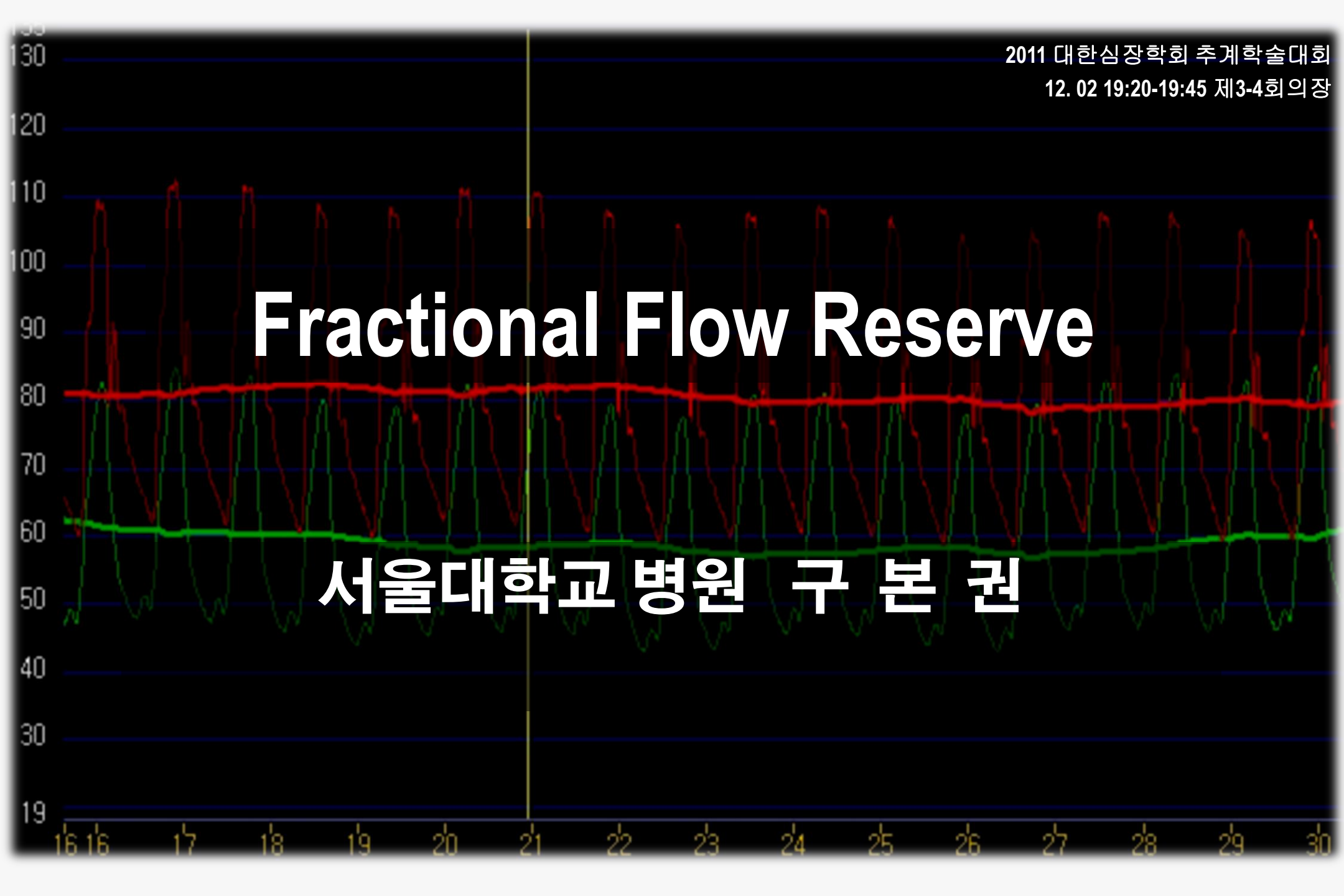
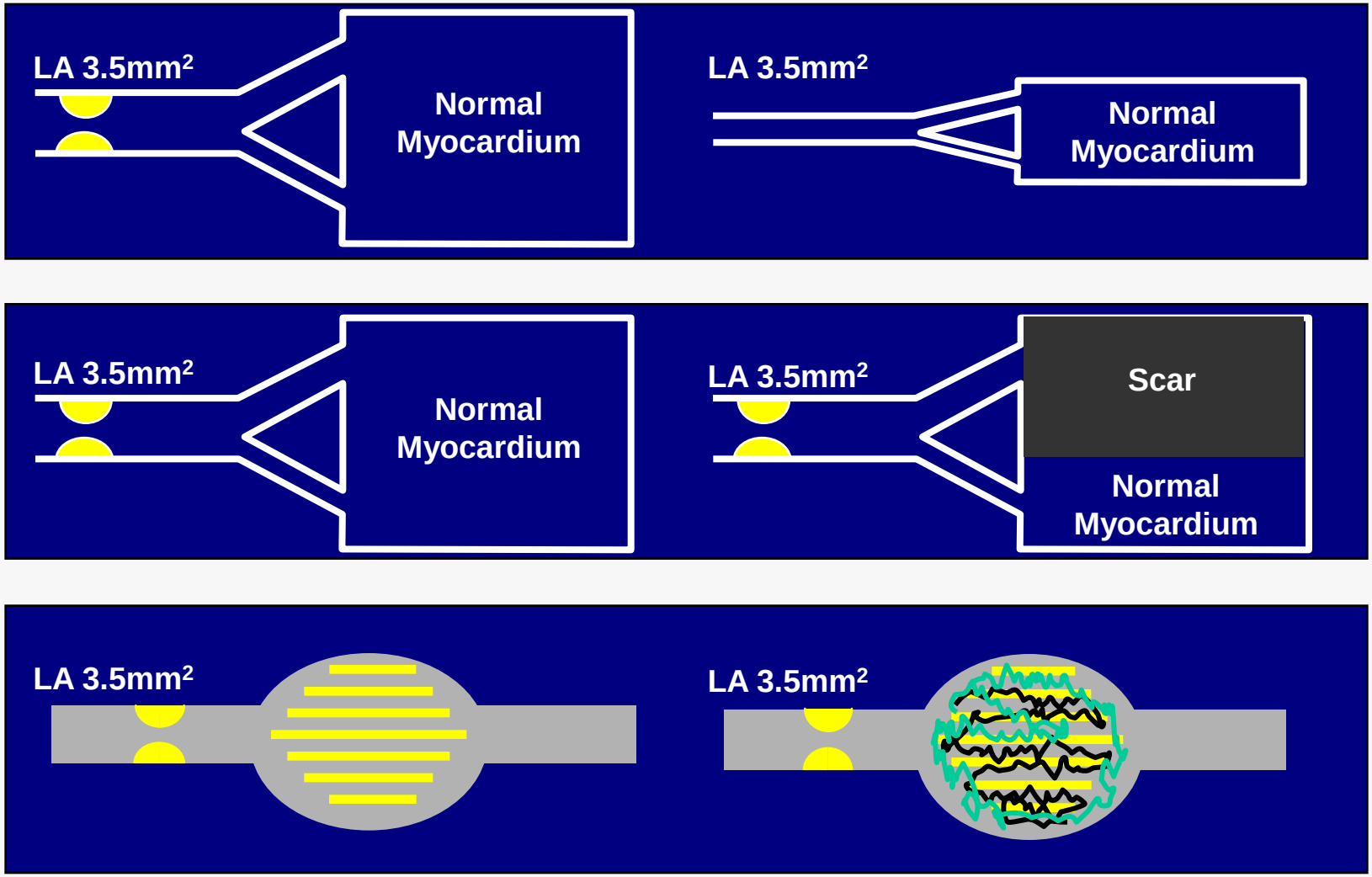

2011 대한심장학회 추계학술대회
12. 02 19:20-19:45 제3-4회의장
Fractional Flow Reserve
서울대학교 병원 구 본 권

Same stenosis, same functional significance ?



LA: Lumen cross sectional area

Evaluation of Coronary Stenosis

An ideal parameter should account for the interaction between

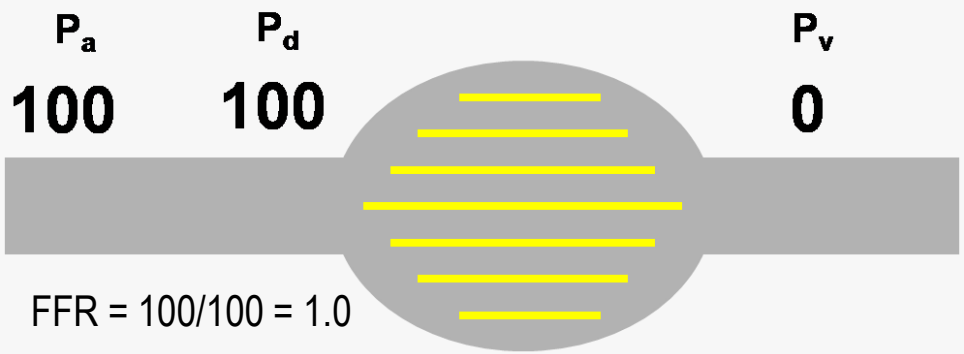
- *Epicardial stenosis severity*,
- **Extent of the perfusion territory,**
- **Myocardial blood flow including collaterals**
- **Microvascular function**

→ ***Physiologic or functional evaluation***

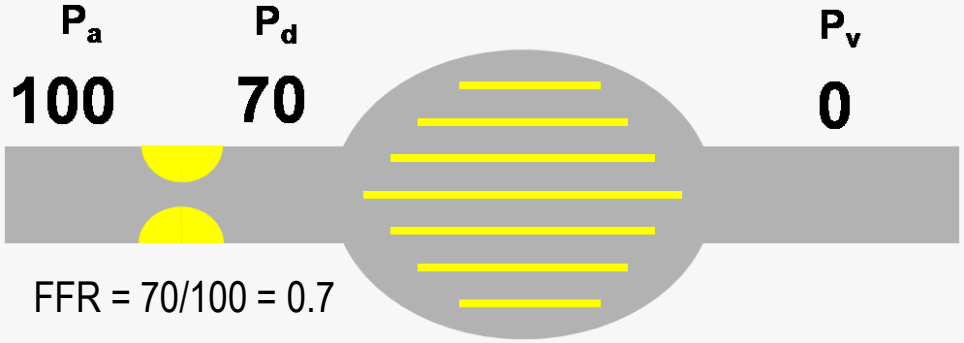
(살아 있는 심근이 필요로 하는 만큼의 적절한 혈류가 공급되고 있는지를 평가하는 방법)

Fractional Flow Reserve (FFR)

$$FFR = \frac{\text{Maximum flow in presence of stenosis}}{\text{Normal maximum flow}} = \frac{Q^S_{max}}{Q^N_{max}} = \frac{(Pd-Pv)/R}{(Pa-Pv)/R} = \frac{\text{Distal Pr } (P_d)}{\text{Proximal Pr } (P_a)}$$

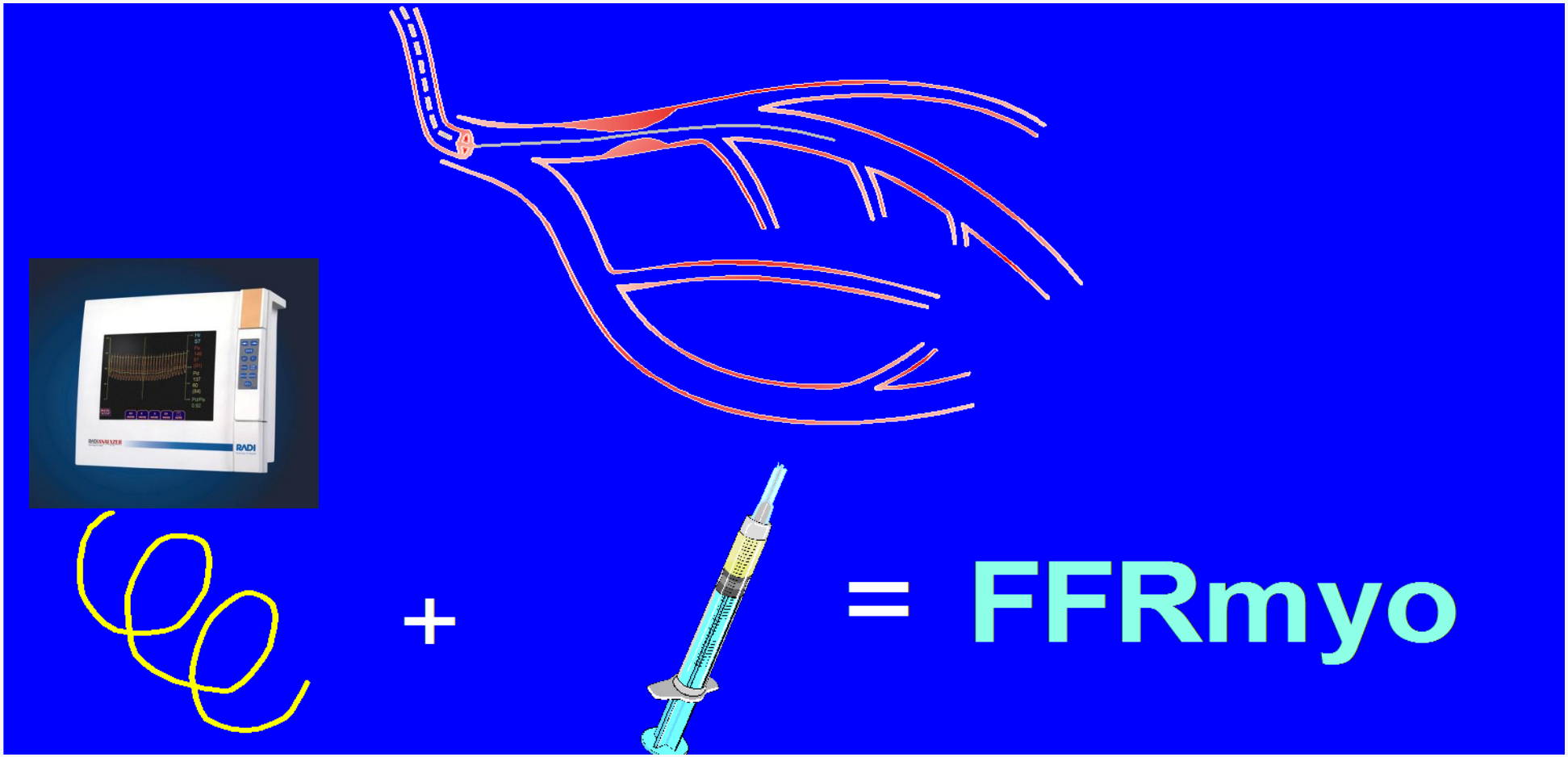


FFR = 100/100 = 1.0



FFR = 70/100 = 0.7

Application in the cath lab



Pressure Wire Adenosine

Fractional Flow Reserve

Unique Features of FFR

Easily obtained

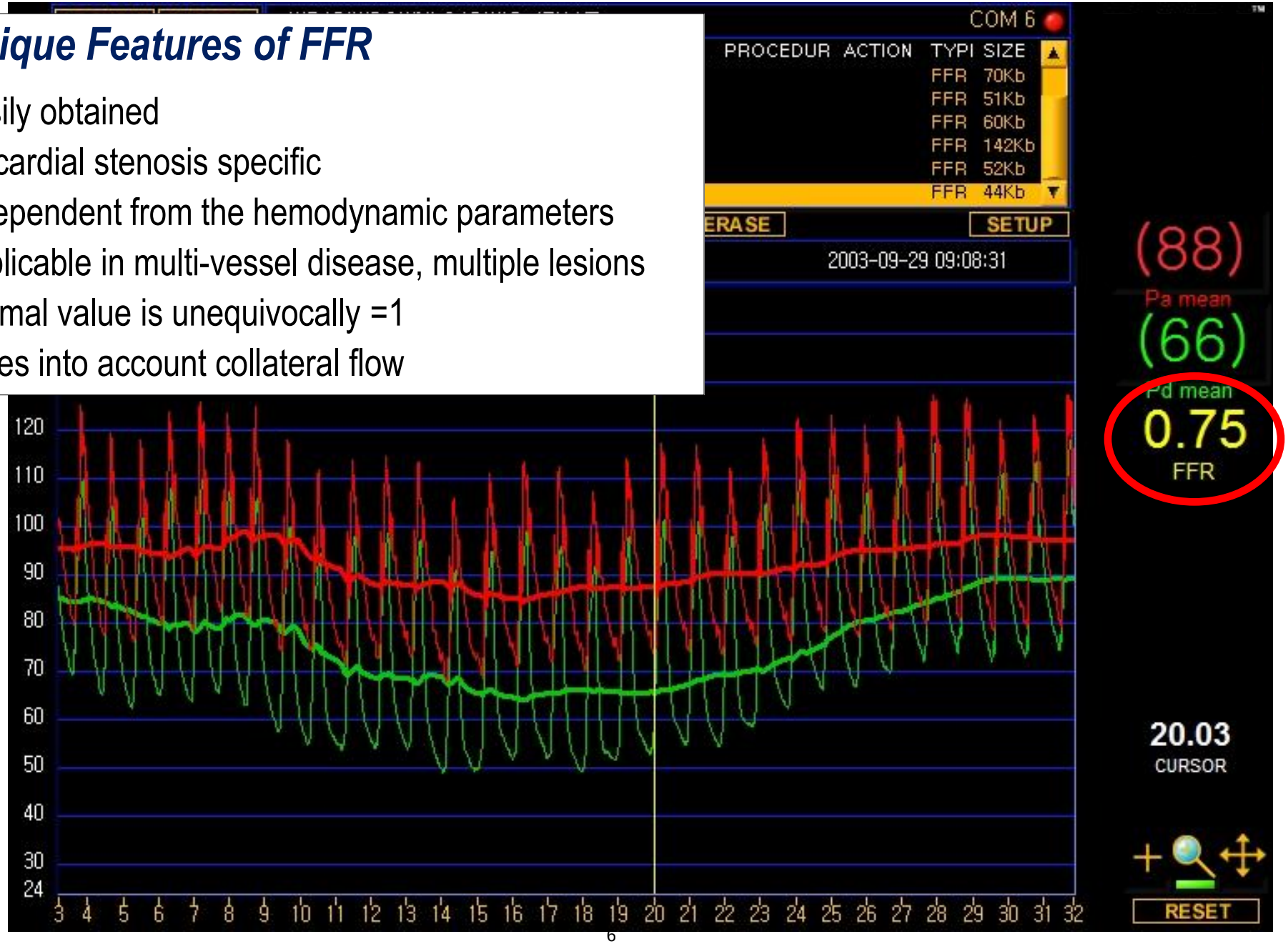
Epicardial stenosis specific

Independent from the hemodynamic parameters

Applicable in multi-vessel disease, multiple lesions

Normal value is unequivocally =1

Takes into account collateral flow



FFR = 0.6 means:

"Due to this particular stenosis, blood flow to the myocardium is only 60 % of normal maximal flow"

If, post PCI FFR = 0.9, this means:

"Blood flow has increased by 50% and is 90% of normal maximal flow"

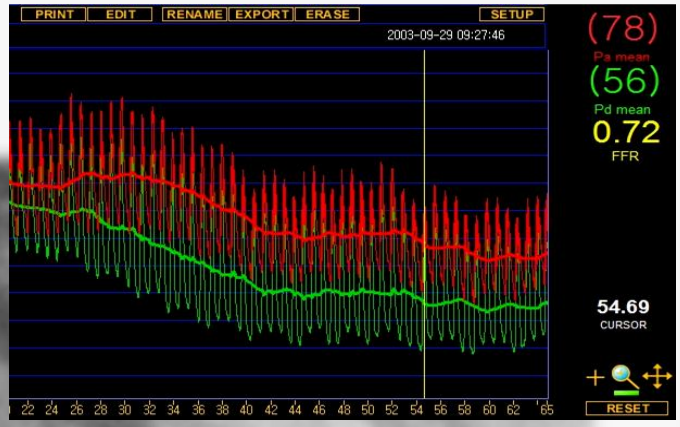
FFR vs. Myocardial ischemia

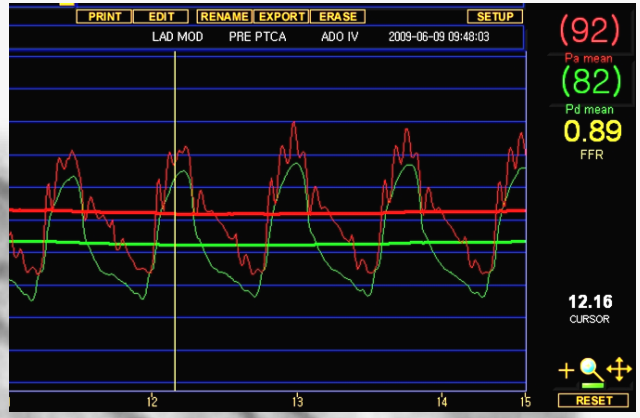
Overall results for FFRmyo	Percentage
Sensitivity	88 %
Specificity	100 %
Pos. Pred. Value	100 %
Neg. Pred. Value	88 %
Accuracy	93 %

All pts with FFR below 0.75 (21 pts) had inducible ischemia whereas in the majority, 87.5 % (21/24 pts) of patients with FFR higher than 0.75 ischemia could not be induced.

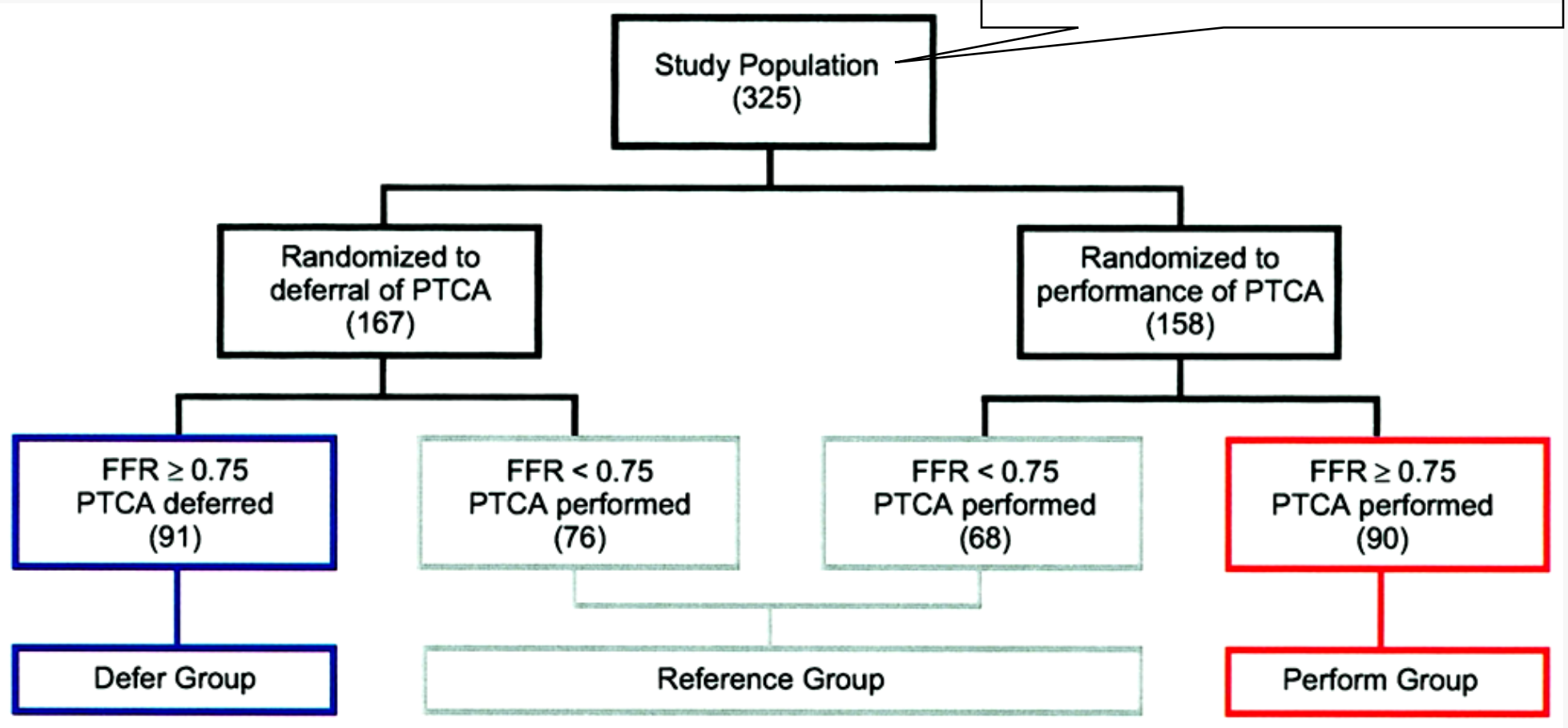
Pijls et al. NEJM 1996;334

Intermediate lesions



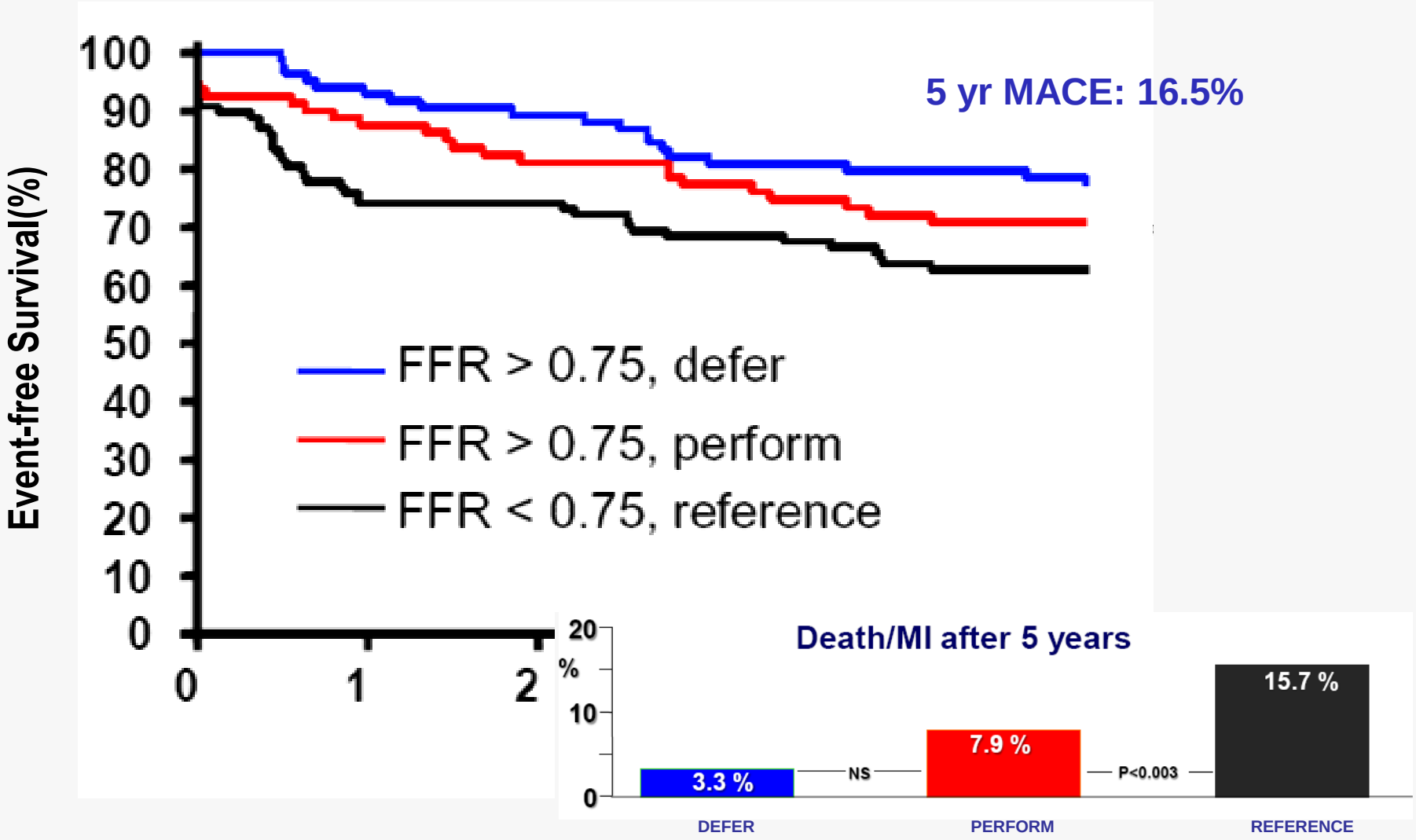


DEFER study



Circulation 2001

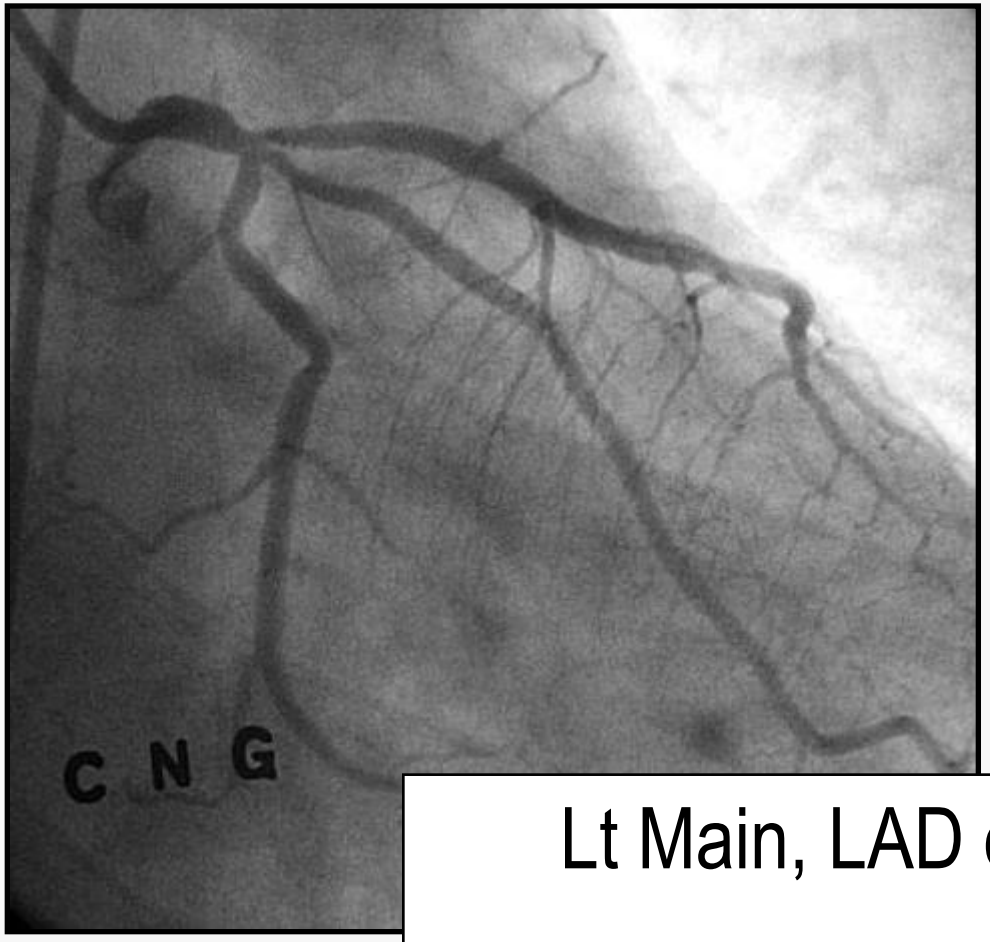
DEFER study – *5 yr follow-up*

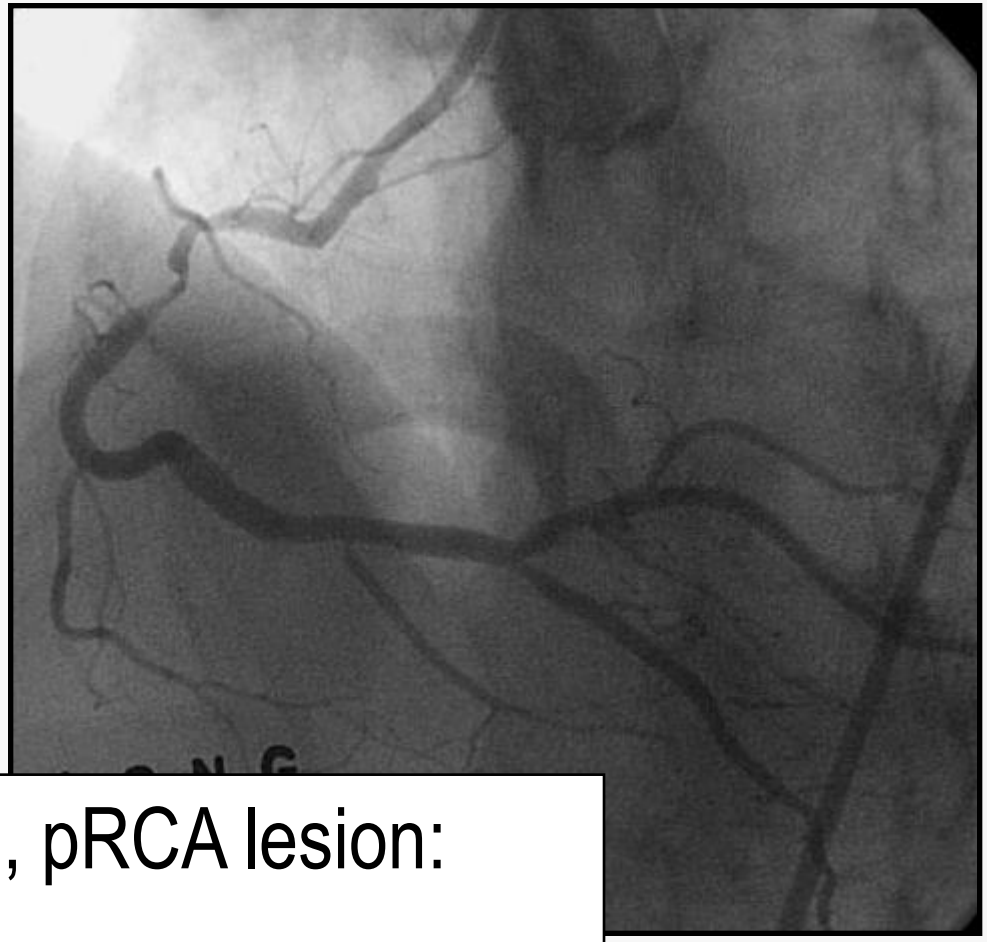


Pijls, JACC 2006

M/63 HT, Hyperlipidemia

Referred from other hospital after CAG for urgent CABG





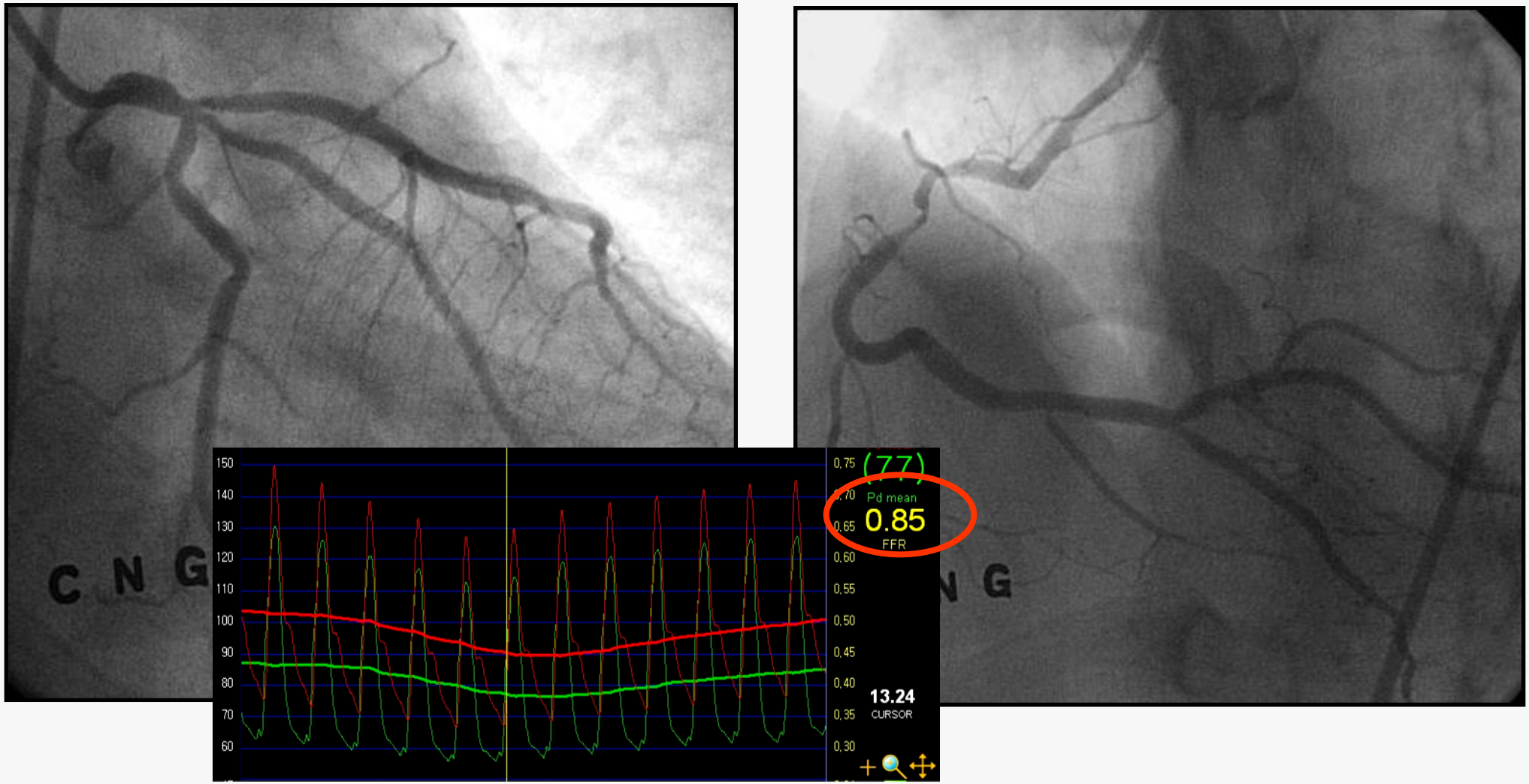
Lt Main, LAD os, pRCA lesion:

CABG? PCI?

M/63 HT, Hyperlipidemia

Recent onset resting and exertional chest pain

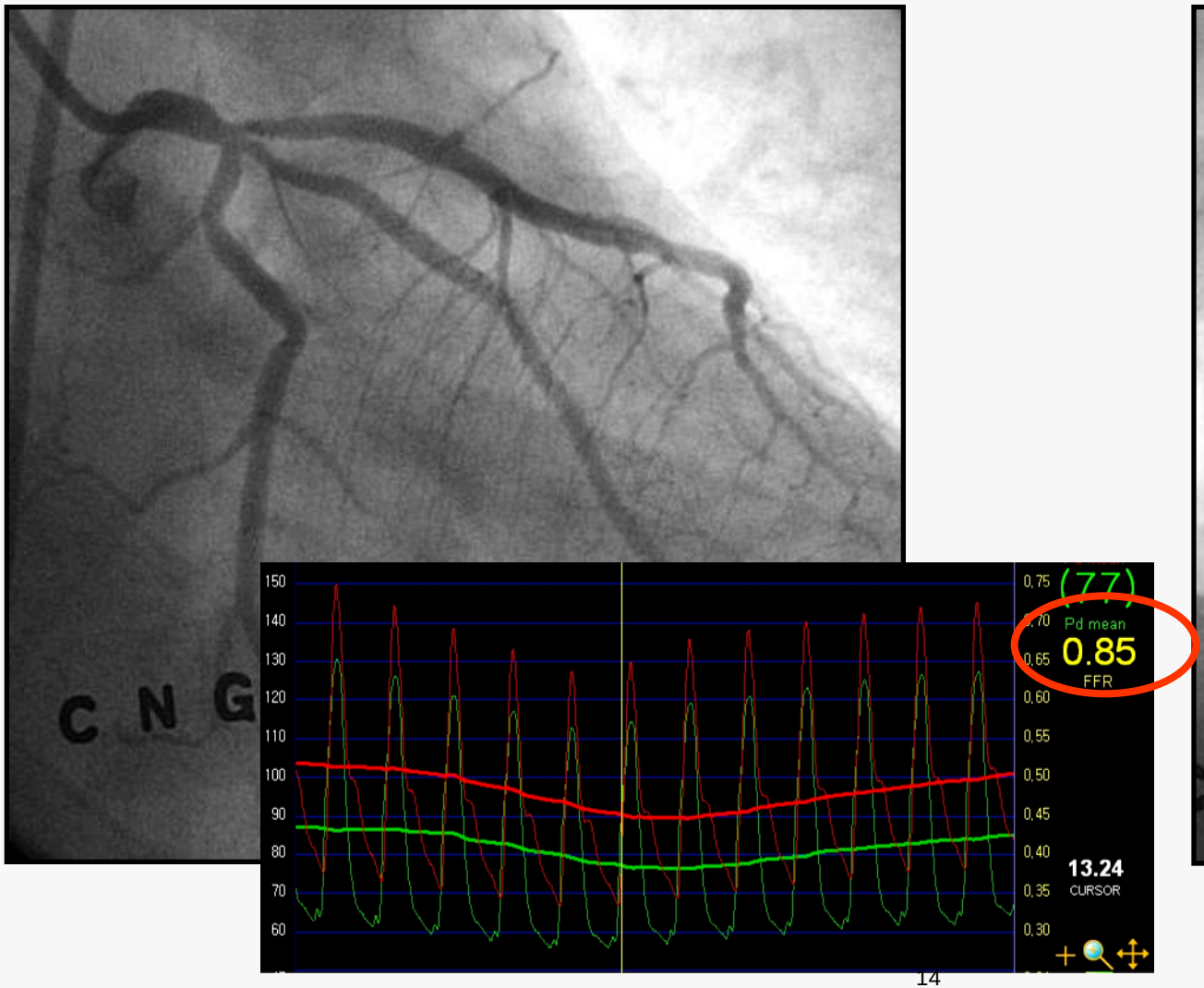
Referred from other hospital after CAG for urgent CABG



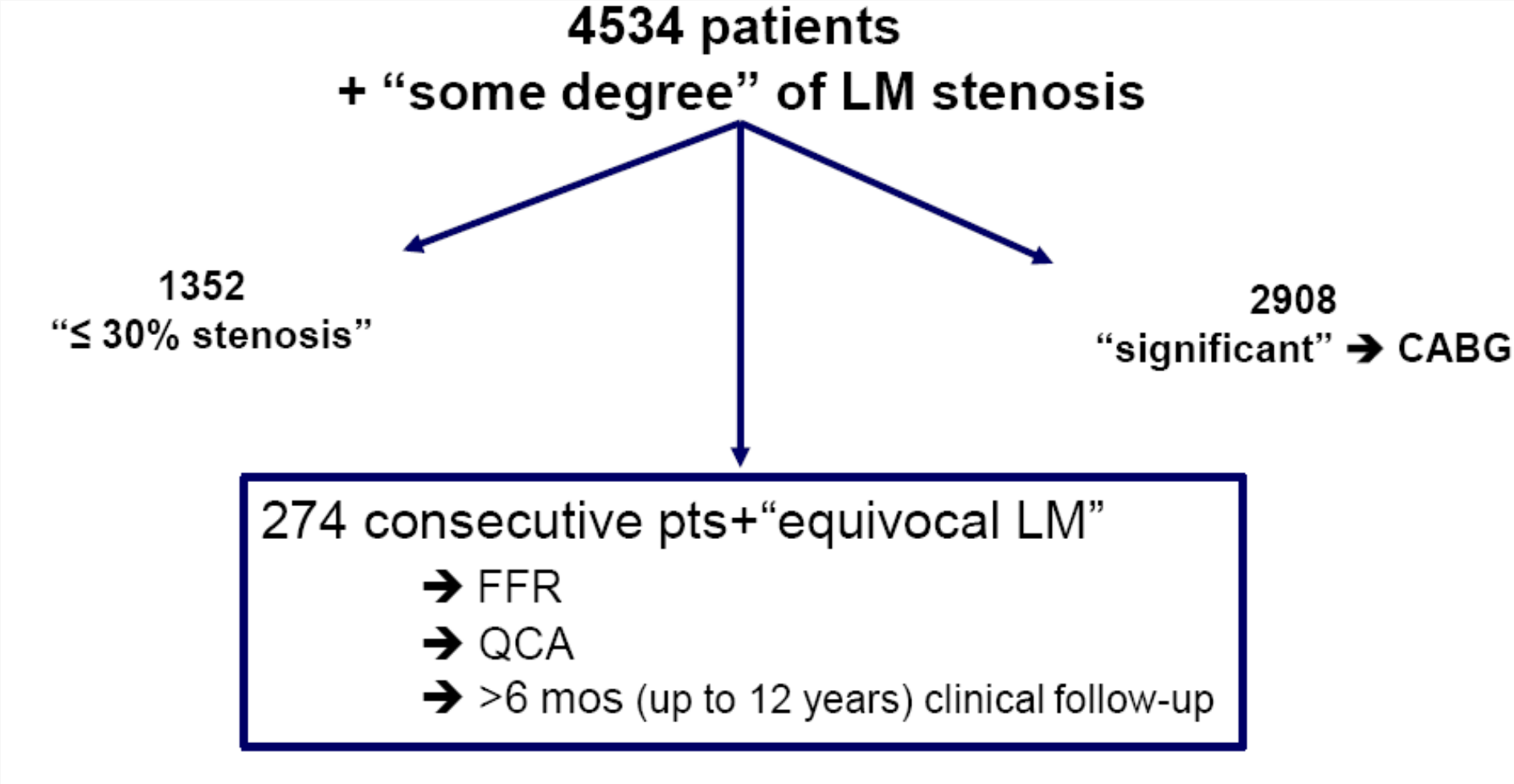
M/63 HT, Hyperlipidemia

Recent onset resting and exertional chest pain

Referred from other hospital after CAG for urgent CABG

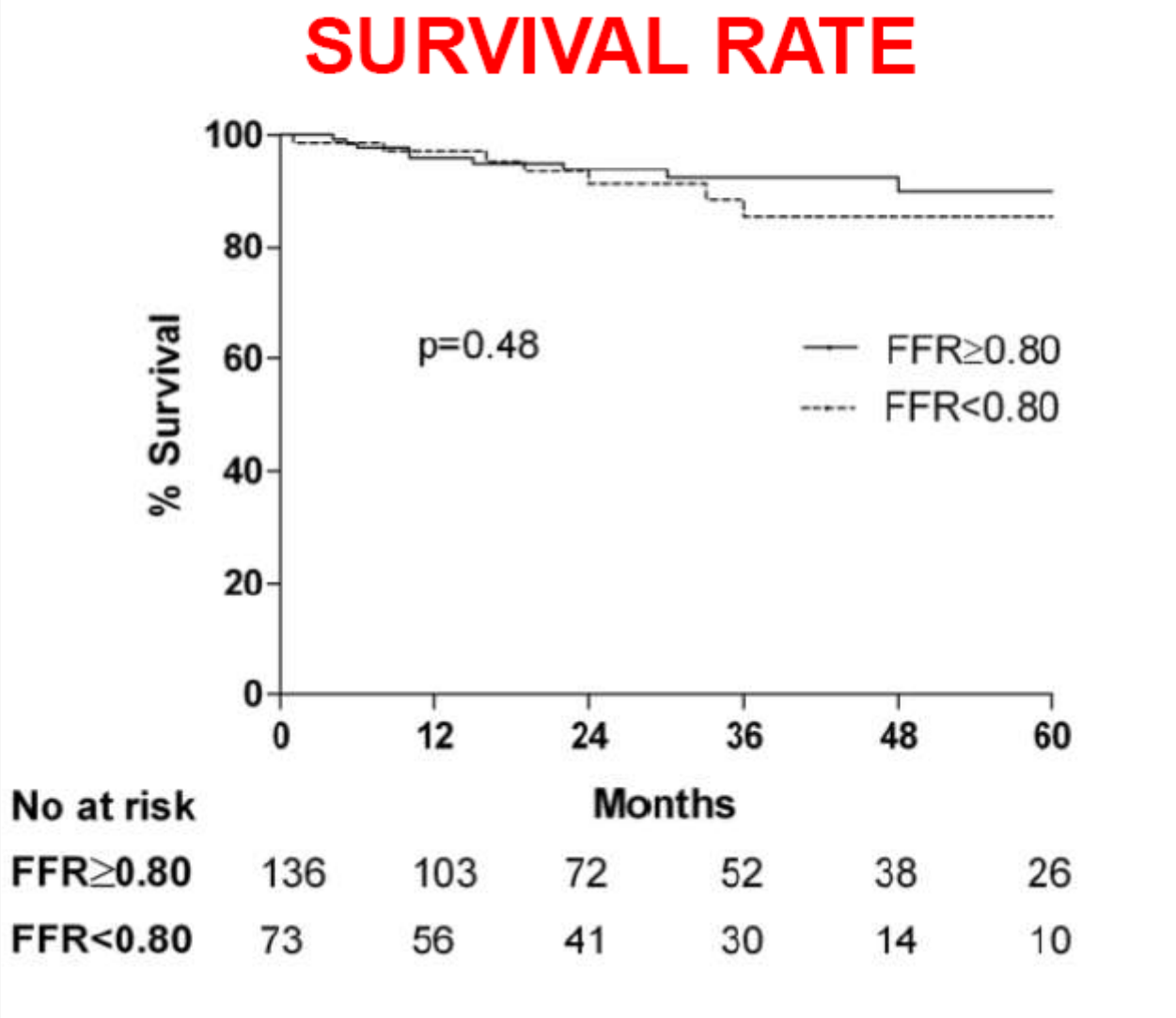


FFR-guided Decision Making in Left Main Stenosis



Hamilos, et al. Circulation 2009

FFR-guided Decision Making in Left Main Stenosis

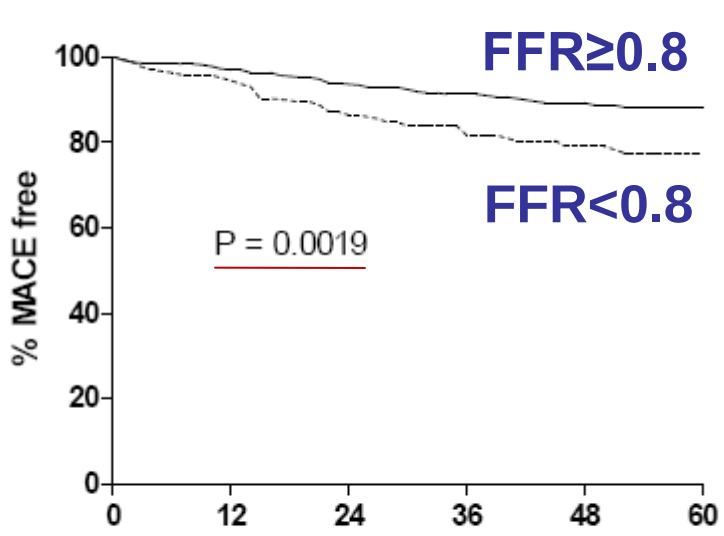


Hamilos, et al. Circulation 2009

FFR-guided Decision Making in prox LAD

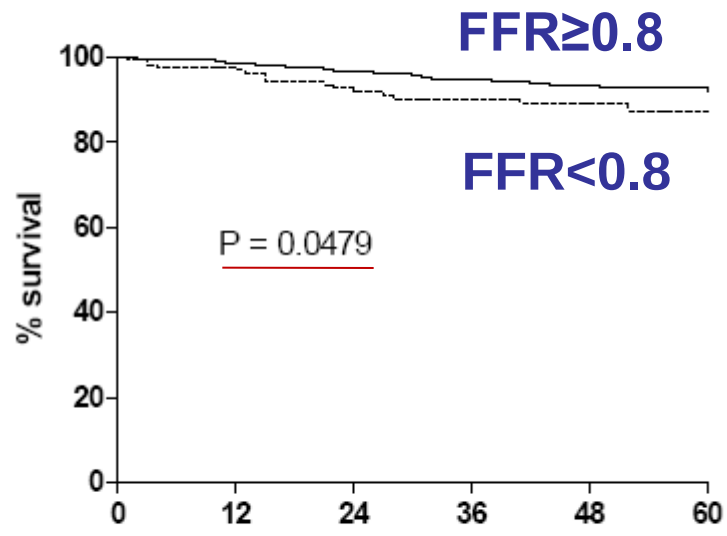
N= 730 Patients
Mean follow-up: 40±2 months

MACE



No at risk						
FFR 0.80	544	477	392	303	200	121
FFR<0.80	165	143	107	79	56	40

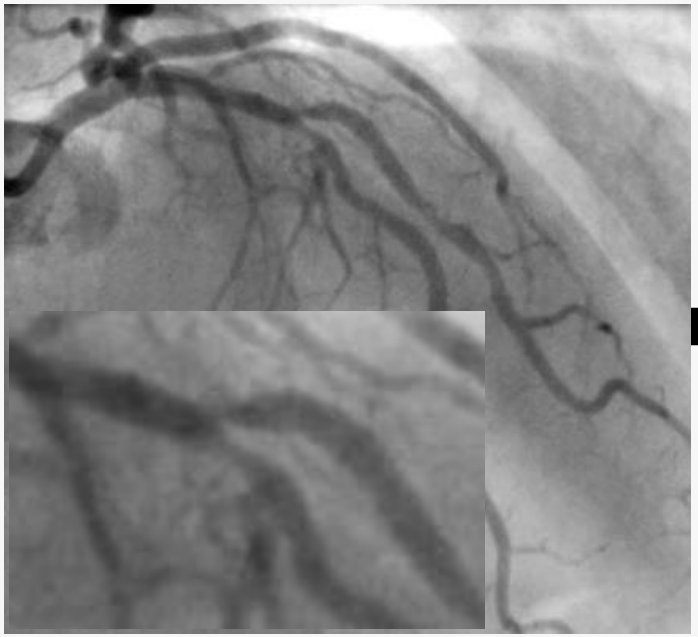
SURVIVAL

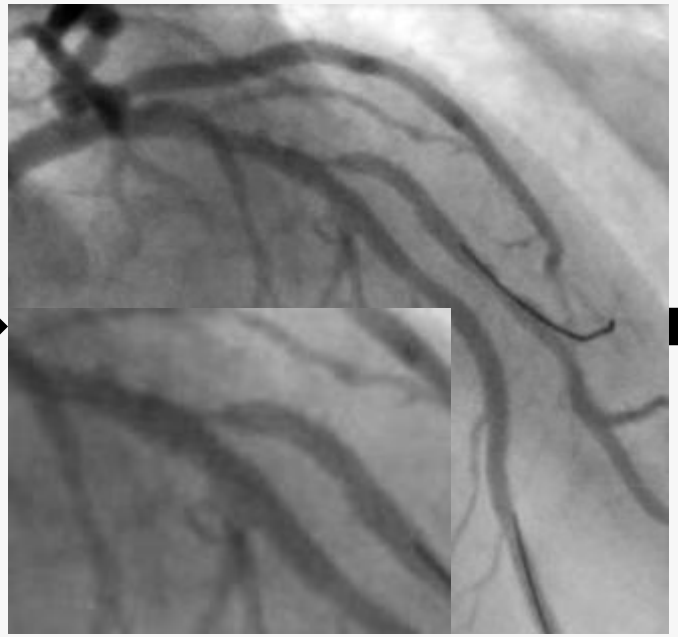


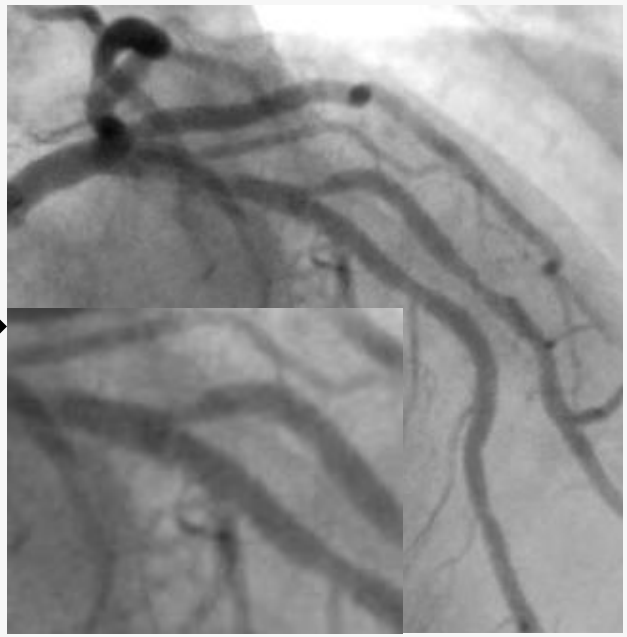
No at risk						
FFR 0.80	564	503	423	332	222	140
FFR<0.80	166	150	117	87	65	43

Muller, et al. AHA 2009

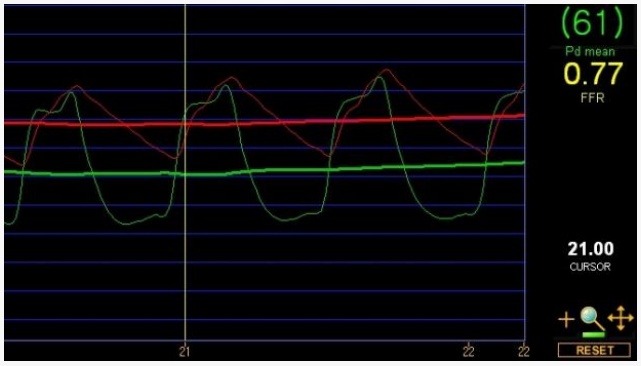
Bifurcation lesions



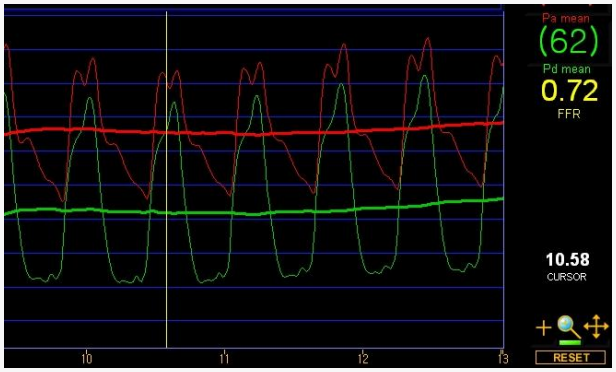




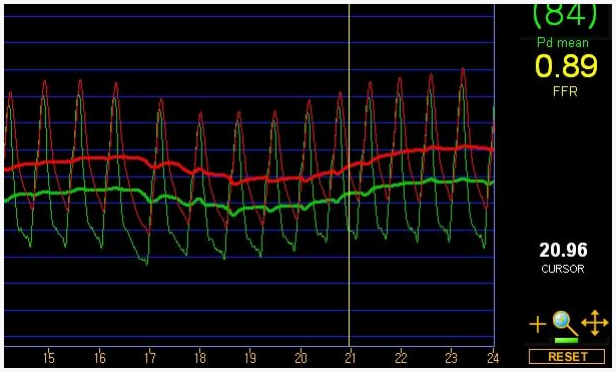
Before PCI



After MB stenting

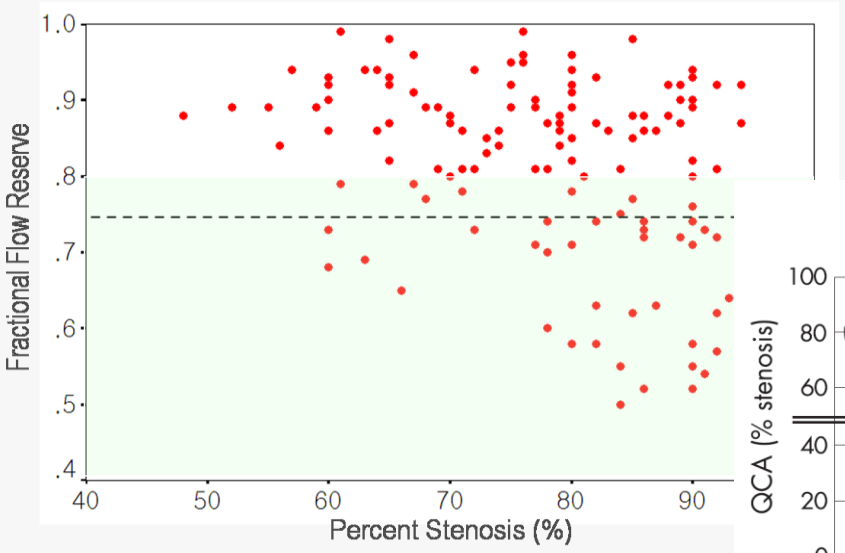


After kissing balloon

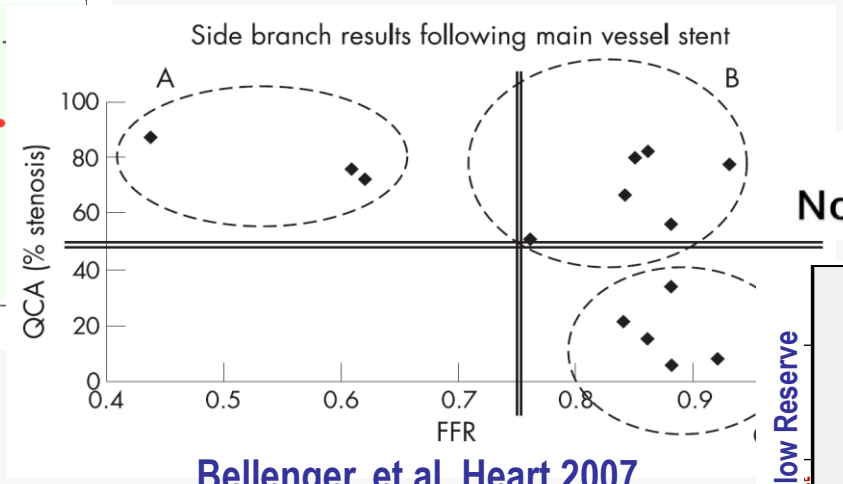


Can anatomical severity predict the functional significance?

FFR vs. % diameter stenosis in Jailed side branches

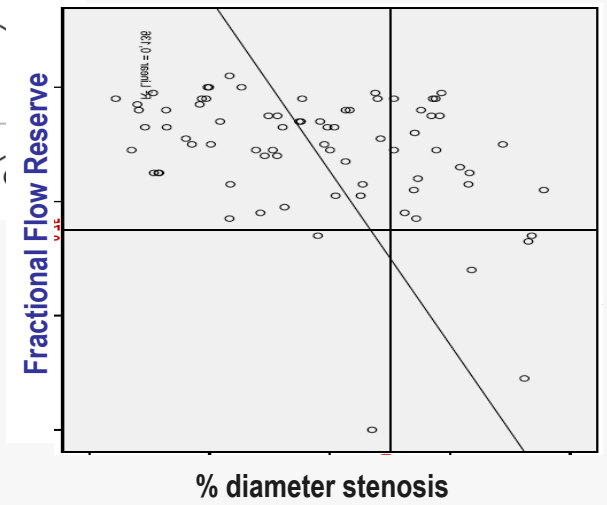


SNUH SB-FFR registry



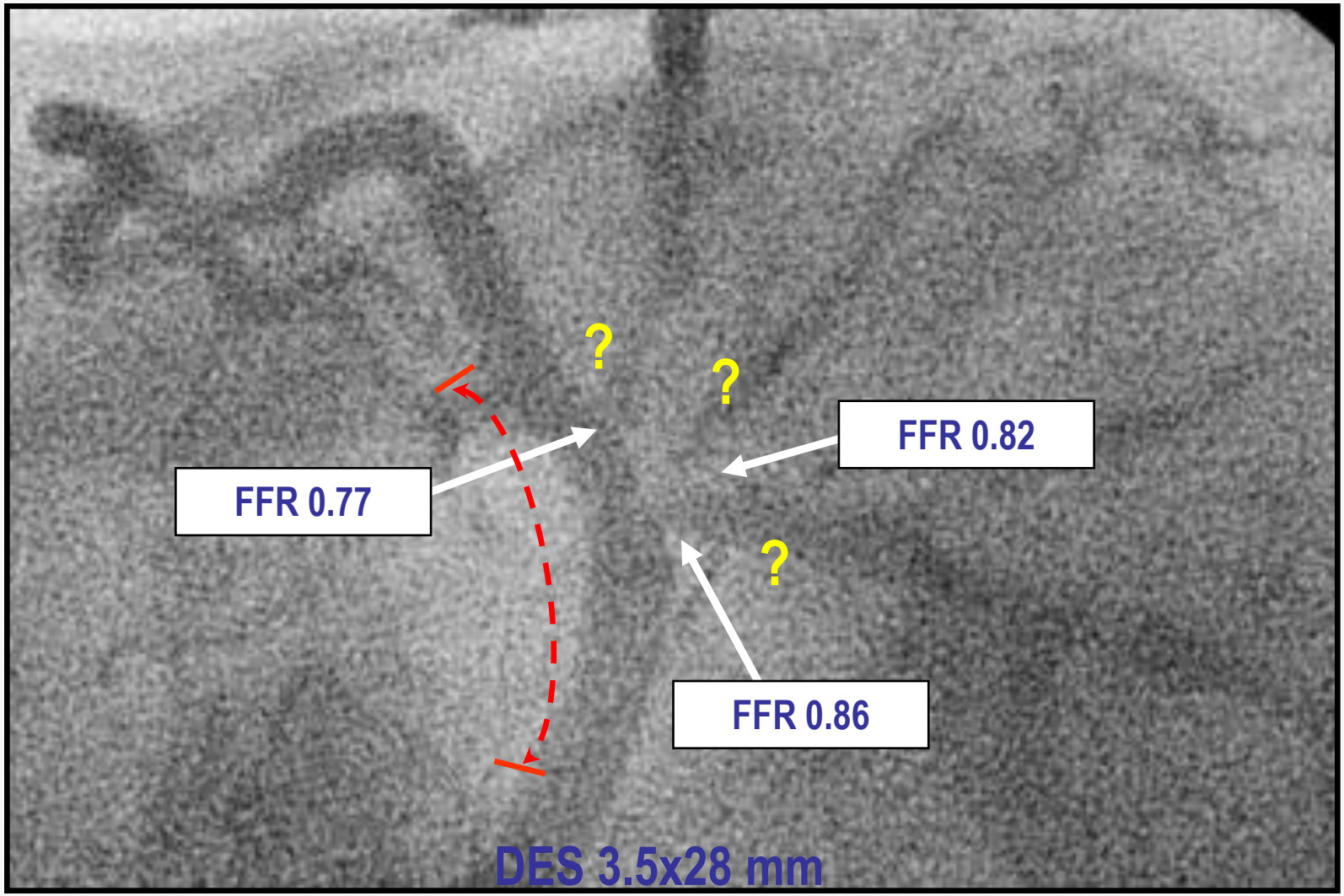
Bellenger, et al. Heart 2007

SB FFR substudy
Nordic Baltic Bifurcation III



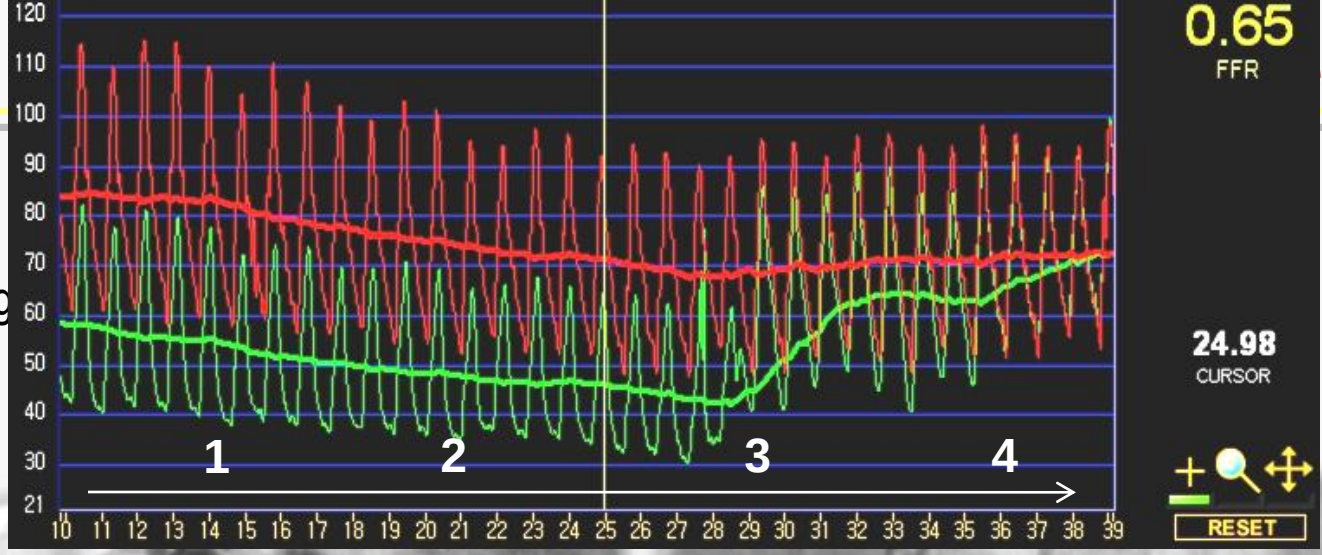
Kumsars I, et al. Eurointervention 2011

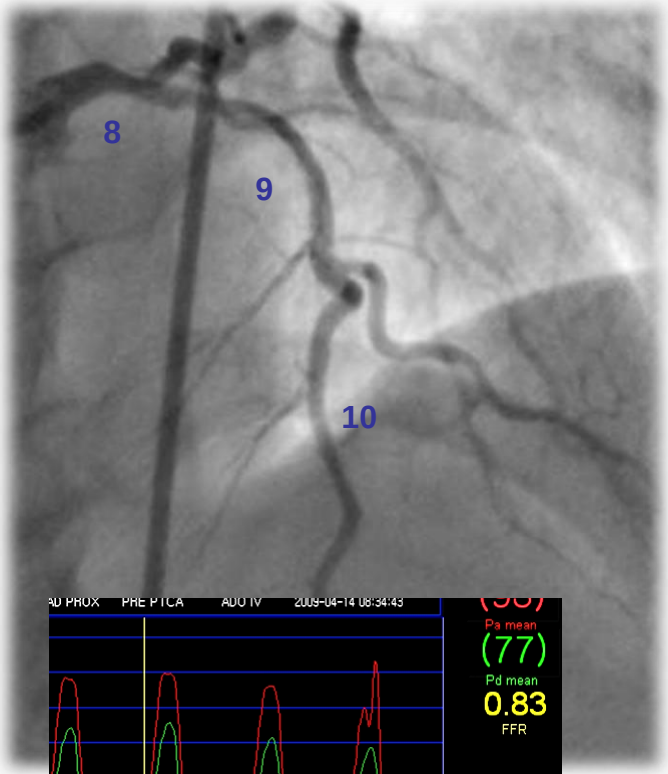
F/67 Unstable angina, Distal left main and LAD os lesion+

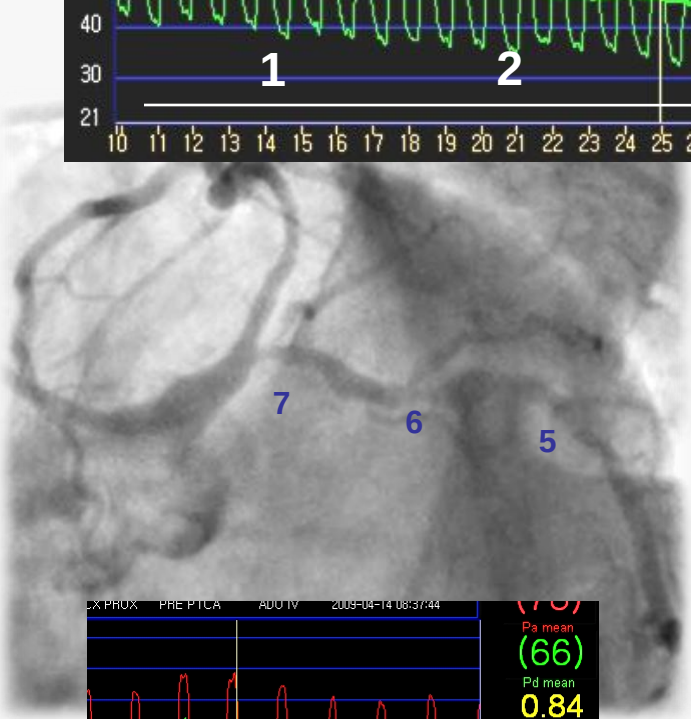


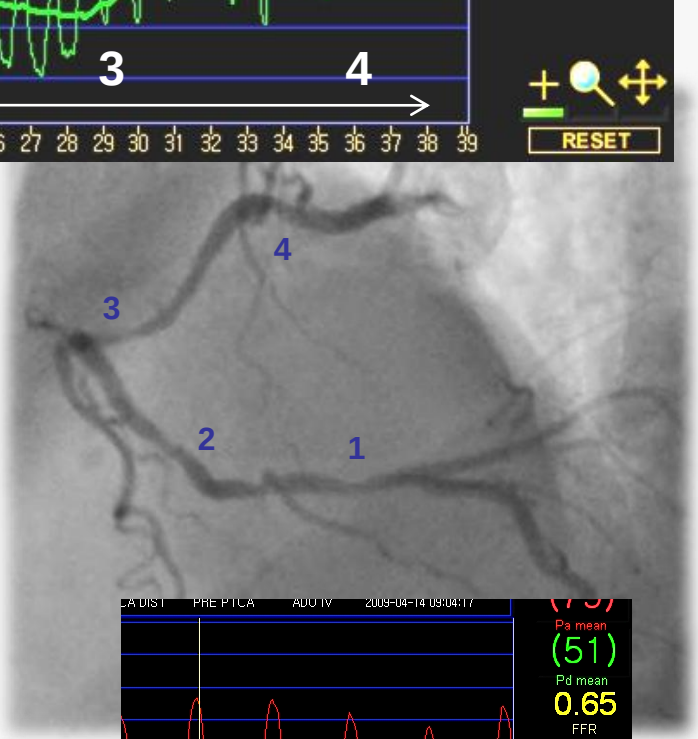
F/52

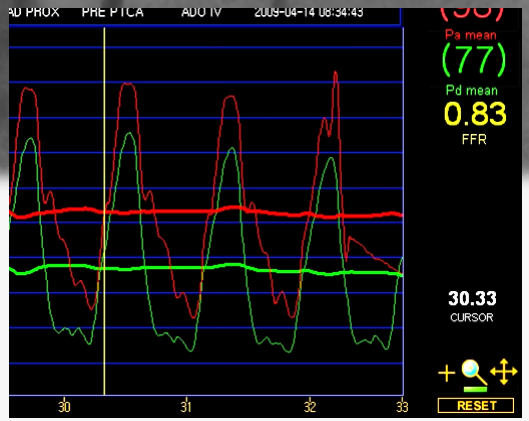
Stable angina, 3VD by CT coronary angiog

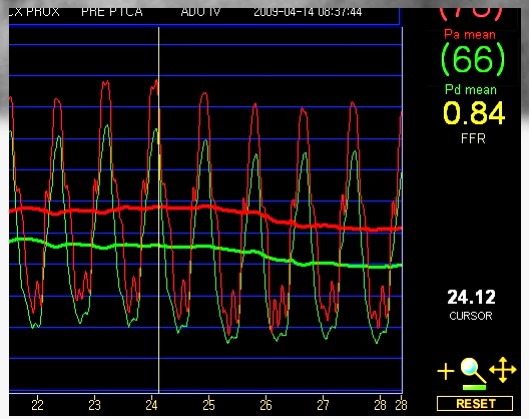


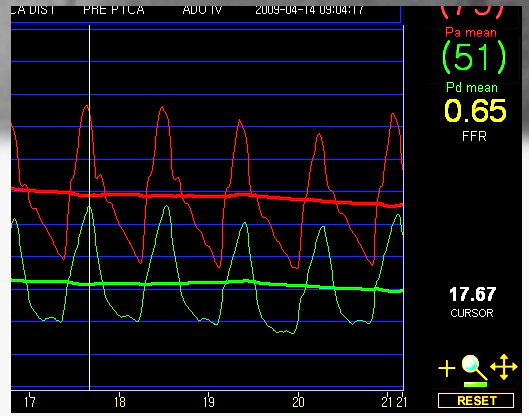




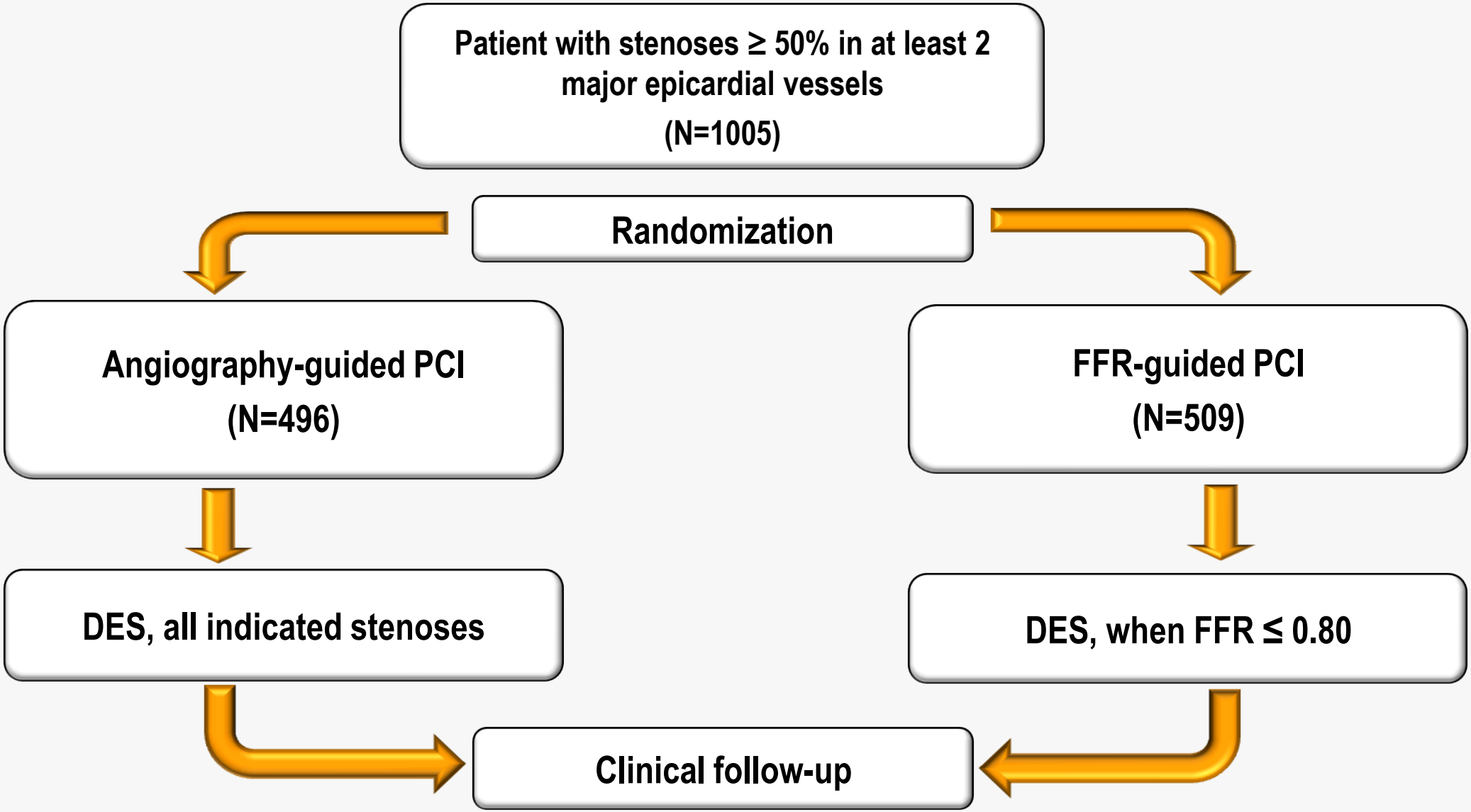








FAME study



DES: drug-eluting stents

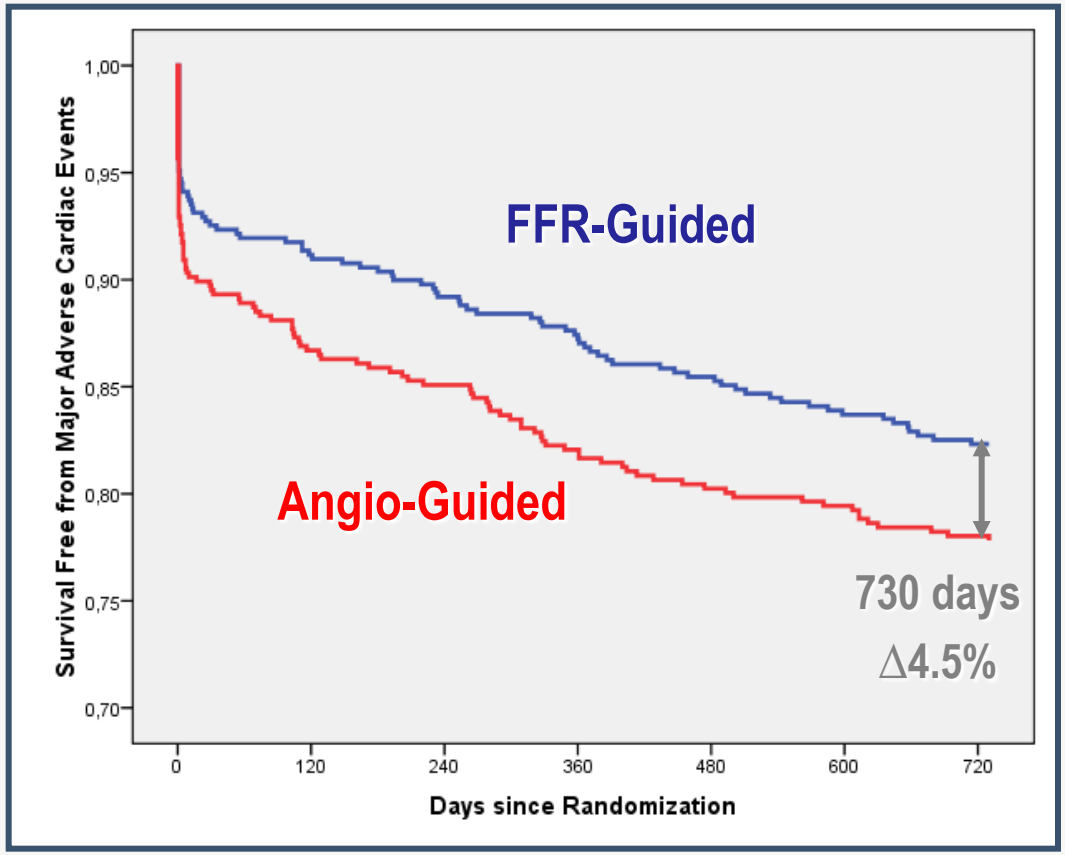
Tonino, et al. NEJM 2009

FAME study: *Procedural Results*

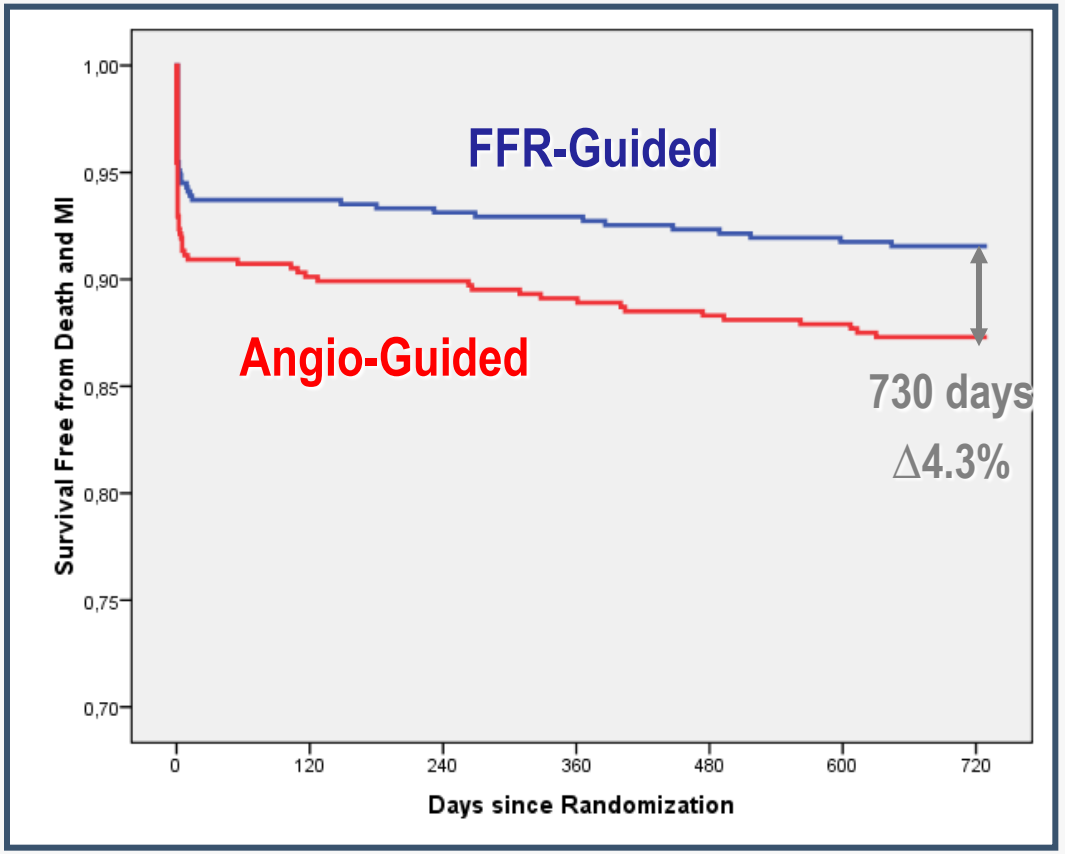
	ANGIO-group N=496	FFR-group N=509	P-value
No of stents per patient	**2.7± 1.2**	**1.9 ± 1.3**	<0.001
Procedure time (min)	**70 ± 44**	**71 ± 43**	0.51
Contrast agent used (ml)	**302 ± 127**	**272 ± 133**	<0.001
Materials used at procedure (US $)	**6007**	**5332**	<0.001

FAME study: 2-year outcomes

2 Year MACE-free Survival



2 Year Death/MI-free Survival

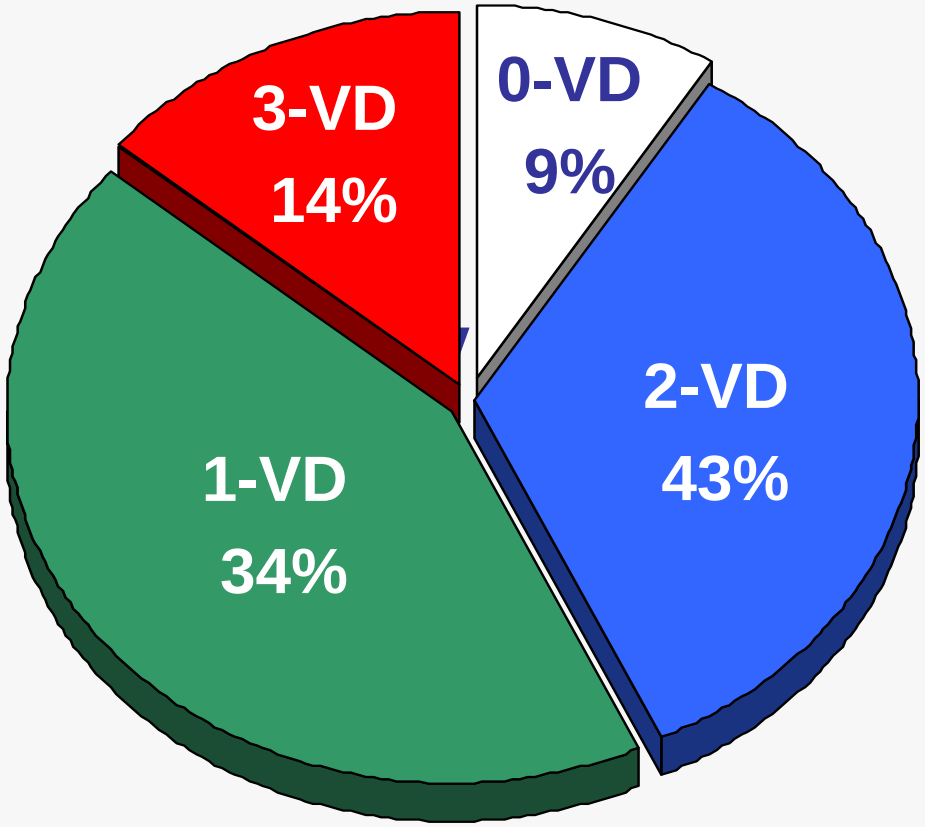


MACE: Death, MI, re-PCI, CABG

Fearon, et al JACC

Inside the hall of "FAME"

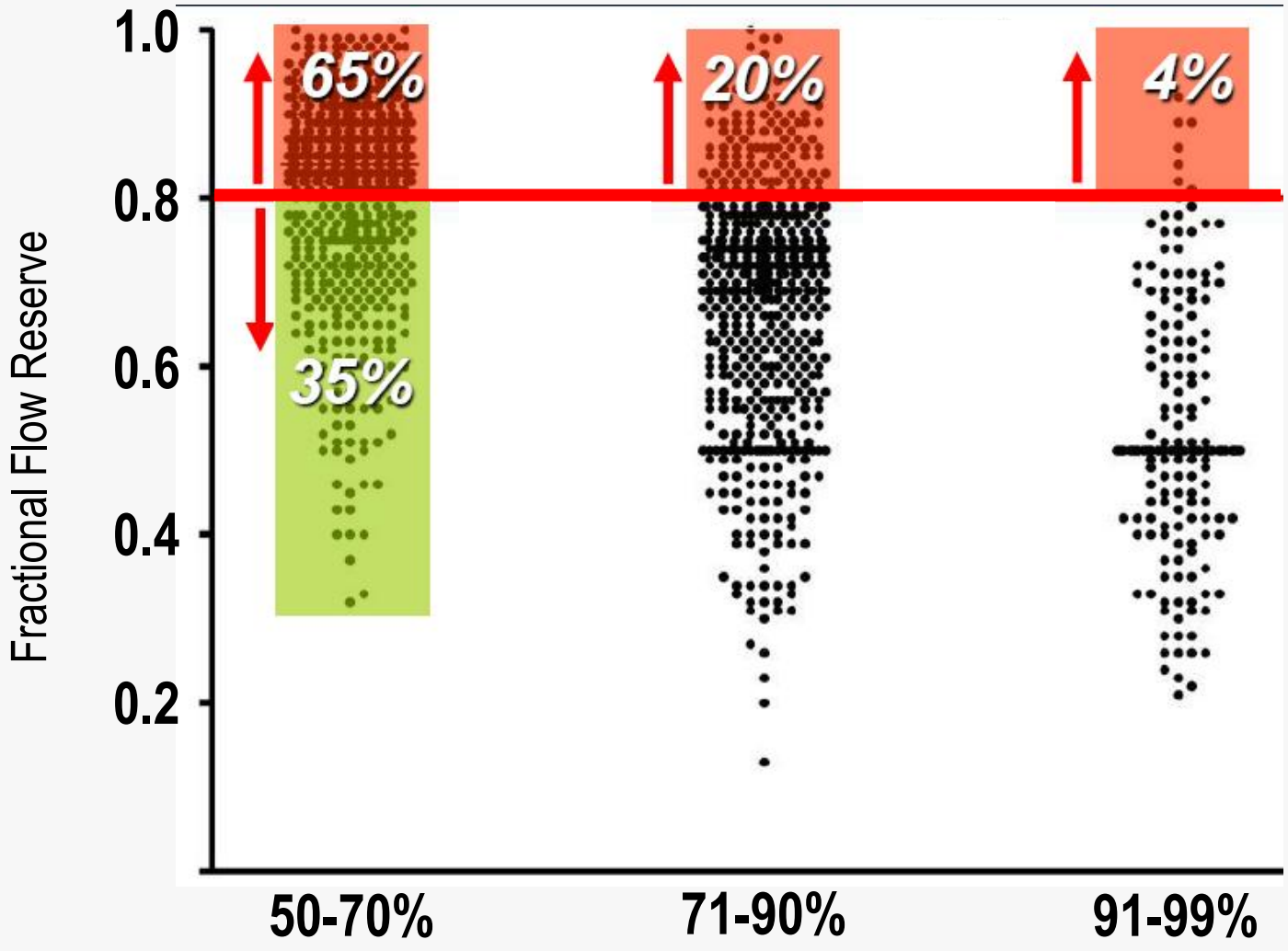
Proportions of functionally diseased coronary arteries in patients with angiographic 3 vessel disease



Tonino JACC 2010

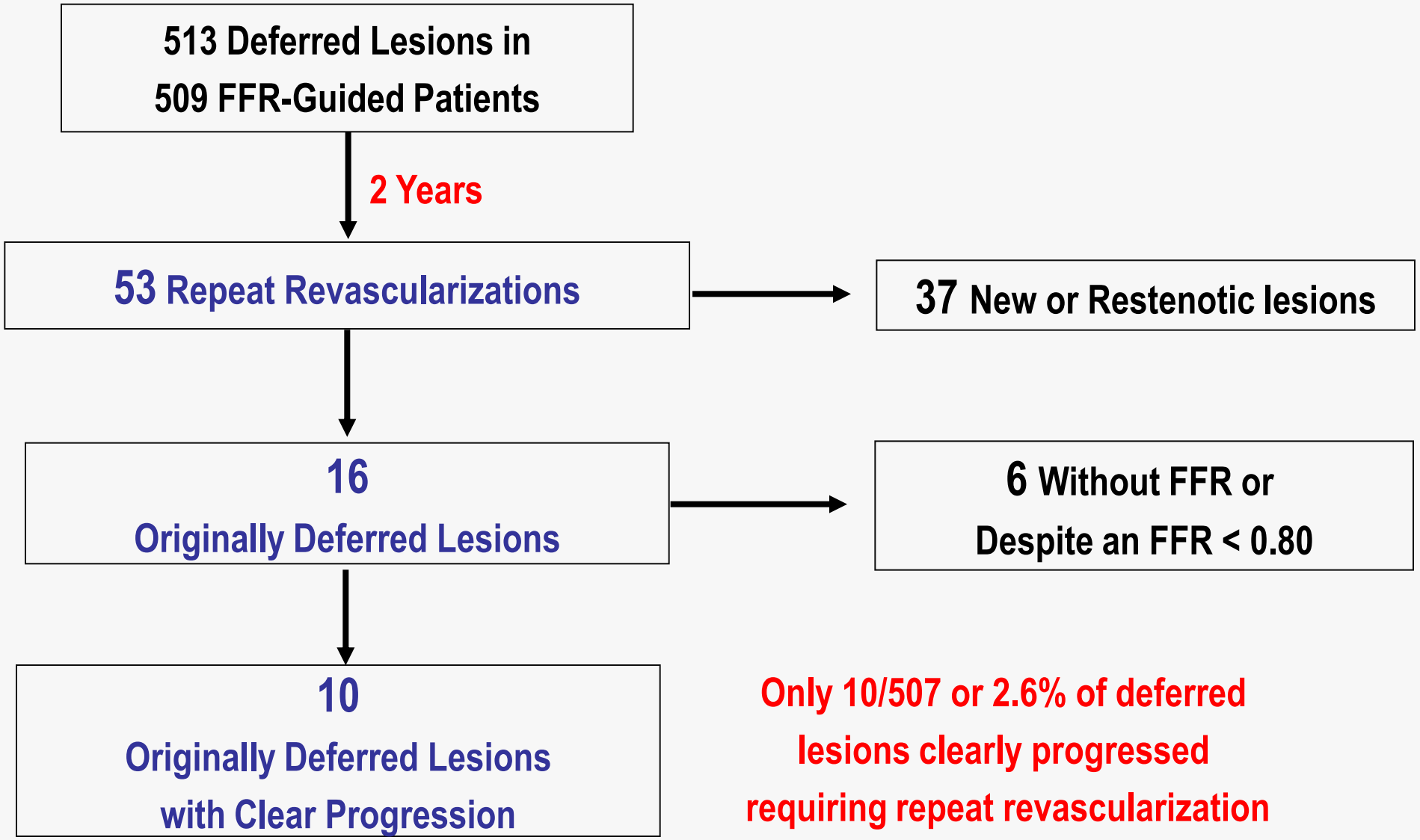
Inside the hall of "FAME"

FFR versus Angiography



Tonino JACC 2010

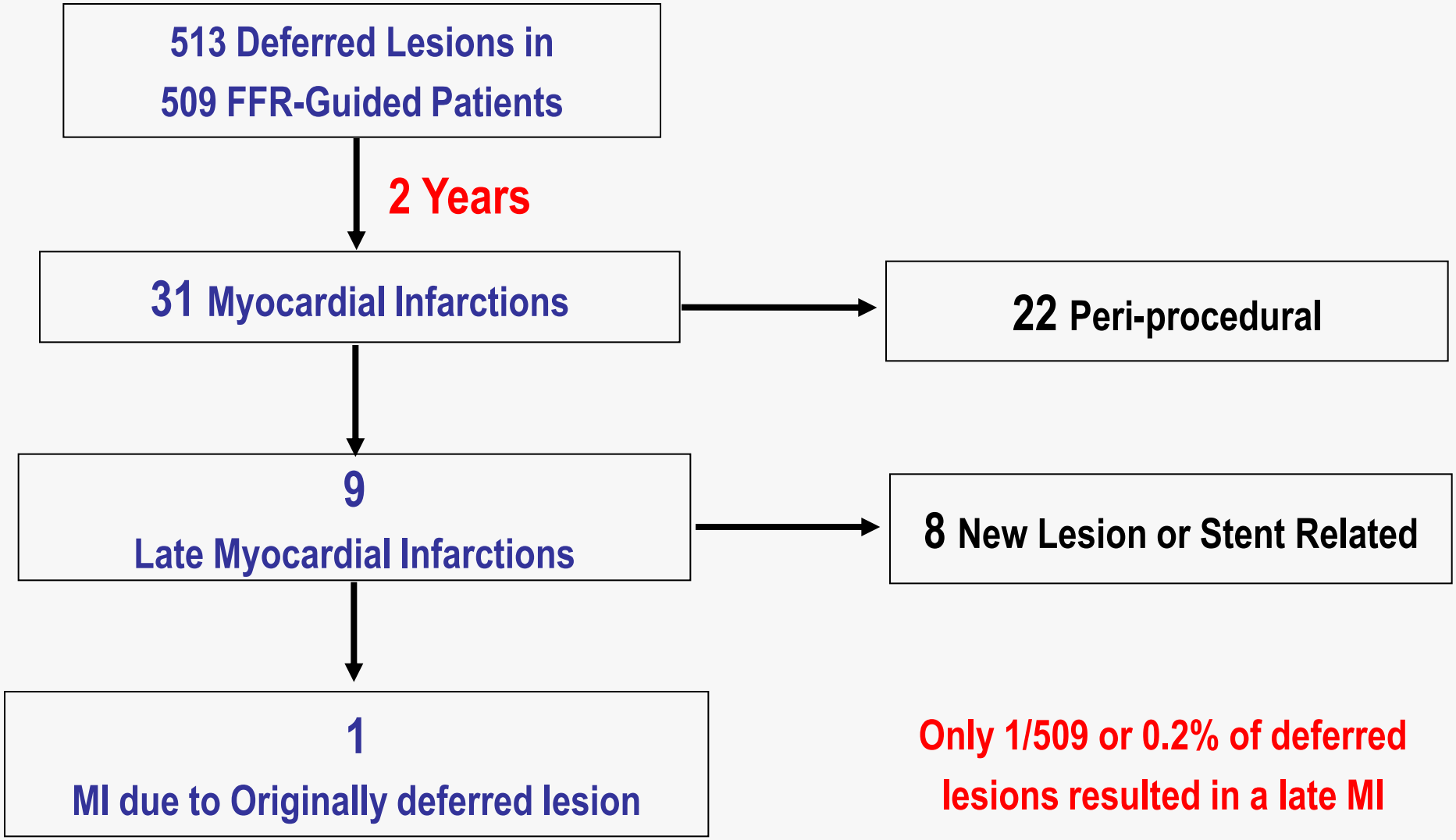
Outcome of Deferred Lesions



Only 10/507 or 2.6% of deferred lesions clearly progressed requiring repeat revascularization

Fearon, et al JACC

Outcome of Deferred Lesions



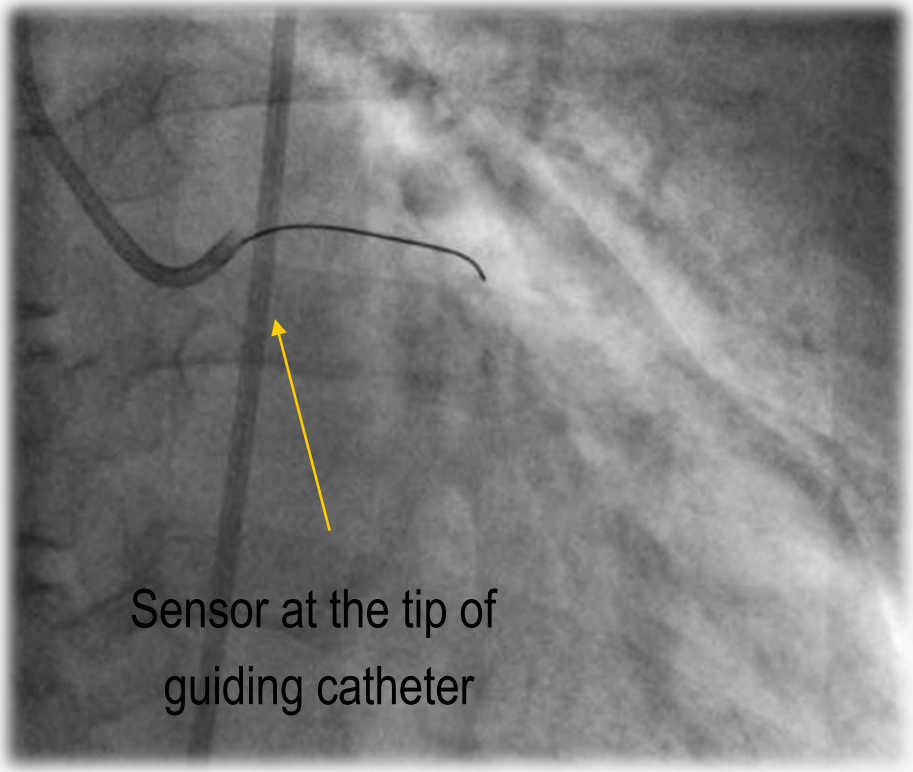
Only 1/509 or 0.2% of deferred lesions resulted in a late MI

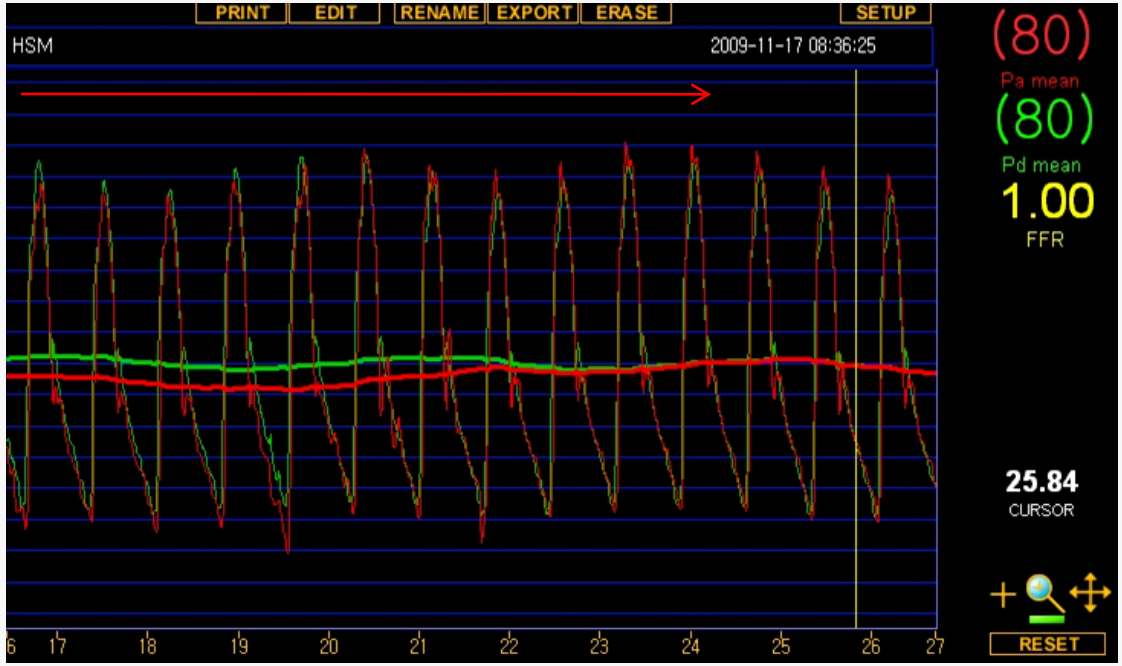
Fearon, et al JACC

There seems to be many false (+)/false(–) FFR cases…

Pitfalls with FFR measurements

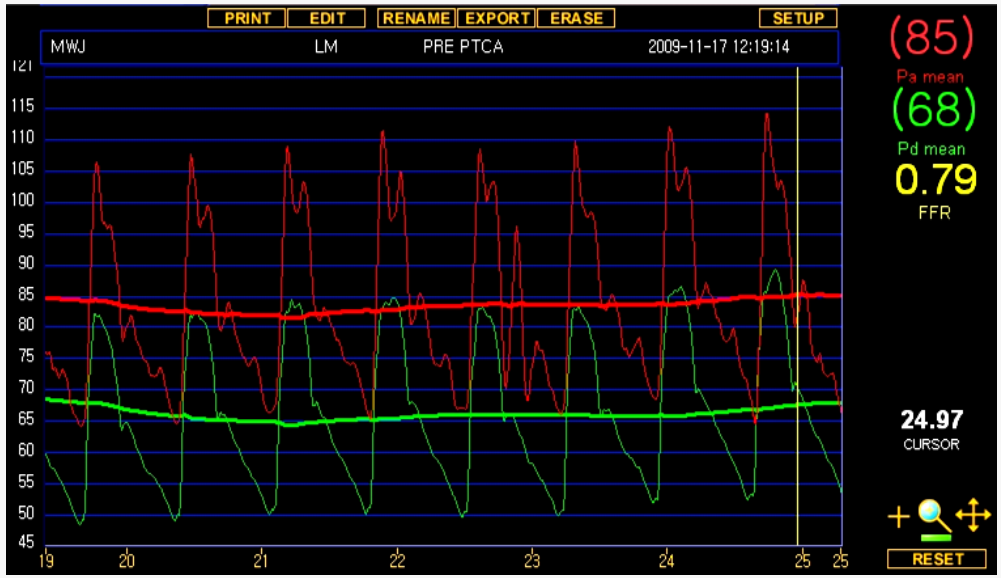
Equalization between aorta and sensor pressures

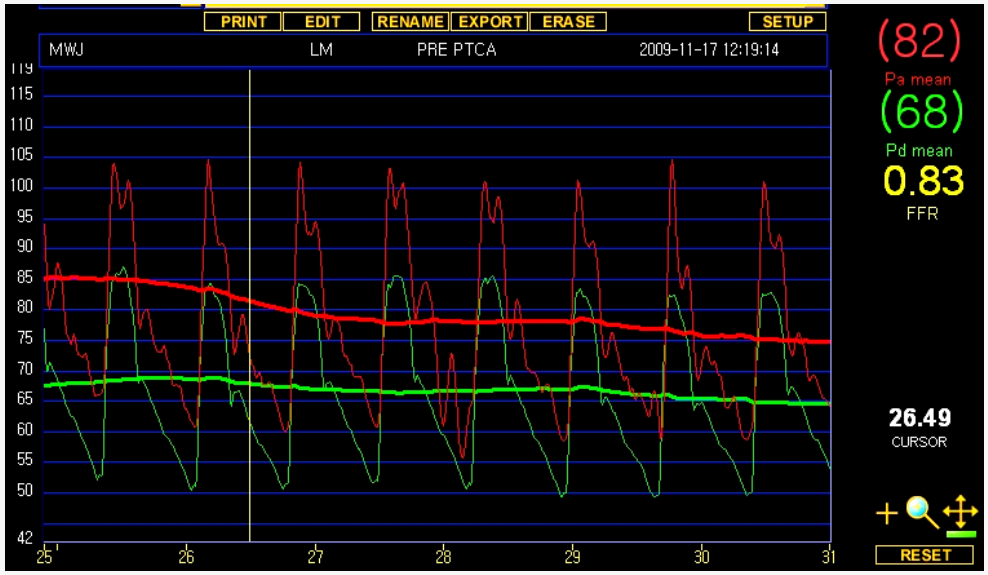


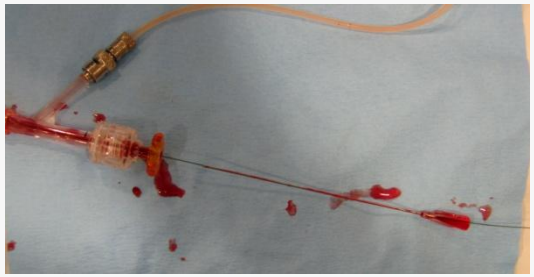


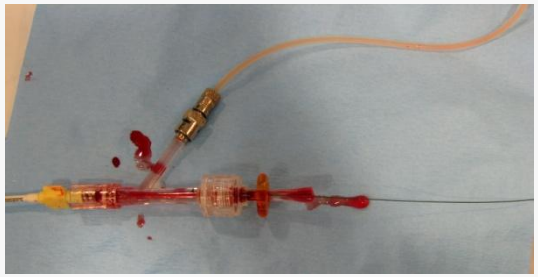
Don’t equalise with an **“INTRODUCER”** in place

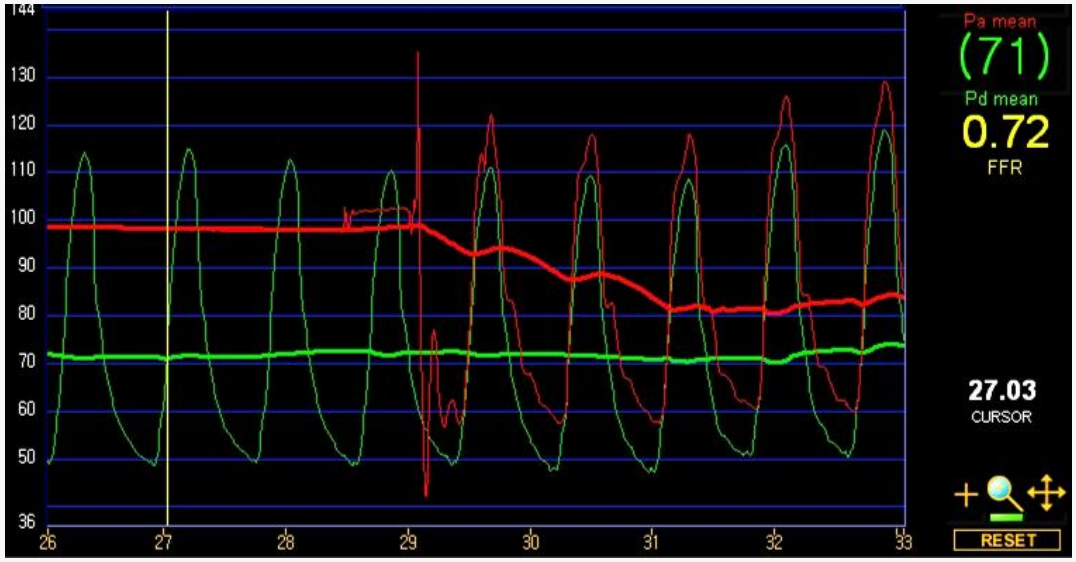
Don’t measure FFR with an “**INTRODUCER**” in place



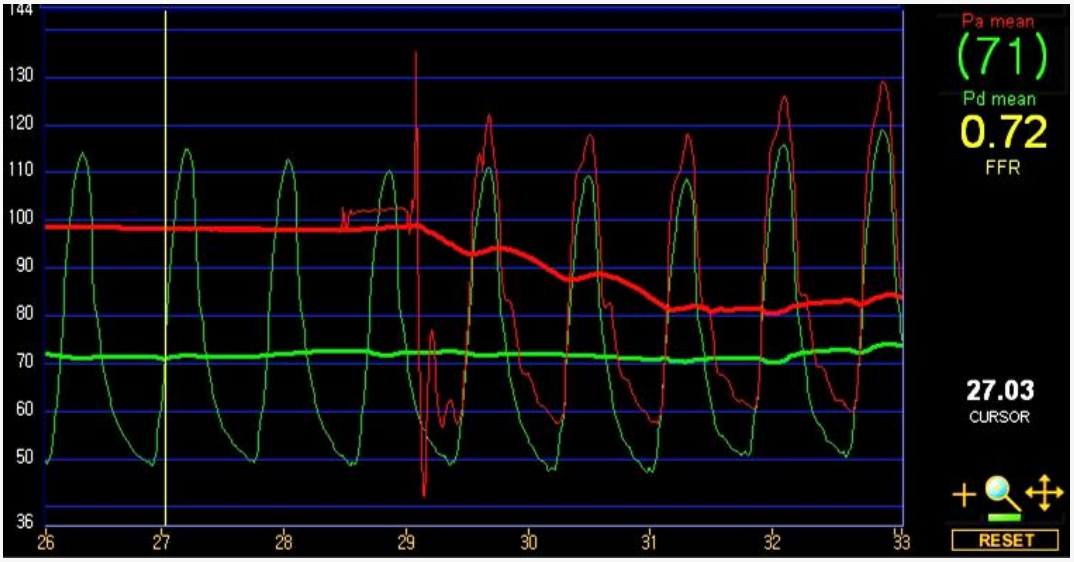


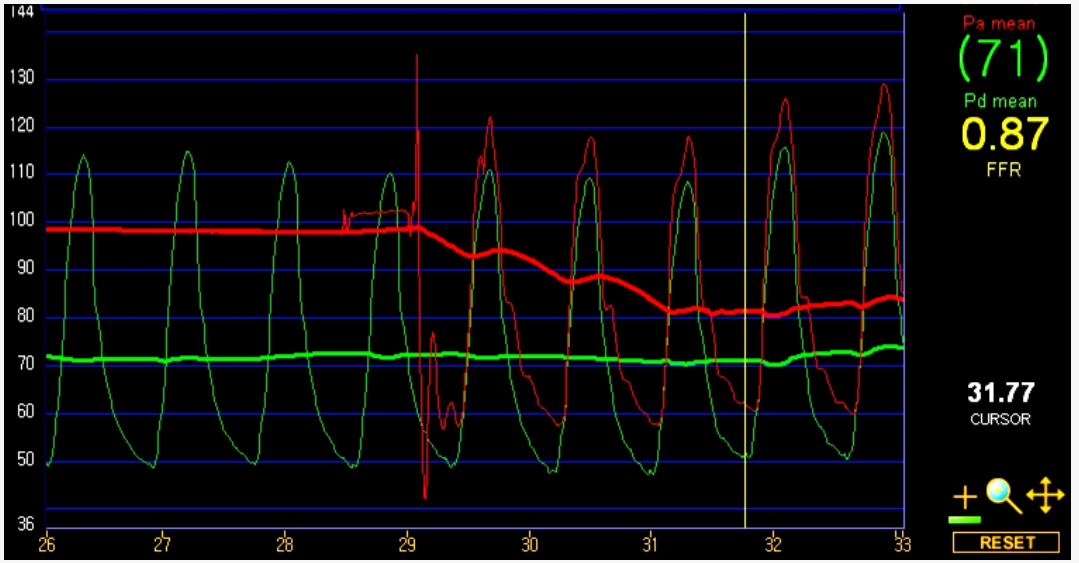


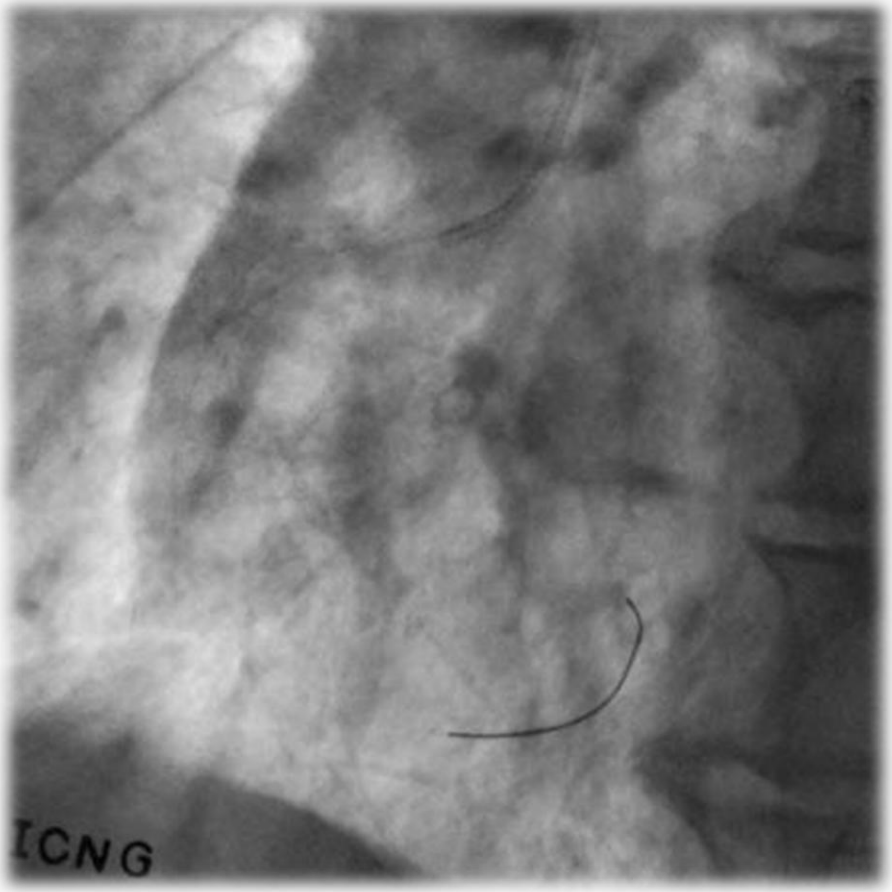



144
130
120
110
100
90
80
70
60
50
36
26
27
28
29
30
31
32
33
Pa mean
(71)
Pd mean
0.72
FFR
27.03
CURSOR
RESET

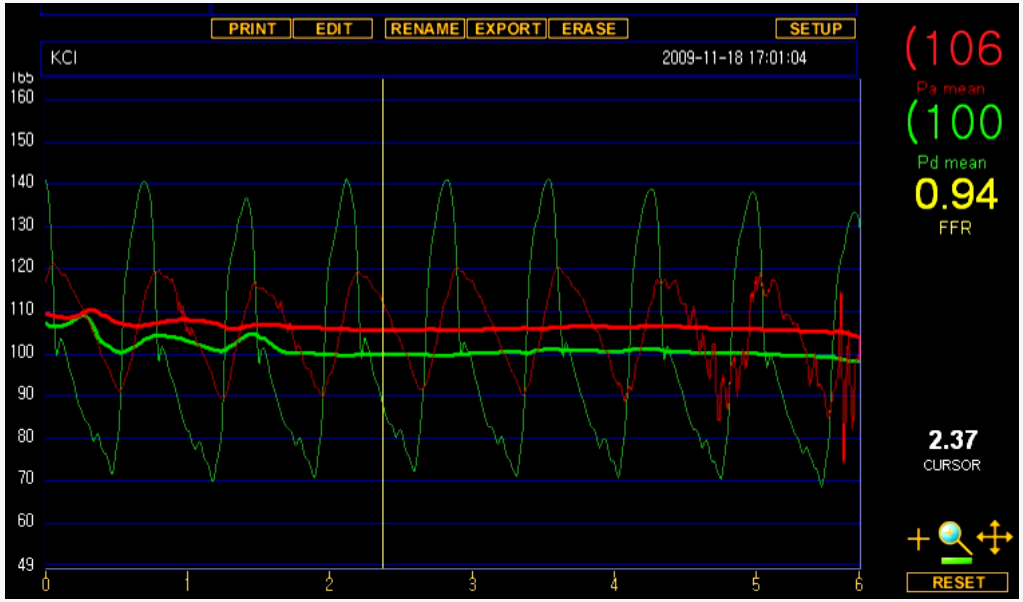
Check the **“CURSOR”** location





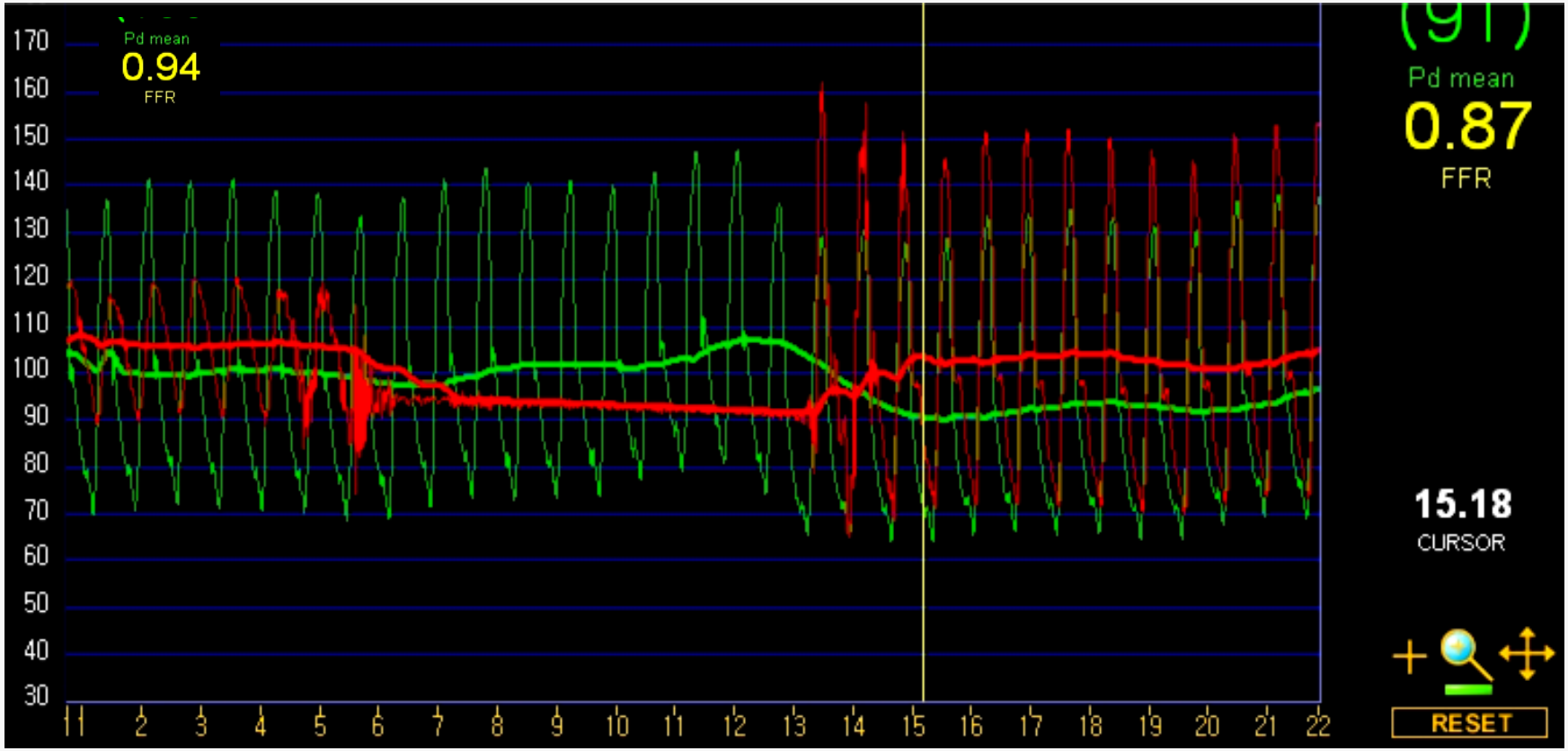


5 Fr guiding catheter, radial approach

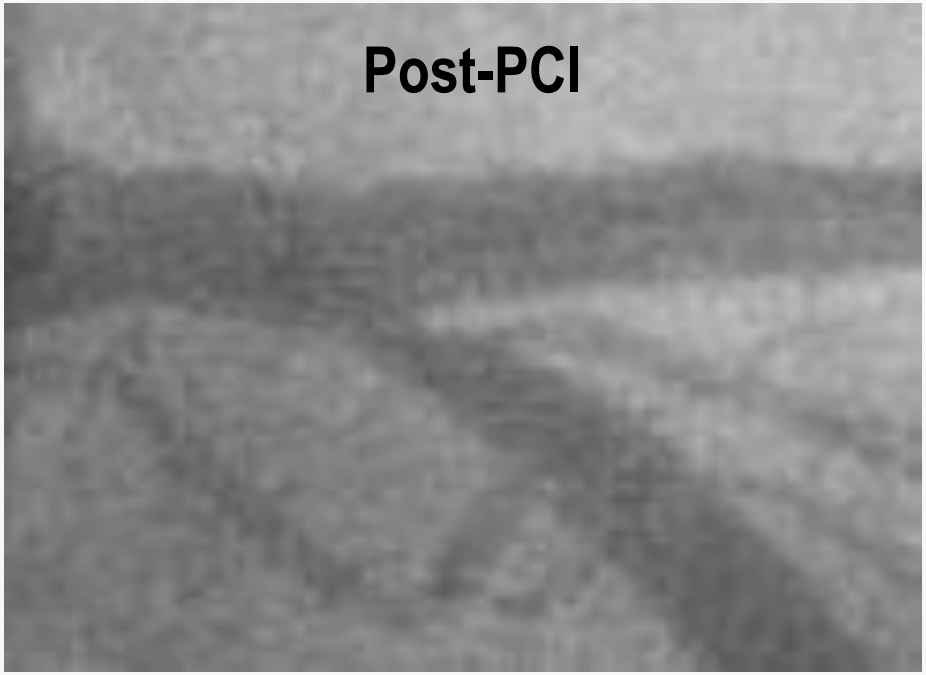


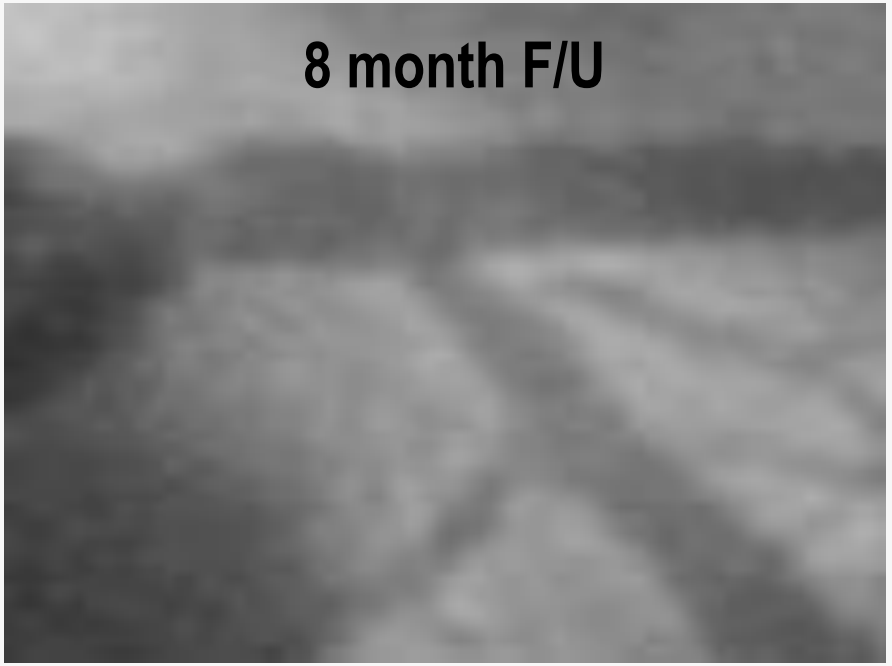
Hyperemia: IV adenosine infusion

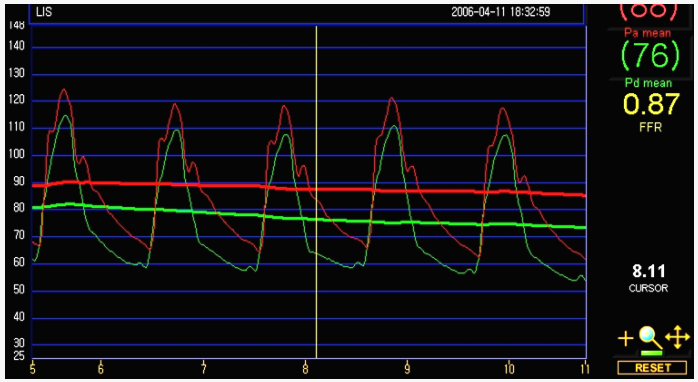
“**FLUSH**” the guiding catheter

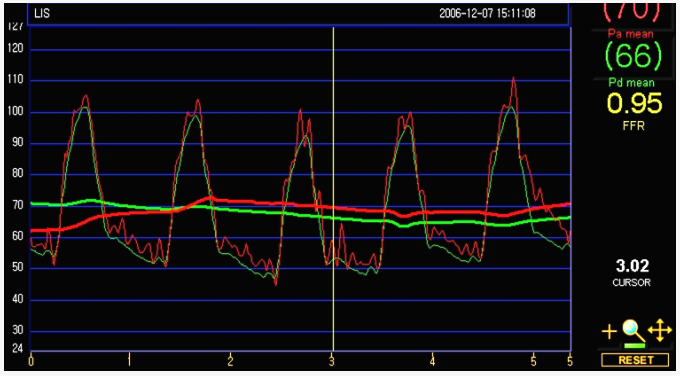


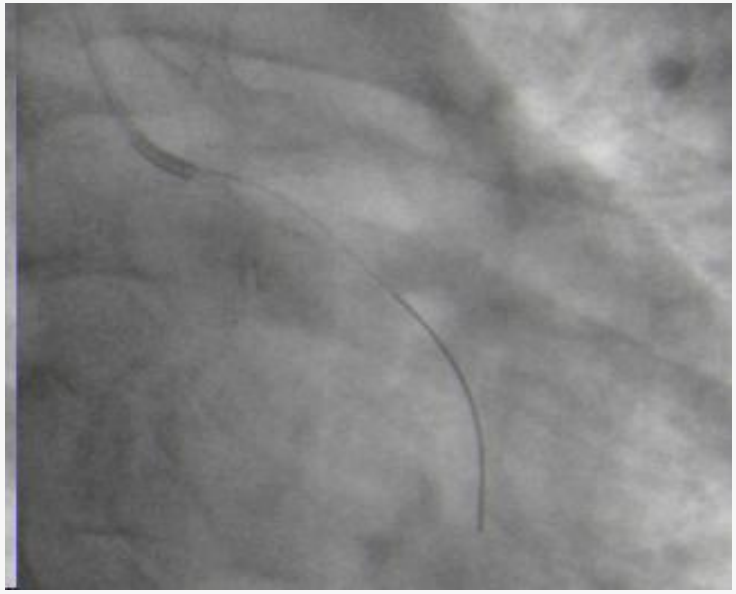
Check the shape of “**PRESSURE CURVE**”

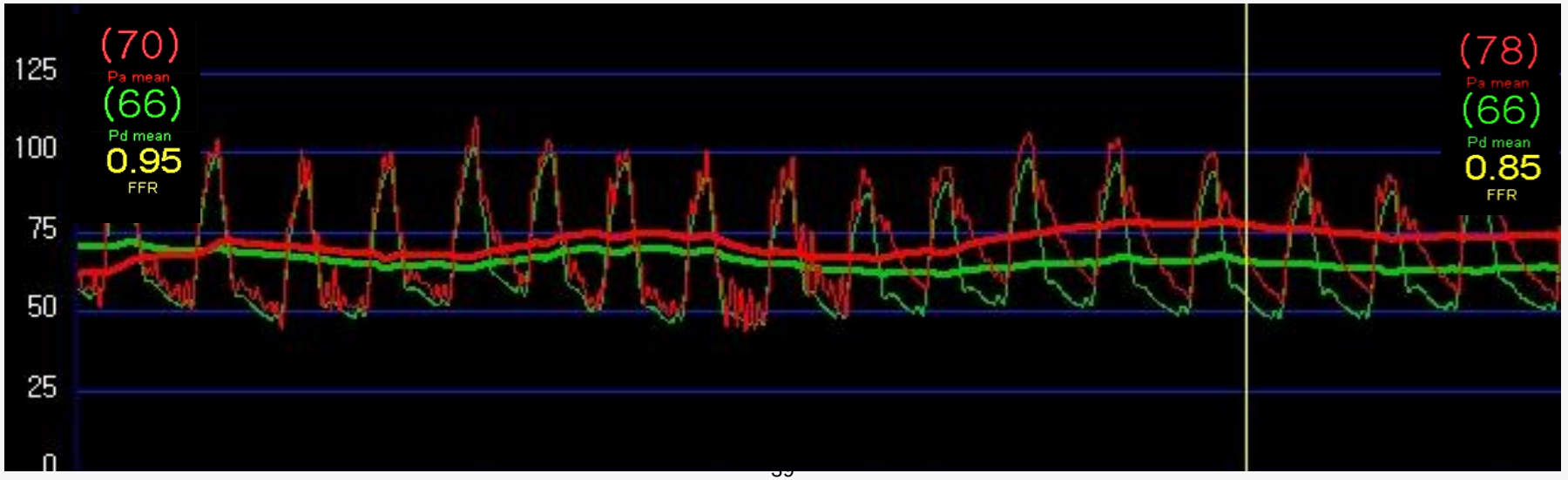


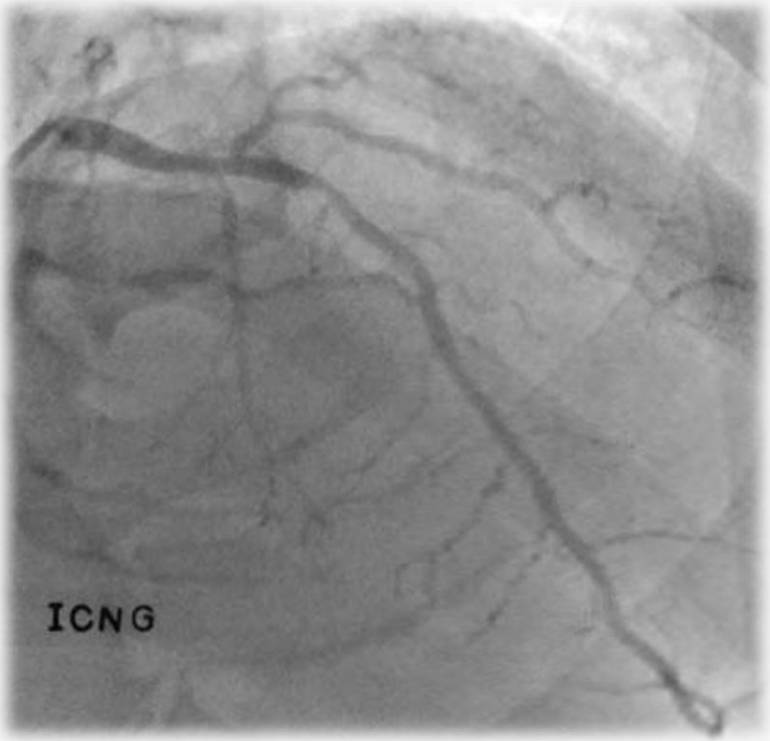


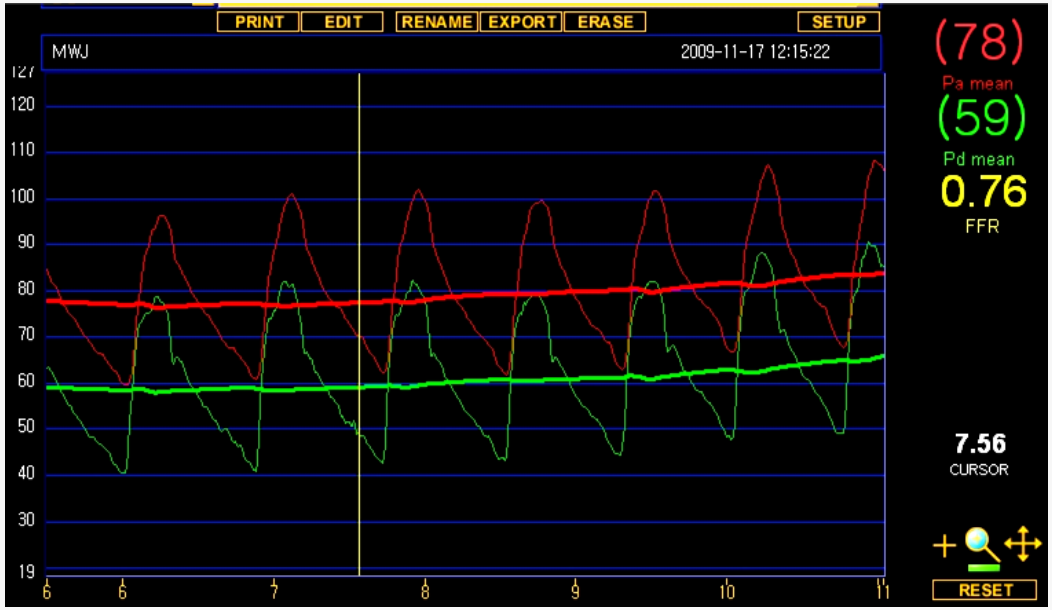


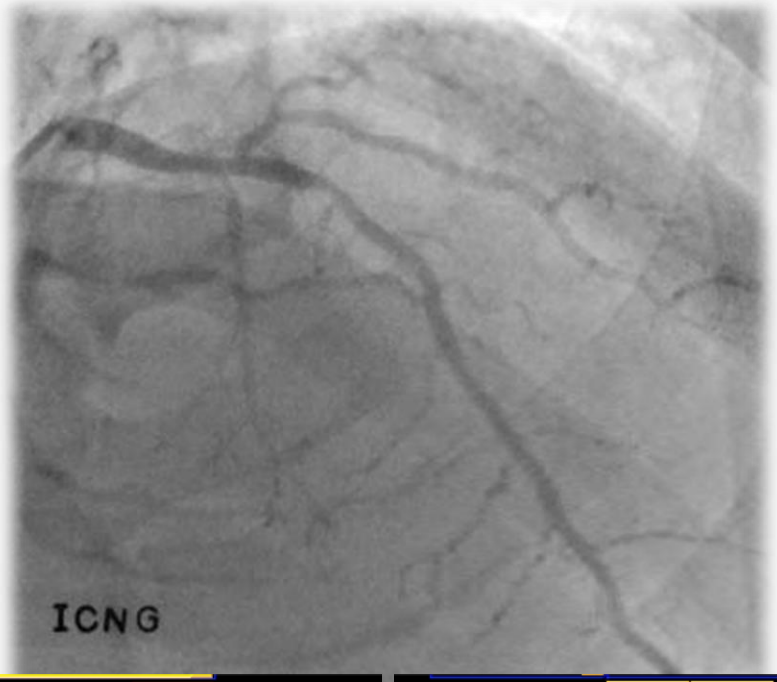




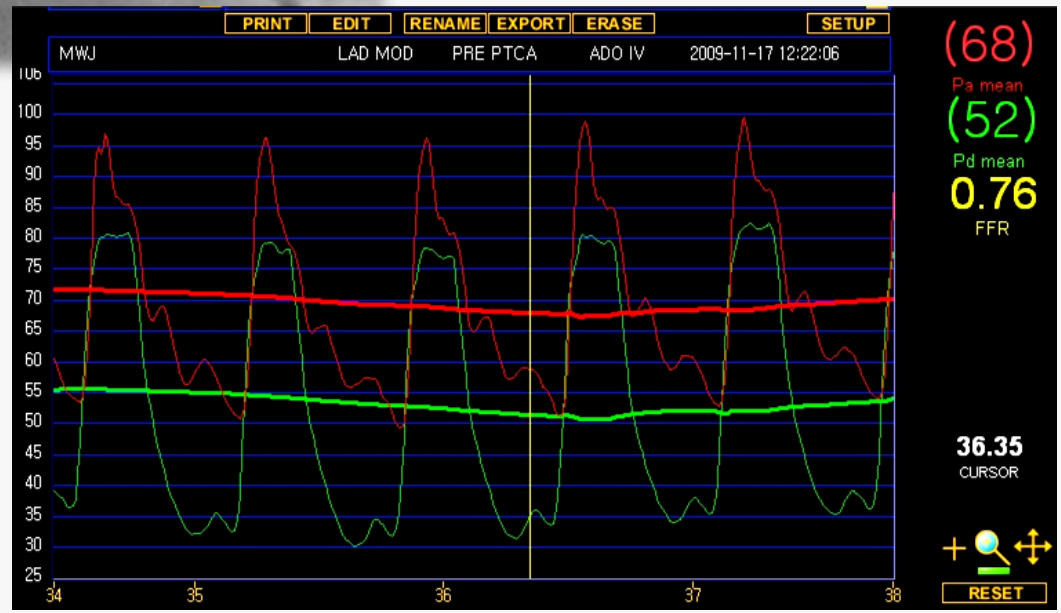

(70)
Pa mean
(66)
Pd mean
0.95
FFR
125
100
75
50
25
0
(78)
Pa mean
(66)
Pd mean
0.85
FFR


ICNG

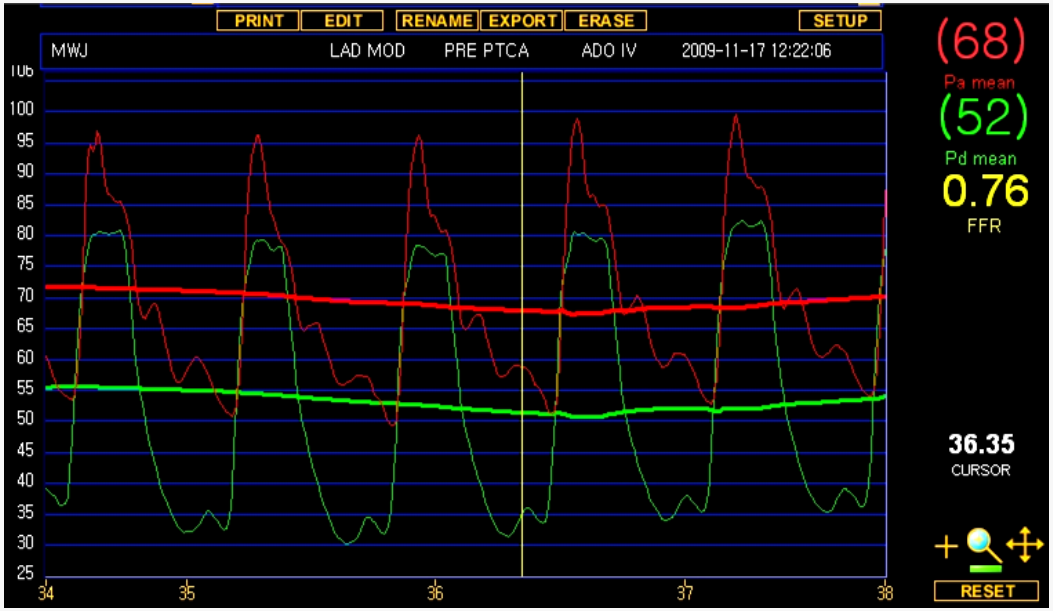

PRINT
EDIT
RENAME
EXPORT
ERASE
SETUP
MWJ
2009-11-17 12:15:22
120
110
100
90
80
70
60
50
40
30
19
6
6
7
8
9
10
11
(78)
Pa mean
(59)
Pd mean
0.76
FFR
7.56
CURSOR
RESET


ICNG

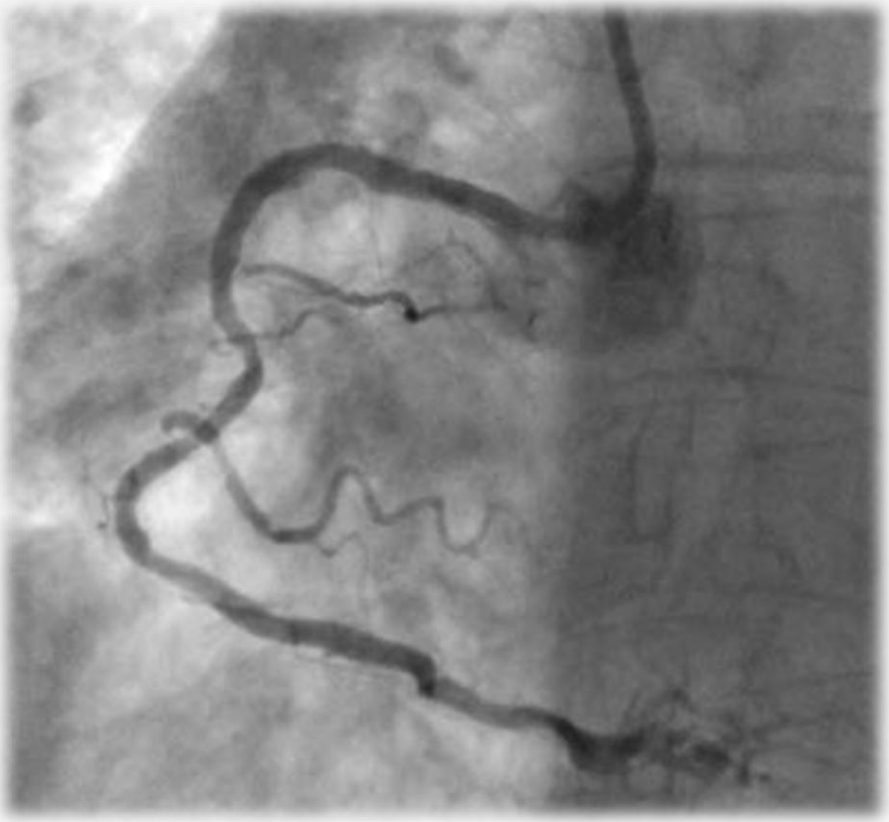

PRINT
EDIT
RENAME
EXPORT
ERASE
SETUP
MWJ
2009-11-17 12:15:22
(78)
Pa mean
(59)
Pd mean
0.76
FFR
7.56
CURSOR
RESET

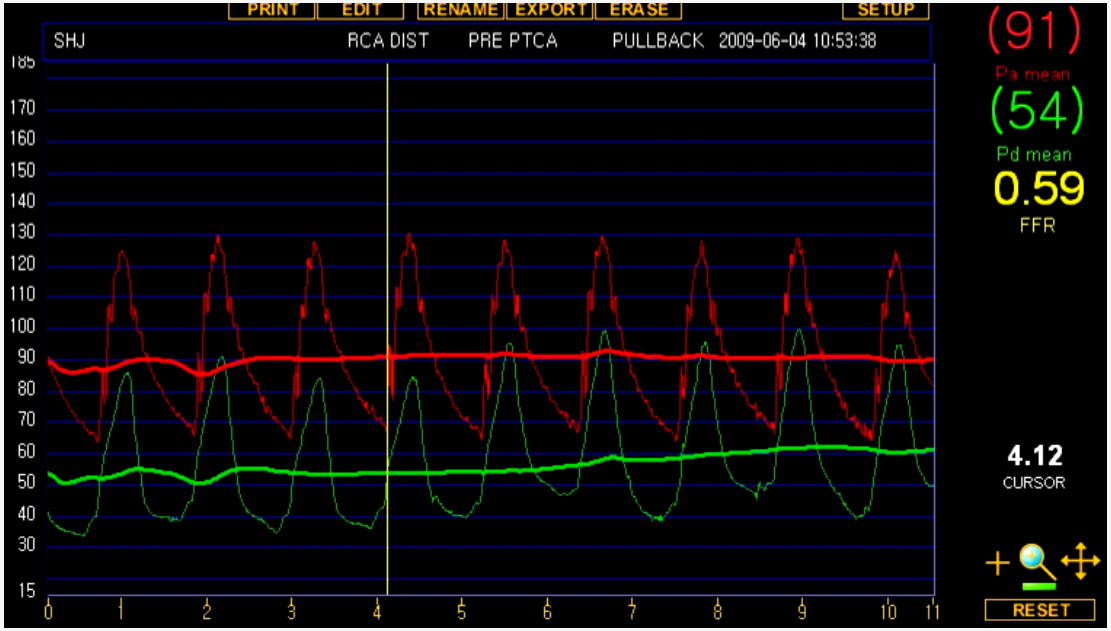

PRINT
EDIT
RENAME
EXPORT
ERASE
SETUP
MWJ
LAD MOD
PRE PTCA
ADO IV
2009-11-17 12:22:06
(68)
Pa mean
(52)
Pd mean
0.76
FFR
36.35
CURSOR
RESET

Artificial gradient due to **“DRIFT”**

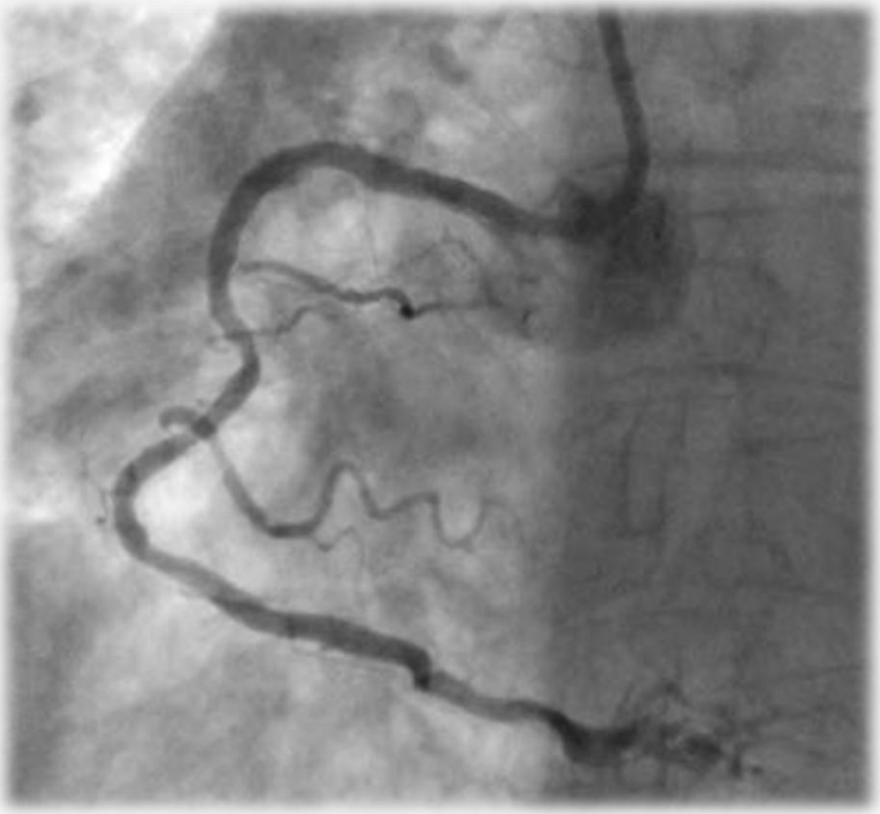


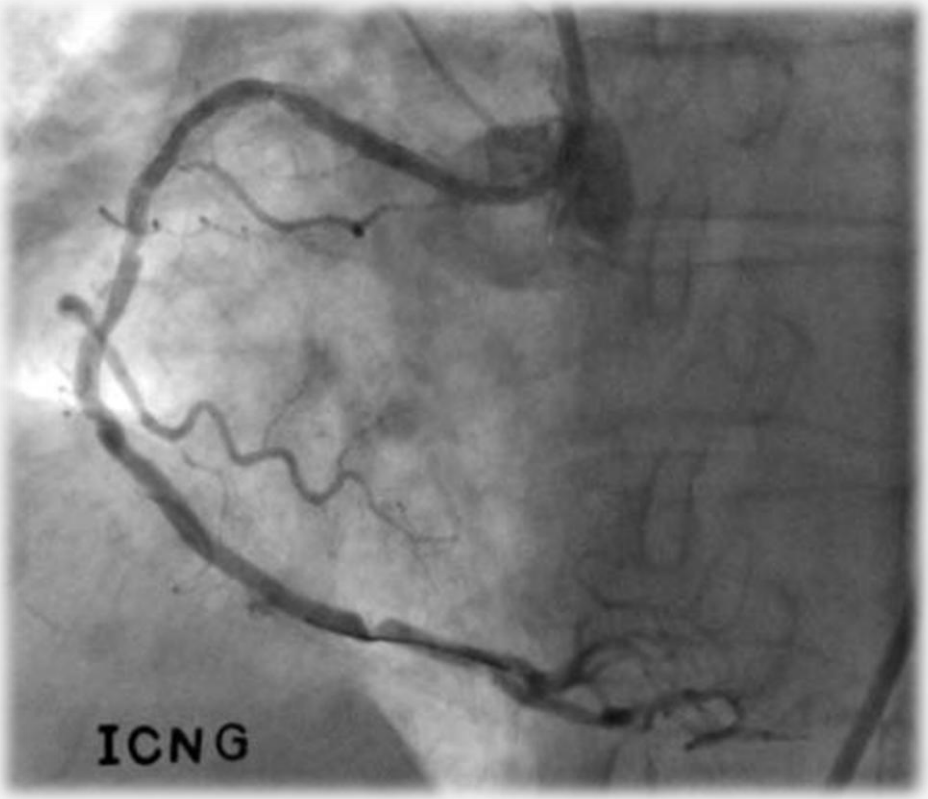
- Shape of pressure curve: Identical
- Aortic notch in the distal curve +
- If drift is suspected “re-equalisation” is necessary.




PRINT
EDIT
RENAME
EXPORT
ERASE
SETUP
SHJ
RCA DIST
PRE PTCA
PULLBACK
2009-06-04 10:53:38
185
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
15
0
1
2
3
4
5
6
7
8
9
10
11
(91)
Pa mean
(54)
Pd mean
0.59
FFR
4.12
CURSOR
RESET

Aware of “**Accordion effect**”

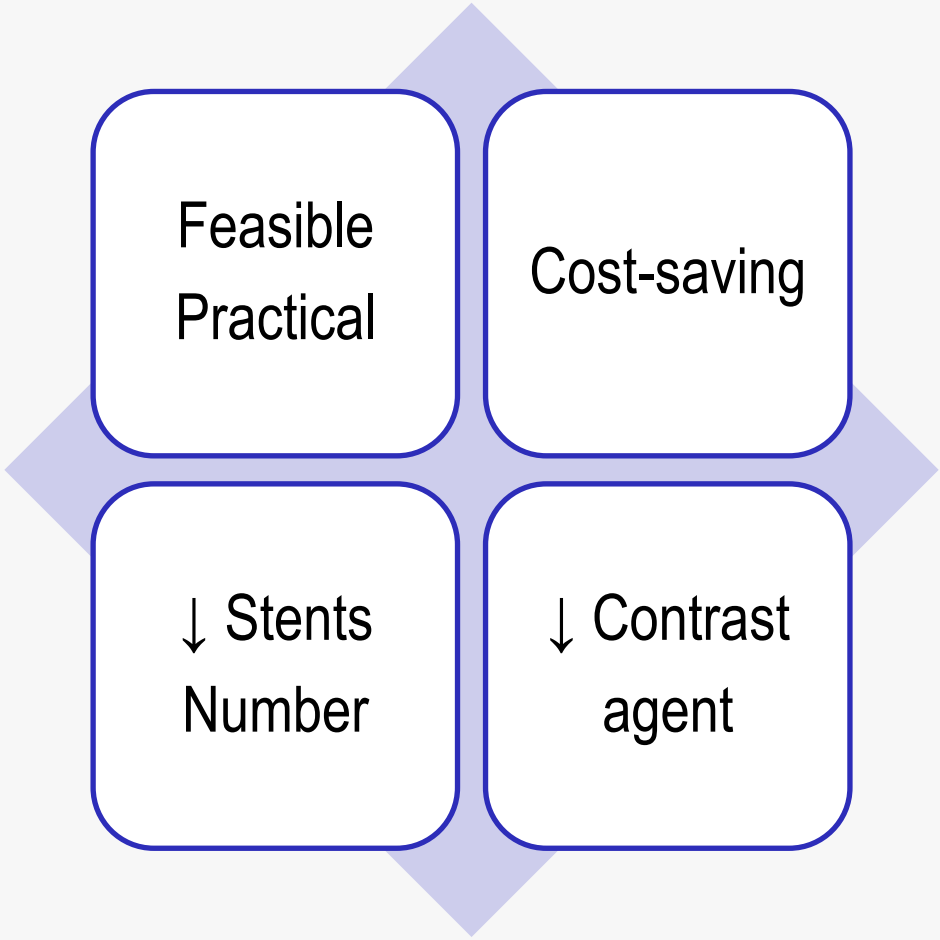




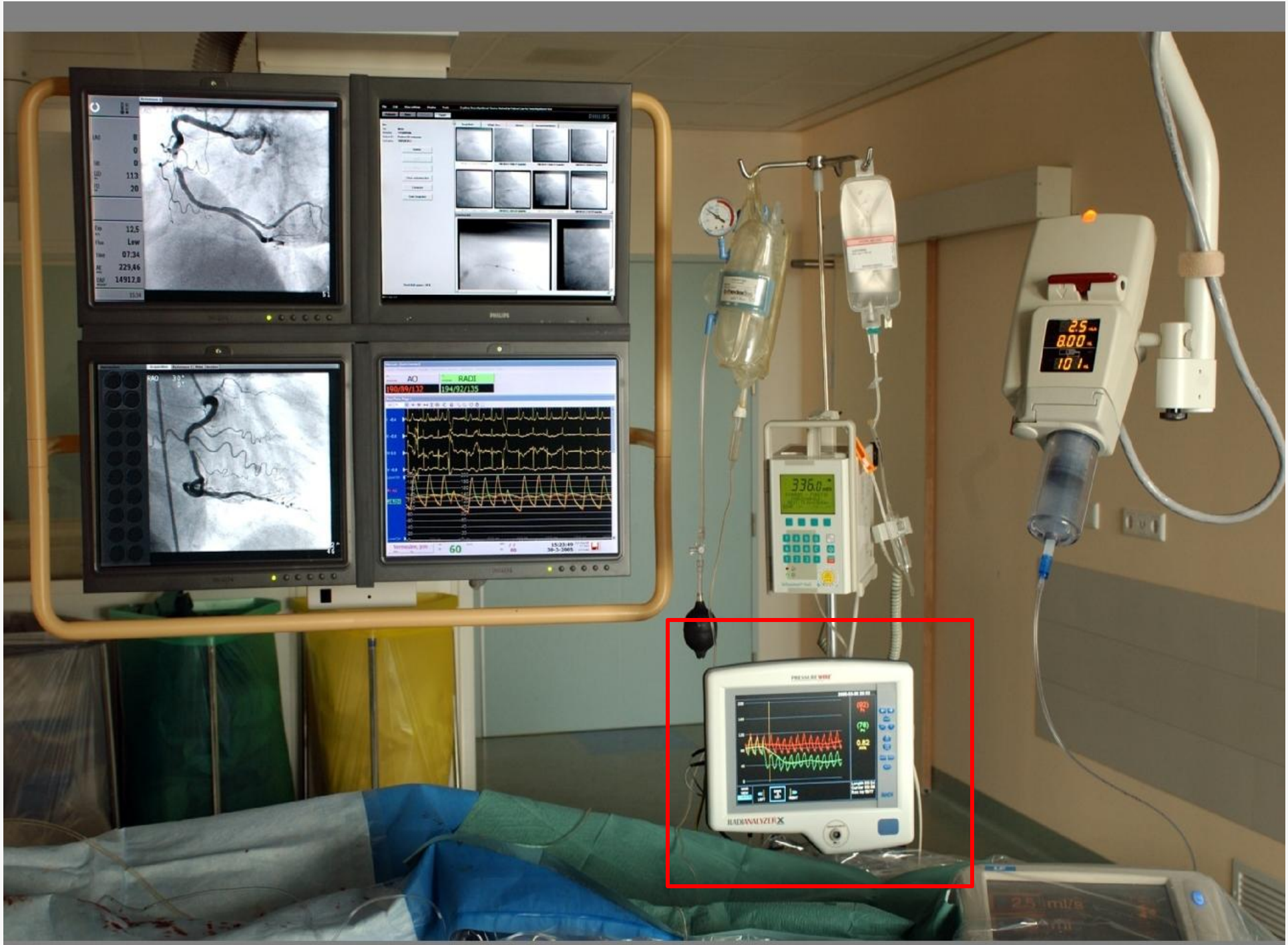
Checklists for possible pitfalls

- Infusion pump or connection site
- Introducer in place?
- Check the cursor location
- Check the shape of pressure curves
- Guide catheter problem
  - Side-holes
  - Flush
  - Disengage during recording
- Drift
  - Re-equalise
- Spasm/Accordion effects

Coronary revascularization by FFR



Reduce unnecessary PCIs and related complications!


AO
RADI
60
RADIANALYZER X