

Vulnerable Plaque Detection by Grayscale IVUS and NIRS

Akiko Maehara, MD

**Cardiovascular Research Foundation/
Columbia University Medical Center
New York City, NY**

Conflict of Interest Disclosure

- Akiko Maehara
 - Personal: Consultant for ACIST, Boston Scientific Corporation, Speaker for St Jude Medical
 - Cardiovascular Research Foundation: Boston Scientific Corporation

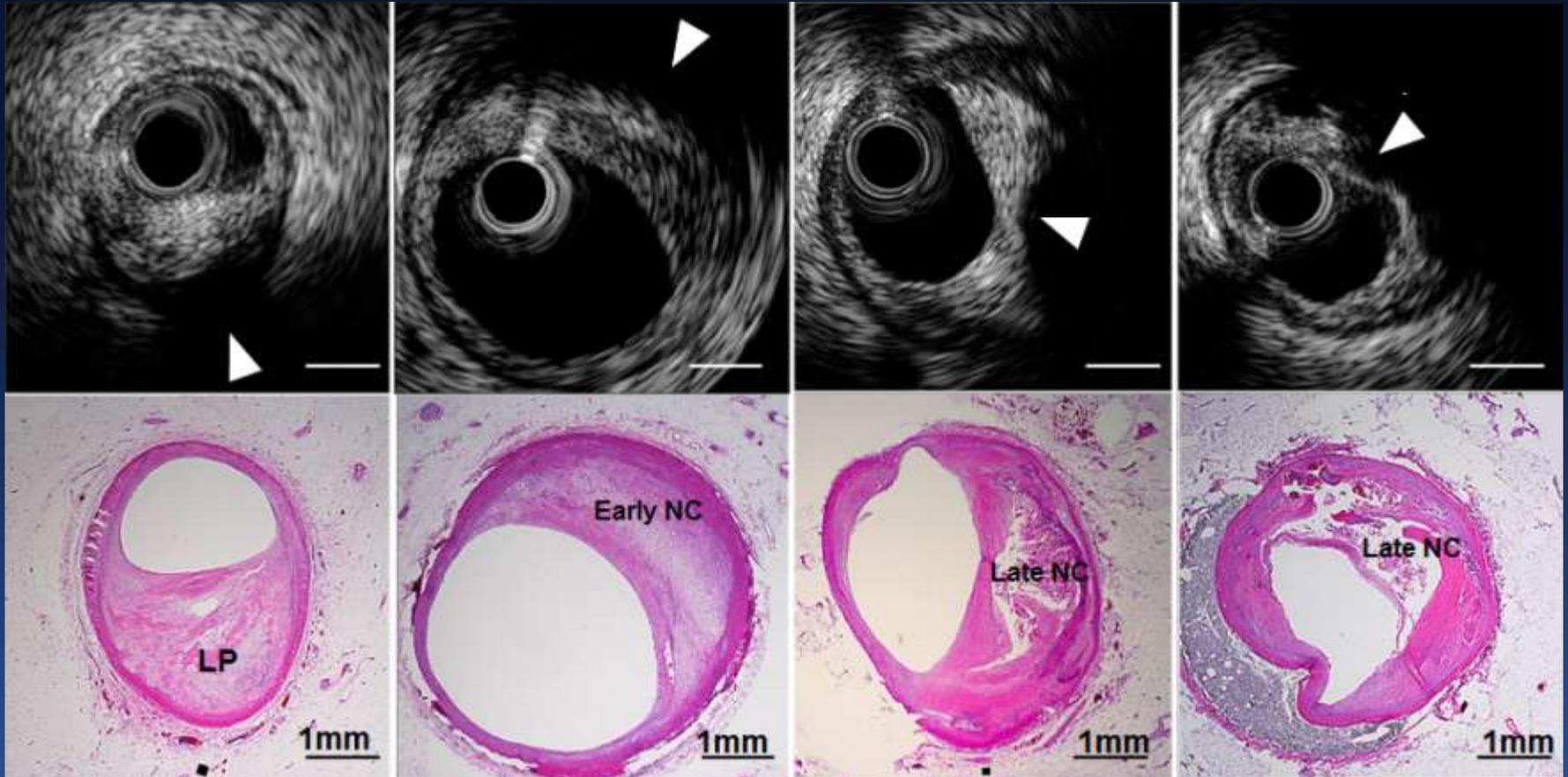
Comparison between IVUS and Pathology

- 2,292 2-mm long segments from 151 coronary specimens in 62 autopsy hearts.
- 64 (51, 78) years old, 66% of male
- 77% cardiovascular death
- Data obtained in the CDEV3 Study, Gardner et al, JACC Imaging, 2008, sponsored by InfraReDx, Inc.
- Diagnosed by Virmani R, et al at CVpath.

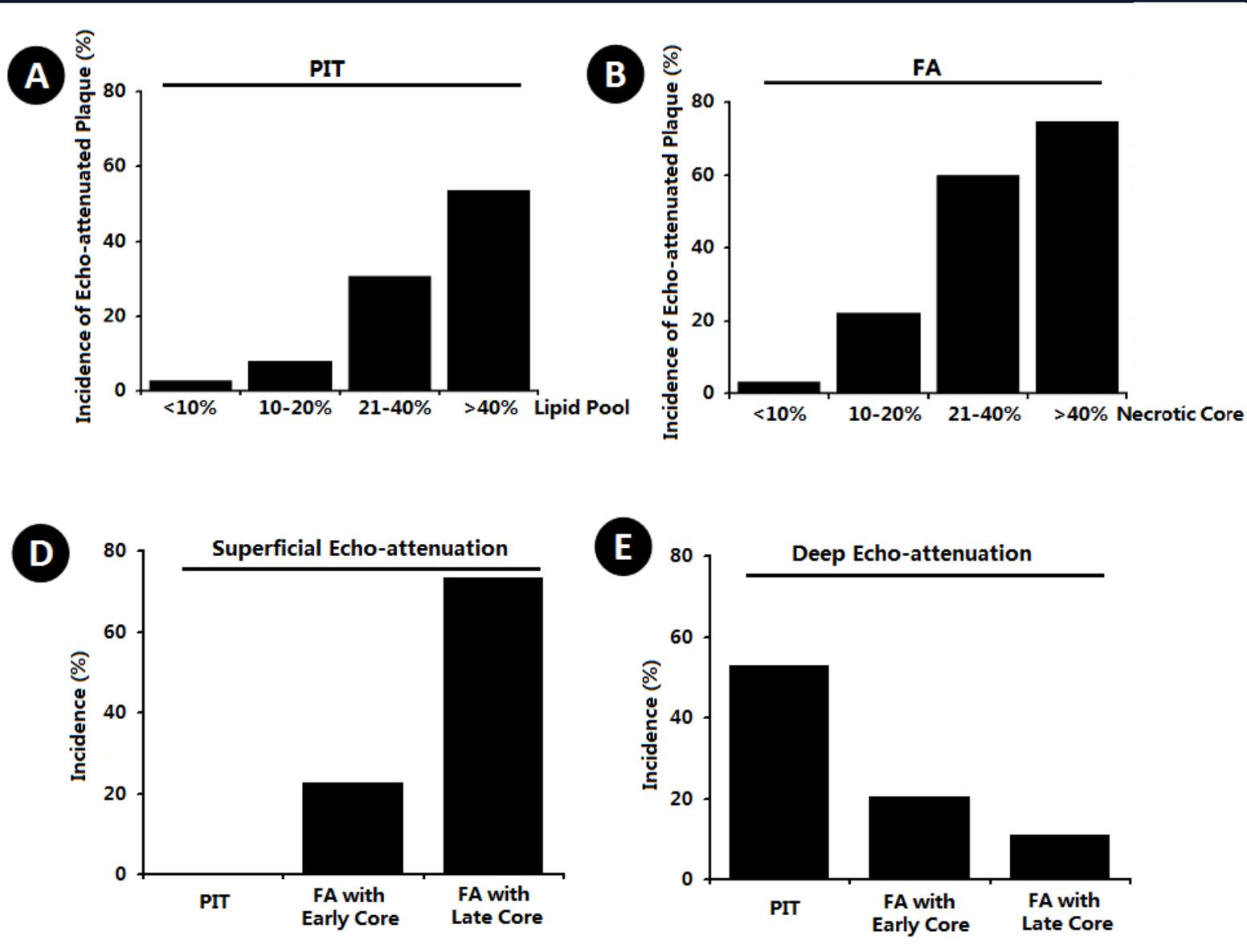
Attenuated Plaque (Superficial, Deep)

Deep Attenuated Plaque

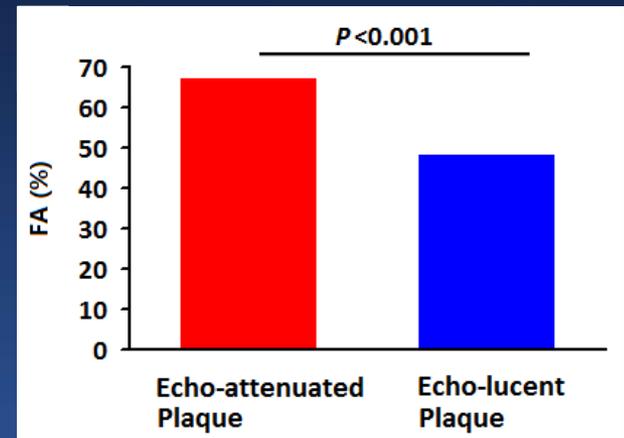
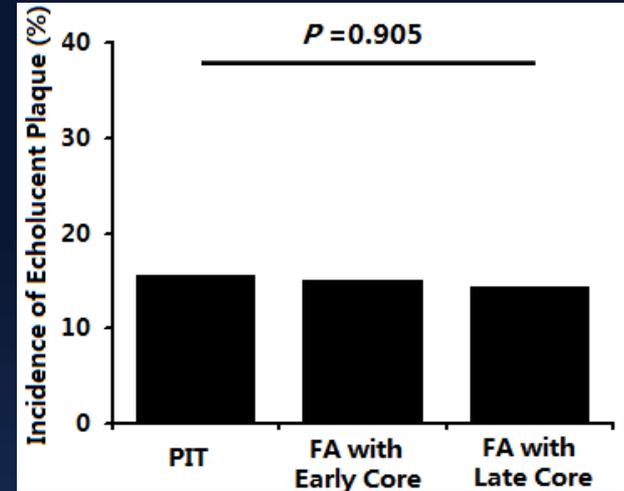
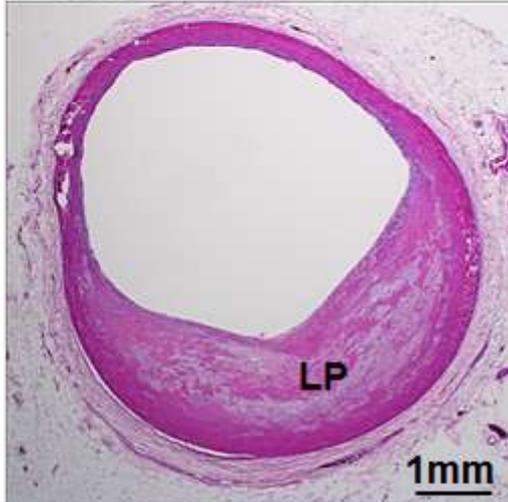
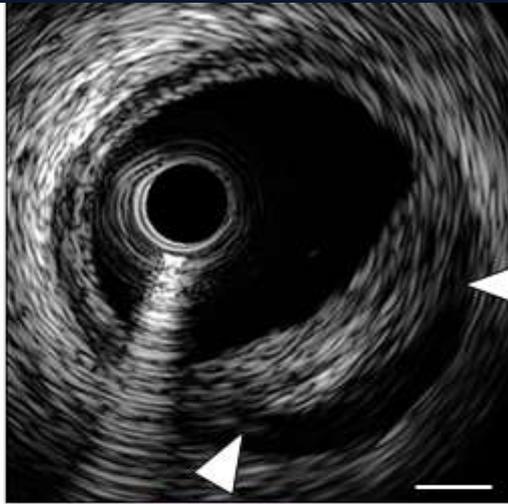
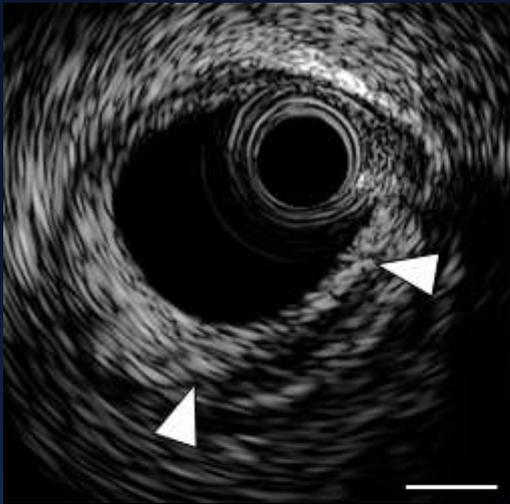
Superficial Attenuated Plaque



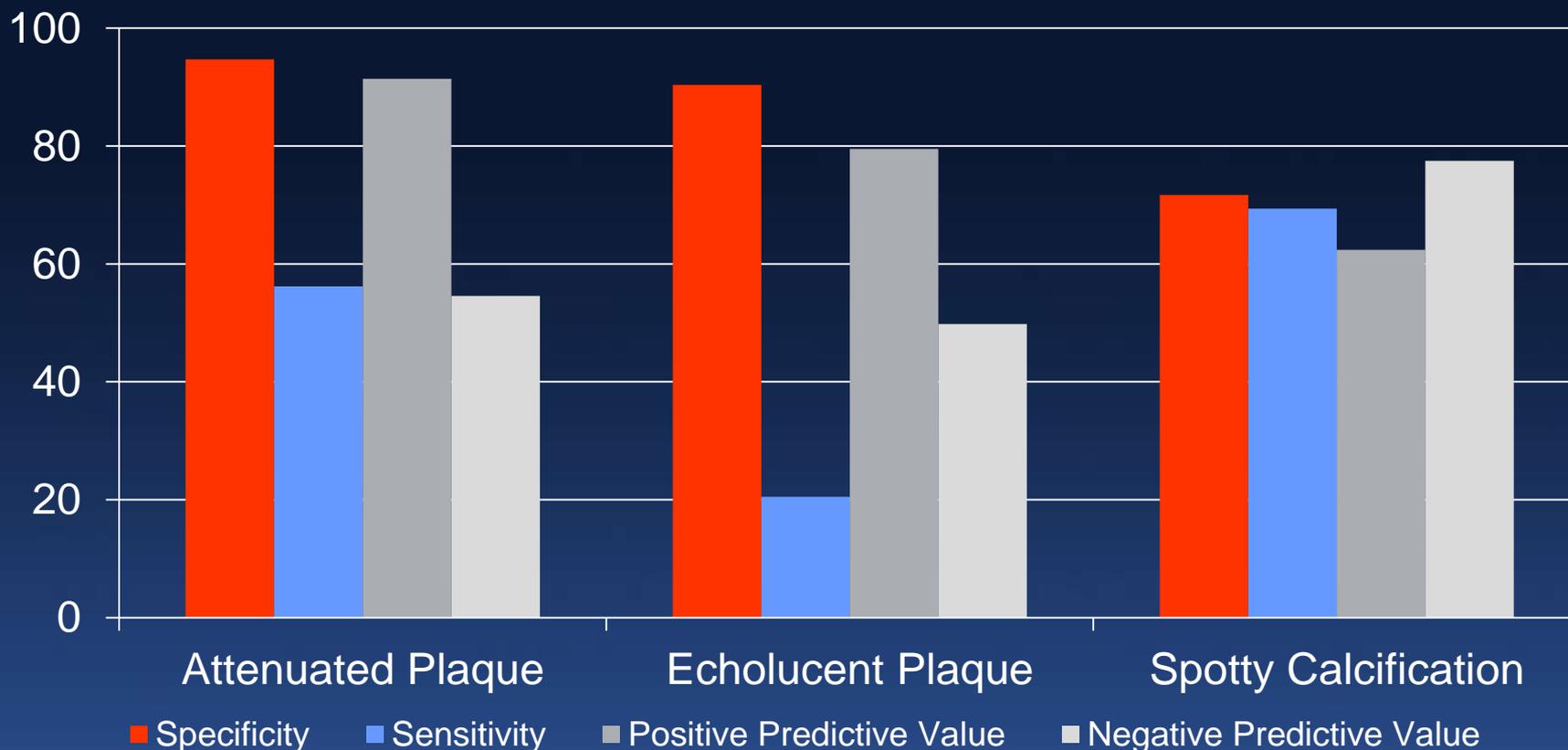
Attenuated Plaque (Superficial, Deep)



Echolucent Plaque (Superficial, Deep)



Diagnostic Summary



Intraplaque hemorrhage



- **Pathologic diagnosis : Late fibroatheroma**
- **IVUS diagnosis : Echolucent plaque**
- **Plaque burden = 67.6 %**
- **Echolucent burden = 17.6 %**

Results

2140 segments
106 Coronary arteries / 57 autopsy hearts

Histopathological Hemorrhage

YES

18 segments
(12 patients, 20.1%)

NO

2122 segments
(45 patients, 79.1%)

IVUS Findings

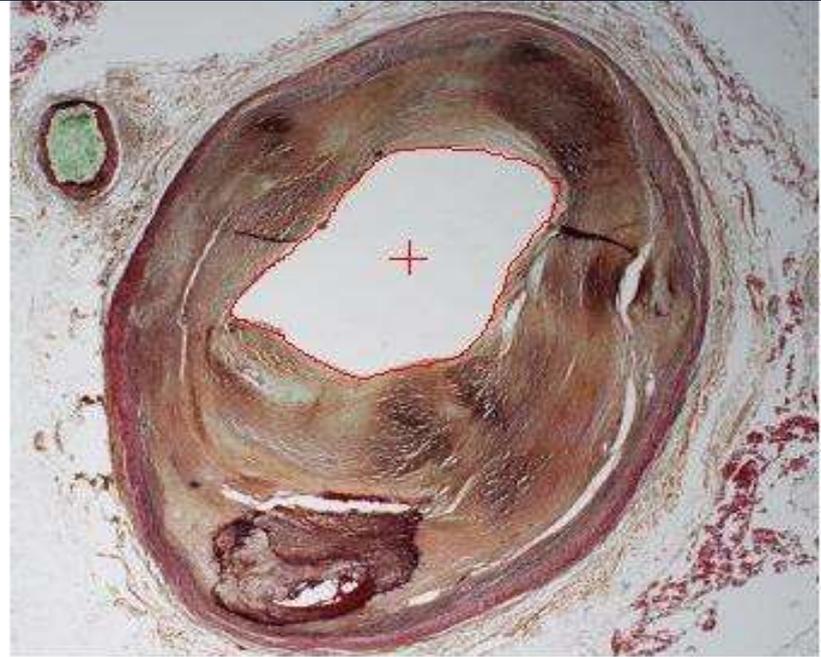
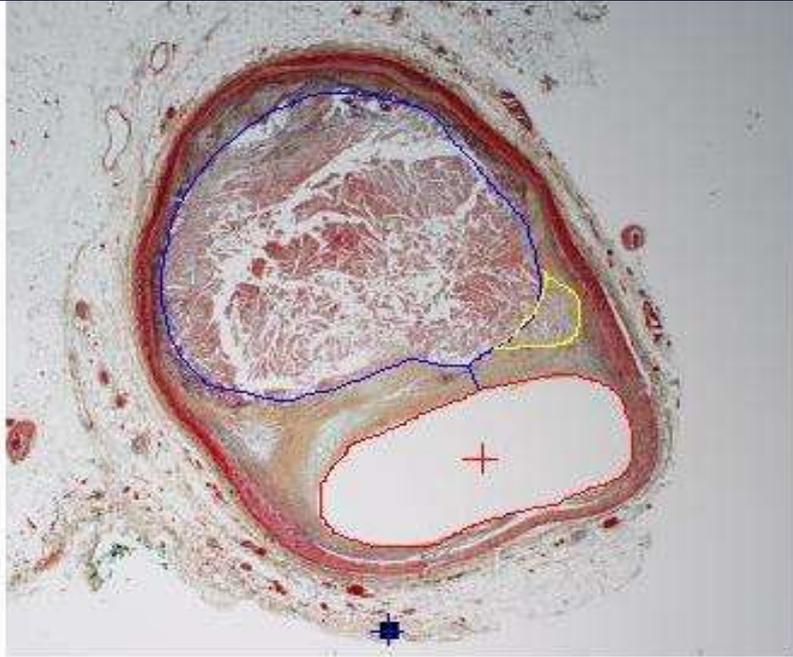
Echolucent Zone
with IH
(16 segments)

Echolucent Zone
without IH
(73 segments)

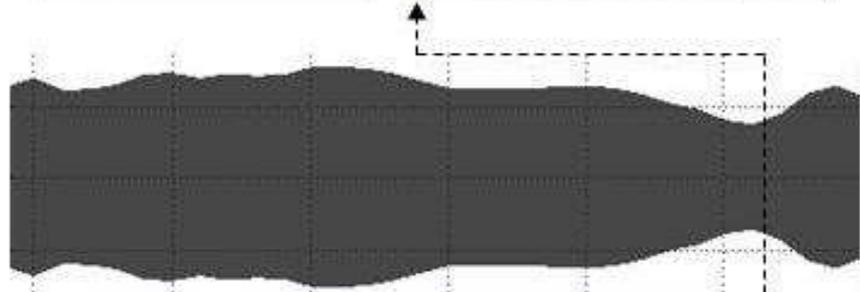
Histopathological IH vs No IH

	Histopathologic Hemorrhage (n=18)	No Histopathologic Hemorrhage (n=2122)	P Value
<i>Histopathological findings</i>			
Any FA, % (n)	72.2 (13)	20.6 (438)	<0.0001
Early FA, % (n)	5.6 (1)	6.2 (132)	0.91
Early FA with calcium, % (n)	0 (0)	3.4 (72)	0.43
Late FA, % (n)	50.0 (9)	4.9 (104)	<0.0001
Late FA with calcium, % (n)	16.7 (3)	4.3 (92)	0.016
Any calcification, % (n)	22.2 (4)	28.2 (599)	0.57
<i>IVUS analysis</i>			
EEM CSA, mm ²	16.9±4.2	13.1±5.5	0.0014
Lumen CSA, mm ²	6.1±2.1	6.4±3.0	0.53
Plaque burden, %	63.8±10.7	49.1±15.5	<0.0001
Plaque burden ≥40%, % (n)	100 (18)	73.4 (1558)	0.011
Plaque burden ≥60%, % (n)	72.2 (13)	24.9 (529)	<0.0001

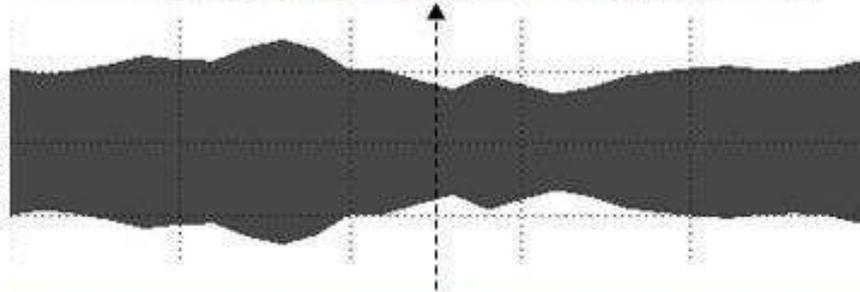
NIRS can Distinguish Lipid-rich from Fibrotic Plaques



IVUS
DIAMETER



IVUS
DIAMETER



CHEMOGRAM

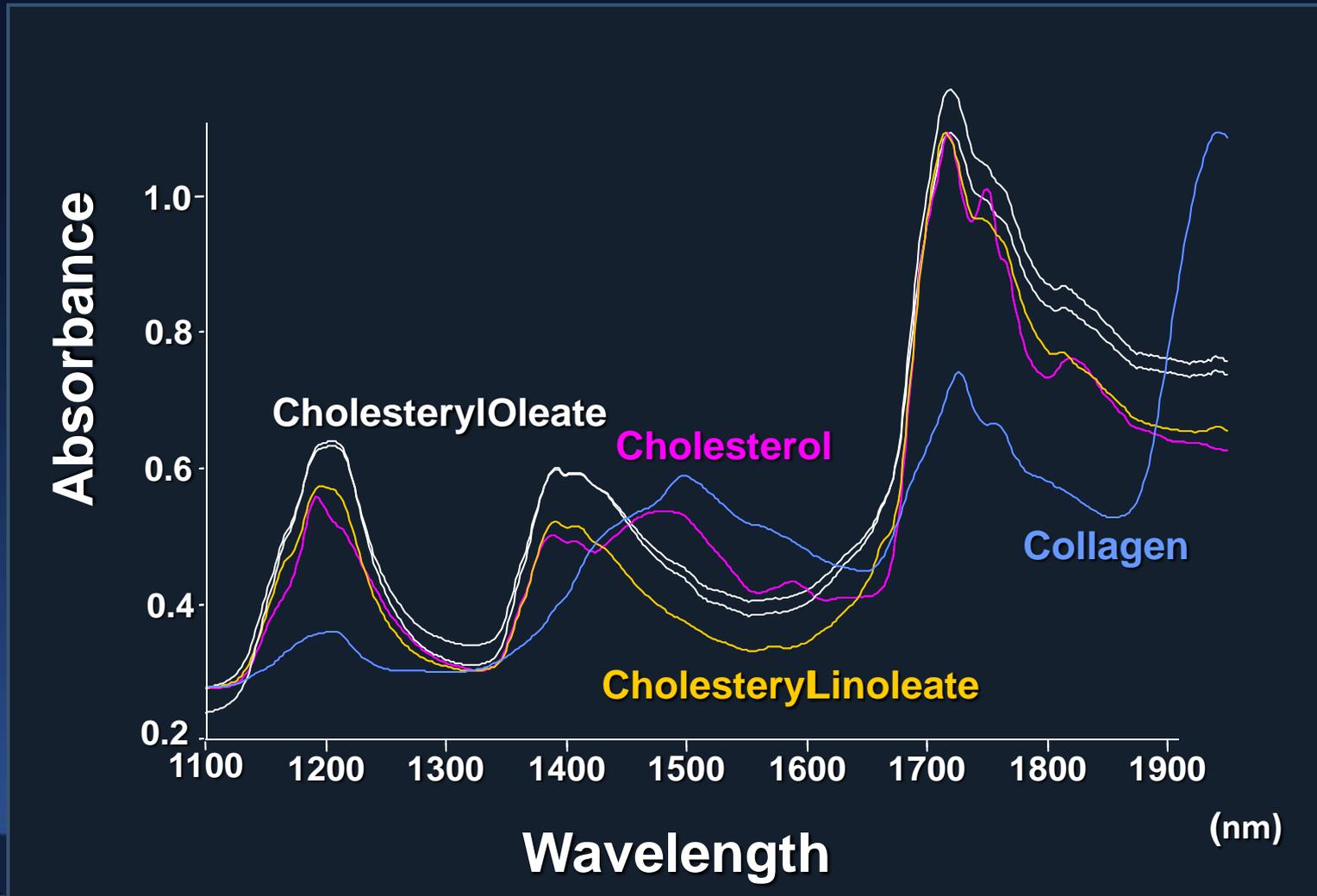


CHEMOGRAM

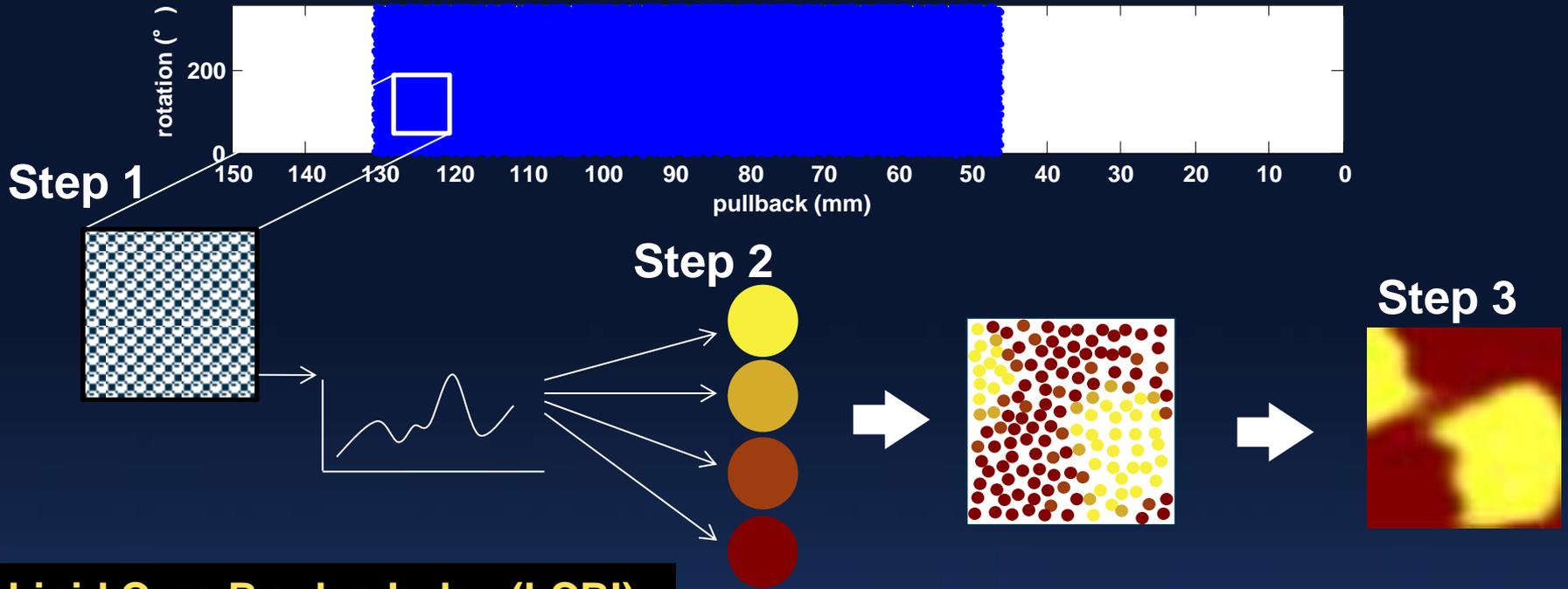


NIR Spectroscopy

- Necrotic Core $>0.2\text{mm}$ thick, $>60^\circ$, Cap $<0.45\text{mm}$

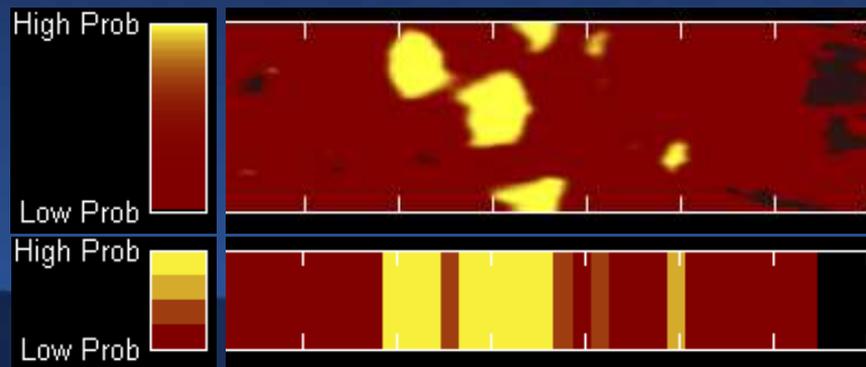


Near Infrared Spectroscopy



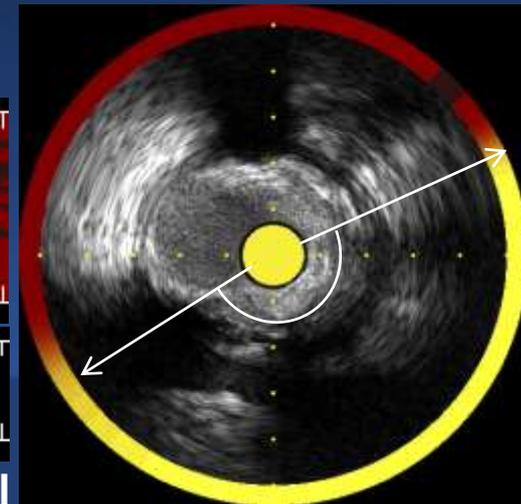
Lipid Core Burden Index (LCBI)
 = Yellow pixel / All variable pixel
 × 1000

Lesion
 LCBI Max_{4mm}

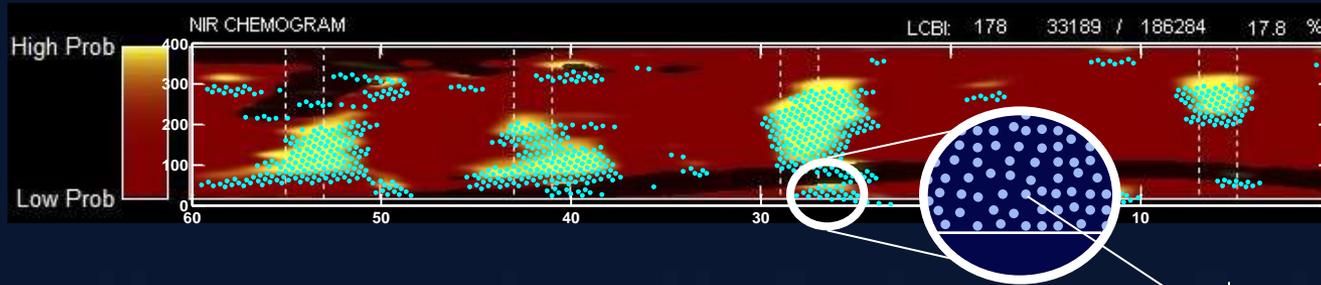


Proximal

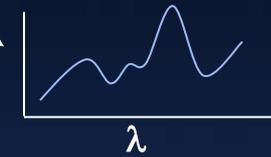
Distal



Formation of the Cap Thickness Prediction Image



Spectra acquired at discrete pullback and rotation positions



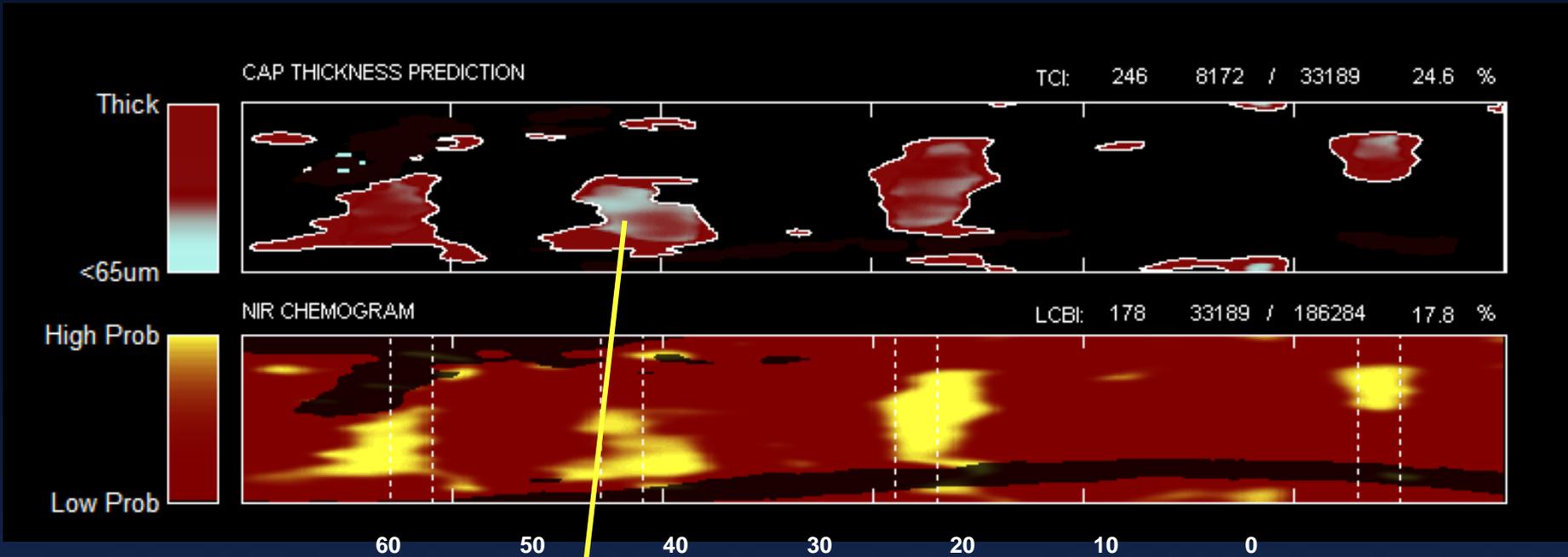
LCP Spectra transformed into posterior probability of thin cap presence



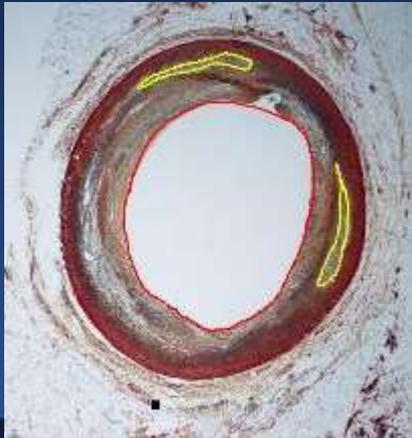
Probability mapped to a color

Pixels formed into an image

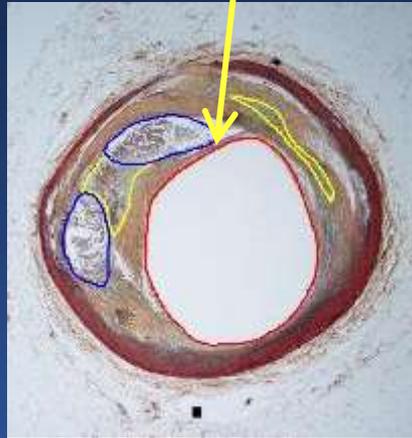




52mm



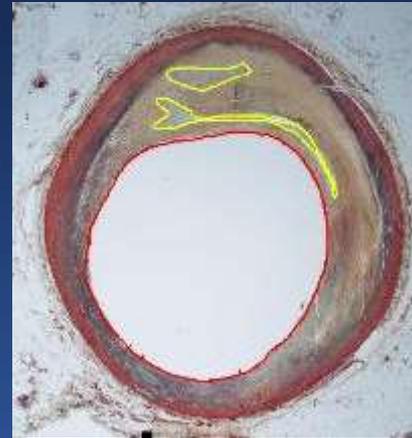
42mm



28mm

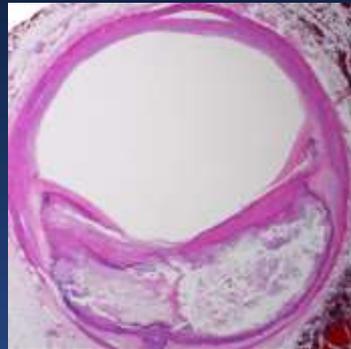
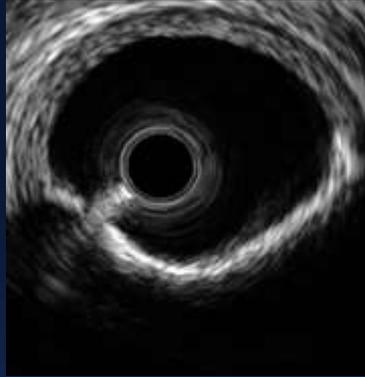


6mm

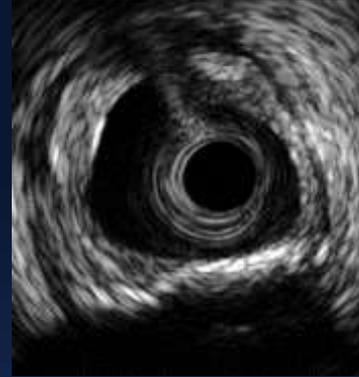


Different type of Calcification

*Necrotic core
behind calcium*

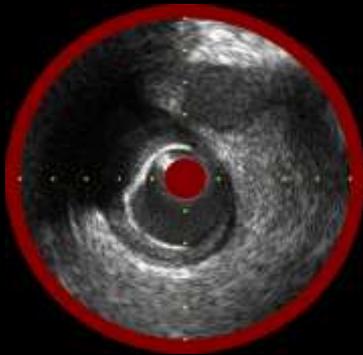


Calcium Only

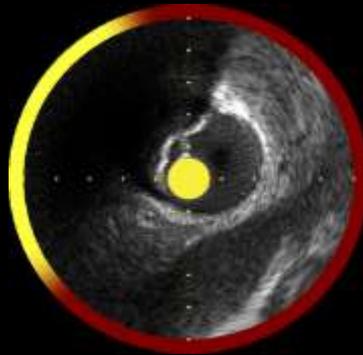


NIRS/IVUS Plaque Phenotype

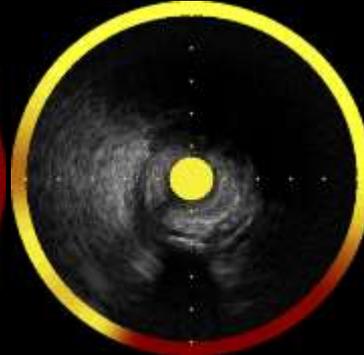
Calcified
Non-LRP



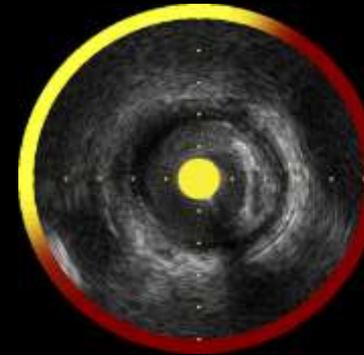
Calcified LRP



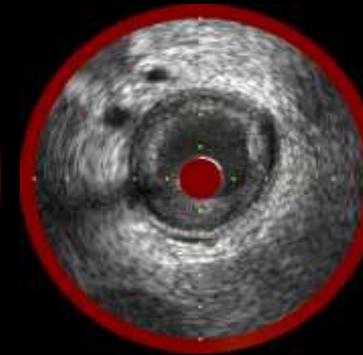
LRP with
Superficial
Attenuation



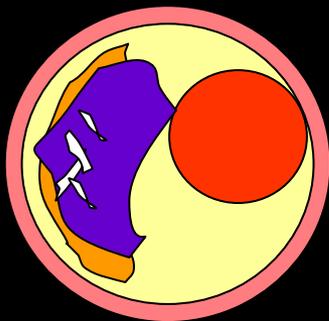
LRP without
Superficial
Attenuation



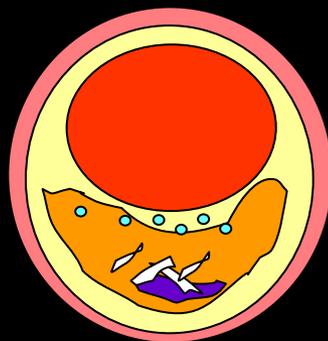
Non-LRP



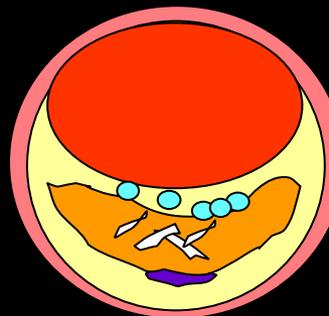
Fibrocalcific



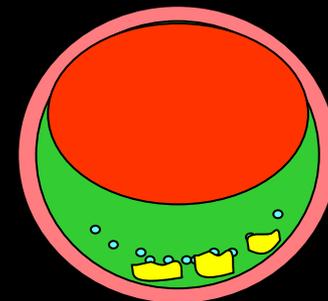
ThCFA



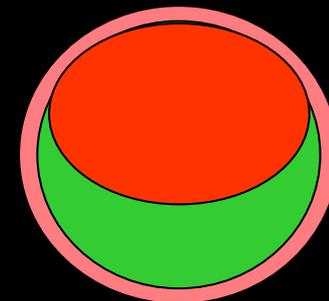
TCFA



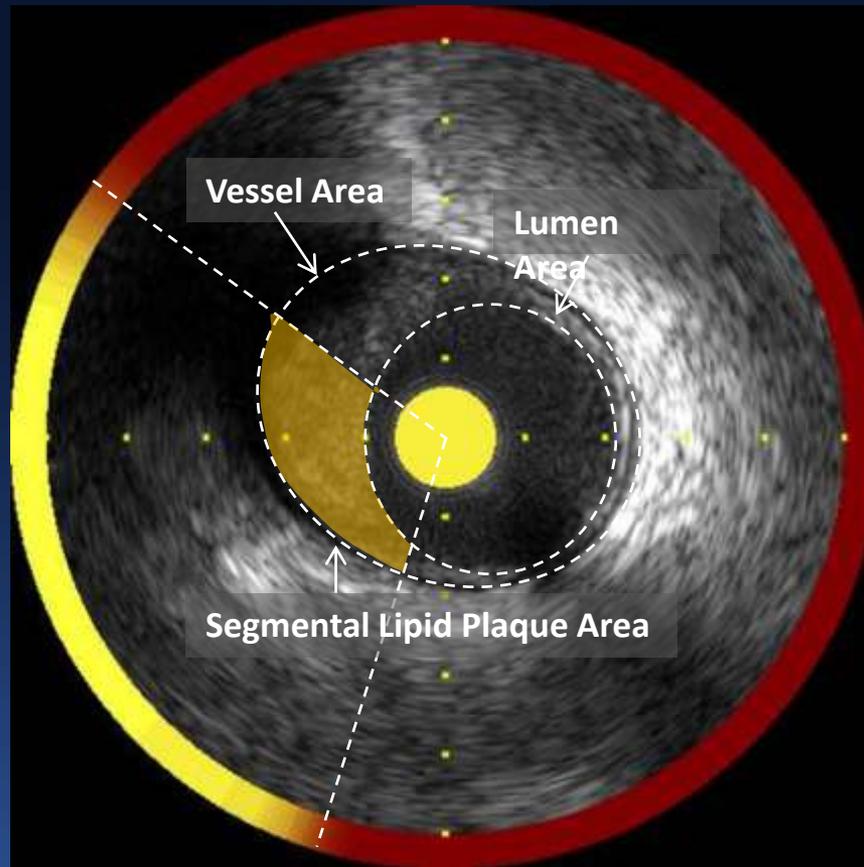
PIT



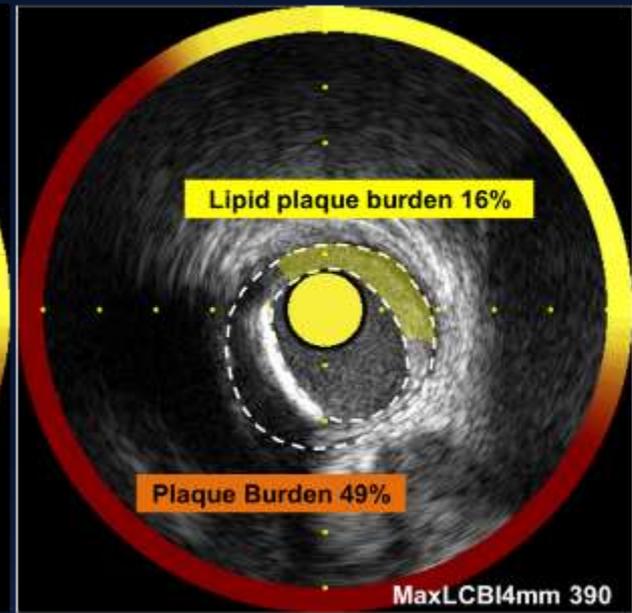
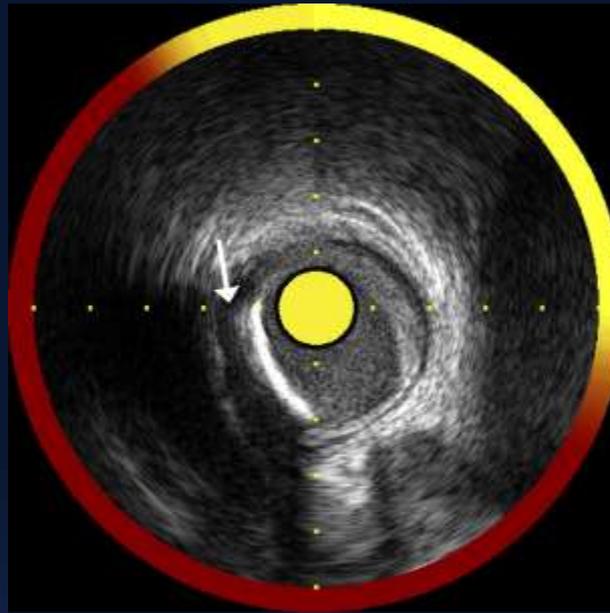
Fibrotic



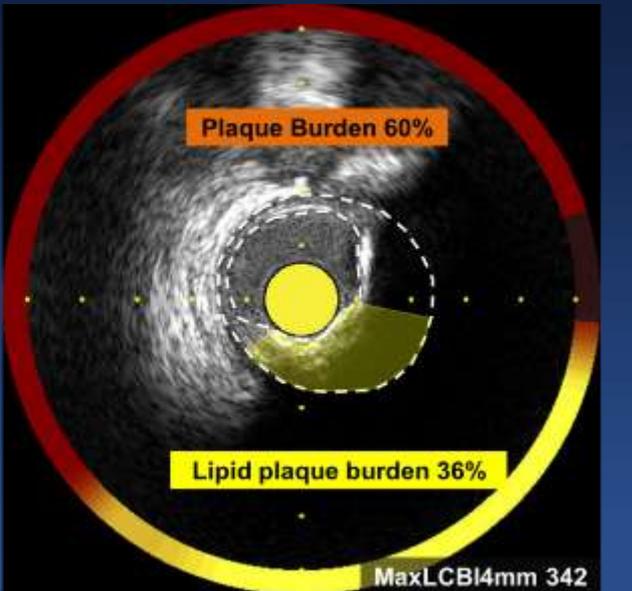
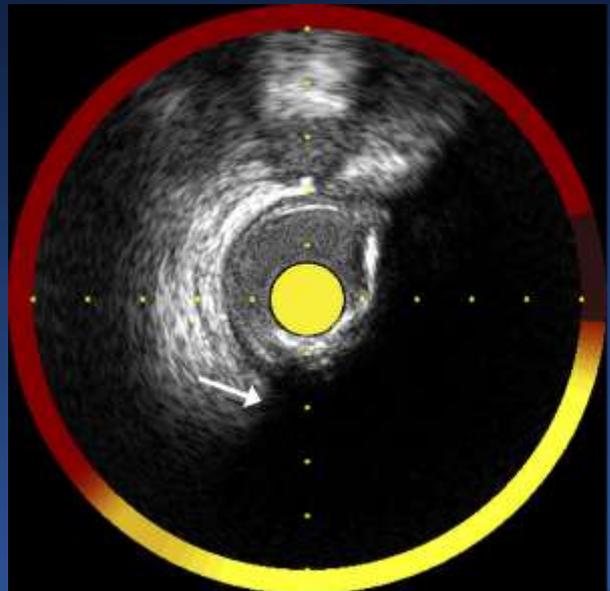
Lipid Rich Plaque Burden



Lipid Rich Plaque
Burden =16%
maxLCBI₄₀₀ =390
Plaque Burden 49%



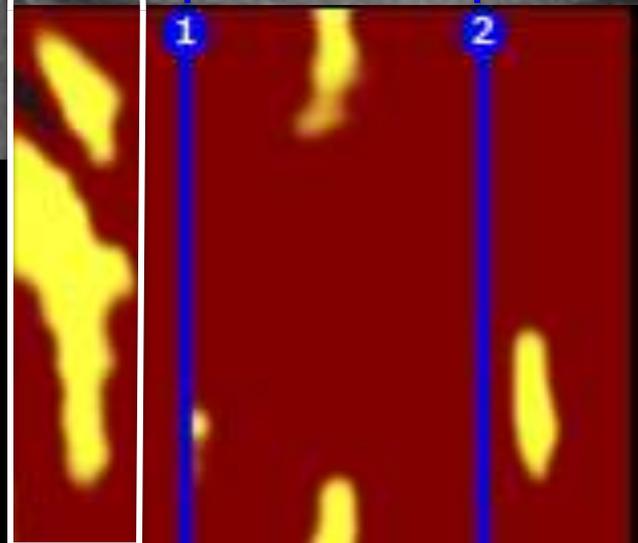
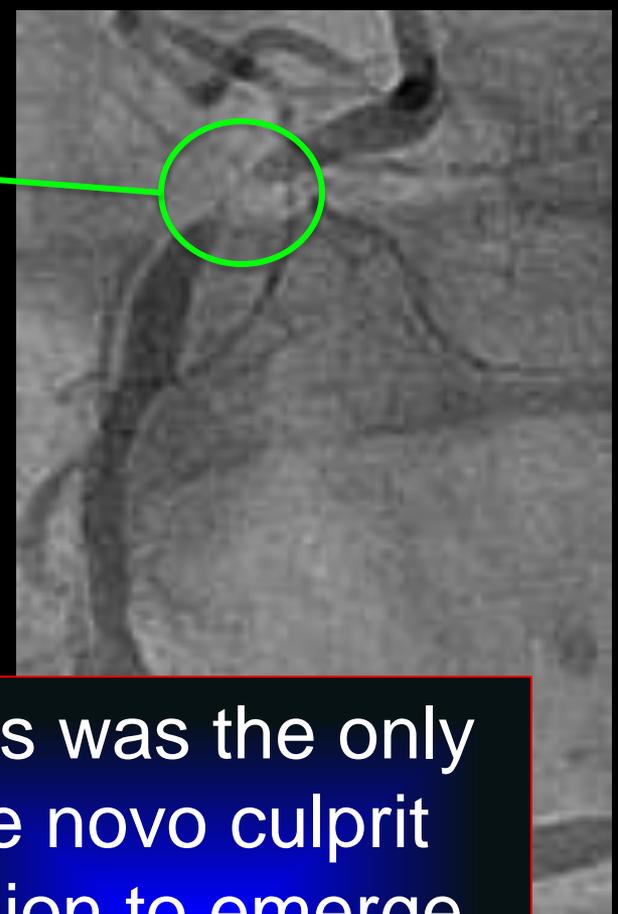
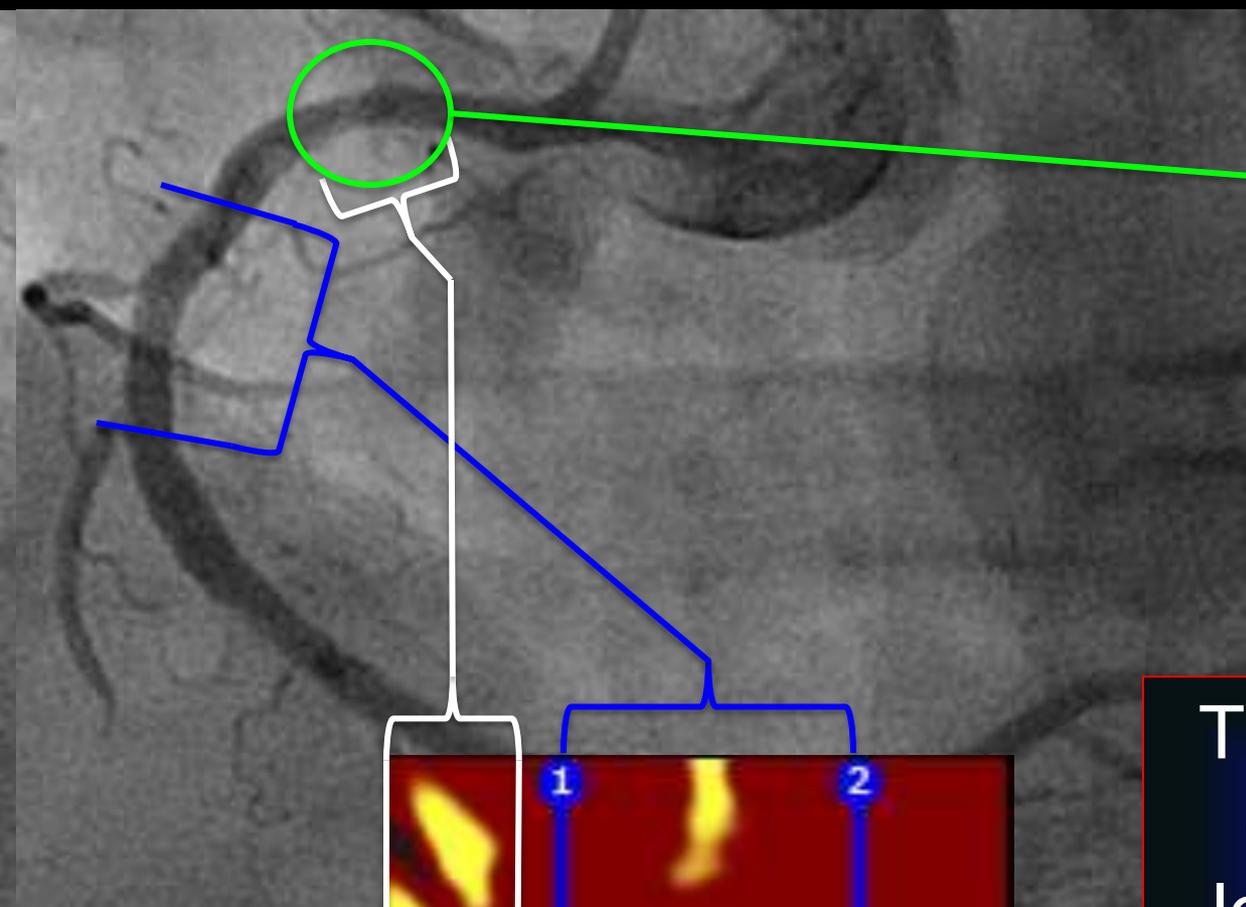
Lipid Rich Plaque
Burden =36%
maxLCBI₄₀₀ =342
Plaque Burden 60%



64 year old presents with STEMI in March 2012



Unstable angina October 2012



maxLCBI_{4mm}
694

This was the only de novo culprit lesion to emerge from the 462 coronary segments imaged at baseline

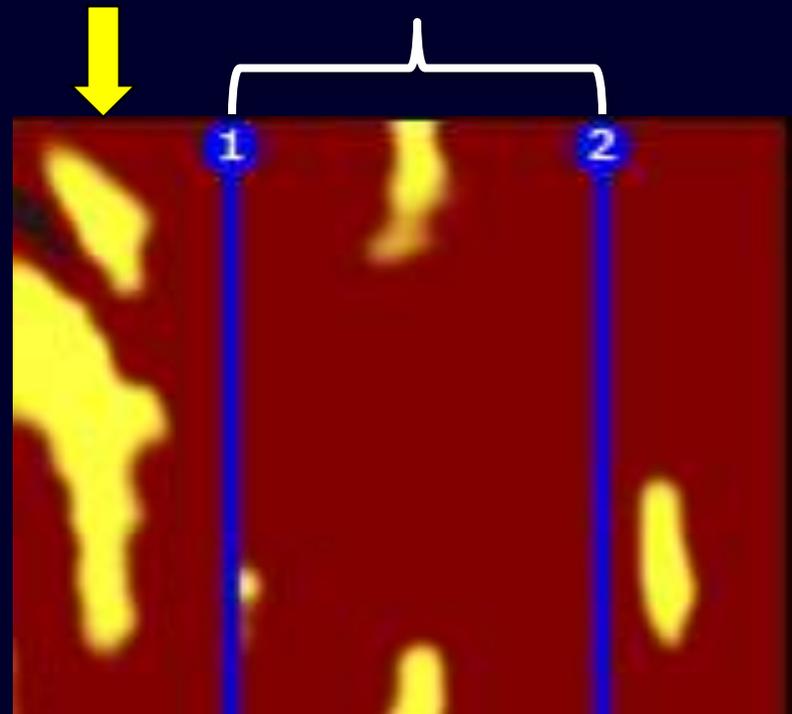


Methods

- Evaluated non-stented coronary segments for large LRP
 - defined as a $\max\text{LCBI}_{4\text{mm}} \geq 500$
- Patients followed for MACCE
 - Composite of all-cause mortality, recurrent ACS requiring revascularization, or acute cerebrovascular events
- Events related to previously stented segments were excluded
- All events adjudicated blinded to the NIRS-IVUS imaging

Large LRP
in
non-
stented
segment

Stented
segment
excluded
from
analysis

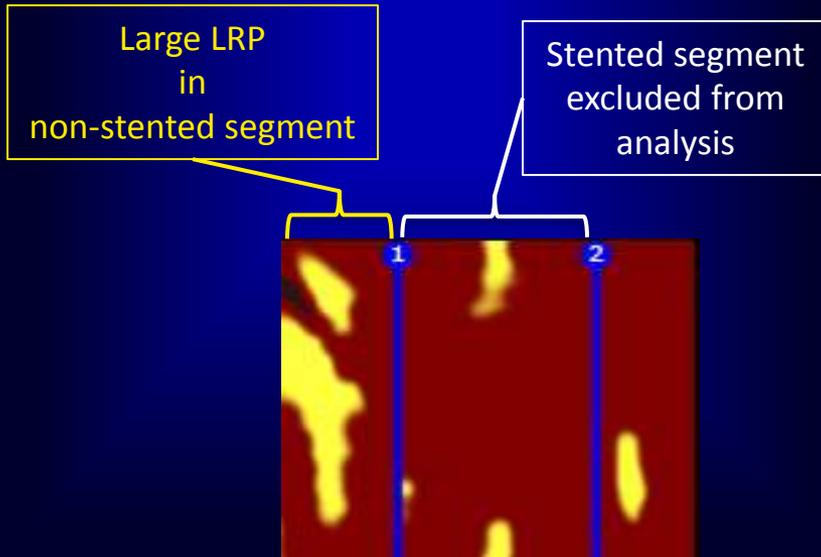




Results

Baseline NIRS Findings

- 462 non-overlapping 10-mm coronary segments analyzed
- A large LRP was detected in 15 (3.2%) segments & in 12 (9.9%) patients

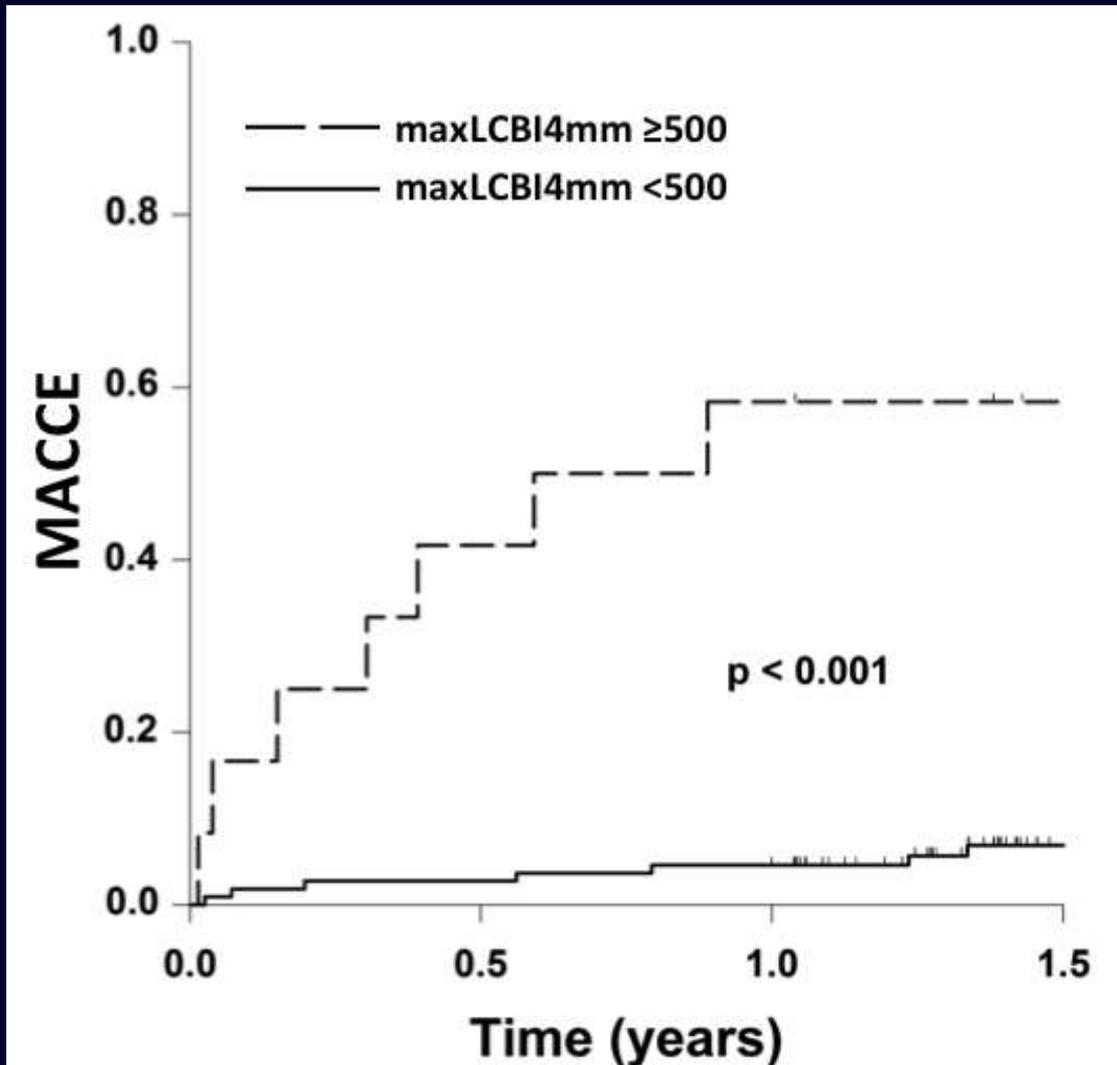


Follow Up Events

- Average follow-up duration was 603 ± 145 days (1.7 years)
- MACCE (unrelated to previously stented segments) occurred in **11.6%** of patients during follow up
 - ➔ All-cause death 4.1%
 - ➔ ACS requiring revascularization 6.6%
 - ➔ CVA 0.8%



Large LRP by NIRS and MACCE



MACCE Rate
Large LRP 58.3%
vs
No large LRP 6.4%
($p < 0.001$)

ACS Requiring Revascularization
Large LRP 25.0%
vs
No large LRP 4.6%
($p < 0.001$)

Take Home Message

- 1. Superficial location of attenuated plaque indicates advanced fibroatheroma.**
- 2. Intraplaque hemorrhage can be observed as echolucent plaque.**
- 3. NIRS shows a distribution of lipidic plaque (fibroatheroma and PIT).**
- 4. Combination of grayscale IVUS and NIRS will differentiate vulnerable plaque than others.**