Paradigm Shift to
Functional PCI

FFR guided decision making and IVUS guided optimization

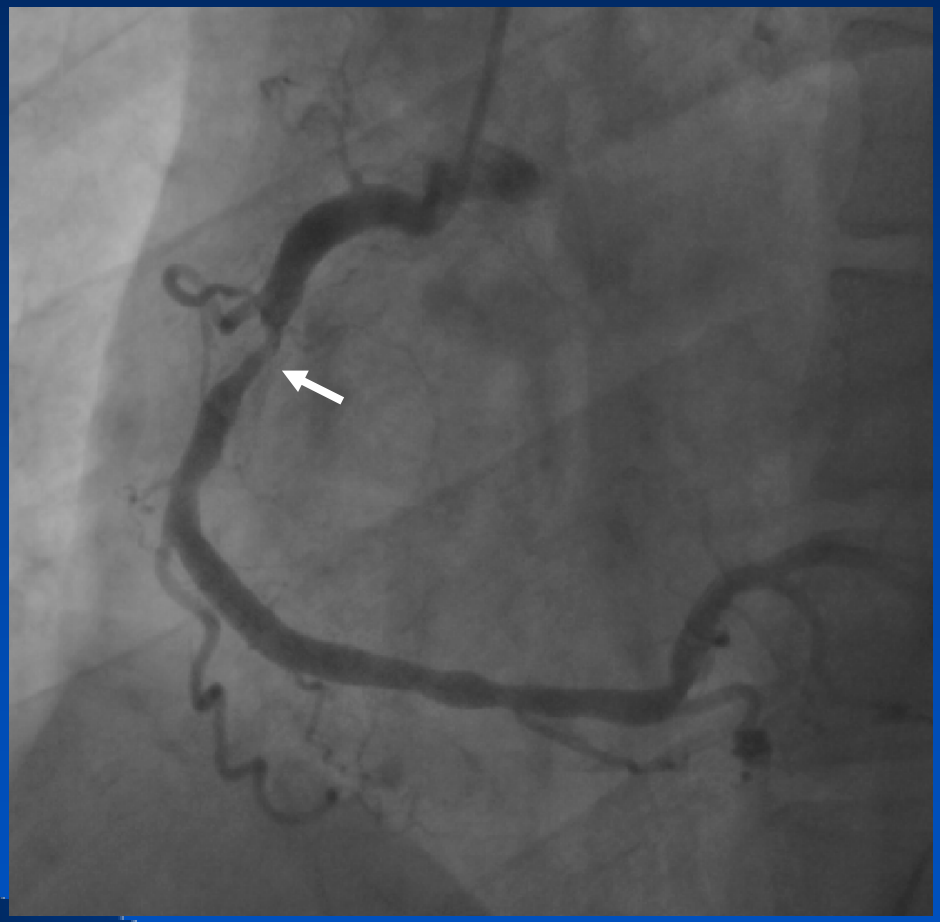
Seung-Jung Park, MD, PhD

Professor of Medicine, University of Ulsan College of Medicine,
Heart Institute, Asan Medical Center, Seoul, Korea

Mismatch Disease

Treat or Not treat

No Doubt about Stenting !



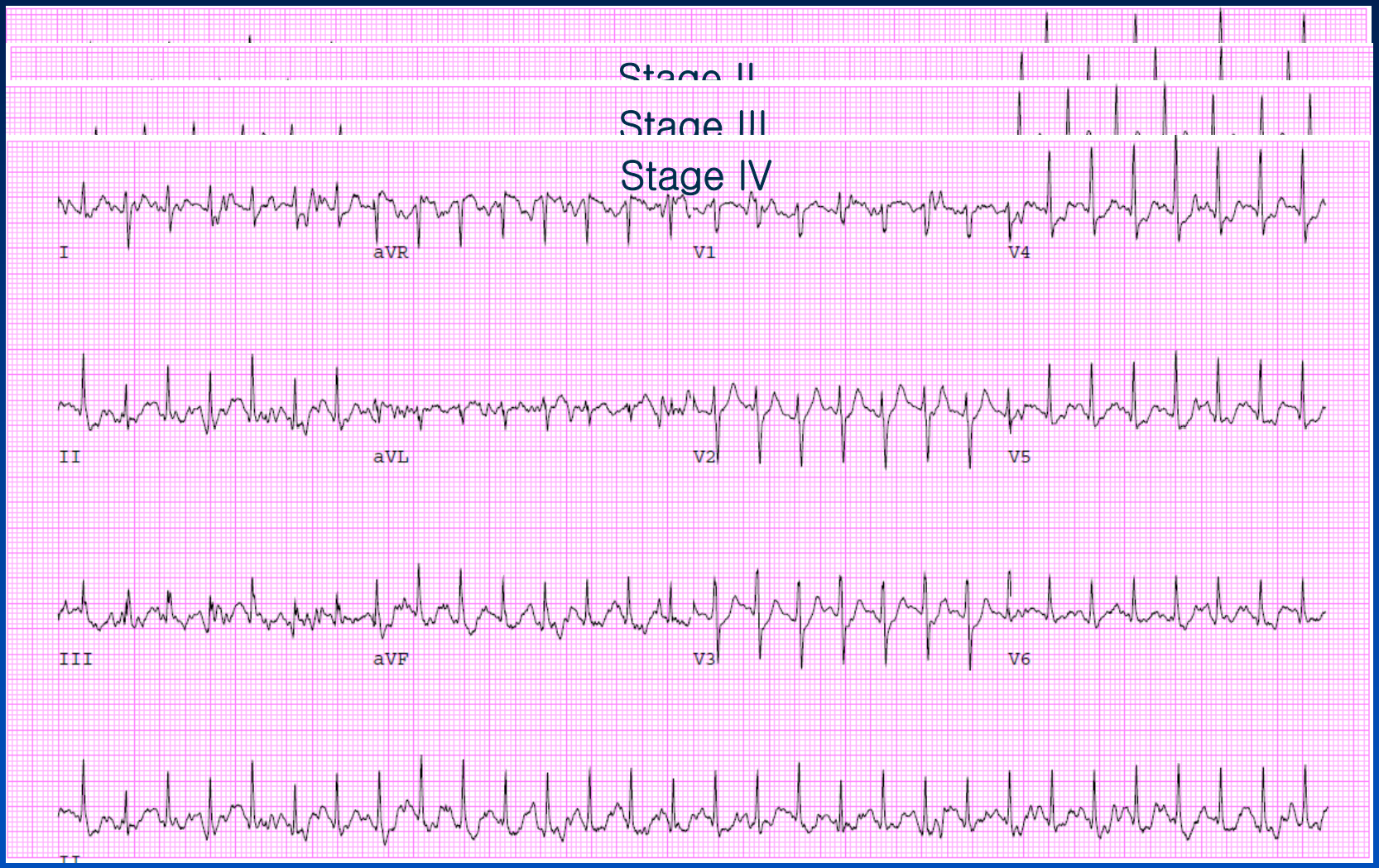
Visual estimation:
85%

IVUS MLA:
2.8 mm^2

FFR

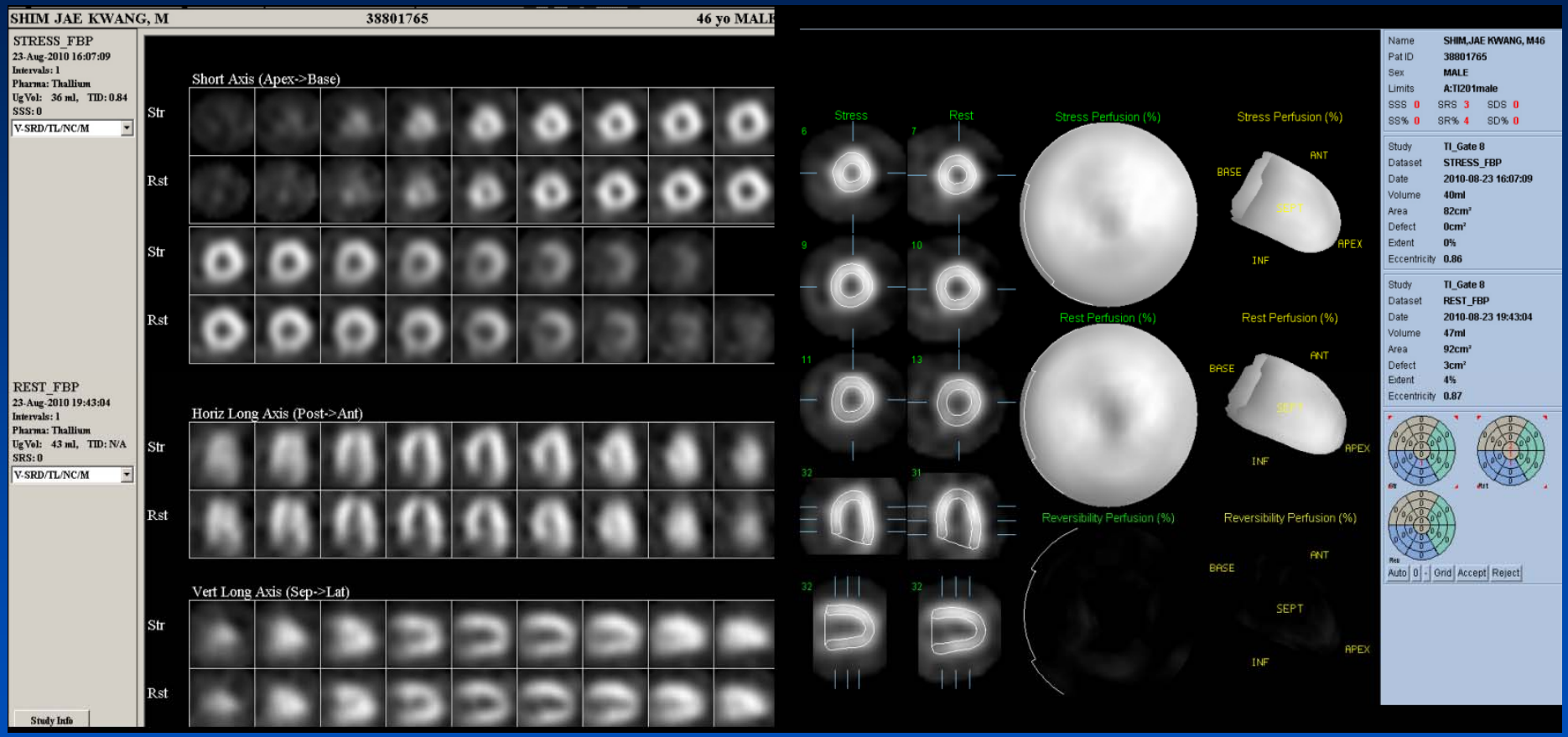
Intravenous adenosine, 160 μg/kg/min

Treadmill test



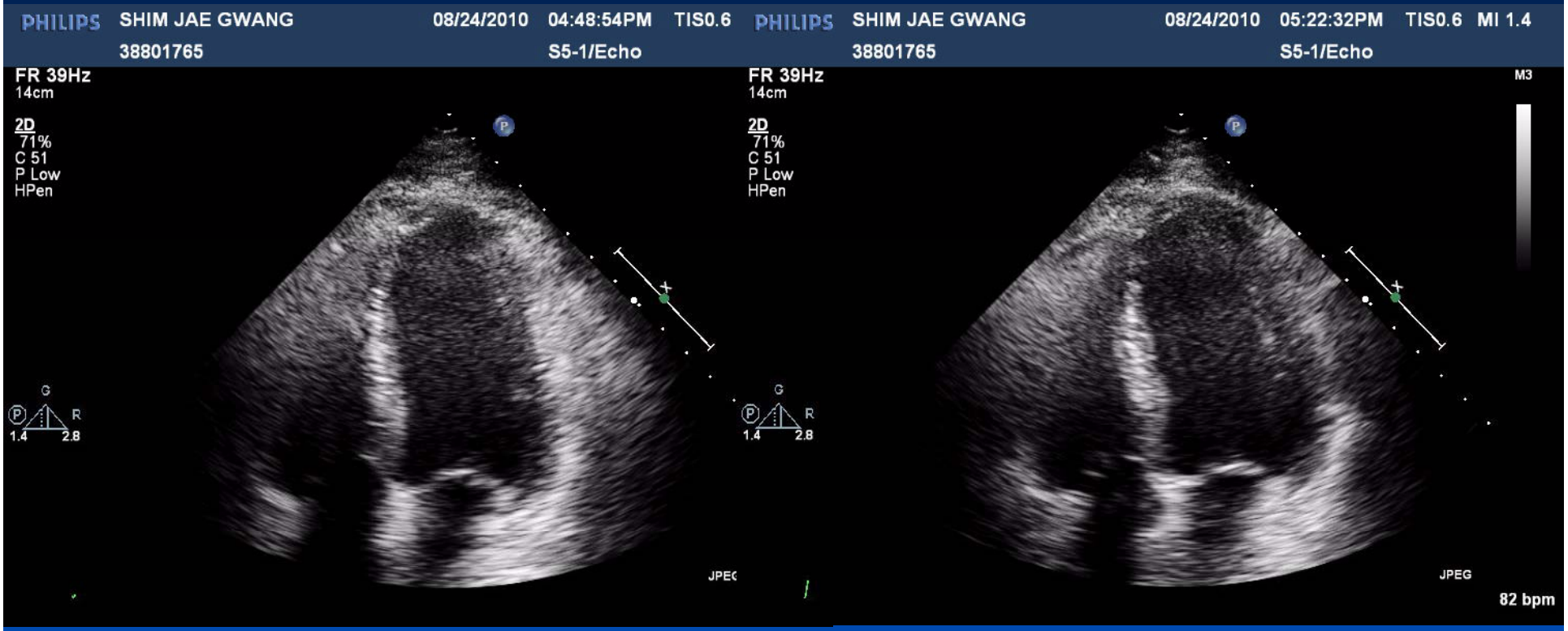
Stage 4 Negative

Thallium SPECT



Normal

Dobutamine Stress EchoCG

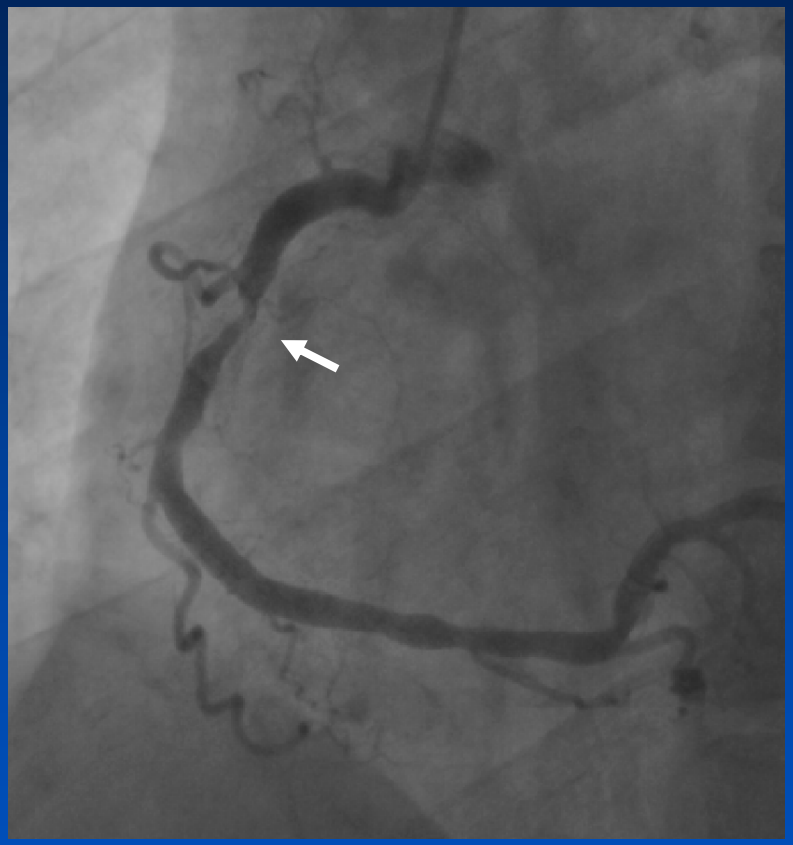


Baseline

Stimulation

Negative

Mismatch Disease



Angiographic DS(%) : 85%
IVUS MLA : 2.8 mm^2

FFR : 0.84
Treadmill test : Negative
Thallium spect : Normal
Stress Echo : Normal

What would you do ?

Treat or Not treat

Evidence Based Medicine

Treatment relies primarily on noninvasive stress test (objective ischemia).

Negative non-invasive stress test means ;

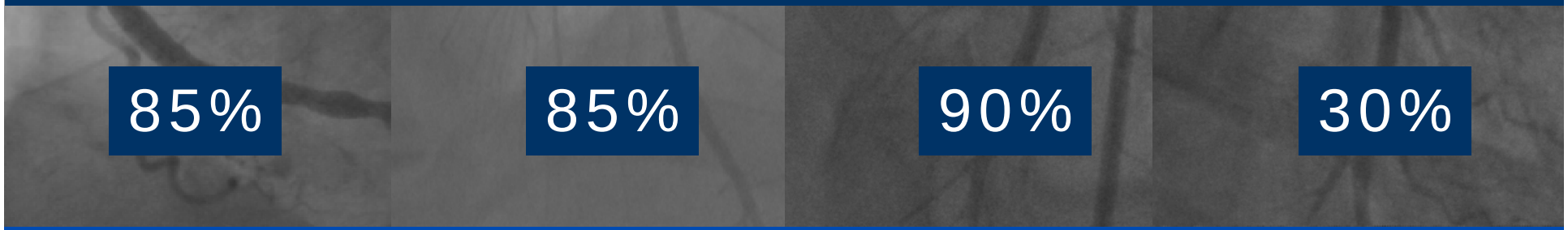
Excellent Prognosis !

Shaw LJ, J Nucl Cardiol 2004;11:171-85 , Prognostic value of gated myocardial perfusion SPECT. Very large meta-analysis. (n=39,173 patients)

Cases of Mismatch Diseases

Do you believe Your Eyes ?

The angiographic severity is not correlated with its ischemic potential.



TMT and Thallium SPECT

Negative | **Positive**

Do you believe IVUS MLA ?

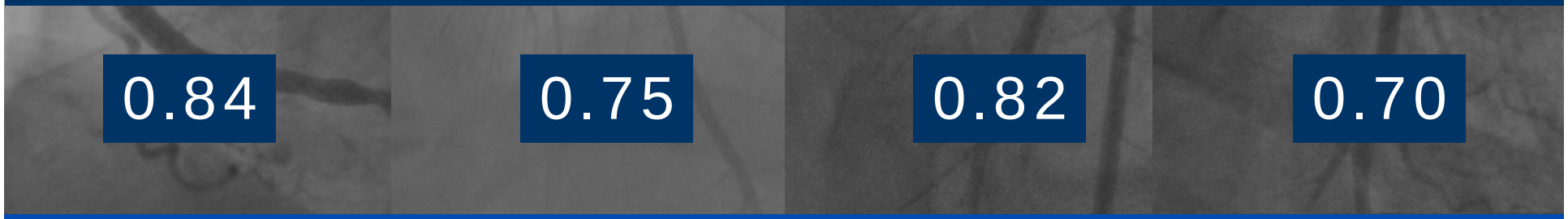
IVUS MLA of 4mm^2 is too big to define clinical ischemia ?

TMT and Thallium SPECT

Negative | **Positive**

Do you believe FFR value ?

FFR is constantly matched with non-invasive stress test (TMT and Thallium SPECT).



TMT and Thallium SPECT

Negative | **Positive**

In Fact,

FFR is the only matched index with noninvasive stress tests (objective ischemia) in the cath lab.

Mismatch Disease

Mismatched problems mainly are between angiographic severity/ IVUS MLA and non-invasive stress test. Not related with FFR.

Mismatch Disease

Do you want to treat the Lesion ?

based on angiography and/or IVUS MLA

Do you want to treat the Patients ?

based on non-invasive stress test
and/or FFR

FFR, Why ?

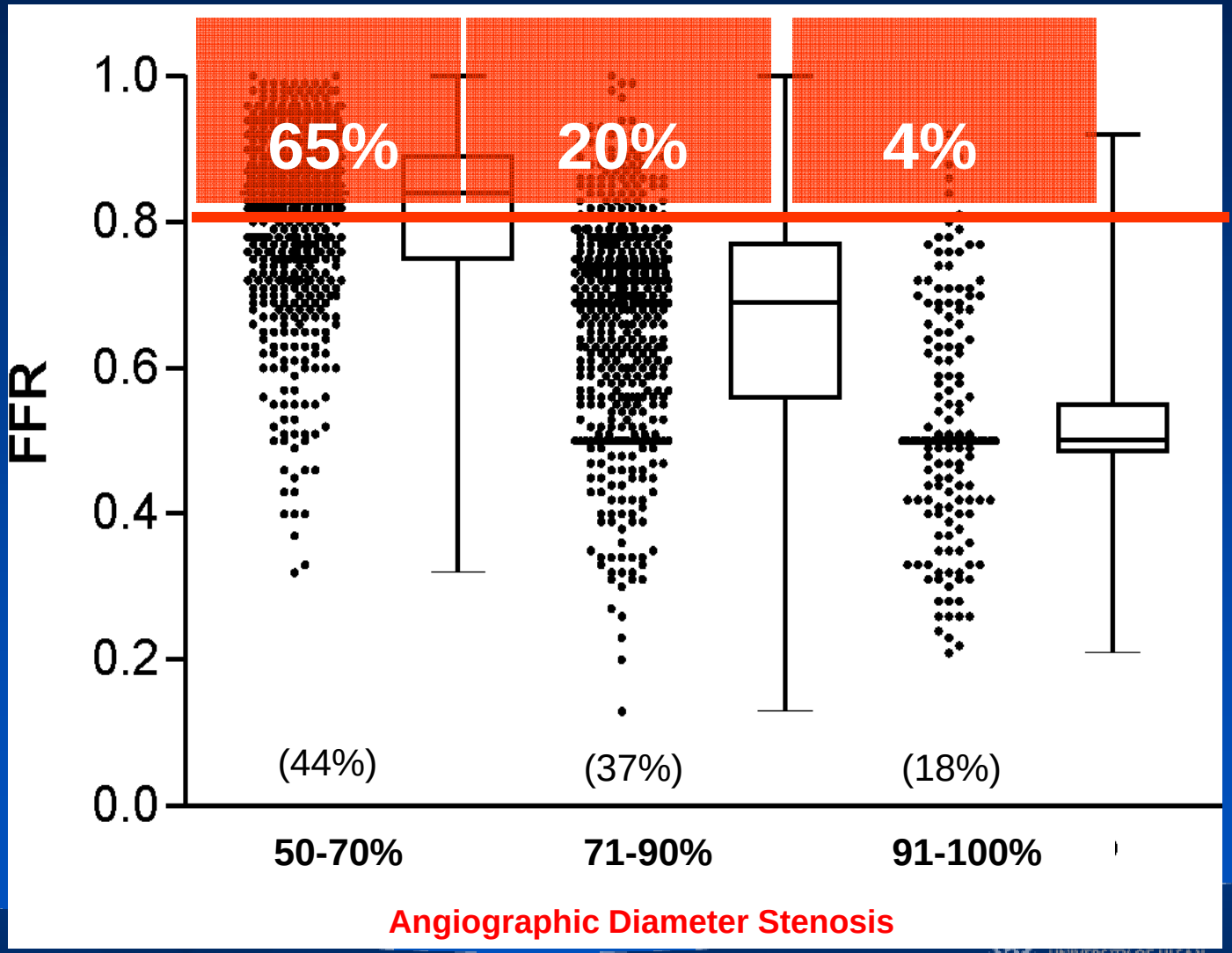
In order to have a decision making - Treat or Not treat,

FFR can be useful as an alternative to stress test in the cath.

FFR, When ?

FAME Study

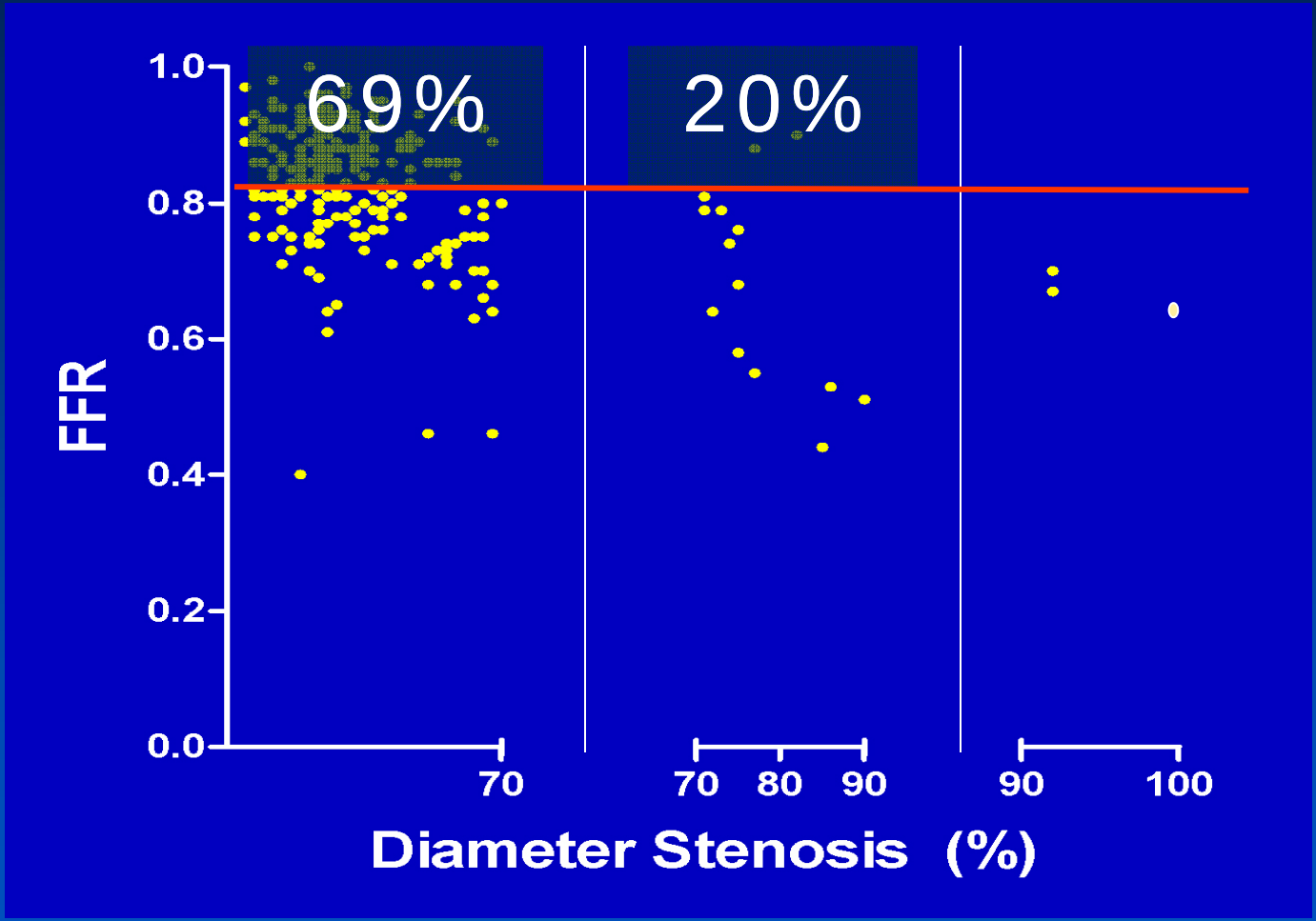
1329 lesions in the FFR-guided arm



Tonino et al., JACC 2009

In Reality at AMC

289 lesions



FFR, When ?

Angiographic DS <80%
(60% of your procedure)
should be considered FFR.

70% out of them would be
negative FFR.

Validation

FFR cut-off value

Author	Number	Stress Test	BCV	Accuracy
Pijls et al.	60	X-ECG	0.74	97
DeBruyne et al.	60	X-ECG/SPECT	0.72	85
Pijls et al.	45	X-ECG/SPECT/pacing/DSE	0.75	93

0.72 - 0.78
(Extremely Reproducible)

BCV = best cut-off value; DSE = dobutamine stress echocardiography; MI = myocardial infarction; SPECT = single-photon emission computed tomography; X-ECG = exercise electrogram

Validation and Threshold of Ischemia

FFR < 0.80
is a good surrogate
for clinical ischemia.

Treat or Not Treat
Operator's discretion

Validation and Threshold of Ischemia

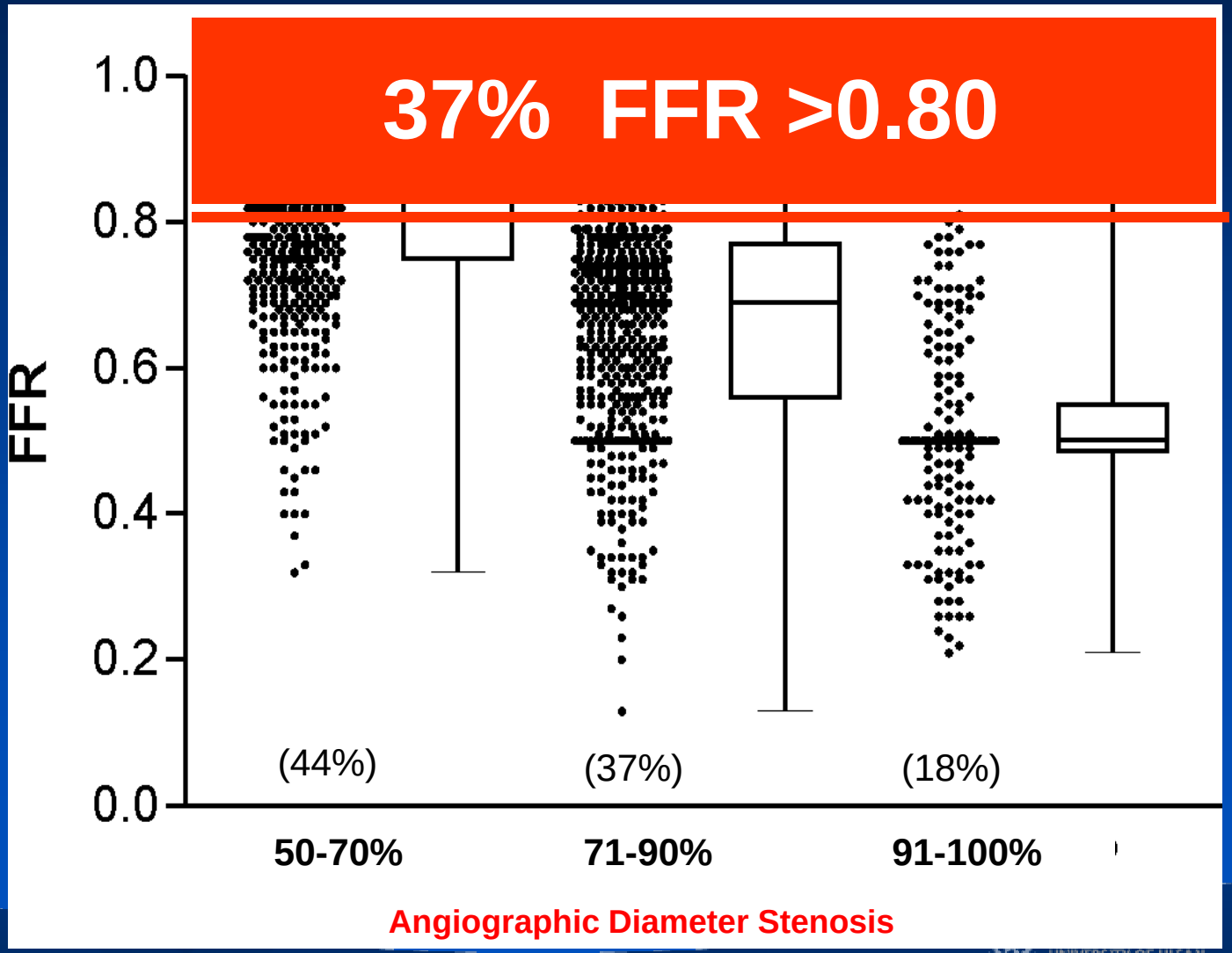
FFR > 0.80
is a perfect surrogate
for absence of ischemia.

100% Specificity
Negative FFR Never Lies

Application

FAME Study

1329 lesions in the FFR-guided arm



Tonino et al., JACC 2009

In Reality at AMC
289 lesions

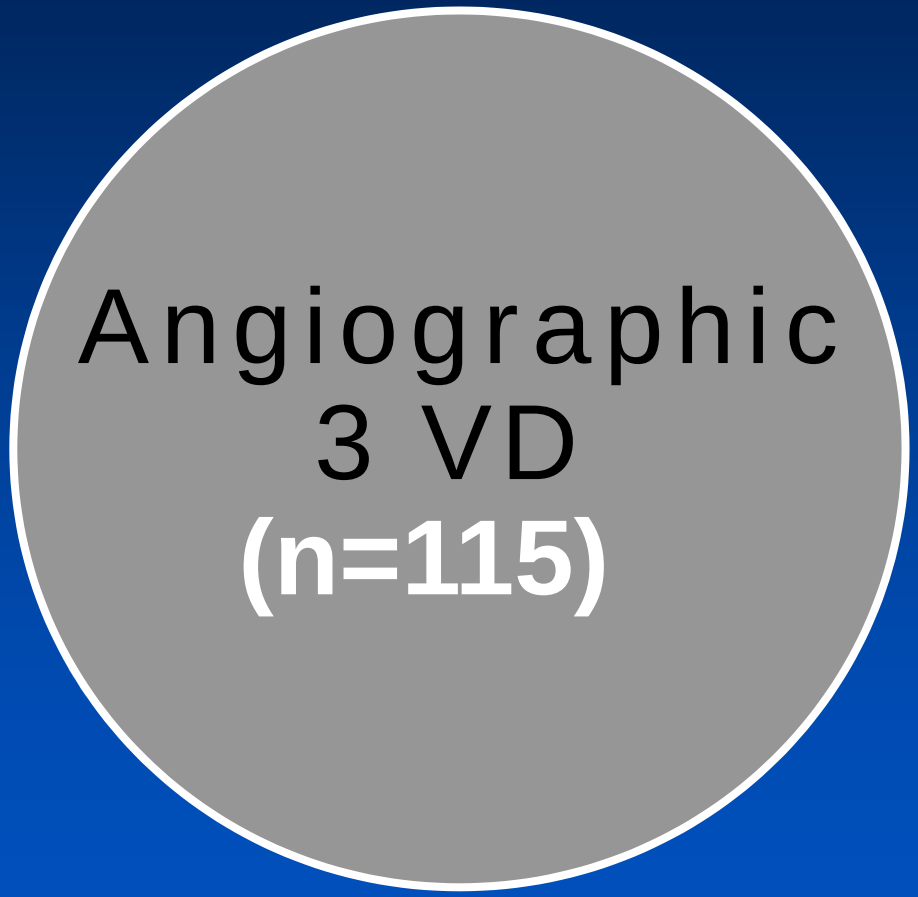
We have learned that angiographic diameter stenosis <80% should be considered by FFR. (70% out of them would be negative FFR)

Application in Real Practice

If you believe,
Negative FFR (>0.80) means
Absence of Ischemia.

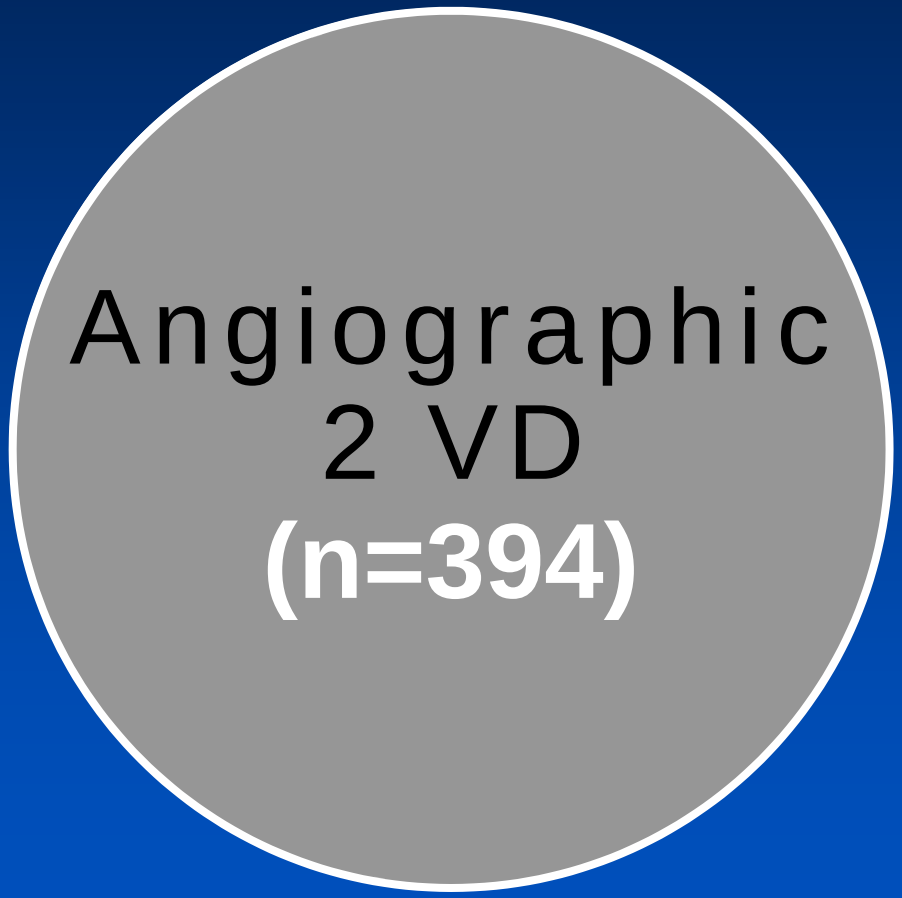
You can avoid
4 stent procedures
out of 10.

Anatomic vs. Functional CAD
After Assessment of FFR >0.80



Tonino et al., JACC 2010;55:2816-2821

Anatomic vs. Functional CAD
After Assessment of FFR >0.80



Tonino et al., JACC 2010;55:2816-2821

Application in Real Practice

If you believe,
Negative FFR (>0.80) means
Absence of Ischemia.

You can avoid
6-7 bypass surgery
out of 10.

FFR vs. IVUS

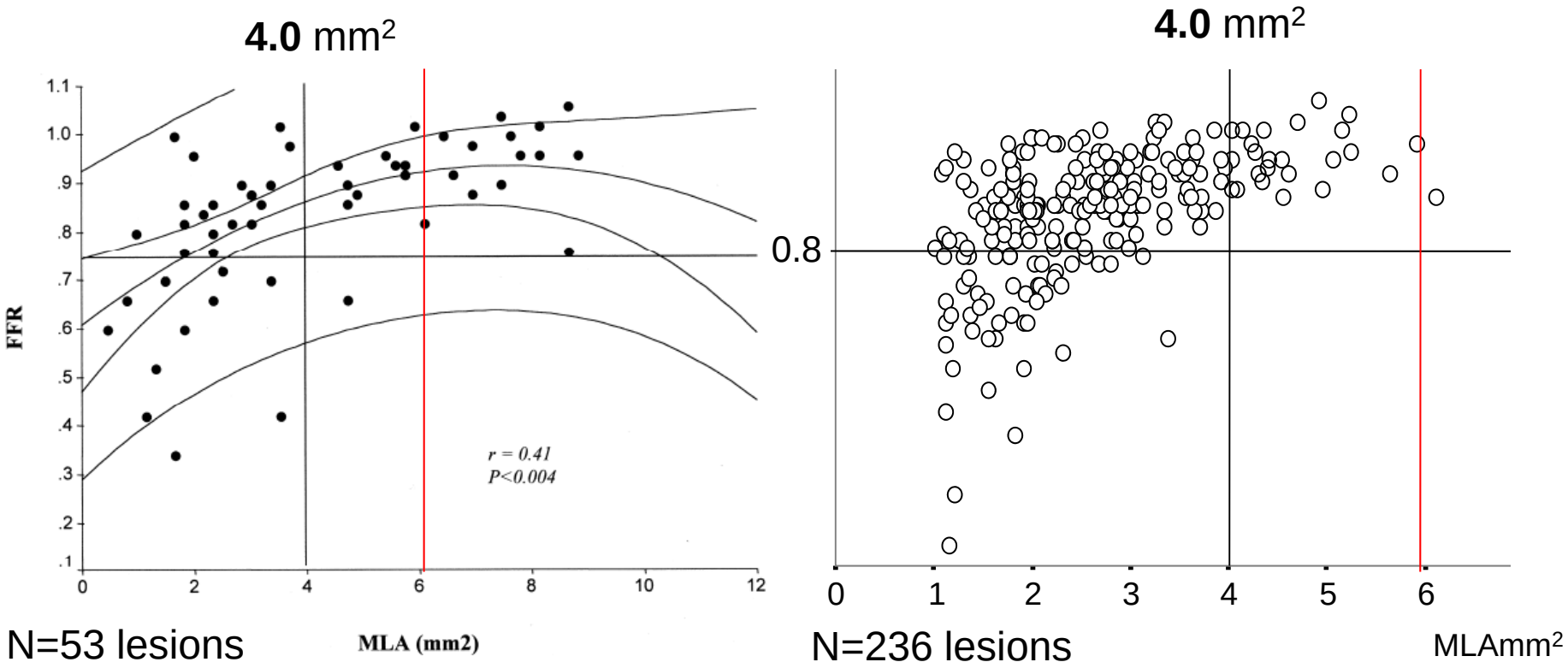
IVUS cutoff Value
Published Data Review

	Nishioka T, JACC 1999	Briguori et al AJC 2001	Takaki et al Cir. 1999	Abizaid et al AJC 1998
	70 lesions	53 lesions	42 pts	86 pts
Cut-off of MLA (mm^2)	<4.0 (Thallium +)	< 4.0 (FFR<0.75)	<3.0 (FFR<0.75)	> 4.0 (CFR >2.0)
Sensitivity Specificity	80% 90%	92% 54%	83 % 92.3 %	Accuracy 92%
QCA VD (mm) DS (%)		3.08±0.3 52±11		
MLA (mm^2)	3.3±2.3	3.9±2.5	3.9±2.0	4.4±2.0
MVA (mm^2)		12.0±4.6		13.2±4.4
Area stenosis%		65±18	55±24	43±24

Is 4 mm^2 of IVUS MLA
a little bigger
to define clinical ischemia ?

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

AMC data



- **Study patients were too small.**
- **Large vessels (negative FFR) were included.**

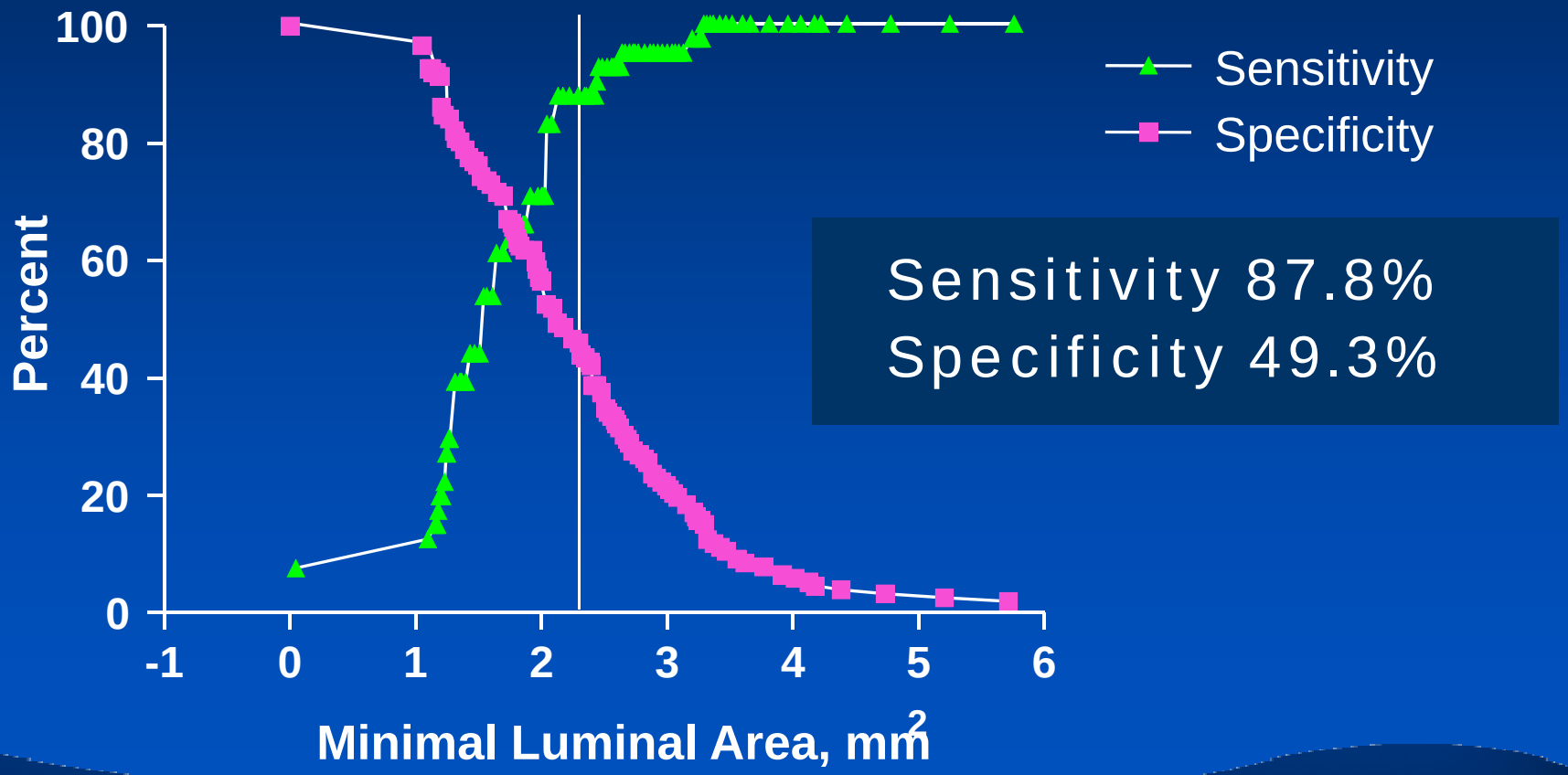
New Comparison Data

AMC prospective cohort registry (n=340 lesions), 2010

Thallium SPECT vs. IVUS MLA

Plots for the sensitivity & specificity of MLA

2.13 mm²



Sensitivity 87.8%
Specificity 49.3%

Thallium SPECT vs. IVUS MLA

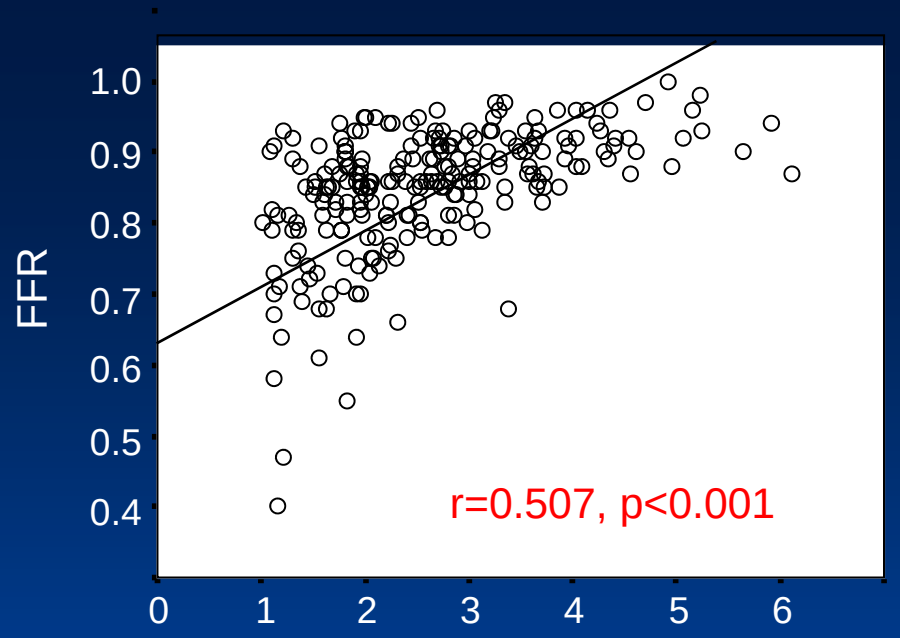
2.13 mm^2

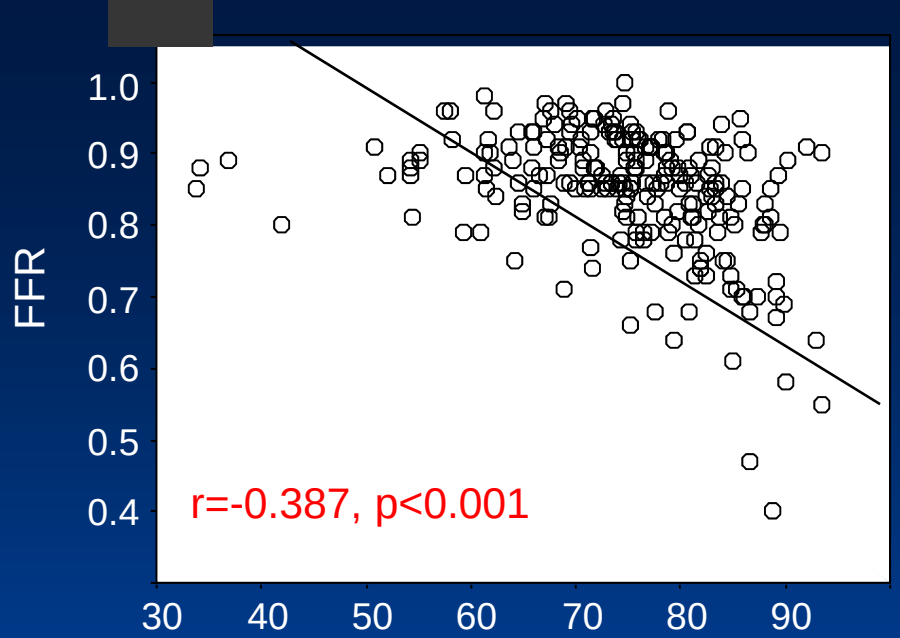
AMC prospective cohort registry
(n=340 lesions), 2010

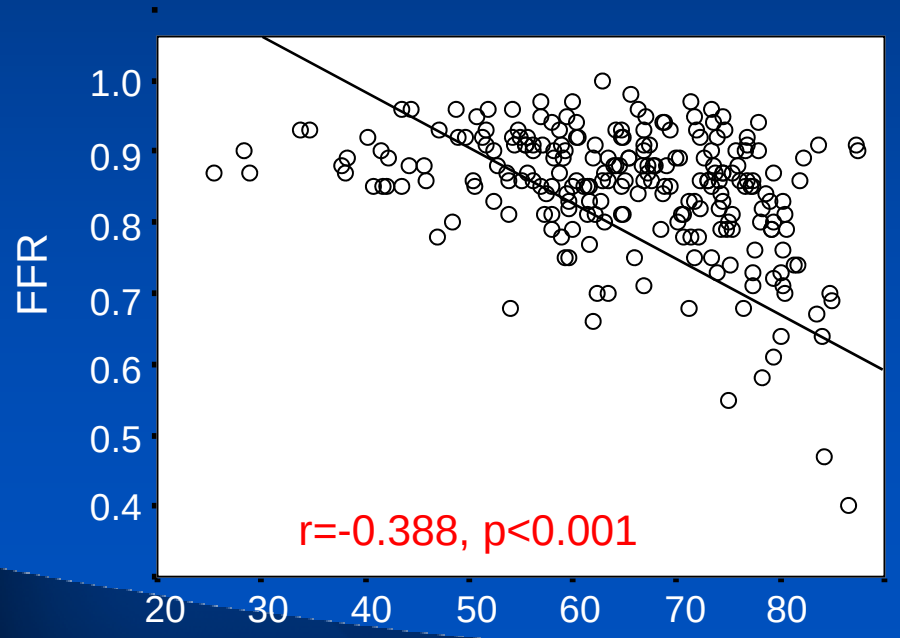
New Comparison Data

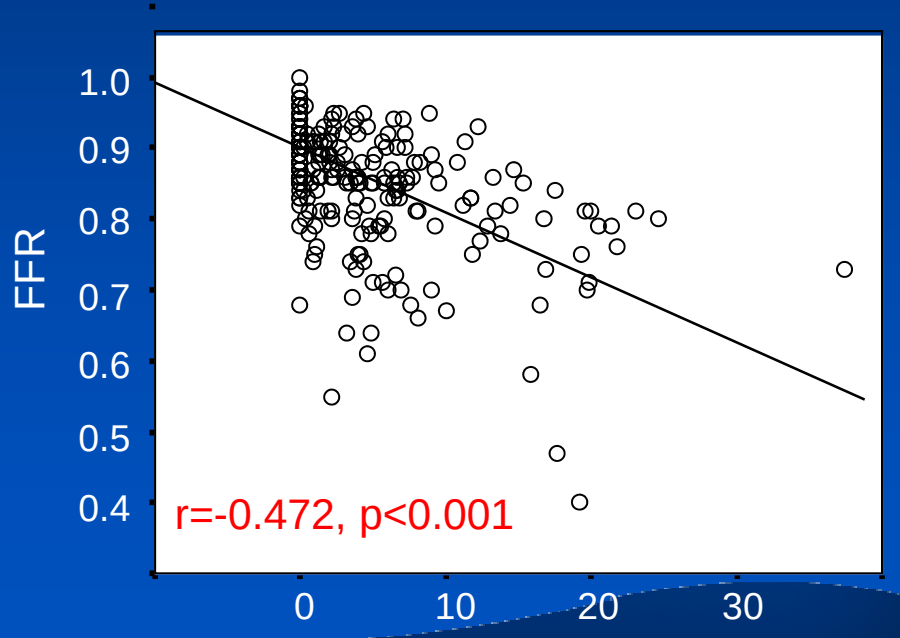
AMC prospective cohort registry (n=236 lesions), 2010

FFR vs. IVUS MLA





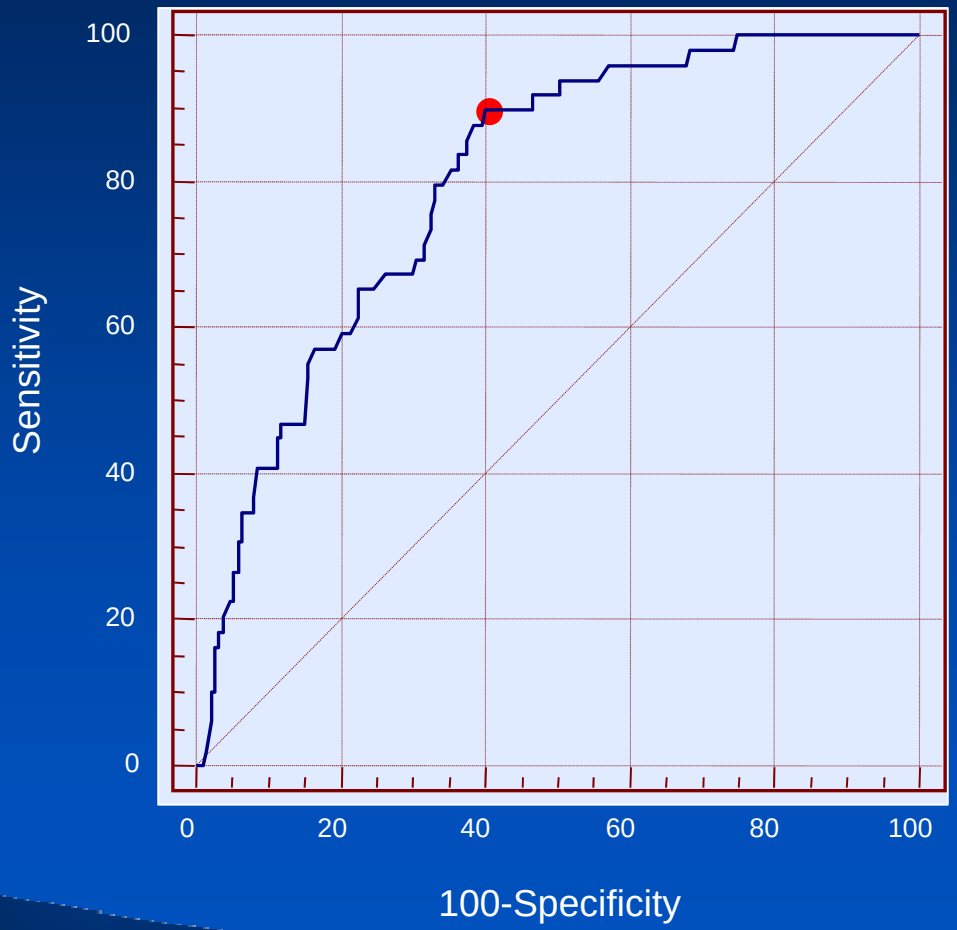




CardioVascular Research Foundation

ASAN Medical Center

New IVUS MLA
matched with FFR <0.80



Cut-off =2.42mm²
AUC=0.800
95% CI=0.742-0.848

Sensitivity=90%
Specificity=60%
PPV=37%
NPV=96%
Accuracy=68%

FFR <0.80 vs. IVUS MLA

2.4 mm^2

AMC prospective cohort registry
(n=236 lesions), 2010

New Cut-off Value of IVUS MLA (mm2)

according to different Vessel Diameter

	FFR <0.8/>0.8	Cut-off	sensitivity	specificity	PPV	NPV	Accuracy	AUC	95%CI
Vessel diameter at the MLA site <3.0mm (n=38)									
MLA	7/31	**1.45**	71	77.4	42	92	76	0.730	0.562-0.861
Length	7/31	12.0	57	83	44	90	78	0.682	0.511-0.823
PB	7/31	75.4	43	94	60	88	85	0.654	0.483-0.801
Area stenosis	7/31	66.8	86	52	28	94	56	0.696	0.526-0.834
Vessel diameter at the MLA site 3.0-3.5mm (n=53)									
MLA	**13/40**	**1.8**	61.5	87.5	61	88	81	0.769	0.633-0.874
Length	13/40	4.9	72.5	84	94	50	80	0.772	0.636-0.876
PB	13/40	74.5	84.6						0.629-0.871
Area stenosis	13/40	75.8	46						0.528-0.794
Vessel diameter at the MLA site 3.5-4.0mm (n=72									
MLA	18/54	**2.15**	83						0.736-0.917
Length	18/54	3.57	83	75	54	93	77	0.813	0.704-0.895
PB	18/54	80.2	83	75	54	93	77	0.850	0.746-0.923
Area stenosis	18/54	70.0	89	72	52	95	76	0.824	0.716-0.904
Vessel diameter at the MLA site >4.0mm (n=73)									
MLA	11/62	**2.41**	91	83	50	98	84	0.874	0.775-0.940
Length	11/62	0.83	91	72.6	37	98	75	0.792	0.682-0.879
PB	11/62	80.7	100	61	31	100	67	0.855	0.753-0.926
Area stenosis	11/62	79.3	55	95	67	92	89	0.770	0.656-0.860

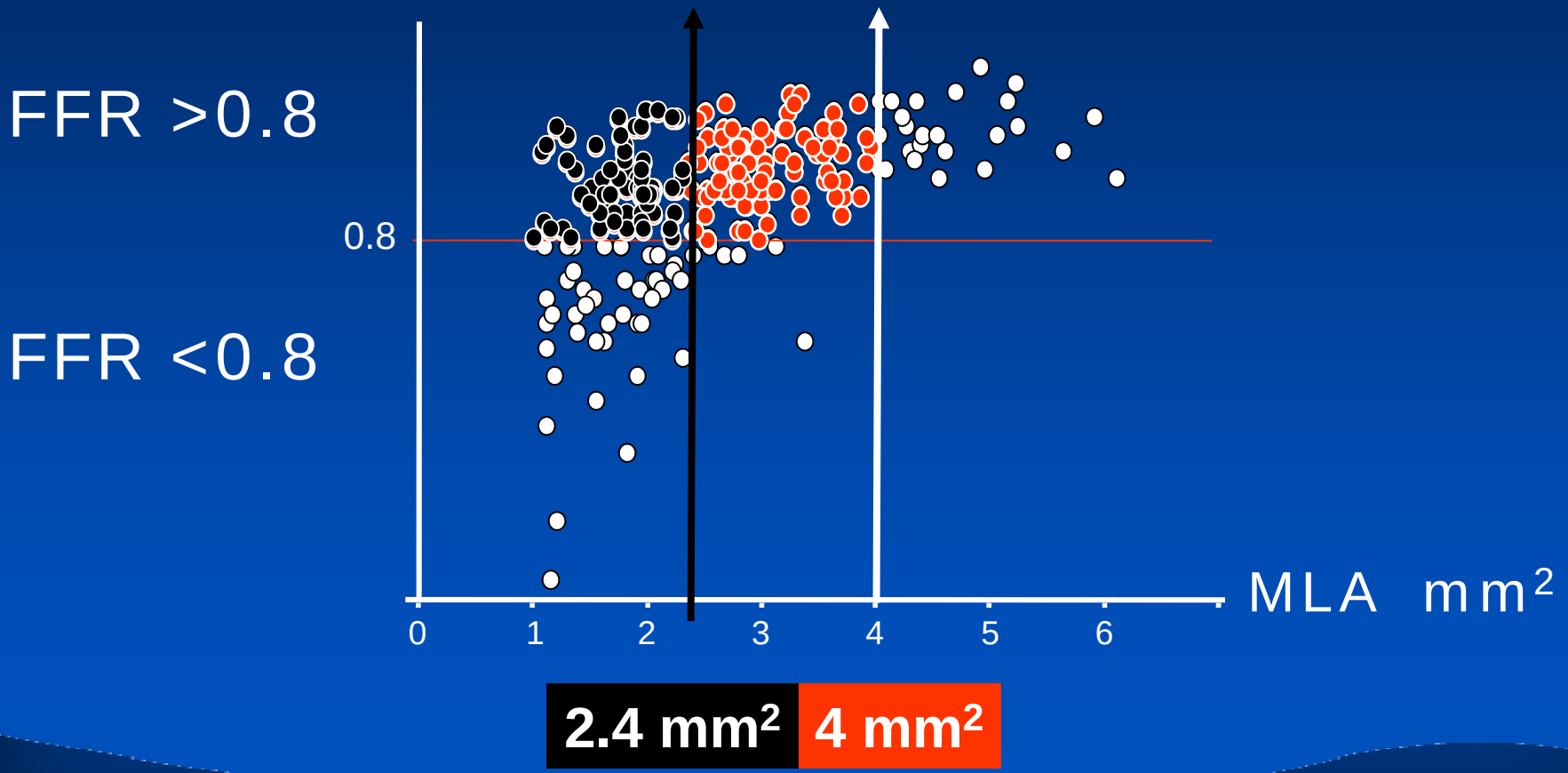
$2.15\ mm^2$

Honestly Speaking, In My Practice...

32%

69%

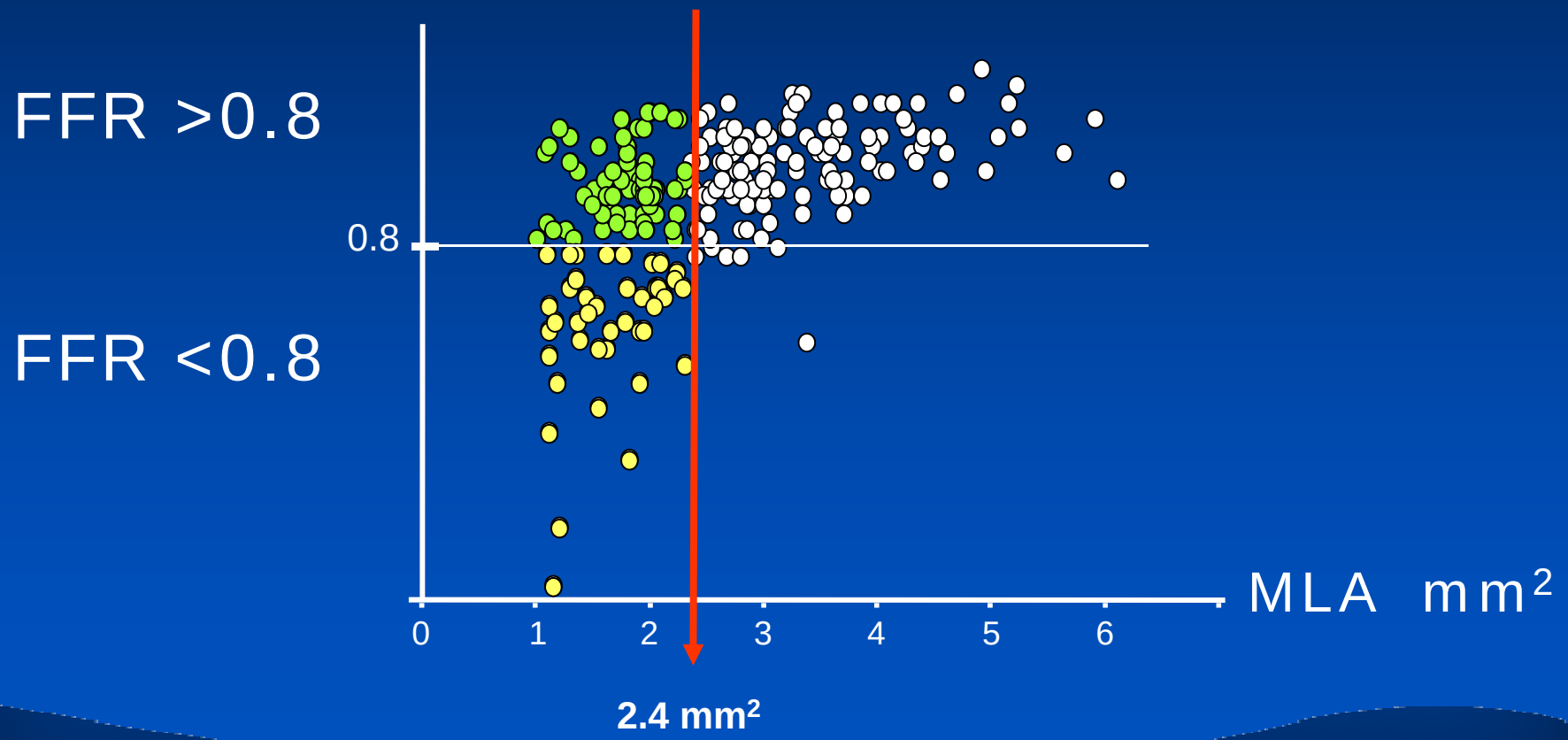
Unnecessary Procedure



Can IVUS MLA Predict FFR <0.8 ?

No !

Can IVUS MLA Predict FFR <0.8 ?



IVUS MLA is only one of many factors affecting coronary flow dynamics.

by FFR

We can do decision making - treat or not treat. (NPV : > 95%)

by IVUS MLA

We can not do decision making - treat or not treat. (PPV : 37%)

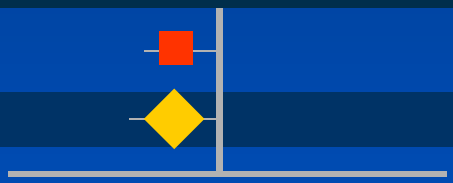
Then,

Why IVUS Guided ?

Binary Restenosis at 6 Mo

Meta-analysis in the Era of BMS (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)
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

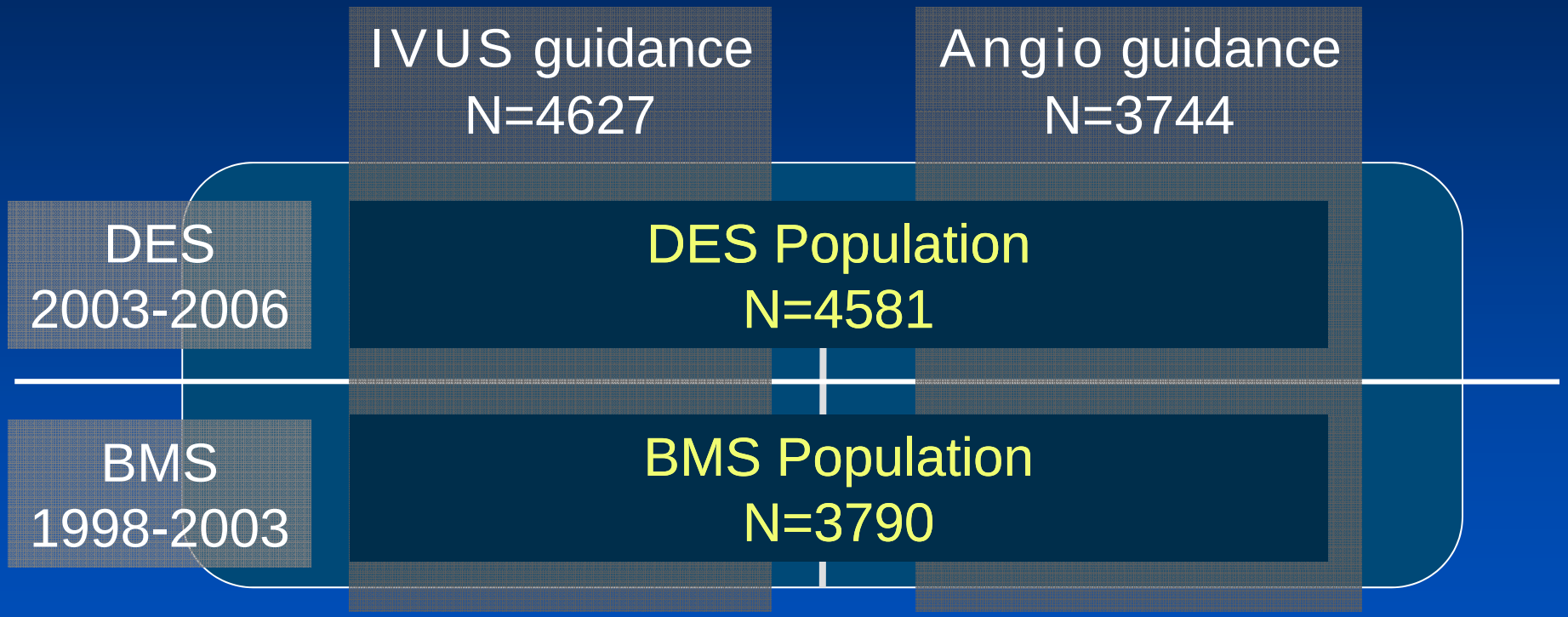
p=0.01

Restenosis Benefit !

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

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

Unselected Real World Registry (AMC) N=8371

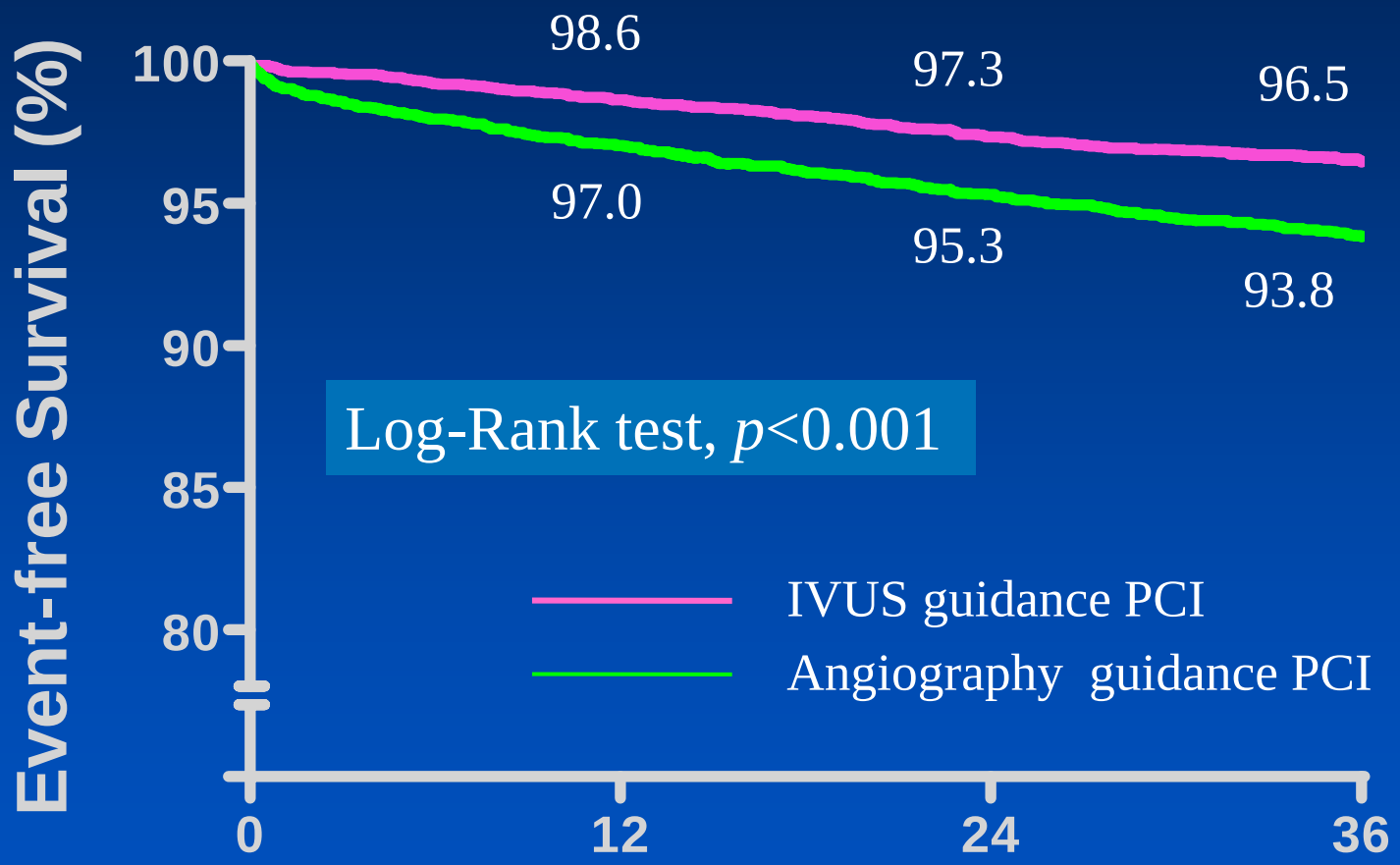


All cause death, MI, TVR, Stent thrombosis, MACE

Unadjusted K-M Curves

Death

Overall Population



Hazard Ratios of Clinical Outcomes
IVUS guidance vs. Angiography guidance

DES Population (n=4581)

Survival Benefit !

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**

Survival Benefit ?

We can make small differences by IVUS guidance.

These small differences can make a big difference in the late clinical outcomes.

Small Difference ?

- **Support** the Decision Making
  ostial lesion assessment, LM bifurcation PCI
- **Real Size** Measurement
  reference VD, degree of remodeling, lesion length, MLA
- Plaque **Characterization**
  attenuated plaque, ruptured plaque, thrombus, calcium
- Procedure **Optimization**
  final stent CSA, stent apposition

We have clear IVUS Criteria for Stent Optimization.

IVUS Predictors

Two procedural factors ; IVUS stent CSA and total stent length, are independent predictors for restenosis and stent thrombosis.

Park, DW. AJC 2006;98:353-356, AMC data
Hong MK, Eur Heart J, 2006:27:1305,AMC data
Suh J, JACC Intv, 2010;3:383-9

IVUS Optimization (Rule of 5)

How Big stent CSA : > 5.5 mm^2

How Long stented length : < 50 mm

< 2 % TLR

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

FFR vs IVUS

Start the procedure with FFR

Finish the procedure with IVUS

Paradigm Shift to

Functional PCI

Making
FFR and IVUS
always available

Paradigm Shift to
Functional PCI

FFR guided decision making (treat or not), and IVUS guided stent optimization can make a good clinical outcomes.