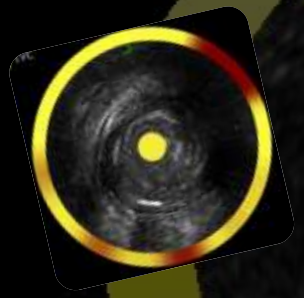


Near Infrared Spectroscopy
Imaging in the Cath Lab
When & Why

Joon Won Kang, RT

Cardiovascular Center, Anam Hospital

Korea University Medical Center

Angiography Alone is Not Enough

Is only physiology enough ???

Role of NIR Spectroscopy-IVUS

Improving PCI Outcomes !!

Preventing Late Events !!

NIRS-IVUS: Multi-Modality Imaging

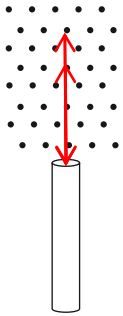
NIRS: Lipid-Core Plaque

- Length of Vessel to Stent
- Distal Embolization Risk
- Plaque Vulnerability

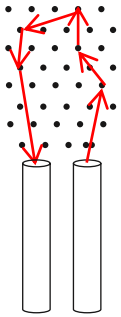
IVUS: Plaque Architecture

- MLA, Length of Vessel to Stent
- Optimal Stent Expansion
- Stent Edge Complications

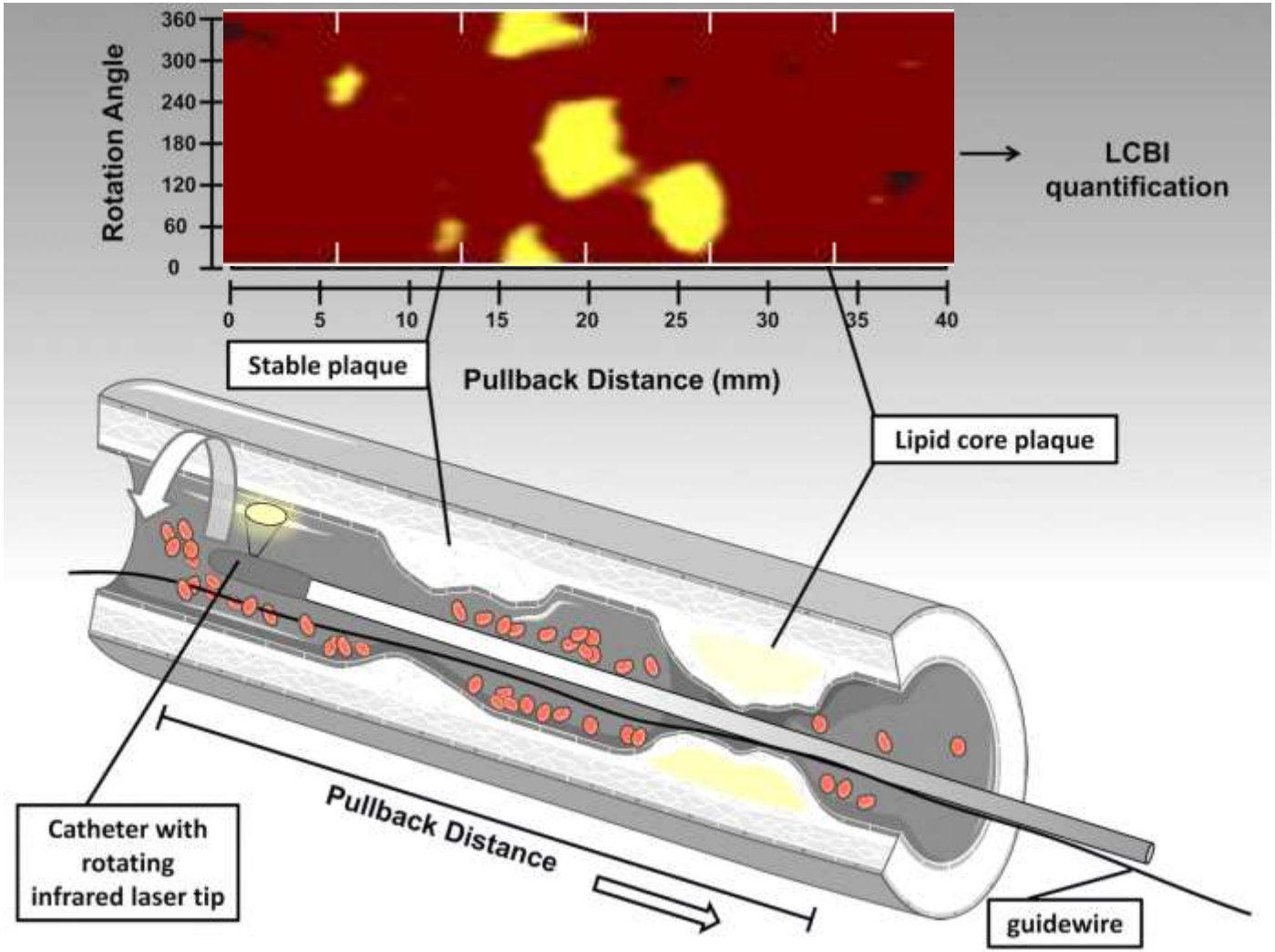
NIRS catheter with a rotating infrared laser tip and resulting NIRS chemogram



IVUS

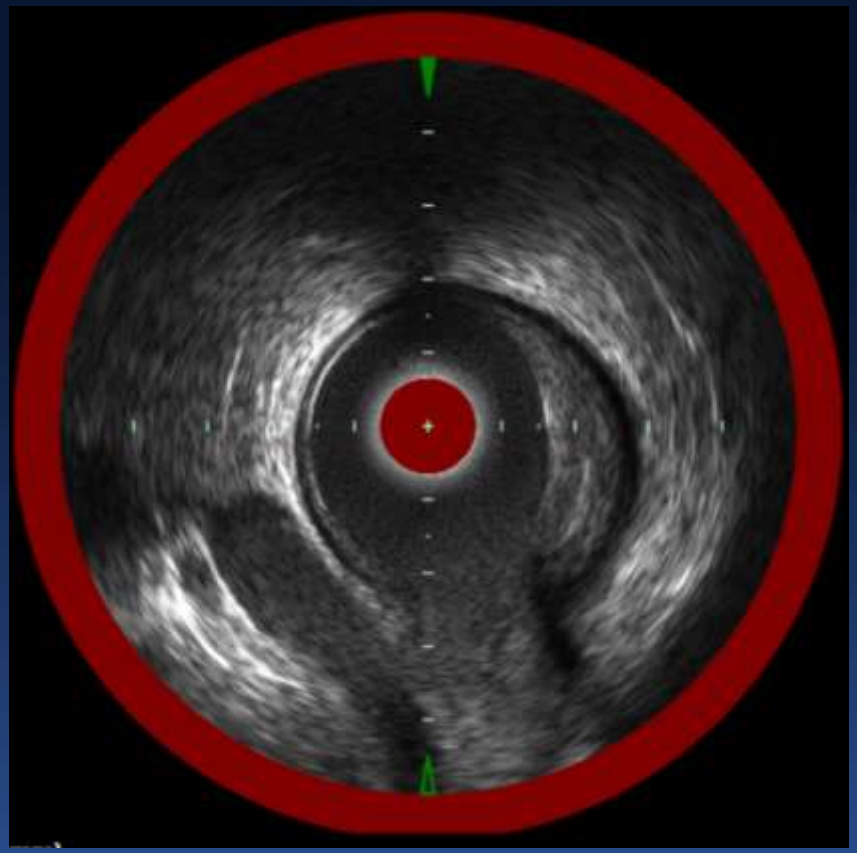


NIRS



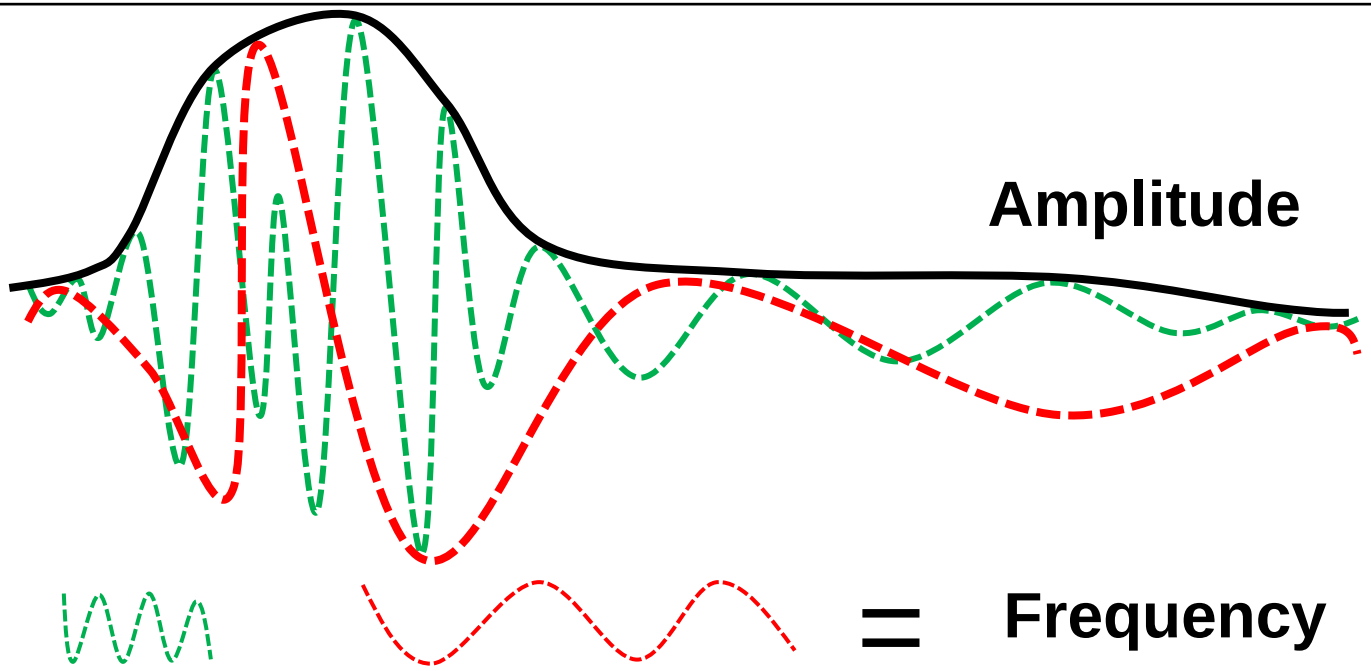
Catherine Gebhard et al. Eur Heart J 2014;35:263-265

Infraredx Launches Advanced TVC Imaging System, *Muller NIRS-IVUS Catheter* at ACC 2015

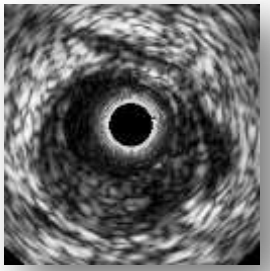


InfraReDx

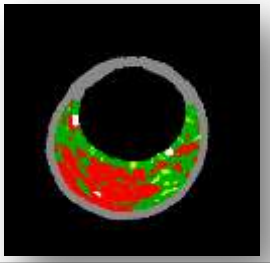
50MHz IVUS Human Coronary Artery

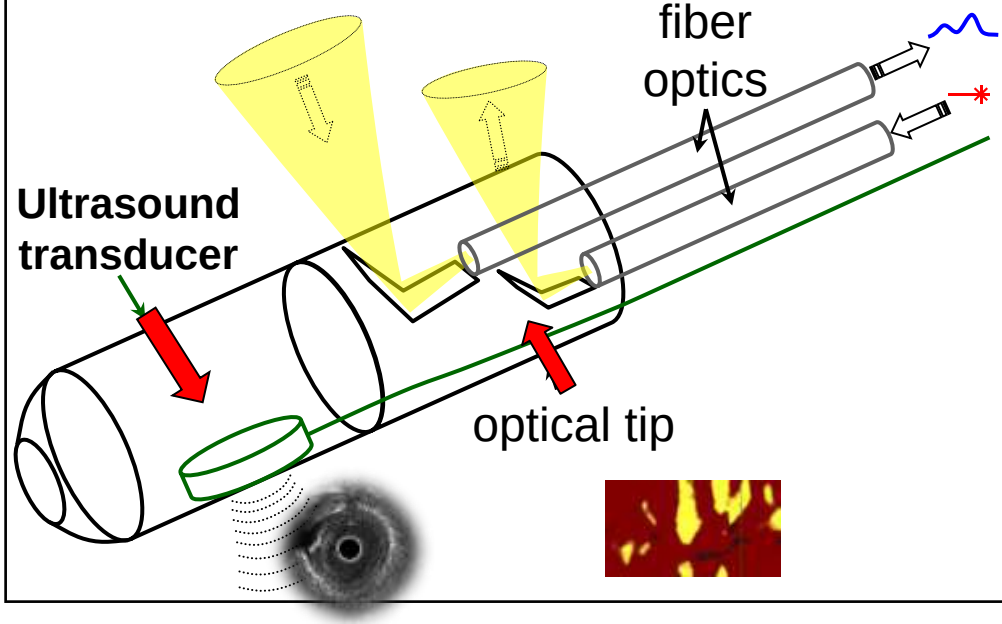


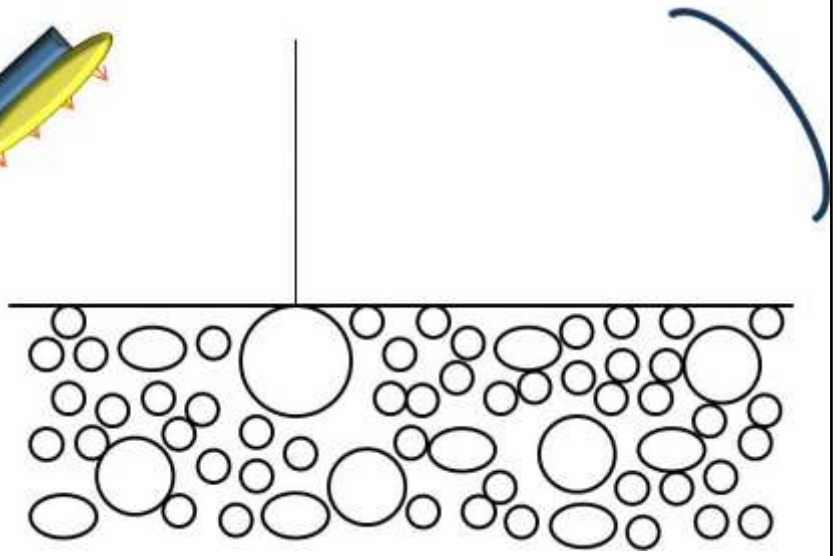
Grey Scale IVUS



VH-IVUS



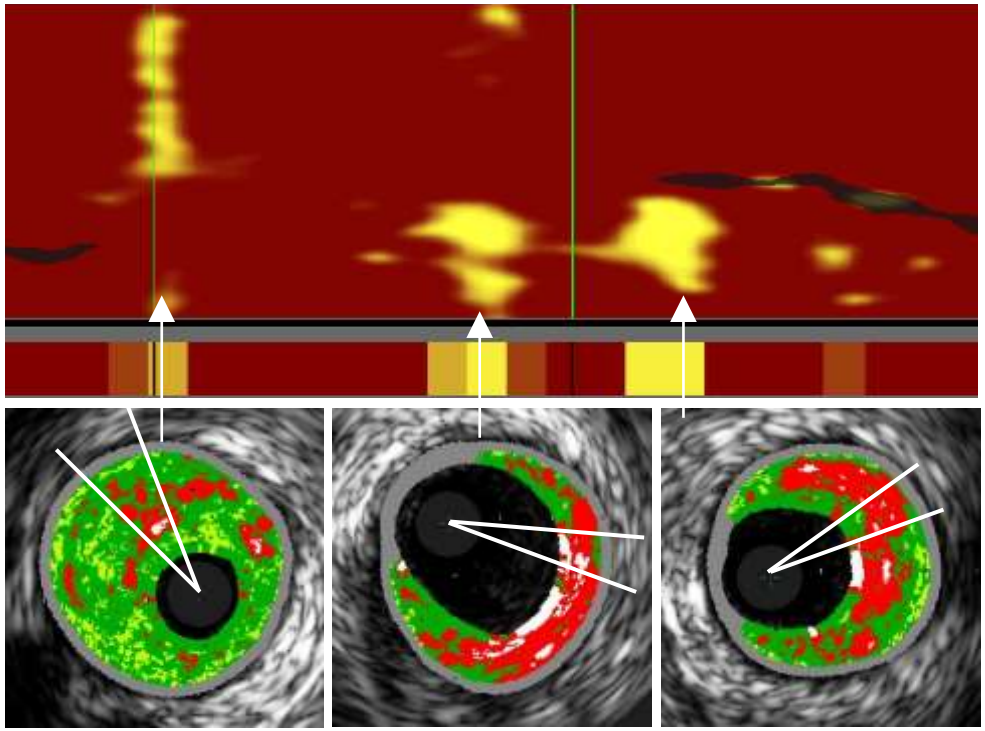


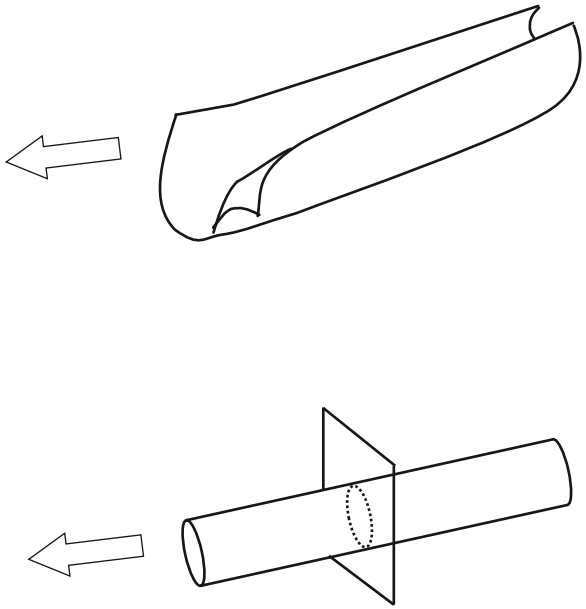


Limitations of VH-IVUS for Detection of Vulnerable Plaque

- Plaque contours must be drawn accurately
  - No automated edge detection software
- Pattern recognition of VH-TCFA is not always straight-forward
  - Definition of VH-TCFA has evolved, and is still not certain even for the “experts”
  - Resolution of IVUS ~150-200 um
- Necrotic core (red) and calcium (white) signals overlap

Comparison between VH and NIRS





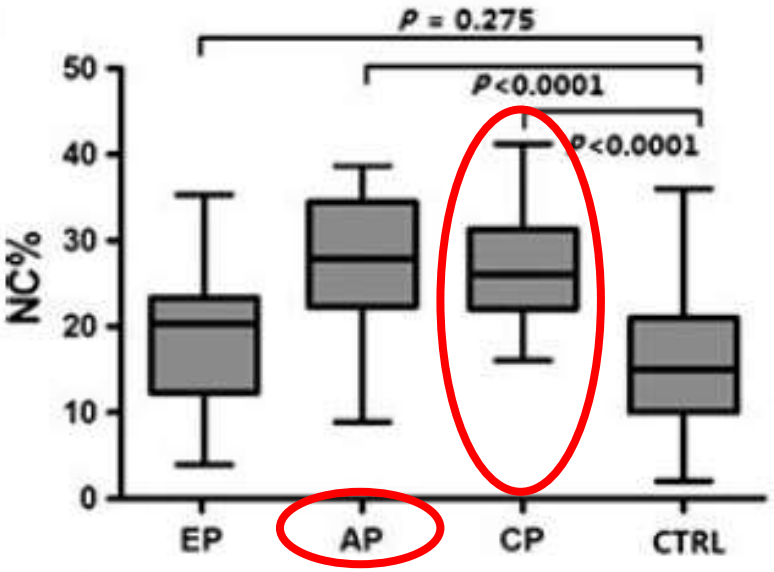
Existence

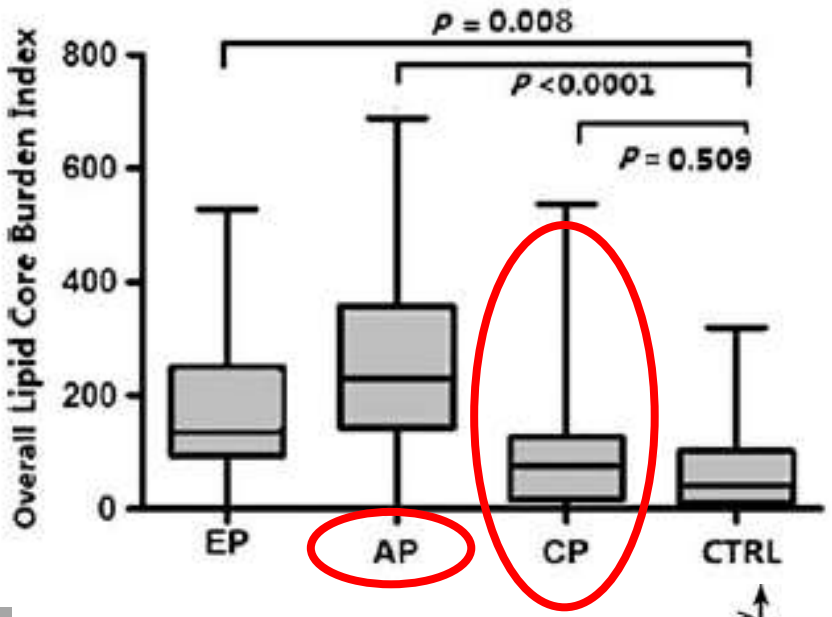
Distribution **of NC** O

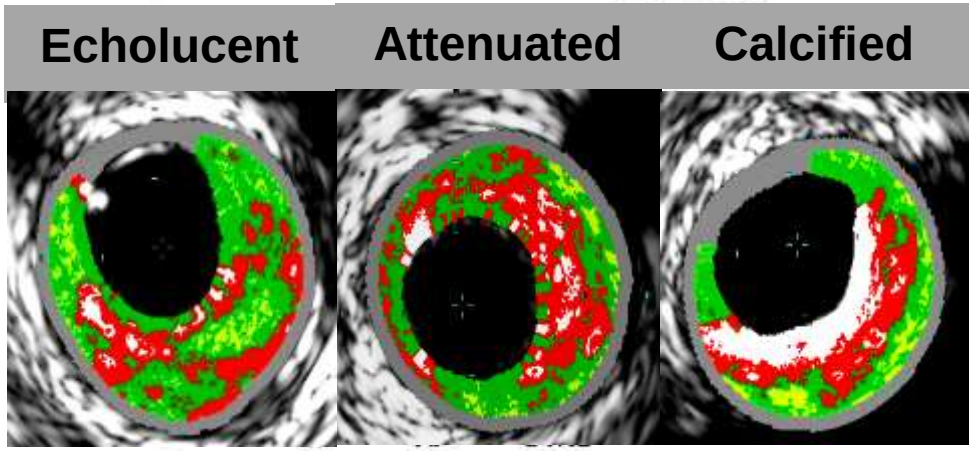
Depth

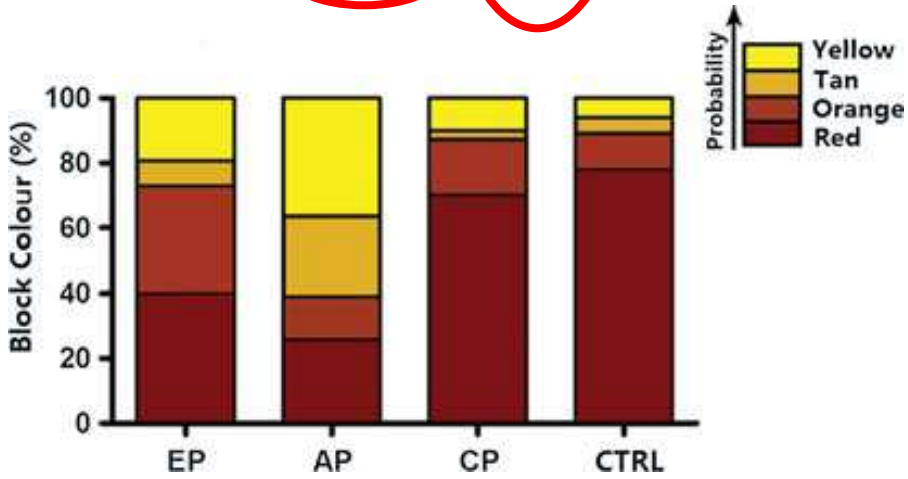
Fibrous cap thickness X

Comparison between VH-%NC and NIRS-LCBI





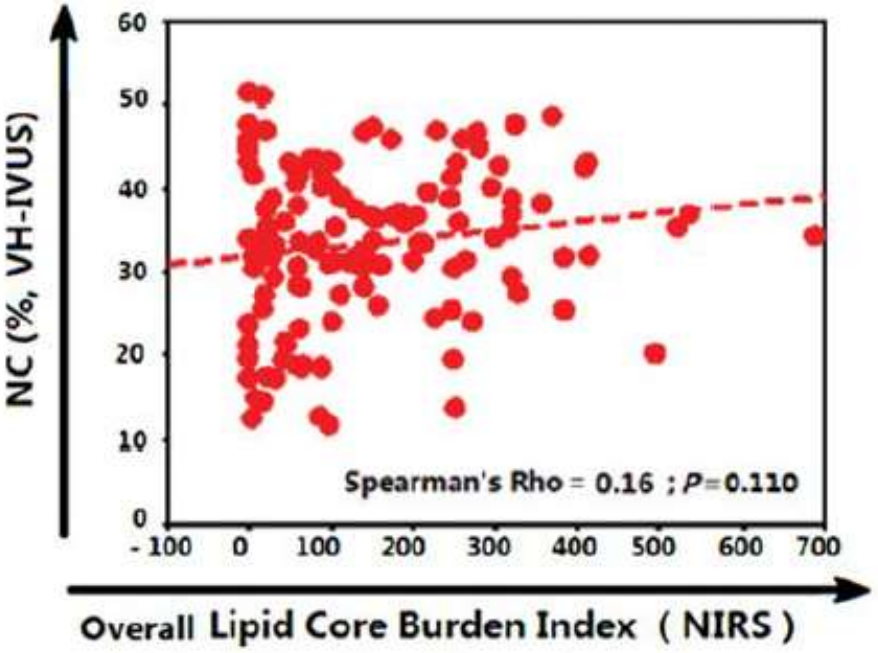




European Heart Journal (2012) 33, 372–383

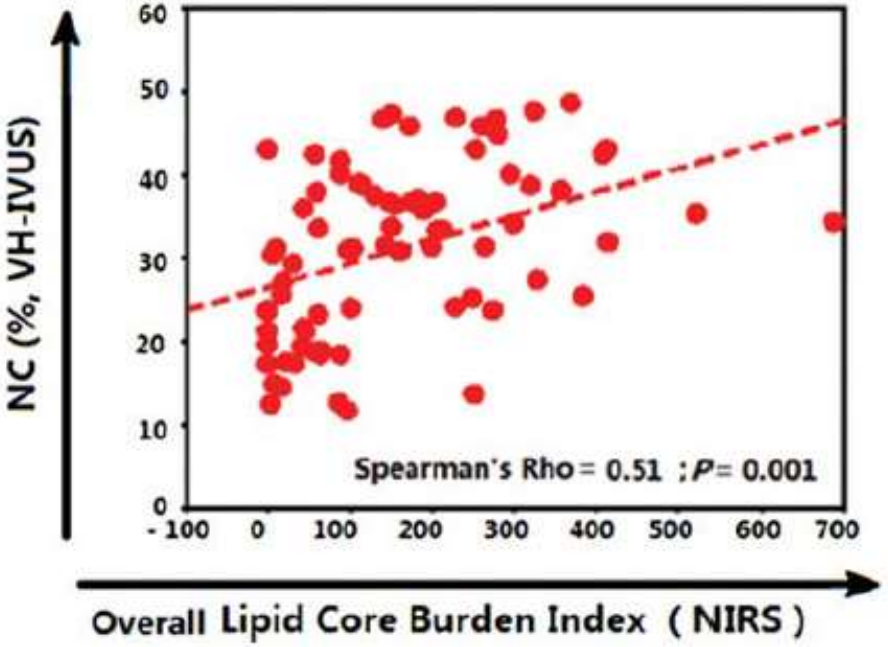
Correlation between VH-%NC and LCBI-NIRS

Overall Plaques



No correlation

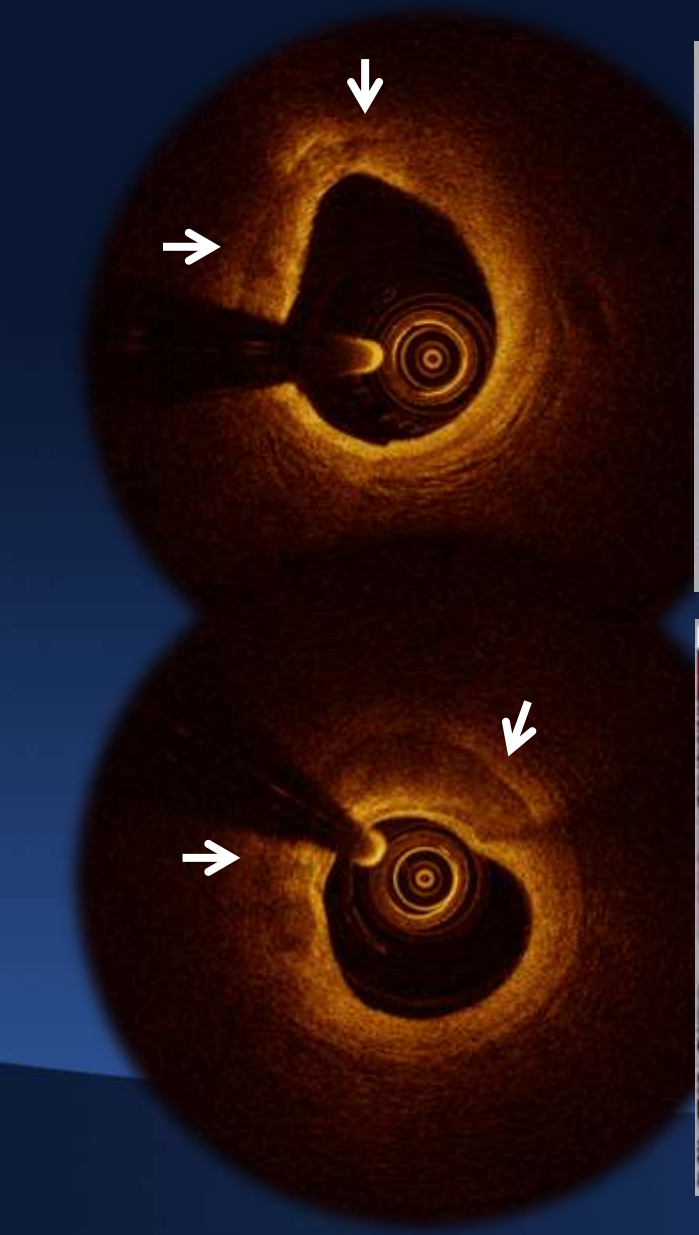
Non-Calcified plaque

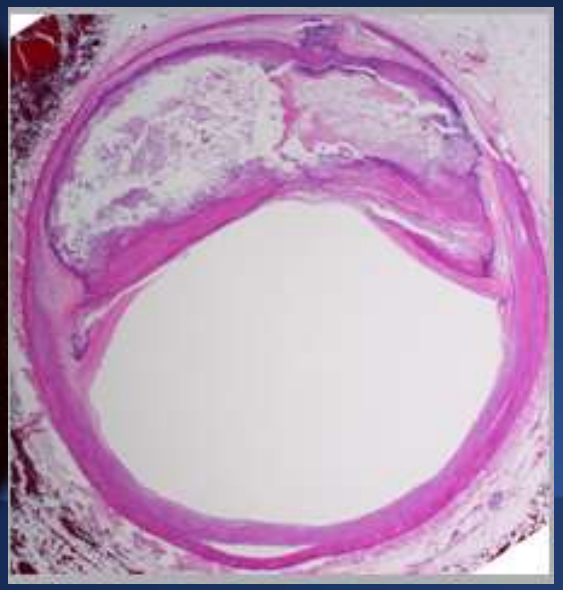


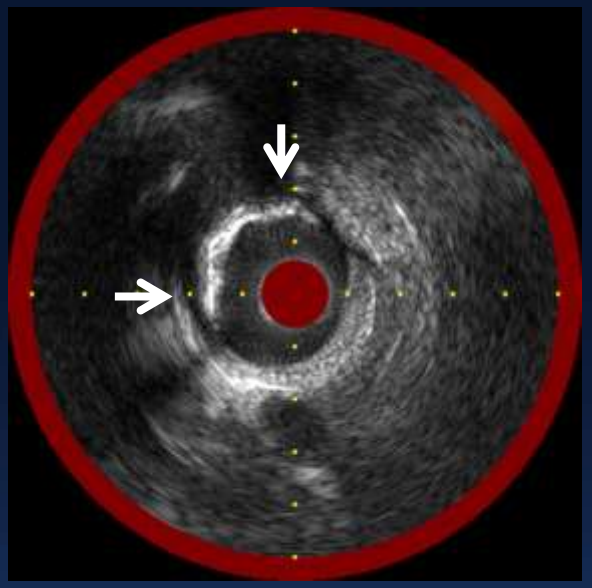
Correlation

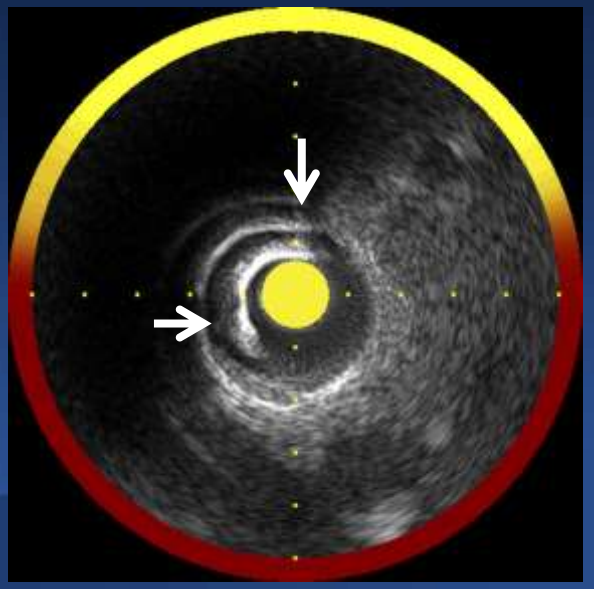
European Heart Journal (2012) 33, 372–383

Different type of Calcified Plaque









NIRS: Lipid-Core Plaque

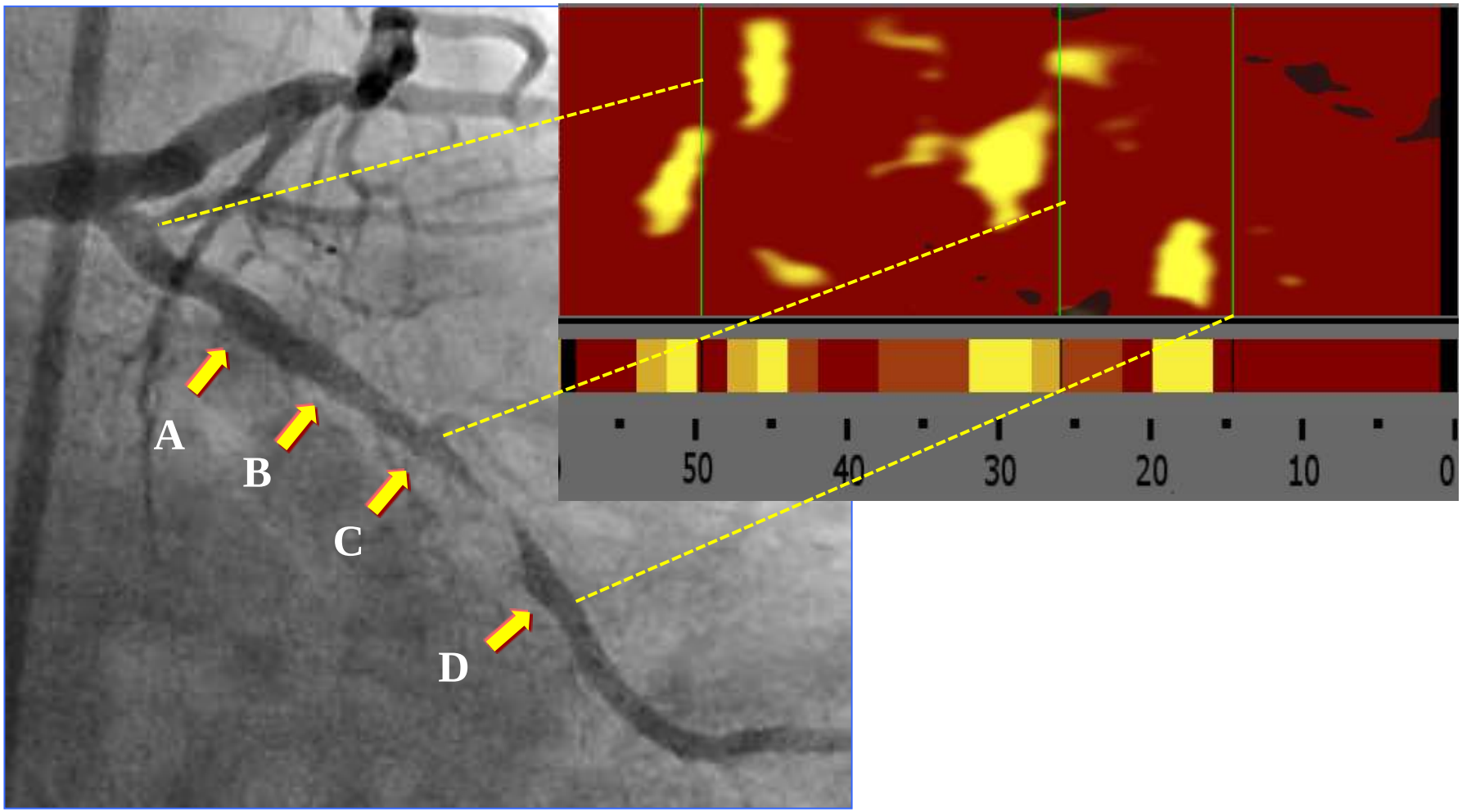
- Length of Vessel to Stent
- Distal Embolization Risk
- Plaque Vulnerability

IVUS: Plaque Architecture

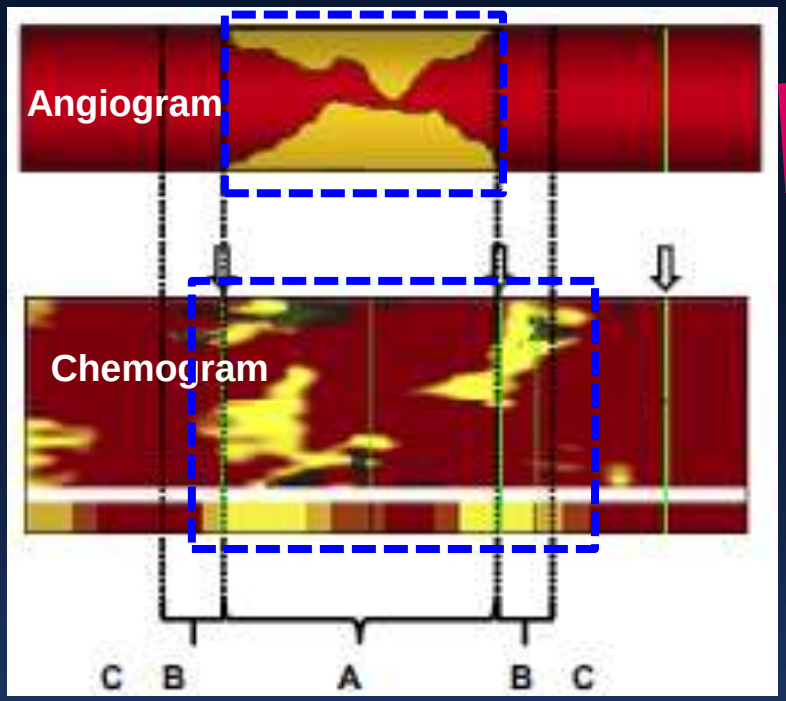
- MLA, Length of Vessel to Stent
- Optimal Stent Expansion
- Stent Edge Complications

Length of Vessel to Stent

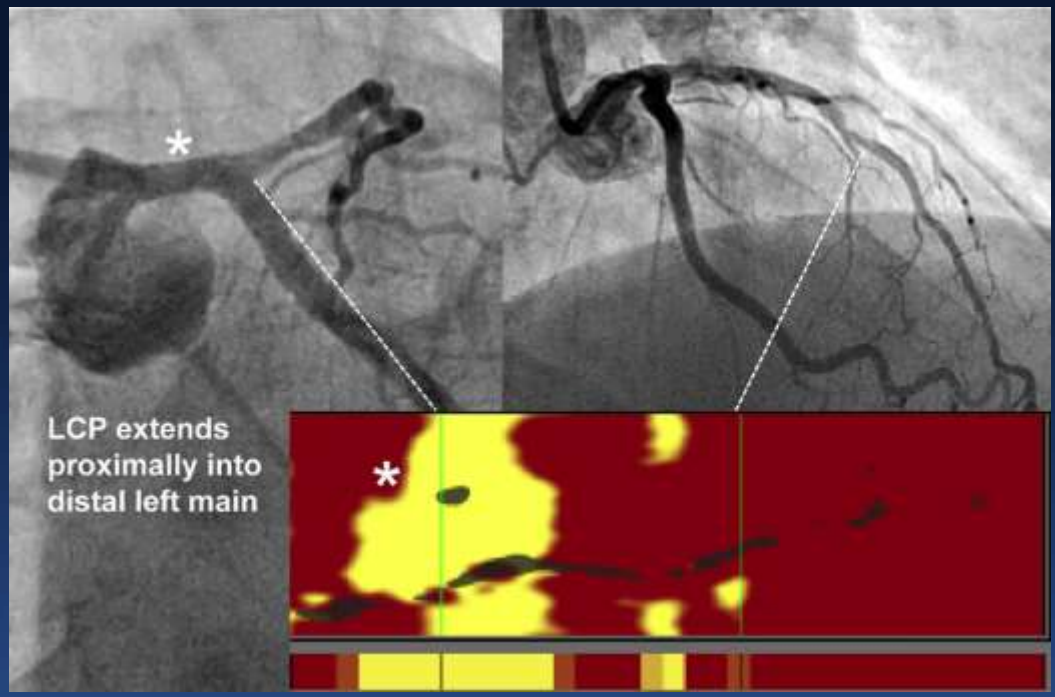
Does Implanting Stent Edge in LCP Impact Outcomes?



LCP extends into RVD of Vessel



20% of Lesions Not Fully Covered



A= LCP only within lesion defined by **angiography**

B= LCP extends **≤ 5mm** beyond the lesion margins

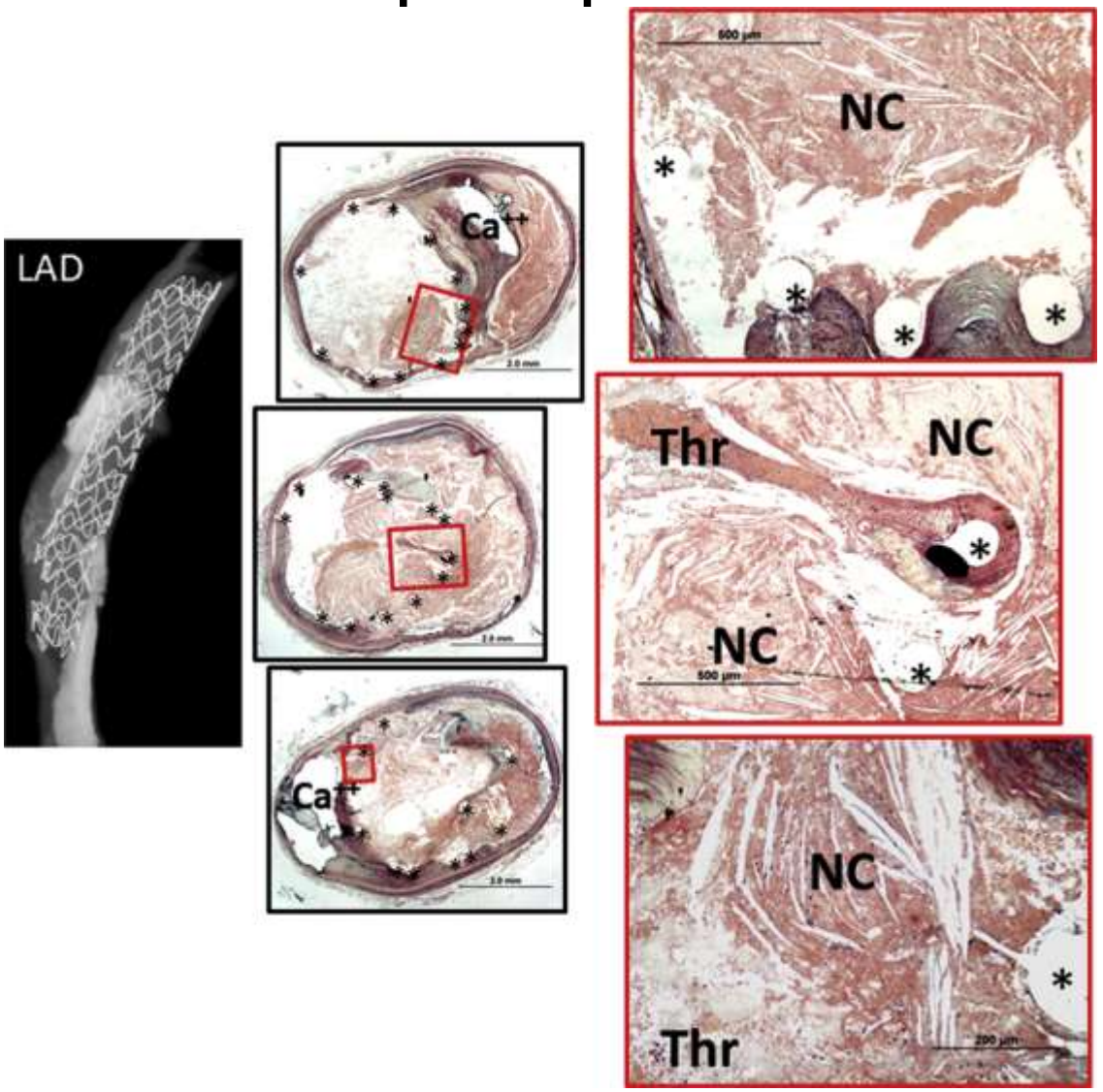
C= LCP extends >5mm beyond the lesion margins

Dixon et al Am J Cardiol Feb 2012

Acute Stent thrombosis:
Necrotic core prolapse

59 pts
58% stent thrombosis

Necrotic Core Prolapse
28% vs 11%
P<0.001



J Am Coll Cardiol. 2014;63(23):2510-2520

NIRS: Lipid-Core Plaque

- Length of Vessel to Stent
- **Distal Embolization Risk**
- Plaque Vulnerability

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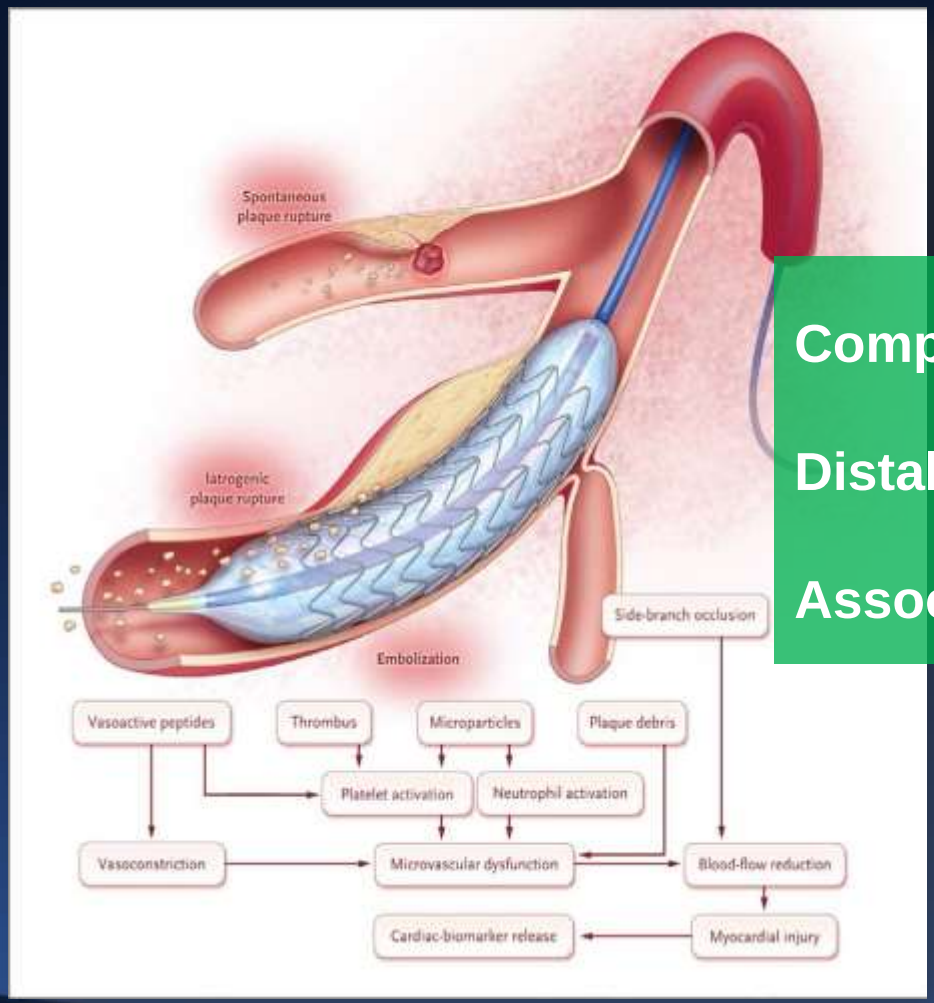
- Optimal Stent Expansion
- Stent Edge Complications

Peri-Procedural MI

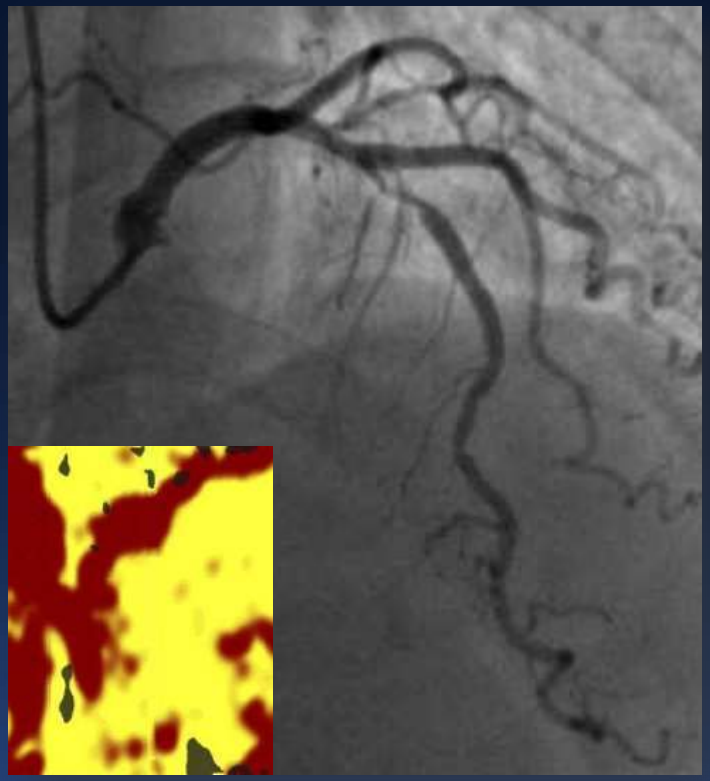


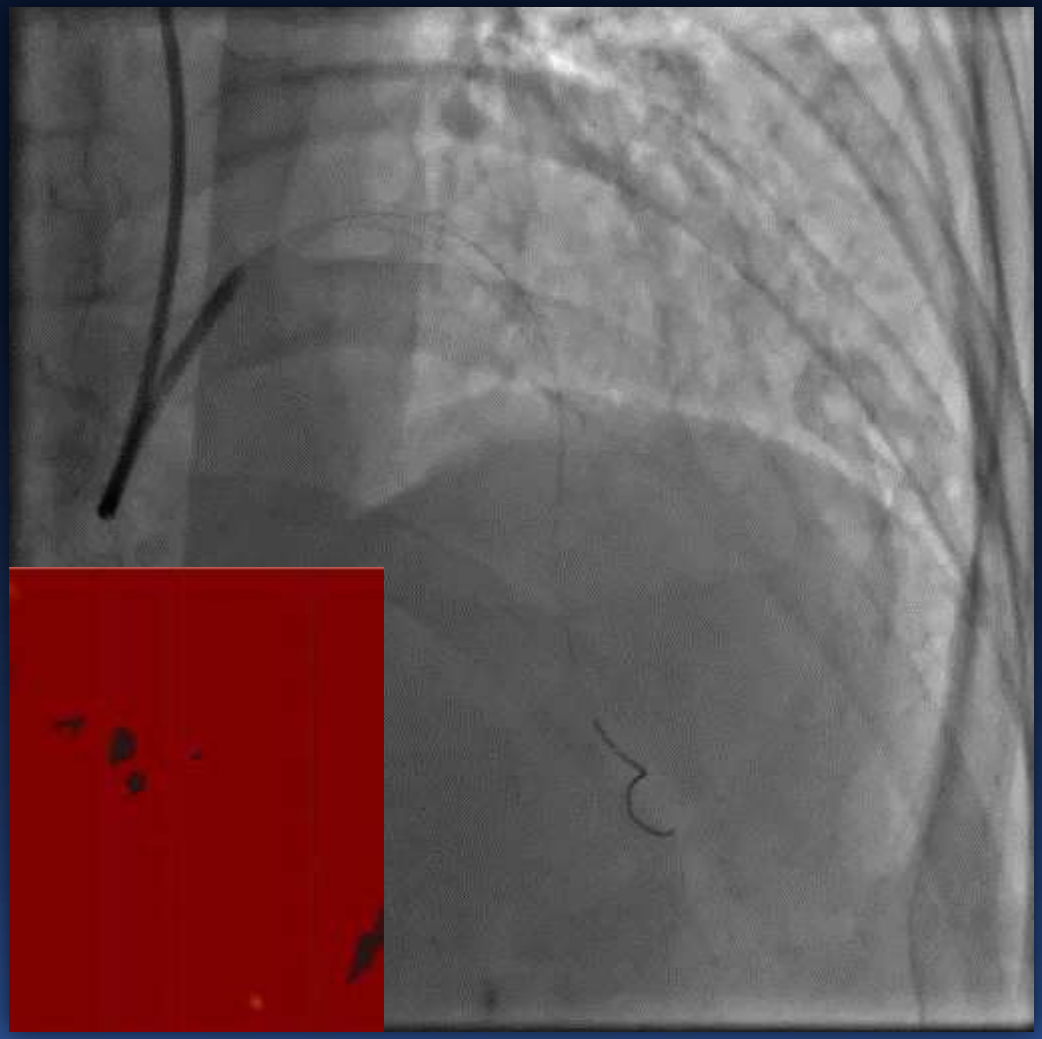
Complicates 12-15% of PCI's

Distal Embolization Lipid common mech

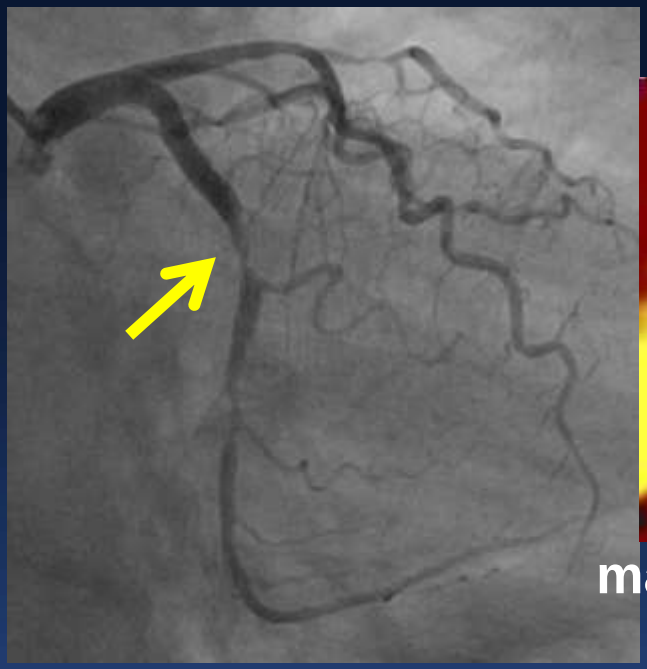
Assoc with Increased Mortality over time

Prasad A, Herrmann J. N Engl J Med 2011;364:453-464

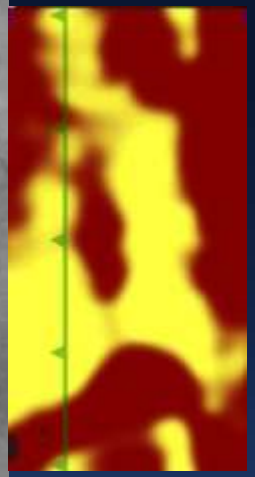




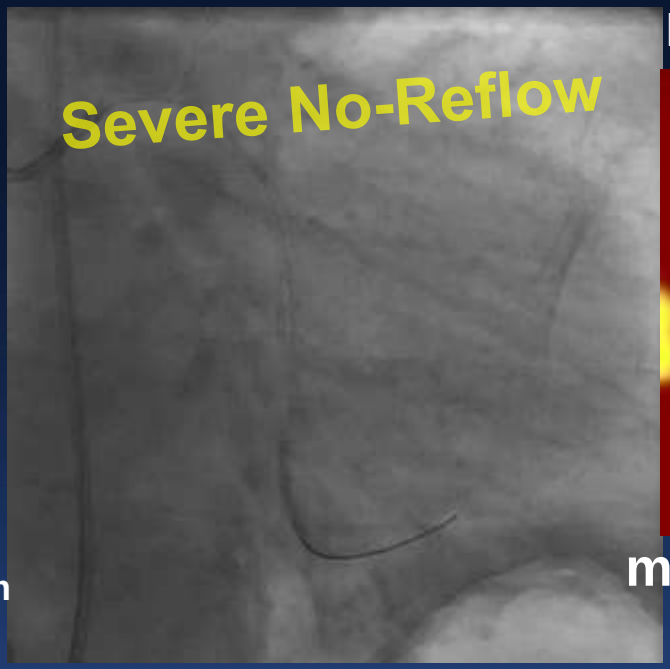
Predictors of MI and No-reflow after PCI



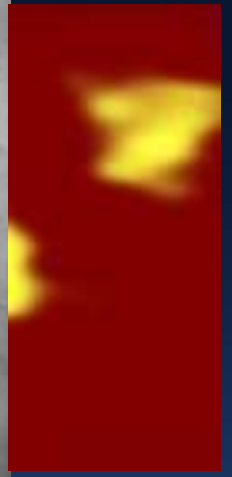
Pre-PCI



max $LCBI_{4mm}$ = 831



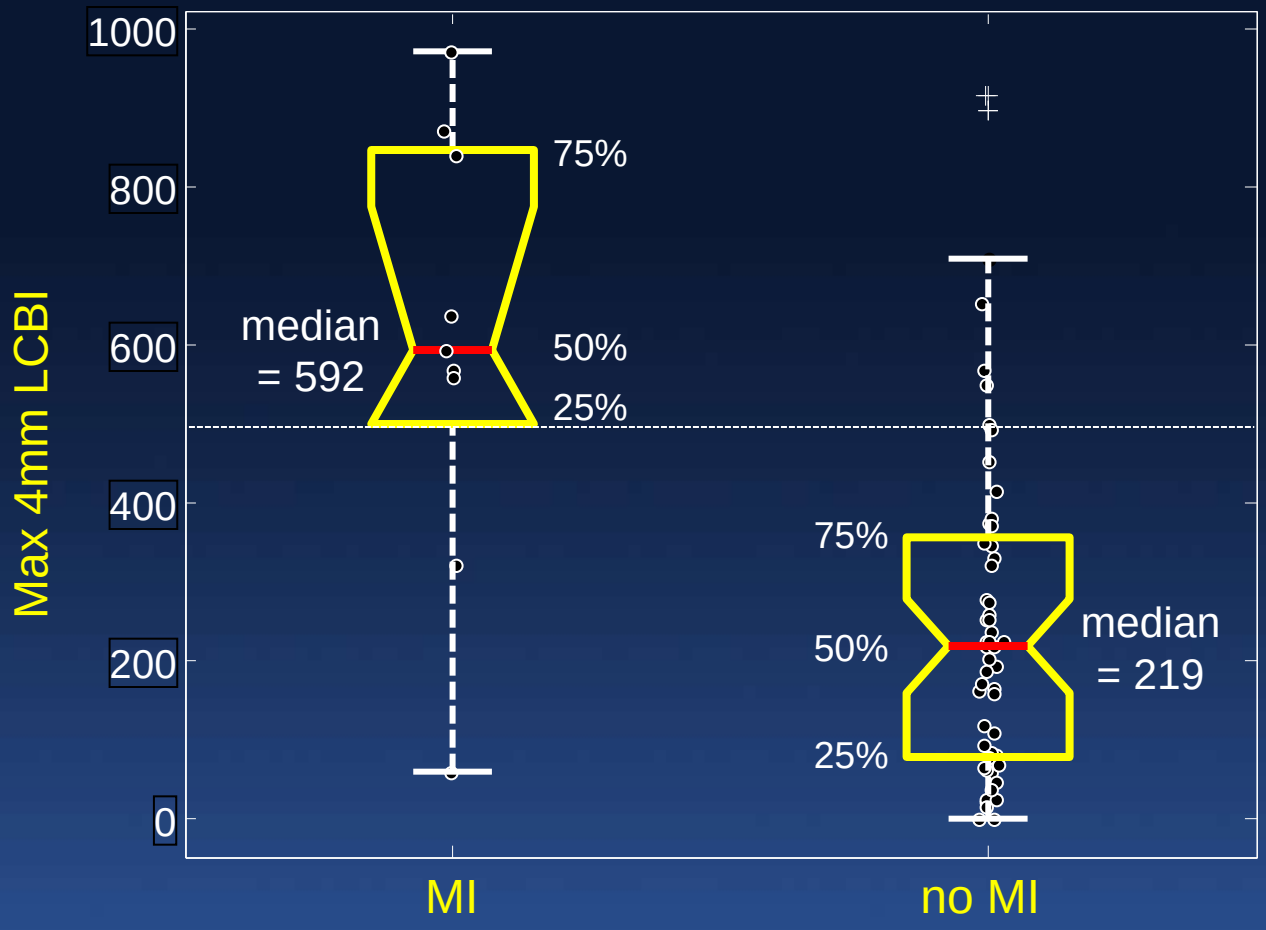
Post-PCI



max $LCBI_{4mm}$ = 187

Lesions with Large LCBI at Risk for Distal Embolization

Association of NIRS-Detected LCP with Peri-Procedural MI (MB or trop >3x NL)



MaxLCBI$_{4mm}$ > 500 Predicts 50% risk Peri-procedure MI

Goldstein JA et al. Circ Cardiovasc Interv. 2011:4:429-437

NIRS: Lipid-Core Plaque

- Length of Vessel to Stent
- Distal Embolization Risk
- **Plaque Vulnerability**

IVUS: Plaque Architecture

- MLA, Length of Vessel to Stent
- Optimal Stent Expansion
- Stent Edge Complications

FFR is helpful to find significant lesions

Recommendations	Class[a]	Level[b]	Ref.[c]
FFR to identify haemodynamically relevant coronary lesion(s) in stable patients when evidence of ischaemia is not available.	I	A	50,51,713
FFR-guided PCI in patients with multivessel disease.	IIa	B	54

ESC Guideline for FFR

However, the evidence for FFR comes mainly from patients with *stable angina*

Late MACE: Natural history of CAD progression cannot be detected with FFR

48y Male, Sudden Coronary Death

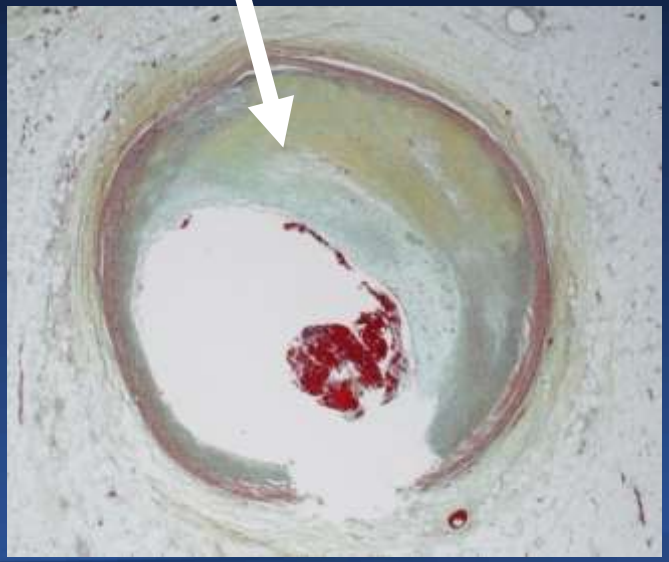


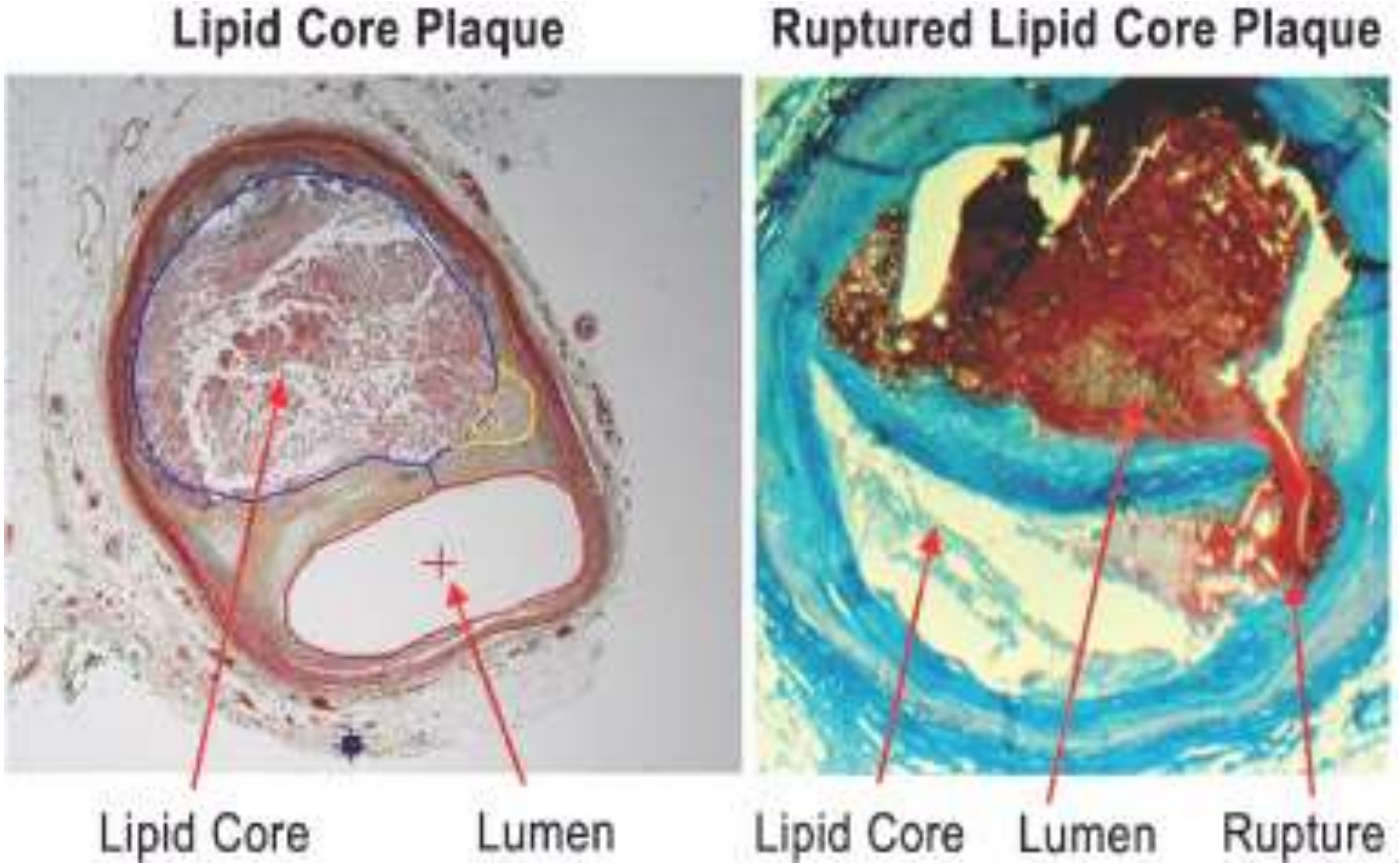
Image is courtesy of Dr.James Muller

World Health Organization

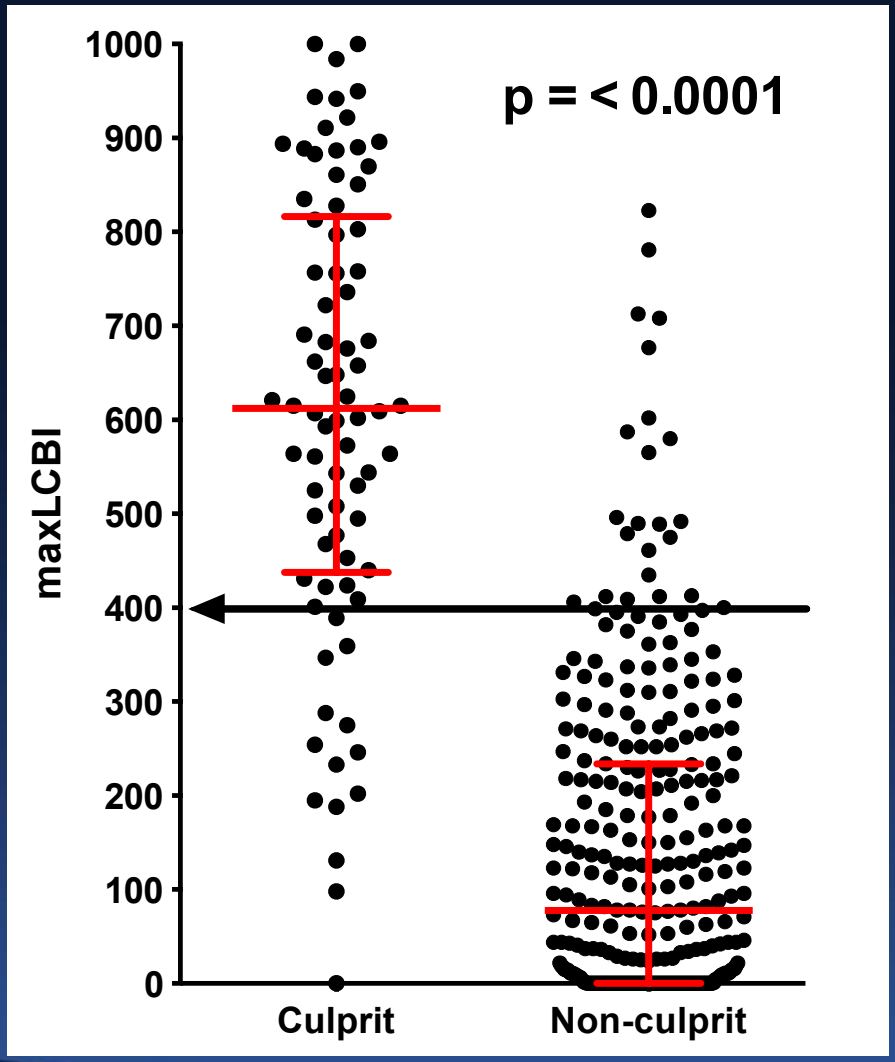
CAD -7.4 million coronary deaths per year

American Heart Association.

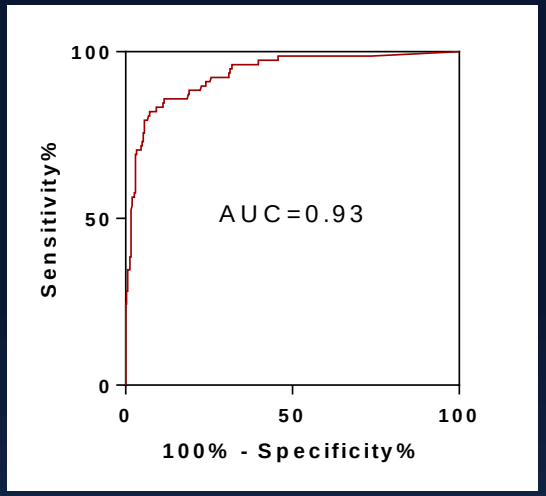
CAD - 1.0 million heart attacks occur each year



STEMI culprit vs Non-culprit segments



Mann-Whitney U test, Median ± interquartile range



maxLCBI >400:
Sensitivity = 82 %
Specificity = 93 %

maxLCBI >400 identifies STEMI plaque with high specificity

Madder…Erlinge TCT 2013
Madder, JACC Card Interv. 2013

NIRS Clinical Trials

Drug Evaluation: YELLOW trial

Prevention of Coronary Events due to Vulnerable Plaque — PROSPECT 2, ABSORB

Prediction of Coronary Events Caused by Vulnerable Plaque — LRP, PROSPECT 2, ORACLE-NIRS

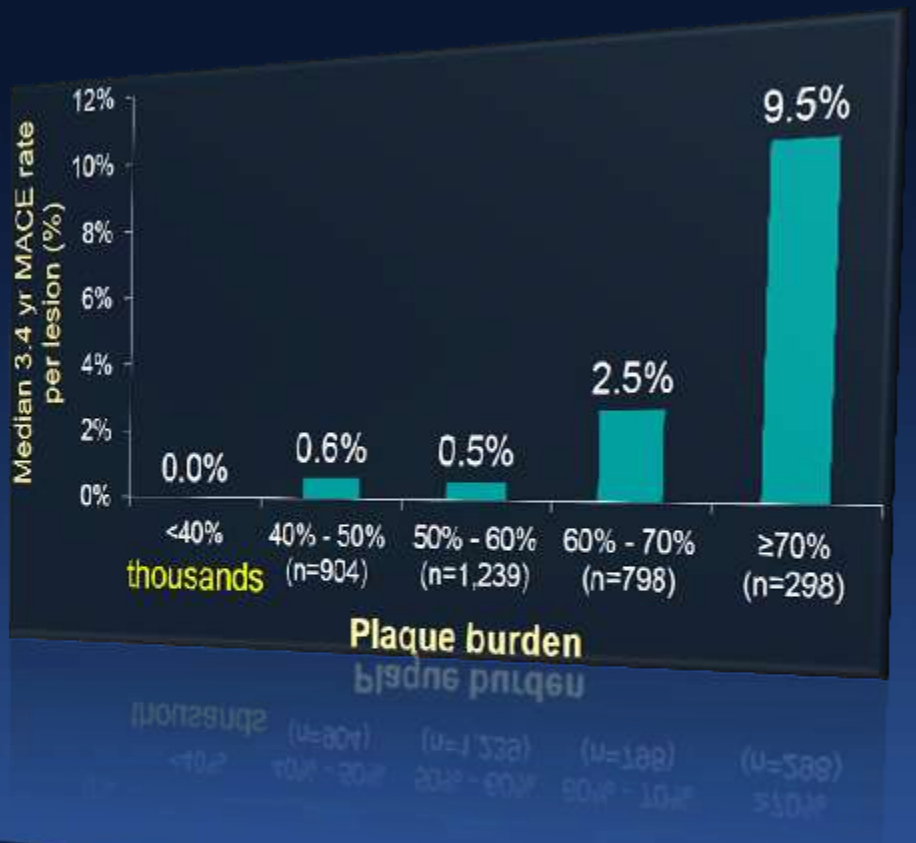
Determination of length of artery to stent — COLOR registry, CANARY Study

Prediction of peri-stenting MI (Distal Embolization)

Detection of LCP & LCP Burden Index — CDEV, SPECTACL

Madder RD et al. JACC Cardiovascular Interv 2013;6:838-46
Madder RD et al. Circ Cardivasc Interv 2012;5:55-61
Goldstein JA et al. Circ Cardiovasc Interv. 2011:4:429-437
Sakhuja R et al. Circulation 2010;122:2349-2350
Kini A et al. JACC 2013; 62: 21-9

PROSPECT : Correlates of Non-culprit Lesion Related Events: Impact of plaque burden



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

McPherson JA et al. JACC Img2012;5:S76–85Median

PROSPECT Study showed 1) *plaque burden>70%*, 2) *MLA<4mm2*, and 3) *TCFA* were the lesion morphology to predict future event

Should we treat vulnerable plaque in physiologically non-significant lesion?

NIRS/IVUS defined vulnerable plaque will be evaluated in natural history **PROSPECT2 study**

PROSPECT II Study

900 pts with ACS at up to 20 hospitals in Sweden, Denmark and Norway (SCAAR)

NSTEMI or STEMI >12º

IVUS + NIRS (blinded) performed in culprit vessel(s)

Successful PCI of all intended lesions (by angio ±FFR/iFR)

Formally enrolled

3-vessel imaging post PCI

Culprit artery, followed by **non-culprit arteries**

Angiography (QCA of entire coronary tree)

IVUS + **NIRS (blinded)** (prox 6-8 cm of each coronary artery)

PROSPECT II Study
PROSPECT ABSORB RCT

900 pts with ACS after successful PCI

3 vessel IVUS + NIRS (blinded)

≥1 IVUS lesion with **≥70%** plaque burden present?

Yes
(N=300)

R
1:1

ABSORB BVS + GDMT (N~150)

Guideline Determined Medical Therapy
(N=150)

No
(n=600)

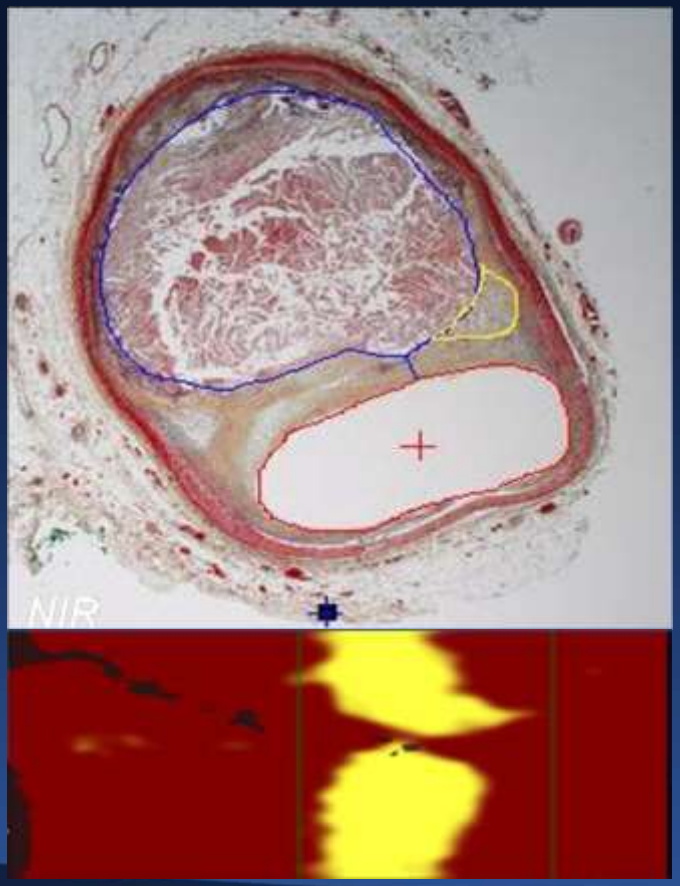
Routine angio/3V IVUS-NIRS FU at 2 years

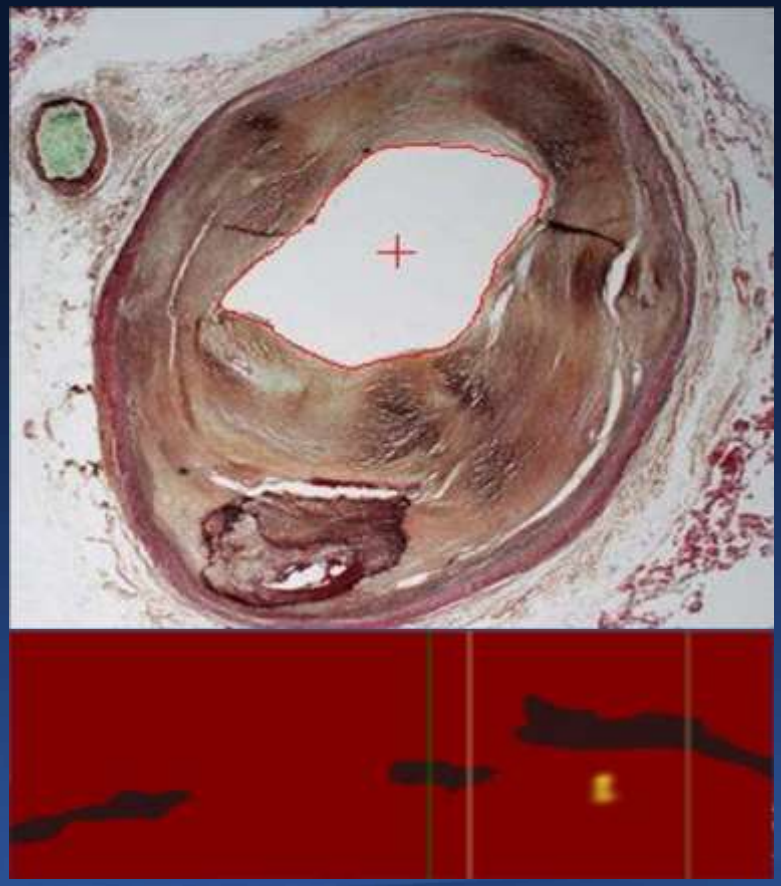
Clinical FU for ≥3 years

PROSPECT ABSORB RCT

- Secondary endpoint -

Safety and efficacy of BVS in lesions with large plaque burden which are LRP+ vs LRP-





- Increasing evidence is accumulating linking LCP to vulnerable plaque, lesions at risk for embolization and stent thrombosis

- Prospective studies are required to validate these observations, followed by therapeutic trials

Current trend

Significant - PCI

Insignificant - Medical therapy?

(Prevention)

Future trend

Treatment ???!!!

Thank you for your time!