CORONARY PHYSIOLOGY IN THE CATHLAB:

FFR POST - PCI

Educational Training Program ESC
European Heart House
april 23rd - 25th 2015

CATHARINA-ZIEKENHUIS

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catharina ziekenhuis

FFR post PCI

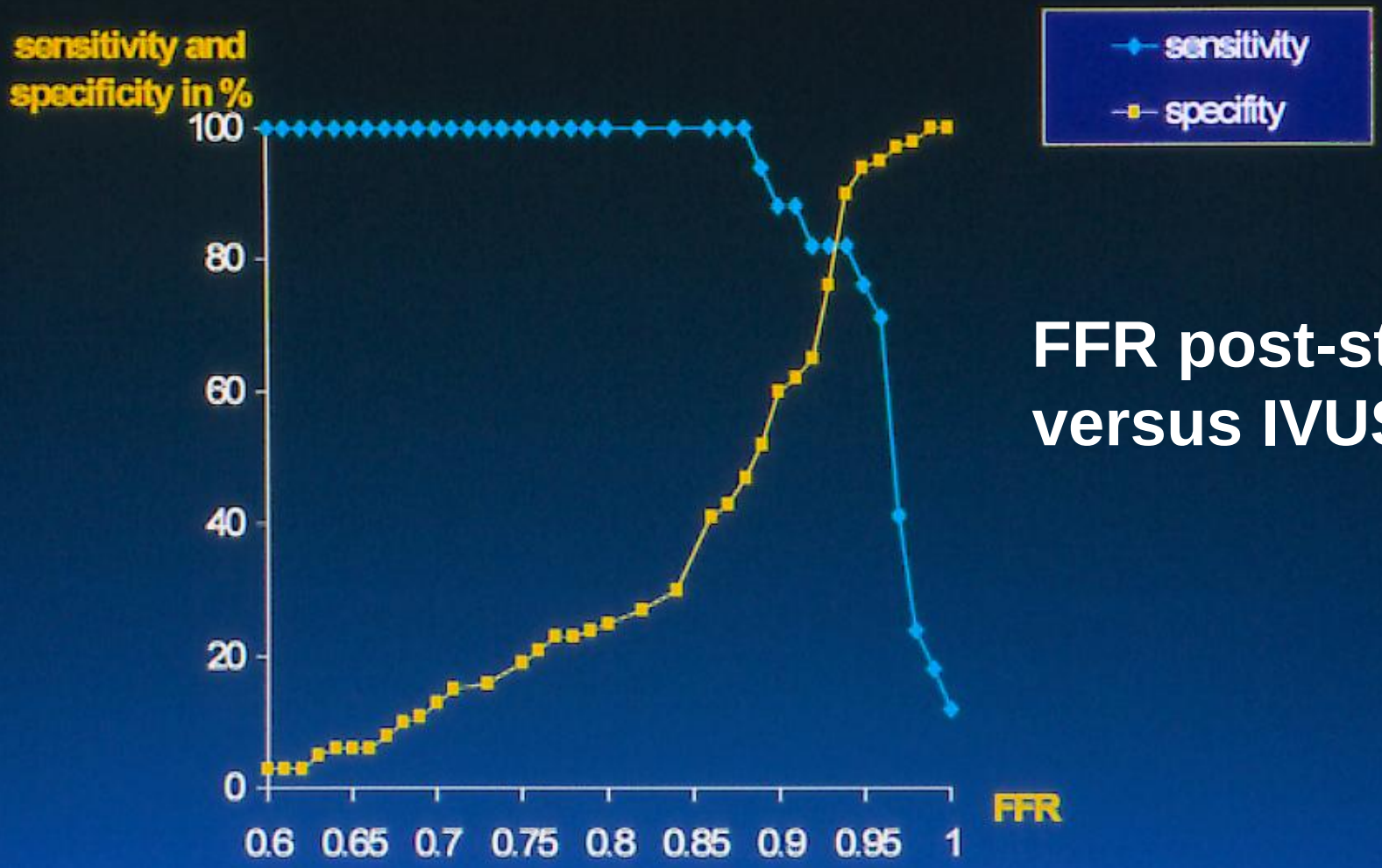
Do we have systematic data?

→ only a few good studies

Because the extreme heterogeneity of patients (inherent to the nature of coronary artery disease) there does not exist one single “uniform” FFR post-stent value indicative for a good result)

Nevertheless, FFR post-stent can give very useful Information, if measured and interpreted in the right way

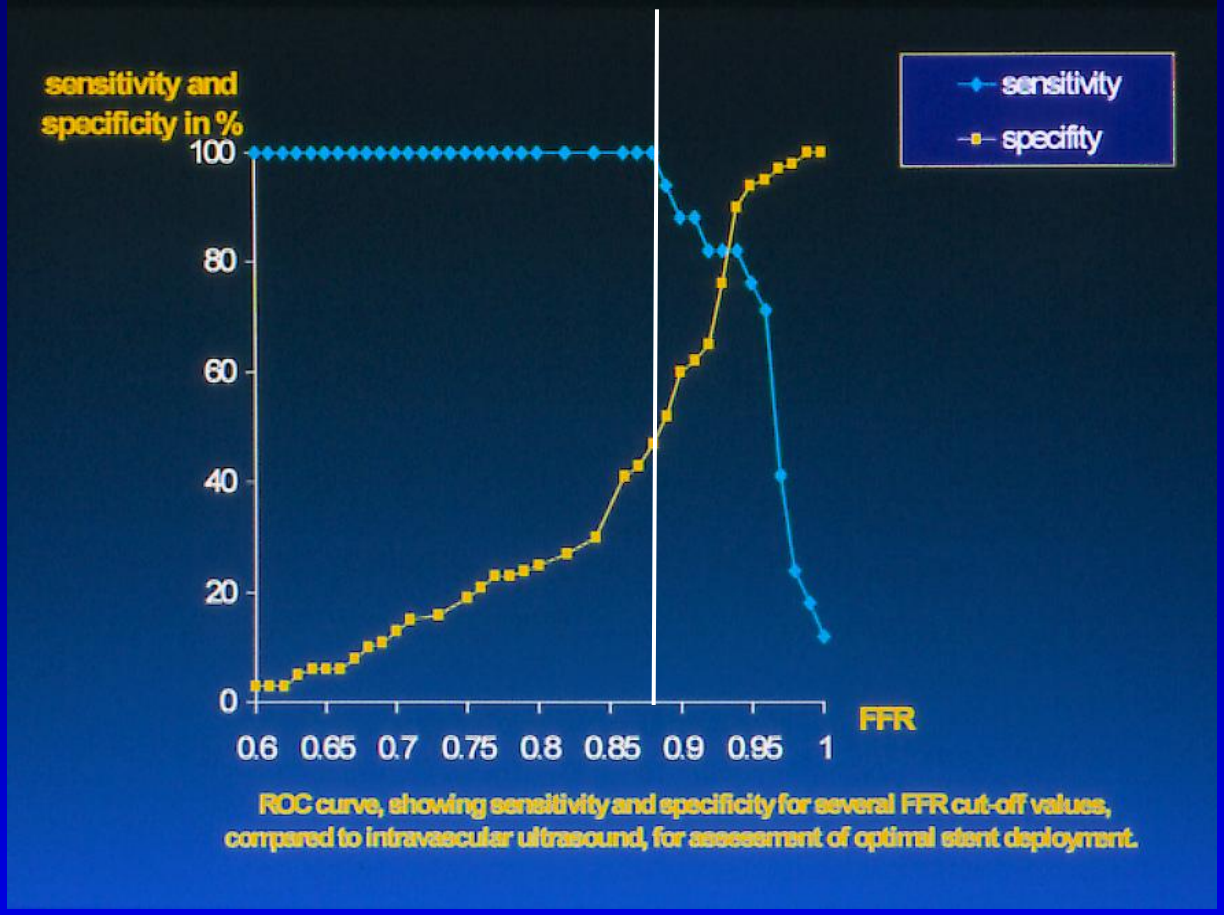
FFR post-stent versus IVUS



ROC curve, showing sensitivity and specificity for several FFR cut-off values, compared to intravascular ultrasound, for assessment of optimal stent deployment.

Hanekamp et al; Circulation 1999;99:1015-1024

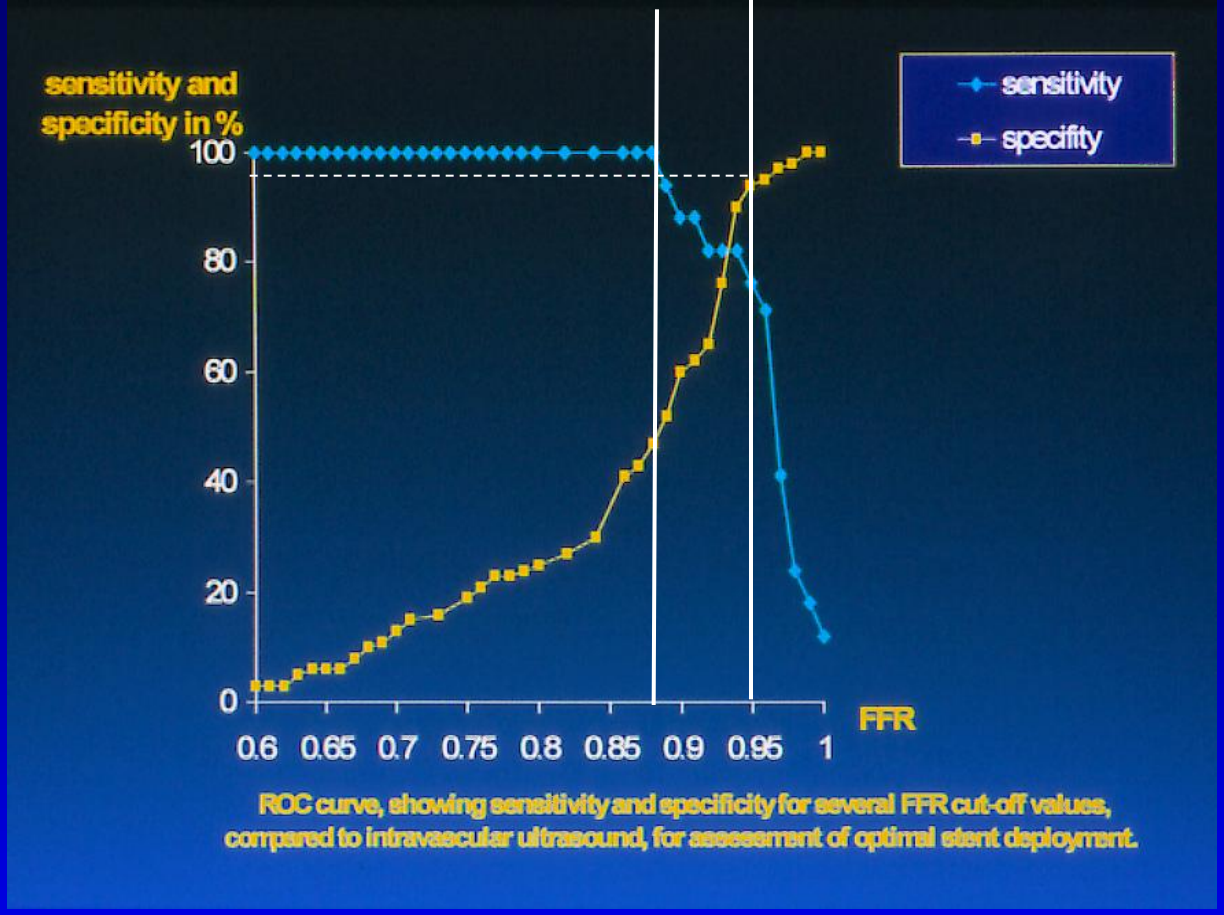
FFR post-stent versus IVUS



FFR ≤ 0.88 → IVUS always abnormal

Hanekamp et al; Circulation 1999;99:1015-1024

FFR post-stent versus IVUS

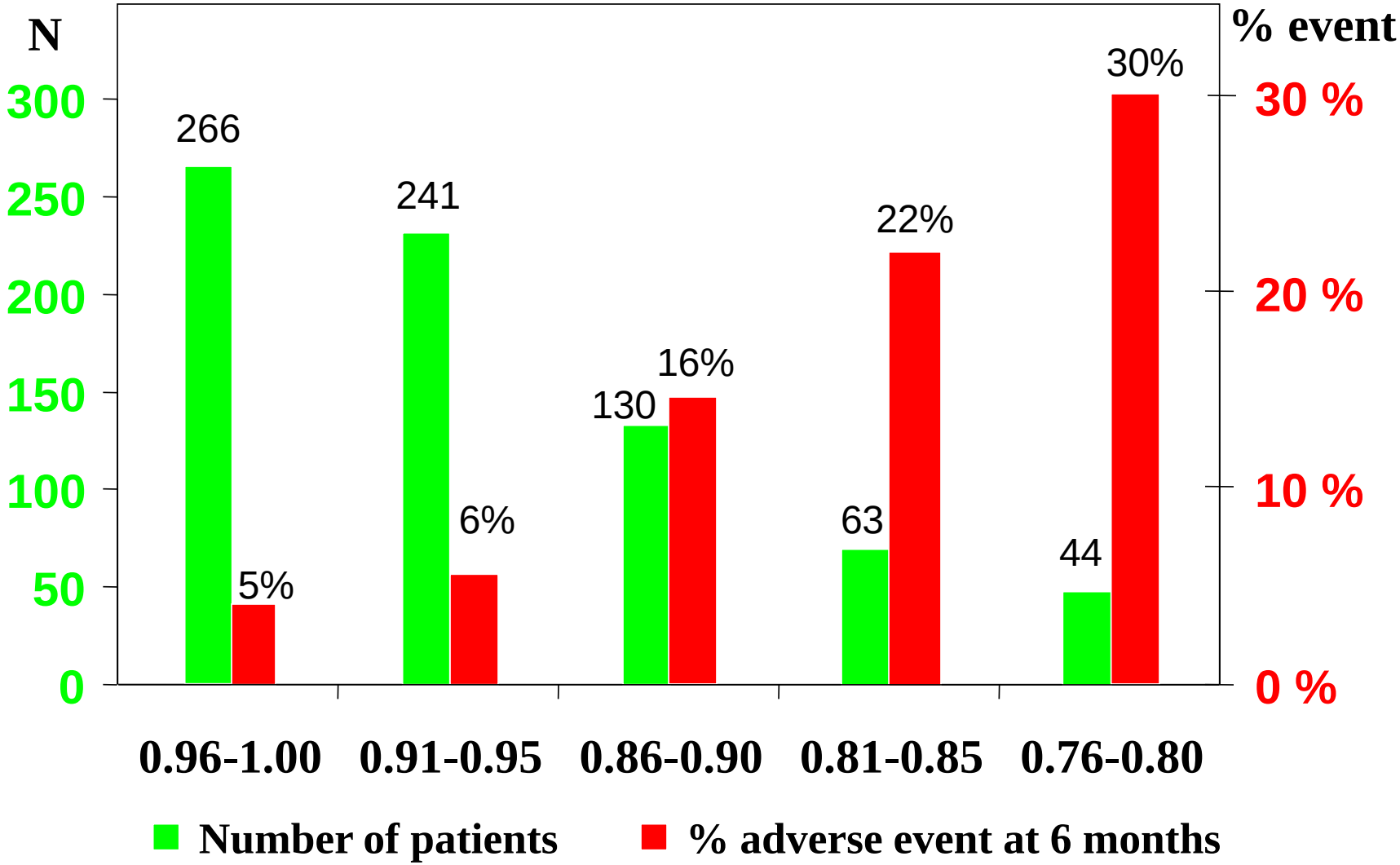


FFR ≥ 0.95 → IVUS is normal in 95% of cases

Hanekamp et al; Circulation 1999;99:1015-1024

FFR-post-STENT Registry (N =750)

% ADVERSE EVENTS AT 6 MONTHS



Circulation 2002

FFR post PCI

The Stent –Registry was performed more than 10 years ago, when the extent of disease and atherosclerotic burden in the average patient was much less than today

It is unknown in the stent Registry, if a persistent gradient was due to focal pressure drop across the stent, or to (focal or diffuse) disease more proximal or distal in the artery.

Events might be promoted by both: by inadequately deployed stents as well as high atherosclerotic burden elsewhere in the artery

FFR post PCI

A residual gradient within the coronary artery after apparently successful stenting, can be caused by:

- *inadequate stent deployment (focal gradient across stent) ,* **or by**

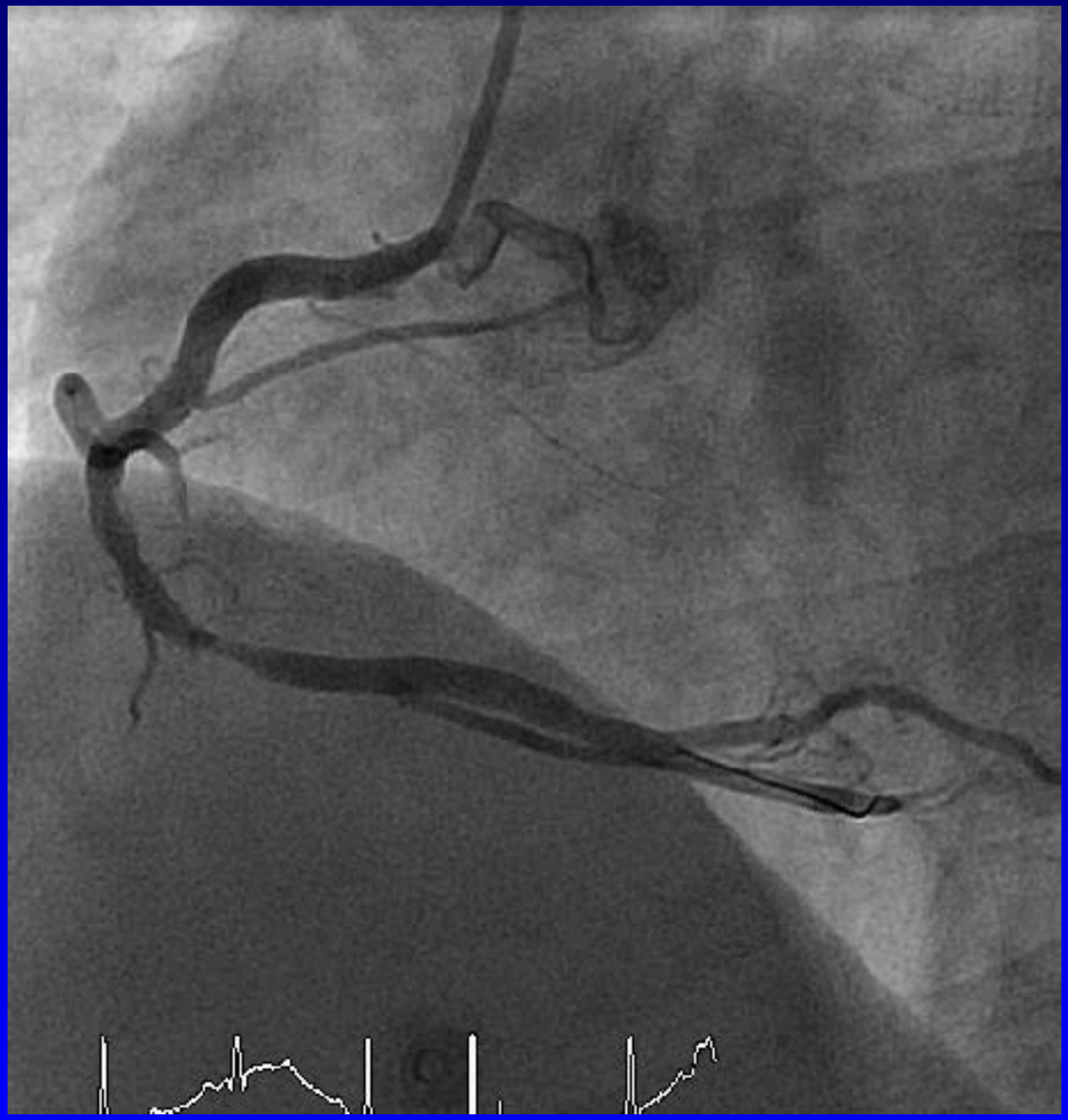
- *diffuse disease or other lesions (more proximal or distal) along the course of the stented artery*

The most reliable way to discriminate this, is a hyperemic pullback recording (i.v adenosine, i.c.papaverine, or i.v. regadenoson bolus) after stenting

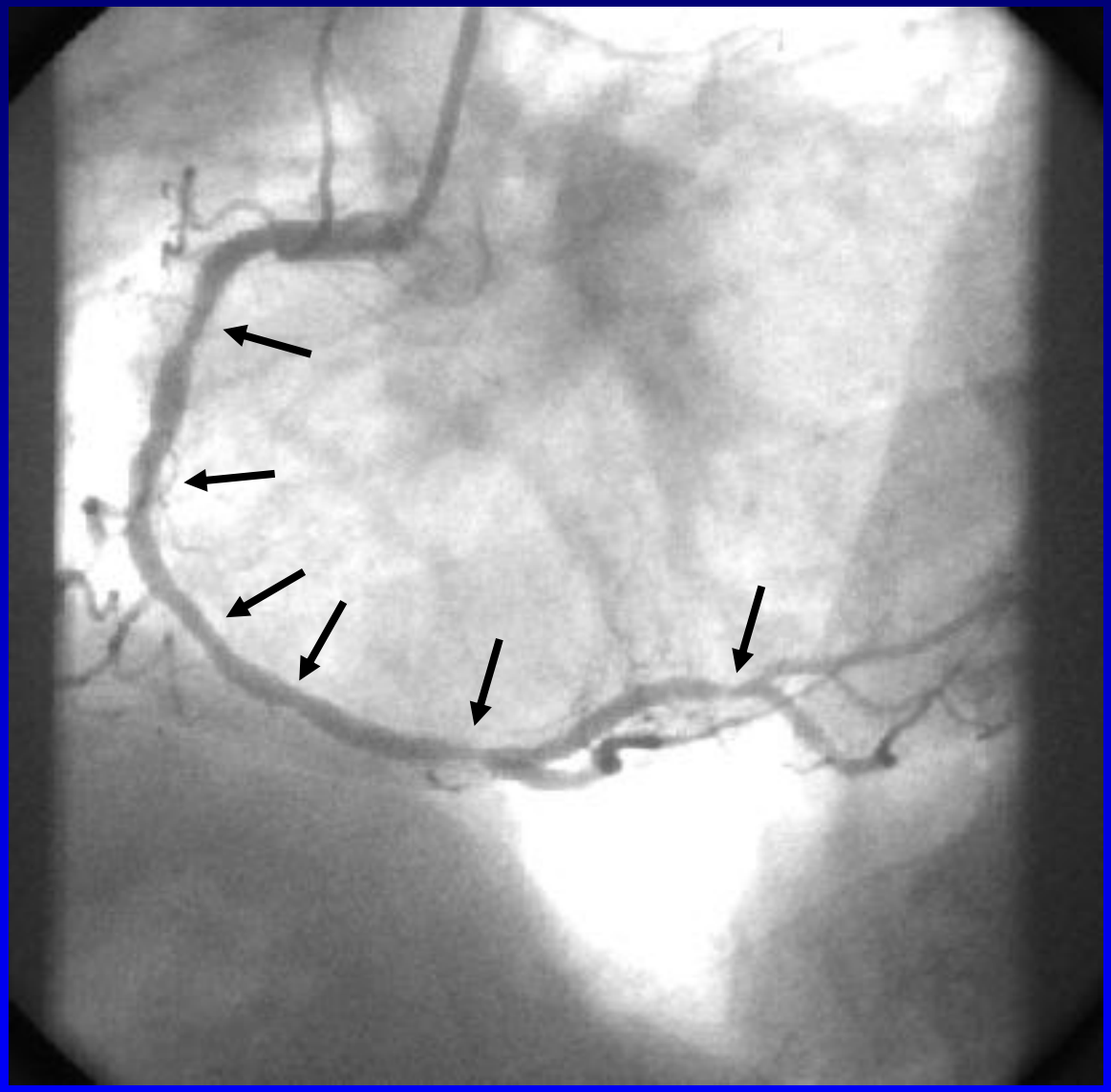
FFR post PCI:

HOW SHOULD WE DO IT IN CLINICAL PRACTICE ?

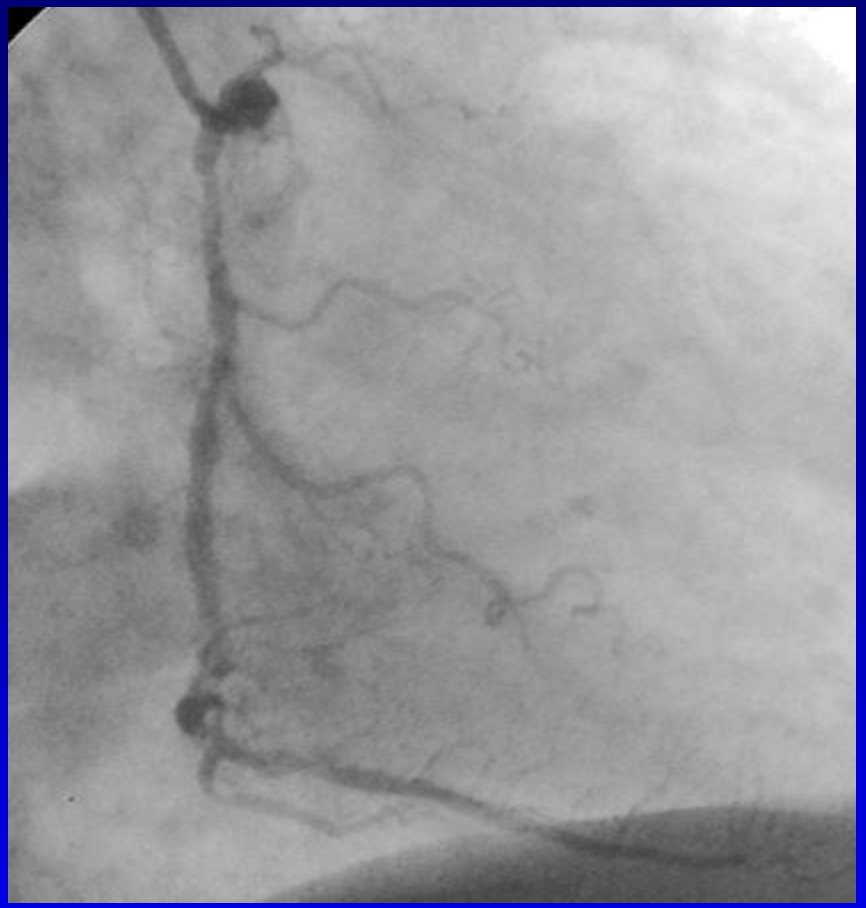
→ Let's have a look at 3 different patients but all with chest pain and a positive MIBI in the inferior wall



Typical chest pain; positive MIBI-Spect inferior wall

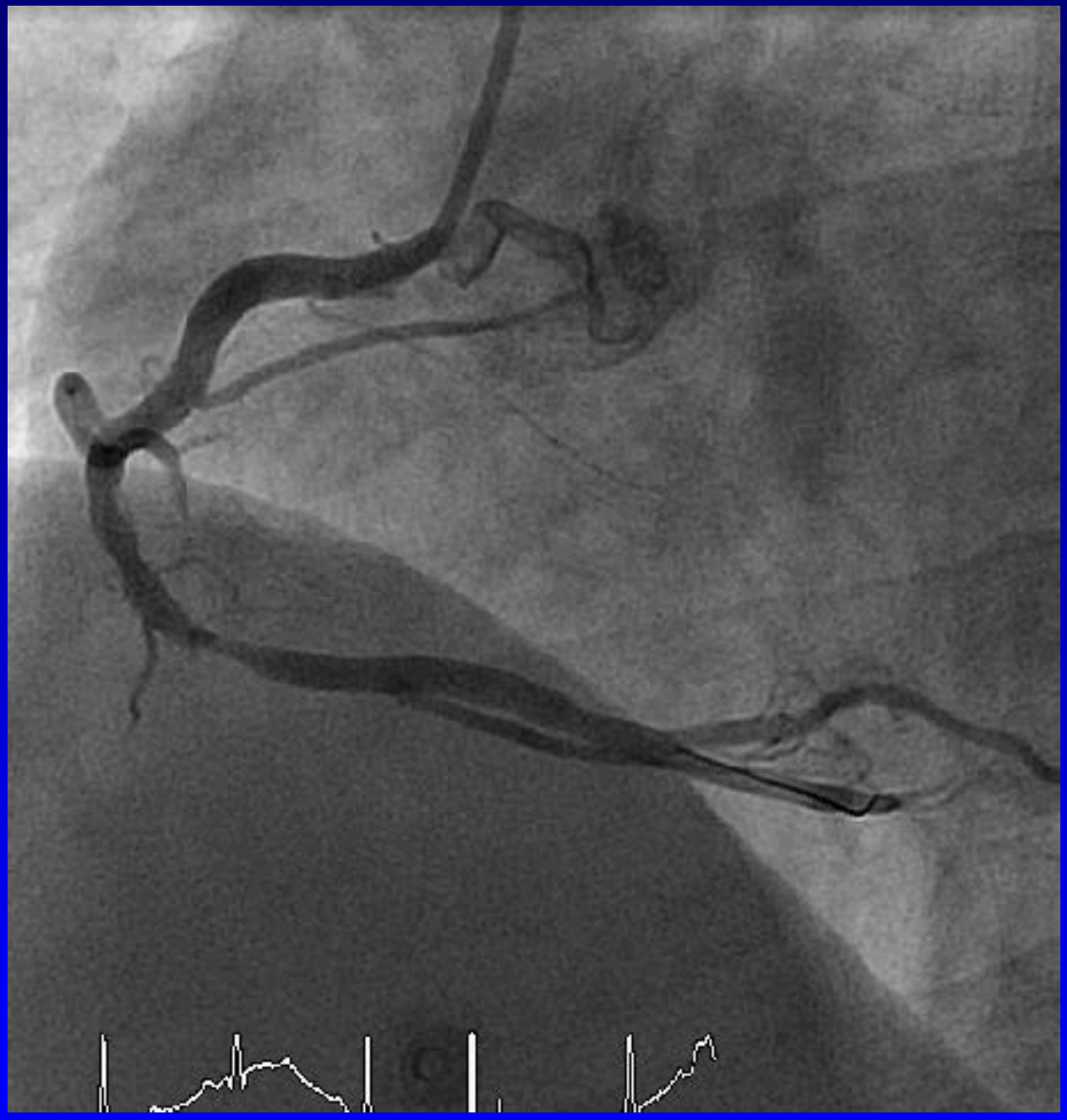


Typical chest pain; positive MIBI-Spect inferior wall

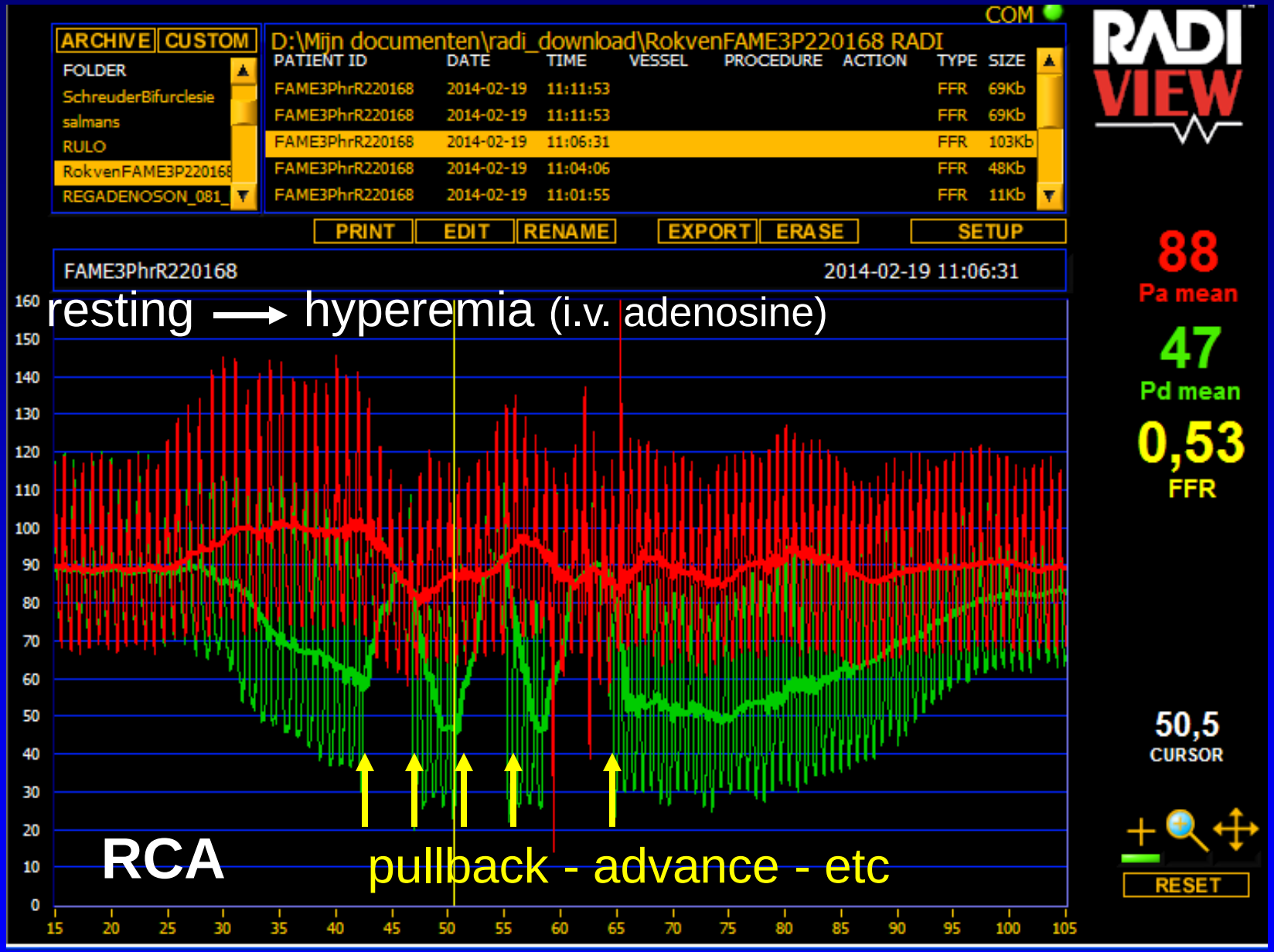


Very obese male,

Typical chest pain; positive MIBI-Spect inferior wall



PressureWire in RCA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ARCHIVE
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RokvenFAME3P220168
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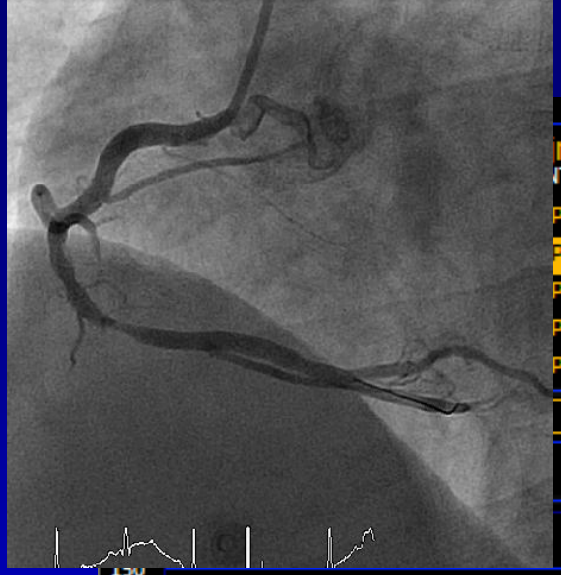
D:\Mijn documenten\radi_download\RokvenFAME3P220168 RADI
PATIENT ID DATE TIME VESSEL PROCEDURE ACTION TYPE SIZE
FAME3PhrR220168 2014-02-19 11:11:53 FFR 69Kb
FAME3PhrR220168 2014-02-19 11:11:53 FFR 69Kb
FAME3PhrR220168 2014-02-19 11:06:31 FFR 103Kb
FAME3PhrR220168 2014-02-19 11:04:06 FFR 48Kb
FAME3PhrR220168 2014-02-19 11:01:55 FFR 11Kb
PRINT
EDIT
RENAME
EXPORT
ERASE
SETUP
FAME3PhrR220168
2014-02-19 11:06:31
resting ⟶ hyperemia (i.v. adenosine)
RADI VIEW
88
Pa mean
47
Pd mean
0,53
FFR
50,5
CURSOR
RESET
RCA
pullback - advance - etc



COM

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T ID	DATE	TIME	VESSEL	PROCEDURE	ACTION	TYPE	SIZE
PhrR220168	2014-02-19	11:11:53				FFR	69Kb
PhrR220168	2014-02-19	11:06:31				FFR	103Kb
PhrR220168	2014-02-19	11:04:06				FFR	48Kb
PhrR220168	2014-02-19	11:01:55				FFR	11Kb
PhrR220168	2014-02-19	10:54:57				FFR	5Kb

PRINT | EDIT | RENAME | EXPORT | ERASE | SETUP

2014-02-19 11:06:31

RADI VIEW

87
Pa mean

47
Pd mean

0,54
FFR

50,4
CURSOR

RESET

resting

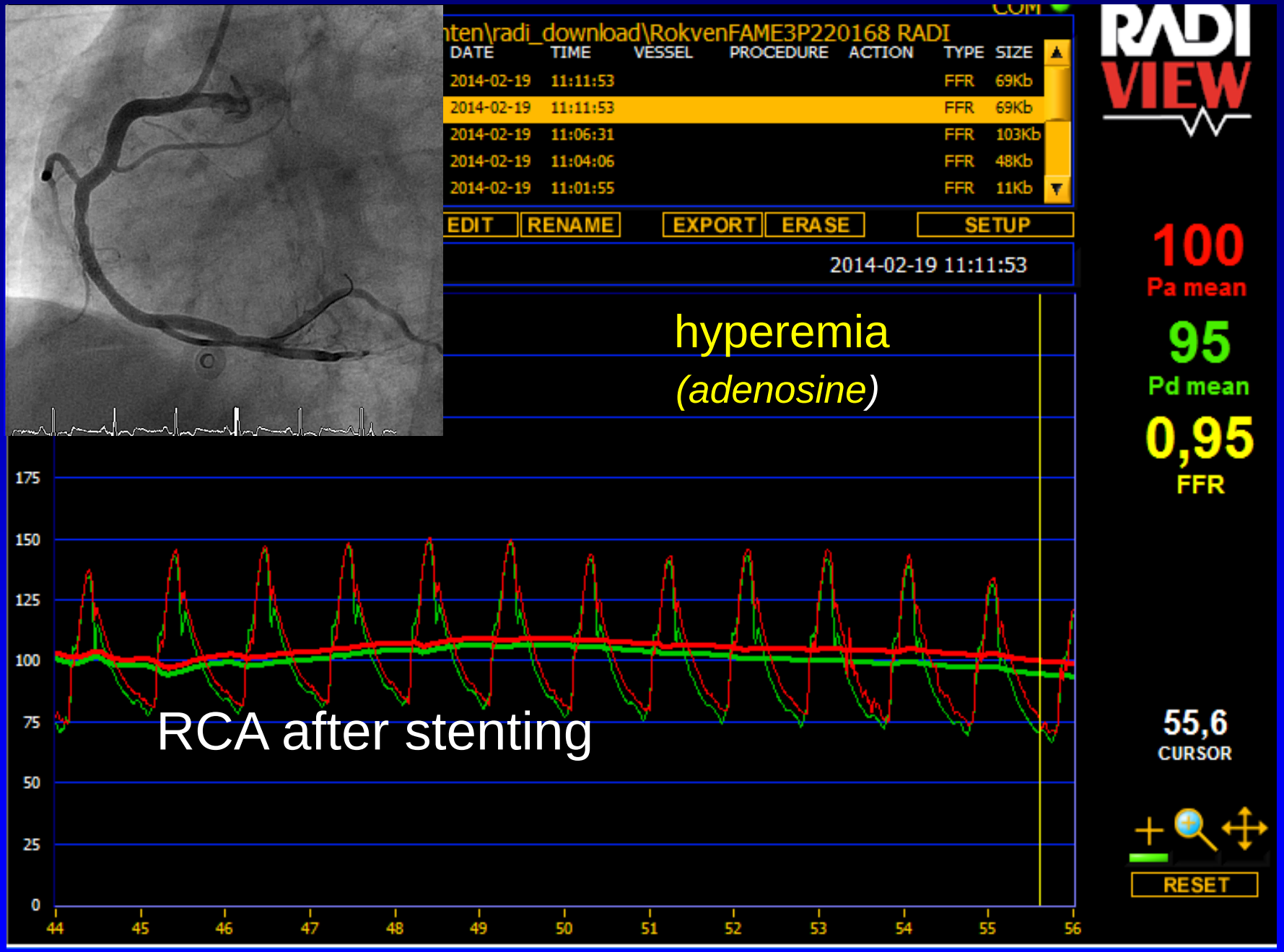
hyperemia (i.v. adenosine)

Pd/Pa = 0.99
iFR = 1.00
FFR = 0.54

pullback - advance - etc

140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

15 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 57


nten\radi_download\RokvenFAME3P220168 RADI
DATE TIME VESSEL PROCEDURE ACTION TYPE SIZE
2014-02-19 11:11:53 FFR 69Kb
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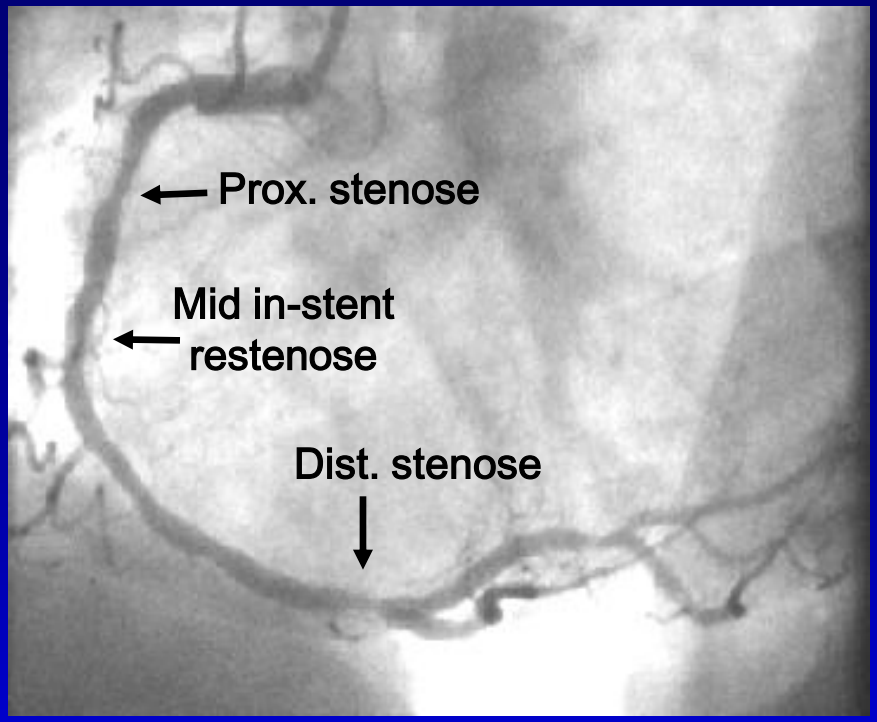
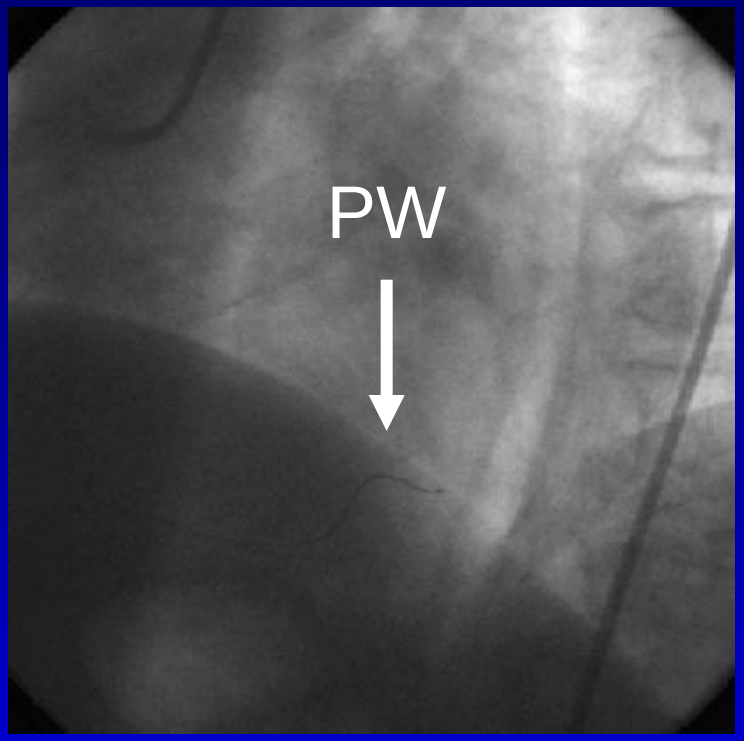
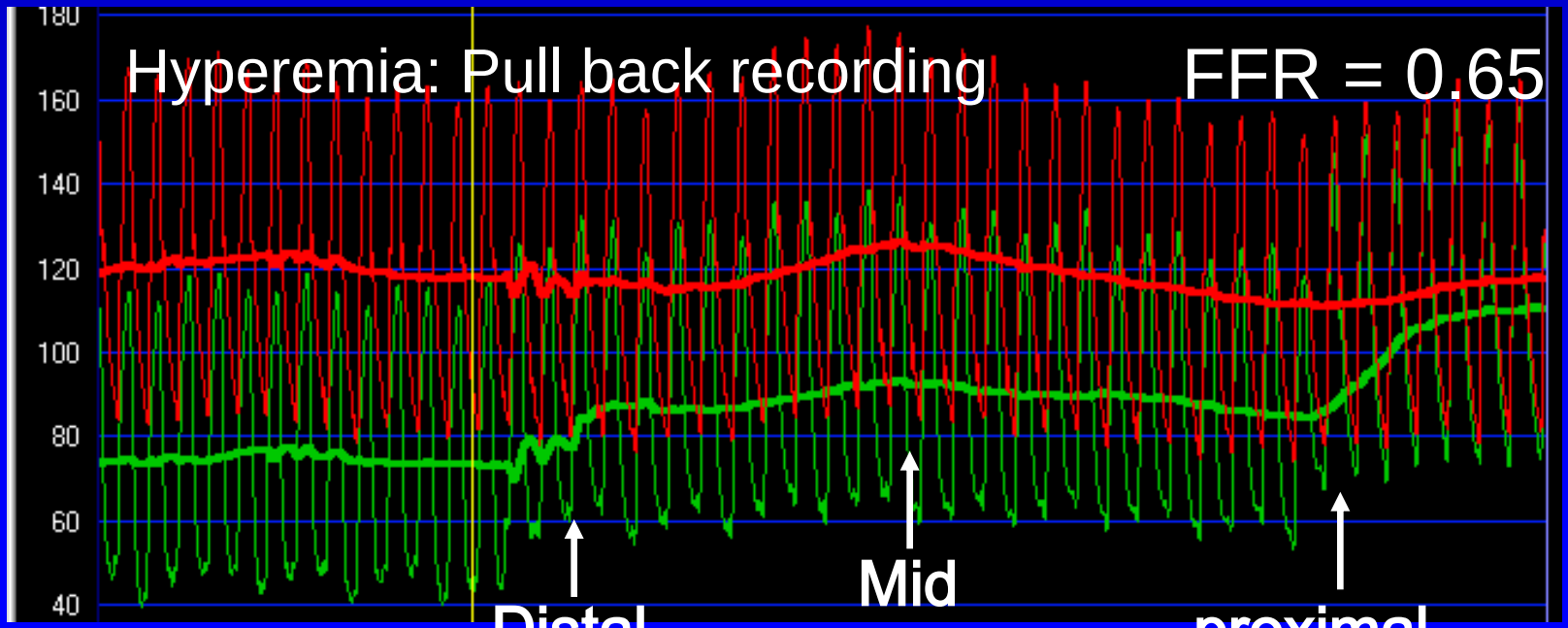
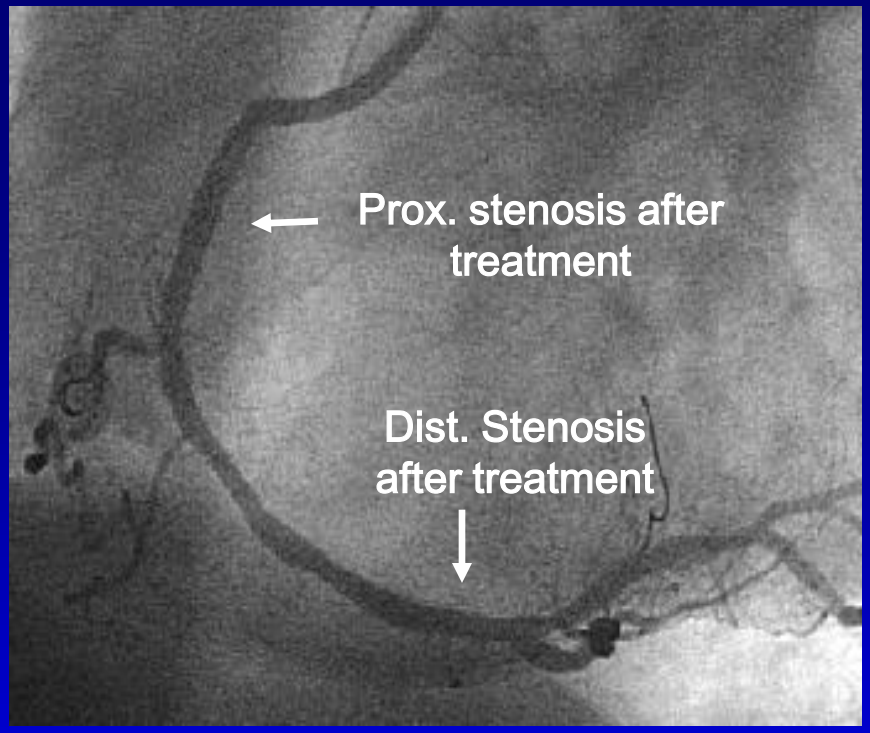
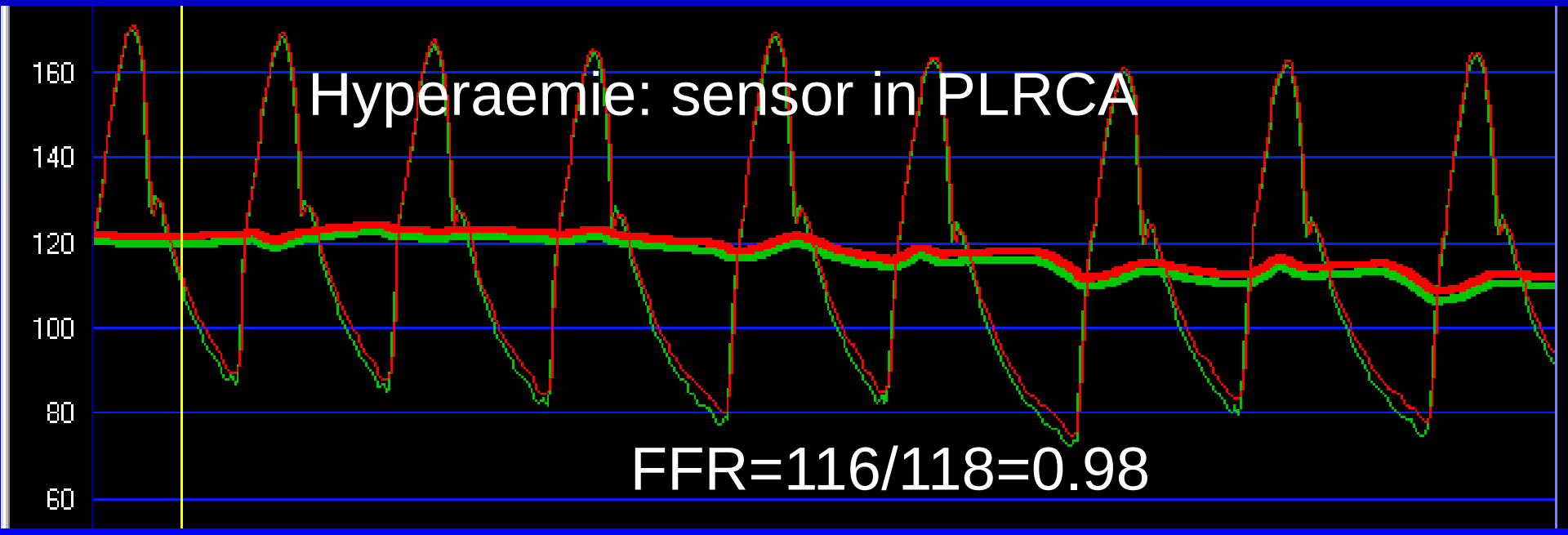
2014-02-19 11:06:31 FFR 103Kb
2014-02-19 11:04:06 FFR 48Kb
2014-02-19 11:01:55 FFR 11Kb
EDIT
RENAME
EXPORT
ERASE
SETUP
2014-02-19 11:11:53
RADI VIEW
100
Pa mean
95
Pd mean
0,95
FFR
hyperemia
(adenosine)
RCA after stenting
175
150
125
100
75
50
25
0
44
45
46
47
48
49
50
51
52
53
54
55
56
55,6
CURSOR
RESET

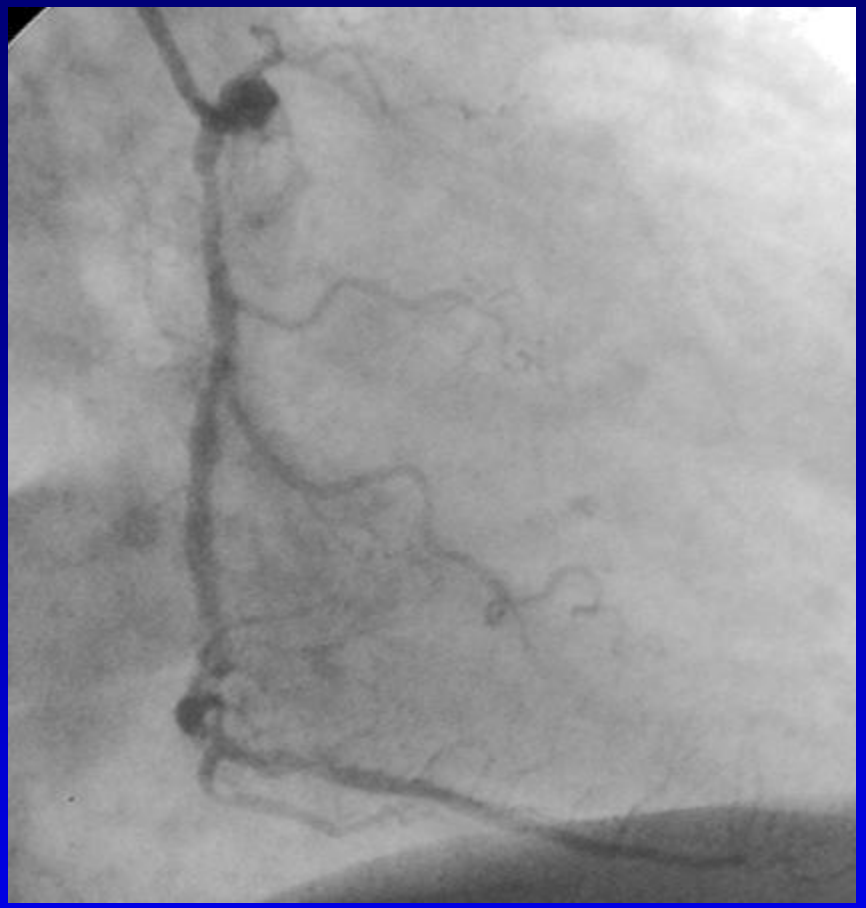

Prox. stenose
Mid in-stent restenose
Dist. stenose


PW


Hyperemia: Pull back recording
FFR = 0.65
180
160
140
120
100
80
60
40
Distal
Mid
proximal


Prox. stenosis after treatment
Dist. Stenosis after treatment


160
140
120
100
80
60
Hyperaemie: sensor in PLRCA
FFR=116/118=0.98



Very obese male,

Typical chest pain; positive MIBI-Spect inferior wall

EDIT RENAME EXPORT ERASE SETUP

2004-06-14 15:55:19

109
Pa mean

84
Pd mean

0,77
FFR

7,9
Cursor

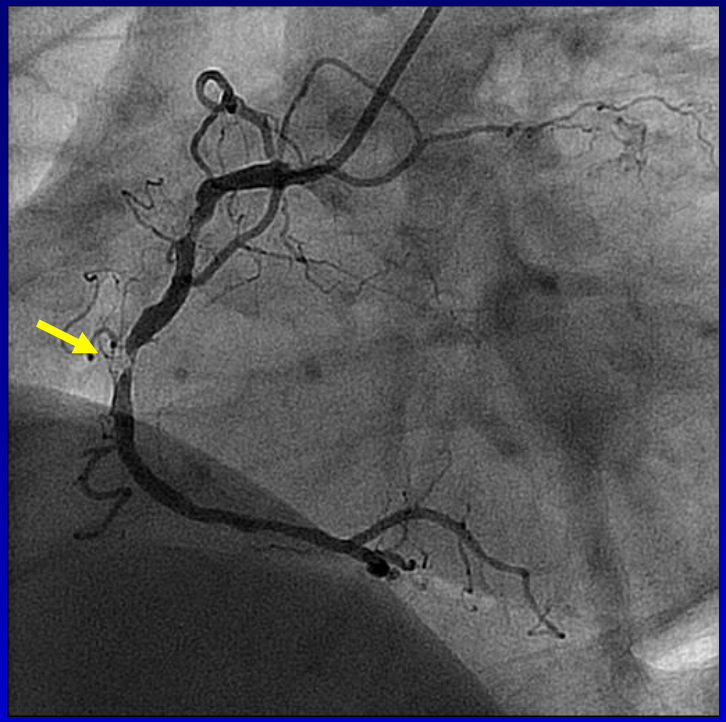
Hyperemic pull-back recording along the RCA

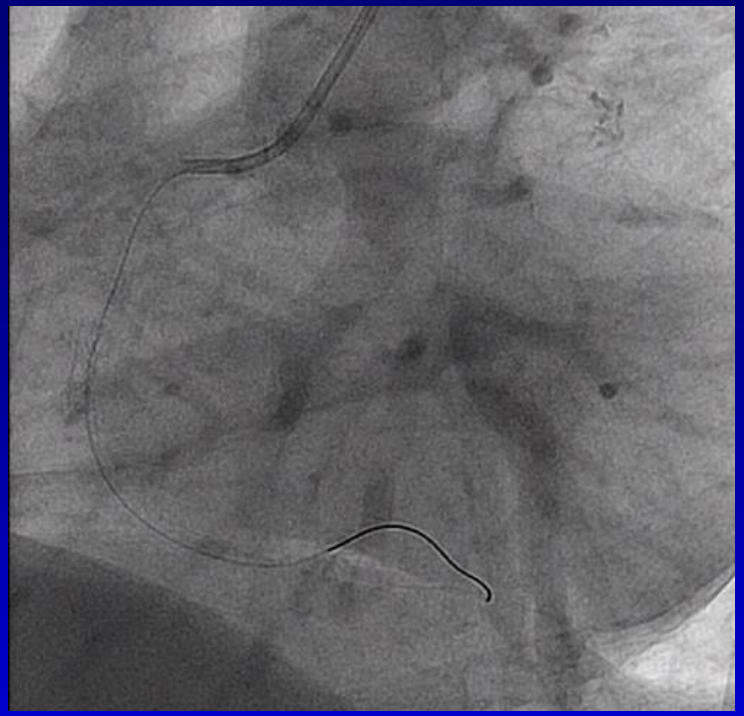
Fundamentally impossible to treat this patient by stenting

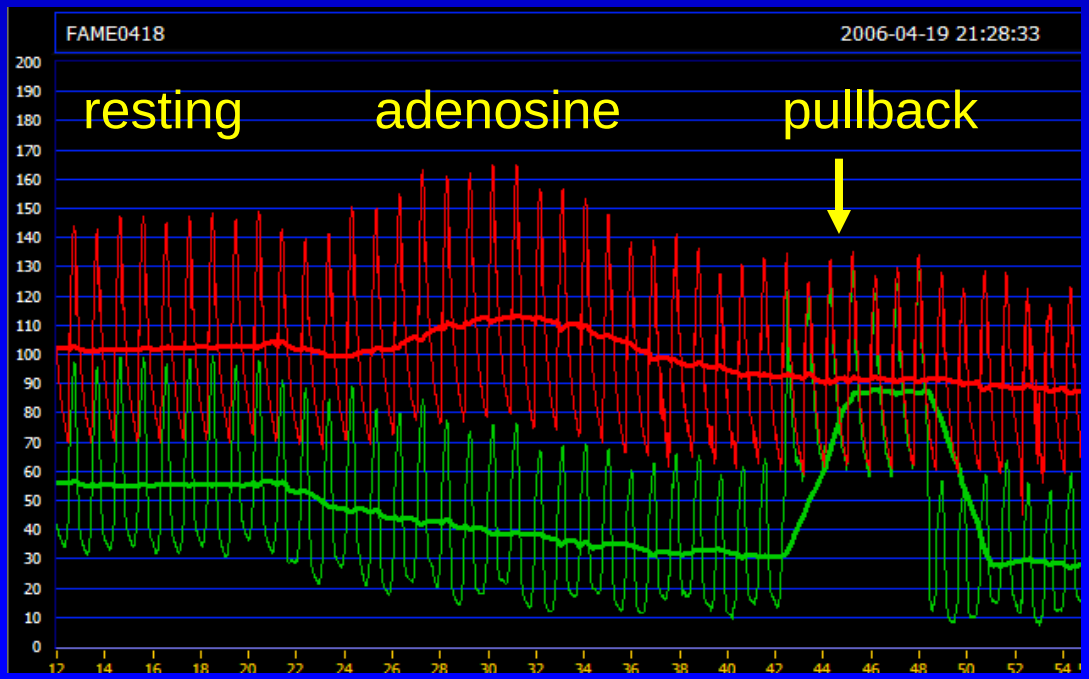
RESET

FFR post PCI

Be aware that after stenting a stenosis, blood flow in the artery will increase and other gradients within the vessel may be unmasked or increase !

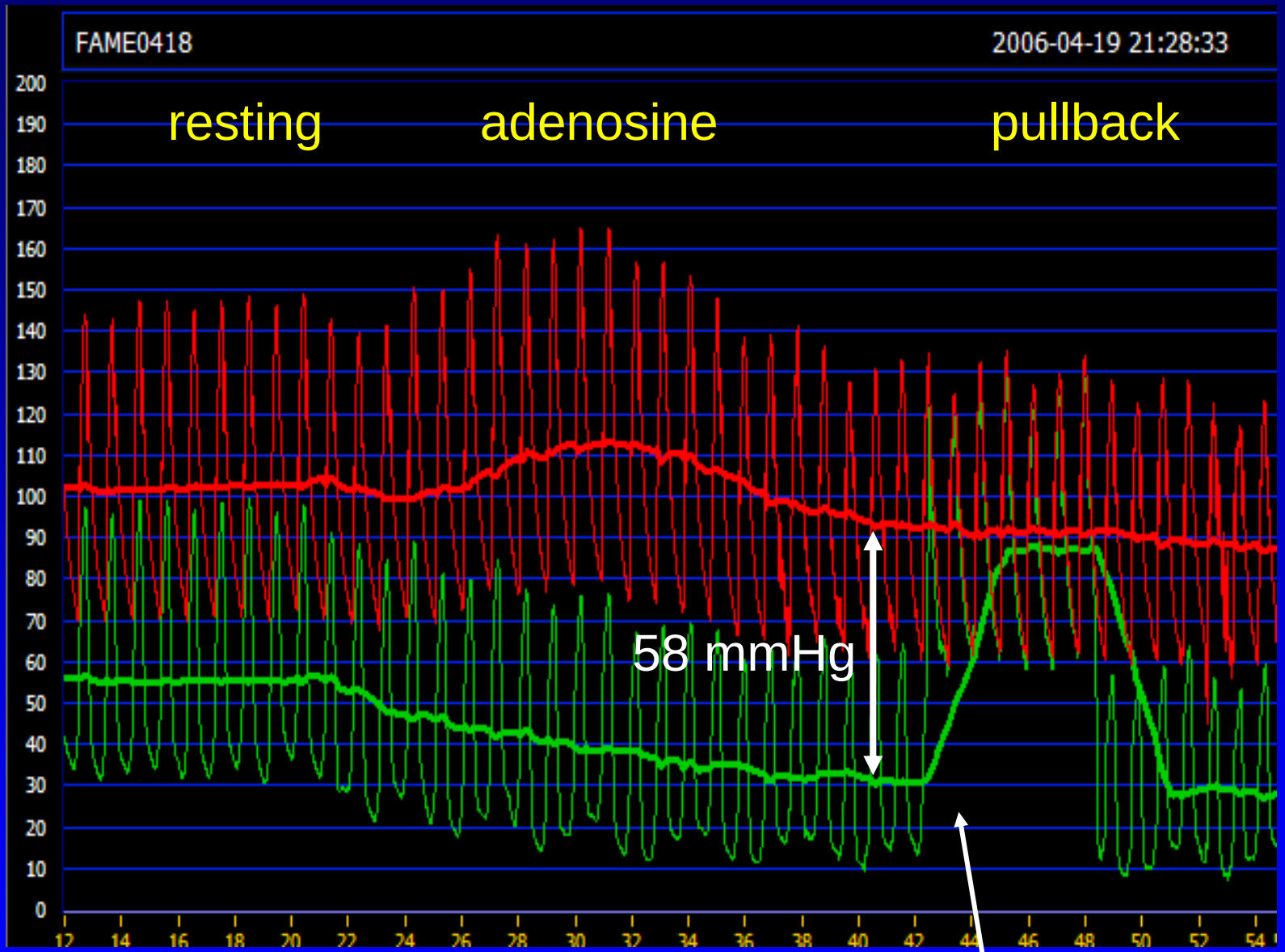


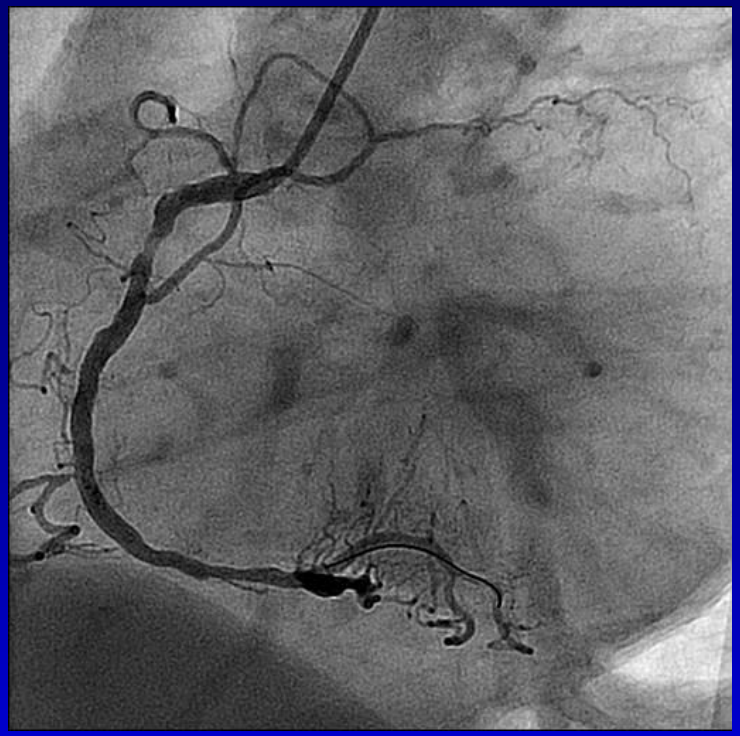


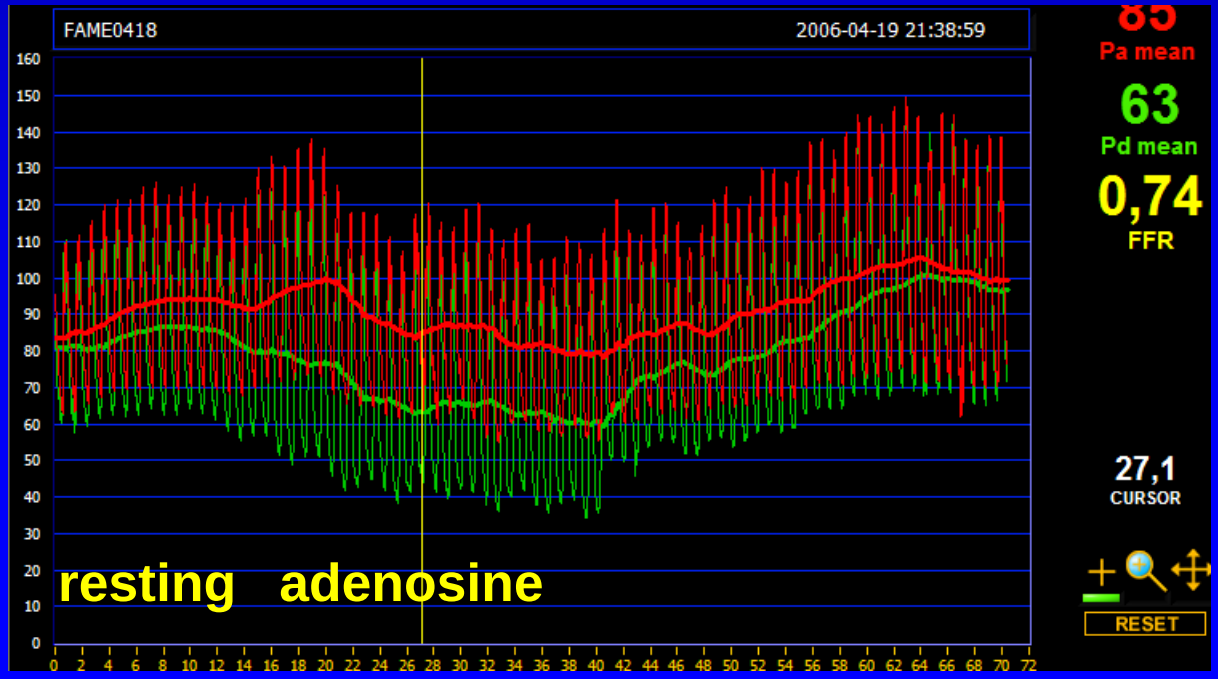

FAME0418
2006-04-19 21:28:33
resting
adenosine
pullback
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54

RCA:

FFR = 0.34


FAME0418
2006-04-19 21:28:33
resting
adenosine
pullback
58 mmHg
5 mmHg
Pull-back across distal stenosis

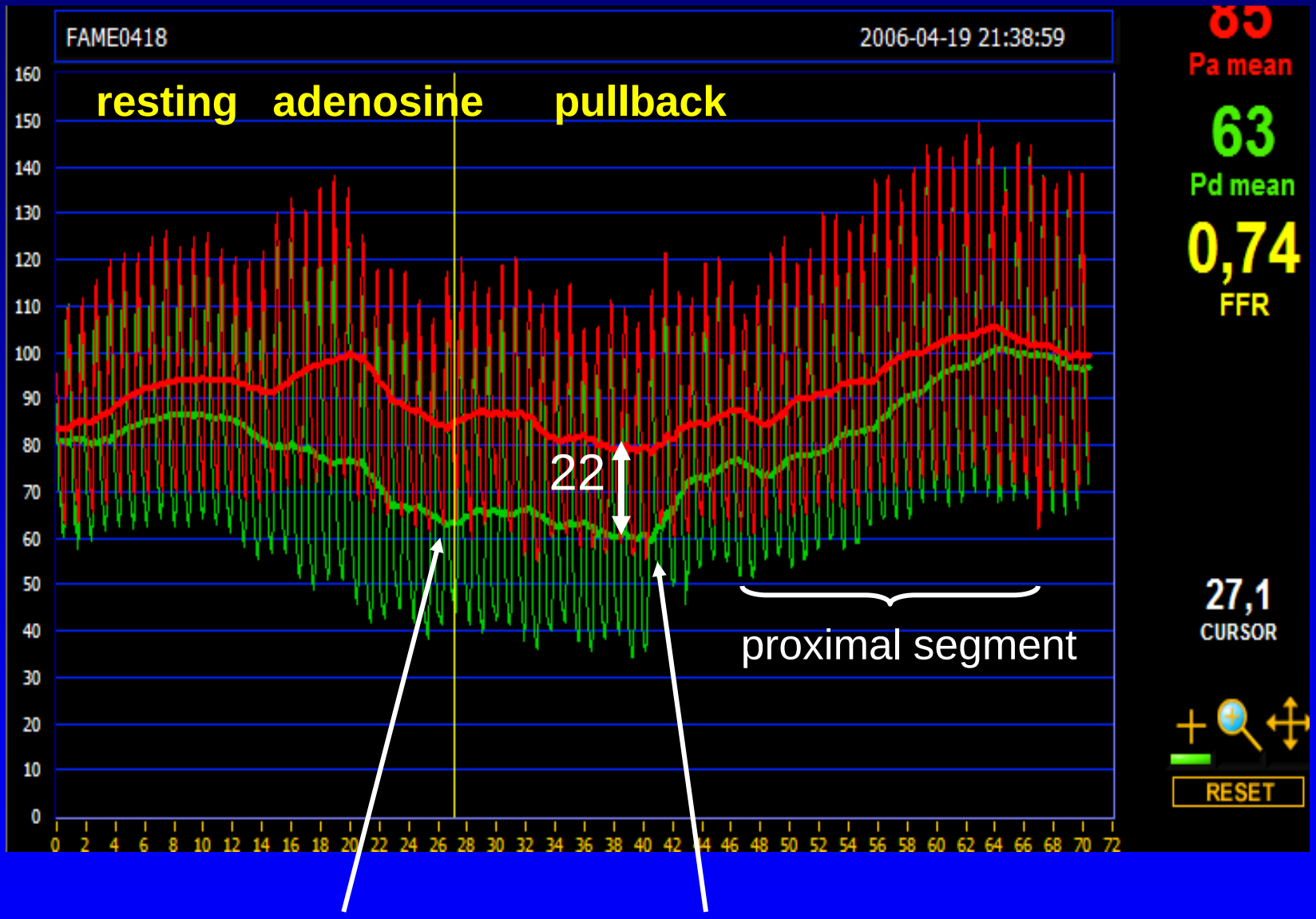




RCA after one stent:

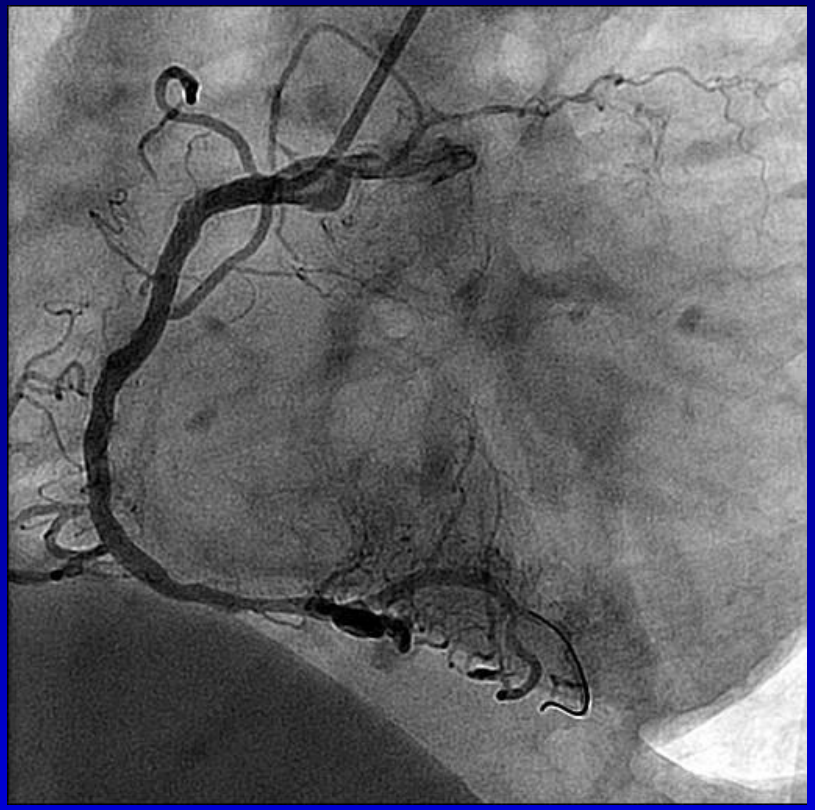
FFR = 0.74

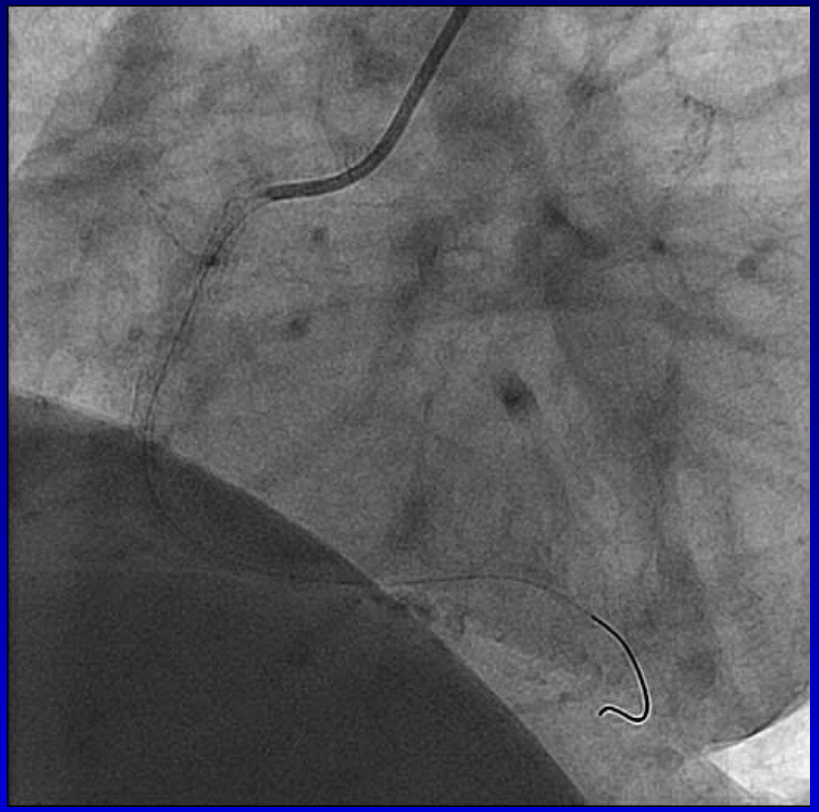
FFR 0.34 → 0.74

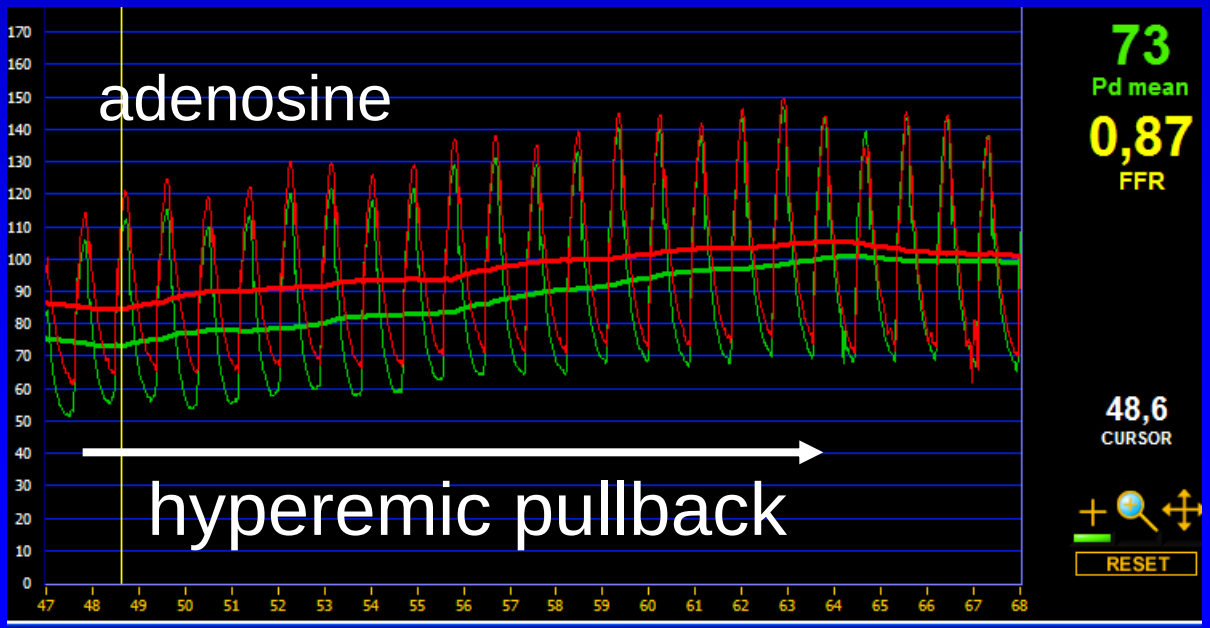


pullback across stent & across proximal stenosis

58 → ~ 0 mmHg 5 → 22 mmHg



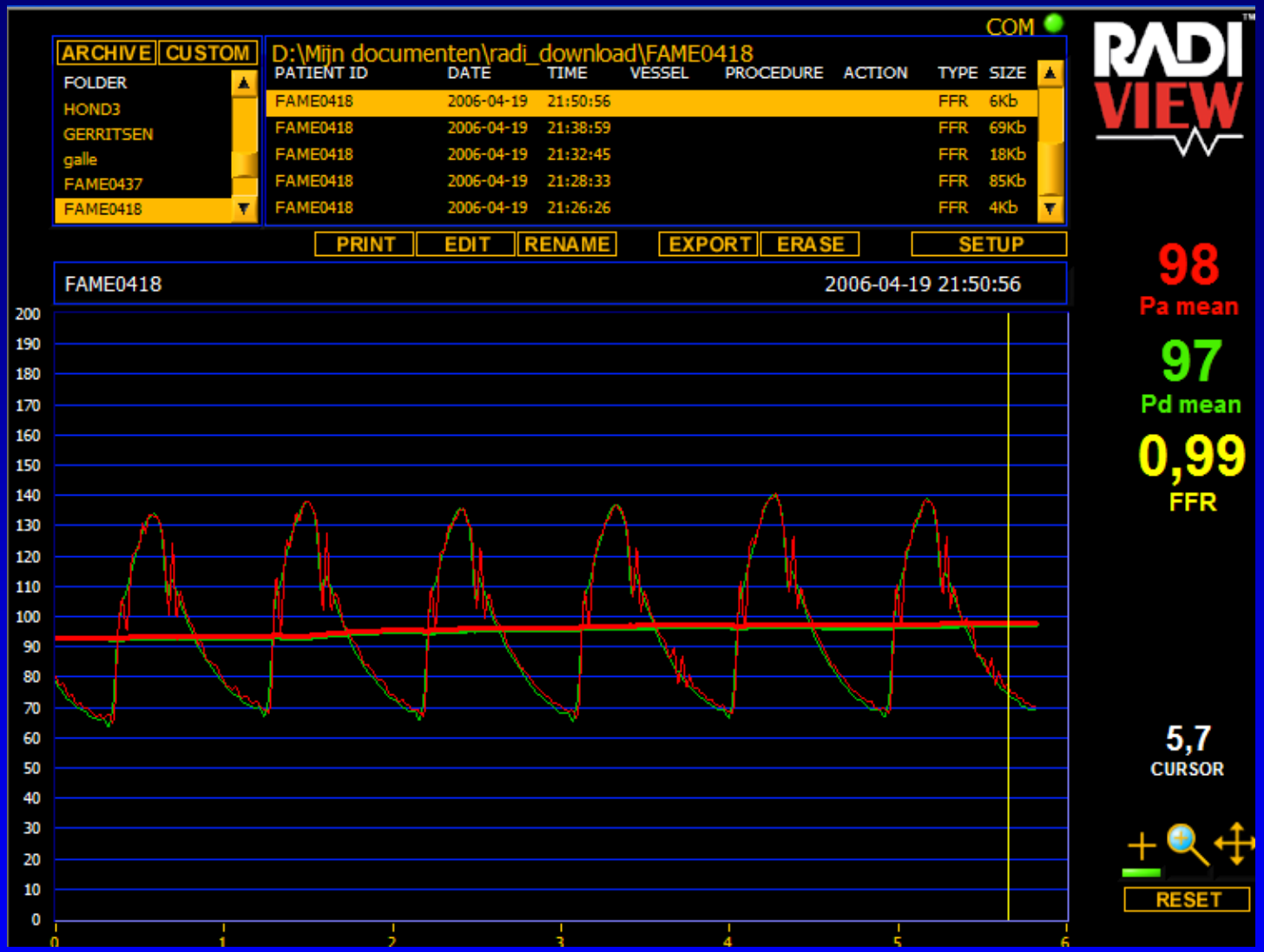




RCA after 2 stents:

FFR = 0.87

(pullback shows diffuse disease but no gradient across any of the stents)



Pressure sensor back at the ostium of the RCA

FFR post PCI

What is a “normal” (or “acceptable”) gradient across a well-deployed stent ?

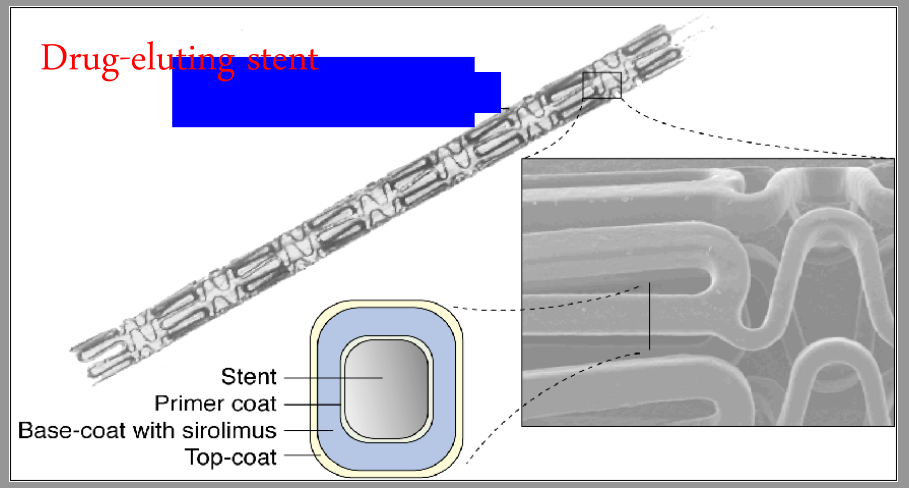
- immediately after implantation
- at follow up

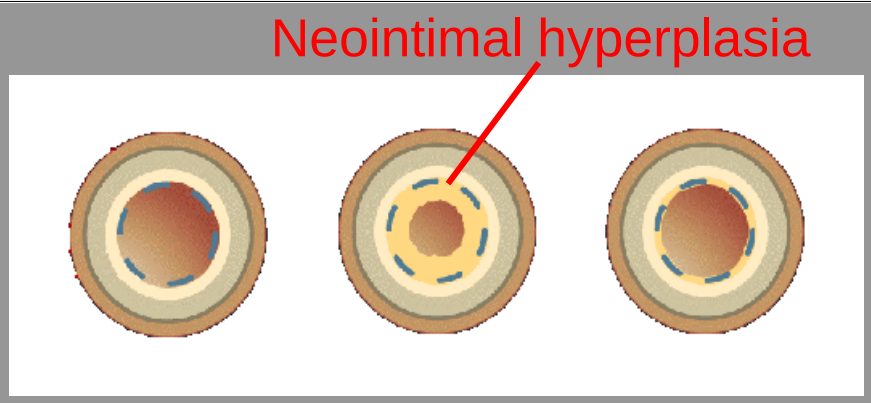
→ Mechanistic study by Van ‘t Veer et al:
“Hemodynamic Characteristics of DES at Implantation and at 6-m Follow-up”

Eur Heart J 2006;27:1811-1817

Sirolimus study (Van ‘t Veer et al, Eur Heart J 2006)

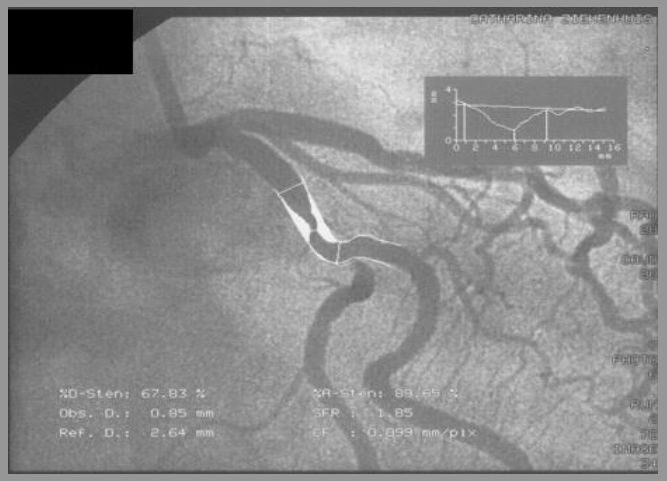
- 20 patients
- 2 stenoses
- comparable (diameter / length)
- 1 DES (Cypher)
- 1 ‘normal’ stent (BX Velocity)
- assigned randomly



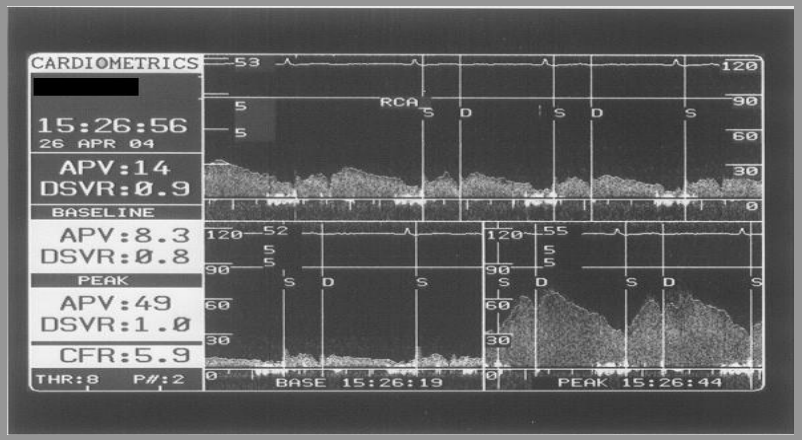


Sirolimus study

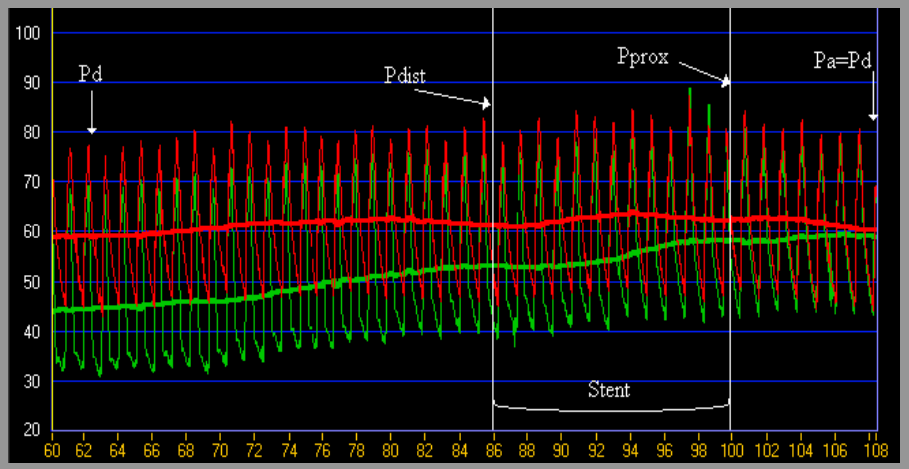
(Van 't Veer et al, Eur Heart J 2006)



- quantitative coronary angiography (QCA)
  - ***% diameter (area) stenosis***
  - ***Minimal Luminal Diameter (MLD)***
  - ***Late loss***



- Physiologic measurents
  - ***Pressure***
  - ***Blood flow velocity***
  - ***Wall shear stress***



- all measurements repeated after 6 months

FFR and hyperemic Pd/Pa before & immediately after stenting, and at 6-month follow-up

FFR	***DES***	***Bare metal***	***P value***
before	***0.61±0.20***	***0.61±0.16***	***NS***
immediately after	***0.90±0.06***	***0.88±0.07***	***NS***
Follow- up	***0.91±0.05***	***0.83±0.10***	***P<0.01***
Hyperemic pressure ratio across stent			
immediately after	***0.97 ± 0.02***	***0.96±0.04***	***NS***
Follow - up	***0.99± 0.01***	***0.91±0.09***	***P<0.01***

Van 't Veer et al, Eur Heart J 2006

Immediately after good stenting, the hyperemic gradient Across the stent is < 5 mmHg

FFR	***DES***	***Bare metal***	***P value***
before	***0.61±0.20***	***0.61±0.16***	***NS***
immediately after	***0.90±0.06***	***0.88±0.07***	***NS***
Follow- up	***0.91±0.05***	***0.83±0.10***	***P<0.01***
Hyperemic pressure ratio across stent			
immediately after	***0.97 ± 0.02***	***0.96±0.04***	***NS***
Follow - up	***0.99± 0.01***	***0.91±0.09***	***P<0.01***

Van 't Veer et al, Eur Heart J 2006

At 6 months, some gradient (approximately 10 mmHg) is present across a BMS stent, but no noticeable gradient across a DES

FFR	***DES***	***Bare metal***	***P value***
before	***0.61±0.20***	***0.61±0.16***	***NS***
immediately after	***0.90±0.06***	***0.88±0.07***	***NS***
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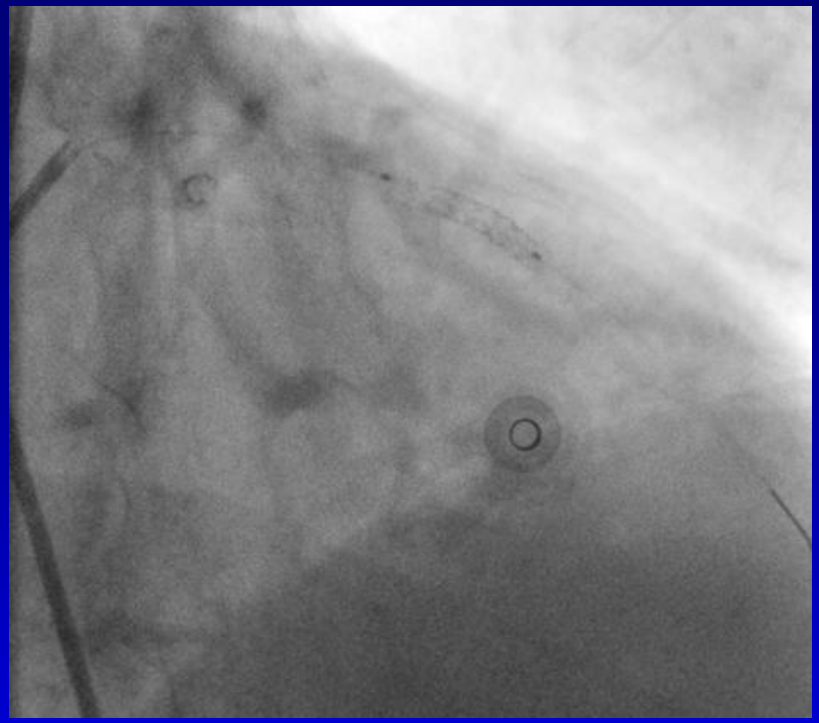
Van 't Veer et al, Eur Heart J 2006

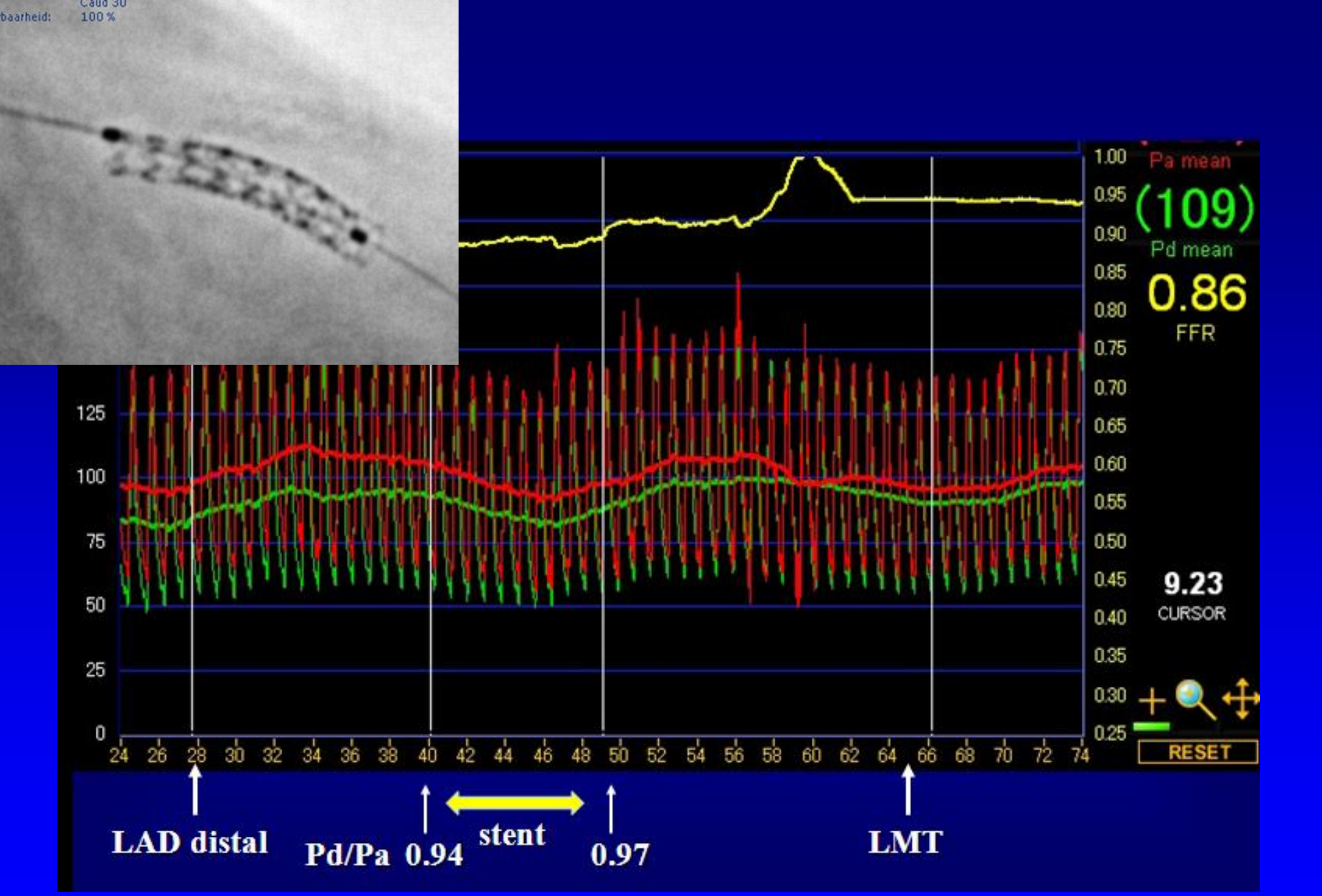


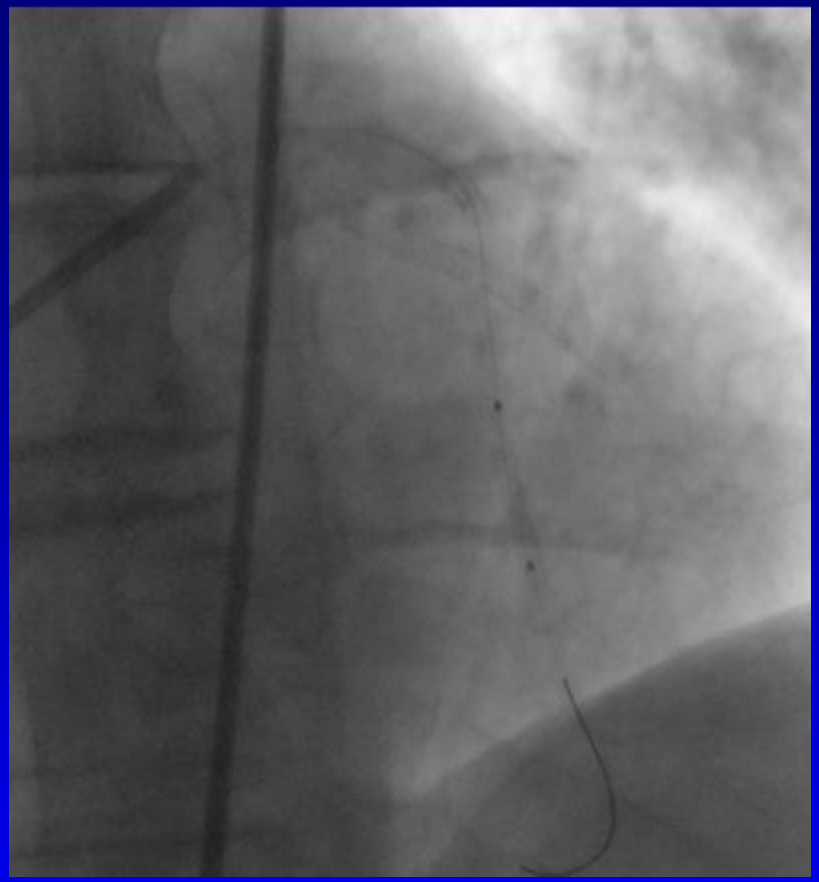
Stent boost technique

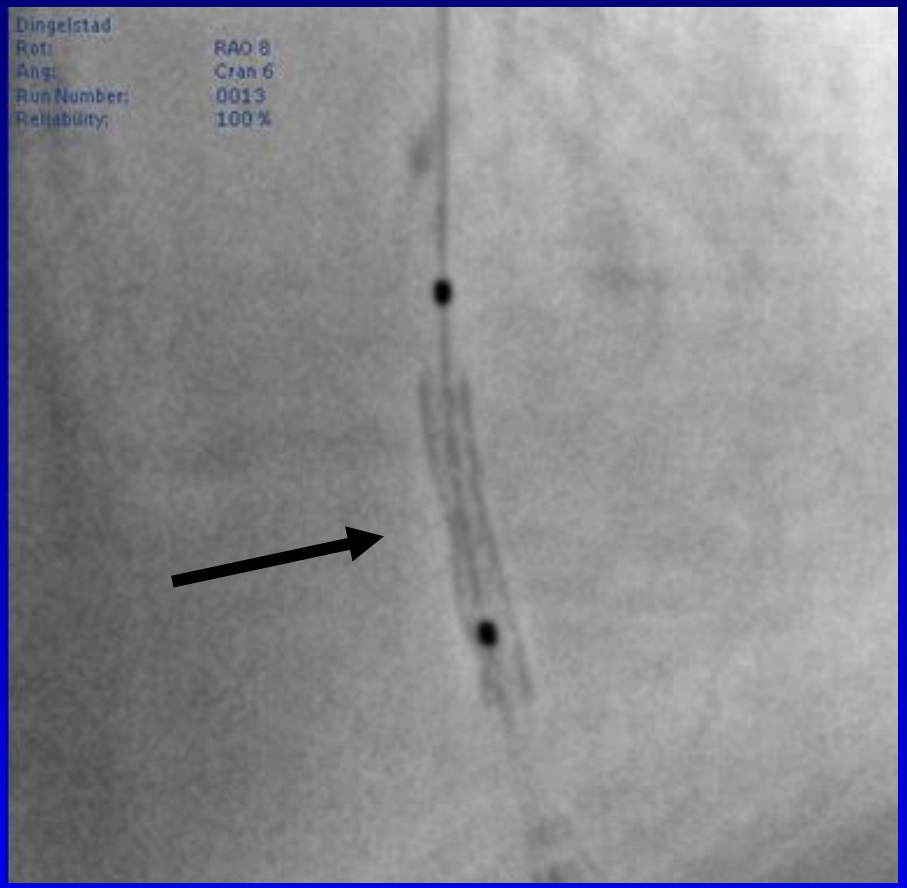
Tanaka et l, Japan Circulation J, 2012:

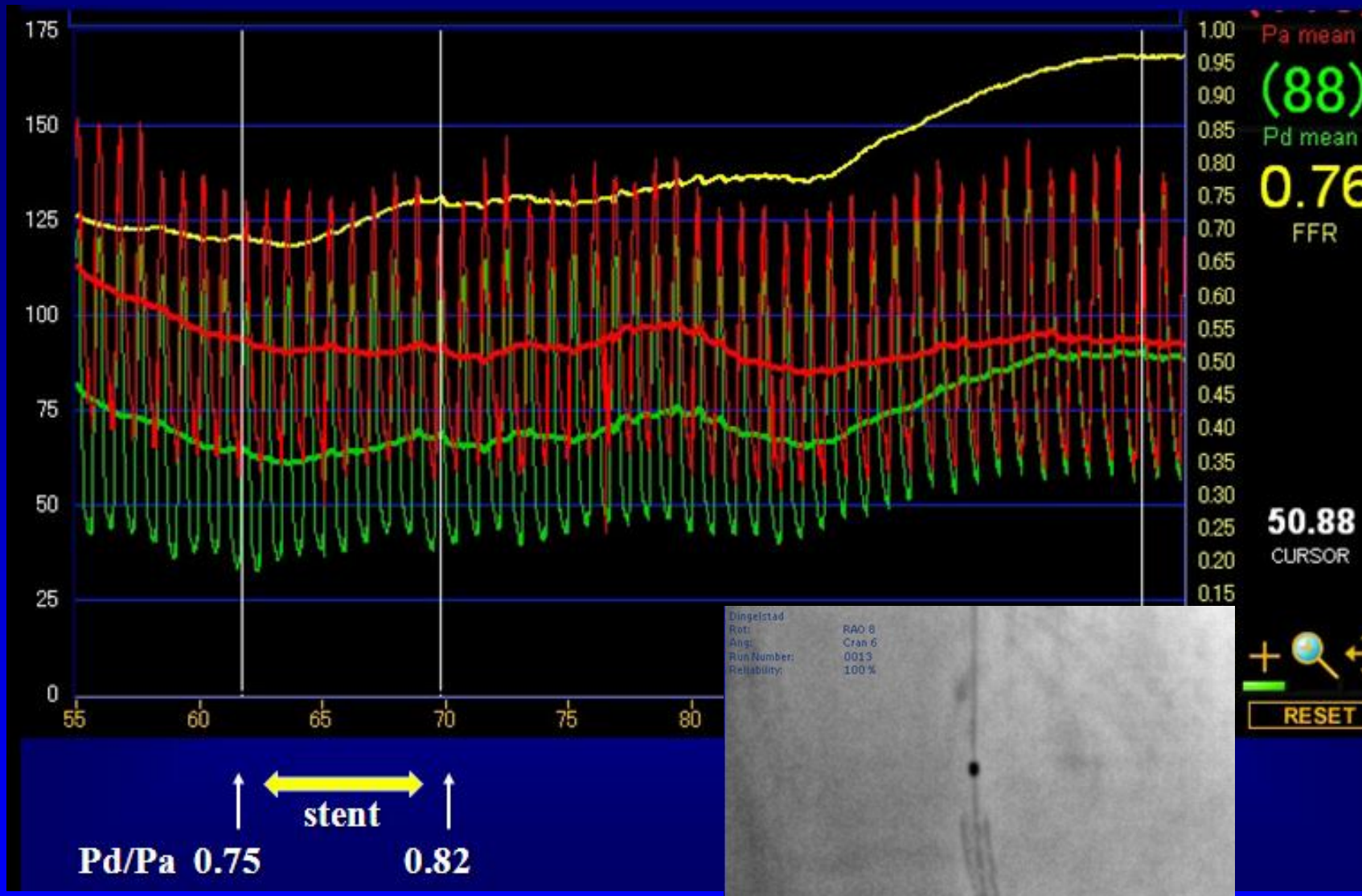
Stent boost vs FFR post-stenting

→ Weak correlation between abnormal stent boost and hyperemic gradient across stent of > 5 mmHG


Caud 30
baarheid: 100 %
Pa mean
(109)
Pd mean
0.86
FFR
9.23
CURSOR
RESET
LAD distal
Pd/Pa 0.94
stent
0.97
LMT




Dingelstad
Rot: RAO 8
Ang: Cran 6
Run Number: 0013
Reliability: 100 %


175
150
125
100
75
50
25
0
55
60
65
70
75
80
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
Pa mean
(88)
Pd mean
0.76
FFR
50.88
CURSOR
RESET
stent
Pd/Pa 0.75
0.82

FFR POST PCI: *Practice in Catharina Hospital*

I. When we use pressure wire for deciding whether or not to stent, we use it as primary guidewire and standardly measure FFR post stenting

II. After angiographically succesful stenting, place the sensor in distal third part of the artery (and at least distal to stented lesion(s) and induce hyperemia for pullback recording:
   - *i.v. adenosine infusion, preferably central line*
   - *i.v. peripheral bolus injection of 400 µg regadenoson*

III. Perform manual pullback recording under fluoroscopy: *and check if remaining gradient is across stent or else where in the coronary artery, accepting the consequences*

FFR post PCI: CONCLUSIONS (1)

- If a stent is deployed adequately, only a negligible hyperemic gradient should be present across the stent
- if a hyperemic gradient of > than 5 mm Hg persists ***across*** the stent, there is most likely a problem and preferably OCT is indicated
- The opposite is not true: even without an hyperemic gradient, a stent can be insufficiently deployed (5 % of cases).
- Therefore, FFR post-stent cannot replace OCT

FFR post PCI: CONCLUSIONS (2)

- FFR post PCI is *extremely useful to detect residual lesions or diffuse disease* with direct consequence for further treatment or preventing unneccesary repeat procedures when recurrent chest pain or ischemia occurs

- The *hyperemic* pressure pullback recording is the most accurate method to analyse the remaining disease along the coronary artery and cannot be replaced by any other technology

Caveat…!!...:

There might be a psychological barrier for measuring FFR after stenting! Sometimes it indicates merciless that we are not always as good as we wish to be

EINDE