

Stat-of-the-Art in High Resolution IVUS

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Conflict of Interest Disclosure

- Akiko Maehara
 - Personal: Consultant for ACIST, Boston Scientific Corporation
 - Cardiovascular Research Foundation: Boston Scientific Corporation

Five Companies Are Working on Next Generation IVUS Systems

- **ACIST, 60MHz (purchased SVMl - has been working on next generation IVUS since 2007)** Available in August, 2015
 - **InfraReDx, 50MHz** Available in US
 - **Boston Scientific, 60MHz**
 - **Volcano, FACT**
 - **OCT Medical Imaging Inc, 60MHz**
- } Under development

Intravascular Imaging System Comparison

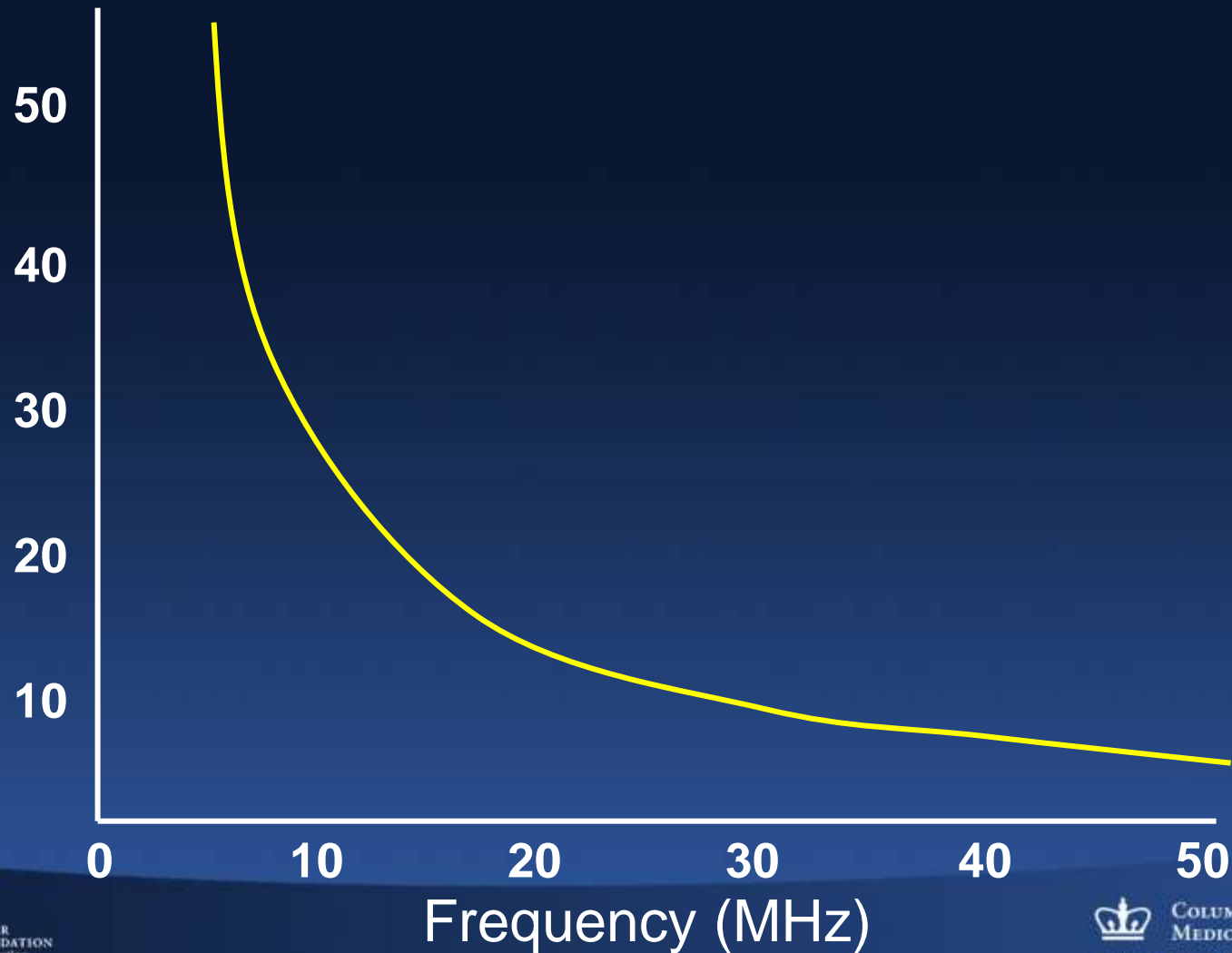
- Angular resolution= $1.22 \times \text{wave length} / \text{diameter of lens}$
- Frequency= speed of wave / wave length

Feature	ACIST HDi / Kodama	Boston Scientific	Volcano FACT	InfraReDx	St Jude Medical OCT
Frequency or Wavelength	60 MHz	60 MHz	Not available	50 MHz	1.3 μm
Nature of the Energy	Ultrasound				Optical
Axial Resolution	40 μm	22 μm	<50 μm	20 μm	15 μm
Lateral Resolution	90 μm	50-140 μm	100-200 μm	<200 μm	40 μm
Soft Tissue Penetration	> 2.5 mm	>3.5 mm			0.8-1.2 mm*
Blood Penetration	> 3.4 mm	>4.0 mm			\leq 1.2 mm
Pullback Speed (mm/s)	0.5, 1.0, 2.5, 5.0, 10	0.5,1.0		0.5	20
Pullback Length (mm)	130	100		150	75

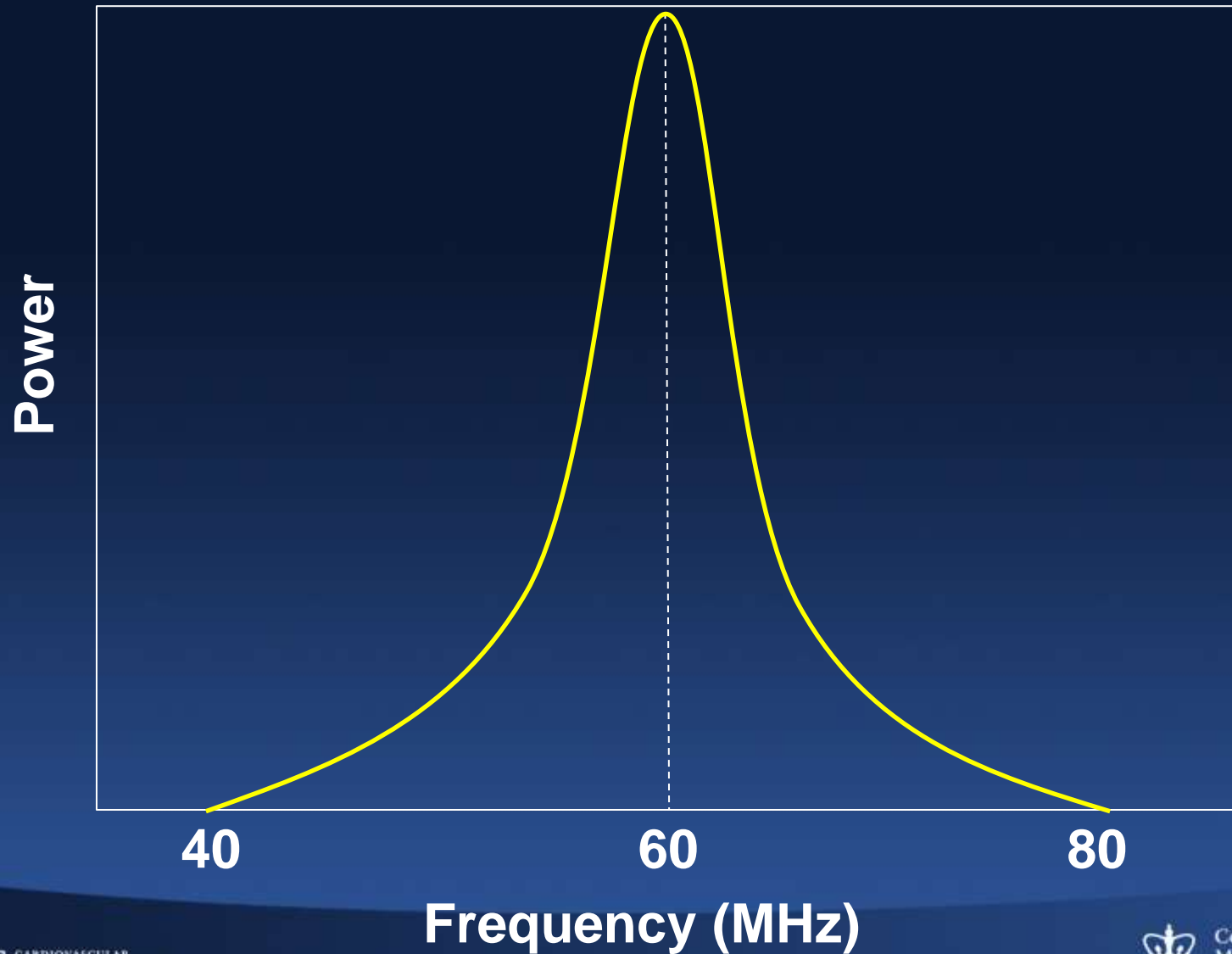
* Soft Tissue Penetration with contrast injection to achieve blood clearing.

Frequency and Penetration

Penetration (mm)

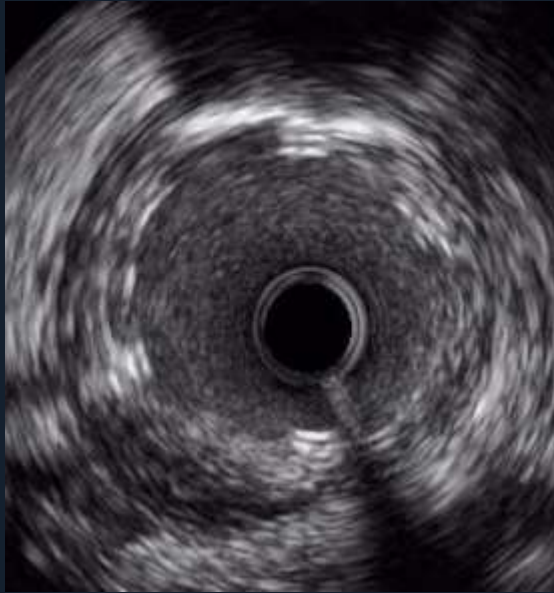


Power Spectrum of Wave

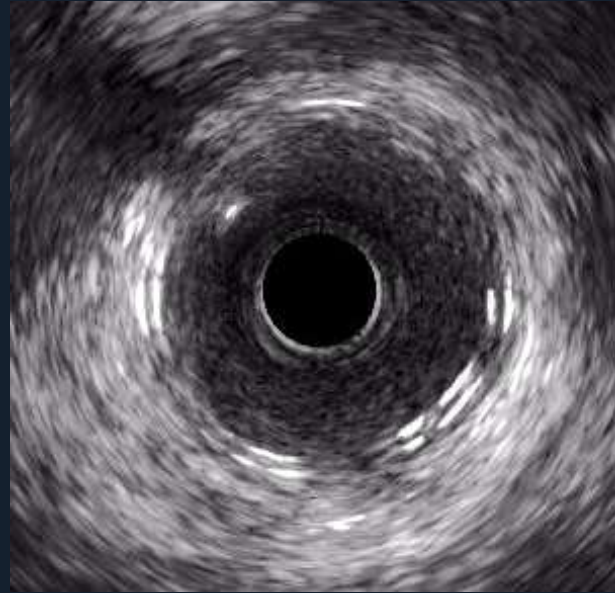


Boston Scientific: HD-IVUS and Bioresorbable Vascular Scaffolds

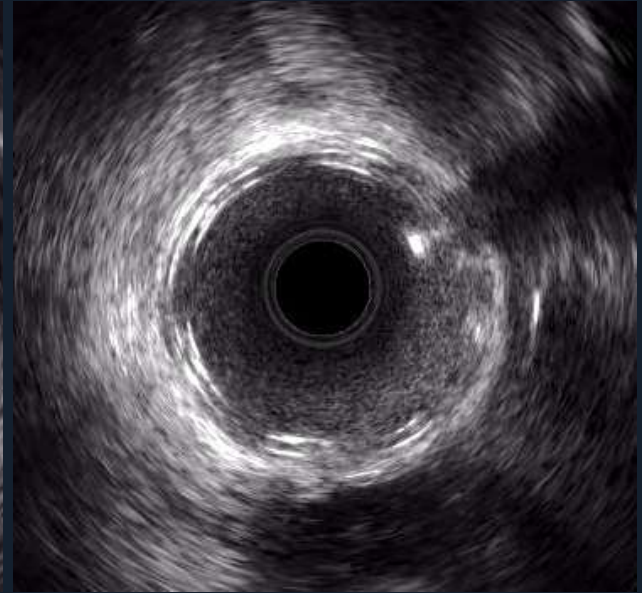
Pro/iCross 40 MHz
43 micron axial



OptiCross 40 MHz
38 micron axial

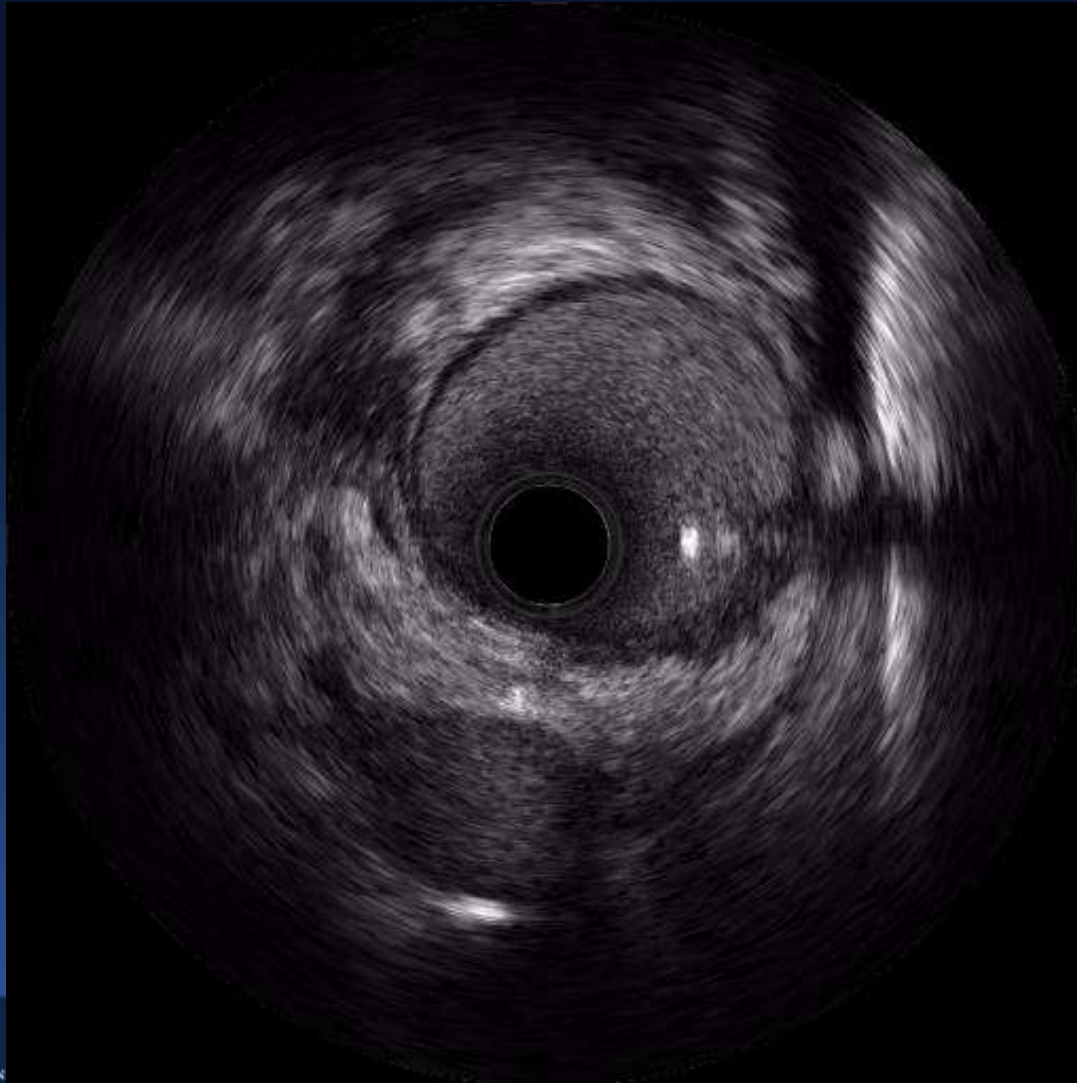


Next Gen IVUS 60 MHz
22 micron axial

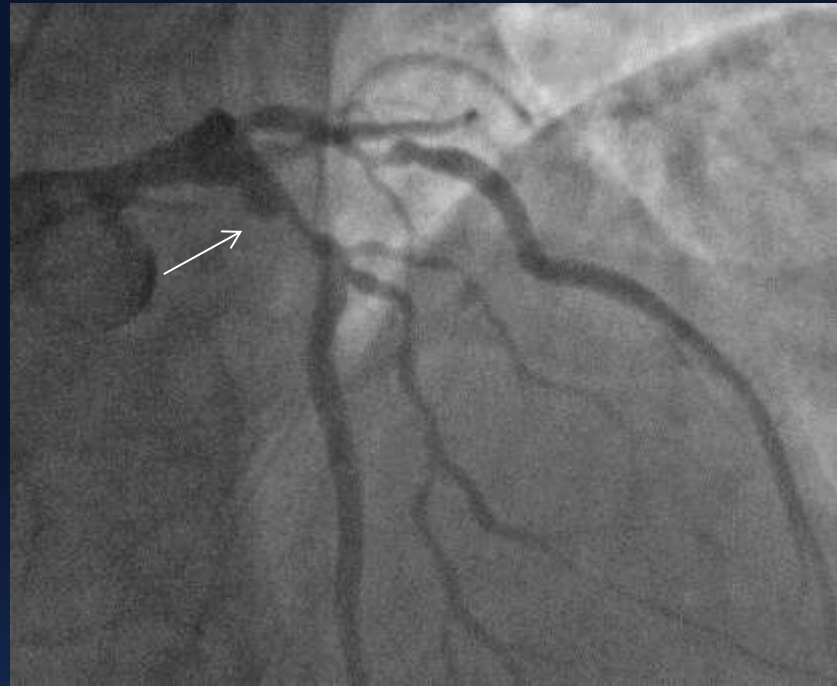


Improving IVUS Resolution without Compromising Penetration

Boston Scientific: 55MHz IVUS in Animal Normal Coronary Artery

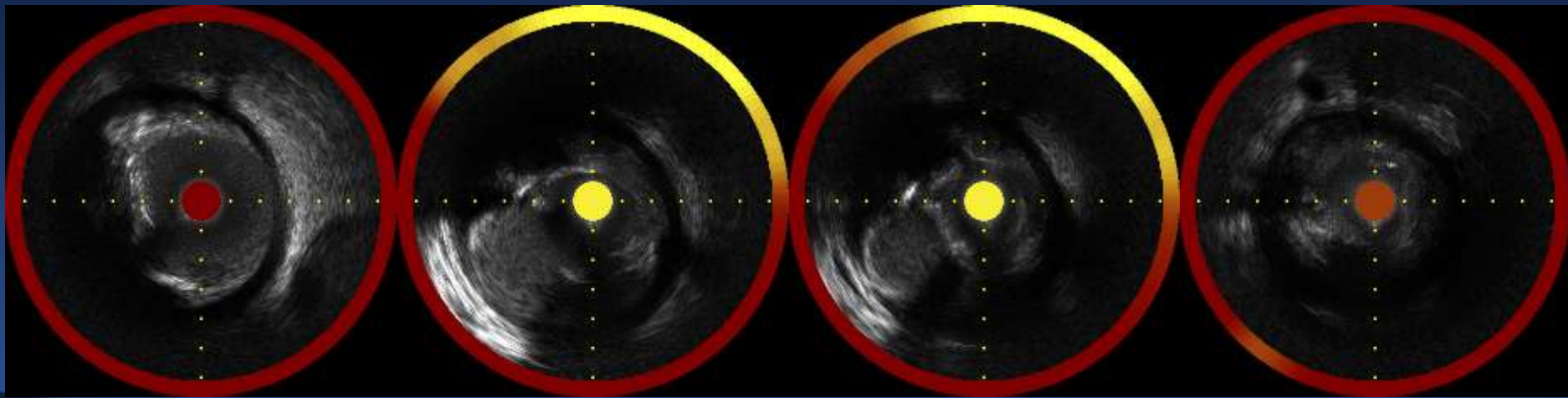


InfraReDx: 50MHz IVUS in Human Plaque rupture

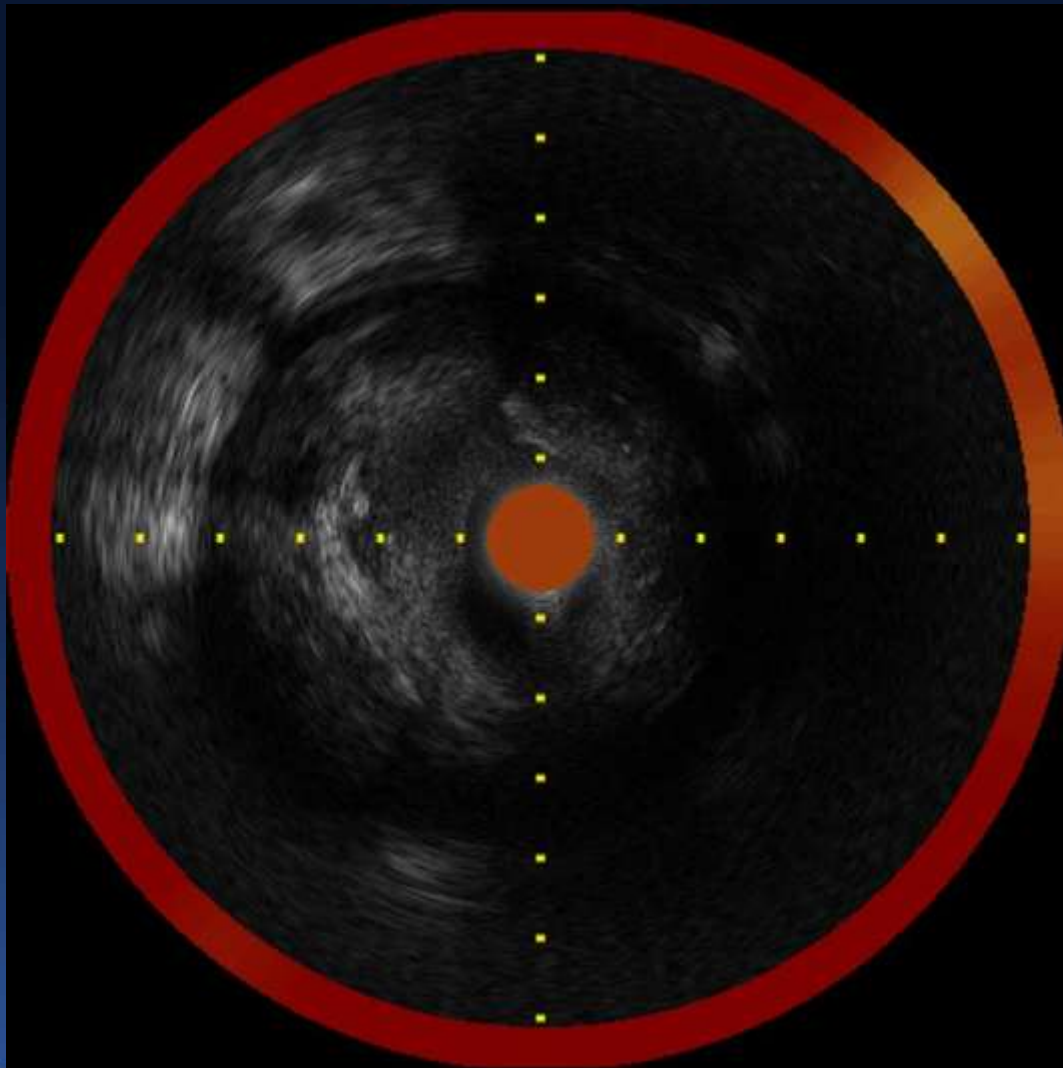


proximal

distal

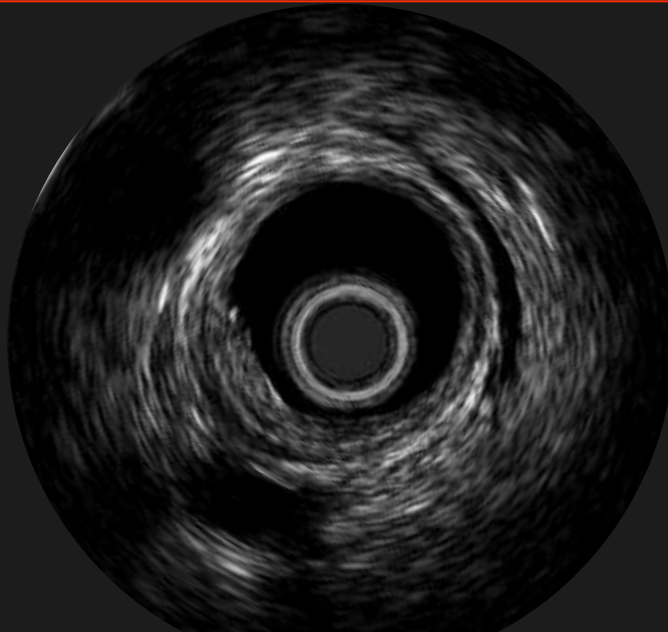


InfraReDx: 50MHz IVUS in Human

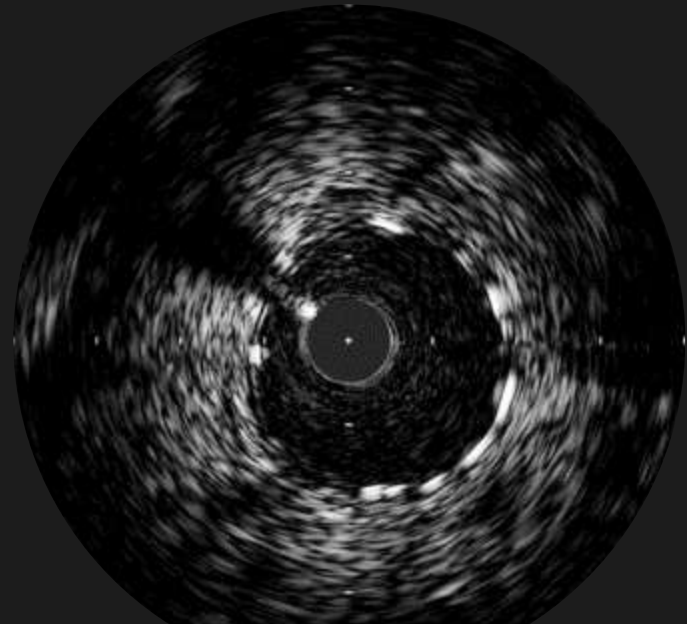


Volcano: FACT (Focused Acoustic Computed Tomography)

FACT ultrasound transducer intended to generate a “cleaner” signal than traditional piezoelectricity, near field resolution close to OCT.

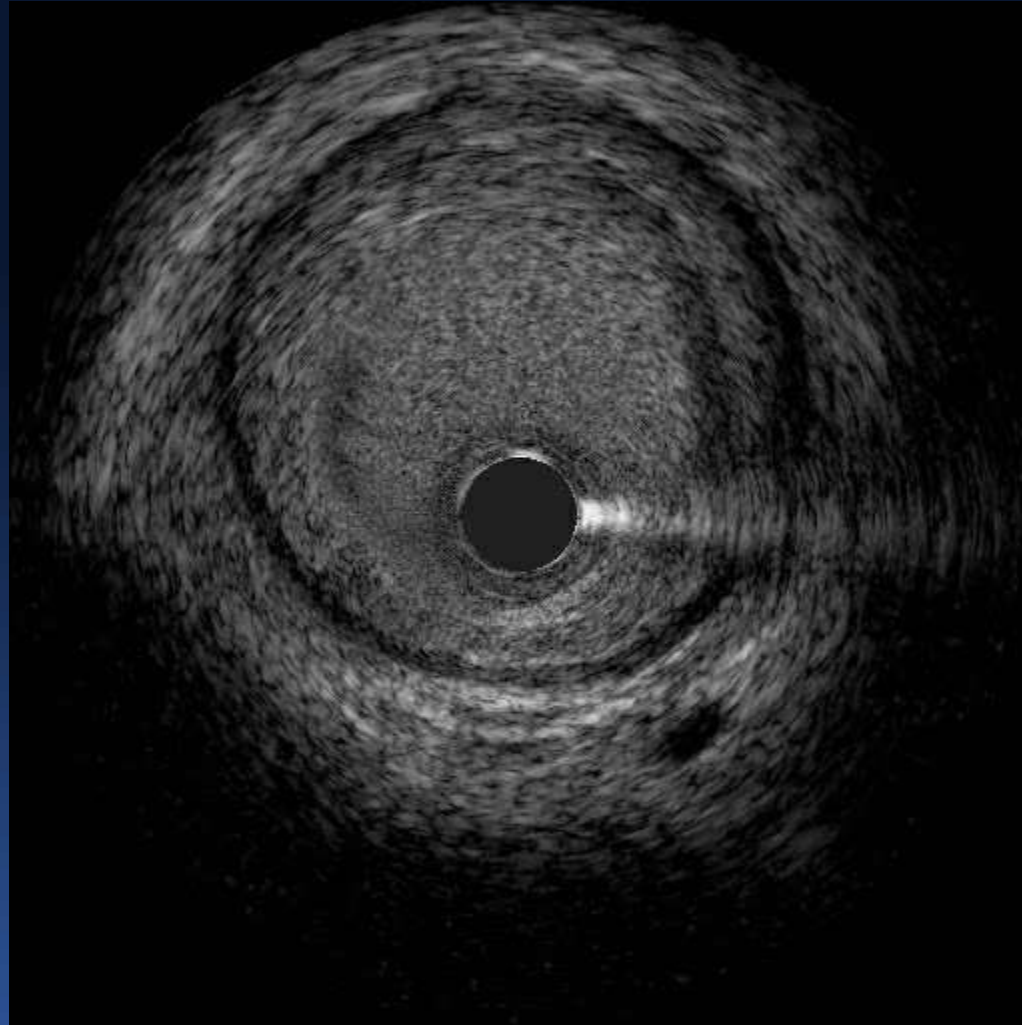


Cadaver Image without blood

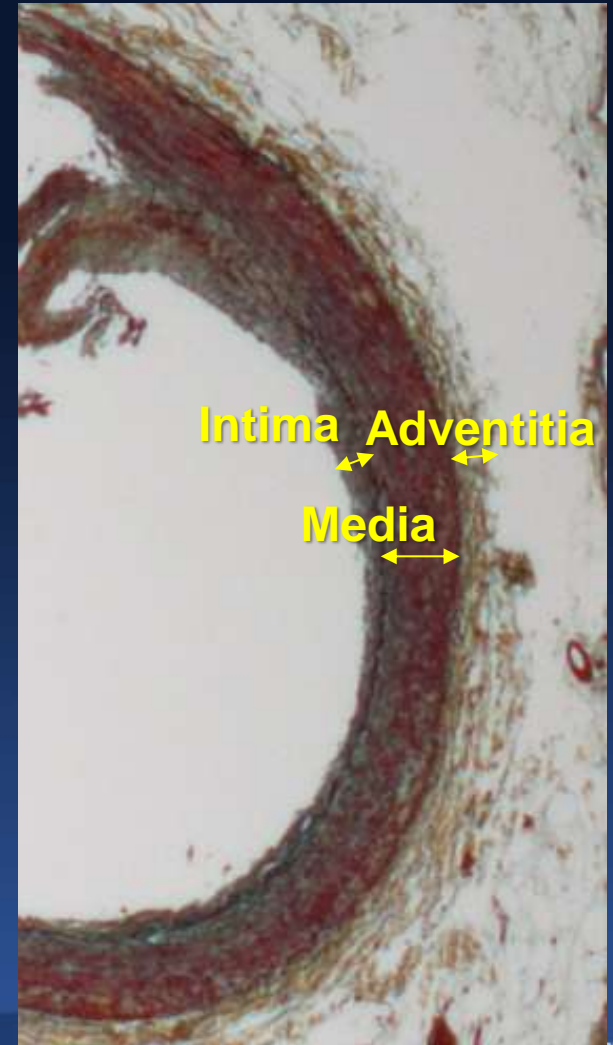
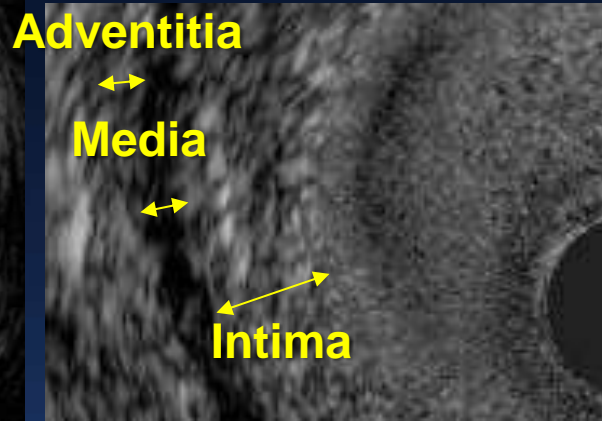
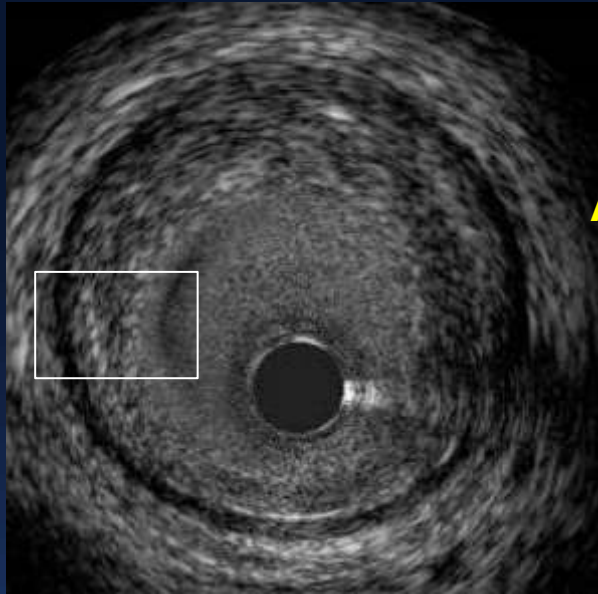


Animal Image with stent

ACIST 60MHz IVUS

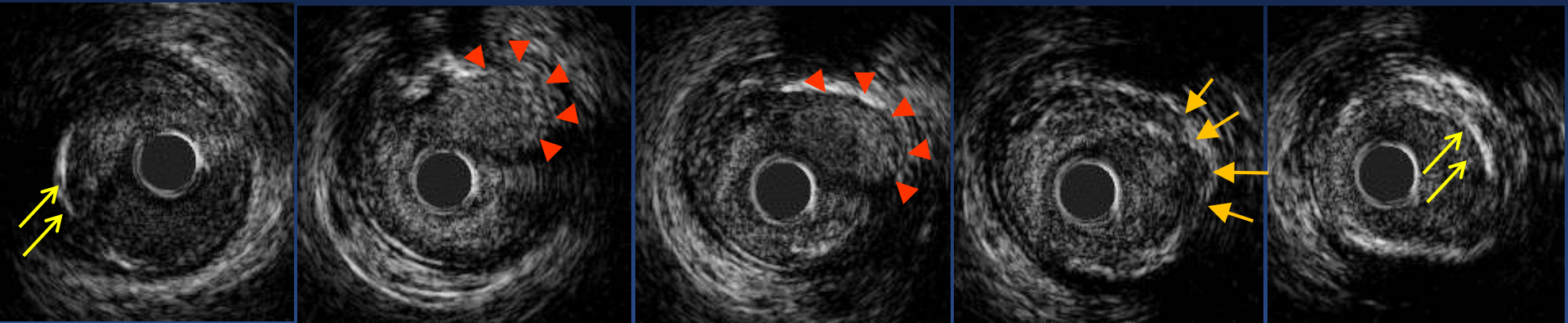
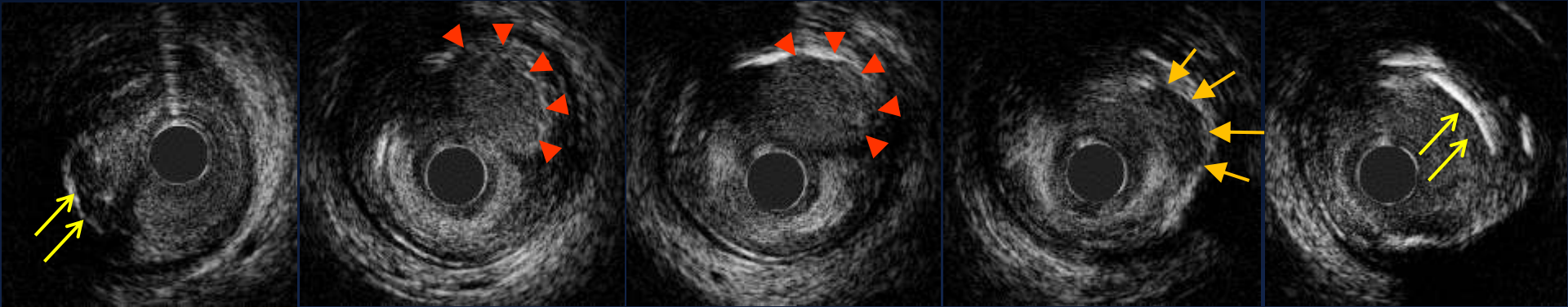


Three Layers Appearance



Difference between 60 and 40 MHz

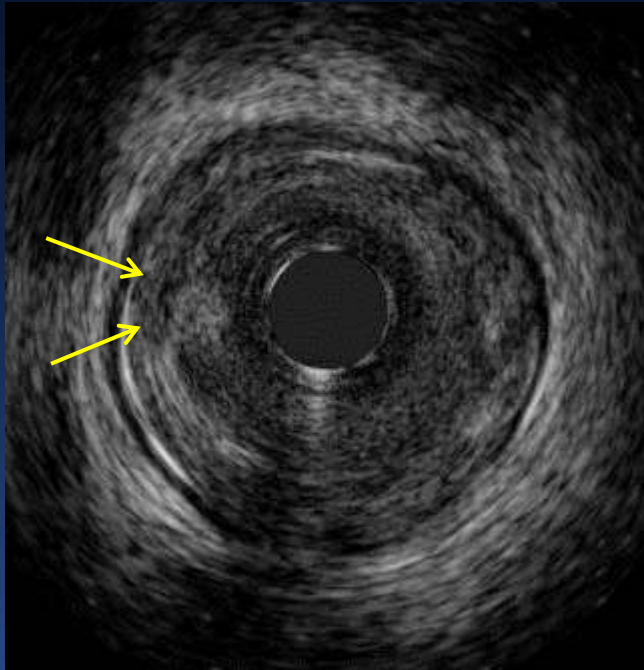
60MHz



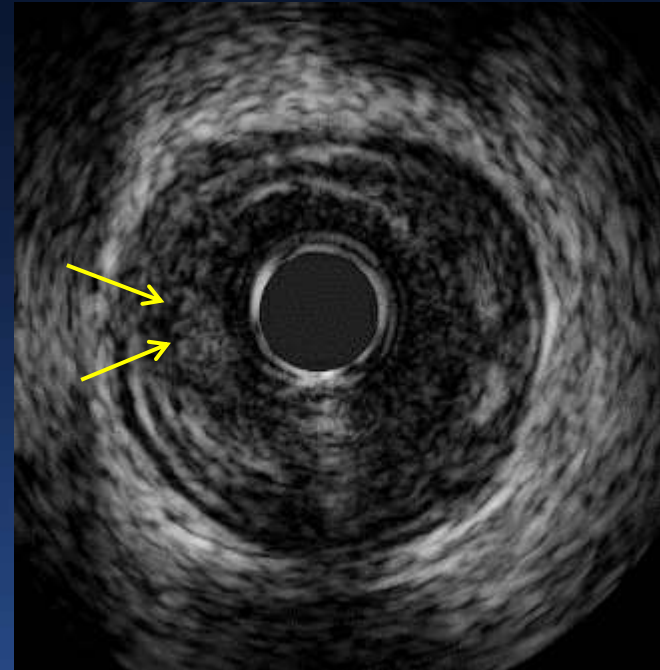
40MHz

Thrombus

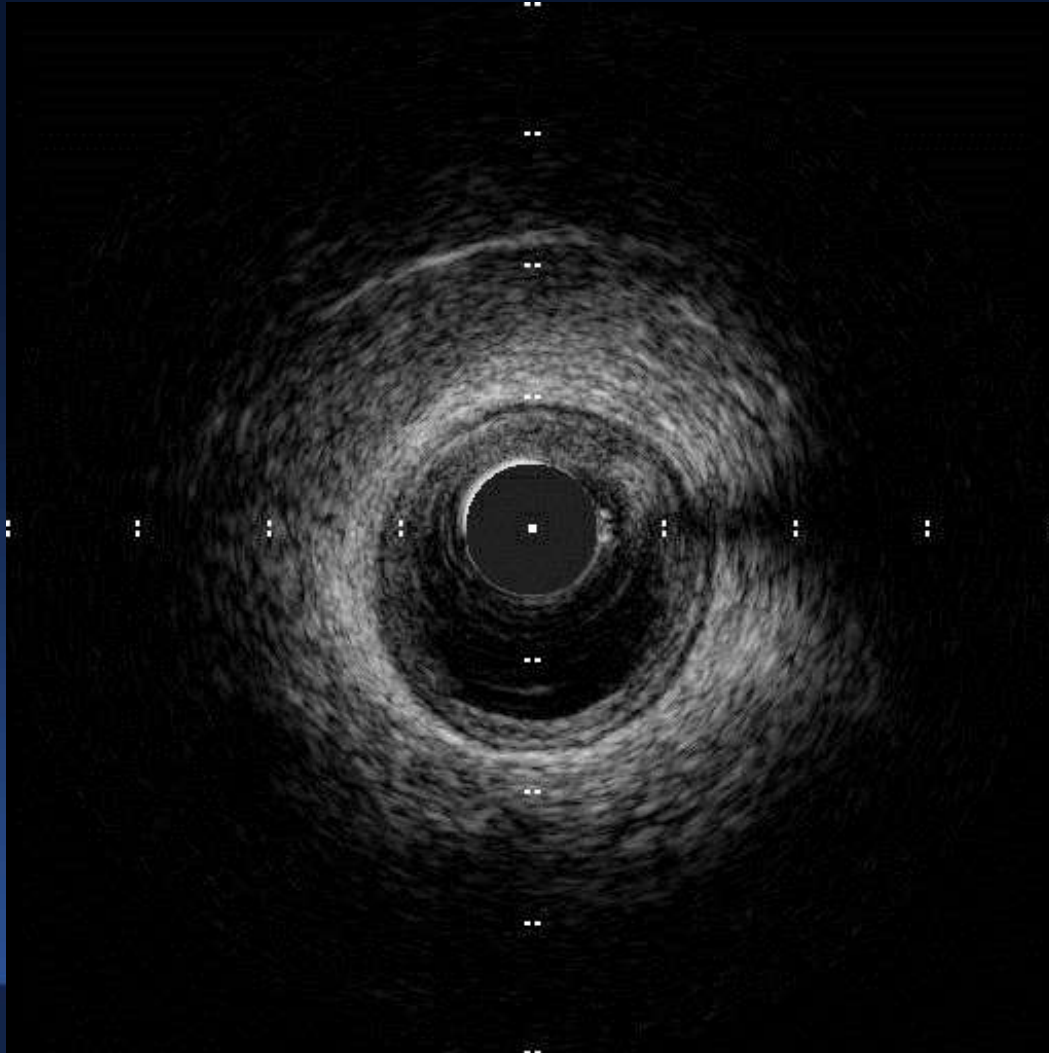
60MHz



40MHz

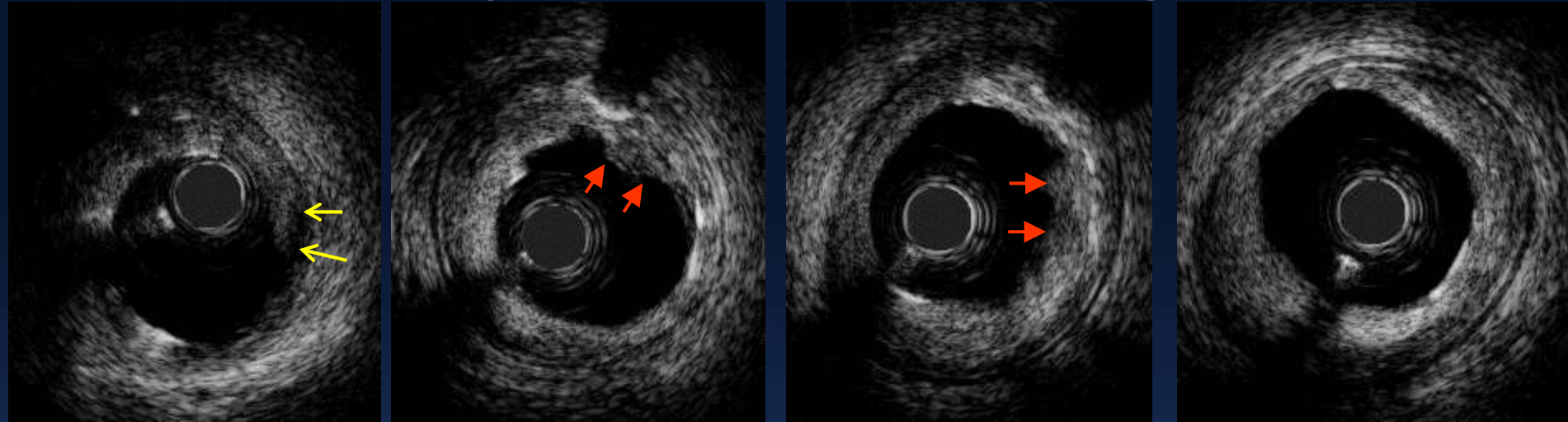


High Speed Pullback (10mm/sec) with Flushing

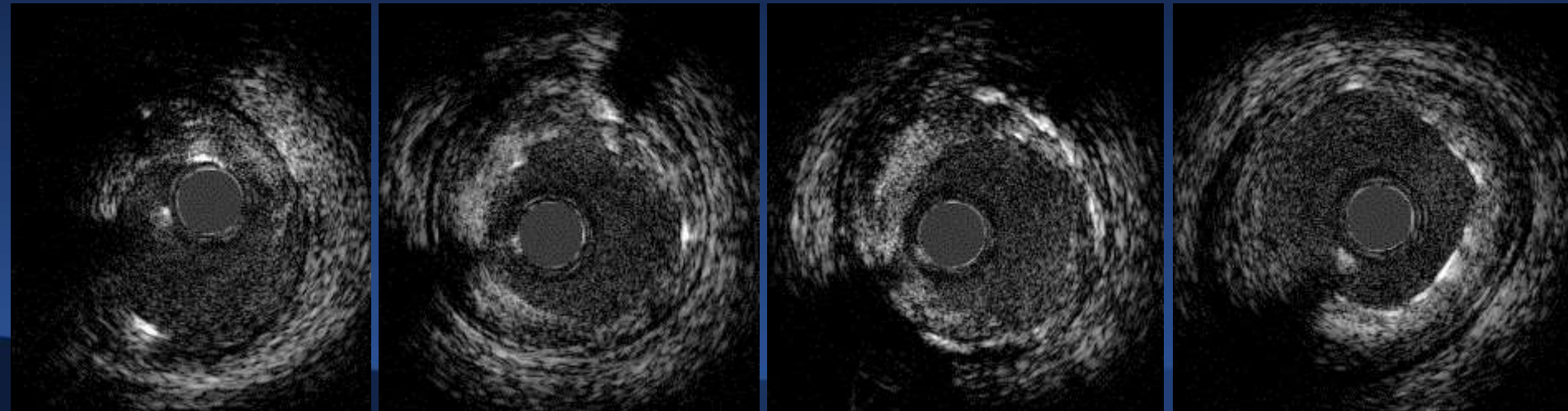


Comparison with vs without Flush

High Speed Pullback with Flushing

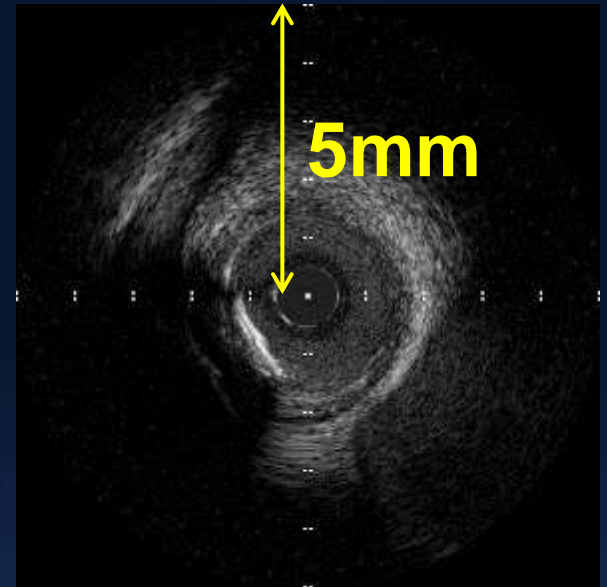
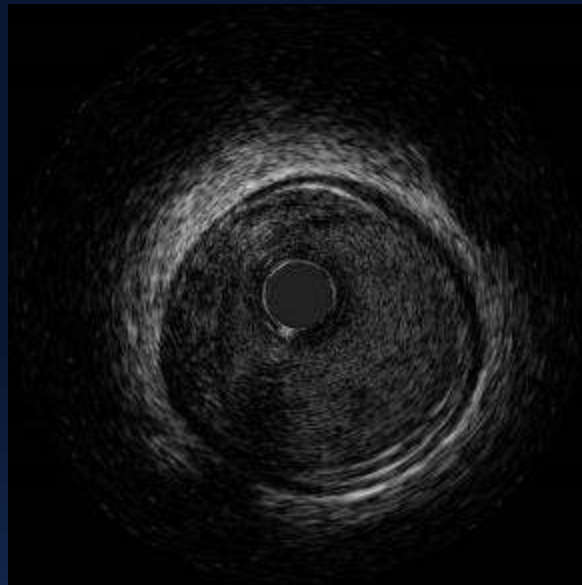


Normal Pullback

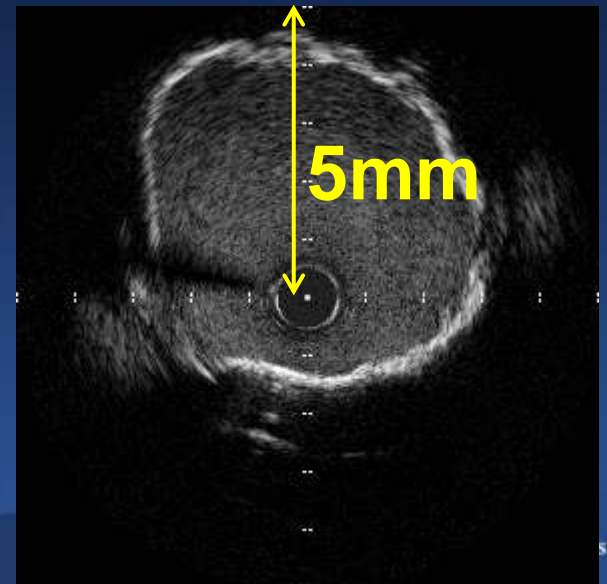
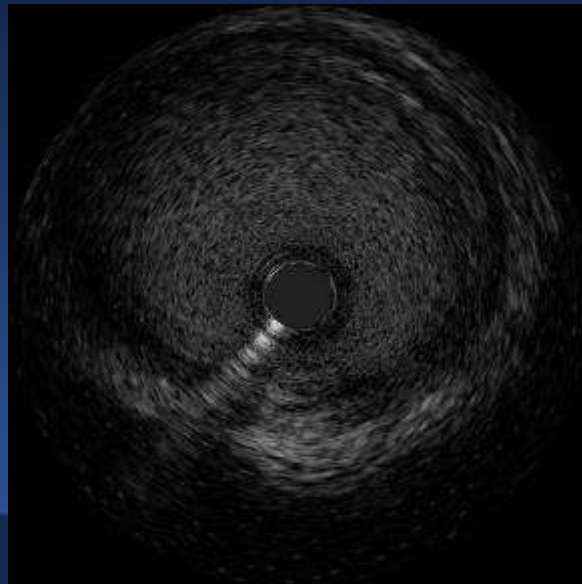


Penetration

Soft Tissue
Penetration

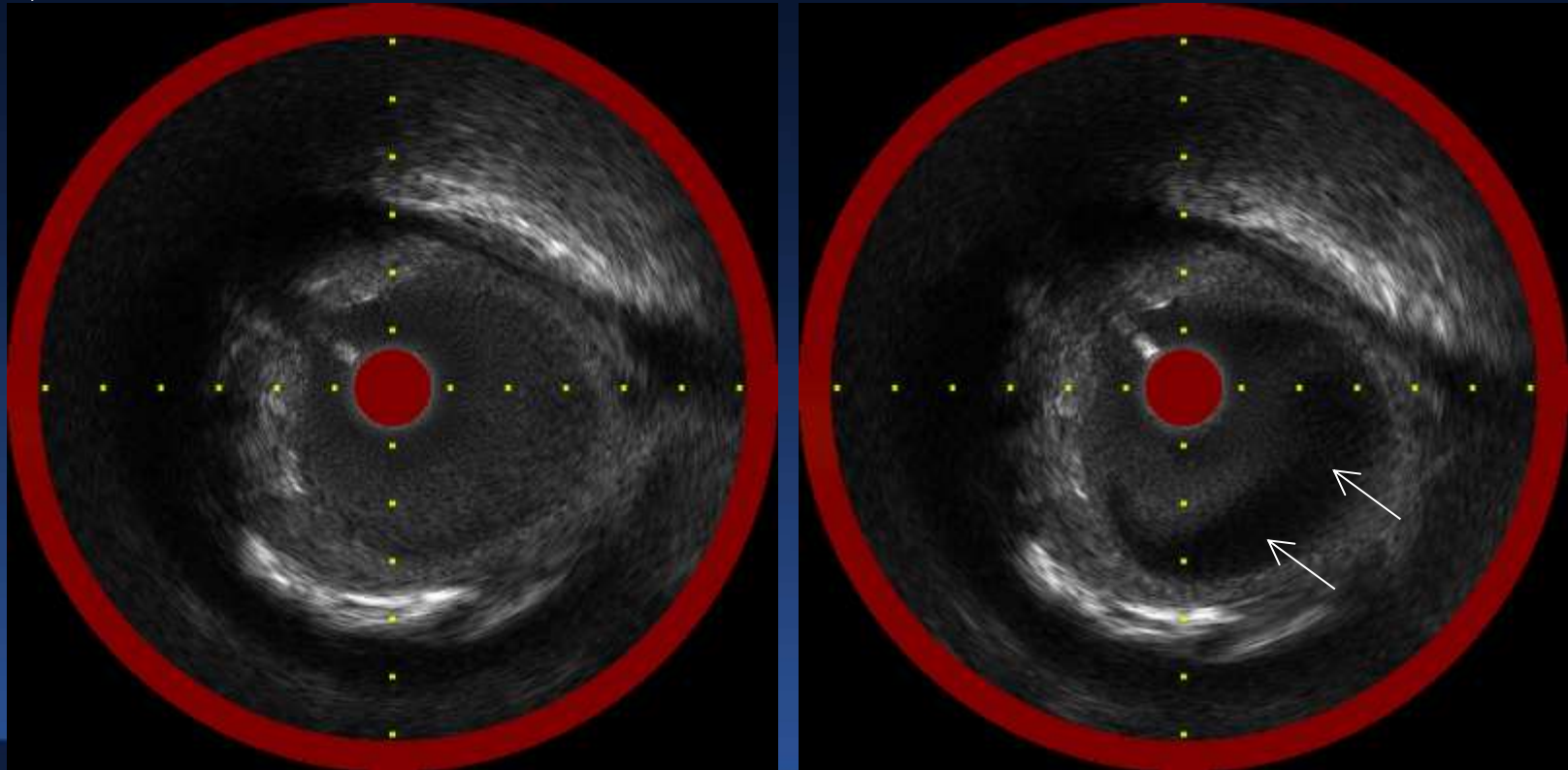


Blood
Penetration



Phase Cancellation Signal Processing Artifact

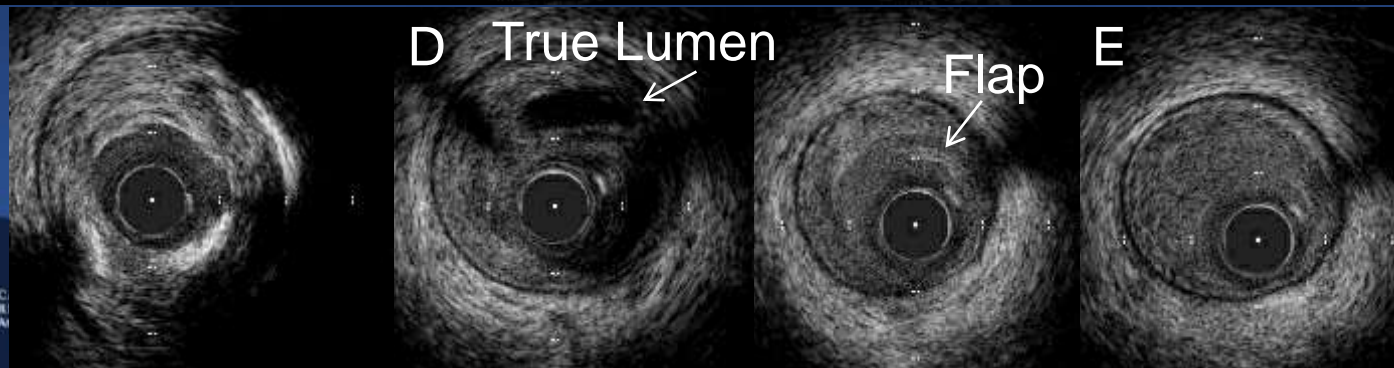
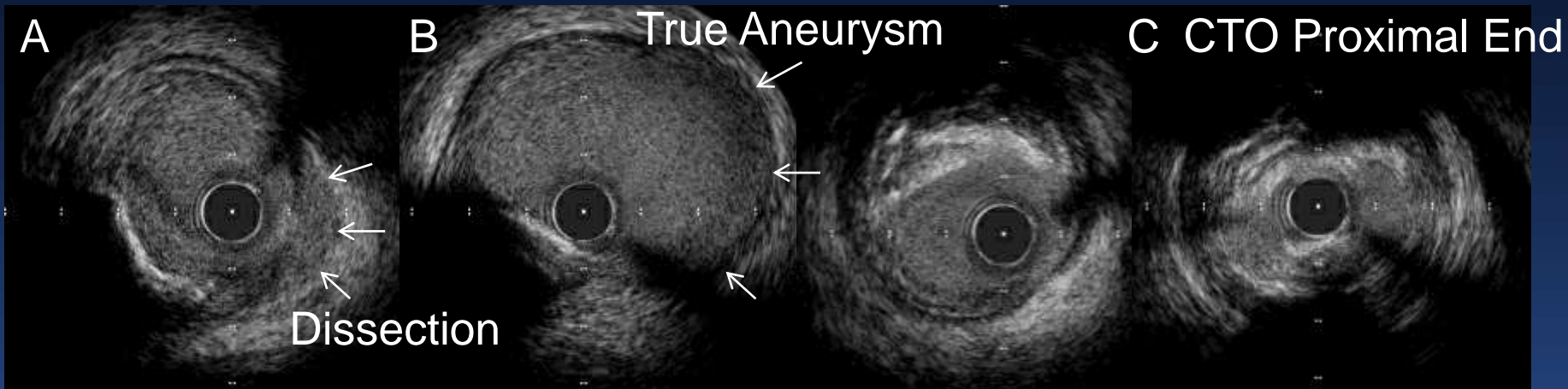
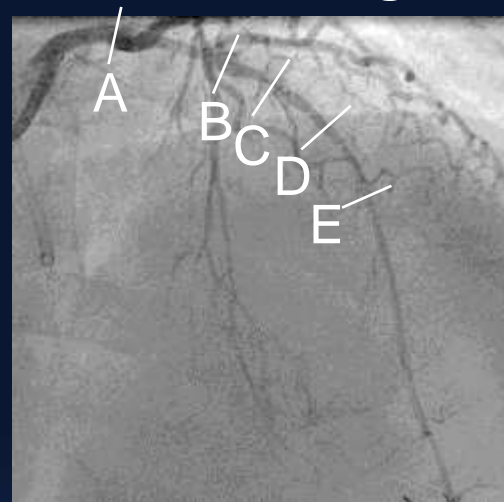
RF averaging across multiple A-lines over a period of around 25 microseconds. If during this averaging period, the target moves slightly, this slight position change results in a 180 degree phase shift of the RF signal so that cancellation occurs and the black region is present.

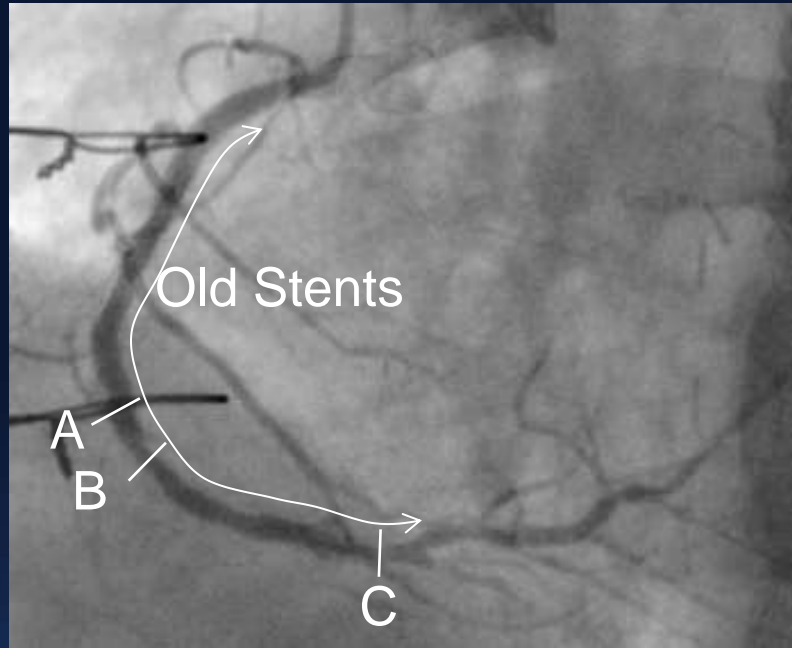


Pre-PCI



Post-Wiring

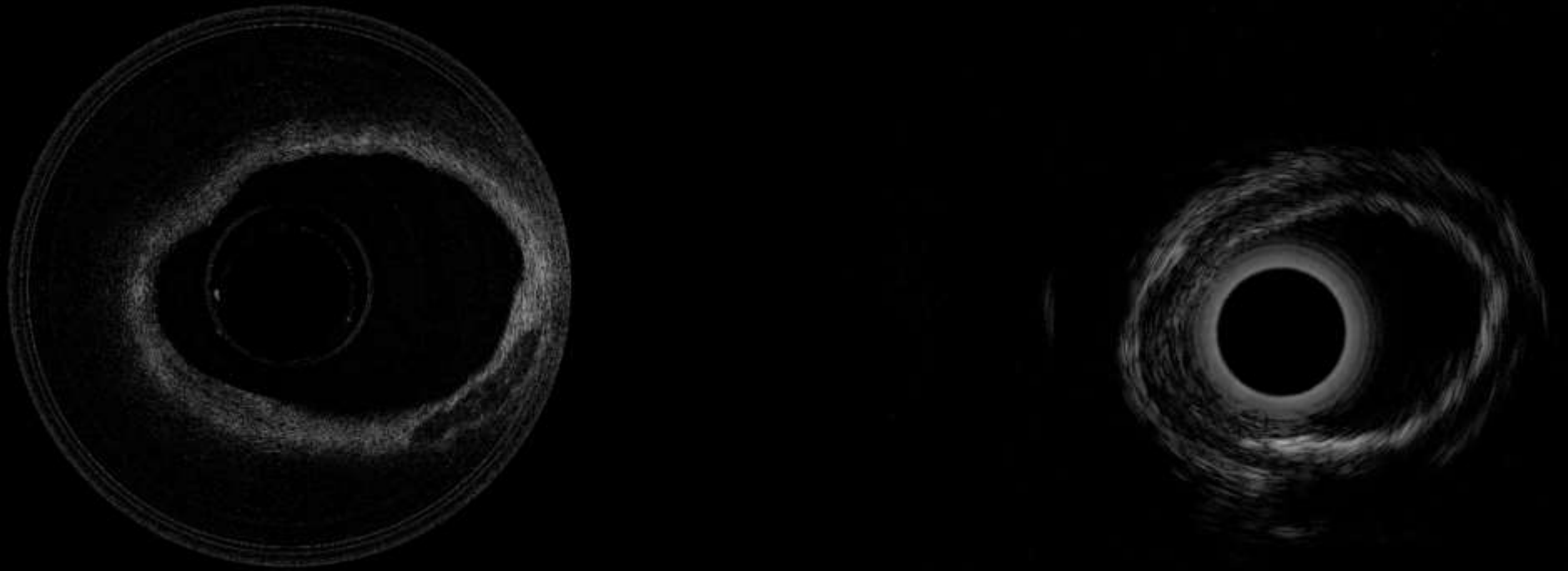




Neointimal
Attenuated Plaque



OCT/IVUS Combined Catheter

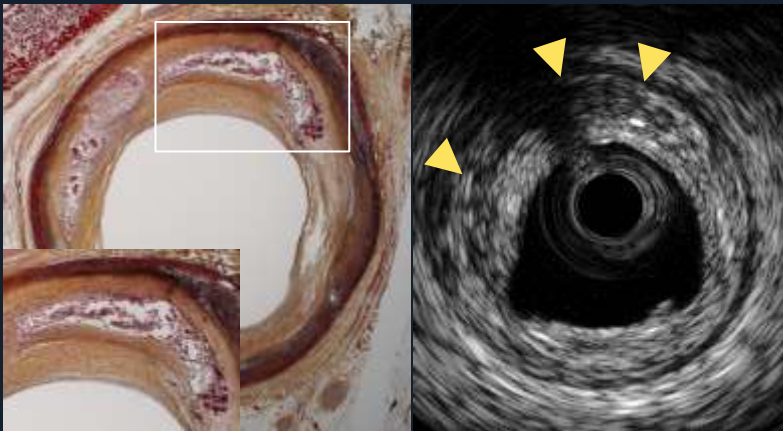


Courtesy for Pranav Patel & Zhongping Chen University of California, Irvine; Ram Ramalingam OCT Medical Imaging Inc.

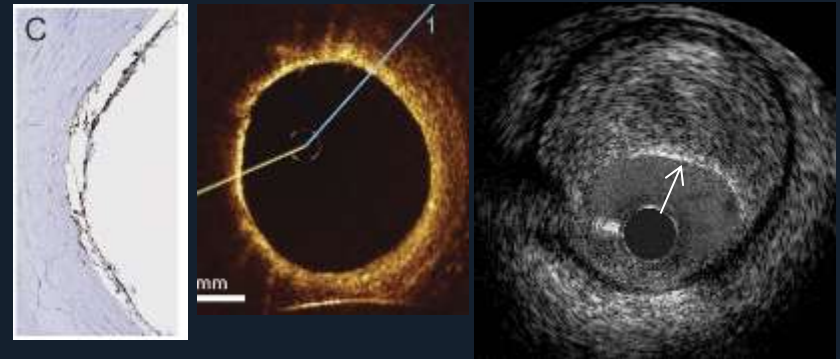
What we are looking for more?

- Intraplaque Hemorrhage
- Thrombus
- Macrophage
- Bioabsorbable scaffold, stent fracture
- Edge dissection

Intraplaque Hemorrhage



Macrophage?



Soest G et al, JACC Img 2011; 4:810-3.

Summary

- 1. New generation of high definition (frequency) of IVUS will provide better resolution (close to OCT) with clinically enough penetration (vessel size evaluation is possible).**
- 2. Clinically useful easier diagnosis such as under-expansion and dissection will be expected.**
- 3. Understanding of plaque vulnerability (intraplaque hemorrhage, macrophage, thrombus) would be promising.**