FFR in bifurcation lesions/stenting

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**Why “functional evaluation” in bifurcation PCI?**

**Pitfalls of anatomical evaluation**

- **Angiography**
  - Single directional assessment
  - Variability in stenosis assessment
  - No validated criteria for intervention
  - Not physiologic

- **IVUS/OCT**
  - Difficult to perform in tight stenosis
  - No validated criteria for intervention
  - Not physiologic

**Uniqueness of side branch lesions**

- Various size, various amount of myocardium
- Side branch stenosis is unique and complex
  - Underlying plaque $\rightarrow$ Eccentric
  - Remodeling $\rightarrow$ Negative remodeling
  - Complex mechanisms of side branch jailing
    - Carina shift, plaque shift, stent struts, thrombus.....

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Koo BK & de Bruyne B, Eurointervention 2010
FFR: When and How in Bifurcation PCI?

- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting
LAD:
Lumen area: 2.8mm²
Plaque area: 6.2mm²
%plaque burden: 69%

Significant bifurcation lesion?

Diagonal:
MLD: 1.7mm
MLA: 2.7mm²
%plaque burden: 46%

Diagonal FFR 0.94
Why FFR?

Diagnostic accuracy of anatomic parameters in pure SB ostial lesions

Koh JS, Koo BK, et al., JACC Intv, 2012
Pitfalls of Side branch FFR: Influence of MB stenosis

Anatomical & functional Medina 0,0,1 lesion?

Pullback pressure tracing
Pre-intervention

• FFR <0.75 does not always mean the clinical relevance of that SB stenosis. FFR should be measured in large SB.

• When SB FFR is measured, the influence of main branch stenosis should always be considered (Don’t forget the pullback pressure tracing!).

• Pre-intervention SB FFR is usually not helpful to predict the jailed SB FFR.
FFR: When and How in Bifurcation PCI?

- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting
Side branch angioplasty?
Side branch angioplasty?

Different criteria from different studies……

> 50% stenosis

TIMI flow <3
Dissection > A
> 90% stenosis
Threatened closure

NORDIC
Circulation 2006

BBB
Eur Heart J 2008

CACTUS
Circulation 2009

BBC-ONE
Circulation 2010

Side branch angioplasty (%)
Degree of stenosis?

- Observer 1: 70%
- Observer 2: 90%
- Observer 3: 75%
- QCA system 1: 66%
- QCA system 2: 76%
- QCA system 3: 79%
How accurate is our assessment?

Variability of QCA and visual estimation in jailed SB lesions

In Jailed side branch lesions, Angiographic severity ≠ Presence of ischemia

No perfusion defect
Estimation of “functional significance” in jailed SB lesions

- PPV
- NPV
- Sensitivity
- Specificity
Anatomical severity ≠ Functional significance

**FFR vs. % diameter stenosis in Jailed side branches**

**SNUH SB-FFR registry**


Ahn JM, et al. JACC intv 2012


Seoul National University Hospital Cardiovascular Center
Anatomical severity ≠ Functional significance

**FFR vs. OCT lumen area in Jailed side branches**

$r = 0.57, p < 0.001$

OCT 2.05 mm$^2$ Vs. FFR 0.80

Sensitivity 71.0%  
Specificity 75.0%  
PPV 54.5%  
NPV 91.5%

Ha J, Kim JS, et al. JACC Img 2013, in press
FFR in all jailed side branches?
After main branch stent implantation

- SB FFR is useful in short ostial SB lesions.
- SB FFR is generally not recommended in very complex SB lesions (severe tortuosity, heavy calcification, diffuse multiple stenosis.....).
- The pressure wire should not be jailed by a MB stent.
- FFR 0.75 seems to be an appropriate criteria for jailed SB intervention considering the clinical relevance of SB and complexity of procedures.
**FFR: When and How in Bifurcation PCI?**

- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting
Side branch stenting?

Post-Kissing balloon inflation
Side branch stenting?

Different criteria from different studies……

- TIMI flow <3
- Dissection > A
- > 50% stenosis

- TIMI flow <3
- Dissection > A
- > 70% stenosis

- Flow limiting dissection
  ≥ 75% stenosis

- Threatened closure

- NORDIC
  Circulation 2006
  TIMI flow = 0
  4.3%

- BBB
  Eur Heart J 2008
  18.8%

- CACTUS
  Circulation 2009
  31.2%

- BBC-ONE
  Circulation 2010
  3%
Angiographic vs. FFR changes during PCI

Before PCI

After MB stenting

After kissing balloon
Functional outcome of Jailed side branches

11 month Follow-Up
Functional outcome of Jailed side branches

SNUH SB FFR registry

Koo BK, et al Eur Heart J 2009

Nordic Baltic Bifurcation III: SB FFR substudy

No kissing group

Final kissing group

After PCI  Follow-up

Functionally complete revascularization
# FFR after complex side branch stenting

## DK crush vs. Provisional

### In cases of crush stenting

#### Pre- and Post- final kissing balloon

<table>
<thead>
<tr>
<th></th>
<th>Pre-KBA FFR</th>
<th>Post-KBA FFR</th>
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<tbody>
<tr>
<td></td>
<td>0.90</td>
<td>0.96</td>
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<td>0.95</td>
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### Table: FFR values

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<thead>
<tr>
<th></th>
<th>DK Group</th>
<th>1-Stent Group</th>
<th>P Value</th>
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<tbody>
<tr>
<td>FFR preprocedure</td>
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<tr>
<td>MB FFR at baseline</td>
<td>0.83 ± 0.15</td>
<td>0.89 ± 0.13</td>
<td>0.109</td>
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<tr>
<td>SB FFR at baseline</td>
<td>0.84 ± 0.15</td>
<td>0.91 ± 0.12</td>
<td>0.100</td>
</tr>
<tr>
<td>MB FFR at hyperemia</td>
<td>0.76 ± 0.15</td>
<td>0.83 ± 0.10</td>
<td>0.029</td>
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<tr>
<td>SB FFR at hyperemia</td>
<td>0.76 ± 0.15</td>
<td>0.83 ± 0.16</td>
<td>0.103</td>
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<tr>
<td>FFR postprocedure</td>
<td></td>
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<tr>
<td>MB FFR at baseline</td>
<td>0.96 ± 0.02</td>
<td>0.95 ± 0.03</td>
<td>0.376</td>
</tr>
<tr>
<td>SB FFR at baseline</td>
<td>0.97 ± 0.02</td>
<td>0.96 ± 0.03</td>
<td>0.043</td>
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<tr>
<td>MB FFR at hyperemia</td>
<td>0.92 ± 0.04</td>
<td>0.92 ± 0.05</td>
<td>0.581</td>
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<tr>
<td><strong>SB FFR at hyperemia</strong></td>
<td><strong>0.94 ± 0.03</strong></td>
<td><strong>0.90 ± 0.08</strong></td>
<td><strong>0.028</strong></td>
</tr>
</tbody>
</table>


Lee BK, et al. Clinical Cardiol 2010
After side branch angioplasty

- Functional outcomes of FFR-guided SB intervention is good regardless of residual stenosis.
- SB FFR is not recommended in case of slow flow or severe dissection.

After side branch stenting

- FFR is useful to detect the residual ischemia.
- However, high FFR does not always guarantee the excellent outcomes of complex intervention for bifurcation lesions.
FFR in Bifurcation lesion

- Bifurcation lesions are unique and different from other stenoses.
- Anatomical evaluations (QCA, IVUS, OCT……) have pitfalls in the evaluation of bifurcation lesions.
- FFR is useful in bifurcation lesions from the beginning till the end of bifurcation PCI and its use can reduce unnecessary complex interventions and their complications.
- However, adequate knowledge on coronary physiology and FFR is required to use FFR properly in complex bifurcation lesions.