

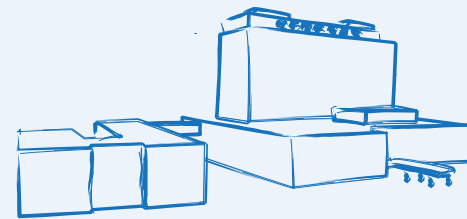
Usefulness of the Trans-Stent FFR Gradient for Predicting Clinical Outcomes

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Department of Cardiology

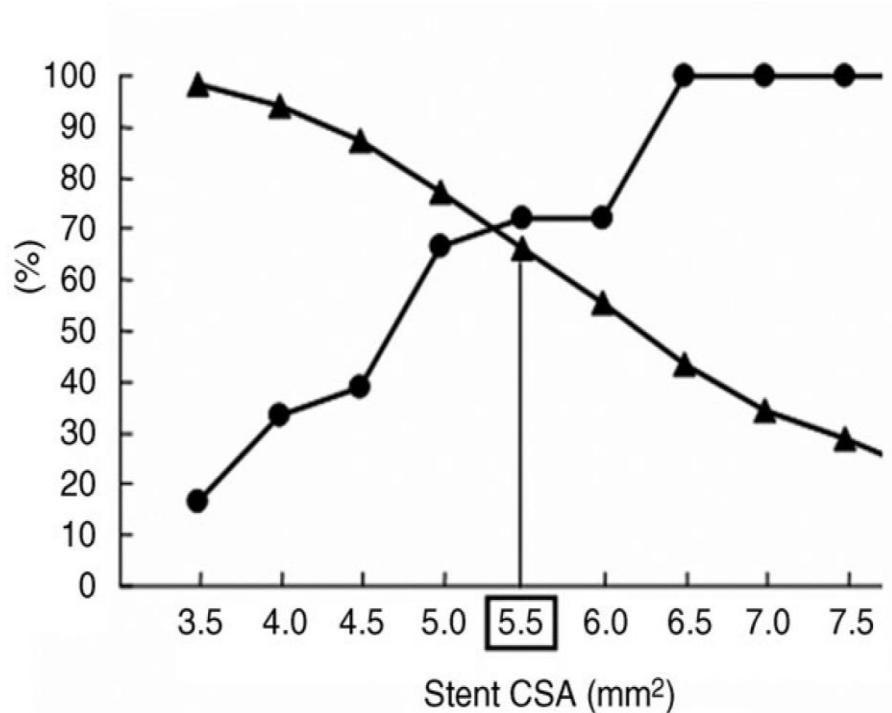
Ajou University Hospital

Post-PCI assessment

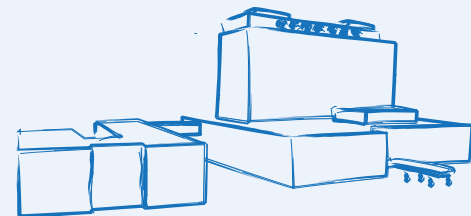


IVUS-MSA

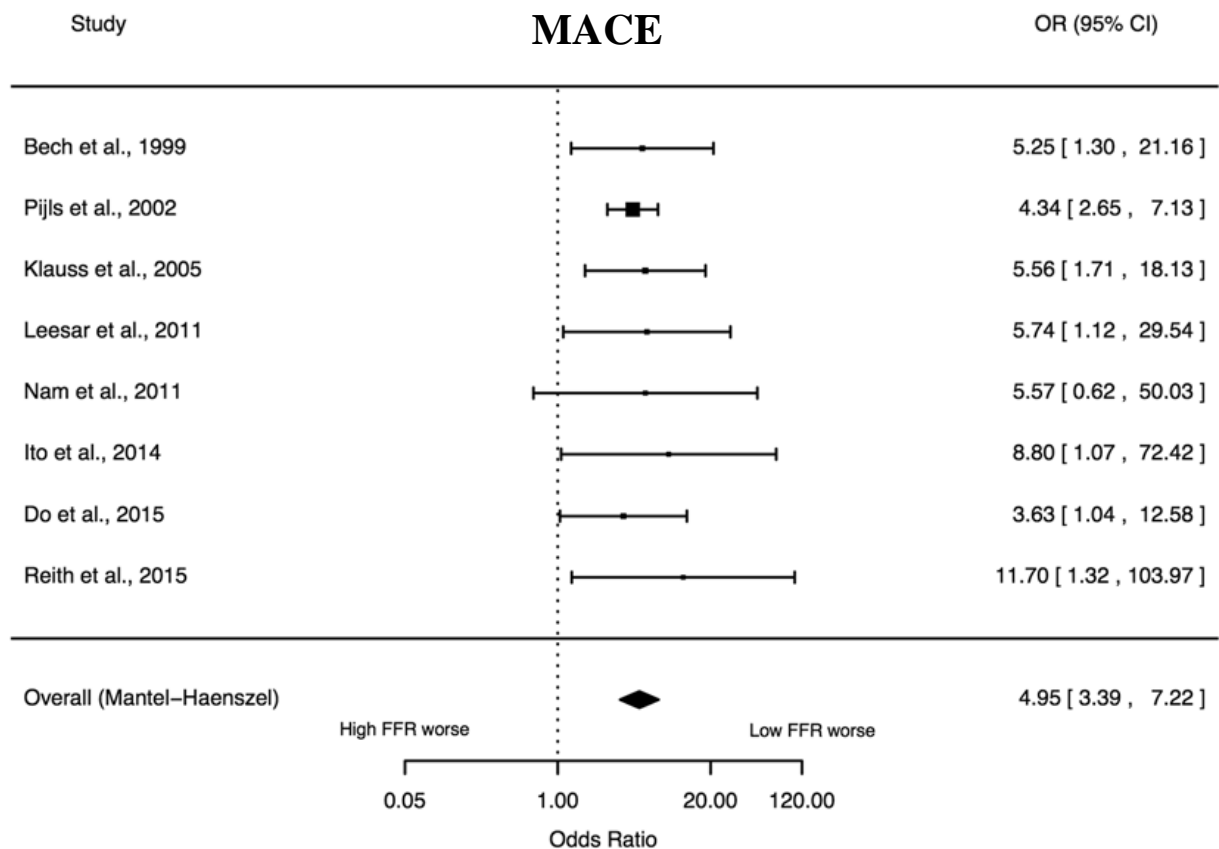
Post-PCI FFR



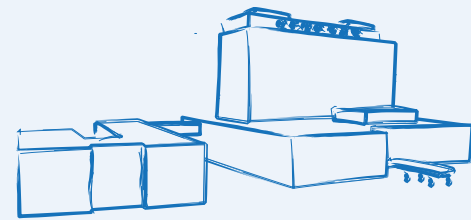
Post-PCI FFR



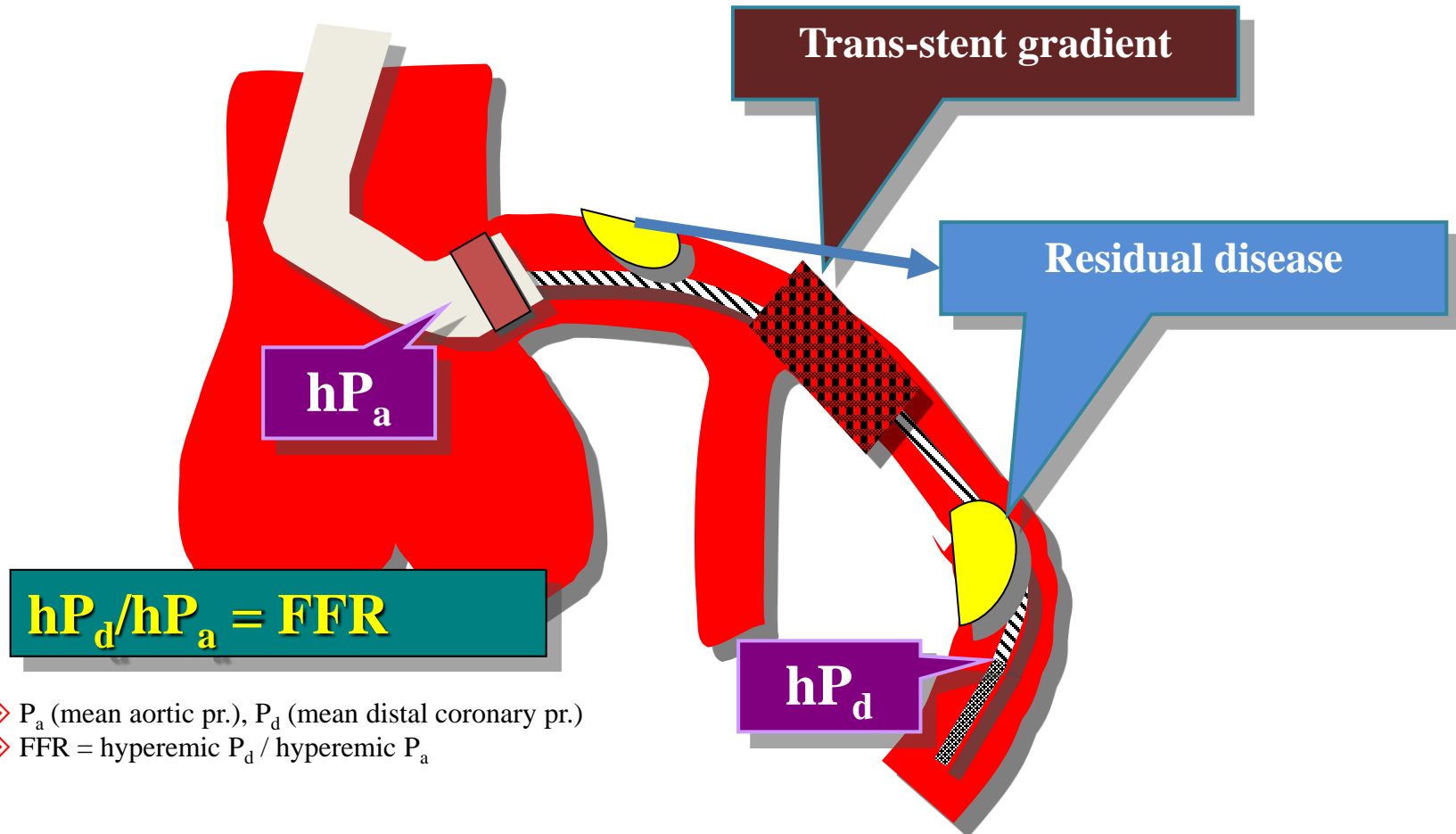
Meta analysis-1,337 patients
 Compared to a satisfactory FFR, a persistently low FFR following PCI
 is associated with a worse clinical outcome.



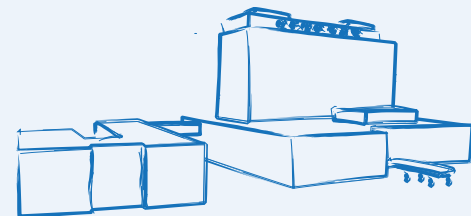
Post-PCI FFR



Post-intervention FFR is affected by
Trans-stent gradient + **Residual disease**



Post-PCI FFR



Trans-stent gradient after PCI

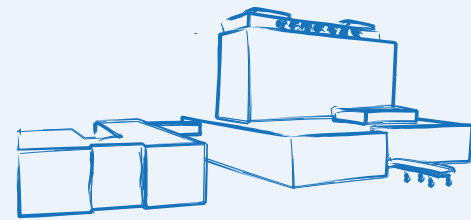
Abnormal blood flow pattern with heterogenous and abnormal low shear stress

- ▶ Sub-optimal deployment of the stent
- ▶ Incomplete apposition / protruding struts
- ▶ Lumen irregularity
- ▶ Dislocation of plaque

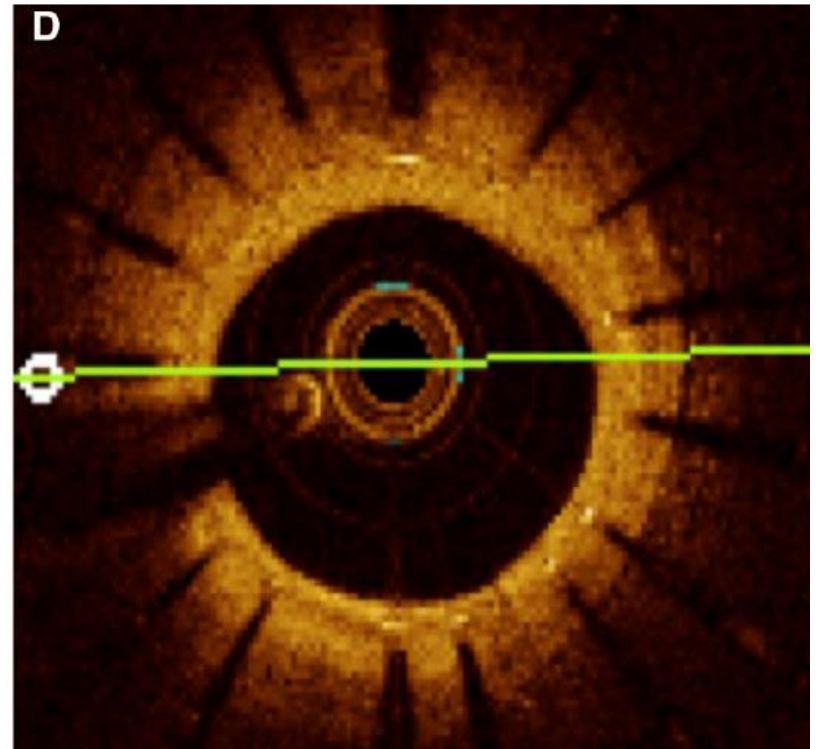
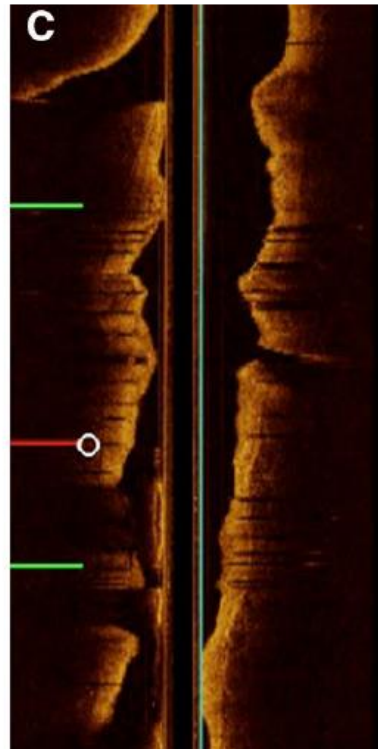
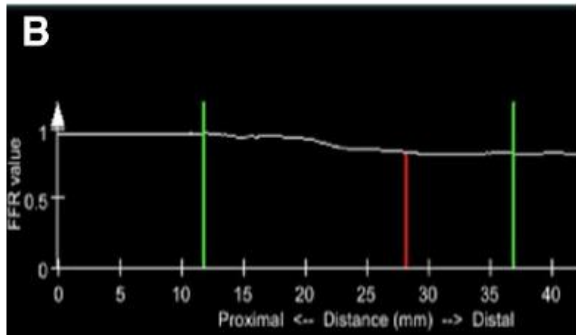
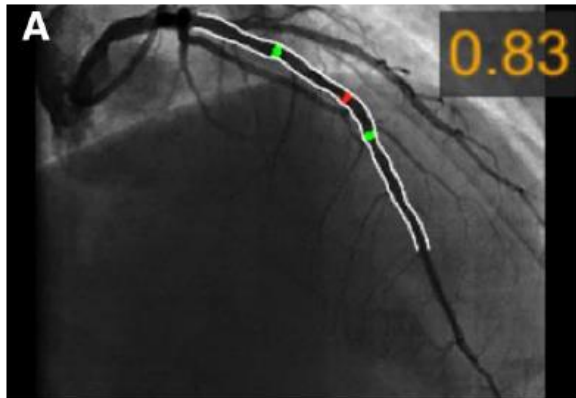
Residual disease

- ▶ Diffuse disease (DM..)
- ▶ Geographical miss
- ▶ Plaque shift at the stent edge

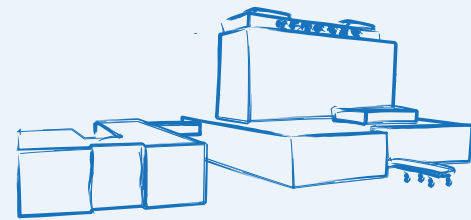
OCT & Trans-stent FFR



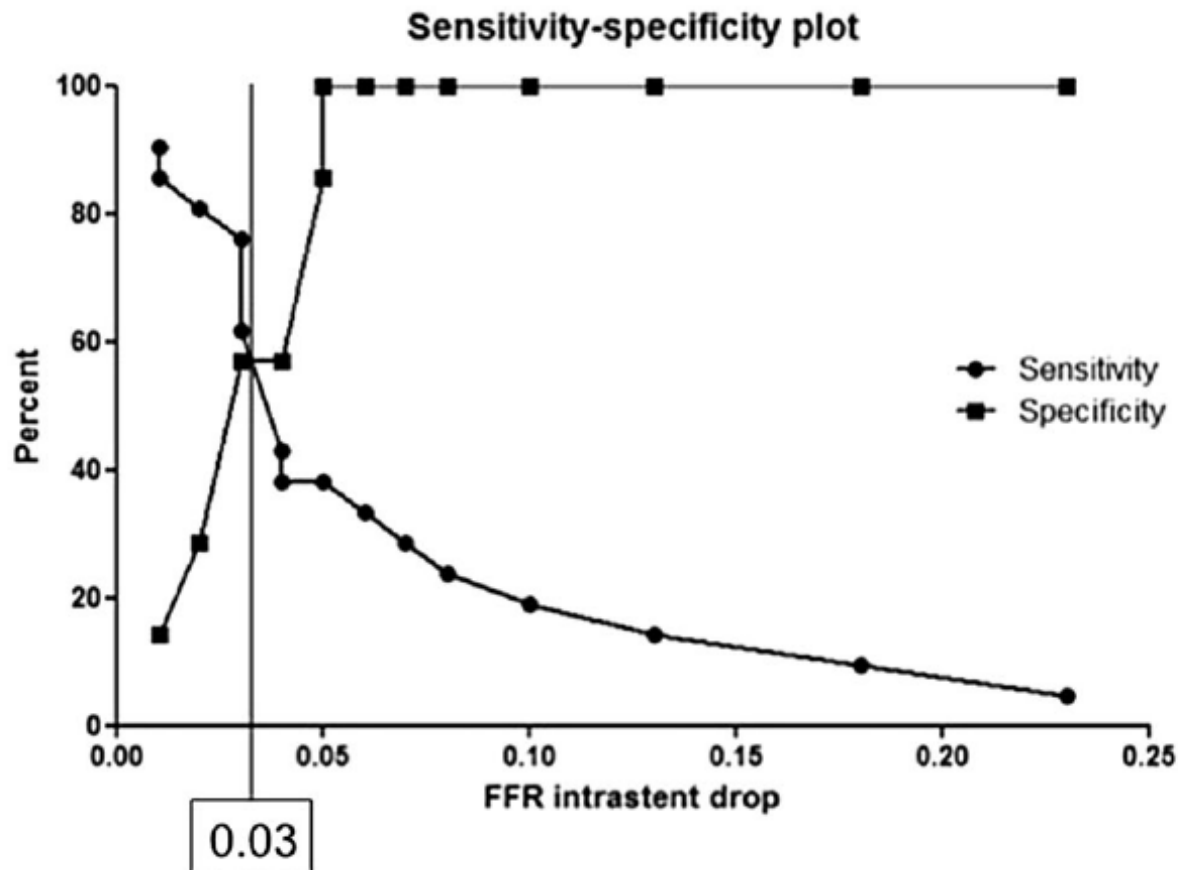
2-Month after PCI



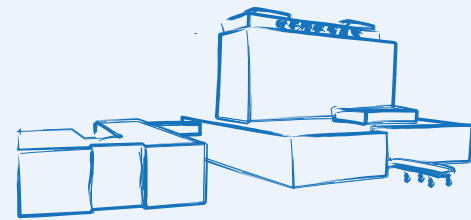
OCT & Trans-stent FFR



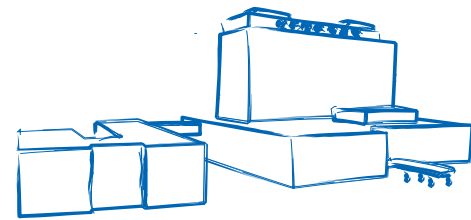
Cut-off value of Trans-stent FFR to predict sub-optimal FFR



OCT & Trans-stent FFR

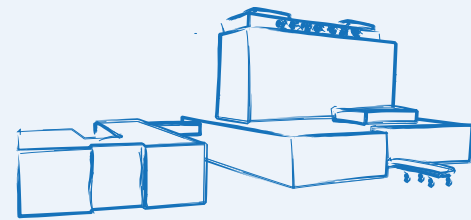


	Sub-optimal FFR	Optimal FFR	P
Proximal-vessel	0.95 ± 0.04	0.99 ± 0.02	0.001
Proximal stent-edge	0.95 ± 0.04	0.98 ± 0.02	0.012
Distal stent-edge	0.87 ± 0.06	0.97 ± 0.02	< 0.001
Distal-vessel	0.84 ± 0.07	0.96 ± 0.02	< 0.001
In-stent gradient	0.08 ± 0.07	0.01 ± 0.02	< 0.001



We evaluated the usefulness of a fractional flow reserve (FFR) gradient across the stent ($\Delta\text{FFR}_{\text{stent}}$) for long-term clinical outcomes after percutaneous coronary intervention (PCI) with a drug-eluting stent (DES).

Study population



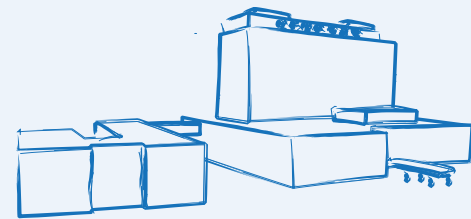
Inclusion Criteria (n=135)

- who underwent both IVUS and FFR after PCI with a DES in the LAD
- Mean follow-up duration was $2,183 \pm 898$ days (6 ± 2.5 years)

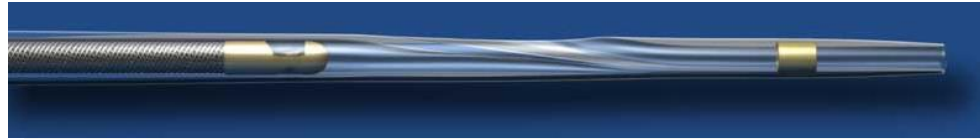
Exclusion criteria

- Infarct-related artery of acute or old myocardial infarction (MI),
- A patient with visible collaterals
- Left main disease
- In-stent restenosis
- Tandem lesion
- Low ejection fraction ($<40\%$).

Methods



IVUS



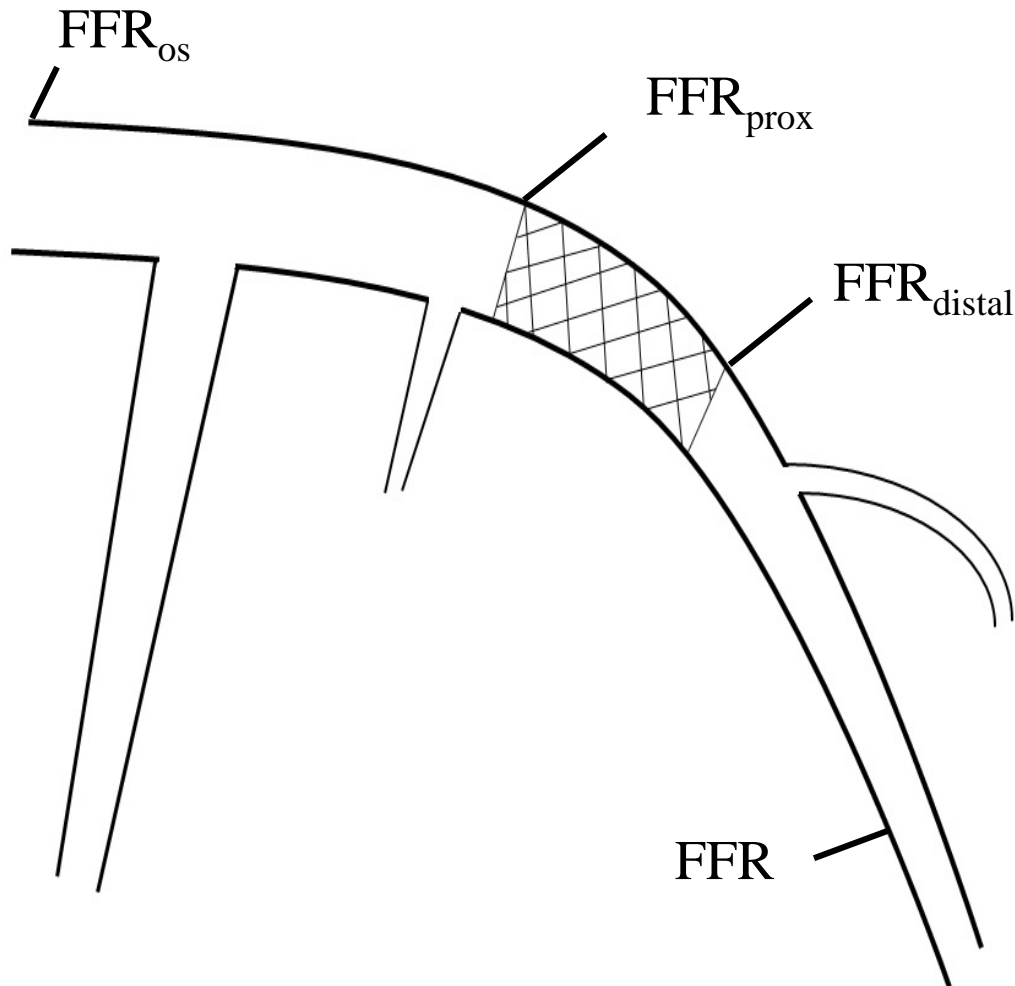
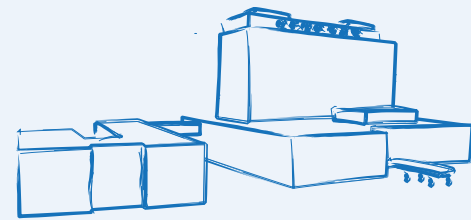
Galaxy and iLab IVUS Imaging System / Atlantis[®]
SR Pro Imaging Catheter (BSC, USA)

Measurement of FFR



Intracoronary Pressure Wire
(St. Jude Medical, USA)

Methods

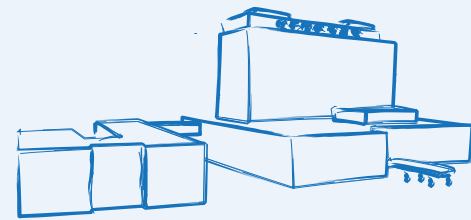


$$\Delta FFR_{stent} = FFR_{distal} - FFR_{prox}$$

$$\Delta FFR_{stent}/length$$

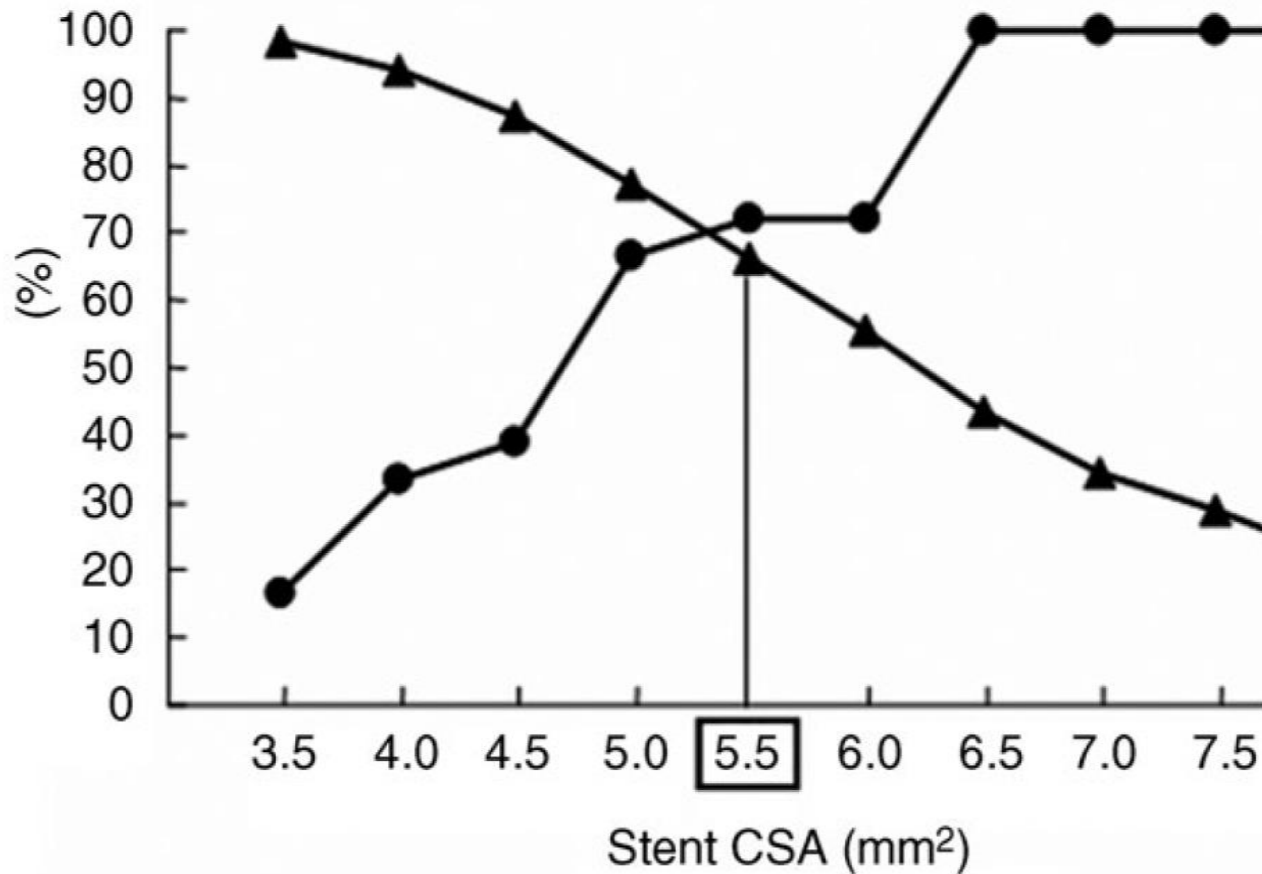
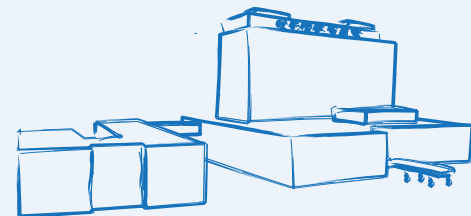
$$= (\Delta FFR_{stent}/total\ stent\ length) \times 10$$

Results-FFR

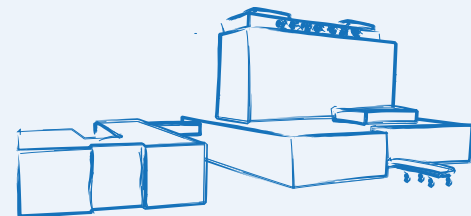


FFR, pre-PCI	0.77 (0.74-0.80)
FFR, post-PCI	
Far distal	0.87 (0.84-0.90)
Stent distal edge	0.92 (0.89-0.94)
Stent proximal edge	0.96 (0.93-0.98)
Ostium	1.0 (1.00-1.00)
$\Delta\text{FFR}_{\text{stent}}$	0.03 (0.02-0.04)
$\Delta\text{FFR}_{\text{stent}} = 0$	2 (1.5)
$\Delta\text{FFR}_{\text{stent}} > 0$	133 (98.5)

Stent underexpansion – IVUS MSA

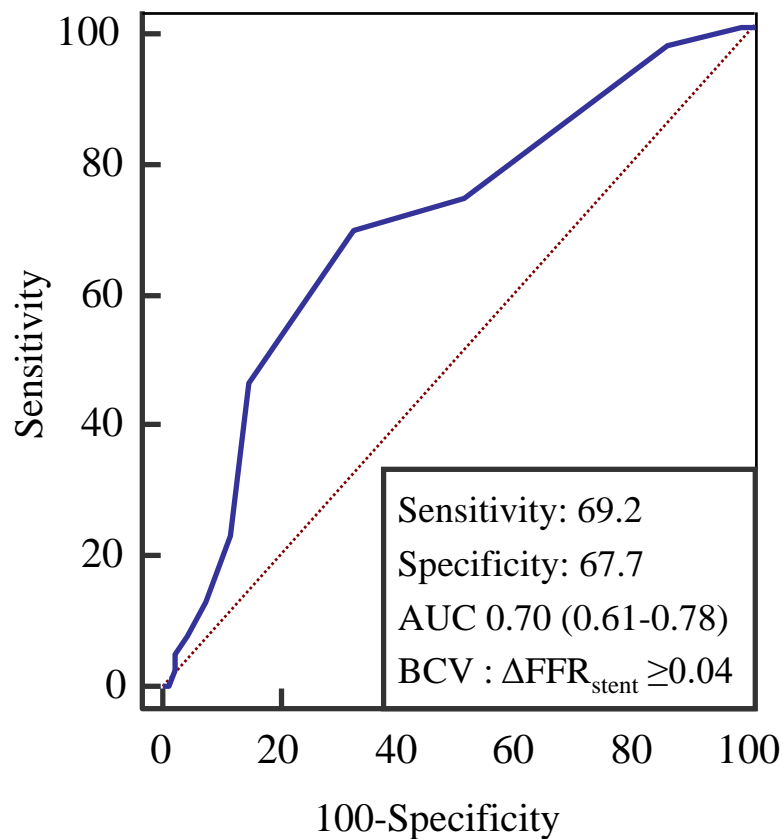


ROC analysis

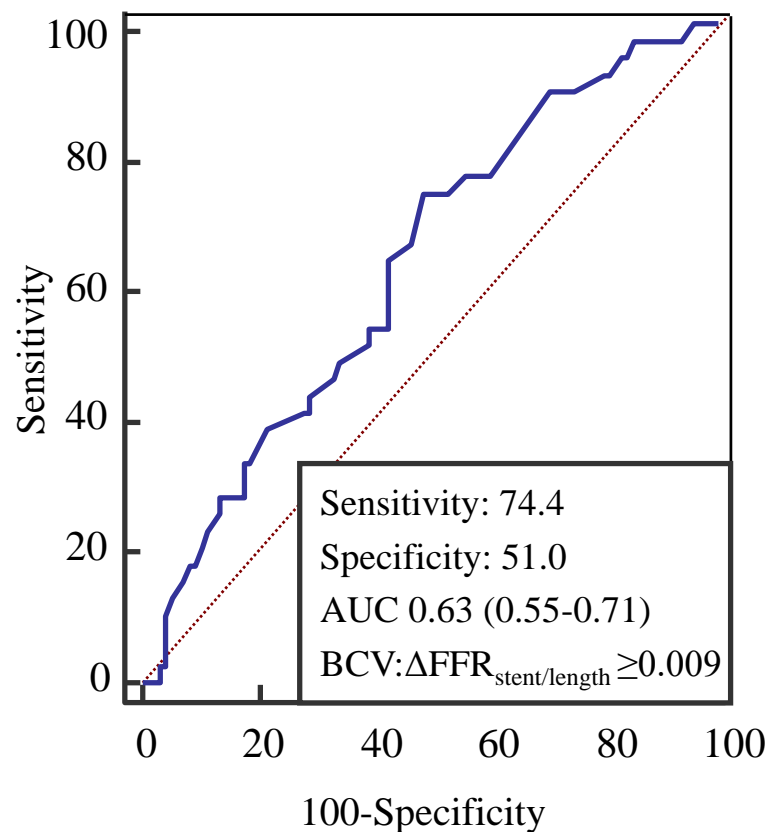


Best cut off value to predict IVUS MSA < 5.5 mm²

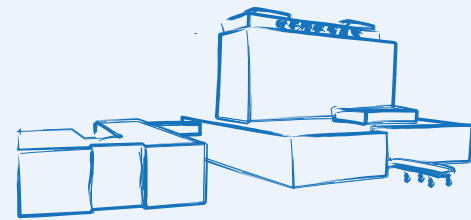
Trans-stent FFR



Trans-stent FFR/length

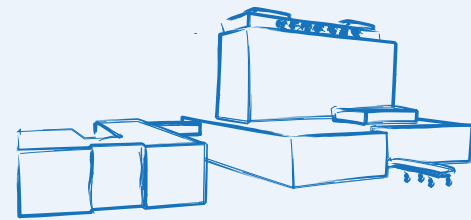


Multivariate logistic regression analysis for the prediction of final MSA < 5.5 mm²



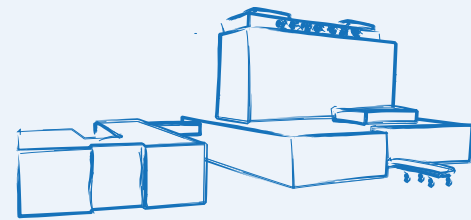
	$\Delta\text{FFR}_{\text{stent}}$		$\Delta\text{FFR}_{\text{stent}}/\text{length}$	
	Odds ratio	P	Odds ratio	P
Diabetes mellitus	4.35	0.038	2.5	0.139
Sex	1.62	0.453	1.07	0.909
Reference vessel diameter	0.30	0.245	0.36	0.284
Final minimal lumen diameter	0.17	0.093	0.18	0.080
Stent length	1.00	0.987		
Post-PCI FFR	0.01	0.368	0.00	0.263
IVUS reference vessel area, distal	0.62	0.007	0.8	0.110
IVUS reference lumen area, distal	0.70	0.200	0.58	0.040
$\Delta\text{FFR}_{\text{stent}} \geq 0.04$	14.0	0.001		
$\Delta\text{FFR}_{\text{stent}}/\text{length} \geq 0.009$			4.13	0.012

Baseline characteristics



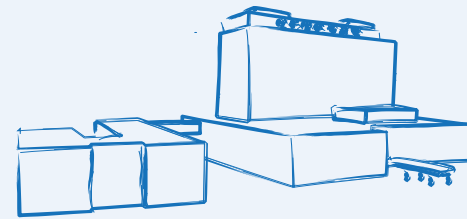
	Total (n=135)	$\Delta\text{FFR}_{\text{stent/length}} < 0.009$ (n=59)	$\Delta\text{FFR}_{\text{stent/length}} \geq 0.009$ (n=76)	P
Male sex	96 (71)	40 (68)	56 (73)	0.454
Age, years	60±10	59±9	61±11	0.281
Hypertension	78 (58)	34 (58)	44 (60)	0.923
Diabetes	30 (23)	15 (26)	15 (21)	0.447
Hyperlipidemia	47 (35)	22 (38)	25 (34)	0.621
Current Smoking	42 (31)	17 (30)	25 (31)	0.584
Clinical presentation				
Stable angina	38 (28)	16 (27)	22 (29)	
Unstable angina	78 (58)	37 (63)	41 (54)	0.446
Silent ischemia	19 (14)	6 (10)	13 (17)	
Number of diseased vessel(s)				0.653
1 vessel disease	67 (50)	29 (49)	38 (50)	
2 vessel disease	47 (35)	19 (32)	28 (37)	
3 vessel disease	21 (15)	11 (19)	10 (13)	

QCA



	Total (n=135)	$\Delta\text{FFR}_{\text{stent/length}}$ < 0.009 (n=59)	$\Delta\text{FFR}_{\text{stent/length}}$ \geq 0.009 (n=76)	P
Reference vessel diameter, mm	3.28 (3.02-3.55)	3.28 (3.00-3.55)	3.24 (3.03-3.54)	0.880
Post-PCI MLD, mm	3.0 \pm 0.3	3.03 \pm 0.33	3.01 \pm 0.35	0.660
Pre-PCI DS, %	60.0 \pm 11.4	61.5 \pm 10.7	59.0 \pm 11.9	0.197
Post-PCI DS, %	8.7 (6.0-12.6)	8.3 (6.2-13.0)	9.0 (6.0-12.6)	0.896
Stent length, mm	33 (24-46)	30 (24-46)	33 (23-45)	0.758
Post-stent balloon dilation	114 (84%)	50 (84.7%)	64 (84.2%)	0.932

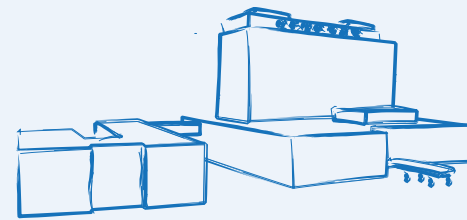
Clinical End point



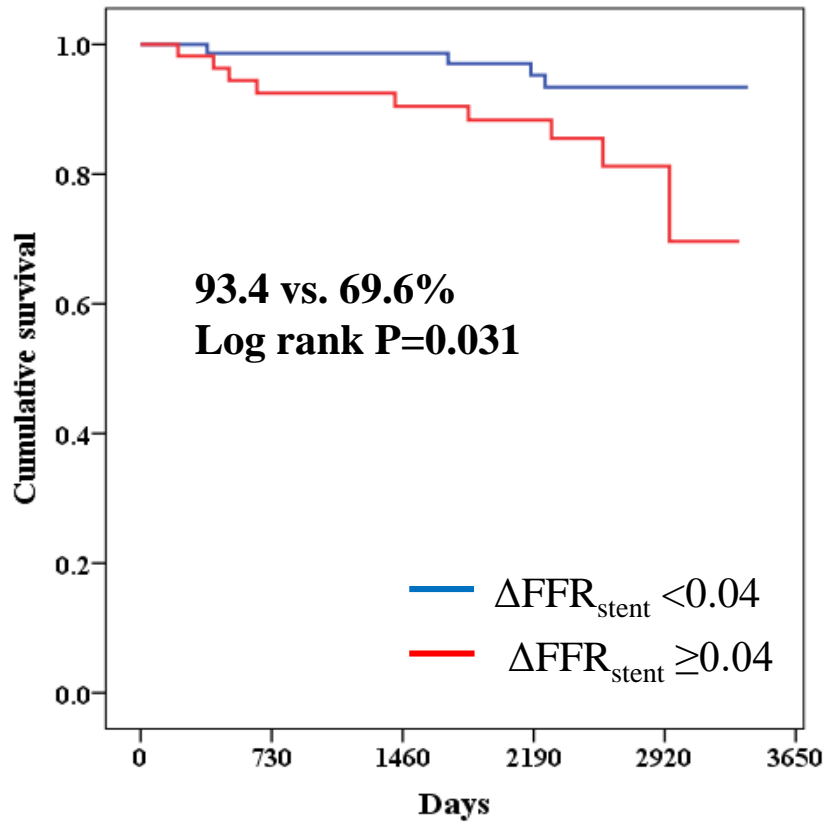
Major adverse cardiac events (MACEs), a composite of
all-cause death,
target vessel-related MI,
and target lesion revascularization (TLR)

Procedural MI was excluded from analyses.

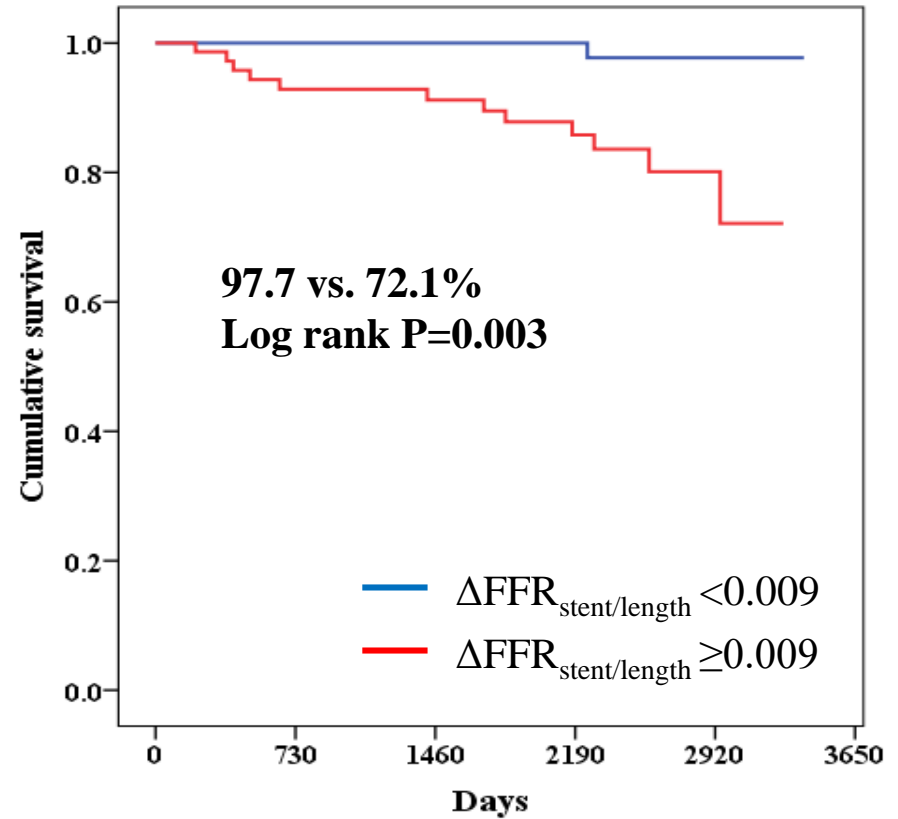
MACE



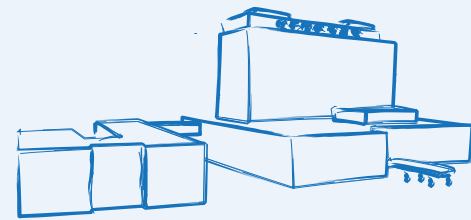
(A) Trans-stent FFR



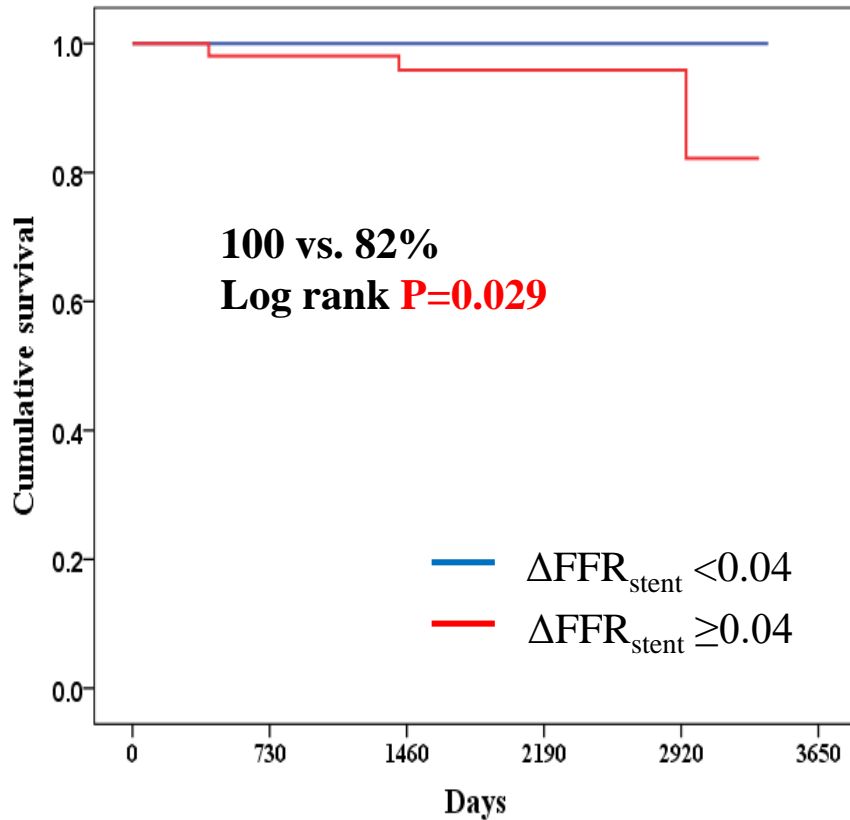
(B) Trans-stent FFR/length



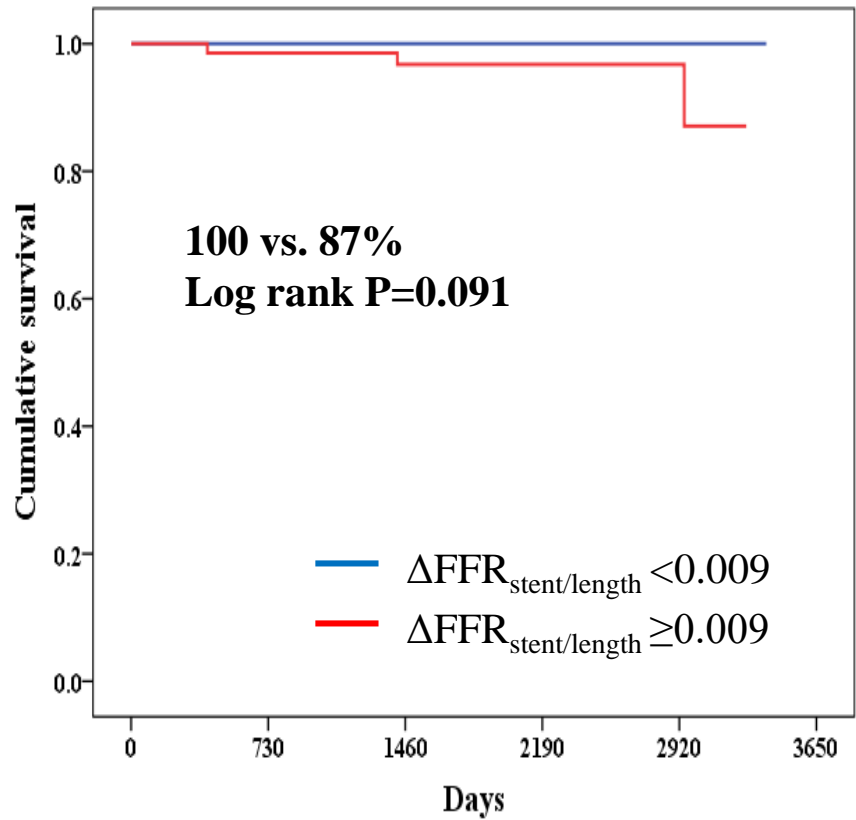
Target-vessel related MI



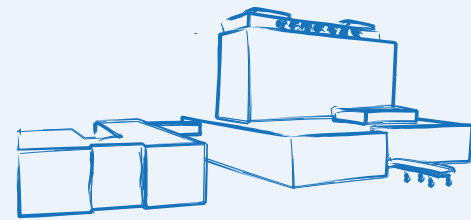
(A) Trans-stent FFR



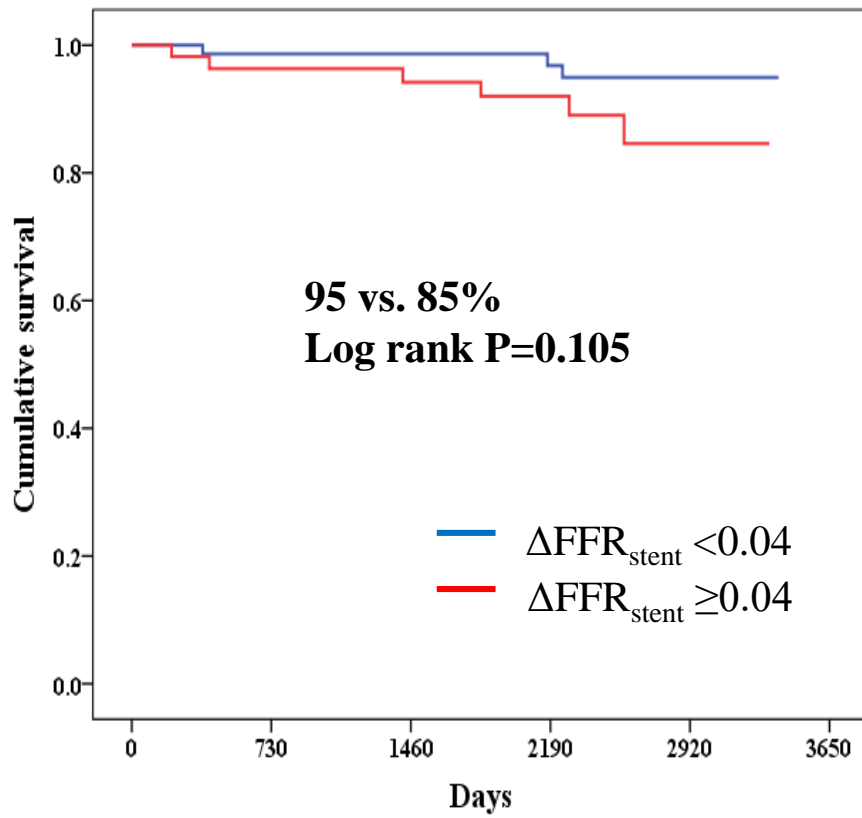
(B) Trans-stent FFR/length



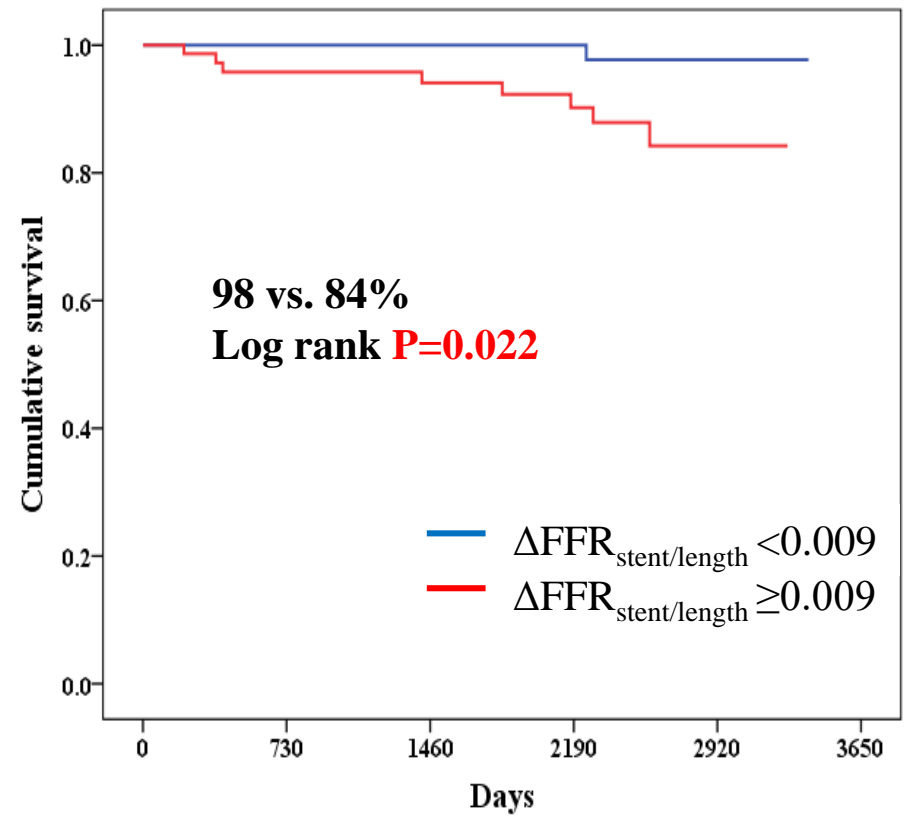
TLR



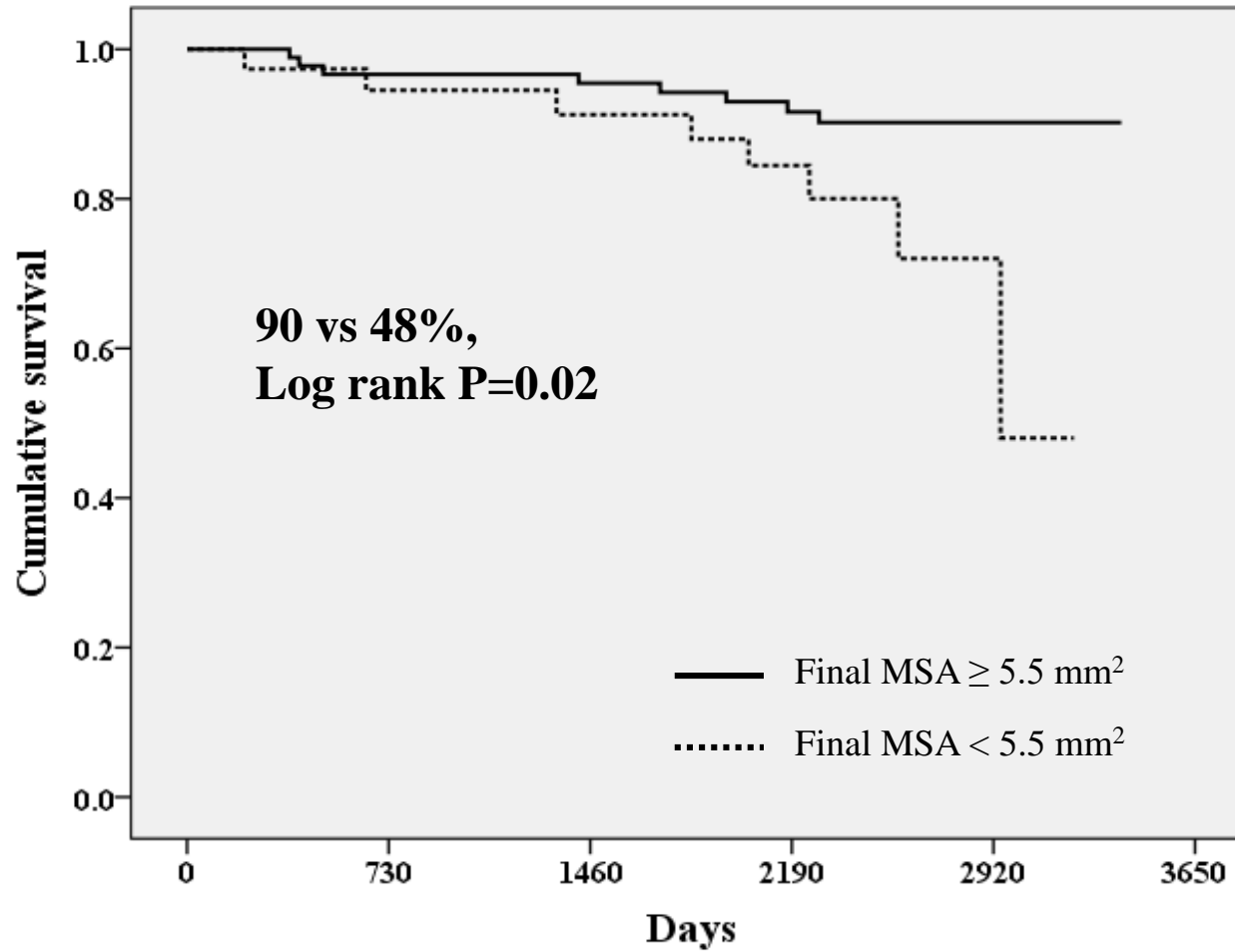
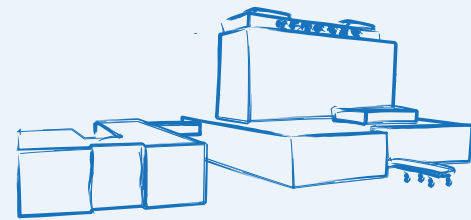
(A) Trans-stent FFR



(B) Trans-stent FFR/length

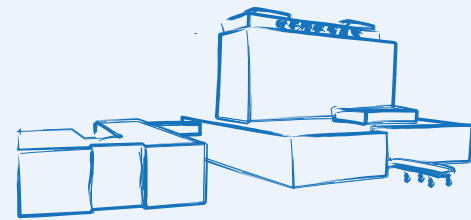


MACE – IVUS MSA



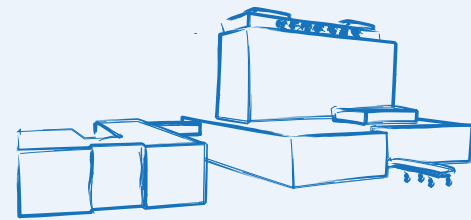
Independent predictor for MACE

- Cox regression -



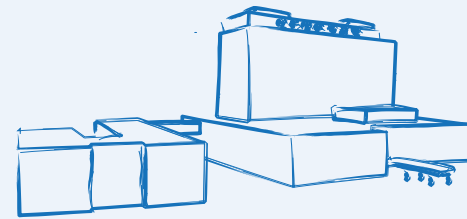
	Odds ratio	95% CI	P
$\Delta\text{FFR}_{\text{stent/length}} \geq 0.009$	10.1	1.2-83.4	0.032
Sex	1.16	0.30-4.51	0.832
Age	1.02	0.97-1.08	0.447
Diabetes mellitus	1.48	0.42-5.33	0.543
Reference vessel diameter	1.07	0.15-7.72	0.945
Final minimal lumen diameter	2.06	0.23-18.90	0.521
Stent length	0.99	0.95-1.04	0.811
Pre-PCI FFR	4.15	0.00-118668	0.786
Post-PCI FFR	0.00	0.00-42.57	0.132
Final MSA < 5.5 mm ²	1.87	0.44-7.88	0.394

Summary



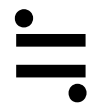
- A hyperemic pressure gradient across the stent is a common phenomenon immediately after PCI as observed in almost all cases despite successful angiographic and IVUS results.
- $\Delta\text{FFR}_{\text{stent}} \geq 0.04$ or $\Delta\text{FFR}_{\text{stent}}/\text{length} \geq 0.009$ measured immediately after PCI is a useful indicator of suboptimal stent expansion that is assessed by IVUS, with a high NPV.

Summary



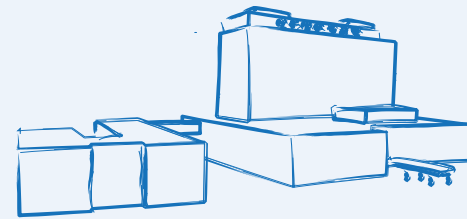
- $\Delta\text{FFR}_{\text{stent}} \geq 0.04$, in particular, $\Delta\text{FFR}_{\text{stent}}/\text{length} \geq 0.009$ is associated with increased long-term MACE risk in DES-treated patients.

Stent length
10 mm



$\Delta\text{FFR} \geq 0.01$

Conclusion

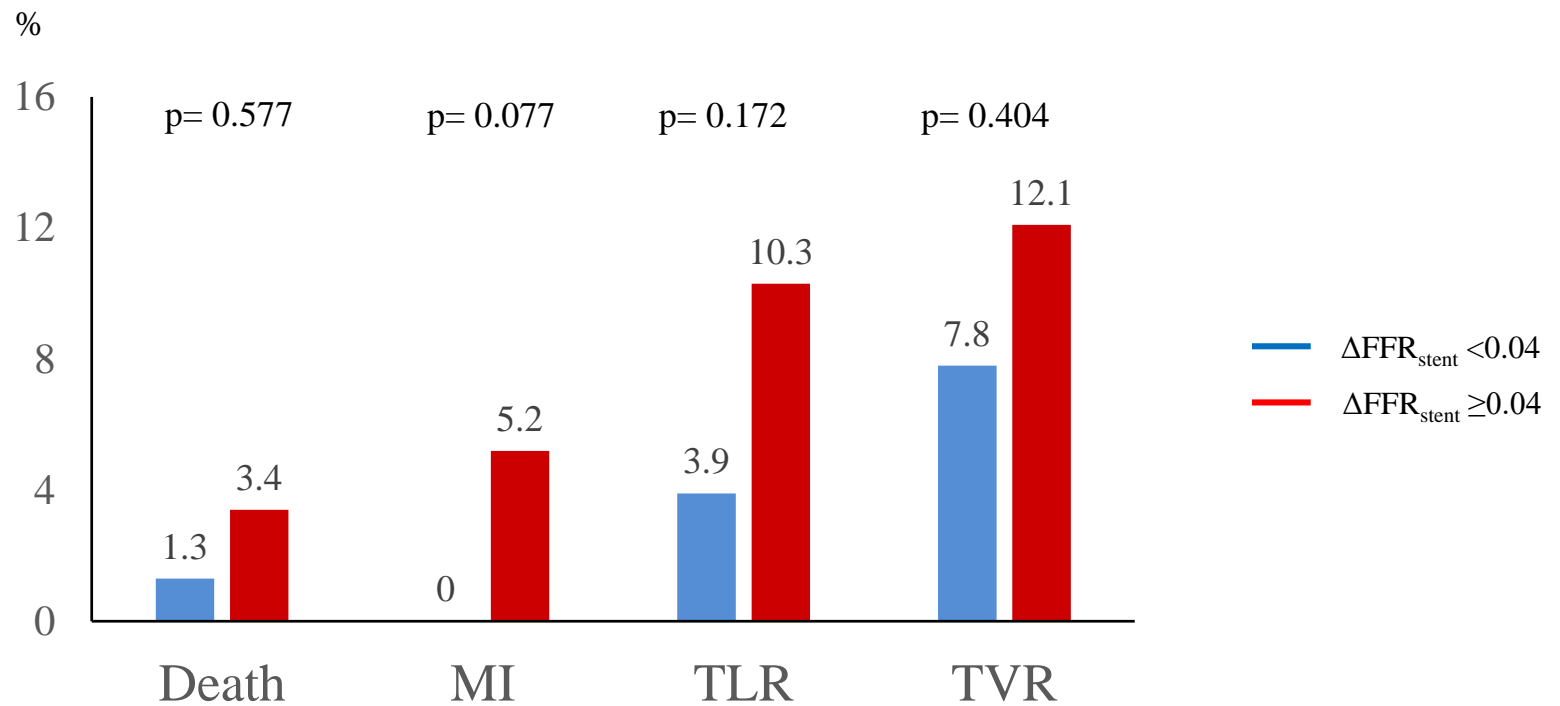
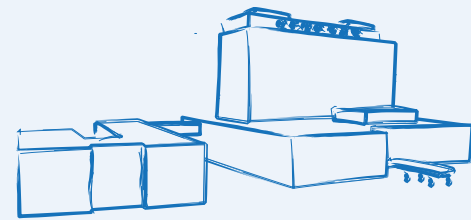


A trans-stent FFR gradient was frequently observed.

$\Delta\text{FFR}_{\text{stent}}$ and $\Delta\text{FFR}_{\text{stent}}/\text{length}$ are related to

long-term outcomes in DES-treated patients.

Results-clinical outcomes



Results-clinical outcomes

