Imaging and physiology summit 2014

Detection of Angioscopically-detected Yellow Plaque by Near-Infrared Spectroscopy (NIRS)

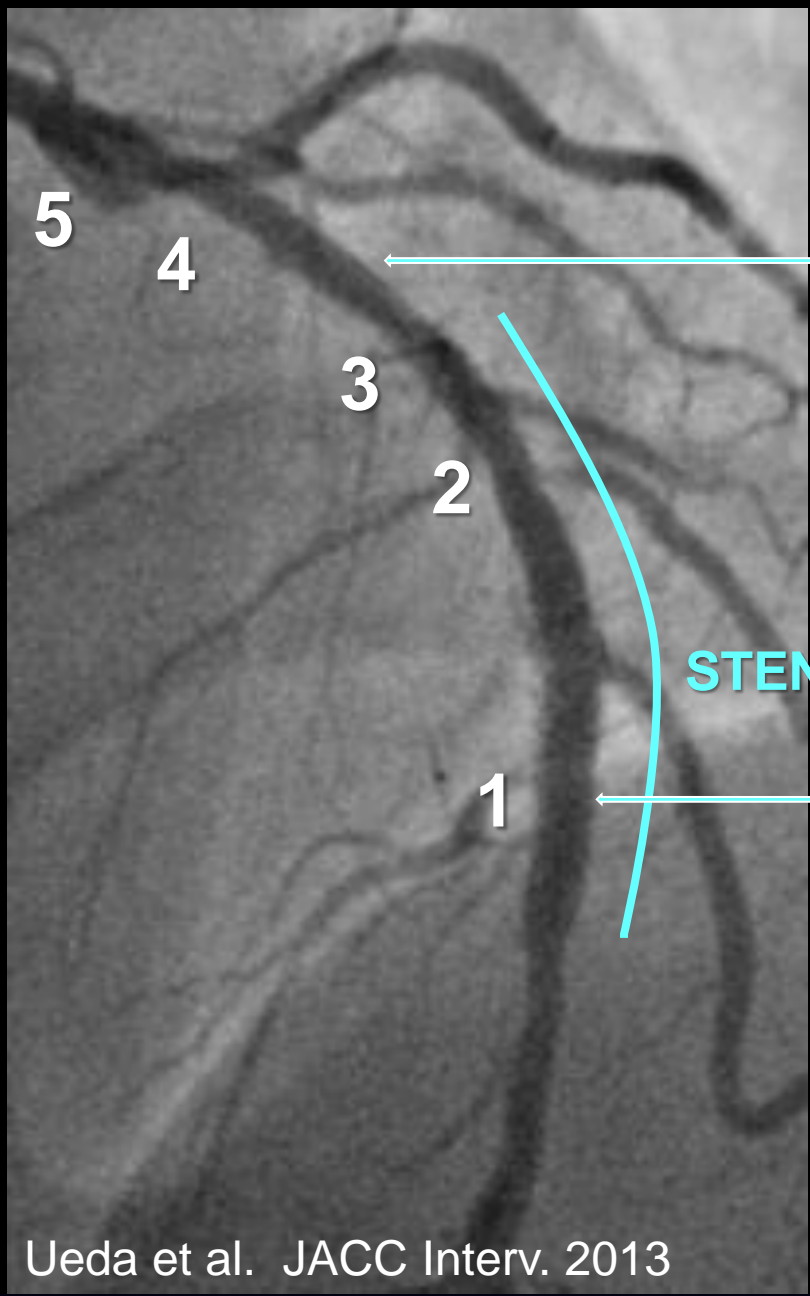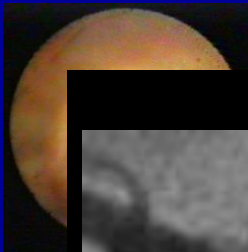Yasunori Ueda, *MD, PhD, FACC, FESC, FJCC*

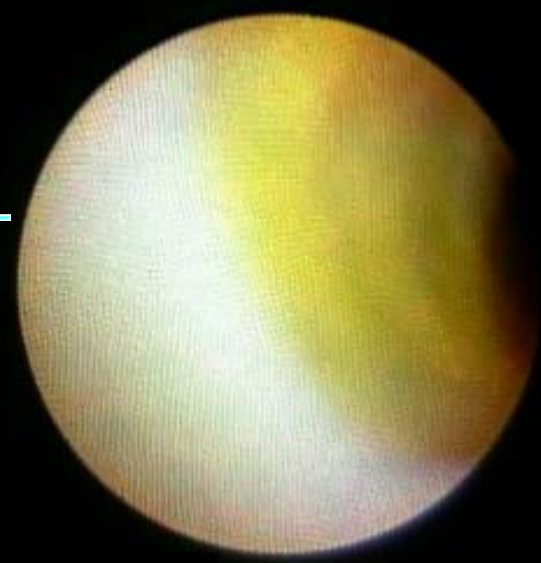*Director, Cardiovascular Division*

Osaka Police Hospital

Clinical Professor, Cardiovascular Medicine
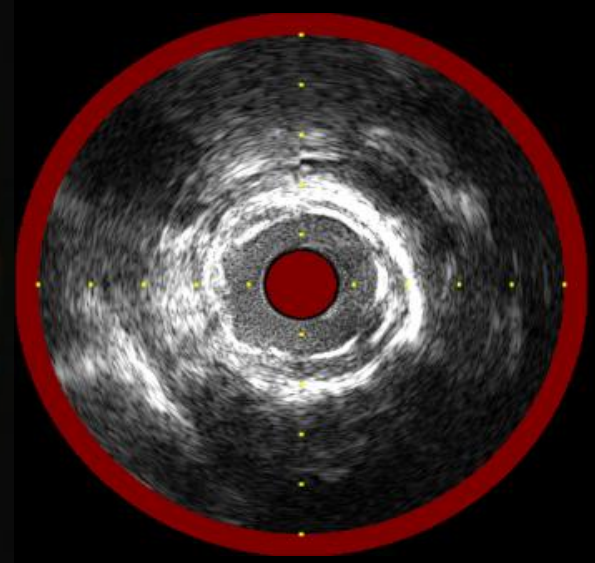
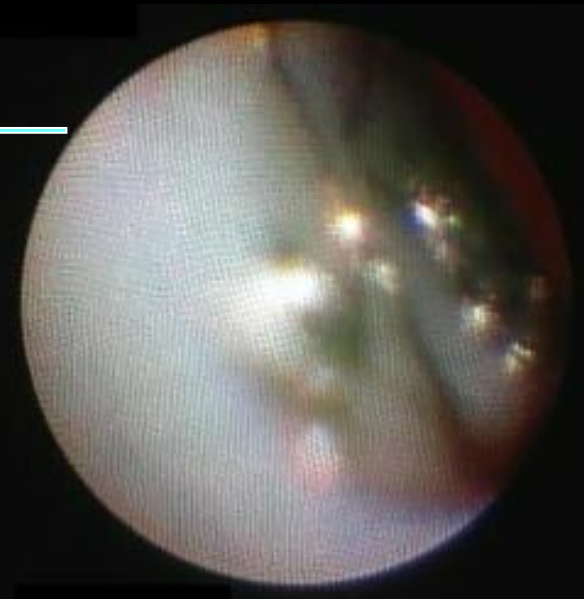*Osaka University Graduate School of Medicine*

Angioscopy

NIRS-IVUS

5

4

3

2

STENT

1

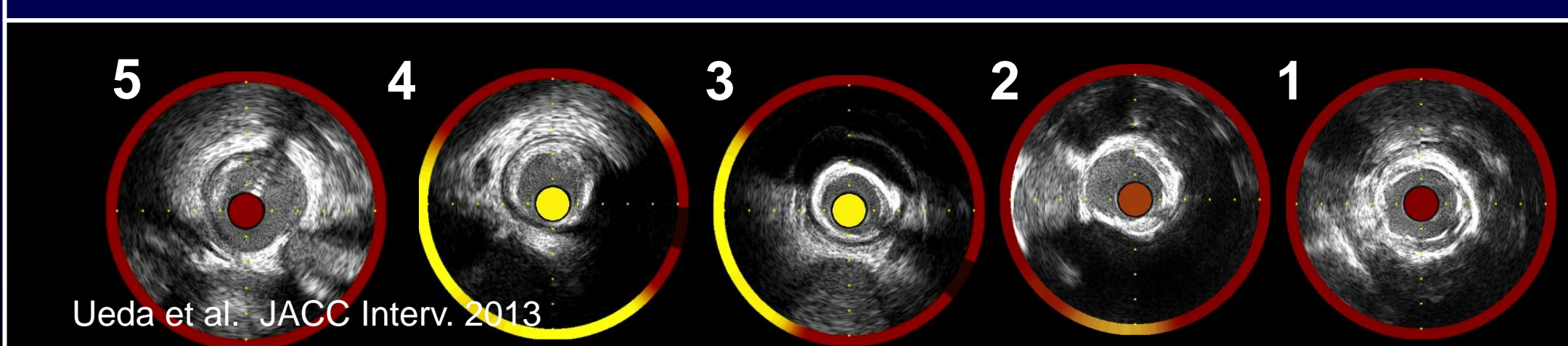Ueda et al. JACC Interv. 2013

STENT

5   4   3   2   1

90   80   70   60   50   40

Ueda et al. JACC Interv. 2013
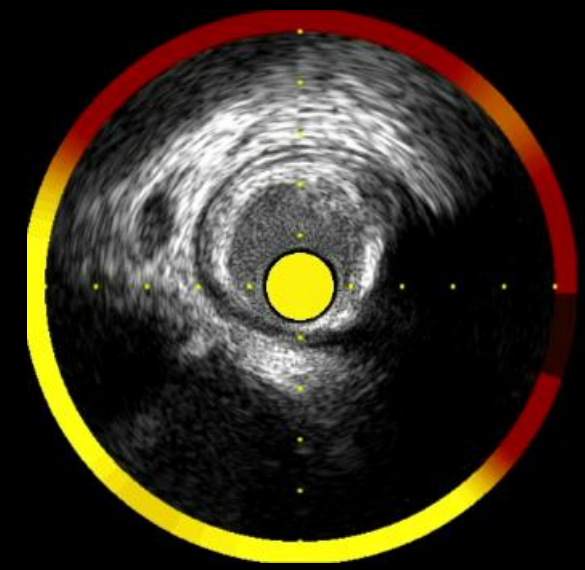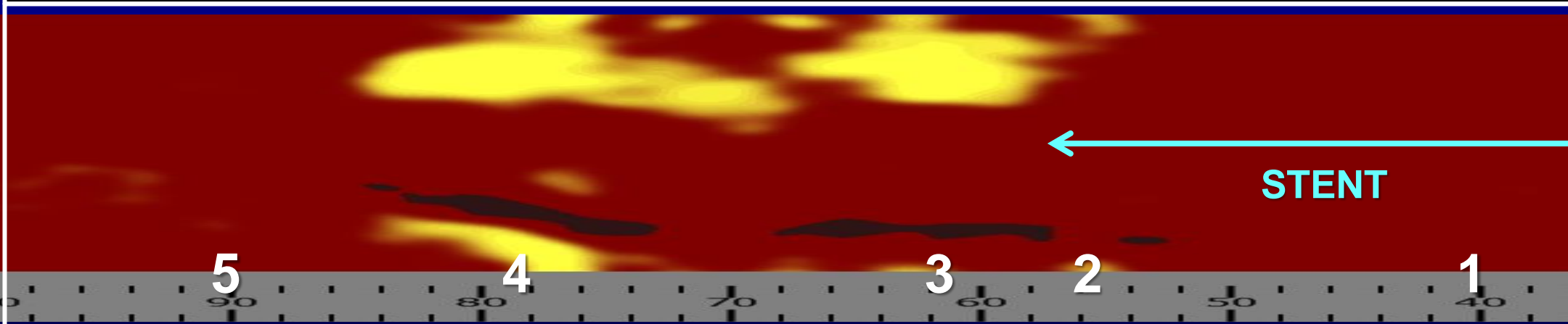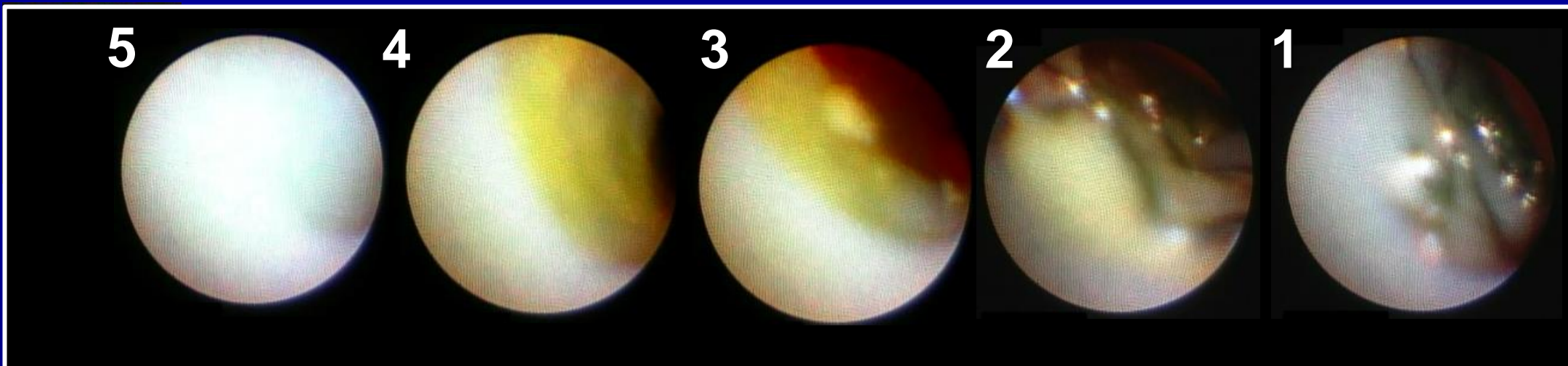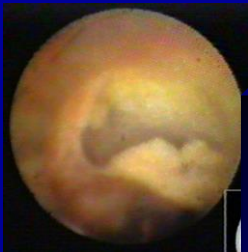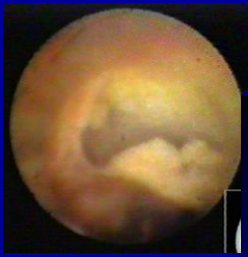
Angioscopy yellow color grade vs. NIRS LCBI
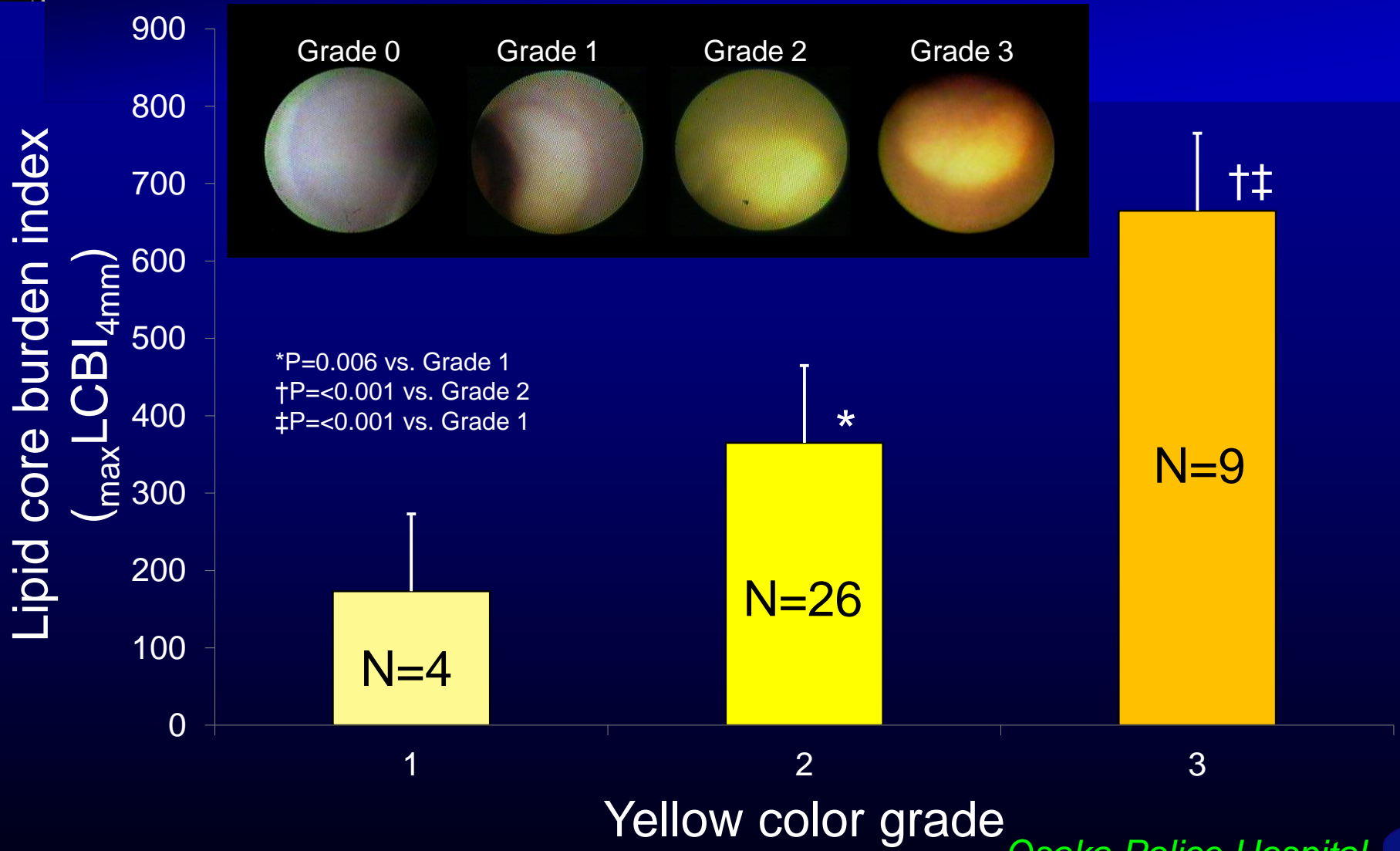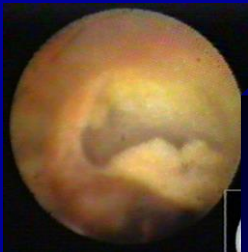
Culprit lesions of ACS

Culprit lesion of unstable angina
= *Yellow plaque*
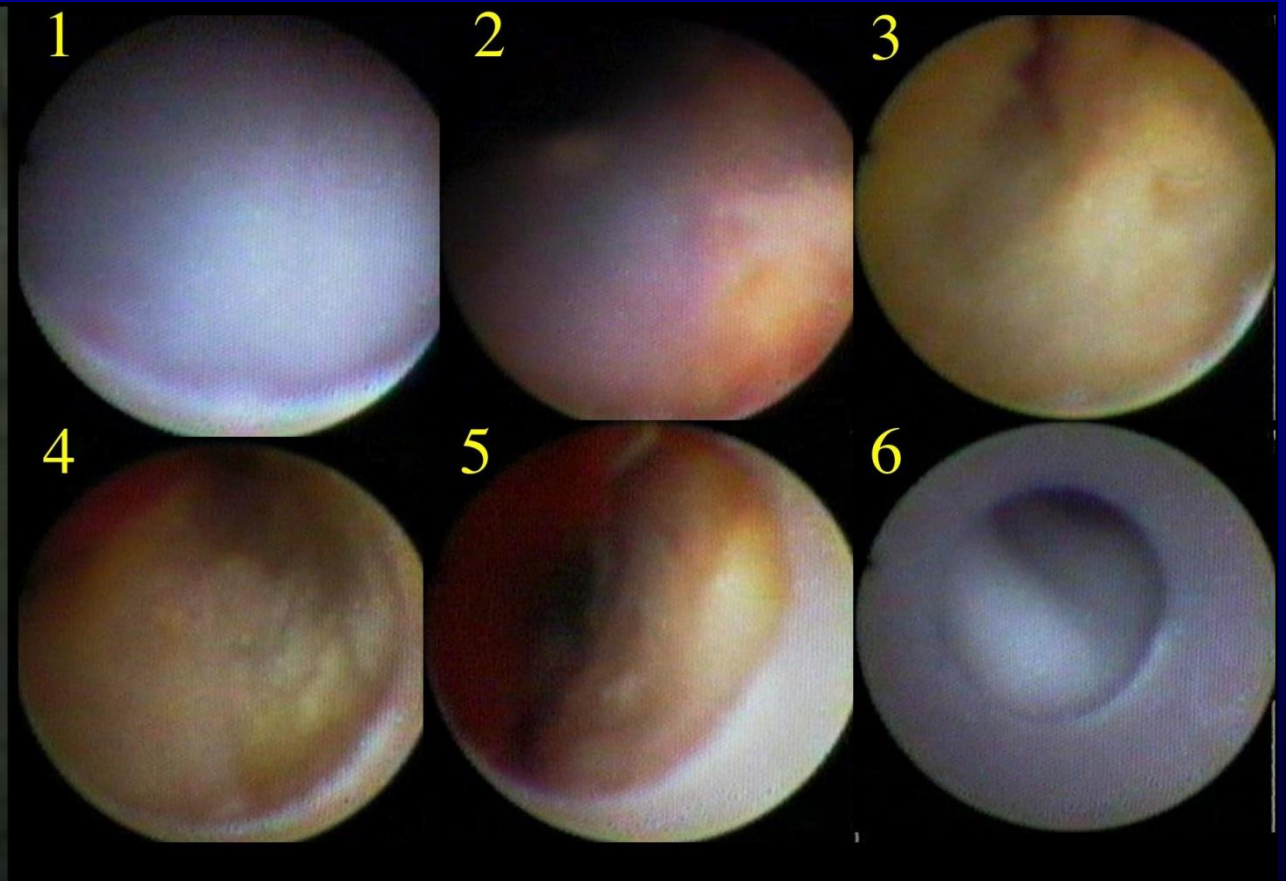
Culprit lesion of acute MI
= *Yellow plaque*

9

1

1   2   3

4   5   6

7   8   9

Osaka Police Hospital

Ueda et al. J Invasive Cardiol. 2006
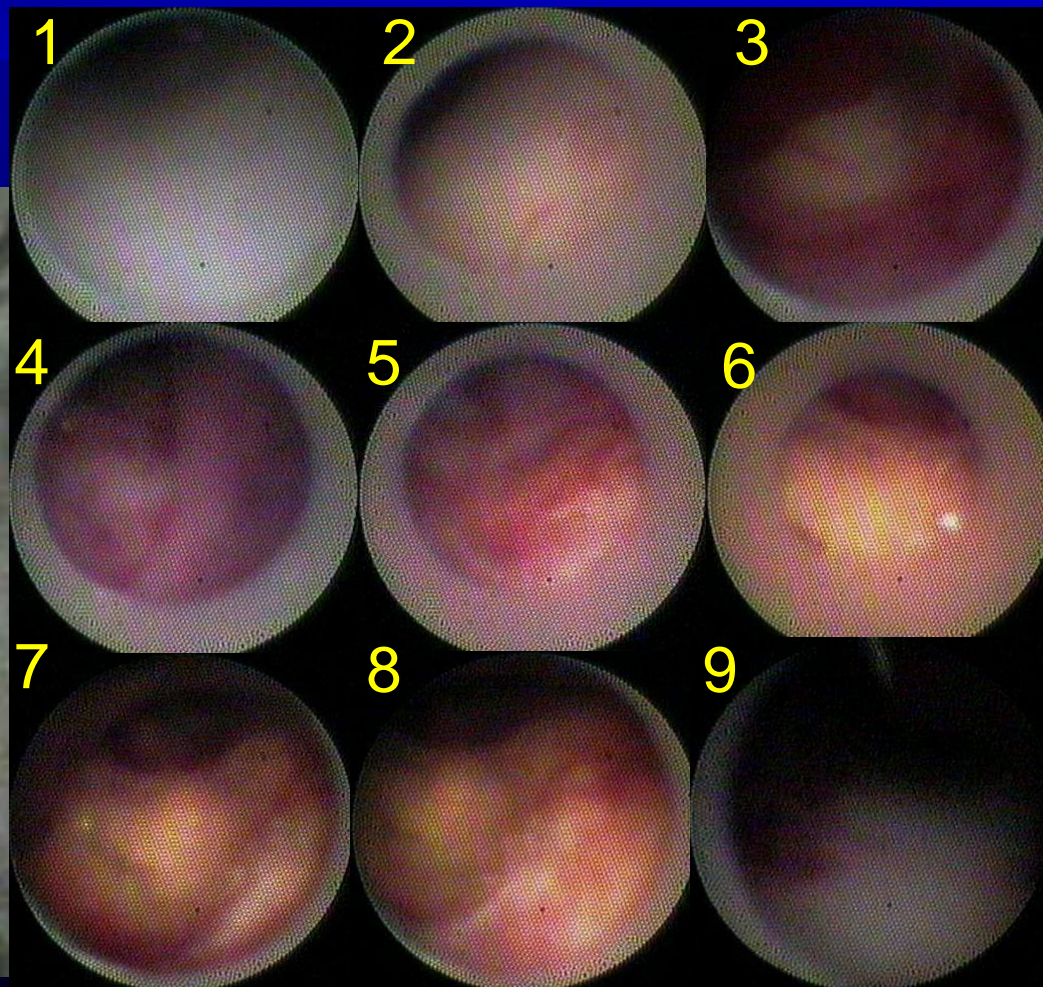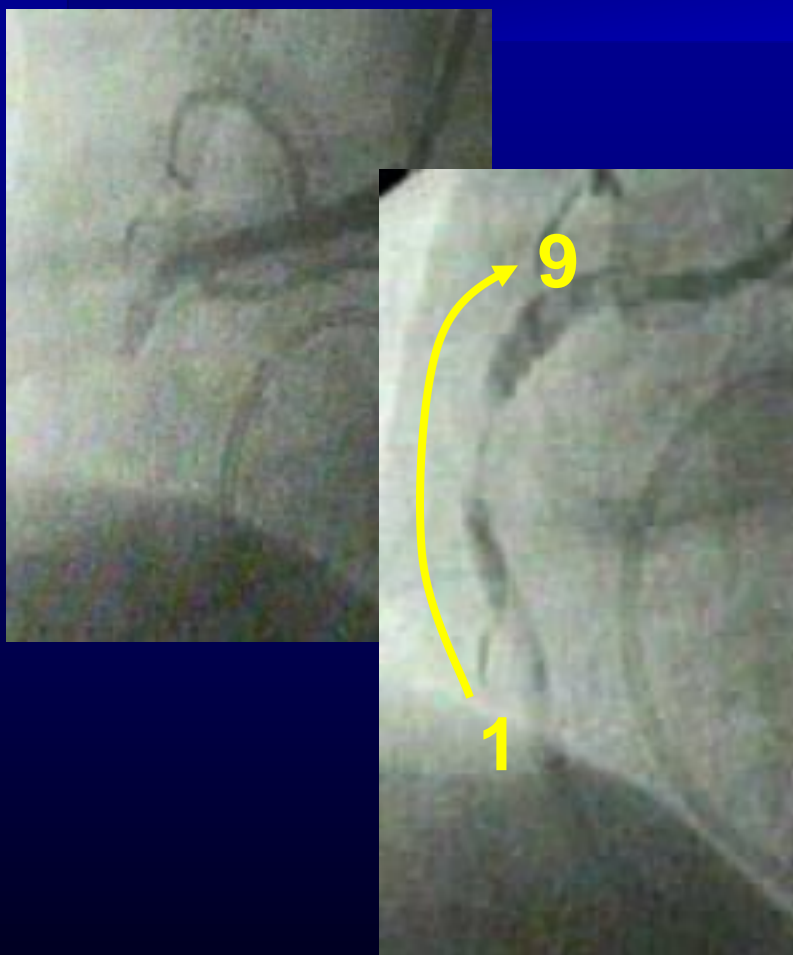
Culprit lesions of ACS by angioscopy = *Yellow plaque*

92.7%   94.7%   47.2%

- White
- Yellow

Acute MI   Unstable AP   Stable AP *Osaka Police Hospital*

Plaque Rupture & Non-rupture (Erosion)
= *Yellow plaque*

Ruptured plaque

Similar VH findings between ruptured and non-ruptured plaques

TCFA　　　　　*ThCFA*

Osaka Police Hospital

Sanidas et al. Am J Cardiol. 2011

Plaque Rupture & Non-rupture (Erosion)
= *Yellow plaque*

Non-Ruptured plaque

Similar VH findings between ruptured and non-ruptured plaques

TCFA

TCFA

Osaka Police Hospital

Sanidas et al. Am J Cardiol. 2011

Culprit lesions of acute MI by NIRS

J Am Coll Cardiol Intv. 2013;6(8):838-846

Osaka Police Hospital

Culprit lesions of acute MI by NIRS

J Am Coll Cardiol Intv. 2013;6(8):838-846

Osaka Police Hospital
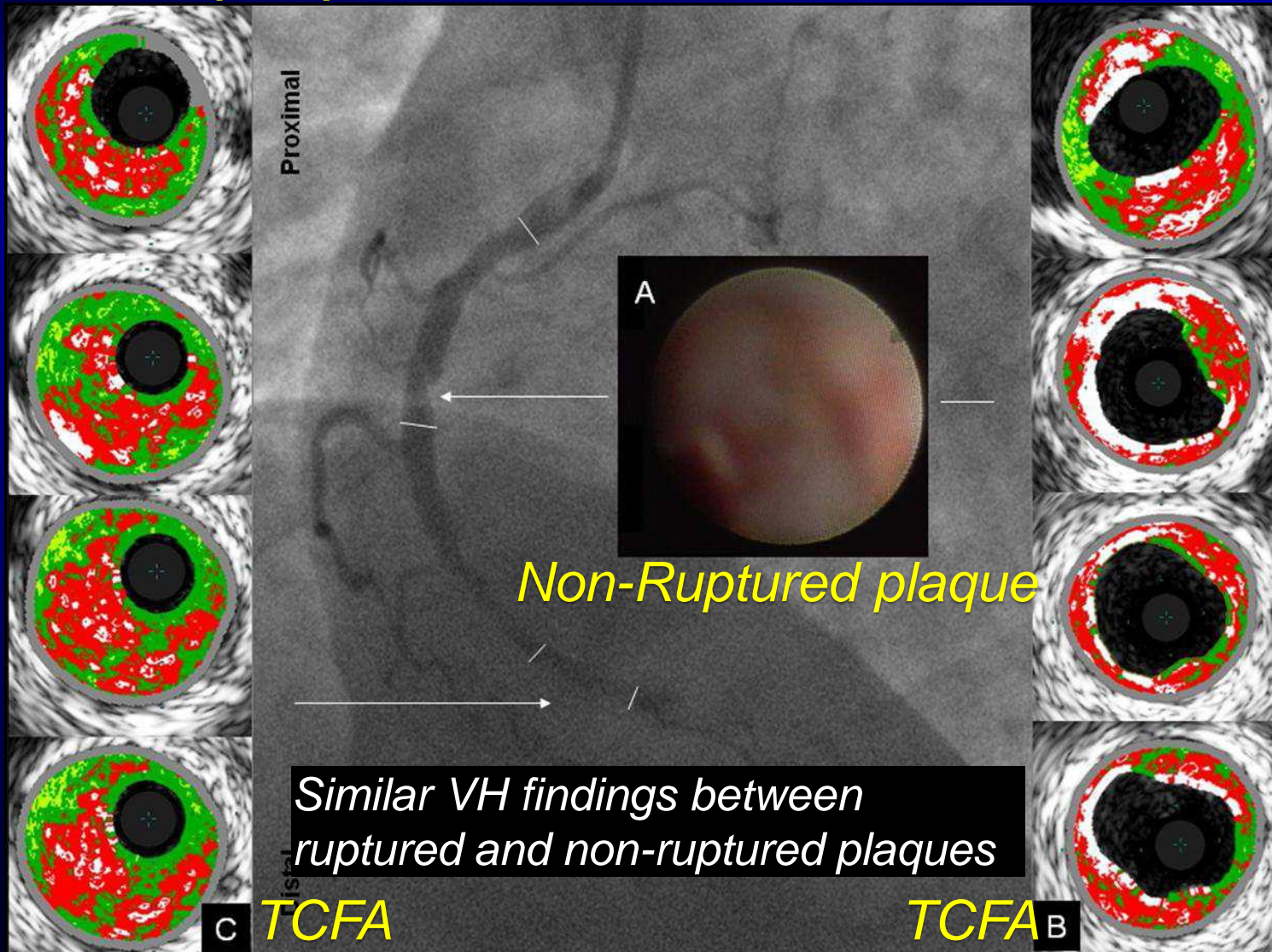
Regression of yellow plaque by statin

Regression of yellow plaque by statin therapy

Before

After 80 weeks
Atorvastatin (10mg/day)

Okada and Ueda et al. J Interven Cardiol, 2007

Osaka Police Hospital
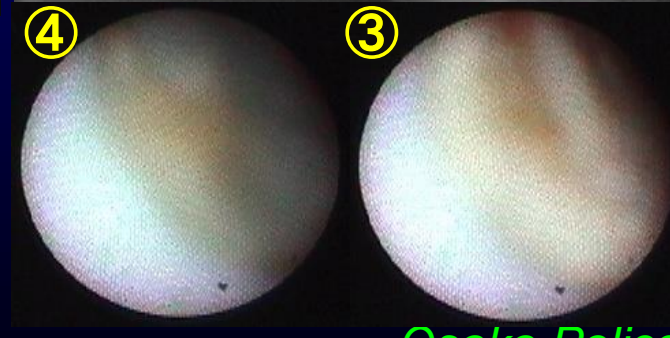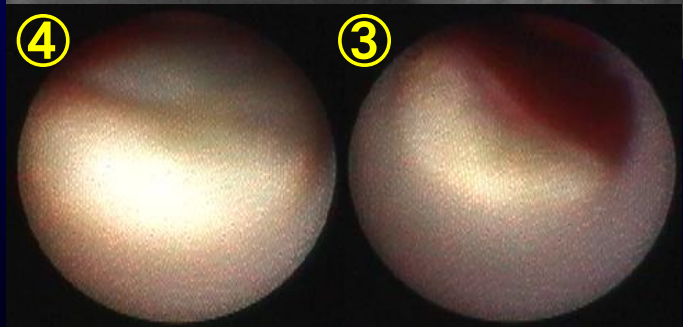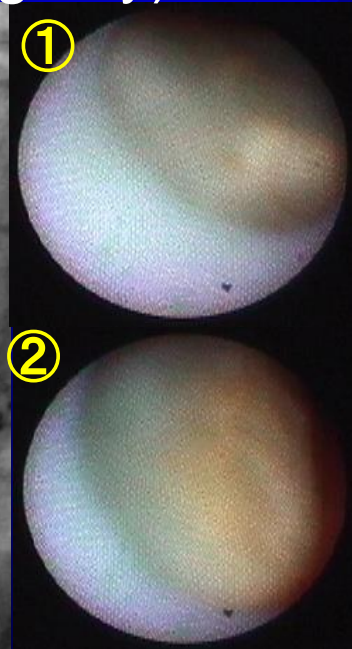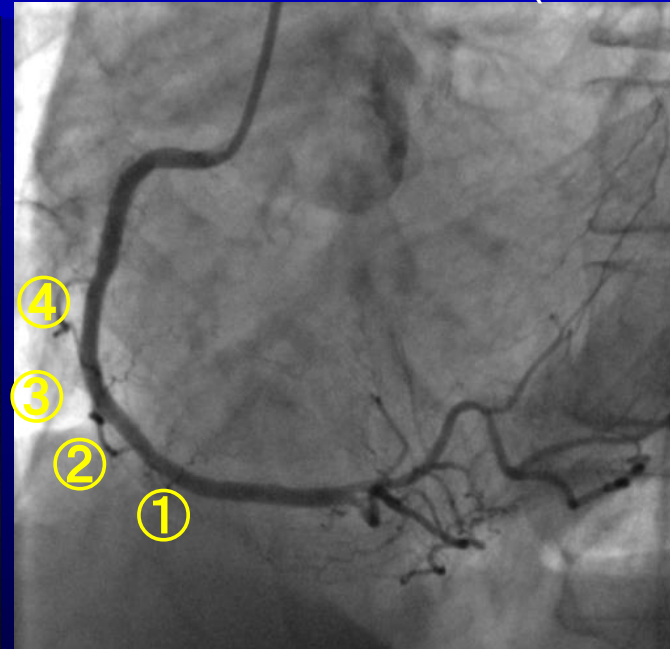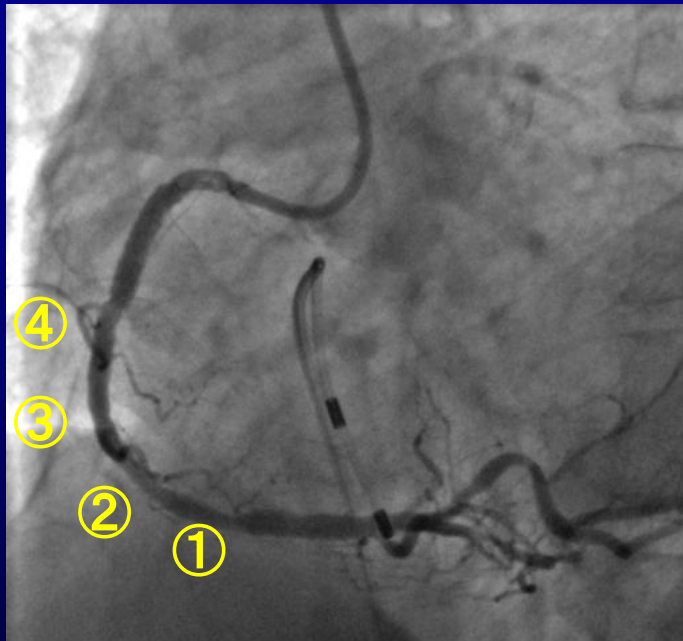
Plaque stabilization and regression by statin

TWINS STUDY

P<0.001**

P=0.003***   P<0.001**

baseline

80 weeks

P=0.024*

P=0.012*

P=0.508*

28 weeks

Mean grade of yellow plaque

2.0

1.5

1.0

0

-25   -20   -15   -10   -5   0

Change in plaque volume (%)

20 patients of matched data
58 yellow plaques
30 IVUS segments

Hirayama A et al. Circ J, 2009

Osaka Police Hospital
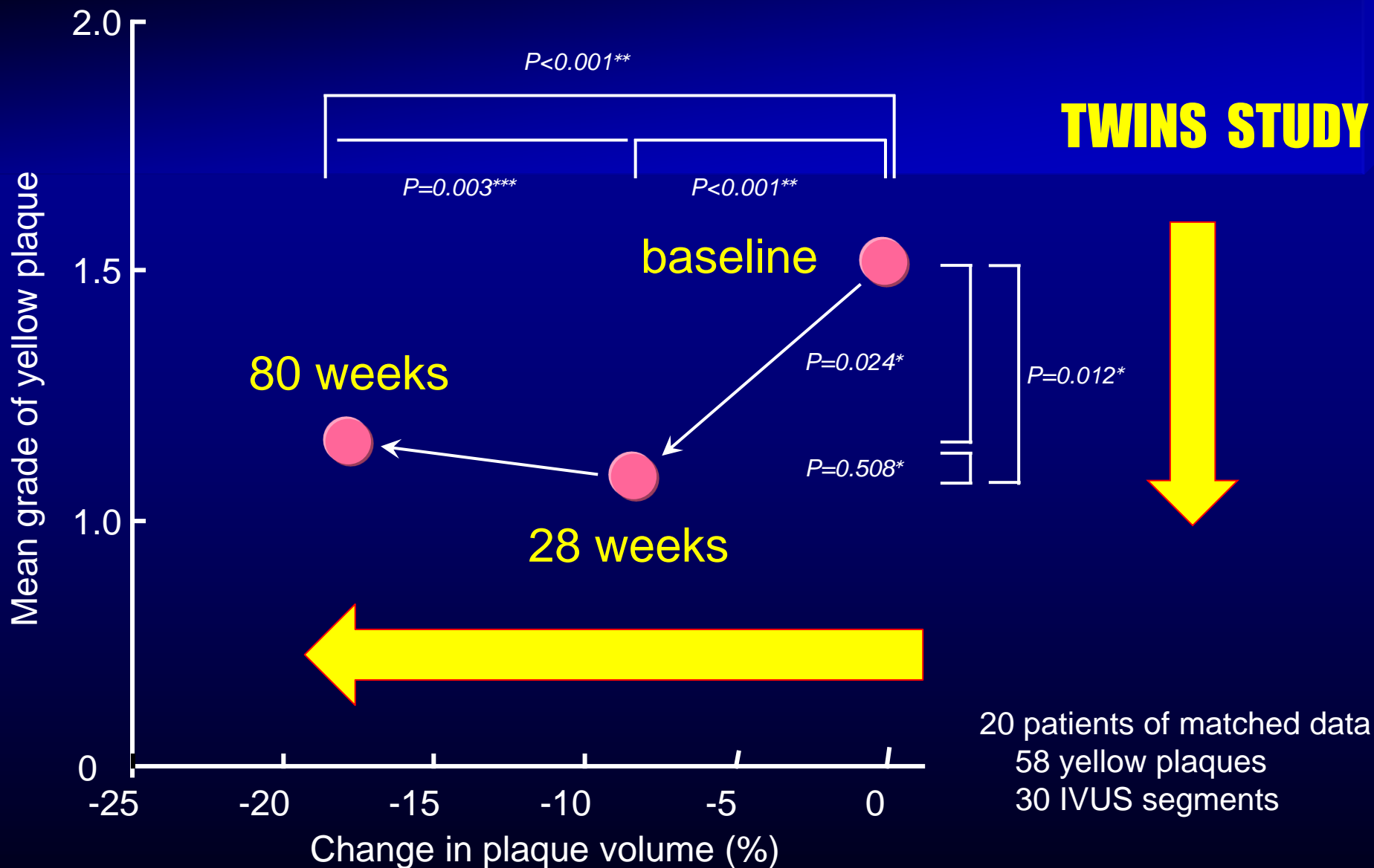
Two/Three Vessel CAD
(n= 87)

After stenting the target vessel
The non-target lesion underwent FFR

FFR≤0.8 →IVUS, NIRS

Randomized

Standard
(n = 43)
Continue statin the patient was taking
Dual antiplatelet therapy for 1 year

Intensive
(n = 44)
Rosuvastatin 40 mg daily
Dual antiplatelet therapy for 1 year
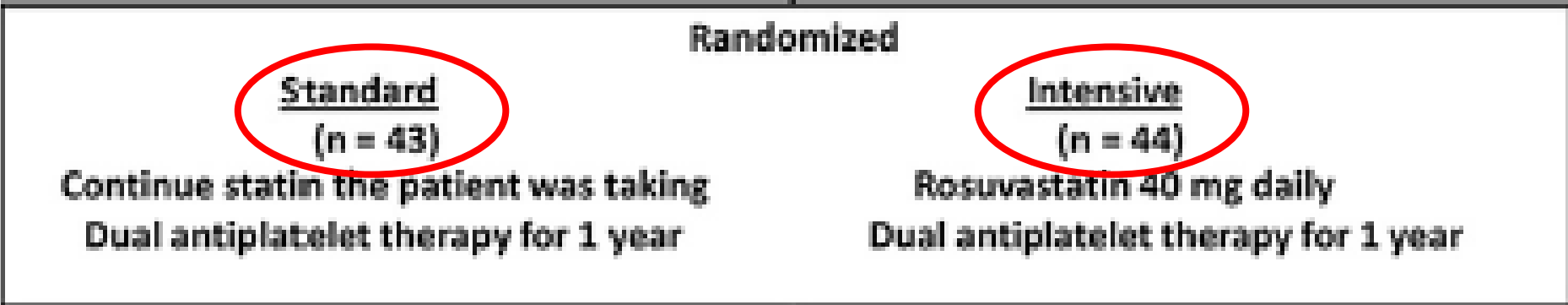
Follow-up Cath (6-8 weeks)
FFR, IVUS and NIRS repeated.
If FFR ≤0.8, lesion stented and imaging repeated.
If FFR > 0.8 the patient was treated medically.

Imaging data analyzed by CRF Core Lab
Data analysis for primary outcome analyzed by MSH independent Core Lab

Kini et

A Baseline

FFR: 0.74

Plaque Area: 5.6mm²
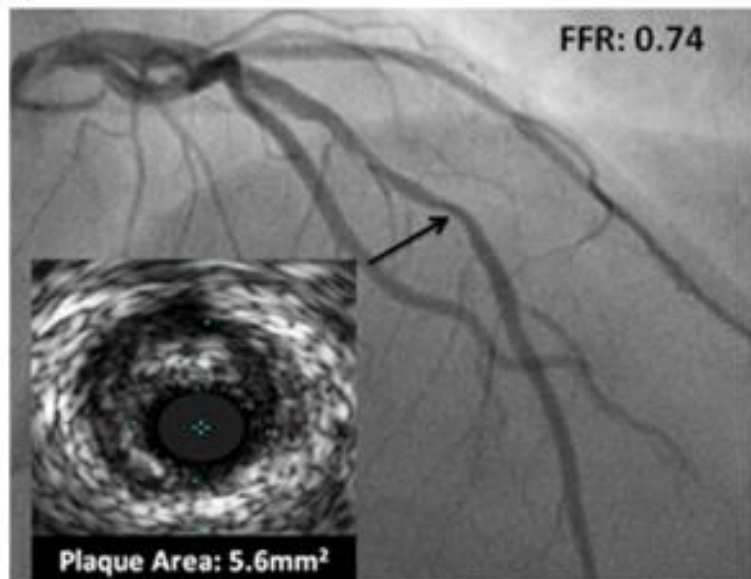
Lesion LCBI: 259

Max4mm LCBI: 802

B Follow-up

FFR: 0.78

Plaque Area: 5.5mm²

Lesion LCBI: 177

Max4mm LCBI: 474

Kini et al. J Am Coll Cardiol 2013;62:21–9

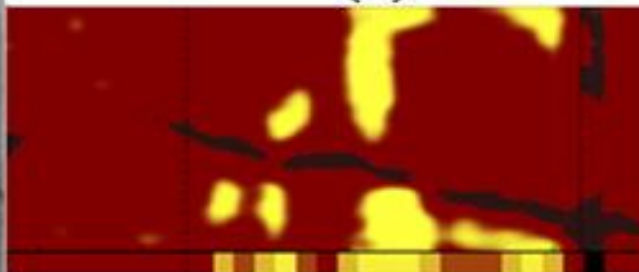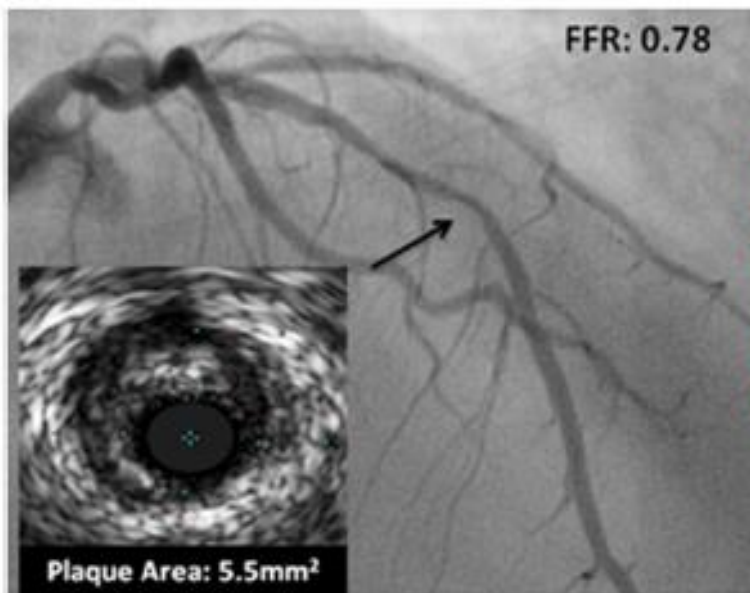|	Standard (n = 34)	Intensive (n = 36)	p Value
Baseline, median (IQR)			
LCBI$_{4mm}$ max	356.7 (145.2 to 509.2)	490.6 (363.8 to 689.7)	0.01
LCBI, lesion	95.4 (29.6 to 174.6)	132.4 (99.0 to 201.2)	0.04
Follow-up, median (IQR)			
LCBI$_{4mm}$ max	385.7 (139.2 to 510.9)	336.1 (252.3 to 479.9)	0.93
LCBI, lesion	99.9 (38.2 to 204.3)	99.8 (64.2 to 159.3)	0.88
Median change (95% CI)†			
LCBI$_{4mm}$ max	2.4 (−36.1 to 44.7)	−149.1 (−210.9 to −42.9)	0.01
LCBI, lesion	8.0 (−7.7 to 22.1)	−22.5 (−59.2 to −3.5)	0.02
Median percent change (95% CI)			
LCBI$_{4mm}$ max	−0.6 (−22.0 to 12.4)	−32.2 (−40.4 to −12.4)	0.02
LCBI, lesion	5.4 (−19.6 to 34.1)	−24.4 (−43.6 to −2.0)	0.03
Any LCBI regression, %			
LCBI$_{4mm}$ max	50.0	80.6	0.01
LCBI lesion	44.1	69.4	0.03

*Table includes LCBI comparisons for study participants with values at both baseline and staged time points (n = 70). †p Values from analysis of covariance models on rank-transformed data controlling for baseline LCBI. All confidence intervals (CI) are distribution free.

IQR = interquartile range; LCBI$_{4mm}$ max = lipid-core burden index at the 4-mm maximal segment.

Kini et al. J Am Coll Cardiol 2013;62:21–9

Osaka Police Hospital

A Median change (95% CI) in LCBI 4_{mm} max by FFR increase

p=0.03

No FFR increase
(n=36)

Any FFR increase
(n=34)

Kini et al. J Am Coll Cardiol 2013;62:21–9
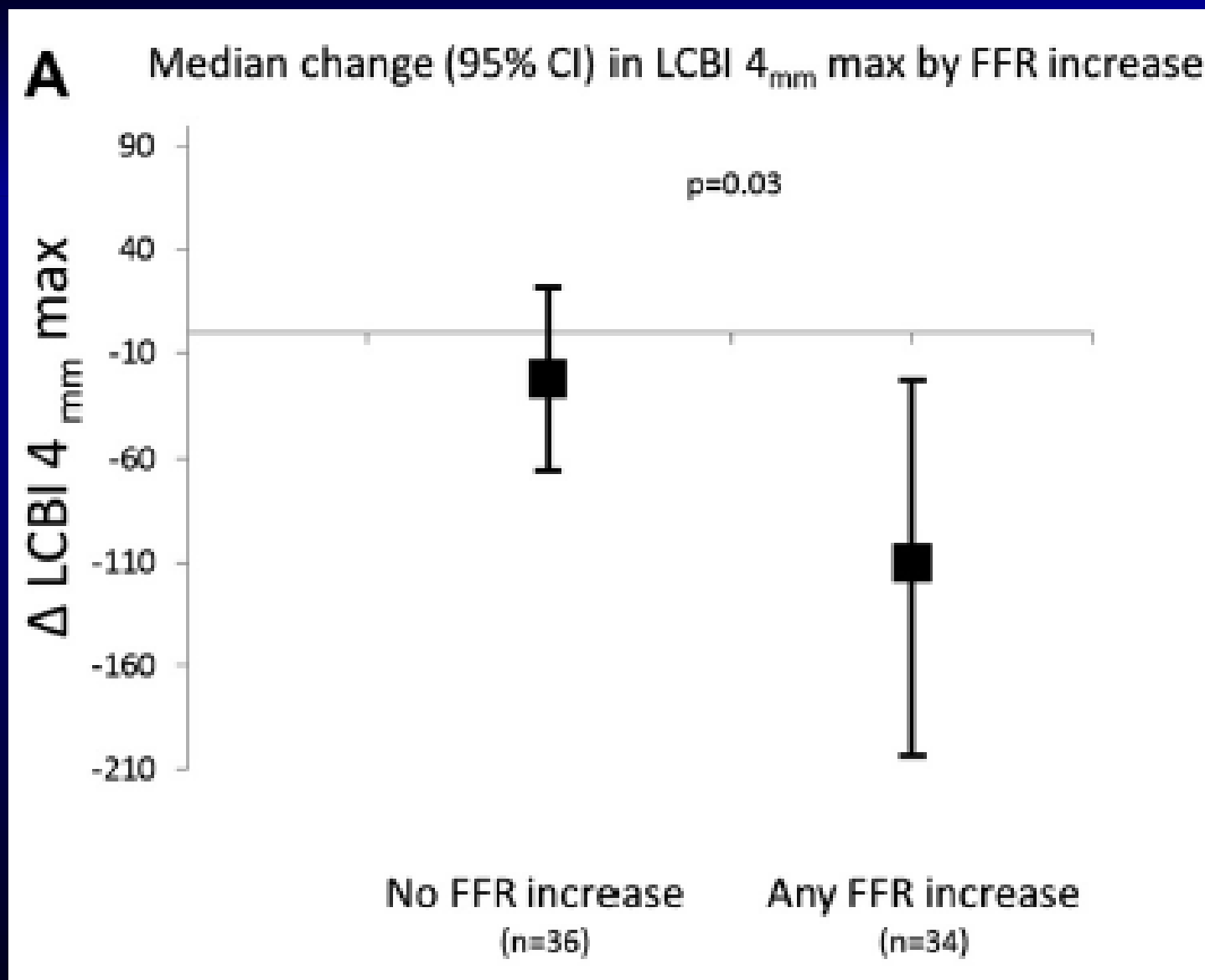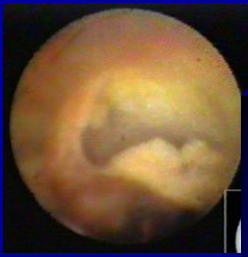
Prediction of slow/ no flow and periprocedural MI

Ruptured yellow plaque
= *Risk of distal embolization/ slow flow phenomenon*

Ruptured plaque   **Plaque debris embolization**
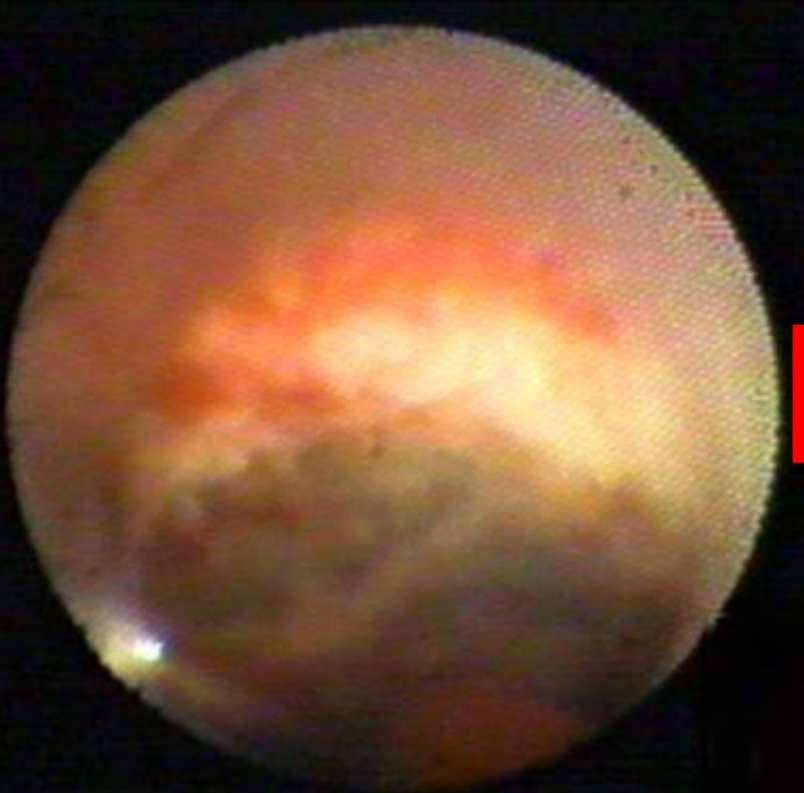

Mizote and Ueda et al. Circulation. 2005

Osaka Police Hospital
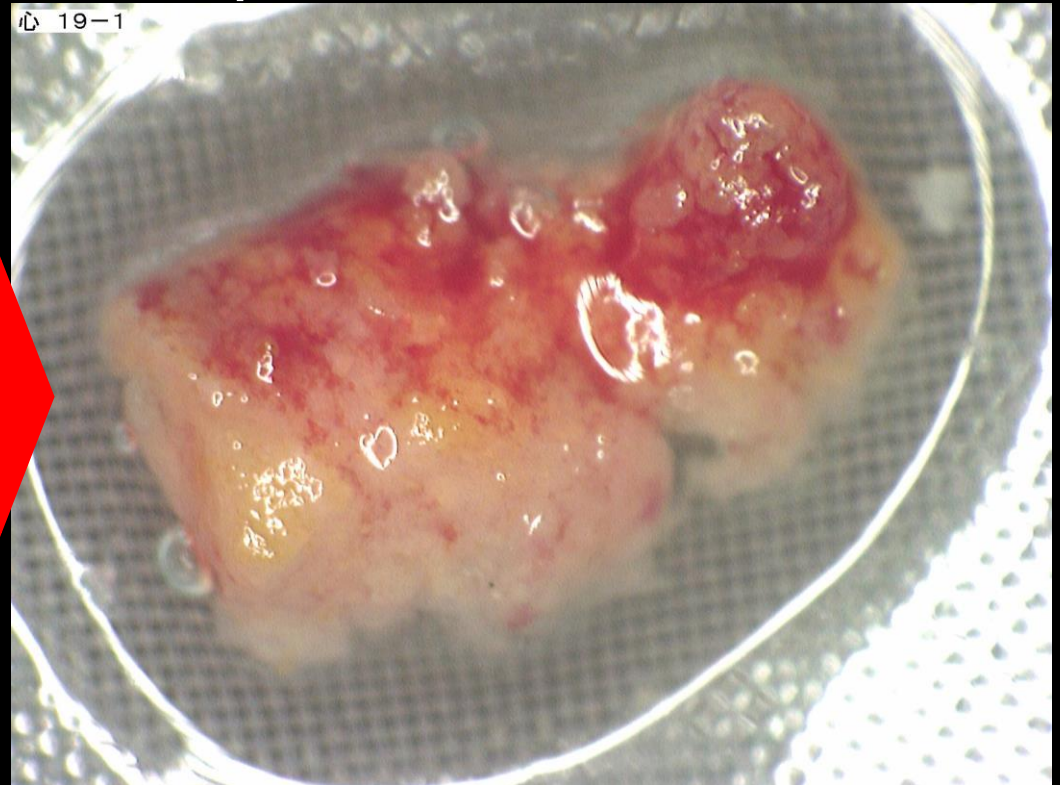
Ruptured yellow plaque
= *Risk of distal embolization/ slow flow phenomenon*

Acute MI patients

(%)

No / slow flow

■ Ruptured plaque
■ No-Ruptured plaque

*p<0.01 vs. others

*

25 —
20 —
15 —
10 —
5 —
0 —

19.4
6.3
4.5
2.7

N   62   48   44   37
No-Distal protection   Distal protection

Mizote and Ueda et al. Circulation. 2005

Osaka Police Hospital
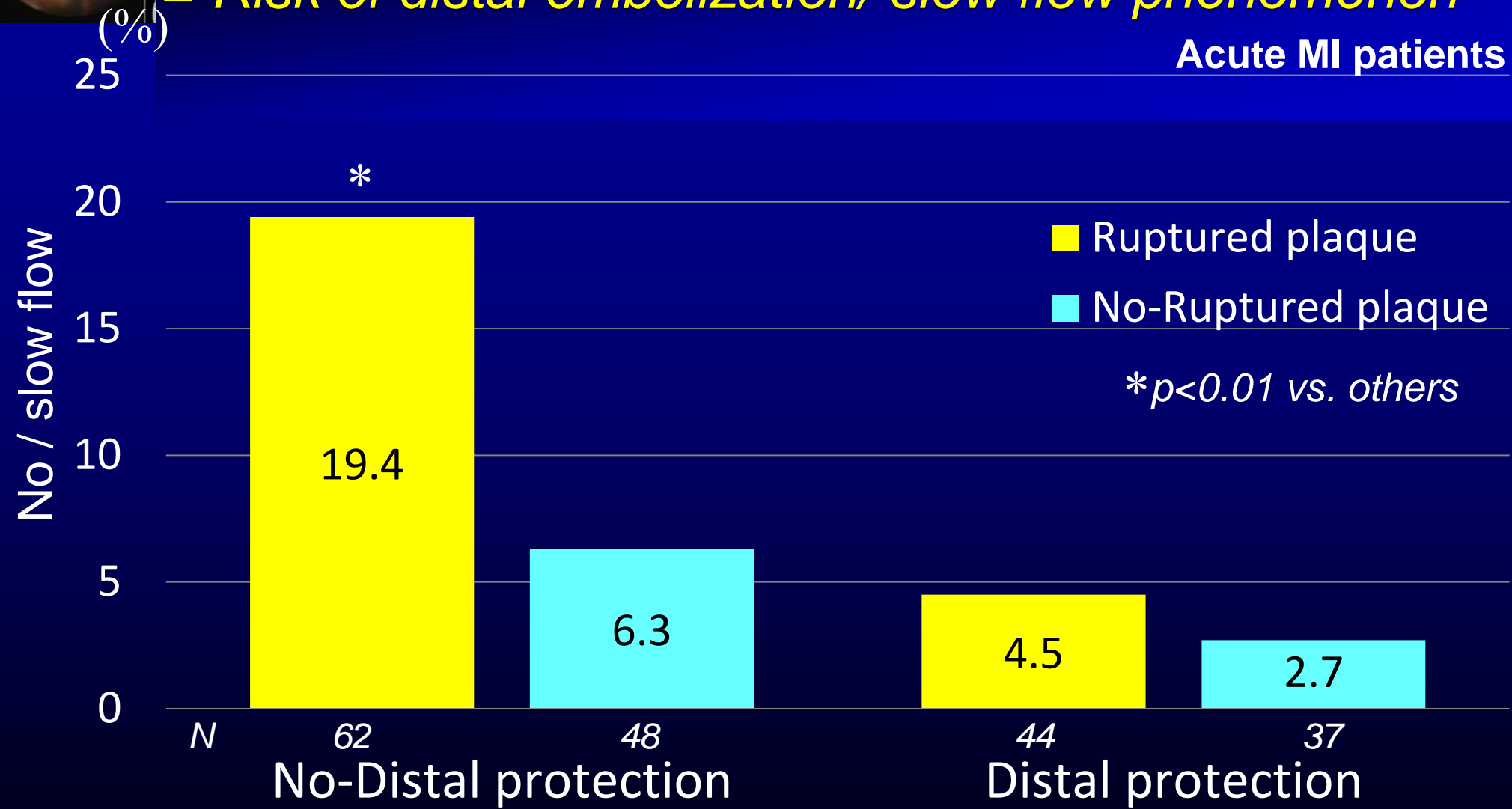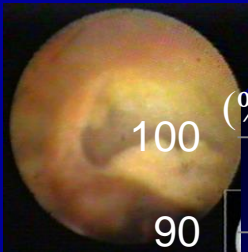
Yellow Plaque = *Risk of distal embolization*

ACS & non-ACS patients

Incidence of plaque debris embolization (%)

Category	YES	NO
ACS	48 *	25
Grade-2/3 Yellow Plaque	52 *	7
Ruptured Plaque	86 *	13
Plaque Burden >75%	50 *	23
Ruptured Plaque & Plaque Burden >75%	85 *	21
Grade-2/3 Yellow Plaque OR Plaque Burden >75%	45 *	7

■ YES ■ NO   *p<0.05, YES vs. NO

Matsuo and Ueda et al. Eurointervention. 2013

Osaka Police Hospital
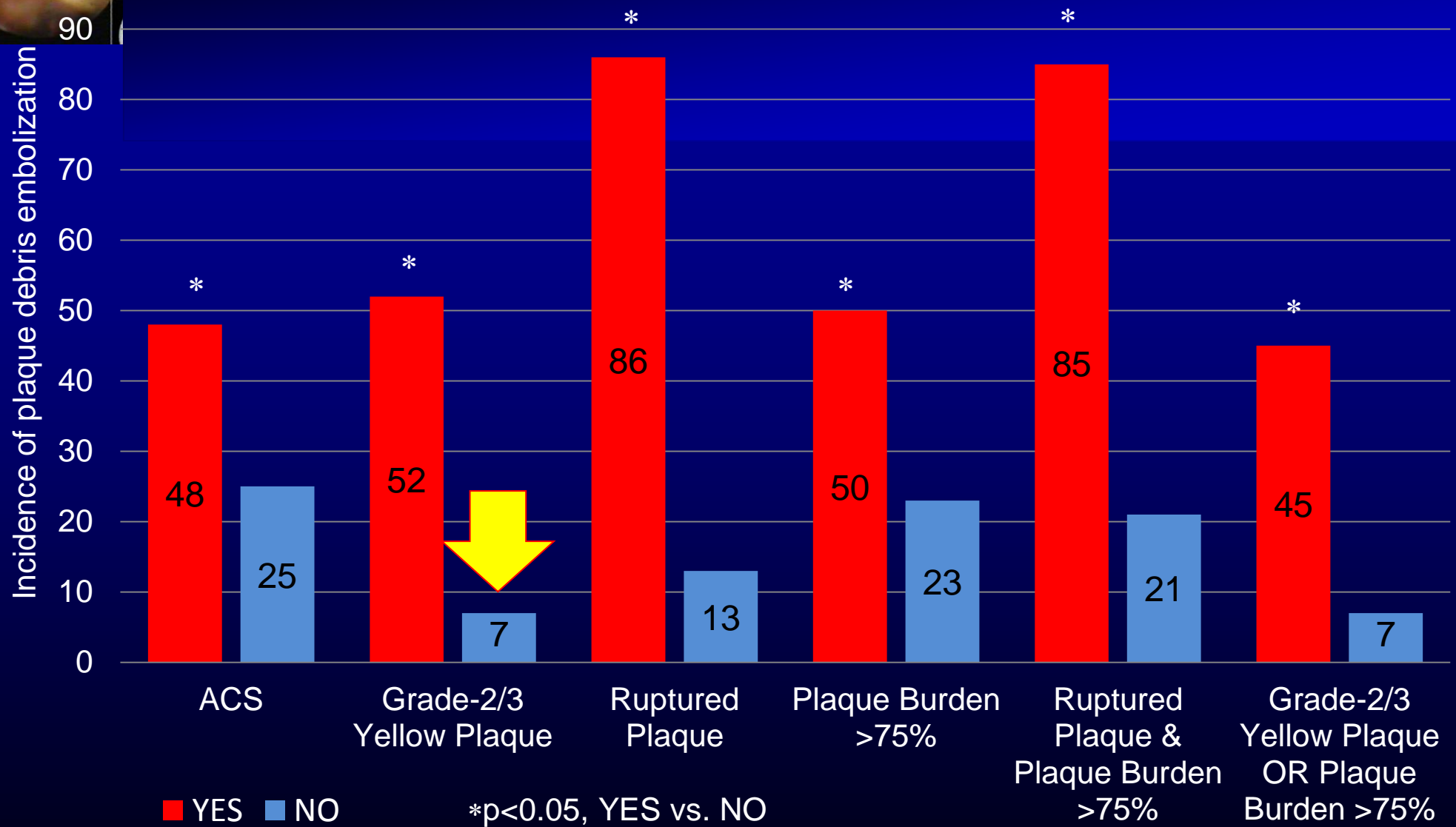
NIRS: $_{max}LCBI_{4\ mm} \geq 500$

Periprocedural MI occurred in 7 of 14 patients (50%) with a $_{max}LCBI_{4\ mm} \geq 500$, compared with 2 of 48 patients (4.2%) patients with a lower $_{max}LCBI_{4\ mm}$ (P=0.0002).
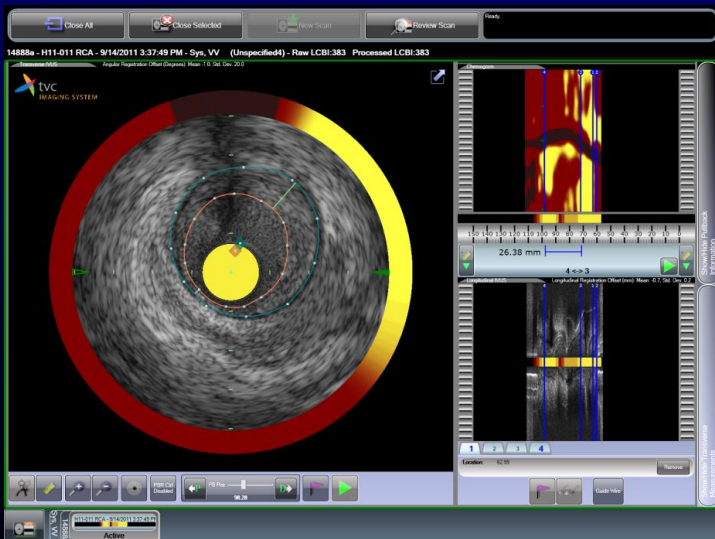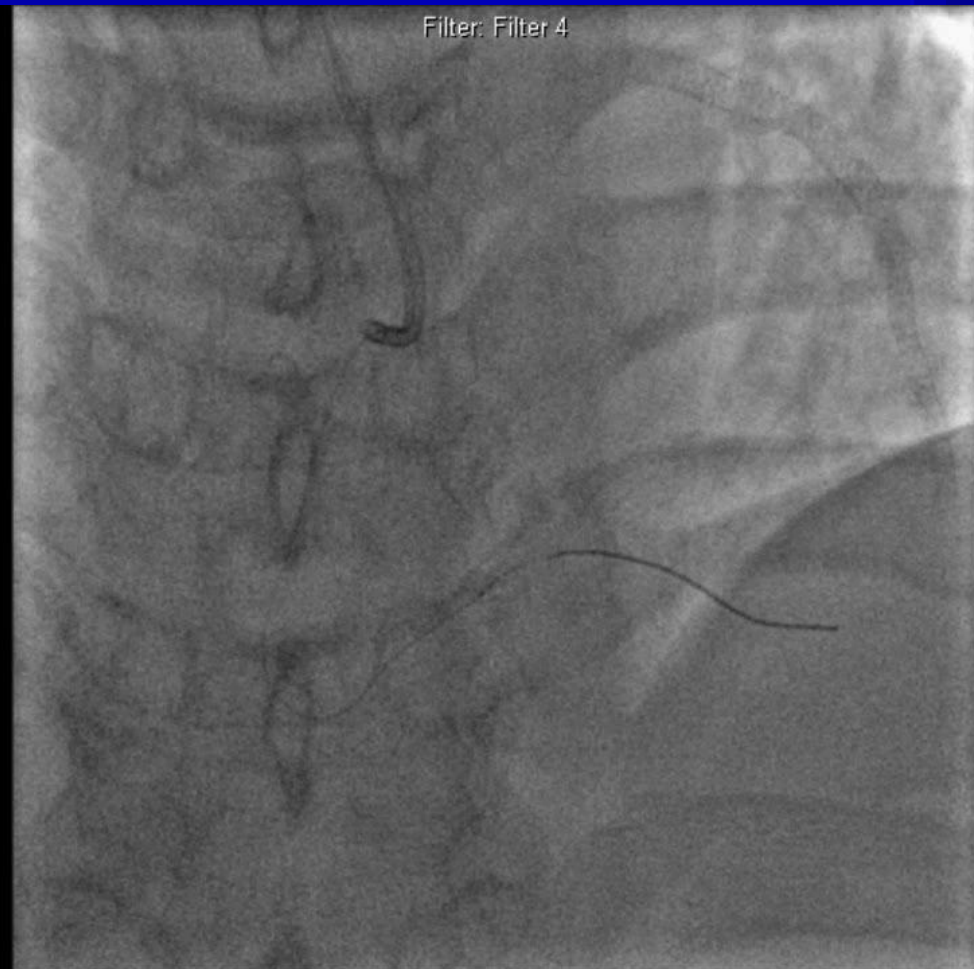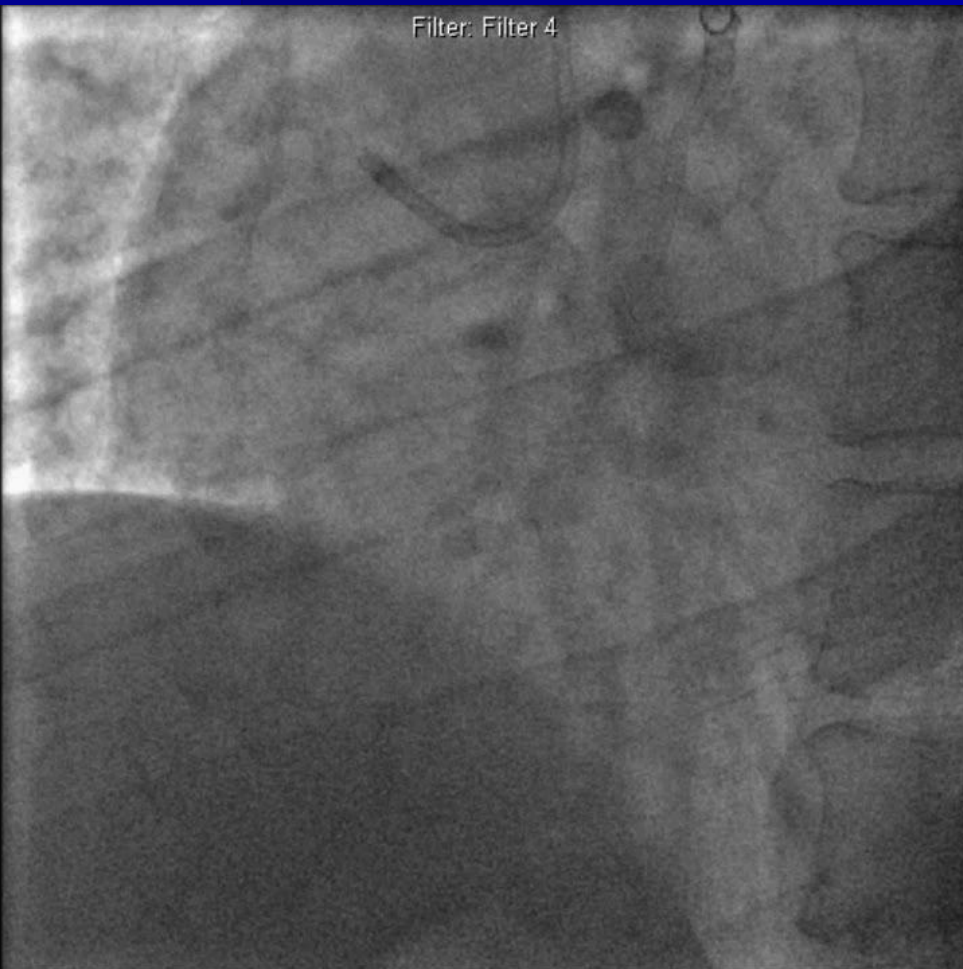

Circulation: Cardiovascular Interventions. 2011; 4: 429-437
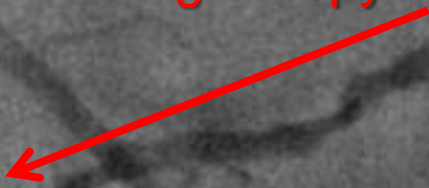
A case of slow flow/ periprocedural MI

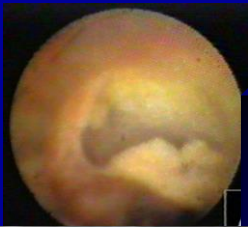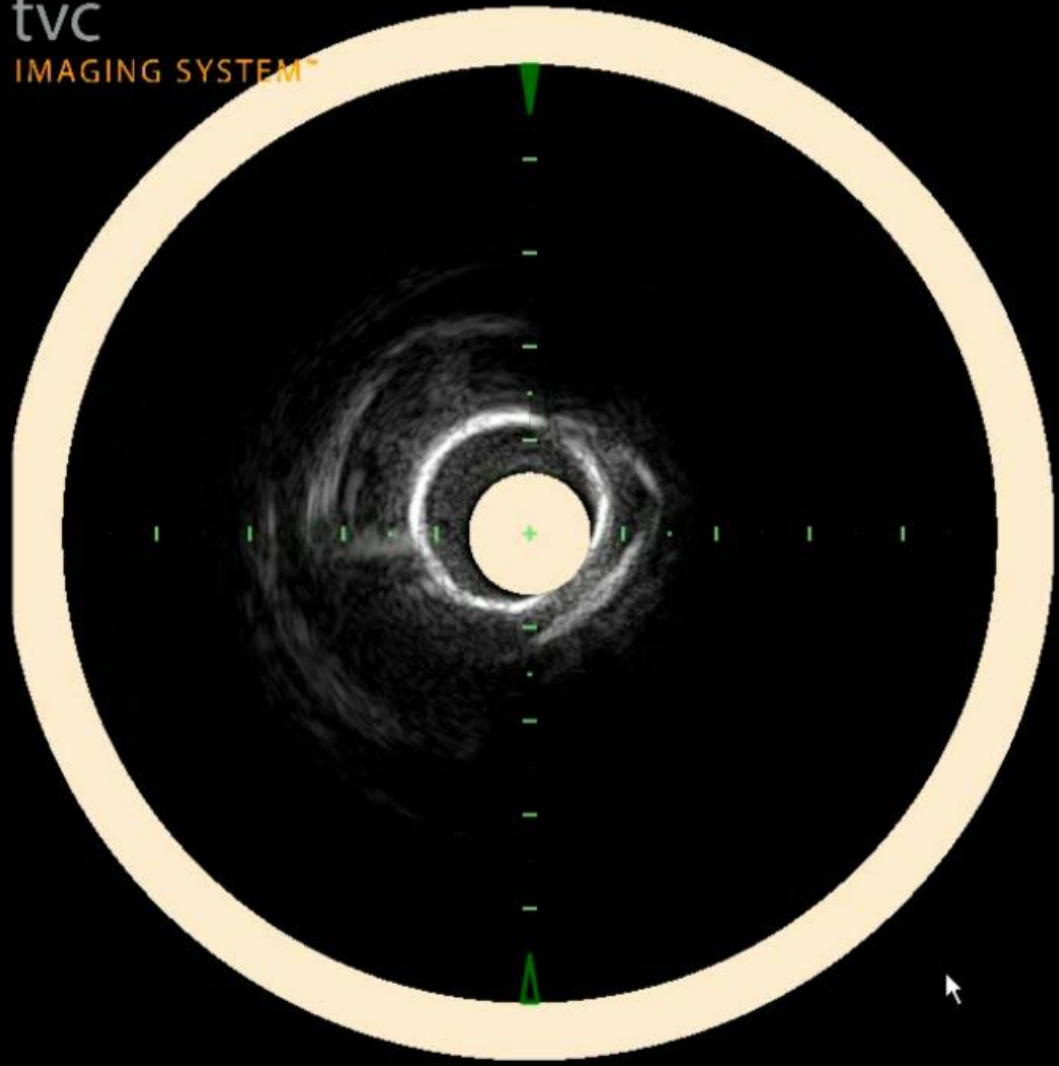*A 41-year-old male patient with silent myocardial ischemia*

Ueda et al. J Cardiol Cases. 2014

Osaka Police Hospital

Examination by angioscopy

Angioscopy

Ueda et al. J Cardiol Cases. 2014

NIRS-IVUS

Examination by NIRS-IVUS

tvc
IMAGING SYSTEM™

Ueda et al. J Cardiol Cases. 2014
Osaka Police Hospital

A case of slow flow/ periprocedural MI
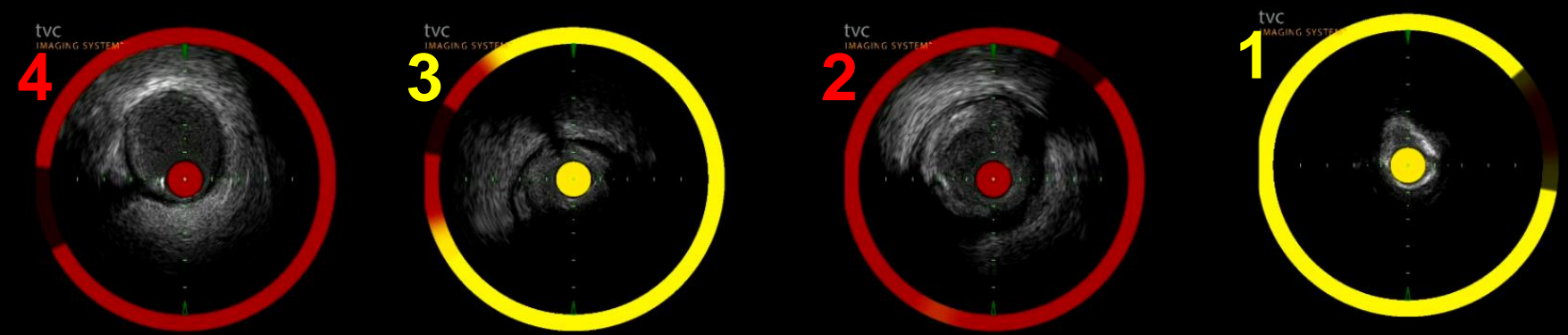
Ueda et al. J Cardiol Cases. 2014

Osaka Police Hospital

$_{max}LCBI_{4\ mm} = 1000$
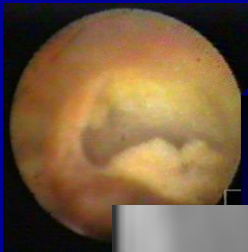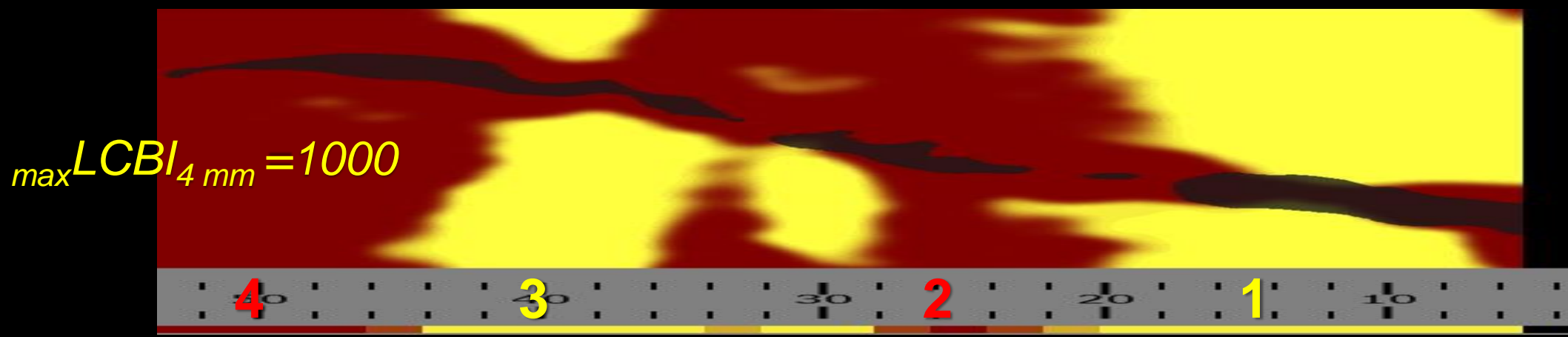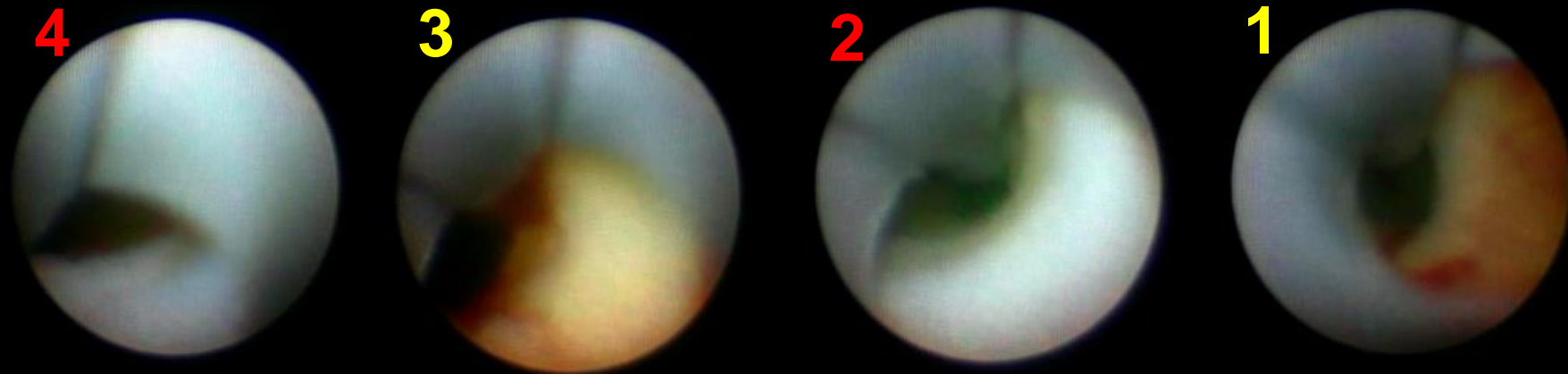
A case of slow flow/ periprocedural MI

Post Stenting

Filter: Filter 4

➢ *Distal protection with Filtrap*

➢ *Predilatation*

➢ *Stent implantation with Xience Prime 3.5x23mm + 3.0x38mm*

No-flow +

Ueda et al. J Cardiol Cases. 2014

A case of slow flow/ periprocedural MI

peak CK 1500 U/L
(CKMB 130 U/L)

Filter Removal

Final

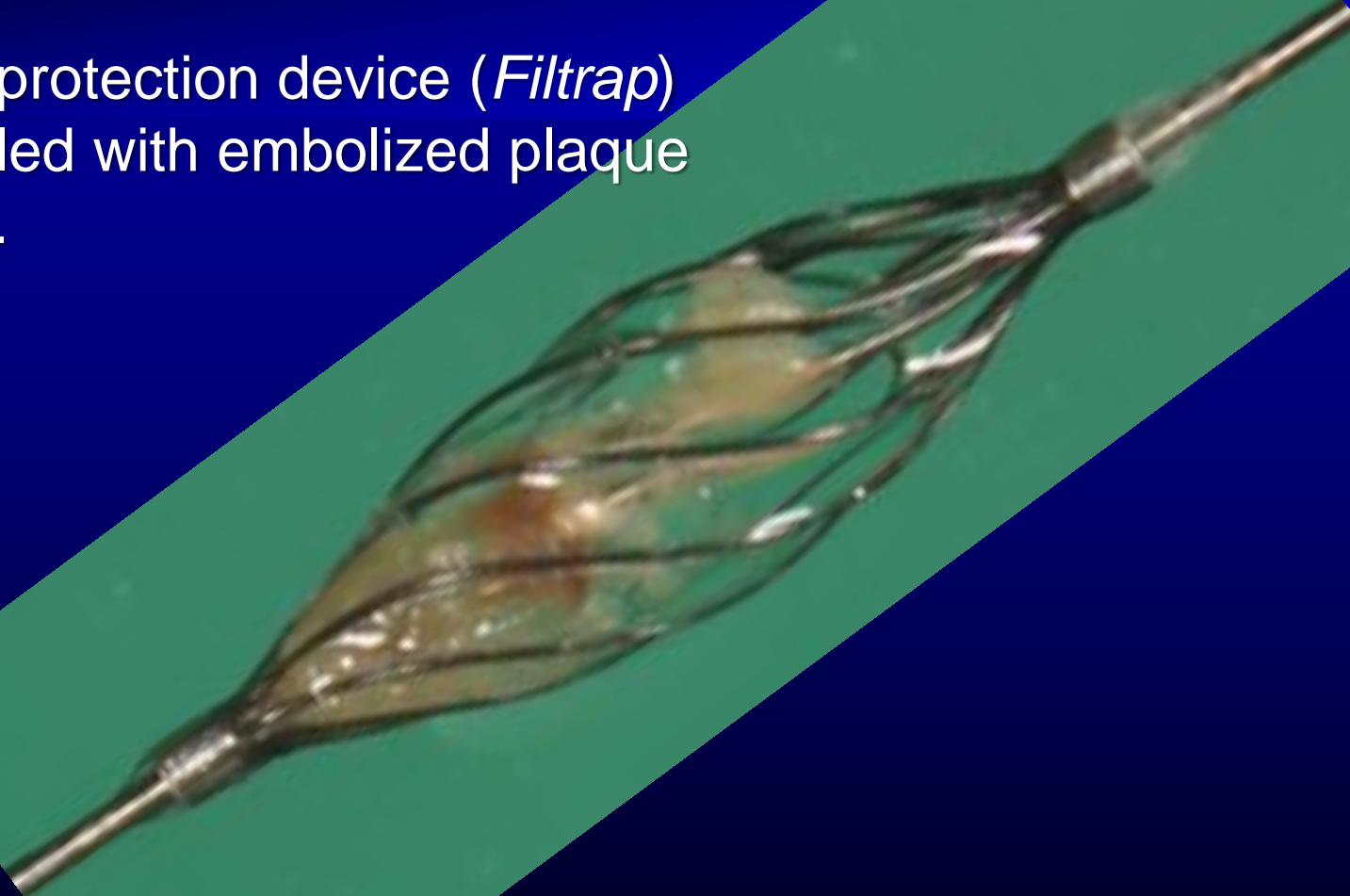Ueda et al. J Cardiol Cases. 2014   *Nicorandil ic*   *Osaka Police Hospital*
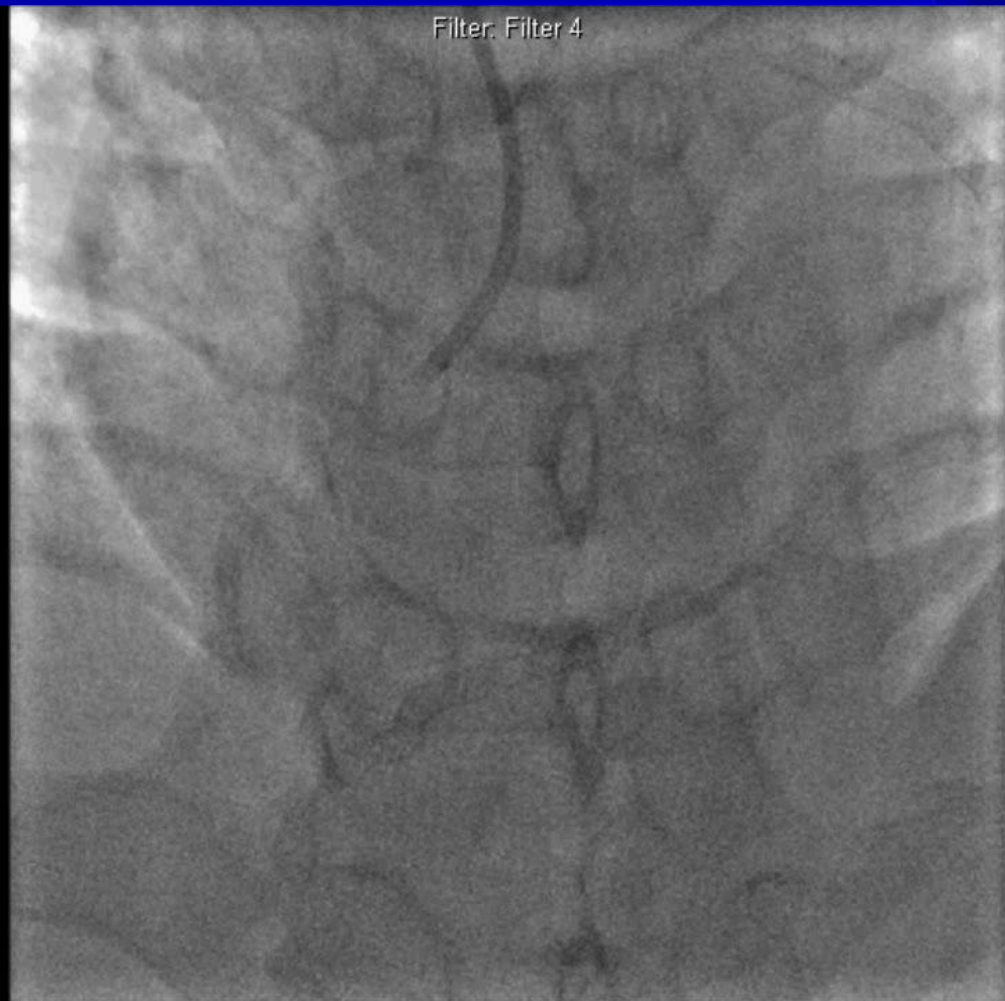
A case of slow flow/ periprocedural MI

Distal protection device (*Filtrap*) was filled with embolized plaque debris.
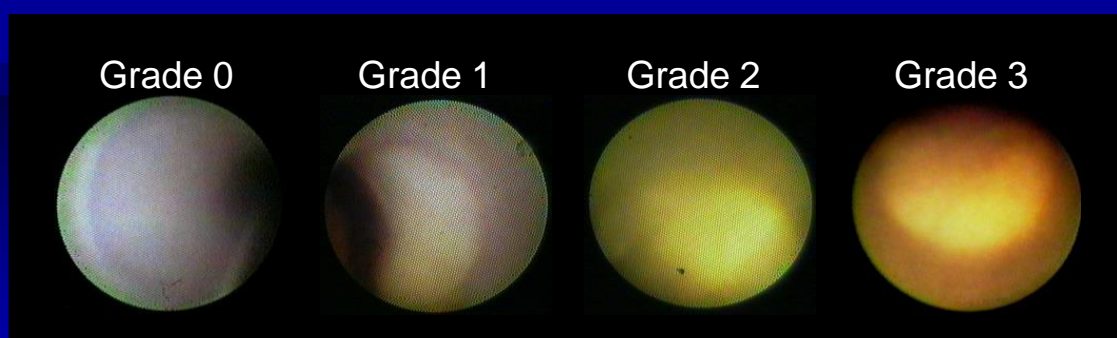
Osaka Police Hospital

Prediction of vulnerable plaques/ patients

Vulnerable Plaque = *Yellow plaque*

Grade 0   Grade 1   Grade 2   Grade 3
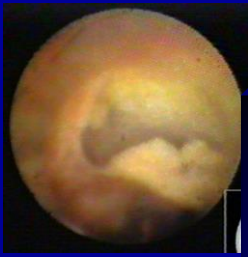
Incidence of plaque disruption

PCI Target Lesions

(%)

* p<0.05 vs. Grade 1
† p<0.05 vs. Grade 2

†

*

n=26

n=104

n=61

n=73

Color Grade
0   1   2   3
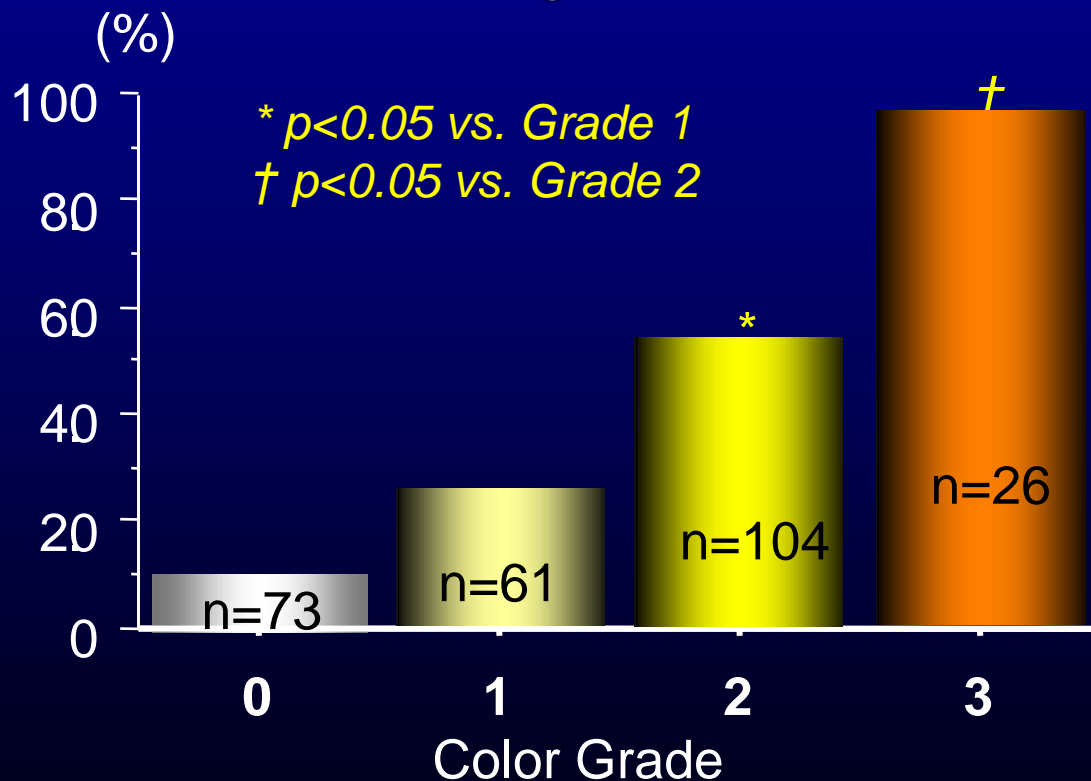
Non-Stenotic Yellow Plaques

(%)

* p<0.05 vs. Grade 1
† p<0.05 vs. Grade 2

†

*

n=187

n=721

n=345

Color Grade
1   2   3

Osaka Police Hospital

Ueda et al. Am Heart J 2004
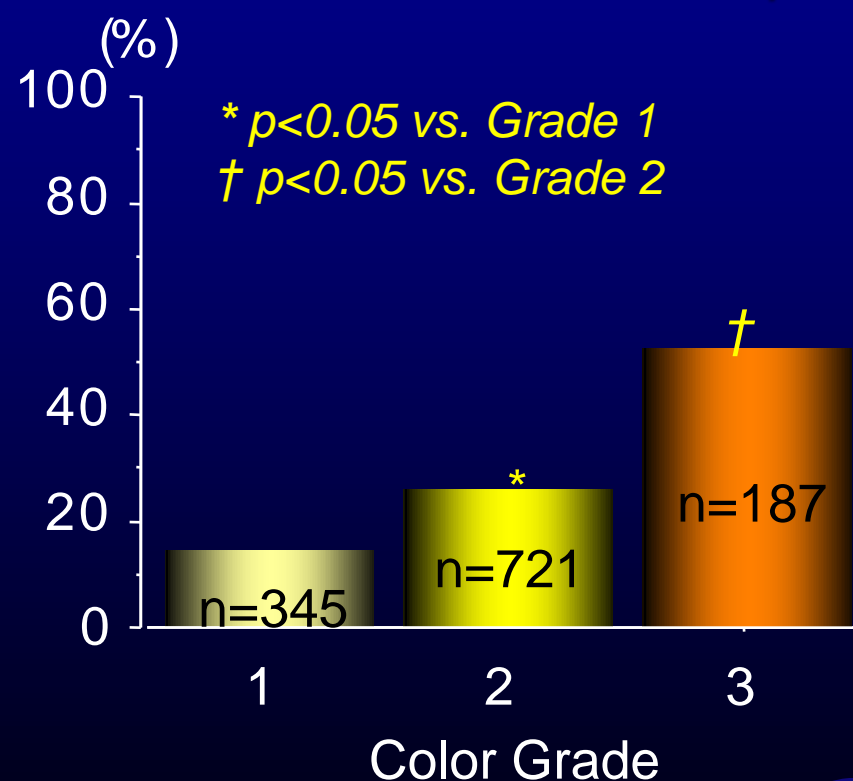
Vulnerable patient = *Multiple yellow plaques*
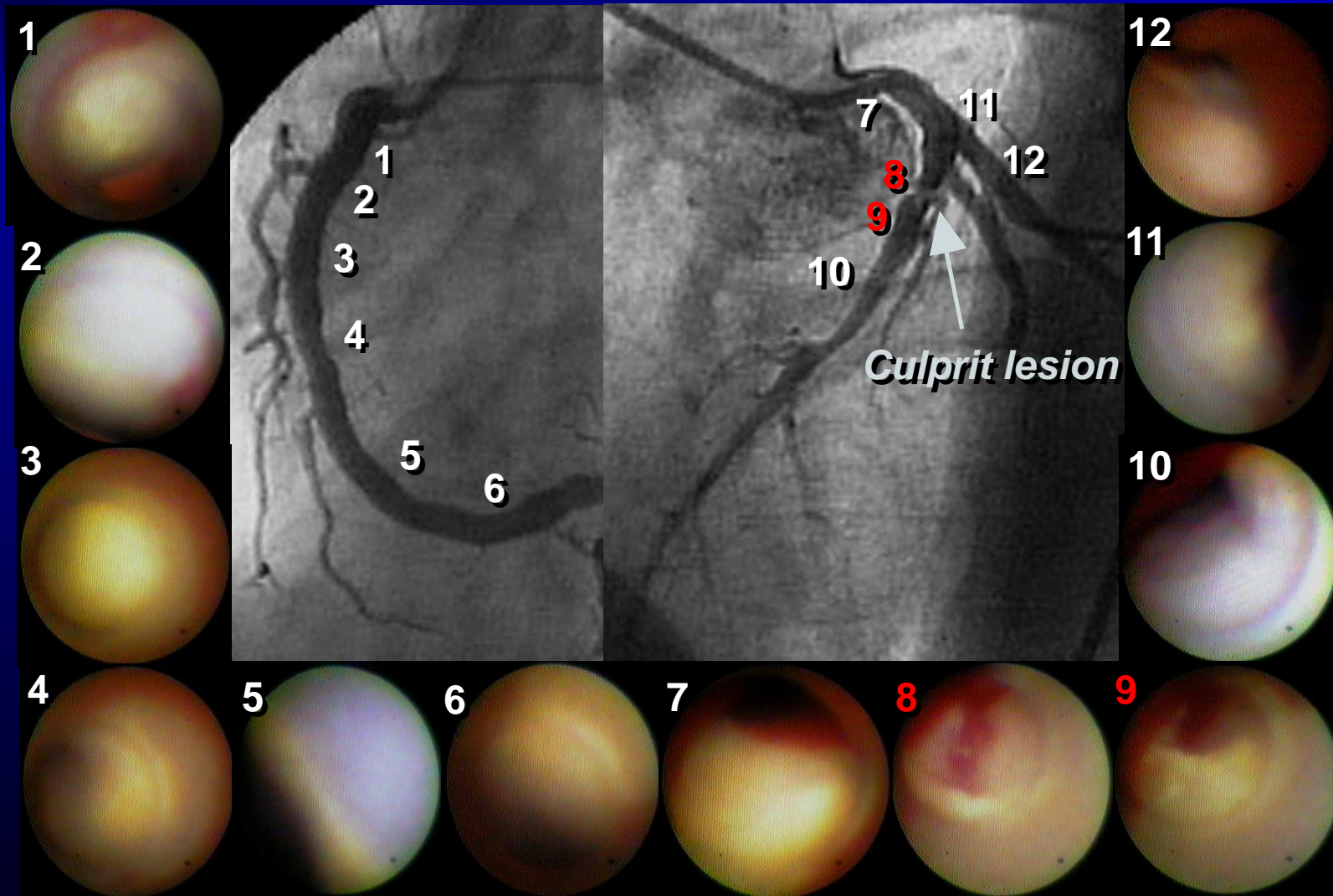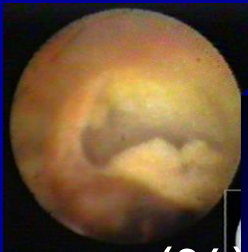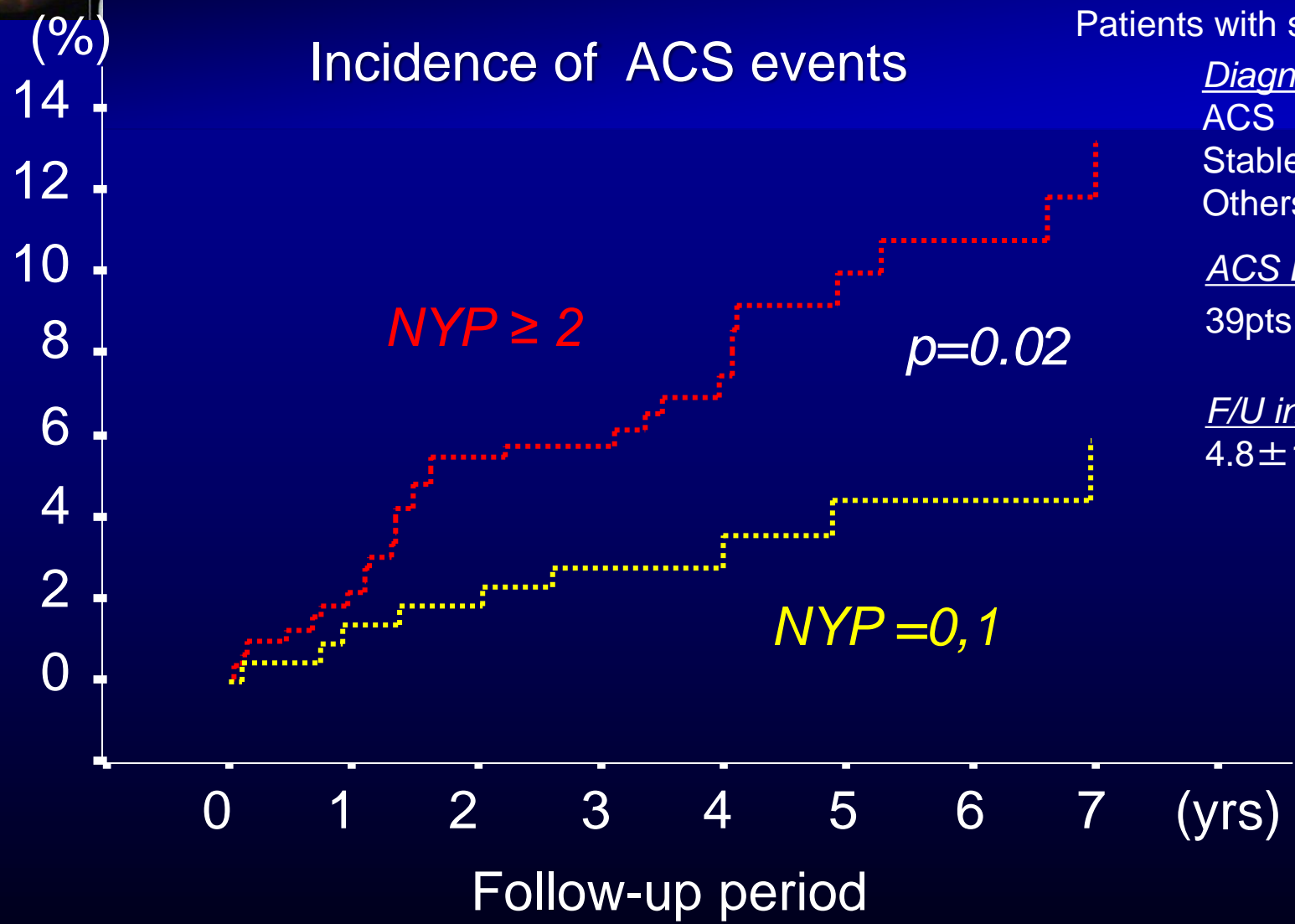
Culprit lesion

Asakura and Ueda et al. J Am Coll Cardiol. 2001

Osaka Police Hospital

Number of yellow plaques and future ACS event

Incidence of ACS events

Patients with suspected CHD, n=552

Diagnosis, n (%)	
ACS	386 (70)
Stable CHD	139 (25)
Others	27 (5)

ACS Event
39pts (7.1%)

F/U interval
4.8±1.8years

NYP ≥ 2

NYP =0,1

p=0.02

Follow-up period

Ohtani and Ueda et al. J Am Coll Cardiol. 2006

Osaka Police Hospital

Number of yellow plaques and future ACS event

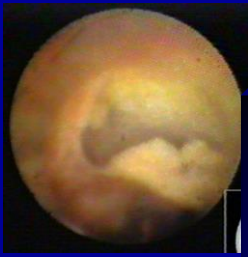Incidence of ACS events

Patients with suspected CHD, n=552

Diagnosis, n (%)
ACS   386 (70)
Stable CHD   139 (25)
Others   27 (5)

ACS Event
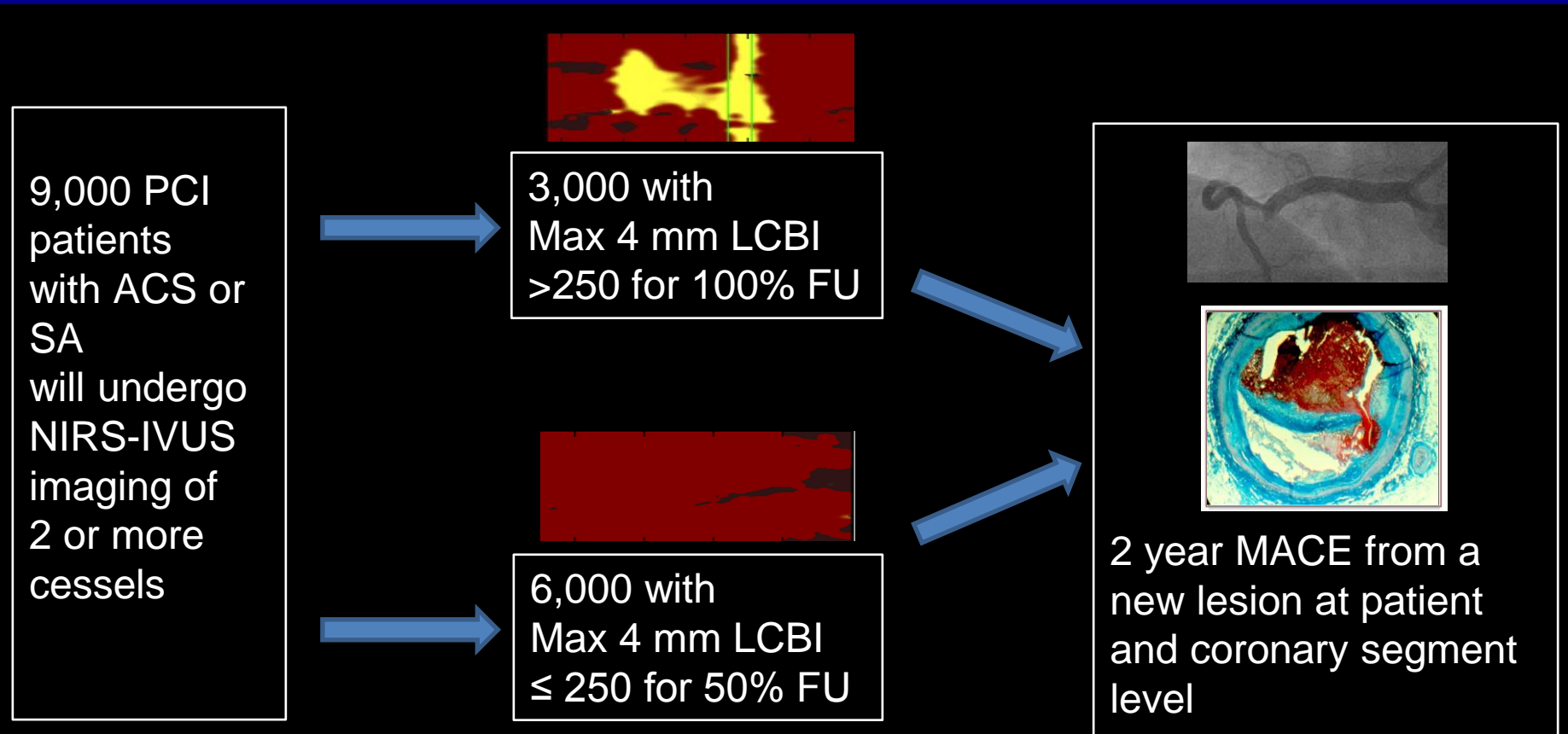39pts (7.1%)

F/U interval
4.8±1.8years

P=0.02

3.8-fold

2.2-fold

15.6%

9.0%

4.1%

NYP=0/1   NYP≥2   NYP≥5

Ohtani and Ueda et al. J Am Coll Cardiol. 2006

Osaka Police Hospital
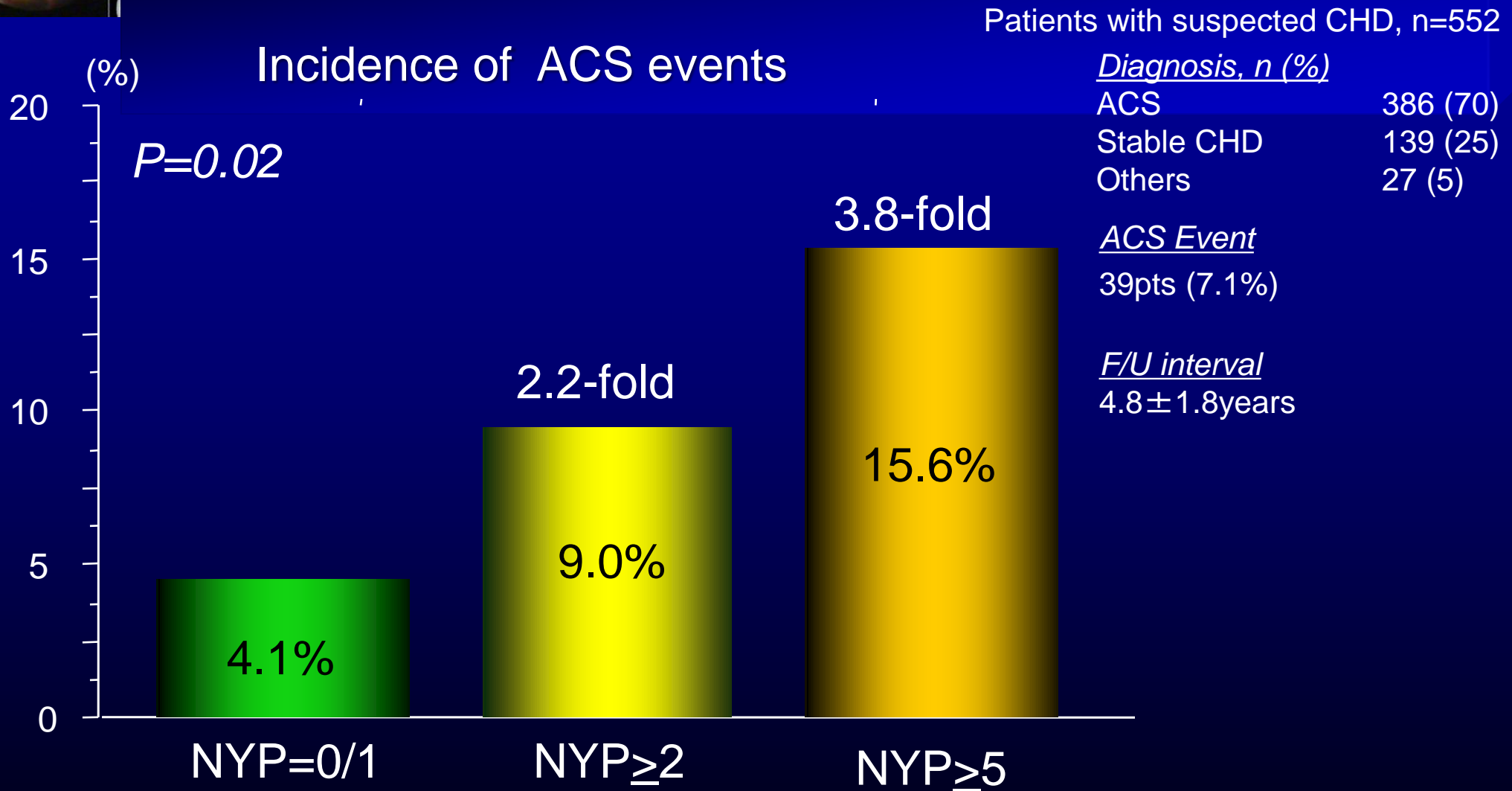
The Lipid Rich Plaque (LRP) study to identify vulnerable patients and vulnerable plaques

Dr. Ron Waksman, PI
PI, Europe, Dr. Carlo di Mario
PI, Japan, Dr. Takeshi Akasaka
Co-PI, Japan, Dr. Yasunori Ueda

9,000 PCI patients with ACS or SA will undergo NIRS-IVUS imaging of 2 or more cessels

3,000 with Max 4 mm LCBI >250 for 100% FU

6,000 with Max 4 mm LCBI ≤ 250 for 50% FU

2 year MACE from a new lesion at patient and coronary segment level

In an innovative design, only 50% of the patients without a large lipid-rich plaque will be followed

Angioscopy plays a role of macroscopic pathology in living patients

tvc
IMAGING SYSTEM
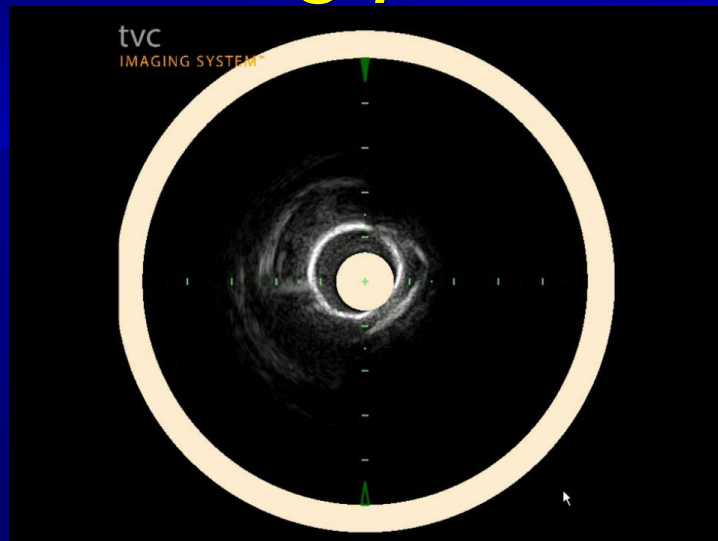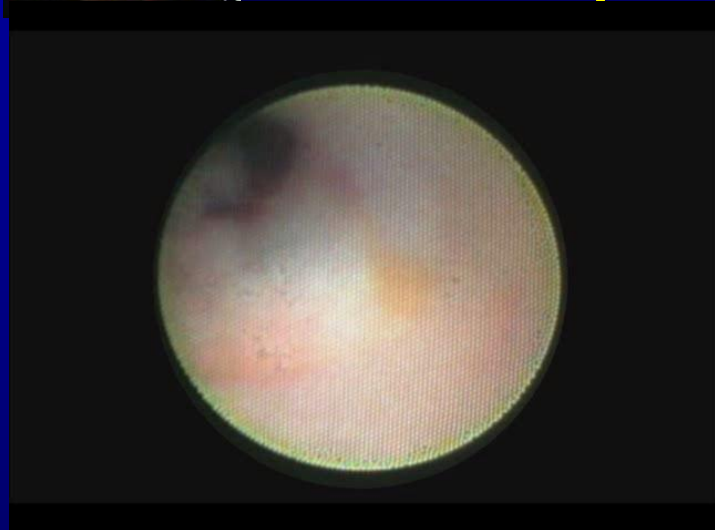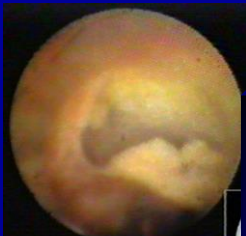
- *Yellow plaque*
- *Plaque rupture*
- *Prot...*
- *Thro...*
- *Sten...*
- *Neo...*
- *.........*

$_{max}LCBI_{4\,mm}=1000$

NIRS can detect angioscopically-detected yellow plaques very well and can evaluate them more quantitatively.