Functional Assessment in Coronary Tandem Lesion

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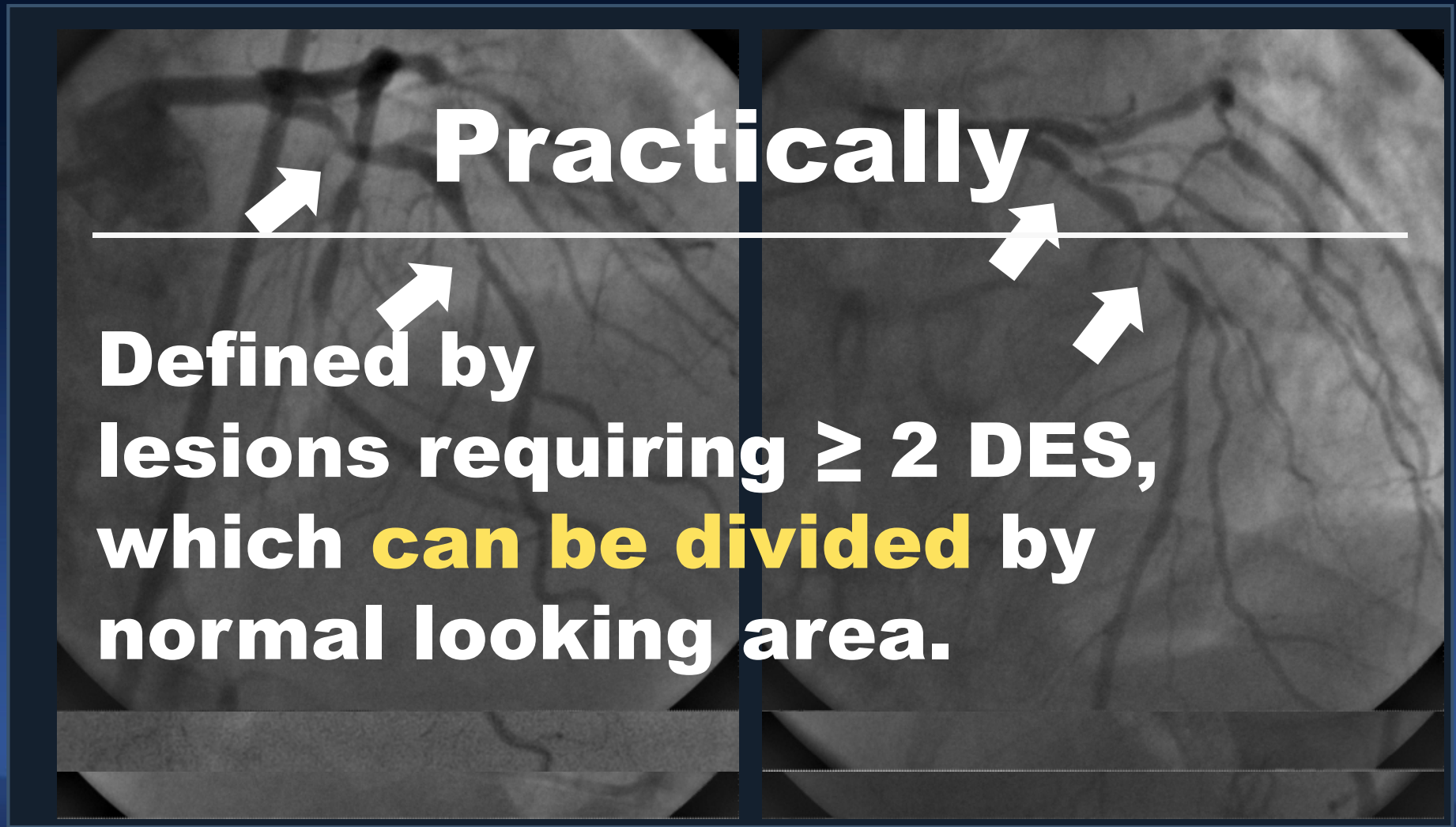
Diffuse and Multiple Involvement of Coronary Atherosclerosis

- In 884 native coronary arteries, the plaque burden in the angiographically “normal” reference segment was 51 ± 13%

* Mintz GS, et al. Atherosclerosis in angiographically normal coronary artery reference segments. J Am Coll Cardiol 1995;25:1479-1485

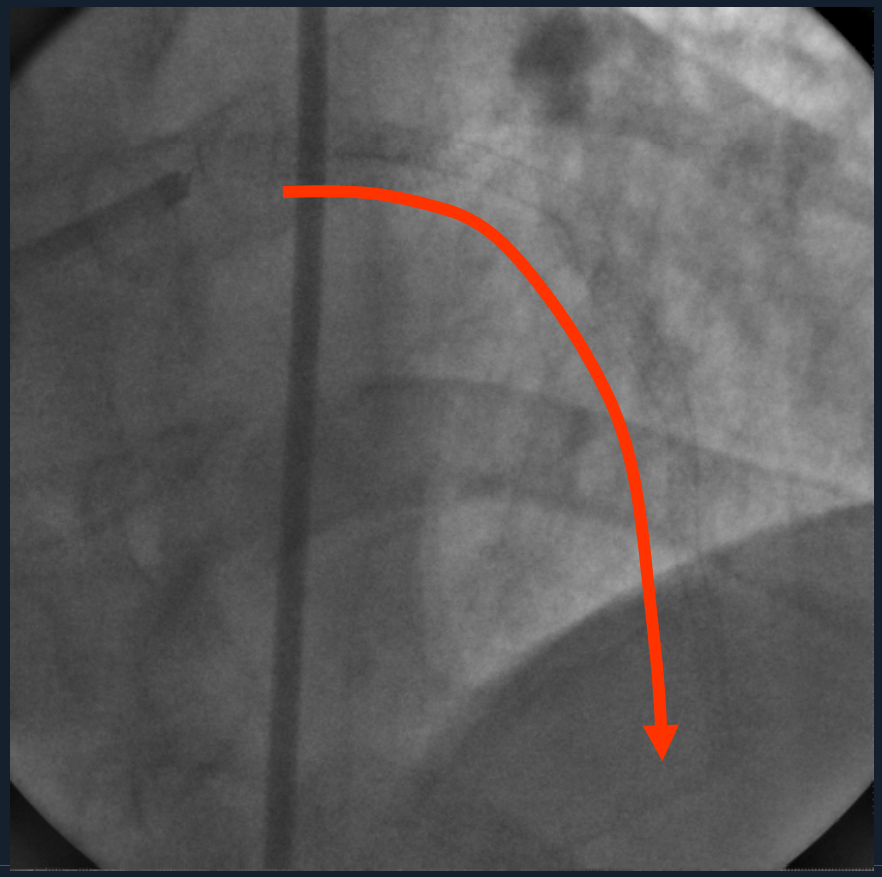
Coronary Tandem Lesions

Multiple stenoses in series along one coronary artery

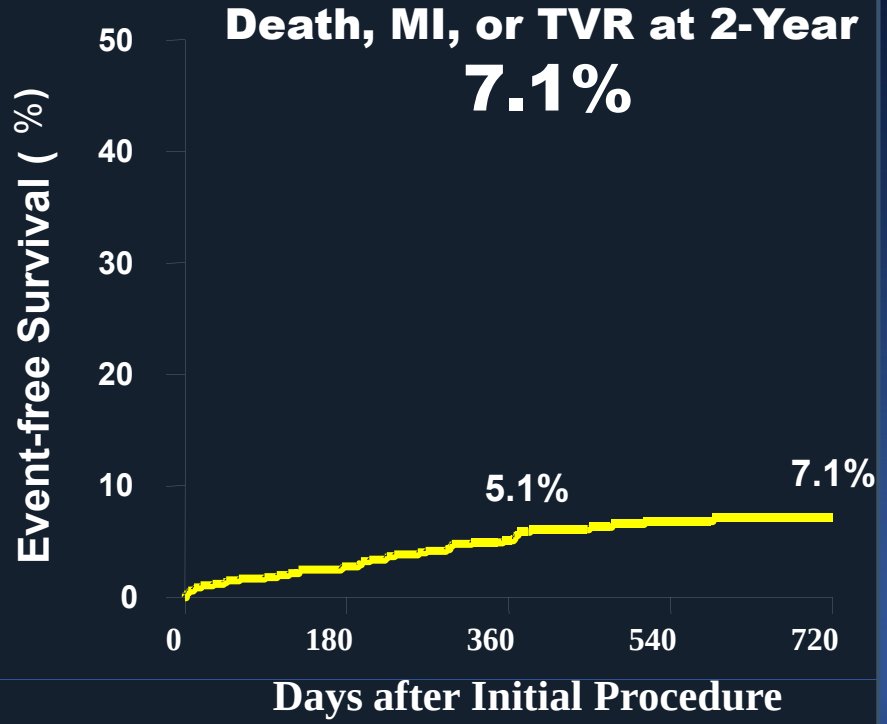


“Full Metal Jacket”

Multiple or overlapping stent implantation



Event rate is Quite acceptable…

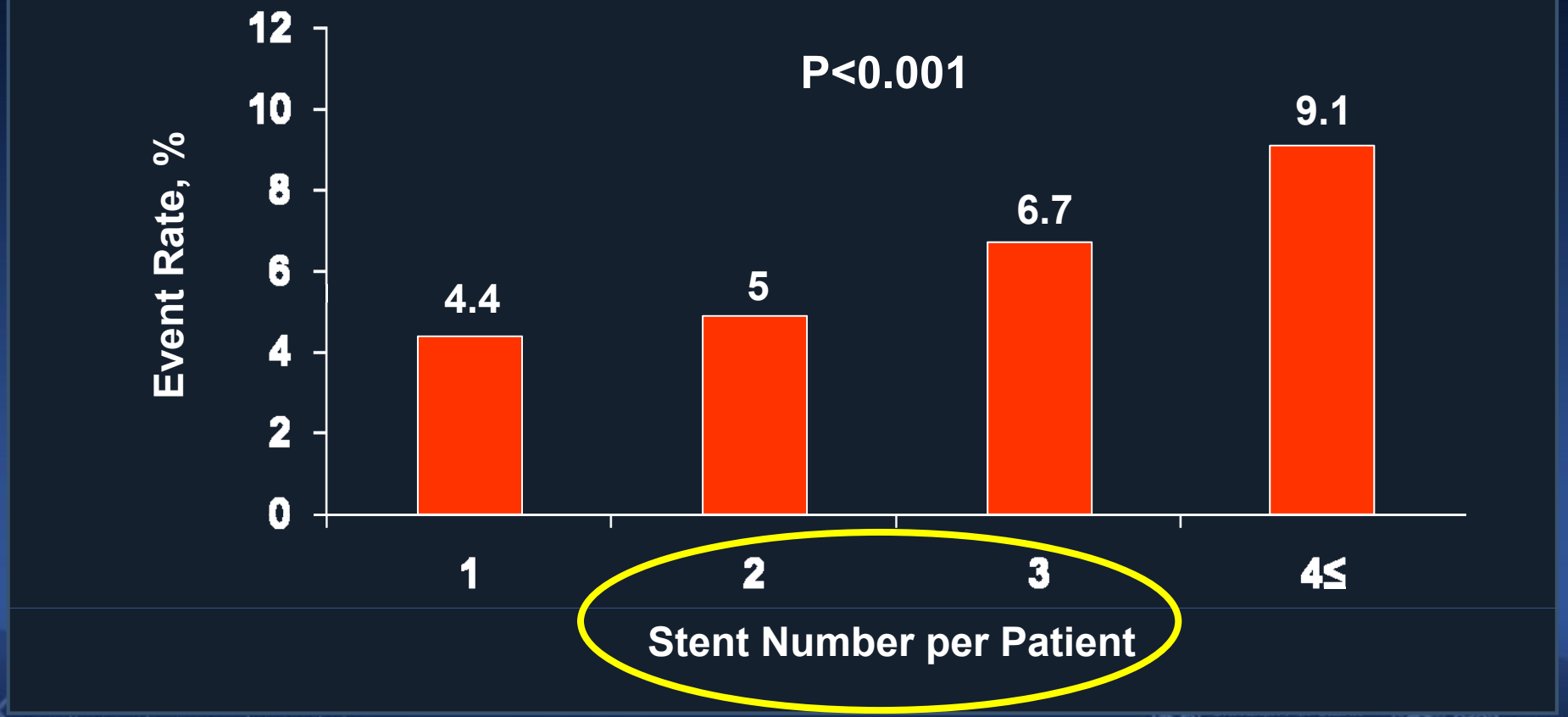


* The unpublished data from the IRIS-DES registry

“Full Metal Jacket”

Multiple or overlapping stent implantation

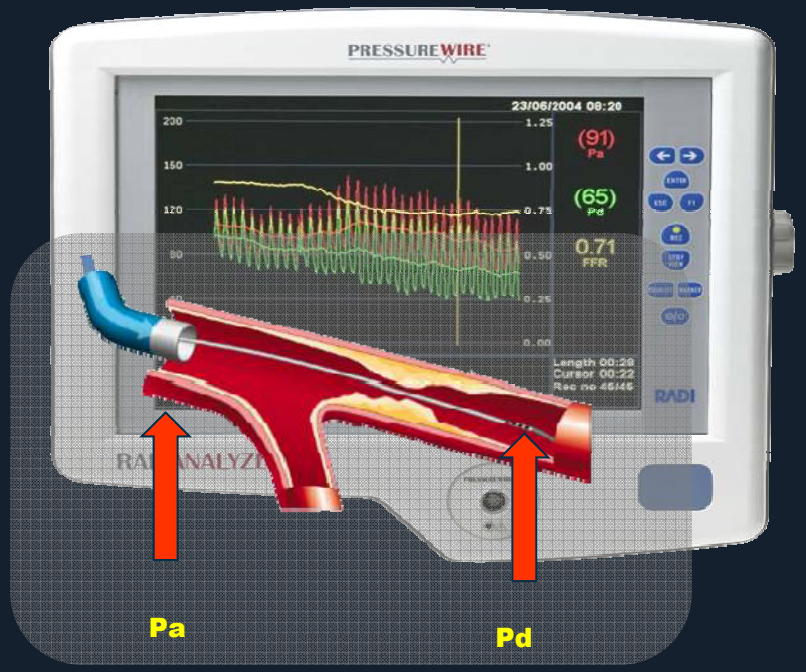
However, Still…



* The unpublished data from the IRIS-DES registry

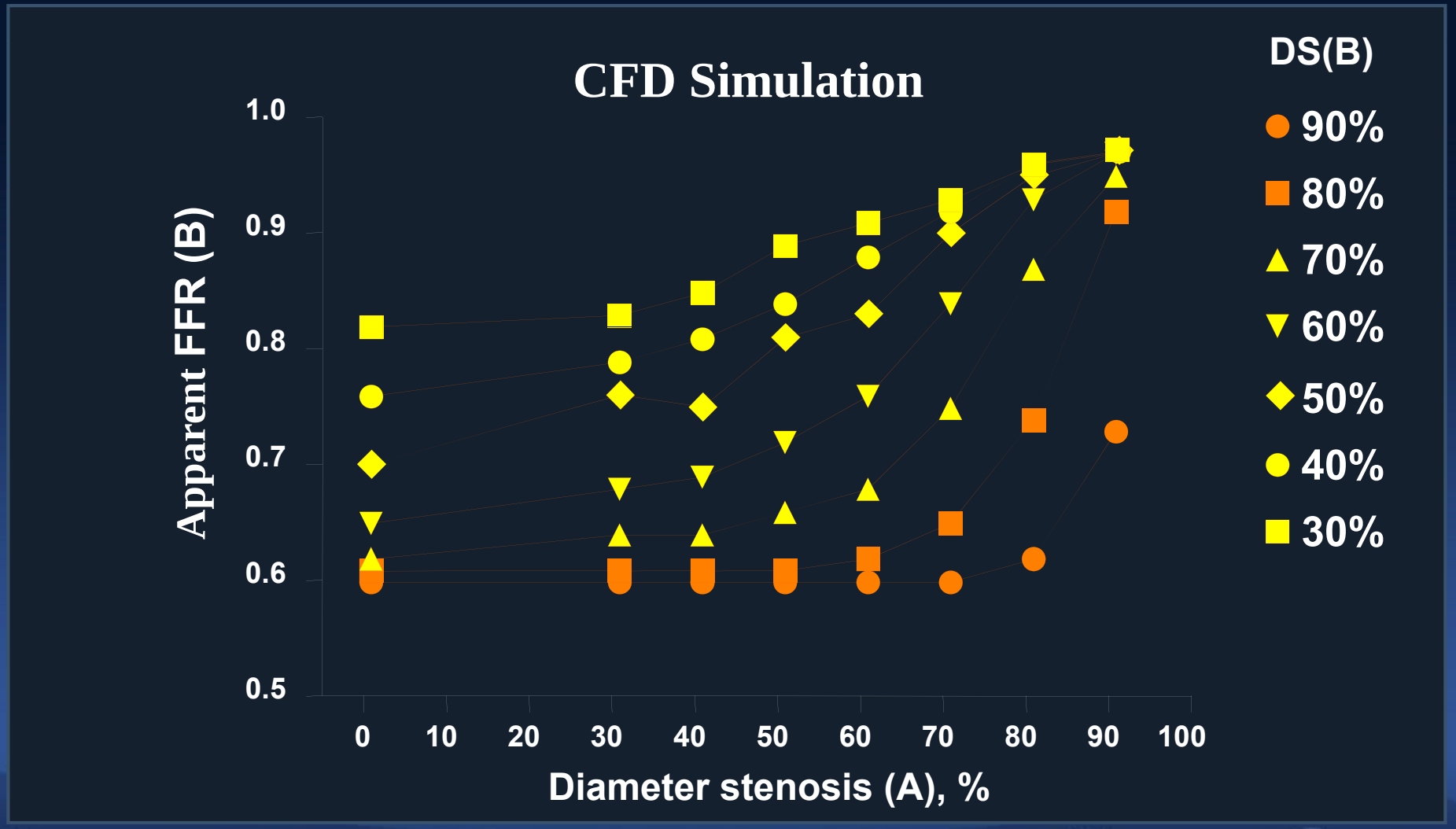
Therefore, tailored stenting approach based on the separate functional assessment for the individual stenosis would be theoretically and clinically useful for PCI optimization and achieving better outcomes.

Fractional Flow Reserve

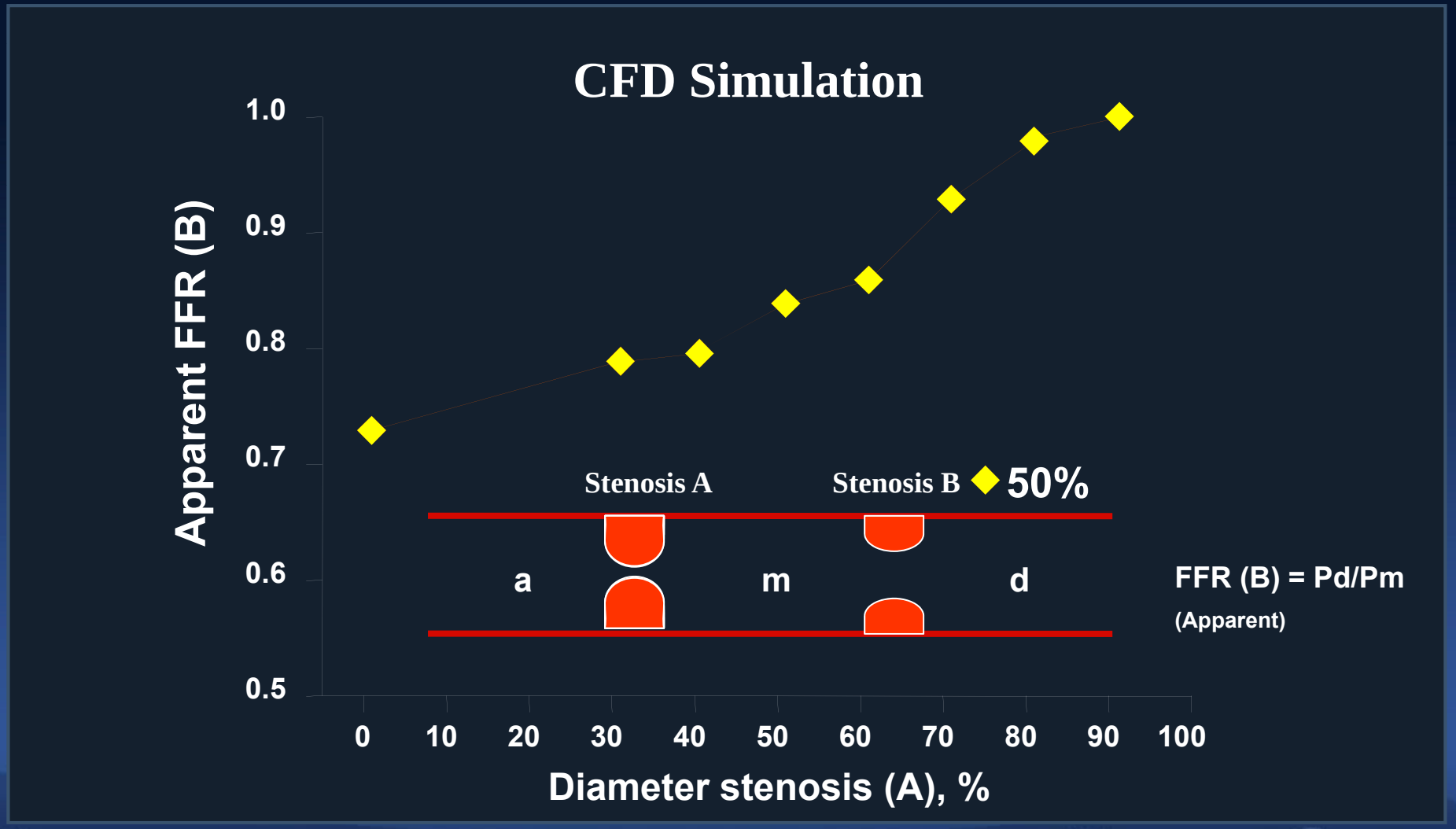


$$FFR = \frac{Q_S^{max}}{Q_N^{max}} = \frac{Pd}{Pa}$$

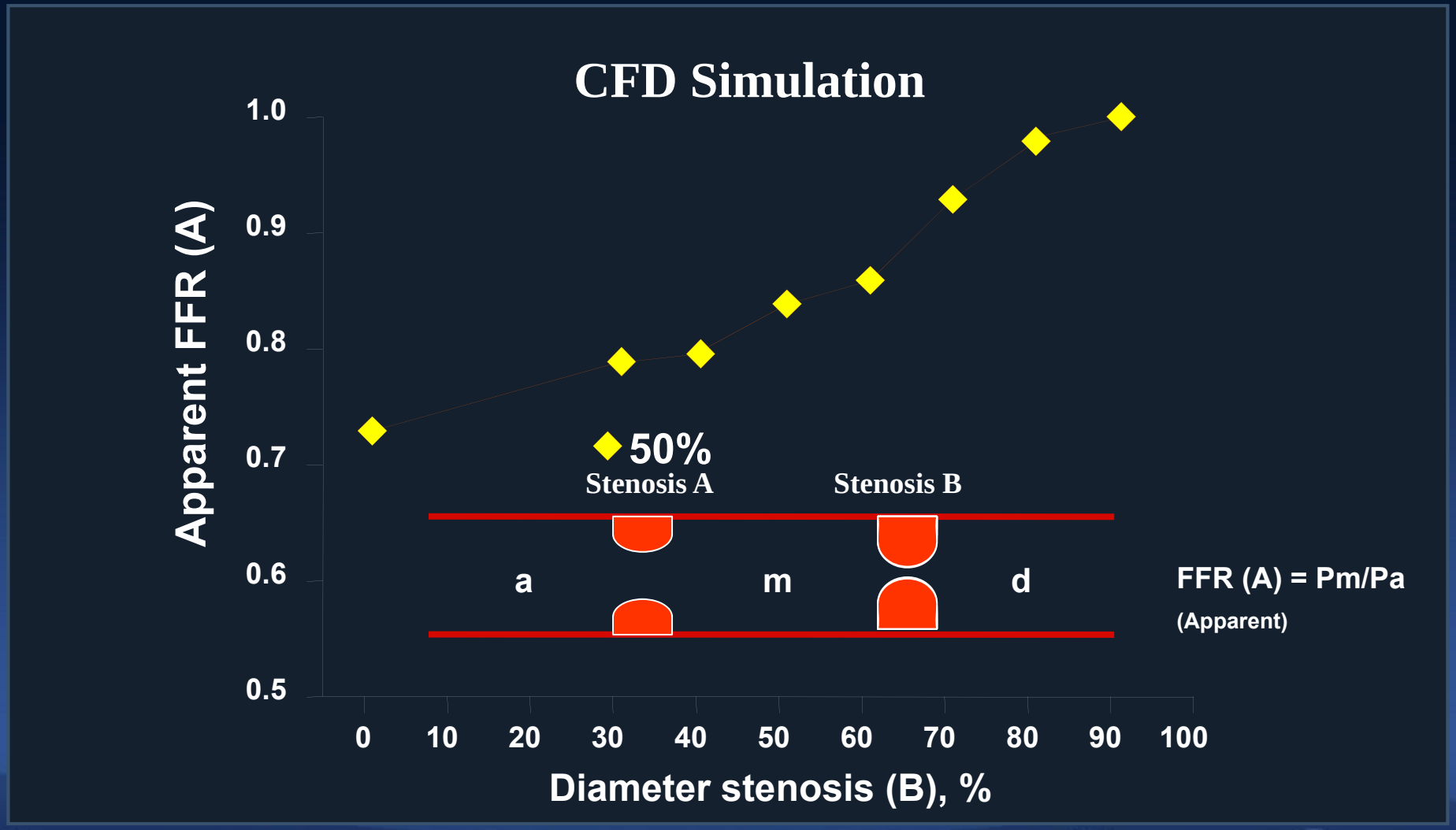
Why FFR (Pd/Pa) Interaction Between Stenosis Is Correct?



Hydromechanical Interaction Between Stenoses



Hydromechanical Interaction Between Stenoses



The Separate Functional Significance of Tandem Stenoses

Only method

$$FFR(A)pred = \frac{Pd-[(Pm/Pa)XPw]}{(Pd-Pm)+(Pd-Pw)}$$

$$FFR(B)pred = 1 - \frac{(Pm-Pd)\ X(Pa-Pw)}{Pax(Pm-Pw)}$$

Nico H.J. Pijls and Bernard De Bruyne et al. Circulation 2000;102:2371-2377.)

Hyperemic Translesional Pressure Gradient

1. Affected by hemodynamic change
2. No clinical validation

Rule of Big Delta

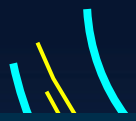
Stenosis (A)

Tighter Stenosis (B)

Treat Distal lesion First !

ΔFFR(A) < Big ΔFFR(B)

Rule of Big Delta



Tighter Stenosis (A)

Stenosis (B)

Treat Proximal lesion First !

Big ΔFFR(A) > ΔFFR(B)

Functional Lesion Assessment for the Coronary Tandem Lesion

In Vitro and In Vivo Validation Using Computational Flow Dynamics and Clinical Application

CardioVascular Research Foundation
UNIVERSITY OF ULSAN COLLEGE MEDICINE
ASAN Medical Center

Hypothesis

- FFR gradient across the individual stenosis (designated ΔFFR) during pressure wire pull back is a surrogate of the **relative functional severity** of each stenosis in coronary tandem lesion.

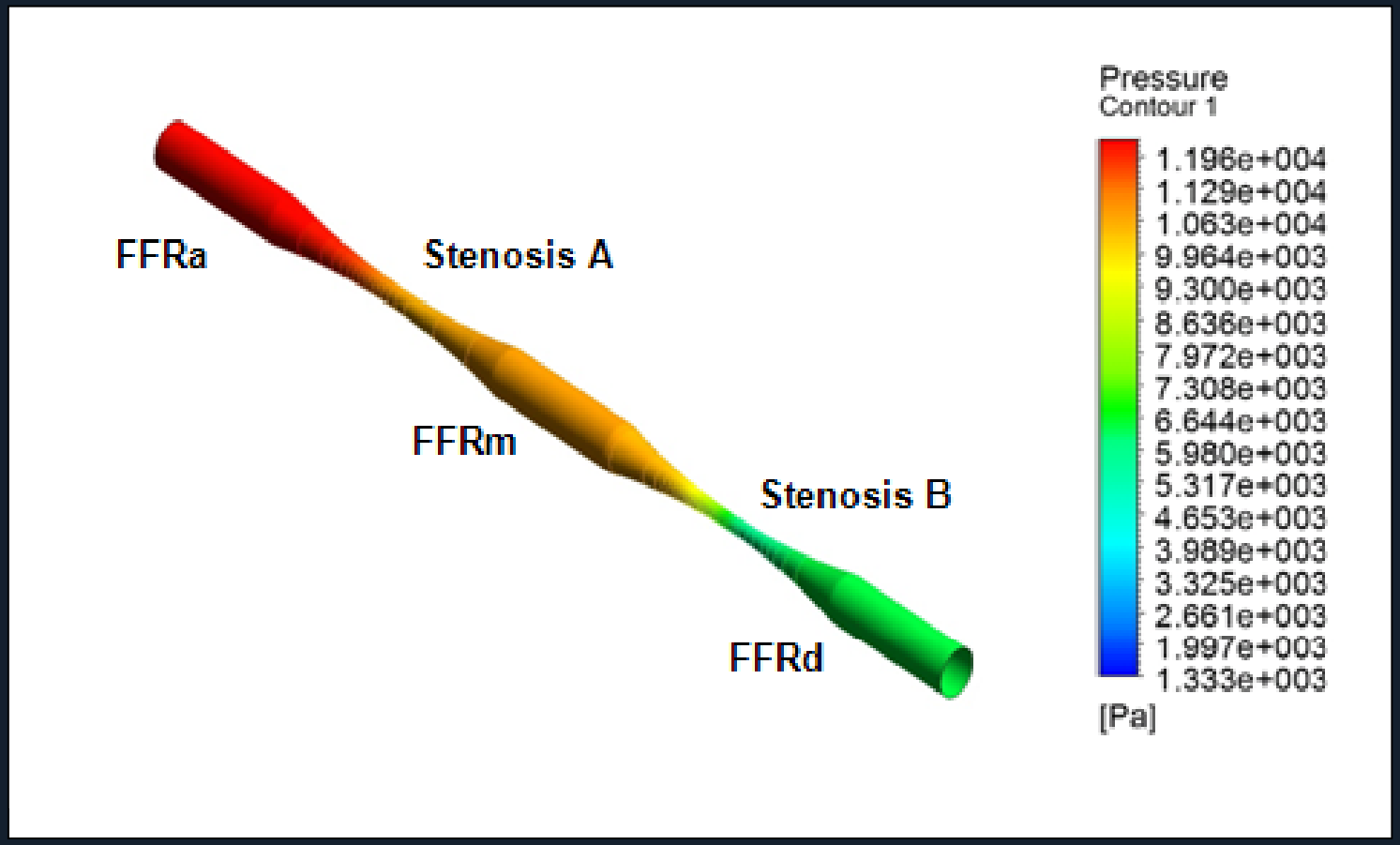
- We proposed the strategy of first treating the lesion with large ΔFFR and subsequently reassessing the FFR for the remaining lesion.

Why relative functional severity ?

- As FFR of the whole coronary tandem lesion was ≤0.80, the revascularization is justified regardless of true FFR of individual lesion.
- The revascularization first for the lesions with more functional severity could increase the chance for the deferral of PCI for the remaining lesions
- Therefore, the determination of more severe functional stenosis between tandem lesion is necessary.

Methods (I)

CFD simulation of Tandem



Methods (II)

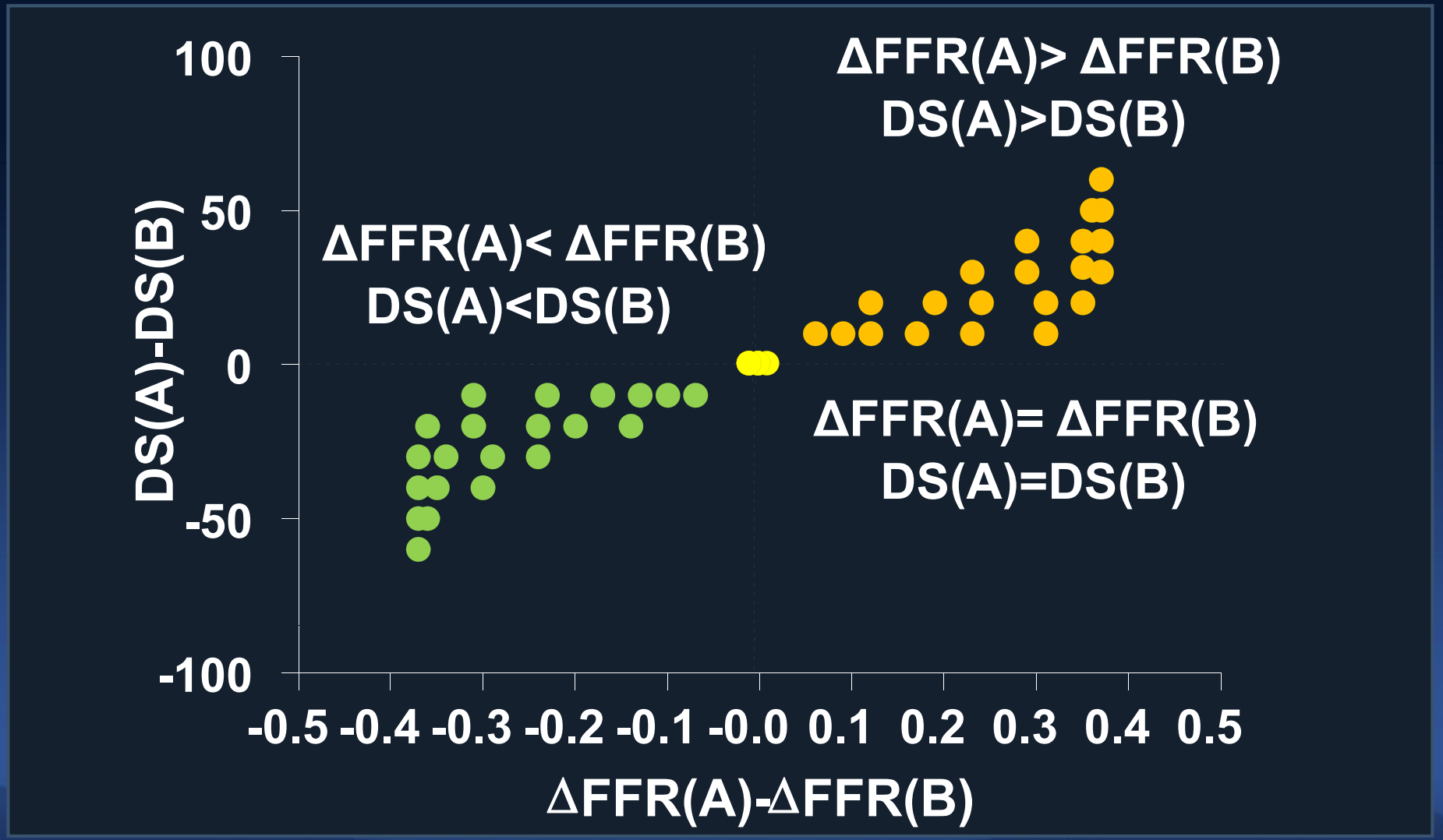
Clinical Cohort for Validation

- Between July 2009 and April 2011, a total of 50 patients with coronary tandem lesion for which FFR value was ≤0.80 at a position distal to the distal stenosis were prospectively enrolled in the current analysis.
- Coronary tandem lesion was defined as two separate stenoses with ≥50% diameter stenosis by visual estimation within one epicardial coronary artery, separated by angiographically normal-looking segment

Results I

Simulation of FFR in coronary tandem lesion

Is ΔFFR Relative Severity of Functional Stenosis ?



Results II

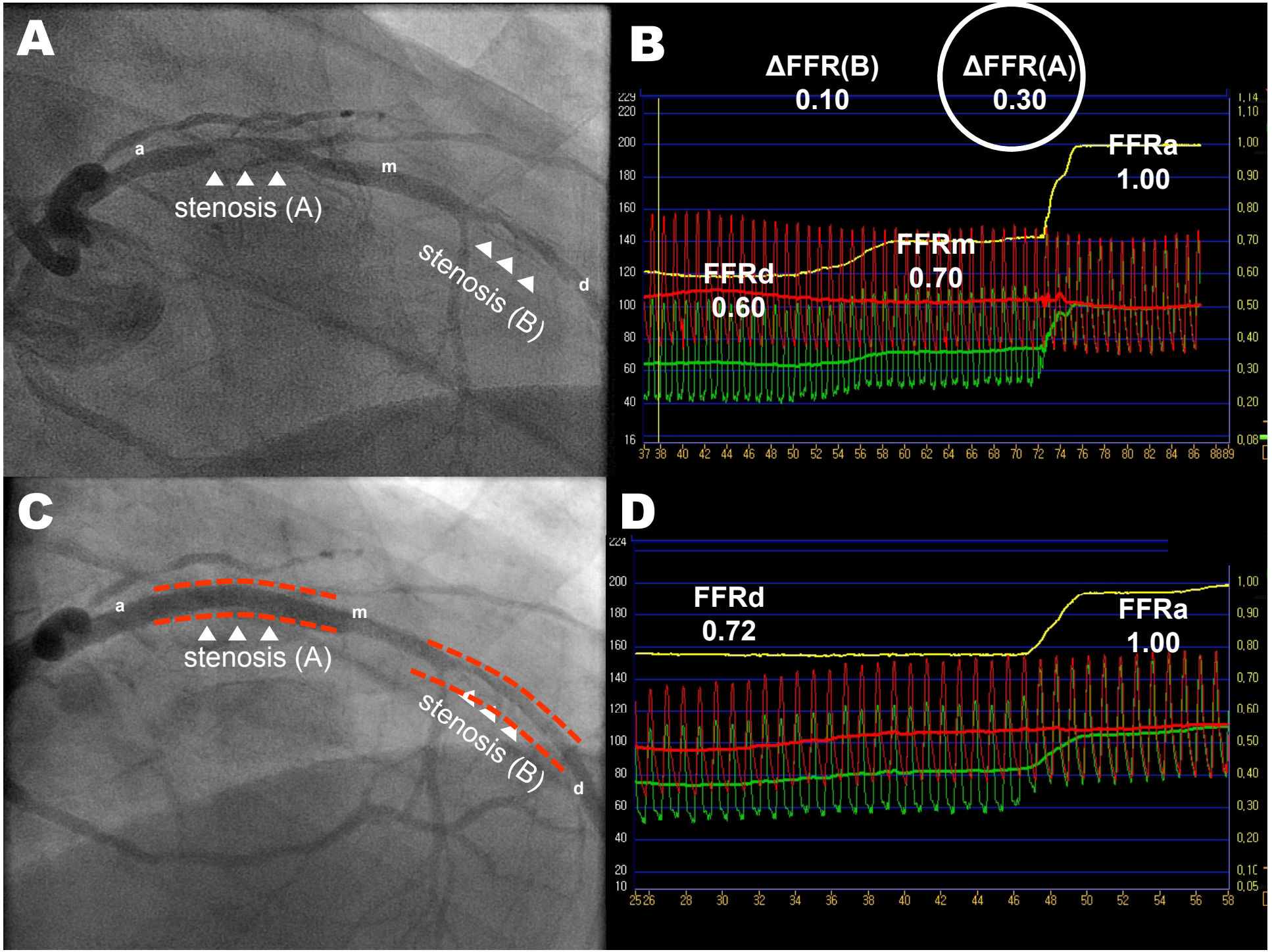
Prospect Cohort for Clinical Validation

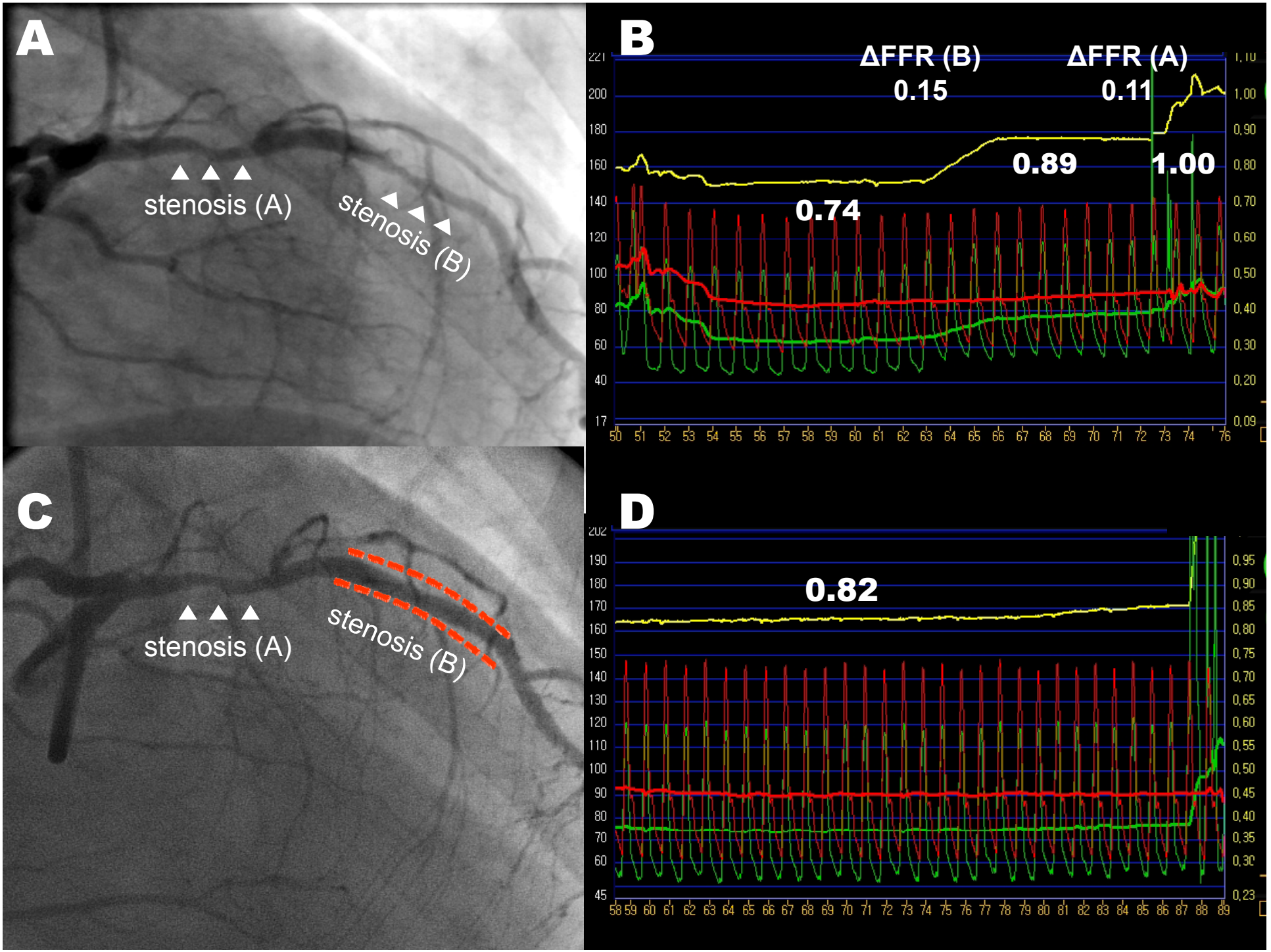
Clinical Characteristics (N=50)

Age (years)	62±9
Male	33 (66%)
Diabetes, N (%)	18 (36%)
Hypertension, N (%)	23 (46%)
Smoking, N (%)	10 (20%)
Hyperlipidemia, N (%)	17 (34%)
Previous PCI, N (%)	122 (12%)
Clinical manifestation	
Stable angina, N (%)	26 (52%)
Unstable angina, N (%)	21 (42%)
Non-ST elevation MI, N (%)	3 (6%)
Mean diameter stenosis, %	57±10

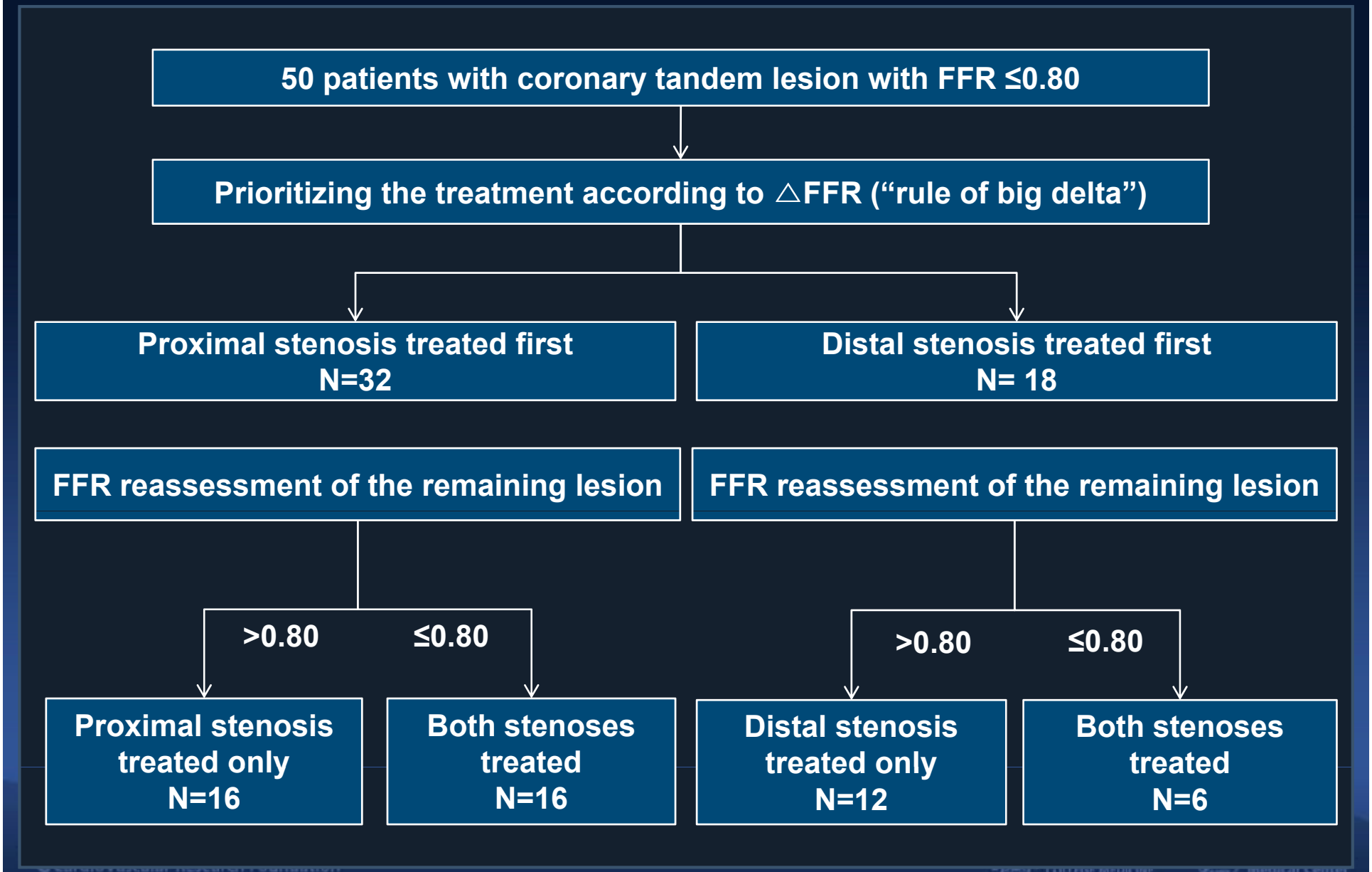
Selected Stenting Strategy

- PCI was performed first for the lesion that showed large △FFR between two stenoses during the pullback of the pressure wire.
- Thereafter, FFR was reassessed for the remaining stenosis.
- If FFR was ≤0.80, PCI was performed, and if FFR >0.80, PCI was deferred.
- The drug-eluting stent implantation was adopted as default strategy under the ***IVUS guidance***.


A
a
m
stenosis (A)
stenosis (B)
d
B
ΔFFR(B)
0.10
ΔFFR(A)
0.30
FFRa
1.00
FFRm
0.70
FFRd
0.60
C
a
m
stenosis (A)
stenosis (B)
d
D
FFRd
0.72
FFRa
1.00


A
stenosis (A)
stenosis (B)
B
ΔFFR (B)
0.15
ΔFFR (A)
0.11
0.89
1.00
0.74
C
stenosis (A)
stenosis (B)
D
0.82

Treatment Results



Treatment Results

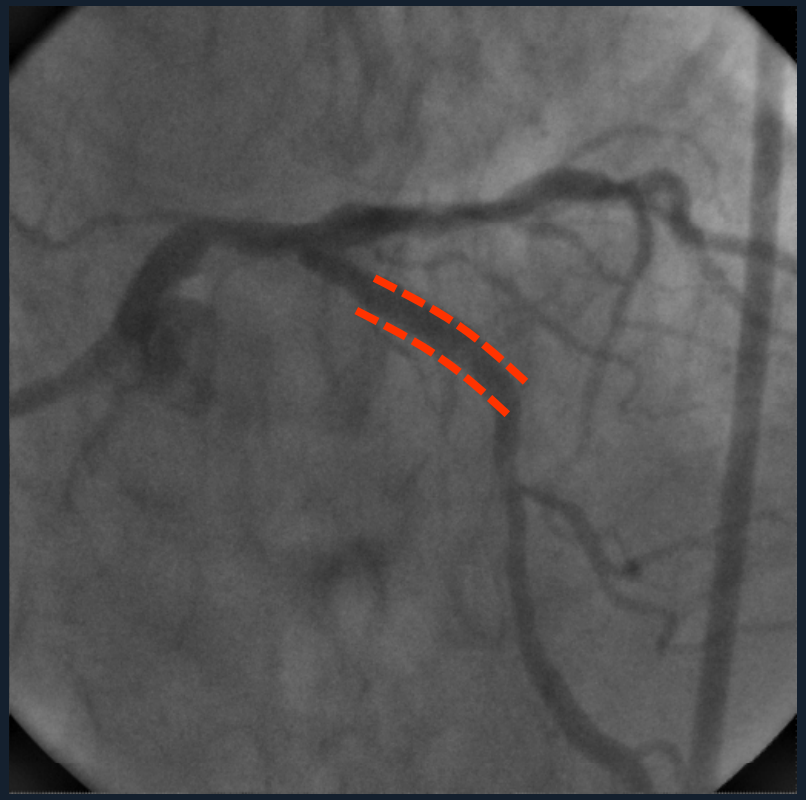
Variables	Singe Lesion (56%, N=28)	Dual Lesion (44%, N=22)	P value
Number of Stented Lesion	28	44	
Total stent length, mm	26.6 ± 9.7	47.3 ± 17.3	<0.001
Total stent number per patient	1.1 ± 0.4	2.0 ± 0.7	<0.001

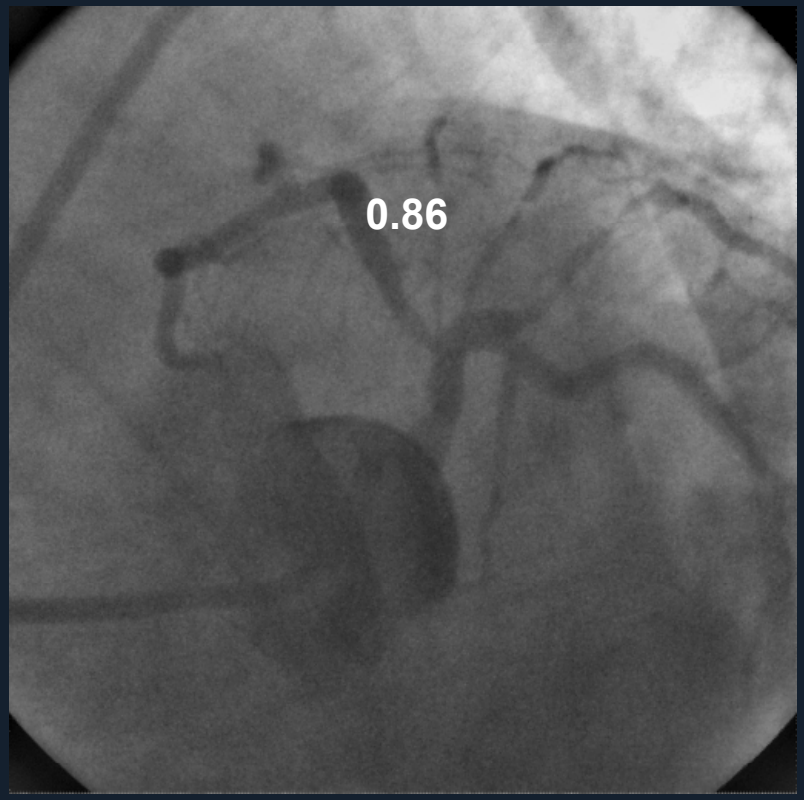
- In 56% of patients, single lesion was treated only and thus 28% of lesions were deferred

9 Month Clinical Follow-Up

Only 1 TVR: The progression of Deferred Proximal Lesion

CASE M/74





9 Month Clinical Follow-Up

Only 1 TVR: The progression of Deferred Proximal Lesion

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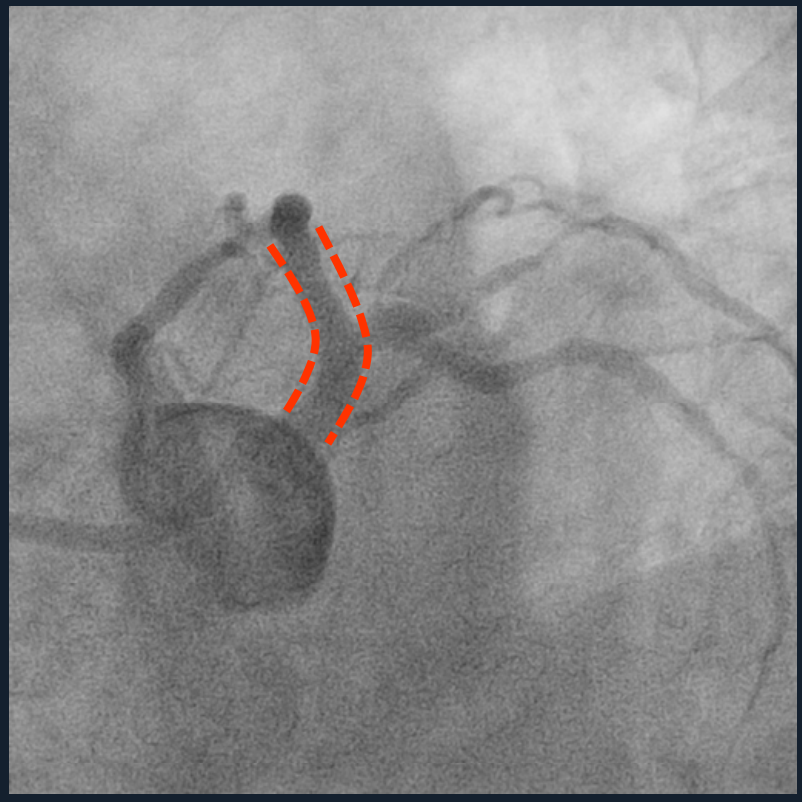

Limitations

- The effect of interposition of side branch between stenoses, which may modify the hemodynamic influence of relative significance of two stenoses, was not considered.

- The long term prognosis of deferred lesion in tandem should be waited.

Conclusions

- For the treatment of the coronary tandem lesion, ΔFFR may be useful index for prioritizing the treatment sequence and optimizing stent length.

- In this way, unnecessary stent implantation could be avoided to achieve favorable functional and clinical outcomes.