Fractional Flow Reserve

Essential diagnostic tool in the modern cath-lab

- Based on sound physiological principles
- Supported by a large body of clinical outcome data (hard clinical end-points)
- Avoids the limitations of coronary angiography
  - 2D luminogram
  - \( \approx 20\% \) visual error margin
  - Does not account for various pathophysiological factors
- Cost effective
Current Recommendations

ESC/EACTS GUIDELINES

Wijns W et al. EHJ 2010

Catheterization and Cardiovascular Interventions 00:00-00 (2013)

Original Studies


Fractional flow reserve (FFR). Definitely Beneficial. In SIHD, when noninvasive stress imaging is contraindicated, discordant, nondiagnostic, or unavailable, FFR should be used to assess the functional significance of intermediate coronary stenoses (50–70%) and more severe stenoses (<90%).
Landmark Studies

**DEFER**

- 1ry endpoint: freedom from MACE

**FAME**

- 1005 patients with MVD randomized to FFR-guided PCI or angiography-guided PCI
- 1ry endpoint: composite of Death, MI and repeat revascularization

*Pijls et al. JACC 2007*

*Tonino et al. NEJM 2009*
Landmark Studies

FAME 2

- 888 patients with SIHD and FFR < 0.8 randomized to PCI + OMT or OMT only
- 1ry endpoint: composite of Death, MI and urgent revascularization
- Registry: patients with FFR > 0.8 on OMT

De Bruyne et al. NEJM 2012

Principles & theoretical background

![Diagram showing pressure, flow, diameter, and mass relationships with microcirculatory resistance](image)
Maximal hyperemia
= minimal & steady microvascular resistance
= linear relationship between perfusion pressure and flow

\[ Q = \frac{P}{R} \]

\[ \frac{Q_s}{Q_n} = \frac{(P_d/R_s)}{(P_a/R_n)} \]

If \( R_s = R_n \), then
\[ \frac{Q_s}{Q_n} = \frac{P_d}{P_a} \]

*NHJ Pijls et al. Circulation 1993*
Definition

**FFR = 0.75 means:**
Due to this particular stenosis, the maximum achievable blood flow to the myocardium supplied by this artery is only 75% of what it would be if this artery were completely normal.

Strengths

- FFR has a normal value of “1.0” for every patient, for every vessel, and in every segment.
- FFR accounts for body size, coronary segment and myocardial territory supplied.
- Highly reproducible
- Not influenced by changes in contractility, loading conditions and/or heart rate
**Strengths**

- Accounts for myocardial mass supplied by vessel (perfusion area)
- Accounts for collateral flow
- Very high spatial resolution: ability to assess individual lesions within the same vessel (pullback) vs. diffuse disease

**Limitations**

- Acute myocardial infarction (culprit vessel)
- Severe LVH *(caution)*
- Severe hypotension *(outside autoregulatory range)*
- Dynamic obstruction: spasm and/or myocardial bridges *(caution)*
Step-by-step measurement

1. Flush the wire while it still is in its sleeve

2. Connect the pressure wire to the analyzer
3. Calibrate the pressure wire (with the wire still in its sleeve)
4. Insert wire in guiding catheter.

5. Equalize guiding (Pa) pressure and wire (Pd) pressure with the pressure sensor placed at the tip of the guiding catheter.

**Caution**: Do not change the height of the aortic transducer after pressure equalization

**Tip**: removing the guidewire introduced needle is preferable if IV adenosine infusion is planned and mandatory with IC adenosine

**Tip**: Ensure that the guiding is not deeply engaged with pressure damping
6. Advance pressure wire, place the sensor distal to the stenosis and give 200 mcg IC GTN

Induce Maximal Hyperemia

IV adenosine infusion (preferred method): 140 mcg/kg/min. NB. Central Vein preferred

Or

IC bolus: at least 180 mcg for left coronary system and 90 mcg for right system. N.B. ensure GC is properly engaged.

Caution:
- Do not use guiding catheter with side-holes
- With IC adenosine: ensure that guiding catheter is properly engaged
- With either method: ensure that guiding catheter does not become deeply engaged (sucked in)
**Effect of Deep Engagement**

\[
\frac{FFR}{87/96} = 90 \quad \text{FFR} = \frac{87}{106} = 82
\]

7. Repeat measurement. Further IC adenosine bolus is required if IC method is used. No need for extra GTN bolus.

*Tip: Checking maximal hyperemia*
8. Check for signal drift.

- True pressure gradient
- Signal drift

Special Situations

Aorto-ostial lesions
- IV adenosine infusion preferred
- Place guiding catheter in aortic root and check that pressure does not become dampened
- With IC adenosine: engage to deliver adenosine, disengage before measurement. Check Pa waveform
Special Situations

Tandem lesions vs. diffuse disease

Strategy: Stent the area with maximal pressure drop then remeasure

Pijls and Willens. JACC 2012
Special Situations

Others

• SVG grafts
  Not recommended: rate of progress unknown

• Bifurcations
  Valuable to detect a pinched SB with provisional stenting.

*Tip: 75/25 rule*¹

¹Koo et al. EHJ 2008
Special Situations

29 yr old male patient
FH and supravalvular AS

One final tip: *Grey zone*

- Vague symptoms, no other evidence of ischemia \(\rightarrow\) defer PCI
- Typical symptoms, non-invasive evidence of ischemia, diabetes \(\rightarrow\) Perform PCI
FFR and clinical outcomes

Ischemic lesion → intrinsic risk 5% per year
Non-ischemic lesion → intrinsic risk 1% per year
Stented stenosis → intrinsic risk 3% per year

Stenting Strategies

“Stent ’em all” → intrinsic risk 12% → 12%
“Stent only the ischemic ones” → intrinsic risk 12 → 8%
Both strategies eliminate ischemia → similar functional class

Pijls and Willens. JACC 2012
Take home message

• Always look for explanations to abnormal findings
• Look at both the pressure waveforms carefully. Do not rely on the figures solely.
• Sensitivity is > 90%: True false negatives are rare
• Specificity is 100%: True false positive are extremely rare

Take home message

• FFR is the current gold-standard for evaluating the physiological significance of epicardial coronary stenoses
• Intracoronary imaging is useful understanding the mechanism(s) of disease and in planning/optimizing PCI
• FFR tells you when to treat, IVUS and/or OCT tell you how to do so.
Case Reports

Coronary Pressure Never Lies

Jacques J. Koolen, MD, PhD and Nico H.J. Piljs, MD, PhD

Trust your measurements: Coronary Pressure Never Lies

Suggested reading

- Functional measurement of coronary stenosis. Piljs N et al. JACC 2012
- Practice and potential pitfalls of coronary pressure measurement. Piljs N, Kern M, Yock P and De Bruyne B. Cath and cardiovasc interv 2000
THANK YOU