How is IVUS Helpful to Treat LM Lesions? IVUS, FFR, Thallium Scan

Gary S. Mintz, MD

Cardiovascular Research Foundation
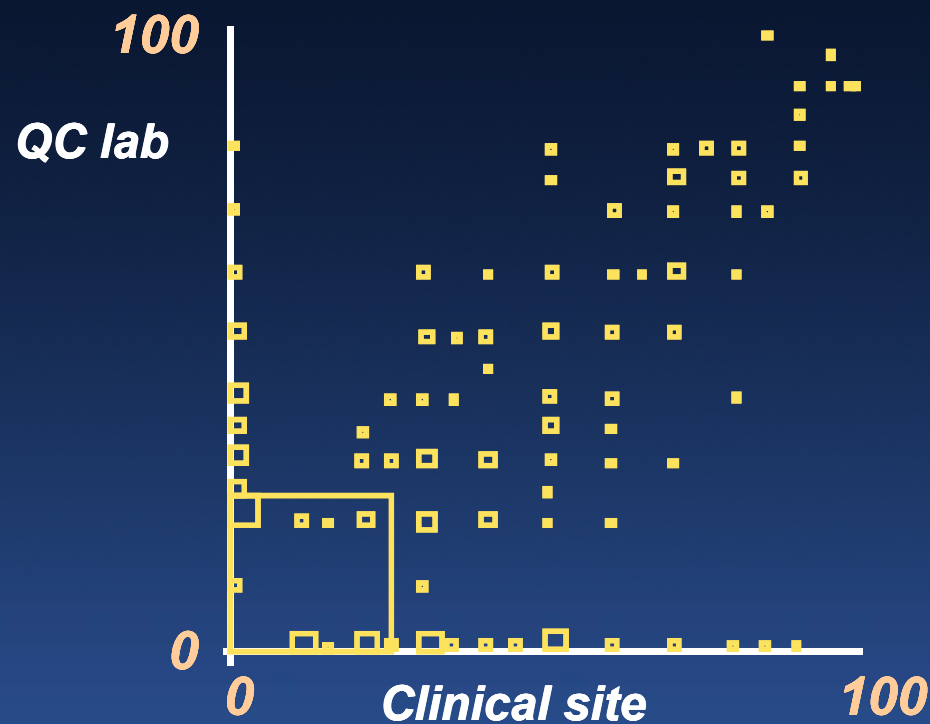
New York, NY

Myocardial Perfusion SPECT

- *Limited data and no typical pattern*
- *Assessment of myocardial perfusion alone underestimates ≥50% LM stenosis (angiography)*
  - *Normal perfusion in only 13%*
  - **Abnormal and suggestive perfusion in 21%**
  - **Moderate to severe defects (>10% of myocardium at stress) in only 56% of patients**
- **Adding non-perfusion findings increases the detection of patients with ≥50% LM stenosis from 56% to 83%**
  - **Transient ischemic dilatation of the LV cavity indicating a large ischemic burden**
  - **Increased radiotracer lung uptake indicating elevated PCWP**

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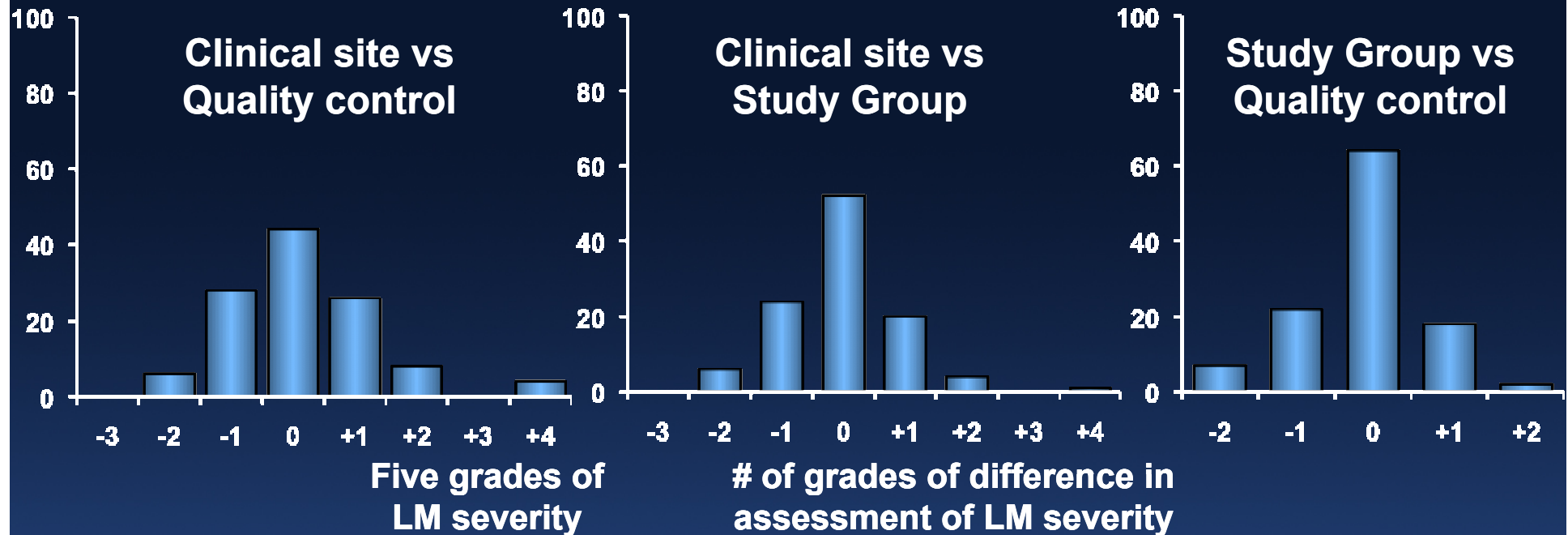
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Of all the coronary segments, the LMCA has the greatest angiographic assessment variability - I

Comparison between percent stenosis assessment from the quality control (QC) lab vs the clinical site in the CASS Study

*area of the square is proportional to the number of cases

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Of all the coronary segments, the LM has the greatest angiographic assessment variability - II

Clinical site vs Quality control

Clinical site vs Study Group

Study Group vs Quality control

Five grades of LM severity

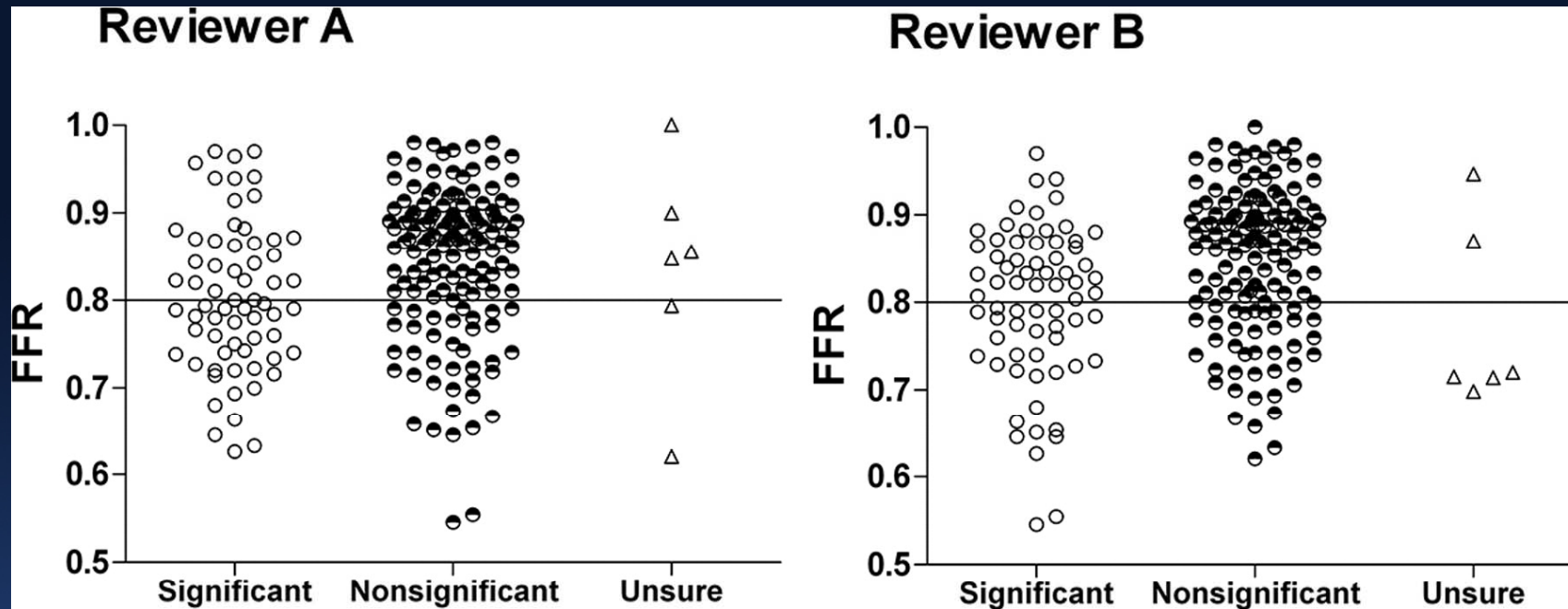**# of grades of difference in assessment of LM severity**

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

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

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But surely we are better today - I!

- *51 intermediate or equivocal LM lesions were evaluated by FFR and angiography. Four experienced interventional cardiologists visually classified lesions as 'significant', 'not significant', or 'unsure.'*
- *The 4 experienced interventional cardiologists achieved correct lesion classification in no more than ~50% of each case regardless of the FFR threshold (≤0.75 or ≤0.80).*
- *Interobserver variability was large, resulting in unanimous correct lesion classification in only 29%!*

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But surely we are better today - II!

In 158 patients (74%), there was agreement between the 2 reviewers. Among these 158 patients, 48 were misclassified: 23 patients had an estimated DS >50% while the FFR was >0.80, and 25 patients had an estimated DS <50% while the FFR was <0.80
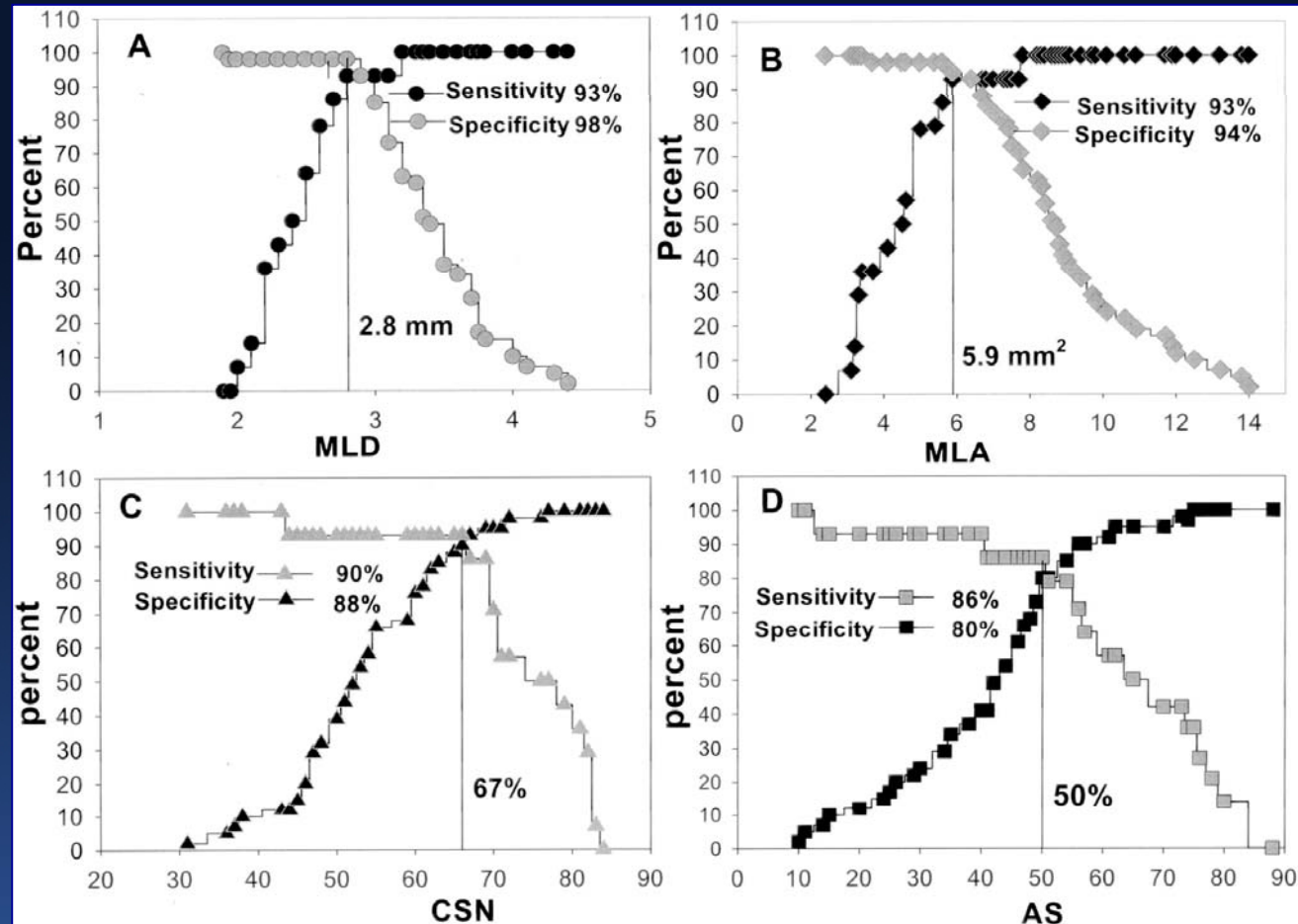
Hamilos et al. Circulation 2009;120:1505-1512

Comparison of Angiography vs IVUS at Asan Medical Center (n=207)

		Angiographic Diameter Stenosis (visual estimation)		
		<50%	>50%	Total
IVUS MLA	<6mm^2	5	140	145
	>6mm^2	25	37	62
	Total	30	177	207

Over-estimation in 37/207=18%

IVUS determinants of LMCA FFR <0.75

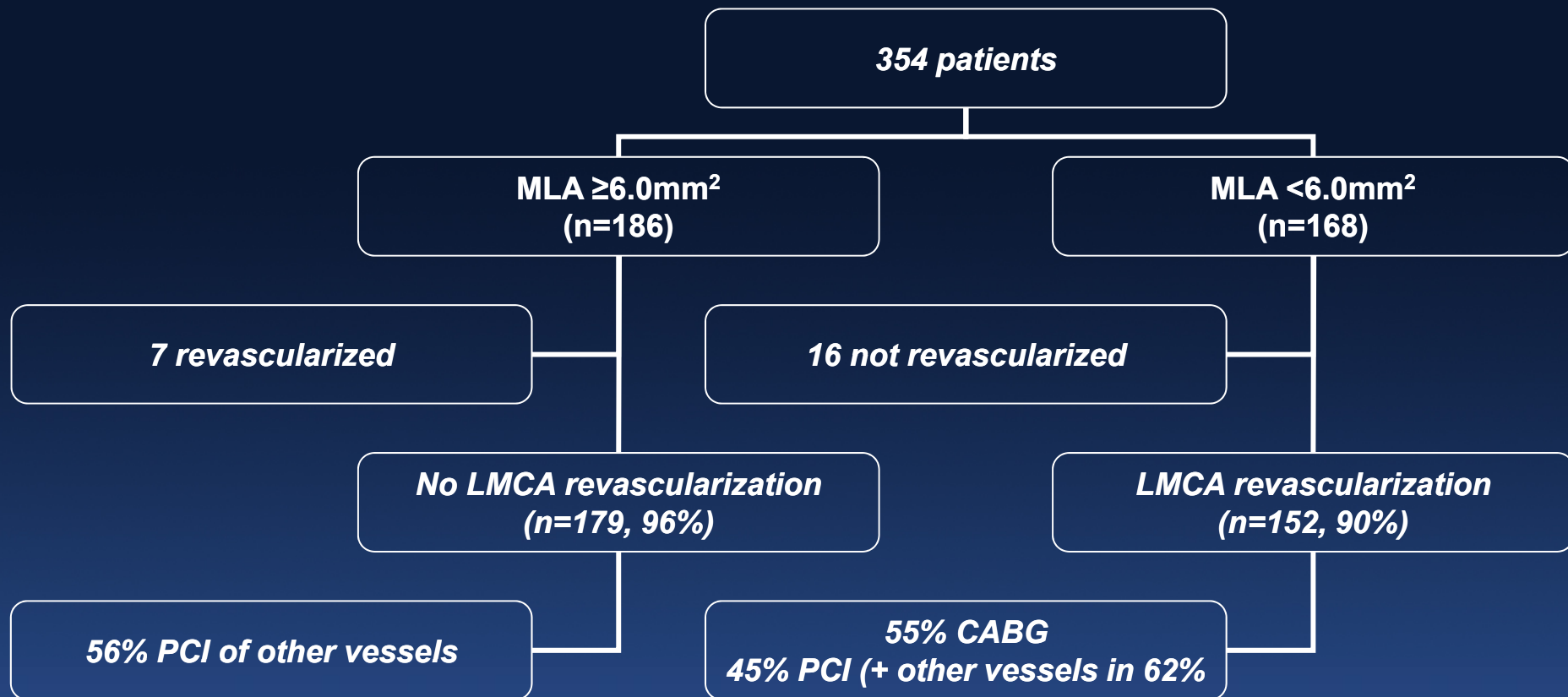# Follow-up of 122 pts with moderate LM disease
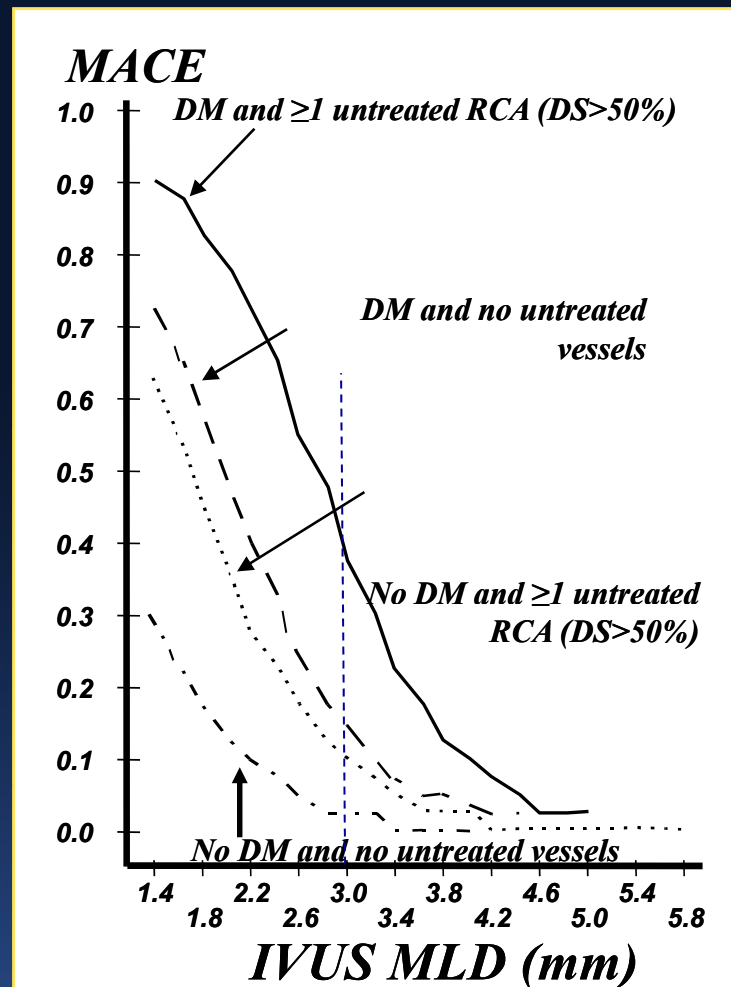
Independent predictors of MACE @11.7 months: DM (p=0.004), untreated RCA lesion >50% (p=0.037), and IVUS MLD (p=0.005) – but NOT the plaque burden.
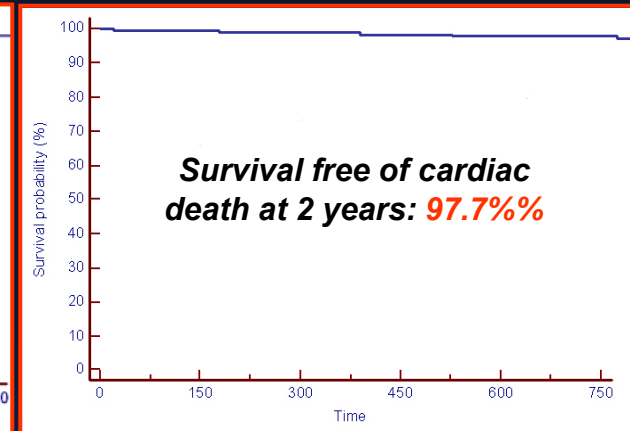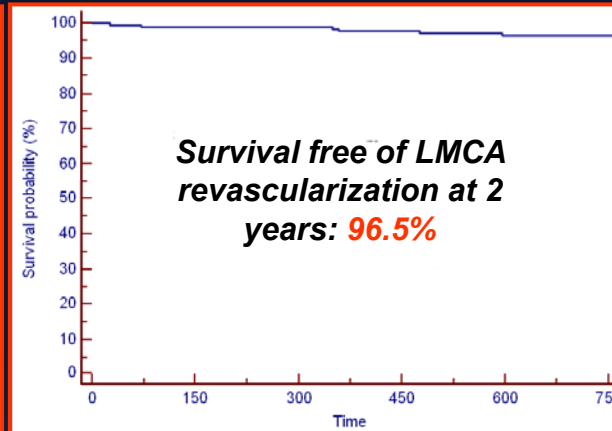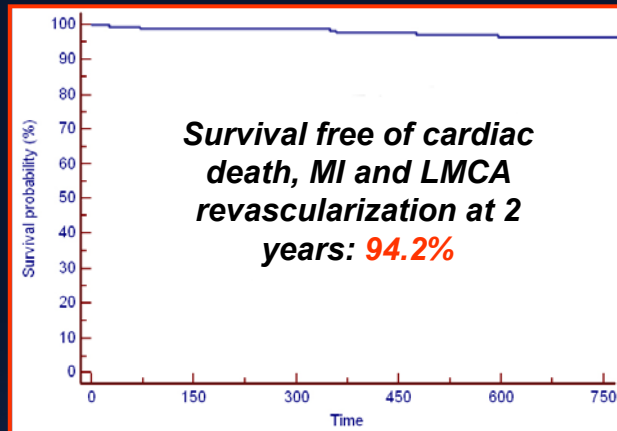
IVUS Criteria for a 'Significant' LMCA Stenosis

- **Most IVUS LMCA studies show either insignificant disease or critical disease**

- **Absolute lumen CSA <6.0mm^2 (or MLD <3.0mm) is the suggested criterion for a significant LMCA stenosis**

  - **Correlates with a LMCA FFR<0.75**

  - **Does not depend on finding a disease-free reference segment**

- **It is not clear whether the same criteria should be used for ostial LM lesions as for mid-shaft/distal bifurcation lesions and for positively vs negatively remodeled lesions**
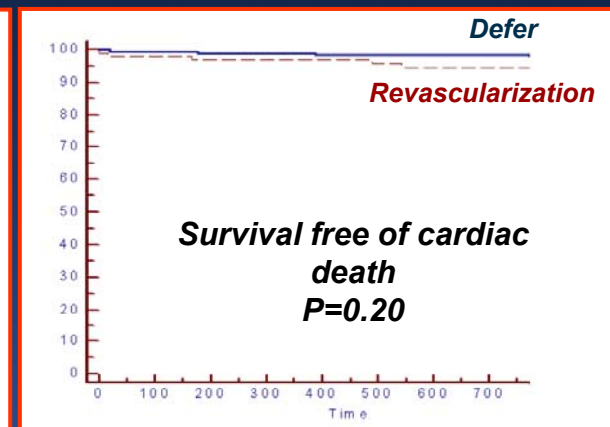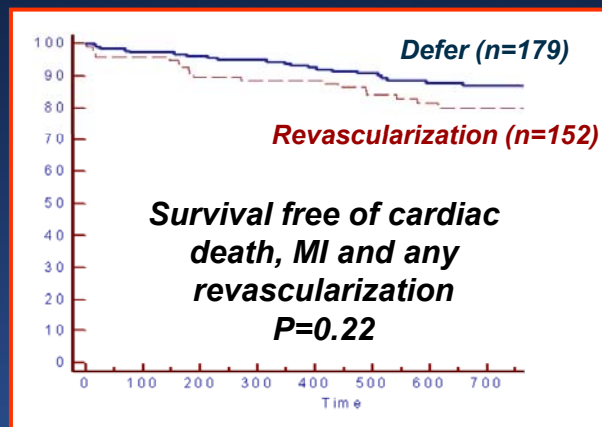
Prospective application of predefined IVUS criteria for revascularization of intermediate left main coronary artery lesions: Results at 2 years from the LITRO study
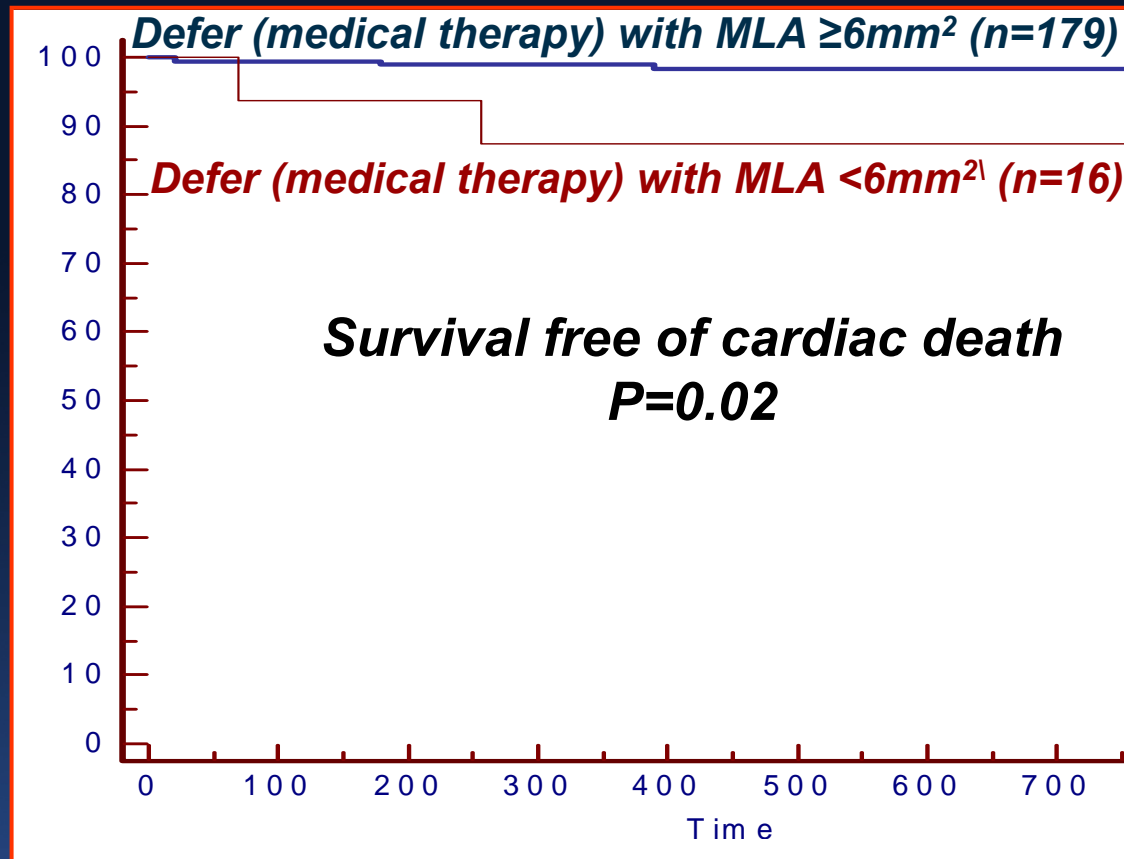
354 patients

MLA ≥6.0mm^2 (n=186)

MLA <6.0mm^2 (n=168)

7 revascularized

16 not revascularized

No LMCA revascularization (n=179, 96%)

LMCA revascularization (n=152, 90%)

56% PCI of other vessels

55% CABG
45% PCI (+ other vessels in 62%

De La Torre Hernandez et al. TCT 2010

Clinical outcome of patients with deferred revascularization (MLA >6mm²)

Survival free of cardiac death, MI and LMCA revascularization at 2 years: *94.2%*

Survival free of LMCA revascularization at 2 years: *96.5%*

Survival free of cardiac death at 2 years: *97.7%%*

Clinical outcome of patients with vs without revascularization

Defer (n=179)

Revascularization (n=152)

Survival free of cardiac death, MI and any revascularization
P=0.22

Defer

Revascularization

Survival free of cardiac death
P=0.20

De La Torre Hernandez et al. TCT 2010

Defer (medical therapy) with MLA ≥6mm² (n=179)

Defer (medical therapy) with MLA <6mm²\ (n=16)

Survival free of cardiac death
P=0.02

Time
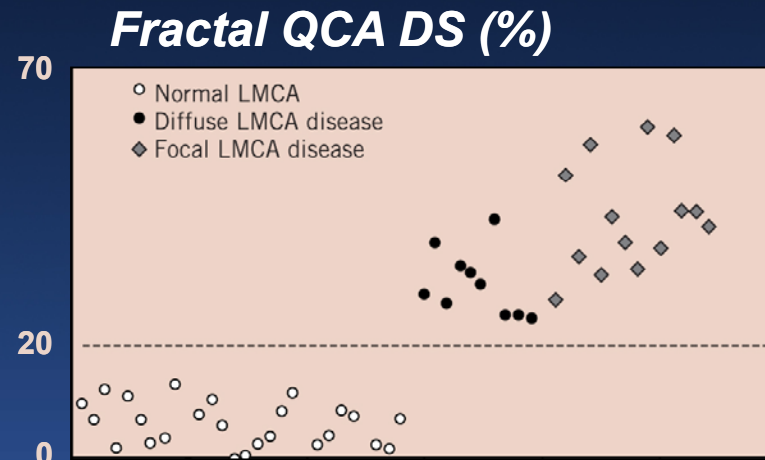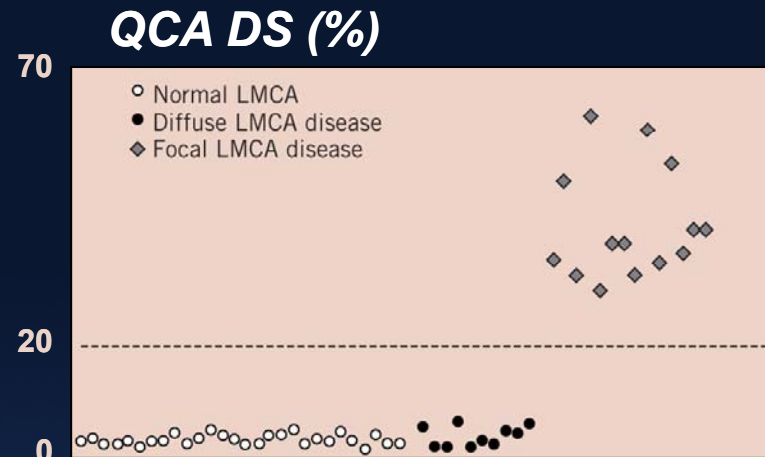
De La Torre Hernandez et al. TCT 2010

IVUS assessment of LM disease significance is based on lumen dimensions, not plaque burden

Plaque burden (P&M/EEM) = 68%
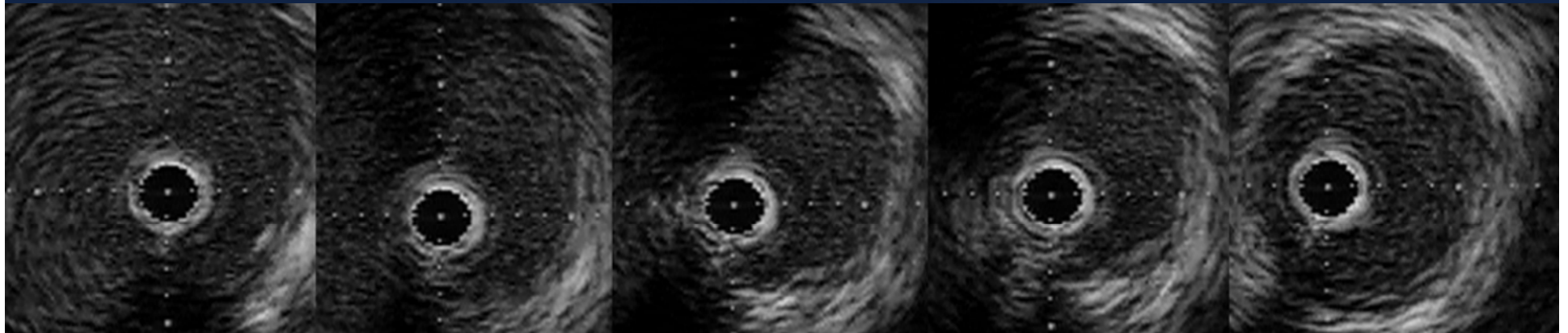MLA=7.2mm^2

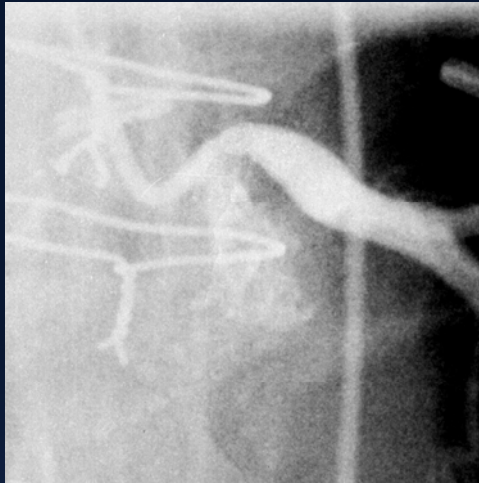# "Small" LM = Diffuse LMCA disease

QCA DS (%)

70
- ○ Normal LMCA
- ● Diffuse LMCA disease
- ◆ Focal LMCA disease

20

0

Fractal QCA DS (%)

70
- ○ Normal LMCA
- ● Diffuse LMCA disease
- ◆ Focal LMCA disease

20

0

- **Murray's Law**
  - $_{LMCA}r^3 = {}_{LAD}r^3 + {}_{LCX}r^3$
- **Fractal Geometry**
  - $_{LMCA}D = 0.678\,({}_{LAD}D + {}_{LCX}D)$

QCA				
$E = 0.678 \cdot (C+D)$				
LMDref (A)	(mm)	4.80	2.69	4.09
LMMLD (B)	(mm)	4.70	2.62	2.58
Diameter Stenosis	(%)	2	3	37
LADref (C)	(mm)	3.93	3.32	3.72
LCxref (D)	(mm)	3.17	2.28	3.13
QCA fractal	LMDfractal (E)	(mm)	4.81	3.80	4.64
	Diameter Stenosis fractal	(%)	2	31	44
	LMDref-LMDfractal	(mm)	-0,01	-1,11	-0,55

QIVUS				
LM MLA (F)	(mm²)	15.32	6.02	4.42
LMML PB (G)	(%)	17	66	65
LMML EEM (H)	(mm²)	18.45	17.58	12.76
LMDref	(mm)	4.44	2.88	4.09
LMMLD	(mm)	4.42	2.77	2.37
Diameter Stenosis	(%)	1	4	42
LADref	(mm)	3.95	3.70	3.73
LCxref	(mm)	3.04	2.60	2.94
QIVUS fractal	LMDfractal	(mm)	4.74	4.27	4.52
	Diameter Stenosis fractal	(%)	7	35	48
	LMDref-LMDfractal	(mm)	-0.30	-1.39	-0.43

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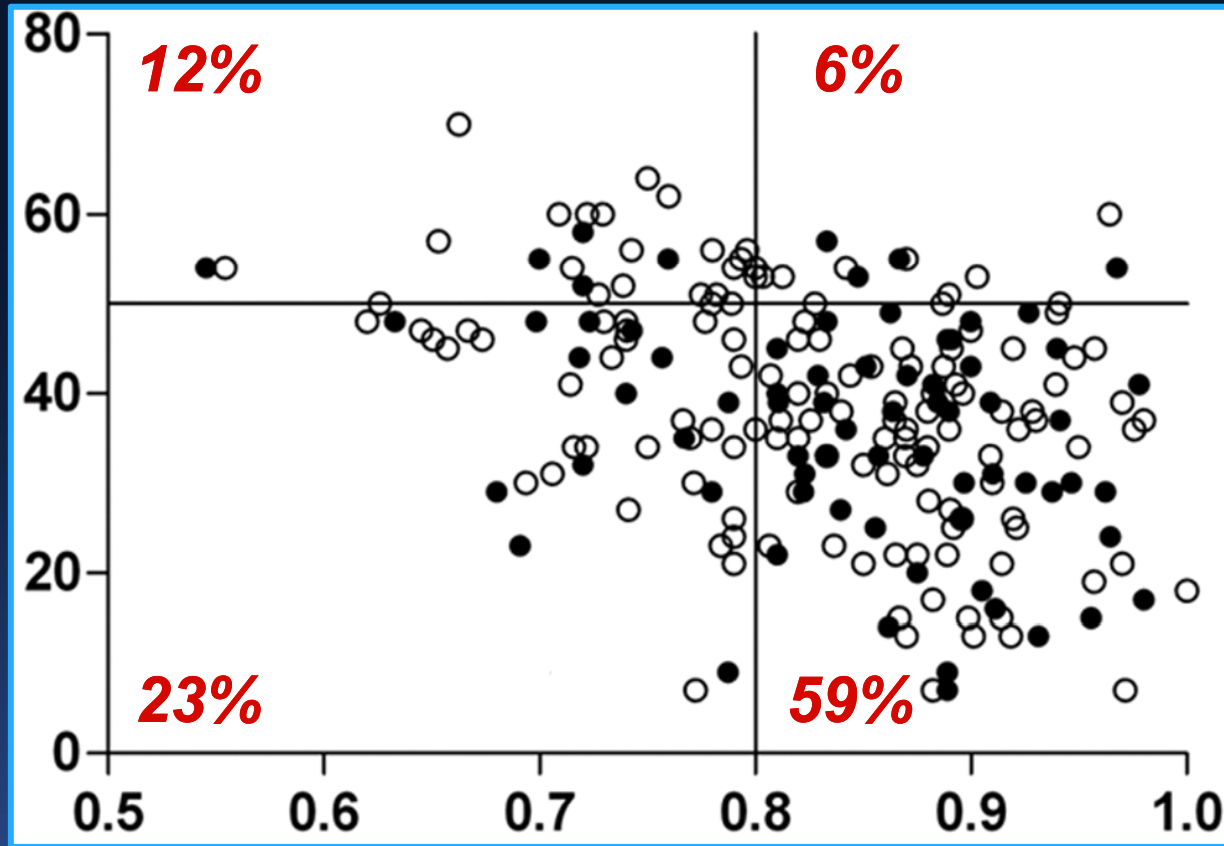0 ──────→ 1.0 ──────────────────────────→ 4.0mm

- ***In 25% of patients, the left main MLA differed by 1mm^2 when imaged from a pullback beginning in the LAD vs a pullback beginning in the LCX.***
- ***Since IVUS can artificially increase, but not decrease lumen dimensions, the smallest MLA is always the most accurate***
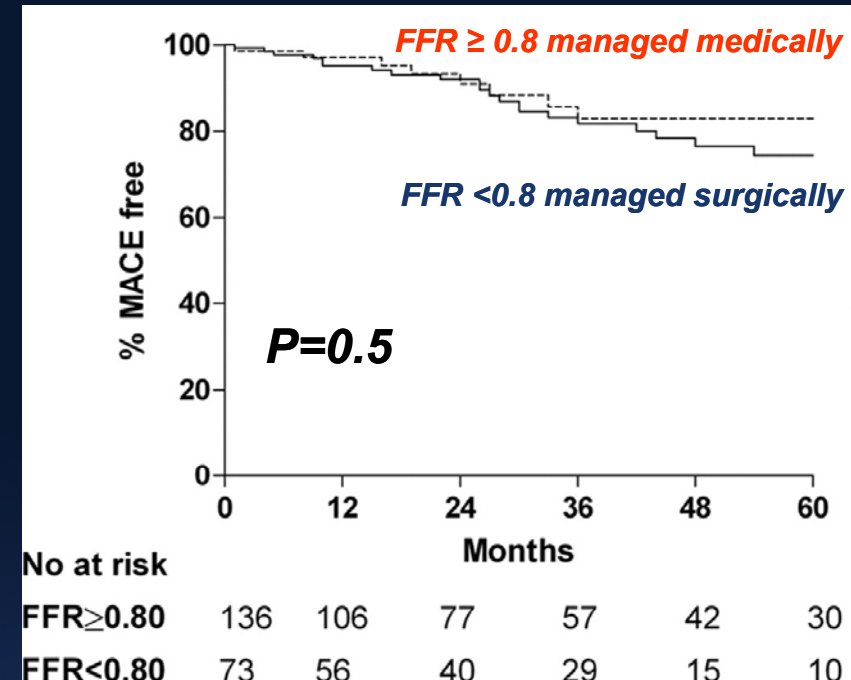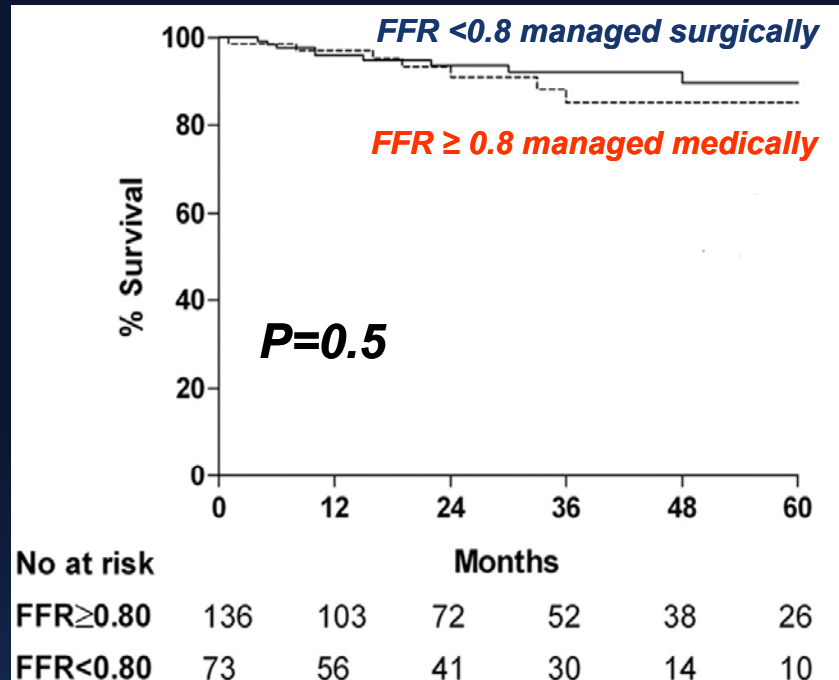
LCX

0 → 1.0 → 5.0mm

LAD

0 → 1.0 → 4.0mm

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QCA vs FFR (n=213)

Y-axis: Angiogrpahic DS (%, QCA)
X-axis: FFR

Quadrant labels: 12%, 6%, 23%, 59%
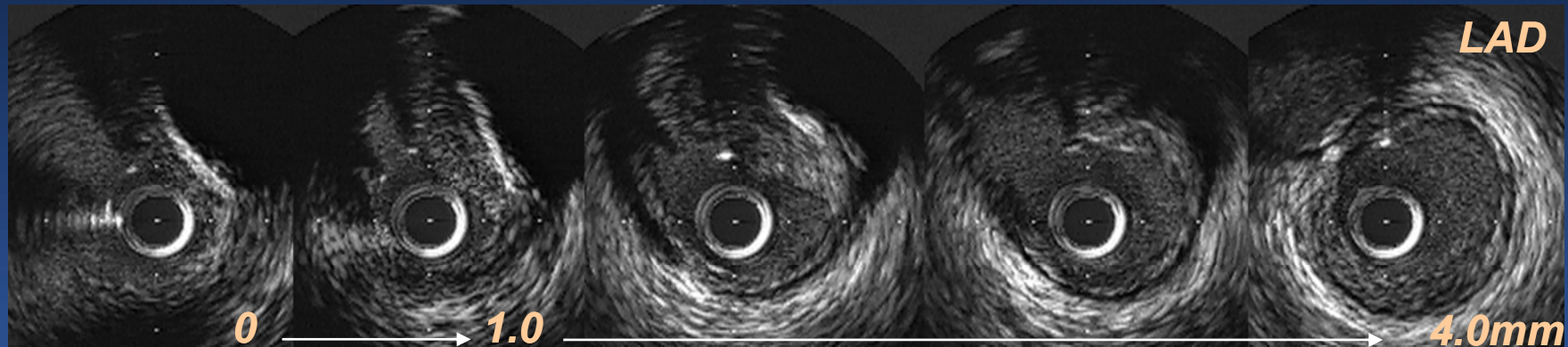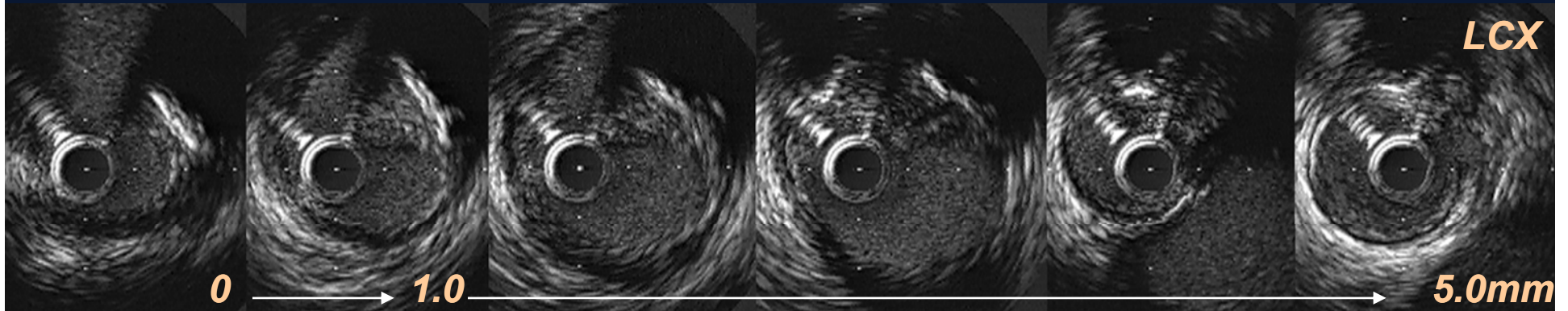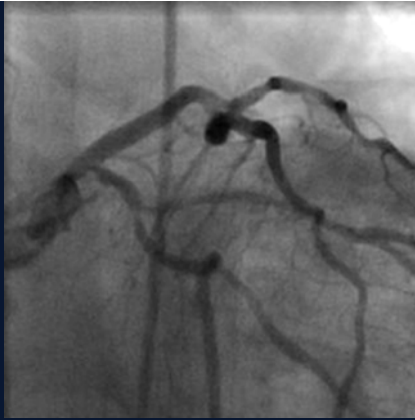
- Sensitivity, specificity, and diagnostic accuracy of QCA DS>50% to predict FFR <0.80 were 33%, 91%, and 71%, respectively.
- When only isolated LMCA stenosis was considered, sensitivity, specificity, and diagnostic accuracy were 26%, 92%, and 75%, respectively.
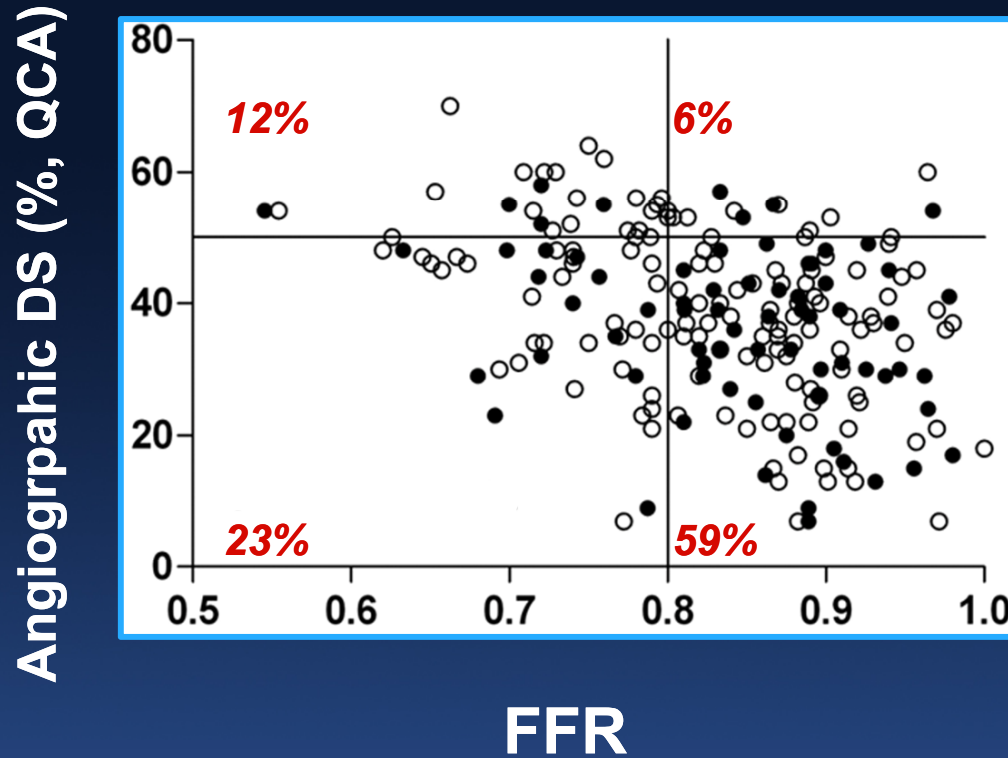
Hamilos et al. Circulation 2009;120:1505-1512

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Stepwise Cox regression analysis showed that a RCA stenosis was the sole independent predictor for MACE.

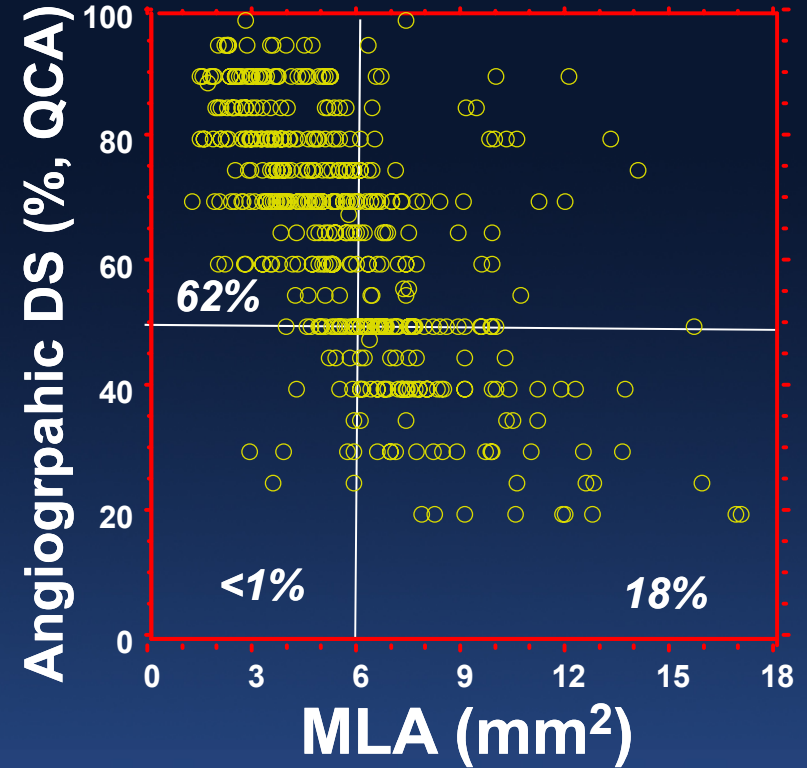When only the patients with an isolated LMCA stenosis were considered, survival estimates at 5 years were 100% in the nonsurgical group and 75% in the surgical group (P=0.32). MACE survival rates at 5 years in the nonsurgical and surgical groups were 70% and 66%, respectively (P=0.54).
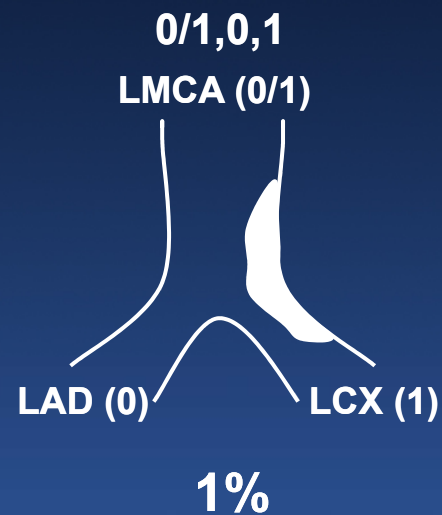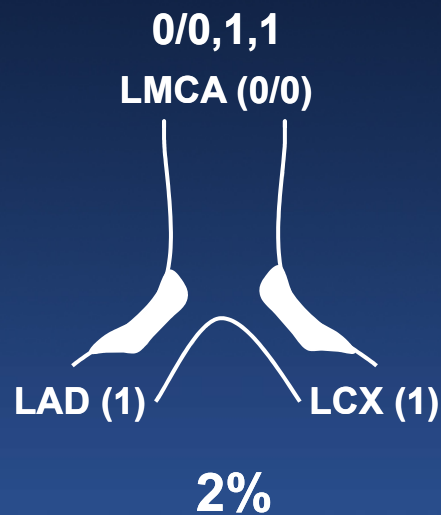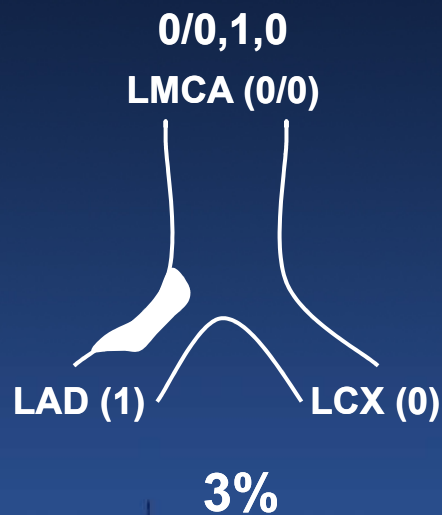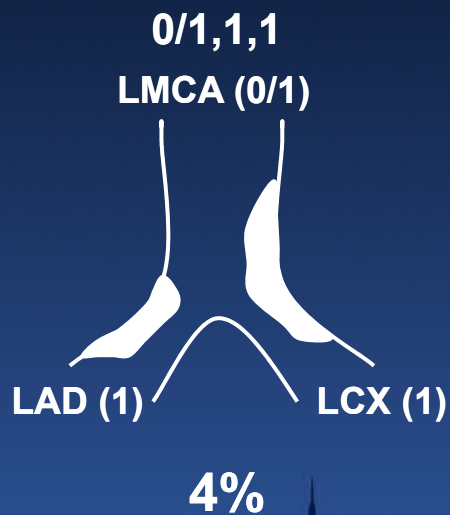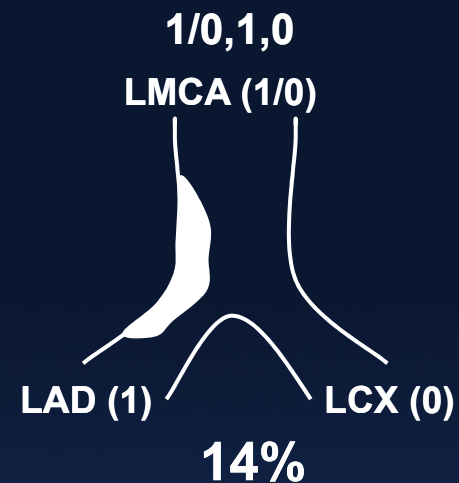
QCA vs FFR (n=213)
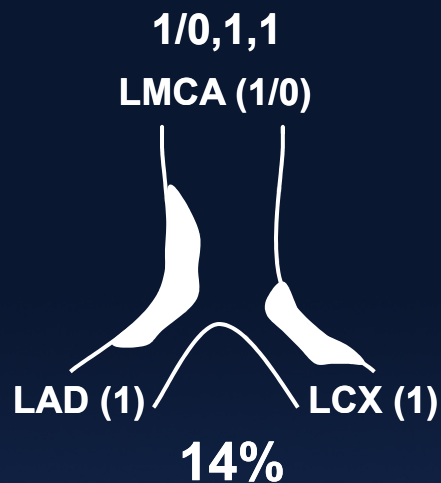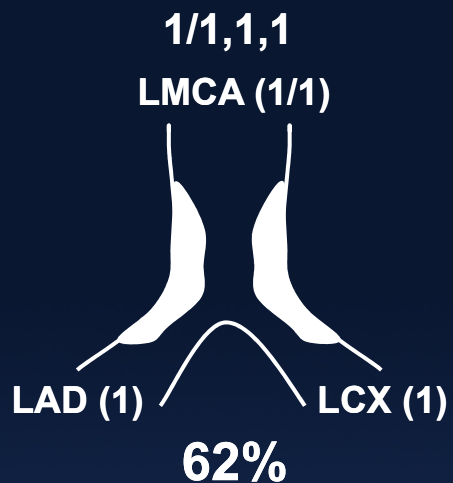
QCA vs IVUS (n=438)

Hamilos et al. Circulation 2009;120:1505-1512

IVUS plaque distribution in 140 distal LMCA bifurcation lesions

Oviedo et al. Circ Cardiovasc Interv. 2010;3:105-12

Others

All lesions (n=80)				
Medina 1,1,1 (n=21)				
Medina 1,1,0 (n=9)				
Medina 1,0,1 (n=6)				
Medina 0,1,1 (n=11)				
Medina 1,0,0 (n=7)				
Medina 0,1,0 (n=14)				
Medina 0,0,1 (n=12)				
Medina 0,0,0 (n=60)				

0%   100%

Oviedo et al. Circ Cardiovasc Interv. 2010;3:105-12

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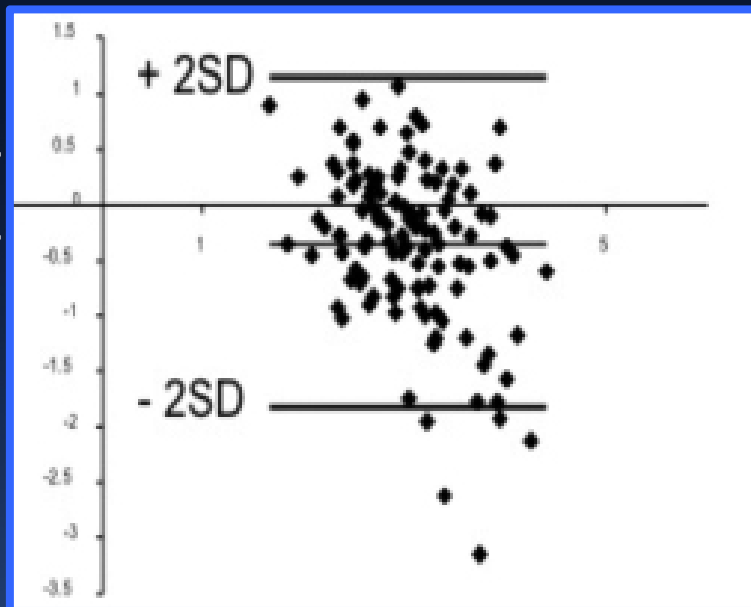
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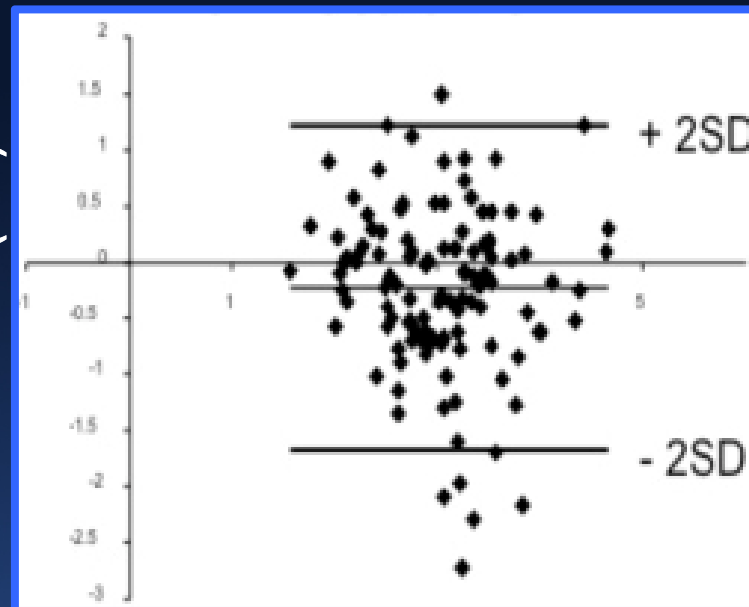# IVUS assessment of LCX ostium from the LAD-LM (or vice versa) - MLD

Evaluation of the LAD from the LM-LCX pullback

Difference between estimated and directly measured lumen diameters (mm)

Evaluation of the LCX from the LM-LAD pullback

Difference between estimated and directly measured lumen diameters (mm)

If you want to quantify the degree of lumen compromise, you must image the daughter branches directly.

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IVUS assessment of LCX ostium from the LAD-LM (or vice versa) – plaque burden

Evaluation of the LAD from the LM-LCX pullback

	Sensitivity	Specificity
Plaque burden >40 %	59%	45%
Plaque burden >70 %	78%	42%

Evaluation of the LCX from the LM-LAD pullback

	Sensitivity	Specificity
Plaque burden >40 %	67%	55%
Plaque burden >70 %	88%	42%

If you want to quantify the plaque burden, you must image the daughter branches directly.

Oviedo et al. Am J Cardiol 2010;105:948-54

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MAIN-COMPARE Registry

- **975 pts with unprotected LMCA stenosis underwent elective stenting under IVUS (n=756) or angiographic (n=219) guidance and were followed for 3 years**

- **IVUS-guidance was significantly associated with reduced death (HR=0.31 overall and HR=0.27 in DES) as compared with angiography guidance**

- In 201 propensity score-matched pairs of pts in the overall cohort, there was a tendency for reduced 3-year mortality with IVUS-guidance compared with angiography guidance (6.0% vs. 13.6%, HR=0.54).

- In 145 propensity score-matched pairs of pts treated with DES, 3-year mortality was lower with IVUS-guidance as compared with angiography-guidance (4.7% vs. 16.0%, HR=0.39, p=0.048)

- However, the use of IVUS-guidance did not reduce the risk of myocardial infarction or target vessel revascularization.

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Impact of IVUS Guidance on All-Cause Mortality After LMCA DES Implantation

IVUS (n=595)

95.2%

No IVUS (n=210)

85.6%

HR=0.43, p=0.019

Cumulative Incidence (%)

100

90

80

70

0.0   0.5   1.0   1.5   2.0   2.5   3.0

Years after DES implantation

Park et al. TCT 2007

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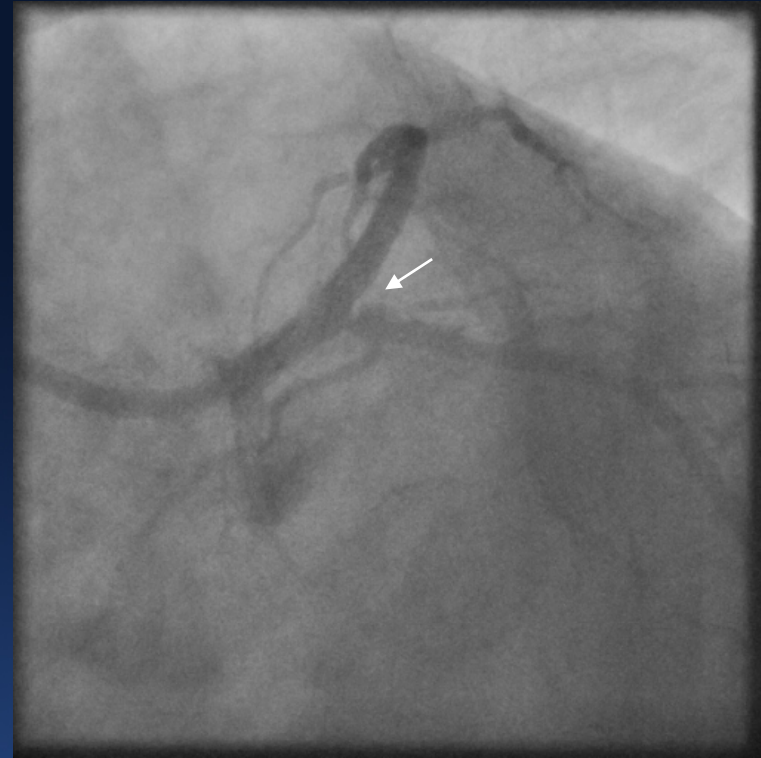**201 propensity score matched pairs (DES+BMS)**   **145 propensity score matched pairs (DES)**   **47 propensity score matched pairs (BMS)**
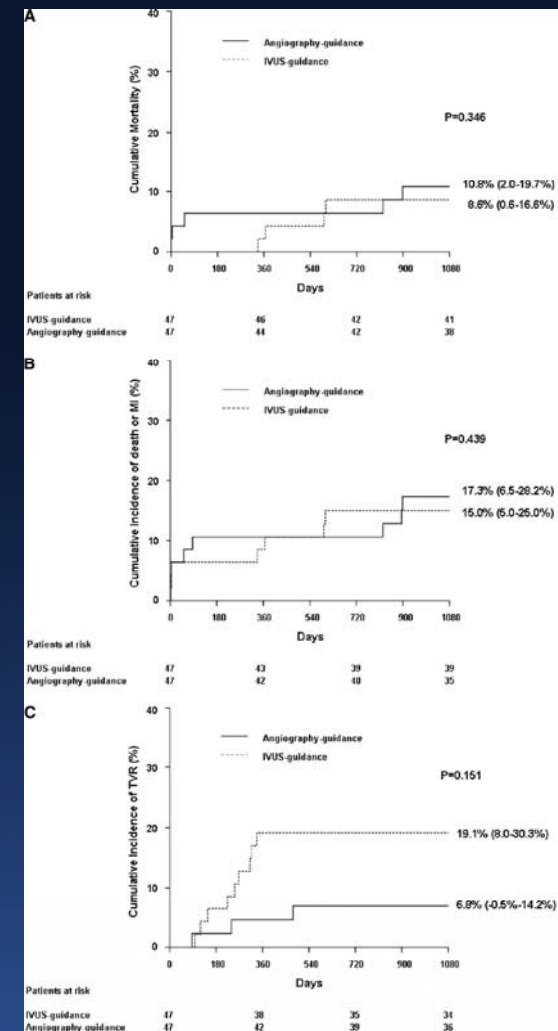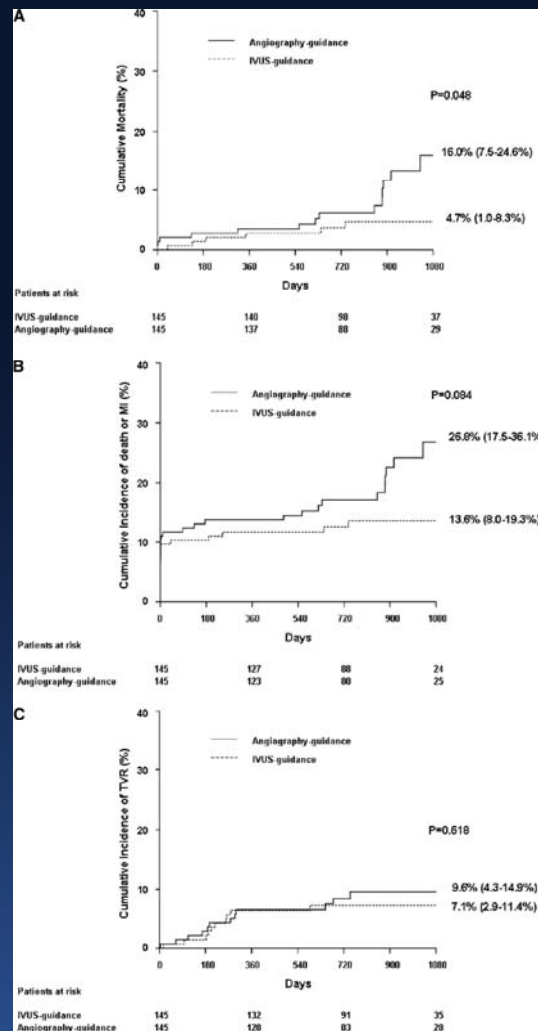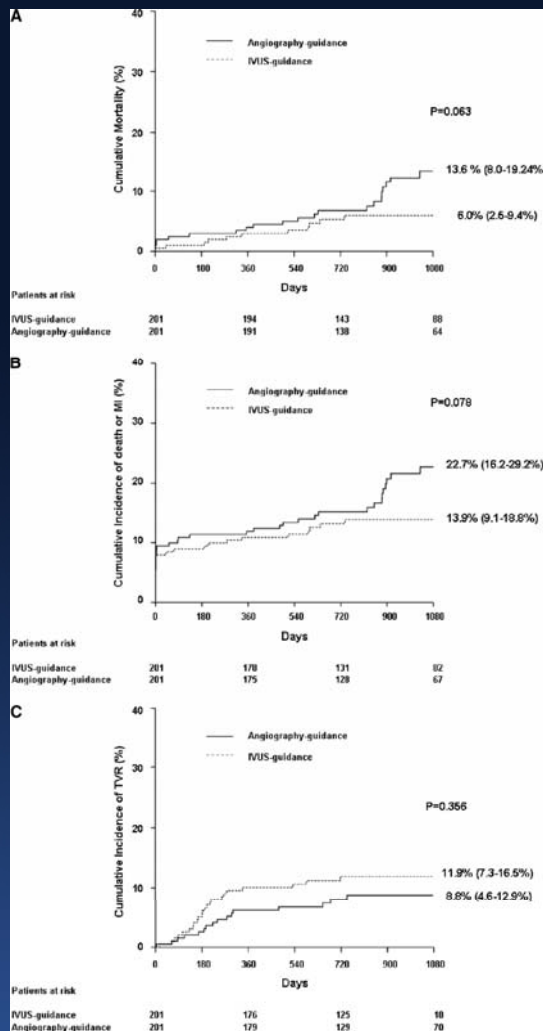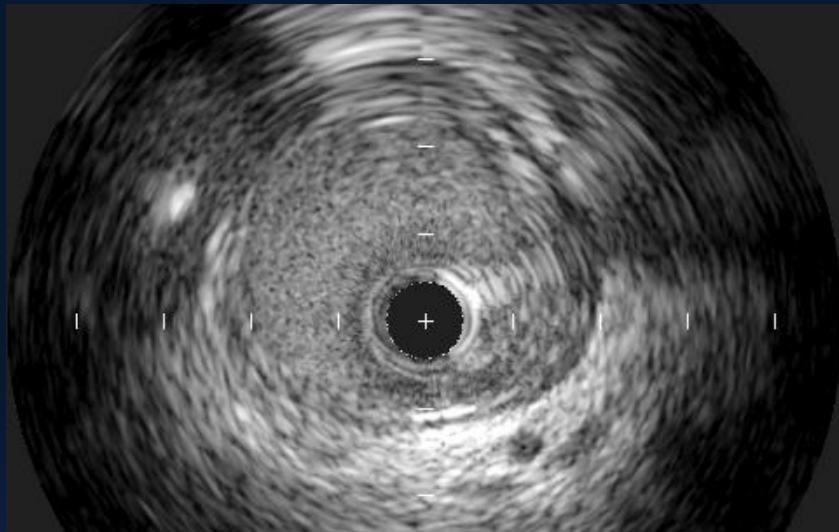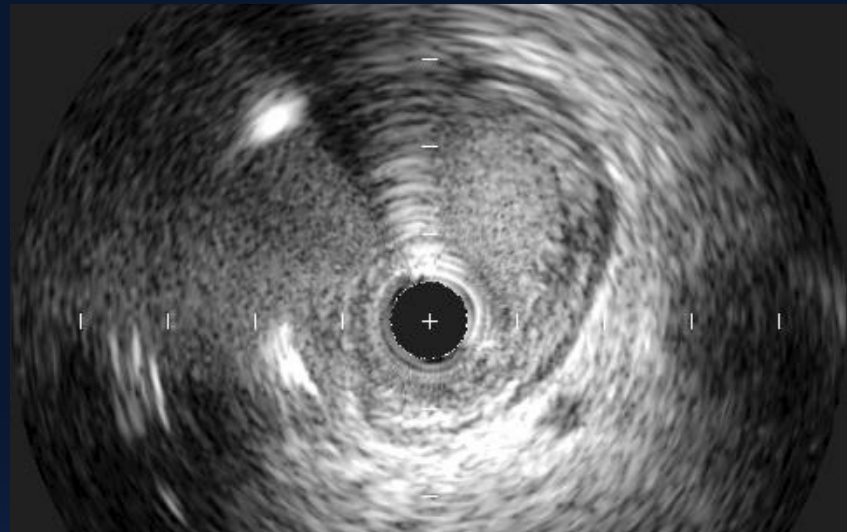
Pre-intervention

Post-intervention
(1 stent cross-over)

Pre

Post

LAD

LCX

LAD

LCX