FFR-Guided Stenting for Diffuse Coronary Lesions

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Diffuse Coronary Lesion

- More diabetic
- Low ejection fraction
- Older
- Small vessel involvement
- Multivessel disease
- Bifurcation involvement
Case 1: Recent Chest Pain

- F / 80
- Chest pain and dyspnea for 1 month
- Multiple stenosis including LM by coronary CT in another hospital
- Normal EKG
- Normal echocardiography with 65% of LV EF
- Good exercise performance before symptom
- No coronary risk factor
Coronary Angiogram
Coronary Angiogram
How to do?

- Medical vs. revascularization
- PCI vs. CABG
- Techniques of PCI
  - Ad hoc vs. staged procedure
  - Angiography-guided vs. function-guided
  - FFR vs. SPECT vs. other perfusion studies
## ESC 2011 Update

### Indications of Revascularization

<table>
<thead>
<tr>
<th>Subset of CAD by anatomy</th>
<th>Class</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For prognosis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left main &gt;50% *</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td>Any proximal LAD &gt;50% *</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td>2VD or 3VD with impaired LV function *</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>Proven large area of ischemia (&gt; 10%LV)</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>Single remaining patent vessel &gt;50% stenosis *</td>
<td>I</td>
<td>C</td>
</tr>
<tr>
<td>1VD without proximal LAD and without &gt;10% ischemia</td>
<td>III</td>
<td>A</td>
</tr>
<tr>
<td><strong>For symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any stenosis &gt;50% with limiting angina or angina equivalent, unresponsive to OMT</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td>Dyspnea/CHF and &gt;10%LV ischemia/viability supplied by &gt;50% stenotic artery</td>
<td>IIa</td>
<td>B</td>
</tr>
<tr>
<td>No limiting symptoms with OMT</td>
<td>III</td>
<td>C</td>
</tr>
</tbody>
</table>

* With documented ischemia or FFR < 0.8
<table>
<thead>
<tr>
<th>Subset of CAD by anatomy</th>
<th>&lt;&lt; CABG</th>
<th>&lt;&lt; PCI</th>
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<tbody>
<tr>
<td><strong>ESC</strong></td>
<td><strong>ACC</strong></td>
<td><strong>ESC</strong></td>
</tr>
<tr>
<td>1VD or 2VD – non-proximal LAD</td>
<td>IibC</td>
<td>Ila B</td>
</tr>
<tr>
<td>1VD or 2VD – proximal LAD</td>
<td>IA</td>
<td>IA</td>
</tr>
<tr>
<td>3VD simple lesions, full functional revascularization achievable with PCI, SYNTAX score &gt; 22</td>
<td>IA</td>
<td>IB</td>
</tr>
<tr>
<td>3VD complex lesions, incomplete revascularization achievable with PCI, SYNTAX score &gt; 22</td>
<td>IA</td>
<td>-</td>
</tr>
<tr>
<td>Left main (isolated or 1VD, ostium/shaft)</td>
<td>IA</td>
<td>IB</td>
</tr>
<tr>
<td>Left main (isolated or 1VD, distal bifurcation)</td>
<td>IA</td>
<td>IB</td>
</tr>
<tr>
<td>Left main + 2VD or 3VD, SYNTAX score ≤ 32</td>
<td>IA</td>
<td>IB</td>
</tr>
<tr>
<td>Left main + 2VD or 3VD, SYNTAX score ≥ 33</td>
<td>IA</td>
<td>IB</td>
</tr>
</tbody>
</table>
Functional SYNTAX Score in FAME

Nam et al, JACC 2011;58:1211-18
How to do?

- Medical vs. **revascularization**
- **PCI** vs. CABG
- Techniques of PCI
  - Ad hoc vs. staged procedure
  - Angiography-guided vs. function-guided
  - FFR vs. SPECT vs. other perfusion studies
### Ad hoc PCI

**Not recommended in ESC/ACC 2011!**

<table>
<thead>
<tr>
<th>Ad hoc PCI</th>
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<tbody>
<tr>
<td>Haemodynamically unstable patients (including cardiogenic shock).</td>
</tr>
<tr>
<td>Culprit lesion in STEMI and NSTE-ACS.</td>
</tr>
<tr>
<td>Stable low-risk patients with 1- or 2- vessel disease (pLAD excluded) and favourable morphology (RCA, non-ostial LCx, mid or distal LAD).</td>
</tr>
<tr>
<td>Non-recurrent restenotic lesions.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Revascularization at an interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesions with high-risk morphology.</td>
</tr>
<tr>
<td>Chronic heart failure.</td>
</tr>
<tr>
<td>Renal failure (eGFR &lt;60 mL/min), if total contrast volume required &gt;4 mL/kg.</td>
</tr>
<tr>
<td>Stable patients with MVD including LAD involvement.</td>
</tr>
<tr>
<td>Stable patients with ostial or complex pLAD lesion.</td>
</tr>
<tr>
<td>Any clinical or angiographic evidence of higher periprocedural risk with ad hoc PCI.</td>
</tr>
</tbody>
</table>
How to do?

- Ad hoc PCI with FFR
- Staged procedure with SPECT
- Staged procedure with other functional test
- Staged procedure without functional test
- **Staged procedure with FFR**
- CABG
- Medication
Planning

- Pre-FFR
- 1 stent in pLAD
- Post-FFR after stenting
- 1 stent in other LAD if p-FFR $\leq 7.5$

- Pre-FFR
- 1 stent in dRCA
- Post-FFR after stenting
- 1 stent in pLAD if p-FFR $\leq 7.5$

- 1 stent in LCX
RCA Intervention
Pre-FFR 0.72 in dRCA

Xience-Prime 3.5x18 mm

Post-FFR
IVUS and LCX Stenting without FFR

Xience-Prime 2.75 x 23 mm
LAD Intervention with FFR

0.82
Stenting followed by NC

Xience-Prime 3.0 X 23 mm
NC 3.5 X 18 mm
Post-FFR
Case 2: Stable Angina

- M / 58
- Effort chest pain for 9 months
- Hypertension
- Normal EKG
- Treadmill test: stage 3 +
- Normal echo with 64% of LV EF
- Thallium SPECT: medium-seized reversible inferolateral wall
- Intermediate RCA
- LCX CTO with collateral from RCA
- Diffuse intermediate LAD
Medical Treatment in RCA and LCX

How to Treat LAD?

• Total occlusion in another left-side artery
• Negative thallium
• Unstable morphology
• Diffuse disease
• Bifurcation involvement
• Ostial involvement
Plan for Diffuse & Bifurcation LAD

- Single-stent technique in LAD if FFR < 0.8
- FFR in D1 if compromised
Stenting through FFR wire in LAD

Compliant B 2.5 x 20 mm

Xience-Prime 3.5 x 33 mm
FFR wire in D1
Case 3: Stable Angina

- 64 / F
- Hypertension, DM, Hyperlipidemia
- Normal EKG
- Normal echo
- Abnormal thallium
Thallium SPECT

Reversible medium sized mild-to-moderately decreased perfusion in apical-mid anterior wall
LCX and RCA are normal
Diseased LAD
FFR measurement

The image shows a coronary angiogram with arrows pointing to areas of interest. The graph on the right indicates FFR measurements: 0.72, 0.88, and 1.0.
PCI

BMW guide-wire insertion

Pre-balloon using Dura Star 2.5x20

Cypher stent 2.75 x 28 implantation

Adjuvant balloon dilatation using Dura Star 2.5x20
Repeated FFR Measurement
Hydromechanical Interaction Between Stenoses

CFD Simulation

Apparent FFR (B) = Pd/Pm (Apparent)

Diameter stenosis (A), %

Stenosis A  Stenosis B

a  m  d

50%

Hydromechanical Interaction Between Stenoses
Hydromechanical Interaction Between Stenoses

Apparent FFR (A) = \frac{P_m}{P_a}

Stenosis A Stenosis B

50% Diameter stenosis (B), %
Rule of Big Delta

Stenosis (A)  Tighter Stenosis (B)

Treat Distal lesion First!

ΔFFR(A)  BigΔFFR(B)

Courtesy of SJ Park
Rule of Big Delta

Tighter Stenosis (A)  Stenosis (B)

Treat Proximal lesion First!

Big $\Delta FFR(A) > \Delta FFR(B)$

Courtesy of SJ Park
<table>
<thead>
<tr>
<th>Clinical Characteristics (N=50)</th>
</tr>
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<tbody>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Diabetes, N (%)</td>
</tr>
<tr>
<td>Hypertension, N (%)</td>
</tr>
<tr>
<td>Smoking, N (%)</td>
</tr>
<tr>
<td>Hyperlipidemia, N (%)</td>
</tr>
<tr>
<td>Previous PCI, N (%)</td>
</tr>
<tr>
<td>Clinical manifestation</td>
</tr>
<tr>
<td>Stable angina, N (%)</td>
</tr>
<tr>
<td>Unstable angina, N (%)</td>
</tr>
<tr>
<td>Non-ST elevation MI, N (%)</td>
</tr>
<tr>
<td>Mean diameter stenosis, %</td>
</tr>
</tbody>
</table>
50 patients with coronary tandem lesion with FFR ≤ 0.80

Prioritizing the treatment according to ΔFFR ("rule of big delta")

Proximal stenosis treated first
N=32

Distal stenosis treated first
N=18

FFR reassessment of the remaining lesion

Proximal stenosis treated only
N=16

Both stenoses treated
N=16

Distal stenosis treated only
N=12

Both stenoses treated
N=6
### Treatment Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Single Lesion (56%, N=28)</th>
<th>Dual Lesion (44%, N=22)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Stented Lesion</td>
<td>28</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Total stent length, mm</td>
<td>$26.6 \pm 9.7$</td>
<td>$47.3 \pm 17.3$</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total stent number per patient</td>
<td>$1.1 \pm 0.4$</td>
<td>$2.0 \pm 0.7$</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

- In 56% of patients, single lesion was treated only and thus 28% of lesions were deferred.
Conclusions

- For diffuse coronary lesions, FFR assessment before PCI has a novel activity to identify ischemia-producing segment.
- Moreover, FFR assessment during the procedure can determine whether the remaining unstented segment in a diffuse lesion requires additional stenting or not.
- Therefore, there is no doubt that FFR plays a crucial role to perform optimal stenting for diffuse coronary lesions.
Therefore, tailored stenting approach based on the separate functional assessment for the individual stenosis would be theoretically and clinically useful for PCI optimization and achieving better outcomes.

**Fractional Flow Reserve**

\[
\text{FFR} = \frac{Q_{S_{\text{max}}}}{Q_{N_{\text{max}}}} = \frac{P_d}{P_a}
\]