Physiology as essential skill

How to be an expert: caveats, shortcuts

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UTHealth The University of Texas Health Science Center at Houston | McGovern Medical School

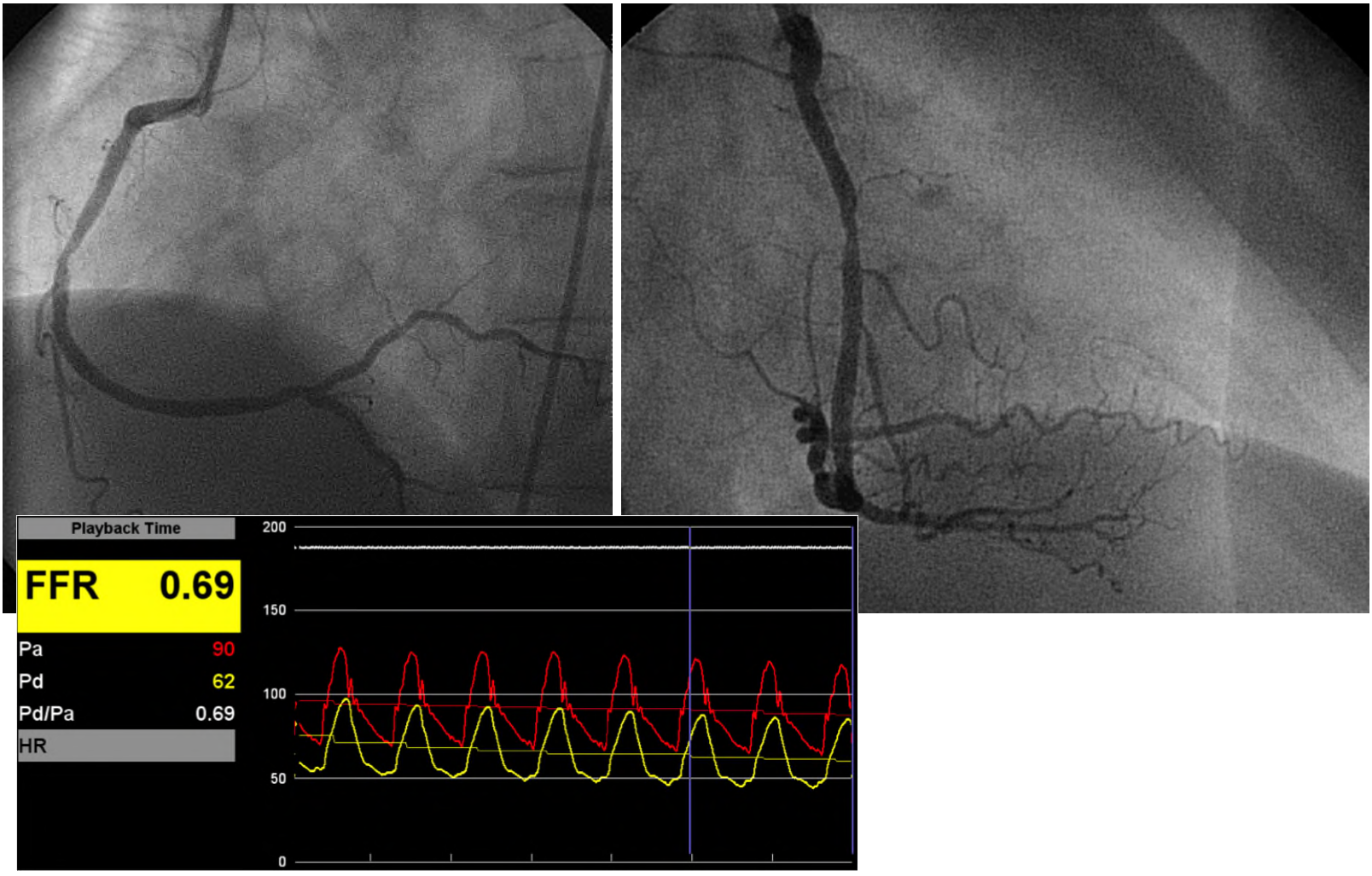
Weatherhead PET Imaging Center

Disclosure Statement of Financial Interest

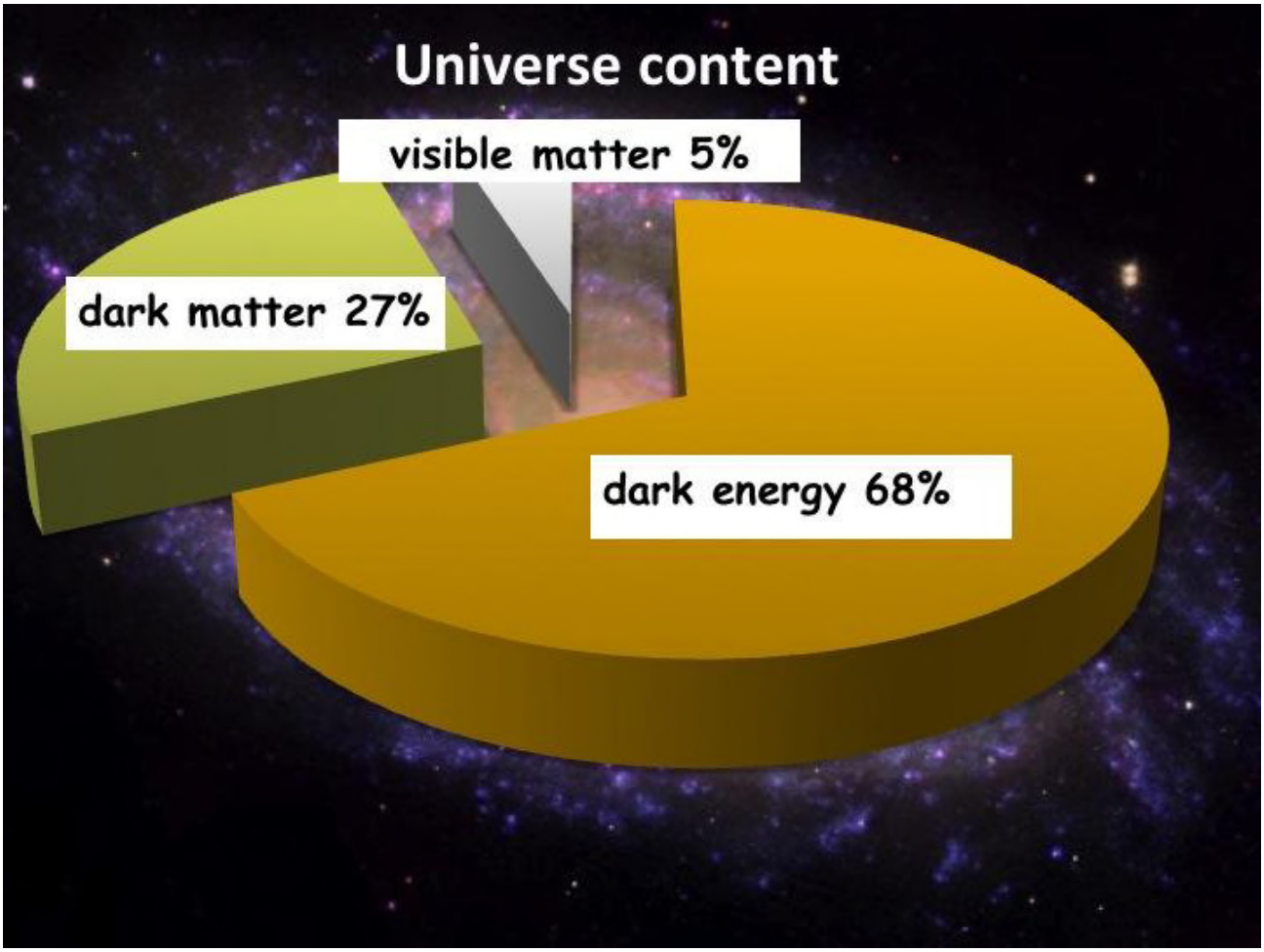
Within the past 12+ months, Nils Johnson has had a financial interest/arrangement or affiliation with the organization(s) listed below.

Affiliation/Financial Relationship	Organizations (alphabetical)
• Grant/research support (to institution)	• St Jude Medical (for CONTRAST study) • Volcano/Philips (for DEFINE-FLOW study)
• Licensing and associated consulting (to institution)	• Boston Scientific (for smart-minimum FFR algorithm)
• Travel support for educational meetings (honoraria donated to institution)	• Various, including academic and industry

FFR 101: The simplest case

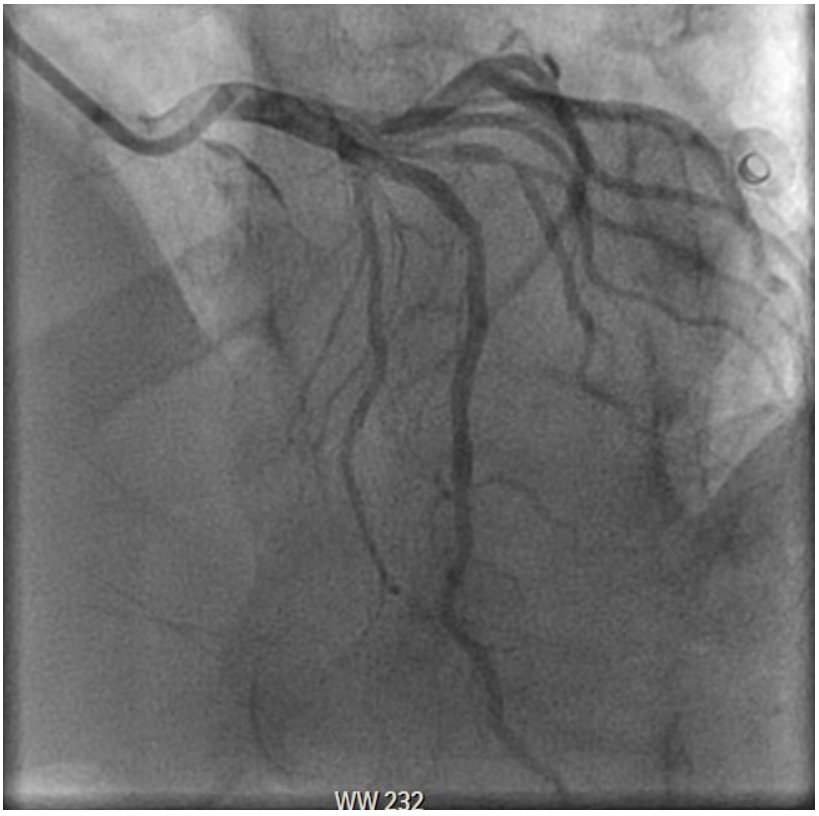


Scenario 1. Dark matter



URL http://www.quantumdiaries.org/wp-content/uploads/2013/06/disk-dark-matter.jpg, accessed November 2, 2016

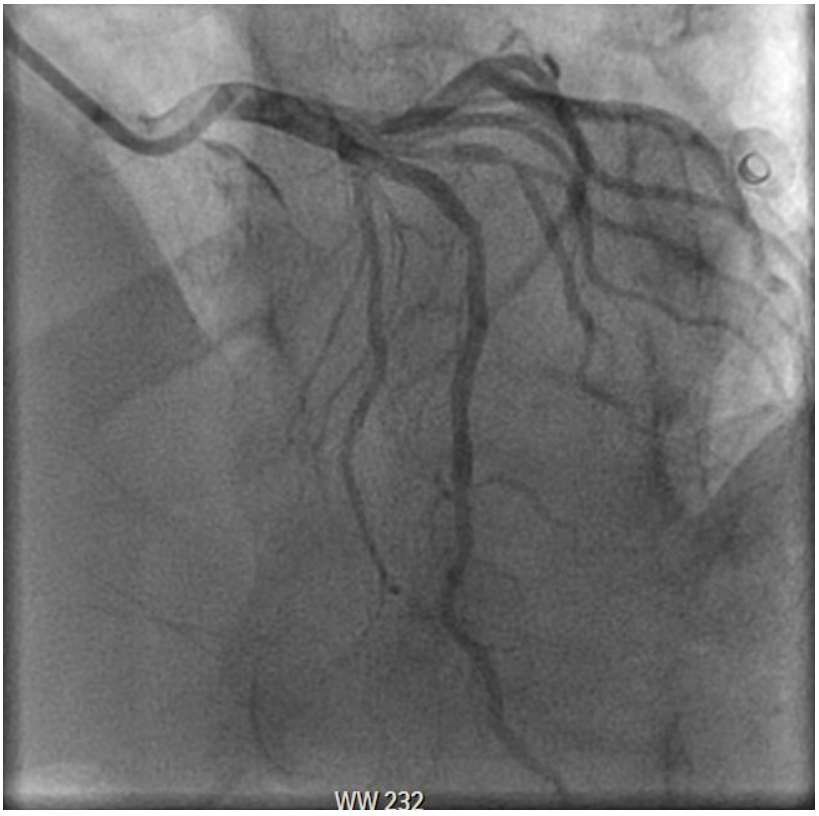
Scenario 1. ¯Dark matter_



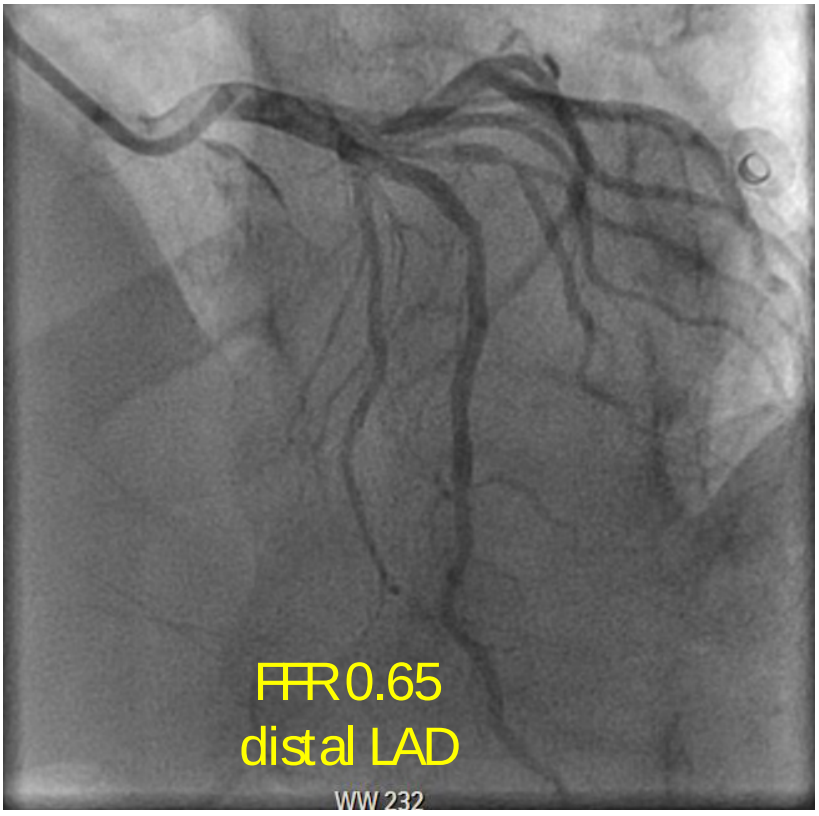
52 year-old man
Classic angina
Prior cath = ¯non-obstructive_
Wanted 2nd opinion

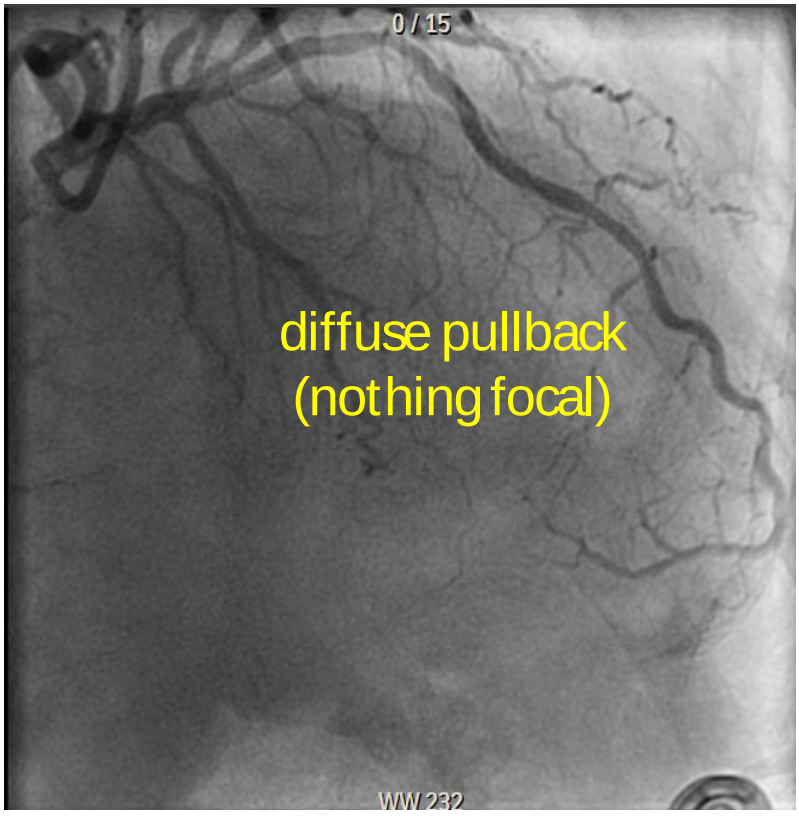
Images courtesy of Frederick Zimmermann, MD (Department of Cardiology, Eindhoven, Netherlands)

Scenario 1. ¯Dark matter_

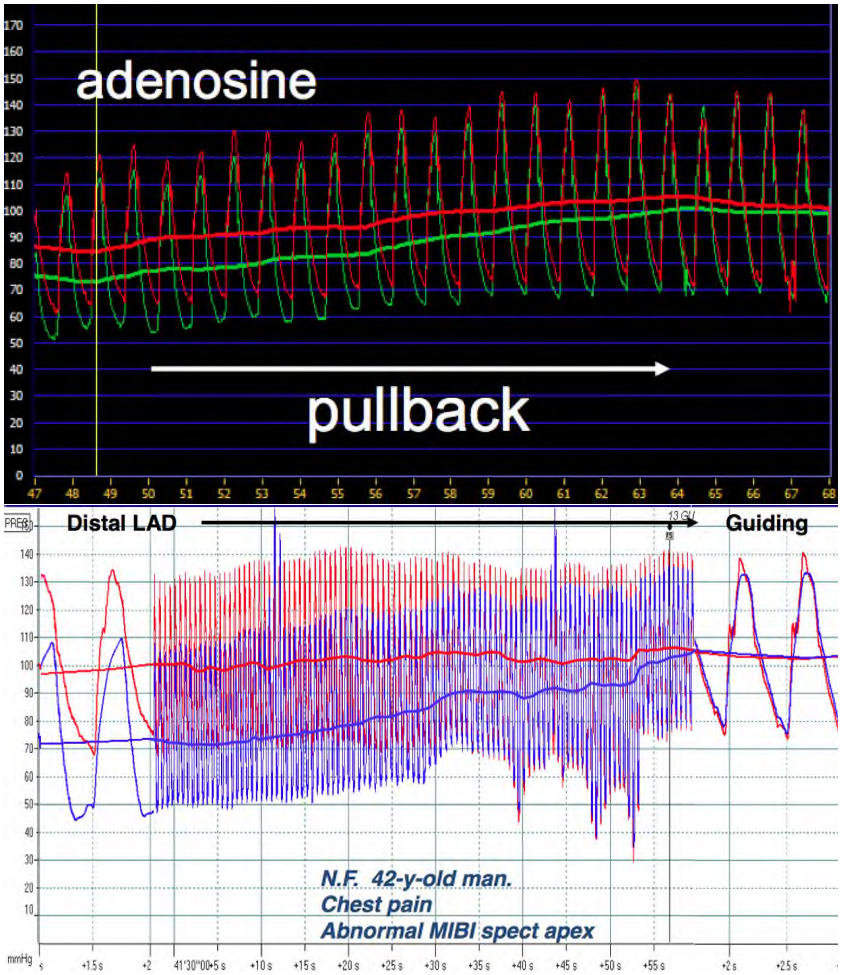


Scenario 1. ¯Dark matter_



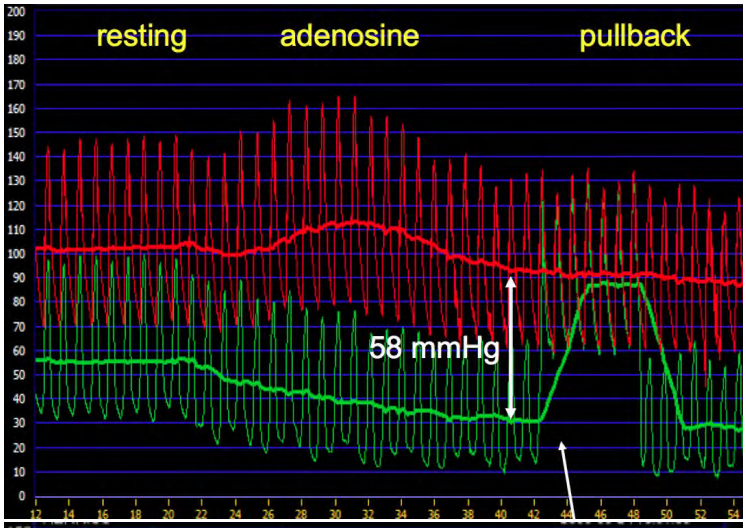


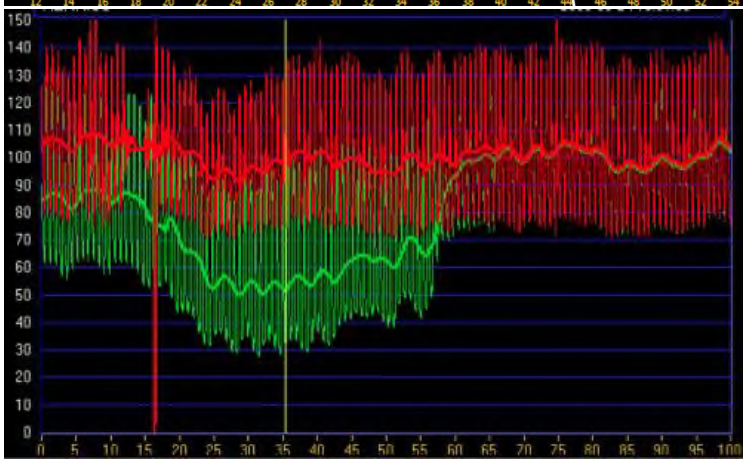
Pullback: diffuse disease

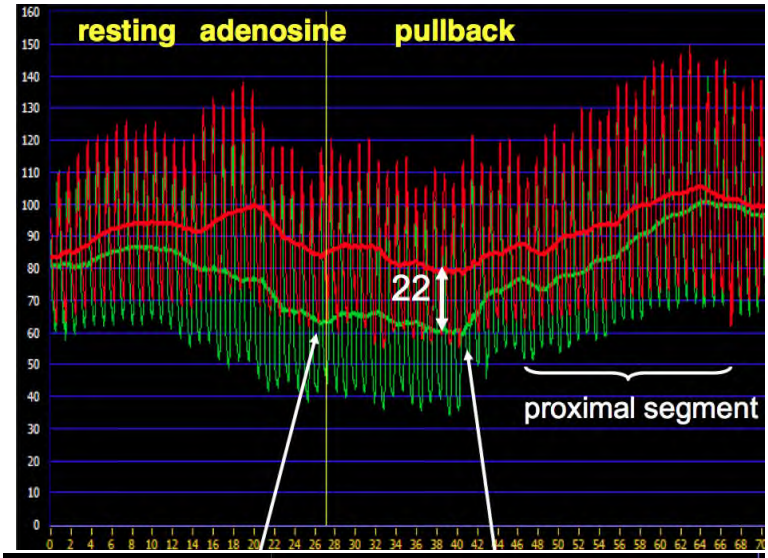


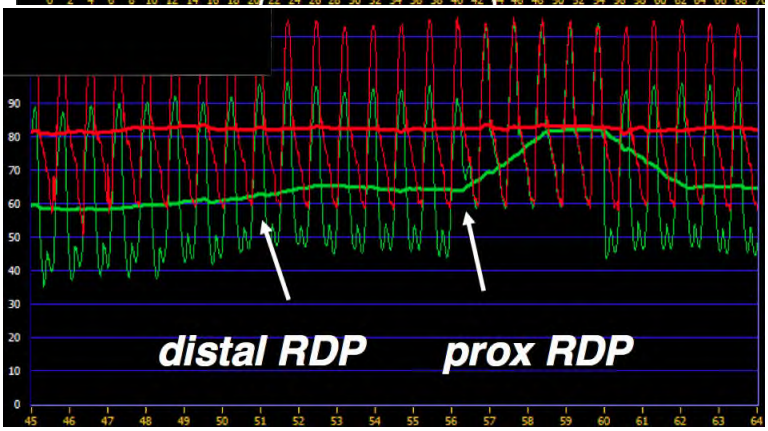
Various pressure tracings from ETP and TCT presentations (De Bruyne, Pijls)

Pullback: focal disease









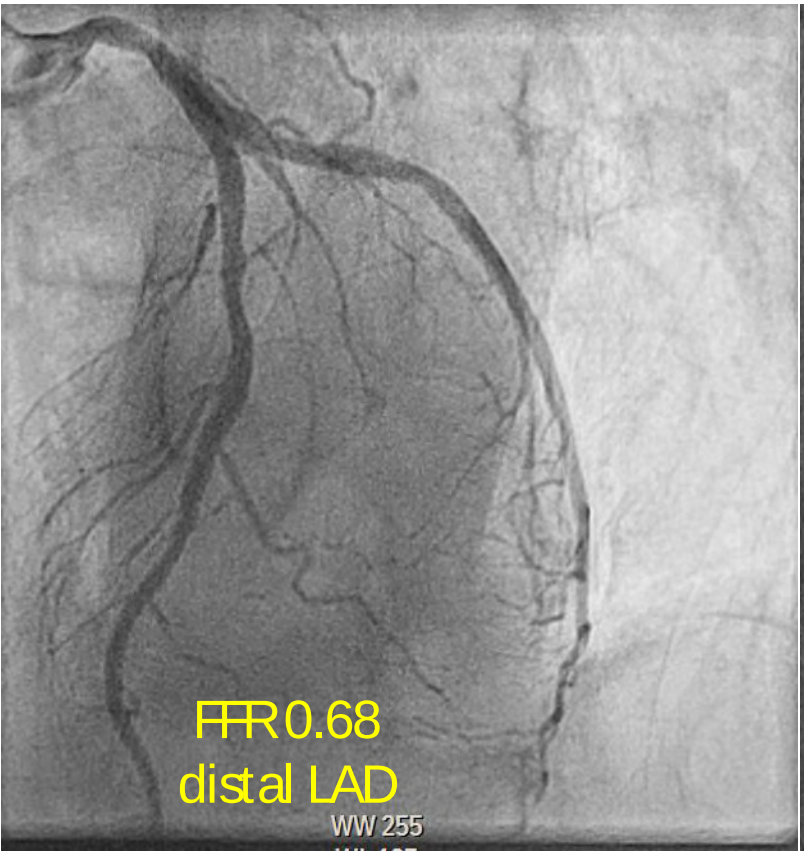
Various pressure tracings from ETP and TCT presentations (De Bruyne, Pijls, Tonino)

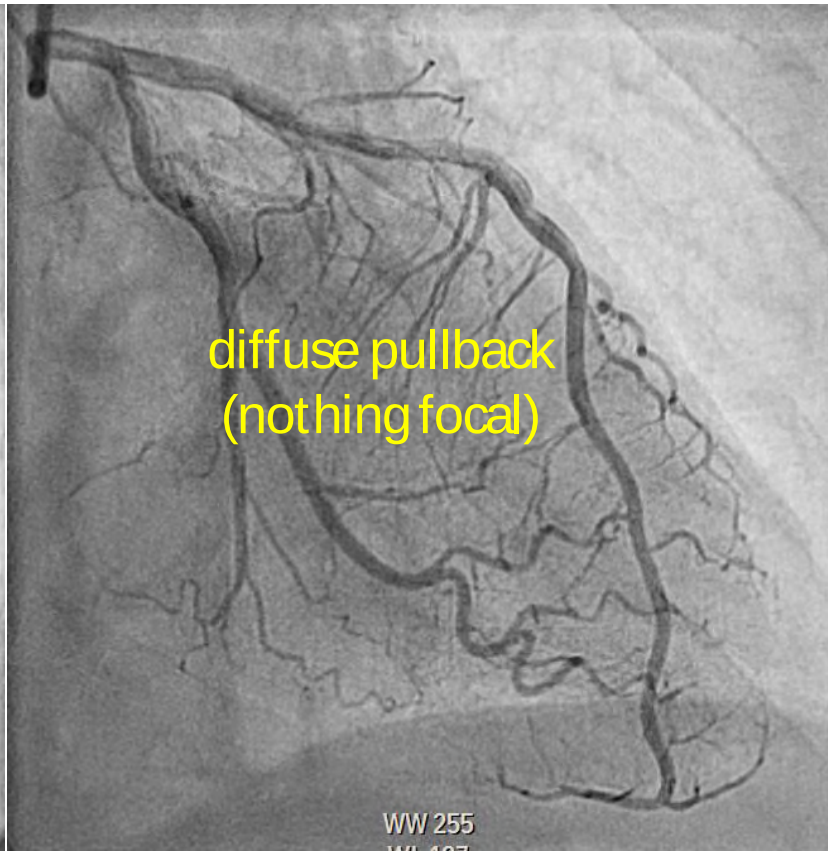
Scenario 1. ¯Dark matter_

61 year-old man
Syncope and VT
Prior cath = ¯non-obstructive_
Referred for 2nd opinion

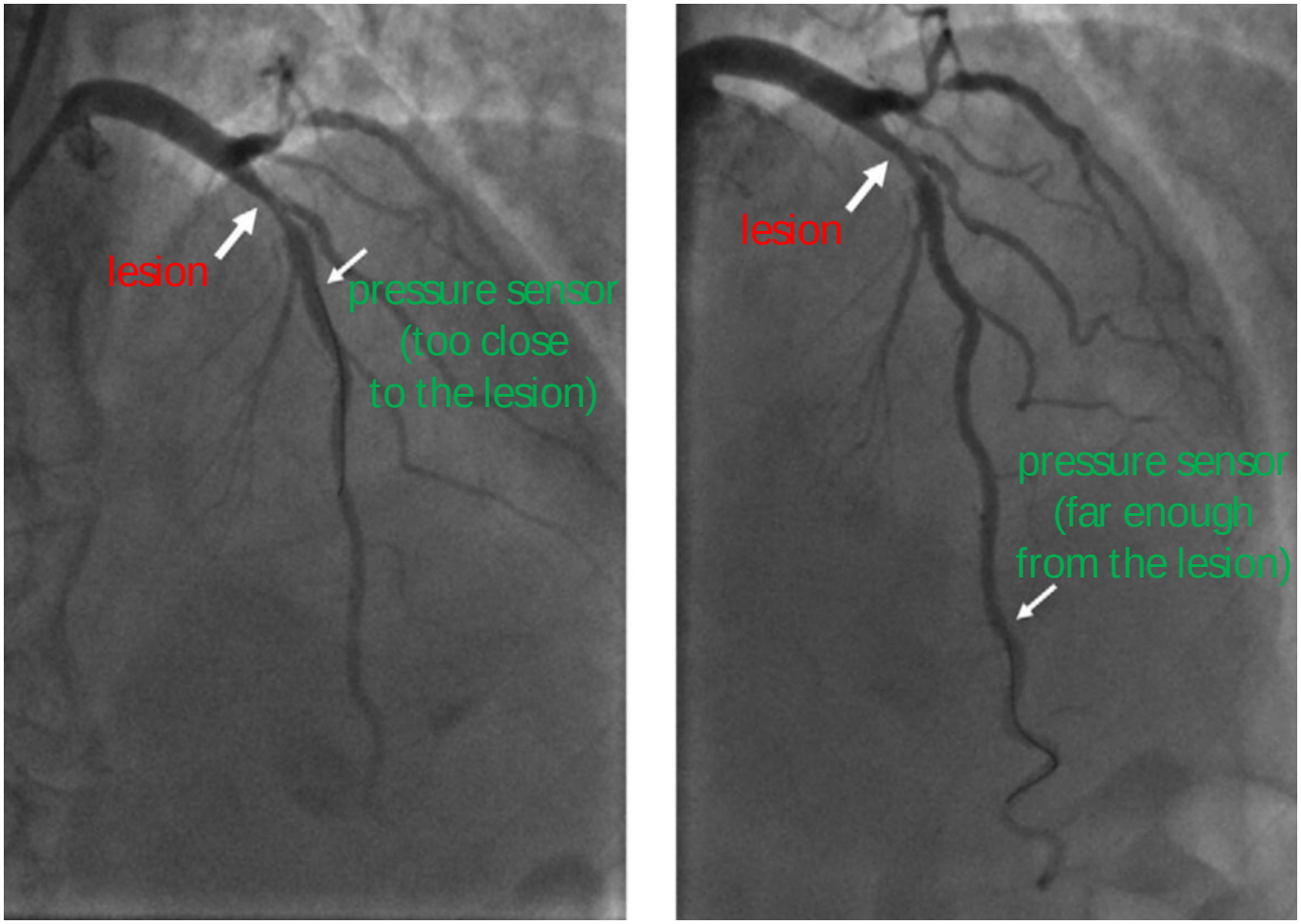
Images courtesy of Frederick Zimmermann, MD (Department of Cardiology, Eindhoven, Netherlands)

Scenario 1. ¯Dark matter_



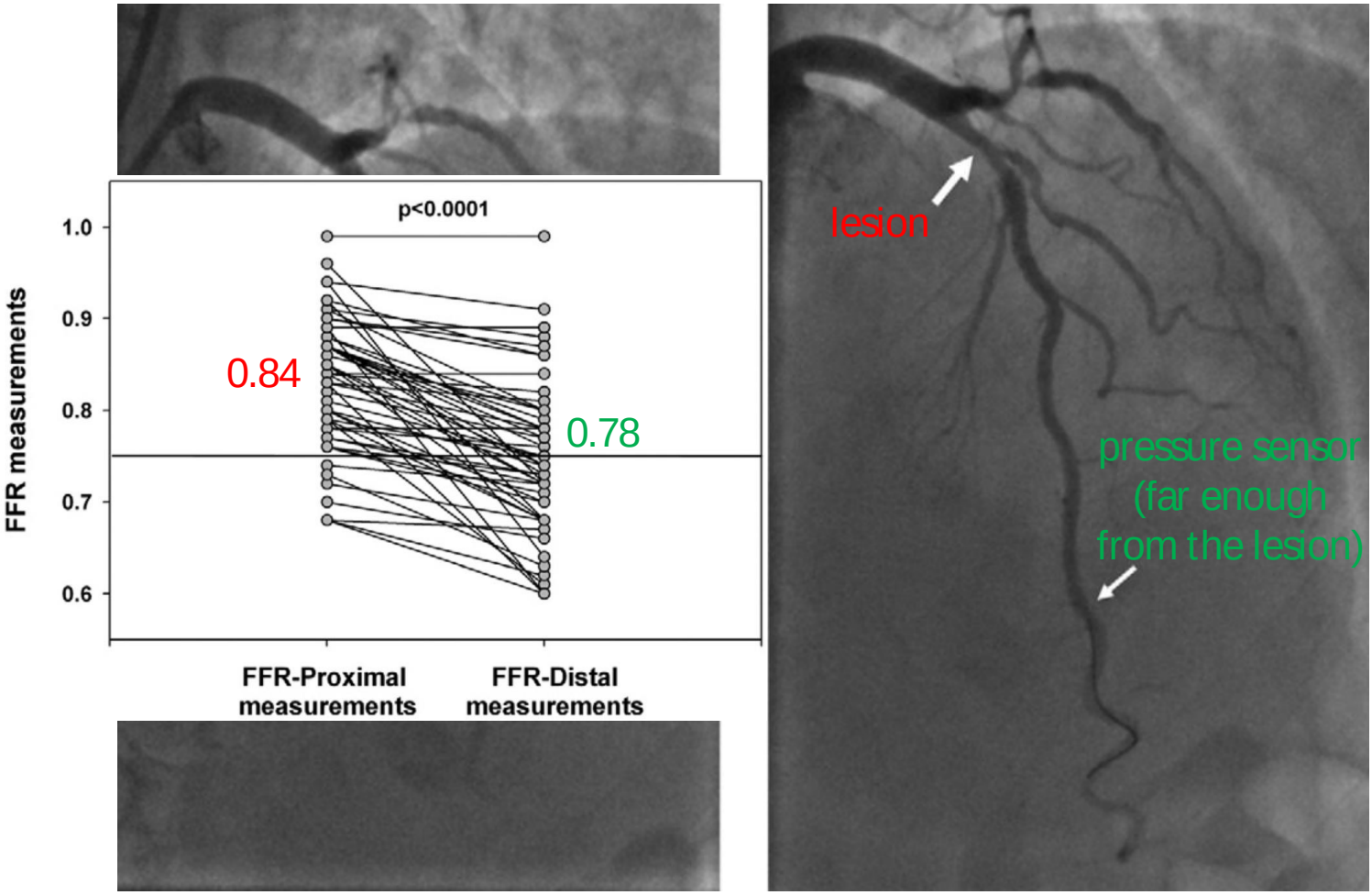


We underappreciate diffuse disease



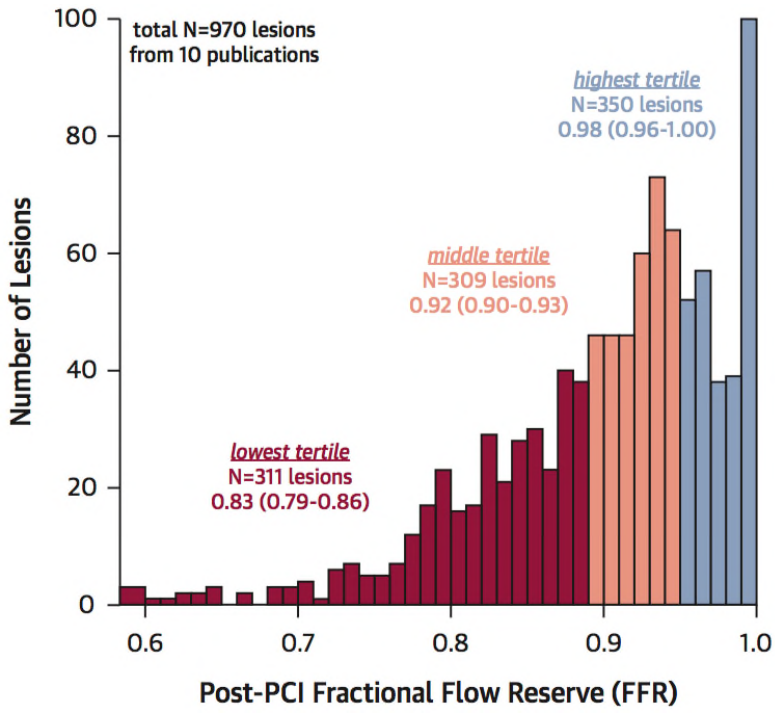
Rodés-Cabau J, Am J Cardiol. 2011 Aug 15;108(4):483-90. (Figure 1 with my annotations)

We underappreciate diffuse disease



Rodés-Cabau J, Am J Cardiol. 2011 Aug 15;108(4):483-90. (Figures 1+3 with my annotations)

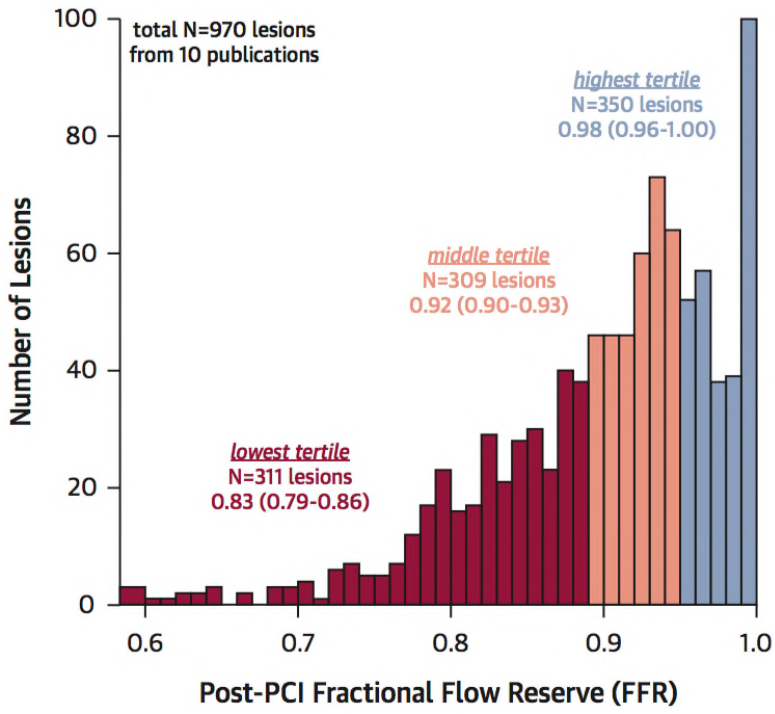
Diffuse disease impacts prognosis

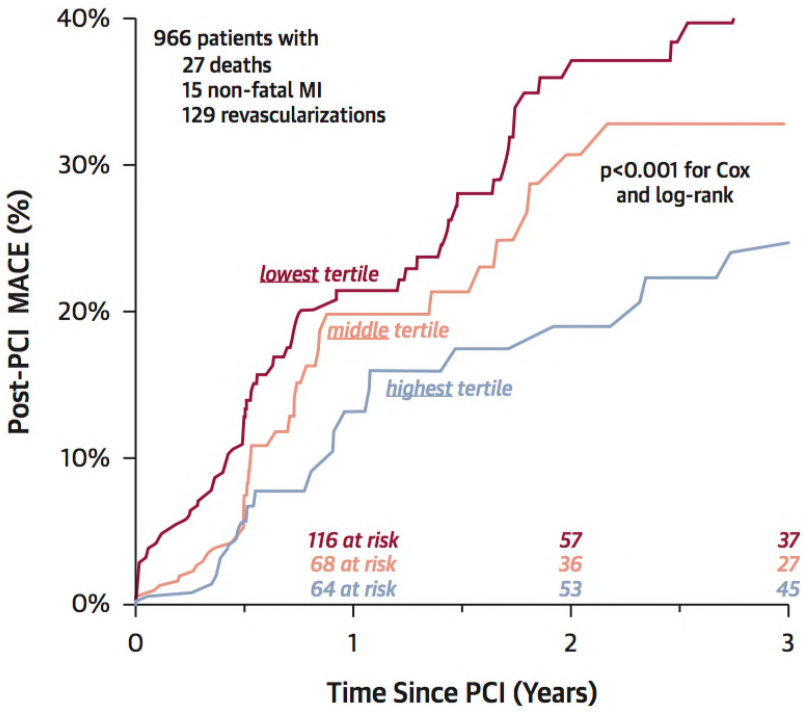


FFR measured AFTER stenting
Focal disease largely gone
Diffuse disease left behind

Johnson NP, JACC. 2014 Oct 21;64(16):1641-54. (Figure 4A)

Diffuse disease impacts prognosis





Johnson NP, JACC. 2014 Oct 21;64(16):1641-54. (Figure 4)

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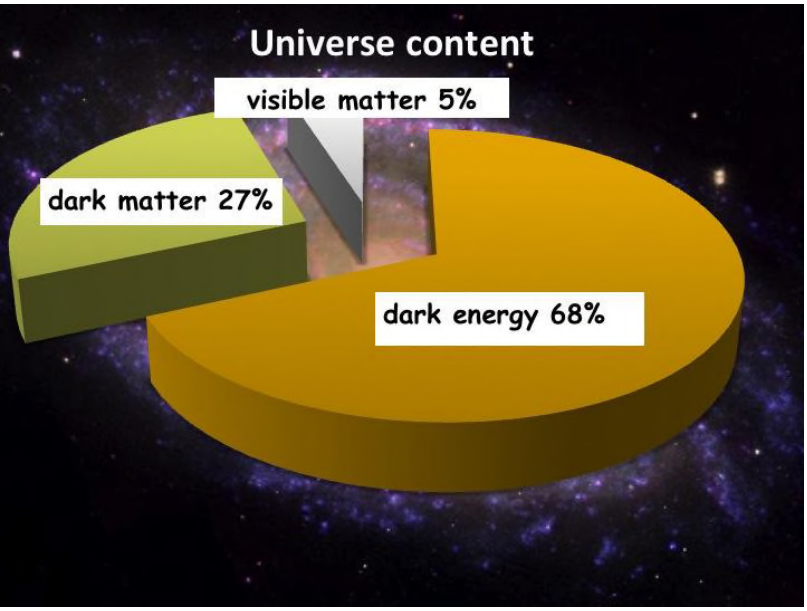
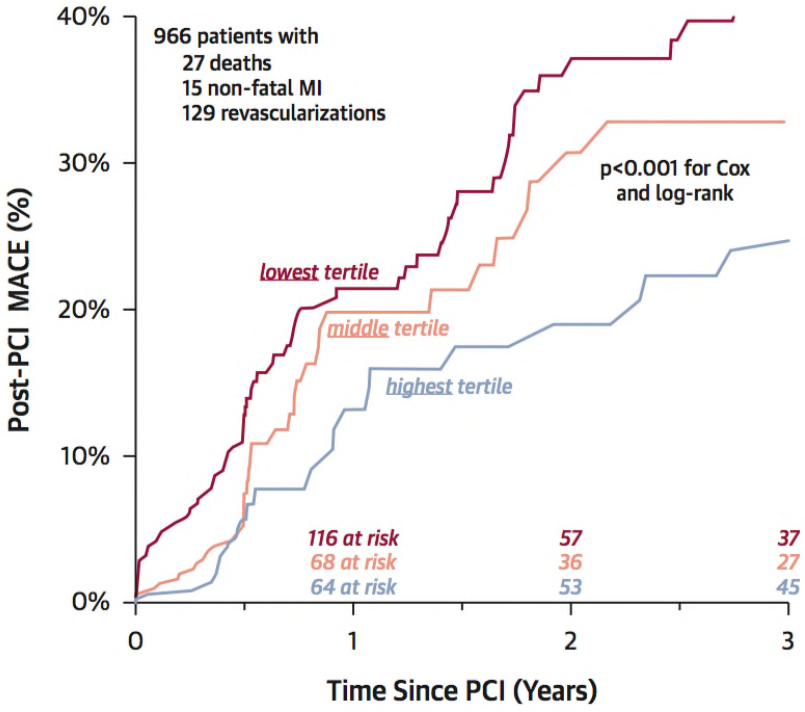
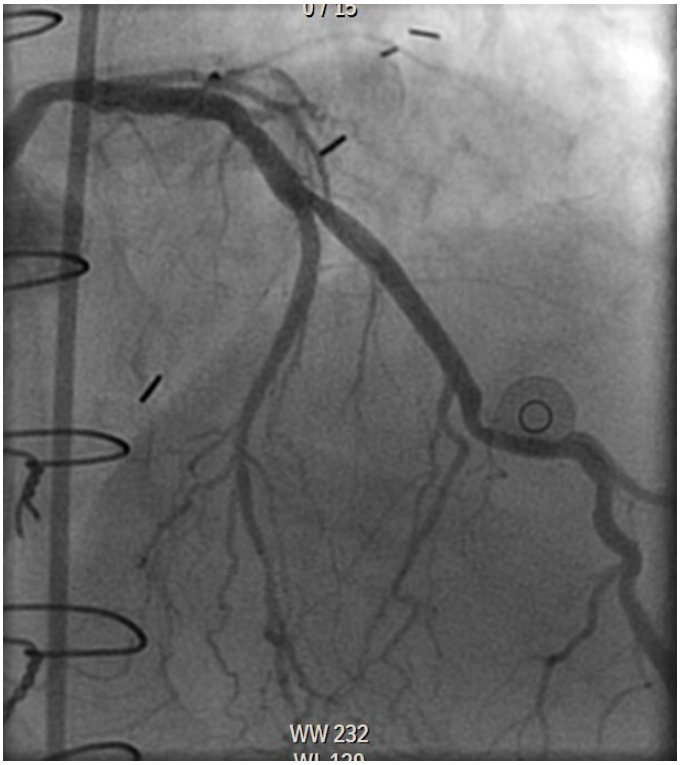




right = Johnson NP, JACC. 2014 Oct 21;64(16):1641-54. (Figure 4B)
left = URL http://www.quantumdiaries.org/wp-content/uploads/2013/06/disk-dark-matter.jpg, accessed November 2, 2016

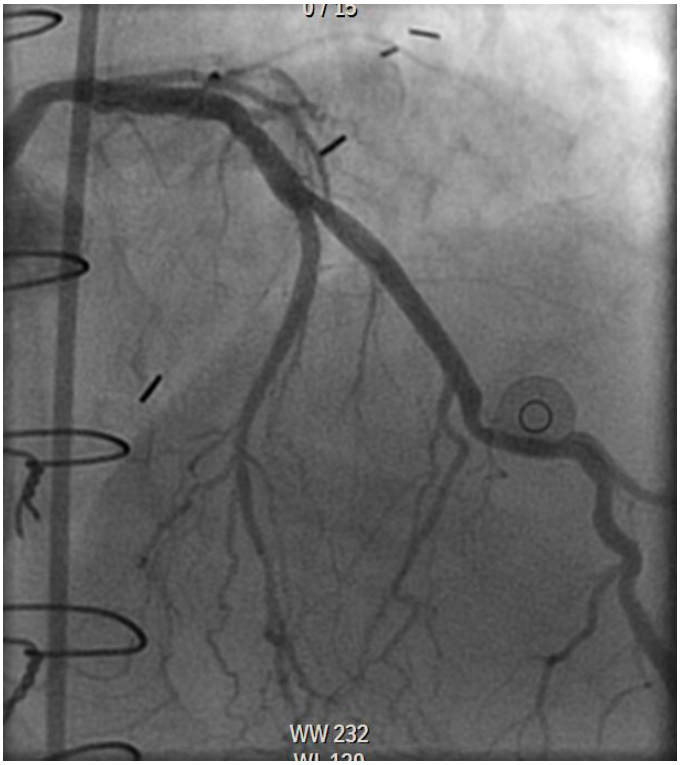
Scenario 2. "Buyer beware"

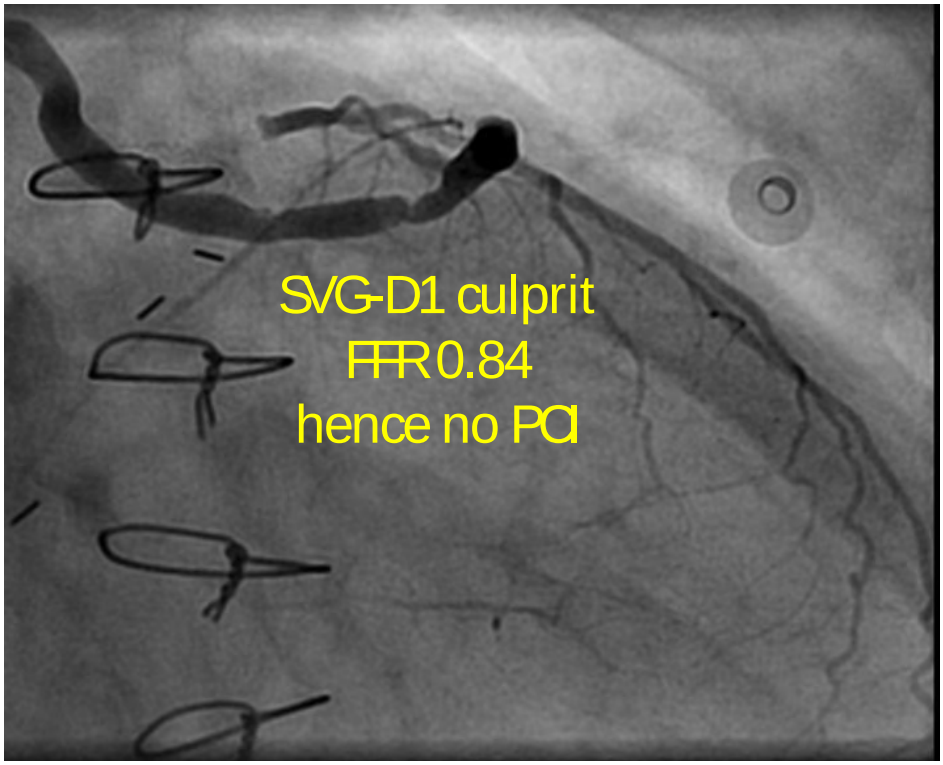


63 year-old man
Inferior MI and CABG 20 years earlier
(SVG-D1 with Y-RIMA to OM+PDA)
Prior PCI of LAD
10 months earlier NSTEMI and VT
CTO's of RCA and LCx, RIMA failed

Images courtesy of Frederick Zimmermann, MD (Department of Cardiology, Eindhoven, Netherlands)

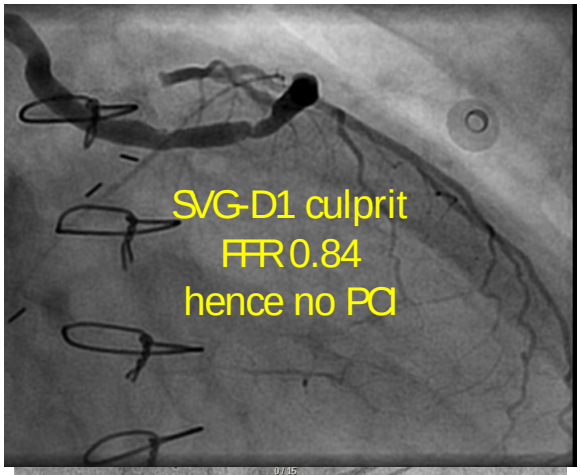
Scenario 2. ¯Buyer beware_

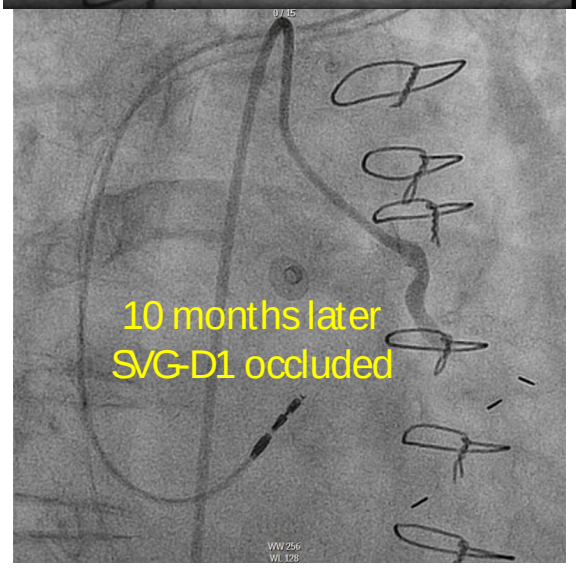




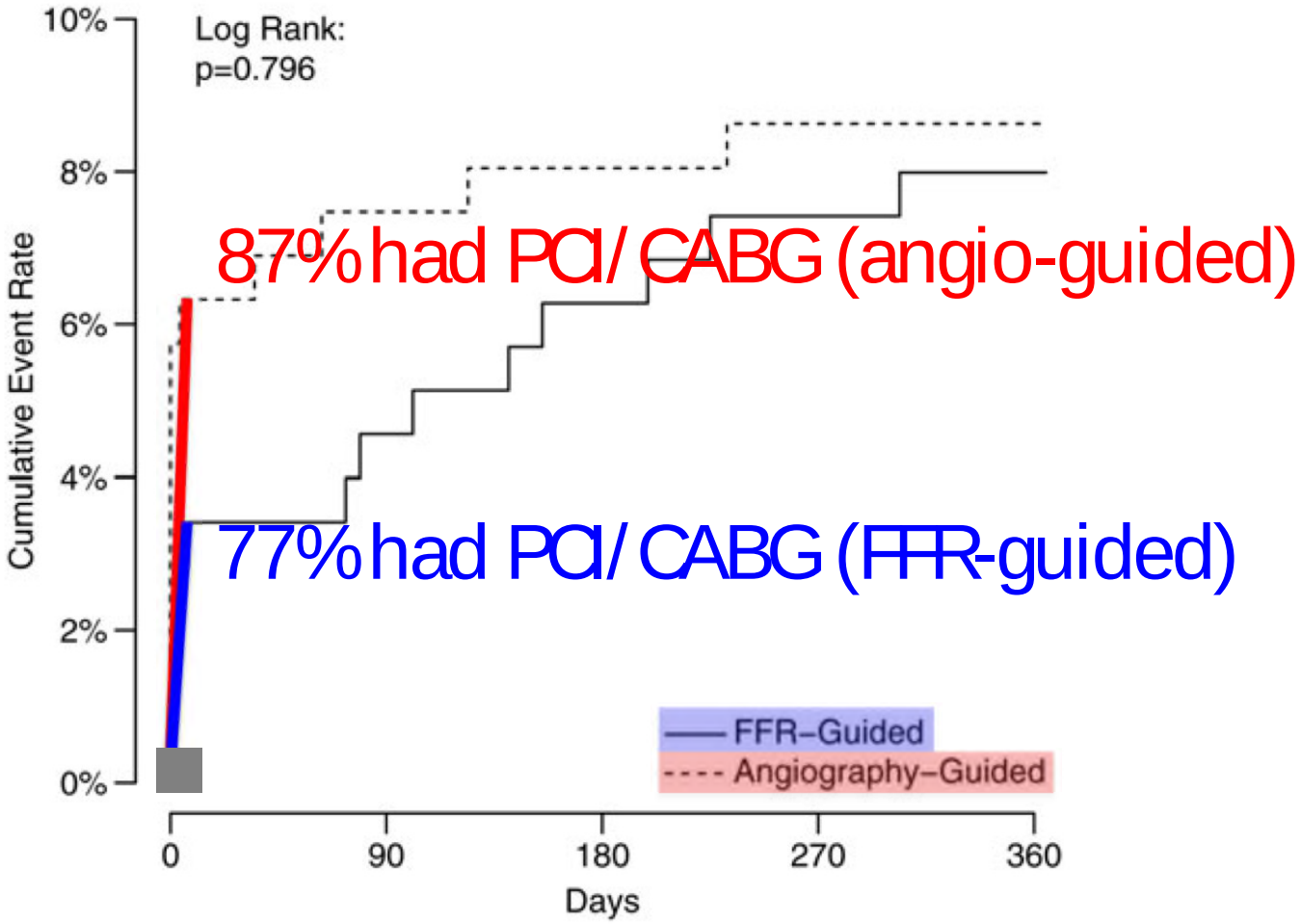
Scenario 2. ¯Buyer beware_

Received ICD for VT's and EF
Presented 10 months later
Electrical storm
SVG-D1 completely occluded



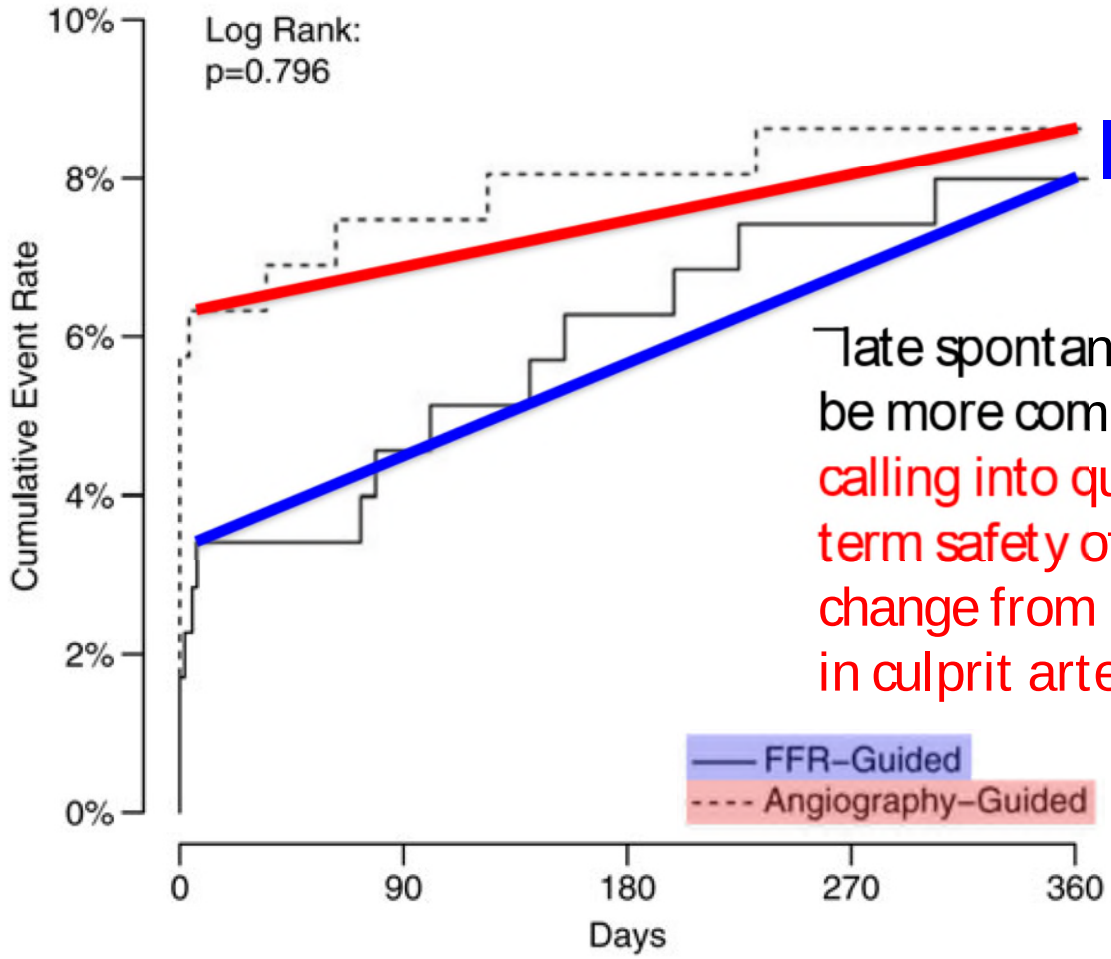


NSTEMI outcomes: FFR vs angio



Layland J, Eur Heart J. 2015 Jan 7;36(2):100-11. (Figure 4, annotated)

NSTEMI outcomes: FFR vs angio



late catch-up?

late spontaneous MACE tended to be more common in the FFR-group, calling into question the longer-term safety of an FFR-guided change from PCI to medical therapy in culprit arteries_

Layland J, Eur Heart J. 2015 Jan 7;36(2):100-11. (Figure 4, annotated plus discussion with my emphasis)

NSTEMI culprits: FFR useful?

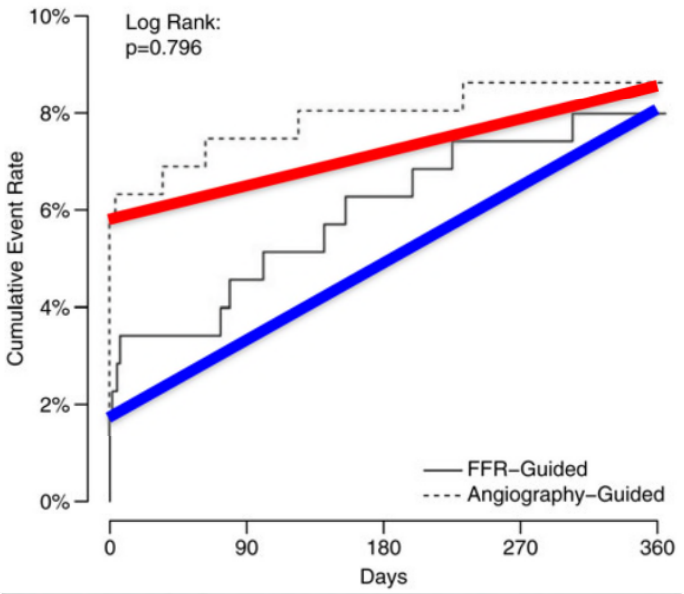
TABLE 1 Indications for FFR-Based Decision Making

Vessel	SIHD	NSTE-ACS	STEMI
Clear culprit	Yes	No	No
Nonculprit	Yes	Yes	Yes

FFR = fractional flow reserve; NSTE-ACS = non–ST-segment elevation acute coronary syndrome; SIHD = stable ischemic heart disease; STEMI = ST-segment elevation myocardial infarction.

Fearon WF, JACC. 2016 Sep 13;68(11):1192-4. (Table 1 with my highlights)

Scenario 2. ¯Buyer beware_



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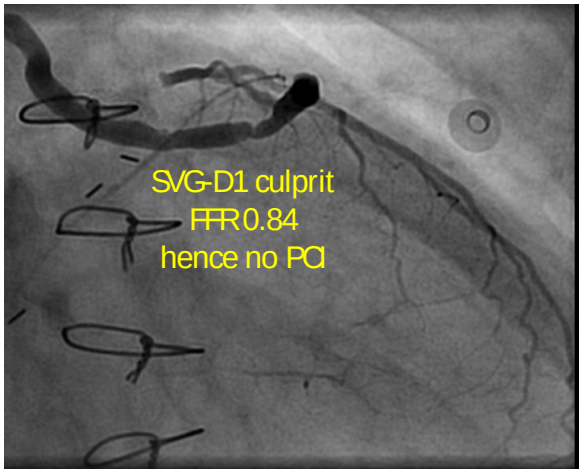
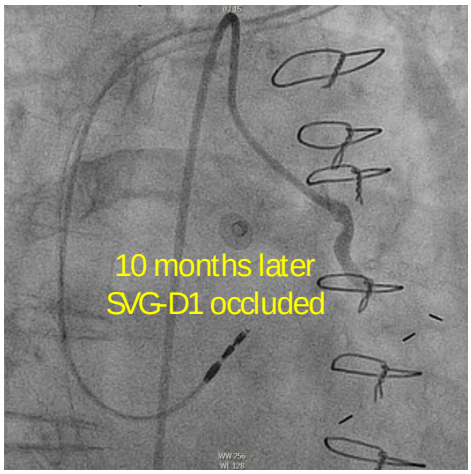
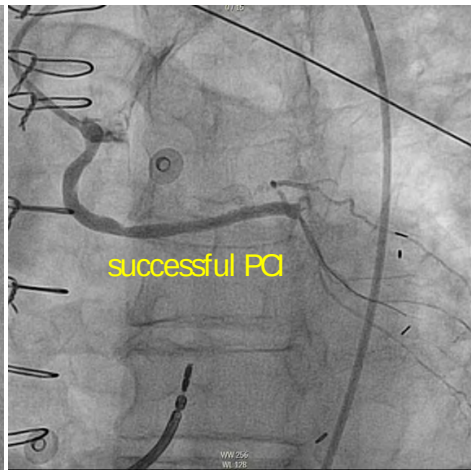






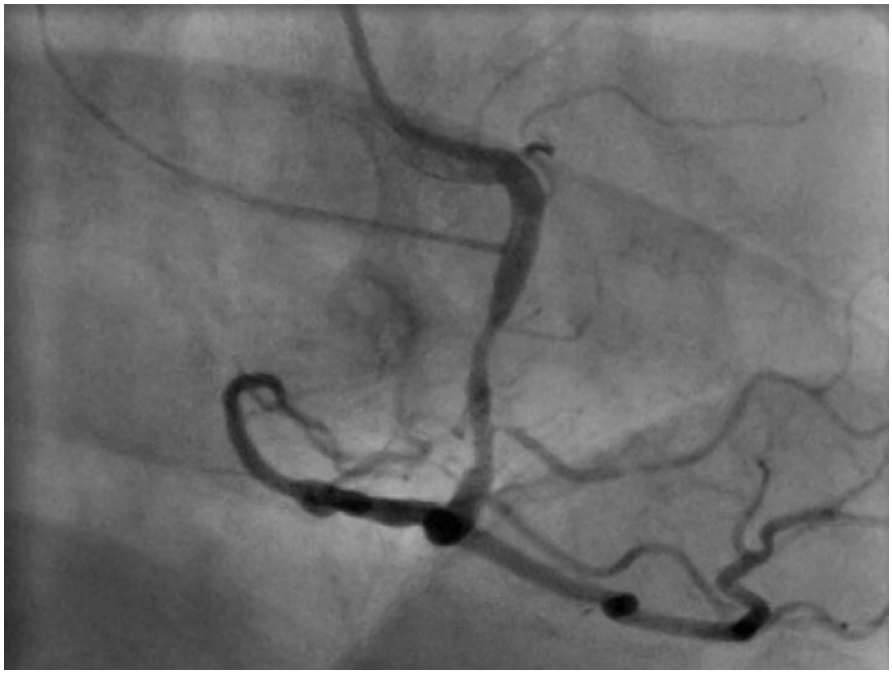
top = Layland J, Eur Heart J. 2015 Jan 7;36(2):100-11. (Figure 4, annotated)
bottom = Fearon WF, JACC. 2016 Sep 13;68(11):1192-4. (Table 1 with my highlights)

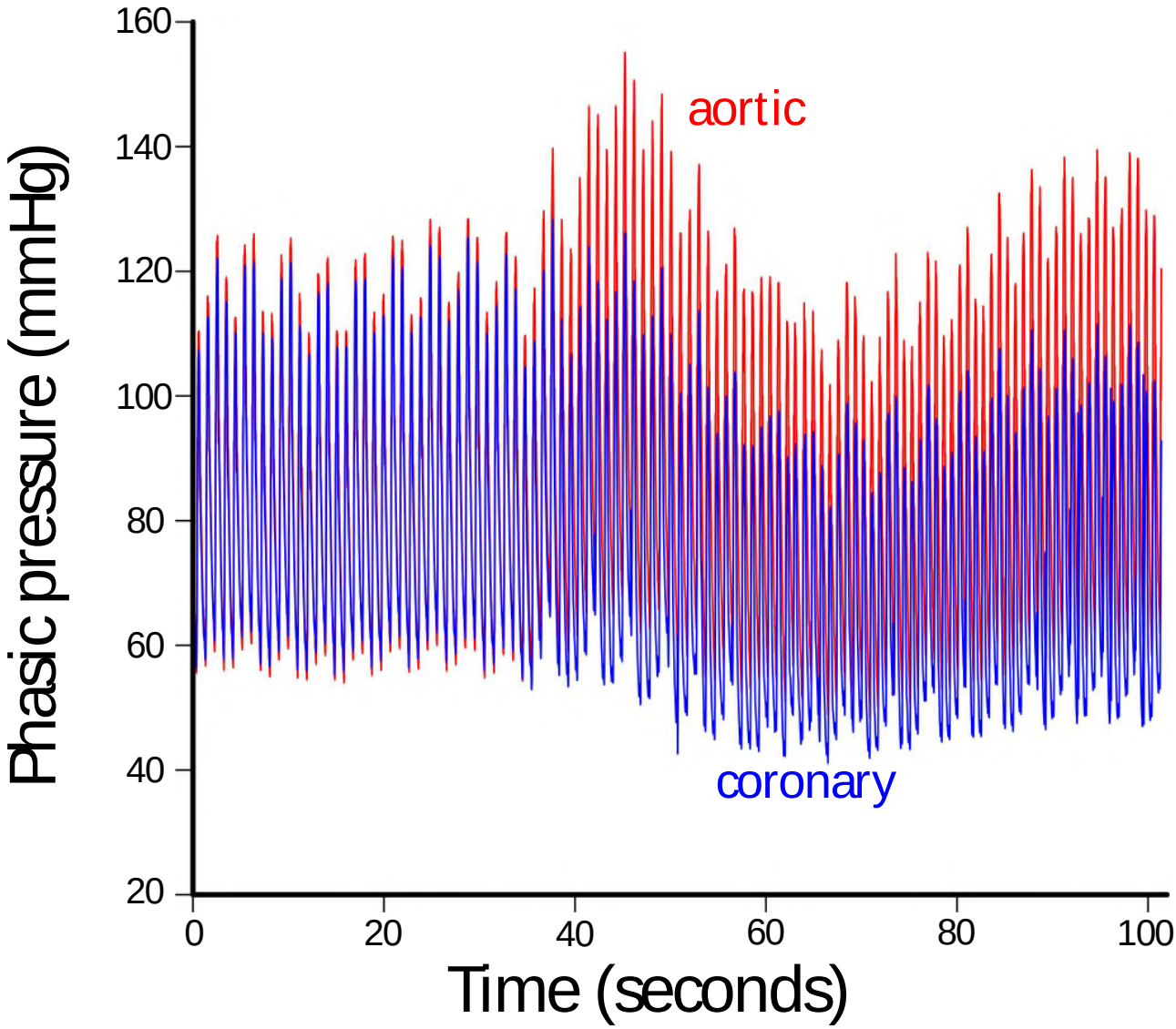
Scenario 3. ¯The lowest bidder_

71 year-old man
Stable angina
Refractory to 3 anti-anginals

Images courtesy of Nils Witt, MD, PhD (Division of Cardiology, “¨ dersjukhuset, Stockholm, Sweden)

Scenario 3. ¯The lowest bidder_




Phasic pressure (mmHg)
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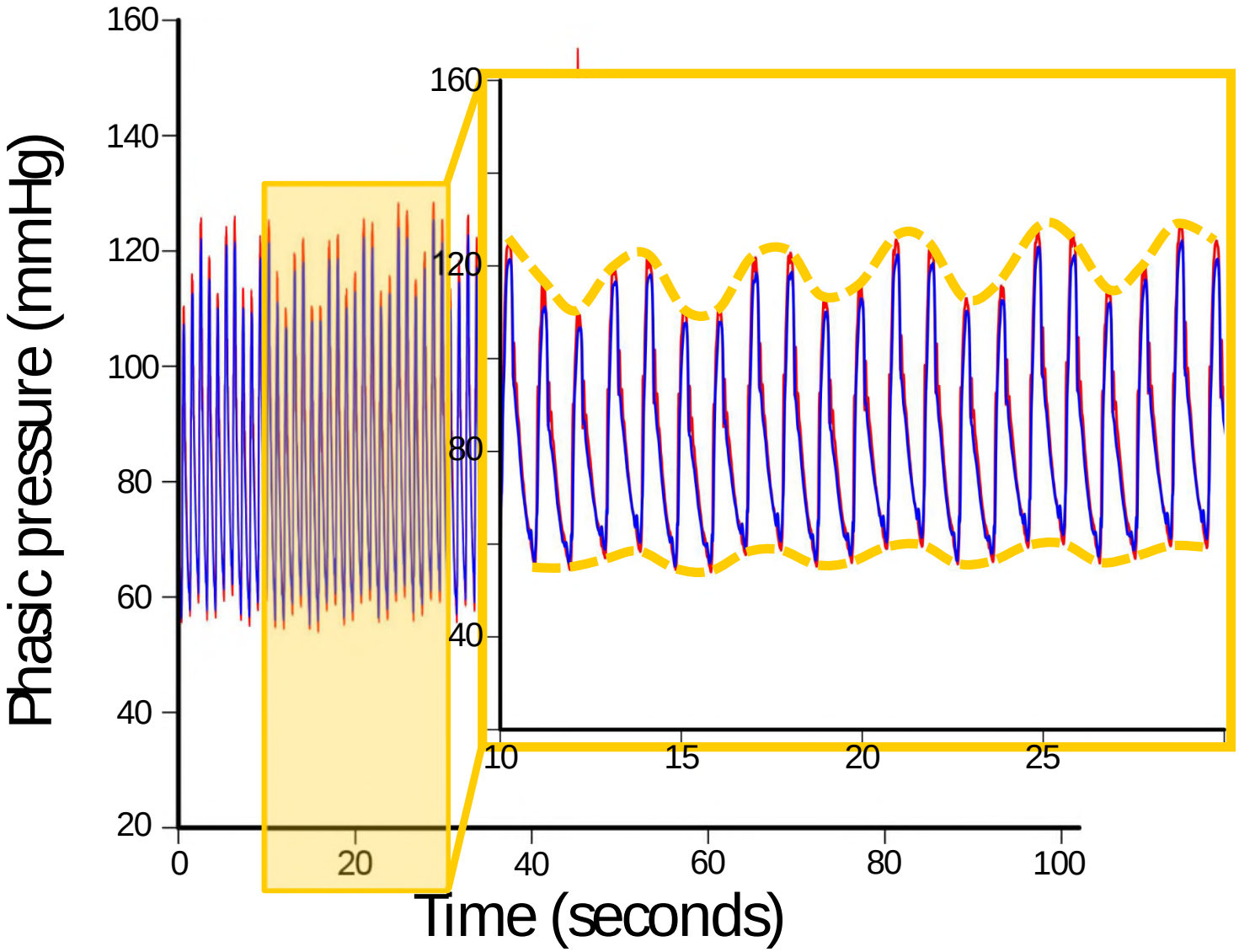
140
120
100
80
60
40
20
aortic
coronary
0
20
40
60
80
100
Time (seconds)


Phasic pressure (mmHg)
160
140
120
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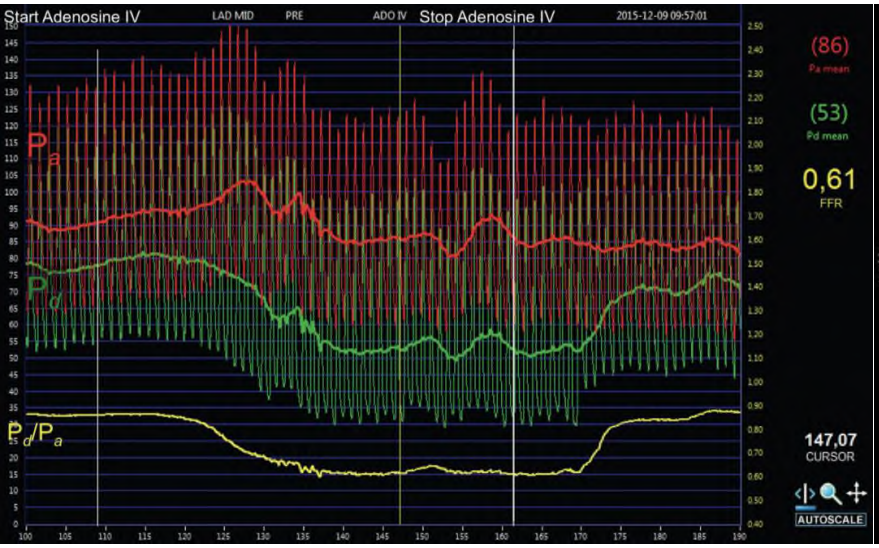
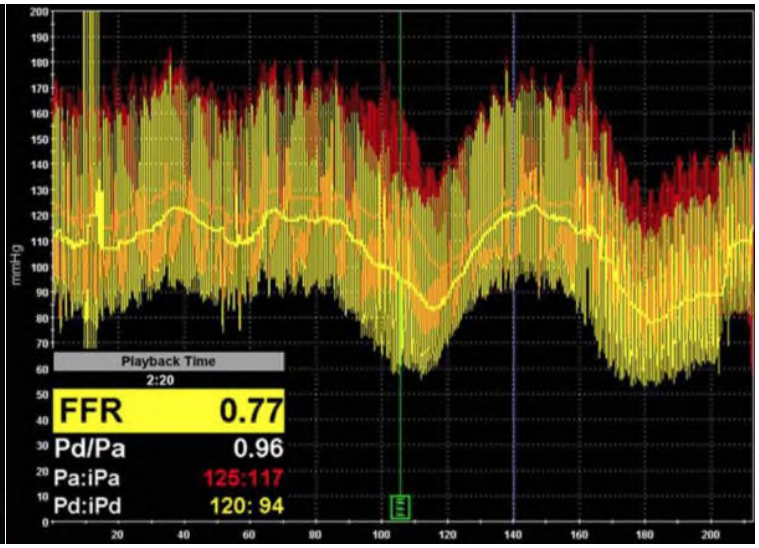
80
60
40
20
0
20
40
60
80
100
Time (seconds)
160
120
80
40
10
15
20
25

If FFR fluctuates, where do I pick?

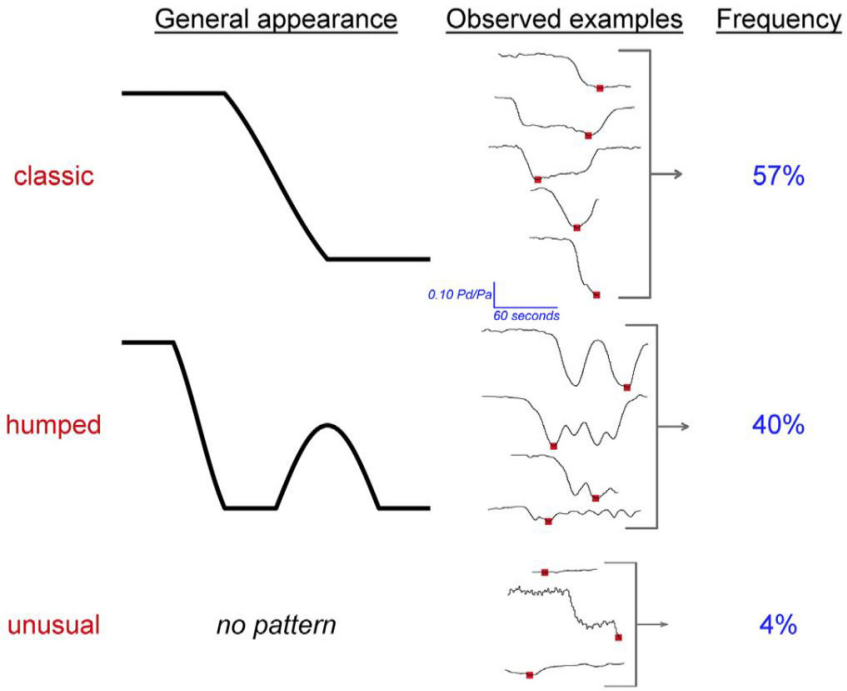




¯stable_ ¯fluctuating_

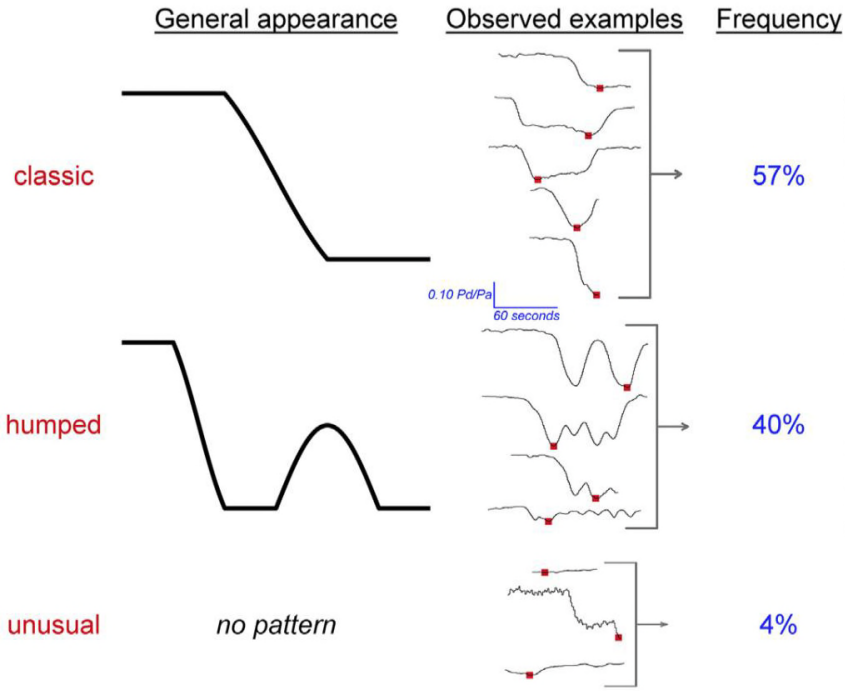
left = Toth GG, JACC. 2016 Aug 16;68(7):742-53. (Figure 3)
right = Seto AH, Catheter Cardiovasc Interv. 2014 Sep 1;84(3):416-25. (Figure 2D)

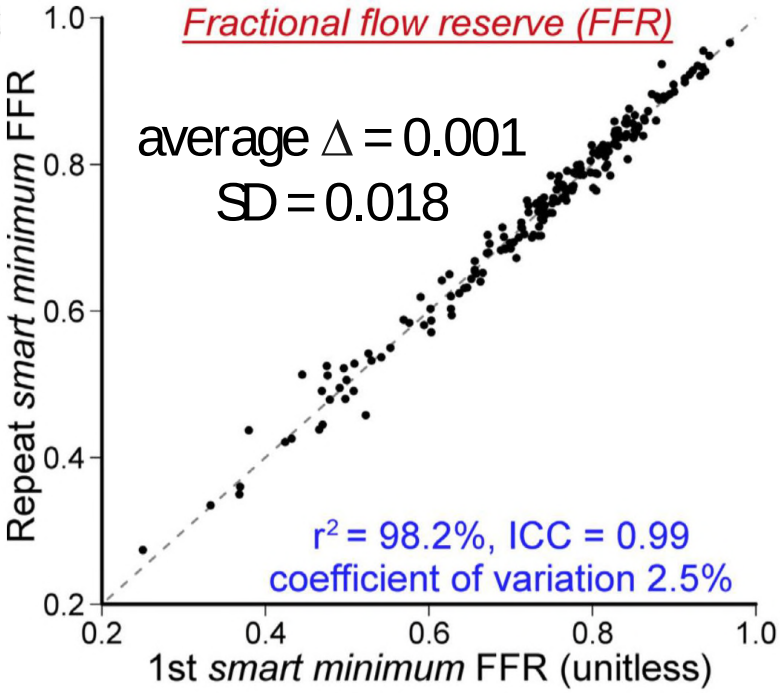
If FFR fluctuates, where do I pick?



Johnson NP, JACC Cardiovasc Interv. 2015 Jul;8(8):1018-27. (Figure 2)

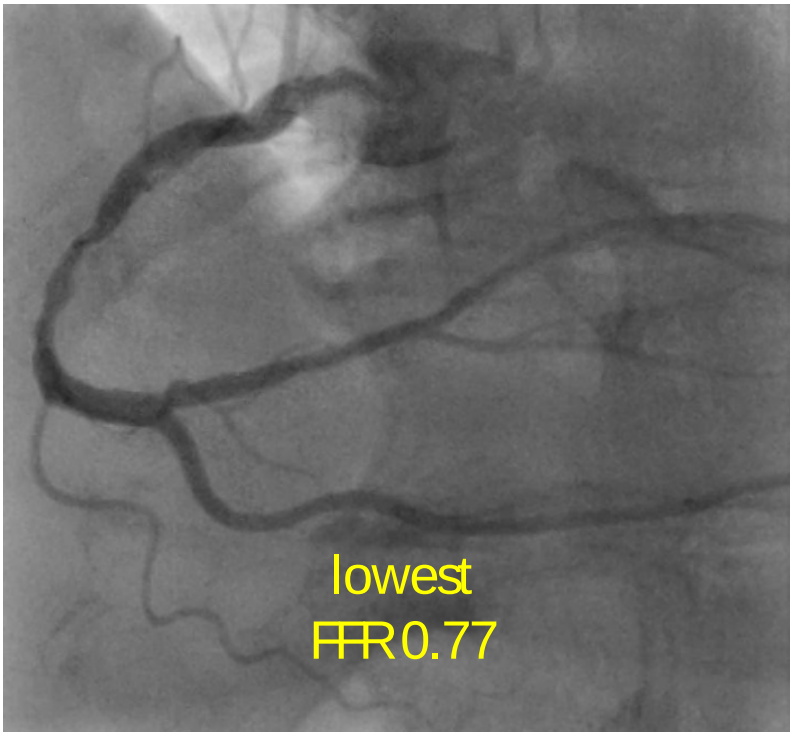
FFR fluctuates? pick lowest

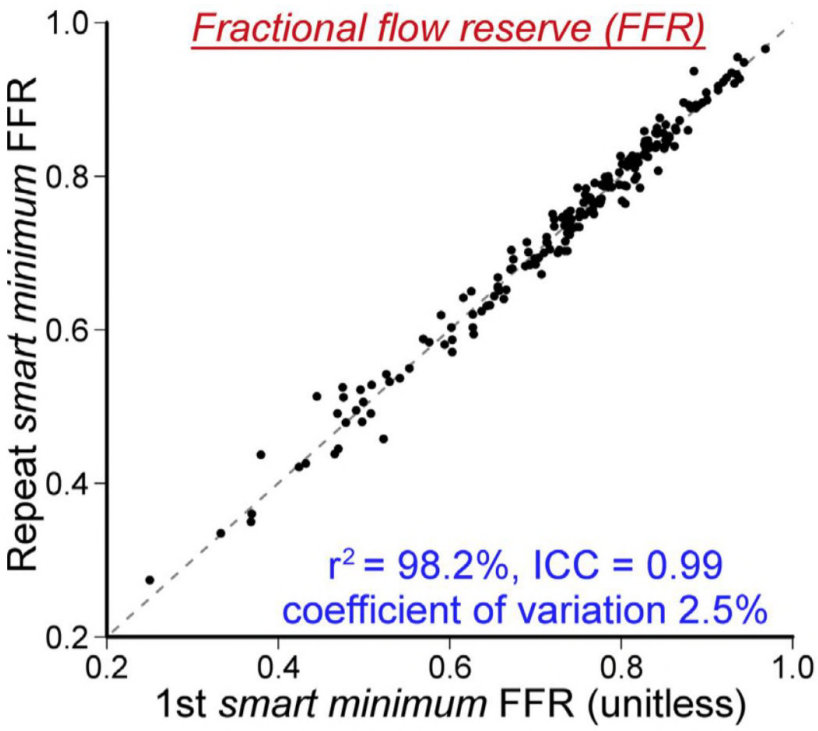




Johnson NP, JACC Cardiovasc Interv. 2015 Jul;8(8):1018-27. (Figures 2 and annotated 4A)

Scenario 3. ¯The lowest bidder_





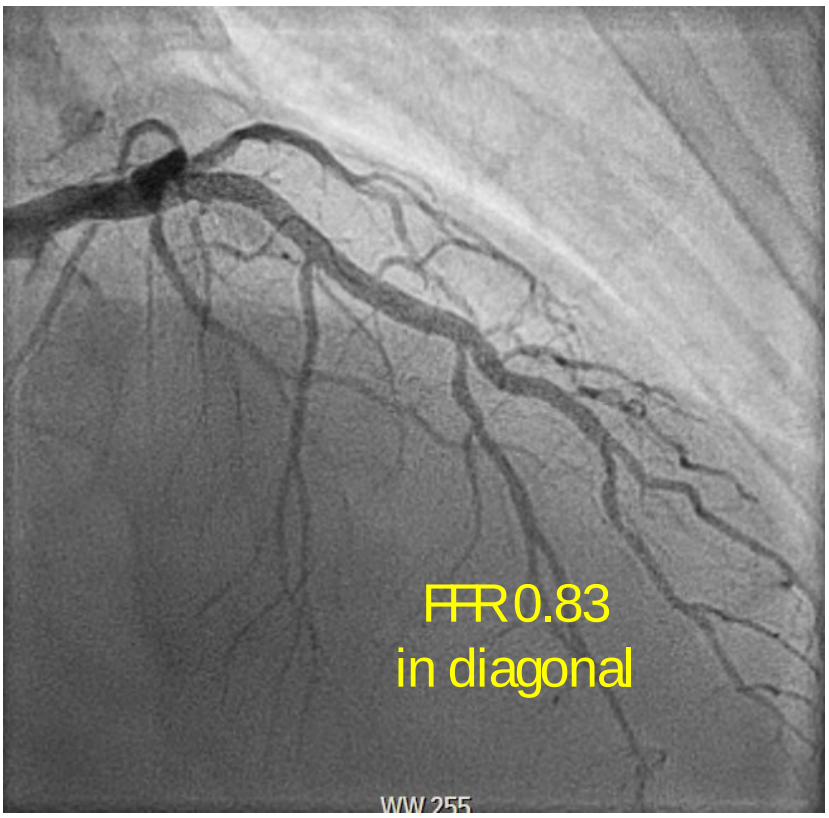
left = image courtesy of Nils Witt, MD, PhD (Division of Cardiology, “¨ dersjukhuset, Stockholm, Sweden)
right = Johnson NP, JACC Cardiovasc Interv. 2015 Jul;8(8):1018-27. (Figure 4A)

Scenario 4. Contrasting views

45 year-old man
Recent STEMI from LAD culprit
Bystander disease in D2 and LCx
Returned for FFR assessment

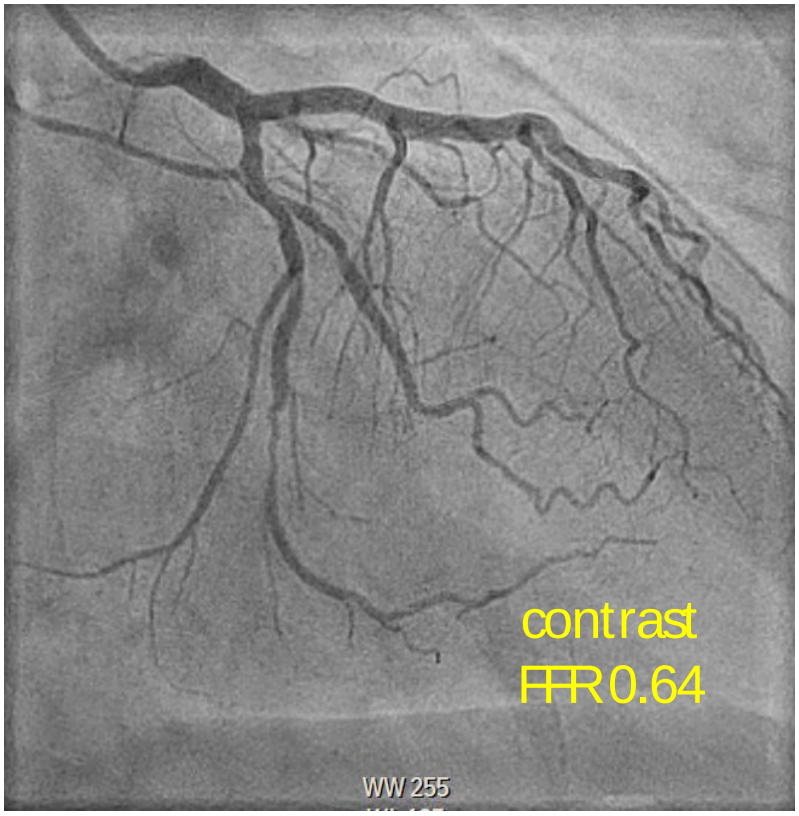
Images courtesy of Frederick Zimmermann, MD (Department of Cardiology, Eindhoven, Netherlands)

Scenario 4. ¯Contrasting views_

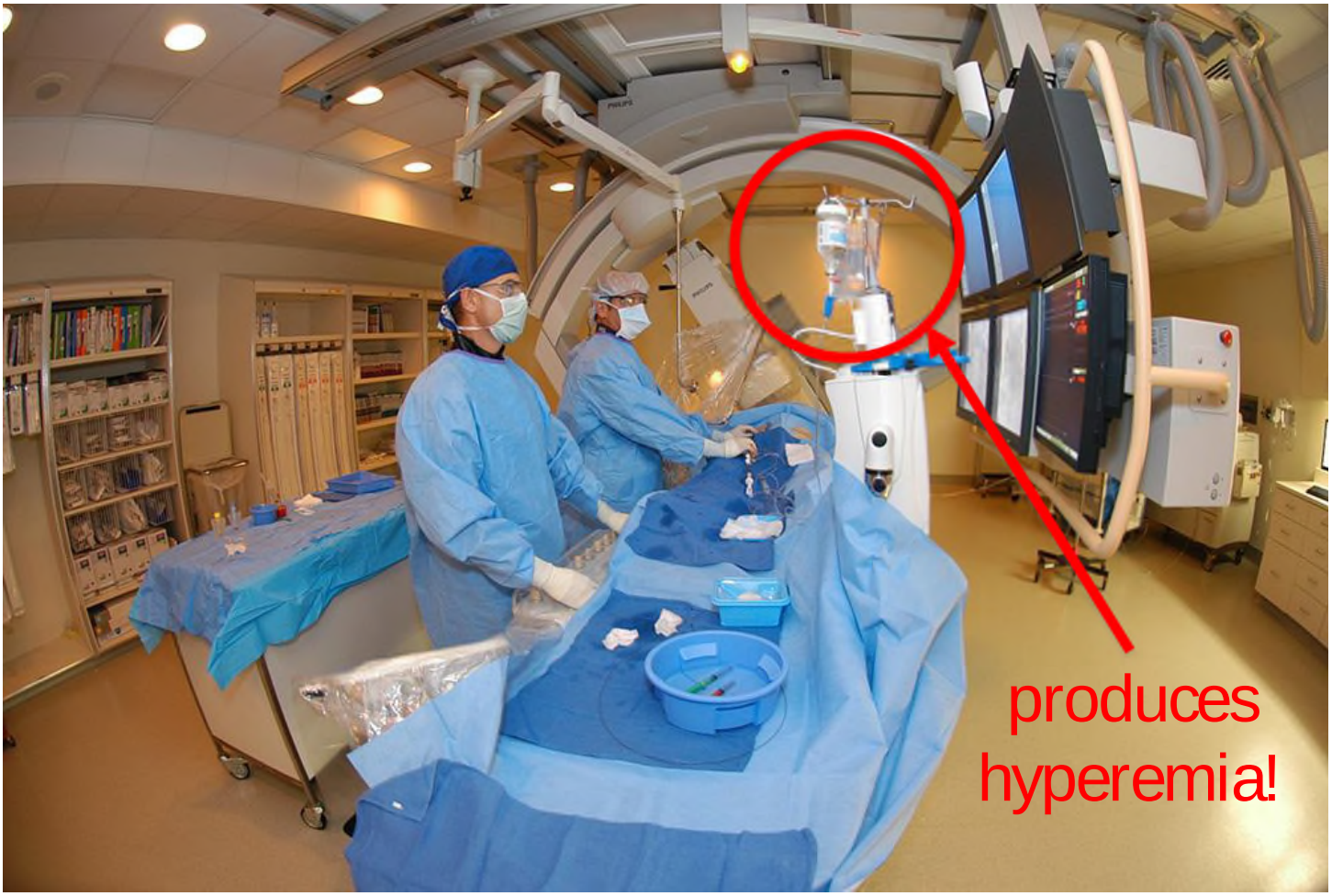


Scenario 4. Contrasting views

Pressure wire switched to LCx
Brief contrast injection to position
Pd/Pa fell immediately to 0.64

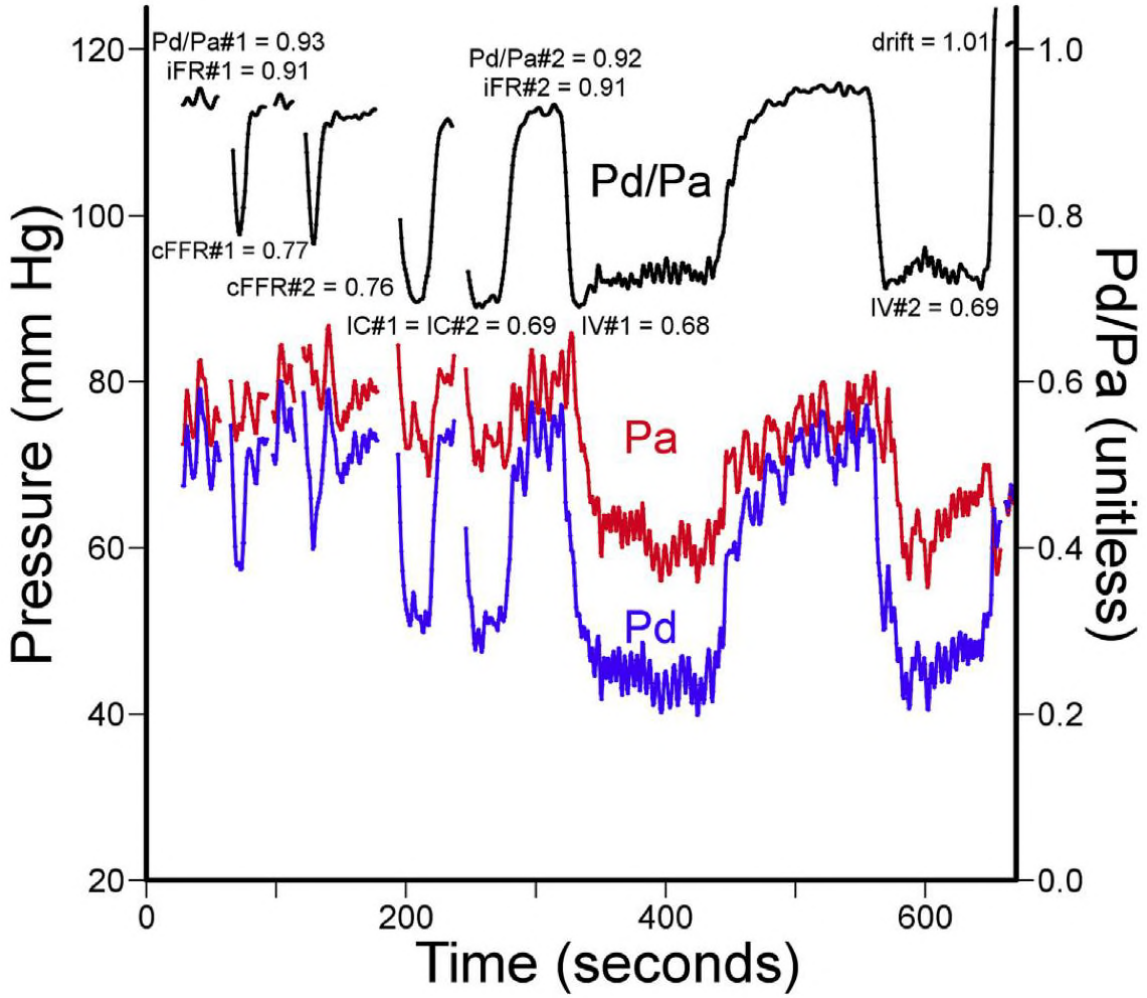


Contrast: always ready, fast, cheap



URL http://www.nghs.com/cardiac-catheterization-lab, accessed October 13, 2016 (annotated).

Contrast FFR (cFFR): example



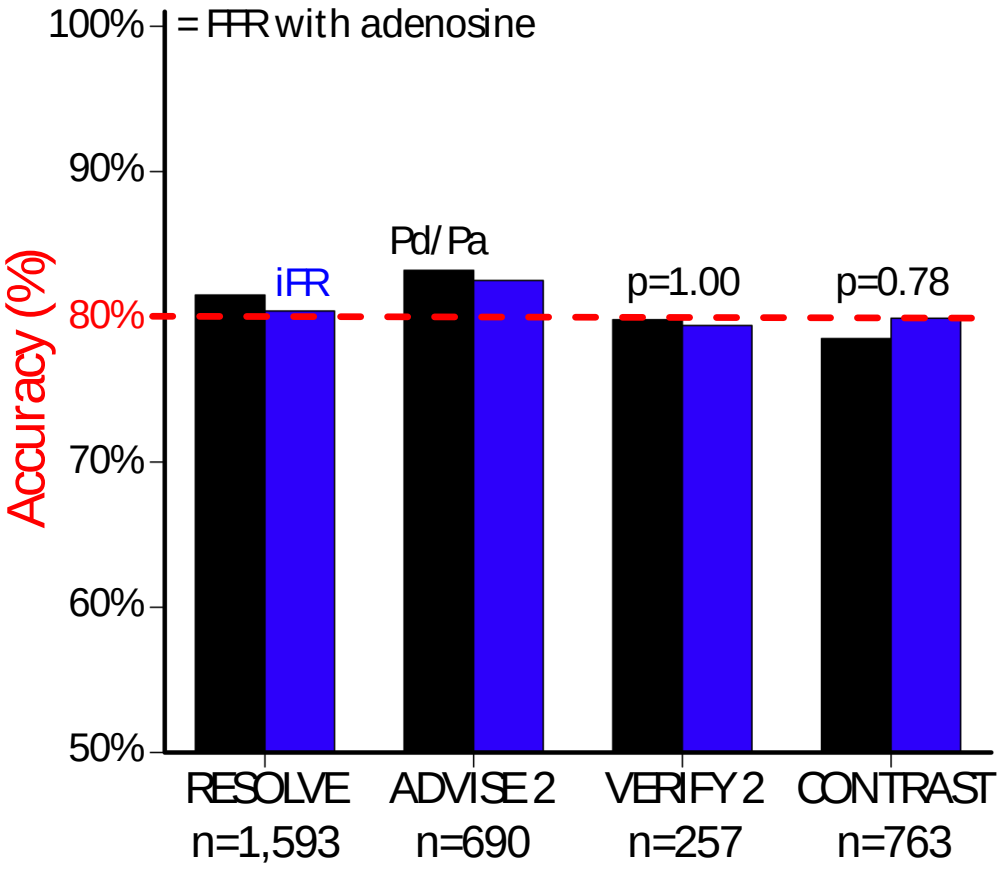
Johnson NP, JACC Cardiovasc Interv. 2016 Apr 25;9(8):757-67. Figure 2

Contrast FFR (cFFR): example

- Rest
  - Pd/Pa = 0.93 and 0.92
  - iFR = 0.91 and 0.91
- IC contrast
  - cFFR = 0.77 and 0.76
- IC adenosine
  - FFR = 0.69 and 0.69
- IV adenosine
  - FFR = 0.68 and 0.69
- Drift check
  - 1.01 at guide

Both Pd/Pa and iFR miss low FFR, but contrast FFR gets it right!

Resting physiology ≈ 80% accuracy

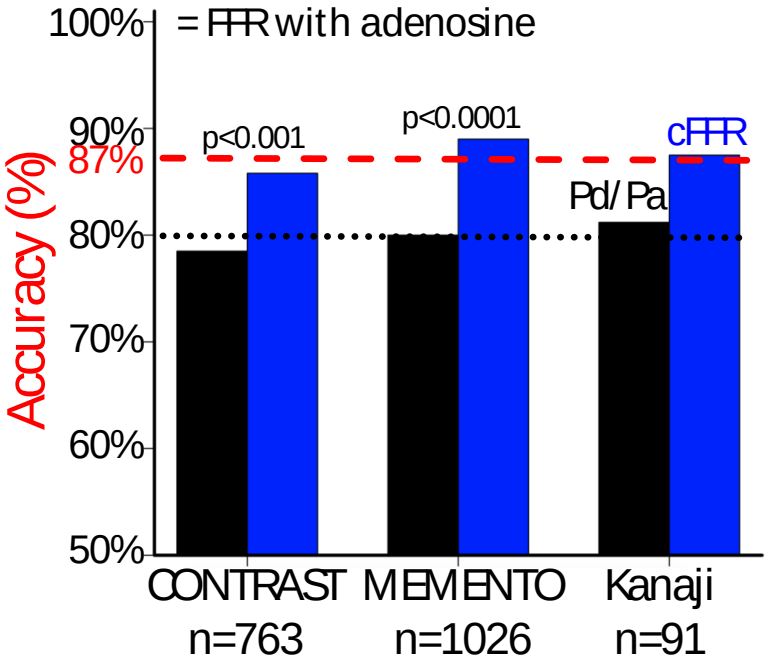


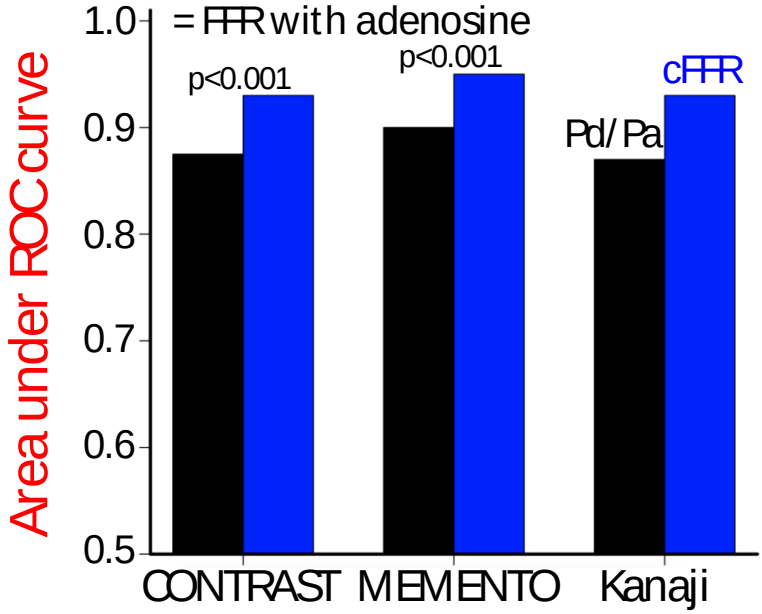
Key conclusions

- 80% accuracy
- Pd/Pa ≈ iFR
- 3,300+ lesions
- multiple studies
- Volcano iFR

RESOLVE = Jeremias A, JACC. 2014 Apr 8;63(13):1253-61
ADVISE 2 = Escaned J, JACC Cardiovasc Interv. 2015 May;8(6):824-33 and 834-6
VERIFY 2 = Hennigan B, Circ Cardiovasc Interv. In press
CONTRAST = Johnson NP, JACC Cardiovasc Interv. 2016 Apr 25;9(8):757-67

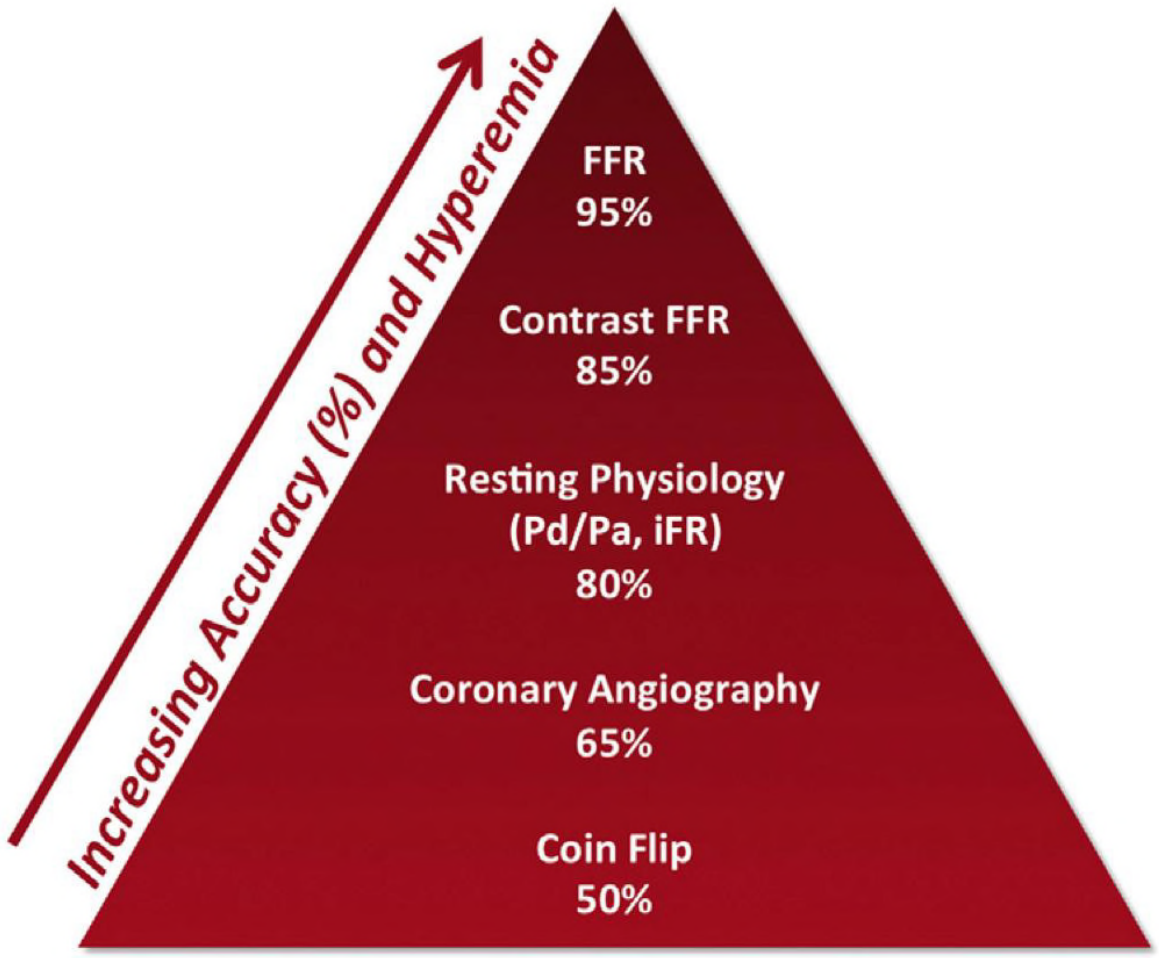
cFFR better than resting physiology





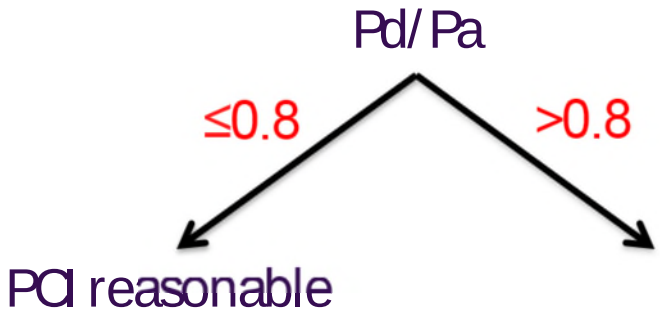
CONTRAST = Johnson NP, JACC Cardiovasc Interv. 2016 Apr 25;9(8):757-67.
MEMENTO = Leone AM, EuroIntervention. 2016 Aug 20;12(6):708-15.
Kanaji = Kanaji Y, Int J Cardiol. 2016 Jan 1;202:207-13.

Pyramid of diagnostic accuracy



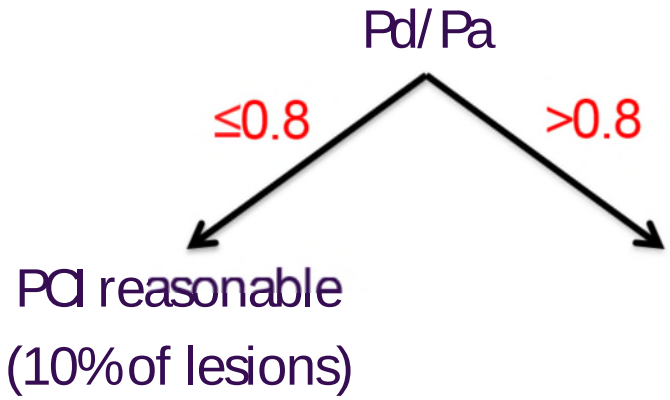
Johnson NP, JACC Cardiovasc Interv. 2016 Apr 25;9(8):757-67. Figure 1

Practical algorithm



Based on discussion with Keith Oldroyd, March 27, 2016.

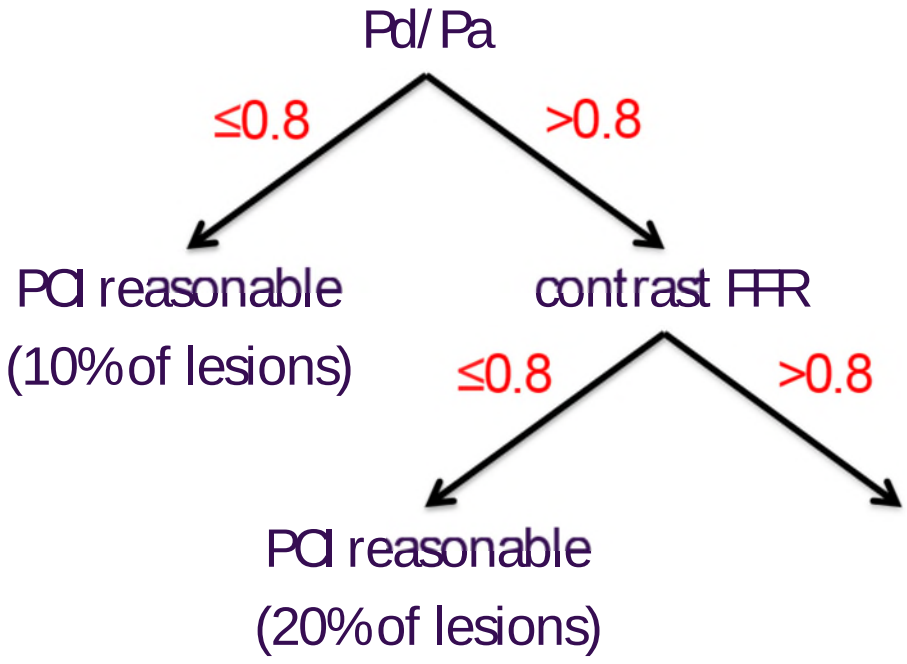
Practical algorithm



- less information about depth of ischemia!
- pullback less sensitive (smaller pressure jumps)

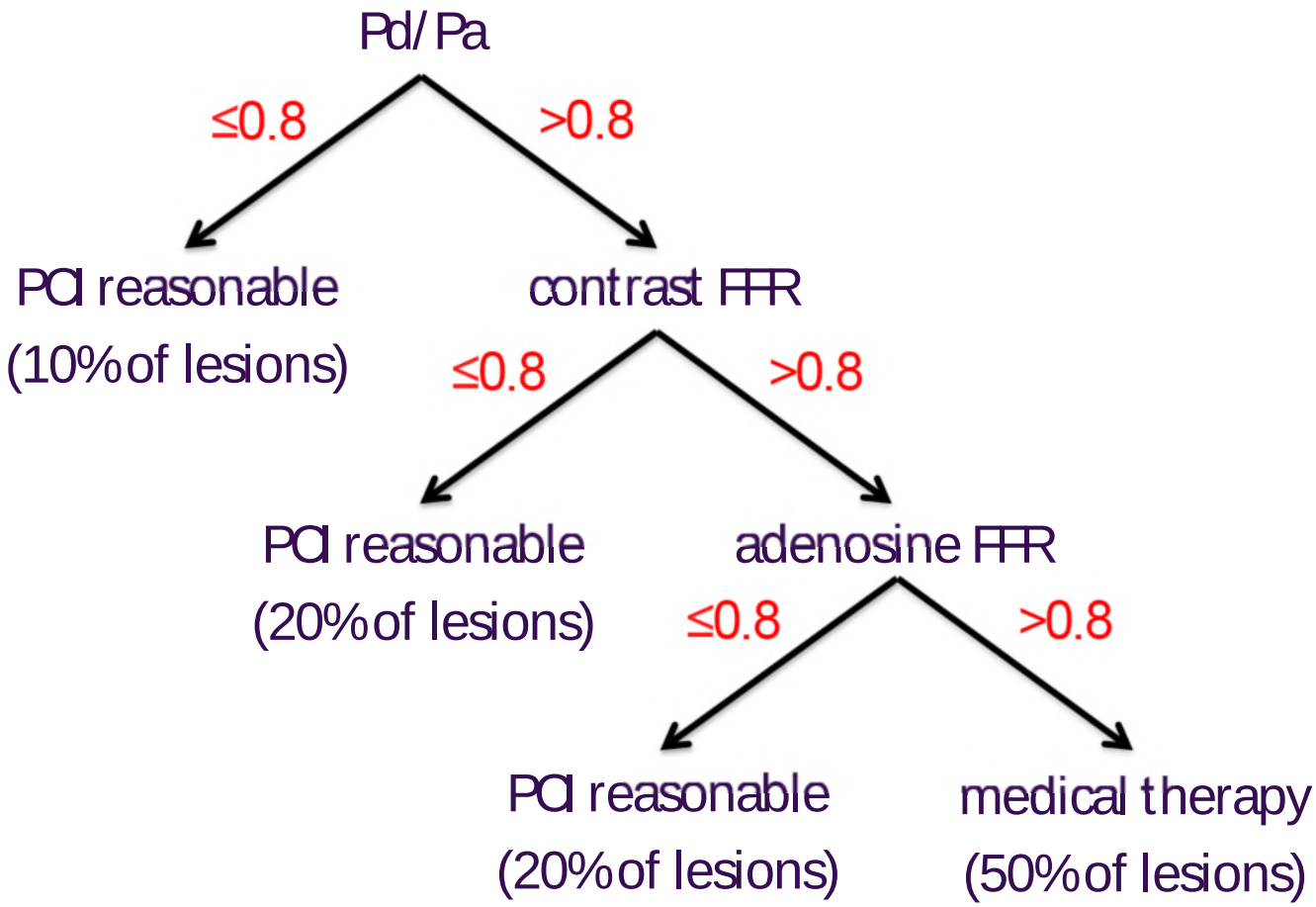
Approximate percentages from CONTRAST

Practical algorithm



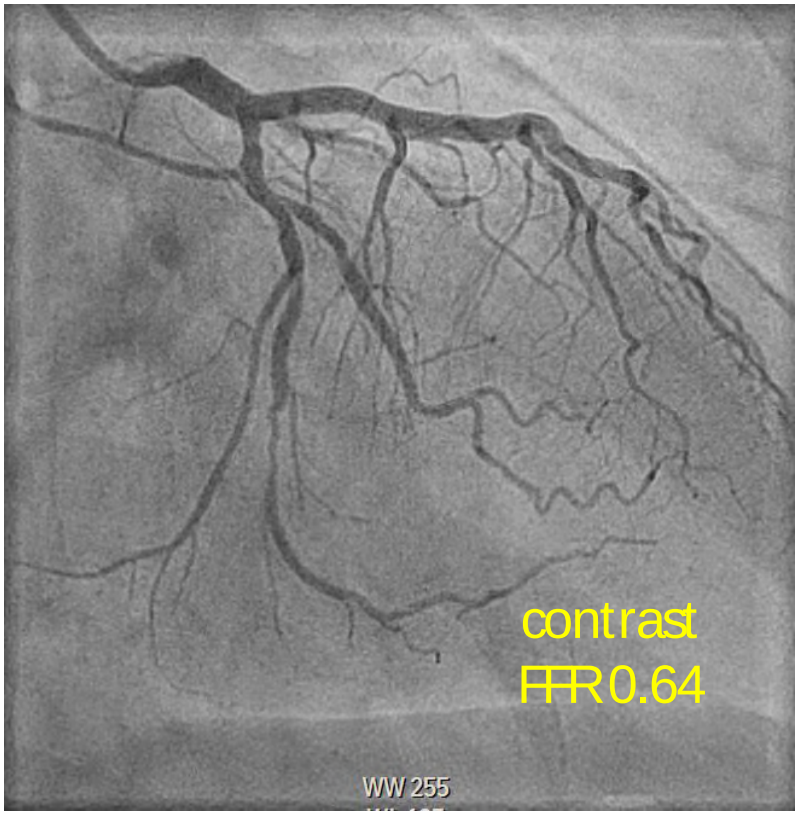
- maintains 100% accuracy
- reduces adenosine use by 30%

Practical algorithm

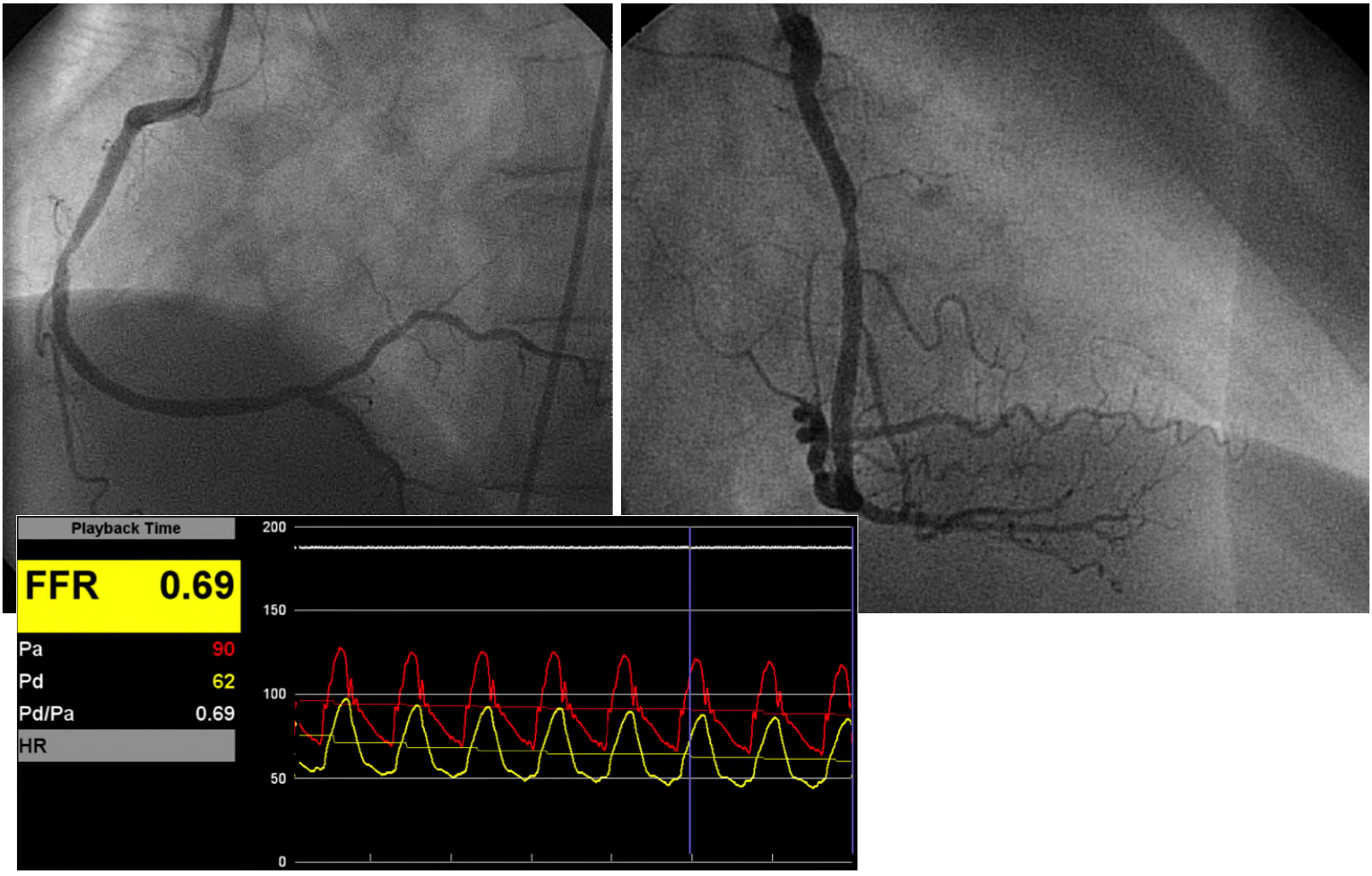


Scenario 4. Contrasting views

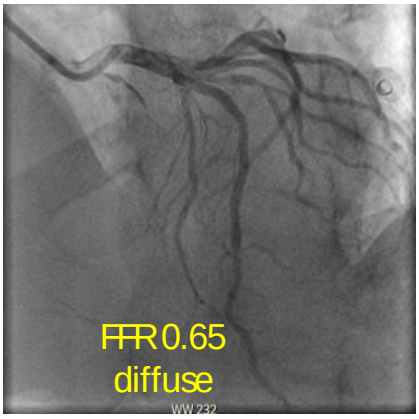
Brief contrast injection to position
Pd/Pa fell immediately to 0.64
No adenosine, proceeded with PCI



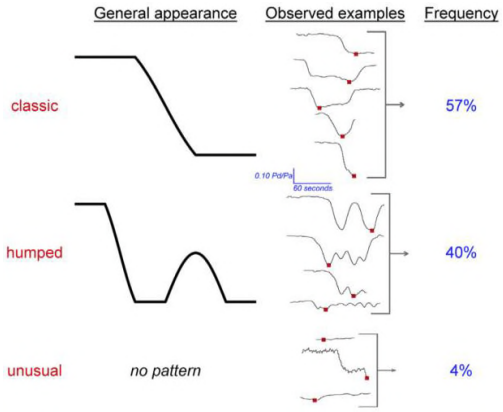
FFR 101: The simplest case



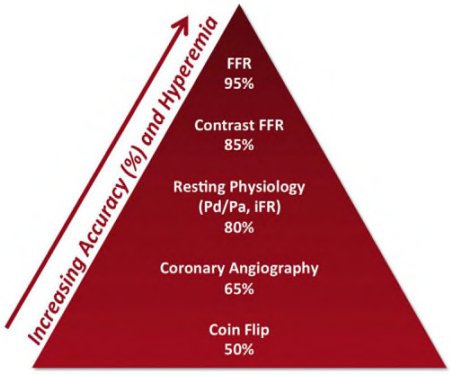
Expert FFR: caveats and shortcuts



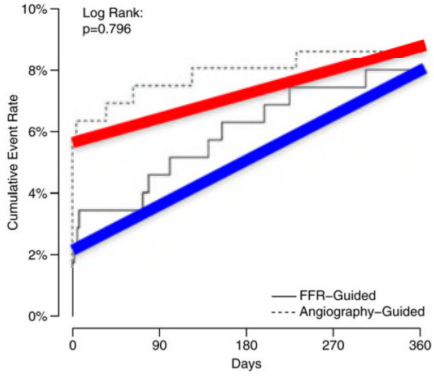
¯Dark matter_
(risk from diffuse disease)



¯Lowest bidder_
(choose FFR at nadir)



¯Contrasting views_
(contrast FFR to simplify)



¯Buyer beware_
(caution with FFR in culprits)