Index of Microvascular Resistance (IMR) and Absolute Coronary Blood Flow (ACF)

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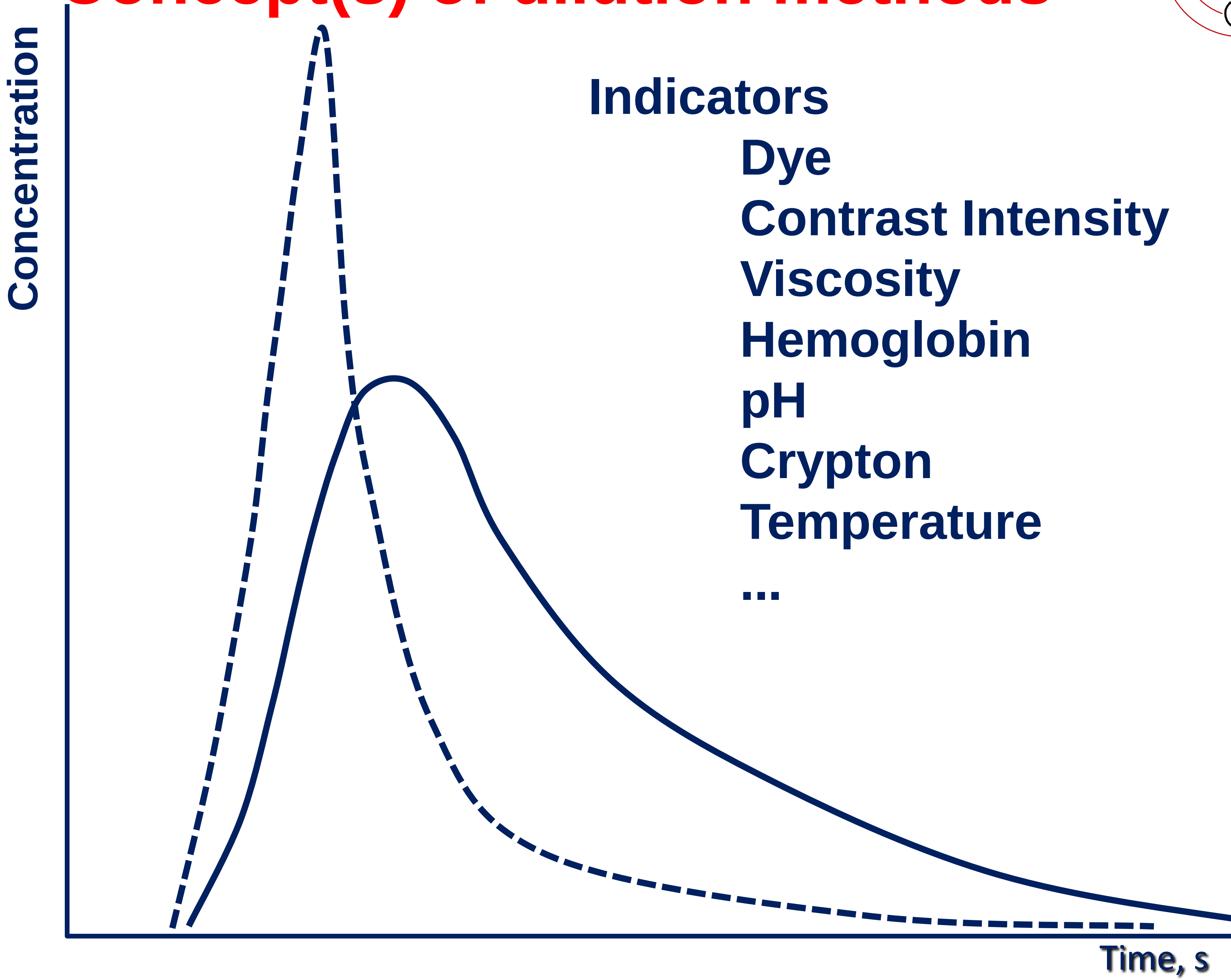
1. **Concept(s) of dilution methods**

2. **Bolus injection: IMR**

3. **Continuous Infusion: ACF**

Concept(s) of dilution methods



Indicators

- Dye
- Contrast Intensity
- Viscosity
- Hemoglobin
- pH
- Crypton
- Temperature
- ...

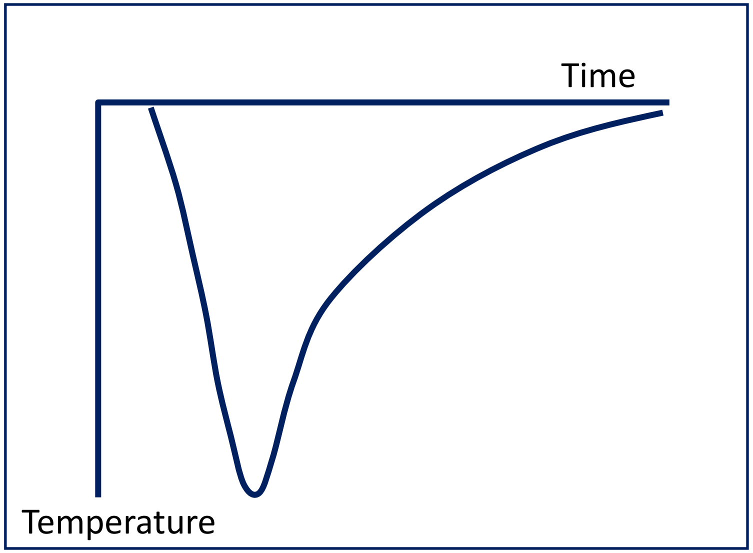
Concept(s) of dilution methods

If

1. Mixing of the indicator is complete
2. Heat exchange with adjacent tissue is negligible
3. Flow is constant during the measurement
4. No recirculation of the indicator during the measurement
5. The injection of the indicator does not cause any change to the flow

K. Pávek et al. Circ Res 1964

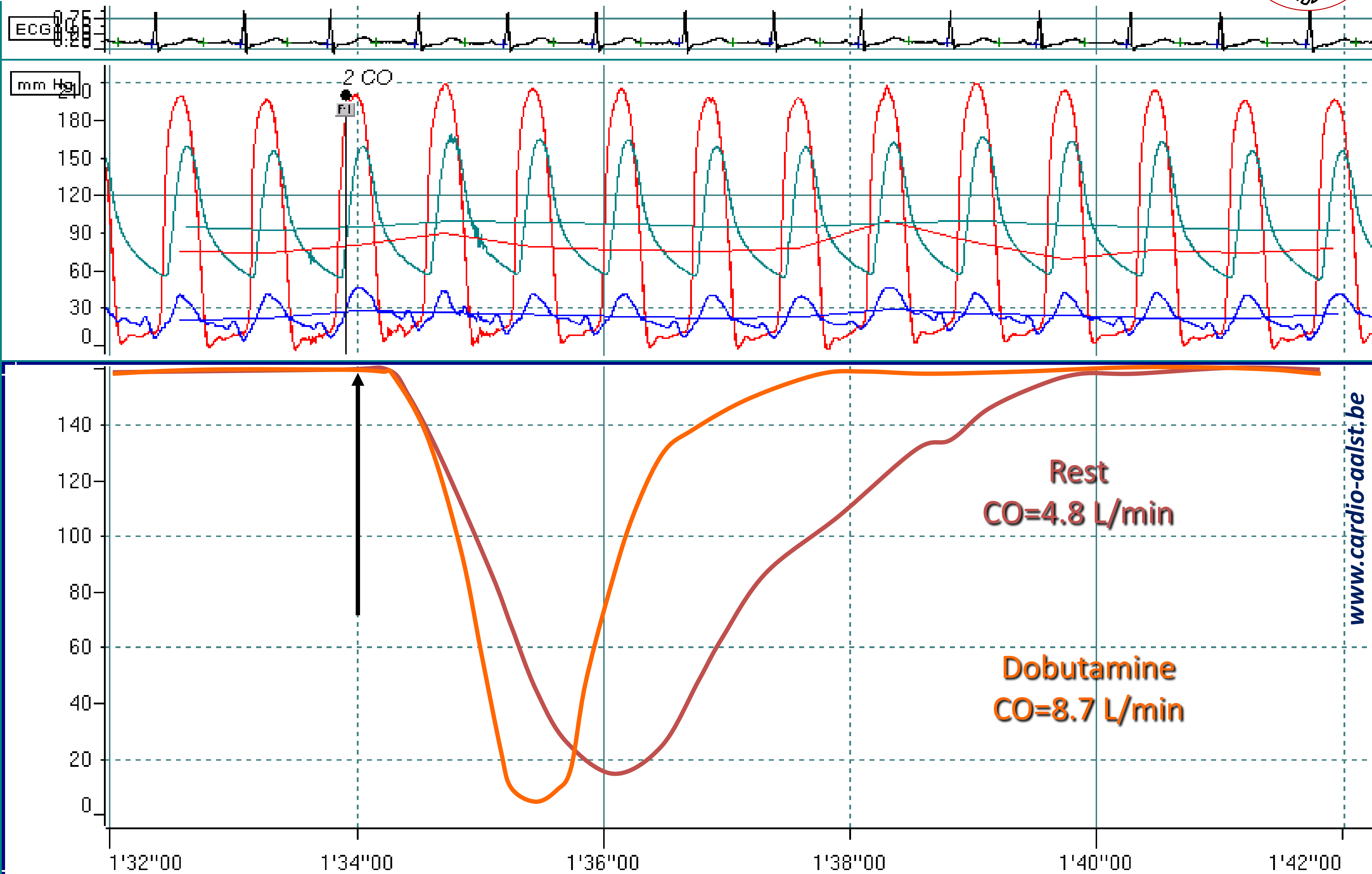
Concept(s) of dilution methods



$$F = M \Big/ \int_0^\infty c(t)\,dt$$

- Amount ‘M’ of indicator should be known
- Vascular volume should not be known

Concept(s) of dilution methods



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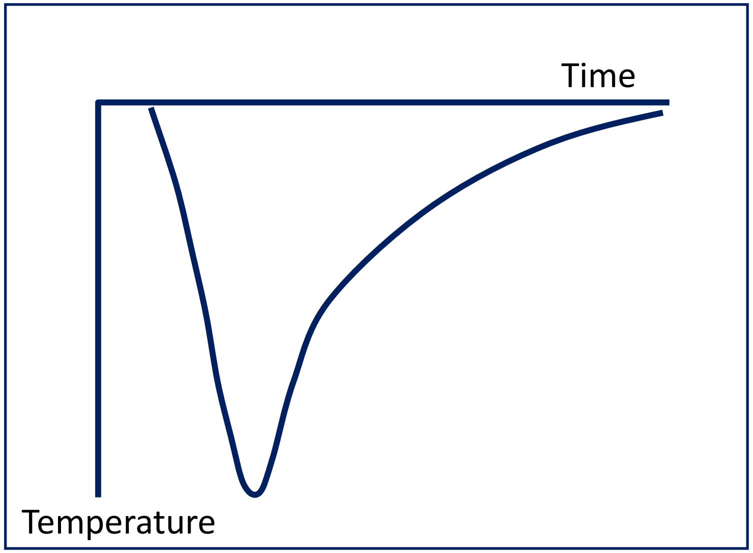
Concept(s) of dilution methods



$$F = M \Big/ \int_0^\infty c(t)\,dt$$

- Amount 'M' of indicator should be known
- Vascular volume should <u>not</u> be known

$$F = \frac{V}{T_{mn}}$$

- Amount of 'indicator' should <u>not</u> be known
- Vascular volume 'V' should be known

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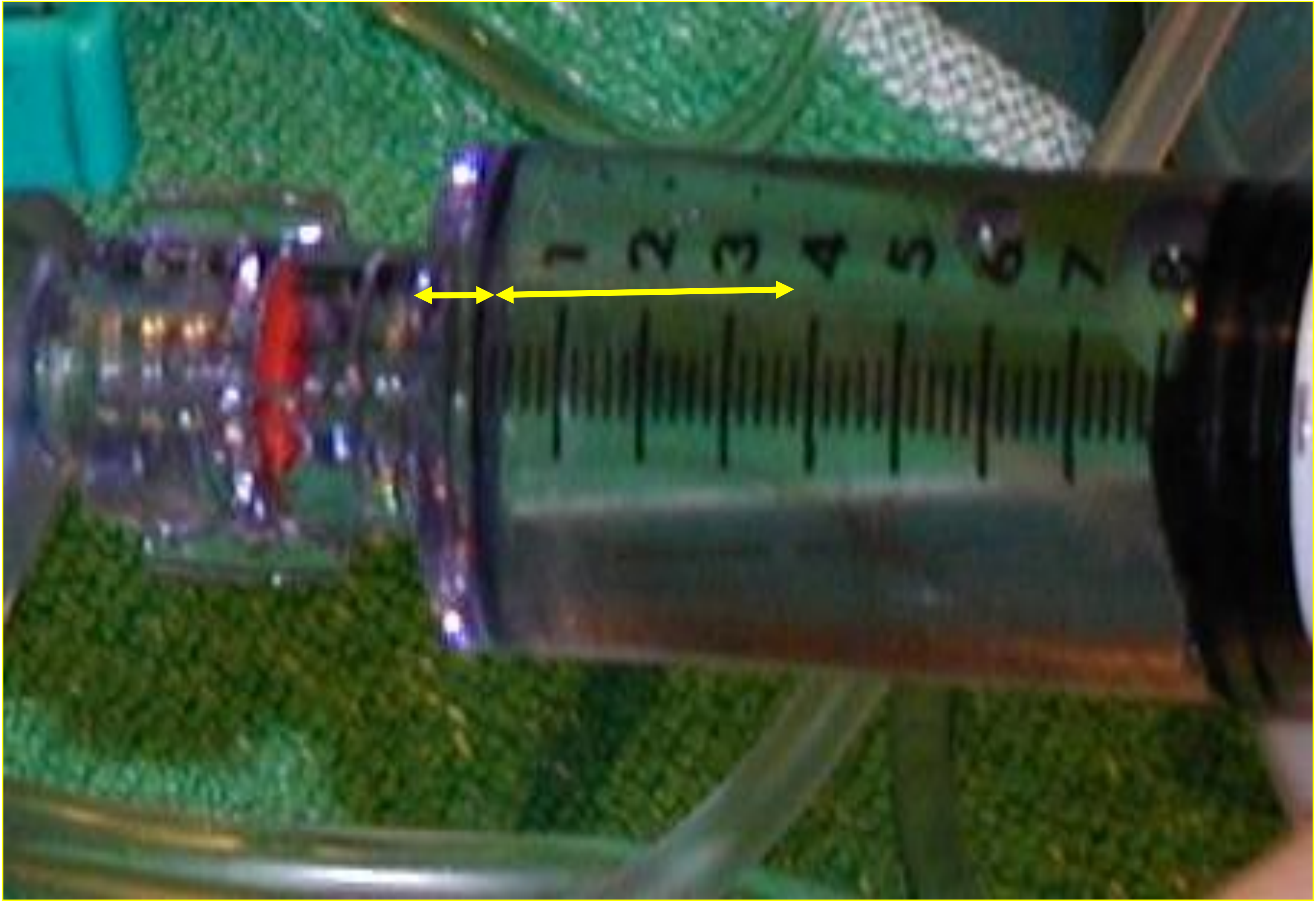
Concept(s) of dilution methods



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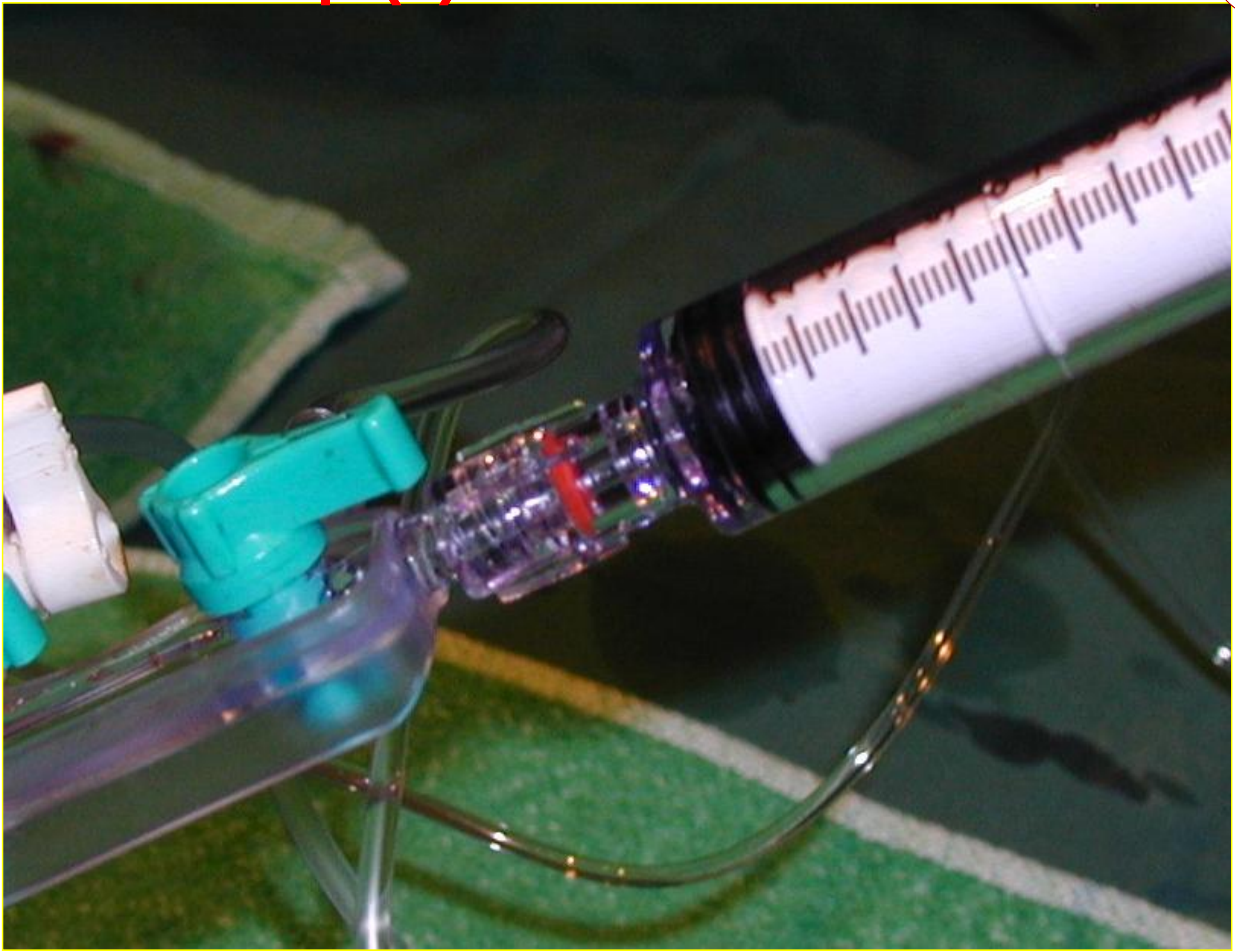

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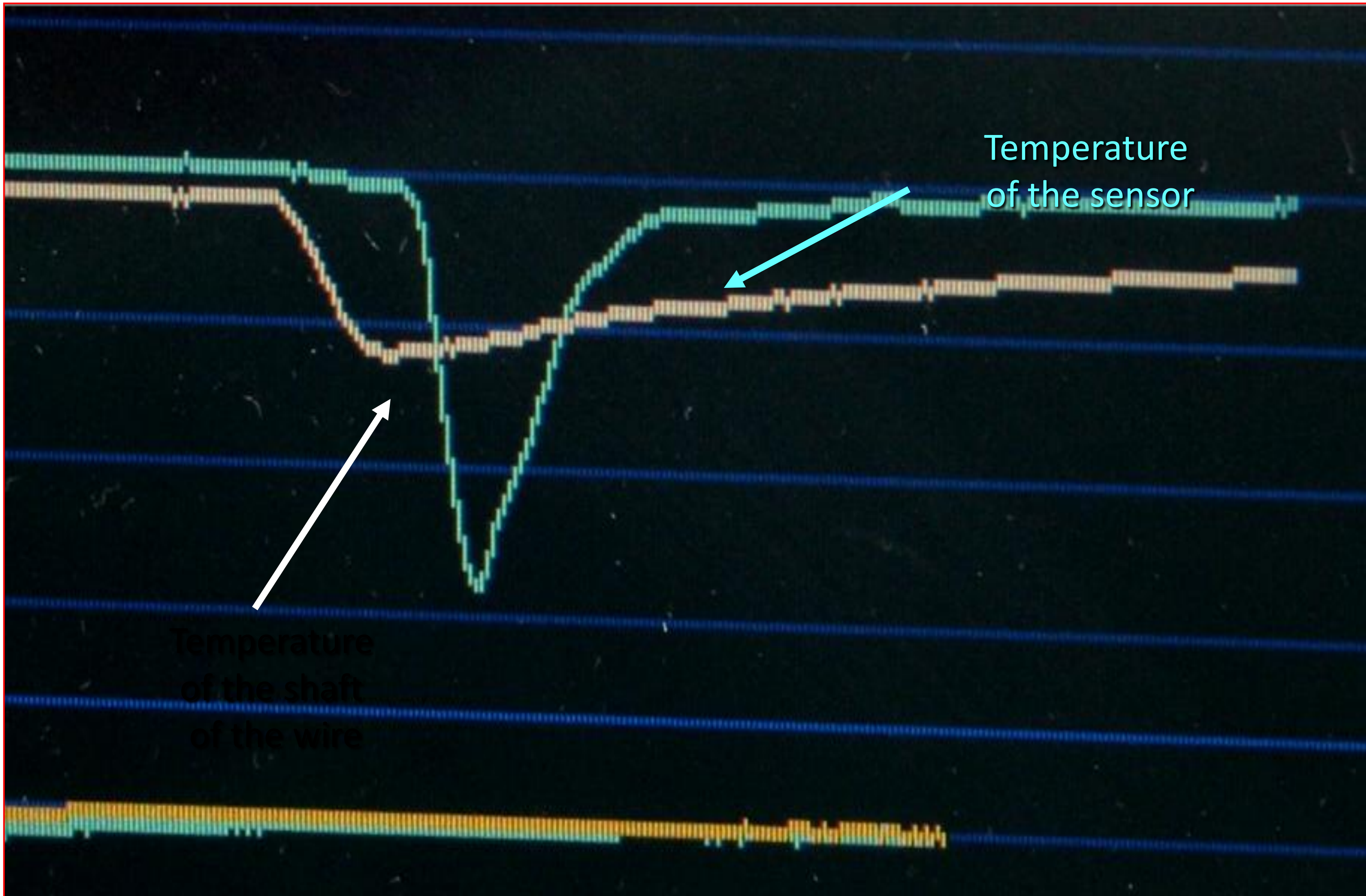

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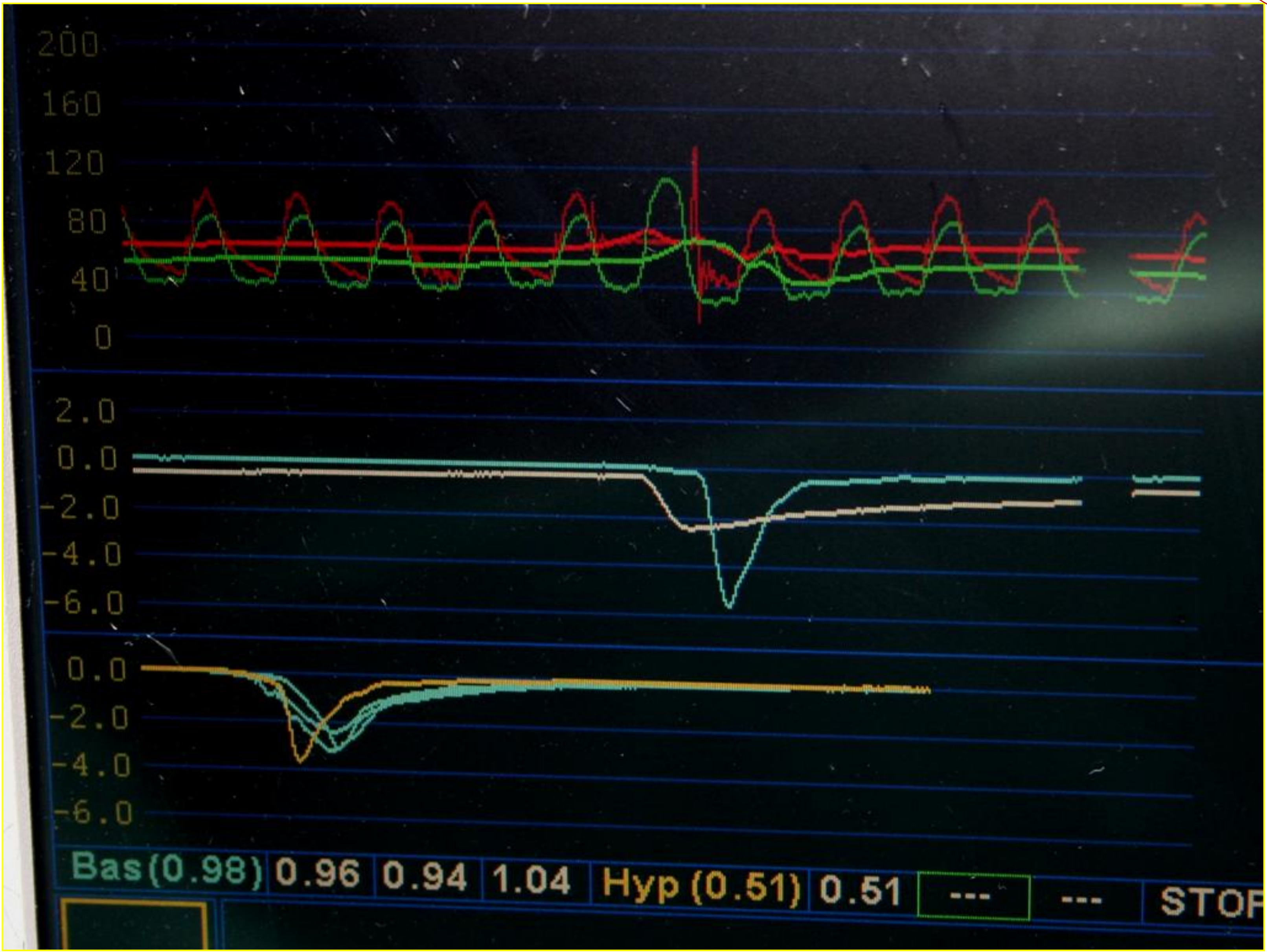
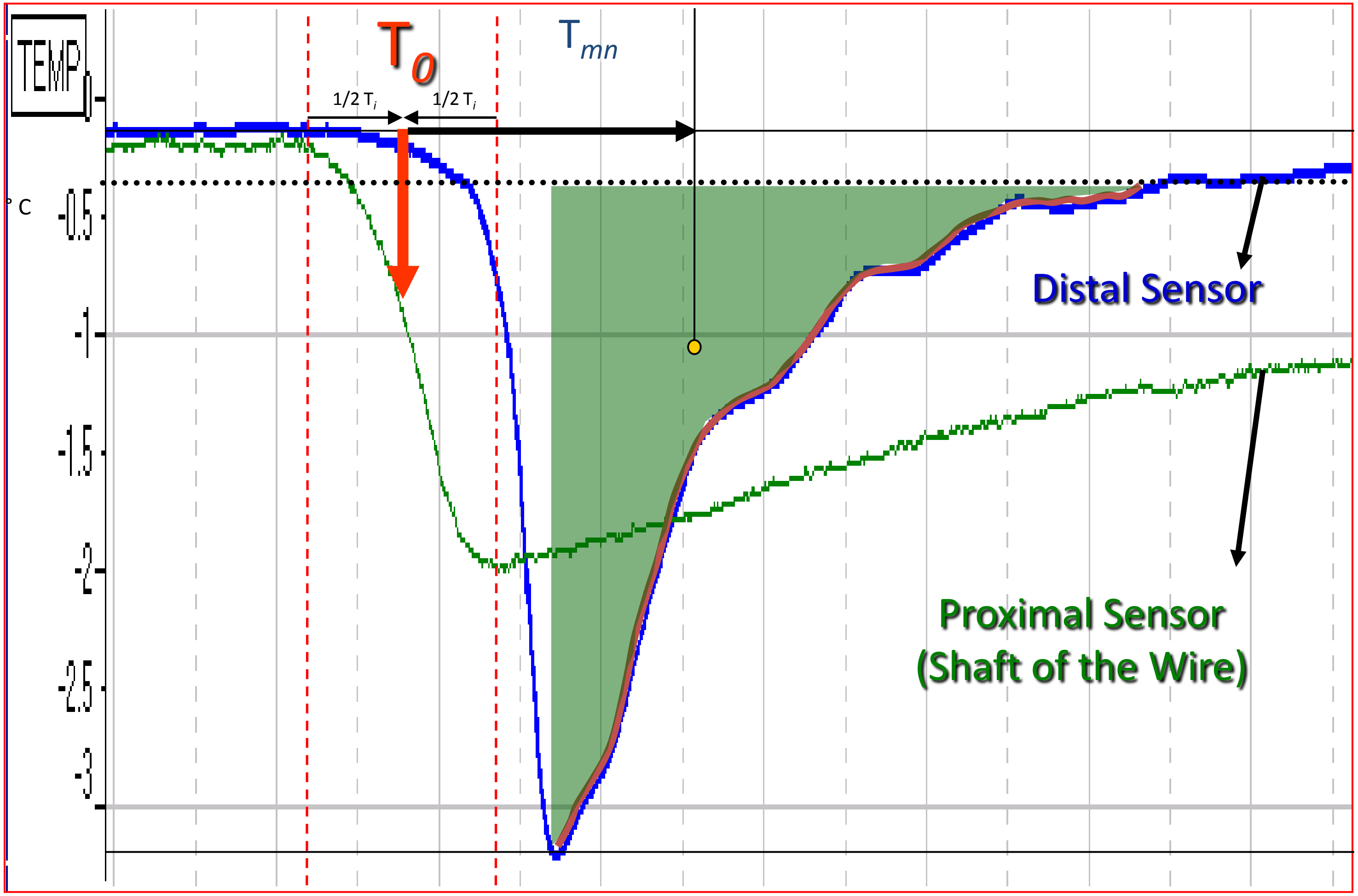


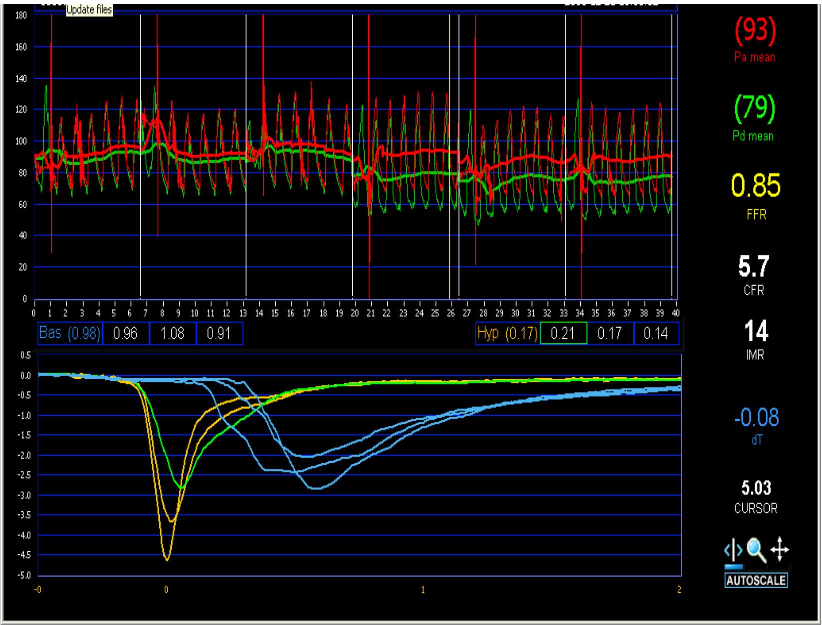
Mean Transit Time, T_{mn}

= Mean time needed for the indicator to travel from the guiding to the sensor



De Bruyne B et al Circulation 2001;104:2003
Pijls NHJ et al Circulation 2002 105:2482

General Principle of Coronary Thermodilution



$$F = \frac{V}{T_{mn}}$$

$$T_{mn}\ (s) = \frac{V\ (mL)}{F\ (mL/s)}$$

T_{mn} (s) = an index of flow

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T_{mn} **(s)** = an index of flow

CFR

IMR

IMR: Definition

Myocardial Resistance (R_{myo}) = $\frac{P_d - P_v}{F}$ (mm Hg.mL^{-1}.min^{-1})

Since: (1) $F \approx 1 / T_{mn}$

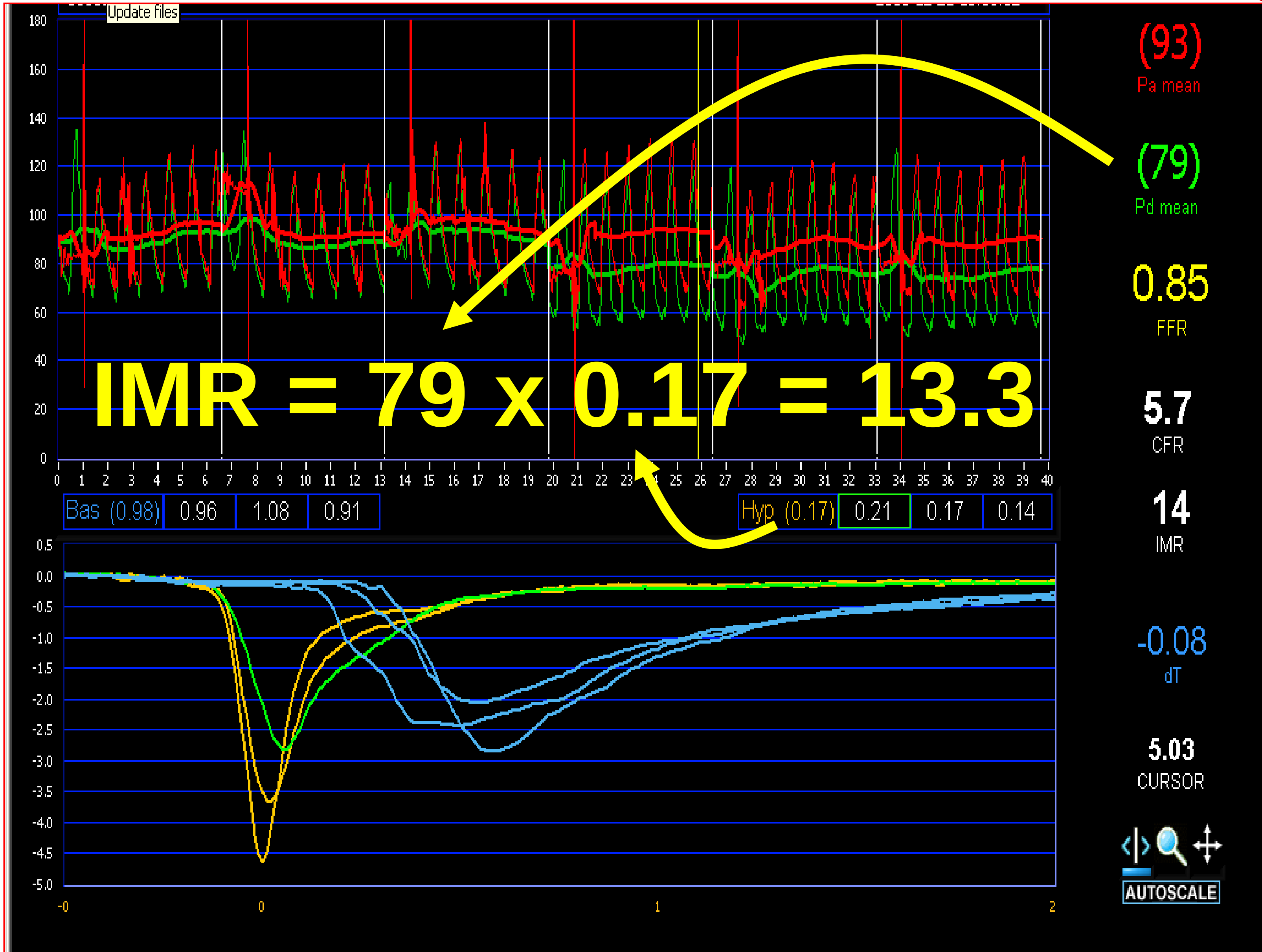
(2) $P_v \approx 0$ mm Hg

Then, $$IMR = \frac{P_d}{1 / T_{mn}}$$

$$IMR = P_d \times T_{mn}$$

Fearon WF et al Circulation 2003;107:3129

IMR in Practice



Bolus Coronary Thermodilution

Pitfalls and Limitations

- Location of the sensor too close to guiding
- Injection time (T_{inj}) too long
- 'Wedging' of the guiding in the ostium
- T_{mn} too short (< 0.1 s)
- Side branches (especially when far from the guiding)

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IMR: Definition

$$IMR = P_d . T_{mn}$$

To take into account the effect of collaterals

Driving Pressure Across the Myocardium
Myocardial Flow

$$\mathbf{IMR = P_a \cdot T_{mn} \cdot \frac{P_d - P_w}{P_a - P_w}}$$

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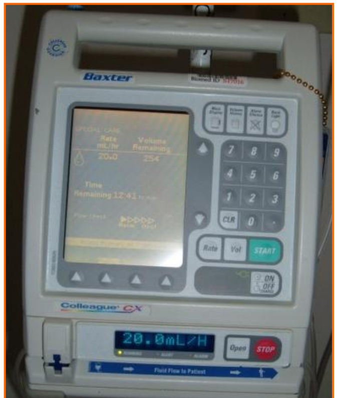
2. Bolus injection: IMR

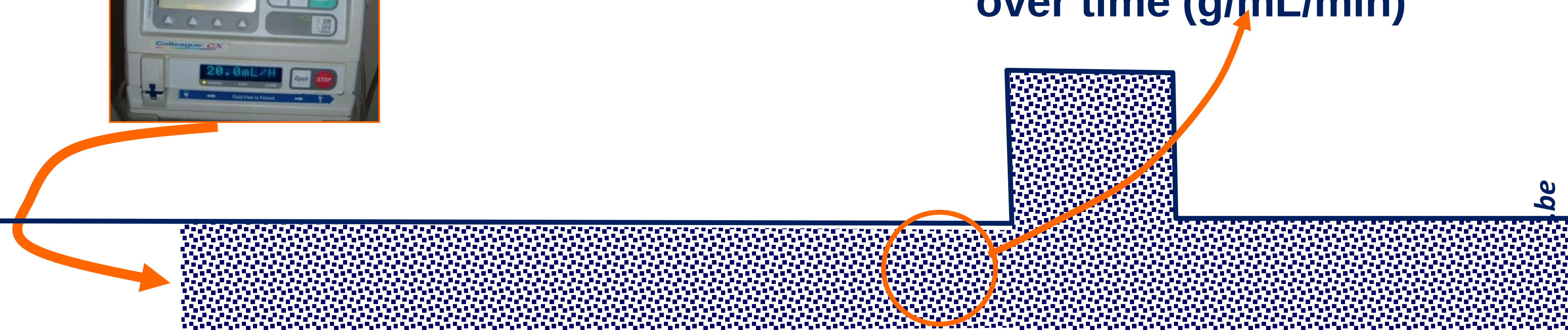
3. Continuous Infusion: ACF

Continuous Infusion: ACF



Constant Flow of injectate (mL)

Concentration (temperature) over time (g/mL/min)

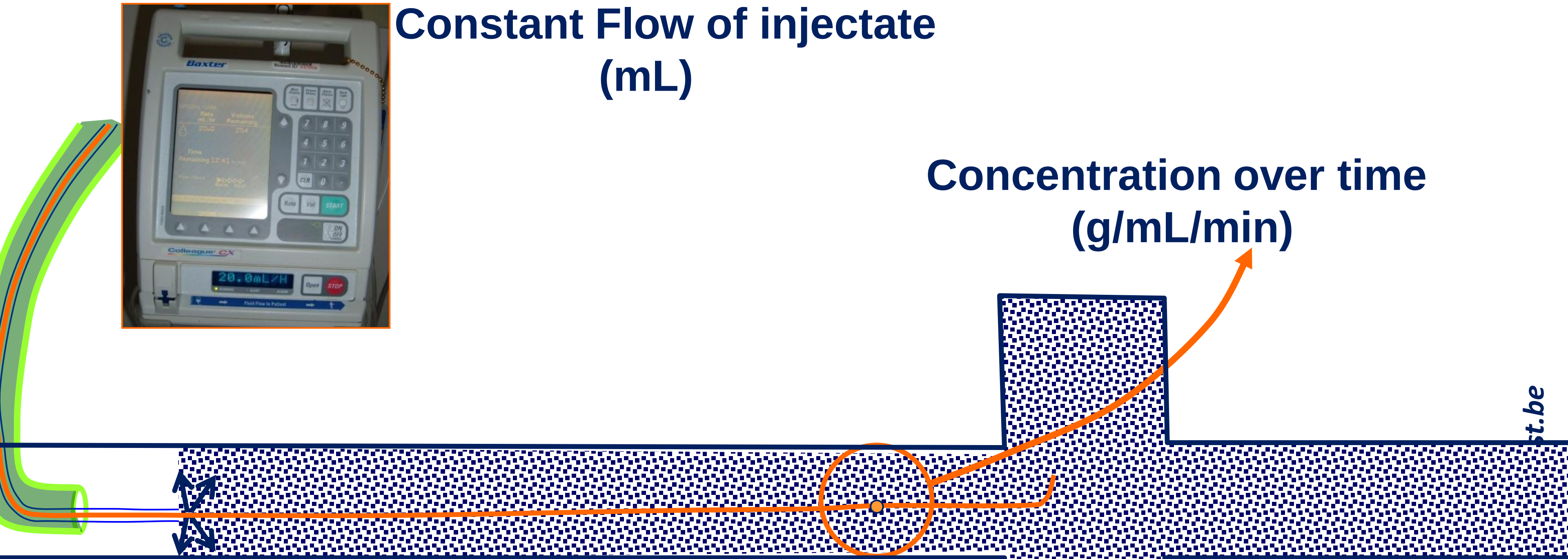


To be known: **Flow of the pump (20 mL/min)**
Proximal Temperature
Distal Temperature

$$Q = Q_i \times \frac{T_i}{T} \times 1.08$$

Aarnoudse W et al J Am Coll Cardiol 2007;50:2294

Continuous Infusion: ACF



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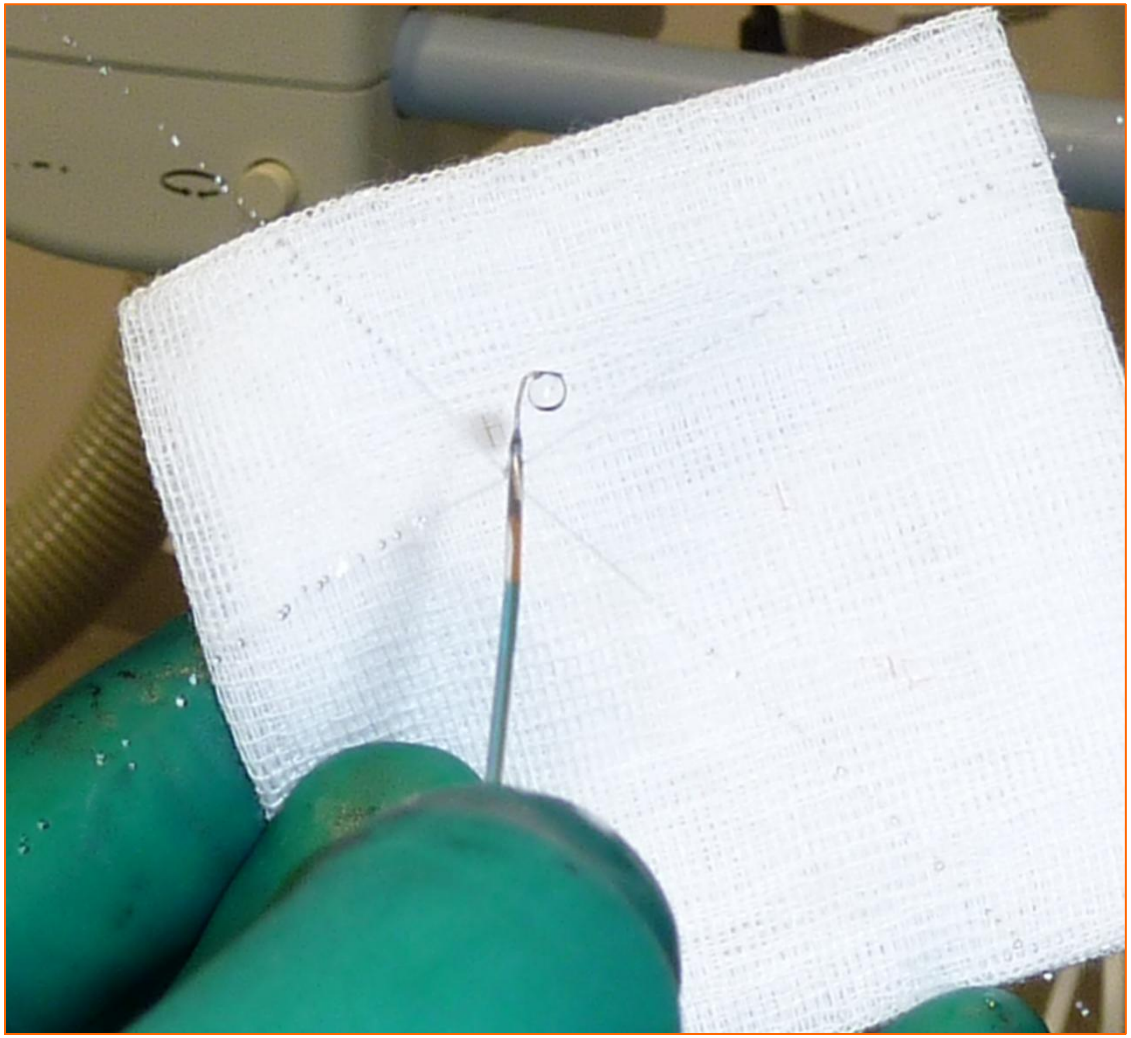
Catheter for continuous saline infusion

- 4 side holes allowing optimal mixing of saline
- Minimal or no saline dripping through the distal port



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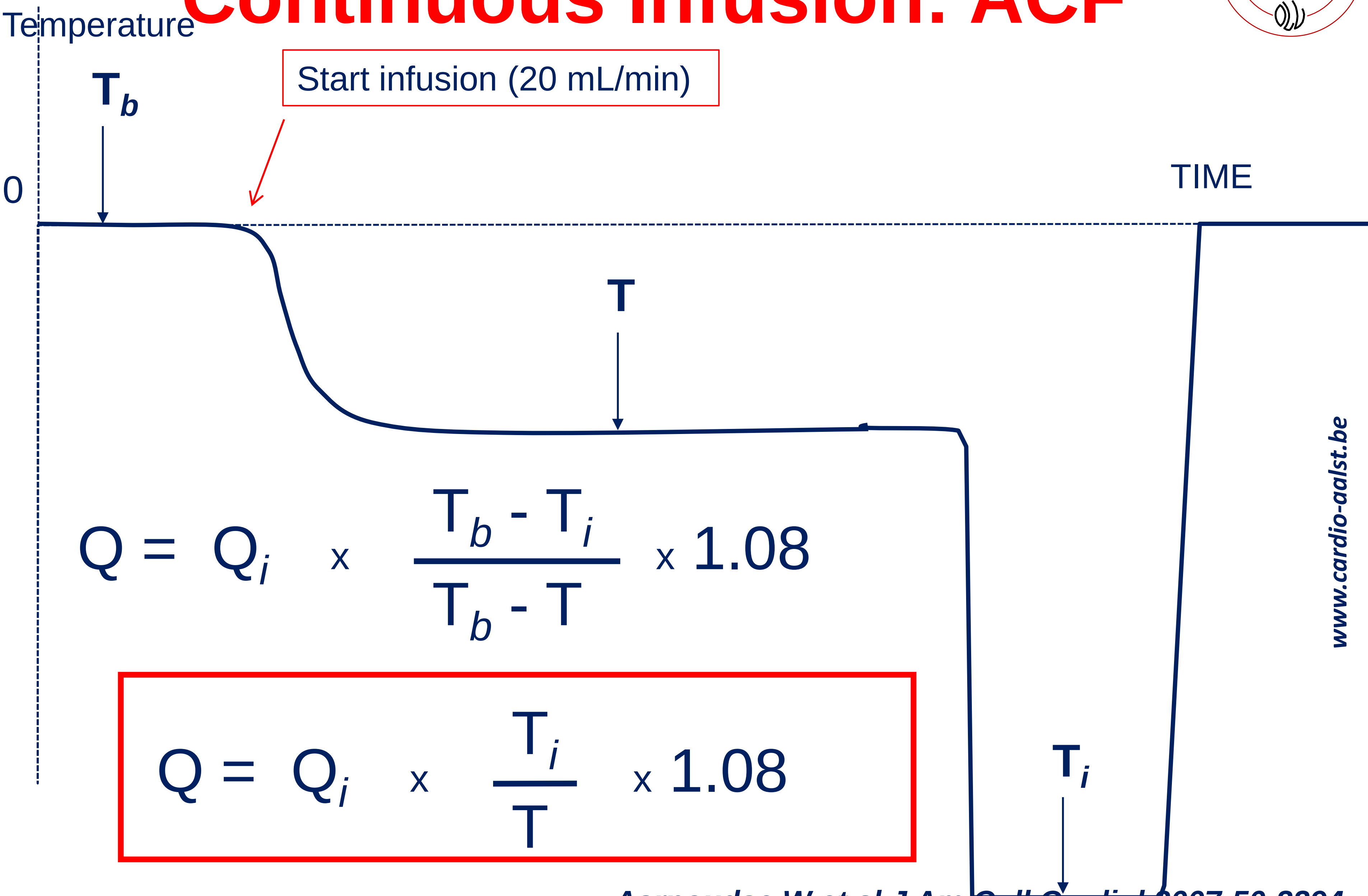

$$Q = Q_i \times \frac{T_b - T_i}{T_b - T} \times 1.08$$

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ETP, Sofia Antipolis, April 2013

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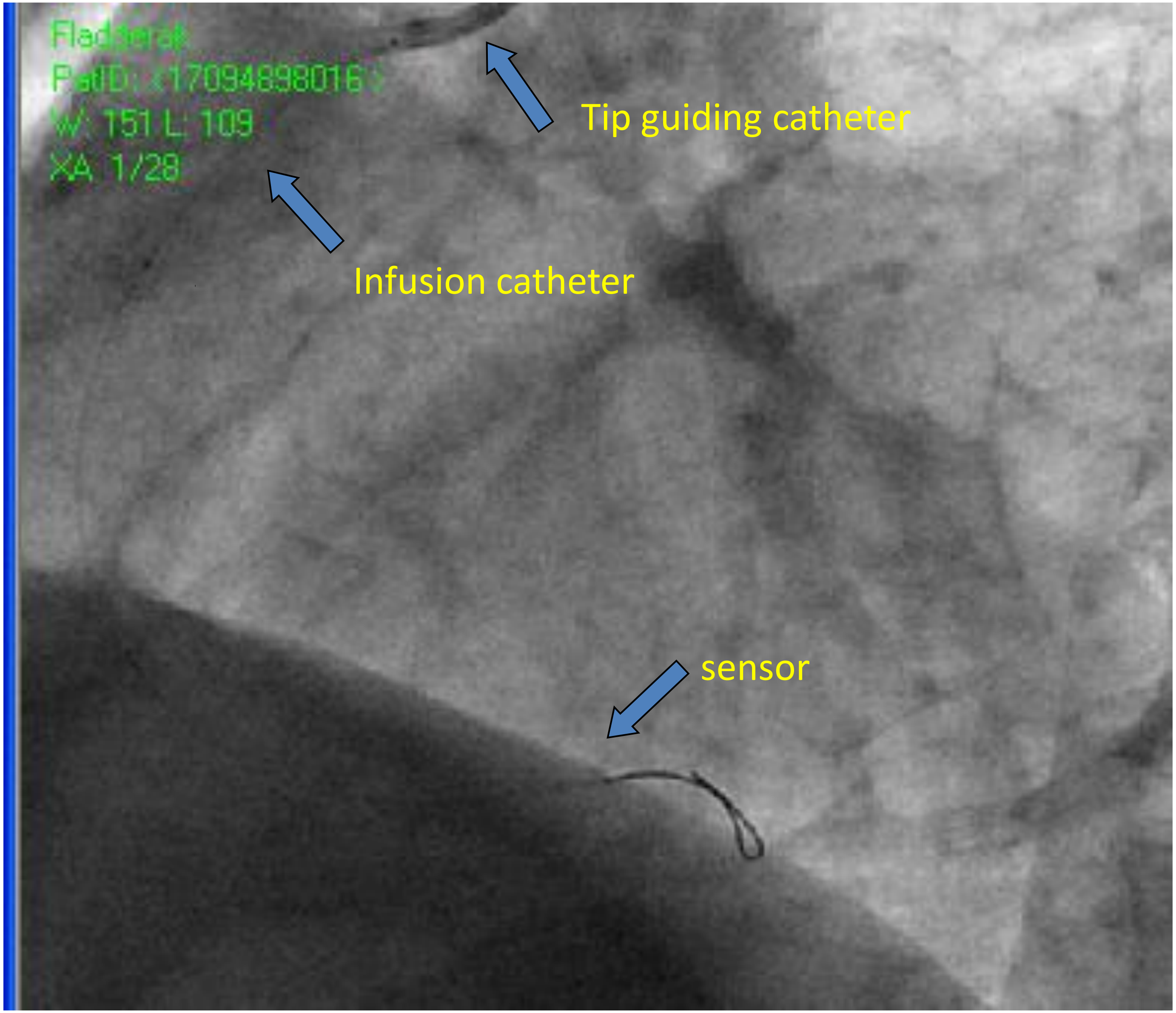

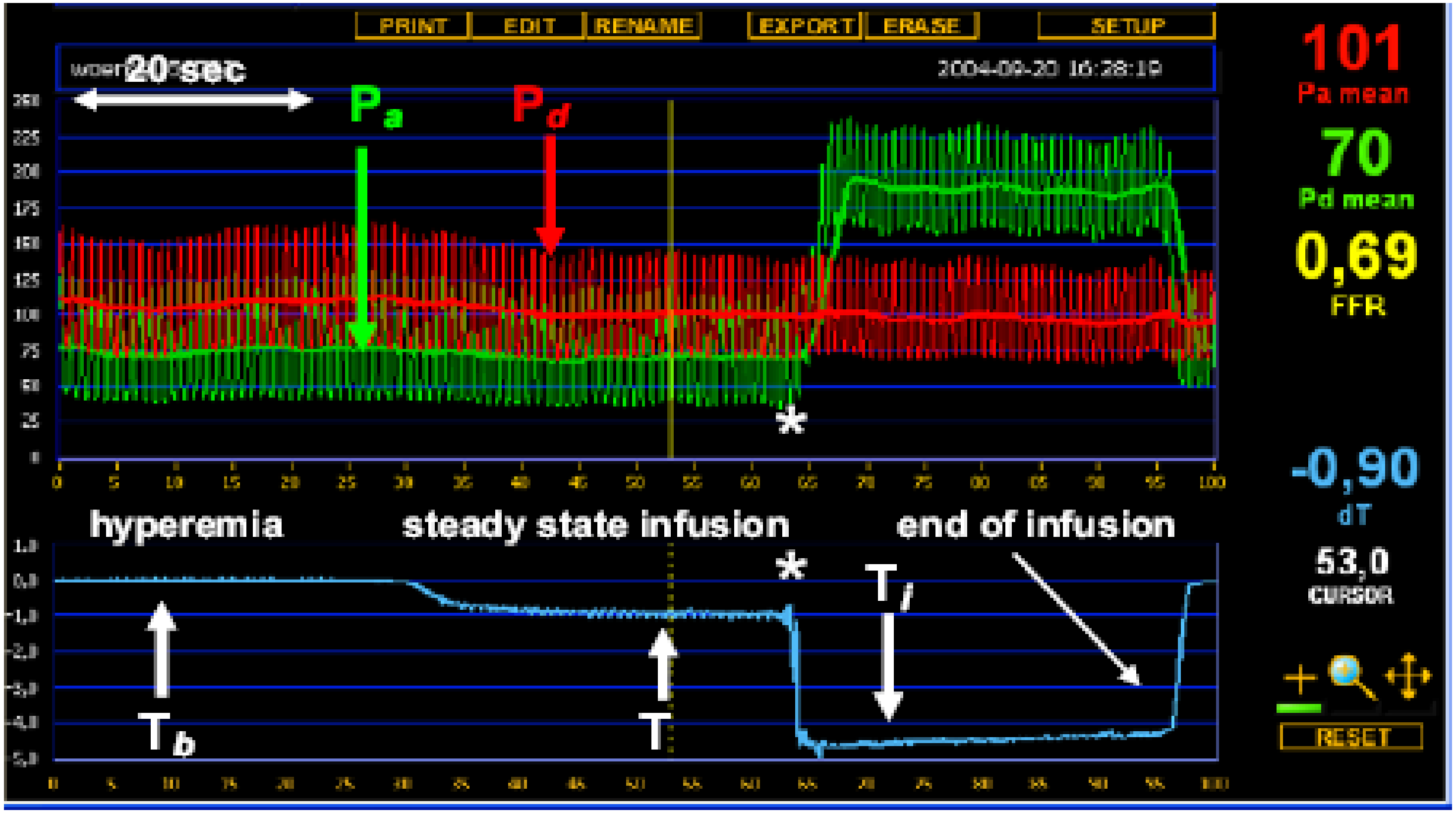

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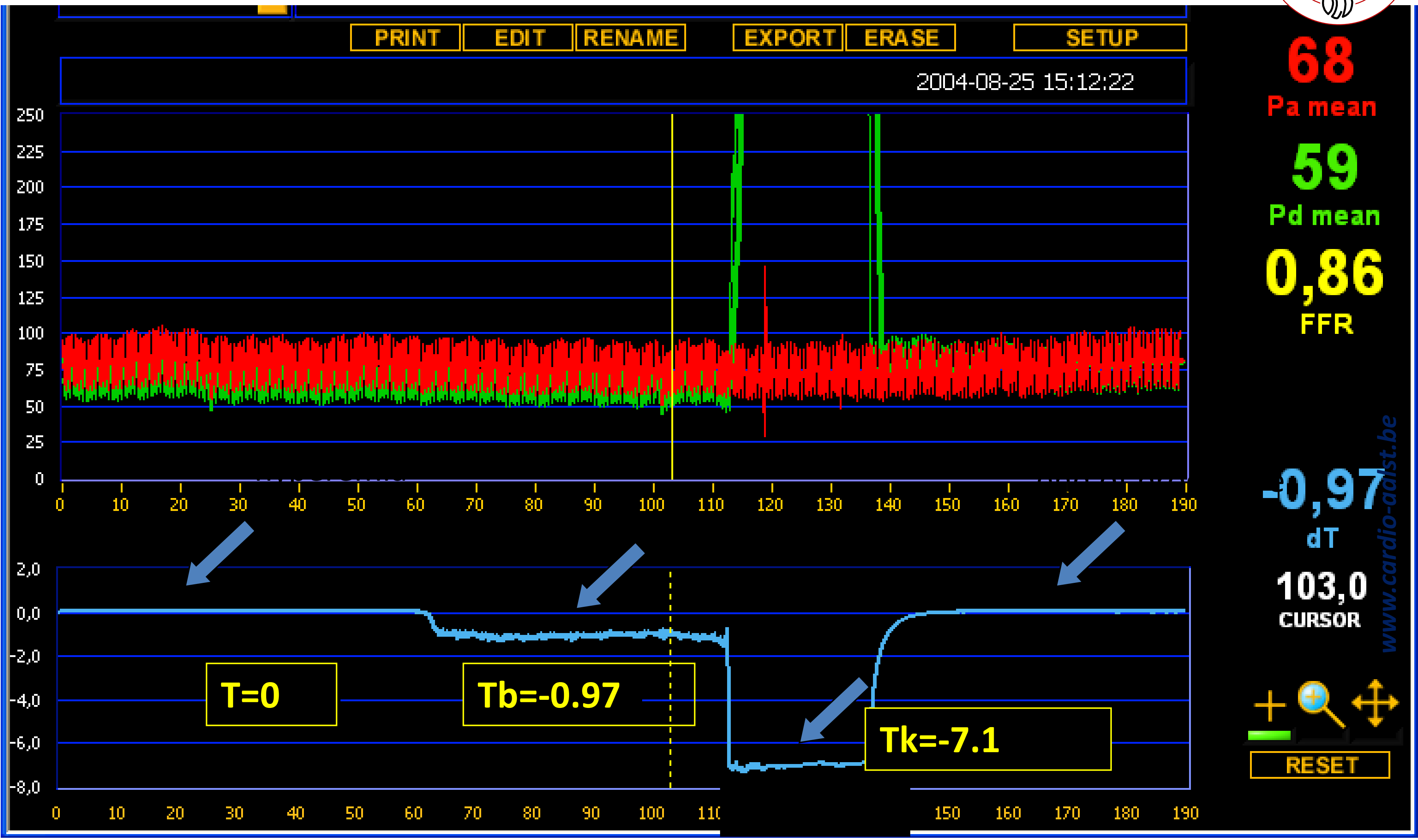
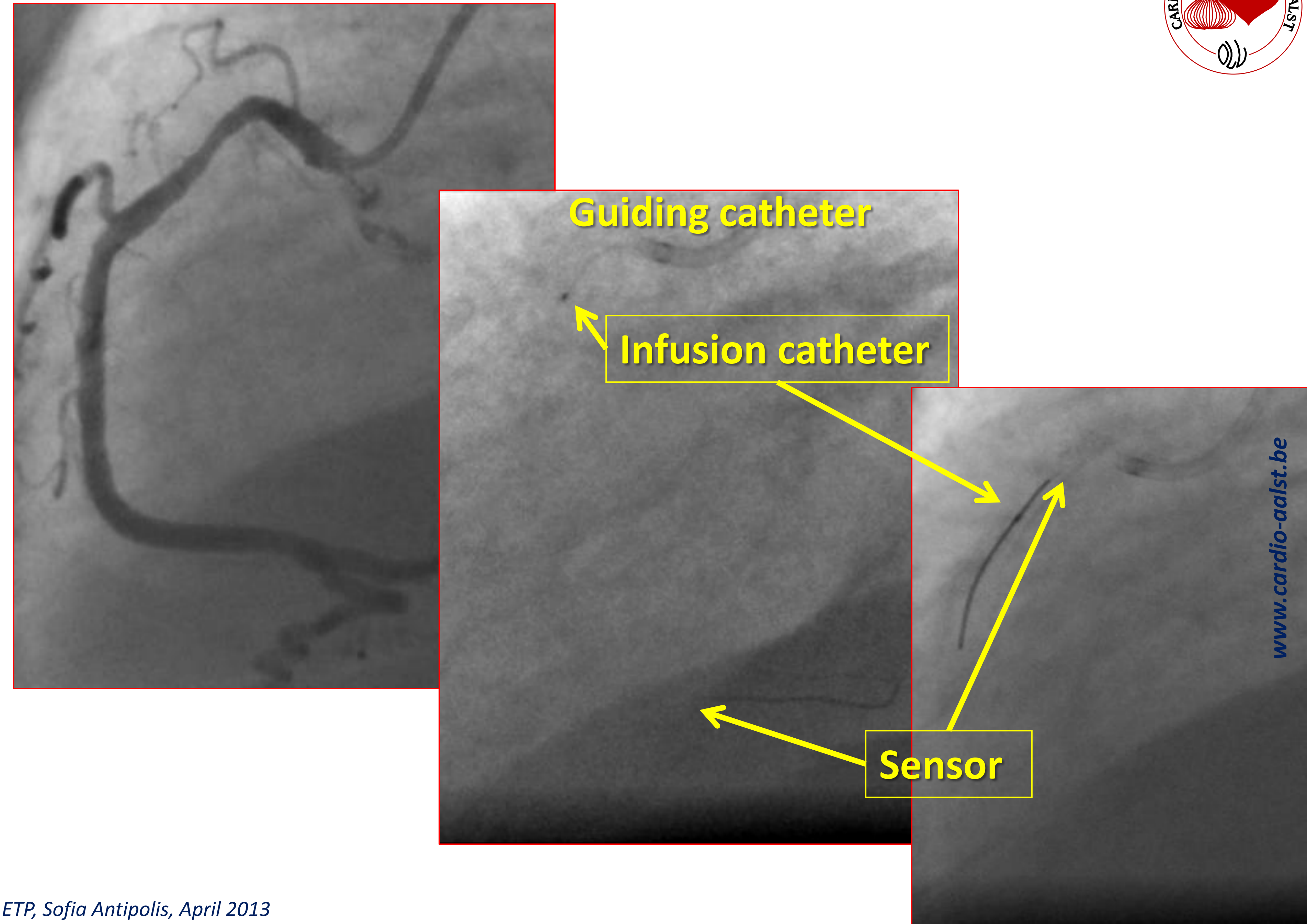


$$Q = 25 \times (7.1 / 0.97) \times 1.08 = 173 \text{ mL/min}$$

IMR and ACF



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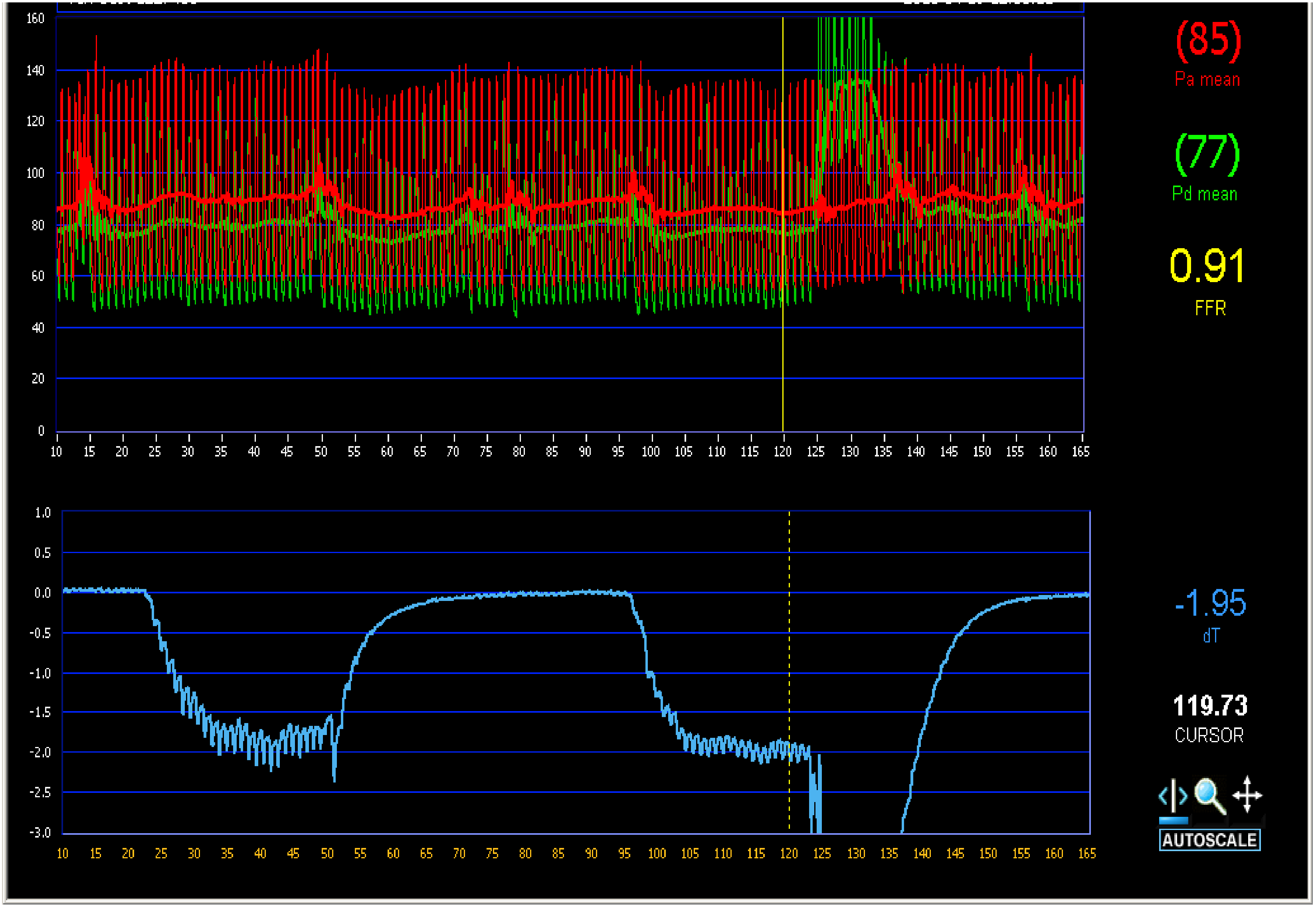
IMR and ACF



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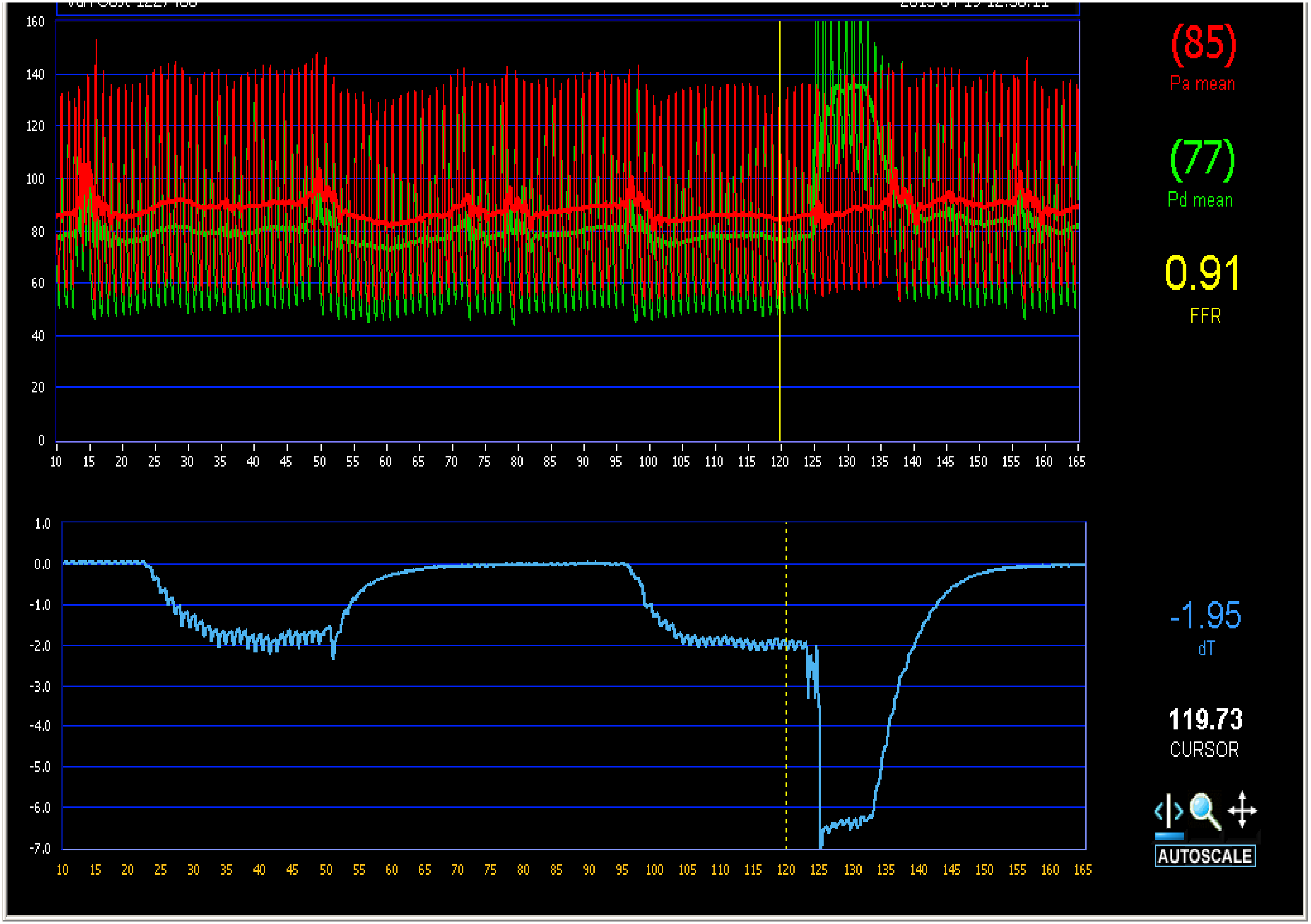

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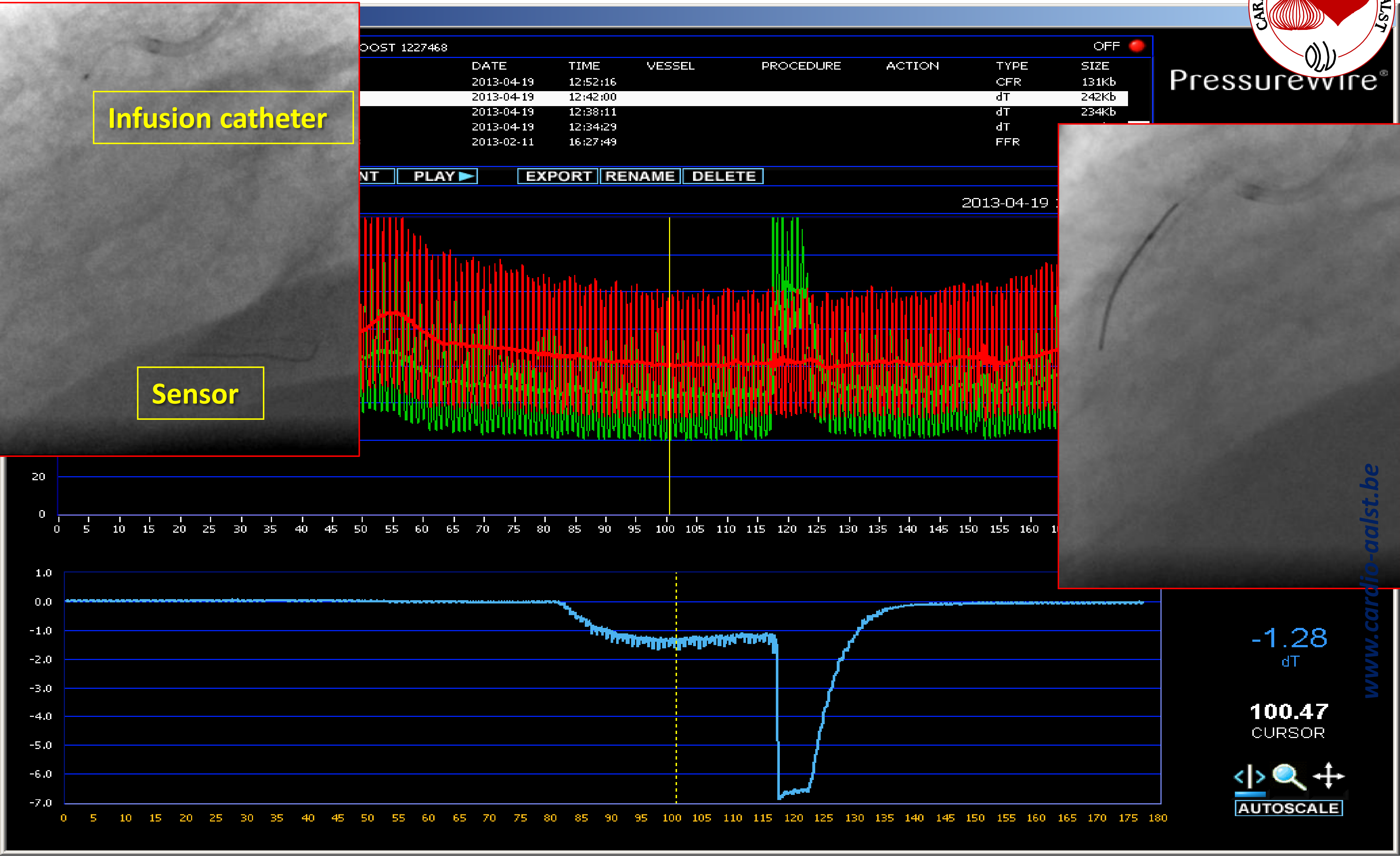
IMR and ACF

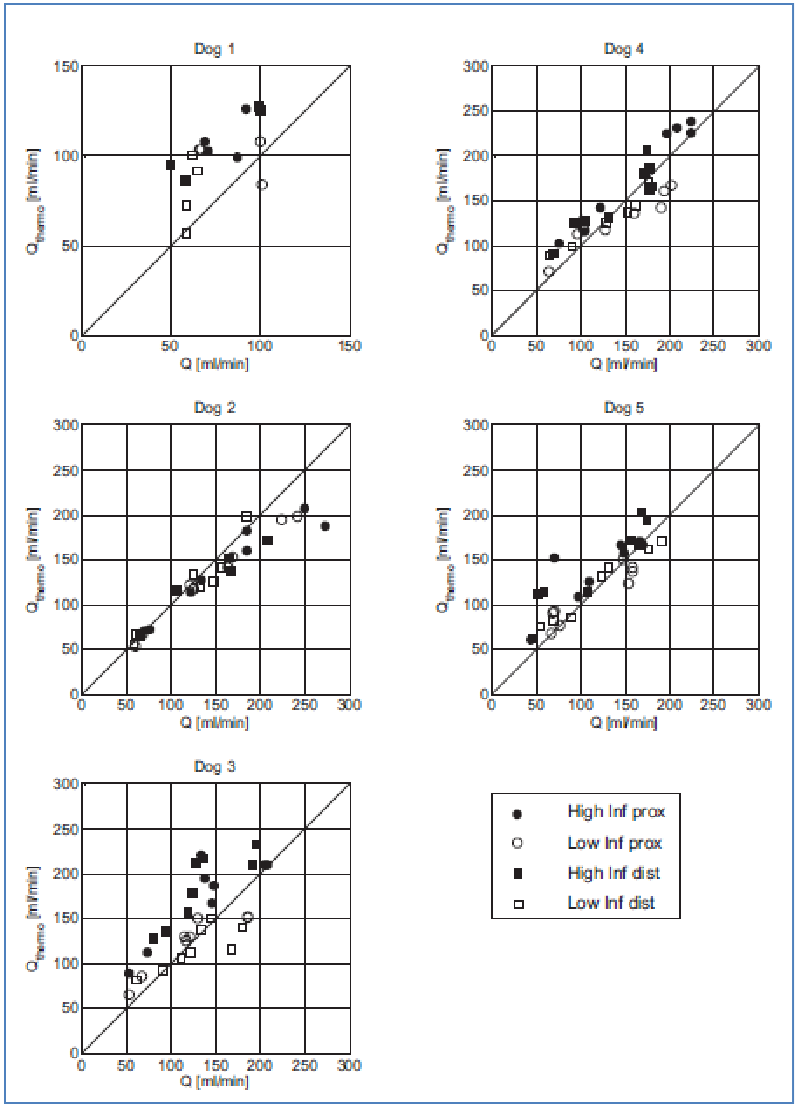


Absolute hyperemic coronary flow: 126 mL/min

Minimal myocardial resistance: 0.436 mm Hg/mL/min

ACF: Validation Studies

DOGS



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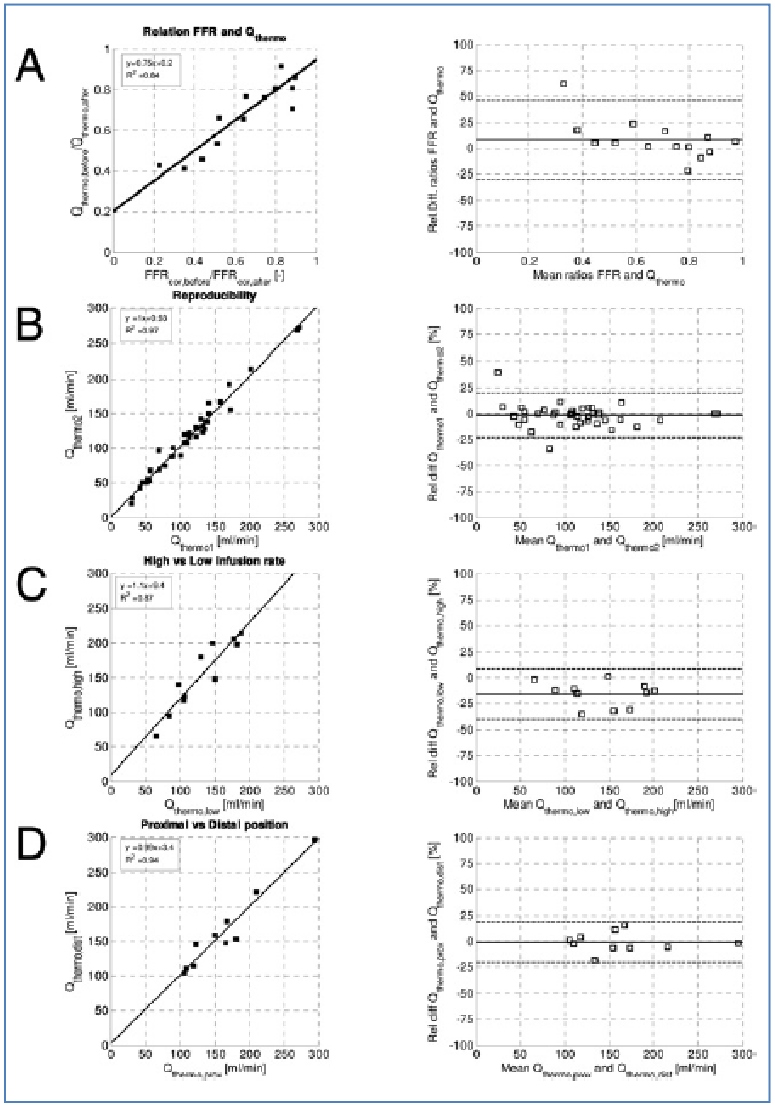

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Conclusion

Coronary thermodilution using a bolus injection allows the mesurements of the mean transit time (Tmn, an index of coronary flow) and of IMR

Coronary thermodilution by continuous infusion allows the measurement of absolute coronary blood flow