IVUS and PCI: Pre-intervention Lesion Assessment

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Most of the concepts used in IVUS-guided intervention are no different from those used in angiography-guided intervention. However, unlike angiography, IVUS is actually able to make precise measurements and assess lesion morphology.

- Weigh potential problems (i.e. LM disease, significant proximal or distal disease)
- Assess lesion severity
- Assess unusual lesion morphology (i.e., aneurysms, calcium, thrombi, in-stent restenosis, etc.)
- Measure vessel size
- Measure lesion length
- Determine and fine-tune the final result of interventions
- Assess complications

Assessment of Lesion Severity

Validation of IVUS Assessment of Ischemia Producing Stenosis (Doppler FloWire and SPECT)

	IVUS MLA $\geq 4.0mm^2$	IVUS MLA $<4.0mm^2$
CFR < 2.0	2	27
CFR $\geq$ 2.0	39	4

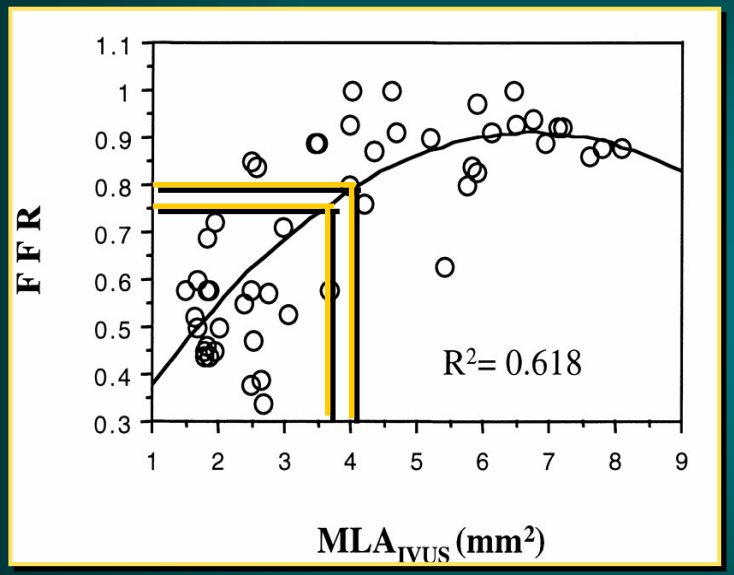
Diagnostic accuracy = 92%. Abizaid et al, AJC 1998;82:42-8

	IVUS MLA $\geq 4.0mm^2$	IVUS MLA $<4.0mm^2$
+ Spect	4	42
- Spect	20	1

Diagnostic accuracy = 93%. Nishioka et al, JACC 1999;33:1870-8

Validation of IVUS Assessment of Ischemia Producing Stenosis (Pressure Wire)

Comparison of IVUS and pressure wire (measurement of fractional flow reserve: FFR_{myo})



	Sensativity	Specificity
AS >70%	100%	68%
MLD <1.8mm	100%	66%
MLA <4.0mm²	82%	56%
Length >10mm	41%	80%

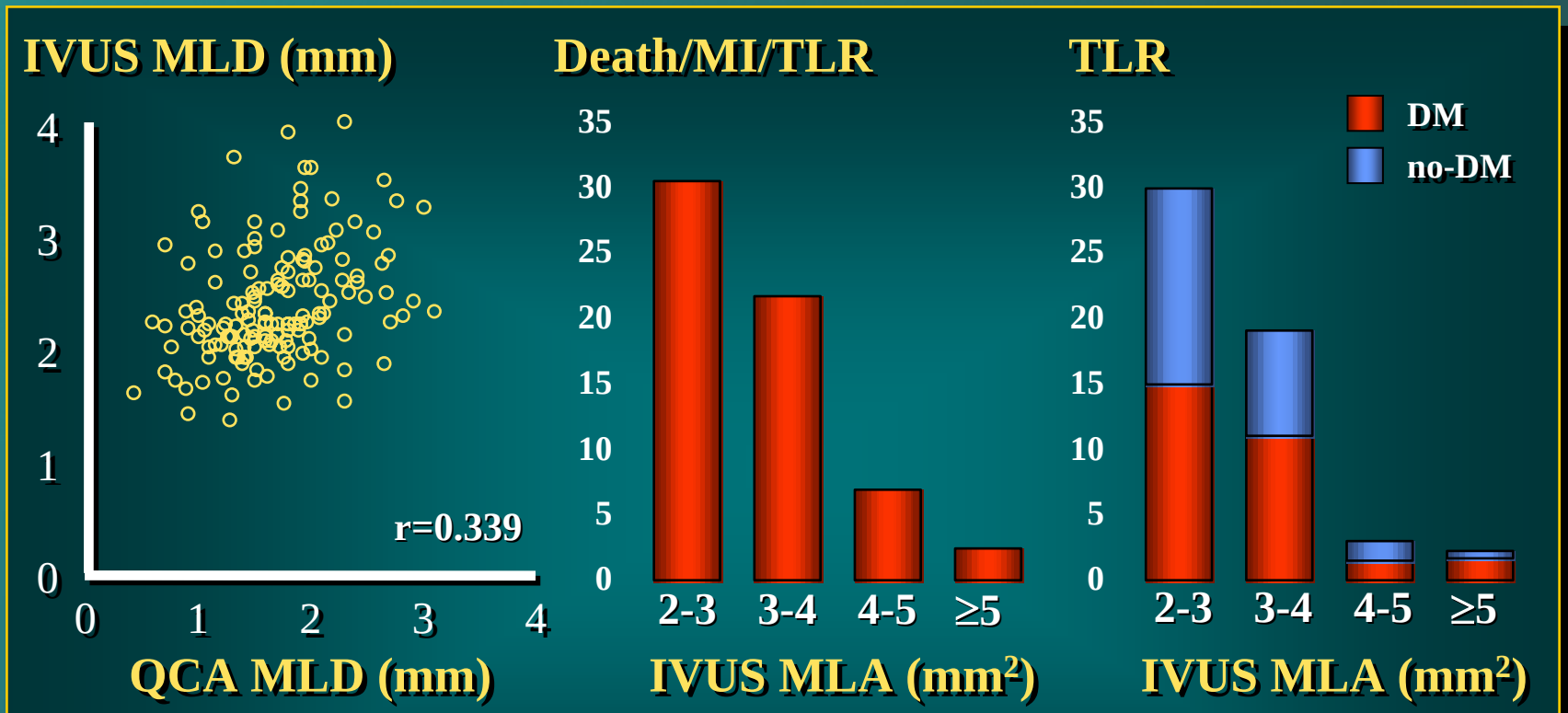
Takagi, et al. Circulation 1999;100:250-5

Briguori, et al. AJC 2001;87:136-41

IVUS Criteria for a 'Significant' Stenosis

- Based on the studies comparing IVUS to flow wire, pressure wire, or SPECT thallium and based on studies with clinical outcome - most feel that a lumen area less than 4.0 mm^2 in a proximal epicardial artery ***excluding the Left Main*** (and SVGs) is a flow limiting stenosis

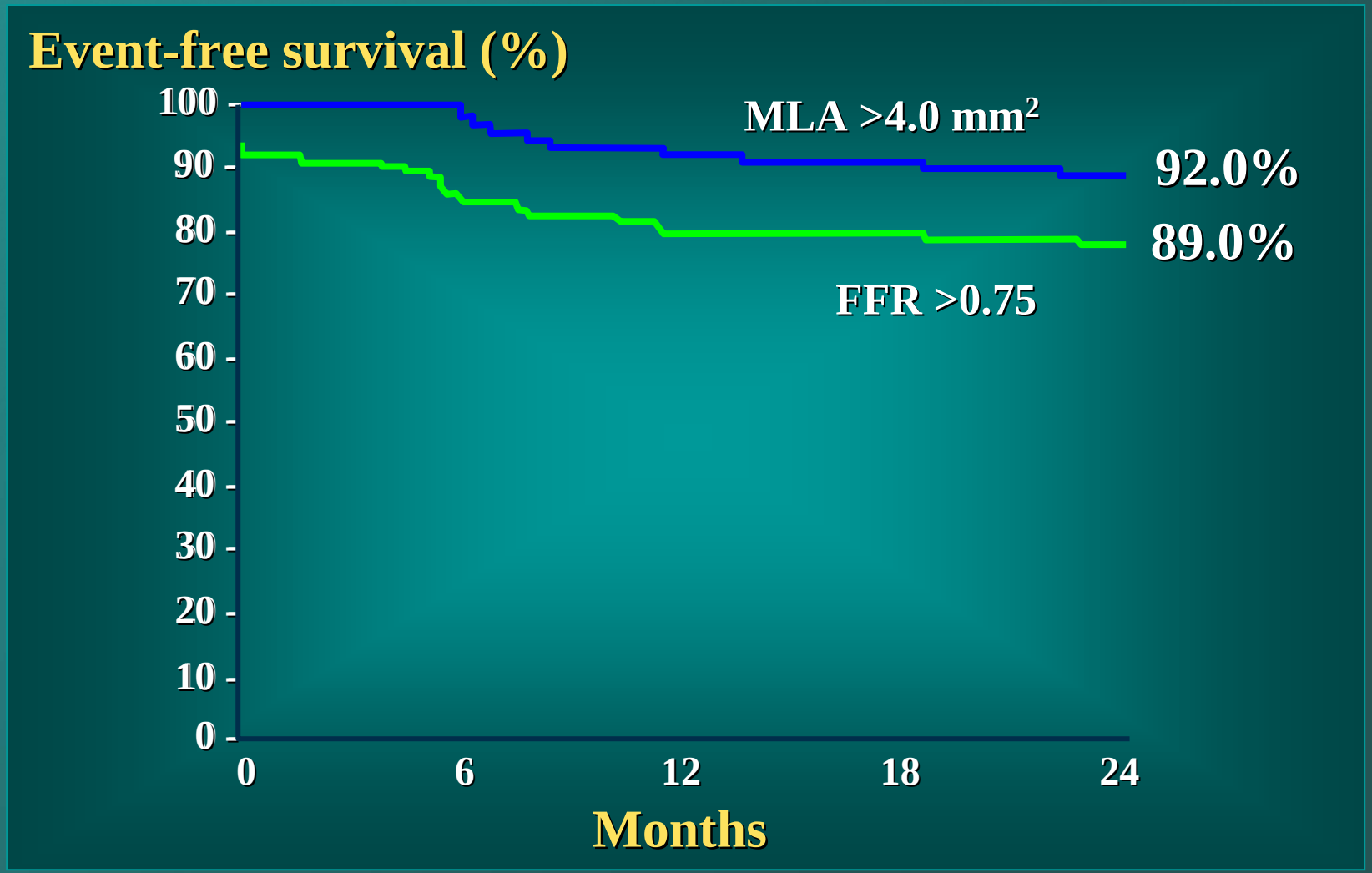
Clinical Follow up in 357 intermediate lesions in 300 pts deferred intervention after IVUS imaging



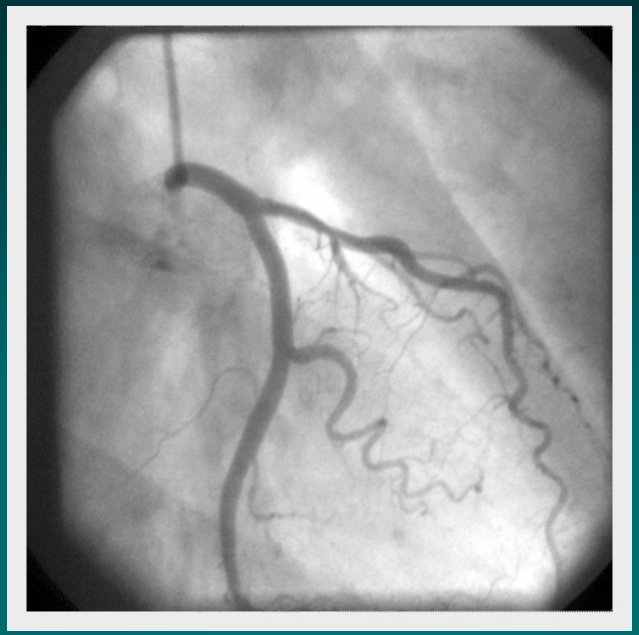
- Death/MI/TLR @ (mean) 13 mos = 8% overall (2% death/MI and 6% TLR)
- Death/MI/TLR @ (mean) 13 mos = 4.4% in lesions with MLA >4.0mm^2
- Only independent predictor of death/MI/TLR was IVUS MLA (p=0.0041)
- Independent predictors of TLR were DM (p=0.0493) and IVUS MLA (p=0.0042)

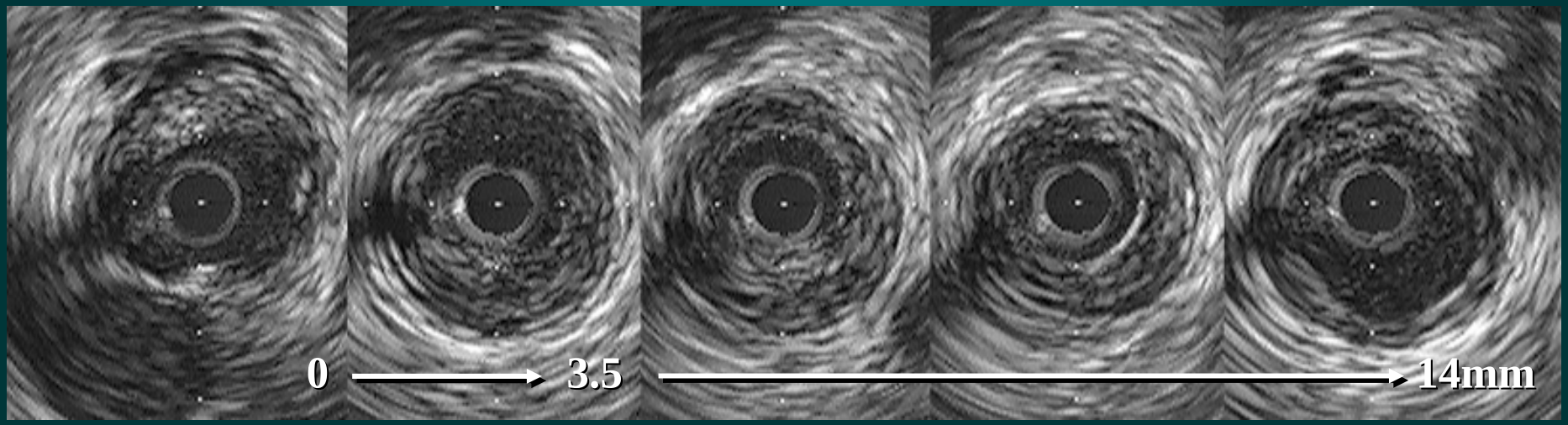
(Abizaid, et al. Circulation 1999;100:256-61)

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)

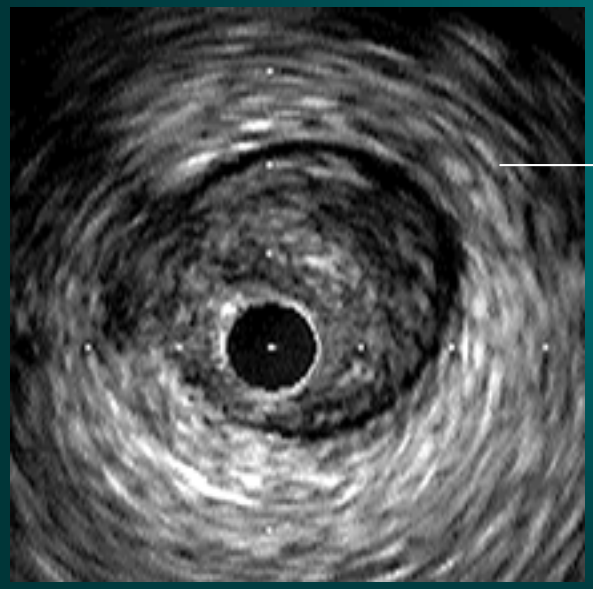


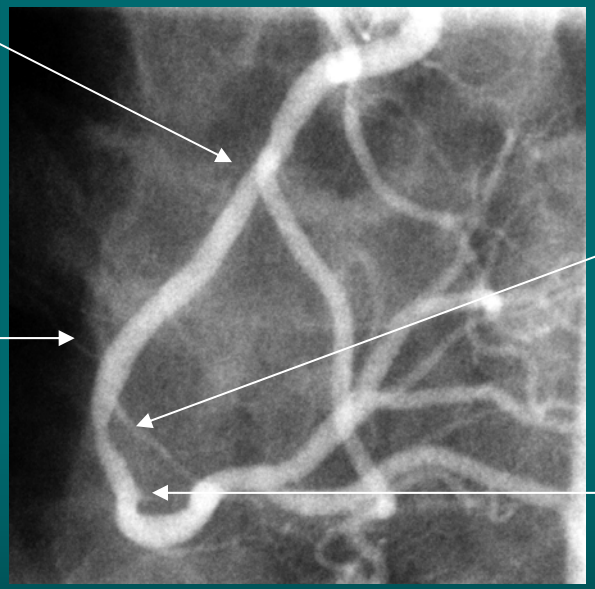

0
3.5
14mm

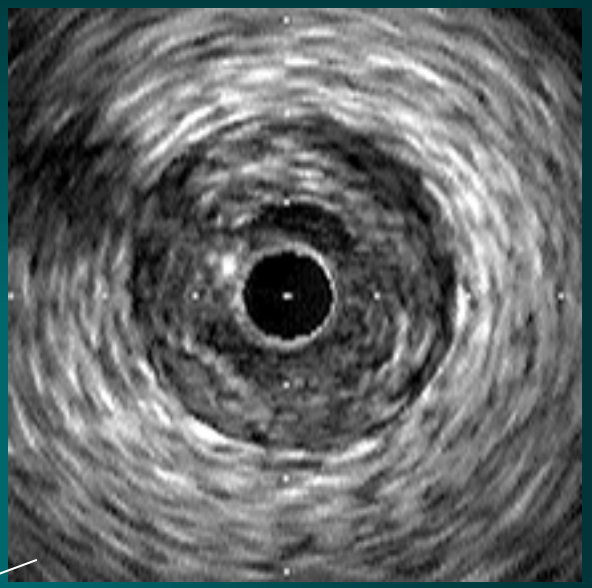
On pre-intervention IVUS, 404 pts with 436 arteries had 500 lesions with an IVUS minimum lumen area <4.0mm^2. 28% (140/500) had an angiographic DS<50%. Predictors of these lesions were

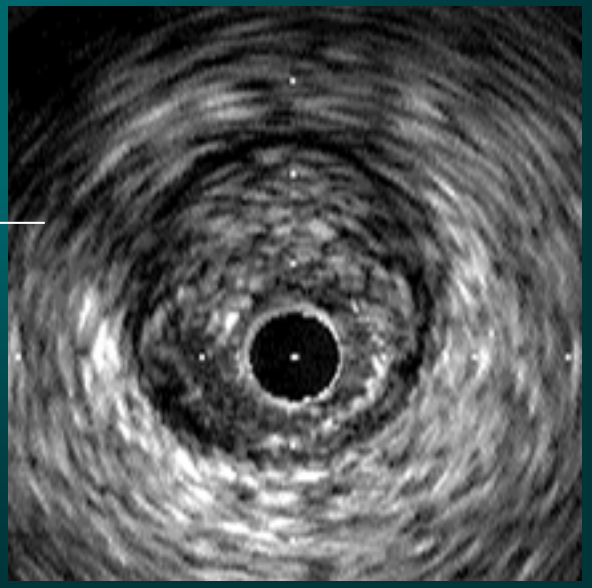
	Odds Ratio	p
Multiple lesions in same artery	2.7	0.0003
Right coronary artery	1.7	0.03
Lesion maximum lumen diameter	9.5/1mm	<0.0001
Lesion plaque burden	0.44/10%	0.0001
Mean reference lumen area	0.75 /1mm^2	0.0002
Diabetes mellitus	1.6	0.1

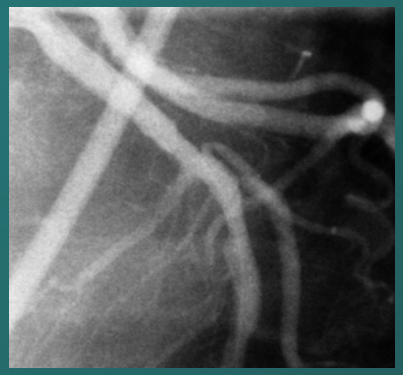
(Maehara et al. Am J Cardiol 2003;91:1335-8)



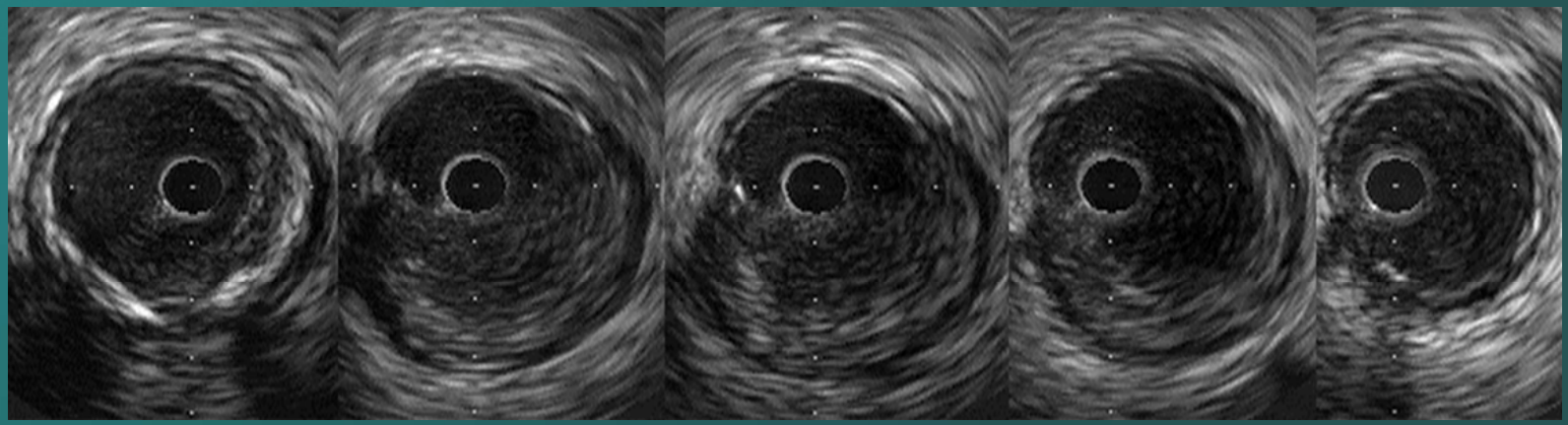




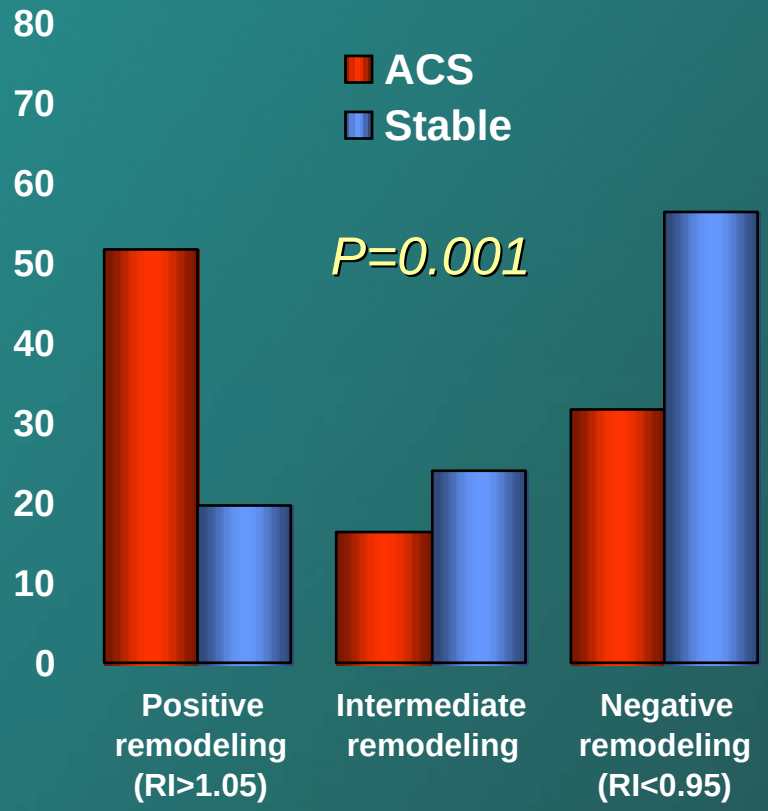




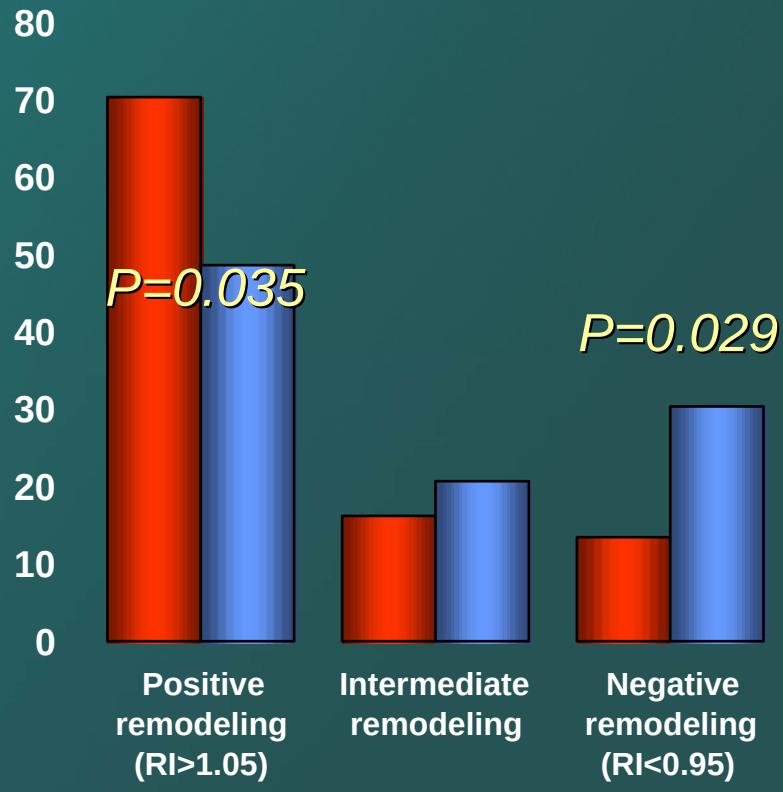
0 → 3 → 12mm



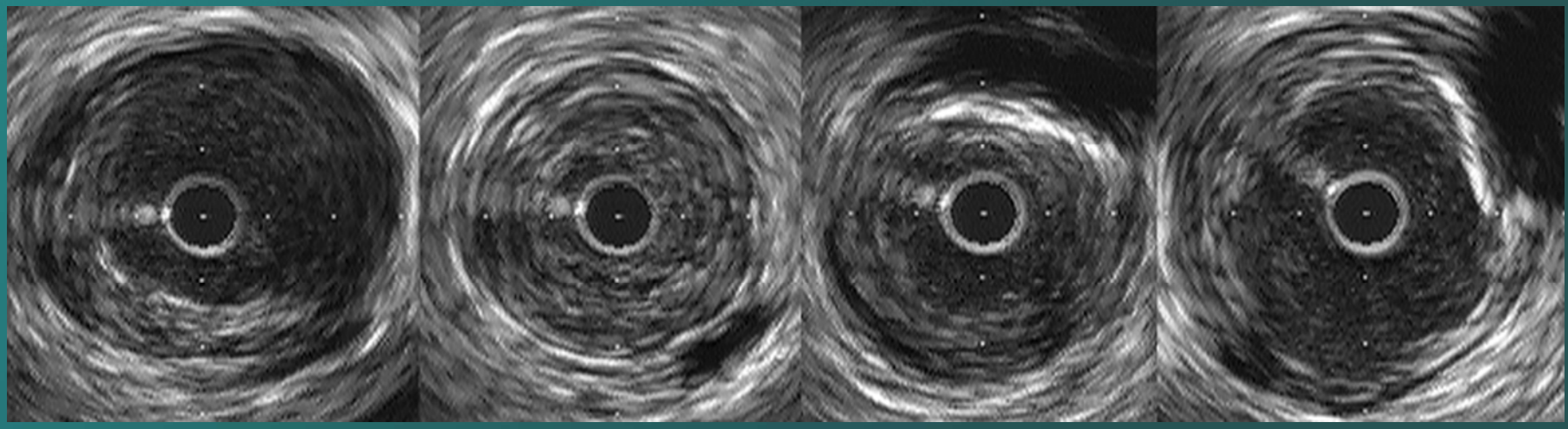
Association of positive remodeling and ACS



Schoenhagen et al. Circulation 2000;101:598-603



Prati et al. Circulation 2003;107:2320-5

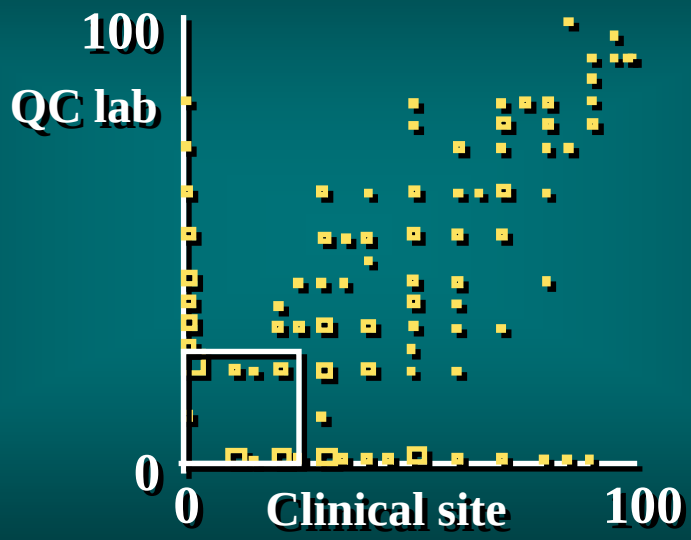


0 → 2.0 → 6.0mm

Of all the coronary segments, the LMCA has the greatest angiographic assessment variability

Poor interobserver agreement in the CASS study - I

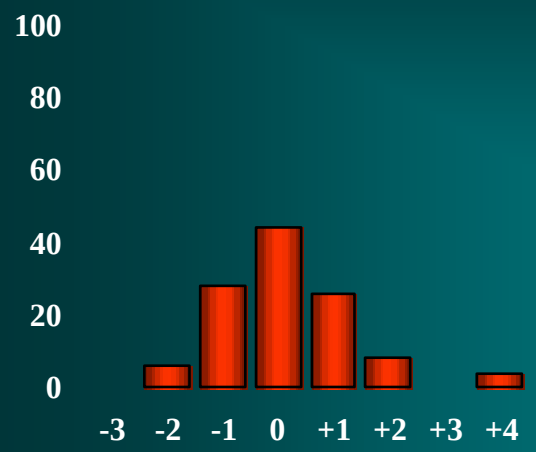
Comparison between percent stenosis assessment from the quality control lab vs the clinical site

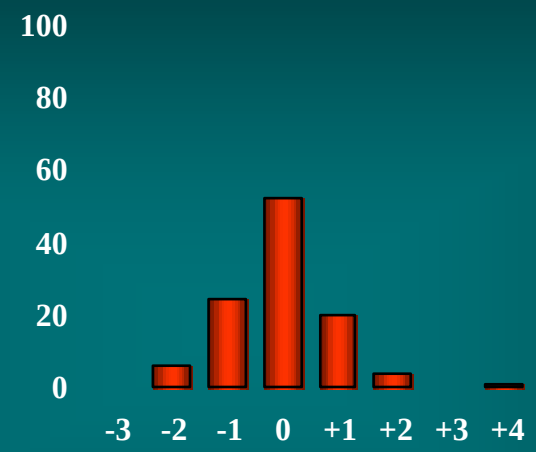


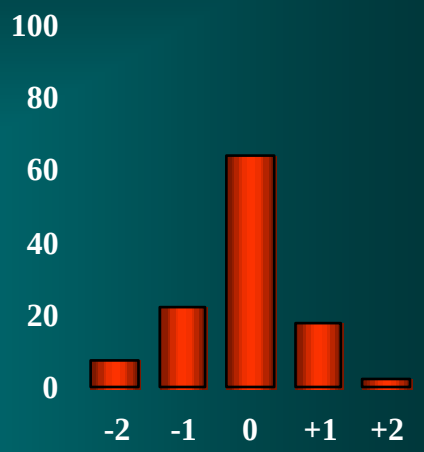
*area of the square is proportional to the number of cases with the given reading

(Fisher et al. CCD 1982;8:565-575)

Poor interobserver agreement in the angiographic assessment of LMCA stenosis in the CASS study - II







Five grades of LM severity

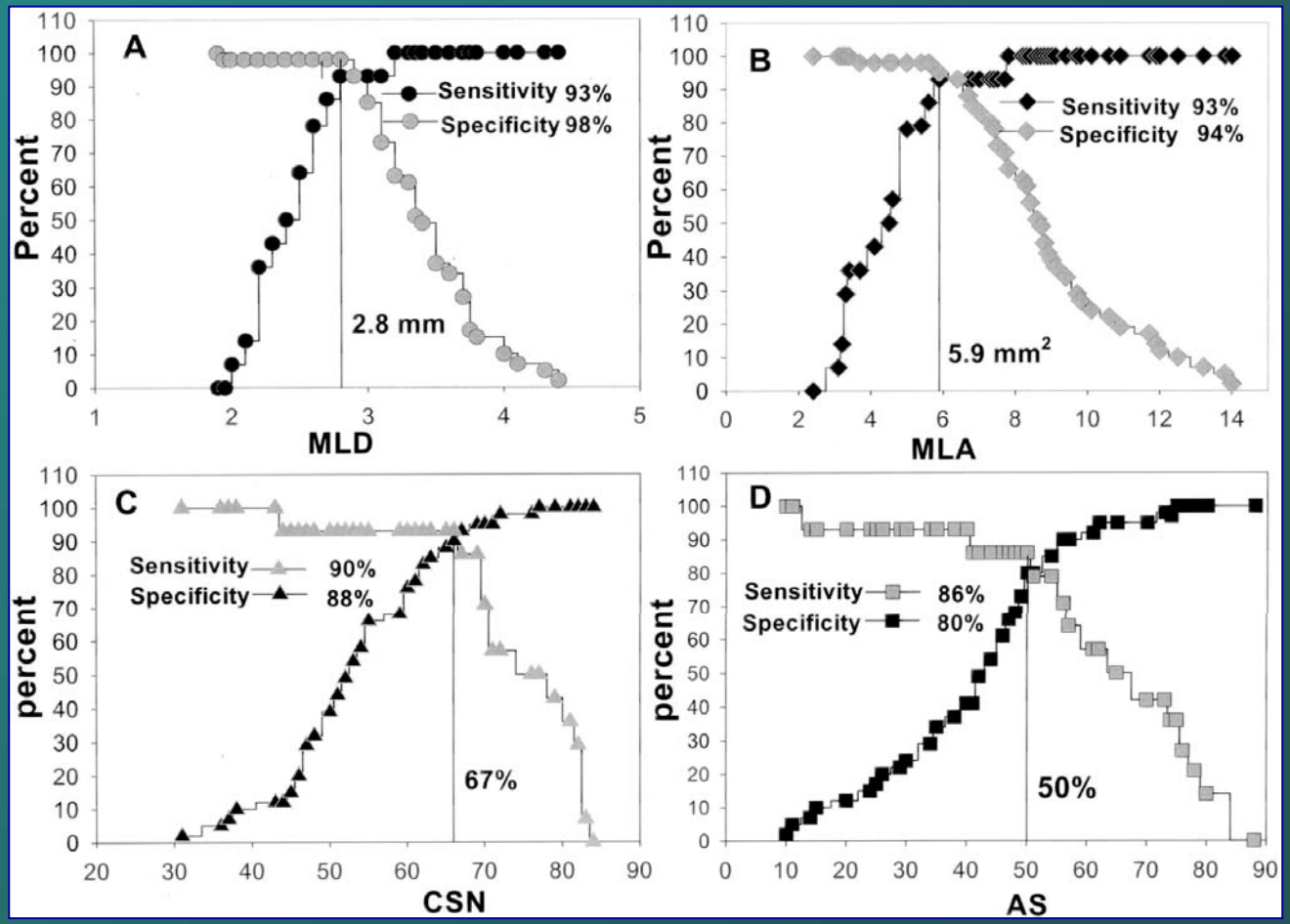
1:	0-24% DS
2:	25-49% DS
3:	50-74% DS
4:	75-89% DS
5:	90-100%DS

# of grades of difference in assessment of LM severity

0:	no difference
+1 or -1:	1 grade difference
+2 or -2:	2 grades of difference
+3 or -3:	3 grades of difference
+4 or -4:	4 grades of difference

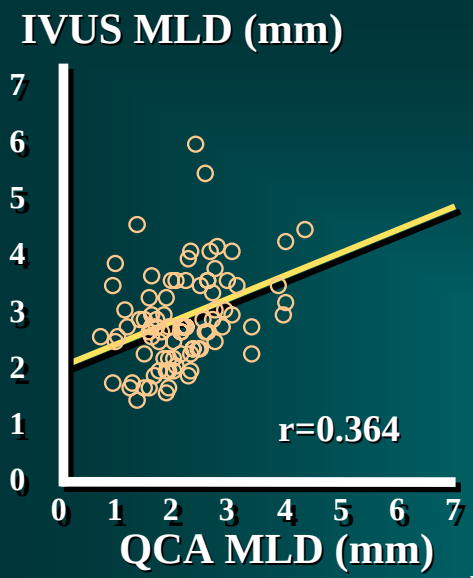
(Cameron et al. Circulation 1983;68:484-489)

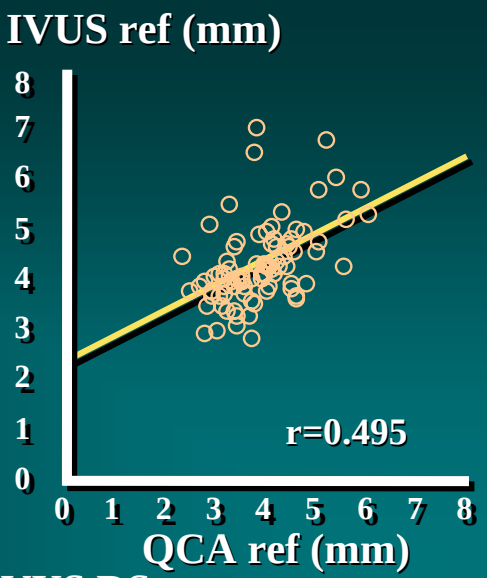
IVUS determinants of LMCA FFR <0.75



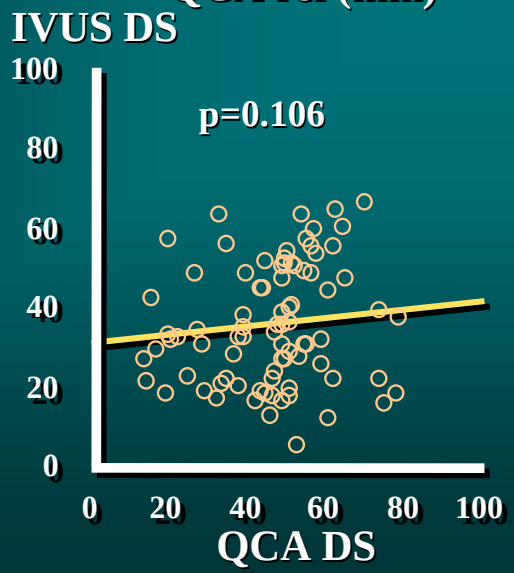
(Jasti et al. Circulation 2004;110:2831-6)

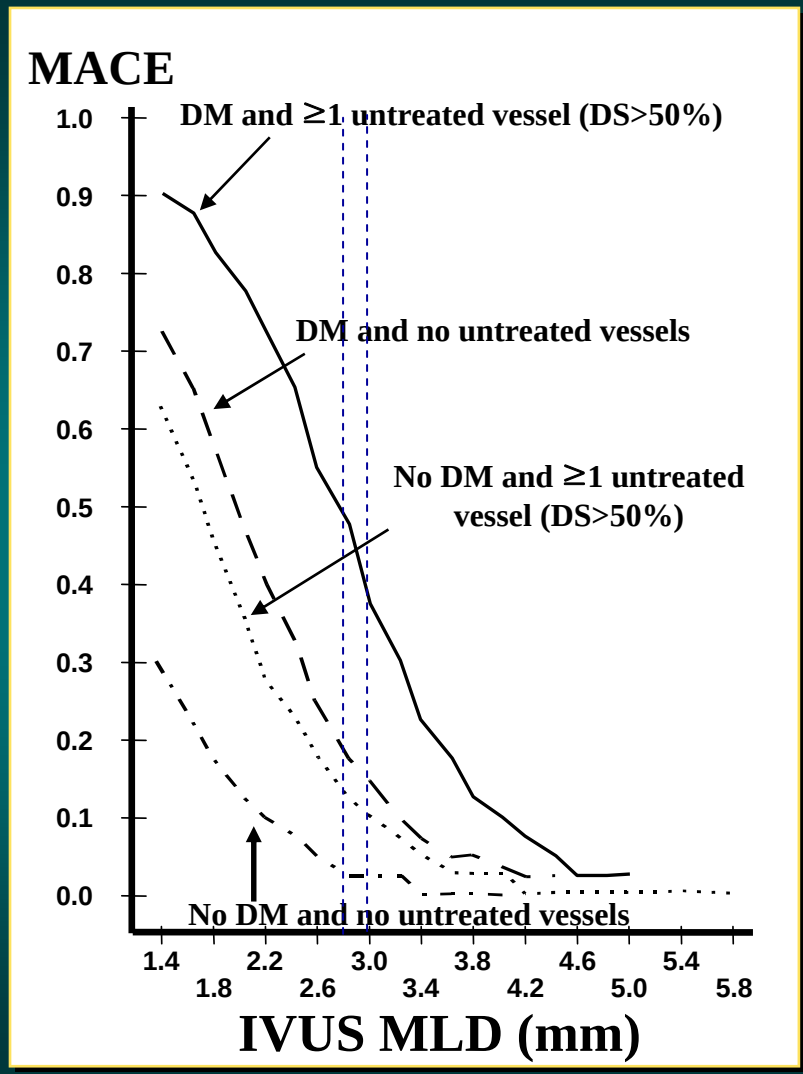
Follow-up of 122 pts with moderate LM disease



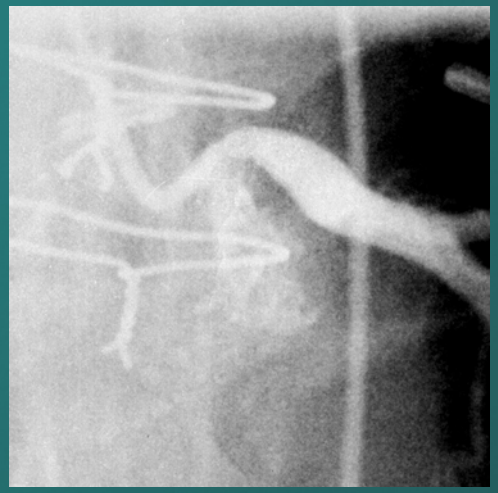


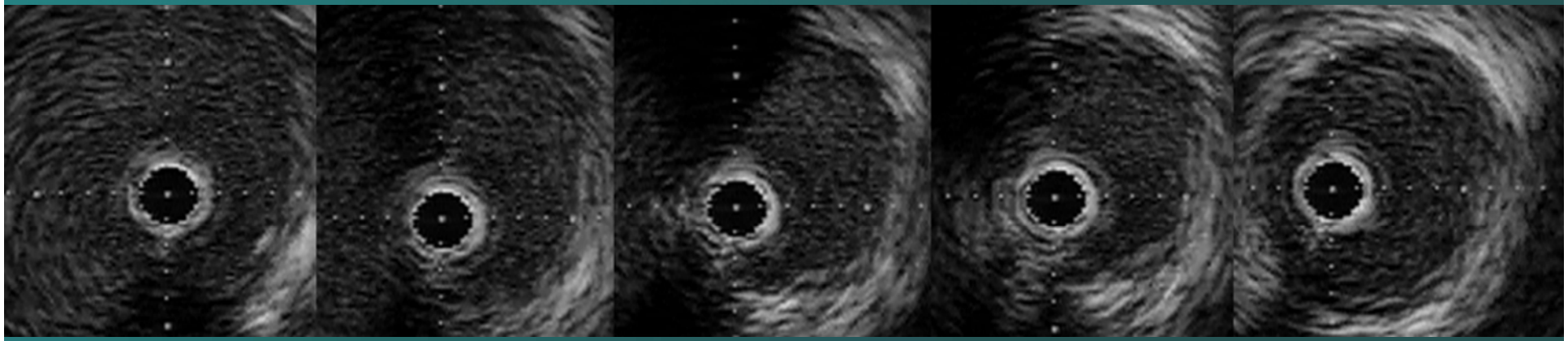
Independent predictors of MACE @11.7 months: DM (P=0.004), an untreated lesion >50% (p=0.037), and IVUS MLD (P=0.005).



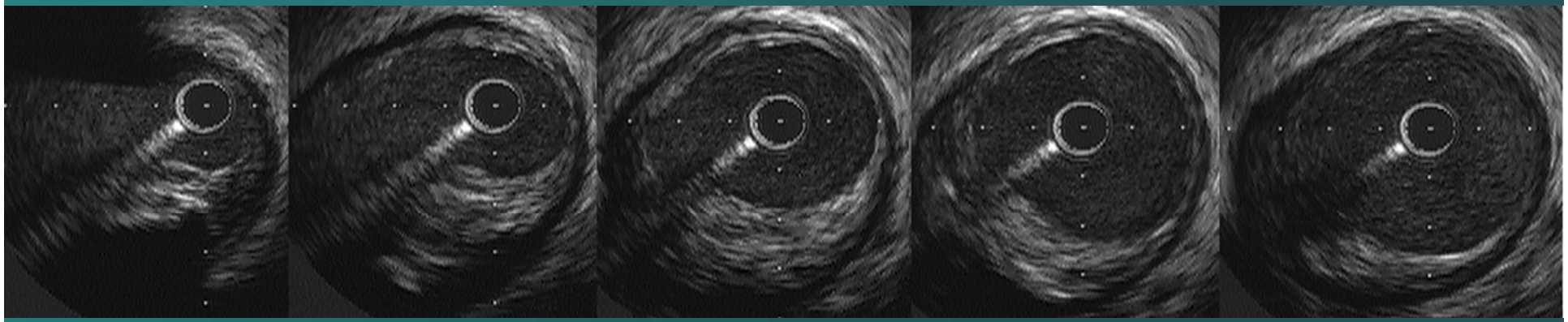


(Abizaid AS et al. JACC 1999;34:707-15)





0 → 1.0 → 4.0mm



0 → 2.0 → 8.0mm

IVUS Criteria for a 'Significant' LMCA Stenosis

- Most IVUS LMCA studies show either insignificant disease or critical disease, only a minority require careful quantification
- Based on studies comparing IVUS to LMCA pressure wire and based on Murray's Law* - most feel that an LMCA lumen area less than 6.0 mm^2 (or an MLD <2.9mm) is flow limiting

*Murray's Law: $(r_{\text{parent vessel}})^3 = \sum (r_{\text{daughter vessel}})^3$

Unusual Lesions

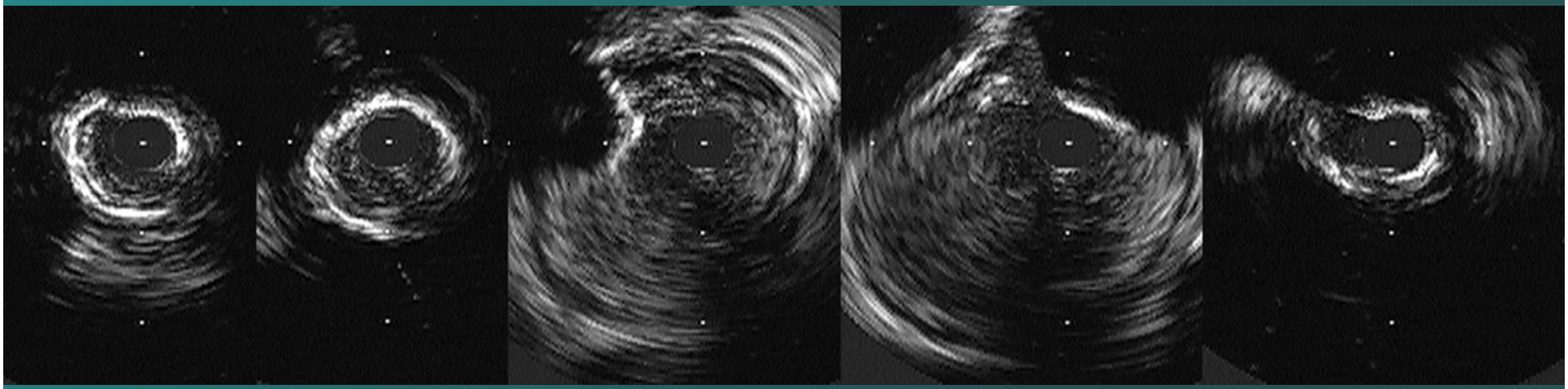
- Aneurysms
- Filling Defects
- Acute Coronary Syndromes
- Spontaneous Dissections
- Hazy Lesions

IVUS Classification of Angiographic Aneurysms

- Of 77 angiographic aneurysms
  - 21 (27%) true aneurysm
  - 3 (4%) pseudoaneurysm
  - 12 (16%) complex plaques or unhealed dissections
  - 41 (53%) normal segment adjacent to one or more stenoses

	True Aneurysm	PSA	Complex Plaque	Normal Site with Adjacent Stenoses
No prior PCI	10	0	6	26
Prior PCI	11	3	6	15

(Maehara et al Am J Cardiol 2001;88:365-70)



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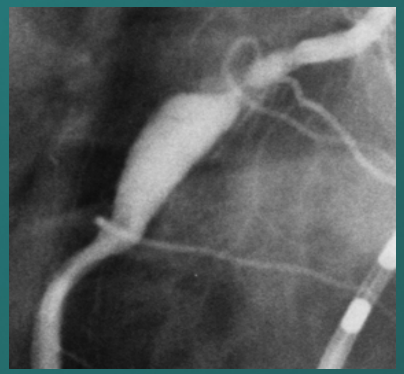
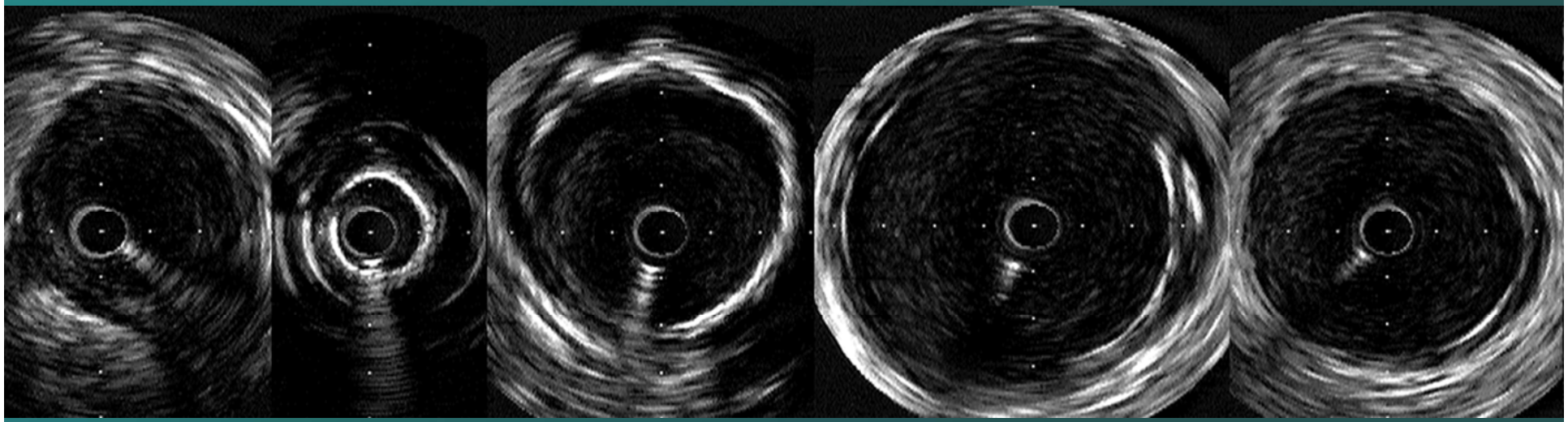
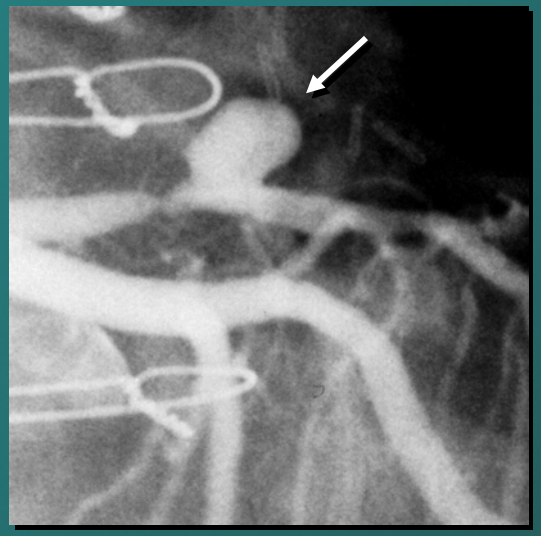
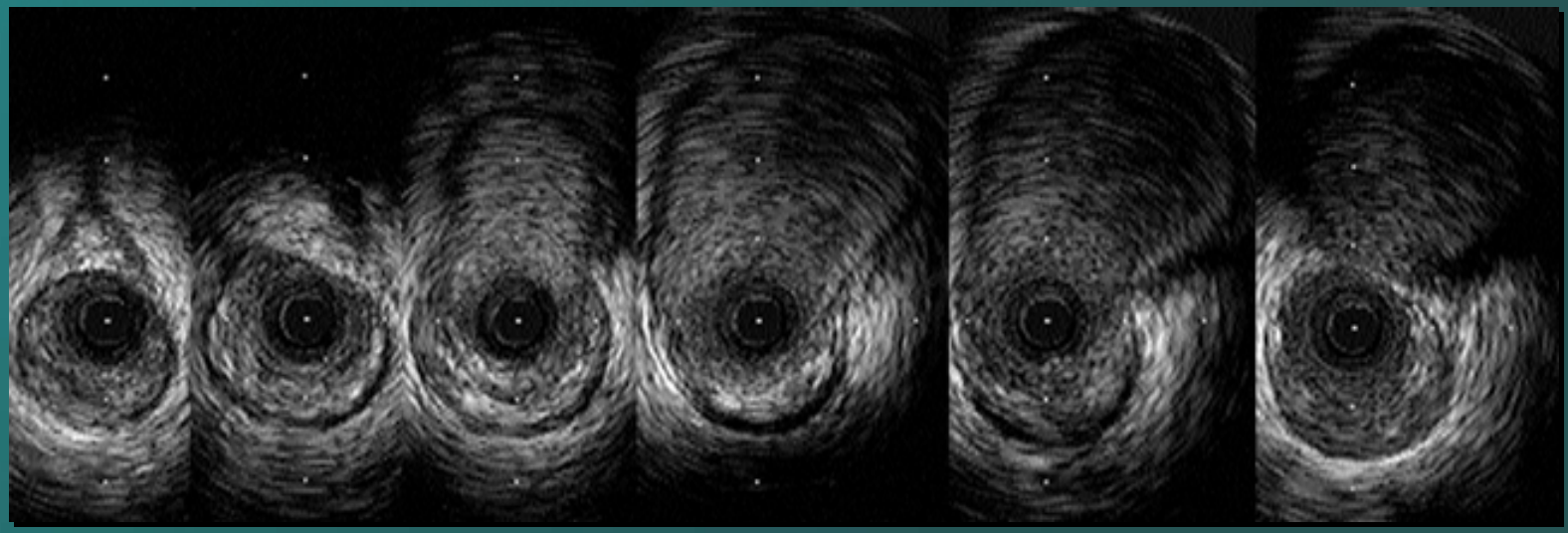


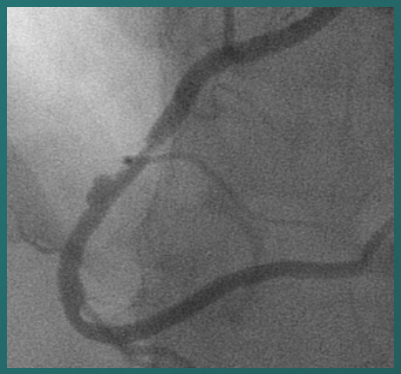


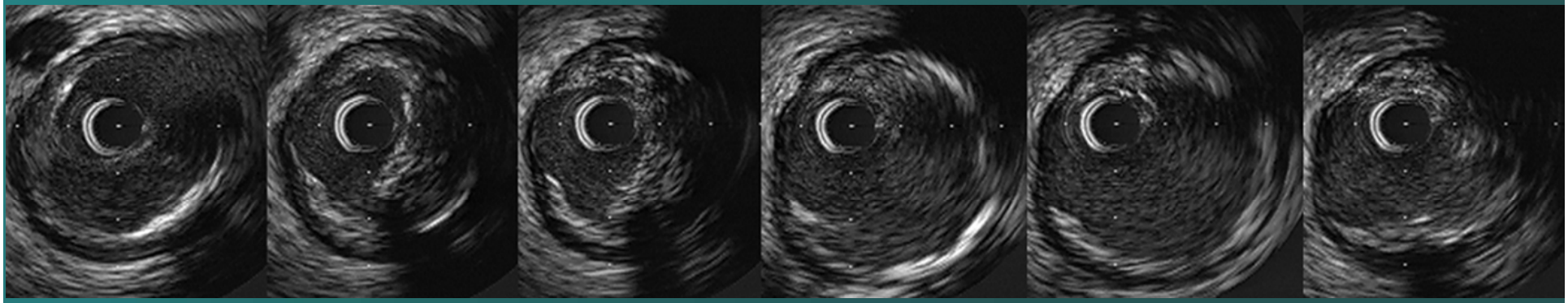
0 → 2.5 → 10.0mm



0 → 2mm → 10mm



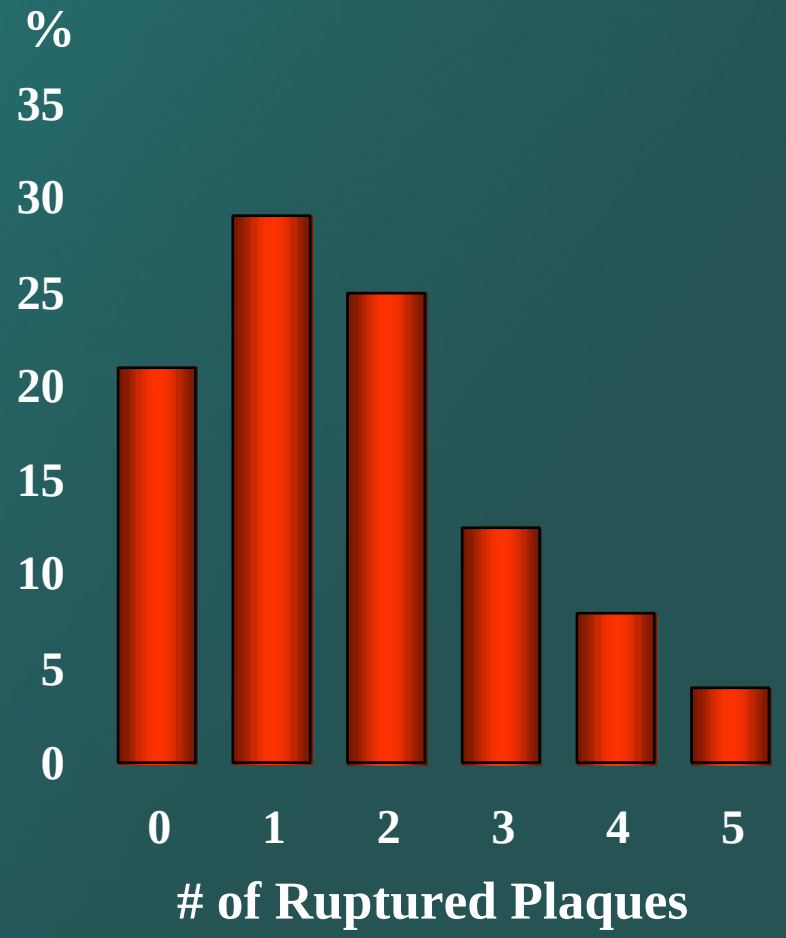




0 → 1.5 → 7.5mm

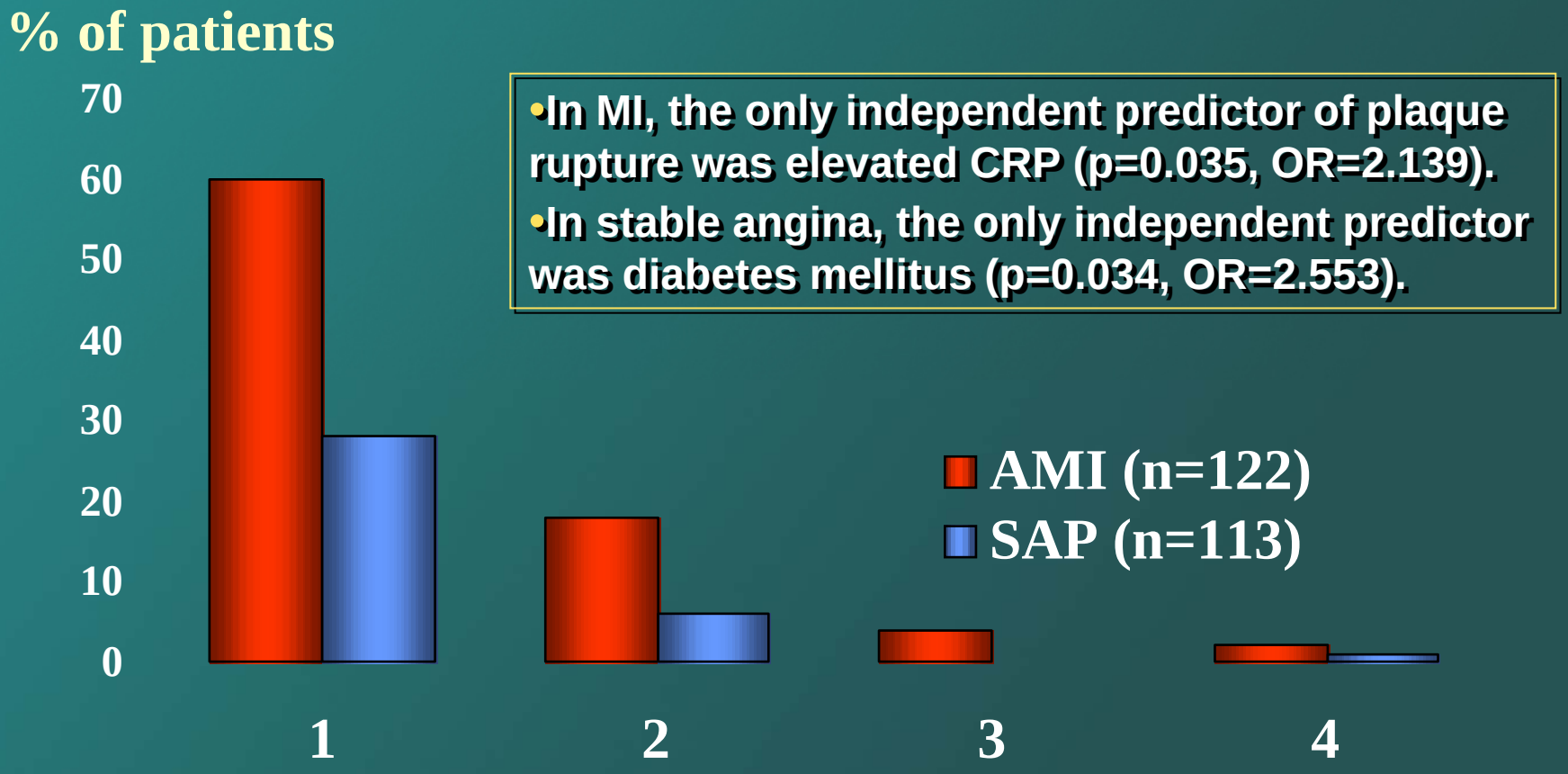
Three Vessel IVUS Imaging in 24 Pts with ACS and Positive Tn

- 50 ruptured plaques
  - 9 culprit lesion
  - 41 nonculprit lesion
- 19 pts had at least 1 nonculprit plaque rupture (79%)
  - 17 pts had 1 plaque rupture in a second artery
  - 3 pts had plaque ruptures in all 3 arteries



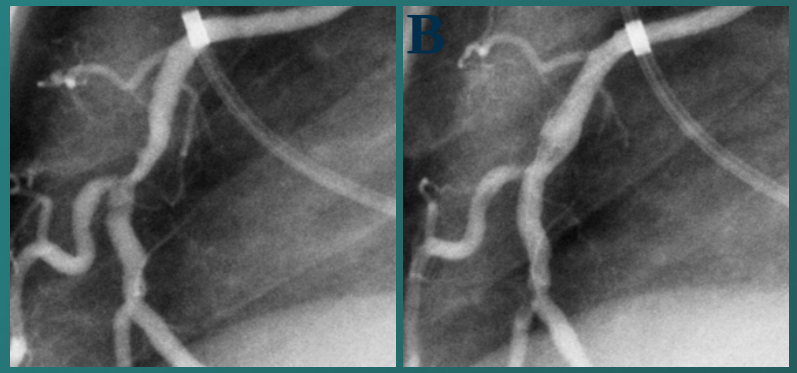
(Rioufol et al Circulation 2002;106:804-808)

Ruptured plaques in patients with MI and stable angina



- In MI, the only independent predictor of plaque rupture was elevated CRP (p=0.035, OR=2.139).
- In stable angina, the only independent predictor was diabetes mellitus (p=0.034, OR=2.553).

(Hong et al Circulation 2004;110:928-33)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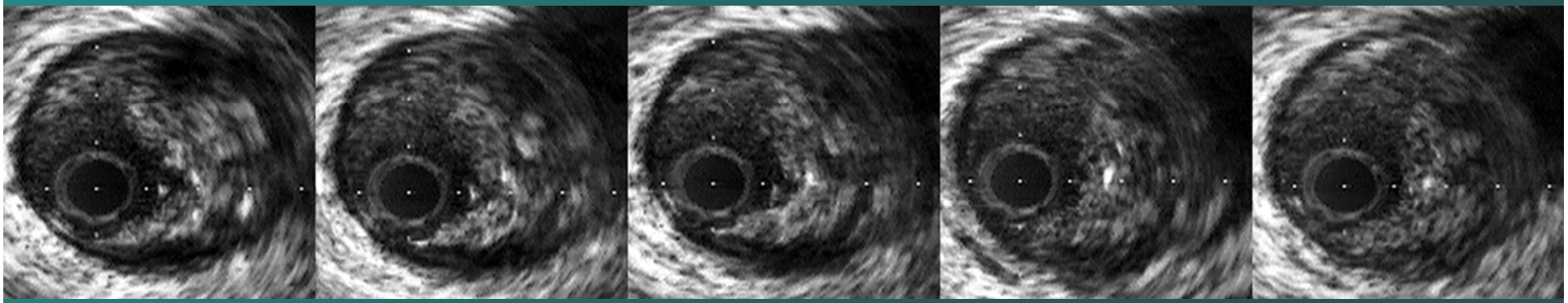
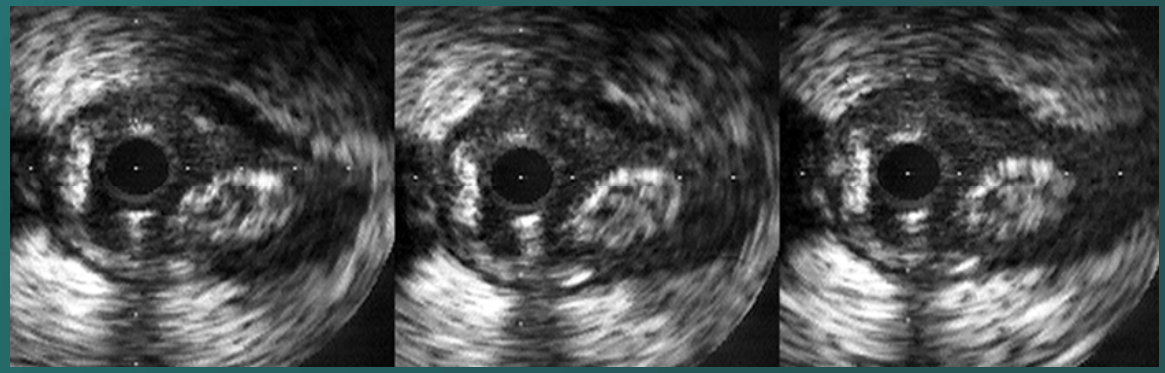
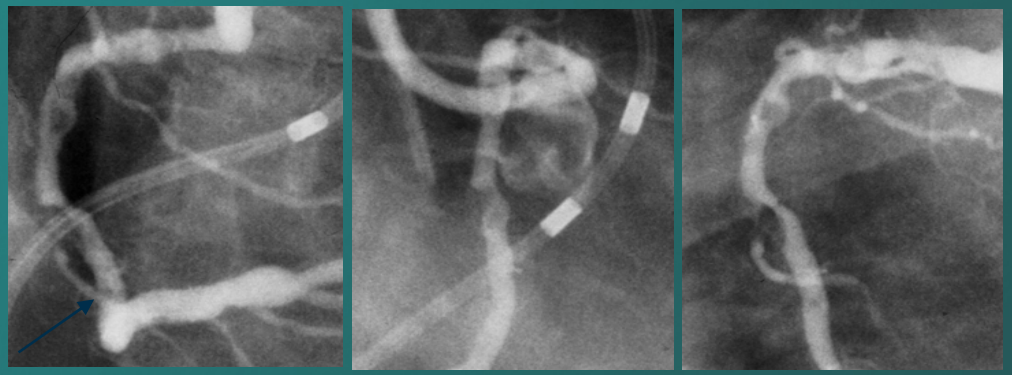
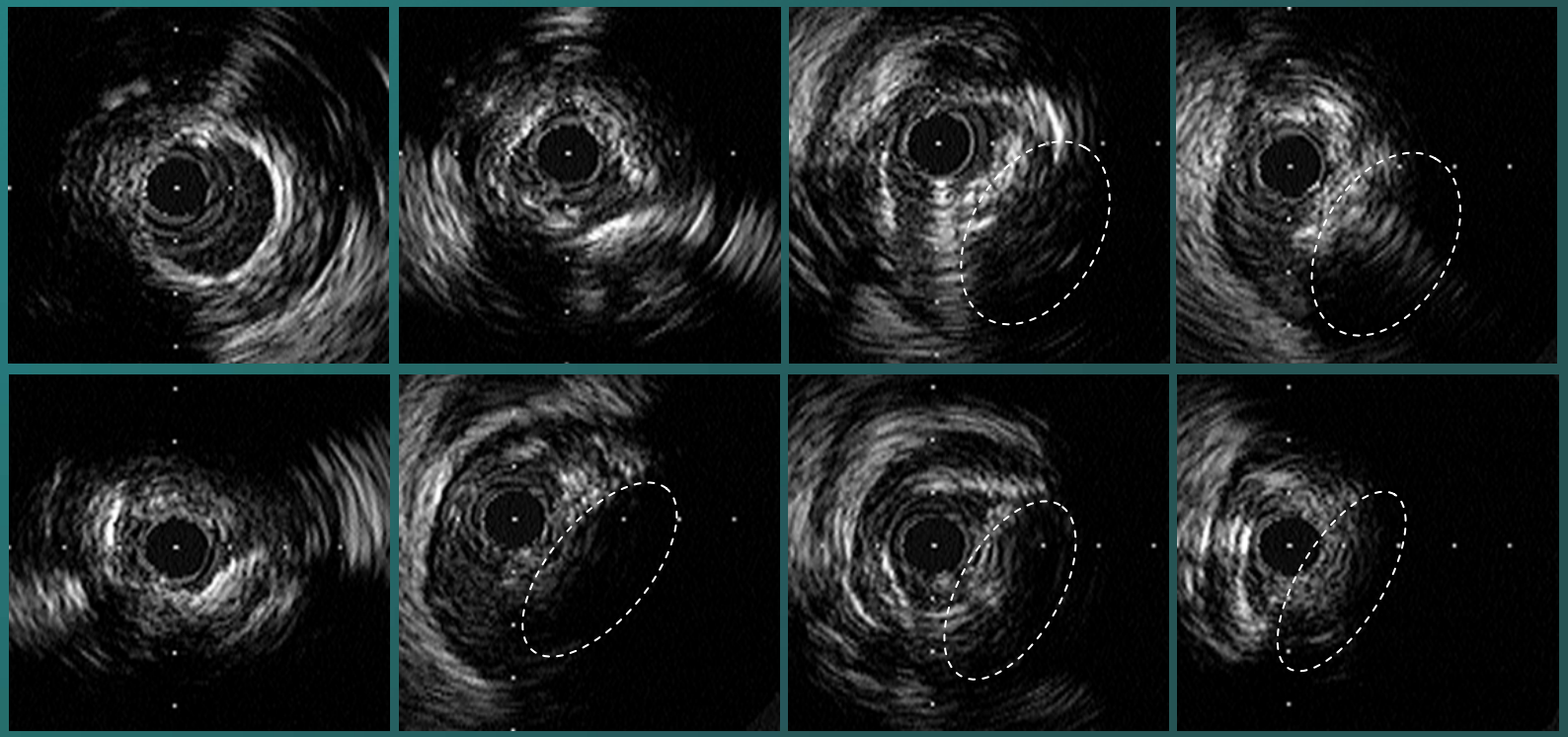
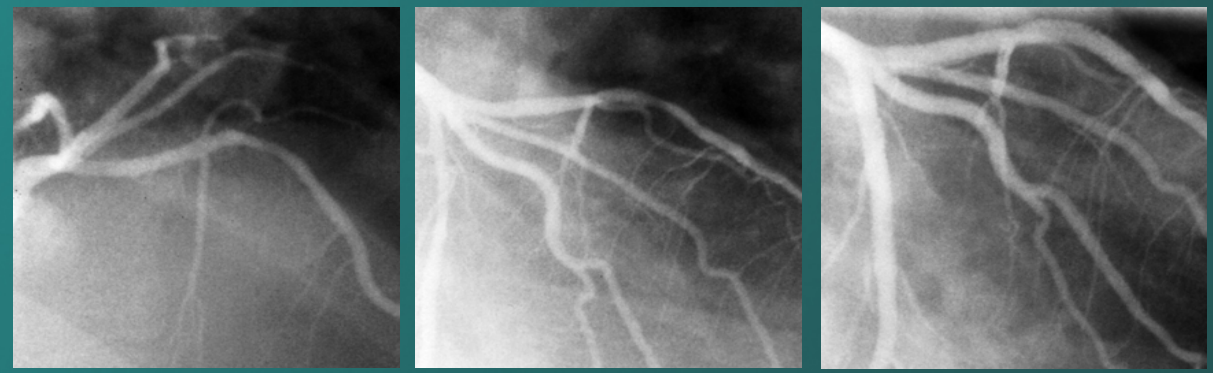
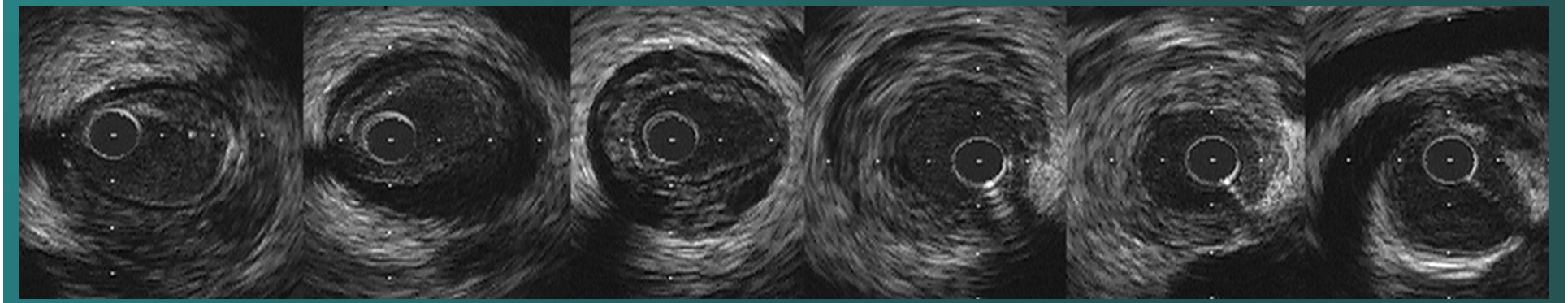




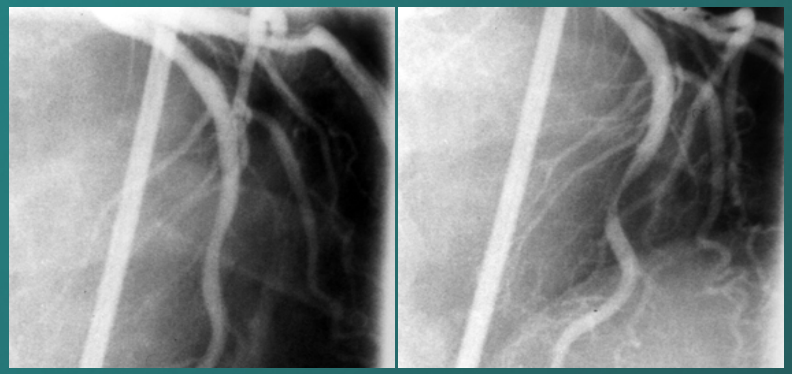


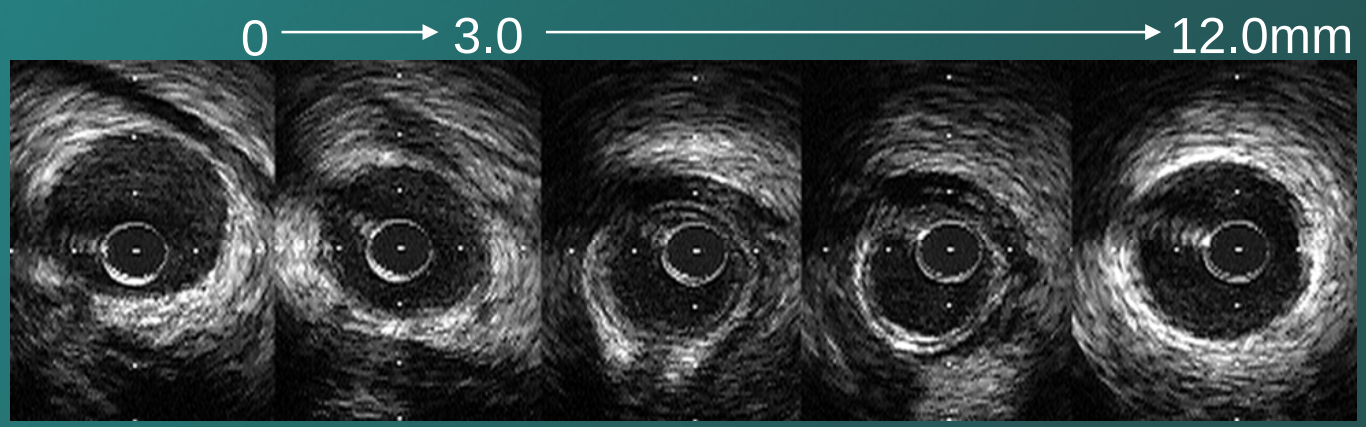






0 → 8 → 40mm

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3.0
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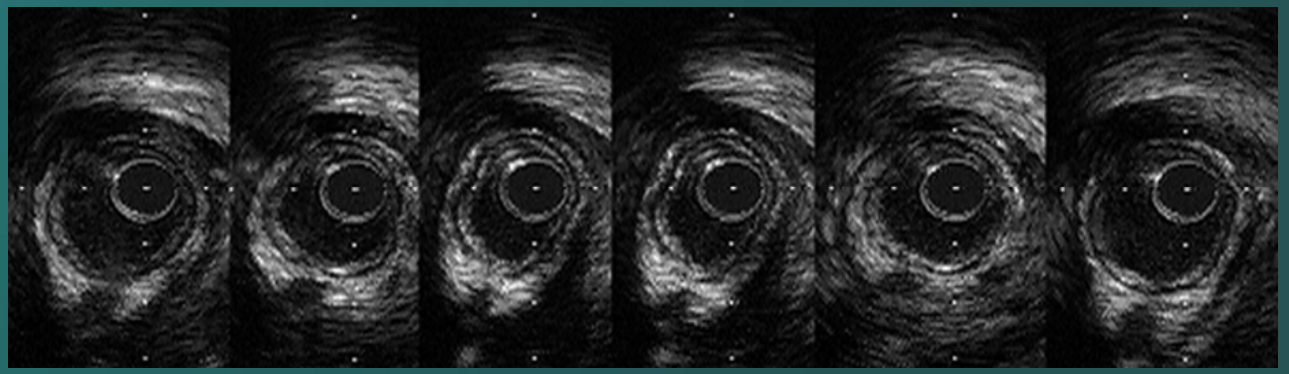
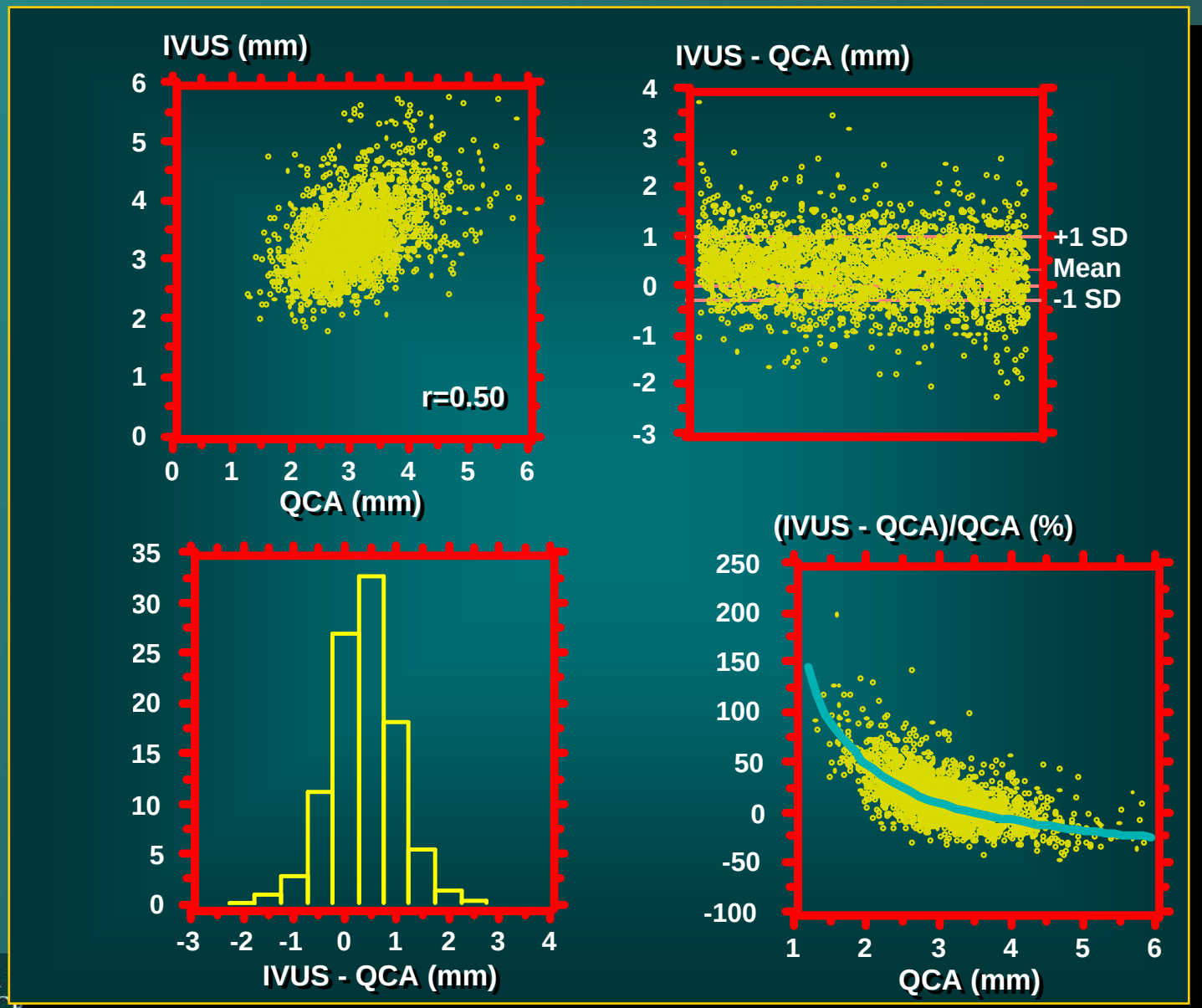
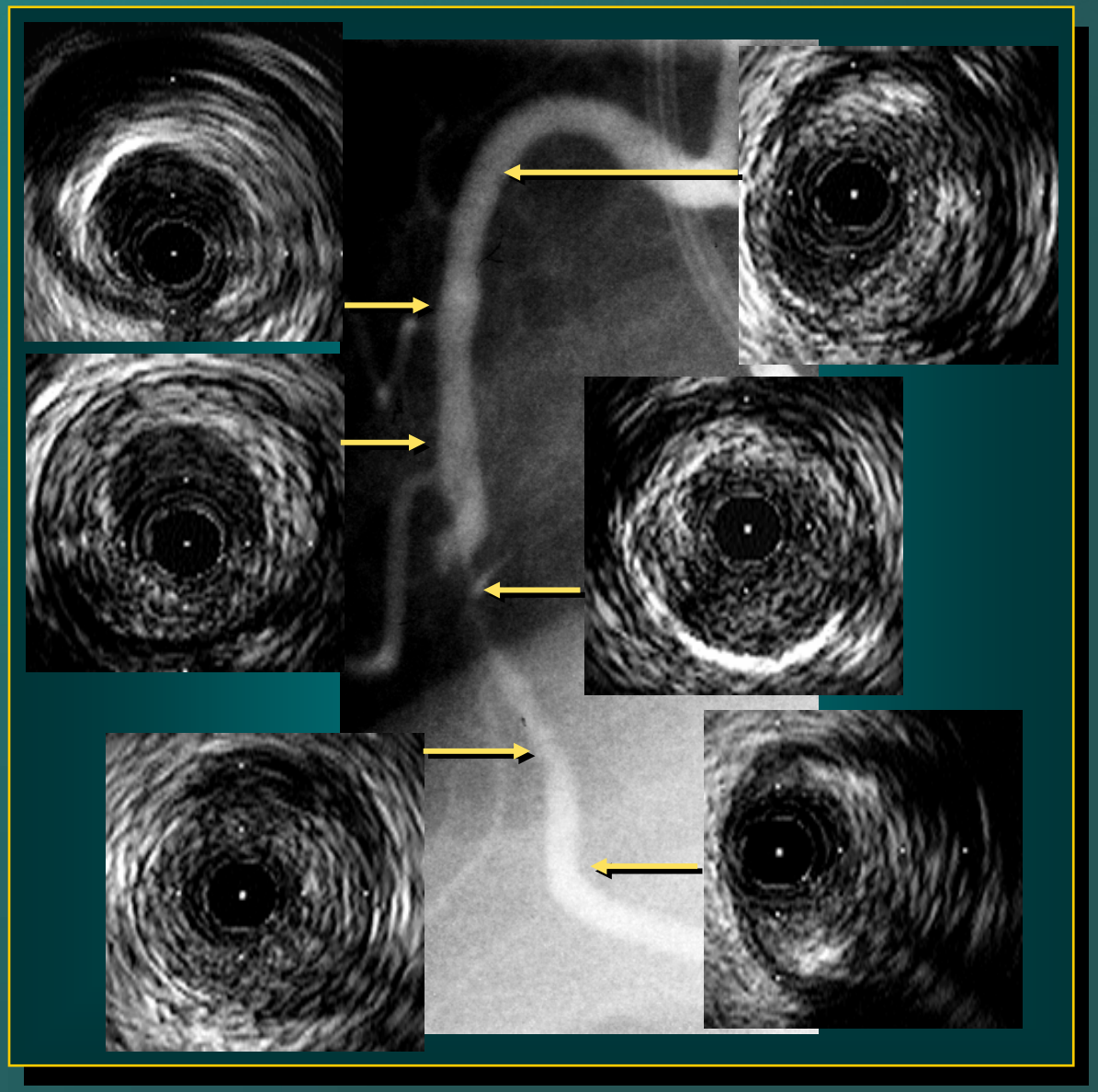


IVUS vs QCA measurements of reference lumen dimensions (3311 nonostial lesions)

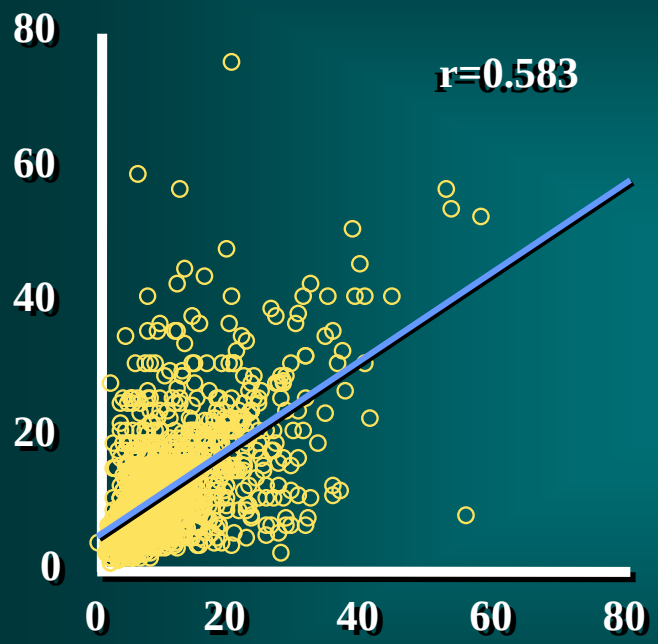


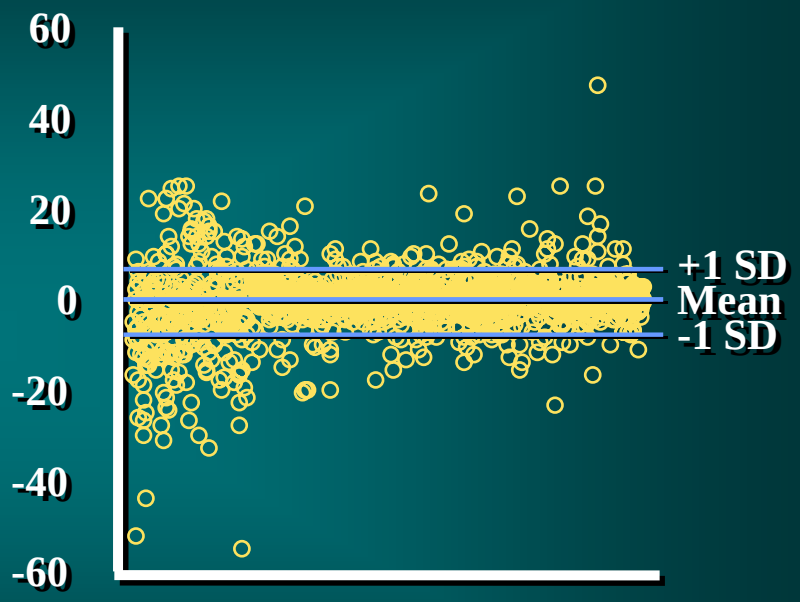
In 884 native coronary arteries, plaque burden in angiographically “normal” reference segments was 51±13%



(Mintz et al. J Am Coll Cardiol 1995;25:1479-1485)

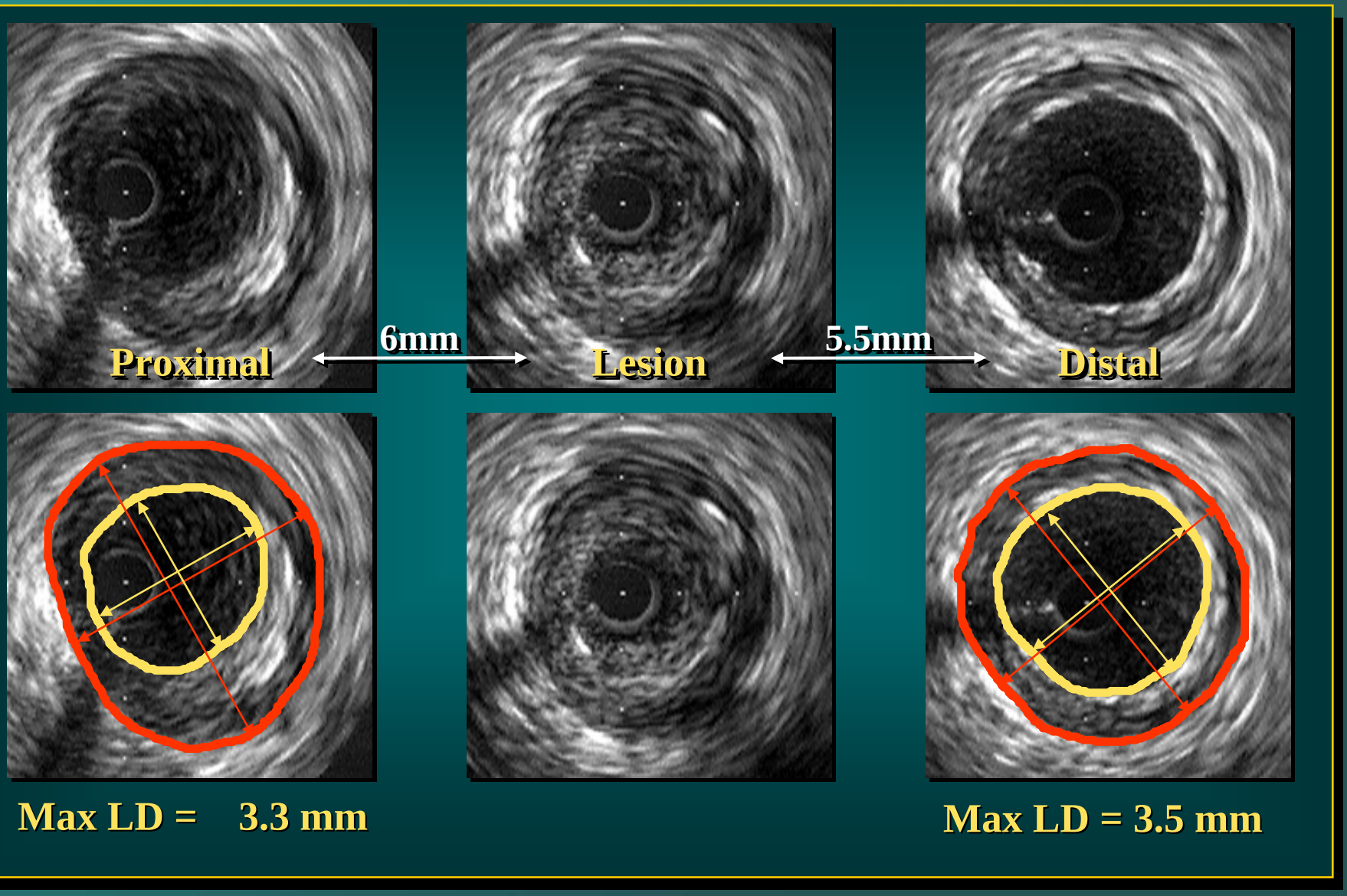
IVUS vs QCA measurement of lesion length





IVUS-QCA length= 0.6±7.2mm

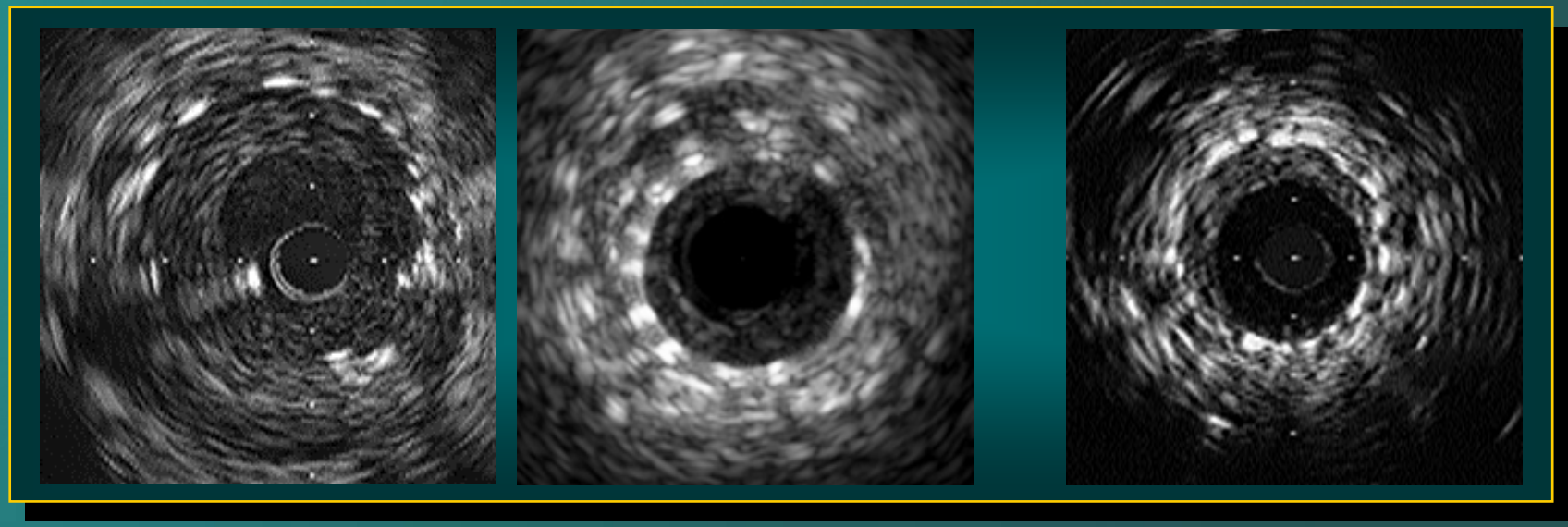
Stent sizing using IVUS



Fate of intermediate in-stent restenosis lesions

- 142 patients with 150 intermediate ISR lesions (angiographic diameter stenosis of 40-75%)
  - 34% of lesions had a diameter stenosis >50%
  - 17% of patients had a positive exercise thallium
- Repeat intervention was deferred if the IVUS minimum lumen area measured >3.5mm^2 regardless of symptoms, noninvasive testing, or angiographic findings
- At follow-up that averaged 32 months
  - 10% of patients had events
  - 2-year event-free survival was 96.5%.

(Nishioka et al AHA 2002)



The intimal hyperplasia characteristic of early in-stent restenosis often appears as tissue with very low echogenicity, at times less echogenic than the blood speckle in the lumen. The intimal hyperplasia of late in-stent restenosis may appear more echogenic.

Appropriate system settings are critical to avoid suppressing this relative non-echogenic material.

Unexpanded stent in vein graft