Imaging & Physiology Summit: FFR Workshop

BASIS CONCEPTS OF FFR

Seoul, Korea, december 5th, 2014

CATHARINA-ZIEKENHUIS

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Disclosures:

- Dr Pijls received institutional research grants from St Jude Medical and Maquet and is consultant for St Jude Medical

- Dr Pijls has equity interest in Philips, General Electric, and Heartflow

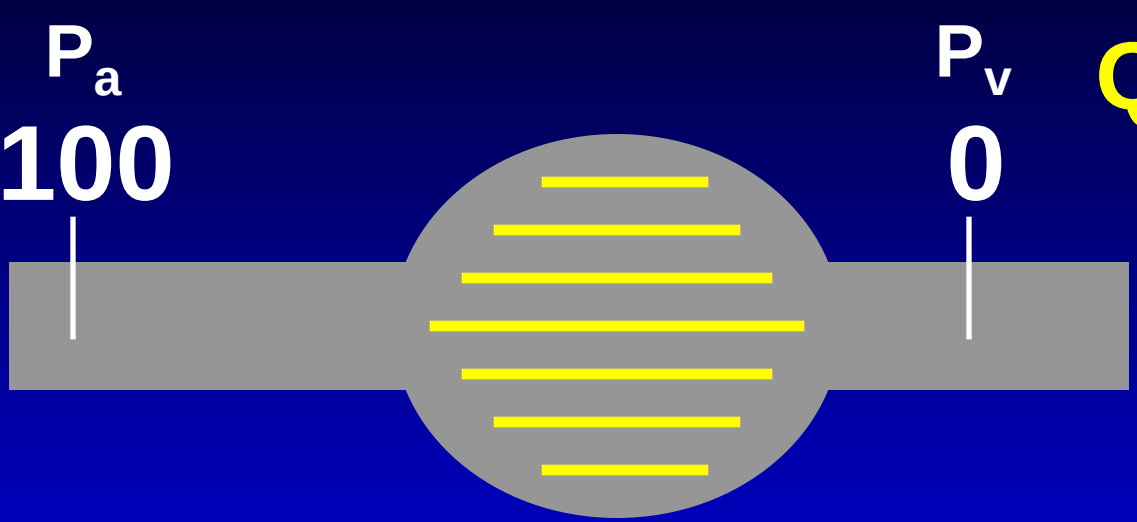
FRACTIONAL FLOW RESERVE:

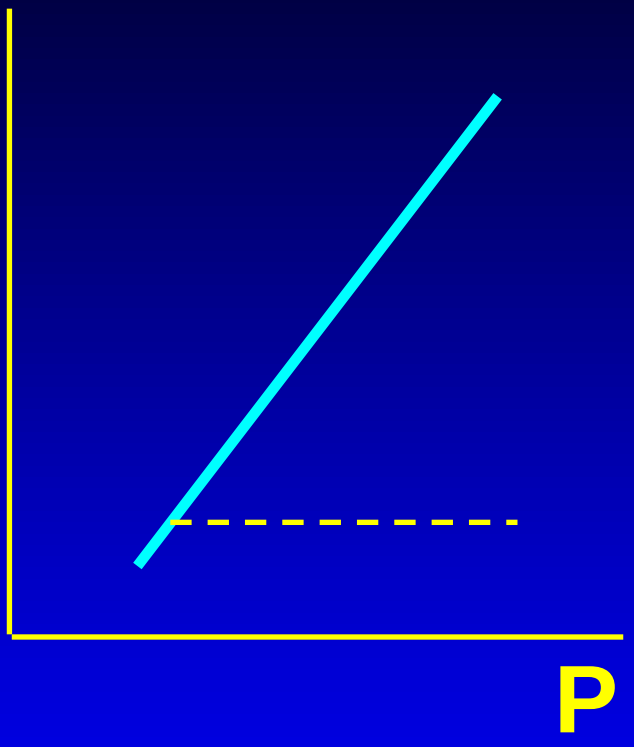
The index FFR (***Fractional Flow Reserve***)
is based upon the two following principles:

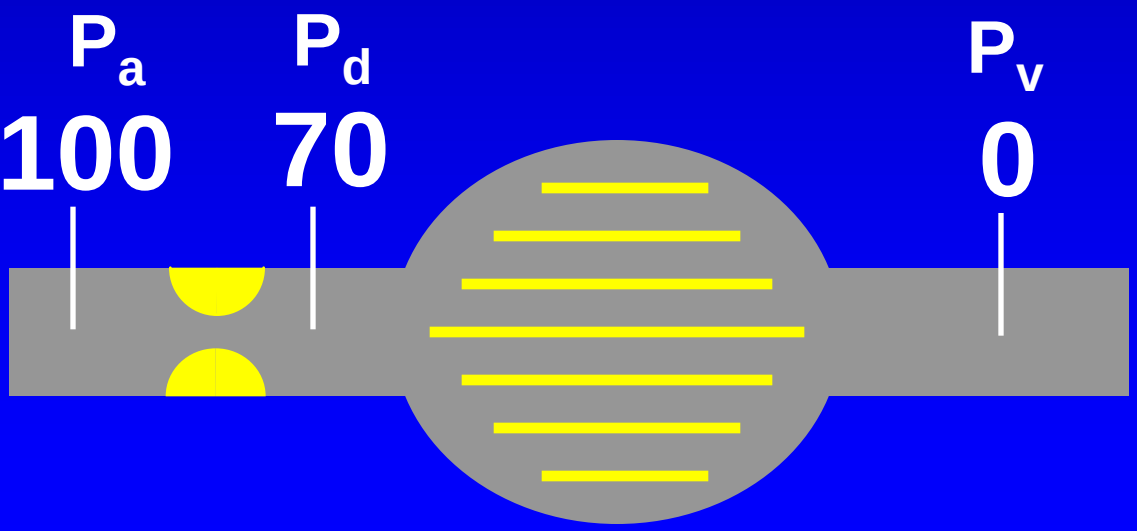
- *It is not resting flow, but **maximum achievable flow** which determines the functional capacity (exercise tolerance) of a patient*

- *At maximum vasodilation (corresponding with maximum hyperemia or with maximum exercise), blood flow to the myocardium is proportional to **myocardial perfusion pressure***
  *(**~hyperemic distal coronary pressure**)*

During Maximal Vasodilatation







$$FFR_{myo} = \frac{P_d}{P_a}$$

$$= 0.70$$

FRACTIONAL FLOW RESERVE =

$$\frac{\text{MAXIMUM FLOW IN THE PRESENCE OF A STENOSIS}}{\text{NORMAL MAXIMUM FLOW}}$$

~

$$\text{FFR}_{myo} = \frac{P_d}{P_a}$$

P_a = mean aortic pressure at maximum hyperemia

P_d = mean distal coronary pressure at maximum hyperemia

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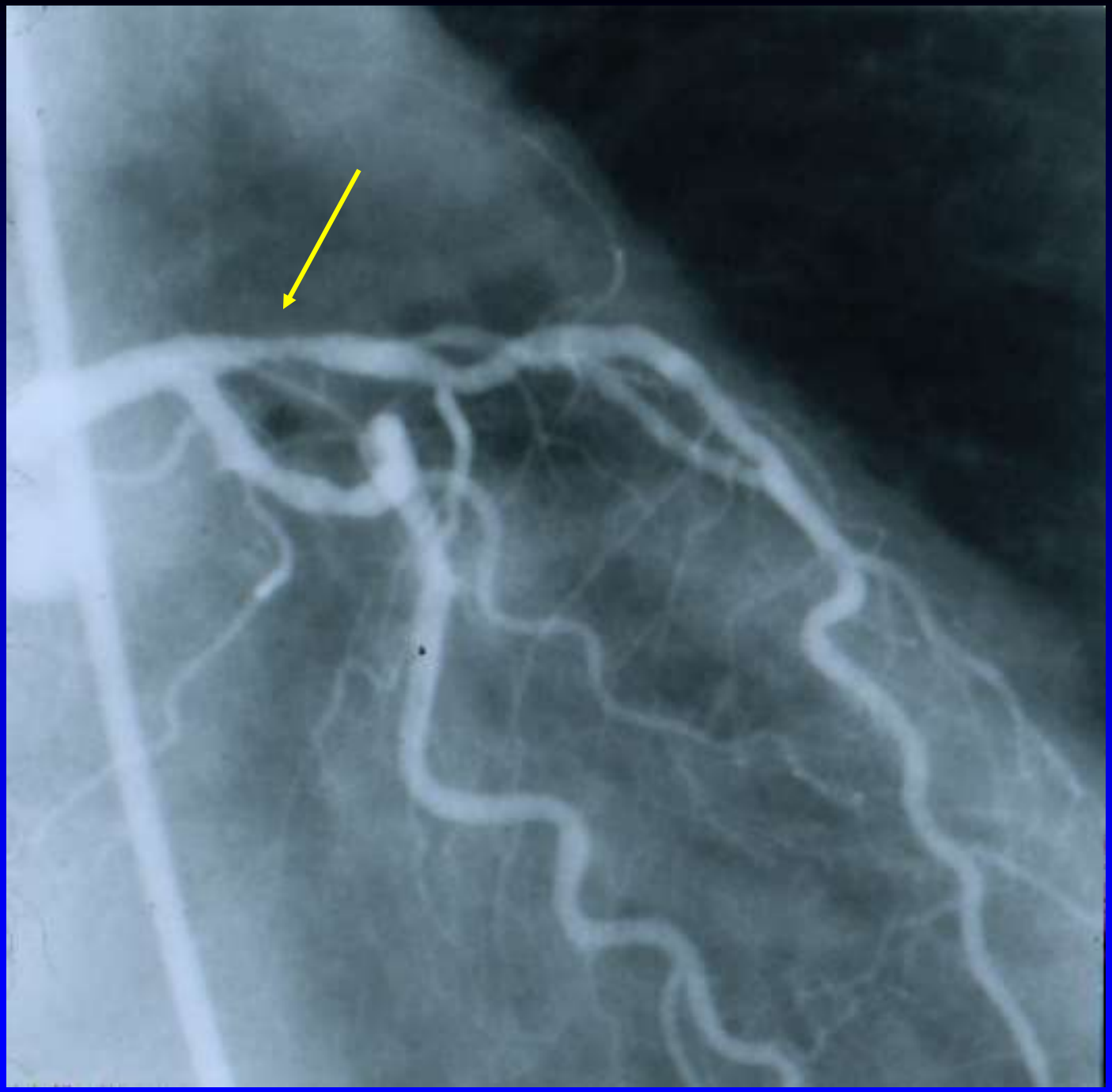
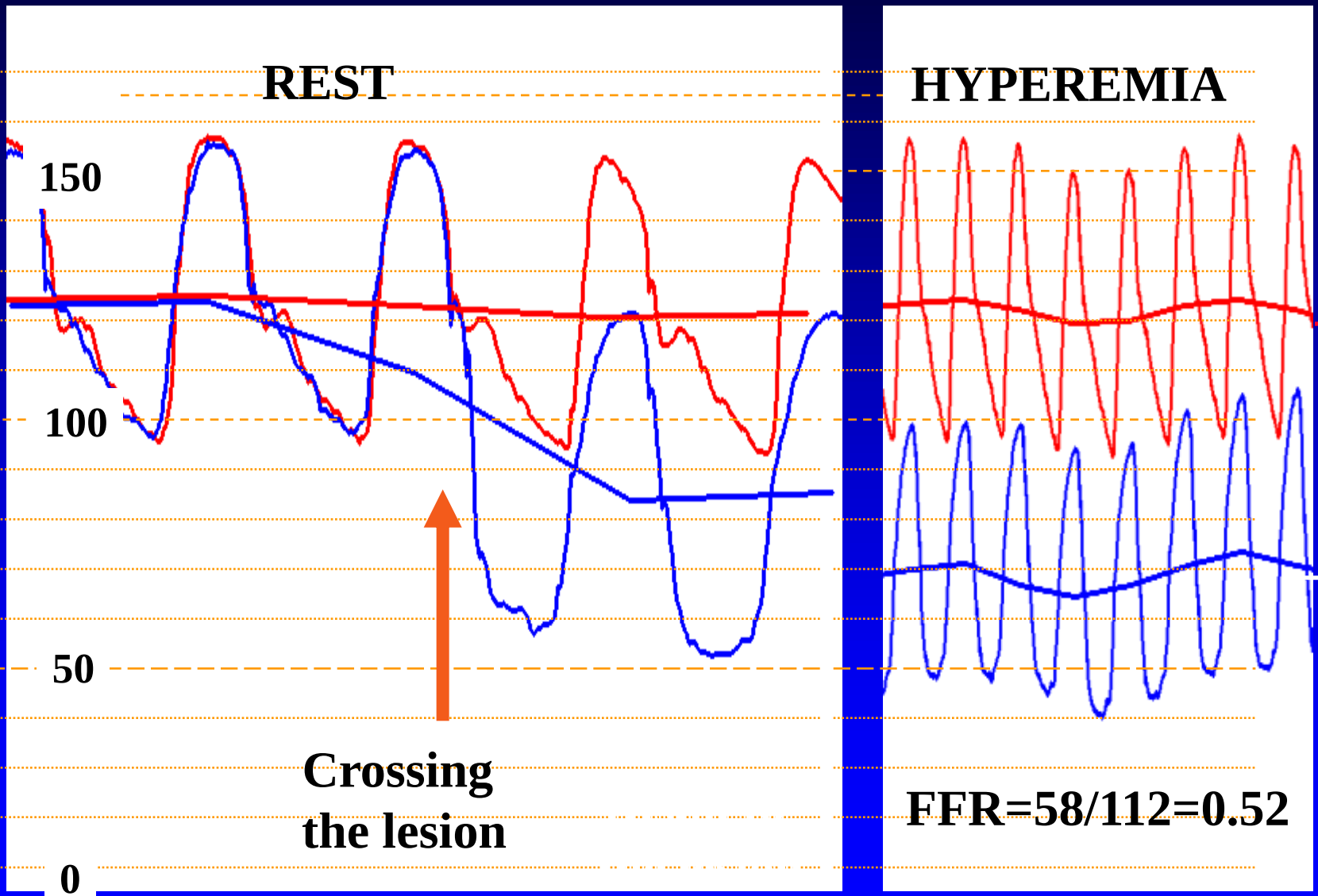
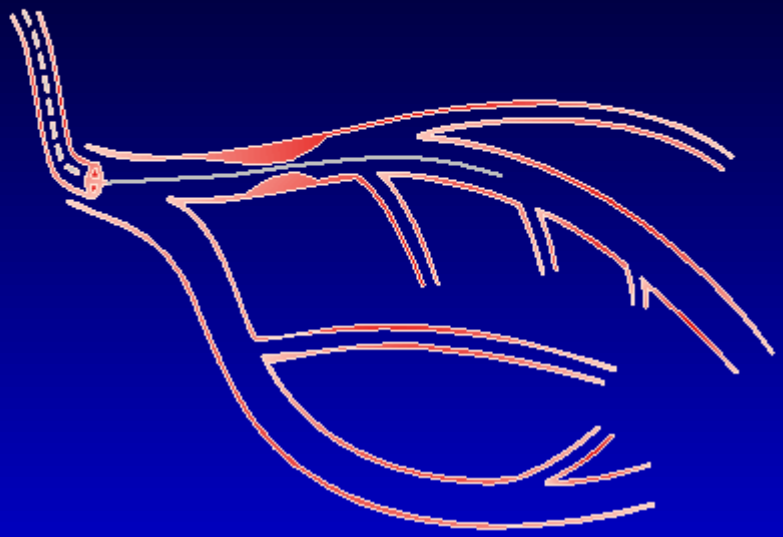


Fractional Flow Reserve in Clinical Practice

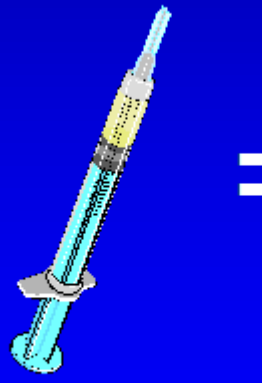


Application in catherization laboratory



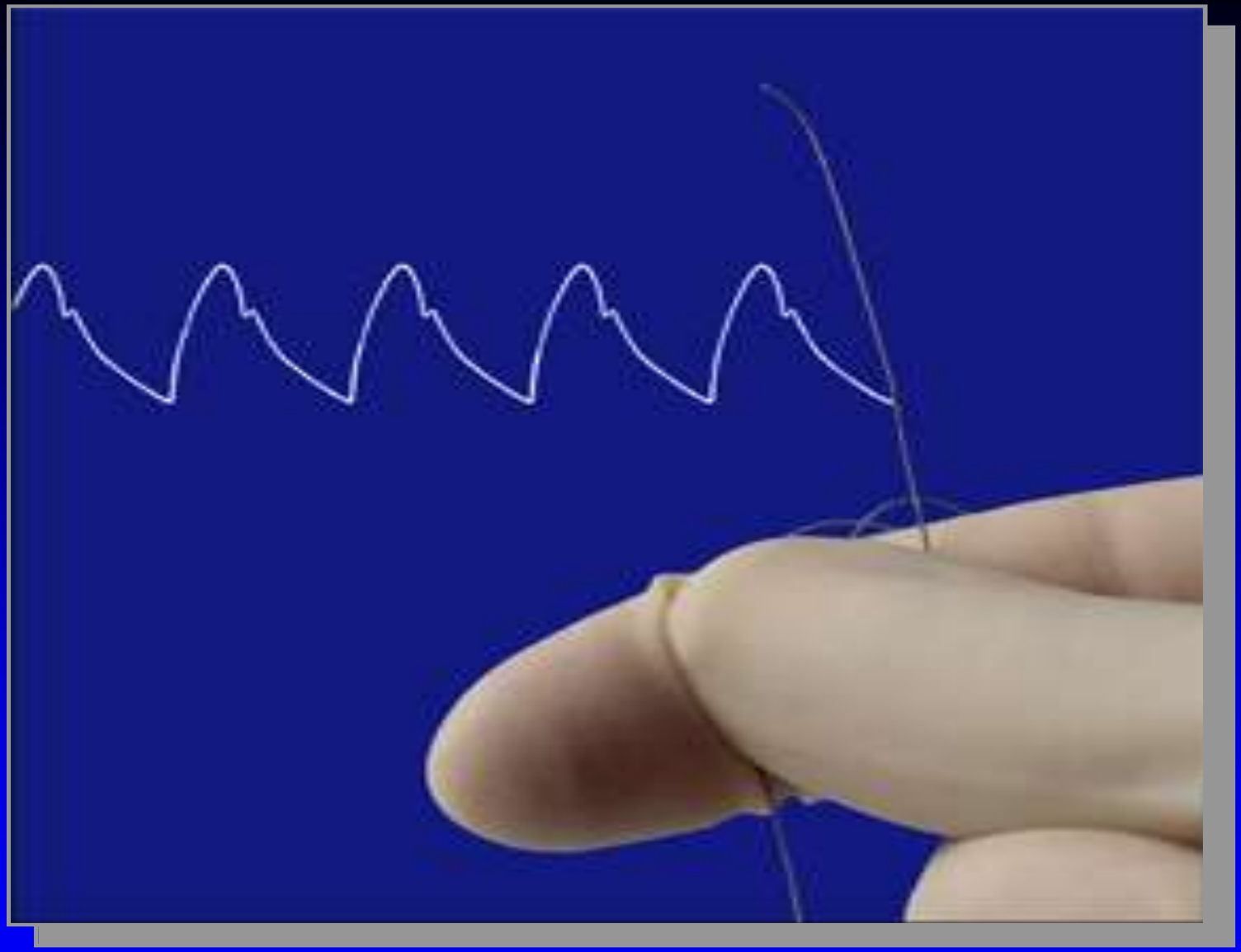
pressure wire

+



hyperemic stimulus

= **FFRmyo**



0.014 sensor-tipped PTCA guidewire

users friendly, “quiet” interface

→ *Practical set-up lecture by Dr Fearon*

MAXIMUM VASODILATORY STIMULI

Maximum hyperemia is paramount for optimum accuracy

- **PAPAVERINE i.c.**
- **ADENOSINE i.c.**
- **ADENOSINE i.v. infusion**
- **ATP i.c**
- **ATP i.v.**
- **REGADENOSON i.v. bolus**

→ *Lecture by Dr Bon-Kwon Koo*

→ *debate tomorrow in main arena at 09.50 by Dr Matsuo & Dr Pijls*

BASIC FEATURES OF FFR

- ***Normal value = 1.0* for every patient and every artery**
- FFR is *not influenced by changing hemodynamic conditions* (heart rate, blood pressure, contractility)
- FFR specifically relates the influence of the epicardial stenosis to myocardial perfusion area and blood flow
- FFR accounts for collaterals
- FFR has a *circumscript threshold value* (~ 0.75 – 0.80) to indicate ischemia
- FFR is *easy* to measure (success rate 99 %) and extremely *reproducible*
- Pressure measurement has un *unequaled spatial resolution*

Fractional Flow Reserve in Normal Coronary Arteries

33 truely normal coronary arteries in patients\ without coronary artery disease:

FFR = 0.98 +/- 0.02 (range 0.93 – 1.00)

Pijls, Circulation 1995;92: 183-193

86 apparently normal contralateral arteries In patients with coronary disease:

FFR = 0.87 +/- 0.09 (range 0.64 – 0.97)

De Bruyne, Circulation 2001; 104:2401-2406

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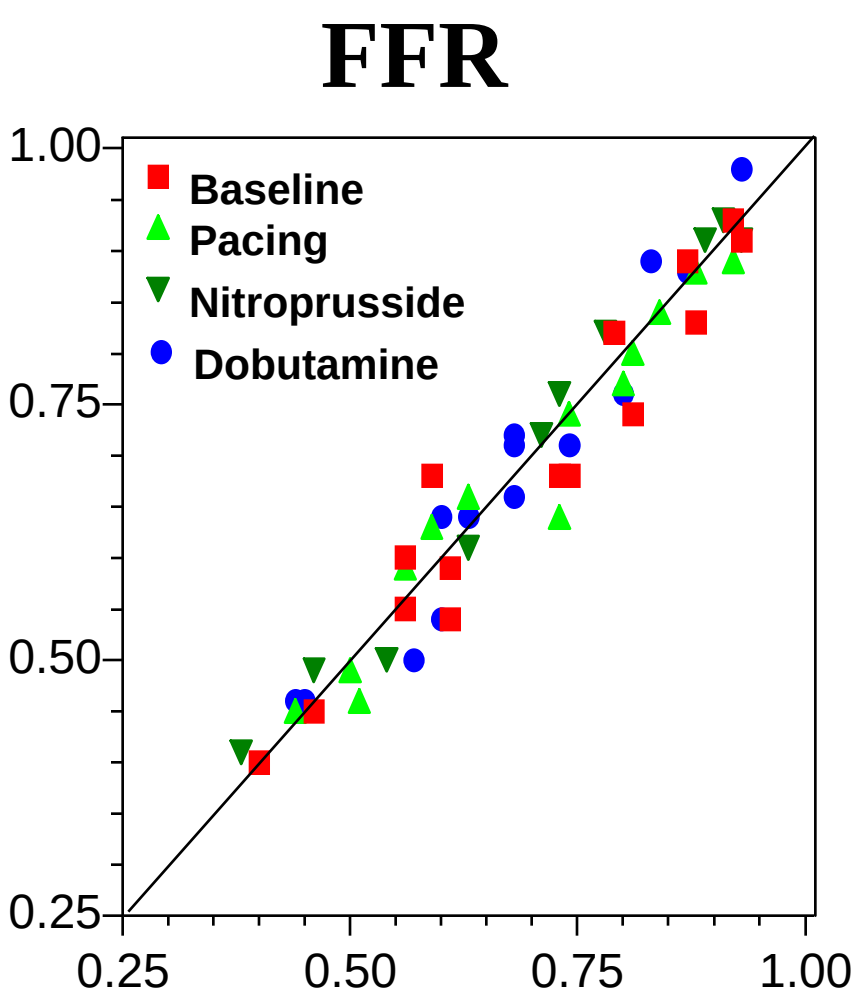
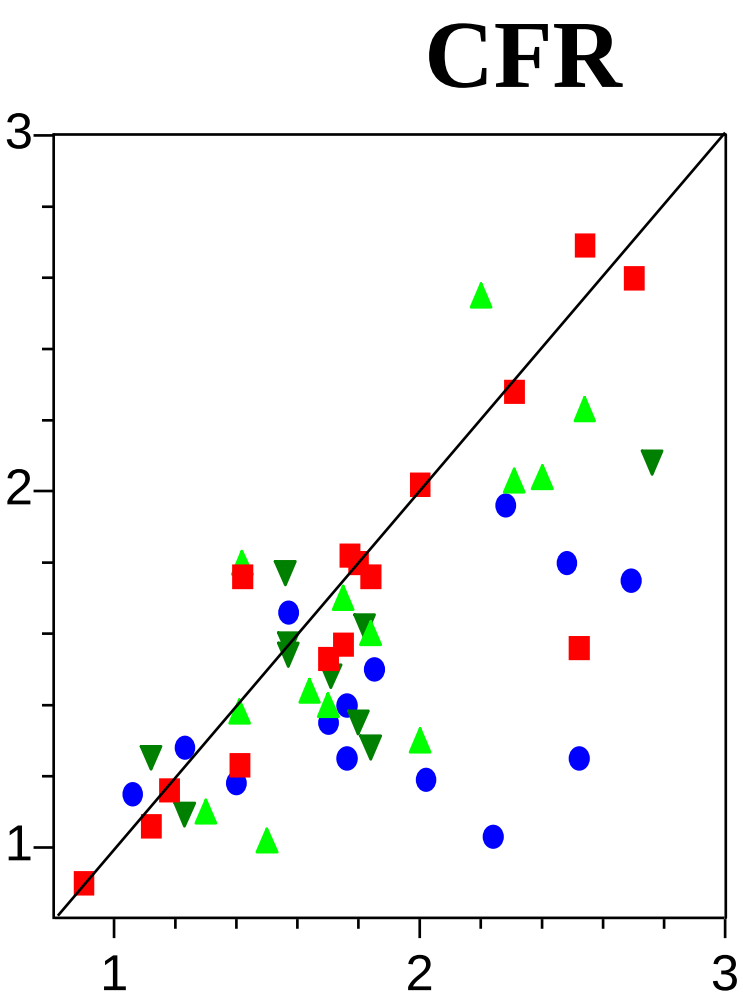
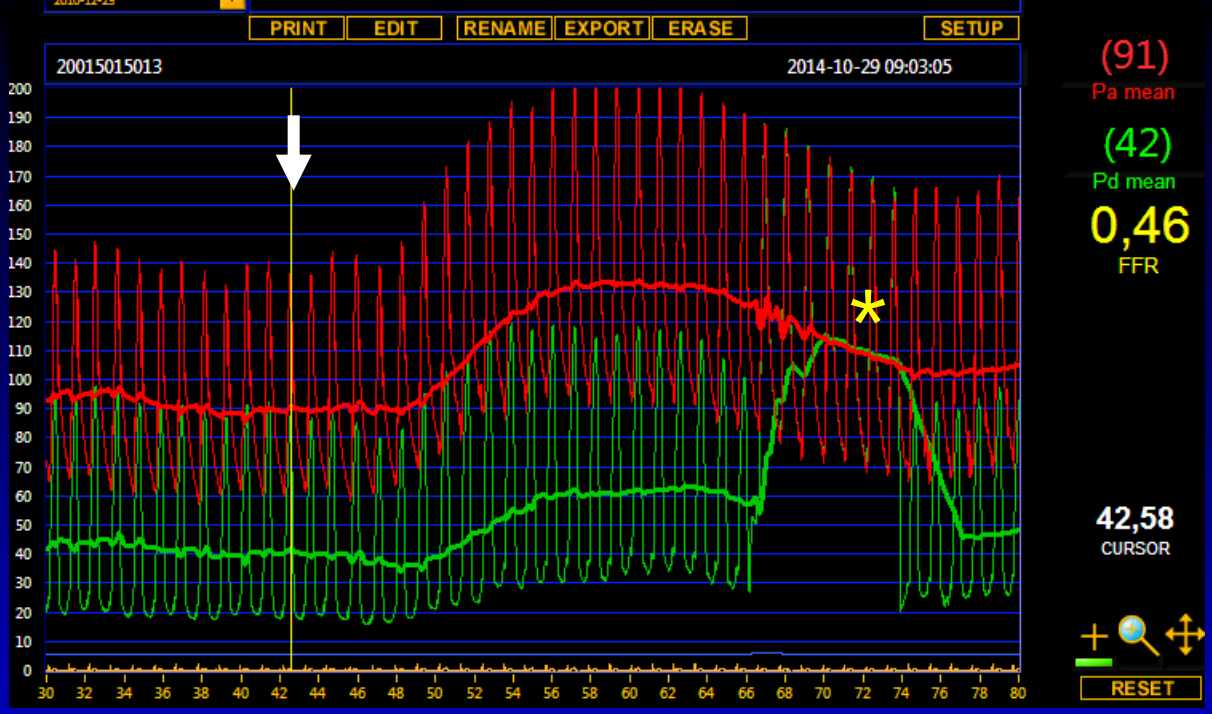
Hemodynamic Variability of FFR_{myo} and CFR



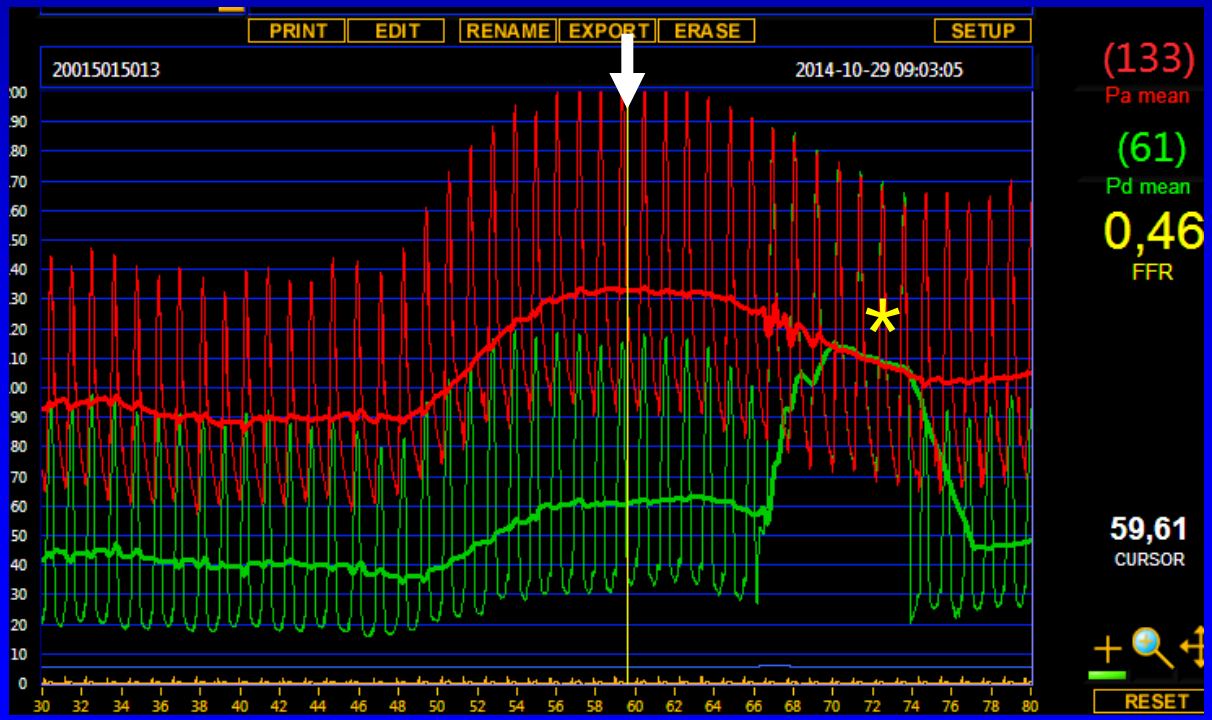


B. De Bruyne et al Circulation 1996



aortic pressure 91
Pa = 91 mmHg
Pd = 42 mmHg

FFR = 42/91 = **0.46**



VALSALVA:

aortic pressure 133
Pa = 133 mmHg
Pd = 61 mmHg
FFR = 61/133 = **0.46**

* = pullback/advance

BASIC FEATURES OF FFR

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- FFR specifically relates the influence of the epicardial stenosis to myocardial perfusion area and blood flow
- FFR accounts for collaterals
- ***FFR has a circumscript threshold value with small gray zone (~ 0.76 – 0.80) to indicate ischemia***
- FFR is *easy* to measure (success rate 99 %) and extremely *reproducible*
- Pressure measurement has un *unequaled spatial resolution*

Threshold value of FFR to detect significant stenosis

→ Lecture tonight at 6 pm

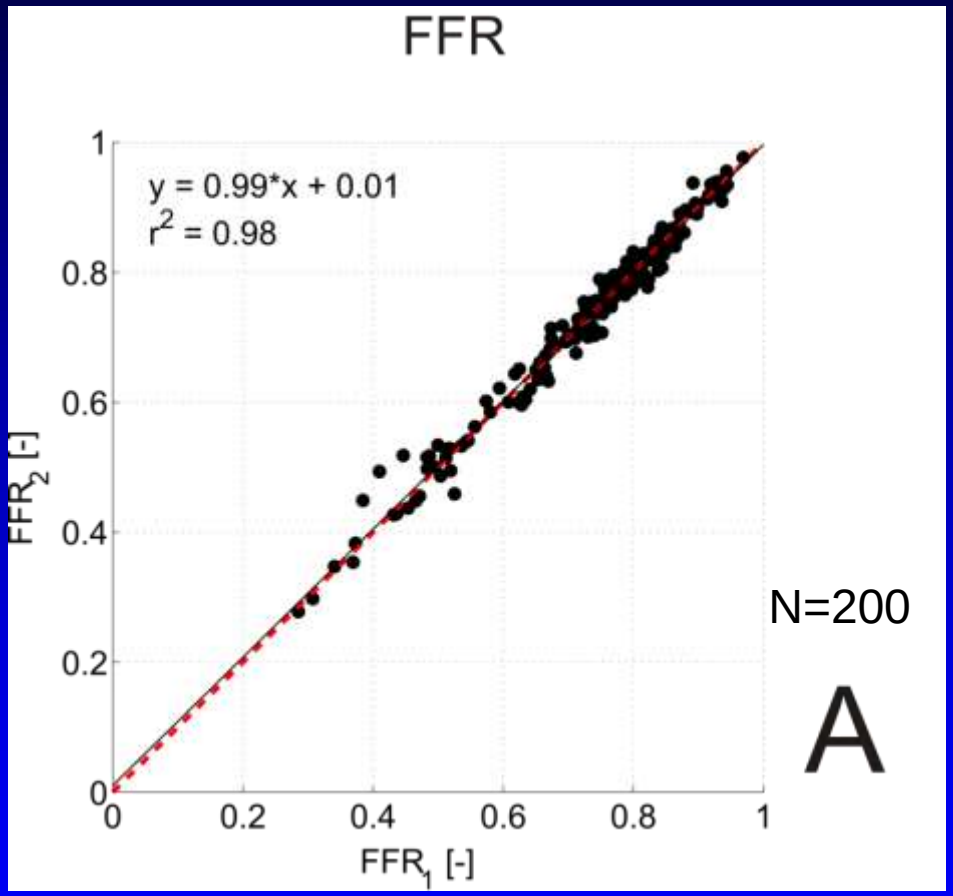
FFR is the ***only*** functional index which has ever been validated versus a **true gold standard**.
(Prospective multi-testing Bayesian methodology)

ALL studies ever performed in a wide variety of clinical & angiographic conditions, found threshold between 0.75 and 0.80

Sensitivity : 90%
Specificity : 100%

N Engl J Med 1996; 334:1703-1708

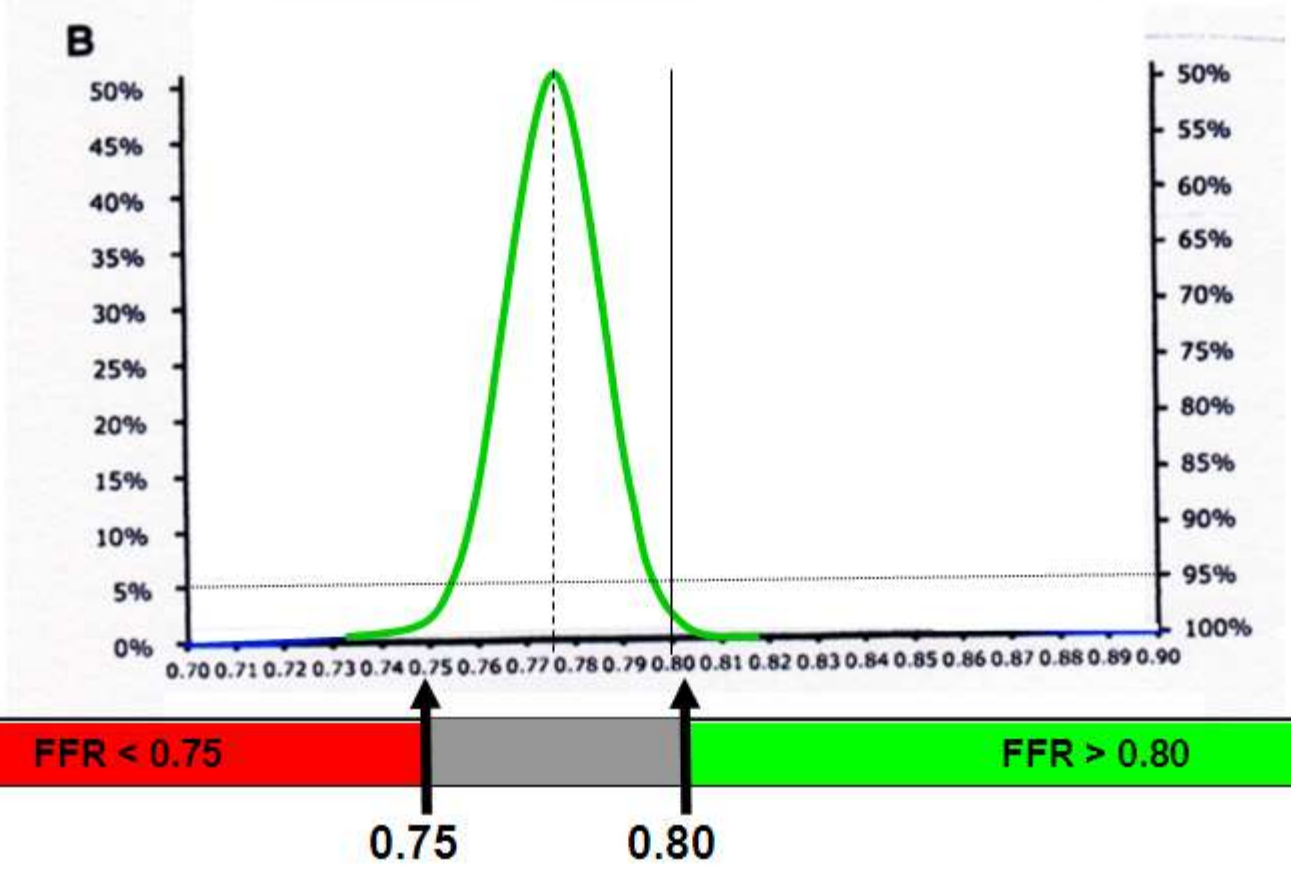
Reproducibility of FFR



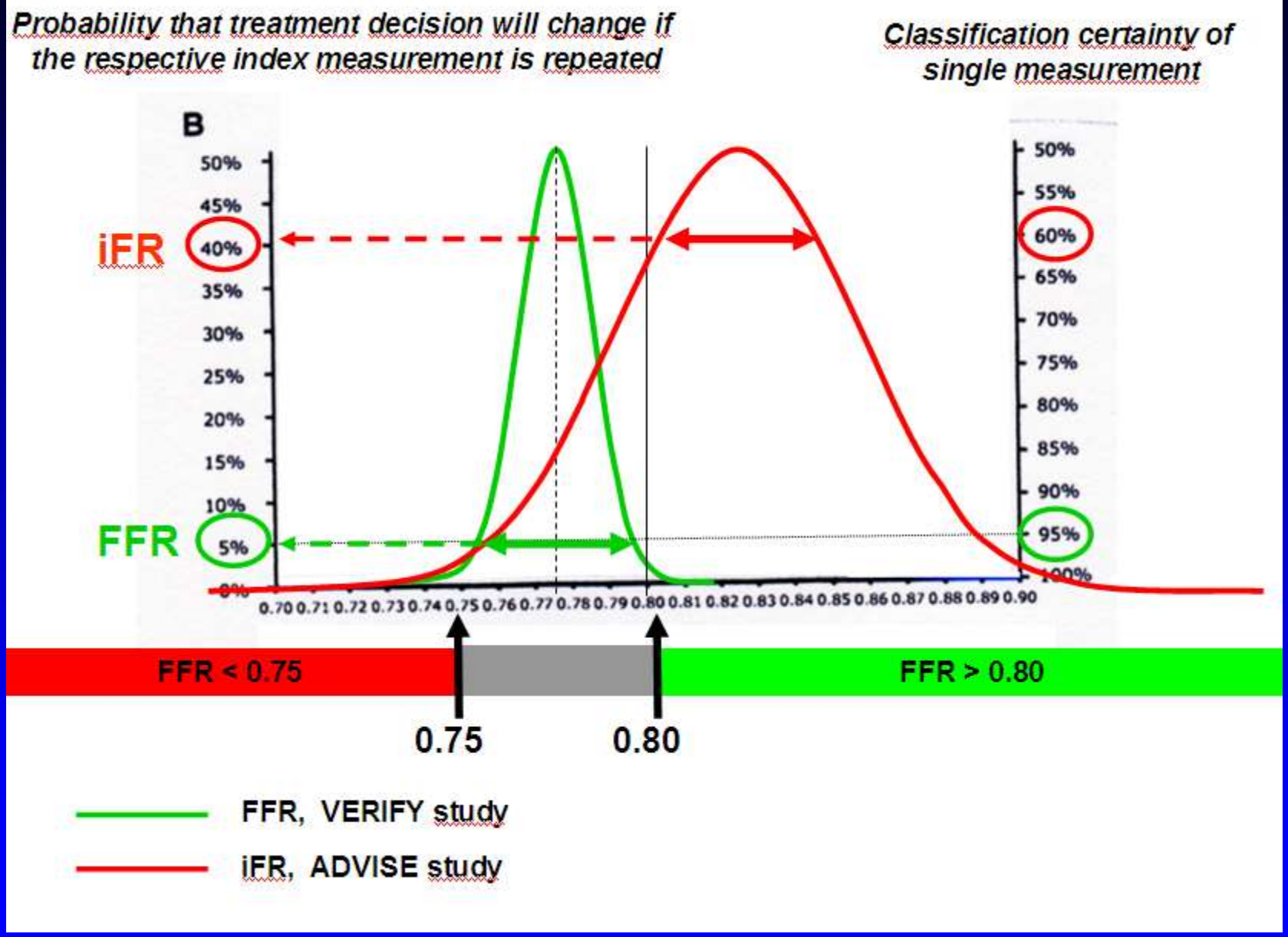
VERIFY study, Berry et al, JACC 2012 (in press)

Probability that treatment decision will change if the respective index measurement is repeated

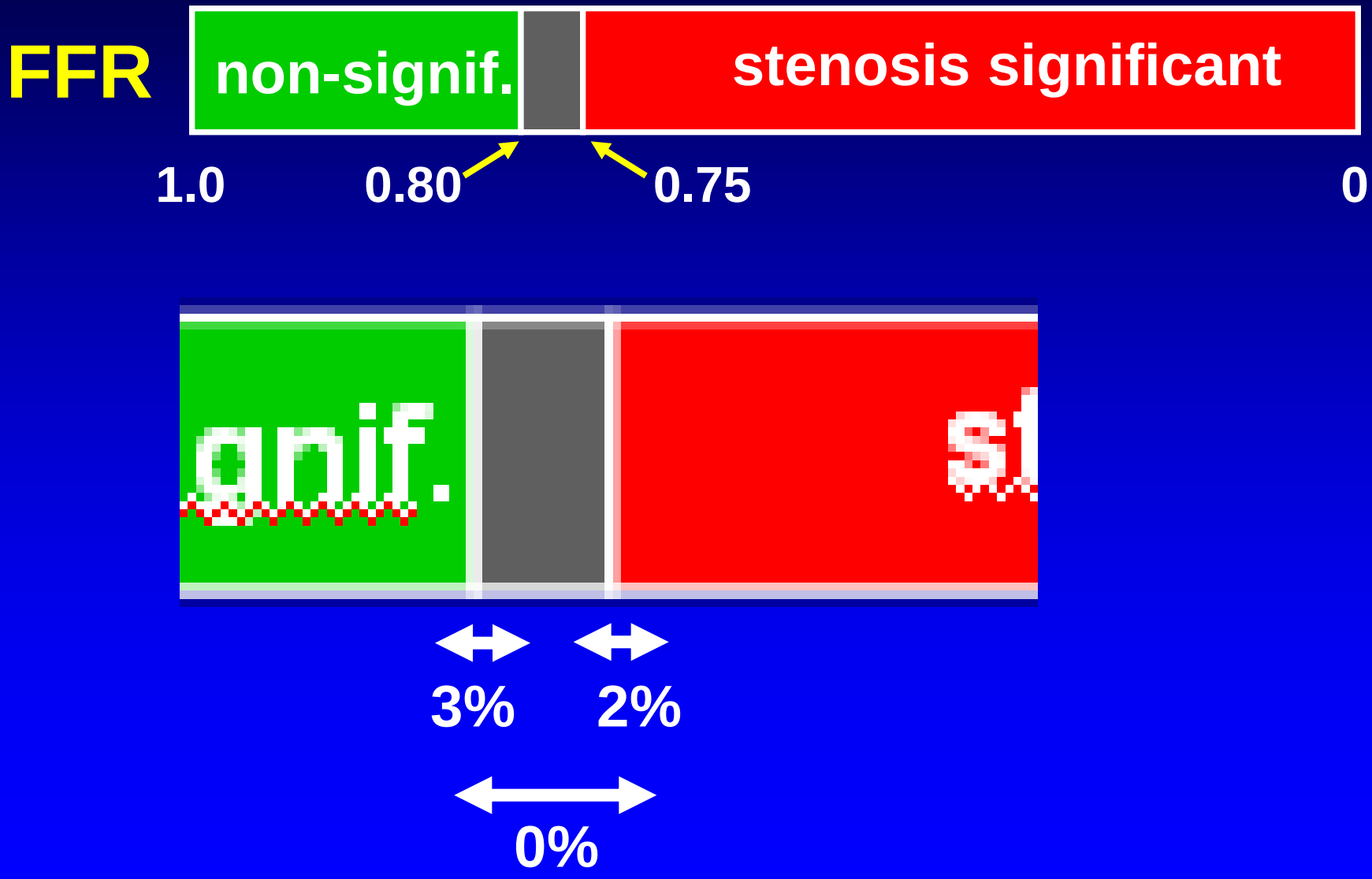
Classification certainty of single measurement



2.4 % of patients go from green to gray or v.v. and 2.4 % from red to gray
Almost nobody ever crosses from red to green or v.v.


Probability that treatment decision will change if the respective index measurement is repeated
Classification certainty of single measurement
B
iFR
FFR
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%
100%
0.70 0.71 0.72 0.73 0.74 0.75 0.76 0.77 0.78 0.79 0.80 0.81 0.82 0.83 0.84 0.85 0.86 0.87 0.88 0.89 0.90
FFR < 0.75
FFR > 0.80
0.75
0.80
FFR, VERIFY study
iFR, ADVISE study

At <u>1200</u> consecutive in-duplo measurements of FFR, there was <u>NOT ANY cross-over</u> across the gray zone



BASIC FEATURES OF FFR

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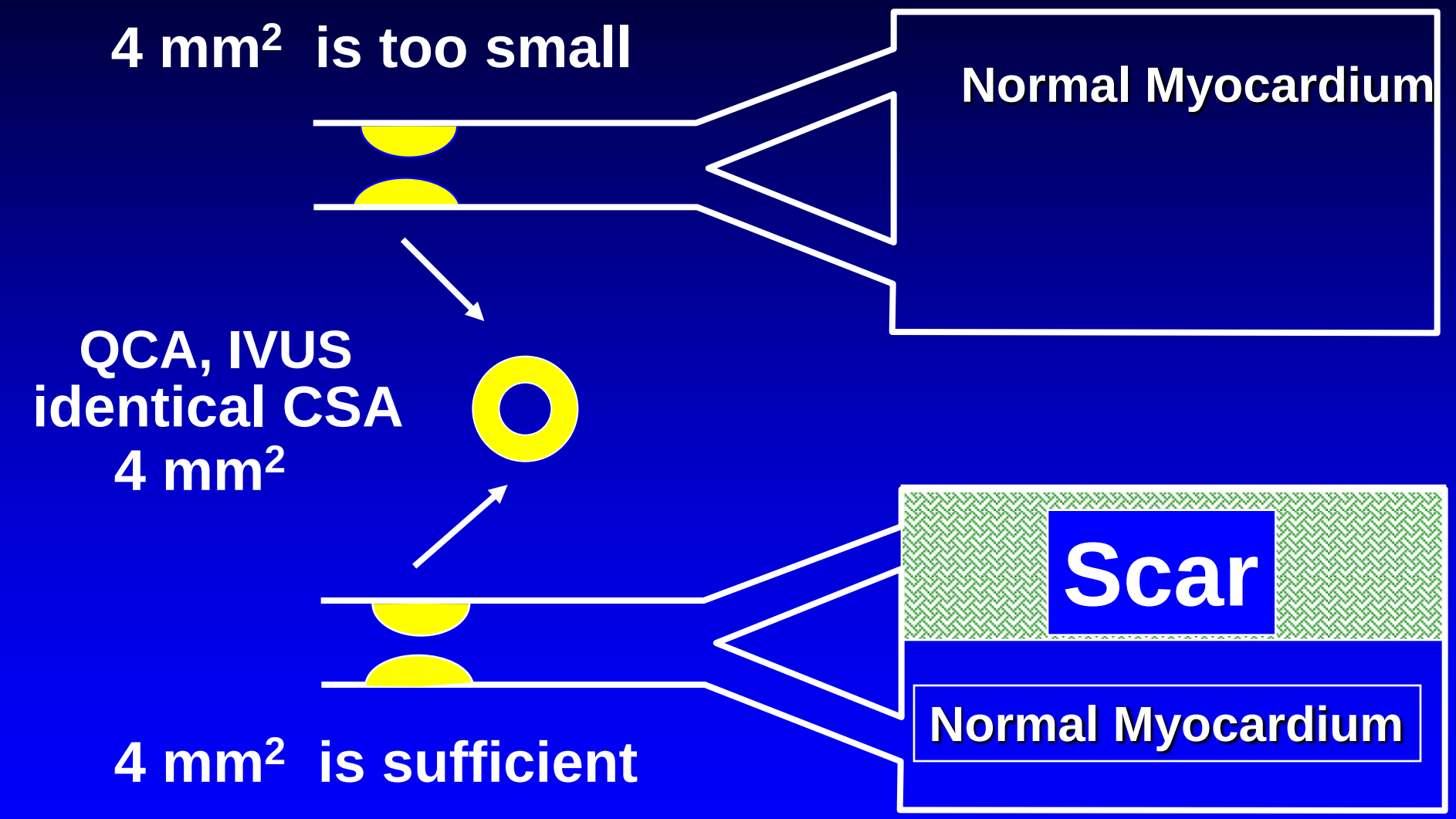
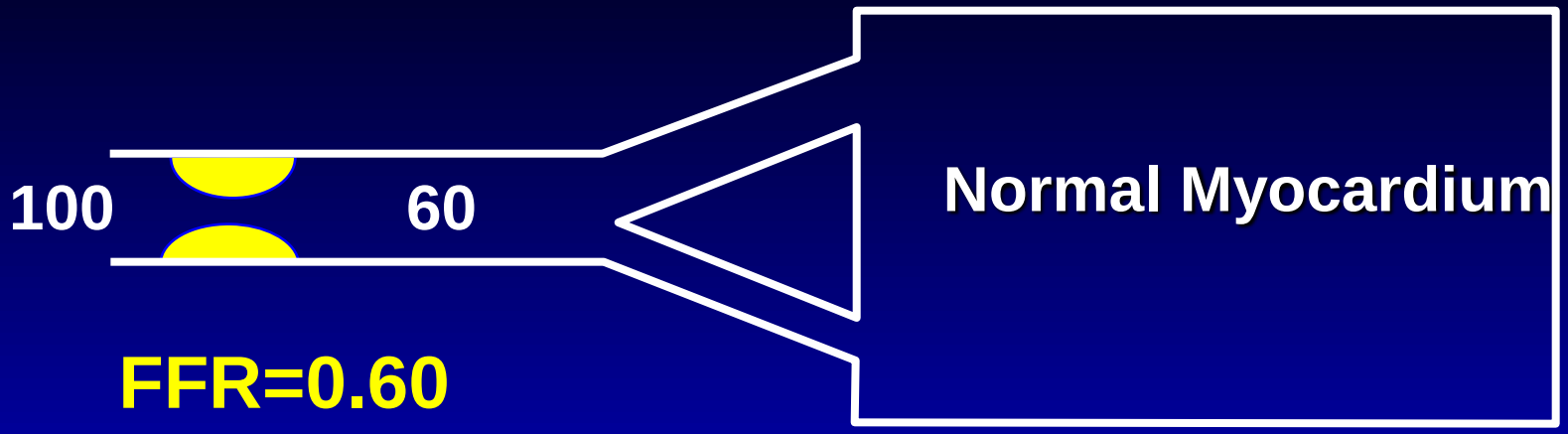
With permission of Dr Haitma Amin, Bahrain

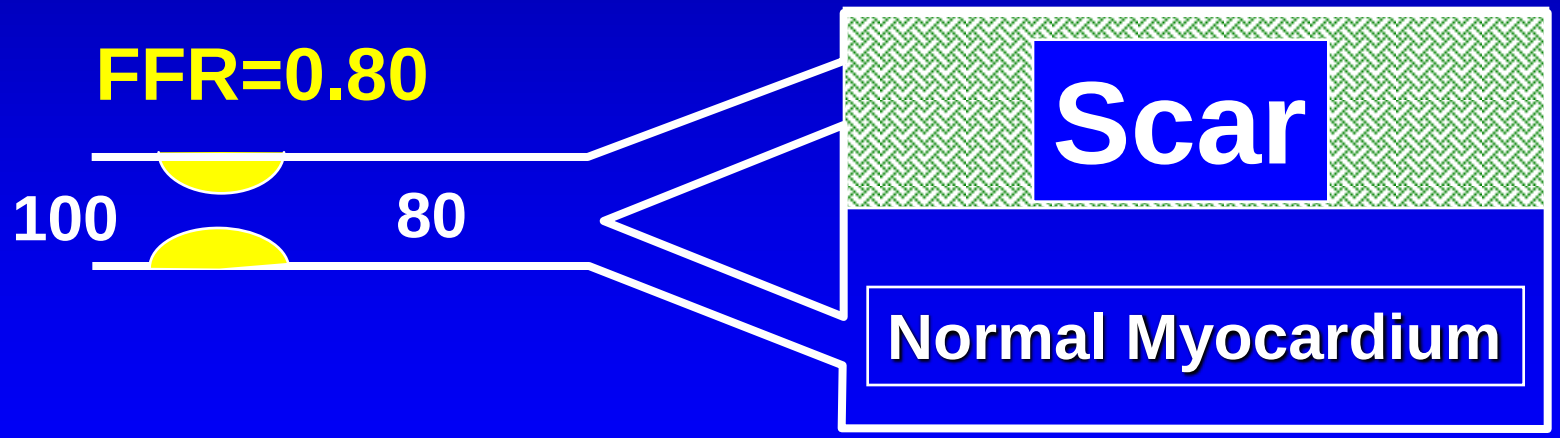
similar stenosis but different extent of perfusion area



identical CSA, but different significance of stenosis

FFR accounts for the extent of the perfusion area:





Anatomic stenosis severity by IVUS or QCA is identical but physiologic severity has decreased.

→ *FFR accounts for these changes !!!*

FEASIBILITY OF FFR MEASUREMENT

DEFER study: *(Circulation 2001;103:2928-2934)*

325 patients in 14 centers

STENT Registry: *(Circulation 2002;105:2950-2954)*

750 patients in 15 centers;

FAME STUDY

1005 patients with complex MVD

FAME-2 STUDY

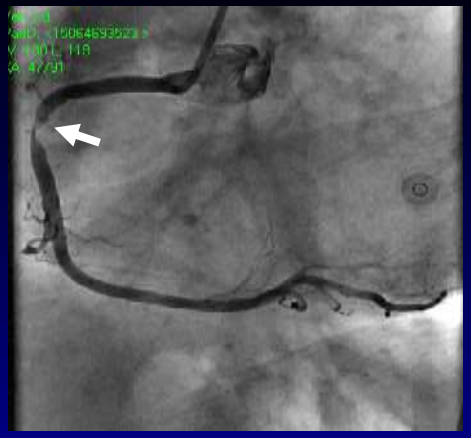
1206 patients with any type of coronary artery disease

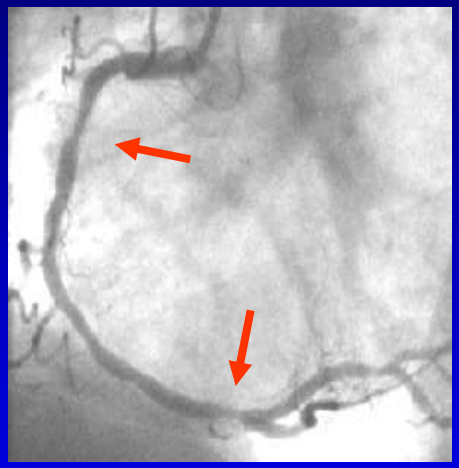
→ Successful FFR measurement in 98 – 99.5 % of all patients with minimal loss of time

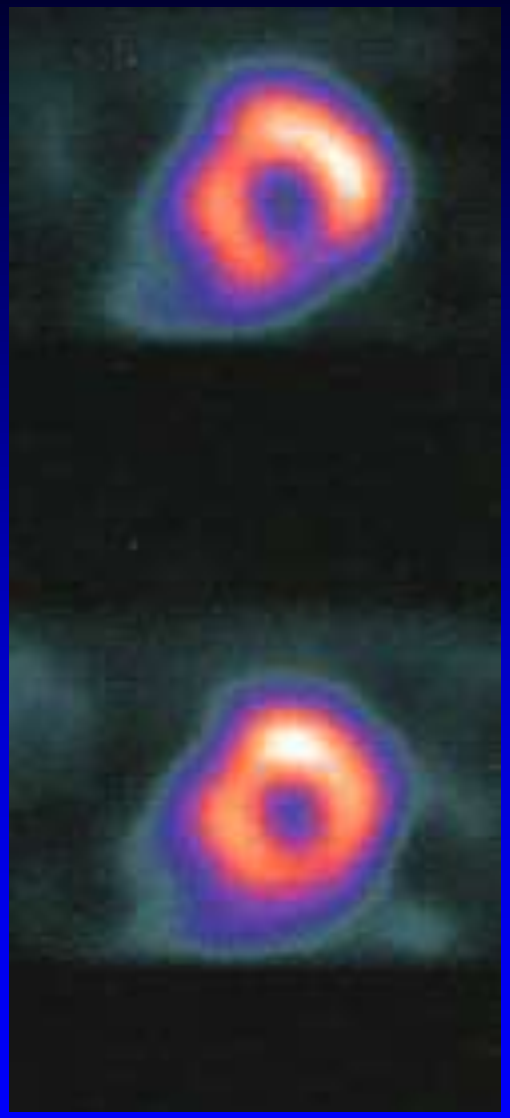
BASIC FEATURES OF FFR

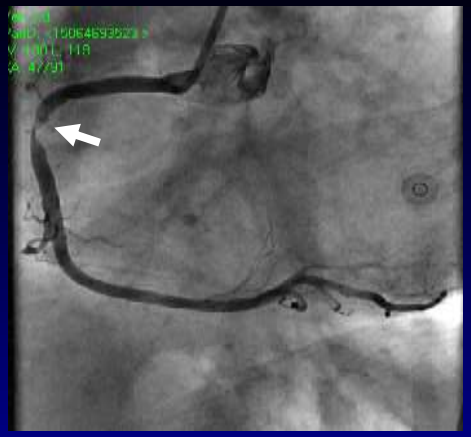
Pressure measurement has un *unequaled spatial resolution*

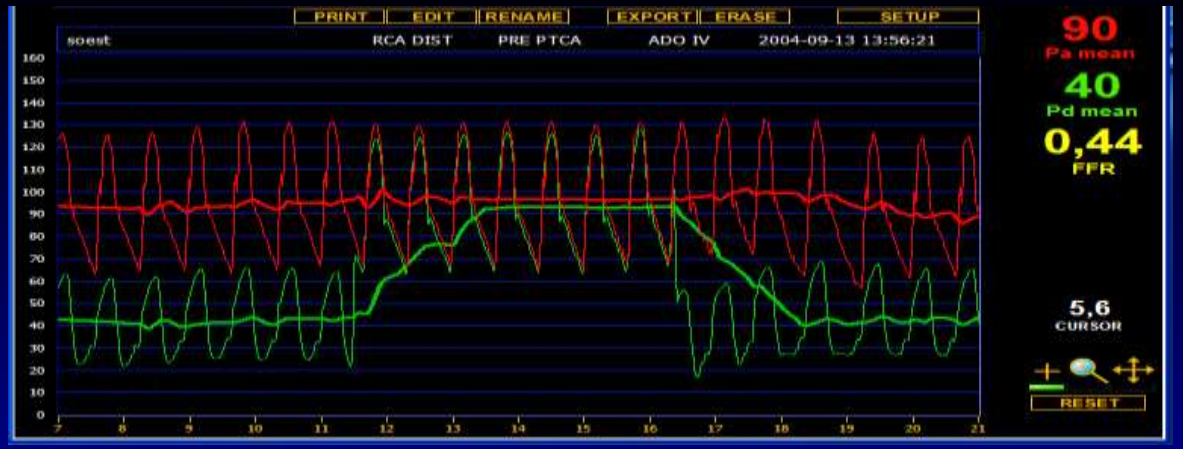
→ ***Hyperemic Pull-back Recording***







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Pa mean
40
Pd mean
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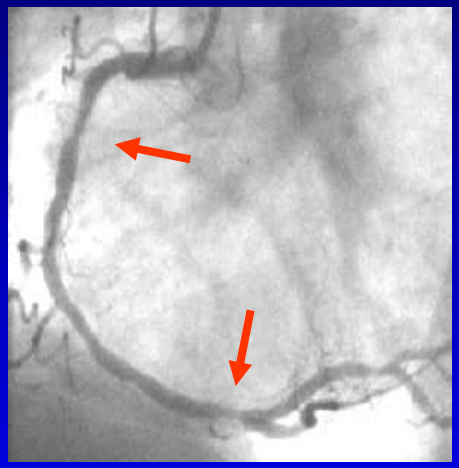
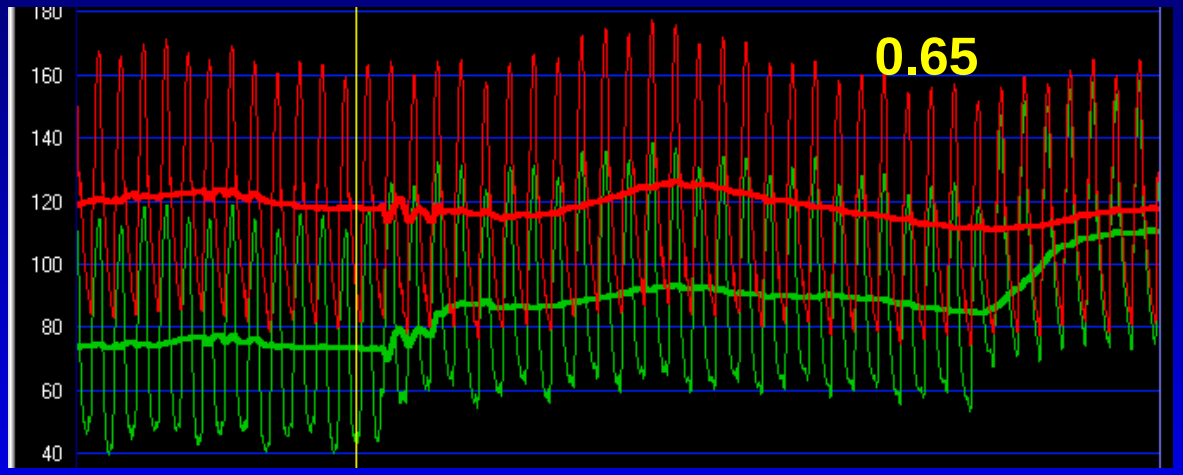
FFR
5,6
CURSOR
RESET




0.65


84
Pd mean
0,77
FFR
7,9
Cursor

FFR: The Pressure Pull-back Curve

Pressure pull-back curve at maximum hyperemia:

- place sensor in distal coronary artery
- induce sustained maximum hyperemia by i.v. adenosine, or i.c. papaverine
- pull back the sensor slowly under fluoroscopy
- the individual contribution of every segment and spot to the extent of disease can be studied in this way

Coronary pressure is unique in this respect and such detailed spatial information cannot be obtained by any other invasive or non-invasive method

Practical logistics in the cath lab: *Keep it simple*

(next lecture by Dr Fearon)

CONCLUSIONS:

- FFR is a simple, straightforward, easy-to-perform way to evaluate the functional significance of a stenosis, with
- unequaled accuracy and reproducibility
- and important implications for outcome
  (tonight (DEFER) & several lectures tomorrow: FAME)
- some tricks and pitfalls
  (presentation later in this session by Dr Nam)
- maximum hyperemia mandatory for optimum benefit
  (presentation later in this session by Dr Koo)