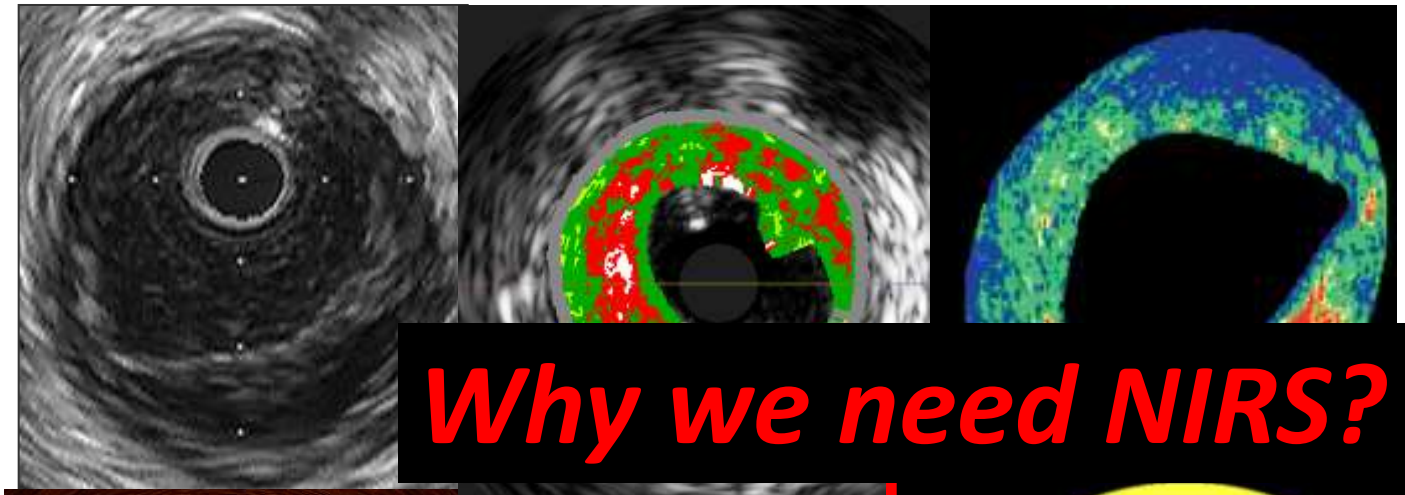
Better Diagnosis by using Combined NIRS/IVUS vs. IVUS

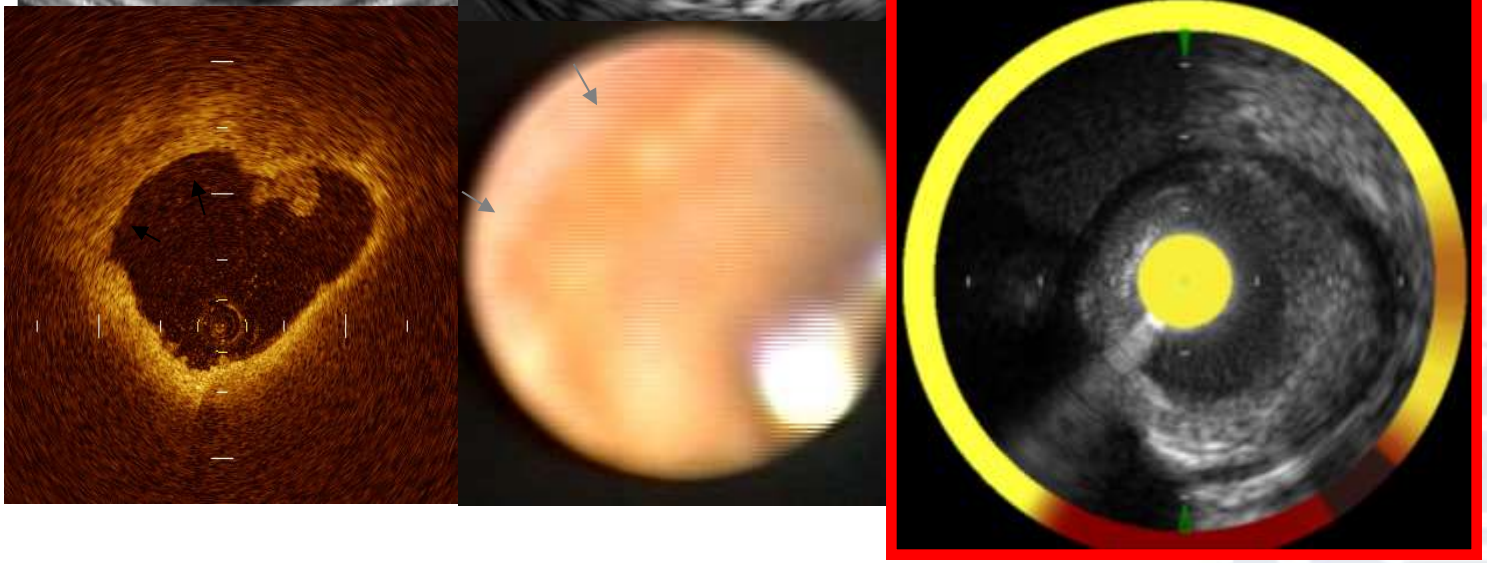
Shanghai Ren Ji Hospital

Pu Jun, MD, FESC

For the Detection of Human plaques



Why we need NIRS?



NIRS is Unique!

Unique Spectroscopic Method

NIRS can typically penetrate much farther into a sample

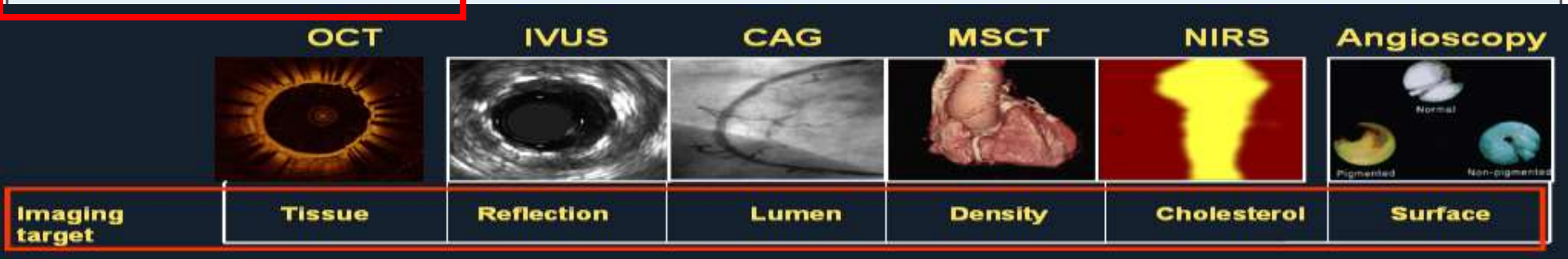
NIRS can detect specific features of chemical components.

NIRS can be specifically for LIPID CORE

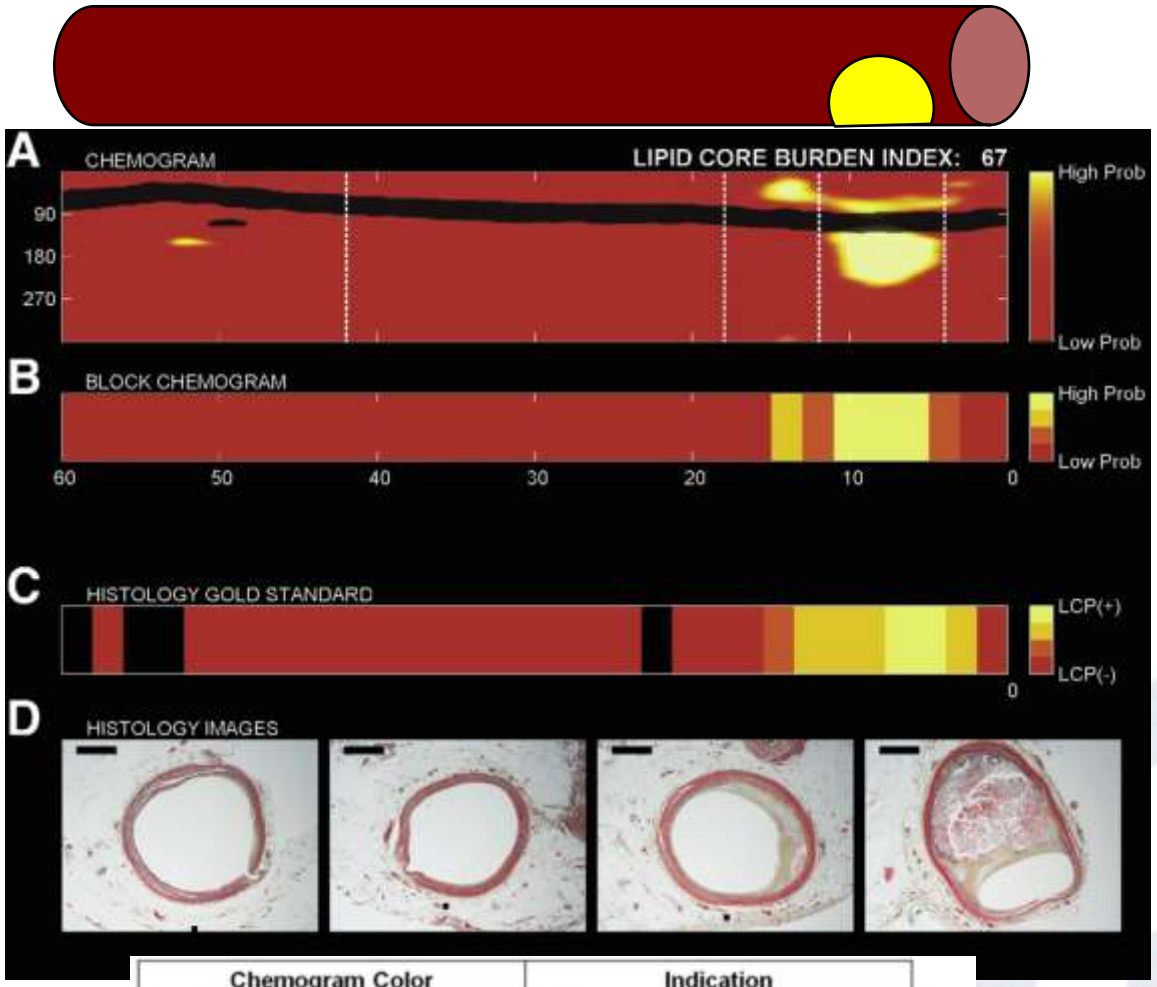
Compared with other Imaging methods

	Angiography	Angioscopy	OCT	IVUS	NIRS
Cap Thickness		○	●	○	○
Expansive Remodeling				●	
Plaque Volume				●	
Calcification	●		○	●	
Thrombus	○	●	●	○	○
Inflammation Macrophages			○		
Lipid Core		○	○	○	●
Requires Blood-Free FOV	No	Yes	Yes	No	No

● *Direct, robust, and/or validated;* ○ *Indirect, inferred, and/or unvalidated*



Lipid-core plaque detected with NIRS



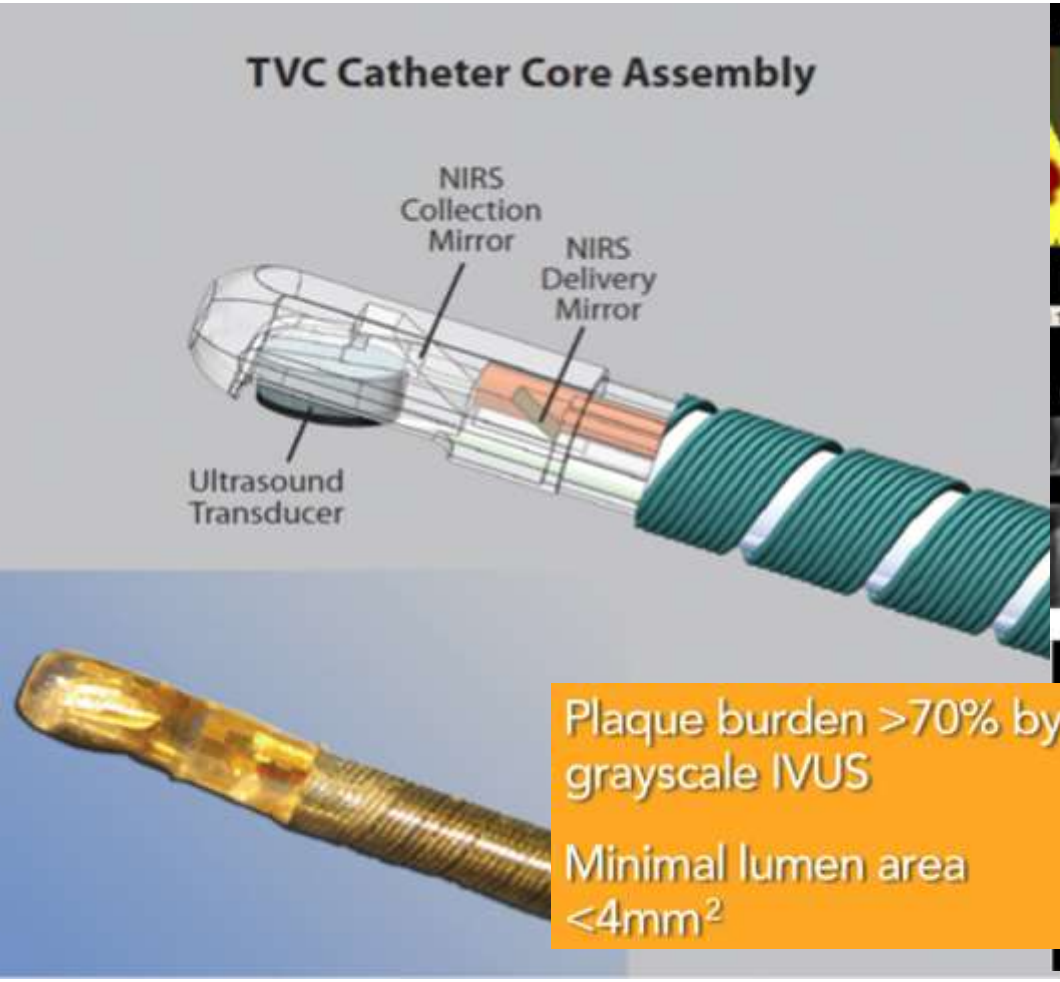
Chemogram Color	Indication
Red	Low probability of LCP
Yellow	High probability of LCP
Black overlay	Indeterminate

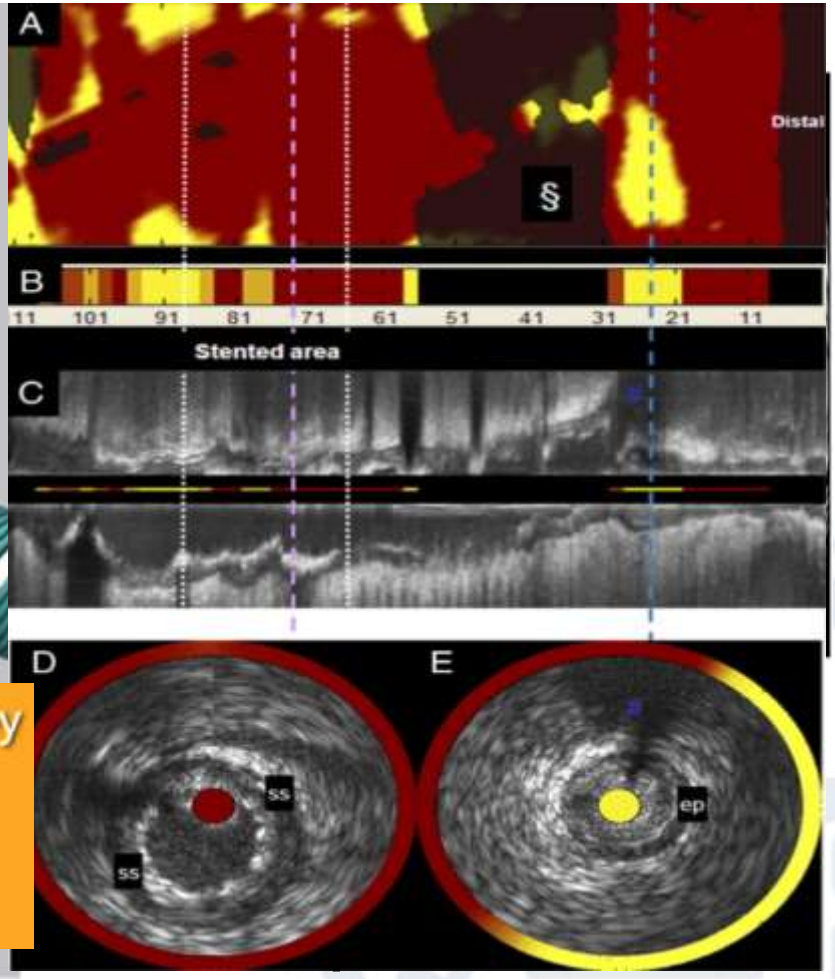
Possible causes:
- Guide wire
- Thrombus
- Flow disturbance

Simple To Read

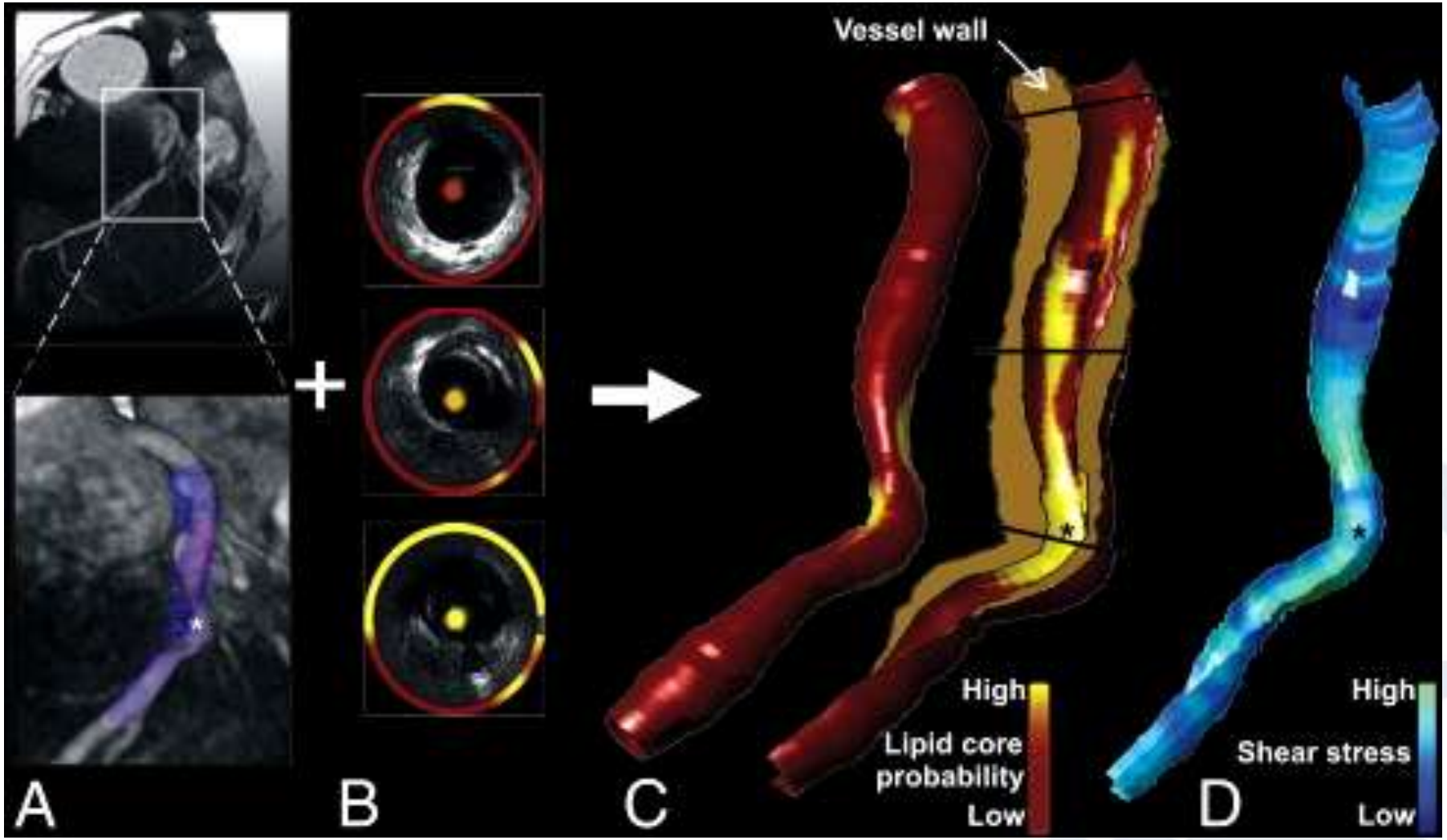
Combined NIRS/IVUS provide better Diagnosis

NIRS Vs. IVUS

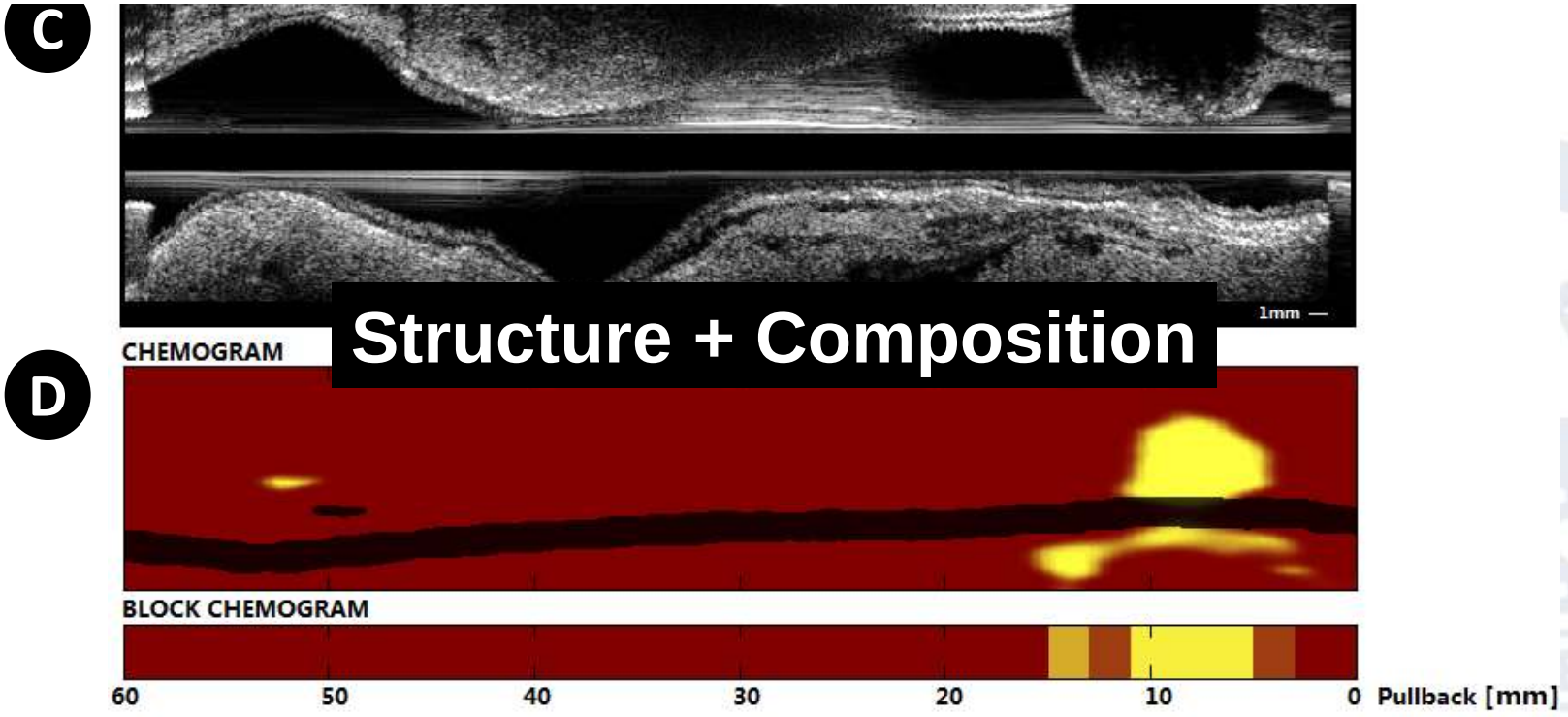




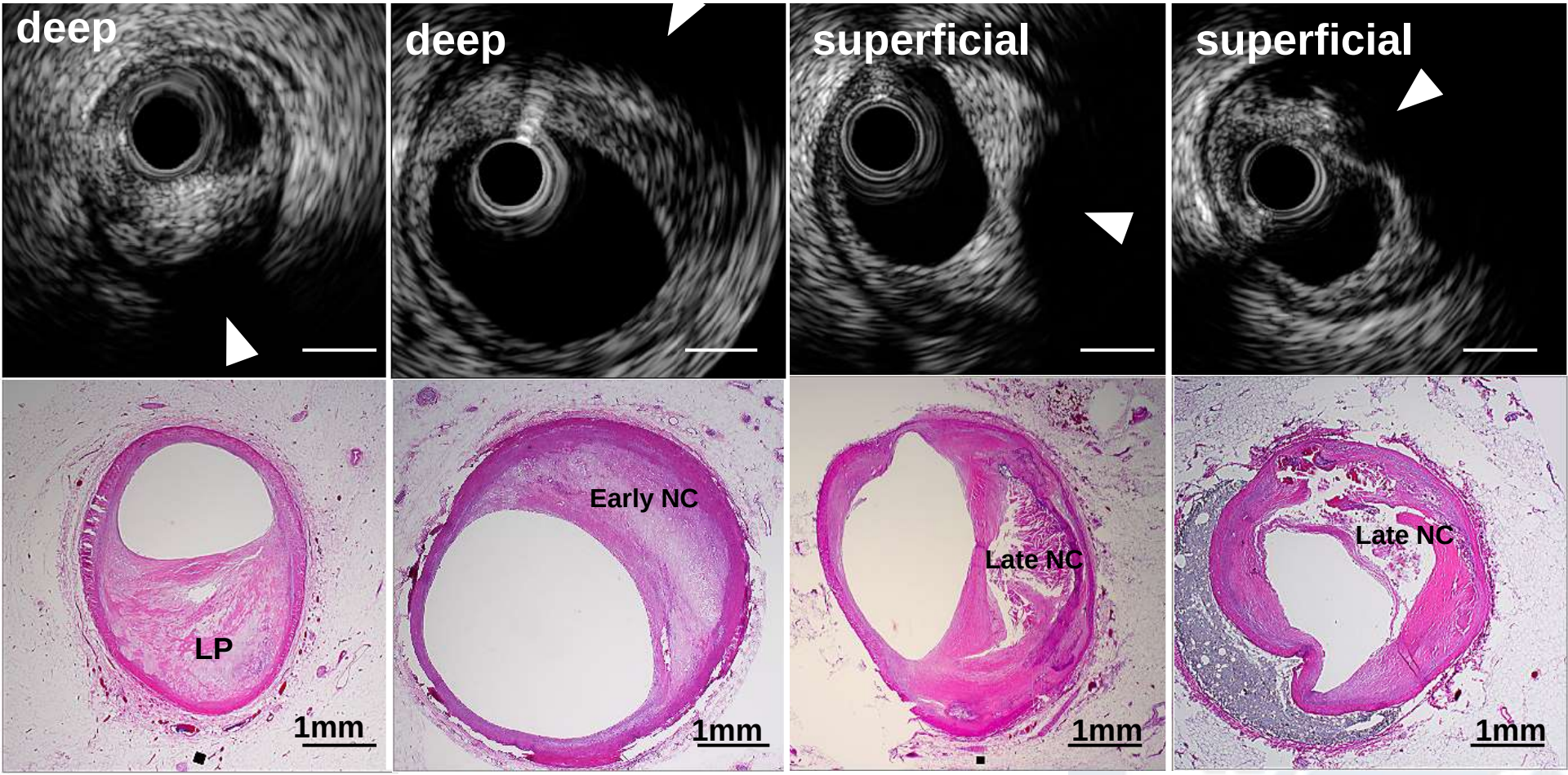
3-D NIRS/IVUS


Vessel wall
High
Lipid core probability
Low
High
Shear stress
Low
A
B
C
D

GS IVUS can detect Echo-attenuated plaque as lipid/NC contained plaque

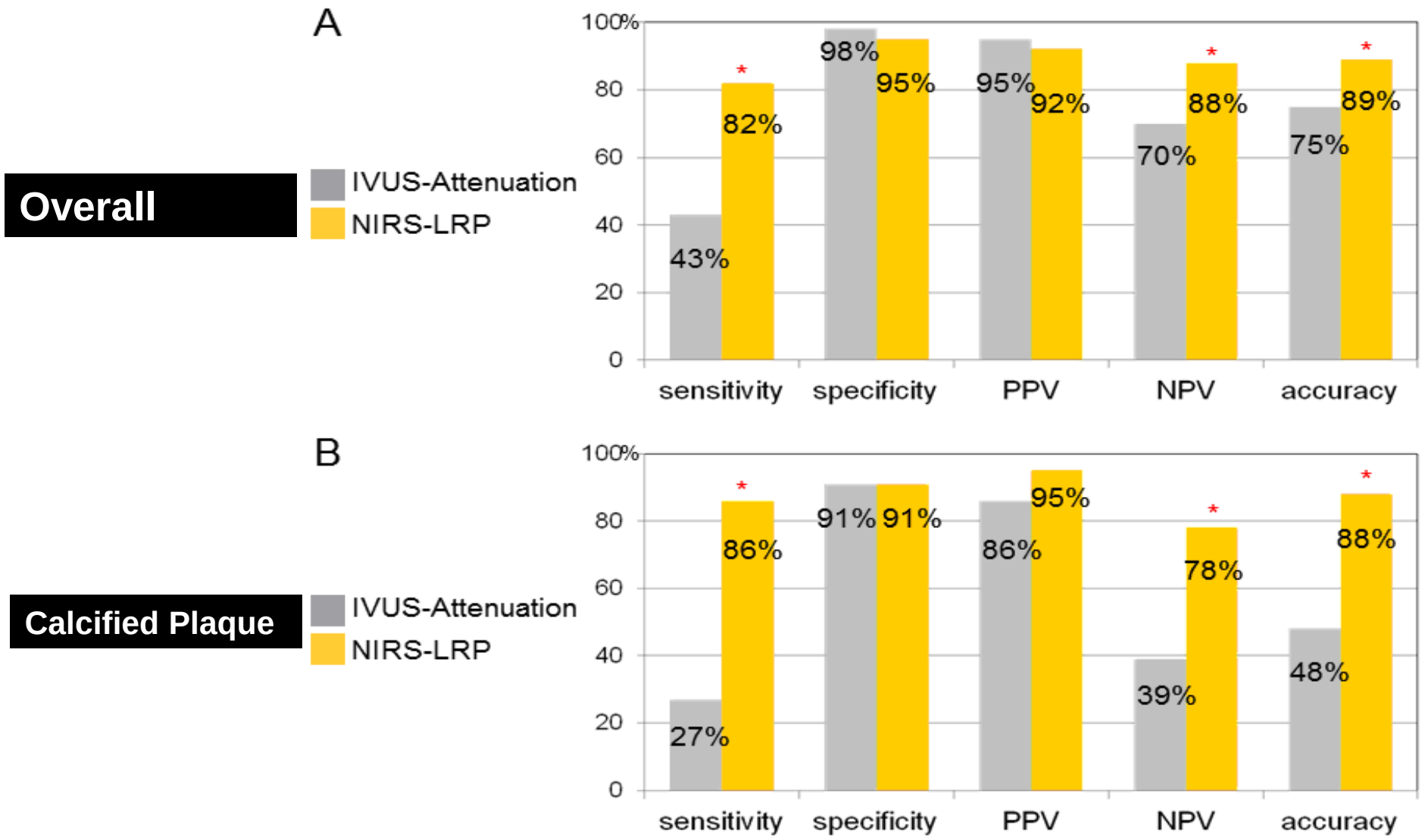


Location of the Echo-attenuation is the key point: Young LP or Late NC



***Superficial location** is a reliable IVUS signature for high-risk plaque*

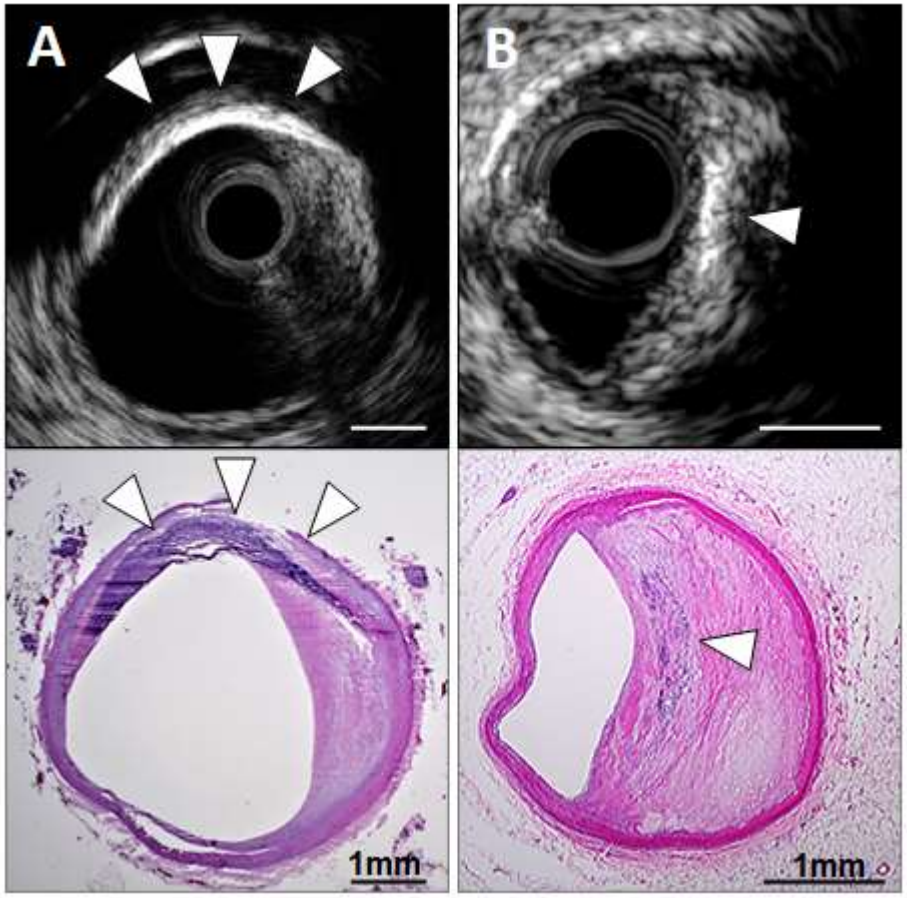
Histological validation study of human coronary specimens from cardiovascular death victims



NIRS-LRP was more accurate than IVUS, especially at calcified plaque

For Calcified Plaque, a recent novel finding

Extensive vs. Spotty Calcification



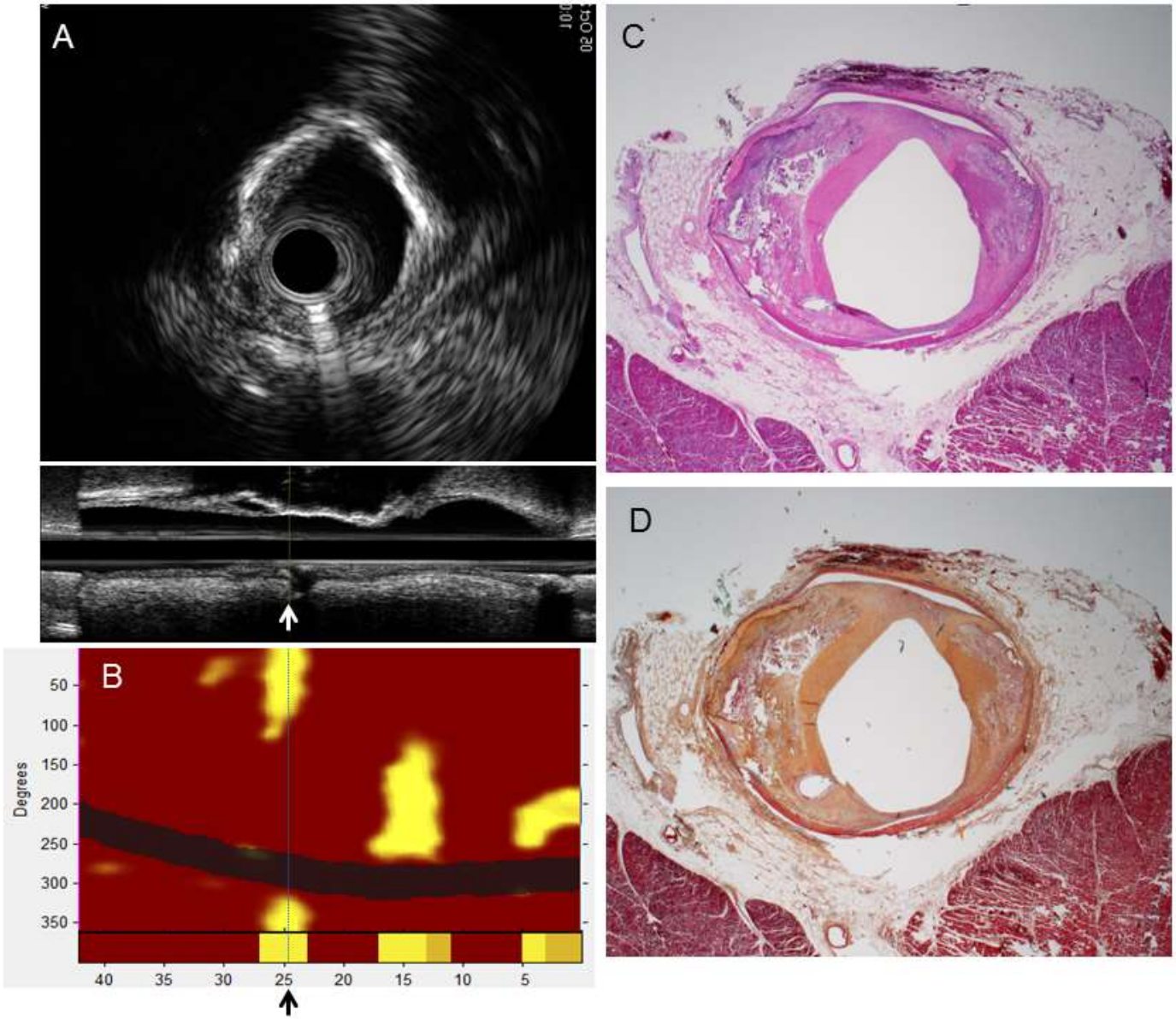
Spotty calcification,

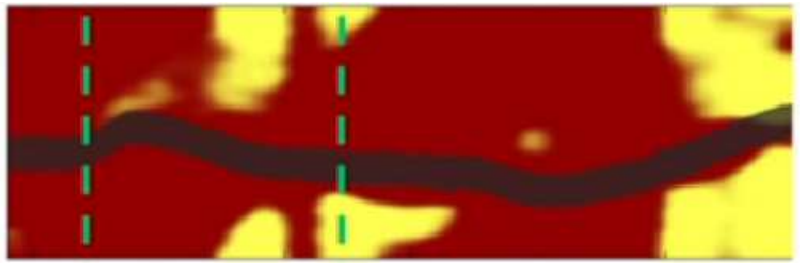
especially when superficial in location, was often associated with necrotic core

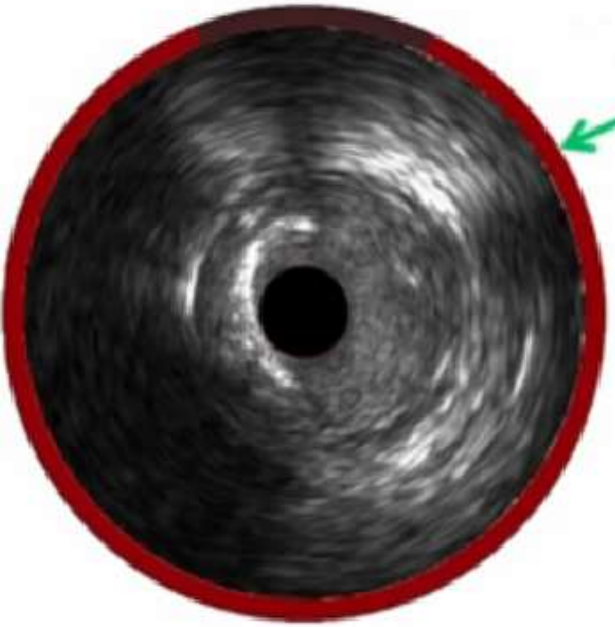
Table 2 Summary of the Correlations of IVUS Plaque Characteristics With Histopathologic Lipid/Necrotic Core

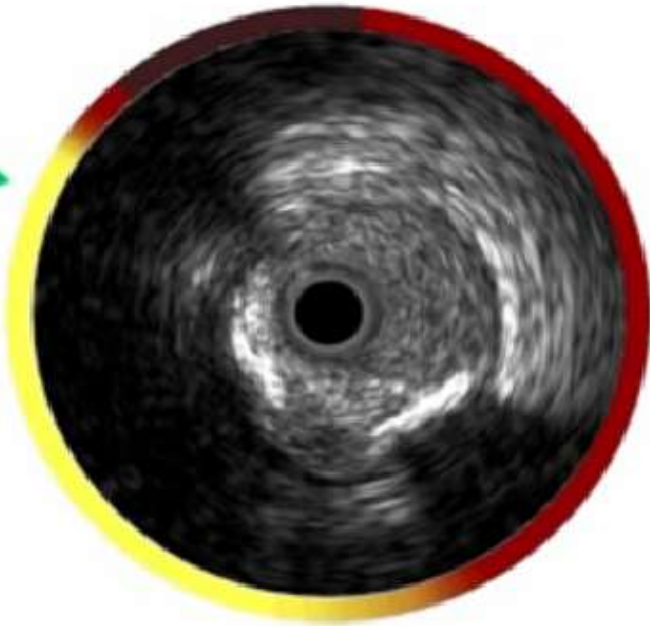
	Specificity	Sensitivity	Positive Predictive Value	Negative Predictive Value
Echo-attenuated plaque	94.7	56.2	91.4	54.6
Echolucent plaque	90.4	20.5	79.5	49.8
Plaque with spotty calcification	71.7	69.4	62.4	77.5

IVUS can not penetrate into Calcium
NIRS can & “see" NC behind the calcification







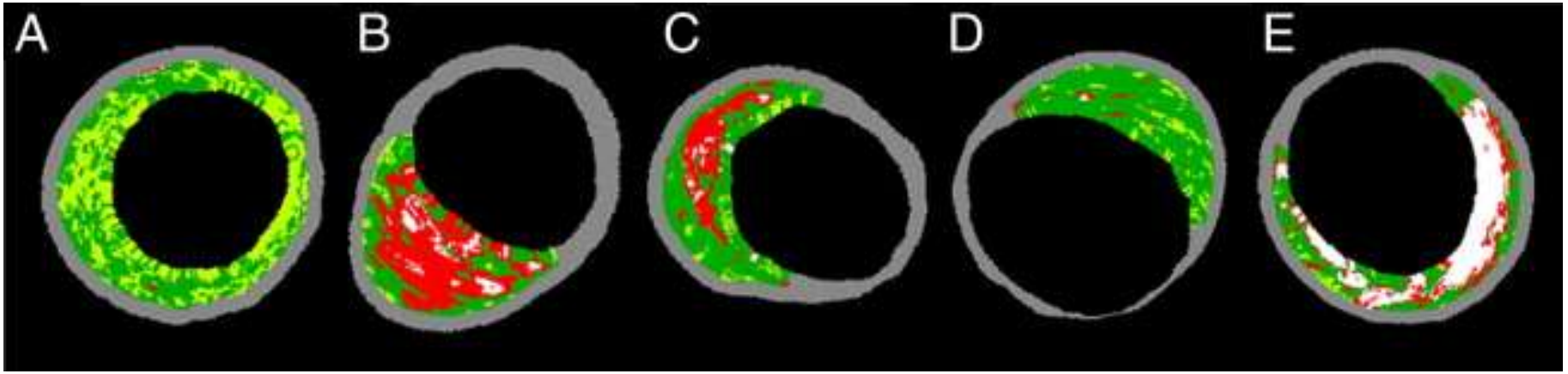


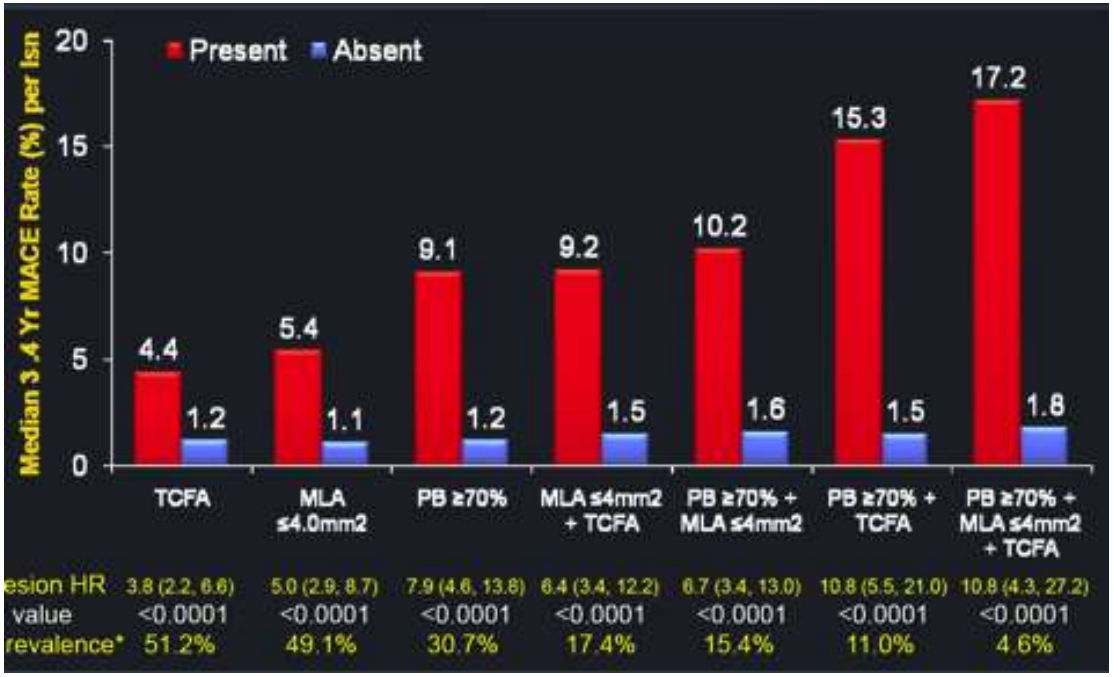
Histology Confirms Calcified Fibrous Plaque at A

And Lipid Core Plaque at B

How about VH-IVUS?

VH-IVUS is a validated imaging method for VP





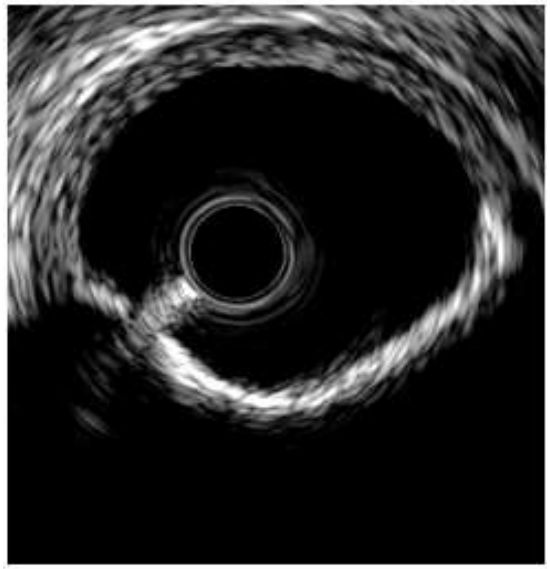
However,

When interpret the VH-IVUS imaging

Caution should be taken in Several Settings

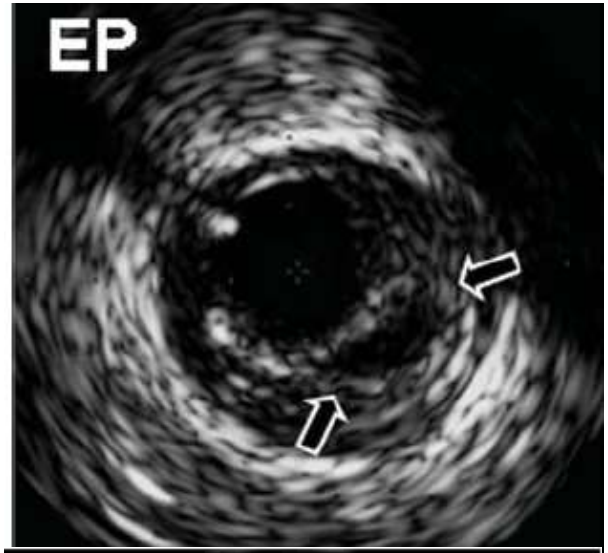
In the setting of heavy calcification, VH may not be accurate

VH-IVUS always put red "necrotic core" behind the calcium

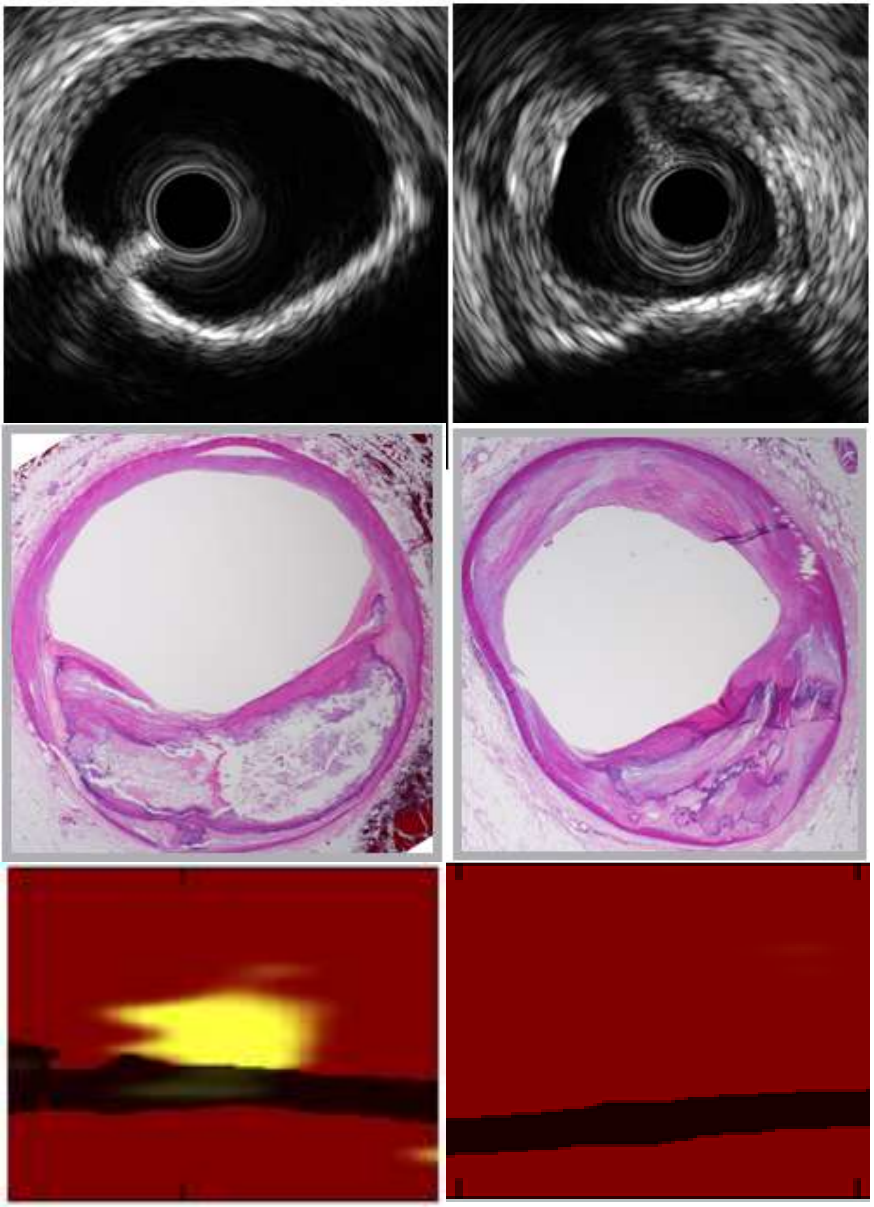


In the setting of low ultrasound signal, VH may not be accurate

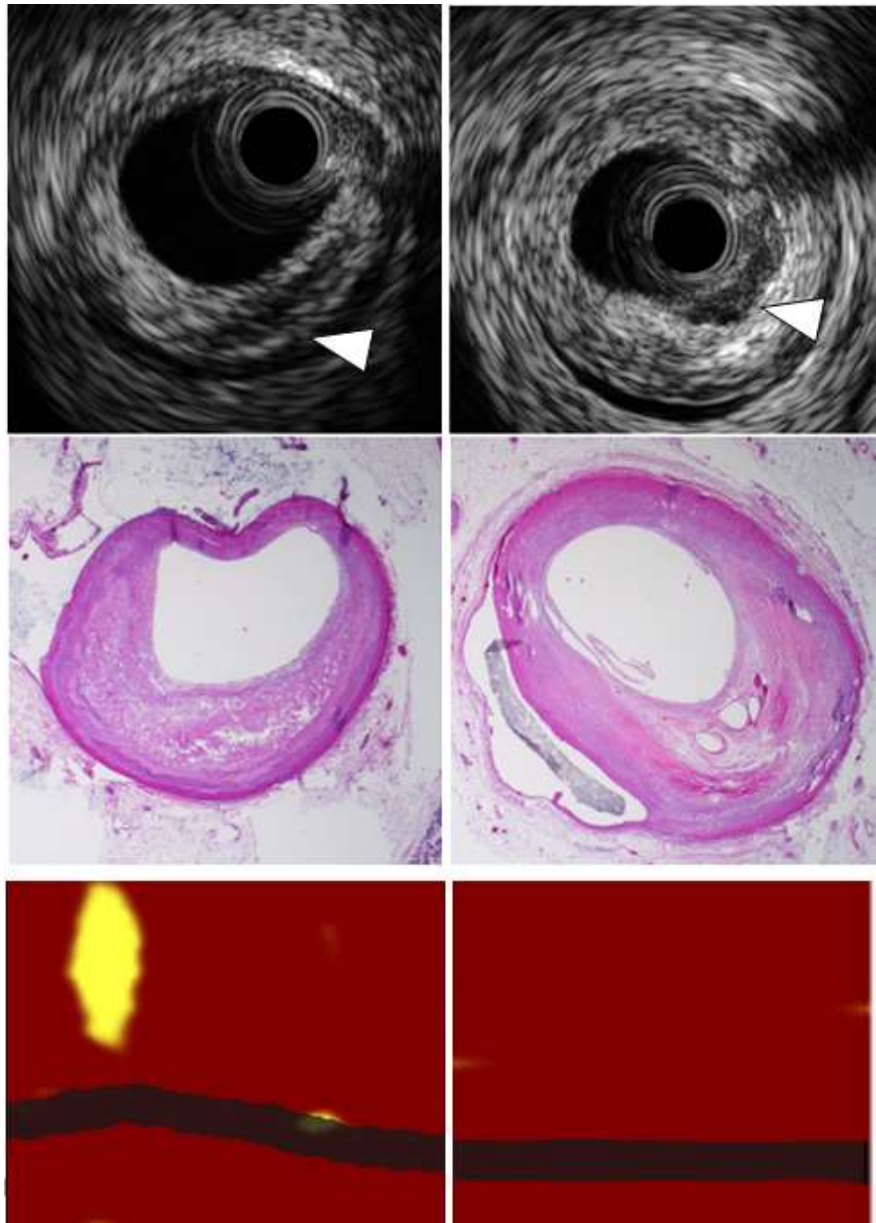
VH-IVUS always put fibrofatty (light green) & fibrous tissue (dark green) in the area of low ultrasound signal



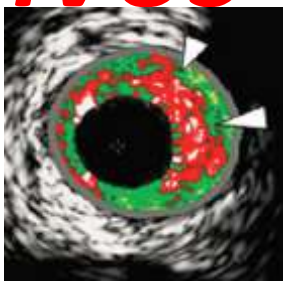
Plaque with calcification

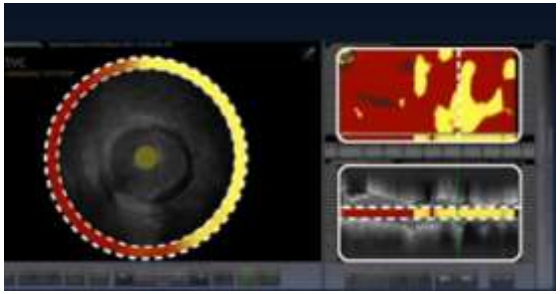


Echolucent area



VH-IVUS vs. NIRS/IVUS



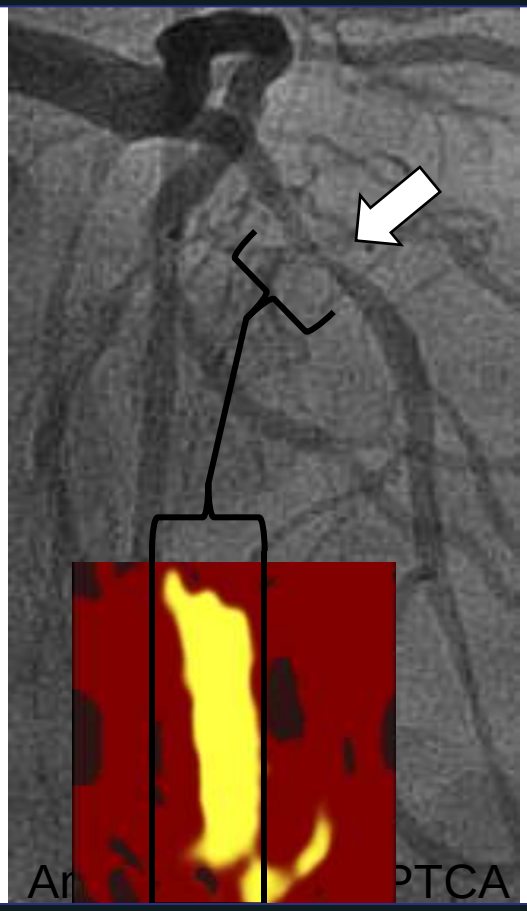


	VH-IVUS (20 MHz)	OCT	NIRS-IVUS (40 MHz)
Hybrid intravascular imaging	No	No	Yes
Imaging through blood	++	-	++
Imaging through stents	No	Yes	Yes
Imaging through calcium	No	Yes	Yes for NIRS – No for IVUS
Need for manual image processing for LCP detection	Yes	Yes	No

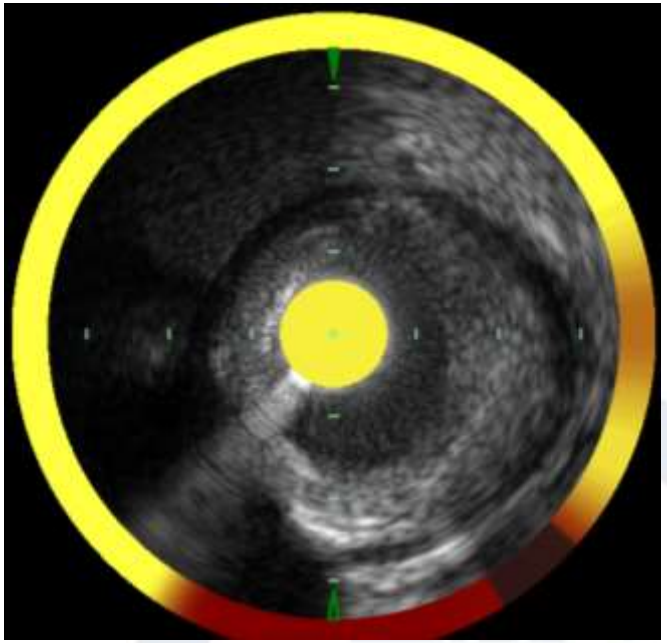
Why might a large lipid burden be important?

35 year old male with sudden cardiac arrest while mowing his lawn.

Initial angiogram



Ar PTCA



maxLCBI$_{4mm}$ = 813

Plaque burden = 67%

The curprit lesion contained a large lipid core.

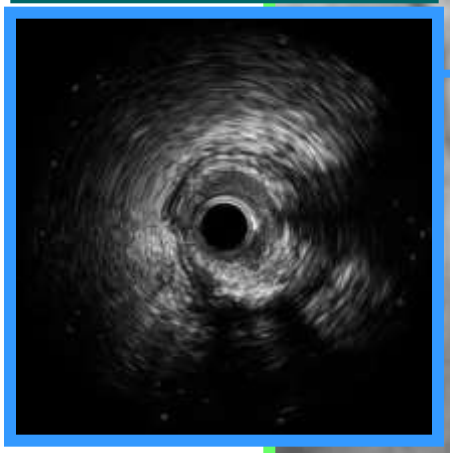
Can the Combination of NIRS-IVUS be used to Guide PCI?

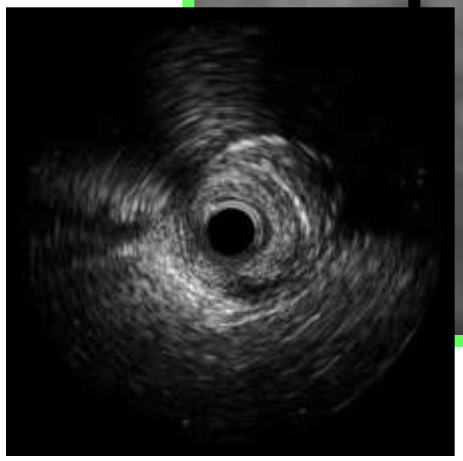
IVUS: Plaque structure

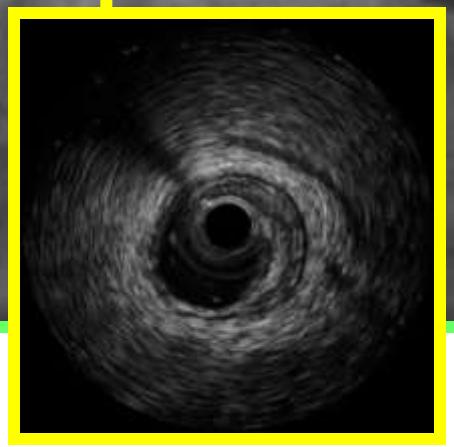
- MLA
- Length of Vessel to Stent
- Optimal Stent Expansion
- Stent Edge Complications

NIRS: Lipid Core

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







When we perform PCI

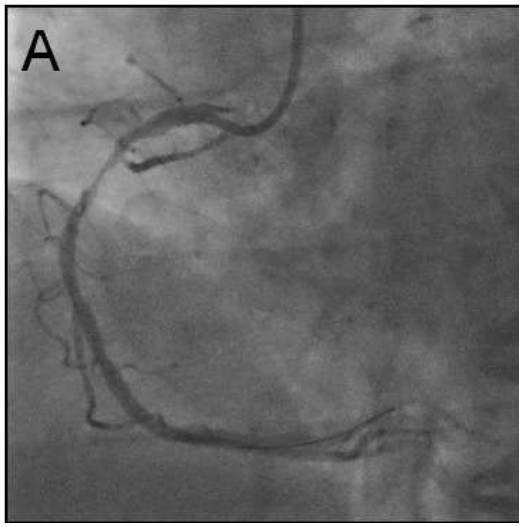
Stenting: Where To Start and Stop?

Is Implanting Stent Edge in LCP safe?

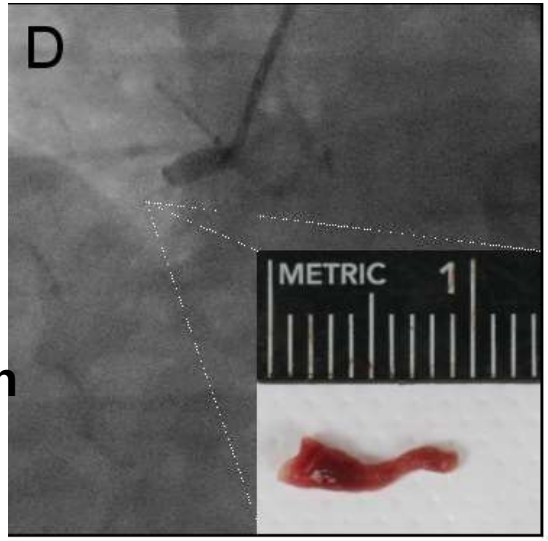
Stent thrombosis post incomplete LCP coverage

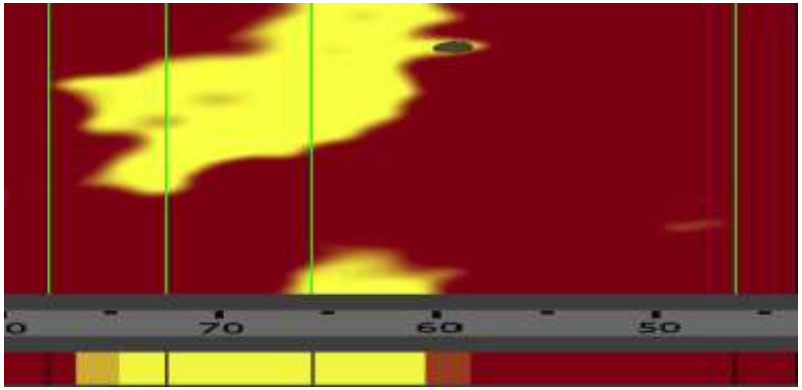
63 y.o.

male



Recurrent pain eight hours post stenting



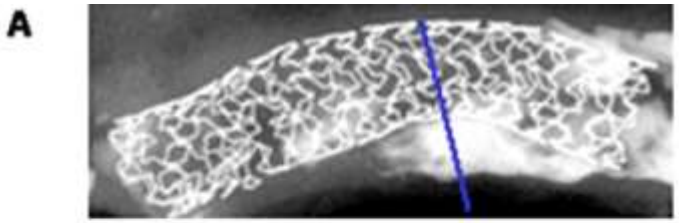


The proximal end of the stent that thrombosed was located in a lipid-core

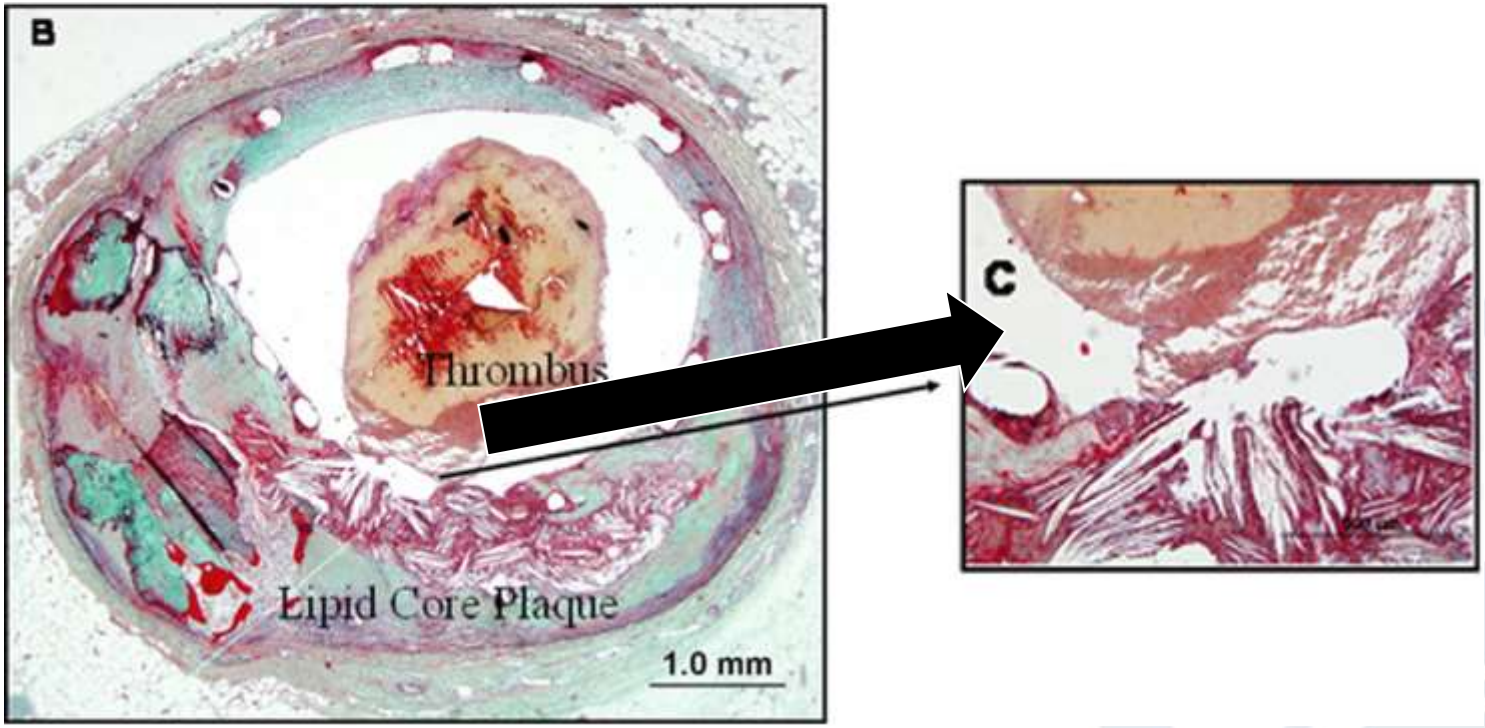
Proximal

Sakhura et al. Circulation 2010

Fatal Thrombus Within a DES Located Over a LCP

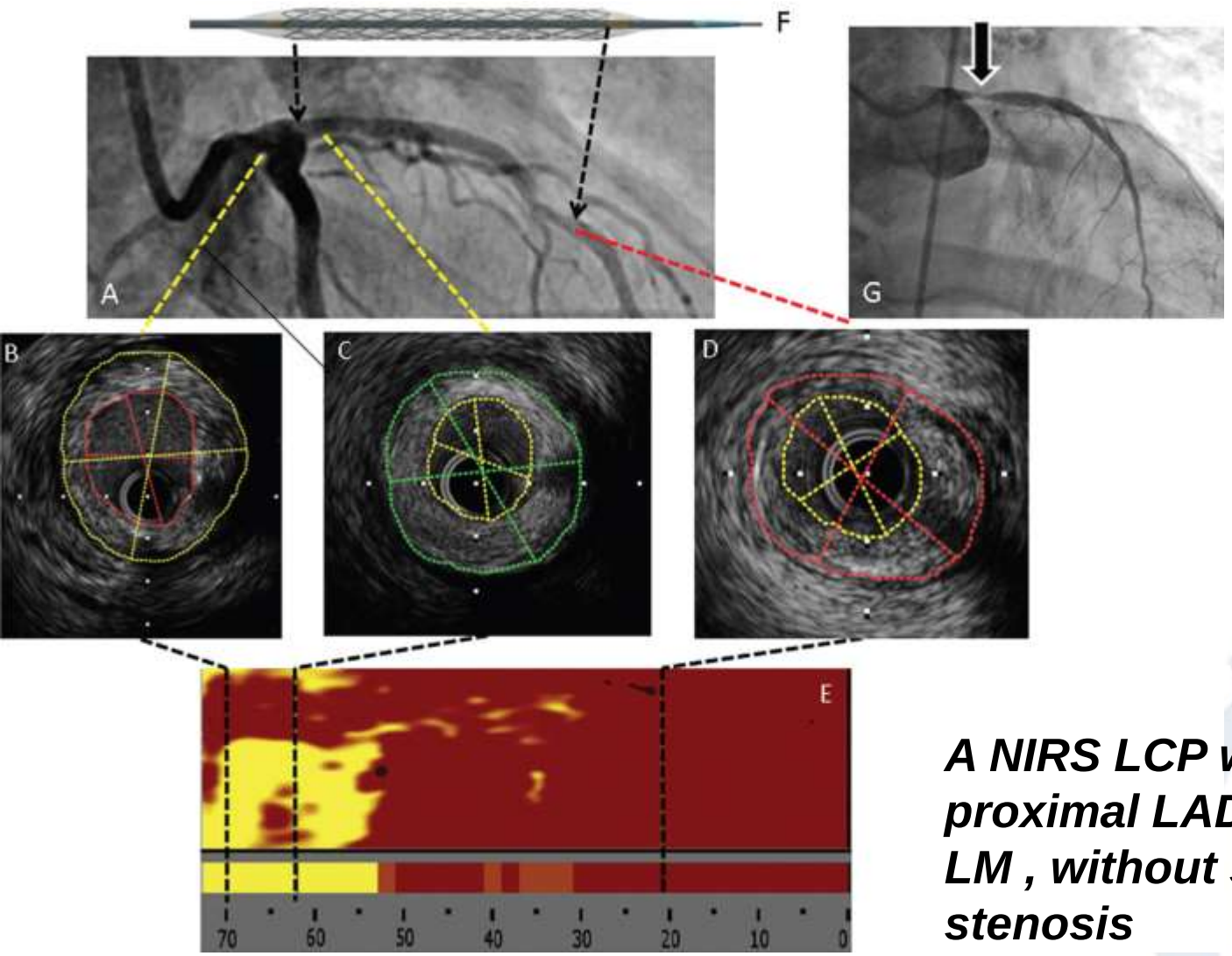


Increased stent length can lead to stent thrombosis
However, missing critical lesions with too short stent may be not good



Muller J E et al. JACC Img 2010;3:881-891

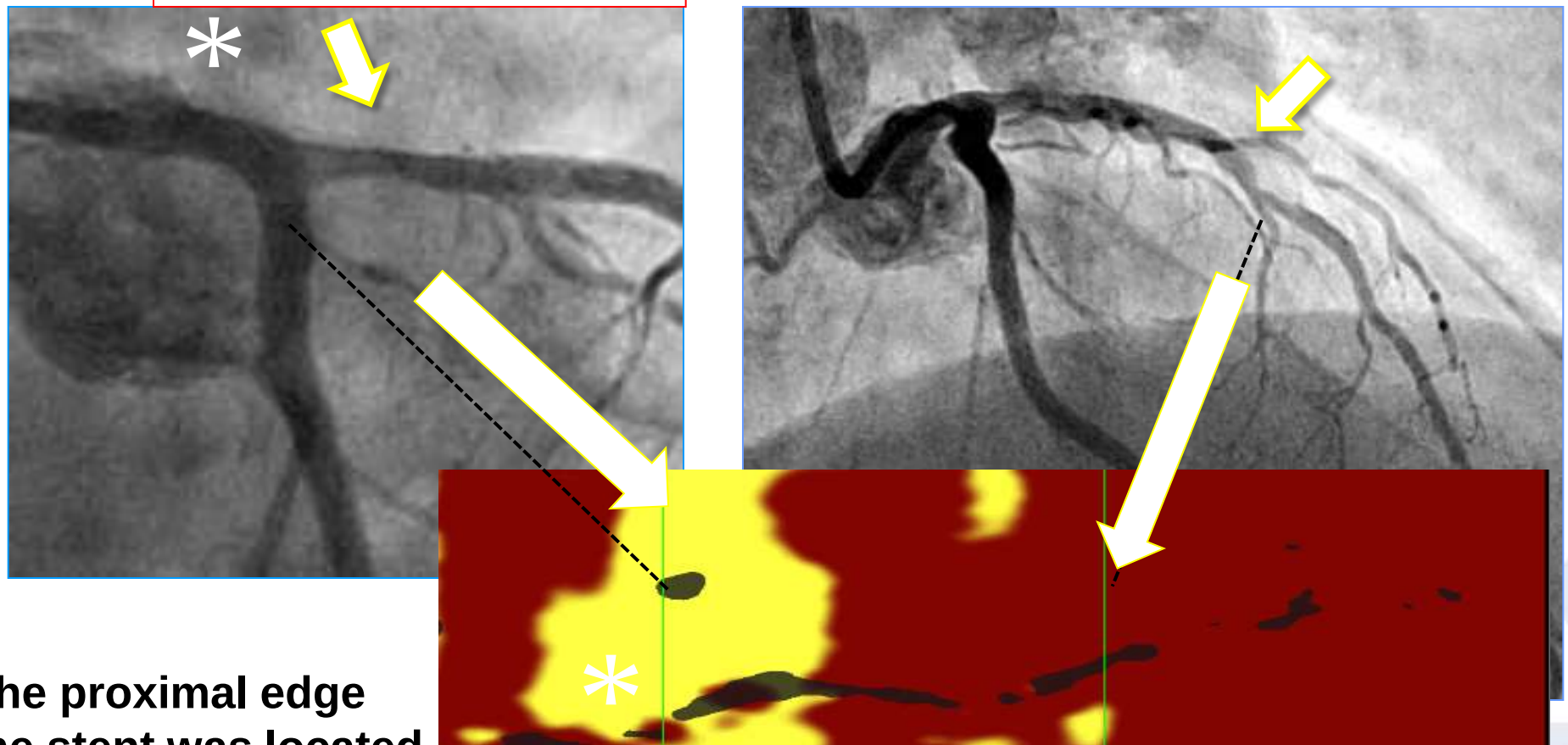
Hazards of Uncovered LCP



A NIRS LCP was identified in the proximal LAD extending into the LM , without significant LM stenosis

Prox LAD Plaque

Mid LAD Landing Zone



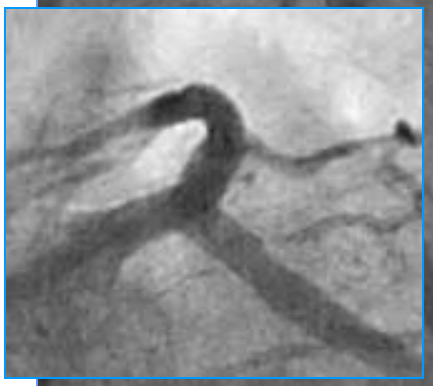
The proximal edge the stent was located in a lipid-core *without significant stenosis*

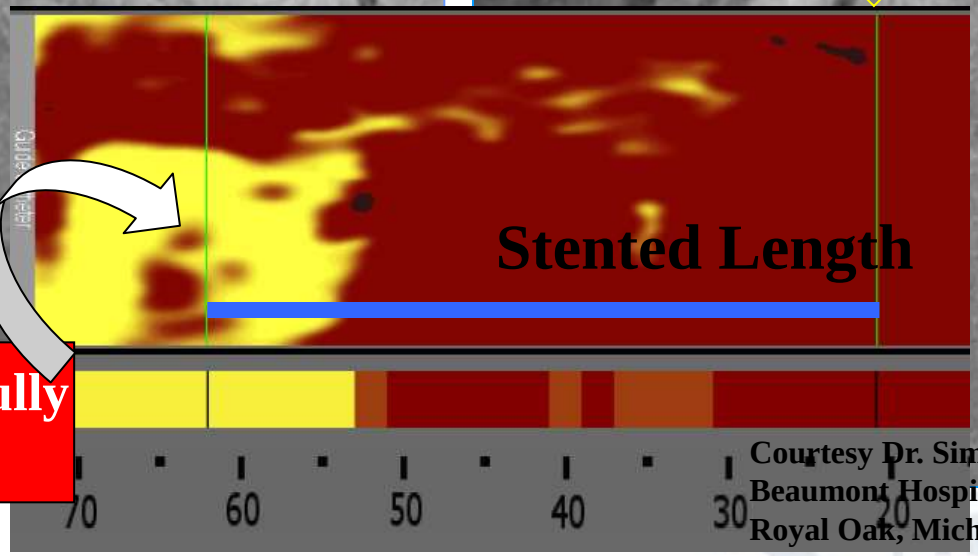
Prox Stent Edge

Looks good after stenting

Distal Stent Edge

Lipid Core Proximal to and Behind LAD Stent

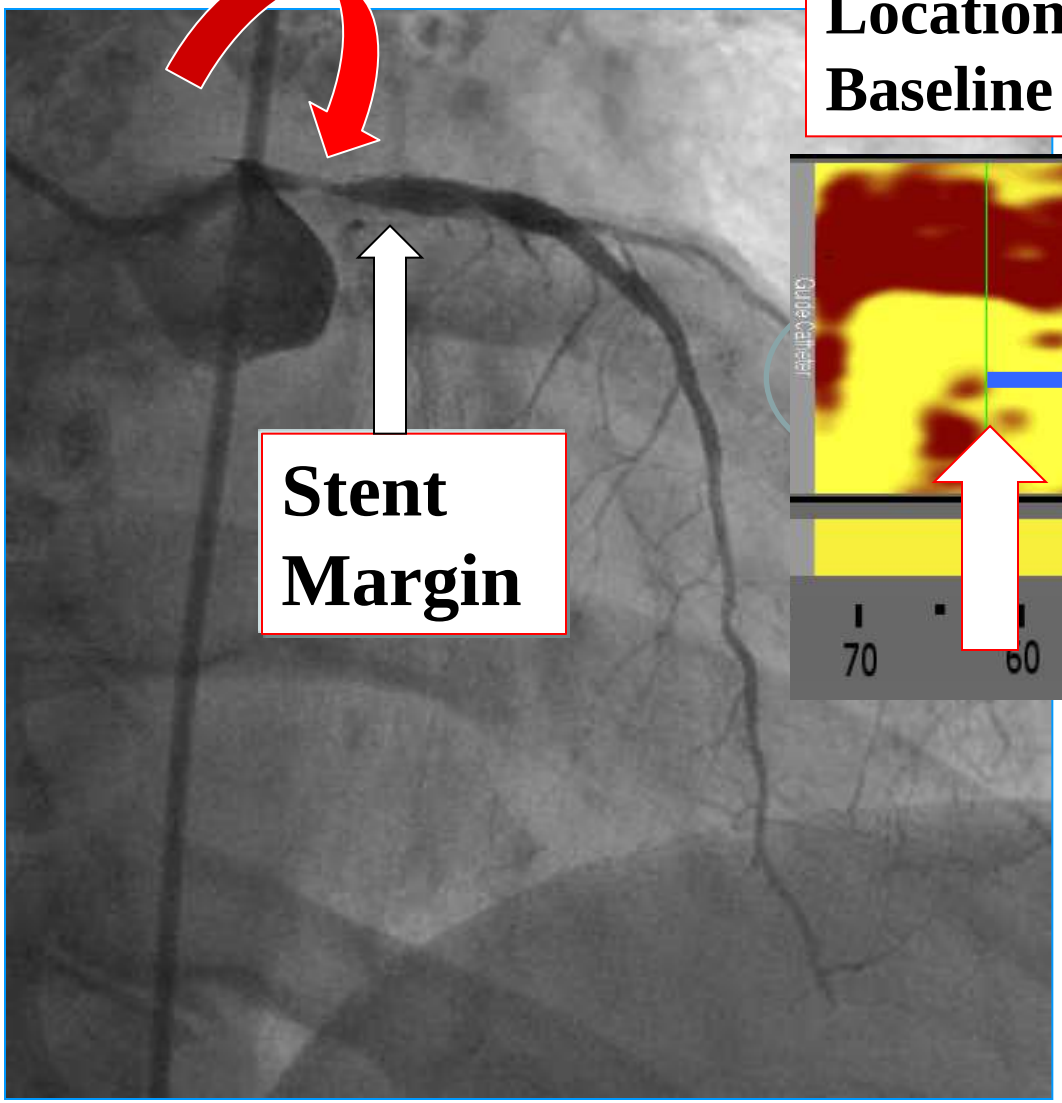




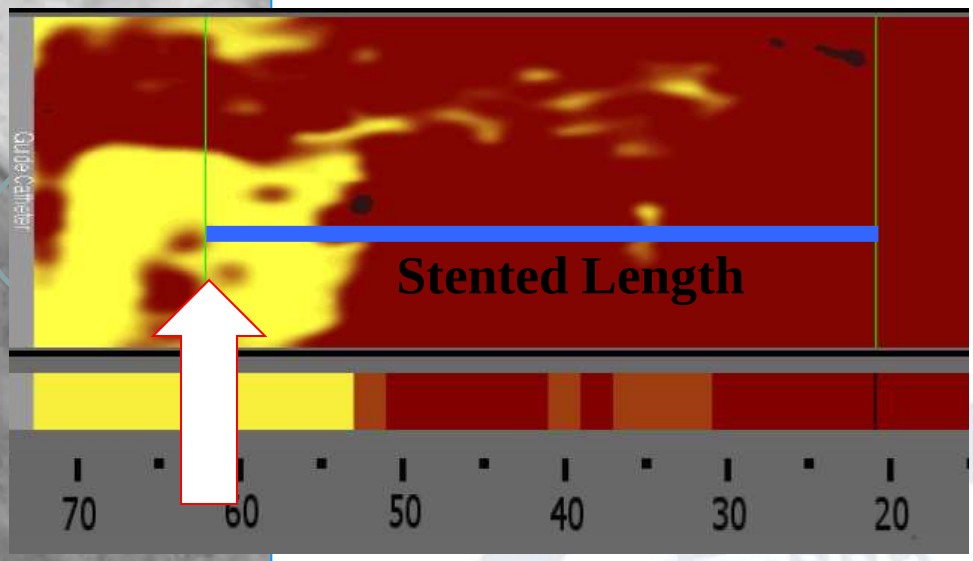
Large LCP was Not Fully Covered by DES

Courtesy Dr. Simon Dixon
Beaumont Hospital
Royal Oak, Michigan

6 Months Later --New LM Stenosis in Lipid Core Area Proximal to LAD Stent



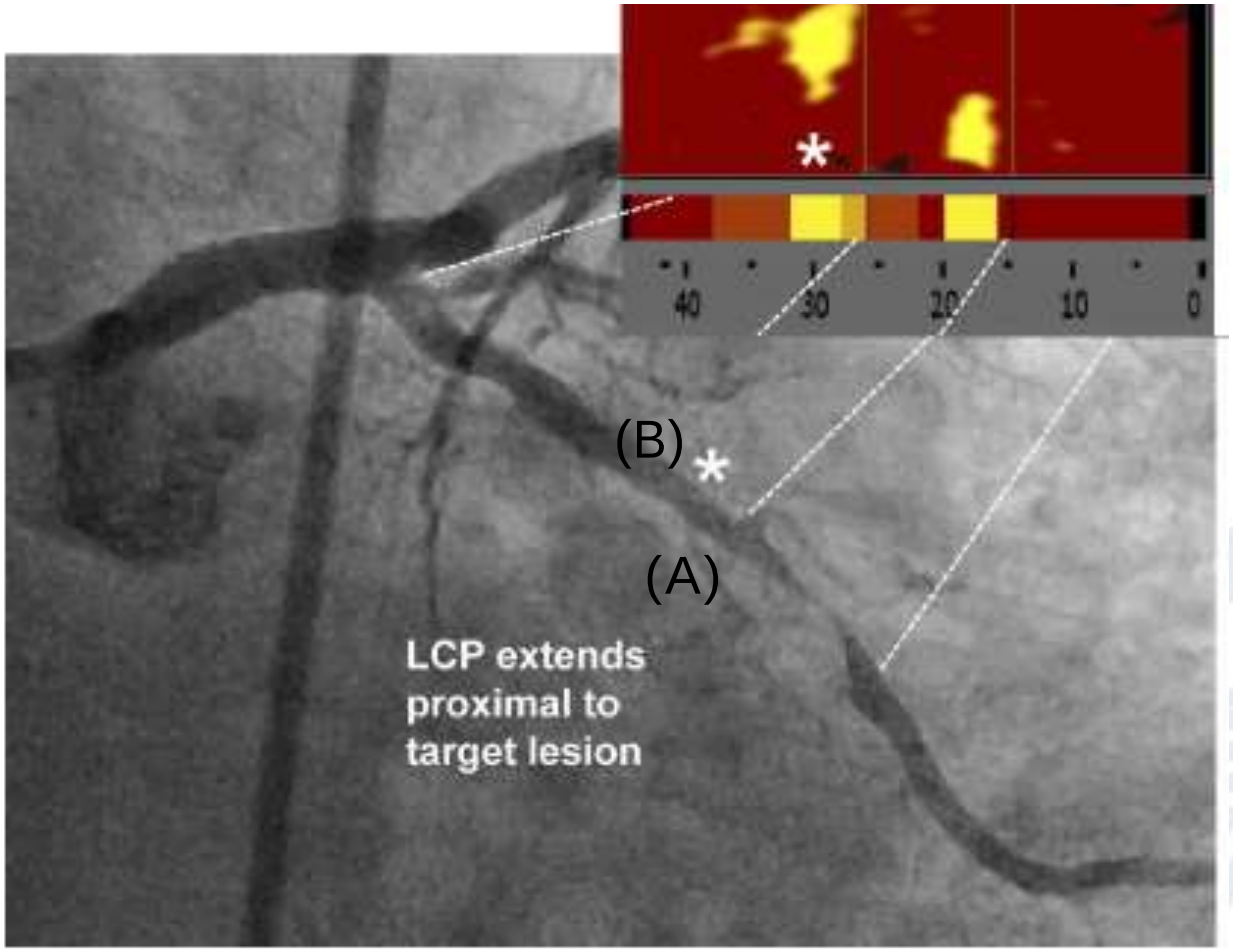
Location of Stent and LCP On Baseline Chemogram



Courtesy Dr. Simon Dixon
Beaumont Hospital
Royal Oak, Michigan

How to decide the Length of Vessel to Stent?

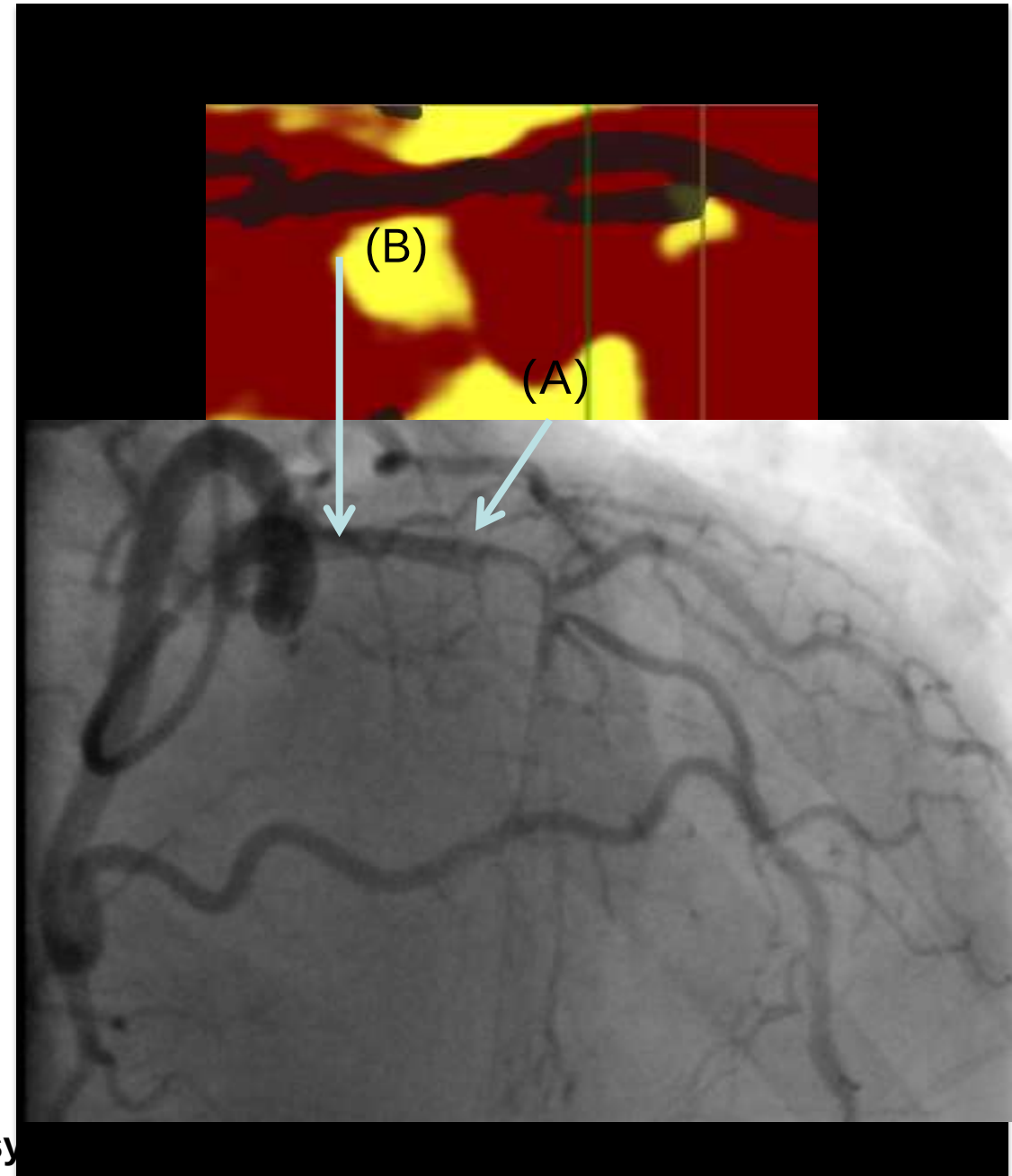
Too Long or Too Short?



Dixon et al. AJC 2011

Acute Anterior MI

- Abundant lipid core at culprit site (1)
- Additional large LCP proximal to culprit (2)



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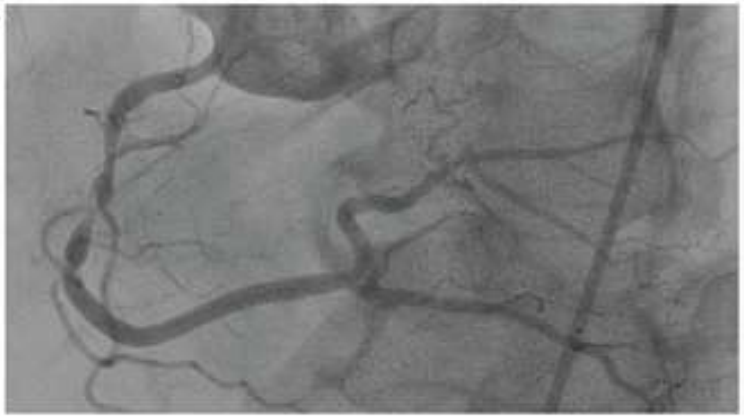
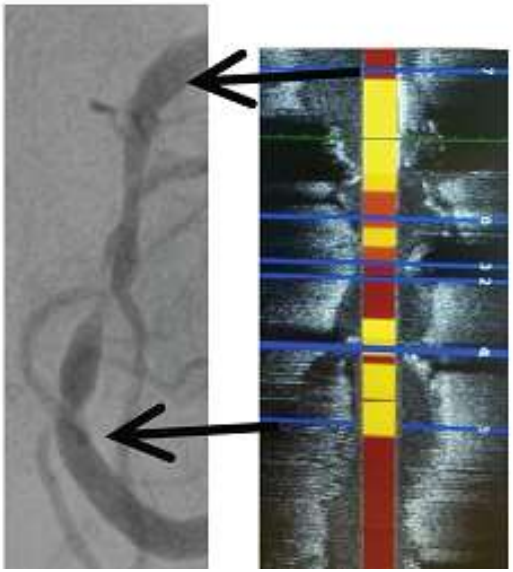
Implanting a Stent according to the edge of the LCP

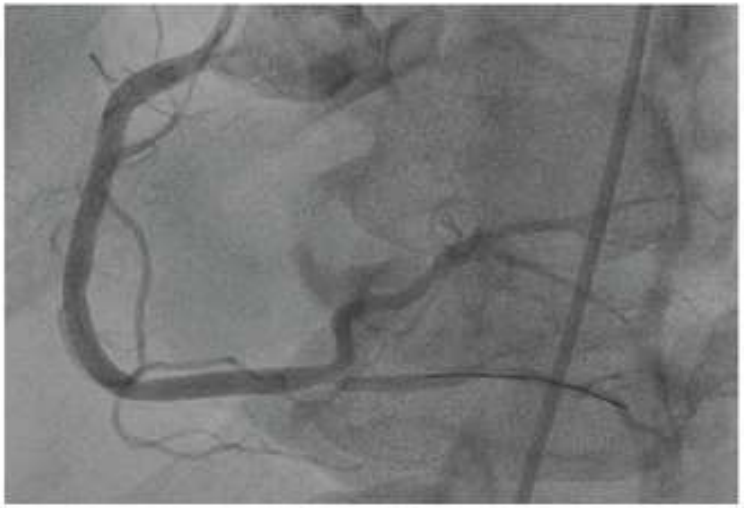
A.



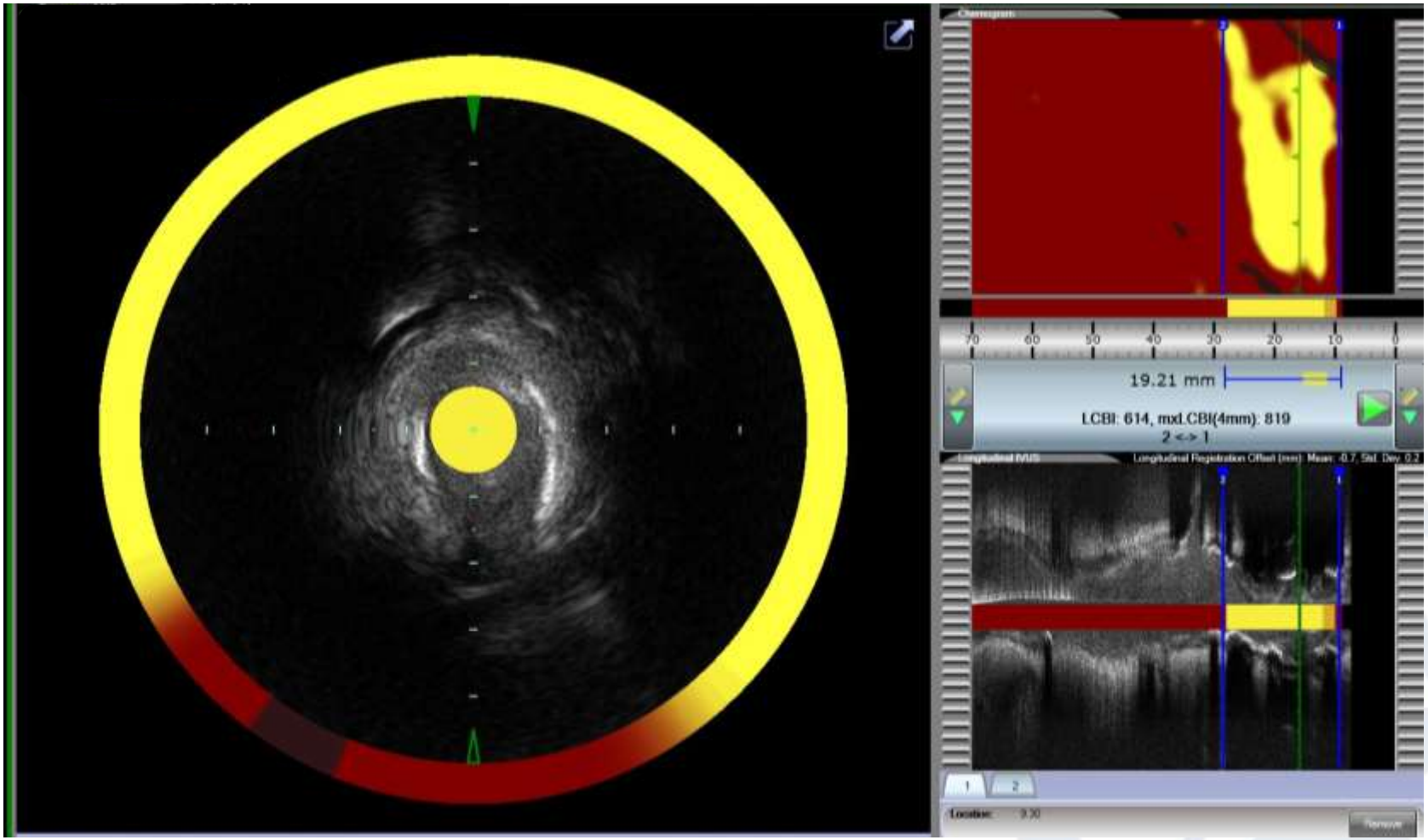
B.



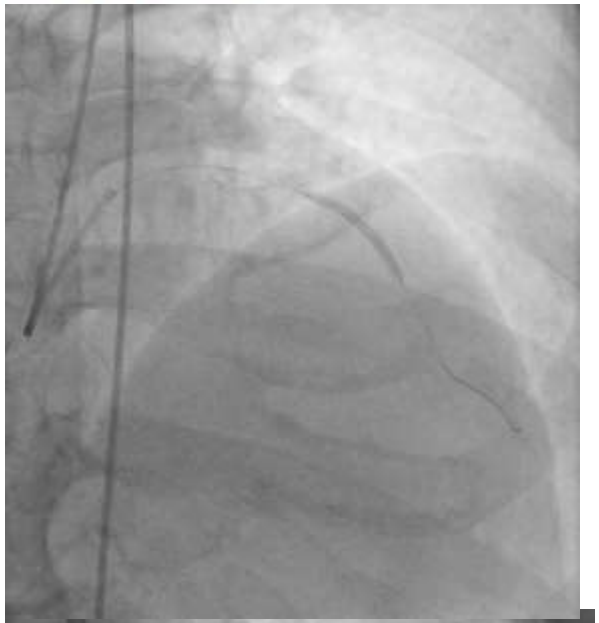
C.

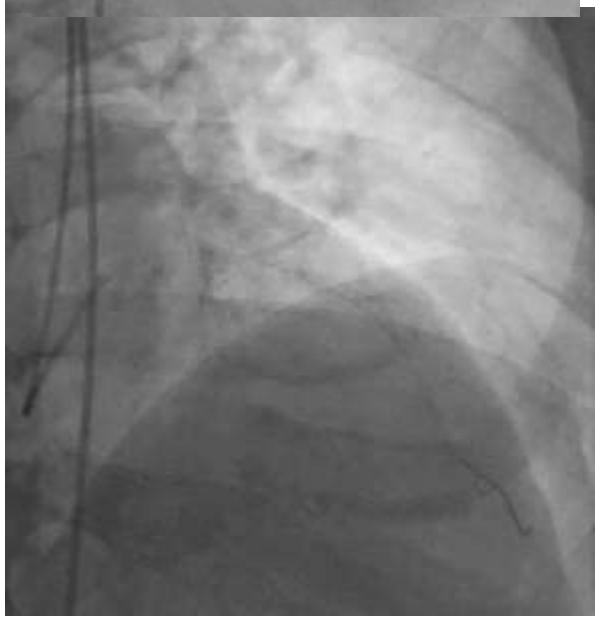


Case – Linking NIRS LCP to Distal Embolization During PCI

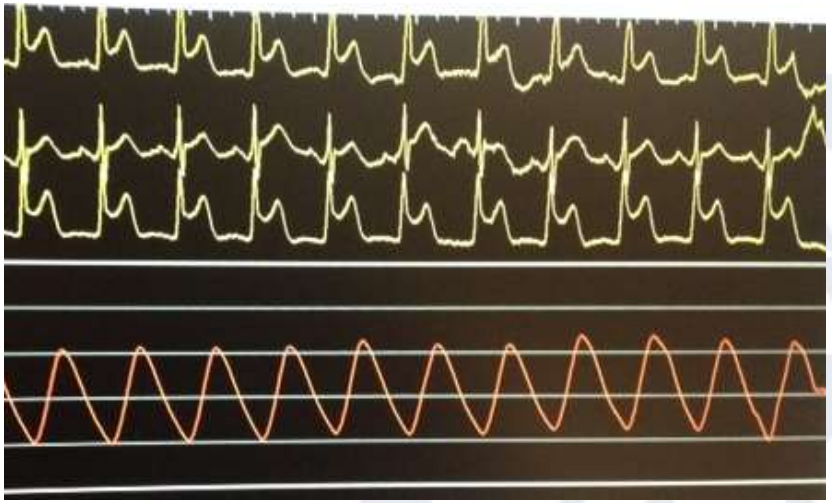


Post stent deployment



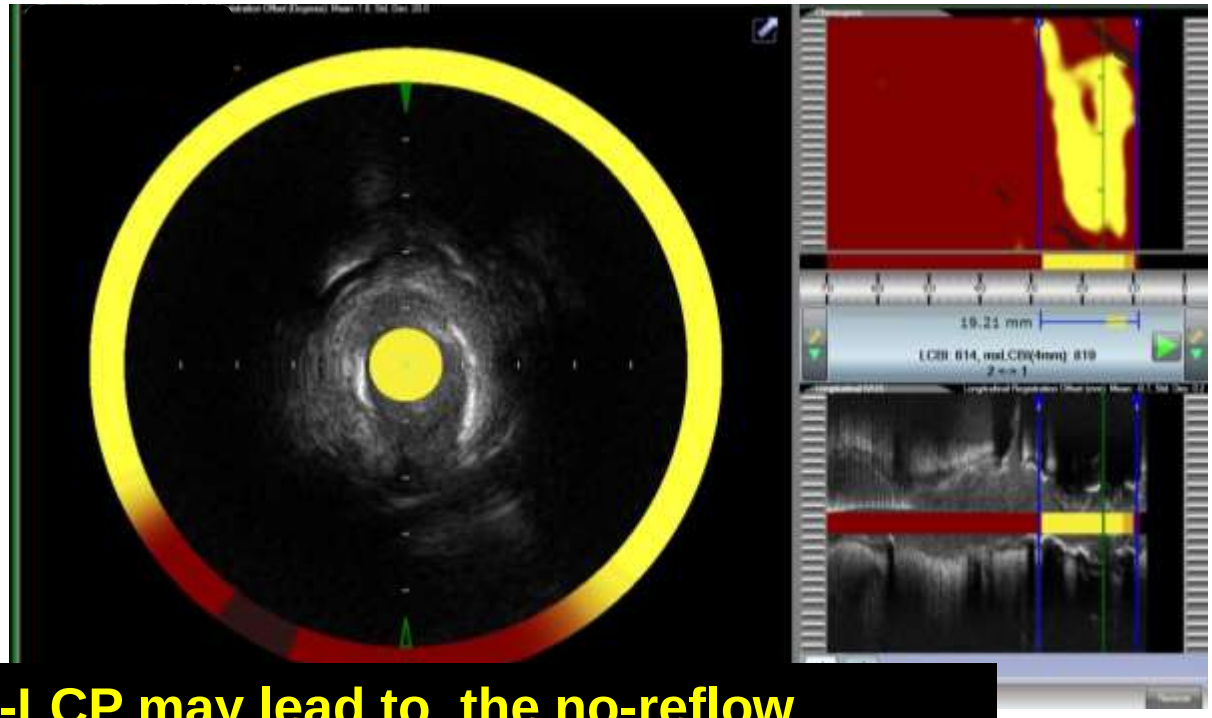


Severe chest pain and ST-elevation occurred!



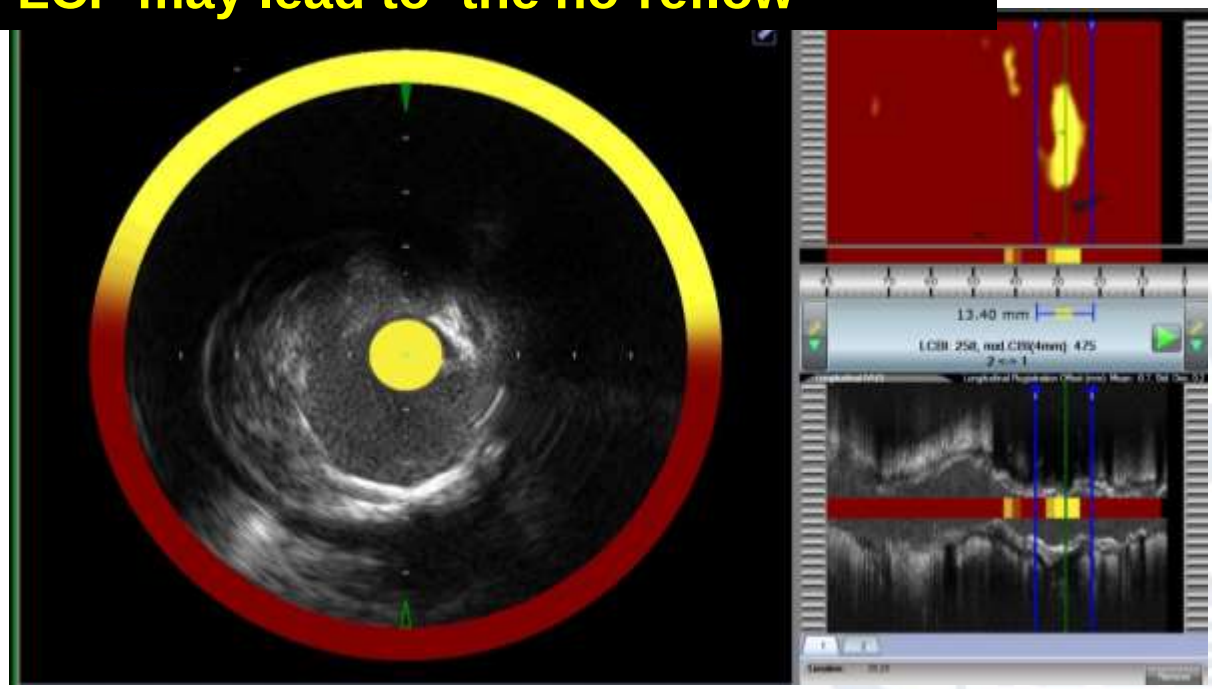
NIRS imaging

Before

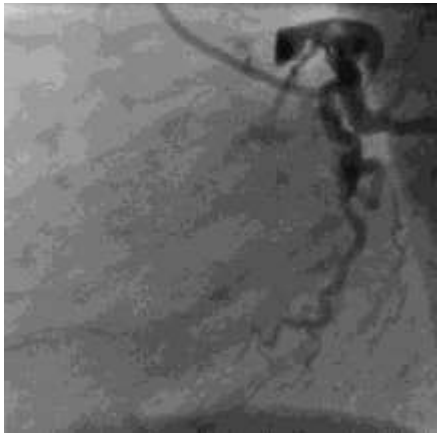


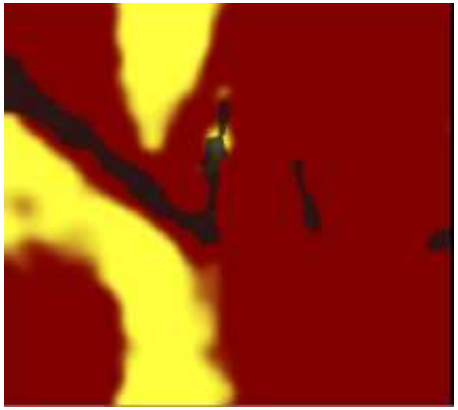
The deceased of HR-LCP may lead to the no-reflow

After



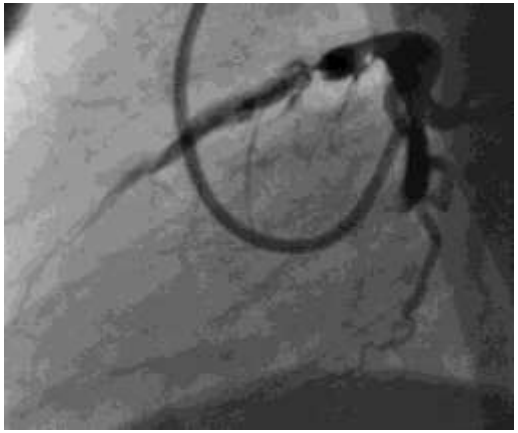
Reduced lipid core by aspiration can be detected by NIRS

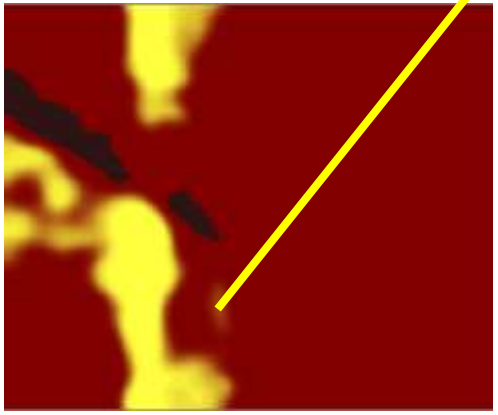




LCBI: 604

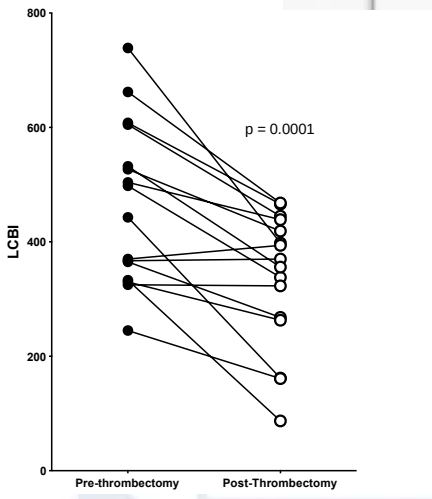
Thrombectomy





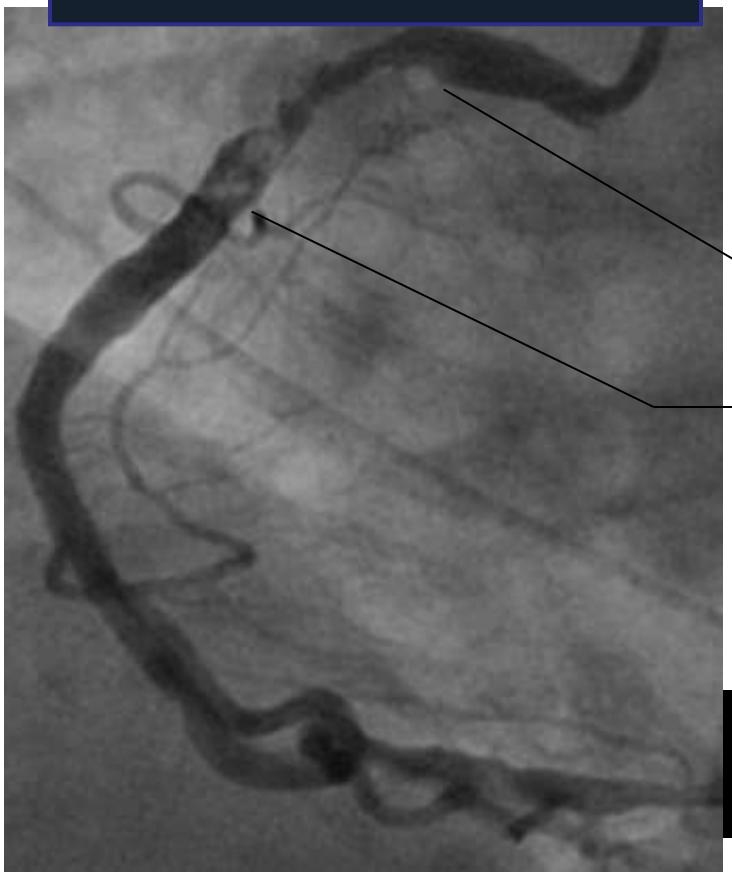
LCBI: 466

Lipid-rich Aspirate

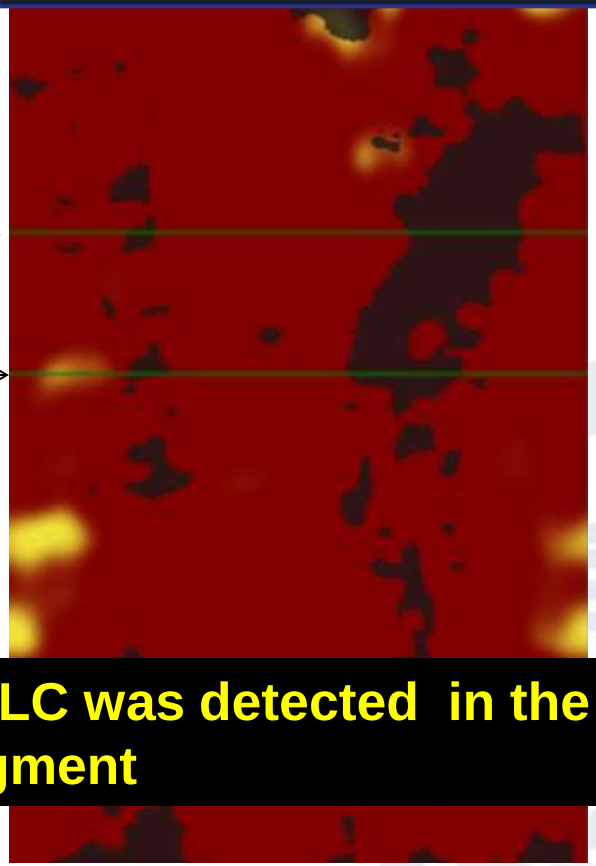


56 Year Old Female with Inferior STEMI

Initial Angiogram:
Large Thrombus in Proximal RCA

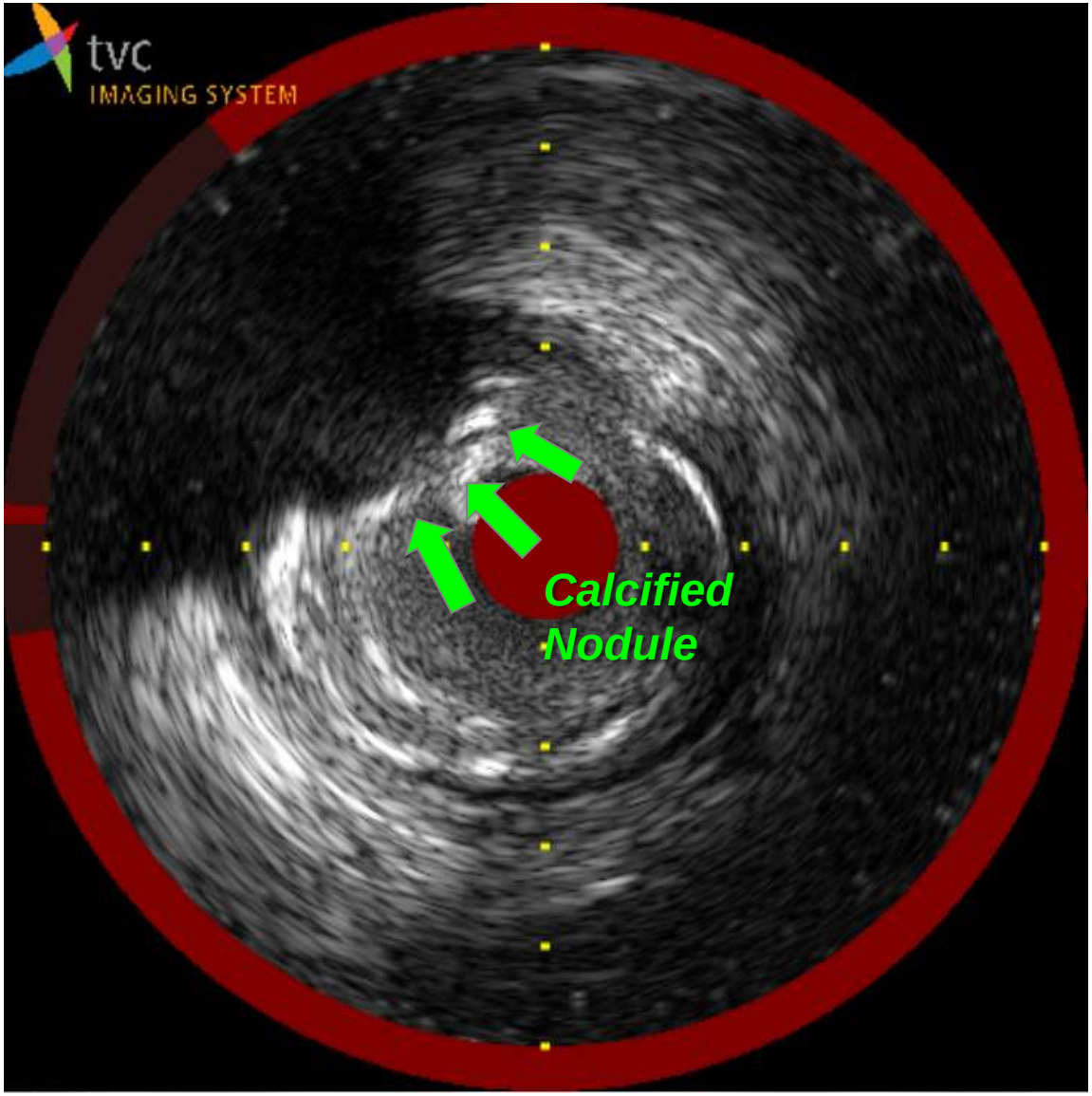


Chemogram:
No LCP in Culprit Segment



No LC was detected in the Culprit Segment

STEMI caused by Calcified Nodule without LC



Calcified Nodule in the STEMI Culprit Segment

NIRS –IVUS Imaging Clinical Applications

Optimal Stenting Procedures

- **Measure Length of Vessel to Stent**
  - Precise Stent Length
- **Optimal Stent Expansion**
  - Minimize Subacute & Late Thombosis Restenosis
- **Characterize Lesions at Embolic Risk**
  - Distal Protection Devices

Plaque Characterization