Coronary Intervention ; Future Perspective

Paradigm Shift to **Functional PCI**

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Functional PCI

Smart **In-corporation** of recent **Evidences** into **Clinical Practice.**

Functional PCI

Treat or Not treat :
FFR guided - Decision making
(Physiologic assessment)

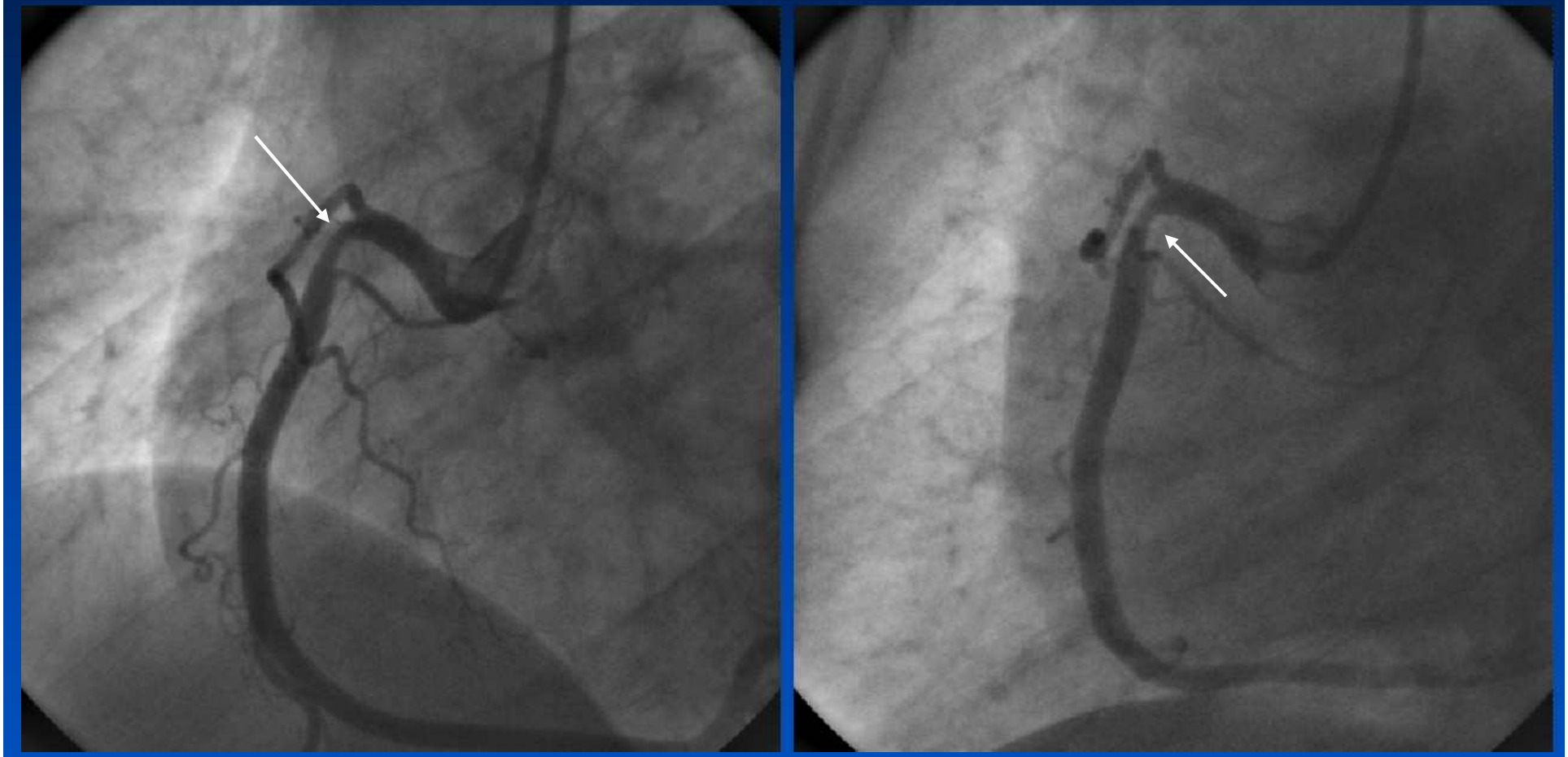
How to treat :
IVUS guided - Optimizing procedure
(Anatomical optimization)

Functional PCI

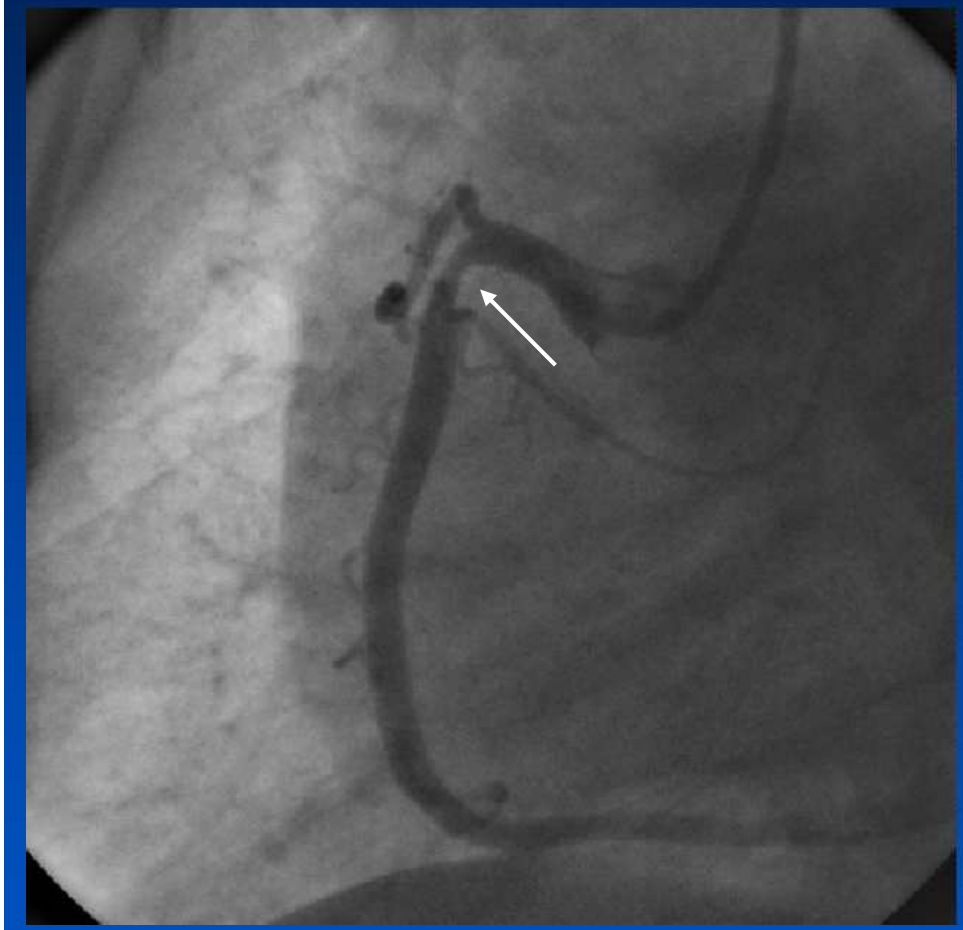
Treat or Not treat :
FFR guided - Decision making
(Physiologic assessment)

A Case

M/58,
Atypical chest pain, Hyperlipidemia, Ex-smoker

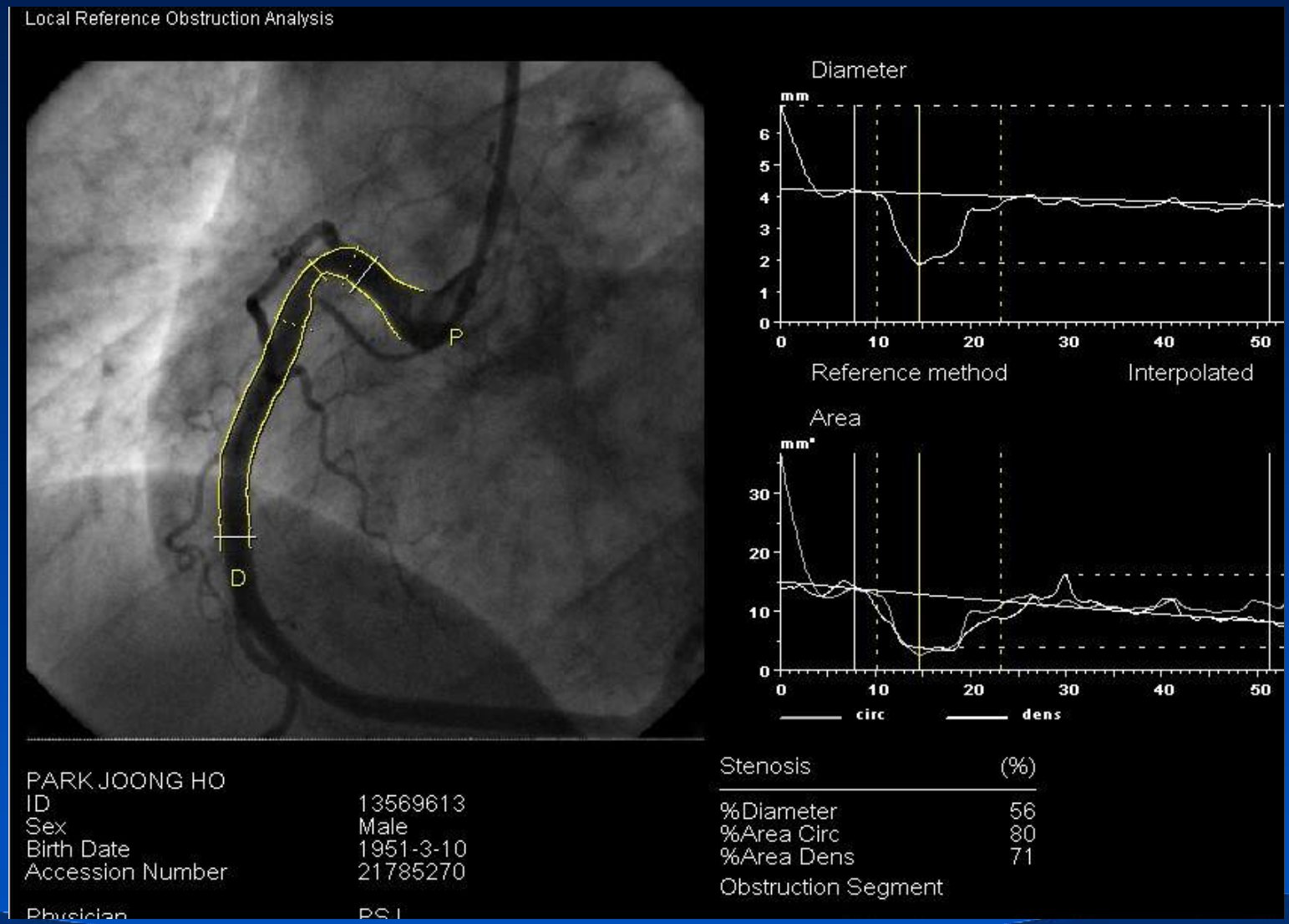


Treat or Not treat ?

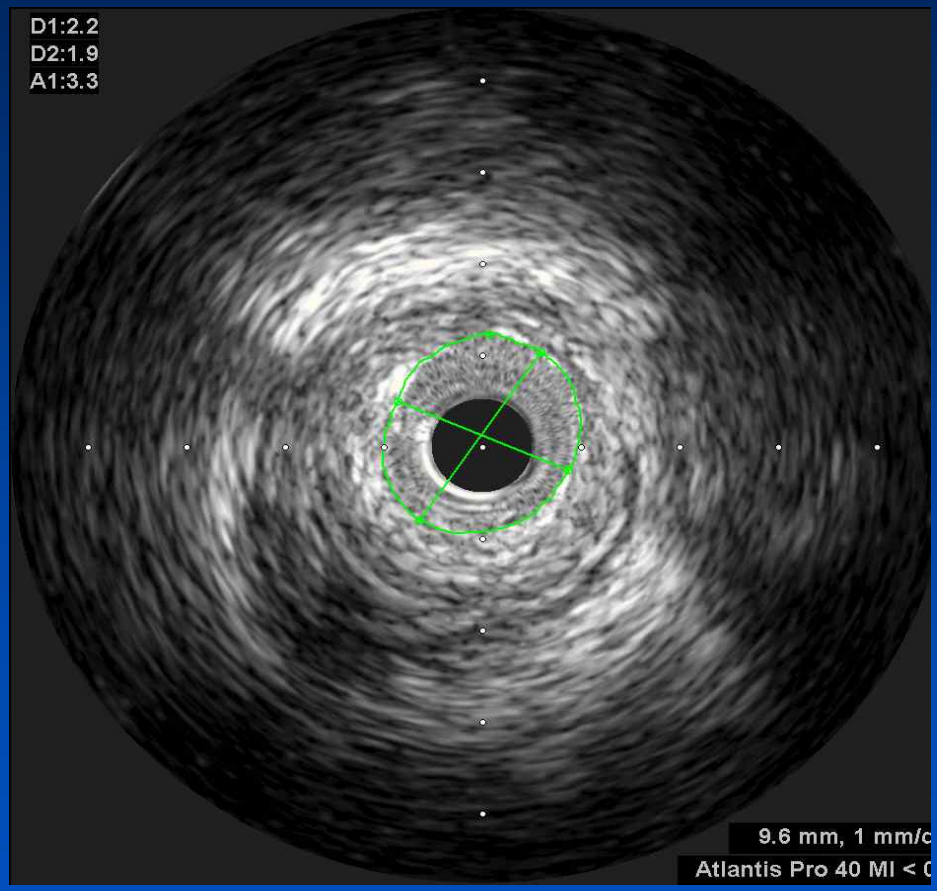


Visual Estimation
80%

QCA ; 56%

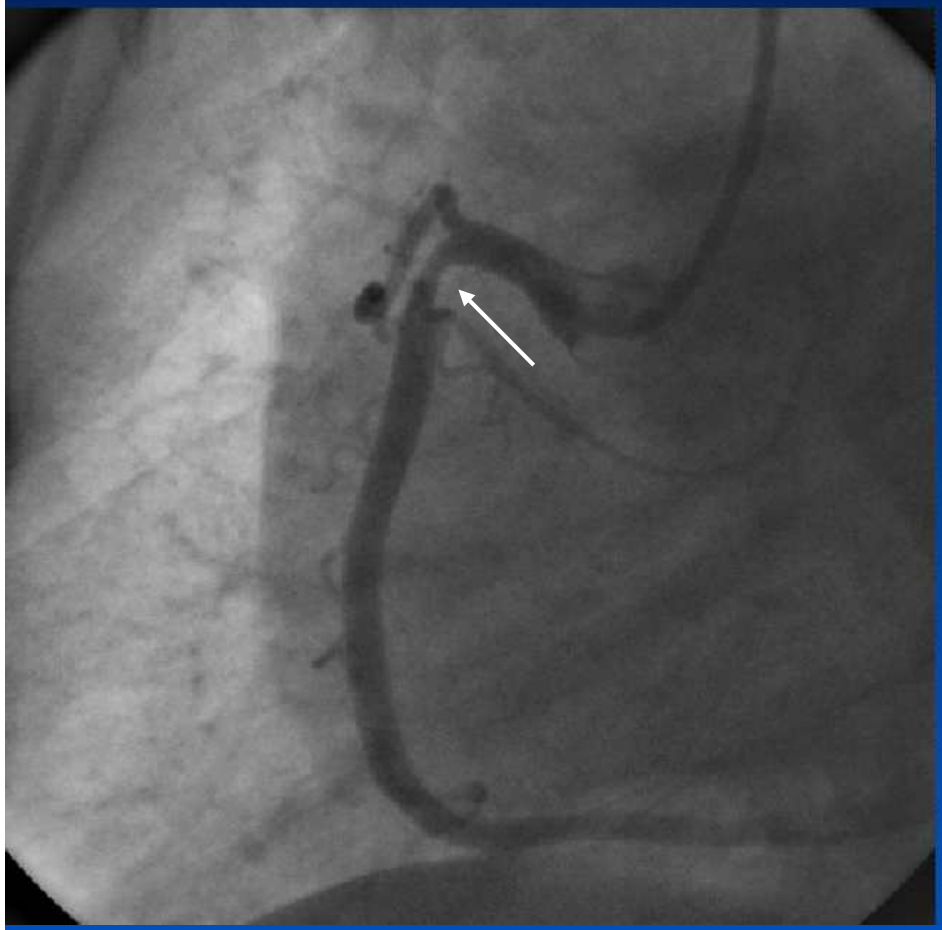

Local Reference Obstruction Analysis
P
D
Diameter
mm
6
5
4
3
2
1
0
0
10
20
30
40
50
Reference method
Interpolated
Area
mm²
30
20
10
0
0
10
20
30
40
50
circ
dens
PARK JOONG HO
ID 13569613
Sex Male
Birth Date 1951-3-10
Accession Number 21785270
Physician PS I
Stenosis (%)
%Diameter 56
%Area Circ 80
%Area Dens 71
Obstruction Segment

IVUS



MLA : 3.2 mm^2
Ref. VD : 4.5 mm
Plaque Burden : 80.2%

Treat or Not treat ?



Visual Estimation: 80%

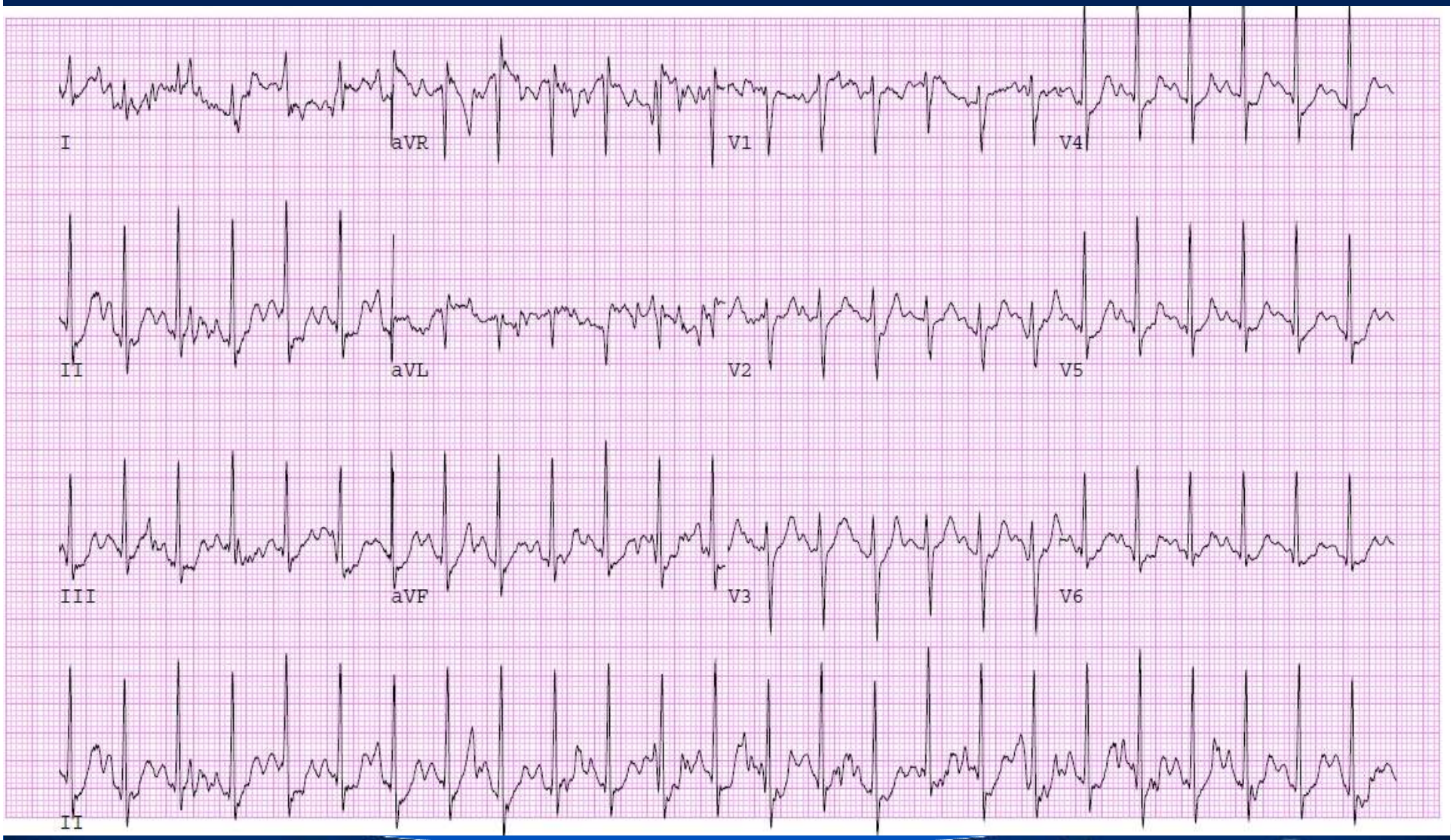
IVUS: MLA 3.2 mm^2

Plaque Burden: 80.2%

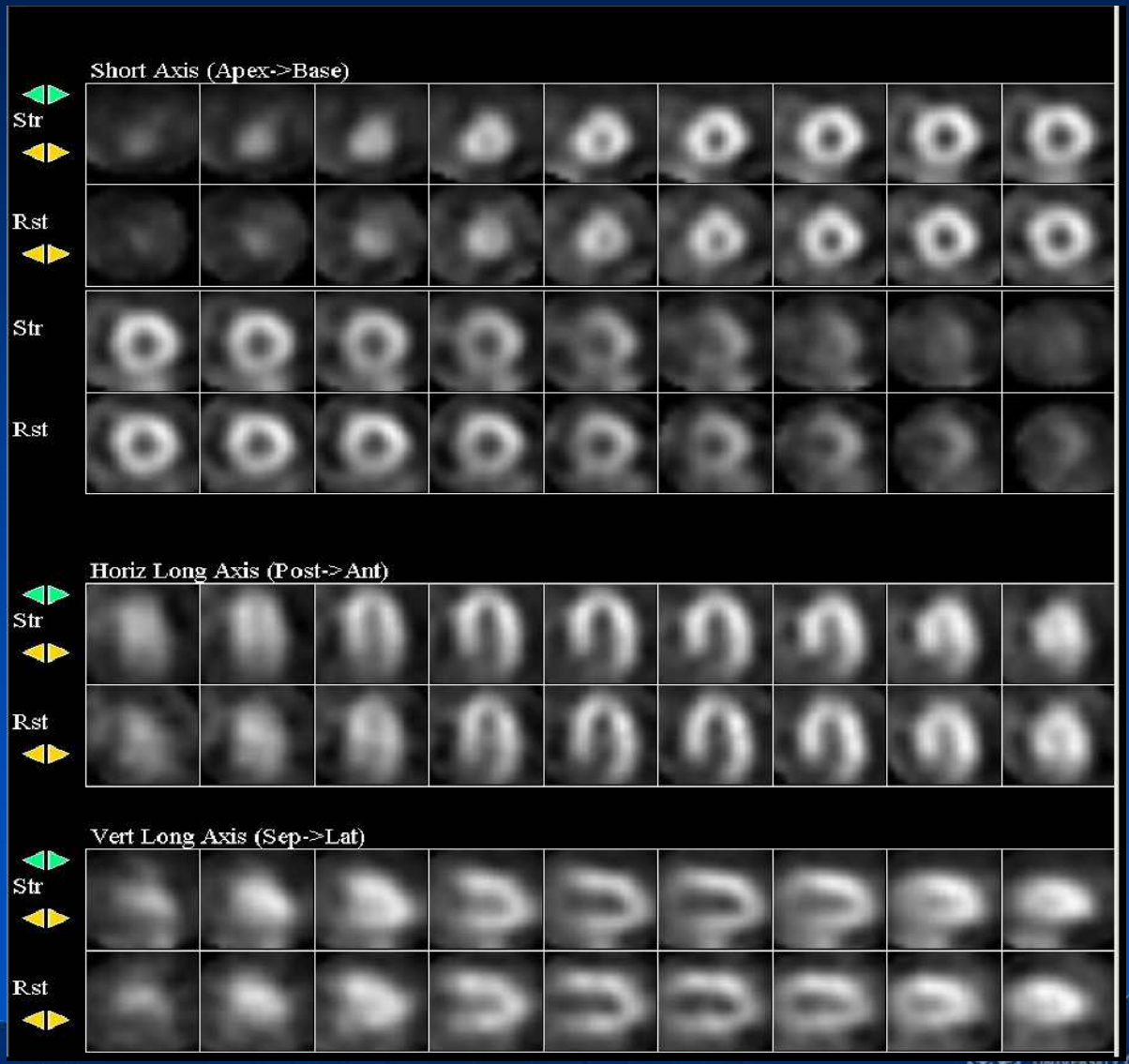
FFR

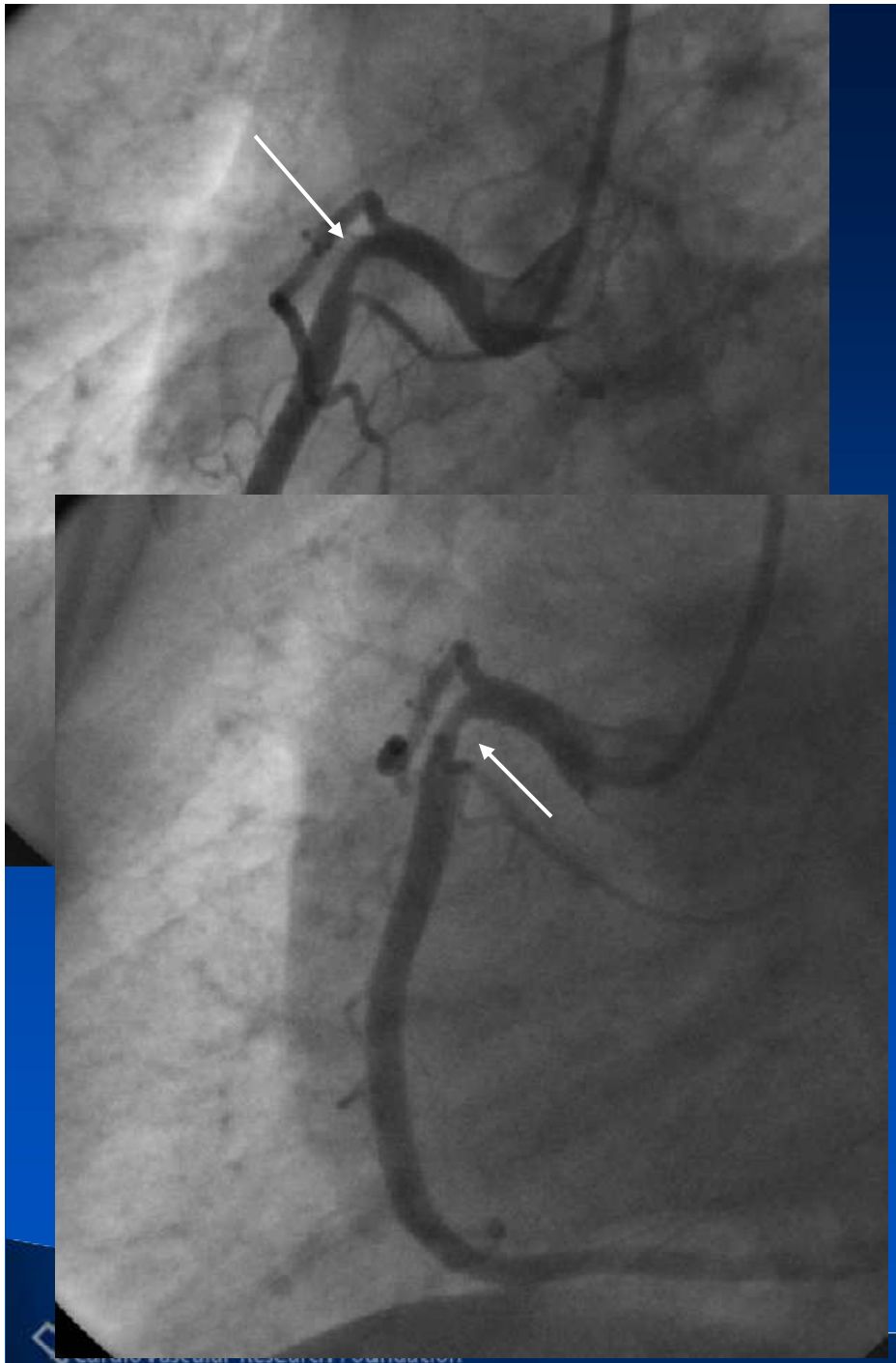
(intravenous adenosine, 140 μg/kg/min)

TMT Stage 4 - Negative



Thallium Spect ; Normal





Visual Estimation : 80%

IVUS : MLA 3.2 mm^2

FFR : 0.91

Treadmill test : Negative

Thallium spect : Normal

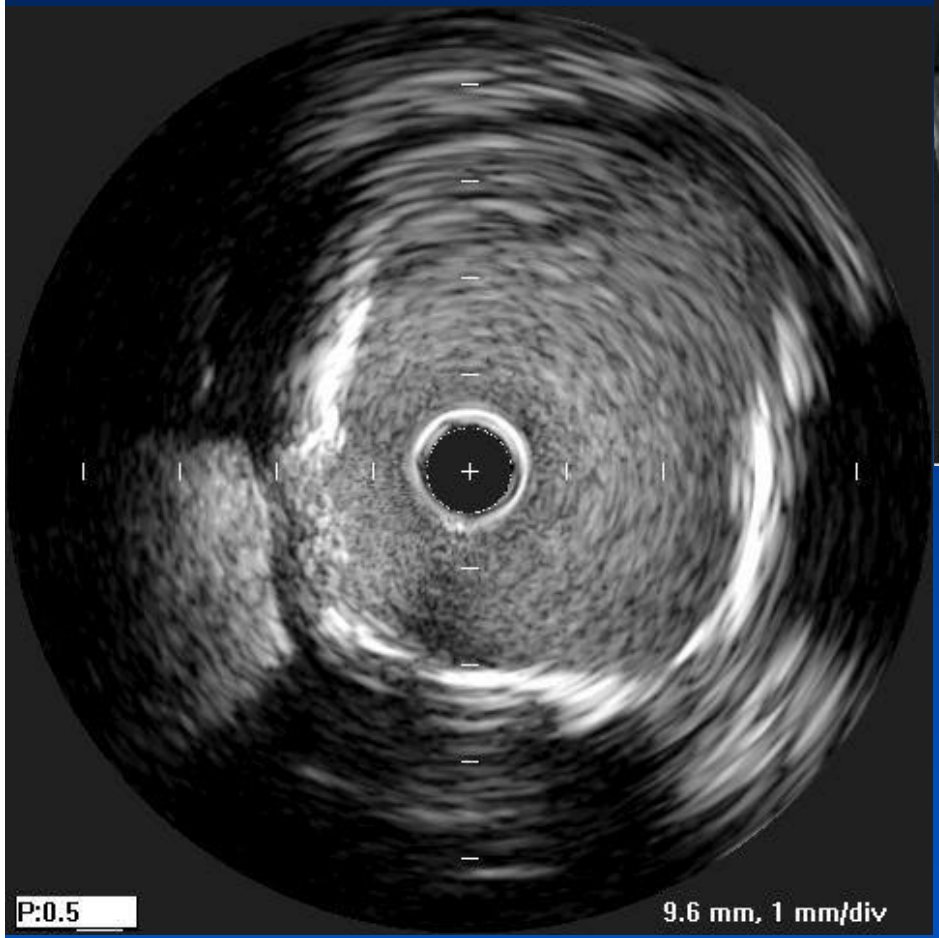
Do you still want to treat ?

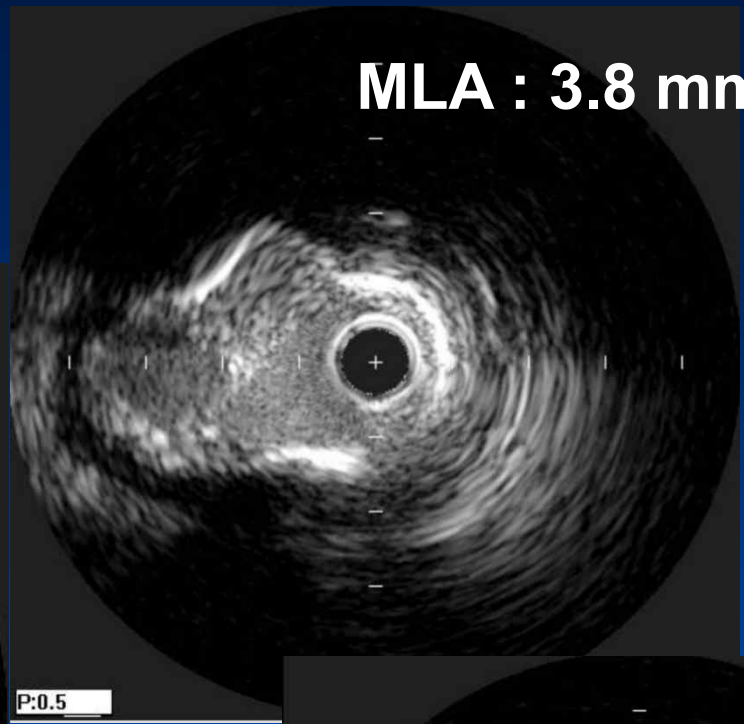
A Case

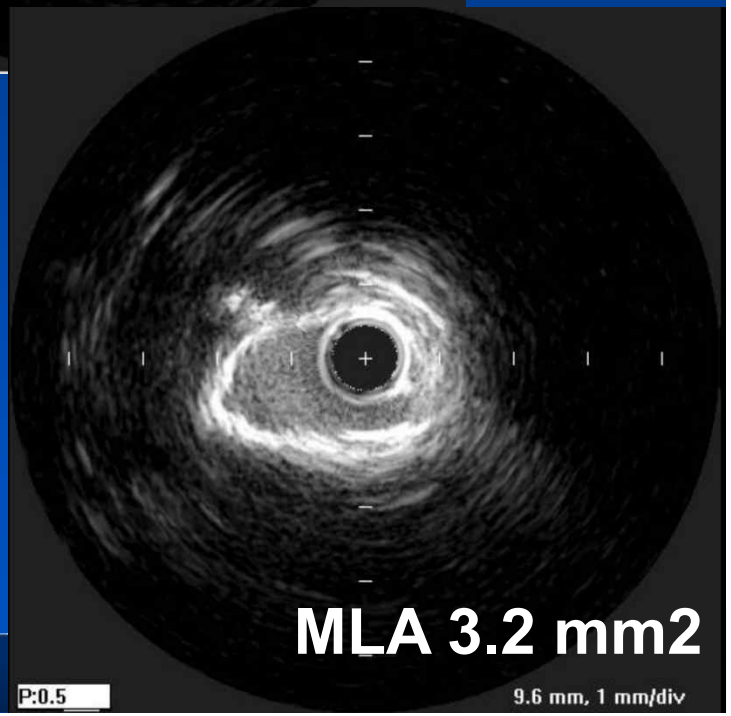
M/74,
Multiple stenosis on Coronary CT,Silent ischemia,
Hypertension, DM, Hyperlipidemia, Ex-smoker,

Visual Estimation: 60%
Ruptured Plaque

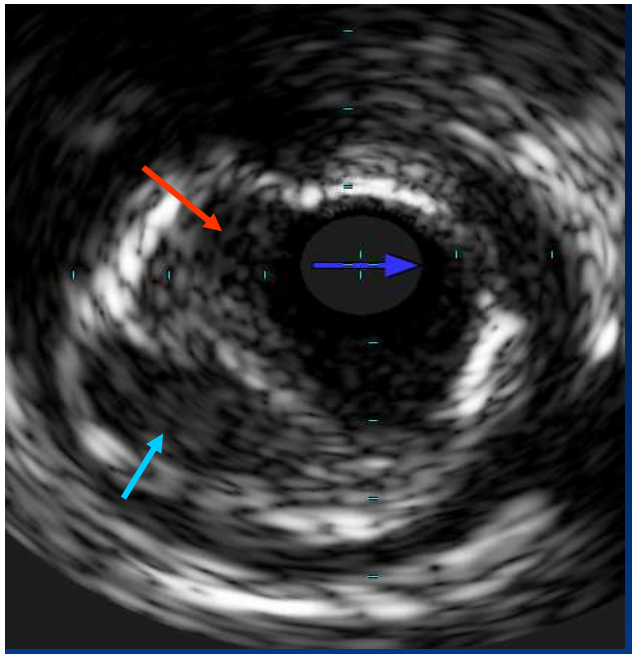
IVUS
(LAD pullback)

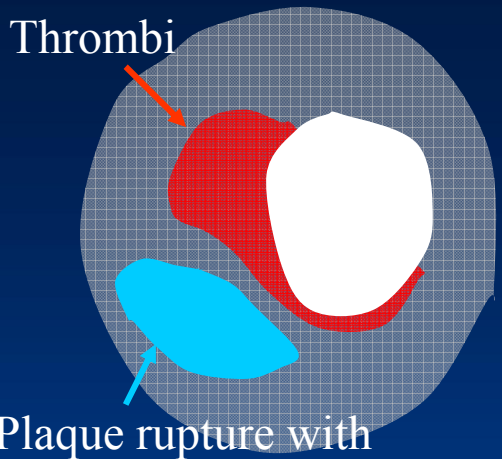


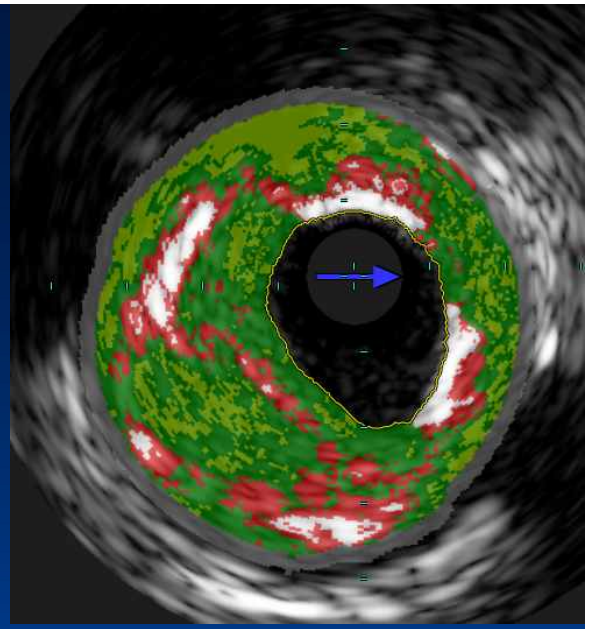


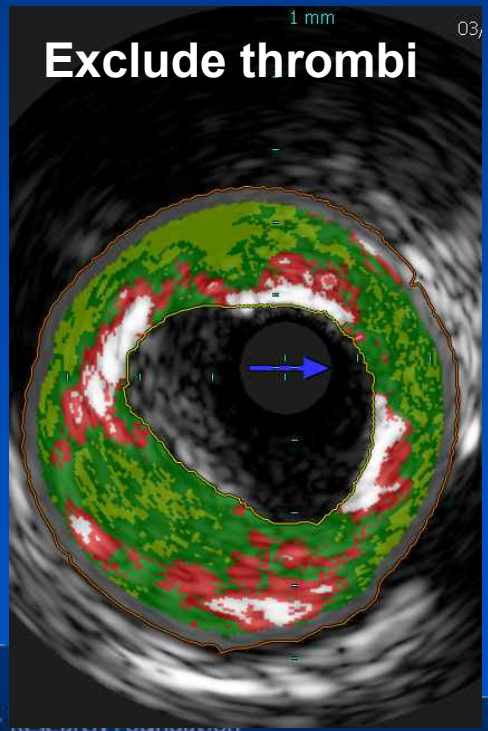


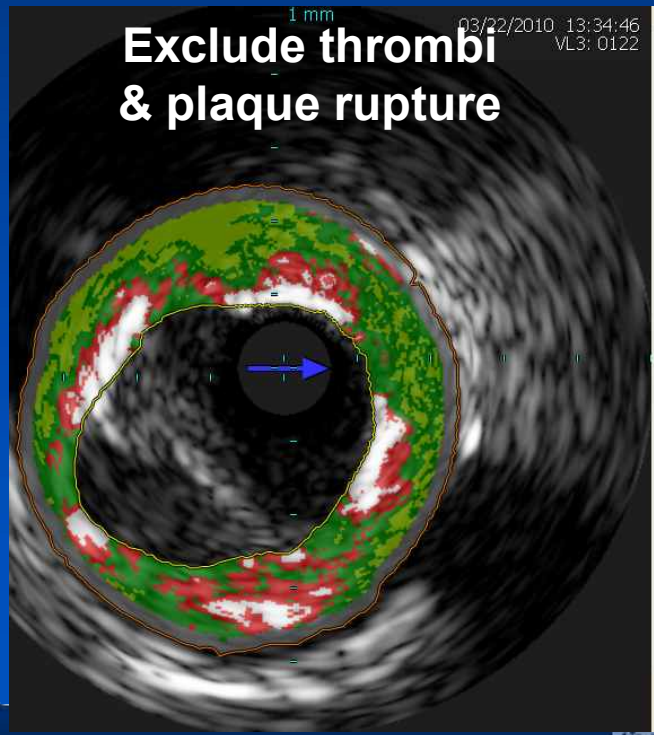
CardioVascular Research Foundation

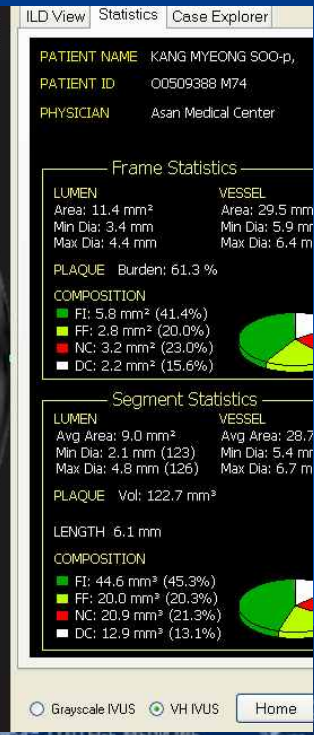












Treat or Not treat ?

Visual Estimation: 60%

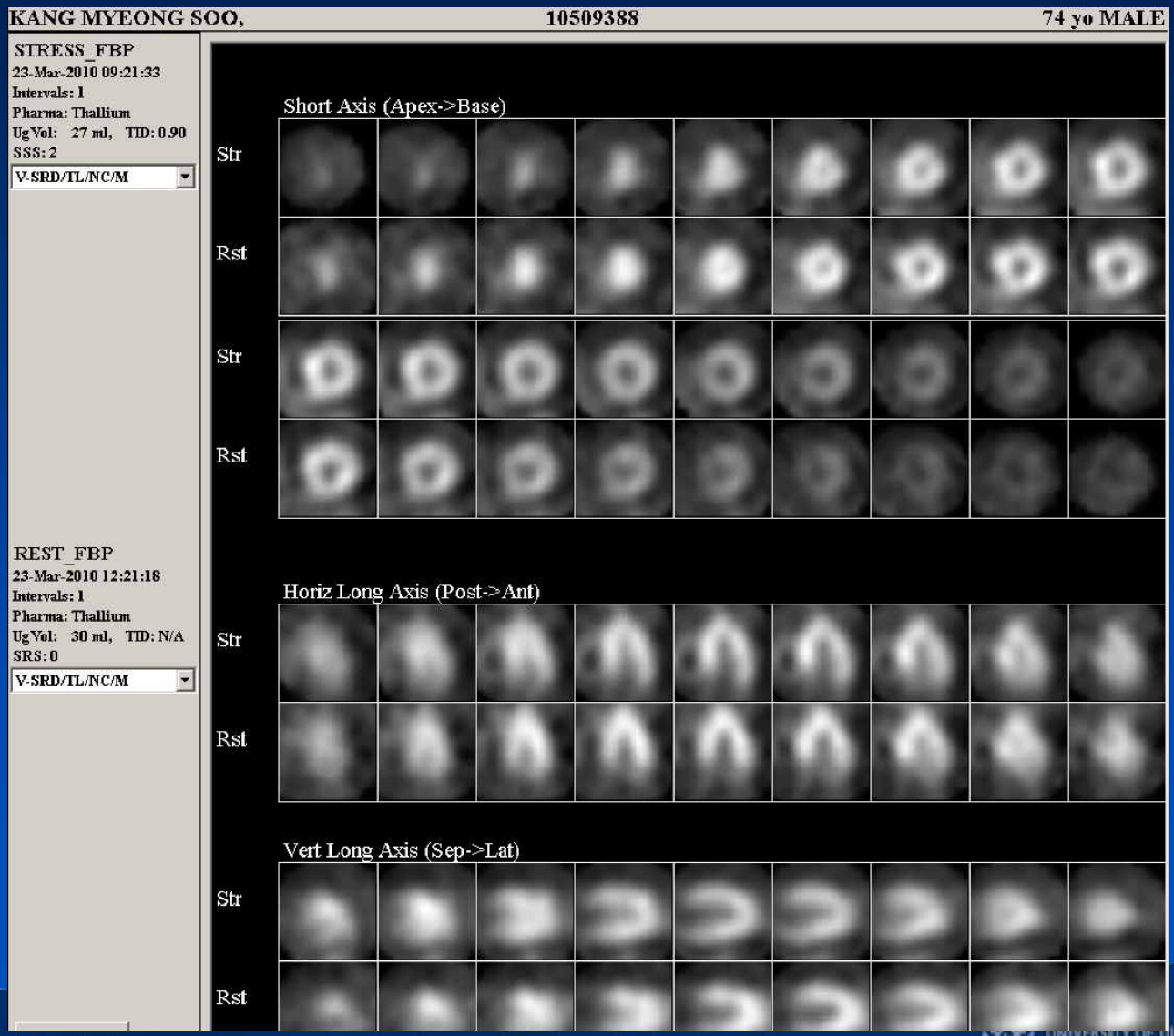
IVUS: MLA 3.8-3.2mm^2

VH-IVUS: Ruptured Plaque with large necrotic core

FFR

(intravenous adenosine, 140 μg/kg/min)

Thallium Spect ; Normal Perfusion



M/74,

Visual Estimation: 60%

IVUS: MLA 3.8-3.2mm^2

VH-IVUS: Ruptured Plaque with large necrotic core

Thallium scan : Normal

Do you want to treat ?

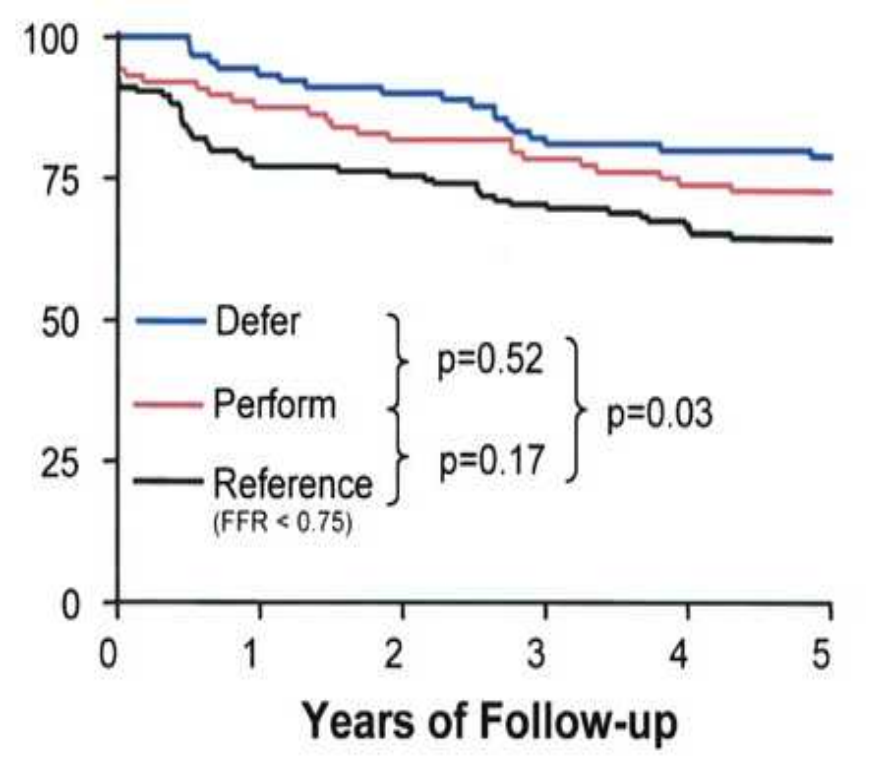
What you see may not be everything.
Looks can be deceiving.

FFR > 0.8 is a really perfect surrogate for absence of clinical ischemia.
(Specificity 100%, Sensitivity 88%)

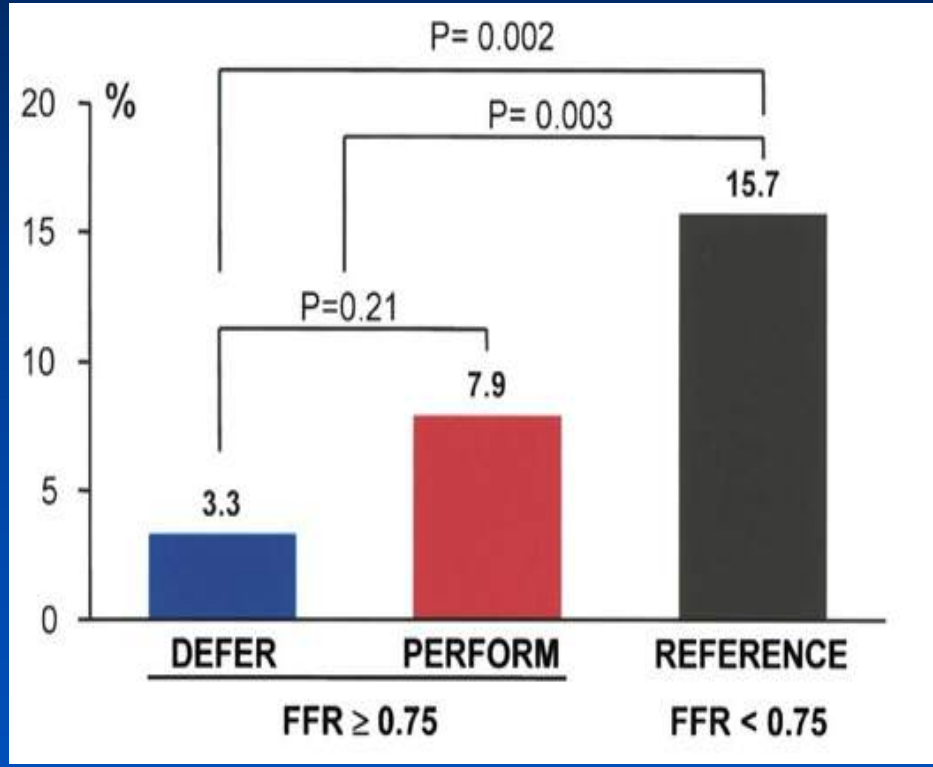
Milestone Study

DEFER 5 Year Results

Event Free Survival



Cardiac Death and MI



Pijls et al. J am Coll Cardiol 2007;49:2105-11

FAME

*F*ractional Flow Reserve *VS A*ngiography for *M*ultivessel *E*valuation

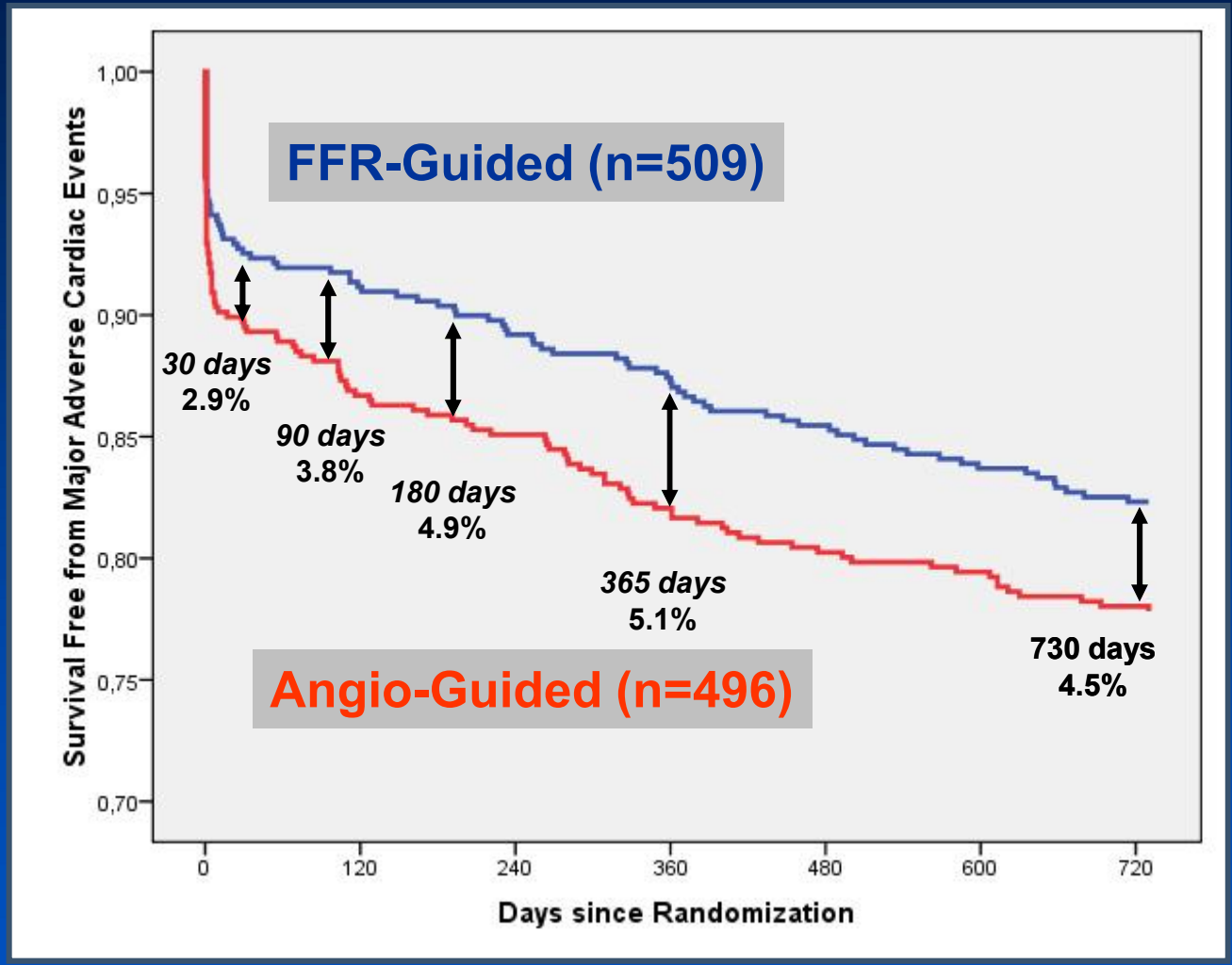
New Engl J Med 2009;360:213-24

FAME : Procedural Results

	ANGIO-group N=496	FFR-group N=509	P-value
# indicated lesions per patient	2.7 ± 0.9	2.8 ± 1.0	0.34
FFR results			
Lesions succesfully measured, No (%)	-	1329 (98%)	-
Lesions with FFR ≤ 0.80, No (%)	-	874 (63%)	-
Lesions with FFR > 0.80, No (%)	-	513 (37%)	-
Stents per patient	2.7 ± 1.2	1.9 ± 1.3	<0.001
Lesions succesfully stented (%)	92%	94%	-
DES, total, No	1359	980	-

2 Year Survival Free of MACE

MACE : Composite of Death, Myocardial Infarction, or Repeat Revascularization



Late Breaking Trial, TCT 2009

Why FFR guided ?

- Avoid unnecessary procedures
- Avoid unnecessary surgery
- Minimize MACE
- Maximize clinical outcomes
- Save money
- Save lives

Functional PCI

How to treat :

IVUS guided - Optimizing procedure (Anatomical optimization)

Why IVUS guided ?

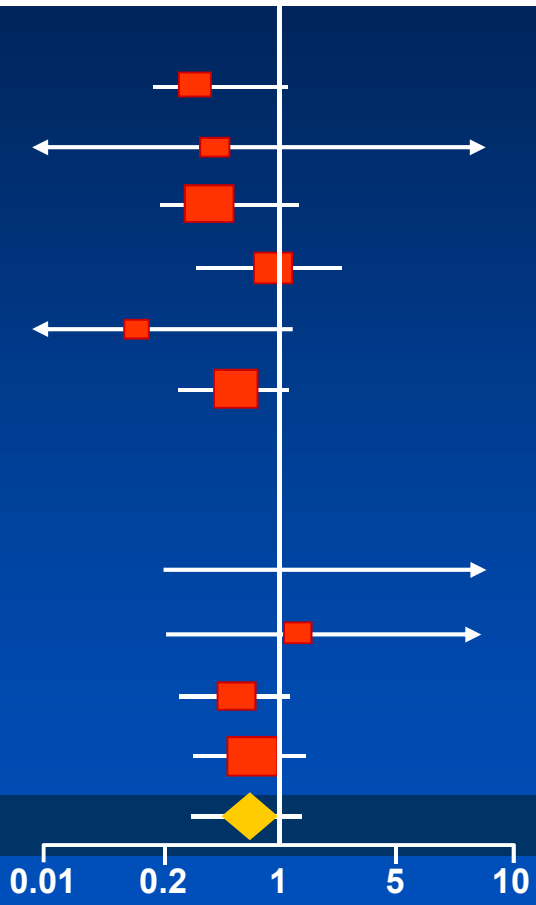
IVUS guidance
Saves Lives !!

Usefulness of IVUS study
In the era of BMS

Combined Endpoints (Death & MI) at 6 Mo

Meta-analysis (N=2972)

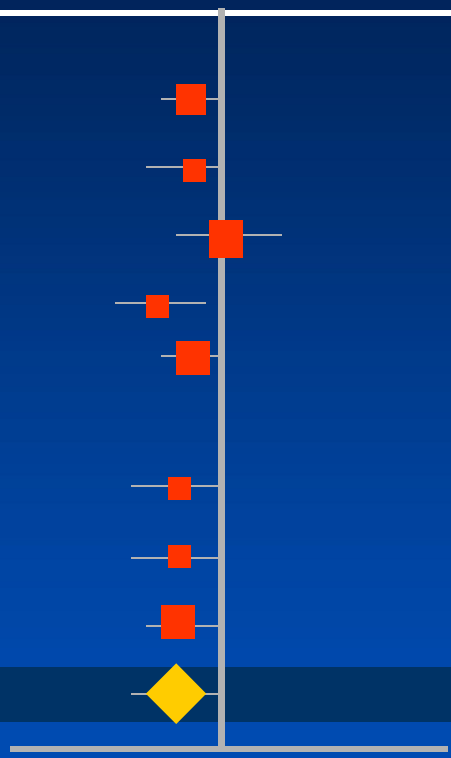
Study	IVUS-guided	Angio-guided	Odds ratios and 95% CI Fixed	OR and 95% CI
Radnomizedtrials				
SIPS,1996	5/121 (4.1%)	0/148 (6.7%)		0.59 (0.20-1.79)
RESIST. 1997	1/79 (1.2%)	1/76 (1.3%)		0.96 (0.06-15.65)
OPTICUS.1998	9/273 (3.3%)	10/277 (3.6%)		0.91 (0.36-2.28)
AVID. 1999	25/372 (6.7%)	17/387 (4.4%)		1.57 (0.83-2.95)
TULIP. 2001	1/73 (1.3%)	5/77 (6.5%)		0.20 (0.02-1.75)
Subtotal	41/918 (4.4%)	43/965 (4.4%)		1.02 (0.65-1.57)
Registries				
Albiero et al. 1995	5/18 (3.1%)	0.15 (0%)		11.07 (0.61-201.97)
Choi et al. 1997	4/178 (2.2%)	1/100 (1%)		2.28 (0.25-20.65)
CRUISE. 2000	19/270 (7%)	16/229 (7%)		1.01 (0.51-2.01)
Subtotoal	28/606 (4.6%)	17/483 (3.5%)		1.37 (0.74-2354)
Total	69/1,524 (4.5%)	60/1,448 (4.1%)		1.13 (0.79-1.61)



Binary Restenosis at 6 Mo

Meta-analysis (N=2972)

Study	IVUS-guided	Angio-guided	OR and 95% CI
Randomized trials			
SIPS, 1996	48/166 (29%)	66/190 (34.7%)	0.76 (0.49-1.20)
RESIST, 1997	17/71 (22.5%)	21/73 (28.7%)	0.72 (0.34-1.53)
OPTICUS, 1998	56/229 (24.4%)	52/228 (22.8%)	1.10 (0.71-1.69)
TULIP, 2001	15/73 (20.5%)	28/77 (36.4%)	0.45 (0.22-0.94)
Subtotal	135/539 (25%)	167/568 (29%)	0.81 (0.62-1.06)
Registries			
Albiero et al, 1995	29/158 (18.3%)	40/154 (26%)	0.64 (0.37-1.10)
Blasini et al,1995	22/105 (20.9%)	32/107 (29.9%)	0.62 (0.33-1.16)
Subtotal	51/263 (19%)	72/261 (27.5%)	0.63 (0.42-0.95)
Total	186/802 (23%)	239/829 (28.8%)	0.75 (0.60-0.94)



IVUS-guided better Angio-guded better

p=0.01

Substantial ***25% reduction*** of binary restenosis in IVUS-guided stenting

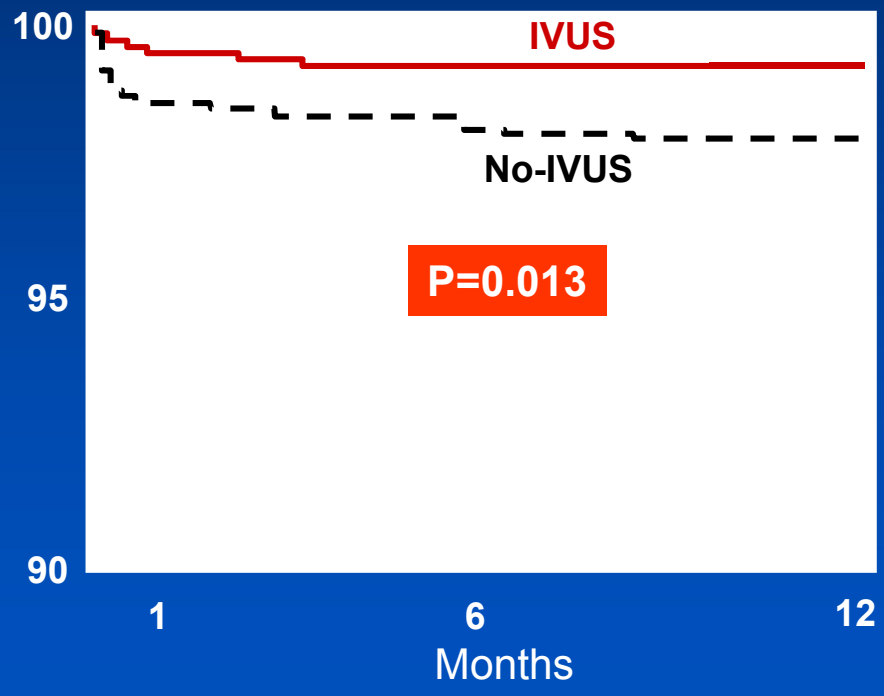
Casella et al. Cathet Cardiovasc Intervent 2003;59:314-21

Usefulness of IVUS study
In the era of DES

IVUS-guidance vs. Angio-guidance
(Propensity–Matched) in DES-Treated Lesions

	IVUS-guided	Angio-guided	p value
30-day			
MACE	2.8%	5.2	0.010
ST	0.5%	1.4%	0.046
TLR	0.7%	1.7%	0.050
1-year			
MACE	14.5%	16.2%	0.330
Definite ST	0.7%	2.0%	0.014
Probab ST	4.0%	5.8%	0.080
TLR	5.1%	7.2%	0.070
Late ST	0.2%	0.7%	0.160

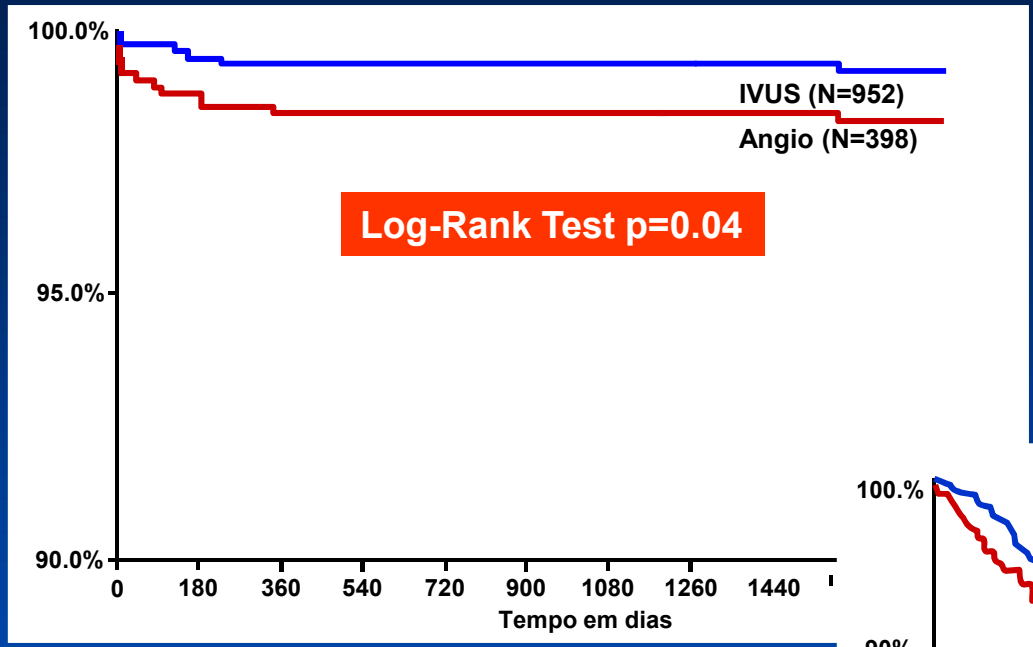
Stent Thrombosis Free Survival (%)



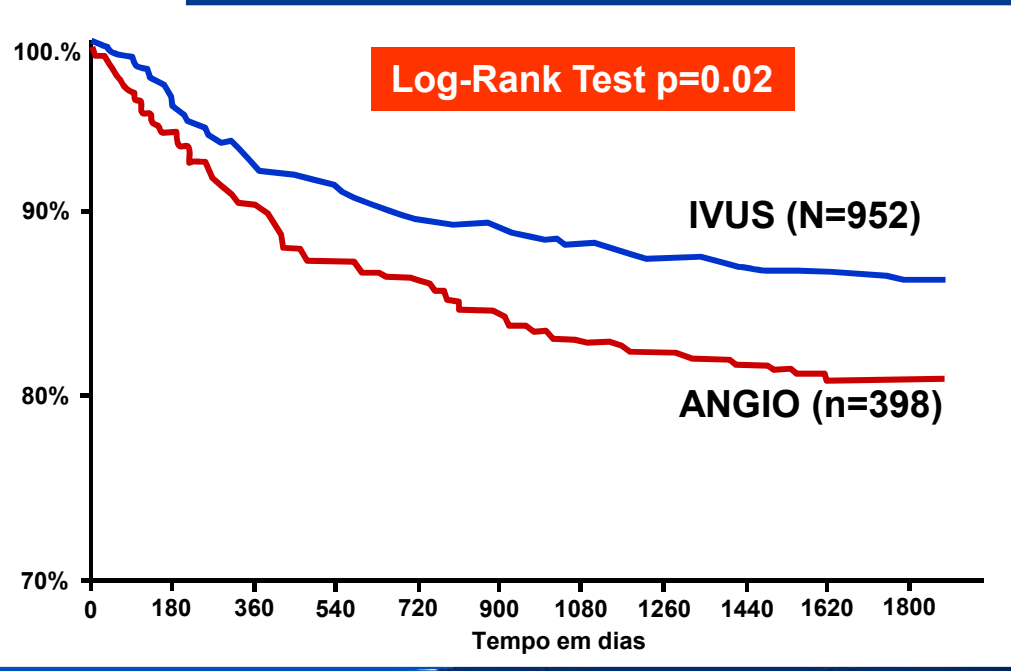
IVUS-Guided (n=952) **vs. Angio-Guided** (n=398) **in the era of DES**

	IVUS-guided	Angio-guided	p
Age	63.4±0.36 yrs	63.5±0.42 yrs	
Diabetes	27%	35%	0.007
ACS	26%	27%	NS
Multivessel disease	54%	45%	0.001
LAD	46%	15%	<0.001
Stents/lesion	1.01	1.04	NS
%DES	93%	81%	<0.01
Stent diameter (mm)	3.0±0.4	2.9±0.5	<0.001
Stent length (mm)	24.0±7.4	22.9±7.8	<0.0001

Thrombosis Free Survival
at 3 year F/U



TVF Free Survival

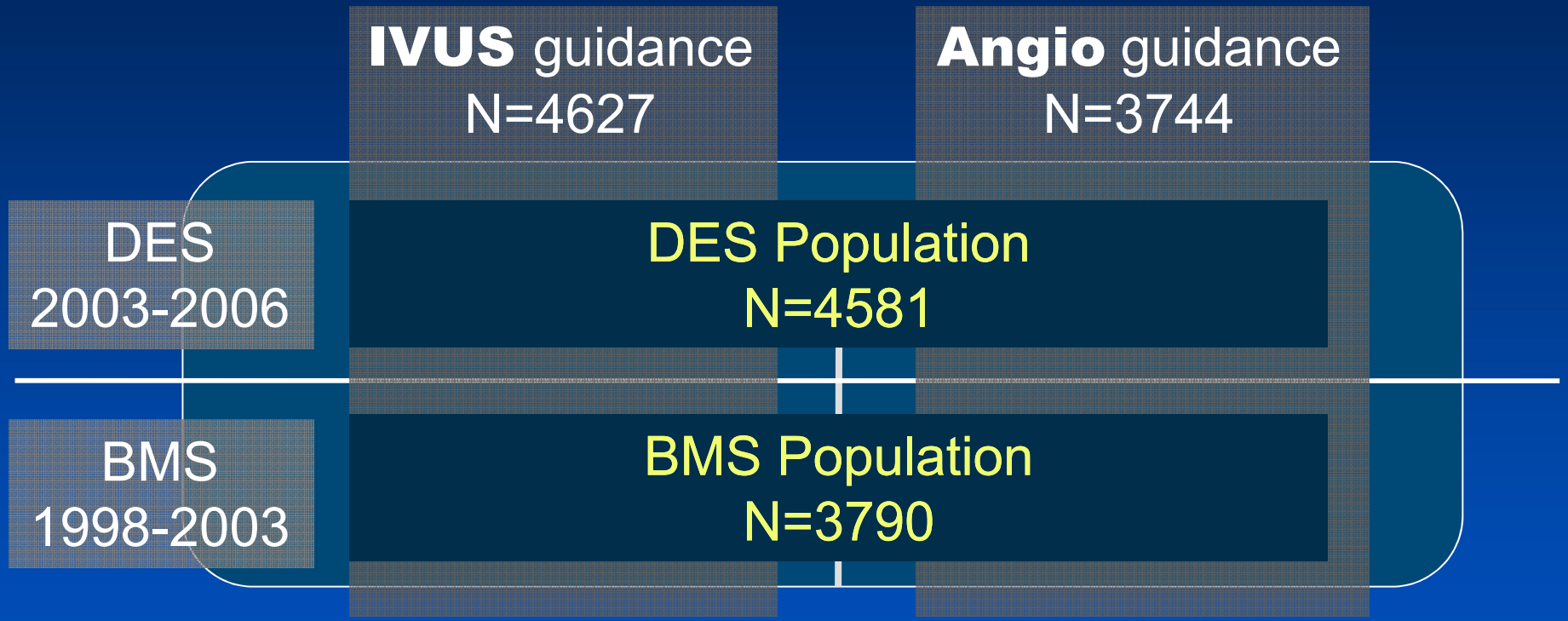


IVUS guided procedure
in the era of DES – Matched registry data

Survival Benefit !

Unselected “Real World” PCI Registry
IVUS guided vs. Angio-guided
(n=8371, 2 centers registry)

Overall population
N=8371

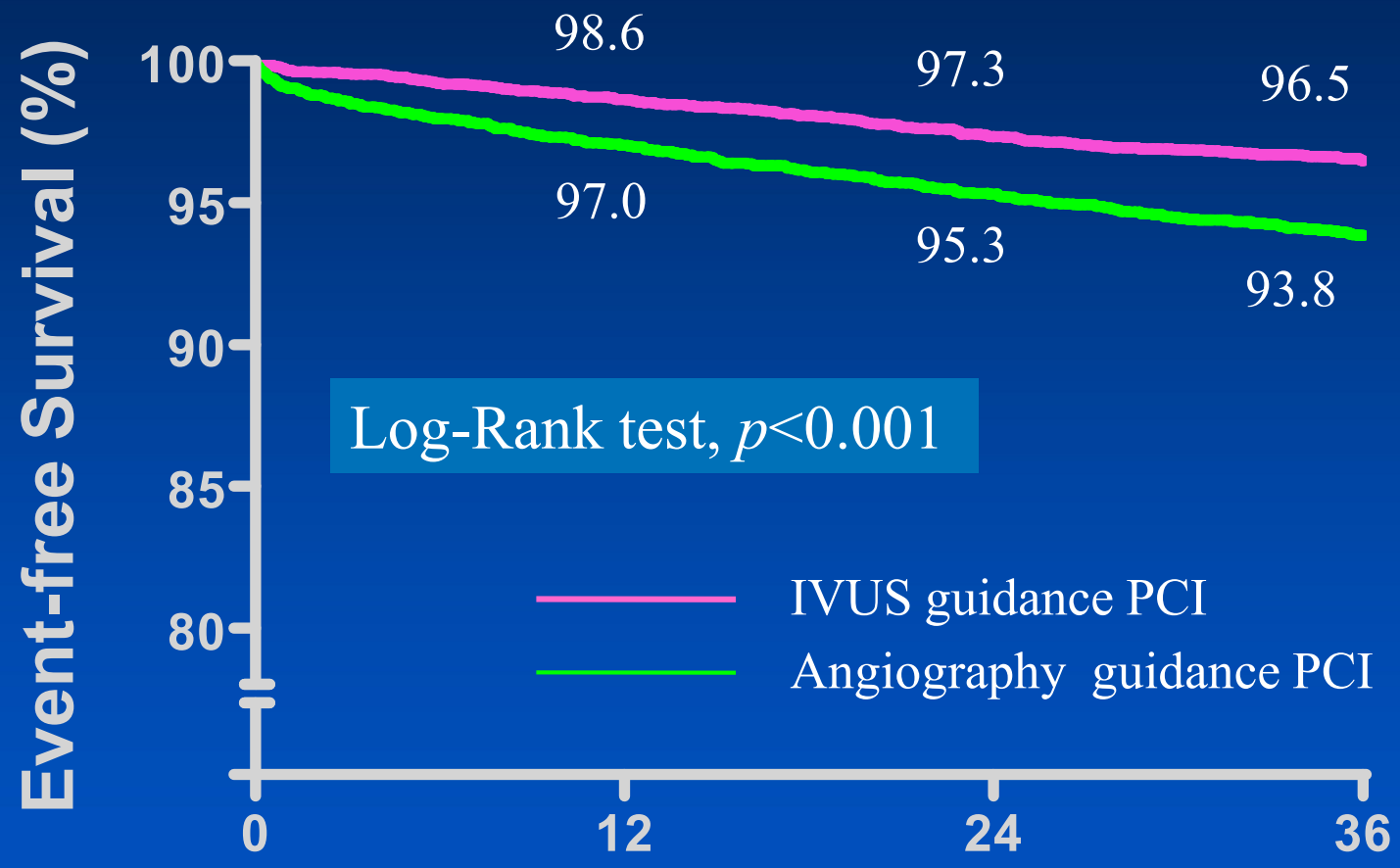


All cause death, MI, TVR, Stent thrombosis, MACE

Unadjusted K-M Curves

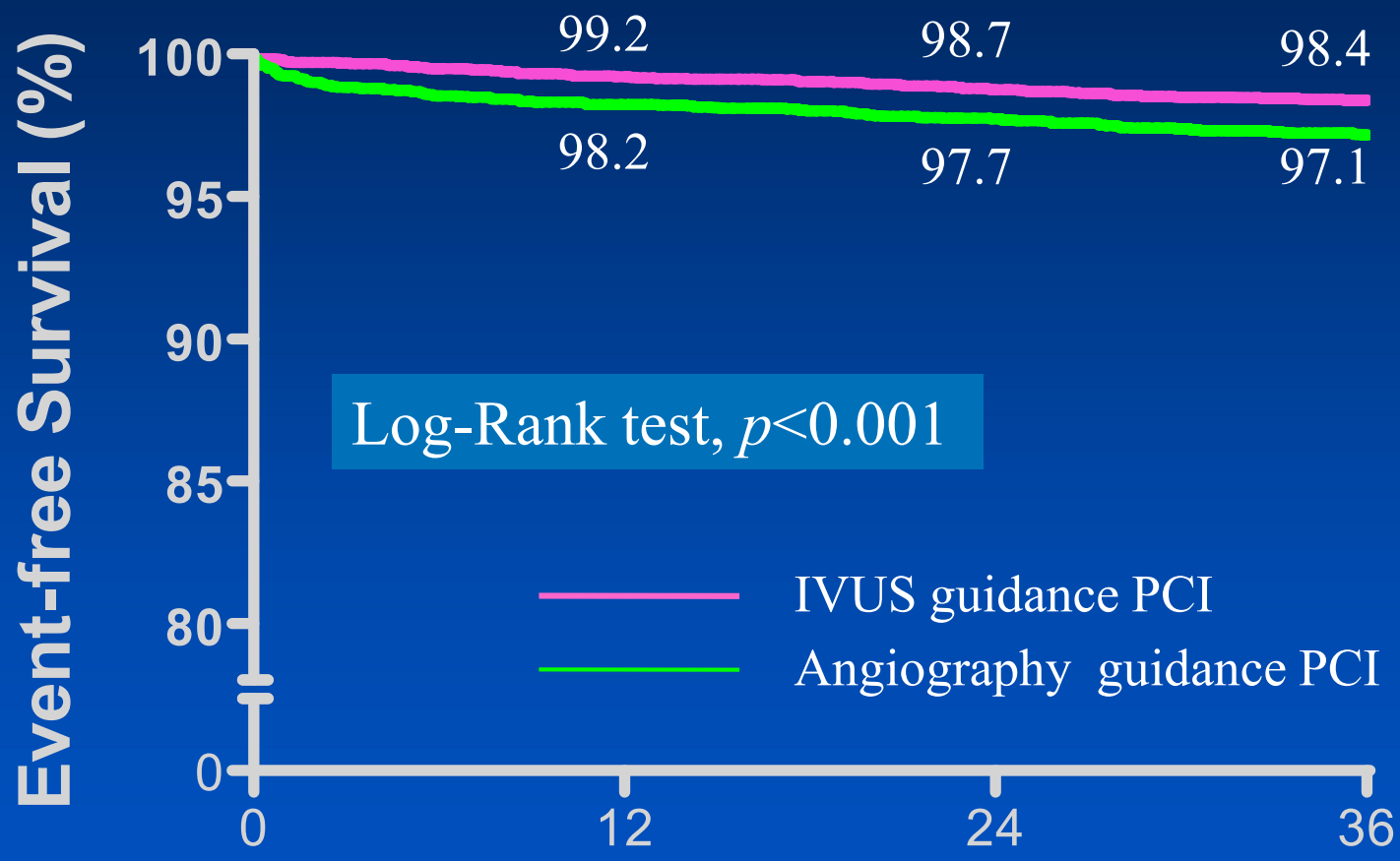
Death

Overall Population



Cardiac Death

Overall Population



Hazard Ratios of Clinical Outcomes

IVUS guidance vs. Angiography guidance

Overall Population

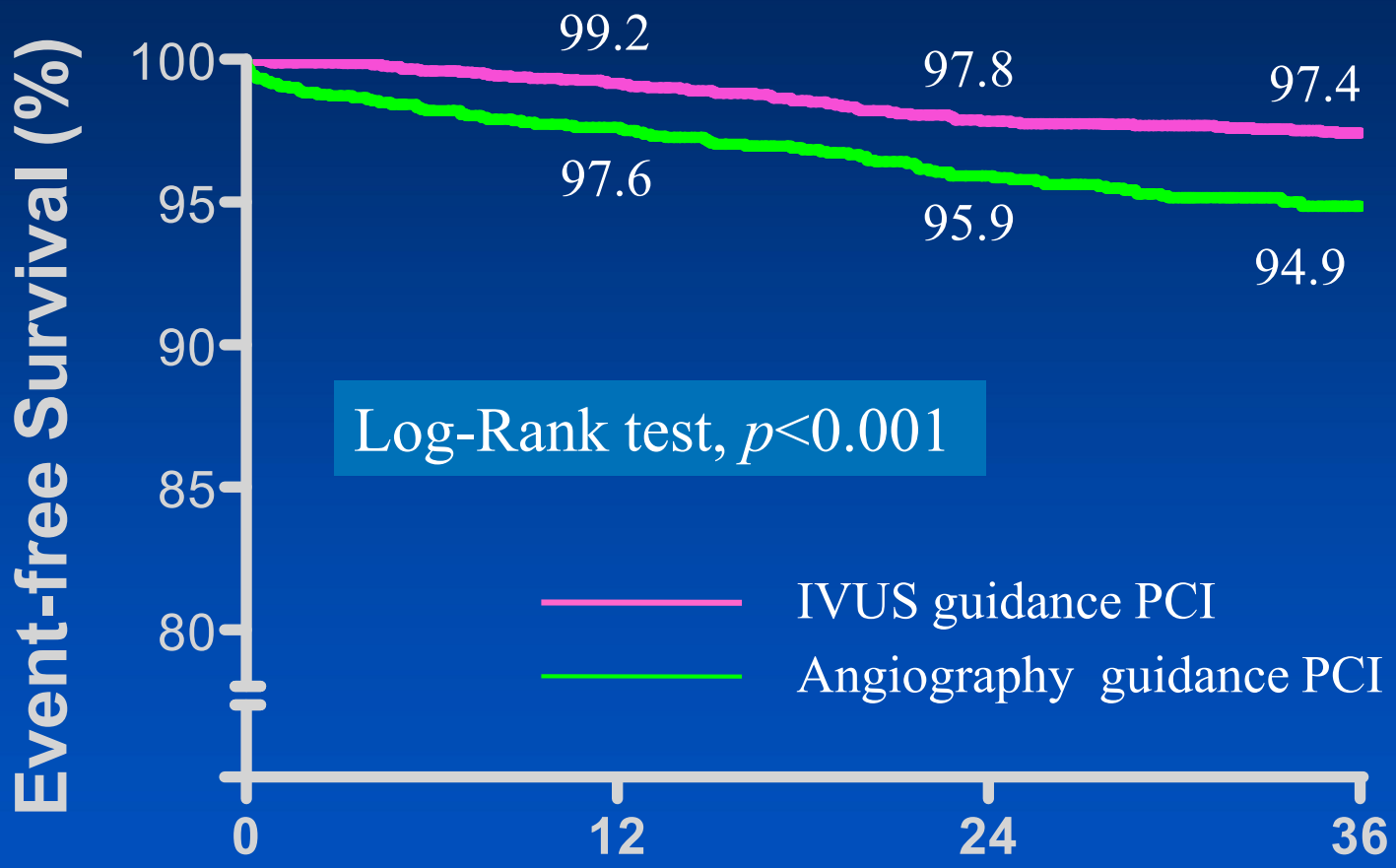
	Multivariate Adjusted HR (95% CI)	*p*	Adjusted for Propensity HR (95% CI)	*p*
Death	0.49 (0.34-0.71)	<0.01	0.66 (0.53-0.83)	<0.01
Cardiac death	0.46 (0.28-0.76)	<0.01	0.58 (0.41-0.81)	<0.01
MI	1.01 (0.65-1.58)	0.96	1.08(0.71-1.63)	0.73
TVR	0.97 (0.83-1.13)	0.66	1.05 (0.90-1.22)	0.54
ST	0.87(0.60-1.27)	0.48	0.83 (0.58-1.17)	0.29
MACE	0.89 (0.77-1.02)	0.09	0.92 (0.81-1.05)	0.21

DES Population

N = 4581 Patients

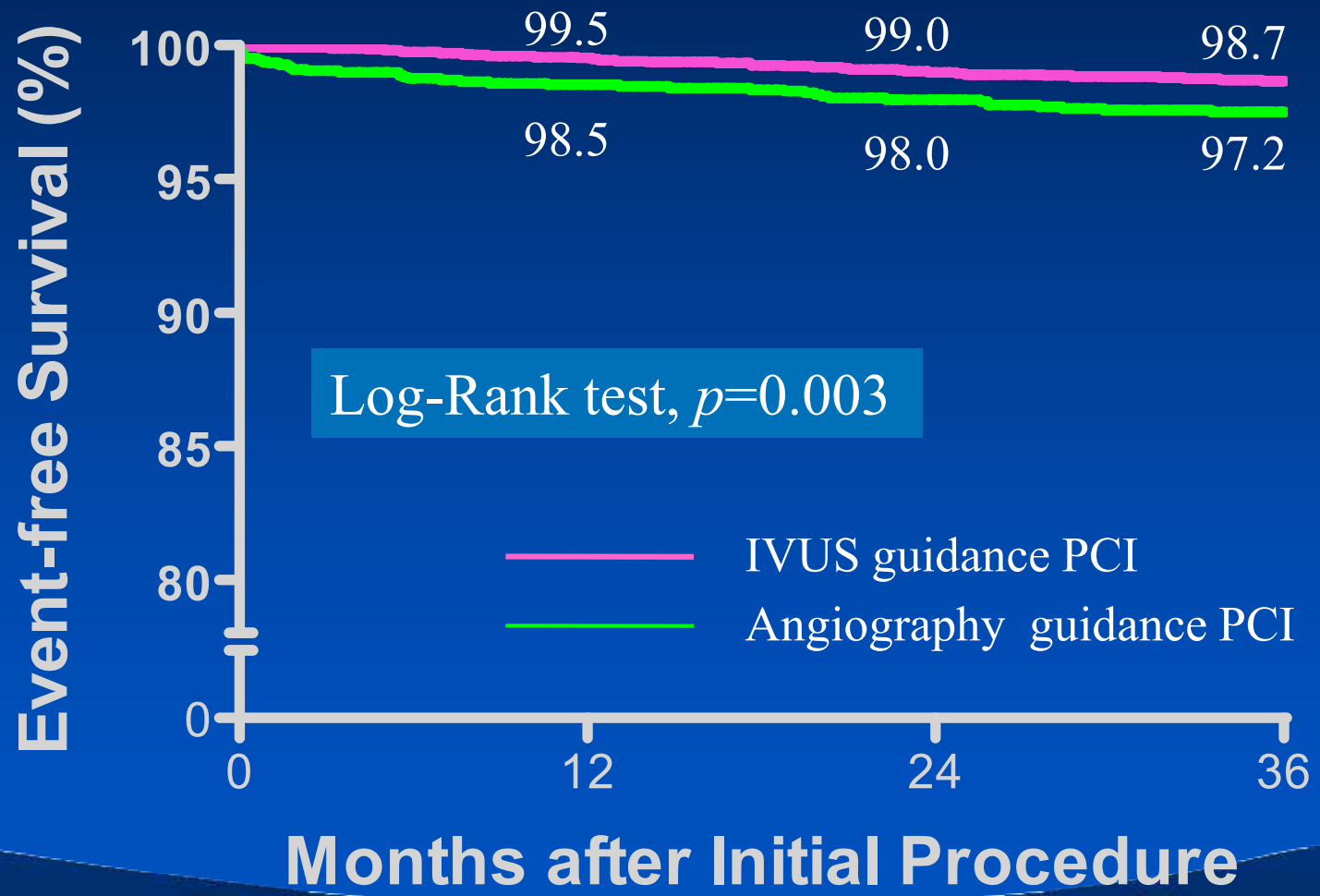
Death

DES Population



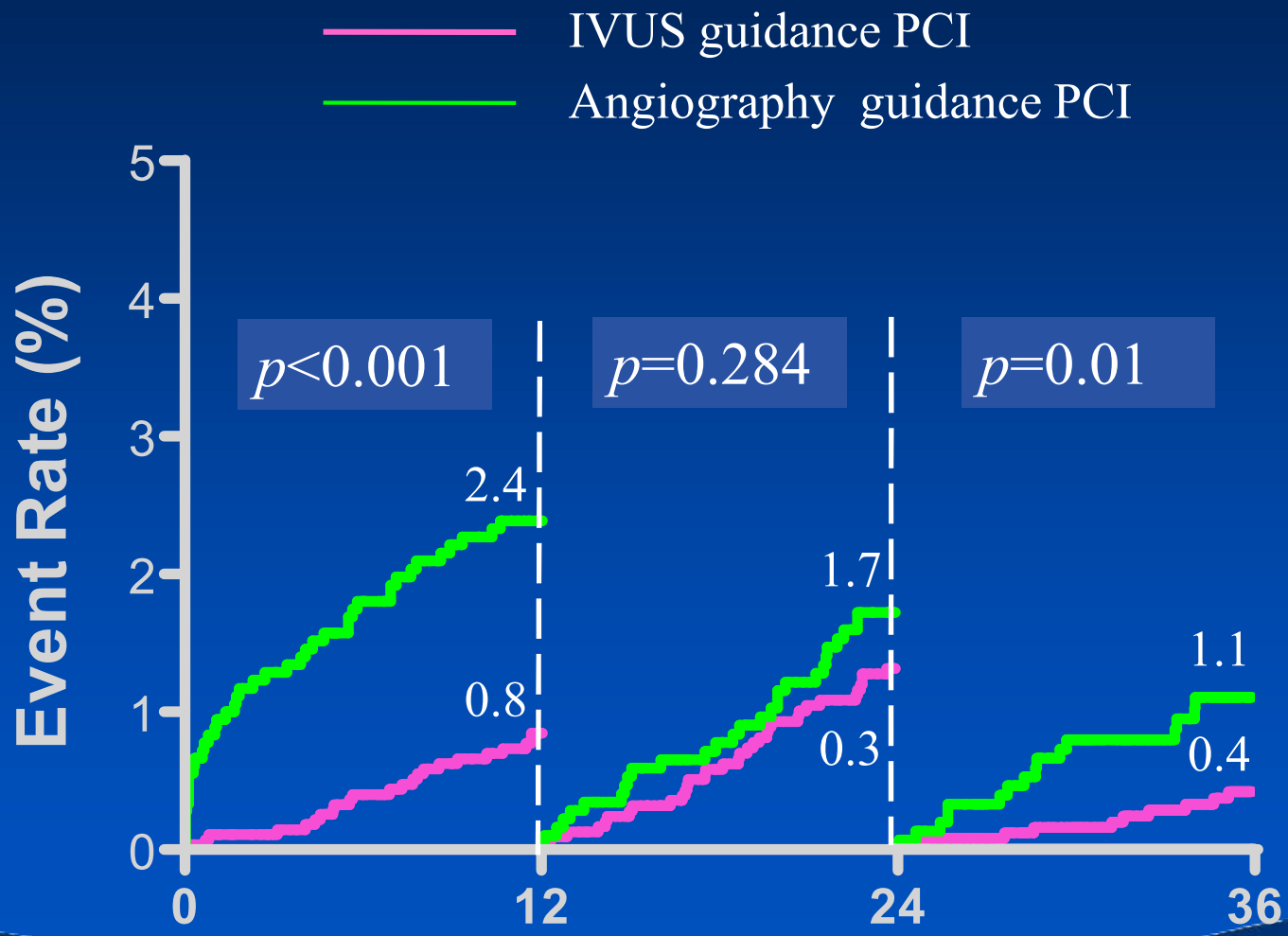
Cardiac Death

DES Population



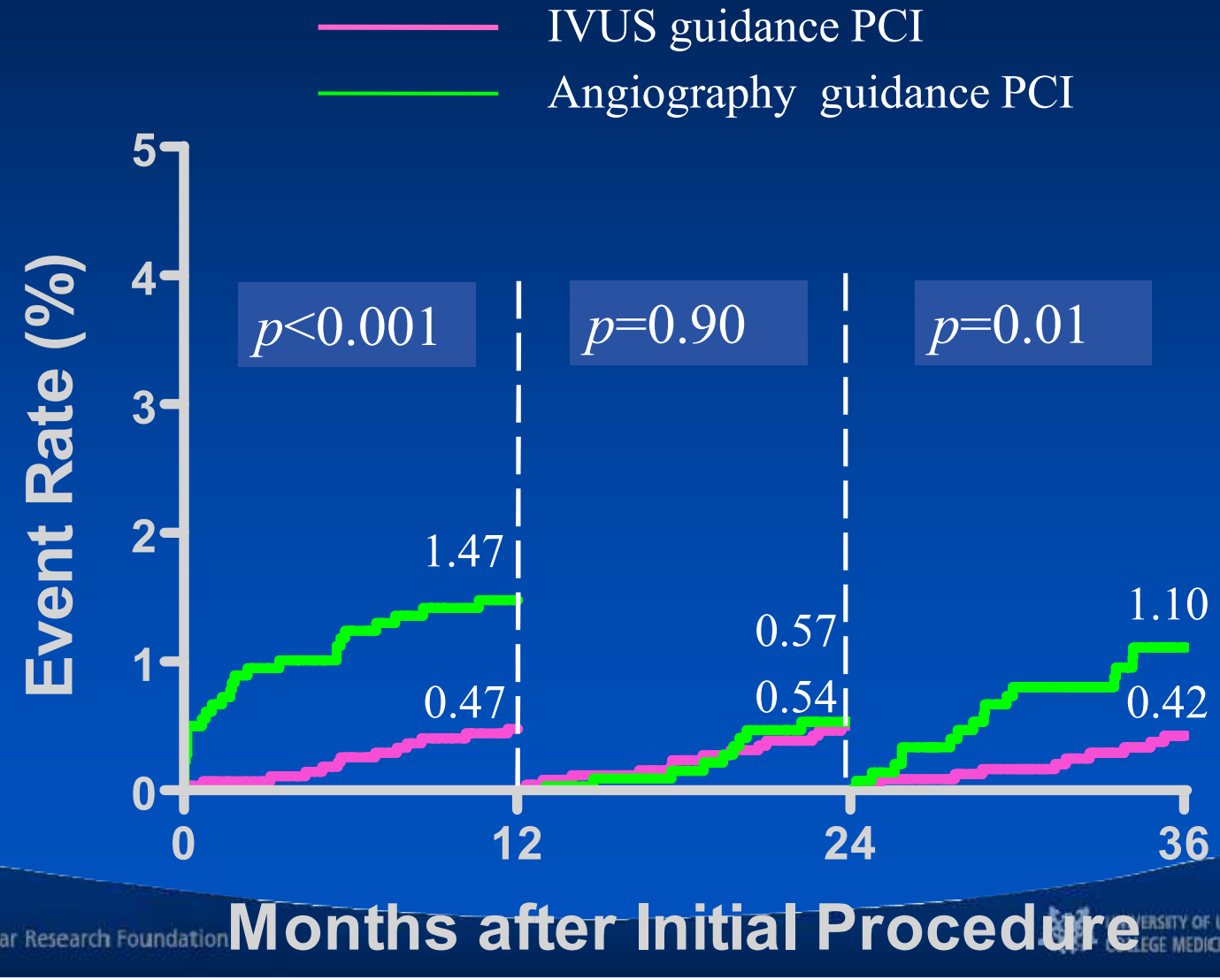
Death

DES Population



Cardiac Death

DES Population



Hazard Ratios of Clinical Outcomes

IVUS guidance vs. Angiography guidance

DES Population

	Multivariate Adjusted HR (95% CI)	*p*	Adjusted for Propensity HR (95% CI)	*p*
Death	0.52 (0.37-0.73)	<0.01	0.50 (0.36-0.70)	<0.01
Cardiac death	0.46 (0.28-0.76)	<0.01	0.47 (0.29-0.75)	<0.01
MI	0.43 (0.16-1.14)	0.09	0.21 (0.28-1.32)	0.21
TVR	1.00 (0.75-1.34)	0.99	1.04 (0.80-1.35)	0.79
ST	0.87 (0.52-1.47)	0.61	0.77 (0.48-1.23)	0.28
MACE	0.75 (0.60-0.95)	0.01	0.78 (0.64-0.95)	0.01

Although we have the limitation of registry data, 45-50 % relative reduction of cardiac mortality in IVUS guided procedure is very substantial in the era of DES.

BMS Population

N = 3790 Patients

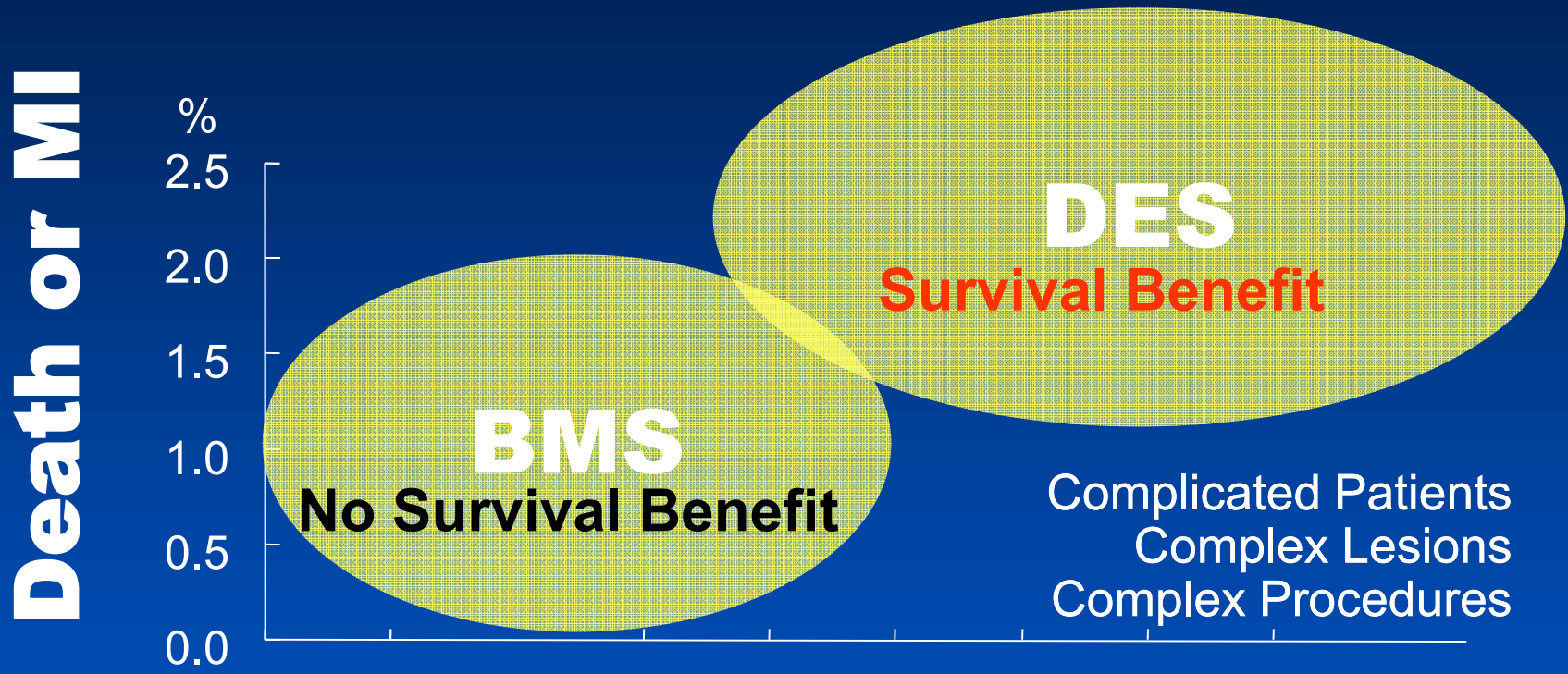
Hazard Ratios of Clinical Outcomes

IVUS guidance vs. Angiography guidance

BMS Population

	Multivariate Adjusted HR (95% CI)	*p*	Adjusted for Propensity HR (95% CI)	*p*
Death	0.88 (0.64-1.21)	0.42	0.85 (0.62-1.16)	0.31
Cardiac death	0.96 (0.58-1.58)	0.86	1.42 (0.88-2.33)	0.16
MI	1.43 (0.87-2.36)	0.16	1.36 (0.83-2.24)	0.22
TVR	1.14 (0.95-1.38)	0.15	1.13 (0.94-1.36)	0.18
ST	0.98 (0.57-1.67)	0.93	0.96 (0.56-1.63)	0.87
MACE	1.09 (0.92-1.30)	0.31	1.08 (0.91-1.28)	0.38

IVUS Guidance gives…



Paradigm Shift in the era of DES

IVUS guided procedure
in the era of DES -Various Registry data-

Constantly reduced long-term mortality !

IVUS guided procedures have Better Survival…

Can you explain this ?

Small difference made by IVUS guidance can make a big difference in the late clinical outcomes.

How can we make a small difference using the IVUS guidance in real practice ?

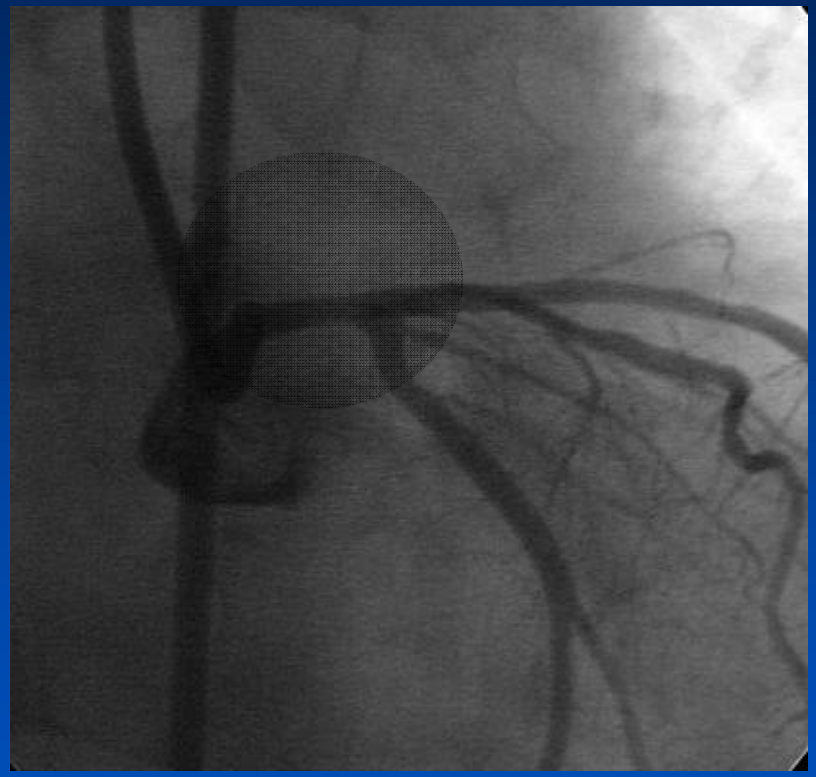
Usefulness of IVUS study

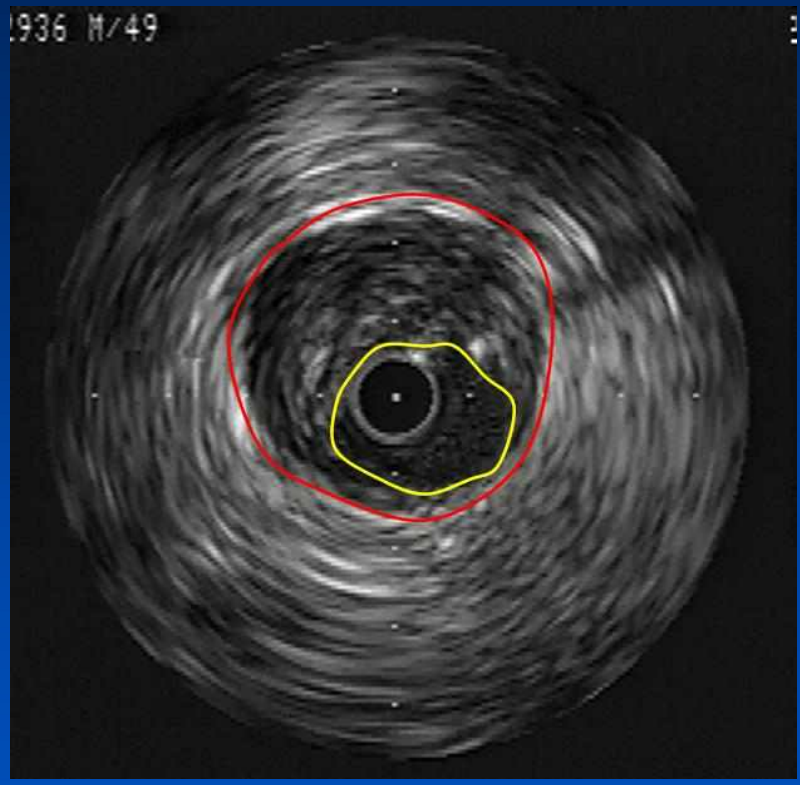
We can make a small difference

- Treat or not treat
  (Intermediate lesion evaluation, Ostial lesion assessment, LM bifurcation PCI)
- Measurement of MLA, lesion length, reference VD, degree of remodeling
- Plaque characterization
- Procedure Optimization

Treat or not Treat

Big discrepancy !

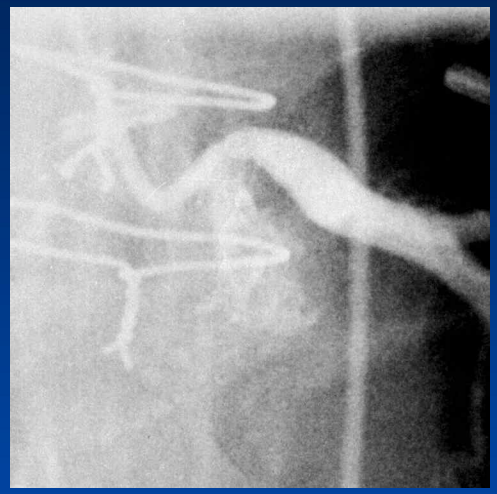


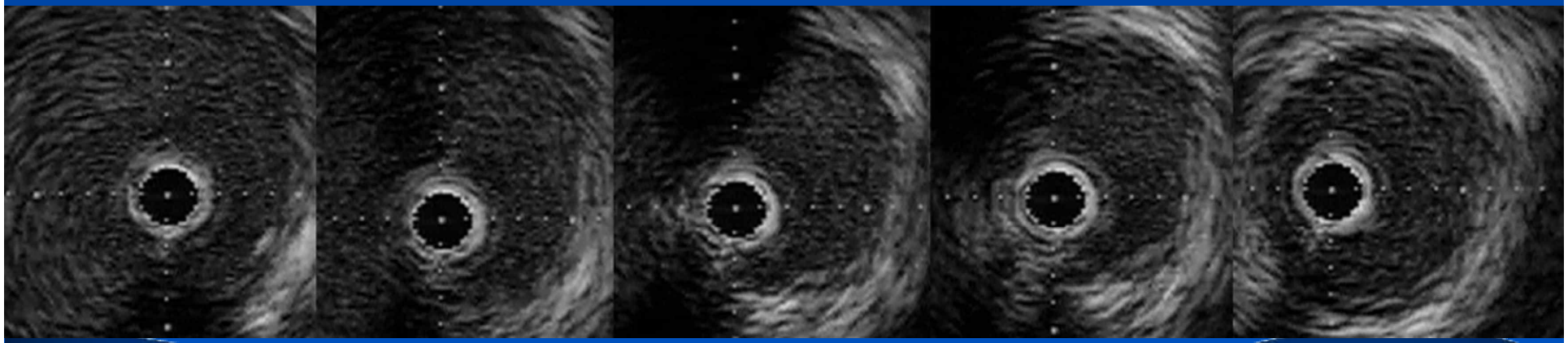


EEM : 14.04 mm^2
Lumen : 3.2 mm^2
Area stenosis : 71.5%

Treat or not Treat

Big discrepancy !





0 → 1.0 → 4.0mm

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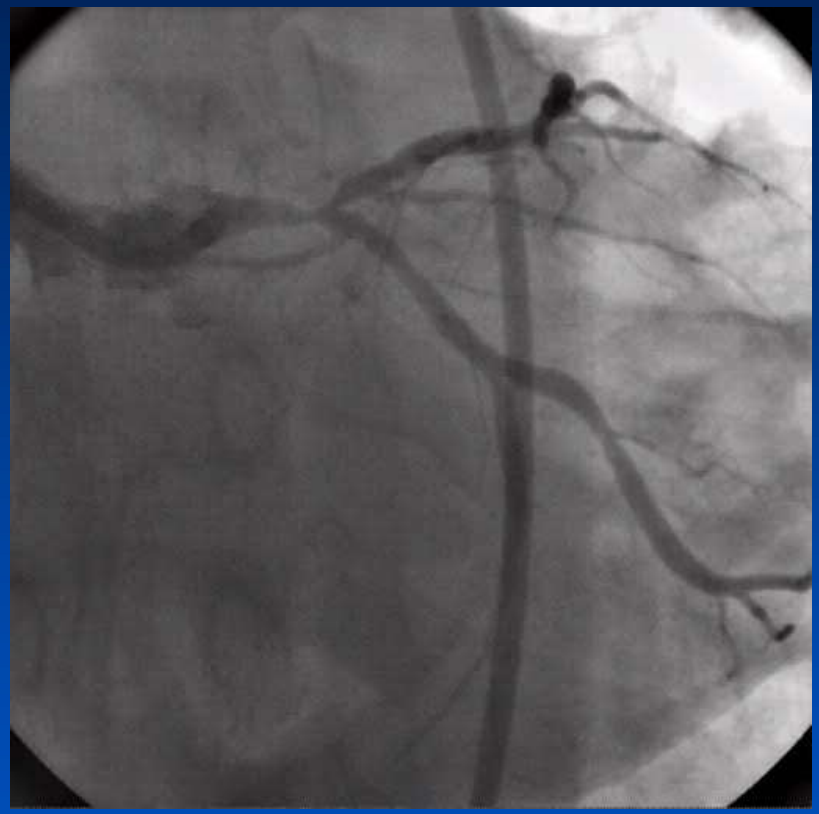
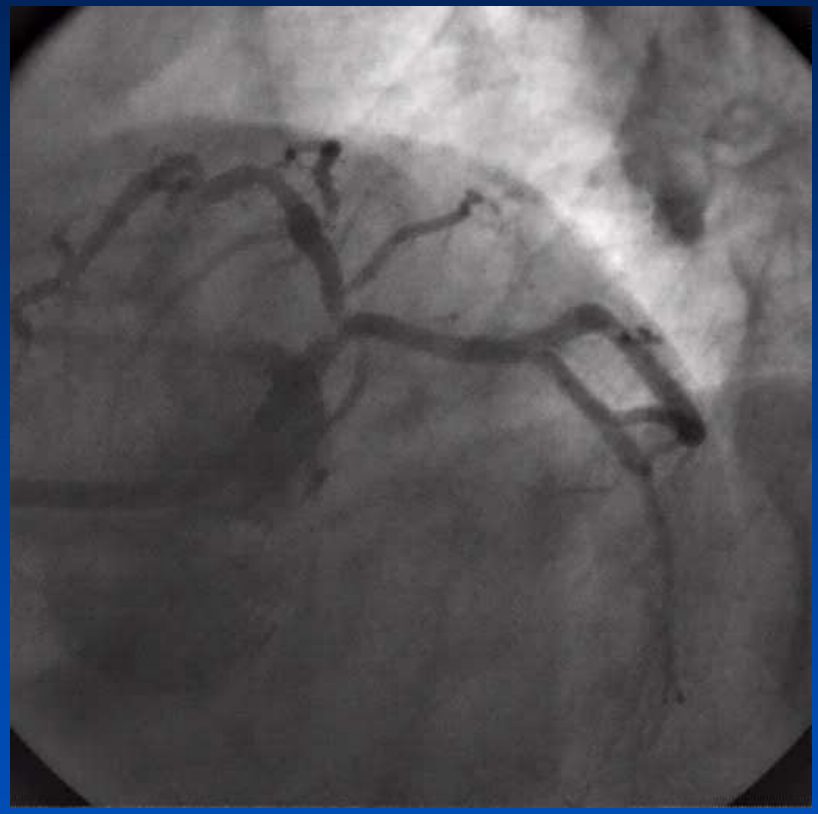
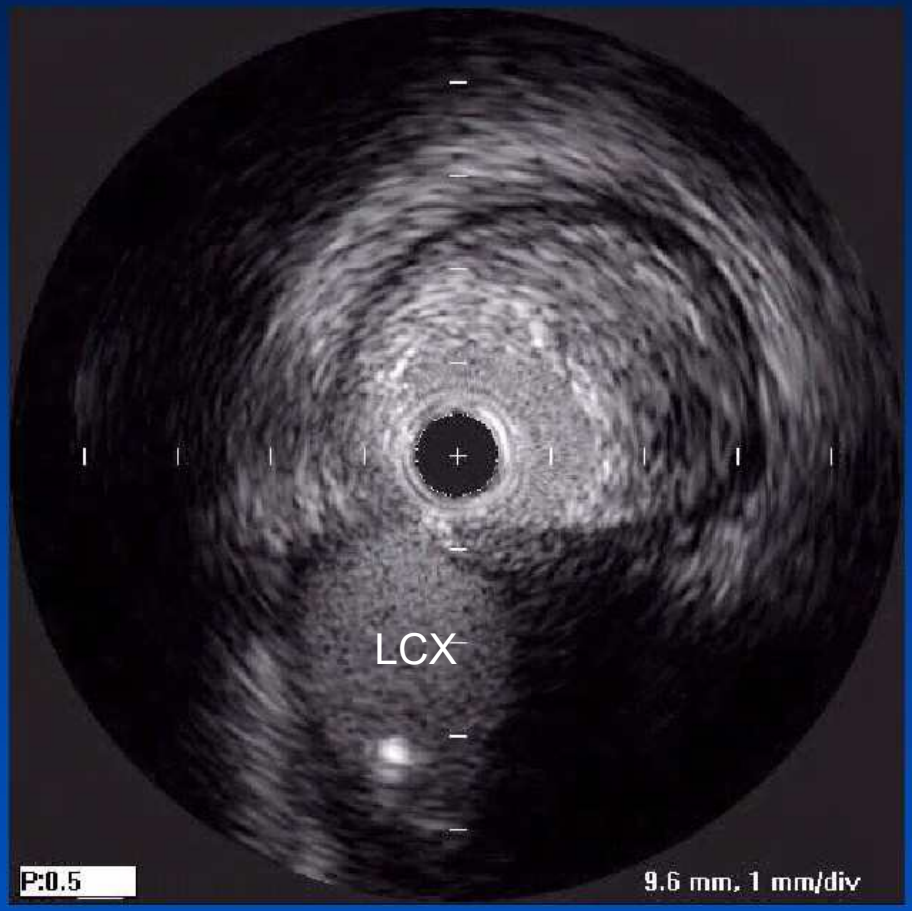
Treat or not Treat



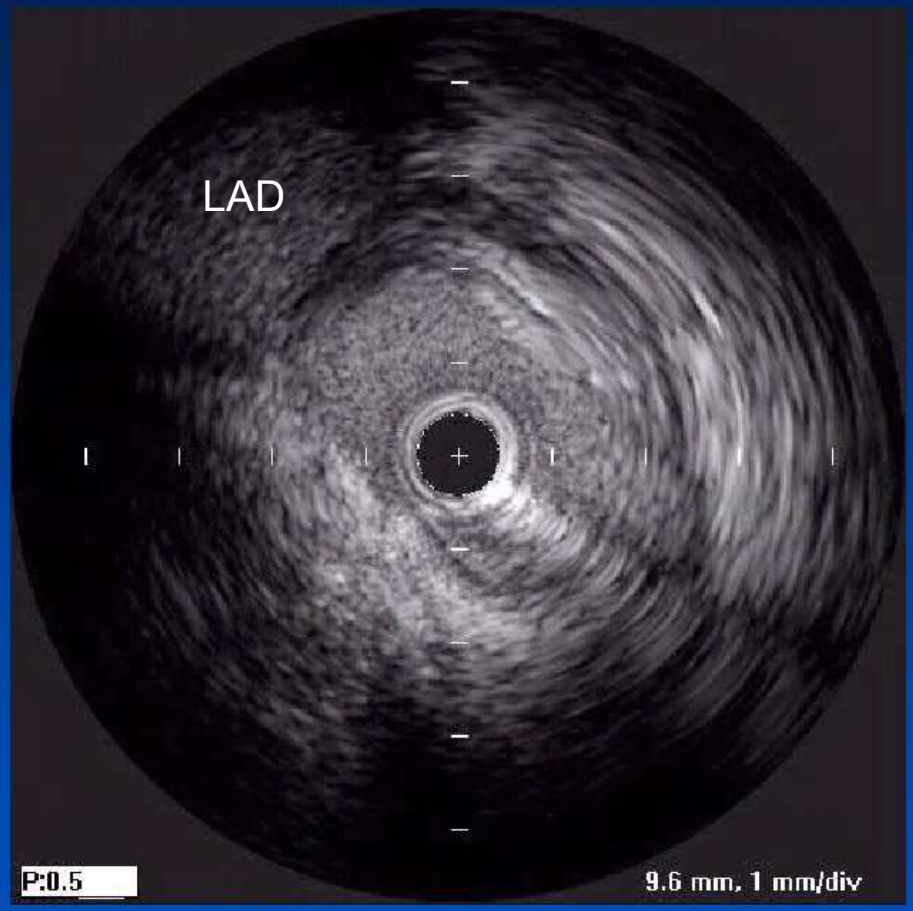


2 stent or 1 stent ?

IVUS evaluation before stenting showed Minimal-disease on the LCX OS…

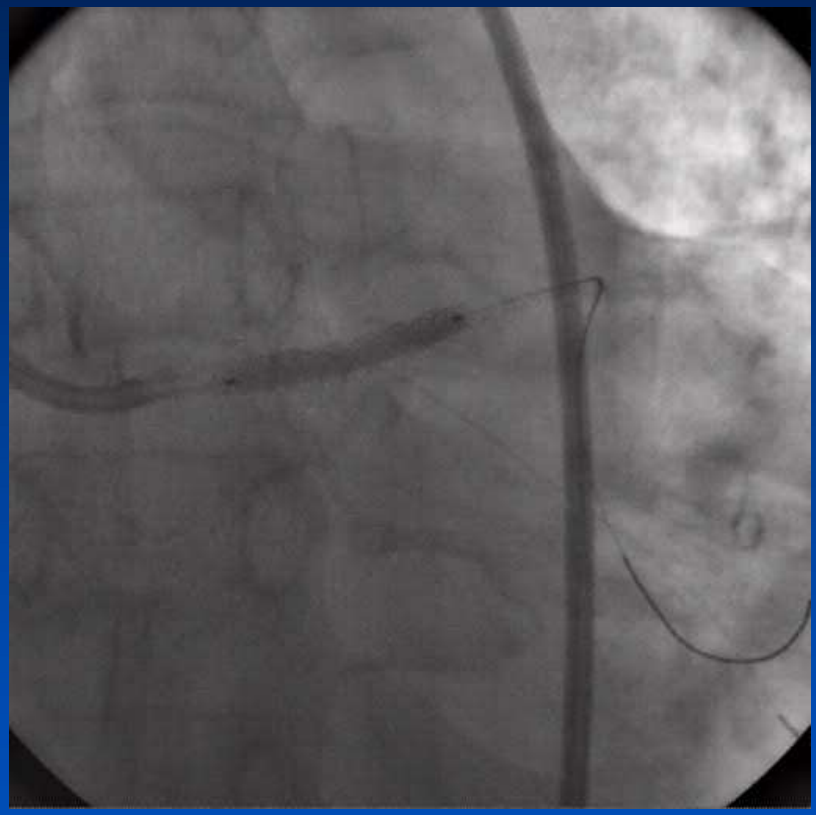


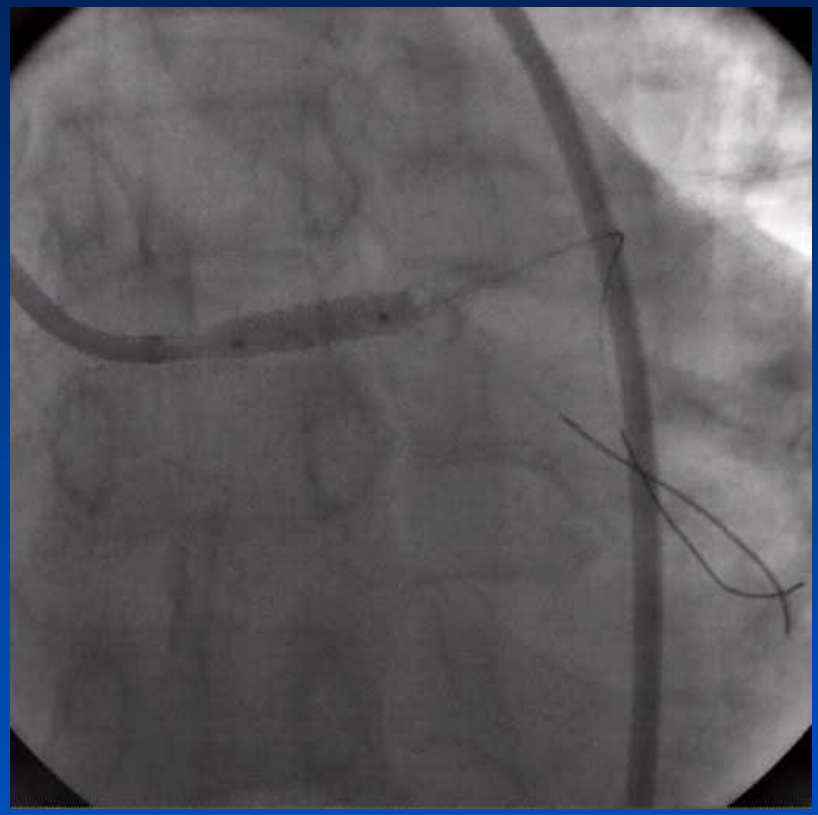
LAD Ostium



LCX Ostium

Single Stenting Cross-Over
with minimal-disease at LCX OS

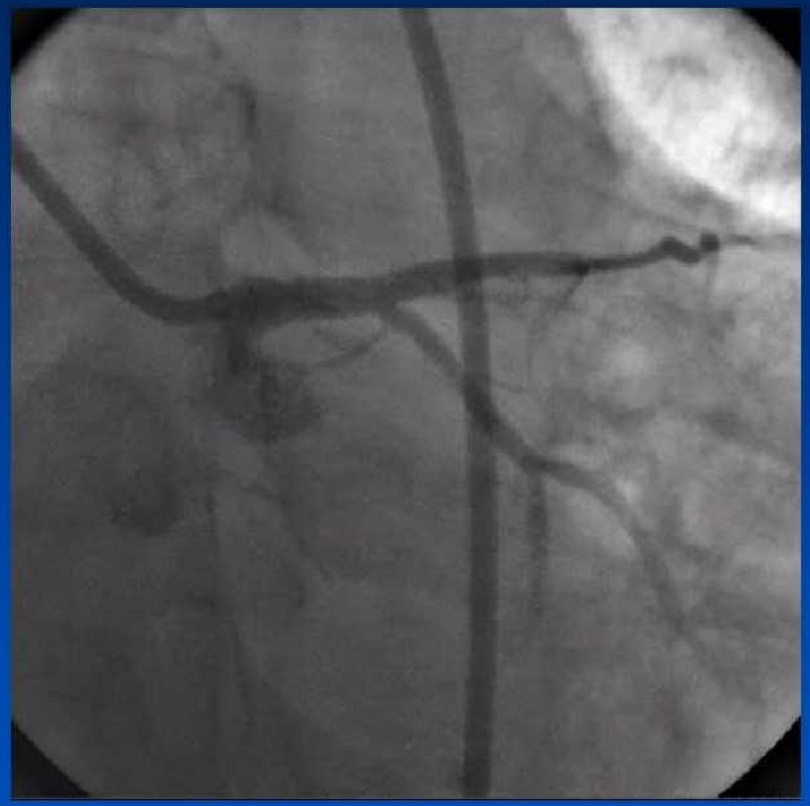




Cypher 3.5 × 23 mm

Additional high pressure
Inflation with 4.0 mm
Non-compliant balloon

Single Stenting Cross-Over
with minimal-disease at LCX OS

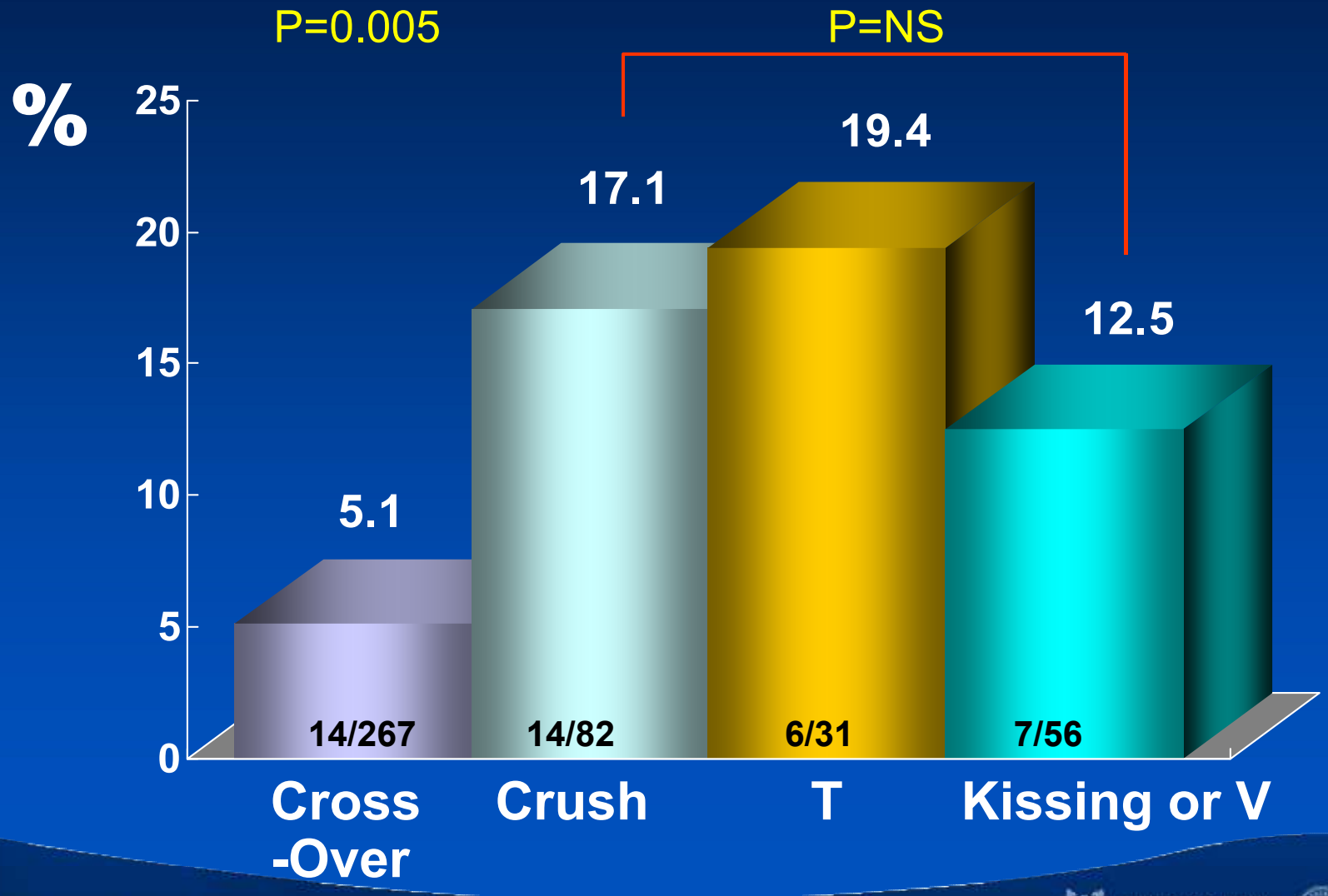


Perfect Result !

I can avoid two stents technique under the IVUS guidance.

I can make a small difference !!

TLR at 4 year



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Data from MAIN COMPARE Registry

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Usefulness of IVUS study

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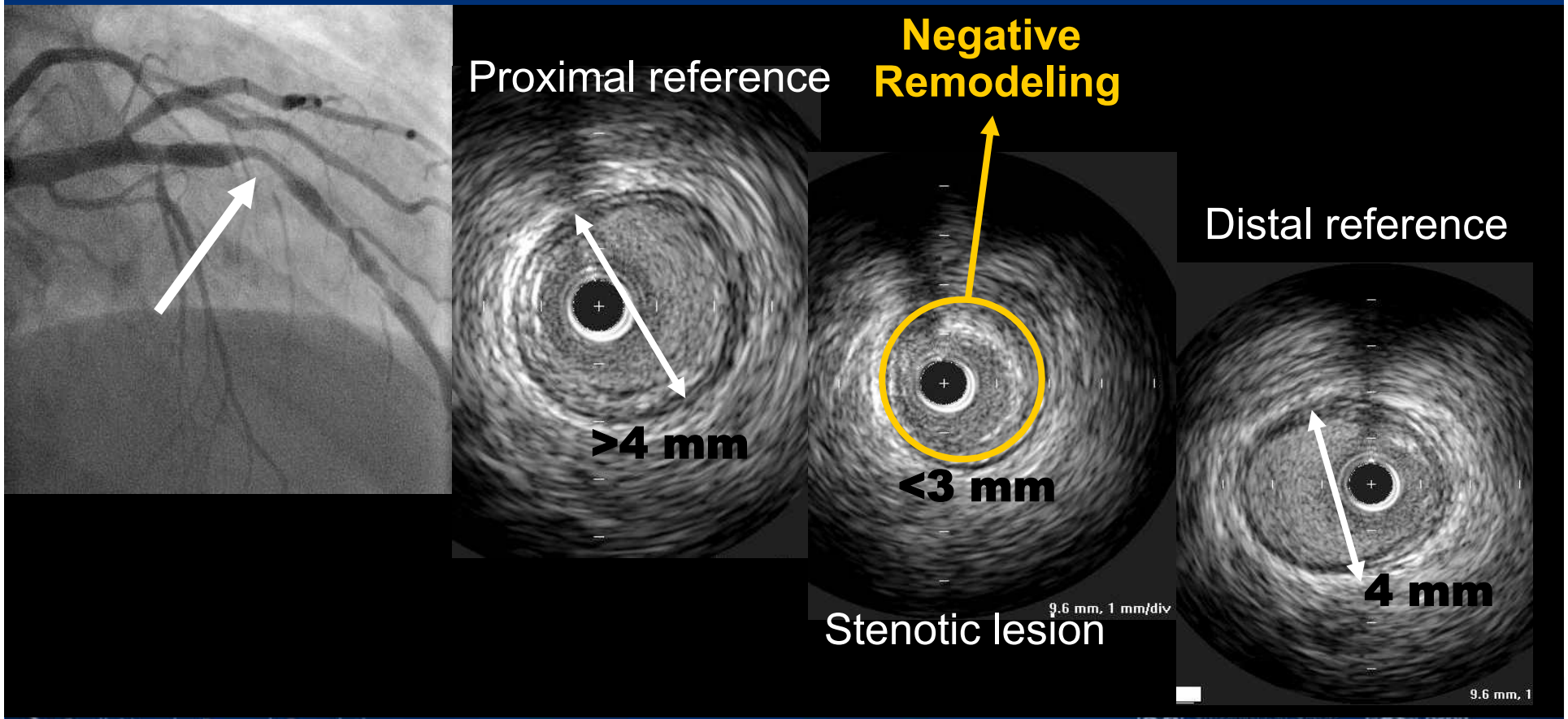
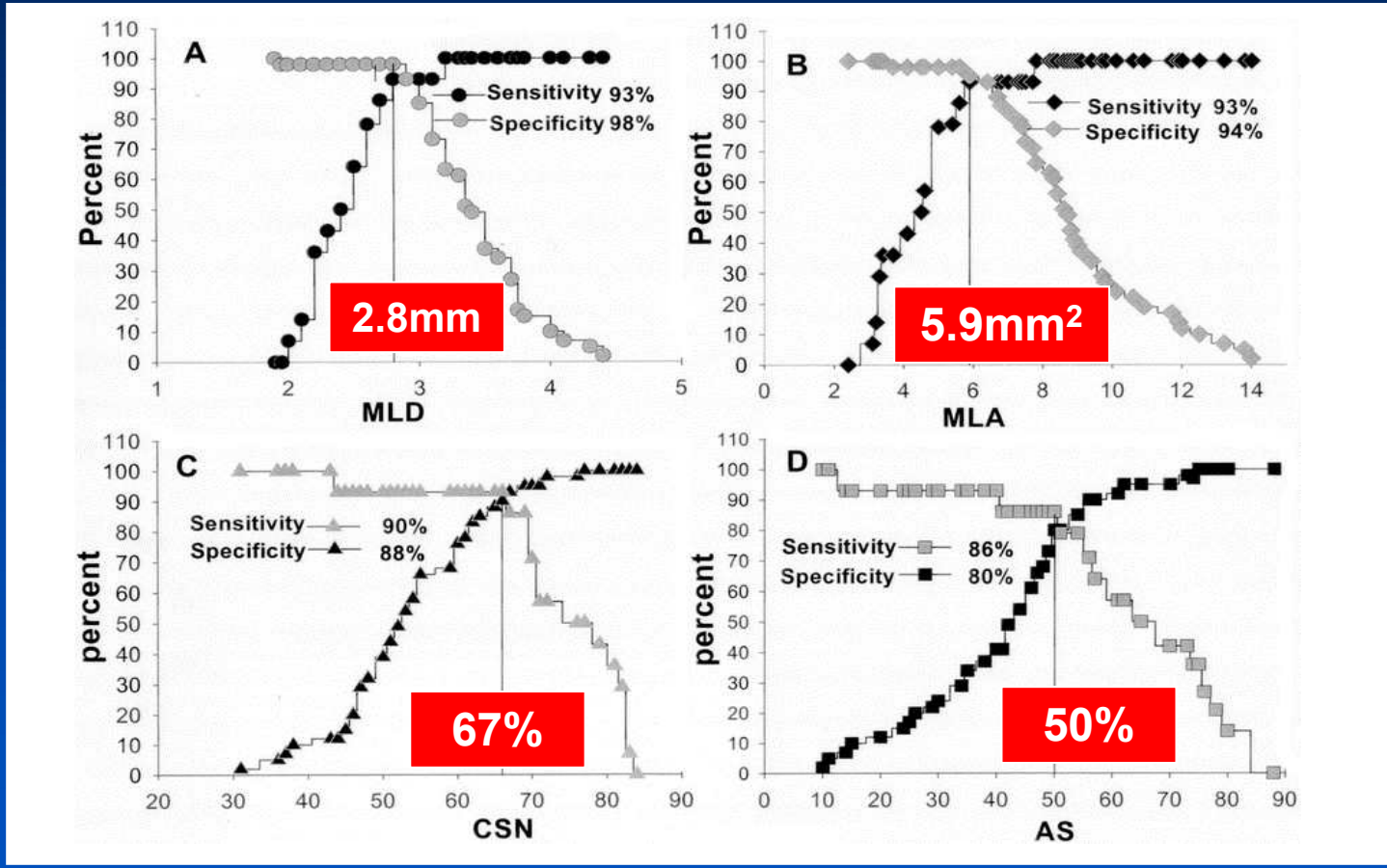
Real estimation of

the reference vessel diameter, MLA, lesion length and degree of remodeling are important to choose appropriate stent size.



Left Main disease
MLA < 6.0 mm^2

Prediction of FFR (0.75) with IVUS parameter



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

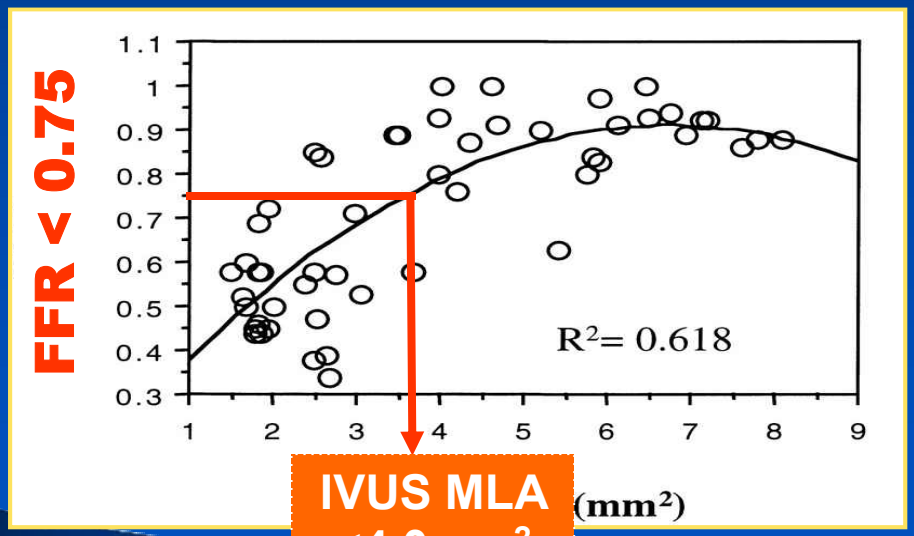
Epicardial Artery disease
MLA < 4.0 mm^2

	IVUS MLA ≥4.0mm^2	IVUS MLA <4.0mm^2
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 ≥4.0mm^2	IVUS MLA <4.0mm^2
+ 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

Usefulness of IVUS study

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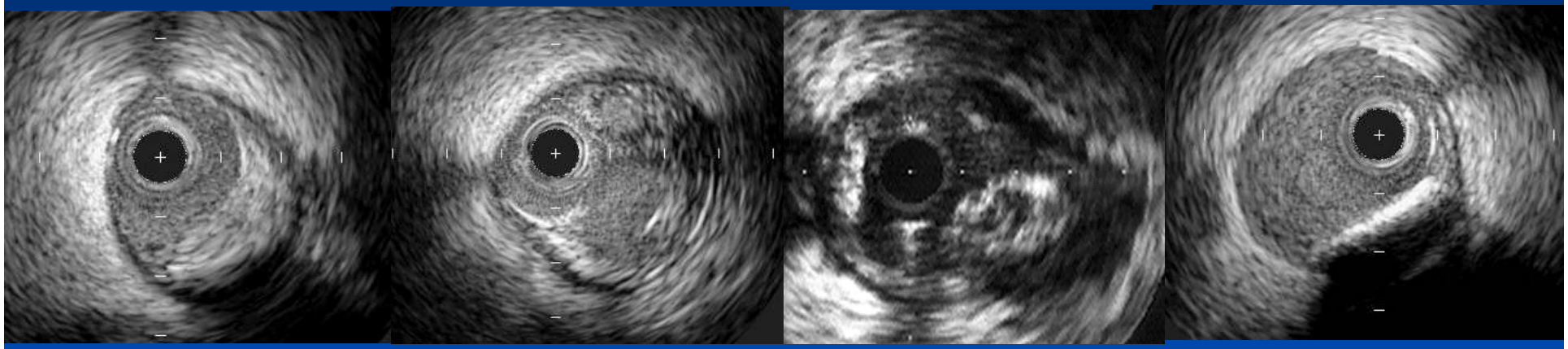
- Plaque characterization

Plaque characterization is important.

We need some plaque modification for calcific lesions and some pre-treatment for vulnerable plaque.



Fibrous plaque **Plaque rupture** **Thrombi** **Calcification**

Usefulness of IVUS study

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IVUS predictors
of Angiographic Restenosis

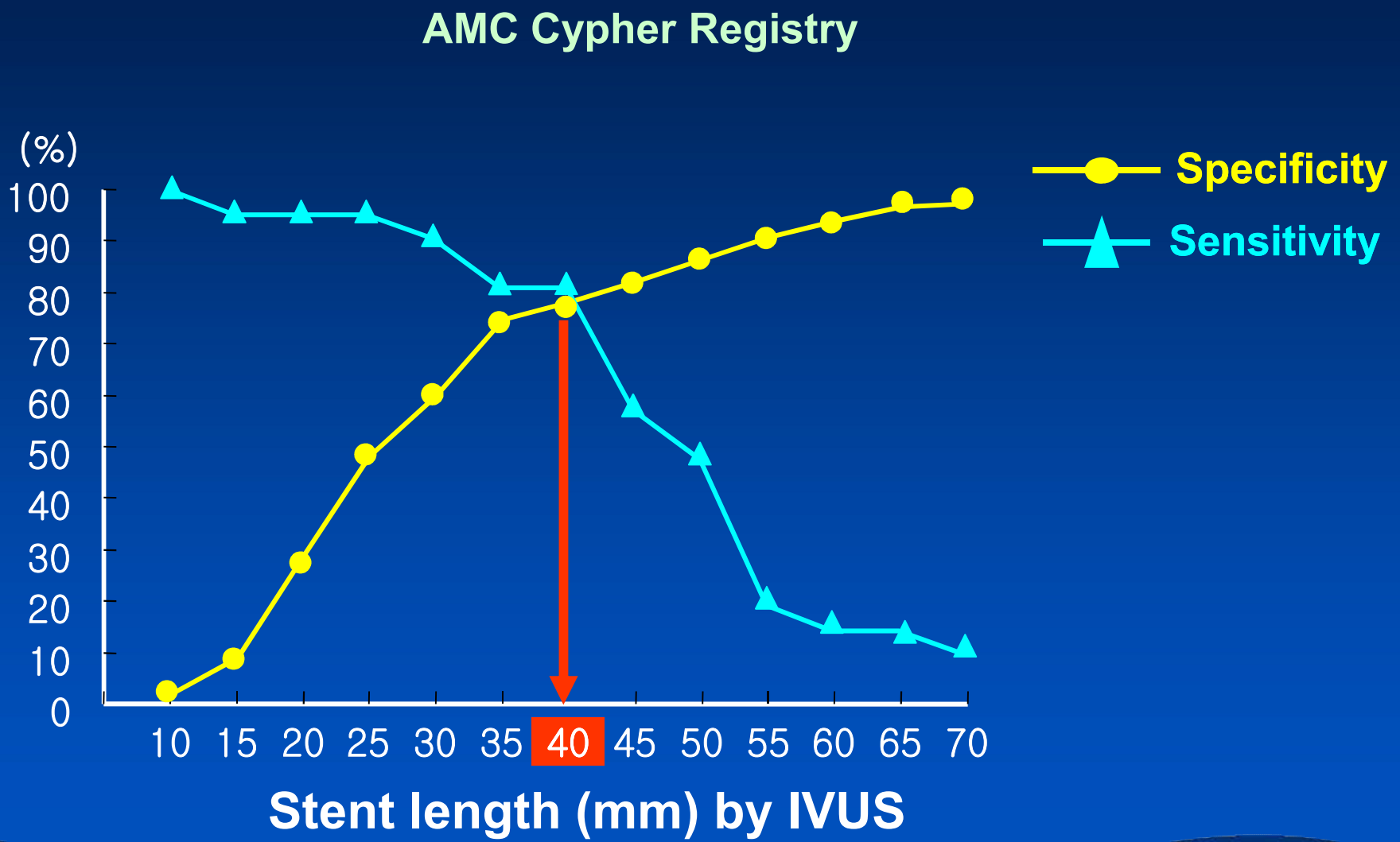
Stent CSA
Total stent length

odds ratio=0.584, 95% CI 0.385–0.885, p=0.011
odds ratio=1.028, 95% CI 1.002–1.055, p=0.038

Park, DW. AJC 2006;98:353-356, **AMC data**
Hong MK, Eur Heart J, 2006:27:1305, **AMC data**

How Long **stented Length and *How Big* stent CSA would be good for the long-term outcomes in real practice ?**

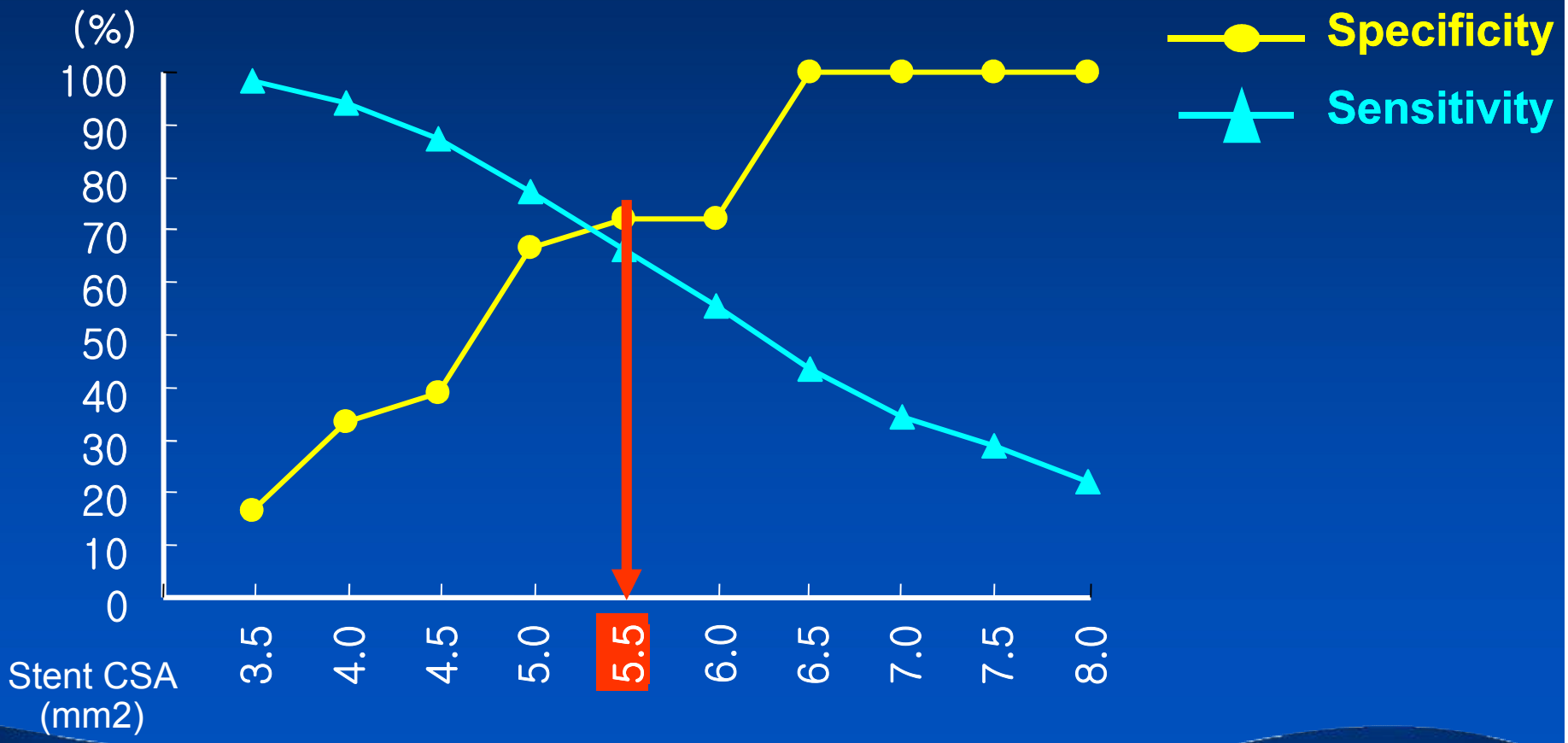
Epicardial Artery disease
Total stent length < 40 mm



Hong MK, Eur Heart J, 2006:27:1305,

Epicardial Artery disease
Stent CSA > 5.5 mm²

AMC Cypher Registry



Hong MK, Eur Heart J, 2006:27:1305

Restenosis Rate according to Stented Length and Stent CSA by **IVUS**

AMC Cypher Registry

Stent length (mm)		Stent area (mm^2)	Restenosis Rate	*P* value
≤ 40	and	≥ 5.5	1/284 (0.4%)	
≤ 40	or	< 5.5	3/127 (2.4%)	*P* <0.001
> 40	or	≥ 5.5	6/ 70 (8.6%)	
> 40		< 5.5	11/62 (17.7%)	

Restenosis Rate according to Stented Length by **QCA**

AMC Cypher Registry

	Restenosis (n=20)	No Restenosis (n=257)
Stented length ≥ 46 mm	14 (13.5%)	90 (86.5%)
Stented length < 46 mm	6 (3.5%)	167 (96.5%)

Sensitivity = 70%, Specificity = 65%, Positive predictive value = 14%,
Negative predictive value = 97%

IVUS Guidance in Real Practice (Rule of 5)

How Big **stent CSA : > 5.5 mm2**
How Long **stented length : <50 mm**

< 5% TLR rate

Why IVUS guided ?

A small difference made by IVUS guidance can make a big difference in late clinical outcomes – SURVIVAL BENEFIT !

Old Issue
but New Insight !

Epicardial Artery disease
MLA < 4.0 mm²

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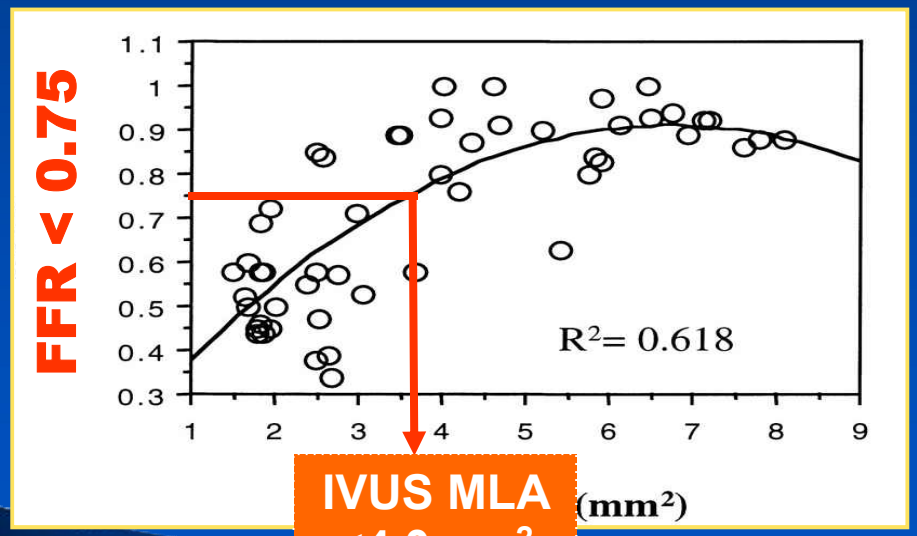


No doubt about it ?

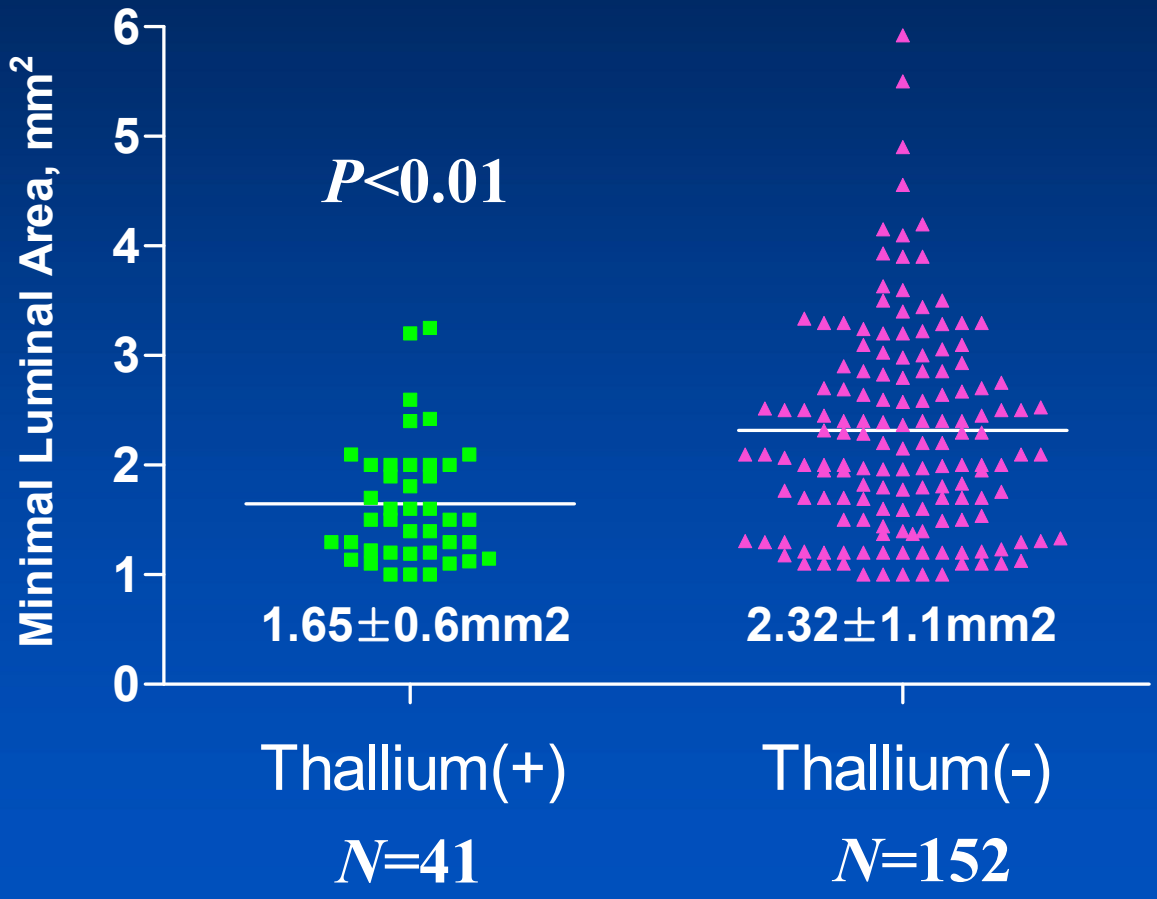
Takagi, et al. Circulation 1999;100:250-5

Old Issue
but New Insight !

We need re-validation of IVUS MLA for assessment of significant coronary stenosis; Comparison with Stress Myocardial Perfusion Imaging

Comparison study of IVUS and Thallium scan
AMC prospective cohort registry
Preliminary analysis, 2010 TCTAP

Distributions of MLA in all lesions (n=193 lesions, 156 pts)



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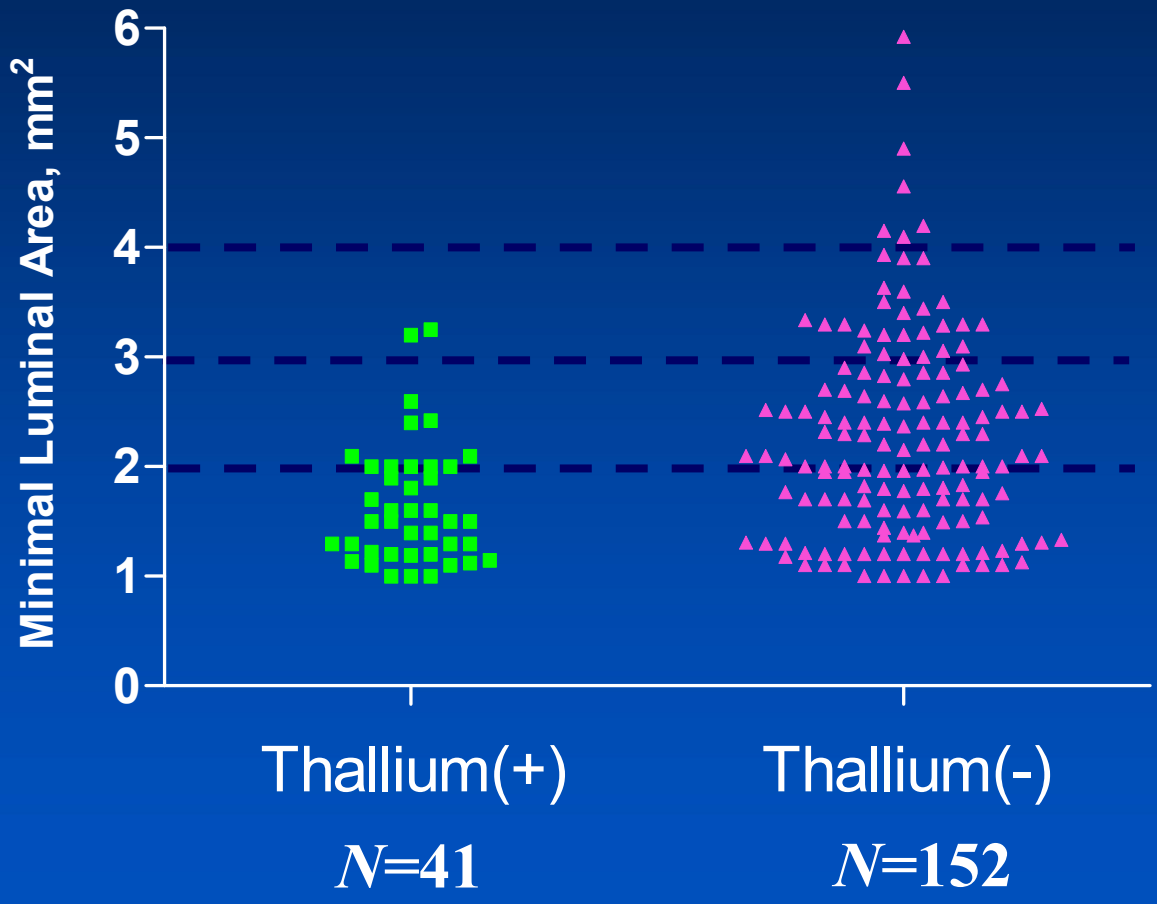
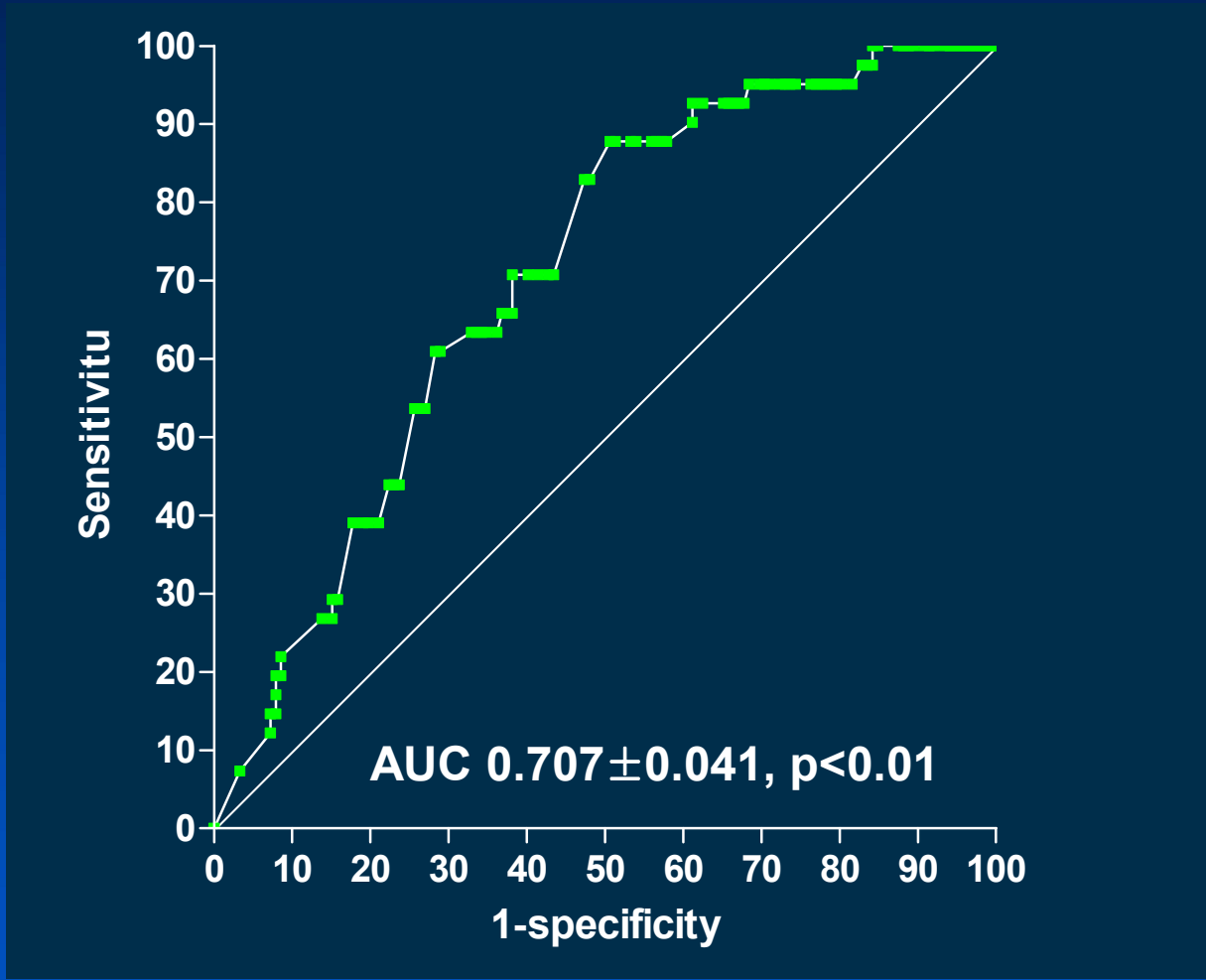
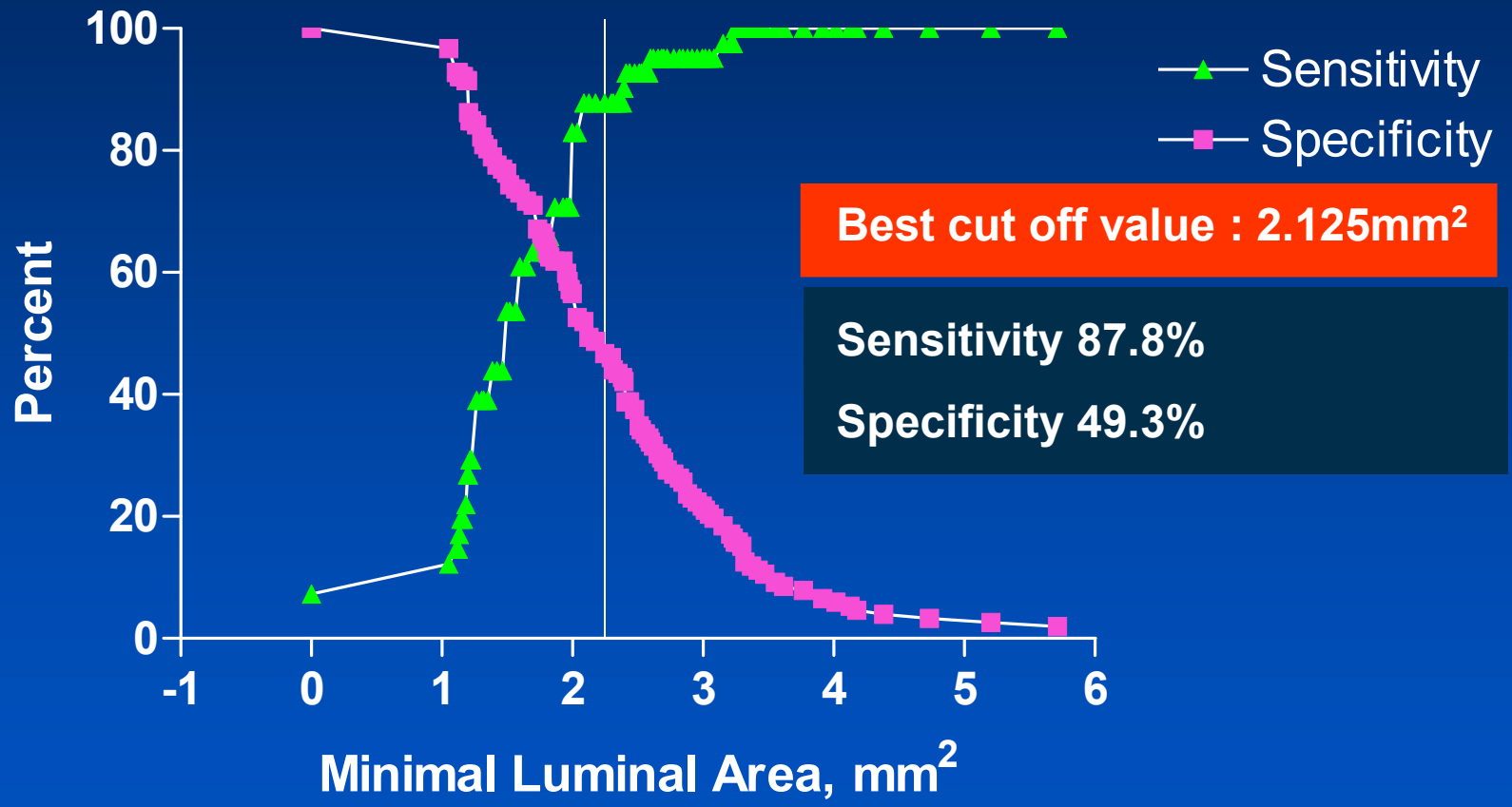


ROC curves for MLA measured by IVUS to discriminate thallium scan (+) and (-)



Plots for the sensitivity & specificity of MLA



If you compared the baseline IVUS findings, you may understand why previous cut-off values are so big.

	AMC 2010,preliminary	Briguori et al 2001,AJC	Takaki et al 1999,Circ	Abizaid et al 1998,AJC
No.	142	53	42	
FFR	0.85 ± 0.09			
MLA, mm^2	2.5±1.0	3.9±2.5	3.9±2.0	4.4±2.0
MVA, mm^2	10.9±4.5	12.0±4.6		13.2±4.4
Area stenosis %	65±16	65±18	55±24	43±24
Plaque burden %	75±10			
Cut-off of MLA mm^2	1.86 (FFR<0.8)	4.0 (FFR<0.75)	3.0 (FFR<0.75)	4.0 (CFR<2.0)

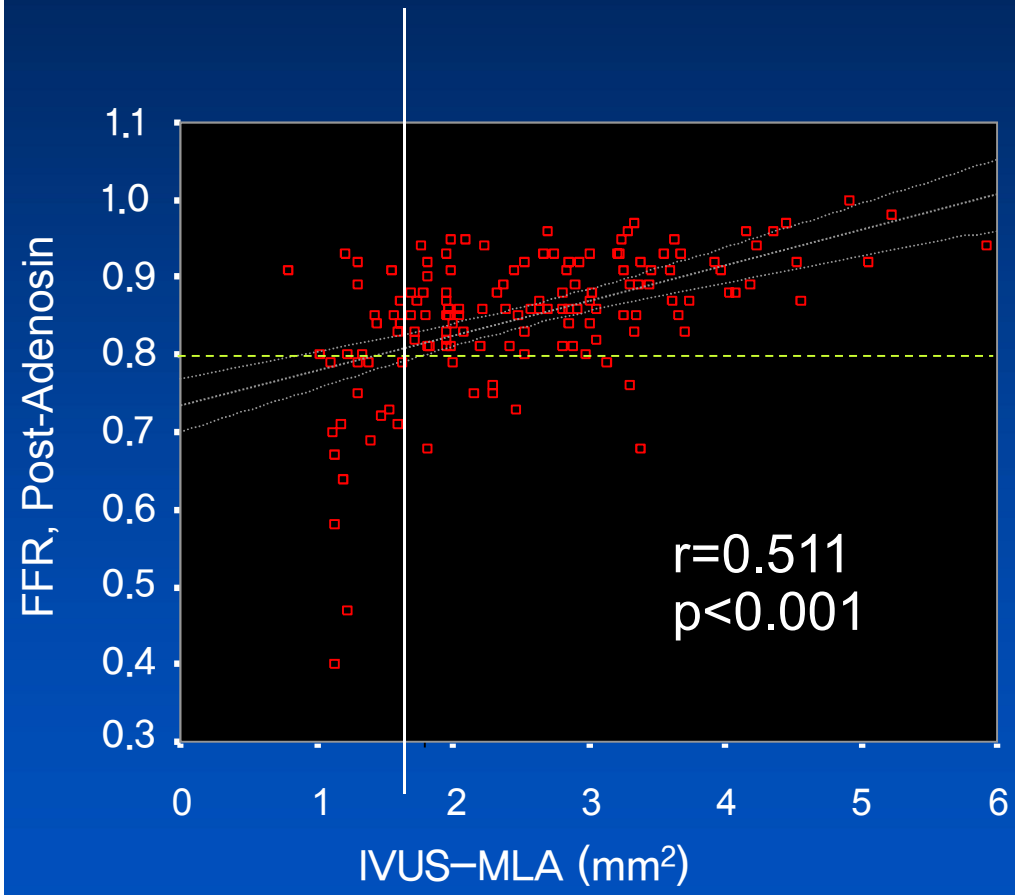
Can MLA measured by IVUS be used as a surrogate for clinical ischemia defined with FFR <0.8 ?

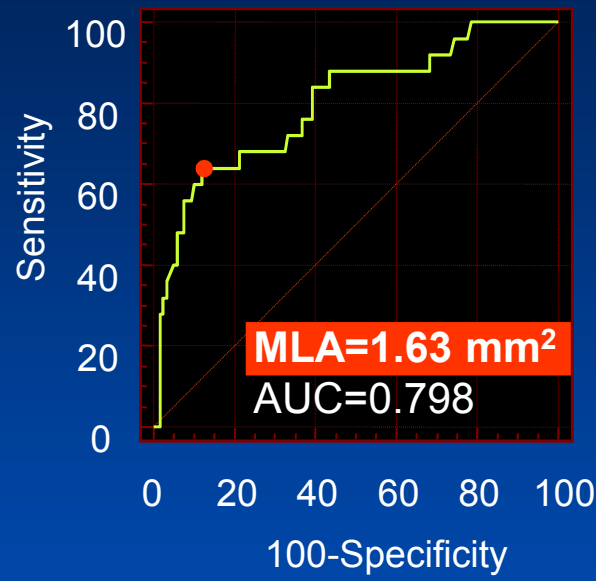
Comparison study of FFR, IVUS, TMT, and Thallium scan
AMC prospective cohort registry
Preliminary analysis, 2010 TCTAP

Intermediate Lesions
N=142

	Mean±SD	Range
FFR, baseline	0.95 ± 0.65	0.4 - 1.0
FFR, adenosine	0.85 ± 0.89	0.4 - 1.0
MLA, mm^2	2.54 ± 1.01	0.8 - 5.9
MVA, mm^2	10.97 ± 4.00	2.6 - 22.1
Length of lumen area <3.0 mm^2, mm	4.89 ± 6.11	0 - 25.9
Plaque burden,%	75 ± 10	34 - 94
Vessel		
LAD	95 (67%)	
LCX	15 (11%)	
RCA	32 (22%)	

Can MLA cut-off value by IVUS predict FFR <0.8 ?





Sensitivity 64%
Specificity 88%
PPV 53%
NPV 92%

(95% CI = 0.722 - 0.861)

Functional PCI

Treat or Not treat :
FFR guided –
Decision making

How to treat :
IVUS guided –
Optimizing procedure

At this stage, do we have to choose only one ?

Coronary Intervention ; Future Perspective

Functional PCI

FFR guided - Decision making
IVUS guided - Optimizing procedure

You Can Save Lives !!


Thank You !!
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