'ELITEAM'- ESTABLISHMENT OF THE ELI INSTITUTE AT THE UNIVERSITY OF SZEGED: FOUNDATION OF INTERDISCIPLINARY RESEARCH IN THE FIELD OF LASERS AND THEIR APPLICATIONS

APPLICATION OF OPTICAL COHERENCE TOMOGRAPHY IN CORONARY INTERVENTIONS

ATTILA THURY MD PHD

INVASIVE CARDIOLOGY UNIT, CARDIOLOGY CENTER UNIVESITY OF SZEGED

TÁMOP-4.2.2.D-15/1/KONV-2015-0024 project

SZÉCHENYI 2020

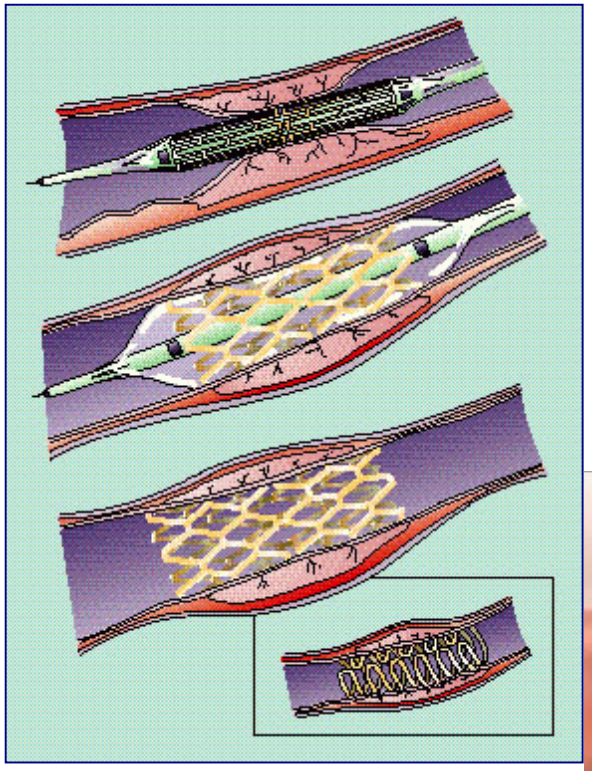
HUNGARIAN GOVERNMENT

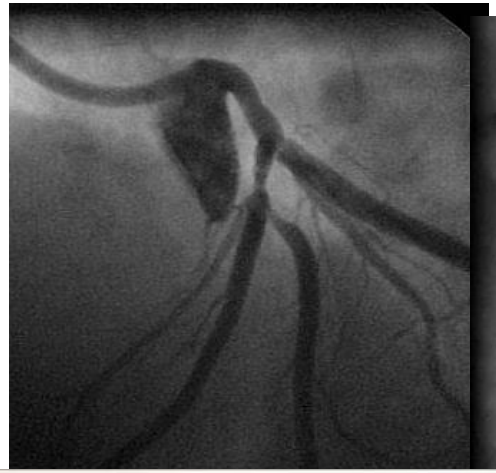
European Union
European Social Fund

INVESTING IN YOUR FUTURE

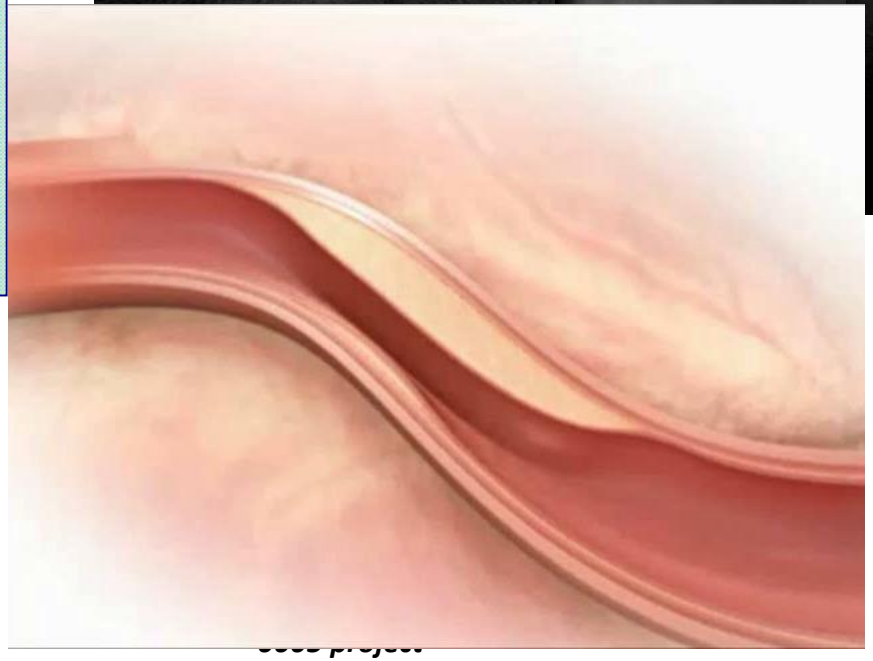
Percutaneous Coronary Intervention:

One the most frequently performed intervention/operation in the world





Procedural result



Coronary angiography

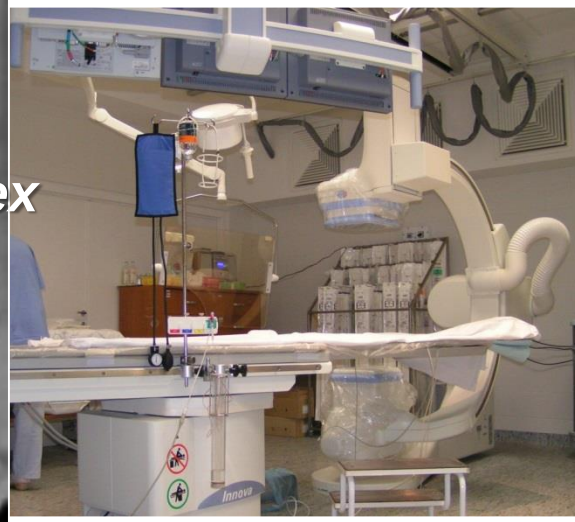
Normal left main

Non significant left anterior descending stenosis

Irregular left anterior descending artery

Critical circumflex artery stenosis

Thrombus & ectatic malformation in the circumflex



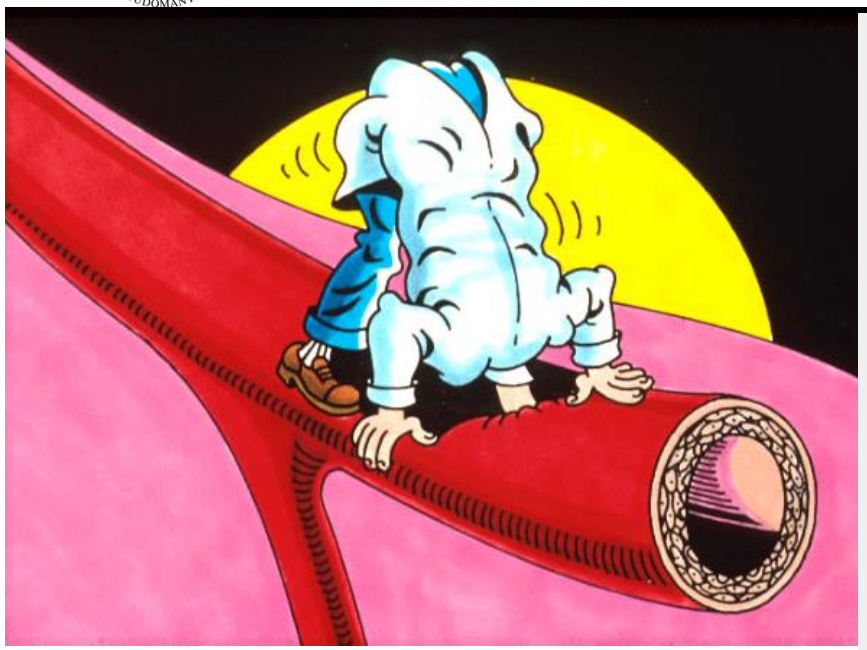
NEW SZÉCHENYI PLAN

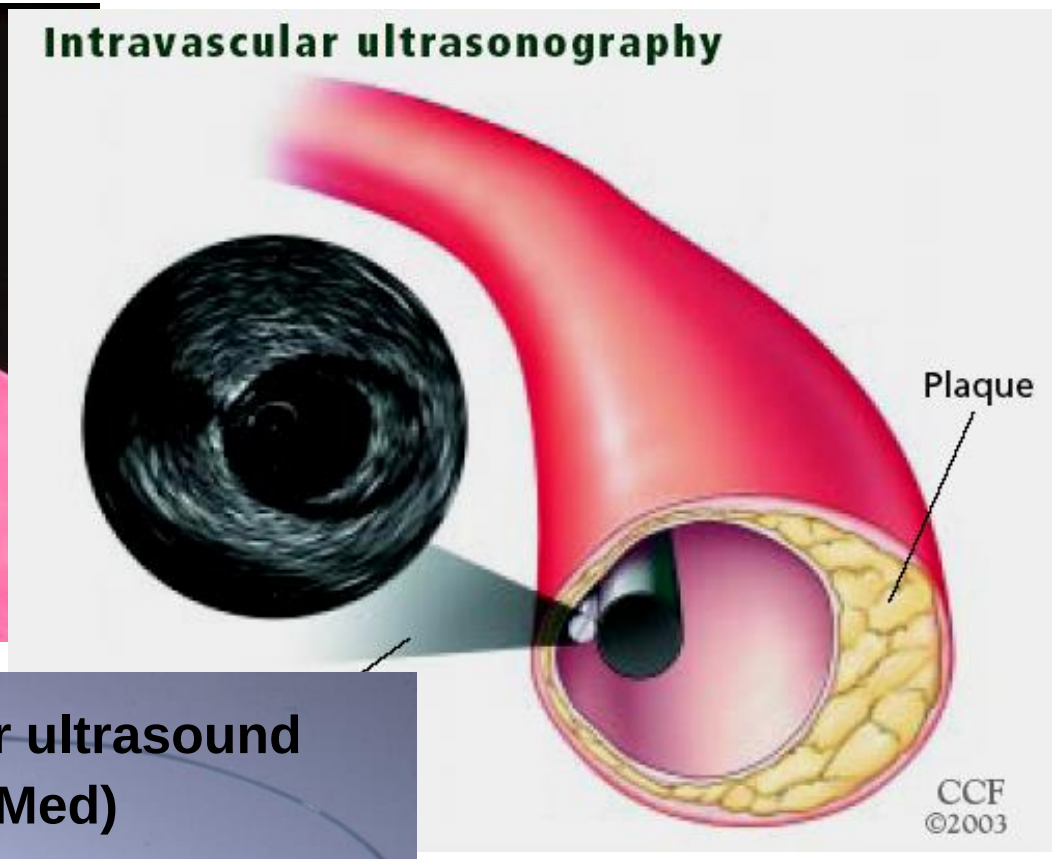
HUNGARIAN BIOPHYSICAL SOCIETY

ROLAND EÖTVÖS PHYSICAL SOCIETY (HUNGARY)

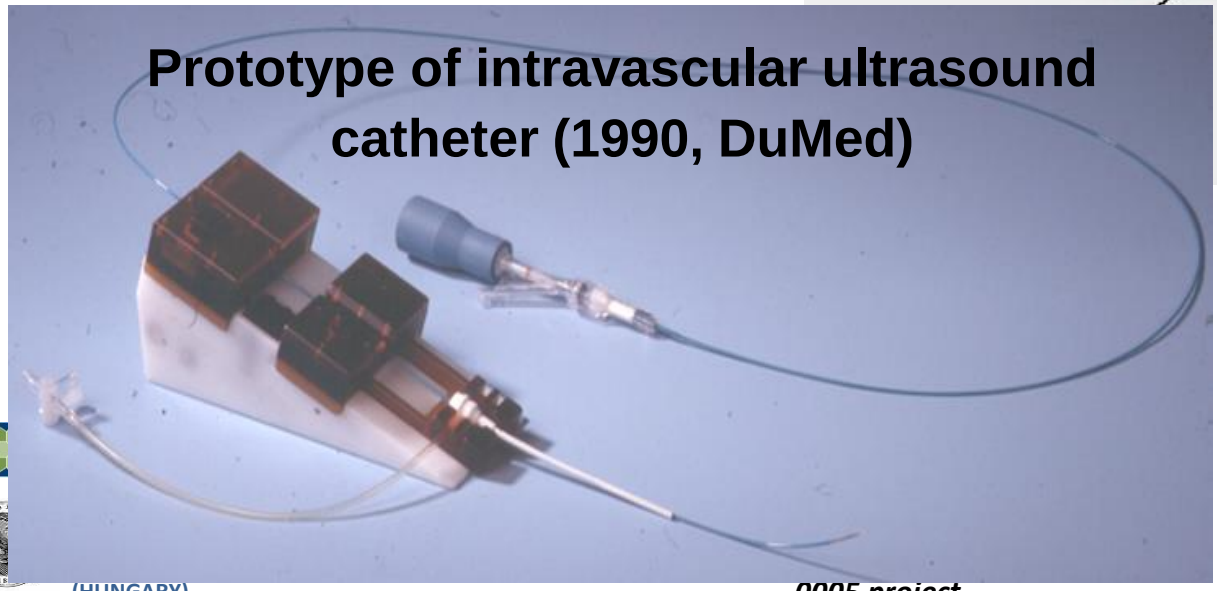
HUNGARY'S RENEWAL

The project is supported by the European Union and co-financed by the European Social Fund.





Prototype of intravascular ultrasound catheter (1990, DuMed)



HUNGARY'S RENEWAL
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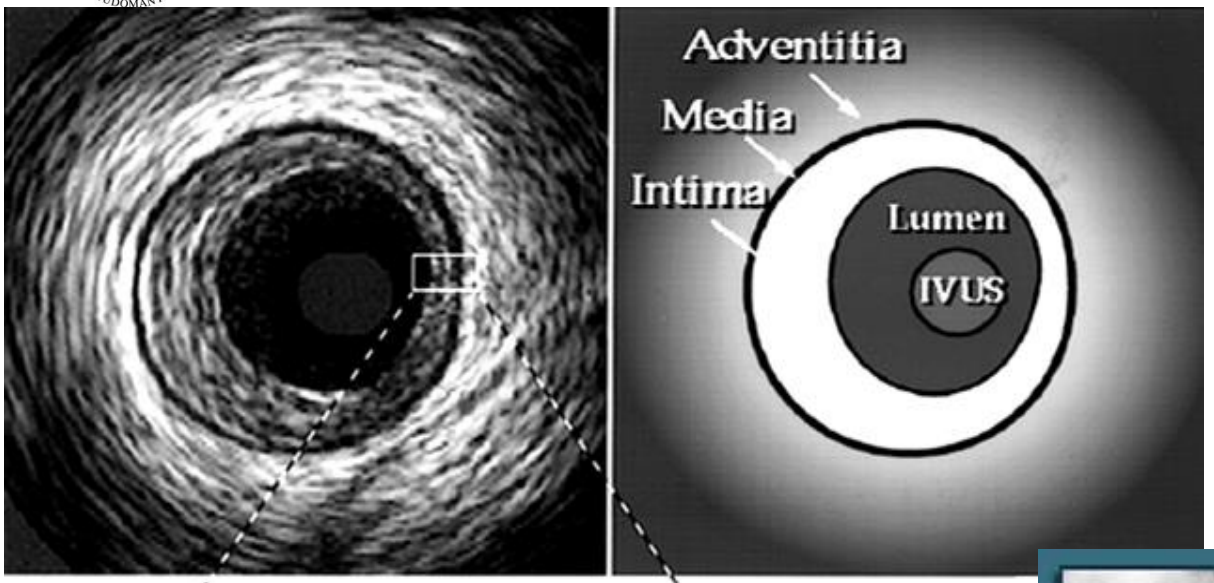
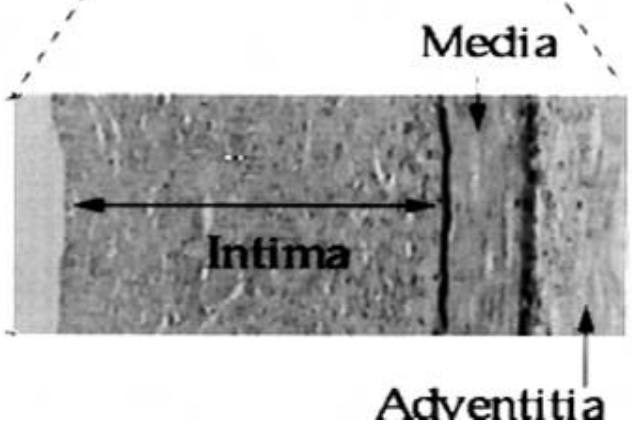

Adventitia
Media
Intima
Lumen
IVUS


Media
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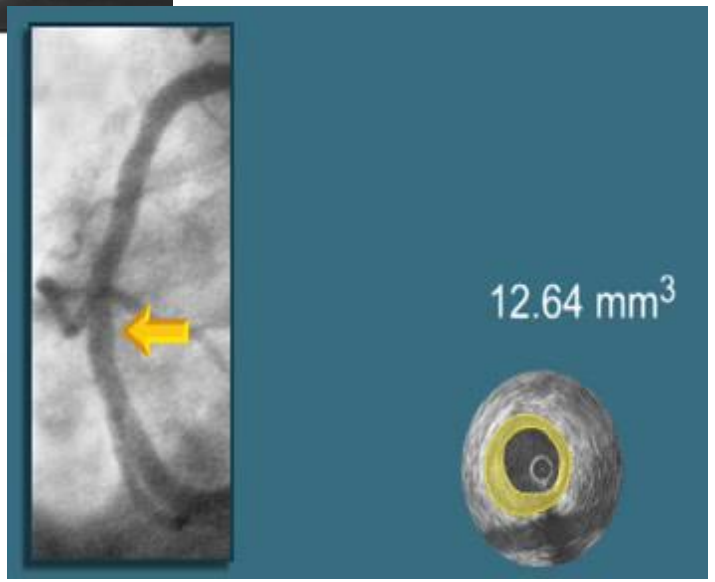

12.64 mm3

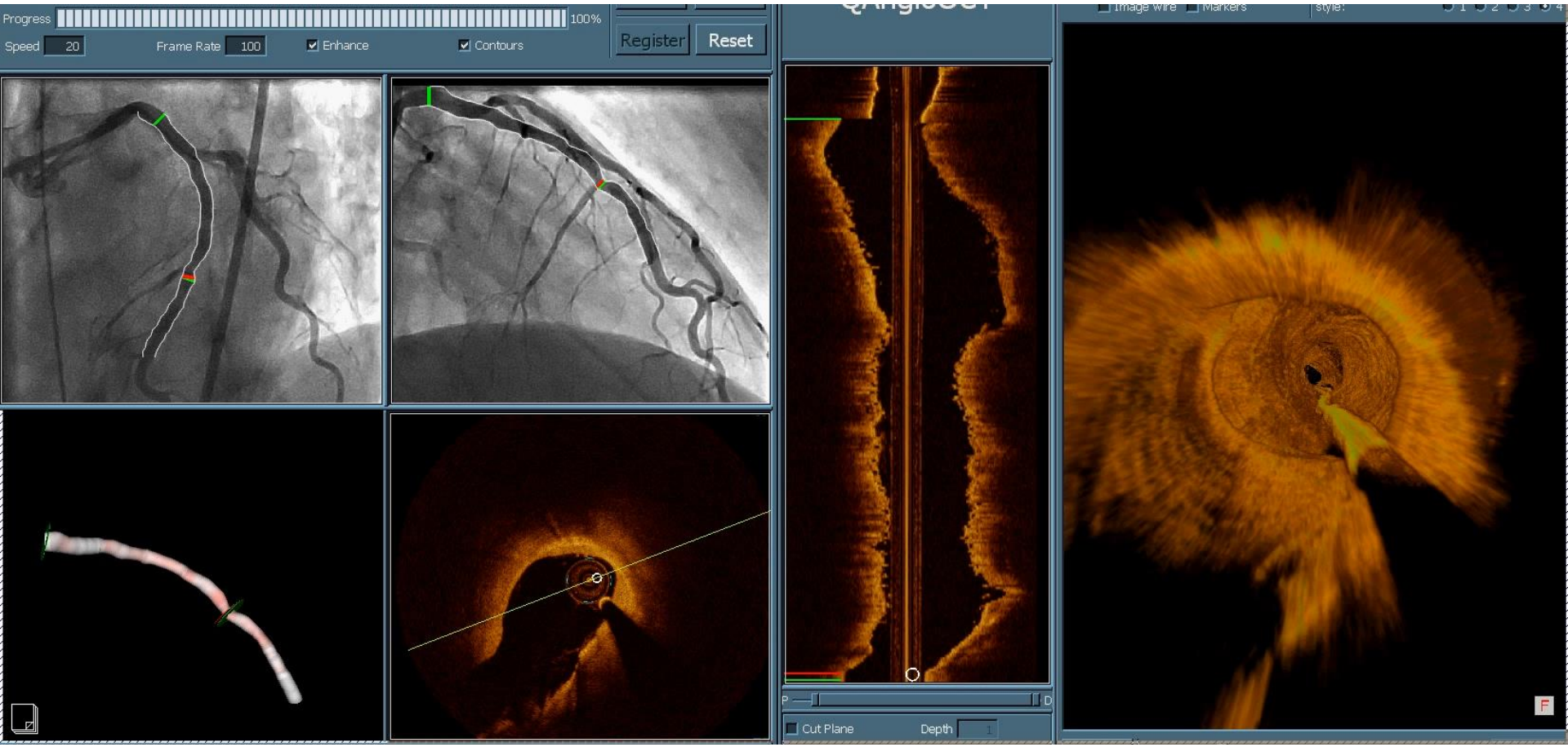
Intracoronary imaging & physiology in ESC guideline 2014

Recommendations	Class[a]	Level[b]	Ref.[c]
FFR to identify haemodynamically relevant coronary lesion(s) in stable patients when evidence of ischaemia is not available.	I	A	50,51,713
FFR-guided PCI in patients with multivessel disease.	IIa	B	54
IVUS in selected patients to optimize stent implantation.	IIa	B	702,703,706
IVUS to assess severity and optimize treatment of unprotected left main lesions.	IIa	B	705
IVUS or OCT to assess mechanisms of stent failure.	IIa	C	
OCT in selected patients to optimize stent implantation.	IIb	C	

Eur Heart J. 2014;35:2541-2619

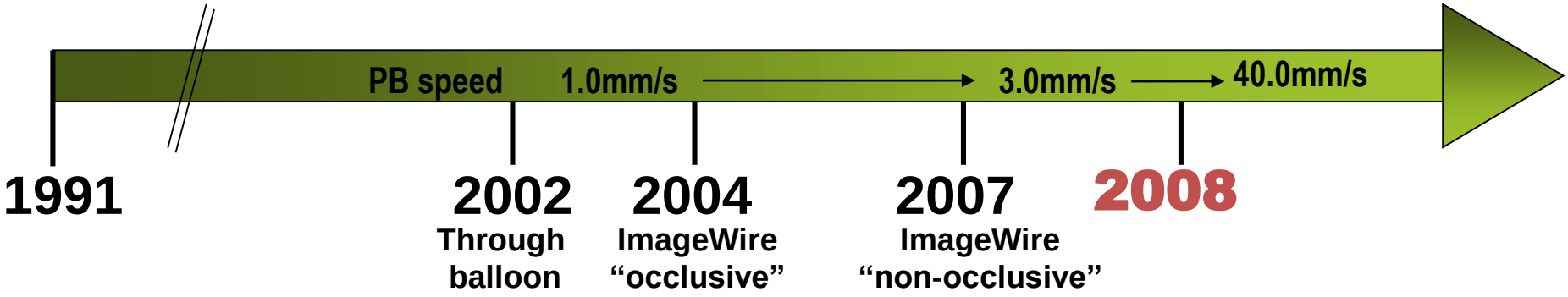
Optical Coherence Tomography (OCT) in coronary arteries

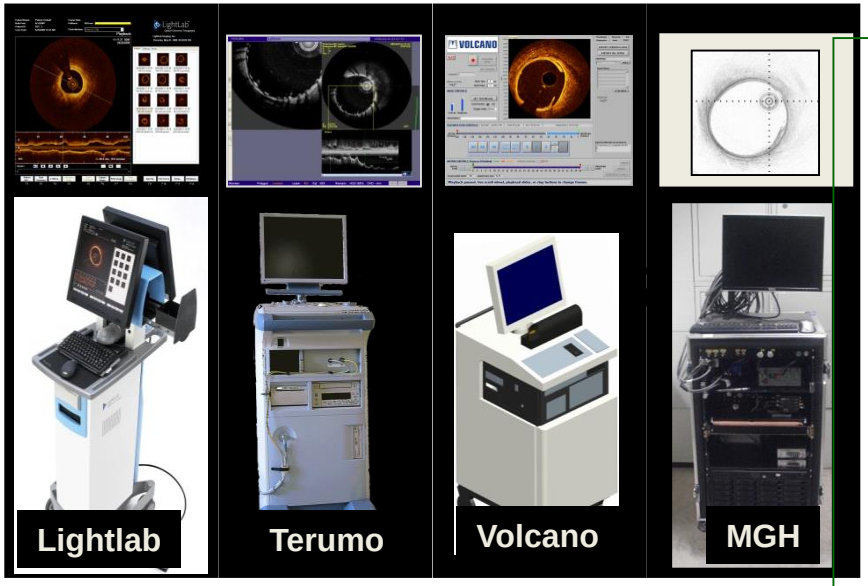
Today’s State of the Art - 2016



Coregistration: Tu, Regar et al. Int J Cardiovasc Imaging 2012

Evolution of intracoronary OCT imaging





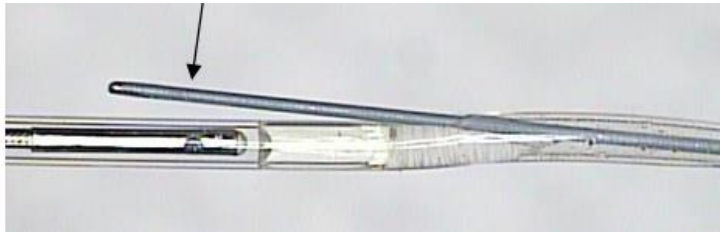
2nd Generation OCT

Fourier Domain OCT

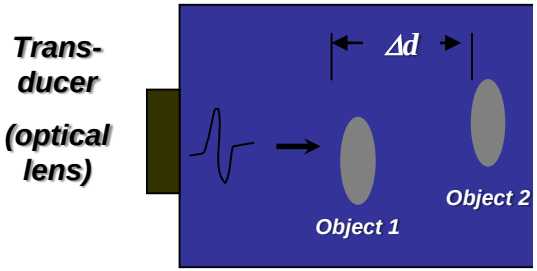
(OFDI/Frequency/Spectral Domain/Swept Source)

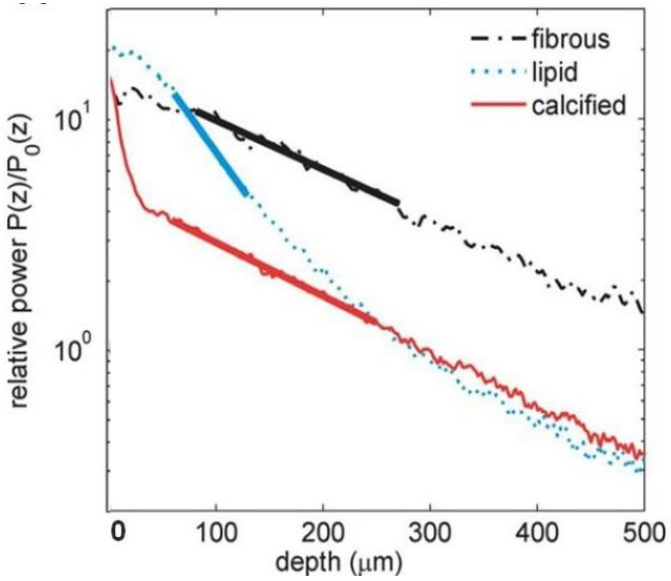
Monorail Imaging Catheter

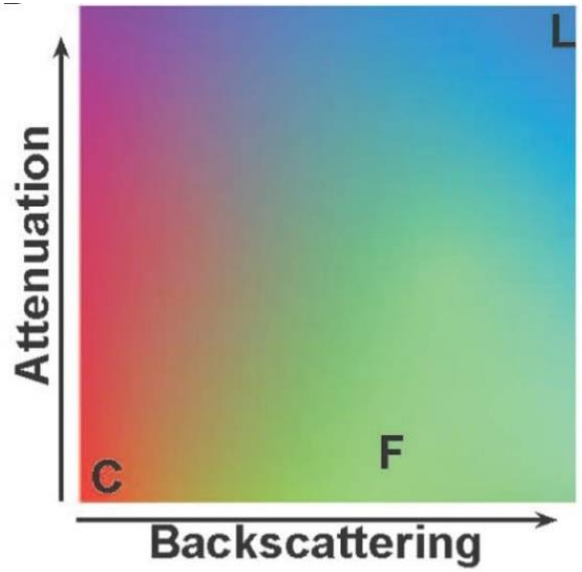
Non-Occlusive

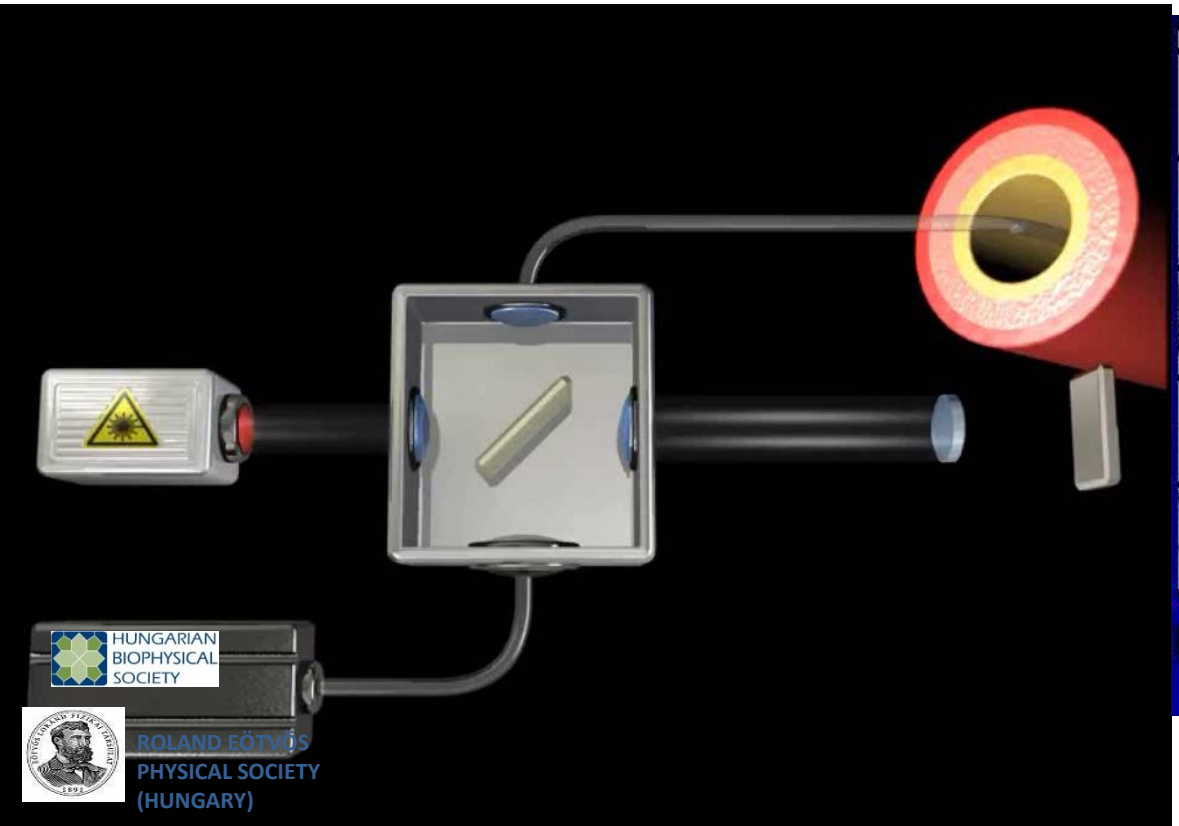


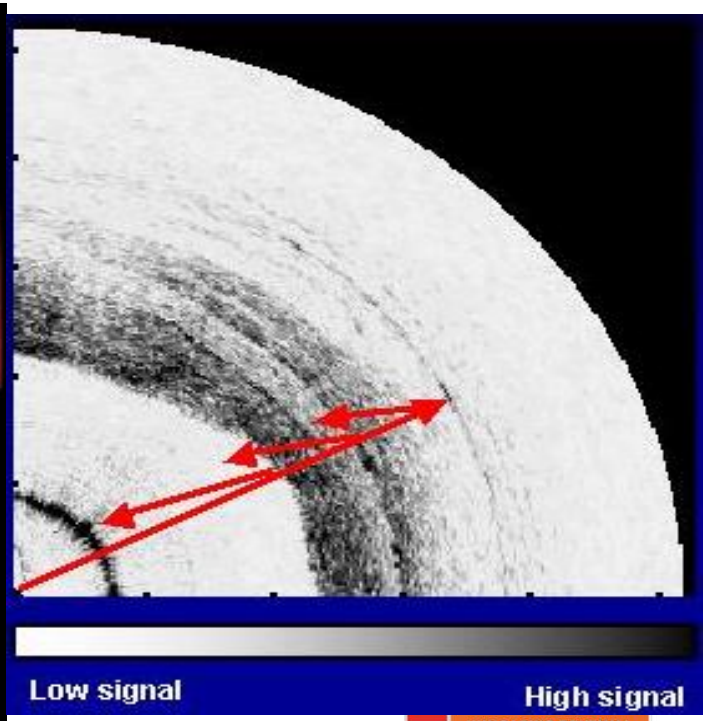
„Preparat
and R&D a











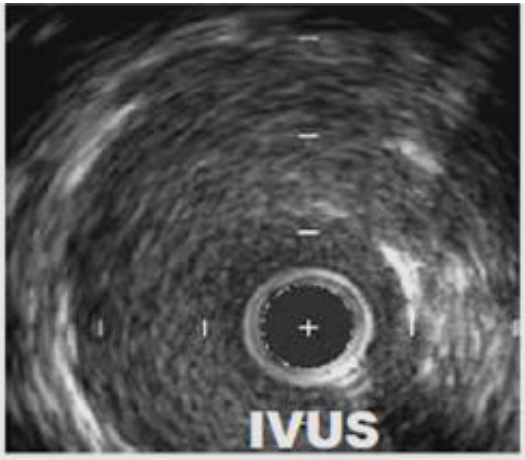
HUNGARIAN BIOPHYSICAL SOCIETY

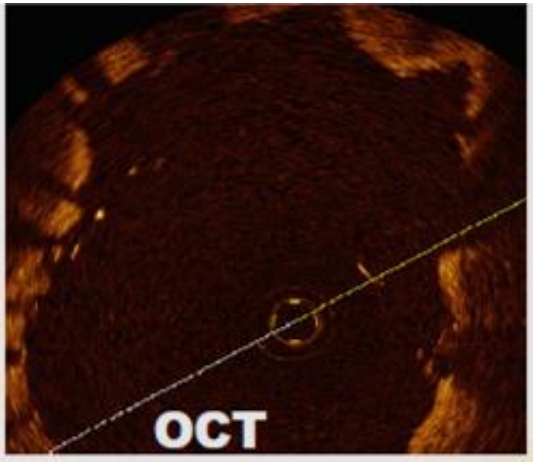
ROLAND EÖTVÖS PHYSICAL SOCIETY (HUNGARY)

HUNGARY'S RENEWAL

The project is supported by the European Union and co-financed by the European Social Fund.

EBC

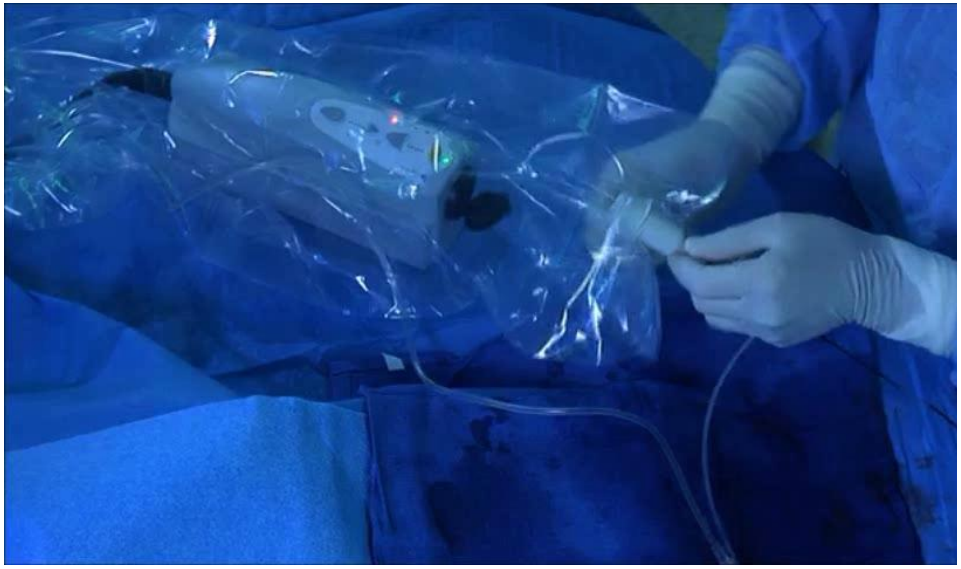


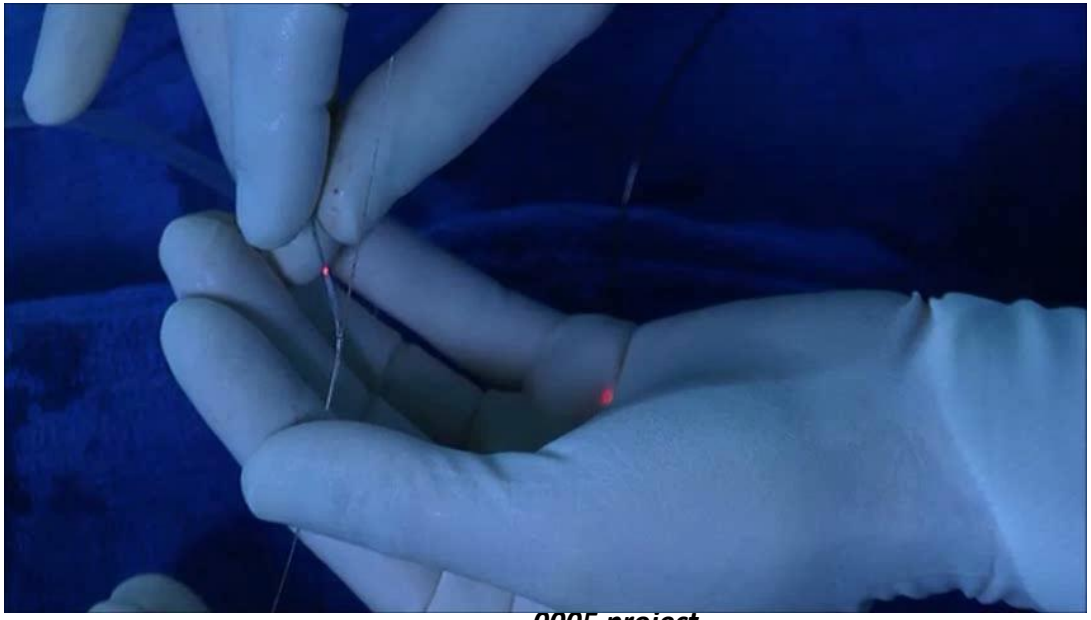


	IVUS	OCT
Dynamic range	40-60dB	90-110dB
Resolution (axial)	100-150μm	10-15μm
(lateral)	150-300μm	25-40μm
Penetration (tissue)	4-8mm	1.5mm
Frame rate	30/sec	100/sec
Pull-Back Speed	0.5-1.0mm/sec	20mm/sec
Wire artefacts	++	+

Tanigawa J, Barlis P, Di Mario C. EuroIntervention. 2007

„Preparation of the concerned sectors for educational and R&D activities related to the Hungarian ELI project ”





HUNGARIAN BIOPHYSICAL SOCIETY

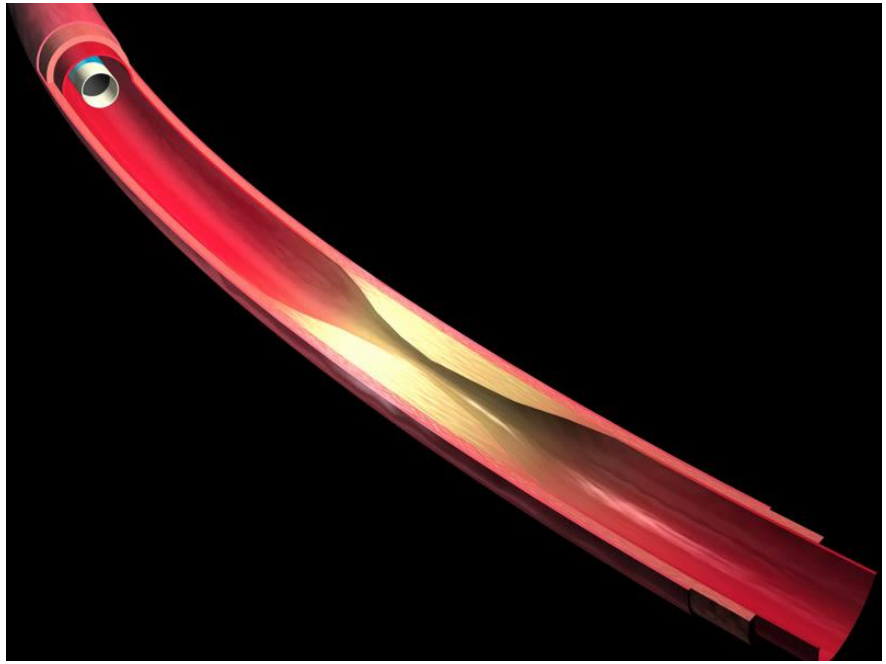
ROLAND EÖTVÖS PHYSICAL SOCIETY (HUNGARY)

0005 project

HUNGARY'S RENEWAL

The project is supported by the European Union and co-financed by the European Social Fund.

- **Fast, safe & easy imaging procedure**
- **2 OCT vendors**
- **Reliable diagnostic tool**
- **Important lesson‘s learned**



6F guide catheter

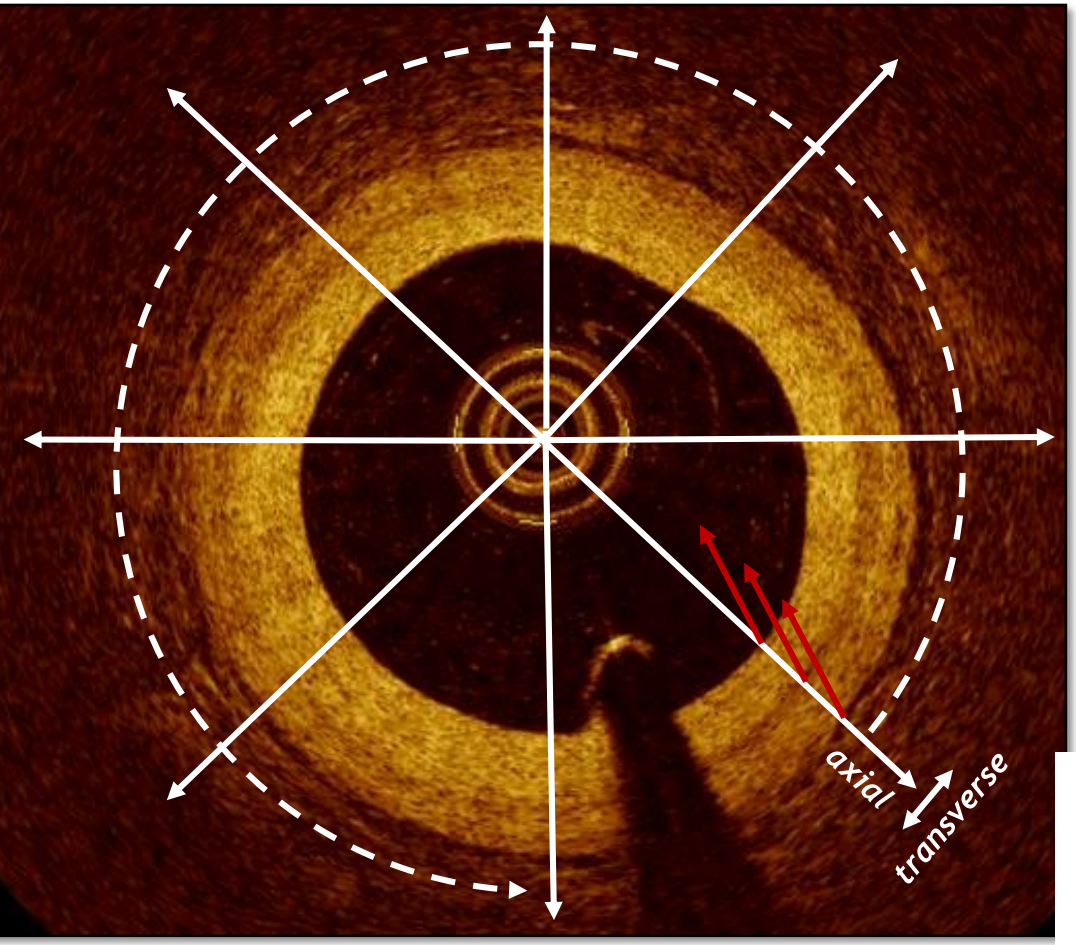
Guidewire of choice!

Sleek OCT catheter!

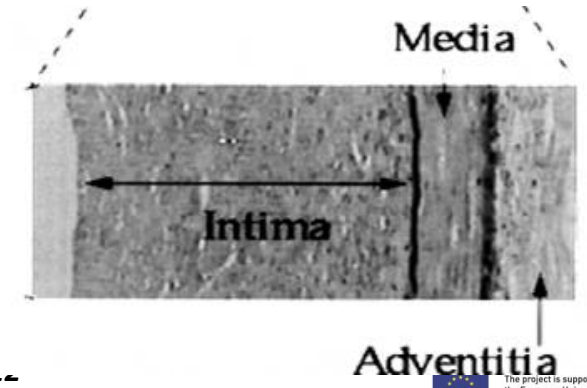
Imaging within 3 seconds

Limited contrast ~ 15ml

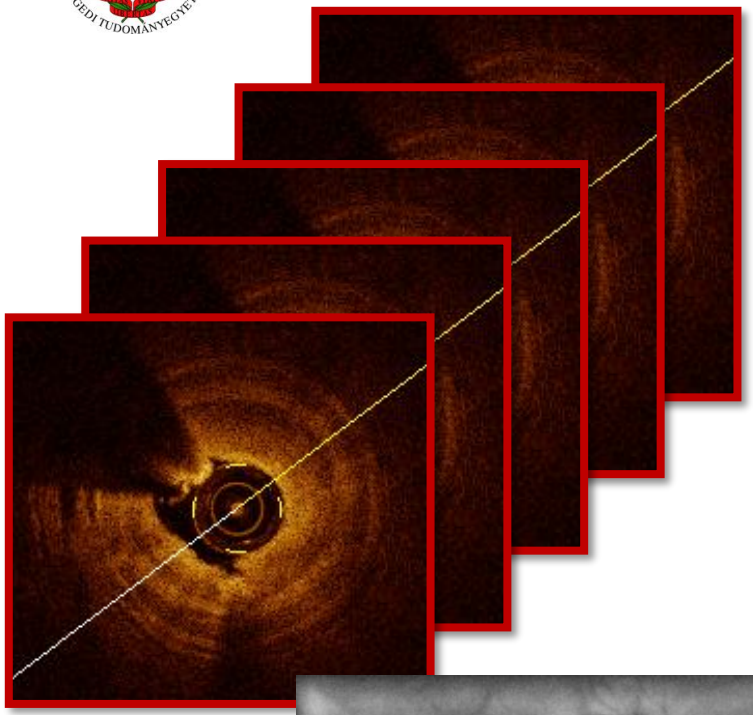
Image Generation

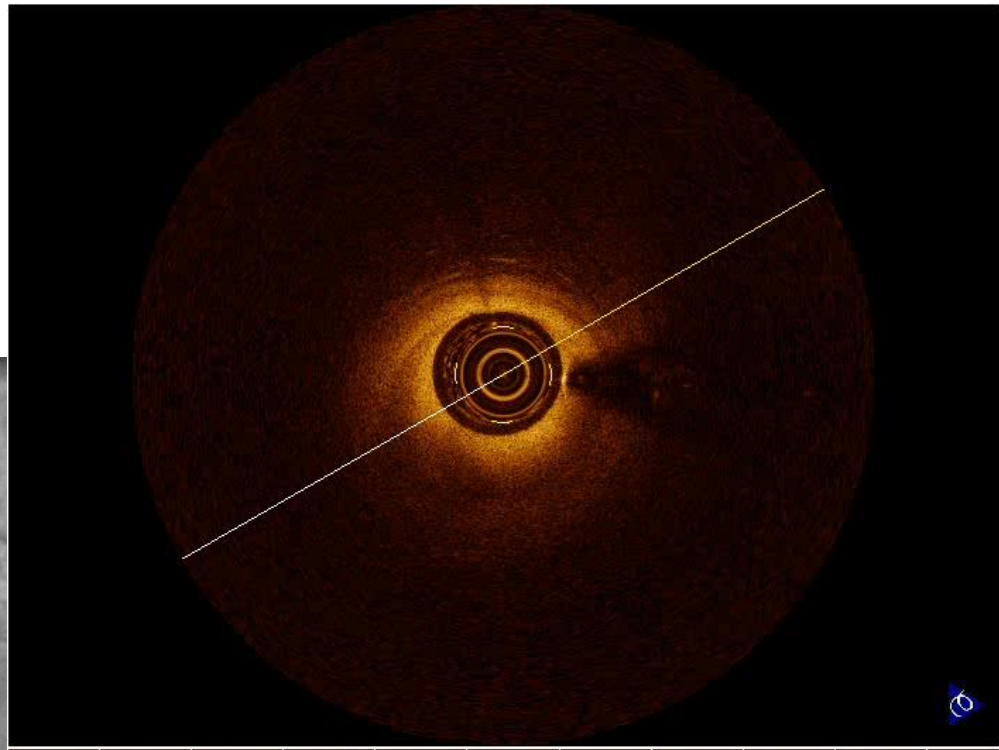


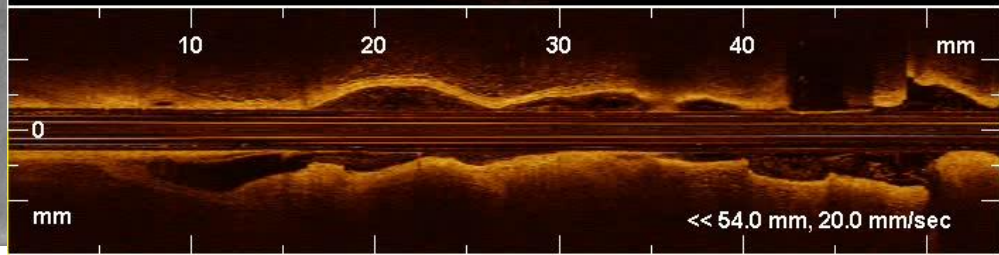
- Measure echo time delay of reflected light waves
- One pixel → 5 x 19 um
- One axial line → 1024 pixels
- One frame → 500 axial lines
- *Optical resolution → 15 axial, 20 to 40 um transverse*



Pullback – image generation



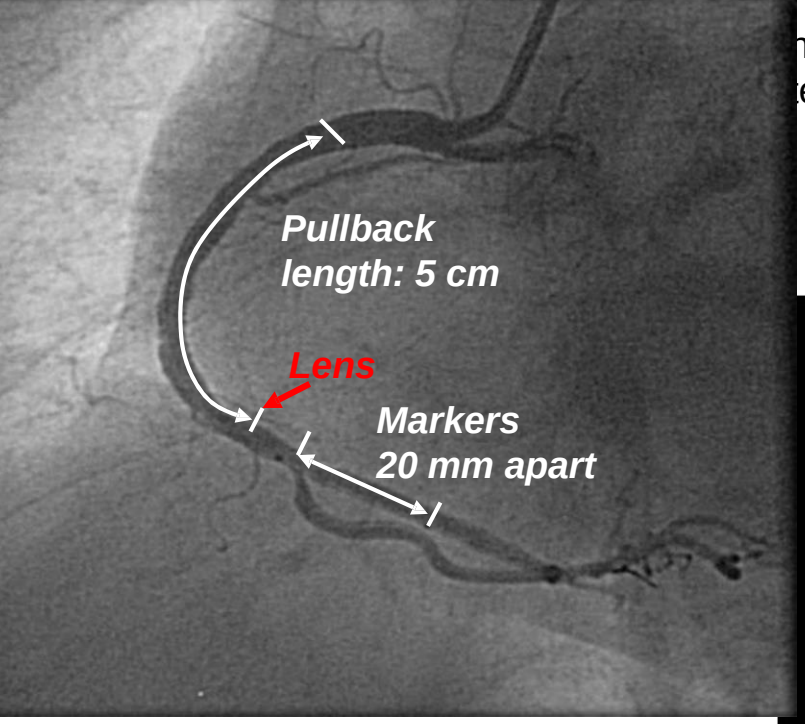


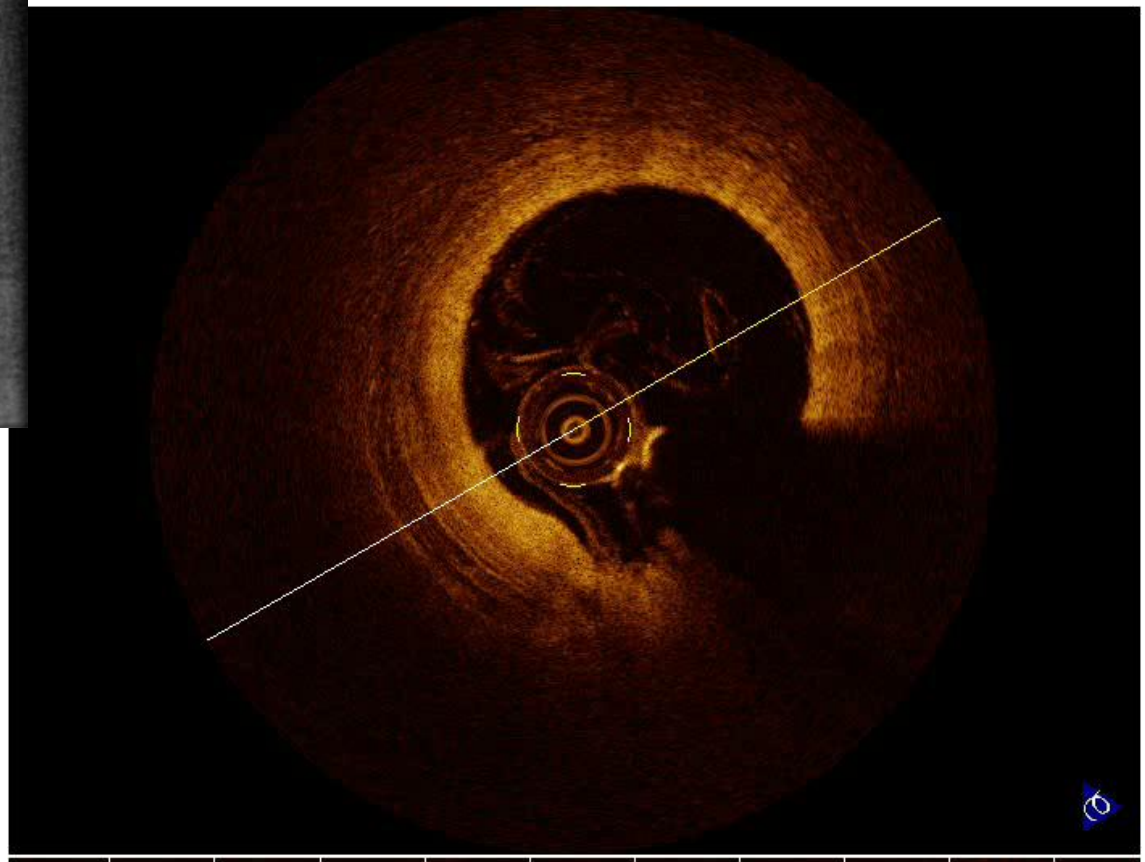


ncerned sectors for educational
ed to the Hungarian ELI project ”

NEW SZÉCHENYI PLAN

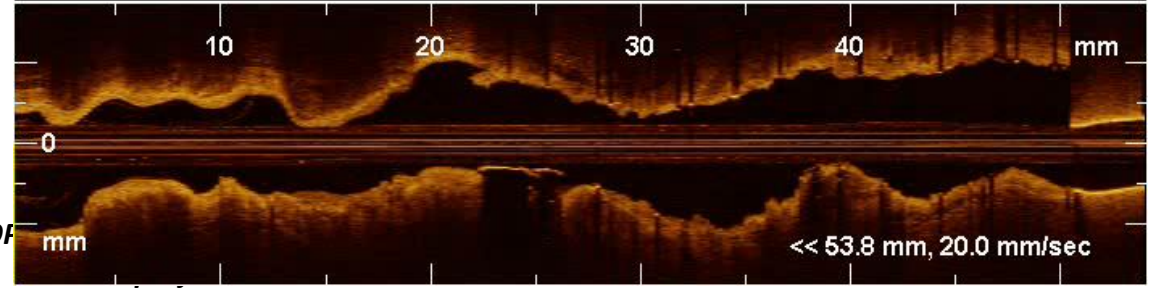
Pullback vs. Image Display





“B-Mode”
cross-sectional view →

“L-Mode”
longitudinal view →

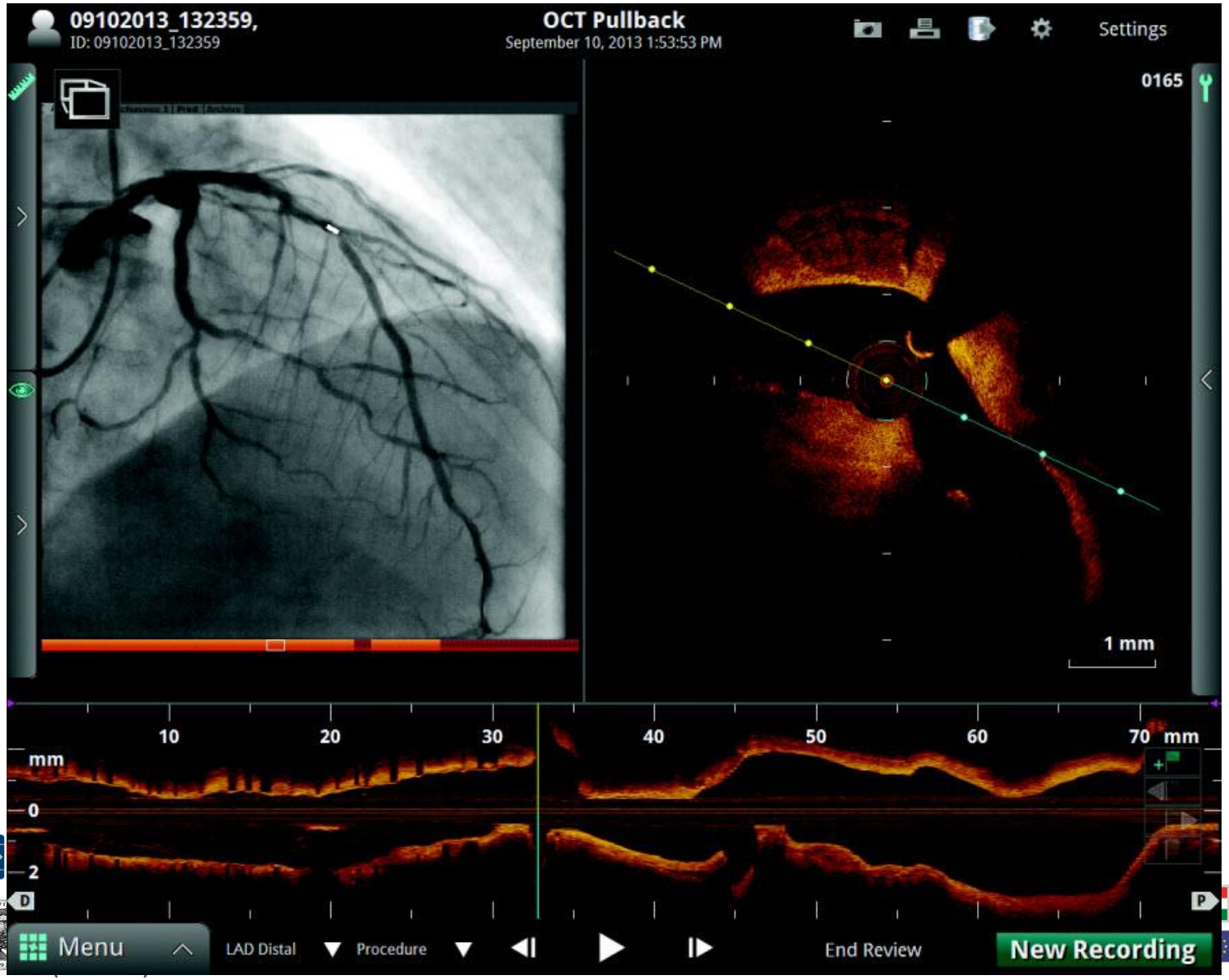


HUNGARIAN BIOPHYSICAL SOCIETY

ROLAND EÖTVÖS PHYSICAL SOCIETY (HUNGARY)

TÁMOP

Pullback vs. Image Display



“B-Mode”

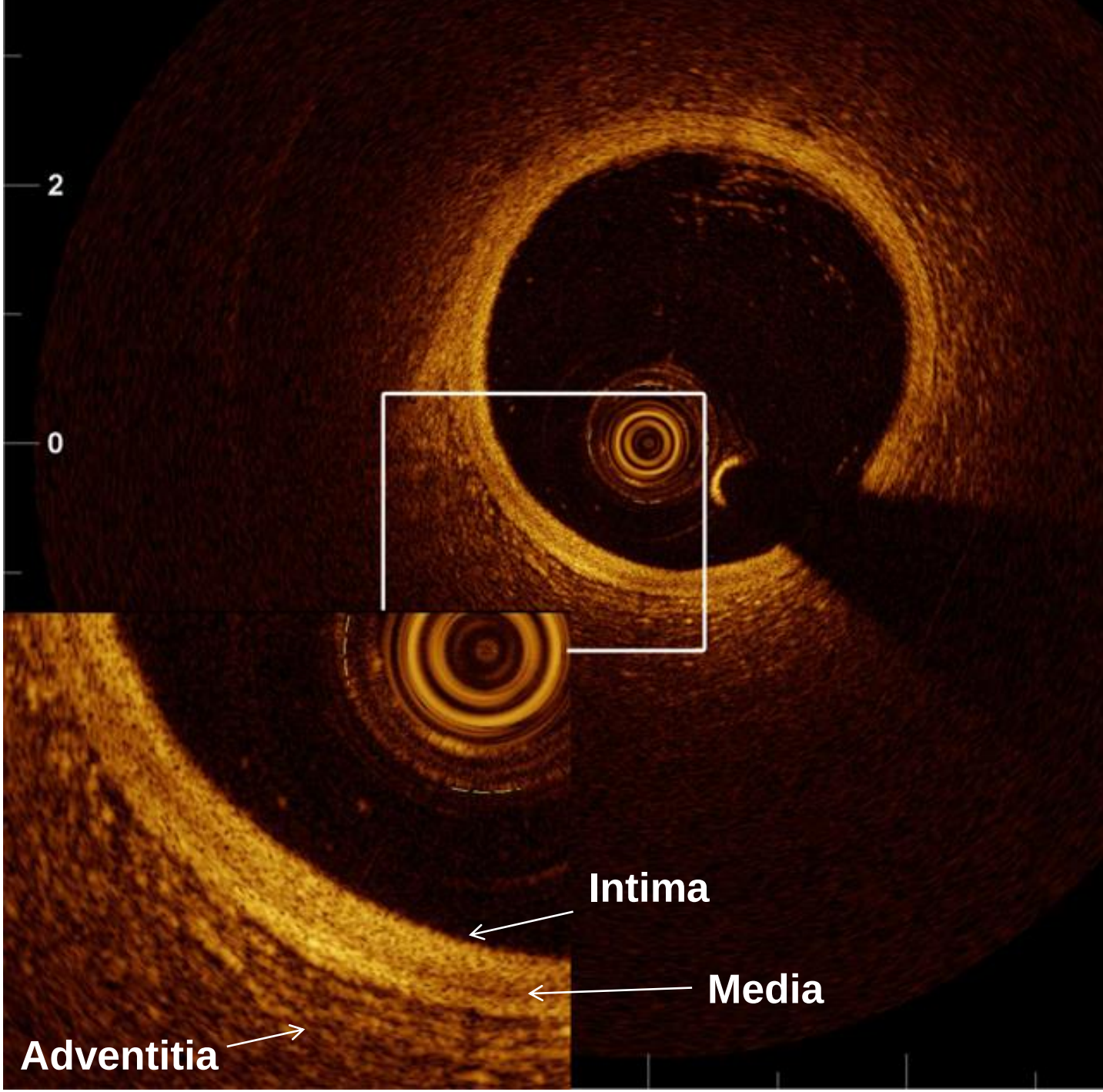
cross-sectional view

“L-Mode”

longitudinal view

HUNGARY'S RENEWAL
The project is supported by the European Union and co-financed by the European Social Fund.

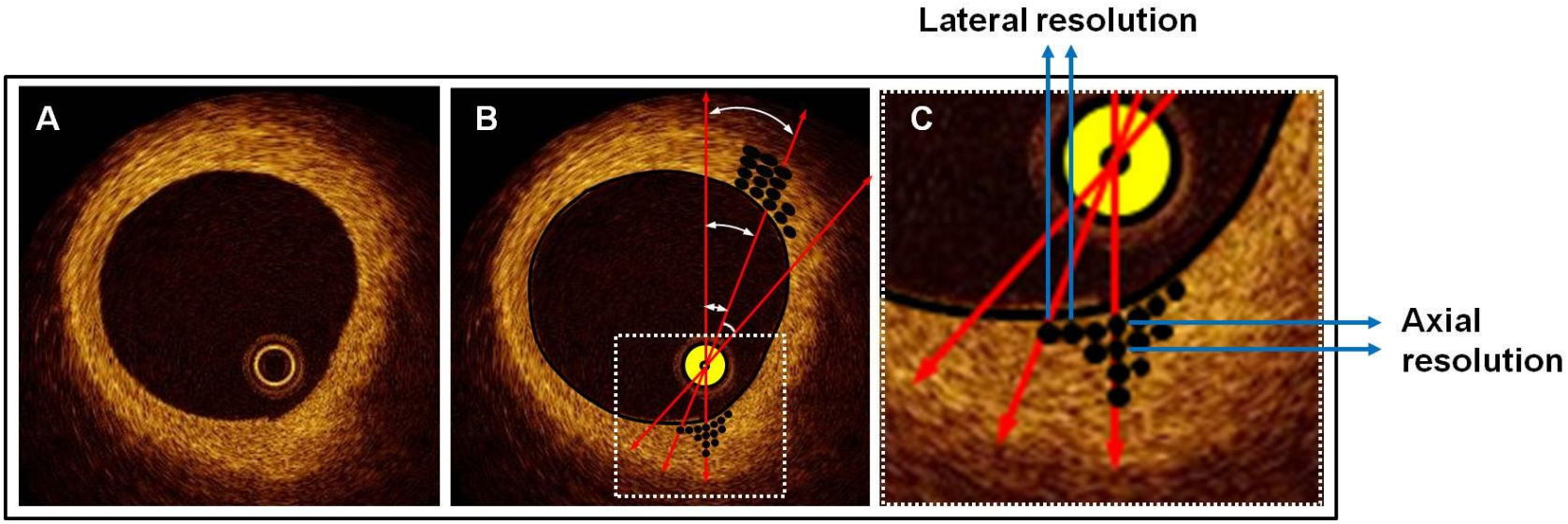
OCT cross-sectional image of a „normal” coronary artery



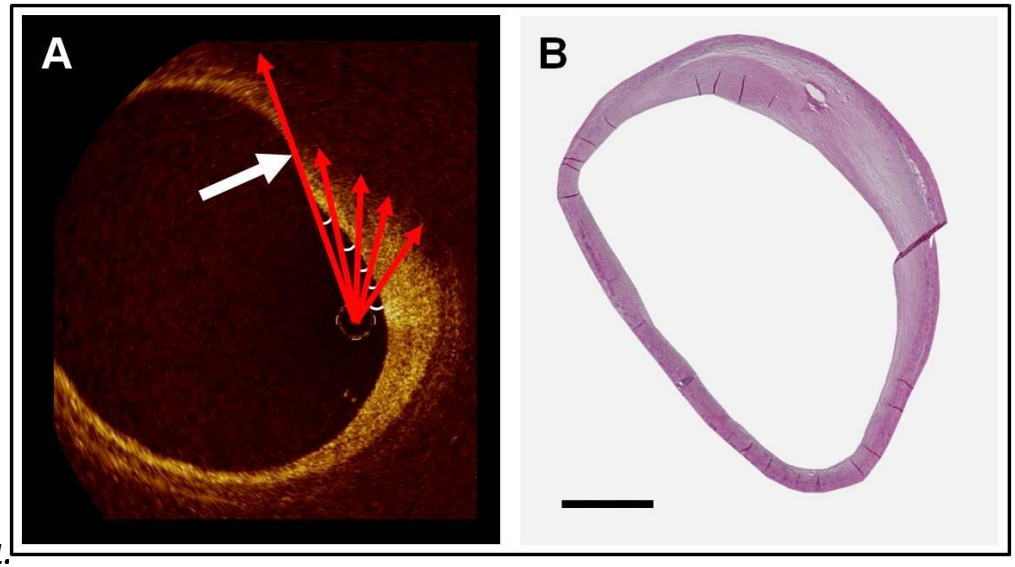
HUNGARIAN BIOPHYSICAL SOCIETY

ROLAND EÖTVÖS PHYSICAL SOCIETY (HUNGARY)

Image: pitfalls and potential artefacts



Tangential signal drop-out



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Optical Coherence Tomography (OCT)

Today – 2016: Reliable Diagnostic Tool !

European Heart Journal
doi:10.1093/eurheartj/ehp433

REVIEW

Expert review document on methodology, terminology, and clinical applications of optical coherence tomography: physical principles, methodology of image acquisition, and clinical application for assessment of coronary arteries and atherosclerosis

Francesco Prati[1*], Evelyn Regar[2], Gary S. Mintz[3], Eloisa Arbustini[4], Carlo Di Mario[5], Ik-Kyung Jang[6], Takashi Akasaka[7], Marco Costa[8], Giulio Guagliumi[9], Eberhard [illegible], Expert's O[illegible]

European Heart Journal
doi:10.1093/eurheartj/ehs095

CURRENT OPINION

Expert review document part 2: methodology, terminology and clinical applications of optical coherence tomography for the assessment of interventional procedures

Francesco Prati[1,2*], Giulio Guagliumi[3], Gary S. Mintz[4], Marco Costa[5], Evelyn Regar[6,7], Takashi Akasaka[8], Peter Barlis[9], Guillermo J. Tearney[10,11], Ik-Kyung Jang[12], Elosia Arbustini[13], Hiram G. Bezerra[5], Yukio Ozaki[14], Nico Bruining[6,7], Darius Dudek[15], Maria Radu[6,7], Andrejs Erglis[16], Pascale Motreff[17], Fernando Alfonso[18], Kostas Toutouzas[19], Nieves Gonzalo[20], Corrado Tamburino[21], Tom Adriaenssens[22], Fausto Pinto[23], Patrick W.J. Serruys[6,7], and Carlo Di Mario[24,25], for the Expert's OCT Review Document

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MINI-FOCUS ISSUE: OPTICAL COHERENCE TOMOGRAPHY — Clinical Research

Consensus Standards for Acquisition, Measurement, and Reporting of Intravascular Optical Coherence Tomography Studies

A Report From the International Working Group for Intravascular Optical Coherence Tomography Standardization and Validation

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Lukasz Koltowski, MD, Takashi Kubo, MD, PhD, Teruyoshi Kume, MD, Hiroyuki Kyono, MD,
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Akiko Maehara, MD, Olivia Manfrini, MD, Gary S. Mintz, MD, Kyiouchi Mizuno, MD,
Marie-angéle Morel, MD, Seemantini Nadkarni, PhD, Hiroyuki Okura, MD, Hiromasa Otake, MD,
Arkadiusz Pietrasik, MD, Francesco Prati, MD, Lorenz Räber, MD, Maria D. Radu, MD,
Johannes Rieber, MD, Maria Riga, MD, Andrew Rollins, PhD, Mireille Rosenberg, PhD, Vasile Sirbu, MD
Patrick W. J. C. Serruys, MD, PhD, Kenei Shimada, MD, Toshiro Shinke, MD, Junya Shite, MD,
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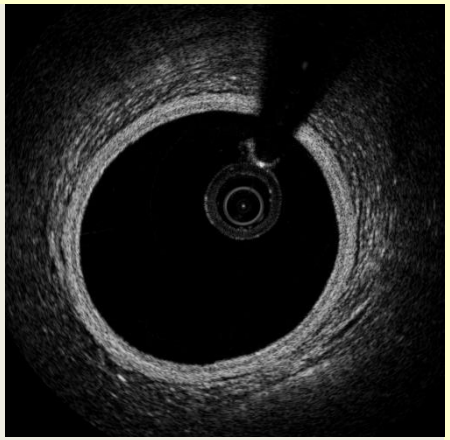
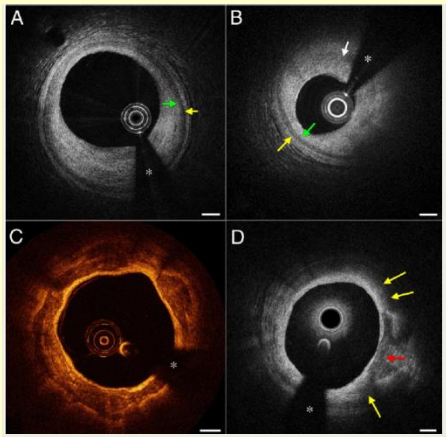
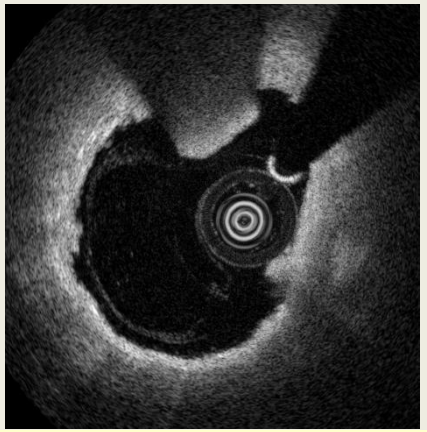
Gerrit-Ann van Es, PhD, Gijs van Soest, PhD, Renu Virmani, MD, Sergio Waxman, MD,
Neil J. Weissman, MD, Giora Weisz, MD
Boston, Massachusetts; Rotterdam, the Netherlands; and Wakayama, Japan

Optical Coherence Tomography (OCT)

Today – 2016: Reliable Diagnostic Tool !

High Evidence Level

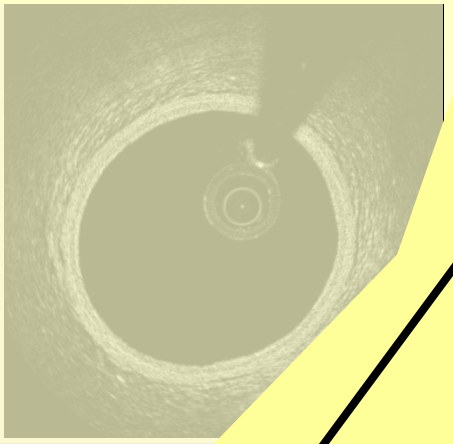
Normal vessel wall	*Atherosclerosis*	*Thrombus*
		

Optical Coherence Tomography (OCT)

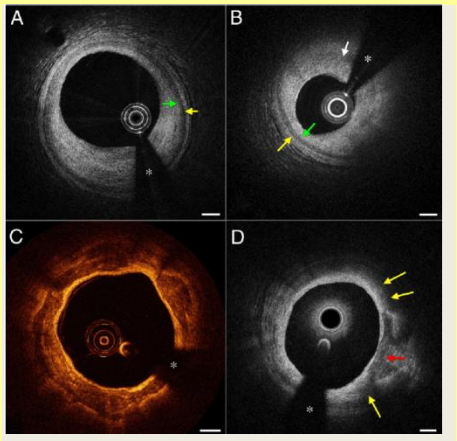
Today – 2016: Reliable Diagnostic Tool !

High Evidence Level

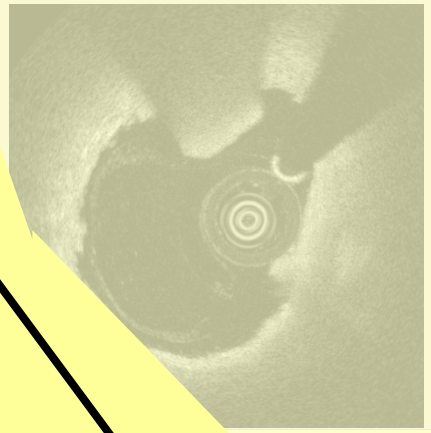
Normal vessel wall



Atherosclerosis



Thrombus

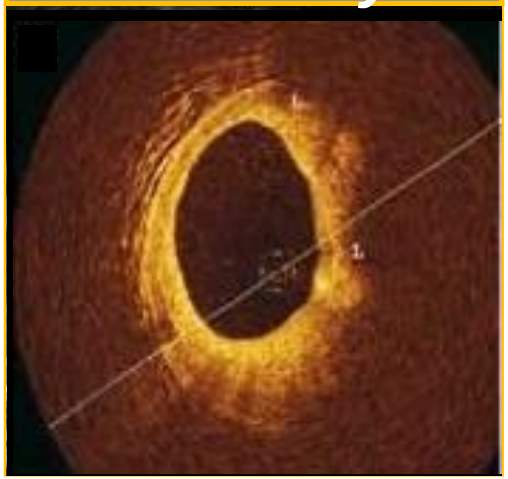


Fibrous Fibrocalcific Lipid pool Fibrous cap Rupture

2. Assess Plaque Composition

Fibrous

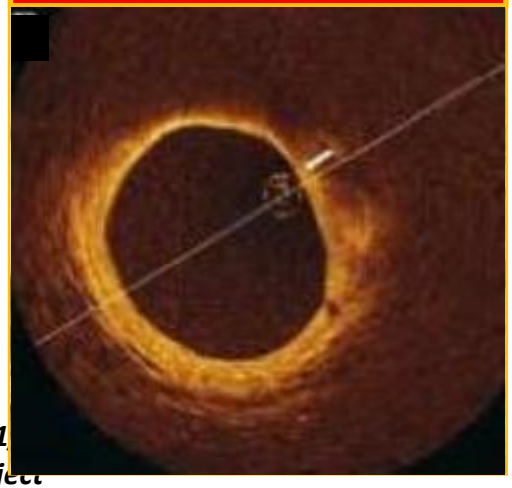
Fibro-Fatty



Calcific

Rotablator

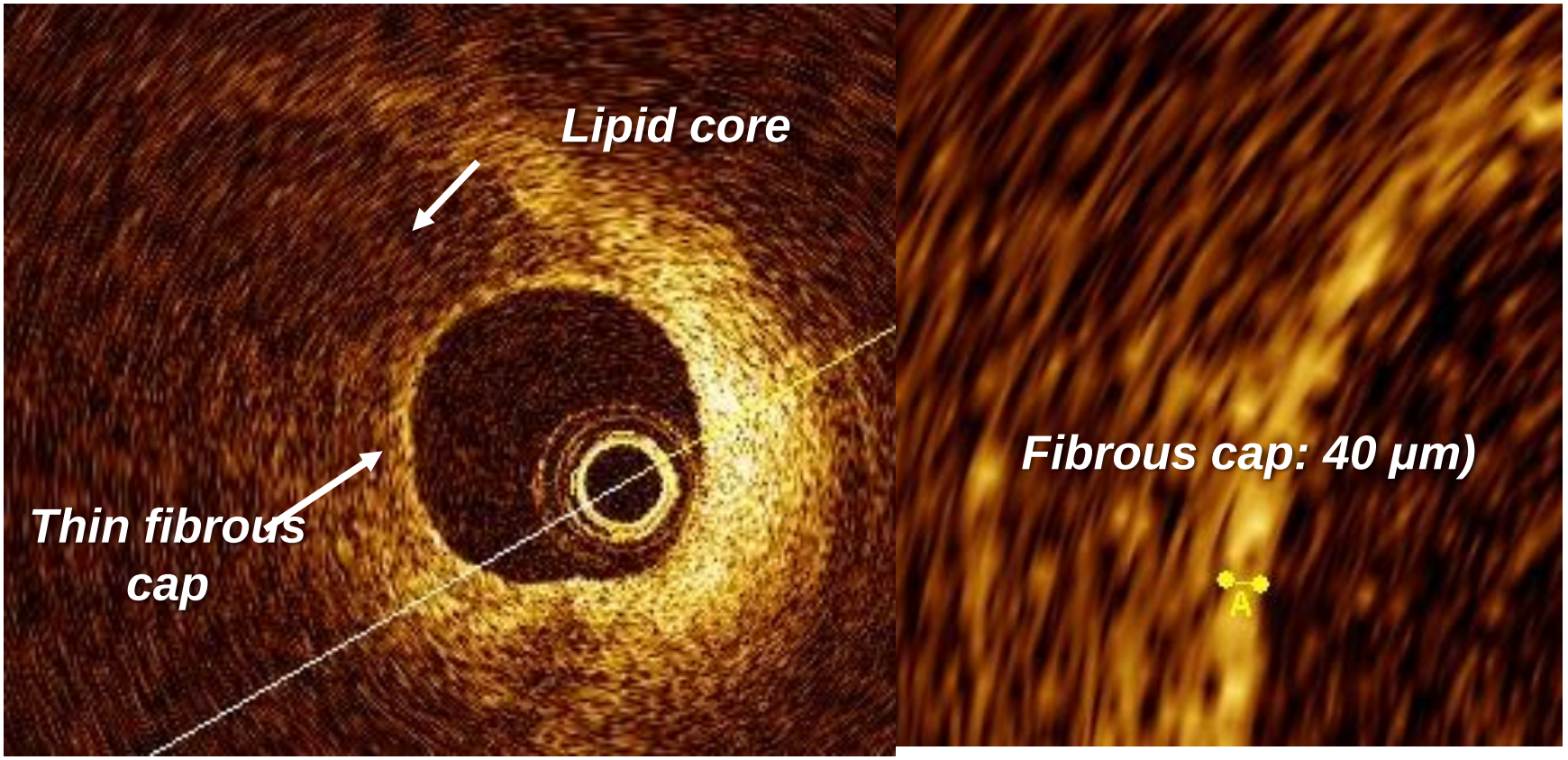
Necrotic Core



- ***Cutting Balloon***
- ***High Pressure***

Optical Coherence Tomography (OCT)

Potential tool for detection of TCFA – pathological substrate for future myocardial infarction !



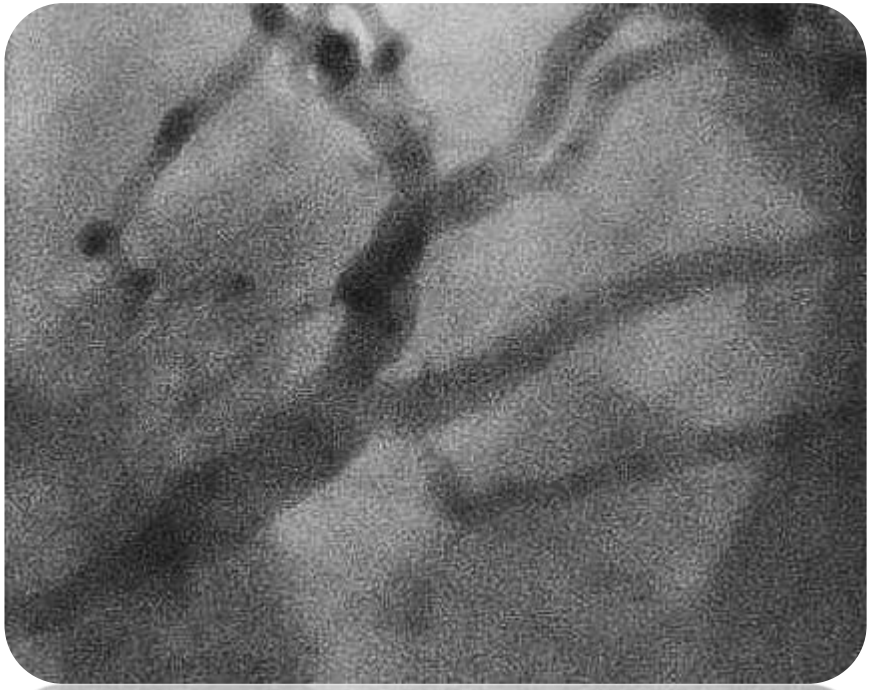
TCFA: lipid-rich atheroma with thin (< 65 μm) fibrous cap

Optical Coherence Tomography (OCT)

Today – 2016: Reliable Diagnostic Tool !

OCT is superior to angiography in LM

Is there a left main lesion?



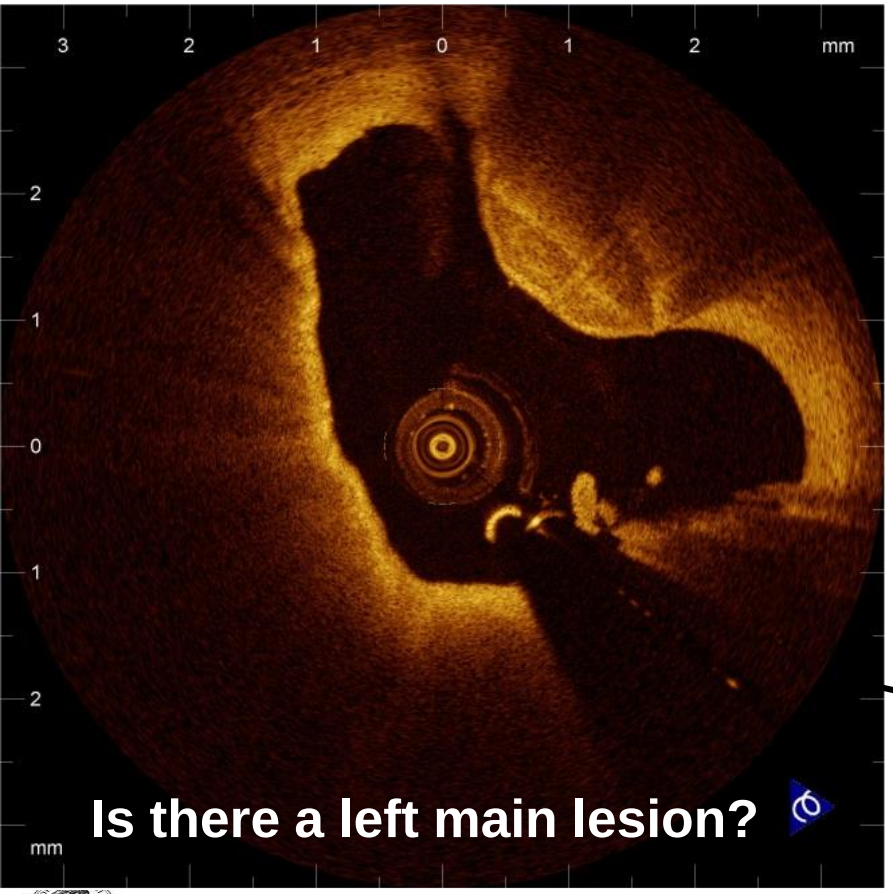
OCT: Lightlab/St.Jude

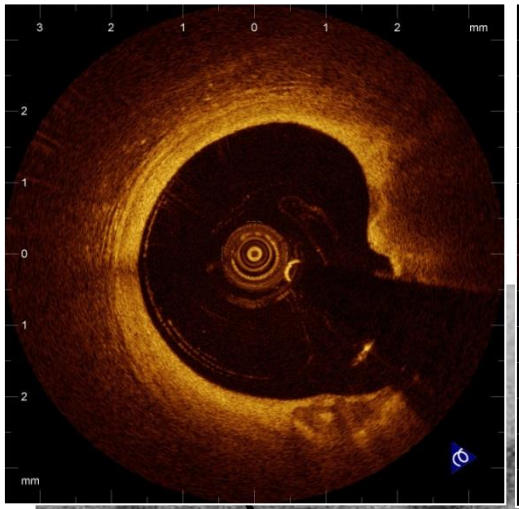
TÁMOP-4.1.1.C-12/1/KONV-2012-0005 project

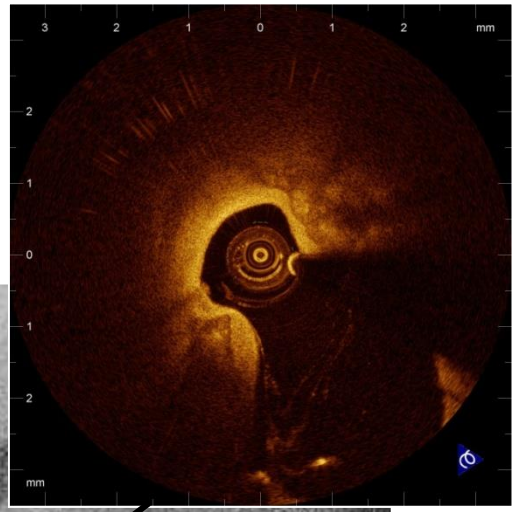
Optical Coherence Tomography (OCT)

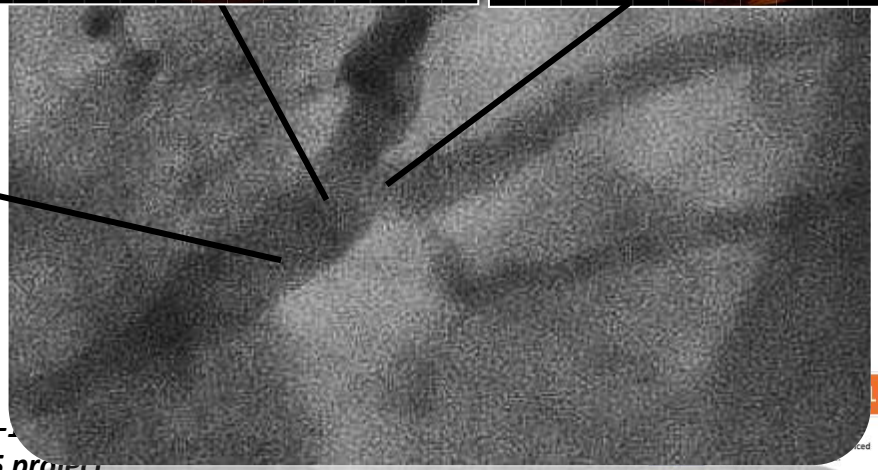
Today – 2016: Reliable Diagnostic Tool !

OCT is superior to angiography in LM









Optical Coherence Tomography (OCT)

Today – 2016: Reliable Diagnostic Tool !

OCT is superior to angiography

Left Main stem lesions
Complex lesions

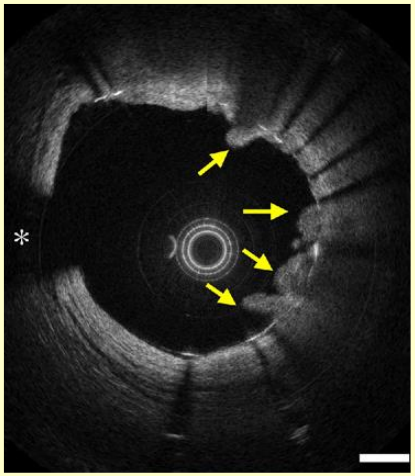
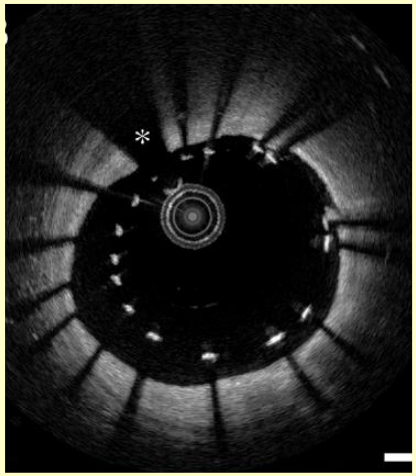
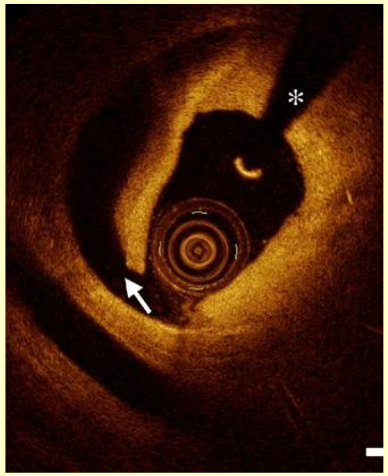
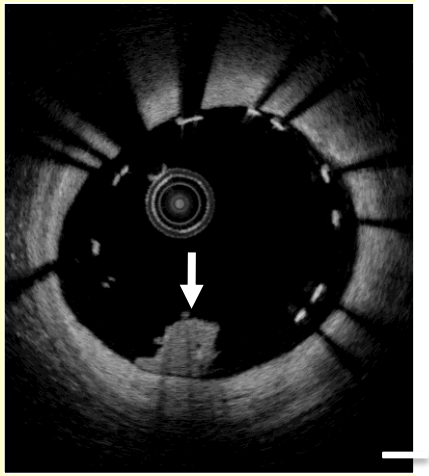
OCT is prognostic in stenting

Periprocedual complications
Clinical outcome **?**

Optical Coherence Tomography (OCT)

Today – 2016: Guidance in PCI (after stenting)

High Evidence Level

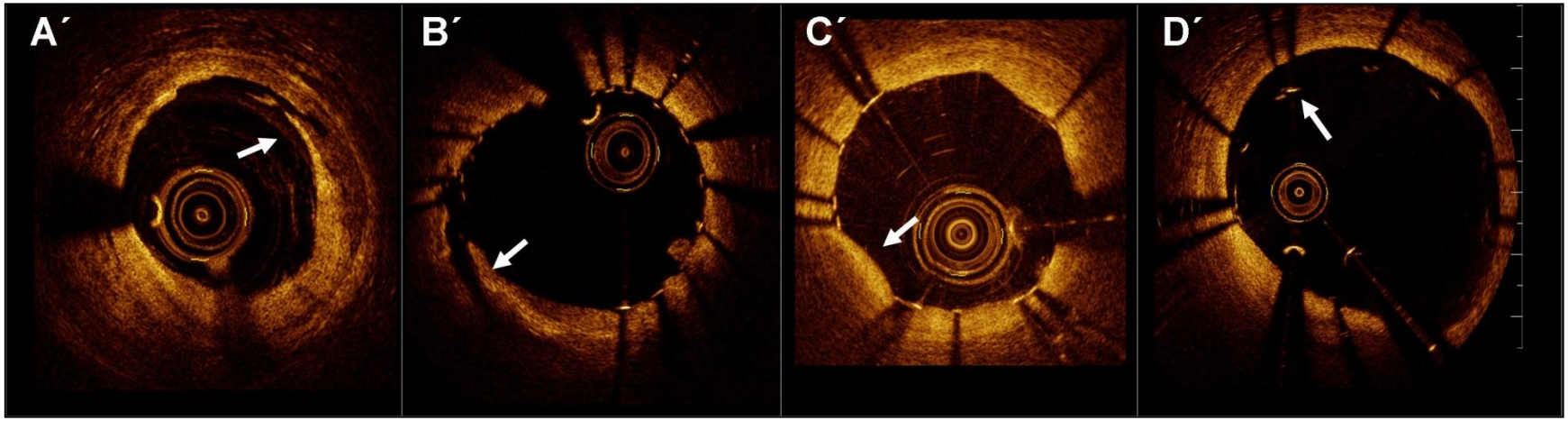
Prolapse	*Apposition Malapposition*	*Dissection*	*Thrombus*
			

J Am Coll Cardiol. 2012

Optical Coherence Tomography (OCT)

Today – 2016: Guidance in PCI (after stenting)

Suboptimal acute stent result is frequent and missed by angiography



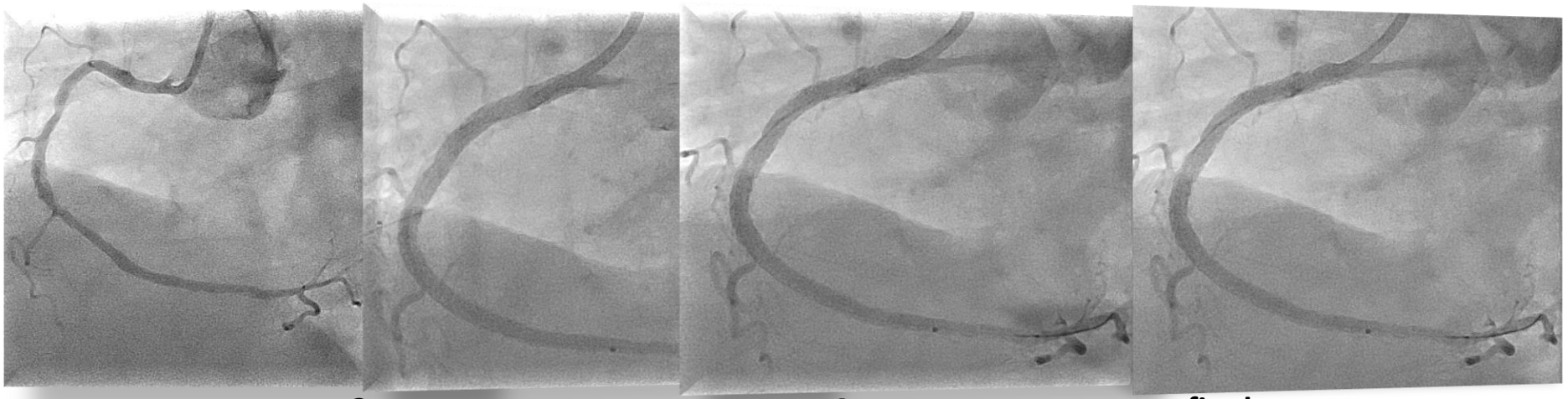
Edge dissection	Intra-stent dissection	Tissue prolapse	Strut malapposition
26.0%	87.5%	97.5%	65.5%

Gonzalo N et al., Heart 2009

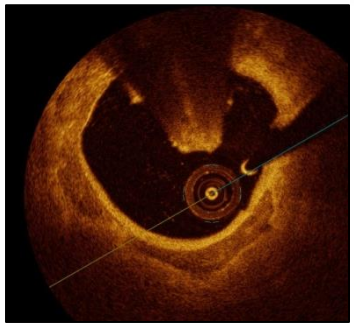
OCT: Lightlab/StJUDE

Today – 2016: Guidance in PCI (after stenting)

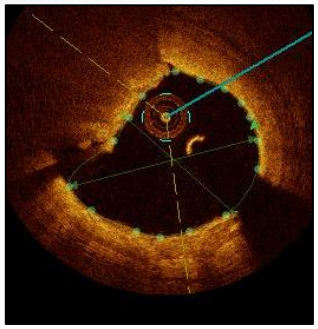
Suboptimal acute stent result is frequent and missed by angiography



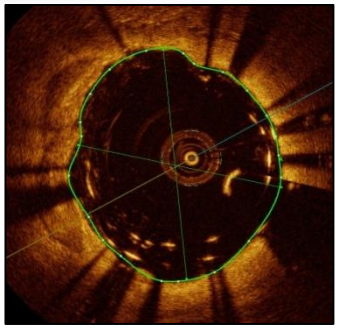
pre | 3 stents | 4 stents | final



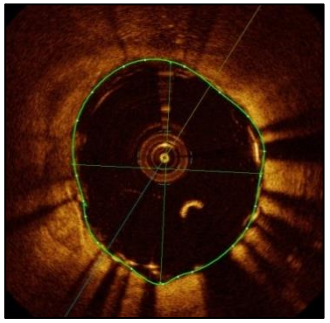
thrombus



gap



malapposition



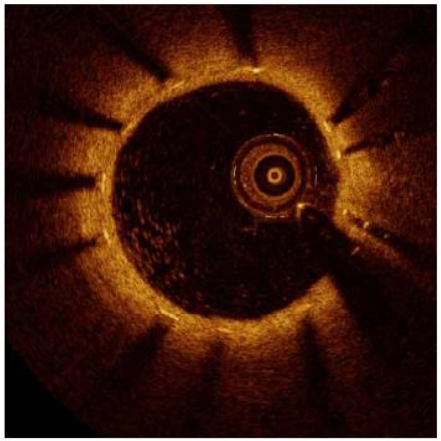
optimal

OCT: Lightlab/StJUDE

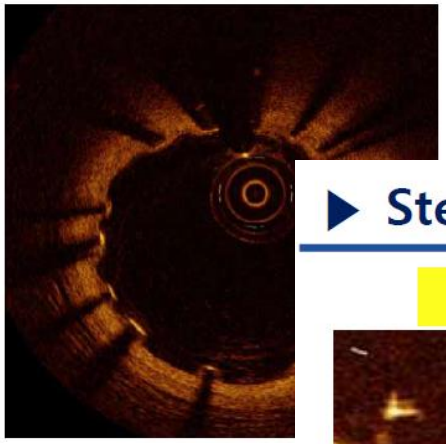
TÁMOP-4.1.1.C-12/1/KONV-2012-0005 project

Today – 2016: Guidance in PCI (long after stenting)

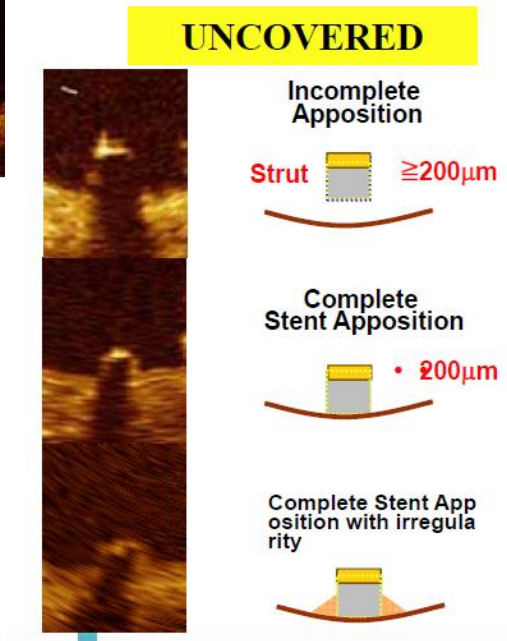
Coverd stent

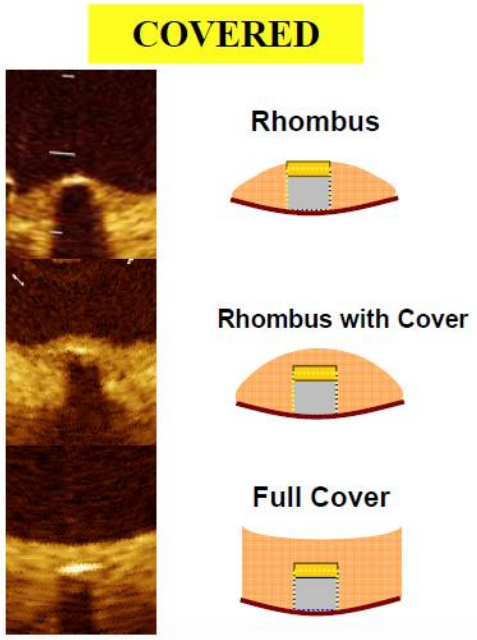


Uncoverd stent



Stent Strut Coverage Patterns



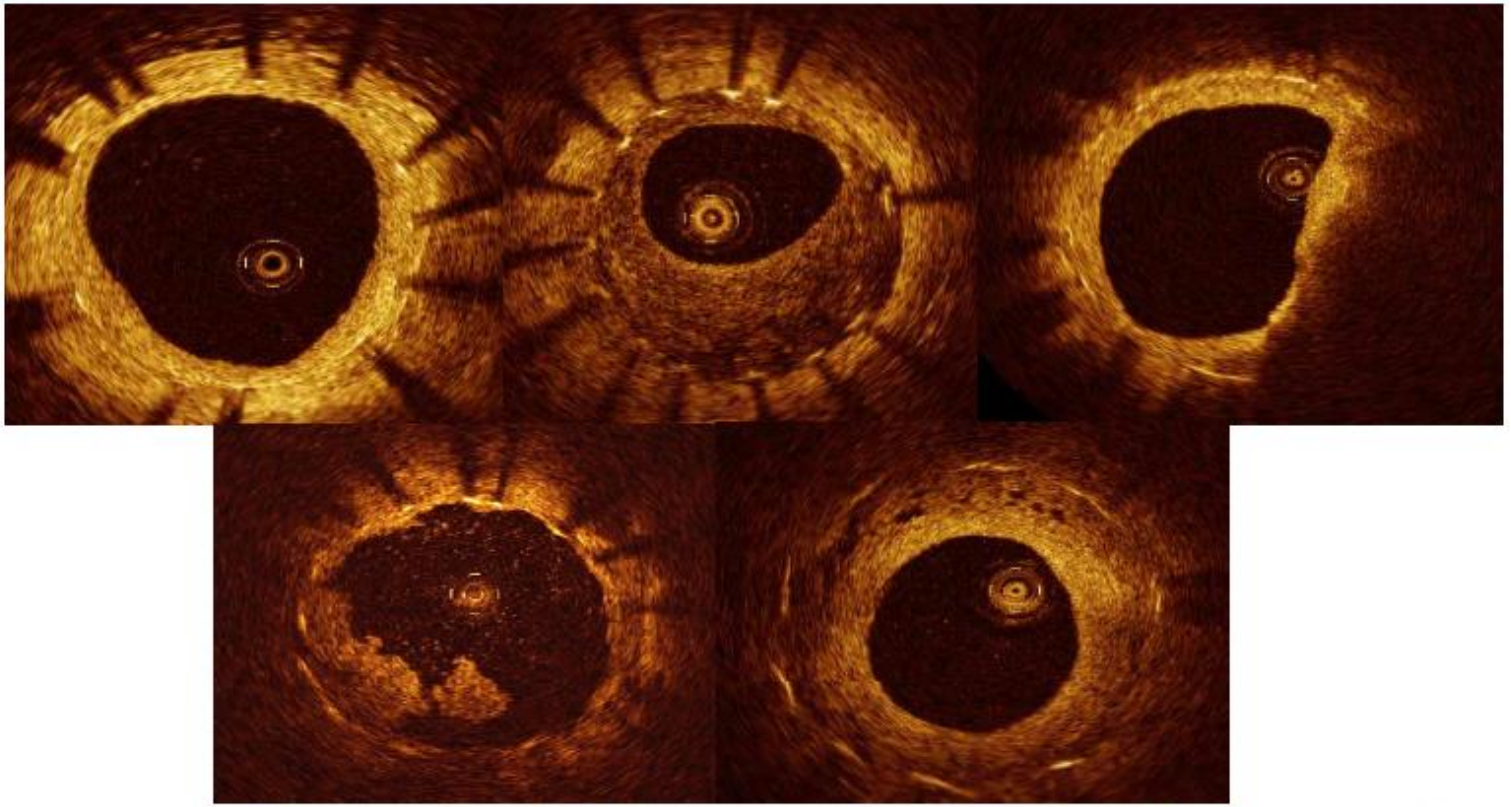


중앙대학교병원 CHUNG-ANG UNIVERSITY HOSPITAL

Dr. Suzuki, Toyohashi Heart Center

Today – 2016: Guidance in PCI (long after stenting)

Qualitative neointimal Evaluation



(A) Homogeneous , (B) heterogeneous , (C) TCFA-like neointima (arrows) and lipid laden neointima (a rrowheads), (D) intracoronary thrombi (arrow), (E) neovascularization (arrows).

Optical Coherence Tomography (OCT)

Today – 2016: Lesson's Learned

OCT is superior to angiography

Left Main stem lesions
Complex lesions

OCT is prognostic in stenting

Periprocedual complications
Clinical outcome

?

OCT changed the paradigm of DES failure

Neoatherosclerosis

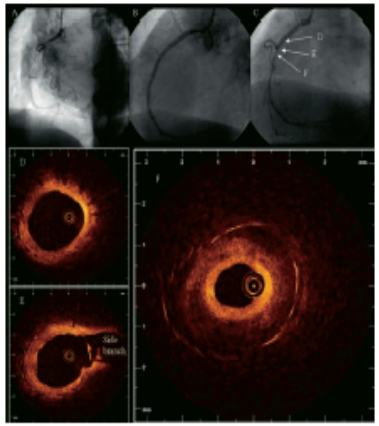
EuroIntervention

Paclitaxel-eluting stent restenosis shows three-layer appearance by optical coherence tomography

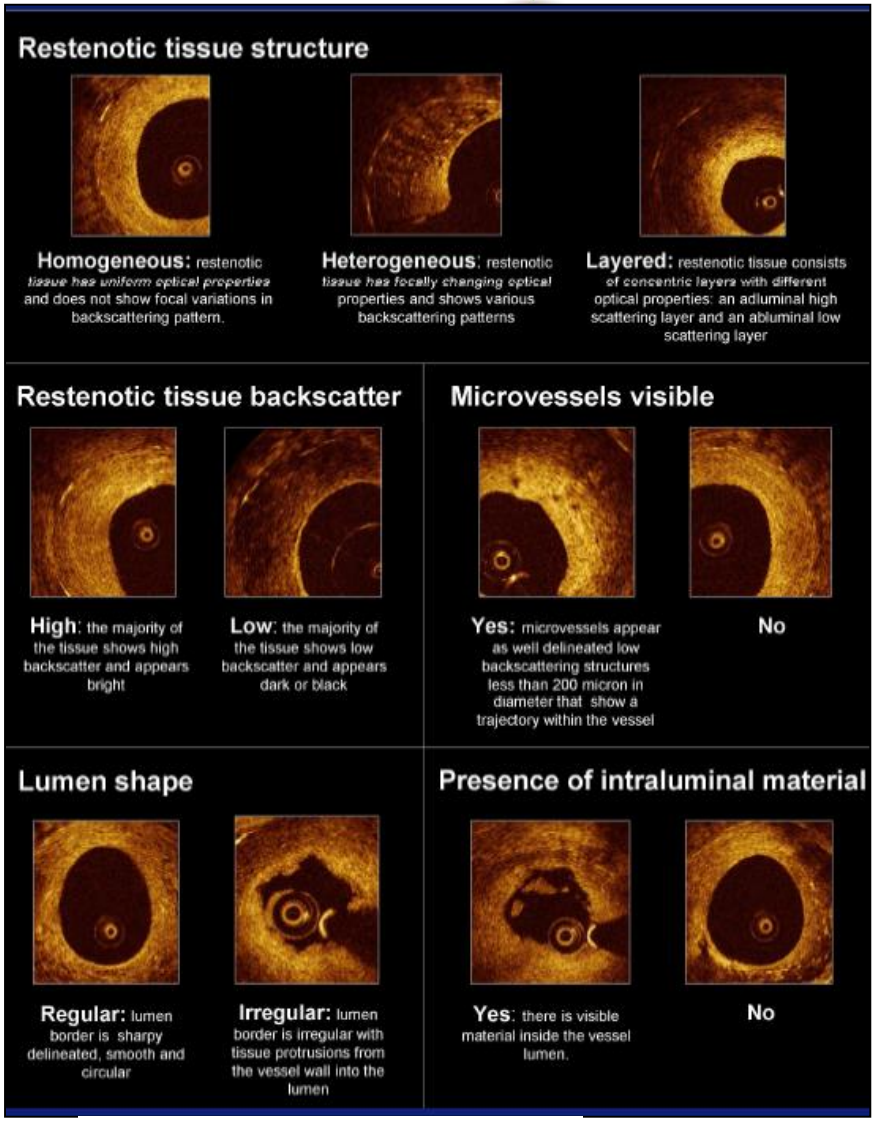
Shuzou Tanimoto, MD; Jiro Aoki, MD; Patrick W. Serruys, MD, PhD; Evelyn Regar*, MD, PhD

Thoraxcenter, Erasmus Medical Center, Rotterdam, The Netherlands.

A 73-year-old woman with hypertension, hyperlipidemia and positive familial history of coronary artery disease presented with Canadian Cardiovascular Society class III angina and underwent coronary angiography, which showed a chronic occluded right coronary artery (Panel A). The vessel was recanalized and treated with three paclitaxel-eluting stents (TAXUS®, Boston Scientific: 3.5 x 32 mm distally, 3.5 x 28 mm in the middle part, 3.5 x 12 mm proximally). Postintervention coronary angiography showed a good result (Panel B). Twelve-month follow-up angiography revealed focal in-stent restenosis (Panel C). Intracoronary optical coherence tomography (OCT: LightLabImaging™, Boston, MA, USA) pullback displayed well-expanded stents covered with a thin, homogenous, highly reflective neointimal layer (Panel D, E). In contrast, the narrowest lesion site (minimal lumen area 1.1 mm²; stent area 9.0 mm²) showed a three-layer appearance of the neointima (Panel F). The inner luminal layer appeared concentric, homogenous and signal-rich (maximal thickness 0.27 mm). A second layer consisting of a low-reflective area with poorly delineated borders followed. The third layer was in direct contact with the stent struts and revealed only minimal signal intensity. These signal-poor areas (maximal thickness 1.18 mm) might represent acellular fibrinoid deposition that has been well described in experimental studies. The patient was re-treated with repeat paclitaxel-eluting stent implantation. OCT is an analogue of intravascular ultrasound with an ultra-high resolution (10 µm) superior to any current available imaging modalities. This imaging device may be useful in visualizing neointimal growth in drug-eluting stents and improve our understanding of its underlying physiopathology in the future.



Tanimoto et al. Eurointervention 2006



Gonzalo et al. Am Heart J 2009

Optical Coherence Tomography (OCT)

Today – 2016: Lesson's Learned

Accepted Manuscript

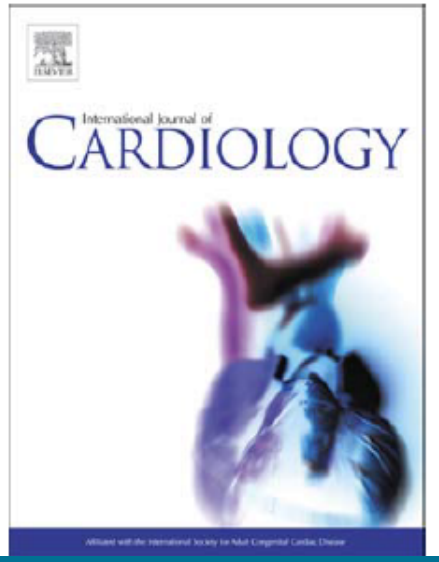
Intracoronary thrombus on optical coherence tomography in a patient with variant angina; treatment and follow-up

Péter Hausinger, Imre Ungi, Gyula Szántó, László Hajtman, Tamás Forster, Evelyn Regar, Attila Thury

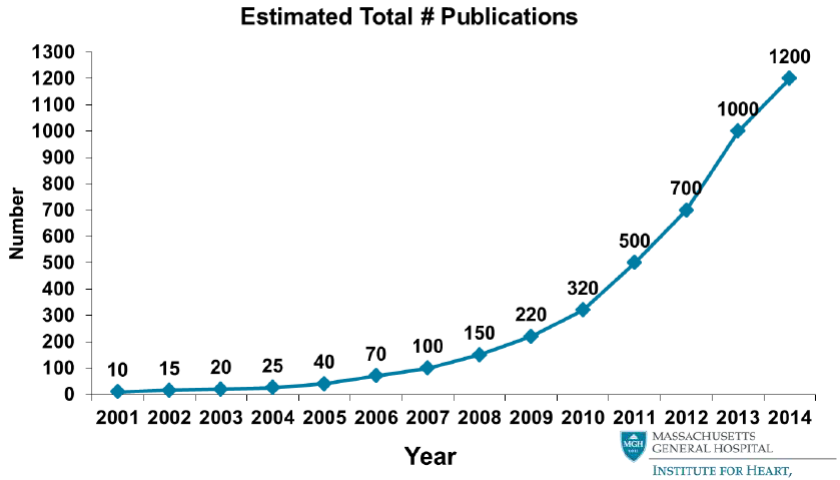
PII: S0167-5273(14)01242-X
DOI: doi: 10.1016/j.ijcard.2014.07.050
Reference: IJCA 18368

To appear in: *International Journal of Cardiology*

Received date: 18 May 2014
Accepted date: 5 July 2014



Intra-Coronary OCT Publications



HUNGARIAN BIOPHYSICAL SOCIETY

ROLAND EÖTVÖS PHYSICAL SOCIETY (HUNGARY)

TÁMOP-4.1.1.C-12/1/KO
0005 project

MASSACHUSETTS GENERAL HOSPITAL
INSTITUTE FOR HEART,

tct 25
In Partnership with the ACC
Reinventing the Future
Every Year
October 27- November 1, 2013
The Moscone Center
San Francisco, CA

Severe, persistent variant angina caused by intracoronary thrombus detected by optical coherence tomography

Peter Hausinger, Imre Ungi, Gyula Szanto, Attila Thury

Cardiology Center, University of Szeged, Hungary

Clinical data

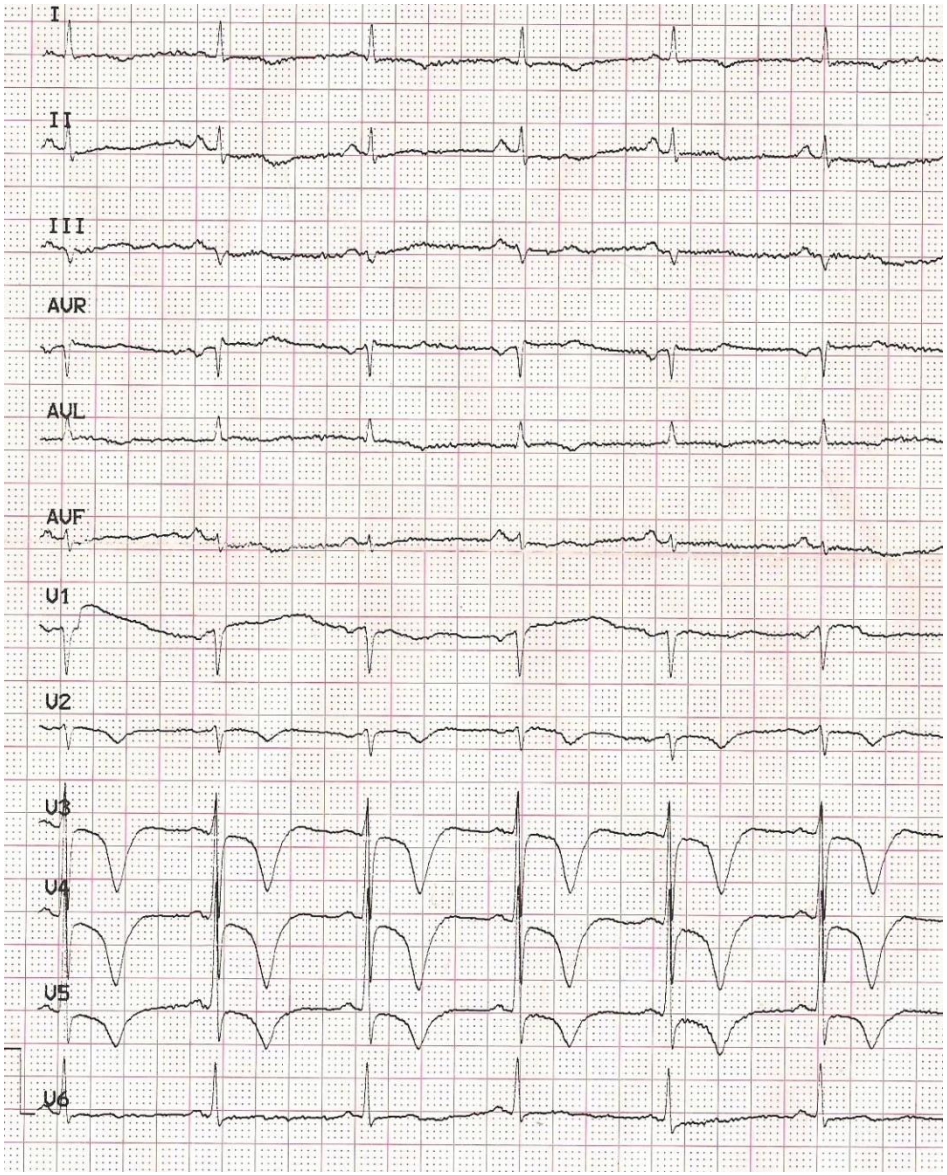
80-year-old male

Risk factors:
-hypertension
-smoker

Three-week history of occult gastrointestinal bleeding (active peptic ulcer)

One-week history of unstable angina (CCS4)

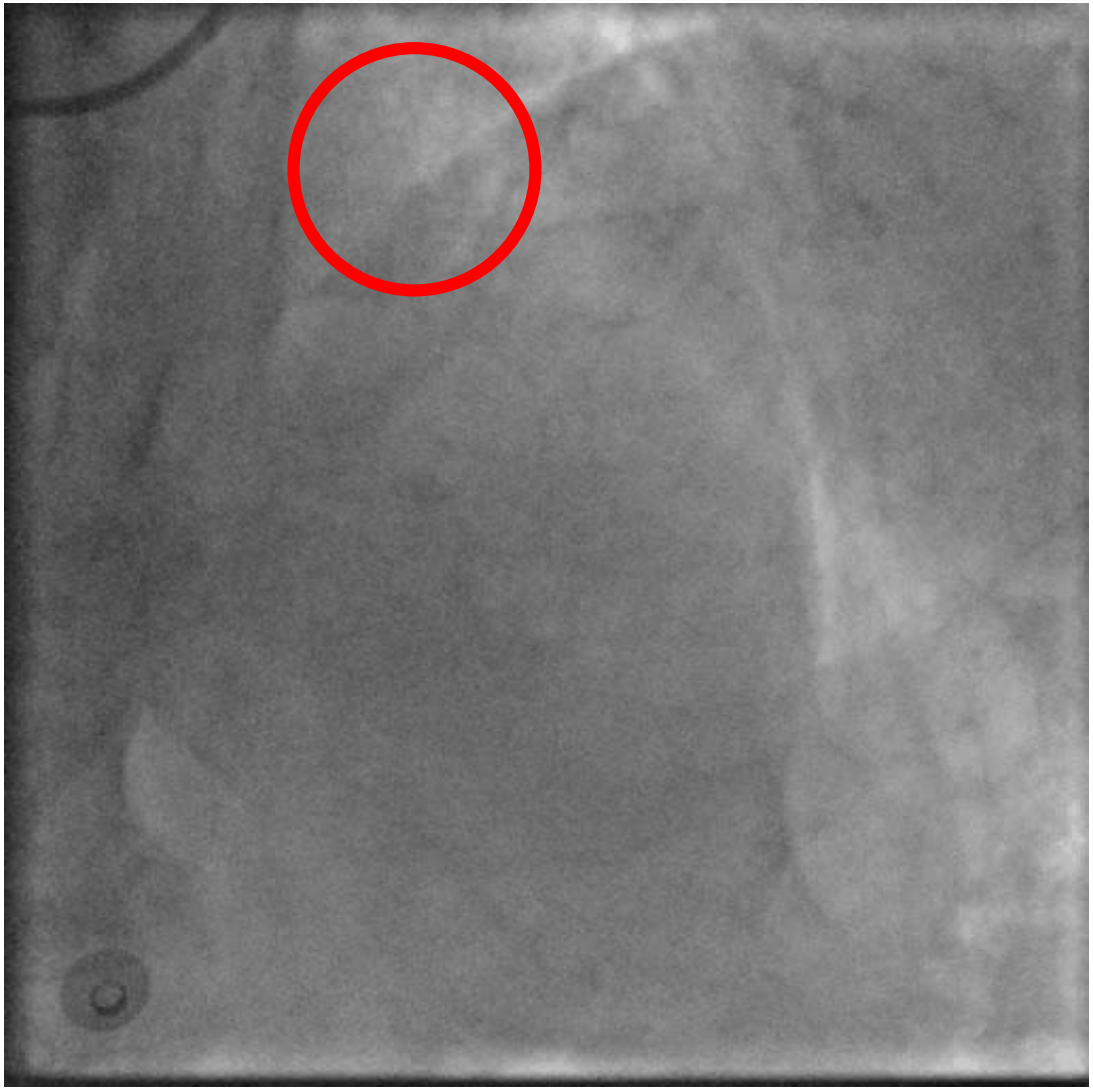
On admission



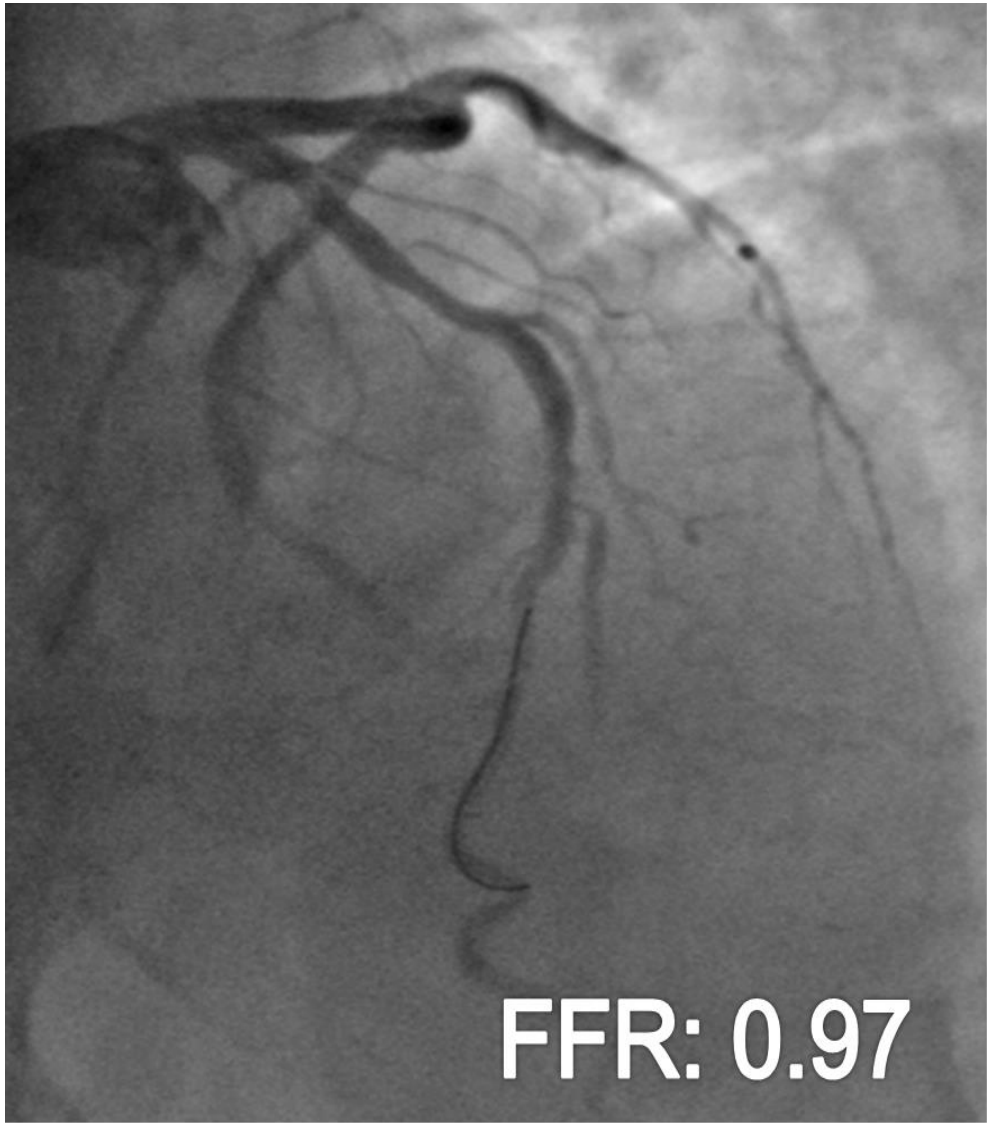
Baseline ECG on admission:

- **T wave inversion in precordial leads**
- **Patient free of angina**

Diagnostic Cardiac Catheterization



FFR measurement

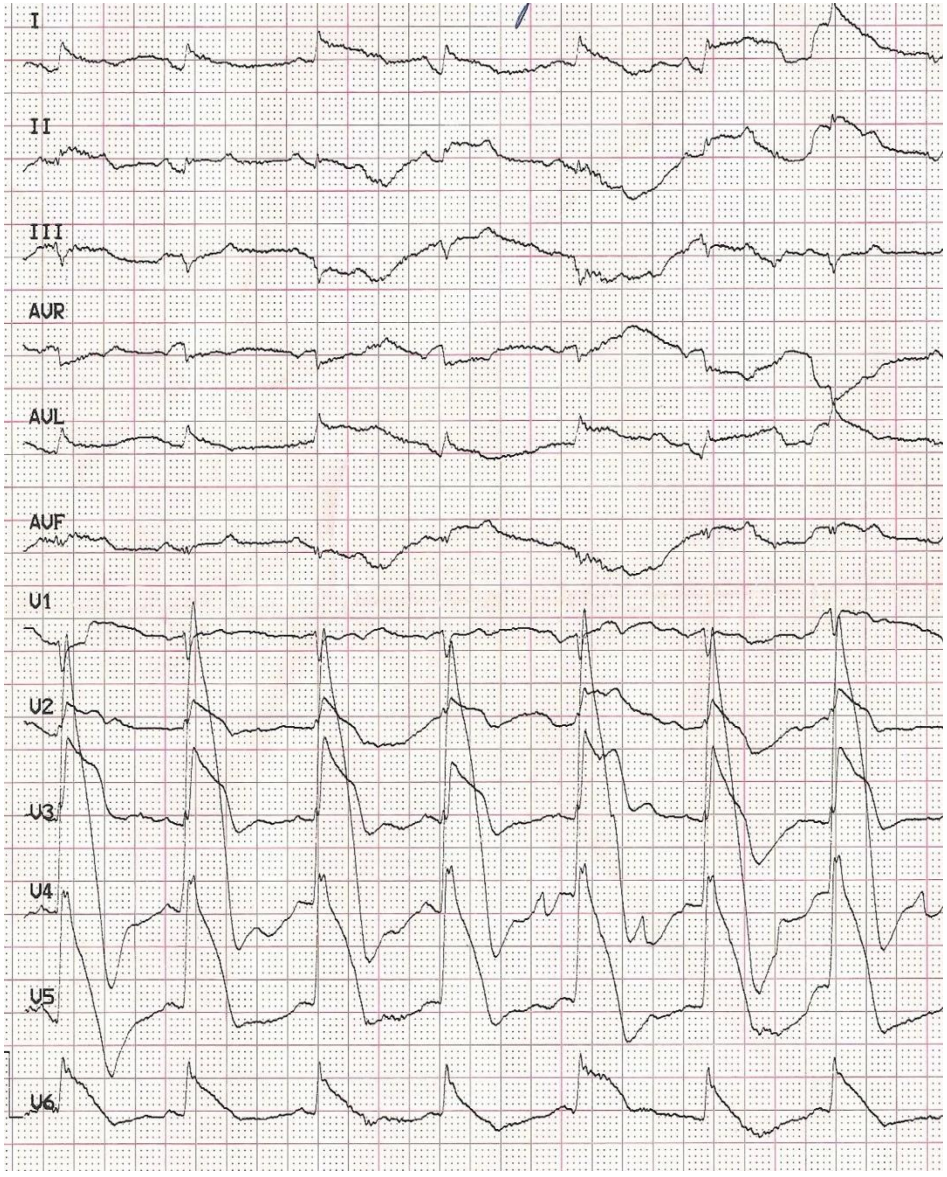


200 ug NTG +
240ug adenosine

Patient discharged to step-down unit with complete medication

- ASA 1x100mg
- Clopidogrel 1x75mg
- LMWH 2x0.6ml s.c.
- Ramipril 1x2.5mg
- Rosuvastatin 1x20mg
- Nebivolol 1x5mg

Recurrent angina at rest



- Immediately relieved by s.l. NTG

+

- Complete resolution on ECG

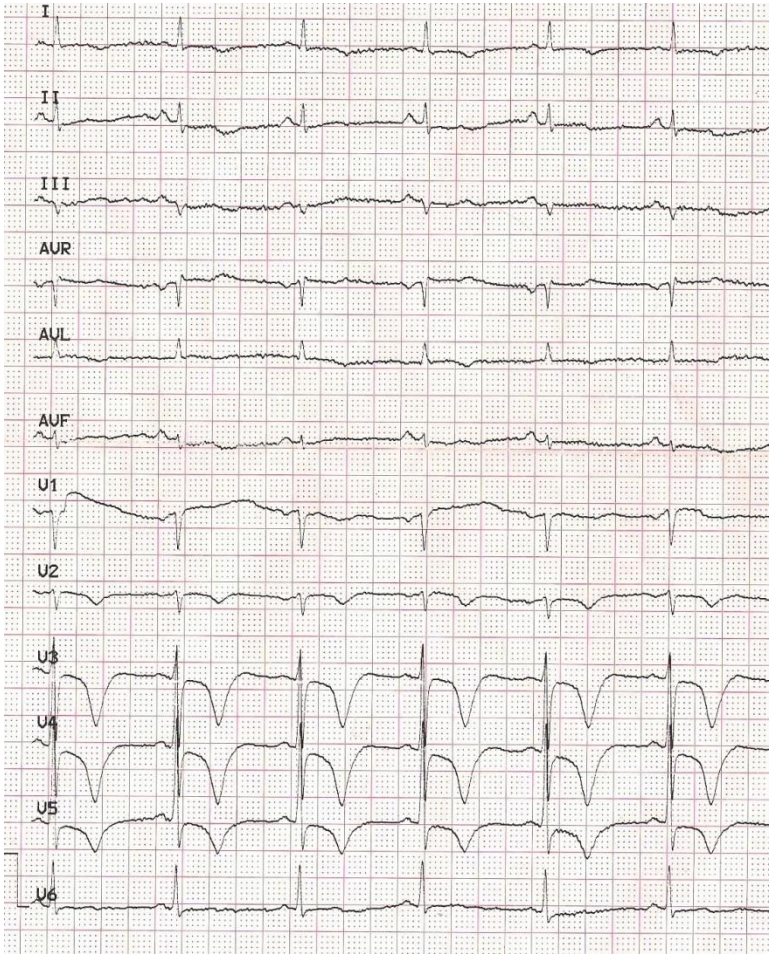
- ASA 1x100mg
- Clopidogrel 1x75mg
- LMWH 2x0.6ml s.c.
- Ramipril 1x2.5mg
- Rosuvastatin 1x20mg
- ~~Nebivolol 1x5mg~~

Nisoldipin 2x10mg

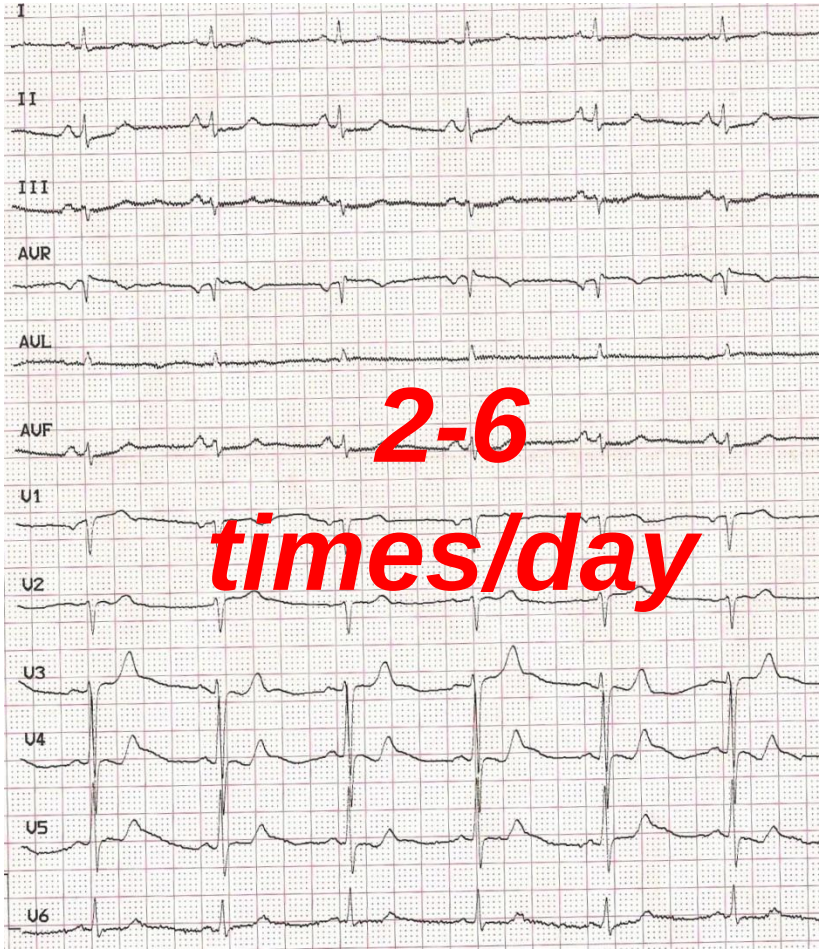
+

Iv NTG

Despite medical therapy

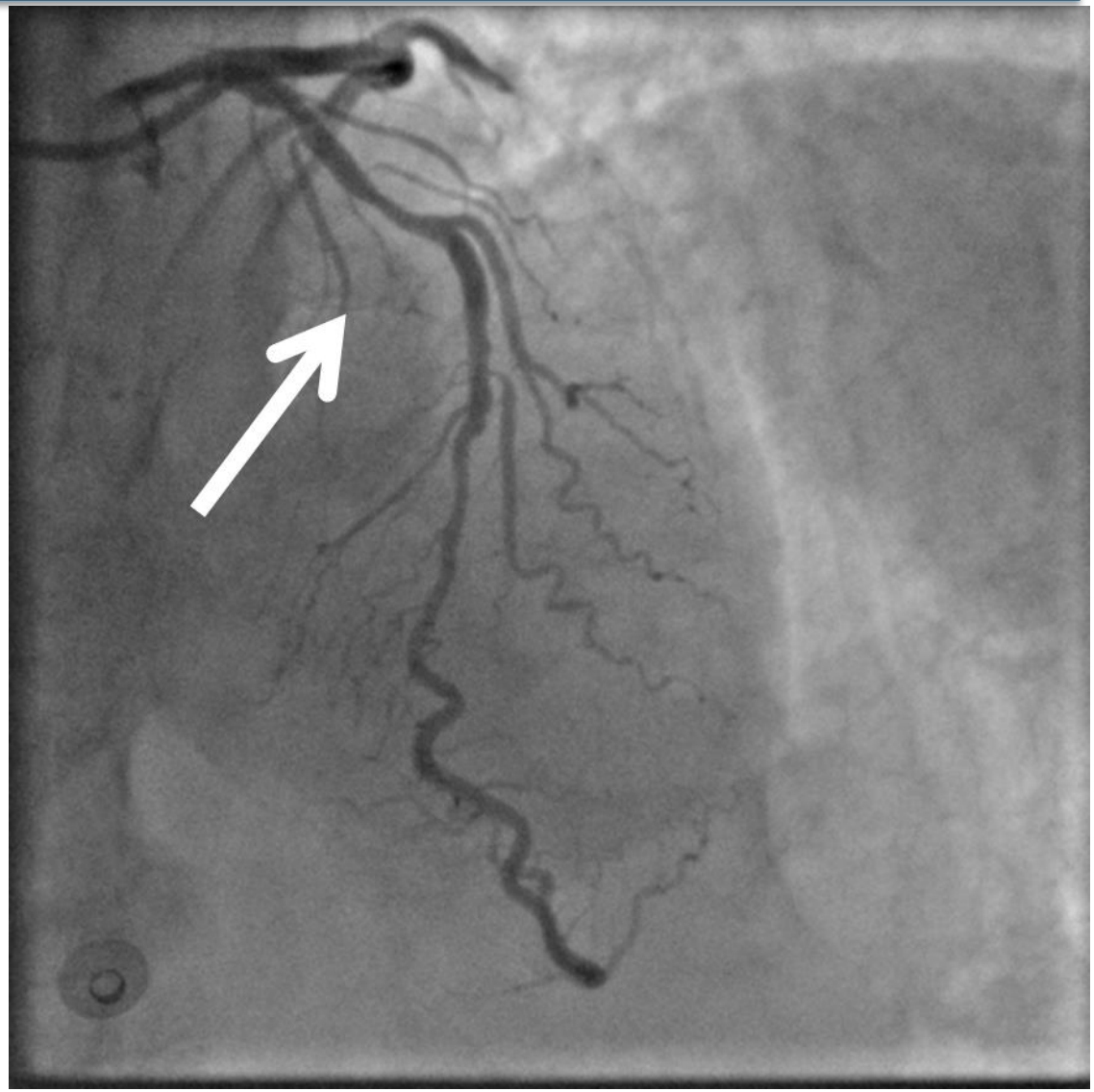


No angina

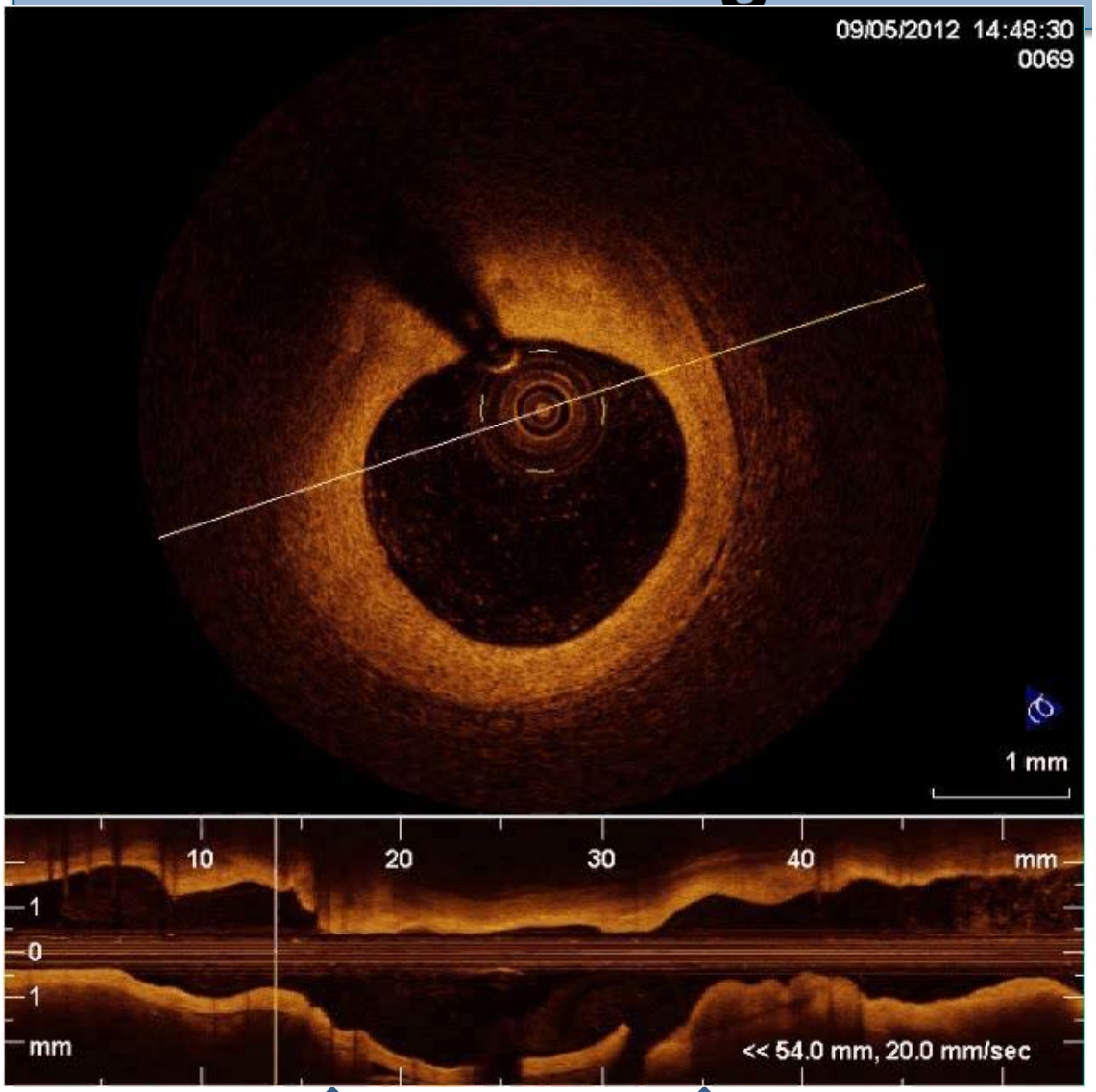


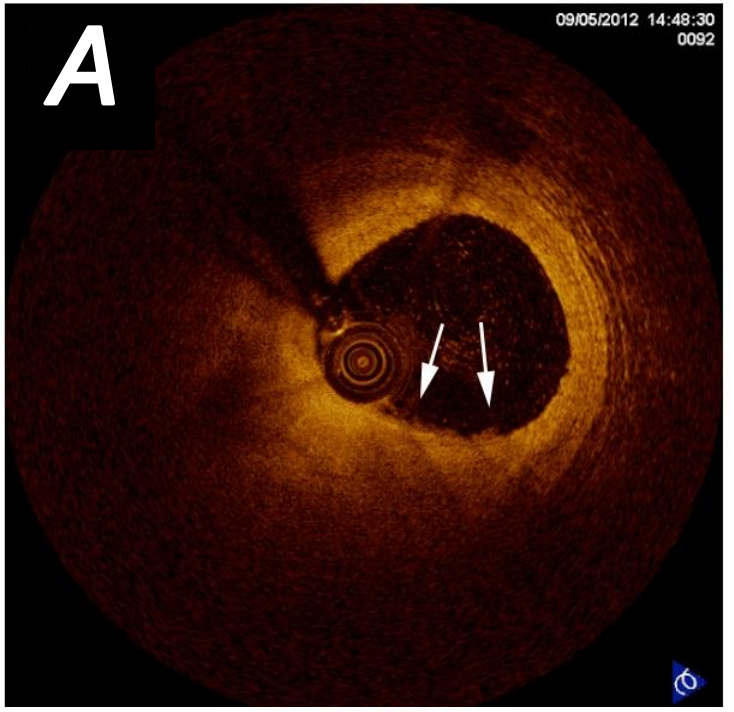
Angina

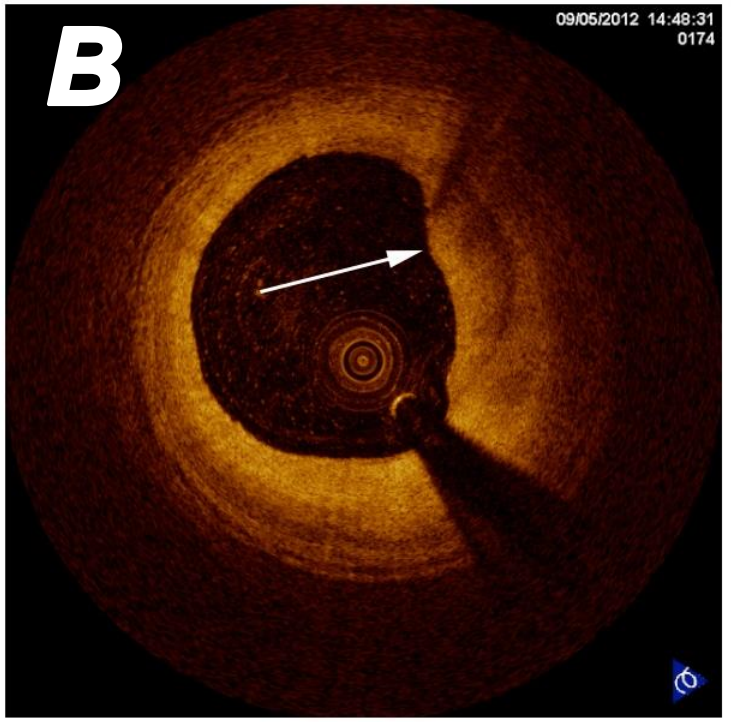
Repeated Cardiac Catheterization

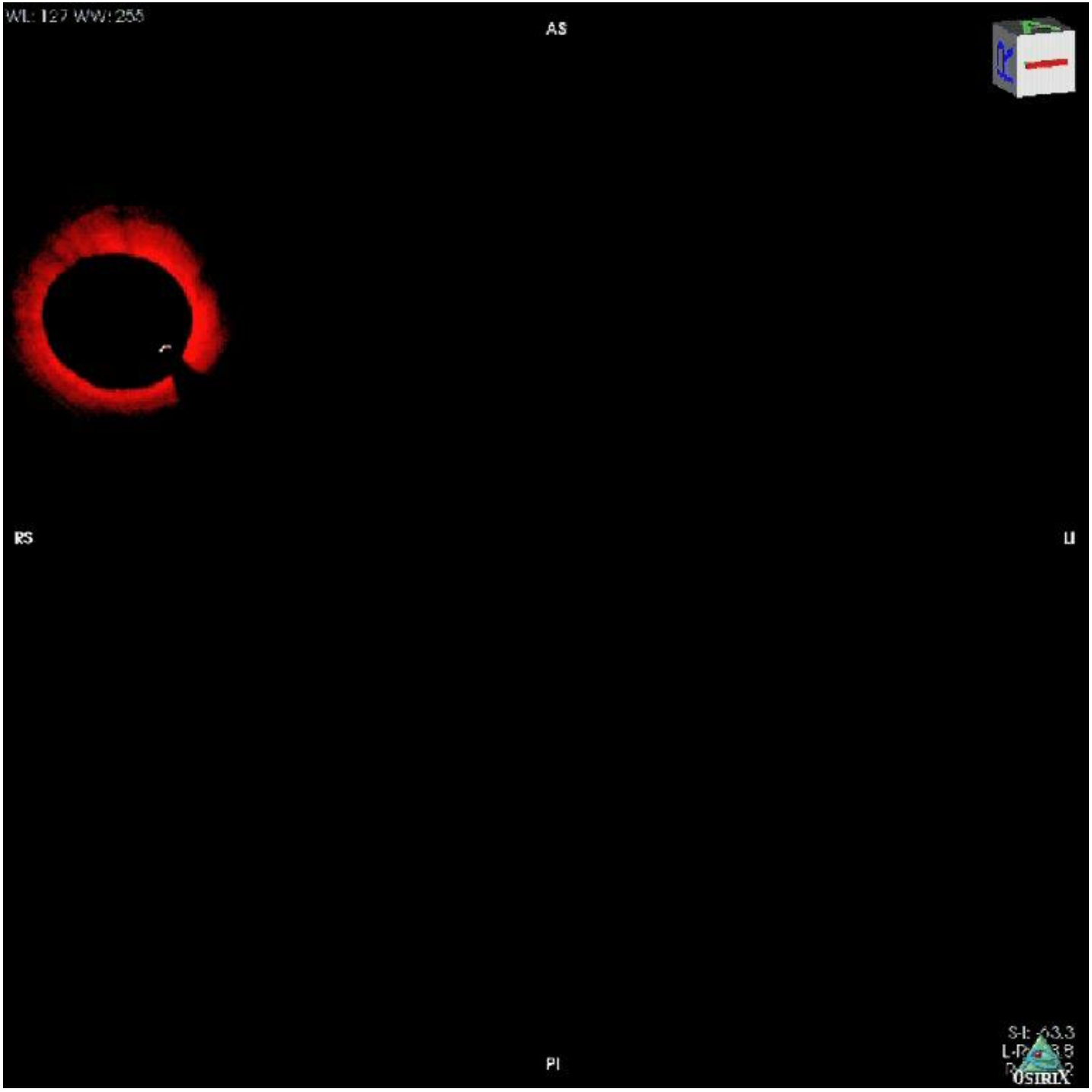


OCT Interrogation

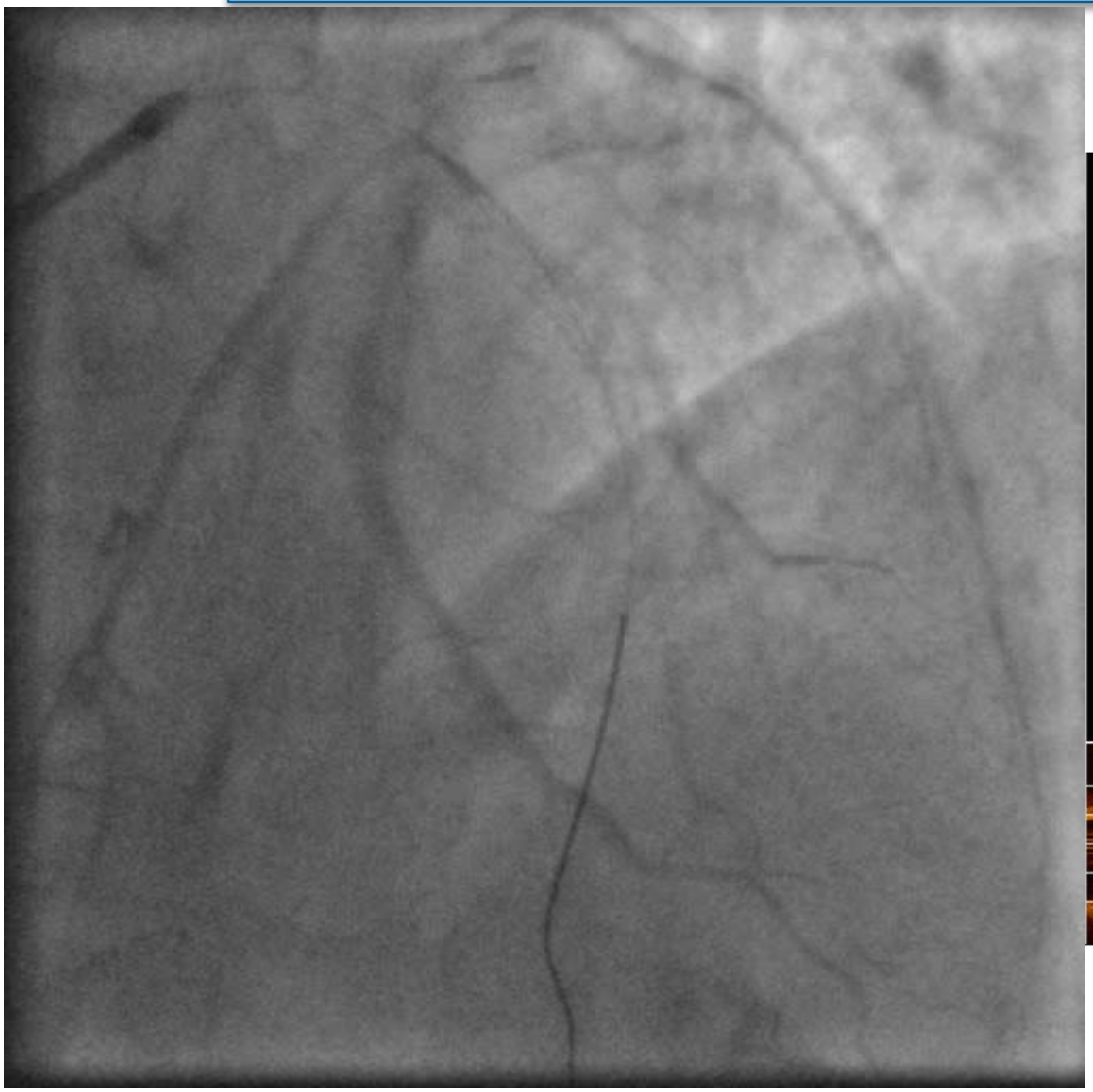


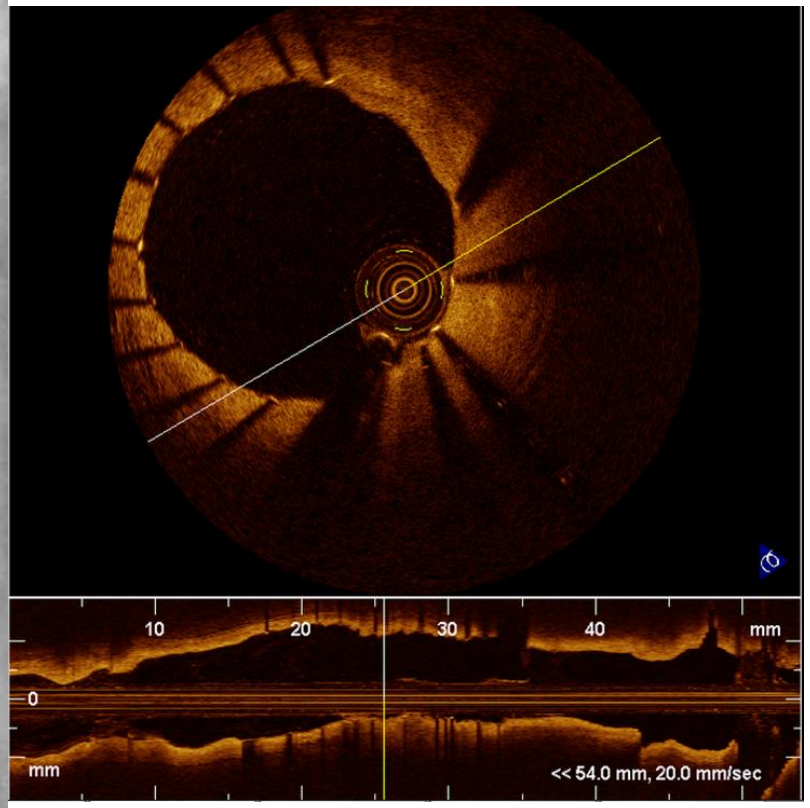





WL: 127 WW: 255
AS
RS
LI
PI
OSIRIX

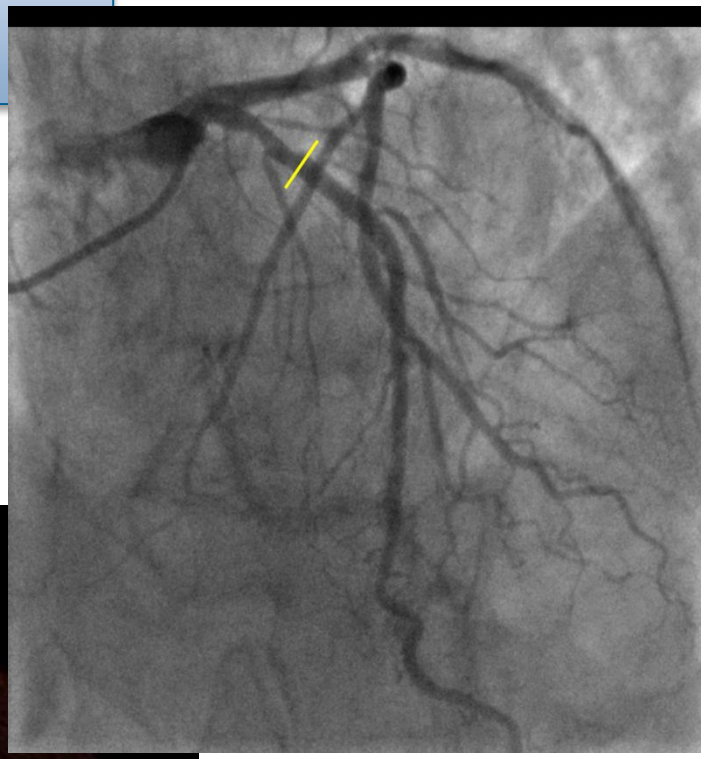
Interventional Management

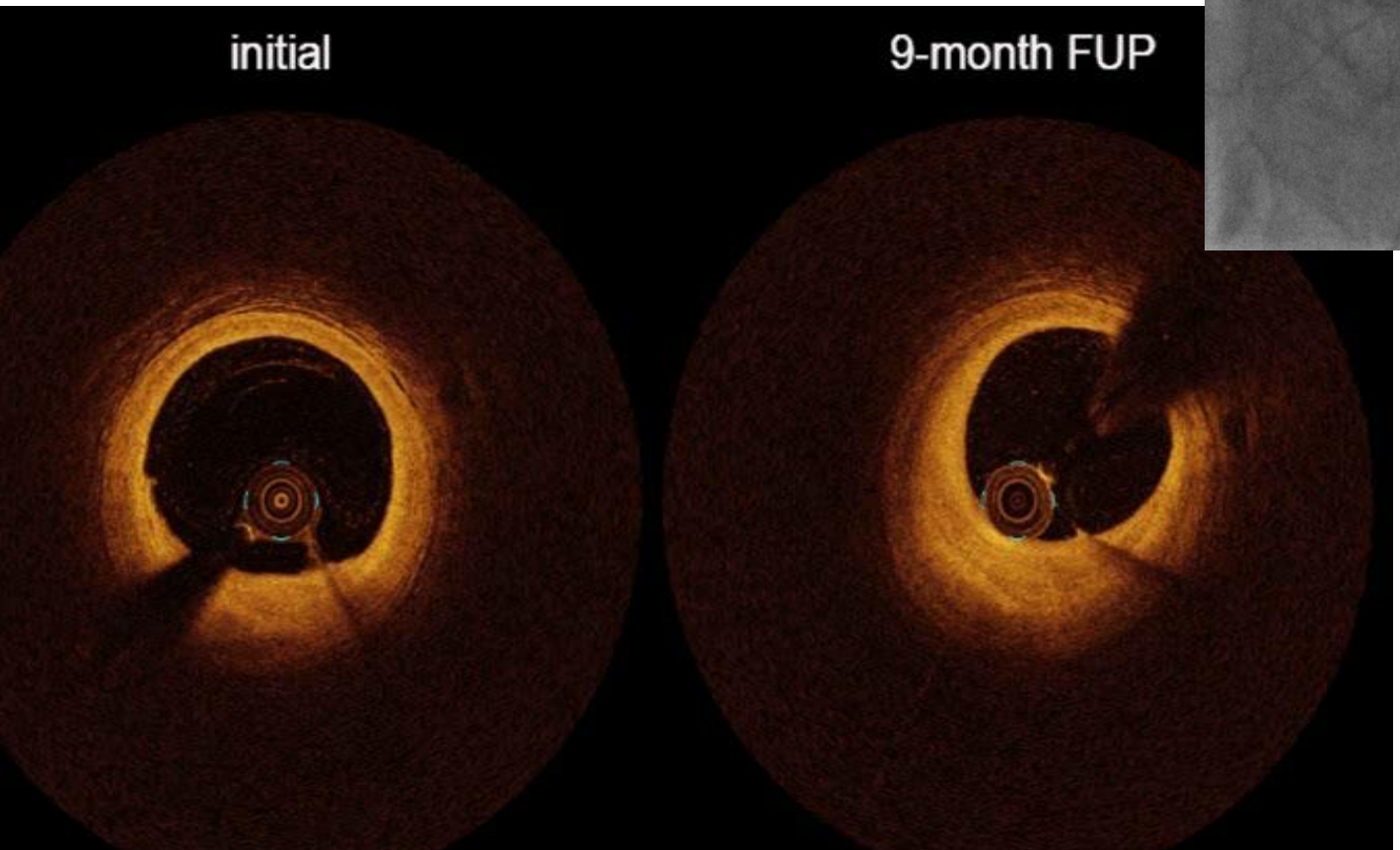




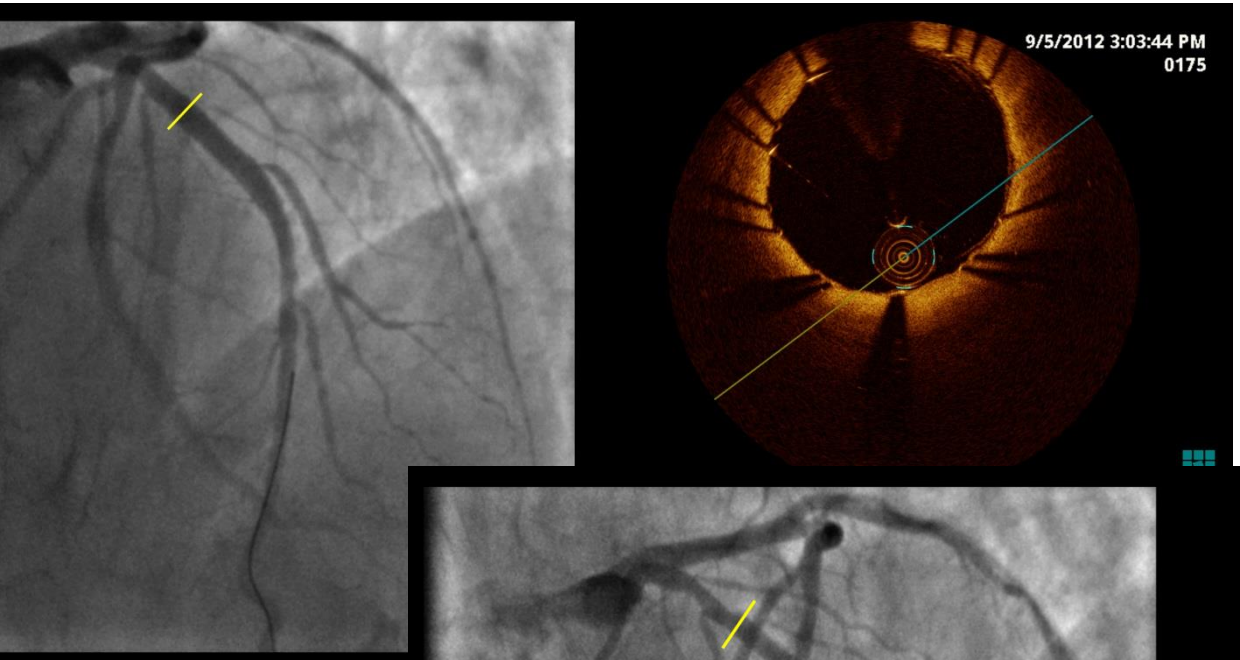
Nine-month follow-up

Patient is free of angina

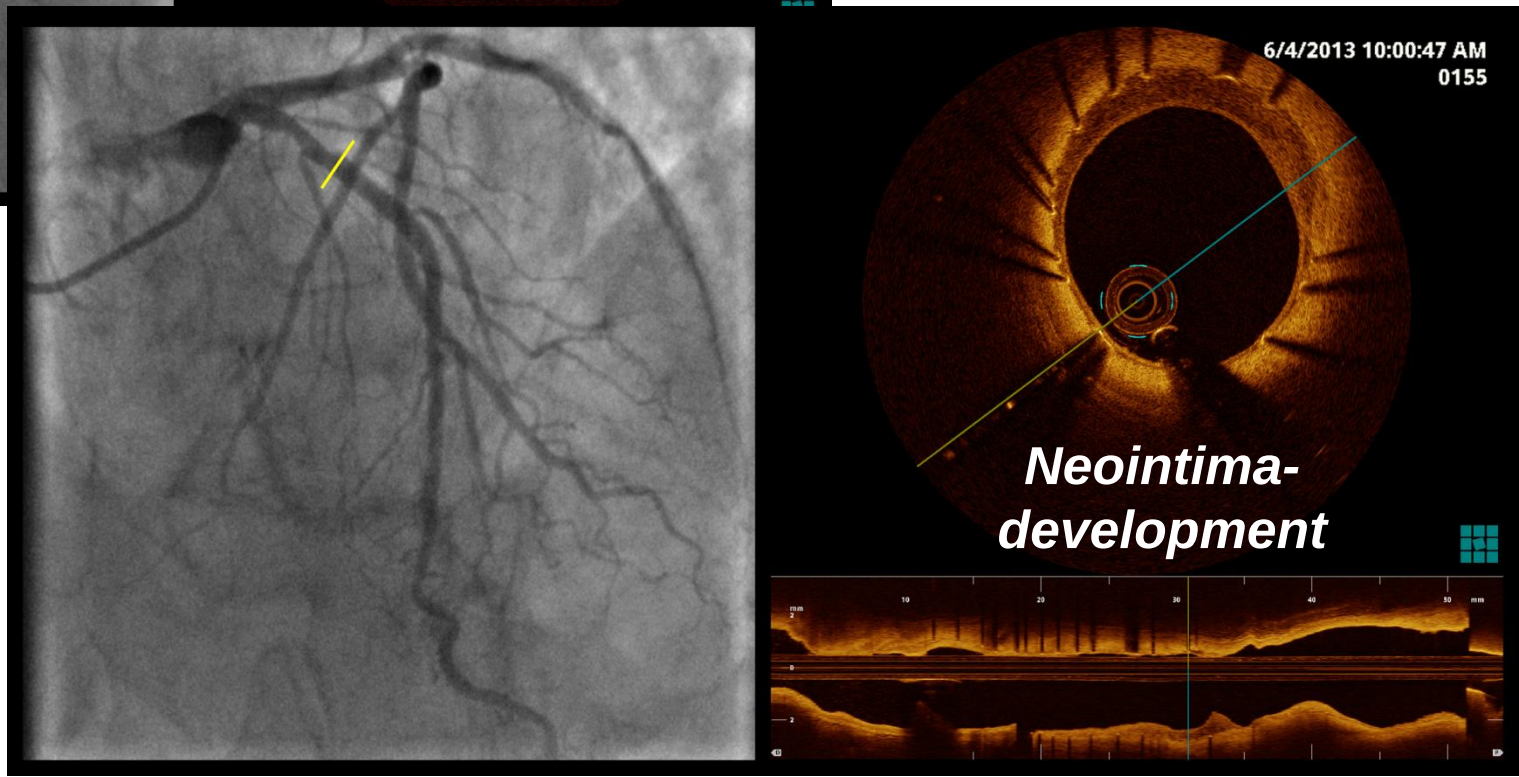




„Preparation of the concerned sectors for educational and R&D activities related to the Hungarian ELI project”



Neo-atherosclerosis ?



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Optical Coherence Tomography (OCT) in coronary arteries

Today – 2016: Reliable Diagnostic Tool !

- Extremely fast (a couple of seconds!)
- Reliable
- Provides a clear answer
- User-independent
- Superior to angiograpy
- All relevant quantitative/qualitative data
- **As physician, I can focus on therapy!**

'ELITEAM'- ESTABLISHMENT OF THE ELI INSTITUTE AT THE UNIVERSITY OF SZEGED: FOUNDATION OF INTERDISCIPLINARY RESEARCH IN THE FIELD OF LASERS AND THEIR APPLICATIONS

THANK YOU FOR YOUR ATTENTION!

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