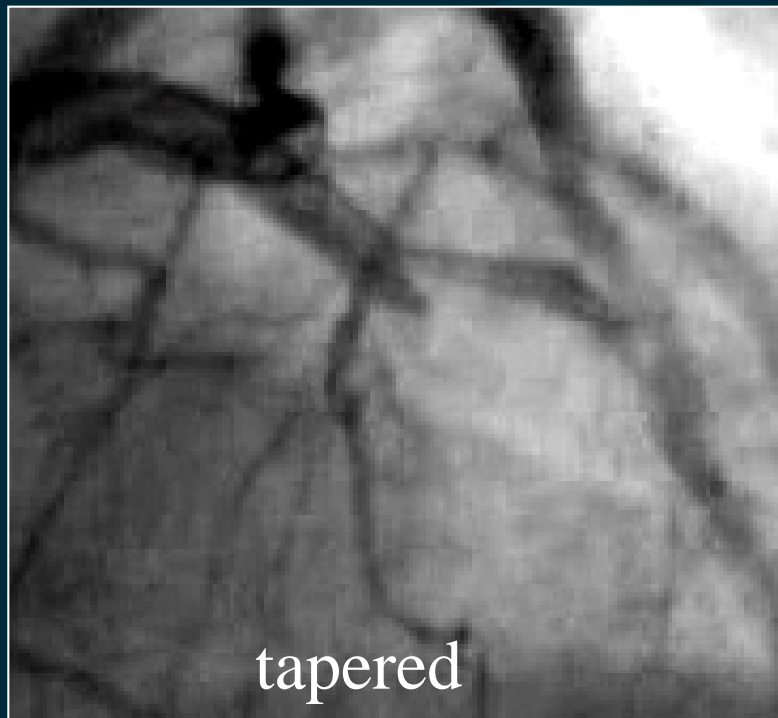
Version 1.0

Variables and definitions		
<p><b>Tapered</b></p>	<p><b>Blunt</b></p>	<p><b>Entry shape</b></p> <p>Entry with any tapered tip or dimple indicating direction of true lumen is categorized as “tapered”.</p> <p><input type="checkbox"/> Tapered (0)</p> <p><input type="checkbox"/> Blunt (1)</p>
		point
<p><b>Calcification</b></p>		<p>Regardless of severity, 1 point is assigned if any evident calcification is detected within the CTO segment.</p> <p><b>Calcification</b></p> <p><input type="checkbox"/> Absence (0)</p> <p><input type="checkbox"/> Presence (1)</p>
		point
<p><b>Bending &gt;45degrees</b></p>		<p>One point is assigned if bending &gt; 45 degrees is detected within the CTO segment. Any tortuosity separated from the CTO segment is excluded from this assessment.</p> <p><b>Bending &gt;45°</b></p> <p><input type="checkbox"/> Absence (0)</p> <p><input type="checkbox"/> Presence (1)</p>
		point
<p><b>Occlusion length</b></p>		<p>Using good collateral images, try to measure “true” distance of occlusion, which tends to be shorter than the first impression.</p> <p><b>Occl.Length</b></p> <p><input type="checkbox"/> &lt;20mm (0)</p> <p><input type="checkbox"/> ≥20mm (1)</p>
		point
<p><b>Re-try lesion</b></p> <p>Is this Re-try (2<sup>nd</sup> attempt) lesion ? (previously attempted but failed)</p>		<p><b>Re-try lesion</b></p> <p><input type="checkbox"/> No (0)</p> <p><input type="checkbox"/> Yes (1)</p>
		point
<p>Category of difficulty (total point)</p> <p><input type="checkbox"/> easy (0)    <input type="checkbox"/> Intermediate (1)</p> <p><input type="checkbox"/> difficult (2)    <input type="checkbox"/> very difficult (≥3)</p>		<p><b>Total</b></p> <p><input type="checkbox"/> points</p>

# Incidence of Side Branches

N=494 including failure cases

	<b>Tapered</b>	<b>Blunt</b>	<b>p</b>
Incidence of SB	84.7%	92.2%	<0.0001



# GW position in the GW success cases (n=273)

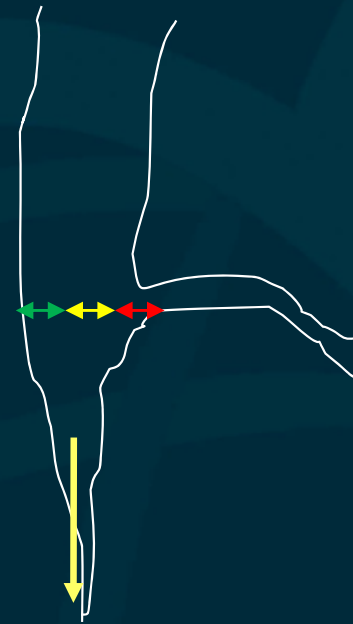
## tapered type



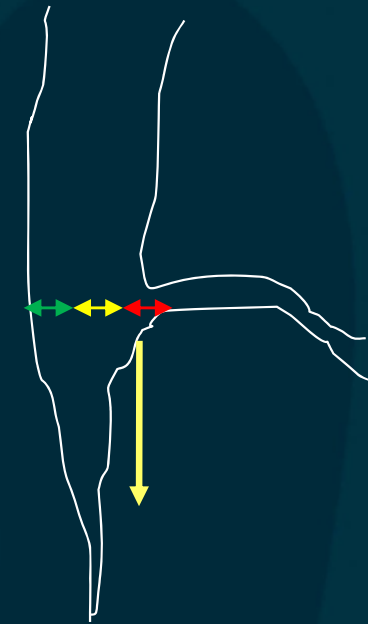
1. Tapered tip  
83.1%



2. Opposite side  
to branch  
0.4%



3. center  
8.2%

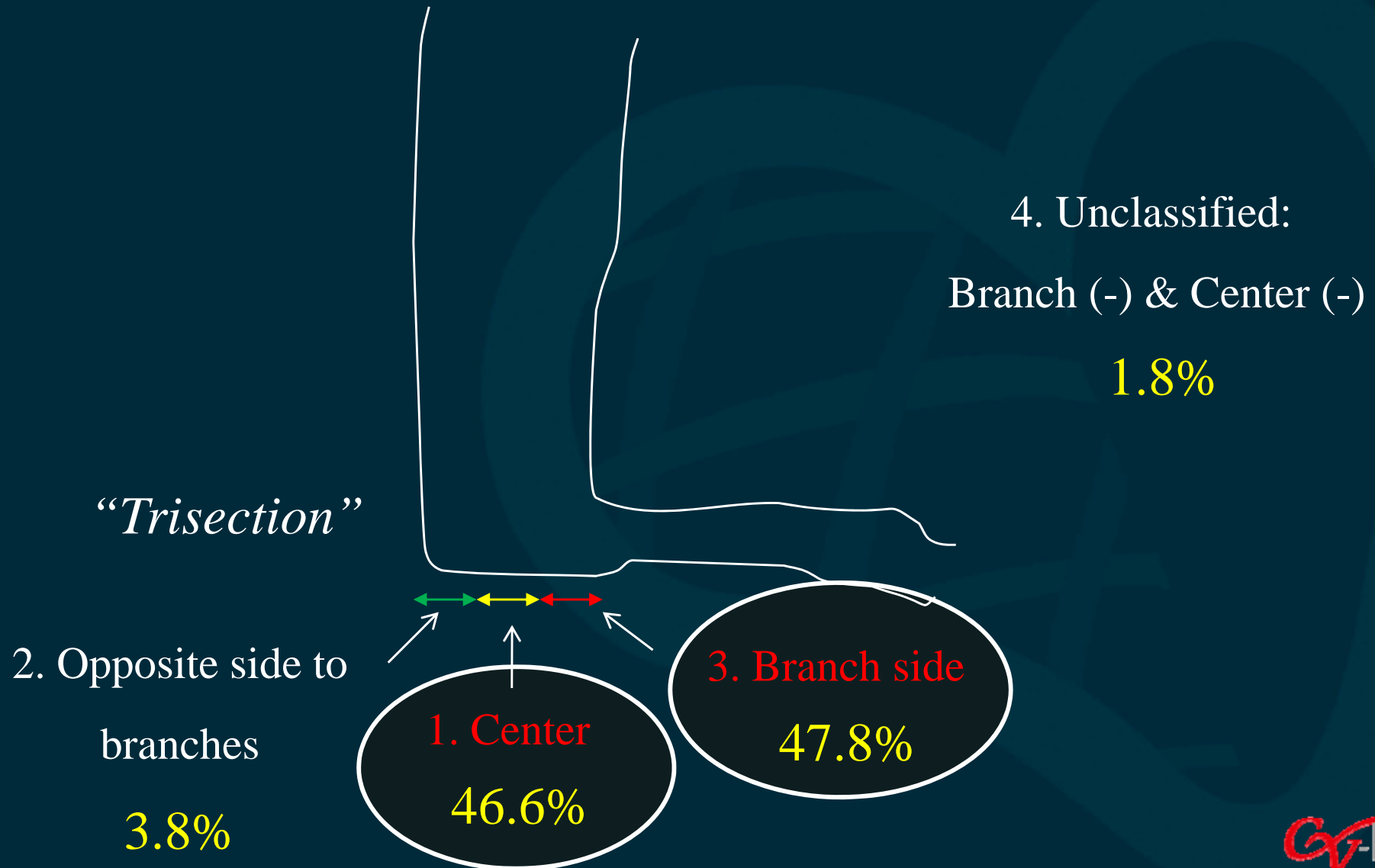


4. Branch side  
2.9%

5. Unclassified : branch (-) & taper tip (-) & center (-) 5.4%

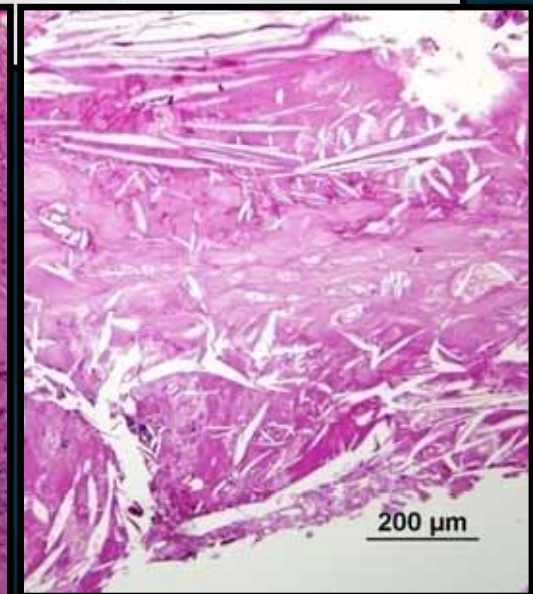
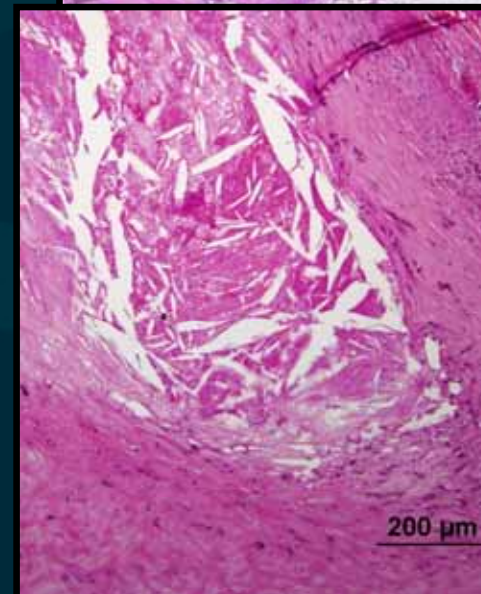
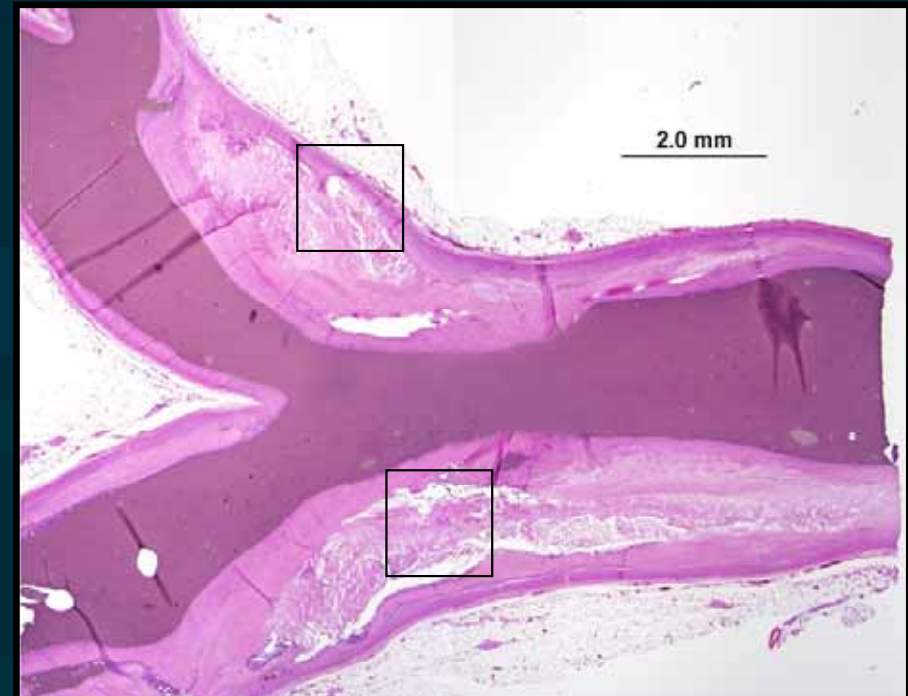
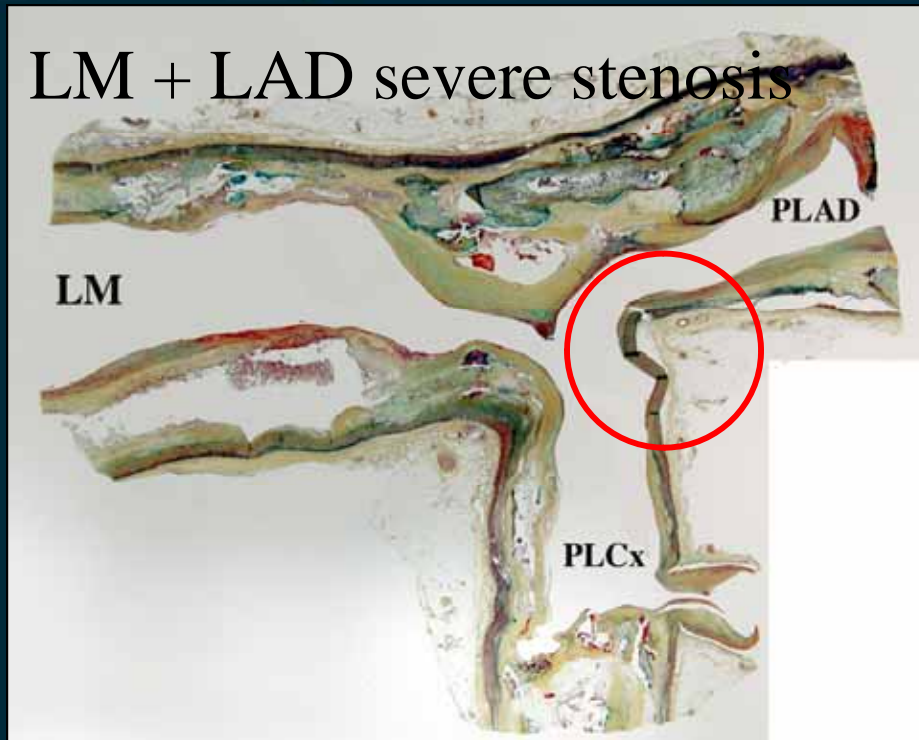
# GW position in the GW success cases (n=157)

blunt stump

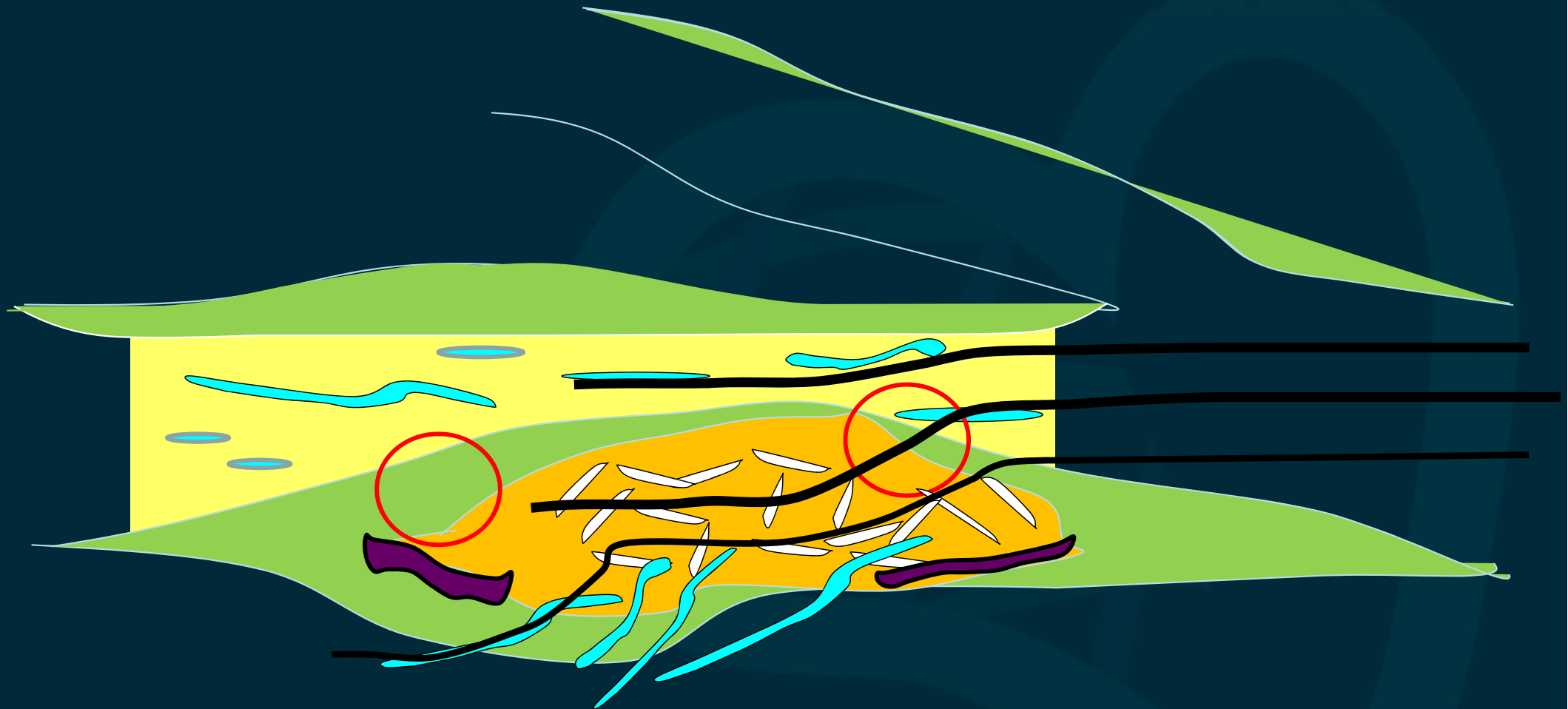




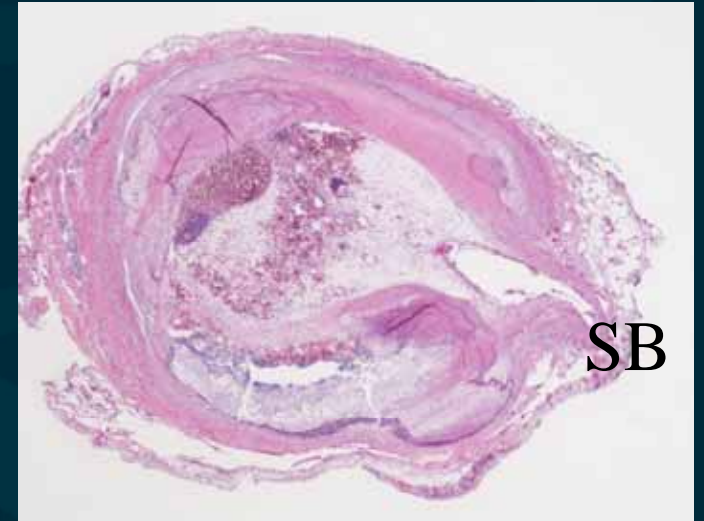
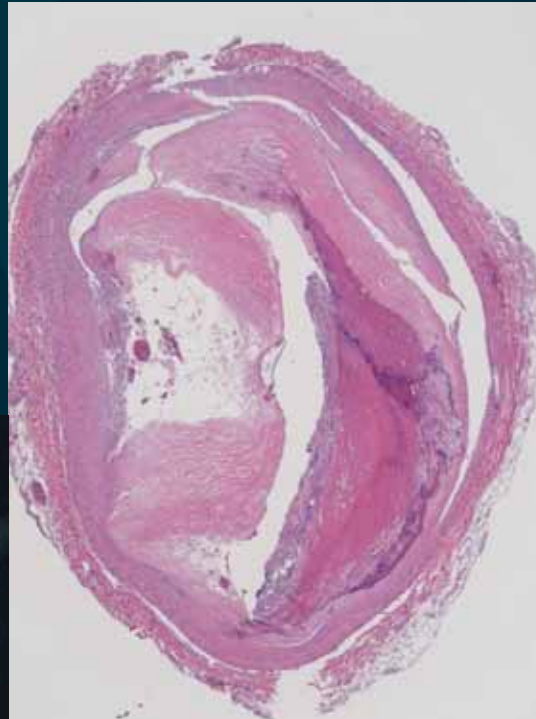
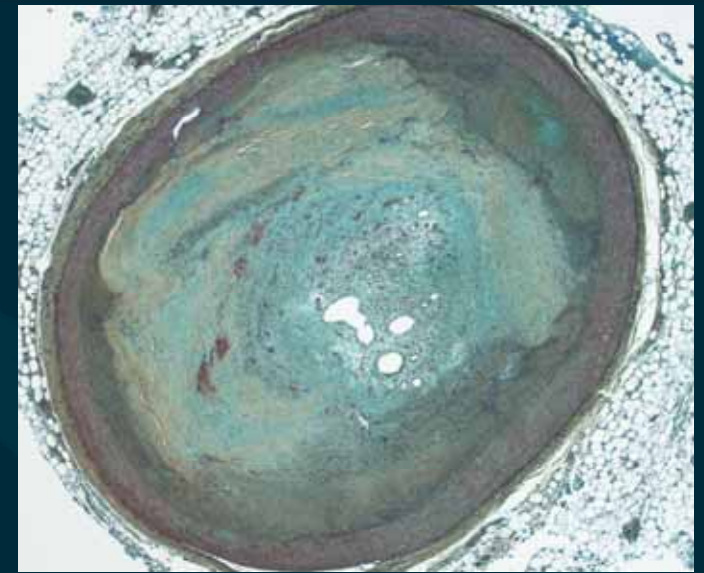
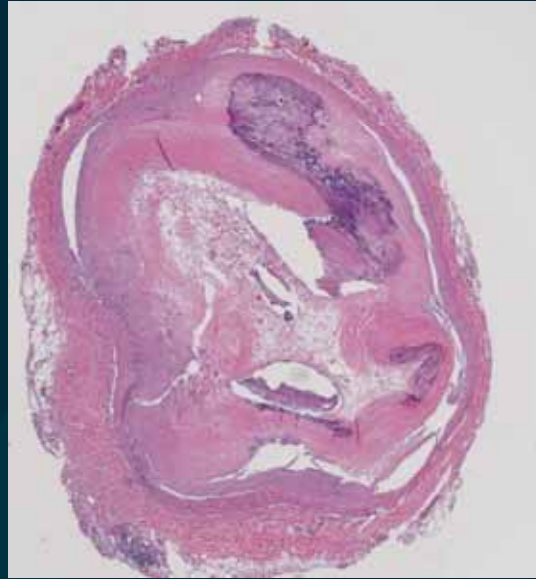
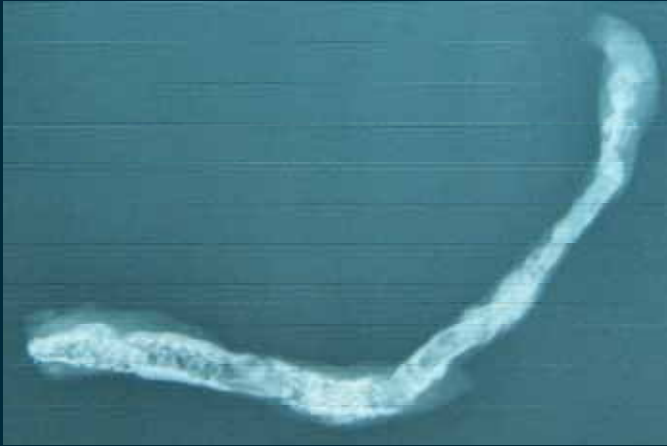
# Plaque Formation @ Bifurcation



# Strategy for PCI in CTO lesions – Consideration from the nature of CTO



# However...



# Chronic Total Occlusion

- Pathology of CTO from review of the literature
- Experience from autopsy at CVPath
- Nature of CTO lesions
- Fate of False Lumen Stenting

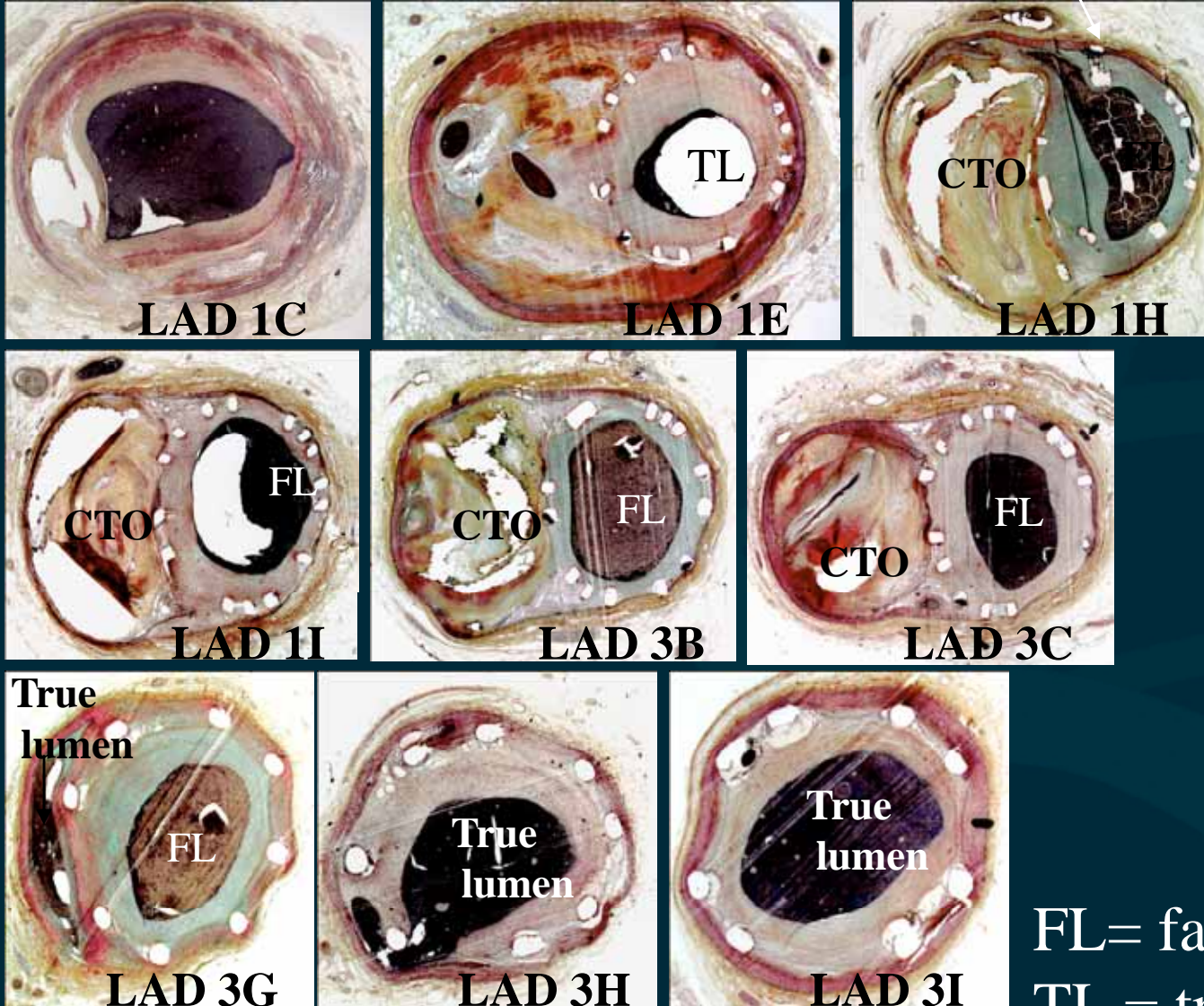
# Chronic Total Occlusion

- Pathology of CTO from review of the literature
- Experience from autopsy at CVPath
- Nature of CTO lesions
- Fate of False Lumen Stenting

# Case

- 51 year-old male found unresponsive wearing a nitroglycerin patch

Stent in false lumen



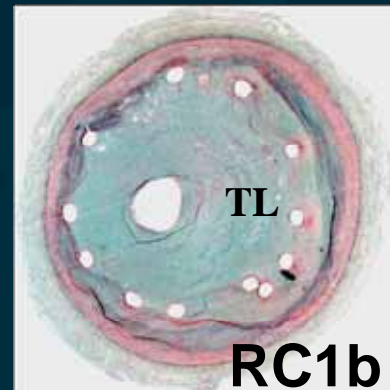
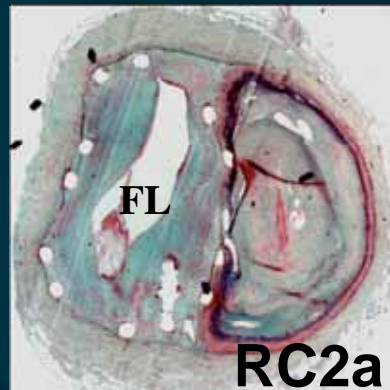
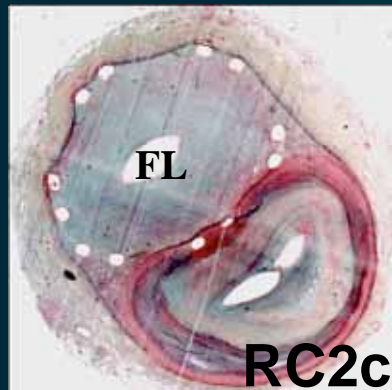
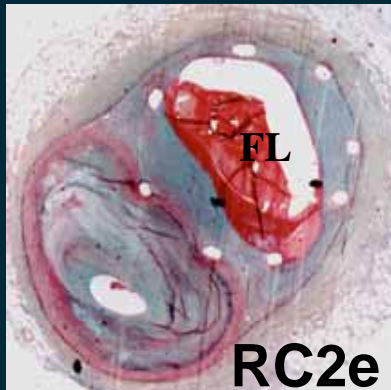
FL = false lumen;  
TL = true lumen

# Case

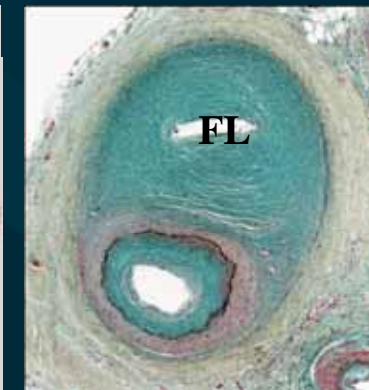
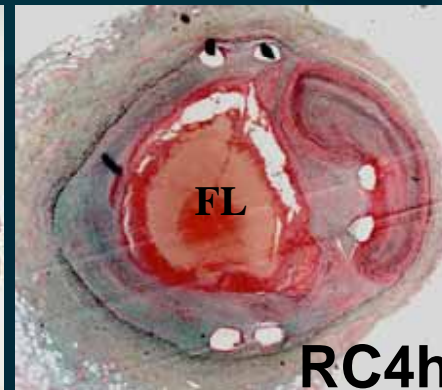
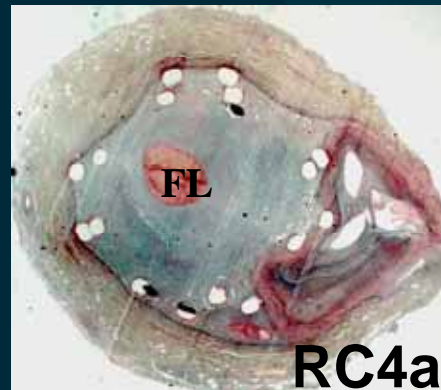
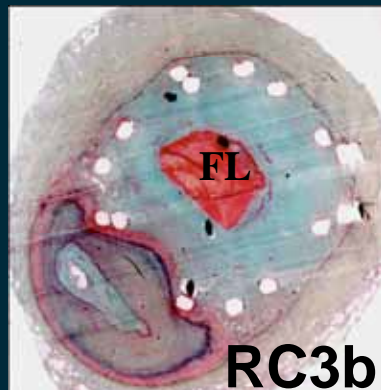
52-year-old black female with H/O systemic hypertension, DM and CAD underwent stenting of a totally occluded RCA (4 months prior to death).



Proximal



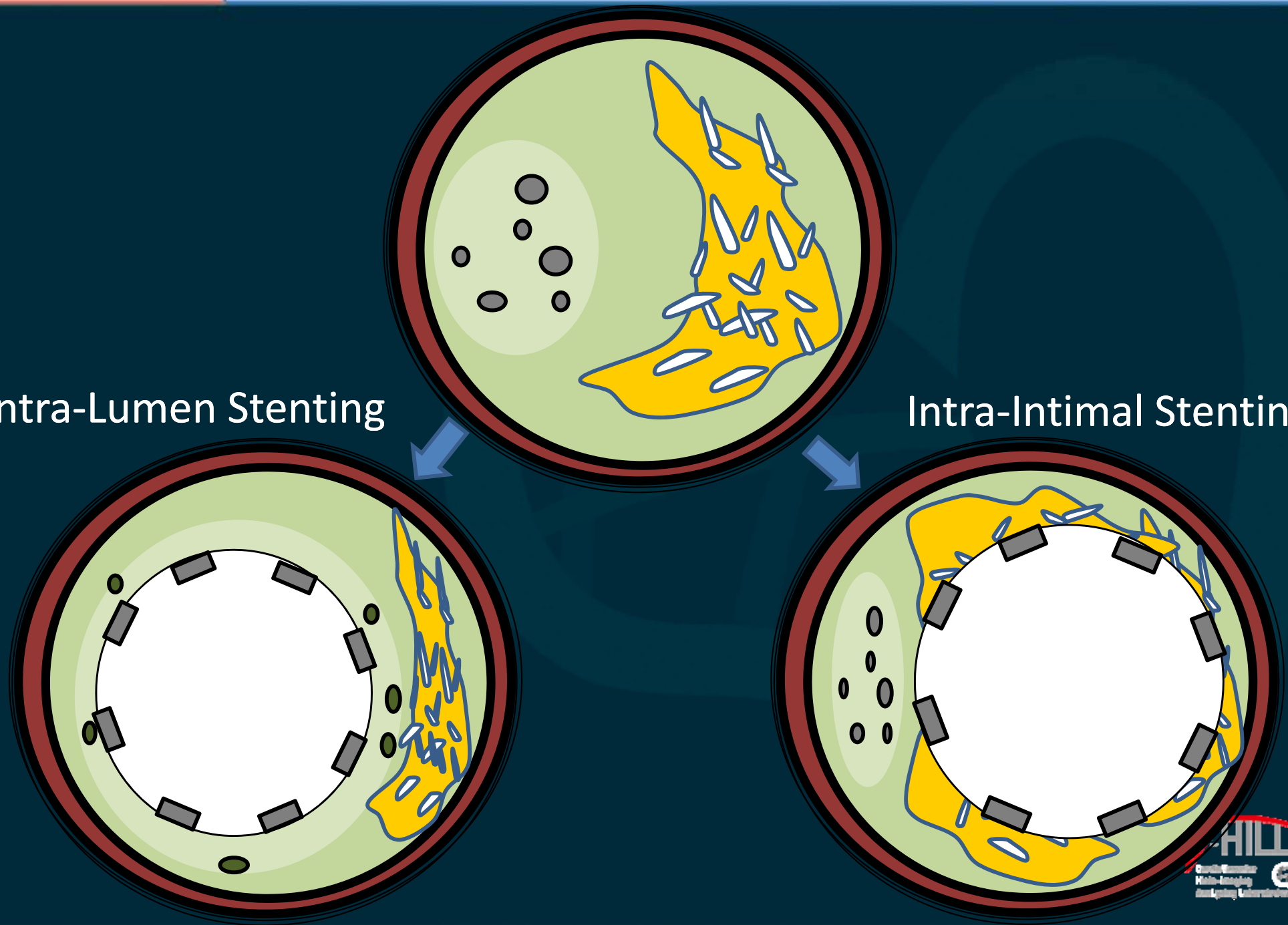
Distal



# True Lumen Stenting

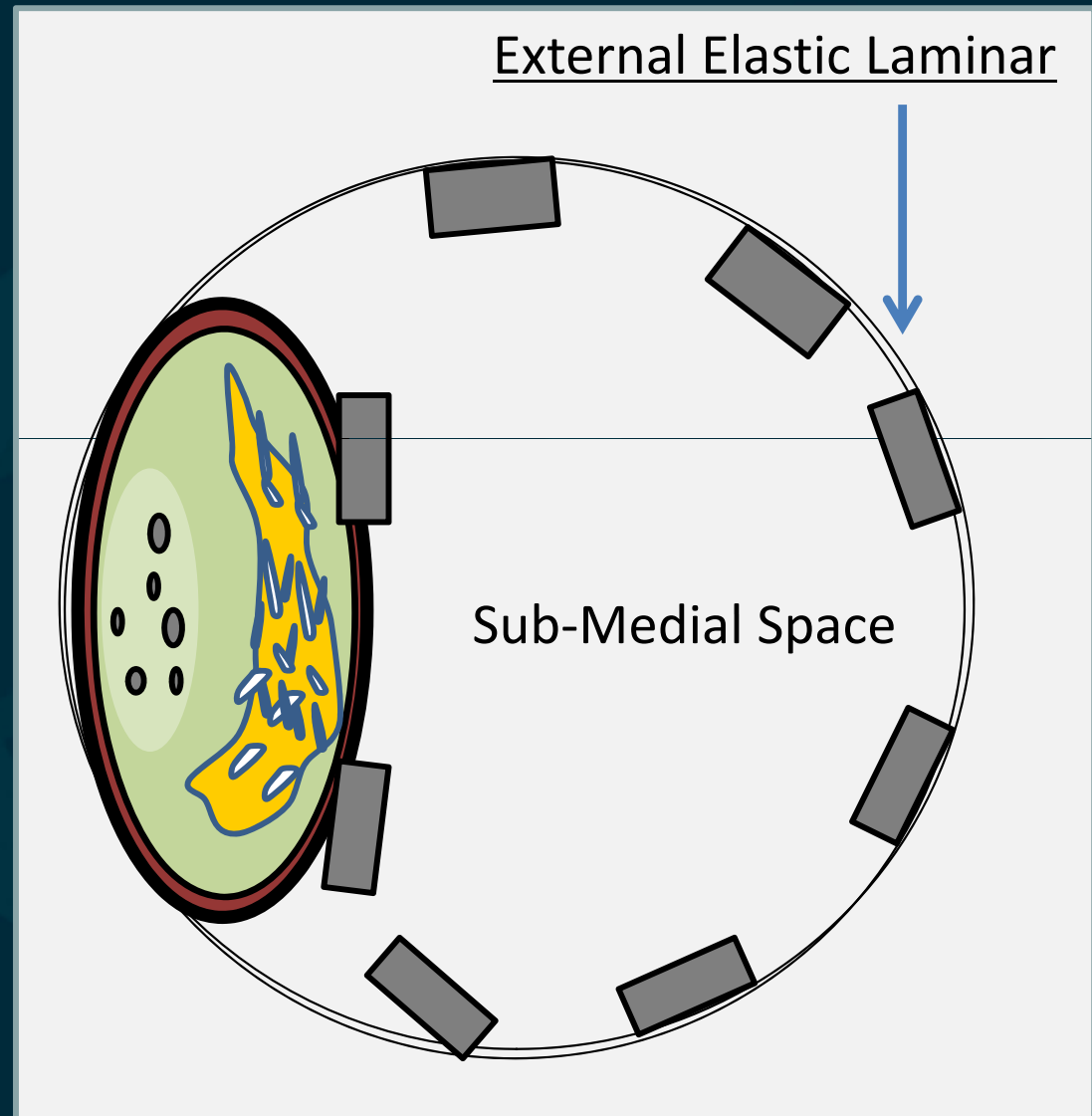
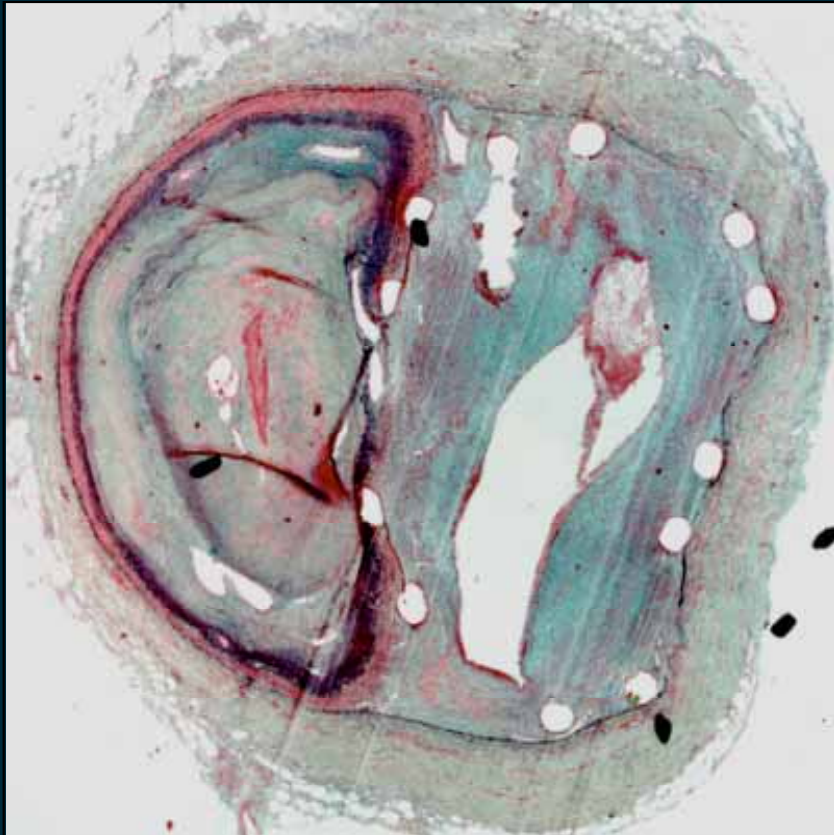
Intra-Lumen Stenting

Intra-Intimal Stenting

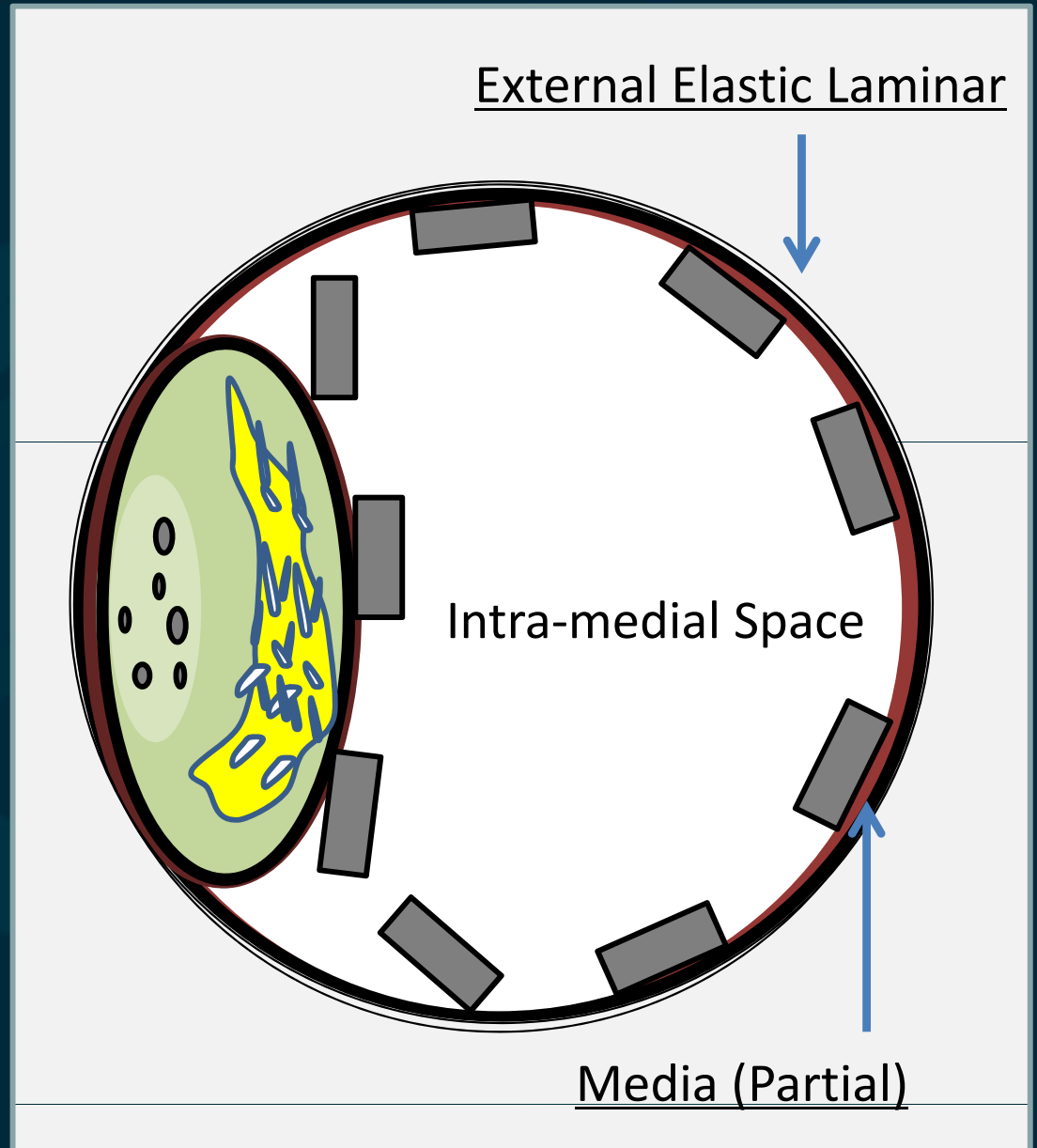
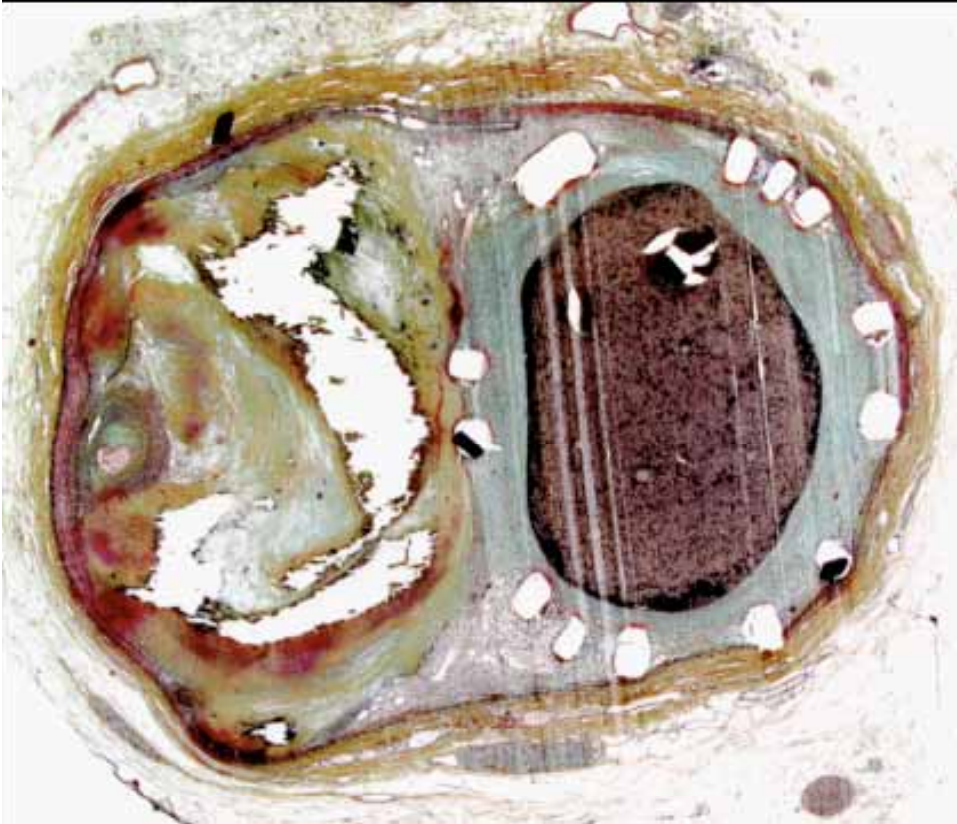




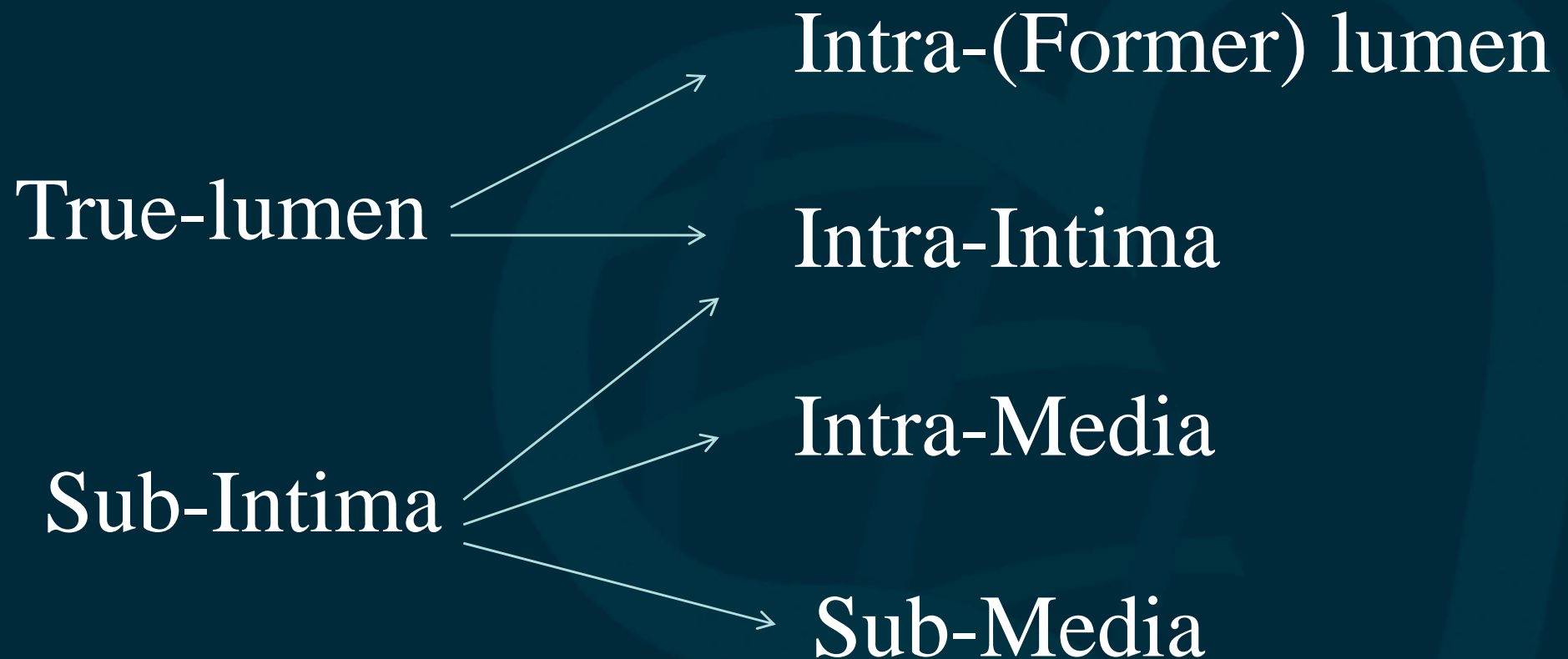
# “Sub-Medial” Stenting



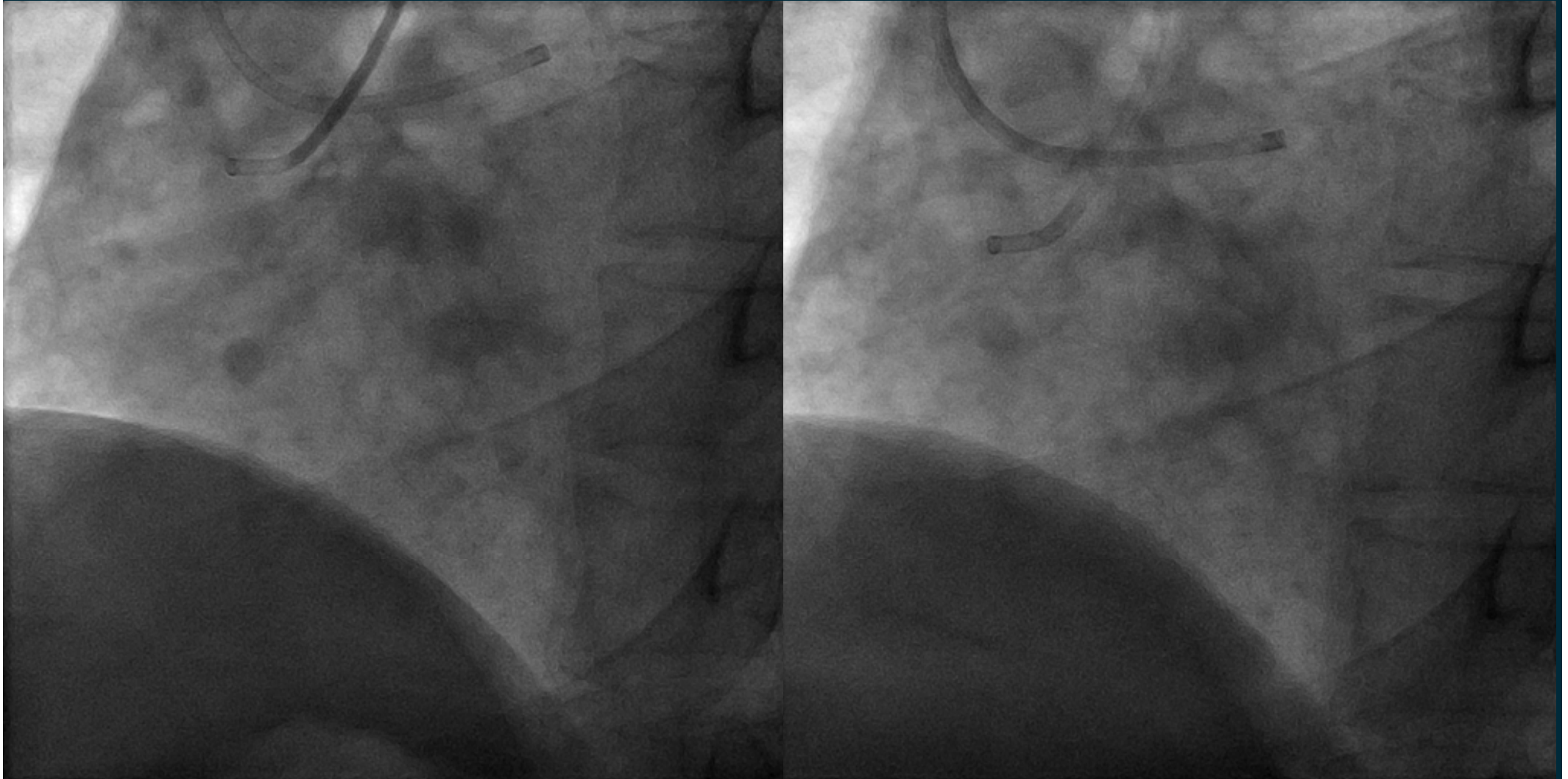
# “Sub-intimal” or “intra-medial”?? Stenting



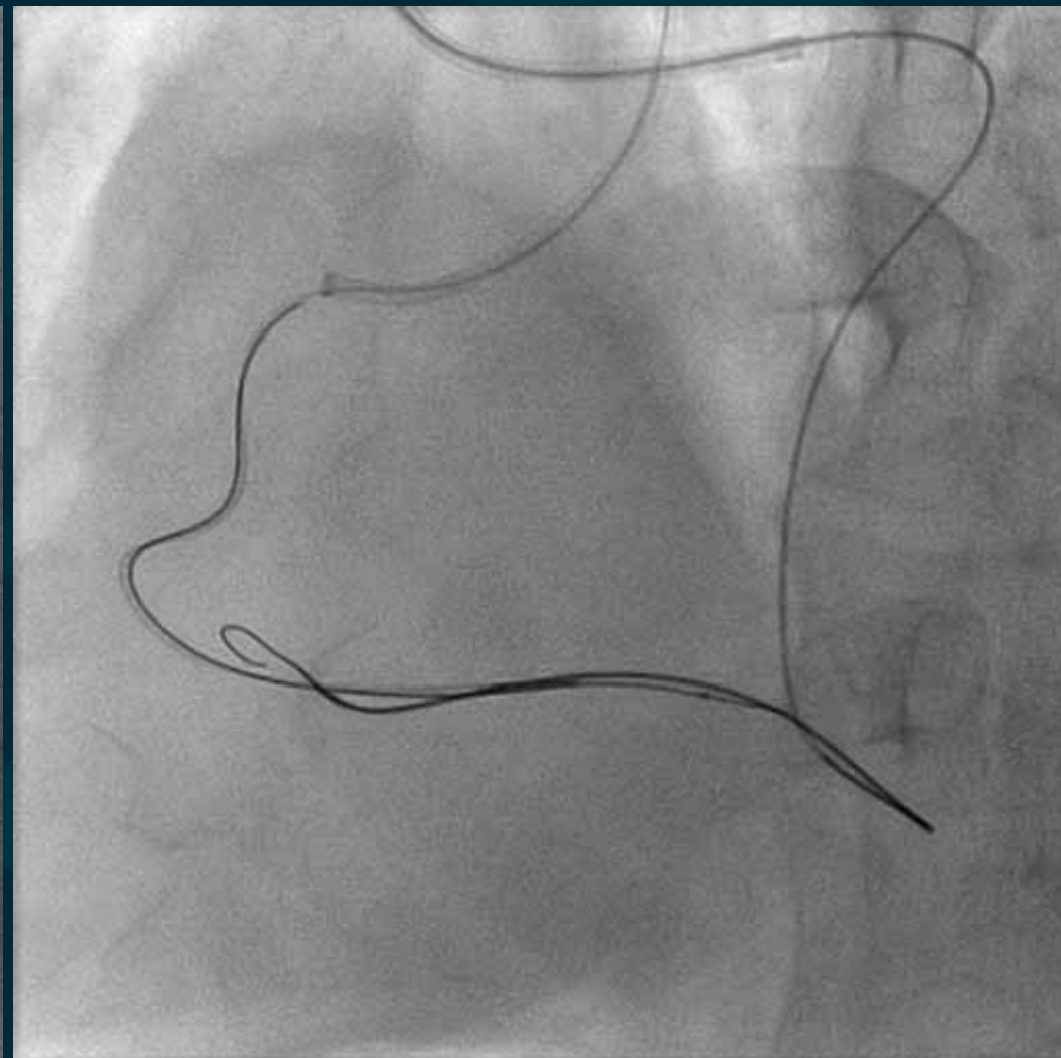
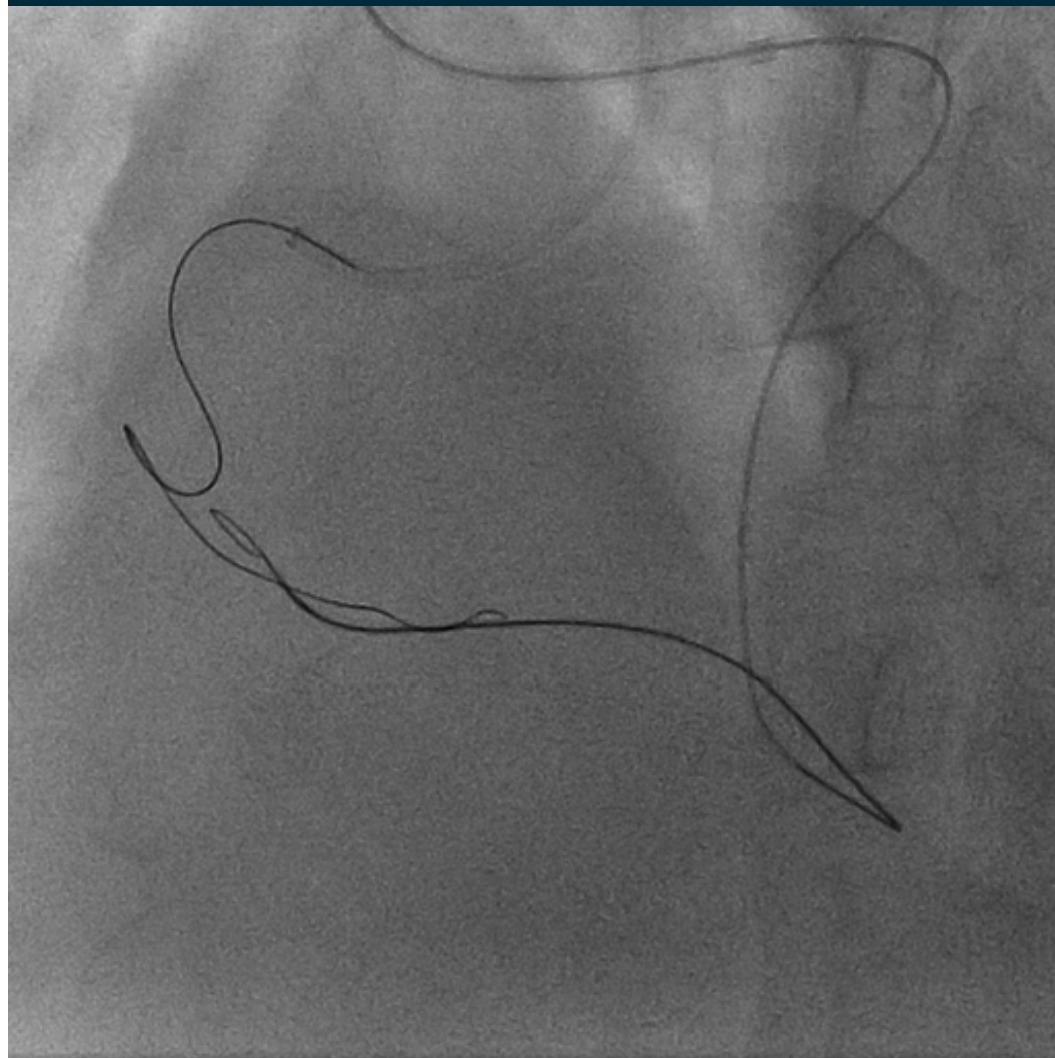
# Terminology of CTO Wiring



# A Case of CTO in RCA

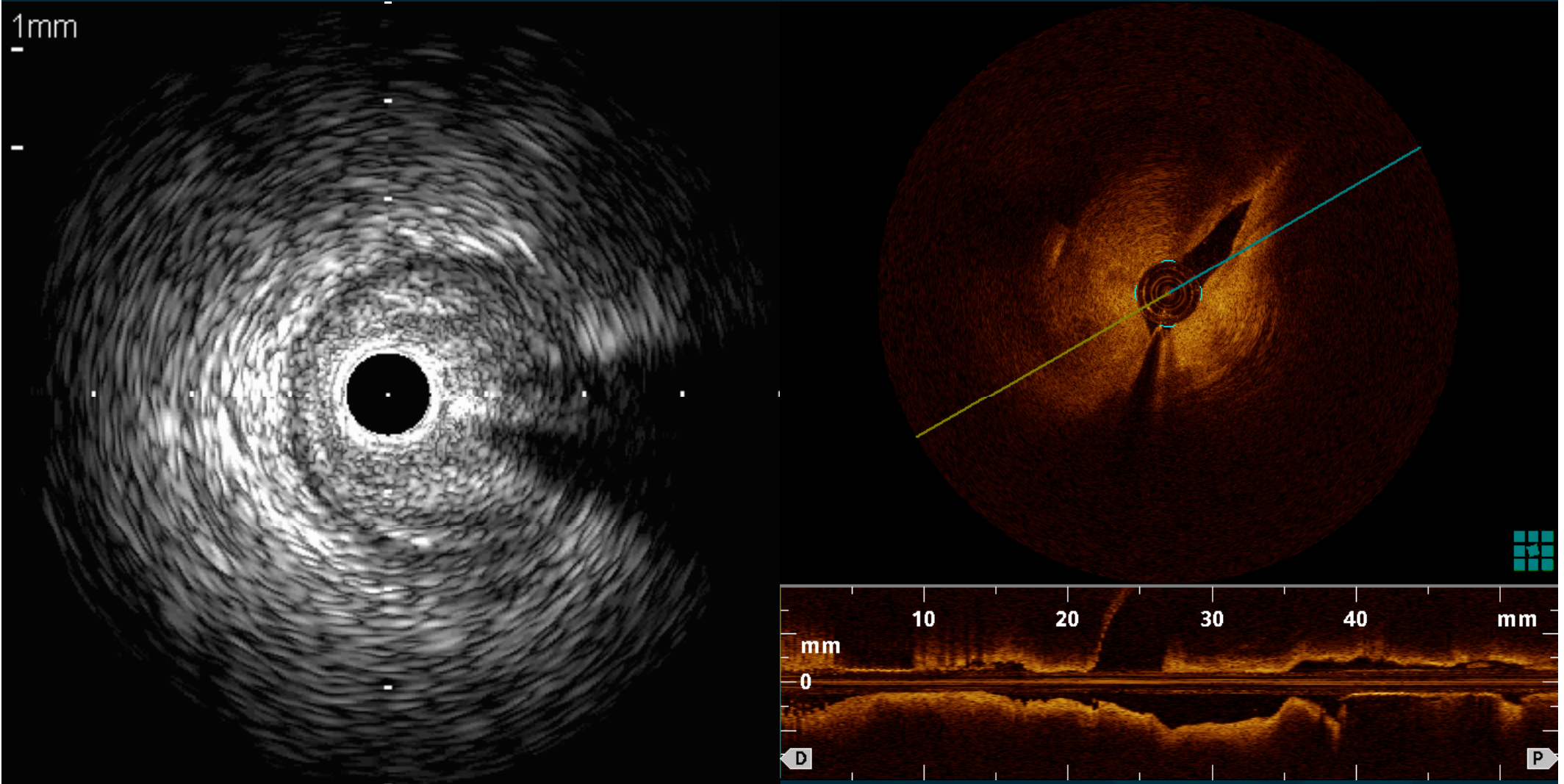


# Ante-grade Wire Cross the lesion...

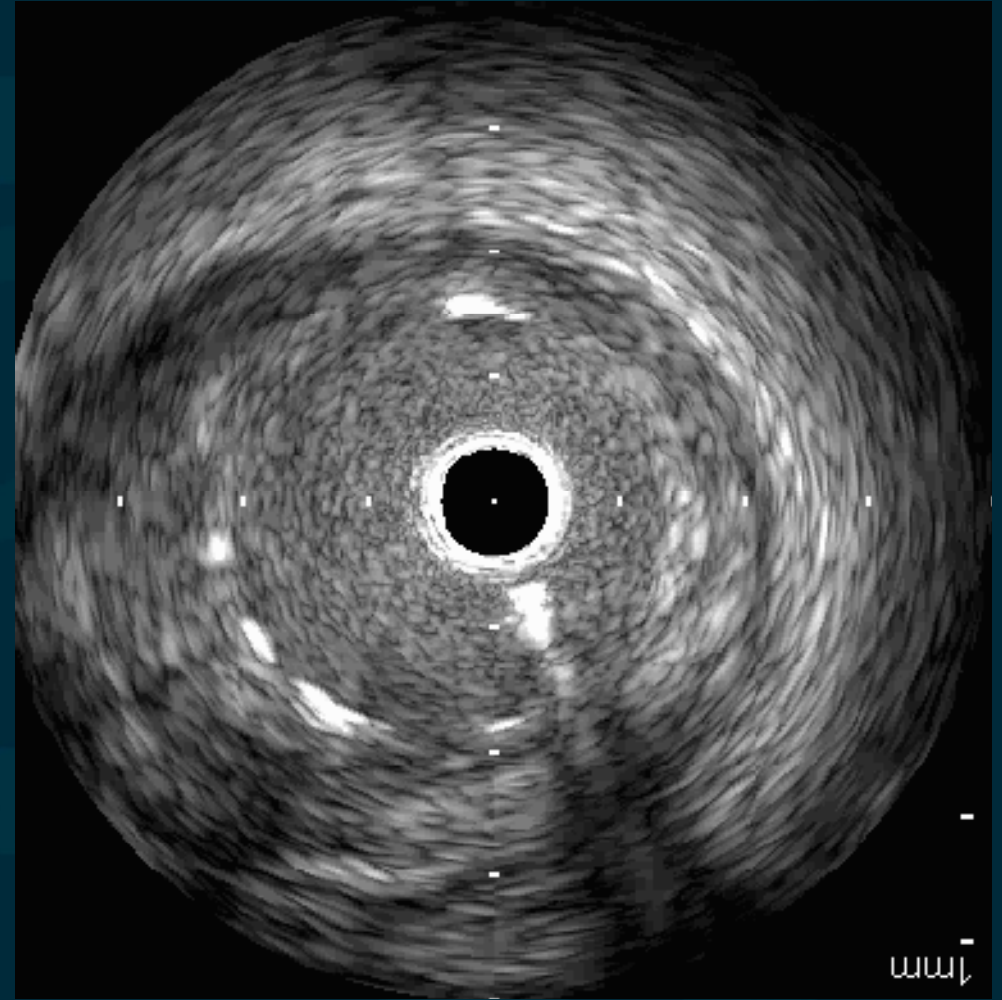
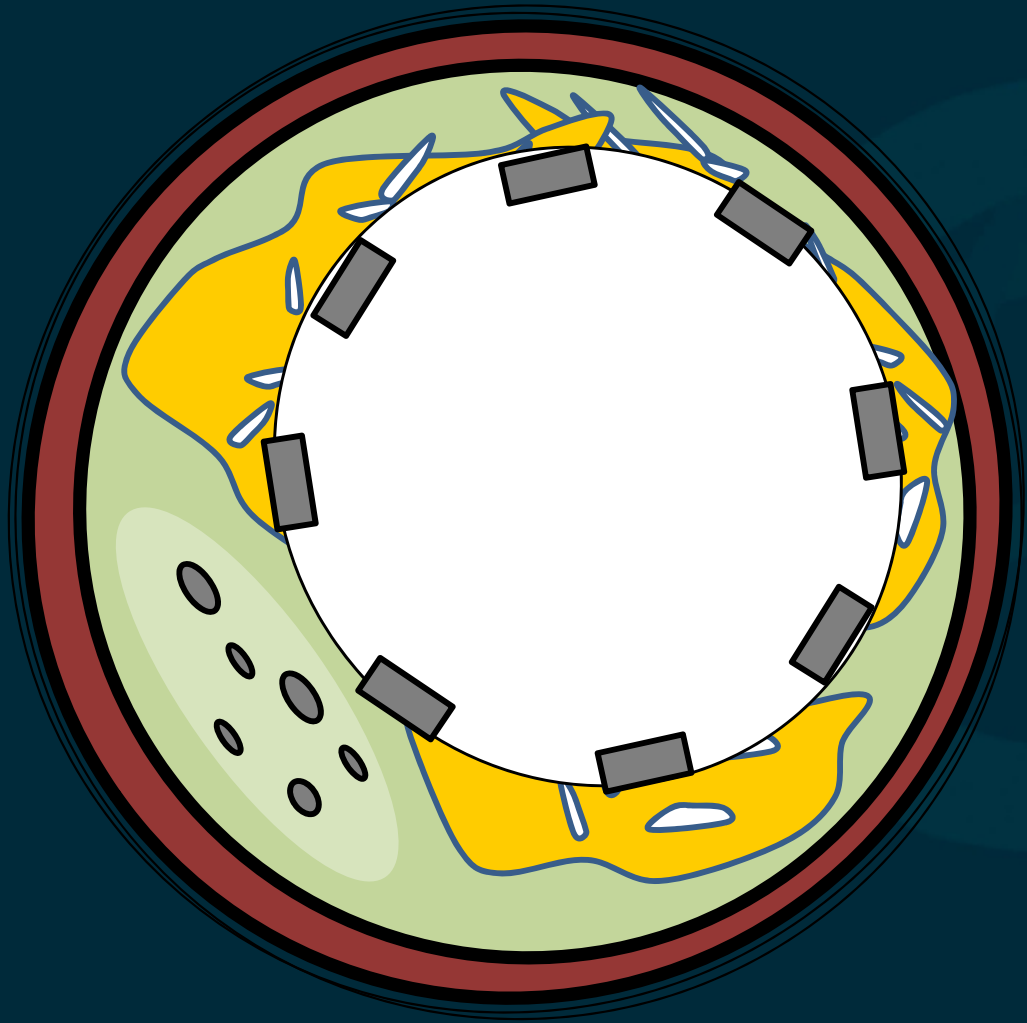


# Passing Intra-Intima...

1mm

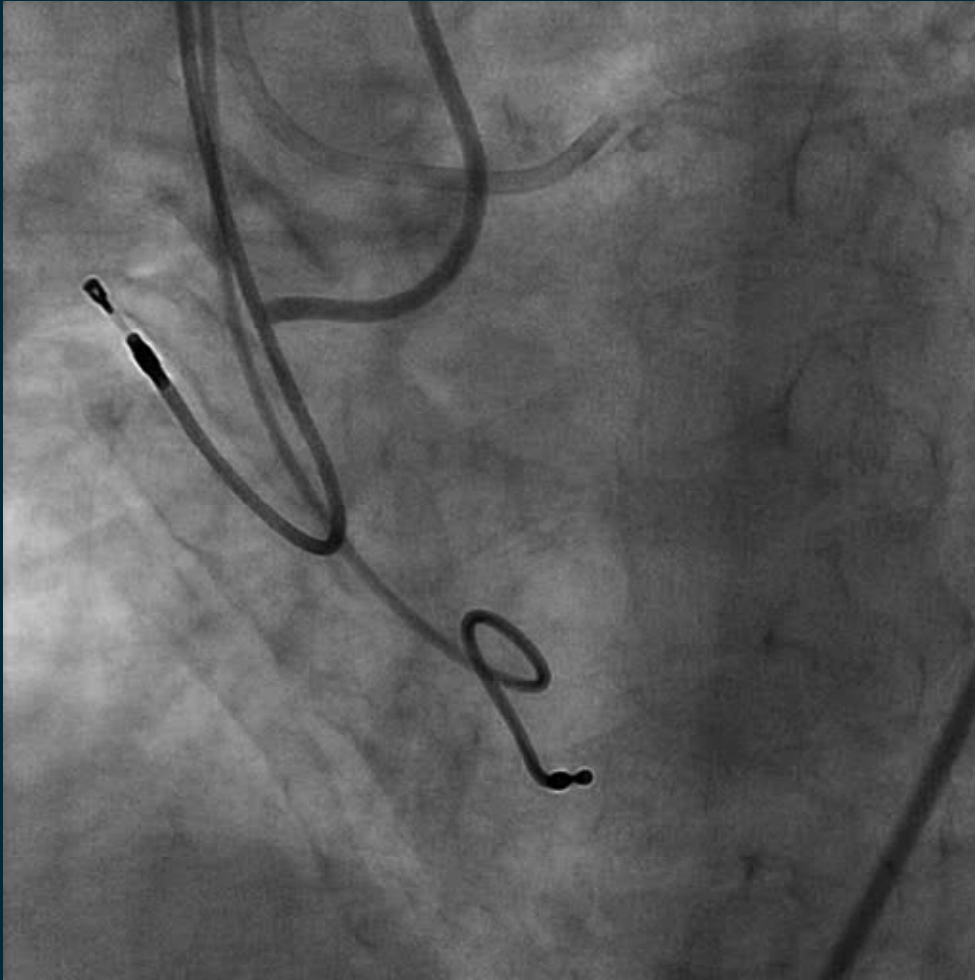


# Passing Intra-Intima...

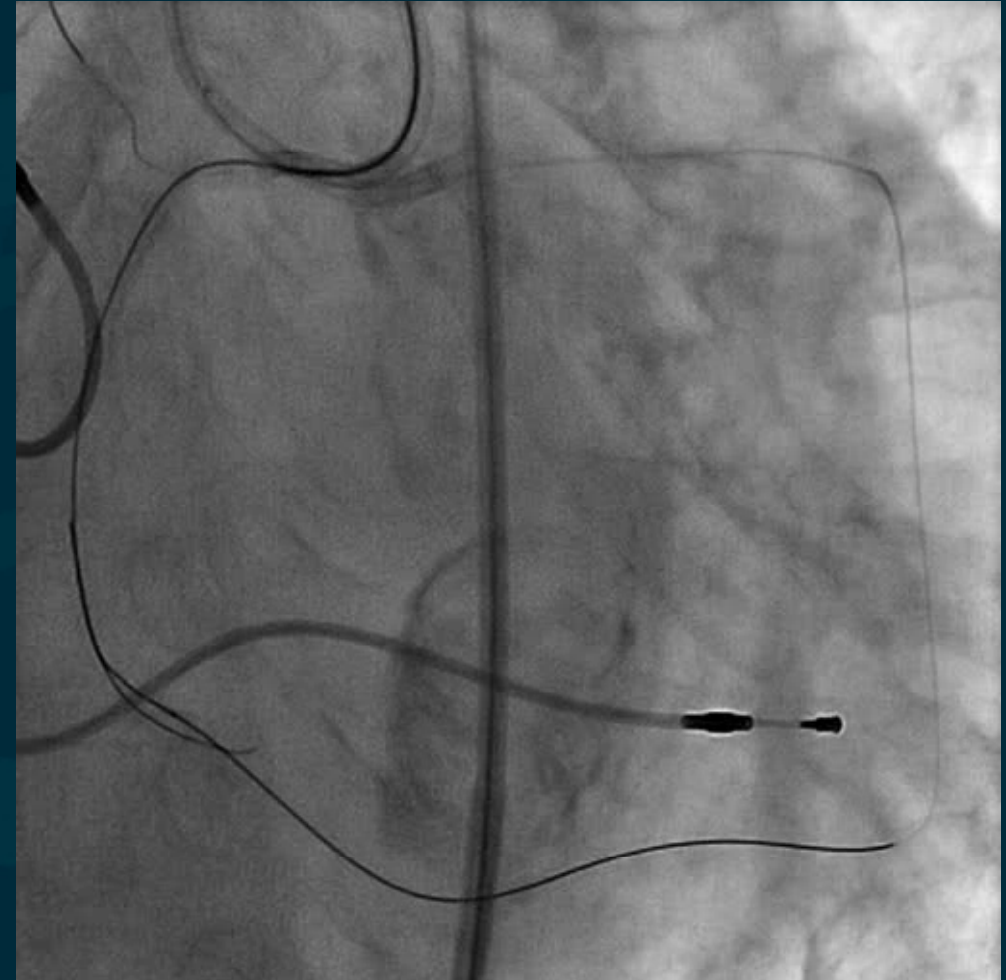


# DES implantation in Sub-Media

Baseline



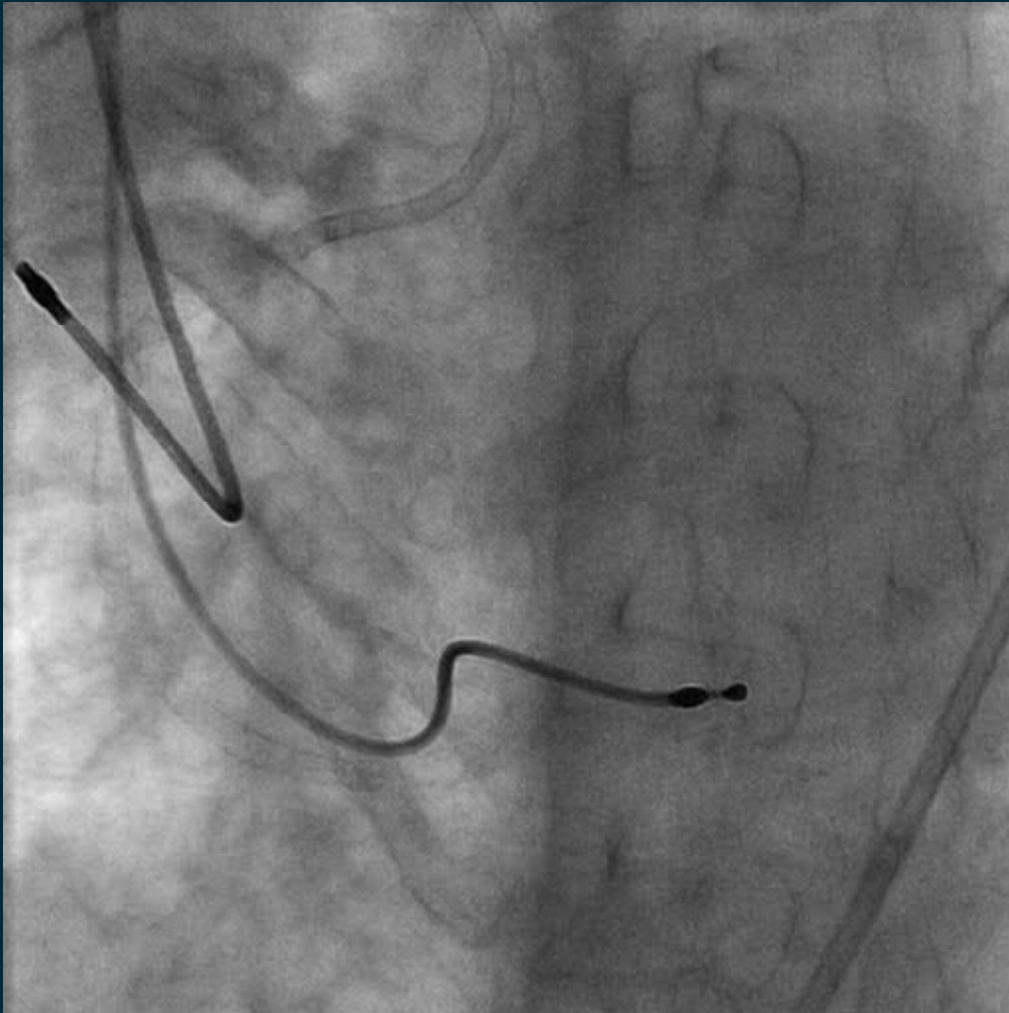
Procedure



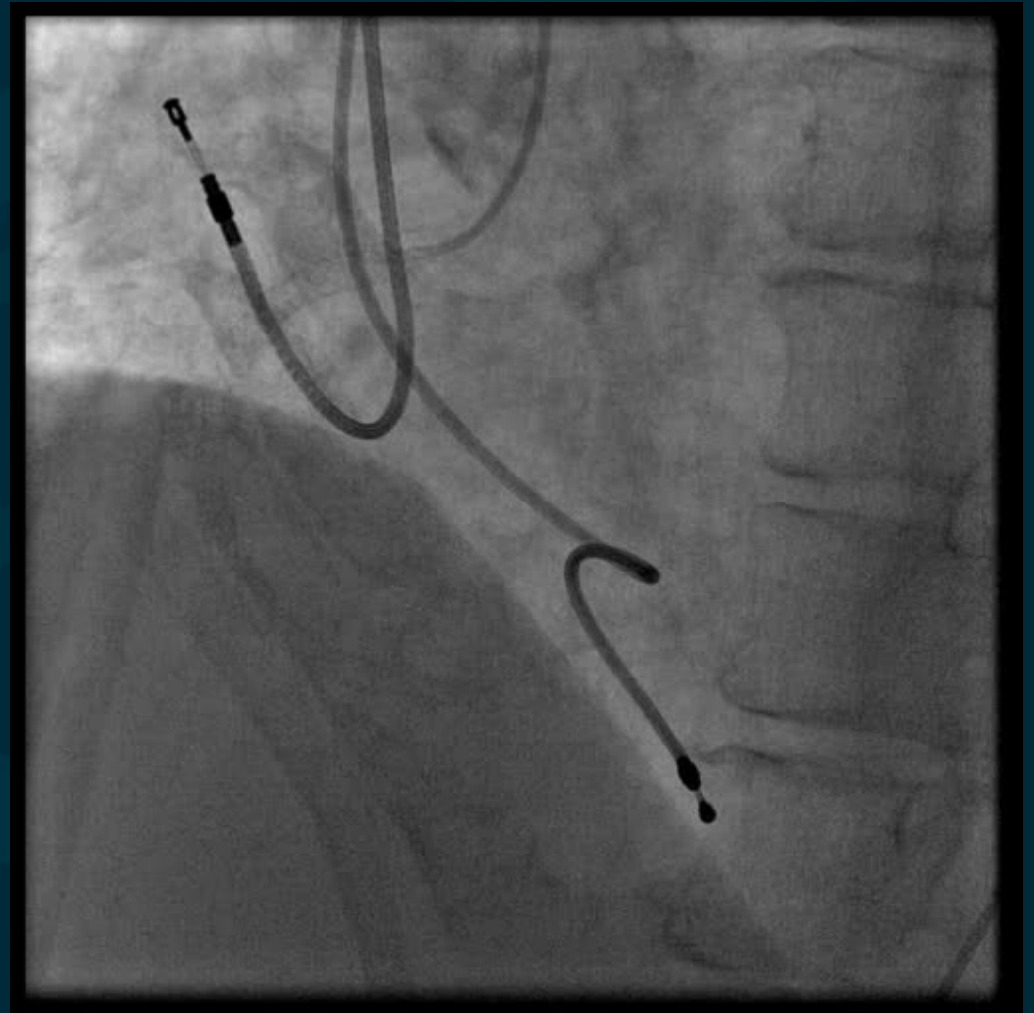


# PSS following Sub-Medial Stenting

Post



FU



Segmental - Irregular-contour\*\*\*



# Summary

- “Tapered type” show loose tissue with neocapillaries (micro-channel) at the entry point, whereas abrupt type is associated with brunch point with thick fibrous cap at the entry
- Neocapillaries (micro-channel) in former lumen area are more frequent in early CTOs (<1year) as compared to old CTO, and it is rarely connected to IP or adv NC

# Summary

- Pathologic anatomy shows that the exit of the total occlusion (distal end) is usually “tapering” and consists of looser tissue especially with the “brunt type”
- False lumen stenting... we need more data to confirm the safety of this procedure