Integrated Use of FFR and IVUS in Non-LM Revascularization

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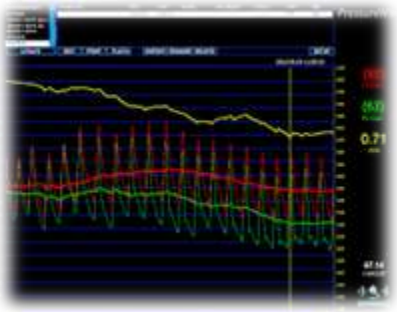
Fractional Flow Reserve (FFR)

"**FFR-guided PCI strategy** for CAD has proved its benefit over **angiography-guided PCI or medical treatment** by previous randomized clinical trials"

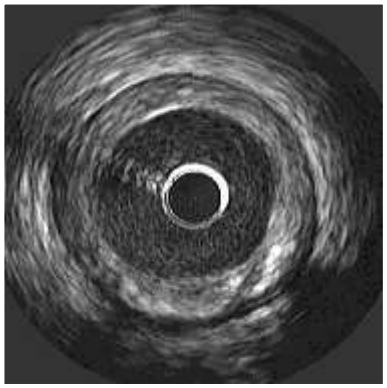


FAME	FAME	FAME 2
Death/MI At 2-Year	Cost At 1-Year	Urgent RR In Stable CAD
35%	$ 2400	87%

Pijls NH et al., J Am Coll Cardiol. 2010;56:177-184 / Van Nunen et al., Lancet 2015 Nov 7;386(10006):1853-60
Fearon W. et al., Circulation 2010;122:2545-2550 / De Bruyne B, et al., N Engl J Med. 2014;371:1208-1217

Intravascular Ultrasound (IVUS)

"**IVUS-guided PCI strategy** for CAD has proved its benefit over **angiography-guided PCI** by previous randomized clinical trials/registries/meta-analysis"



ADAPT-DES	Bifurcation	CTO	Long Stent
MACE At 1-Year	Death/MI At 3-Year	MACE At 1-Year	MACE At 1-Year
33%	56%	65%	52%

SAMSUNG MEDICAL CENTER

Witzenbichler B. et al., Circulation. 2014;129(4):463-70 / Kim JS et al. Am Heart J 2011;161:180-7
Kim BK et al. Circ Cardiovasc Interv. 2015 / JAMA. 2015;314:2155-2163

FFR and IVUS
- Complementary Role in Patients Management -

- **Complementary Role in PCI**
  - Pre-Procedural Lesion Assessment
  - During- or Post-Procedural Optimization of PCI

- **Fundamental Reason**
  1. Pre-PCI : Discordance Between Anatomy and Functional Significance
  2. During- or Post-PCI: Intravascular imaging can provide much information for stented segment
  3. Physiologic assessment can stratify high risk patient after successful revascularization

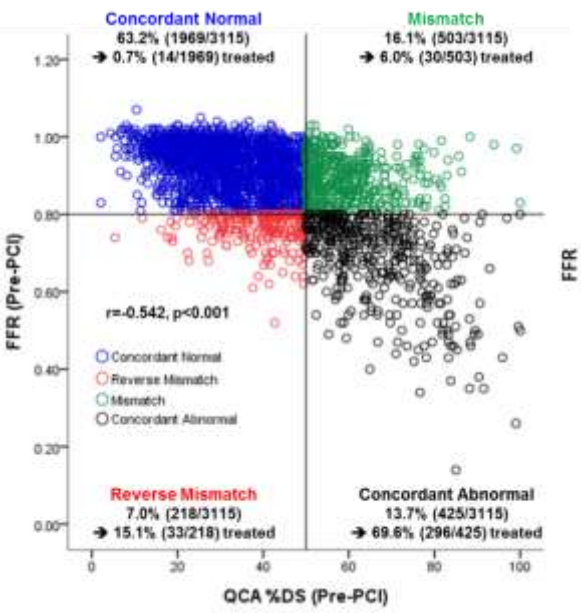
FFR and QCA : Pre-Intervention

- Discordance Between Anatomy and Functional Significance -

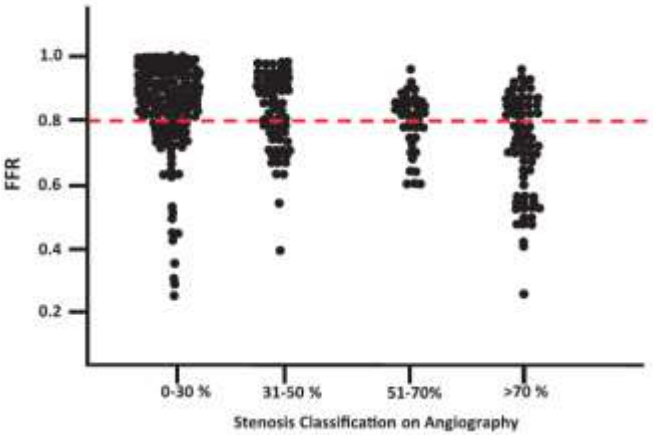
Routine 3-Vessels FFR (Regardless of Stenosis Severity)

FFR as Clinical Indication (At lease one Intermediate Stenosis)

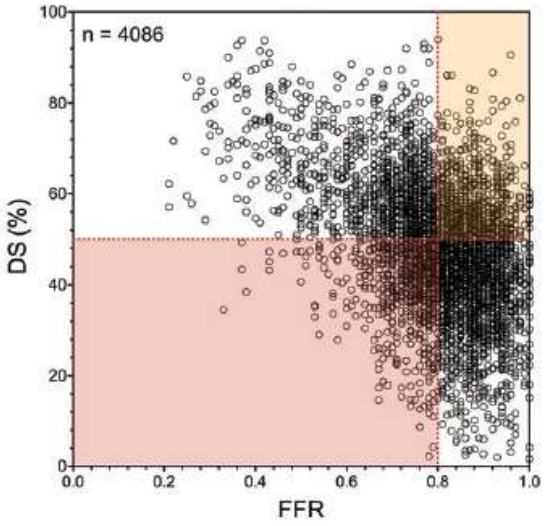
3V-FFR-FRIENDS Study



RIPCORD Trial



Real-World Pooled Registry



Among 3115 vessels
Reverse Mismatch : 7.0%
Mismatch : 16.1%

Total 23.1% Discordance

Among 569 vessels
Reverse Mismatch : 13.1%
Mismatch : 9.5%

Total 22.6% Discordance

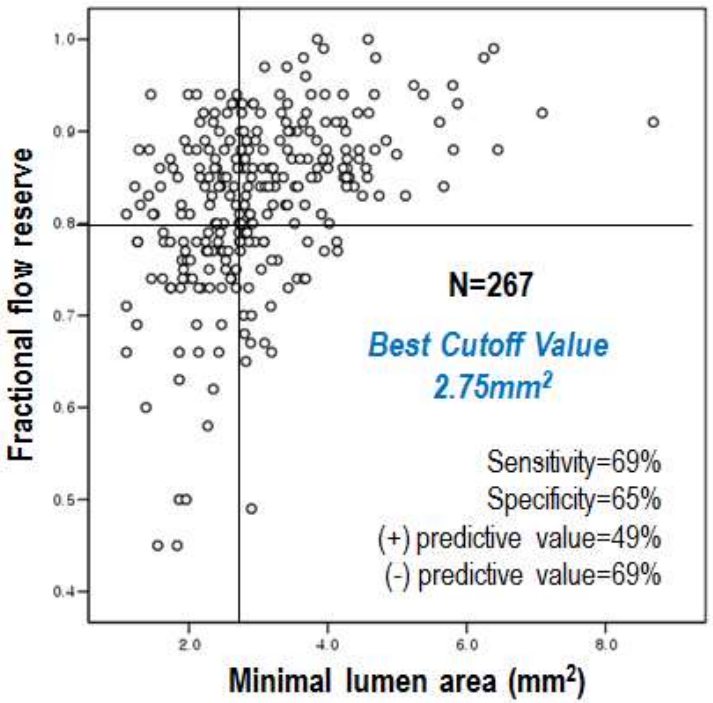
%DS>50% to Predict FFR≤0.80
Sensitivity : 61.2%
Specificity : 66.9%

3V-FFR-FRIENDS Study, Under Review
Curzen et al. RIPCORD, Circ Intervention 2014
Toth et al. EHJ 2014

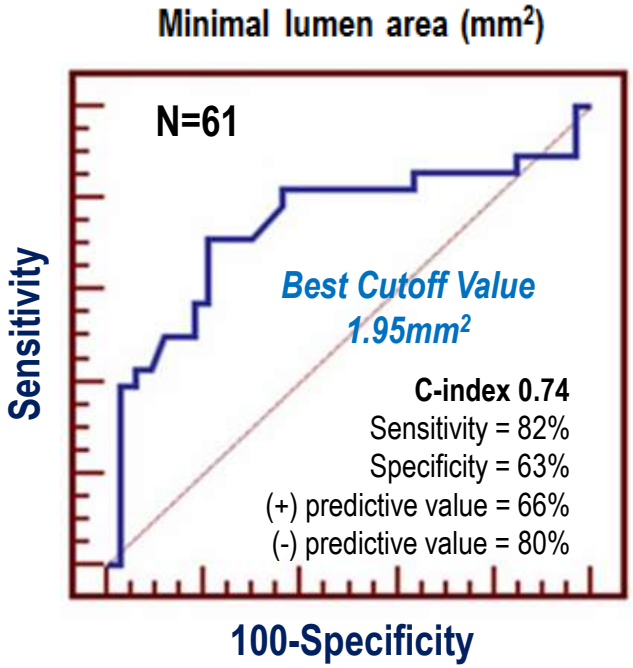
FFR and Invasive Imaging: Pre-Intervention

- Discordance Between Anatomy and Functional Significance -

IVUS



OCT

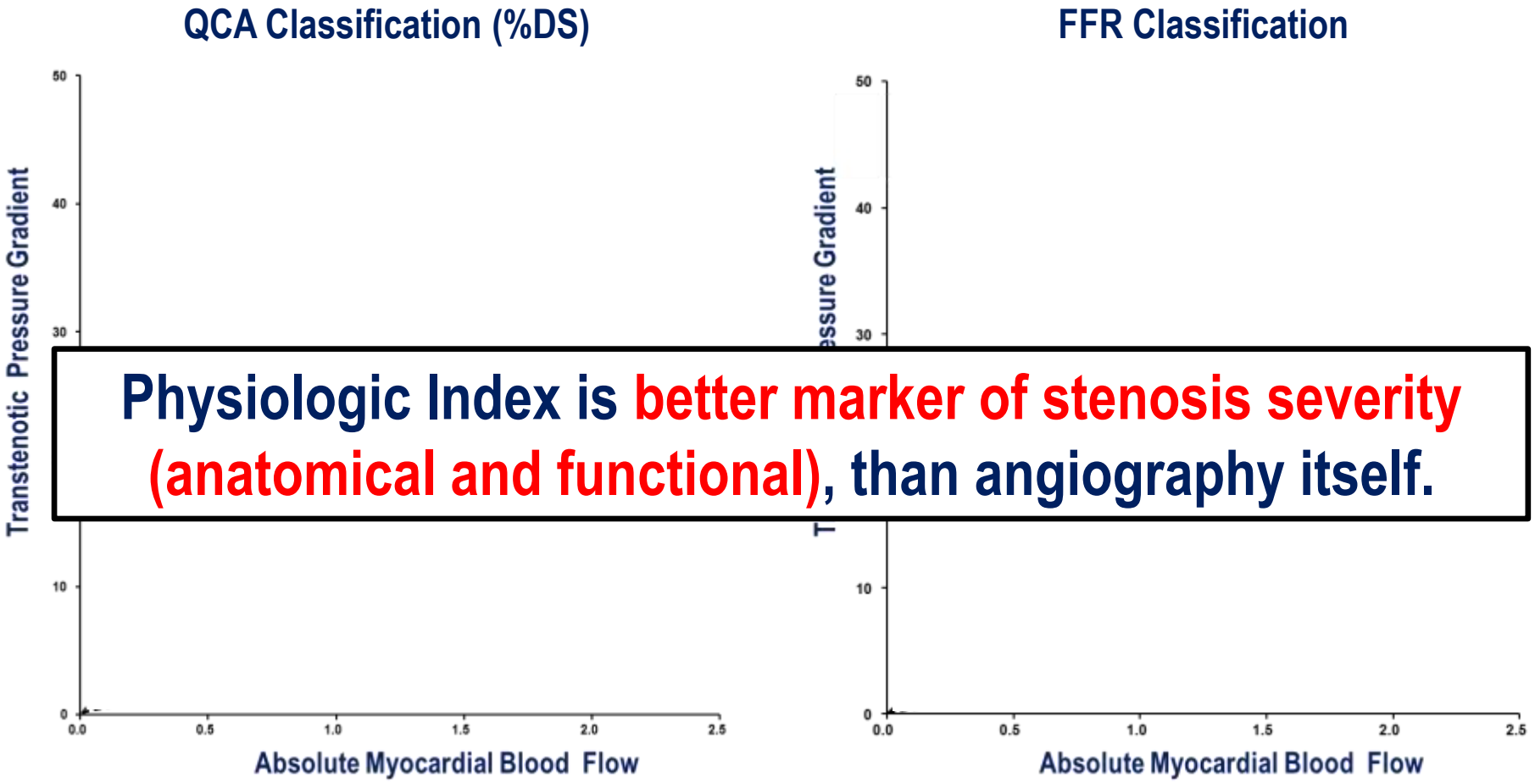


Discordance between Stenosis Severity and Functional Significance
Is not a problem of "How accurate in measuring stenosis severity"

Functional significance cannot be predicted using stenosis severity.

Koo BK et al. JACC Intervention 2011
Gonzalo et al. JACC 2012

Physiologic Index is Better Marker of Stenosis Severity



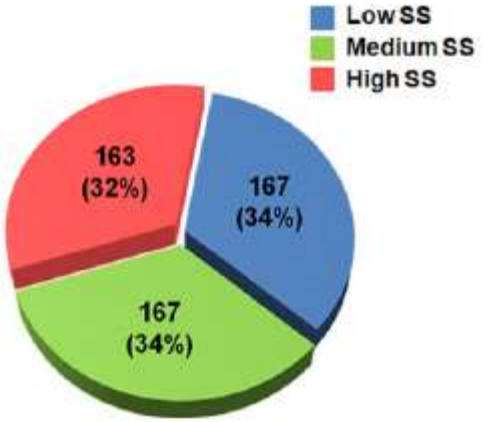
Physiologic Index is better marker of stenosis severity (anatomical and functional), than angiography itself.

Stenosis severity defined by FFR better discriminates an "Unique Pressure Gradient – Absolute Myocardial Blood Flow" relationship than by angiographic %DS.

Lee JM, Koo BK, Under Review

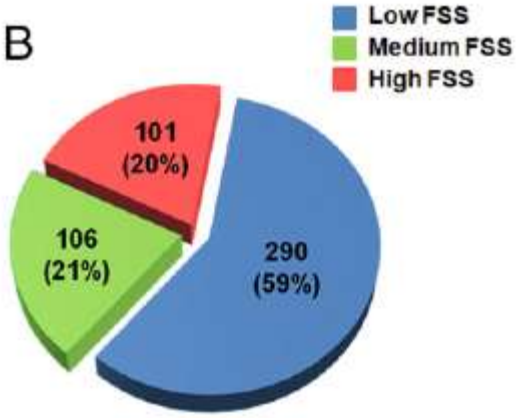
Re-Classification of Disease Extent : FFR

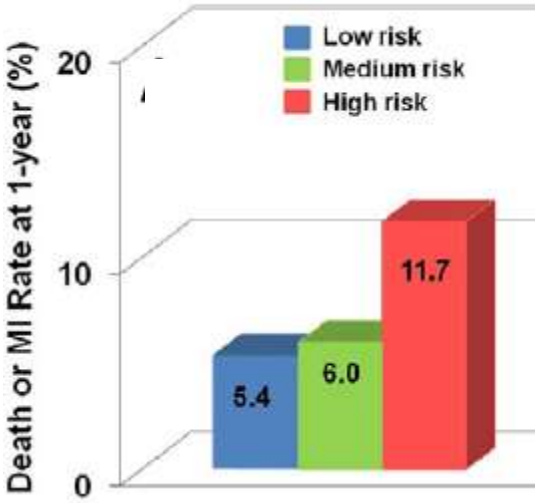
Anatomical SYNTAX



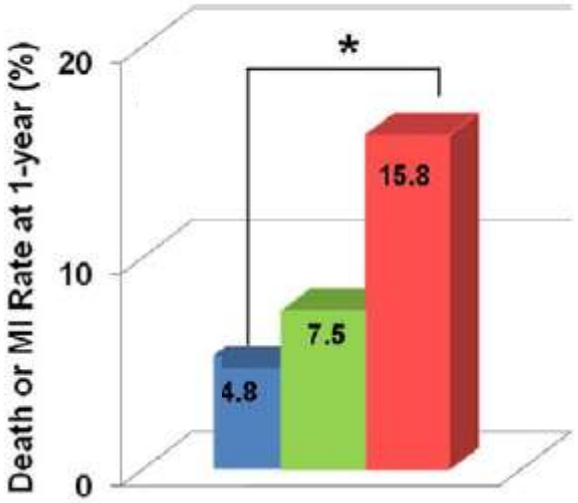
32% Moved to
Lower-Risk Group

Functional SYNTAX





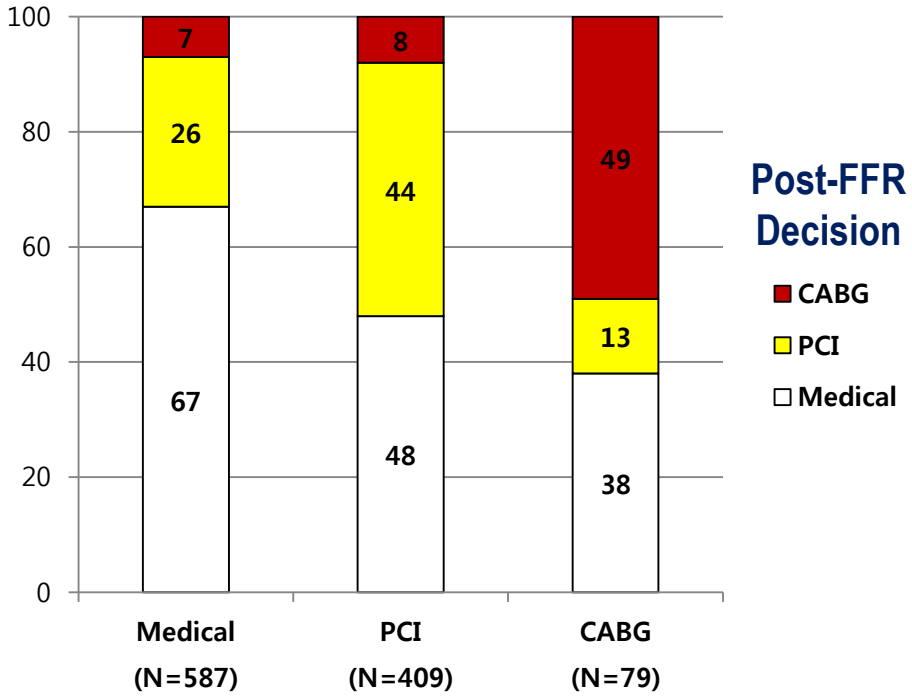
Better Discrimination
Death/MI



Nam CW, JACC 2011

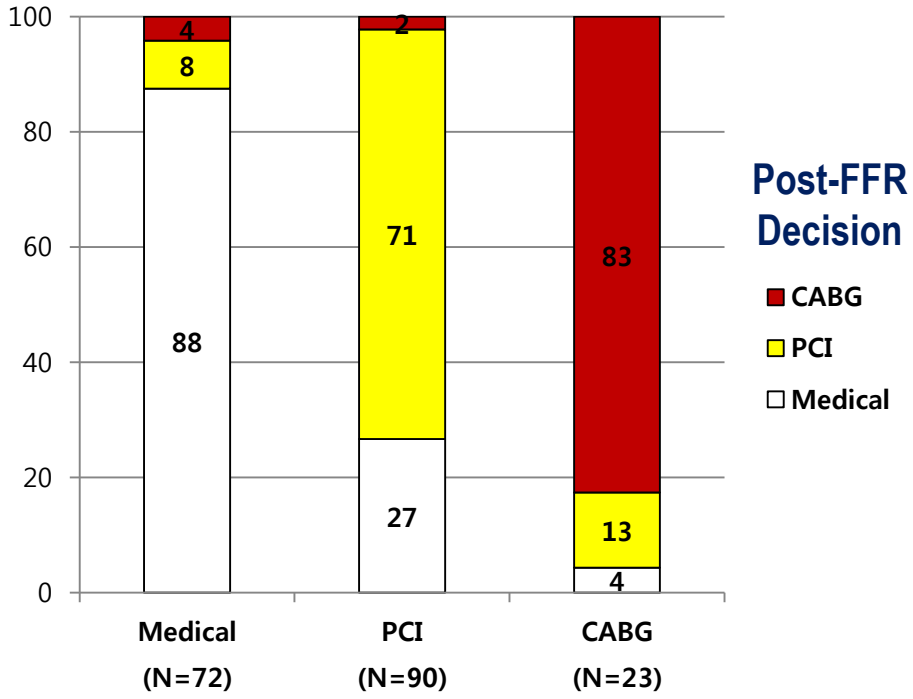
Per-Patient Decision of Treatment Strategy : FFR

R3F Registry (N=1075)



Change in Treatment Decision was occurred in 43% of Population

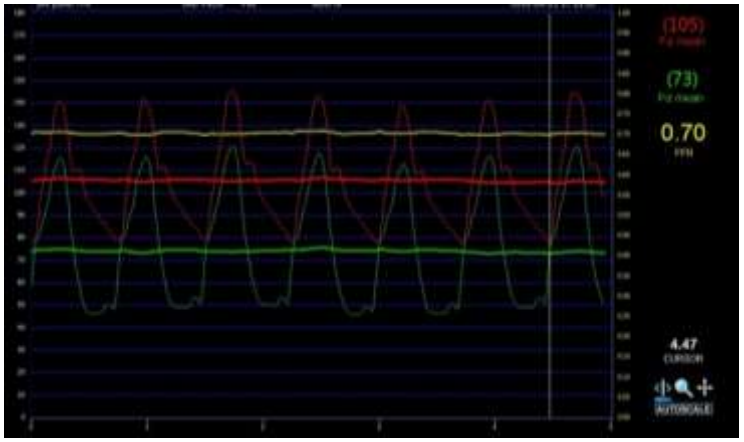
RIPCORD Trial (N=200)



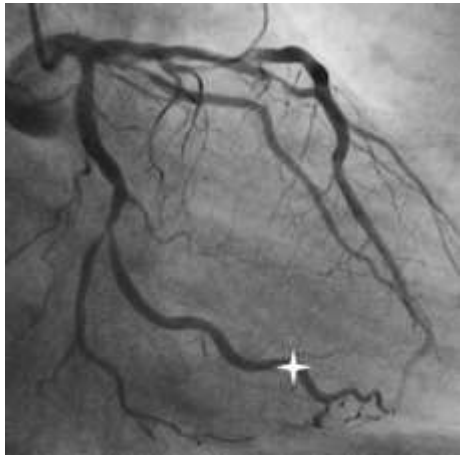
Change in Treatment Decision was occurred in 26% of Population

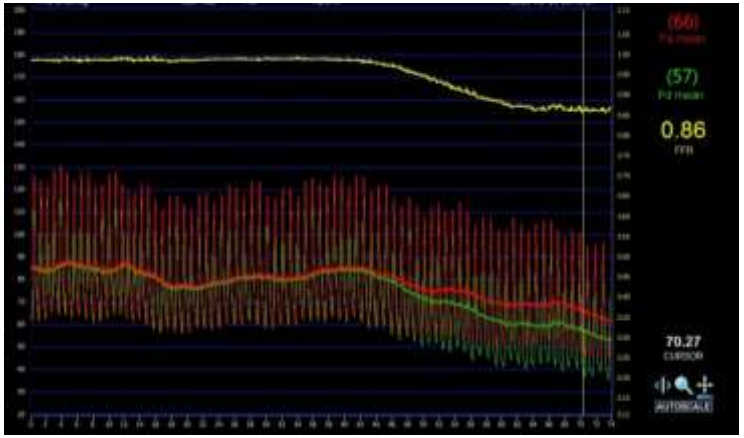
Van Belle E et al. Circulation 2014
Curzen et al. RIPCORD, Circ Intervention 2014

Per-vessel Treatment Decision for Revascularization : FFR



"Consider † " Revascularization & Secondary Prevention ‡

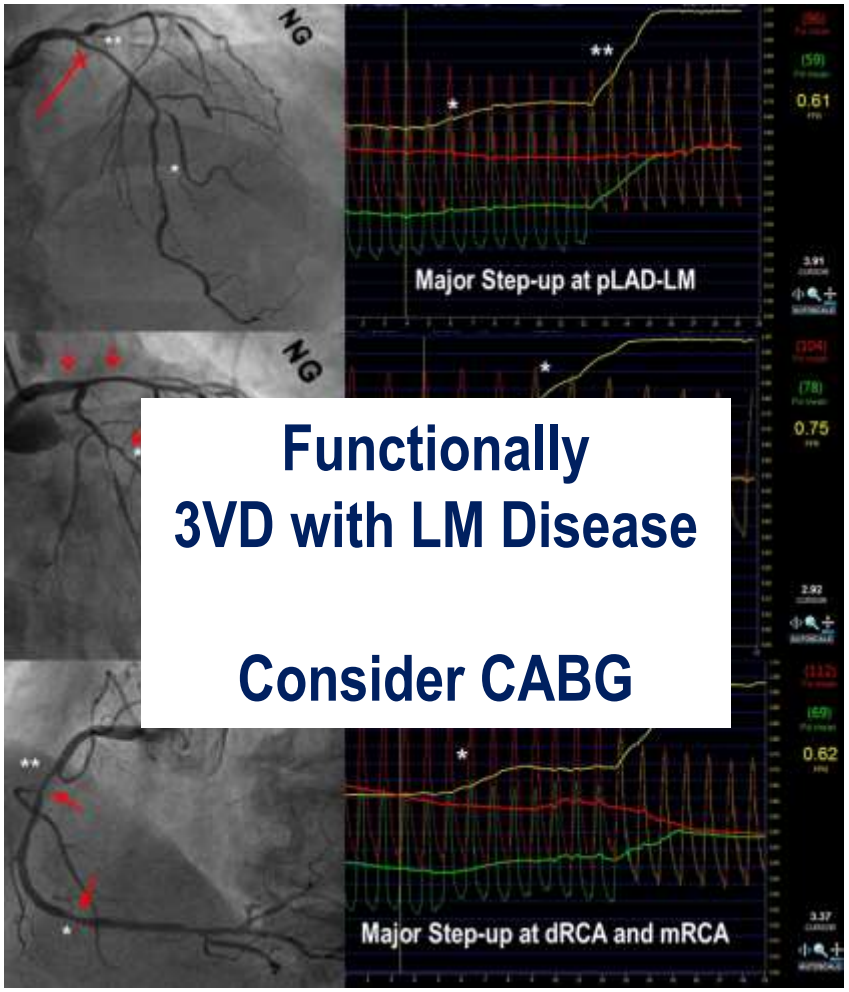




"Deferral" of revascularization & Secondary Prevention ‡

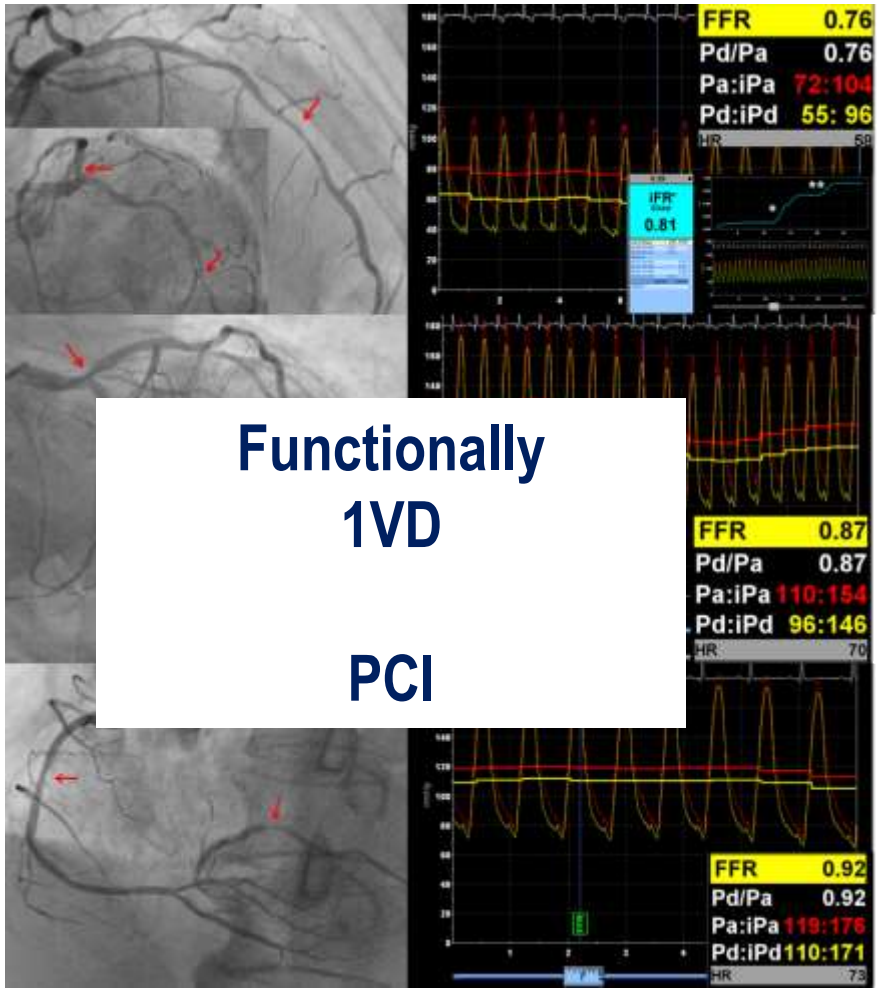
† According to clinical and socioeconomic status of patient and technical difficulty of revascularization
‡ More important in patient care than FFR-guided decision.

Per-Patient Treatment Decision : Routine Application of FFR



Functionally
3VD with LM Disease

Consider CABG

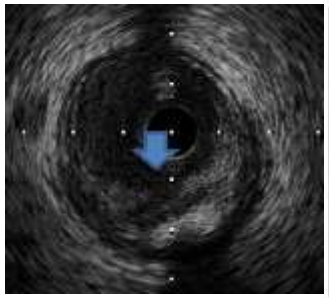


Functionally
1VD

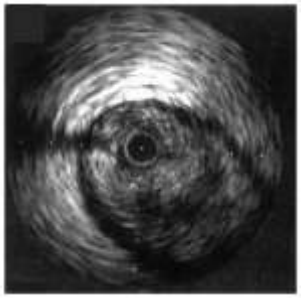
PCI

Pre-Procedural Planning of PCI : IVUS
- Plaque Characterization -

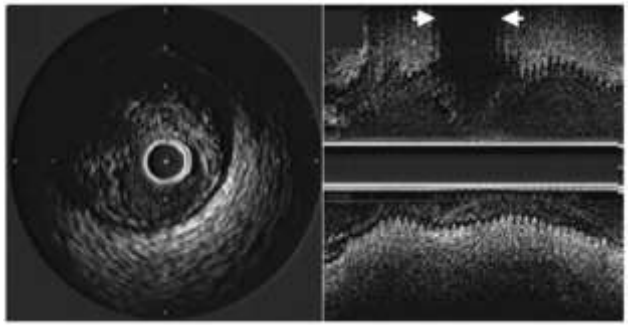
Plaque Rupture



Echolucent Plaque



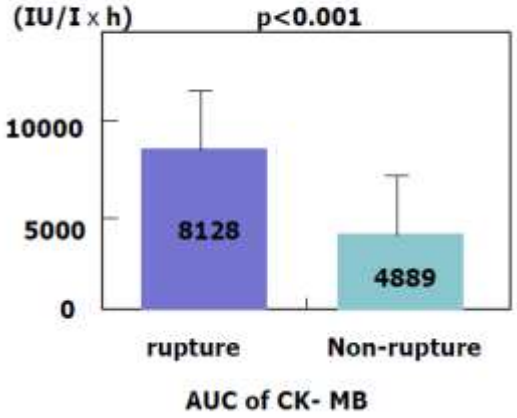
Attenuating Plaque



Gray-scale IVUS plaque character associated with worse clinical outcome

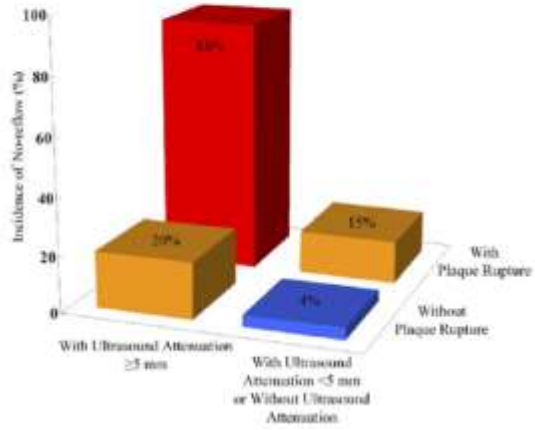
Infarct Size

91 patients with acute STEMI
54 with PR vs 37 without PR

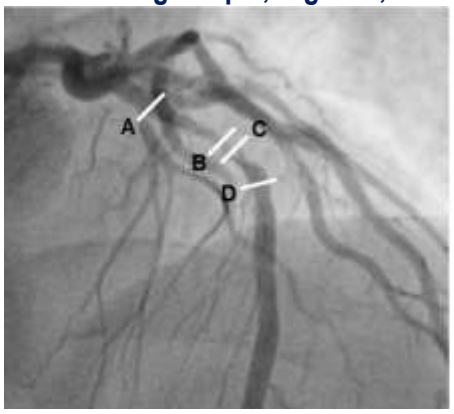


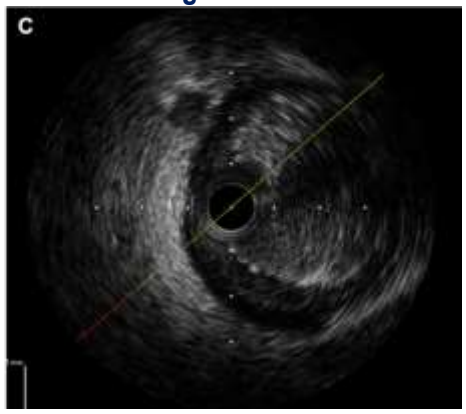
No Reflow

170 patients with acute STEMI
underwent PCI within 12 h



Attenuating Plaque, High PB, Positive Remodeling

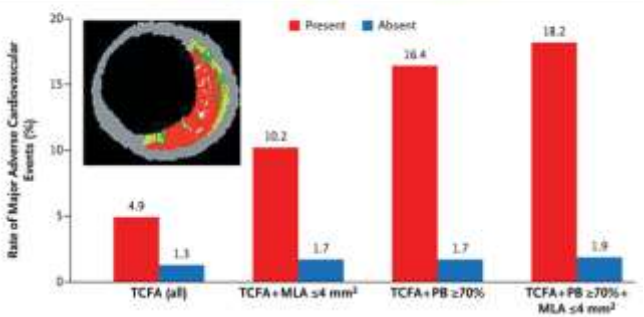




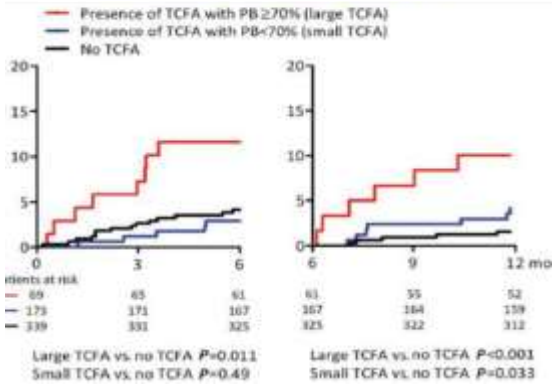
Kusama et al. JACC 2007
Endo et al, JACC Intervention 2010
J Am Coll Cardiol Img 2012;5:S111–8

Pre-Procedural Planning of PCI : IVUS
- Plaque Characterization and Outcome -

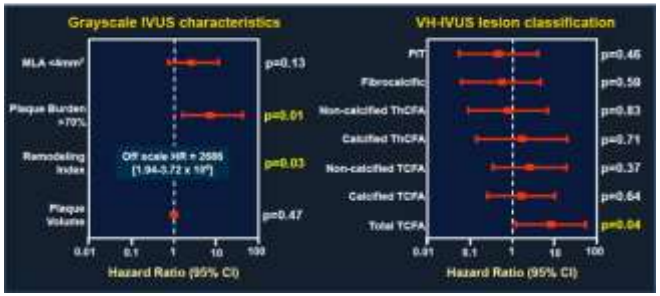
PROSPECT Trial



ATHEROREMO



VIVA



Predictor	Multivariable HR (95% CI)	P value
PB (MLA) ≥ 70%	5.03 (2.51-10.11)	<0.001
VH-TCFA	3.35 (1.77-6.36)	<0.001
MLA ≤ 4.0mm^2	3.21 (1.61-6.42)	0.001

Predictor	Adjusted HR (95% CI)	P value
PB (MLA) ≥ 70%	2.90 (1.60-5.25)	<0.001
VH-TCFA	1.98 (1.09-3.60)	0.026
MLA ≤ 4.0mm^2	1.23 (0.67-2.26)	0.05

Predictor	Univariate HR (95% CI)	P value
PB (MLA) ≥ 70%	8.13 (1.63-40.56)	0.011
VH-TCFA	7.53 (1.12-50.55)	0.038
Remodeling index	2686 (1.94-3.72*10^6)	0.032

Vulnerable Plaque in IVUS (High plaque burden, Positive remodeling, low MLA, VH-TCFA) is Associated with Worse Clinical Outcome in ACS patients

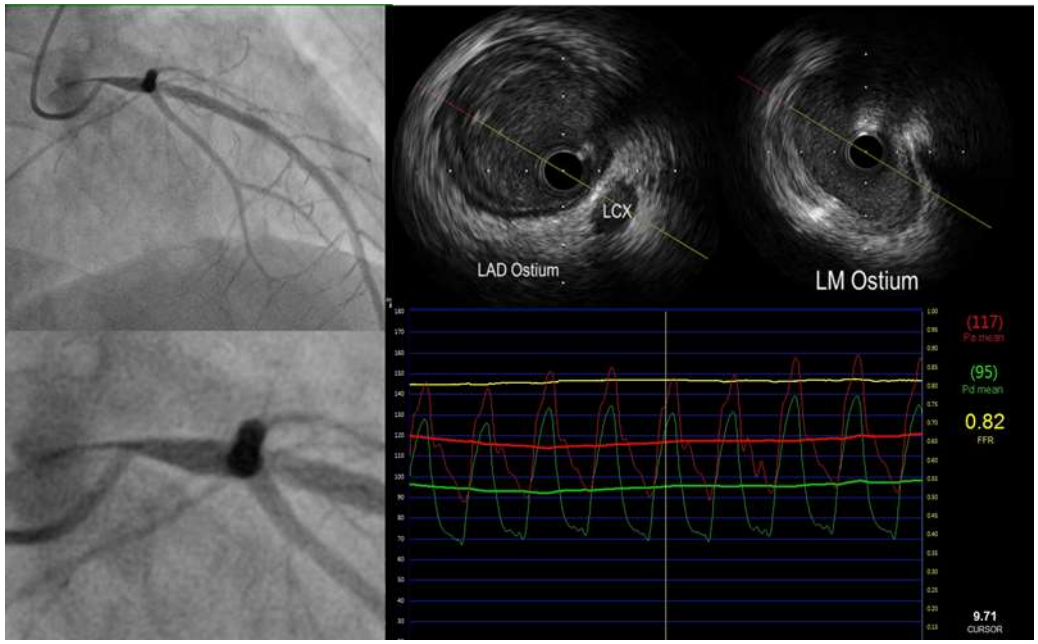
PROSPECT, NEJM 2011
ATHEROREMO IVUS, EHJ 2014
VIVA, Calvert et al. JACC Imaging 2011

Pre-Procedural Planning of PCI : IVUS

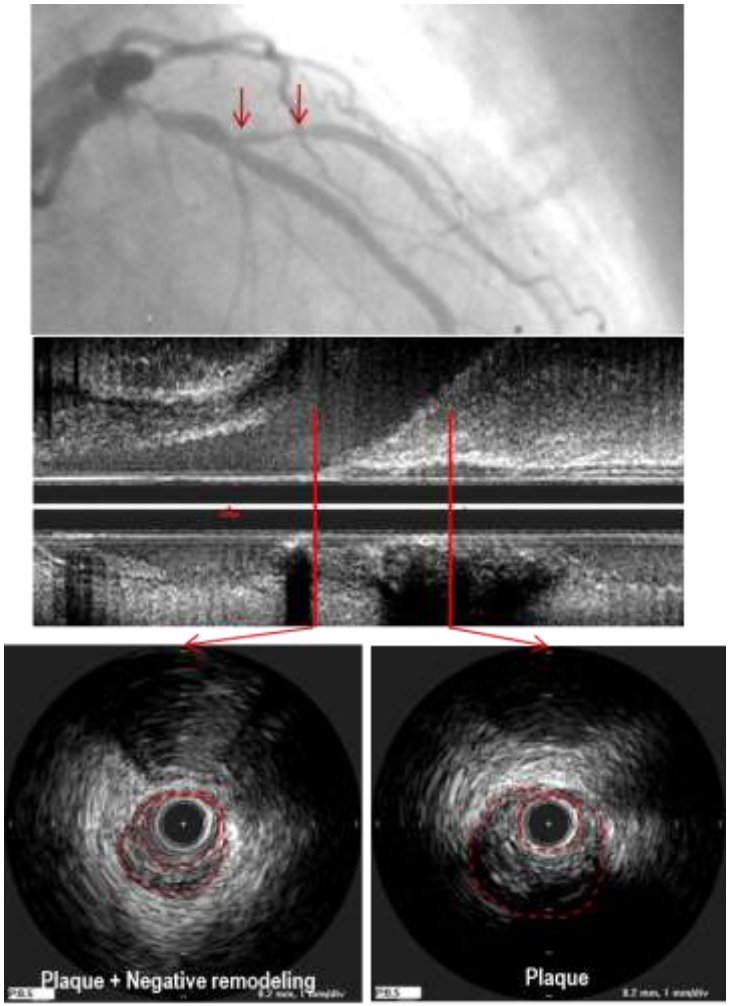
- Lesion Severity and Mechanism of Luminal Narrowing -

- Quantitative evaluation of lumen, plaque, and vessel
- Mechanism of narrowing
- Plaque and Vessel Geometry (especially important in bifurcation PCI)

LM Ostium



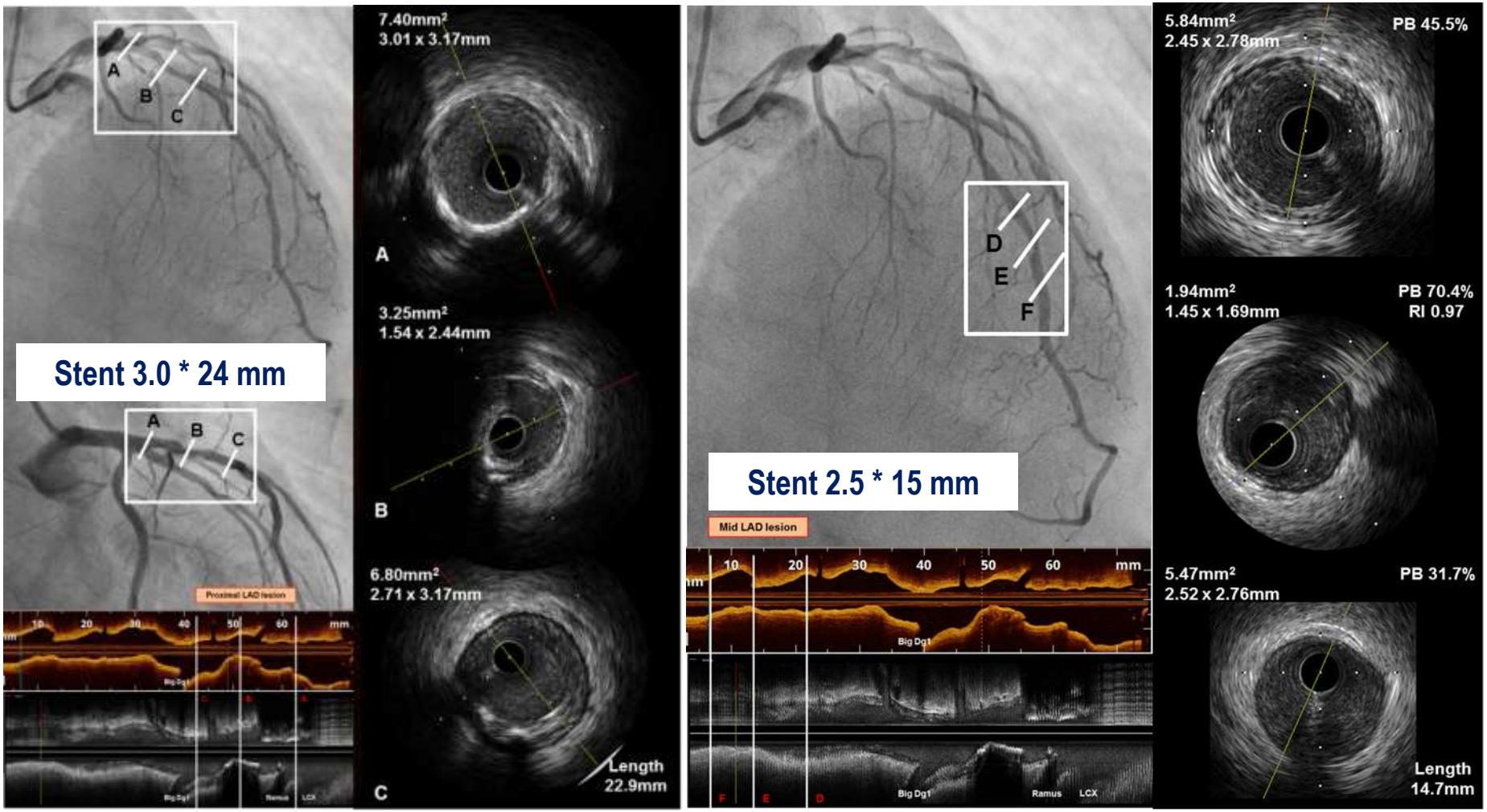
Bifurcation (SB)



Courtesy to My Mentor, Prof. Koo BK

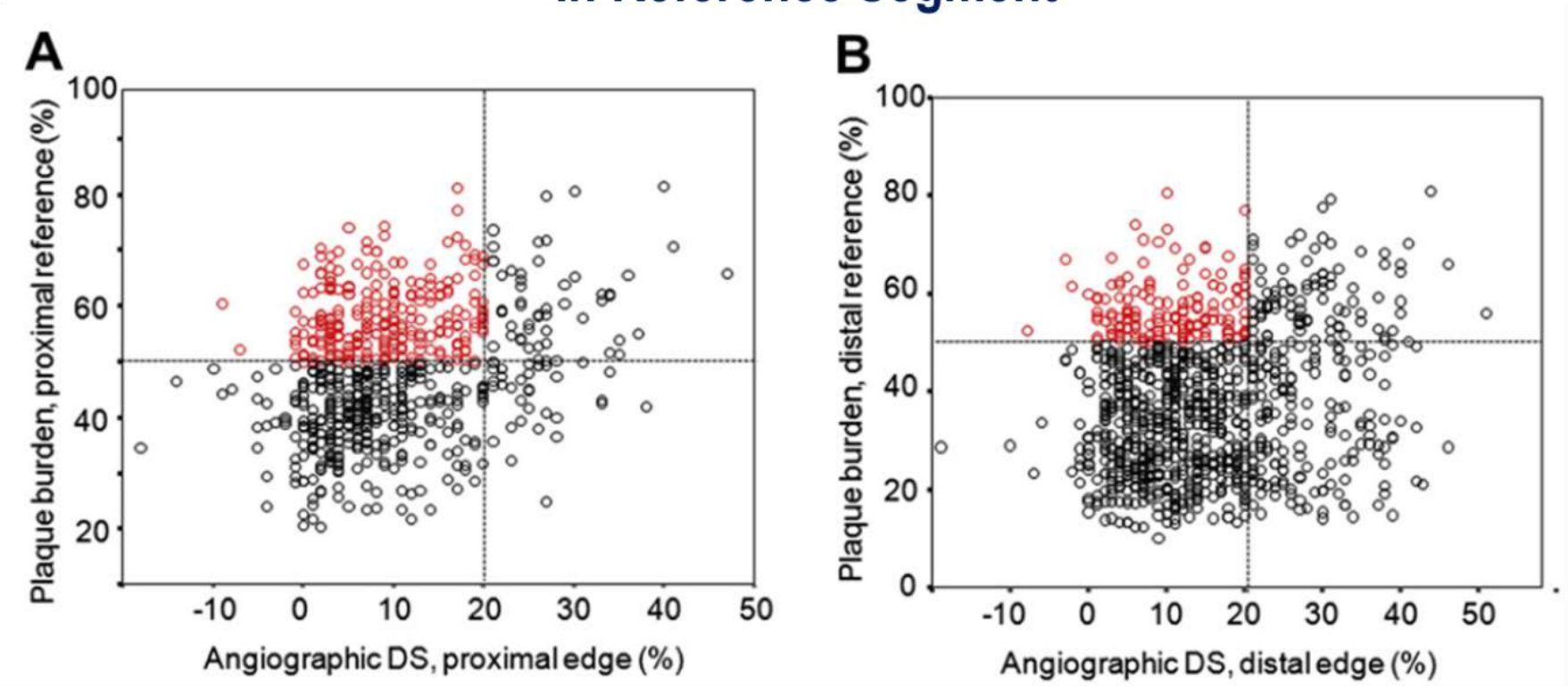
Lee JM, Koo BK, The Role of IVUS in the OCT Era (Chapter in the Textbook, In Press)

Pre-Procedural Planning of PCI : IVUS
- Appropriate Sizing -



Pre-Procedural Planning of PCI : IVUS
- Proper Landing Zone -

Poor Correlation with Angiographic %DS and IVUS Plaque Burden In Reference Segment



(A) Of 785 proximal reference segments with %DS <20%, 290 (37%) had plaque burden >50%.

(B) Of 724 distal reference segments with %DS <20%, 153 (21%) had plaque burden >50%.

Kang SJ et al. Am J Cardiol 2013.

Post-Procedural Optimization of PCI : IVUS
- Adequate Expansion -

990 lesions treated by SES, ZES, and EES

Post-PCI MSA was the only Independent Predictor for 9-Month ISR

Variable	OR	95% CI	P value
Univariable			
DM	0.981	0.449-2.144	0.002
Smoker	2.241	0.997-5.037	0.051
Multivessel disease	0.608	0.297-1.248	0.608
IVUS MSA	0.710	0.569-0.887	0.002
IVUS Post-EEM	0.929	0.853-1.013	0.095
IVUS Reference vessel diameter	0.404	0.180-0.970	0.028
IVUS Post-PCI In-stent MLD	0.535	0.268-1.065	0.075
Multivariable			
IVUS MSA	**0.722**	**0.581-0.897**	**0.003**

IVUS MSA Best Cutoff Value (To prevent 6-9Mo ISR)

	Stent	Sample Size	MSA
SIRIUS	**SES**	**72**	**5.0mm^2**
Hong et al.	**SES**	**550**	**5.5mm^2**
TAXUS Meta	**PES**	**1098**	**5.7mm^2**
Song et al.	**ZES**	**220**	**5.3mm^2**
Song et al.	**EES**	**229**	**5.4mm^2**

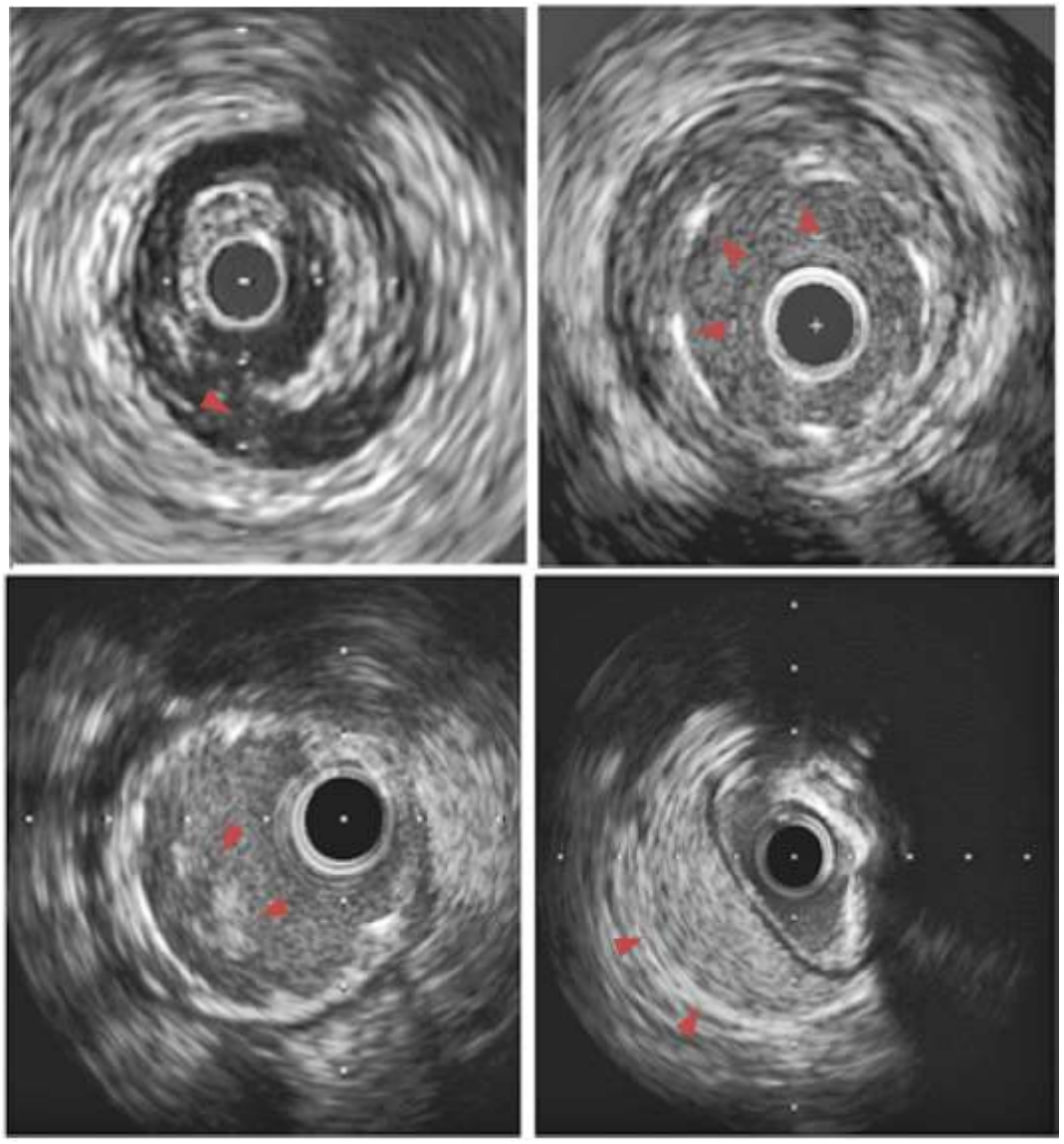
Adequate stent expansion is still important in the DES era.

J Am Coll Cardiol 2004;43:1959–63 / Catheter Cardiovasc Interv. 2014;83:873-8.
Hong MK et al. Eur Heart J 2006./ Doi H et al. J Am Coll Cardiol Intv 2009.

Post-Procedural Optimization of PCI : IVUS
- Evaluating Acute Complication -

Edge dissection

ISA



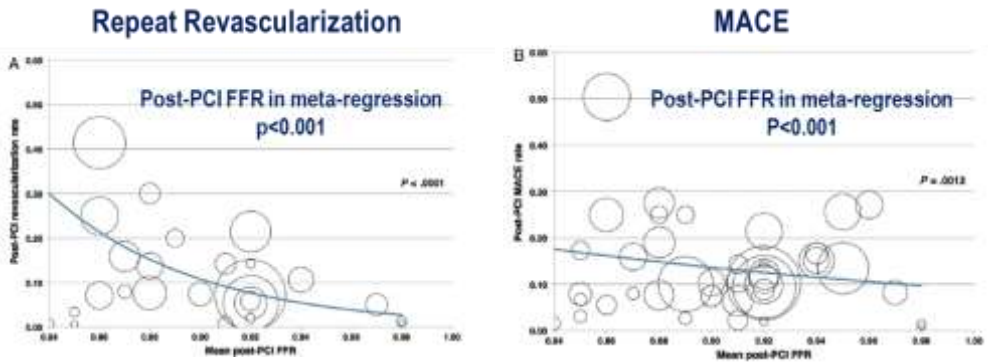
Thrombi or
Tissue prolapse

Hematoma

Hahn JY et al. Catheter-Based Cardiovascular Interventions, Chapter 19

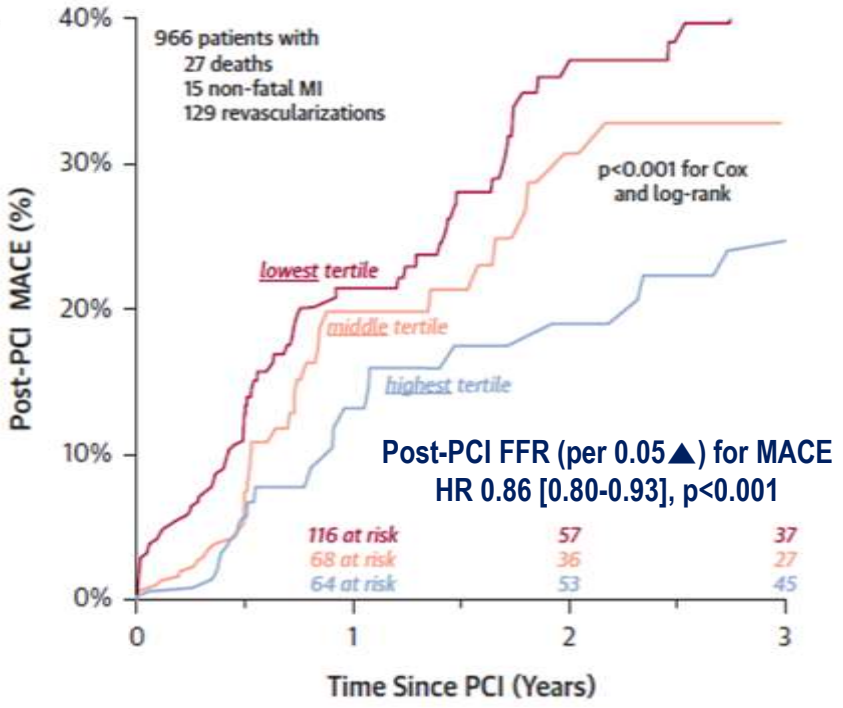
Post-Procedural Optimization of PCI : FFR
- Evaluating Functional Completeness -

Study-level meta (N=7470)



Post-PCI FFR ≥0.90
Repeat Revascularization 55% ▼
MACE 30% ▼

Patient-level meta (N=966)

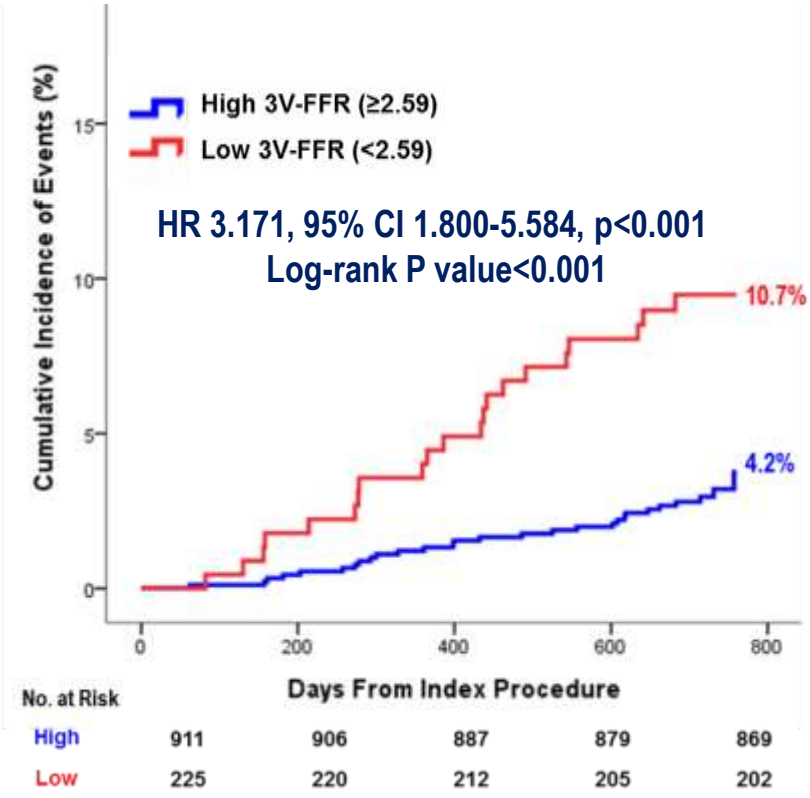


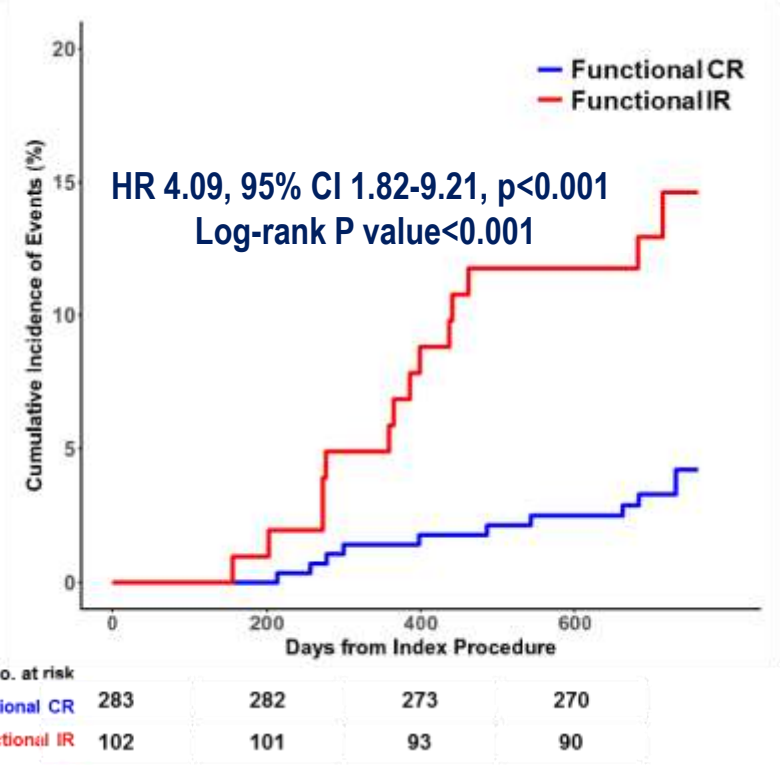
High Post-PCI FFR (Per-vessel) is
Significantly Associated with Lower Risk of Future Events

Rimac et al. AHJ 2017
Nils P. Johnson et al. JACC 2014

Post-Procedural Optimization of PCI : FFR
- Beyond Per-Vessel Evaluation -

1136 Patients with Mandatory Measurement of Final Per-vessel FFR
3V-FFR : Total Sum of Final FFR in all 3 vessels
2-Year MACE





Results from 3V-FFR-FRIENDS Study

① 3V-FFR is a Prognostic Indicator as Global Marker of Physiologic Atherosclerotic Burden

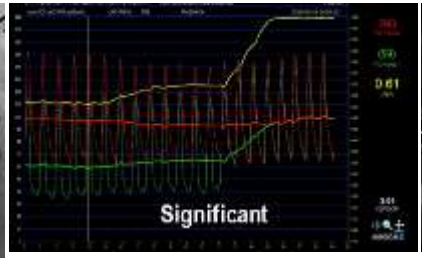
② Functional Incomplete Revascularization (residual functional SYNTAX ≥0) showed higher MACE

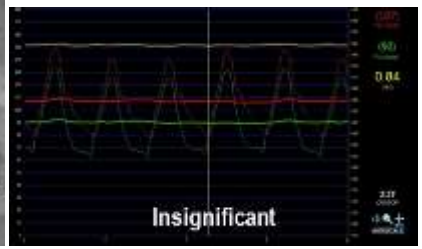
3V-FFR-FRIENDS Study, Under Review
Pre-specified Sub-study of 3V-FFR-FRIENDS, Under Review

Integrated Use of FFR and IVUS
- Summary -

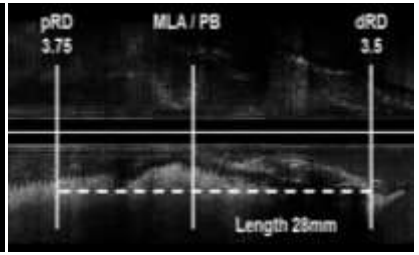
Stenosis
Myocardial Mass
Subtended

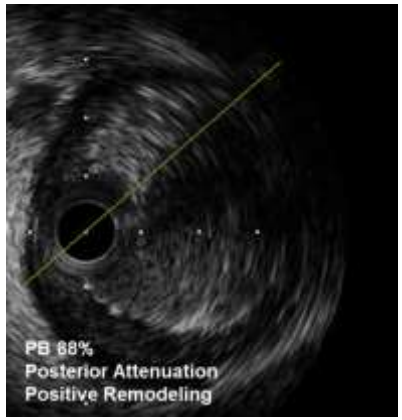
Functional Significance
Lesion Reclassification
Treatment Decision (Patient)



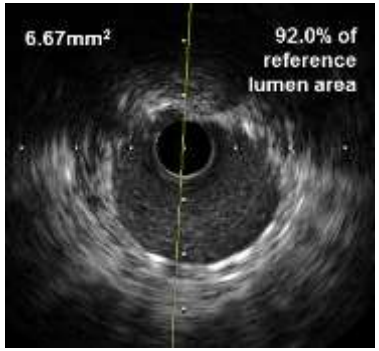


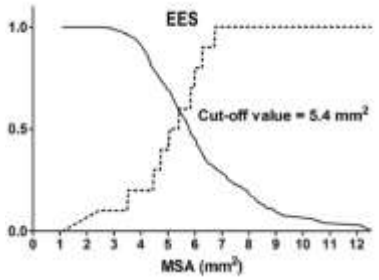
Plaque Character
Proper Sizing
Landing Zone



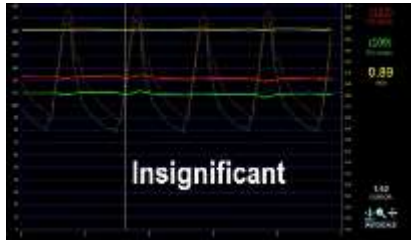


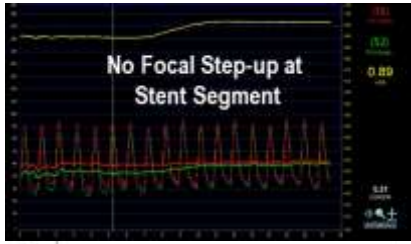
Stent
Optimization

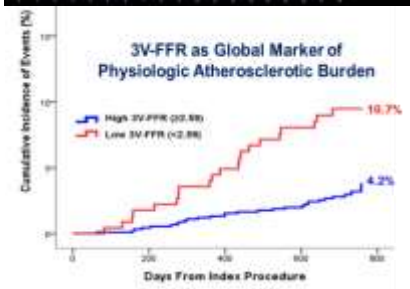




Evaluating
Functional
Completeness







Integrating Imaging and Physiology will Enhance Patient Outcome

Thank You For Your Attention !

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If you have any question, don't hesitate to e-mail me.

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