IVUS EXPLOSION
The Latest Data, The Latest Tips and Tricks

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Clinical History

Age: 48 y Gender: Female

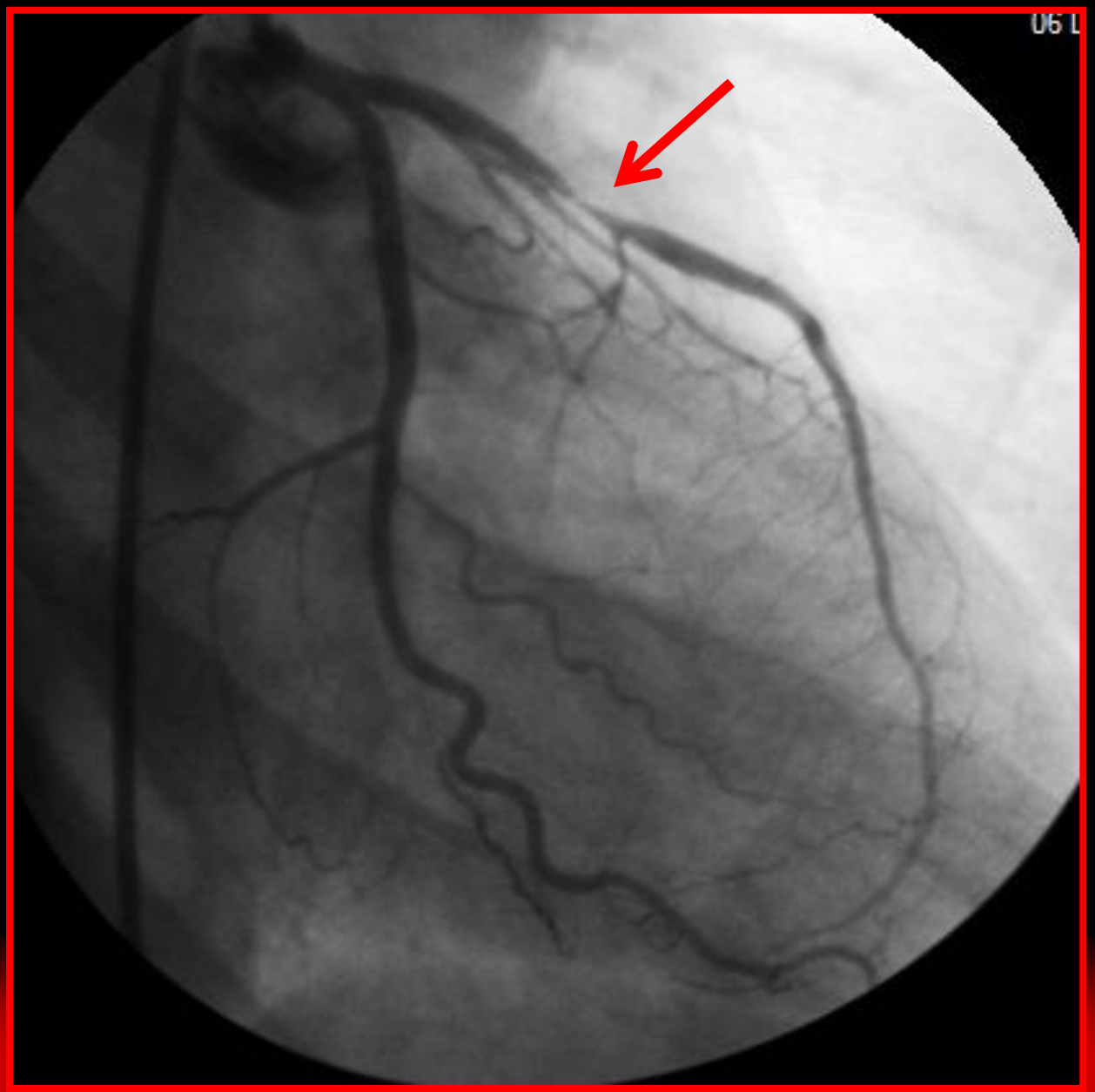
No risk factor for CAD

Presented in 09/2005 with recent onset of chest pain during moderate exercise .

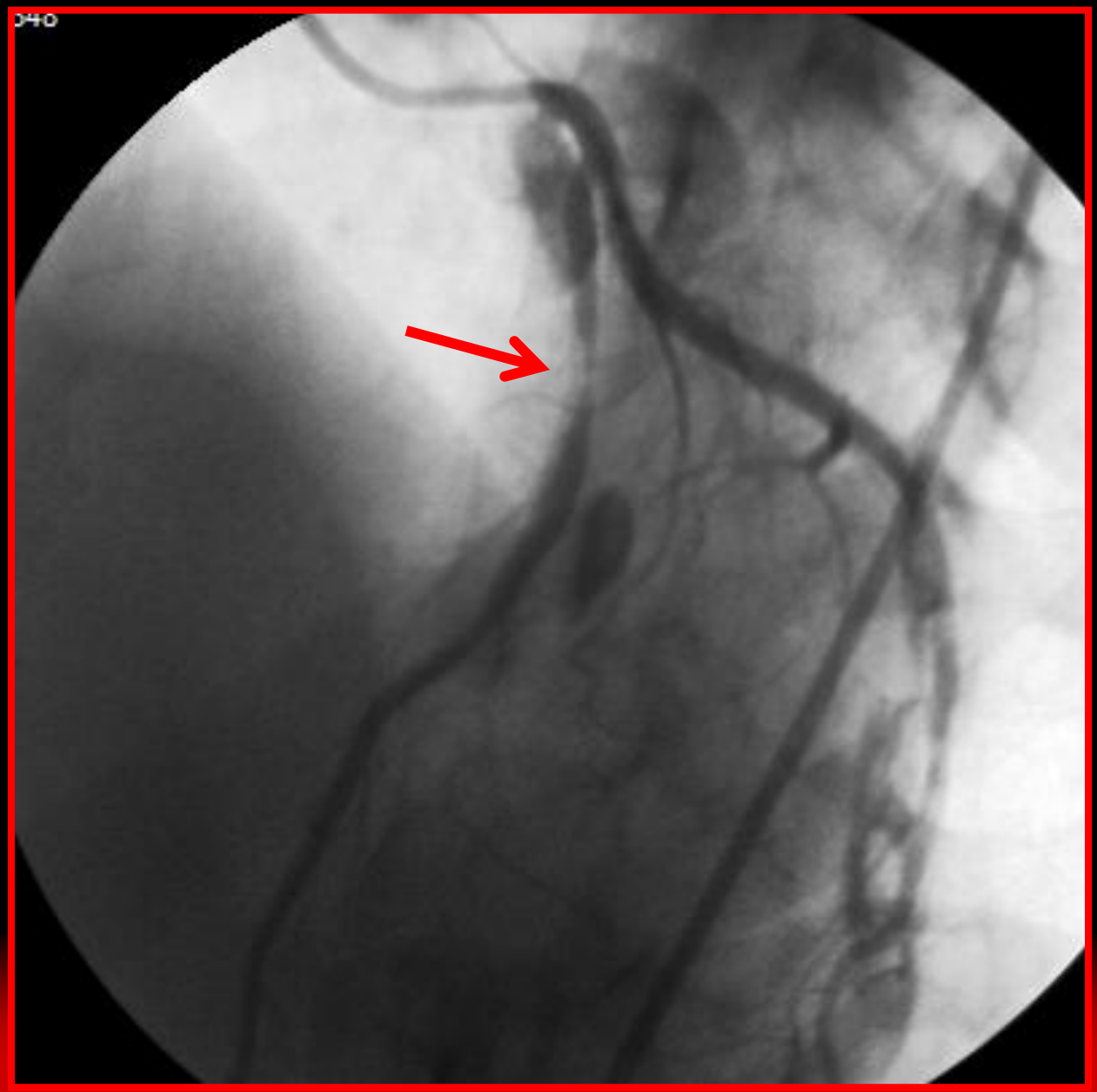
- **Medications : B-Blockers, Statins , and ASA**

- **Anterior Ischemia in the Nuclear Study**

December/ 2005



December/ 2005



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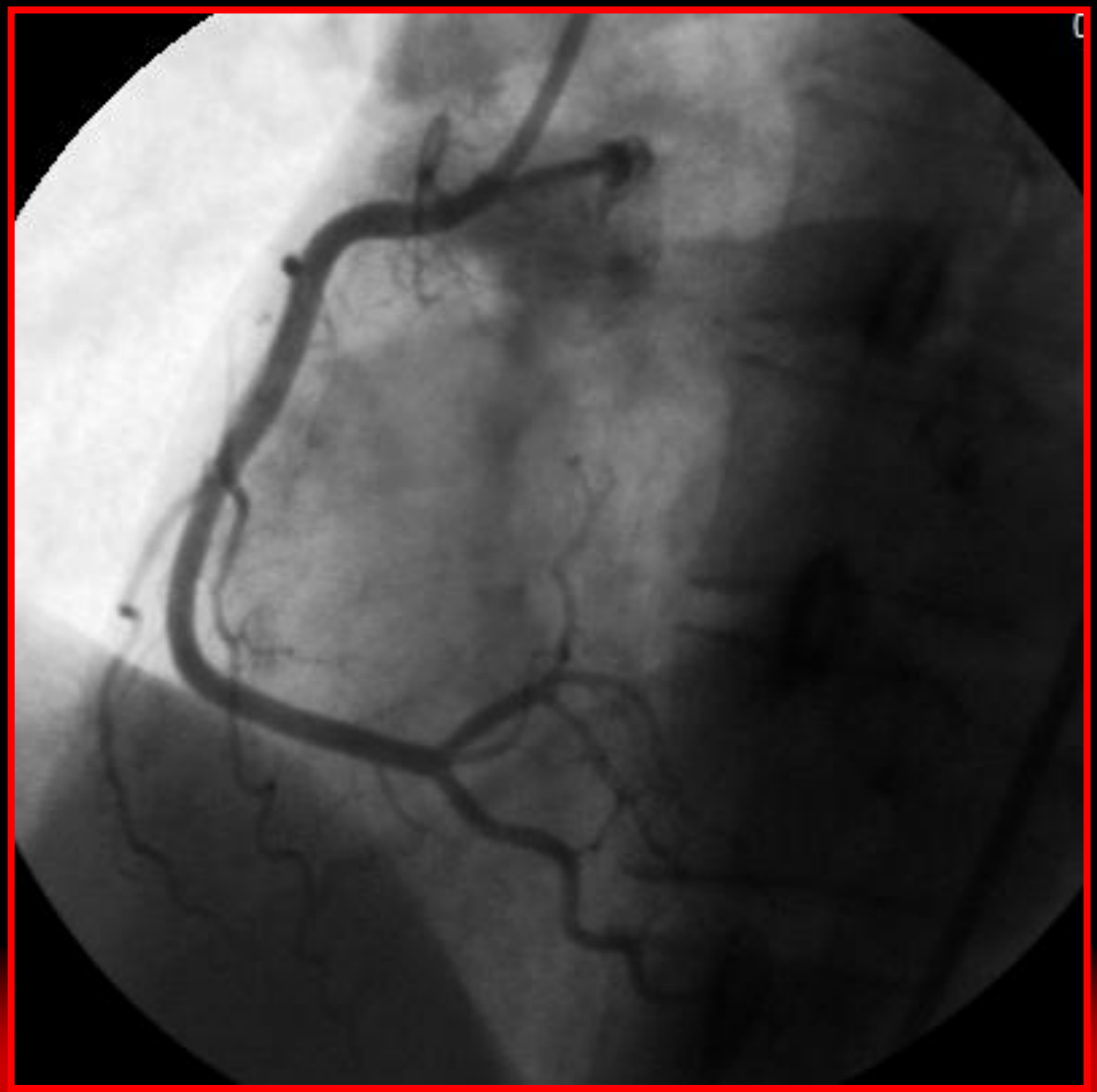

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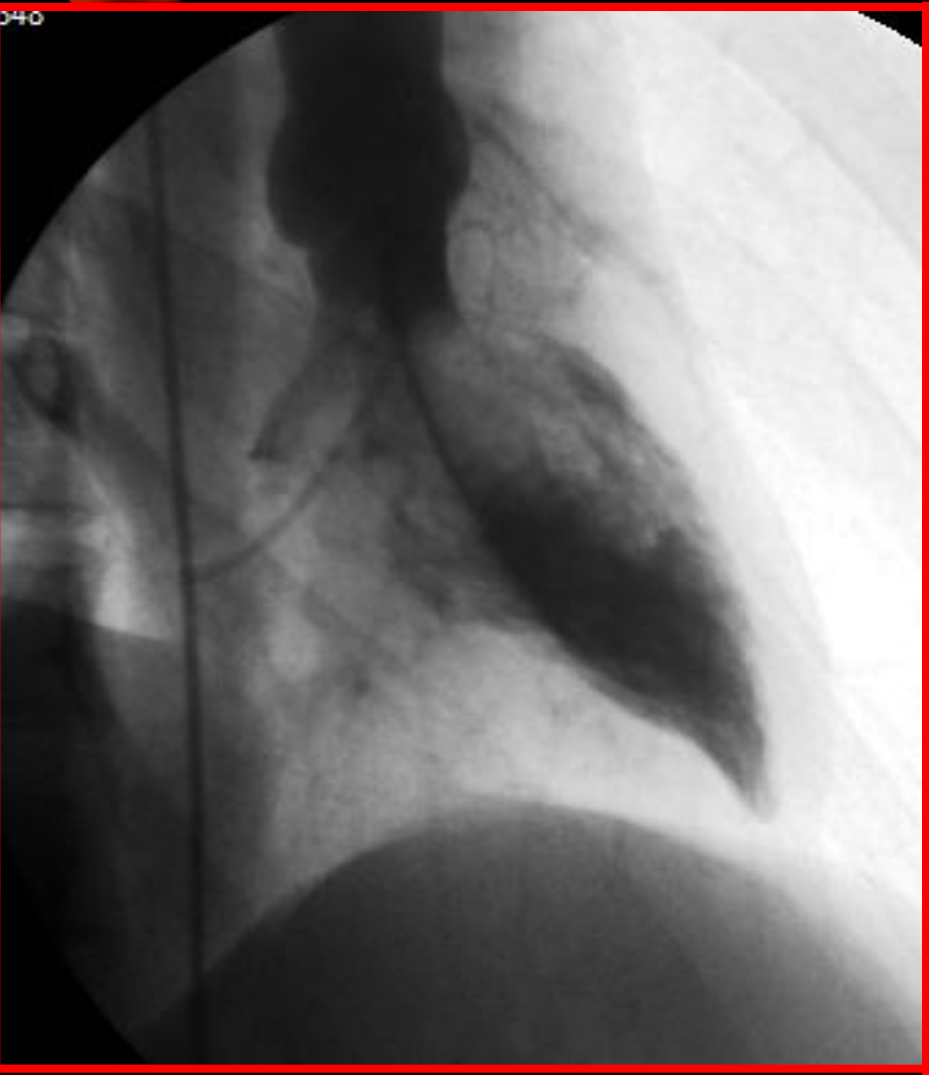
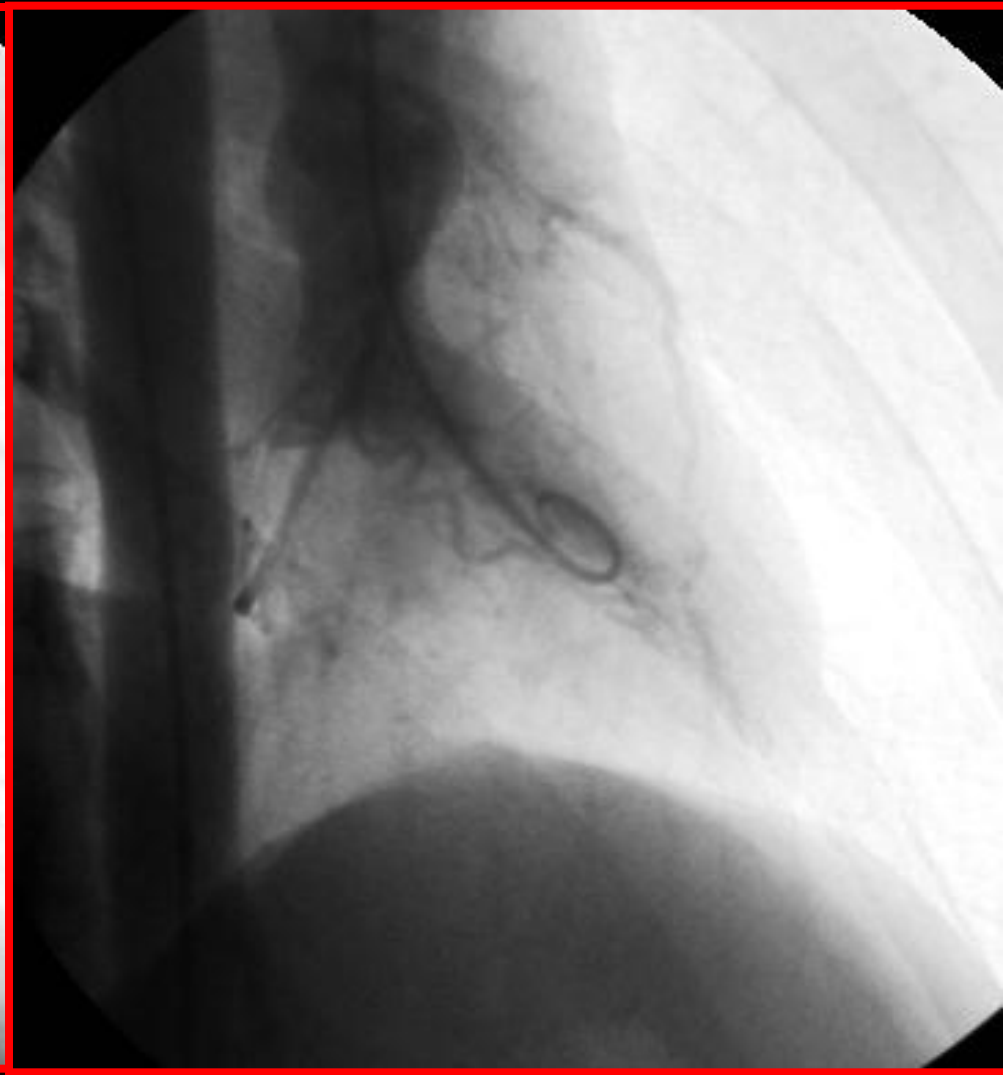
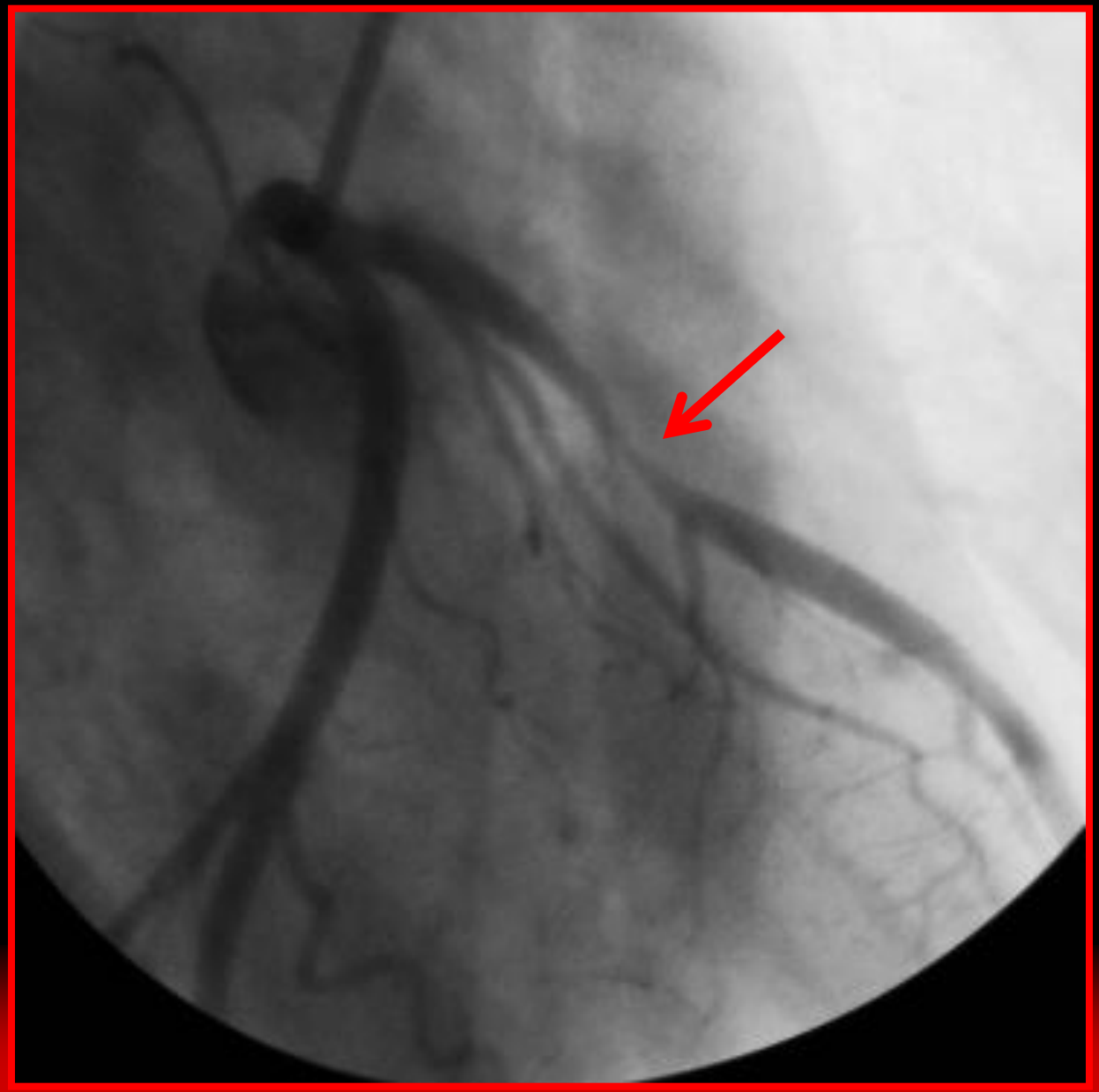
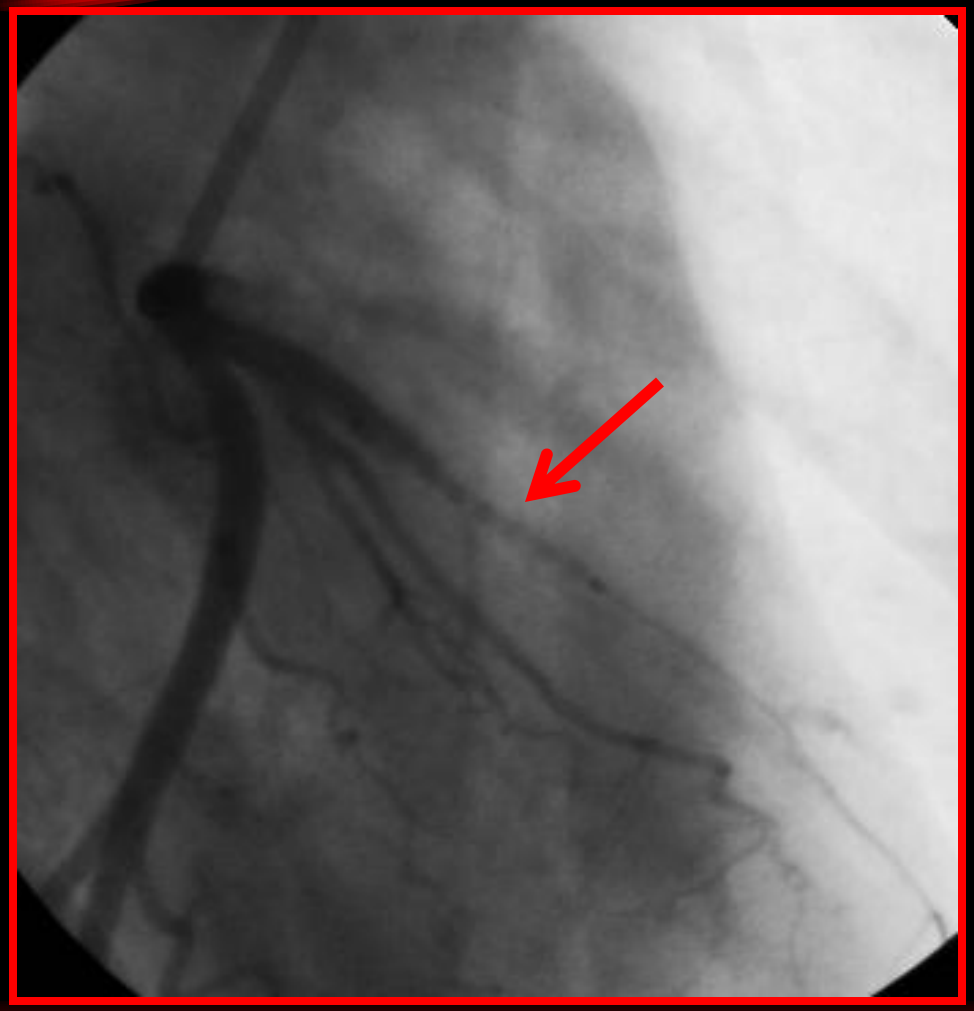


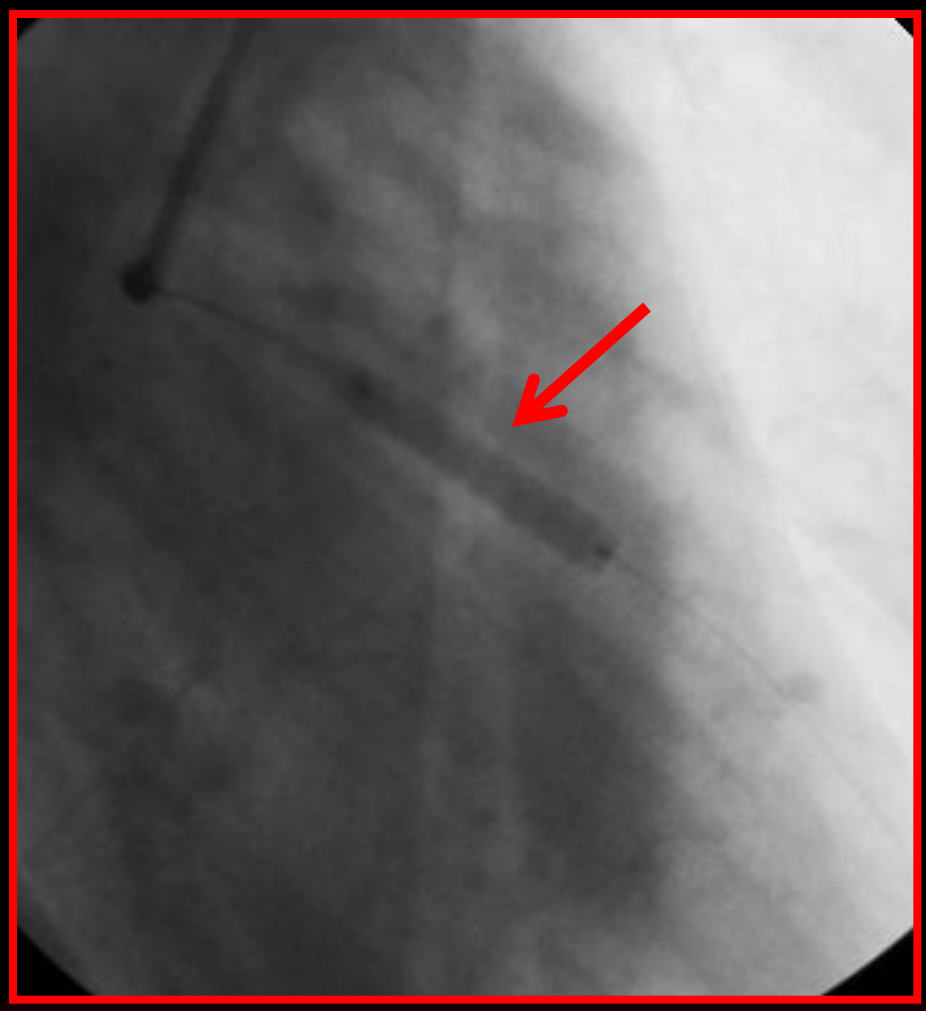


December/ 2005 : PCI

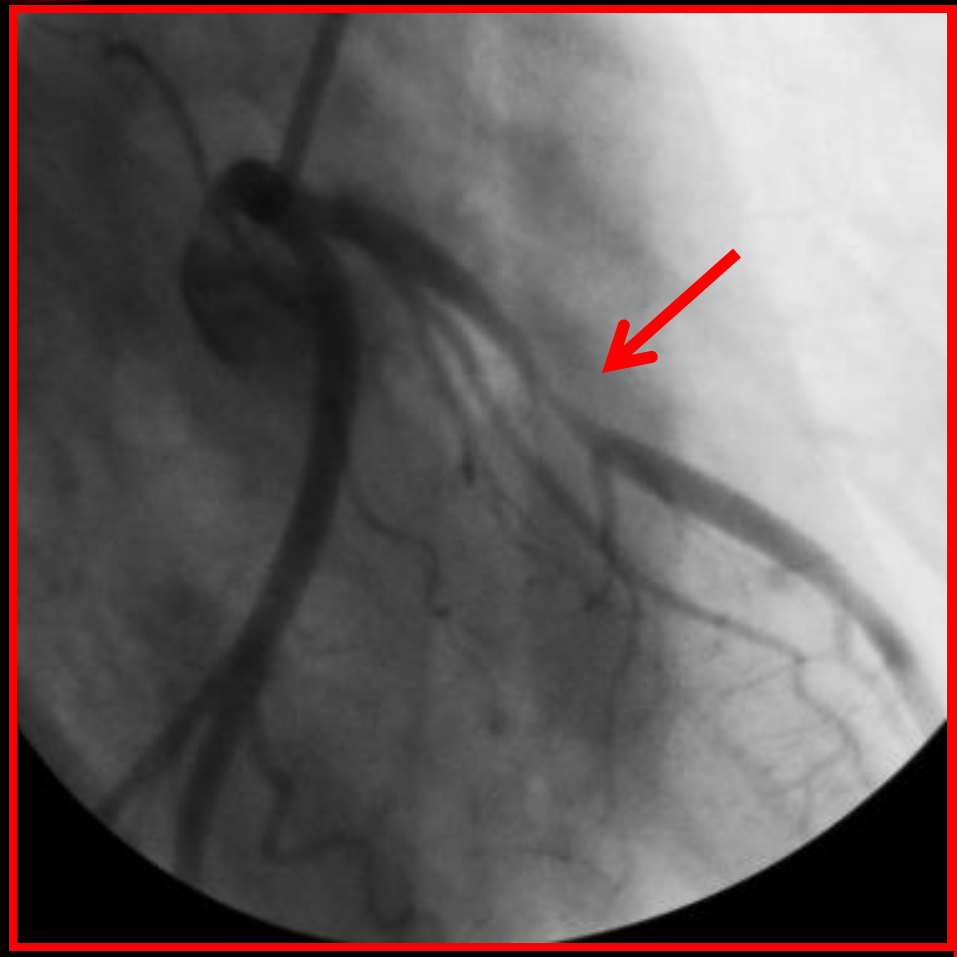


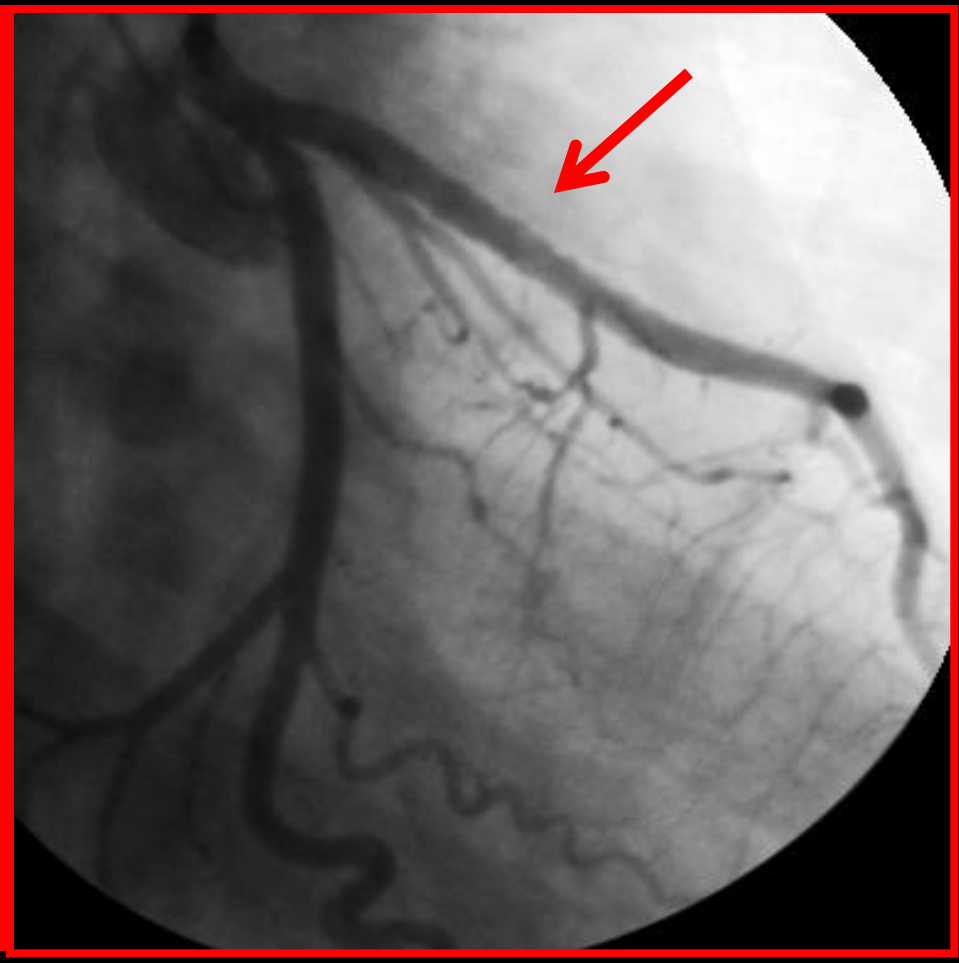
December/ 2005 : PCI-Cypher 3.5/18mm



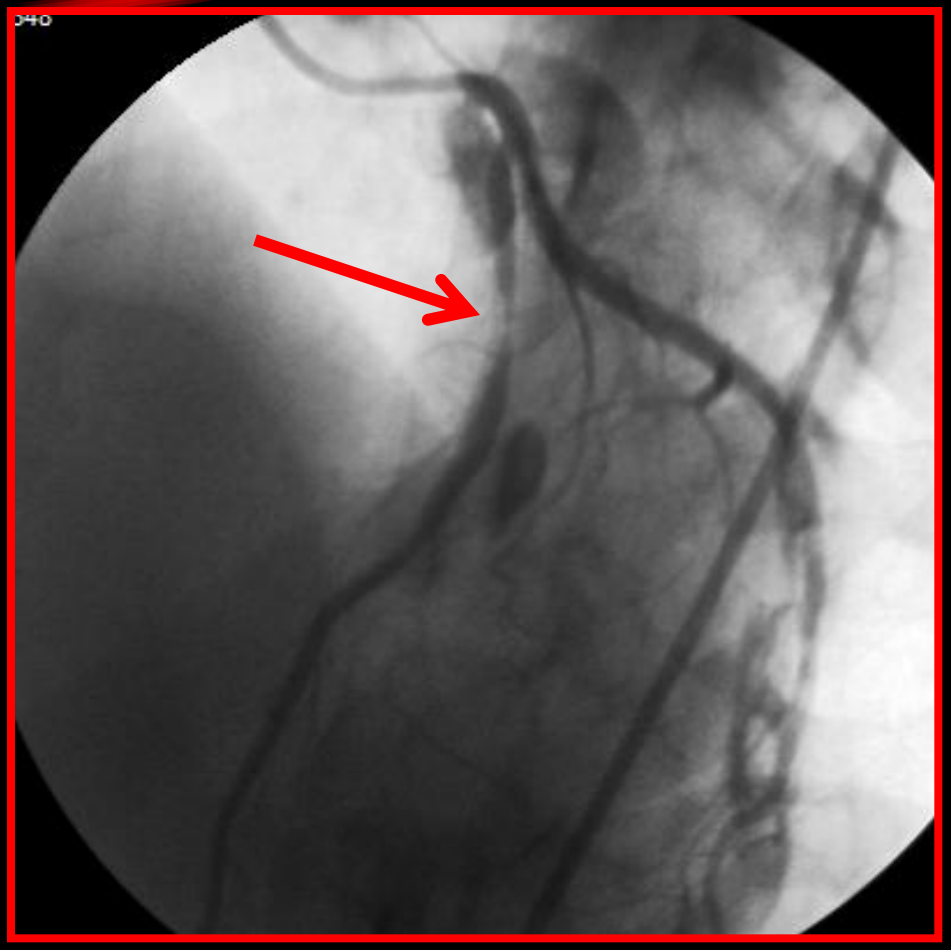


December/ 2005 : Post Cypher 3.5/18mm





December/ 2005 : Post Cypher 3.5/18mm



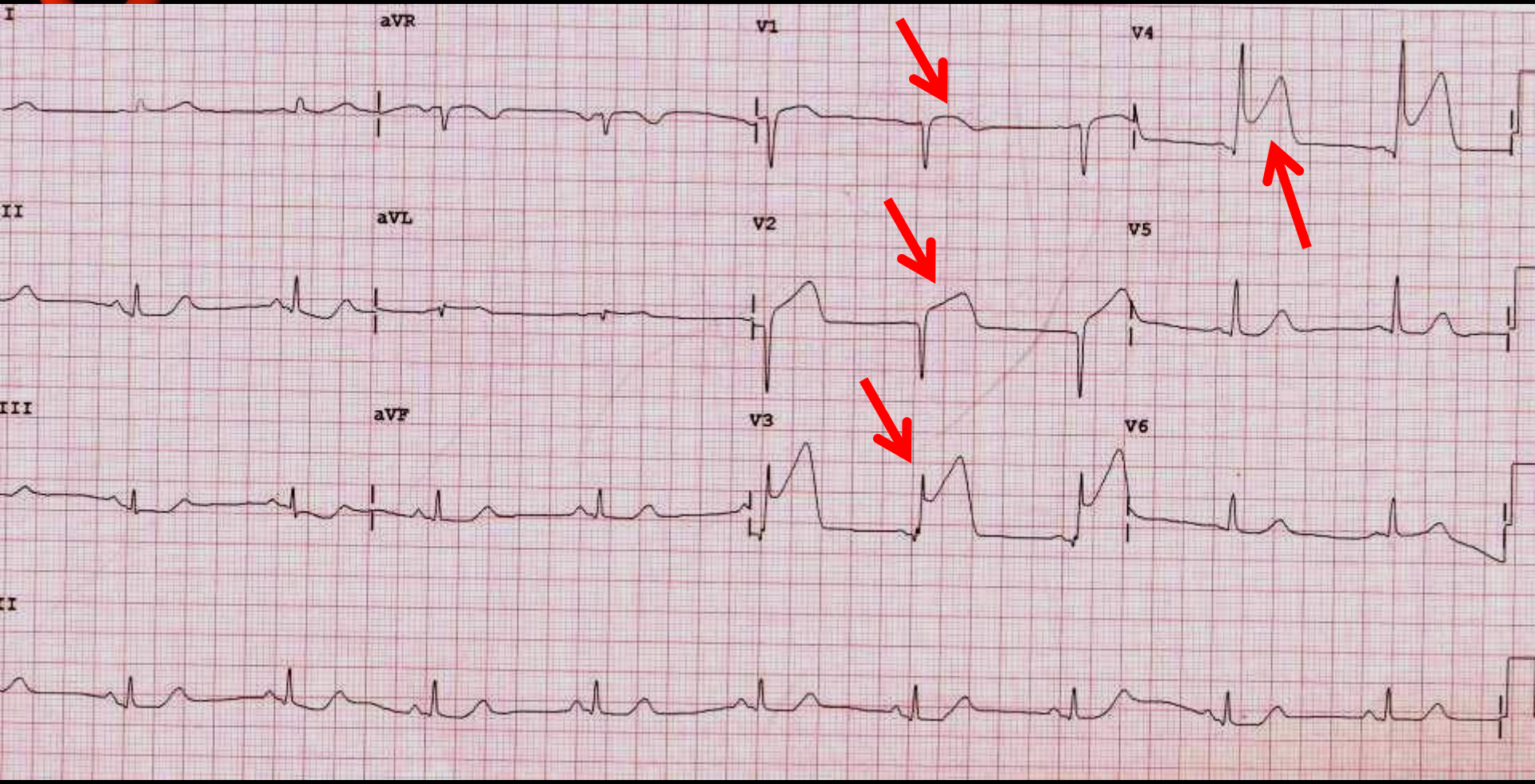
Clinical History II : October / 2008

Age: 51 y Gender: Female

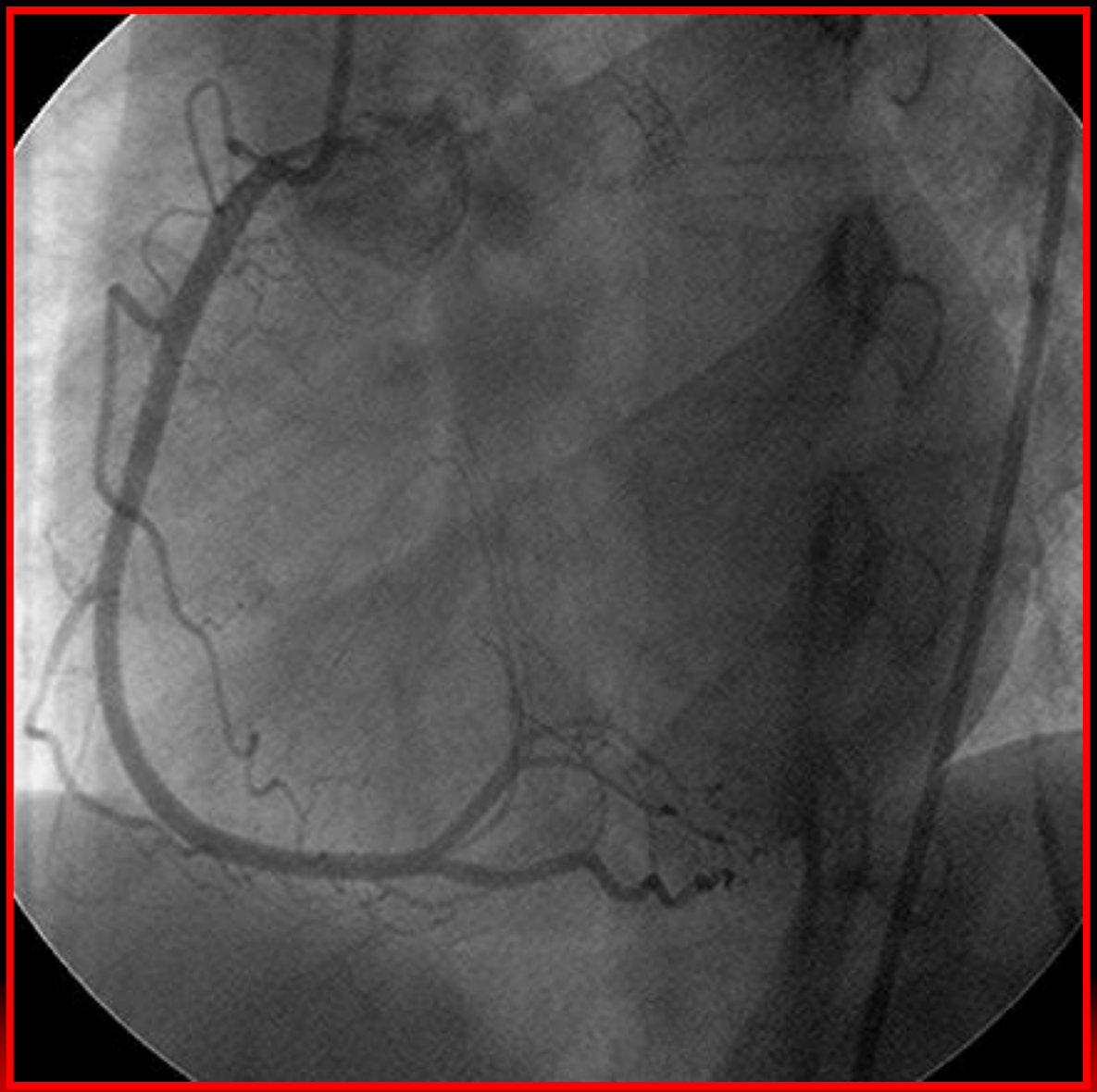
- **Cypher implantation in 12 / 2005**

Presented with severe chest pain at rest at MER

October 22nd / 2008

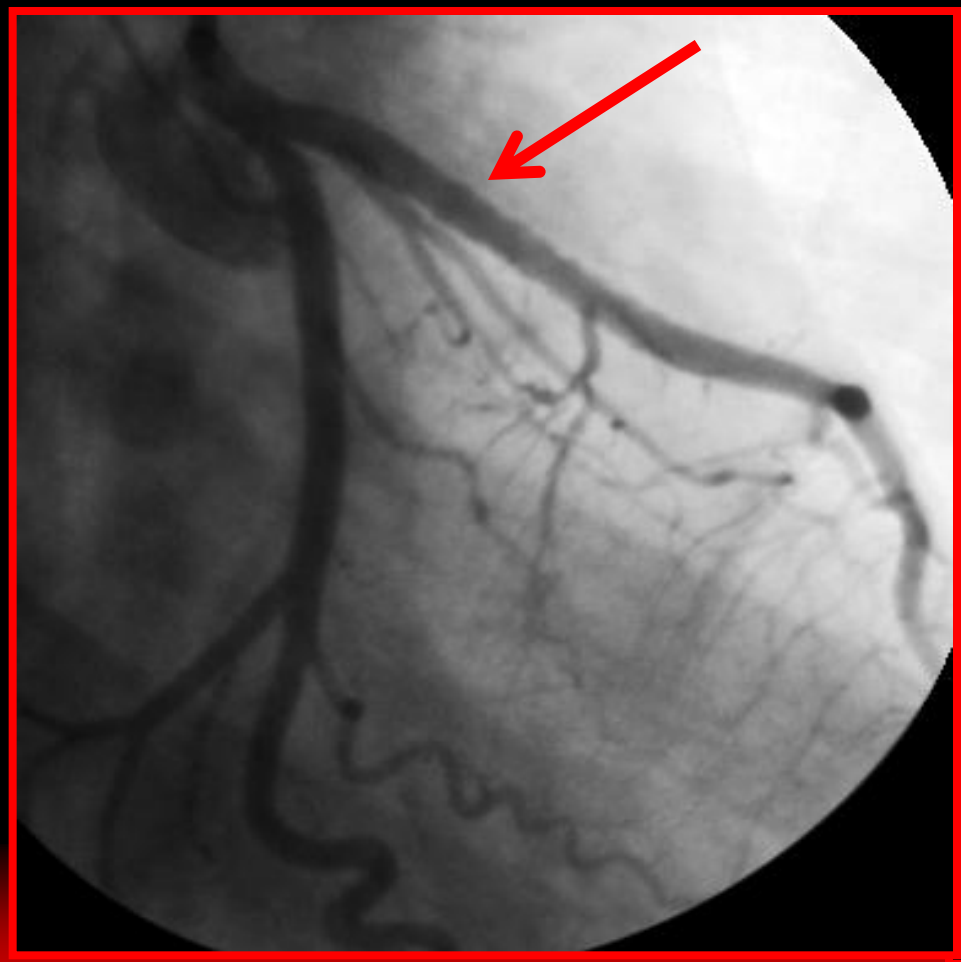


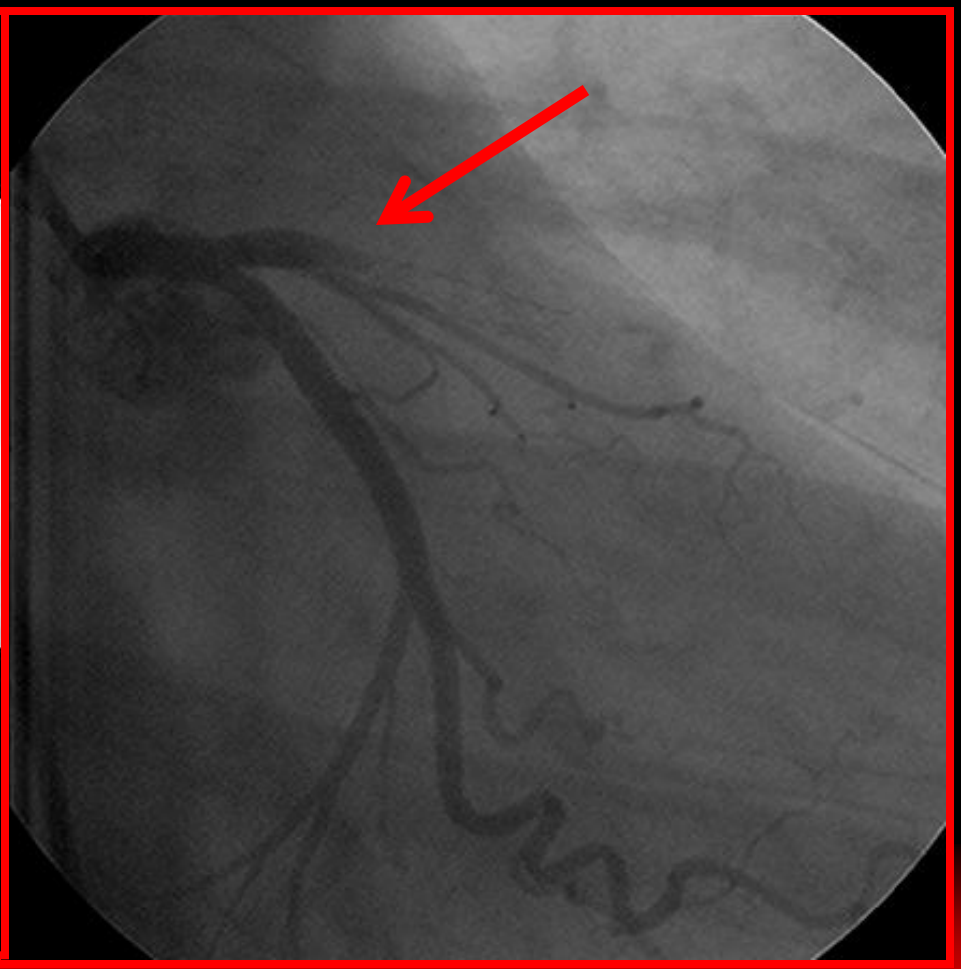
October 22nd / 2008



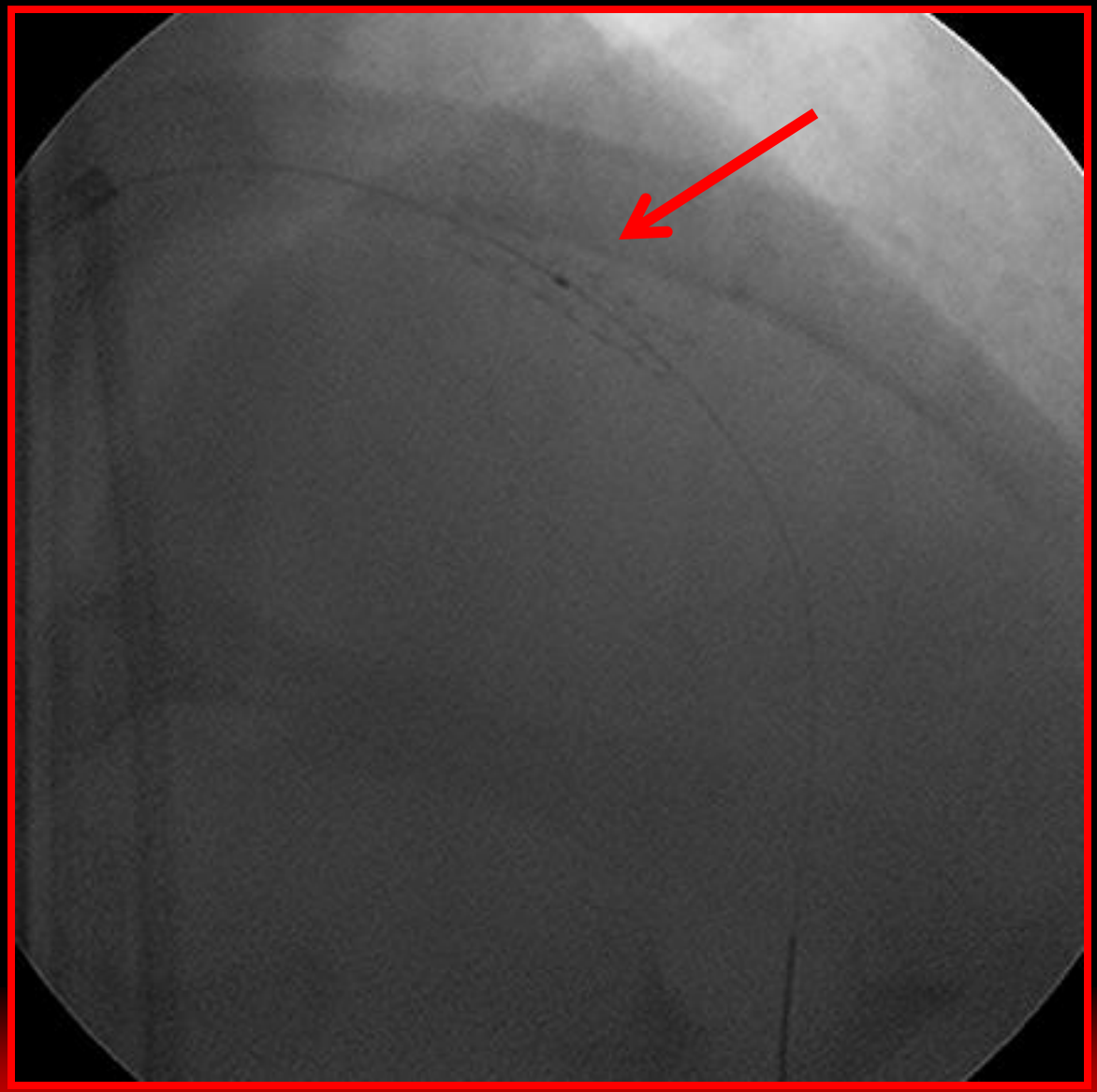
December/2005

October/2008

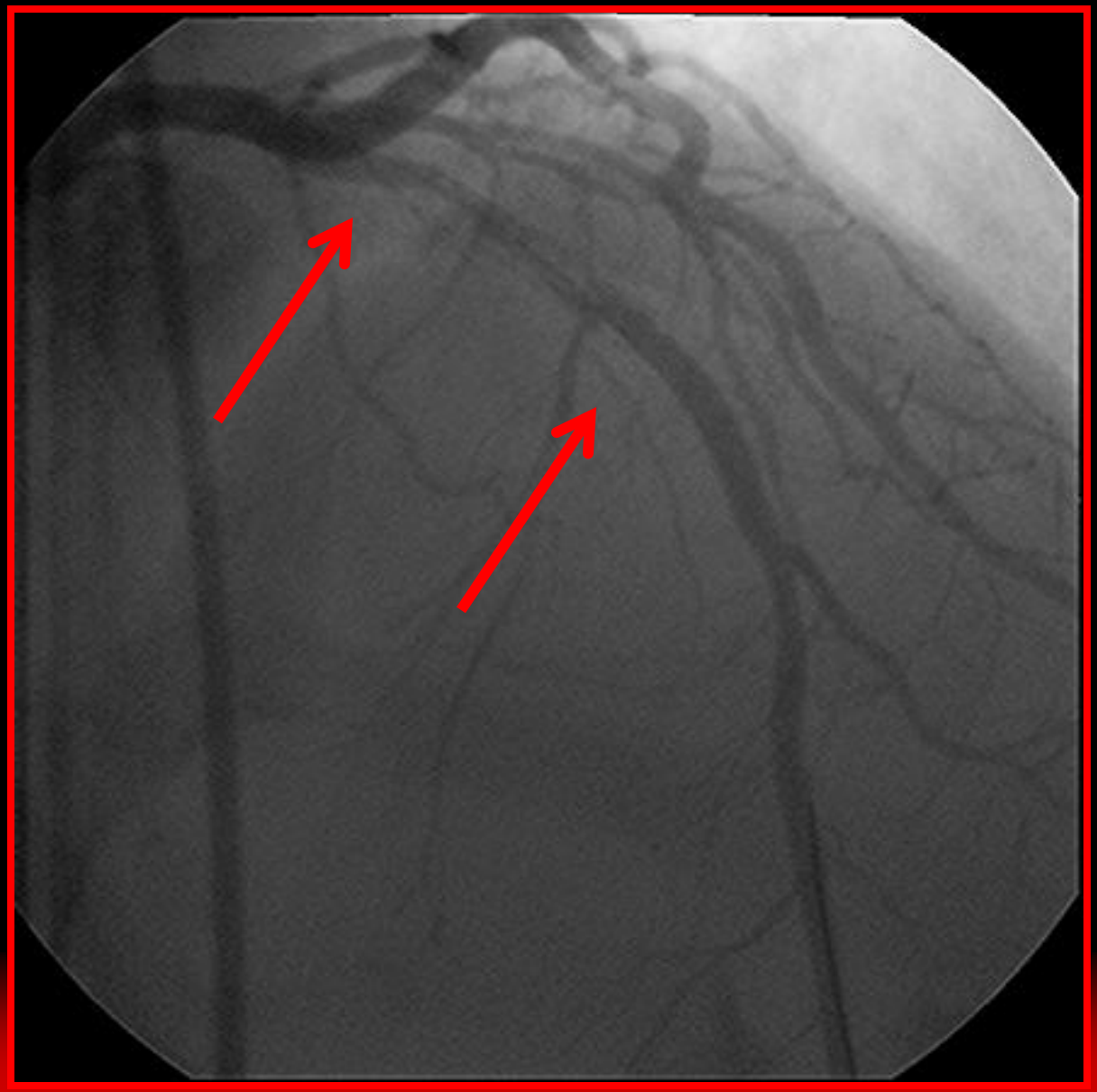




Export Aspiration Catheter



Post Thrombus Aspiration



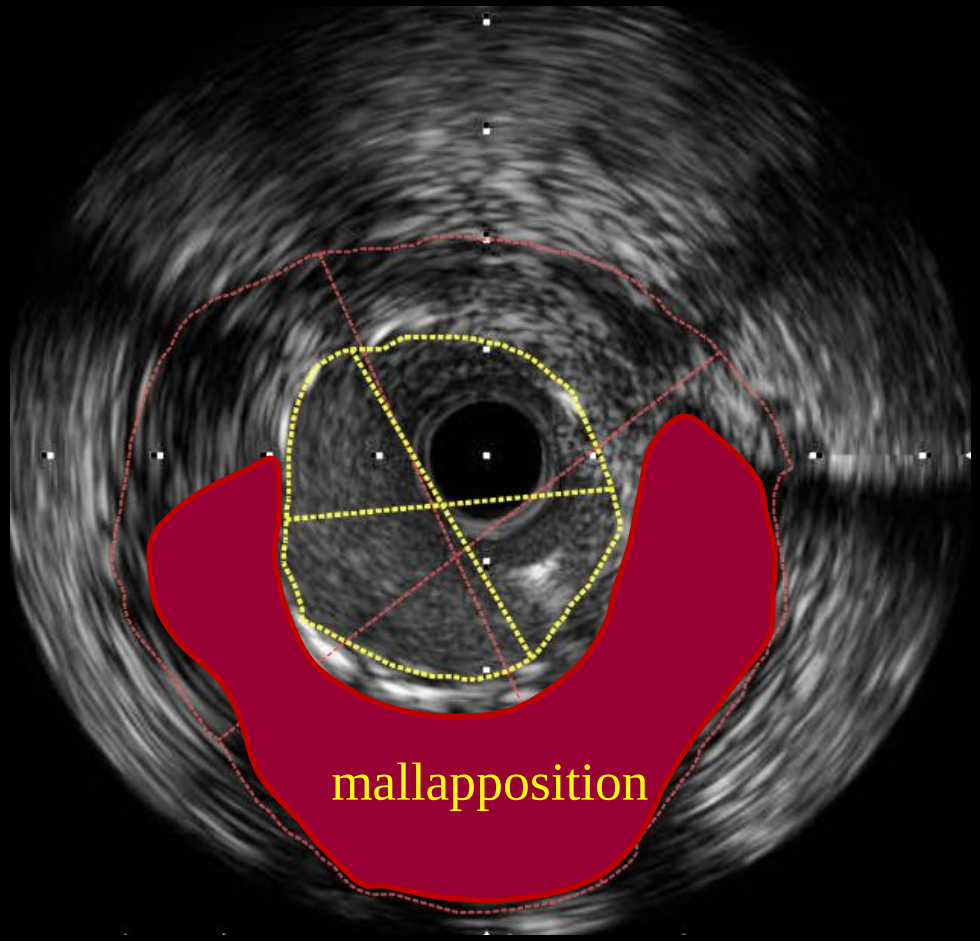
What would you do at this point?

A. Heparin, IIb/IIIa and CCU

B. Balloon and check the result

C. Stent

D. IVUS trying to identify the mechanism of this very late stent thrombosis



Measurements

iA1 28,89 mm²

5,78/6,32 mm

iA2 7,58 mm²

2,98/3,27 mm

Incomplete Stent Apposition and Very Late Stent Thrombosis After Drug-Eluting Stent Implantation

Stéphane Cook, MD; Peter Wenaweser, MD; Mario Togni, MD; Michael Billinger, MD; Cyrill Morger, MD; Christian Seiler, MD; Rolf Vogel, MD, PhD; Otto Hess, MD; Bernhard Meier, MD; Stephan Windecker, MD

Background—Stent thrombosis may occur late after drug-eluting stent (DES) implantation, and its cause remains unknown. The present study investigated differences of the stented segment between patients with and without very late stent thrombosis with the use of intravascular ultrasound.

Methods and Results—Since January 2004, patients presenting with very late stent thrombosis (>1 year) after DES implantation underwent intravascular ultrasound. Findings in patients with very late stent thrombosis were compared with intravascular ultrasound routinely obtained 8 months after DES implantation in 144 control patients, who did not experience stent thrombosis for ≥2 years. Very late stent thrombosis was encountered in 13 patients at a mean of 630±166 days after DES implantation. Compared with DES controls, patients with very late stent thrombosis had longer lesions (23.9±16.0 versus 13.3±7.9 mm; $P<0.001$) and stents (34.6±22.4 versus 18.6±9.5 mm; $P<0.001$), more stents per lesion (1.6±0.9 versus 1.1±0.4; $P<0.001$), and stent overlap (39% versus 8%; $P<0.001$). Vessel cross-sectional area was similar for the reference segment (cross-sectional area of the external elastic membrane: 18.9±6.9 versus 20.4±7.2 mm^2; $P=0.46$) but significantly larger for the in-stent segment (28.6±11.9 versus 20.1±6.7 mm^2; $P=0.03$) in very late stent thrombosis patients compared with DES controls. Incomplete stent apposition was more frequent (77% versus 12%; $P<0.001$) and maximal incomplete stent apposition area was larger (8.3±7.5 versus 4.0±3.8 mm^2; $P=0.03$) in patients with very late stent thrombosis compared with controls.

Conclusions—Incomplete stent apposition is highly prevalent in patients with very late stent thrombosis after DES implantation, suggesting a role in the pathogenesis of this adverse event. (***Circulation***. **2007;115:2426-2434.**)

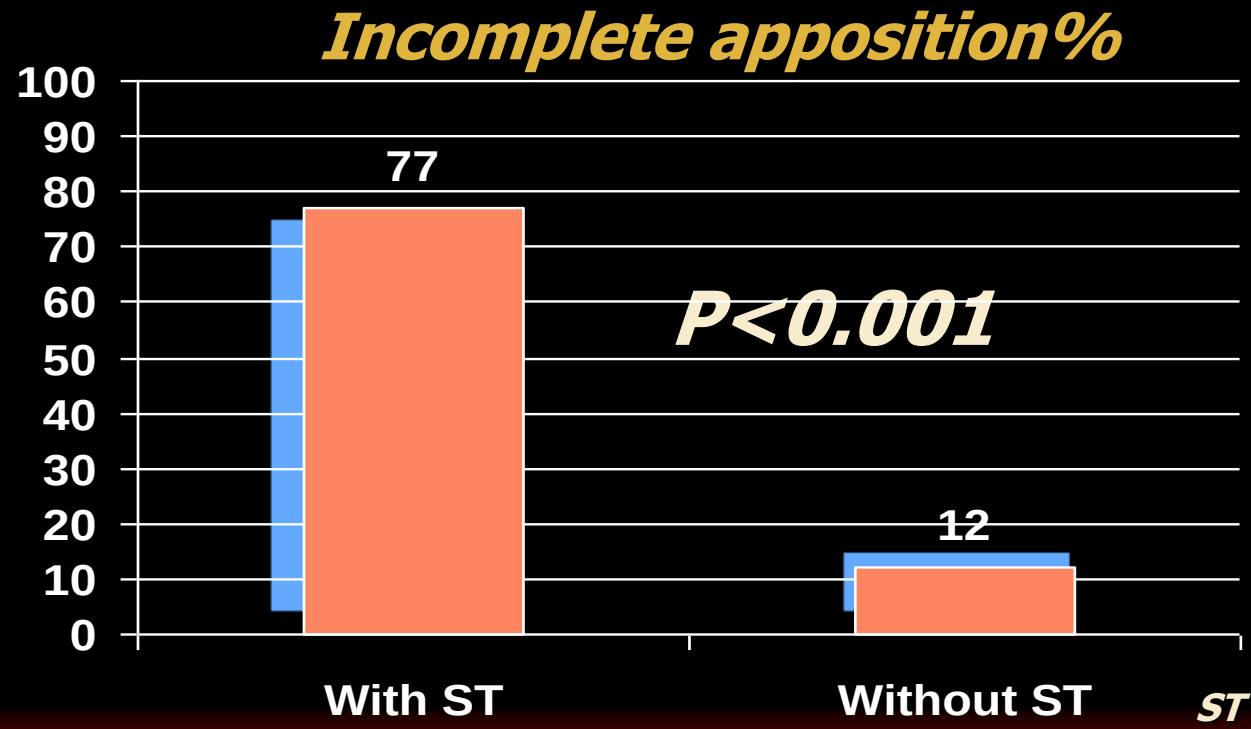
Key Words: coronary disease ■ imaging ■ patients ■ stents ■ ultrasonics

Cook S, et al. Circulation 2007; 115:2426-24

Late Incomplete Apposition and Late Thromb

13 patients with late thrombosis > 1 year post pr

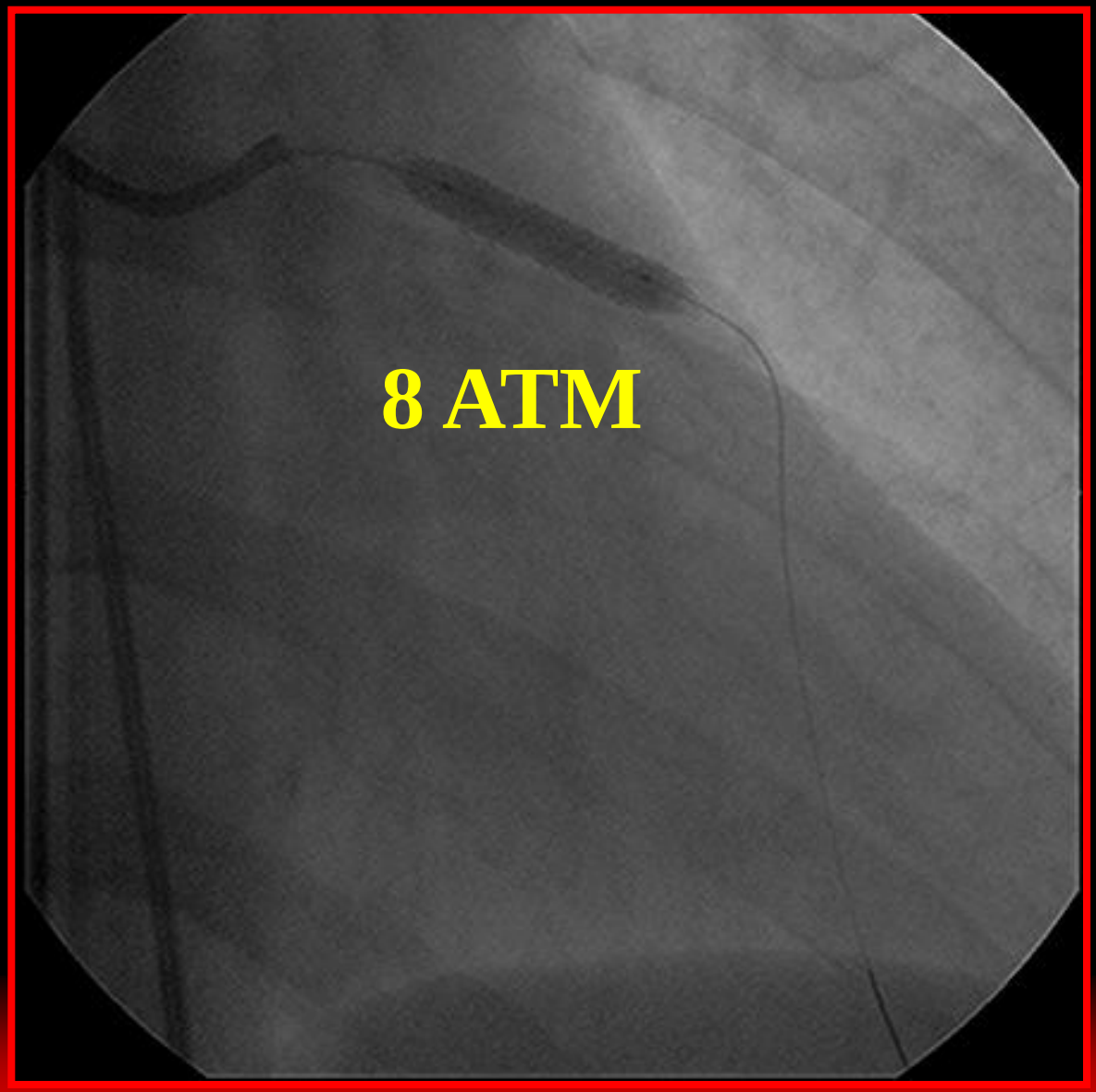
144 controls without late thrombosis



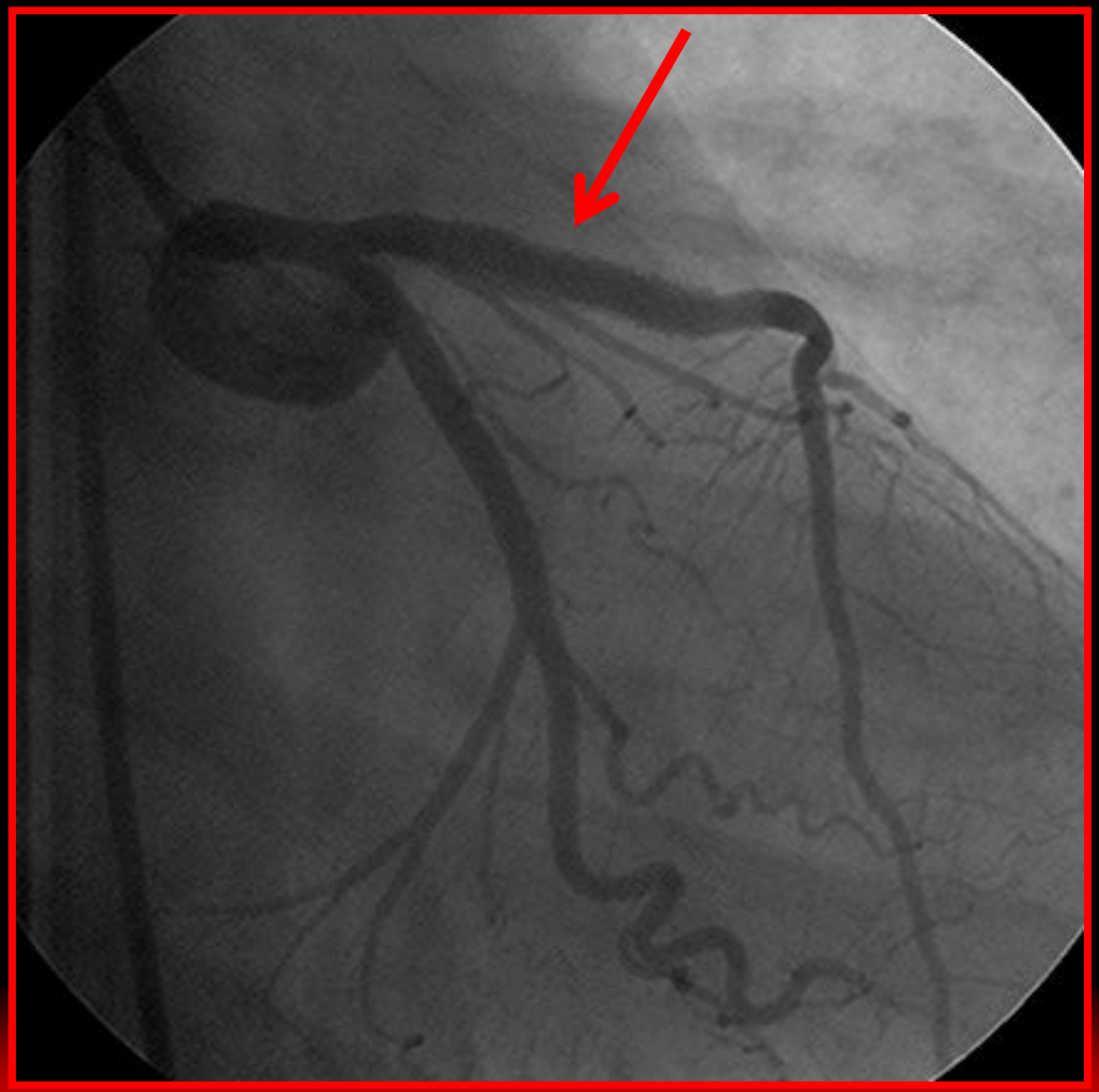
ST = Stent Thrombosis

Cook S, et al. Circulation 2007; 115:2426-2434

Balloon 5.0x20.0mm



Post - Balloon 5.0x20.0mm



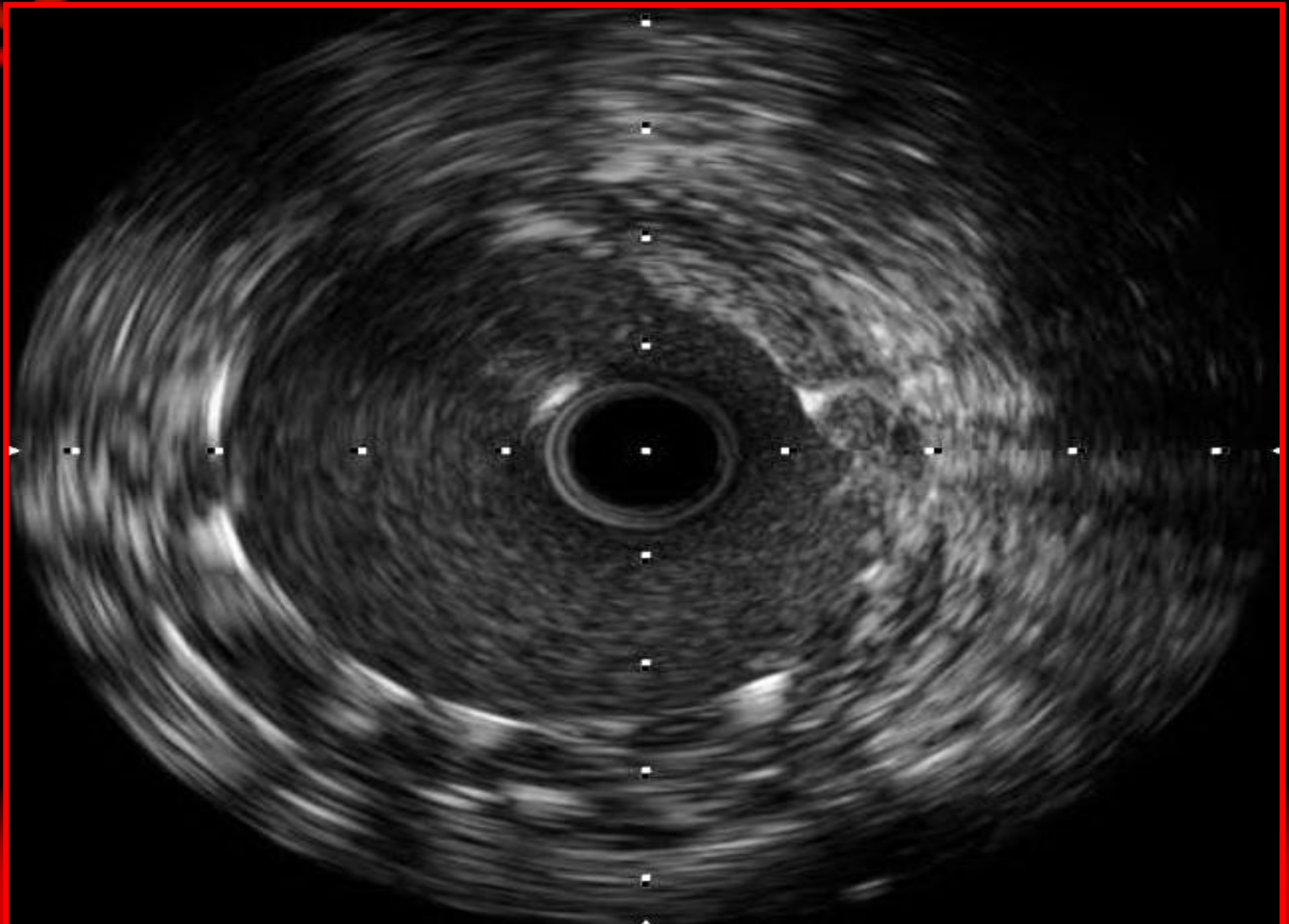
What would you do at this point ?

A. Finish, angio looks beautiful!

B. Post dilatation to get an optimal result

C. IVUS to decide

Post - Balloon 5.0x20.0mm



What you

SEE

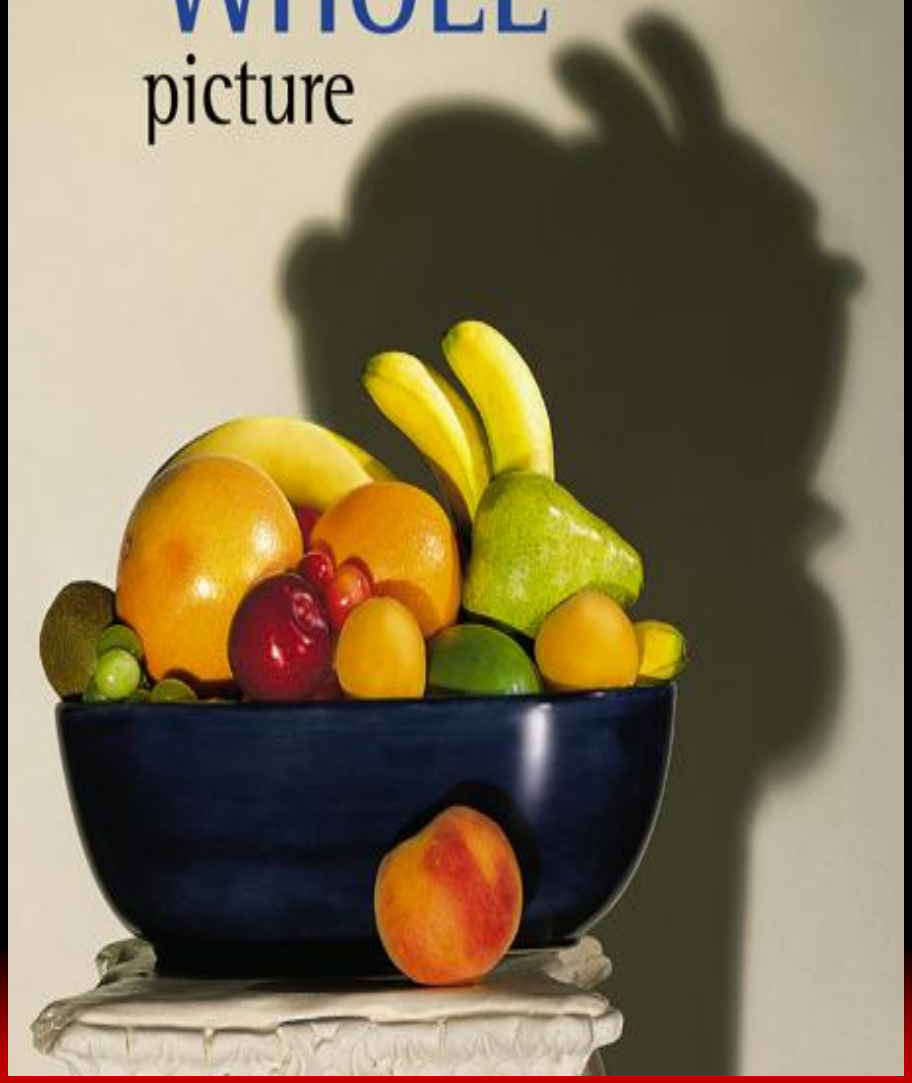
isn't always

what you get

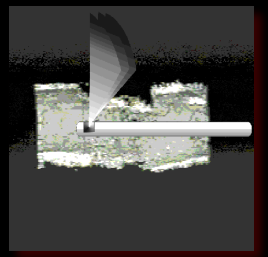
Get the

WHOLE

picture

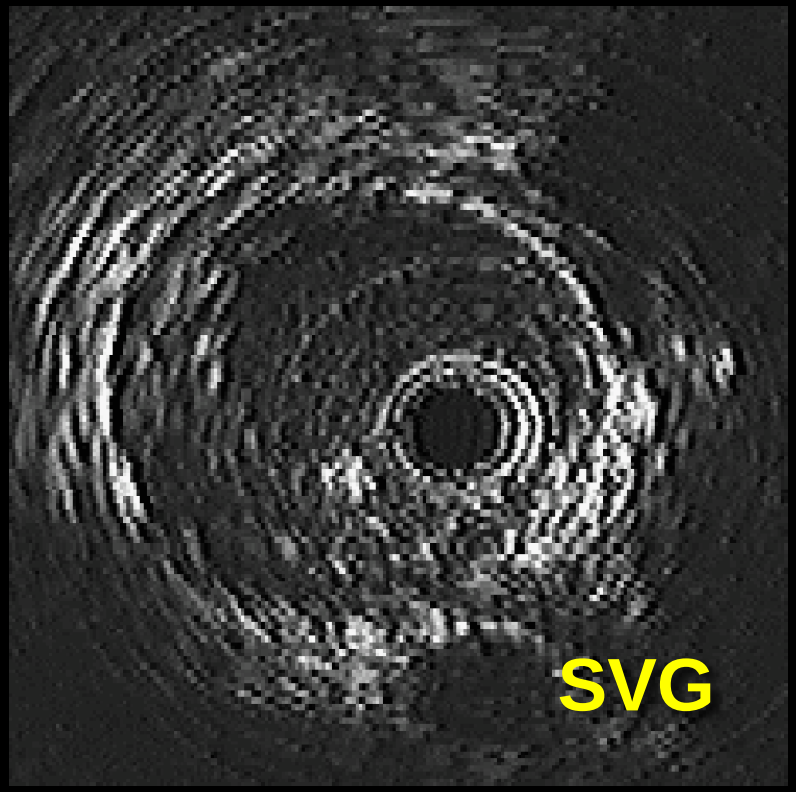


IVUS Use in the US (2009)



- Approximately **1200 active interventional** catheterization laboratories in the US (**criteria:** ordering DES from any vendor)
- **1000 laboratories (~83%)** have IVUS (one or both present IVUS vendors)
- Based on catheter volume it is estimated that **10%** of all PCI's involve the use of IVUS (may reach **40% to 90%** depending on the presence a **teaching program** and institutional preferences).

IVUS Technology 2010



1994

2009

Clinical Value of IVUS

- ***Known: IVUS is superior to angiography for the evaluation of:***
  - Lesion severity
  - Vessel/lumen diameter/area
  - Lesion calcification (vs thrombus)
  - Stent placement results
  - In-stent restenosis
  - Complications of PCI (dissection), ST
- ***Question: Which IVUS tips and tricks used during PCI improve clinical results?***

Lumen Diameter Measurement

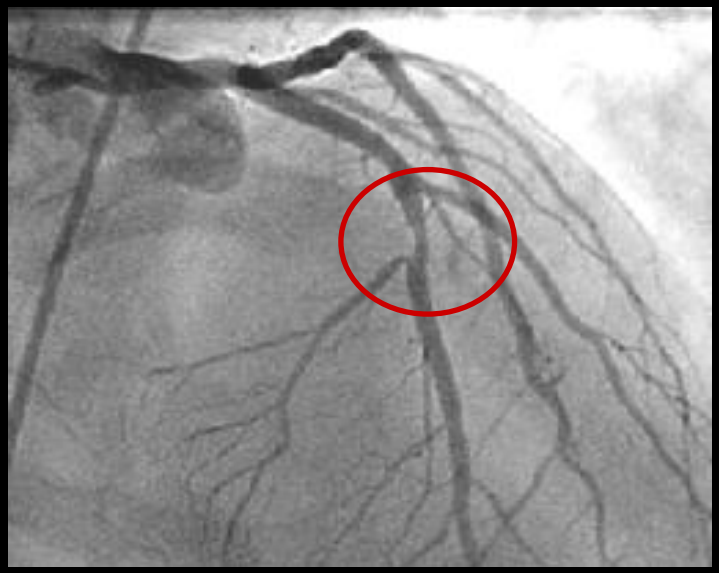
- Angiography consistently and **significantly underestimates** lumen diameter when compared to IVUS measurements
- This underestimation leads to the use of **undersized devices** and a smaller final result of PCI
- Smaller final lumen MLA/MLD are associated with an increase in short and long-term cardiac events
- This association is seen for both **bare-metal (BMS) and drug-eluting stents (DES)**

Pre-PCI IVUS Assessment of Lesion Length

- Using an automatic pullback device with (or without) longitudinal reconstruction
- The true lesion length may be determined
- As a result, an appropriate stent length may be selected:
  - Cost effective (number of stents)
  - May decrease the risk of stent restenosis associated by inadequate lesion coverage (DES technology)

The Limitations of Angiography

A 70% lesion by angio could be…



Ischemic
Plaque burden of 80%
MLA of 3.5 mm^2
Lesion length of 18 mm
Severe calcium, difficult to expand
VH Thin-Cap Fibroatheroma
Necrotic Core proximal to lesion

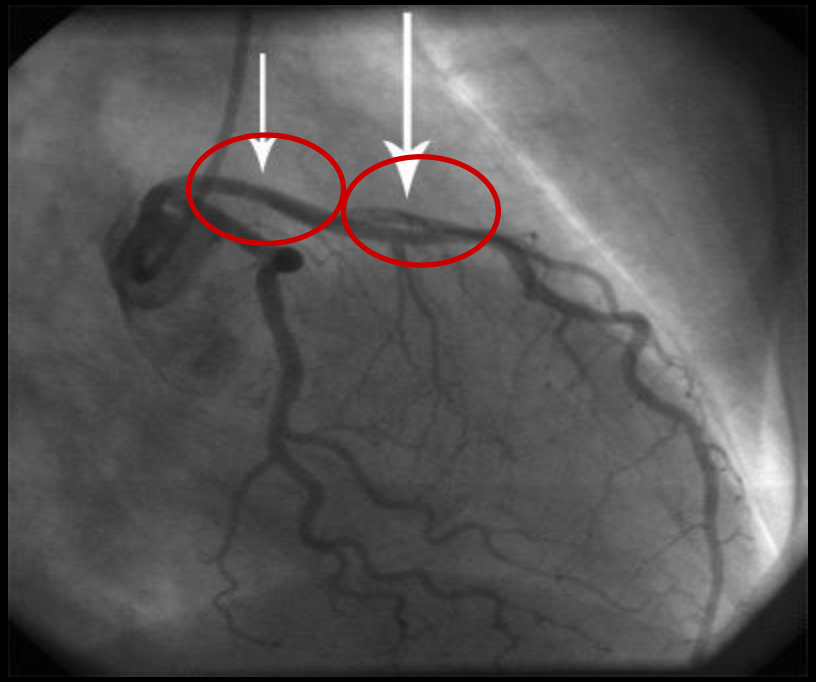
or

Non-Ischemic
Plaque burden 40%
MLA of 6.5 mm^2
Lesion length of 4 mm
No calcification
Pathological Intimal Thickening
Necrotic core at area of MLD

Would you treat this lesion…

…differently from this lesion…?

A “good angiographic result” could be…



CSA of 4.5 mm^2
Severe malapposition
Edge dissection
Uncovered proximal Necrotic Core
Stent extending into Ostium

or

CSA of 7.5 mm^2
Good stent apposition
No dissections
Full lesion coverage
Side-branch preserved

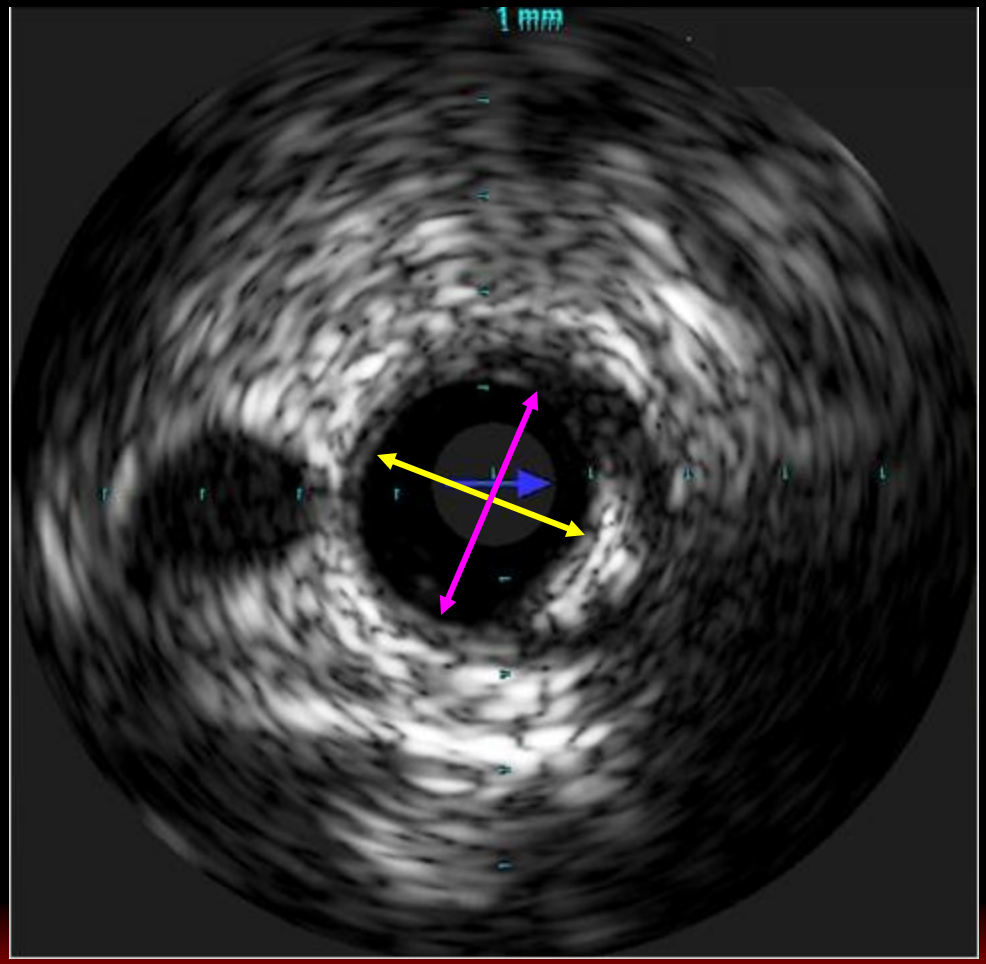
Would you treat this lesion…

…differently from this lesion…?

Why IVUS?

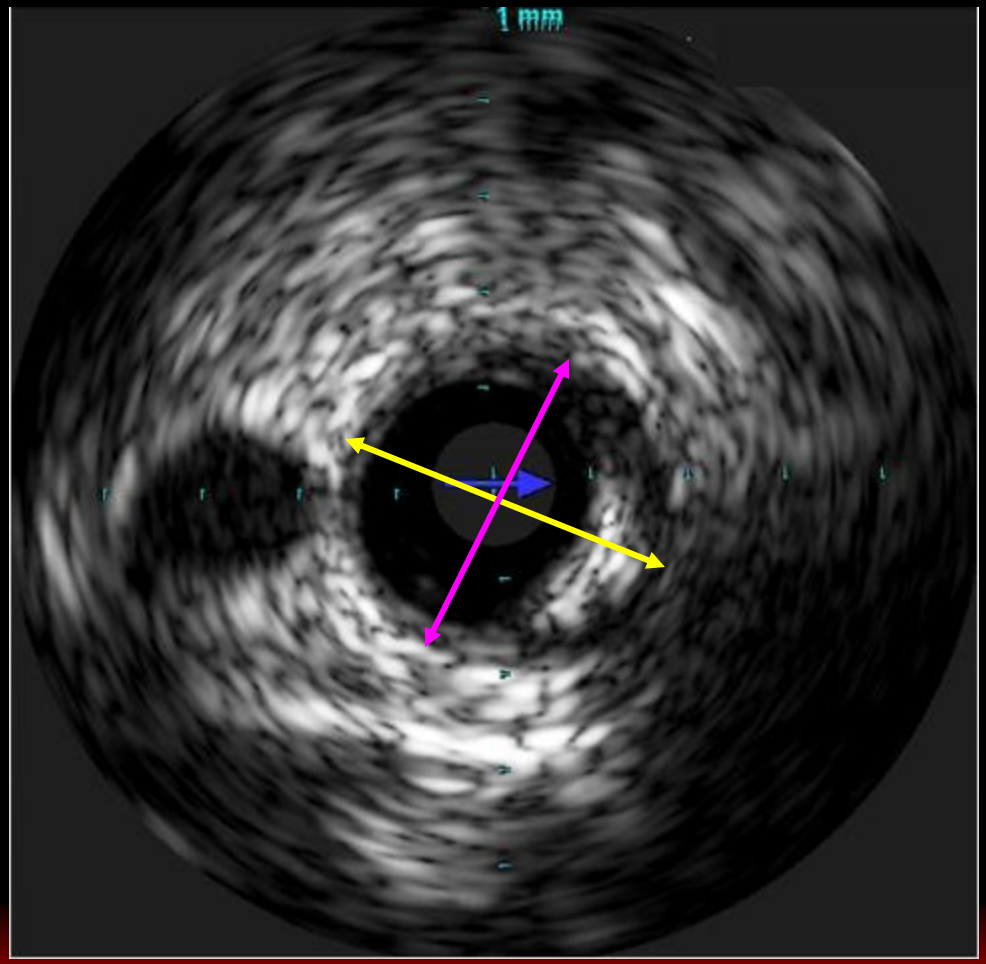
Measurements

- *Lumen diameter – measure intima to intima*



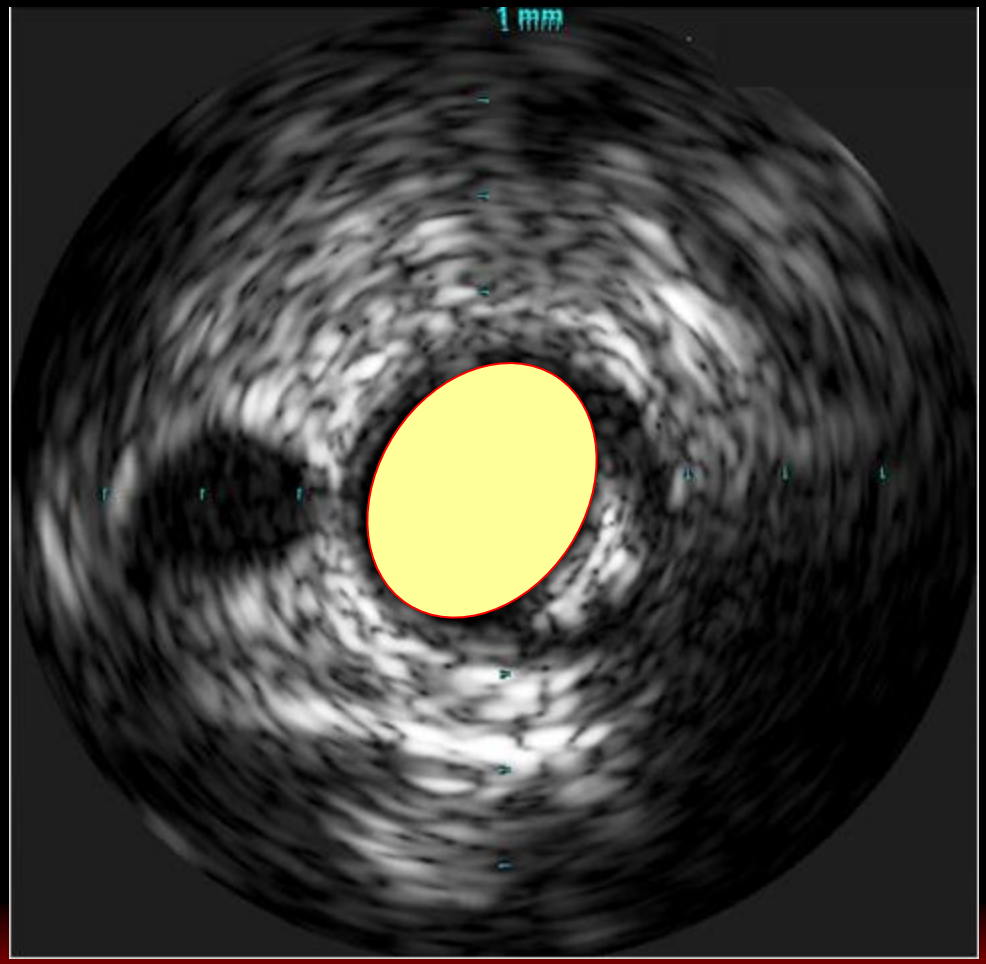
Measurements

- *Vessel diameter – measure adventitia to adventitia (EEM to EEM)*



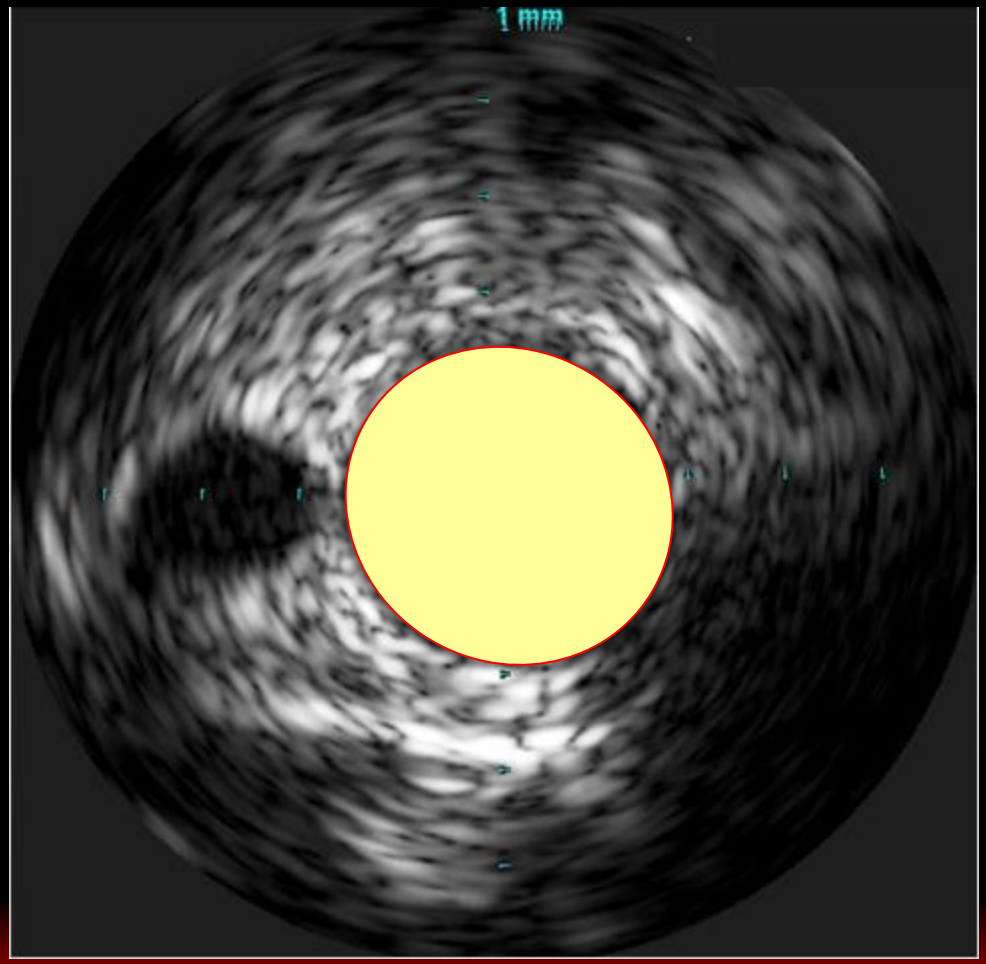
Measurements

- *Lumen area – measure cross sectional area inside of lumen*



Measurements

- *Vessel area – measure cross sectional area inside of adventitia*



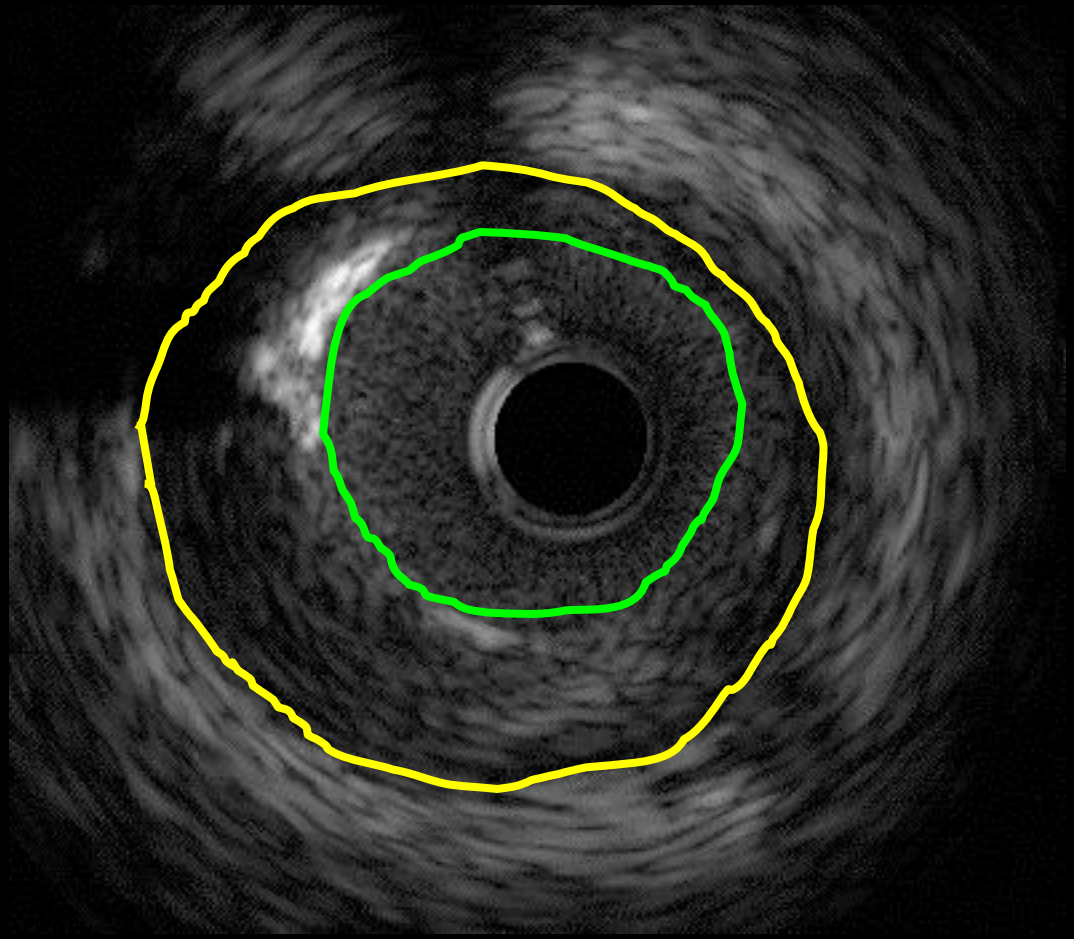
Do not do this!

EEM: 16.7 mm^2

Lumen: 6.5 mm^2

% stenosis: 61%

Good!: Let's Stent



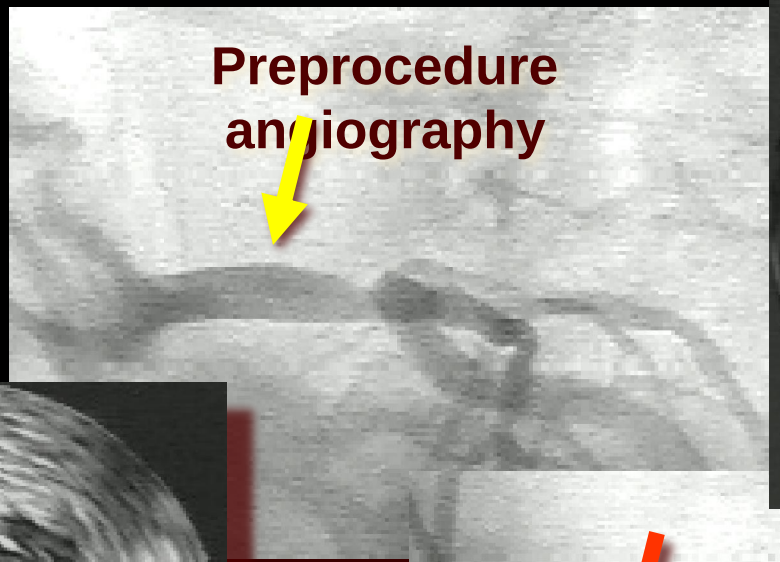
This is a measure of plaque burden,
NOT lumen compromise

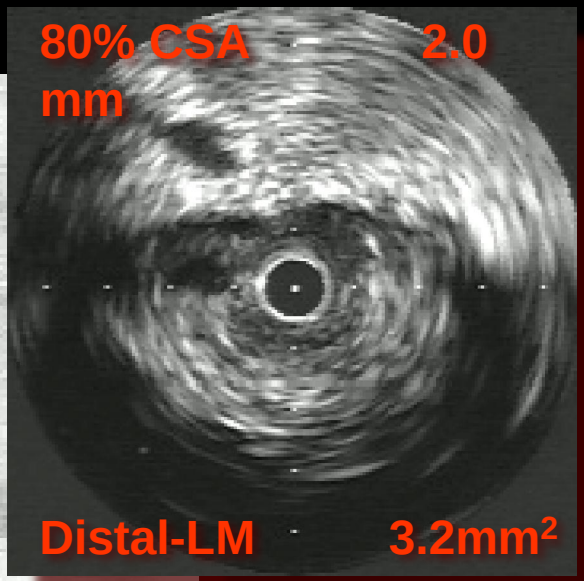
When to use IVUS

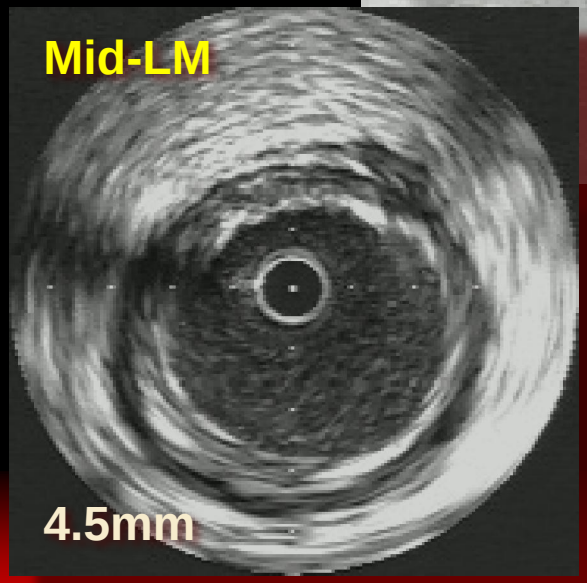
- All PCI with BMS
- All PCI of DES when vessel size is <3.5
- All Complex PCI (branches, LM)
- All stent complications
- All cases of anything that doesn't look right after PCI
- If you have a concern about calcium
- Left main diagnostics

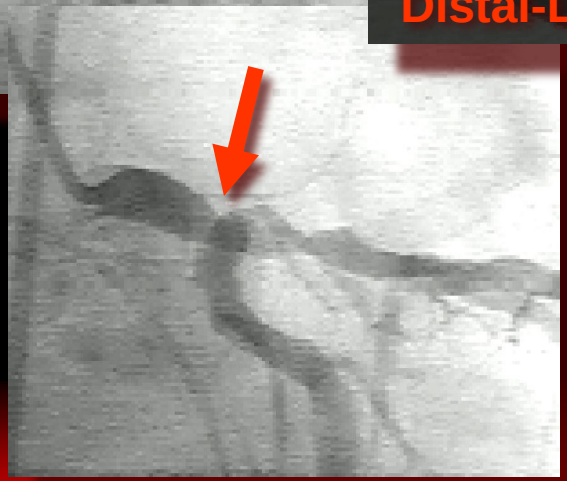
Diagnostic Left Main IVUS

Intermediate distal left main lesion by angiography and high-grade disease by IVUS assessment









LEFT MAIN IVUS REGISTRY

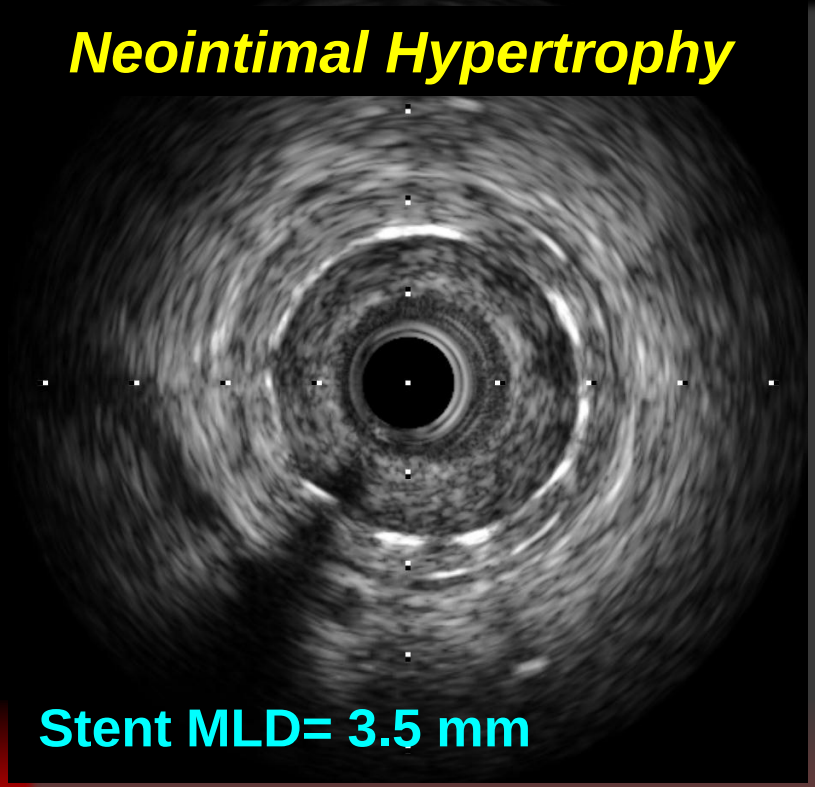
Stent Restenosis

- ***Several mechanisms of stent restenosis may be differentiated by IVUS:***
  - Stent underexpansion
  - Neointimal hyperplasia
  - Inadequate lesion coverage (too short)
  - Stent fracture
  - Unstented segment
- ***Each type of stent restenosis is treated with a different revascularization strategy***

Stent Restenosis

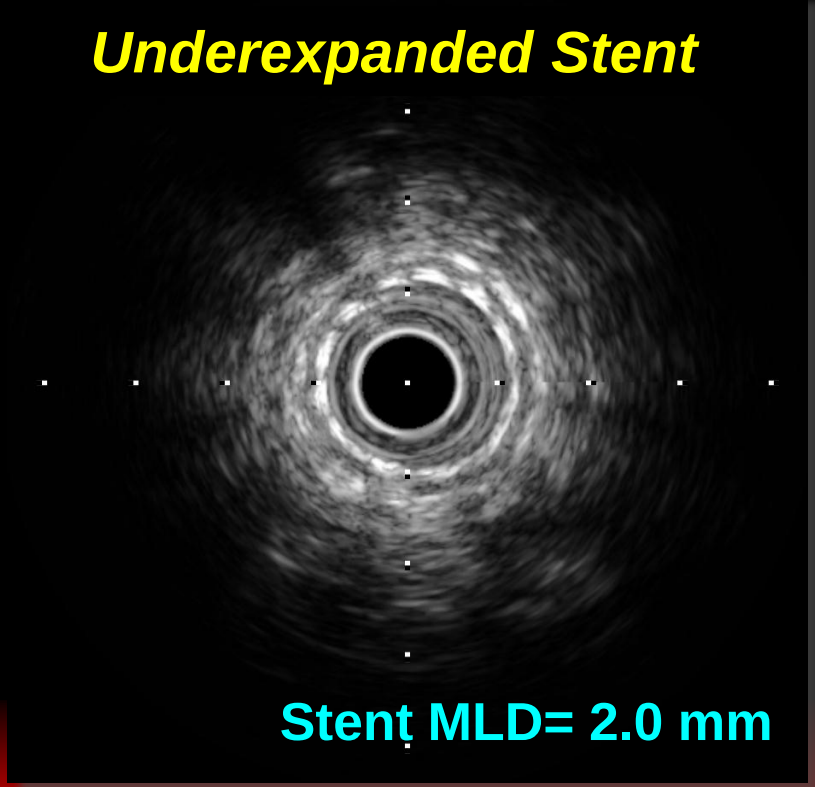
Pre-procedure IVUS assessment of stent restenosis for treatment strategy

Neointimal Hypertrophy



Stent MLD= 3.5 mm

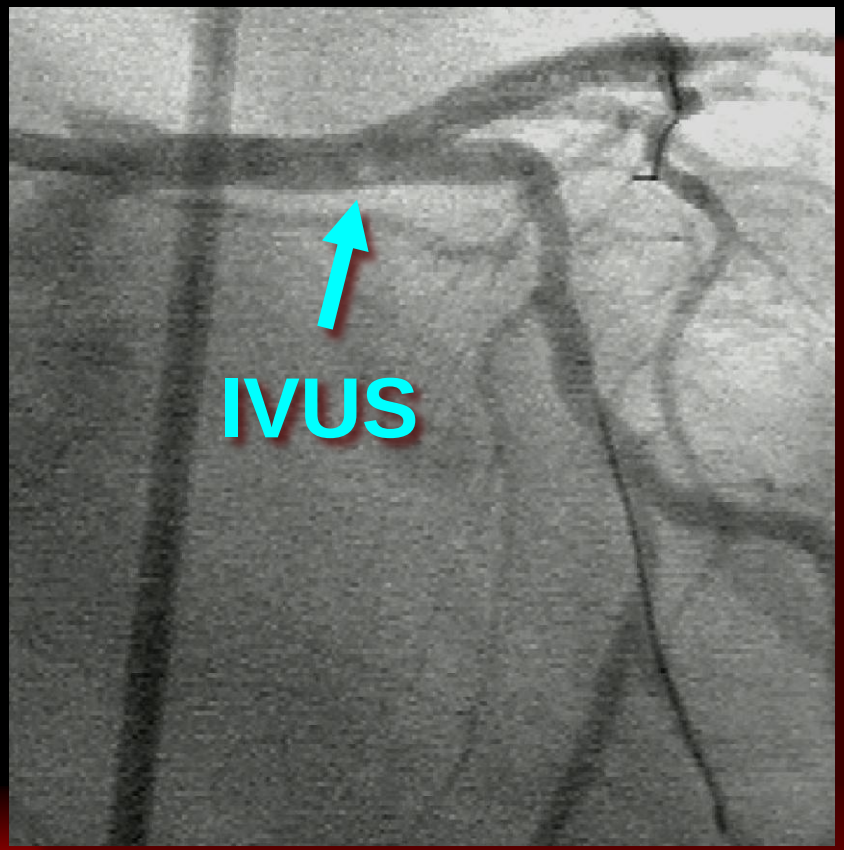
Underexpanded Stent

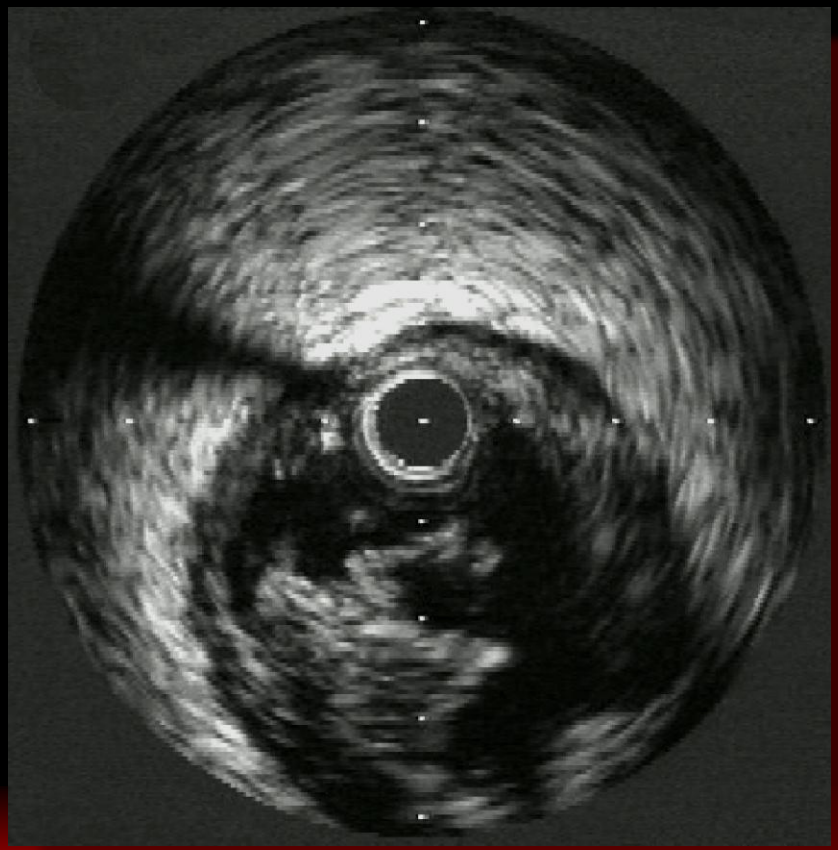


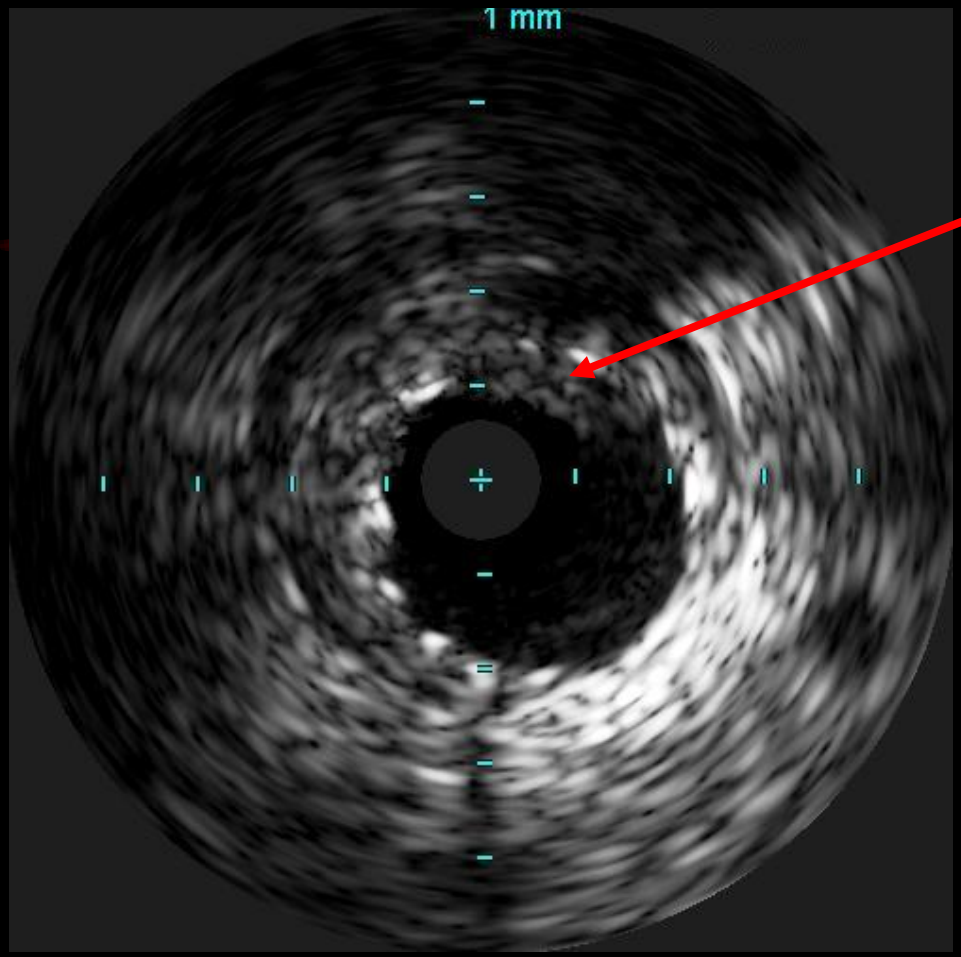
Stent MLD= 2.0 mm

Complications of PCI

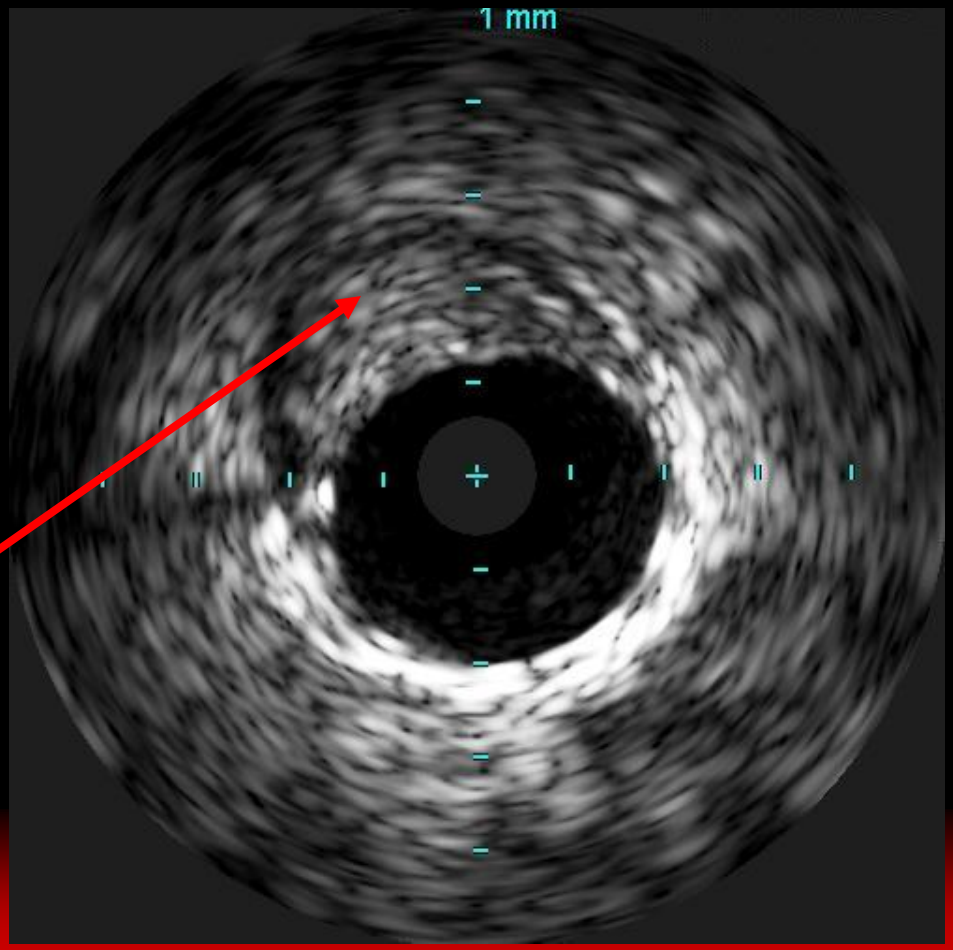
A LM filling defect is noted after LCx stent placement with intraluminal thrombus and dissection by IVUS



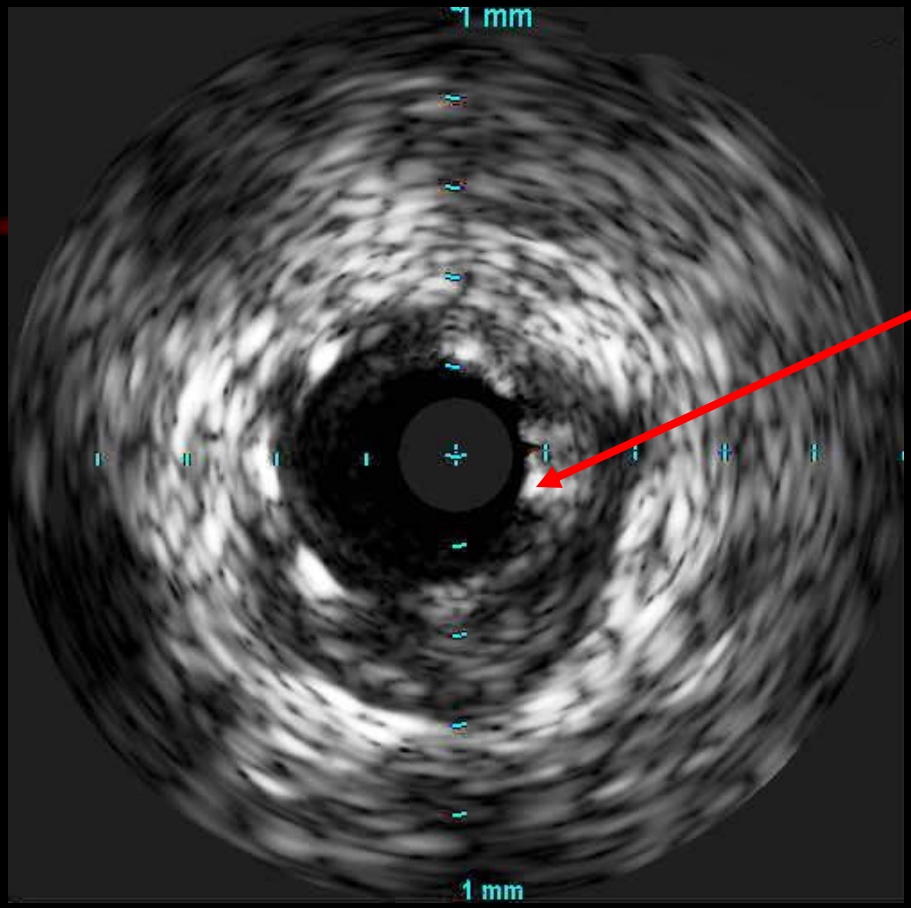




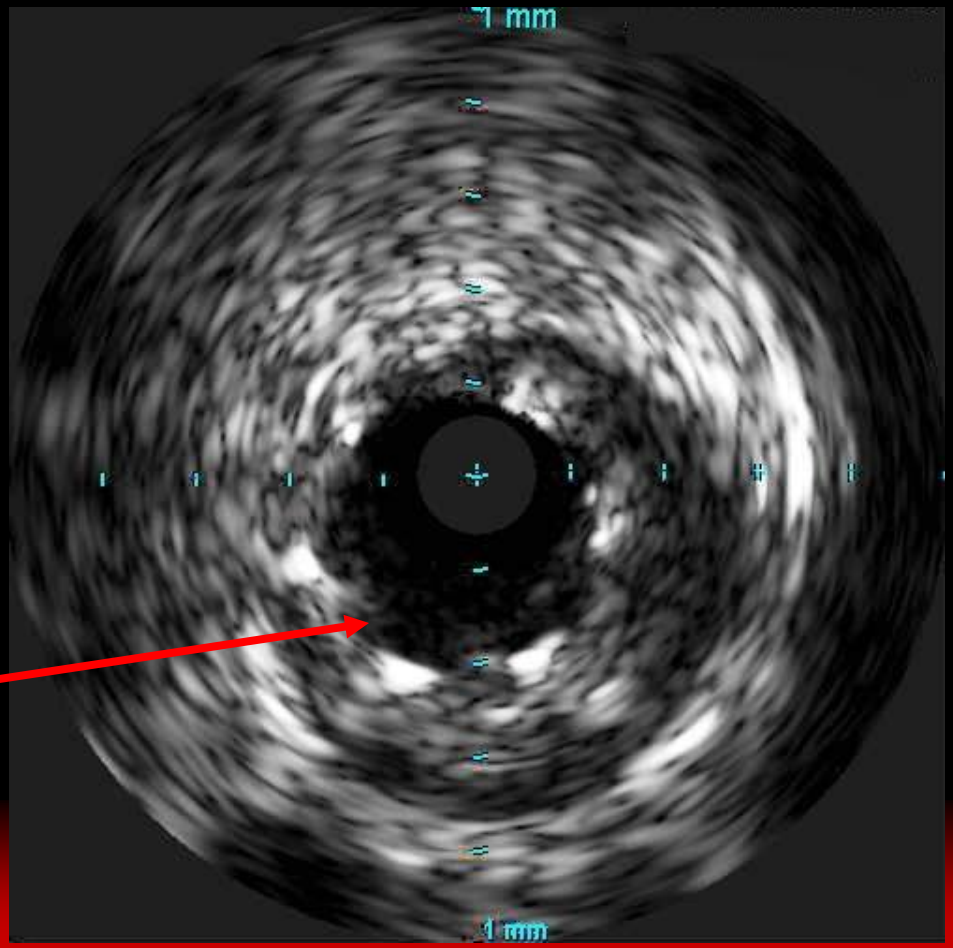
Plaque protrusion through stent struts



Soft plaque with positive remodeling



Undersized stent

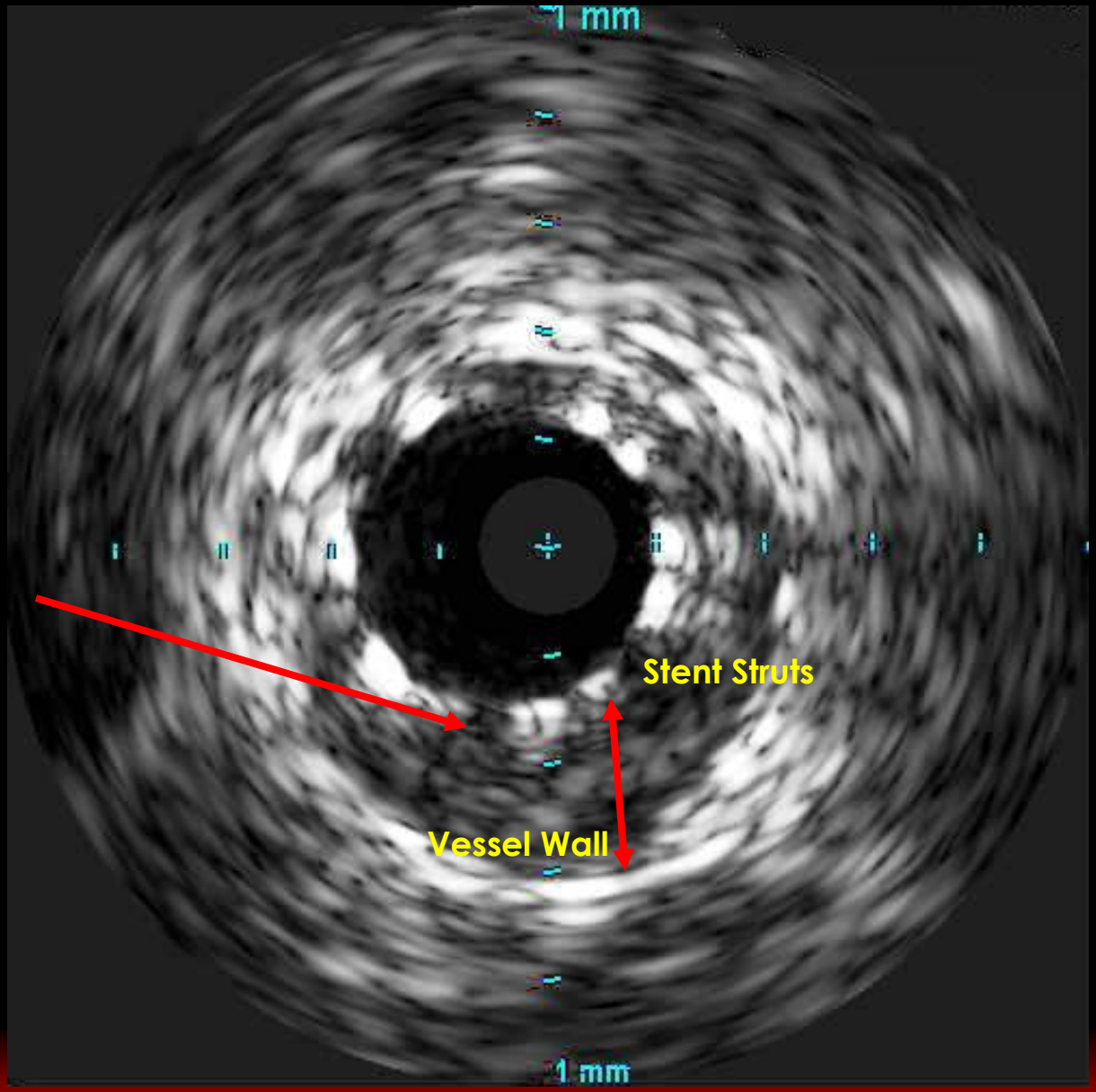


Undersized stent post high pressure inflations

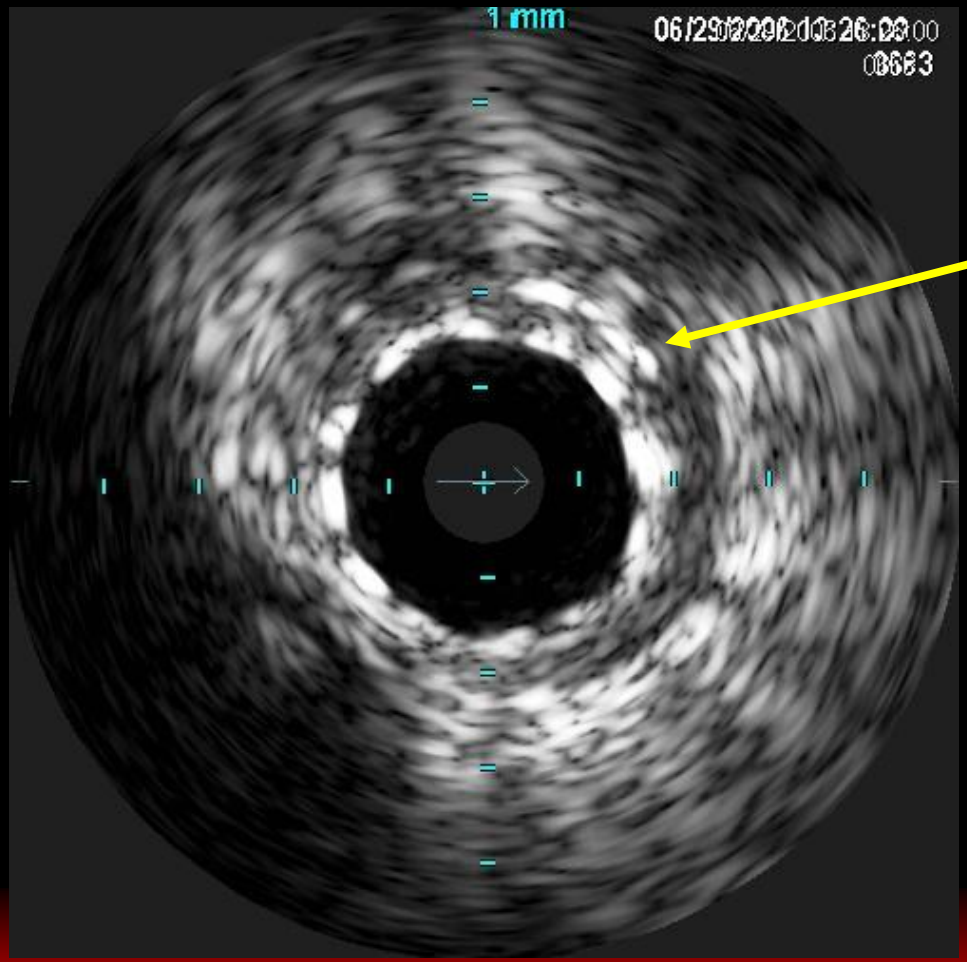
This is the same undersized stent as in the previous slide after NC Balloon inflation.

It still has not gotten any bigger.

IVUS (not angiography) shows the importance of accurate sizing of a DES.



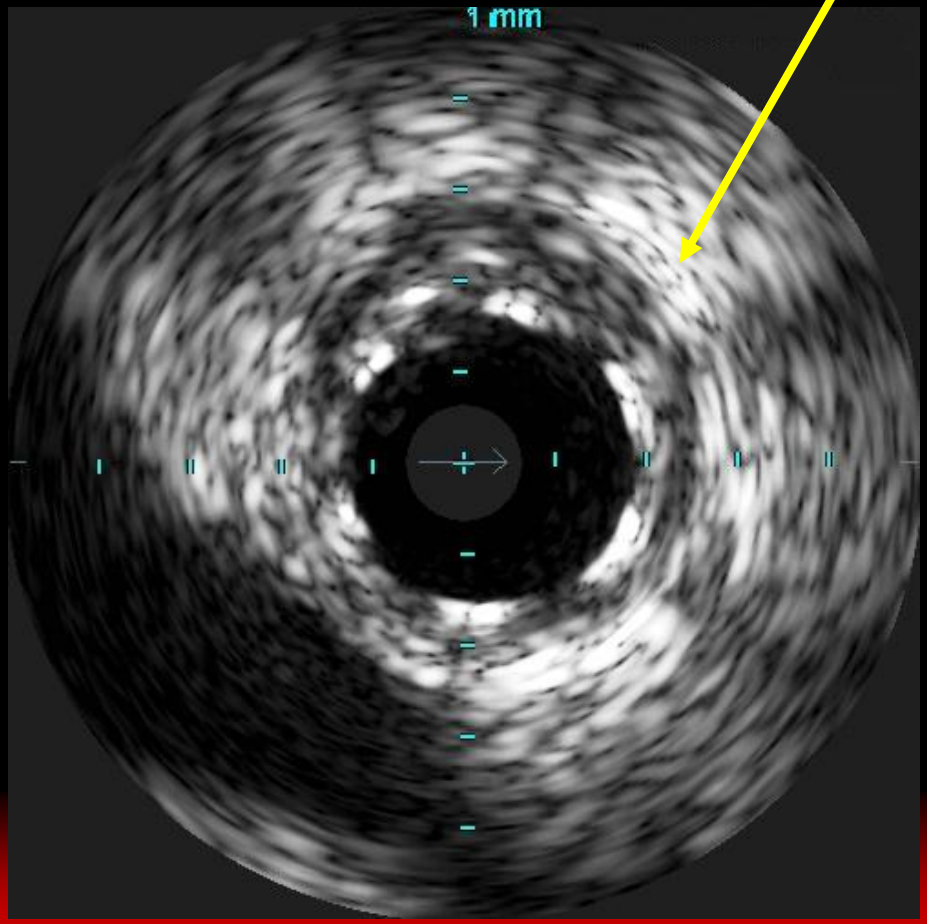
Expansion is Everything
The End point of Stenting

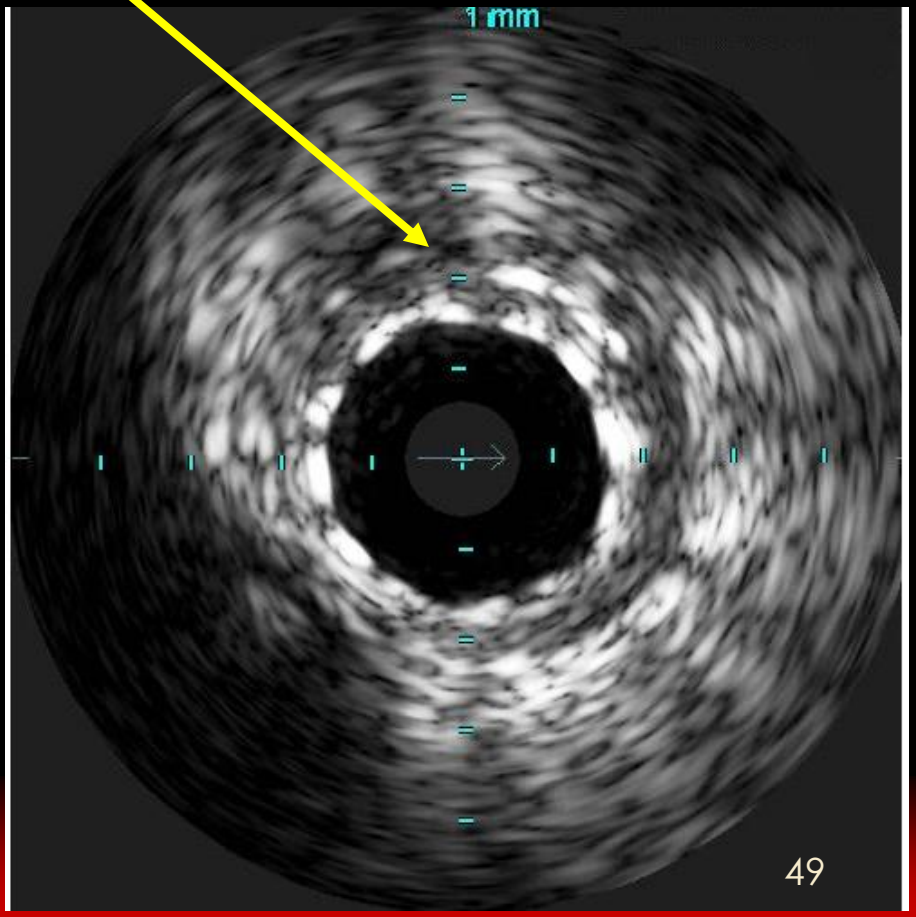


Good deployment of stent

Expansion is Everything

Well apposed stents

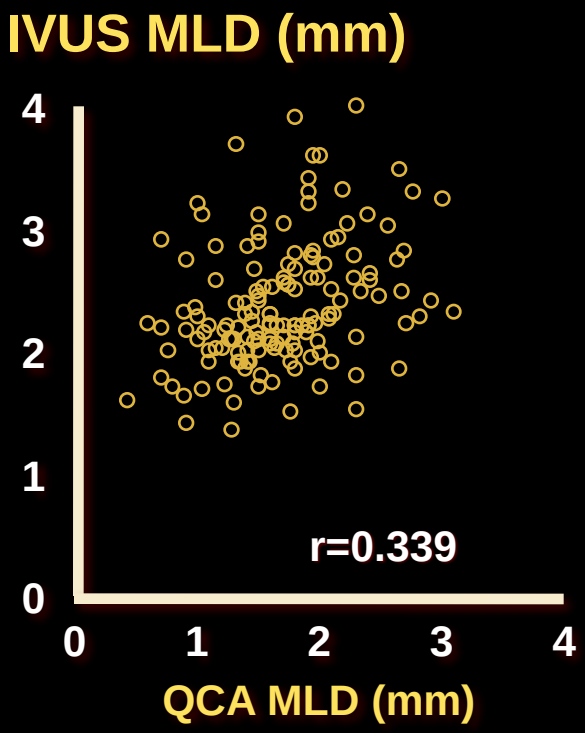


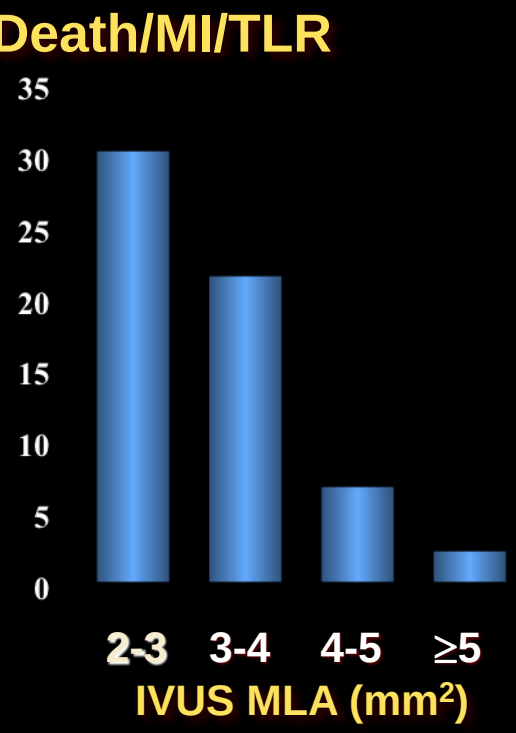


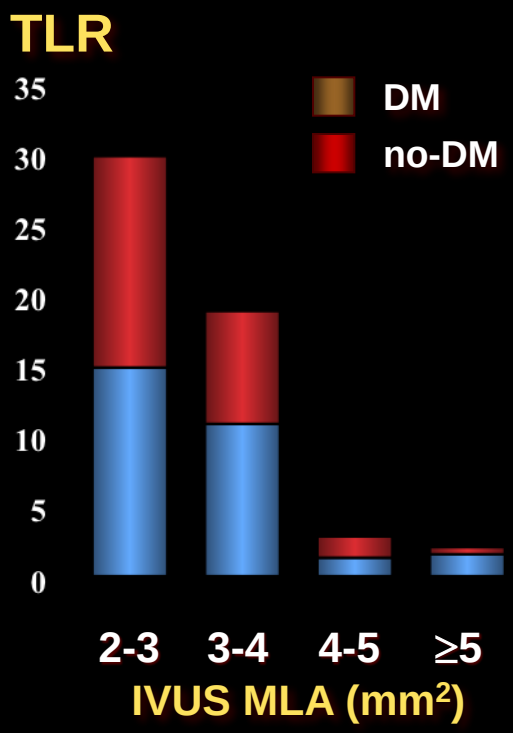
Suggested IVUS Criteria for a 'Significant' Stenosis

- Most IVUS studies show either insignificant disease or critical disease, only a minority require careful quantification
- Most authorities feel that a lumen area less than 4.0 mm^2 in a proximal epicardial artery *excluding Left Main and SVG lesions* is a flow limiting stenosis

Clinical follow-up in 357 intermediate lesions in 300 pts with deferred intervention after IVUS imaging







- Death/MI/TLR @ (mean) 13 mos = 8% overall (2% death/MI and 6% TLR)
- Death/MI/TLR @ (mean) 13 mos = 4.4% in lesions with MLA >4.0mm^2
- Only independent predictor of death/MI/TLR was IVUS MLA (p=0.0041)
- Independent predictors of TLR were DM (p=0.0493) and IVUS MLA (p=0.0042)

Abizaid et al. Circulation 1999;100:256-61

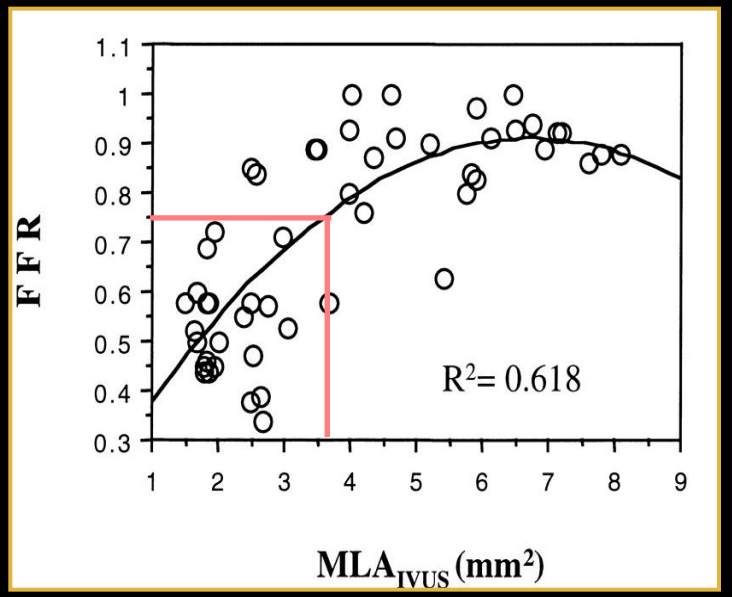
Validation of IVUS assessment of ischemia-producing stenoses (Doppler FloWire, SPECT, and Pressure Wire)

	IVUS MLA ≥4.0mm²	IVUS MLA <4.0mm²
CFR < 2.0	2	27
CFR ≥ 2.0	39	4

Diagnostic accuracy = 92%.
Abizaid et al. Am J Cardiol 1998;82:42-8

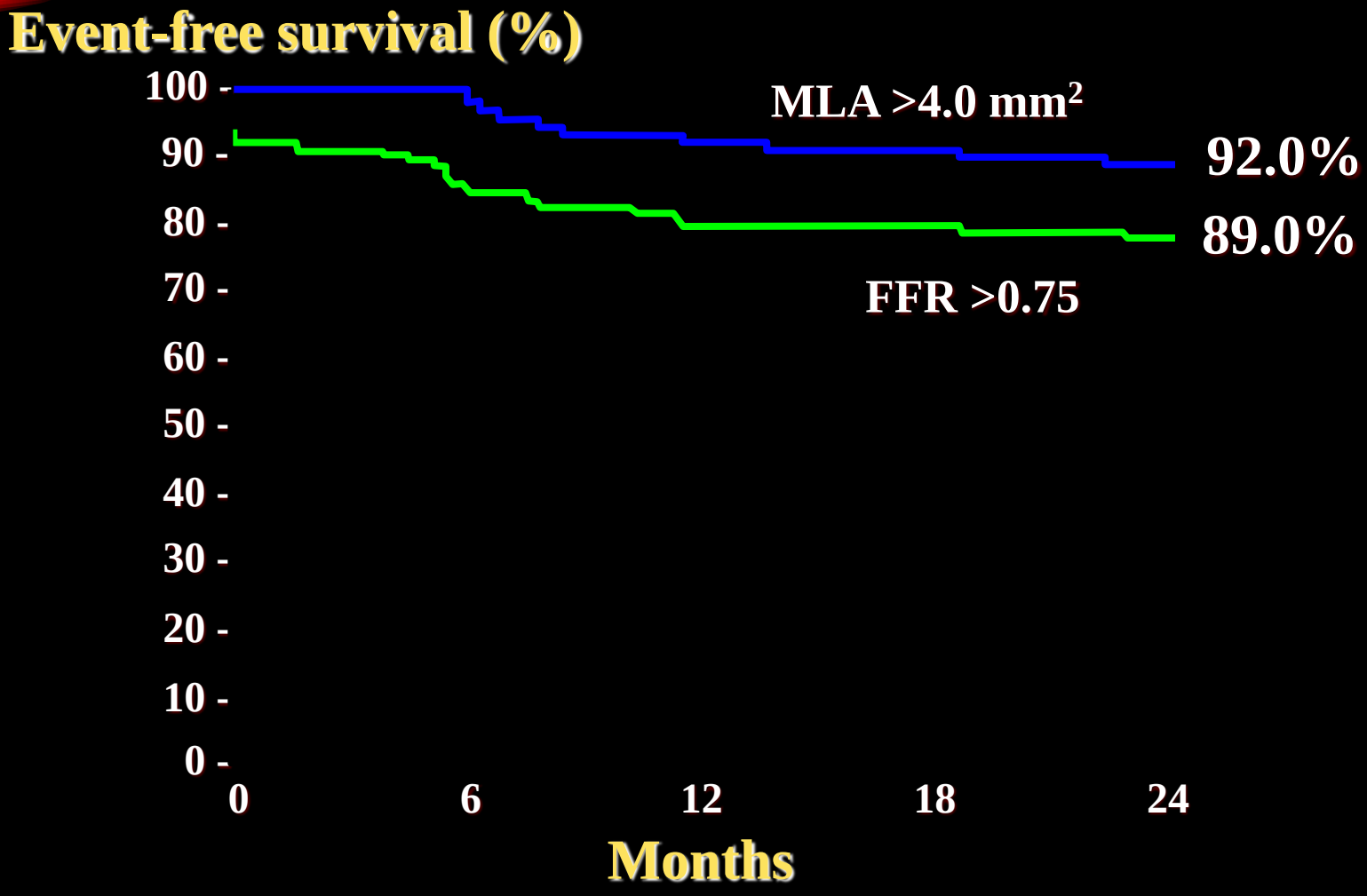
	IVUS MLA ≥4.0mm²	IVUS MLA <4.0mm²
+ Spect	4	42
- Spect	20	1

Diagnostic accuracy = 93%.
Nishioka et al. J Am Coll Cardiol 1999;33:1870-8



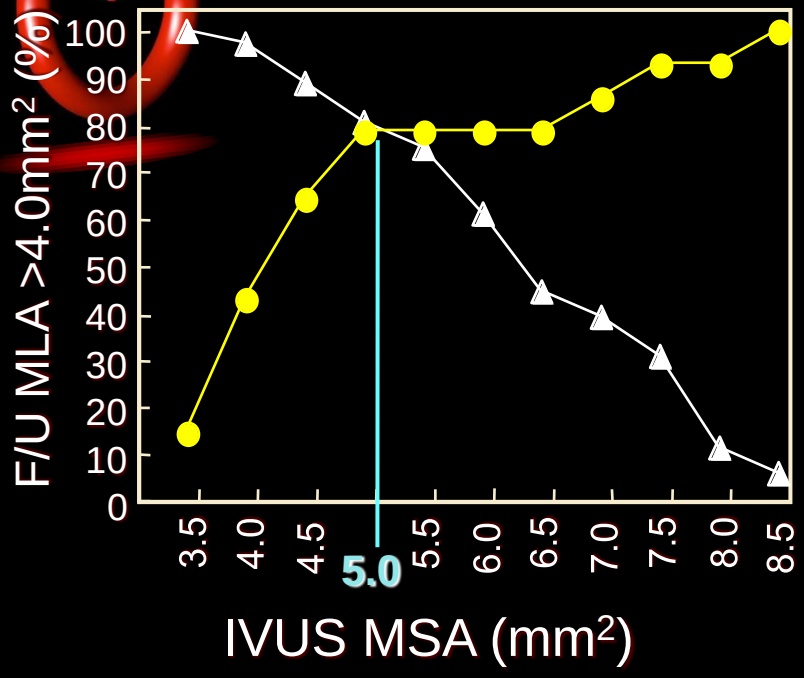
Takagi, et al. Circulation 1999;100:250-5

Event-Free Survival Curve of Patients with Intermediate Lesions and Deferred Procedures

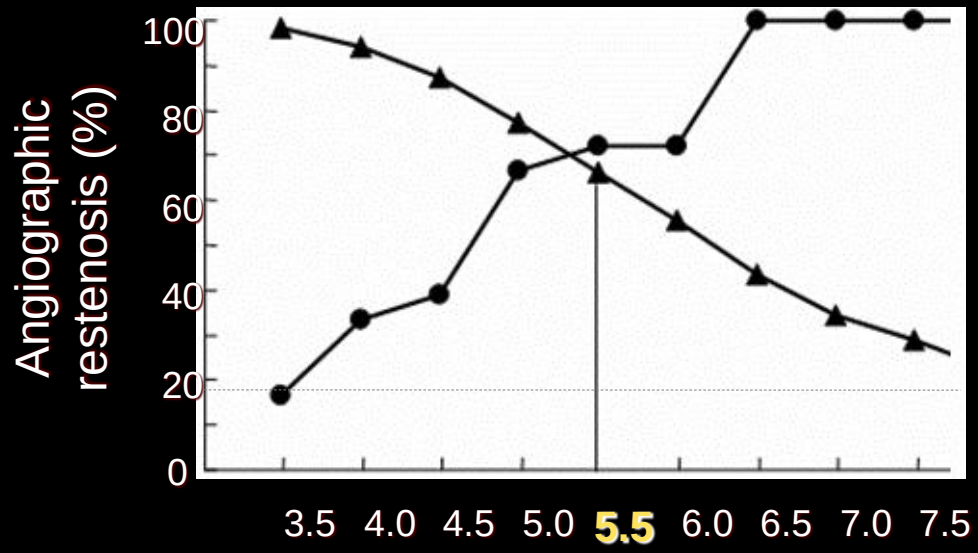


(Abizaid AS, et al. Circulation 1999;100:256-261)
(Bech G, et al. Circulation 2001;103:2928-2934)

Cypher in SIRIUS*

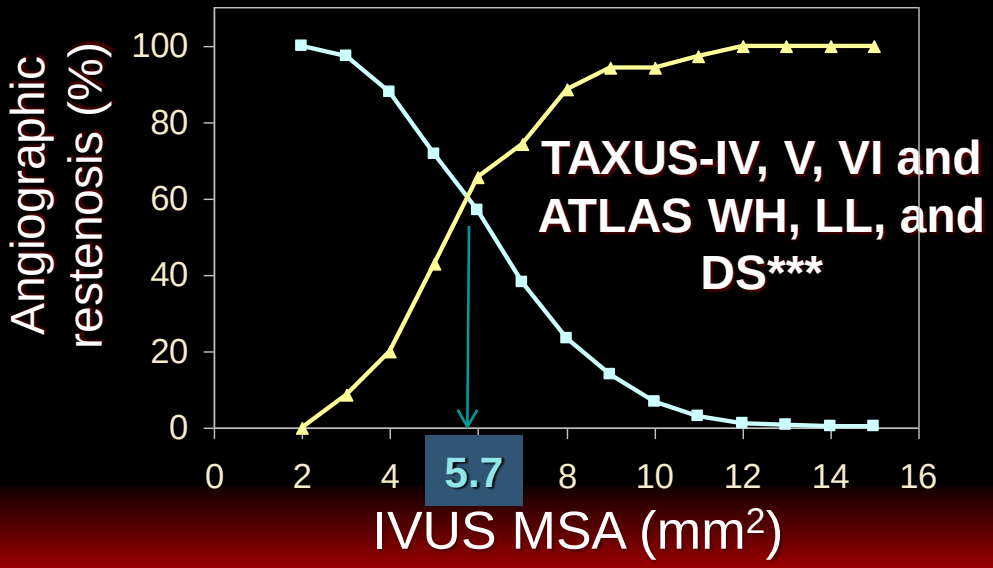


Cypher at AMC**



By definition, sensitivity/specificity curve analysis "must" identify a single MSA that best separates restenosis from no restenosis

C-statistic for TAXUS was only 0.64



*(*Sonoda et al. J Am Coll Cardiol 2004;43:1959-63)*

*(**Hong et al. Eur Heart J 2006;27:1305-10)*

*(***Doi et al. JACC Cardiovasc Interv. 2009;2:1269-75)*

1296 IVUS-guided, DES-treated lesions in 884 pts vs 1312 propensity-score-matched, angio-guided, DES-treated lesions in 884 pts

	IVUS-guided	Angio-guided	p
30 day			
MACE	2.8%	5.2%	0.01
Stent thrombosis	0.5%	1.4%	0.045
TLR	0.7%	1.7%	0.045
1 year			
MACE	14.5%	16.2%	0.3
Definite stent thrombosis	0.7%	2.0%	0.014
Probably stent thrombosis	4.0%	5.8%	0.08
TLR	5.1%	7.2%	0.06
Late definite stent thrombosis	0.2%	0.7%	0.3

(Roy et al. Eur Heart J 2008;29:1851-7)

Summary

- ***Tip:*** **Routine use of IVUS (selected lesions) improves the results of PCI by appropriate pre-procedure lesion assessment, and for the evaluation of results of stent placement, and treatment of complications of PCI.**
- **Best present use for DES is adequate lesion coverage (stent length selection)**
- **IVUS has proven value as a diagnostic imaging modality (left main lesions)**
- **Treatment of stent restenosis and stent thrombosis is best determined after IVUS assessment**
- **The future: Treatment of CTO, and for improved**