Fractional Flow Reserve: 
*When, Why, and How*

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Disclosure Statement of Financial Interest

Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below:

<table>
<thead>
<tr>
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<th>Company</th>
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<tbody>
<tr>
<td>Grant/Research Support:</td>
<td>NIH R01 HL093475 (PI)</td>
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<td>Major Stock Shareholder/Equity Interest:</td>
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<td>Royalty Income:</td>
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<td>Ownership/Founder:</td>
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<td>Salary:</td>
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<td>Intellectual Property Rights:</td>
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<td>Other Financial Benefit:</td>
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How to Measure FFR
Incorporating Physiology

• Educating your assistants
  – Limitations of angiography
  – Benefits of physiology
  – Measure FFR in 10 consecutive cases
  – Obey FFR result

• Streamlining set-up
  – Identify point person
  – Post medication mixing and dosing instructions
  – Keep analyzer connected at all times
Incorporating Physiology
Performing FFR

1. IC NTG and IV heparin/bivalirudin
2. Equalize Pressures
Potential Pitfalls

Consider disconnecting the wire from the interface connector.

Can use exchange catheter to more safely position pressure wire.

Wiring the Lesion

Distal end of wire

Interface connector

Stanford
Potential Pitfalls

Recognizing Drift

Adapted from Pijls et al. Cathet Cardiovasc Intervent 2000;49:1-16
Inadequate Hyperemia

IC vs. IV Adenosine

Inadequate Hyperemia

FFR measured in 50 patients with intermediate lesions

Potential Pitfalls

• Inadequate hyperemia
  – Intracoronary adenosine
    • Short-lasting peak effect (~5 seconds)
    • Don’t use a guiding catheter with sideholes
    • If one suspects inadequate hyperemia, then increase dose or use intravenous adenosine
Potential Pitfalls

• Inadequate hyperemia
  – Intravenous adenosine
    • Should be administered via central vein
    • May require higher doses (>140 ug/kg/min) if given peripherally
    • If the patient doesn’t develop symptoms and/or hemodynamic changes, the patient is likely not receiving IV adenosine
Performing FFR

Pressure Pullback

Focal LAD Lesion

Proximal Edge of LAD lesion

Distal LAD

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Performing FFR

Pullback in Moderately and Diffusely Diseased LAD
Catheter Issues
Catheter Issues

FFR of the LAD...
Is this correct?
Catheter Issues

Unseating of Guide Catheter Reveals True FFR

![Graph showing FFR values with annotations for Pa mean, Pd mean, and FFR 35.0 Cursor.]
Impact of Catheter Size on Hyperemic Flow

When and Why to Measure FFR
FFR vs. Angiography for Multivessel Evaluation (FAME Study)

≥2 Vessels which Require Stenting

Randomized

FFR-guided PCI

Angiography-guided PCI

Primary Endpoint:
MACE at 1 Year

## Procedural Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Angio-Guided (n = 496)</th>
<th>FFR-Guided (n = 509)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicated lesions / patient</td>
<td>2.7 ± 0.9</td>
<td>2.8 ± 1.0</td>
<td>0.34</td>
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<td>Stents / patient</td>
<td>2.7 ± 1.2</td>
<td>1.9 ± 1.3</td>
<td>&lt;0.001</td>
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<td>&lt;0.001</td>
</tr>
<tr>
<td>Procedure time (min)</td>
<td>70 ± 44</td>
<td>71 ± 43</td>
<td>0.51</td>
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<tr>
<td>Contrast agent used (ml)</td>
<td>302 ± 127</td>
<td>272 ± 133</td>
<td>&lt;0.001</td>
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<tr>
<td>Equipment cost (US $)</td>
<td>6007</td>
<td>5332</td>
<td>&lt;0.001</td>
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<tr>
<td>Length of hospital stay (days)</td>
<td>3.7 ± 3.5</td>
<td>3.4 ± 3.3</td>
<td>0.05</td>
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## Adverse Events at 1 Year

<table>
<thead>
<tr>
<th>Event</th>
<th>Angio-Guided n = 496</th>
<th>FFR-Guided n = 509</th>
<th>P Value</th>
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<tbody>
<tr>
<td>Total no. of MACE</td>
<td>113</td>
<td>76</td>
<td></td>
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<tr>
<td>Death</td>
<td>15 (3.0)</td>
<td>9 (1.8)</td>
<td>0.19</td>
</tr>
<tr>
<td>Myocardial Infarction</td>
<td>43 (8.7)</td>
<td>29 (5.7)</td>
<td>0.07</td>
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<tr>
<td>Small / peri-PCI (CK-MB 3-5xNI)</td>
<td>16</td>
<td>12</td>
<td></td>
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<tr>
<td>Other infarctions (“late or large”)</td>
<td>27</td>
<td>17</td>
<td></td>
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<tr>
<td>CABG or repeat PCI</td>
<td>47 (9.5)</td>
<td>33 (6.5)</td>
<td>0.08</td>
</tr>
<tr>
<td>Death or Myocardial Infarction</td>
<td>55 (11.1)</td>
<td>37 (7.3)</td>
<td>0.04</td>
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<tr>
<td>Death, MI, CABG, or re-PCI</td>
<td>91 (18.3)</td>
<td>67 (13.2)</td>
<td>0.02</td>
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1 Year Economic Evaluation

Bootstrap Simulation

1 Year Costs

Angio ~ $14,000 / patient
FFR ~ $12,000 / patient

AHA 2009
## Adverse Events at 2 Years

<table>
<thead>
<tr>
<th></th>
<th>Angio-Guided n = 496</th>
<th>FFR-Guided n = 509</th>
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<tbody>
<tr>
<td>Total no. of MACE</td>
<td>139</td>
<td>105</td>
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<td><strong>Individual Endpoints</strong></td>
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<tr>
<td>Death</td>
<td>19 (3.8)</td>
<td>13 (2.6)</td>
<td>0.25</td>
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<tr>
<td>Myocardial Infarction</td>
<td>48 (9.7)</td>
<td>31 (6.1)</td>
<td>0.03</td>
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<tr>
<td>CABG or repeat PCI</td>
<td>61 (12.3)</td>
<td>53 (10.4)</td>
<td>0.35</td>
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<td><strong>Composite Endpoints</strong></td>
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<tr>
<td>Death or Myocardial Infarction</td>
<td>63 (12.7)</td>
<td>43 (8.4)</td>
<td>0.03</td>
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<tr>
<td>Death, MI, CABG, or re-PCI</td>
<td>110 (22.2)</td>
<td>90 (17.7)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Late Breaking Trial, TCT 2009
2 Year Outcome of Deferred Lesions

513 Deferred Lesions in 509 FFR-Guided Patients

2 Years

31 Myocardial Infarctions

9 Late Myocardial Infarctions

1 Myocardial Infarction due to an Originally Deferred Lesion

22 Peri-procedural

8 Due to a New Lesion or Stent-Related

Only 1/513 or 0.2% of deferred lesions resulted in a late myocardial infarction
Patients with angiographically 3VD (N=115), proportions per number of diseased vessels after assessment by FFR

Angiographic 3 Vessel Disease

Tonino et al., JACC 2010 (in press)
Which Lesions Need FFR?

1329 lesions in the FFR-guided arm

Stenosis classification by angiography

Need FFR

Tonino et al., JACC 2010 (in press)