Evaluation of Intermediate Coronary lesions:

Can You Handle the Pressure?

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Disclosures

- Consultant-
- St Jude Medical
- Boston Scientific

- Speaker-
- Volcano Corporation
Heart Disease

- 2011- Number one cause of death in the United States
- Cancer is only 20,000 patients behind
- Of those that die- 50% are due to coronary heart disease
- Unpredictable
- Traditional risk factors only get you so far
**Presentation**

**In the ER**
- Chest pain
- Unstable Angina
- NSTEMI
- STEMI

**Work Up**
- ETT/ESE
- Nuclear
- CT Scan
- Angiogram
Angiogram

- Historically the gold Standard to assess coronary lesions
- Easy if you find a clear cut lesion
- What if you don’t?
- Do you have a stress test to rely on?
- How did this patient really present?
- Did you have time to talk with them?
Angiography

- Clear intrinsic limitations
- 2-D image of a 3-D structure
- Foreshortening and overlap
Figure 1  Why Does the Angiogram Fail to Predict Physiology?

The angiogram is a 2-dimensional image of 3-dimensional structures. Most intermediate lesions are oval shaped with 2 diameters, 1 narrow and 1 wide dimension. The angiogram of an eccentric lesion cannot reliably indicate flow adequacy. Other lesions (lower right) may appear hazy but widely patent, only to be responsible for angina due to plaque rupture, as demonstrated by intravascular ultrasound cross-section (far right corner). Figure illustration by Rob Flewell.
"I am better than that"

-Lindstaedt et al
IJC 2007

- 51 patients with intermediate lesions
- 40-80%
- 4 Experienced interventional cardiologists
- Is the lesion significant or not?

FFR values of 0.75 and 0.80

- The right answer was reached in no more than 50% of the cases for EACH of the physicians
Coronary revascularization is appropriate when the expected benefits, in terms of survival or health outcomes (symptoms, functional status, and/or quality of life) exceed the expected negative consequences of the procedure.

- 17 member panel
- 59 scenarios are scored
Ratings

• Scoring system 1-3, 4-6, 7-9
• Divided- ACS, Stable CAD with or without prior CABG
• If you have an intermediate lesion- further assessment might be necessary before an intervention is undertaken
• Physiologic or anatomic evaluation
Your Patient
Guidelines for Intermediate Lesions

• 4.4.1. Fractional Flow Reserve
  Class Ila
• 1. Fractional flow reserve is reasonable to assess angiographic intermediate coronary lesions (50% to 70% diameter stenosis) and can be useful for guiding revascularization decisions...(Level of Evidence: A)
• Base your decision on solid data
What is FFR?

Fractional Flow Reserve (FFR) is a lesion specific, physiological index determining the hemodynamic severity of intracoronary lesions.

FFR can accurately identify lesions responsible for ischemia which in many cases would have been undetected or not correctly assessed by angiography or IVUS.

FFR can only be measured at maximum hyperemia.
When no epicardial stenosis is present (blue lines), the driving pressure $P_a$ determines a normal (100%) maximal myocardial blood flow. In the case of stenosis responsible for a hyperemic pressure gradient of 30 mm Hg (red lines), the driving pressure will no longer be 100 mm Hg but instead will be 70 mm Hg ($P_d$). Because the relationship between driving pressure and myocardial blood flow is linear during maximal hyperemia, myocardial blood flow will only reach 70% of its normal value. This numerical example shows how a ratio of 2 pressures ($P_d/P_a$) corresponds to a ratio of 2 flows ($Q_s^{max}/Q_N^{max}$). It also illustrates how important it is to induce maximal hyperemia. $P_v$ = central venous pressure.
What is FFR?

The distal pressure in the coronary artery is measured by a tiny sensor located 3 cm from the tip of an 0.014” guidewire, called PressureWire®.
**Figure 2  Maximum Hyperemia Induced by Intravenous Adenosine**

Typical example of simultaneous aortic pressure ($P_a$) and distal coronary pressure ($P_d$) recordings at rest and during maximal steady-state hyperemia as induced by an intravenous (i.v.) infusion of adenosine. Fractional flow reserve (FFR) is simply calculated as the ratio of $P_d$ and $P_a$ during steady-state maximum hyperemia.
How accurate is it?

FFR < 0.75: Sensitivity = 88%
Specificity = 100%

Fractional Flow Reserve

Exercise Test
Thallium Scan
Stress Echo

○ Negative
● Positive

FFR has been validated against a “gold standard” of reversible ischemia, composed of all non-invasive tests.
FFR
- independent of size of perfusion area

Large perfusion area

FFR = 0.60

Small perfusion area

FFR = 0.85
FFR
- independent of size of perfusion area
FFR
- independent of contribution of collaterals

Poorly developed collaterals

\[ \text{FFR} = 0.70 \]
FFR
independent of contribution of collaterals

Well developed collaterals

$F_{FR} = 0.85$
Serial stenoses

By performing a pullback over the stenoses the "culprit lesion" can be identified.
Side branch lesions

Measurement of FFR in side branch lesions suggests that most of these lesions do NOT have functional significance, despite morphologic appearance.

Angiography vs FFR for Side Branches

TABLE 2  Ostial Lesions: Angiography Versus Fractional Flow Reserve

<table>
<thead>
<tr>
<th>FFR</th>
<th>( \geq 70% ) Angiographic Stenosis</th>
<th>50%–70% Angiographic Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \geq 0.75 )</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>&lt;0.75</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Sensitivity 100\%, specificity 55\%, and test accuracy 60\%.

Ziaee et al. Am J Cardiol 2004;93:1404-1407
The risk of “non-significant” stenoses causing death or AMI is < 1 % per year

Pijls et al, J Am Coll Cardiol 2007;49:2105–11
Anatomy

- “It looks hazy”
- “It looks fuzzy”
- “I don’t see anything on the angiogram to explain the patients symptoms”
Intravascular Imaging

- Intravascular Ultrasound
- Ultrasound - 100-150 um resolution
- OCT - near infrared light that allows you to visualize what is going on inside the vessel
- 10x the resolution of IVUS
High frequency sound waves are sent from a transducer, echo off vessel walls and are sent back to system.

System electronics process the signal.

Results from case studies shown in this slide presentation are not predictive of results in other cases. Results in other cases may vary.
Volcano
• Abizaid et al – Circulation 1999
• 300 patients with intermediate lesions
• No PCI if the MLA > 4mm² or the MLD > 2 mm
• No angiographic element was significant
• In 248 lesions with a minimum lumen area ≥ 4.0 mm², the event rate was only 4.4 %
Figure 5. A screen shot from the ILUMIEN system. The system allows physicians to move between FFR and OCT modalities with one touch. (Photo courtesy St. Jude Medical.)
Intravascular OCT

- Flexible fiberoptic catheter used for light delivery
- Catheter rotates to create image frames
- Catheter pulls back to map vessel segment
- Lesion analysis, stent planning, post-stent assessment, follow-up
Pre-Intervention Use of OCT

- OCT is accurate in visualizing all three arterial layers
- You can determine plaque morphology
- Lumen dimensions
- Fibrous cap thickness
- IVUS will overestimate the vessel size by 20% or so in small vessels
- 61 intermediate stenosis were assessed by FFR
- FFR less than 0.80 was considered significant
- OCT vs IVUS on these vessels for anatomic assessment
- In vessels less than 3 mm in diameter OCT was superior to IVUS in identifying functionally significant lesions
- MLA for IVUS was $2.36 \text{ mm}^2$/OCT $1.95 \text{ mm}^2$
- MLD for IVUS was $1.59 \text{ mm}$/OCT $1.34 \text{ mm}$
Summary

• Don’t believe you can accurately assess intermediate coronary lesions without help
• FFR is the standard of care
• < 0.80 and intervention is needed
• IVUS and OCT can be used to assess lesions
• IVUS- MLD < 2mm and MLA< 4 mm²
Thank You