FRACTIONAL FLOW RESERVE USE IN THE CATH LAB

BECAUSE ANGIOGRAPHY ALONE IS NOT ENOUGH!!!!!!!!!

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Implementing FFR

- Interventional cardiologist’s job is to diagnose and treat ischemic stenoses in major epicardial vessels.
- It is often difficult to tell the physiologic severity of a stenosis on an angiogram.
- We should be treating only the significant stenoses with PCI.
- Stenting a stenosis that is non-ischemic does not help a patient.
- We do not “cure” CAD, but we hope that we alter the slope of our patients decline in a positive way.
Why learn to measure FFR?

- “Stress test” in the Cath Lab that tells you the physiologic significance of a coronary stenosis quickly and accurately.
- Significant % of stenoses of intermediate severity.
- You can diagnose significant lesions that don’t look severe angiographically.
- You can avoid getting yourself into PCIs you wish you hadn’t started.
- You can evaluate your result after stenting.
- Pre and Post FFR can be measured with the wire used to deliver the stent.
Three subsets of patients where having FFR capability changes things

- Borderline/moderate stenoses, especially in the proximal LAD
- Diffusely diseased arteries
- Multi-vessel disease

It’s difficult to do these kinds of cases confidently without FFR
Lesions causing ischaemia are prognostically important.....
There is no benefit to treating lesions without ischaemia
Risk assessment using single-photon emission computed tomographic technetium-99m sestamibi imaging
Sherif Iskander, and Ami E. Iskandrian
*J. Am. Coll. Cardiol.* 1998;32;57-62

"In patients with a similar degree of anatomic disease the most important predictor of outcome is the presence and extent of inducible ischaemia"

The risk for death or MI in the next 5 years is thus 20 times higher for an ischaemic lesion compared to a non-ischaemic one

Figure 1. Rate of hard cardiac events (death or nonfatal MI) in patients with normal and abnormal stress SPECT images.

12000 patients with similar coronary stenosis severity at angio

24-Sep-11
Fundamental Truth #2:
*If ischaemia, rather than anatomy, is what you are interested in then:*

- **Current Non Invasive Tests Have Disadvantages**
Proportion of Patients with Adequate Exercise ECG (n=1814)

- Adequate (635) 35%
- Unable to exercise (374) 21%
- Uninterpretable (433) 24%
- Submaximal (372) 21%

Thomas H. Marwick et al. 1994
We need a test that will direct us to what needs revasc and what doesn’t.

We need a definitive test for ischaemia at the time of angiography to make a diagnosis.

We need a test that will tell us when we have succeeded.
Incorporating Physiology
What is Maximal Hyperemia?

Maximal Hyperemia

Means

Maximal Vasodilation

or

Maximal Possible Blood-Flow to the Myocardium
Flow-PRESSURE RELATIONSHIP

- We are measuring coronary pressure to measure coronary flow.
- It is at the point of maximal hyperemia that FFR is proportional to blood flow.
- At this point further blood flow is impossible, thus 100% flow = FFR 1.0.
With a stenosis, maximal blood flow is lower despite maximal stimulation of the microvasculature - in this case only reaching 70% compared to normal.

The corresponding Pd/Pa pressure will therefore be proportional to the flow at this new point.

70% blood flow is proportional to FFR=0.70.
Pharmacologic Hyperemic Stimuli

*Intravenous Adenosine Infusion*

- Current gold standard for FFR measurement
- Hyperemia mediated via A2 receptor on cell membrane on resistance vessels
- Exogenously administered adenosine causes profound microvascular dilation
- Hyperemia is independent of metabolic demand
- Produces “steady-state” hyperemia
Intravenous Adenosine

* **Dose:** 140 mcg/Kg/min

<table>
<thead>
<tr>
<th>Effects</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Effect</td>
<td>&lt;2 min</td>
</tr>
<tr>
<td>Duration of Effect</td>
<td>Within 2 min after D/C</td>
</tr>
<tr>
<td>Side Effects</td>
<td>Rare</td>
</tr>
<tr>
<td>AV Block</td>
<td>Bronchospasm</td>
</tr>
<tr>
<td>Do NOT use in pts. with Asthma/COPD</td>
<td>Usually 10-20%</td>
</tr>
<tr>
<td>↓BP and ↑HR</td>
<td>Harmless, not ischemia, resolves within few min.</td>
</tr>
<tr>
<td>Burning sensation in chest</td>
<td></td>
</tr>
</tbody>
</table>
## Intravenous Adenosine

**Give IC NTG prior to Measurement**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steady State Hyperemia</td>
<td>Infusion in Femoral Vein</td>
</tr>
<tr>
<td>Measurement of CFR possible</td>
<td>Large cubital vein alternative</td>
</tr>
<tr>
<td></td>
<td>Inadequate infusion leads to suboptimal hyperemia</td>
</tr>
</tbody>
</table>

### Advantages:
- Steady State Hyperemia
- Measurement of CFR possible

### Limitations:
- Infusion in Femoral Vein
- Large cubital vein alternative
- Inadequate infusion leads to suboptimal hyperemia

### Setup:
- High-Volume Infusion Pump Required
- Setup cumbersome and time consuming

### Routine Use Improves Efficiency
<table>
<thead>
<tr>
<th><strong>Effects</strong></th>
<th><strong>Side Effects/Precautions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Effect</td>
<td>10 sec</td>
</tr>
<tr>
<td>Duration of Effect</td>
<td>20 sec</td>
</tr>
<tr>
<td><strong>Side Effects/Precautions</strong></td>
<td>Common; Transient</td>
</tr>
<tr>
<td>AV Block</td>
<td>Inadequate Drug Delivery</td>
</tr>
<tr>
<td>Do NOT use Guide with SH</td>
<td>Pa underestimated, FFR</td>
</tr>
<tr>
<td>Do NOT use Guide when Pressure Damped</td>
<td>↓</td>
</tr>
<tr>
<td>Interruption of Pa as short as possible</td>
<td>If too long, peak hyperemia may be missed</td>
</tr>
</tbody>
</table>
### Intracoronary Adenosine

**Give IC NTG prior to Measurement**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy Administration</td>
<td>No IV Setup Required</td>
</tr>
<tr>
<td>Rapid Testing</td>
<td>No Central Vein Access</td>
</tr>
<tr>
<td>Pull-Back Curve not Possible</td>
<td>No Wait for Max. Hyperemia</td>
</tr>
<tr>
<td>Measurement of CFR not</td>
<td>Hyperemia too Transient</td>
</tr>
<tr>
<td>Possible</td>
<td>Hyperemia too Transient</td>
</tr>
<tr>
<td>Dose Escalation Frequently</td>
<td>Sub-Maximal Hyperemia at Lower Doses</td>
</tr>
<tr>
<td>Necessary</td>
<td></td>
</tr>
</tbody>
</table>
Lesions warranting PCI identified

Randomized

PCI performed on indicated lesions only if FFR <0.80

Composite of death, MI and repeat revasc. (MACE) at 1 year

Key Secondary Endpoints

Individual rates of death, MI, and repeat revasc., MACE, and functional status at 2 years

FFR-Guided

Angio-Guided
2 Year Survival Free of Death/MI

Data presented at TCT Late Breaking Trial Session September 23, 2009

* By chi-square testing
FFR-guidance in multivessel disease PCI

Some criticism….

I do not stent lesions unless they are at least 70%, what about that?

Or…

Do we really have to measure FFR in all these lesions?
Lesions warranting PCI identified

PCI performed on indicated lesions only if FFR < 0.80

Randomized

FFR-Guided

Angio-Guided

• Before randomization the operator indicated all stenoses ≥ 50% requiring stenting and classified them into: 50-70%, 71-90% and 91-99%

• In the FFR-group all indicated lesions were measured by FFR (N=1329)
FFR versus angiography
routine stenting of stenoses of 50-70%, based on the angiogram, means unnecessary stenting in 65% of such stenoses.
not stenting 50-70% lesions routinely, leaves 35% of ischemic stenoses untreated

Submitted data
In stenoses between 71 and 90% narrowed, the percentage of unnecessary stent placement, is 20%.
Almost all stenoses >90% narrowed are significant by FFR.

Submitted data

Stenosis classification by angiography
Angiography versus FFR

• In patients with multivessel CAD, whether or not taking into account clinical data one cannot rely on the angiogram to identify ischemia-producing lesions when assessing stenoses between 50 and 90%

• In this setting, routine stenting without FFR guidance is justified only for stenoses >90%, because almost all of these lesions are functionally significant
Anatomic vs. Functional CAD

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 (submitted)
Let’s go to a case example, a ‘FAME-like’ patient

A rather common patient in our cath lab today…….

- male born 1952
- Smoker
- Admitted with USA
- Referred for Cath
Clinical dilemma: what should we do?

MVS vs. CABG

70% stenosis prox LAD
70% stenosis ostium OMCX
50-70% stenosis PLRCA
80% + 2x 50% stenosis in RPDA
Pressure wire in LAD
FFR LAD (i.v. adenosine)

resting

hyperemia
Pressure wire in OMCX
rest  adenosine  pull-back

FFR measurement in OMCX
Pressure wire in PL-RCA
FFR measurement in PL-RCA

resting  hyperemia
Pressure wire in RPDA
resting hyperemia
FFR in PCI: deferring therapy

Cardiac Death and Acute MI after 5 Years

P = 0.002
P = 0.003
P = 0.21

3.3 7.9 15.7

DEFER  PERFORM  REFERENCE
FFR ≥ 0.75  FFR < 0.75

JACC 2007;49:2105-2111
Potential Pitfalls

Wiring the Lesion

Consider disconnecting the wire from the interface connector

Can use exchange catheter to more safely position pressure wire

Distal end of wire

Interface connector
Potential Pitfalls

Recognizing Drift

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

10. 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
Catheter Issues

FFR of the LAD... Is this correct?
Impact of Catheter Size on Hyperemic Flow

Catheter Issues

Unseating of Guide Catheter Reveals True FFR
Conclusion – The Clinical Value of the Concept

✓ FFR measurement has expanded our ability to deliver ischaemia-driven therapy
✓ FFR allows us to tell which lesions are significant & just as importantly which aren’t!!
✓ FFR allows us to check that we have stented successfully

What effect would a routine pressure wire-directed approach pre- and post-stenting have had on the outcome of:

ARTS?
SYNTAX?
COURAGE?
THANK YOU