Do we need both pressure and flow?

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Disclosure Statement of Financial Interest

Within the past 12 months, Nils Johnson has had a financial interest/ arrangement or affiliation with the organization(s) listed below.

Affiliation/Financial Relationship	**Company**
• Grant/Research Support (*pending* to institution)	• St Jude Medical • Volcano Corporation
• Non-disclosure agreements (non-financial)	• St Jude Medical • Volcano Corporation

However, Nils Johnson has *never* personally received *any* money from *any* commercial company.

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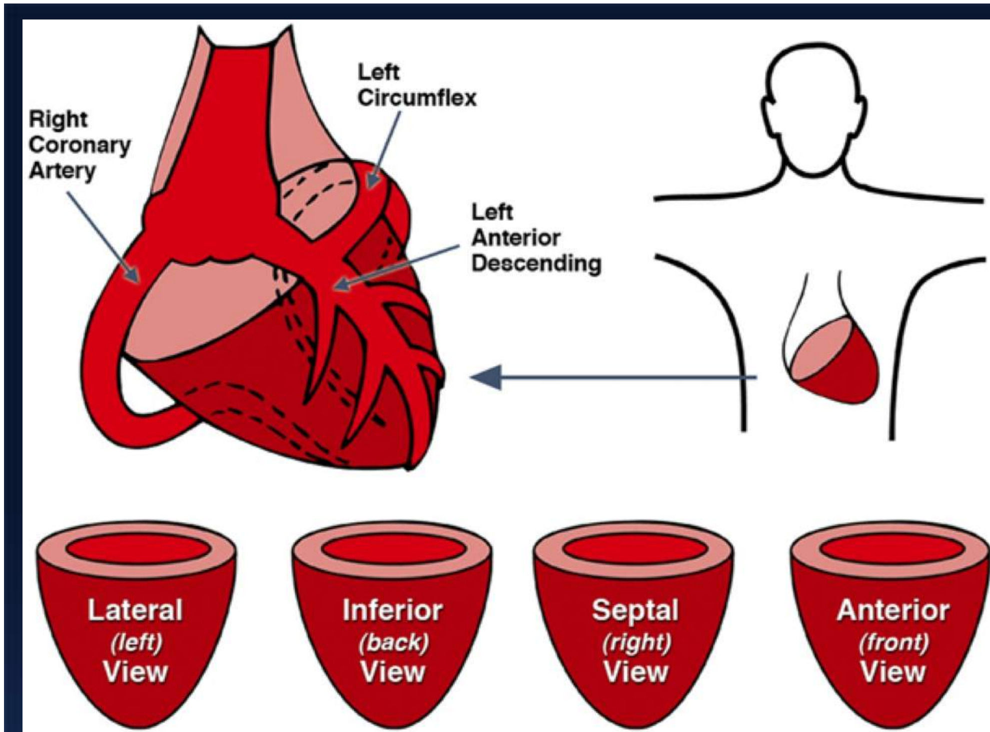
71 year-old man who presented with *abnormal SPECT*:

- Modifiable risk factor:
  - o Hypertension (treated with beta blocker)
- Symptoms
  - o None with typical daily activities
  - o Occasional palpitations and non-exertional chest discomfort, but mild and brief
  - o Classic but mild angina *once* when digging a ditch in very hot weather
- Workup
  - o Unremarkable echocardiogram and Holter
  - o Treadmill showed no angina but 2mm ST depression after 6:30 minutes of Bruce protocol
  - o SPECT showed partially reversible inferolateral defect



Johnson NP, *JACC Cardiovasc Imaging*. 4(9):990, 2011, Figure 1

"topographic"

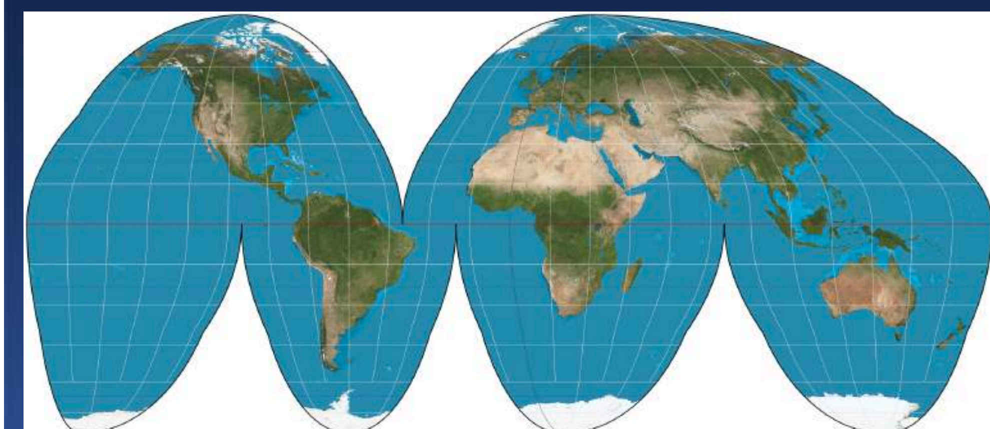
PET map

(3D into 2D)

3D

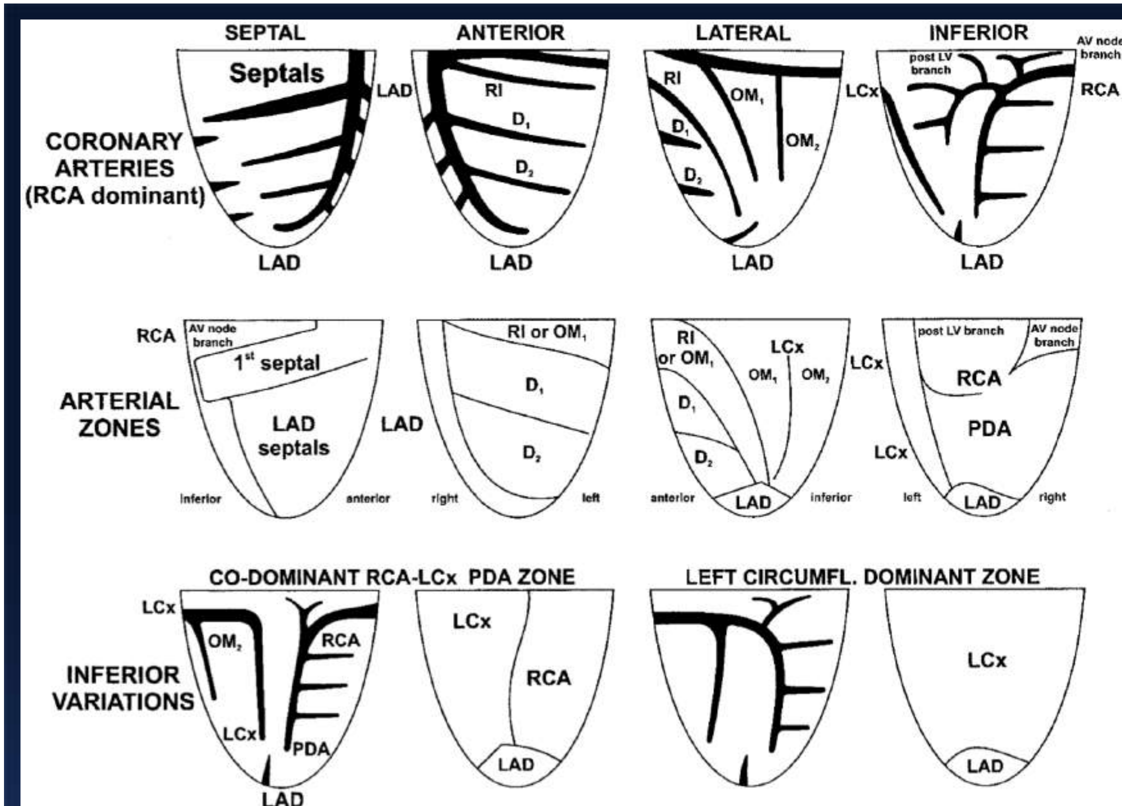
make 2D

minimal distortion



Wikipedia "Goode homolosine projection"

http://www.sos.noaa.gov/Education/earth_system.html



Nakagawa Y, *J Nucl Cardiol*. 8(5):580, 2001, Figure 1

normal
mild
>75% max

mild
moderate
50-75% max

moderate
severe
<50% max

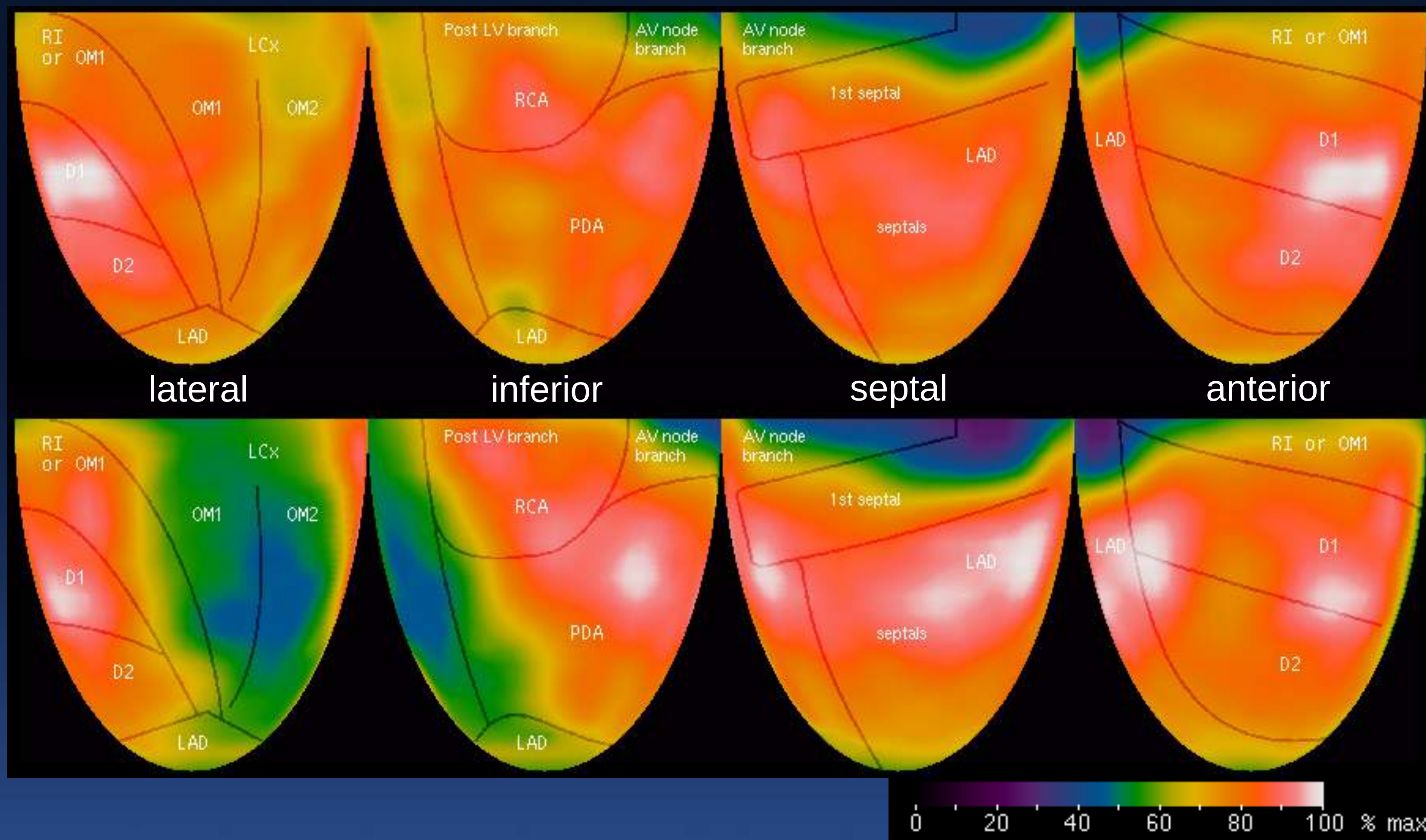
"atlas"
high resolution

"color scheme"
relative uptake

Case. 71 year-old man with one episode of mild angina

rest

stress



Dipyridamole produced *no angina*
and *no significant ST depression*

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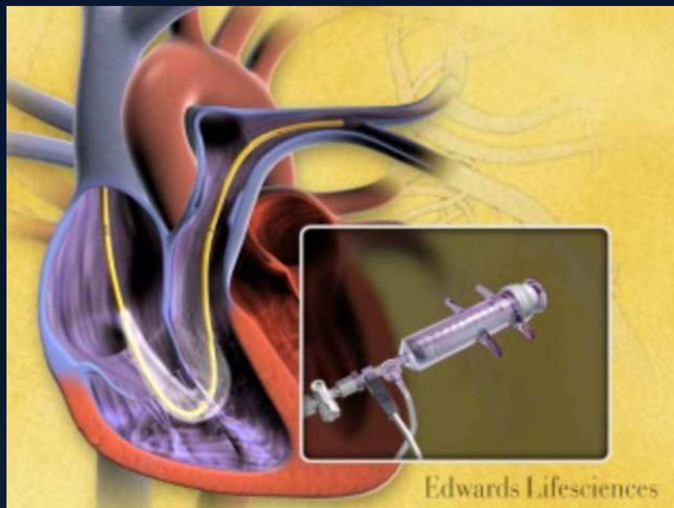
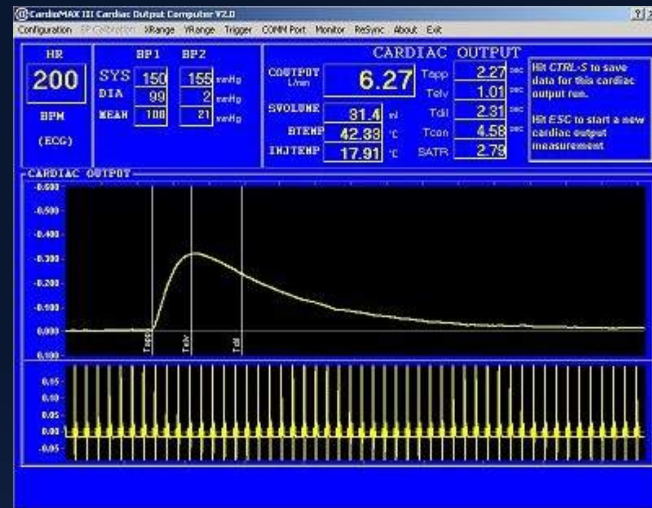
bolus + *tracking* = *flow*

cath lab



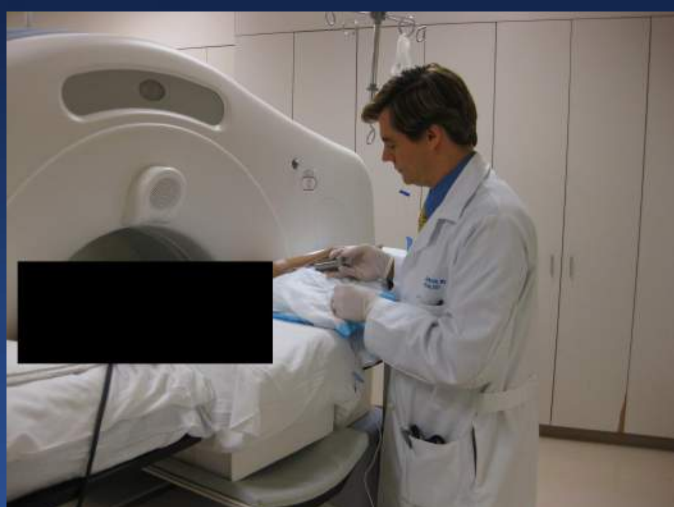
cold saline



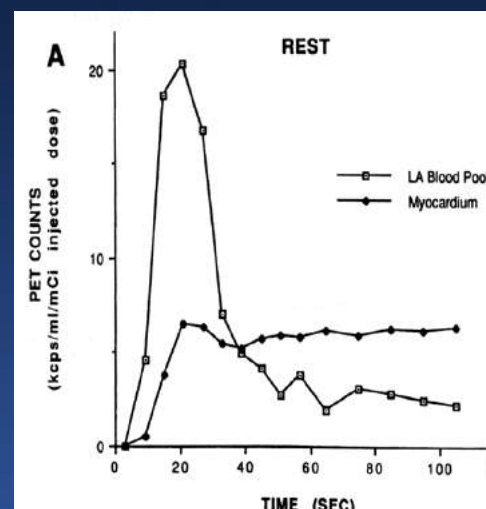
time-temperature curve

L/min (cardiac output)

PET lab



"hot" radiotracer

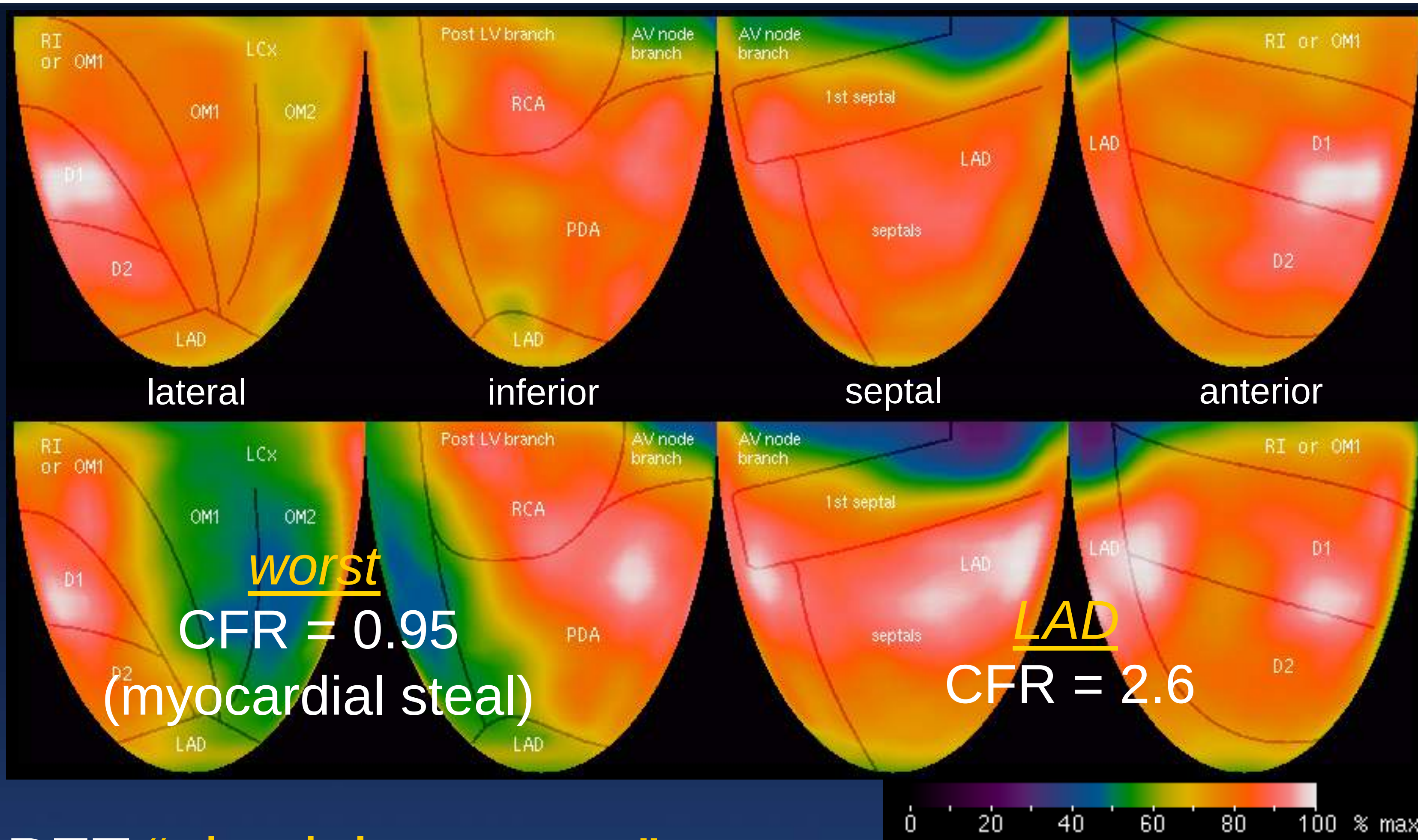


time-activity curve

cc/min/gm (myocardial perfusion)

rest

stress



PET "physiology-gram":

- CFR<1 in OM1/OM2 distribution implies total occlusion supplied by collaterals
- CFR = 2.6 in LAD distribution

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Total occlusion of large OM branch supplied by collaterals

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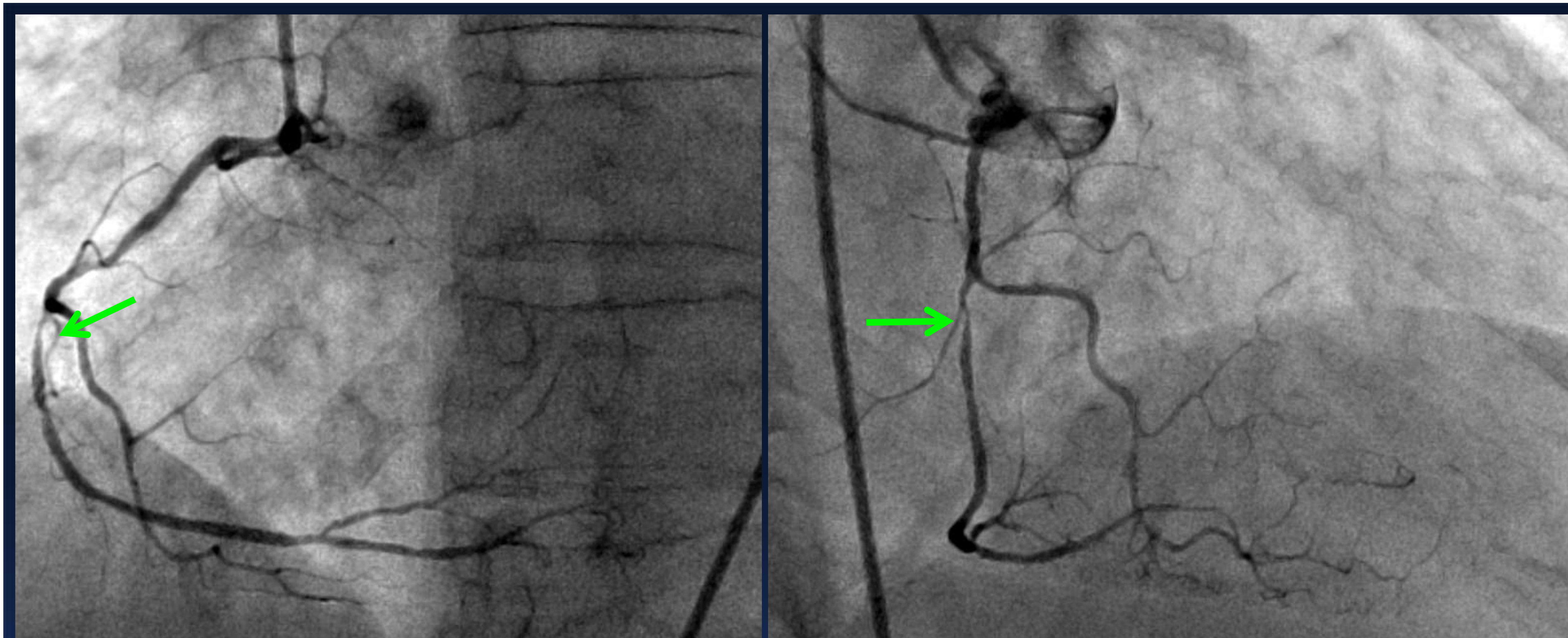
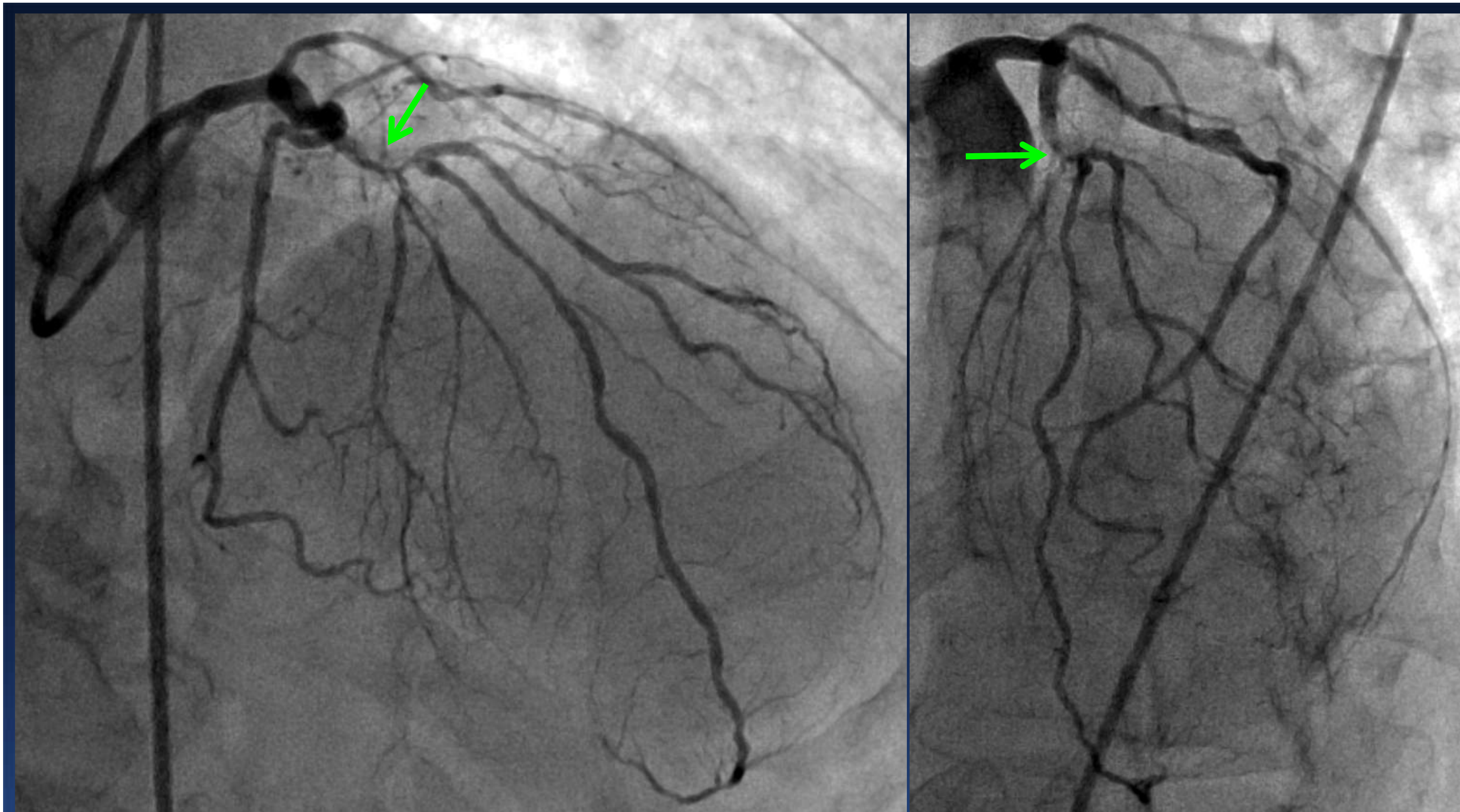
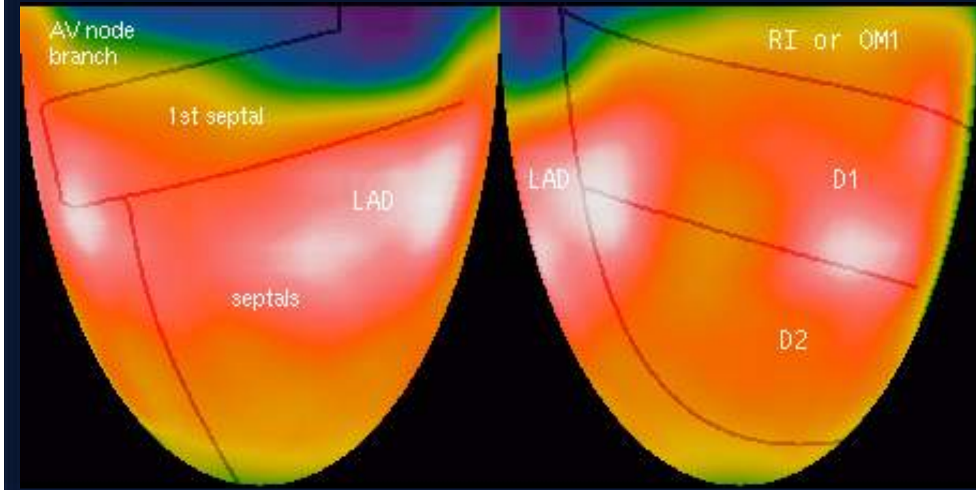
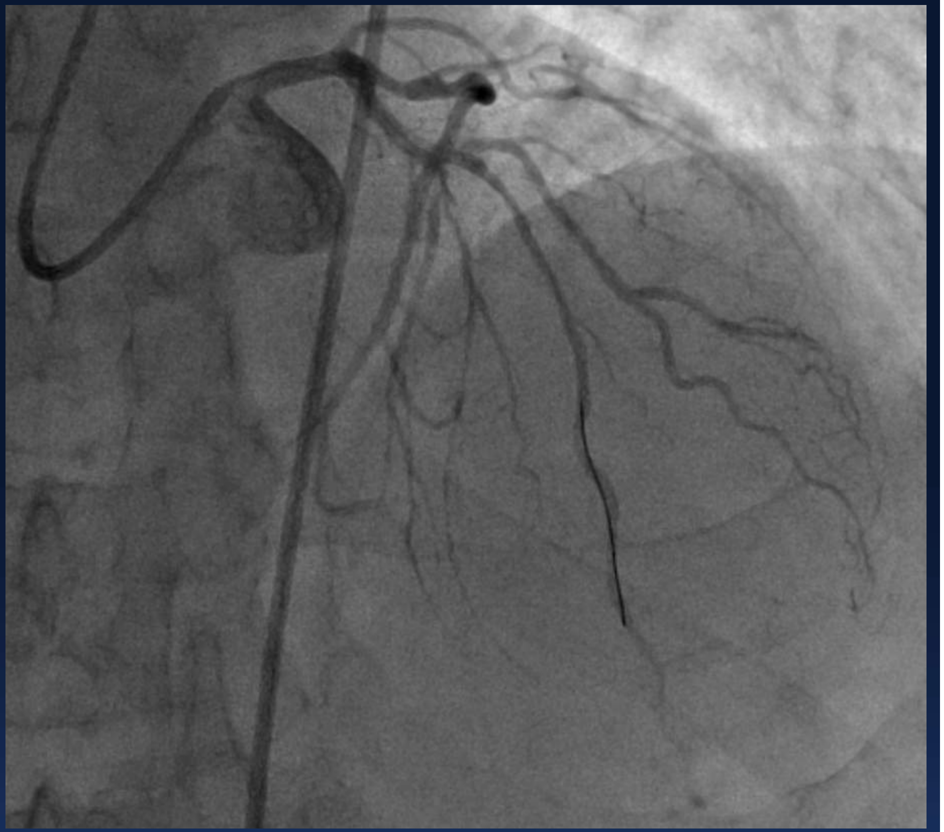


Small caliber, codominant RCA with mid lesion



Calcified trifurcation lesion in mid LAD





PET: LAD
CFR = 2.6

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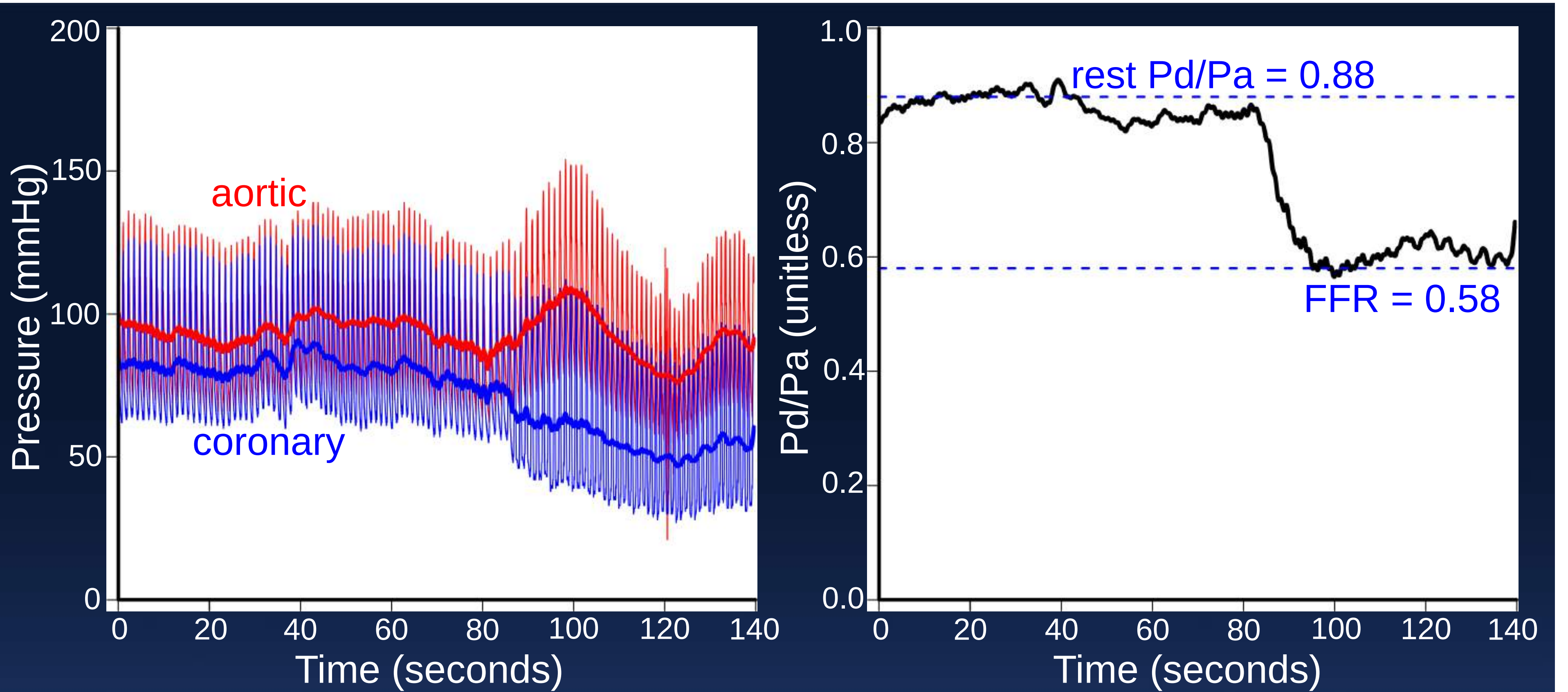

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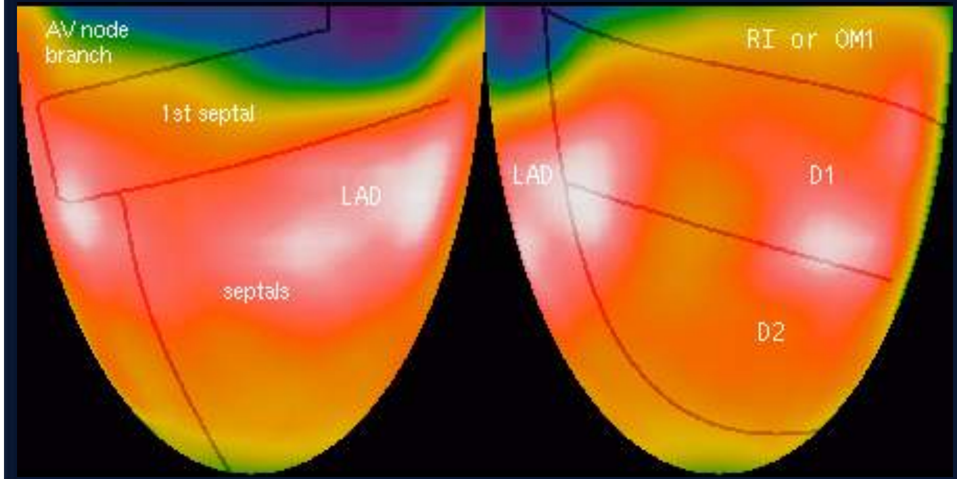
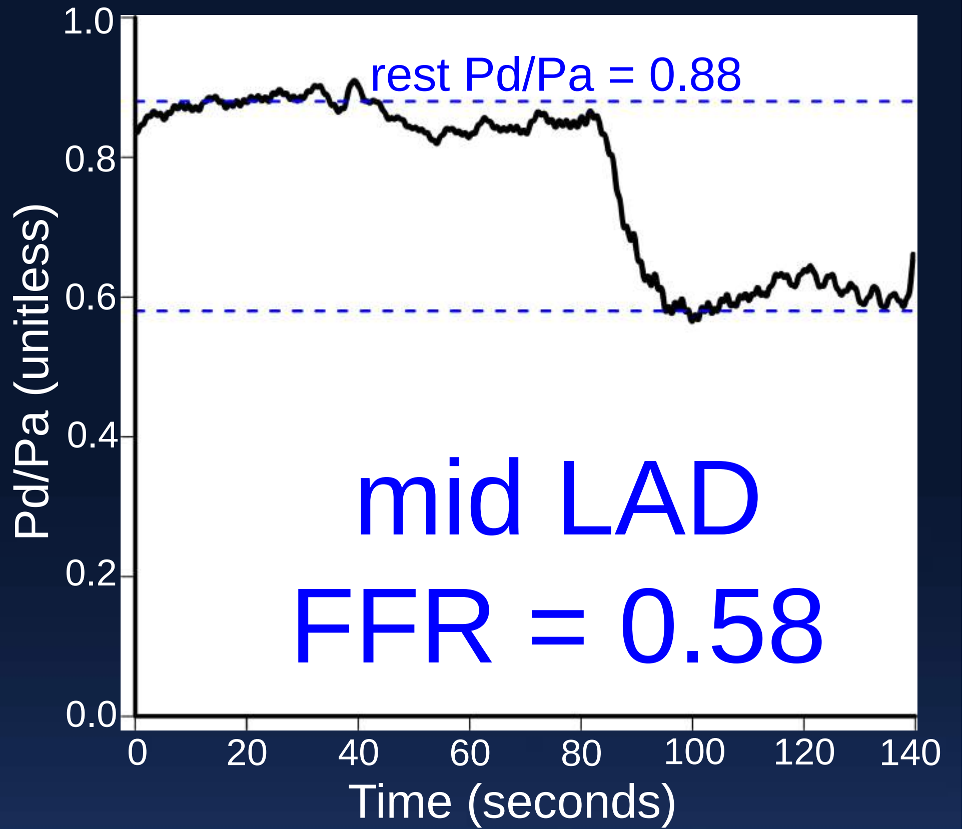


PET: LAD
CFR = 2.6

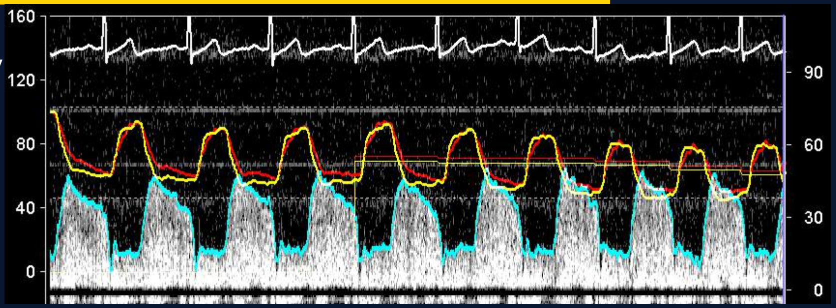


discordance

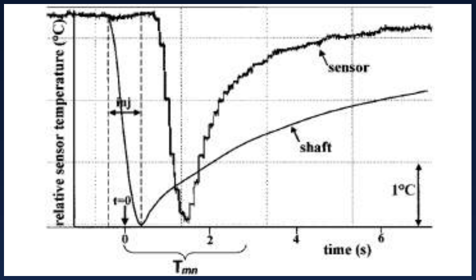
CFR > 2.0 FFR ≤ 0.8

Invasive tools to estimate flow

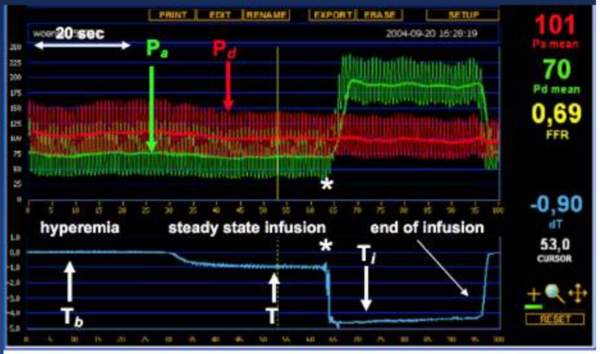
- Doppler velocity



- Bolus thermodilution

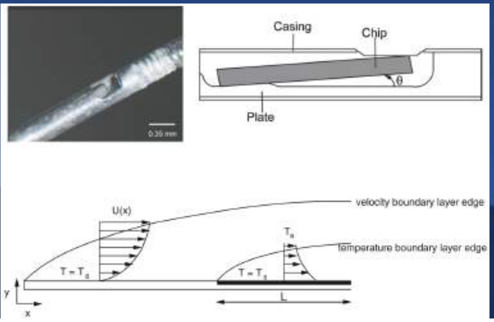


- Continuous thermodilution

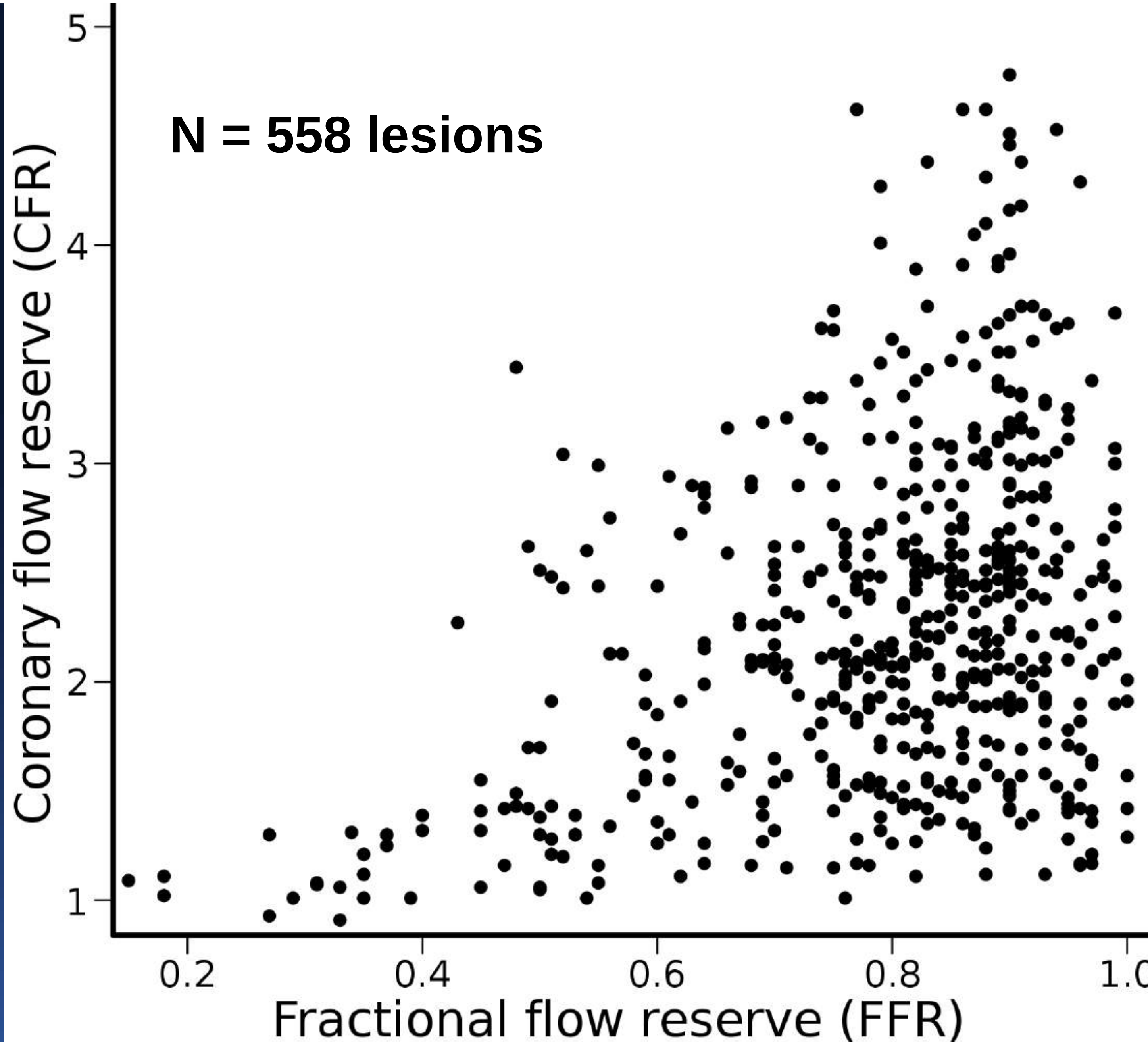


Q_b = 15 x (- 4.5 / - 0.9) x 1.08 = 81 ml/min

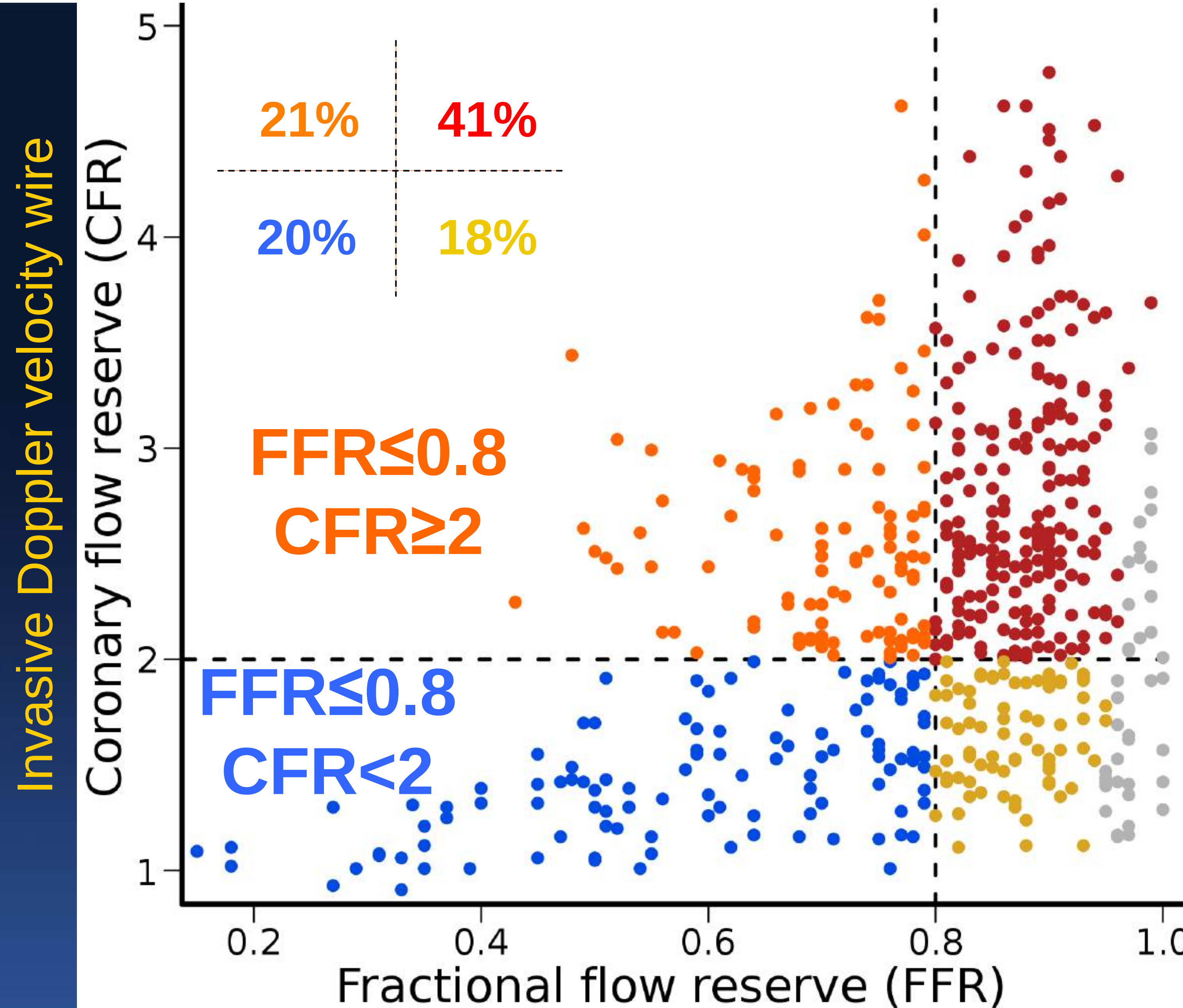
- Thermal anemometry



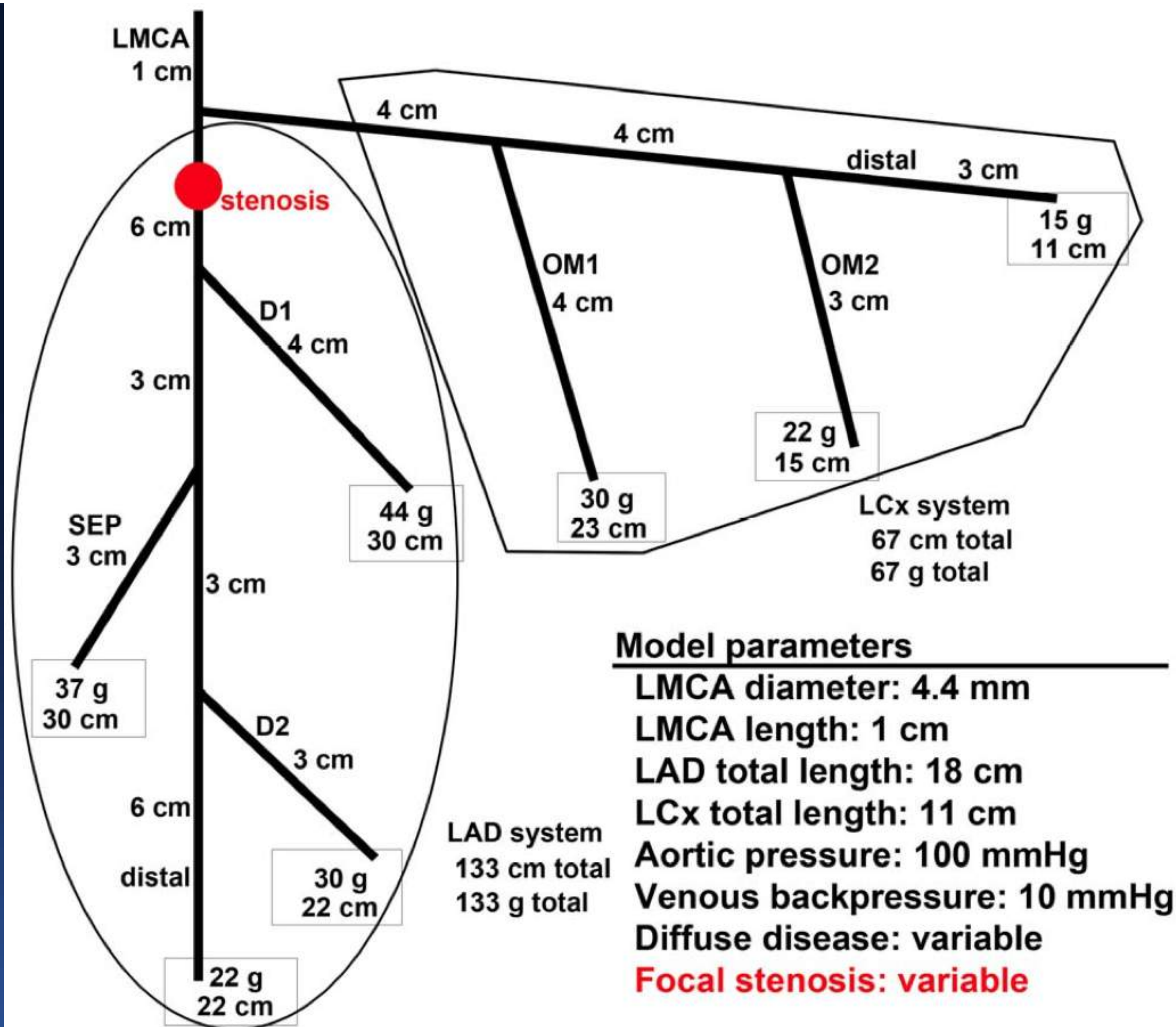
Pijls NH, *Circulation*. 105(21):2482, 2002, Figure 2
Aarnoudse W, *JACC*. 50(24):2294, 2007, Figure 7
van der Horst A, *Med Eng Phys*. 33(6):684, 2011, Figures 1 and 2



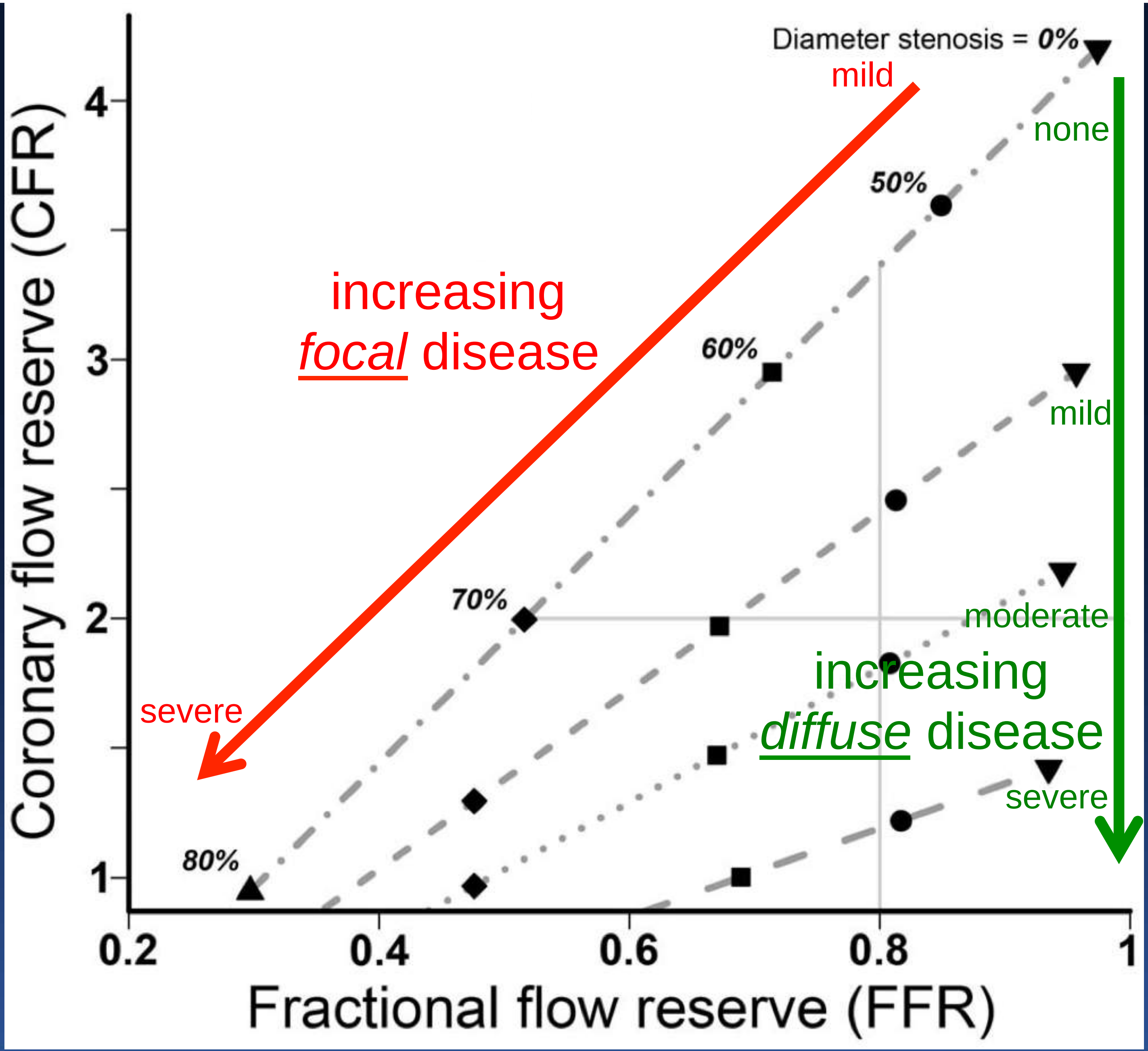
Based on Johnson NP, *JACC Cardiovasc Imaging.* 5(2):193, 2012, Figure 1 (plus 120 new lesions)



Based on Johnson NP, *JACC Cardiovasc Imaging.* 5(2):193, 2012, Figure 1 (plus 120 new lesions)



Johnson NP, *JACC Cardiovasc Imaging.* 5(2):193, 2012, Supplement Figure F1



Johnson NP, *JACC Cardiovasc Imaging.* 5(2):193, 2012, Supplement Figure F2

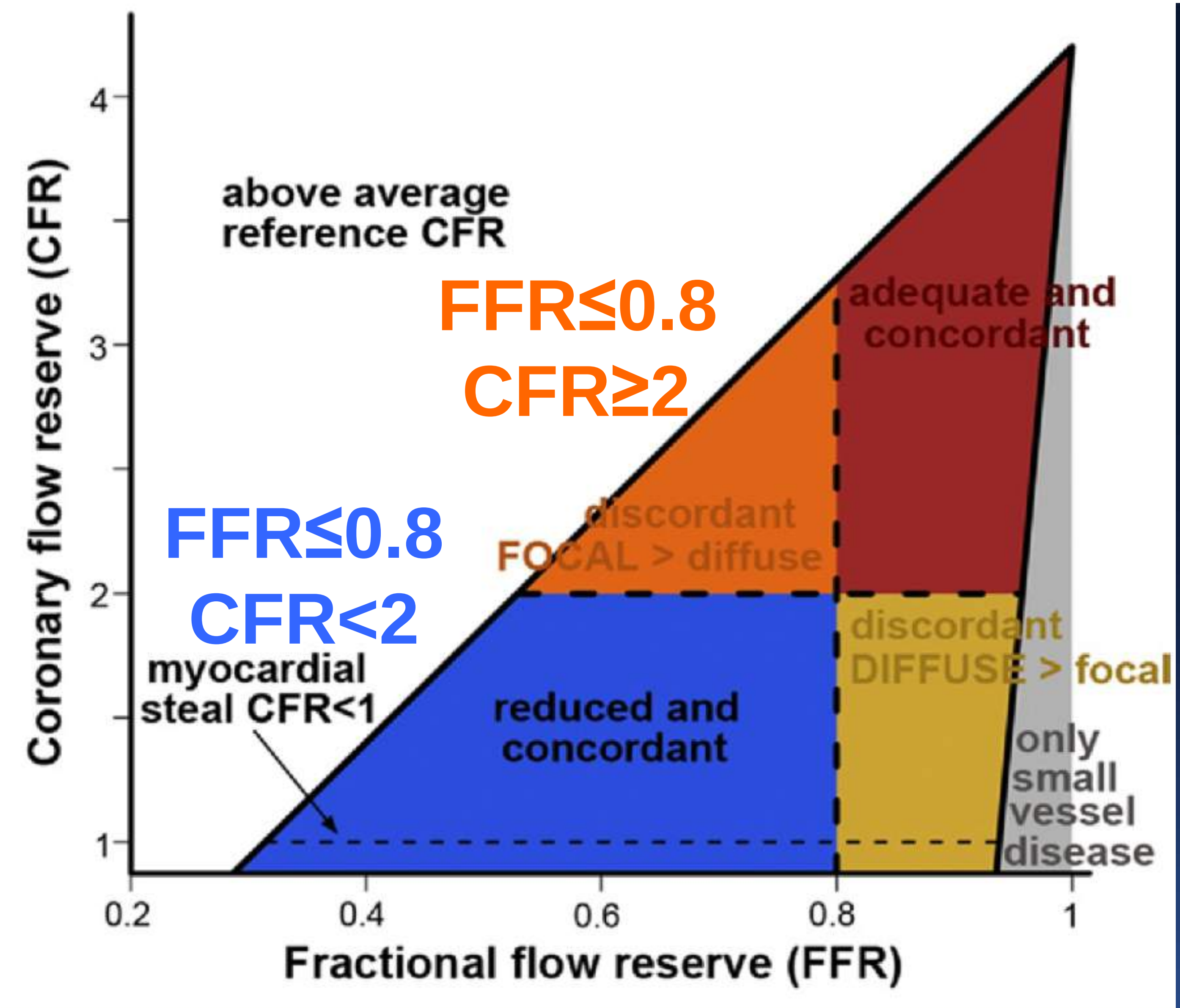
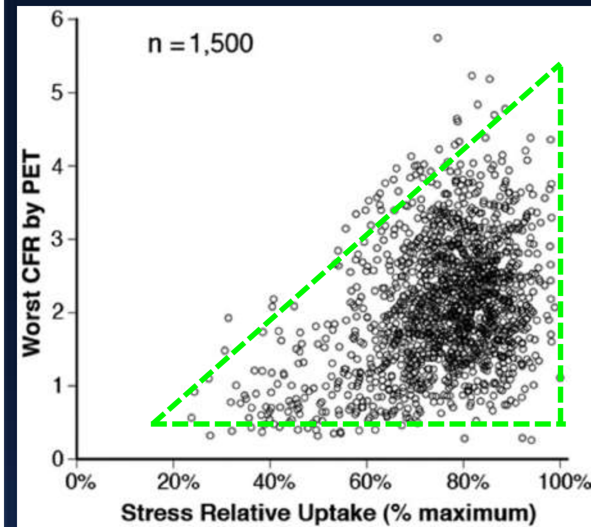
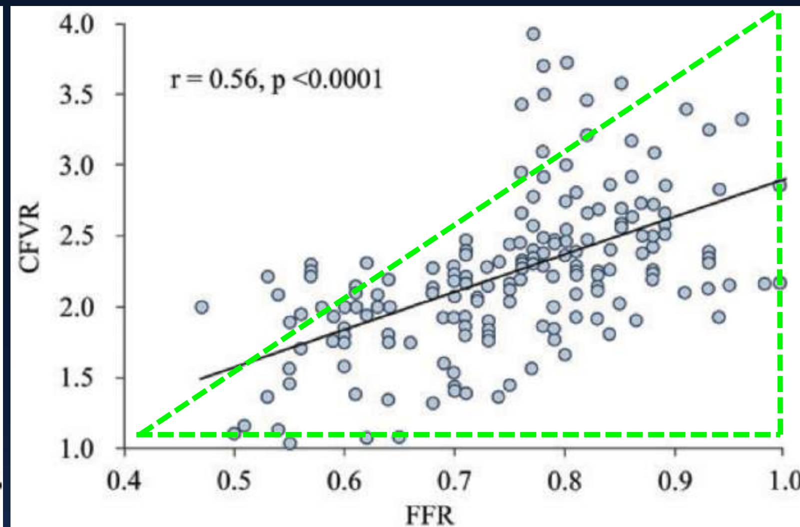


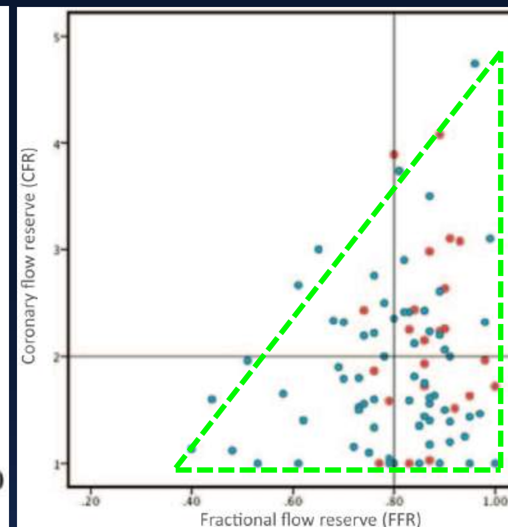
Figure 3. **Conceptual Plot of CFR and Fractional Flow Reserve Regions**

Johnson NP, *JACC Cardiovasc Imaging.* 5(2):193, 2012, Figure 3

Universal CFR/FFR triangle







CFR by PET
Texas (2012)

CFR by thoracic echo
Japan (2014)

CFR by thermo
Madrid (2013)

43% discordance

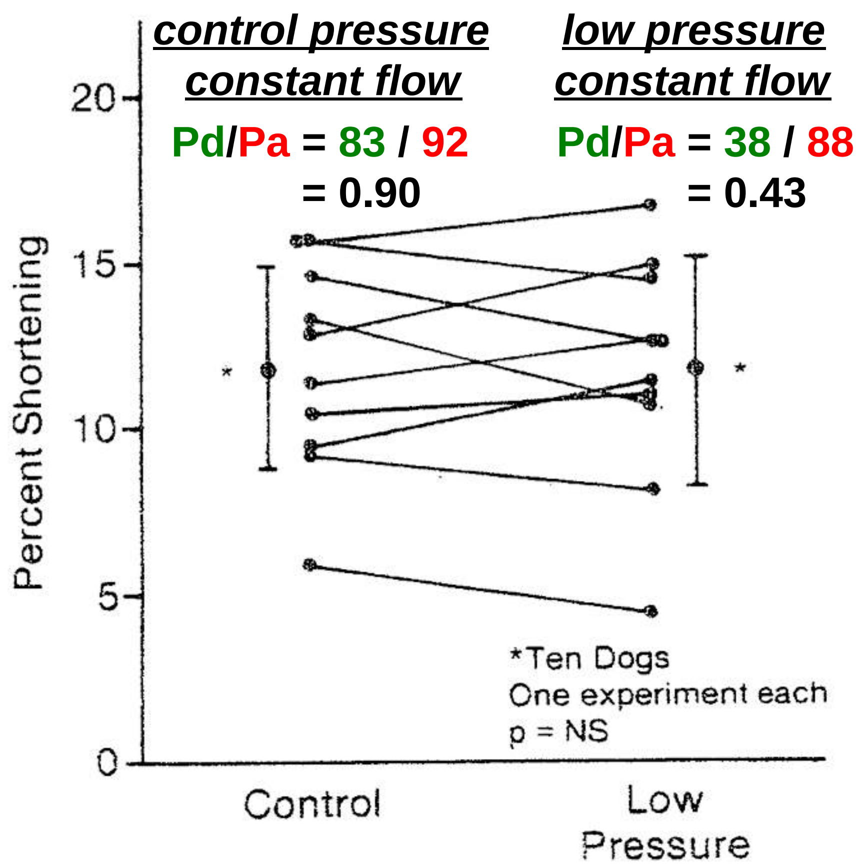
35% discordance

44% discordance

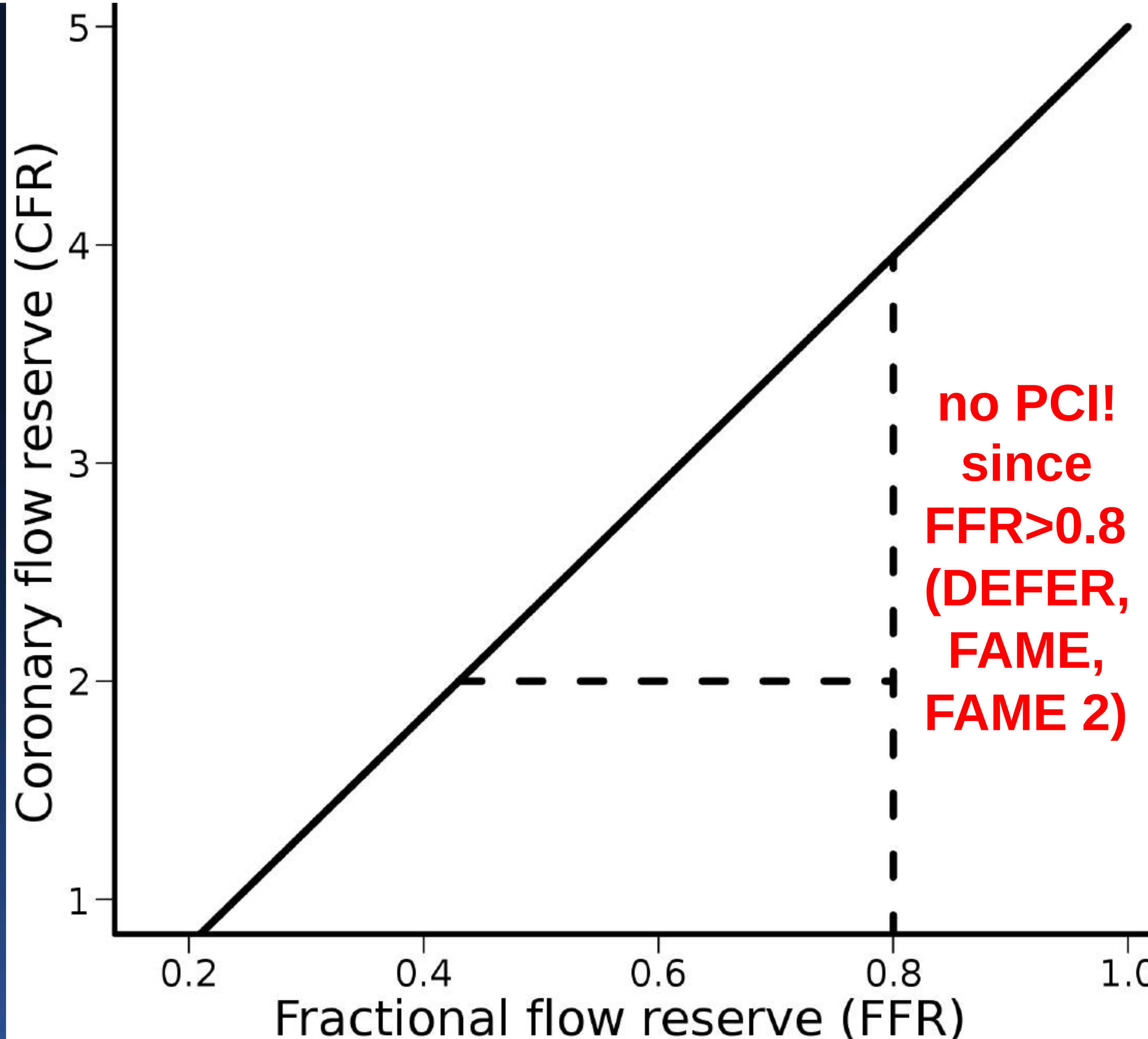
PET = Johnson NP, *JACC Cardiovasc Imaging*. 5(2):193, 2012, Figure 1B
Thoracic echo = Wada T, *Eur Heart J Cardiovasc Imaging*. 15(4):399, 2014, Figure 6
Thermodilution = Echavarria-Pinto M, *Circulation*. 128(24):2557, 2013, Figure 1B

"… regional <u>contractile function</u> is *<u>dependent</u>* on *subendocardial blood flow* and is *<u>independent</u>* of *coronary perfusion pressure*"

Figure 3. Percent segmental shortening during the ejection period in 10 chronically instrumented dogs during the control state and with circumflex artery depressurization. Mean values ± 1 standard deviation appear on either side of individual data.



Smalling RW and Kirkeide RL, *JACC.* 5(4):948, 1985, Figure 3 (annotated)



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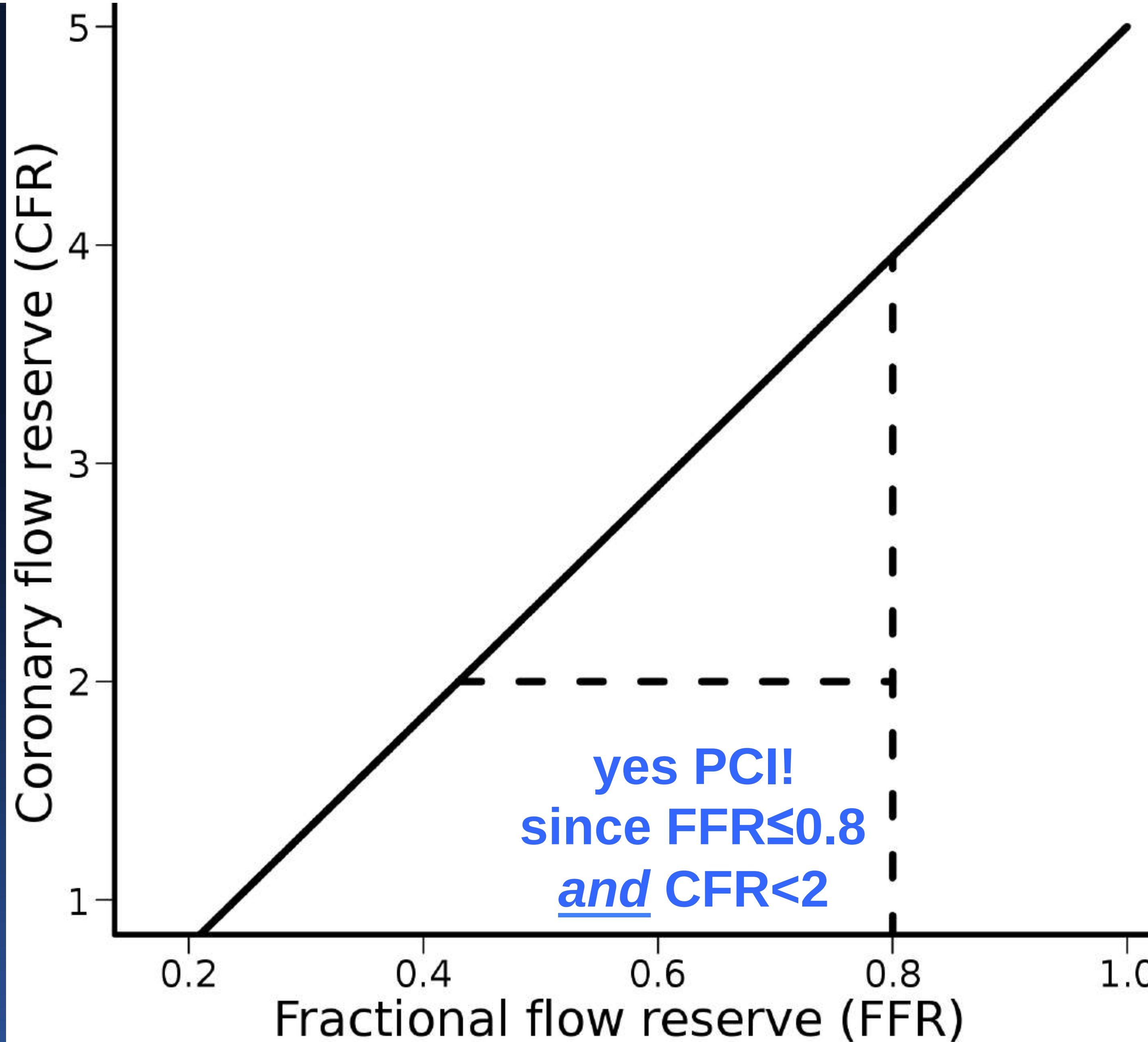

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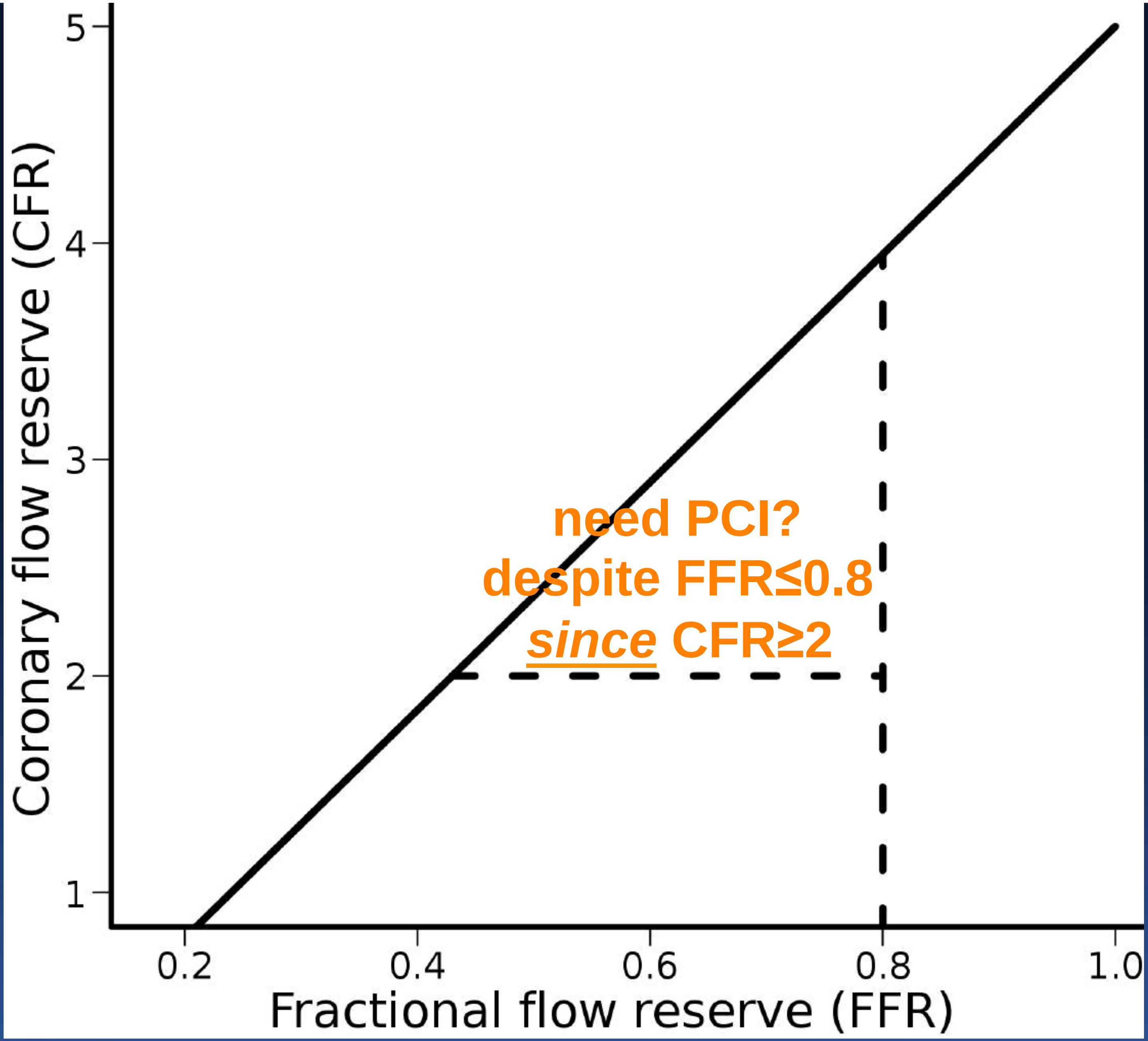

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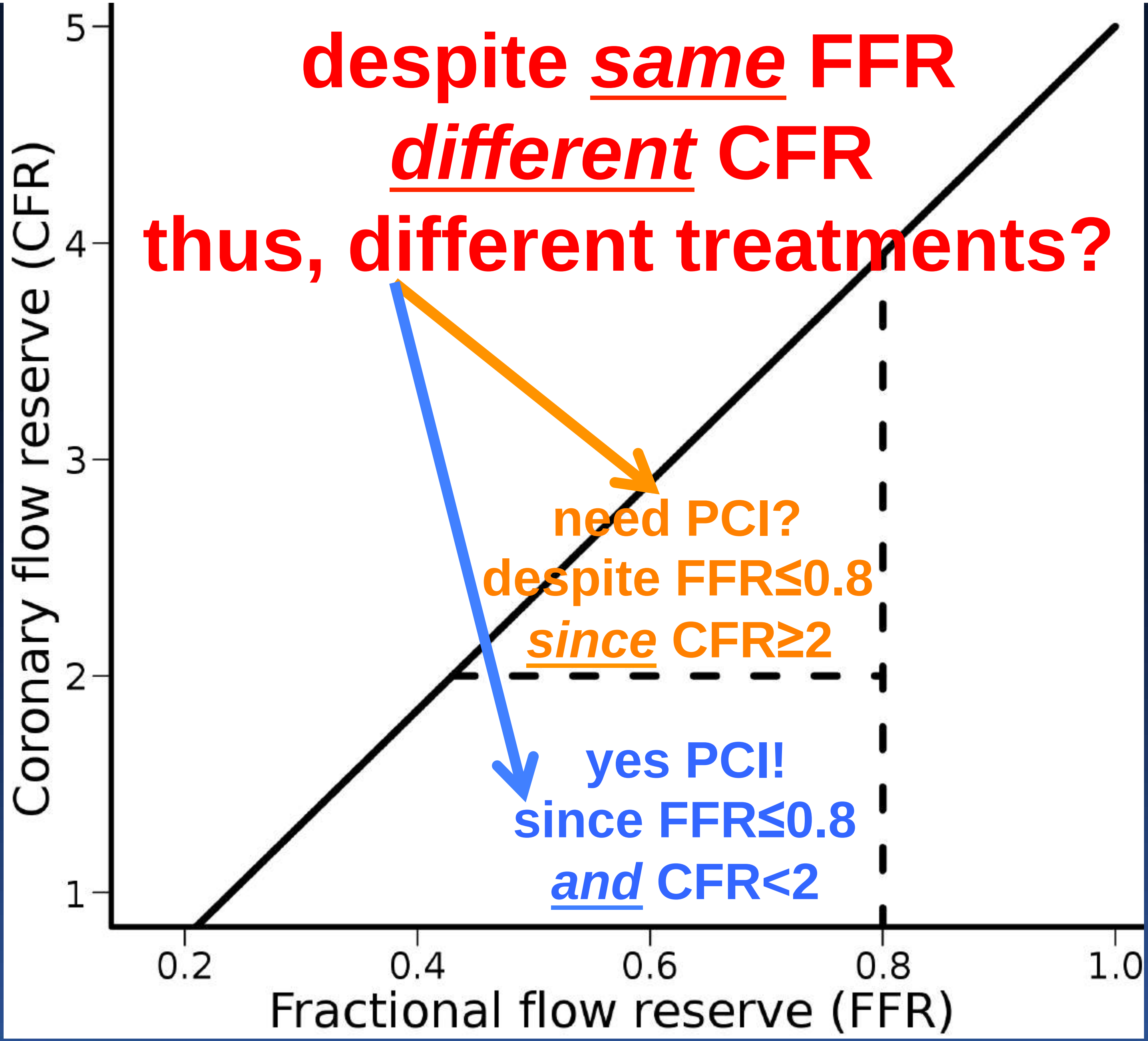

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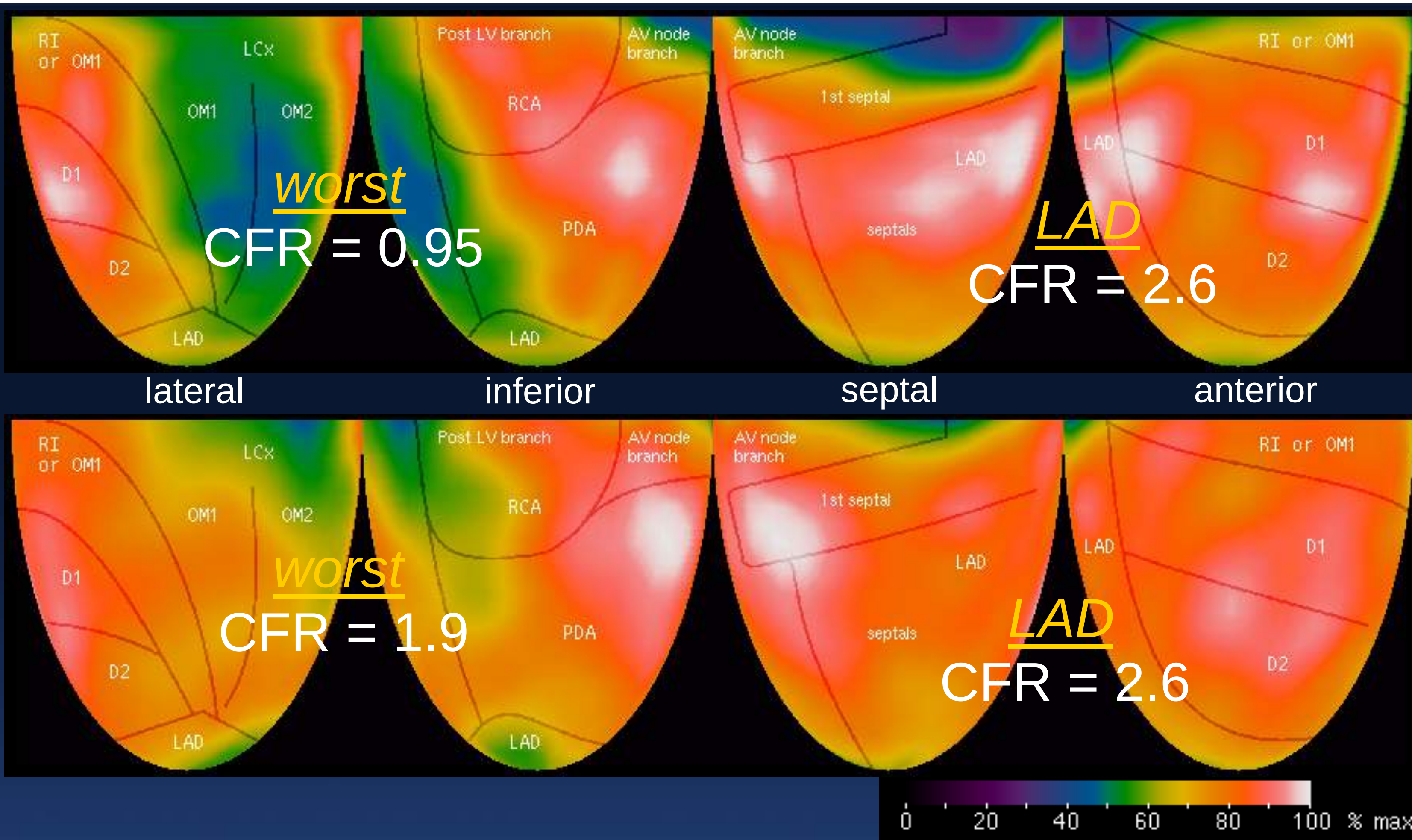
Before CABG

After CABG

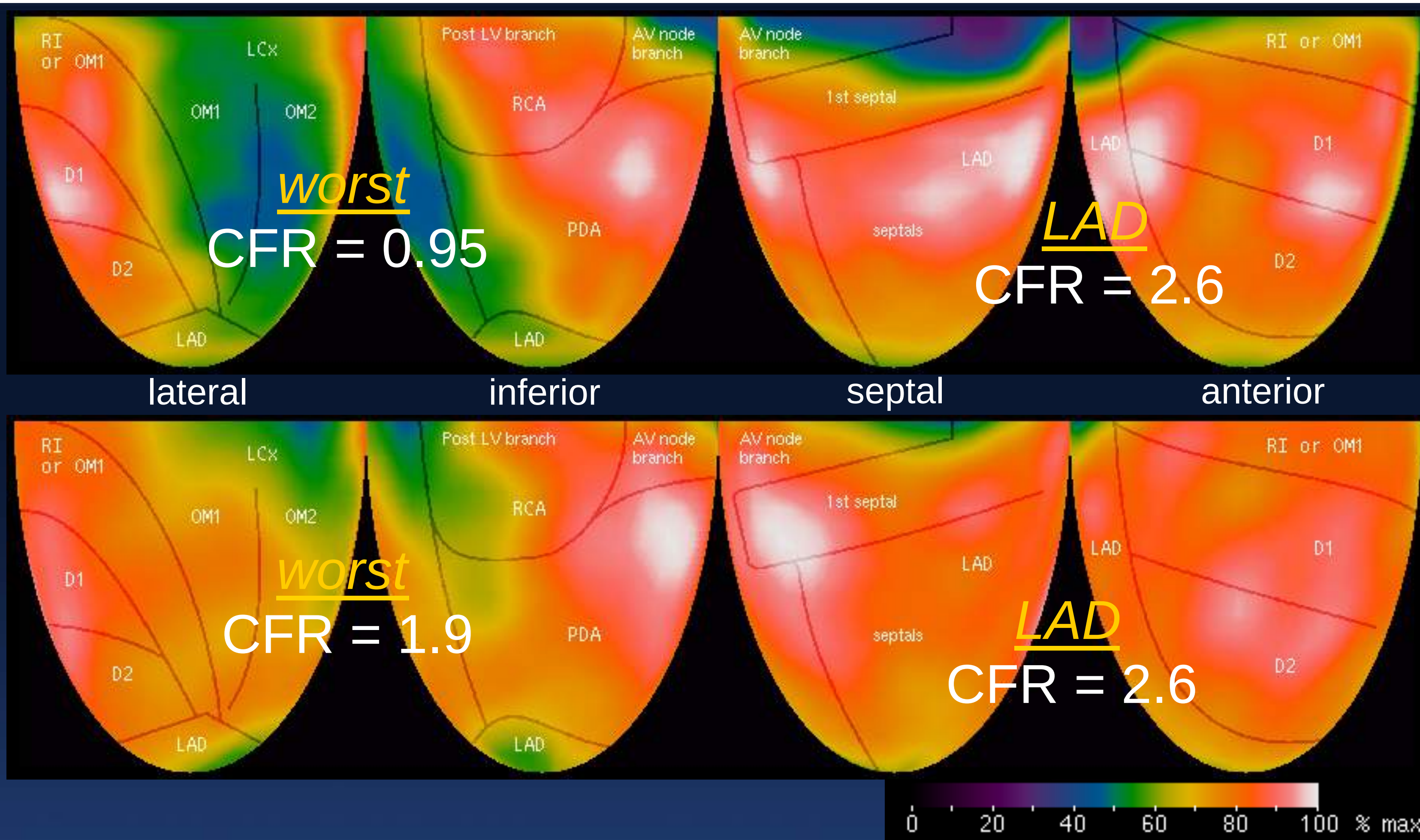


Referred for CABG:

- LIMA-LAD
- SVG-DIAG
- SVG-OM
- SVG-RCA

Before CABG

After CABG



PET flow in LAD during *hyperemia*:

- Before CABG = 1.78 cc/min/gm
- After CABG = 2.82 cc/min/gm
- Flow ratio before/after = 1.78/2.82 = 0.63
- Invasive, pressure-derived FFR = 0.58

"… pressure and flow represent the two sides of the same coin … from the physiologic point of view, both techniques are highly *complementary*."

-Kern MJ, De Bruyne B, Pijls NH. *JACC*. 30(3):613, 1997. (my color and *emphasis* added)

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