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When to Use IVUS and When would FFR be a Better Choice?

William F. Fearon, M.D.
Associate Professor
Division of Cardiovascular Medicine
Stanford University Medical Center

Disclosure Statement of Financial Interest

I, William Fearon, DO NOT have a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation.

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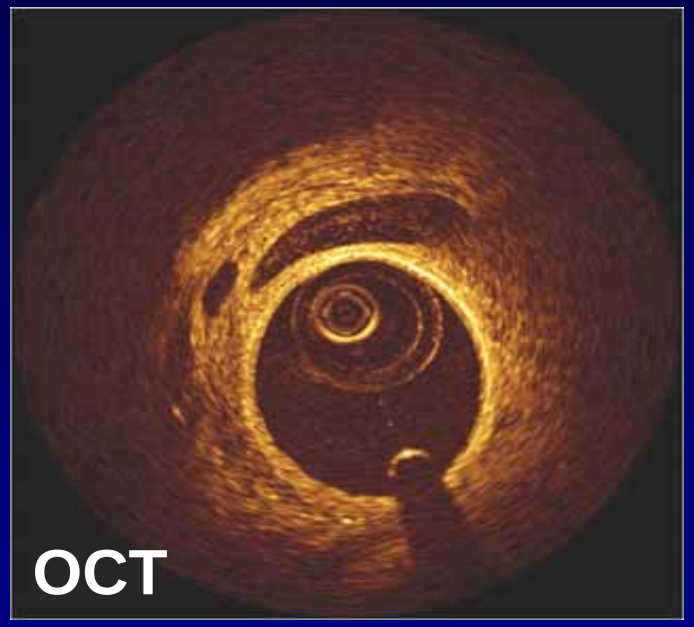
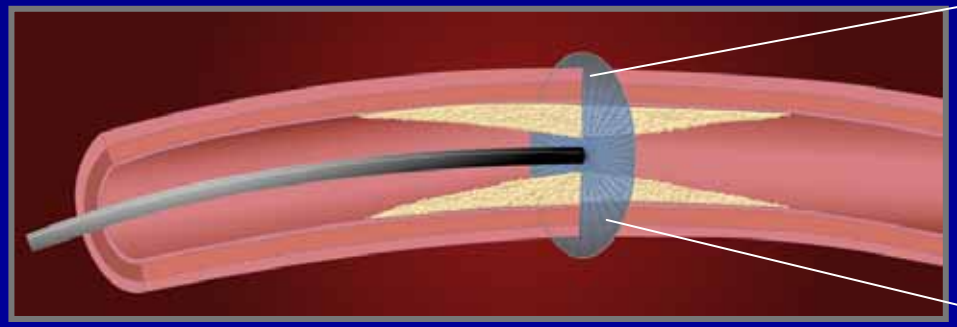
Why not IVUS/OCT?





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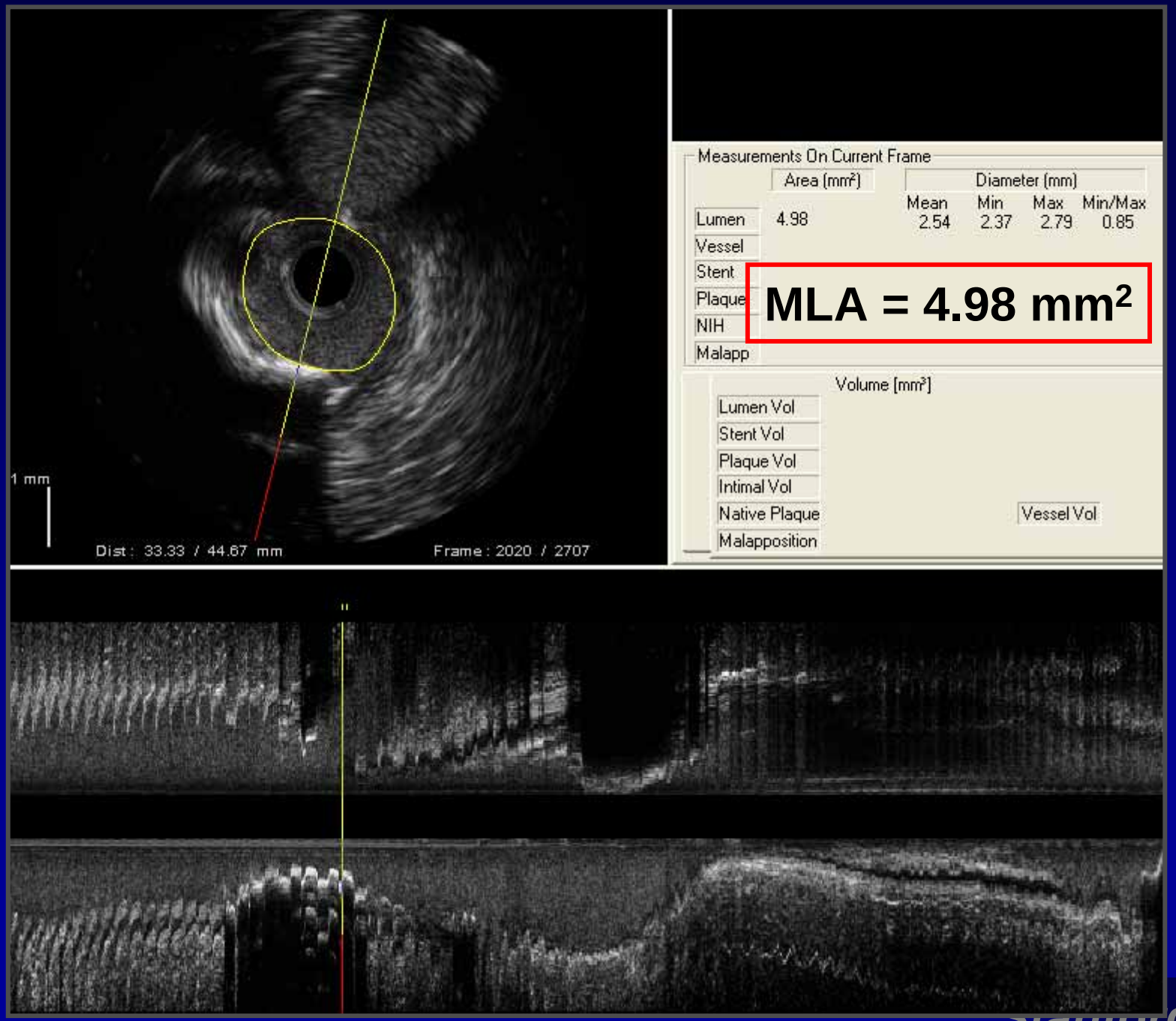
1 mm
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Frame : 2020 / 2707
Measurements On Current Frame
Area (mm²)
Diameter (mm)
Mean
Min
Max
Min/Max
Lumen
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2.54
2.37
2.79
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Vessel
Stent
Plaque
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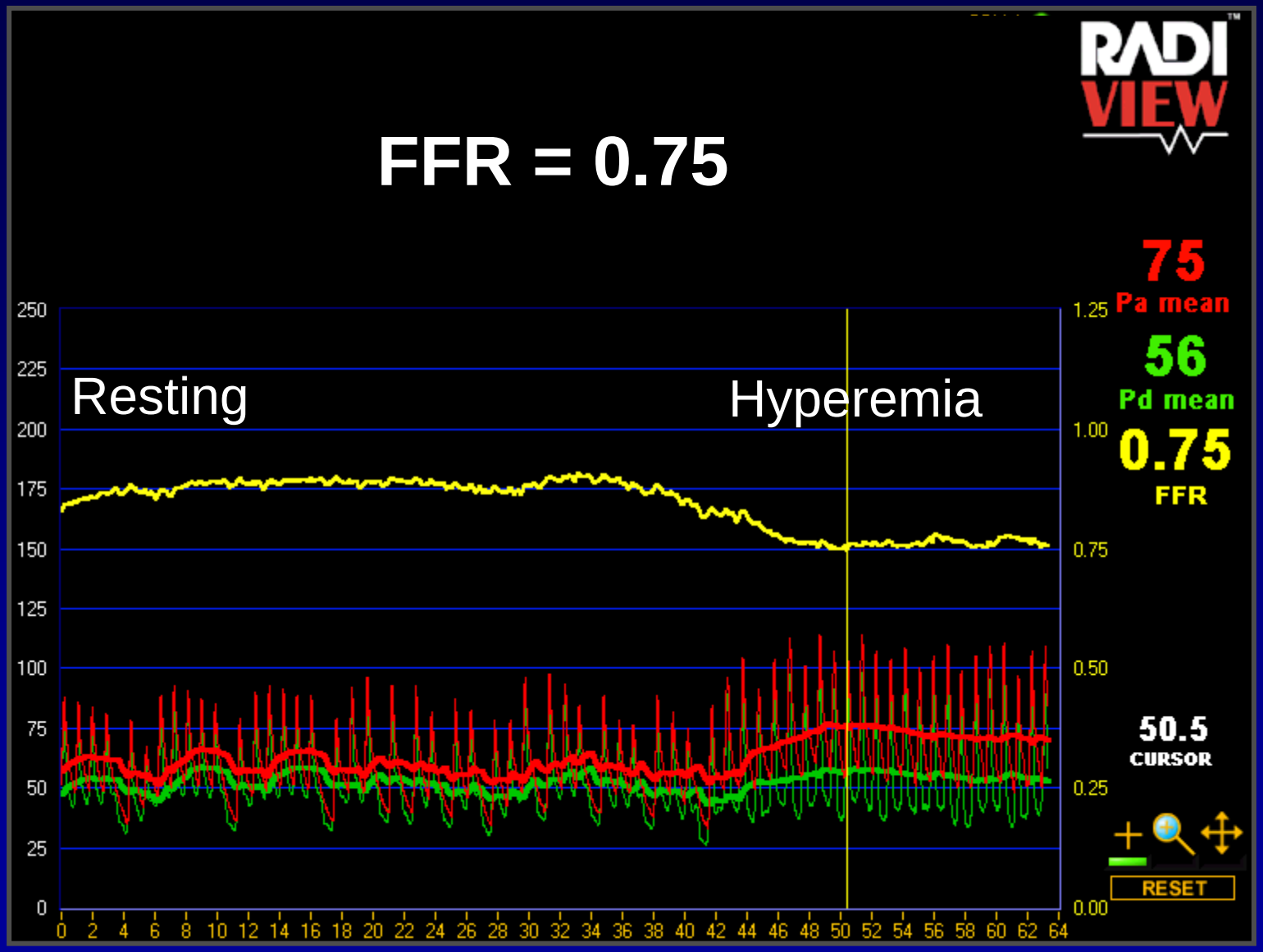
FFR = 0.75
RADI VIEW
75
Pa mean
56
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FFR
Resting
Hyperemia
250
225
200
175
150
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CURSOR
RESET

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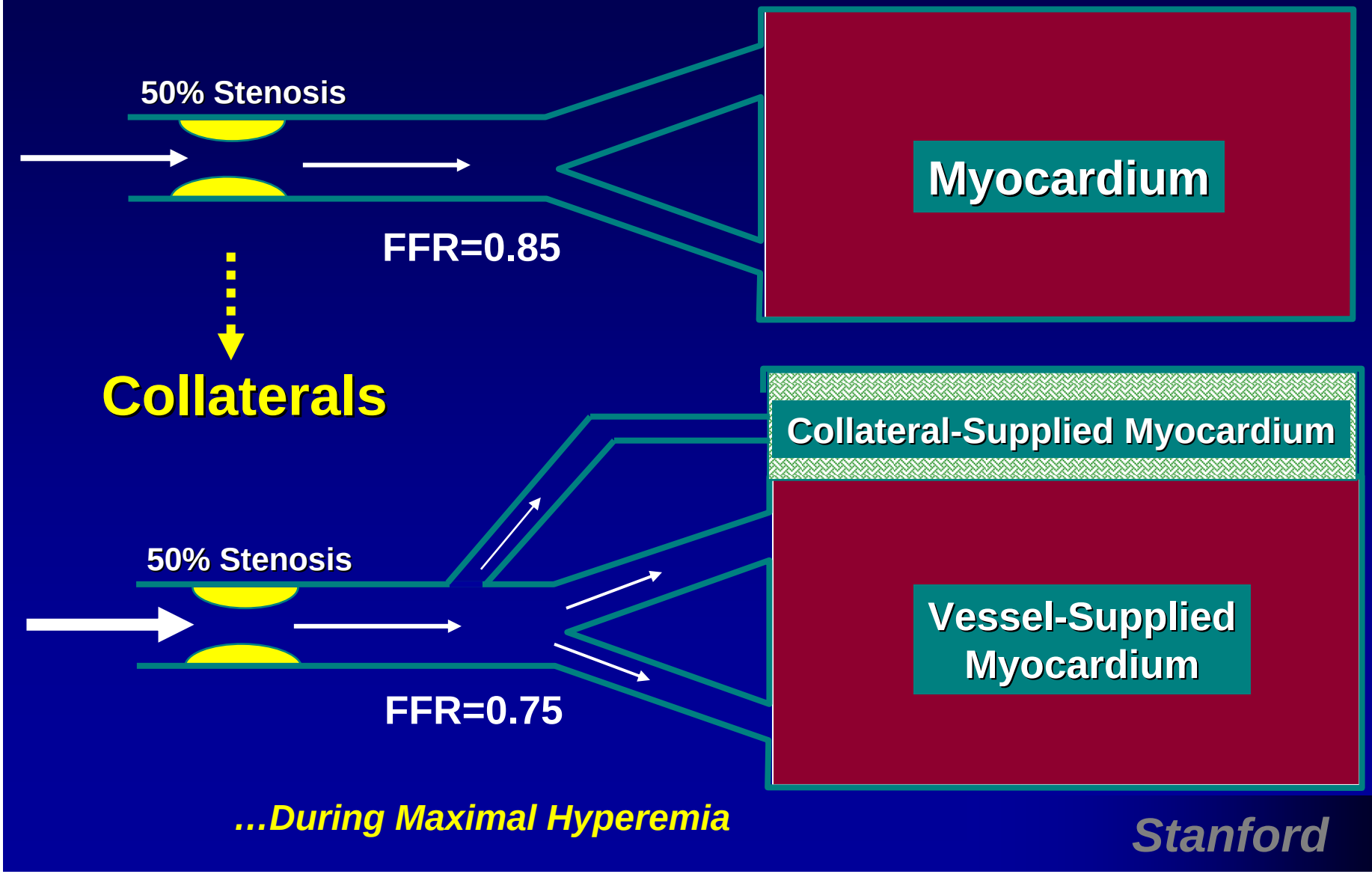
Disconnect between Anatomy and Physiology



…During Maximal Hyperemia

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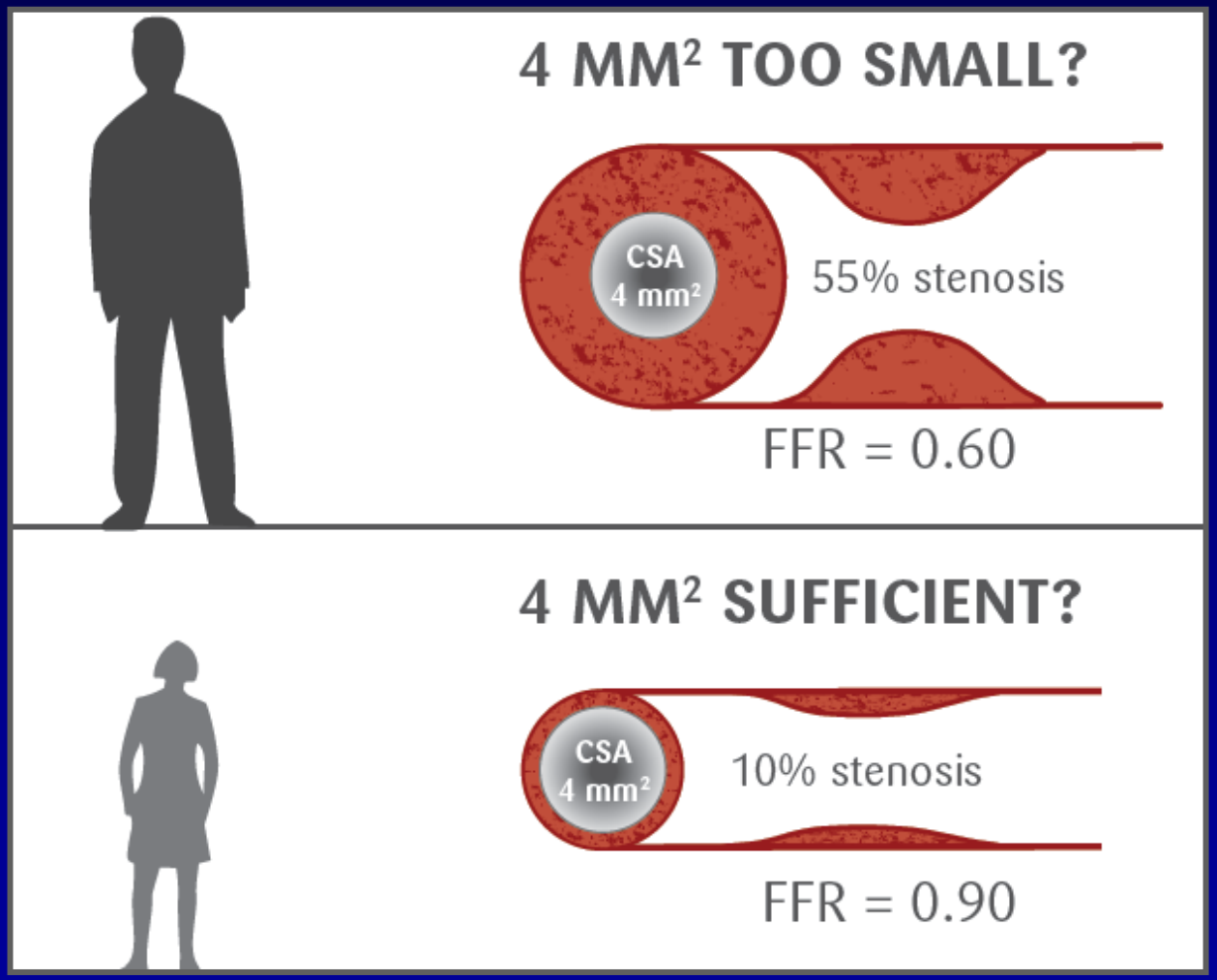
IVUS cutoff is affected by size of vessel



IVUS Criteria for Flow-Limiting Stenosis

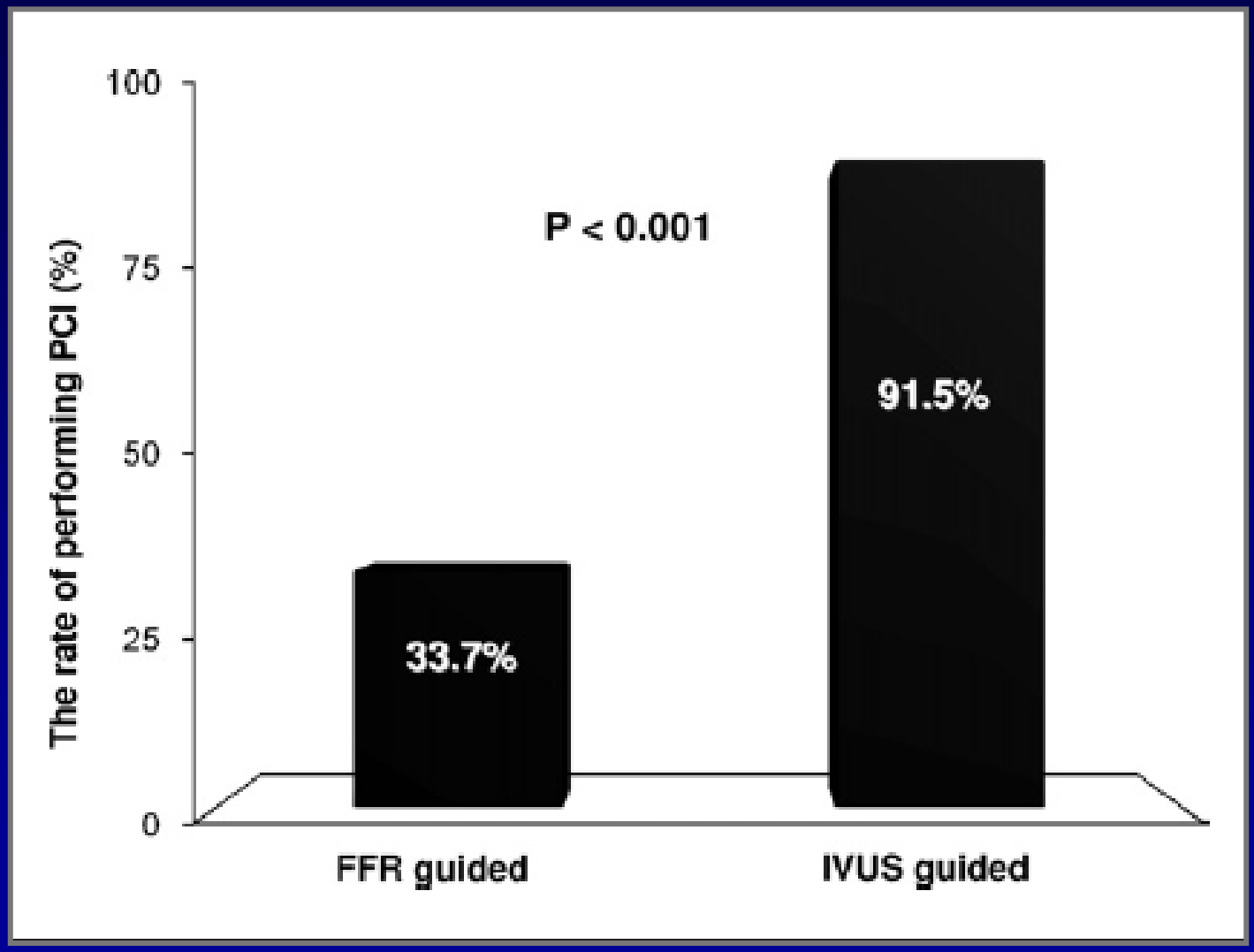
	Comparison	Threshold
Briguori, et al. (AJC 2001)	FFR	MLA < 4.0 mm^2
Takagi, et al. (Circ 1999)	FFR	MLA < 3.0 mm^2
Kang, et al. (In press)	FFR	MLA < 2.4 mm^2

FFR versus IVUS-guided PCI

- 167 consecutive patients with intermediate lesions (40-70%) in the proximal or mid vessel
- 83 lesions evaluated by FFR (cuttoff 0.80)
- 94 lesions evaluated by IVUS (cuttoff 4 mm^2)
- Primary endpoint: Death, MI, TVR at 1 year

Nam et al. J Am Coll Cardiol Intv 2010; 3:812-17

PCI Rate Based on FFR vs IVUS:



Nam et al. J Am Coll Cardiol Intv 2010; 3:812-17

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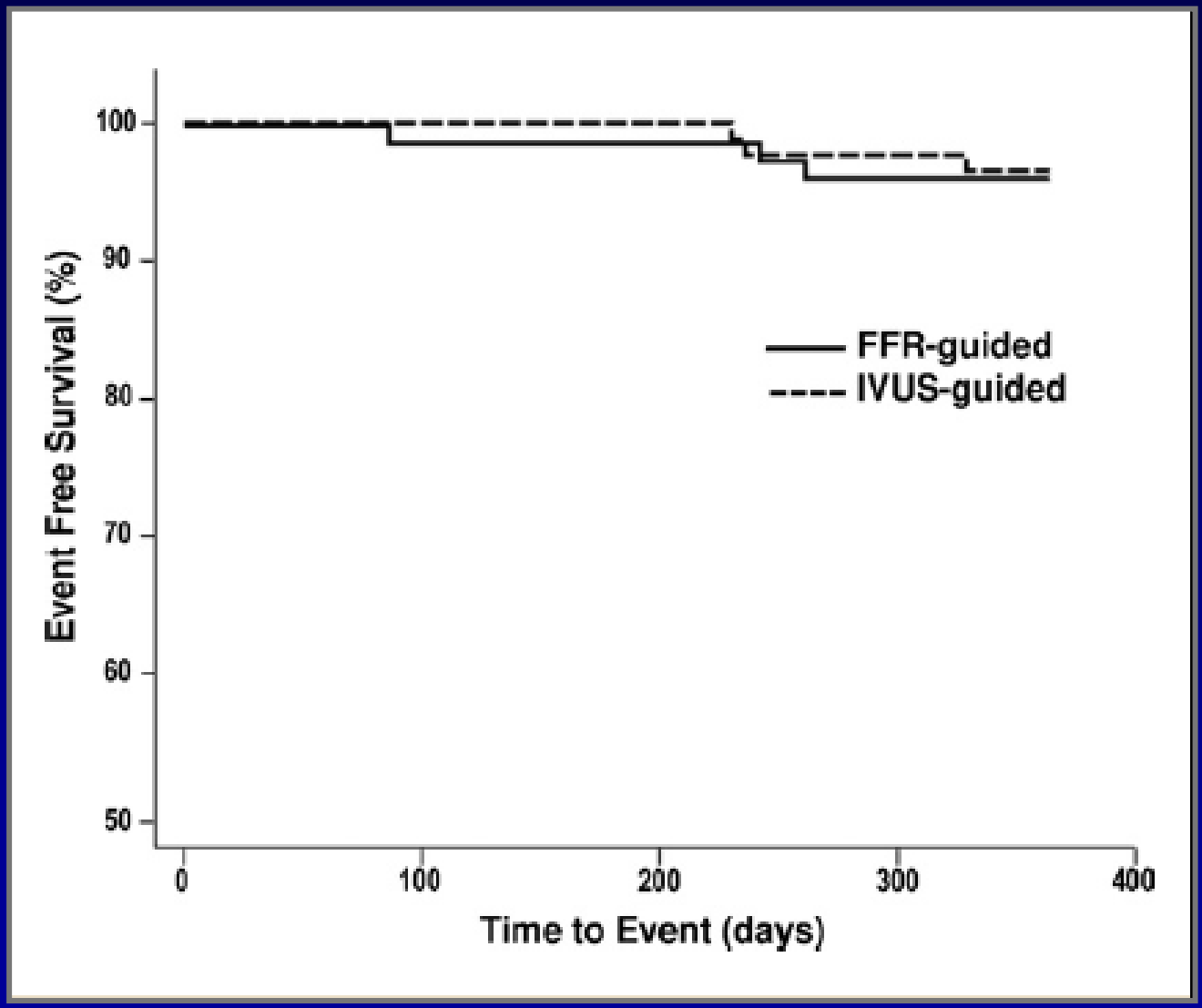
One Year Outcomes:



Nam et al. J Am Coll Cardiol Intv 2010; 3:812-17

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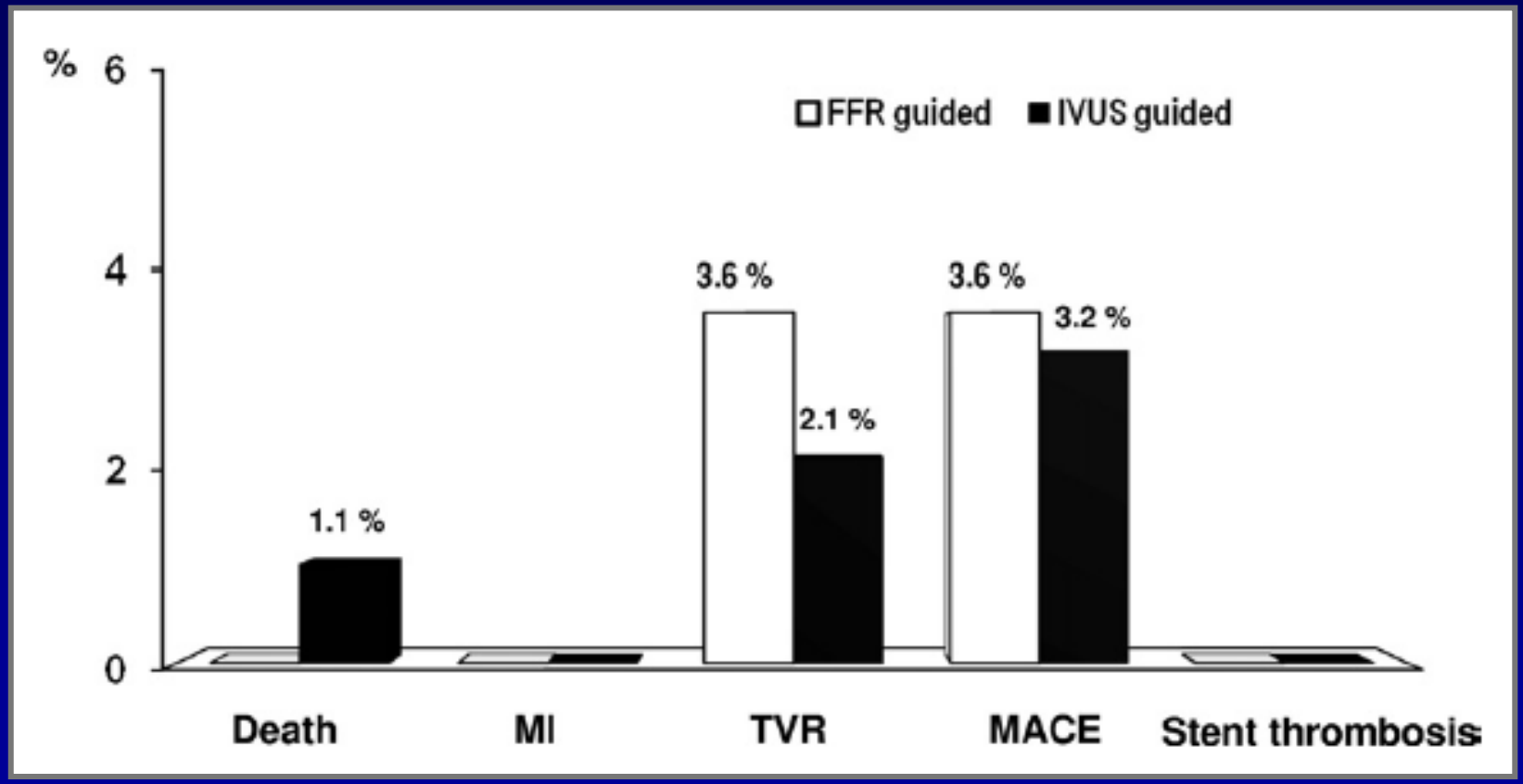
One Year Outcomes:

FFR Guided: 3 TVR (1 deferred lesion, 1 ISR, 1 new lesion)
IVUS Guided: 1 non cardiac death, 2 ISR



Nam et al. J Am Coll Cardiol Intv 2010; 3:812-17

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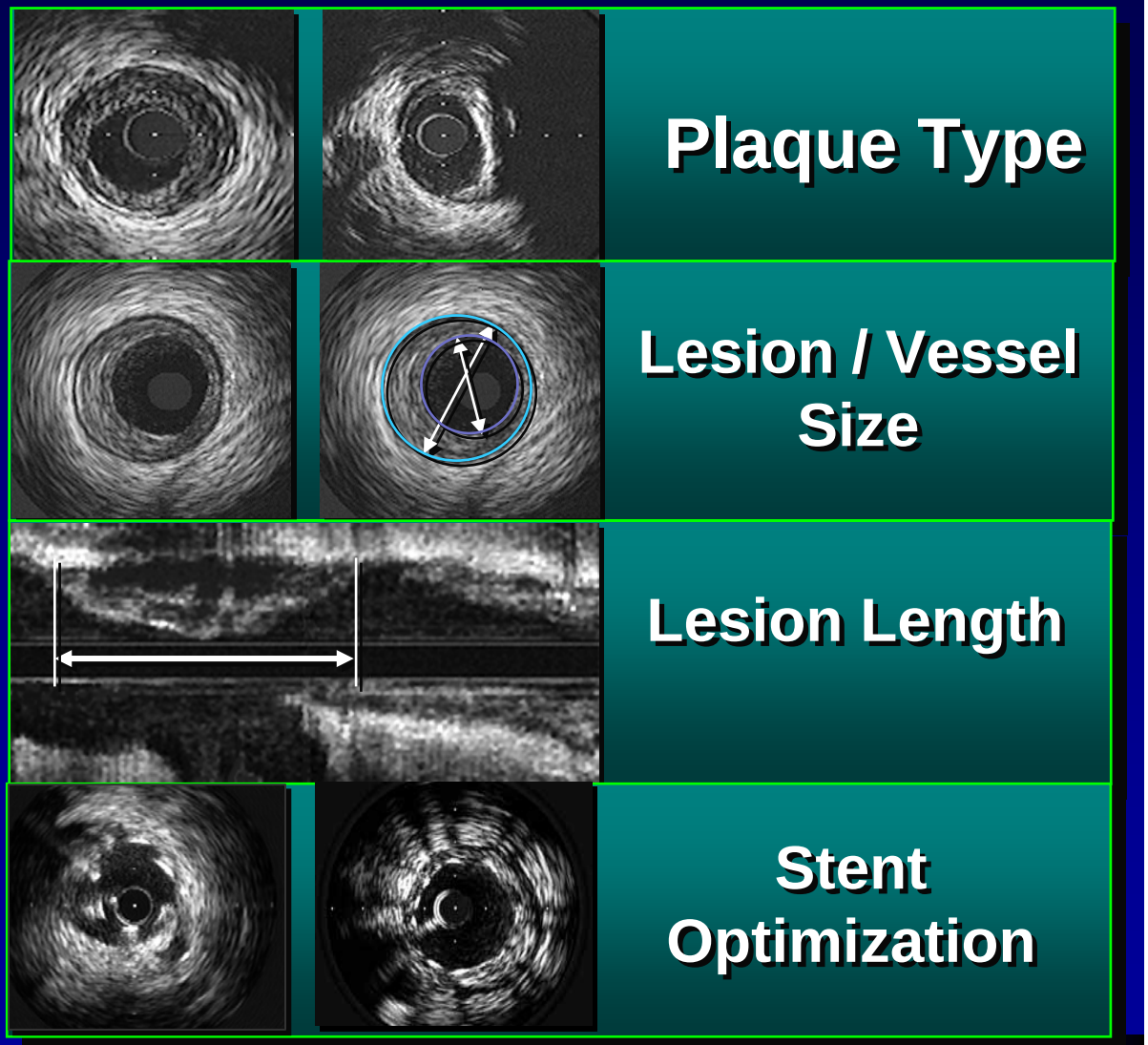
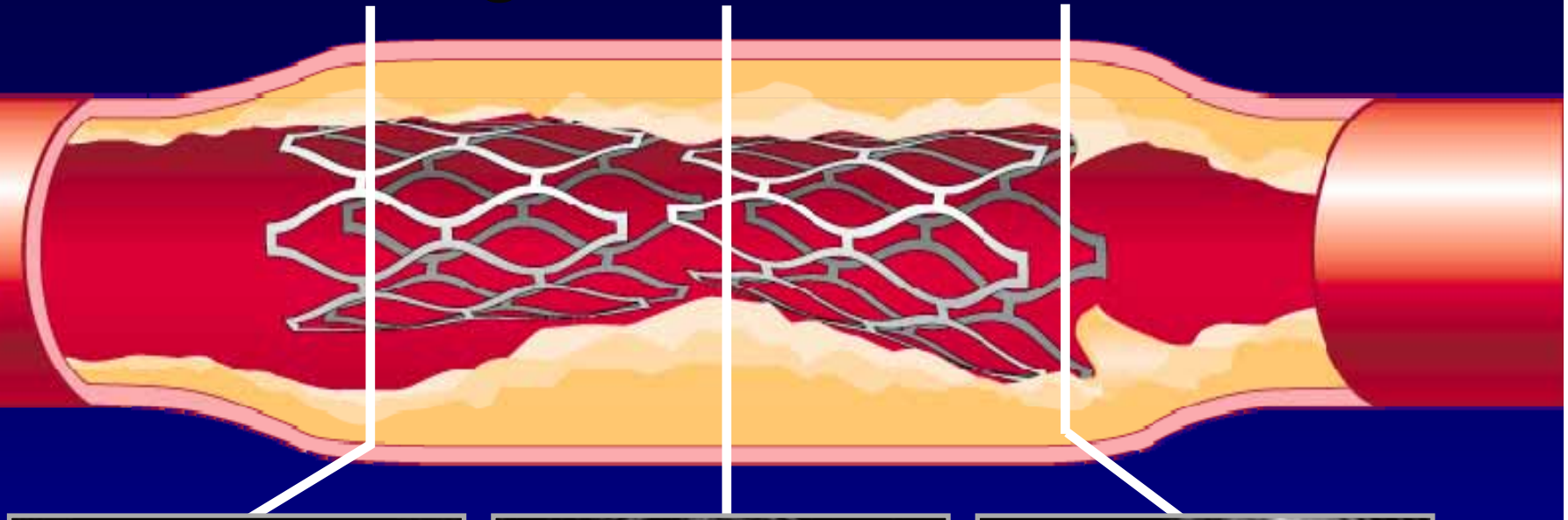
So when should we use IVUS?

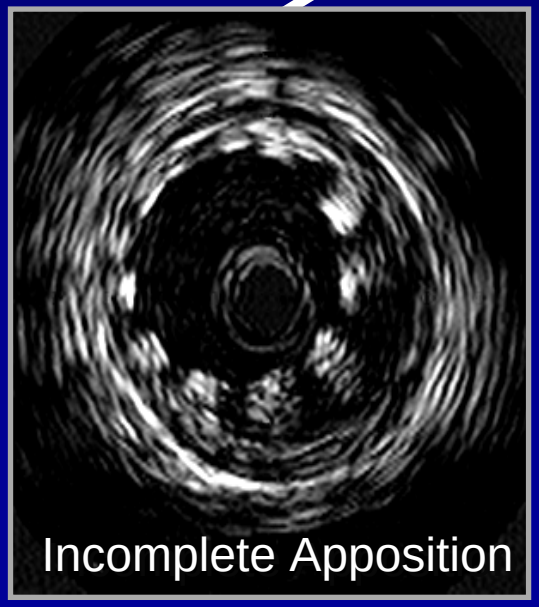
Once an ischemia-producing lesion has been identified:

- To determine lesion length, vessel size, plaque composition, relationship to bifurcation

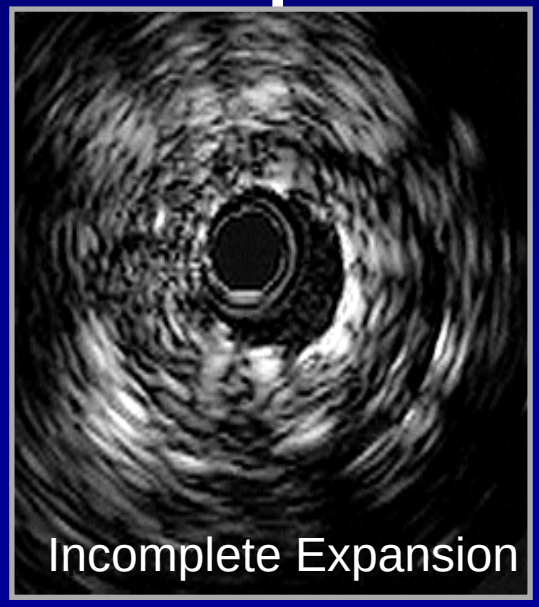


Assessing Stent Placement …

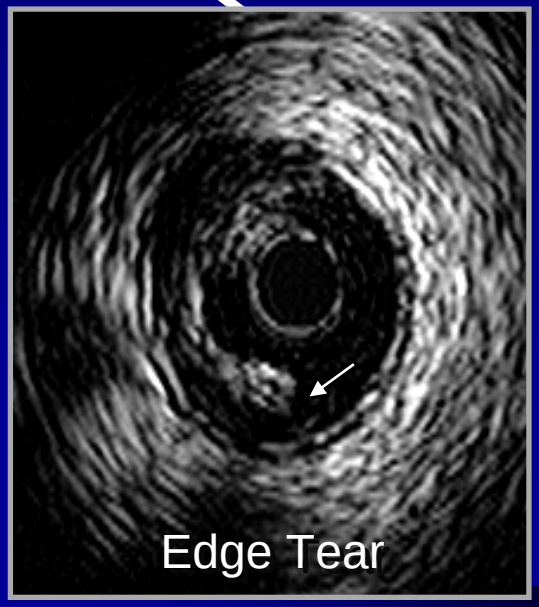




Incomplete Apposition



Incomplete Expansion



Edge Tear

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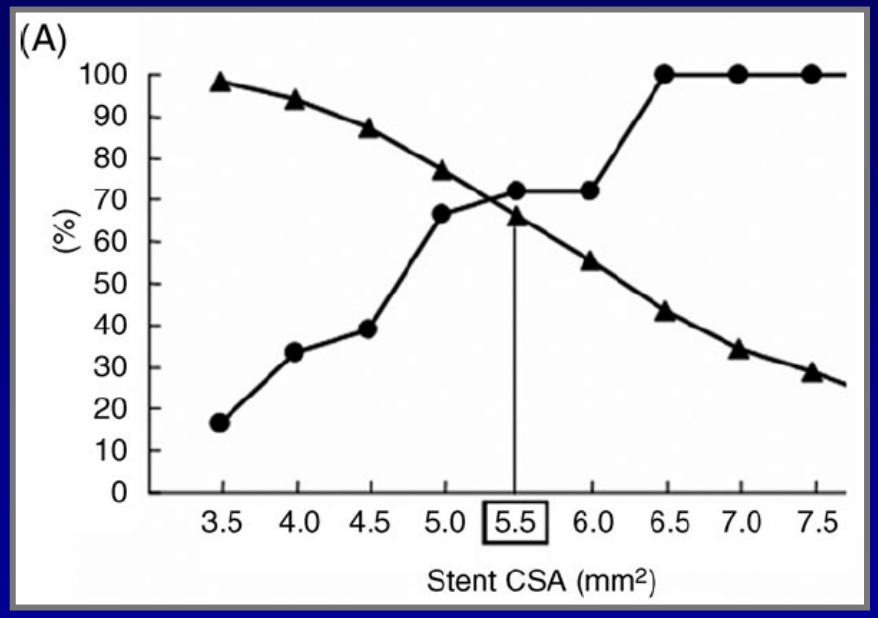
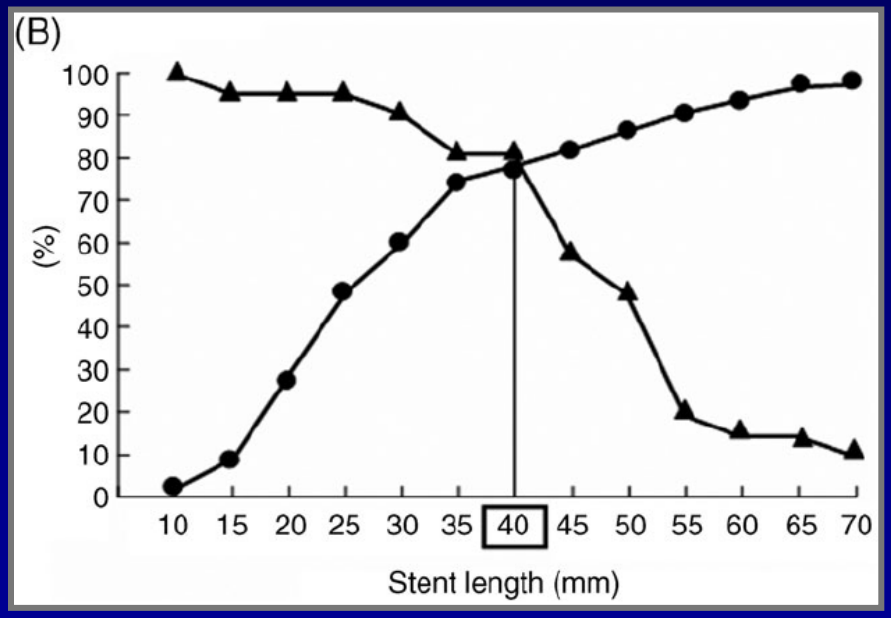
IVUS Predictors of DES Restenosis

6 month angio available in 449 patients with baseline IVUS after receiving SES for 543 lesions





Final MSA and IVUS measured stent length were the only independent predictors of DES restenosis

Hong et al., Eur Heart J 2006;27:1305-10.

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IVUS Predictors of DES Restenosis

6 month angio available in 449 patients with baseline IVUS after receiving SES for 543 lesions

Stent length (mm)	Stent CSA (mm^2)	Restenosis rates	*P* trend
≤40	≥5.5	1/284 (0.4%)	
≤40	<5.5	3/127 (2.4%)	<0.001
>40	≥5.5	6/70 (8.6%)	
>40	<5.5	11/62 (17.7%)	

Hong et al., Eur Heart J 2006;27:1305-10.

IVUS Predictors of DES Thrombosis

- 15 patients with SES thrombosis compared to 45 matched controls
- MSA and stent expansion were significantly smaller in the thrombosis group
- Residual reference segment stenosis was significantly greater in the thrombosis group

Fujii, Carlier, Mintz et al. J Am Coll Cardiol 2005;45:995-8.

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Case Presentation:

- 82 year old frail woman (4’9”, 90 pounds) with HTN, dyslipidemia presents with chest pain
- 2 weeks prior to this presentation, patient had NSTEMI with PCI to circumflex. Because of concern regarding aspirin allergy, patient received BMS to proximal circumflex and PTCA to OM. Ejection fraction normal.

Case Presentation:

- ECG with nonspecific ST/T wave changes, not significantly different from prior
- Initial enzymes negative.
- However, because of concerning symptoms and recent history (particularly PTCA), brought to cath lab…


CRUDA, VICENTAL
21576335
FEARON, BILL
Stanford Cath/Agio Rm6
Filter: Enhance 6
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1
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18.40 RAO
22.30 CAU

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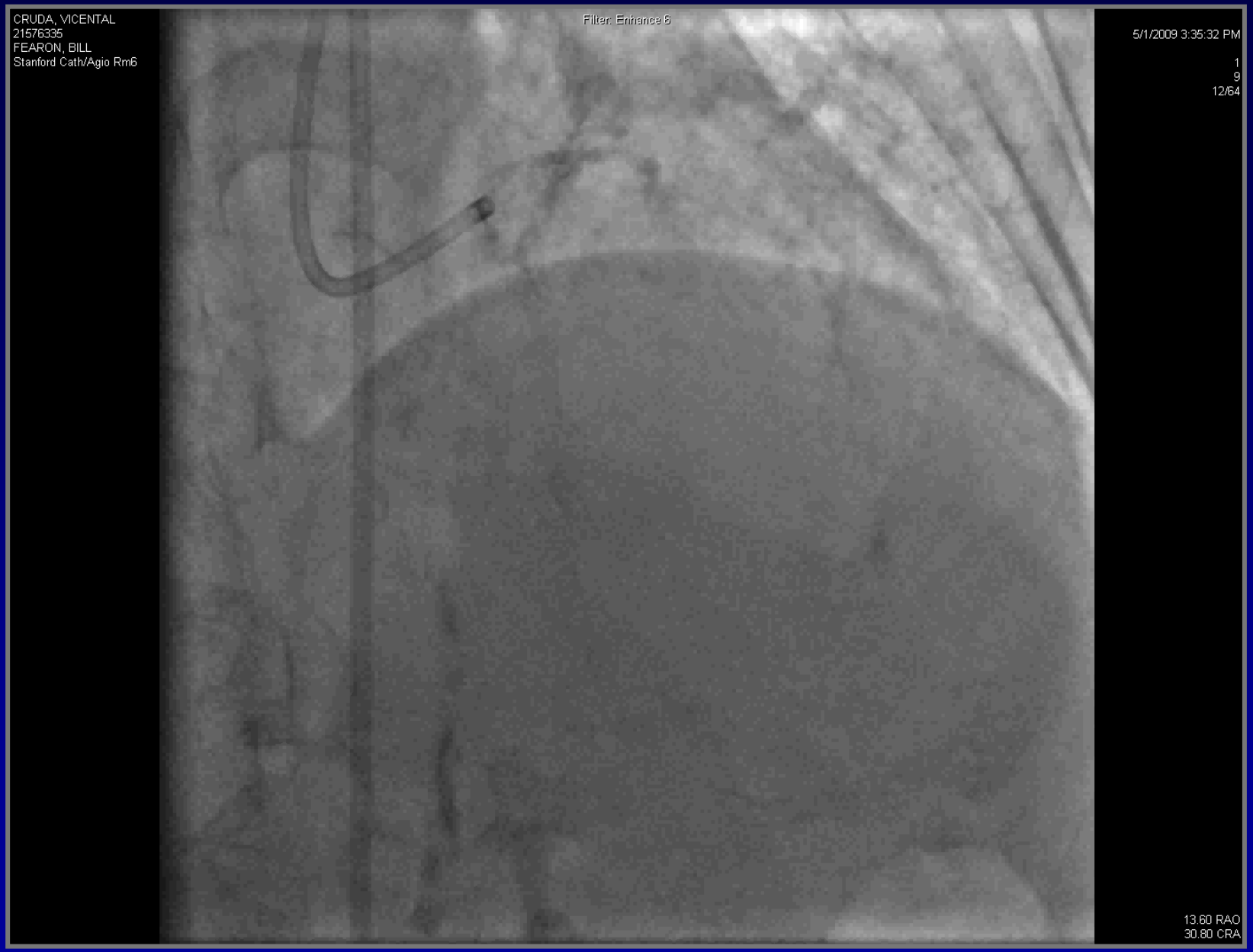
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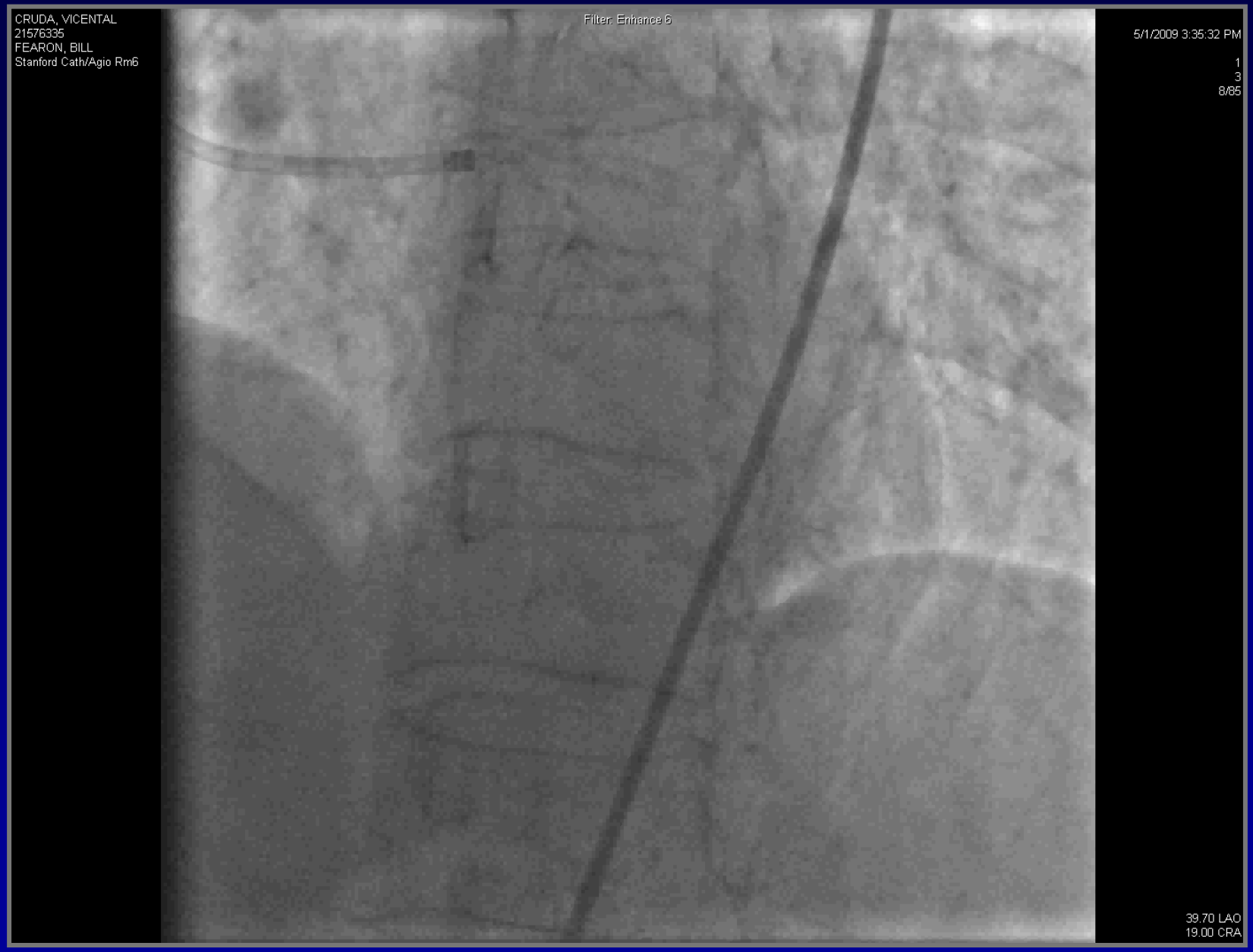
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39.70 LAO
19.00 CRA

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30.30 CAU

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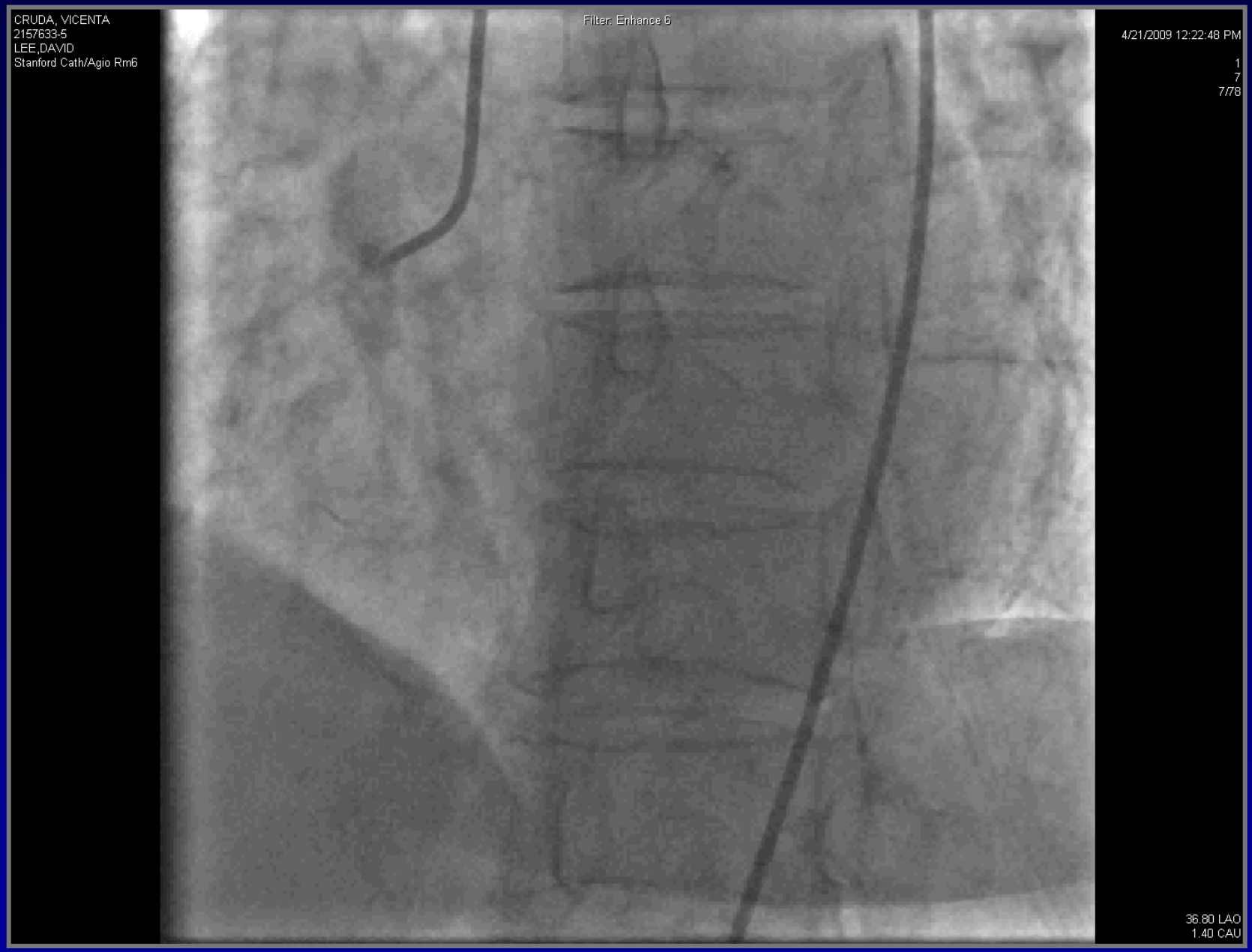
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Stanford Cath/Agio Rm6
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36.80 LAO
1.40 CAU

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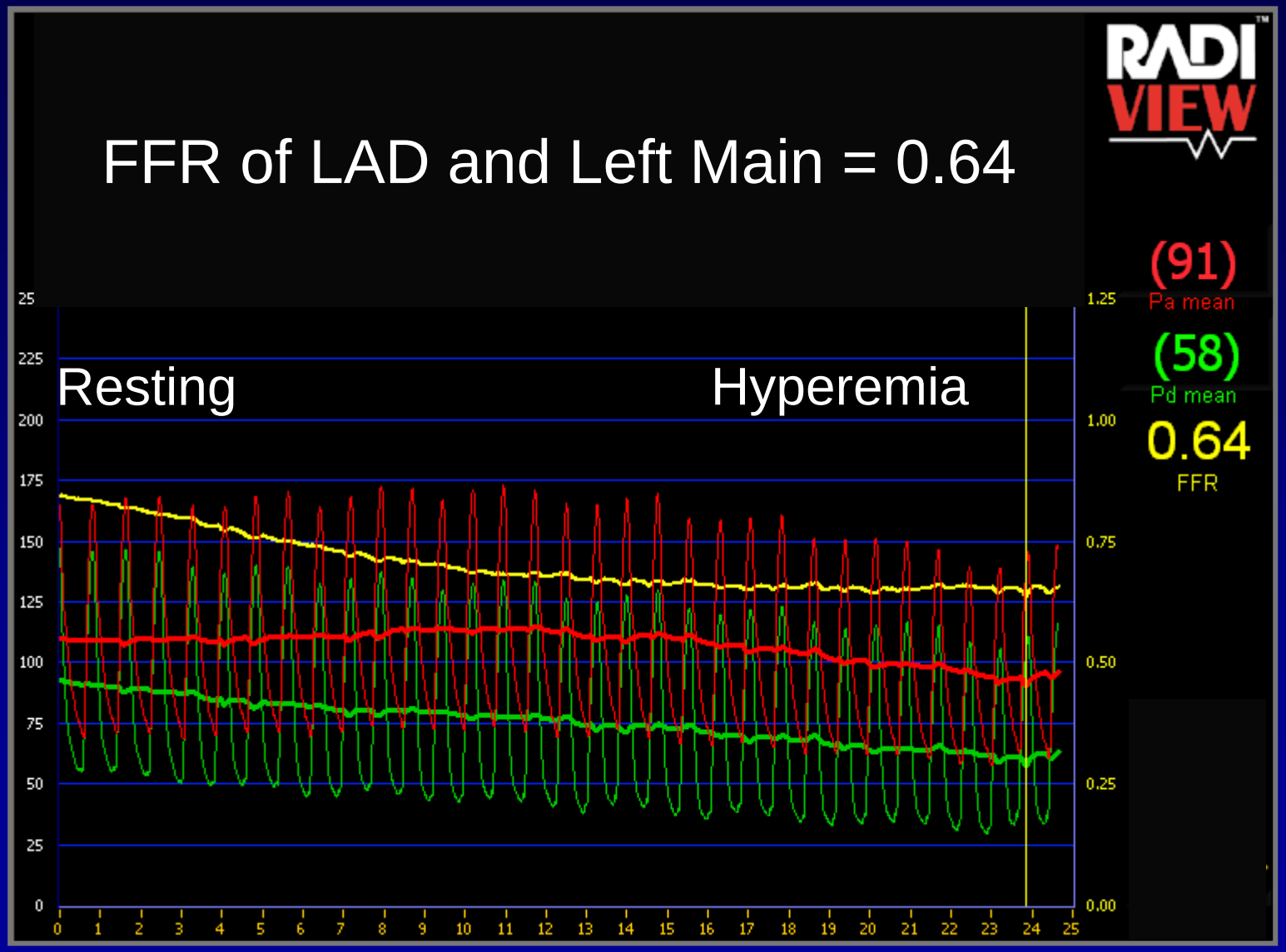
Further Interrogation with FFR



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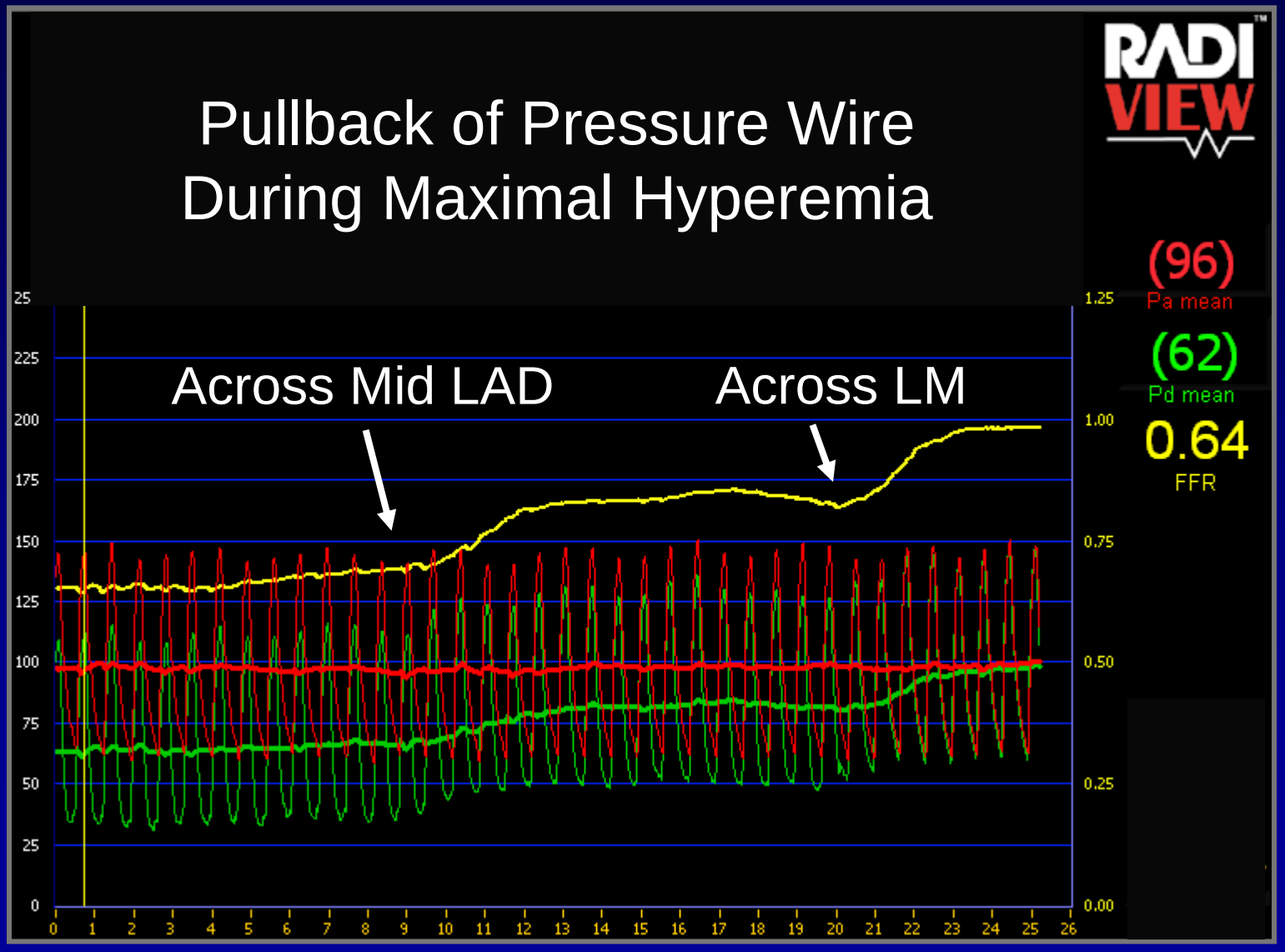
Further Interrogation with FFR



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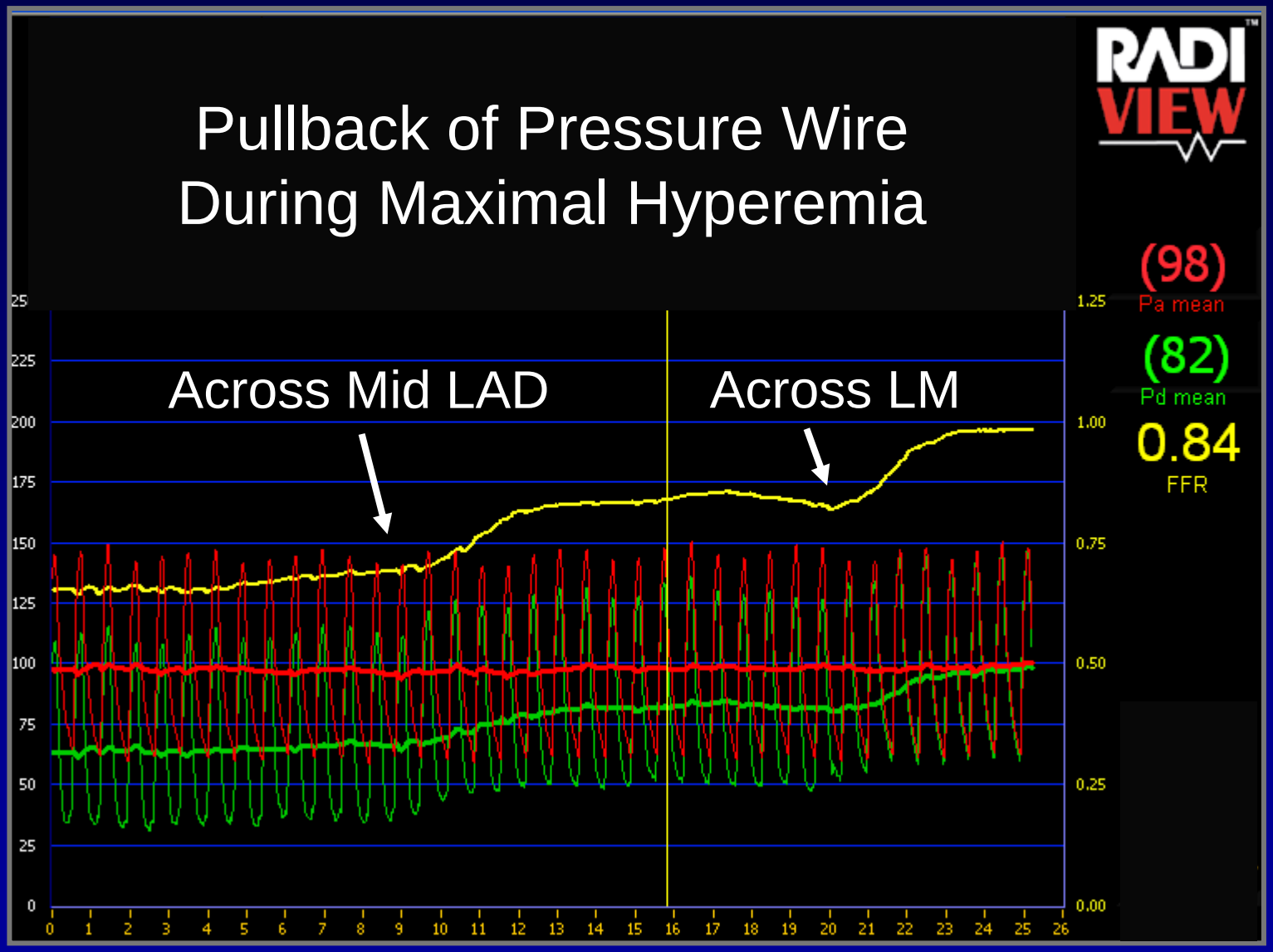
Further Interrogation with FFR



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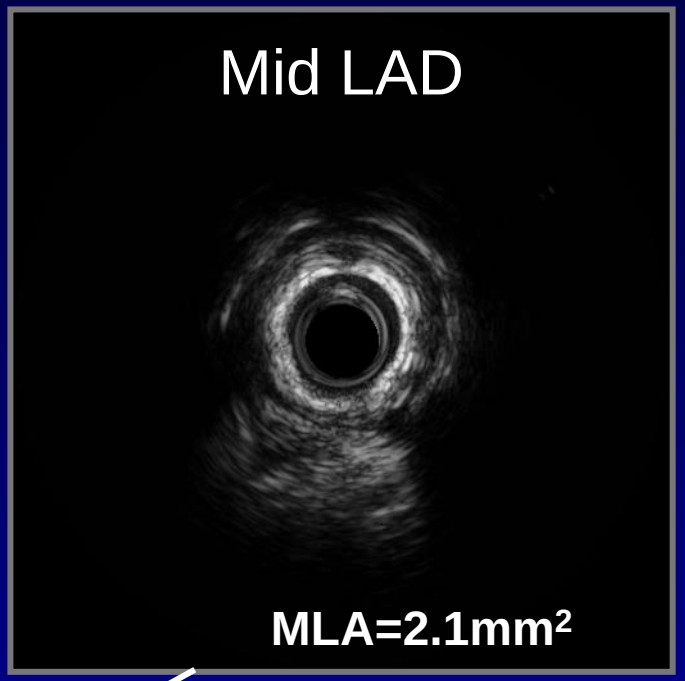
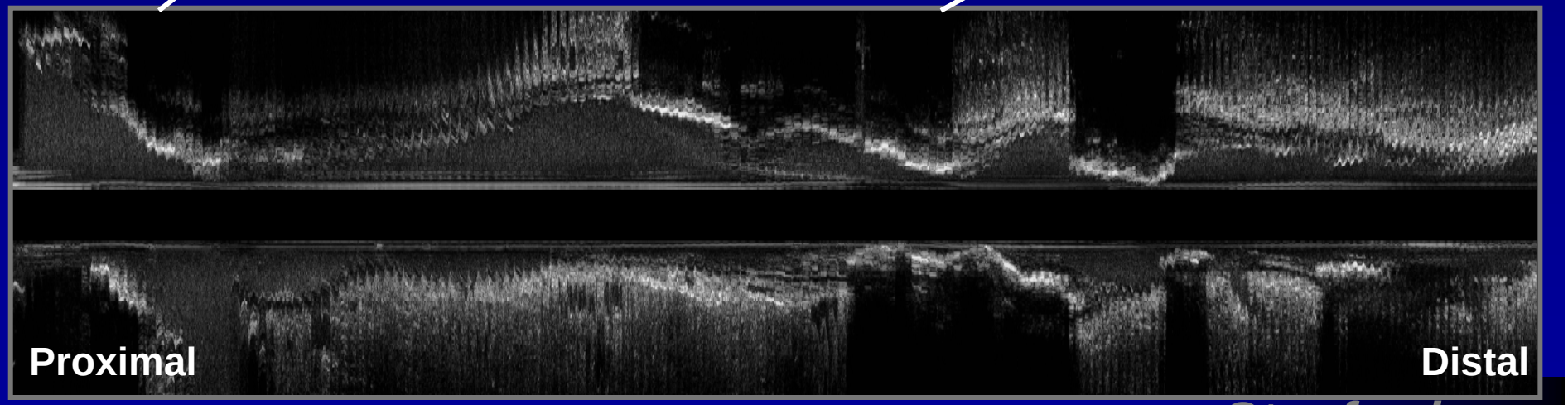
Further Interrogation with IVUS





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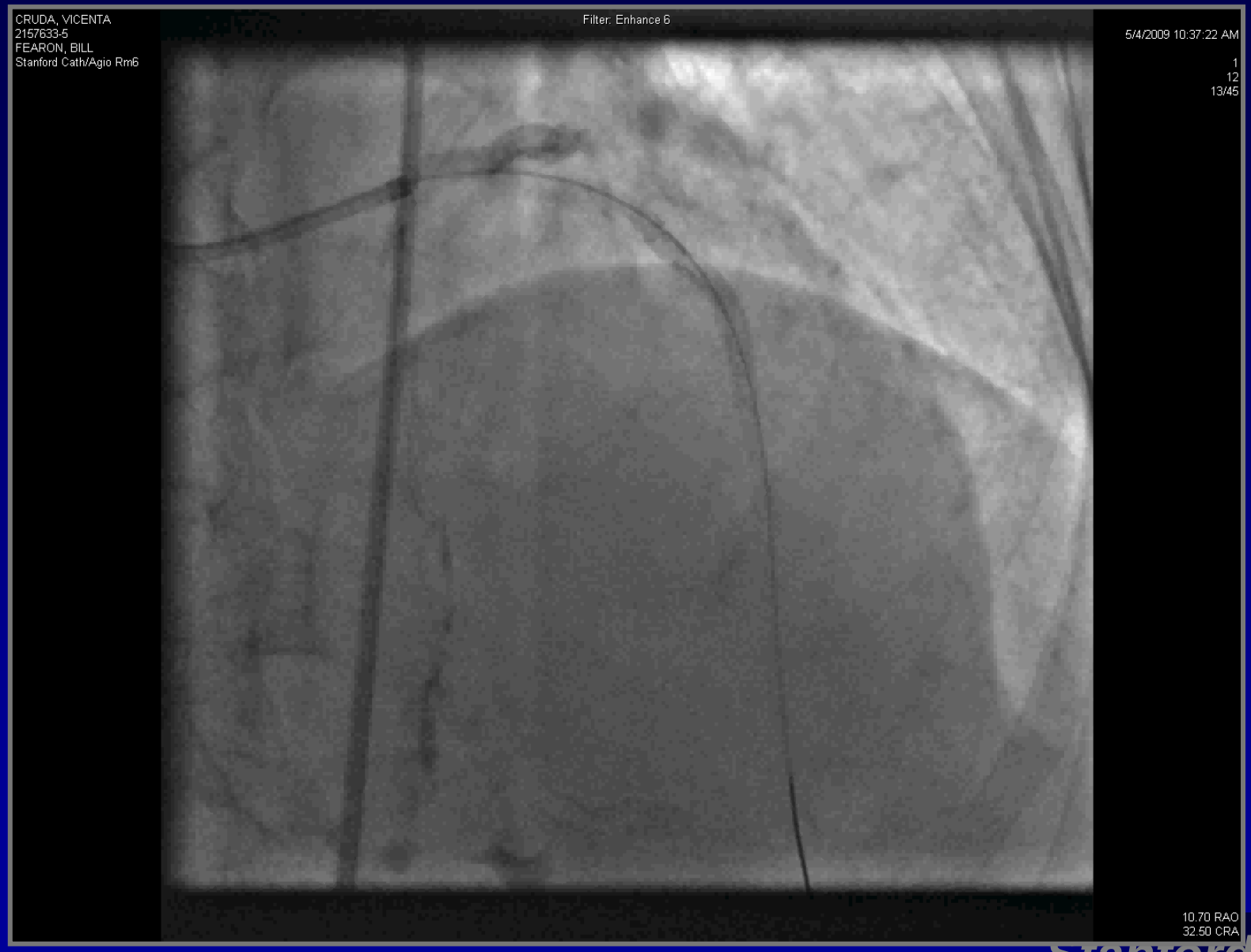
Decision Process

- Based on FFR and IVUS, LAD and LM both appear significant. SYNTAX score = 23.
- Stopped procedure and discussed options with patient and family.
- Presented case to other cardiologists and cardiac surgeons at cath conference. No aspirin allergy. No enthusiasm by surgeons…

After rotational atherectomy and 2.5x28 mm DES, post-dilated to 3.0 mm



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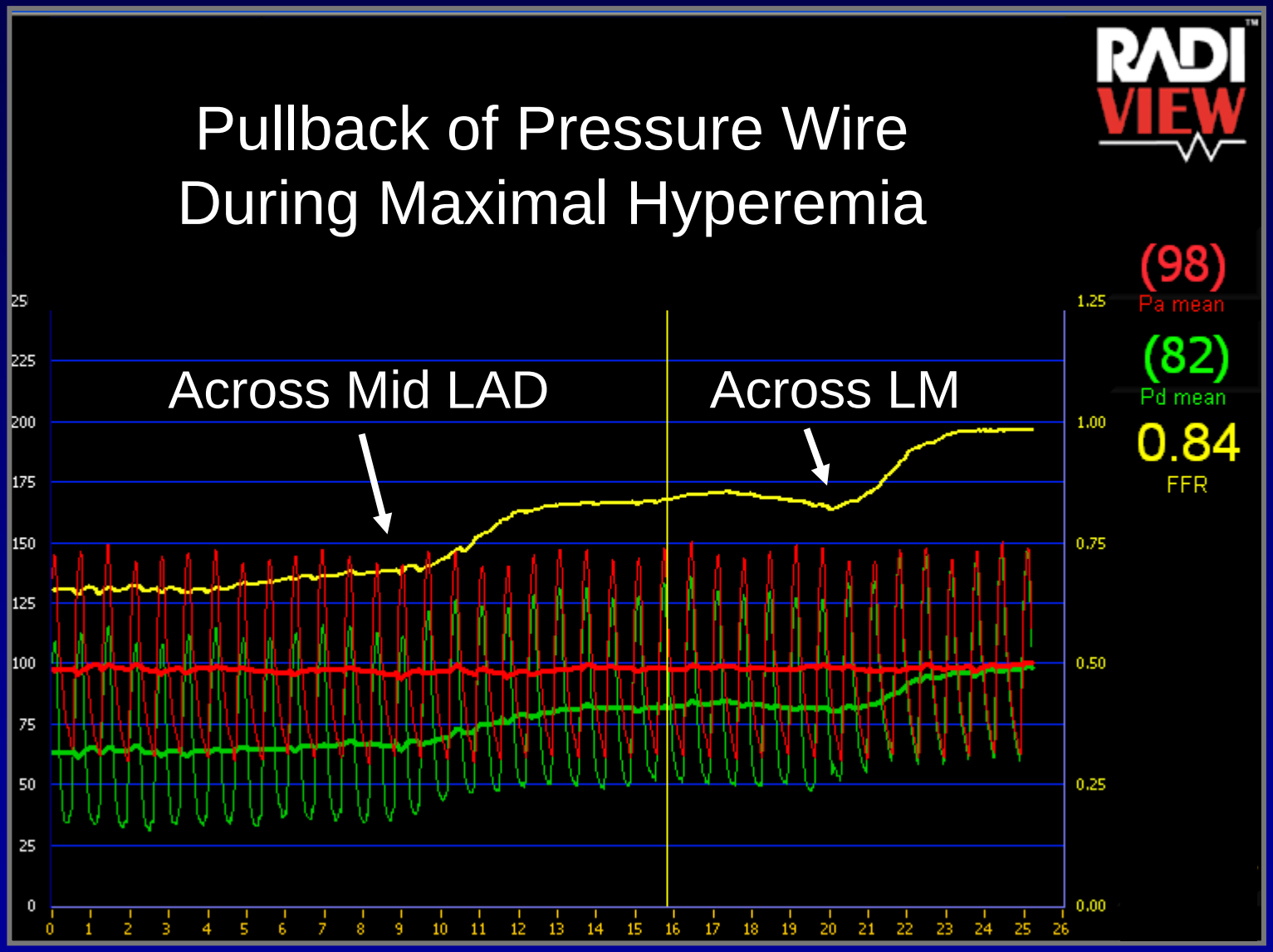
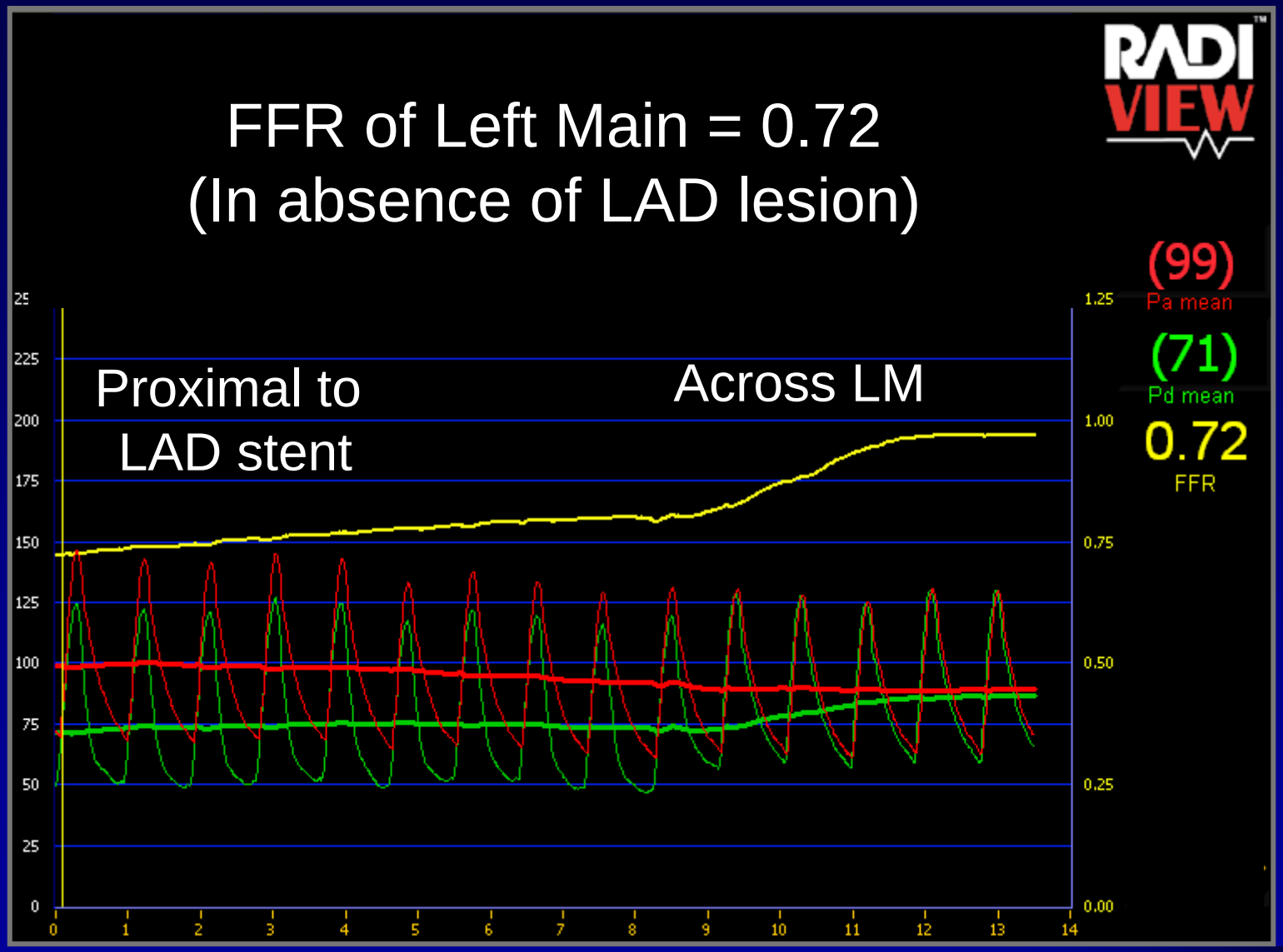
Further Interrogation with FFR



Further Interrogation with FFR



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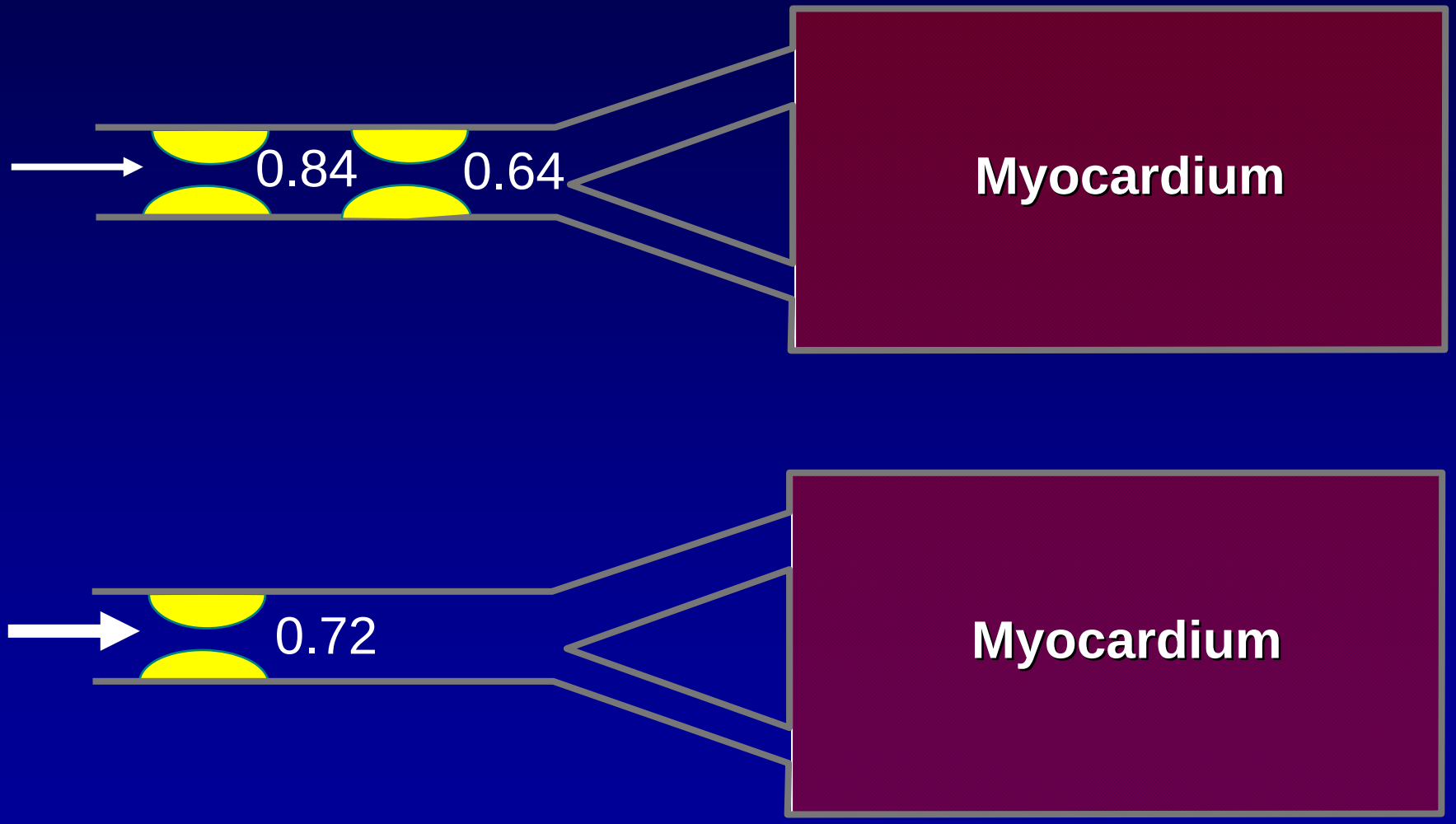
Effect of serial lesions



3.0x18 DES to LM/prox LAD, post-dilated to 3.5 mm
Final IVUS MSA LM=7.0 mm2 , MSA LAD=5.0mm2

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STATE-OF-THE-ART PAPER

Assessment of Intermediate Severity Coronary Lesions in the Catheterization Laboratory

Jonathan Tobis, MD, Babak Azarbal, MD, Leo Slavin, MD

Los Angeles, California

demonstrated benefit in guiding therapy in small trials in patients with ACS.

The no-reflow phenomenon, defined by the acute reduction in coronary flow in the setting of a patent epicardial coronary artery is an uncommon complication of PCI (0.08% to 2.0%) (101). More frequently, it occurs during aortocoronal atherectomy, interventions involving SVGs, and AMI (102). Up to 30% of PCIs performed in the setting of AMI are complicated by the "no-reflow" phenomenon where no blood flow proceeds distally despite a successful balloon dilation or stent insertion (104,105). Although, the precise pathophysiology of no-reflow is still uncertain, various mechanisms, including microvascular spasm, distal embolization of thrombus or atherosclerotic debris, oxygen-free radical-mediated endothelial injury, or capillary inflammatory injury have been proposed (103). Intravascular ultrasound can predict lesions at higher risk for "no-reflow" after PCI, owing to the plaque mass and loose tissue components of the plaque (105). In addition, IVUS can rule out other causes of poor flow after PCI such as coronary dissection or residual stenosis (106).

Ostial lesions. Analogous to assessment of lesion severity in bifurcation stenoses, assessment of ostial lesion severity is confounded by vessel overlap with the aorta, angulation, and deep seating of the catheter beyond the ostial lesion (107). In a study of 46 patients where 55 ostial lesions were evaluated, 20 of 25 patients (80%) determined to have stenosis severity of 70% or greater had an FFR ≥0.75 (86). Although sensitivity of angiography in this study was 100%, the specificity was only 55%; there was an excellent correlation between presence of ischemia by noninvasive stress imaging studies and FFR.

Intravascular ultrasound is also helpful for diagnosing and treating ostial lesions. Intravascular ultrasound can delineate the extent of stenosis as well as the plaque burden at the ostial location, although heavy calcification limits the penetration of the ultrasound images. Precise placement of the stent at the aorta-ostial juncture is often challenging when using fluoroscopic guidance. The corresponding position of the IVUS catheter on the fluoroscopic image at the cross section where the ostium is observed on the ultrasound image can be very useful in ensuring correct stent placement. Without moving the image intensifier, the stent is placed in the same position as the IVUS catheter was when the aorta-ostial juncture was seen by ultrasound. After PCI, IVUS is helpful to confirm that the entire ostium has been covered by the stent, which will decrease the chance of restenosis.

Comparison of IVUS and FFR

Although IVUS does not provide direct estimation of the hemodynamic severity of a coronary lesion, several studies have demonstrated a strong correlation between anatomic data obtained from IVUS and ischemia by myocardial perfusion SPECT imaging (108), CFR (109), and FFR (110,111). Briguori et al. (111) evaluated 53 lesions in 43 patients with both IVUS and FFR. Receiver operating characteristic curve analysis demonstrated that the following IVUS parameters correlated with an abnormal FFR value (≤0.75) (in order of decreasing sensitivity and specificity): >70% area stenosis, minimal lumen diameter ≤1.8 mm, minimal lumen cross-sectional area ≤4.0 mm², and lesion length >10 mm. Another study by Takagi et al. (110) evaluated 51 lesions in 42 patients with both FFR and IVUS. Intravascular ultrasound parameters that best correlated with an FFR value ≤0.75 were >40% area stenosis and a minimal lumen cross-sectional area <3.0 mm². By providing precise information on vessel size, extent of the atherosclerosis, and plaque characteristics, IVUS images help guide PCI strategy, equipment selection, and assessment of the adequacy of the results.

Fractional flow reserve provides important physiologic information on the hemodynamic severity of a coronary lesion and is helpful in the cardiac catheterization laboratory to determine whether PCI should be performed without stopping the procedure and sending the patient for a noninvasive stress test. Fractional flow reserve is easy to perform and provides an accurate and lesion-specific index of functional severity of coronary stenosis that correlates with noninvasive tests of myocardial ischemia in patients with intermediate lesions (112). Fractional flow reserve has been compared with IVUS as a measurement for optimal stent deployment. One retrospective analysis showed that FFR ≥0.94 after stent deployment had a concordance rate of 91% with IVUS and displayed accuracy in guiding stent deployment (55). However, another study revealed that FFR ≥0.96 did not reliably predict an optimum stent result (113). The correlation between adverse outcomes after angioplasty and stenting and the FFR index has been evaluated. Bech et al. (114), in 63 patients, showed excellent clinical outcomes at 2 years in patients with diameter stenosis ≥50%, and FFR ≥0.90. Pijls et al. (56) showed that a post-stent FFR ≥0.90 was associated with low incidence of the composite end point of death, MI, or total vessel revascularization at 6 months.

The heterogeneity of the patients studied in the multiple registries and differences in methodology between studies create difficulty in evaluating the efficacy of IVUS and FFR in specific clinical settings. There are no randomized,

tion laboratory to provide critical anatomic and functional data that permit more accurate decisions in the management of the patient. In our laboratory, both methods are used: FFR is preferred to identify whether an intermediate lesion is functionally significant, and IVUS is preferred when assessing the anatomy of a lesion for sizing, position of plaque, and adequacy of stent deployment.

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J Am Coll Cardiol 2007;49:839-48.

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