Imaging Criteria of Vulnerable Plaques

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
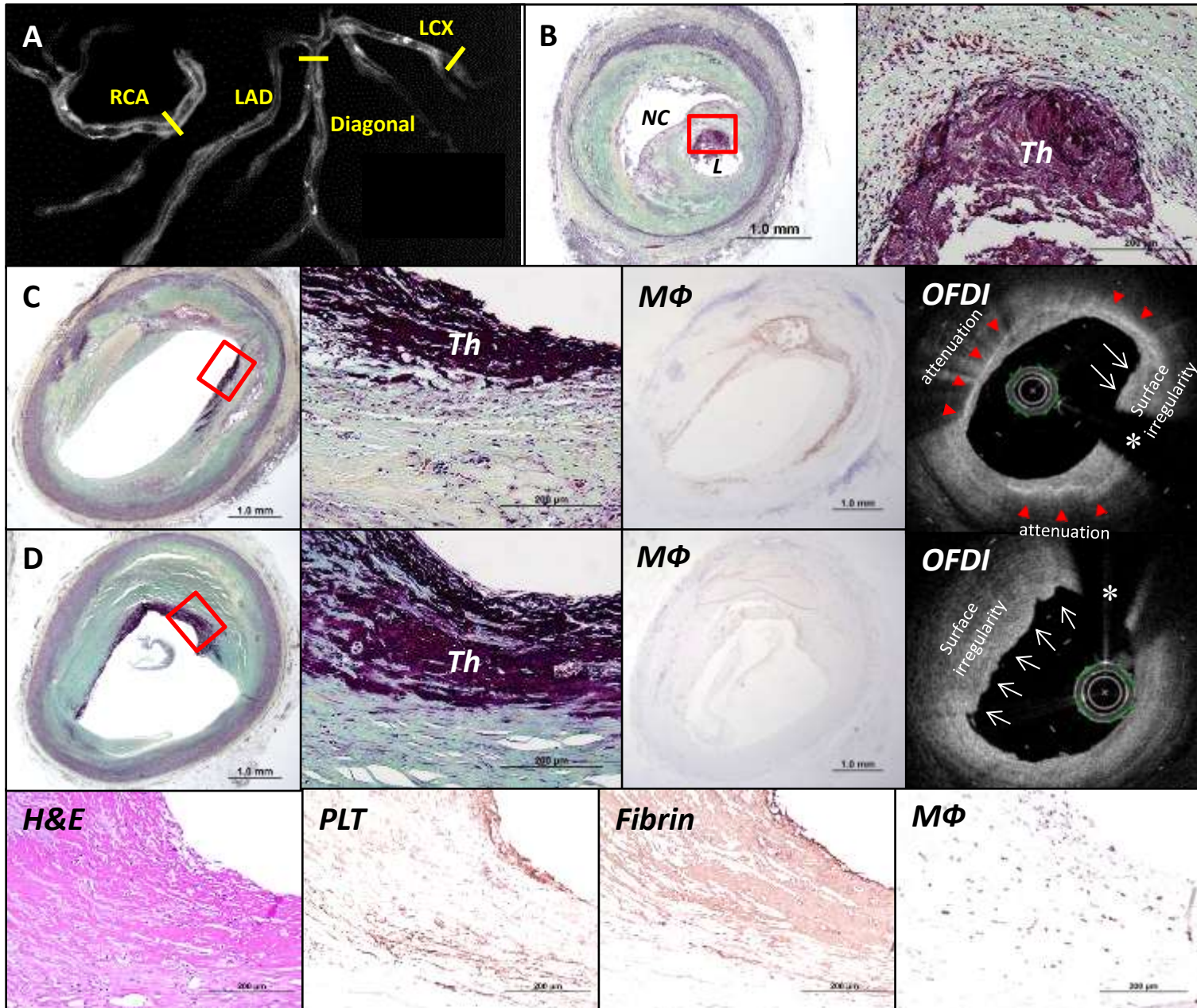
Causes of Coronary Thrombosis

**Joner M
CRT2015**

Lesions with acute thrombi

Rupture	Erosion		Calcified nodule	Plaque Fissure
	Underlying PIT	*Underlying FA*		
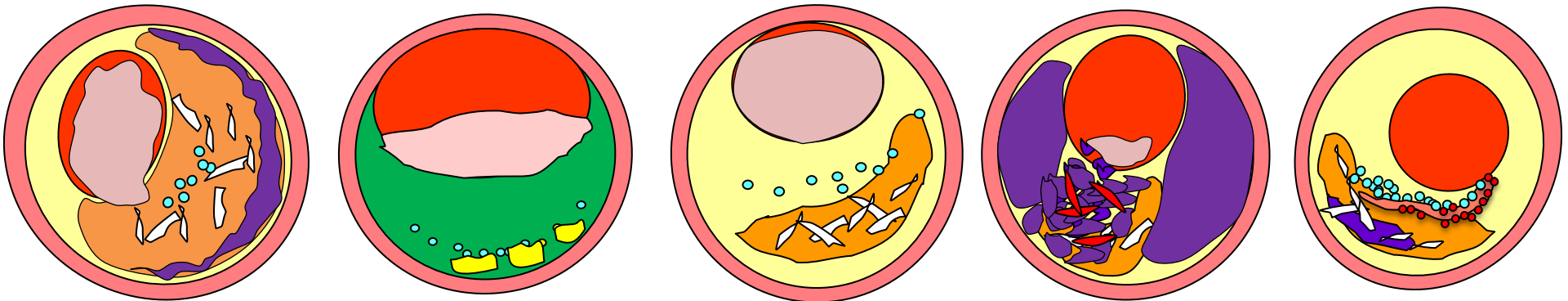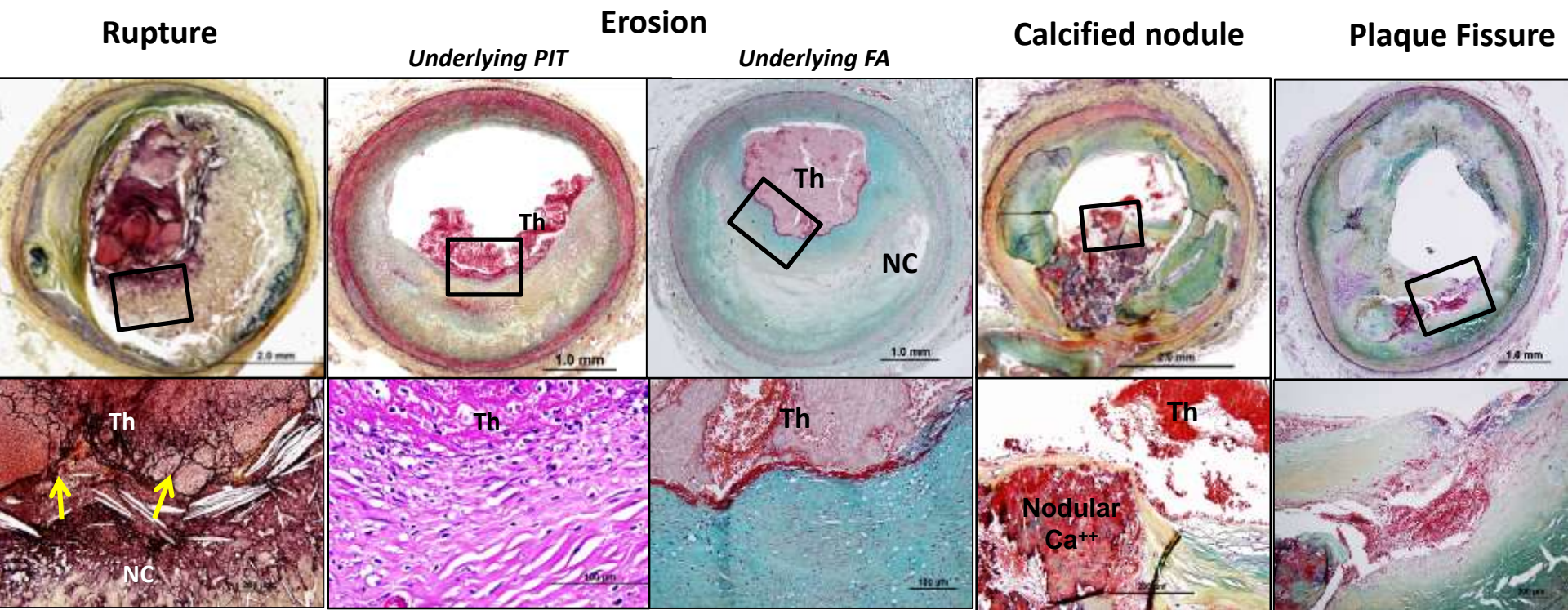
Erosion - Thrombus in the Absence of Rupture

Presence of Necrotic Core

**Joner M
CRT2015**

MGH Multicenter OCT Registry (n=126)

Definite OCT-Erosion
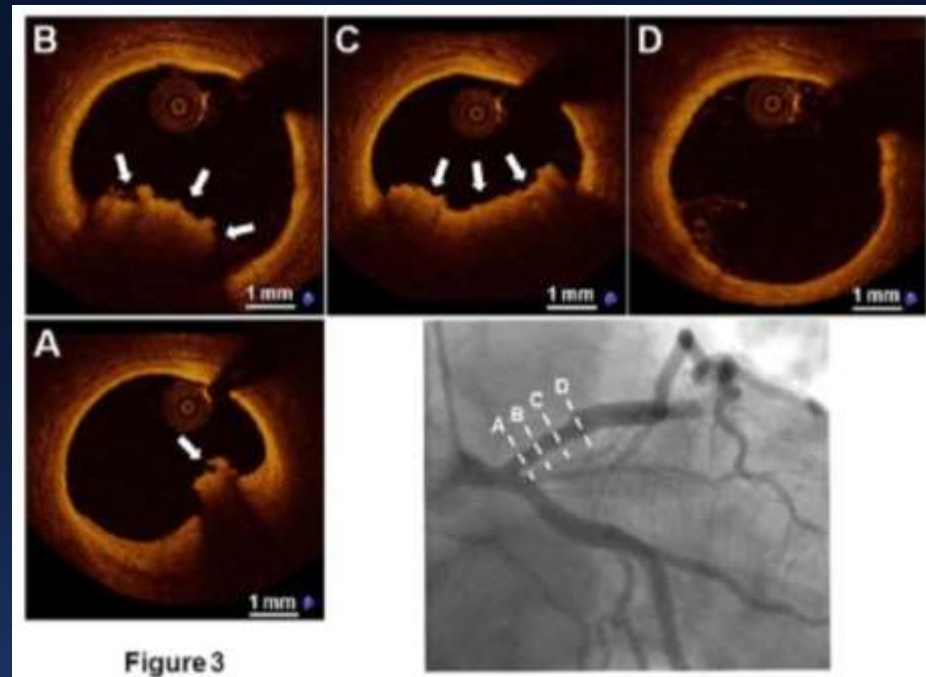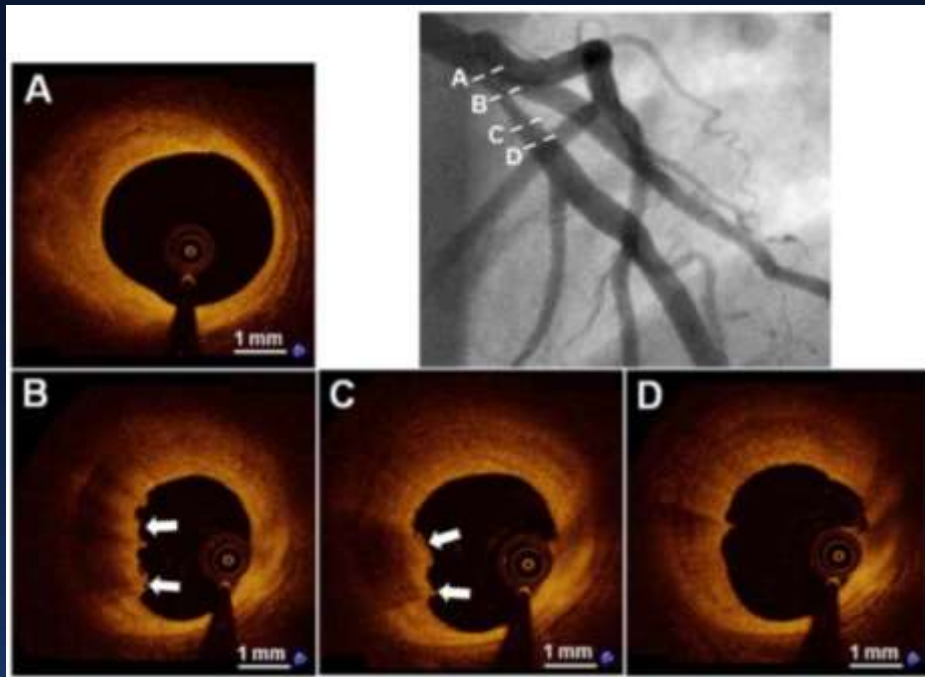
Presence of attached thrombus overlying an intact and visualized plaque

Probable OCT-Erosion

Figure 3

1) Luminal surface irregularity without thrombus
2) Attenuation of underlying plaque by thrombus without superficial lipid or calcification immediately proximal or distal site

Lesion Morphology and Plaque Burden in Pathology

Otsuka F, et al. ATVB 2014; 34:724-36.
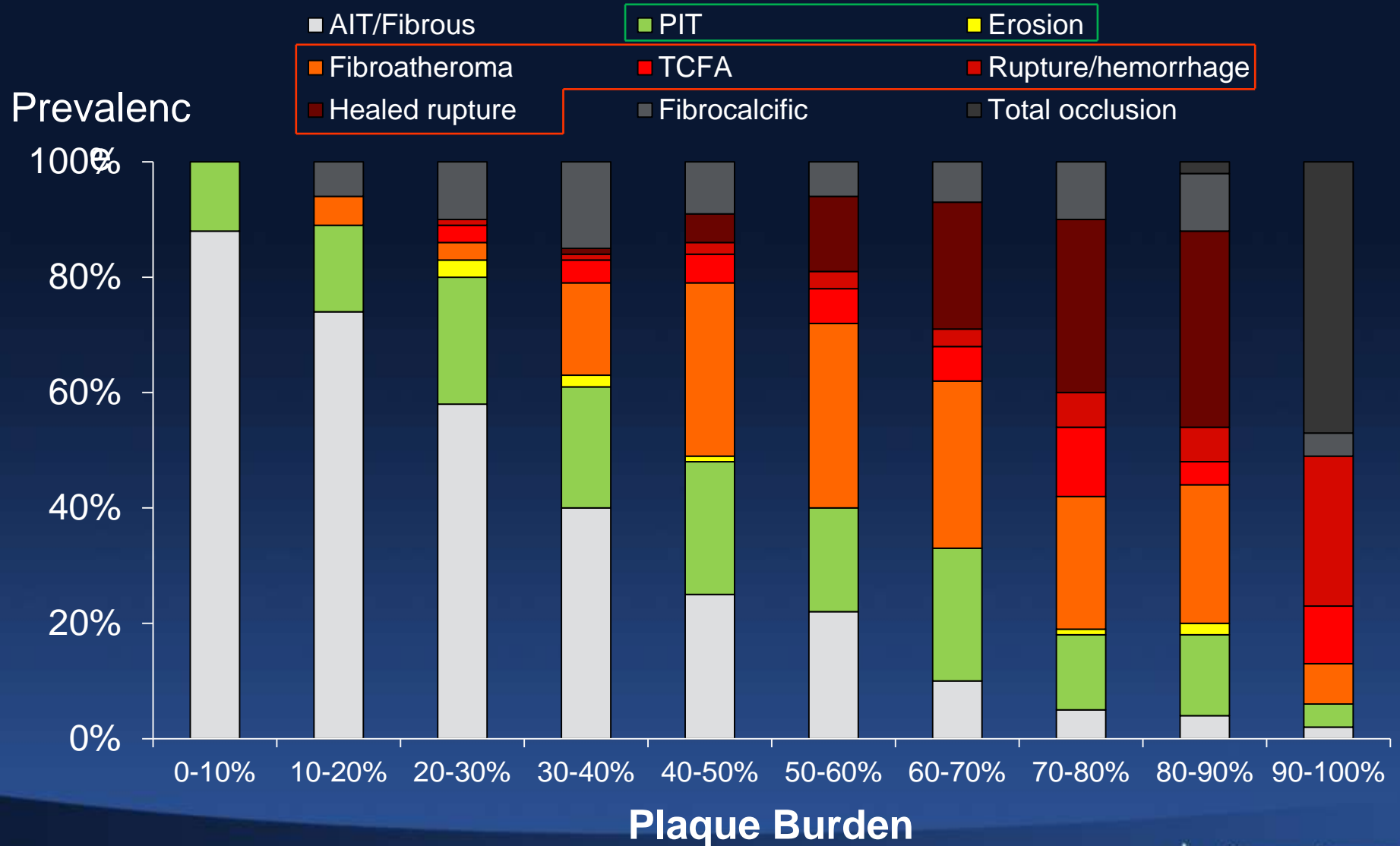
OCT Defined Underlying Plaque in ACS

Plaque Rupture · No Rupture · Calcified Nodule

Prevalence (%) by study: Jia / MGH Registry, Niccoli / Italy, Wang / Italy, Higuma / Japan, Saia / Italy
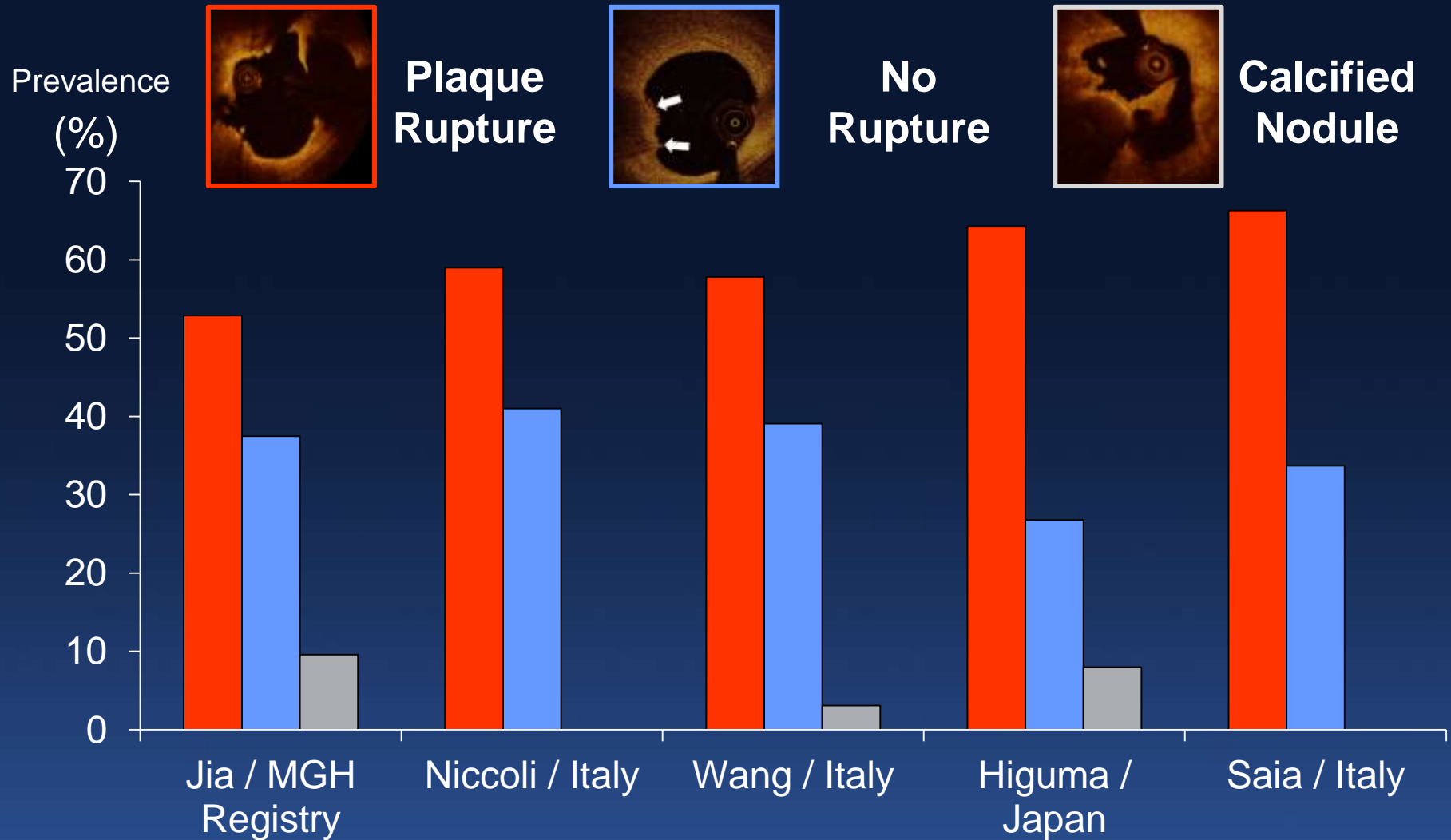
Jia H, et al. JACC 2013;62:1748-58. Niccoli G et al. EHJ 2015; 36:1377-84.Wang L et al. EHJI 2015 doi:10.1093/ehjc.jev105 Higuma T et al. JACC Interv 2015;8:1166-76. Saia JACC Img 2015; 8: 566-75.
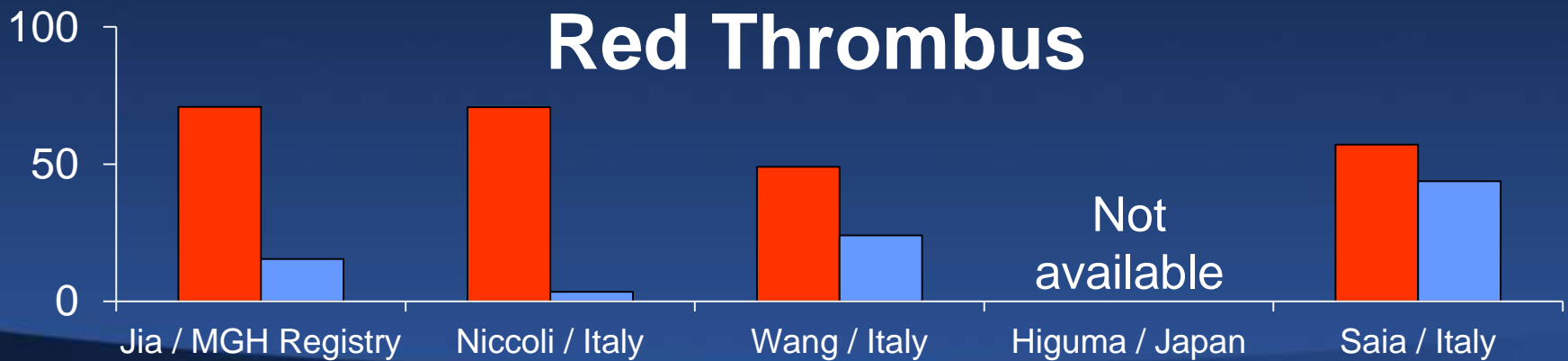
Difference of Morphology

Prevalence

(%)

 Plaque Rupture   **No Rupture**

TCFA

100

50

0

| Jia / MGH Registry | Niccoli / Italy | Wang / Italy | Higuma / Japan | Saia / Italy |

Red Thrombus

100

50

0

Not available

| Jia / MGH Registry | Niccoli / Italy | Wang / Italy | Higuma / Japan | Saia / Italy |
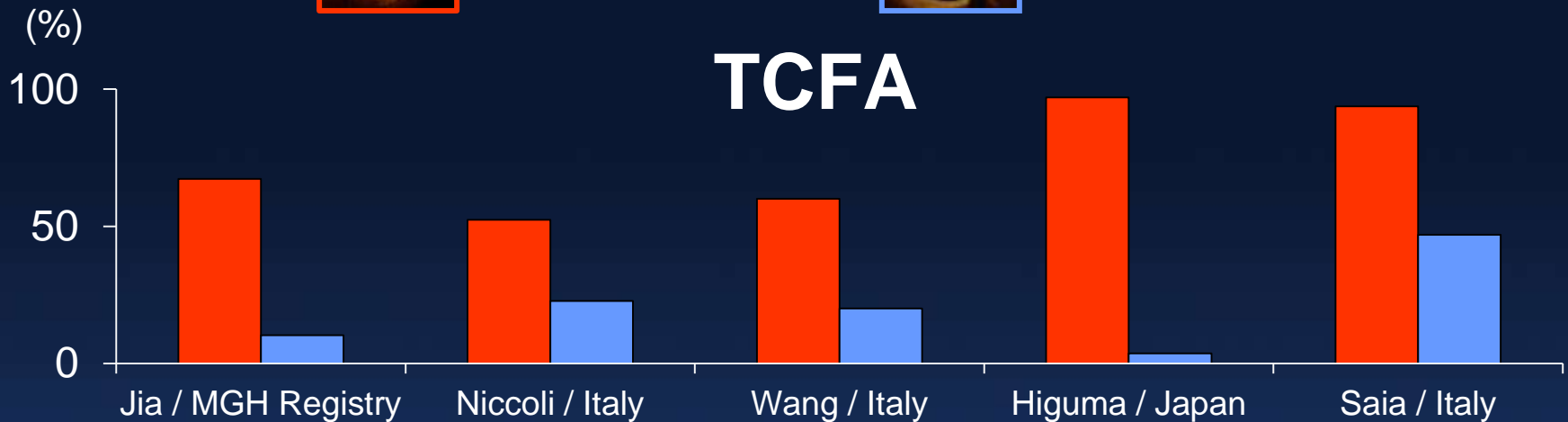
ADAPT-DES VH-IVUS Comparison

	STEMI (n=167)	NSTEMI /UAP (n=217)	Stable CAD (n=292)	P-Value
Plaque Rupture	56%	36%	24%	<0.0001
VH-TCFA	65%	53%	44%	<0.0001
Ca-ThCFA	10%	19%	26%	<0.0001
Minimum lumen area (mm^2)	2.5±0.7	2.8±1.0	3.0±1.1	<0.0001
Plaque Burden at MLA (%)	80.3±12.3	76.5±10.1	74.0±10.5	<0.0001
Remodeling index	1.11±0.47	1.02±0.36	0.99±0.41	0.0002

Dong L, AJC 2015
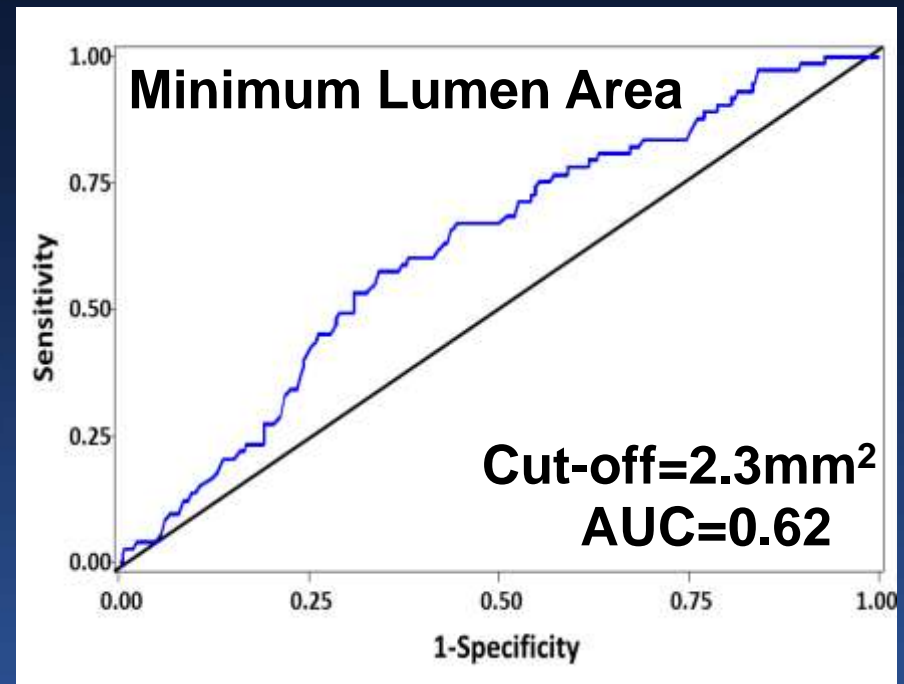
Predictor of STEMI

With Plaque Rupture

Plaque Burden per 10%
Odds Ratio: 2.8 [1.6, 4.8]
p=0.0001
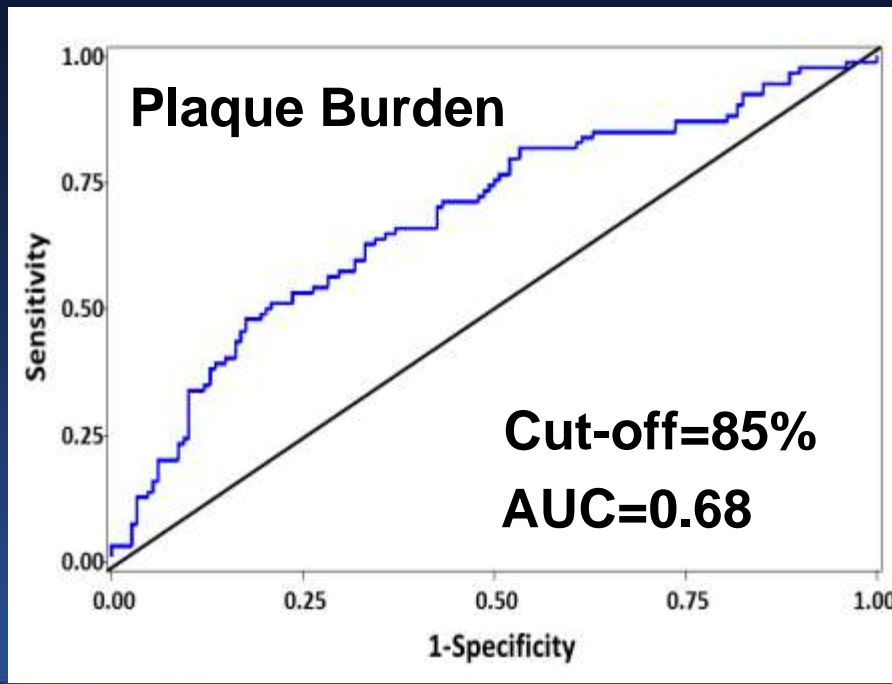
Without Plaque Rupture

MLA per 1.0 mm^2
Odds Ratio: 0.64 [0.44, 0.94]
p=0.022

Plaque Burden

Cut-off=85%
AUC=0.68

Minimum Lumen Area

Cut-off=2.3mm^2
AUC=0.62

WHC STEMI/NSTEMI IVUS

Acute MI 2002-2005
N=1400, 67% NSTEMI

N=189 (14%)
Age≥80

N=739 (53%)
Age<65

N=472 (33%)
Age:65-79

NSTEMI
71%

STEMI
29%

NSTEMI
63%

STEMI
37%

30 (71%)

12 (29%)

23 (44%)

29 (56%)

IVUS

Hassani et al. JACC 2006:47; 2413-9

IVUS Findings

	Age>80	Age<65	p-value
Thrombus	1 (2%)	7 (14%)	0.04
Calcified Plaque	57%	10%	0.009
Calcified Length, mm	5.5±2.9	3.5±2.8	0.006
Lesion Max Calcified Arc, °	199±91	115±71	<0.0001
Prox Ref Calcified Arc, °	90±50	65±23	0.2
Distal Ref Calcified Arc, °	68±30	49±18	0.4
MLA, mm^2	2.6±1.2	2.8±1.8	0.5
Remodeling Index, mm^2	0.85±0.2	1.03±0.2	0.0004

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COLUMBIA UNIVERSITY MEDICAL CENTER
NewYork-Presbyterian

FAME 2: Landmark Analysis of Death or MI

≤7 days: HR 7.99 (0.99-64.6); p=0.038

≥8 days: HR 0.42 (0.17-1.04); p=0.053

P-interaction: p=0.003

De Bruyne B et al. NEJM 2012:367:991-1001
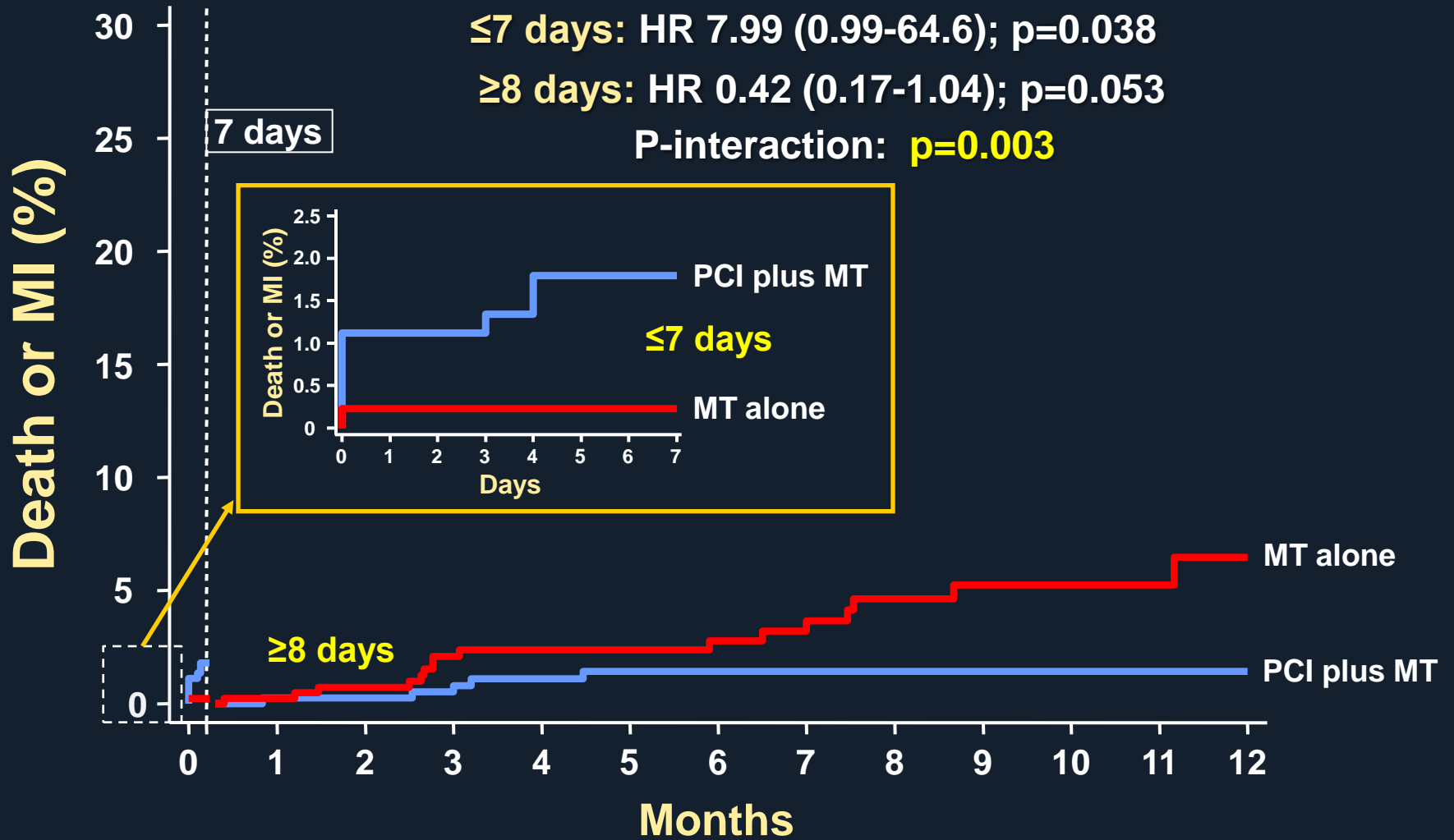
Lesion morphology with angiographic DS>30% by OCT/IVUS

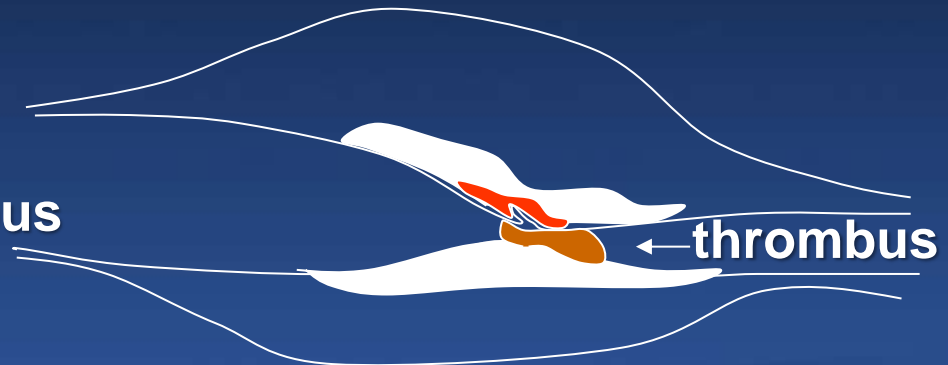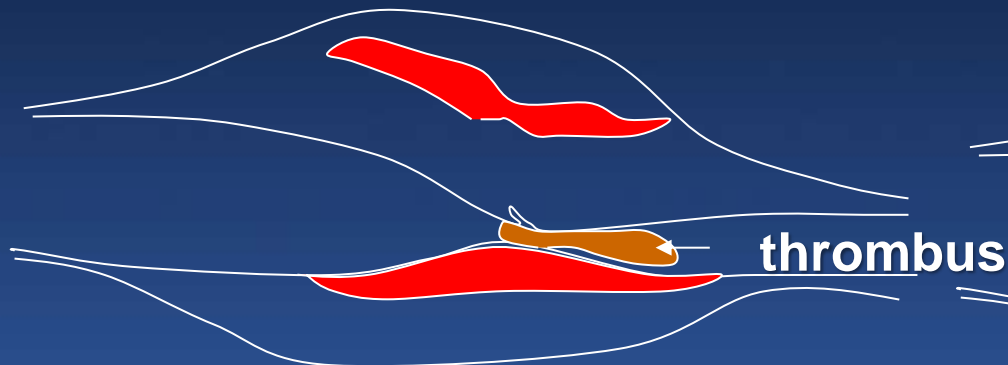| Angio DS	30-49%	50-69%	>70%
OCT			
Prevalence of TCFA	18% (58/325)	18% (40/227)	36% (33/91)
Fibrous cap thickness (µm)	57.0±6.6	56.0±7.5	49.0±9.2
Lipid arc (°)	214±56	209±55	204±59
Lipid length (mm)	9.4±4.6	10.5±5.5	9.6±4.5
IVUS			
Lumen area (mm^2)	5.8±2.4	4.5±2.1	3.2±2.3
Plaque burden (%)	58.1±8.4	67.5±9.4	80.1±7.4
Remodeling index	0.98±0.10	1.02±0.13	1.09±0.13

Tian J, et al. JACC 2014;64:672-80.

Large rupture with large thrombus

Erosion with small thrombus
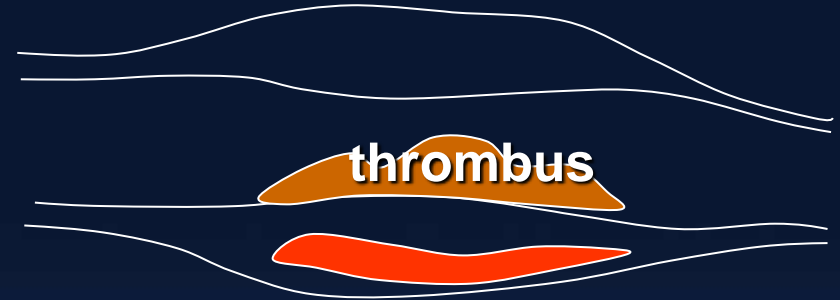
thrombus

thrombus

Severe stenosis with small thrombus with or without erosion

thrombus

thrombus

A PROSPECT Case

Index

9 Months later

MLA=4.0mm², TCFA

*Septal

prox
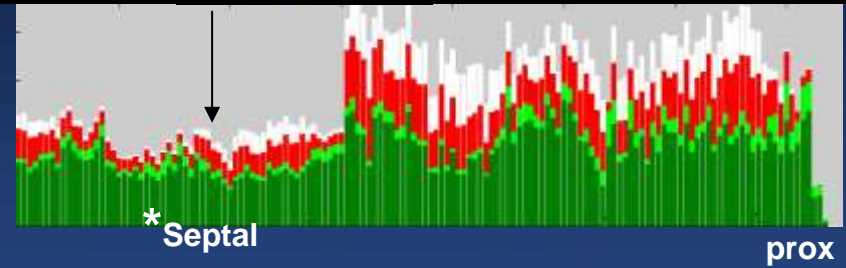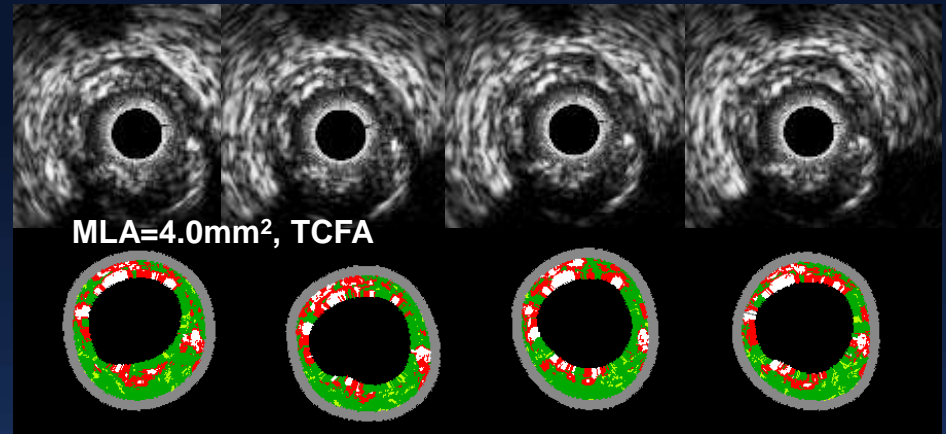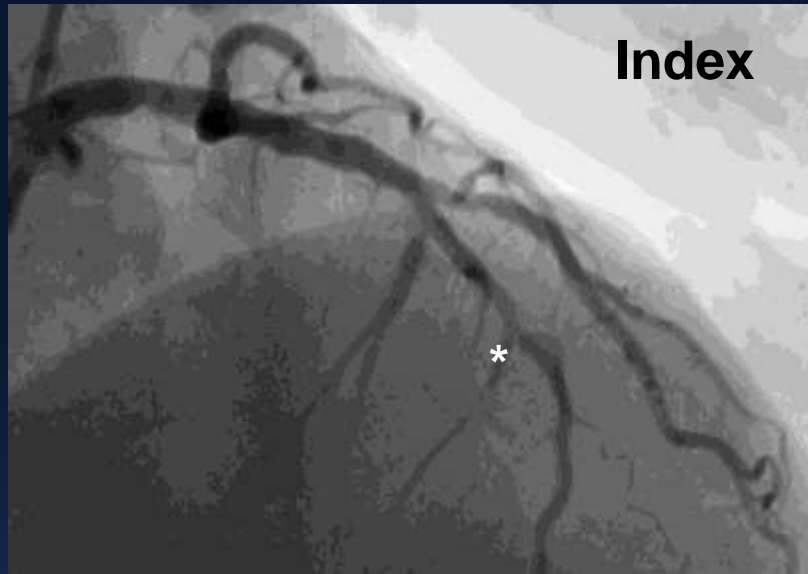
The PROSPECT Trial

700 pts with ACS

UA (with ECGΔ) or NSTEMI or STEMI >24⁰
undergoing PCI of 1 or 2 major coronary arteries
at up to 40 sites in the U.S. and Europe

Metabolic S.
- **Waist circum**
- **Fast lipids**
- **Fast glu**
- **HgbA1C**
- **Fast insulin**
- **Creatinine**

PCI of culprit lesion(s)
Successful and uncomplicated

Formally enrolled

Biomarkers
- *Hs CRP*
- *IL-6*
- *sCD40L*
- *MPO*
- *TNFα*
- *MMP9*
- *Lp-PLA2*
- *others*

PI: Gregg W. Stone
Sponsor: Abbott Vascular; Partner: Volcano

PROSPECT: Multivariable Correlates
of Non Culprit Lesion Related Events

## Independent predictors of lesion level events by Cox Proportional Hazards regression

Variable	HR [95% CI]	P value
PB_{MLA} ≥70%	5.03 [2.51, 10.11]	<0.0001
VH-TCFA	3.35 [1.77, 6.36]	0.0002
MLA ≤4.0 mm^2	3.21 [1.61, 6.42]	0.001

Variables entered into the model: minimal luminal area (MLA) ≤4.0 mm^2; plaque burden at the MLA (PB_{MLA}) ≥70%; external elastic membrane at the MLA (EEM_{MLA}) <median (14.1 mm^2); lesion length ≥median (11.2 mm); distance from ostium to MLA ≥median (30.4 mm); remodeling index ≥median (0.94); VH-TCFA

64 year old presents with STEMI in March 2012 → Unstable angina October 2012

maxLCBI$_{4mm}$ 694

R. Madder, Spectrum Health
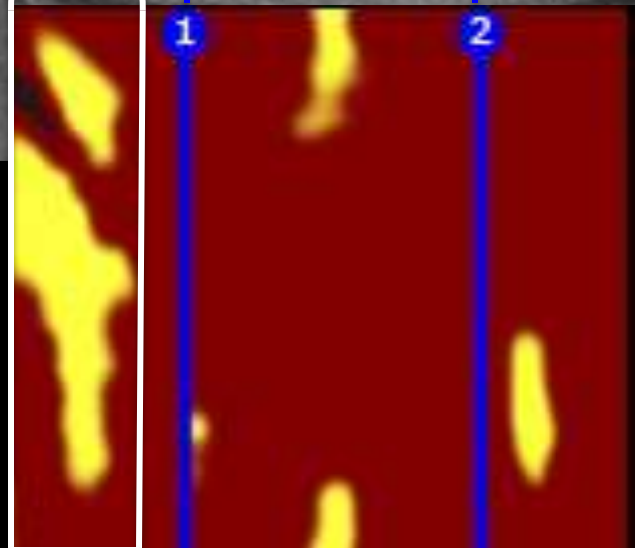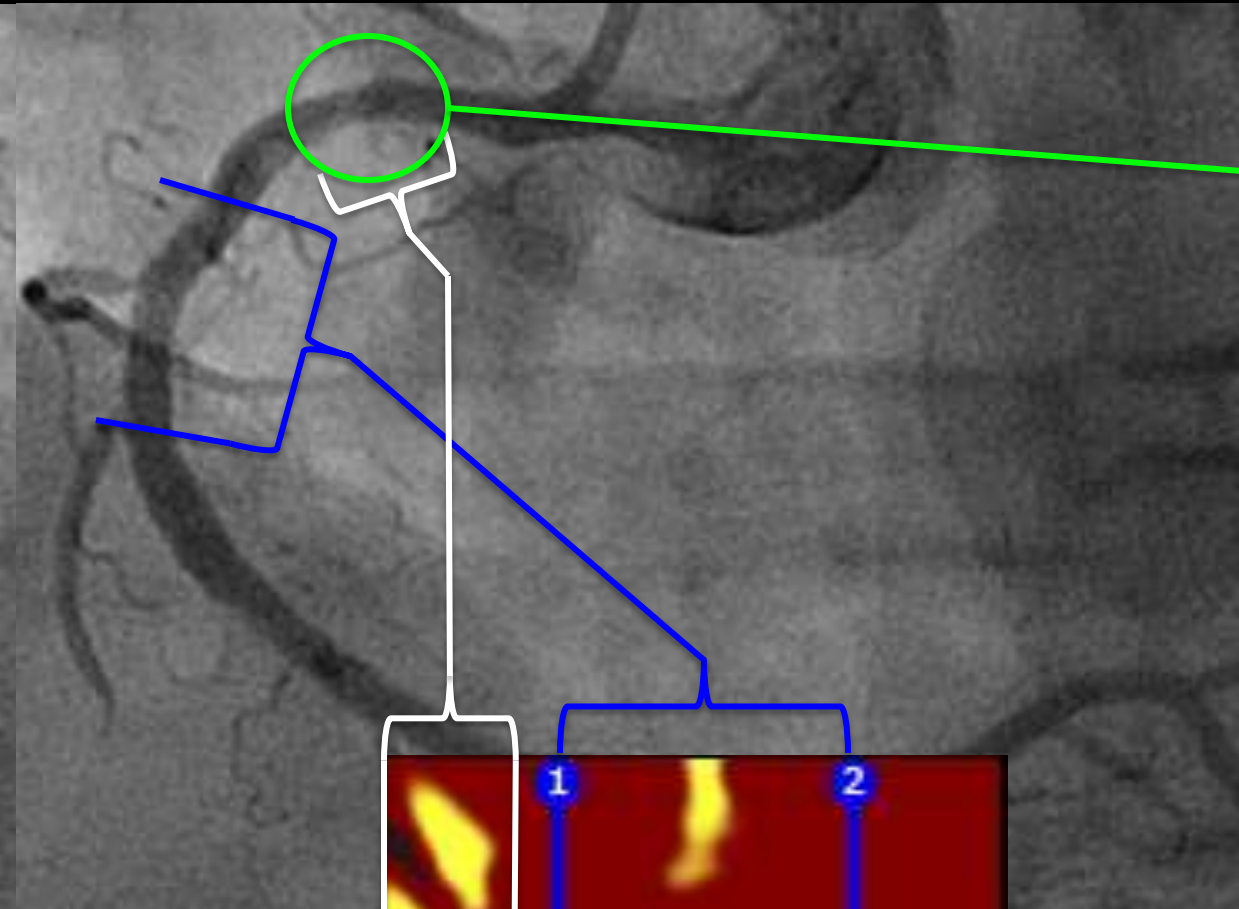
Methods

- Evaluated non-stented coronary segments for large LRP

  - defined as a $maxLCBI_{4mm} \geq 500$

- 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

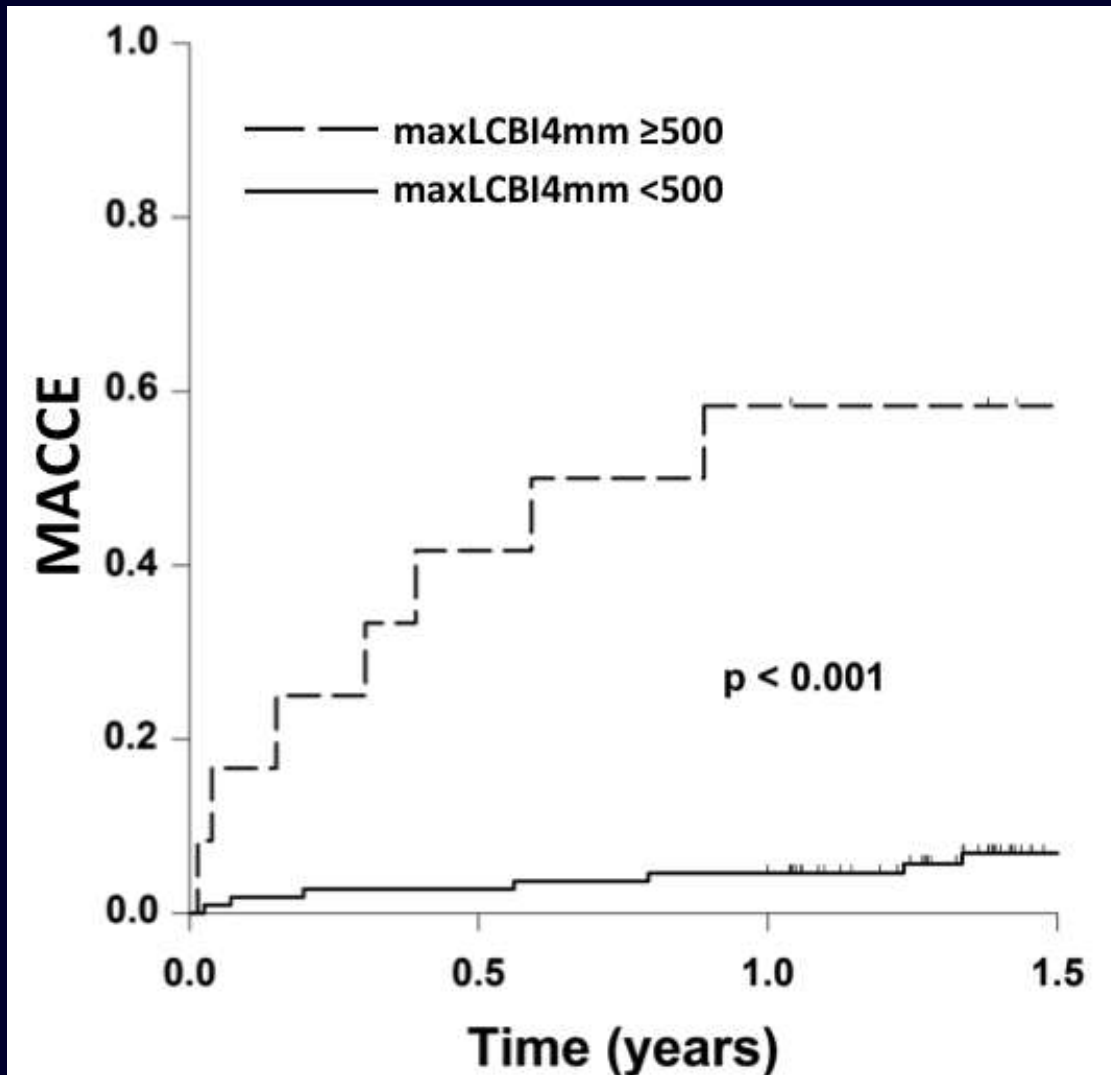- All events adjudicated blinded to the NIRS-IVUS imaging

Large LRP in non-stented segment

Stented segment excluded from analysis
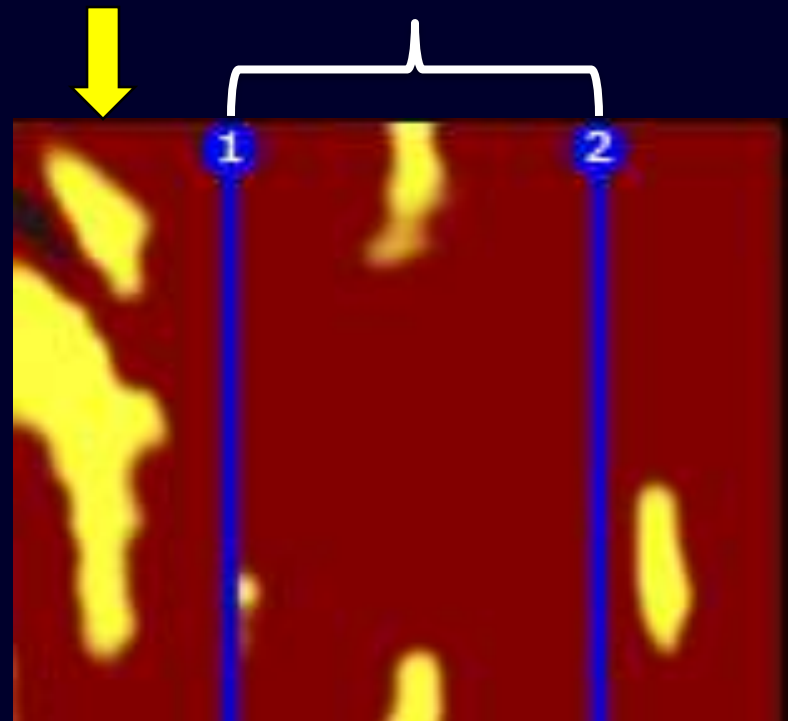
Large LRP by NIRS and MACCE

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)

How to Define Vulnerable Plaque? What Does It Mean?

1. Large amount of necrotic core with thin cap fibroatheroma causing plaque rupture with large thrombus

2. Mild-severe plaque burden with pathological intimal thickening or early fibroatheroma causing plaque erosion with limited amount of thrombus. Prediction is difficult.

3. Severe stenosis with any kind of underlying plaque causing limited amount of thrombus without rupture

4. All together, vulnerable plaque should be defined as "large plaque burden, small lumen area, and TCFA".