Vulnerable plaque detection：What is new in 2018 OCT

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Disclosure Statement of Financial Interest

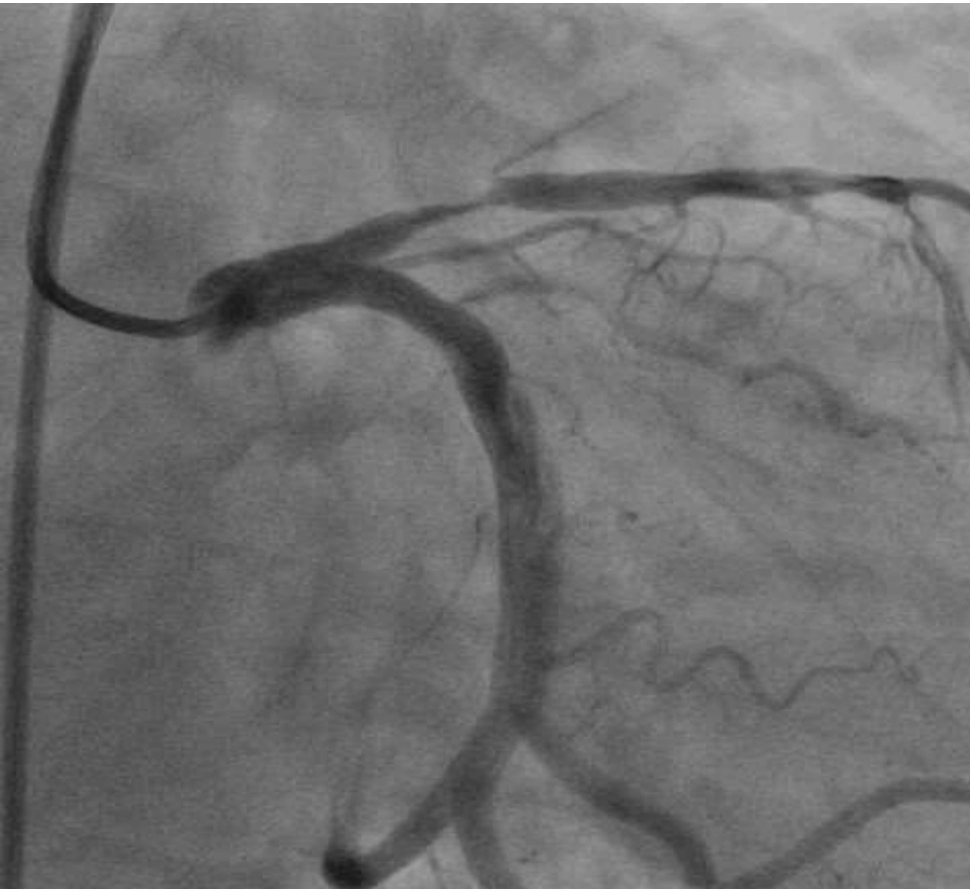
Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

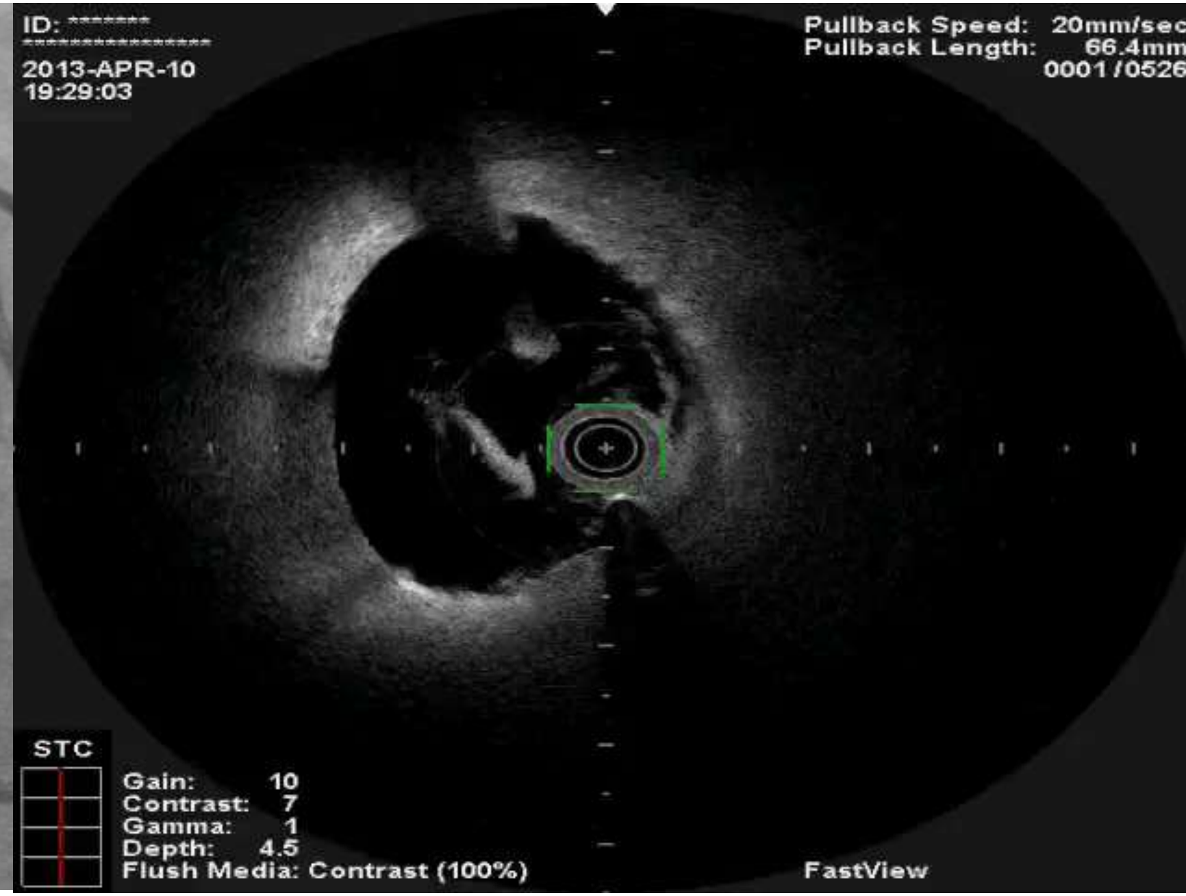
Affiliation/Financial Relationship

- **Grant/Research Support** : **Abbott Vascular Japan**
  Boston Scientific Japan
  Goodman Inc.
  St. Jude Medical Japan
  Terumo Inc.

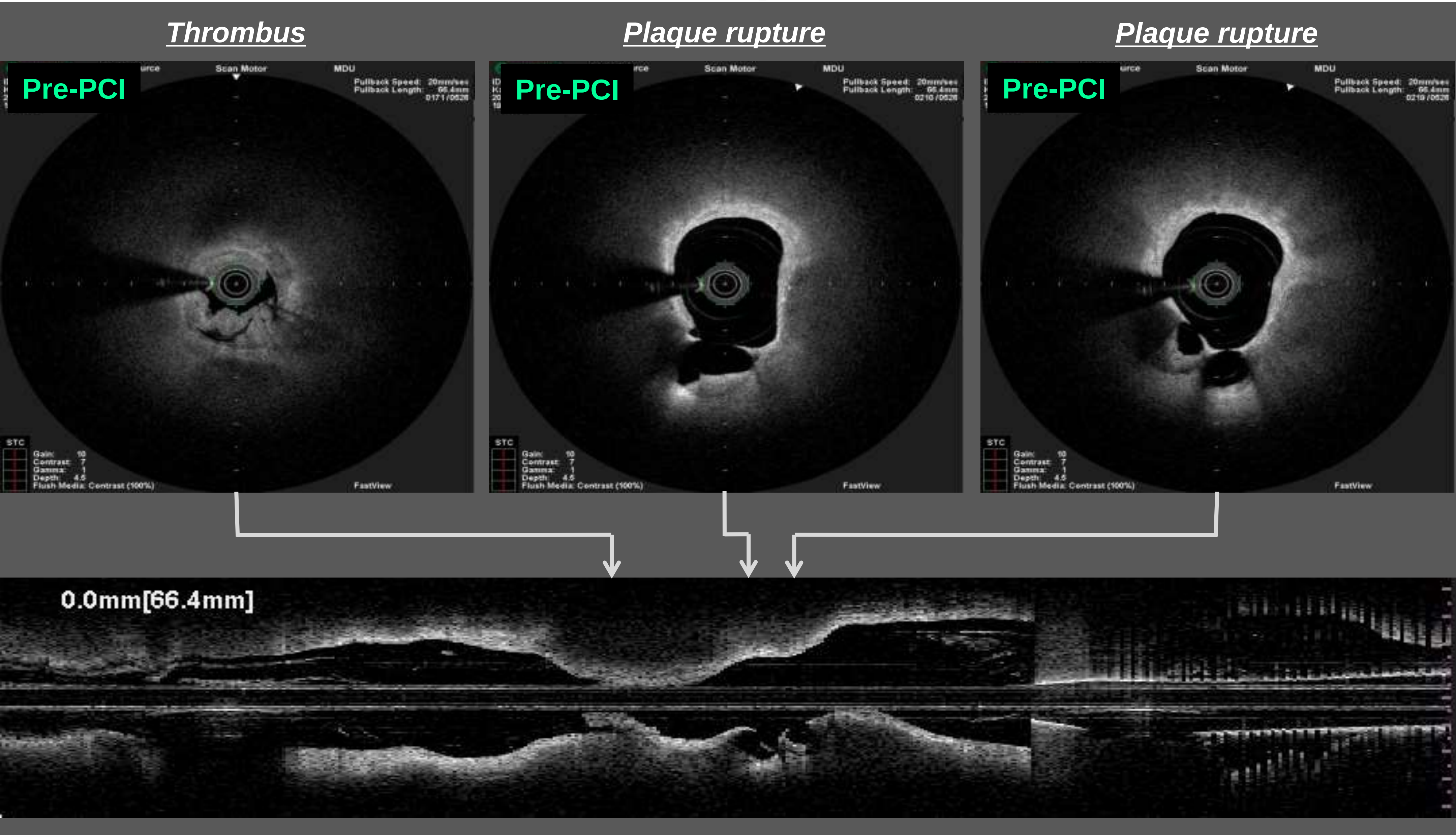
- **Consulting Fees/Honoraria** : **Daiichi-Sankyo Pharmaceutical Inc.**
  Goodman Inc.
  St. Jude Medical Japan
  Terumo Inc.

Pre-PCI OFDI (65 y.o. male, UAP)

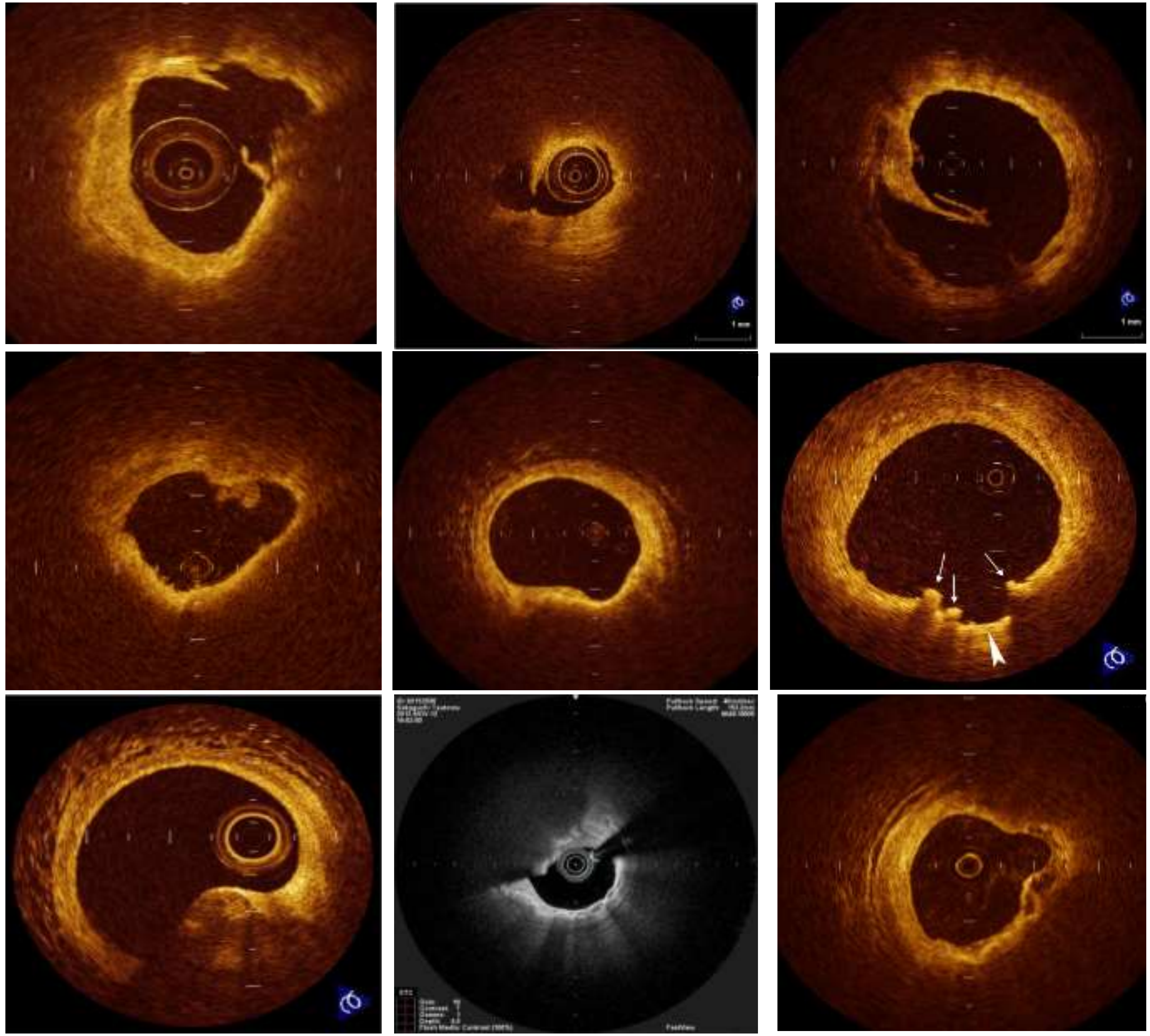




OFDI at culprit site



Demonstration of various causes in ACS



Plaque rupture

60 – 70 %

Plaque erosion

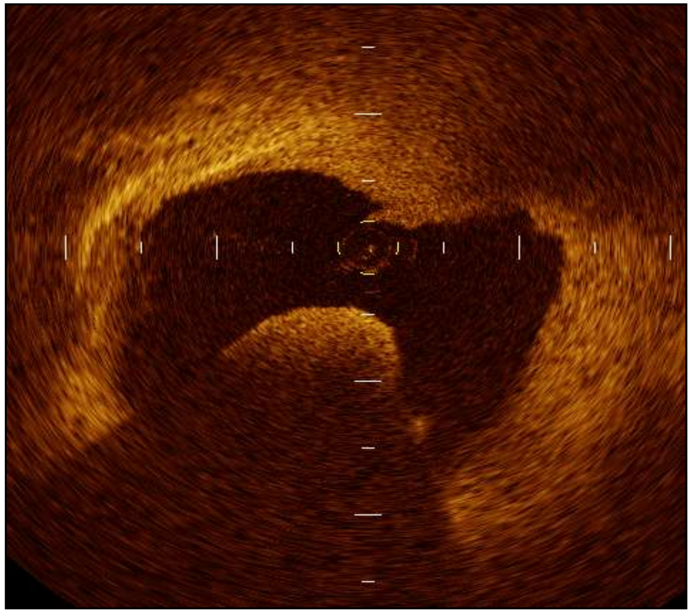
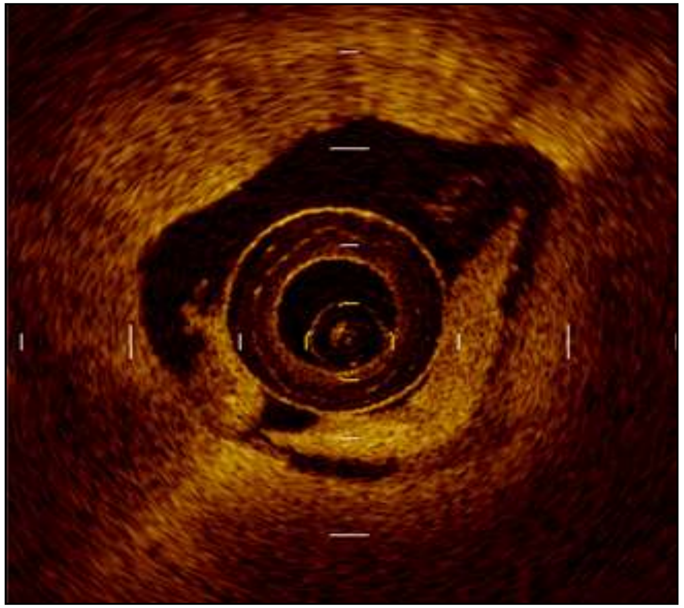
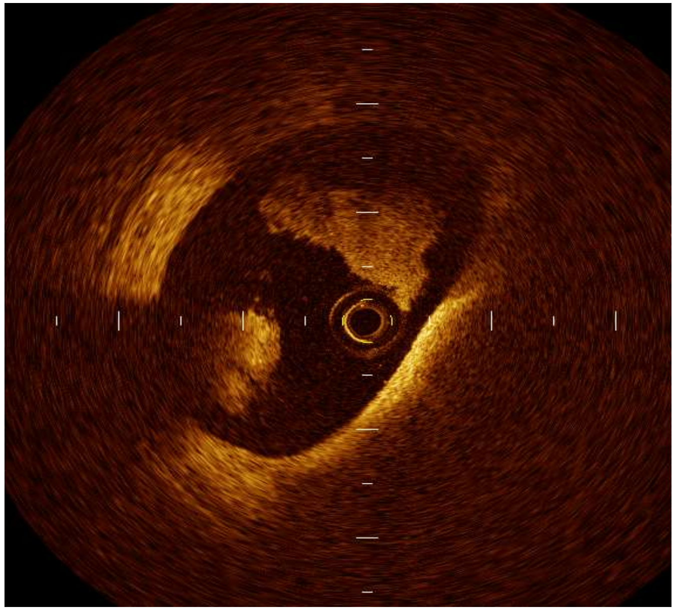
20 – 30 %

Calcified nodule

5 – 6 %

Kubo T, Akasaka T, et al. (J Am Coll Cardiol 50:933-939,2007)

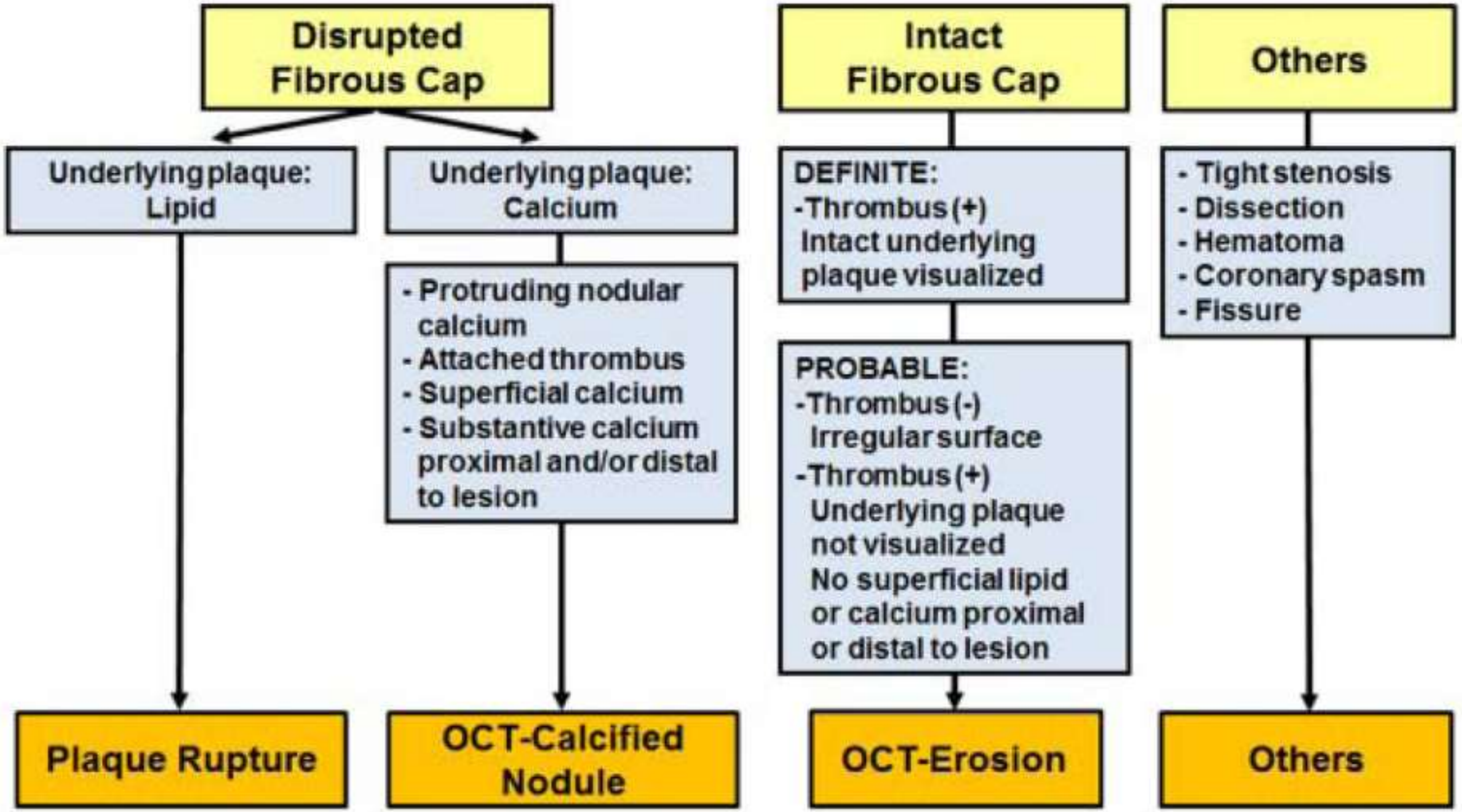
Red & white thrombus

Red thrombus	White thrombus	Mixed thrombus
		
Protrusion mass with shadow	Protrusion mass without shadow	Protrusion mass with & without shadow

Kume T, Akasaka T, et al. (Am J Cardiol 97:1713-1717, 2006)
Kubo T, Akasaka T, et al. (J Am Coll Cardiol 50:933-939,2007)

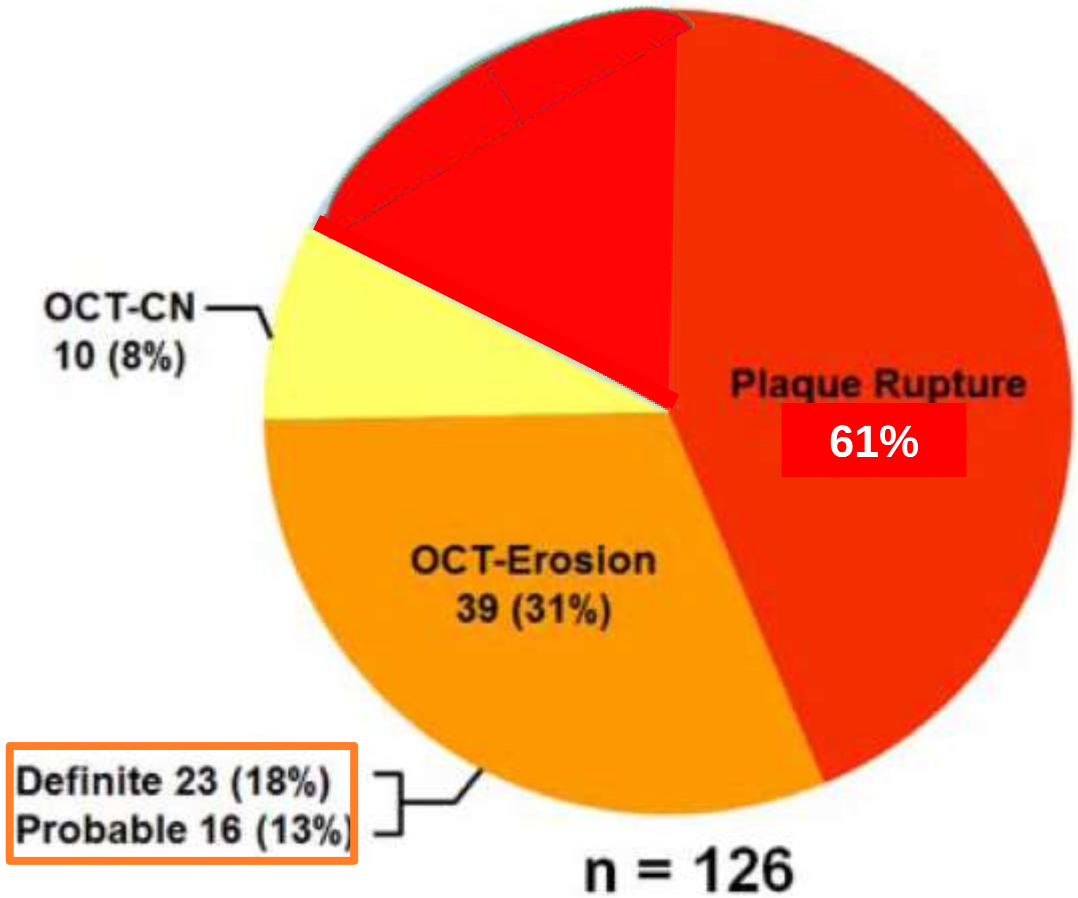
Plaque Classification Algorithm by OCT

Jia H, et al. J Am Coll Cardiol 2007;50:933–999



Incidence of plaque rupture, erosion and calcified nodule in 126 lesions in pts with ACS

Jia H, et al. J Am Coll Cardiol 2007;50:933–999



OCT Findings of Underlying Plaque Characteristics

	PR (n = 55)	OCT-erosion (n = 39)	OCT-CN (n = 10)	p value	p value* PR vs. OCT-erosion	p value* OCT-erosion vs. OCT-CN	p value* PR vs. OCT-CN
Fibrous plaque	0 (0.0%)	22 (56.4%)	10 (100%)	< 0.001	< 0.001	0.027	< 0.001
Lipid plaque	55 (100%)	17 (43.6%)	0 (0.0%)	< 0.001	< 0.001	0.027	< 0.001
TCFA	37 (67.3%)	3 (10.3%)	0 (0.0%)	< 0.001	< 0.001	1.000	< 0.001
Calcification	22 (40.0%)	5 (12.8%)	10 (100%)	< 0.001	0.016	< 0.001	0.001
MicroChannel	21 (38.2%)	7 (17.9%)	2 (6.7%)	0.083	N/A	N/A	N/A
Thrombus	45 (81.8%)	33 (84.6%)	10 (100%)	0.242	N/A	N/A	N/A
Red thrombus	39 (70.9%)	6 (15.4%)	4 (40.0%)	< 0.001	< 0.001	0.541	0.226
White thrombus	6 (10.9%)	27 (69.2%)	6 (60.0%)	< 0.001	< 0.001	1.000	0.005

Data are presented as n. (%).

PR = plaque rupture; OCT-CN = OCT-calcified nodules; TCFA = thin-cap fibroatheroma.

OCT for the Identification of Vulnerable Plaque in Acute Coronary Syndrome

CrossMark

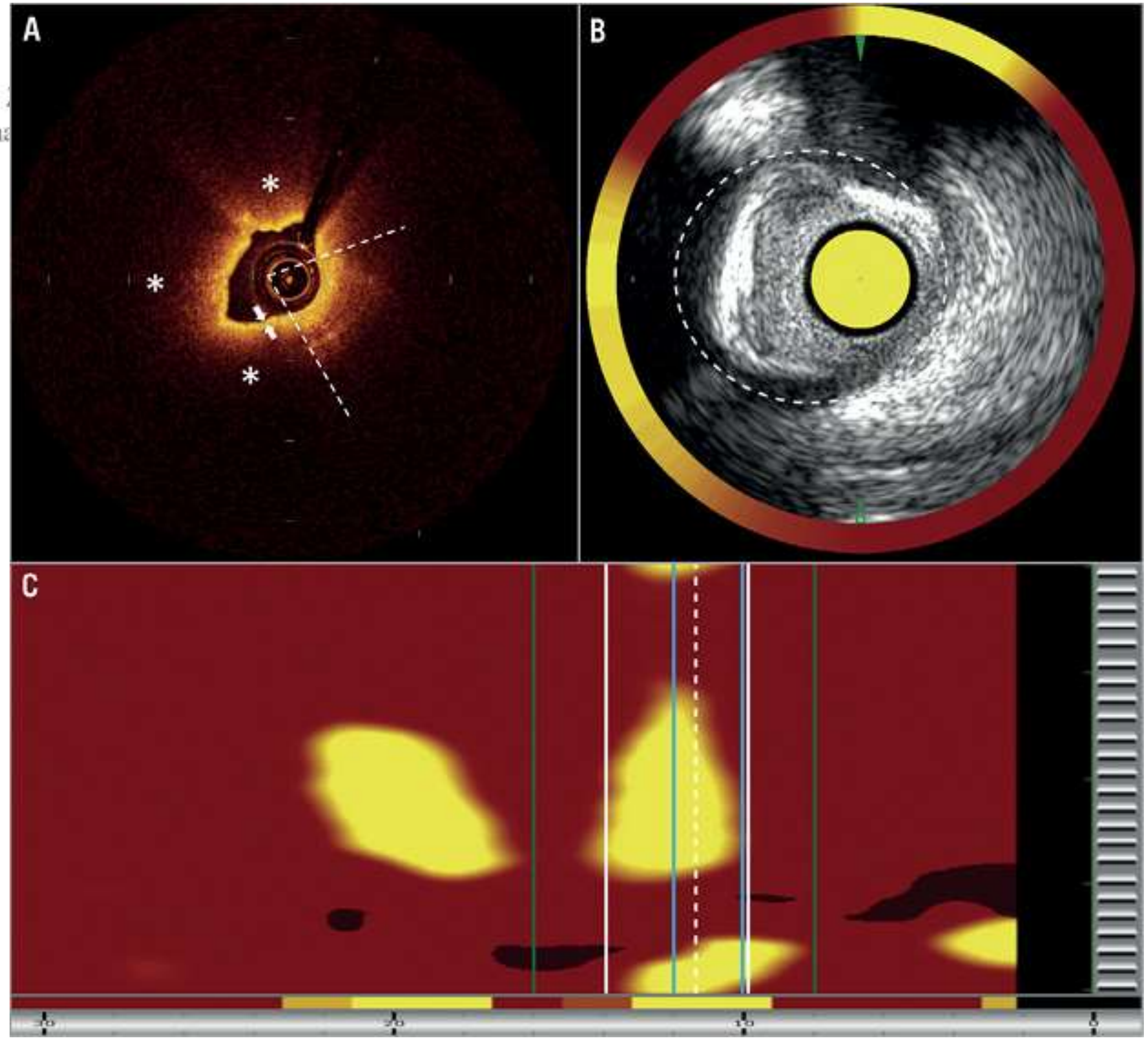
Hannah Sinclair, MB, ChB,[*,†] Christos Bourantas, MD, PhD,[†] Alan Bagnall, MB, ChB, PhD,[†] Gary S. Mintz, MD,[‡] Vijay Kunadian, MBBS, MD[*,†]

ABSTRACT

After 2 decades of development and use in interventional cardiology research, optical coherence tomography (OCT) has now become a core intravascular imaging modality in clinical practice. Its unprecedented spatial resolution allows visualization of the key components of the atherosclerotic plaque that appear to confer "vulnerability" to rupture—namely the thickness of the fibrous cap, size of the necrotic core, and the presence of macrophages. The utility of OCT in the evaluation of plaque composition can provide insights into the pathophysiology of acute coronary syndrome and the healing that occurs thereafter. A brief summary of the principles of OCT technology and a comparison with other intravascular imaging modalities is presented. The review focuses on the current evidence for the use of OCT in identifying vulnerable plaques in acute coronary syndrome and its limitations. (J Am Coll Cardiol Img 2015;8:198–209)

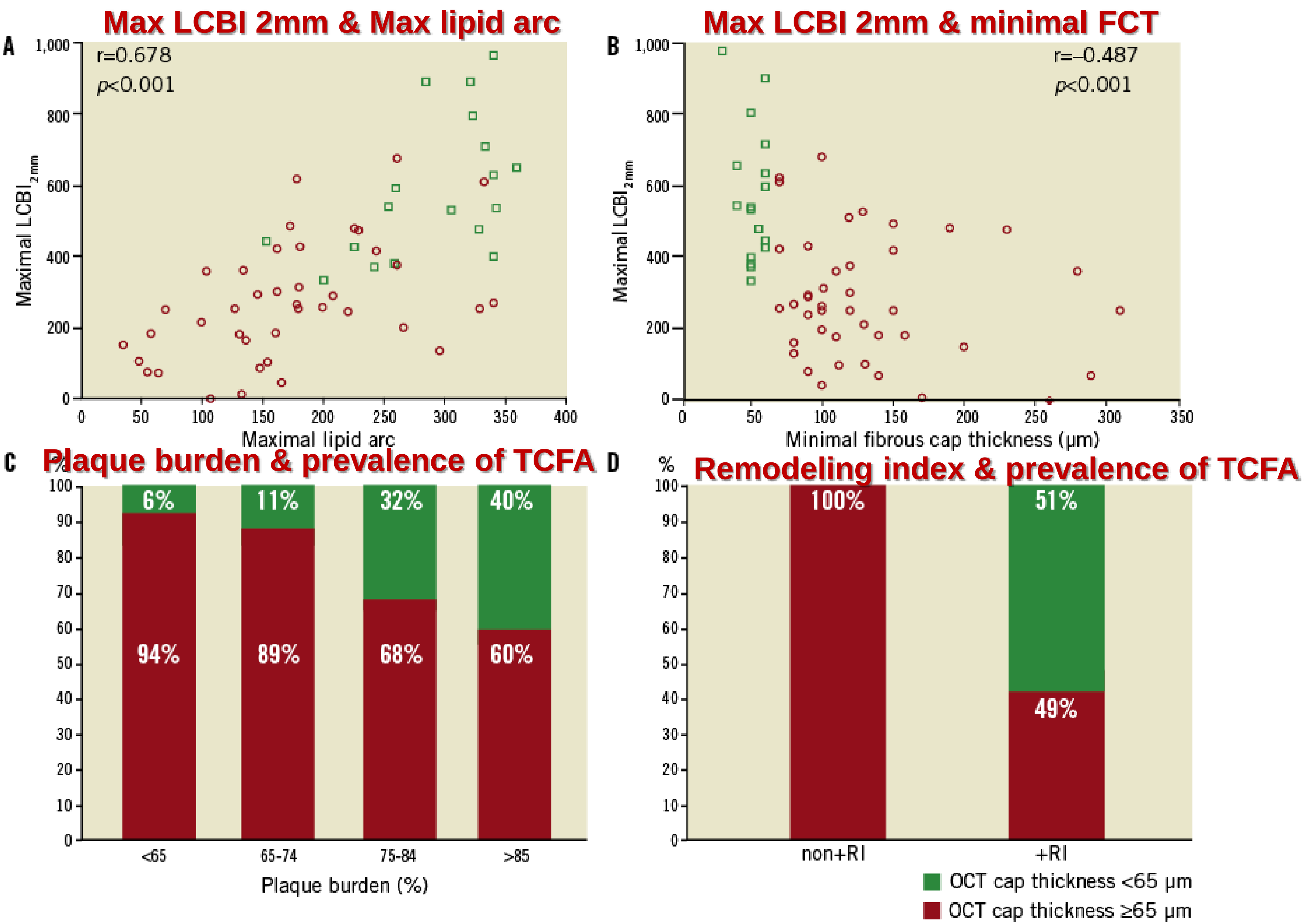
Combined NIRS and IVUS imaging detects vulnerable plaque using a single catheter system: a head-to-head comparison with OCT

Tomasz Roleder[1], MD, PhD; Jason C. Kovacic[1], MD, PhD;
Ecatarina Cristea[1], MD ; Pedro Moreno[1], MD; Samin K. Sha
Annapoorna S. Kini[1]*, MD



Roleder T, et. Al, EuroIntervention 2014;10:303-311

NIRS-IVUS parameters & OCT-defined plaque characteristics



Roleder T, et. Al, EuroIntervention 2014;10:303-311

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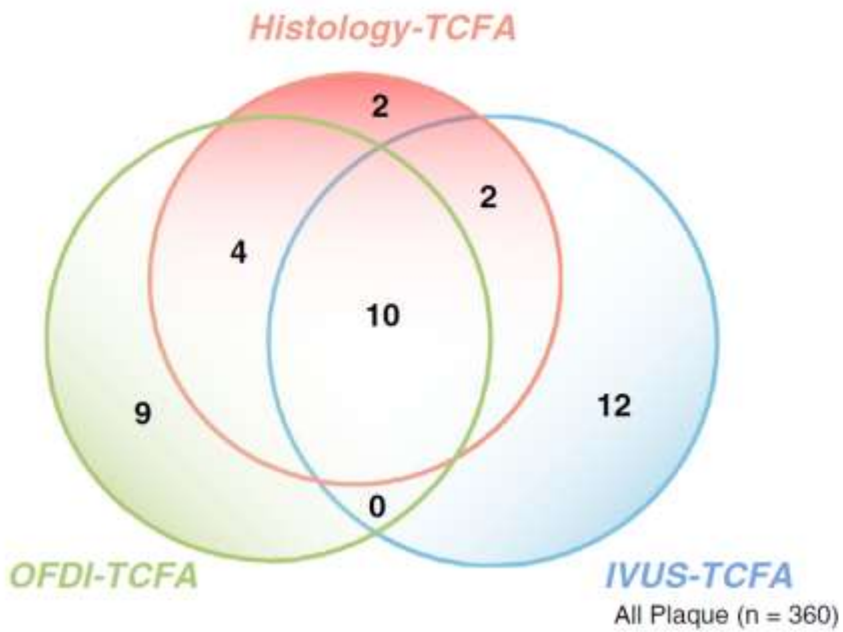
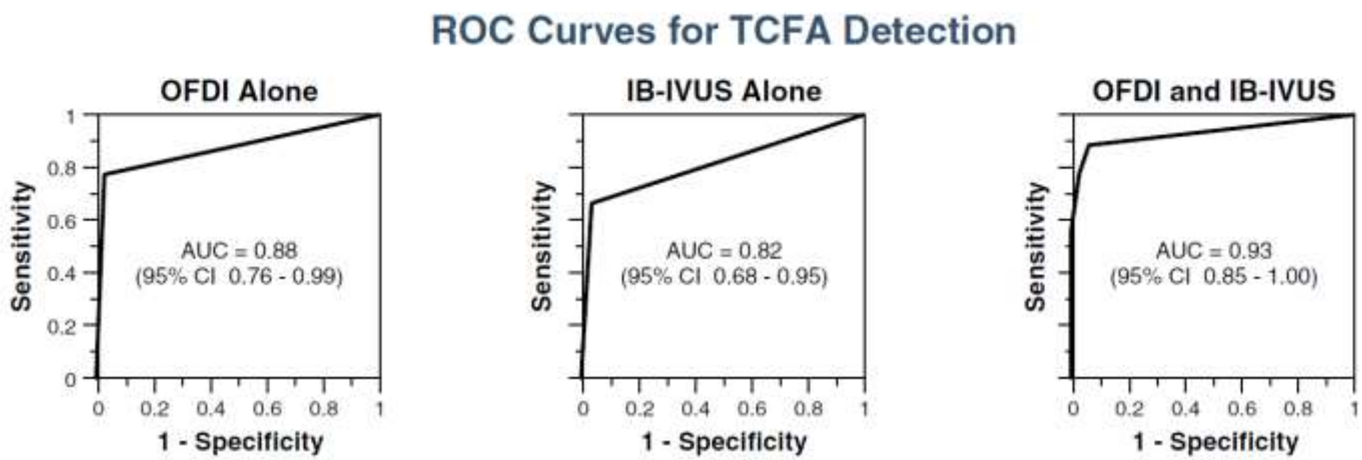
Diagnostic performance of FD-OCT & IB-IVUS for detection of TCFA

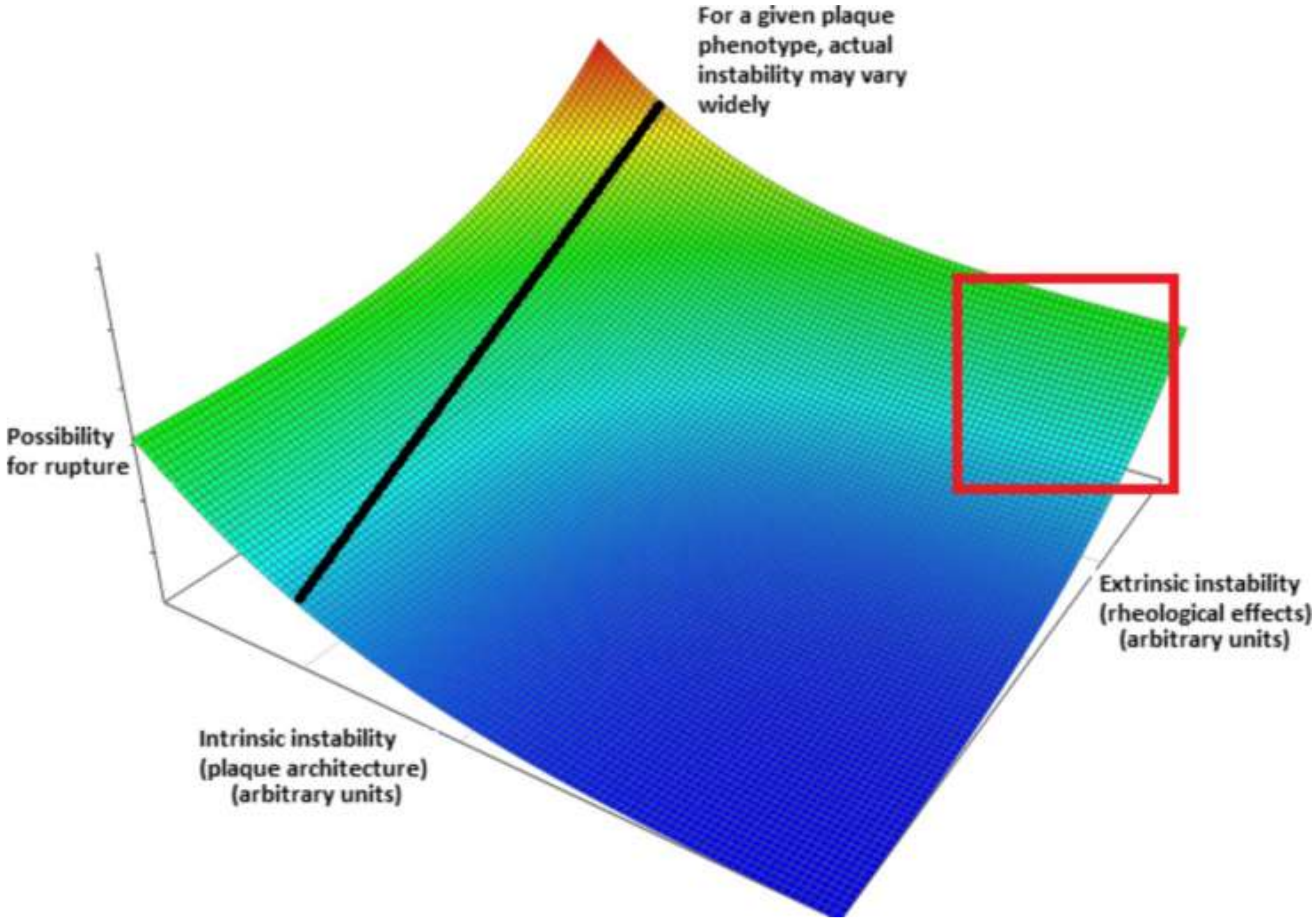




Nakano M, et. Al, J Am Coll Cardiol Img 2016;9:163-172

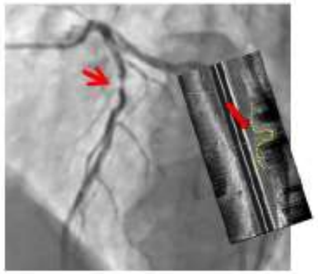
Inadequacy of modern approaches to detect plaque vulnerability.

Stefanadis C, et al. J Am Heart Assoc 2017;6:e005543



EMERALD Study
Study protocol

2012-06 Acute MI



2011-04 CT, Asymptomatic

Patients with Acute Coronary Syndrome
From 11 International Cardiovascular Centers
(Korea, Japan, Belgium, Denmark, the Netherlands)

↓

Patients who underwent Coronary CT angiography
before ACS event (1 month – 2 year before the event)
(N=128)

↓

Validation with clinical data, cCTA and coronary angiography

→ Screening Failure (N=45)
- No adequate CT image: 26
- Unclear diagnosis: 14
- No definite culprit lesion on Angiography: 5

Exclusion by core laboratory due to CT image quality (N=12)

↓

Final Enrollment for cCTA and CFD analysis
(N=71)

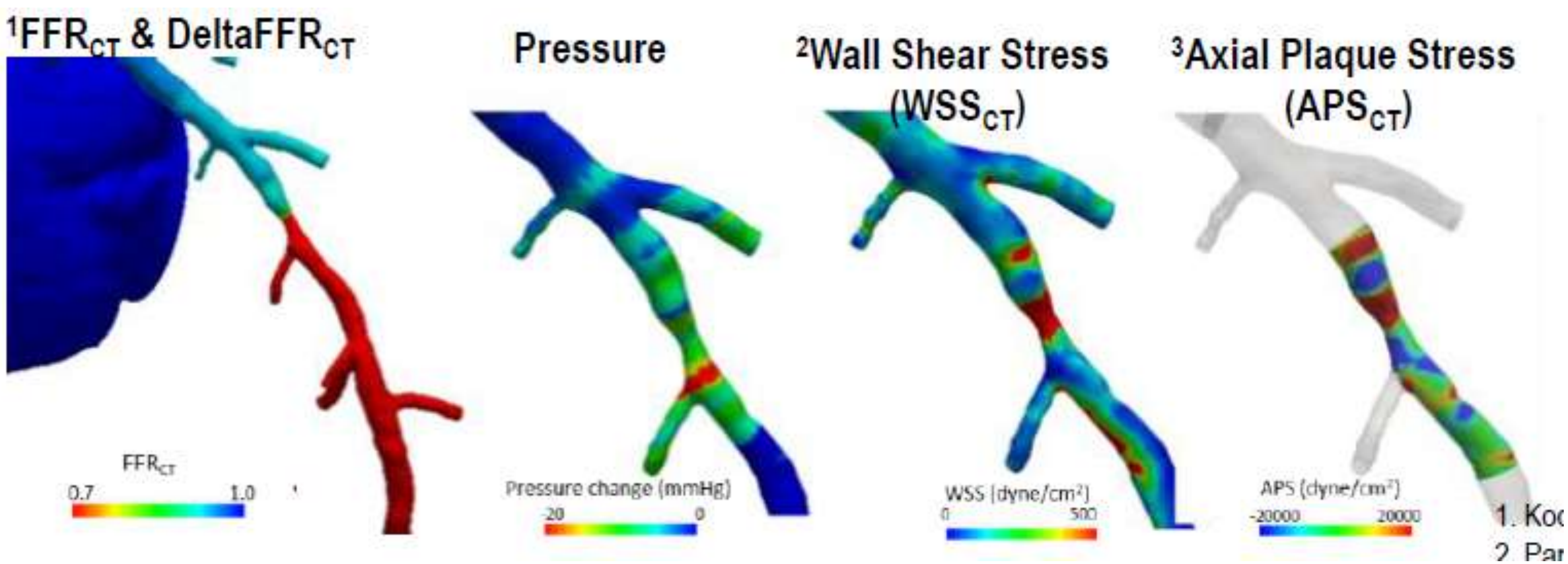
CASE	CONTROL
Culprit Lesion (N=75)	Non- Culprit Lesion (N=151)

↓

cCTA analysis	+	CFD analysis
adverse plaque characteristics		Non-invasive hemodynamics
(Core Lab – SNU Bundang Hospital)		(Core Lab - HeartFlow Inc.)

Lee JM, et al. JACC Interv 2018;in press

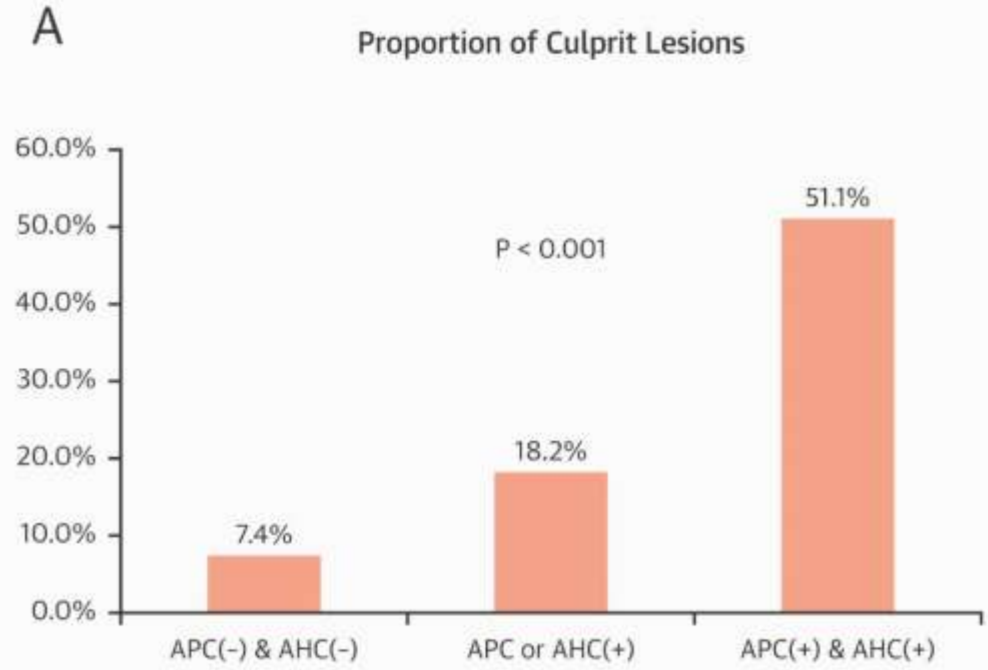
Exploring the MEchanism of the Plaque Rupture in Acute Coronary Syndrome using Coronary CT Angiography and ComputationaL Fluid Dynamics



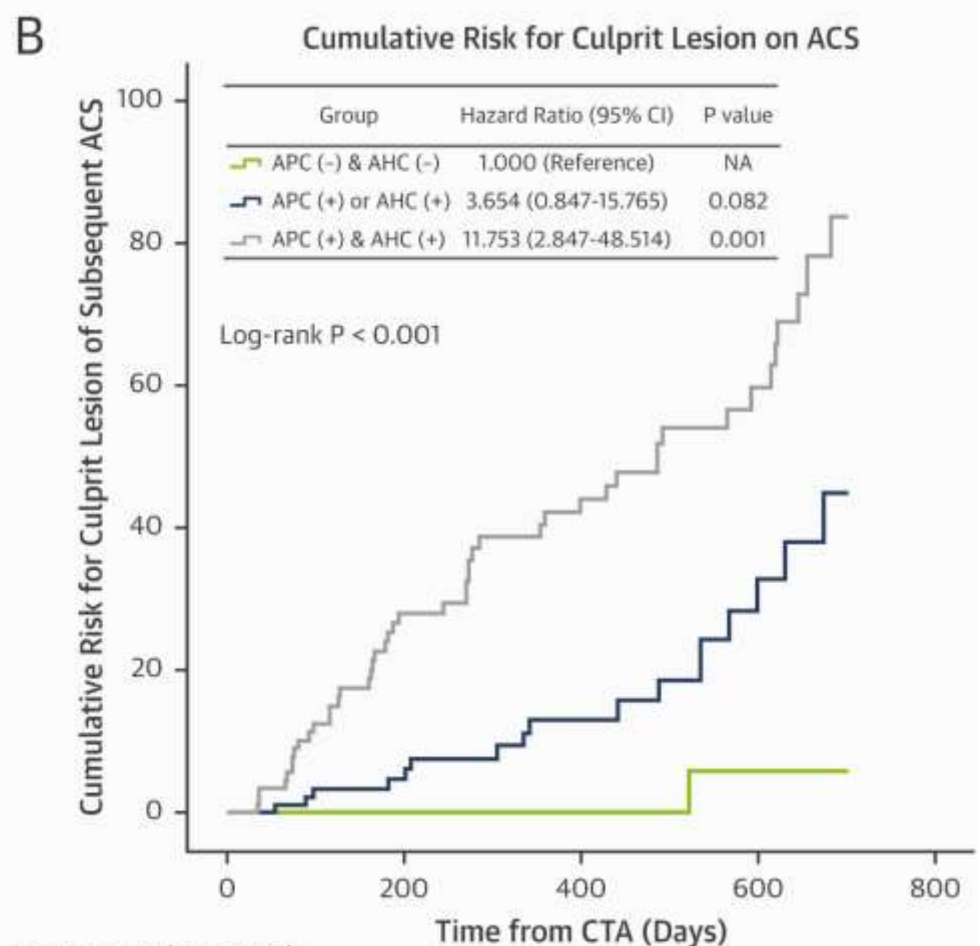
1. Koo BK, et al JACC 2011
2. Park JB, et al. Heart 2016
3. Choi GW & Lee JM, et al, JACC Imaging 2015

Lee JM, et al. JACC Interv 2018;in press

Proportion of culprit lesions & the risk for culprit lesion on ACS among 3 groups classified by the presence of adverse plaque & hemodynamic characteristics



Lesion No	27	99	90
Culprit No	2	18	46



Lesion number at risk

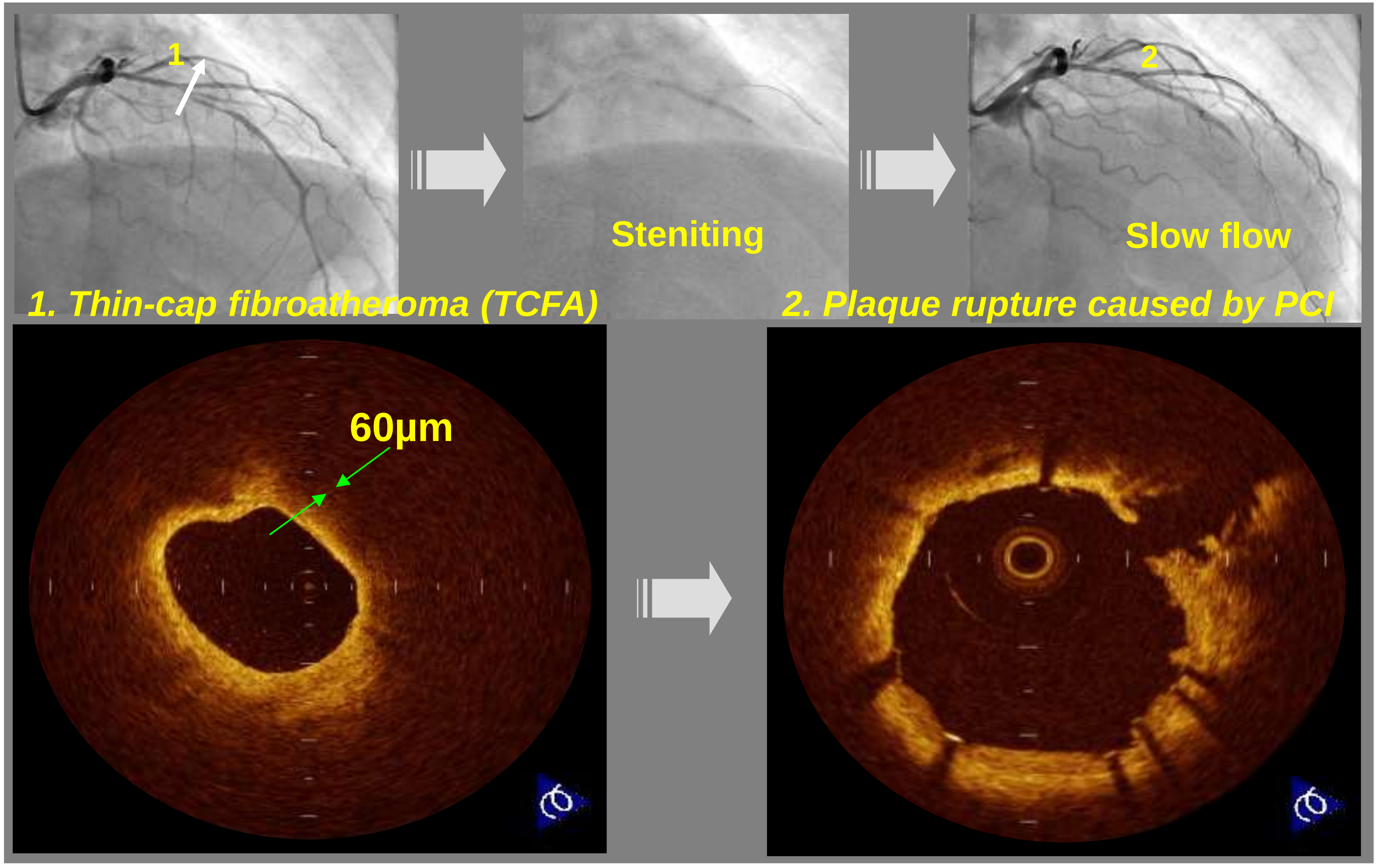
APC (-) & AHC (-)	27	21	19	9	8
APC (+) or AHC (+)	99	67	38	16	12
APC (+) & AHC (+)	90	54	29	13	7

Lee JM, et al. JACC Interv 2018;in press

Prediction of angiographic slow flow

Tanaka A, Kubo T, Akasaka T et al. Eur Heart J 2009;30:1348-55

A 73 y.o. male underwent PCI for mid-LAD lesion (arrow).



In pre-PCI OCT image, the culprit lesion presented lipid-rich plaque with TCFA.

After stenting, angiogram showed slow flow, and OCT disclosed plaque rupture behind stent.

TCFA might be easy to be ruptured by PCI and has a high risk for coronary slow flow.

Prediction of No-reflow Post-PCI

	No-reflow n=14	Reflow n=69	*p*-value
Plaque rupture, %	71	48	0.053
Thrombus, %	79	80	0.567
TCFA, %	**50**	**16**	**0.034**
Lipid-arc, degree*	**166**	**44**	**0.012**

Tanaka A, Kubo T, Akasaka T et al. Eur Heart J 2009;30:1348-55

Prediction of Microvascular Obstruction

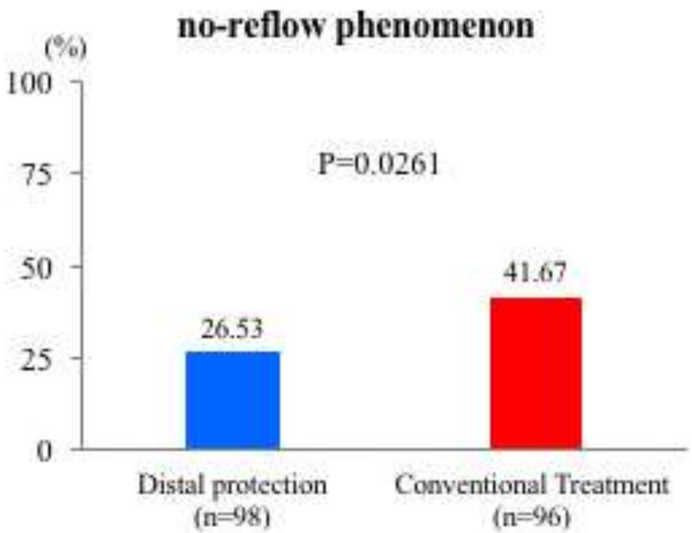
	OR	95% CI	*P*
ST-elevation myocardial infarction	48.05	2.85–809.11	0.007
TCFA at culprit	5.43	1.27–23.32	0.023
Thrombectomy	0.014	0.001–0.35	0.009
Diameter stenosis, %	1.1	1.02–1.19	0.011

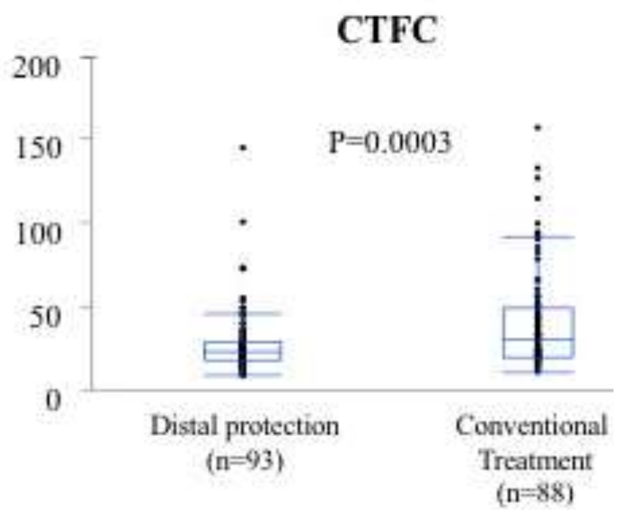
Ozaki, Kubo, Akasaka et al. Circulation Img 2011;4:620-7

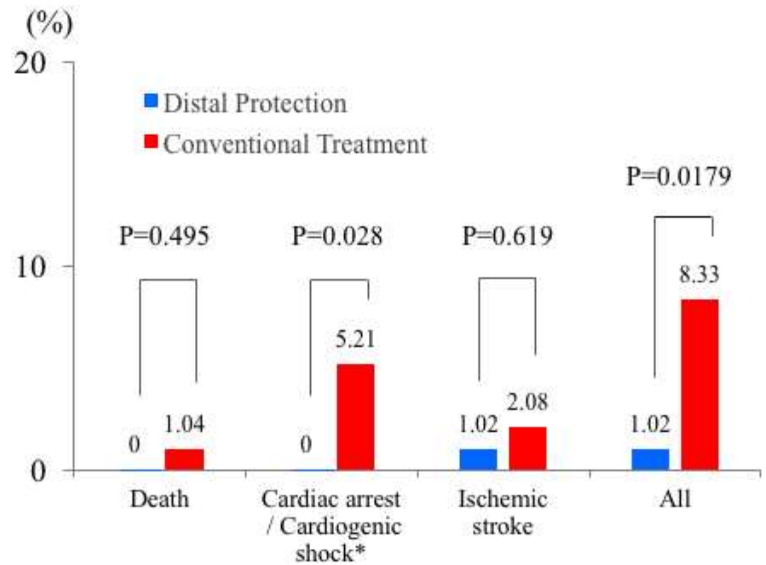
There is not enough data demonstrating the efficacy of distal protection during OCT-guided PCI.

Efficacy of distal protection during PCI
VAMPIORE 3 trial

Hibi K, et al. J Am Coll Cardiol CV Interv 2018;in press





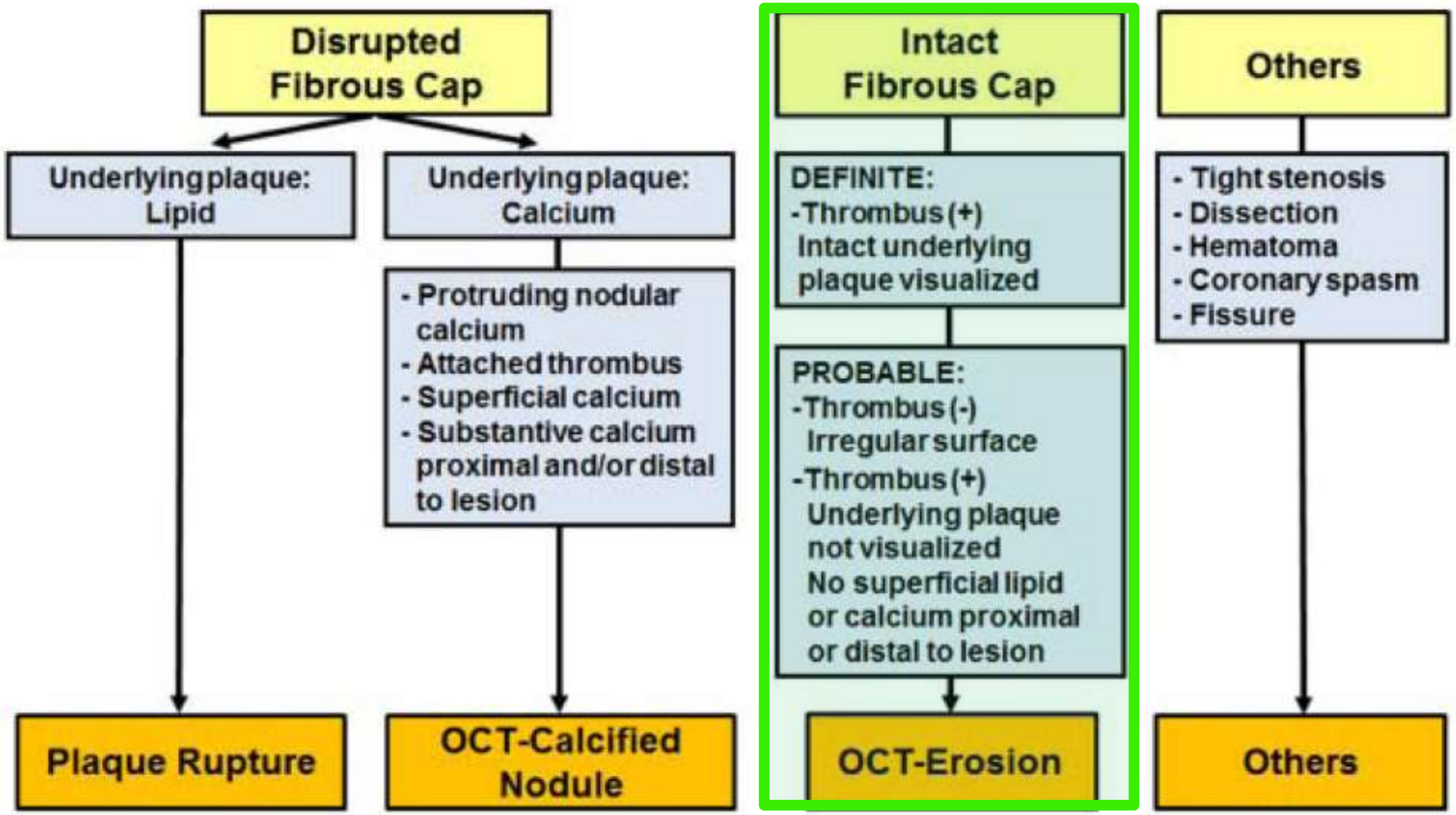


In cases with attenuated plaque ≧5mm by IVUS, distal protection reduced no-reflow phenomenon & MACE, although there were no significant difference in infarct size (CK or CK-MB).

Attenuated plaque ≧5mm by IVUS might demonstrate large lipid core with red thrombus by OCT, and similar study should be planed using OCT.

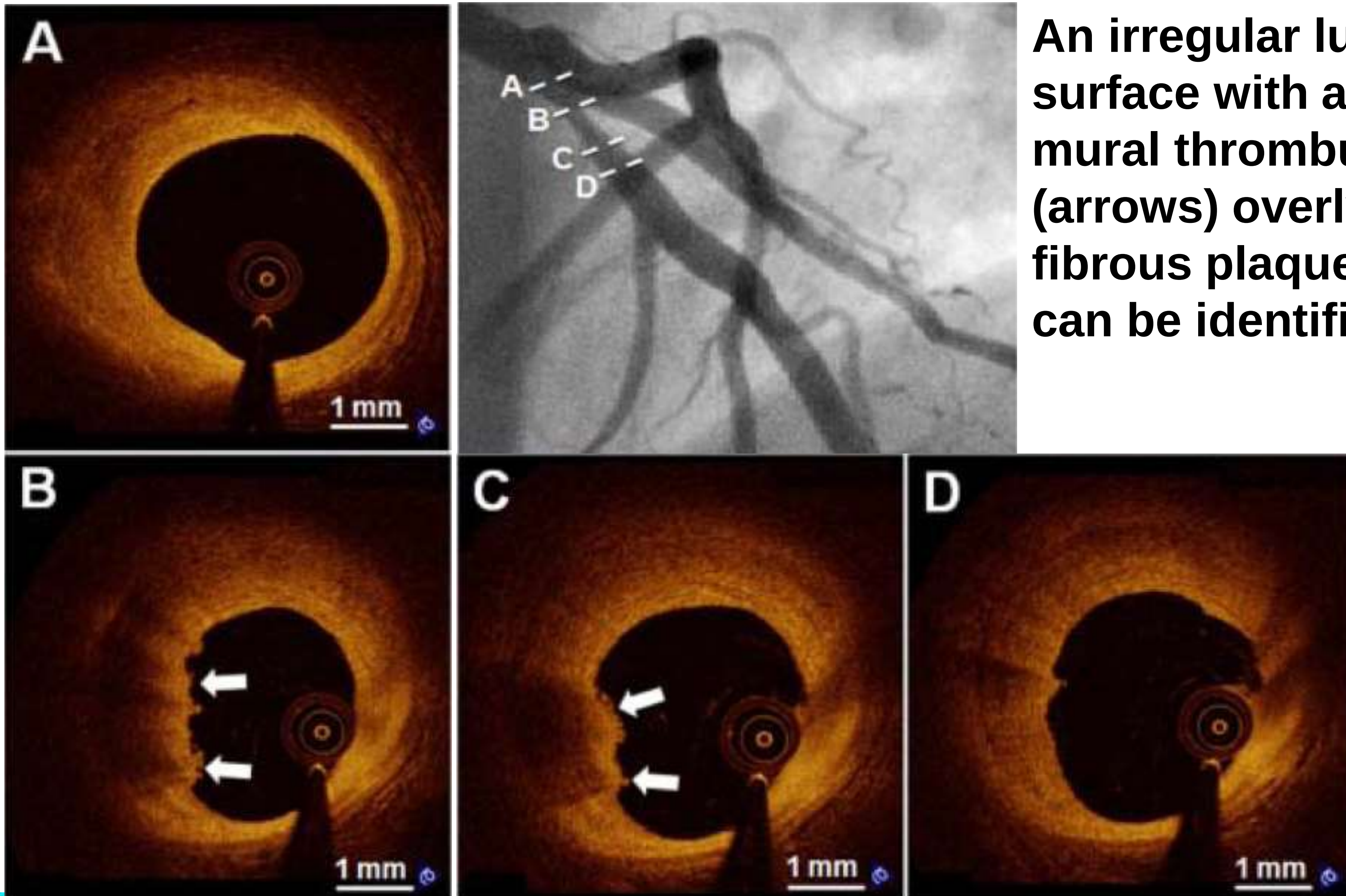
Plaque Classification Algorithm by OCT

Jia H, et al. J Am Coll Cardiol 2007;50:933–999



Conservative pharmacologic treatment without revascularization might be appropriate in some ACS patients with an intact fibrous cap, especially if the lumen is enough big (MI with non-obstructive coronary arteries: MINOCA).

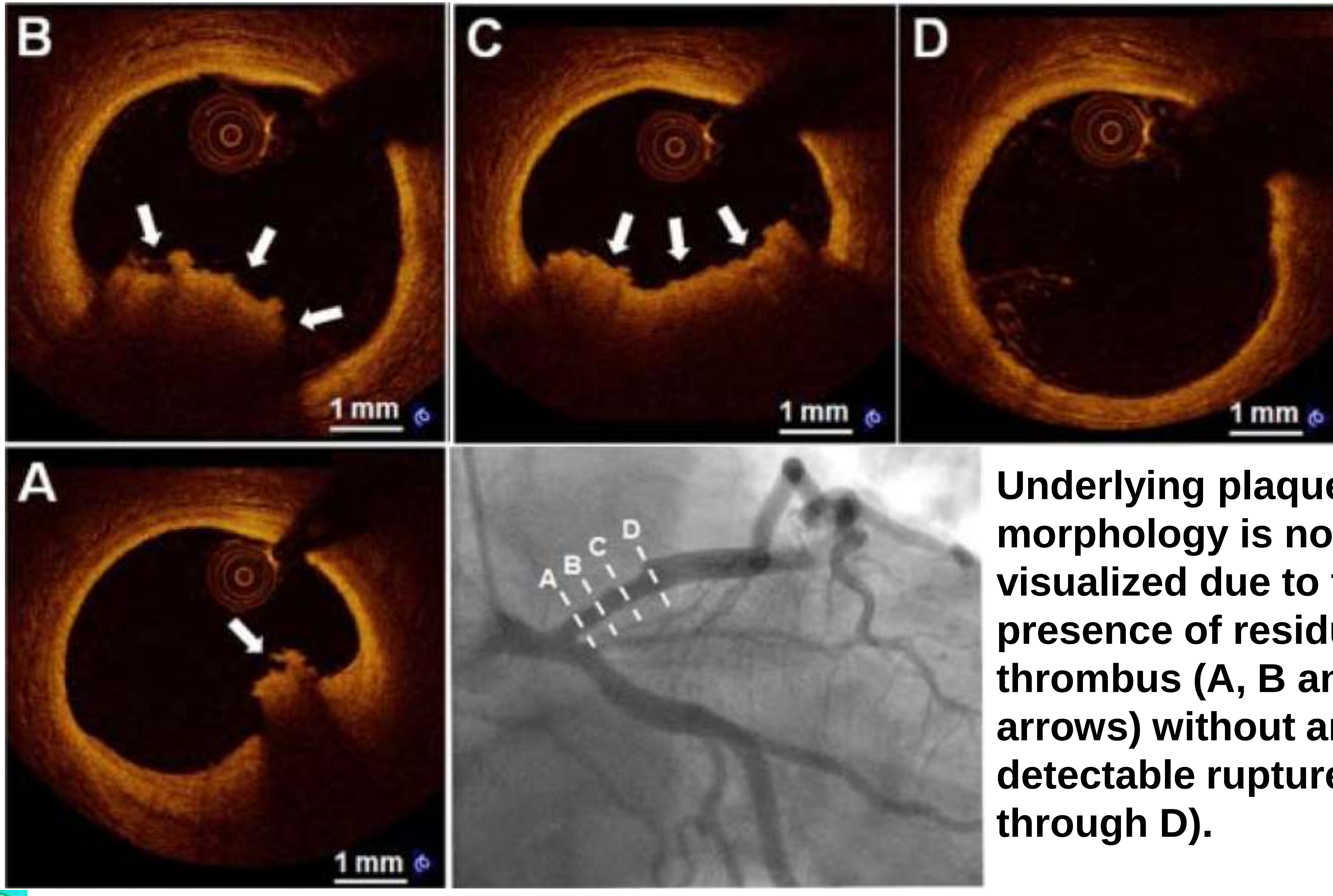
Representative case of definite OCT-erosion



An irregular lumen surface with attached mural thrombus (arrows) overlying a fibrous plaque (B,C) can be identified.

Jia H, et al. J Am Coll Cardiol 2007;50:933–999

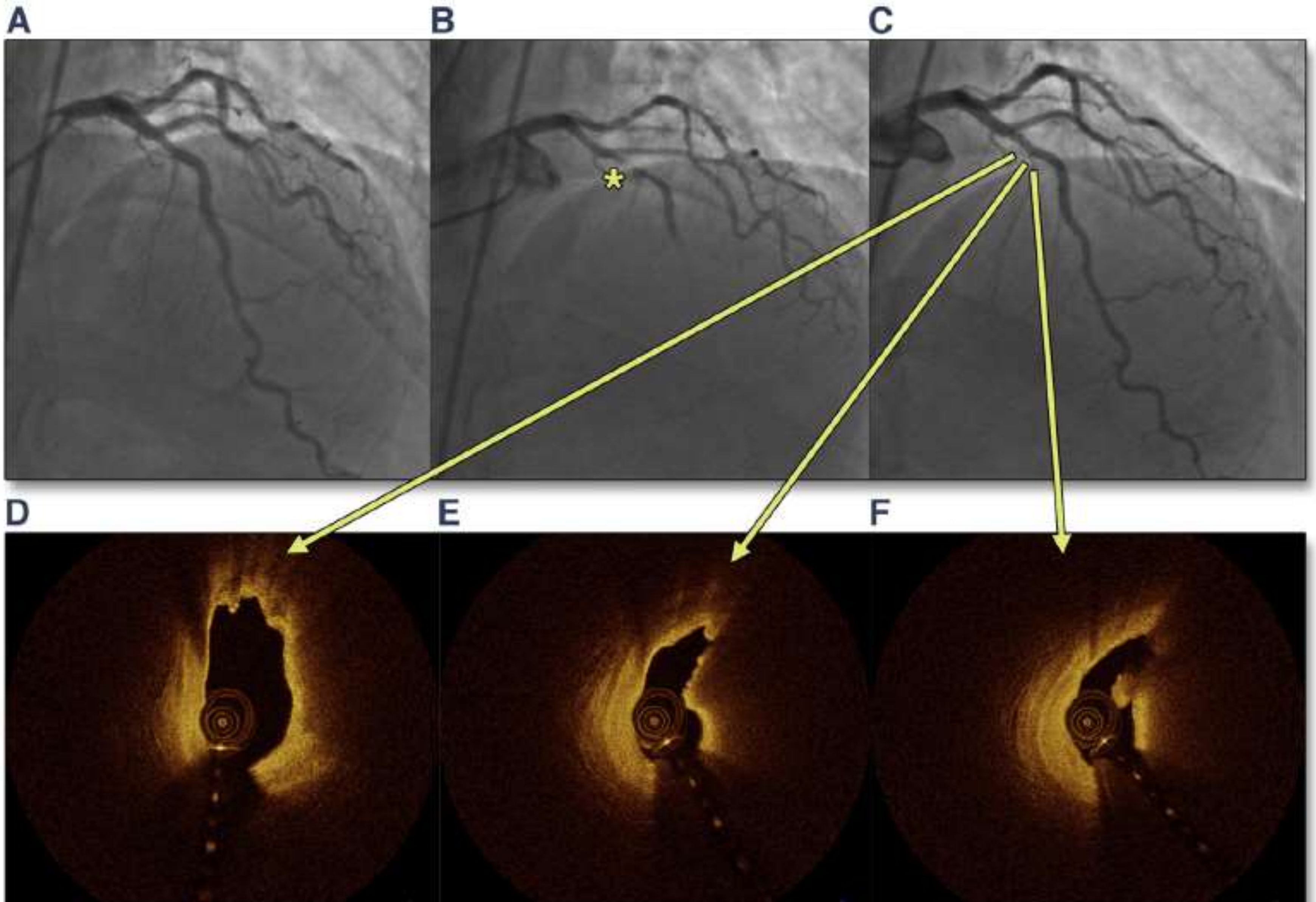
Representative case of probable OCT-erosion



Underlying plaque morphology is not well visualized due to the presence of residual red thrombus (A, B and C, arrows) without any detectable rupture (A through D).

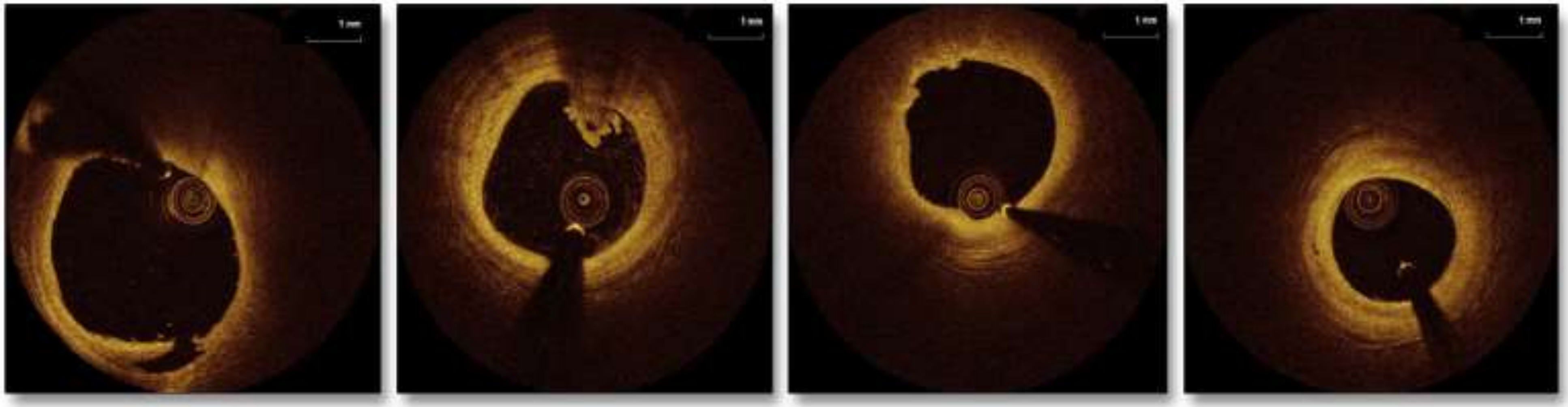
Jia H, et al. J Am Coll Cardiol 2007;50:933–999

Representative Case of OCT-Defined Errosion



Shin ES, et al., J Am Coll Cardiol Img 2015;8:1059-1067

Characteristics of Spasm Sites as Assessed by OCT In Patients With VSAP



Fibrous Cap Disruption: Fibrous cap discontinuity with or without a cavity formed inside the plaque

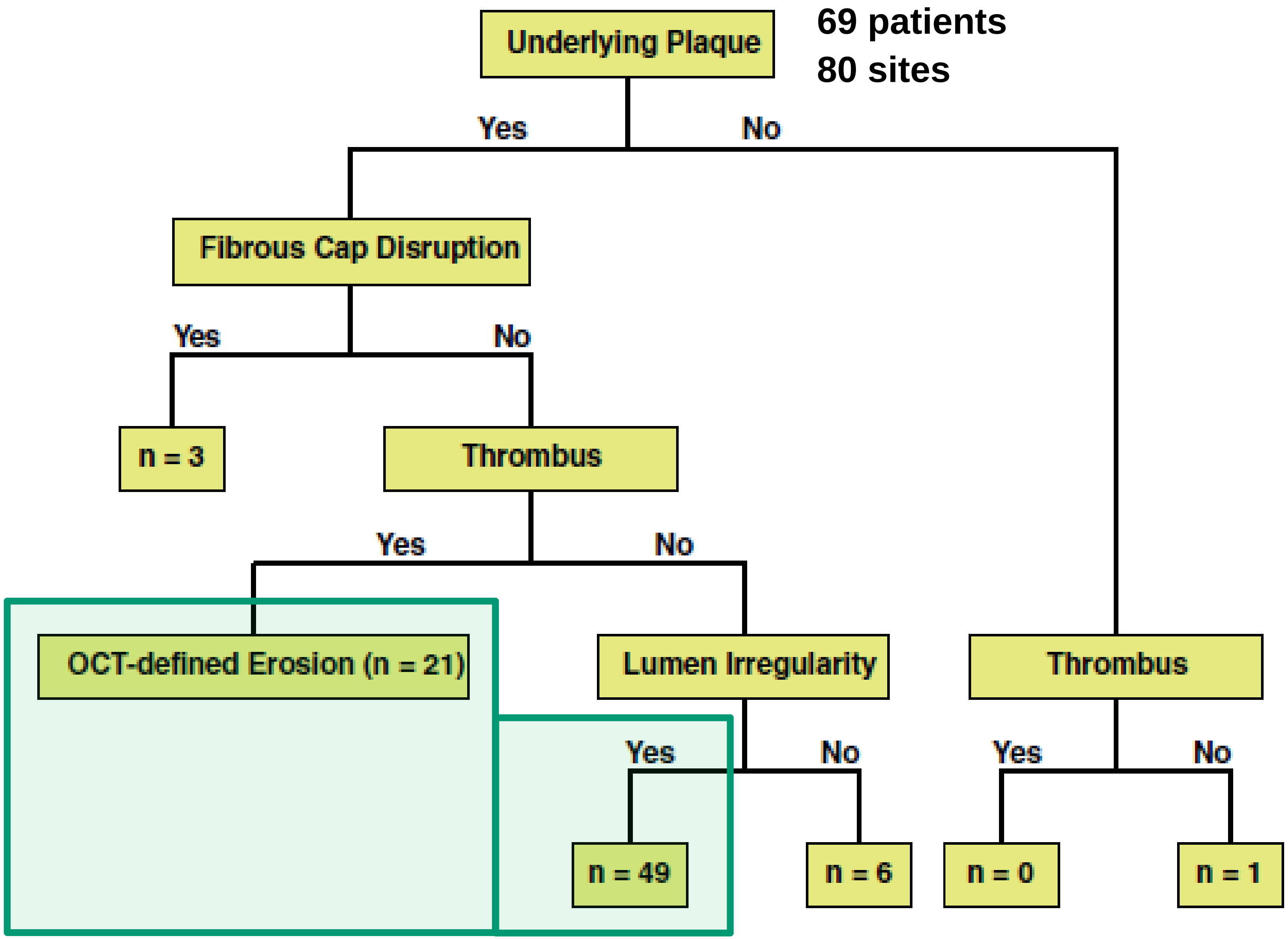
OCT-defined Erosion: Underlying visualized plaque with intact fibrous cap, lumen irregularity and thrombus

Luminal irregularity

No luminal irregularity or thrombus

Shin ES, et al., J Am Coll Cardiol Img 2015;8:1059-1067

OCT-Defined Morphological Characteristics of Spasm Sites in Patients With VSAP



Shin ES, et al., J Am Coll Cardiol Img 2015;8:1059-1067

Acute coronary syndromes without coronary plaque rupture

Nat Rev Cardiol 2016;13:257-265

Siddak S. Kanwar[1], Gregg W. Stone[2], Mandeep Singh[3], Renu Virmani[4], Jeffrey Olin[1], Takashi Akasaka[5] and Jagat Narula[1]

Abstract | The latest advances in plaque imaging have provided clinicians with opportunities to
treat acute coronary
based not only on cli
but also on the findi
originate from plaqu
plaque rupture arisi
advances in our und
data from intravascu
a roadmap for more

Key points

- Disruption of the fibrous cap on vulnerable atherosclerotic coronary plaques leads to exposure of the thrombogenic lipid core to the bloodstream, and is responsible for two-thirds of all coronary events
- In approximately one-third of patients with acute coronary syndrome (ACS), the thrombus develops after intimal erosion without fibrous cap rupture
- Advances in plaque imaging have allowed clinicians to treat patients with ACS based not only on clinical manifestations, angiographic characteristics, and biomarker data, but also on plaque morphology
- The use of optical coherence tomography without angiographically obvious plaque rupture can assist in identification and characterization of the culprit lesion plaque morphology
- Conservative pharmacologic treatment without revascularization might be appropriate in some patients with an intact fibrous cap

European Heart Journal (2017) 38, 792–800
doi:10.1093/eurheartj/ehw381

FASTTRACK CLINICAL RESEARCH
ESC Hot Line

Acute coronary syndromes

Effective anti-thrombotic therapy without stenting: intravascular optical coherence tomography-based management in plaque erosion (the EROSION study)

Haibo Jia[1†], Jiannan Dai[2†], Jingbo Hou[1†], Lei Xing[2], Lijia Ma[1], Huimin Liu[1], Maoen Xu[1], Yuan Yao[1], Sining Hu[1], Erika Yamamoto[2], Hang Lee[3], Shaosong Zhang[1], Bo Yu[1]*, and Ik-Kyung Jang[2]*

underlying pathology and therefore may
ts with acute coronary syndrome (ACS)
vithout stent implantation.

/. Patients with ACS including ST-segment
ıspiration thrombectomy was performed.
ıy (OCT) and residual diameter stenosis
/ without stenting. OCT was repeated at
: >50% reduction of thrombus volume at 1 month compared with baseline. The secondary endpoint was a composite of cardiac death, recurrent ischaemia requiring revascularization, stroke, and major bleeding. Among 405 ACS patients with analysable OCT images, plaque erosion was identified in 103 (25.4%) patients. Sixty patients enrolled and 55 patients completed the 1-month follow-up. Forty-seven patients (47/60, 78.3%; 95% confidence interval: 65.8–87.9%) met the primary endpoint, and 22 patients had no visible thrombus at 1 month. Thrombus volume decreased from 3.7 (1.3, 10.9) mm^3 to 0.2 (0.0, 2.0) mm^3. Minimal flow area increased from 1.7 (1.4, 2.4) mm^2 to 2.1 (1.5, 3.8) mm^2. One patient died of gastrointestinal bleeding, and another patient required repeat percutaneous coronary intervention. The rest of the patients remained asymptomatic.

Conclusion For patients with ACS caused by plaque erosion, conservative treatment with anti-thrombotic therapy without stenting may be an option.

Wakayama Medical University

European Heart Journal (2017) **38**, 792–800
doi:10.1093/eurheartj/ehw381

*FAST*TRACK CLINICAL RESEARCH
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Acute coronary syndromes

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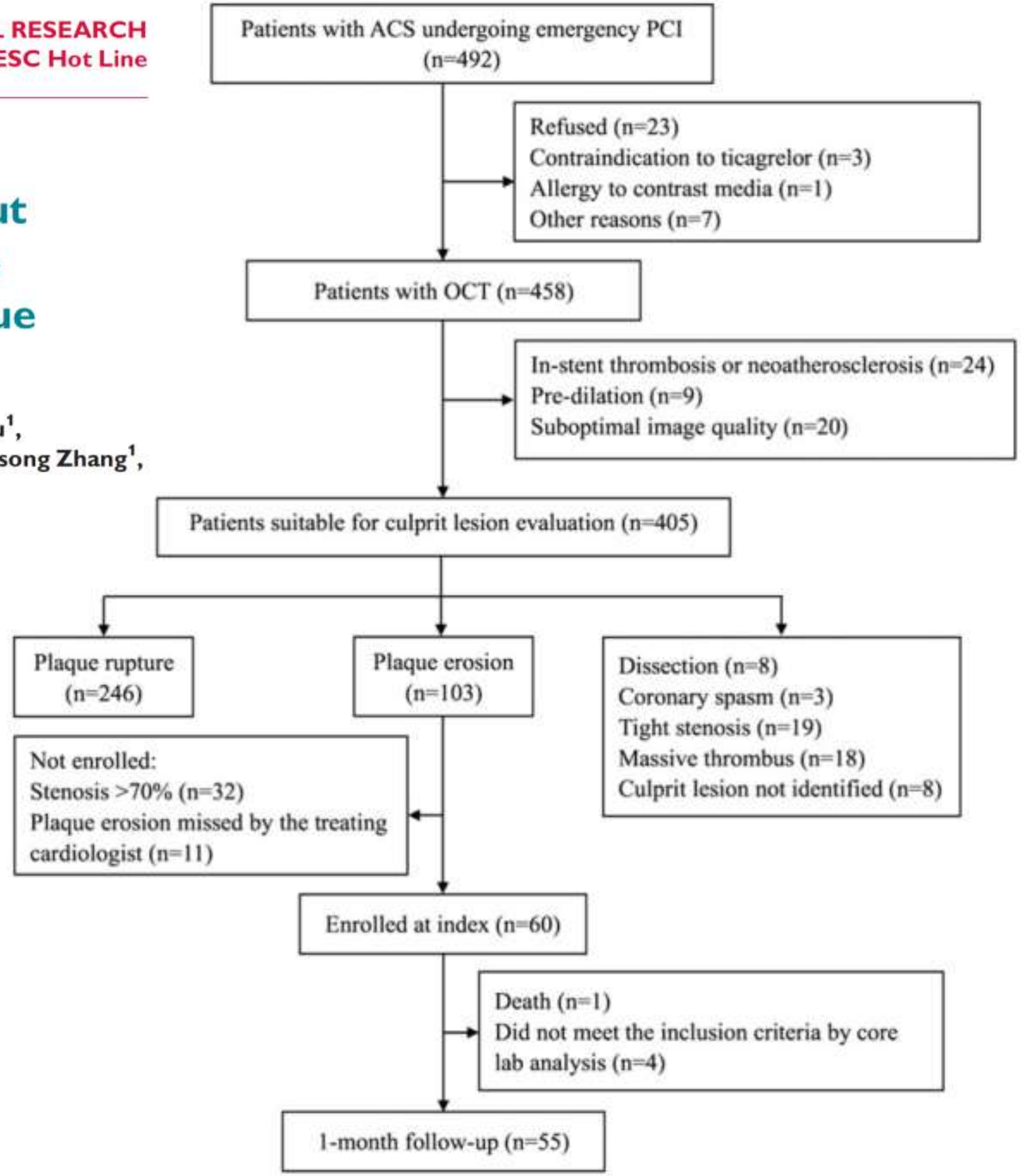
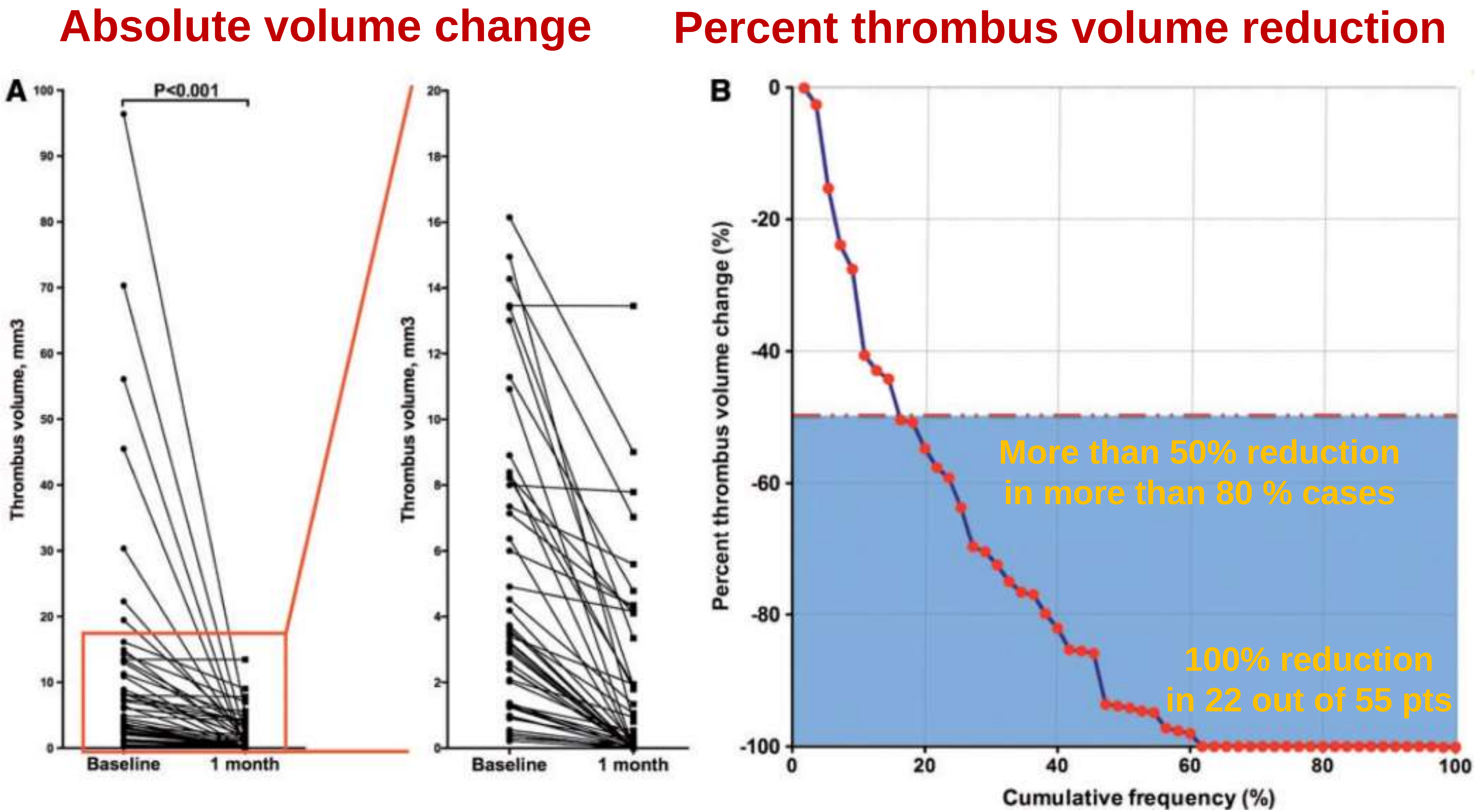


Changes in thrombus volume in ACS with plaque erosion



Circ J 2018; **82:** 302–308
doi:10.1253/circj.CJ-17-1373

REVIEW

Optical Coherence Tomography Guidance in Management of Acute Coronary Syndrome Caused by Plaque Erosion

Haibo Jia, MD, PhD; Takashi Kubo, MD, PhD;
Takashi Akasaka, MD, PhD; Bo Yu, MD, PhD

For several decades, most physicians have believed that acute coronary syndrome (ACS) is caused by coronary thrombosis resulting from rupture of vulnerable plaque characterized by a thin fibrous cap overlying a large necrotic core and massive inflammatory cell infiltration. However, nearly one-third of ACS cases are caused by plaque erosion characterized by intact fibrous cap, less or absent necrotic core, less inflammation, and large lumen. Because of the limitations of current imaging modalities, including angiography and intravascular ultrasound, the importance of plaque erosion as a cause of acute coronary events is less well known. Optical coherence tomography (OCT) as an emerging modality with extremely high resolution is the only intravascular imaging modality available for identification of plaque erosion in vivo, which provides new insight into the mechanism of ACS. More importantly, the introduction of OCT to clinical practice enables us to differentiate the patients with ACS caused by plaque erosion from those caused by plaque rupture, thereby providing precise and personalized therapy based on the different underlying mechanisms. We systematically review the morphological characteristics of plaque erosion identified by OCT and its implications for the management of ACS.

Take home message

- Plaque rupture is demonstrated as main mechanism (60-70%) of ACS with high incidence of TCFA, lipid rich plaque and red thrombus compared with erosion or calcified nodule by OCT.
- These features of the ruptured plaque in ACS may relate the higher risk of slow flow & microvascular damage during PCI, and distal protection may allow us to improve the prognosis.
- Simple morphological information of plaques by OCT might not be enough to predict future adverse event, and combination with other imaging modalities and hemodynamic information may provide us to improve the identification of vulnerable plaques.
- Greater impact has been reported in the diagnosis of erosion and MINOCA with a possibility to treat the culprit lesion without stenting by OCT.