FFR assessment for complex lesions (LM, Bifurcation, Tandem lesions) - validity and how to evaluate.

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Intermediate (40-70%) left main stenosis: angiographic interpretation

Challenges of angiographic assessment:

- Short segment, lack of clear reference segment, overlapping side branches

Especially difficult in:

- Ostial lesions

FFR vs %DS in LMCA disease

Intermediate (40-70%) left main stenosis
The importance of making the right call

1. Conservative management of otherwise significant LM disease leads to a rise in mortality
2. Conversely premature invasive treatment leads to unnecessary perioperative risk and potential graft failure in the long run

CABG/PCI vs conservative management?
Intermediate (40-70%) left main stenosis: additional modalities for evaluation

- **FFR**

  FFR=0.83 (NS lesion)

- **IVUS**

  MLA=10.08 mm² (NS lesion)

*Ragosta M. JACC Cardiovasc Interv. 2012*
Left main FFR technical aspects

• Guide catheter should not be in wedge position potentially to leading false negative FFR values ($\text{FFR}_{\text{true}} < \text{FFR}_{\text{app}}$)

• Continuous venous adenosine administration is recommended

Ostial left main stenosis

FFR=0.9 with guide catheter in the ostium, 0.83 after removal
Intermediate LM lesion and concomitant flow limiting stenosis /CTO of the RCA.

- Possibility of false positive results (FFRtrue>FFRapp) due the enlarged area of myocardium supplied.
Left main FFR technical aspects

Intermediate LM lesion and concomitant distal run off disease: a common problem (2.5/3 major arteries effected*)

- Is it appropriate to measure in the unaffected LM?

*Bulkley BH et al. Circulation. 1976
Roberts WC
Downstream coronary stenosis: impact on FFR measurement in the non effected vessel for intermediate LM disease

Yong AS., et al., Circ Cardiovasc Interv. 2013

Fearon WF., et al., JACC Cardiovasc Interv. 2015

FFRtrue

FFRapp
Downstream coronary stenosis: impact on FFR measurement in the non effected vessel for intermediate LM disease

FFR of LM in nondiseased LCx

\[ \text{FFR}_{\text{true}} = 0.77 \quad \text{FFR}_{\text{app}} = 0.82 \]

After balloon inflation, \( \text{FFR}_{\text{epi}} \) decreases to 0.35

Fearon WF., et al., JACC Cardiovasc Interv. 2015
Downstream coronary stenosis: impact on FFR measurement in the non effected vessel for intermediate LM disease

Major findings:

- Statistically significant, however in most cases clinically irrelevant effect (ΔFFR≈0.02)
- Most prominent in case of severe LAD disease (FFRepi<0.45), (ΔFFR≈0.05)

Clinical implications:

- Referral for revascularization FFR<0.8
- Deferral if FFR>0.85
- 0.8<FFR<0.85 and FFRepi<0.45 further investigation warranted (IVUS)

Fearon WF., et al., JACC Cardiovasc Interv. 2015
FFR assessment in tandem lesions

\[ \text{FFR}(A)_{\text{true}} = \frac{P_d}{P_a} \]

\[ \text{FFR}(B)_{\text{true}} = \frac{P_d}{P_m} \]

\[ \text{FFR}(A)_{\text{app}} = \frac{P_m}{P_a} \]

\[ \text{FFR}(B)_{\text{app}} = \frac{P_d}{P_m} \]

De Bruyne B., et al., Circulation. 2000
Is FFR suitable for lesion specific assessment of CHD with serial stenoses?


\[ \Delta \text{FFR} = 0.13 \]
Is FFR suitable for lesion specific assessment of CHD with serial stenoses?

Conclusion

- The interaction between 2 stenoses is such that FFR of each lesion separately cannot be calculated by the equation for isolated stenoses (Pd/Pa during hyperemia) applied to each separately but can be predicted by more complete equations taking into account Pa, Pm, Pd, and Pw.

\[
\text{FFR(A)}_{\text{pred}} = \frac{P_d - (P_m/P_a) P_w}{P_a - P_m + P_d - P_w}
\]

\[
\text{FFR(B)}_{\text{pred}} = 1 - \frac{(P_a - P_w)(P_m - P_d)}{P_a(P_m - P_w)}
\]

FFR assessment of tandem/serial lesions clinical practice

- Start measurement distal to the most distal lesion;
- Measure with 140 μg/kg/min i.v. adenosine, if <0.80 – PCI is appropriate;
- Pull-back recording under fluoroscopy;
- Review the “pressure profile” of the full length;
- Start stenting at the highest pressure jump;
- Repeat pull-back measurement;
- Where pressure jump ≥ 10 mmHg → consider spot stent;
- Finish with final pull back recording;
- Do not stent at spots of <10 mmHg even if the global FFR < 0.80.
Jailed side branch severity: Is angiographic assessment enough?
Jailed side branch severity assessment: FFR vs %DS

Koo BK et al. J Am Coll Cardiol 2005
Concerns regarding use of FFR in sidebranch jail severity assessment

- Validity of SB FFR after MV stenting may be controversial due to local edema, thrombus and debris in the ostium, and distal

Routine FFR evaluation of the jailed side branch is not advised (BBC consensus 2014)

- Failure to recross to the side branch and preform FFR (10%)
FFR vs angiography guided provisional T-stenting

Chen SL., et al., JACC
Cardiovasc Interv. 2015
FFR vs angiography guided provisional T stenting

MACE  NS

MI  NS

TVR  NS

Chen SL., et al., JACC Cardiovasc Interv. 2015

Bulgarian Bifurcation and Complex Coronary Interventions Course
22-23 January 2016 Tokuda Hospital, Sofia
FFR vs angiography guided provisional T stenting

• Kissing balloon inflation (63.1% v 56.3%), stenting (31.9% v 13.8%) was more common in the angiographic group

• Formal cost analysis was not preformed, but the cost of more stents in the angiography group is offset by the cost of upfront FFR wire use in the FFR group.

Routine FFR evaluation of the jailed side branch is not advised (BBC consensus 2014)
Tips and tricks to facilitate safe rewiring for FFR in difficult anatomy

Step 1. Rewiring upfront using (floppy/hydrophilic) wires of choice.

Step 2/a.
Change to FFR wire over microcatheter or OTW balloon.

Step 2/b.
Conclusion

- LM disease, serial lesions and bifurcation disease can be challenging cases for the assessment of lesion significance by FFR

- The difficulties of interpretation and potential pitfalls of these lesion subsets do not mean a real limitation for FFR measurement
Thank you for your attention!
FFR assessment in tandem lesions

- The presence of a second stenosis hinders maximum transtenotic flow through the first stenosis even after achieving maximal hyperemia.
- This phenomenon is more pronounced if the second lesion is distal to the first.
- Pw also has to be measured to account for increasing collateral flow

\[
\text{FFR(A)}_{\text{pred}} = \frac{P_d - (P_m/P_a) P_w}{P_a - P_m + P_d - P_w}
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\]

Is decision making based on FFR evaluation in intermediate left main stenosis evidence based?

Based on the DEFER, FAME and FAME 2 trials "Fractional flow reserve measurement is indicated for the assessment of the functional consequences of moderate coronary stenosis".

Patients with LM stenosis excluded from these trials.
Meta-analysis of prospective cohort studies in FFR guided LM revascularization for intermediate lesions

<table>
<thead>
<tr>
<th>Study</th>
<th>Year of publication</th>
<th>Definition of intermediate LMCA stenosis</th>
<th>FFR cutoff value</th>
<th>Total number of patients</th>
<th>Mean FU (months)</th>
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<tr>
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<tr>
<td>Bech et al.⁷</td>
<td>2001</td>
<td>40–60%</td>
<td>&lt;0.75</td>
<td>54 (CABG)</td>
<td>29 ± 15</td>
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<tr>
<td>Jiménez-Navarro et al.⁹</td>
<td>2004</td>
<td>30–50%</td>
<td>&lt;0.75</td>
<td>27 (CABG, 1 PCI)</td>
<td>26 ± 12</td>
</tr>
<tr>
<td>Legutko et al.¹⁰</td>
<td>2005</td>
<td>30–60%</td>
<td>&lt;0.75</td>
<td>38 (12 CABG, 5 PCI, 1 OMT)</td>
<td>24 ± 12</td>
</tr>
<tr>
<td>Lindstaedt et al.¹²</td>
<td>2006</td>
<td>40–80%</td>
<td>&lt;0.75³</td>
<td>51 (CABG)</td>
<td>29 ± 16</td>
</tr>
<tr>
<td>Courtis et al.¹³</td>
<td>2009</td>
<td>30–60%</td>
<td>&lt;0.75³</td>
<td>142 (54 CABG, 6 PCI)</td>
<td>14 ± 11</td>
</tr>
<tr>
<td>Hamilos et al.¹⁴</td>
<td>2009</td>
<td>30–70%</td>
<td>&lt;0.80</td>
<td>213 (CABG)</td>
<td>36 (6-99)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>525 (CABG)</td>
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Meta-analysis of prospective cohort studies in FFR guided LM revascularization for intermediate lesions

Composite endpoint of death, revascularisation and MI: NS

3 year mortality (4.5%) in the defer group vs (50%) historical data in significant untreated LMCA disease

Is decision making based on FFR evaluation in intermediate left main stenosis good clinical practice?

„in ambiguous LMCA disease, deferral of revascularization based on FFR results is safe in terms of overall mortality and myocardial infarction” and „FFR can be used to identify patients who are likely to benefit from revascularization”

FFR assessment of bifurcation lesions: indication for stenting

„MV FFR is recommended in stable patients when no other objective evidence of ischaemia is available”

FFR vs angiography guided provisional T stenting

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Left main FFR technical aspects

Intermediate LM lesion and concomittant distal run off disease (LAD)

- FFRproxLAD = 0.92
- FFRmidLAD = 0.74
- FFRproxCX = 0.90

NS LM disease, significant LAD