How do I choose my Imaging modality in clinical practice?

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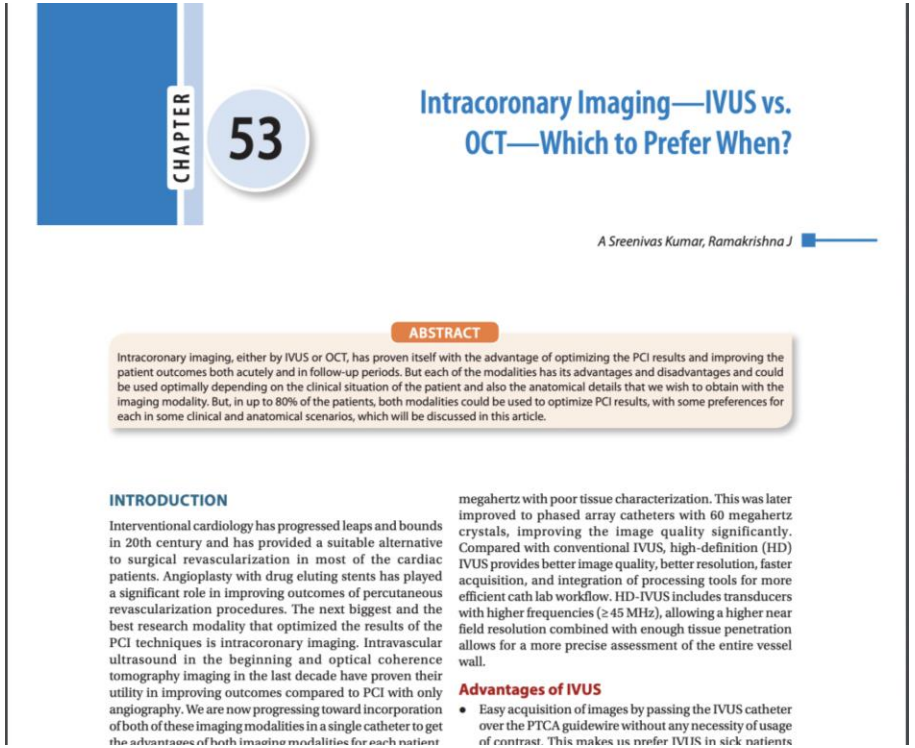
Chapter in WCC ICC update book



CHAPTER 53

Intracoronary Imaging—IVUS vs. OCT—Which to Prefer When?

A Sreenivas Kumar, Ramakrishna J

ABSTRACT

Intracoronary imaging, either by IVUS or OCT, has proven itself with the advantage of optimizing the PCI results and improving the patient outcomes both acutely and in follow-up periods. But each of the modalities has its advantages and disadvantages and could be used optimally depending on the clinical situation of the patient and also the anatomical details that we wish to obtain with the imaging modality. But, in up to 80% of the patients, both modalities could be used to optimize PCI results, with some preferences for each in some clinical and anatomical scenarios, which will be discussed in this article.

INTRODUCTION

Interventional cardiology has progressed leaps and bounds in 20th century and has provided a suitable alternative to surgical revascularization in most of the cardiac patients. Angioplasty with drug eluting stents has played a significant role in improving outcomes of percutaneous revascularization procedures. The next biggest and the best research modality that optimized the results of the PCI techniques is intracoronary imaging. Intravascular ultrasound in the beginning and optical coherence tomography imaging in the last decade have proven their utility in improving outcomes compared to PCI with only angiography. We are now progressing toward incorporation of both of these imaging modalities in a single catheter to get the advantages of both imaging modalities for each patient

megahertz with poor tissue characterization. This was later improved to phased array catheters with 60 megahertz crystals, improving the image quality significantly. Compared with conventional IVUS, high-definition (HD) IVUS provides better image quality, better resolution, faster acquisition, and integration of processing tools for more efficient cath lab workflow. HD-IVUS includes transducers with higher frequencies (≥ 45 MHz), allowing a higher near field resolution combined with enough tissue penetration allows for a more precise assessment of the entire vessel wall.

Advantages of IVUS

- Easy acquisition of images by passing the IVUS catheter over the PTCA guidewire without any necessity of usage of contrast. This makes us prefer IVUS in sick patients

Intravascular Imaging Guidance for PCI:

A "Real-Time" Updated Network Meta-analysis

Gregg W. Stone MD

Ilumien 4, octivus, October, Renovate complex pci trials

Summary of Included Studies

20 randomized trials

(publication years 2010 – 2023)

12,428 randomized patients

(range 85 – 2487 pts per trial)

IVUS: 13 randomized arms, 3120 pts

OCT: 10 randomized arms, 2826 pts

OCT or IVUS: 1 randomized arm, 1092 pts

Angiography: 18 randomized arms, 5390 pts

ongest FU: Range 6 – 60 months (weighted mean 26.4 mo)

Conclusions

The present network meta-analysis from 20 RCTs in 12,428 pts with follow-up ranging from 6-60 months demonstrates that:

- Compared with angiography-guided PCI, IVI-guided PCI with OCT or IVUS reduces **TLF by** 31% , driven by 46%, 20%, and 29% reductions in cardiac death, TV-MI, and TLR respectively
- IVI-guided PCI also reduces **stent thrombosis by** 52% , all MI by 18%, and **all-cause death by** 25%

Decision making - Indications for ICI.

- Diagnostic – Lesion severity assessment – LAD/ LM – focal eccentric lesions – area assessment /ostial lesion assessment.

  - Morphology assessment - ?thrombus ? Calcium

  - Branch vessel/Bifurcation assessment

- Therapeutic – Precision PCI , Stent Optimisation (must in LM)

  - prov/ 2nd stent implantation

  - complication assessment esp.- edge dissection/under-expansion./malapposition/ Final area measurement .

- ISR/SAT/ Strut endotheliasation – assessment.

Comparison of Newer Imaging Modalities

	Grey Scale IVUS	VH	OCT	NIR Spectroscopy	Angioscopy
Axial Resolution (μm)	100	200	20	NA	10-50
PCI	++	+/-	+	-	+/-
TCFA	+/-	+	++	+/-	+
Necrotic Core	+/-	+	+	++	+
Thrombus	+/-	-	++	+/-	++
Stent Coverage	+	+	++	-	++

Contemporary CathLab…

IVUS AND OCT ARE COMPLEMENTARY

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Application of OCT vs IVUS in ISR

+++ Excellent
++ Good
+ Poor
- Not advised

	IVUS	OCT
Assessing lesion severity in LM disease	+++	+
Assessing de novo lesion characteristics		
• Thin-cap fibroatheroma	-	+++
• Thrombus	+	+++
• Plaque rupture	++	+++
• Calcified nodule	+	+++
• Dissection	++	+++
• Positive remodeling	+++	+
• Plaque burden	+++	+
• Aorto-ostial disease	+++	-
Stent optimization		
• Expansion	++	+++
• Apposition	++	+++
Stent failure		
• Neointimal hyperplasia	+	++
• Under expansion	++	+++
• Malapposition	++	+++
Renal impairment	+++	+

Pragmatic Trial Design

Optical **C**oherence **T**omography–guided versus **I**ntra**V**ascular **U**ltra**S**ound–guided percutaneous coronary intervention (ESC Aug 2023/Circ.8/2023

OCTIVUS Trial

2,000 patients with obstructive CAD undergoing PCI in routine PCI clinical practice

A permuted block size of 4 or 6, stratified randomization by (1) trial center

OCT-guided PCI strategy (N=1,000)

IVUS-guided PCI strategy (N=1,000)

The composite primary end point (target-vessel failure) was cardiac death, target-vessel myocardial infarction, or ischemia-driven target vessel revascularization at 1-year

Result - No difference

Kang DY, Park DW et al. *Am Heart J* 2020;228:72-80

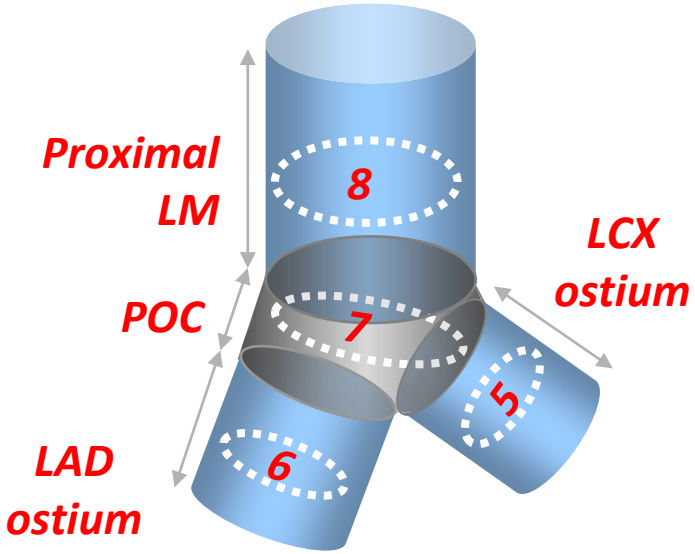
IVUS Advantages

- Easy acquisition of images - prefer IVUS in sick patients with LV dysfunction and in CKD patients.
- Image acquisition from point of start off the catheter to the point of entry into the guide catheter so that the imaging of Ostial lesions is also possible with I VUS catheter.
- The higher penetration of IVUS gives info reg. arterial wall up to media and adventitia/ correct Media to media diameter and correct area calculations.
- IVUS can visualize the external elastic lamina due to depth penetration , and quantify the plaque burden, an important predictor of clinical outcome.

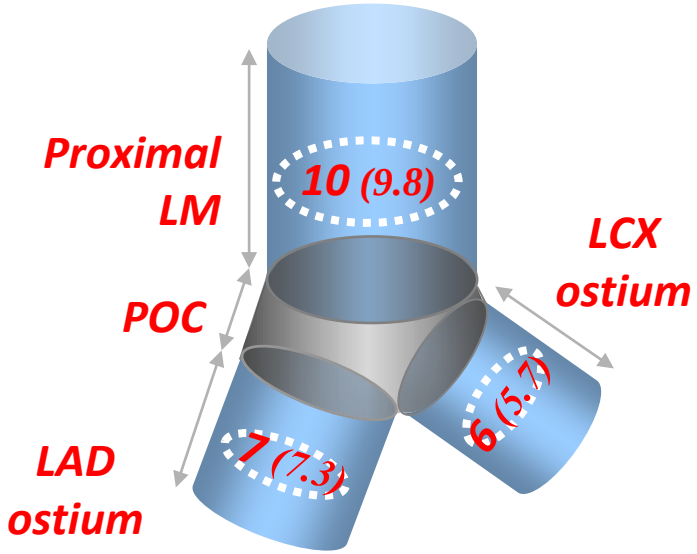
EXCEL: IVUS Substudy

Minimum Achievement Criteria of MSA

(Small person) Criteria



Caucasian (Large person) Criteria



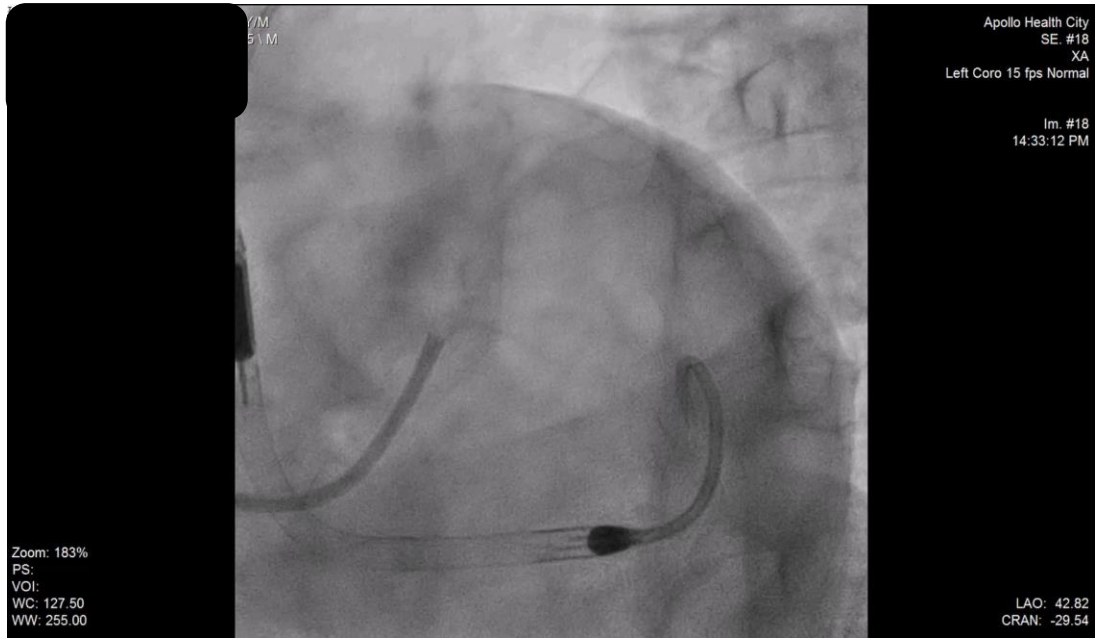
IVUS Disadvantages

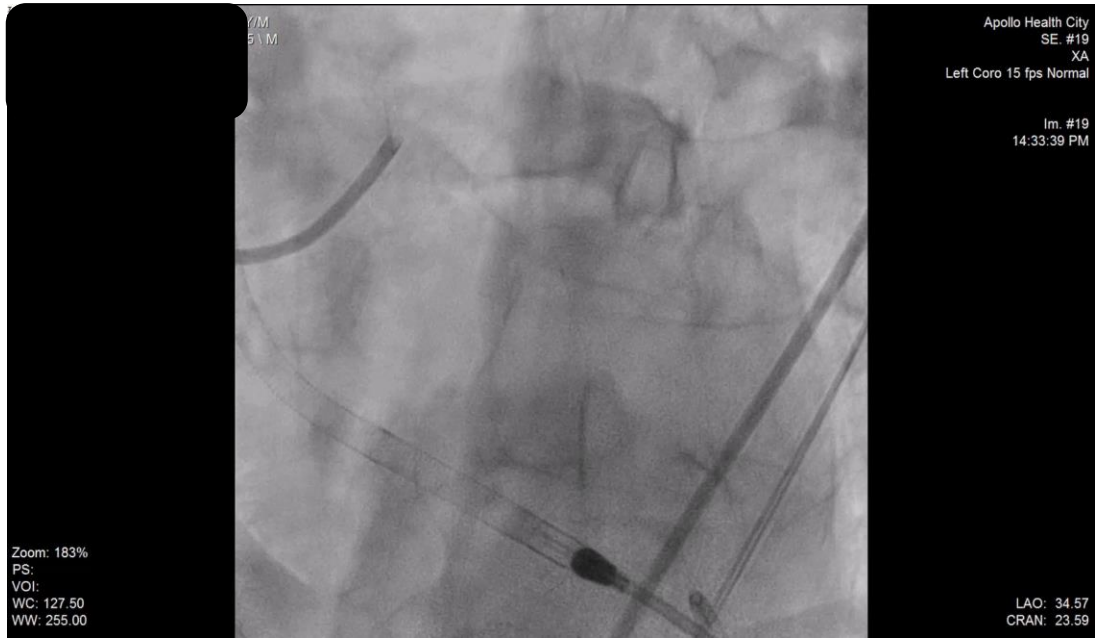
- The lower resolution makes it difficult to interpret the features like minor dissections and mall oppositions of the stent.
- The bright signal reflection from metal struts of the stents limits the ability to study the vessel wall adjacent to the stent struts .
- Ultrasound beam cannot cross the calcific structures so that the depth assessment and thickness assessment of calcium is difficult and the morphology behind the calcium also cannot be assessed by IVUS.
- Though image acquisition is easy but longer learning curve .

IVUS Preferable -

- Sick patients with severe LV dysfunction
- CKD patients with increased serum creatinine levels.
- Left main Ostial disease.
- Zero contrast or low contrast PCI
- Chronic total occlusions IVUS is preferred over OCT for real time guidance.
- Ectatic ,aneurysmal segments imaging.

LM ostial Disease



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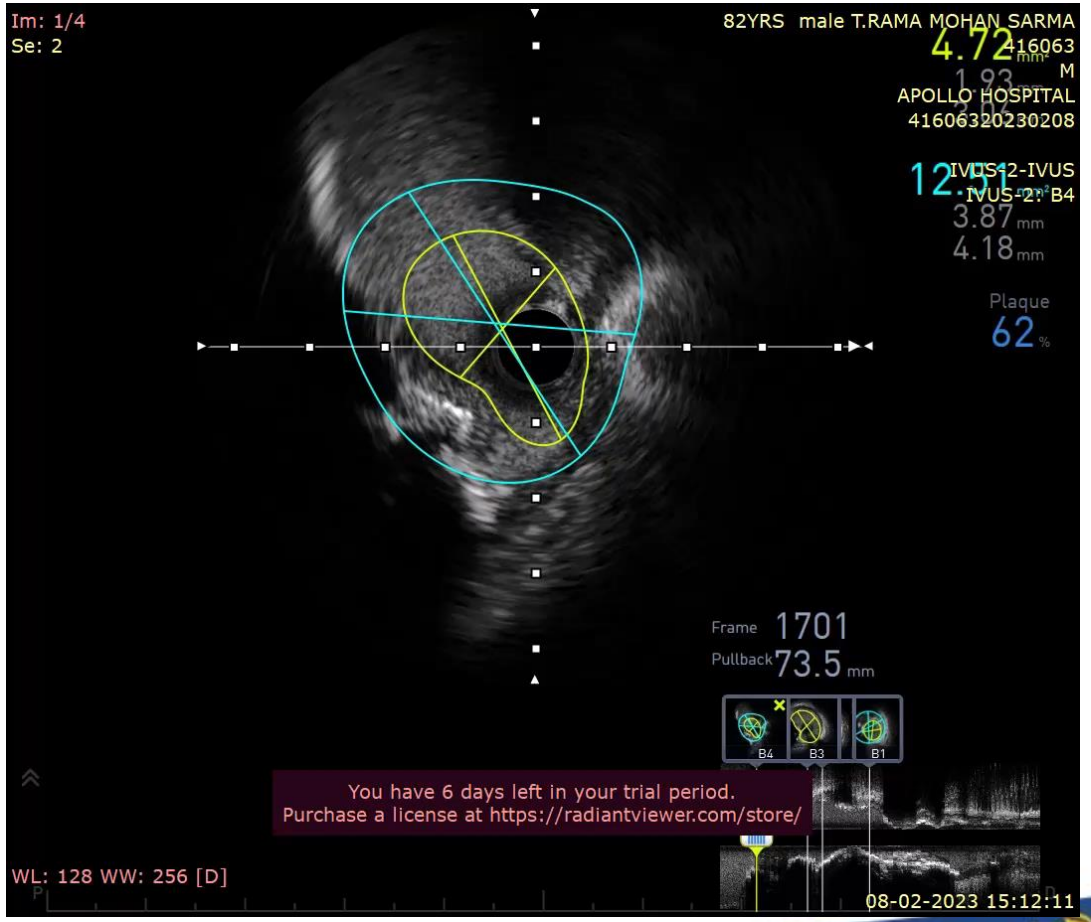
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IVUS-2: B4
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4.18 mm
Plaque
62 %
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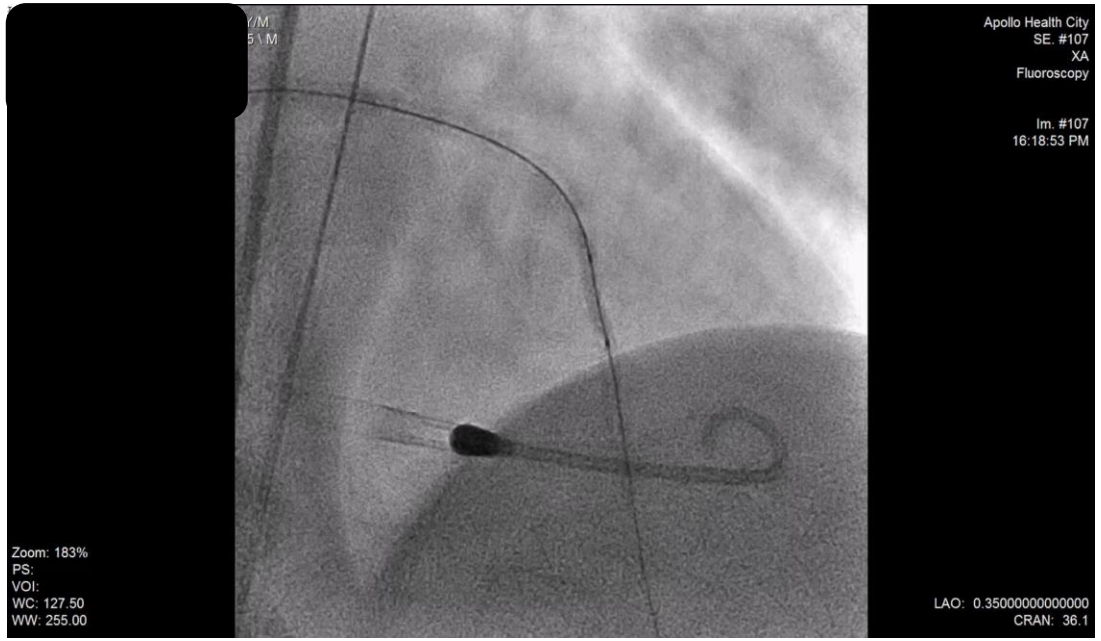
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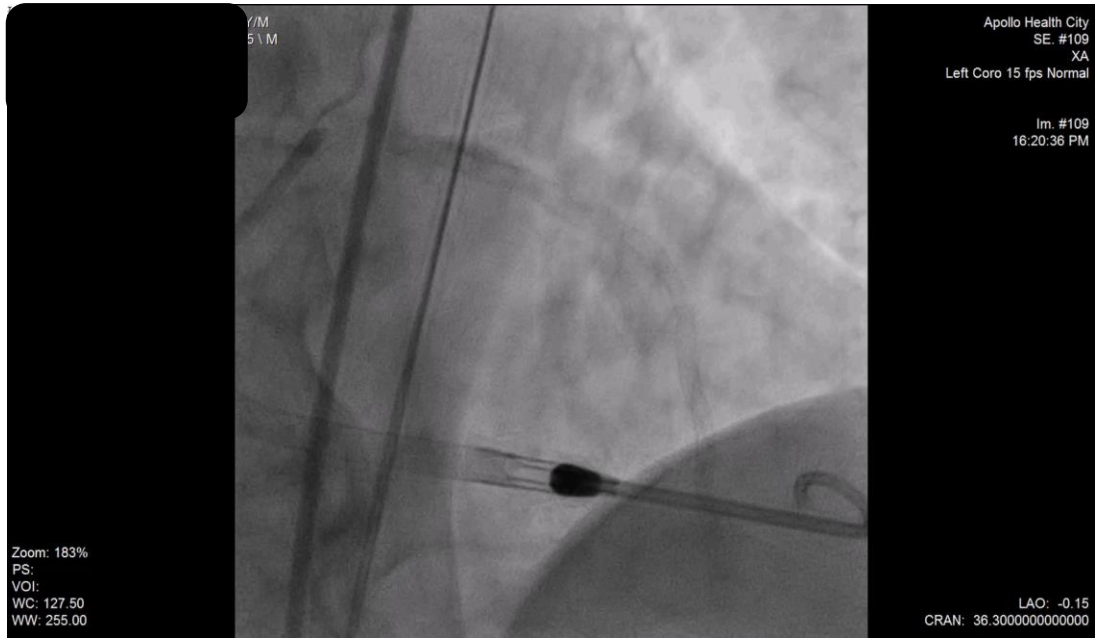
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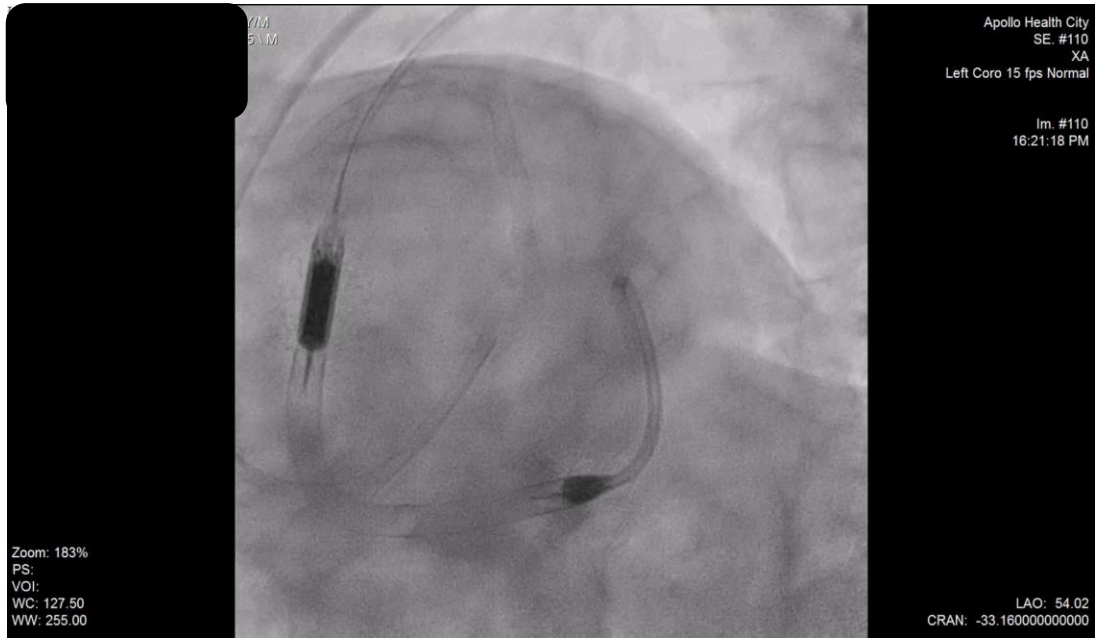
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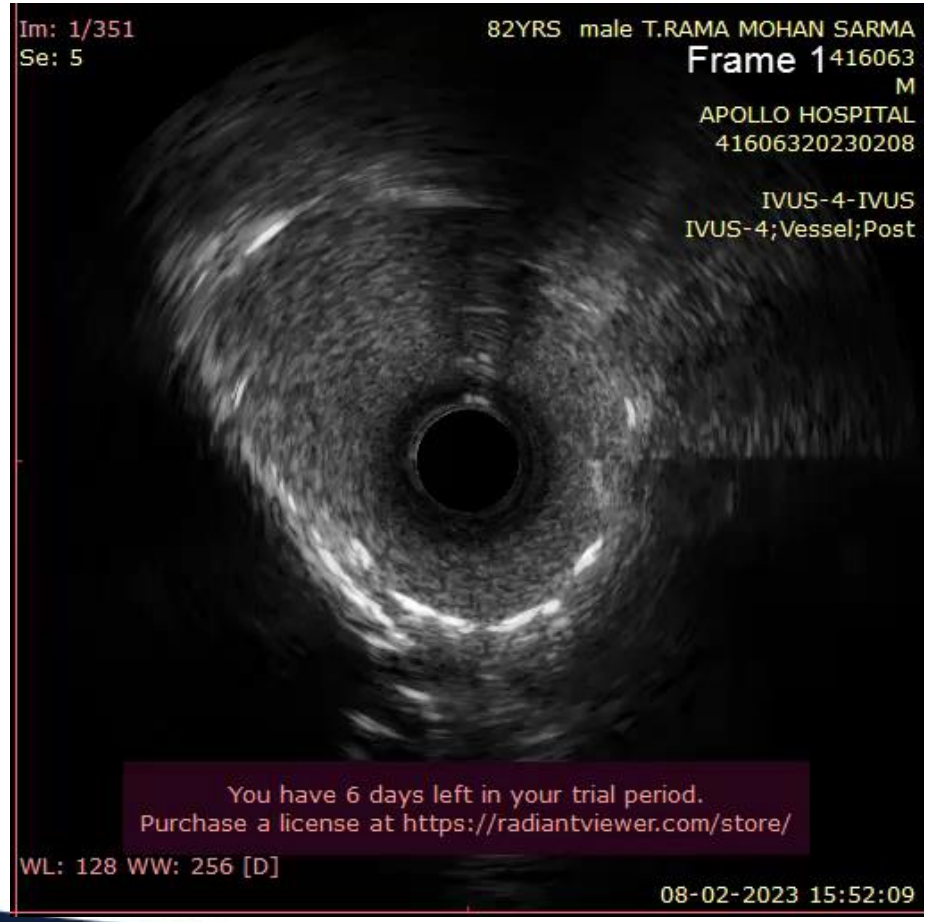
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IVUS-4;Vessel;Post
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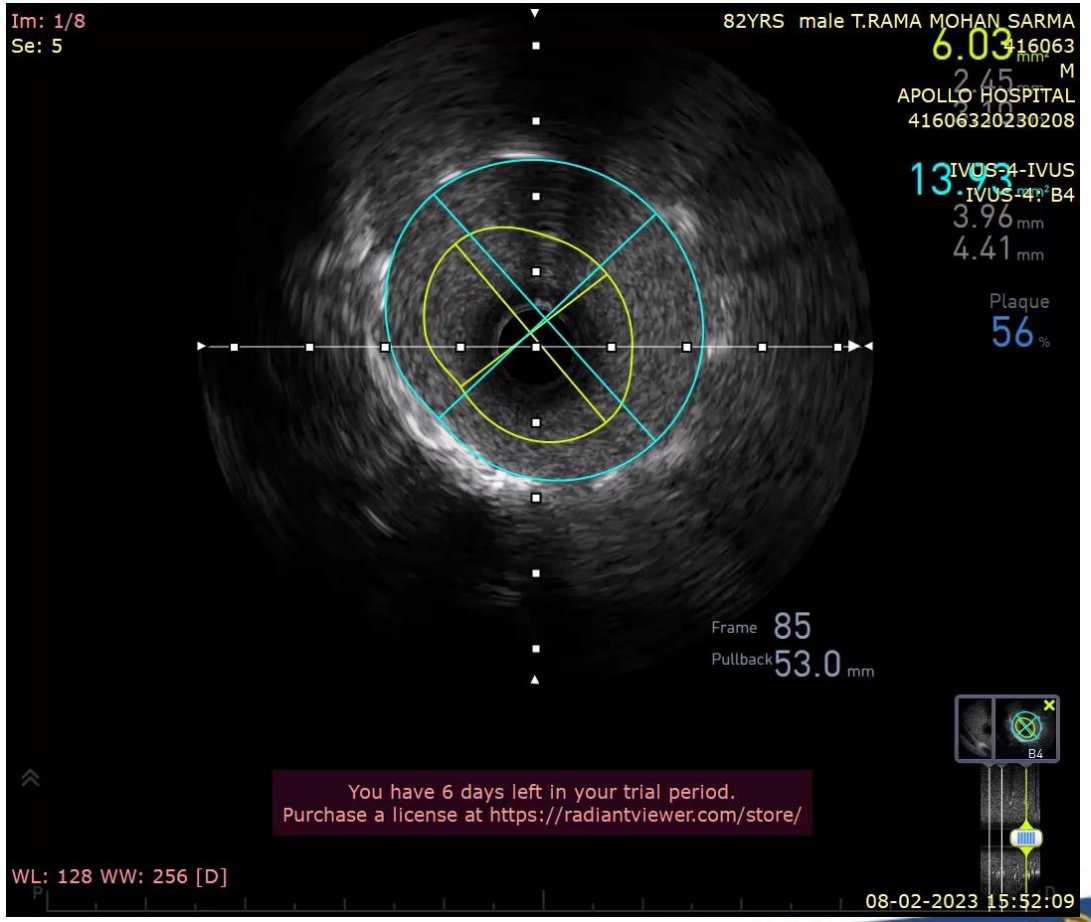
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2.76 mm
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APOLLO HOSPITAL
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13.93 mm²
IVUS-4-IVUS
IVUS-4: B4
3.96 mm
4.41 mm
Plaque
56 %
Frame 85
Pullback 53.0 mm
B4
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Purchase a license at https://radiantviewer.com/store/
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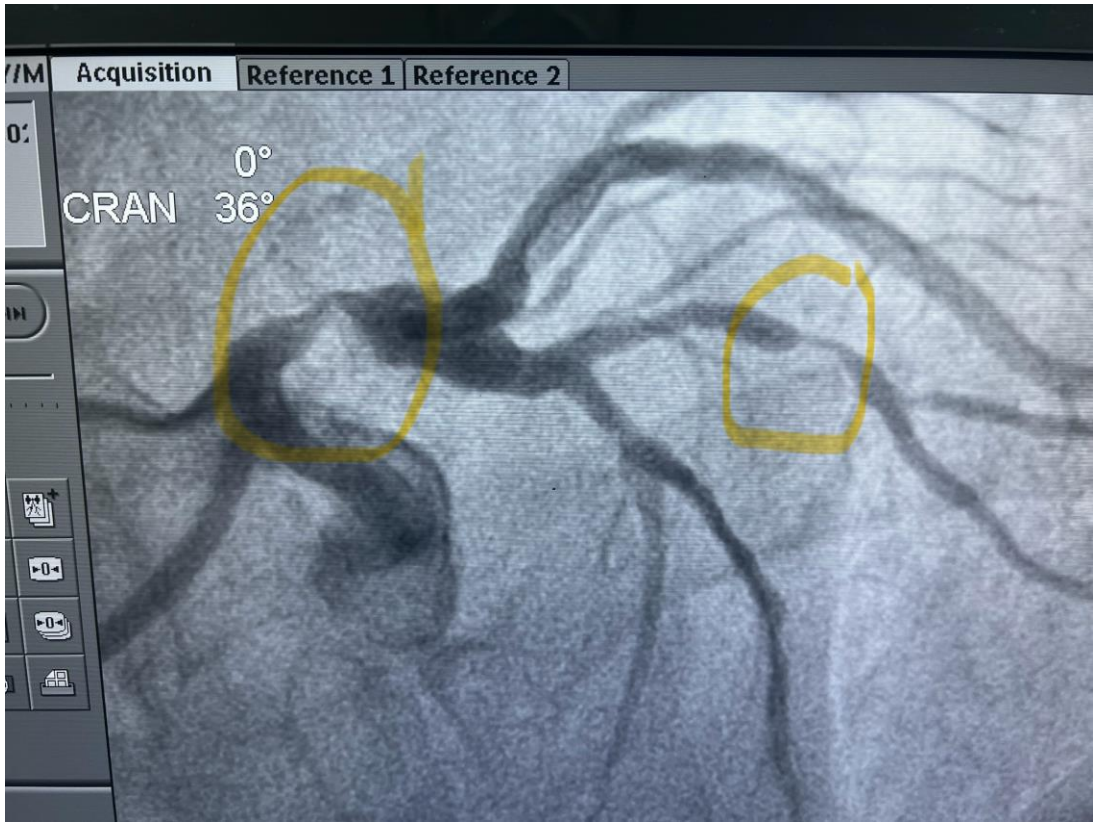
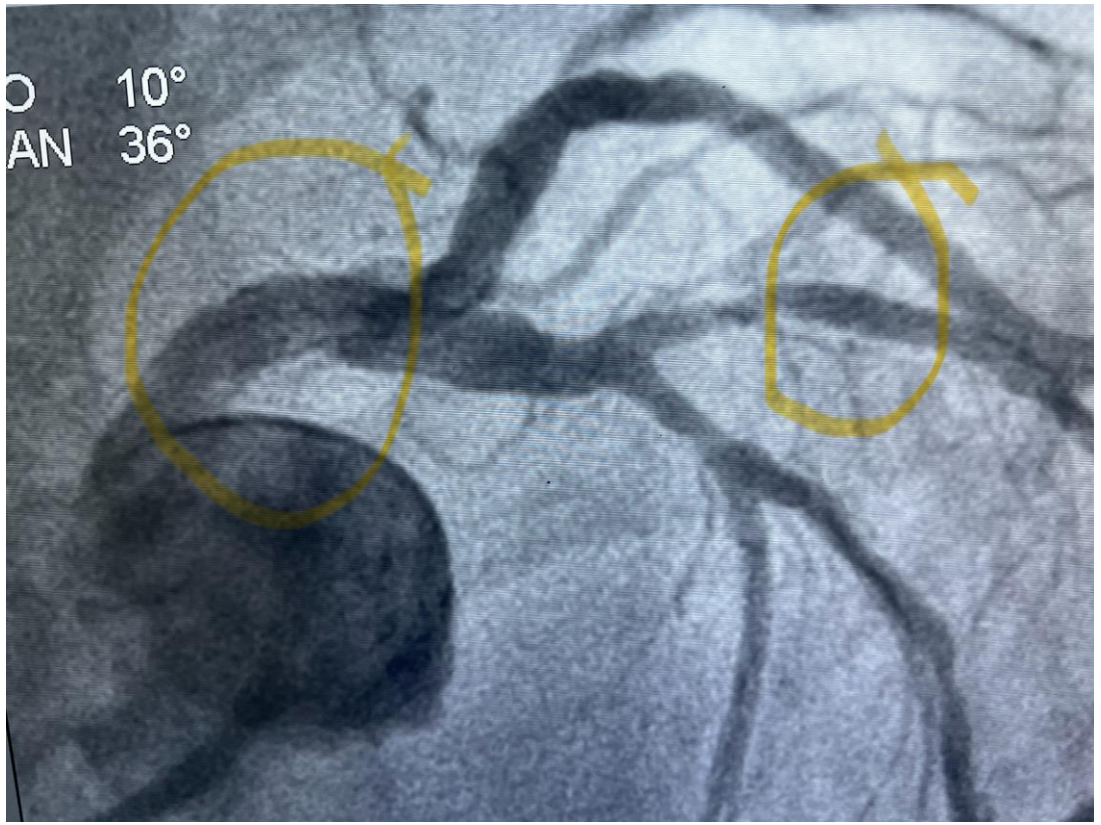
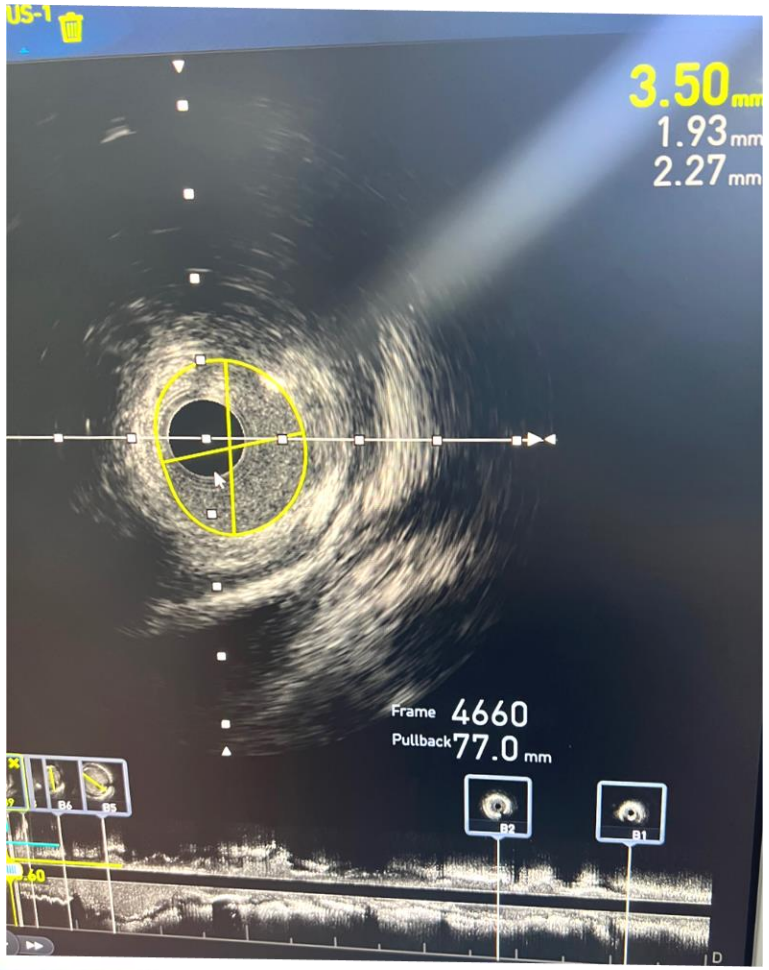
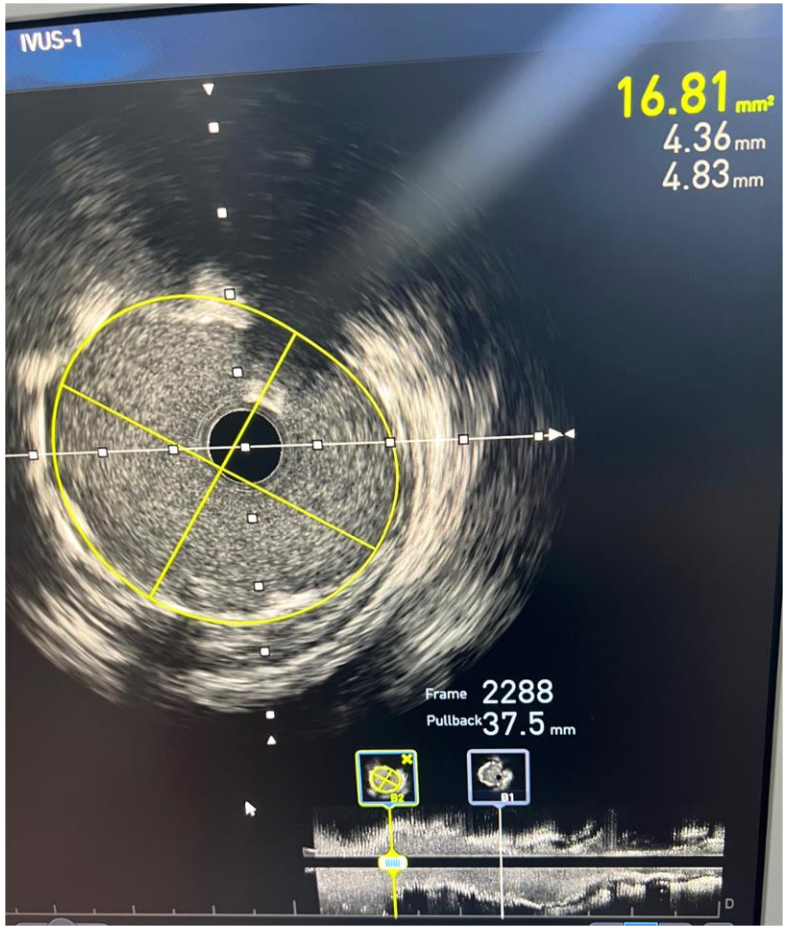
LM PCI _ Pre & Post





LM IVUS – Pre & Post PCI





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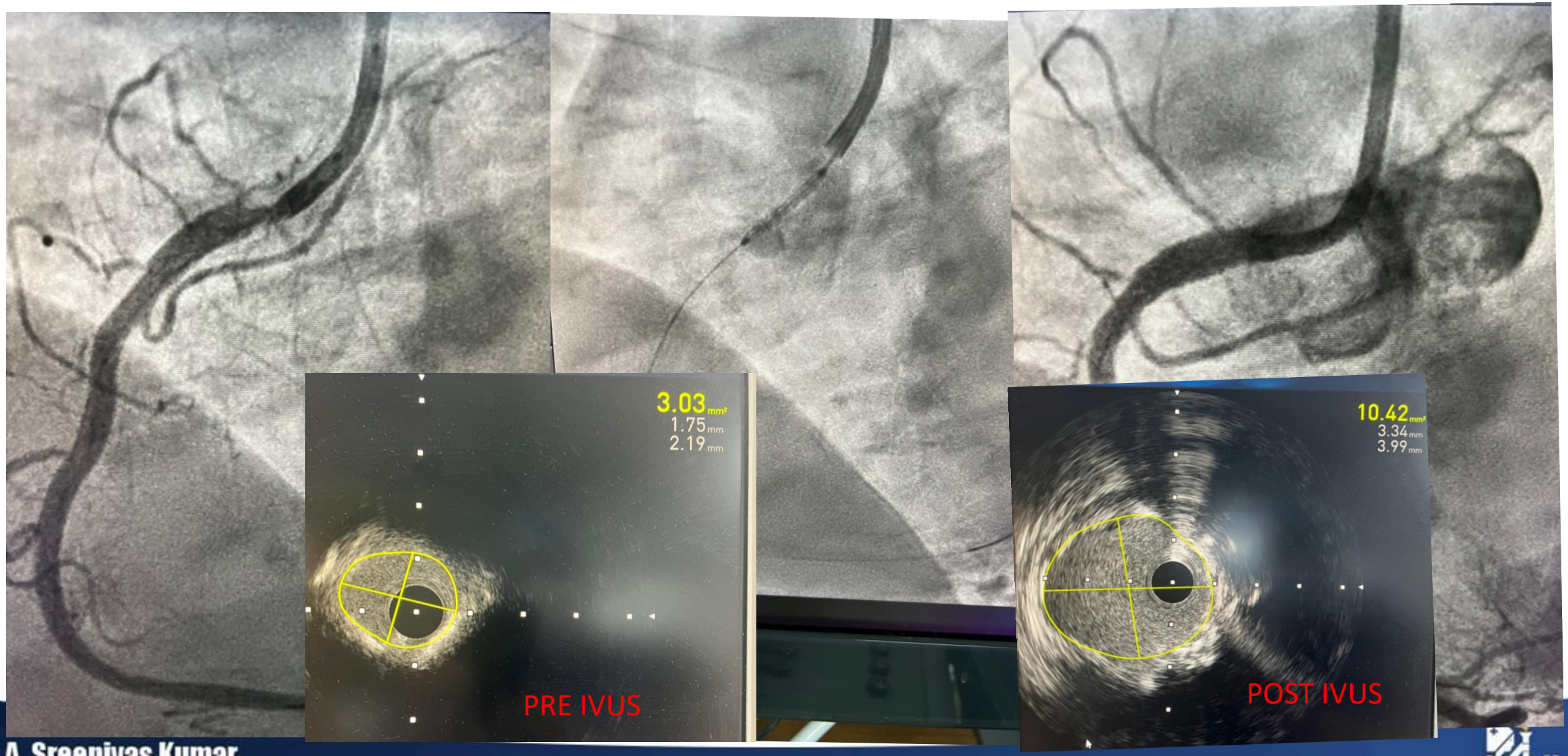
Ostial RCA Disease



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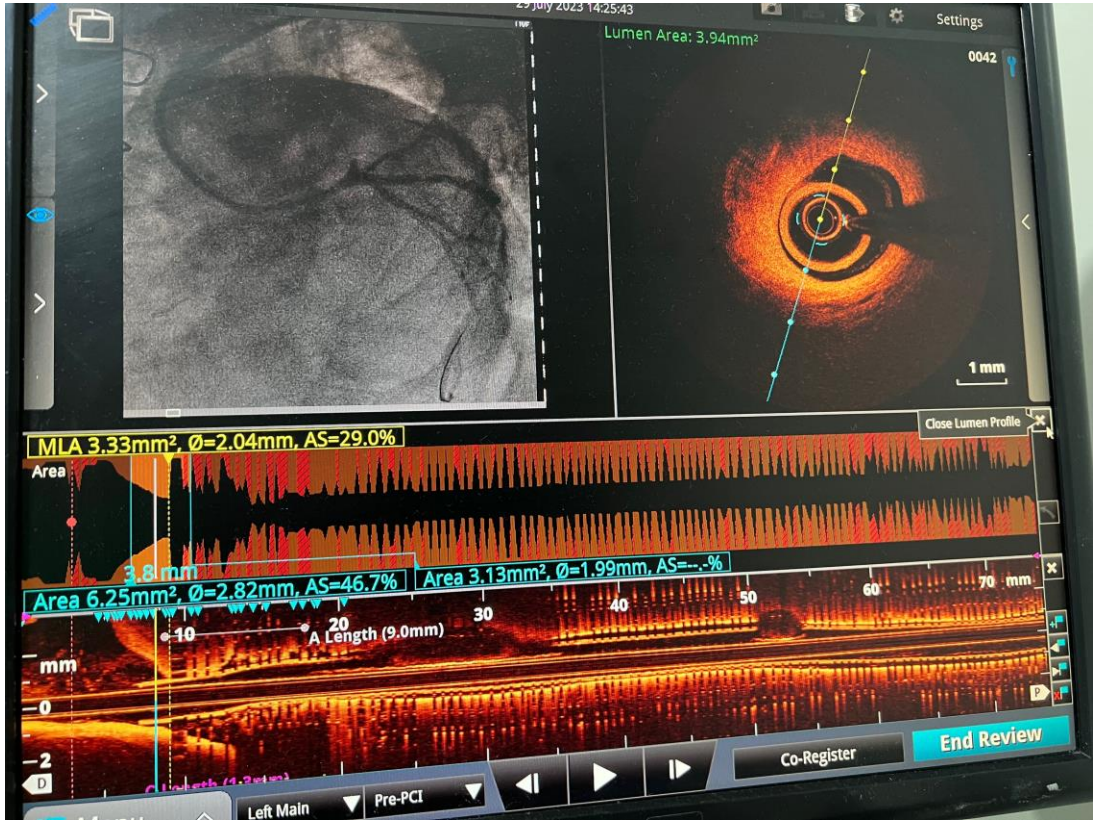
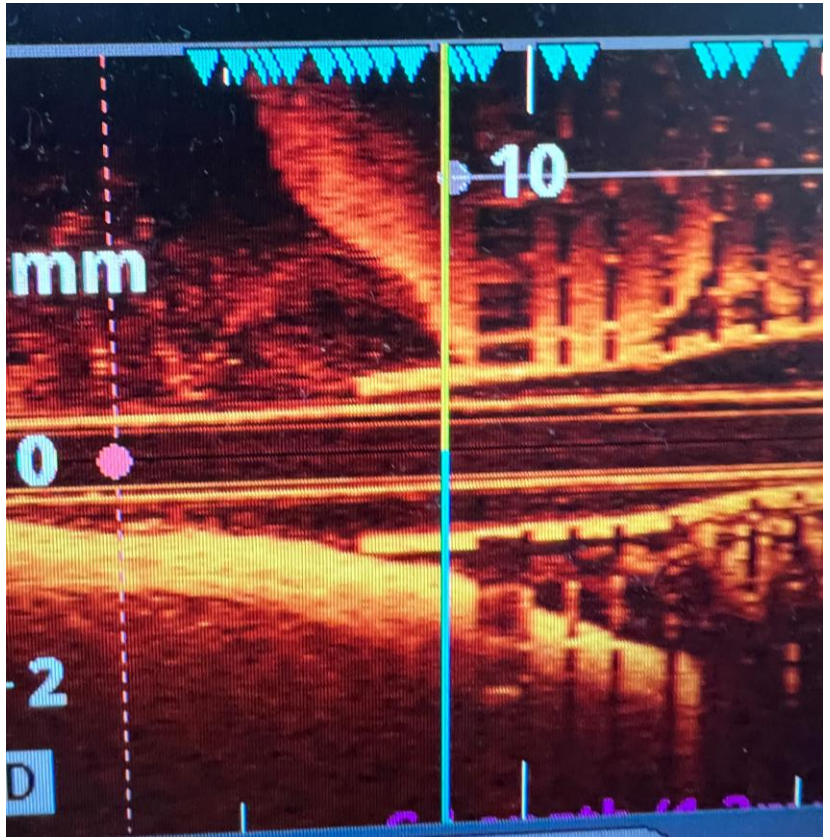
Ostial Left Main (Protected LM) – OCT / Telescope





OCT - Disadvantages

- The small rapid exchange portion of the catheter makes it sometimes difficult to take it across the bends and calcified lesions.
- Difficult Image acquisition
- The utility of contrast to get high quality images sometimes could lead to Contrast nephropathy and precipitation of LVF in patients with LV dysfunction.
- OCT visualises intima to intima and hence underestimates the vessel diameters and does leading to implantation of smaller diameter stents.
- OCT remains inferior to IVUS in regard to its depth of penetration

OCT Preferable -

- OCT gives more clear images in measuring intima media thickness than IVUS and can visualize intimal thickness, intimal hyperplasia, and the internal and external elastic lamina.
- Assessment of instent restenosis where OCT gives us better assessment of morphology of ISR allowing us to plan the appropriate treatment
- Endothelialisation of stent struts especially with BVS stents could be better assessed by OCT due to its high resolution images.
- Stent under expansion or malapposition is also better visualised by OCT .
- Bifurcation Lesions.

OCT preferred Clinical Scenarios

- Stable patients, Normal Renal Function, Good LV or Mild LVD pts.
- Smaller vessels, distal lesions , proximal vessels also unless vessels are ectatic , > 5mm (eg. LM).
- Bifurcation lesions – modality of choice
- Post PCI assessment – Stent expansion, apposition, fup endotheliasation, ISR etc.
- Assessment of Dissections – more sensitive.
- Beginners easy to learn and assess.

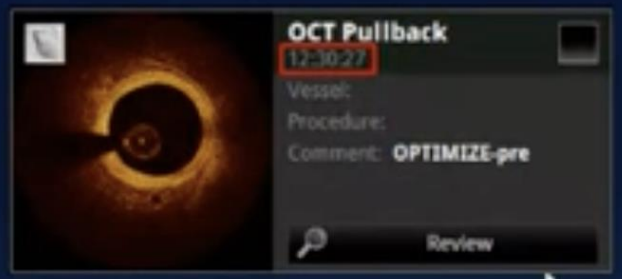
Optimal PCI

Pre-PCI OCT | Strategize

- Morphology ✓
- Length ✓
- Diameter ✓

Post-PCI OCT | Optimize

- Apposition ✓
- Expansion ✓
- Dissection ✓



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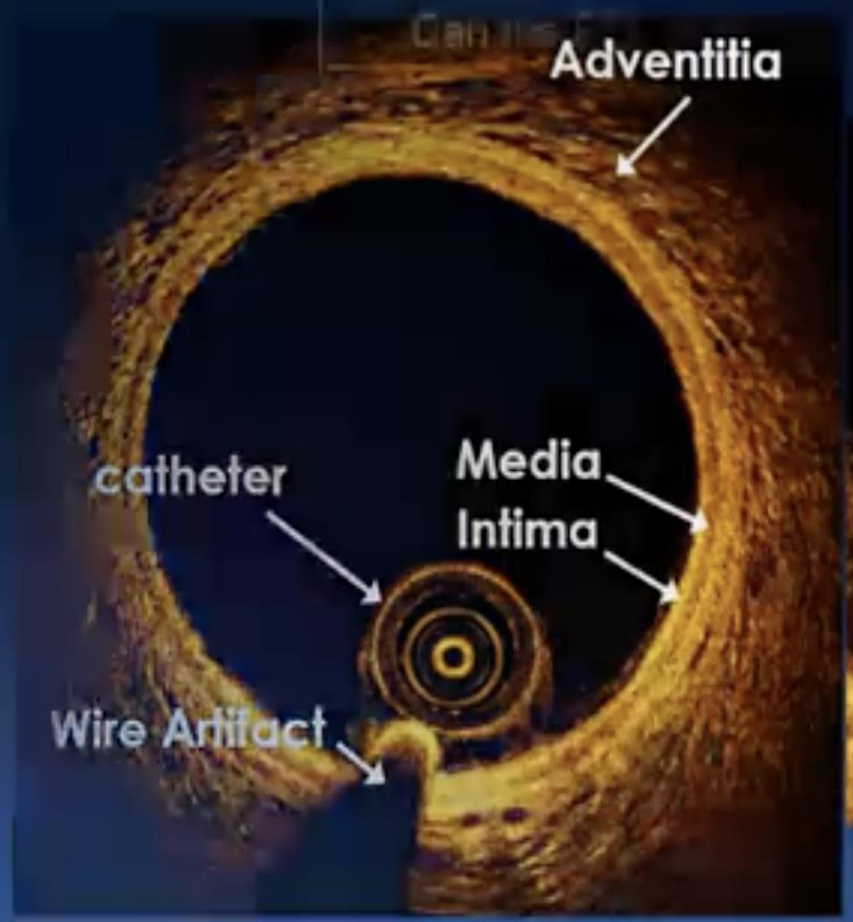
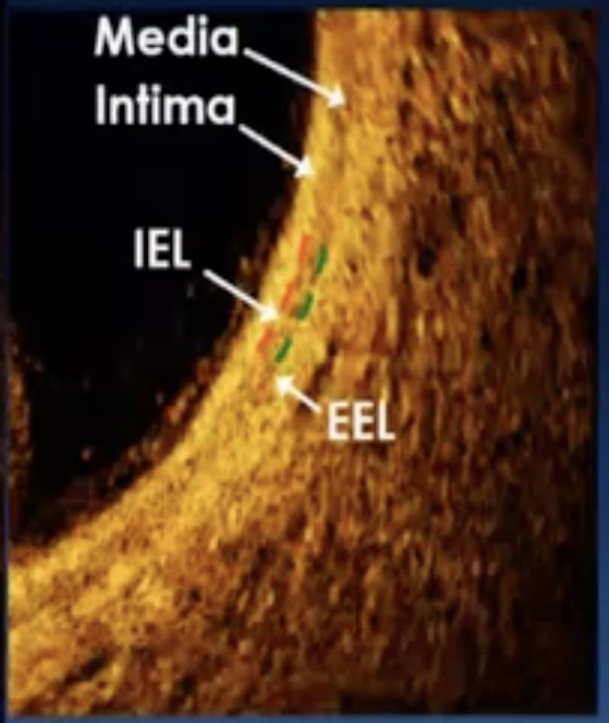
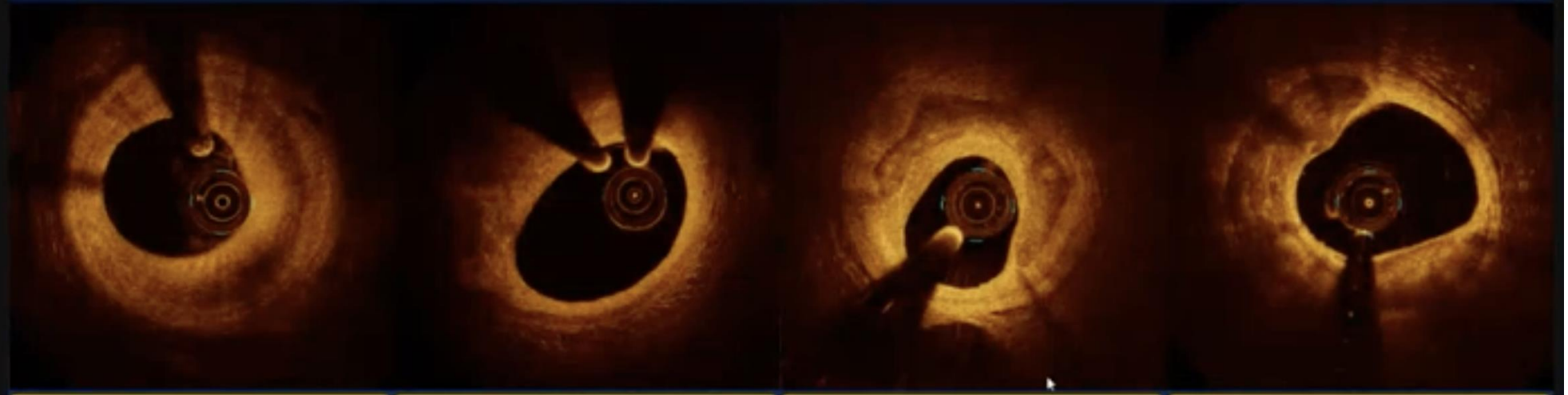
Normal Artery Morphology on OCT





1) Intima = sponge
2) IEL = rubber band
3) Media = soft rope
4) EEL = rubber band
5) Adventitia = mesh

Morphology Guided Lesion Preparation



FIBROTIC	LIPIDIC	MILD/MODERATE Ca^{2+}	SEVERE Ca^{2+}

DIRECT STENTING

COMPLIANT BALLOON

NON-COMPLIANT BALLOON

ATHERECTOMY OR IVL

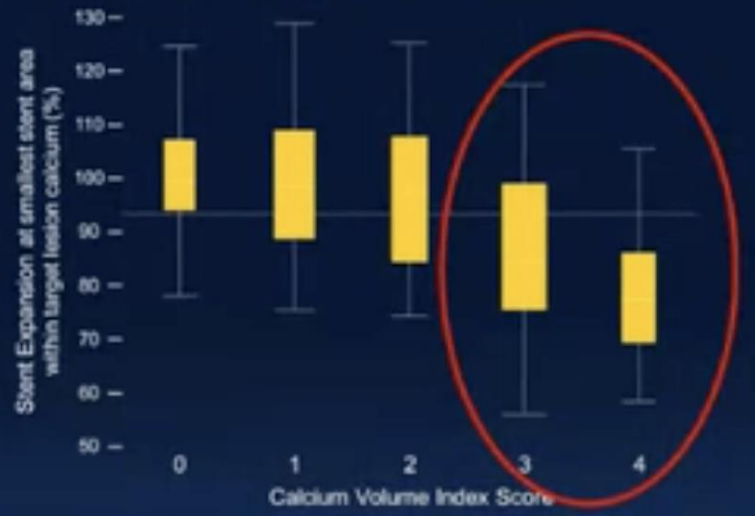
is sharing your screen. Stop sharing Hide

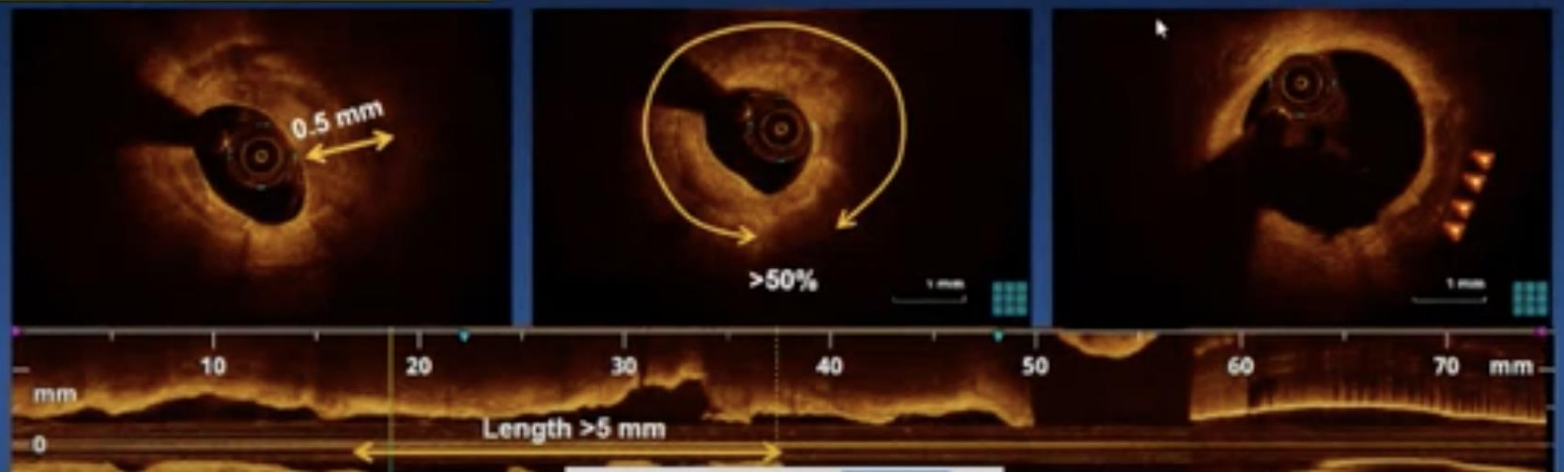
Influence of Ca^{2+} on stent Expansion by OCT

OCT-based Calcium Volume Index Score	
1. Maximum Calcium Angle (°)	≤ 90 ° ⇒ 0 point 90° < Angle ≤180° ⇒ 1 point > 180 ° ⇒ 2 points
2. Maximum Calcium Thickness (mm)	≤ 0.5 mm ⇒ 0 point > 0.5 mm ⇒ 1 point
3. Calcium Length (mm)	≤ 5.0 mm ⇒ 0 point > 5.0 mm ⇒ 1 point
Total score	**0 to 4 points**

Rule of 5's

- 0.5mm thickness
- 5mm long
- 50% vessel arc





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MR. P – 31yr/M - CAG

31yr/M

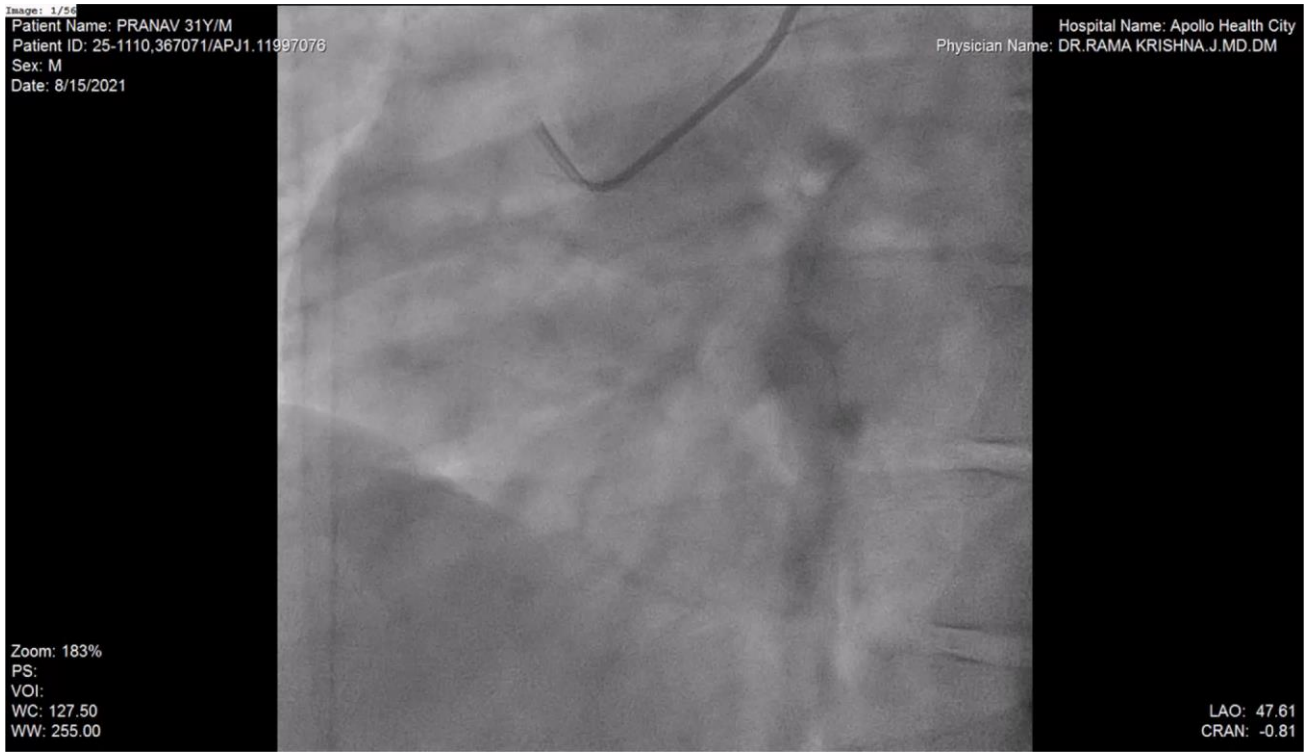
Smoker/ Drug H/o

CAD – Ant MI – w.period – 4hrs

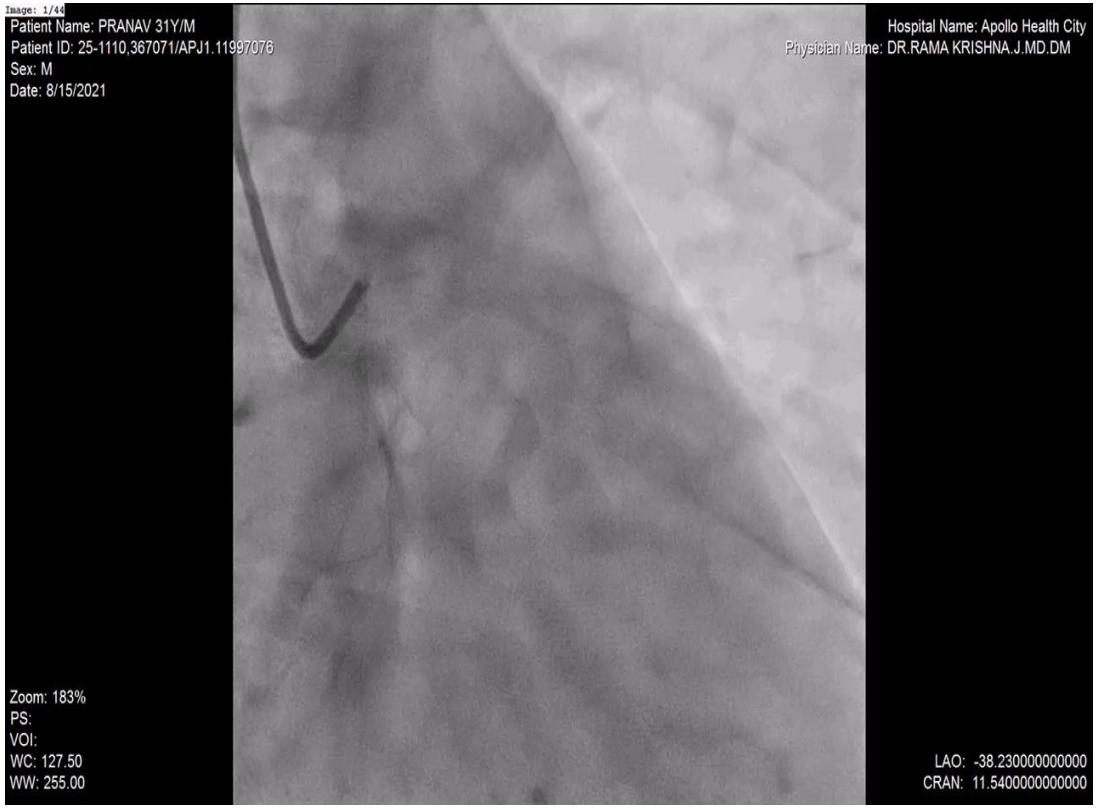
Ecg – St elevation in lat leads

Echo – RWMA +, but good LV fn.

Labs – Normal.



CAG - LCA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Date: 8/15/2021
Hospital Name: Apollo Health City
Physician Name: DR.RAMA KRISHNA.J.MD.DM
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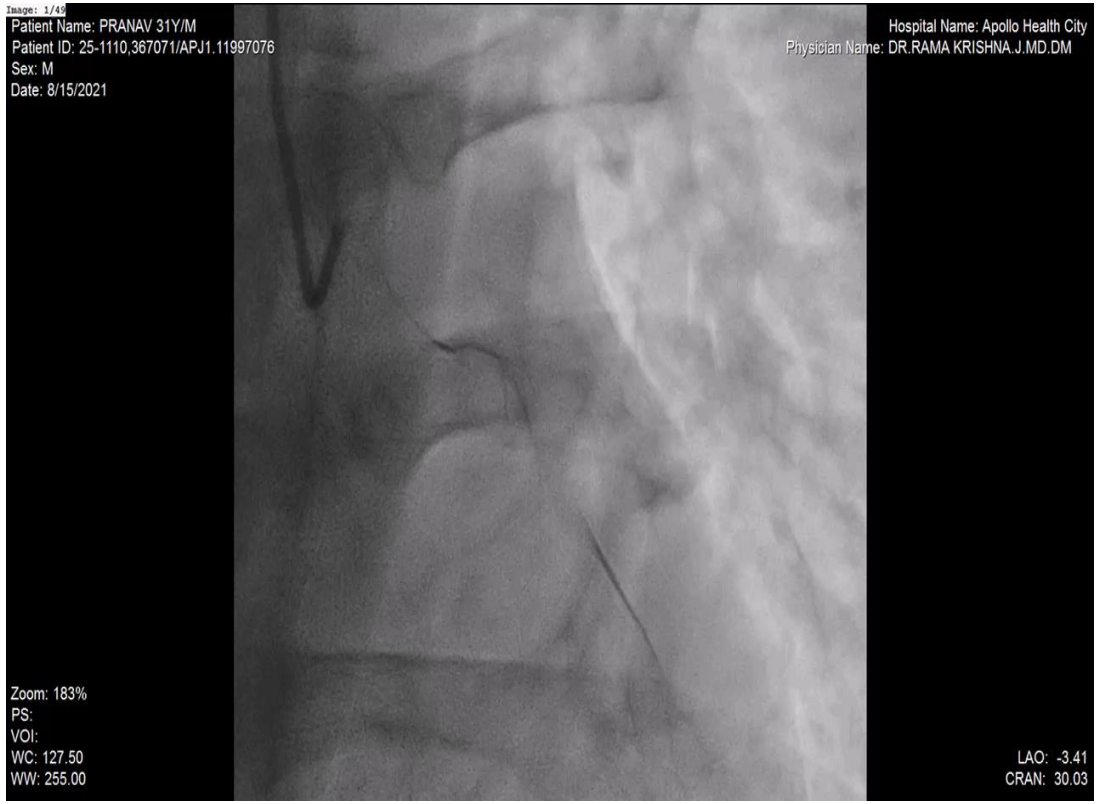
CRAN: 11.5400000000000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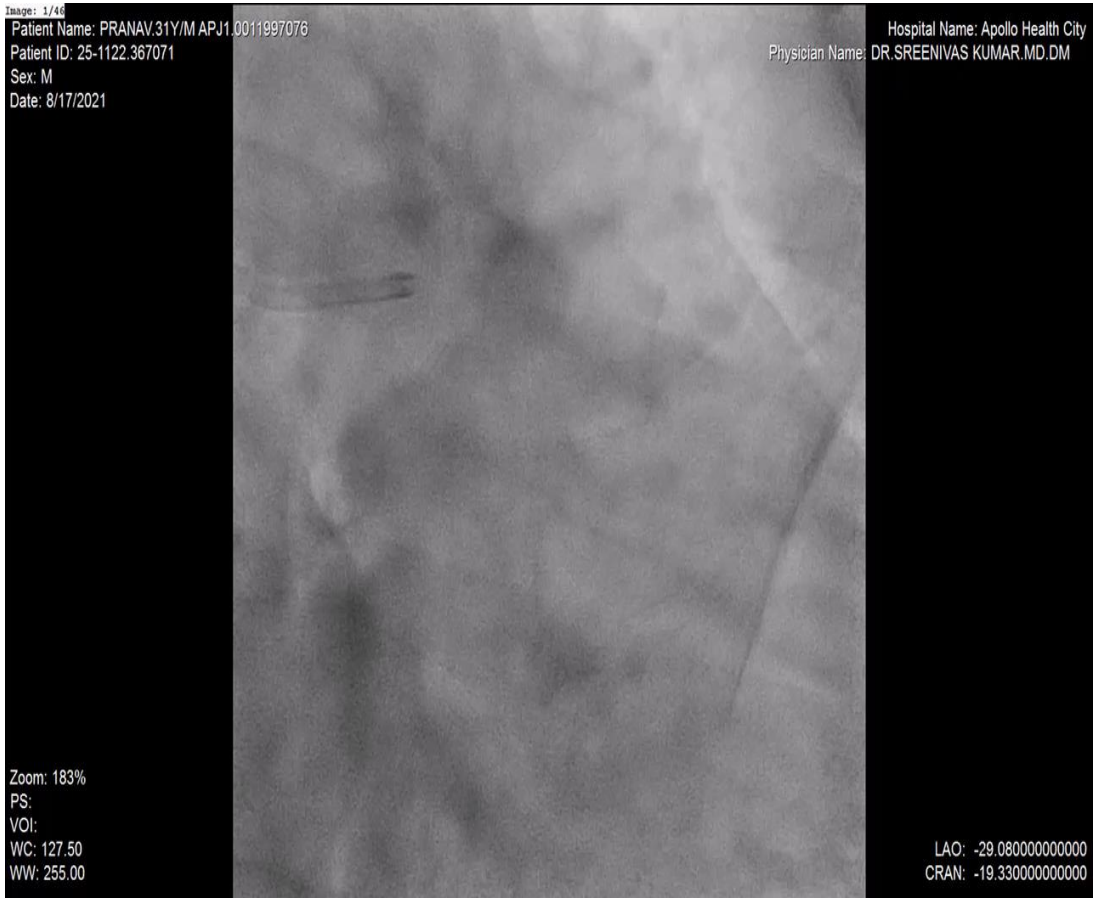
PTCA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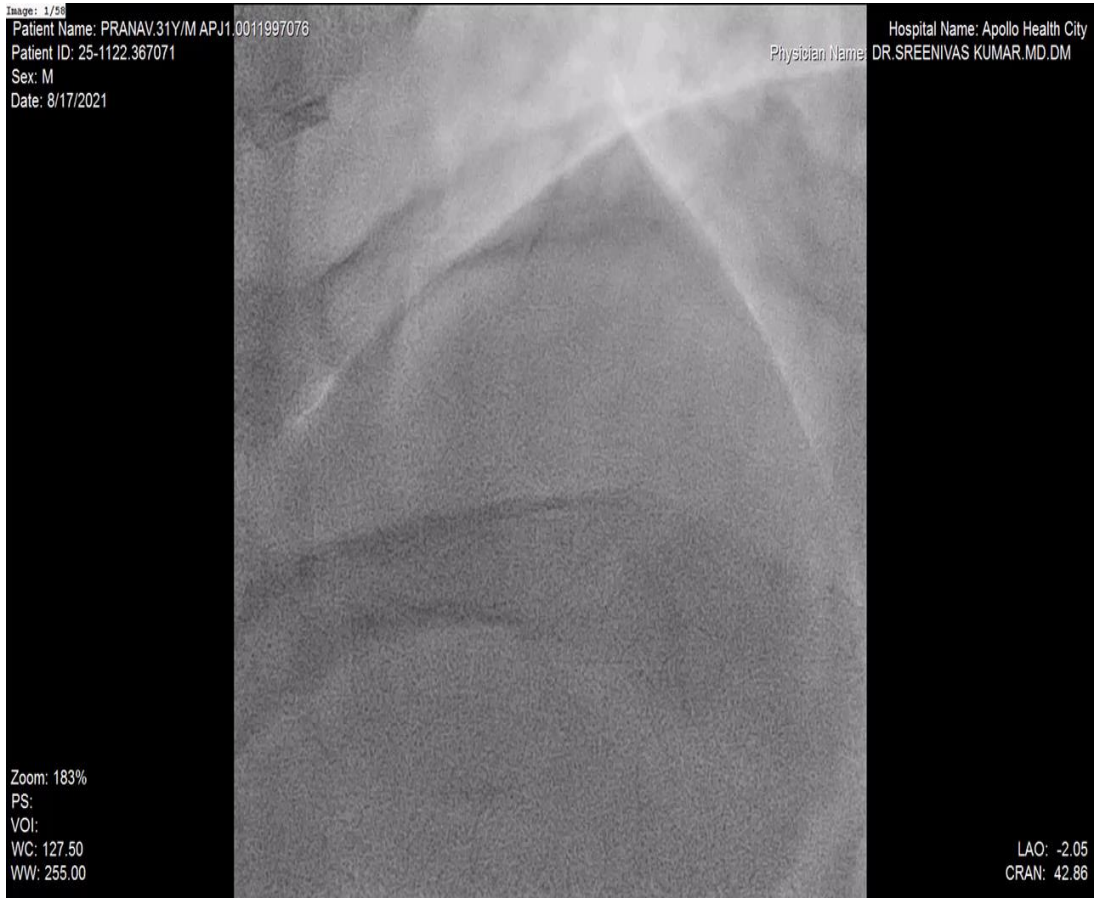
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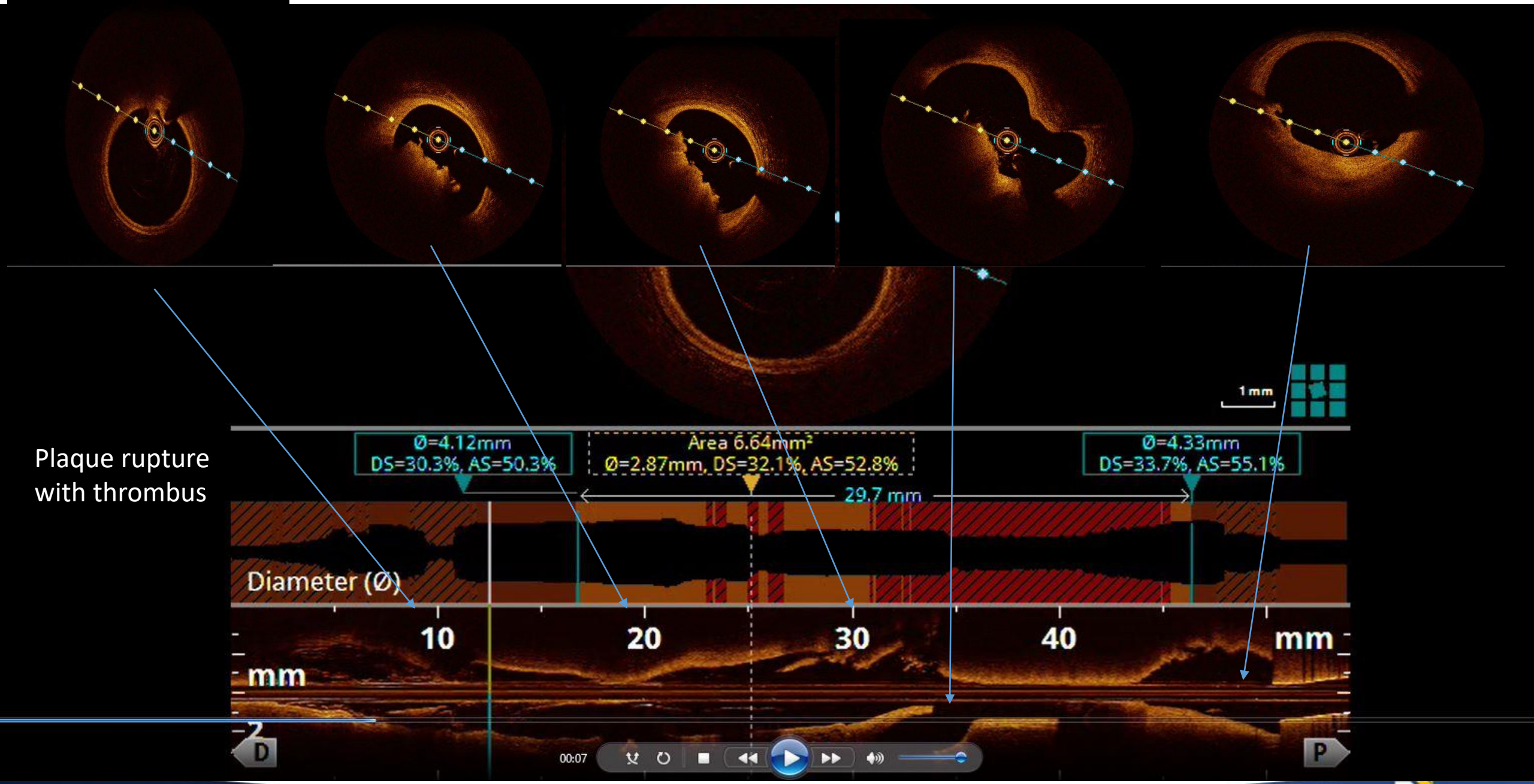
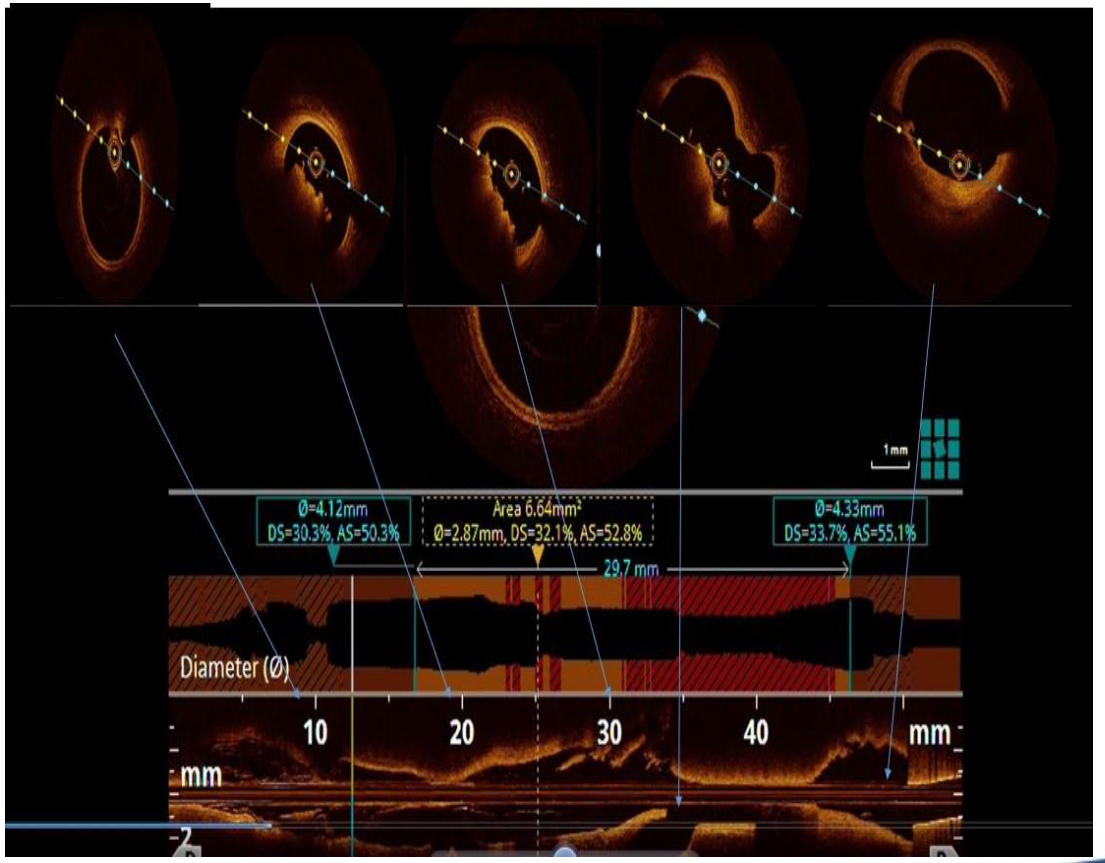
LAO: -2.05
CRAN: 42.86



Plaque rupture with thrombus

plaque rupture with red thrombus



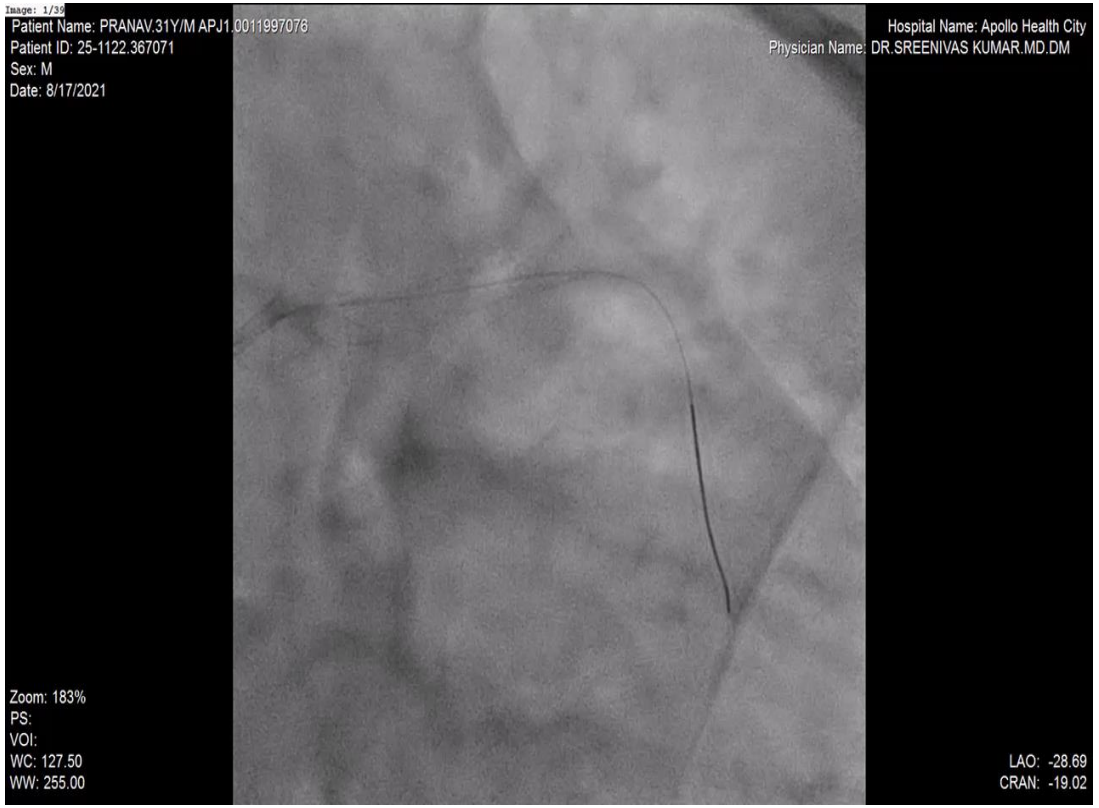


Image: 1/39
Patient Name: PRANAV.31Y/M APJ1.0011997076
Patient ID: 25-1122.367071
Sex: M
Date: 8/17/2021
Physician Name
Hospital Name: Apollo Health City
DR.SREENIVAS KUMAR.MD.DM
Zoom: 183%
PS:
VOI:
WC: 127.50
WW: 255.00
LAO: -28.69
CRAN: -19.02

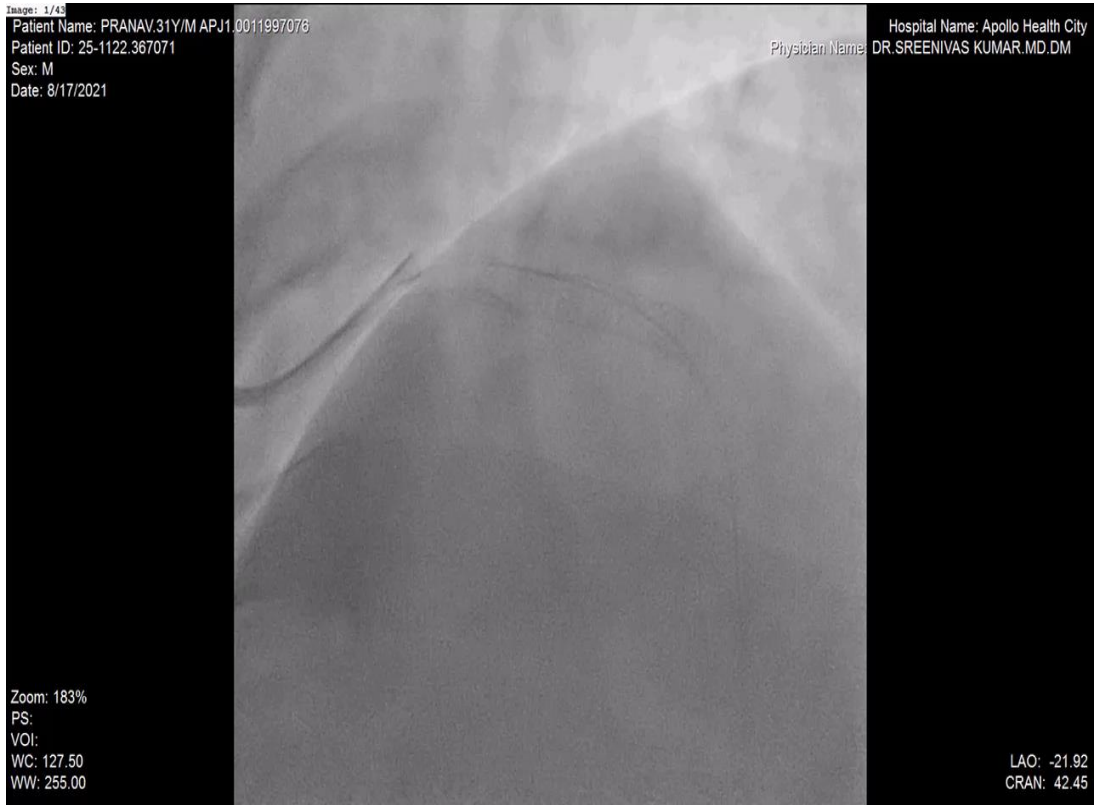
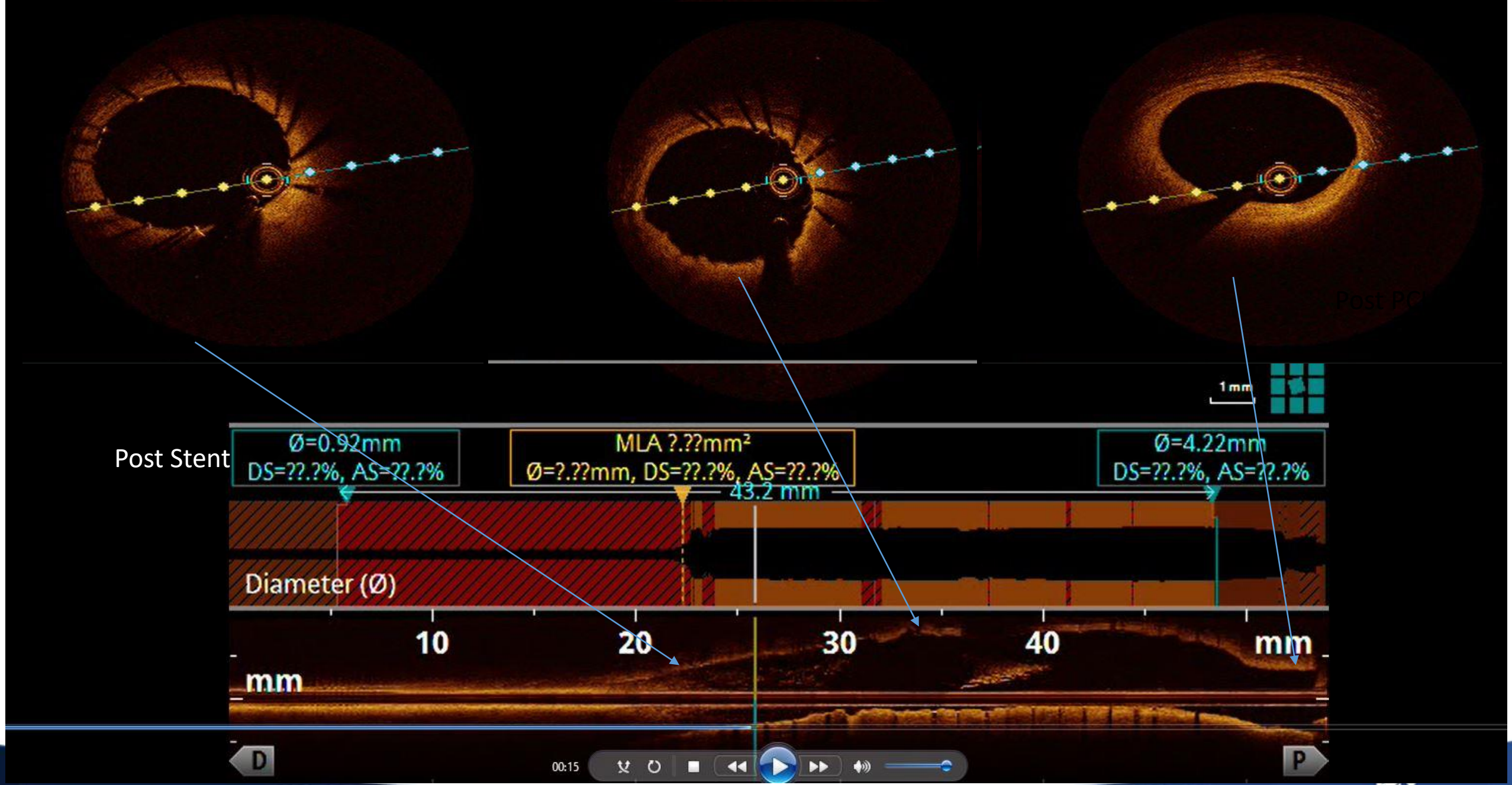
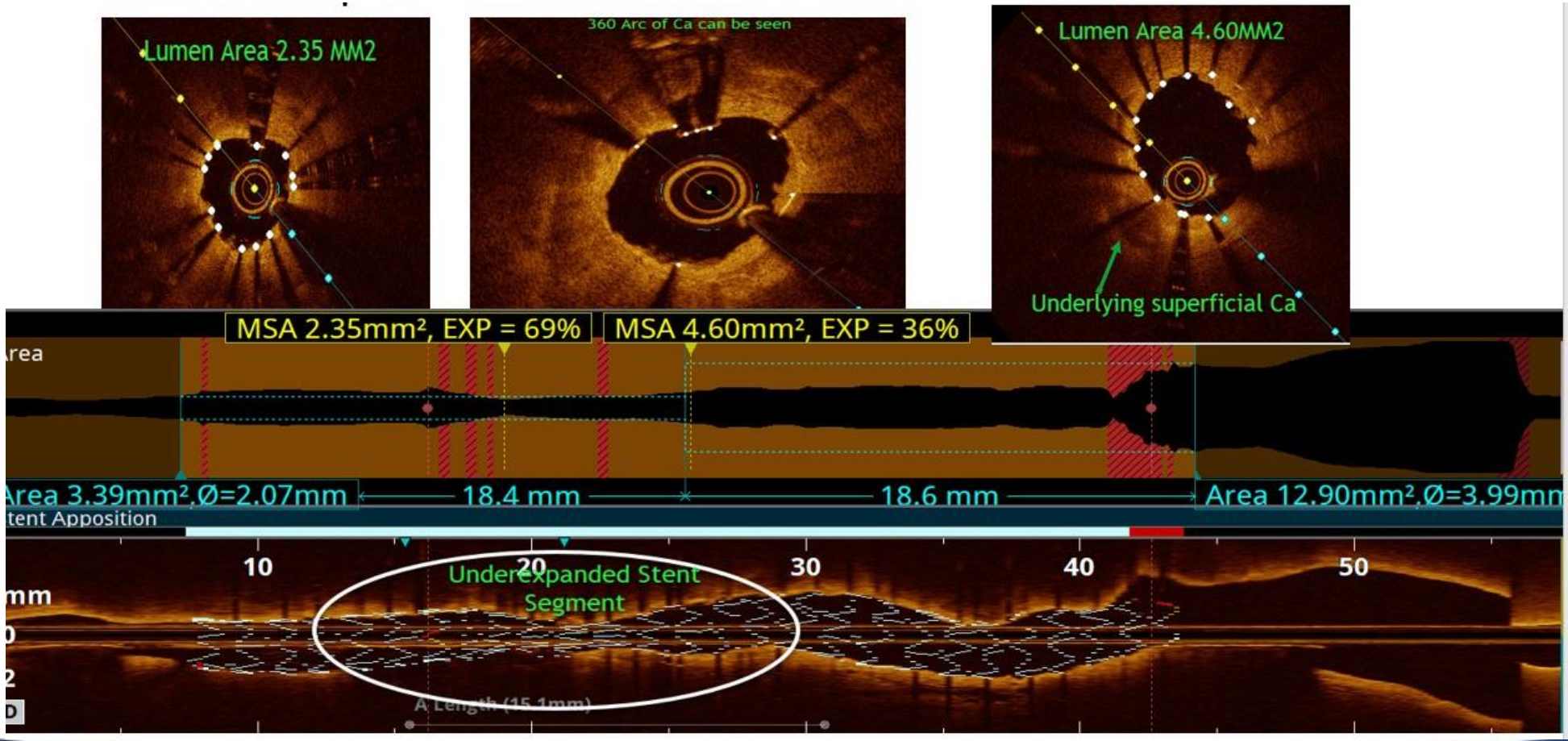


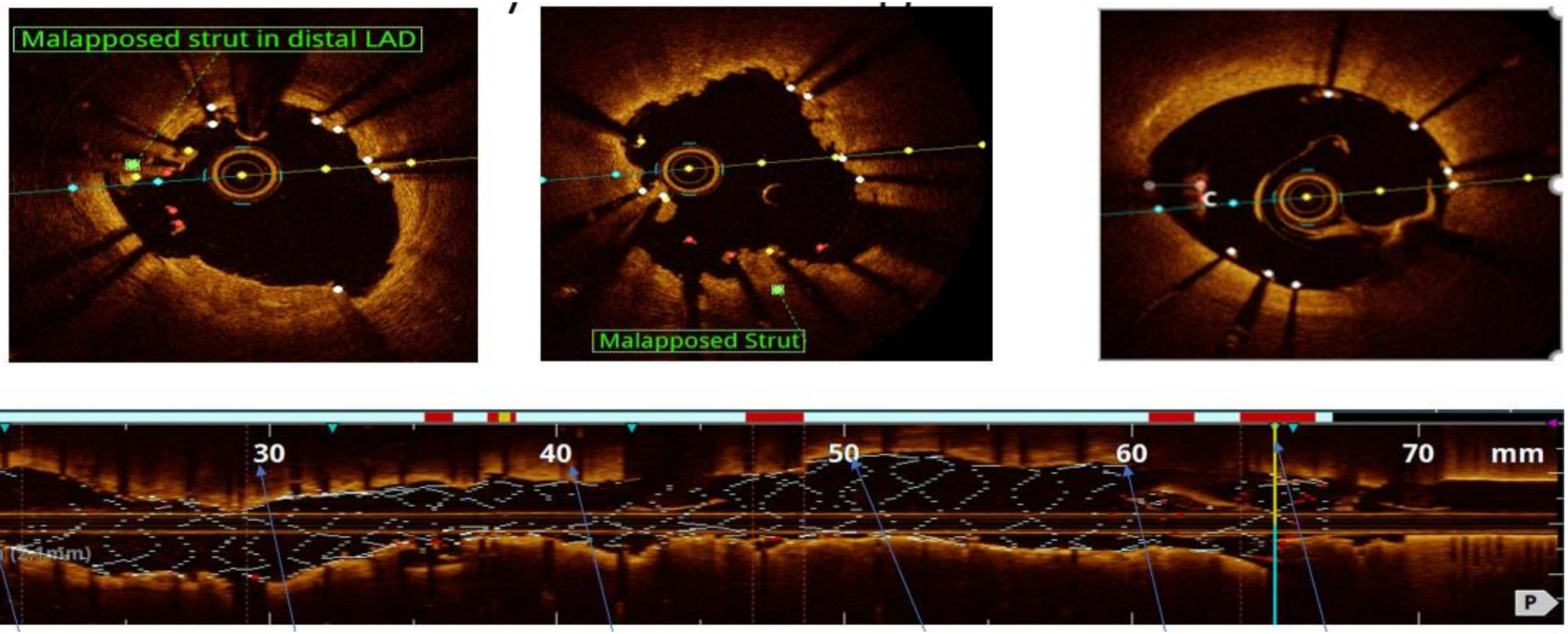
Image: 1/43
Patient Name: PRANAV.31Y/M APJ1.0011997076
Patient ID: 25-1122.367071
Sex: M
Date: 8/17/2021
Physician Name
Hospital Name: Apollo Health City
DR.SREENIVAS KUMAR.MD.DM
Zoom: 183%
PS:
VOI:
WC: 127.50
WW: 255.00
LAO: -21.92
CRAN: 42.45


Post PCI
Post Stent
1 mm
Ø=0.92mm
DS=??.?%, AS=??.?%
MLA ?.??mm²
Ø=?.??mm, DS=??.?%, AS=??.?%
Ø=4.22mm
DS=??.?%, AS=??.?%
43.2 mm
Diameter (Ø)
10
20
30
40
mm
mm
D
00:15
P

Stent Underexpansion



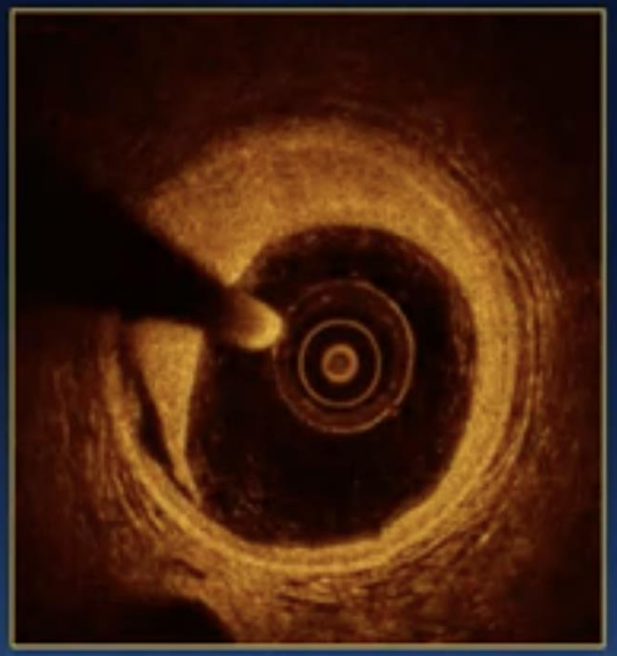
Stent Malapposition



Dissections

Intimal

Medial



Intramural Hematoma

Consider additional DES (particularly distal)

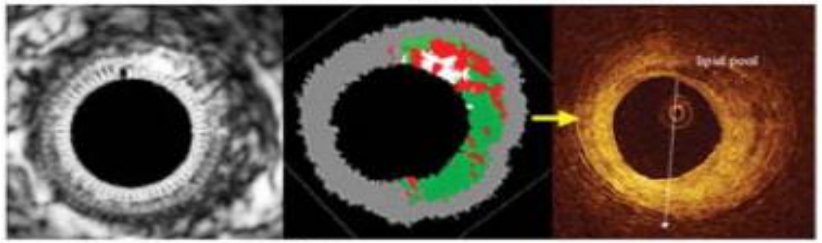
- ≥ 1 quadrant in arc from the center of the vessel
- Penetrates the medial layer

Circulation. 2014 28;129(4):463-70.

EuroIntervention. 2014 22;(9):1085-94.

OCT in diagnosis of thin cap fibrous atheroma

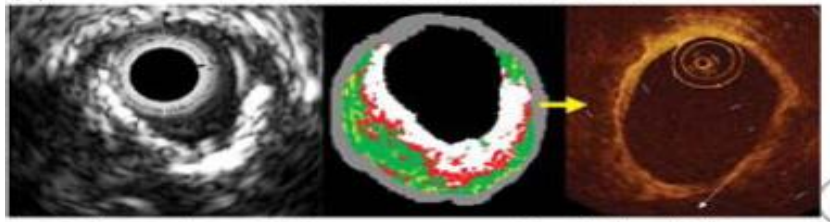
(A) Non-thin-cap IVUS-derived TCFA



%plaque-volume; 47.6%
%necrotic-core; 15%
Angle of the major NCCL 15.3°
Angle of the total NCCL 35.8°

Cap thickness; 90 µm

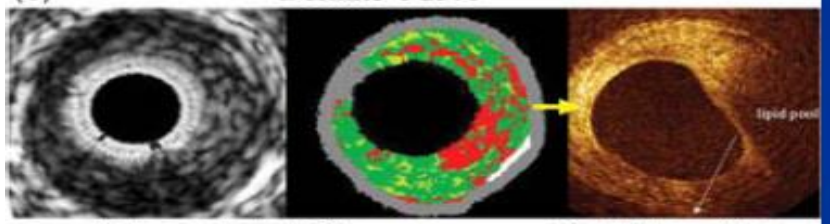
(B) Non-NCCL OCT-derived TCFA



%plaque-volume; 57.6%,
%necrotic-core; 22%,
%dense-calcium; 44%

Cap thickness?; 50 µm

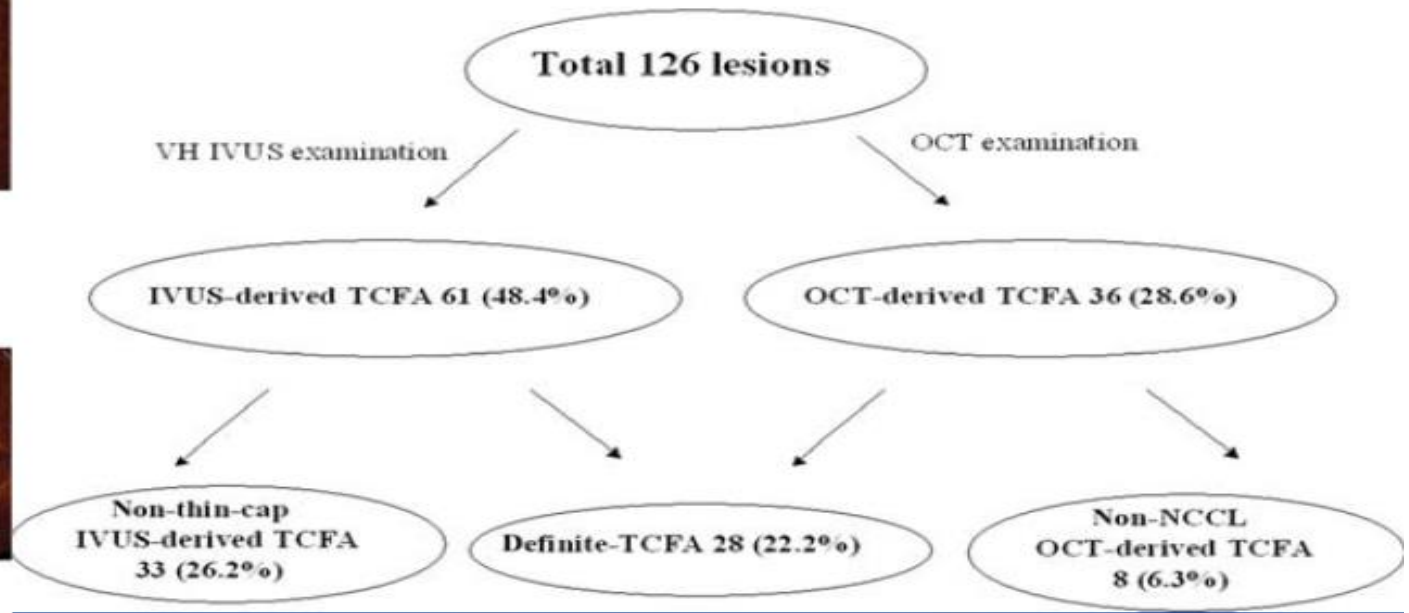
(C) Definite-TCFA



%plaque-volume; 55.8%
%necrotic-core; 22%
Angle of the major NCCL 24.8°
Angle of the total NCCL 100.3°

Cap thickness; 40 µm

Summary of lesion diagnosis

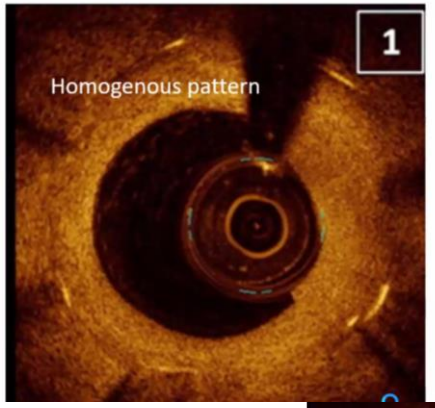


Neither modality alone is sufficient for detecting TCFA. The combined use of OCT and VH-IVUS might be a feasible approach for evaluating TCFA.

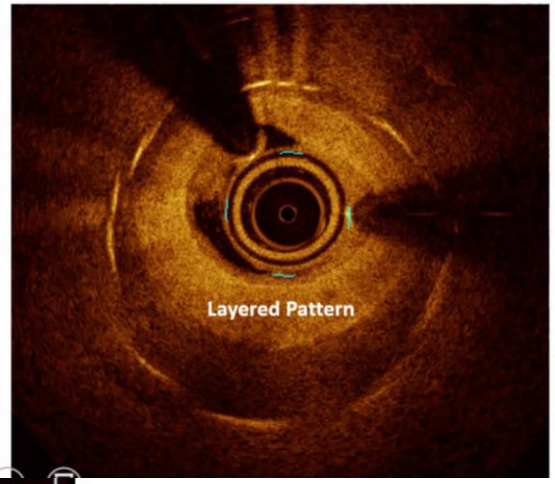
Sawada T et al. Eur Heart J 2008

OCT Pics of ISR Types..

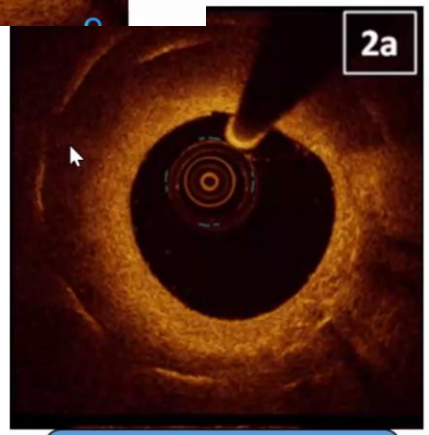
Homogenous - ISR



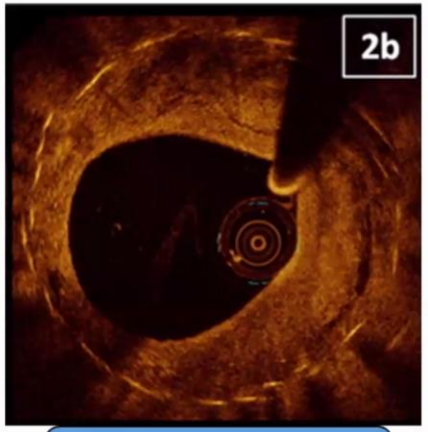
Layered ISR



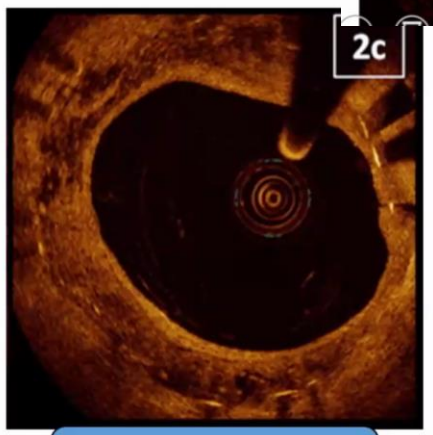
Heterogeneous ISR



Layered



Patchy



Speckled

In-Stent Restenosis

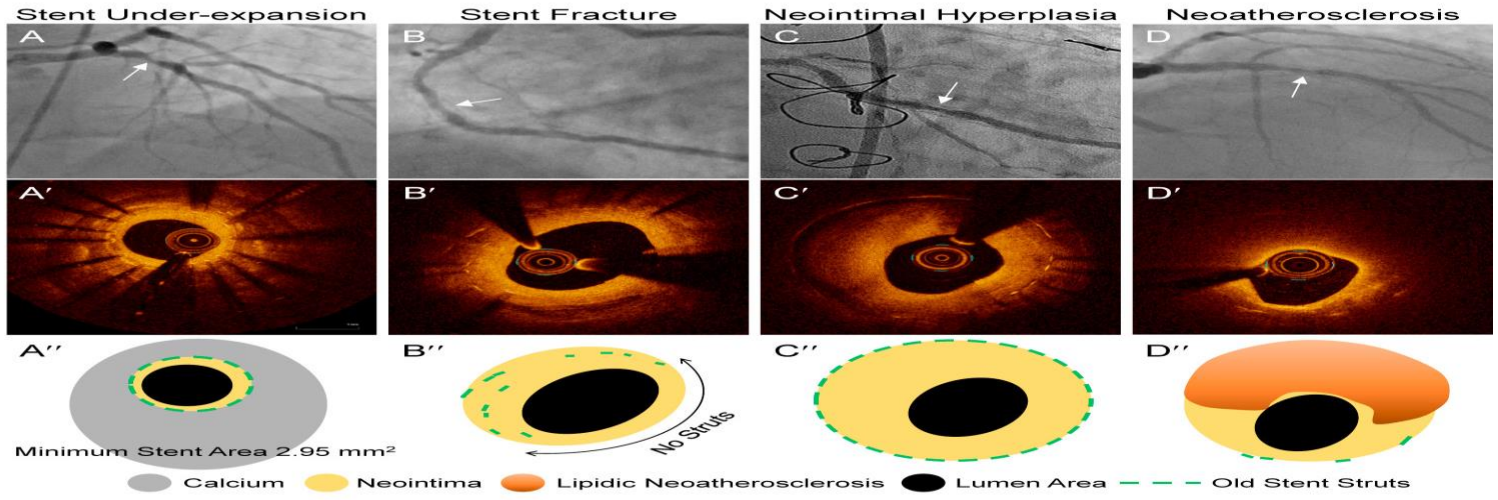
- Mechanisms

Top

Coronary Angiogram

OCT

Mechanism of Stent Failure

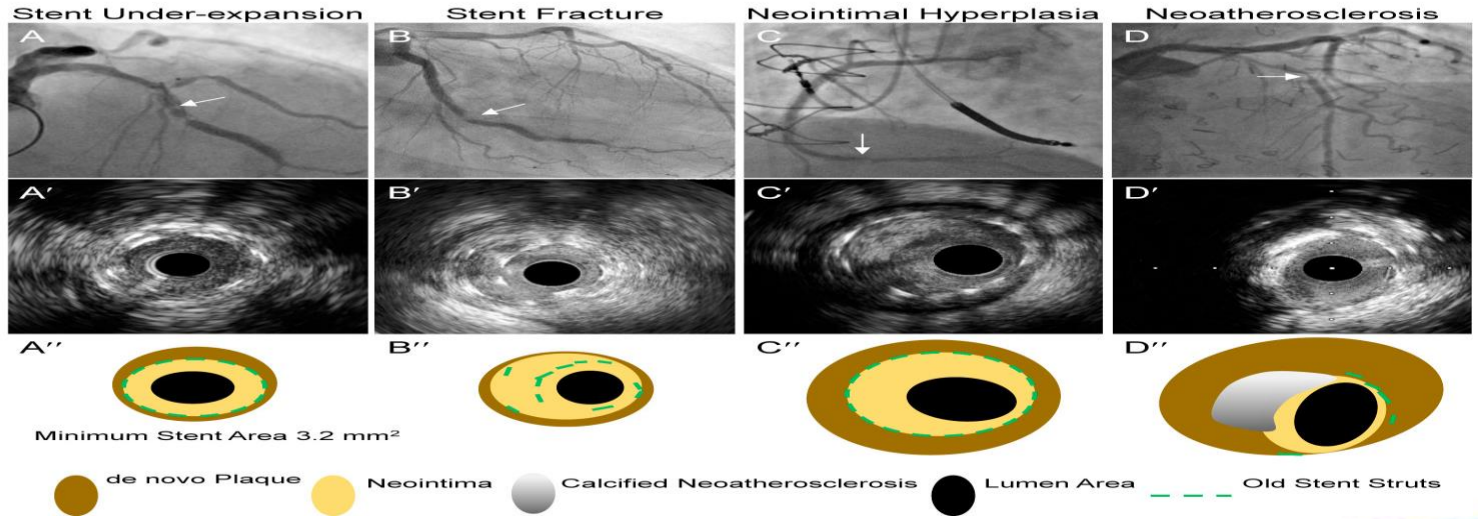


Bottom

Coronary Angiogram

IVUS

Mechanism of Stent Failure



ISR – Case egs

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Apollo Hospitals

Apollo Health City, Jubilee Hills

Hyderabad, INDIA.

Founder Director, FACTS Foundation & FPS.

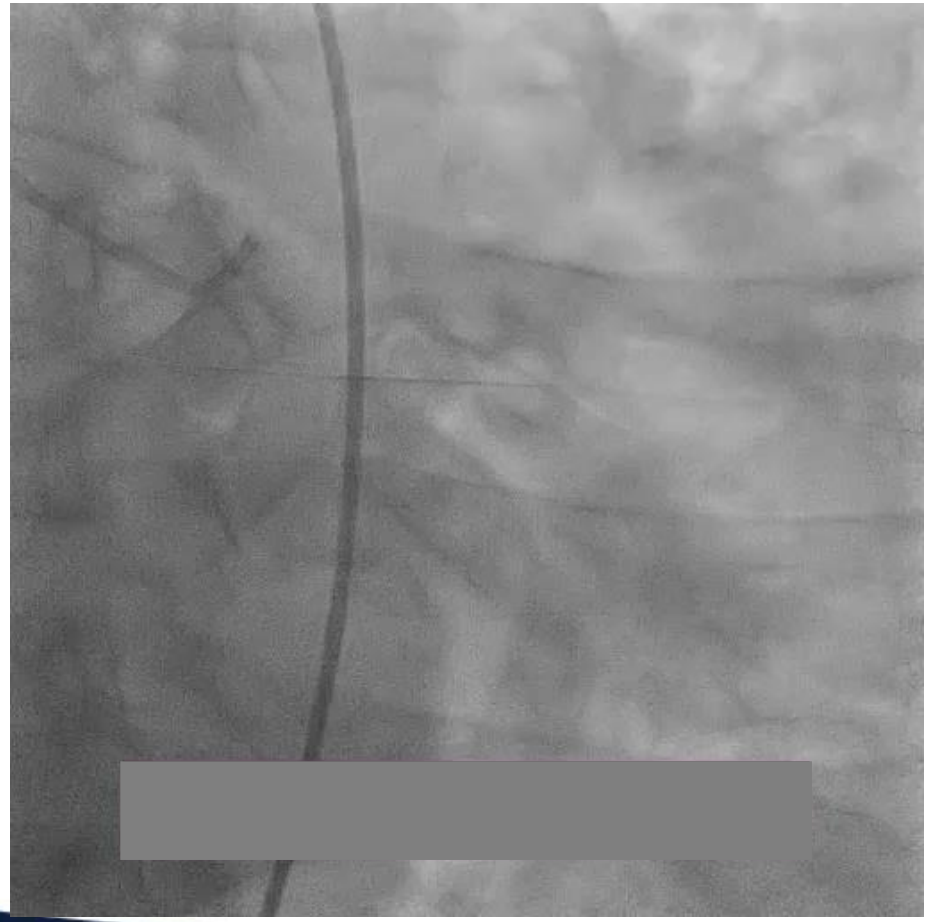
PTCA report

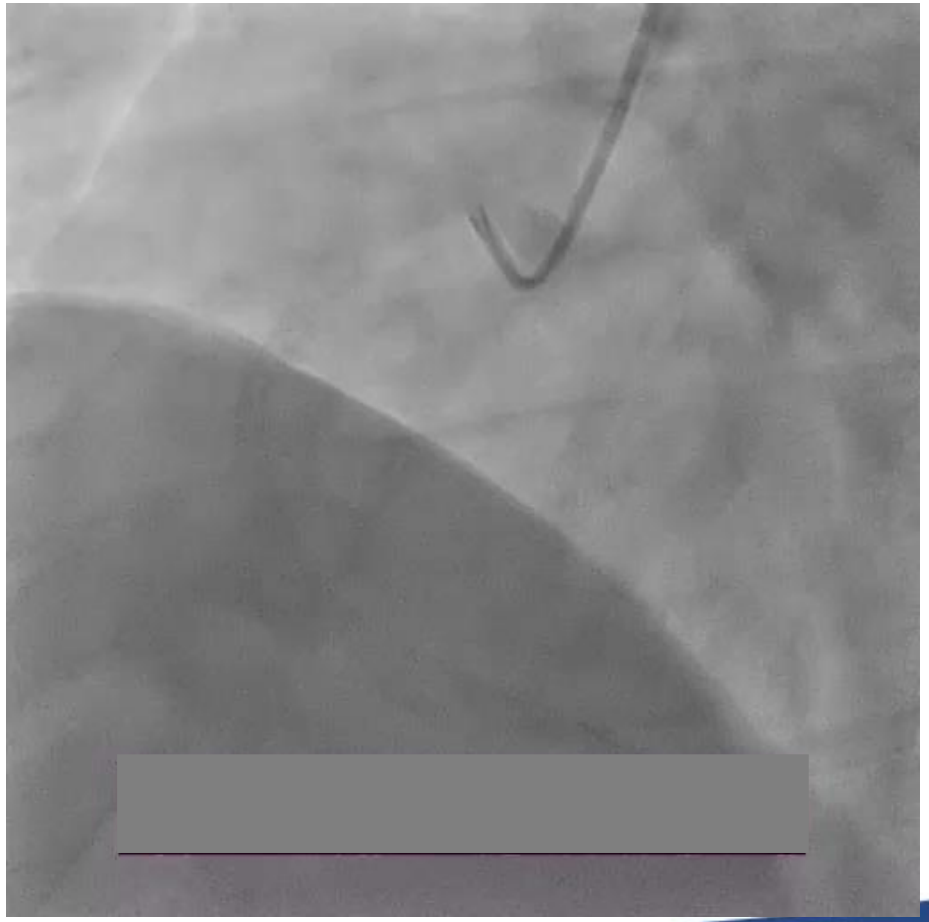
Pre angioplasty diagnosis	:	Coronary artery disease
Procedure	:	PTCA + stenting to RCA [OCT guided]
Anaesthesia	:	Local
Contrast used	:	Omini 100 ml
Catheter used	:	JR 3.5 6F Dragonfly OPTIS [OCT]
Guide Wire Used	:	0.014 x 180 cm Runthrough 0.014 / 0.009 x 190 cm Fielder XT
Anticoagulation	:	Heparin
Balloon	:	1.5 x 10 mm Ryurei 2.0 x 12 mm Traveler 3.0 x 12 mm NC Quantum Apex 3.0 x 25 mm Magic Touch 3.0 x 35 mm Magic Touch 3.0 x 10 mm Wolverine Coronary Cutting balloon [Boston Scientic]
Approach	:	Femoral
Stent	:	3.0 x 15 mm Xience Alpine 3.5 x 12 mm Xience Alpine

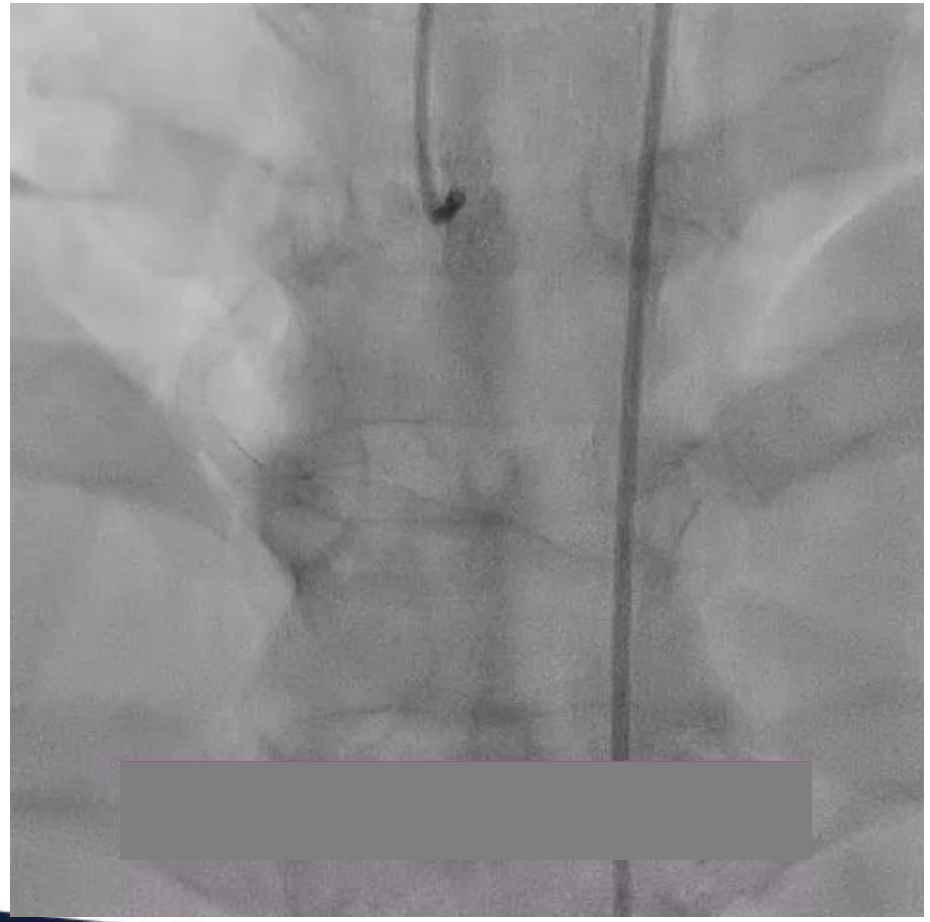
Reports	:	After informed consent, under local anesthesia, under cover of Inj. Heparin, through Right Femoral approach, RCA was engaged with JR 3.5 6F guiding catheter. The RCA lesion was crossed with 0.014 x 180 cm Runthrough guide wire and 0.014 / 0.009 x 190 cm Fielder XT wire also used. RCA lesion predilated with 1.5 x 10 mm Ryurei balloon. OCT run showed proximal stent MLA 1.35 mm2 with new plaque formation with mixed type Distal stent has NIH 600 um thickness and MLA 2.3 mm2 Further RCA lesion dilated with 2.0 x 12 mm Traveler balloon, 3.0 x 10 mm Wolverine Coronary Cutting [Boston Scientific] balloon and 3.0 x 12 mm NC Quantum Apex balloons. Previous stent area dilated with 3.0 x 35 mm Magic Touch DEB balloon to proximal stent and 3.0 x 25 mm Magic Touch DEB balloon to distal stent. Then, a 3.0 x 15 mm Xience Alpine stent was deployed between the stents portion followed by proximal portion stented with 3.5 x 12 mm Xience Alpine stent overlapping with previous proximal stent. TIMI III flow achieved. Post PCI OCT run showed MLA [mean]5.6 mm2 with well opposed stents and no dissection. Final check angiogram revealed optimally deployed stents with TIMI III flow and grade 3 TMP score. There was no residual stenosis or thrombus or dissection.
Final Result	:	Successful PTCA and stenting of RCA done with good result.

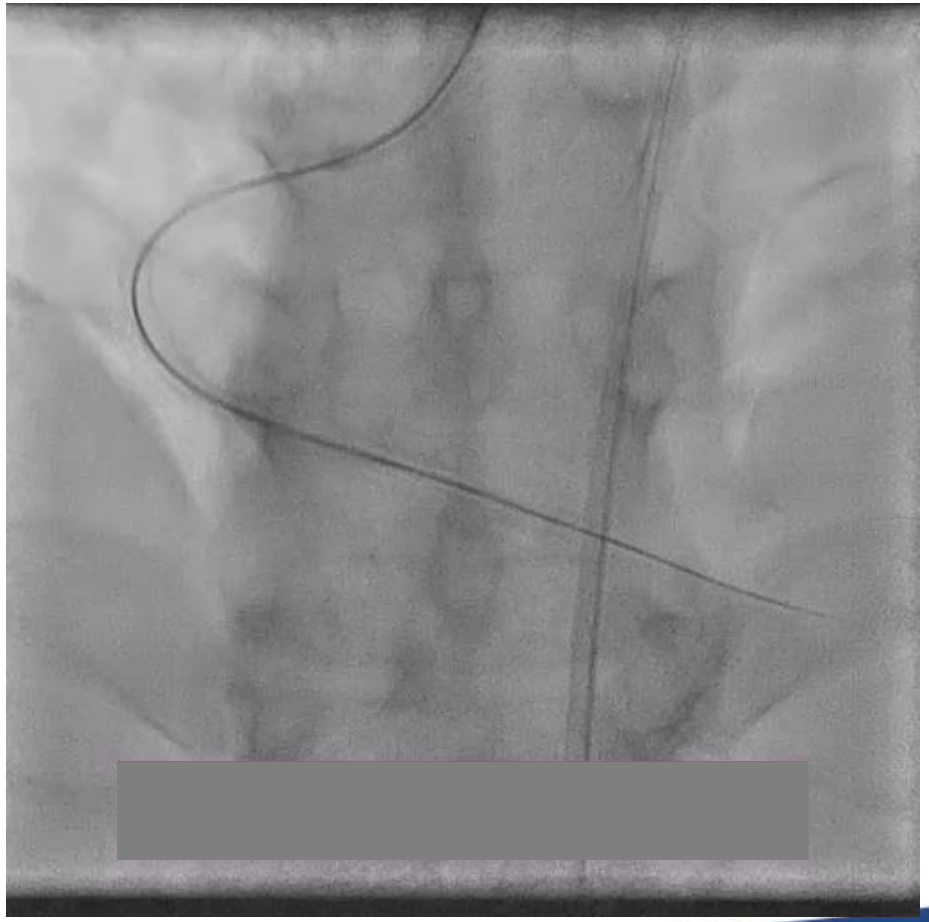
DRAFT

Mr. P – Cresecendo Angina (old H/oInf MI RCA Stenting- 2015/2016>> 2023)

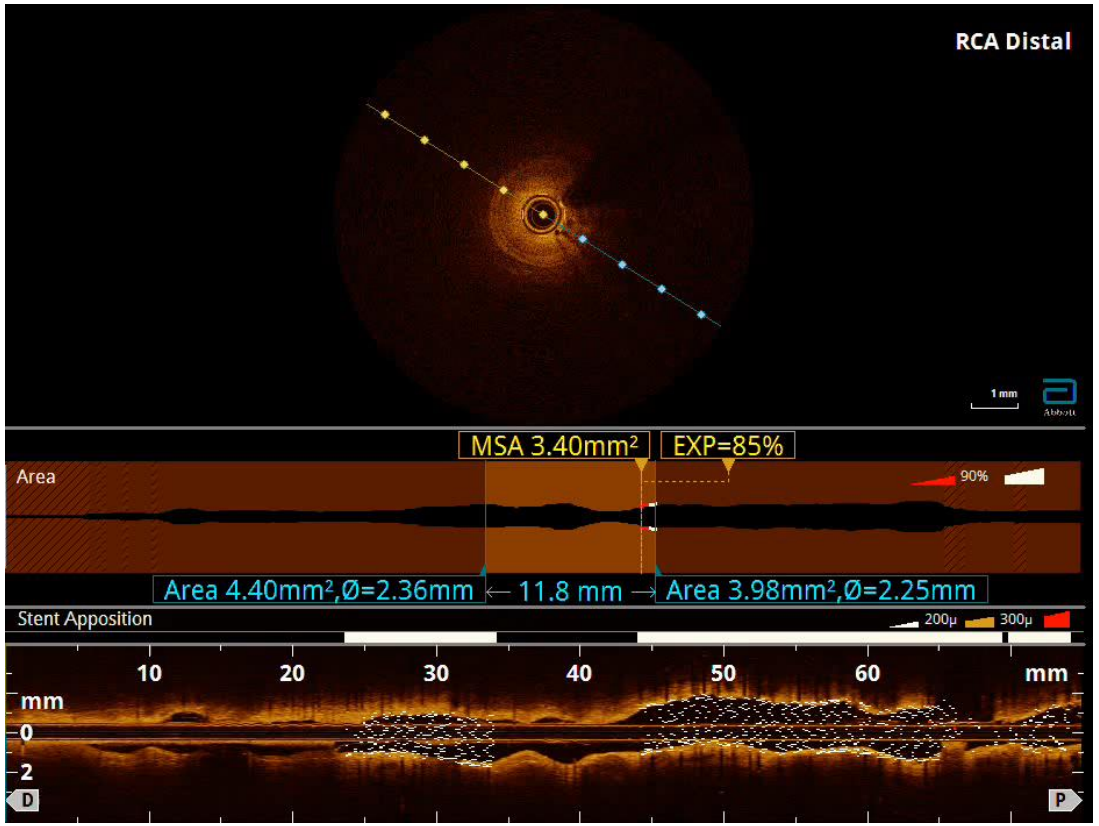


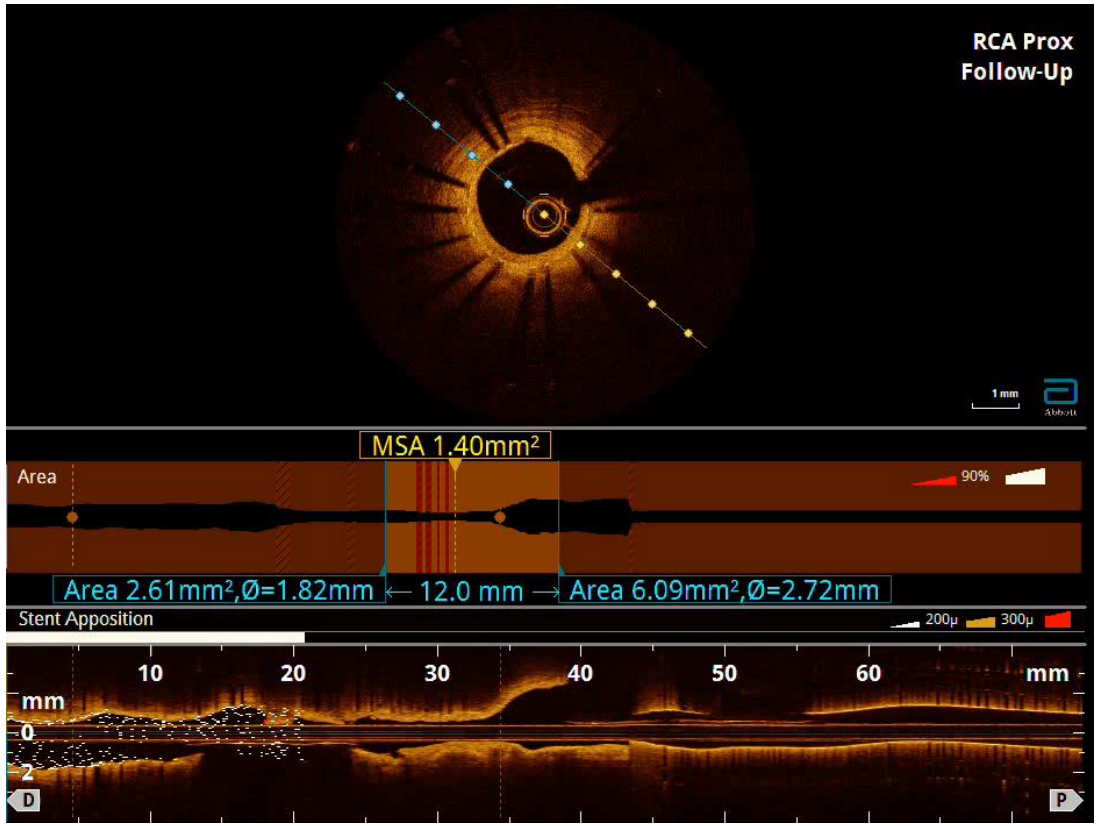




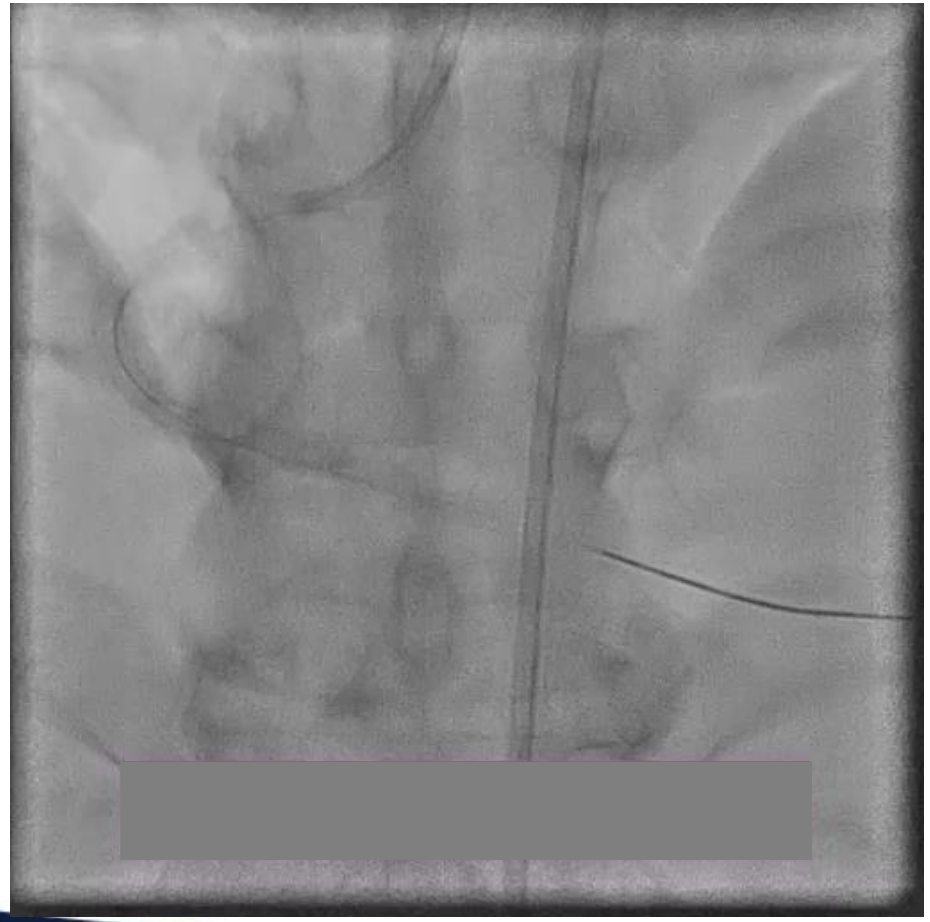


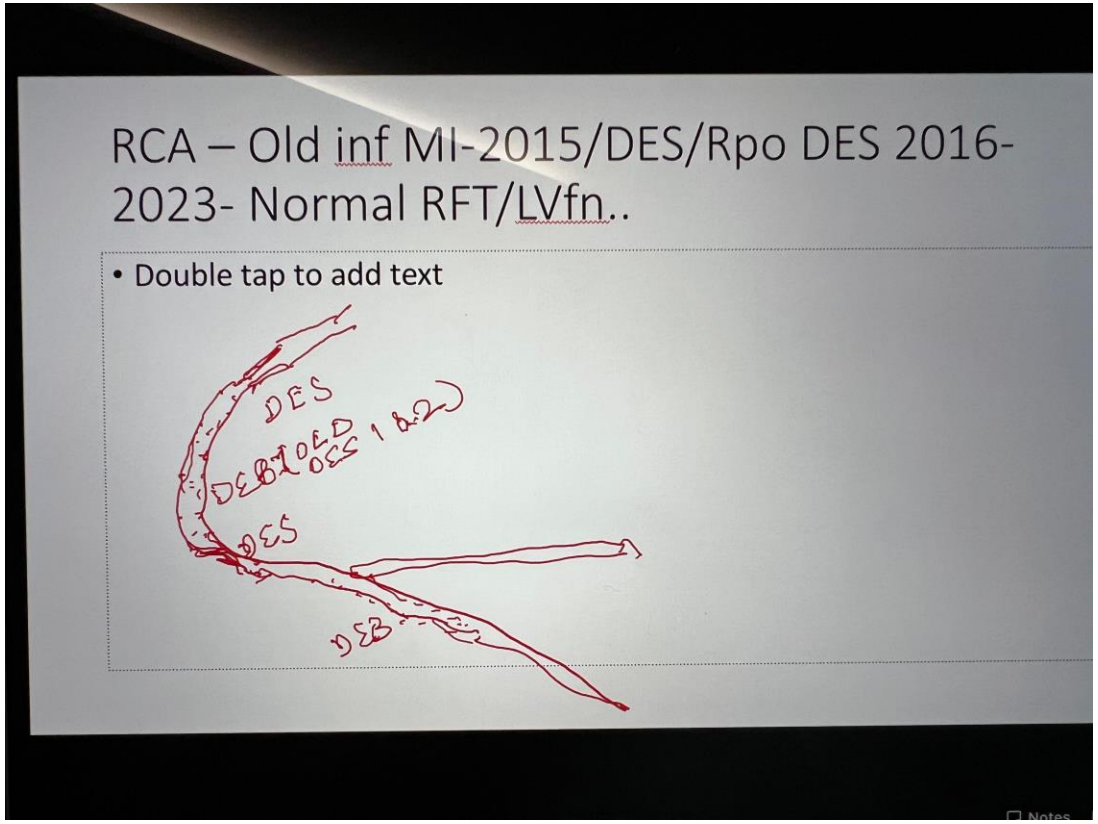
OCT


RCA Distal
1 mm
MSA 3.40mm²
EXP=85%
Area
90%
Area 4.40mm²,Ø=2.36mm
11.8 mm
Area 3.98mm²,Ø=2.25mm
Stent Apposition
200µ
300µ
10
20
30
40
50
60
mm
mm
0
2
D
P

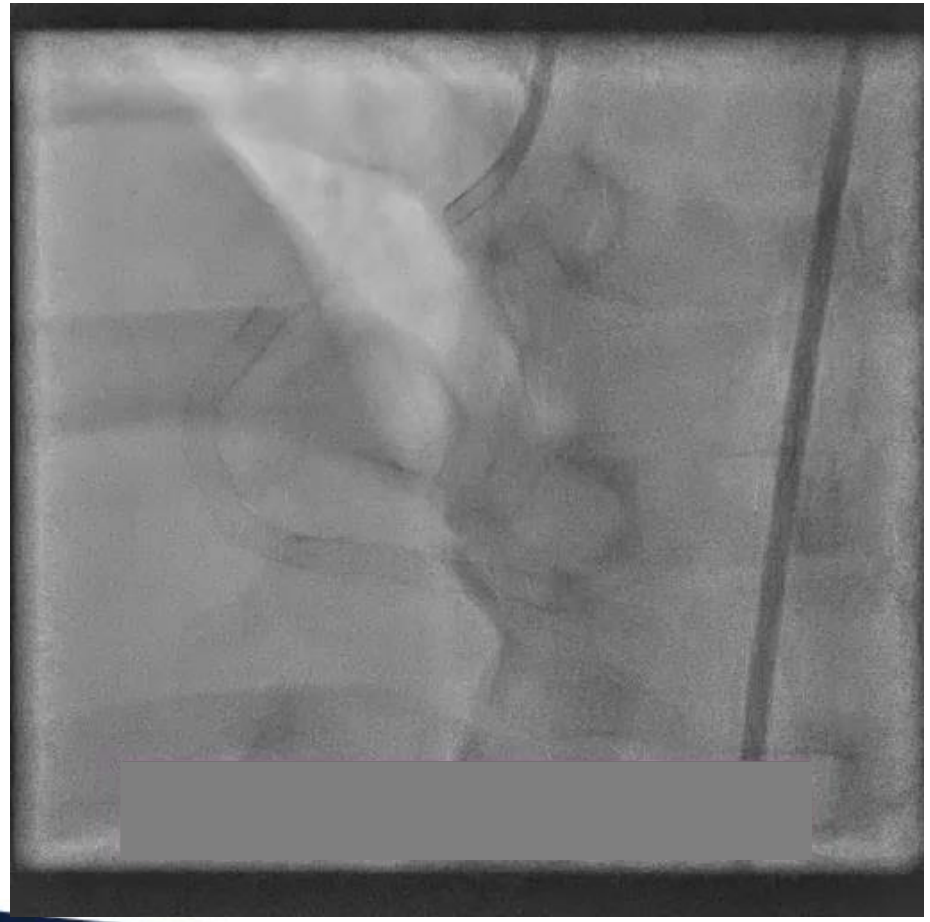

RCA Prox
Follow-Up
1 mm
MSA 1.40mm²
Area
90%
Area 2.61mm²,Ø=1.82mm
12.0 mm
Area 6.09mm²,Ø=2.72mm
Stent Apposition
200µ
300µ
10
20
30
40
50
60
mm
mm
0
2
D
P

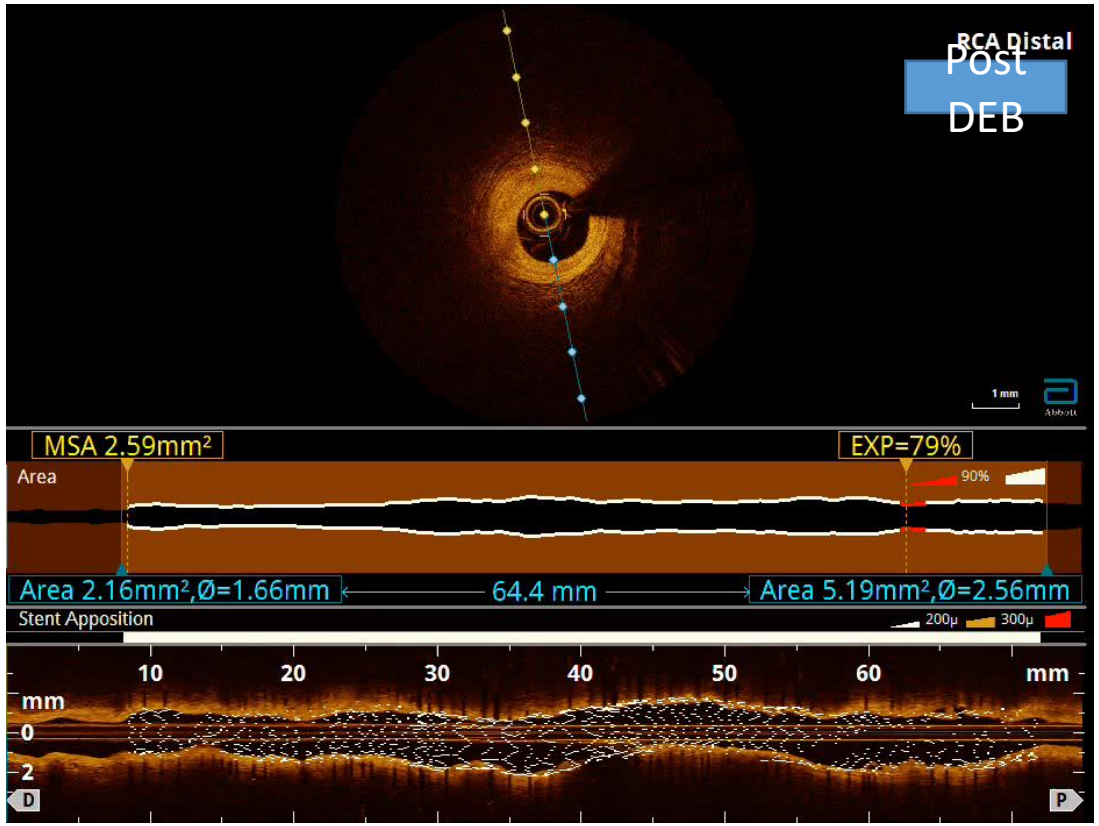
RCA – Plan after OCT



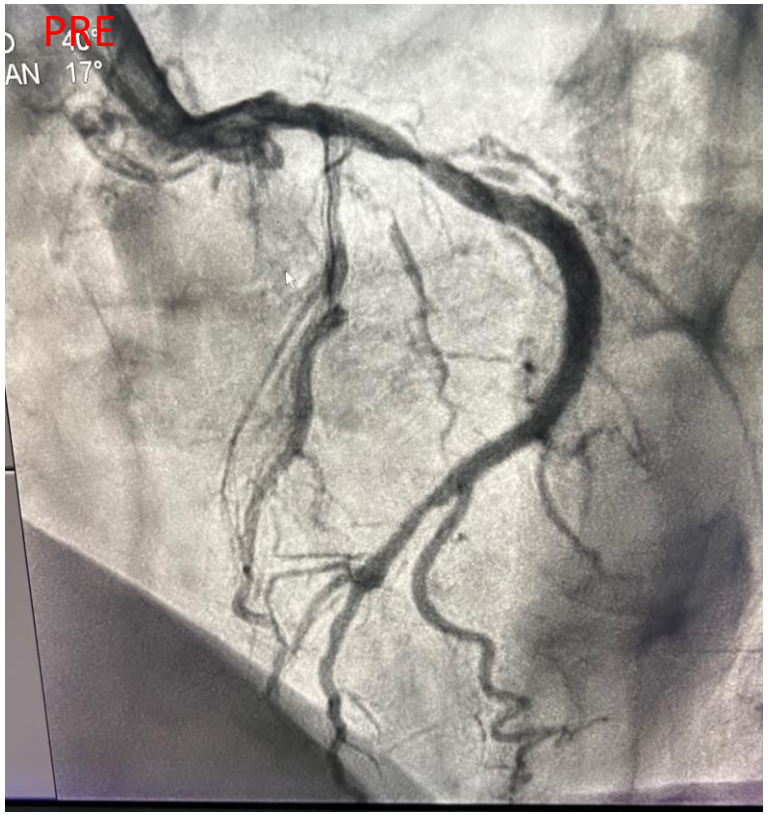


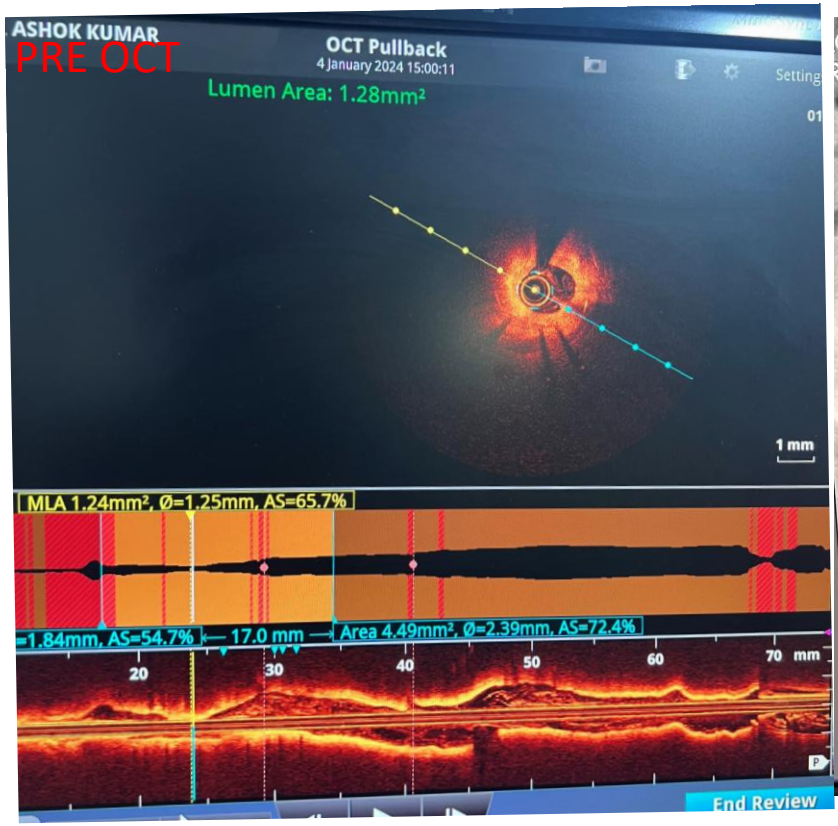
RCA – Final Result

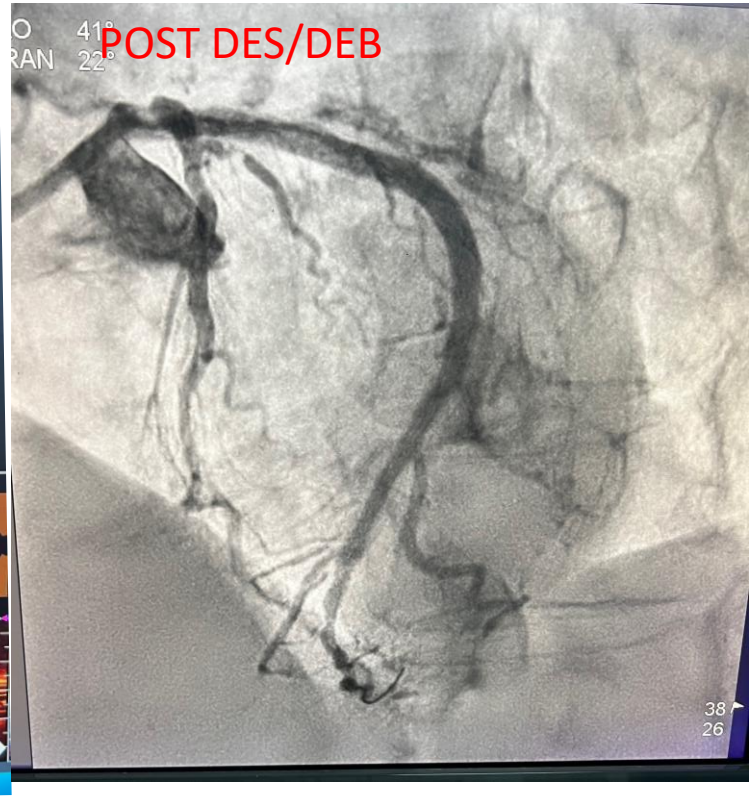




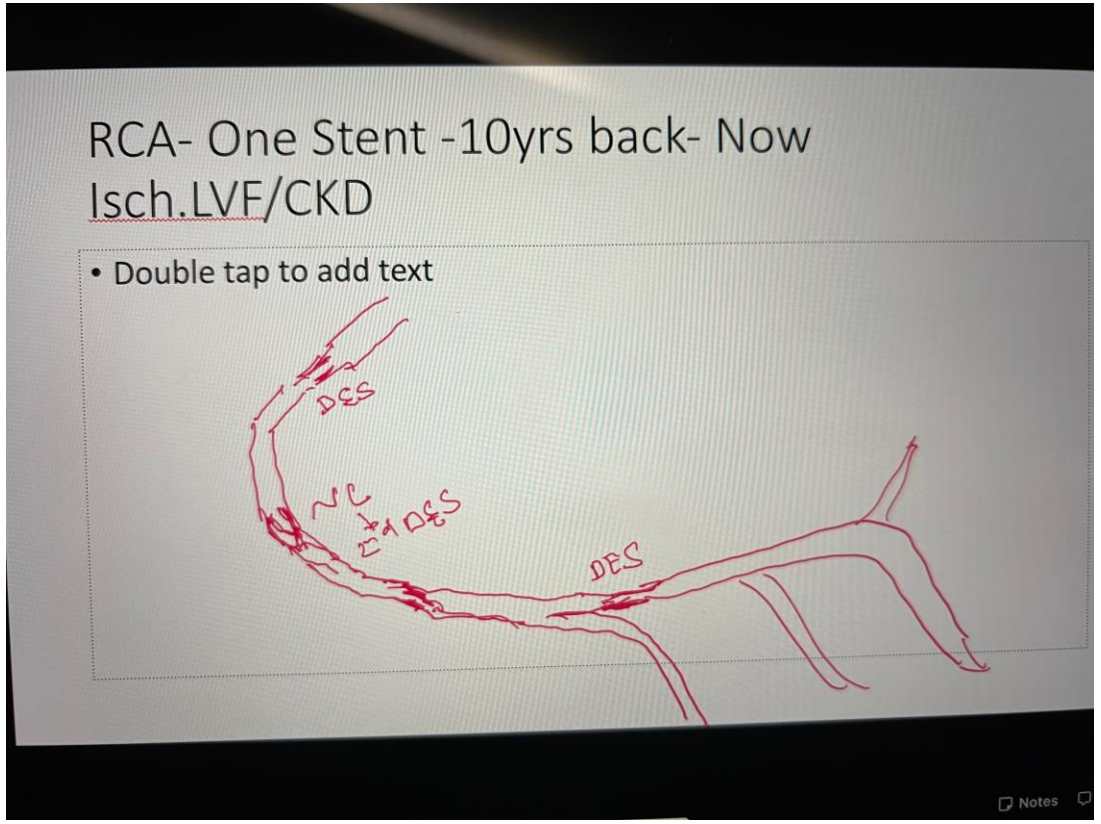
72yr/M-Post Distal LCx Stent – Angina/TMT+ve.



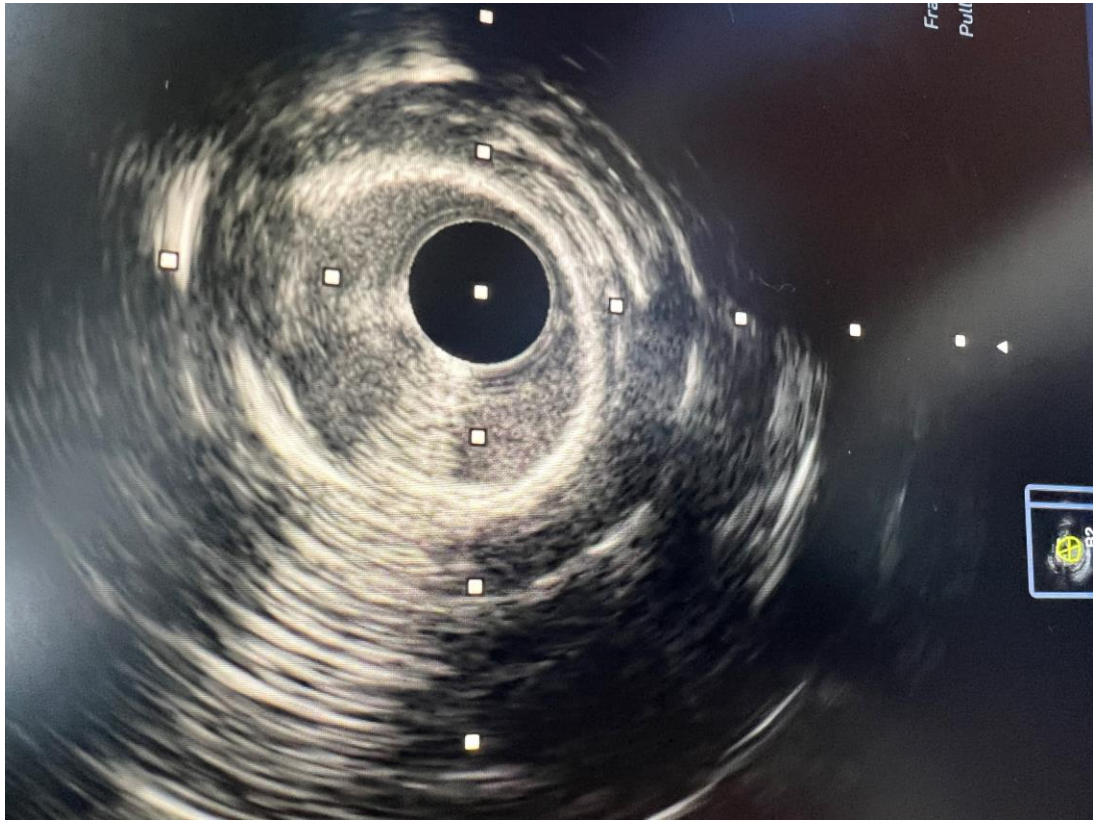


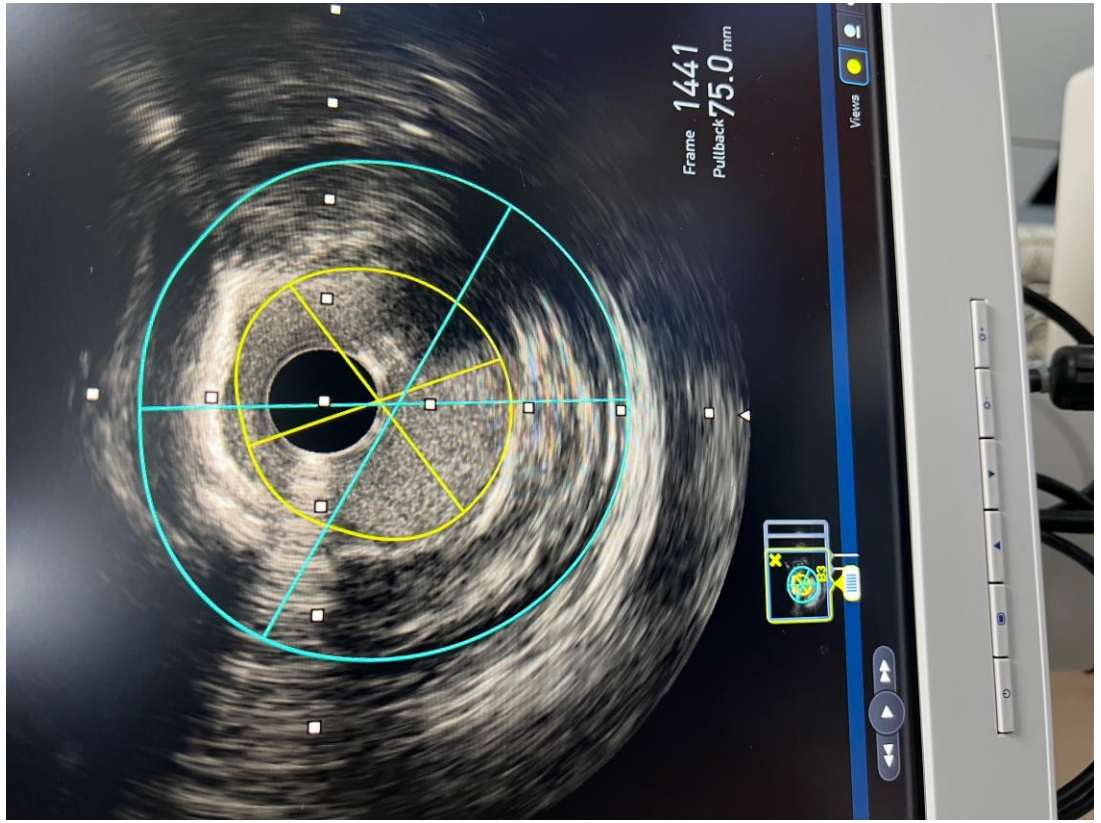


79 yr/M – Old RCA stent -10yrs back/CKD

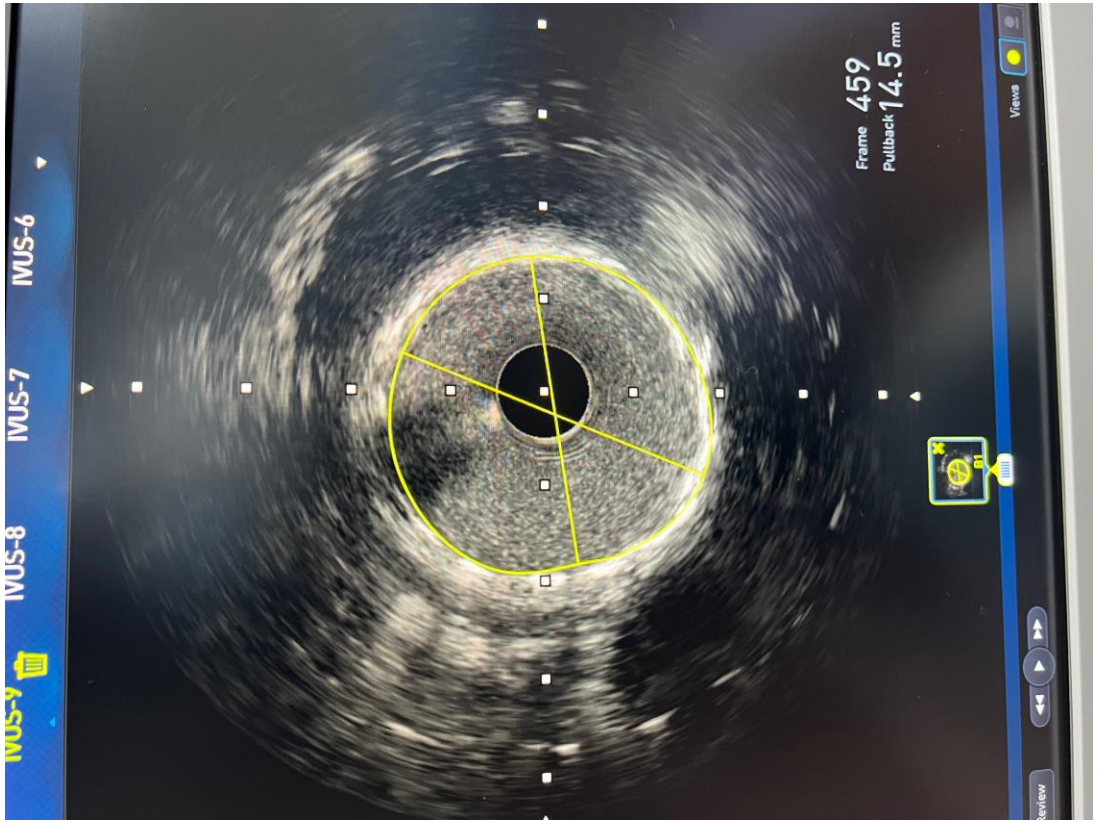


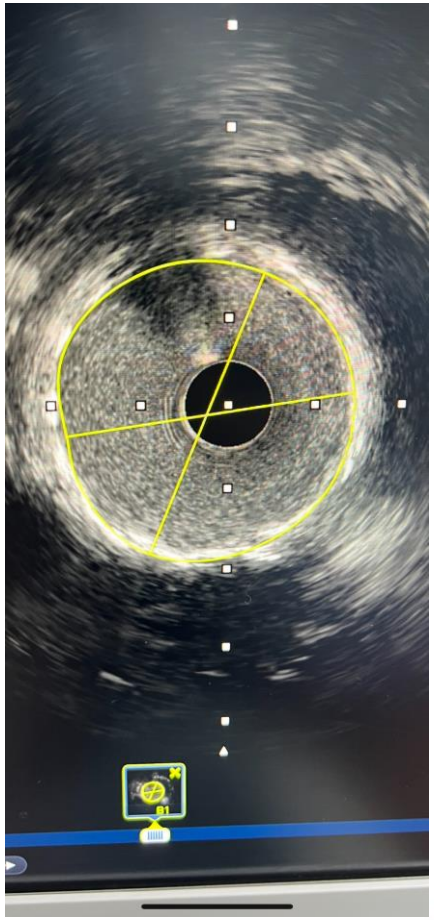
RCA- IVUS – Neointimal Hyperplasia





RCA – Post Stent IVUS- Prox & Distal



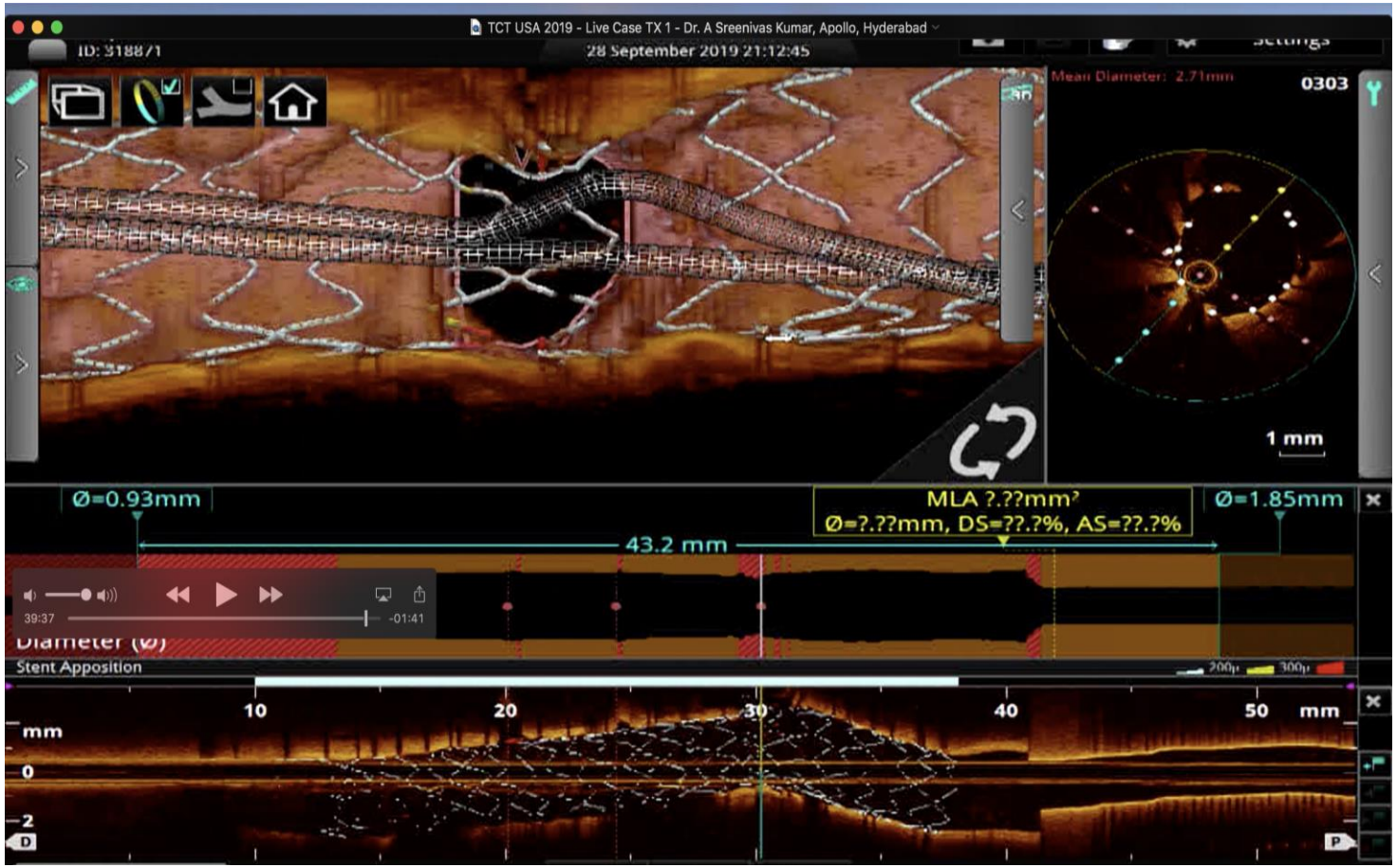


RCA – Pre & Post PCI – Documentation Cine.

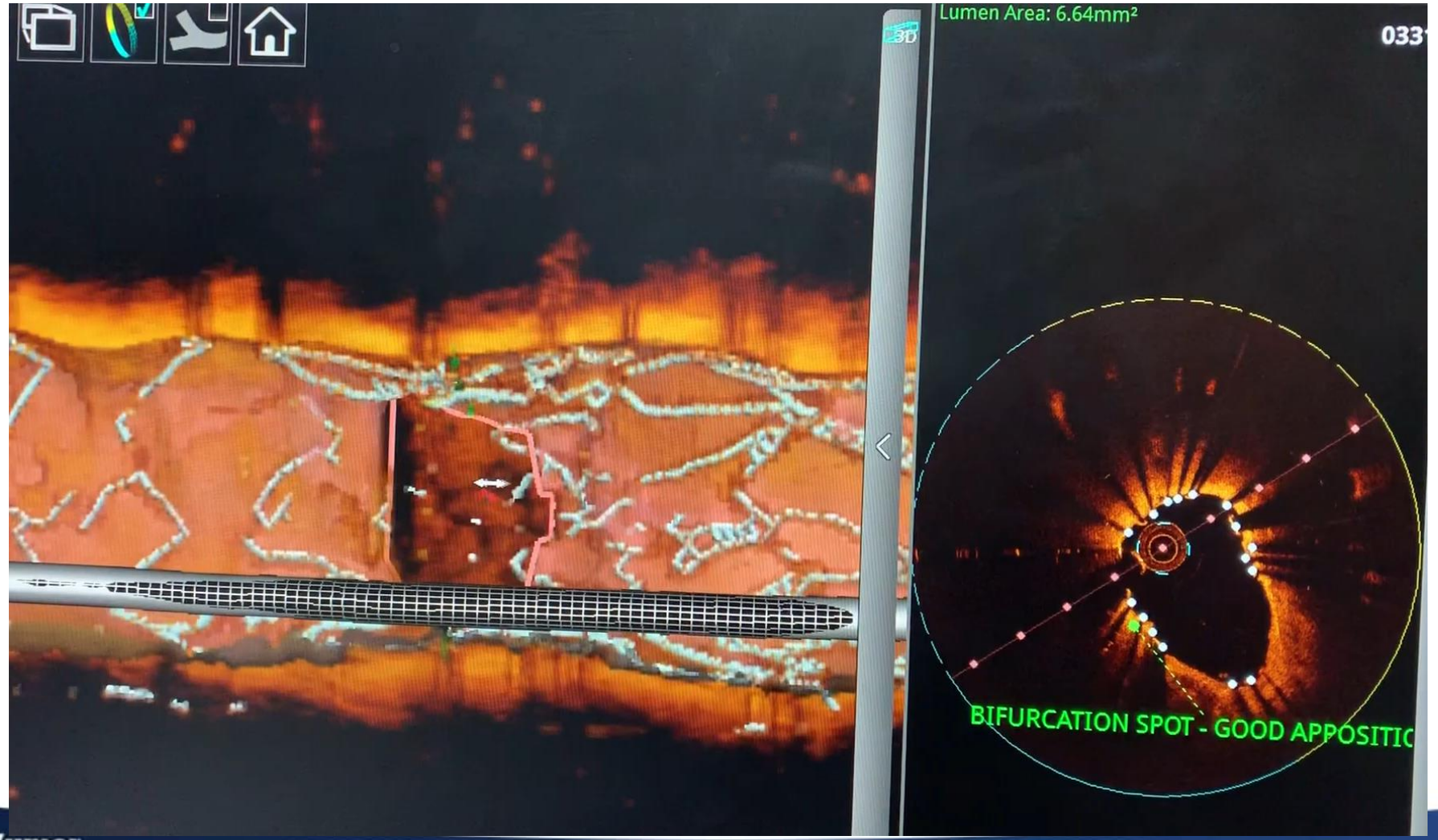
OCT in Bifurcation Disease

- MV & Side branch Assessment
- Strut Crossing – Distal strut in Provisional, Mid or Prox- 2Stent Str.
- Bifurcation Mode/Fly through Modes/Carinal Modes.
- Rule out Ostial Miss
- Optimal Kiss
- Optimal POT
- Final POT

Post PCI – OCT Bifurc. View –Ost LCX

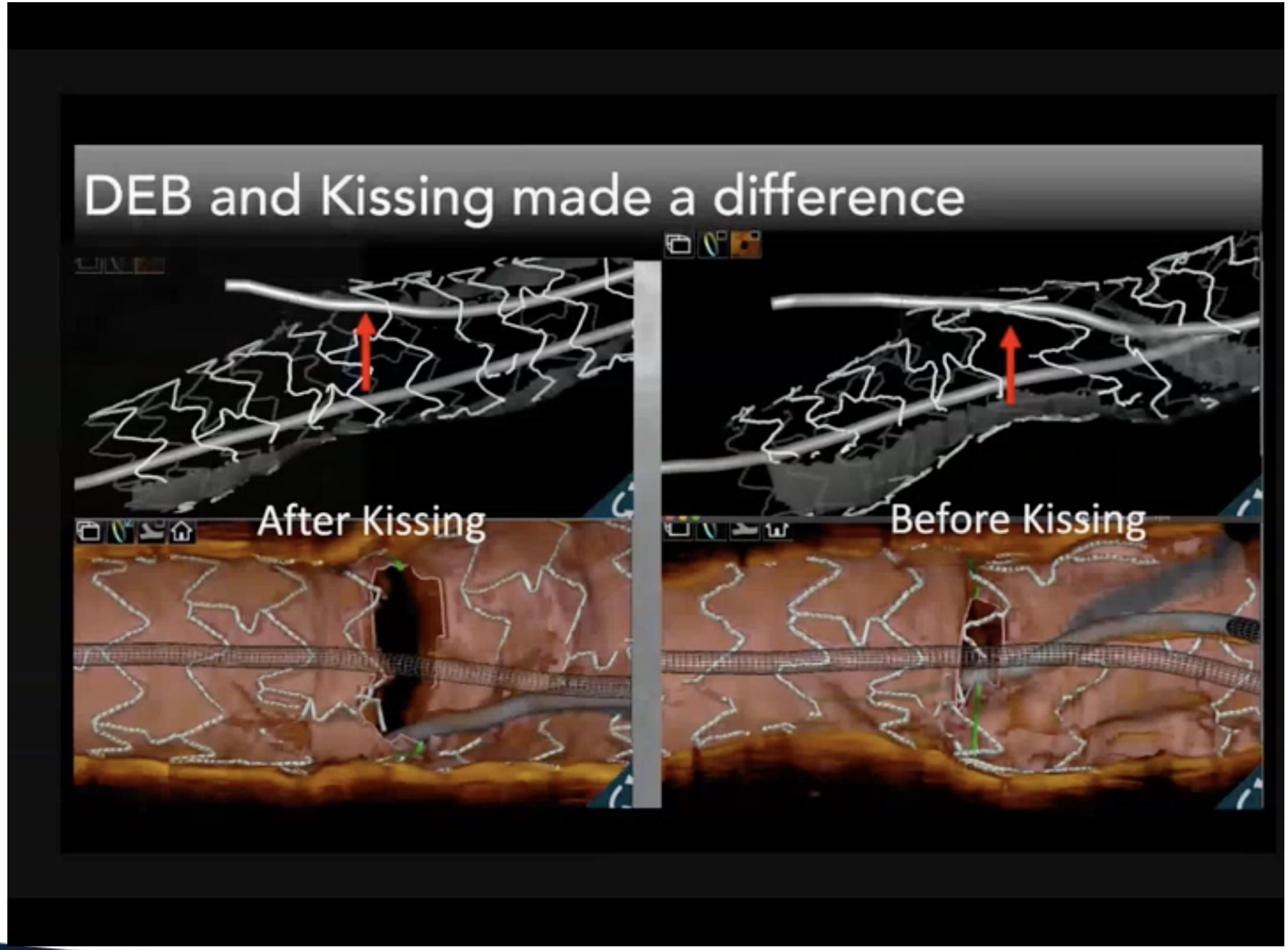


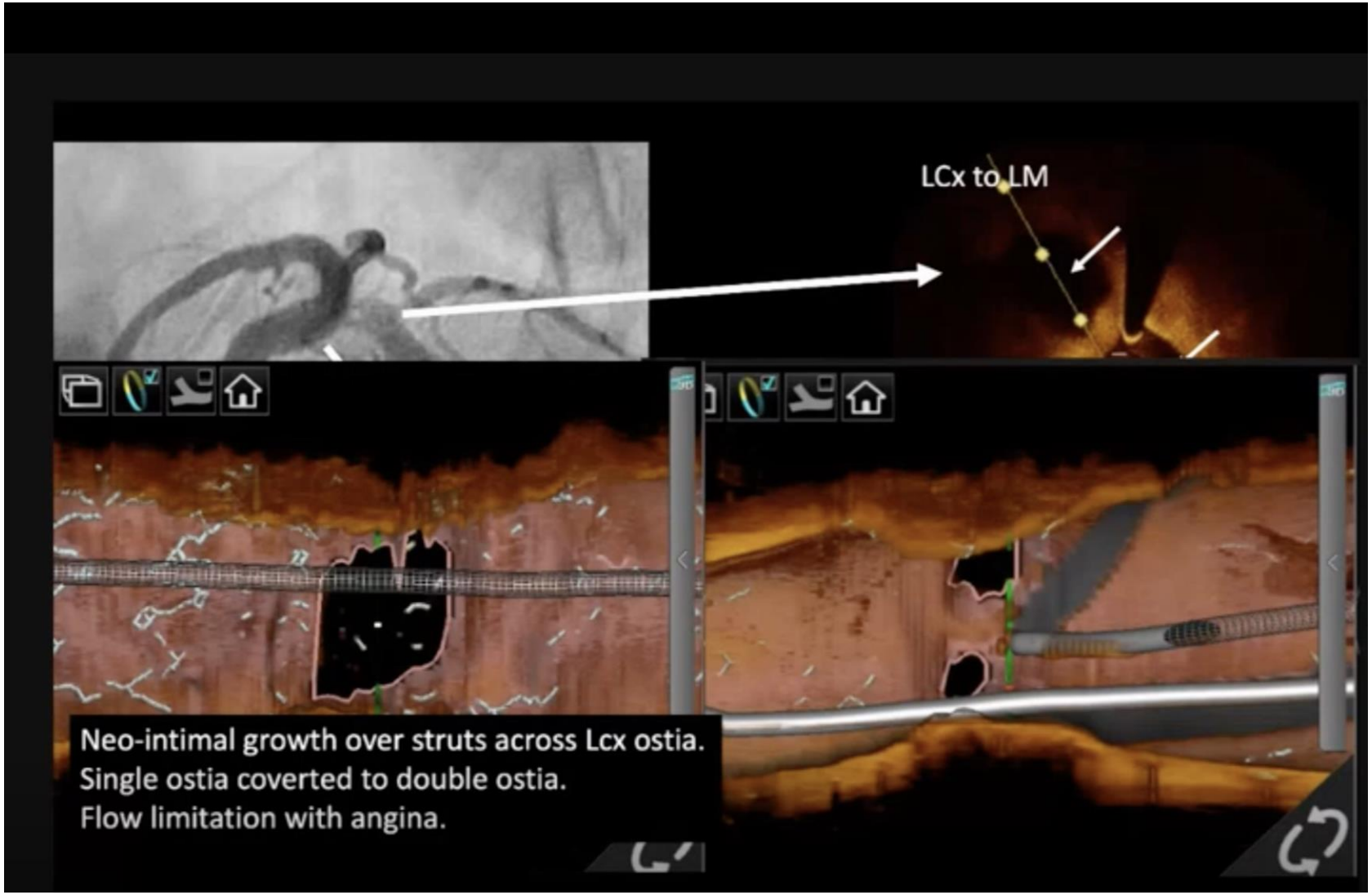
Bifurcation Mode- Assessment of SB Ostium



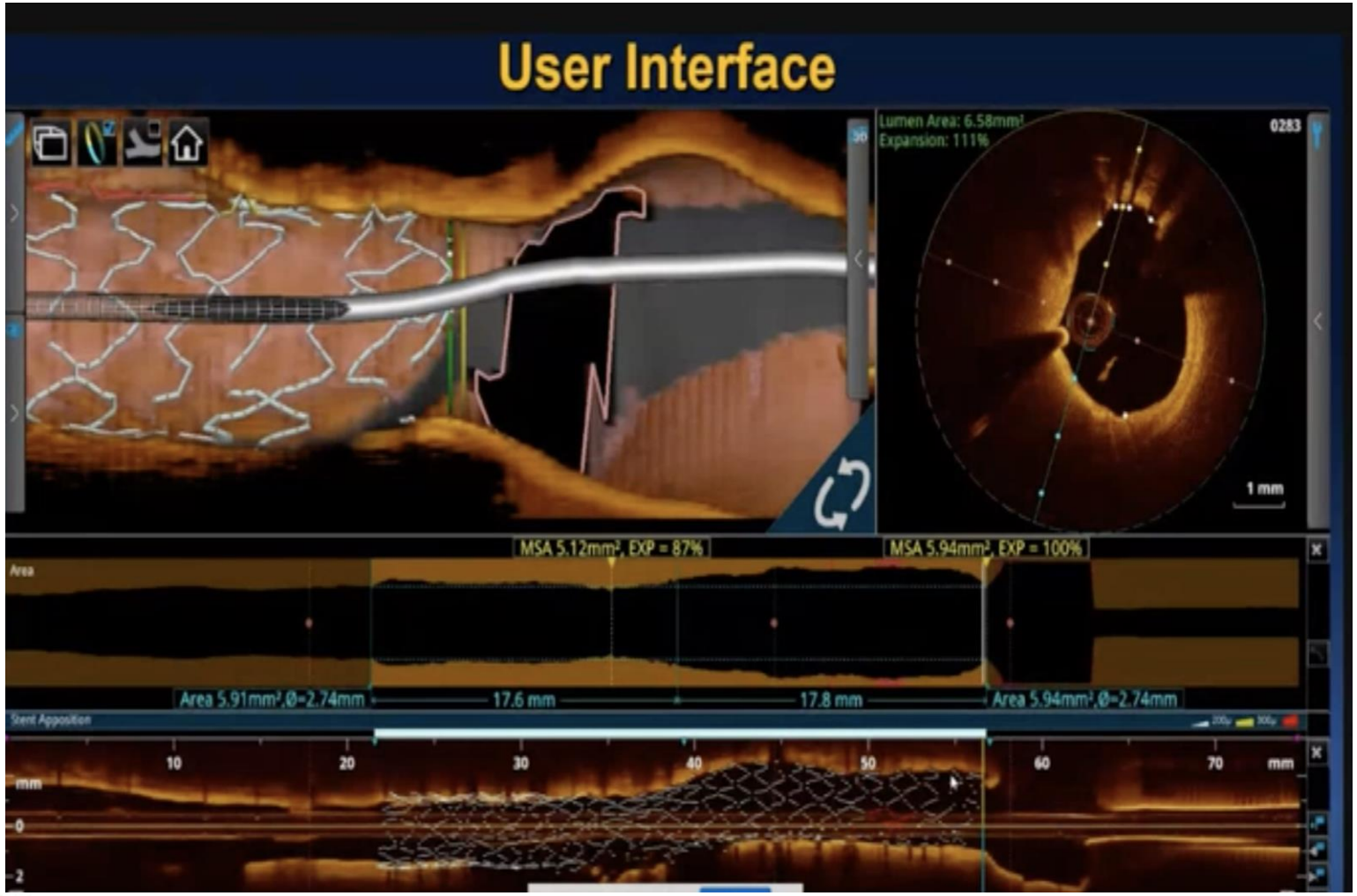
Dr. A. Sreenivas Kumar
Director, Cardiology & Clinical Research.

Apollo HOSPITALS
TOUCHING LIVES

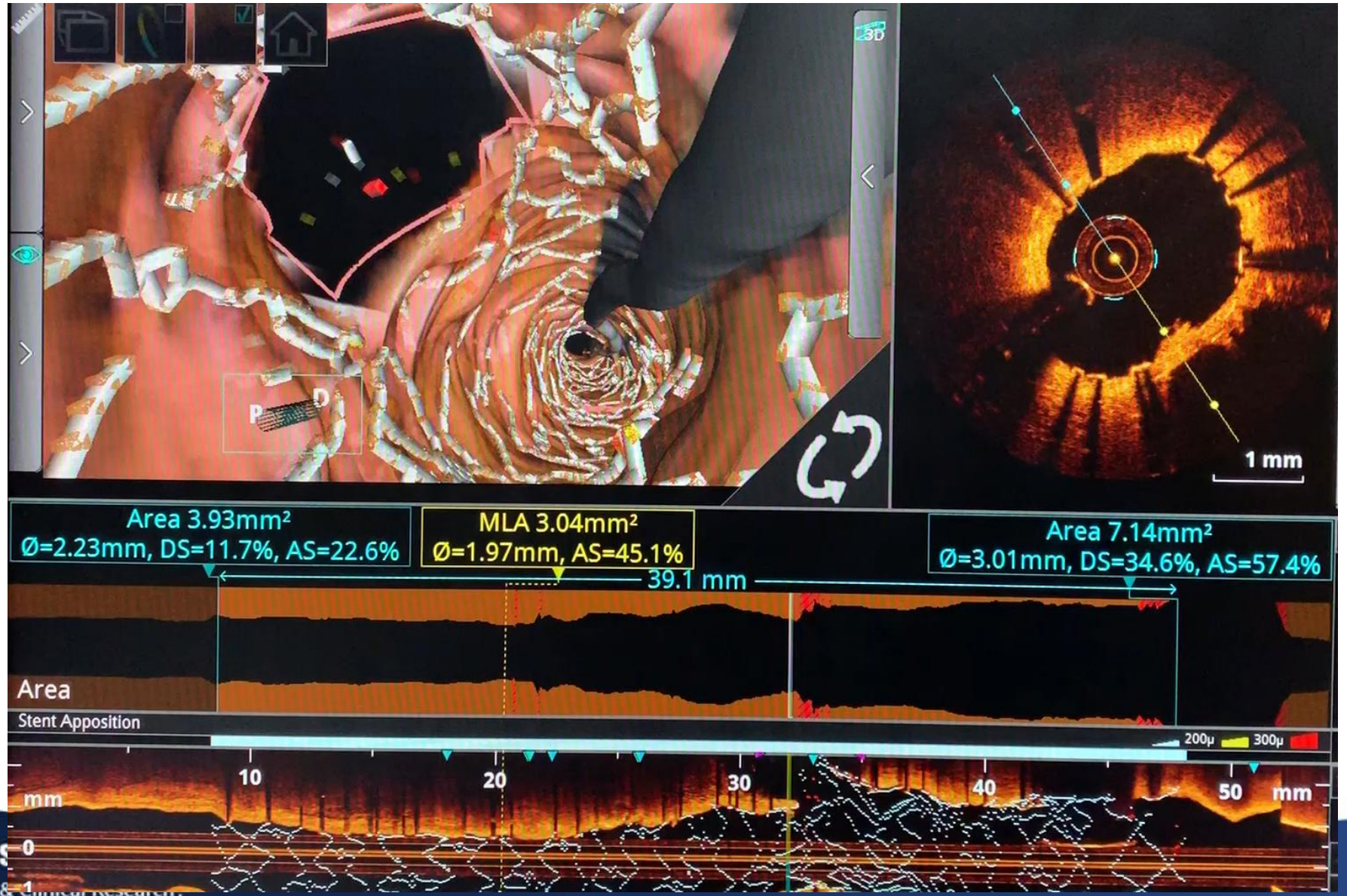

DEB and Kissing made a difference
After Kissing
Before Kissing


LCx to LM
Neo-intimal growth over struts across Lcx ostia.
Single ostia coverted to double ostia.
Flow limitation with angina.

Ostial miss


User Interface
Lumen Area: 6.58mm²
Expansion: 111%
0283
1 mm
MSA 5.12mm², EXP = 87%
MSA 5.94mm², EXP = 100%
Area
Area 5.91mm², Ø=2.74mm
17.6 mm
17.8 mm
Area 5.94mm², Ø=2.74mm
Stent Apposition
10
20
30
40
50
60
70
mm

Post stent MB flythrough mode-Assessment of SB



Conclusions

- 80% of cases can be done by either modality- use as per availability and operator comfort.
- IVUS – Ostial Lesions/ CKD/ LVD- Sick Patients./CTO lesions.

Easy to Acquire Images – little difficult in interpretation(learning curve)

- OCT – ACS/Morphology assessment / Stent Expansion/Mal apposition/ISR/ Bifurcation /Stable patients.

Difficult to acquire good images – but once obtained crystal clear images –easy to interpret (less learning curve)