Assessment of plaque morphology by OCT in patients with ACS

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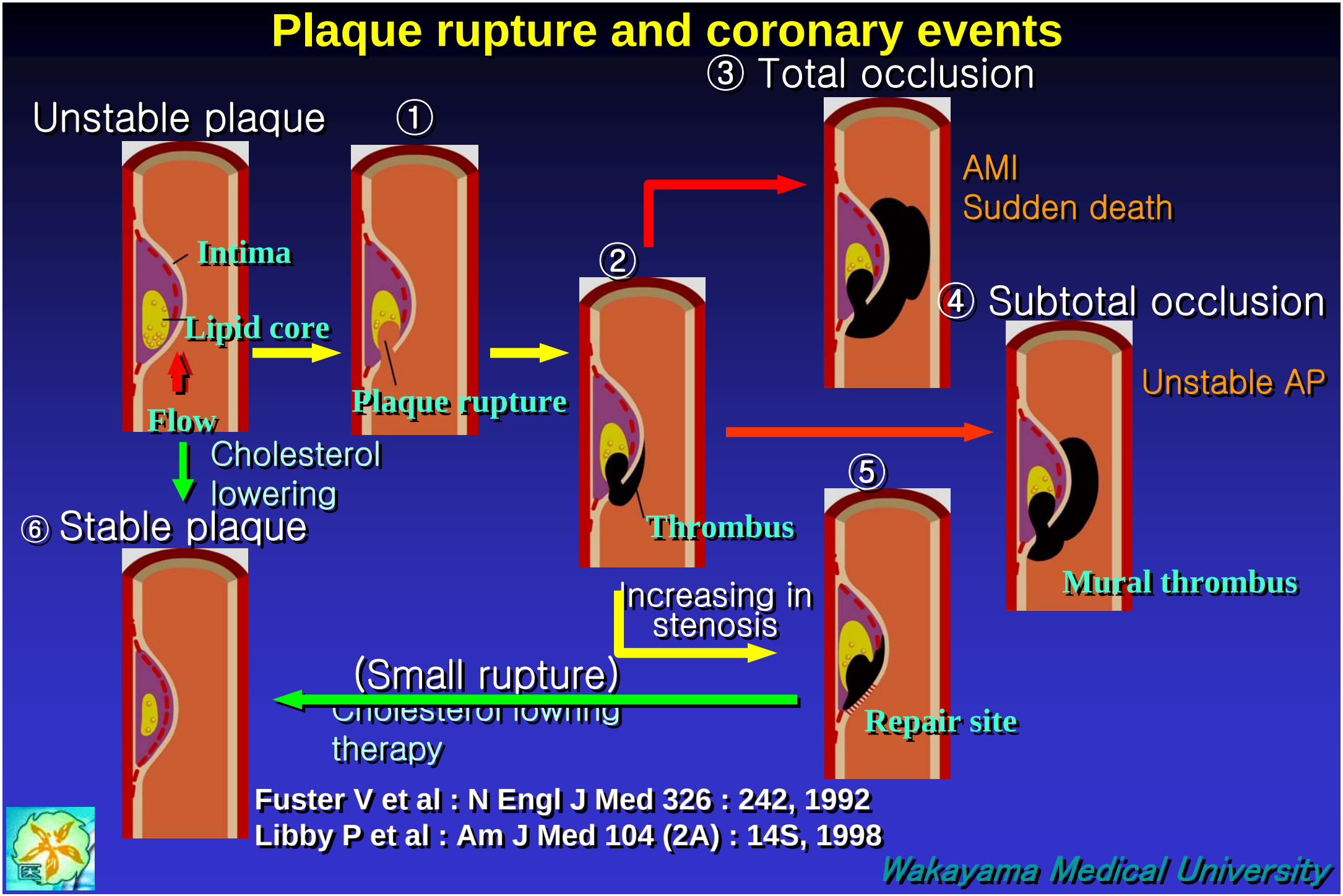
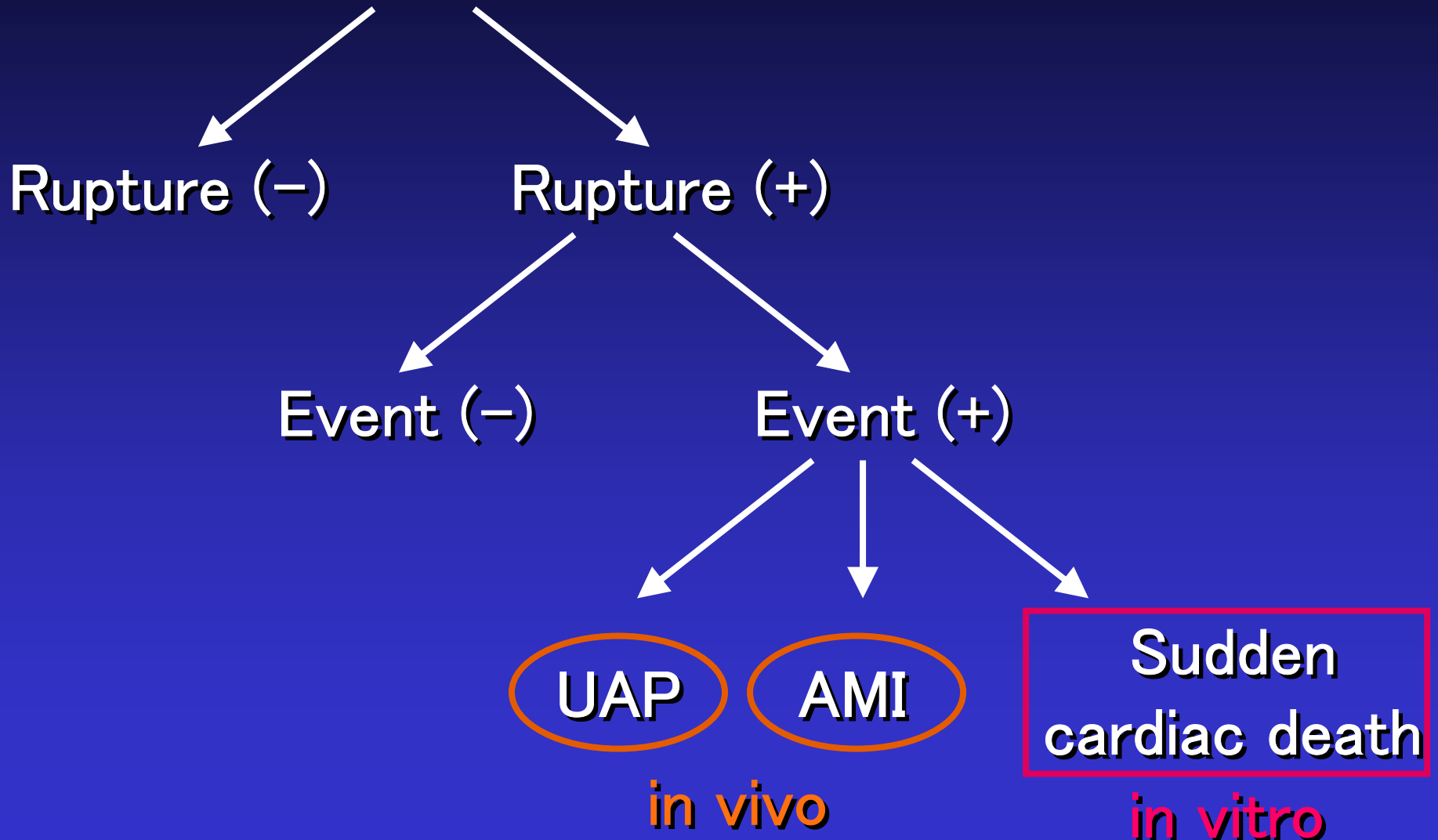
Plaque rupture and coronary events



Fuster V et al : N Engl J Med 326 : 242, 1992
Libby P et al : Am J Med 104 (2A) : 14S, 1998

Identification of vulnerable plaque

- Plaque prone to rupture



Study Design

Oral aspirin (162 mg) and intravenous heparin (100 U/kg) were administered before PCI.

Cardiac catheterization was performed by the femoral approach, using a 7F sheath and catheters.

- **Thrombectomy** ***(Export catheter ® Medtronic Japan)***

  ↓ **TIMI grade III**

- **IVUS** ***(Atlantis SR Pro® 2.5F, 40-MHz; Boston Scientific, Natick, MA, USA)***

  ↓

- **CAS** ***(Angioscope MC-800E and the optic fiber AS-003, Nihon Kohden)***

  ↓

- **OCT** ***(ImageWire®; LightLab Imaging, Westford, MA, USA)***

Study Population

Inclusion criteria

Acute Myocardial Infarction

continuous chest pain lasted > 30 minutes,

arrival within 6 hours from the onset of chest pain

ST elevation ≧ 0.1 mV in 2 or more contiguous leads

culprit lesion with diameter stenosis ≧ 75%

TIMI flow ≦ 2 identified by CAG

Exclusion criteria

left bundle-branch block

pacemaker rhythm

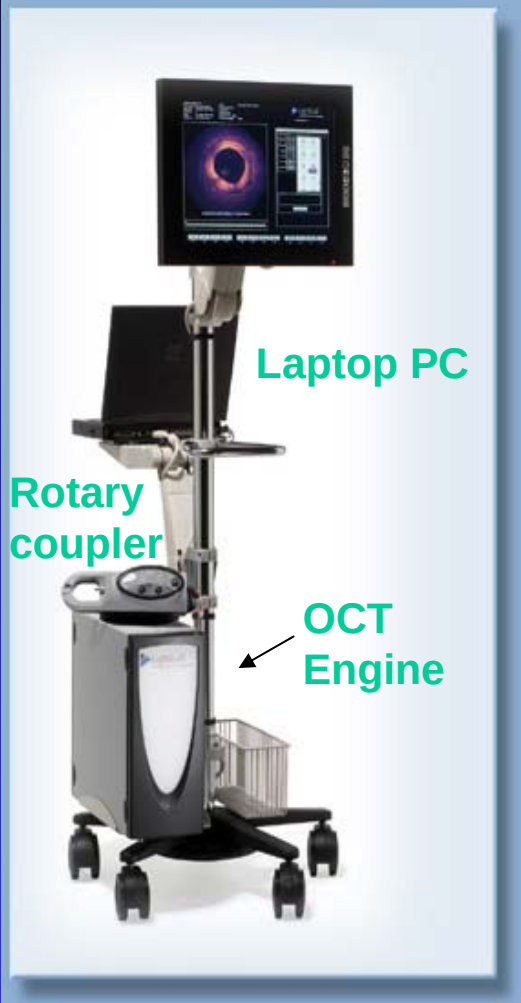
a culprit lesion in the left main coronary artery

history of prior MI

cardiogenic shock

unsuccessful reperfusion < TIMI III flow by thrombectomy

OCT system (LightLab Inc.)

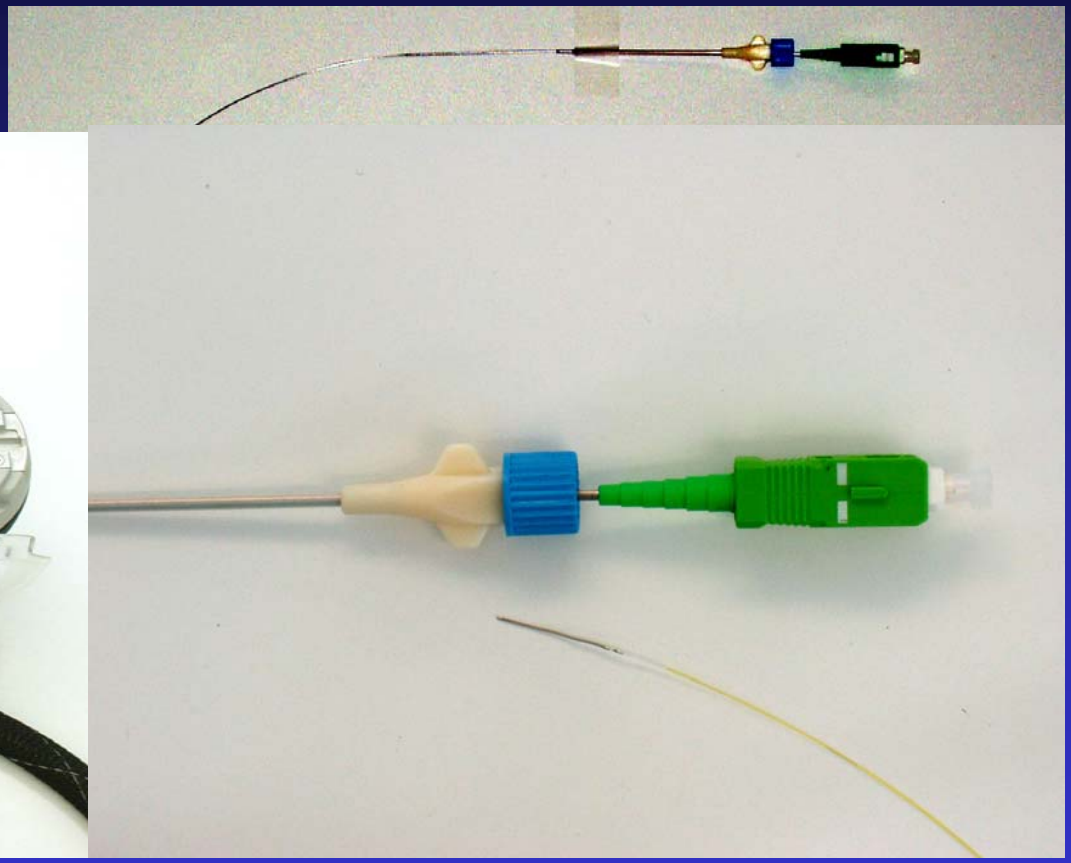


Prototype

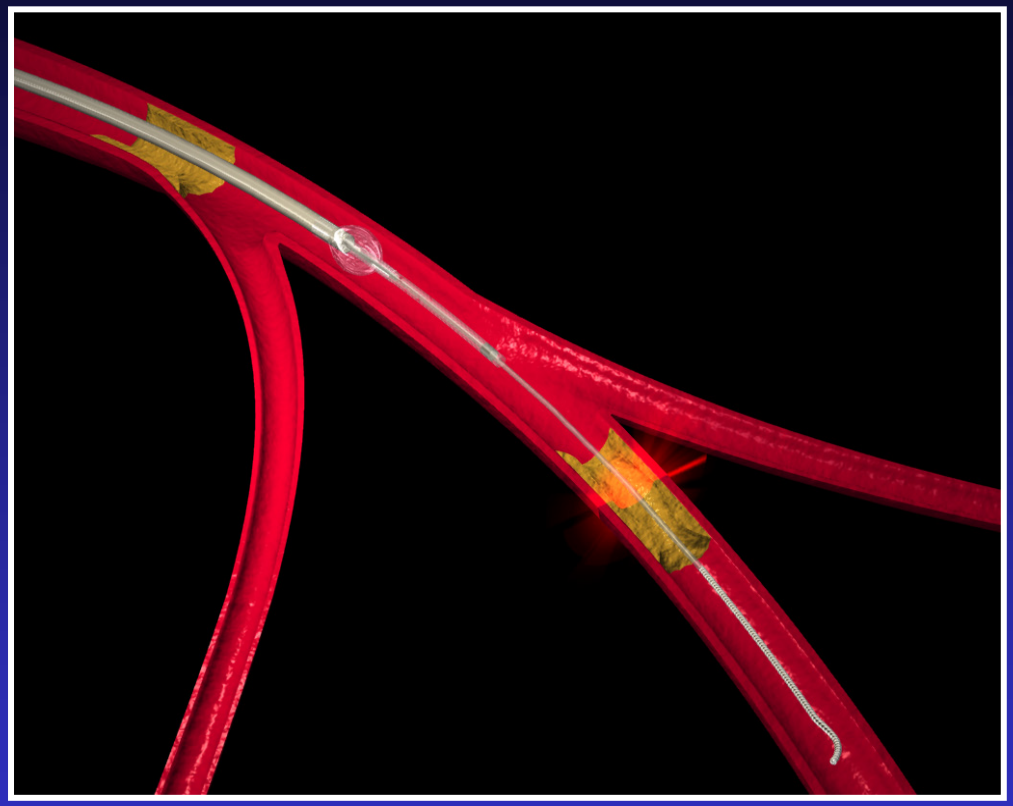
Commercially available system

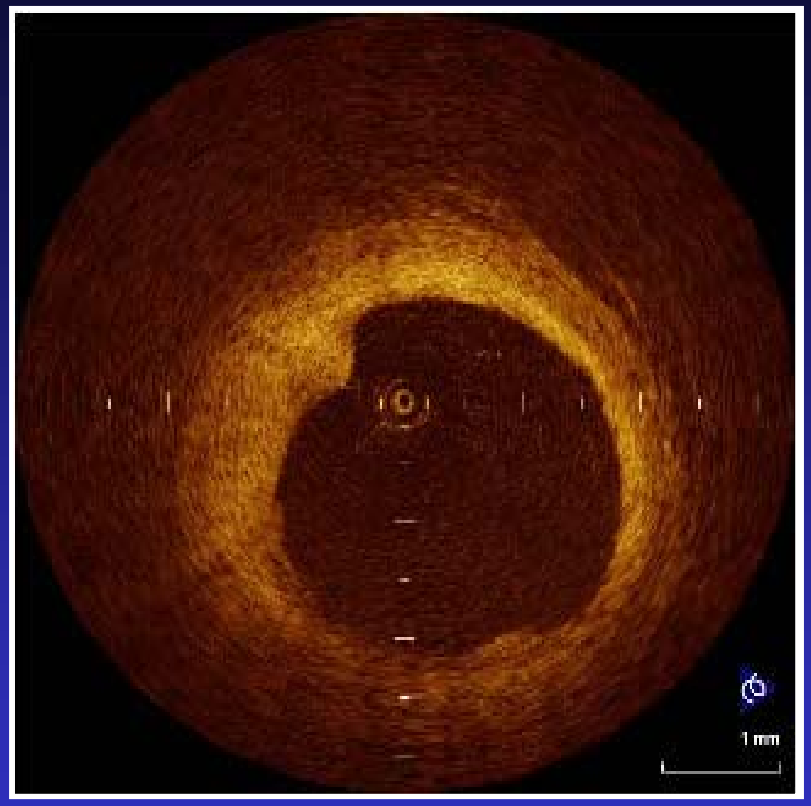
OCT system (LightLab)

ImageWire®



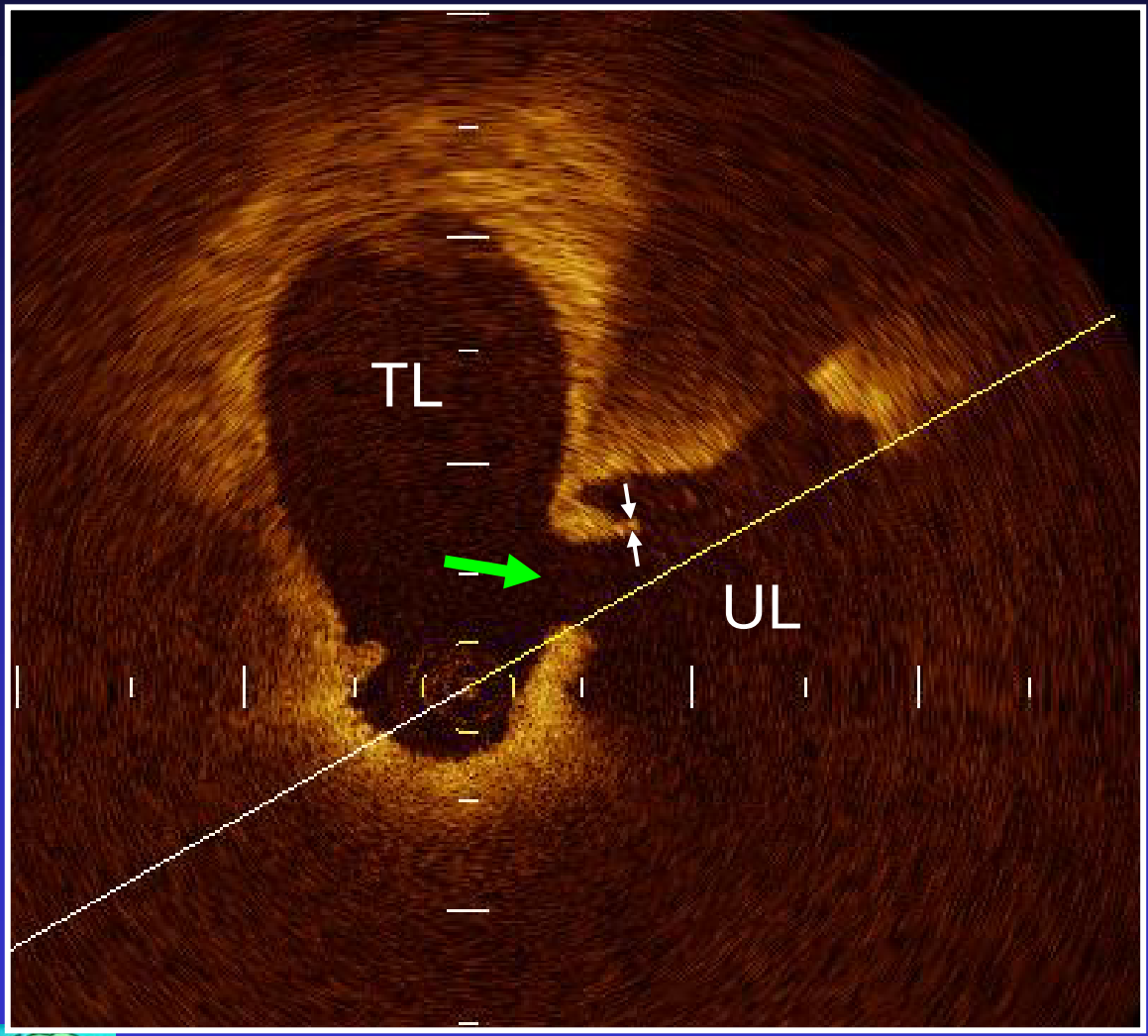
Optical Coherence Tomography (OCT)





- Size of imaging core (0.4 mm)
- Microscopic resolution (10-20 μ m)
- Real time Imaging (15 frames/s)

Inferior-AMI（71y.o., M） Plaque Rupture

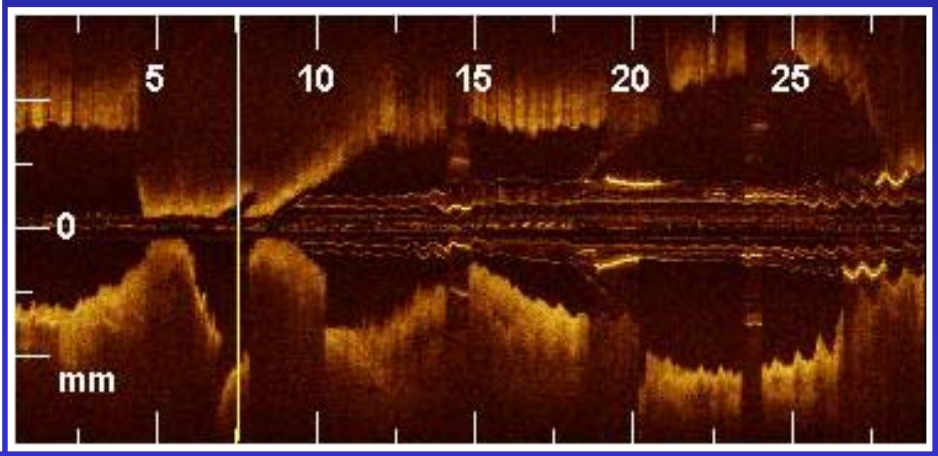


→ Ruptured Fibrous Cap

↕ Fibrous Cap Thickness
= 40μm

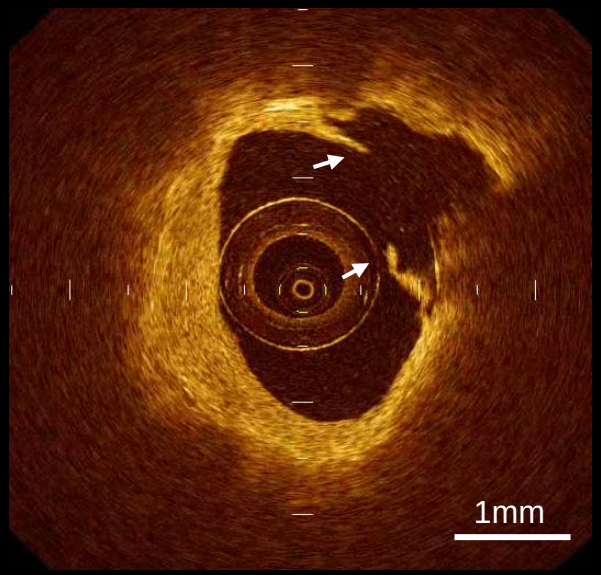
TL : True Lumen

UL : Ulceration



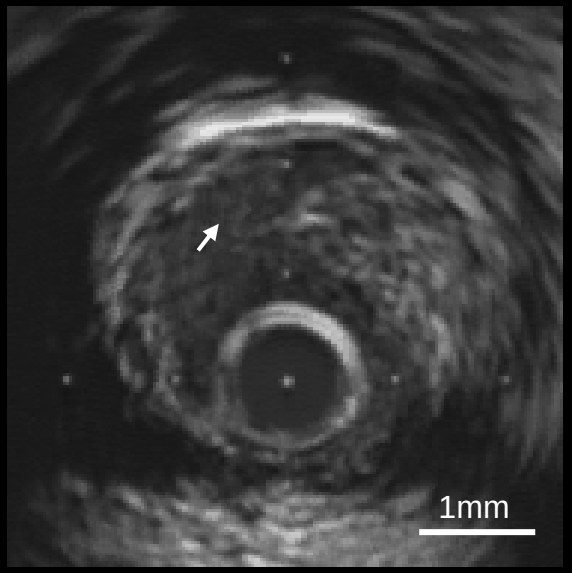
Ruptured Fibrous Caps

OCT

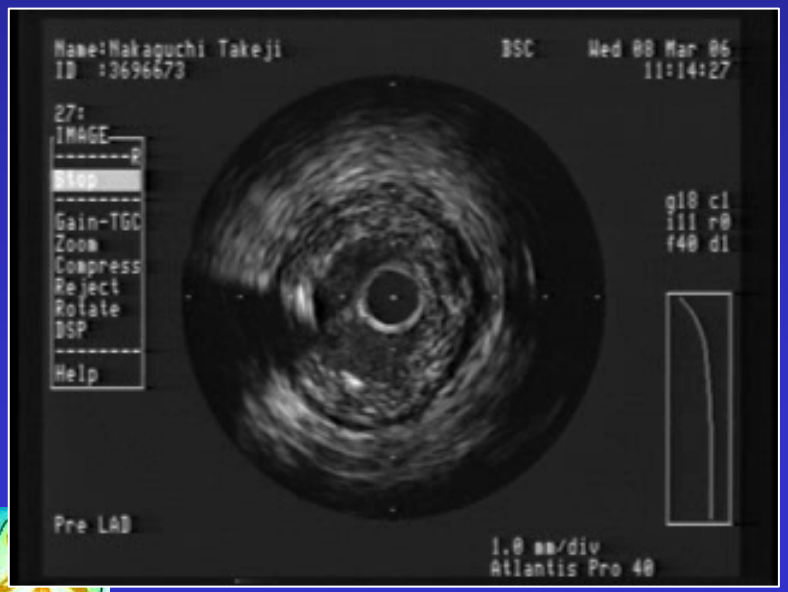


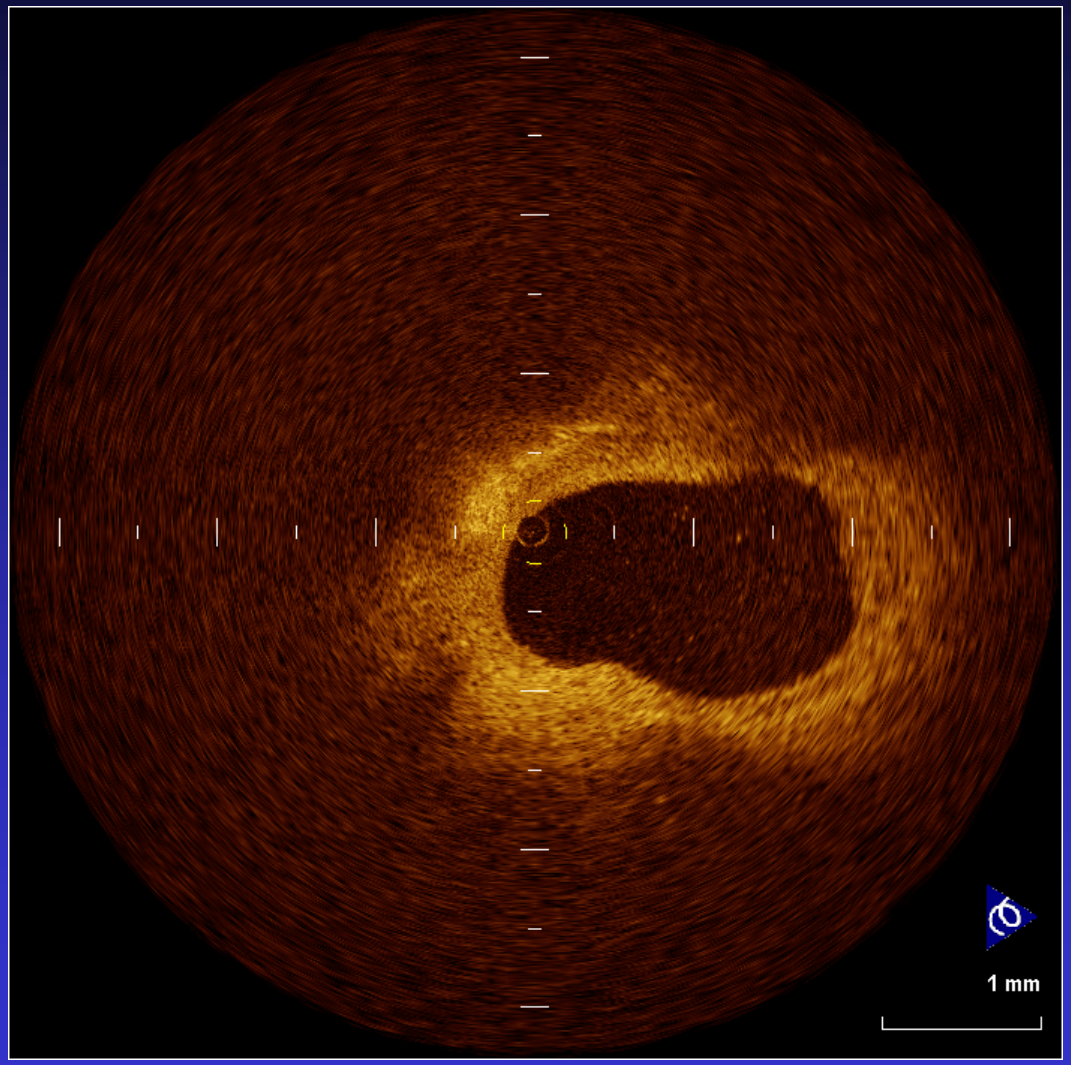
CAS

IVUS

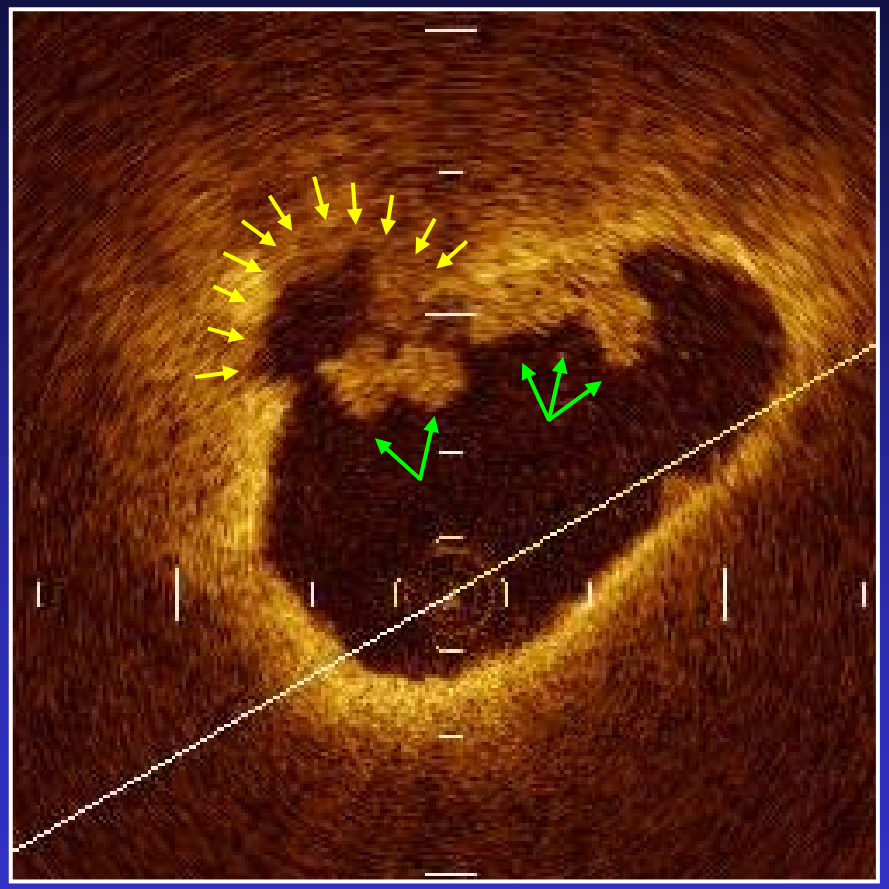


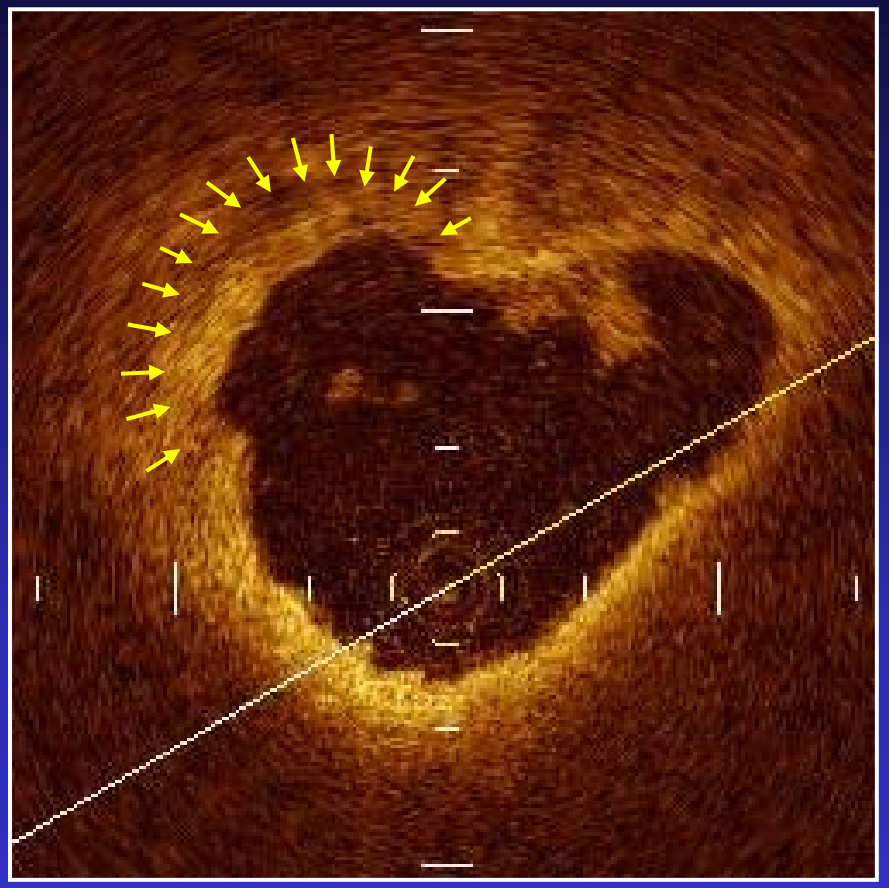
Anteroseptal AMI （80y.o., M）





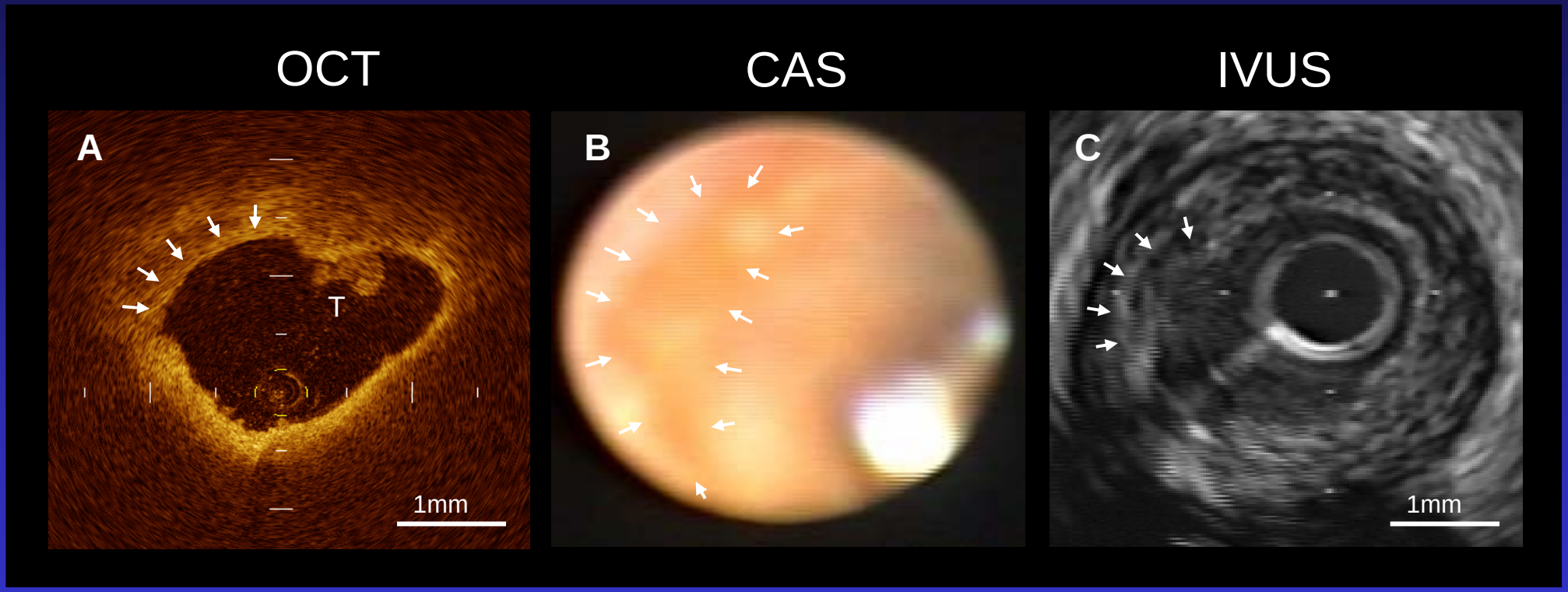
Anteroseptal AMI （80y.o., M）



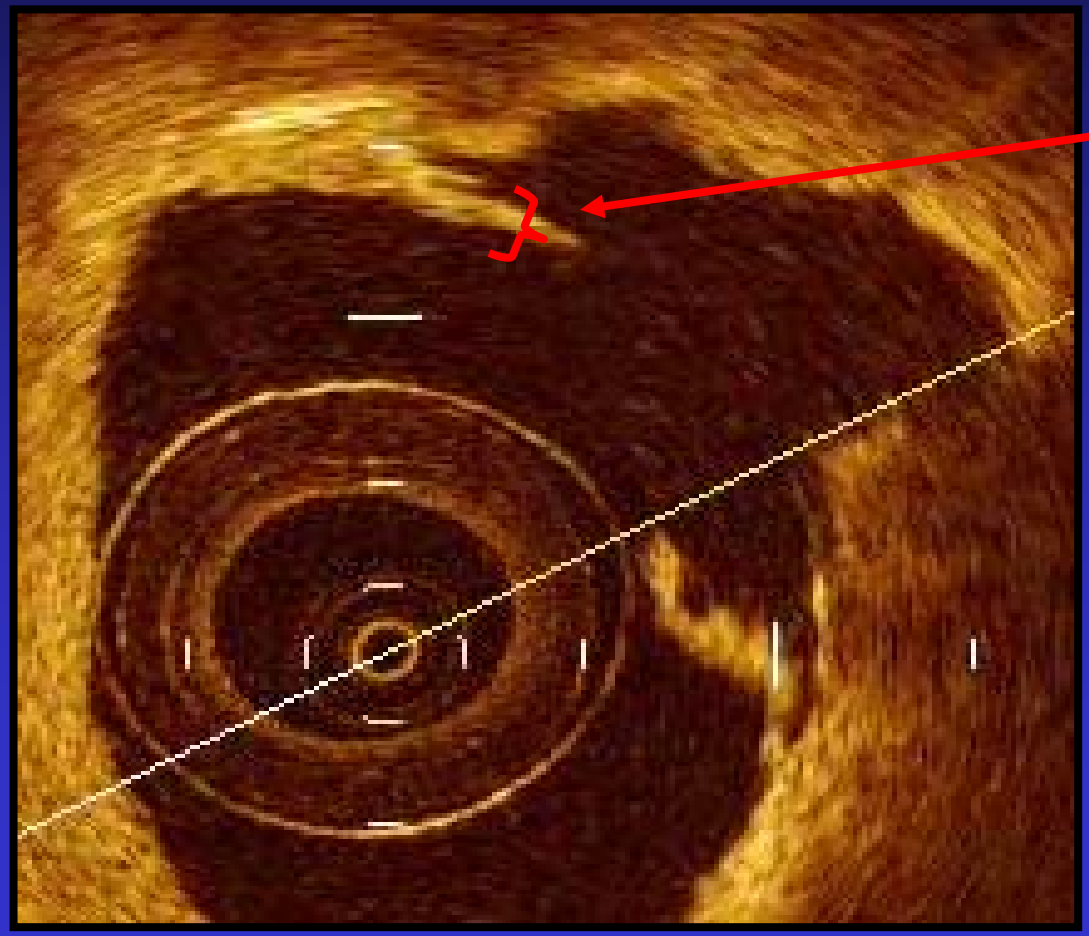


- Erosion (Ulceration)
- Thrombus

Plaque Erosion

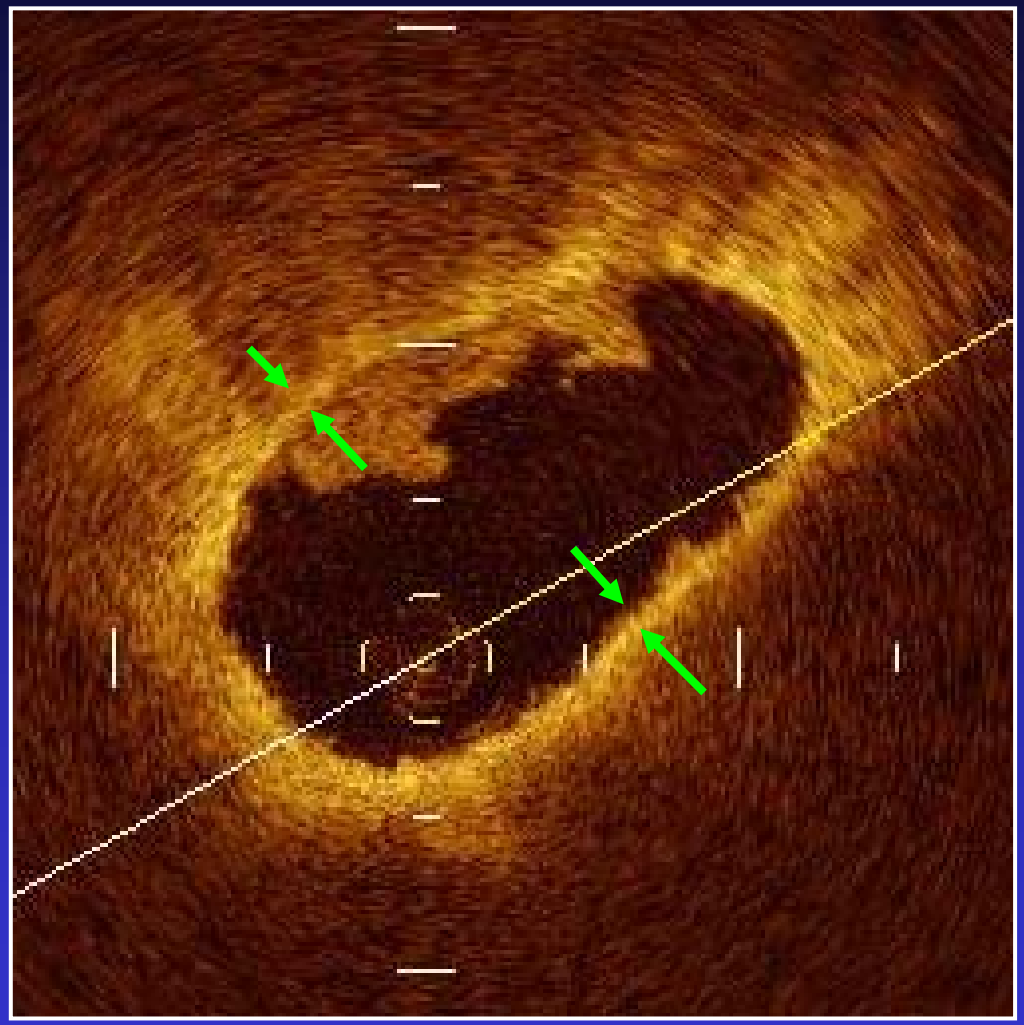


Thickness of Fibrous Cap



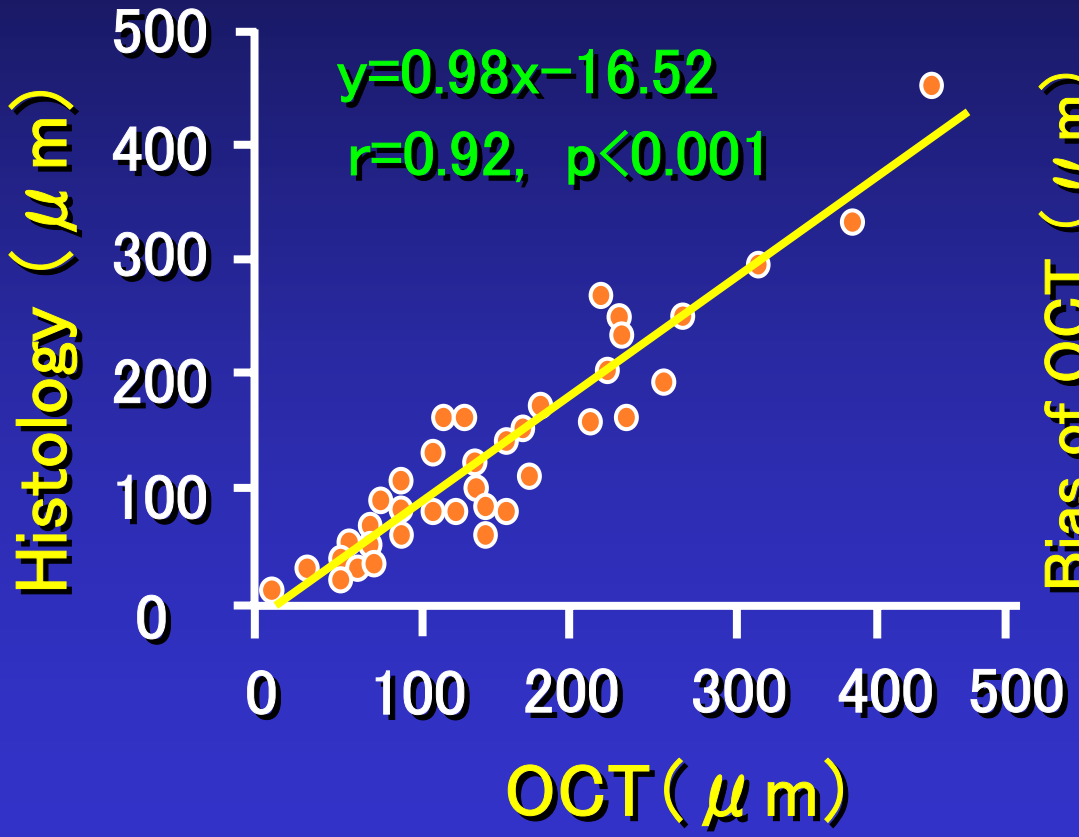
Thickness of fibrous cap was 42 μm

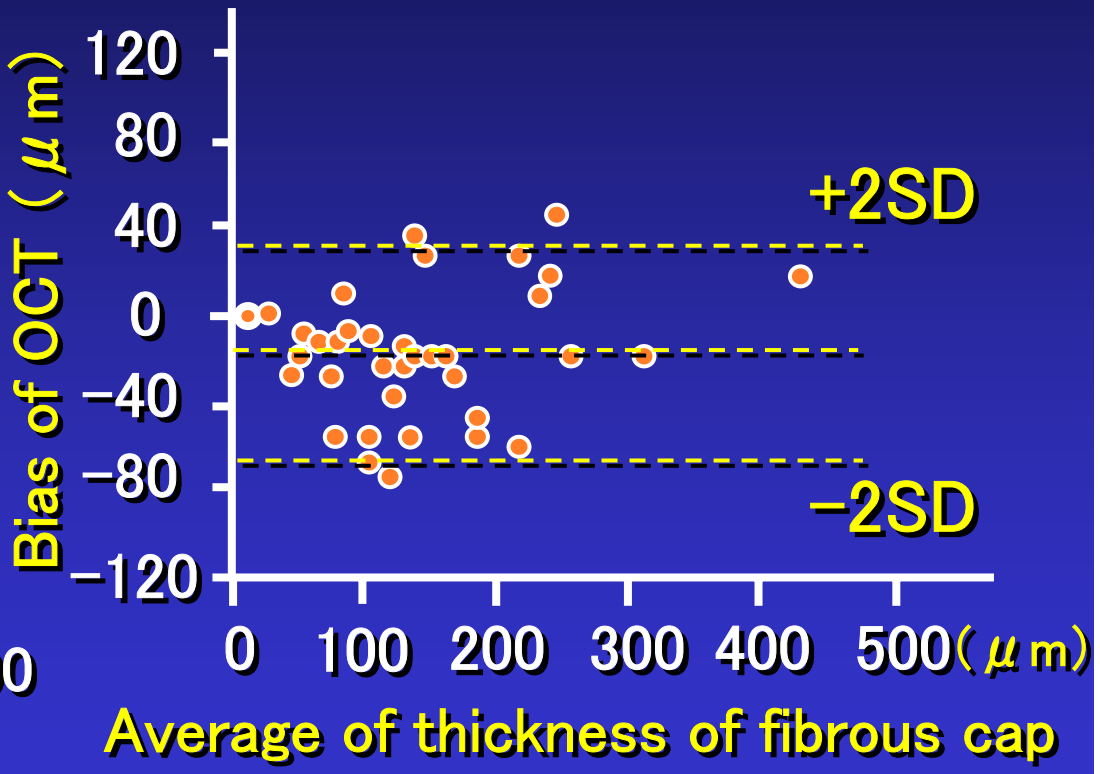
Anteroseptal AMI （80y.o., M）



Fibrous cap thickness = 60 μm

Thickness of fibrous caps
Histology vs OCT

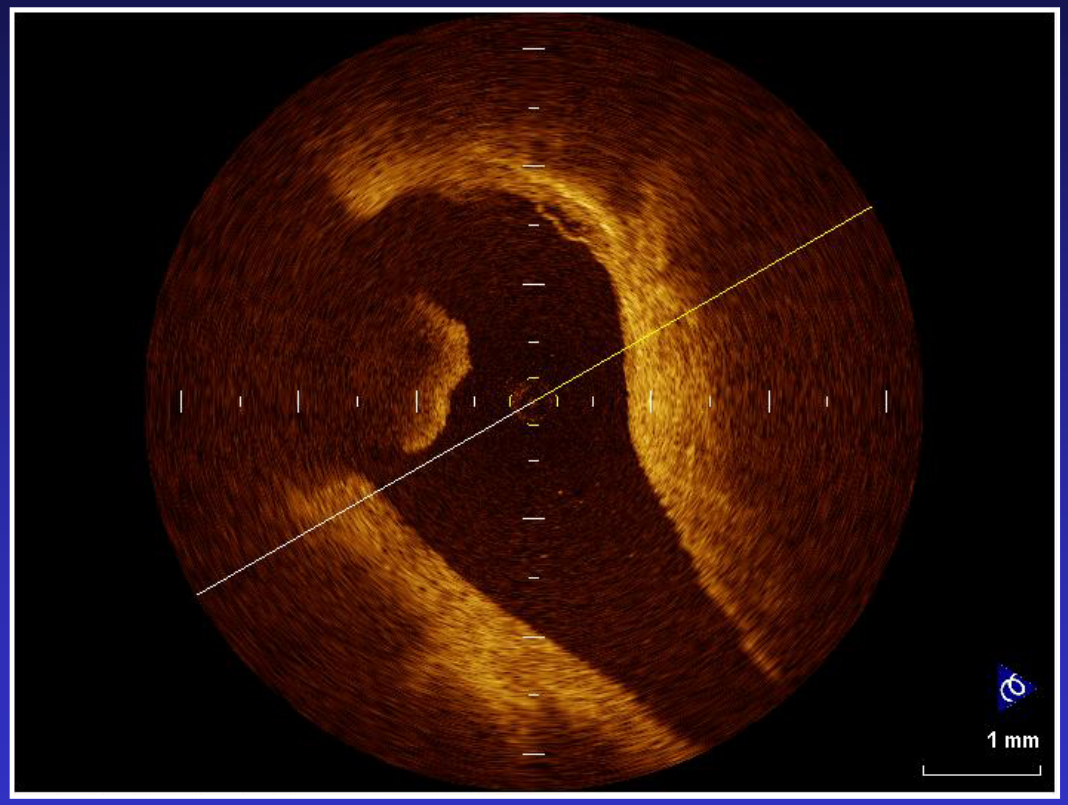


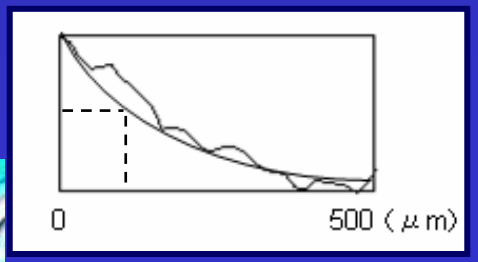


Kume T, Akasaka T, et al (Am Heart J . 152:755, 2006)

Inf-AMI （71y.o., M） Thrombus

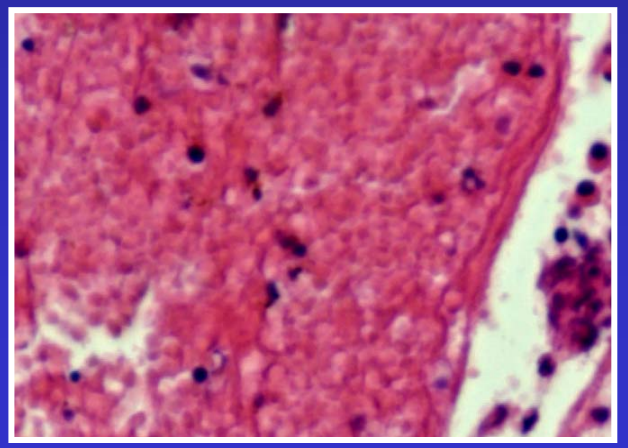
Red Thrombus



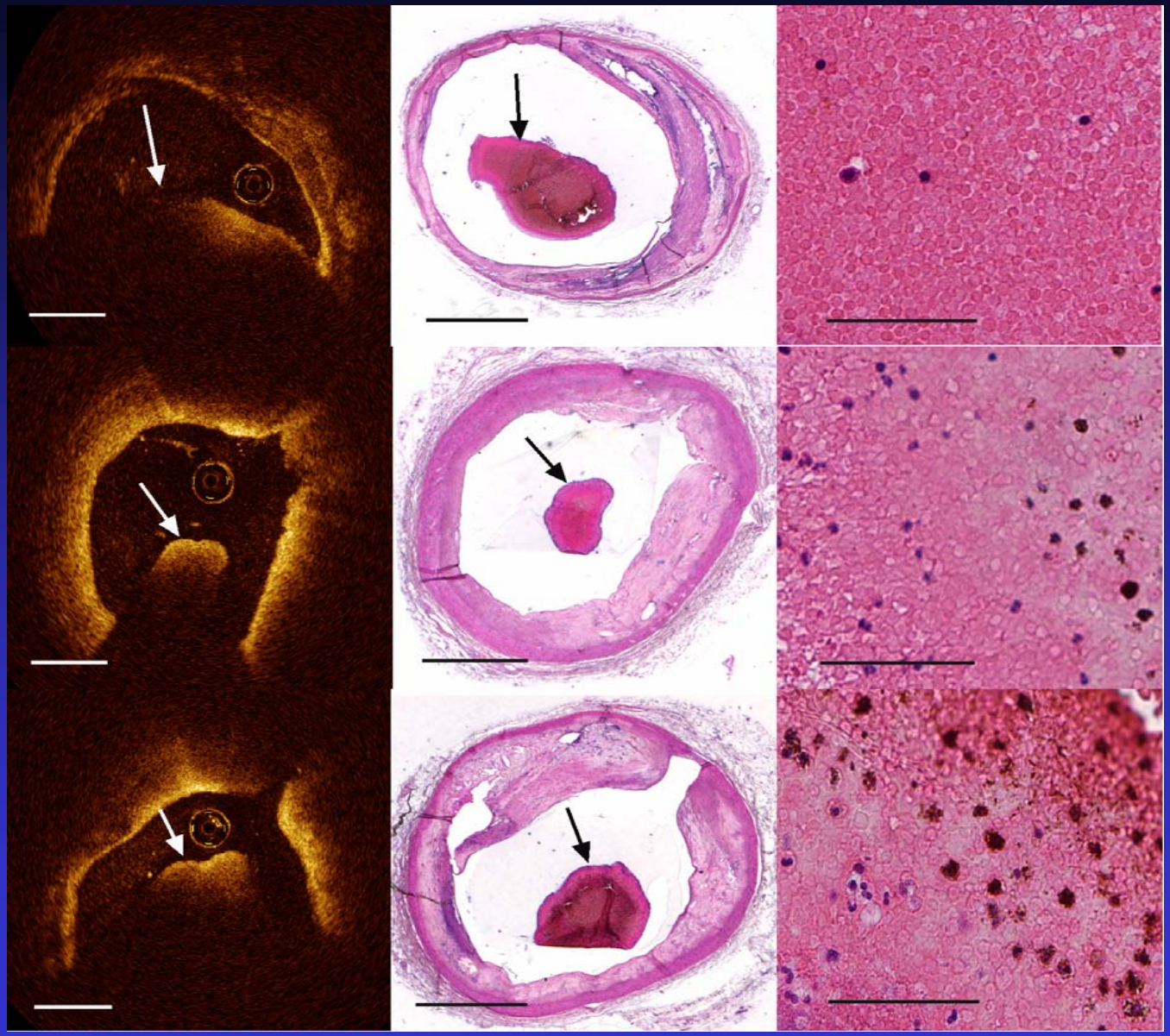


Intensity Half Distance
= 135 μm

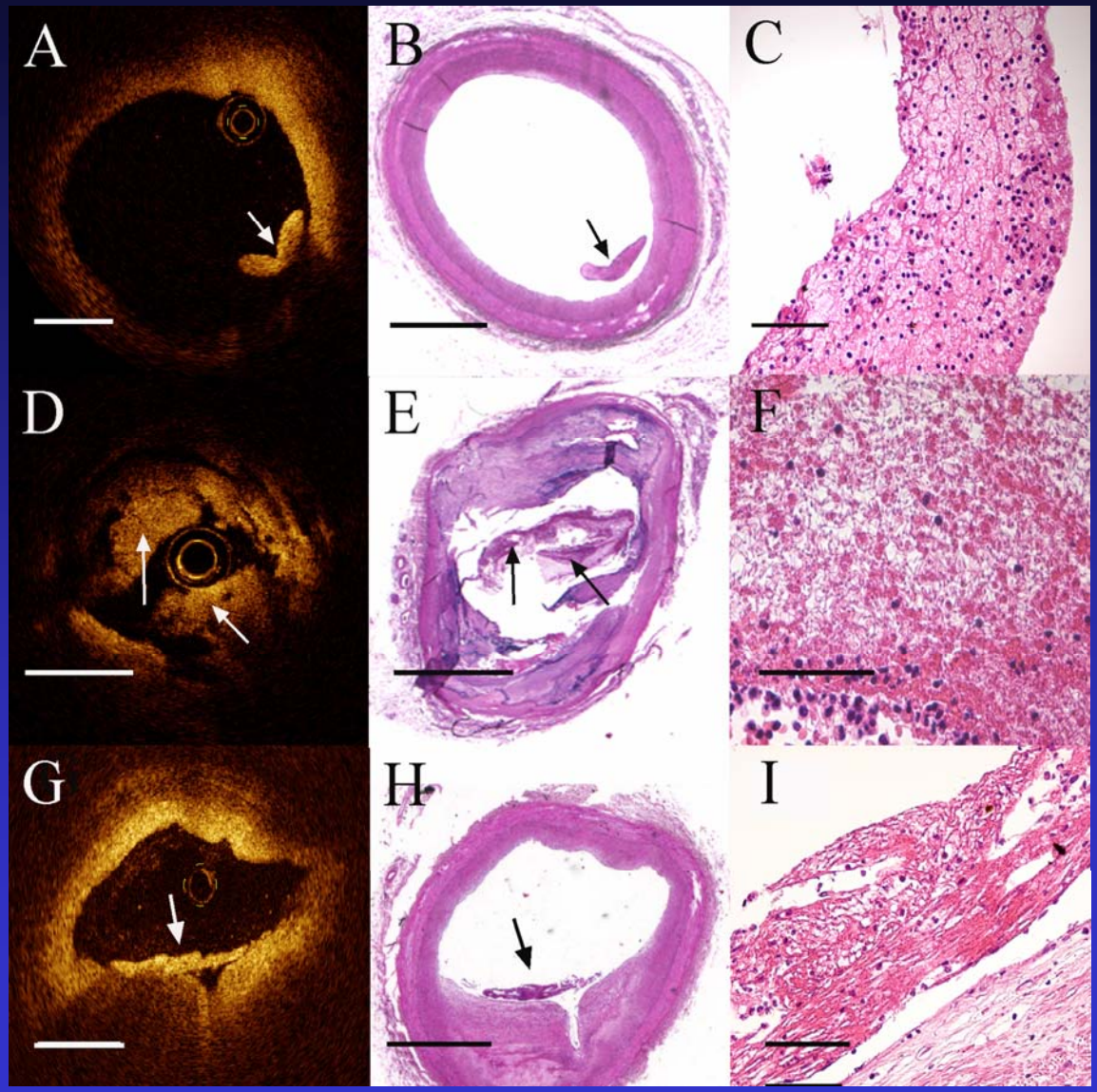
Thrombectomy



Red thrombus

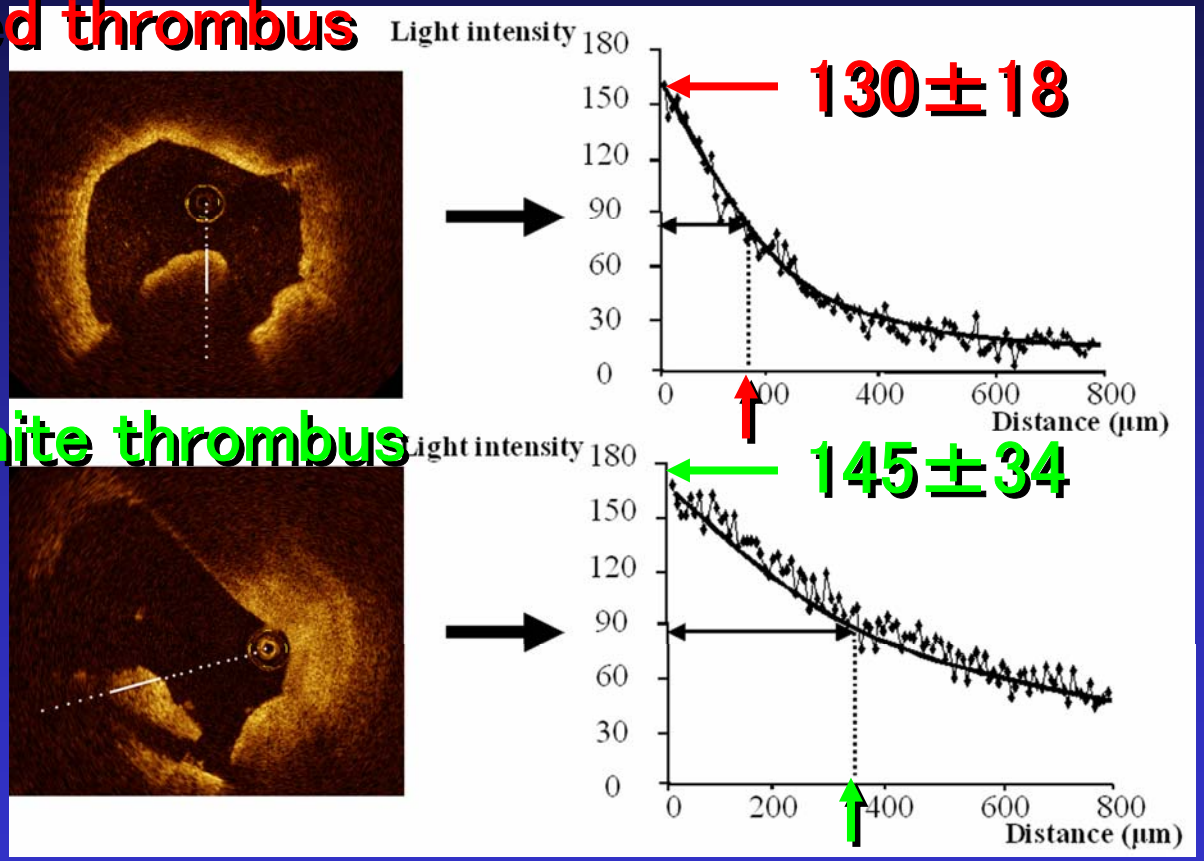


White thrombus



Differentiation between red and white thrombus

	Peak intensity	Intensity half distance
Red thrombus	130±18	183±42
White thrombus	145±34	324±50 *



* p = 0.0001

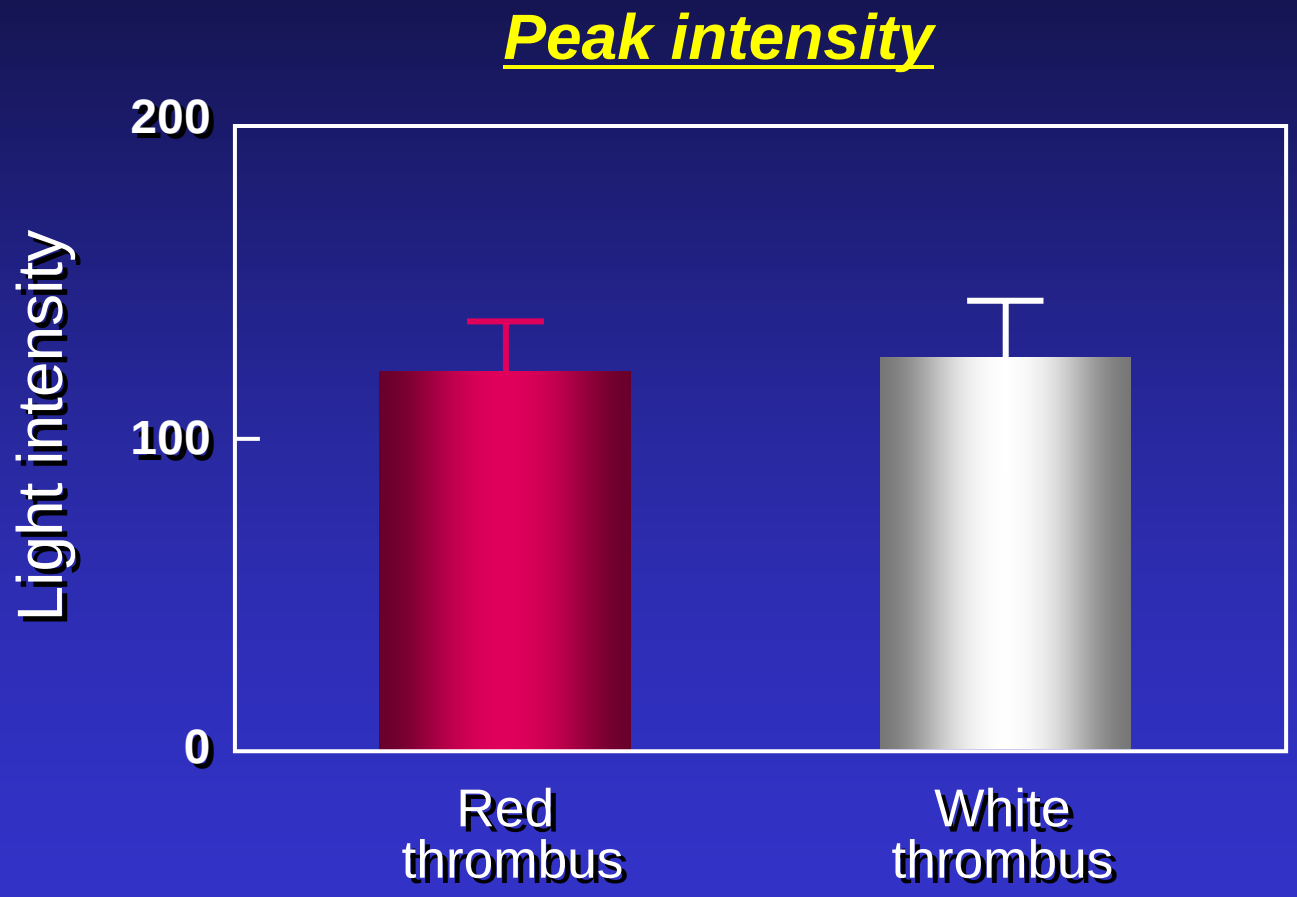
Kume T, Akasaka T, et al (Am J Cardiol . 2006, 97:1713-1717)

Baseline characteristics

	Coronary angioscopy		*p*
	Red thrombus (n=19)	White thrombus (n=24)	
Age, y*	69 ± 5	69 ± 7	0.99
Male sex	12 (62)	14 (59)	0.74
Diabetes mellitus	6 (34)	8 (33)	0.90
Hypertension	16 (85)	20 (83)	0.94
Hypercholesterolemia	9 (46)	10 (40)	0.71
Culprit vessel			
LAD	9 (47)	11 (46)	0.92
LCx	2 (11)	3 (13)	0.84
RCA	8 (42)	10 (41)	0.98

Values are given as n (%) or *mean ± SD.
LAD, left anterior descending coronary artery; LCx, left circumflex artery; RCA, right coronary artery.

Comparison of light intensity properties in OCT images between yellow and white plaques



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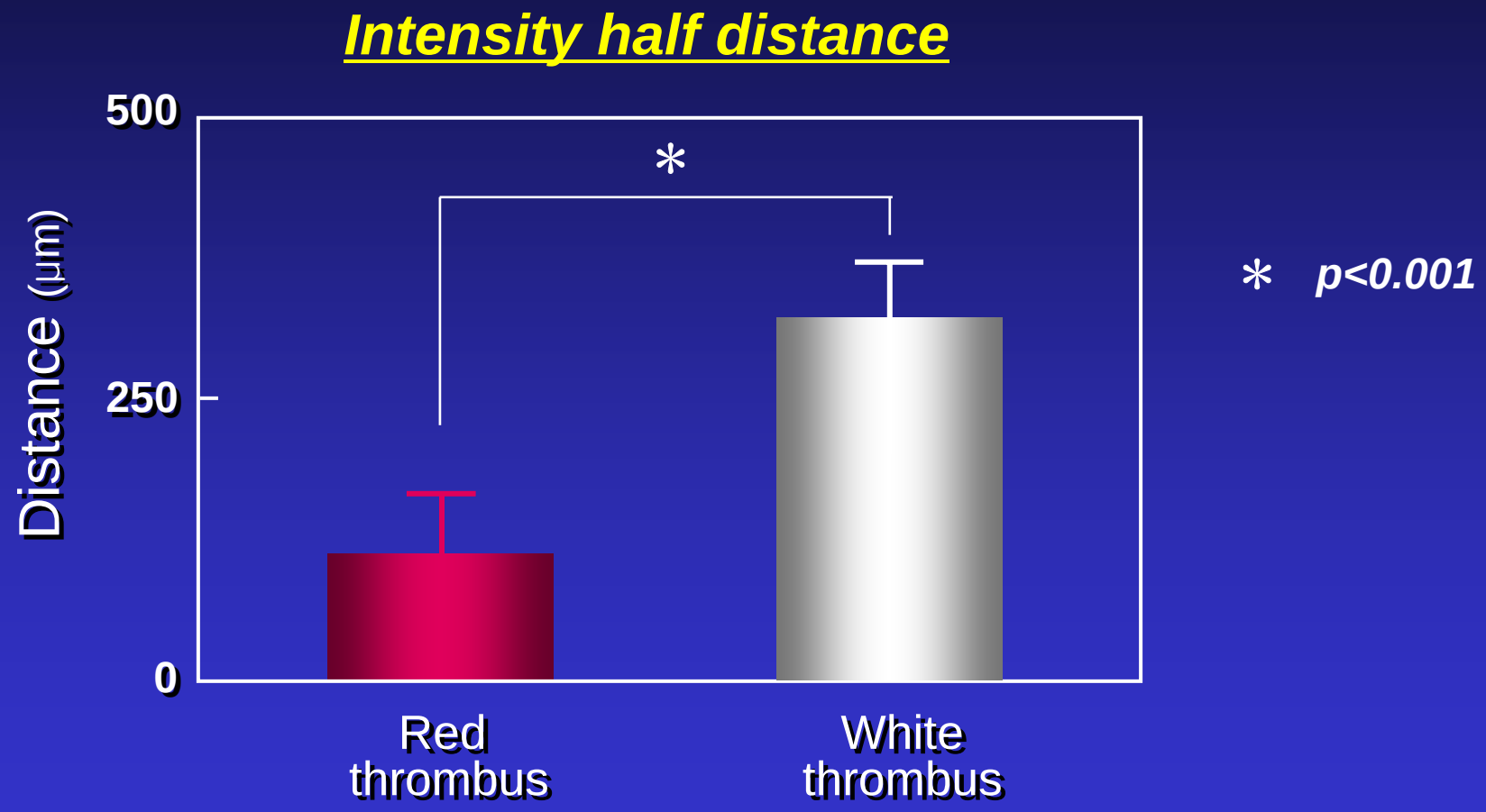


Accuracy of intra-coronary OCT for differentiation between red and white thrombus

		Angioscopy	
		Red thrombus	White thrombus
OCT	Intensity half distance ＜250 μm	18	3
	Intensity half distance ≧250 μm	1	21

Sensitivity = 95%

Specificity = 88%

Positive predictive value = 86%

Negative predictive value =95%

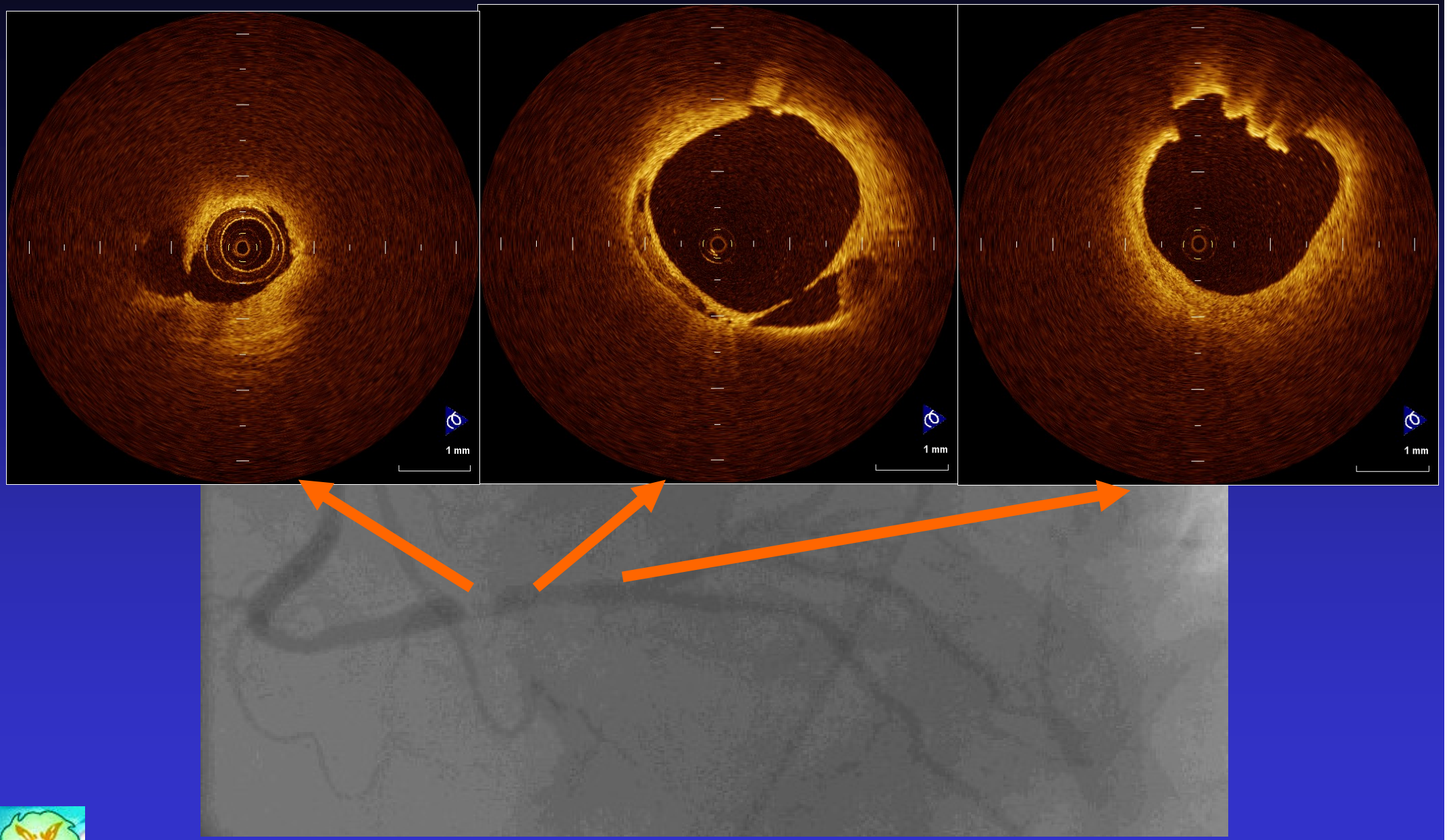
Comparison of plaque Images in AMI (OCT vs. CAS vs. IVUS) n=30

（Kubo T, Akasaka T, et al. J Am Coll Cardiol in press）

	OCT	*CAS	**IVUS	*p	**p
Plaque Rupture (%)	73	47	40	0.035	0.009
Ulceration (erosion) (%)	23	3	0	0.022	0.005
Thrombus (%)	100	100	33	1.000	<0.001
Red thrombus (%)	100	90	-	0.076	-
White thrombus (%)	100	93	-	0.150	-
TCFA（≦65μm）(%)	85	-	-	-	-
Fibrous cap thickness (μm)	59±13	-	-	-	-
LRP (Lipid Arch＞120°) (%)	57	-	67	-	NS

TCFA; Thin Cap Fibro-Atheroma, LRP; Lipid Rich Plaque

Unstable AP



Comparison of plaque Images among AMI, UAP & SAP

Finding	AMI (n=30)	UAP (n=11)	SAP (n=63)	*p - value*
Plaque rupture	22 (73) * #	3 (27) $	2 (3)	<0.0001
Erosion	7 (23) #	4 (36) $	1 (2)	0.0002
Thrombus	30 (100) * #	7 (64) $	3 (5)	<0.0001
Fibrous cap thickness (μm)	49 ± 21 * #	113 ± 64 $	305 ± 97	<0.0001
TCFA	25 (83) * #	4 (36) $	2 (3)	<0.0001

Values are given as n (%) or mean ± SD.
TCFA ; thin-cap fibroatheroma
(lipid > 2 quadrants & fibrous cap thickness < 65 μm).

* p<0.05; AMI vs UAP, # p<0.001; AMI vs SAP, $ p<0.005; UAP vs SAP.

Summary

- OCT can identify lipid-rich plaques more sensitively compared with IVUS.
- OCT can demonstrate rupture or erosion of fibrous cap with higher detection rate than that of IVUS and CAS.
- OCT could detect intracoronary thrombus almost exclusively which was confirmed by CAS.
- OCT may have a potential to estimate macrophage accumulation within fibrous caps.

Conclusion

OCT may allow us to assess the pathophysiology of ACS by demonstrating *lipid-rich plaques*, *thin cap fibro-atheroma* with rupture or erosion, and *thrombi*, which are proposed by pathohistology, compared with IVUS and CAS