Imaging the vulnerable plaque

Thanks to: Dr. Tom Johnson

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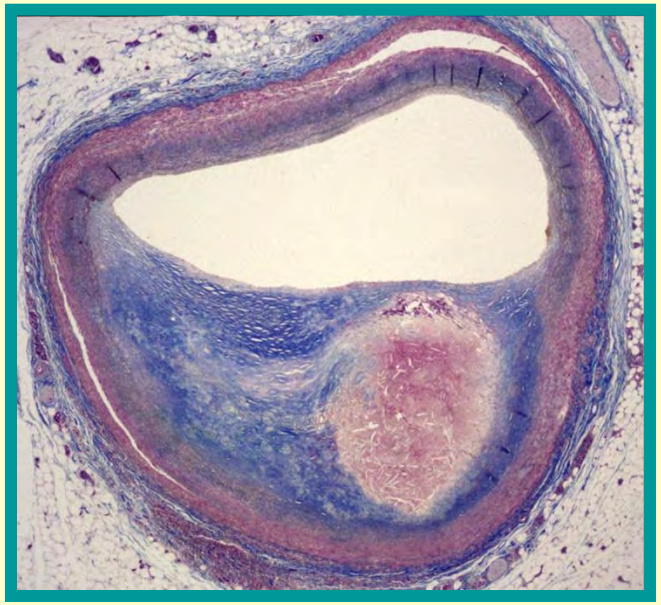
Topics

- Why do it?
- What's available
- How to chose an appropriate method
- Examples

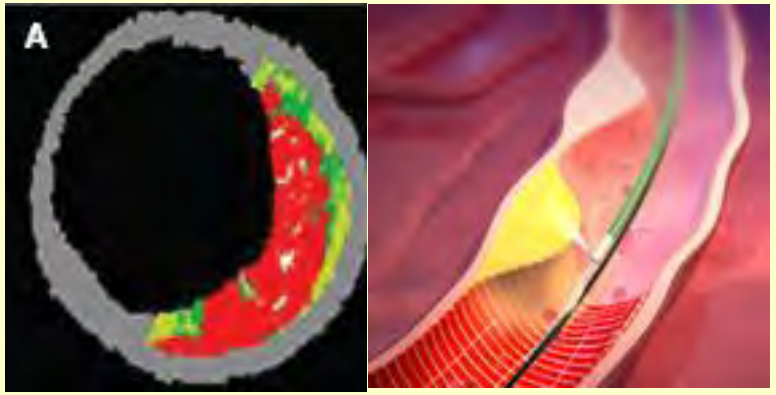
Why?

- Diagnosis and treatment
- Prognostic indicator
- Surrogate endpoint in a trial

Vulnerable plaque imaging in vivo

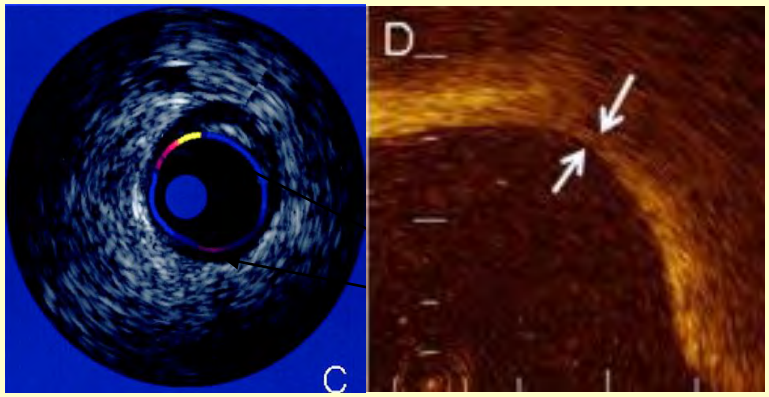


Plaque size → Carotid ultrasound, CT, MRI Angiography IVUS,



Large core → MRI, VH, OCT, IVMRI

Macrophages → MRI, PET, OCT



Thin cap → IVUS Palpography, OCT

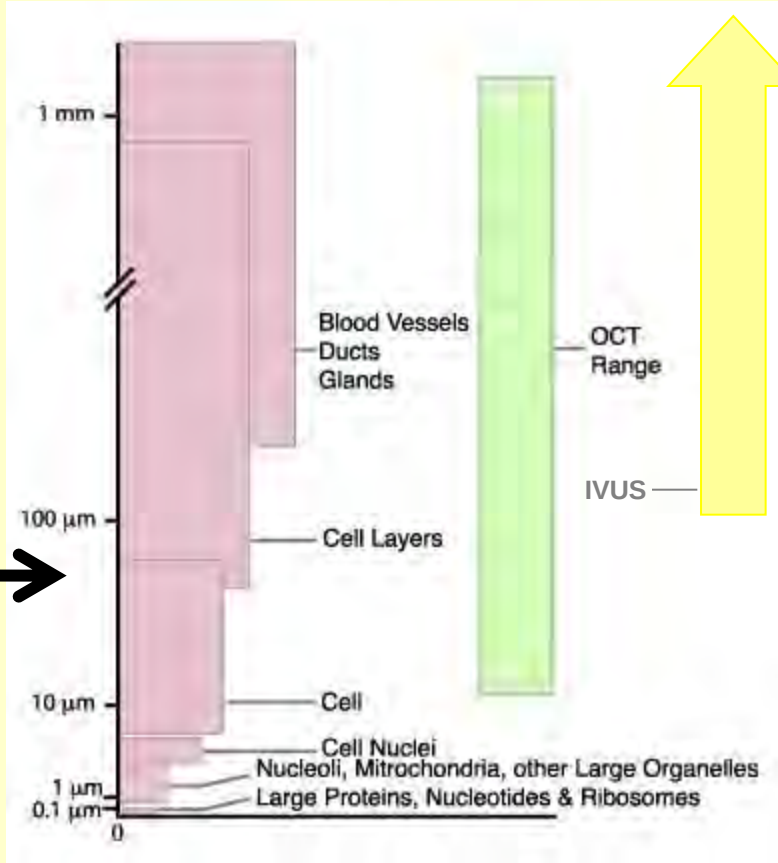
Best method?

- Invasive or non-invasive
- Resolution
- Tissue penetration
- Ability to discriminate different components

Resolution?

- Physical limits
- Focus
- Movement (acquisition time)

Thin fibrous cap atheroma →



MRI

Ultra-high Radio frequency

Infra-red light

Visible light

X-rays

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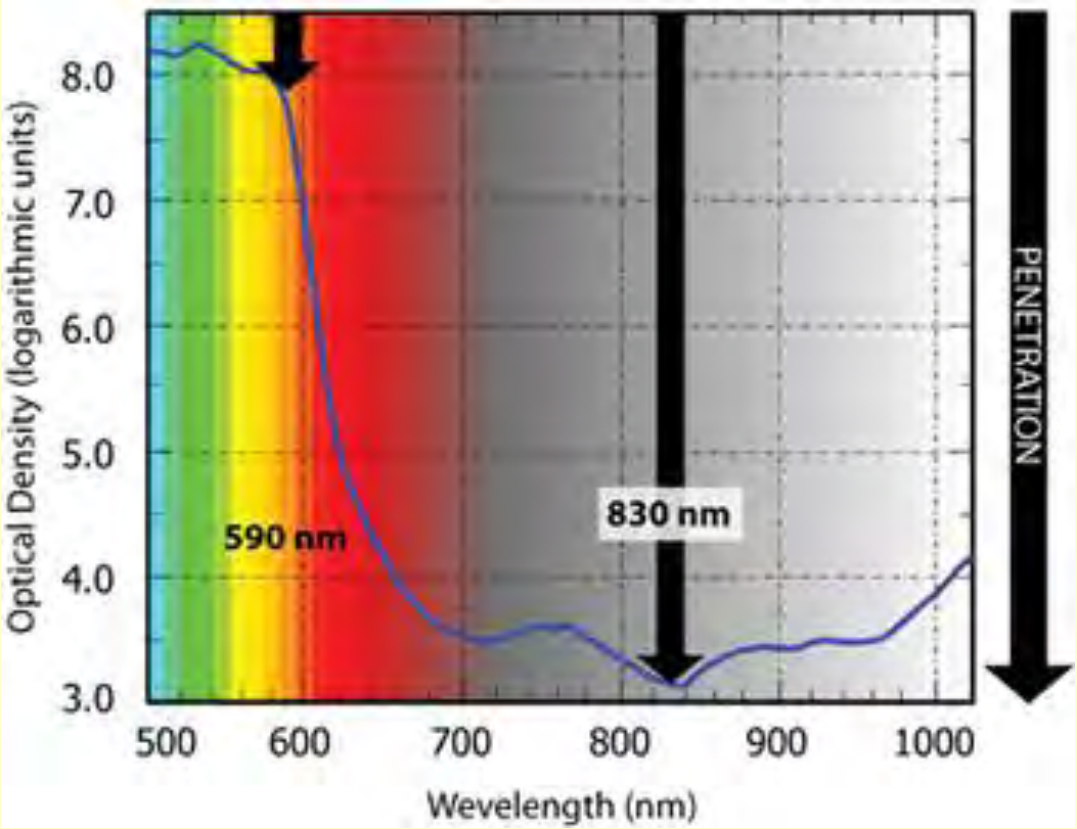
Tissue penetration?



X-rays Visible light Infra-red light IVUS MRI

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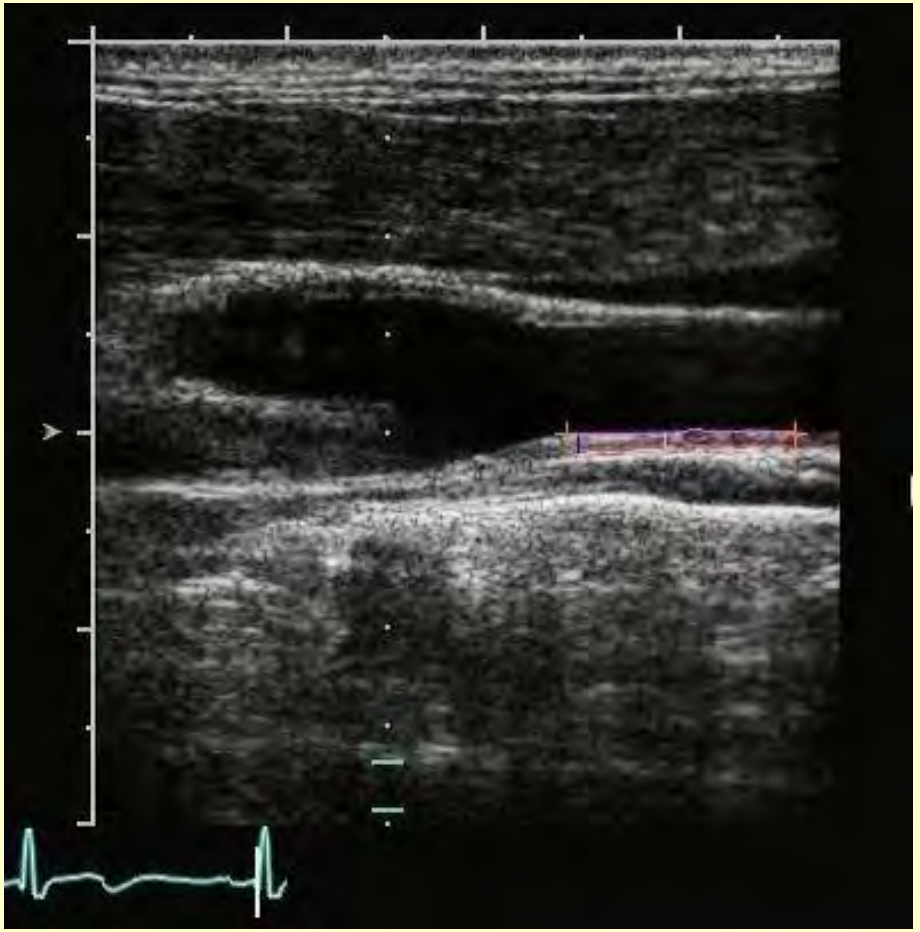
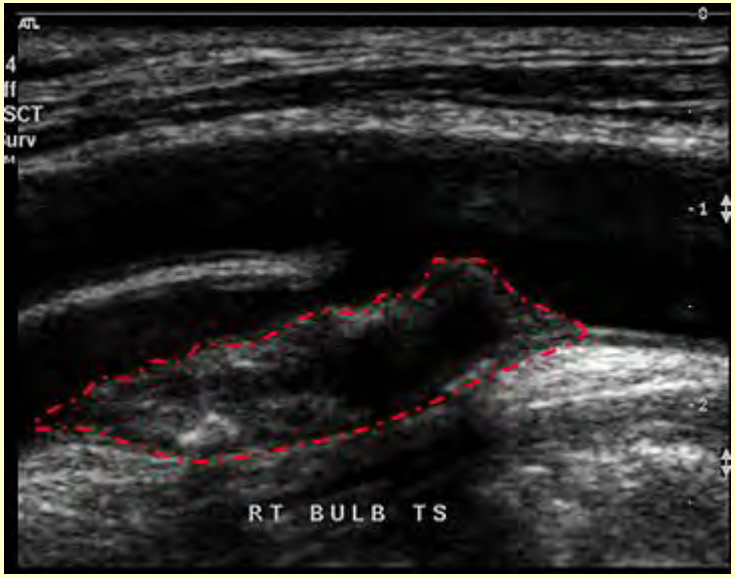
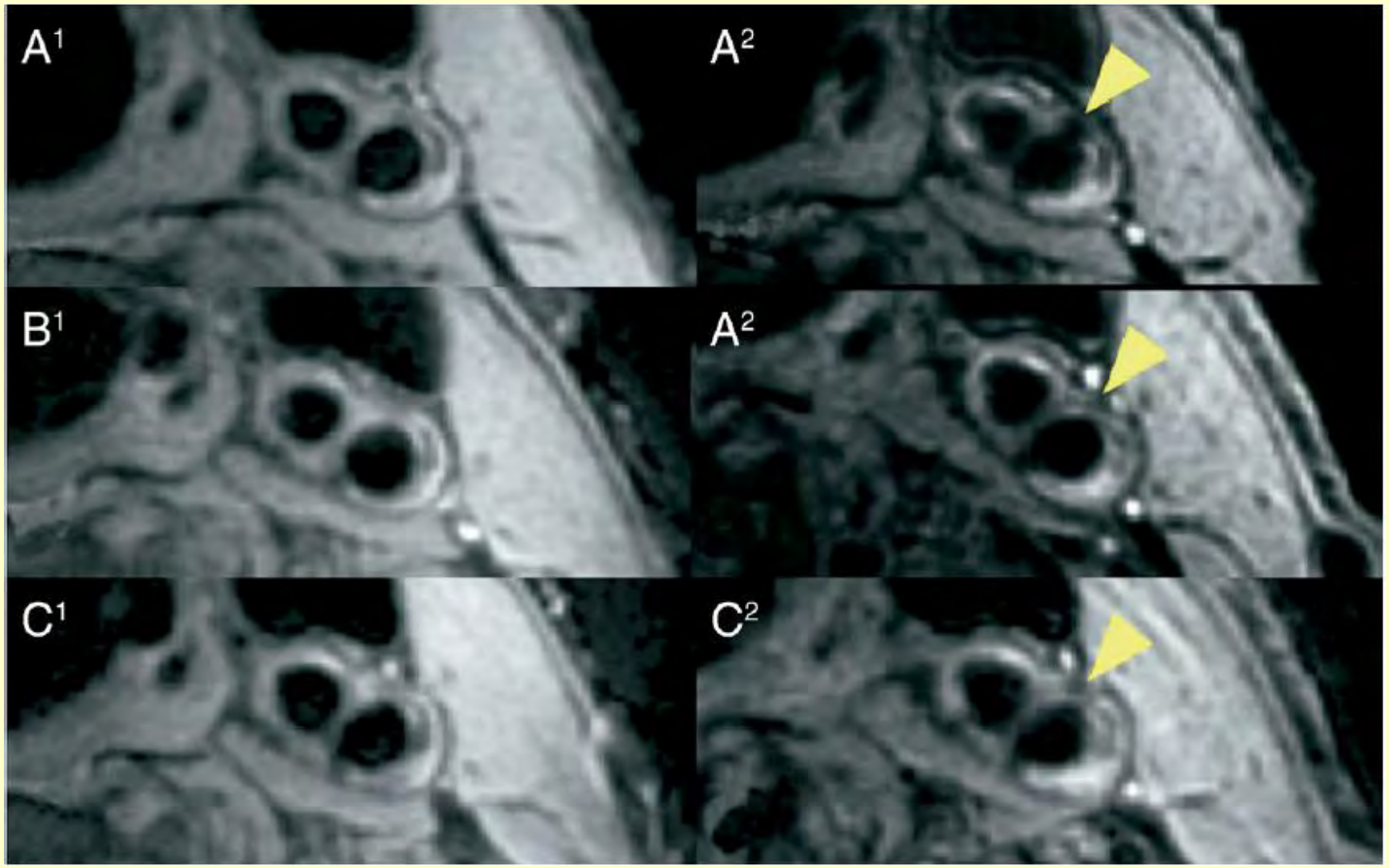
Carotid ultrasound





Carotid MRI with USPIOs



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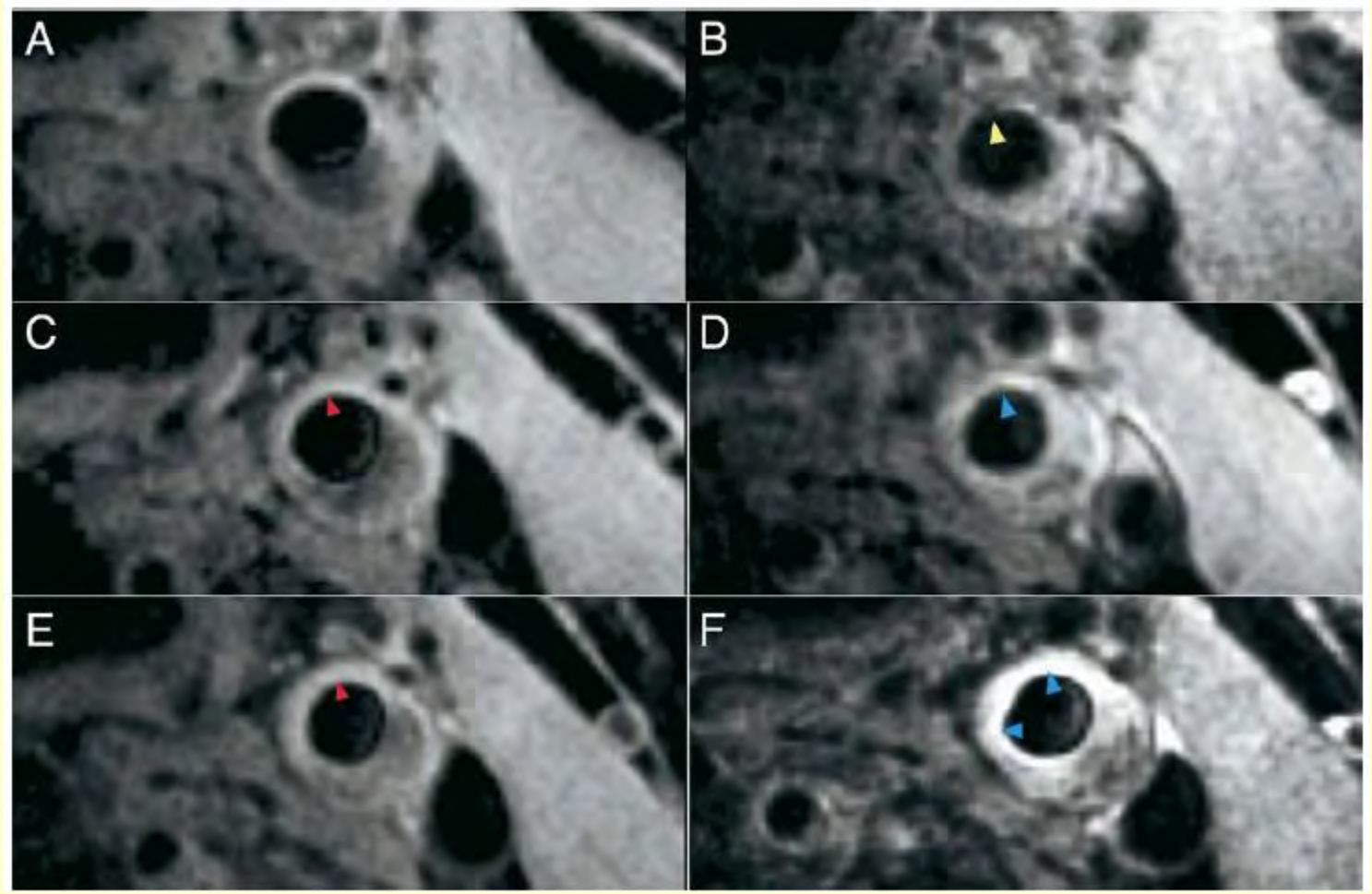
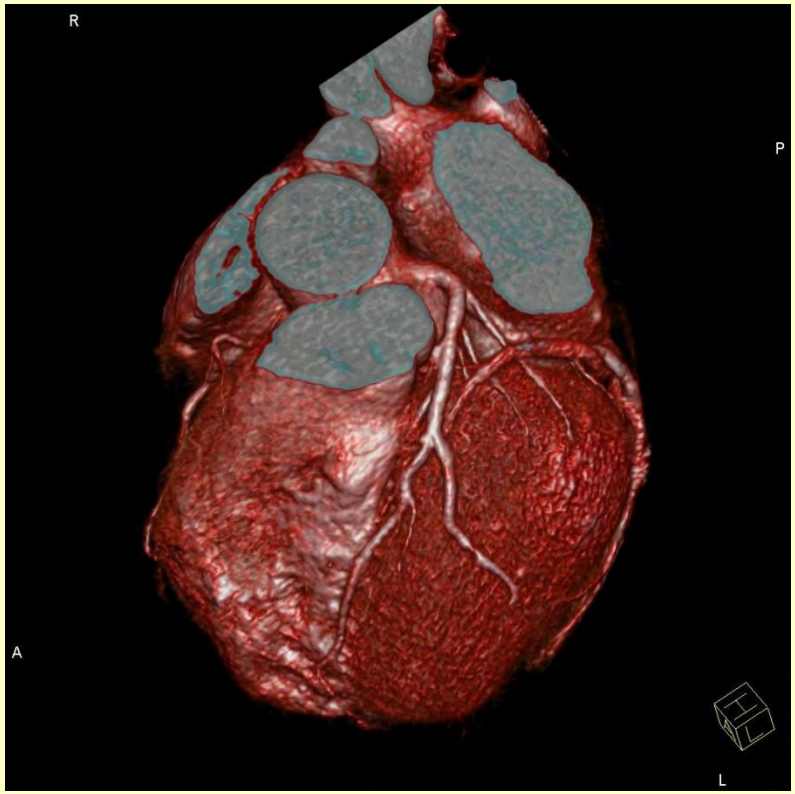
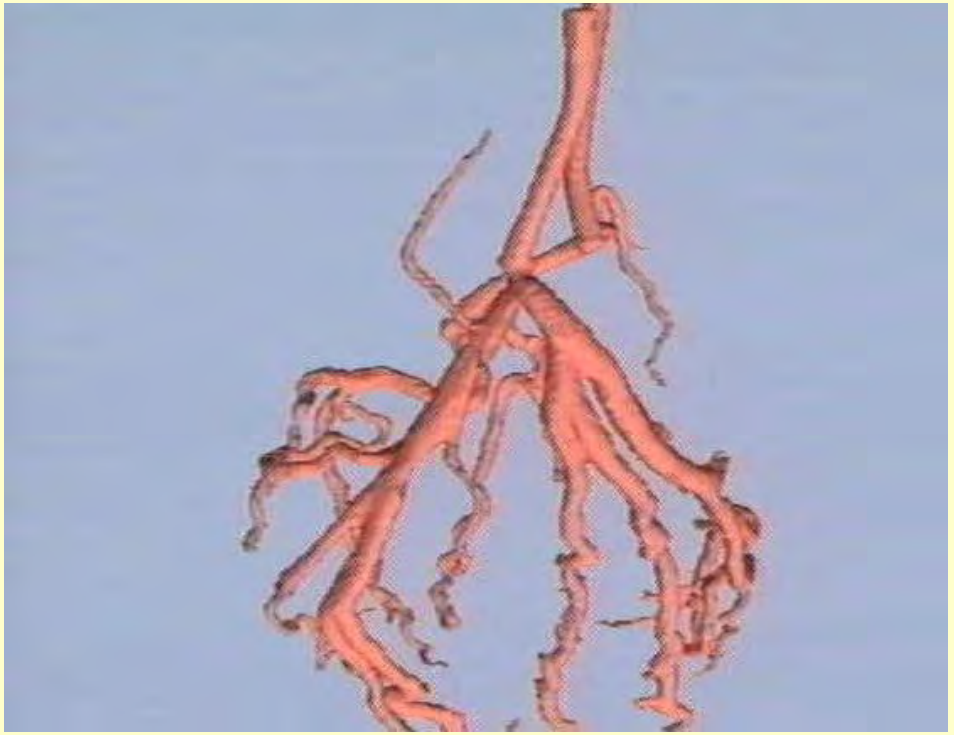
Treatment with statins



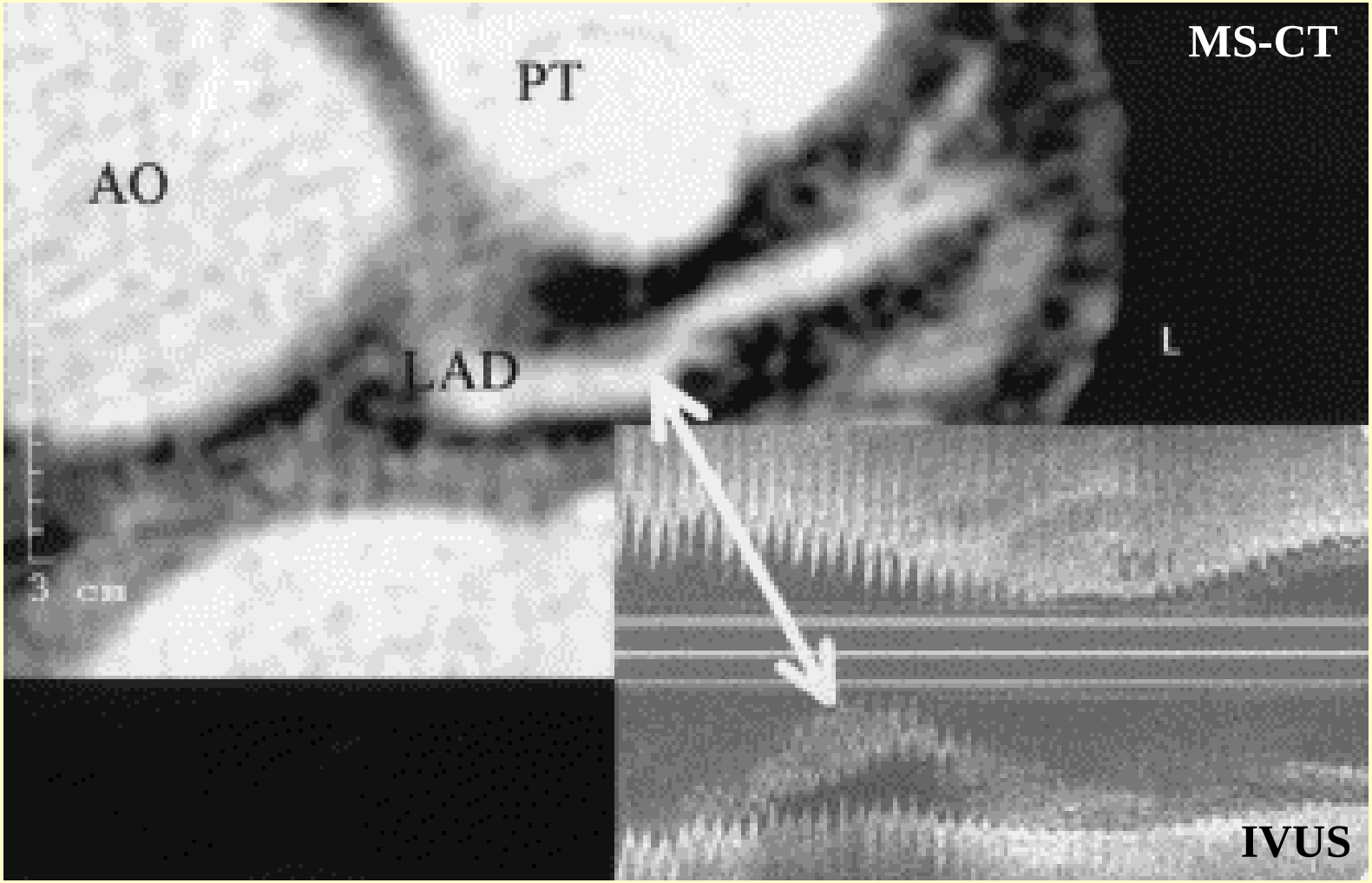
Tang, et al. J Am Coll Cardiol. 2009 Jun 2;53(22):2039-50.

Multiple slice computed tomography



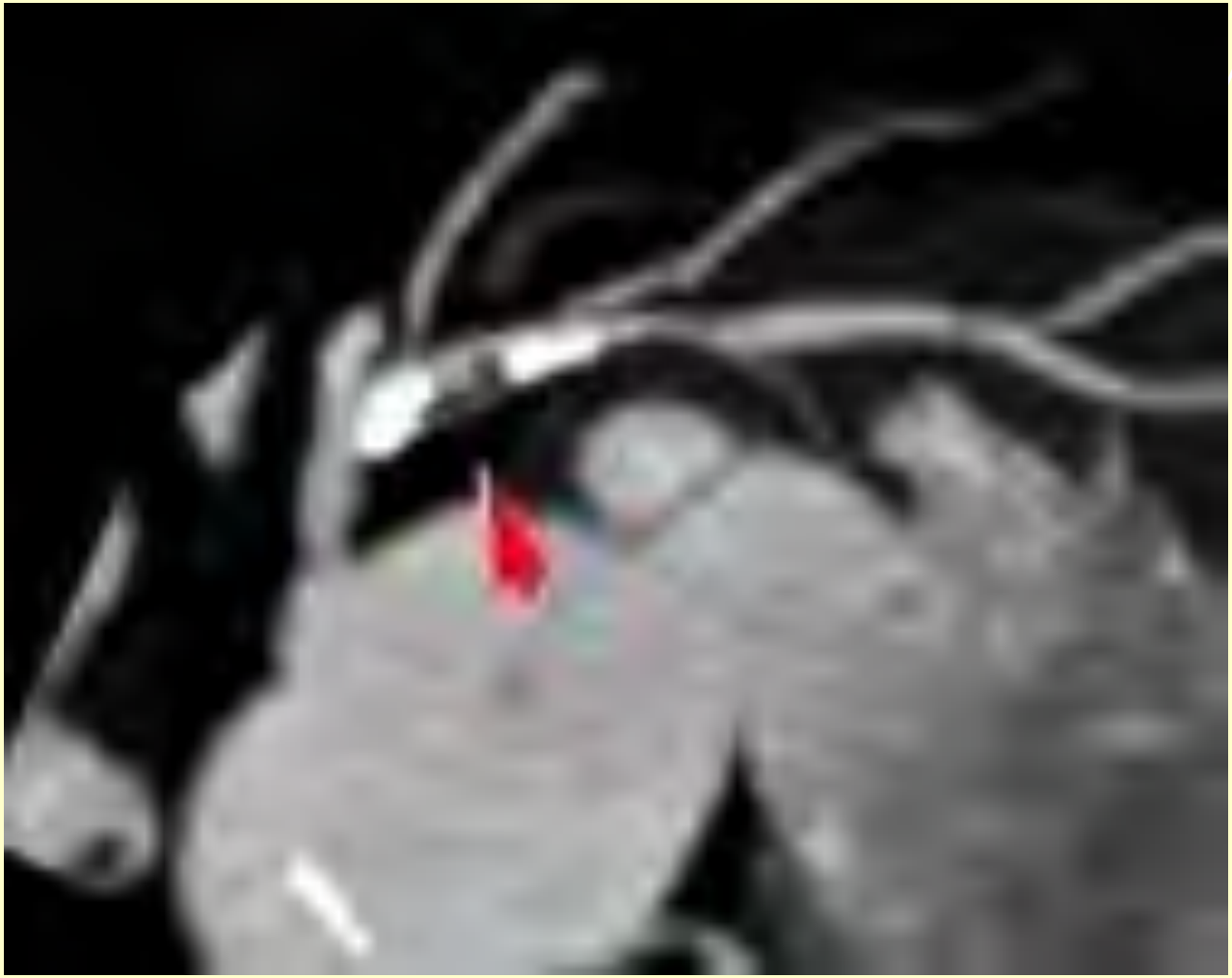


Multiple slice computed tomography



Karsch KR et al. J Am Coll Cardiol 2001;37(5):1430-5.

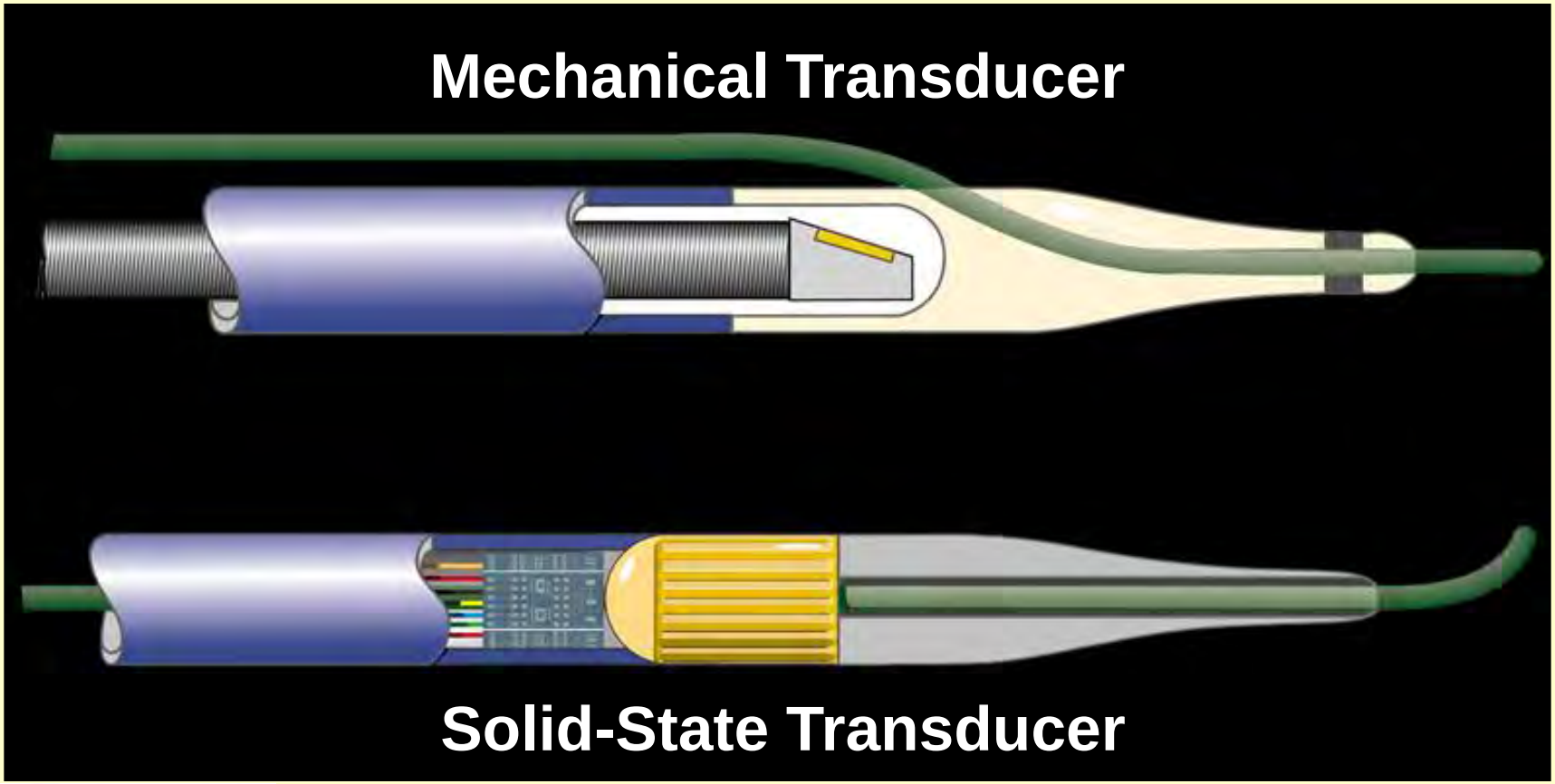
Multiple slice computed tomography



Calcified lipid-rich plaque

Intravascular Ultrasound

IVUS



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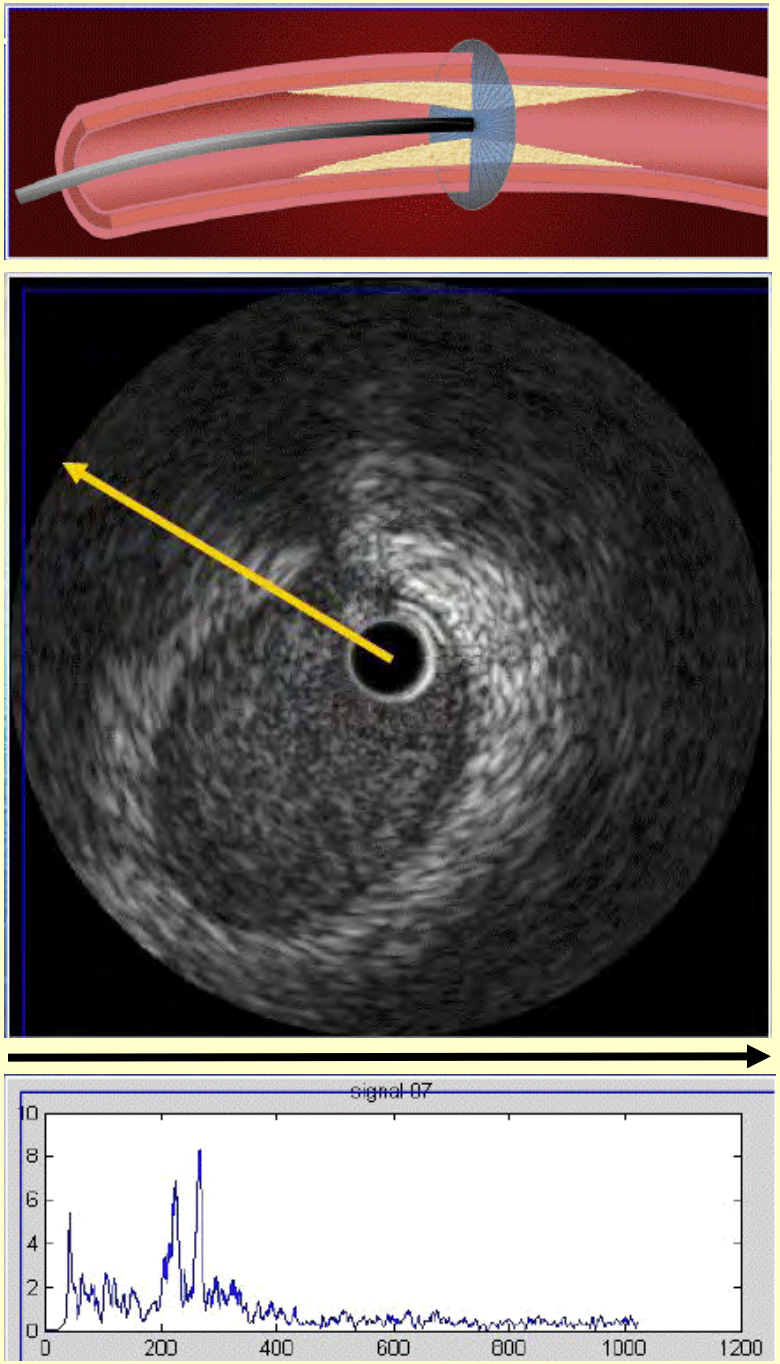
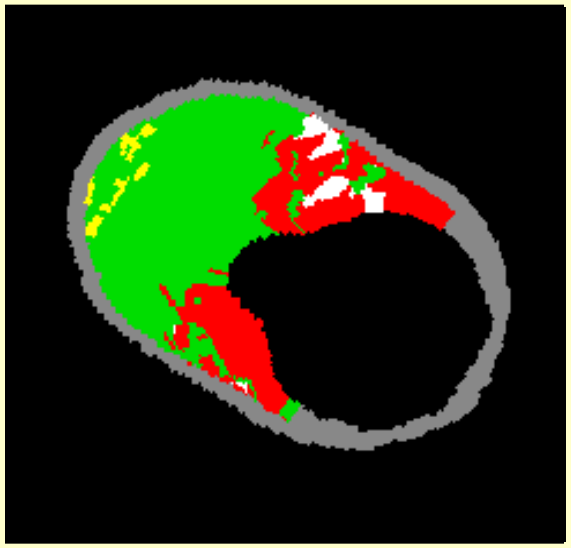


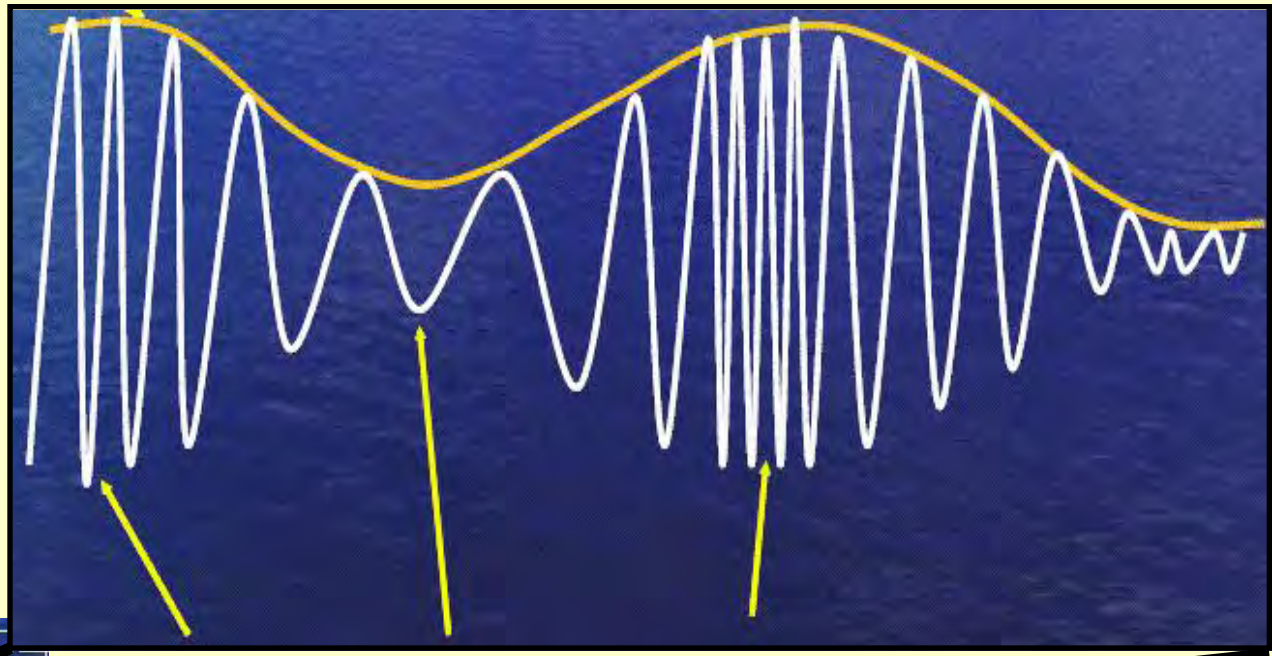
IVUS Image Formation

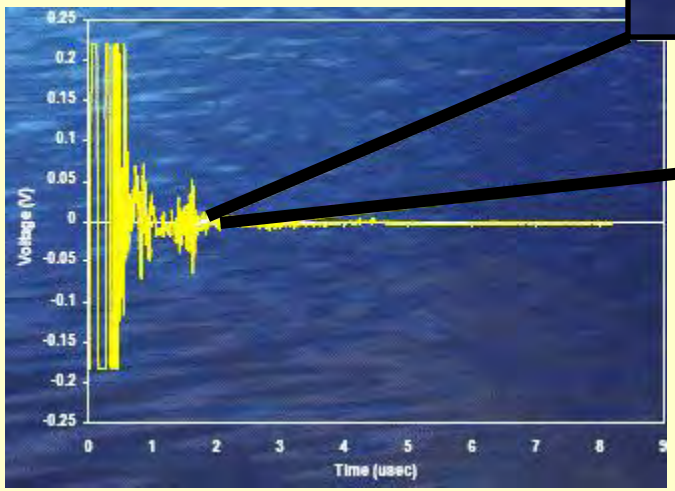
- High frequency sound waves reflect off interfaces
- Echo intensity lines are scaled and converted to gray-scale to make the ultrasonic image

K Gorski, EuroPCR 2006

Virtual Histology IVUS (VH-IVUS)





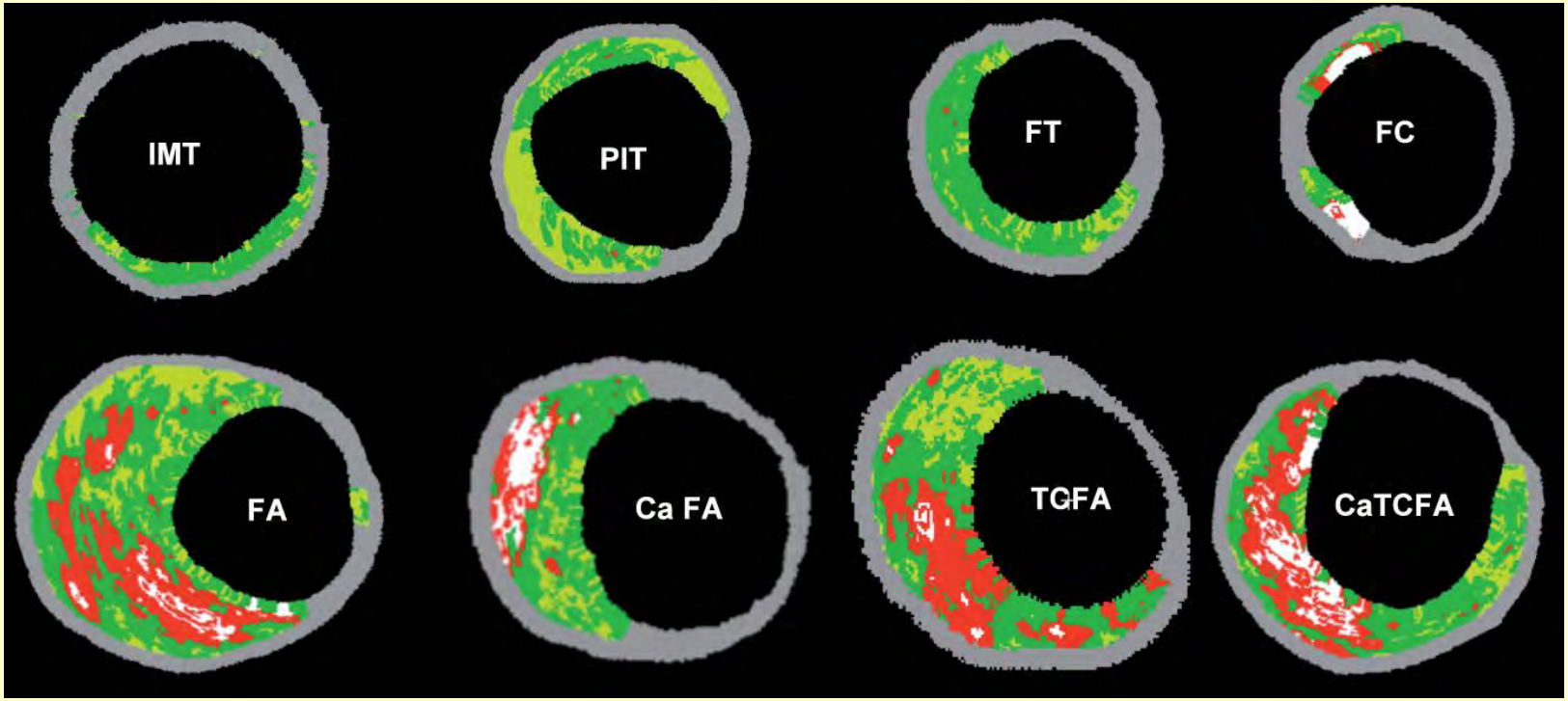


Frequency & Amplitude analysed in VH-IVUS

K Gorski, EuroPCR 2006

VH-IVUS

May facilitate detection of vulnerable plaque



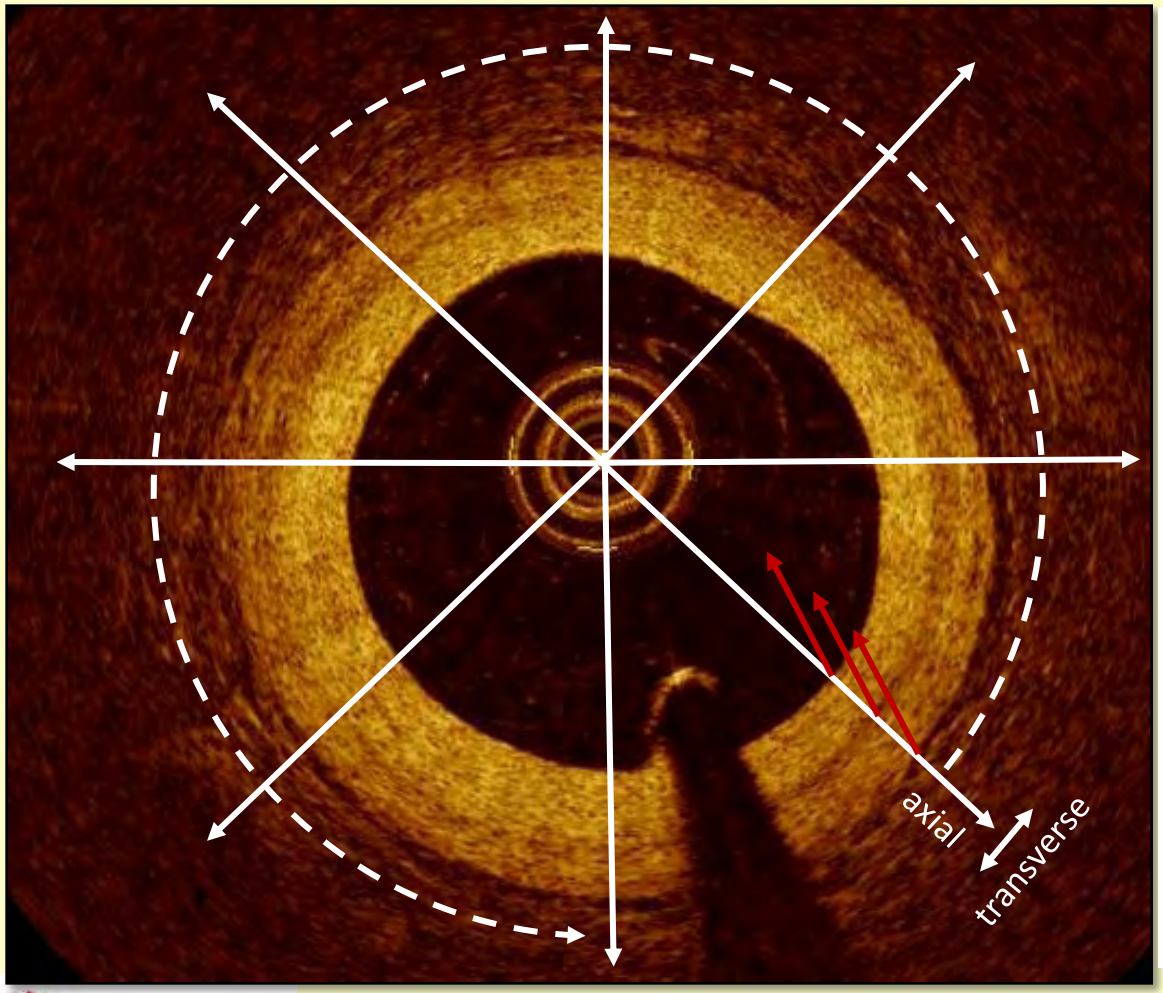
IMT	intimal medial thickening
PIT	pathological intimal thickening
FT	fibrotic plaque
FC	fibrocalcific plaque
FA	fibroatheroma
caFA	calcified fibroatheroma
TCFA	thin cap fibroatheroma
Ca TCFA	calcified thin cap fibroatheroma

FIBROUS
FIBROLIPIDIC
CALCIFIED
LIPID NECROSIS

EuroIntervention 2009;5:177-189

Image Generation

Slide courtesy of LightLab



- Measure echo time delay of reflected light waves
- One pixel → 5 x 19 um
- One axial line → 1024 pixels
- One frame → 500 axial lines
- *Optical resolution → 15 axial, 20 to 40 um transverse*

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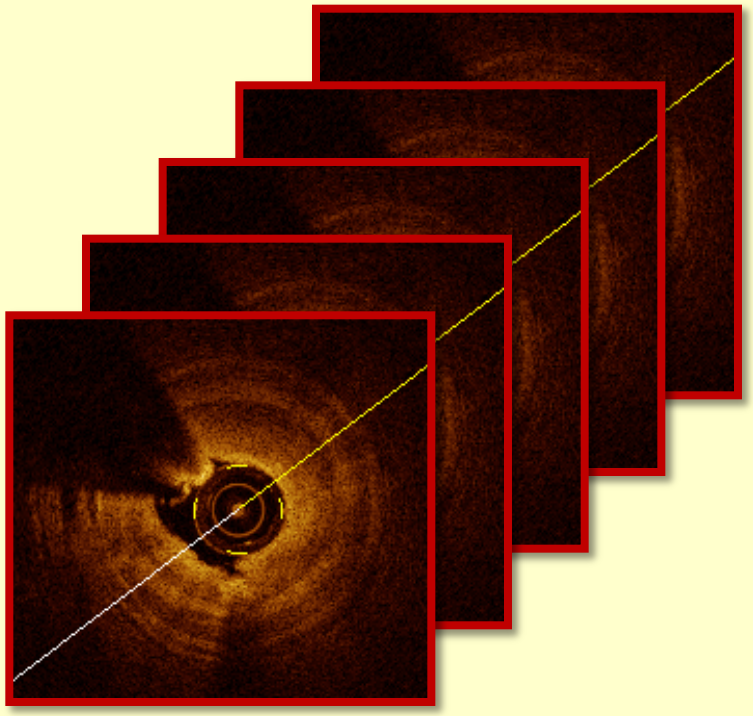
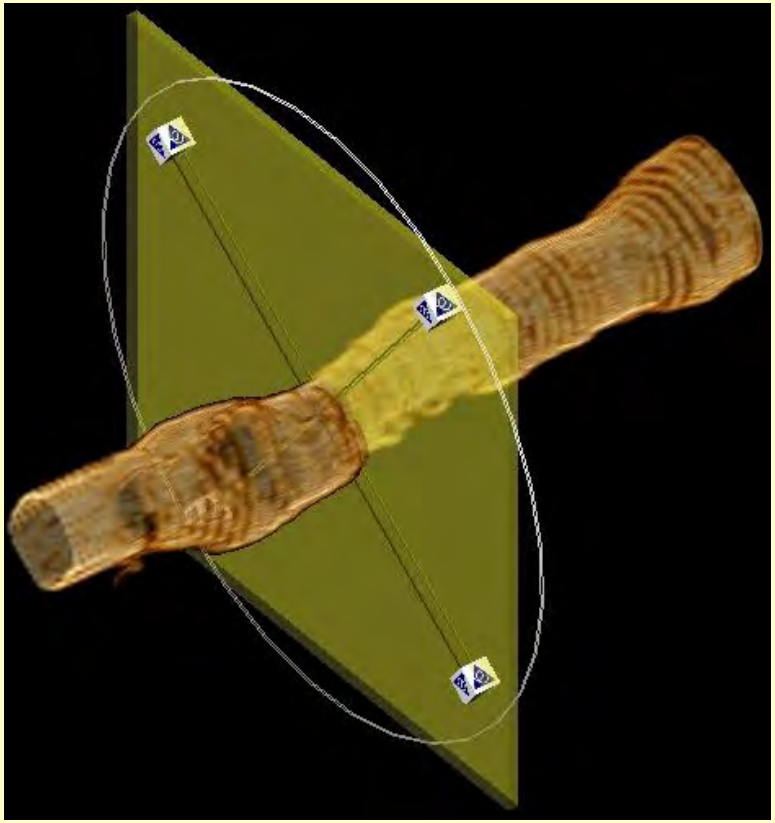
Pullback Generation

Slide courtesy of LightLab





- One pullback → 270 frames

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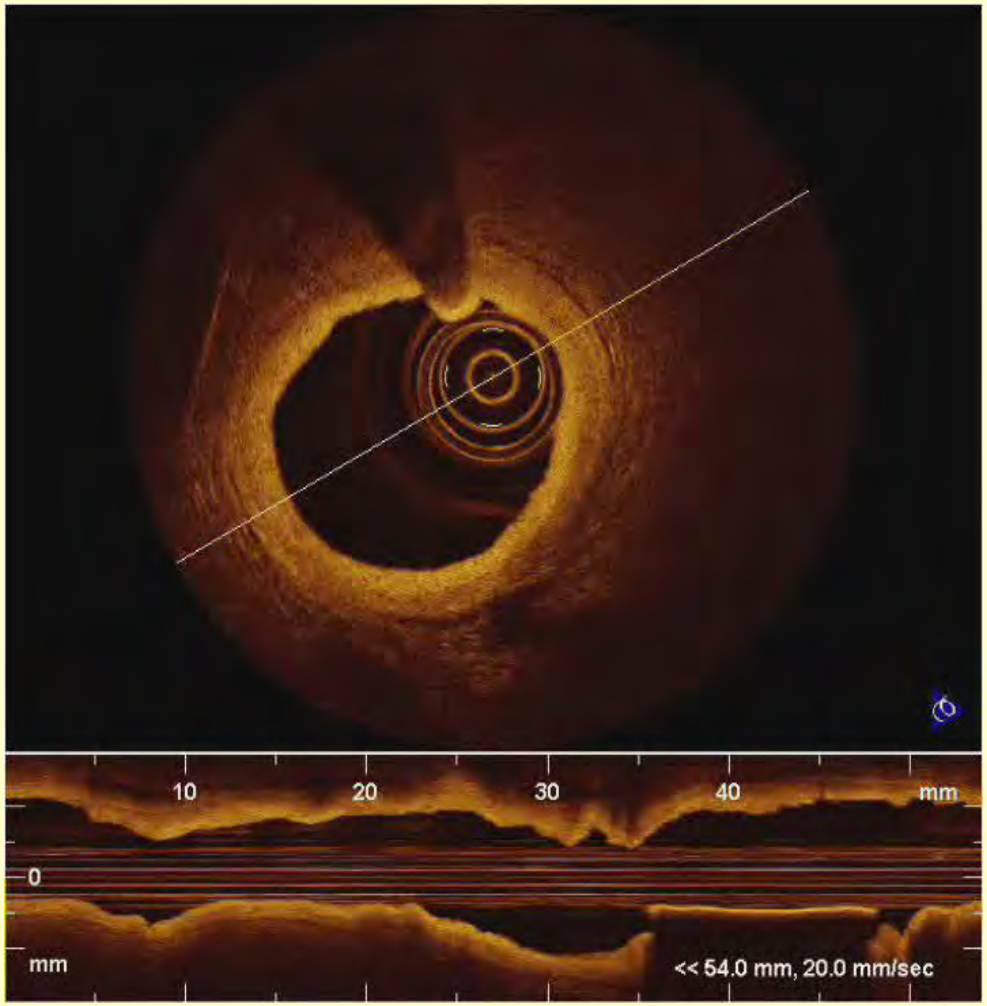
Pullback Generation

"B-Mode"
cross-sectional view

"L-Mode"
longitudinal view



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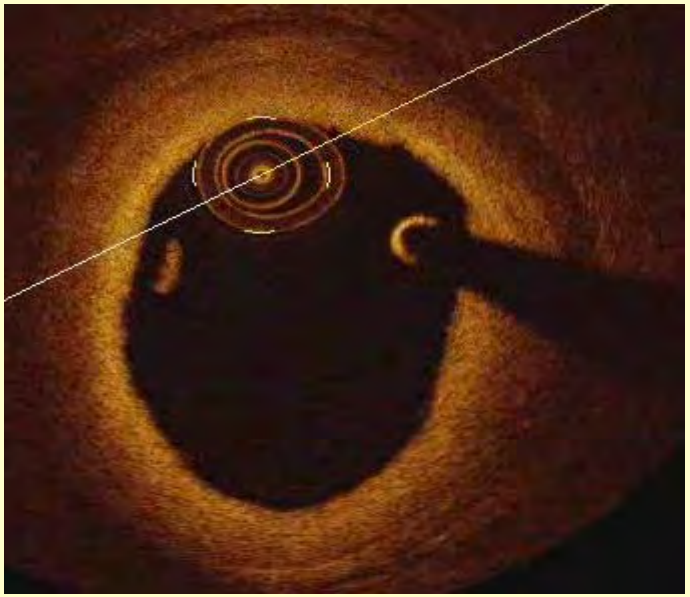
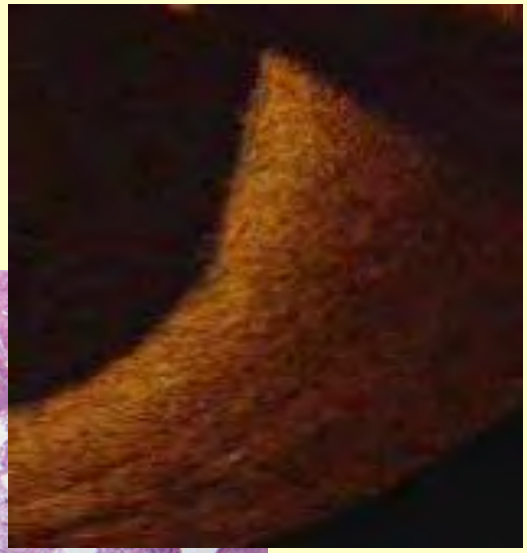
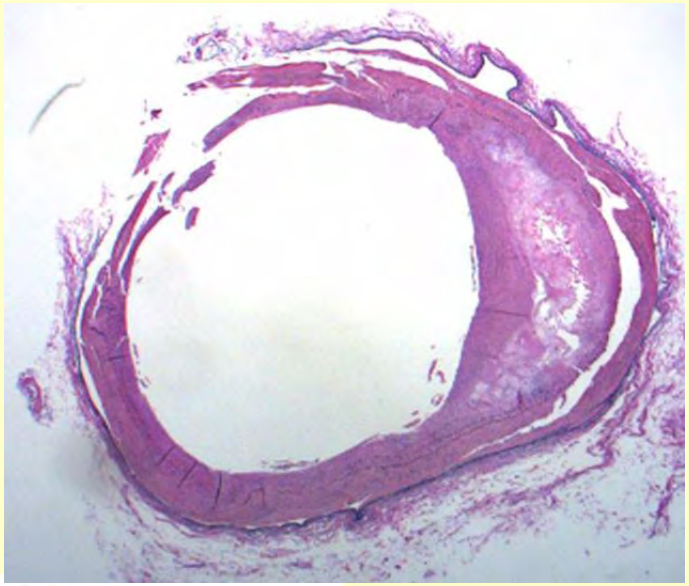
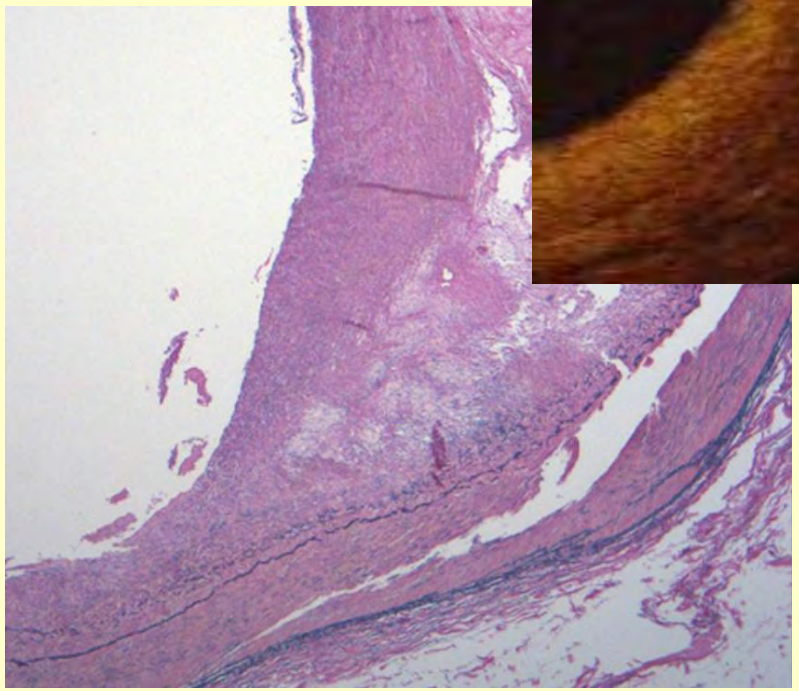
OCT vs Histology

& IVUS
+ VH IVUS

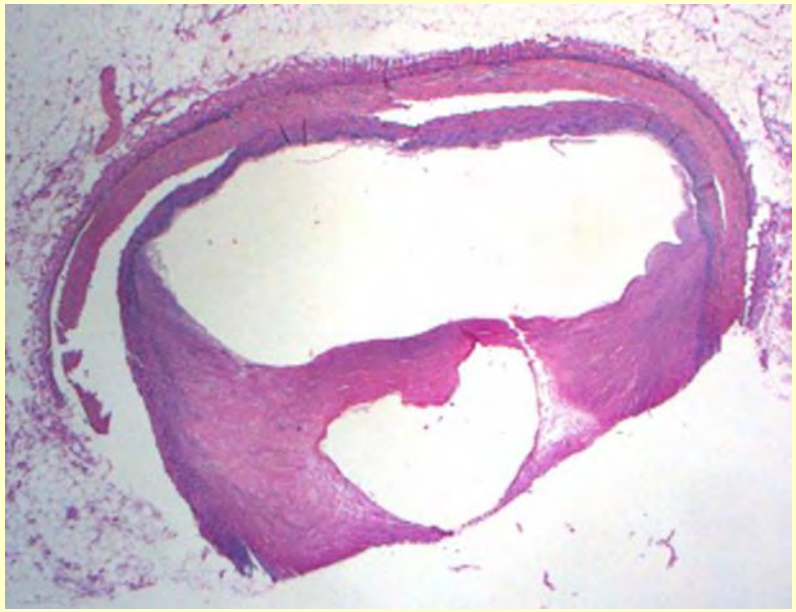


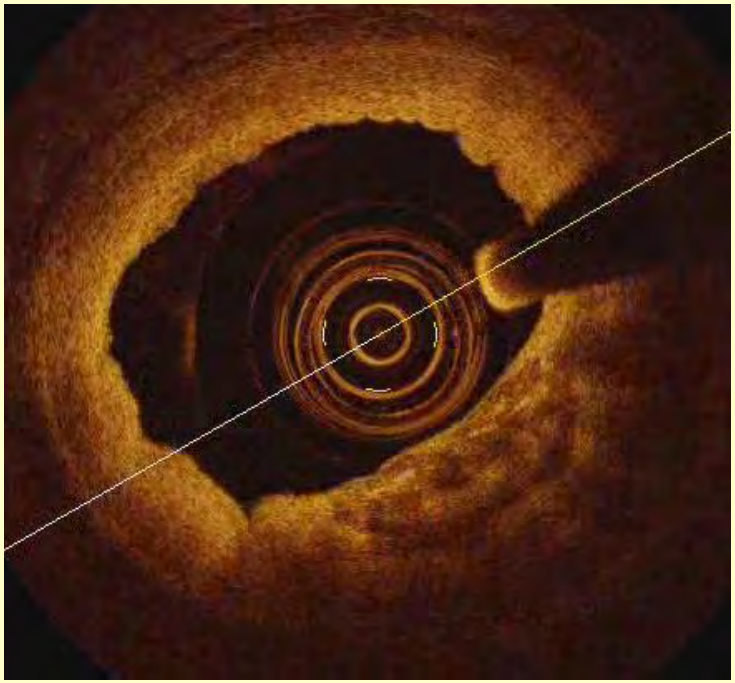






BCB88 - Calcified Plaque





Characterising Plaque In-Vivo

JACC 2007 50(10):933-9

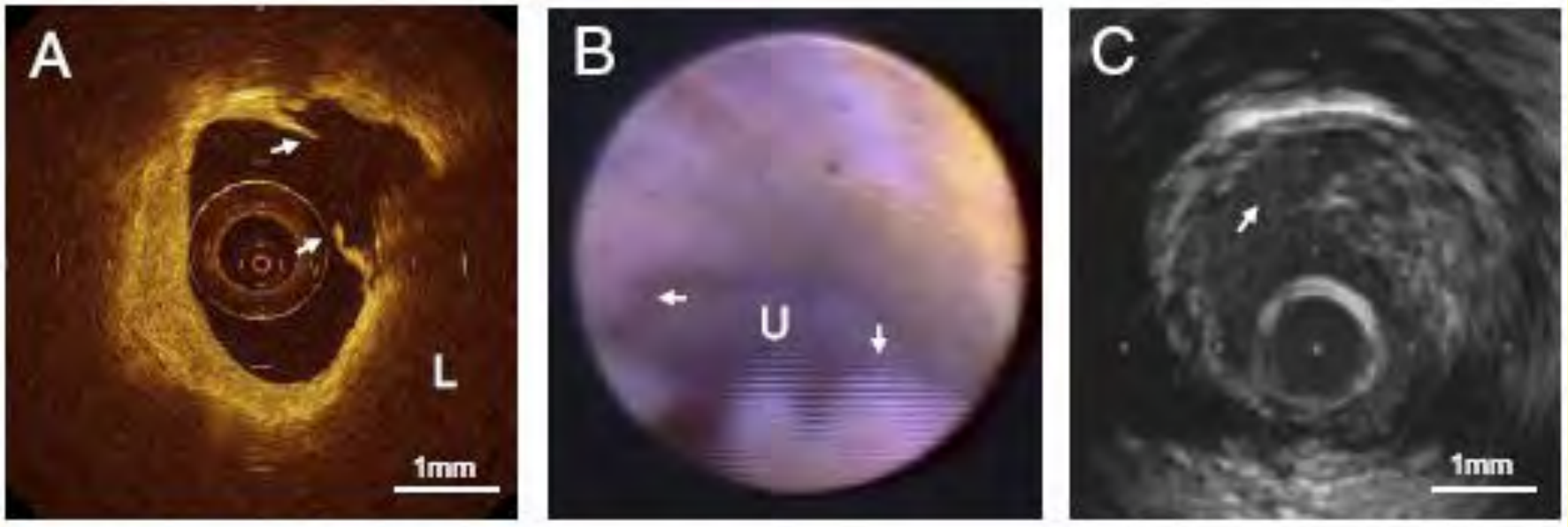
CLINICAL RESEARCH Atheroma Morphology

Assessment of Culprit Lesion Morphology in Acute Myocardial Infarction

Ability of Optical Coherence Tomography Compared With Intravascular Ultrasound and Coronary Angioscopy

Takashi Kubo, MD, PHD, Toshio Imanishi, MD, PHD, Shigeho Takarada, MD, PHD, Akio Kuroi, MD, Satoshi Ueno, MD, Takashi Yamano, MD, Takashi Tanimoto, MD, Yoshiki Matsuo, MD, PHD, Takashi Masho, MD, Hironori Kitabata, MD, Kazushi Tsuda, MD, PHD, Yoshiaki Tomobuchi, MD, PHD, Takashi Akasaka, MD, PHD

Wakayama, Japan



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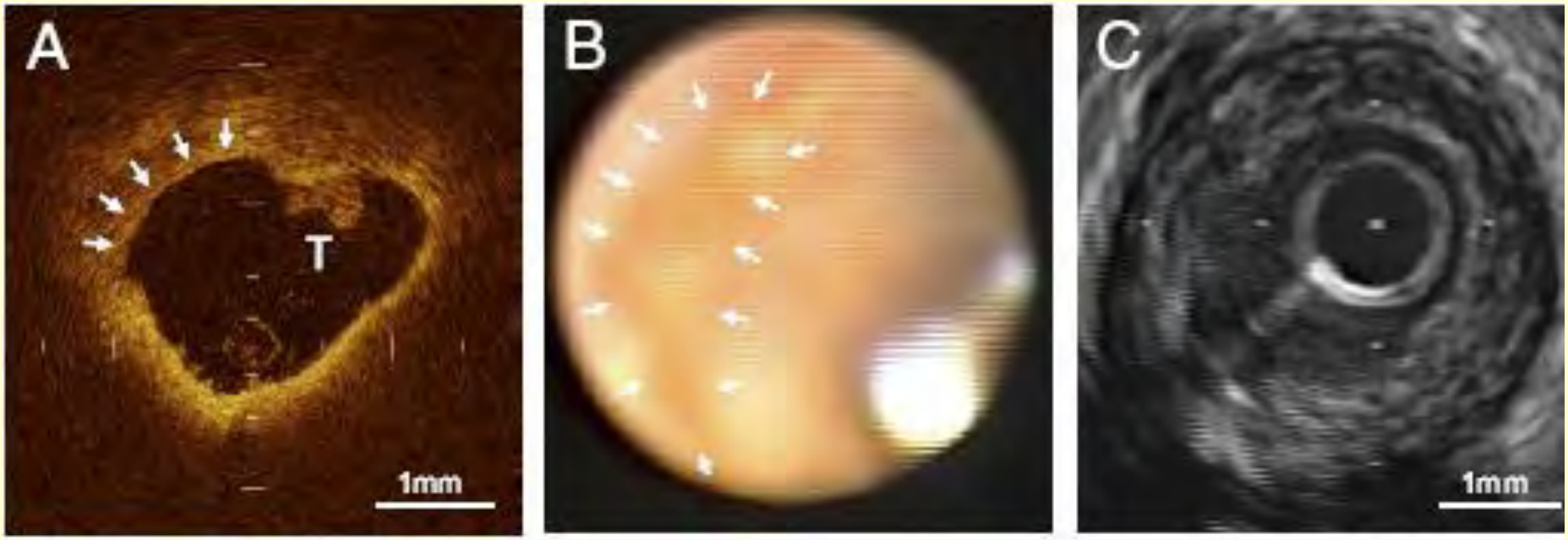

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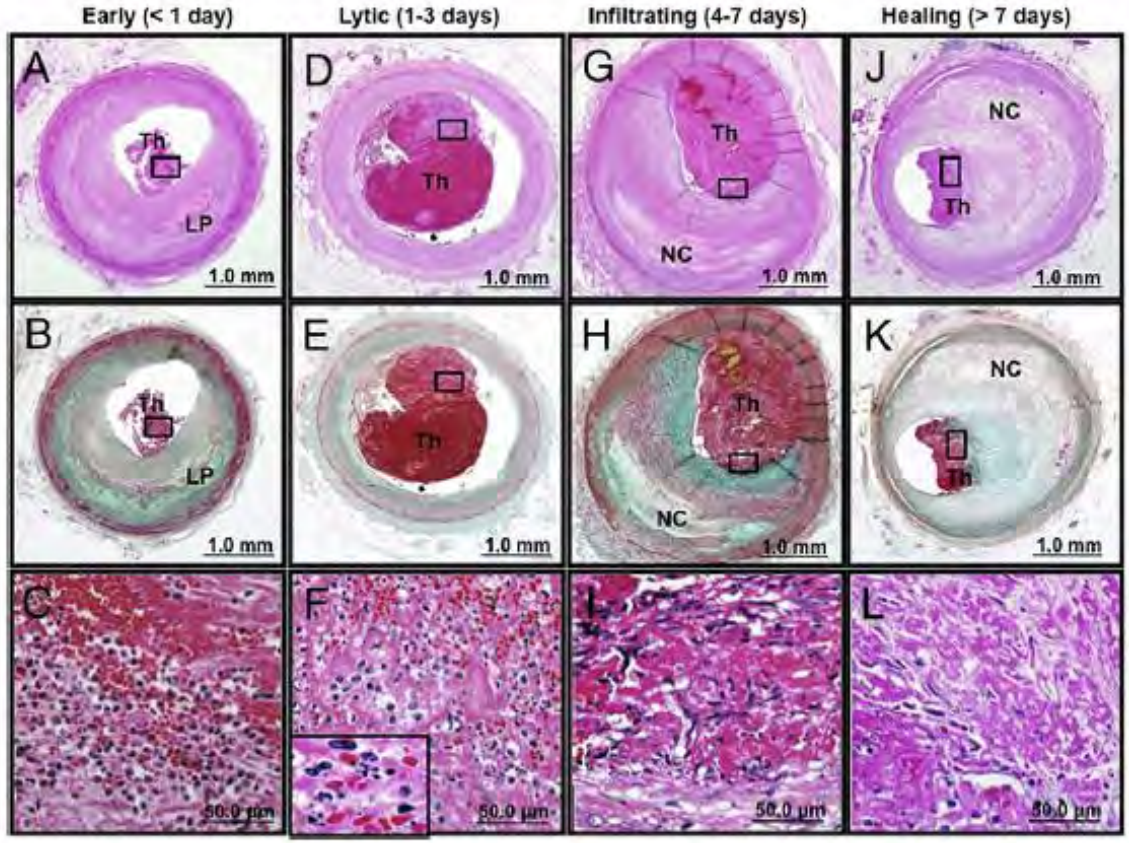
JACC 2009 55(2):122-32

EXPEDITED PUBLICATION

Relationship of Thrombus Healing to Underlying Plaque Morphology in Sudden Coronary Death

Miranda C. A. Kramer, MD,* Saskia Z. H. Rittersma, MD, PHD,* Robbert J. de Winter, MD, PHD,* Elena R. Ladich, MD,‡ David R. Fowler, MD,§ You-Hui Liang, MD,‡ Robert Kutys, MS, PA,‡ Naima Carter-Monroe, MD,‡ Frank D. Kolodgie, PHD,‡ Allard C. van der Wal, MD, PHD,† Renu Virmani, MD‡

Amsterdam, the Netherlands; and Gaithersburg and Baltimore, Maryland



111 Dead patients
115 Culprit plaques

65 Plaque Ruptures

Plaque Area
Plaque Burden
Necrotic Core
Intimal Macrophage

50 Plaque Erosions

Younger
Female

Mature Thrombus
Occlusive Thrombus

Summary

- Carotid ultrasound and MRI can be used as surrogate endpoints
- CT may replace angiography for diagnosis but not yet
- IVUS can identify TCFA (just) but invasive
- OCT can tell rupture from erosion but invasive