Coronary Physiology or Imaging…

Or Both

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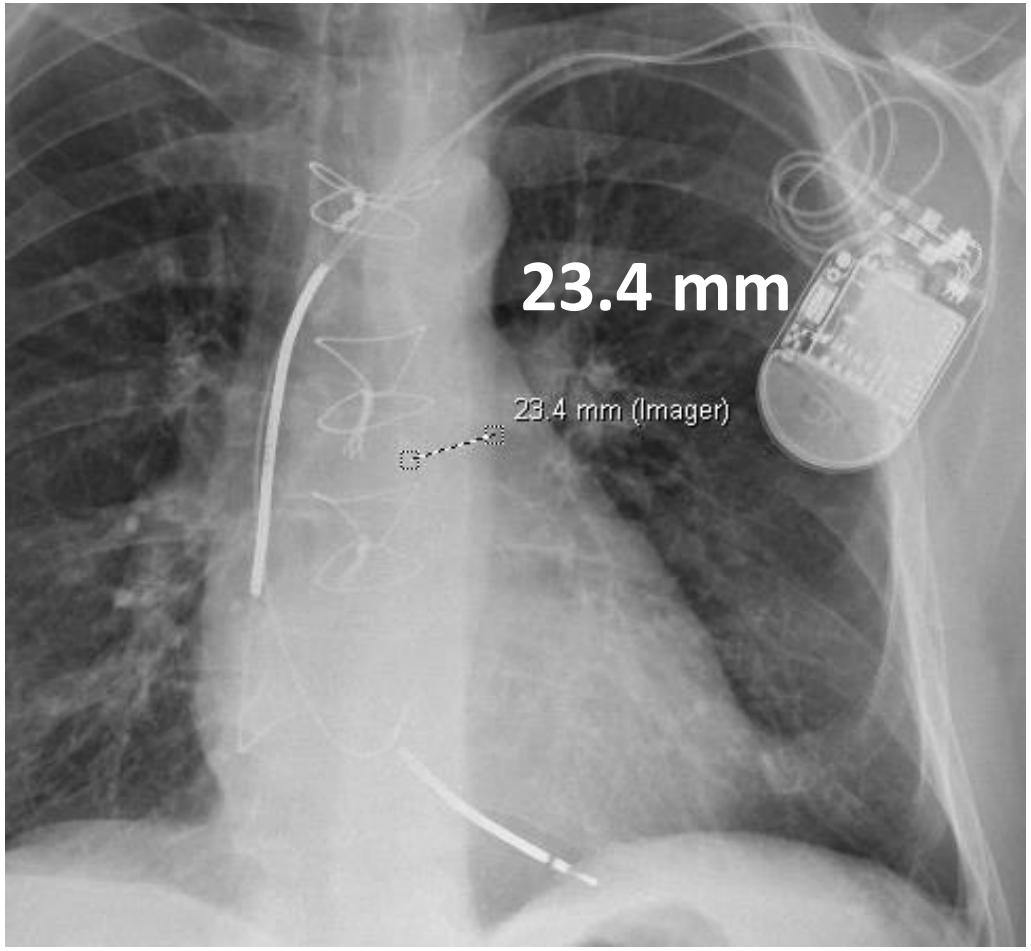
Disclosure Statement of Financial Interest

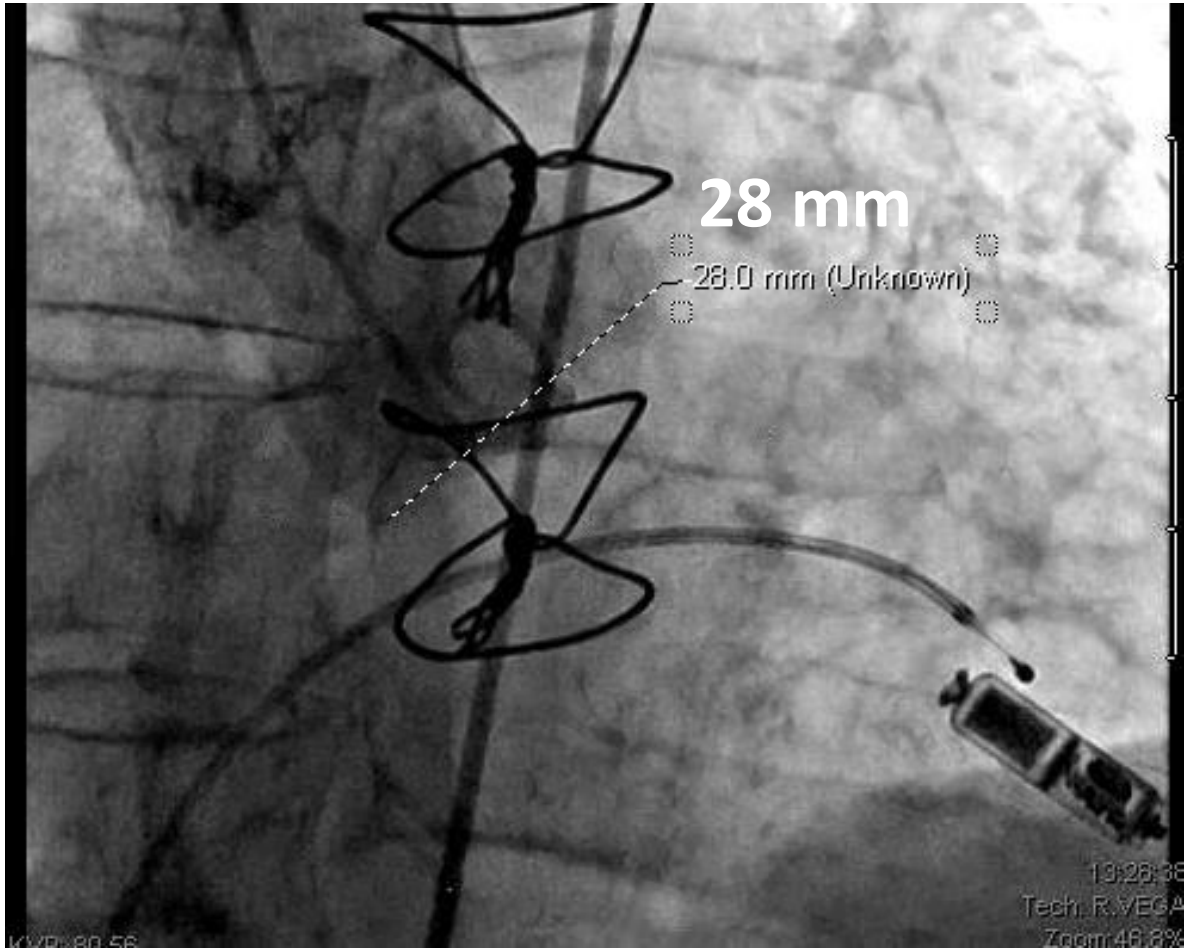
Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

Affiliation / Financial Relationship	Company
Grant/Research Support	NA
Consulting Fees / Honoraria	Philips
Major Stock Shareholder/Equity	NA
Royalty Income	NA
Ownership/Founder	NA
Intellectual Property Rights	NA
Other Financial Benefit	NA

Case Presentation

- 82-year-old woman presents with exertional dyspnea and pre-syncope.
- Medical History
  - Hypertension
- Physical Exam
  - BP 168/90; HR 90;
  - Clear Lungs
  - 4/6 systolic late peaking crescendo-decrescendo murmur
- Echo with normal EF and severe AS; V_{max} 5.2 m^2 and MG of 50 mmHg
- Coronary Angiogram shows normal coronaries
- Heart Team Decided TAVR was the best option for AVR





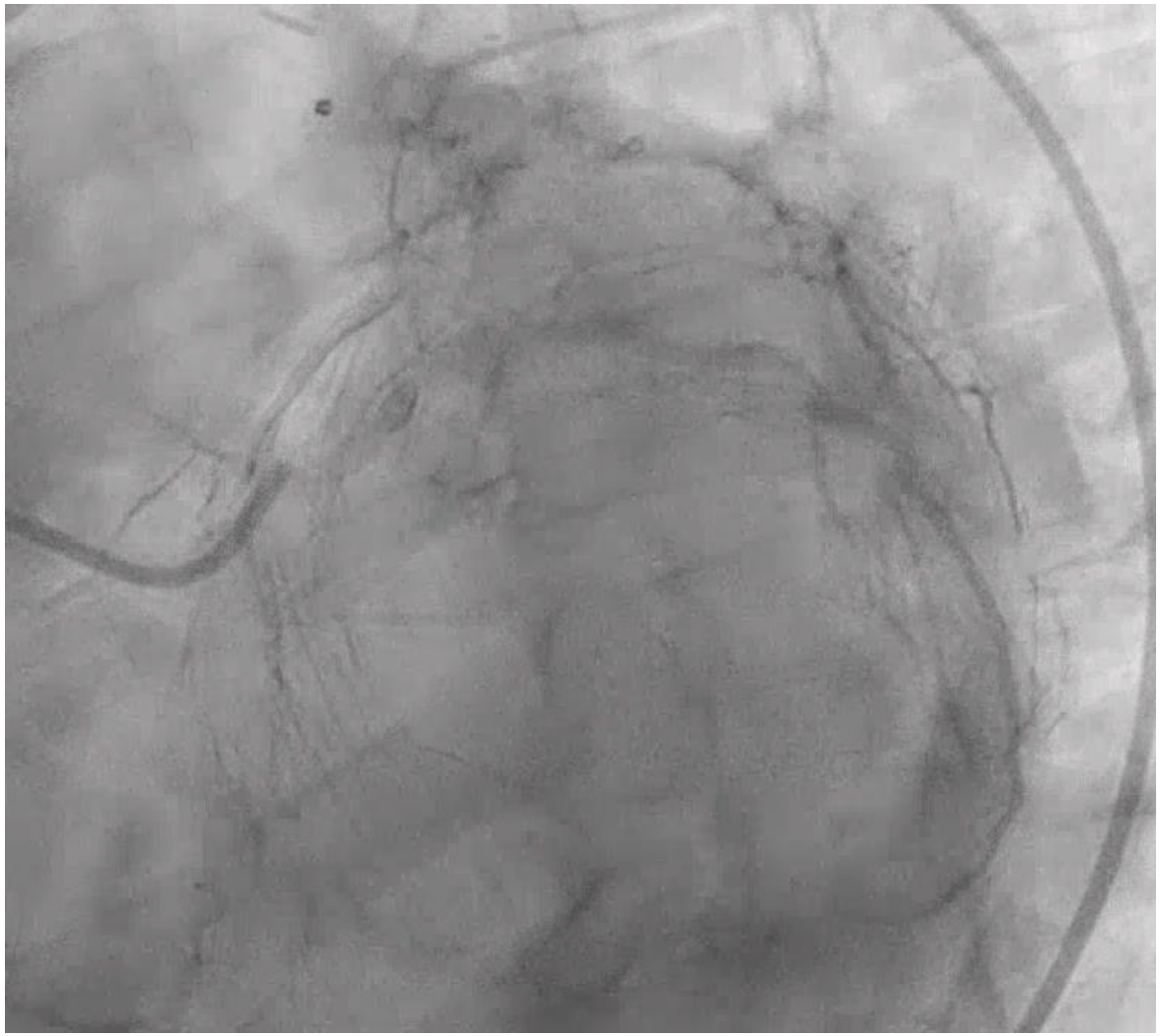
Based on X-Ray Imaging, what size valve do you place?

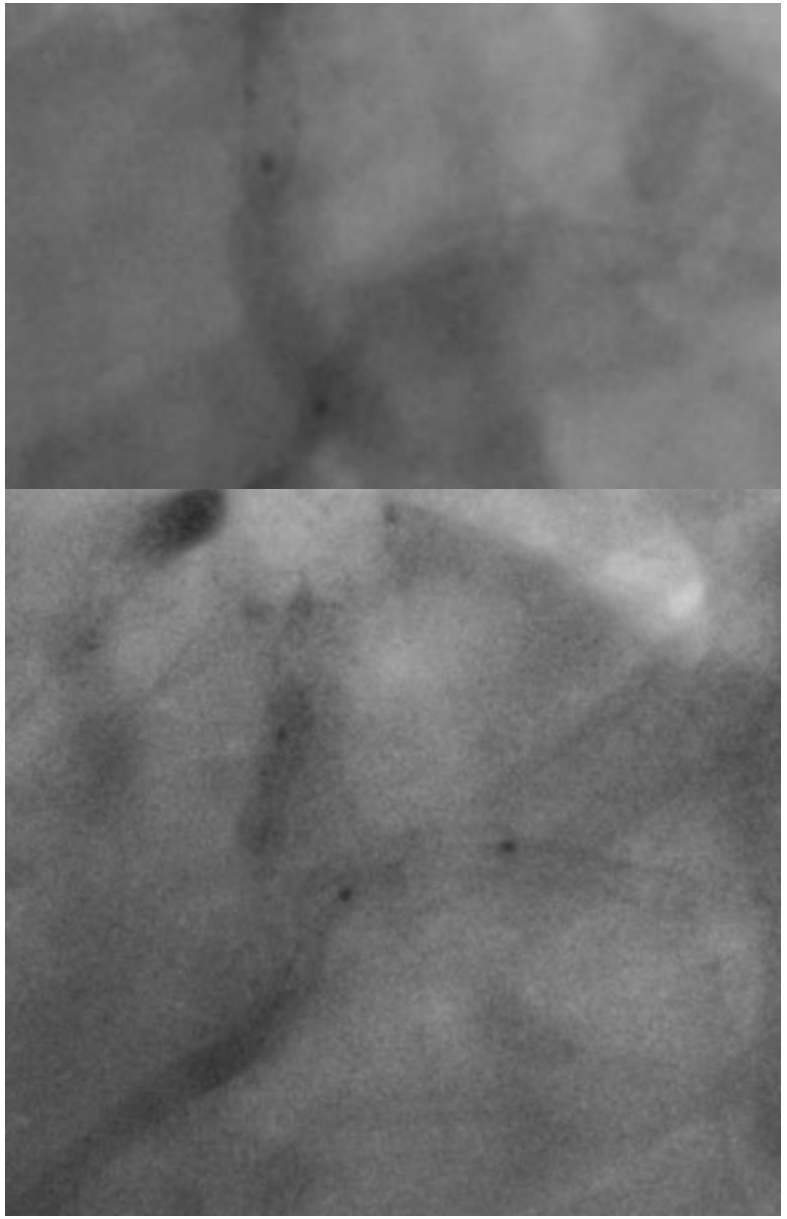
Modes of Stent / Target Lesion Failure

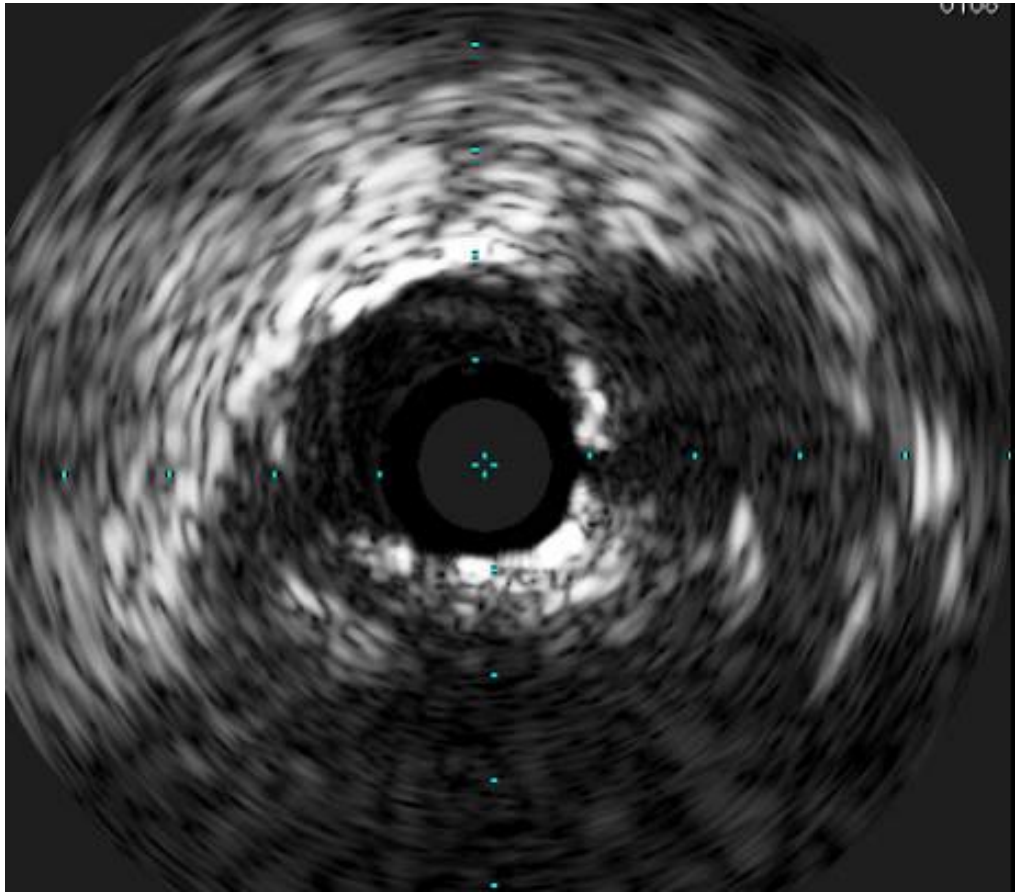
- Primary Drivers:
  - Small Minimal Stent Area (Stent Underexpansion)
    - **Calcium** or Too Small of a Stent
  - Edge Problems
    - Geographic Miss, Large plaques, Calcium, Dissections
- Secondary / Other Drivers
  - Plaque Protrusion (particularly in AMI)
  - *Stent Length*
  - *Asymmetry/Eccentricity*
  - *Acute Malapposition*

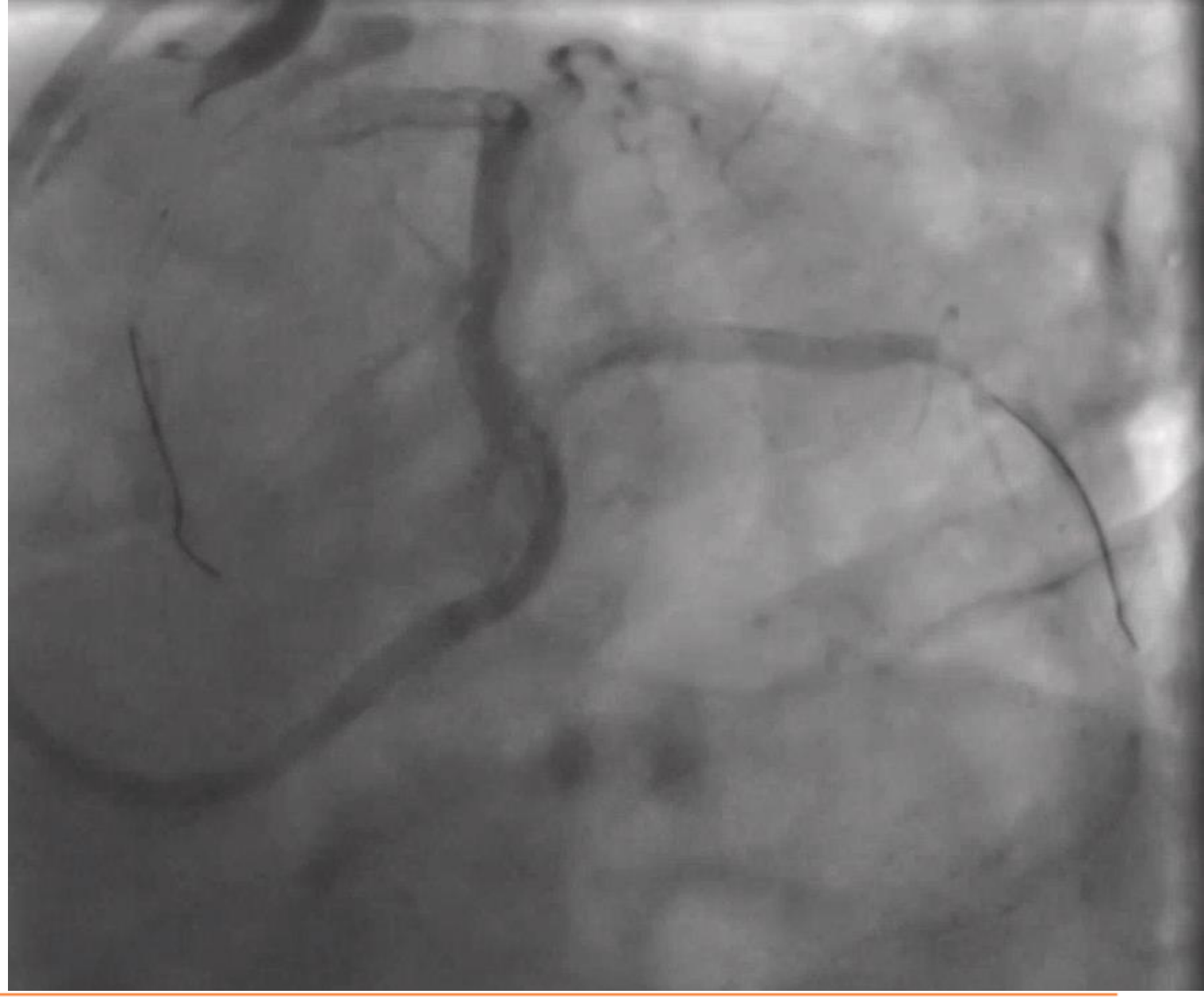
Liu et al. JACC Cardiovasc Interv. 2009;2:428-34
Lee etal. Circ Cardiovasc Interv. 2021;14:e011124.
Park et al. JACC Cardiovasc Interv 2020;13:1403-13
Kobayashi et al. Circ Cardiovasc Interv. 2016;9:e003553
Jeremias et al. J Am Coll Cardiol Intv. 2019;12(20):1991-2001

Mistakes I've tried not to repeat…









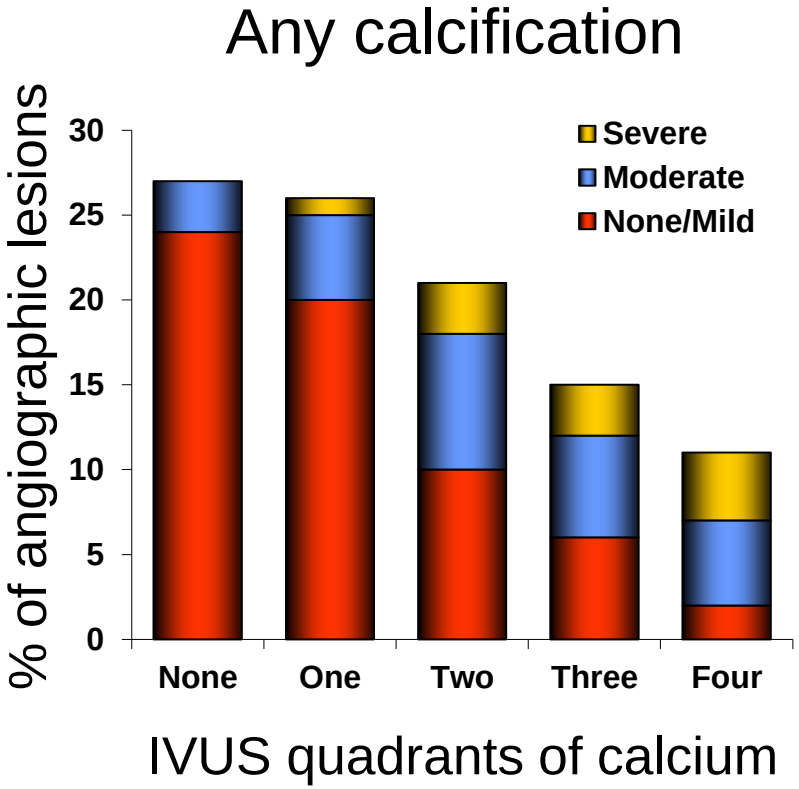
ARTICLE

Patterns of Calcification in Coronary Artery Disease

A Statistical Analysis of Intravascular Ultrasound and Coronary Angiography in 1155 Lesions

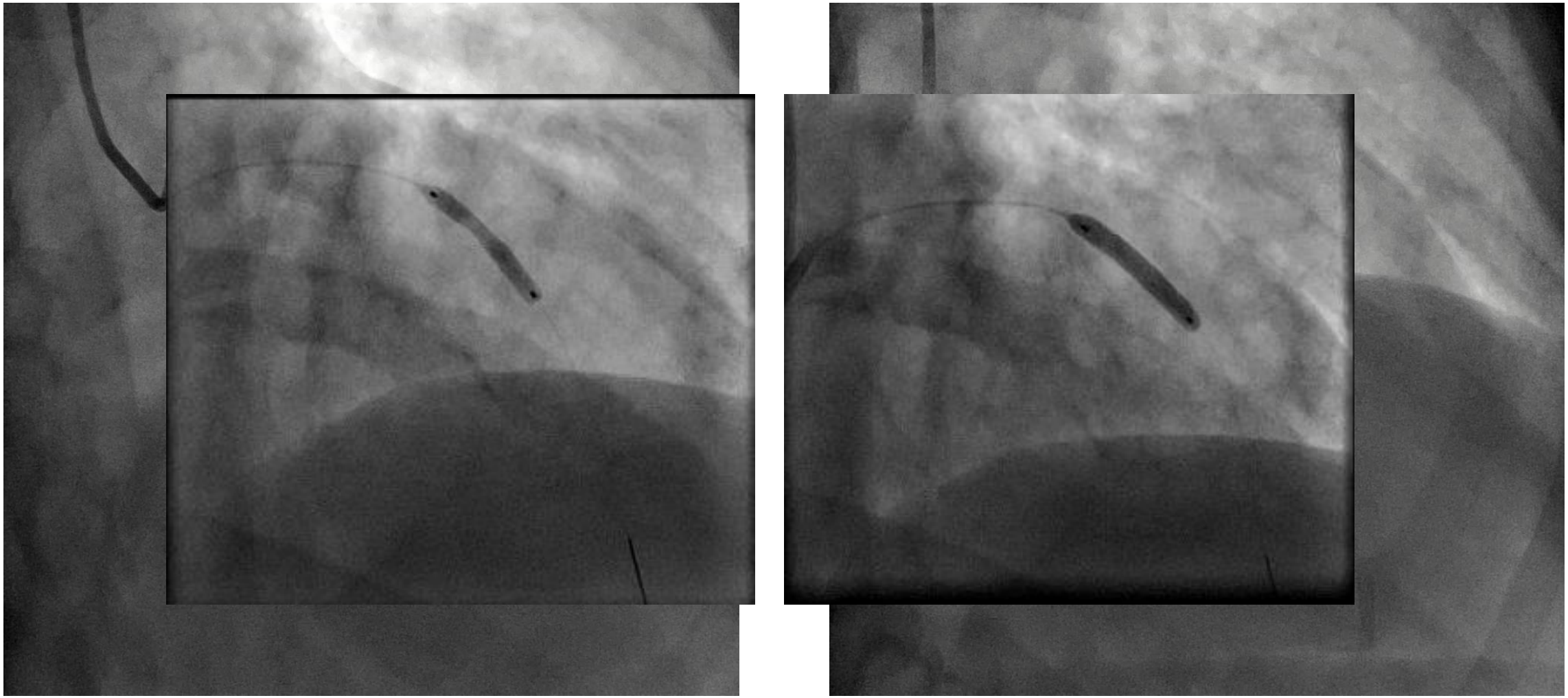
Gary S. Mintz, Jeffrey J. Popma, Augusto D. Pichard, Kenneth M. Kent, Lowell F. Satler, Ya Chien Chuang, Christine J. Ditrano, and Martin B. Leon

- In 1155 lesions
  - Angiography detected calcium in 38%
    - *Moderately sensitive for extensive lesion calcium (sensitivity 60% overall and 85% for 3-4 quadrant calcium)
  - IVUS detected lesion calcium in 73%



Mintz et al. Circulation 1995;91:1959-65.

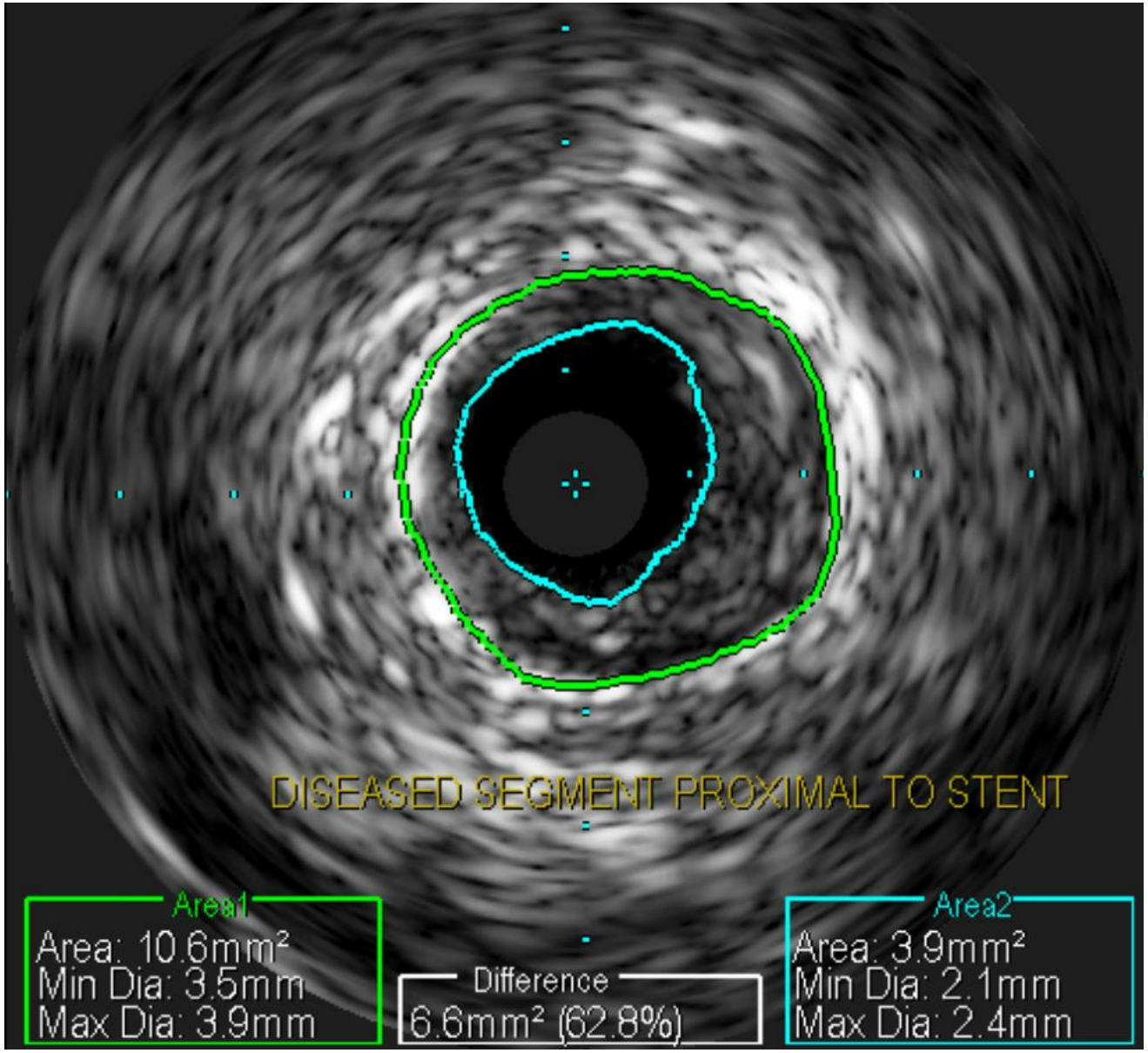
Minimal Stent Area (and TLF) – Geographic Miss



TVL Mechanism: Geographic Miss

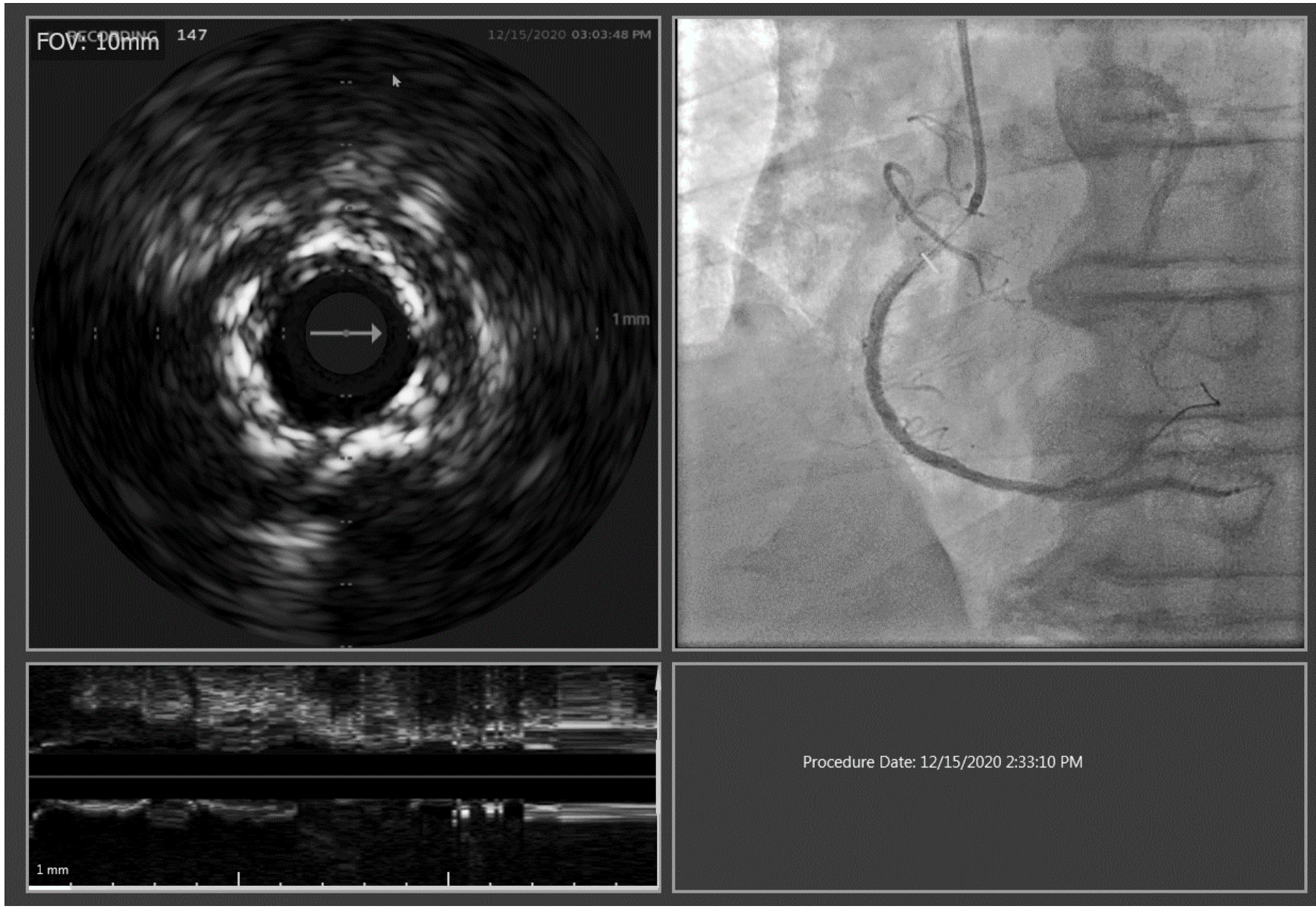
884 native coronaries

- 60 (6.8%) angiographic reference segments were normal by IVUS
- Plaque burden in the angiographically “normal” reference averaged 50 +/- 13%



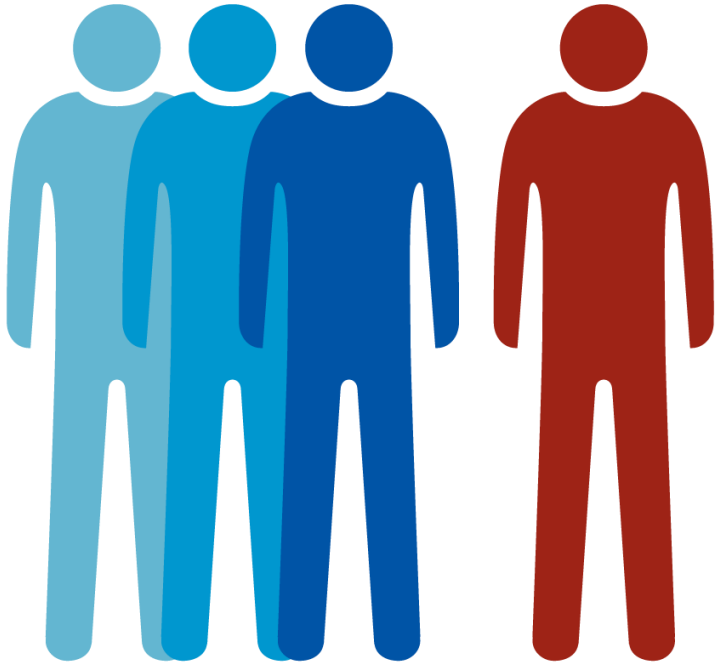
Mintz et al. J Am Coll Cardiol 1995;25:1479-85

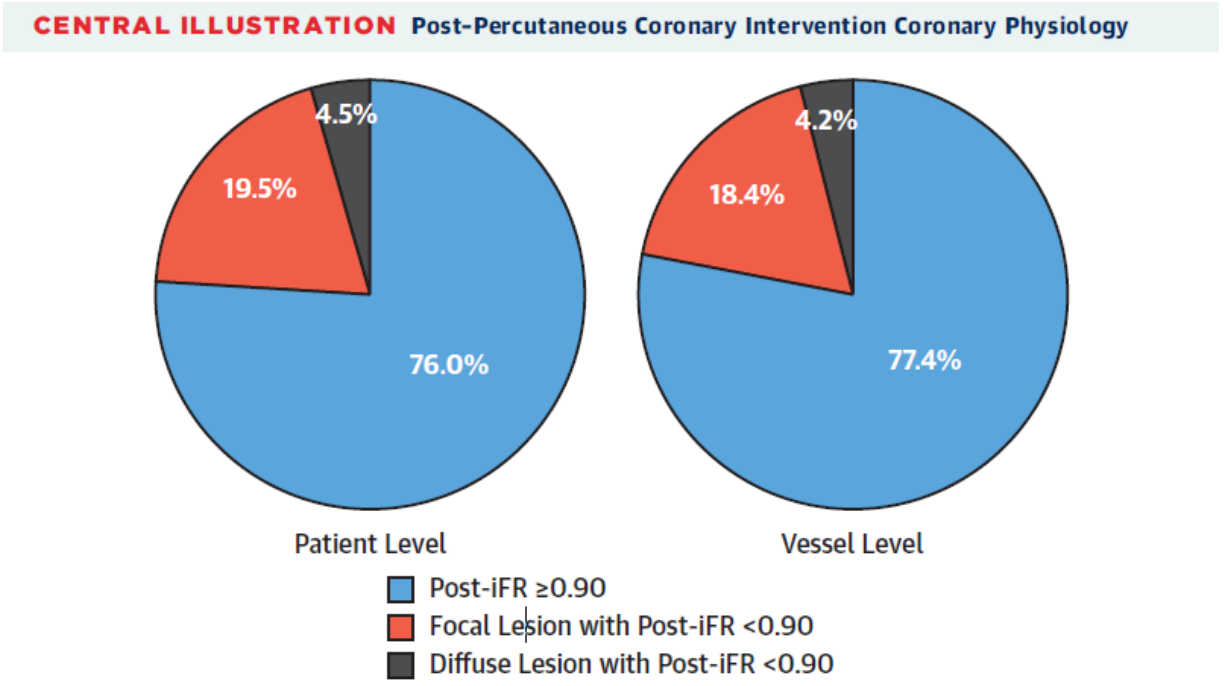
TVL mechanism →
Plaque burden at stent edge + Calcium



What the Data Says about how often we miss or undersize

- 1 in 4 patients leave the cath lab with residual ischemia by iFR
- The majority of the disease is focal in nature!
  - Geographic Miss or Stent Underexpansion

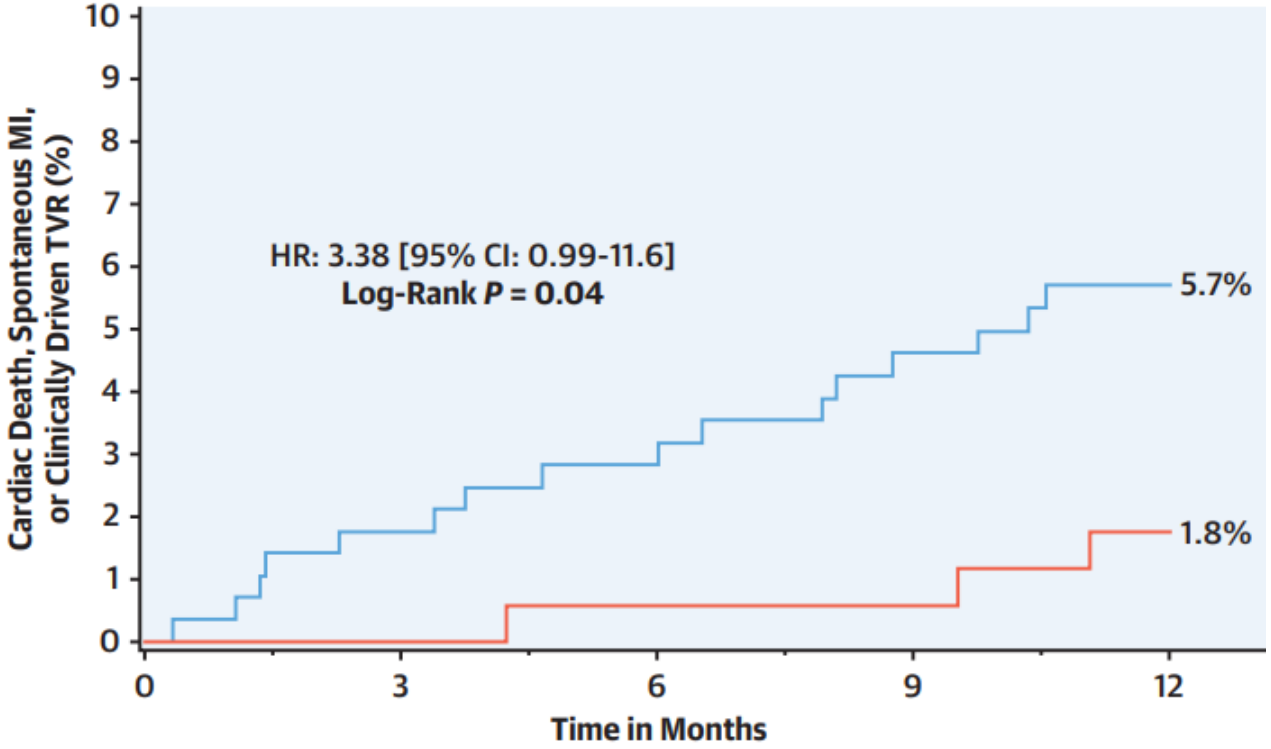


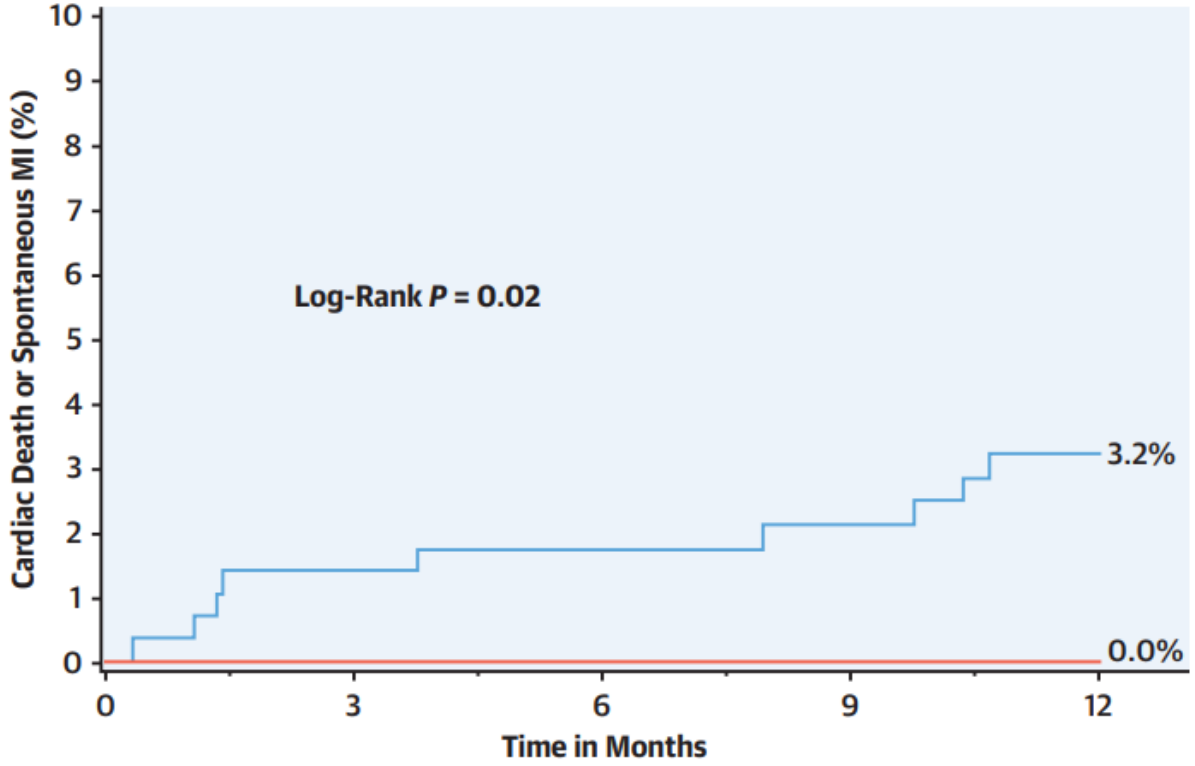


Jeremias et al. J Am Coll Cardiol Intv. 2019;12(20):1991-2001

VA | U.S. Department of Veterans Affairs | UHealth University of Miami Health System | University of Miami Miller School of Medicine

Define PCI 1 Year Outcomes





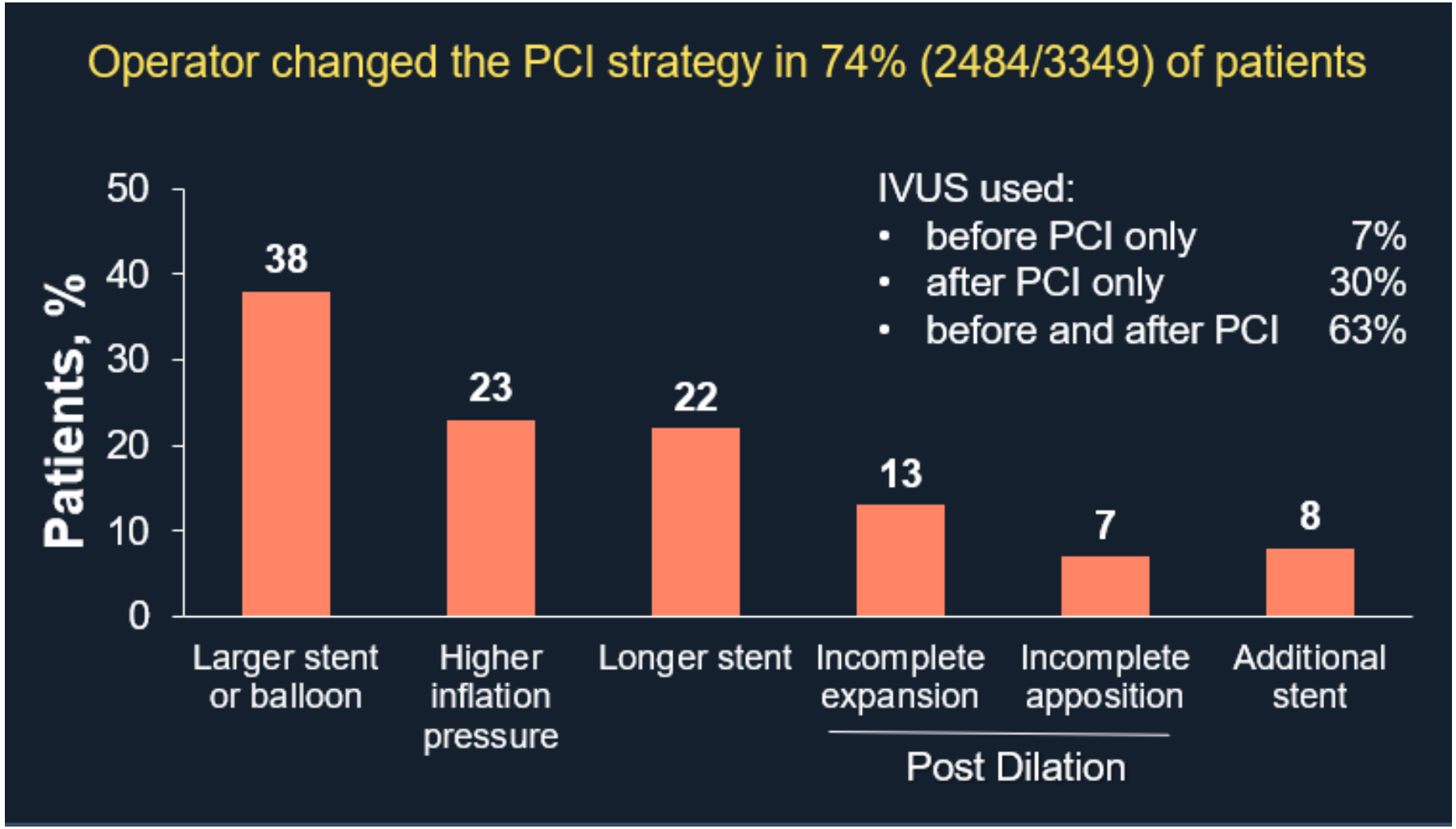
Cardiac Death, Spontaneous MI, or Clinically Driven TVR

Cardiac Death or Spontaneous MI

Patel et al. JACC: Cardiovascular Interventions Vol. 15, No. 1, 2022


Thought Provoked
Perfection is not attainable, but if we chase perfection we can catch excellence.
Vince Lombardi

ADAPT DES: IVUS versus Angiographic Eyes

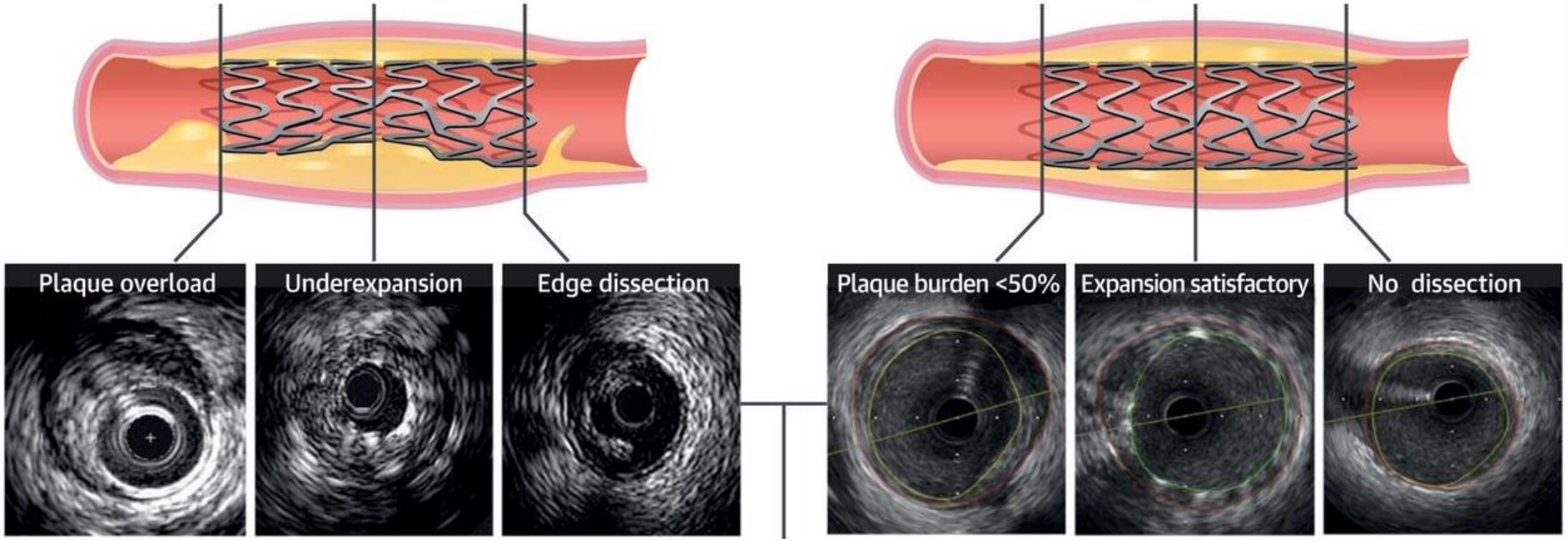


Witzenbichler B et al.
Circulation 2014;129:463-470

How to Optimize PCI – Use Imaging

1) Characterize Plaque for adequate lesion prep
2) Size the Vessel appropriately
3) Identify landing zones without significant plaque (<50% PB)

The ULTIMATE Trial



Zhang et al. J Am Coll Cardiol 2018;72:3126–37

PRE-PCI IVUS

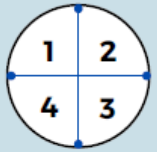
Plaque Morphology:

Plaque:

☐ Fibrotic ☐ Fatty ☐ Mixed

Quadrants of Calcium:

☐ 1 ☐ 2 ☐ 3 ☐ 4



Geometry:

☐ Concentric ☐ Eccentric

Other:

☐ ISR ☐ Dissection

Lesion Prep:

Atherectomy/IVL:

☐ Laser ☐ Orbital

☐ Rotational ☐ Lithotripsy

Pre-dilate:

☐ Regular balloon ☐ NC

Specialty balloon:

☐ Scoring ☐ Cutting

Sizes:

_____

_____

_____

Measurements:

Distal Reference*	mm
Proximal Reference*	mm
Lesion Length**	mm

*For Reference Diameter:

- If reference segment is healthy, use media to media mean.
- If unable to obtain healthy reference, use intima to intima mean.
- If eccentric, use short axis.

** Healthy to healthy

Percent Area Stenosis

Minimal Lumen Area:

_____ mm^2

Reference Area:

_____ mm^2

Percent Area Stenosis:

(MLA/RA) x 100 =_____%

Stent Selection:

Stent 1:

_____

Diameter Length

Stent 2: (if needed)

_____

Diameter Length

Post Dilation:

☐ Regular ☐ NC

_____

Diameter Length

☐ Regular ☐ NC

_____

Diameter Length

Notes:

_____

_____

_____

_____

_____

POST-PCI IVUS

Ultimate Criteria 1: Landing Zone Plaque Burden less than 50%

Proximal Landing Zone:

Lumen:

_____ mm^2

Vessel:

_____ mm^2

Plaque Burden:

(LA/VA) x 100 = _____%

Distal Landing Zone:

Lumen:

_____ mm^2

Vessel:

_____ mm^2

Plaque Burden:

(LA/VA) x 100 = _____%

Criteria Met: ☐

Ultimate Criteria 2: MSA >90% of Distal Reference Area or >5 mm^2

Minimal Stent Area:

_____ mm^2

Distal Reference Area:

_____ mm^2

(MSA/DRA) x 100:

_____ %

Criteria Met: ☐

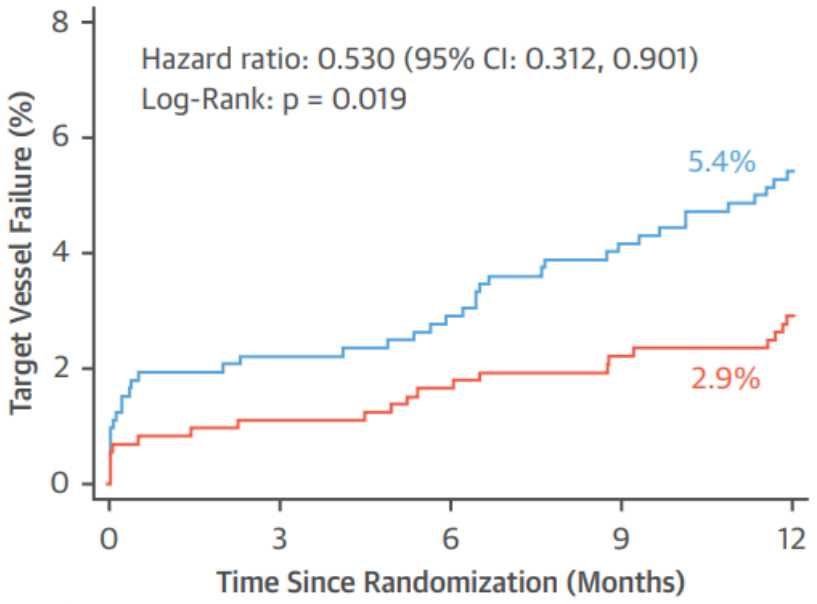
Ultimate Criteria 3: Absence of Edge Dissection Involving media with length >3 mm

Edge Dissection: ☐ Present ☐ Absent

Criteria Met: ☐

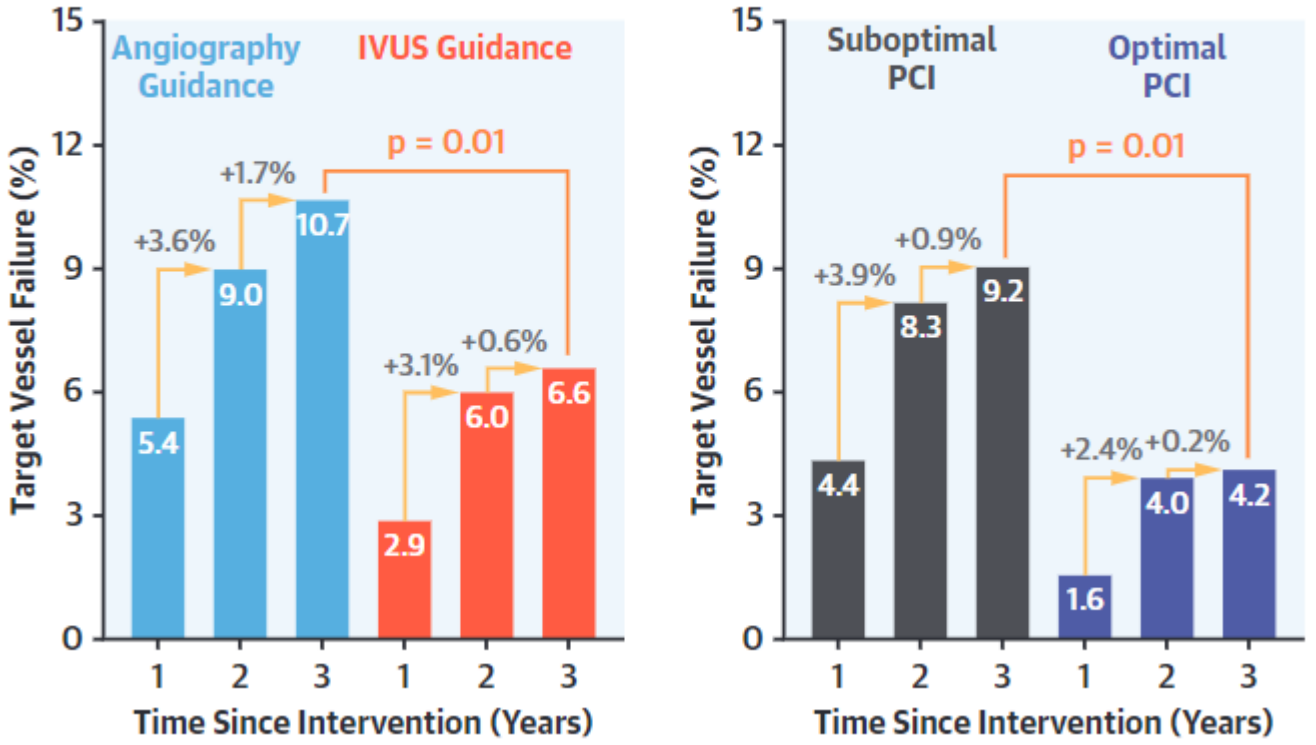
Intravascular Ultrasound Versus Angiography-Guided Drug-Eluting Stent Implantation

The ULTIMATE Trial



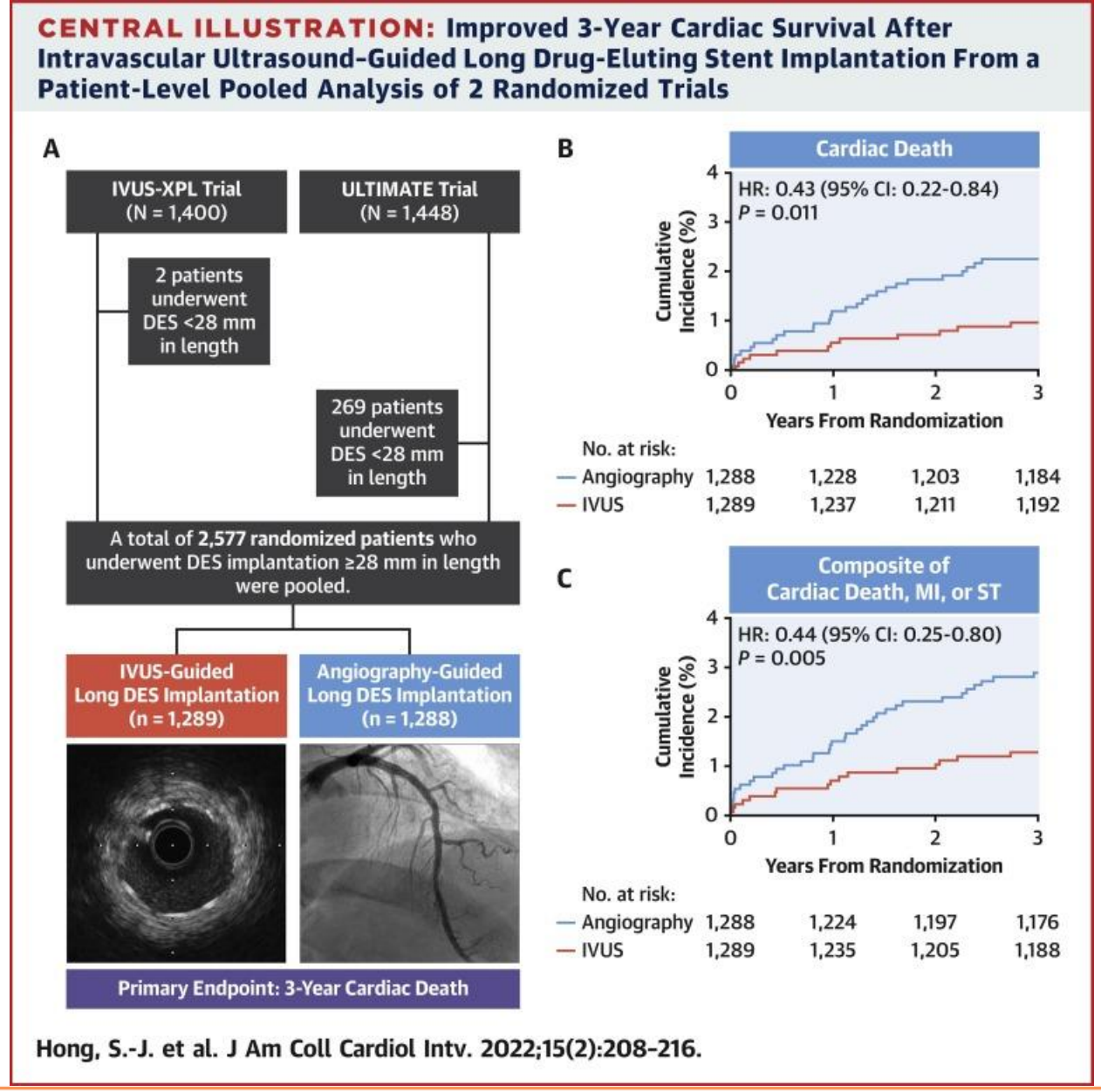
1448 “All-Comers” randomized to IVUS vs Angiographic Guided PCI

CENTRAL ILLUSTRATION 3-Year Follow-Up of the IVUS-Guided Drug-Eluting Stents Implantation in All-Comers Coronary Lesions Trial



Gao, X. et al. J Am Coll Cardiol Intv. 2021;14(3):247-57.
Zhang et al. J Am Coll Cardiol 2018;72:3126-27

Optimal PCI vs Suboptimal PCI… The Data is Clear



Hong, S.-J. et al. J Am Coll Cardiol Intv. 2022;15(2):208-216.

Randomized Trial Publications (n=28)

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7) Tan Q, Wang Q, Liu D, et al. Intravascular ultrasound–guided unprotected left main coronary artery stenting in the elderly. Saudi Med J 2015;36:549-53.
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9) Mariani J Jr, Guedes C, Soares P, et al. Intravascular ultrasound guidance to minimize the use of iodine contrast in percutaneous coronary intervention: the MOZART (Minimizing cOntrast utiliZation With IVUS Guidance in coRonary angioplasTy) randomized controlled trial. JACC Cardiovasc Interv. 2014;7:1287-93
10) Zhang J, Gao X, Kan J, et al. Intravascular Ultrasound-Guided Versus Angiography-Guided Implantation of Drug-Eluting Stent in All-Comers: The ULTIMATE trial. J Am Coll Cardiol 2018;72:3126-37
11) Liu XM, Yang ZM, Liu XK, et al. Intravascular ultrasound-guided drug-eluting stent implantation for patients with unprotected left main coronary artery lesions: A single-center randomized trial. Anatol J Cardiol. 2019;21:83-90
12) Hong SJ, Mintz GS, Ahn CM et al. Effect of Intravascular Ultrasound-Guided Drug-Eluting Stent Implantation: 5-Year Follow-Up of the IVUS-XPL Randomized Trial. JACC Cardiovasc Interv. 2020;13:62-71
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15) Lee YJ, Zhang JJ, Mintz GS, et al. Is Routine Postdilation During Angiography-Guided Stent Implantation as Good as Intravascular Ultrasound Guidance?: An Analysis Using Data From IVUS-XPL and ULTIMATE Circ Cardiovasc Interv. 2022 Jan;15(1):e011366. doi: 10.1161/CIRCINTERVENTIONS.121.011366.
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20) Ali ZA, Karimi Galougahi K, Maehara A, et al. Outcomes of Optical Coherence Tomography Compared With Intravascular Ultrasound and With Angiography to Guide Coronary Stent Implantation: One-Year Results from the ILUMIEN III: OPTIMIZE PCI trial. EuroIntervention 2021;16: 1085-91.
21) Chamié D, Costa JR Jr, Damiani LP, et al. Optical Coherence Tomography Versus Intravascular Ultrasound and Angiography to Guide Percutaneous Coronary Interventions: The iSIGHT Randomized Trial. Circ Cardiovasc Interv. 2021 Mar;14(3):e009452. doi: 10.1161/CIRCINTERVENTIONS.120.009452
22) Kim J-S, Shin D-H, Kim B-K, et al. Randomized comparison of stent strut coverage following angiography- or optical coherence tomography-guided percutaneous coronary intervention. Rev. Espanola Cardiol. 2015;68:190–7
23) Meneveau N, Souteyrand G, Motreff P, et al. Optical Coherence Tomography to Optimize Results of Percutaneous Coronary Intervention in Patients with Non-ST-Elevation Acute Coronary Syndrome: Results of the Multicenter, Randomized DOCTORS Study (Does Optical Coherence Tomography Optimize Results of Stenting). Circulation. 2016;134:906-17
24) Lee SY, Kin JS, Yoon HJ et al. Early Strut Coverage in Patients Receiving Drug-Eluting Stents and its Implications for Dual Antiplatelet Therapy: A Randomized Trial. JACC Cardiovasc Imaging. 2018;11:1810-19.
25) Kubo T, Shinke T, Okamura T, et al. Optical frequency domain imaging vs. intravascular ultrasound in percutaneous coronary intervention (OPINION trial): one-year angiographic and clinical results. Eur Heart J. 2017;38:3139-47.
26) Kala P, Cervinka P, Jakl M, et al. OCT guidance during stent implantation in primary PCI: A randomized multicenter study with nine months of optical coherence tomography follow-up. Int J Cardiol. 2018;250:98-103
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Meta-analyses (n=37)

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Advanced Kidney Disease

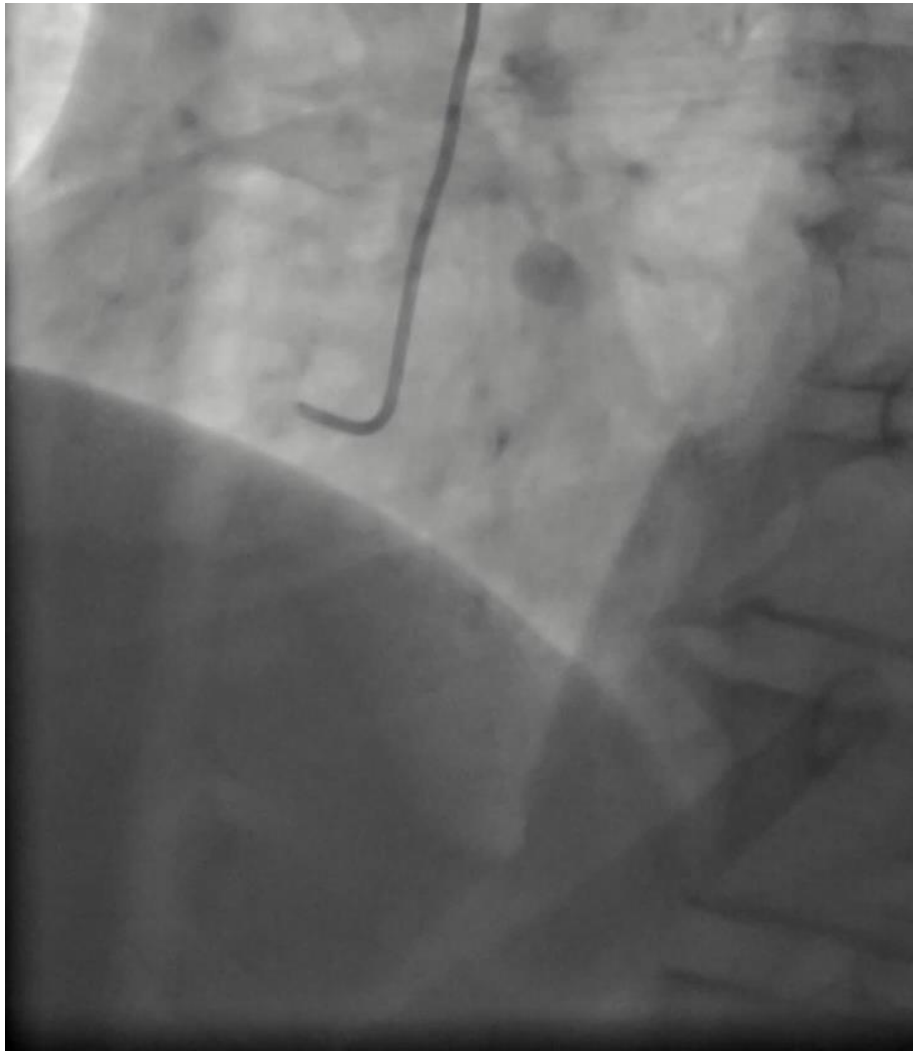
A growing subset of patients

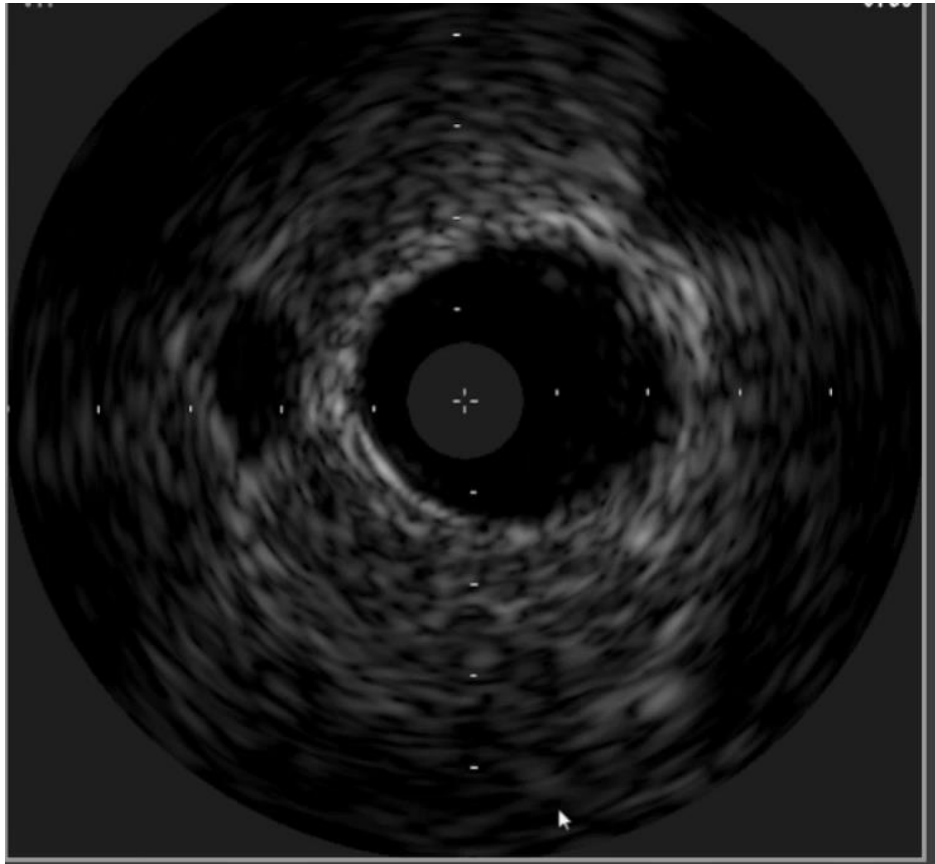
- 30-40% of patients undergoing PCI have concomitant CKD
- Consistently found to have worse outcomes after AMI and PCI

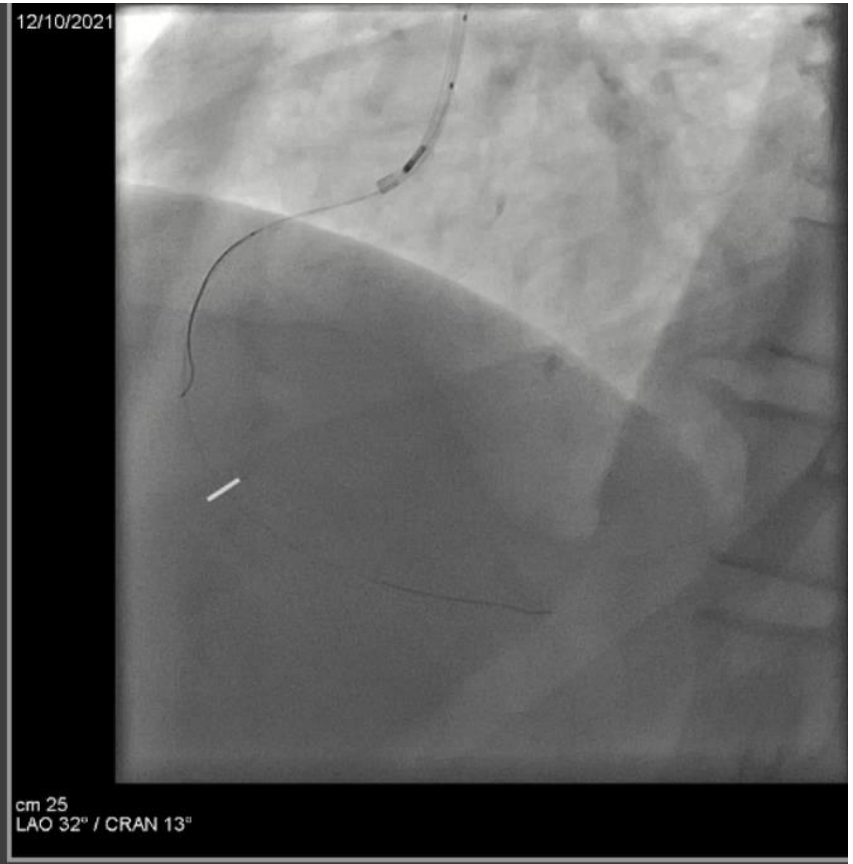
Case Presentation

- 66-year-old veteran with stage IV CKD, eGFR 15, who has angina refractory to medical therapy.
- A Diagnostic Angiogram was done at an outside institution with 30cc of contrast and he was transferred for PCI.

Know your tools and know how to use them



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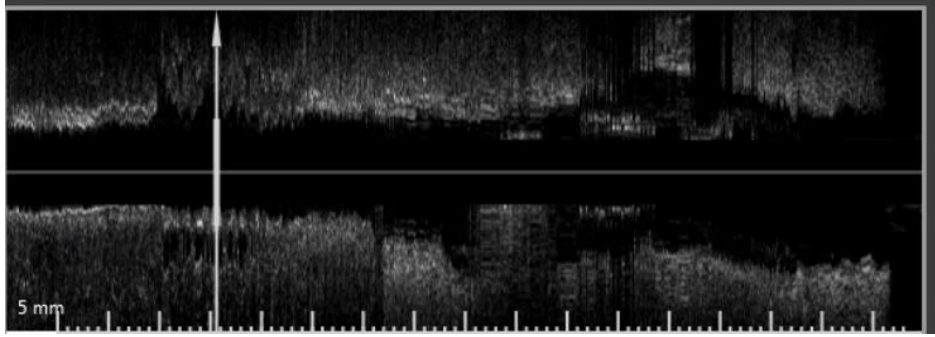
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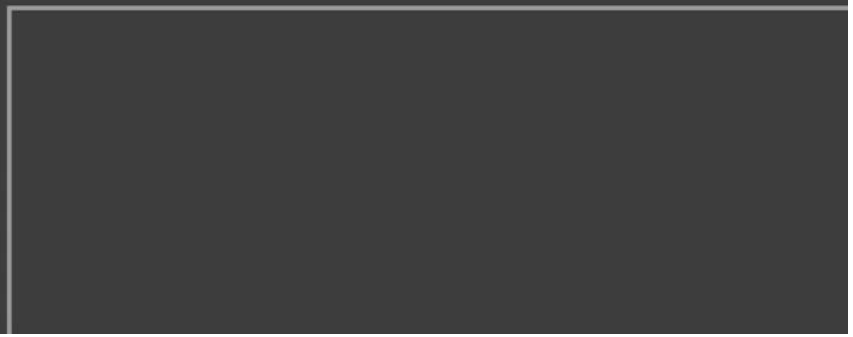
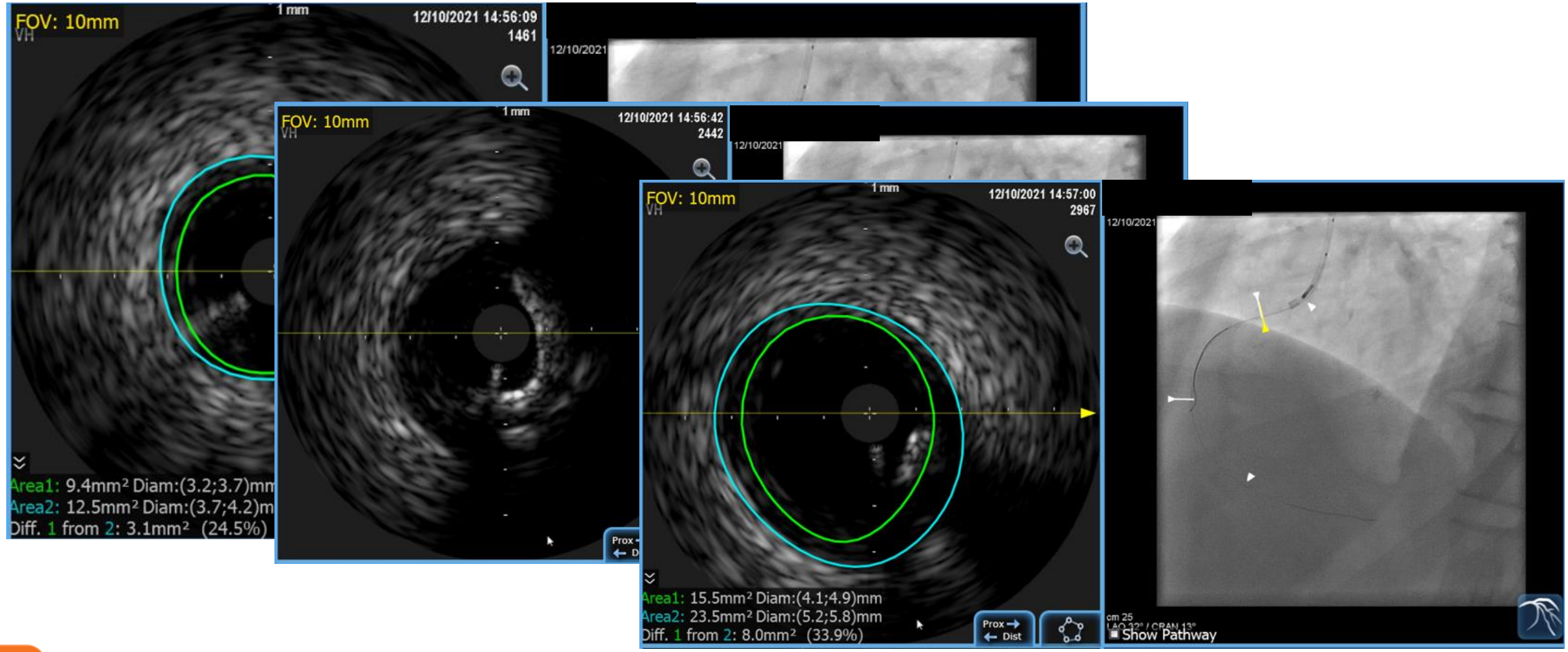


Still at 0cc of Contrast



Final Result – 3cc of Contrast

No Contrast or Ultra-Low Contrast PCI

Don’t Forget Your Physiology

Are you really going to decide on PCI vs Medical Therapy on the next 3 magnified views of that vessel with an intermediate stenosis?

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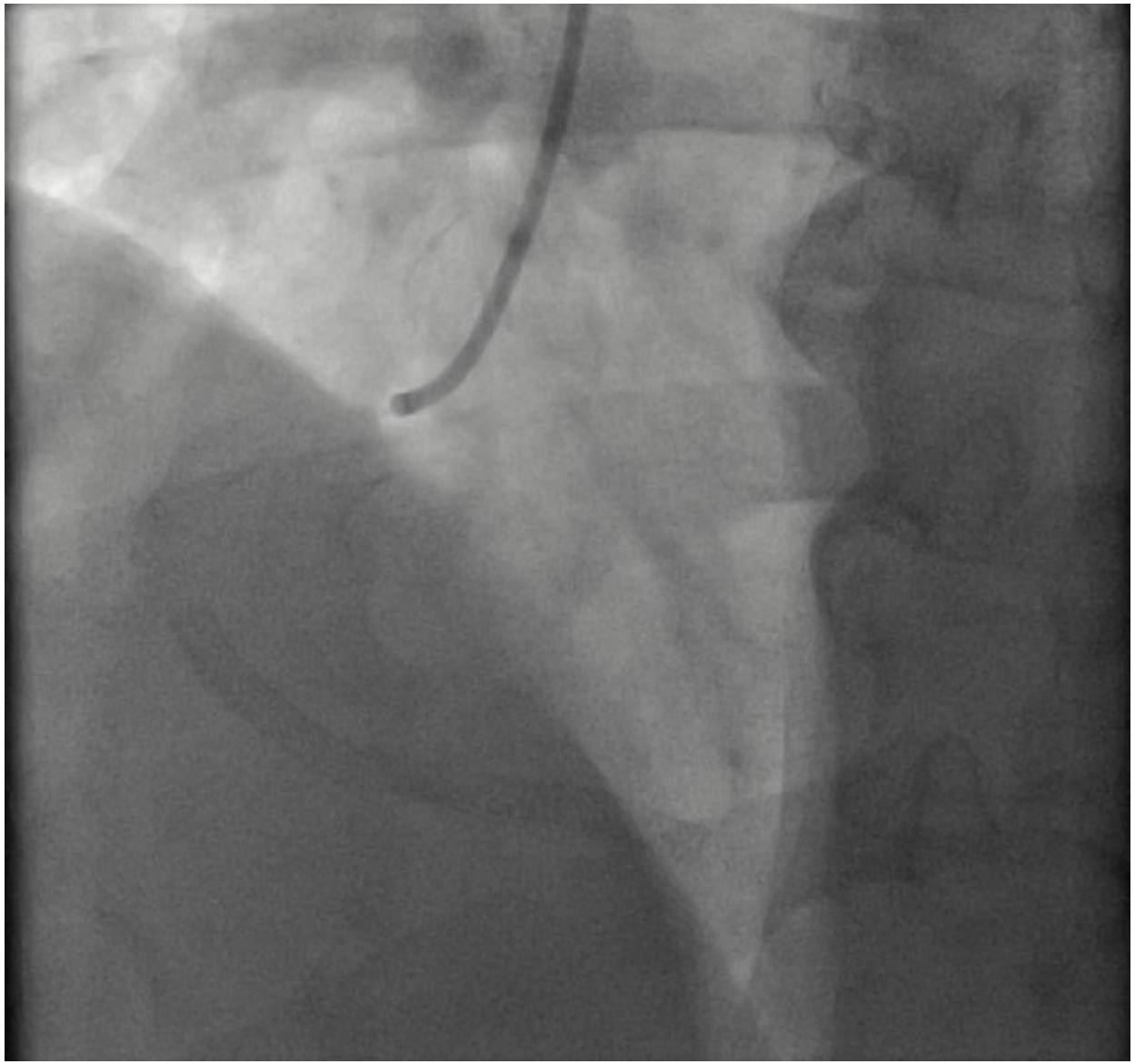
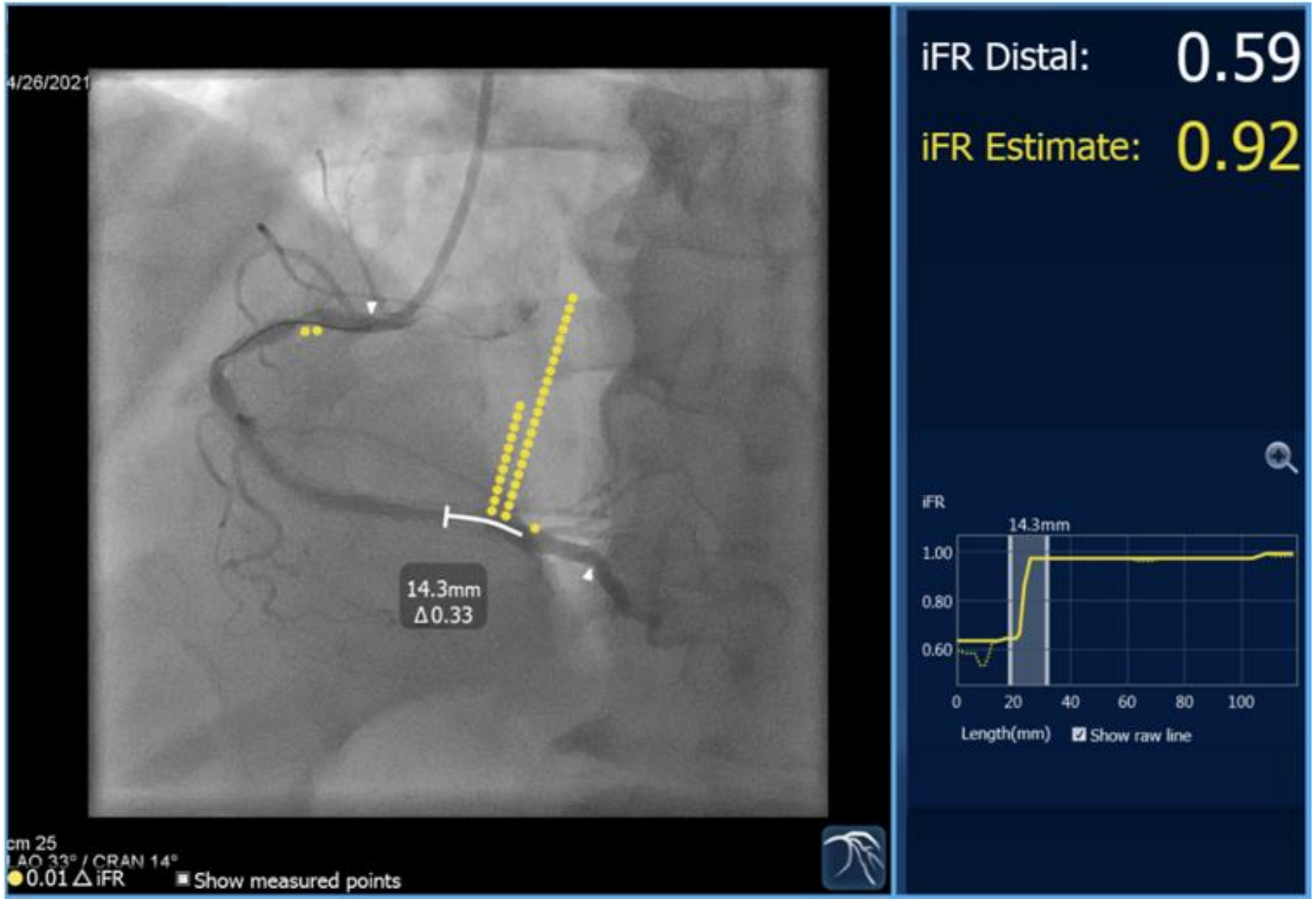
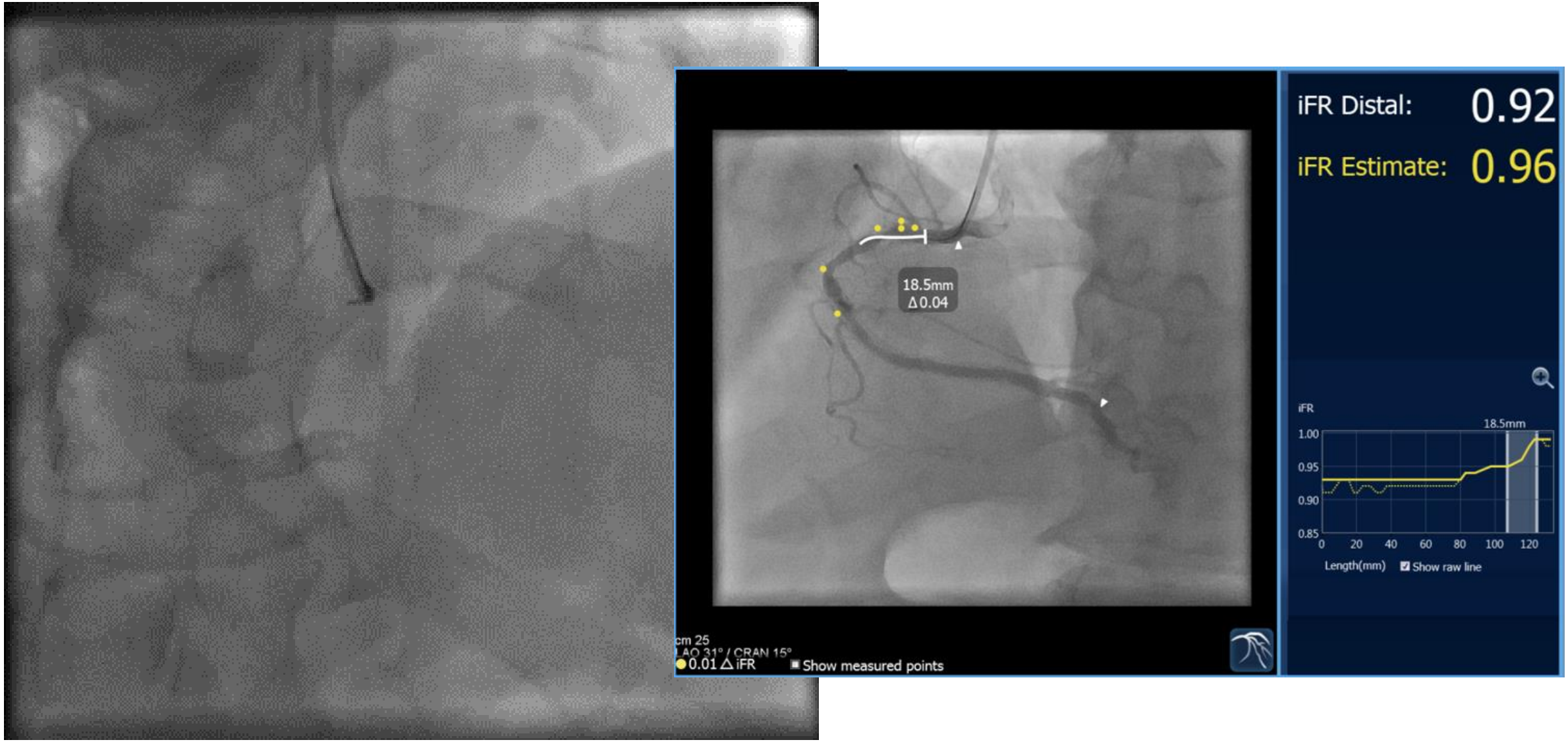
A 46-year-old referred for recurrent angina

He has 11 stents in the RCA…

You're dreaming of IVUS guided ISR diagnosis and therapy




4/26/2021
14.3mm
Δ0.33
cm 25
LAO 33° / CRAN 14°
0.01 Δ iFR
Show measured points
iFR Distal: 0.59
iFR Estimate: 0.92
iFR
14.3mm
1.00
0.80
0.60
0
20
40
60
80
100
Length(mm)
Show raw line


18.5mm
Δ0.04
iFR Distal: 0.92
iFR Estimate: 0.96
iFR
18.5mm
1.00
0.95
0.90
0.85
0
20
40
60
80
100
120
Length(mm)
Show raw line
cm 25
LAO 31° / CRAN 15°
0.01 Δ iFR
Show measured points

How to Assess and Deal with calcium

Recommendations for the Treatment of Calcified Lesions
Referenced studies that support the recommendations are summarized in Online Data Supplement 27.

COR	LOE	Recommendations
2a	B-R	1. In patients with fibrotic or heavily calcified lesions, plaque modification with rotational atherectomy can be useful to improve procedural success.[1-3]
2b	B-NR	2. In patients with fibrotic or heavily calcified lesions, plaque modification with orbital atherectomy, balloon atherotomy, laser angioplasty, or intracoronary lithotripsy may be considered to improve procedural success.[4-8]

Lawton JS, Circulation 2022 Jan 18;145(3):e4-e17.

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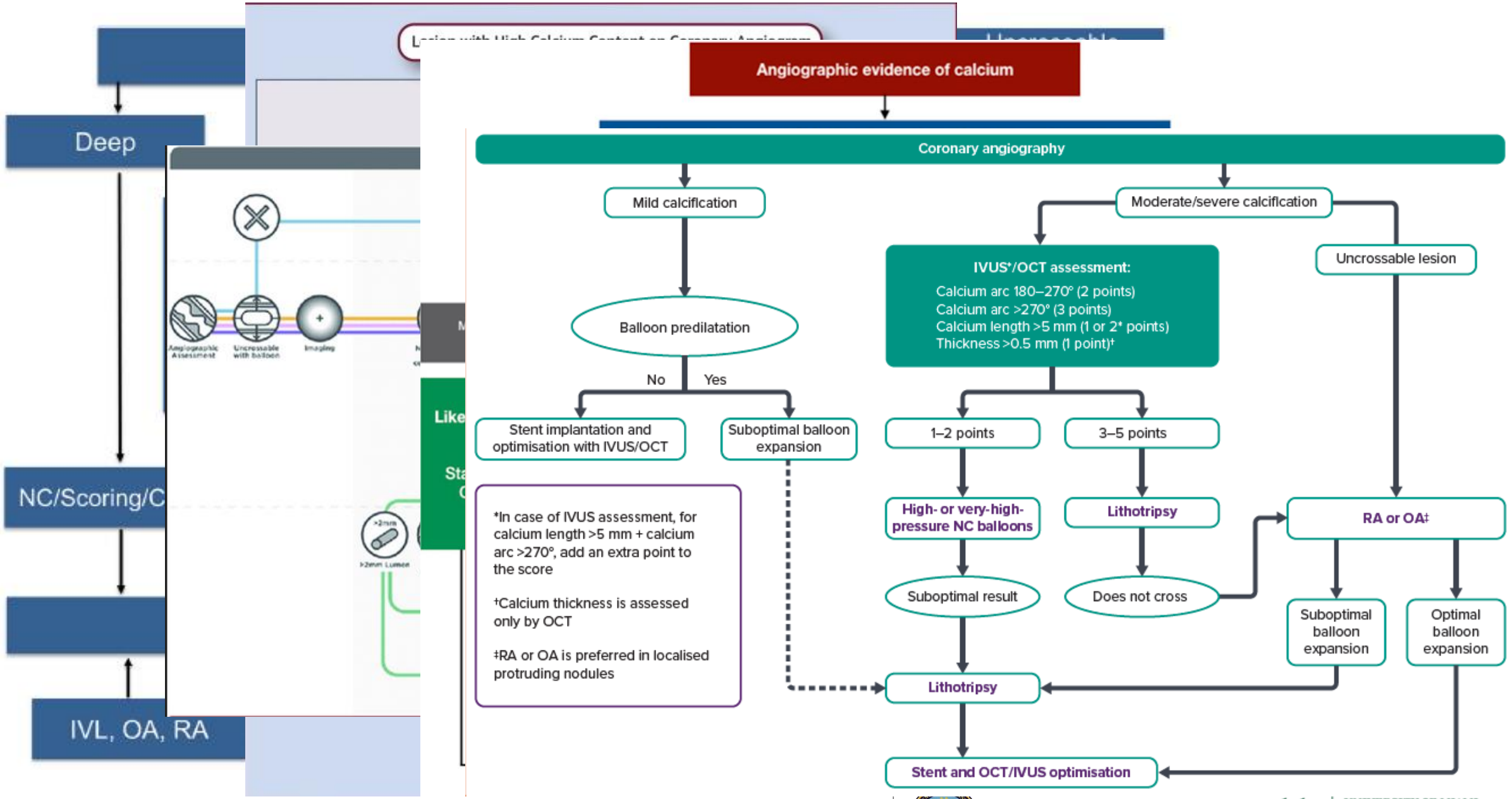

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Key Takeaways from All Algorithms

- Intravascular Imaging Should be Used
  - Angiography is not a good tool to assess calcium burden
  - There are scoring systems available for IVUS and OCT if you choose to use them
- If your tools (imaging catheter and/or balloons) will not cross:
  - Rotational or Orbital Atherectomy will be needed
- If your balloons do not expand – DO NOT expect a stent to expand
  - Rethink your strategy – NC/Cutting/Scoring/IVL
- High Risk Features on Intravascular Imaging
  - ≥ 3 arcs (≥ 270°) of calcium
    - *@ ≥ 2 arcs (≥ 180°) of calcium you can start to consider modification strategies*
  - Continuous calcium burden of >5mm
  - Calcified Nodules (RA/OA given high risk of balloon rupture)
  - Calcium Thickness > 0.5mm (OCT Only)

Putting the Algorithm to Work

Severe Multivessel Disease with Failing Vein Grafts

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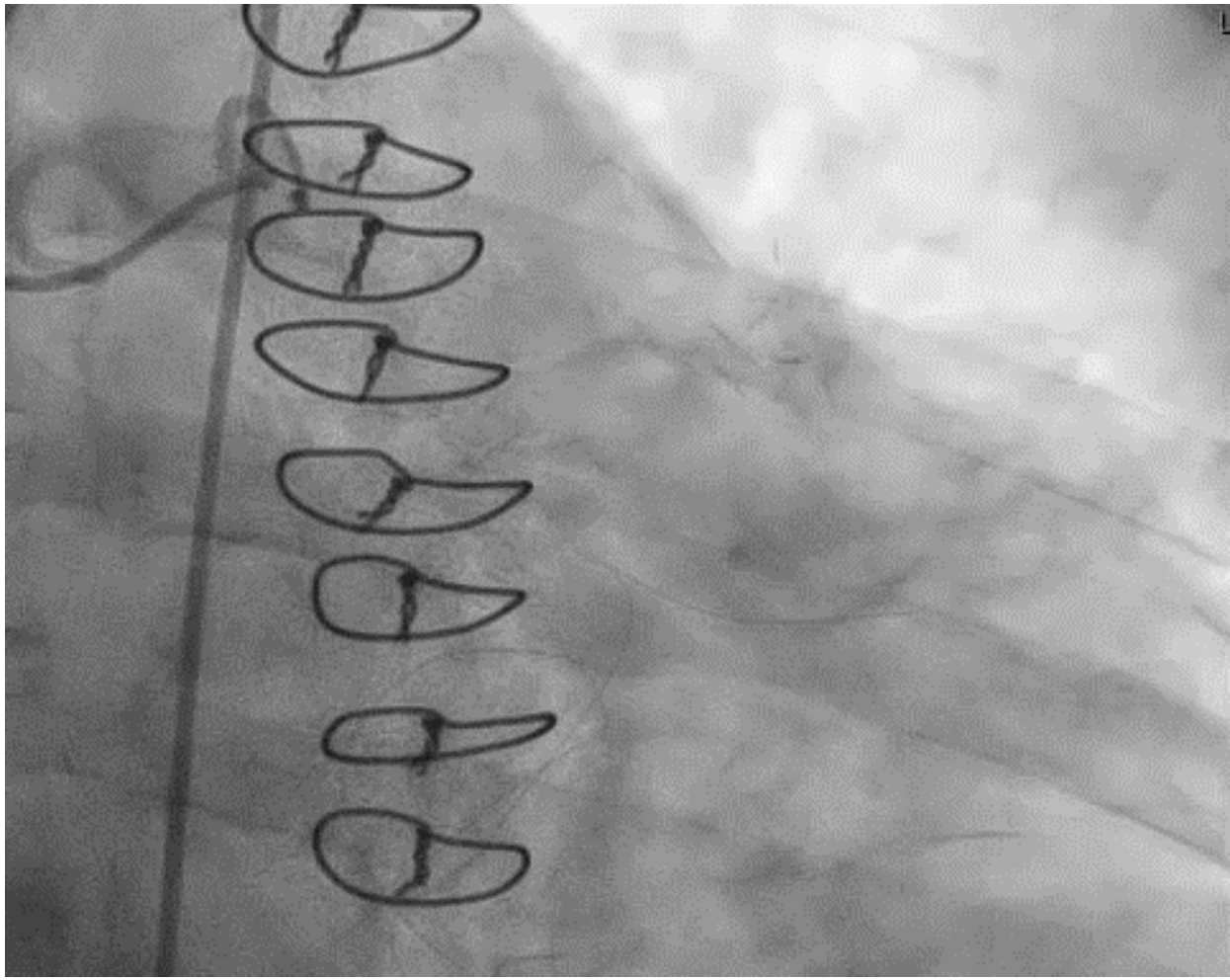
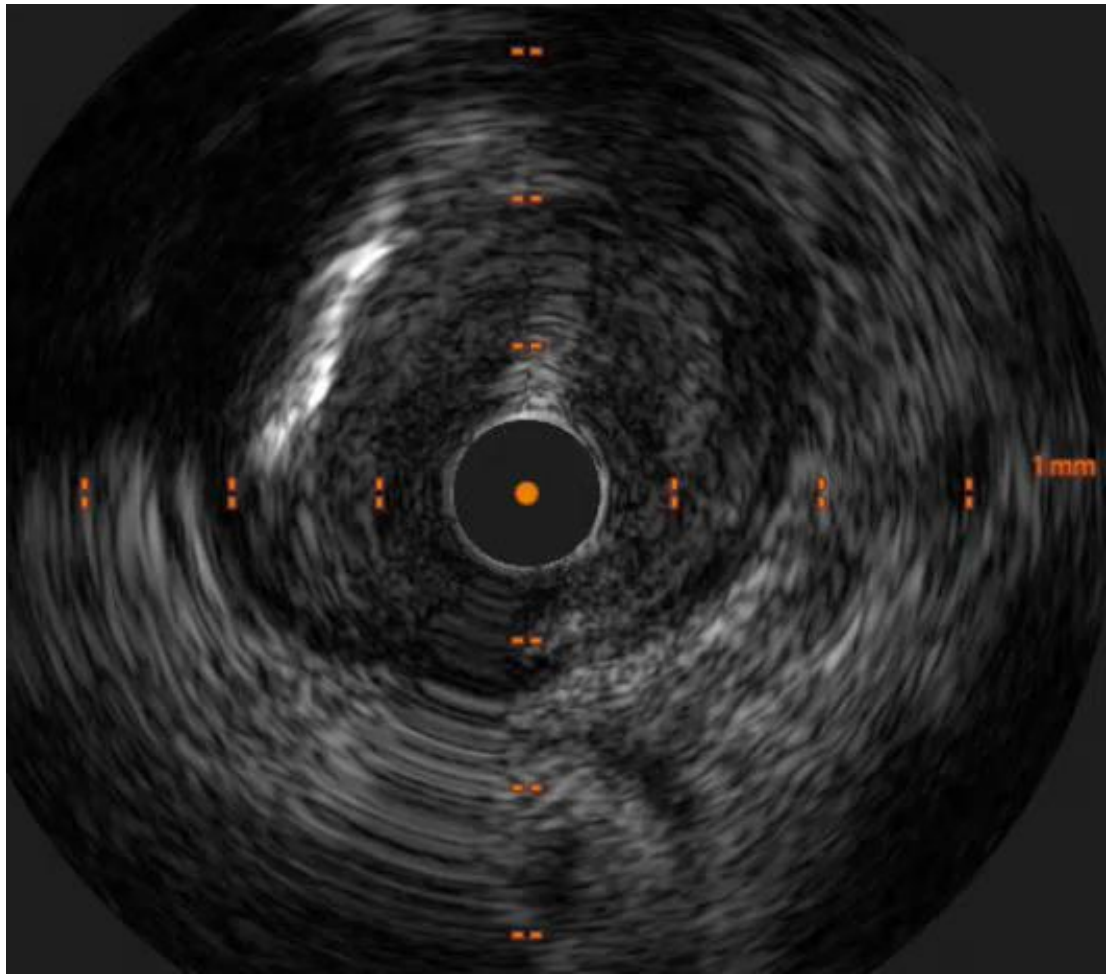
Diagnostic Angiogram



Rotational IVUS Crossed without difficulty

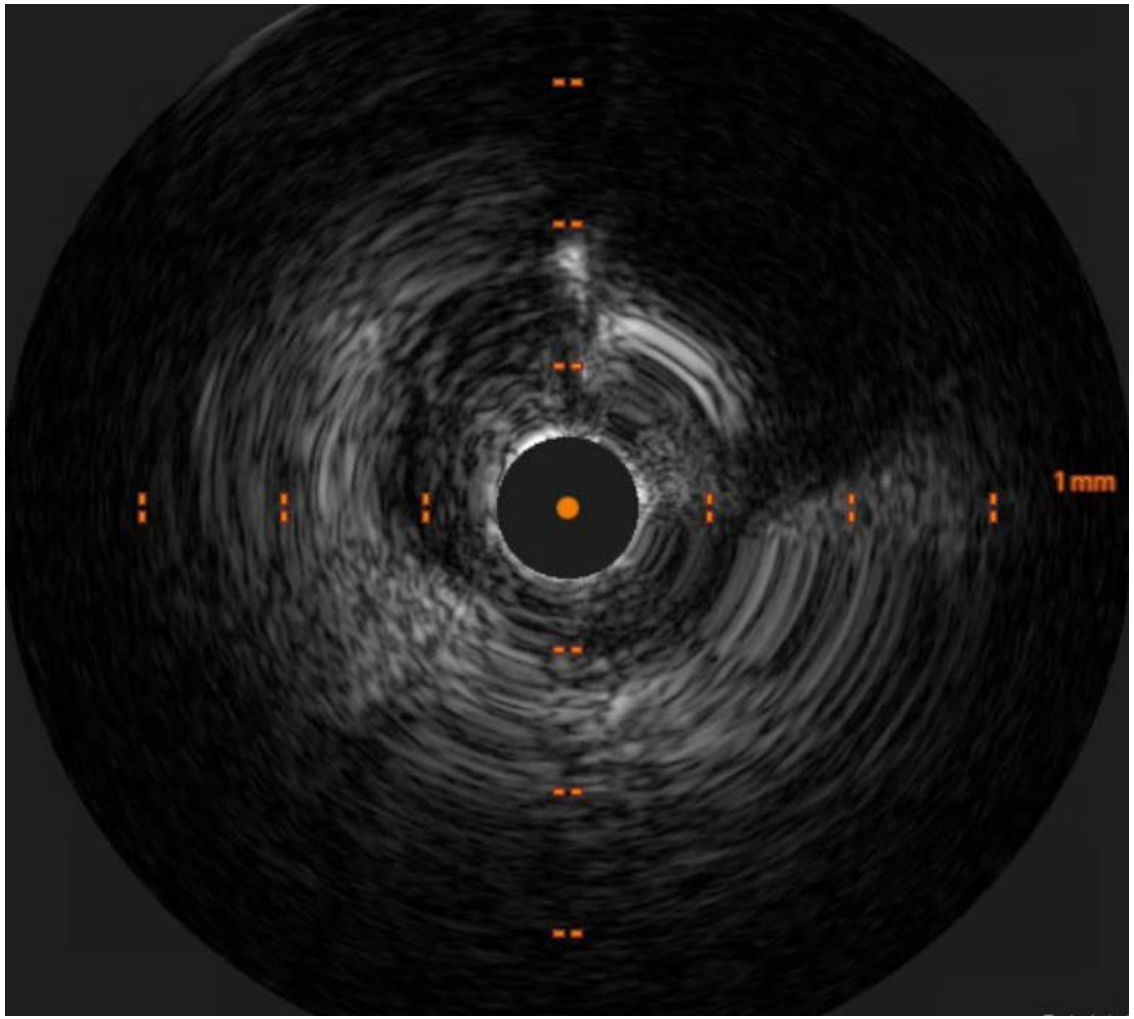


IVUS Clip: Prox LCx → LM

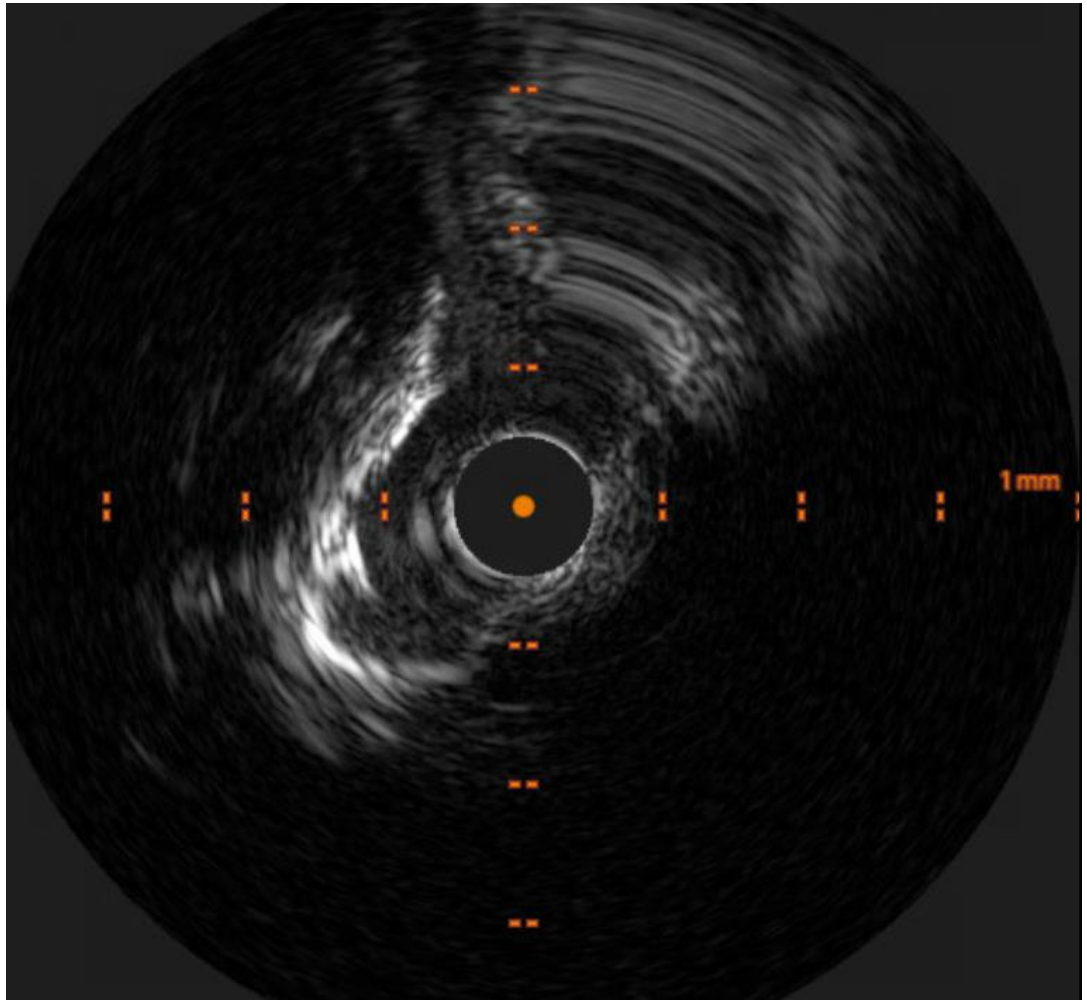
1:1 Sized NC Balloon

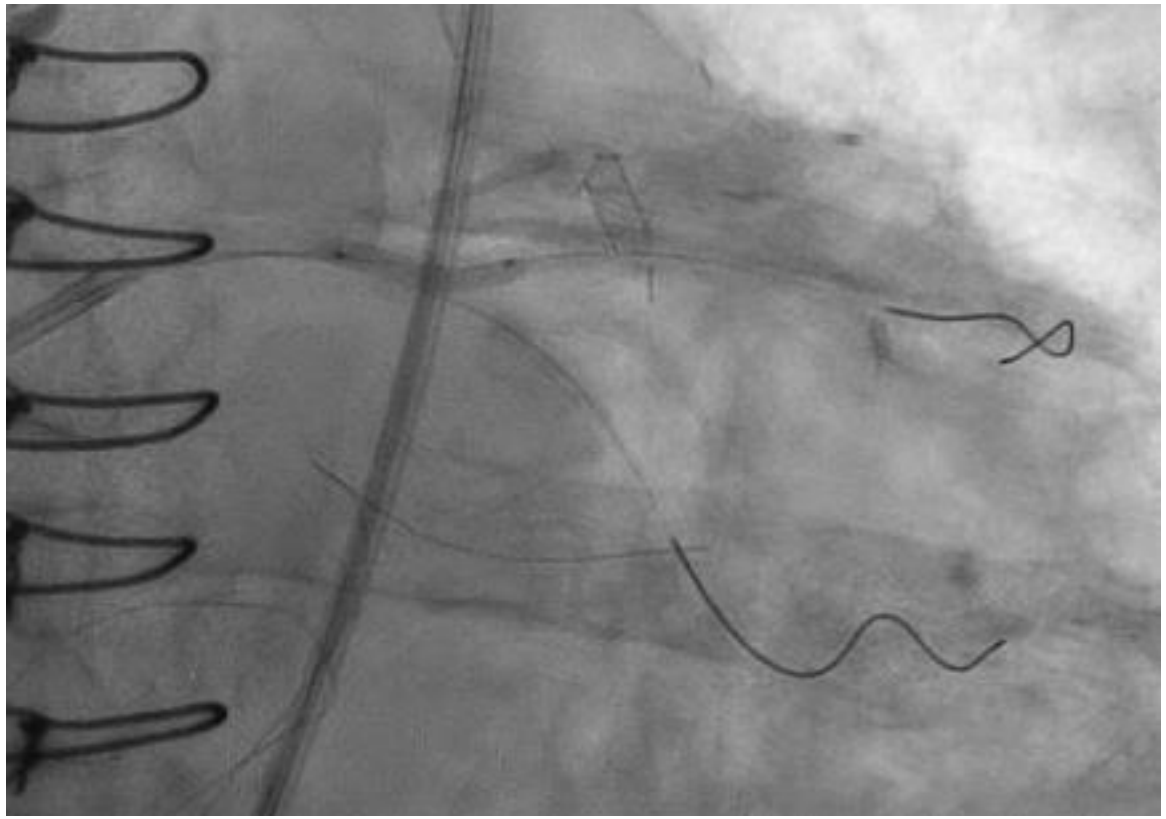
Attention turned to OM CTO with failing SVG

Angioplasty without full expansion



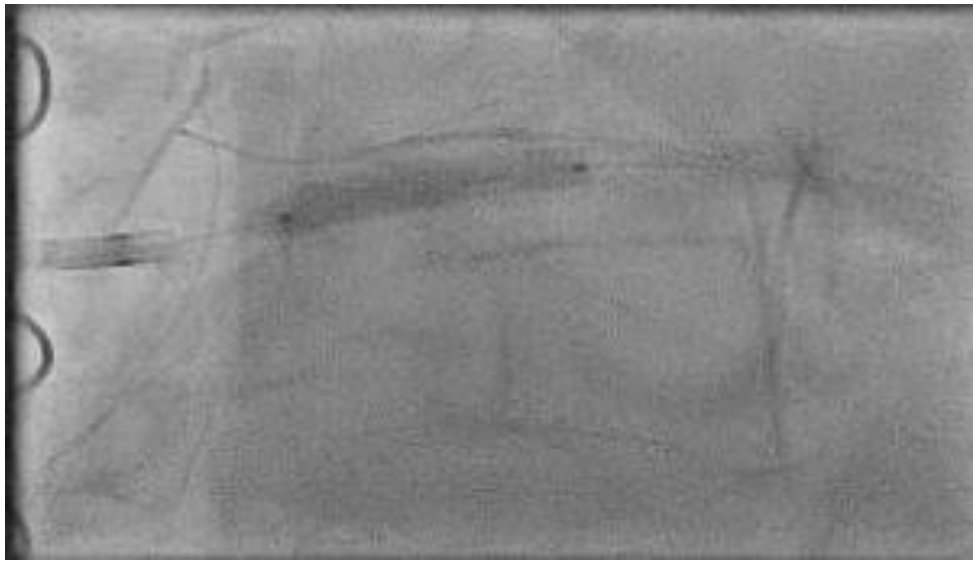
IVUS Clip: Prox OM → Mid LCx

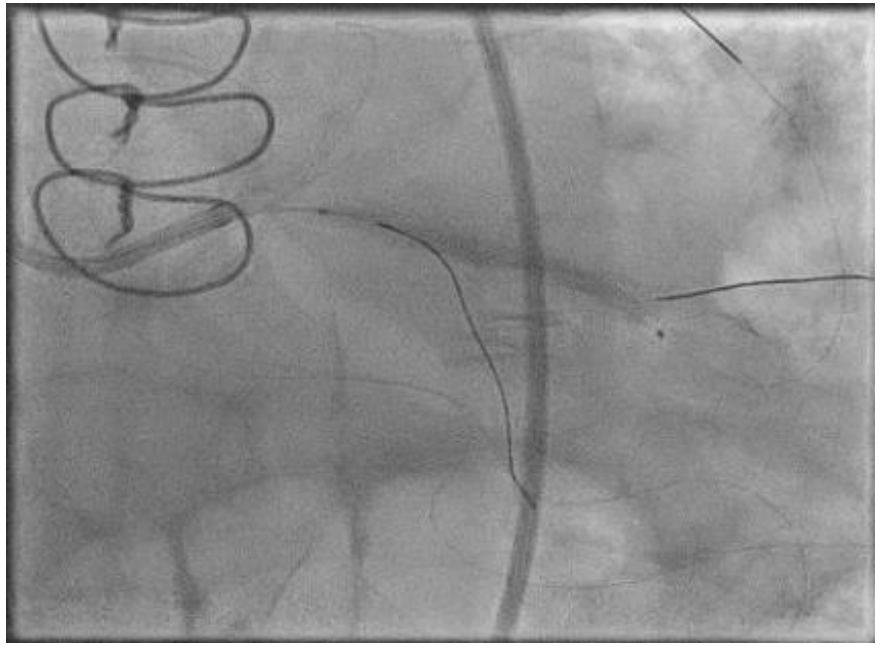


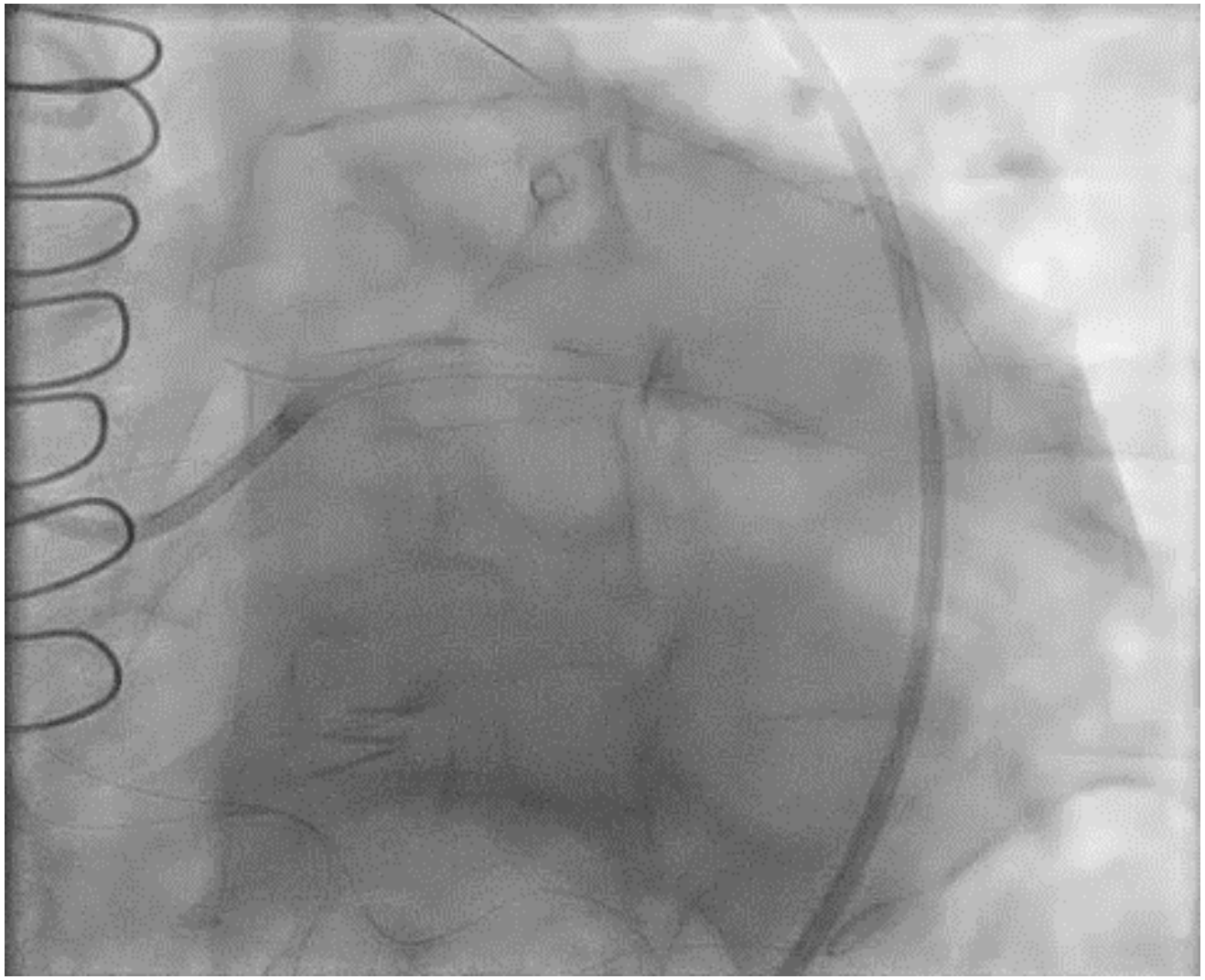


Ostial OM Calcium Burden for ~5mm

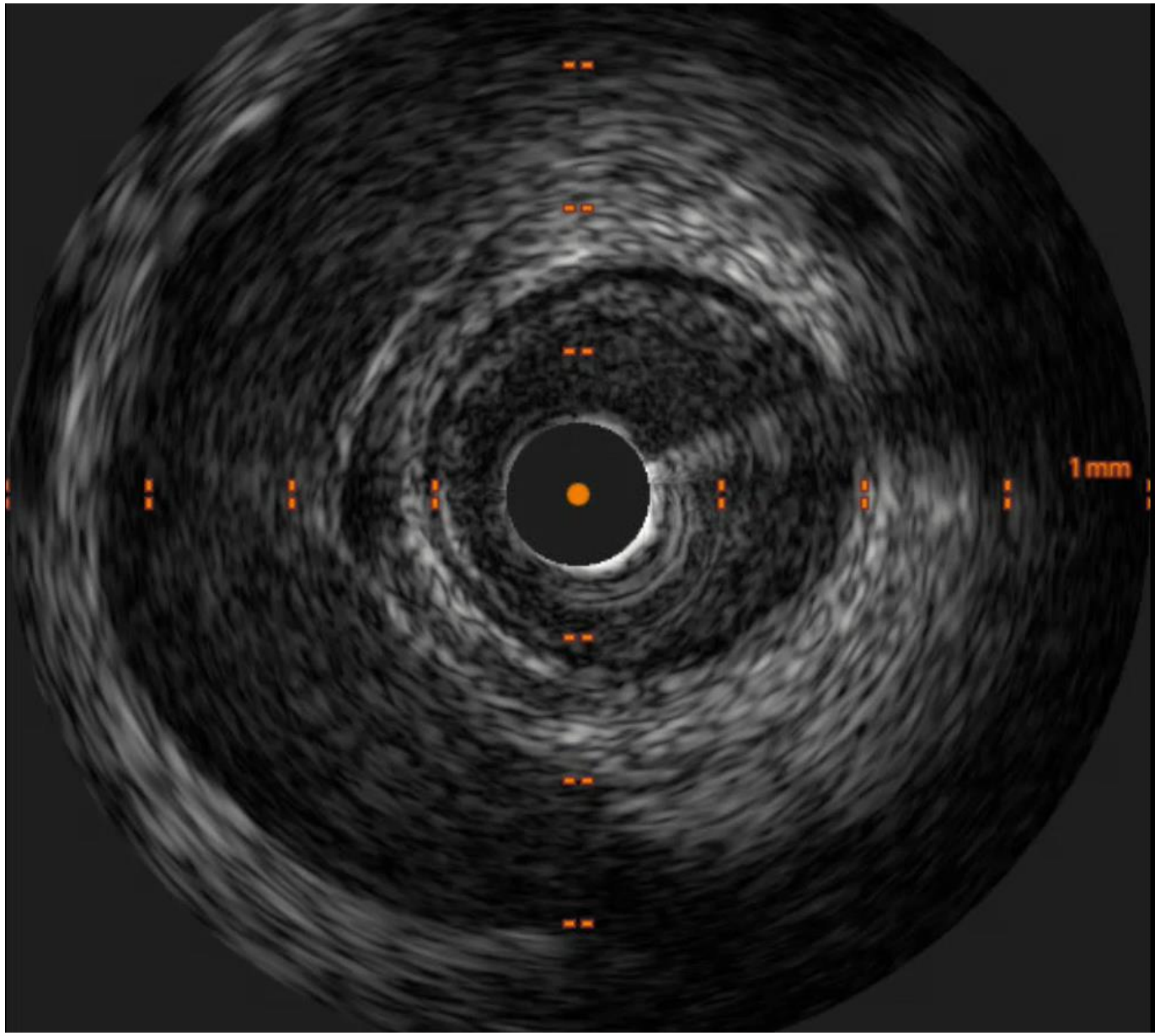
Intravascular Lithotripsy







Post PCI IVUS



Using all your tools to optimize PCI and Eliminate Residual Ischemia

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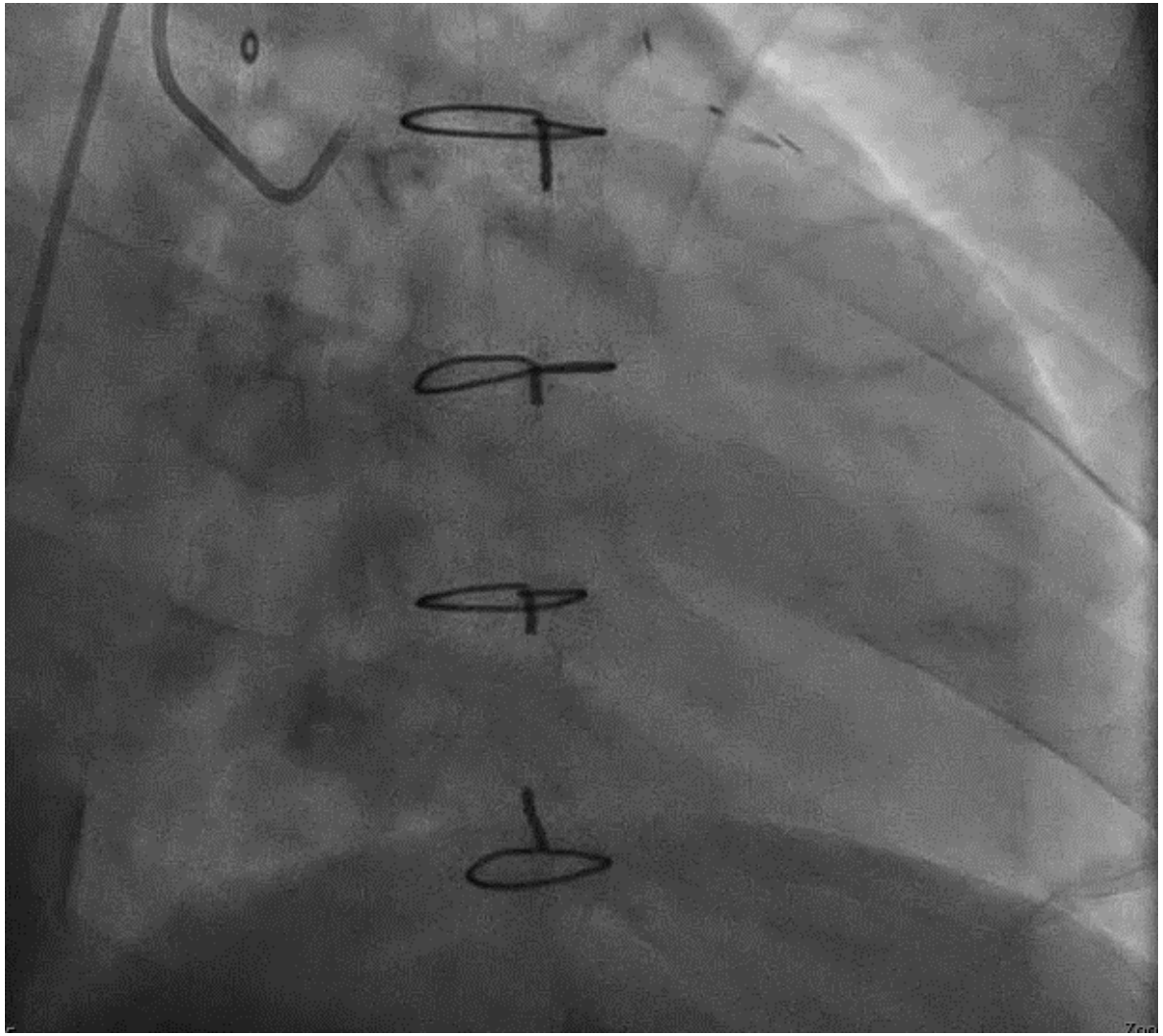
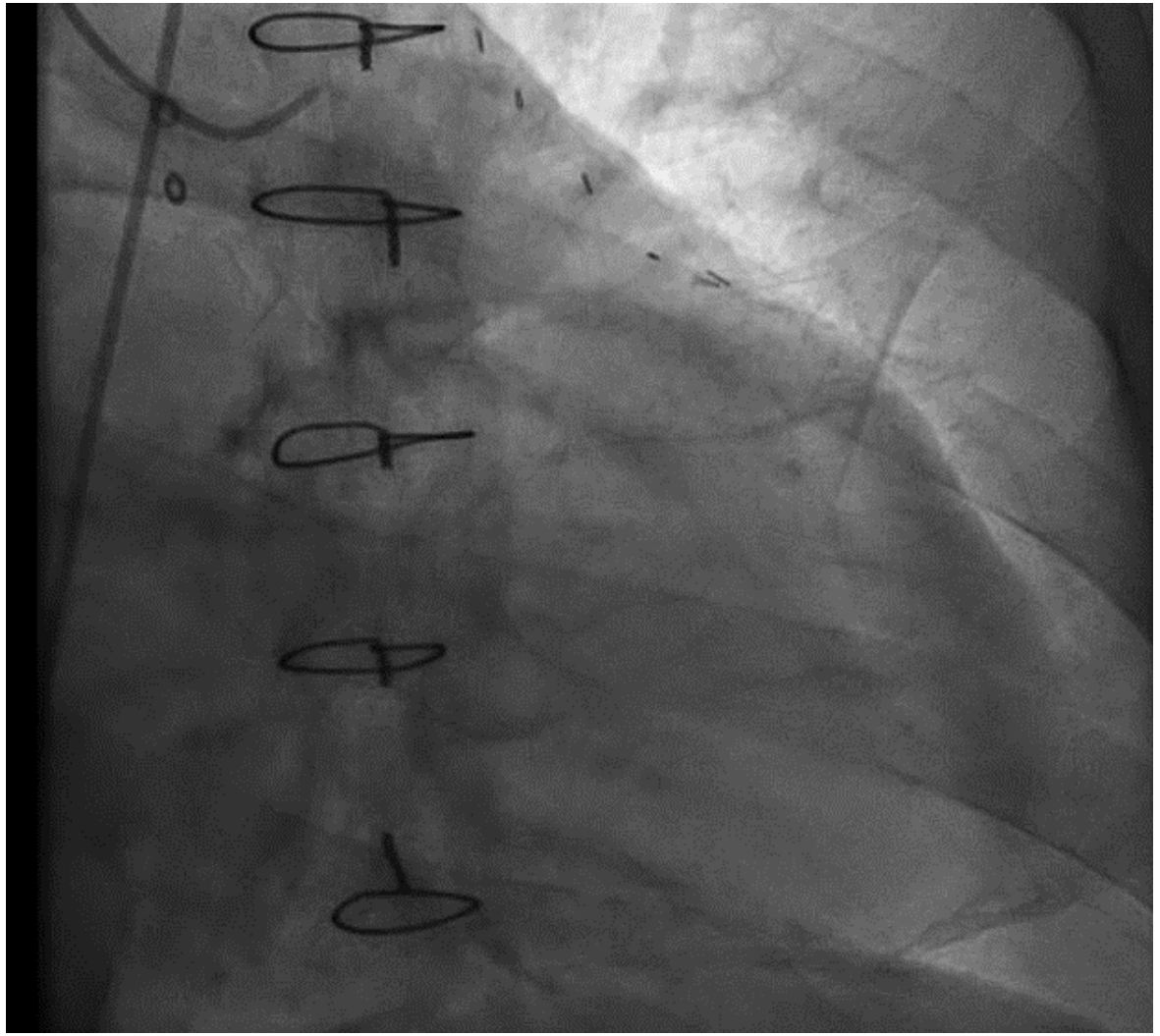
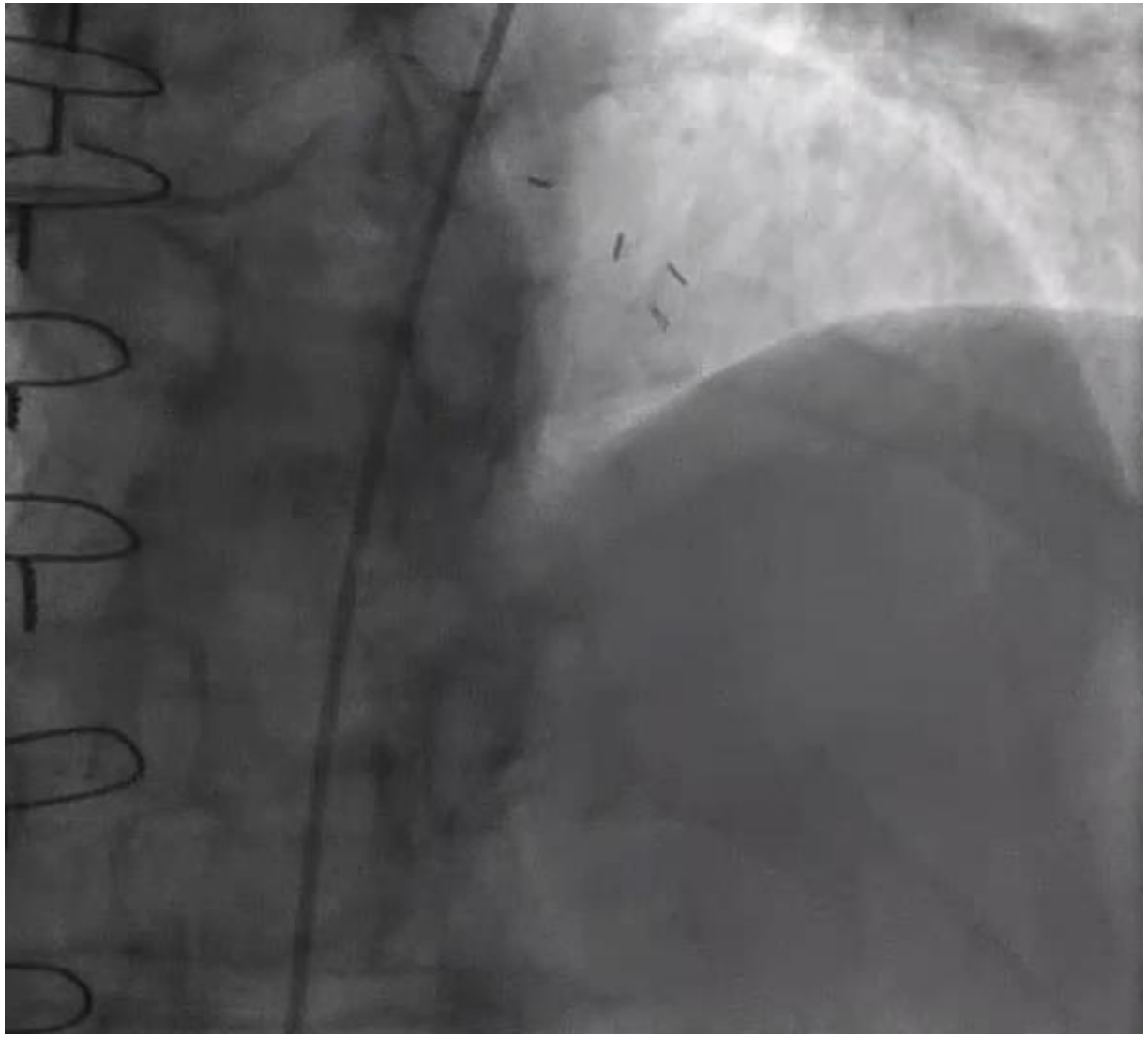
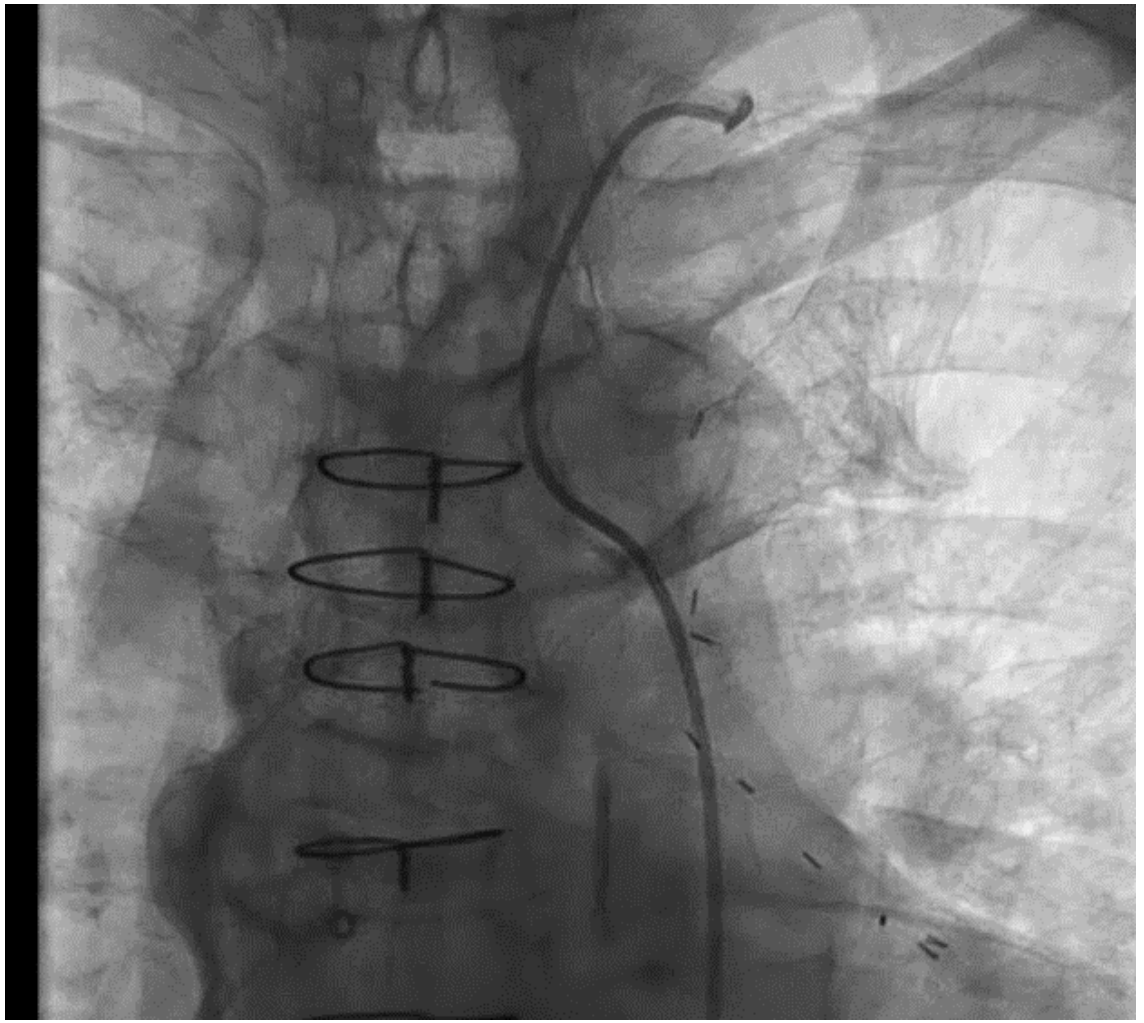
What to fix…

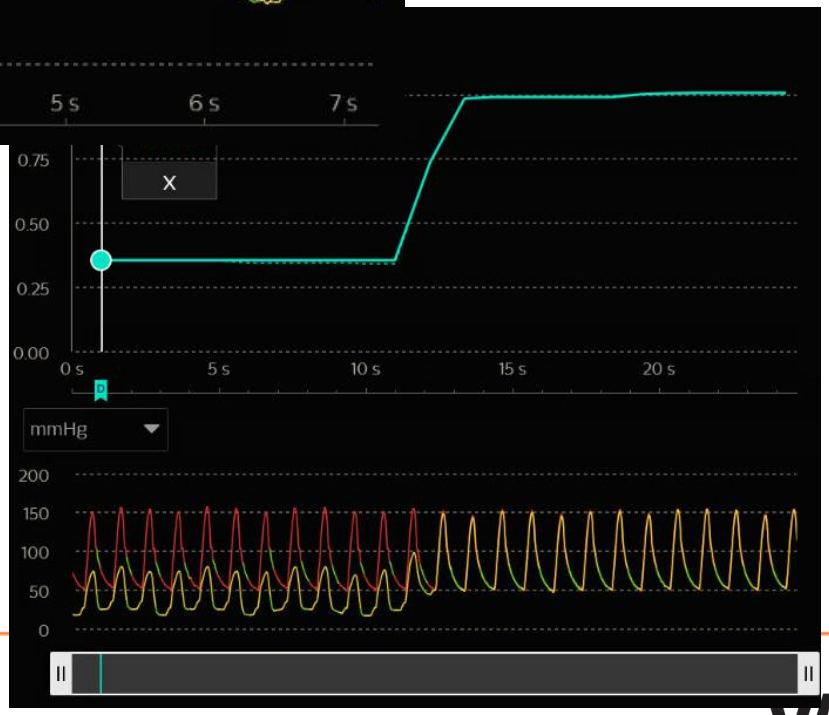




What to Fix…





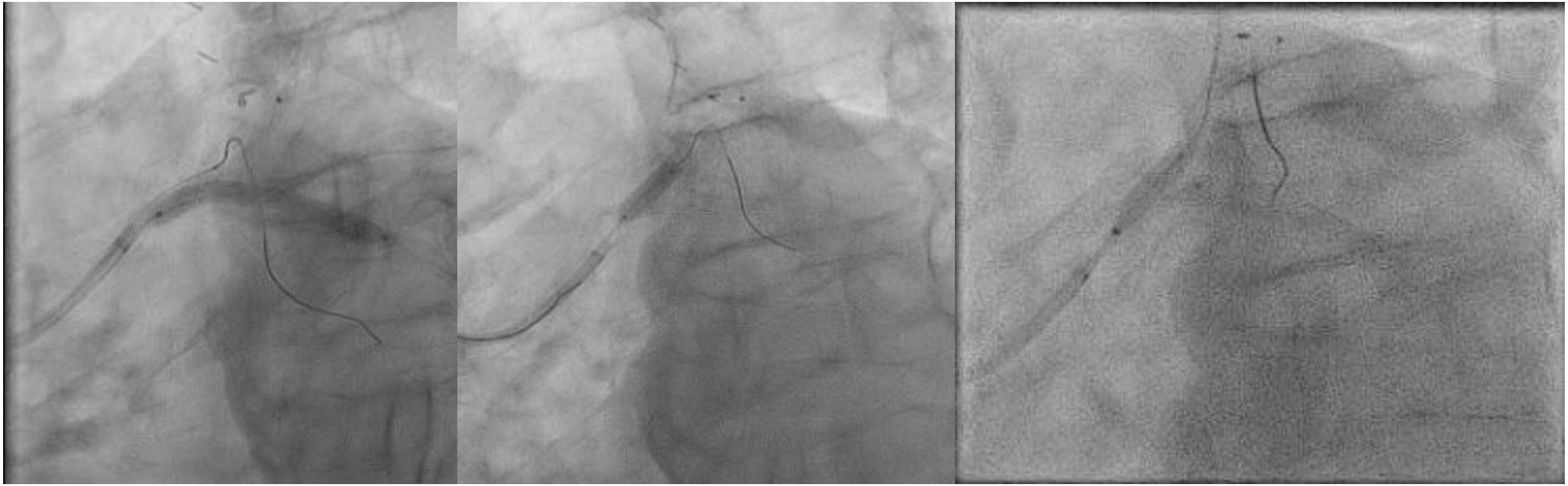


AV Groove LCx

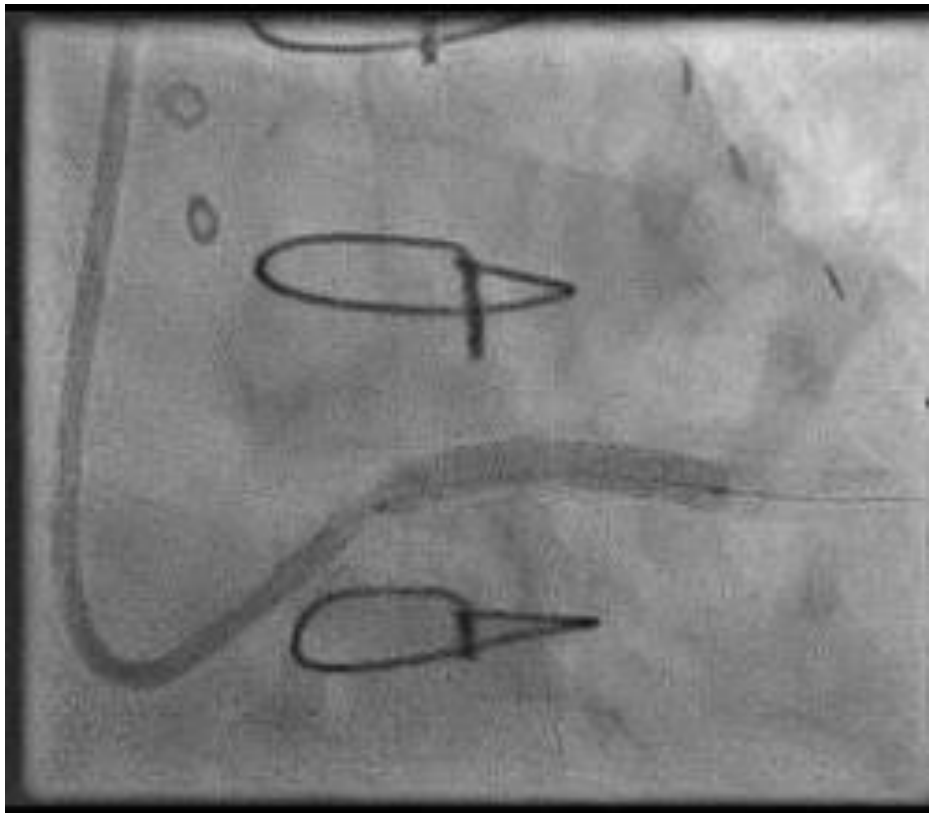
Proximal LAD

1.5 burr wouldn’t cross…1.25 → 1.5mm Burrs

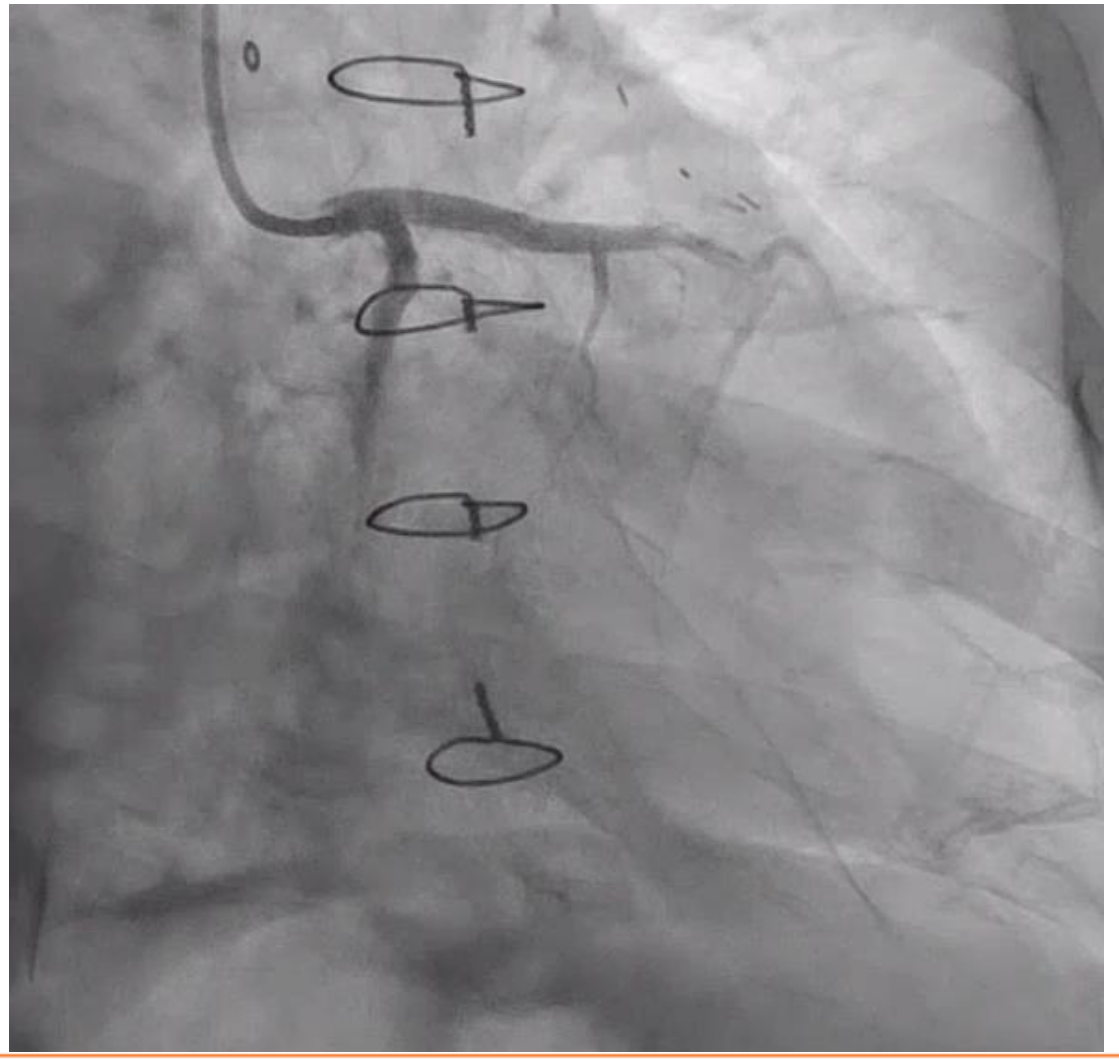
PCI LCx & LAD with LM DK Crush…



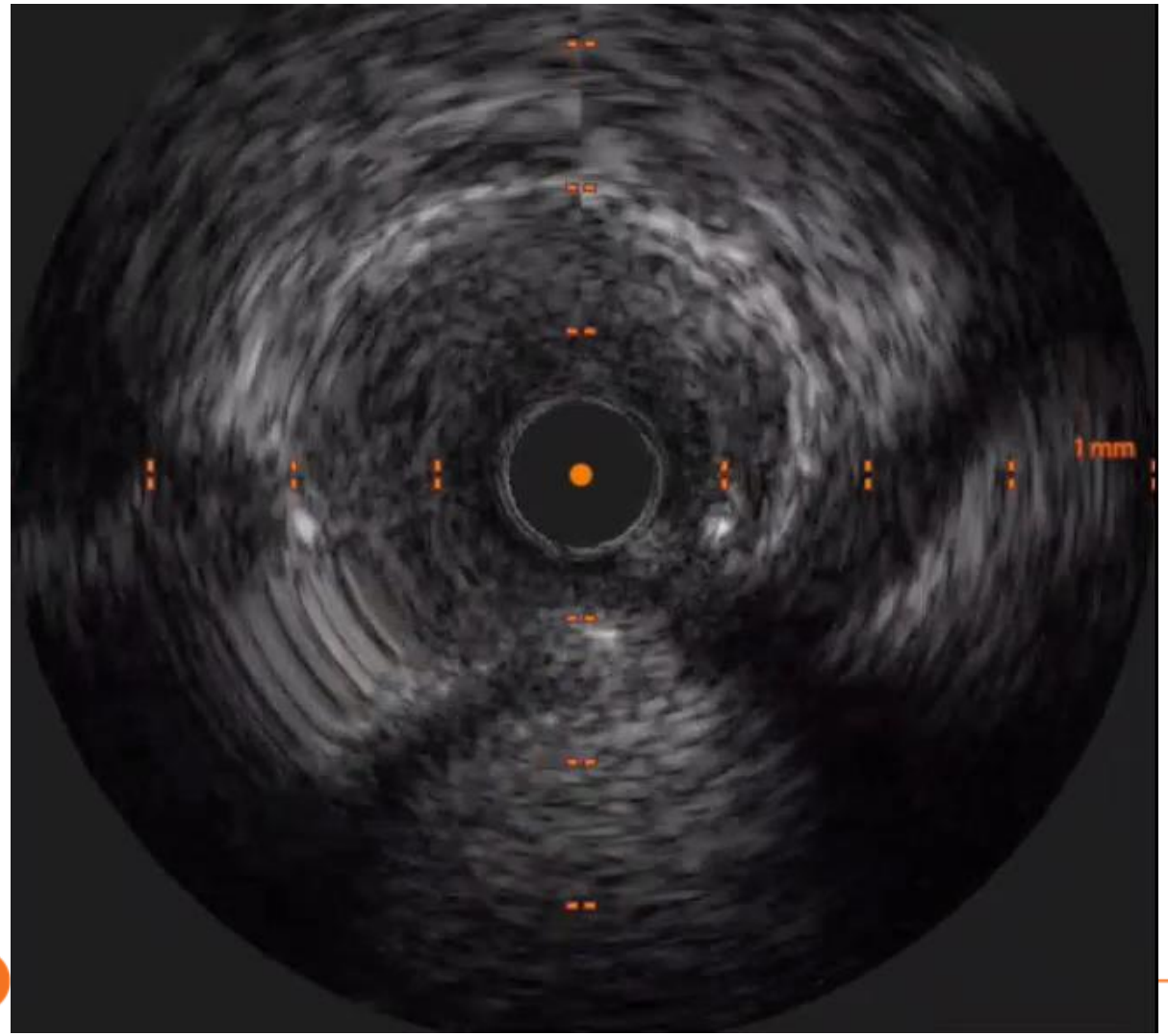
PCI LCx & LAD with LM DK Crush…

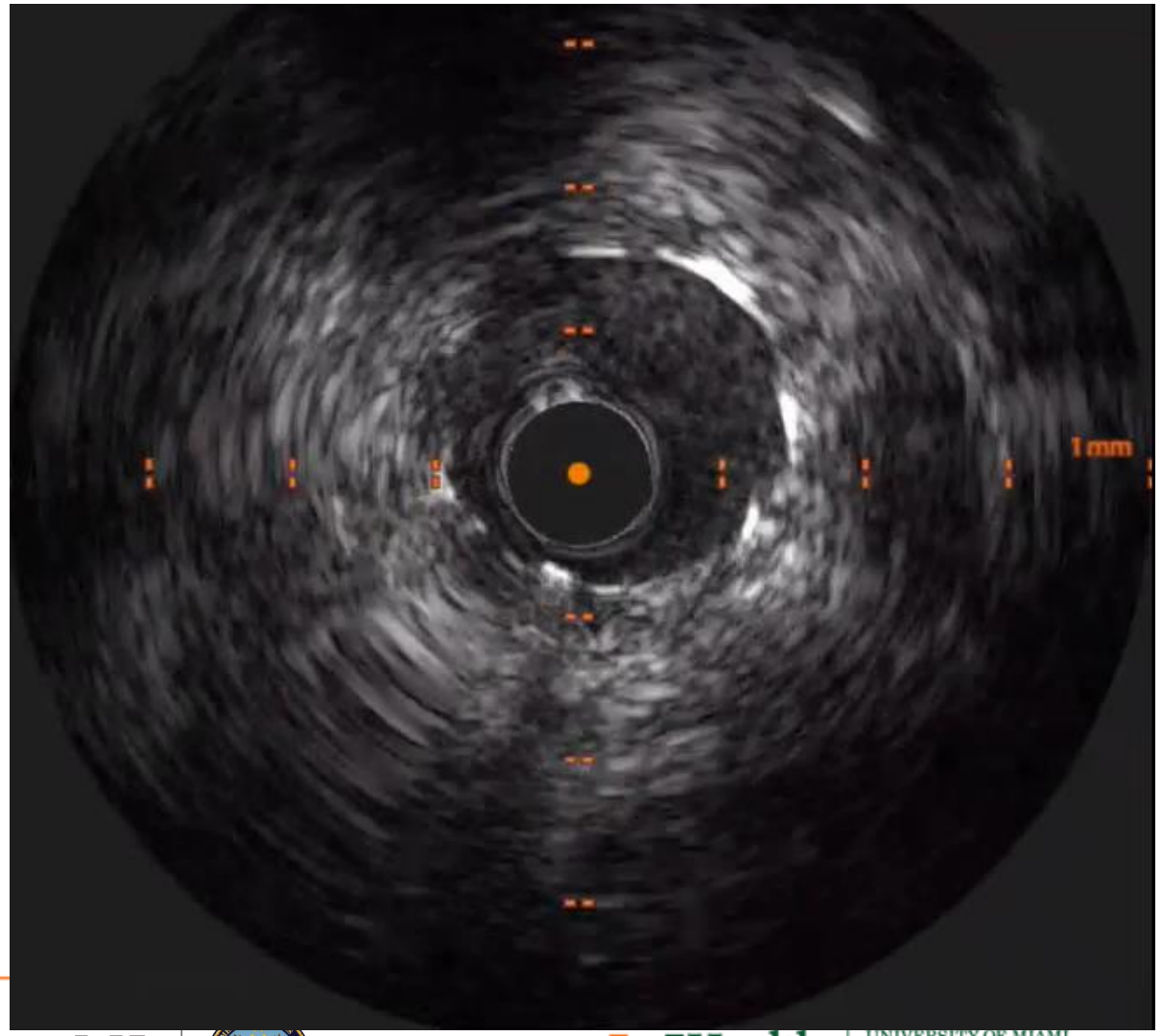


Post PCI Angio

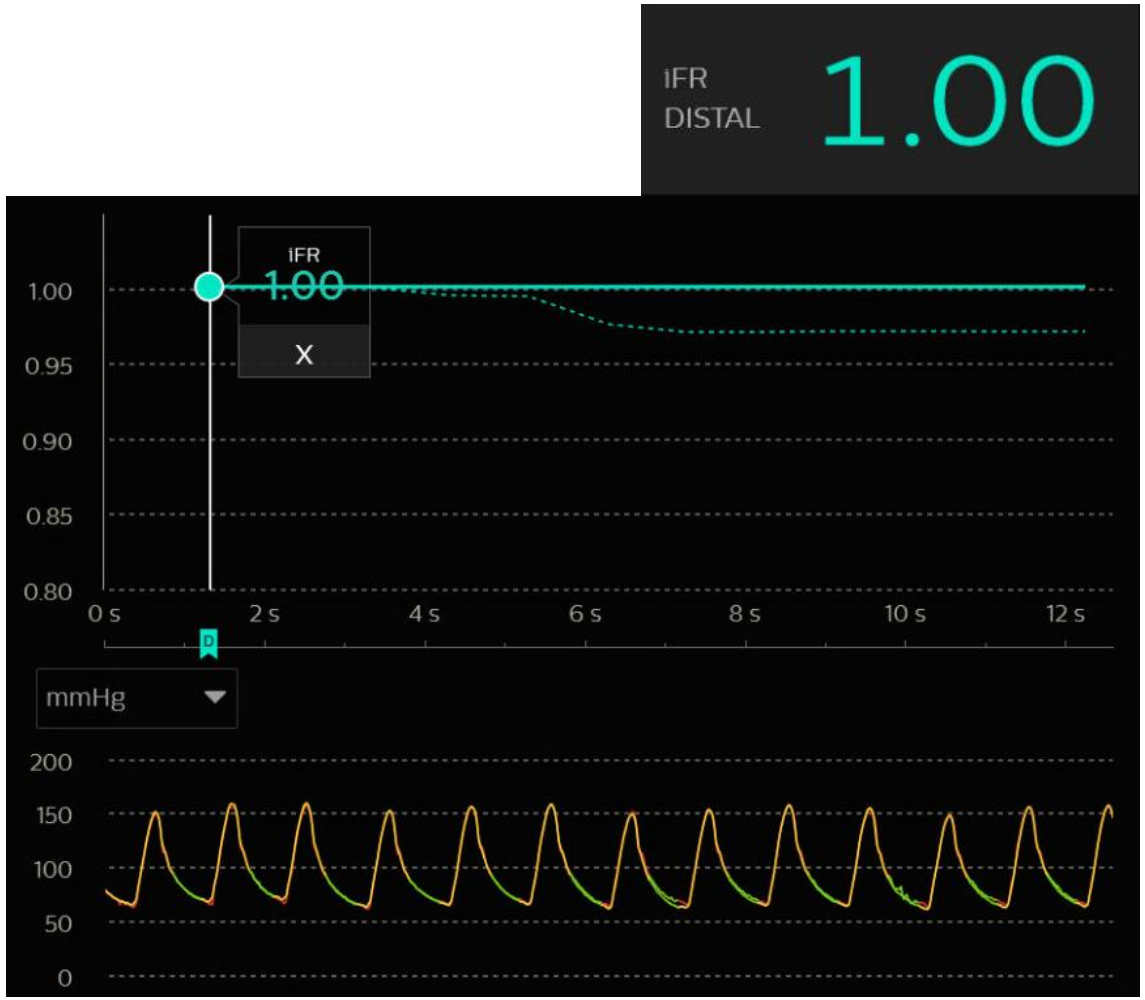


Post PCI IVUS

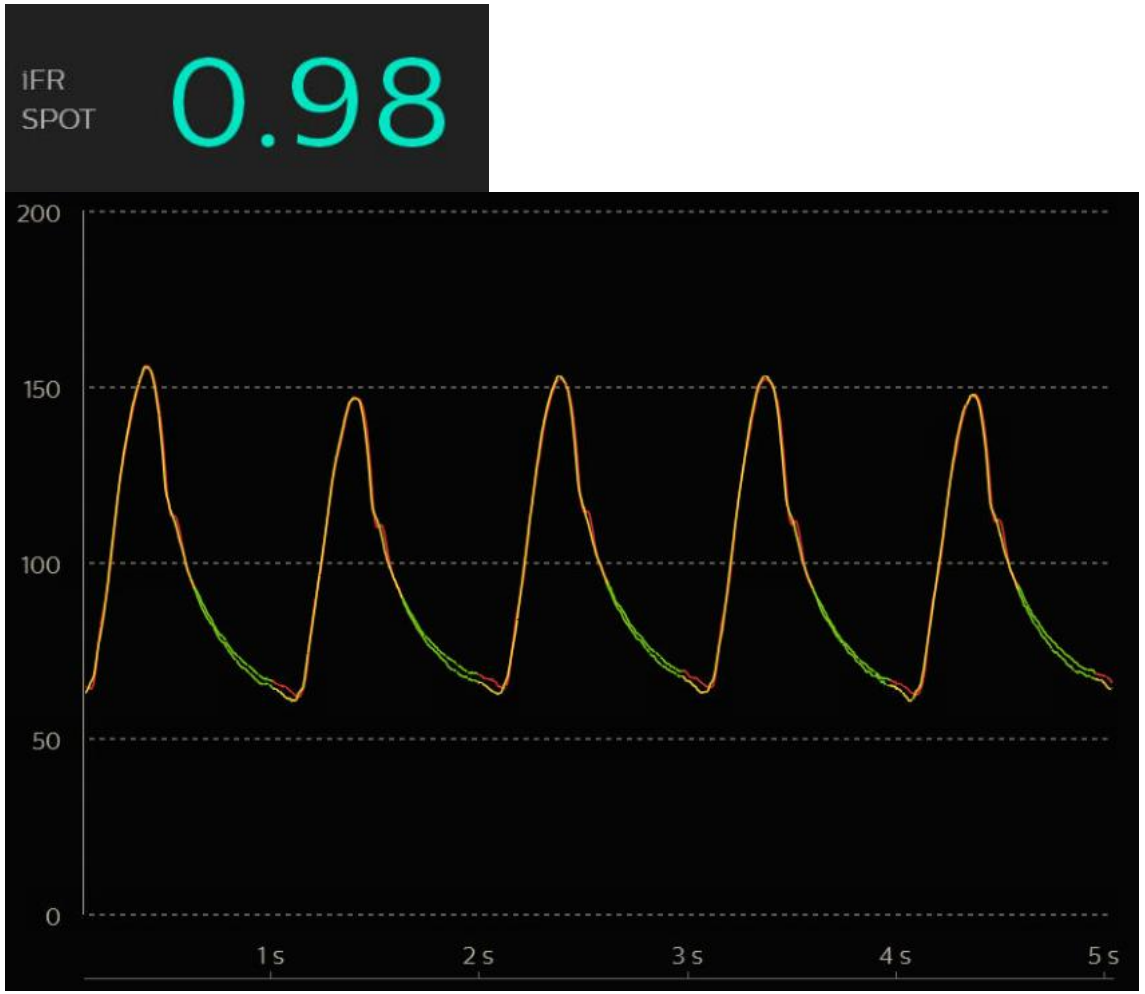




Post PCI Physiology

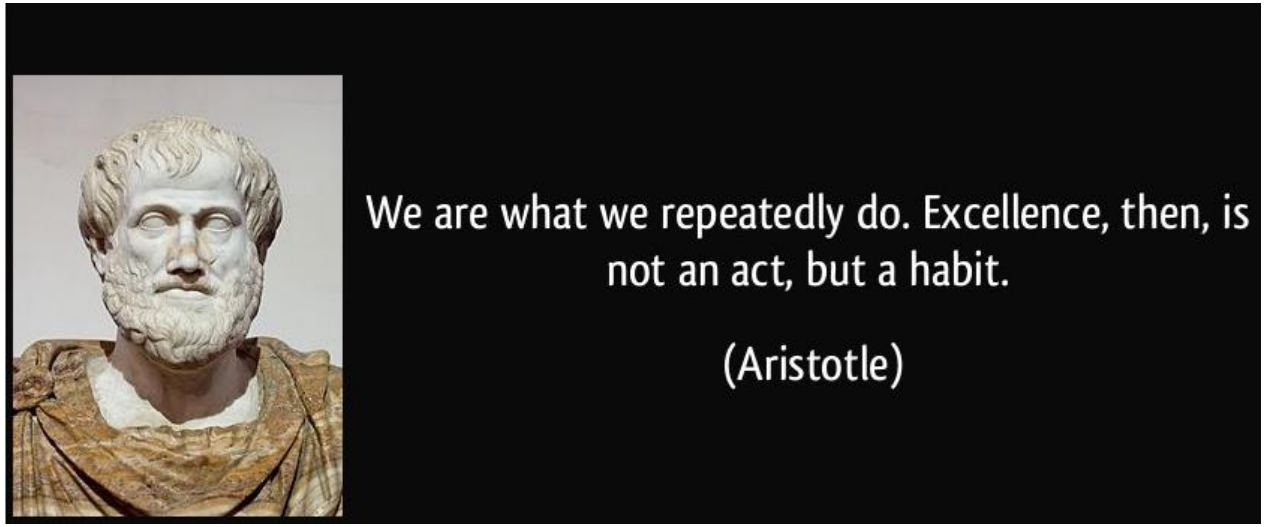


AV Groove LCx



LAD

So…Physiology, Imaging or Both?



- Physiology
  - If you want to appropriately treat epicardial coronary stenosis – Yes
  - If you want to ensure you've helped your patent - Yes
- Anatomy
  - If you want to understand the anatomy you are treating - Yes
  - If you want the best possible outcomes for your patients - Yes
  - If you want to save money – Yes
  - If you want to be excellent and not just good – Yes
- And Finally…IMHO - I don't think it takes that long

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Thank you.