Debate
Should we use FFR ?
I will say NO.

European Bifurcation Club

EBC

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Research fund from

Abbott Korea

Boston Scientific Korea

Medtronic Korea

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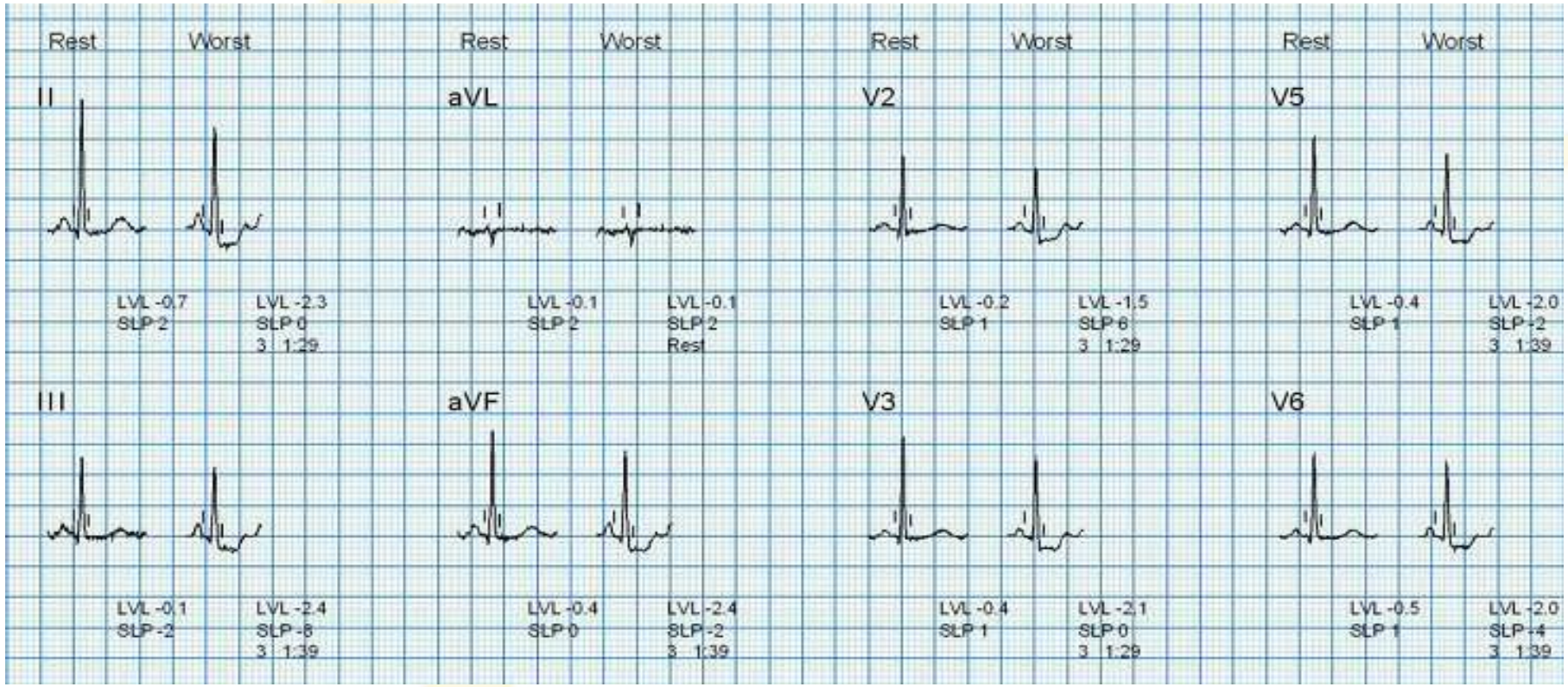
I feel so alone in this FFR session

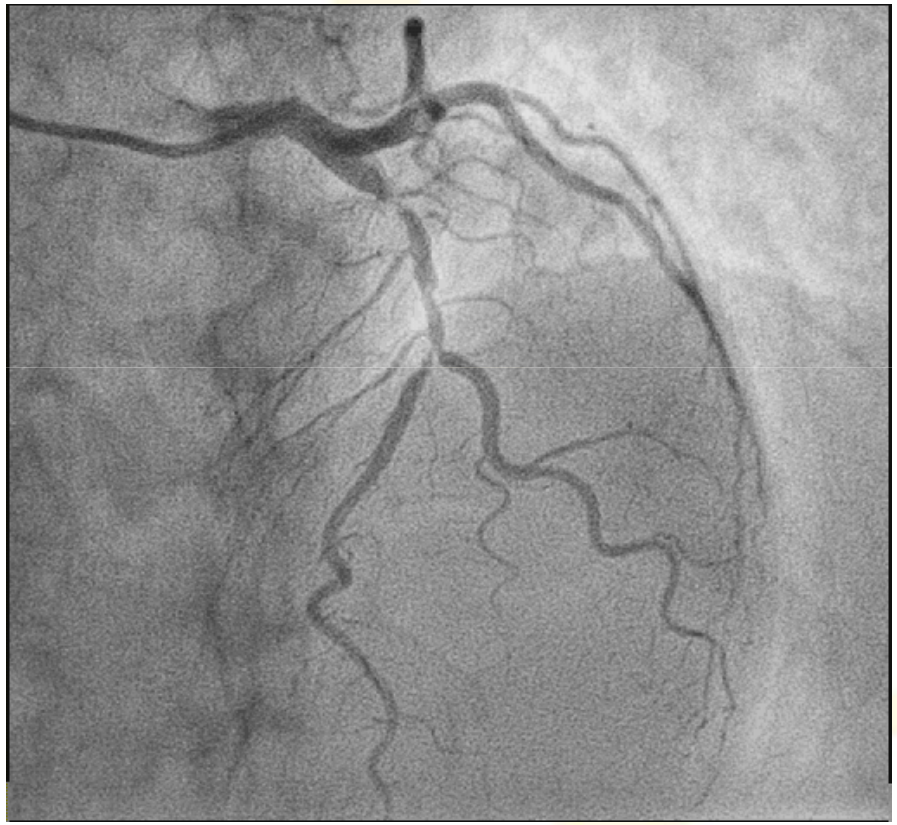
Case. F/65 Stable Angina

- Presented with exertional chest pain CCS class II for 6 months
- Hypertension (+), diabetes (+) for 10 years
- Treadmill test: 7 min 52 sec, positive, chest pain (+)

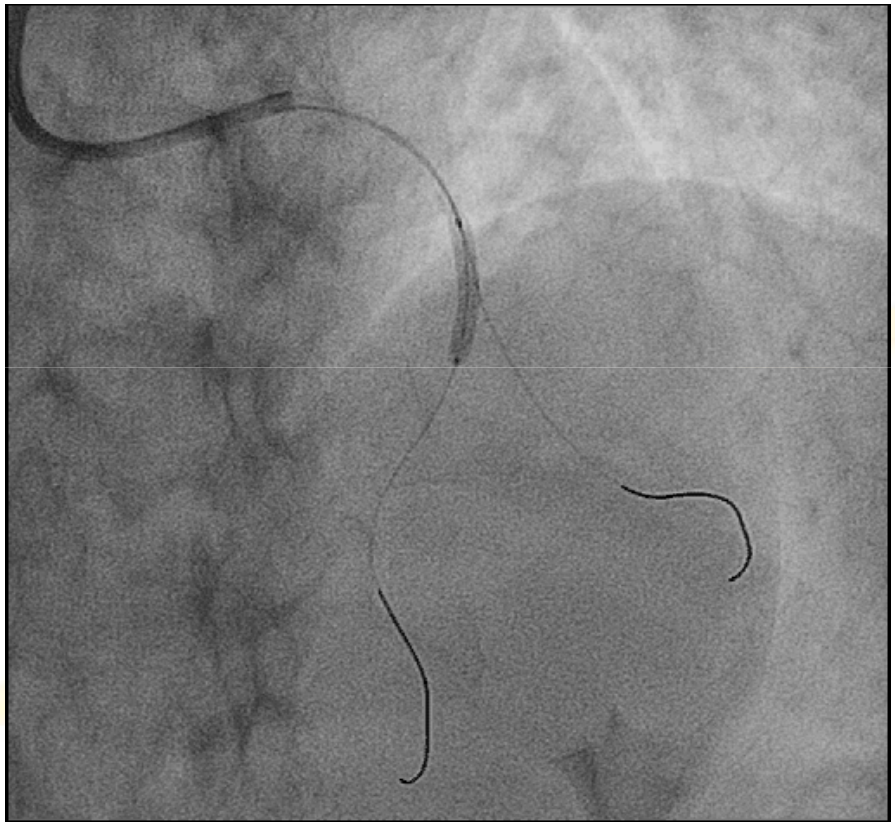


Pt. No. 25825223

Case. F/65 Stable Angina



Baseline CAG



2.5 x 18 mm Promus Element

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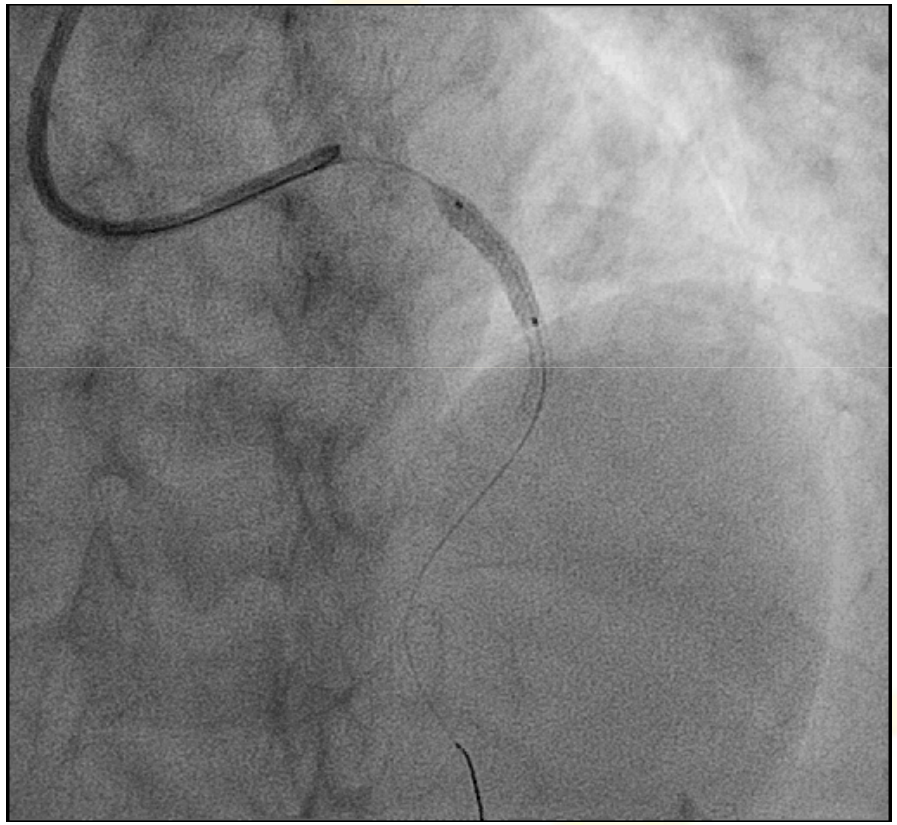
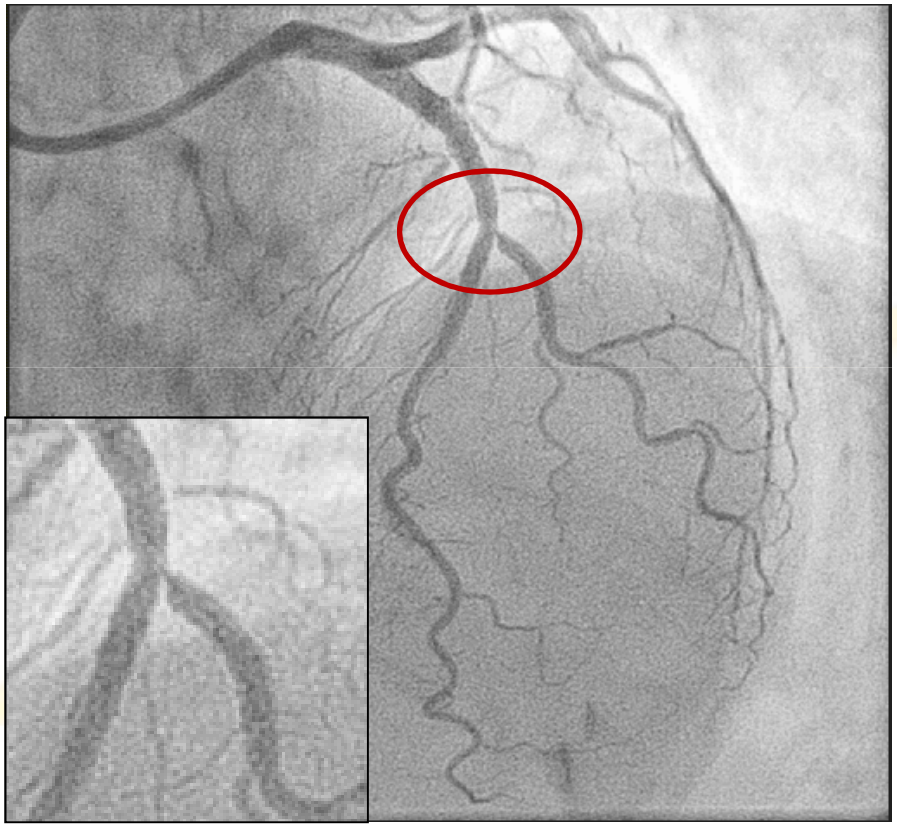
Case. F/65 Stable Angina



3.5 x 18 mm Promus element



Final CAG

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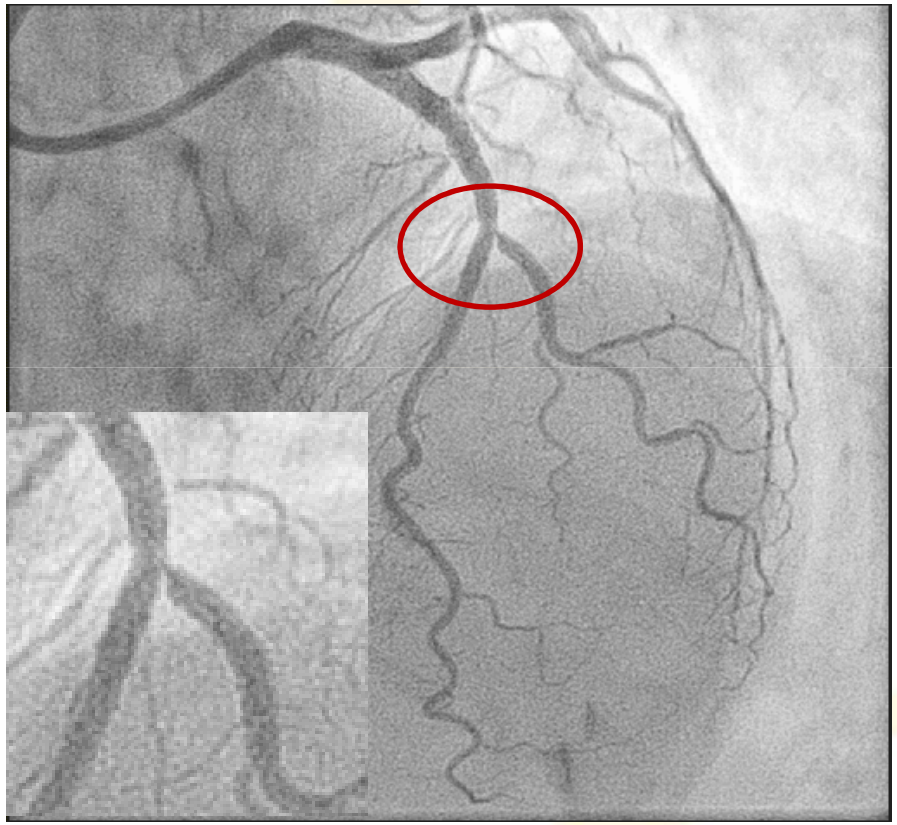
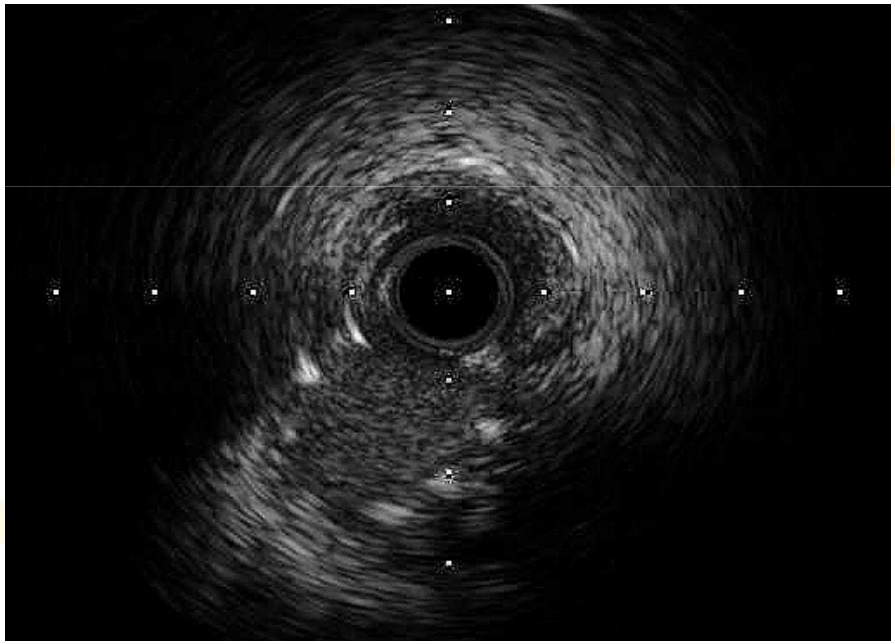
Case. F/65 Stable Angina



- FFR for SB: 0.74
- IVUS of SB ostium



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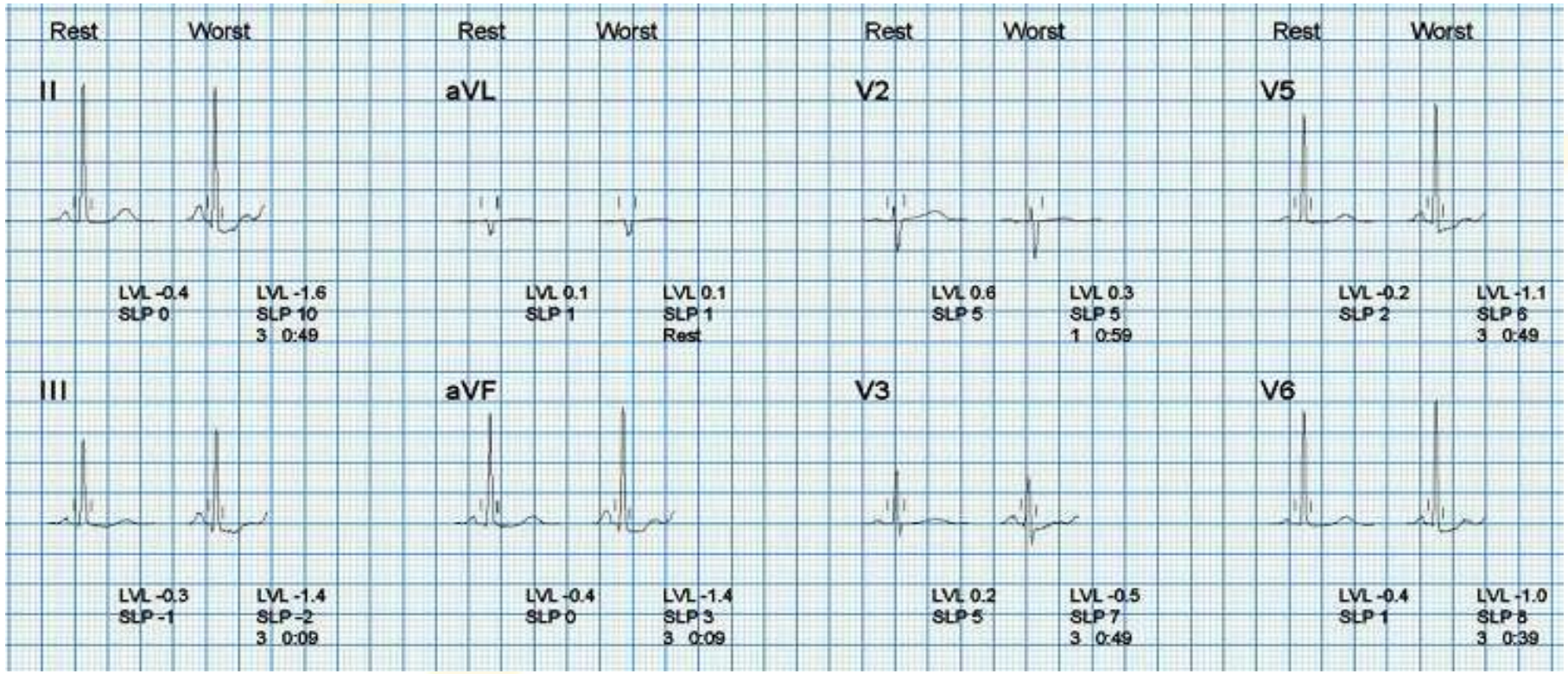
Case. F/65 Stable Angina

- Treadmill test: 8 min 50 sec, equivocal, chest pain (-)
- She has been doing well so far for 1 year



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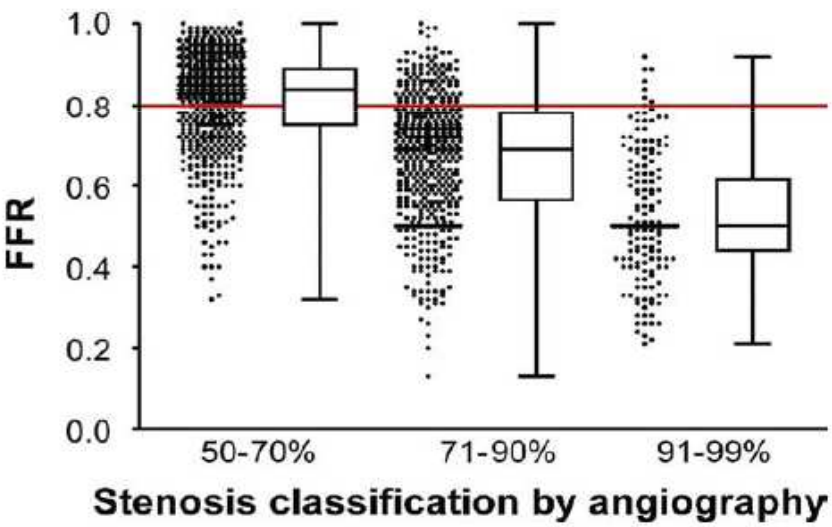
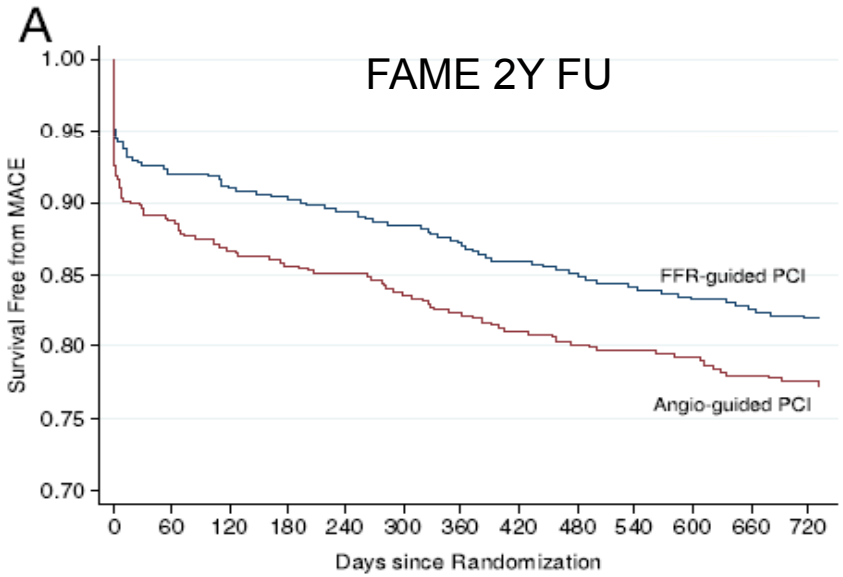
FFR, a gold standard of test for myocardial ischemia?

FFR was better than angiography predicting myocardial ischemia and future clinical events in FAME study (N=1,239)



Angiographic stenosis is a poor indicator of ischemia



FFR-based angioplasty was associated with a better clinical outcome compared to angiography-based angioplasty.

Tonino, JACC 2010, Pijls, JACC 2010

How was FFR derived

$$P_a - P_v = Q(R + R_c)$$

and

$$P_w - P_v = QR$$

Therefore

$$\frac{P_a - P_v}{P_w - P_v} = \frac{(R + R_c)}{R} = 1 + \frac{R_c}{R} = C$$

Equation A1a can also be rearranged into
forms, which will be helpful in later conside

$$\frac{P_w - P_v}{P_a - P_w} = \frac{R}{R_c} = C_2$$

and

$$\frac{P_a - P_v}{P_a - P_w} = \frac{R}{R_c} + 1 = C_3$$

where C_1, C_2, and C_3 are all different constants characterizing collateral resistance relative to the resistance of the myocardial bed supplied by the collaterals at maximum vasodilation.

The second step is the calculation of fractional flow reserve of the stenotic coronary artery (FFR_{cor}). By de

$$FFR_{cor} = \frac{Q_s}{Q_s^N} = \frac{Q - Q_c}{Q^N - Q_c^N}$$

Because $Q_c^N = 0$:

$$FFR_{cor} = \frac{Q - Q_c}{Q^N}$$

$$= \frac{(P_d - P_v)/R - (P_a}{(P_a - P_v)/}$$

$$= \frac{(P_d - P_v) - (P_a -}{(P_a - P_v}$$

Substitution of the constant value C_2, obtain
tion A1b, gives the following:

$$FFR_{cor} = \frac{(P_d - P_v)(P_a - P_w) - (P_a - P_d)(P_w - P_v)}{(P_a - P_v)(P_a - P_w)}$$

$$= \frac{P_d - P_w}{P_a - P_w} \quad \text{(A2a)}$$

$$= 1 - \frac{\Delta P}{P_a - P_w} \quad \text{(A2b)}$$

Next, fractional flow reserve of the myocardium (FFR_{myo}) is calculated as follows:

$$FFR_{myo} = \frac{Q}{Q^N} = \frac{(P_d - P_v)/R}{(P_a - P_v)/R} = \frac{P_d - P_v}{P_a - P_v} \quad \text{(A3a)}$$

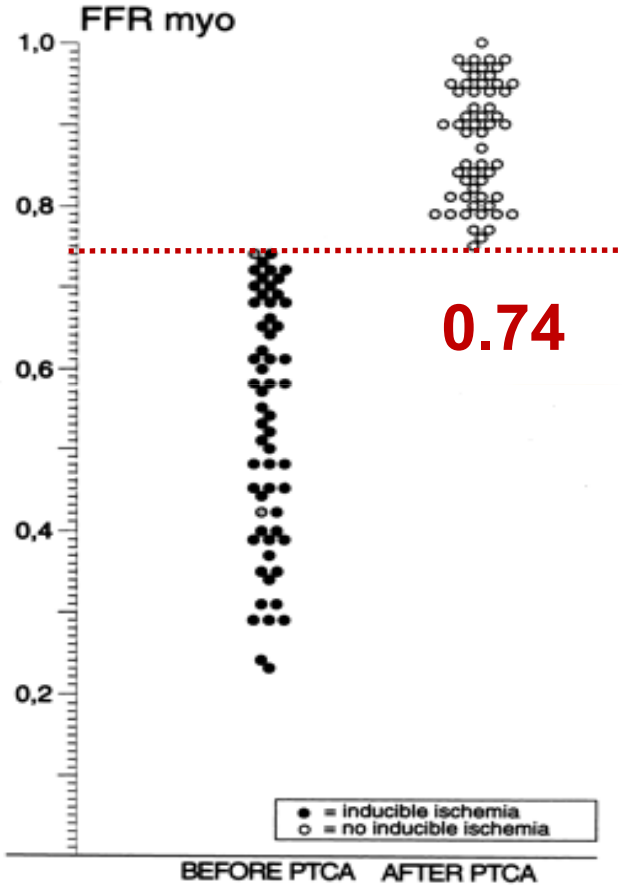
$$= 1 - \frac{\Delta P}{P_a - P_v} \quad \text{(A3b)}$$

An equation derived purely mathematically.

Pijls N, Circulation 1993

How was cut-off value determined?

- N= 60 with single-vessel disease (LAD 39, LCX 8, RCA 13)
- Exercise test (ET)
  - < 24 hours before PTCA and
  - 5 to 7 days after PTCA
- Definition of inducible ischemia
  - Positive ET before PTCA AND
  - Normal ET after PTCA
- In all patients, values of FFR_{myo} definitely associated with ischemia were ≤ 0.74, whereas all except two values not associated with inducible ischemia exceeded 0.74



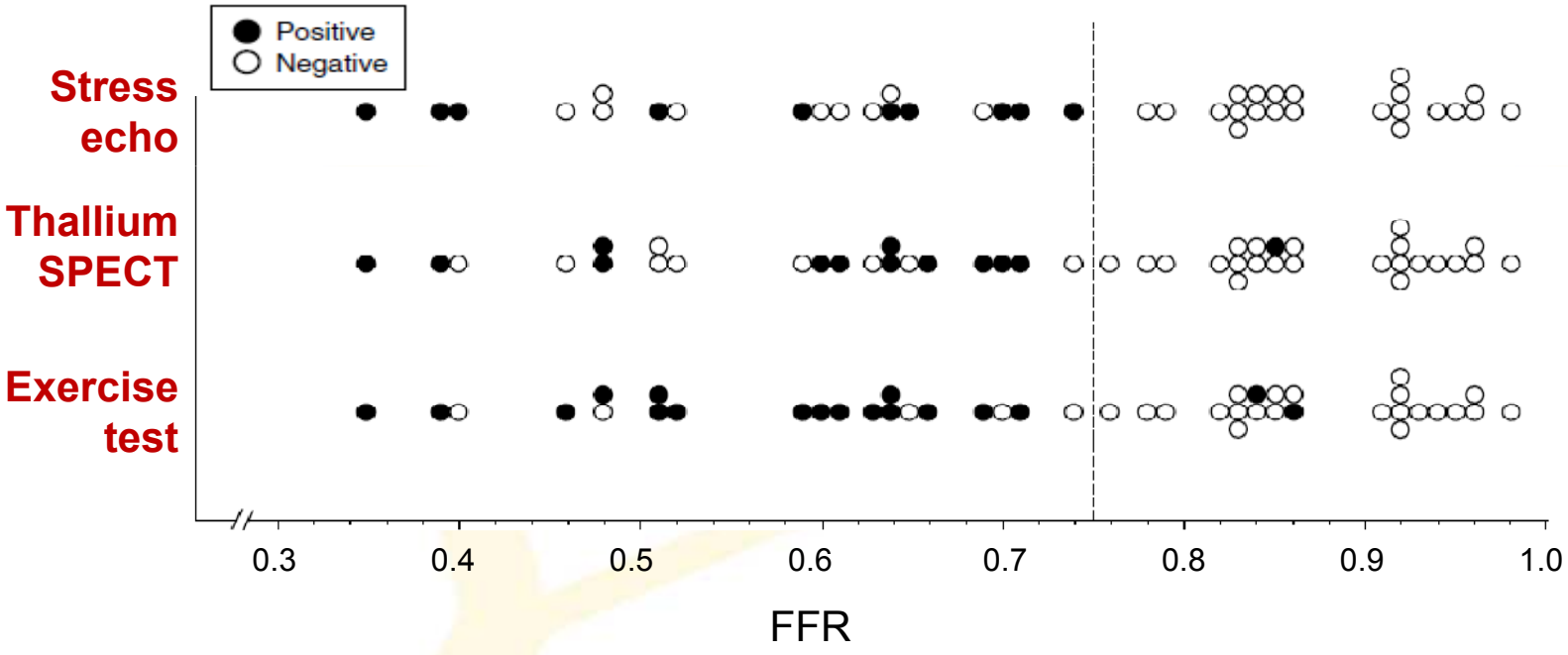
By exercise treadmill test

Pijls N, Circulation 1995

How was cut-off value validated?

N=45, FFR < 0.75 for any ischemia

Sensitivity 85%, Specificity 100%



By non-invasive functional tests

Pijls NH, NEJM 1996

Why do we believe in FFR as a gold standard of myocardial ischemia?

- Sound scientific background

  Cut-ff value given by conventional functional study
- The value reproducible in any situation

  Not proven in small branches (or side branches)
- Predicts clinical outcome

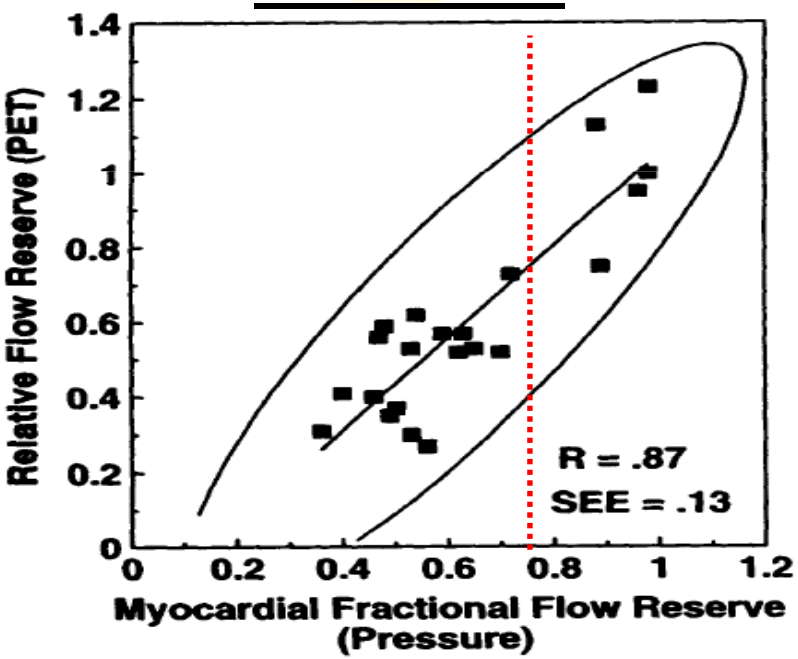
  Any functional test can do that
- Narrow intermediate zone (0.75 – 0.80)

  Really?

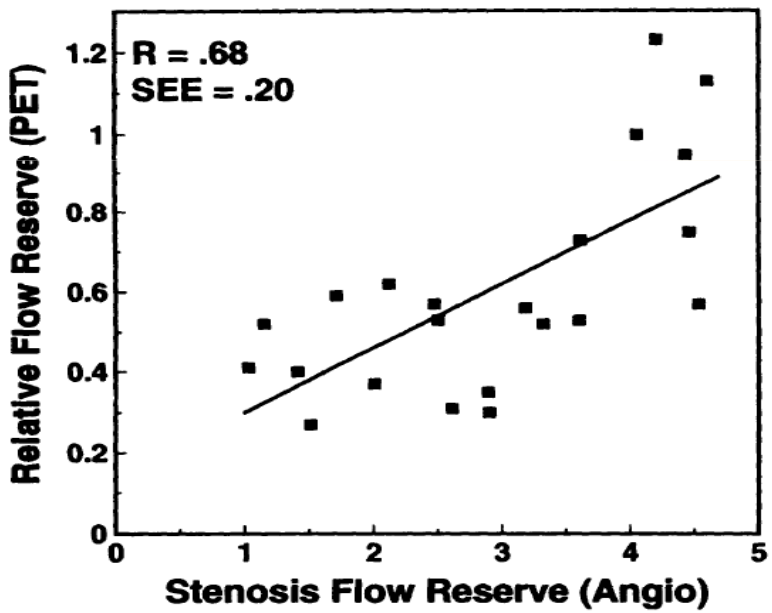
FFR has also some variations.

N=22 isolated, discrete lesion in proximal or mid LAD lesions in patients with normal LV function

FFR vs. PET



QCA vs. PET



FFR between 0.65 to 0.85 indicates an intermediate ischemia.

De Bruyne BD, Circulation 1994

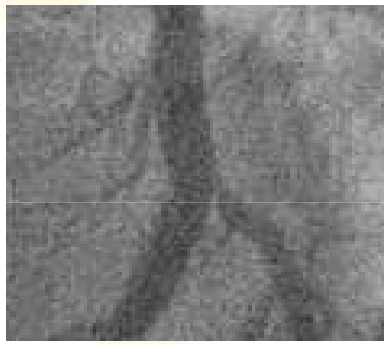
An intermediate lesion is an intermediate lesion, by any means

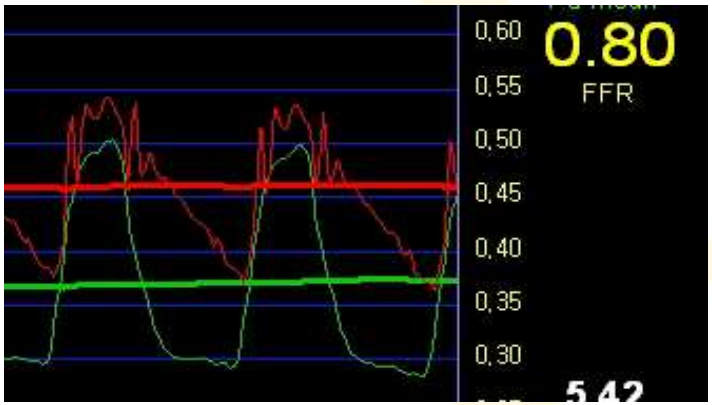
Green is always green, neither yellow nor blue!

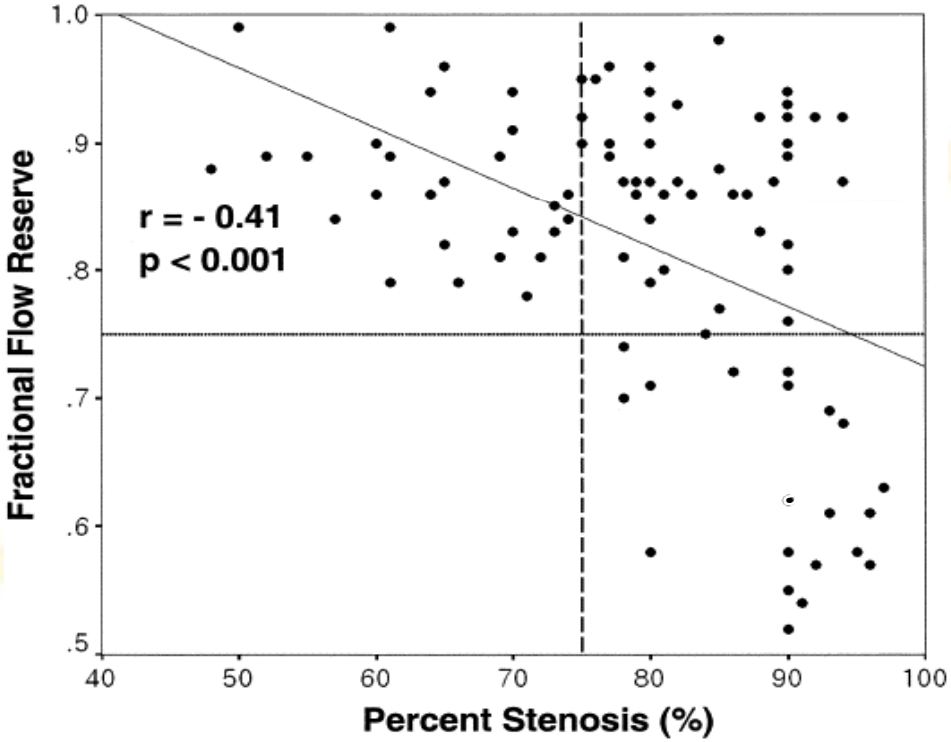
Anatomically significant stenosis is frequently functionally insignificant

- Among side branch lesions > 75% stenosis after main vessel stenting, only 27% were functionally significant.

$$FFR = \frac{P_d}{P_a}$$







Koo BK, J Am Coll Cardiol 2005

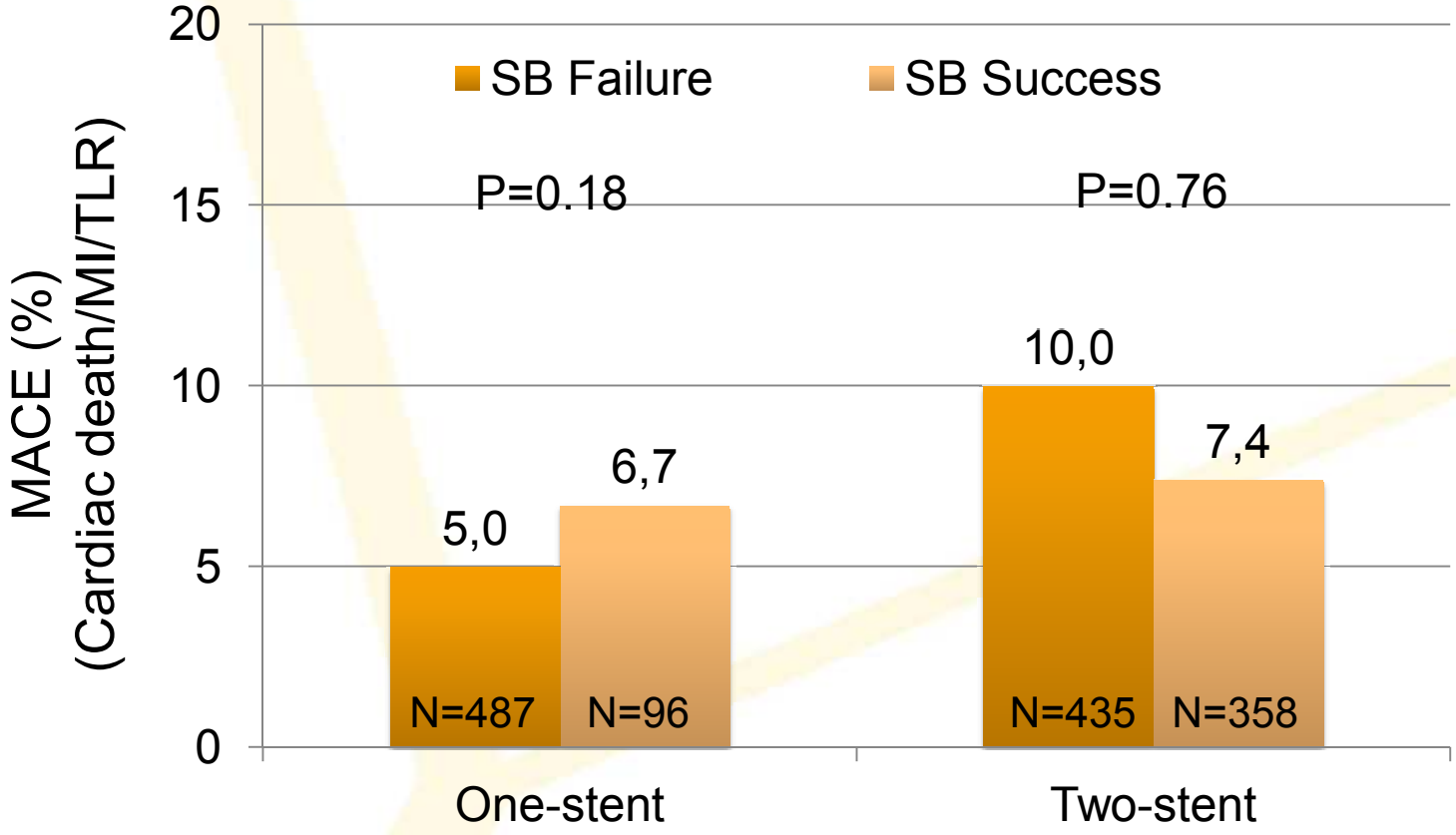
Functionally significant stenosis is frequently clinically insignificant

- Small area of ischemia
- Poor exercise capacity
- Silent ischemia

Clinical target of PCI	
Symptoms	Primary target
LV function	Ischemic CMP
Survival	Primary PCI in AMI

Angiographic success in side branch was not the prognostic factor

Korean Coronary Bifurcation Stenting Registry (N=1668)



SB Angiographic Success: Residual stenosis < 50% and TIMI = 3

Gwon HC, TCT 2010

To treat or not to treat?
Anatomical, Functional, and Clinical Angioplasty

Determinants	Treatment Goal	Assessment
Stenosis severity Microvascular function Ischemic area at risk Functional capacity	Clinical Significance Patients	Symptoms Treadmill test
Stenosis severity Microvascular function	Functional Significance Myocardium	**FFR** CFR SPECT Dobutamine echo
Stenosis severity	Anatomical Significance Coronary artery	CAG IVUS/OCT CT angiography

Clinical Outcome of FFR-guided PCI

- FFR-guided PCI vs. Angiography-guided PCI
- No difference in 9-month cardiac event rates

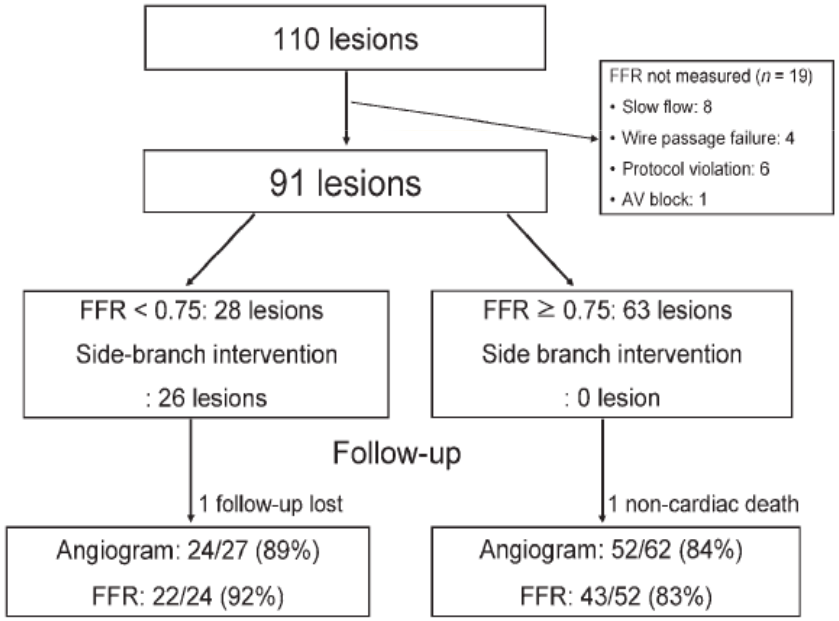


Table 3 Comparison of 9-month clinical outcomes between fractional flow reserve-guided side-branch intervention group (FFR group) and conventional intervention group (conventional group)

	FFR group, $n = 108$[a]	Conventional group, $n = 108$[b]	*P*-value[c]
Cardiac death	0	0	1
Myocardial infarction	0	0	1
Target vessel revascularization, *n* (%)	5 (4.6)	4 (3.7)	0.7

[a]One follow-up loss; one non-cardiac death.
[b]Two follow-up losses.
[c]Not adjusted for multiple comparisons.

Koo BK, Eur Heart J 2008

Should we use FFR ?
I will say NO.

- FFR is one of many functional studies.
- Decision should be made clinically, as well as anatomically and functionally.
- The role of FFR should be limited to small number of occasions