TCT Asia Pacific 2017

ISSUES ABOUT DRIFT WITH FFR, cFFR, iFFR
HOW TO AVOID IT

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Potential conflicts of interest

Speaker's name: NICO H J PIJLS

☒ **I have the following** potential conflicts of interest to report:

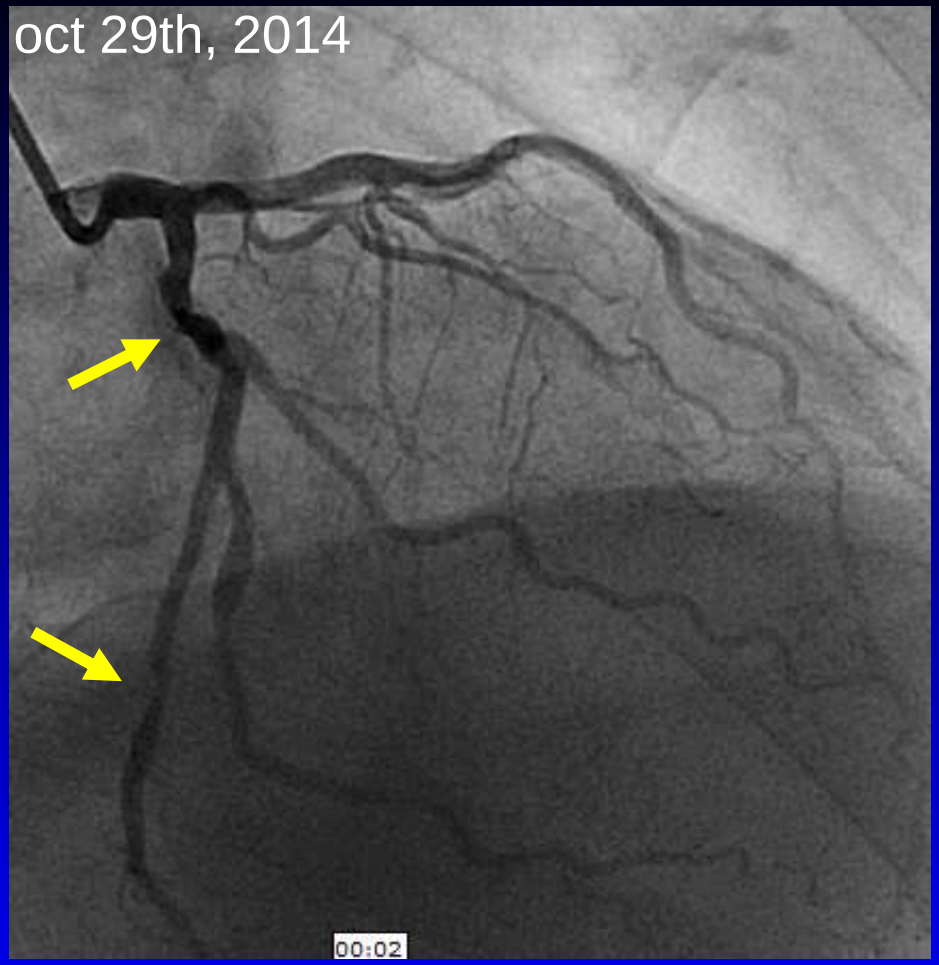
- ☒ Research contracts : St Jude Medical
- ☒ Consulting: St Jude Medical, Opsens
- ☐ Employment in industry
- ☒ Stockholder of a healthcare company: Philips, GE, ASML, Heartflow
- ☐ Owner of a healthcare company
- ☐ Other(s):

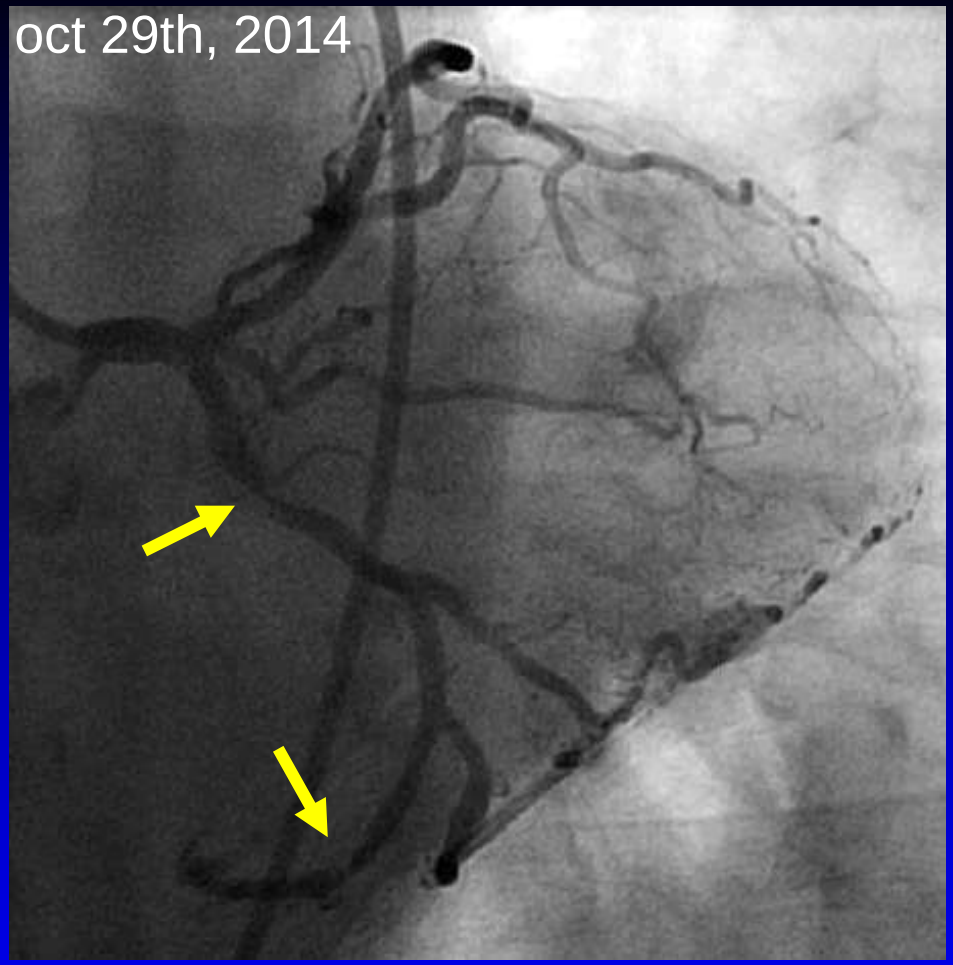
☐ **I do not have any potential conflict of interest**

The ideal world:

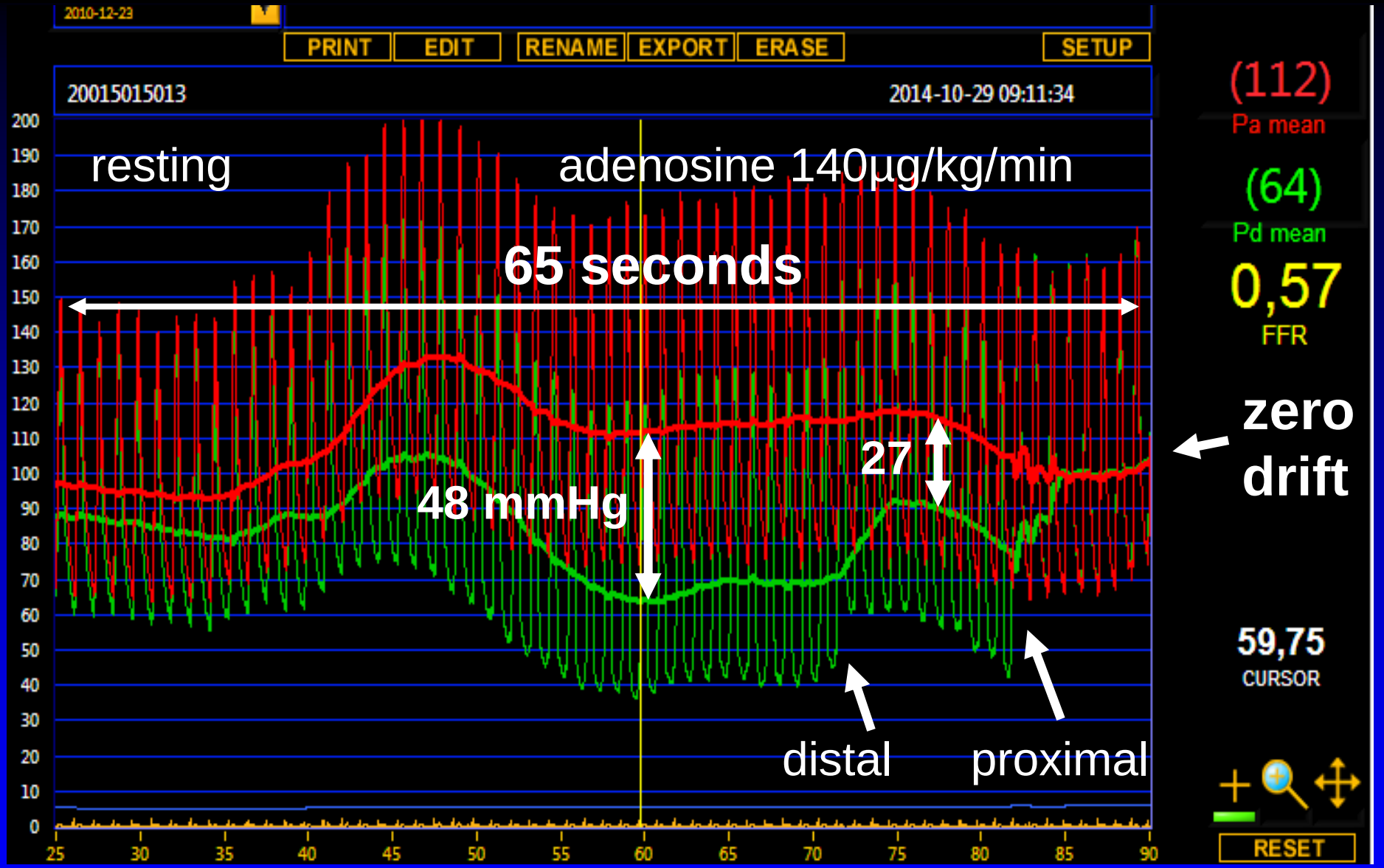
A world without drift

First a few cases of how this ideal world looks like:





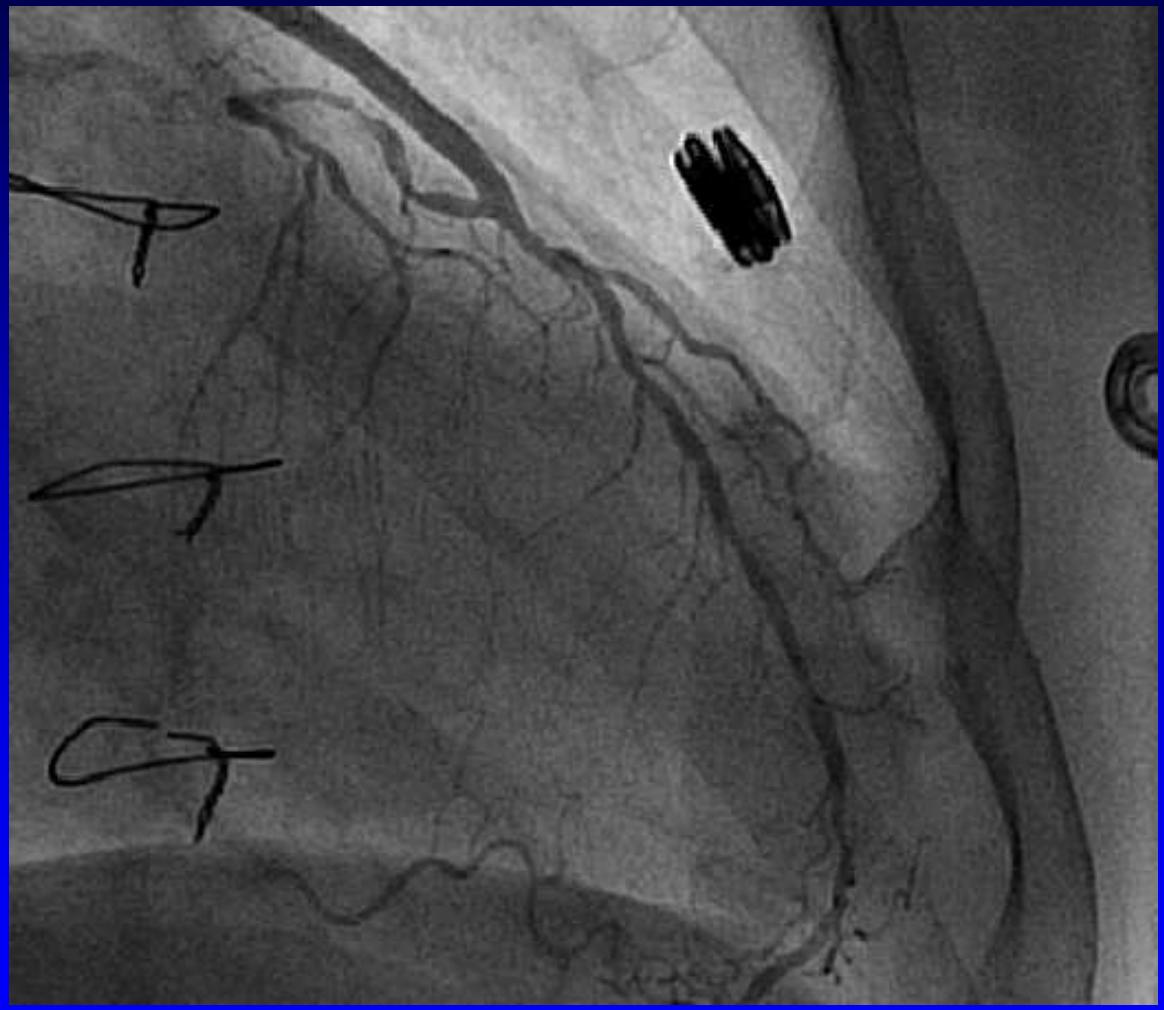
Male, 65-year-old, typical angina,
inferolateral reversible defect at MIBI-SPECT
70% lesions in proximal & distal dominant LCX



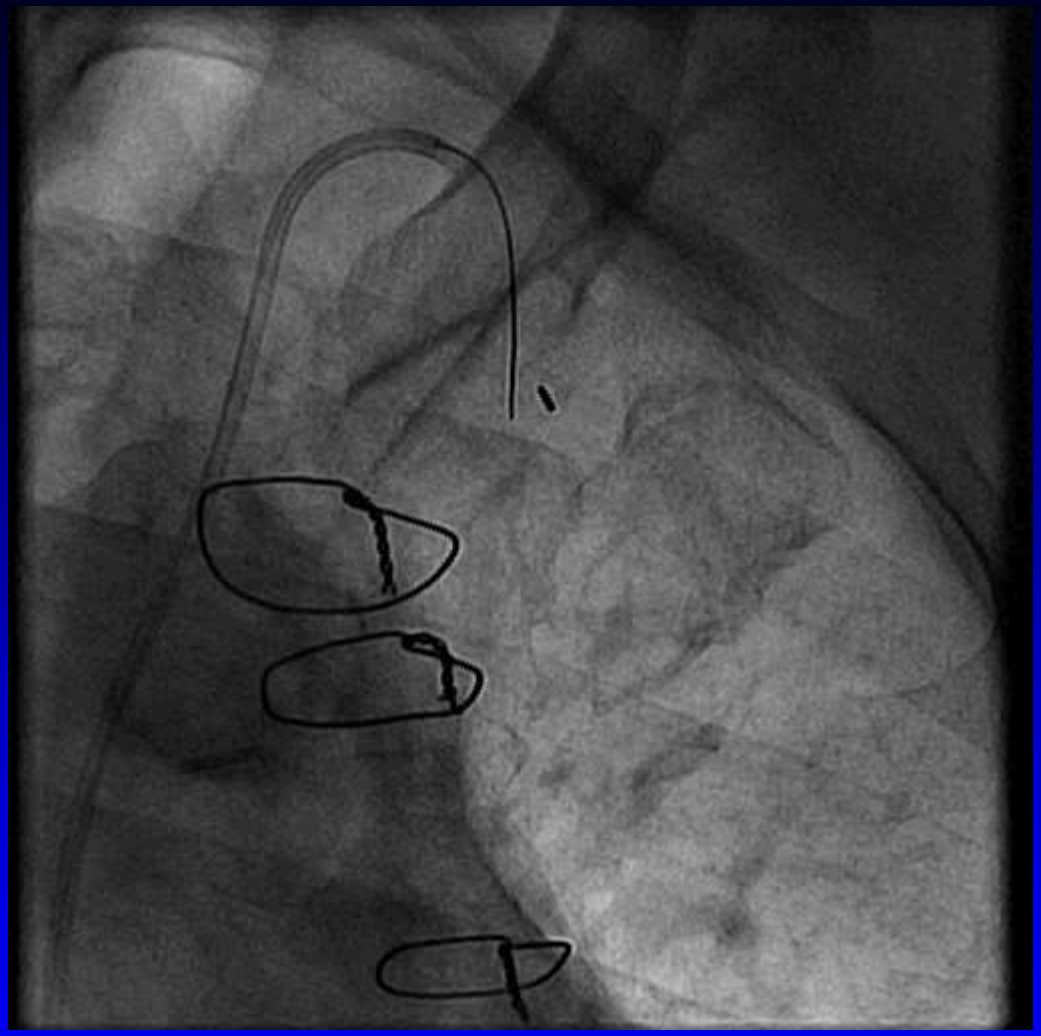
hyperemic pullback recording:

rapid, reliable, detailed information within seconds

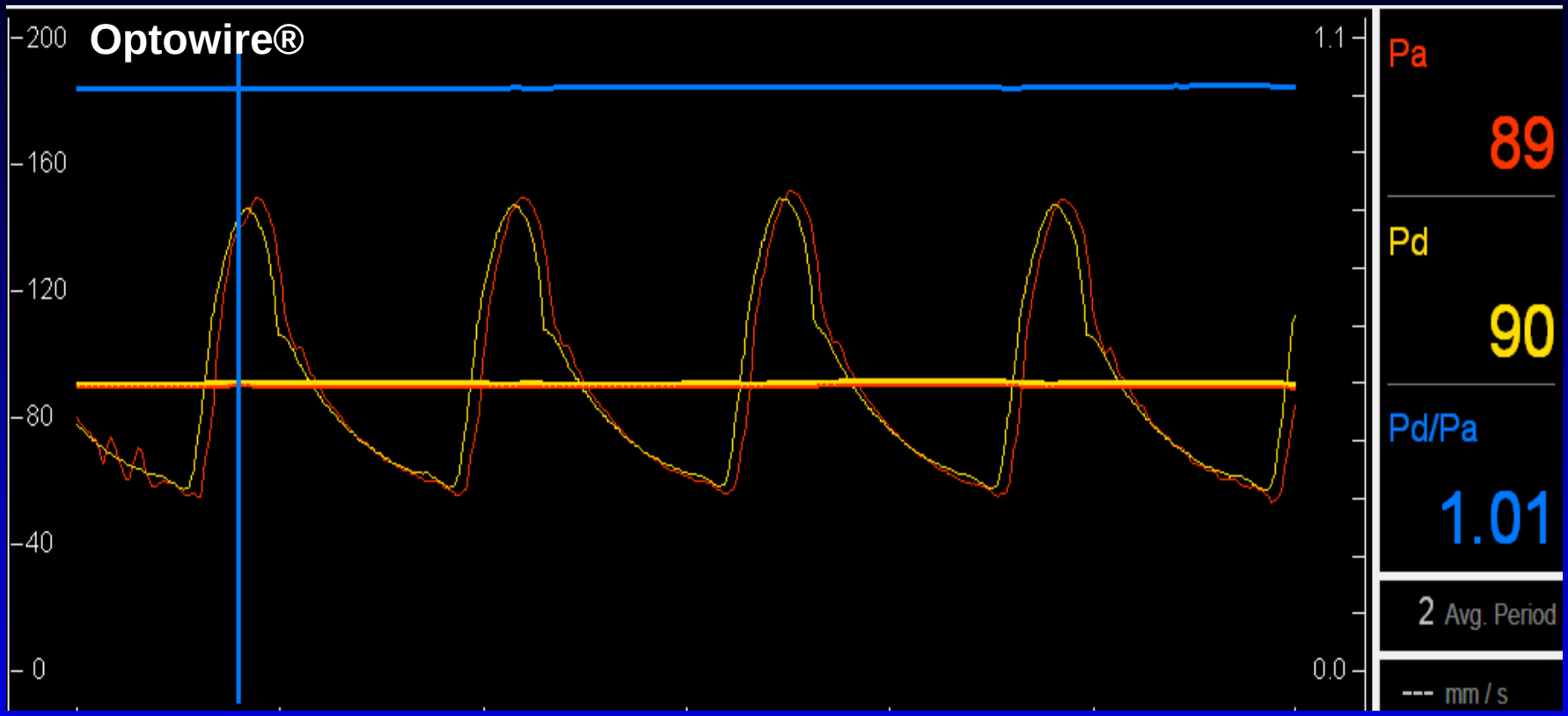
Patient with LIMA in past history; recurrent angina with diffuse disease in occluded, grafted native LAD



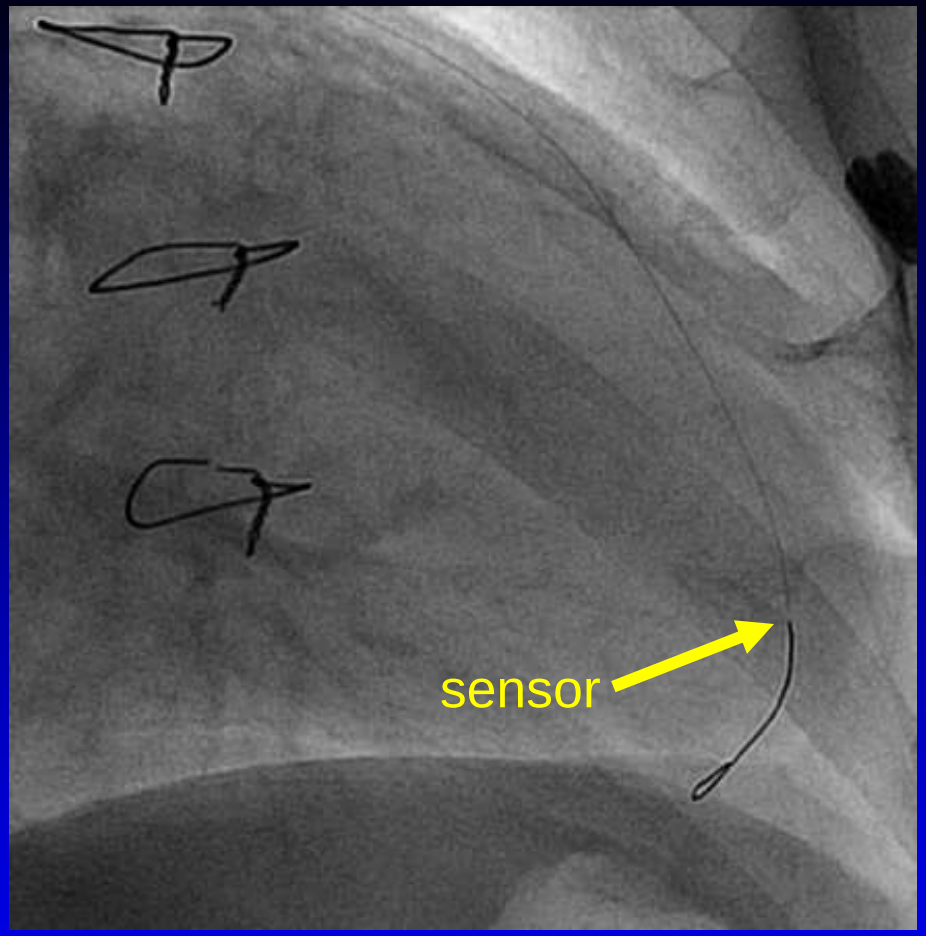
Are the lesions in the LAD significant ? Is LIMA okay?

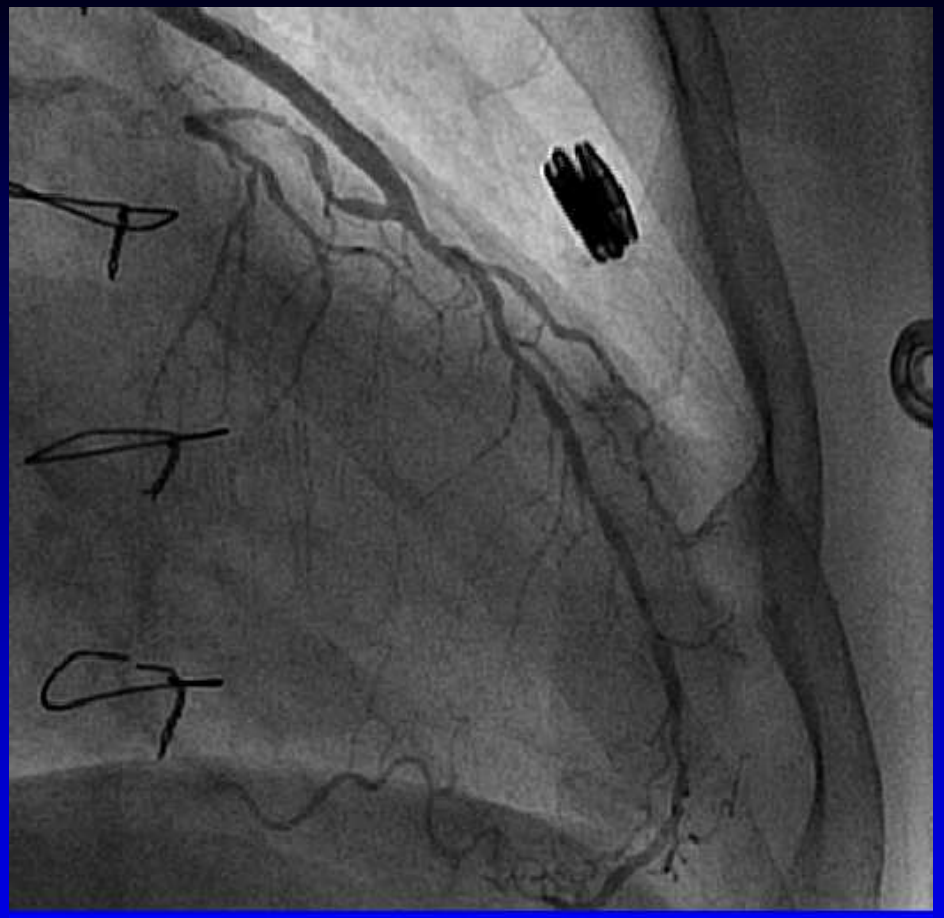


Optowire-deux (Opsens) advanced to ostium of LIMA, equalization performed

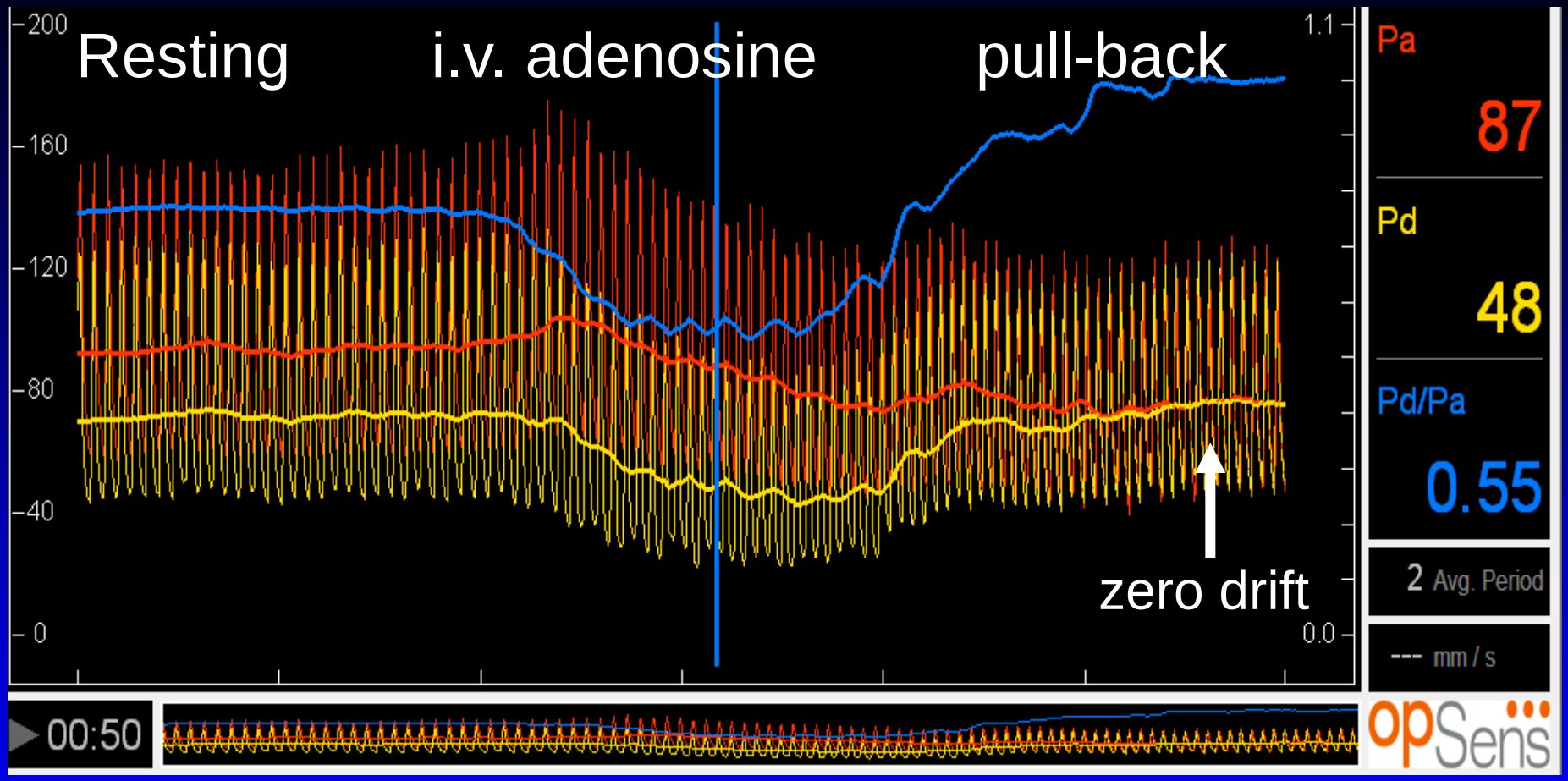


Equalization before entering into LIMA





Optowire smoothly advanced through LIMA, all the way to the very distal LAD, across apex (almost 30 cm), without any problem



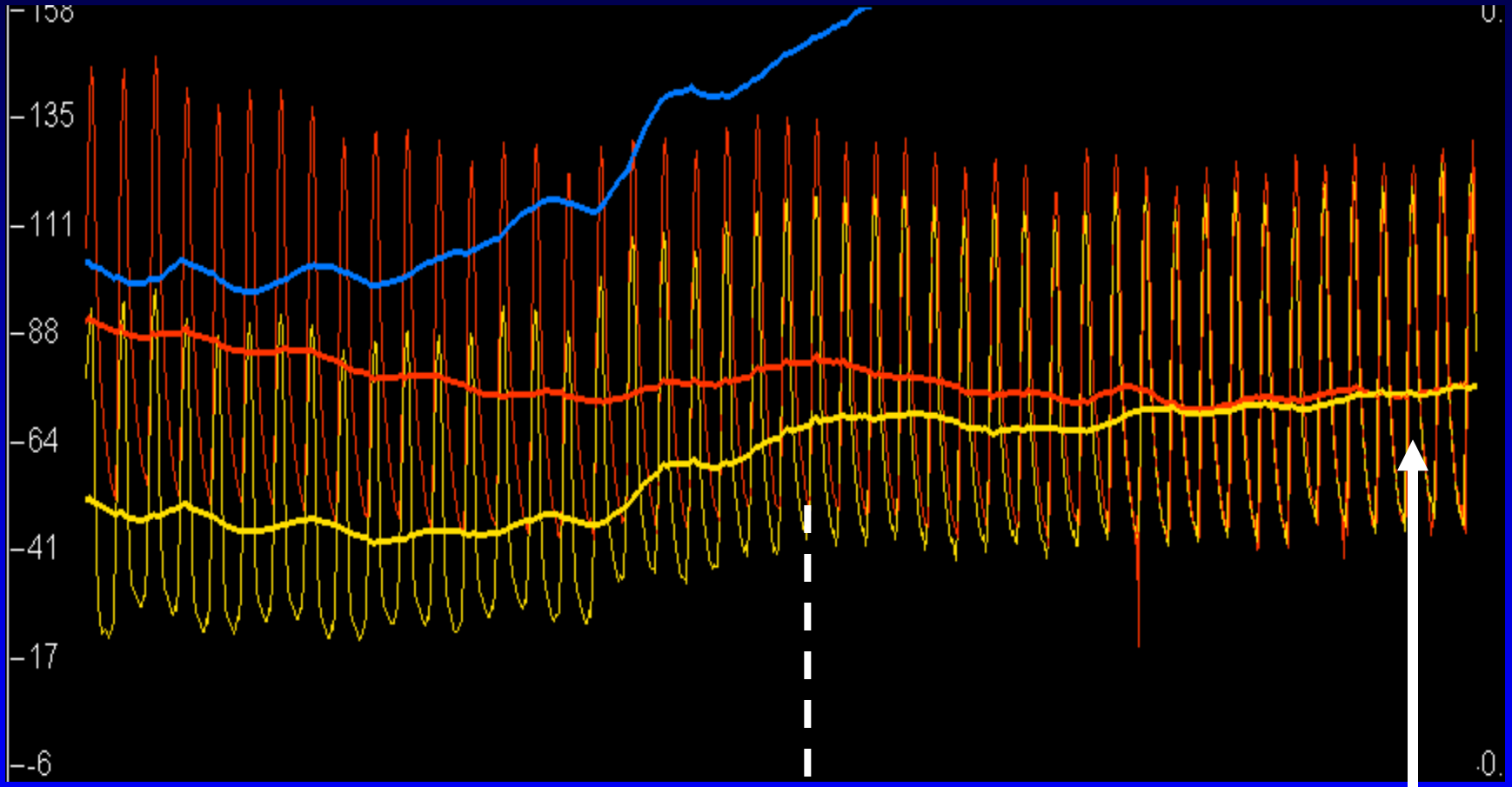
Full tracing of LIMA – LAD measurement

FFR = 0.55

And pull-back recording

(notice again the zero-drift)

Hyperemic pull-back recording from distal LAD (apex) to ostium of LIMA



Glineur et al !

OPTIMUM FFR TECHNIQUE: decrease of drift

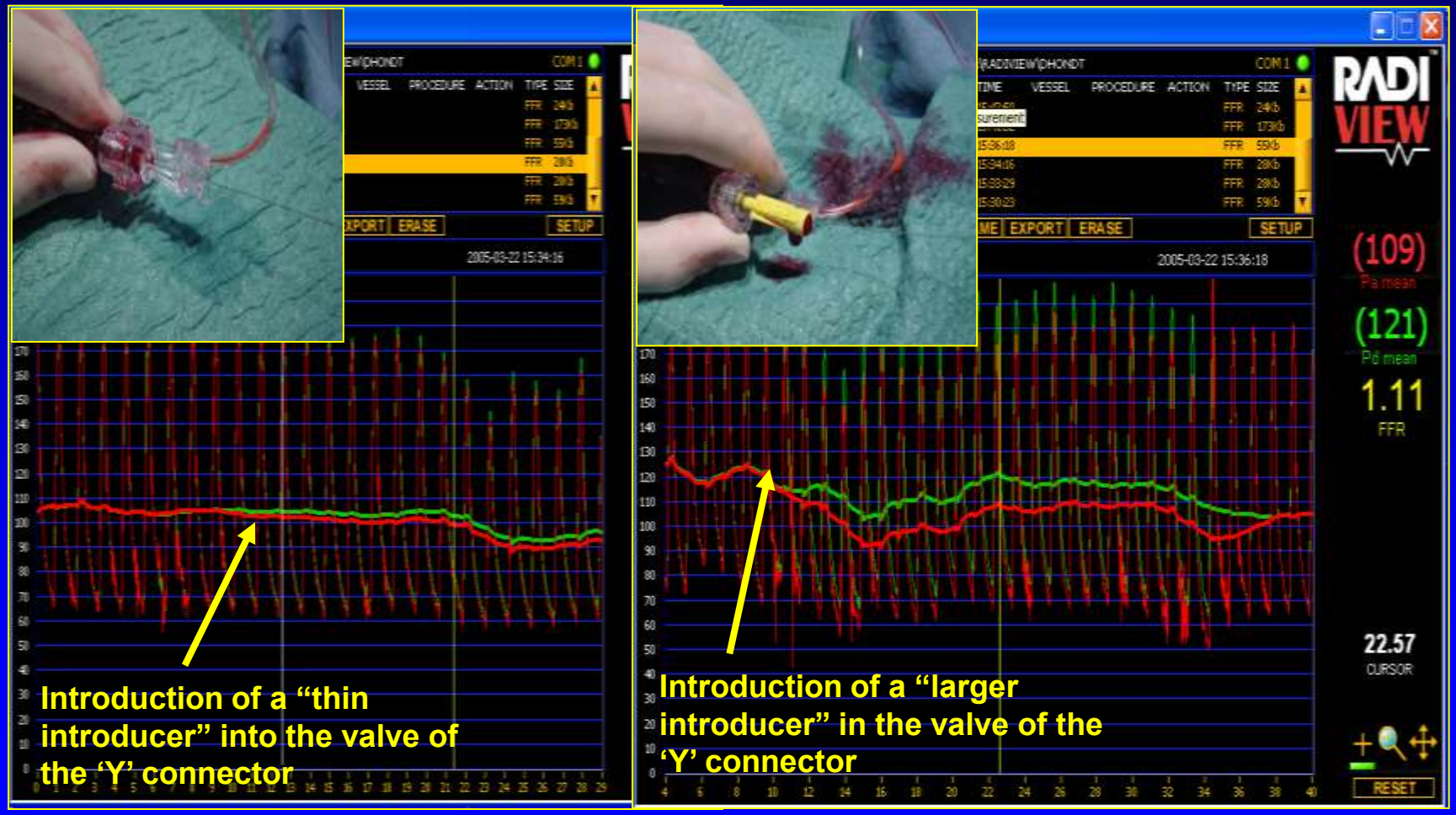
apparent drift

(not related to the pressure wire but caused by the guiding catheter or the operator)

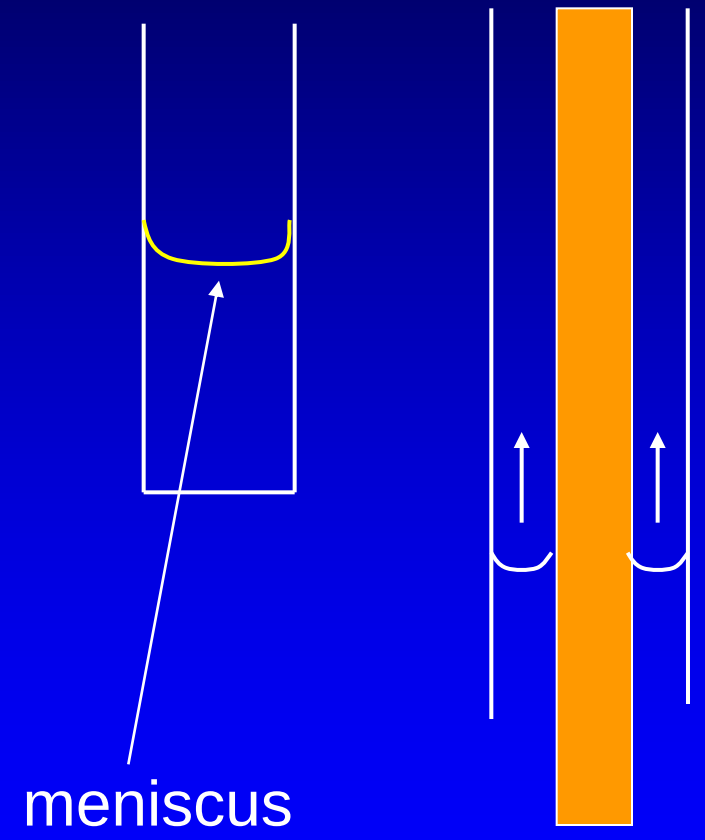
- inappropriate zeroing and equalization
- presence vs absence of introducery needle
- capillary forces in guiding catheter
- drift in the external pressure transducer

Introducer effect *(mistake in live case in PCR 2014!)*

Specifically important when pre-PCI assessment was with introducer and post-PCI assessment without it



Capillary forces in guiding catheter



sometimes capillary forces result in misregistration of pressure by the guiding up to 10 mm Hg

in procedures without pressure wire, this remains unnoticed

vigorous manual flushing of the guiding with 5-10 cc of saline, might restore true aortic pressure

TRUE DRIFT

True Drift

A FEW WORDS ON ***DRIFT***

- electronic wires (SJM, Volcano)
- fiberoptic Wires (Opsens, Boston Sc, (Acist))

OPTIMUM FFR TECHNIQUE: decrease of drift

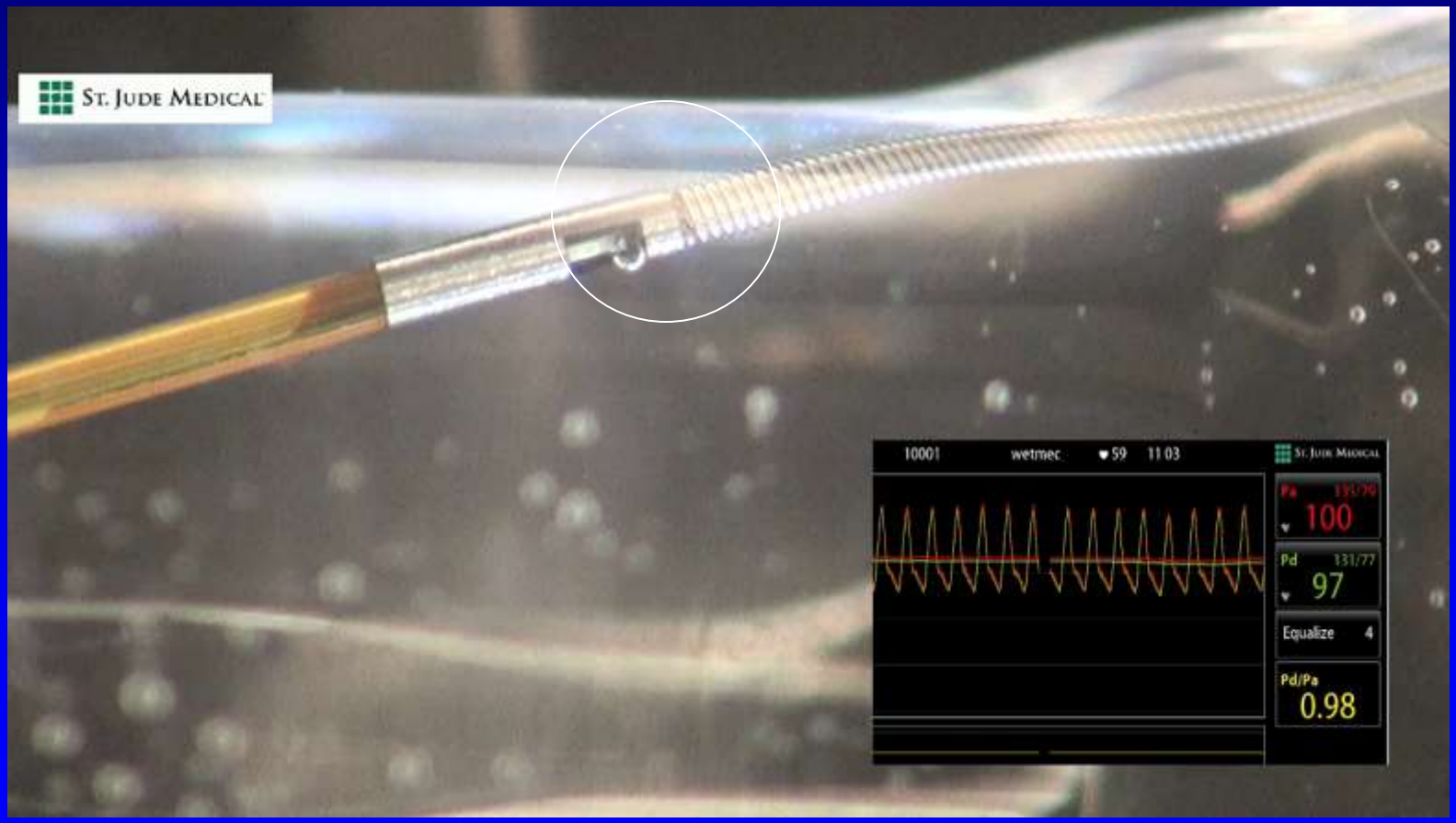
true drift in the Pressure Wire

- entrapment of air-bubbles in sensor cavity
- temperature related drift related to membrane construction
- blood/contrast remnants on the connector after reconnection

  ⟶ *to be minimized by cleaning/drying*

Micro-bubbles example

Pd/Pa 0,98, When µ-volumes of encapsulated gas dissolves from sensor housing
it can also move around causing drift in pressure reading



OPTIMUM FFR TECHNIQUE: decrease of drift

true drift in the Pressure Wire

- entrapment of air-bubbles in sensor cavity

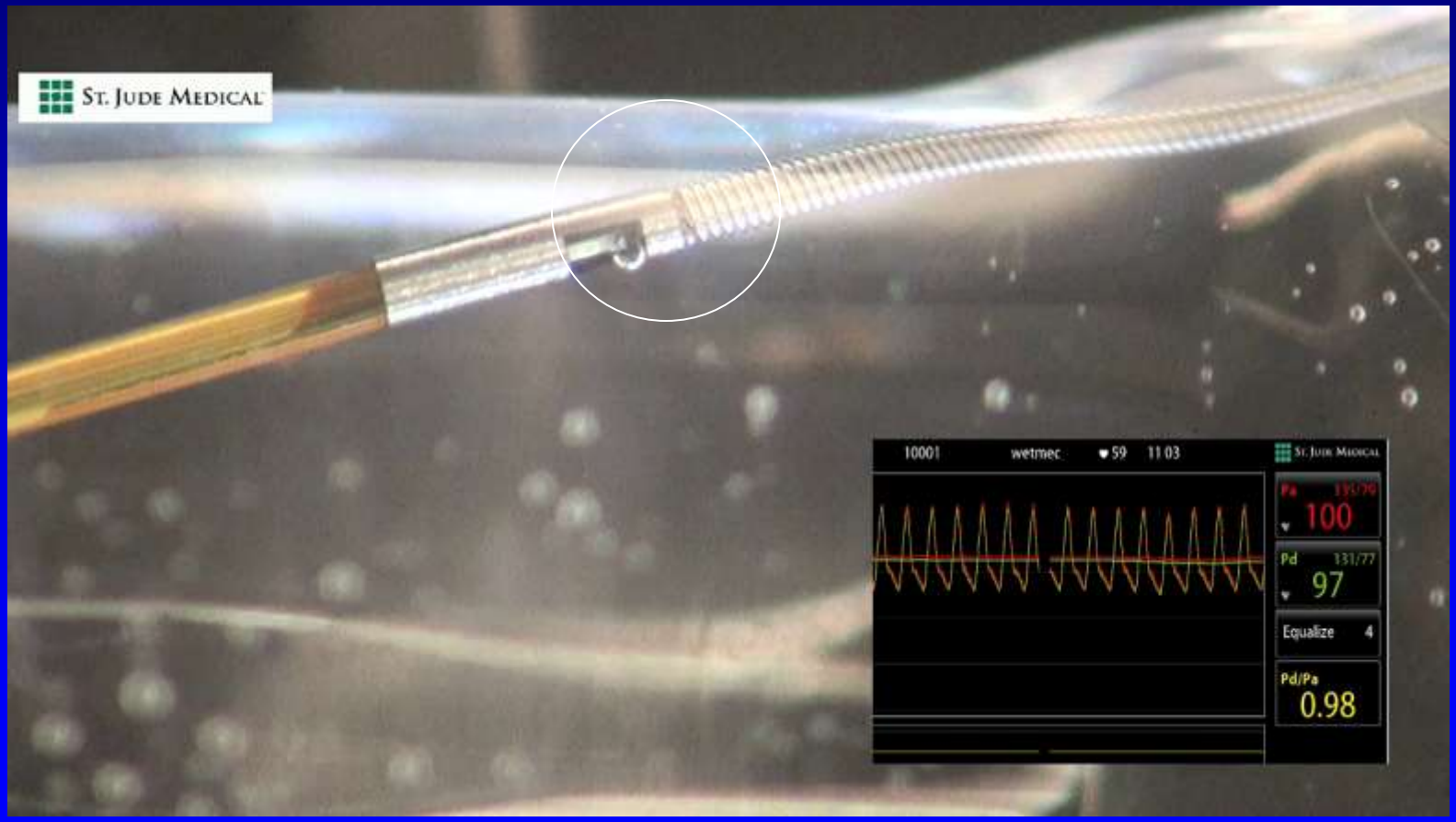
  ⟶ *wait 20-30 sec after equalization before advancing the wire into the coronary artery*

- temperature related drift related to membrane construction

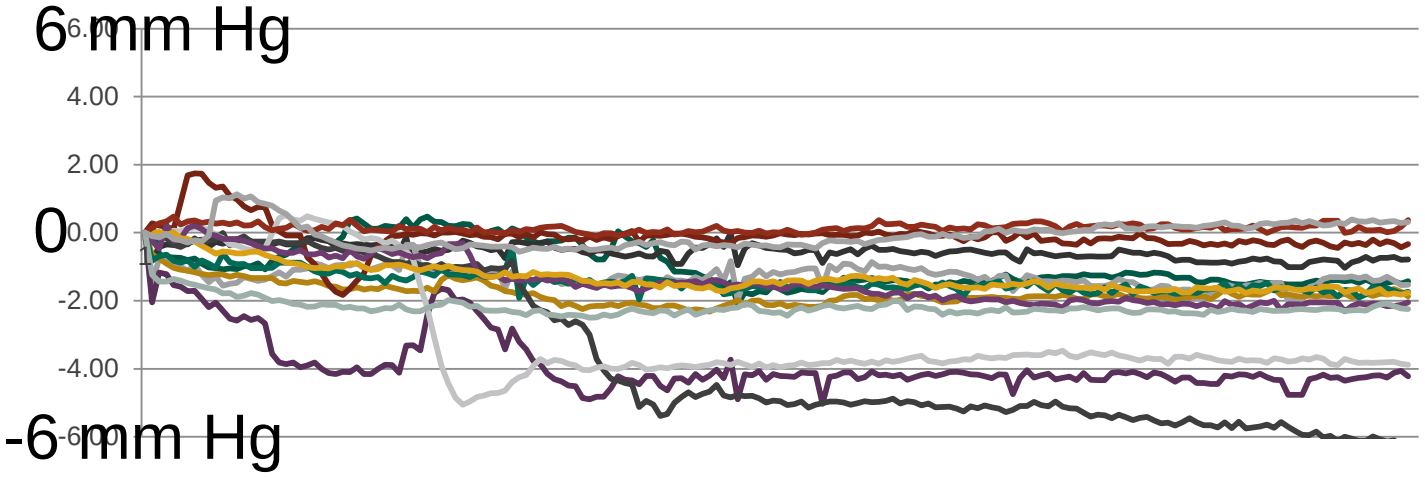
- blood/contrast remnants on the connector after reconnection

  ⟶ *to be minimized by cleaning/drying*

New ***SJM/Abbott Pressure Wire X***: coating on sensor to avoid these airbubbles → *this kind of drift (almost) eliminated*

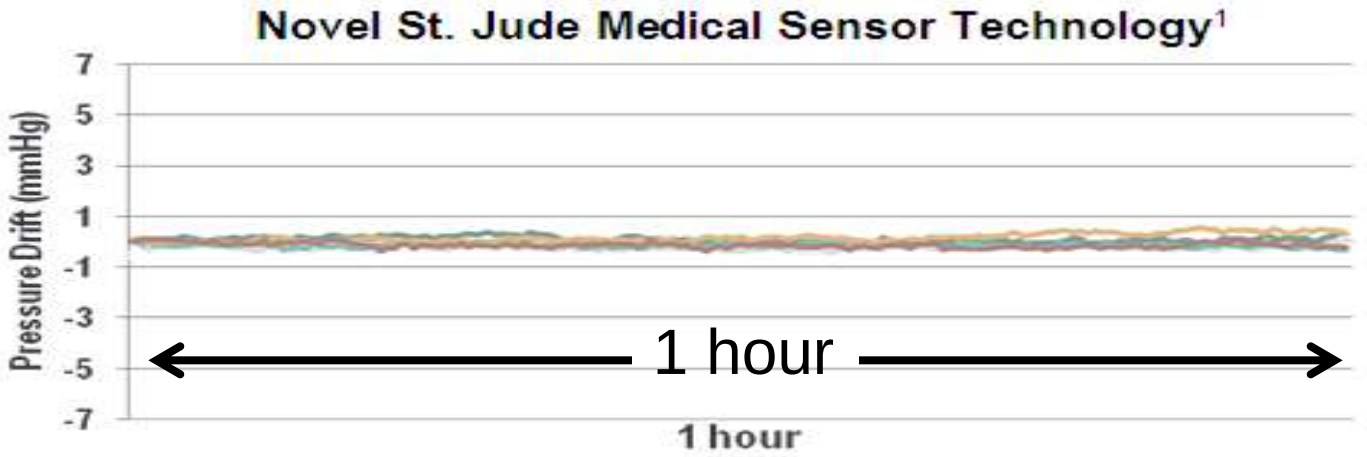


Present SJM Aeris wire:



up to
7 mmHg
per hour

Next generation Aeris (***PressureWireX***)



very little
drift

OPTIMUM FFR TECHNIQUE: decrease of drift

true drift in the Pressure Wire

- entrapment of air-bubbles in sensor cavity

- **temperature related drift related to membrane construction** ⟶ *related to sensor construction*

- blood/contrast remnants on the connector after reconnection

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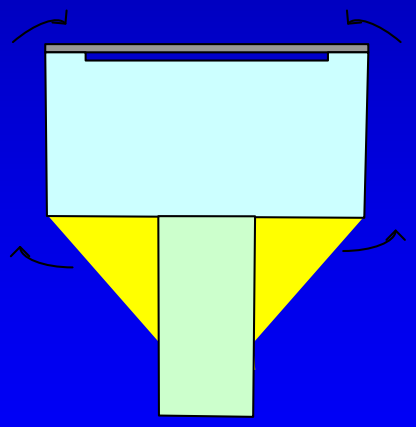
Optical Pressure Sensor – Conventional design (Boston Sc, Acist)

Environmental Effect

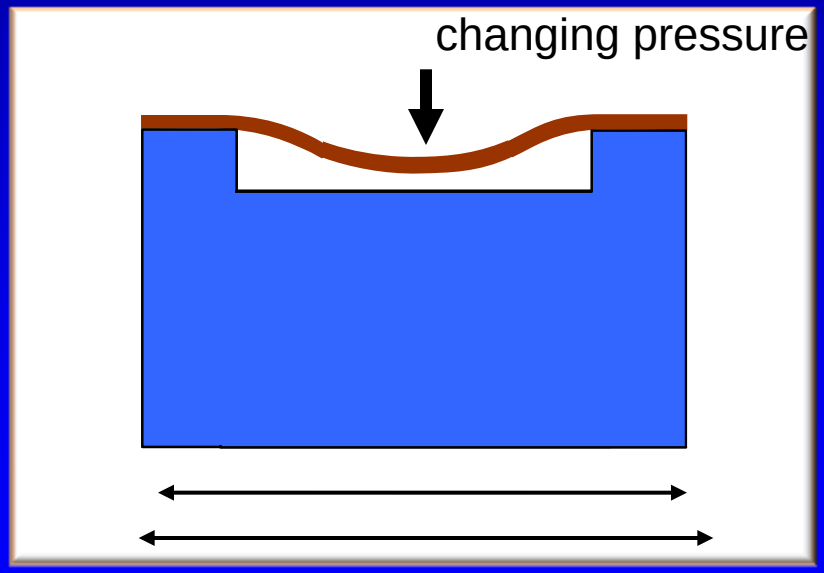
- Temperature-induced pressure shift
  - CTE silicon ≠ CTE Pyrex
- Moisture-induced pressure drift
  - Adhesive swelling induces mechanical stress



Temperature

+

Moisture

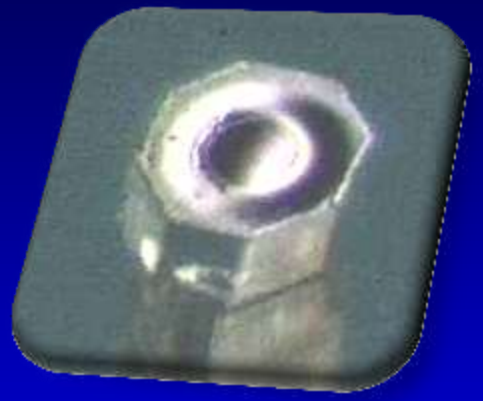


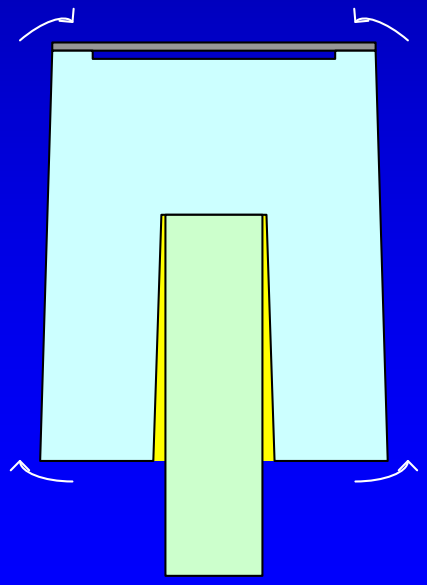
Shrink and expansion of sensor due to changes in temperature and moisture influences pressure on membrane

Optical Pressure Sensor – corrugated design (Opsens Optowire)

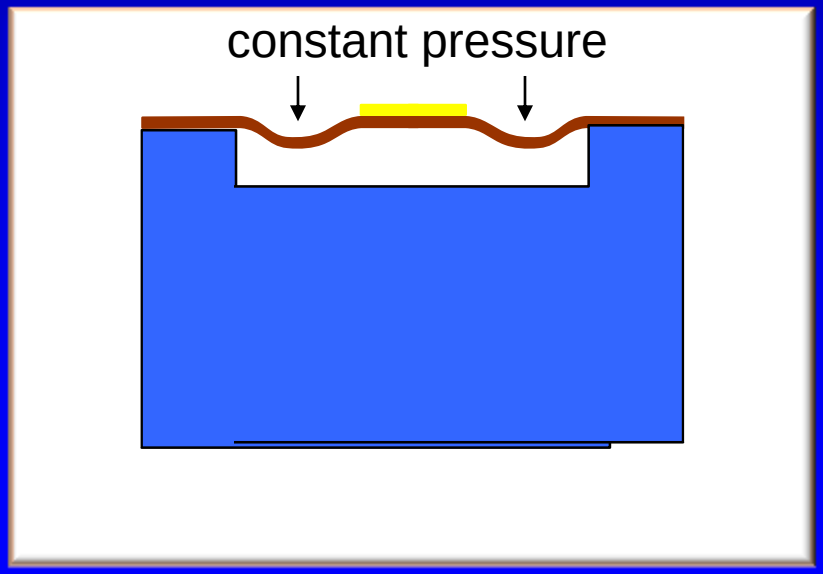
Environmental Effects

- No temperature-induced pressure shift
  - Central dot compensates moves diaphragm outward
- No moisture-induced pressure drift
  - Small amount of adhesive
  - Corrugated diaphragm ⟶ negligible drift





Temperature
+
Moisture



influence of moisture and temperature eliminated

OPTIMUM FFR TECHNIQUE: decrease of drift

true drift in the Pressure Wire

- entrapment of air-bubbles in sensor cavity
  ⟶ *wait 20-30 sec after equalization before advancing the wire into the coronary artery*

- temperature related drift related to membrane construction ⟶ *related to sensor construction*

- **blood/contrast remnants on the connector after reconnection**
  ⟶ *to be minimized by cleaning/drying*

Drift in the different pressure wires, clinical practice:

Electronic wires:

- *St Jude Medical: < 7 mmHg / hour (PW X less?)* * *
- *Philips/Volcano: up to 5mmHg/ 10 min (per FDA)*

New fiberoptic wires * :

- *Opsens: 0 - 2 mmHg*
- *Acist: 5 - 7 mmHg /h*
- *Boston Sc: up to 10 mmHg / hour, bidirectional*

* *Based upon preliminary experience*

* * *Large study in 2000 patients presently performed*

NOTE:

Hyperemia enhances the signal-to-noise ratio of coronary pressure measurement and thereby reduces the confounding effect of drift !

CAVEAT:

Resting indices (like iFR and P_d/P_a at rest) are more sensitive to confounding by drift

Sensitivity of resting indices (like iFR) to drift

- *drift is an absolute entity, e.g 5 mmHg / hour (irrespective of which index you are using)*
- *the total hyperemic pressure gradient within a coronary artery, is generally 2-3 x higher than the resting gradient.*
- *Consequently, the relative error of iFR due to drift, is 2-3 x higher than with hyperemia / FFR*
- *in other words, the accuracy of resting measurements (signal-to-noise ratio) is more affected by drift*
- *and also the resolution of the pull-back recording is 2-3 x lower with iFR or Pd/Pa at rest compared to FFR*

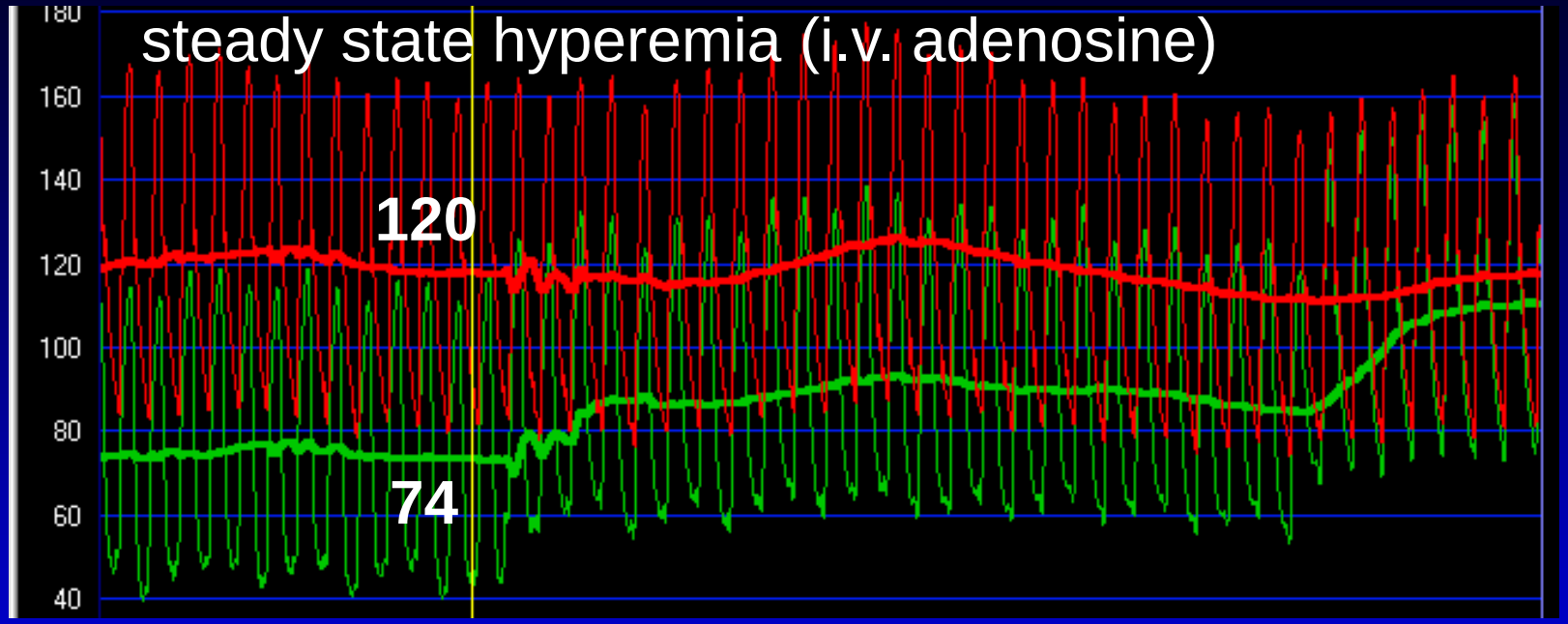
FINALLY:

Can we correct for drift, once it has occurred ?

Yes, but beware…….!

Especially when you are close to the gray zone

How to correct for drift in clinical practice ?



pullback
distal stenosis

pullback
prox stenosis

back in
guiding cath

$$FFR = \frac{74 + 5}{120} = 0.66$$

(be careful if you are close to the grey zone !)

ISSUES WITH DRIFT: CONCLUSIONS

- drift in pressure wires is annoying, although not always completely avoidable

- with careful handling and knowledge about the nature of drift, often it can be avoided or minimized

- with the new Optowire-2 and its corrugated membrane, drift is close to zero.
  Also the Aeris Pressure Wire X, has greatly reduced drift

- *resting indices (iFR) are more sensitive to confounding by drift, compared to hyperemic indices (FFR)*

- *do not always blame the presssure wire: in 50% of cases, drift is due to the guiding catheter*