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Universitair Medisch Centrum Rotterdam

Vulnerable Plaque, Vulnerable Neointima

Clinical Application of VH, OCT and NIR
- Safety, Pitfalls and Future Direction -

E. Regar

Thoraxcenter

Erasmus Medical Center

Rotterdam

The Netherlands

ANGIOPLASTY SUMMIT
TCTAP 2012
TRANSCATHETER CARDIOVASCULAR THERAPEUTICS ASIA PACIFIC
17TH APRIL 24-27, 2012, SEOUL, KOREA
SHERATON GRAND WALKERHILL HOTEL

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Vulnerable Plaque, Vulnerable Neointima

Intravascular Ultrasound **IVUS VH**

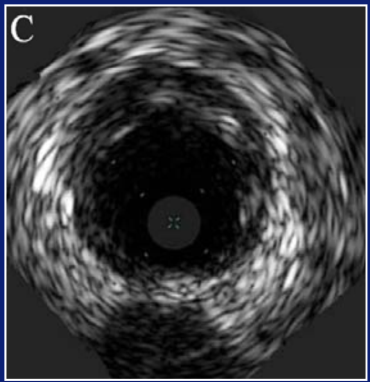
Near Infrared Spectroscopy **NIRS**

Optical Coherence Tomography **OCT**

Safety

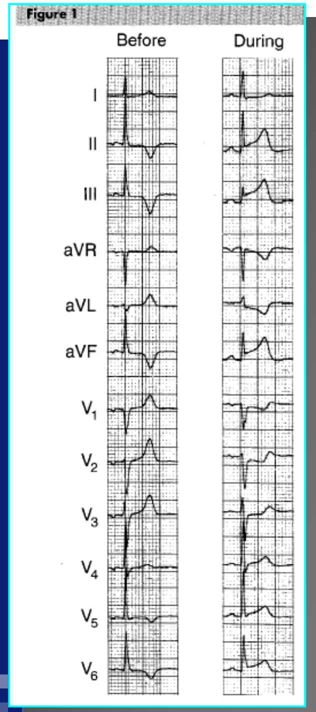
IVUS VH
Safety

IVUS



Frequency, duration, magnitude, and consequences of myocardial ischemia during intracoronary ultrasonography

Barbara J. Drew, RN, PhD,[a] Mary G. Adams, RN, MS,[a] Denise K. McEldowney, RN, MS,[a] Kimberly Y. Lau, RN, MS,[a] Shu-Fen Wung, RN, MS,[a] Christopher L. Wolfe, MD,[b] Thomas A. Ports, MD,[b] and Tony M. Chou, MD[b] *San Francisco, Calif.*

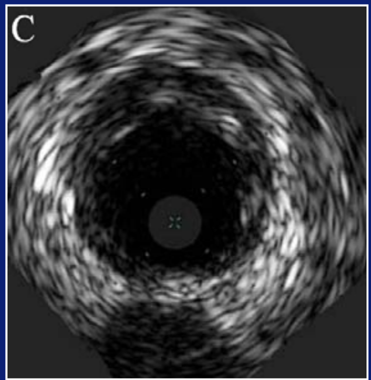


1997: N=27 pts, IVUS 3.2-4.3F

67% ischemia during IVUS imaging

IVUS VH
Safety

IVUS



Journal of the American College of Cardiology
Vol. 45, No. 4, 2005
ISSN 0735-1097/05/$30.00
doi:10.1016/j.jacc.2004.10.063

Published by Elsevier Inc.

Long-Term Safety of Intravascular Ultrasound in Nontransplant, Nonintervened, Atherosclerotic Coronary Arteries

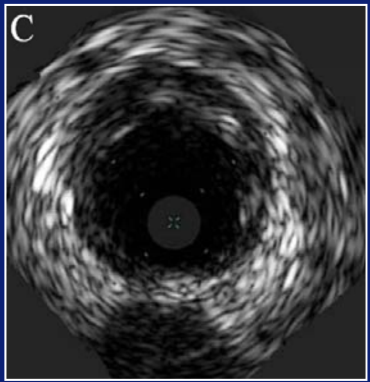
Antoine Guédès, MD, Pierre-Frédéric Keller, MD, Philippe L. L'Allier, MD, Jacques Lespérance, MD, Jean Grégoire, MD, Jean-Claude Tardif, MD
Montreal, Quebec, Canada

2005: N=525 pts, IVUS 2.9-3.2F

is safe in nonintervened arteries and
does not accelerate coronary artery disease

IVUS VH
Safety

IVUS

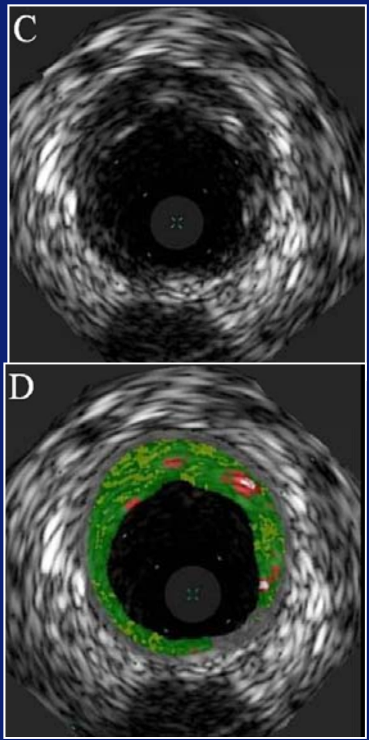


Thermal injury	Temperature rise < 1K
Mechanical injury	Blood cells: None
	Endothelium: Minimal
Ischemia	67% ECG changes
	22% Angina pectoris
Coronary spasm	0.6% - 3%
Dissection	0.1% - 0.3%
Abrupt vessel occlusion	0.2%
Thrombus formation	0.05%
Coronary emolism	0.05%
Myocardial infarction	0.01%

Ge 1991; Hodgson 1989; Drew 1997; Batkoff 1996; Hausmann 1995

IVUS VH
Safety

IVUS VH



The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Prospective Natural-History Study of Coronary Atherosclerosis

Gregg W. Stone, M.D., Akiko Maehara, M.D., Alexandra J. Lansky, M.D., Bernard de Bruyne, M.D., Ecaterina Cristea, M.D., Gary S. Mintz, M.D., Roxana Mehran, M.D., John McPherson, M.D., Naim Farhat, M.D., Steven P. Marso, M.D., Helen Parise, Sc.D., Barry Templin, M.B.A., Roseann White, M.A., Zhen Zhang, Ph.D., and Patrick W. Serruys, M.D., Ph.D., for the PROSPECT Investigators*

Imaging Complications	
All	1.6%
Myocardial infarction	0.5%

Stone G et al. NEJM 2011

Vulnerable Plaque, Vulnerable Neointima

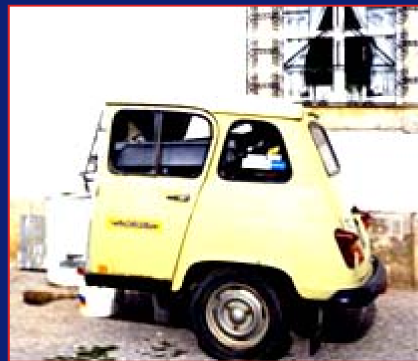
Intravascular Ultrasound **IVUS VH**

Near Infrared Spectroscopy **NIRS**

Optical Coherence Tomography **OCT**

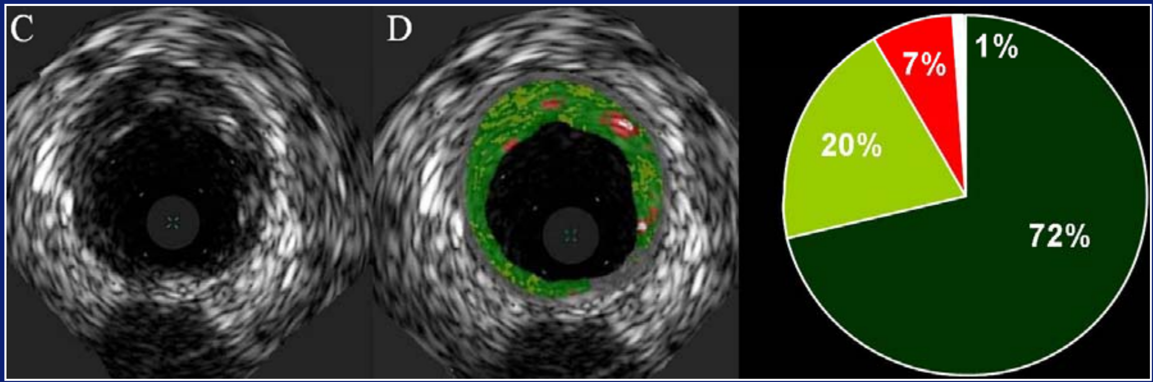
Safety

Pitfalls



IVUS VH

IVUS VH



VH	Color	Accuracy
Fibrous		87 %
Fibro-fatty		87 %
Necrotic core		88 %
Dense calcium		97 %

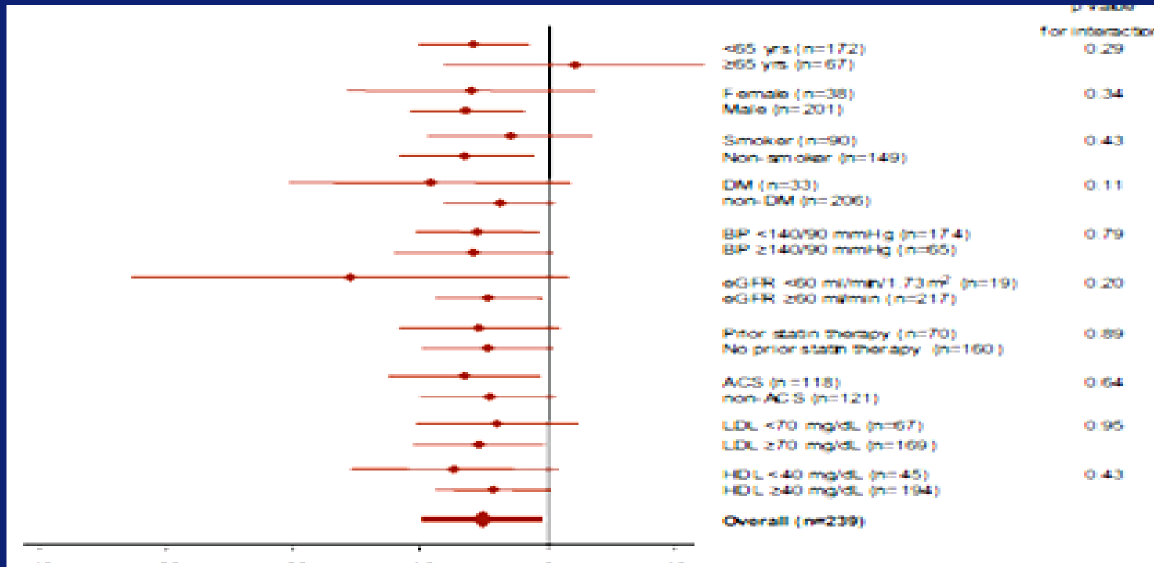
J. Am. Coll. Cardiol 2006;47:2405-2412

IVUS Tissue Characterization
Clinical Trials: IBIS

IBIS 1
Observational, exploratory study

IBIS 2
Prospective, randomized, multicenter study

Difference in **necrotic core volume**



Serruys PW et al., Circulation 2008

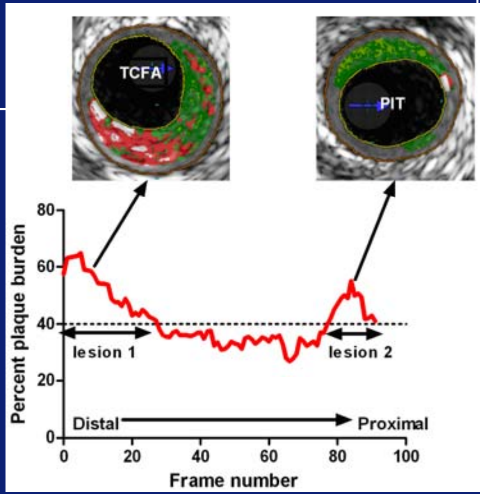
IVUS Tissue Characterization Clinical Trials: Atheroremo

European Collaborative Project on Inflammation and Vascular Wall Remodeling in Atherosclerosis

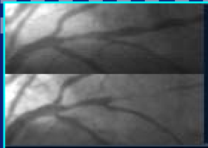
Atheroremo - ongoing

Observational, exploratory study, n=850 pts

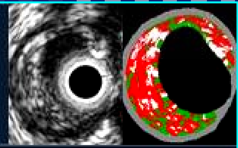
To assess the interplay between the vulnerable plaque as determined by IVUS-VH and genetic profile, biomarkers of inflammation and vascular injury



IVUS Tissue Characterization
Clinical Trials: PROSPECT



PROSPECT: Primary Endpoint



MACE attributable to rapid angiographic progression of a non-culprit lesion*

Most severe

- Cardiac death
- Cardiac arrest
- Myocardial infarction
- Unstable angina
  - Requiring revascularization
  - Requiring rehospitalization
- Increasing angina
  - Requiring revascularization
  - Requiring rehospitalization

Hierarchical

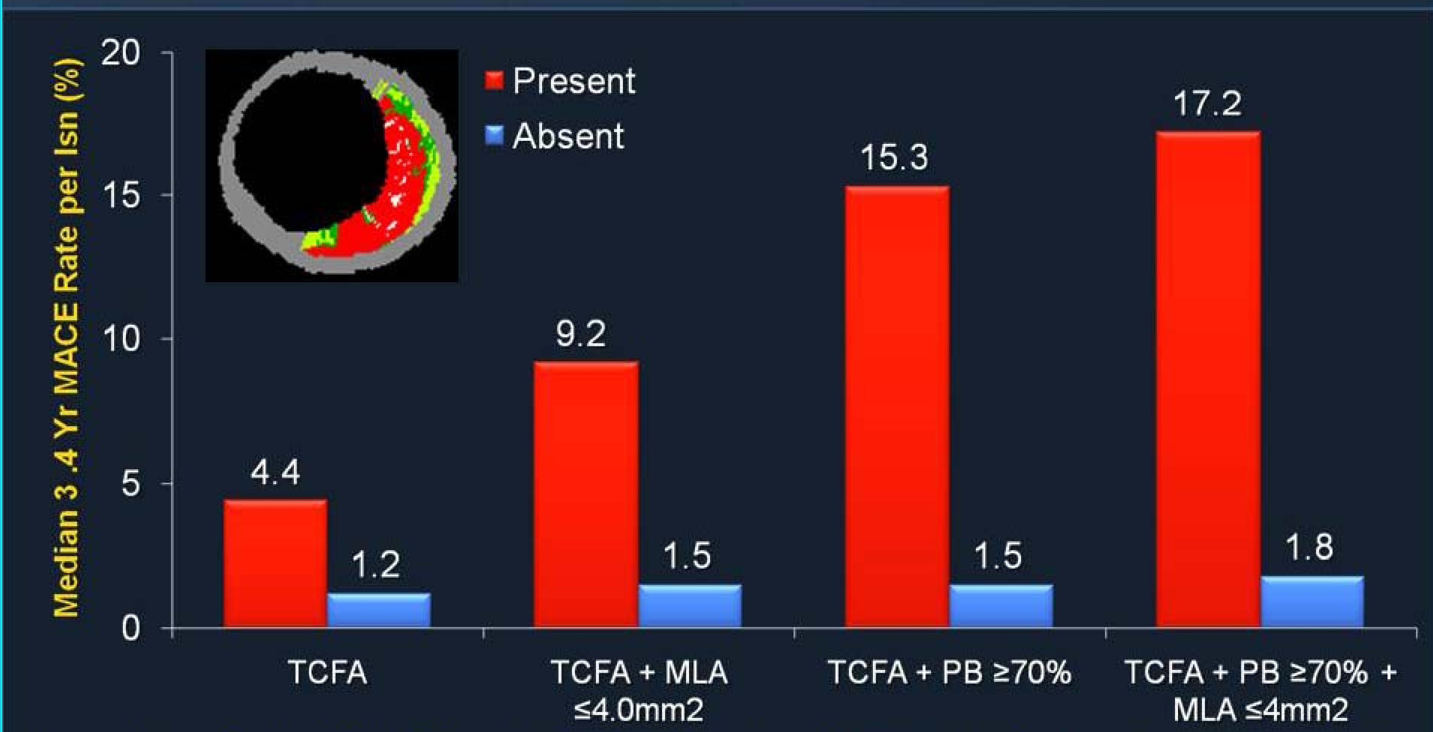
Least severe

MACE during FU were adjudicated by the CEC as attributable to culprit lesions (those treated during or before the index hospitalization) or non culprit lesions (untreated areas of the coronary tree) based on angiography (+ECGs, etc.) at the time of the event; events occurring in pts without angiographic follow-up were considered indeterminate in origin. Rapid lesion progression = ↑ in QCA DS by >20% from baseline to FU.

G.W. Stone, presented at TCT 2009

IVUS Tissue Characterization
Clinical Trials: PROSPECT

PROSPECT: VH-TCFA and Non Culprit Lesion Related Events



	TCFA	TCFA + MLA ≤4.0mm2	TCFA + PB ≥70%	TCFA + PB ≥70% + MLA ≤4mm2
Lesion HR	3.84 (2.22, 6.65)	6.41 (3.35, 12.24)	10.77 (5.53, 21.00)	10.81 (4.30, 27.22)
P value	<0.0001	<0.0001	<0.0001	<0.0001
Prevalence*	51.2%	17.4%	11.0%	4.6%

*Likelihood of one or more such lesions being present per patient. PB = plaque burden at the MLA

G.W. Stone, presented at TCT 2009

IVUS VH
Pitfalls (1)

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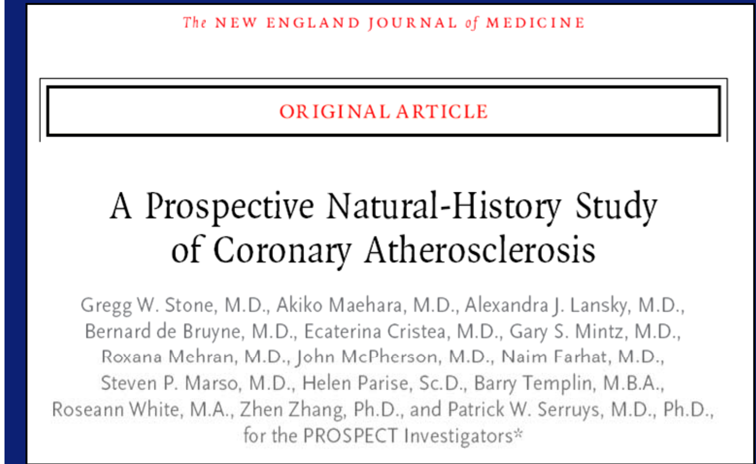

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Patients with ACS (NSTEMI & STEMI)
Medication use as to local standard!

FUP 3.4 years

	Pts
Included	697
IVUS VH	623
IVUS VH -TCFA	313
MACE	135
CV Event	31

Death
Cardiac arrest
MI

IVUS VH
Pitfalls (1)

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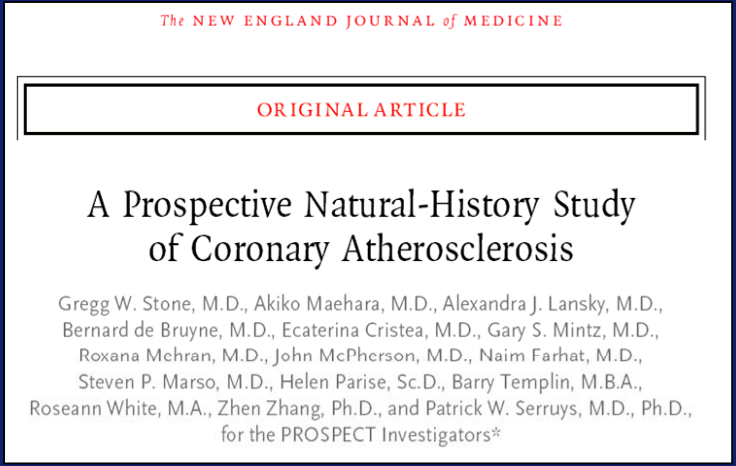

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IVUS VH Pitfalls (1)

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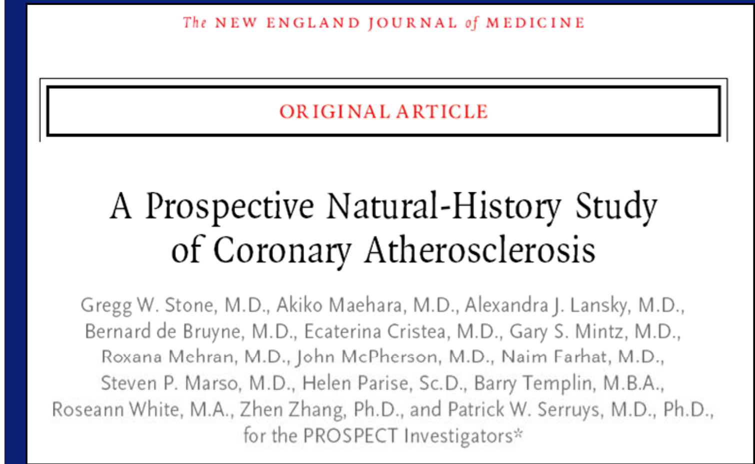
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Patients with ACS (NSTEMI & STEMI)
Medication use as to local standard!

FUP 3.4 years

	Pts	Lesion VH TCFA
Included	697	
IVUS VH	623	
IVUS VH -TCFA	313	596
MACE	135	26
CV Event	31	

Death
Cardiac arrest
MI

Specificity?

IVUS VH
Pitfalls (2)

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Coronary Plaque Classification With Intravascular Ultrasound Radiofrequency Data Analysis

Anuja Nair, MS; Barry D. Kuban, BS; E. Murat Tuzcu, MD; Paul Schoenhagen, MD; Steven E. Nissen, MD; D. Geoffrey Vince, PhD

Background—Atherosclerotic plaque stability is related to histological composition. However, current diagnostic tools do not allow adequate in vivo identification and characterization of plaques. Spectral analysis of backscattered intravascular ultrasound (IVUS) data has potential for real-time in vivo plaque classification.

Methods and Results—Eighty-eight plaques from 51 left anterior descending coronary arteries were imaged ex vivo at physiological pressure with the use of 30-MHz IVUS transducers. After IVUS imaging, the arteries were pressure-fixed and corresponding histology was collected in matched images. Regions of interest, selected from histology, were 101 fibrous, 56 fibrolipidic, 50 calcified, and 70 calcified-necrotic regions. Classification schemes for model building were computed for autoregressive and classic Fourier spectra by using 75% of the data. The remaining data were used for validation. Autoregressive classification schemes performed better than those from classic Fourier spectra with accuracies of 90.4% for fibrous, 92.8% for fibrolipidic, 90.9% for calcified, and 89.5% for calcified-necrotic regions in the training data set and 79.7%, 81.2%, 92.8%, and 85.5% in the test data, respectively. Tissue maps were reconstructed with the use of accurate predictions of plaque composition from the autoregressive classification scheme.

Conclusions—Coronary plaque composition can be predicted through the use of IVUS radiofrequency data analysis. Autoregressive classification schemes performed better than classic Fourier methods. These techniques allow real-time analysis of IVUS data, enabling in vivo plaque characterization. (*Circulation*. 2002;106:2200-2206.)

Key Words: atherosclerosis ■ coronary disease ■ Fourier analysis ■ plaque ■ ultrasonics

No validation in stented segments

- Plaque behind stent
- Tissue coverage at fup

Nair A et al. Circulation 2002

Vulnerable Plaque, Vulnerable Neointima

Intravascular Ultrasound	**IVUS VH**
Near Infrared Spectroscopy	**NIRS**
Optical Coherence Tomography	**OCT**

Near Infrared Spectroscopy (NIRS)

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<u>Unique Aspects:</u>

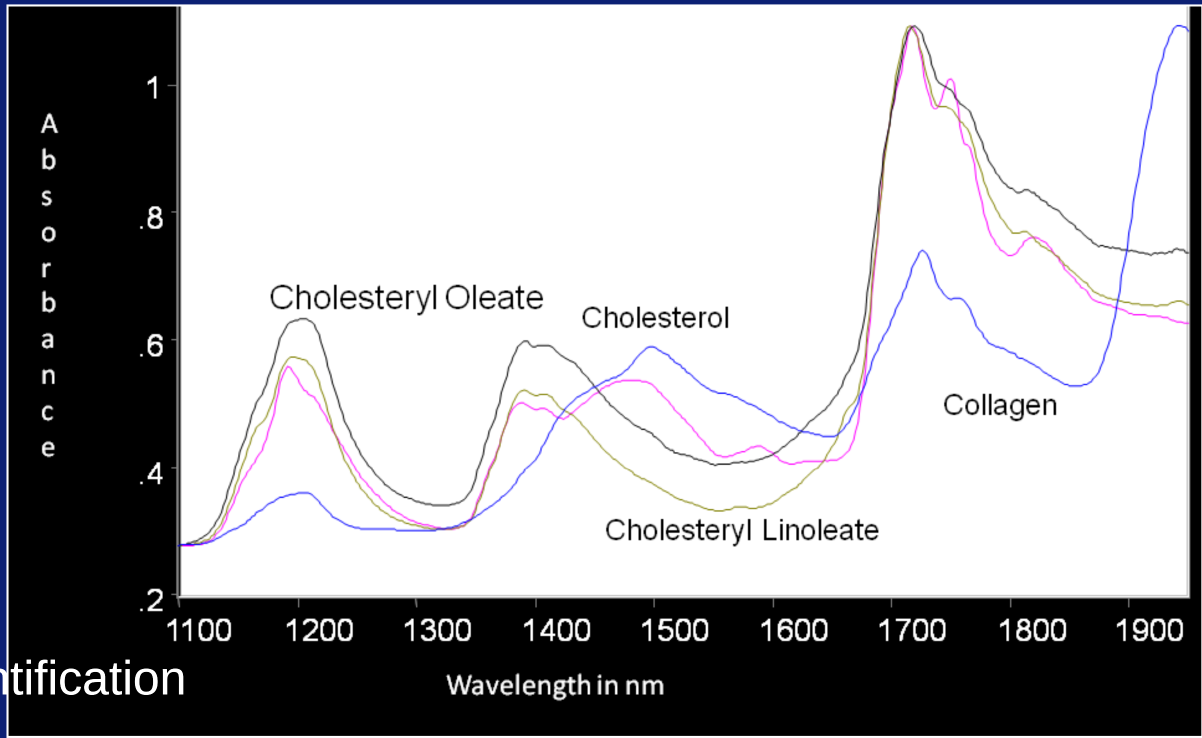
NIR Spectra can uniquely identify organic chemicals.
NIR Spectra are chemical finger prints.

<u>Industry:</u>

- Pharmaceutical;
- Food;
- Agriculture;
- Petrochemical;
- Medical.

<u>Techniques:</u>

- Process control
- Unknown substance identification



Intracoronary Near Infrared Spectroscopy (NIRS) Lipid Core Plaque (LCP) Algorithm

- Intracoronary catheter: 3.2F fibre optic catheter
- Spectra processed by algorithm and displayed to user as a chemical image of lipid rich plaque probability ("Chemogram")

Algorithm Calibration

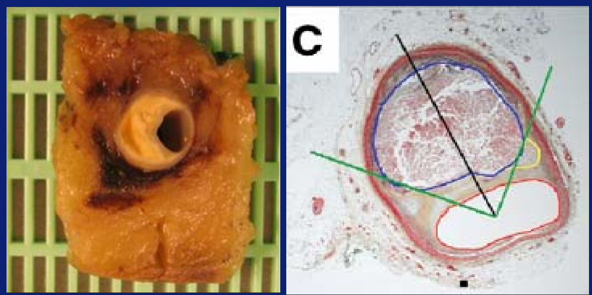
• 4.2 meters of artery from 33 autopsy hearts.

• **Lipid Core Plaque (LCP)** defined as:

Fibroatheroma > 200 µm thick

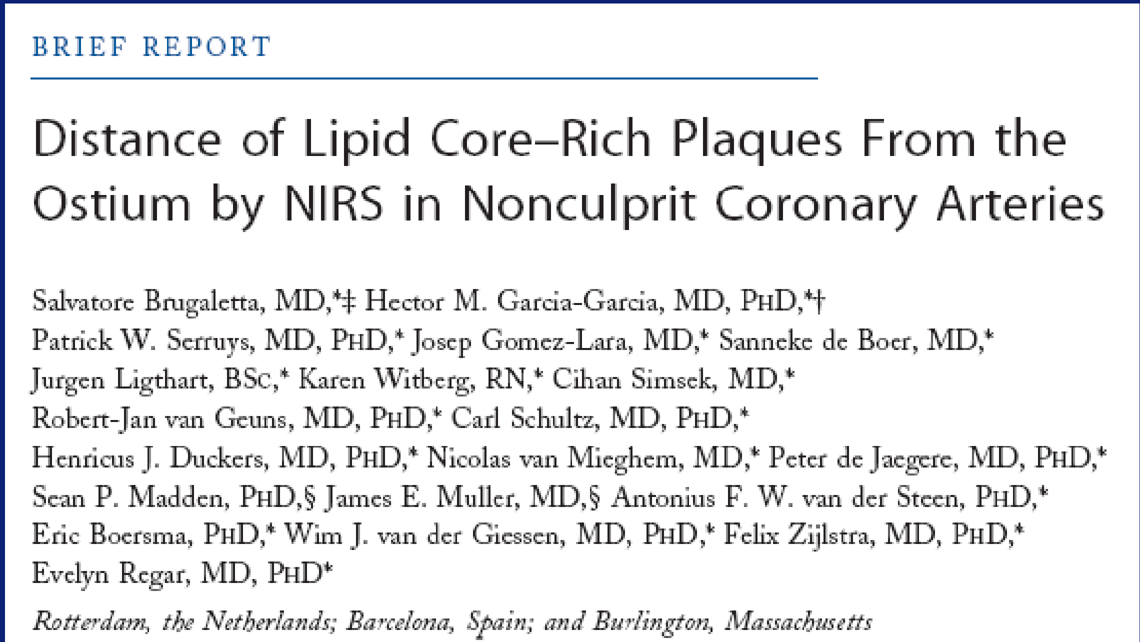
> 60 deg angular extent

Cap < 450 µm thick



Gardner et al: J Am Coll Cardiol Img 2008;1:638–48)

NIRS: Distance From the Ostium
A Predictor of Lipid Core Plaque ?

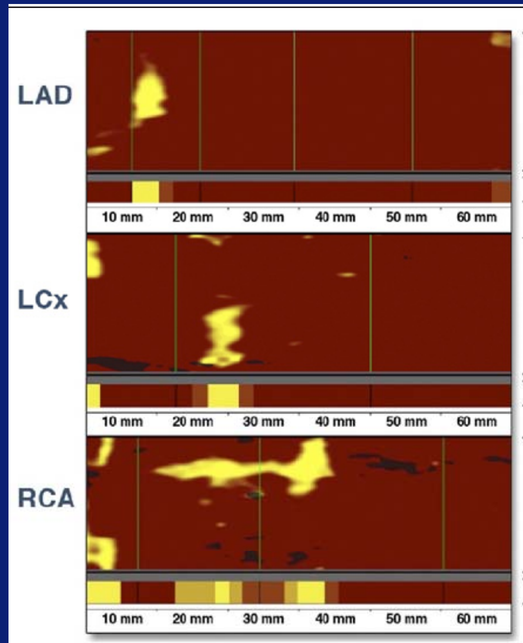


BRIEF REPORT

Distance of Lipid Core–Rich Plaques From the Ostium by NIRS in Nonculprit Coronary Arteries

Salvatore Brugaletta, MD,*‡ Hector M. Garcia-Garcia, MD, PHD,*†
Patrick W. Serruys, MD, PHD,* Josep Gomez-Lara, MD,* Sanneke de Boer, MD,*
Jurgen Ligthart, BSc,* Karen Witberg, RN,* Cihan Simsek, MD,*
Robert-Jan van Geuns, MD, PHD,* Carl Schultz, MD, PHD,*
Henricus J. Duckers, MD, PHD,* Nicolas van Mieghem, MD,* Peter de Jaegere, MD, PHD,*
Sean P. Madden, PHD,§ James E. Muller, MD,§ Antonius F. W. van der Steen, PHD,*
Eric Boersma, PHD,* Wim J. van der Giessen, MD, PHD,* Felix Zijlstra, MD, PHD,*
Evelyn Regar, MD, PHD*

Rotterdam, the Netherlands; Barcelona, Spain; and Burlington, Massachusetts

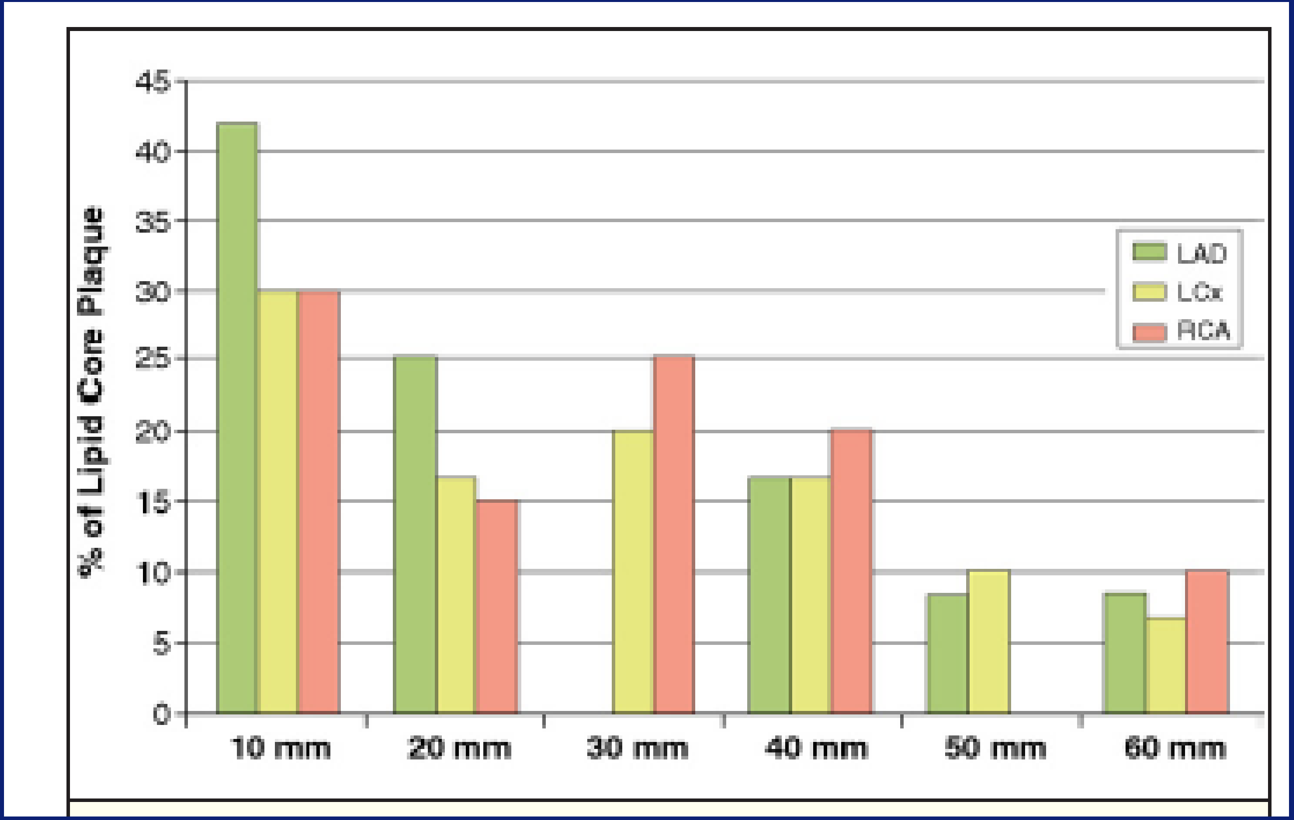


Single center,
observational study
N=68 Pts
Non culprit arteries
ROI 58±4.3mm

Brugaletta et al; JACC Cardiovasc Img 2012

NIRS: Distance From the Ostium
A Predictor of Lipid Core Plaque ?

Distance from the ostium
is an independent predictor of LCP: OR 0.37 ; CI 0.20-0.69



Single center,
observational study
N=68 Pts
Non culprit arteries
ROI   58±4.3mm

Brugaletta et al; JACC Cardiovasc Img 2012

Immediate Stent Complication: Distal Embolization - NIRS Plaque Evaluation

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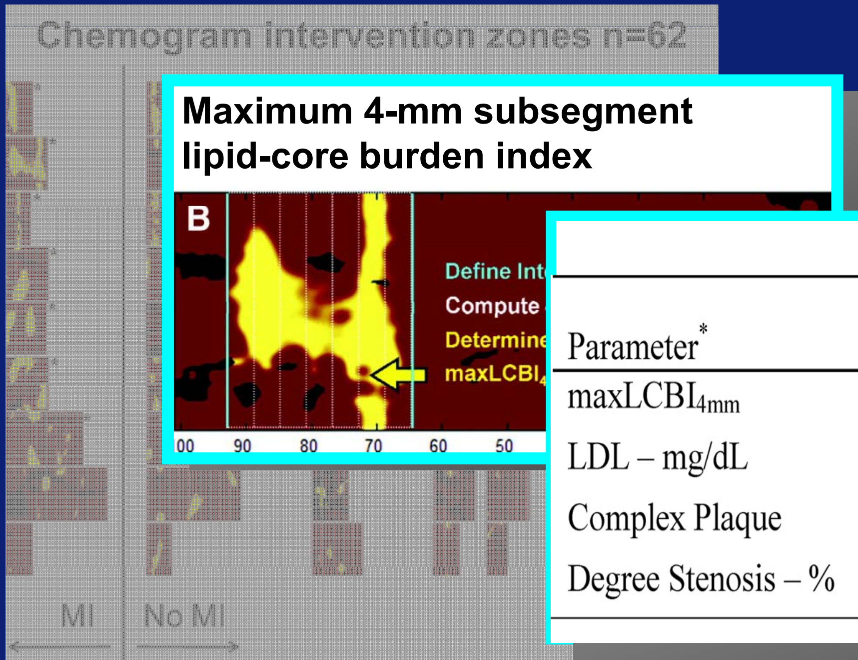
Detection of Lipid-Core Plaques by Intracoronary Near-Infrared Spectroscopy Identifies High Risk of Periprocedural Myocardial Infarction

James A. Goldstein, MD; Brijeshwar Maini, MD; Simon R. Dixon, MBChB; Emmanouil S. Brilakis, MD, PhD; Cindy L. Grines, MD; David G. Rizik, MD; Eric R. Powers, MD; Daniel H. Steinberg, MD; Kendrick A. Shunk, MD, PhD; Giora Weisz, MD; Pedro R. Moreno, MD; Annapoorna Kini, MD; Samin K. Sharma, MD; Michael J. Hendricks, BS; Steve T. Sum, PhD; Sean P. Madden, PhD; James E. Muller, MD; Gregg W. Stone, MD; Morton J. Kern, MD



Relative risk of periprocedural MI

Parameter*	Threshold†	Relative risk of peri-procedural MI (95% CI)		$p^{‡}$
$maxLCBI_{4mm}$	≥500		12 (3.3 to 48)	0.0002
LDL – mg/dL	>100		5.4 (1.4 to 23)	0.03§
Complex Plaque	Y		3.5 (0.91 to 14)	0.15
Degree Stenosis – %	>75		3.1 (0.92 to 11)	0.14**

Goldstein J at el. Circ Cardiovasc Interv 2011:4:429-437

Vulnerable Plaque, Vulnerable Neointima

Intravascular Ultrasound **IVUS VH**

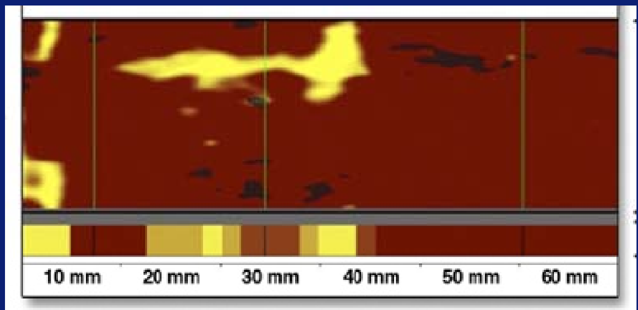
Near Infrared Spectroscopy **NIRS**

Optical Coherence Tomography **OCT**

Pitfalls

NIRS
Pitfalls (1)

Chemogram

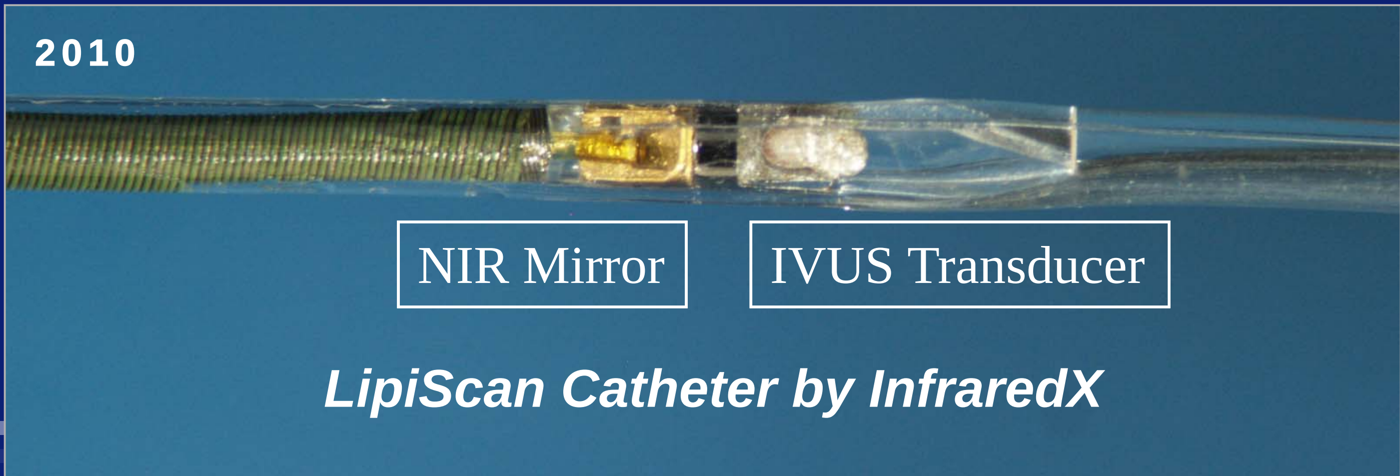


- Poor orientation within the artery
- No anatomic structures
- No information on the extent of plaque

NIRS
Pitfalls -> Solution

- **Catheter: 3.2Fr, 6Fr compatible, 0.014” guidewire**
- **NIRS: Same as LipiScan^{TM}**, cleared by FDA Apr ‘08
- **Ultrasound: 40MHz, 16 fps**
- **Pullback speed: 0.5mm/sec**
- **Single catheter & pullback, thru blood**

  → simultaneous, co-registered NIR & IVUS data



LipiScan Catheter by InfraredX

Savoir Trial

First in Man Evaluation of a Combined Optical/Ultrasound Catheter

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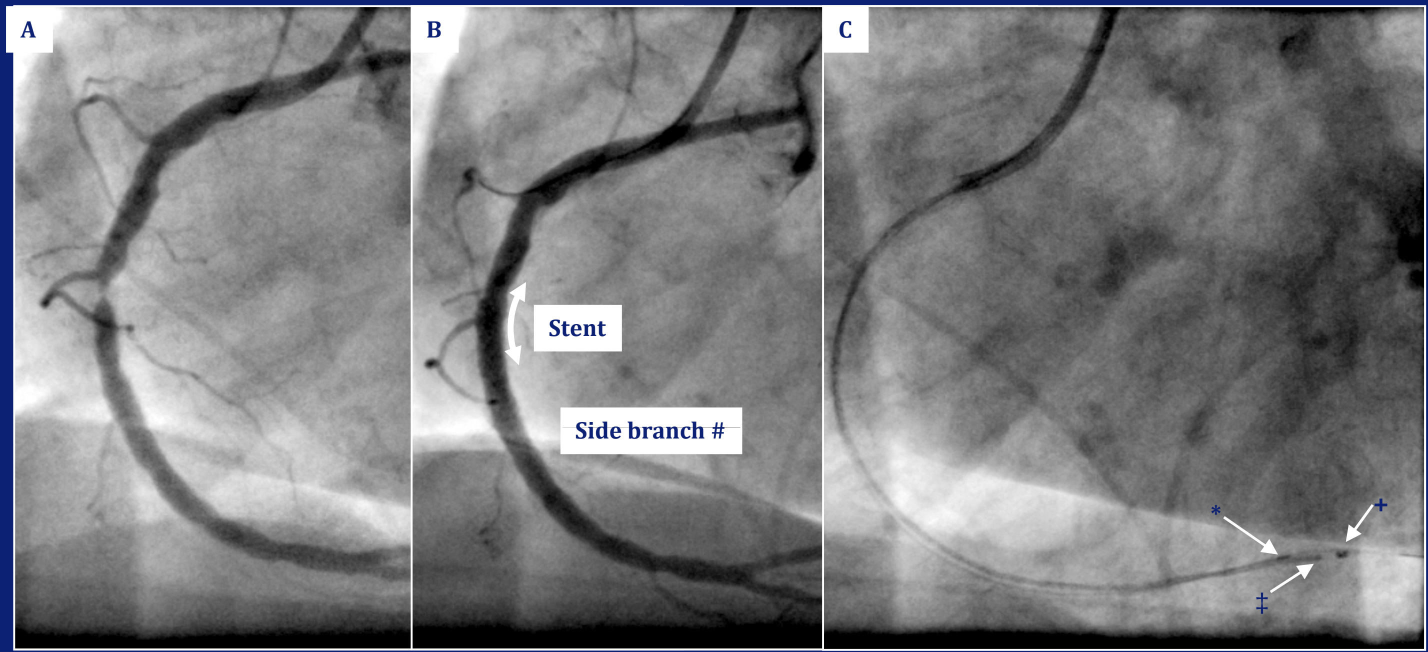
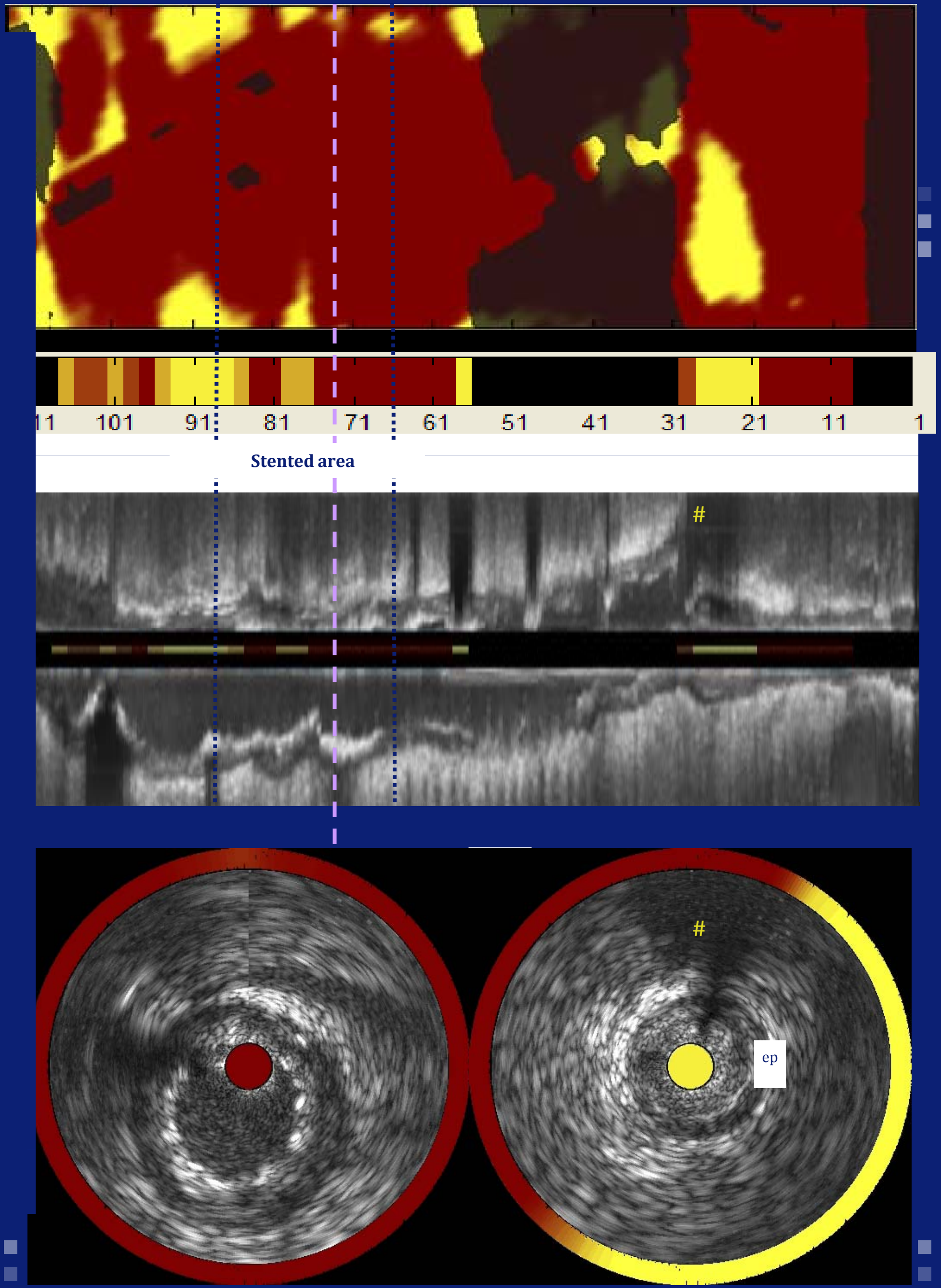
Simultaneous Acquisition of Intravascular Ultrasound and Near Infrared Spectroscopy Data in the Coronary Artery Study





Chemogram

Block chemogram

Automated Detection
of Lipid-core Plaques

Longitudinal IVUS

Cross sectional IVUS

- Lumen Dimension
- Plaque Size
- Stent Expansion

Garg et al; Eurointervention 2010

NIRS Pitfalls (2)

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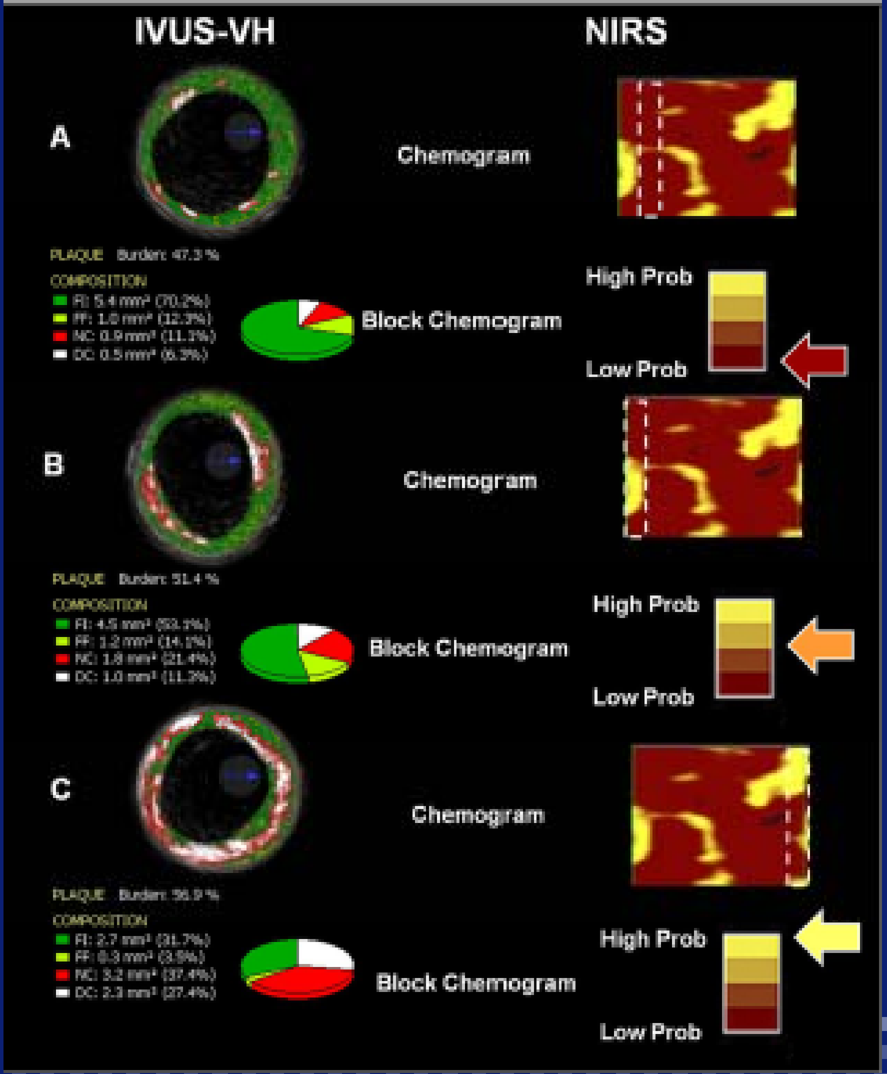

NIRS and IVUS for Characterization of Atherosclerosis in Patients Undergoing Coronary Angiography

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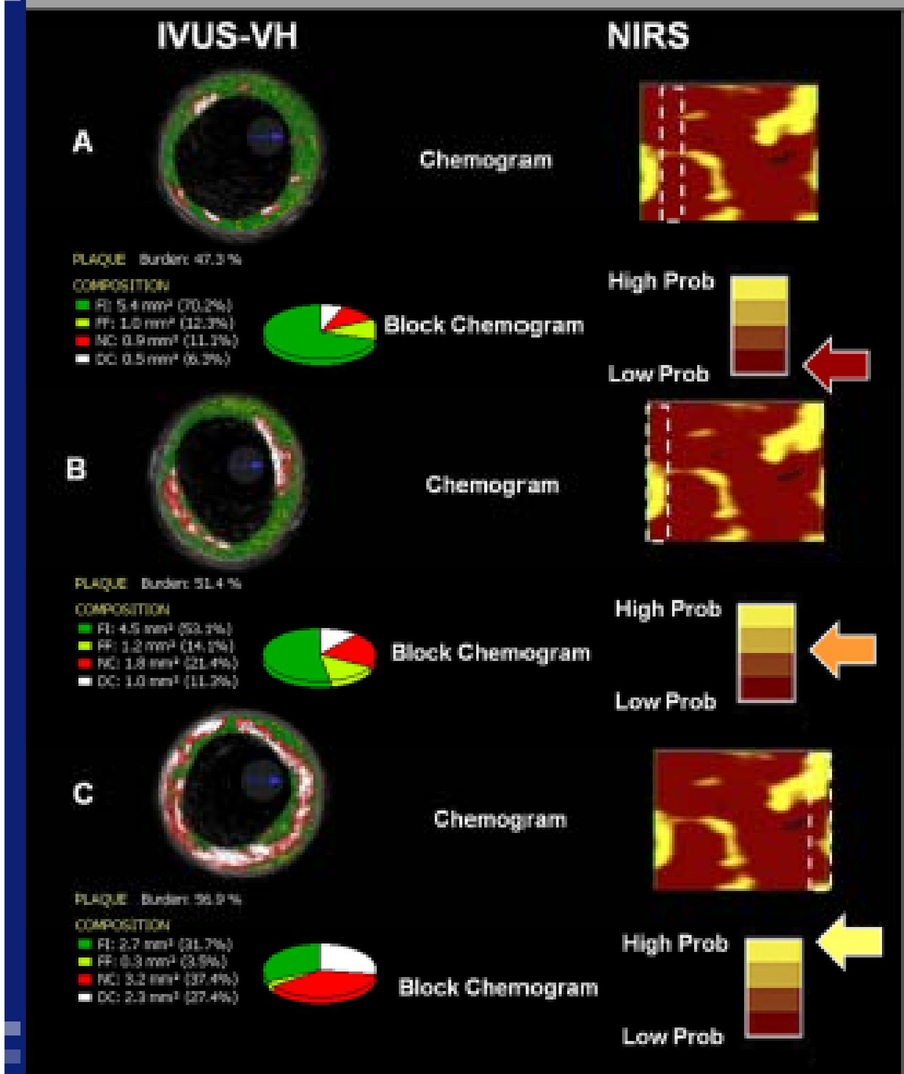
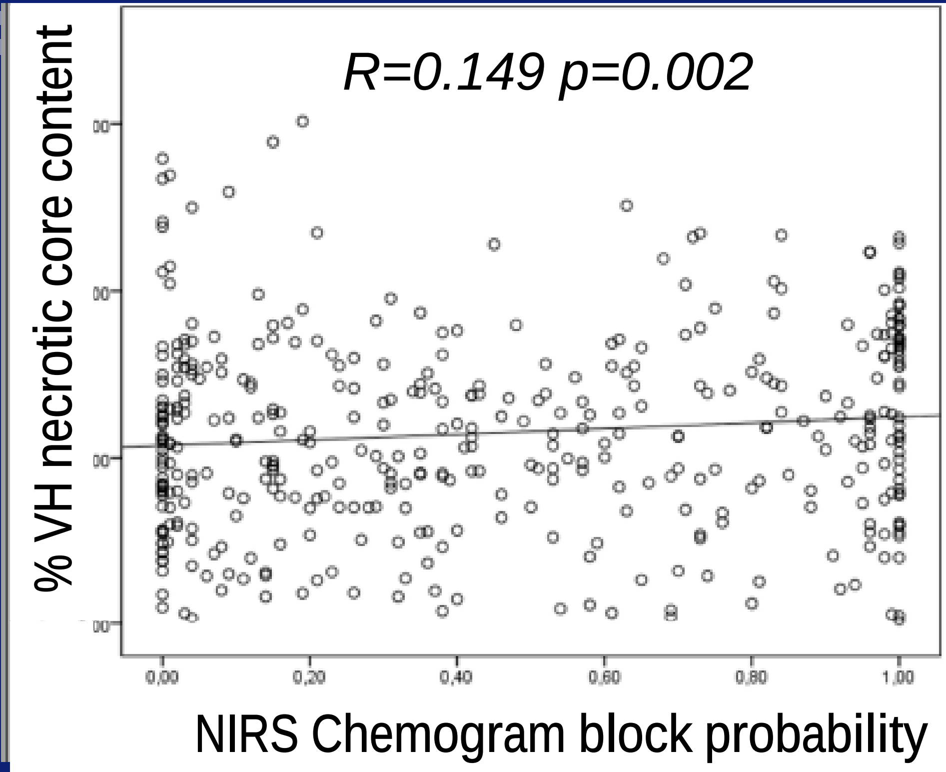
Rotterdam and Amsterdam, the Netherlands; Barcelona, Spain; and Burlington, Massachusetts

Does
“lipid-core plaque” by NIRS &
“necrotic core” by VH
refer to the same anatomical substrate?

Brugaletta et al; JACC Cardiovasc Img 2011

NIRS Pitfalls (2)





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Near Infrared Spectroscopy **NIRS**

Optical Coherence Tomography **OCT**

Safety

OCT Safety: 2nd Generation, Fourier Domain OCT

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Safety and feasibility of frequency domain optical coherence tomography to guide decision making in percutaneous coronary intervention

Fabrizio Imola[1,2], MD; Maria Teresa Mallus[1], MD, PhD; Vito Ramazzotti[1], MD; Alessandro Manzoli[1], MD, PhD; Alessandro Pappalardo[1], MD; Alessandro Di Giorgio[2], MD; Mario Albertucci[2], MD; Francesco Prati[1,2]*, MD

1. Interventional Cardiology, San Giovanni Hospital, Rome, Italy; 2. CLI Foundation, Rome, Italy

Single center, n=90 pts

Imaging success	*99.1%*
X-ray contrast for flush	*49.4±19.0ml*
Serum creatinin pre	*1.17±0.12*
Serum creatinin post	*1.21±0.19*
Coronary spasm	*1 pt*
ECG changes	*0 pt*
Ventricular ectopic beats	*3 pts*
MACE	*0 pt*

First-in-man evaluation of intravascular optical frequency domain imaging (OFDI) of Terumo: a comparison with intravascular ultrasound and quantitative coronary angiography

Takayuki Okamura[1], MD, PhD; Yoshinobu Onuma[1], MD; Héctor M. Garcia-Garcia[2], MD, PhD; Robert-Jan M van Geuns[1], MD, PhD; Joanna J. Wykrzykowska[1], MD; Carl Schultz[1], MD, PhD; Willem J van der Giessen[1], MD, PhD; Jurgen Ligthart[1], BSc; Evelyn Regar[1], MD, PhD; Patrick W Serruys[1]*, MD, PhD

1. Thoraxcenter, Erasmus MC, Rotterdam, The Netherlands; 2. Cardialysis BV, Rotterdam, The Netherlands

Single center, n=19 pts

X-ray contrast for flush	*15.4 ml*
MACE	*0 pt*

Prati et al. EuroIntervention 2010

Okamura et al. EuroIntervention 2011

How does the flushing procedure affect Renal function ?

Erasmus MC

Circulation Journal
Official Journal of the Japanese Circulation Society
http://www.j-circ.or.jp

ORIGINAL ARTICLE
Imaging

Comparison of Contrast Media and Low-Molecular-Weight Dextran for Frequency-Domain Optical Coherence Tomography

Yuichi Ozaki, MD; Hironori Kitabata, MD, PhD; Hiroto Tsujioka, MD, PhD; Seiki Hoso
Manabu Kashiwagi, MD; Kohei Ishibashi, MD; Kenichi Komukai, MD; Takashi Tanimoto, M
Yasushi Ino, MD; Shigeho Takarada, MD, PhD; Takashi Kubo, MD, PhD; Keizo Kimura, M
Atsushi Tanaka, MD, PhD; Kumiko Hirata, MD, PhD; Masato Mizukoshi, MD, PhD
Toshio Imanishi, MD, PhD; Takashi Akasaka, MD, PhD

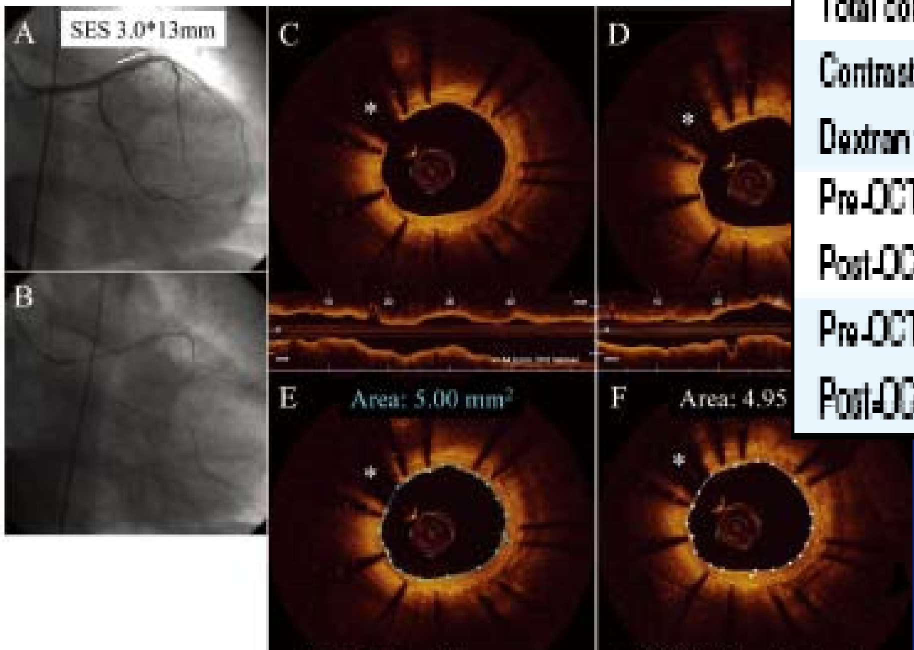

Table 3. Contrast/dextran Volume and Renal Function	
Total contrast media including that for OCT image (ml)	183±43
Total contrast media excluding that for OCT image (ml)	166±44
Contrast for OCT (ml)	16.8±1.7
Dextran for OCT (ml)	18.4±4.2
Pre-OCT Cr (mg/dl)	0.83±0.24
Post-OCT Cr (mg/dl)	0.82±0.24
Pre-OCT eGFR (ml·min^{-1}·1.73m^{-2})	69.9±17.9
Post-OCT eGFR (ml·min^{-1}·1.73m^{-2})	69.9±16.7

FD-OCT X-ray contrast dextran L

Ozaki Y et al. Circ J 2012.

2nd Generation OCT at Thoraxcenter Patient Population (n=838)

Erasmus MC

Age (Years)	61± 10	
Male	628	(75%)
Risk factors		
Hypertension	439	(52%)
Diabetes	142	(18%)
Dyslipidemia	483	(58%)
Smoking	380	(45%)
Family history CAD	377	(45%)
Prior MI	267	(32%)
Prior CABG	49	(6%)
Prior PCI	411	(49%)
Clinical presentation		
Stable angina	299	(36%)
Unstable angina	178	(21%)
AMI	208	(25%)
Previous PCI/Fup	144	(18%)

T. Okamura et al. unpublished

2nd Generation OCT at Thoraxcenter
Patient Population (n=838)

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Major complications during or within 24 hour after the procedure

Death	0
Cerebral infarction	0
TIA	0
Myocardial infarction	0
Emergency CABG	0

Adverse events during or within 24 hour after the procedure*

ECG changes	0
Arrythmia	3
VF	0
Vasospasm	2

* Non self-limiting

T. Okamura et al. unpublished

Vulnerable Plaque, Vulnerable Neointima

Intravascular Ultrasound **IVUS VH**

Near Infrared Spectroscopy **NIRS**

Optical Coherence Tomography **OCT**

Pitfalls

OCT Plaque Characterization
In Vivo Coronary Arteries

Fibroatheroma (A)

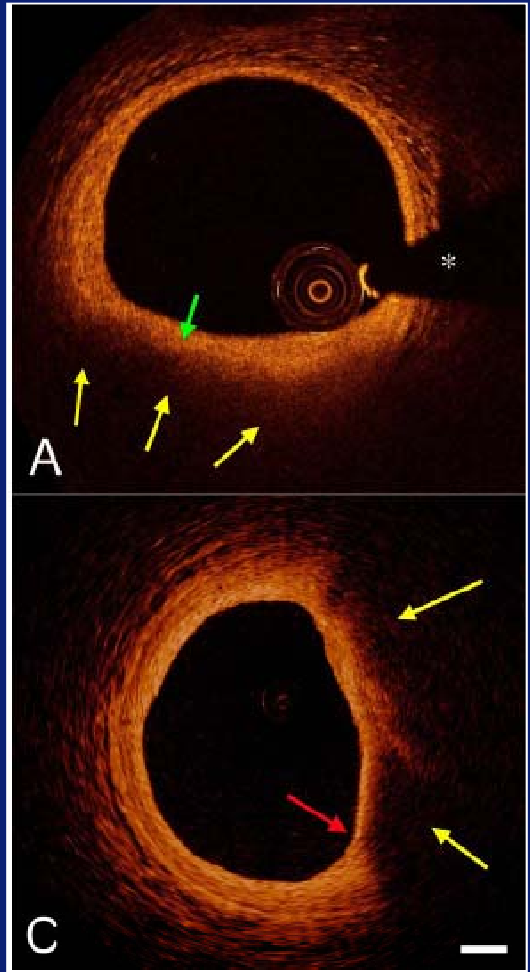
lesion with an OCT-delineated fibrous cap and a lipid pool

OCT thin cap fibroatheroma (C)

an OCT-delineated necrotic core with an overlying fibrous cap where the min. thickness is less than a predetermined threshold

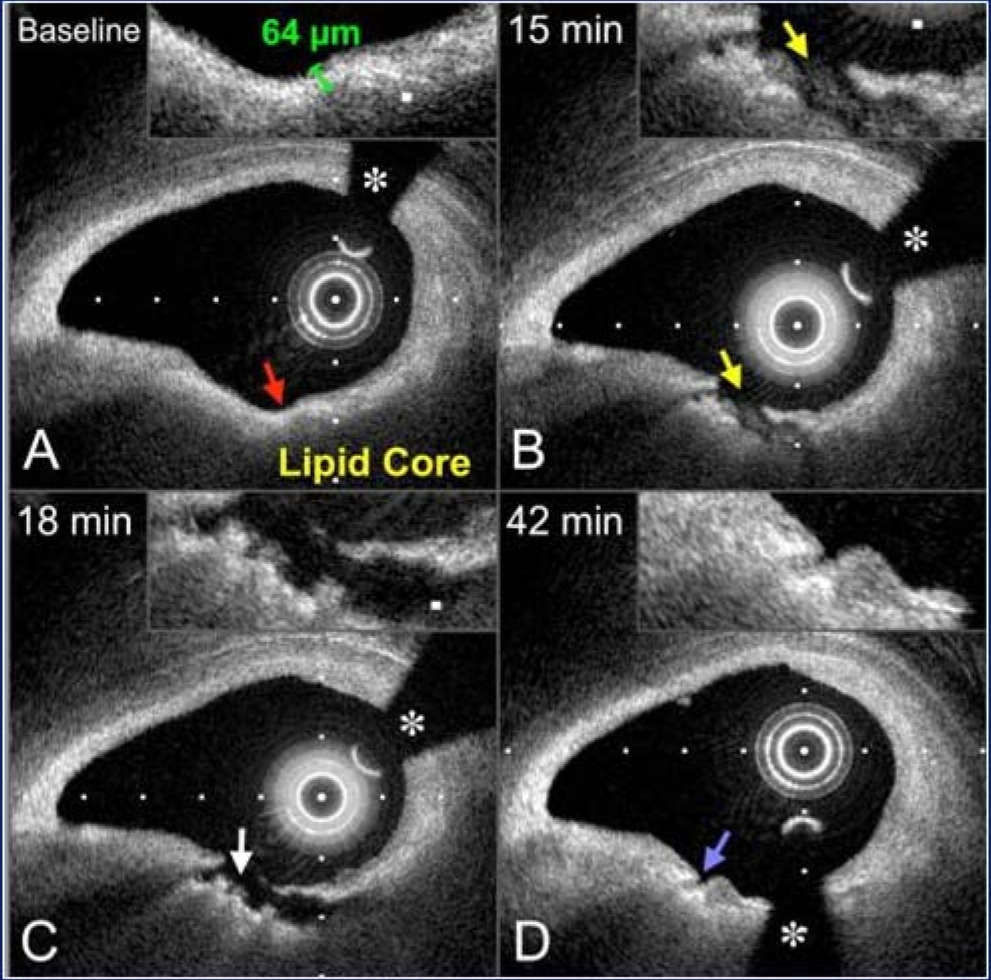
Fibrous cap

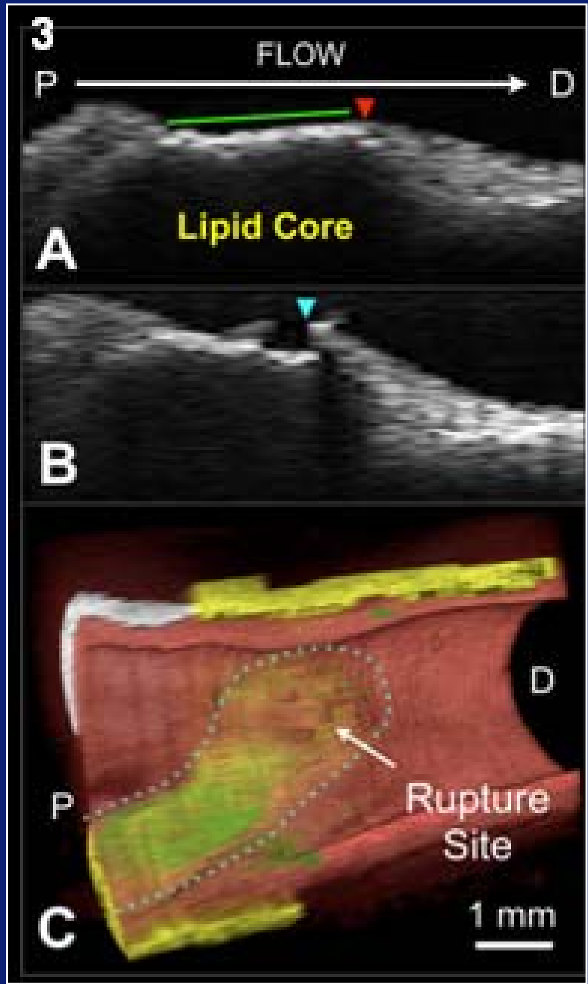
is a tissue layer, which is often signal-rich, overlying a lipid pool, necrotic core, or calcium.



International Working Group on OCT Standardization and Validation; JACC. 2012

OCT: Witnessed Plaque Rupture





Gonzalo N et al. JACC Imaging 2011

OCT Pitfalls (1)

OCT TCFA - Comparison to Histologic Classification

	Fibrous tissue area		
OCT	**Thick** *160-910 µm*	**Medium-thin** *90-140 µm*	**Thin** *30-60 µm*
	38	**9**	**13**
Histo	*25 Thick fibrous cap* *8 Fibro-calcific* *5 Fibrous*	*11 Thin fibrous cap* *11 Fibro-calcific*	

to 2 main limitations of OCT imaging. First, the penetration depth of OCT is limited to 1 to 2 mm, which does not allow the accurate detection of signal-poor areas possibly representing lipid pools or calcium behind fibrous tissue. This may generate false-positive fibrous plaques, false-negative fibrocalcific plaques, and false-negative thick-cap fibroatheromas. Second, OCT analysis often confuses the presence of lipid pools with that of calcium deposits, or vice versa. As

Manfrini et al: **Am J Cardiol 2006;98**

OCT Pitfalls (1)

Confusion of Lipid with Calcium

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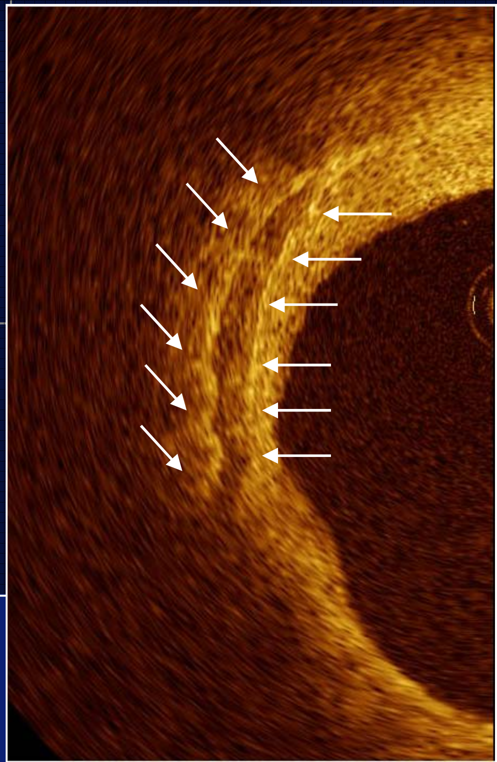
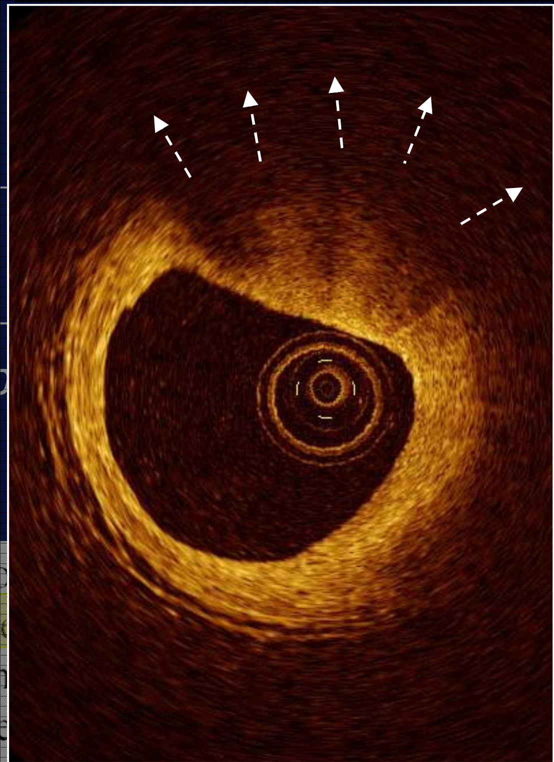
OCT		Thin 30-60 µm
		13
Histo	...n fibrous cap ...ro-calcific	

Calcified lesion



Sharply delineated borders

Lipid-rich lesion



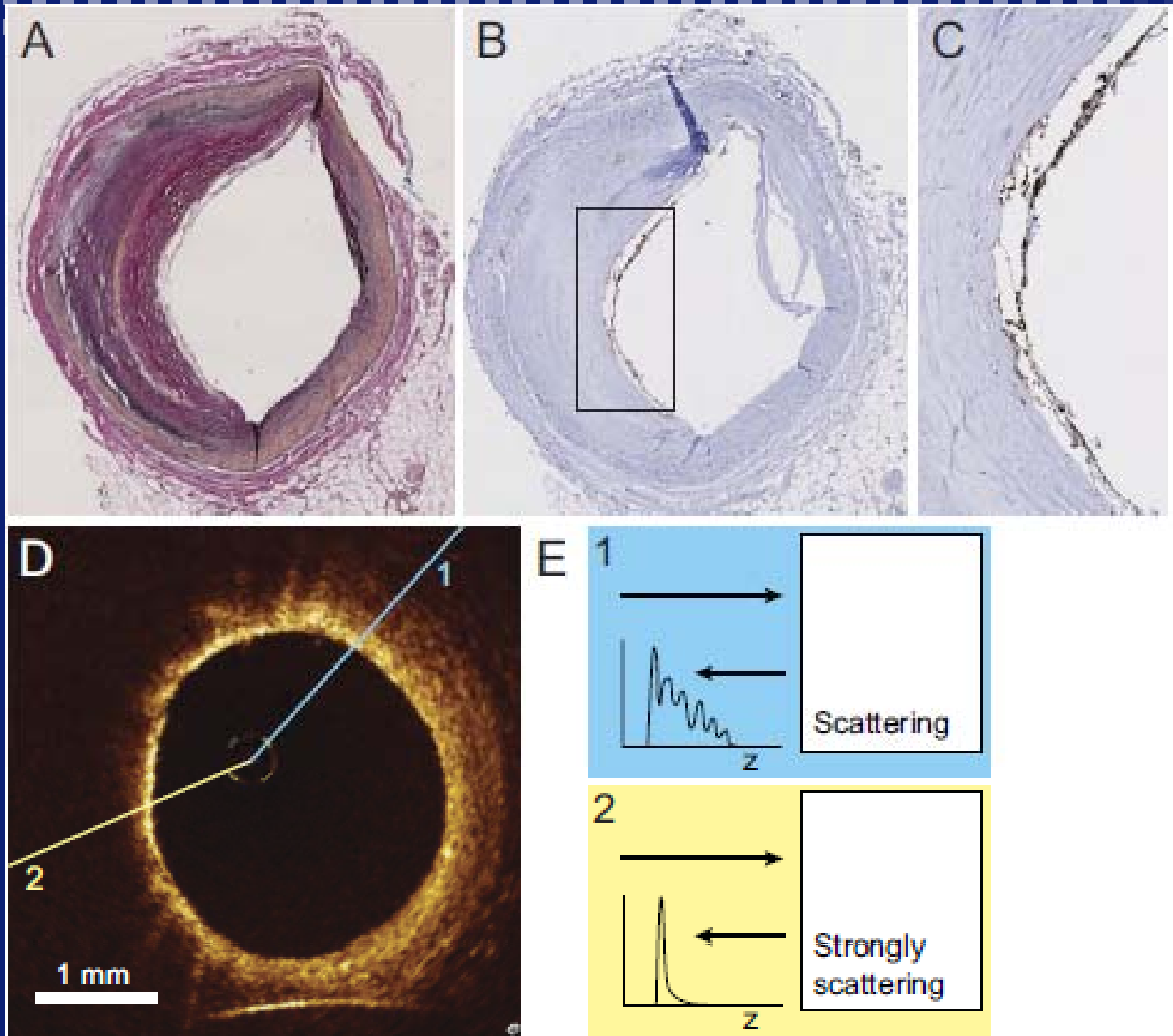
Diffuse borders

...ging. First, the penetration ... mm, which does not allow ... poor areas possibly repre-... behind fibrous tissue. This ... us plaques, false-negative ... gative thick-cap fibroathe-romas. Second, OCT analysis often confuses the presence of lipid pools with that of calcium deposits, or vice versa. As

clinical examples

OCT Pitfalls (2)

Artefacts: Macrophage scattering



The region of thickened intima appears as a TCFA

due to strong scattering & shadowing by macrophages.

Van Soest G et al, J Biomed Opt 2010

OCT Pifalls (2)

Artefacts cause misclassification!

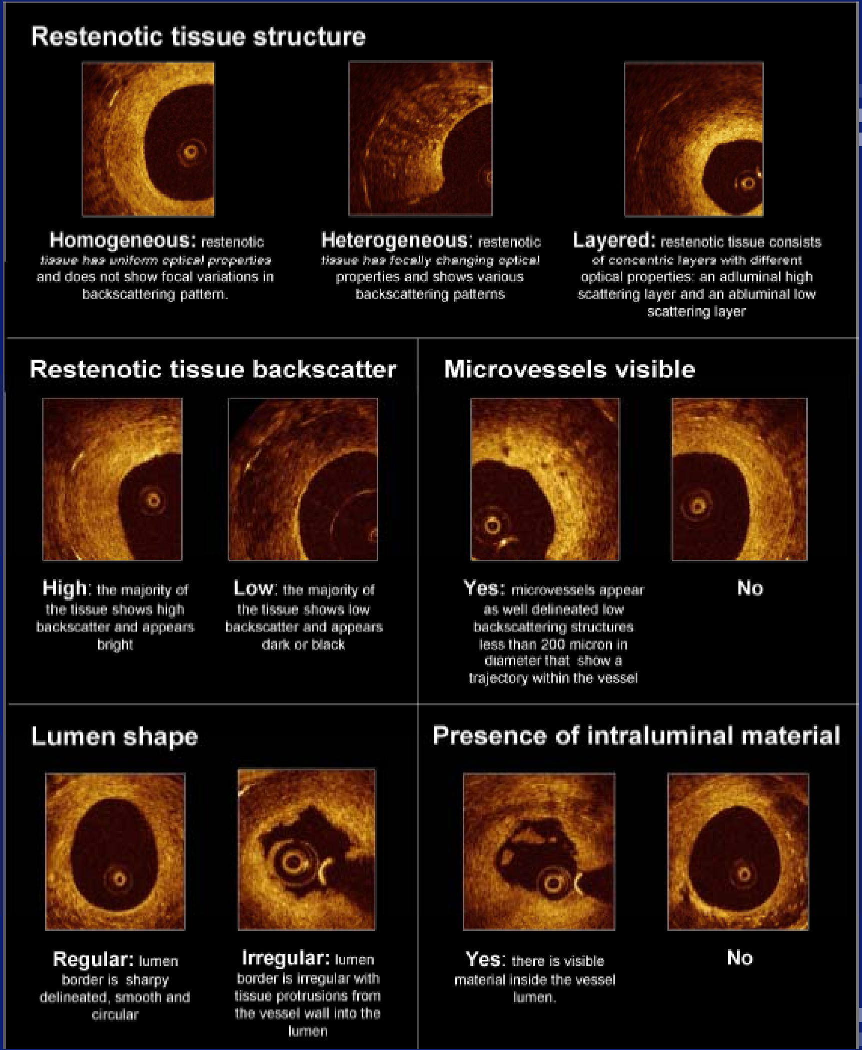
Incidence of artefacts in clinical setting

Category	# observations Pullbacks Total 37	Sections	Frames Total 4597
1: Superficial attenuation	16	26	94
2: Tangential signal dropout	15	27	145
3: Catheter shadowing	12	21	35
4: Axial PSF tail	0	0	0
5: Proximity brightening	12	17	313

Van Soest G et al, J Biomed Opt 2010

OCT Pifalls (3)

Validation



OCT Assessment of Strut Coverage Qualitative Parameters

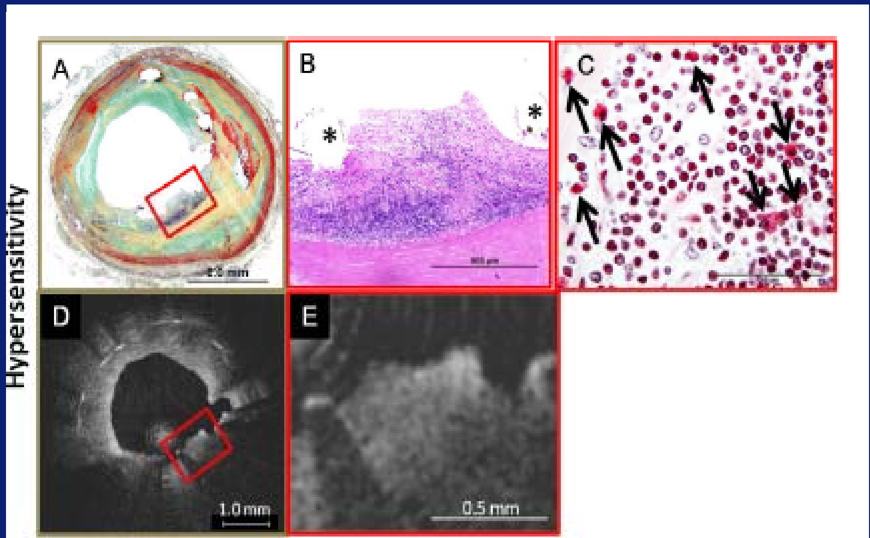
Parameter	K
Restenotic tissue structure	0.92
Restenotic tissue backscatter	0.57
Lumen shape	0.85
Intraluminal material	0.83
Microvessels	0.79

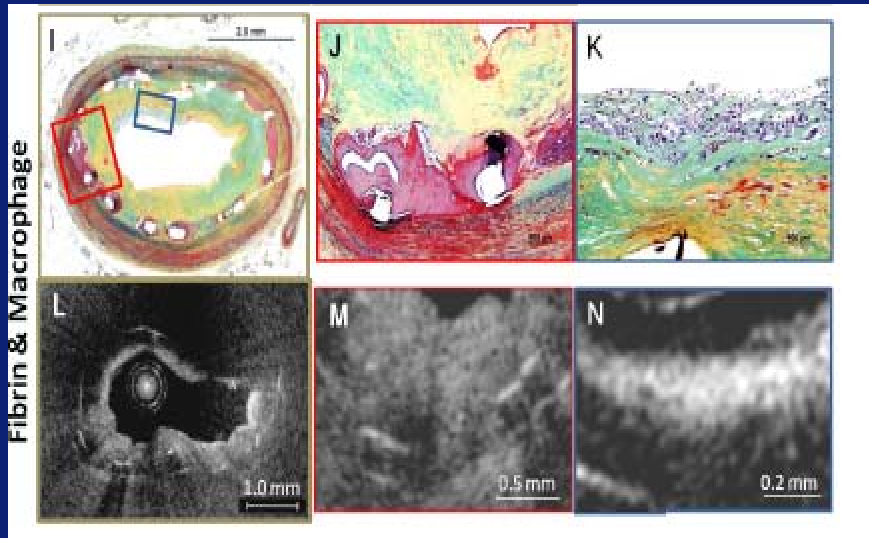
Interobserver reproducibility

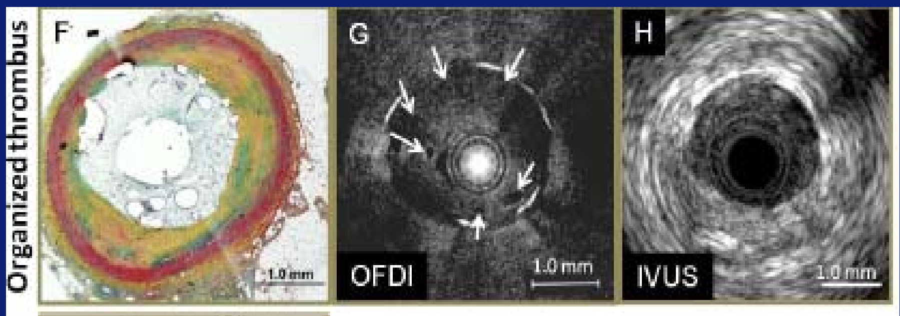
Gonzalo et al. Am Heart J 2009

OCT Pifalls (3)

Validation







Nakano M et al. JACC: Cardiovascular Imaging 2012; 5 (1),71-82

Vulnerable Plaque, Vulnerable Neointima

Intravascular Ultrasound	**IVUS VH**
Near Infrared Spectroscopy	**NIRS**
Optical Coherence Tomography	**OCT**

Safety
Pitfalls

Future Directions

Erasmus MC

Vulnerable Plaque, Vulnerable Neointima

Technology

-Tissue characterization

IVUS VH

-Co- registration with the angiogram

NIRS

-3D rendering (real time)

OCT

Future Directions

Vulnerable Plaque, Vulnerable Neointima

Erasmus MC

Technology

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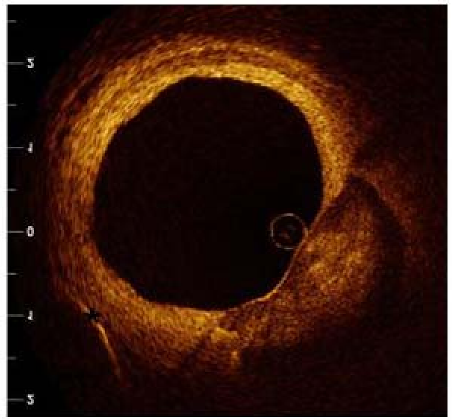
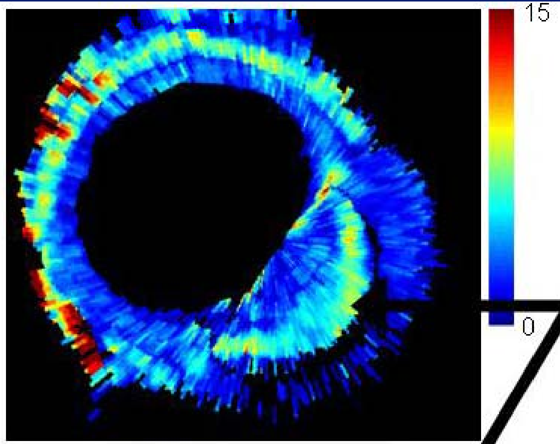
OCT

Future Directions

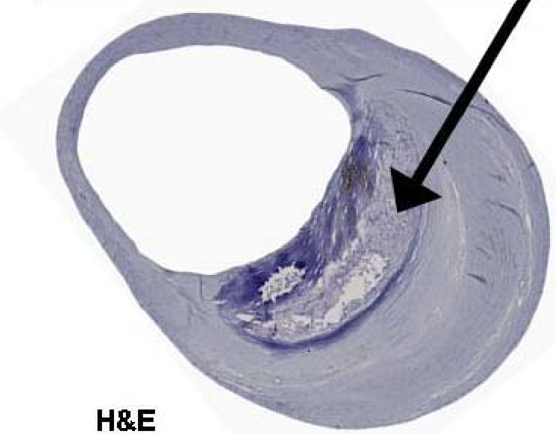
OCT Tissue Characterization
Optical Attenuation Imaging: *Ex-Vivo*

High attenuation is associated with markers of plaque vulnerability





Quantified optical attenuation in OCT image and correlated with tissue type in histology



Necrotic Core

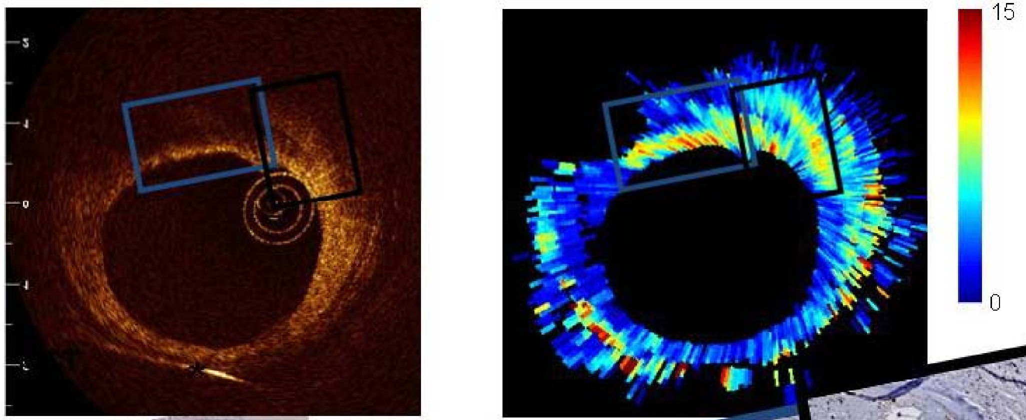
Fibrous	2 – 5 mm^{-1}
Calcium	0 – 5 mm^{-1}
Necrotic core	$\gtrsim$10 mm^{-1}
Macrophages	> 12 mm^{-1}

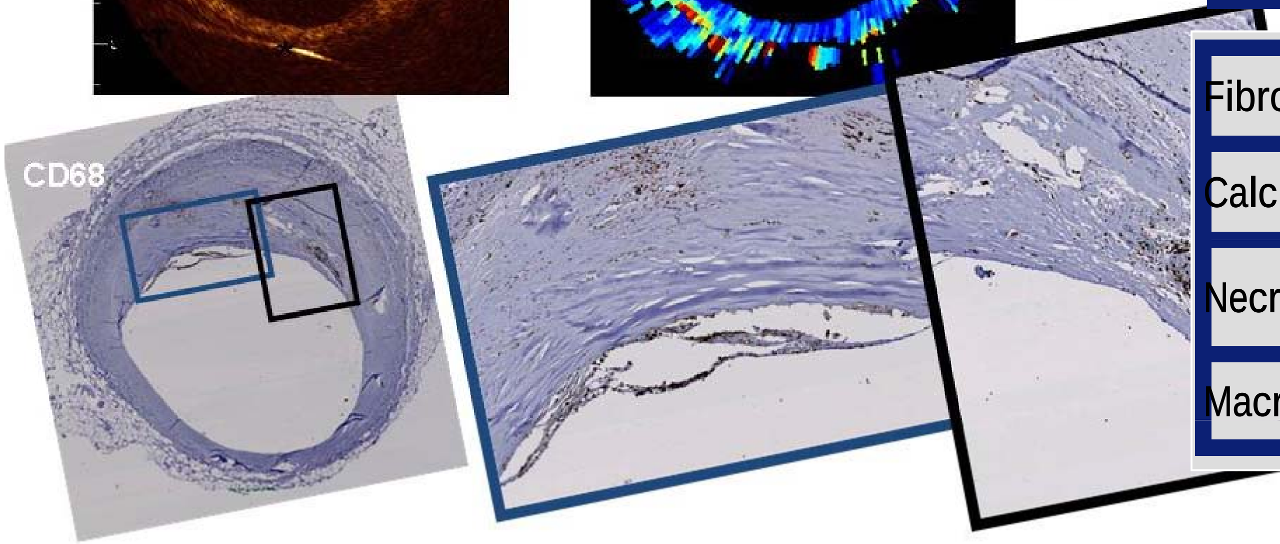
van Soest G et al, J. Biomed. Opt. 2010

OCT Tissue Characterization
Optical Attenuation Imaging: *Ex-Vivo*

Erasmus MC

High attenuation is associated with markers of plaque vulnerability



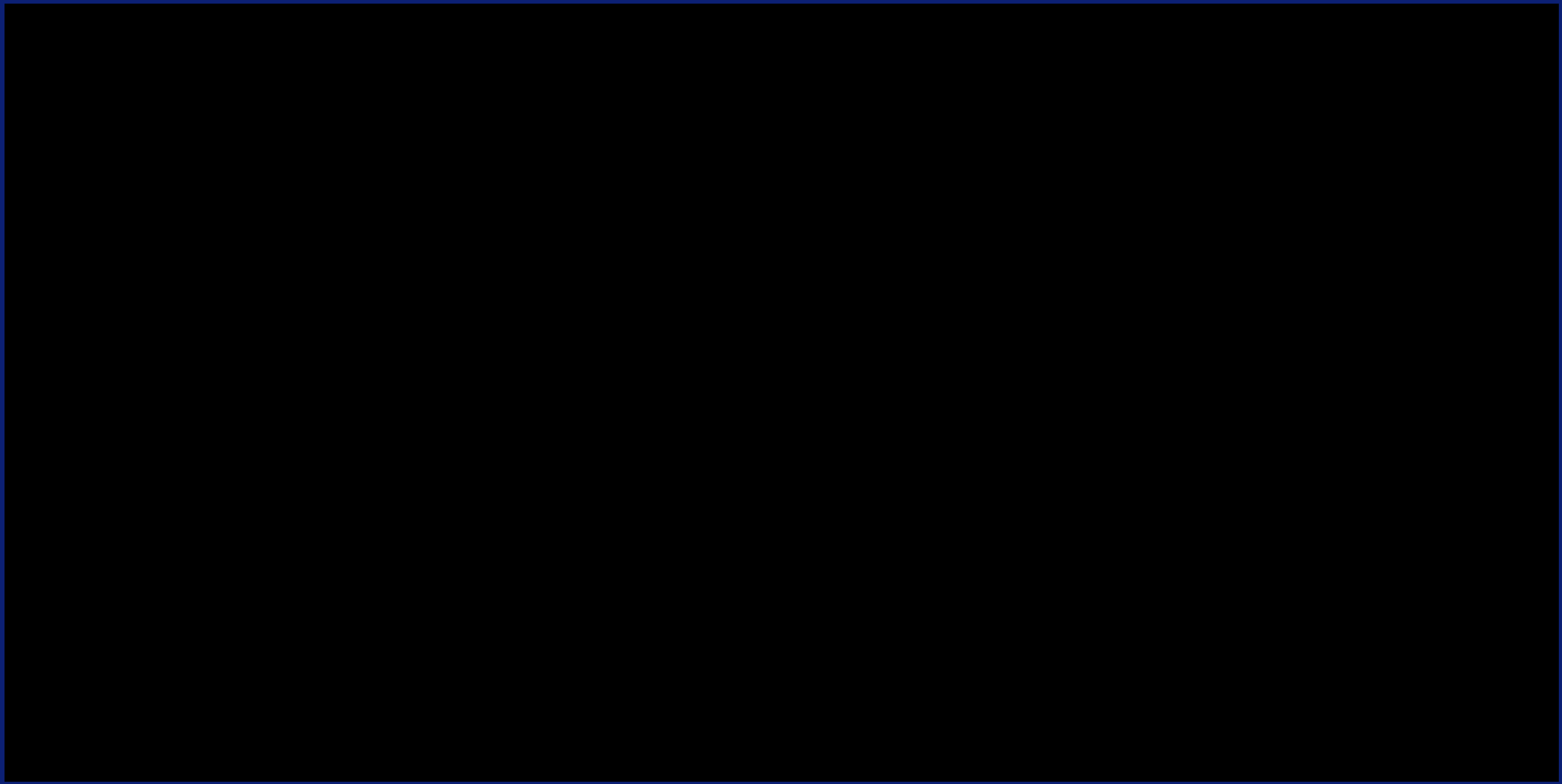


Macrophages

Fibrous	2 – 5 mm^{-1}
Calcium	0 – 5 mm^{-1}
Necrotic core	≳10 mm^{-1}
Macrophages	> 12 mm^{-1}

van Soest G et al, J. Biomed. Opt. 2010

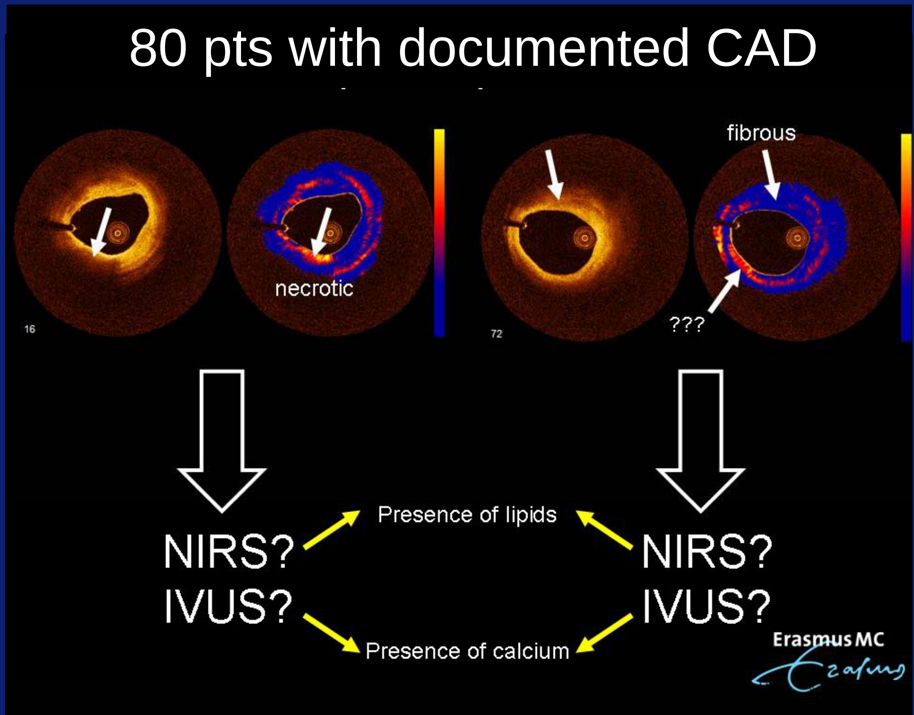
OCT Tissue Characterization
Optical Attenuation Imaging: *In-Vivo*



OCT tissue type Imaging
Validation by Lipiscan-IVUS: OC3T Study

Objective: Validation of OCT-derived tissue optical properties in vivo

Design: Single-center, prospective, observational, cross-sectional



Funded by the Dutch Heart Foundation – 2010B064; MEC-2011-030

Erasmus MC

Vulnerable Plaque, Vulnerable Neointima

Technology

-Tissue characterization

IVUS VH

-Co- registration with the angiogram

NIRS

-3D rendering (real time)

OCT

Future Directions

OCT – Angiography Co-Registration

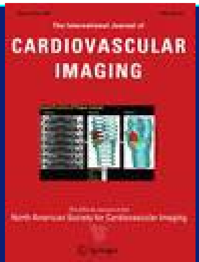
Erasmus MC

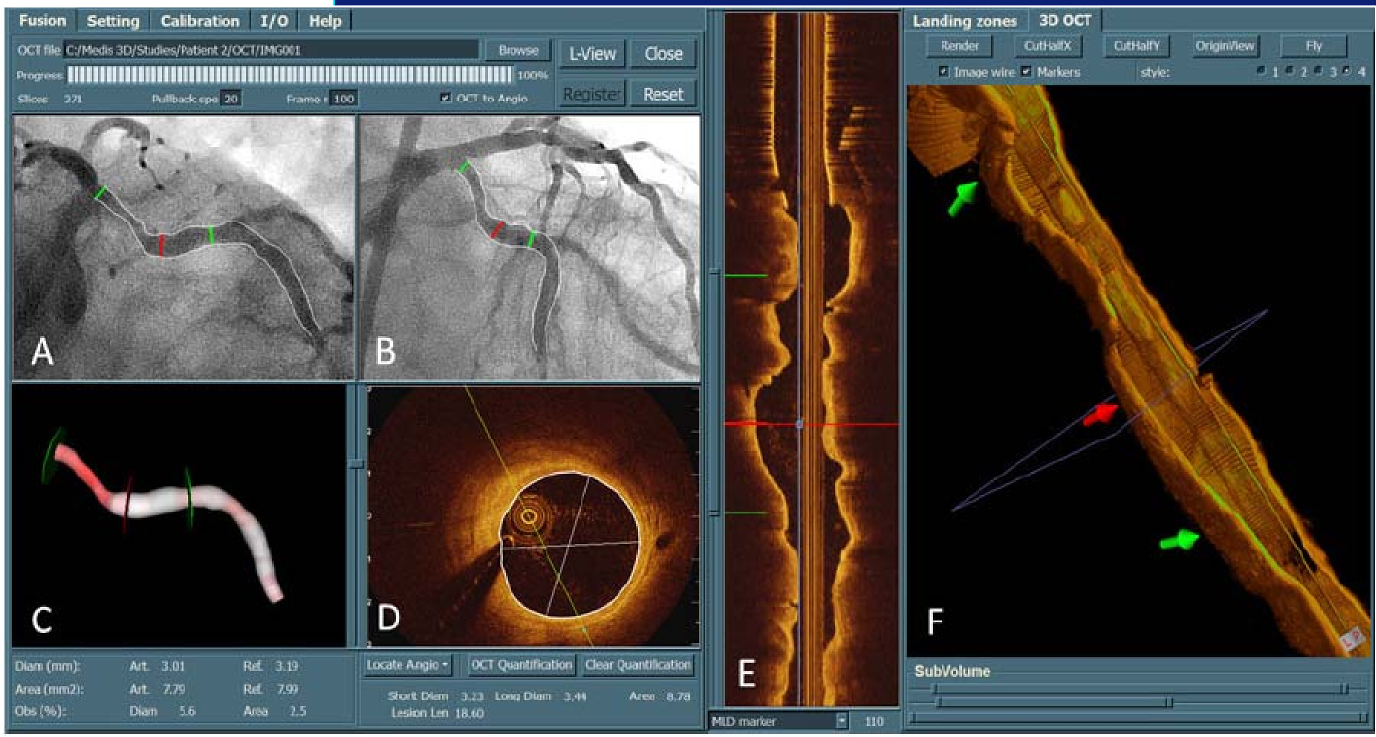
Int J Cardiovasc Imaging
DOI 10.1007/s10554-012-0016-6

ORIGINAL PAPER

In vivo comparison of arterial lumen dimensions assessed by co-registered three-dimensional (3D) quantitative coronary angiography, intravascular ultrasound and optical coherence tomography

Shengxian Tu · Liang Xu · Jurgen Ligthart · Bo Xu · Karen Witberg · Zhongwei Sun · Gerhard Koning · Johan H. C. Reiber · Evelyn Regar





Tu, Regar et al. Int J Cardiovasc Imaging 2012

OCT – Angiography Co-Registration

Erasmus MC

Int J Cardiovasc Imaging
DOI 10.1007/s10554-012-0016-6

ORIGINAL PAPER

In vivo comparison of arterial lumen dimensions assessed by co-registered three-dimensional (3D) quantitative coronary angiography, intravascular ultrasound and optical coherence tomography

Shengxian Tu · Liang Xu · Jurgen Ligt…
Karen Witberg · Zhongwei Sun · Gerha…
Johan H. C. Reiber · Evelyn Regar

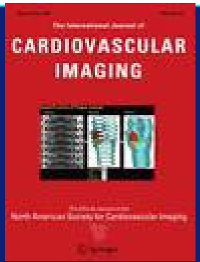


Table 3 Comparison between 3D QCA and OCT in assessing lumen size

	OCT	3D QCA	Difference (95% CI)	Intra-observer variability[a]	Inter-observer variability[a]
Positions, $n = 541$					
Short diameter (mm)	2.70 ± 0.65	2.57 ± 0.61	0.14(0.11–0.16)†	0.000 ± 0.013	0.003 ± 0.029
Long diameter (mm)	3.11 ± 0.72	2.80 ± 0.62	0.30 (0.27–0.33)†	0.003 ± 0.024	0.006 ± 0.035
Lumen area (mm^2)	7.01 ± 3.28	5.93 ± 2.66	1.07 (0.95–1.20)†	0.002 ± 0.039	0.021 ± 0.059
Vessels, $n = 40$					
Short diameter (mm)	2.71 ± 0.46	2.57 ± 0.43	0.14 (0.09–0.19)†	–	–
Long diameter (mm)	3.11 ± 0.52	2.81 ± 0.45	0.30 (0.24–0.37)†	–	–
Lumen area (mm^2)	7.02 ± 2.34	5.94 ± 1.91	1.08 (0.80–1.37)†	–	–

[a] Observer variability was calculated from 165 positions from the first 10 vessels. *CI* Confidence interval; † $P < 0.001$

Tu, Regar et al. Int J Cardiovasc Imaging 2012

OCT – Angiography Co-Registration

Erasmus MC

Int J Cardiovasc Imaging
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ORIGINAL PAPER

In vivo comparison of arterial lumen
by co-registered three-dimensional (3
coronary angiography, intravascular
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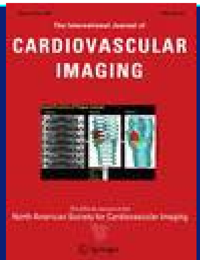
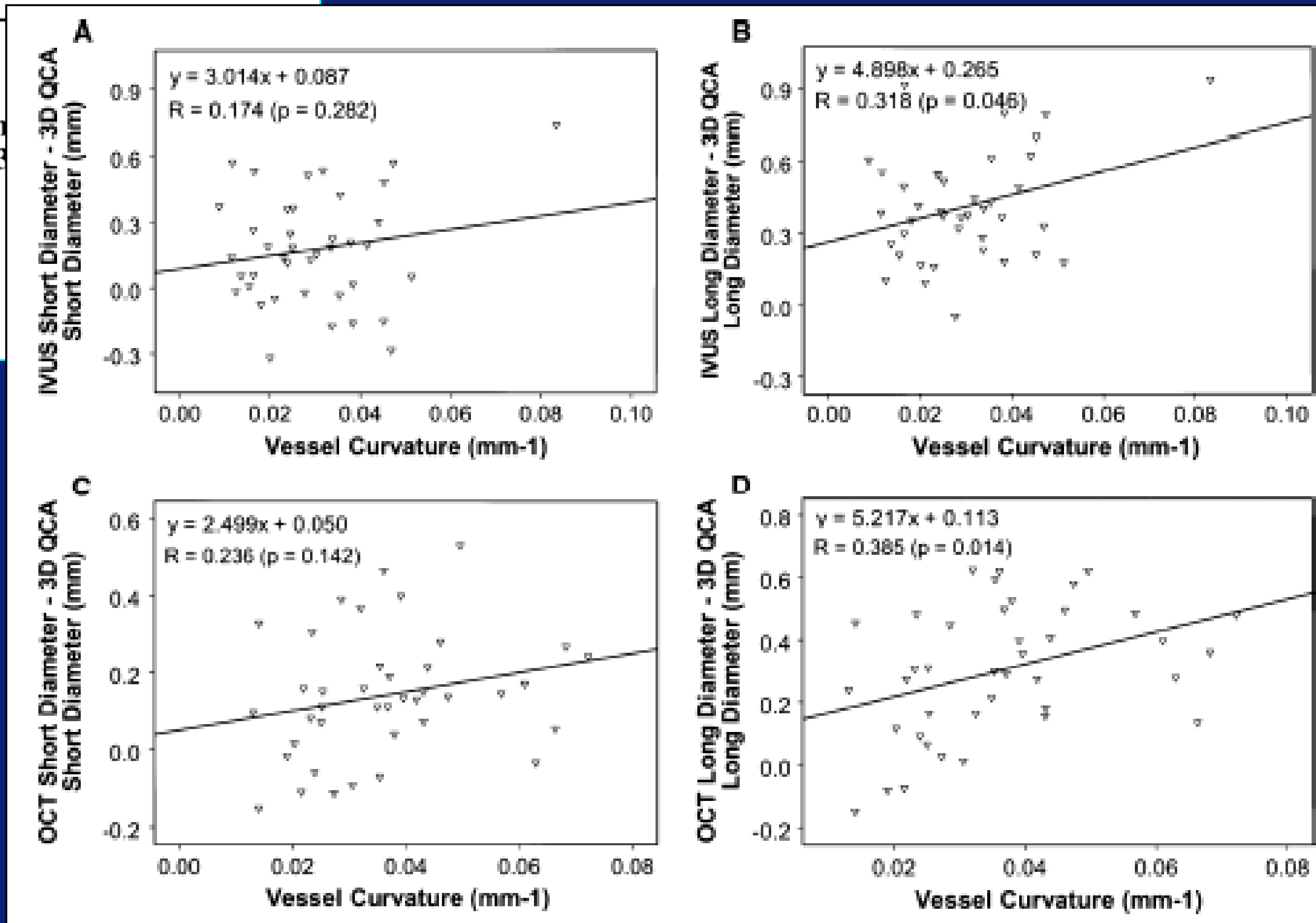
Shengxian Tu · Liang Xu · Jurgen Ligthart · Bo Xu ·
Karen Witberg · Zhongwei Sun · Gerhard Koning ·
Johan H. C. Reiber · Evelyn Regar





Tu, Regar et al. Int J Cardiovasc Imaging 2012

Vulnerable Plaque, Vulnerable Neointima

Erasmus MC

Technology

-Tissue characterization

IVUS VH

-Co- registration with the angiogram

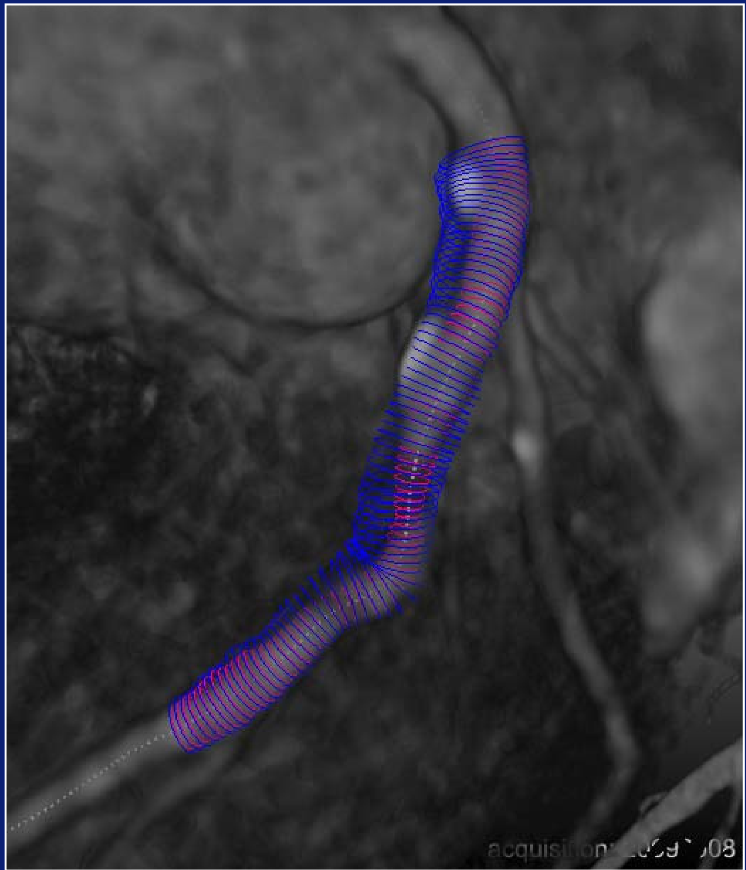
NIRS

-3D rendering (real time)

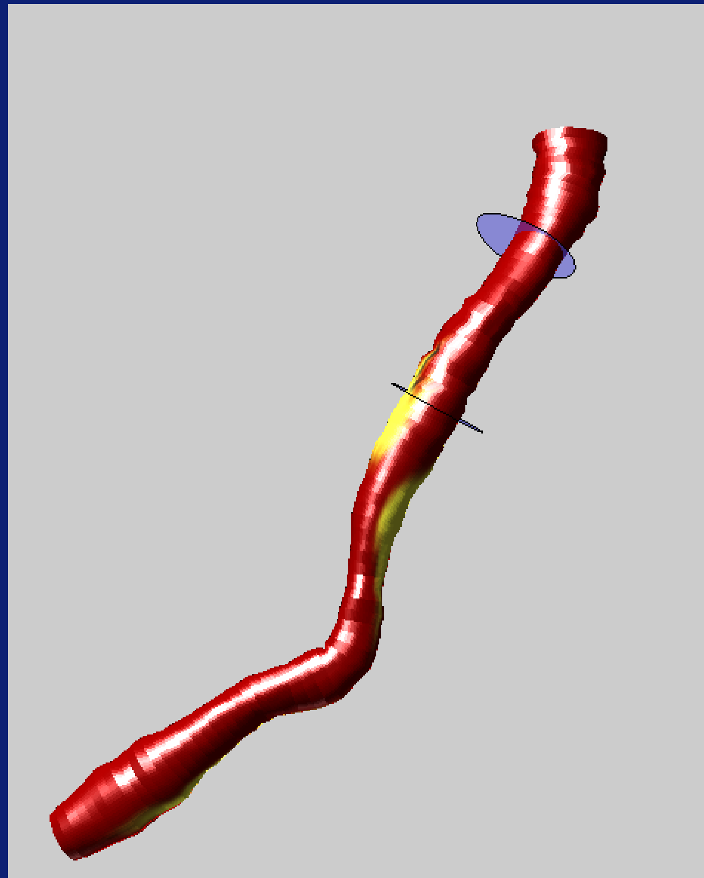
OCT

Future Directions

3D Representation of the Lipid Distribution in a Living Patient



Fusion of LipiScan -IVUS and MSCT

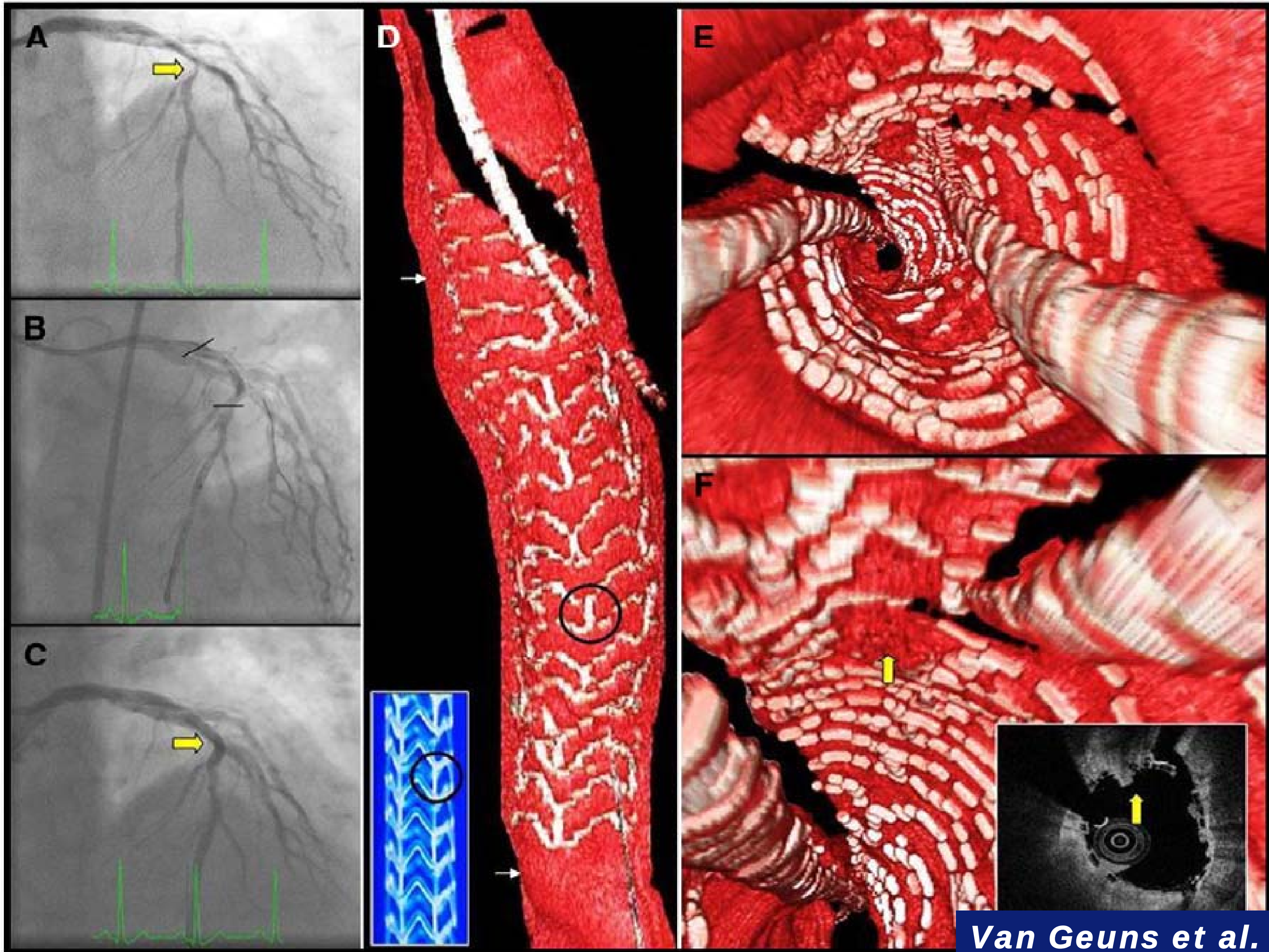


NIR in 3D

based on fusion of Lipiscan-IVUS and MSCT

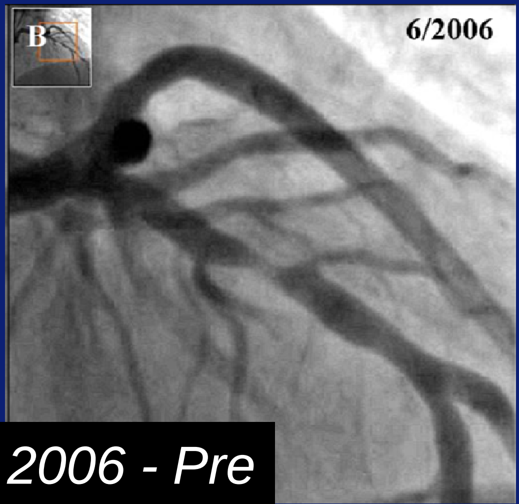
Wentzel et al. Circulation, 2011.

FD OCT- 3D Rendering
Lesion Treated With BVS: Baseline

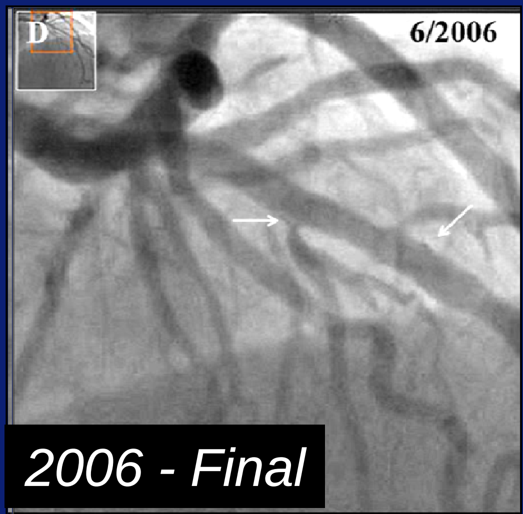


Van Geuns et al. Int J cardiol, 2011.

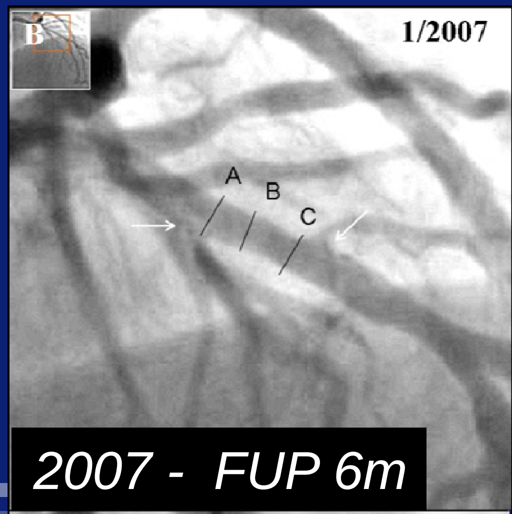
FD OCT- 3D Rendering
BVS: 5Y FUP



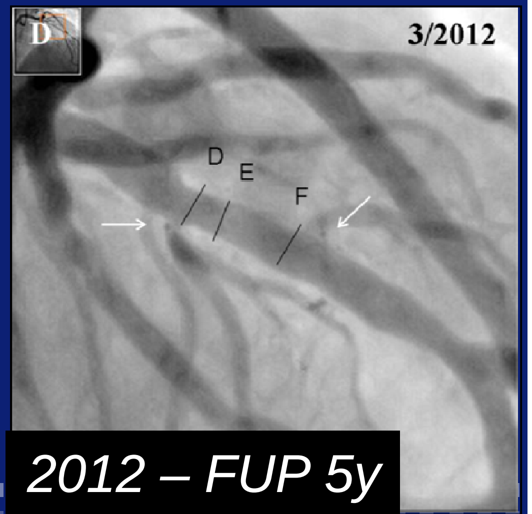
2006 - Pre



2006 - Final

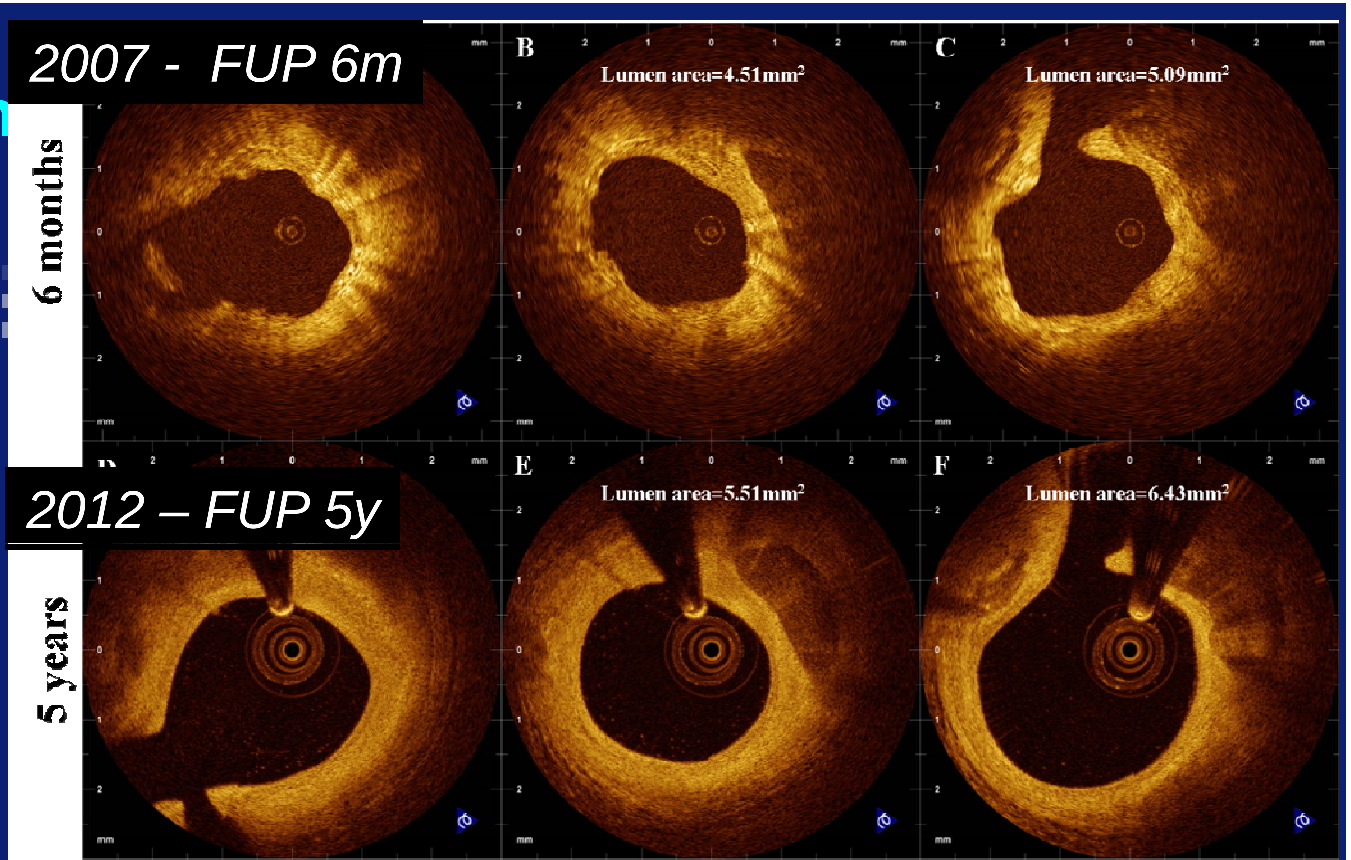


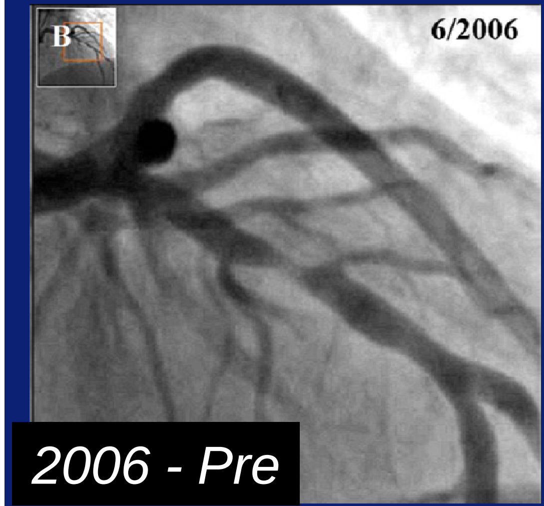
2007 - FUP 6m

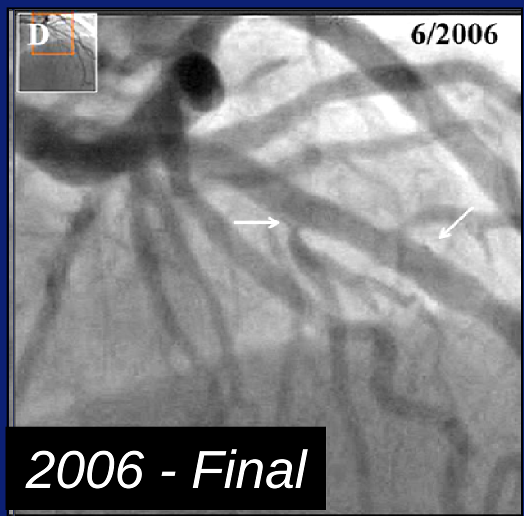


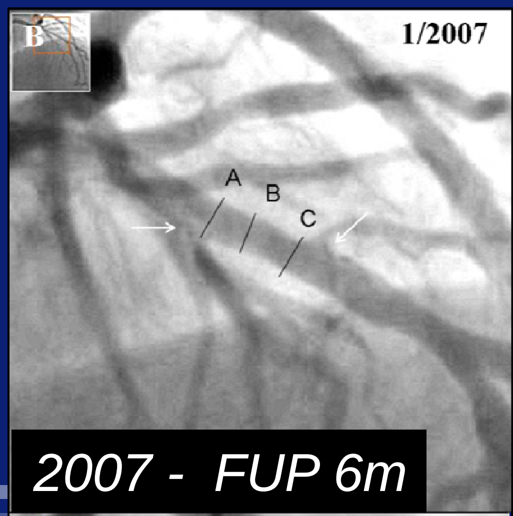
2012 – FUP 5y

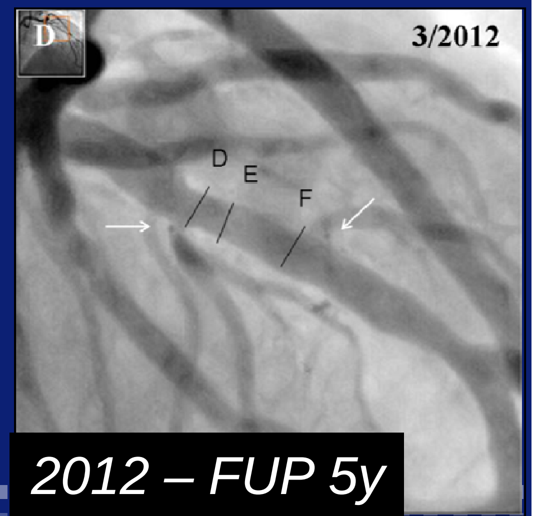
FD OCT- 3D Ren
BVS: 5Y FUP





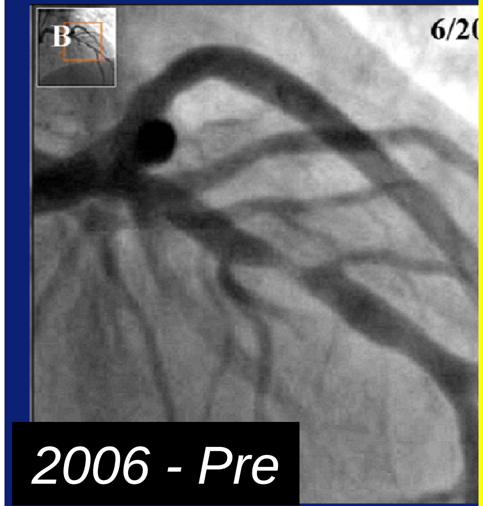


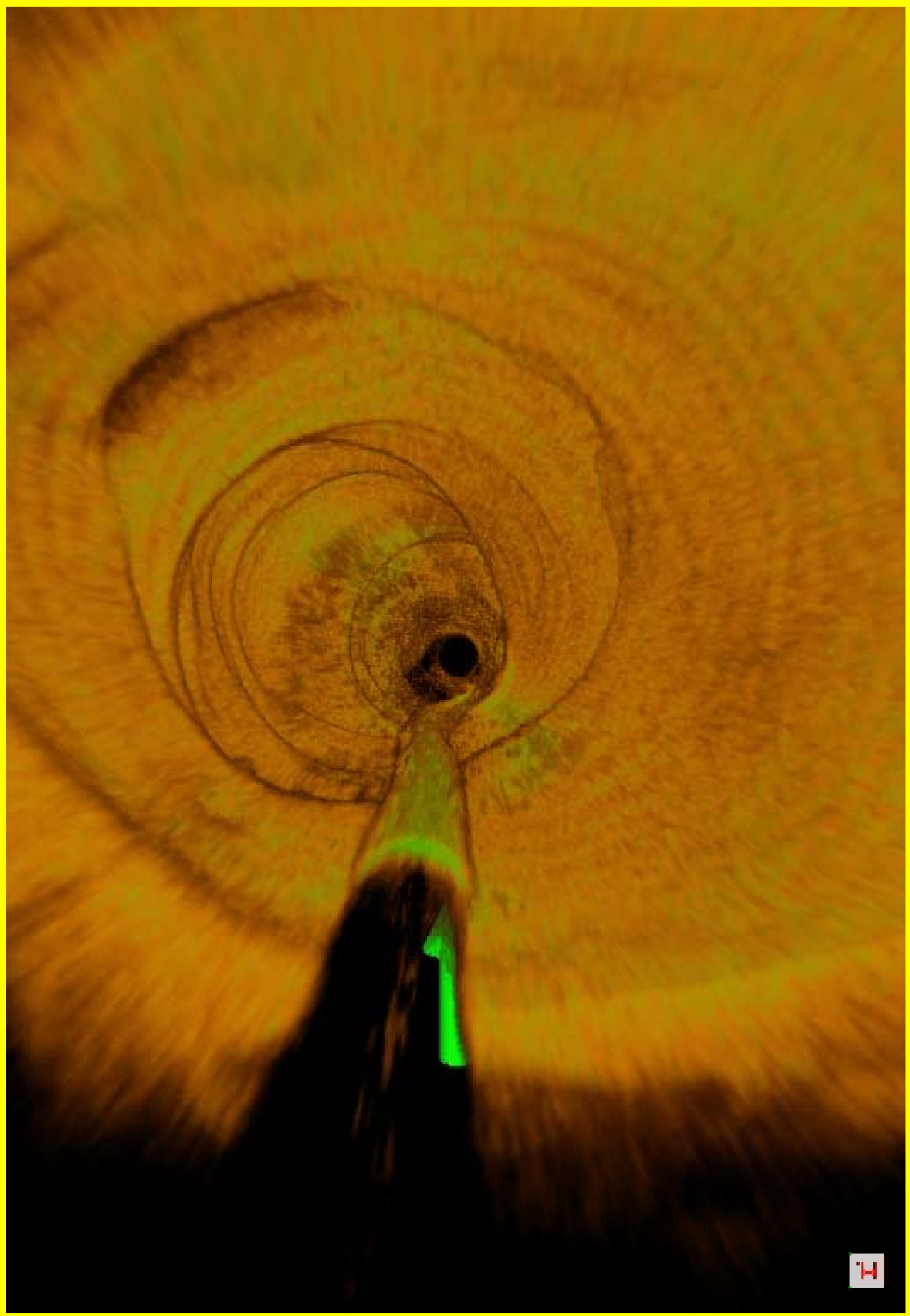


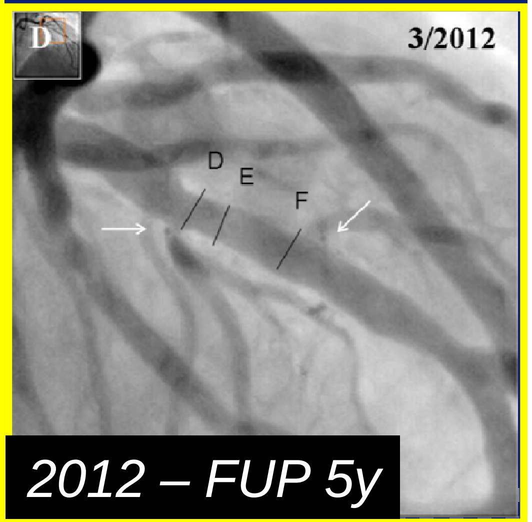


FD OCT- 3D F
BVS: 5Y FUP

Erasmus MC







Thank you for your attention!

PhD students interventional cardiology

A. Karanasos
N. van Ditzhuisen
M. Magro

Interventional Cardiology

R.J. van Geuns
C. Schultz
P. de Jaegere
J. Ligthart
N. van Mieghem
E. Duckers
P.W. Serruys
F. Zijlstra

Experimental Cardiology

H. van Beusekom
W. van der Giessen

Hemodynamics Laboratory

J. Wentzel
F. Gijsen

Bioengineering

G. van Soest
A.F.W. van der Steen

Imaging Group

N. Bruining
S. de Winter
K. Sihan