Invasieve imaging technieken:

OCT en IVUS

Robin Kraak

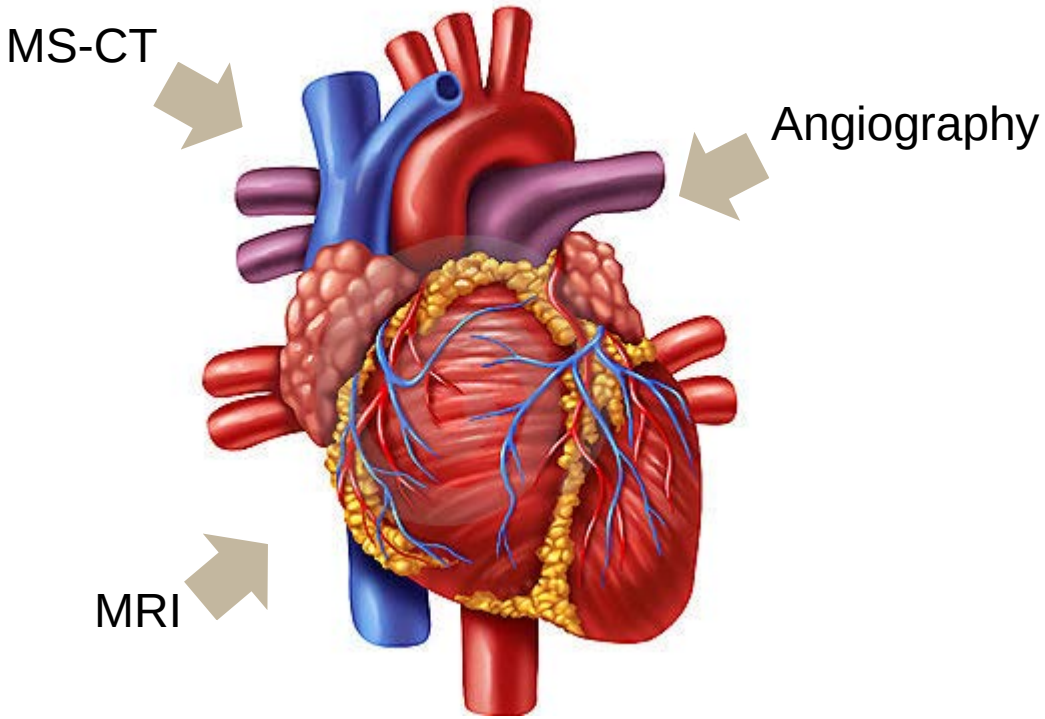
CNE Interventie Cardiologie

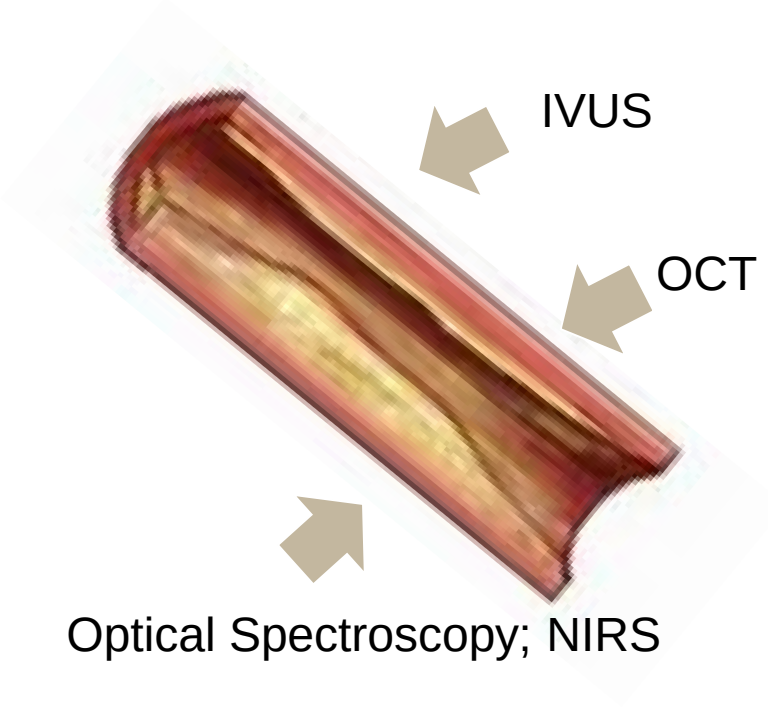
- Basic principles
- Basic interpretatation
- Case examples Imaging Guided PCI

Basic Principles

IVUS vs OCT

Vasculaire imaging technieken





Basic Principles

IVUS vs OCT

- Coronary angiogram

  Limitations:

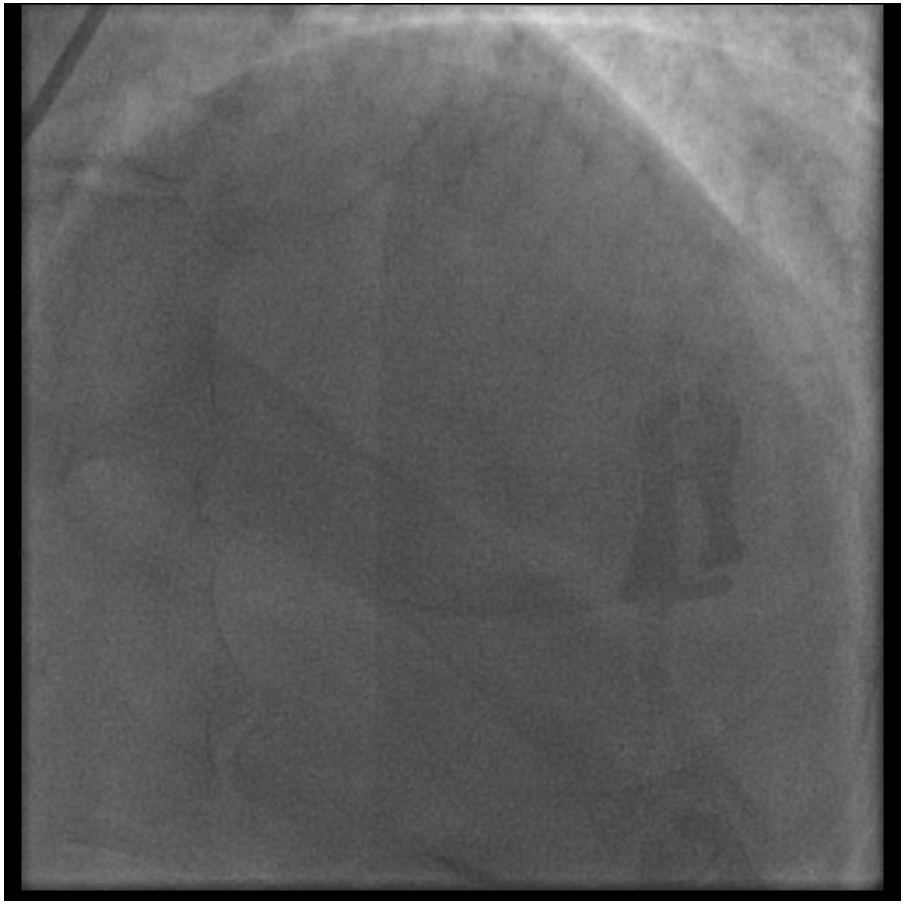
  - Lumenogram

  - Limited information about:
    - Type of plaque
    - Generalized disease
    - Vessel wall / Lumen diameter
    - Stent placement
    - Mechanisms of device

Basic Principles

IVUS vs OCT

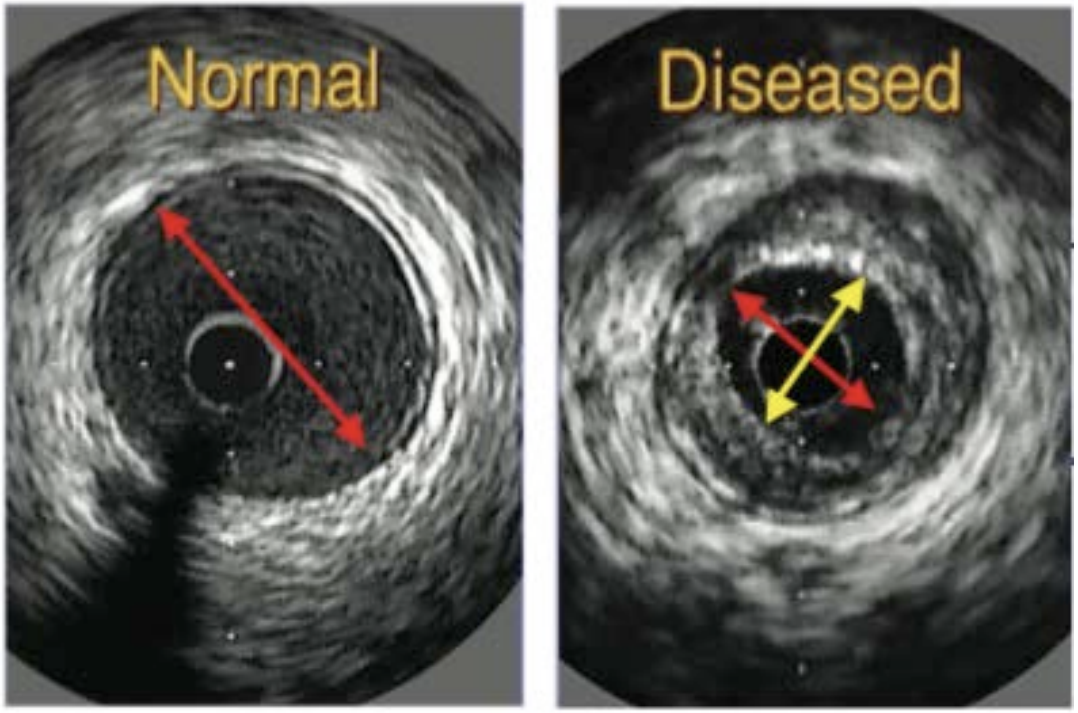
- Intravasculair Imaging
  - OCT
  - IVUS



Basic Principles

IVUS vs OCT

- IntraVascular Ultrasound



Basic Principles

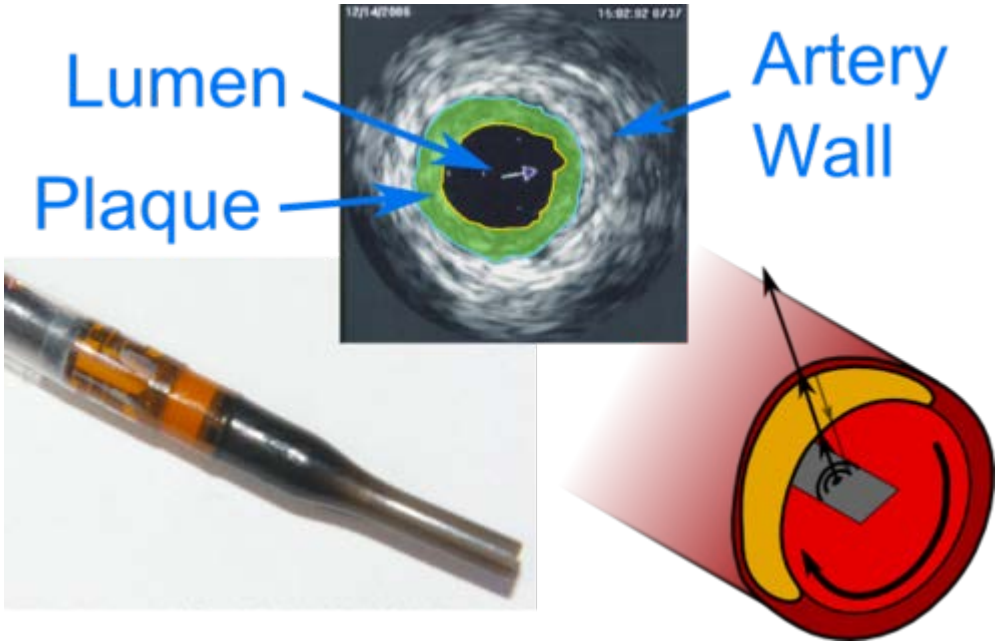
IVUS vs OCT

IVUS

- Maakt gebruik van geluidsgolven
- Verschillen in dichtheid, geleidingscapaciteiten en akoestische impedantie van verschillende weefsels
- Per weefsel verandering in terugkaatsing van geluid

Basic Principles

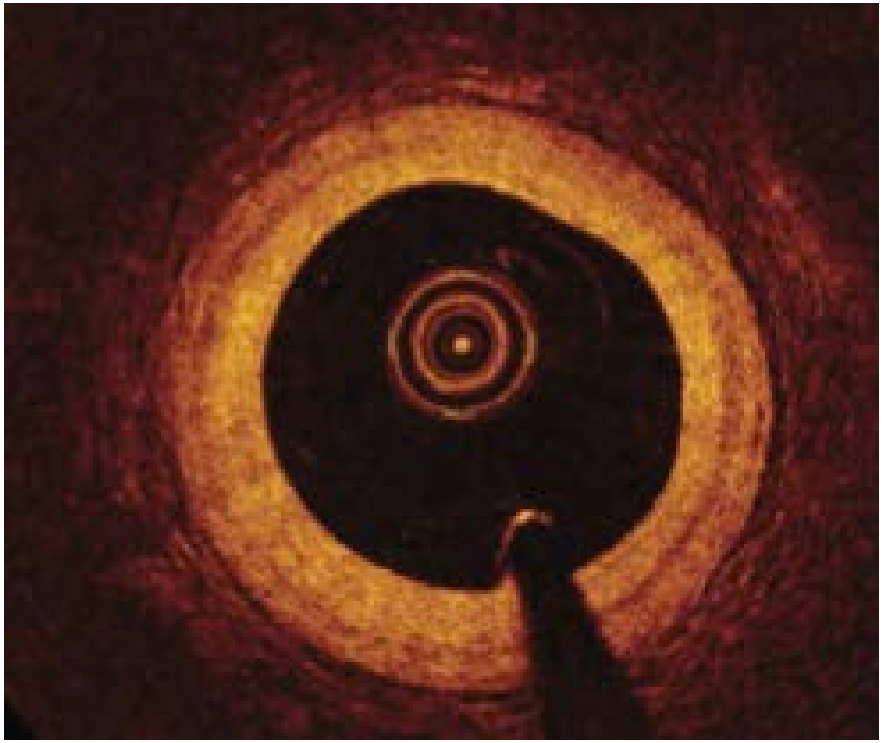
IVUS



Basic Principles

IVUS vs OCT

- Optical Coherence Tomography



Basic Principles

IVUS vs OCT

OCT

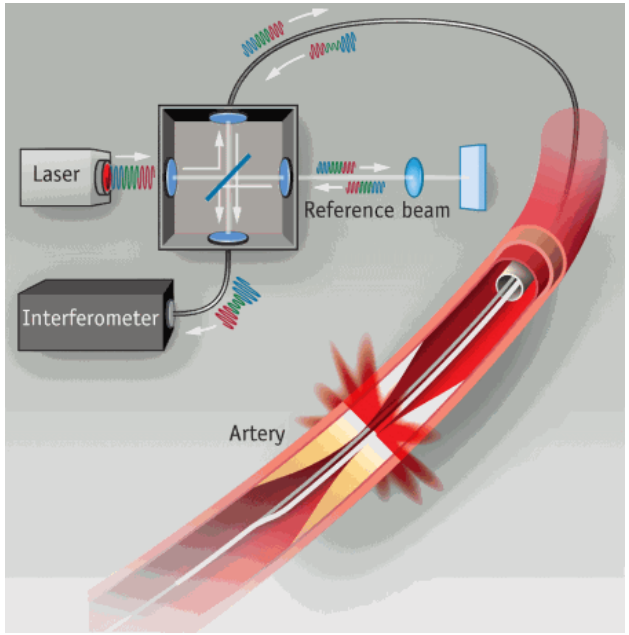
- Maakt gebruik van lichtgolven; Near-Infrared licht

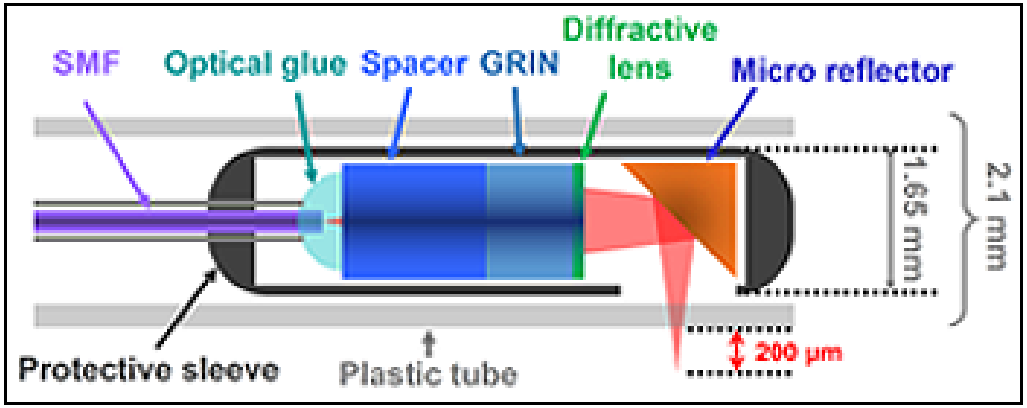
- Verschillen in licht absorptie en licht deflectie / reflectie van verschillende weefsels / materiaal

- Per weefsel verandering in terugkaatsing van het licht

Basic Principles

OCT





Basic Principles

IVUS vs OCT

- Image quality / specifications can be described by two important factors:
  - Spatial resolution (axial and lateral resolution)
  - Contrast resolution (grayscale / dynamic range)

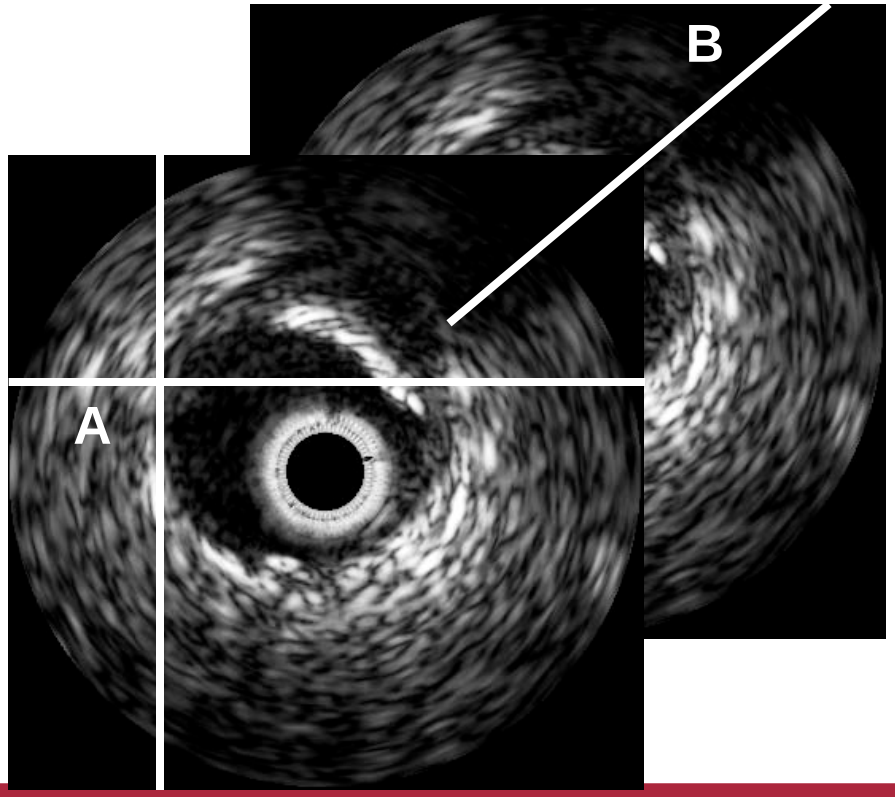
Basic Principles

IVUS vs OCT

- Spatial Resolution (axial and lateral resolution)
  - Ability to discriminate small adjacents objects within the image

A: Axial resolution

B: Lateral resolution



Basic Principles

IVUS vs OCT

	OCT (ILUMIEN St. Jude)	IVUS
Axial Resolution	**12-15 µm**	100-200 µm
Lateral Resolution	**10 µm**	225 µm
Beam Width	**20-40 µm**	200-300 µm
Frame rate	**100 frames/s**	30 frames/s
Pullback Speed	**20mm/s**	0.5-1 mm/s
Max Scan Diameter	10mm	**15mm**
Tissue Penetration	1.0-2.0mm	**10mm**
Blood Clearing	Needed	**Not Needed**

Basic Principles

IVUS vs OCT

- IVUS kijkt dieper in de vaatwand

- OCT door hogere resolutie beter te gebruiken voor het beoordelen van fijne details:
  - Intima dissecties
  - Stent strut appositie
  - Stent resultaat tijdens follow-up

Basic Principles

IVUS vs OCT

- Te gebruiken bij beoordeling bloedvat:
  - Lumen diameter
  - Lesie lengte
  - Plaque compositie

Basic Principles

IVUS vs OCT

- Te gebruiken bij planning van de PCI strategie:
  - Ostiale lesies
  - Overlappende coronairen op angiography
  - Hoofdstam stenosen
  - Calcificaties
  - Bifurcaties

Basic Principles

IVUS vs OCT

- Te gebruiken voor beoordeling stent plaatsing:
  - Stent sizing
  - Stent expansie
  - Stent appostitie

Basic Principles

IVUS vs OCT

- Acquisition Tips:
  - Prepare console before positioning the catheter
  - Test each catheter before insertion
  - Always acquire a pullback of the vessel / lesion of interest and use in case of IVUS a motorized pullback

Basic Principles

IVUS vs OCT

- Acquisition Tips IVUS:
  - Optimize zoom (depth) settings prior to pullback
  - Ring down to prevent RingDown artifact
  - Align pullback device with arterial access site

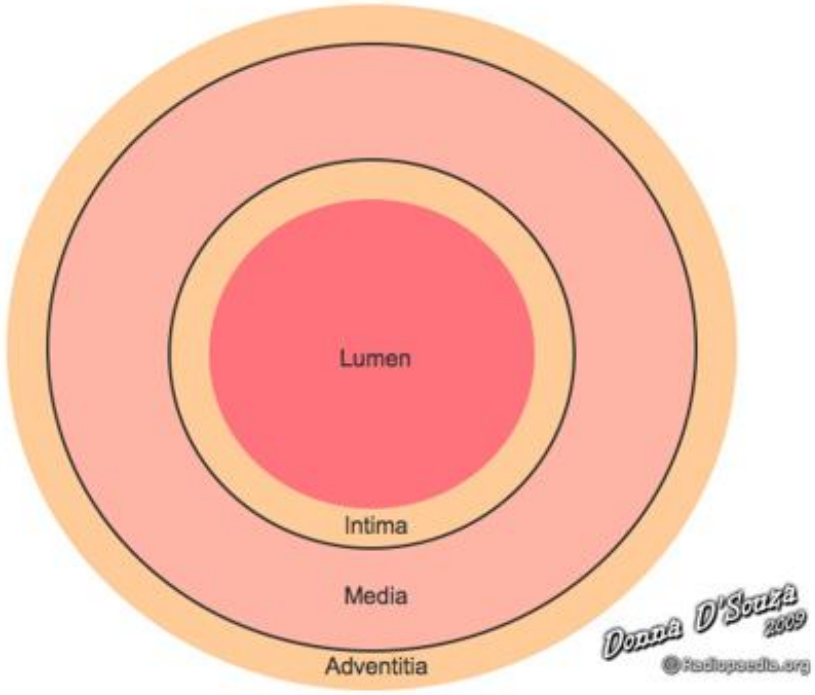
- Acquisition Tips OCT:
  - Determine pullback distance and resolution
  - Allow sufficient contrast in the artery of interest

- Basic principles
- Basic interpretatation
- Case examples Imaging Guided PCI

Basic Interpretation

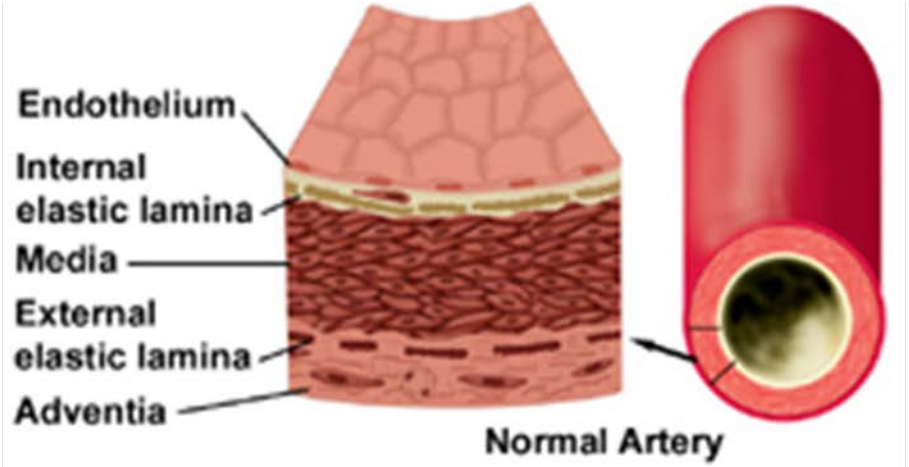
IVUS

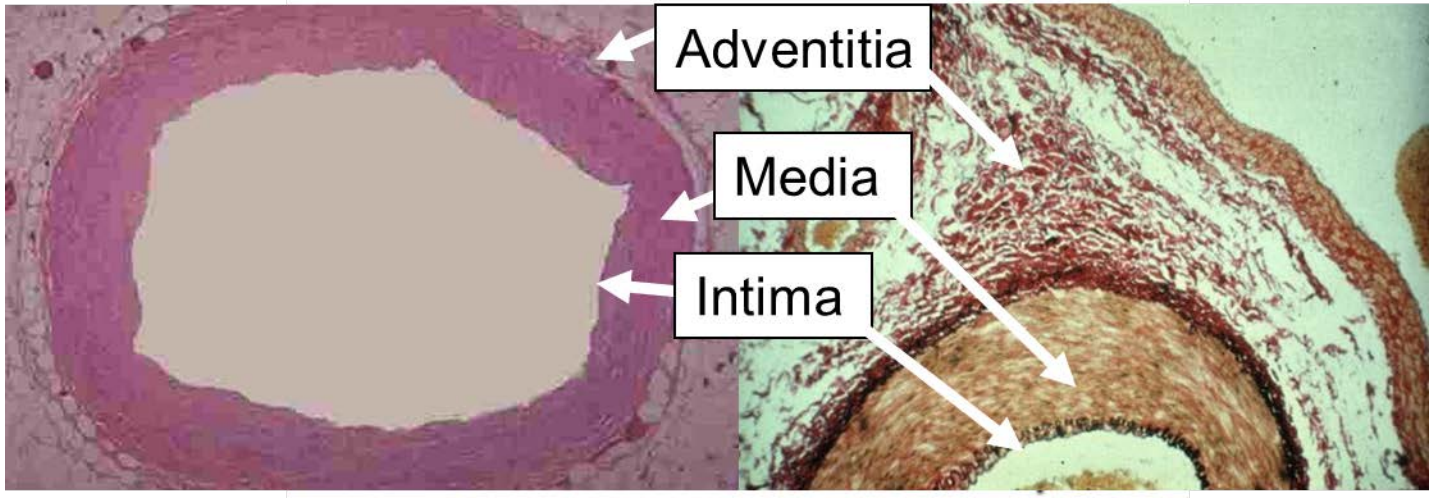
- “Normaal” bloedvat



Basic Interpretation

IVUS



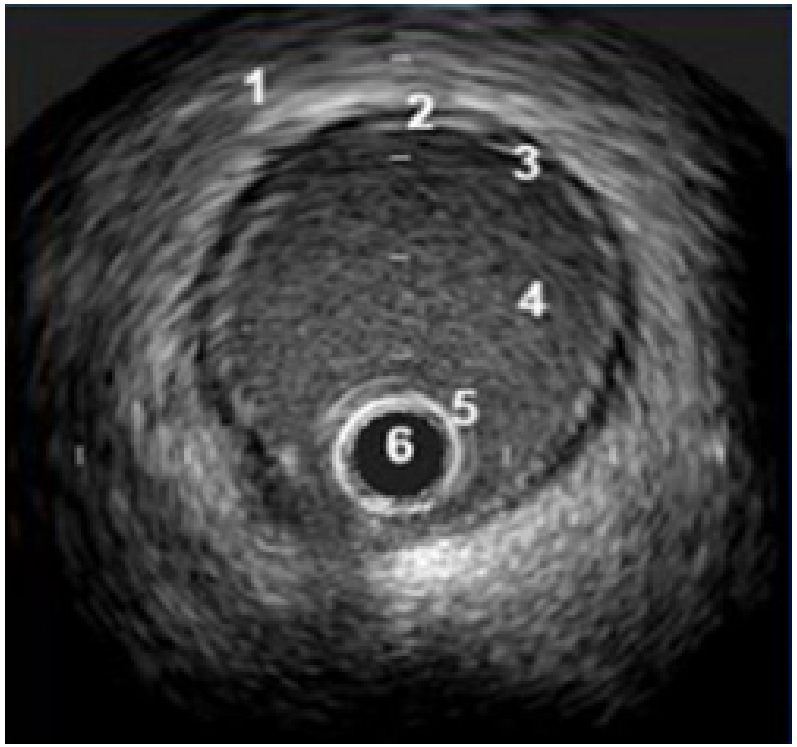


Basic Interpretation

IVUS

- “Normaal” bloedvat

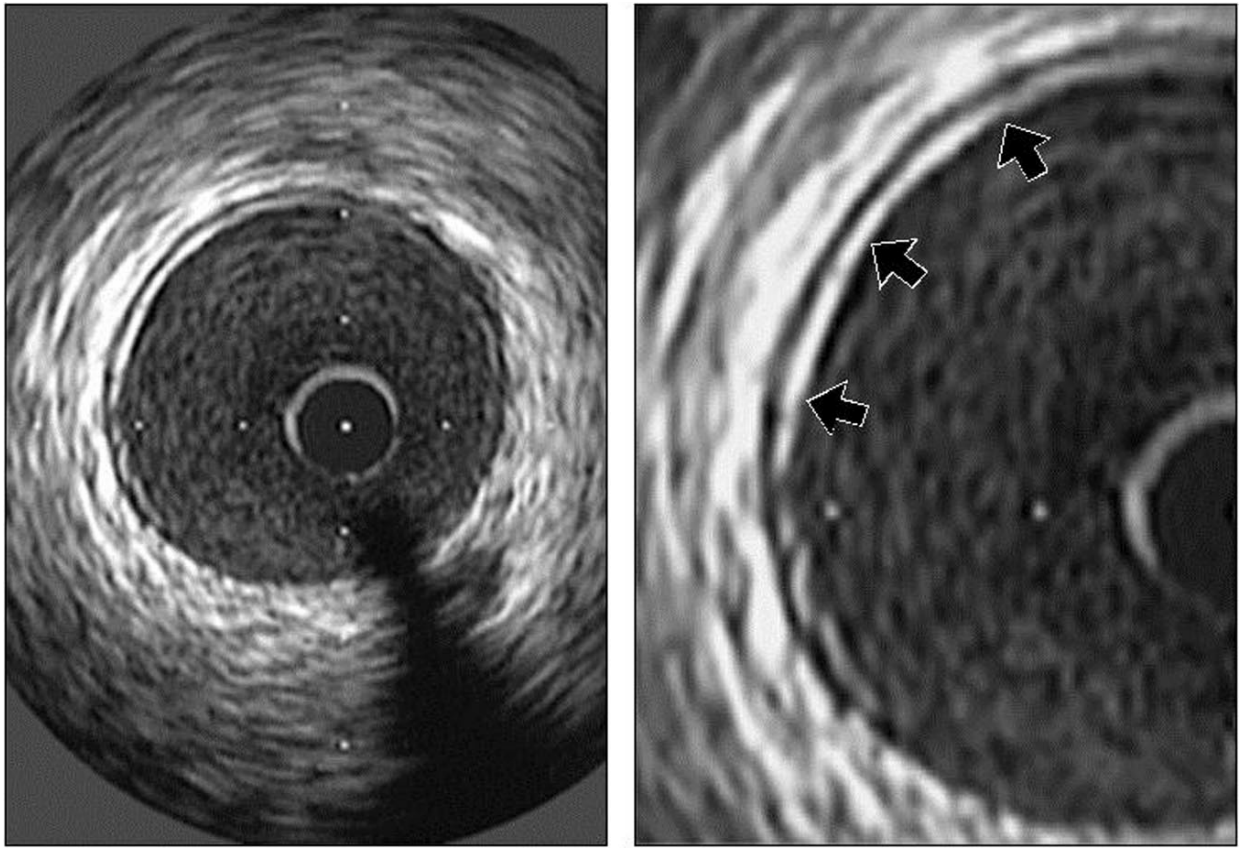
1. Adventitia
2. Media
3. Intima
4. Lumen
5. RingDown
6. Catheter



Basic Interpretation

IVUS

- “Normaal” bloedvat

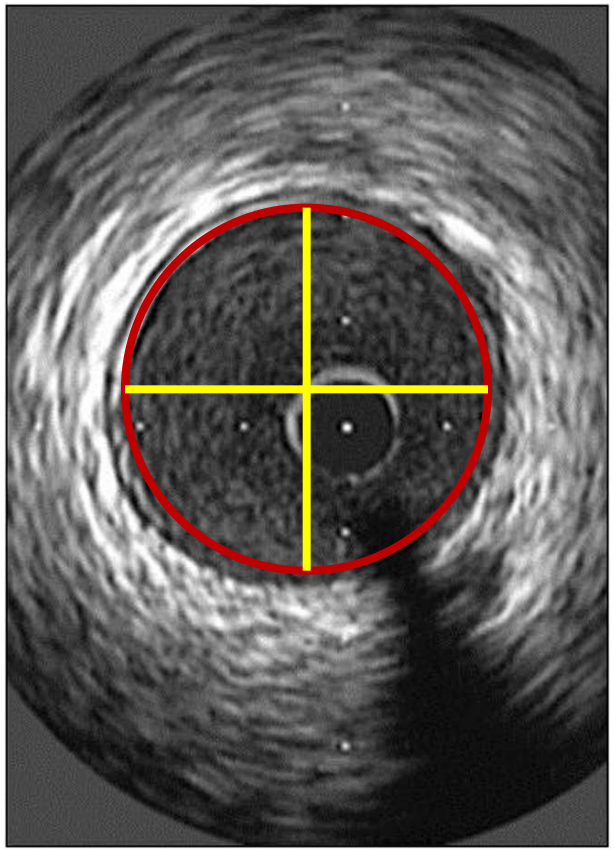


Nissen; Circulation 2001

Basic Interpretation

IVUS

- Measurements
  - Lumen area / diameter
  - Segment lengte

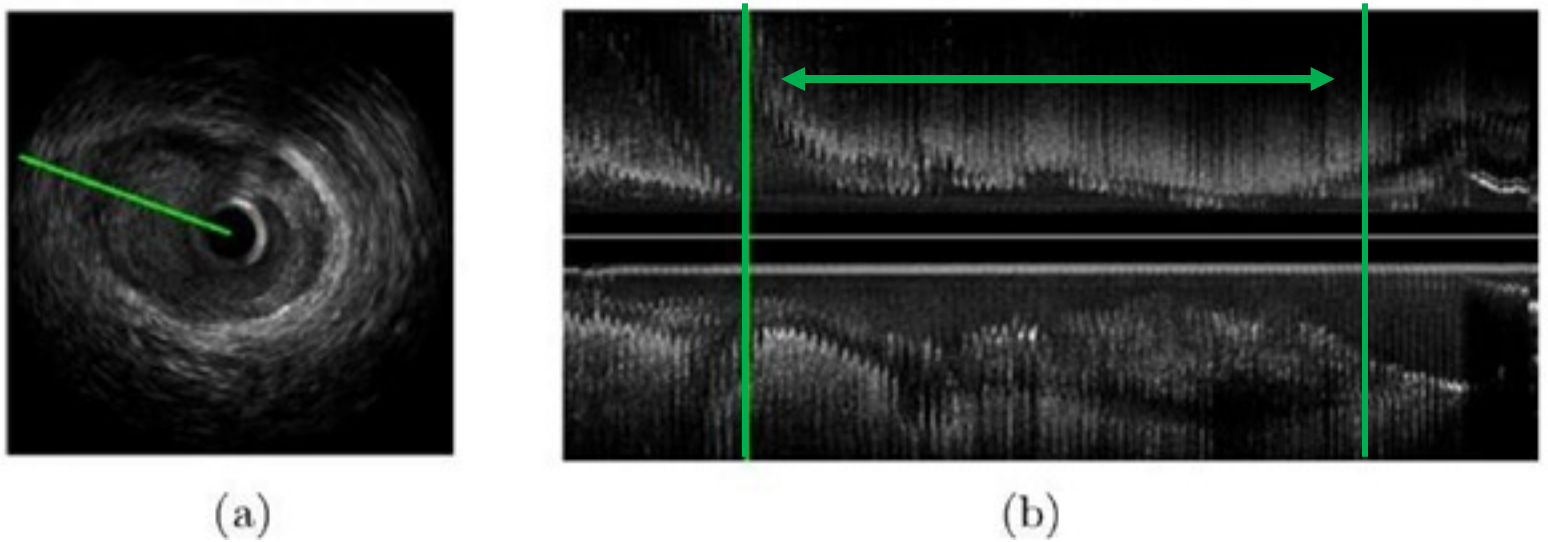


Nissen; Circulation 2001

Basic Interpretation

IVUS

- Measurements
  - Lumen area / diameter
  - Segment lengte

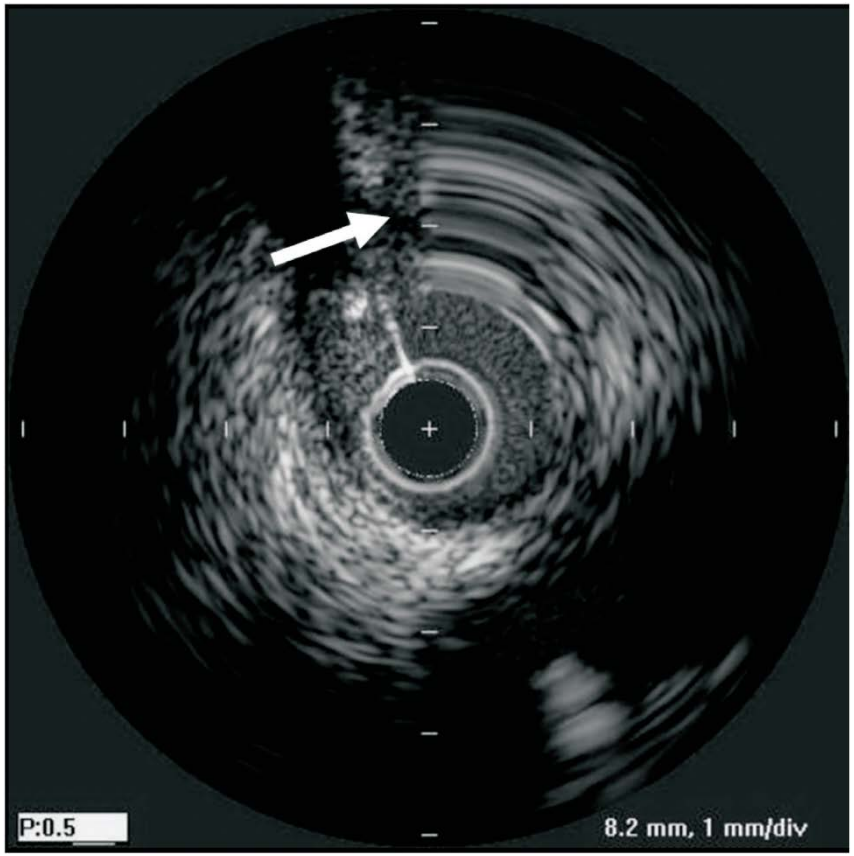


(a) (b)

Basic Interpretation

IVUS

- NERD (motion artefact)



Basic Principles

IVUS vs OCT

Medium	Density (kg/m^3)	Sound Velocity (m/sec)	Accoustic Impedance (Rayl)
Air	1.20	330	0.0004
Water	$1.00\text{^}10^3$	1480	1.47
Blood	$1.03\text{^}10^3$	1570	1.62
Muscle	$1.07\text{^}10^3$	1585	1.67
Fat	$0.93\text{^}10^3$	1450	1.38
Bone (calcium)	$1.91\text{^}10^3$	4080	7.8
Transducer	$7.3\text{^}10^3$	4100	30

Basic Interpretation

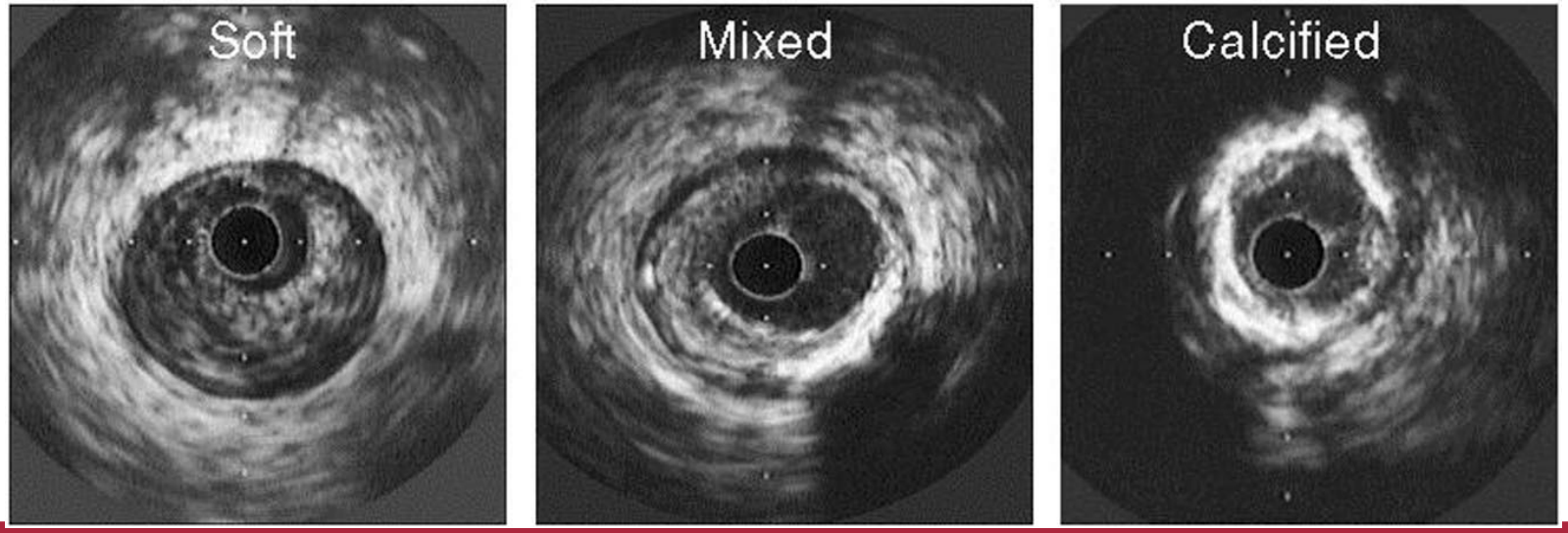
IVUS vs OCT

Tissue Type	Image characteristics	
	OCT	IVUS
Fibre	Homogeneous High reflectivity Low attenuation	Homogeneous High reflectivity
Calcium	Sharp Edges Low reflectivity Low attenuation	Very high reflectivity Shadowing
Lipid	Diffuse Edges High reflectivity High attenuation	Low backscatter
Red Thrombus	Medium reflectivity High attenuation	Medium-high reflectivity
White Thrombus	Medium reflectivity Low attenuation	

Basic Interpretation

IVUS

- Plaque beoordeling
  - Hoe echodenser (m.a.w. hoe witter); hoe hoger de dichtheid van het weefsel → reflectivity
  - Kalk zeer echodens → helder wit met schaduw vorming

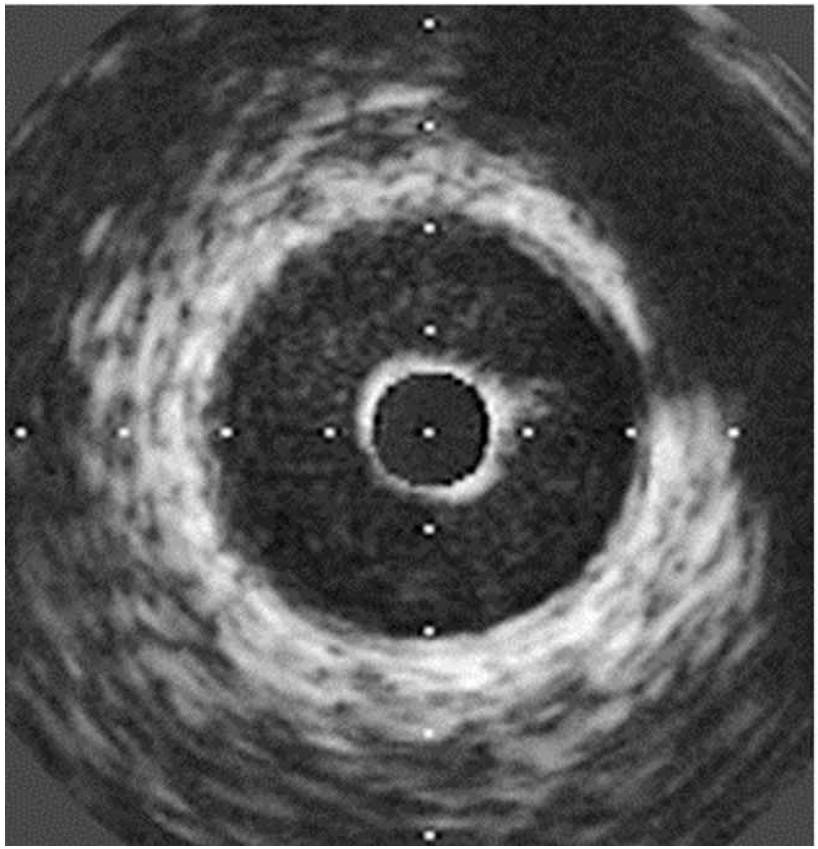


Nissen; Circulation 2001

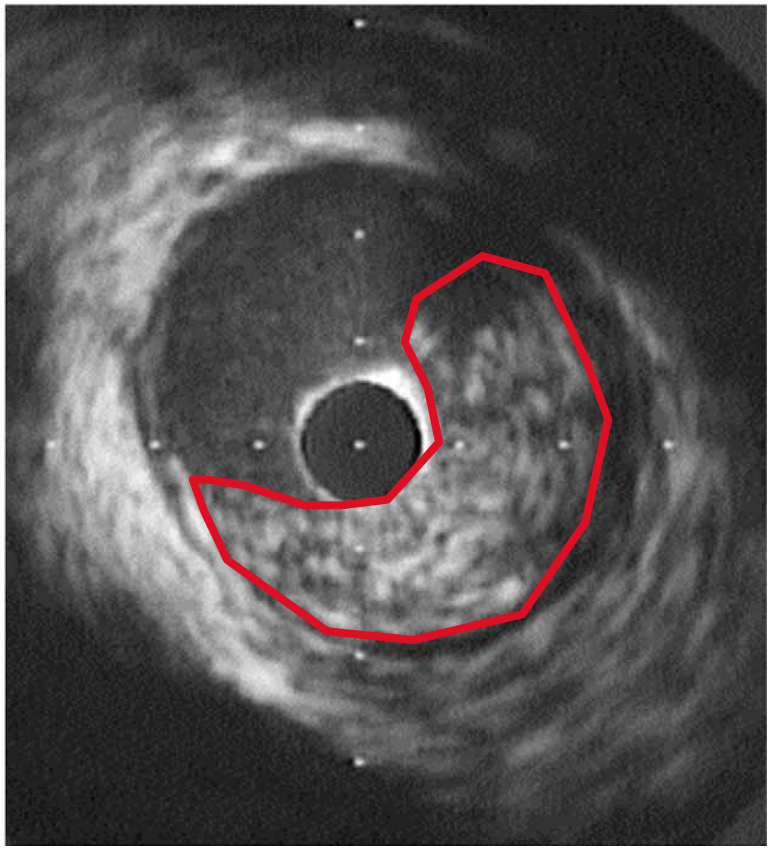
Basic Interpretation

IVUS

“Normaal” bloedvat



Plaque

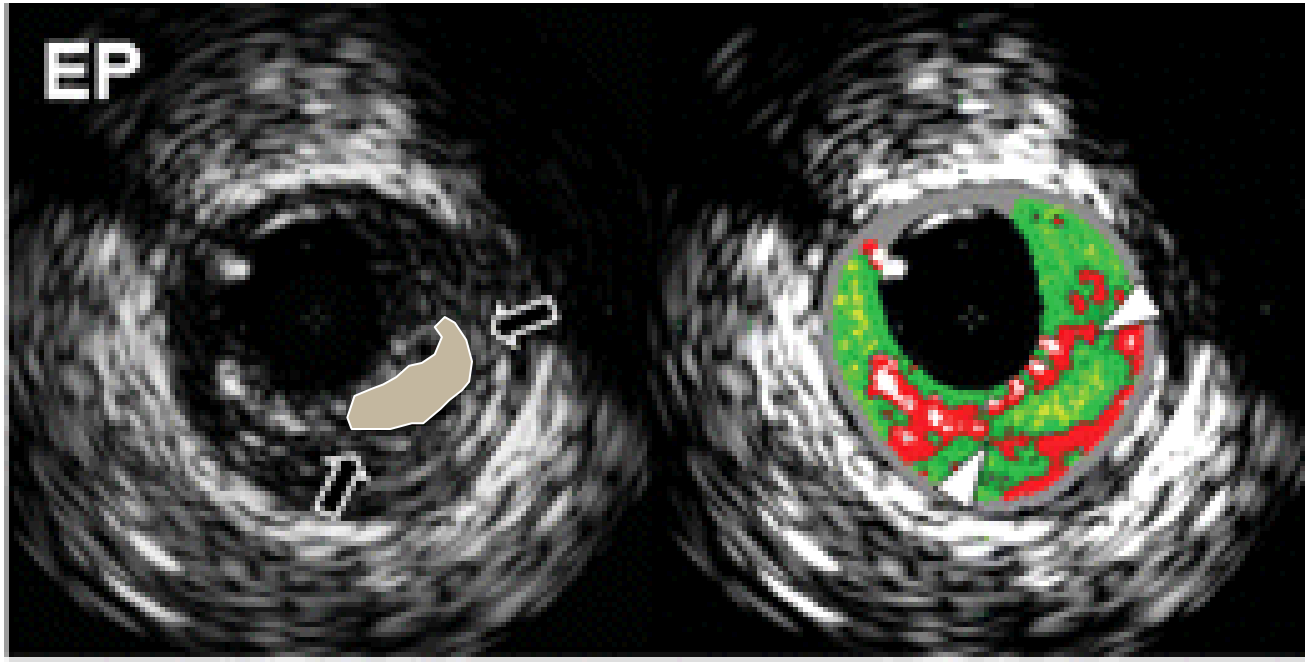


Nissen; JACC 2002

Basic Interpretation

IVUS

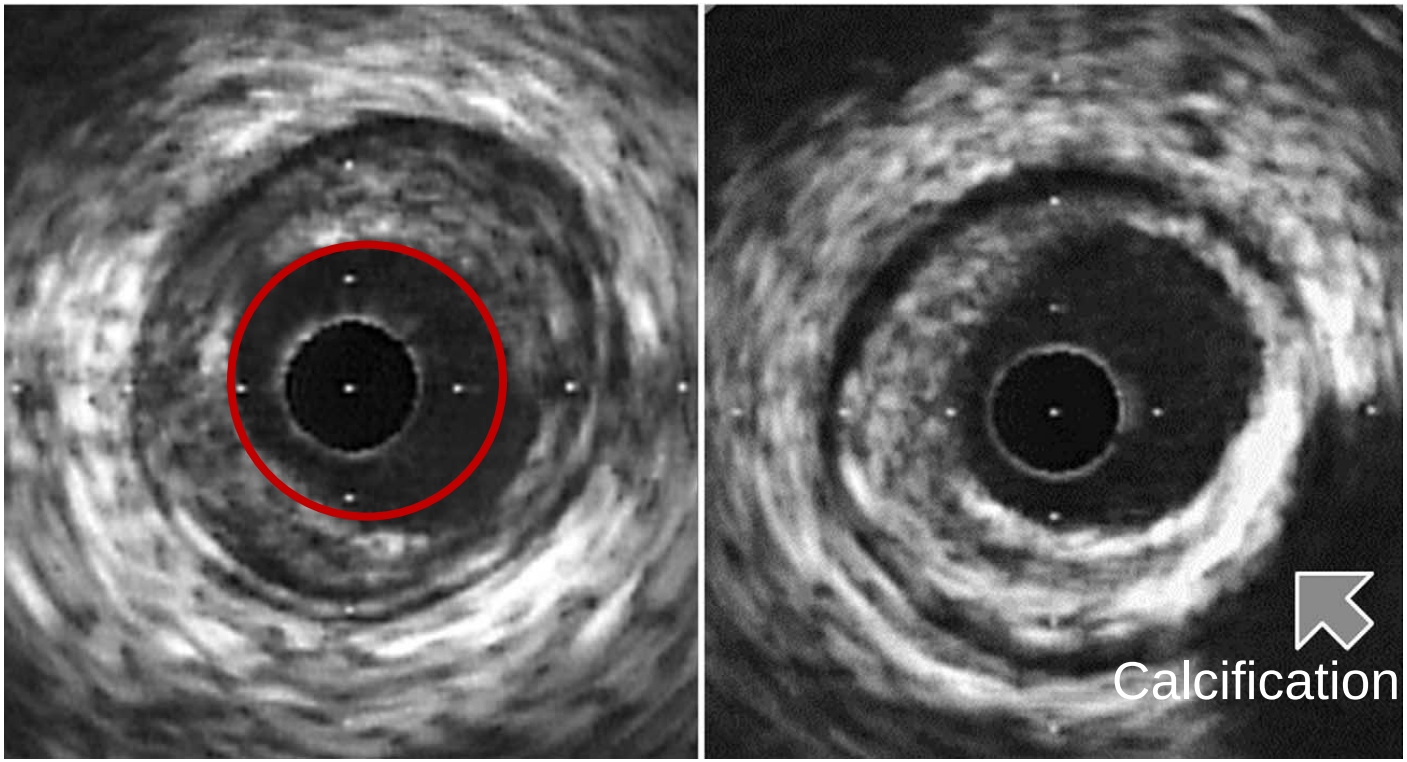
- Lipide pool



Pu; Eur. Heart J. 2011

Basic Interpretation

IVUS

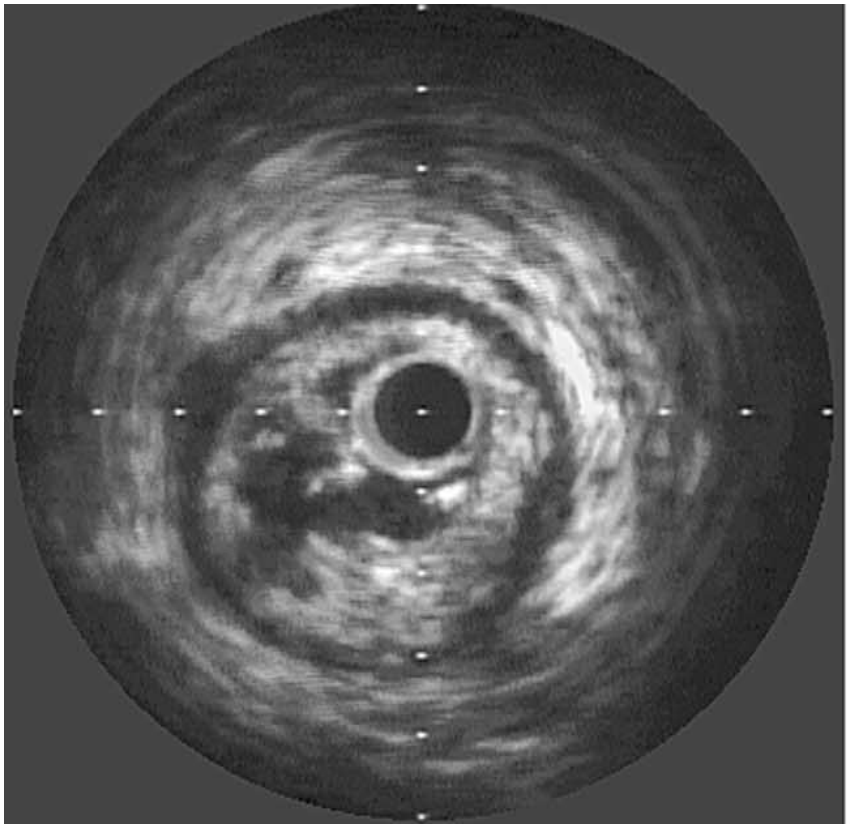


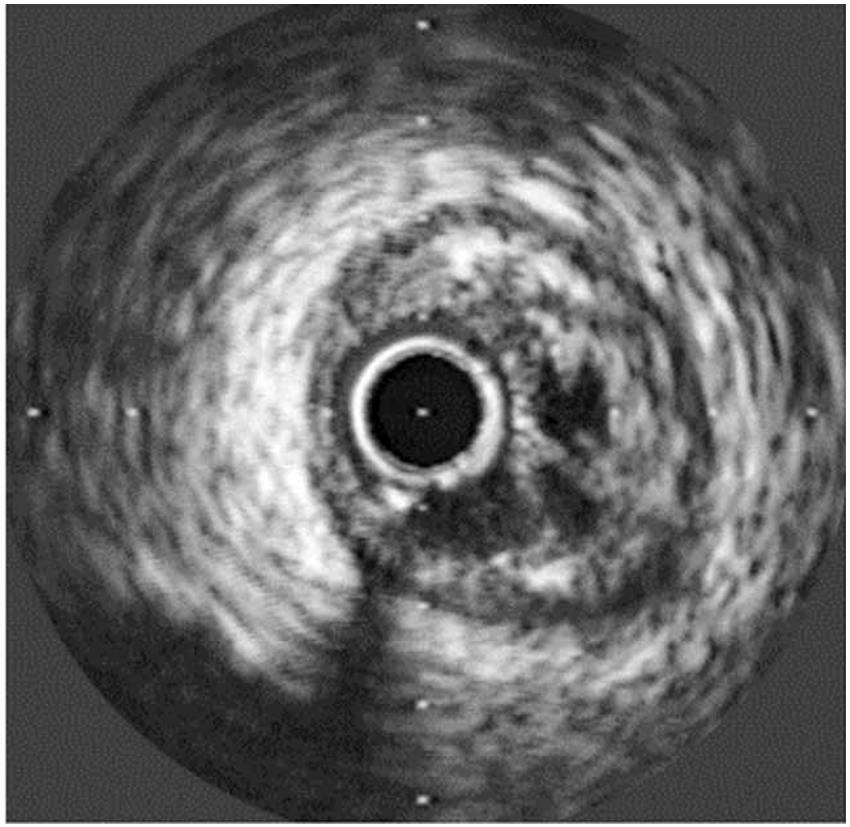
Nissen; 2002

Basic Interpretation

IVUS

Ruptured Plaques

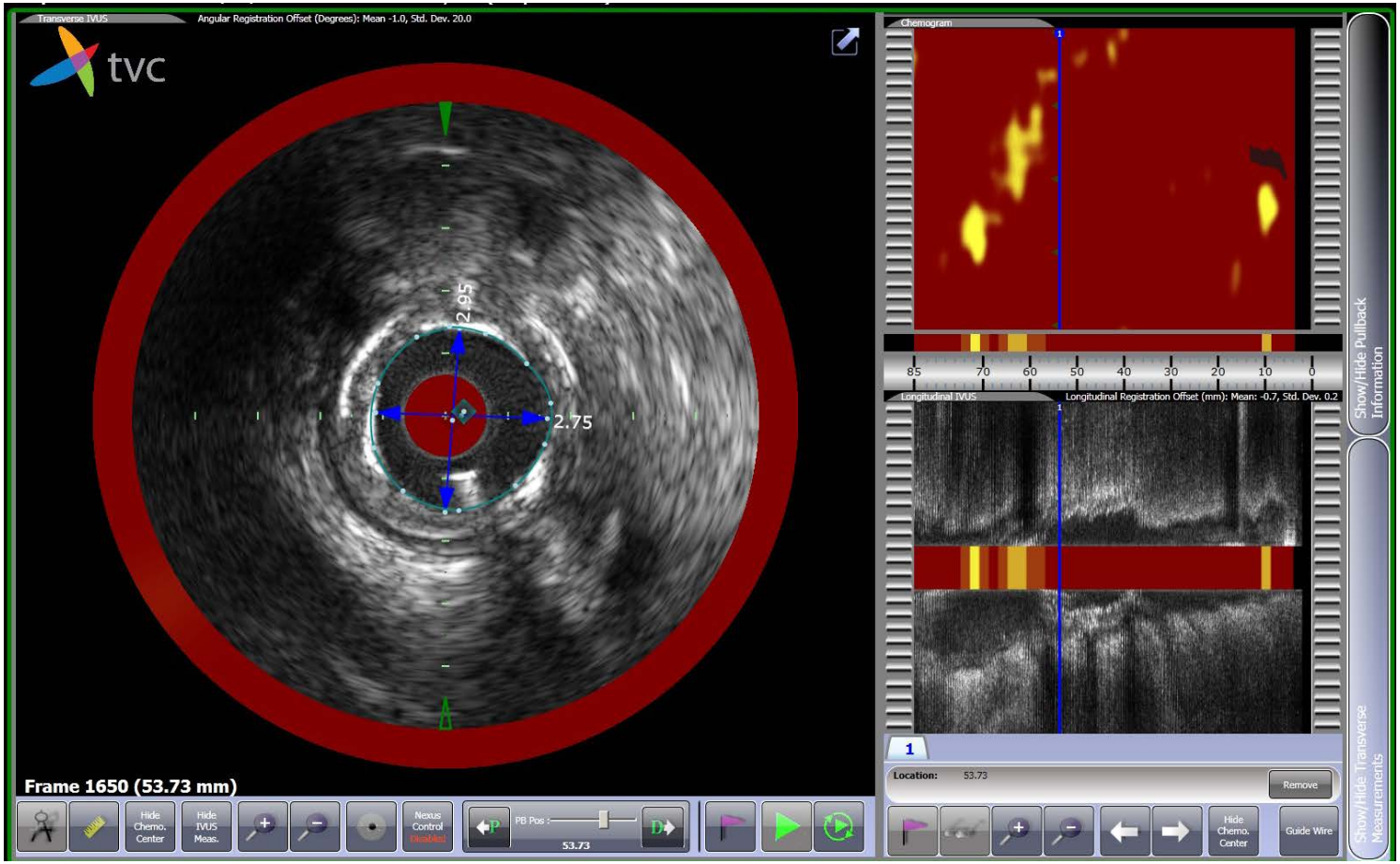




Nissen; 2002

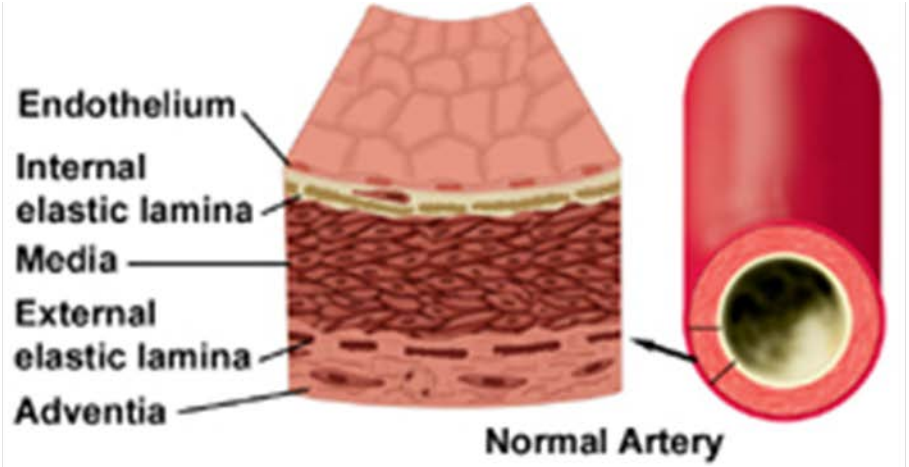
Basic Interpretation

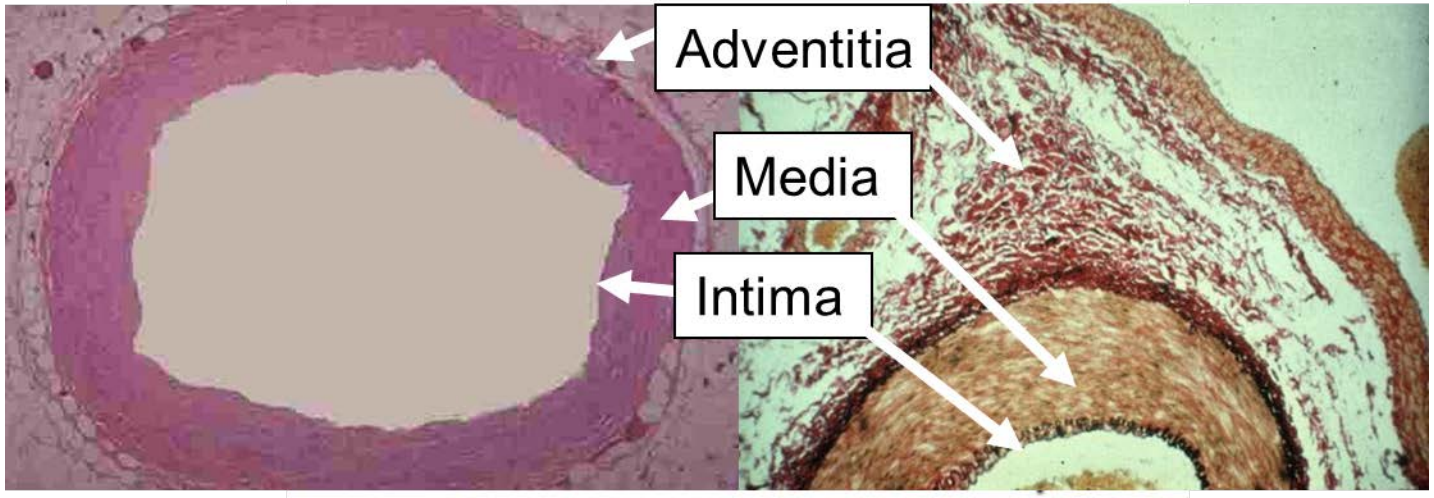
IVUS NIRS



Basic Interpretation

OCT

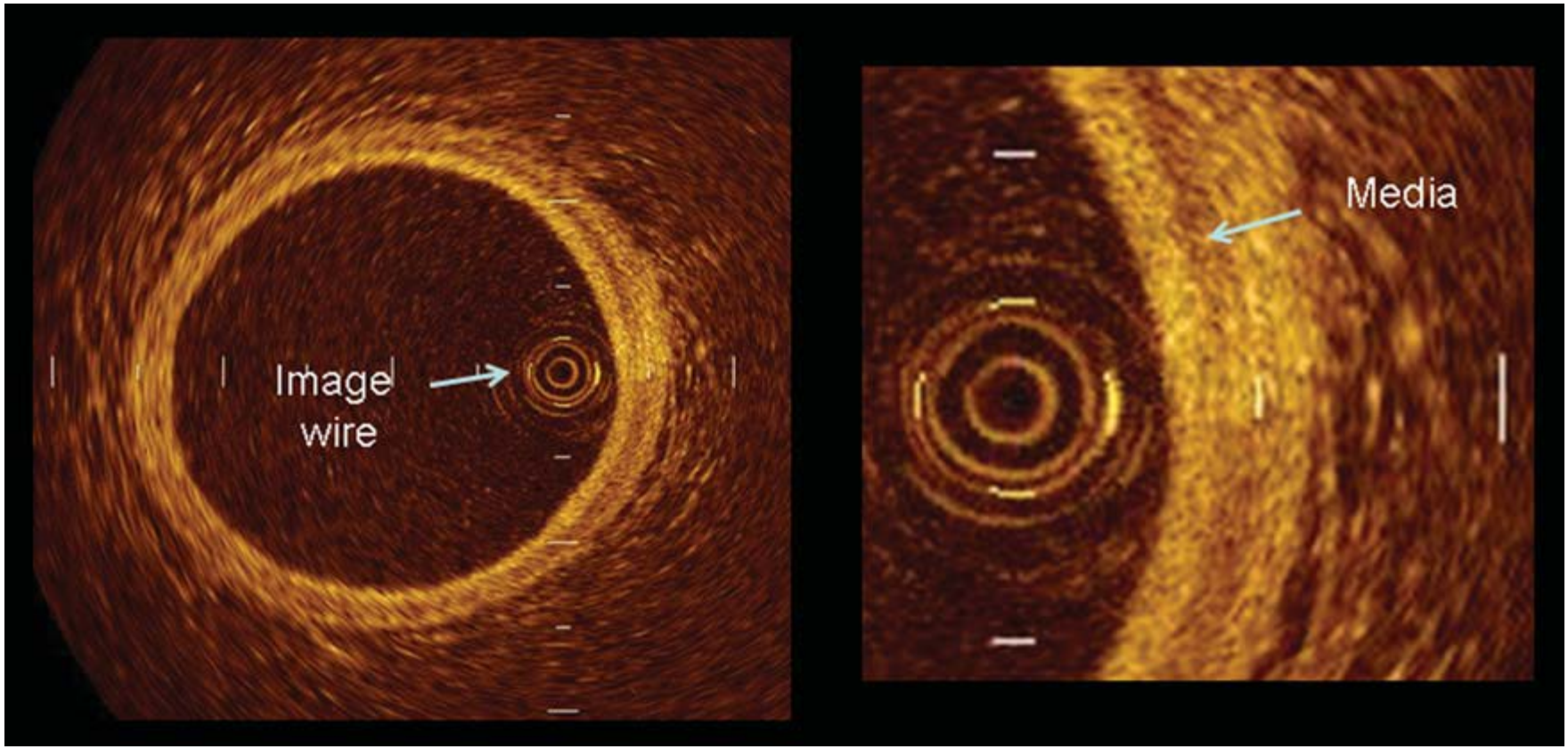




Basic Interpretation

OCT

- “Normaal” bloedvat

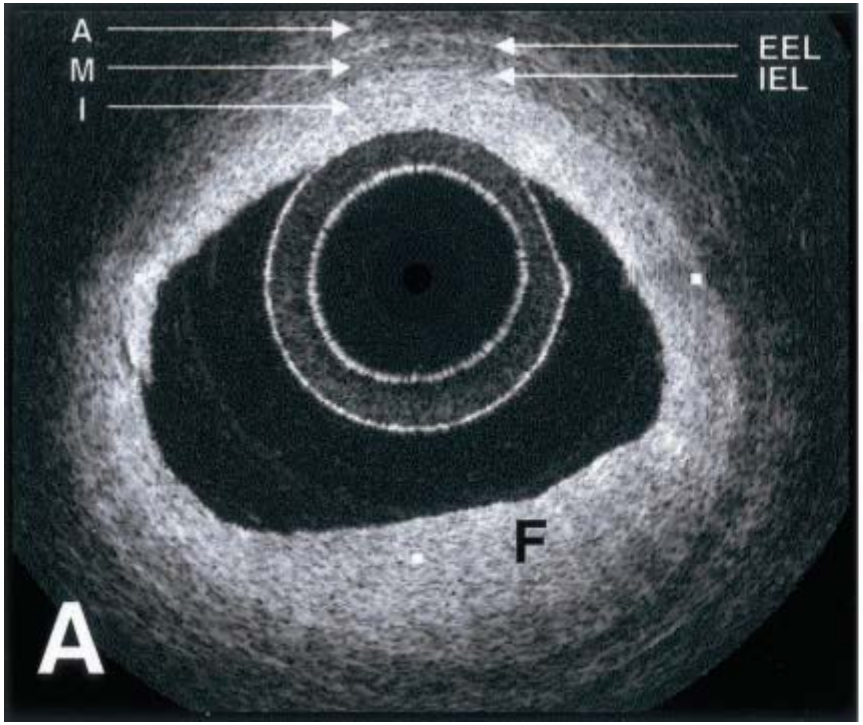


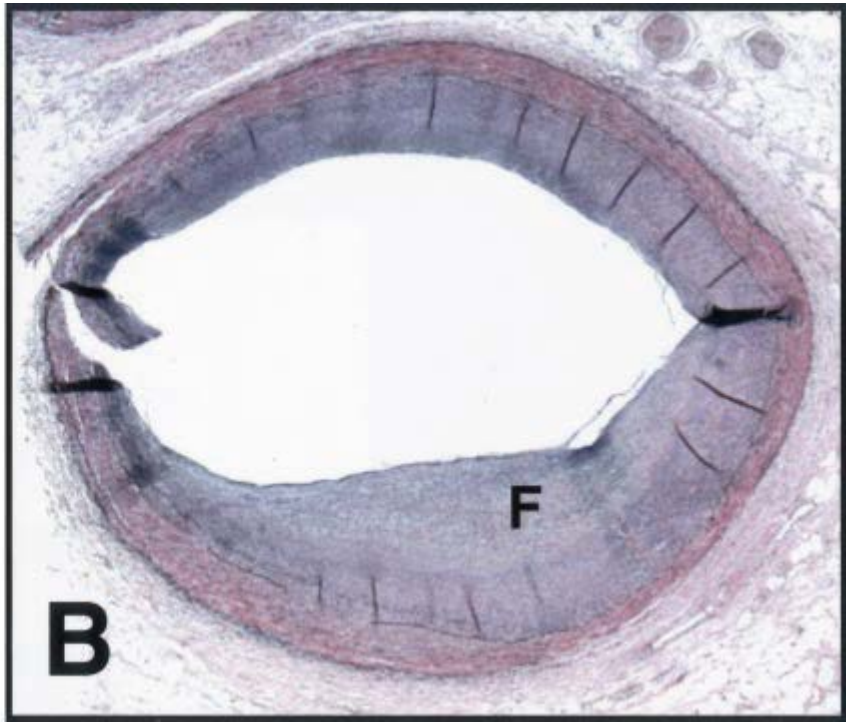
Prati; Eur. Heart J. 2010

Basic Interpretation

OCT

- OCT vs Histology



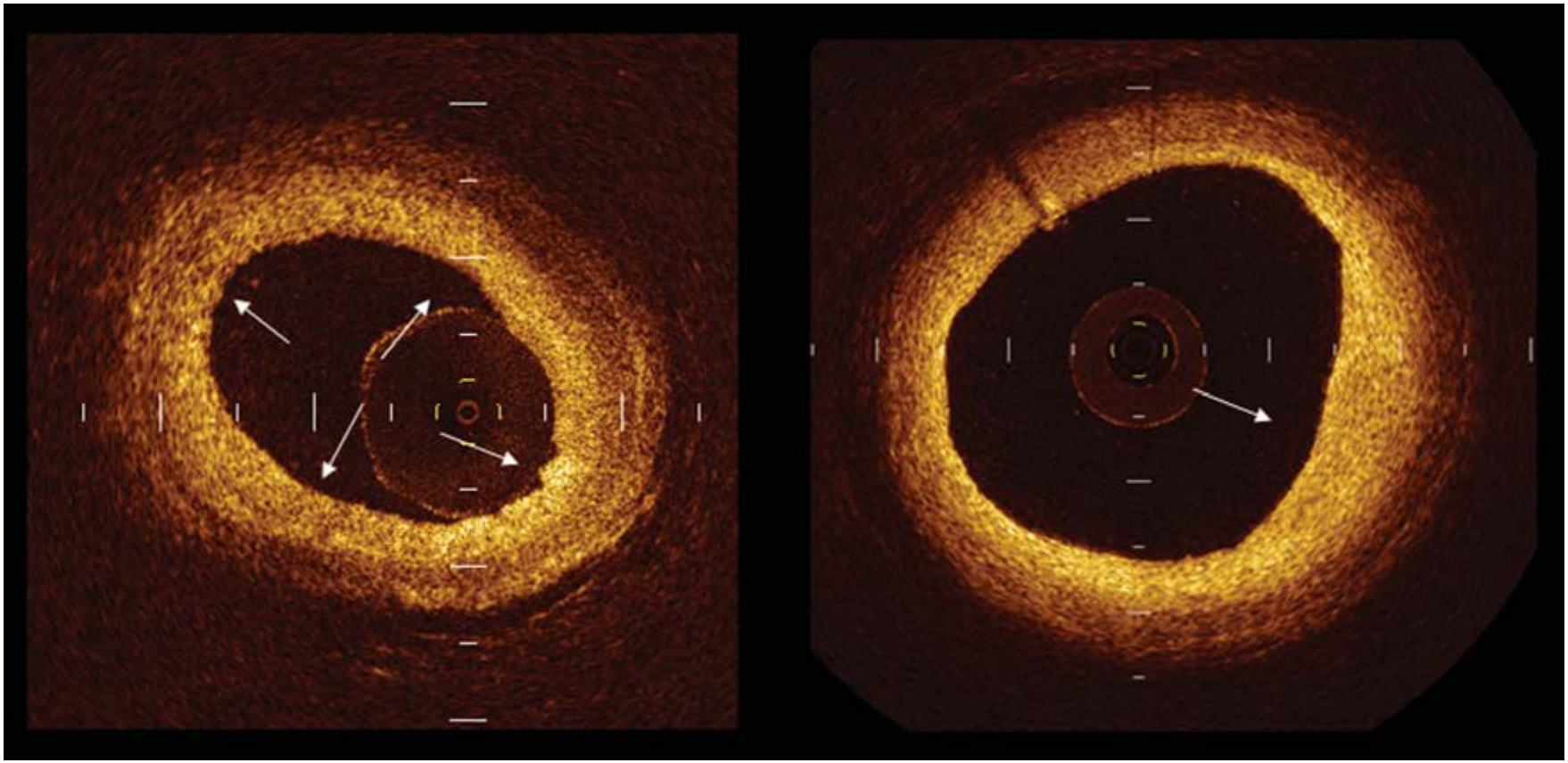


Yabushita; Circulation 2002

Basic Interpretation

OCT

Homogene Intima verdikking



Prati; Eur. Heart J. 2010

Basic Interpretation

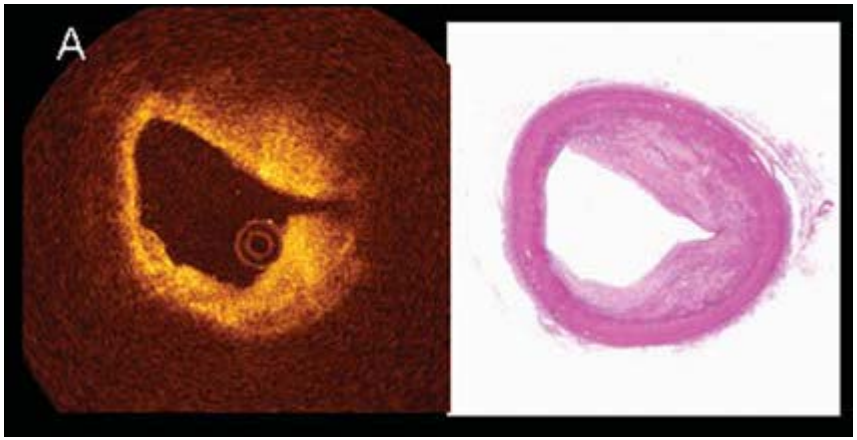
IVUS vs OCT

Tissue Type	Image characteristics	
	OCT	IVUS
Fibre	Homogeneous High reflectivity Low attenuation	Homogeneous High reflectivity
Calcium	Sharp Edges Low reflectivity Low attenuation	Very high reflectivity Shadowing
Lipid	Diffuse Edges High reflectivity High attenuation	Low backscatter
Red Thrombus	Medium reflectivity High attenuation	Medium-high reflectivity
White Thrombus	Medium reflectivity Low attenuation	

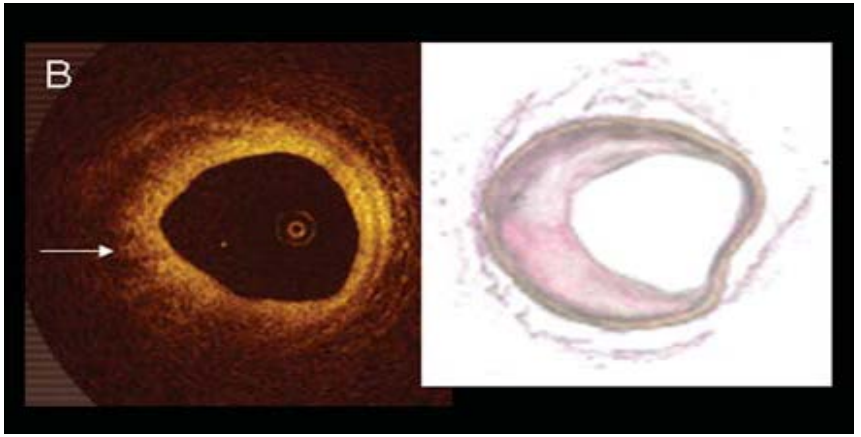
Basic Interpretation

OCT

- Diffuus fibrotische plaque
  - Homogeneous
  - High reflectivity
  - Low attenuation



- Lipid pool
  - Diffuse Edges
  - High reflectivity
  - High attenuation



Prati; Eur. Heart J. 2010

Basic Interpretation

OCT vs IVUS

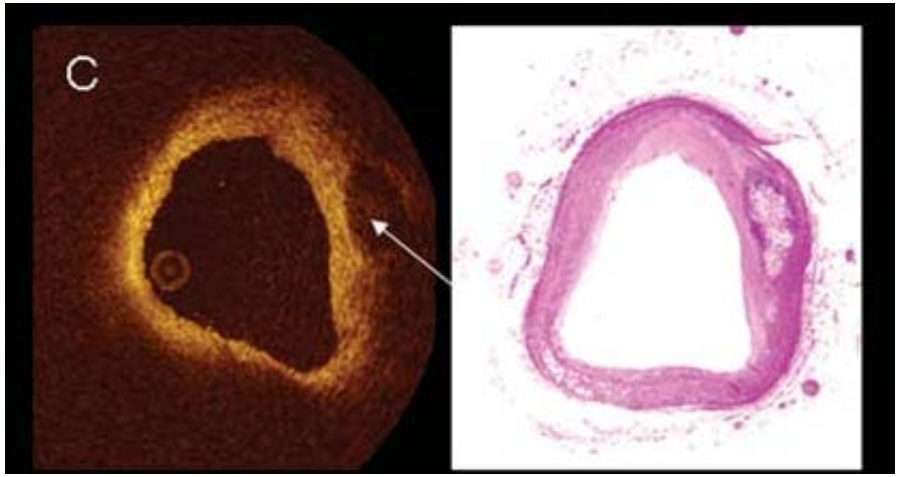
- Lipide pool met thin cap

Miyamoto; 2011

Basic Interpretation

OCT

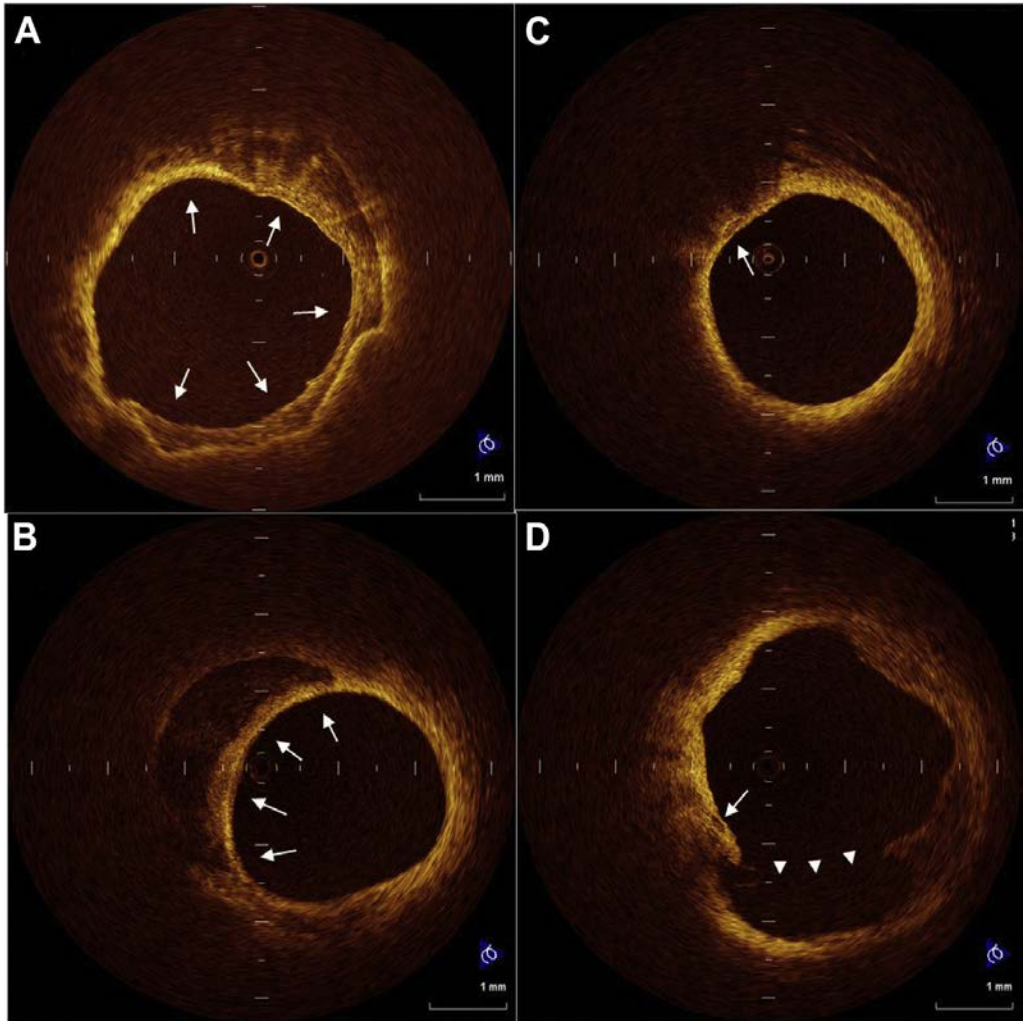
- Calcification
  - Sharp Edges
  - Low reflectivity
  - Low attenuation



Prati; Eur. Heart J. 2010

Basic Interpretation

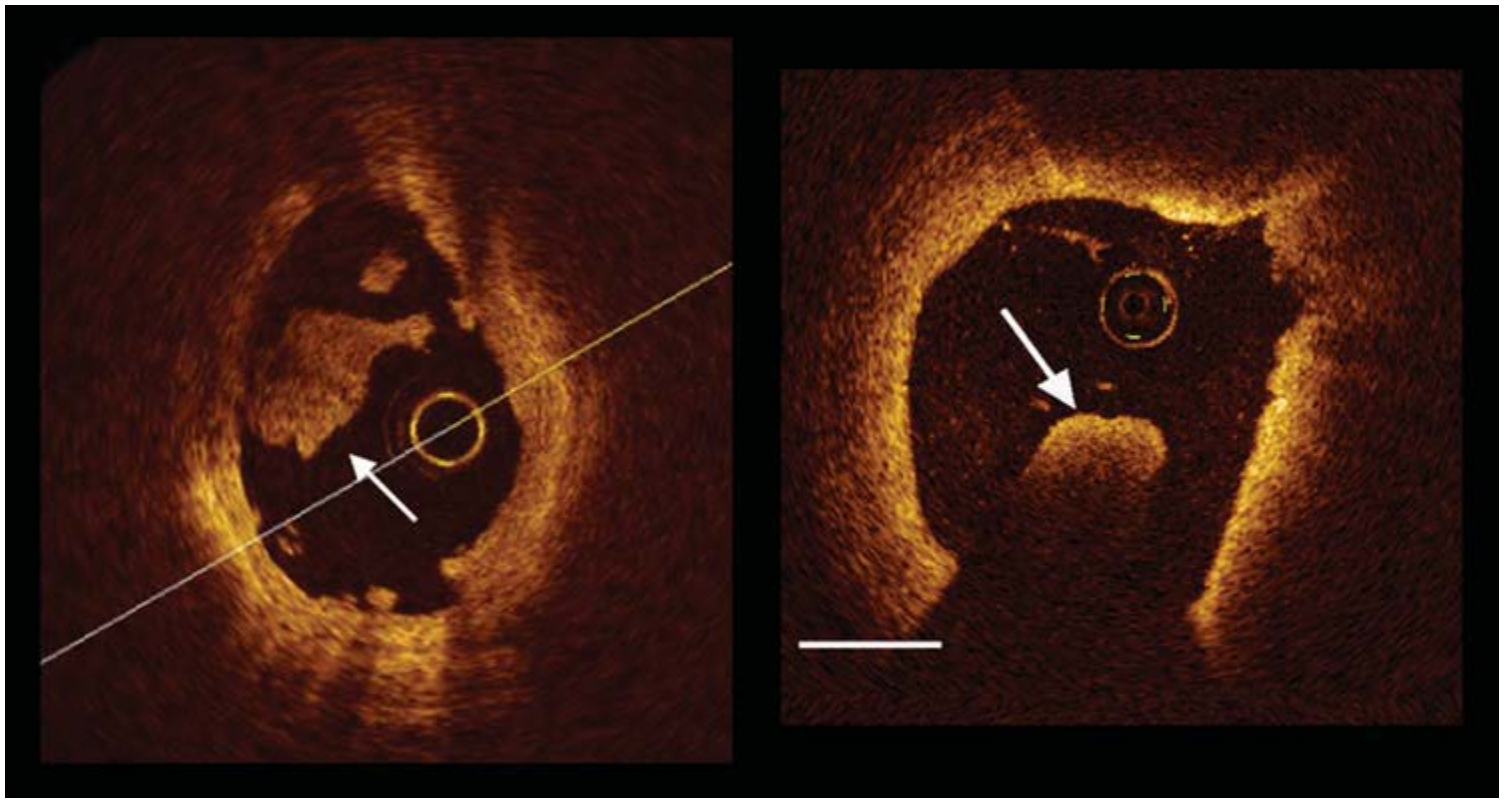
OCT



Basic Interpretation

OCT

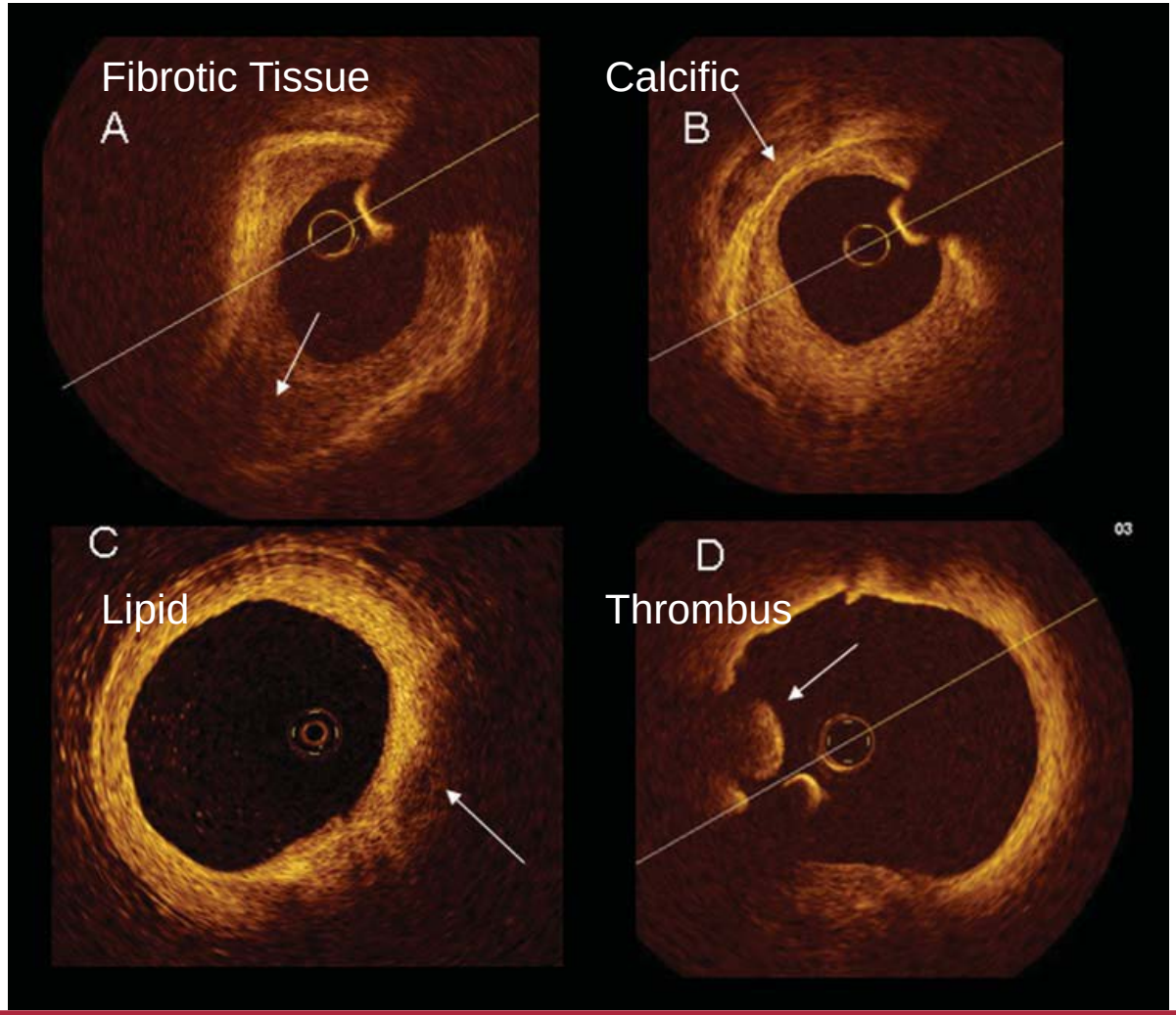
“Witte Thrombus” “Rode Thrombus”



Prati; Eur. Heart J. 2010

Basic Interpretation

OCT



Prati; Eur. Heart J. 2010

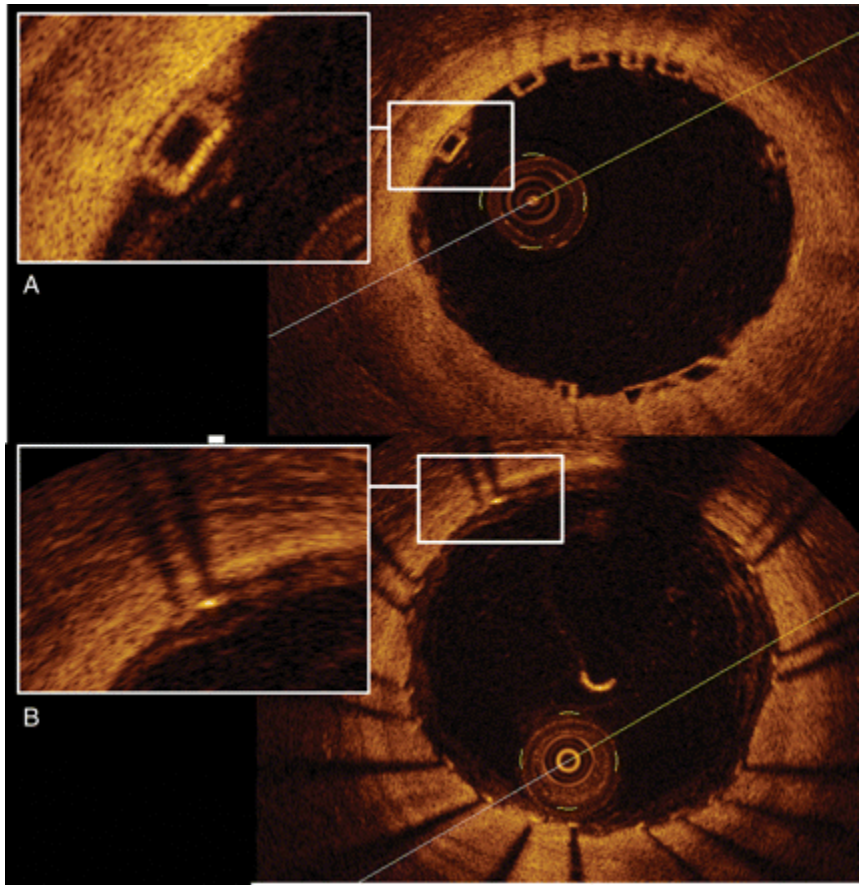
Basic Interpretation

OCT

Basic Interpretation

OCT

- Bioresorbable vascular scaffold imaged on OCT
  - Strut appearance is translucent
  - Perfect imaging of the vessel wall
- Metallic stent imaged on OCT
  - Strut appearance is opaque
  - Shadow into the vessel wall

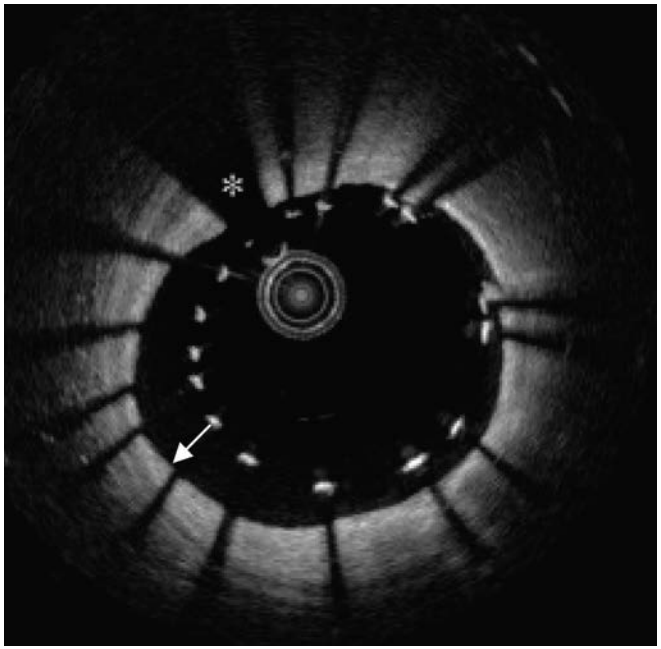


Gomez-Lara et al. Eur Heart J 2011

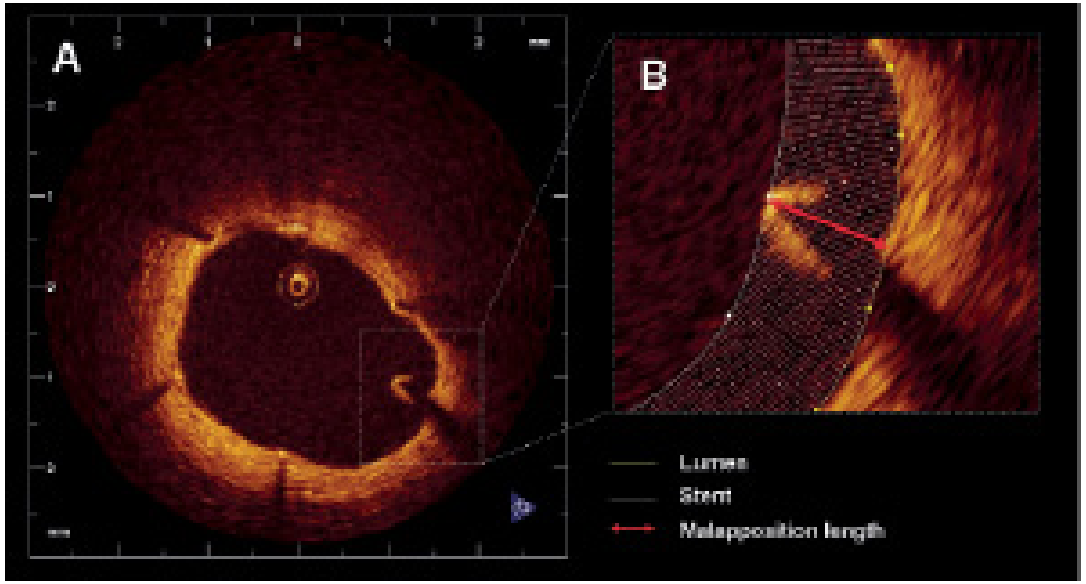
Basic Interpretation

OCT

- Stent malappositie



Baseline



Tearney et al. JACC 2012
Gonzalo et al. Eurointervention 2009

Basic Interpretation

OCT

- Stent thrombosis

Ishihara **et al.** JACC Card. Int. 2013

Basic Interpretation

OCT

- Measurements
  - Lumen area / diameter
  - Segment lengte

- Basic principles
- Basic interpretatation
- Case examples Imaging Guided PCI

Thank You

Academic Medical Center, Amsterdam, The Netherlands