Healthy Opinions, Smart Decisions

When and How to Access Morphology and Function and Why?

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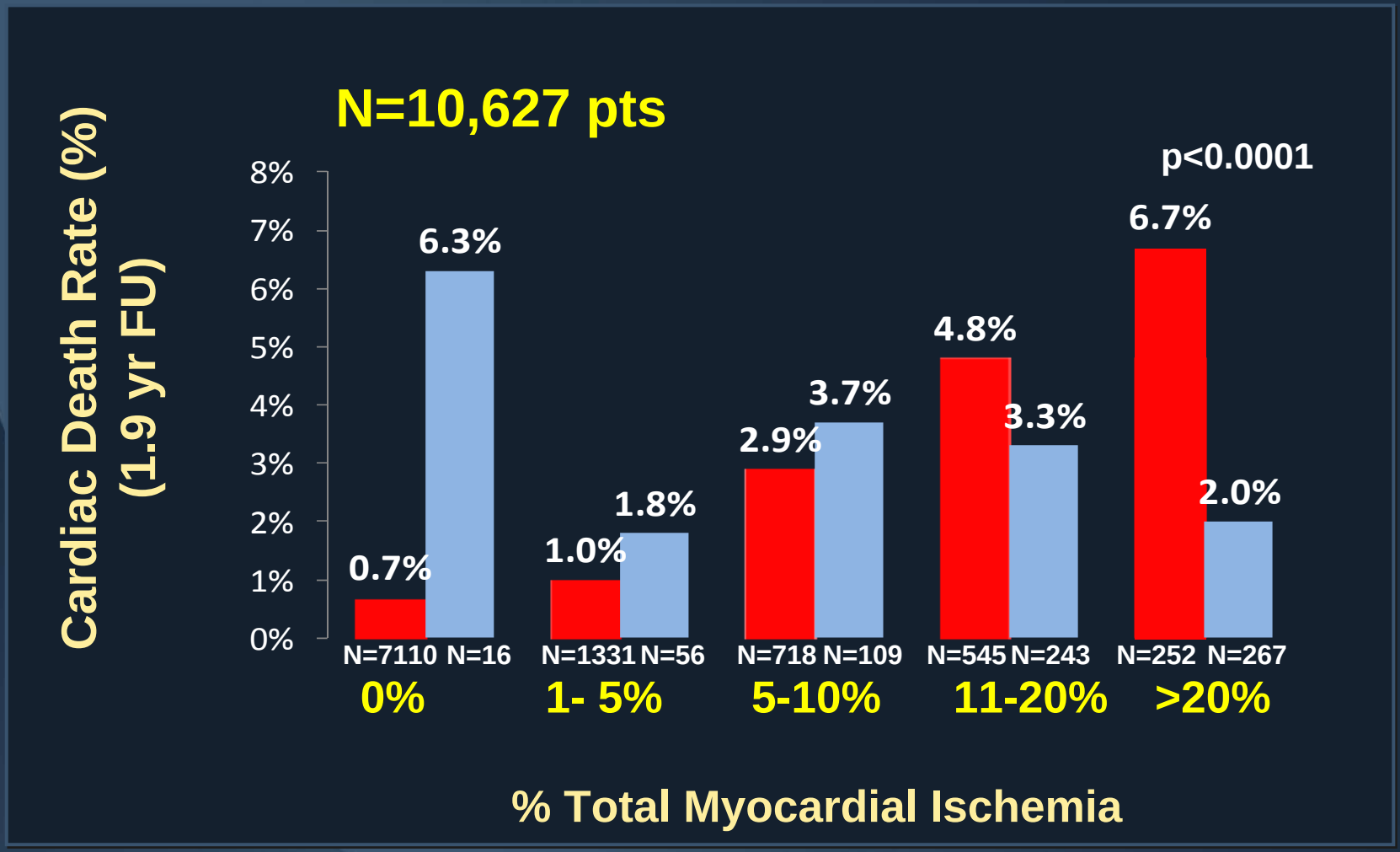
Focus of Today's Talk

1. Why function assessment is important?
2. How IVUS is reliable to assess the lesion severity?
3. LMCA is same with the other lesion in terms of function or as a cause of event?
4. What is vulnerable plaque to cause event and how/when we should evaluate?

Cardiac Mortality in Medically Treated or Revascularized Patients According to Ischemic Risk – CSMC Database



Hachamovitch et al *Circulation*. 2003;107:2900-07

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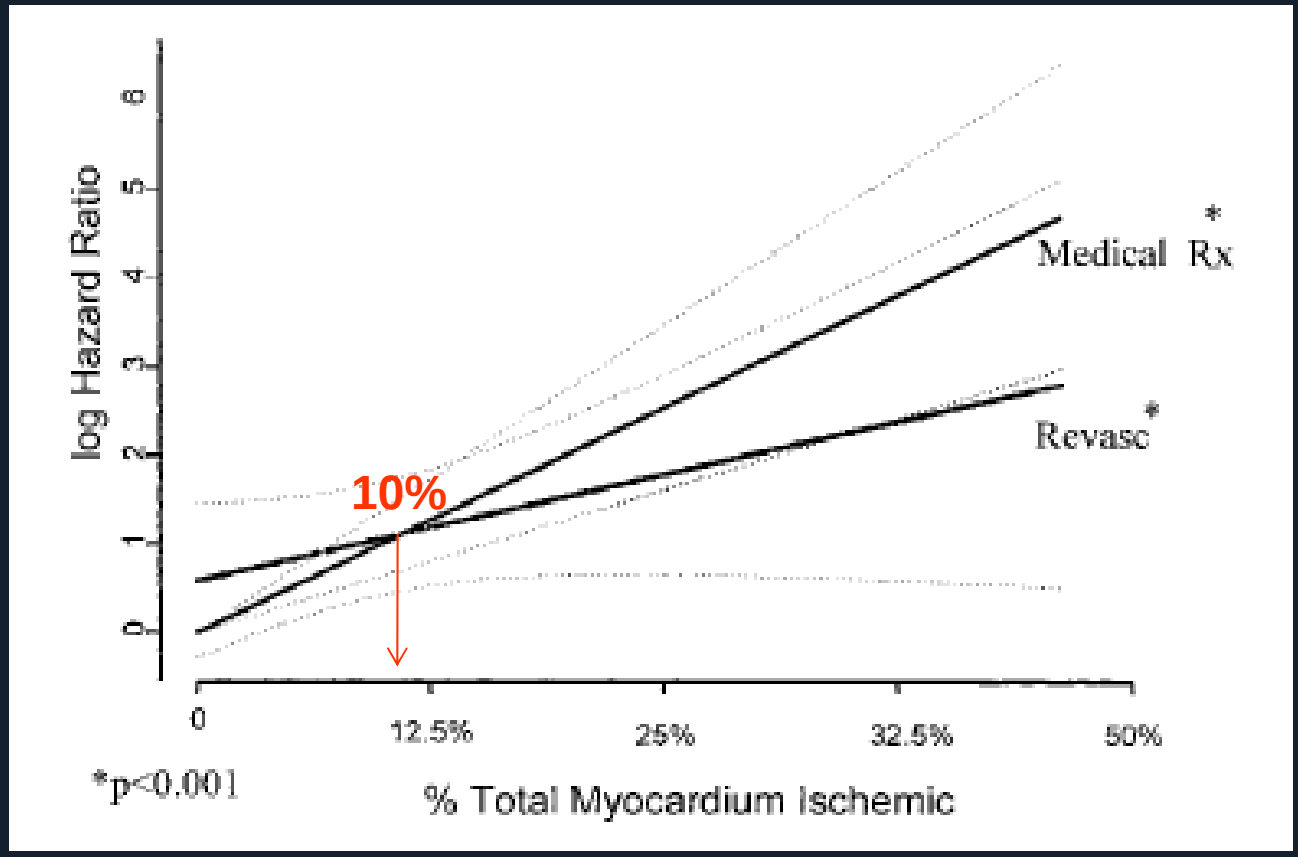
Log Hazard ratio for Revasc vs Medical Therapy as a function of % myocardium ischemia



Hachamovitch et al *Circulation*. 2003;107:2900-07

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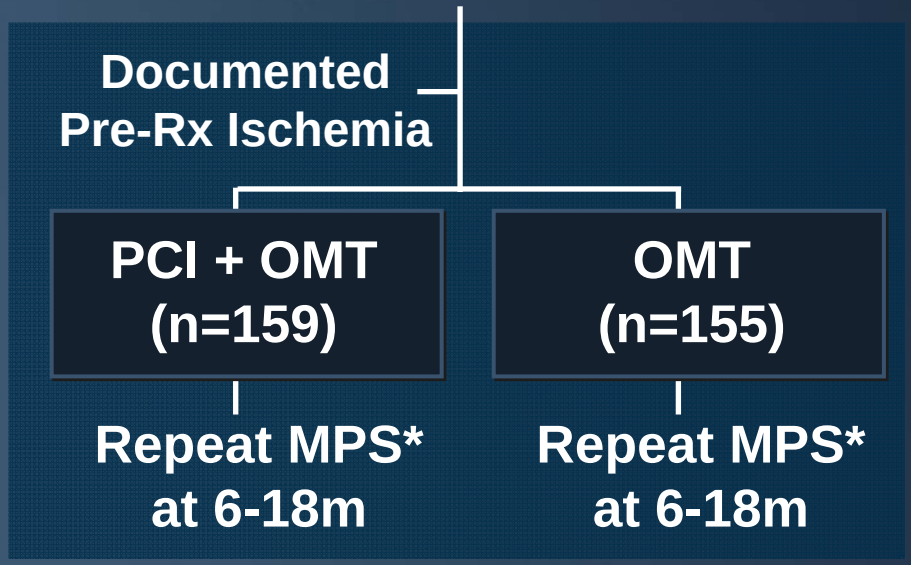
Nuclear Substudy (n=314/2,287)

Hypothesis: Reduction in Ischemia will be greater for patients Randomized to PCI+OMT than for those Randomized to OMT

Serial Rest/Stress Myocardial Perfusion SPECT (MPS)

To Compare Patient Management Strategy for Ischemia Reduction

- Pre-Rx = *Off Meds*
- 6-18m = *On Meds*



* Timing Chosen to Occur Beyond Window of In-Stent Restenosis & Delayed to Allow Effects of Medical Rx to be Observed

Mean = 374 ± 50 days

Shaw LJ, et al. J Nucl Cardiol. 2006;13:685-698.

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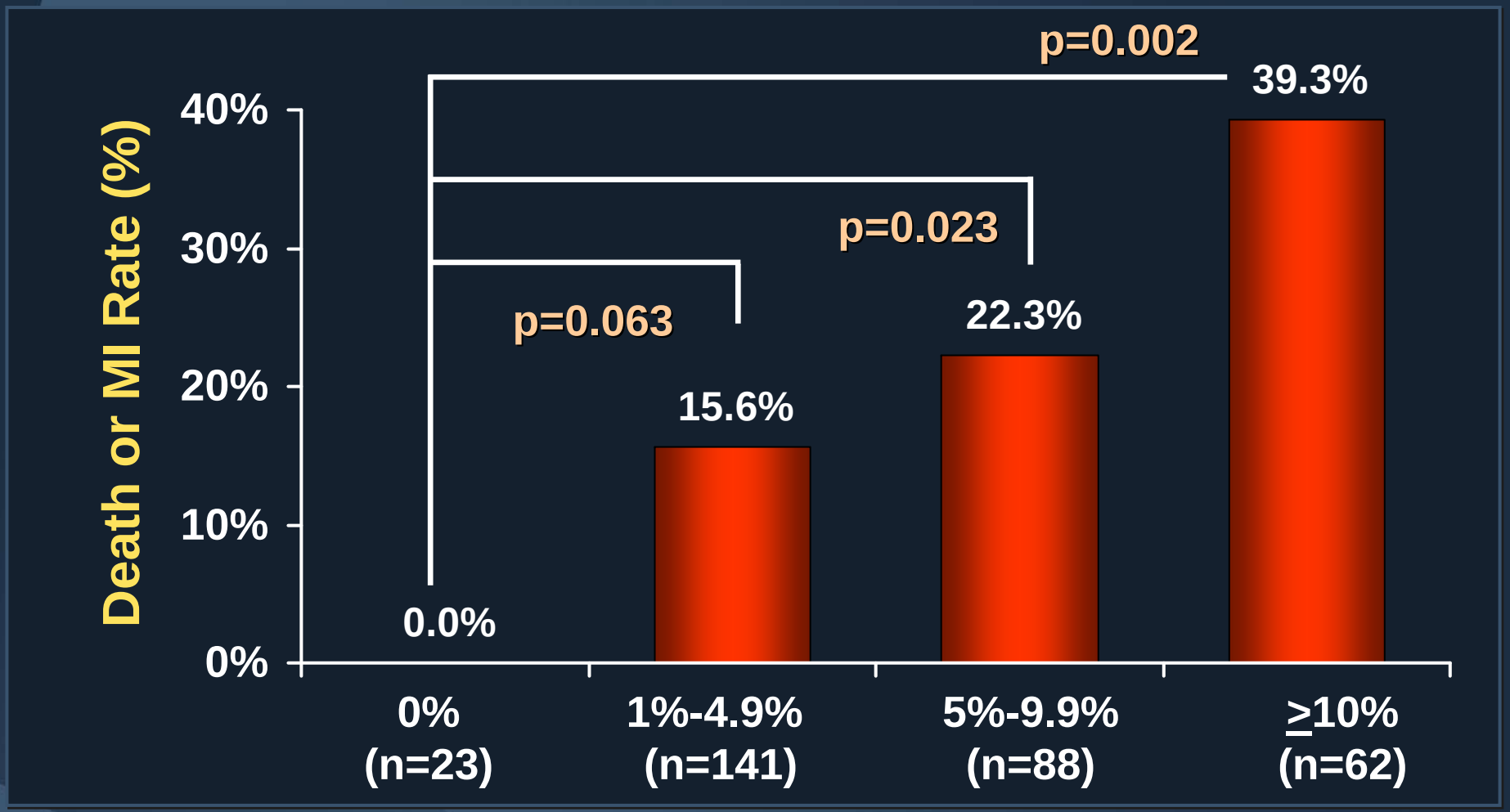
Rates of Death or MI by Residual Ischemia on 6-18m MPS



Shaw et al, *Circ* 2008;117: 1283-91

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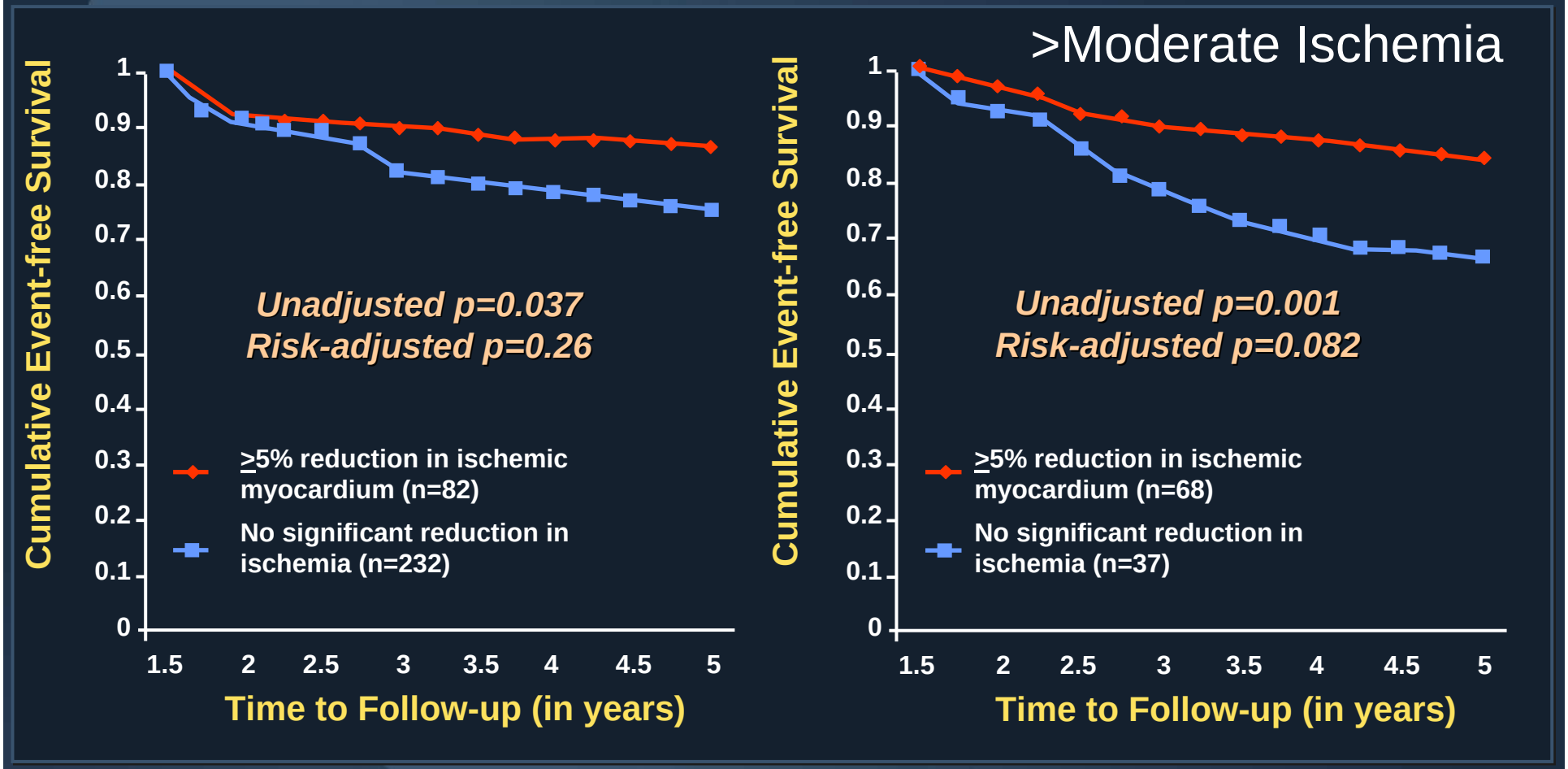
COURAGE :Ischemia Reduction Improves Outcomes



Shaw et al, *Circ* 2008;117: 1283-91

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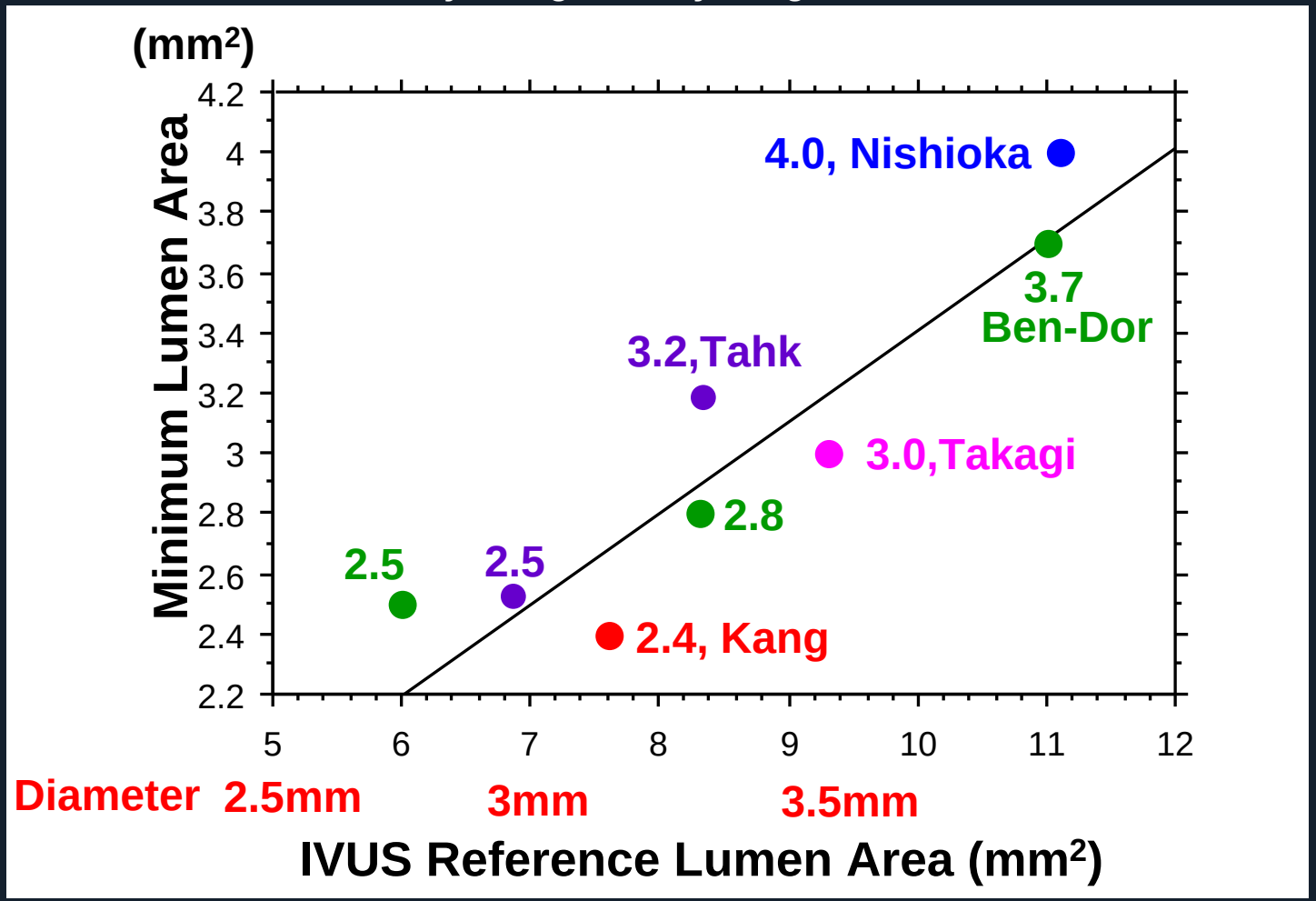
Correlation between IVUS and FFR

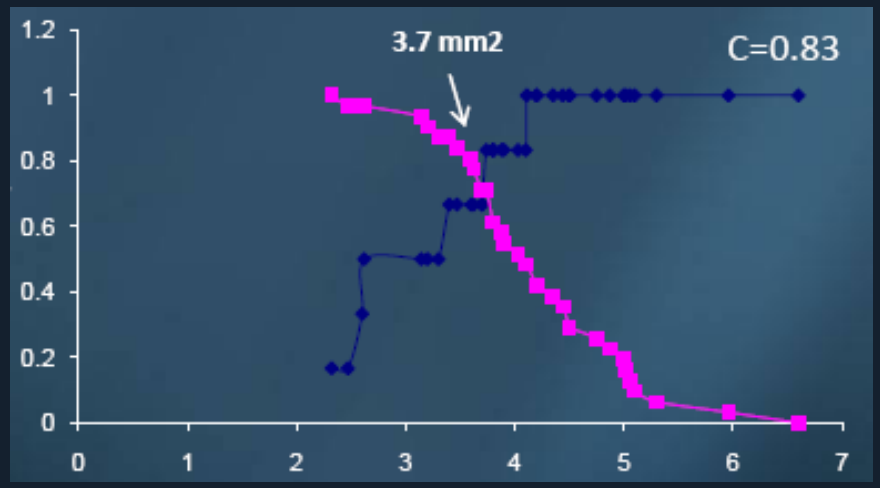
Author	year	Against	n	Cut-Off MLA (mm^2)	Ref Area (mm^2)	Correlation Coefficient
Nishioka	1999	SPECT	70	4.0	11.4±3.9	NA
Takagi		FFR 0.75	51	3.0	9.3±2.7	MLA:r^2=0.62
Kang	2011	FFR 0.80	236	2.4	7.6±2.5	MLA:0.51, Plaque burden:-0.39, Length with LA<4mm^2:-0.45
Ben-Dor			134	2.5,2.8, 3.7	>2.5mm diameter	MLA:0.51, %AS:-0.39, Plaque burden:-0.39, Length with LA<4mm^2:-0.45
Tahk			108	2.5,3.2	prox-mid LAD	MLA:0.42, %AS:-0.31 Plaque burden:-0.35, Lesion Length:-0.30

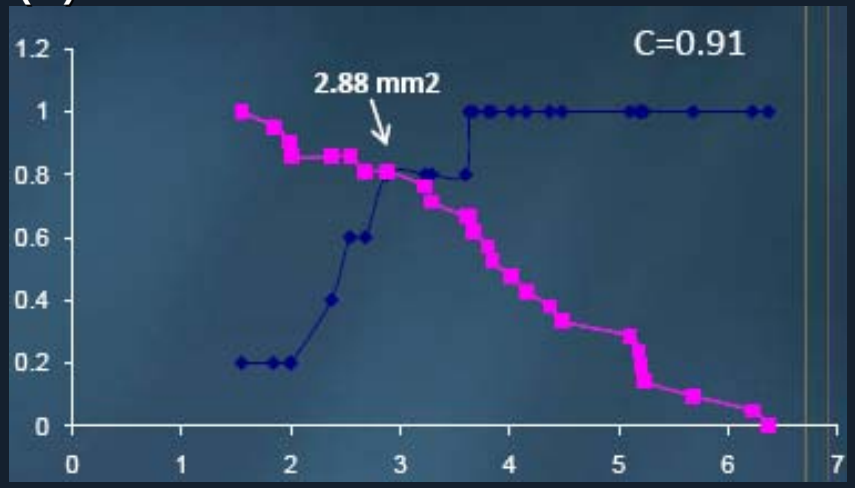
Cut-off MLA and Reference Area

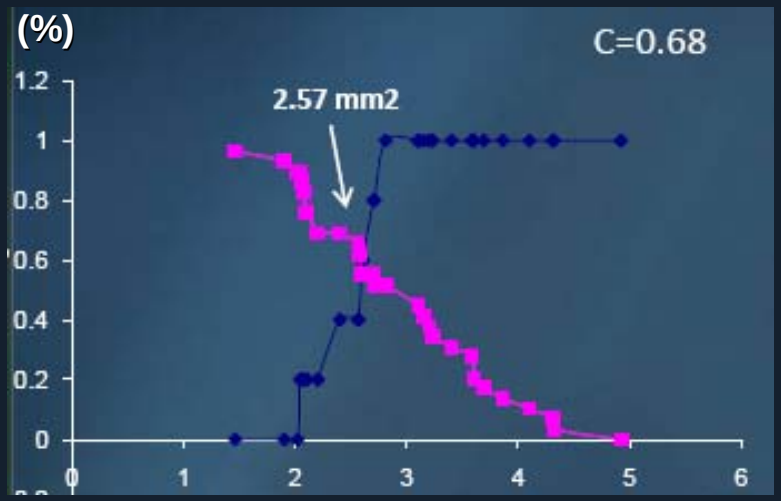
FFR Cut-off: 0.75 by Takagi, 0.80 by Kang, Ben-Dor, Tahk



Cut-off in relation to vessel size

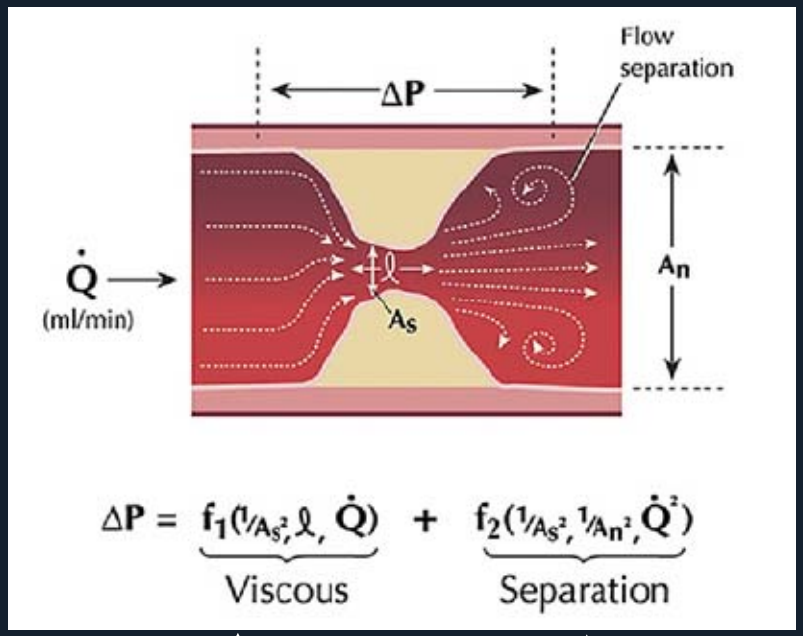






Ben-Dor I et al. ACC2010

Main Determinants for Pressure Drop



Law of Poiseuille ***Law of Bernoulli***

$$\text{Pressure Drop} \propto \frac{\text{Length}}{(\text{Stenotic Area})^2}$$

Kern and Samady, J Am Coll Cardiol, 55:173-85.

Correlation between IVUS and FFR

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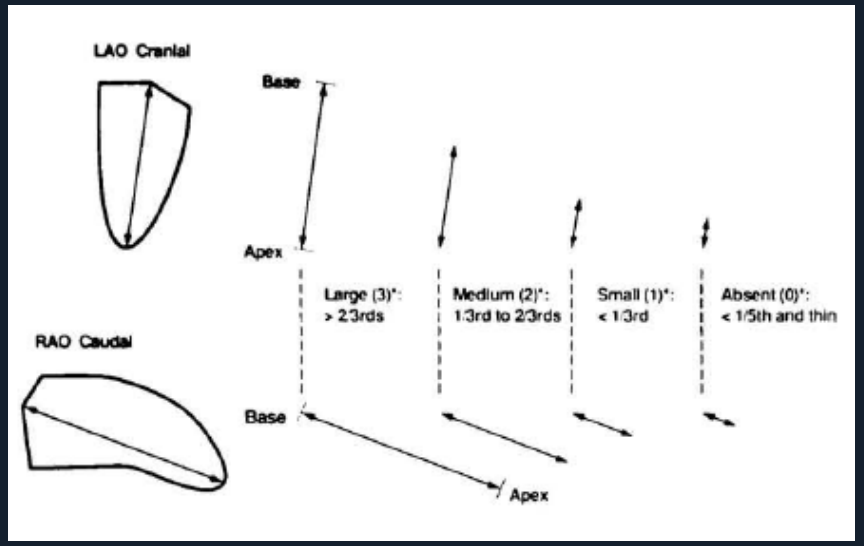
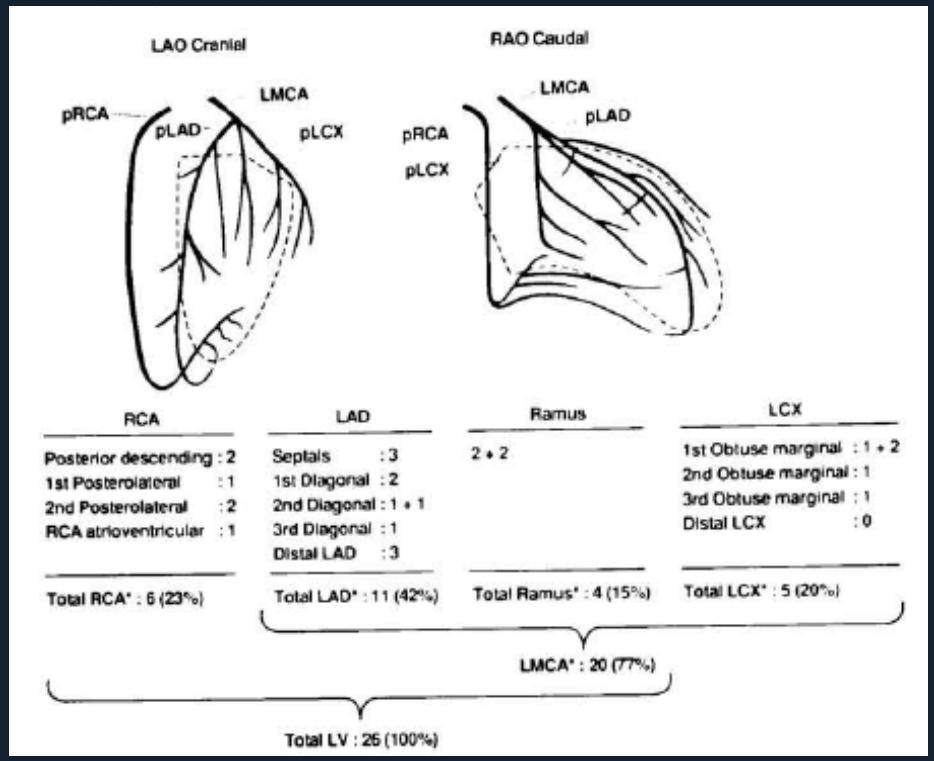
BARI Score to define Territory

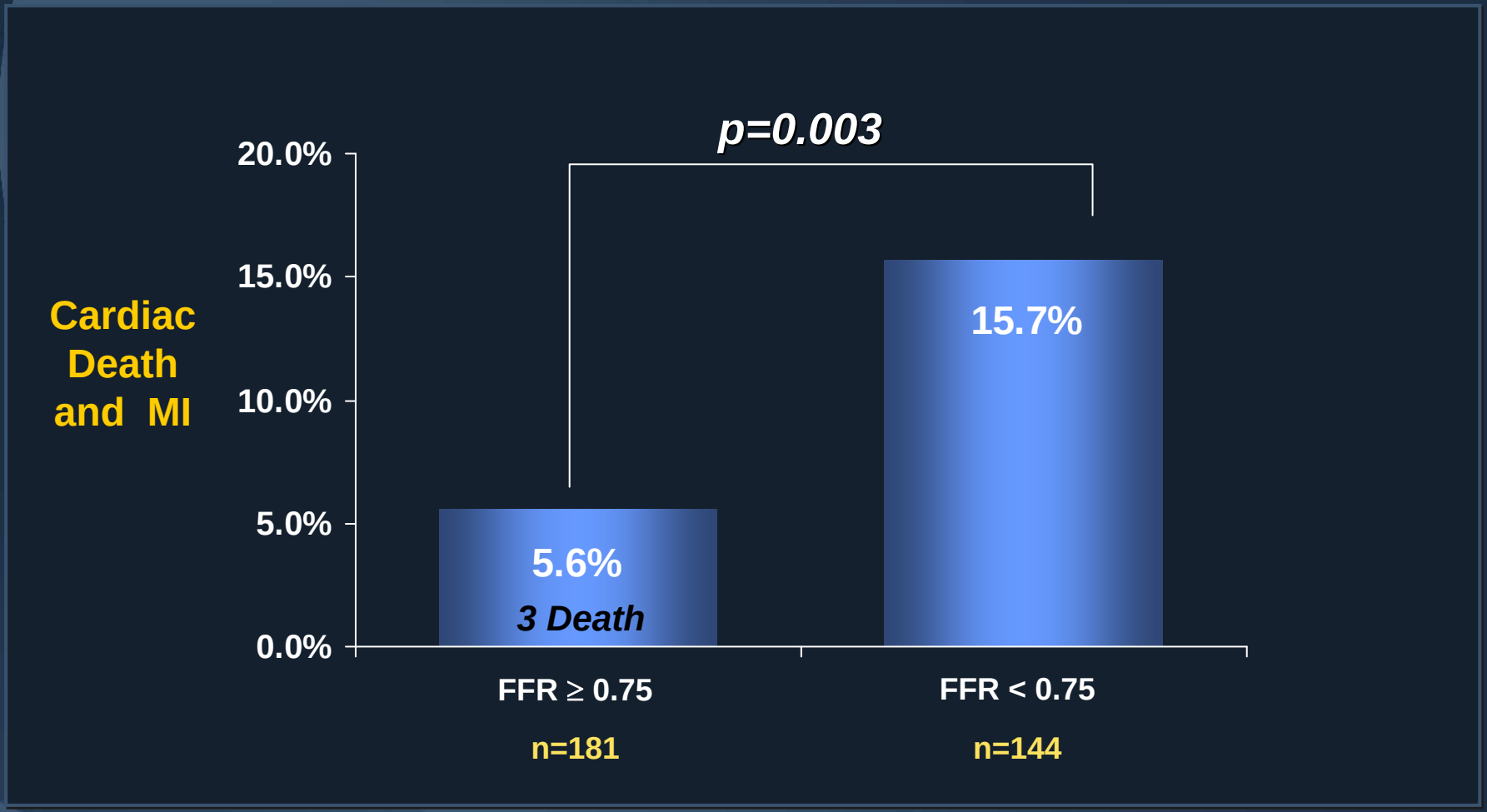
Vessel	LAD	LCX	RCA
Range	43±7 (32-55)%	26±8 (14-44)%	31±7 (15-41)%





Edwin L et al, Coronary Artery Disease 1992;3: 1189-1207

Hemodynamics Predict Prognosis: DEFER Study 5 year follow-up



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Pijls et al. JACC 49, 2007;2105–11

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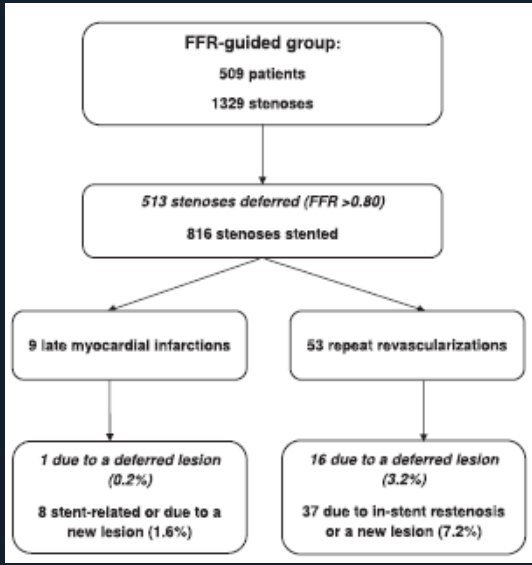
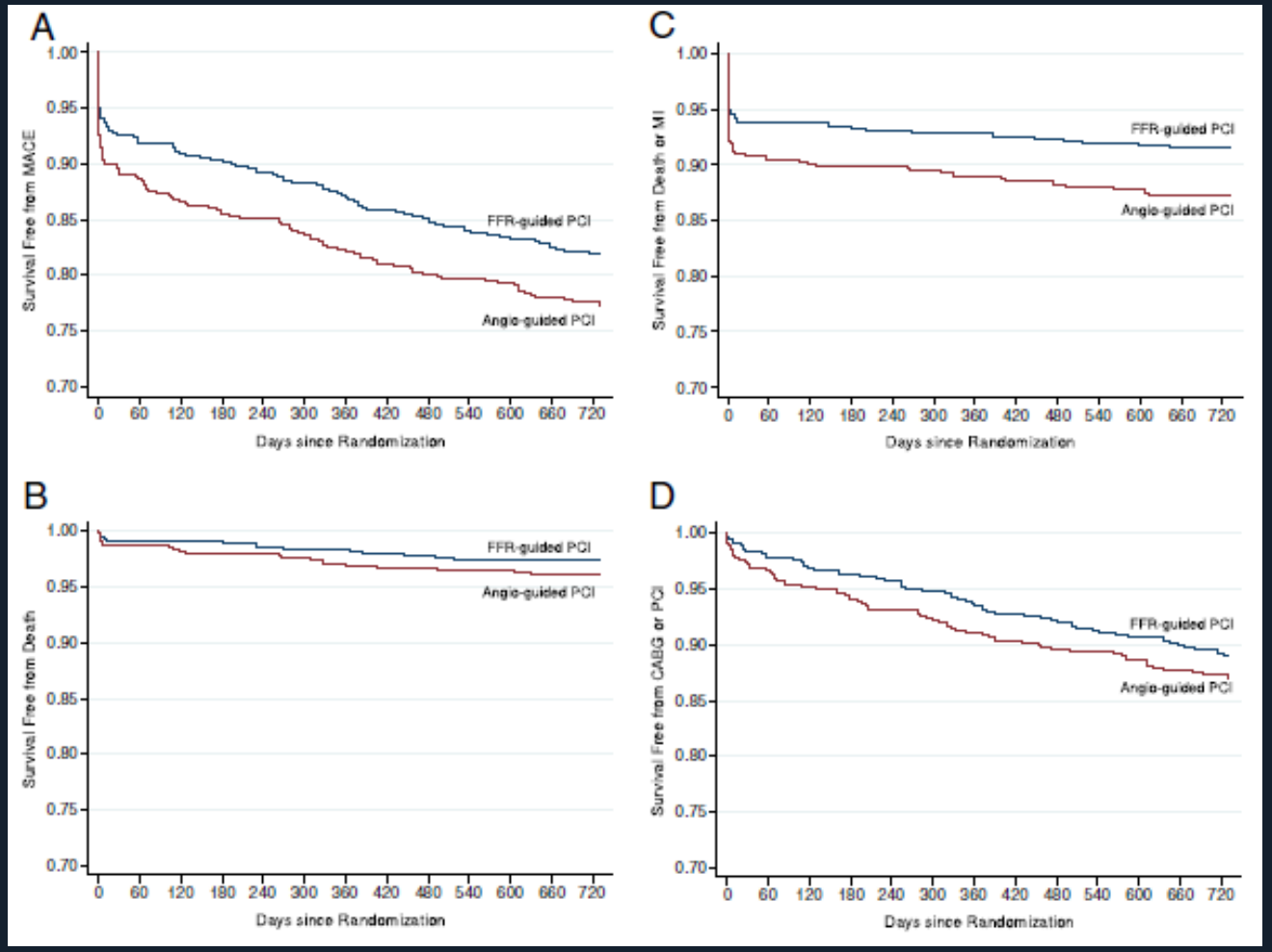
FAME 2 Years Result



FFR Deferred Lesions (n=513)

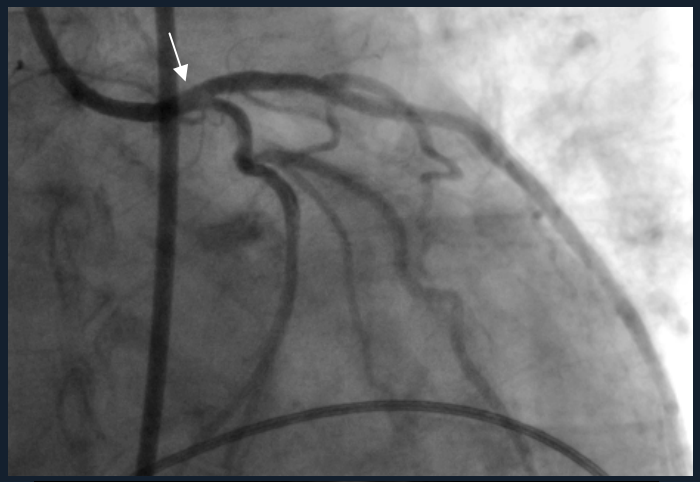
1 MI+10 revasc with clear progression (11/513=2.1%) in 2 yrs

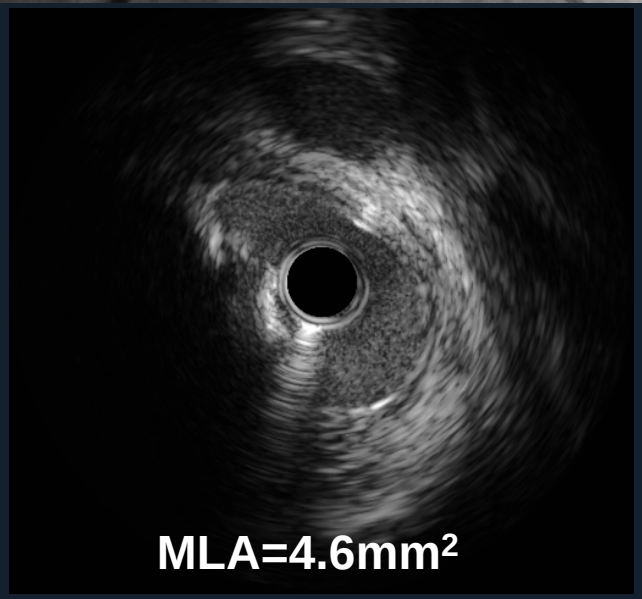


Pijls et al. JACC 56, 2010;177-84

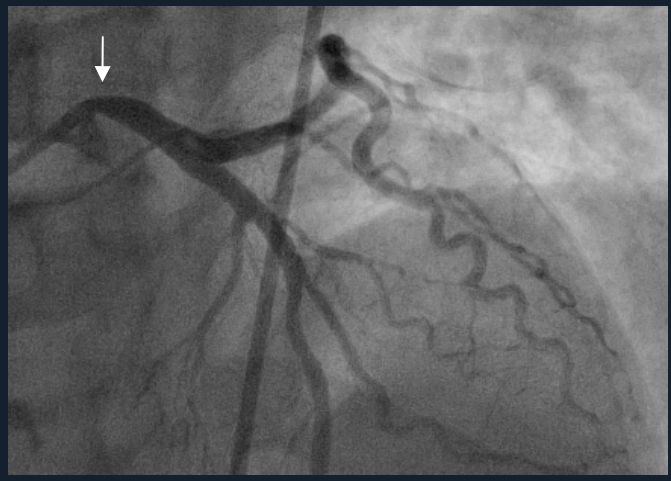
Discrepancy between Angio and IVUS

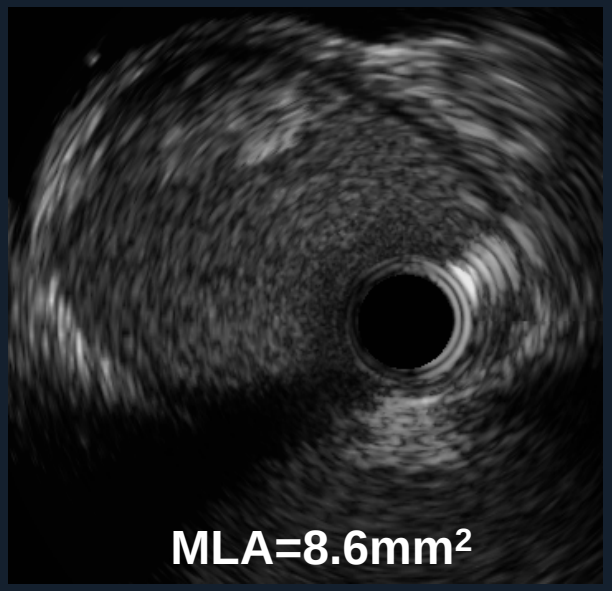
False Negative





False Positive

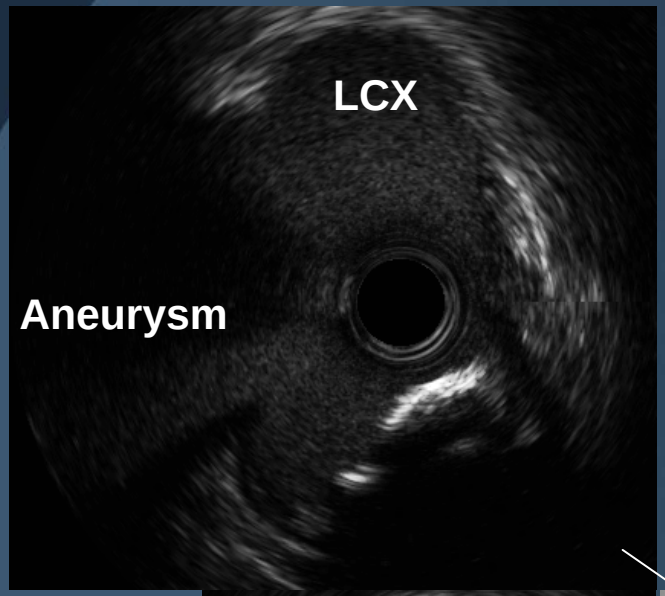


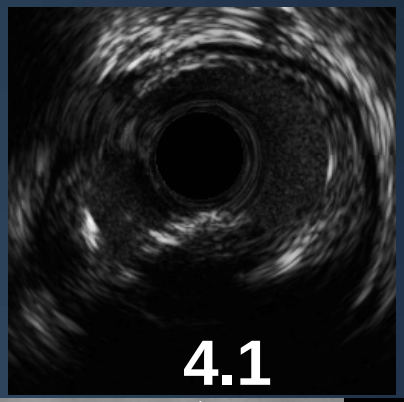


Case

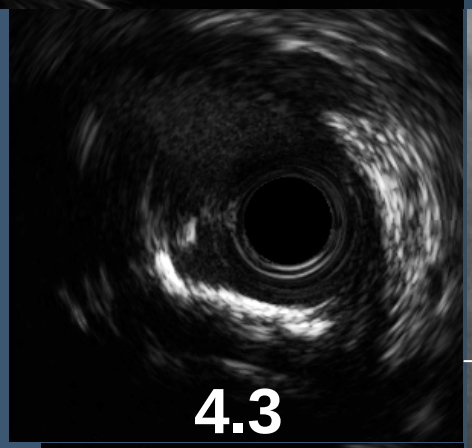
- 80 y.o. Male
- Risk Factor: HT, Dyslipidemia, DM type2
- PH: OMI (’98, inferior), PAD, CRI (Cre 1.4)
- Onset: Congestive Heart Failure
- Echo: EF normal, severe hypo in apical-septal

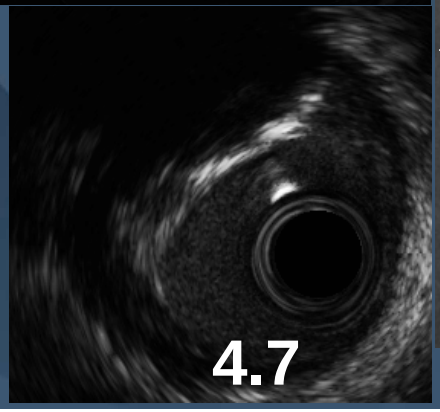
Pre-IVUS

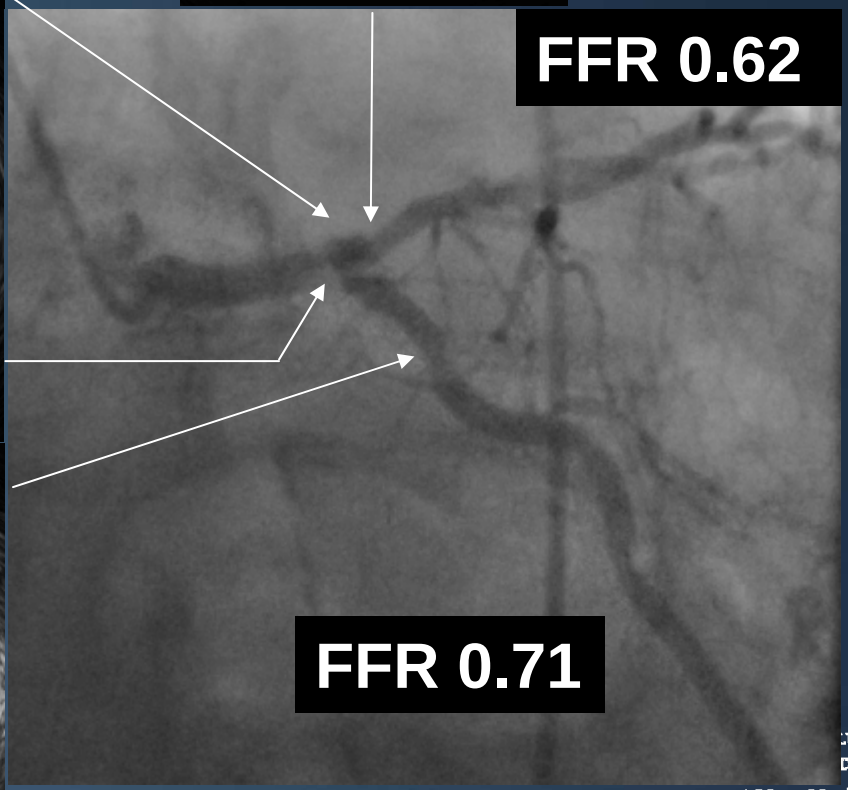




Left Main







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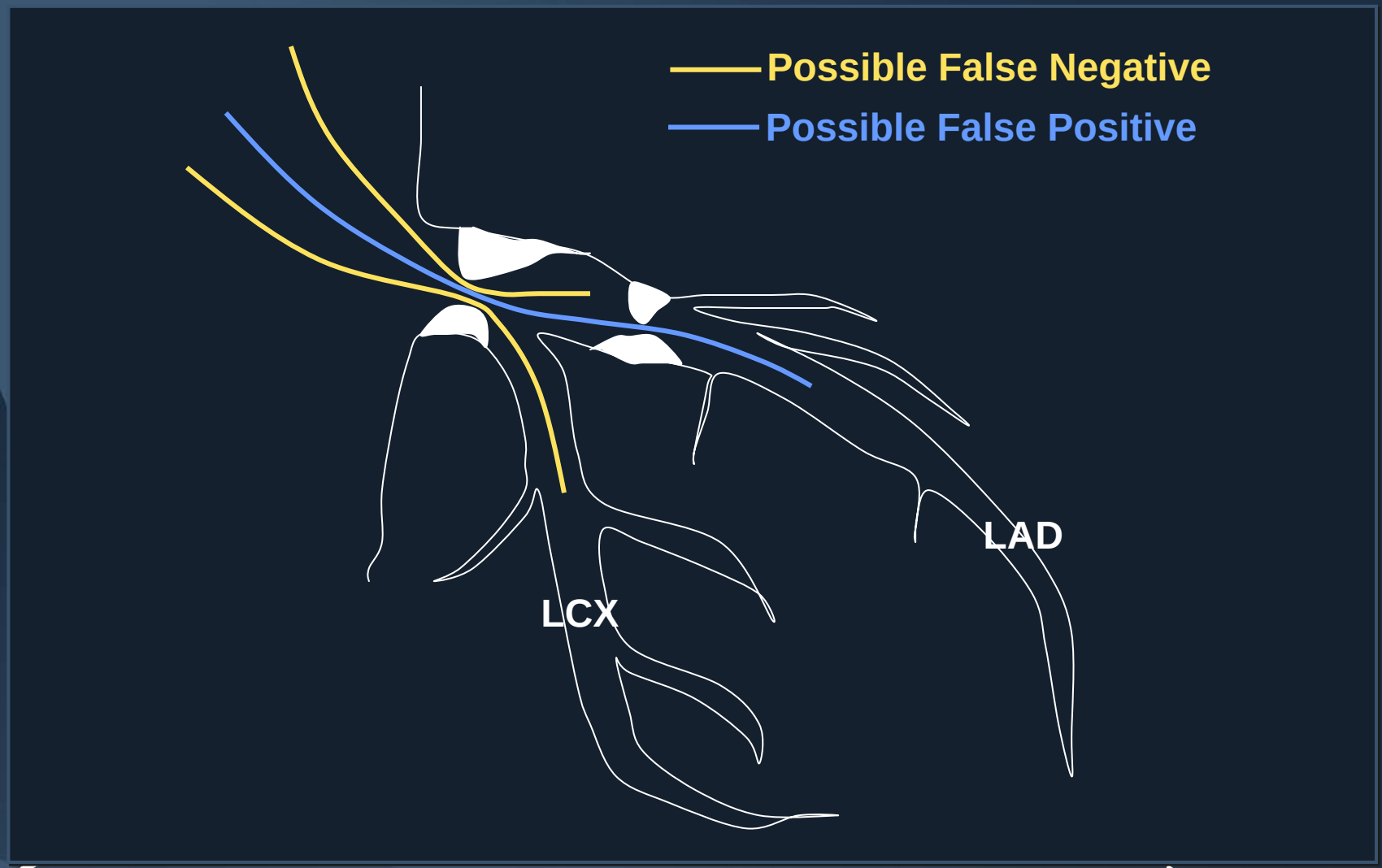
Problem of FFR for LMCA Lesions



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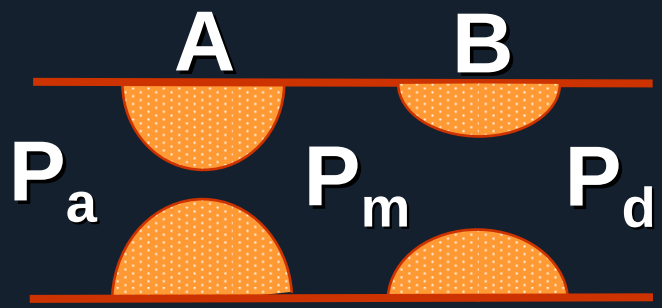
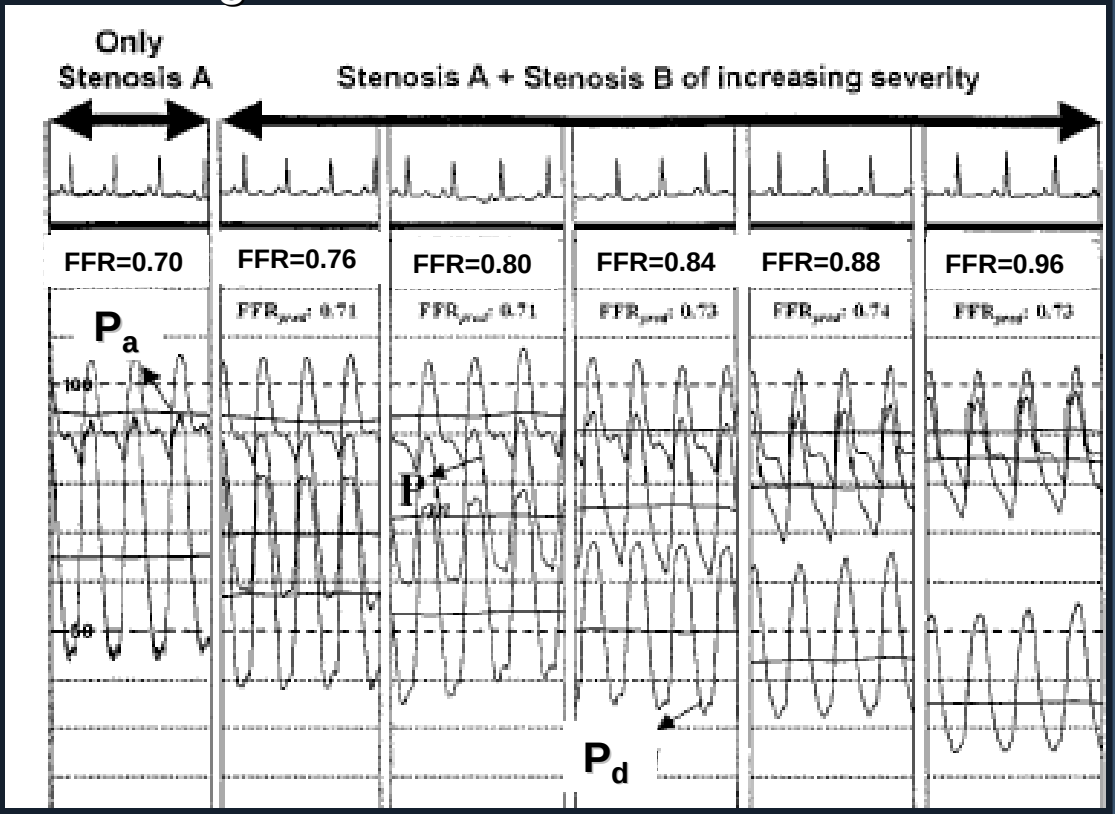
Effect of Another Lesion

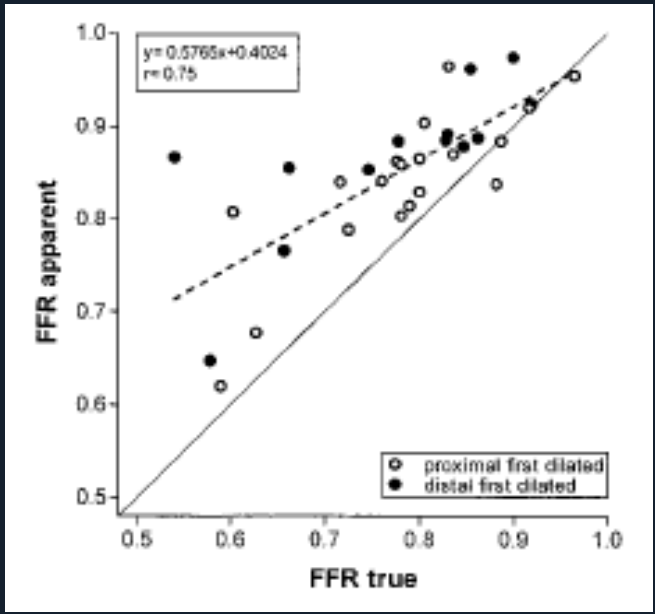


Change severity

Change the 2nd lesion in Animal Model



Treat 2nd lesion in Human



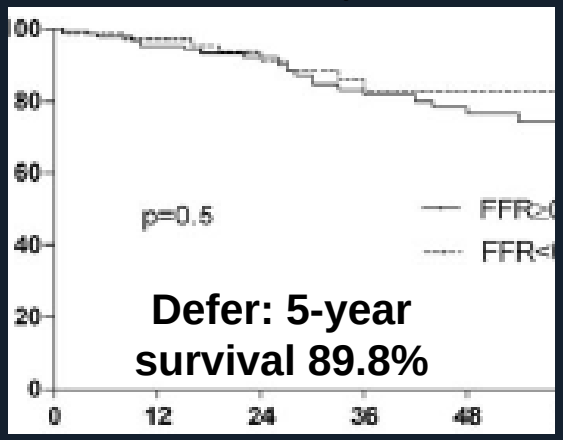
Pijls NHJ, Circulation;2000, 102:2371-77, De Bruyne B, Circulation;2000101:1840-7.

LMCA Defer by FFR

Any Death
LMCA revasc
Other revasc

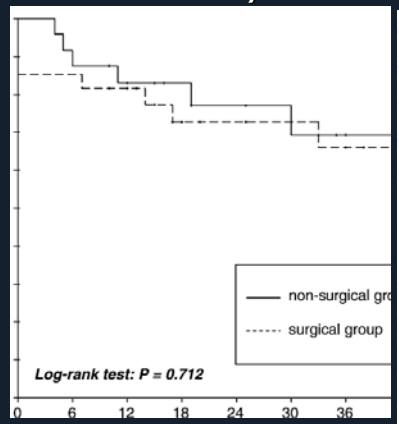
FFR=0.8

Hamilos, 2009

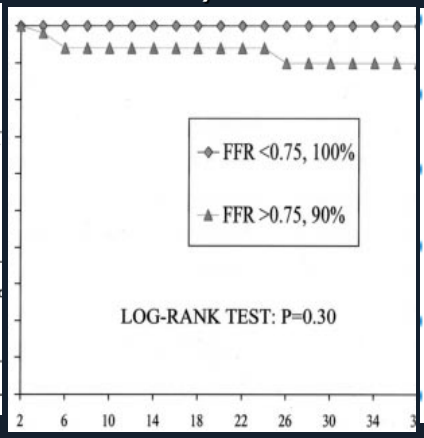


FFR=0.75

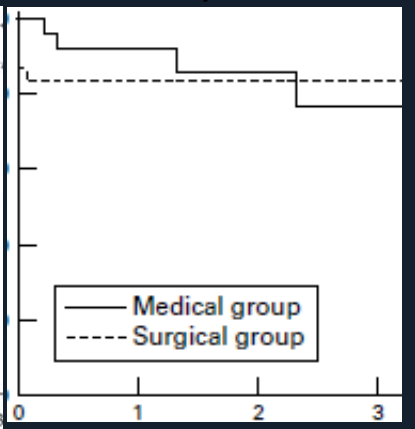
Lindstaedt, 2006

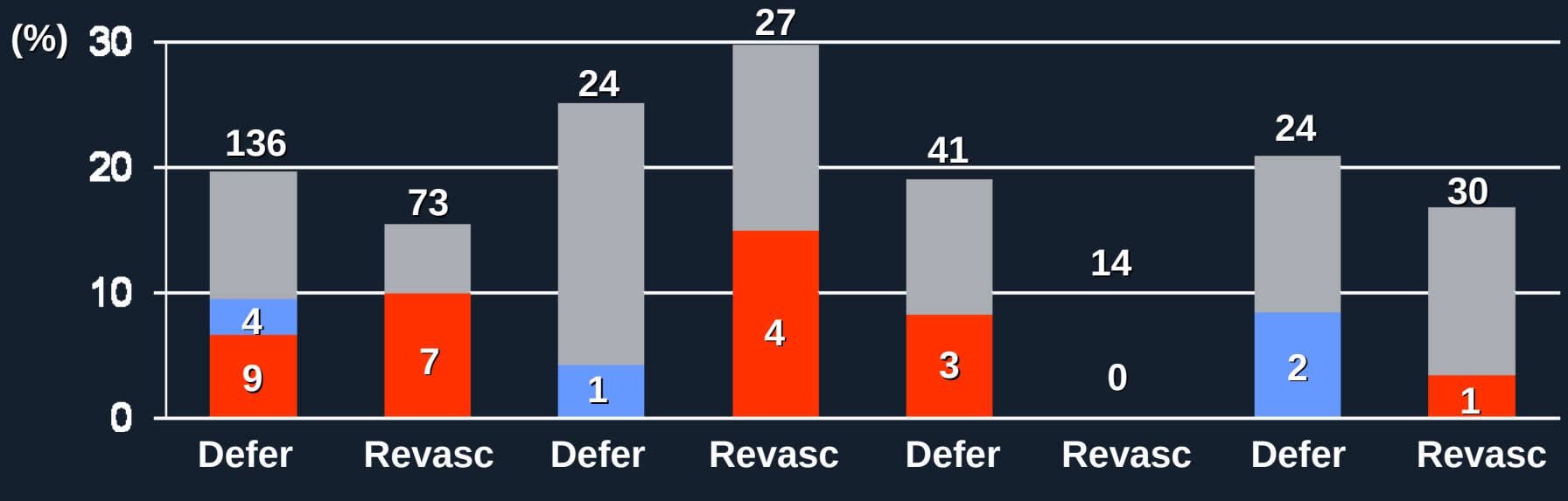


Jasti, 2004



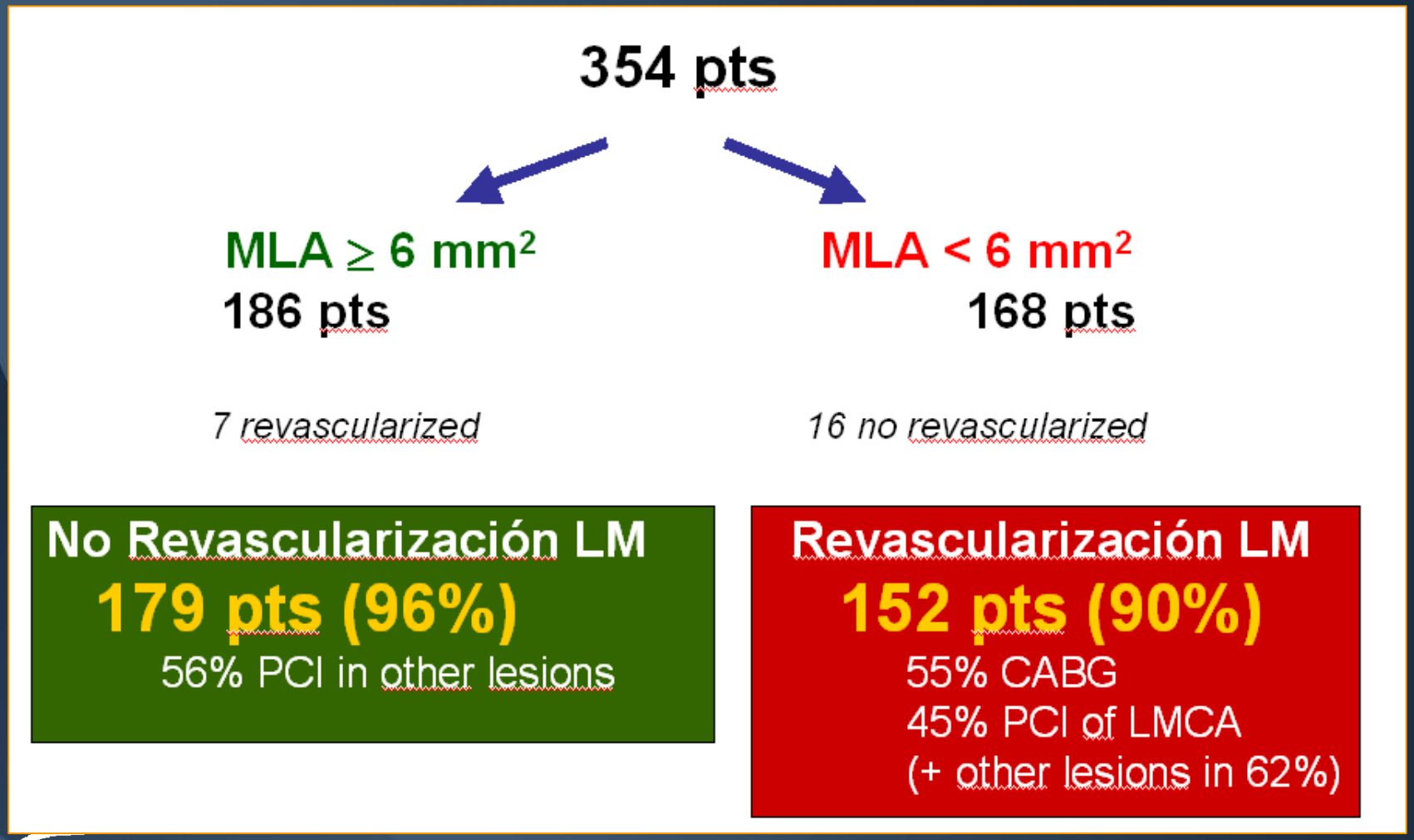
Bech, 2001



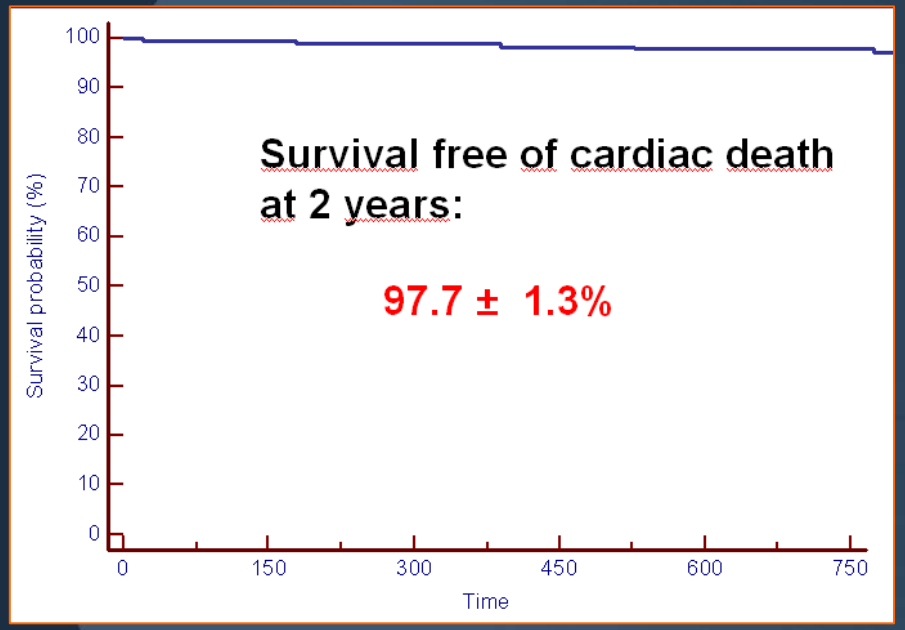


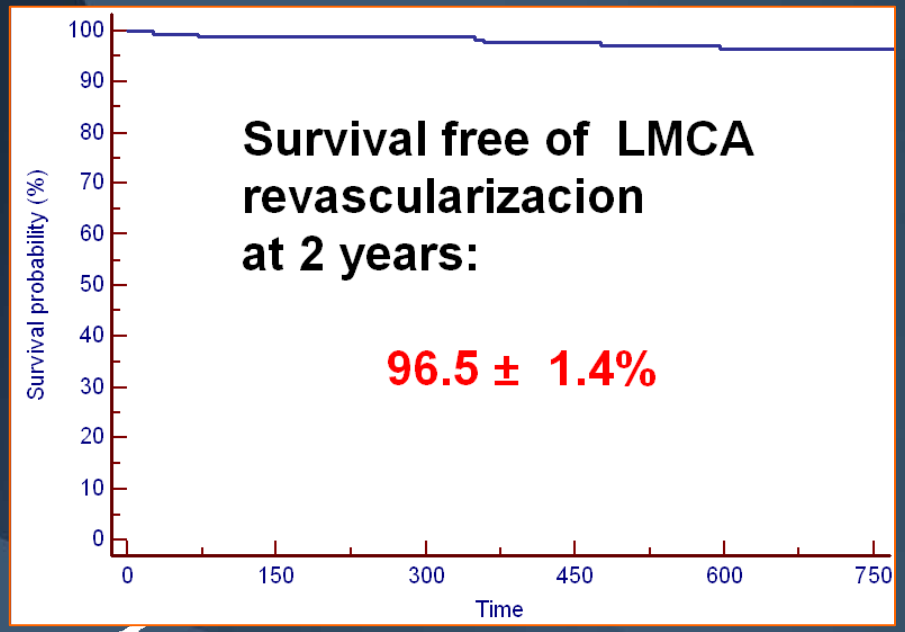
Hamilos, *Circ,* 120:1505, Lindstaedt, Am H J, 2006;152;156, Jasti ,Circ, 2004;110:2831, Bech, Heart, 2001;86:547

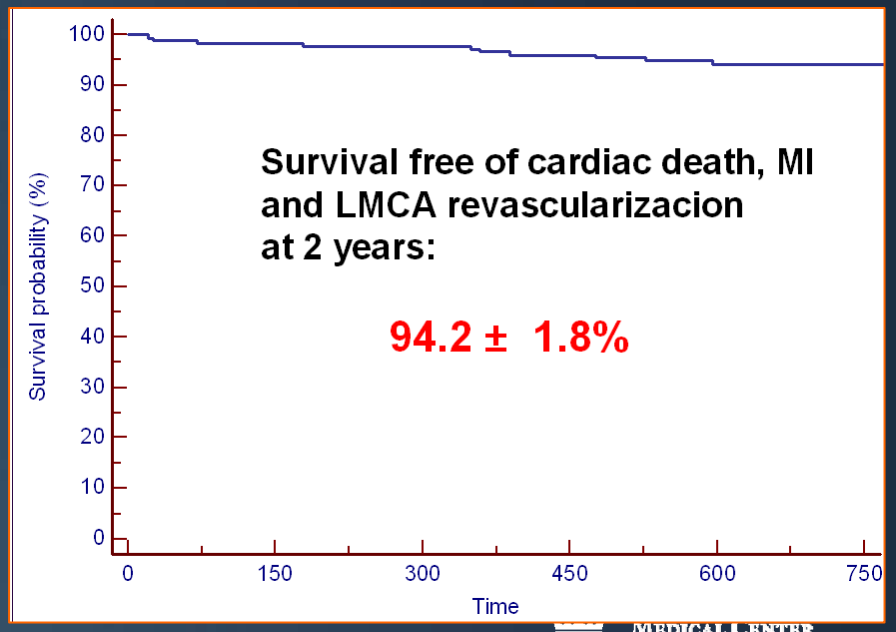
LITRO: Multicenter registry of IVUS-guided deferred intervention in LMCA disease



Clinical outcome of pts with deferred revascularization (MLA >6 mm^2)







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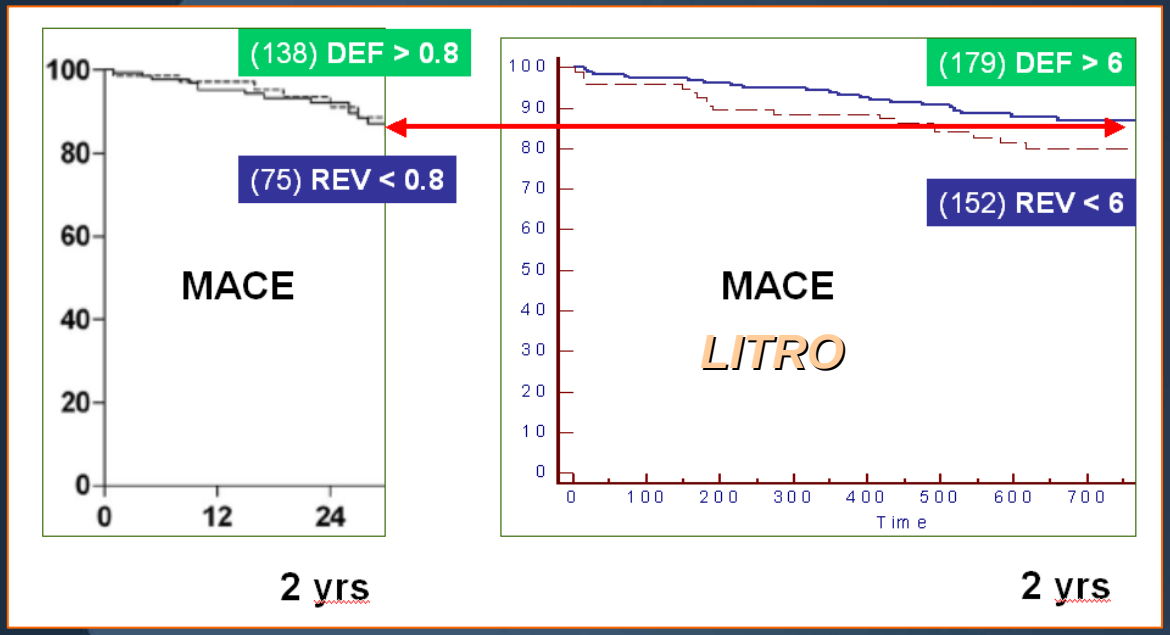
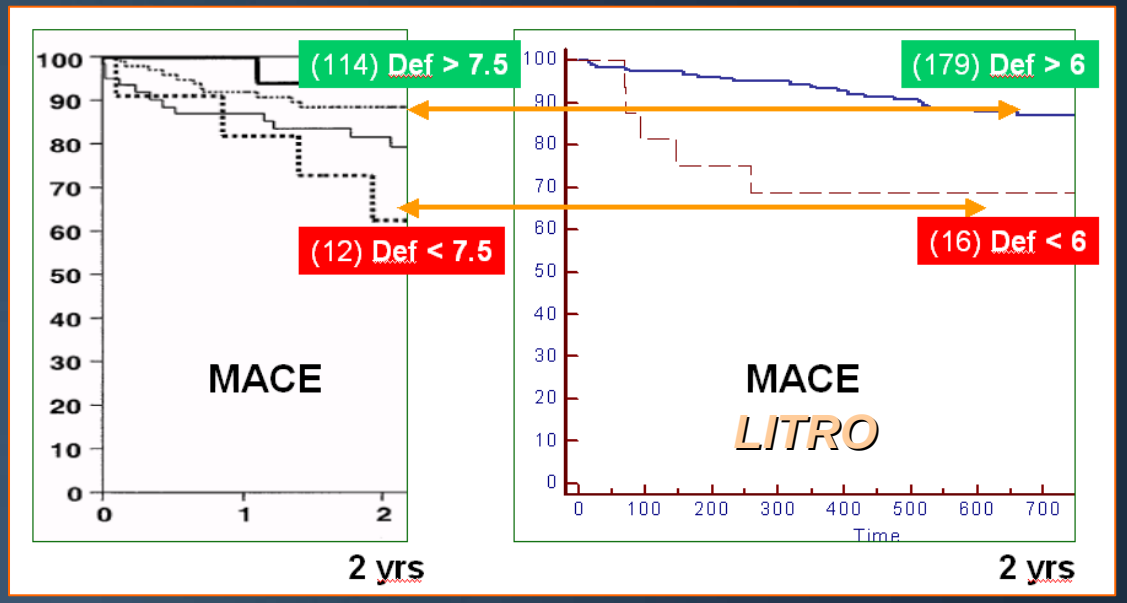
Comparison with previous studies with IVUS / FFR



FFR < 0.8.

Hamilos et al. Circulation 2009;120:1505-12.



IVUS (MLA < 7.5 mm²).

Fassa et al. J Am Coll Cardiol 2005;45:204 –11

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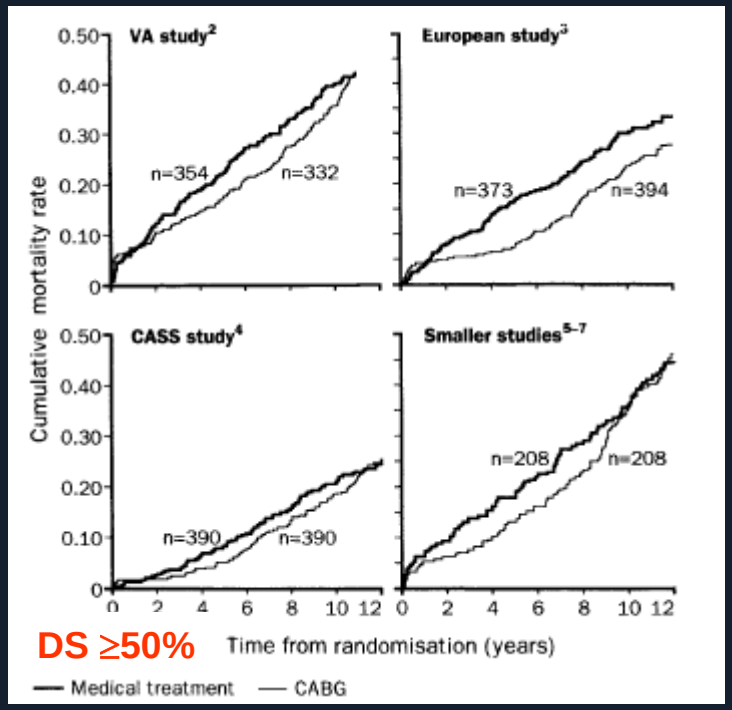
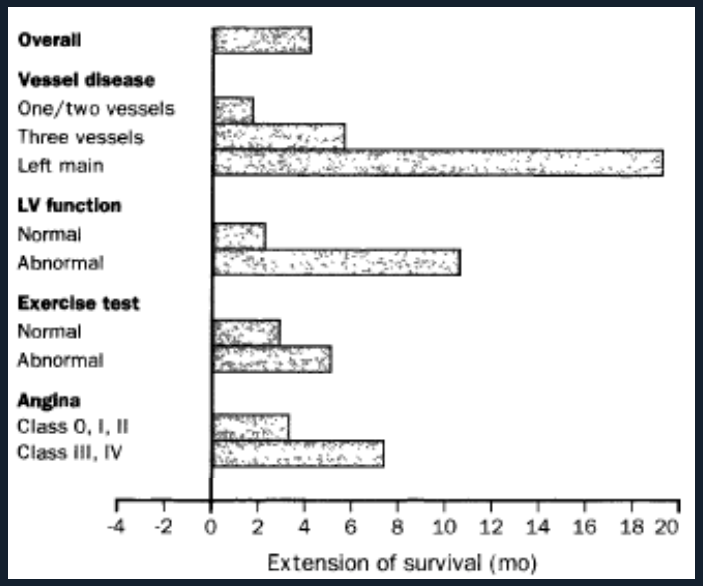
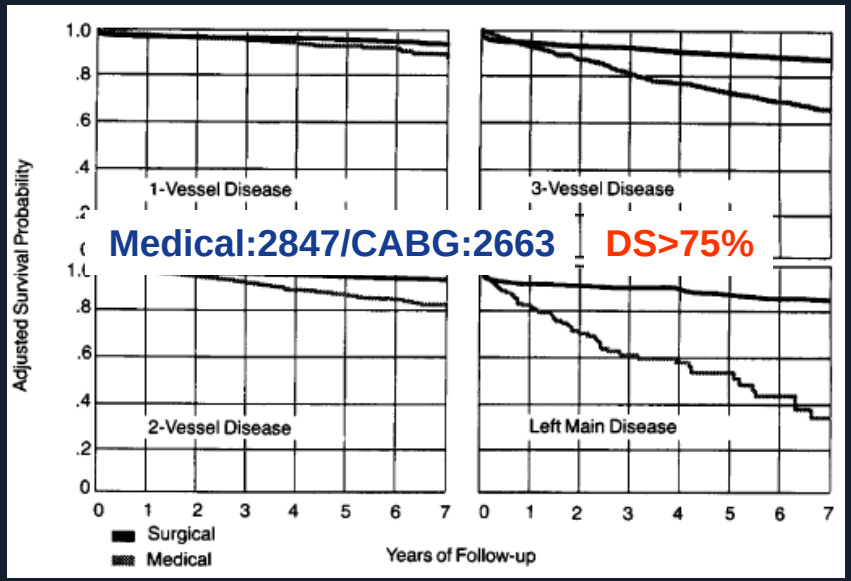
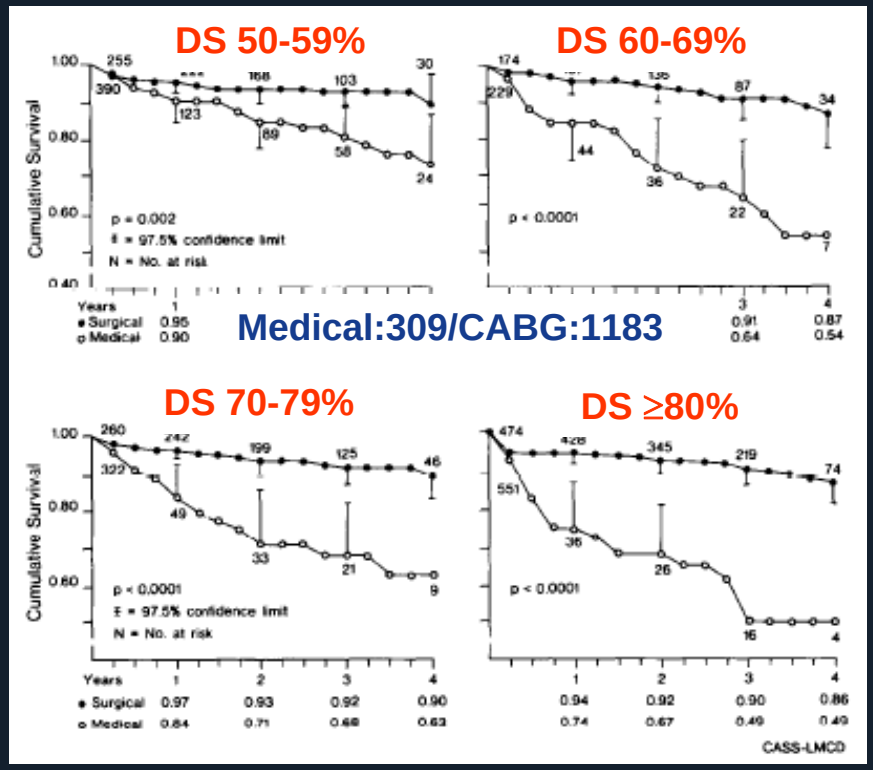


Yusuf et al, *Lancet* 1994;344: 563-70



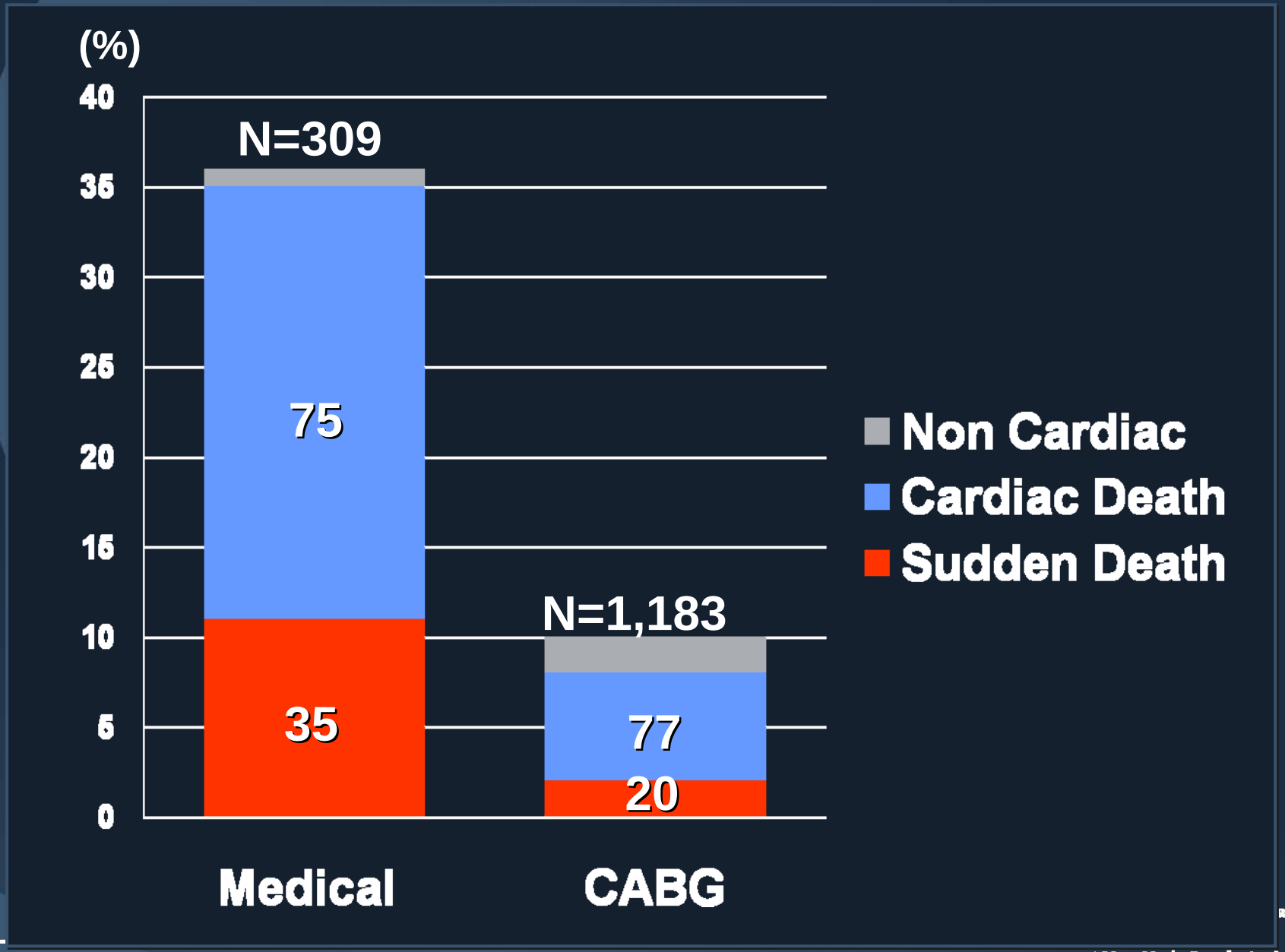


Califf et al, *JAMA* 1989;261: 2077-86



Chaitman et al, *AJC* 1981;48: 765-777

Cause of Death in the Medical and CABG Groups



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ACC/AHA 2004 Guideline Update for Coronary Artery Bypass Graft Surgery

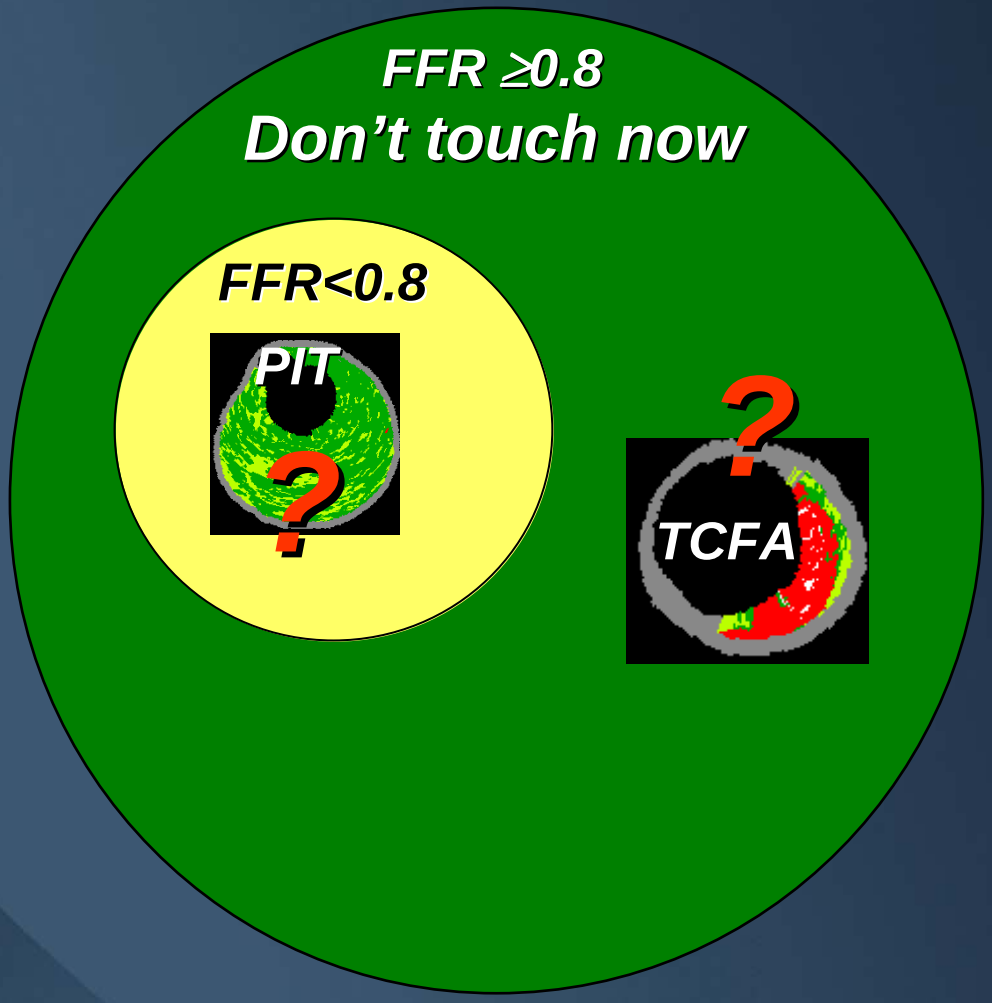
3.2.2. Location and Severity of Stenoses

3.2.2.1. Left Main Disease

The benefit of surgery over medical treatment for patients with significant left main stenosis is little argued. All of the trials define significant left main stenosis as being greater than 50% diameter stenosis as judged by contrast angiography. The median survival for surgically treated patients is 13.3 years versus 6.6 years in medically treated patients (92,93).

Left main equivalent disease, defined as severe (greater than or equal to 70%) diameter stenosis of the proximal LAD and proximal left circumflex disease, appears to behave similarly to true left main disease. Median survival for surgical patients is 13.1 years versus 6.2 years for med-

For the decision making in LMCA, not only function, the prognosis (acute progression→sudden death) should be considered.



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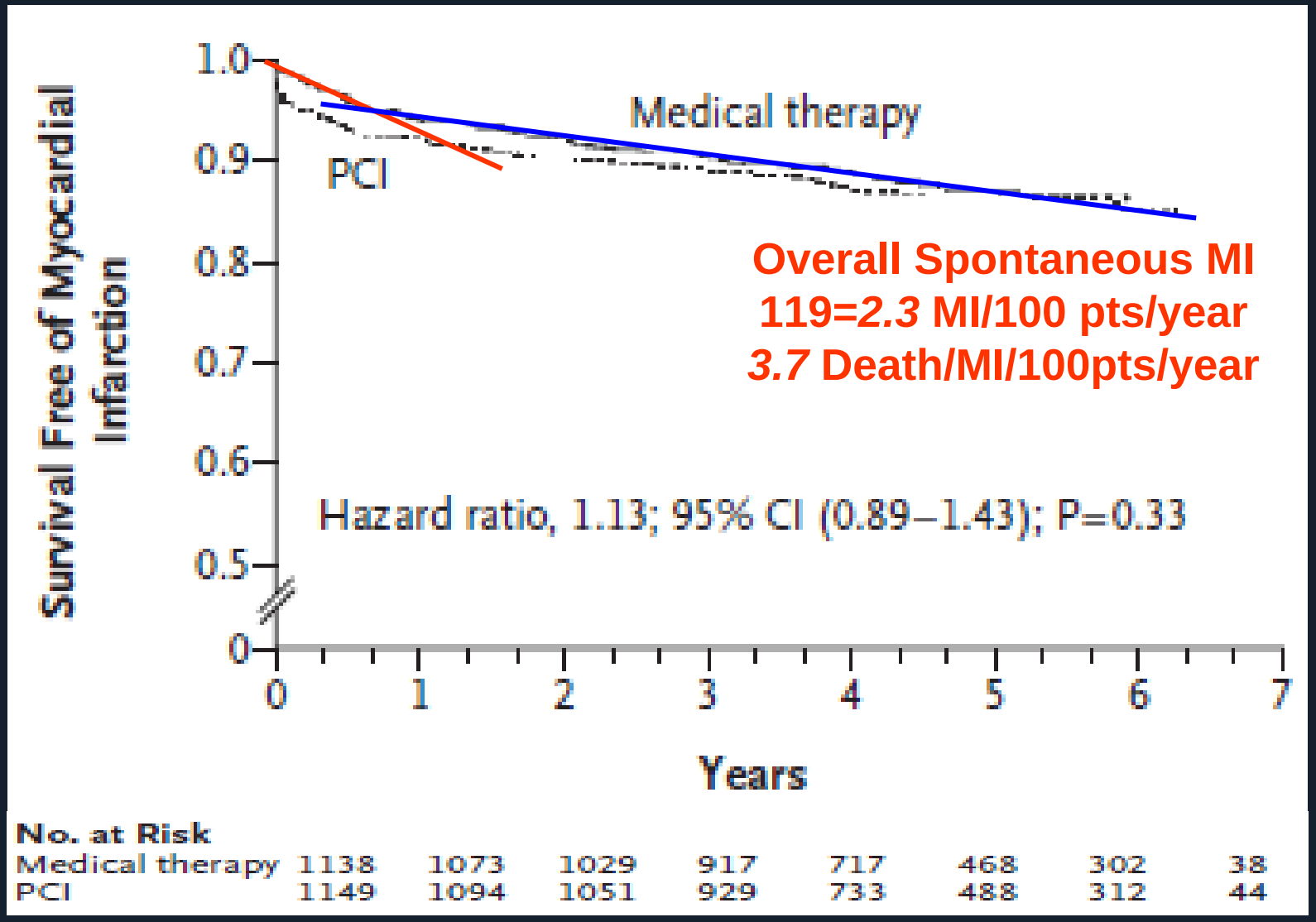
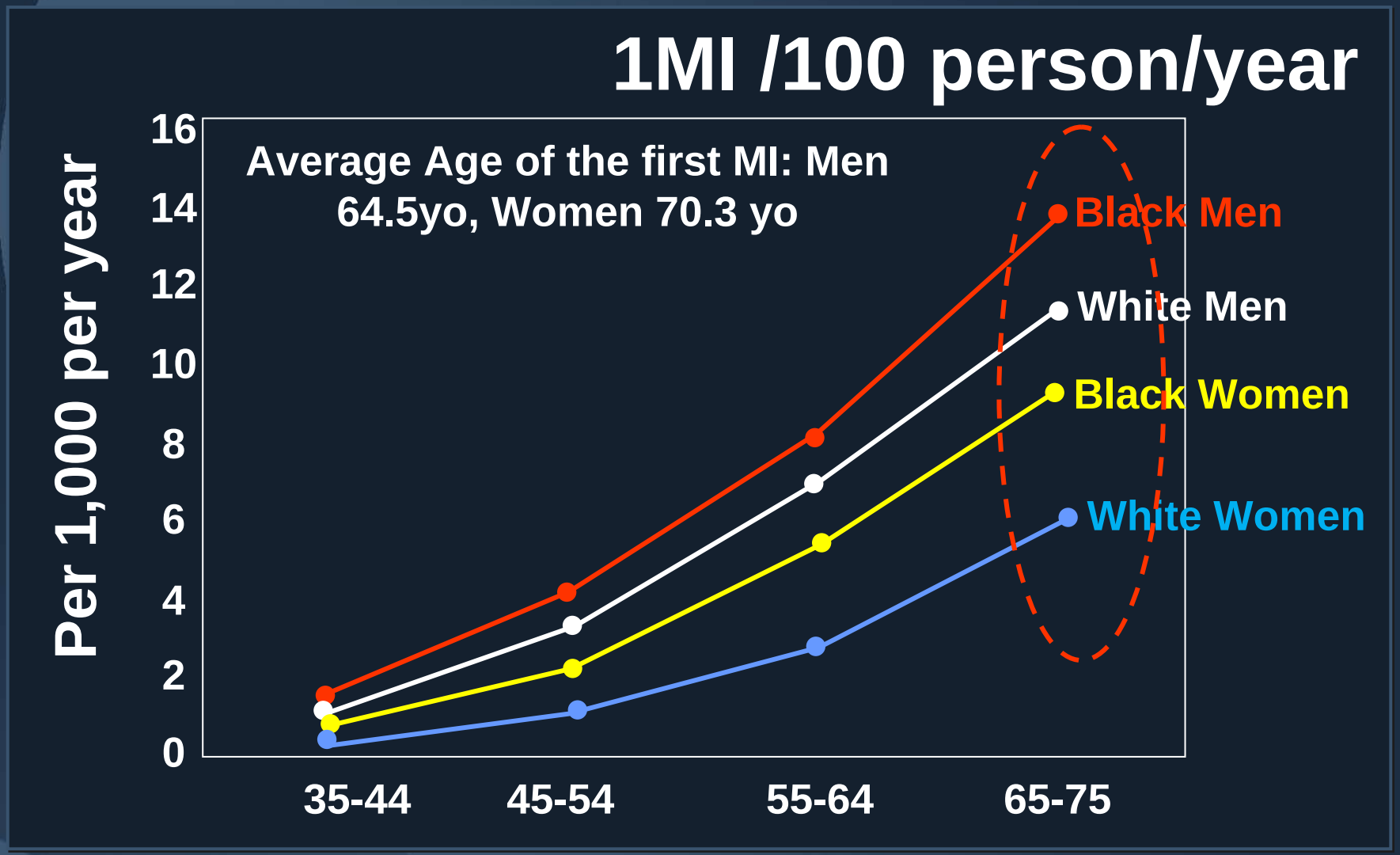
COURAGE :Incidence of true MI

Inclusion: DS>70% with proved ischemia



Boden et al, *NEJM* 2007;356: 1503-16

Incidence of first MI in US



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Heart Disease and Stroke Statistics 2011 Update, Circulation 2011:123;e18-209

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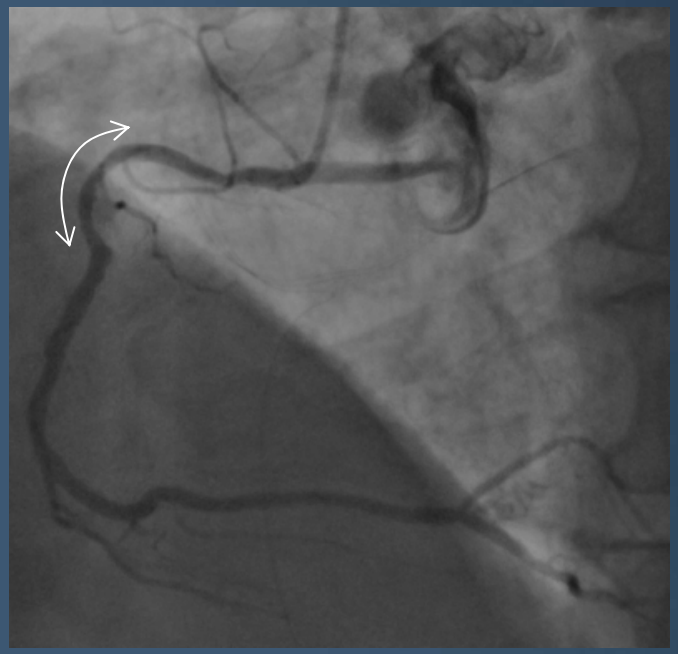
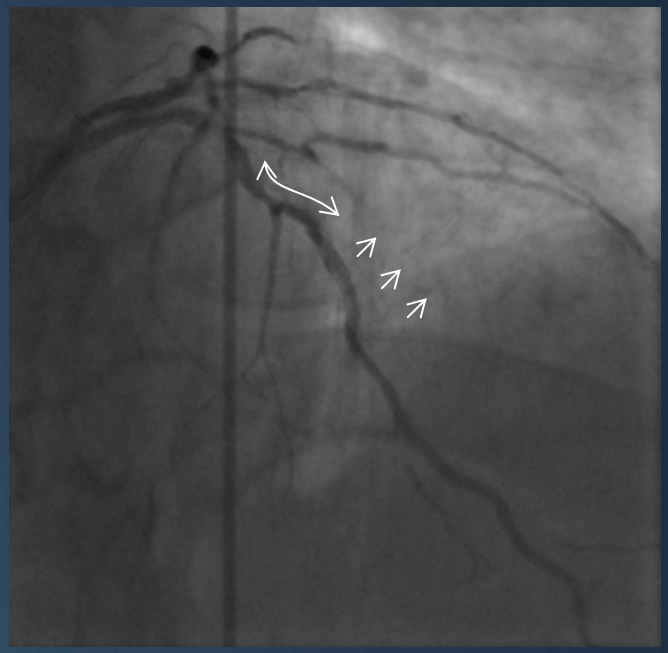
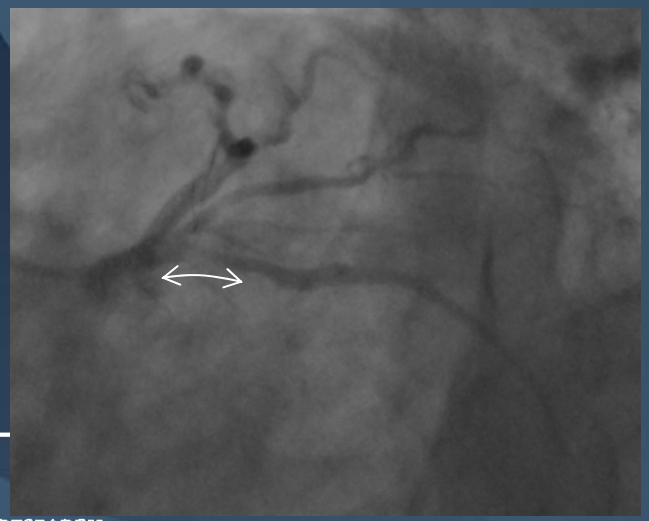
Case

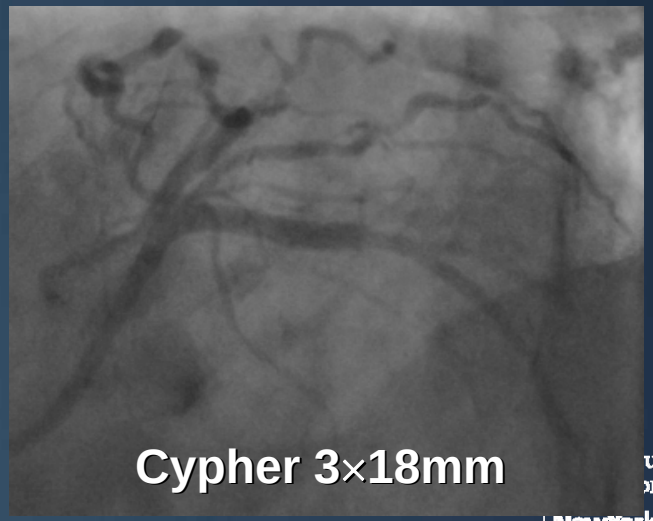
- 63 y.o. Male
- New Onset Angina, now
- Former smoker, HT, HL

1st time of CAG: 4 months ago









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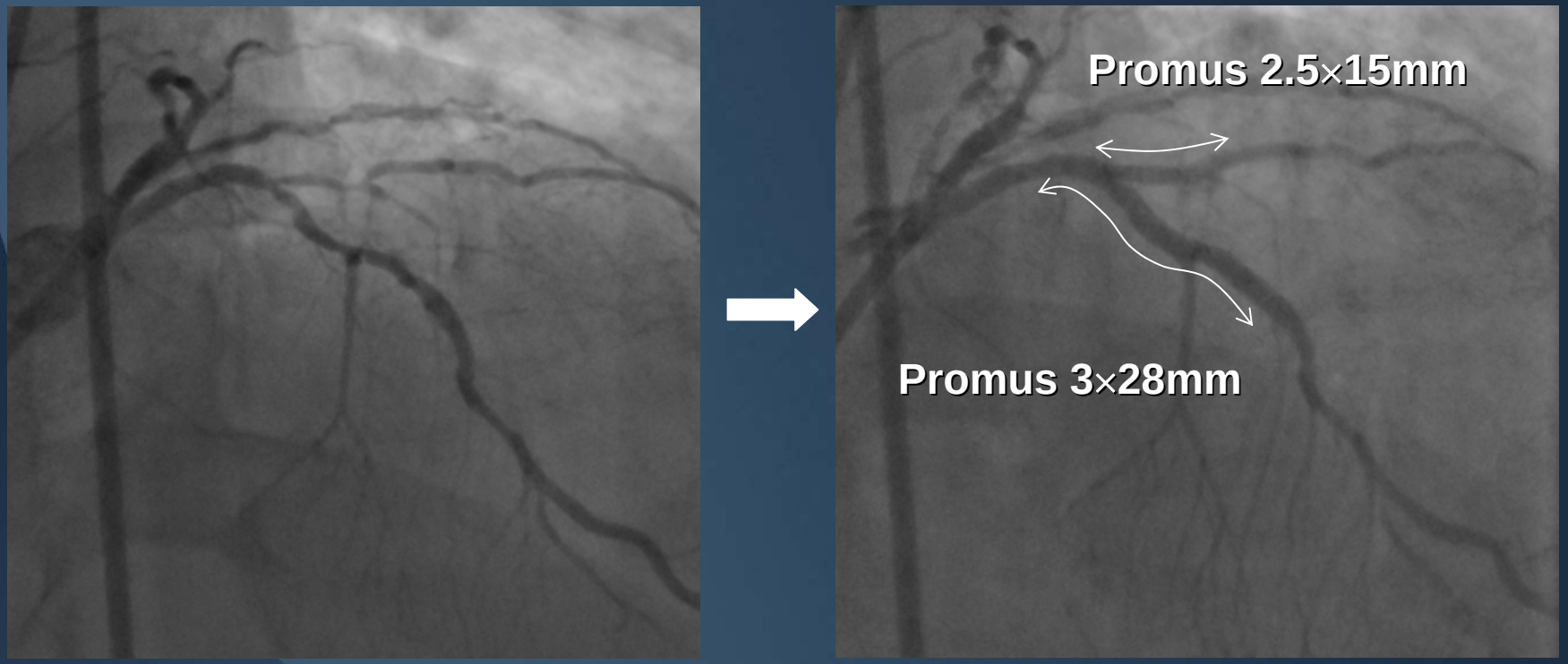
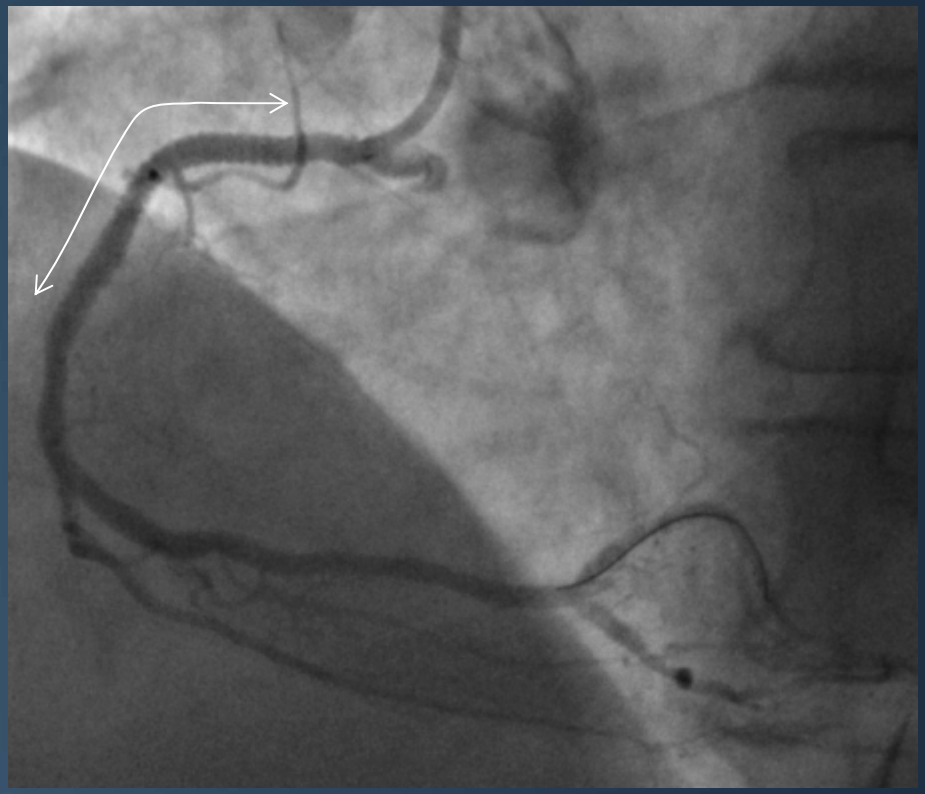
Staged procedure: 3 months ago



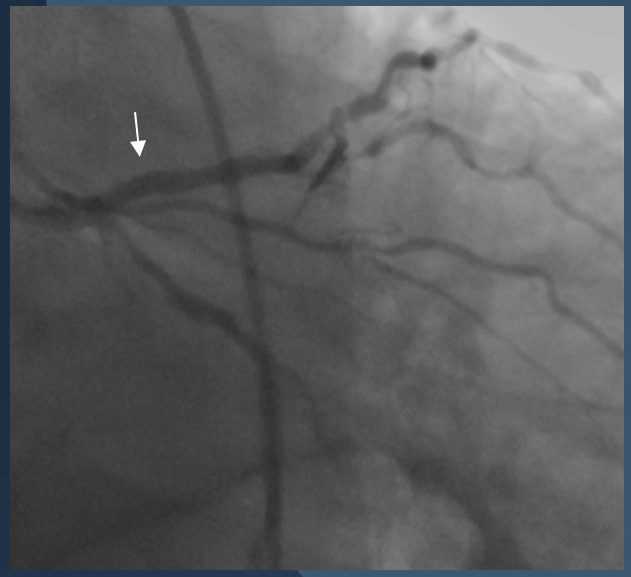
Staged procedure: 2 months ago

Promus 3.5×28mm +
3.5×8mm

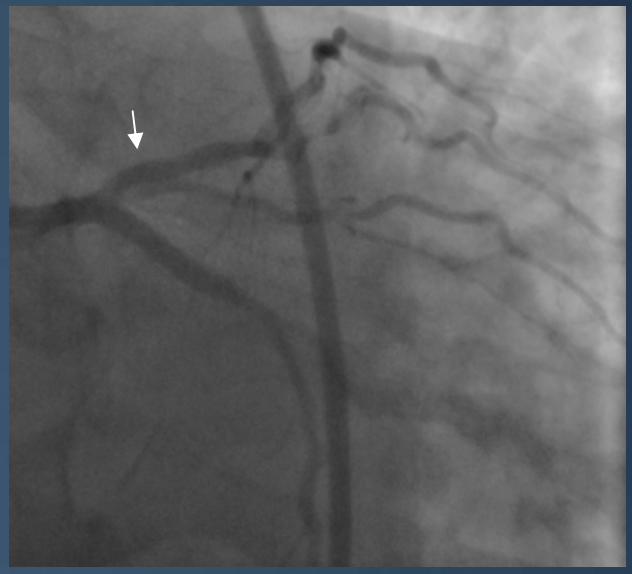


New onset Angina, now

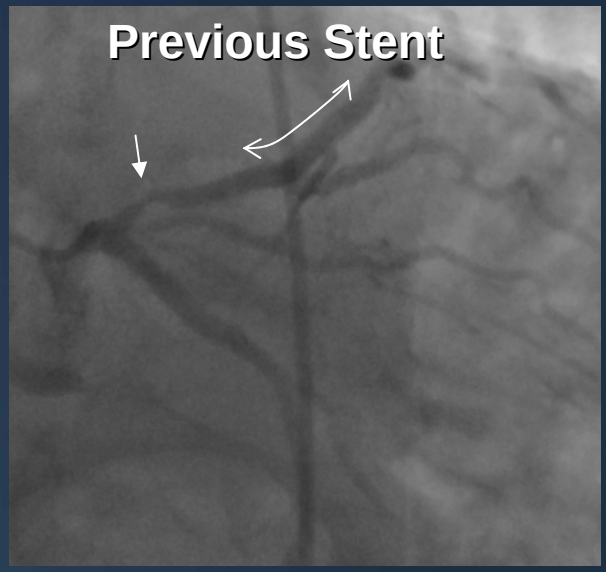
3 Months ago



2 Months ago



Now



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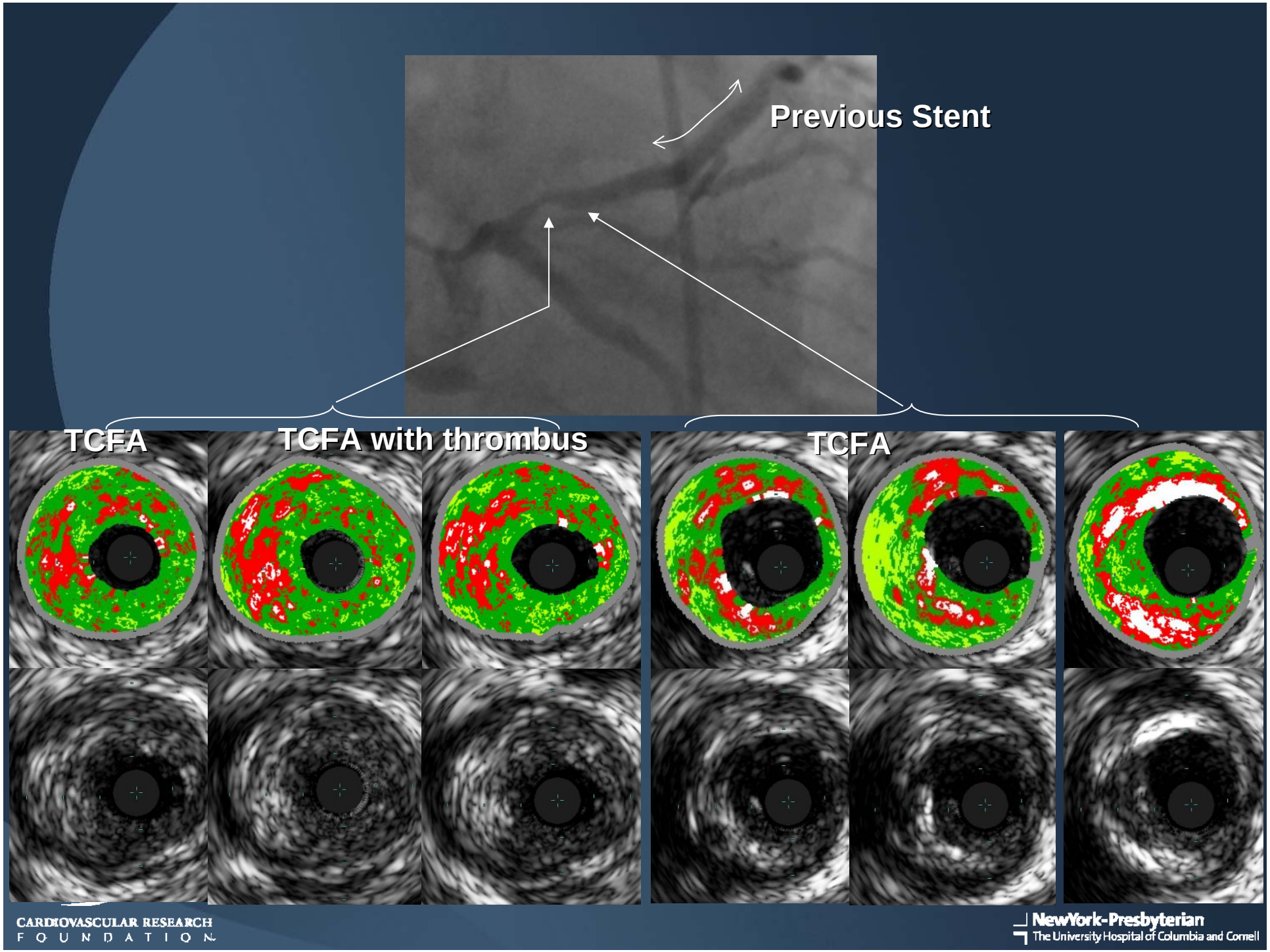

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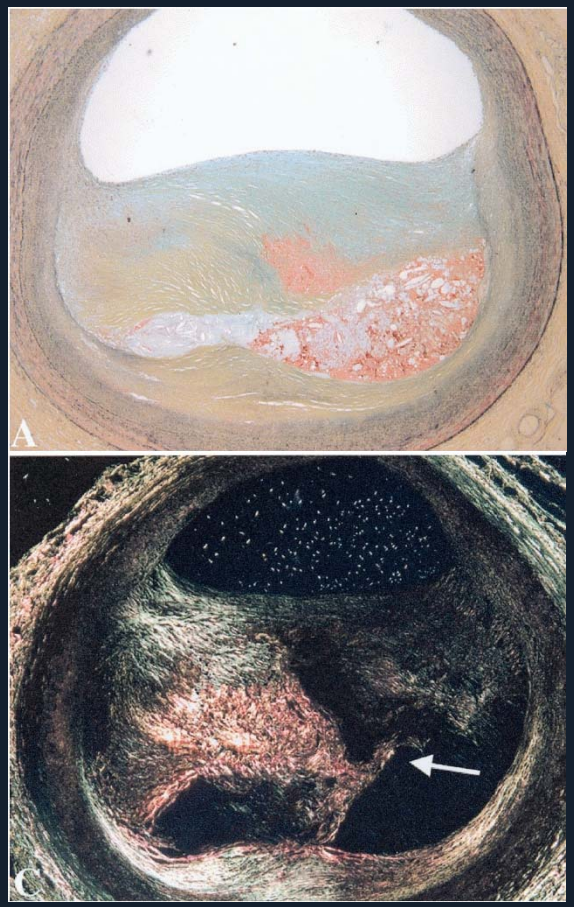
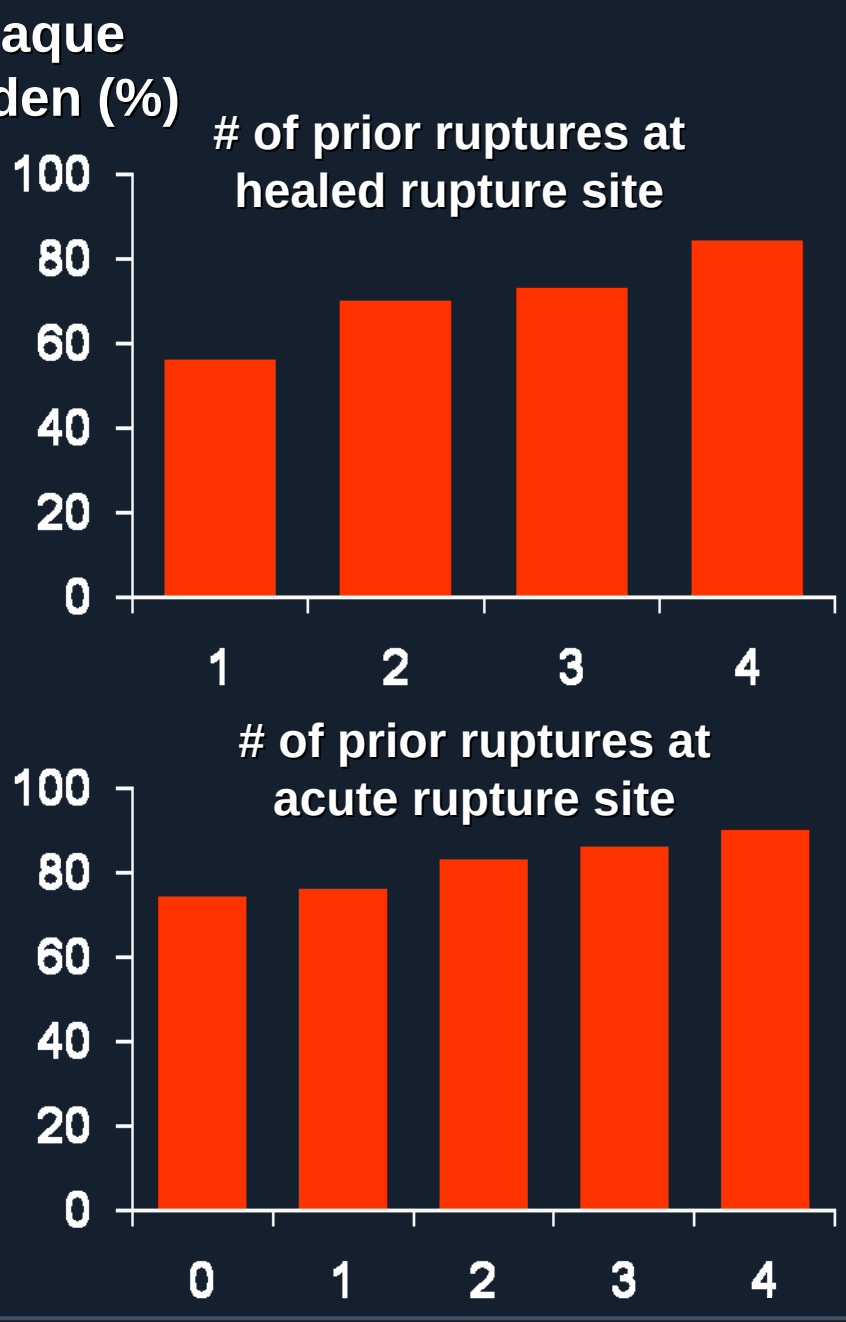
Subclinical plaque rupture increase plaque burden.





Burke et al. Circulation 2001;103:934-40

Plaque Burden in AMI - Histology-

Author	n	Plaque Burden(%)	Necrotic Core (%)	Occluded Thrombus
Erosion	50	71.3±13.8	18.3±24.4	30 (46%)
Rupture	65	77.1±14.9	38.3±24.4	26 (52%)

Kramer et al. JACC 55, 2010;122-32

Plaque Burden and MLA in AMI by IVUS

Author	n	Plaque Burden (%)	MLA(mm^2)
Kotani	78	Culprit/Non-Culprit=86.6/73.8	2.0/3.4
Tanaka	100	No-reflow /Reflow=89/85	2.2/2.3
Hong	122	85.8	2.2

Kotani et al. Circulation, 2003;107:2889, Tanaka Circulation, 2002;105:2148, Hong et al. Circulation 2004;110:928

Grayscale IVUS Finding in Ruptured Plaque

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Grayscale IVUS Finding in Ruptured Plaque

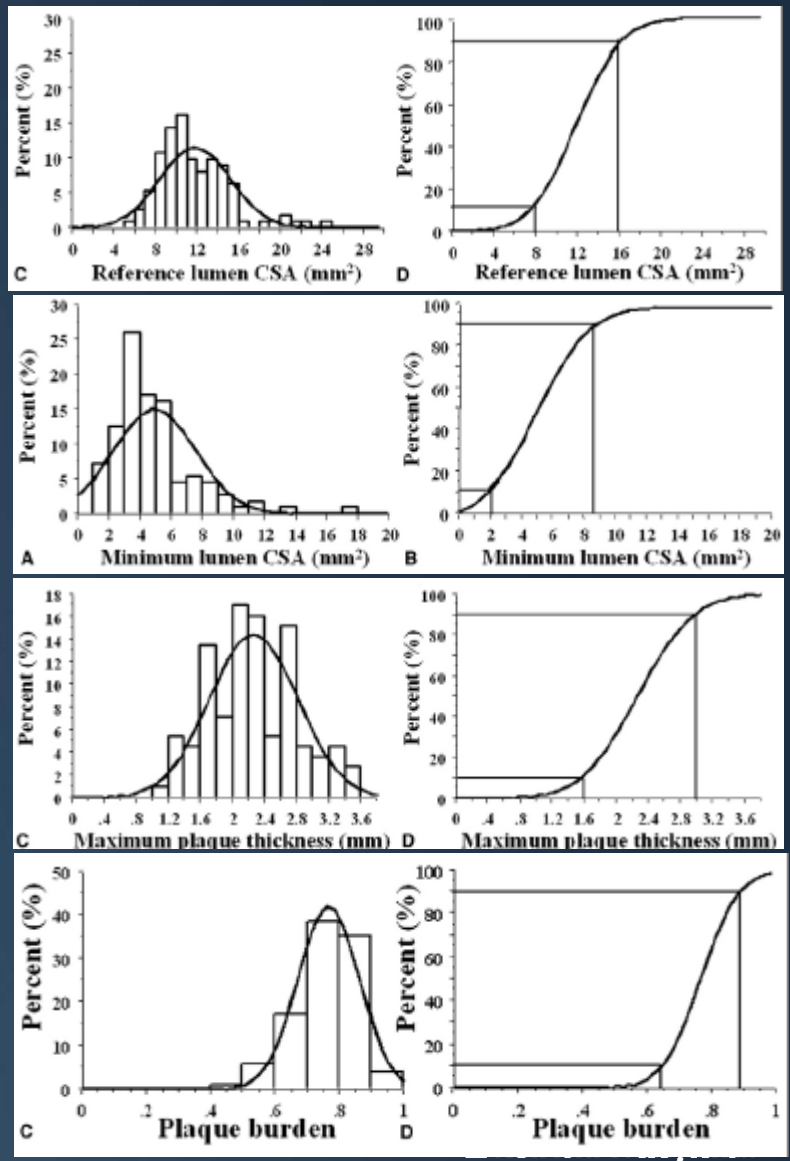
112 Ruptured plaque (ACS:50%)

Large artery ~3mm in diameter

MLA can be small~big: 2-9mm²

Thick plaque>1.6mm thickness

Plaque burden>70%



(Fujii et al, Am J Cardiol. 2006;98:429-435.)

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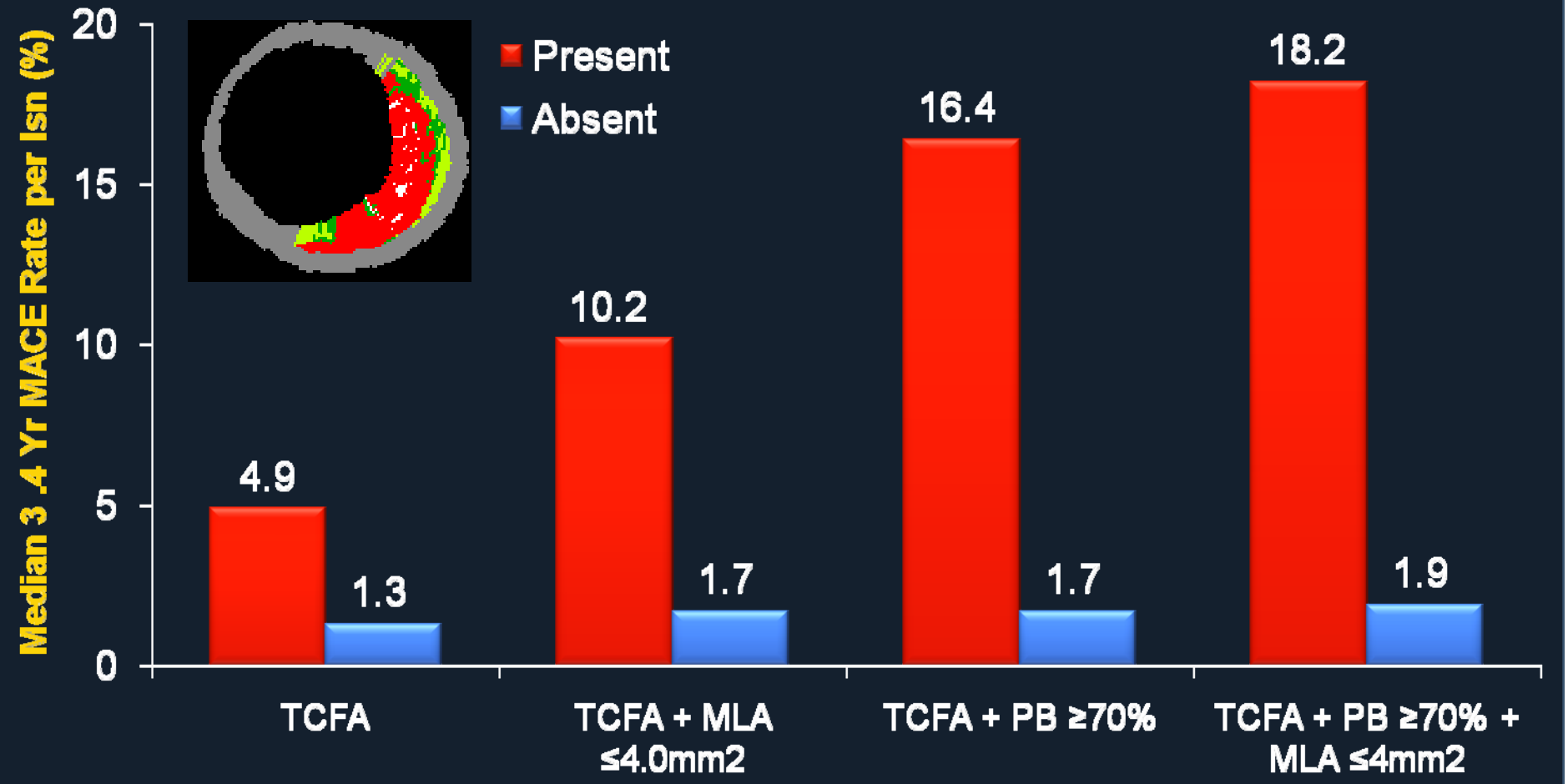
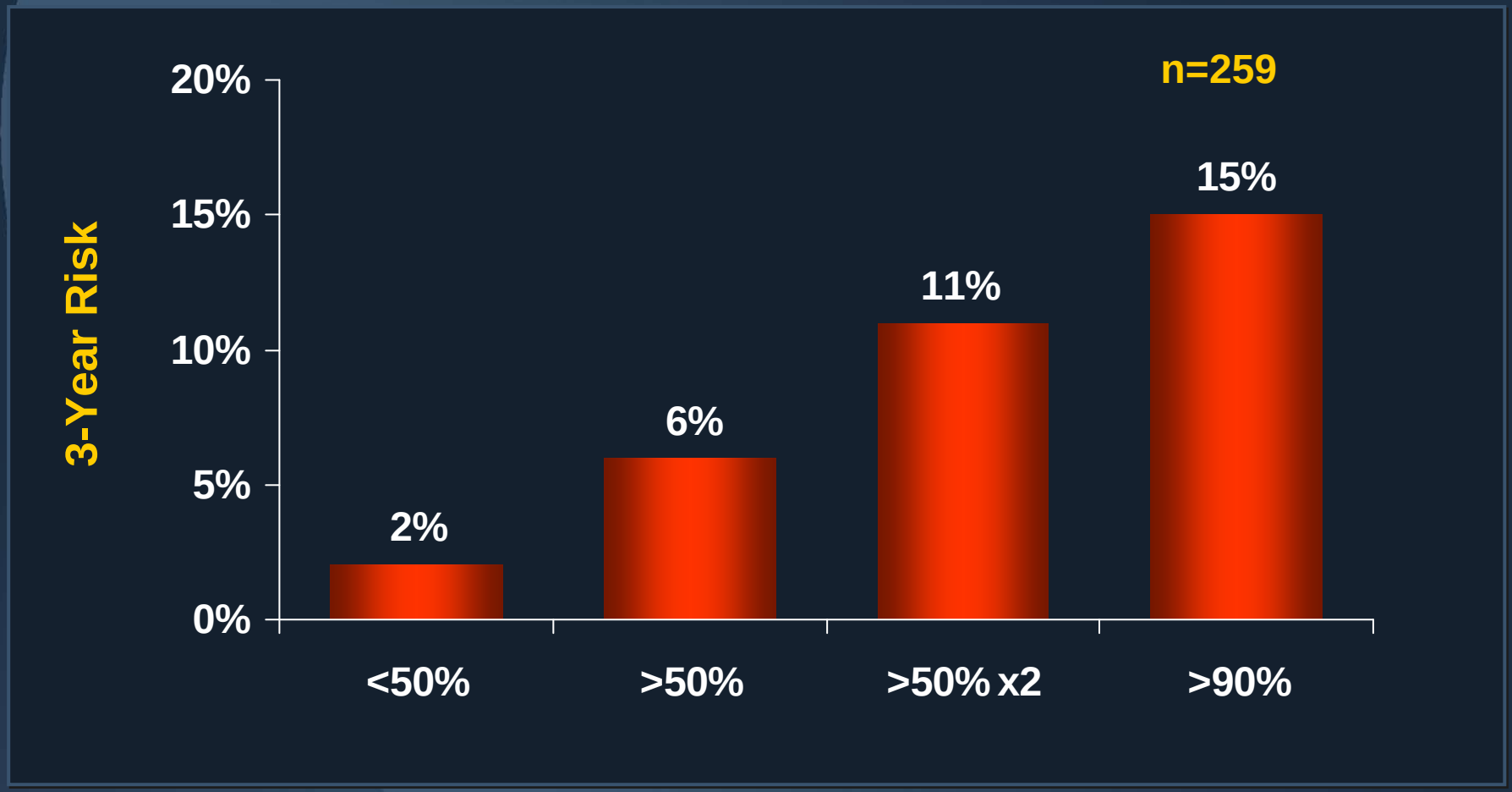
PROSPECT: VH-TCFA and Non Culprit Lesion Related Events



	TCFA	TCFA + MLA ≤4.0mm2	TCFA + PB ≥70%	TCFA + PB ≥70% + MLA ≤4mm2
Lesion HR	3.90 (2.25, 6.76)	6.55 (3.43, 12.51)	10.83 (5.55, 21.10)	11.05 (4.39, 27.82)
P value	<0.0001	<0.0001	<0.0001	<0.0001
Prevalence*	46.7%	15.9%	10.1%	4.2%

*Likelihood of one or more such lesions being present per patient. PB = plaque burden at the MLA

Severe Stenoses have a High Risk of Occlusion: Risk of AMI and Degree of LAD Stenosis in CASS

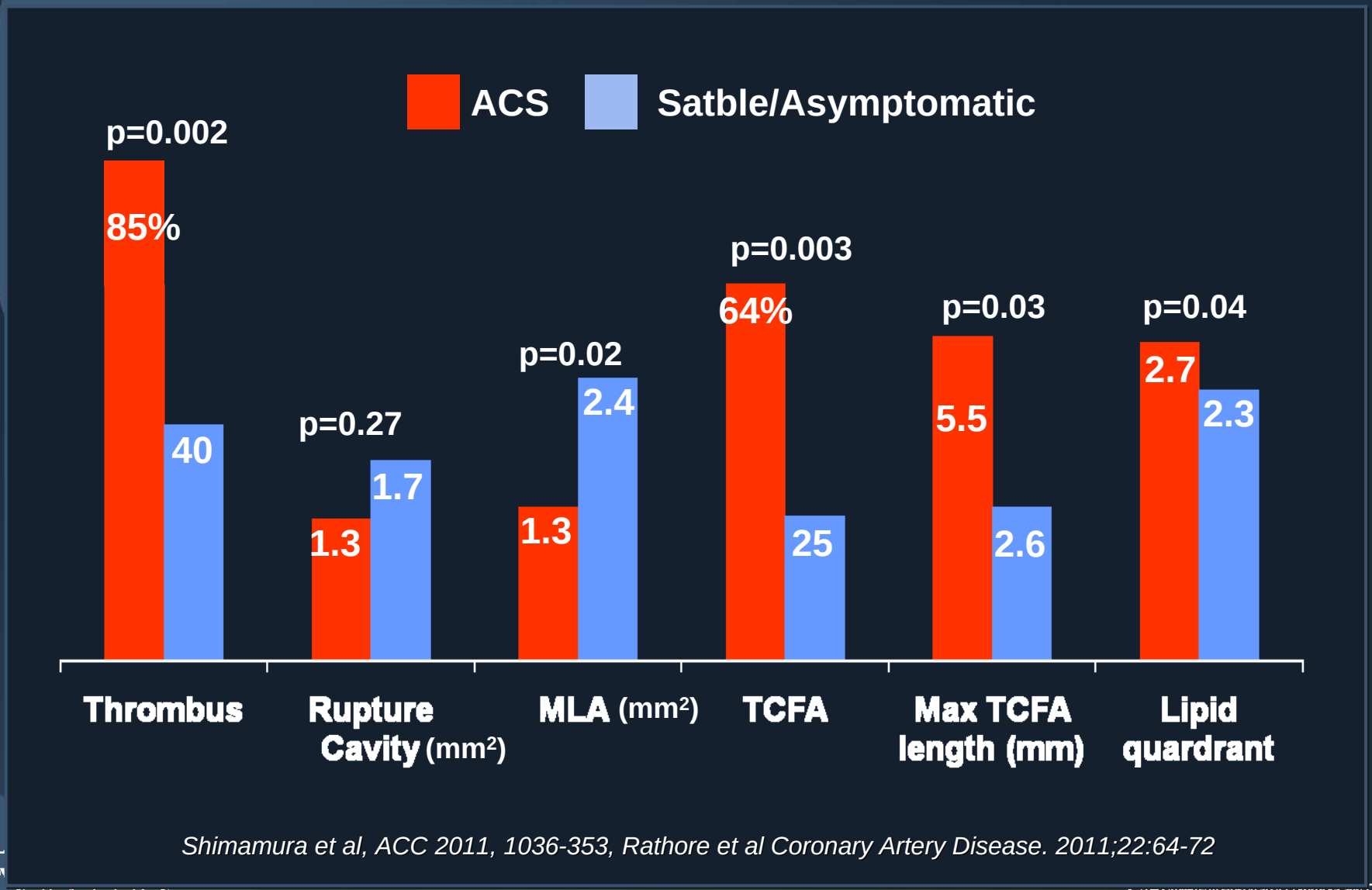


Ellis *JACC* 1988;11:908

Vulnerable Plaque Characteristics by Grayscale and VH-IVUS

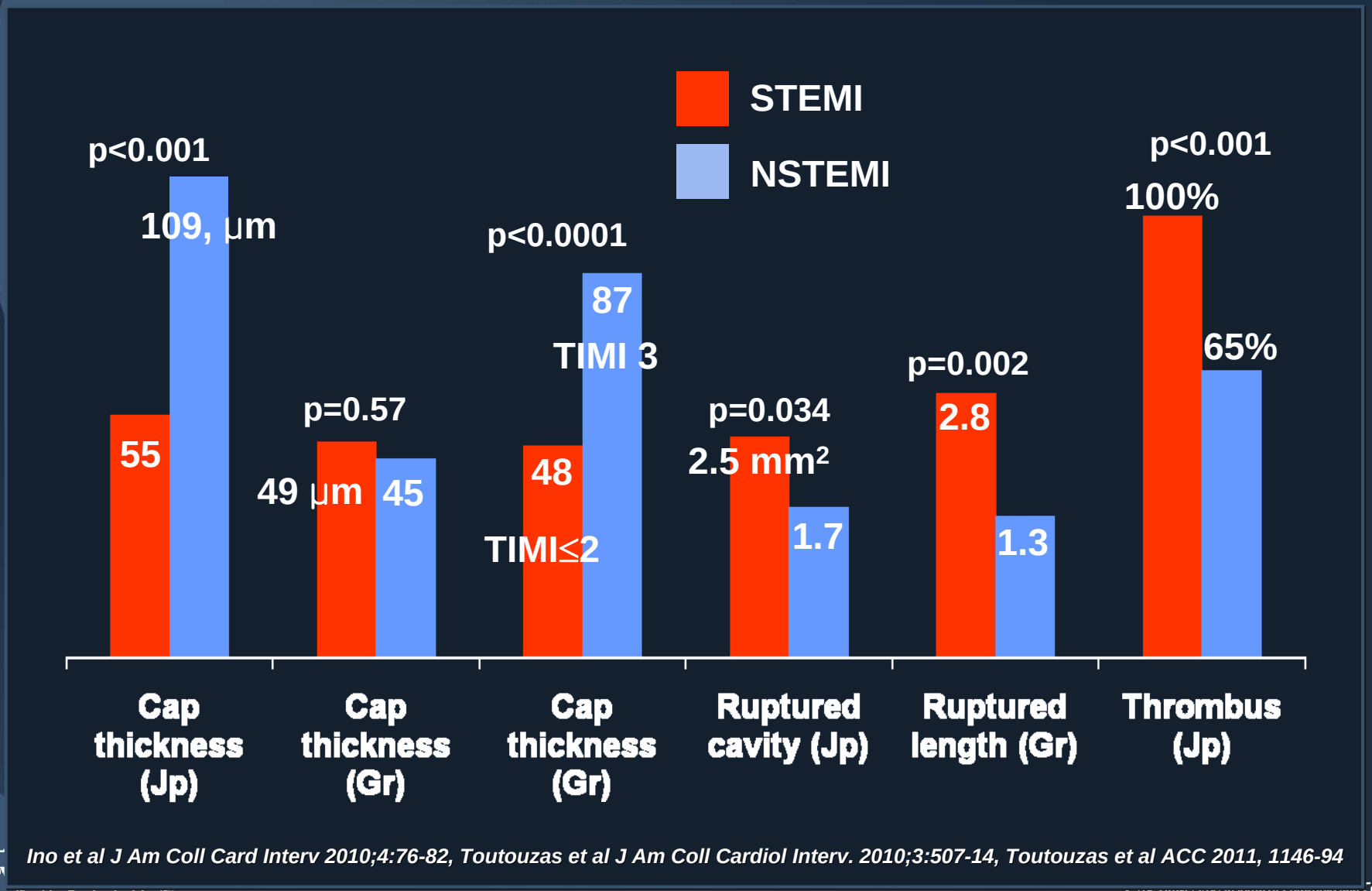
1. *Plaque burden> 60~70%*
2. *Lumen area 4-5mm²*
3. *Large vessel or proximal location*
4. *Attenuated Plaque*
5. *Thin cap fibroatheroma (TCFA)*
6. *Calcified Nodule*

Plaque rupture, TCFA between ACS vs asymptomatic by OCT



Shimamura et al, ACC 2011, 1036-353, Rathore et al Coronary Artery Disease. 2011;22:64-72

Culprit Lesion Comparison between STEMI vs NSTEMI by OCT

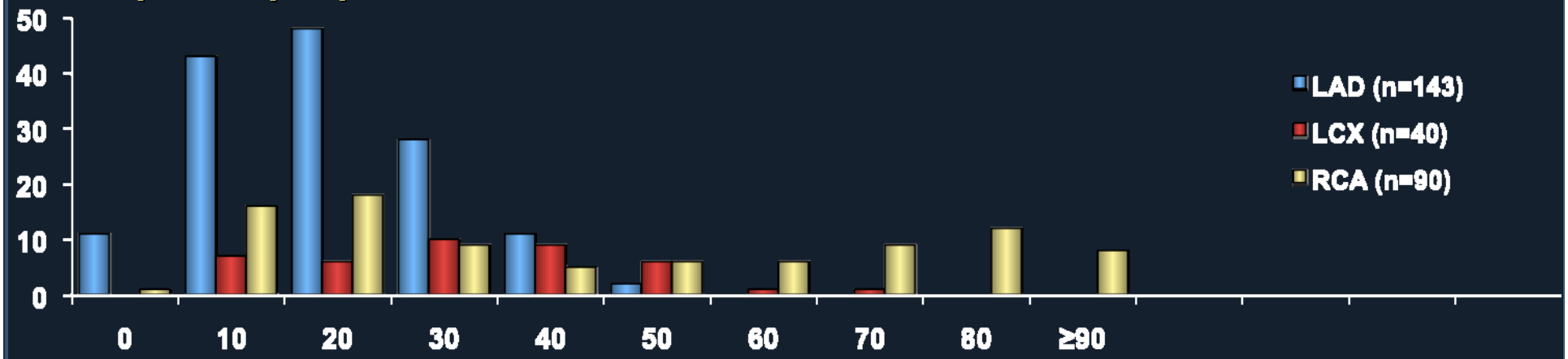


Ino et al J Am Coll Card Interv 2010;4:76-82, Toutouzas et al J Am Coll Cardiol Interv. 2010;3:507-14, Toutouzas et al ACC 2011, 1146-94

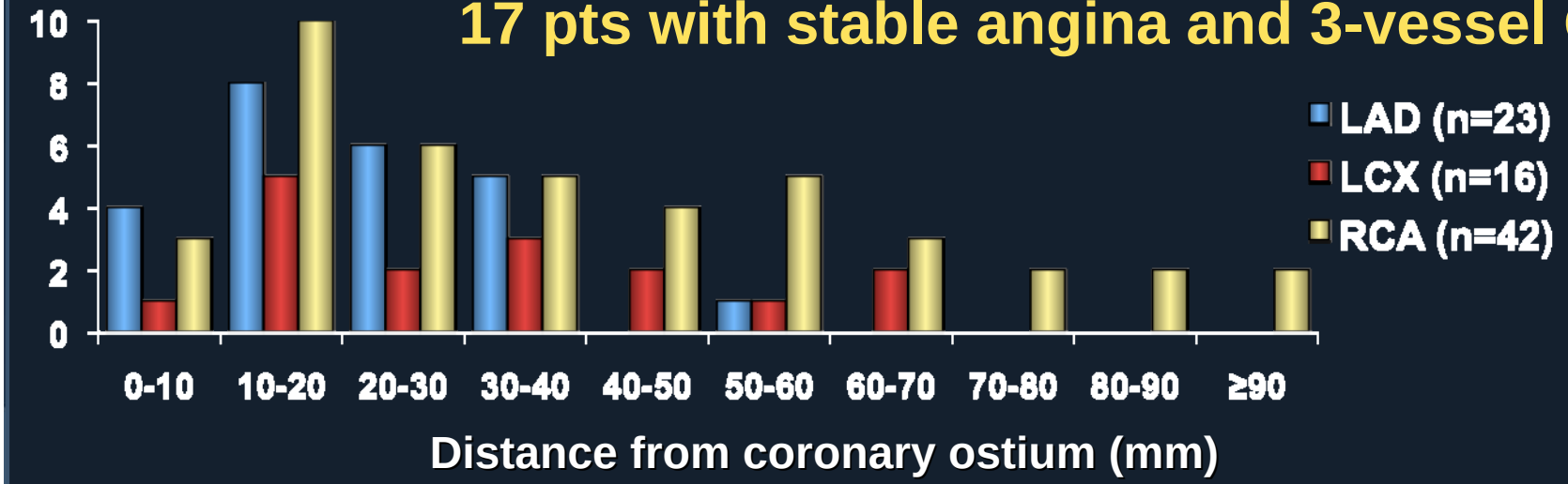
More Symptomatic Vulnerable Plaque Characteristics by OCT

1. *Thrombus existence*
2. *Thinner fibrous cap*
3. *Bigger, thicker necrotic core (circumferentially, longitudinally)*
4. *Minimum lumen area*

Location of 273 ruptured plaques in 158 pts with ACS and 48 pts with stable angina and 3-vessel IVUS

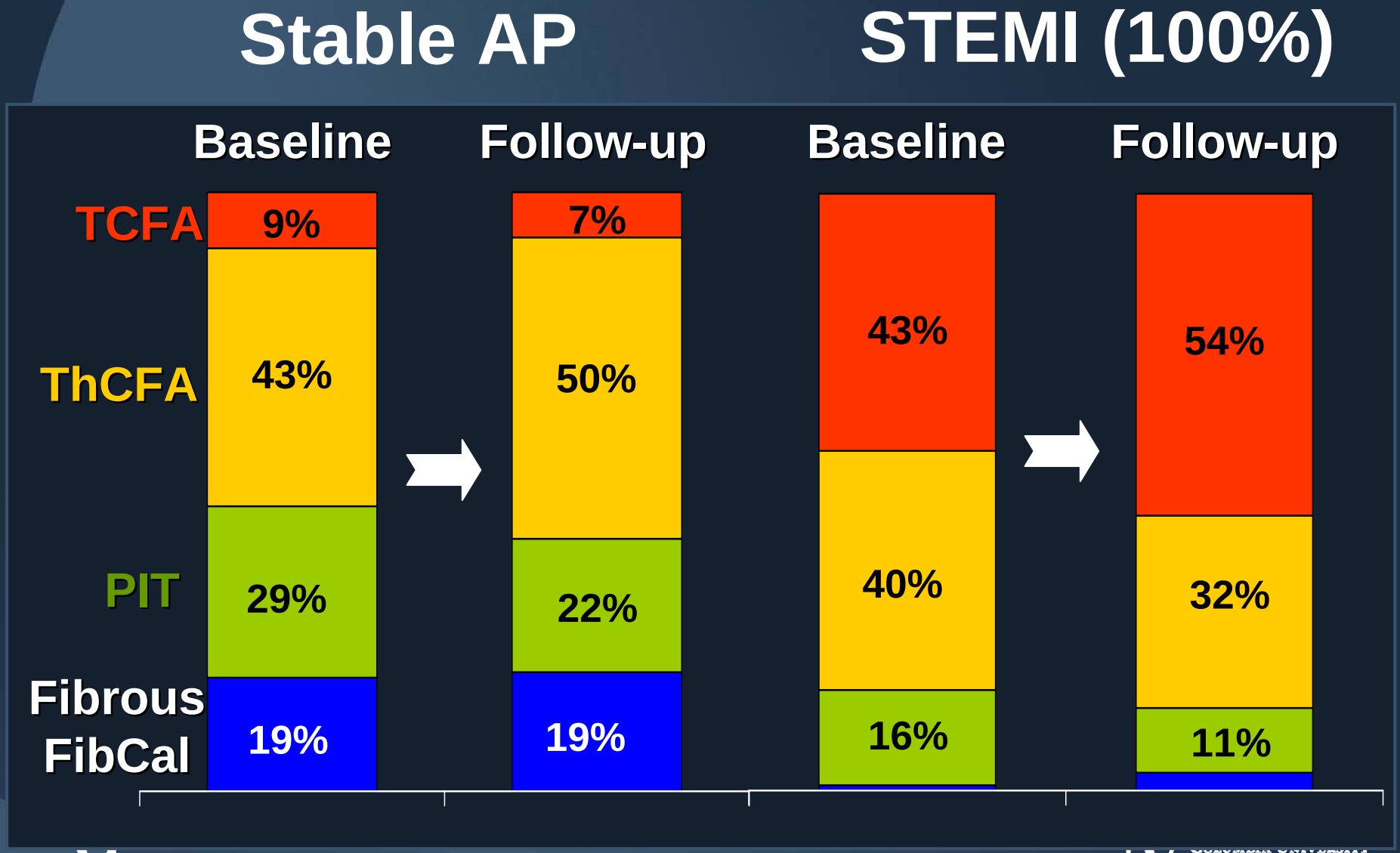


Location of 82 TCFAs in 34 pts with AMI and 17 pts with stable angina and 3-vessel OCT



Hong et al J Am Coll Card 2005;46:261-5, Fujii et al J Am Coll Cardiol. 2008;52:787-8

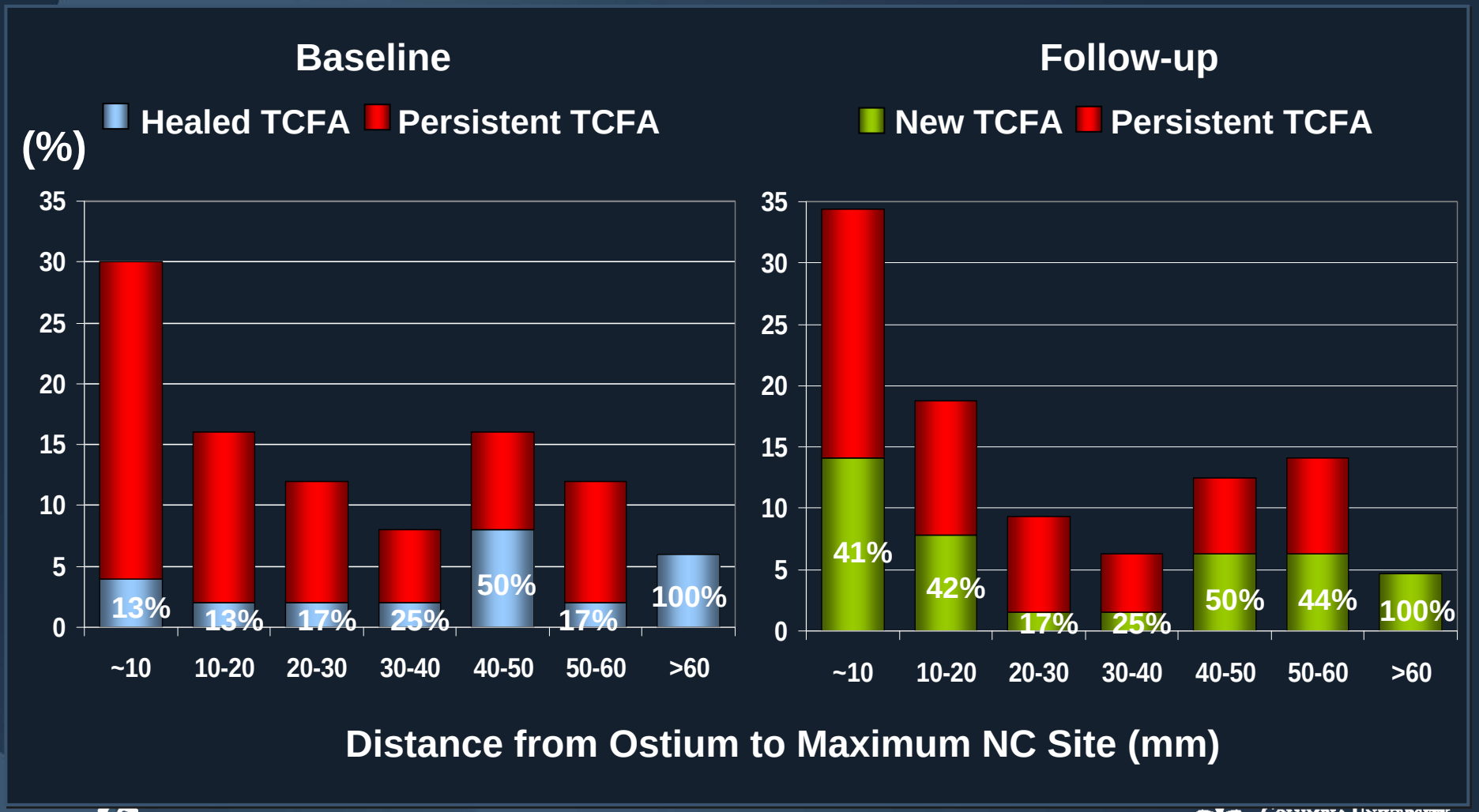
Difference of temporal changes



(Kubo et al, J Am Coll Cardiol, 2010, Zhao et al ACC 2011)

Change of VH-TCFA Distribution

Fibroatheroma level



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Zhao et al. ACC 2011

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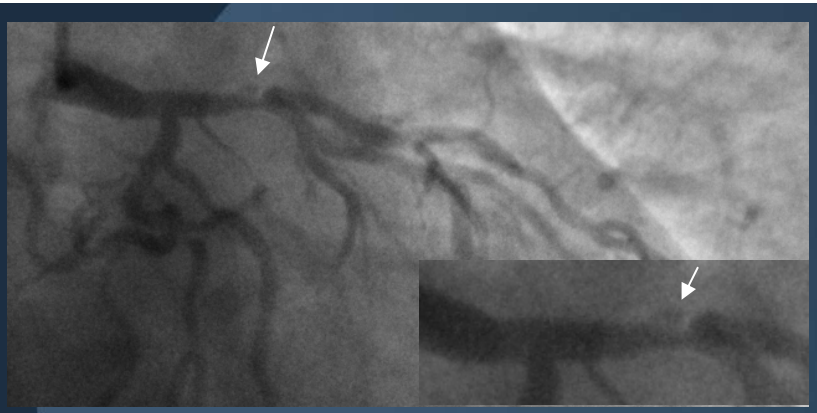
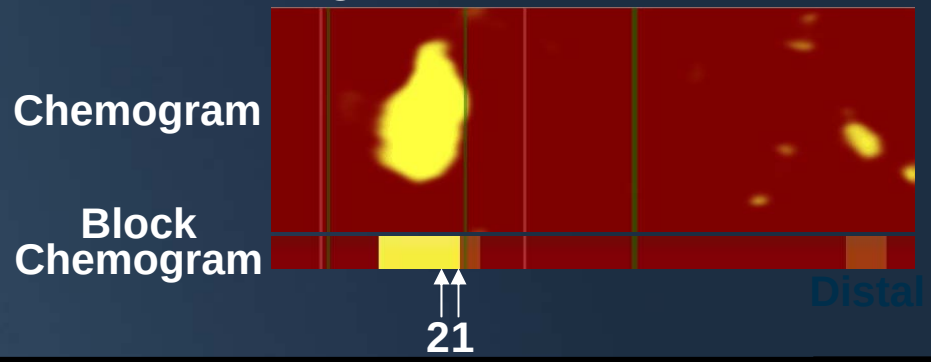
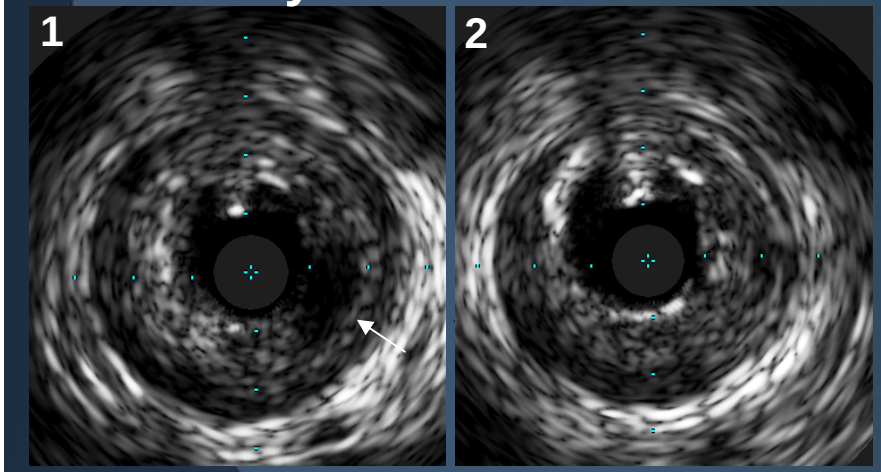
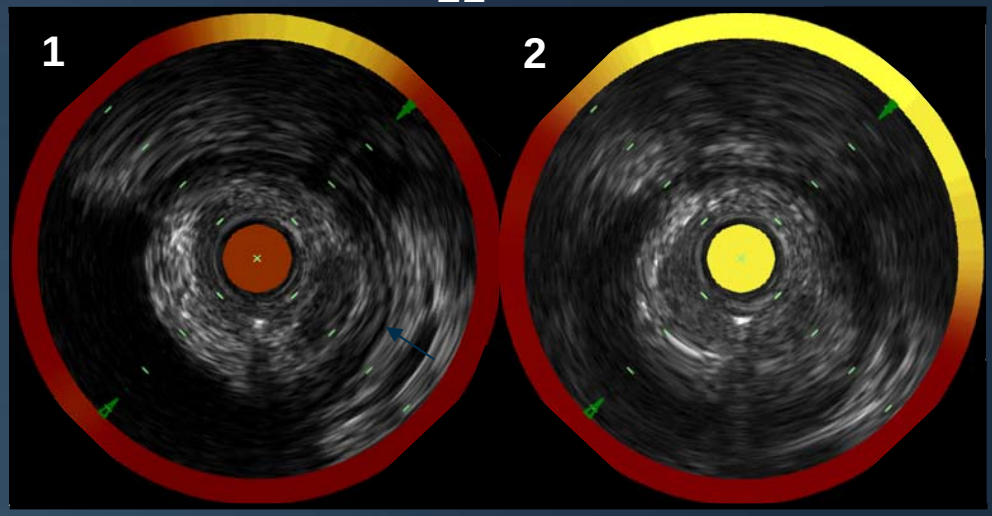


NIR Spectroscopy-IVUS

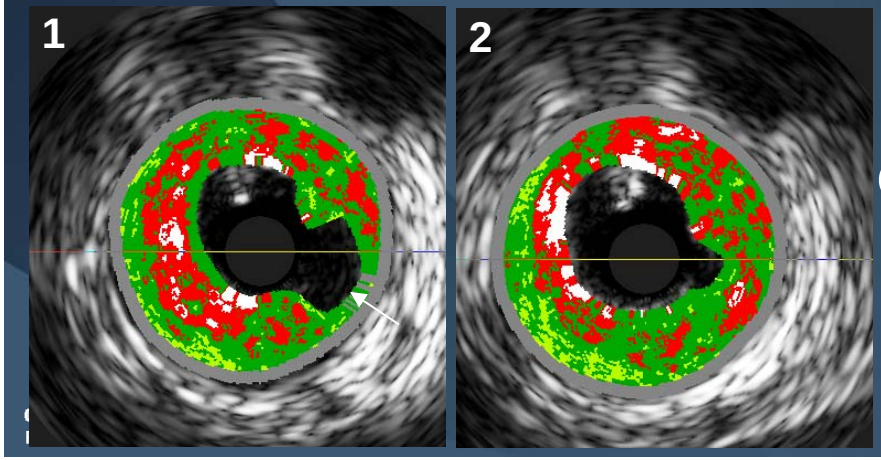


Gray Scale-IVUS

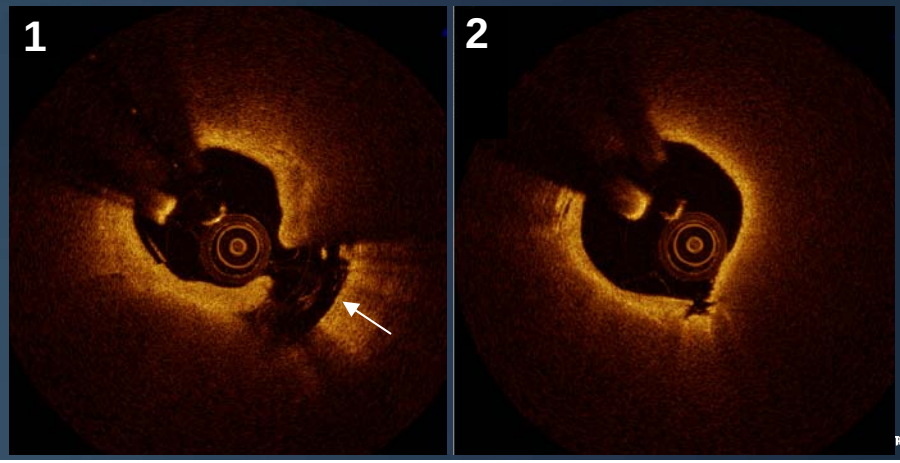




VH-IVUS



OCT



Take Home Message

1. Ischemia driven decision making is necessary.
2. We need to consider “viable myocardium burden” distal to the lesion and FFR is accurate when we consider the individual variation.
3. Assessment for vulnerability (possibility of near future event) may be important for intermediate lesion (60-70% plaque burden) in proximal and LMCA.