Fractional Flow Reserve (FFR)

--Practical Set Up Pressure Measurement--

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Contents

• Concept of Fractional Flow Reserve (FFR)
• Understand FFR Threshold
• Clinical Applications of FFR
• Practical Set-Up Pressure Measurement
• Interpretation and Pitfall
Questions On-The-Treat Coronary Artery Stenosis

- Make sure this stenosis charge to ischemia?
- Absolutely I think so. I hope so… …
Why Do We Need Physiology?

• 2-D angiograms facts

In a study of patients with LMCA stenoses (n=51), 4 experienced cardiologists achieved correct lesion classification no more than 50% of the time using angio when comparing to FFR as the gold standard.

Lindstaedt et al, Int J Cardiol 2007; 120(21): 254-261
Importance of the Inducible Ischemia

- Studies such as Iskander et al. have shown that a person is significantly more likely to die or have a myocardial infarction (M.I.) if they have a lesion causing inducible ischemia compared to one that does not.

- Therefore it is essential to differentiate between both types of lesions.

Average Annual Hard Events
(Death or MI) in > 12000 Patients

Iskander S, Iskandrian A E  JACC 1998
What is Fractional Flow Reserve

FFR =

Max. myocardial blood flow
In the presence of a stenosis

Normal maximum blood flow

* Maximum blood flow achieved by inducing hyperemia in the patient *
Coronary Pressure Gradient

• Prerequisite
  – Epicardial coronary arteries keep minimal vascular resistance.

• Concept
  With epicardial coronary stenosis
  – Resting blood flow maintain even 80% stenosis
  – Hyperemic blood flow decrease just around 50%
Coronary Arterial System

>400μm
Conduit Vessels = Epicardial coronary arteries

<400μm
Resistive vessels = arterioles & capillaries
(Reactive) Hyperemia

• Concept
  – Minimize vascular resistance of the resistive vasculature

• Inducer
  – Ischemia: most potent
  – Adenosine, ATP, papaverine etc.
  – Increase 4-6 folds blood flow
Coronary Flow Reserve

Absolute vs Relative vs Fractional flow reserve

\[
\frac{QS_{\text{max}}}{QS_{\text{rest}}} \quad \frac{QS_{\text{max}}}{Qn'_{\text{max}}} \quad \frac{QS_{\text{max}}}{Qn_{\text{max}}}
\]

**A hyperemic agent is administered IV or IC to induce hyperemia in the patient**

Definition of FFR

\[ FFR_{myo} = \frac{P_d}{P_a} \]

\( P_a \) = mean aortic pressure at maximum hyperemia

\( P_d \) = mean distal coronary pressure at maximum hyperemia
Myocardial Blood Flow ≈ Perfusion Pressure

Maximum myocardial perfusion:

- 100% → 70% → 25%
- FFR: 1.0 → 0.7 → 0.25
FFR Threshold for Ischemia

FFR < 0.75 → inducible ischemia (specificity 100%)
FFR > 0.75 → no inducible ischemia (sensitivity 88%)

Pijls, De Bruyne et al, NEJM 1996
FFR Threshold for Ischemia

FFR for decision-making in the cath lab

- **1.0**
- **0.94**
- **0.90** — Interventional use
- **0.75** — Diagnostic use

**FFR<sub>myo</sub>**

Based on the teaching file of Paul G. Yock, MD, Stanford University.

**Note:** The specificity of this cut-off value is 100% and the sensitivity is 88%.

**References:**
- Pijls NHJ and De Bruyne B. 2000.

Courtesy of Paul Yock, M.D.
Unique Features of FFR (myo)

- Lesion specific index
- Independent HR, BP & contractility
- 1.0 normal value for every situation
- Clear cut-off value: 0.75 & 0.90
- Account the collateral flow to myocardial perfusion
- Easy apply: just measure mean Pa/Pd pressure
From Pressure Gradient Concept
To Fractional Flow Reserve Concept
And Beyond …
FFR Clinical Applications

- Single vessel intermediate lesions
- Serial lesions
- Multi-vessel disease
- Bifurcations and jailed side branches
- Left Main disease
- Secondary lesions
- In-stent restenosis
Actual Practice Measuring FFR
Preparation

- Patient
- Devices
- Physicians and Trained cath lab experts

→ Ready to FFR
Devices
Analyzing Software
DESCRIPTION

• Step-by-step startup guide
Procedure

• Step 1 Pressure wire and analyzer setting
Procedure

- Step 2 Pa/Pd pressure equalization
Procedure

- Step 3
  Wiring, check baseline pressure gradient and induce hyperemia
Inducing Hyperemia

- Hyperemic stimuli by adenosine

- Route:
  - IC bolus,
  - IV infusion,
  - IC infusion

- Dose:
  - IC bolus: RCA 24-40µg, LCA 40-80µg
  - IV infusion: 140µg/kg/min
  - IC infusion: 240µg/kg/min
Hyperemia
Procedure

• Step 4. check hyperemic FFR
Interpretation Pressure Graph
Procedure

- Step 5. check IVUS & perform PCI
  - as a primary GW for angioplasty
  - pressure wire provide additional hemodynamic informations
  - coronary wedge pressure, immediate post ballooning & stenting pressure gradient
Procedure

• Step 6
Post stent FFR
FFR Clinical Applications

- Single vessel intermediate lesions
- Serial lesions
- Multi-vessel disease
- Bifurcations and jailed side branches
- Left Main disease
- Secondary lesions
- In-stent restenosis
Serial Intermediate Stenosis
Bypass or PCI?
How many stents need to treat?

FFR 0.35  FFR 0.94  FFR 0.96
Pitfall and Troubleshooting

• Possible cause of underestimation severity
  – Sub-maximal hyperemia
  – Guiding catheter wedging
  – Other devices in the guiding catheter
  – Pressure signal reversion
  ➔ high FFR value

• Pressure signal drift
Pressure Signal Drift

- Procedure time after equalization
- Guiding cath damping

To avoid...

- Keep the eyes both pressure graph pattern
- Equal pressure should be re-confirmed.
Pressure Signal Drift

Drift: morphology of the pressure tracings is *identical*

Pressure Gradient: morphology of the pressure tracings is *different*
Presssure Signal Reversion

- Affected by lesion location: LCX & RCA
Possible Device Related Problems Compromising Pressure Measurement

- Guiding catheter
- Guidewire Introducer
- Balloon catheter
- Micro-catheter
- Guidewire

→ Acts like ostialstenosis
Guiding Catheter Trouble

- Side hole guiding catheter
- Inappropriate position or allignment
Learning Period and Safety

• Some learning period for everybodies
  – To manipulate pressure wire
  – To make reliable and reproducible hyperemia and pressure gradient
  – To know FFR result means

• Safe?
  – Transient AV block
  – Broncho-spasm

Experts say “Yes” & I think so.
Questions On-The-Treat Coronary Artery Stenosis

Answers are …

FFR 0.35  FFR 0.62  FFR 0.83  FFR 0.70
### 2009 AHA/ACC PCI Guidelines

**TABLE X. Recommendations for Use of Fractional Flow Reserve**

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<thead>
<tr>
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<td><strong>Class IIa</strong></td>
<td>1. Coronary pressure (fractional flow reserve [FFR]) or Doppler velocimetry can be useful to determine whether PCI of a specific coronary lesion is warranted. FFR or Doppler velocimetry can also be useful as an alternative to performing noninvasive functional testing (e.g., when the functional study is absent or ambiguous) to determine whether an intervention is warranted. It is reasonable to use intracoronary physiological measurements (coronary pressure [FFR] $^{30,126-137}$ [Level of Evidence: A] or Doppler velocimetry [Level of Evidence: C]) in the assessment of the effects of intermediate coronary stenoses (30% to 70% luminal narrowing) in patients with anginal symptoms.</td>
<td>Modified recommendation (level of evidence changed from B to A for FFR; C for Doppler).</td>
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*Level of Evidence: B*
Summary

• Fractional Flow Reserve (FFR) is
  – Lesion specific index
  – Independent HR, BP & contractility
  – 1.0 normal value for every situation
  – Clear cut-off value: 0.75 & 0.90
  – Account the collateral flow to myocardial perfusion
  – Easy apply: just measure mean Pa/Pd pressure

• PCI Under Pressure Measurement is one of the reliable and helpful technique make-up anatomical only decision making.

• Knowing setting up process and possible pitfalls is crucial and keep in your mind and eyes to get reproducible and correct FFR results.
Thank you for your attention!