# FRACTIONAL FLOW RESERVE USE IN THE CATH LAB

# BECAUSE ANGIOGRAPHY ALONE IS NOT ENOUGH!!!!!!!

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# Implementing FFR

- Interventional cardiologist's job is to diagnose and treat ischemic stenoses in major epicardial vessels
- It is often difficult to tell the physiologic severity of a stenosis on an angiogram
- We should be treating only the significant stenoses with PCI
- Stenting a stenosis that is non-ischemic does not help a patient
- We do not "cure" CAD, but we hope that we alter the slope of our patients decline in a positive way.

# Why learn to measure FFR?

- "Stress test" in the Cath Lab that tells you the physiologic significance of a coronary stenosis quickly and accurately
- Significant % of stenoses of intermediate severity.
- You can diagnose significant lesions that don't look severe angiographically.
- You can avoid getting yourself into PCIs you wish you hadn't started.
- You can evaluate your result after stenting.
- Pre and Post FFR can be measured with the wire used to deliver the stent.

# Three subsets of patients where having FFR capability changes things

- Borderline/moderate stenoses, especially in the proximal LAD
- Diffusely diseased arteries
- Multi-vessel disease

***It's difficult to do these kinds of cases confidently without FFR***

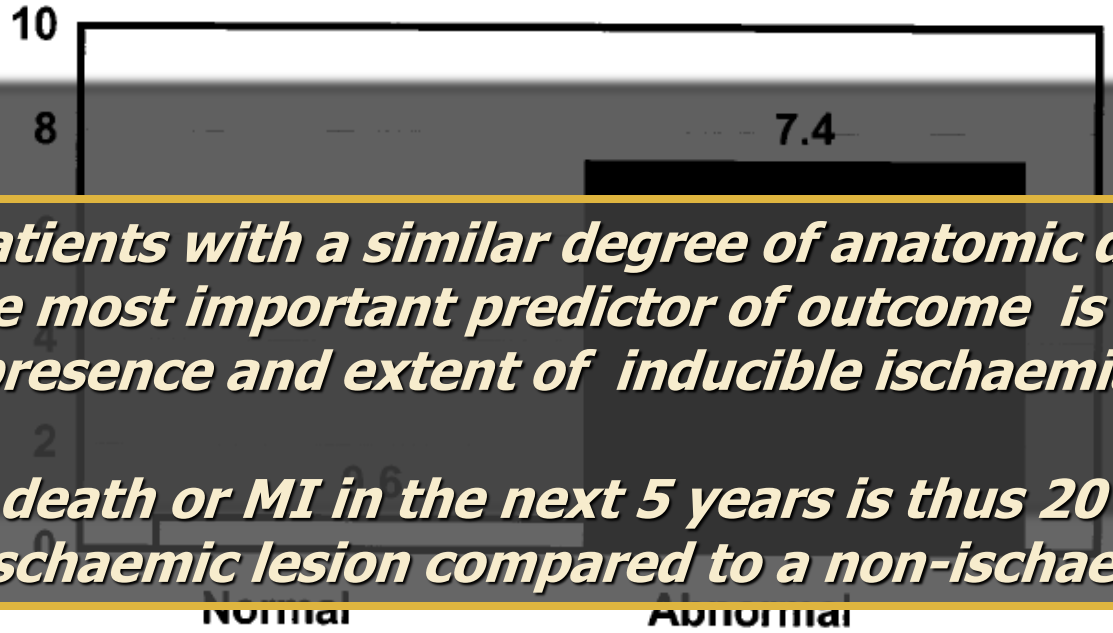
# #1 Fundamental Interventional Truth That Drives the Concept of FFR

*Lesions causing ischaemia are prognostically important.....*
*There is no benefit to treating lesions without ischaemia*

**Risk assessment using single-photon emission computed tomographic technetium-99m sestamibi imaging**

Sherif Iskander, and Ami E. Iskandrian

*J. Am. Coll. Cardiol.* 1998;32;57-62




***"In patients with a similar degree of anatomic disease the most important predictor of outcome is the presence and extent of inducible ischaemia"***

***The risk for death or MI in the next 5 years is thus 20 times higher for an ischaemic lesion compared to a non-ischaemic one***

**Figure 1.** Rate of hard cardiac events (death or nonfatal MI) in patients with normal and abnormal stress SPECT images.

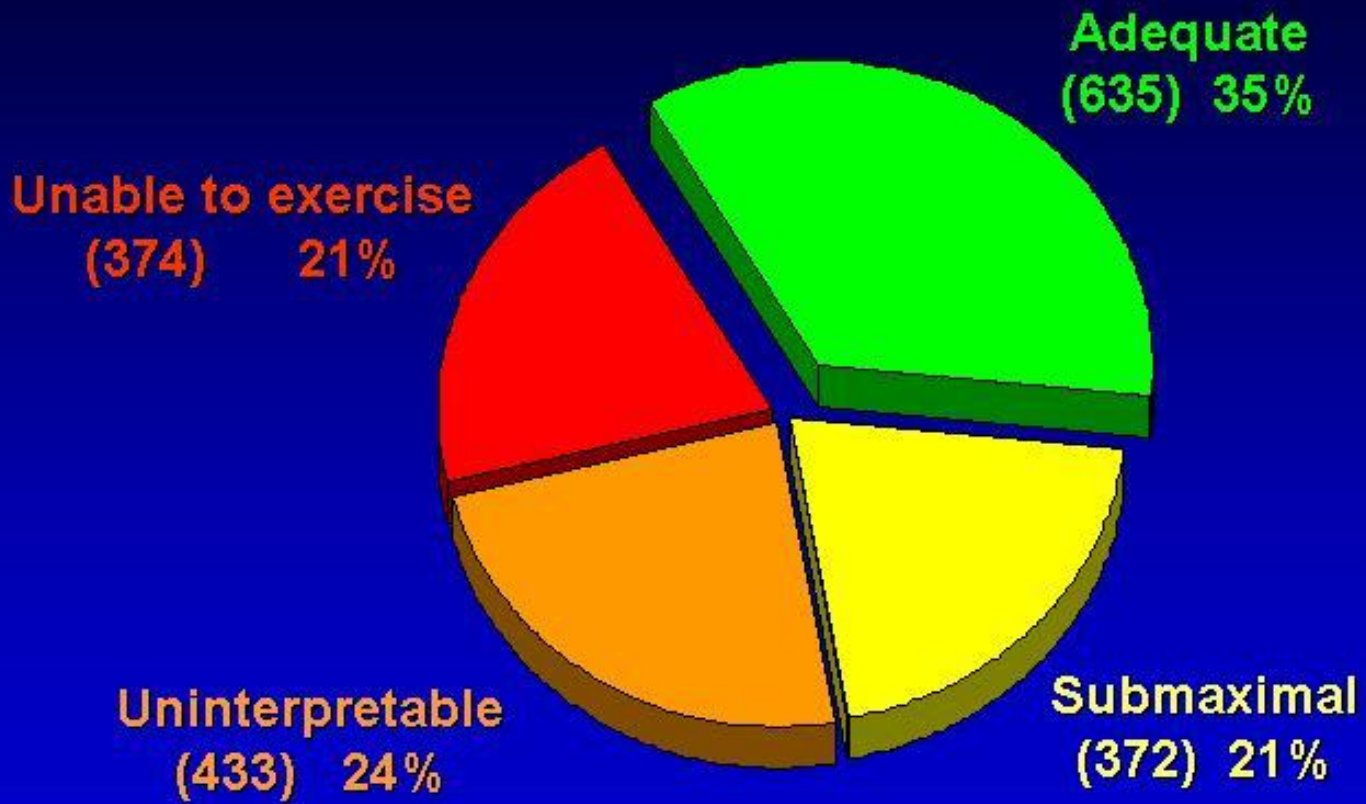
***12000 patients with similar coronary stenosis severity at angio***

*Fundamental Truth #2:*

***If ischaemia, rather than anatomy, is what you are interested in then:***

## ⑩Current Non Invasive Tests Have Disadvantages

# Proportion of Patients with Adequate Exercise ECG (n=1814)




*Thomas H. Marwick et al. 1994*

# So.....

- ✓ *We need a test that will direct us to what needs revasc and what doesn't*
- ✓ *We need a definitive test for ischaemia at the time of angiography to make a diagnosis*
- ✓ *We need a test that will tell us when we have succeeded*

# Incorporating Physiology

# What is Maximal Hyperemia?

**Maximal Hyperemia**

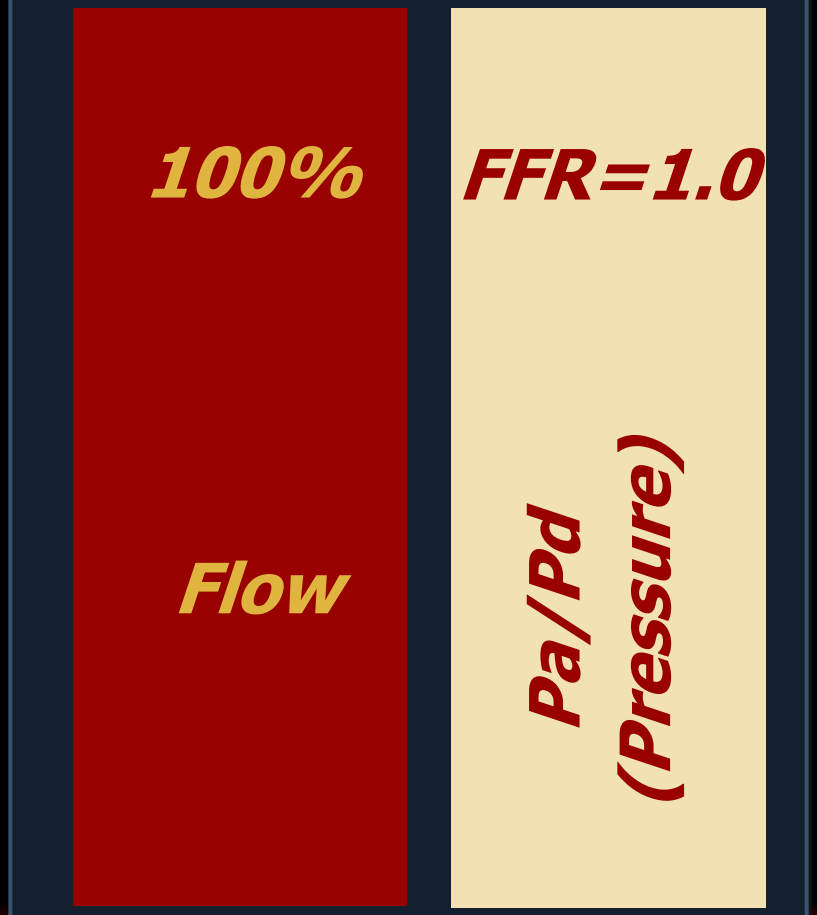
**Means**

**Maximal Vasodilation**

***or***

**Maximal Possible Blood-Flow to the Myocardium**

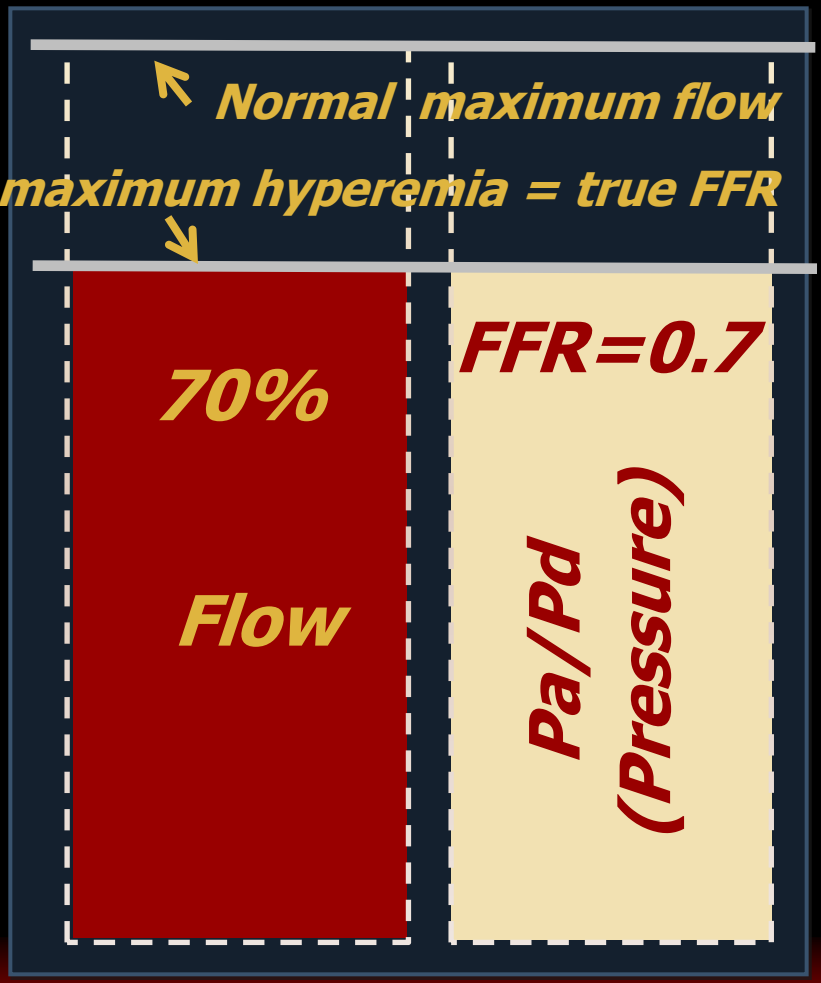
# Flow-Pressure Relationship




- *We are measuring coronary pressure to measure coronary flow*
- *It is at the point of maximal hyperemia that FFR is proportional to blood flow*
- *At this point further blood flow is impossible, thus 100% flow = FFR 1.0*

# Flow-Pressure Relationship

## *Significant Coronary Stenosis*




- *With a stenosis, maximal blood flow is lower despite maximal stimulation of the microvasculature - in this case only reaching 70% compared to normal*
- *The corresponding Pd/Pa pressure will therefore be proportional to the flow at this new point*
- *70% blood flow is proportional to FFR=0.70*

# Pharmacologic Hyperemic Stimuli
## *Intravenous Adenosine Infusion*

- Current gold standard for FFR measurement
- Hyperemia mediated via A2 receptor on cell membrane on resistance vessels
- Exogenously administered adenosine causes profound microvascular dilation
- Hyperemia is independent of metabolic demand
- Produces “steady-state” hyperemia

# Intravenous Adenosine

## *Dose: 140 mcg/Kg/min*

| Effects | |
|---|---|
| Peak Effect | <2 min |
| Duration of Effect | Within 2 min after D/C |
| Side Effects | |
| AV Block | rare |
| Do NOT use in pts. with Asthma/COPD | Bronchospasm |
| ↓BP and ↑HR | Usually 10-20% |
| Burning sensation in chest | Harmless, not ischemia, resolves within few min. |

# Intravenous Adenosine
## *Give IC NTG prior to Measurement*

| Advantages | |
|---|---|
| Steady State Hyperemia | Pullback curve |
| Measurement of CFR possible | Assessment of Microvascular Disease |
| **Limitations** | |
| Infusion in Femoral Vein | Large cubital vein alternative |
| High-Volume Infusion Pump Required | Inadequate infusion leads to suboptimal hyperemia |
| Setup cumbersome and time consuming | Routine Use Improves Efficiency |

# Intracoronary Adenosine

## *Dose: 40-60 mcg in LCA; 20-40 mcg in RCA*

| Effects | |
|---|---|
| Peak Effect | 10 sec |
| Duration of Effect | 20 sec |
| Side Effects/Precautions | |
| AV Block | Common; Transient |
| Do NOT use Guide with SH | Inadequate Drug Delivery |
| Do NOT use Guide when Pressure Damped | Pa underestimated, FFR ↑ |
| Interruption of Pa as short as possible | If too long, peak hyperemia may be missed |

# Intracoronary Adenosine

## *Give IC NTG prior to Measurement*

| | |
|---|---|
| Advantages | |
| Easy Administration | No IV Setup Required<br>No Central Vein Access |
| Rapid Testing | No Wait for Max. Hyperemia |
| Limitations | |
| Pull-Back Curve not Possible | Hyperemia too Transient |
| Measurement of CFR not Possible | Hyperemia too Transient |
| Dose Escalation Frequently Necessary | Sub-Maximal Hyperemia at Lower Doses |

# Flow Chart


Lesions warranting PCI identified

Randomized

**FFR-Guided**

PCI performed on indicated lesions only if FFR <0.80

**Angio-Guided**

PCI performed on indicated lesions

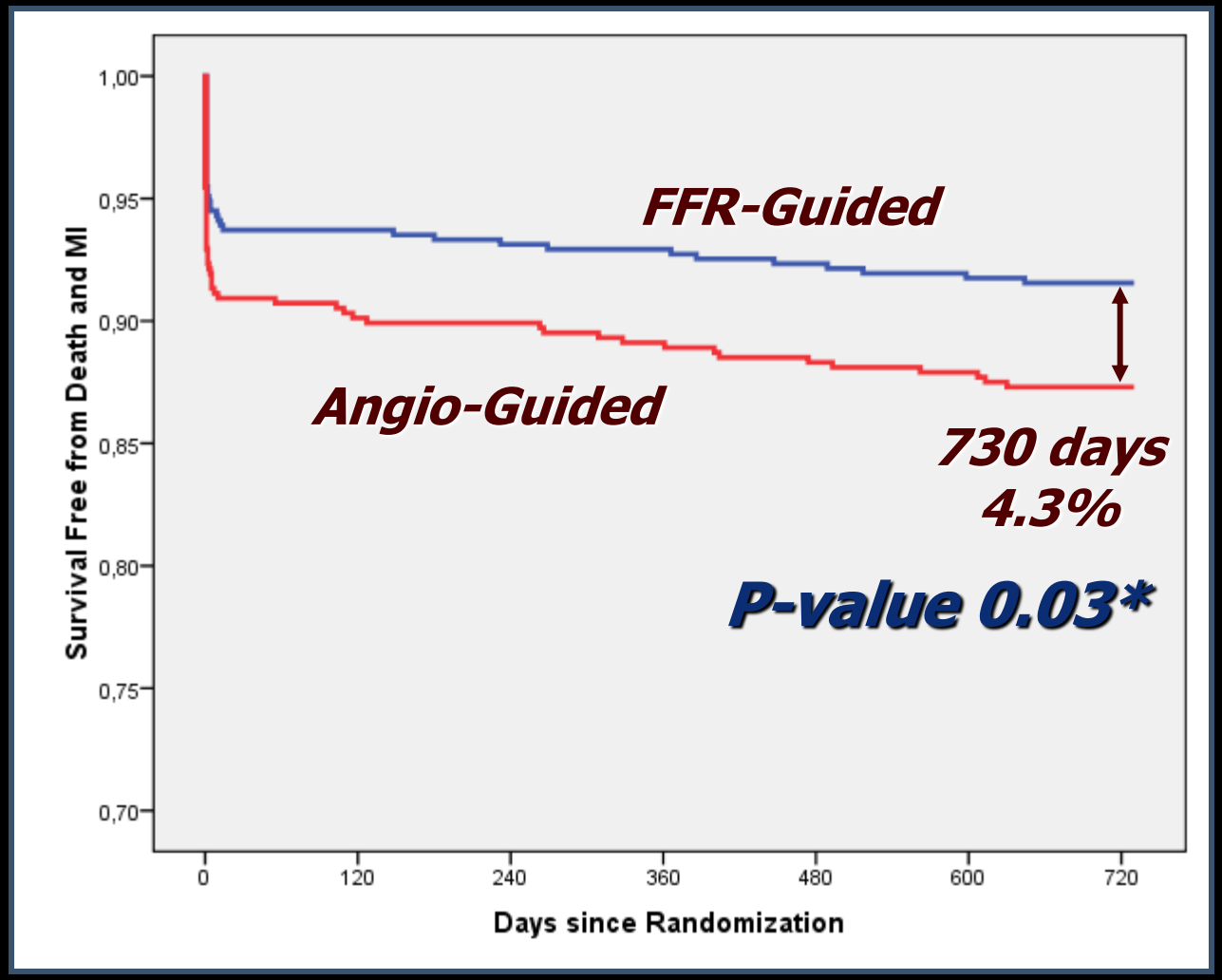
**Primary Endpoint**

Composite of death, MI and repeat revasc. (MACE) at 1 year

**Key Secondary Endpoints**

Individual rates of death, MI, and repeat revasc., MACE, and functional status at 2 years

# 2 Year Survival Free of Death/MI




*Data presented at TCT Late Breaking Trial Session September 23, 2009*

** By chi-square testing*

# FFR-guidance in multivessel disease PCI

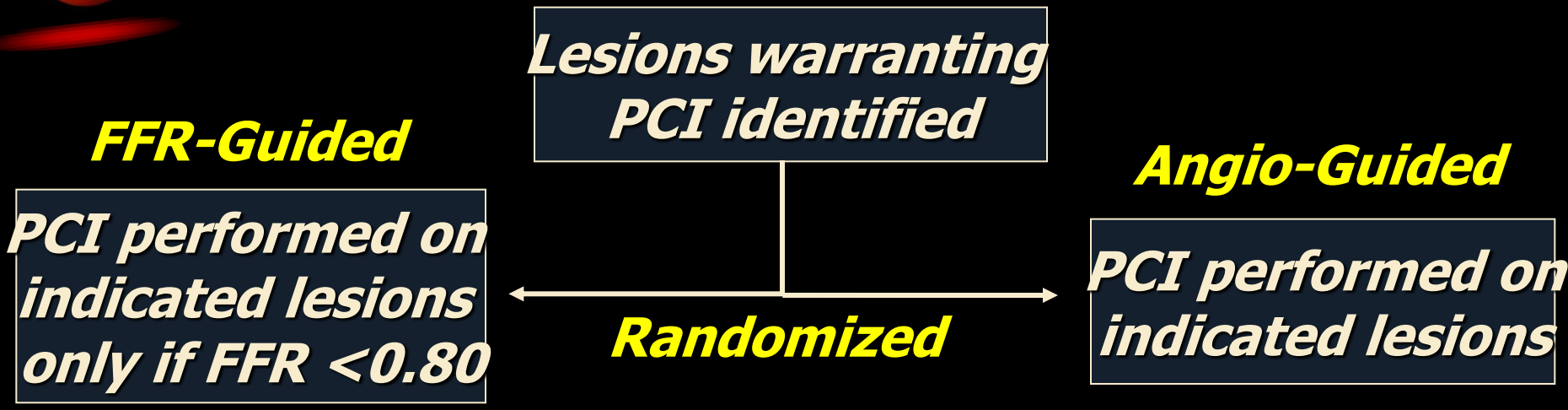
**Some criticism….**

**I do not stent lesions unless they are at least 70%,**
**what about that?**

***Or…***

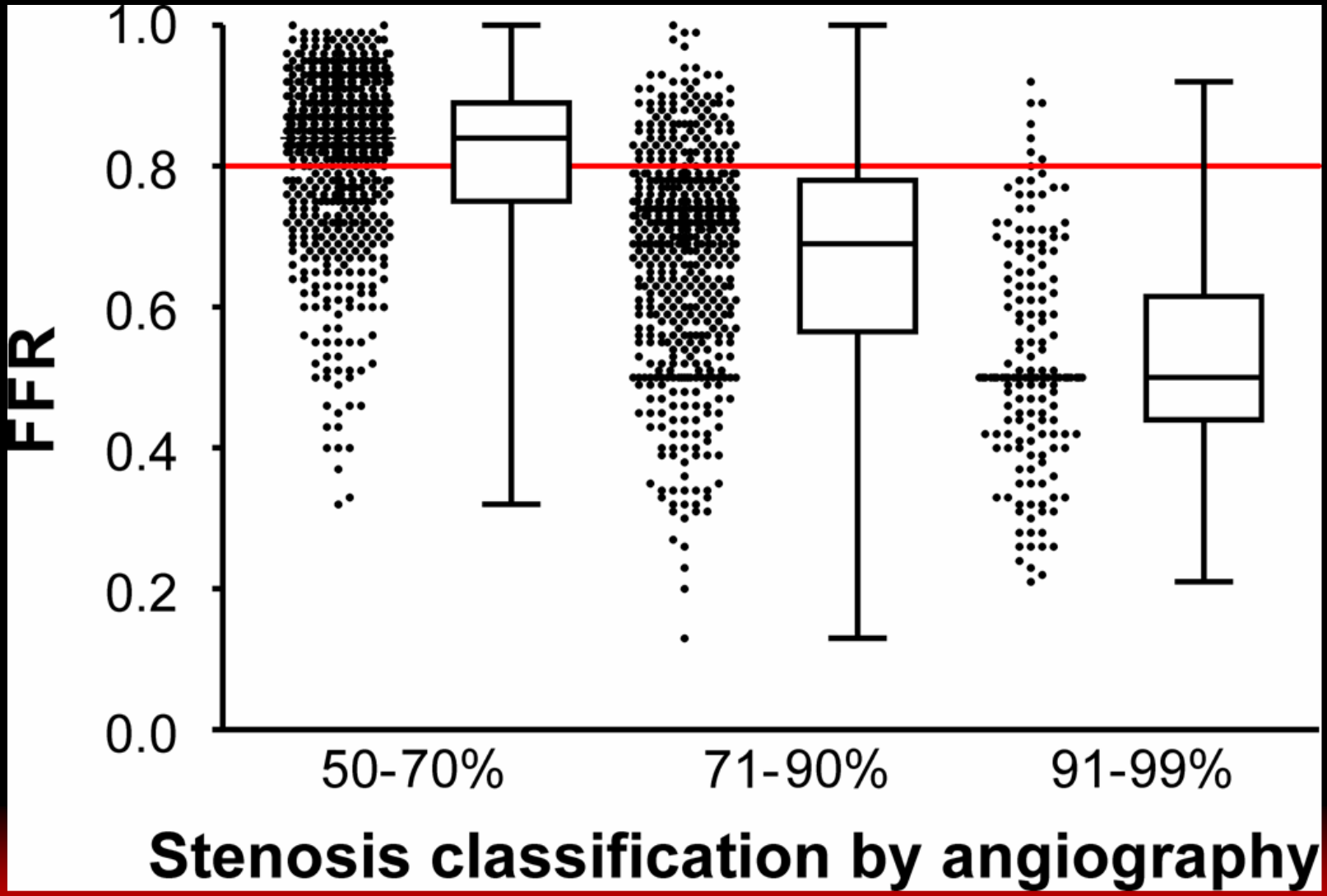
**Do we really have to measure FFR in all these lesions?**

# Flow Chart



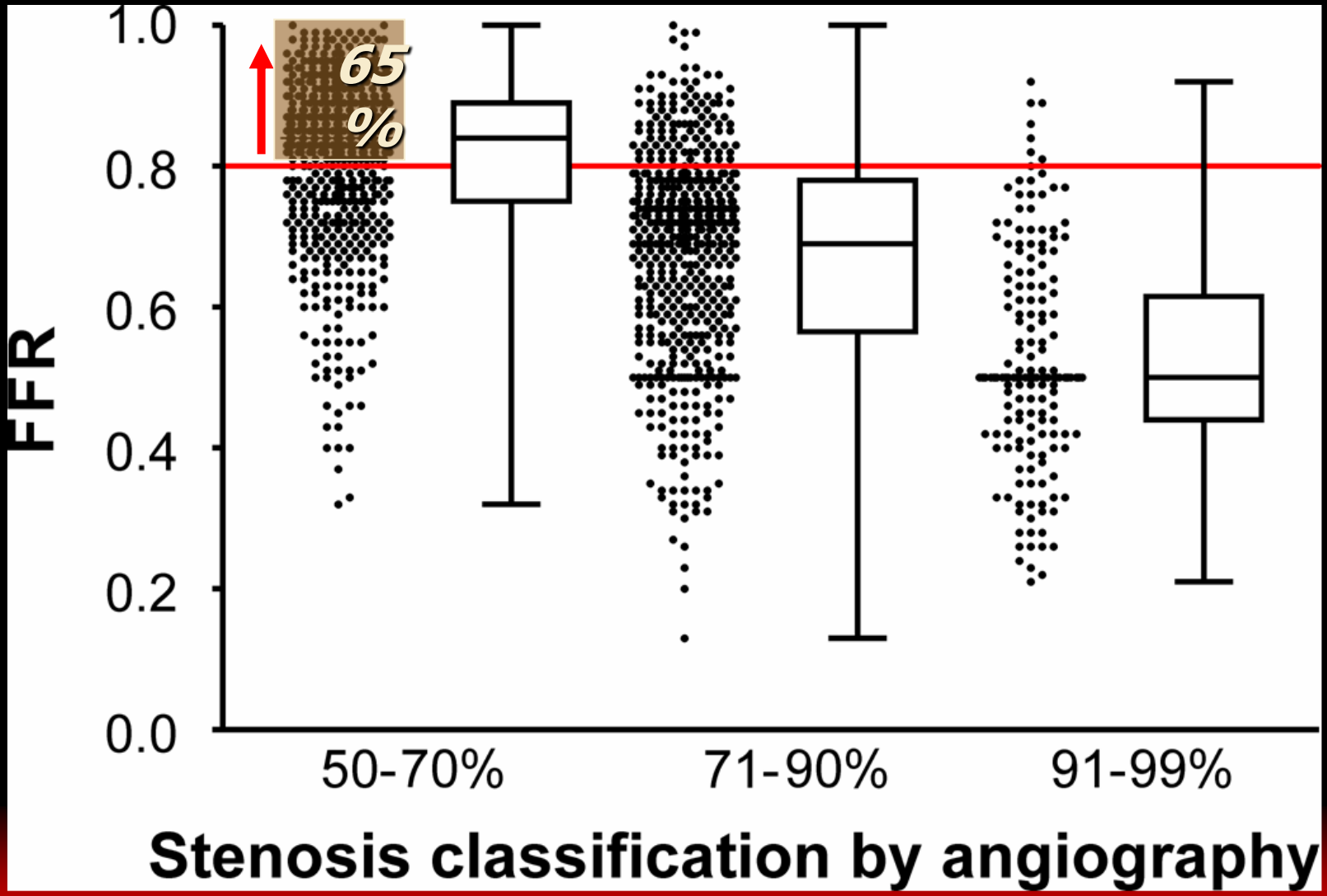

- Before randomization the operator indicated all stenoses
  ≥ 50% requiring stenting and
  classified them into: 50-70%, 71-90% and 91-99%
- In the FFR-group all indicated lesions were measured
  by FFR (N=1329)

# FFR versus angiography



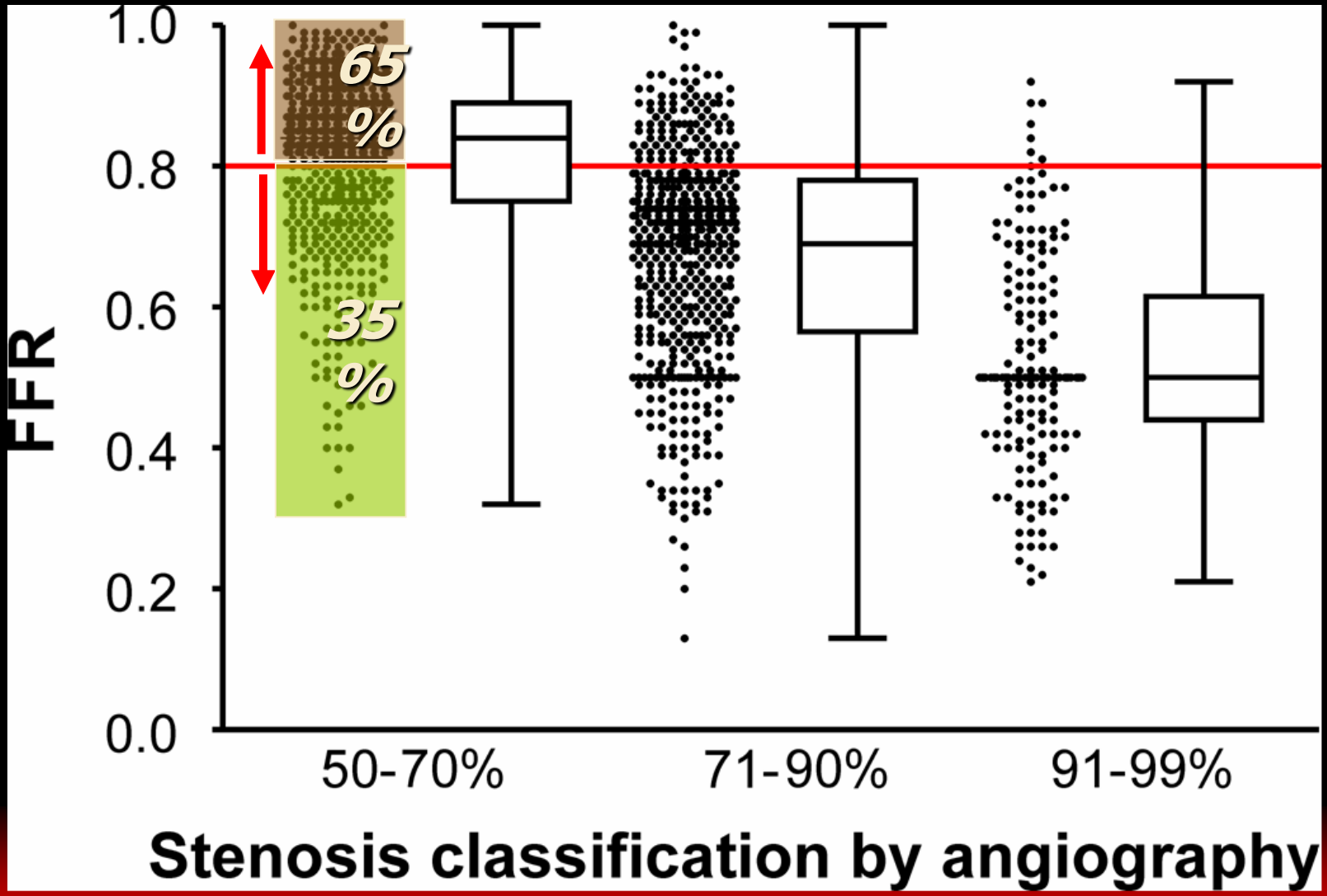

*Submitted data*

# routine stenting of stenoses of 50-70%, based on the angiogram, means unnecessary stenting in 65% of such stenoses



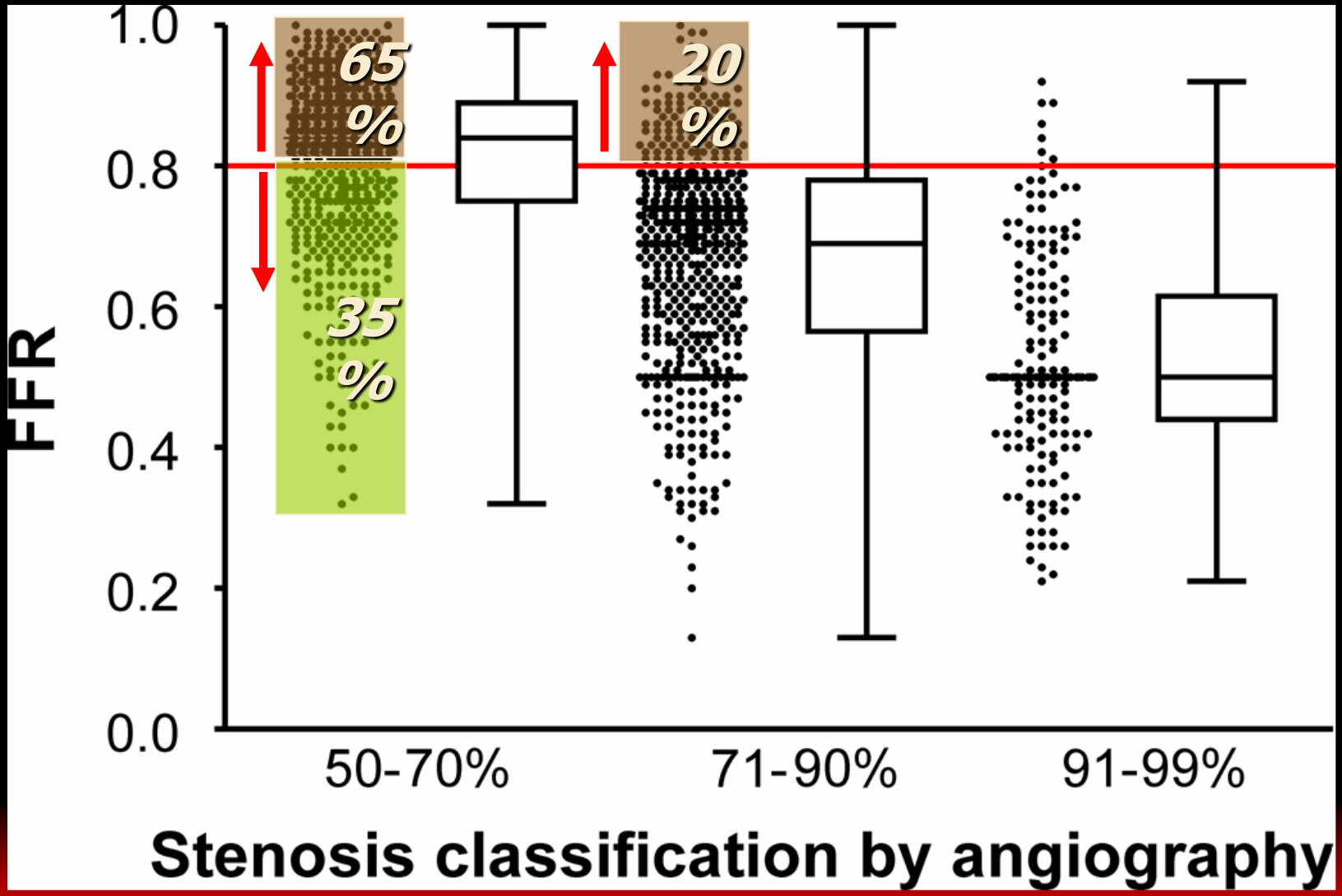

Submitted data

# not stenting 50-70% lesions routinely, leaves 35% of ischemic stenoses untreated



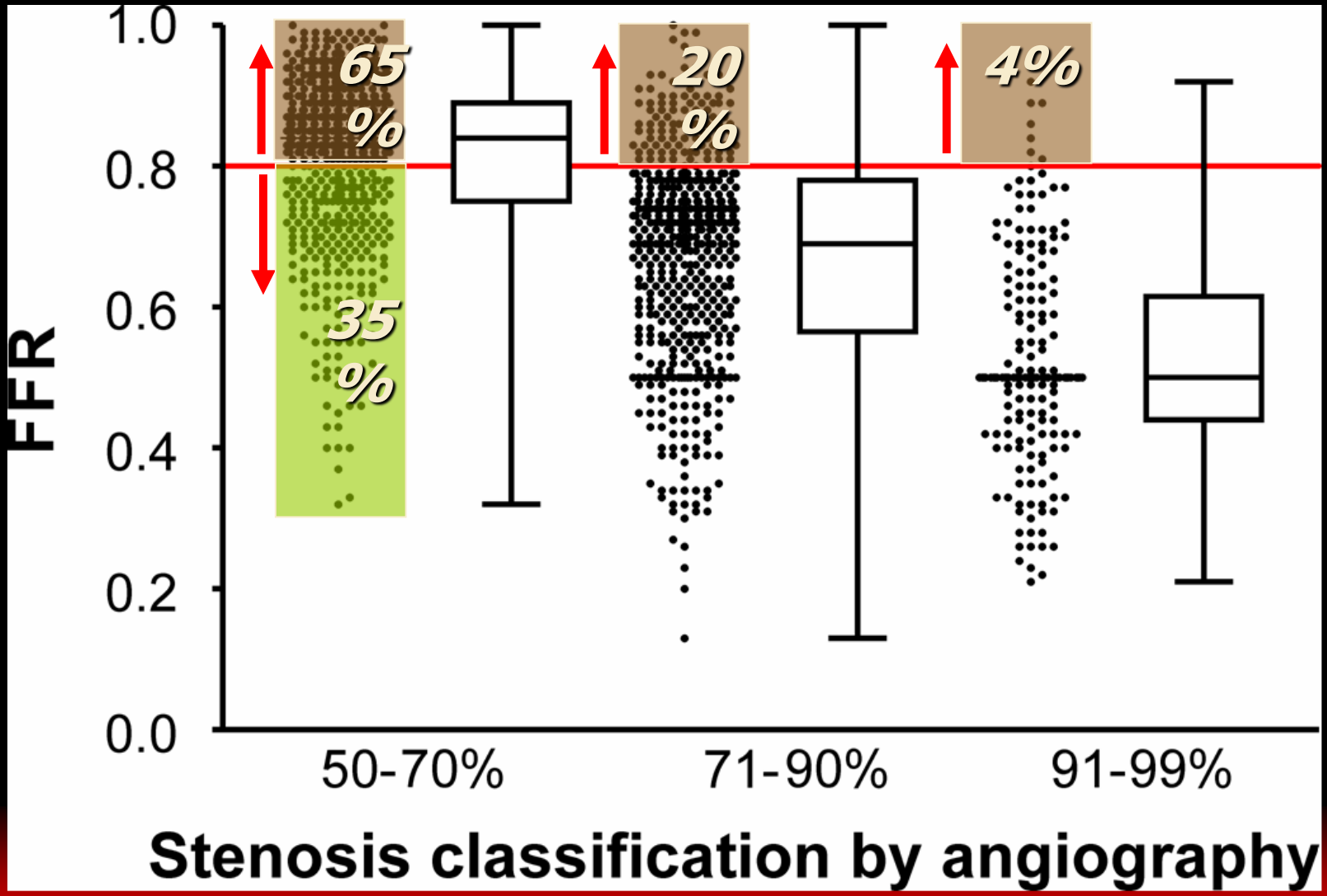

*Submitted data*

# In stenoses between 71 and 90% narrowed, the percentage of unnecessary stent placement, is 20%




*Submitted data*

# Almost all stenoses >90% narrowed are significant by FFR




Submitted data

# Angiography versus FFR

- In patients with multivessel CAD, whether or not taking into account clinical data one cannot rely on the angiogram to identify ischemia-producing lesions when assessing stenoses between 50 and 90%

- In this setting, routine stenting without FFR guidance is justified only for stenoses >90%, because almost all of these lesions are functionally significant

# Anatomic vs. Functional CAD

Patients with angiographically 3VD (N=115), proportions per number of diseased vessels after assessment by FFR

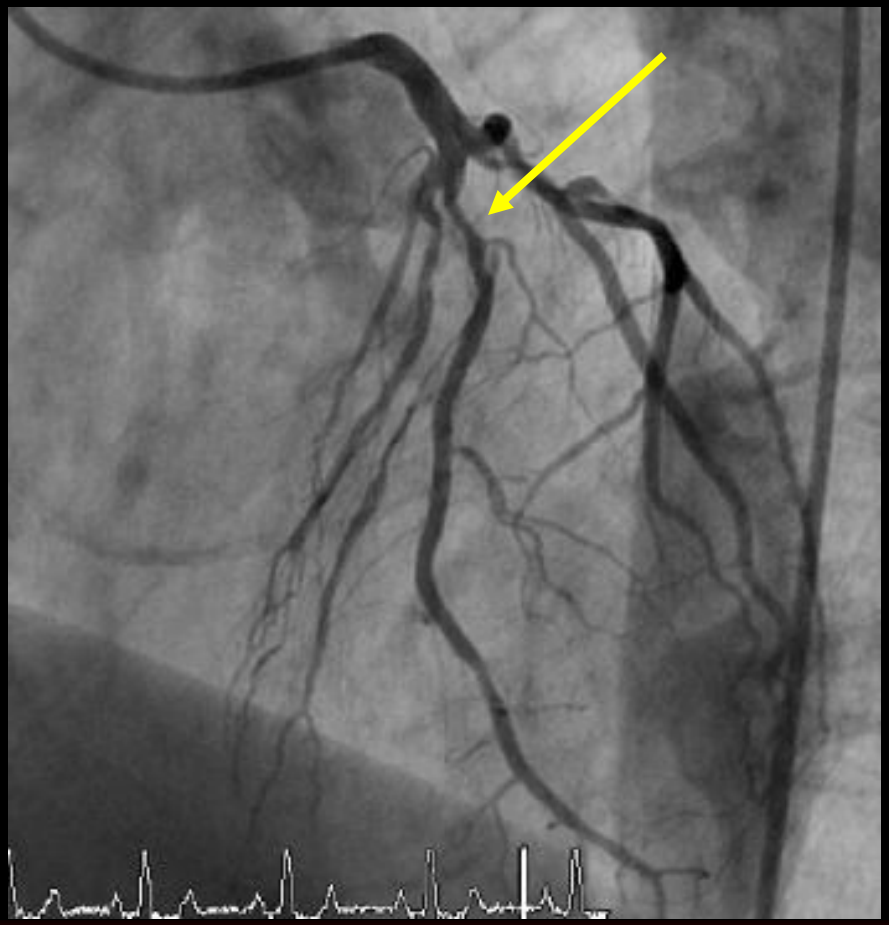

*Tonino et al., JACC 2010 (submitted)*

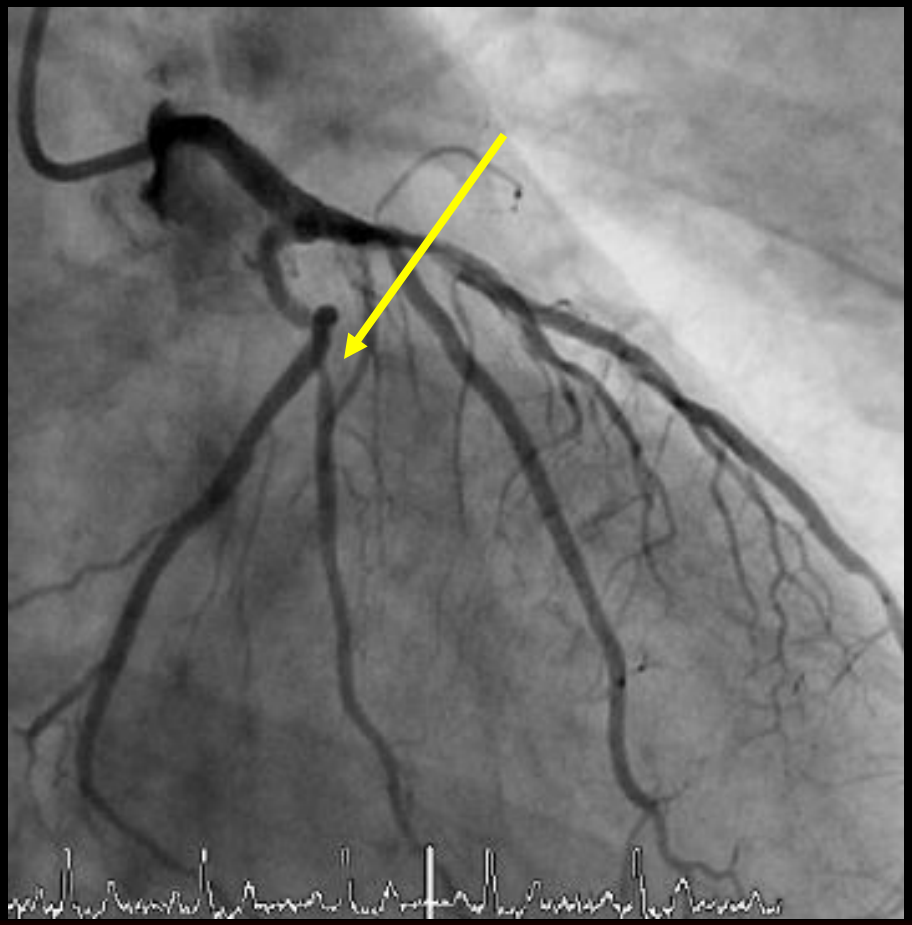
## Let's go to a case example, a 'FAME-like' patient

## A rather common patient in our cath lab today…….

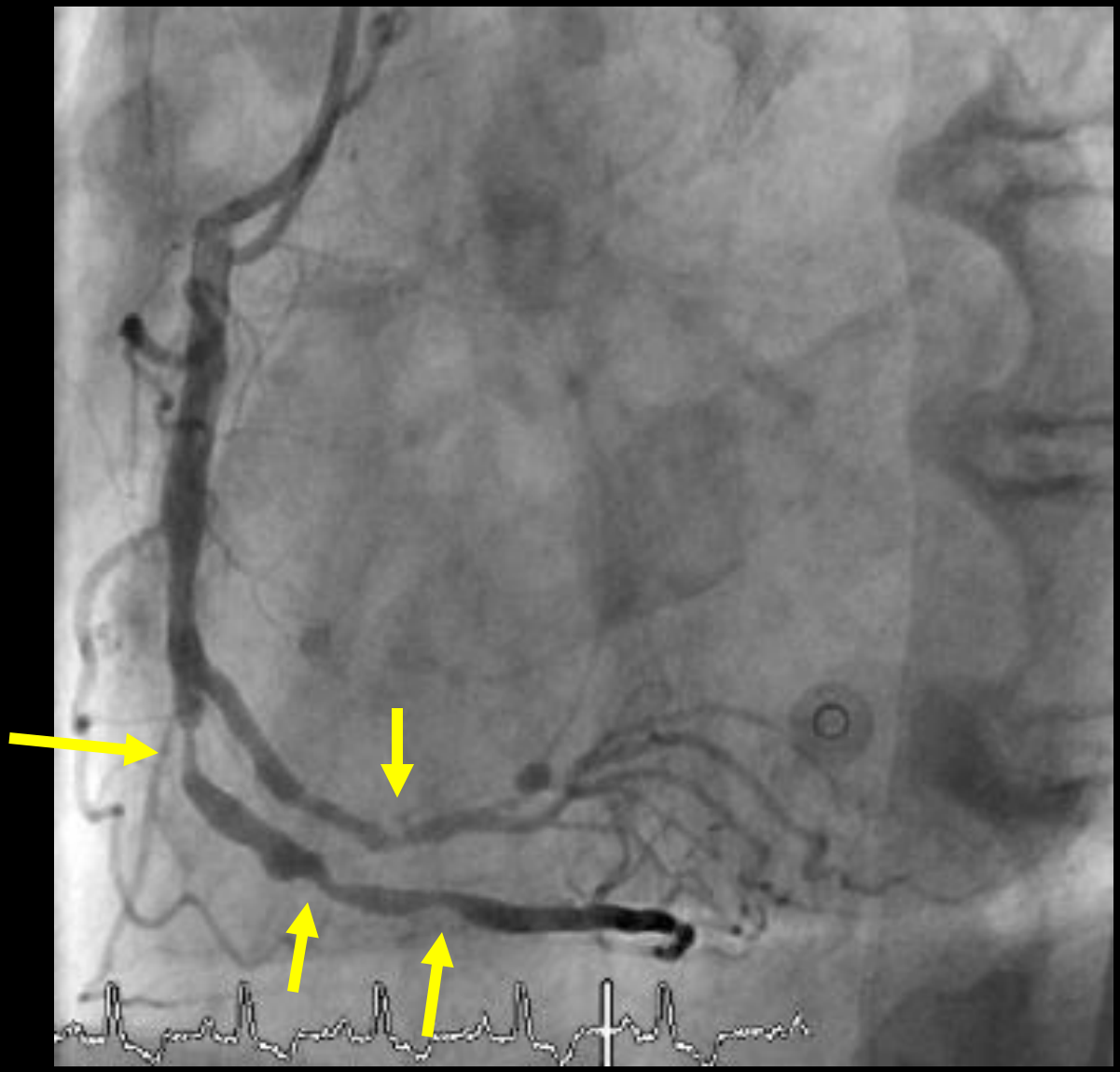
- male born 1952
- Smoker
- Admitted with USA
- Referred for Cath

# Clinical dilemma: what should we do?
# MVS vs. CABG



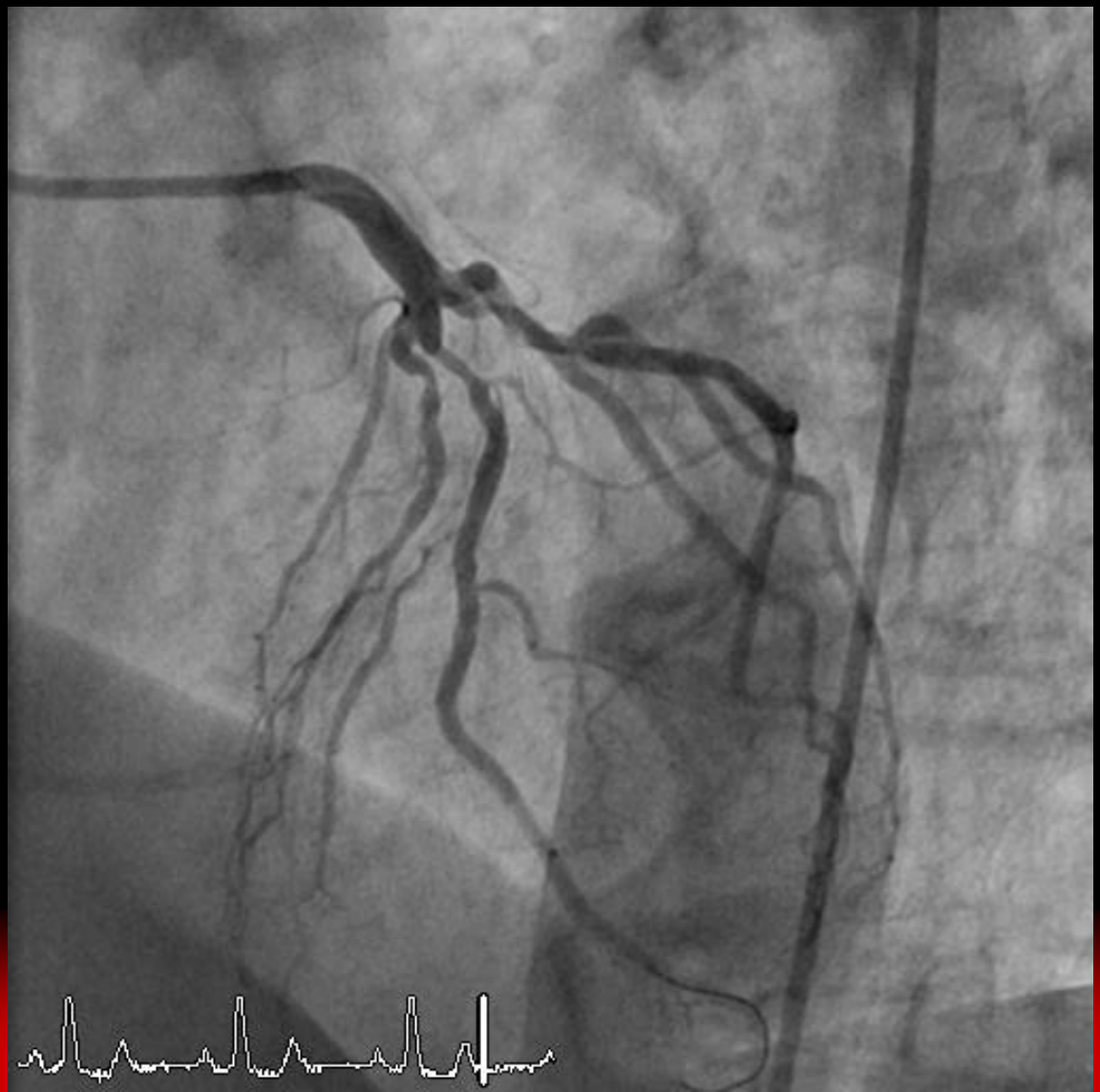


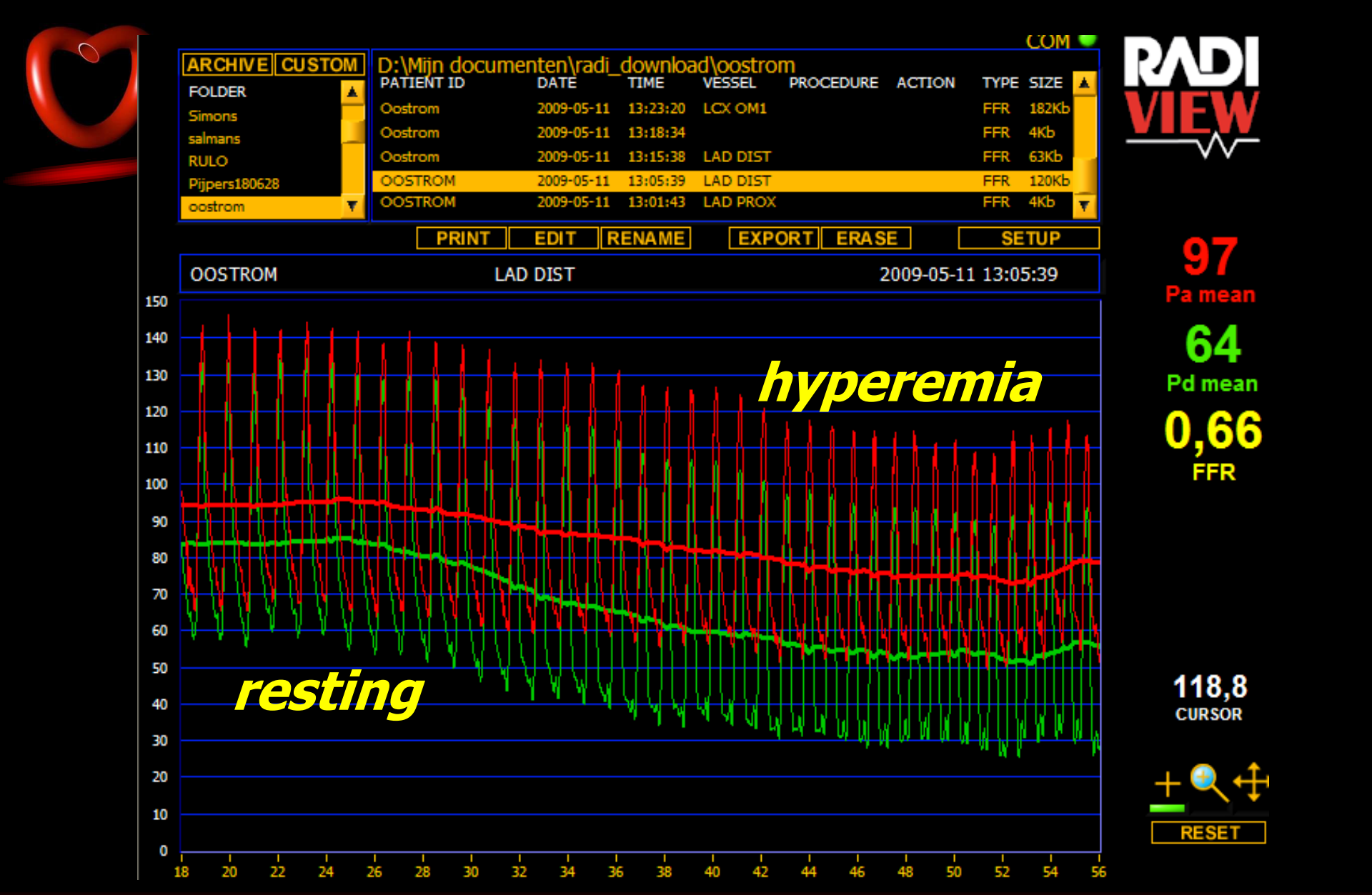
***70% stenosis prox LAD***
***70% stenosis ostium OMCX***



***50-70% stenosis PLRCA***
***80% + 2x 50% stenosis in RPDA***

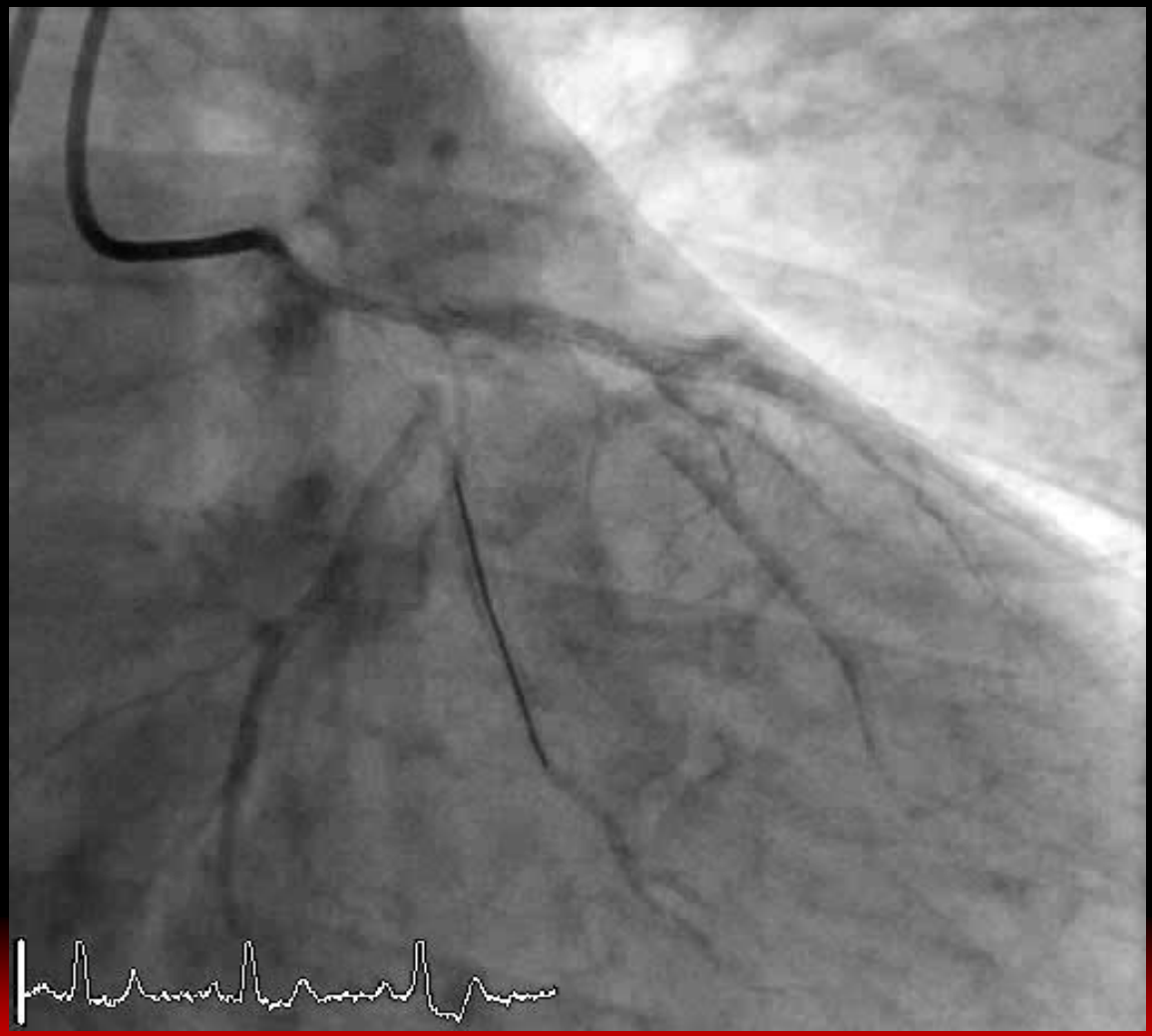
# Pressure wire in LAD





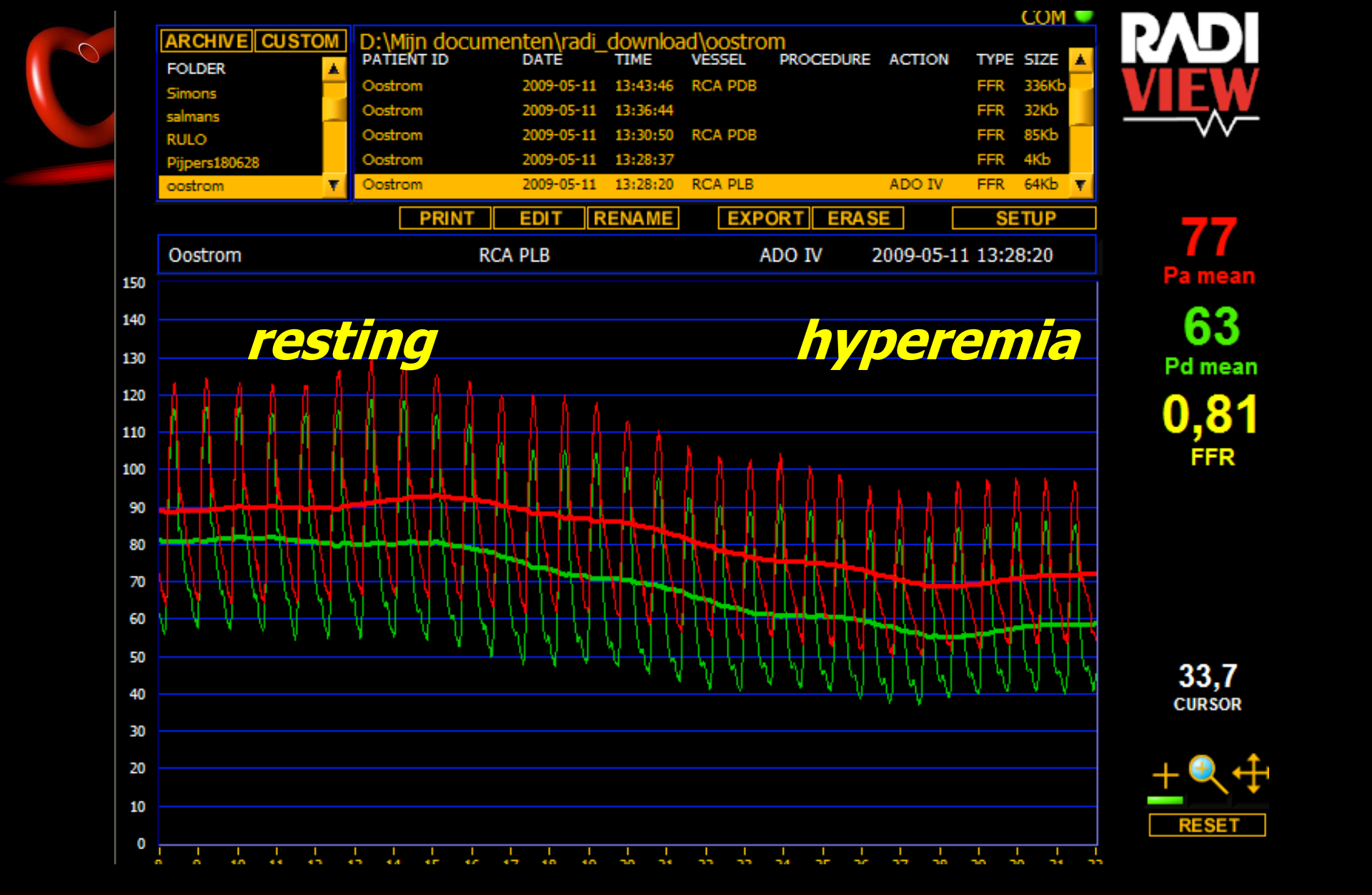

# FFR LAD (i.v. adenosine)

# Pressure wire in OMCX



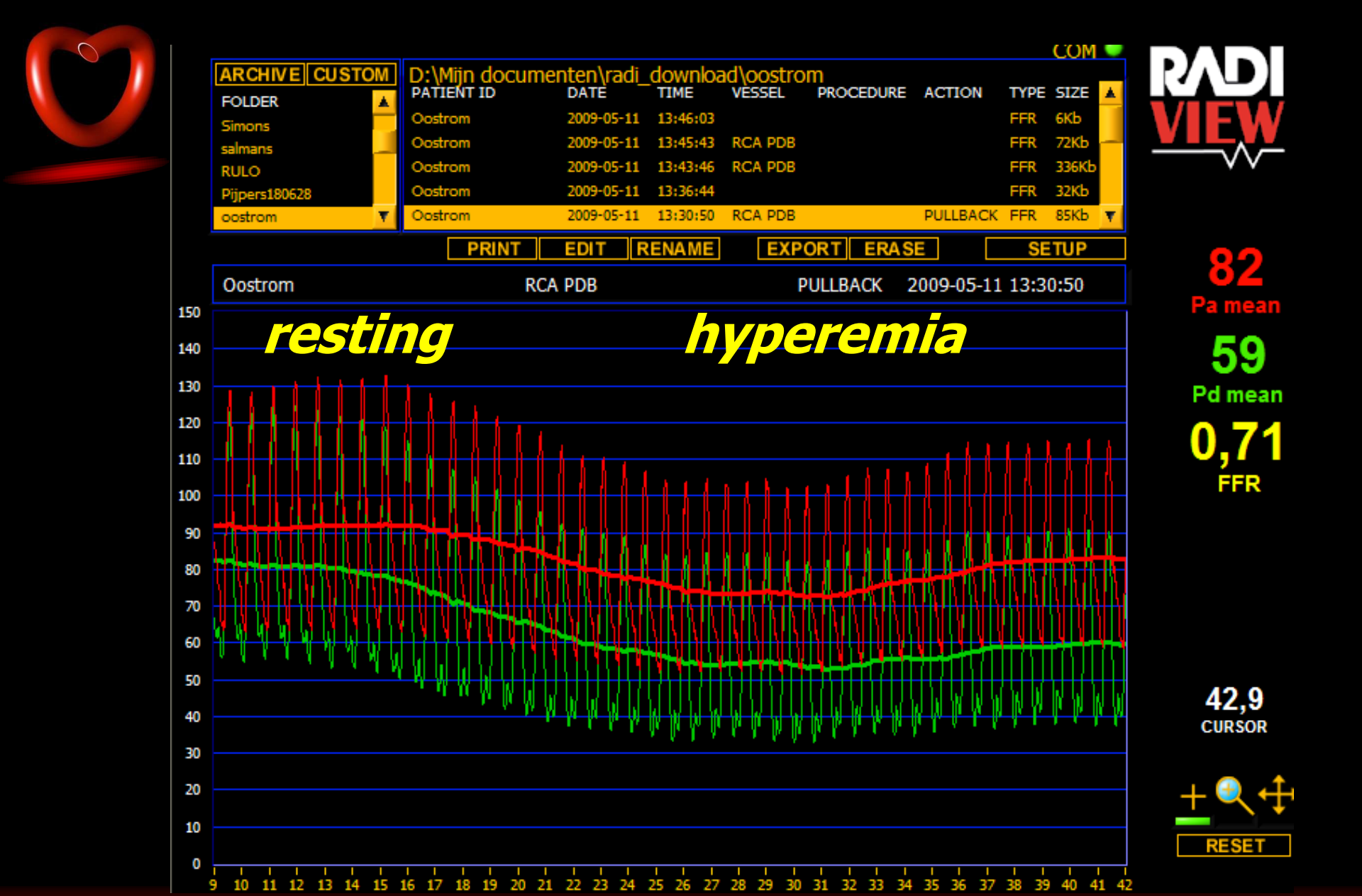

# FFR meaasurement in OMCX

# Pressure wire in PL-RCA



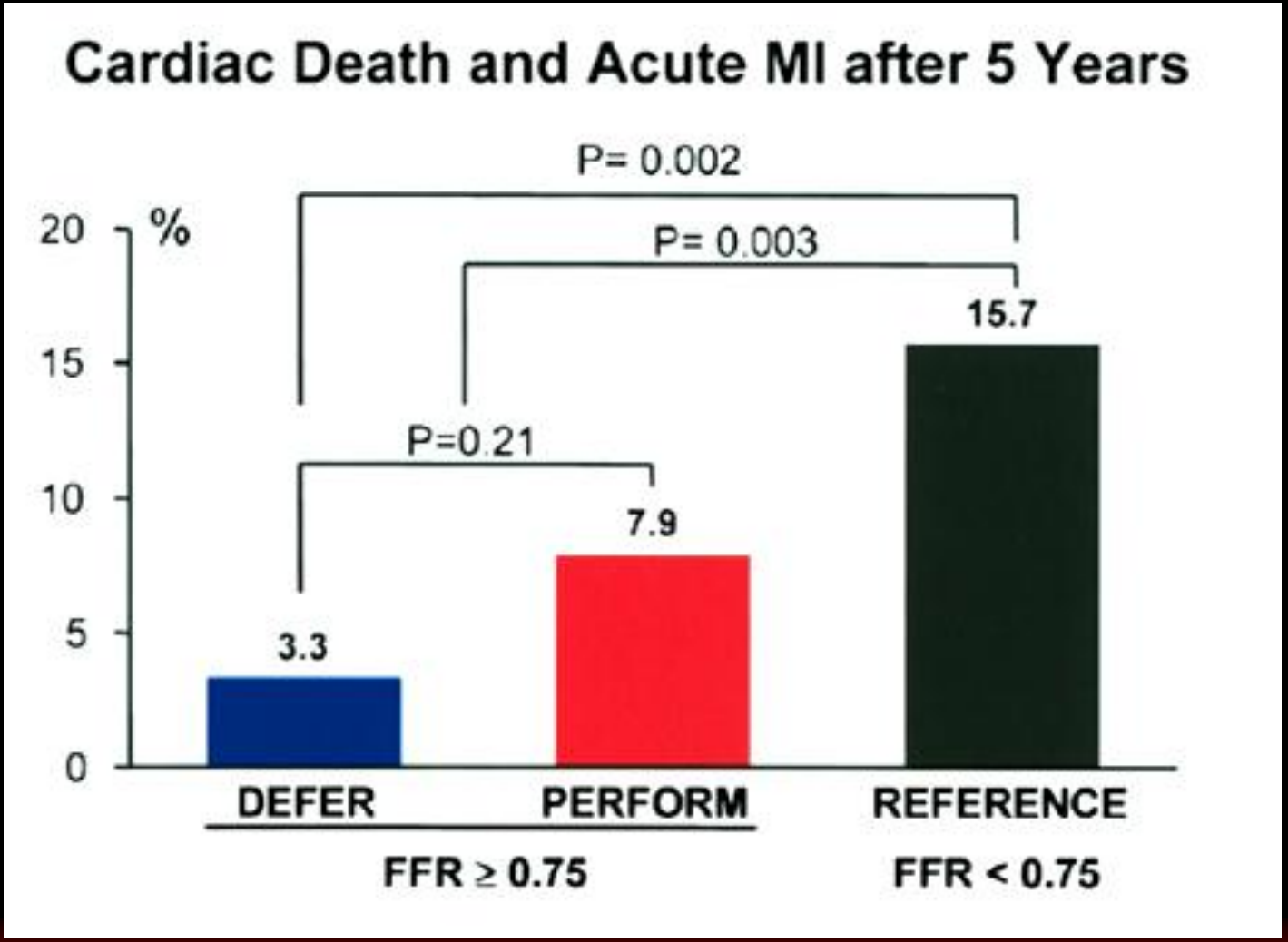

# FFR measurement in PL-RCA

# Pressure wire in RPDA



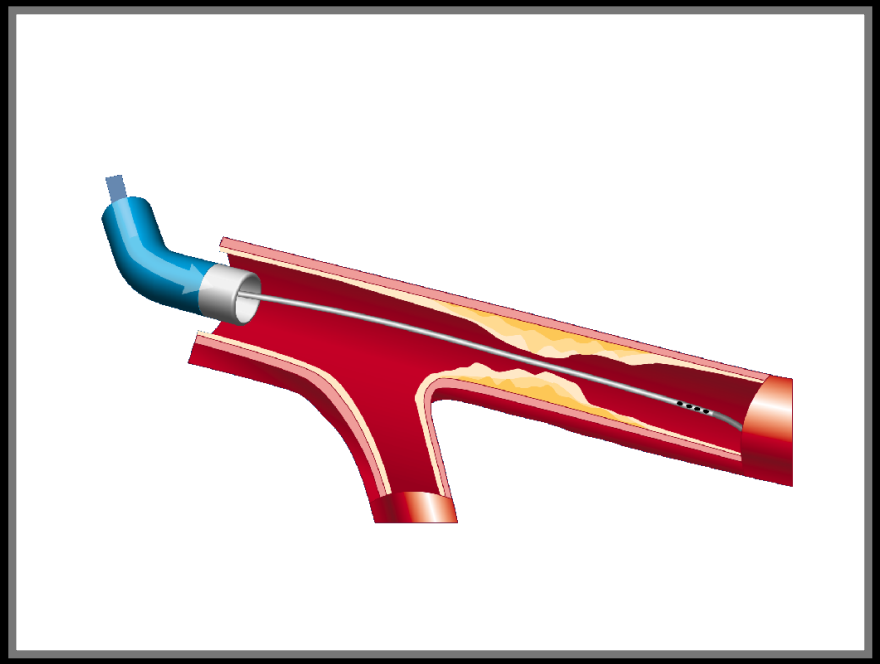

# FFR measurement in RPDA

# FFR in PCI: deferring therapy

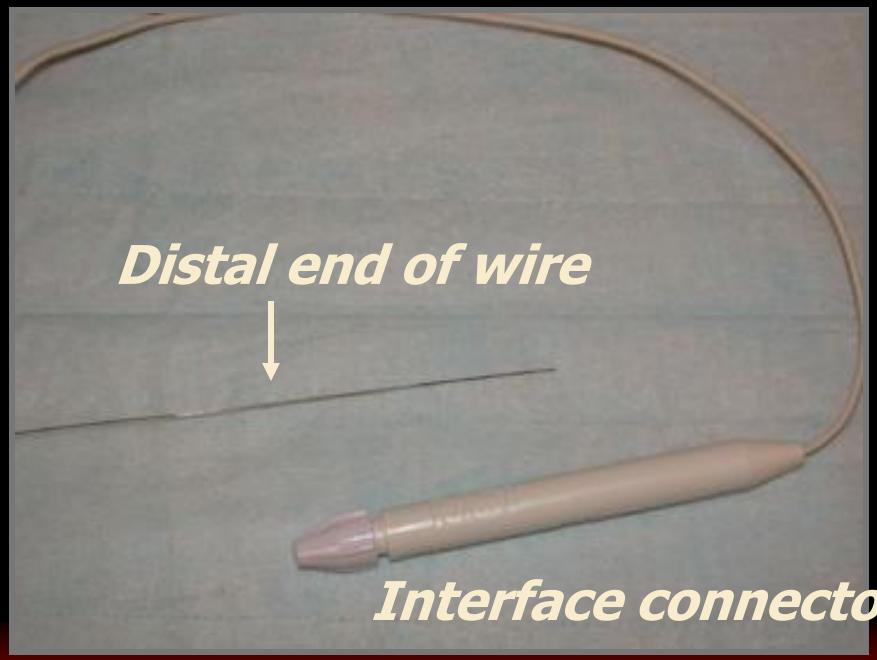



*JACC 2007;49:2105-2111*

# Potential Pitfalls



***Wiring the Lesion***

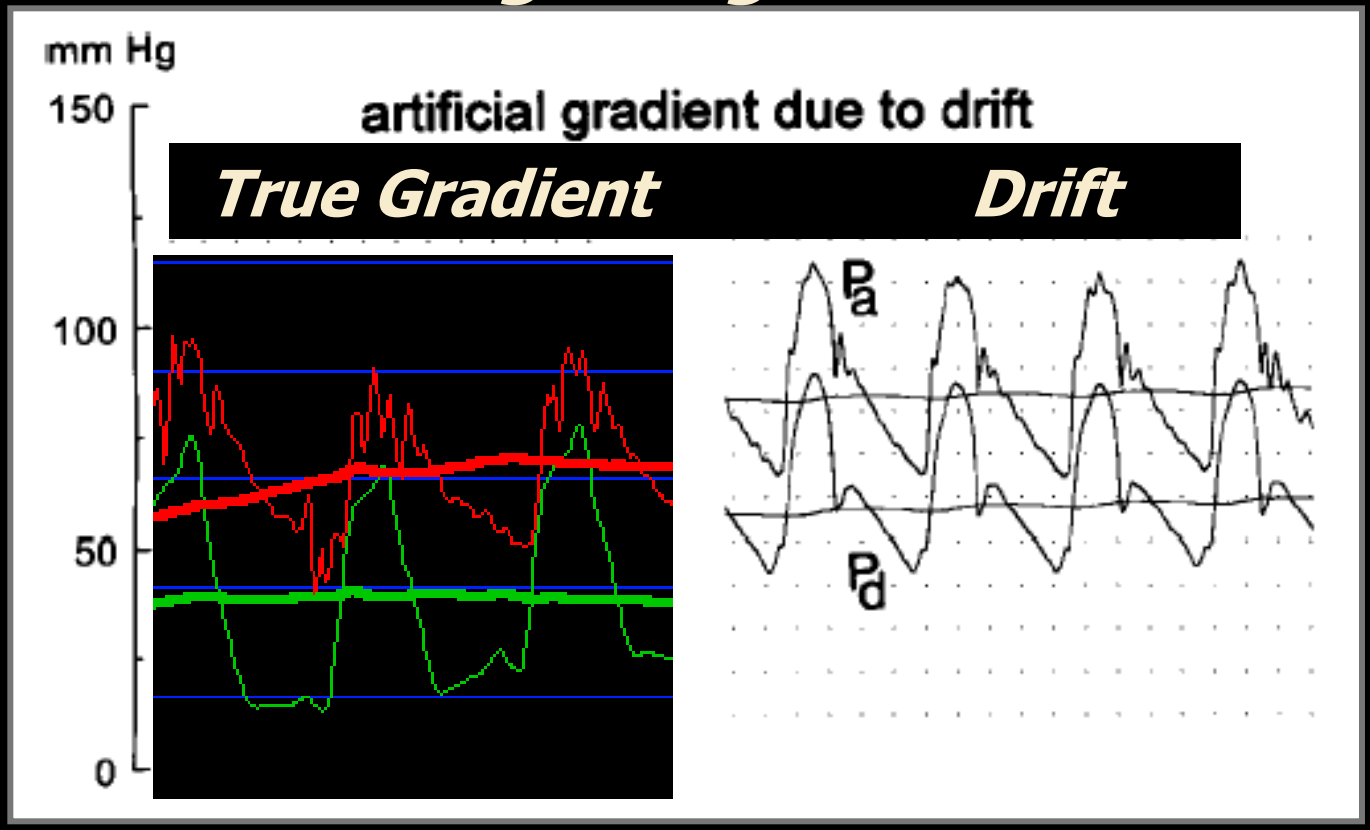



***Consider disconnecting the wire from the interface connector***

***Can use exchange catheter to more safely position pressure wire***

# Potential Pitfalls

## *Recognizing Drift*

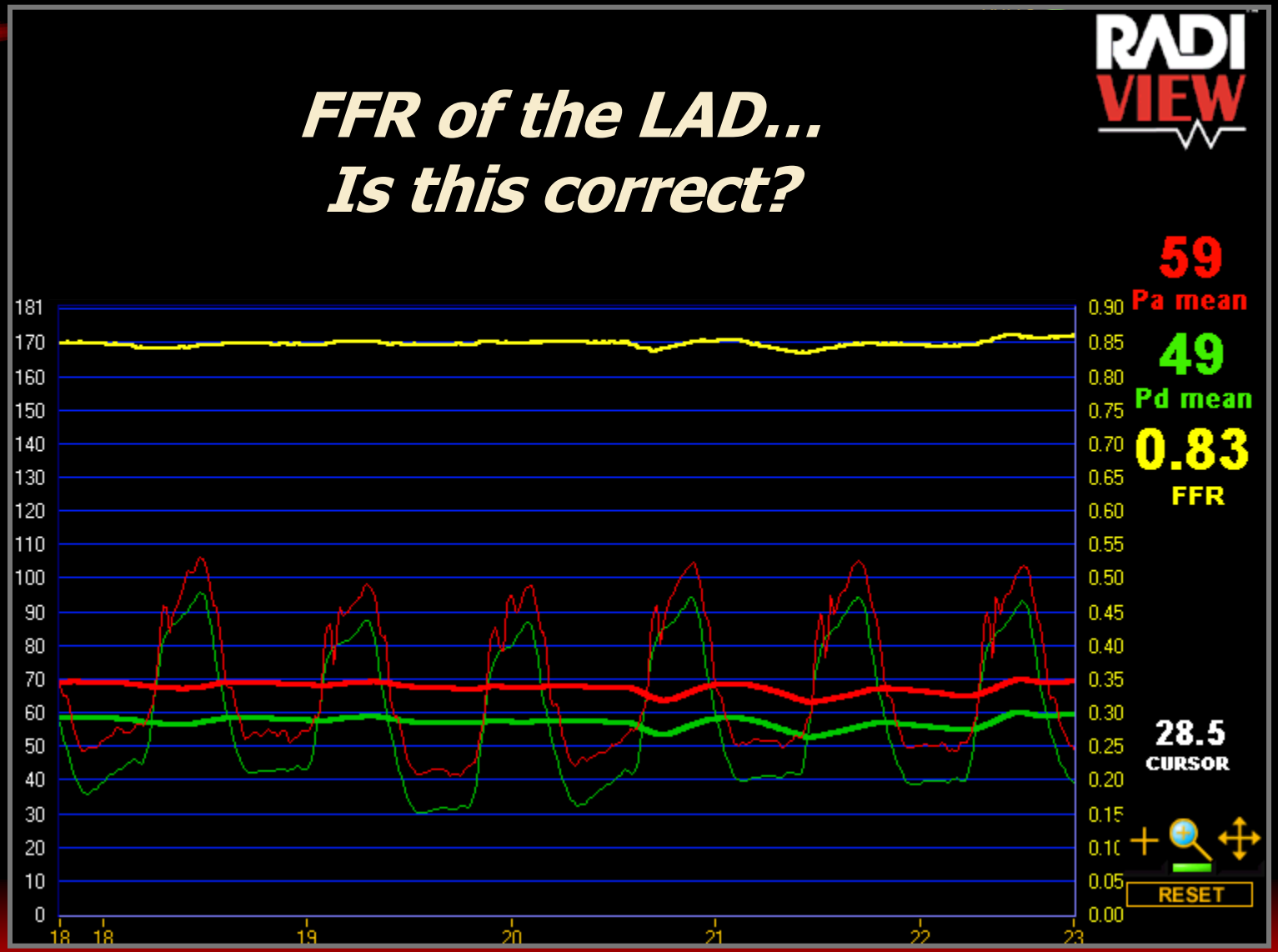



*Adapted from Pijls et al. Cathet Cardiovasc Intervent 2000;49:1-16*

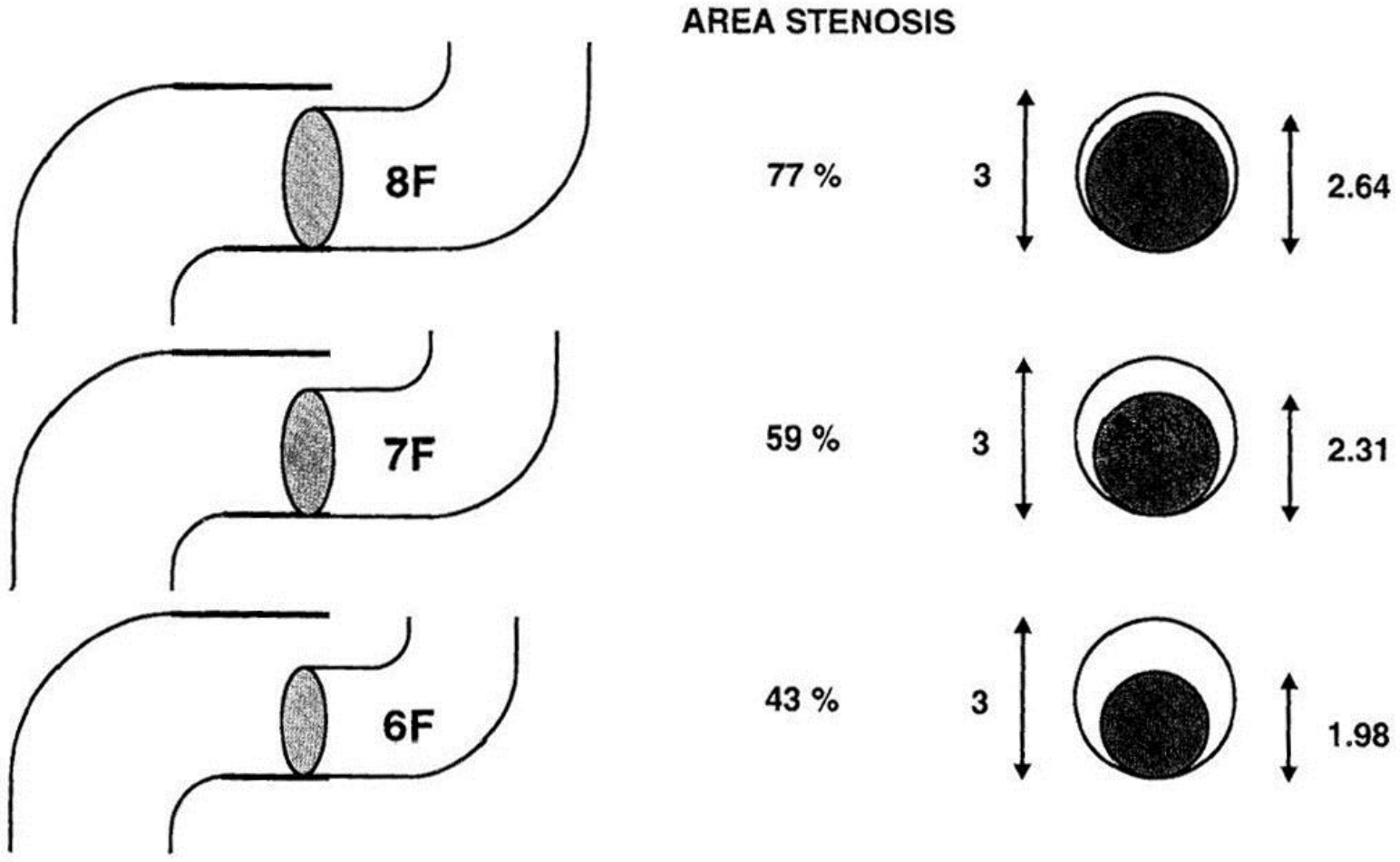
# Potential Pitfalls

- **Inadequate hyperemia**
  - **Intravenous adenosine**
    - **Should be administered via central vein**
    - **May require higher doses (>140 ug/kg/min) if given peripherally**
    - **If the patient doesn’t develop symptoms and/or hemodynamic changes, the patient is likely not receiving IV adenosine**

# Catheter Issues



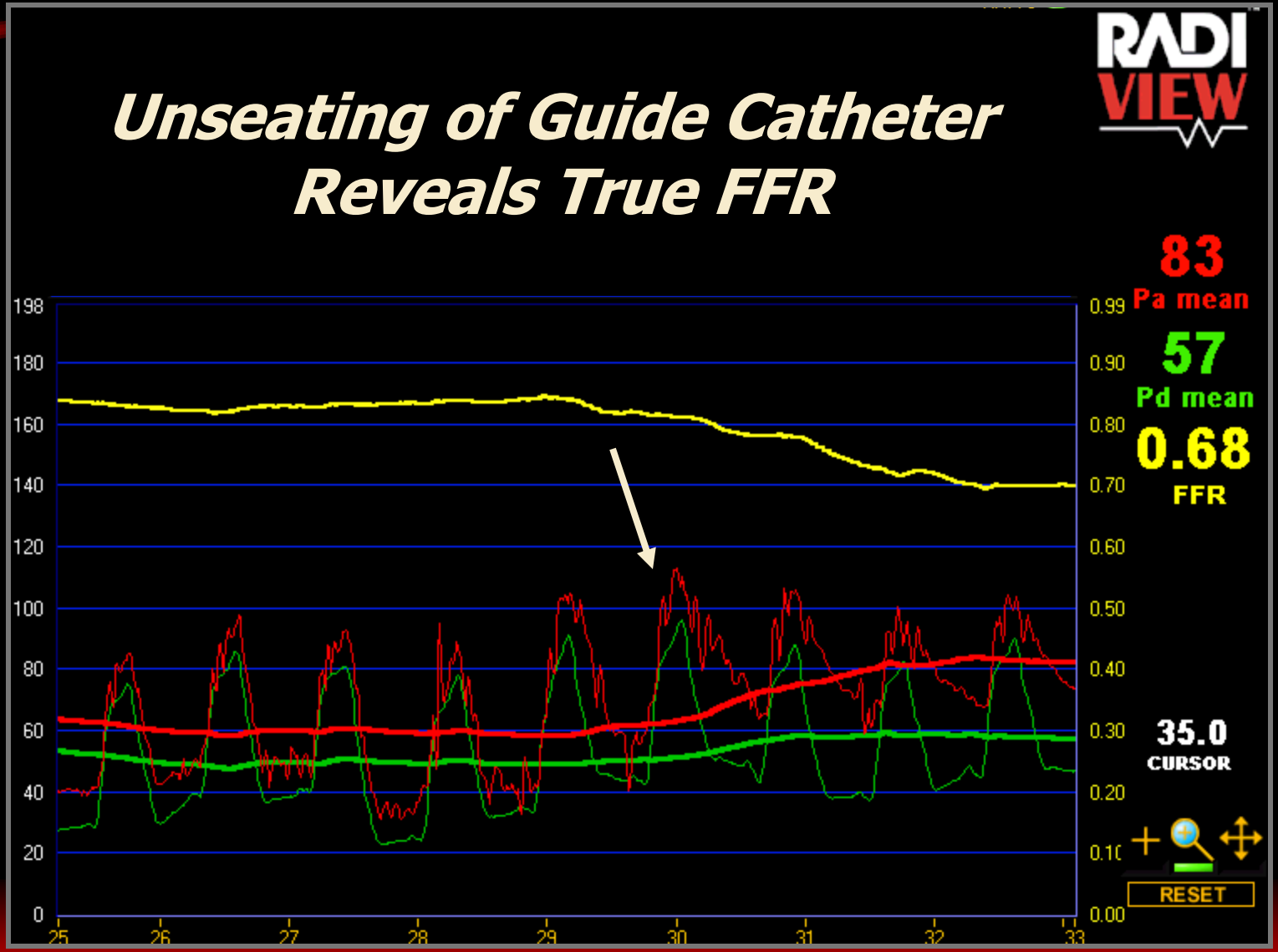
# Impact of Catheter Size on Hyperemic Flow




*De Bruyne et al. Cathet Cardiovasc Diagn 1994;33:145-152.*

# Catheter Issues

***Unseating of Guide Catheter Reveals True FFR***



# Conclusion – The Clinical Value of the Concept

- ✓ *FFR measurement has expanded our ability to deliver ischaemia-driven therapy*
- ✓ *FFR allows us to tell which lesions are significant & just as importantly which aren't!!*
- ✓ *FFR allows us to check that we have stented successfully*

***What effect would a routine pressure wire-directed approach pre- and post-stenting have had on the outcome of:***

***ARTS?***

***SYNTAX?***

***COURAGE?***

***?***

# THANK YOU