EDUCATIONAL FELLOWSHIP IN PCI FOR YOUNG INTERVENTIONALIST CERTIFIED TRAINING COURSE (EAPCI, SCAI, GISE).

Treatment of bifurcation lesion

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Background

- Bifurcation lesion intervention is performed in about 8-15% of PCI at most centers

- Treatment of Bifurcation Lesions is historically associated to higher risk of MACE:
  - most of these lesions are complex (type C of ACC/AHA class)
  - technically challenging with higher learning curve
  - PCI of these lesions requires higher number of devices
  - very high angiographic and clinical restenosis
Many techniques and devices have been attempted, but...

- Kissing balloons
- Atherectomy
- T or TAP stenting
- V or Y Stenting
- Crush
- Culotte
- Provisional
- Dedicated stents

...none offering any clear advantage
FAQ when facing with a bifurcation lesion...

- Under exactly what circumstances should the SB be stented?
- If using a 2-stent strategy, what is the optimal technique?
- Is kissing balloon dilatation always necessary when using a single stent strategy?

There is no single strategy for all bifurcations ...

... we must evaluate each individual lesion
Atherosclerosis at bifurcation site has typical distribution pattern:

- Plaque volume is significantly greater in the proximal segment.
- Plaque distribution significantly more eccentric in the distal segment.
- Vessel wall on myocardial side is atherosclerosis-prone site.
- Plaques are localized almost exclusively on the non-flow dividing walls.
Many definitions have been proposed for a coronary bifurcation stenosis:

- lesion located in a bifurcation point?
- lesion located in a bifurcation point with a SB >2 mm in diameter?
- lesion located in a bifurcation point with a SB that you do not want to loose?
- lesion located in a bifurcation point with a SB that needs to be treated?
Classification

Type A: Proximally stenosis not involving the ostium of the side branch.
Type B: Occlusion of the parent vessel not involving the ostium of the side branch.
Type C: Stenosis of the parent vessel not involving the ostium of the side branch.
Type D: Occlusion involving the ostium of the side branch only.
Type E: Stenosis involving the ostium of the side branch only.
Type F: Proximal occlusion involving the ostium of the side branch.

Duke

Sanborn

Safian

Lefevre

Movahed

Chen - Gao

Medina
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**Limits:**

1) the complex model of plaque distribution at bifurcation site and of vessel remodeling cause a great anatomical variability of bifurcation geometry...
2) suffer limitations of coronary angiography
3) don’t take in account what happen during treatment
True Bifurcation definition

50 to 60% of cases

Medina et al. Rev Esp Cardiol. 2006
Medina classification

1,0,0
1,1,1
0,1,1
0,1,0
Check list for bifurcation PCI

Plan your strategy: think several moves ahead!

0. Assessment of patient (i.e. antiplatelet therapy compliance)
1. Assessment of SB (keep it open or provisional treatment);
2. Choice of guiding catheter (6 French or more, extra back up)
3. Choice of good projection
4. Wiring both the main and the side branches
5. Lesion preparation (predilation, debulking)
6. Choice of stenting technique: single or double stent?
7. Choice of right double stenting technique and stent type
8. Post-dilation with kissing balloon technique
By definition, the side branch is a vessel that you don’t want to lose!

– Due to his diameter (>2.0 mm);
– Due to amount of myocardium at risk

If SB diameter is <2.0 mm = keep it open strategy
If SB diameter is ≥2.0 mm = consider its treatment

In any case, when facing with a bifurcation the choice of SB approach/treatment should be done prior MB treatment.
Several mechanisms are responsible for SB compromising during bifurcation treatment:

1. Plaque shift (“snow plow effect”);
2. Dissection of SB after balloon/stent in MB;
3. Spasm of SB;
4. SB ostium jailing by stent struts
5. Carina stent-induced displacement
Main independent predictors of acute SB occlusion after stent implantation:

**Angiographic**

1. Ostial SB stenosis
2. Involvement of SB origin within the lesion of MB
3. Reference side branch diameter
4. Bifurcation angle <70°?
Identification of side branch at risk

The Interventional Cardiologists “rear” view
Identification of side branch at risk

SB occlusion during PCI

- No SB stenosis: 6.1%
- SB stenosis >50%: 20.8%

Identification of side branch at risk

Main independent predictors of acute SB occlusion after stent implantation:

**Angiographic**

- Ostial SB stenosis
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- Reference side branch diameter
- Bifurcation angle?

**IVUS**

- Diffuse atherosclerotic plaque “truly” involving SB ostium
Main independent predictors of acute SB occlusion after stent implantation:

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Guiding catheter & PCI technique

Catetere guida
6 french (1.75mm):

Catetere guida
7 french (2.06mm):

Standard/inverted crush stenting

Provisional stenting

Culotte stenting

T/reverse-T stenting

Y/V stenting

Step/Reverse crush stenting

SKS stenting
Check list for bifurcation PCI

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Wiring of the side branch

Do not hesitate to put a guide in the SB

“it is better to stop something bad happening than it is to deal with it after it has happened”

1. Prevent its occlusion
2. Often favorably change the angle between the branches
3. In case of occlusion, acts as SB marker
4. Can be used to identify the distal struts for an optimal provisional stenting technique
Double wire changes bifurcation angle
Check list for bifurcation PCI

The Side Branch must be preserved?

No  Yes

Treat it such as a non-bifurcated lesion Wiring of both main and side branches (most difficult lesion first)

Failure of wiring the Side Branch

Modify the shape of tip wire
Change the wire;
Use orientable wires or micro-catheters
Consider the atherectomy of Main Branch;
Predilate the Main Branch

Failure of wiring the Side Branch: ready to loose Side Branch”

Stenting of Main Branch

Stenting of Main Branch

Consider surgery
Keep It Open (KIO) strategy

When the SB has ostial or diffuse disease AND when the SB is not suitable (too small) for stenting or clinically not relevant

1. Wire both branches
2. Dilate MB if needed
3. Stent MB and leave wire in the SB
4. Perform post-dilatation of the MB with jailed wire in the SB

Do not re-wire SB or post-dilate or pre-dilate SB
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4. Wiring both the main and the side branches
5. **Lesion preparation** *(predilation, debulking)*
6. Choice of stenting technique: single or double stent?
7. Choice of right double stenting technique and stent type
8. Post-dilation with kissing balloon technique
Predilation of the MB lesion is recommended in all situations at increased risk of suboptimal stent expansion:

1. lesion on distal coronary segment
2. vessel tortuosity
3. calcified lesion
4. tight lesion

Direct stenting could prevent dissection extending to the side branch but its role is limited in bifurcation.
Predilation of the SB lesion is controversial

It do not affect the risk of occlusion after MB stenting, but in case of dissection treatment of SB first might be obligatory.

On the other hand, when stenting of SB is planned, predilation offer the same advantaged than MB (i.e. facilitate stent positioning).

The REDUCE III and NICECUT studies reported the beneficial effect of the cutting balloon use for SB ostium treatment: it could be a valid alternative to atherectomy in moderately calcific and fibrotic lesion.
Predilation of side branch

Predilation of the SB lesion is controversial
Predilation of the SB lesion is controversial.

Balloon inflated on SB
(should not have been done)
Predilation of side branch

Predilation of the SB lesion is controversial

Rewiring of SB after MB stenting with large dissection
Predilation of the SB lesion is controversial

Perforation of SB attempting to gain true lumen
Predilation of side branch

Predilation of the SB lesion is controversial

Final Result after cover stent on the MB
Lesion preparation: debulking

Rationale:

• when opposed to angioplasty allows to achieve a larger post-procedure lumen and optimize stent expansion;

• in stent neo-intimal proliferation correlates with amount of residual plaque burden outside the stent;

• likely reduce the massive plaque shift on SB ostium;
Lesion preparation: debulking

Caveat:

• Complex techniques associated with increased rate of peri-procedural complication (i.e. peri-procedural MI);

• Techniques very operator dependent (i.e. amount of tissue removal depends on the commitment of operator to perform extensive debulking);

• Lack of benefit in large RCT (i.e. AMIGO, SPORT)

• Need for good operator skill (high back-up guiding catheter, accurate guide wire and devices manipulation)
In spite of the lack of evidence supporting the advantage of plaque debulking in bifurcation lesions...

- **Directional atherectomy** should be considered an optional procedure in presence of appropriate anatomic setting such as large plaque burden shown by IVUS (i.e. left main stenosis) and of plaque characteristics suitable for removal with current devices (i.e. PERFECT study).

- **Rotational atherectomy** is the only procedure to permit lesion dilatation and hence stent delivery in extremely calcified lesions.

The main limitation to the use of these techniques is that it’s impossible to identify “a priori” lesions that will not be successfully treated with conventional angioplasty.
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Provisional stenting: rationale

50 to 60% of cases
Provisional stenting: rationale

- SB LL > 3 mm 20 to 40%
- Significant SB LL > 3 mm 10 to 24%
Provisional stenting: rationale

Correlation between DS by QCA and FFR in 94 jailed side branches:

1. No lesions with DS<75% had FFR<0.75
2. No TVR in those with DS<75%
3. Among those with DS>75%, only 27% were functionally significant

Angiographic suboptimal result in the SB after stenting of the MB should not be an indication to SB stenting

Koo et al JACC 2005
Provisional stenting: rationale

- Why stenting the SB where there is no lesion?
- SB lesions are usually short!
- Why stenting a SB lesion which is already stented?
- Why stent a functionally non significant SB lesion?
- Do we have 1 reason for using 2 DES?
  - Angiographic result: yes
  - Deliverability: no
  - Efficacy: no
  - Safety: no
Double stenting in BMS era

TVR (%)

Anzuini Al Suwaidi Pan Shelban Lefèvre Assali

1 BMS 2 BMS
Double stenting in DES era

- MACE (%)
- 2004 to 2007

- 1 DES
- 2 DES

- Colombo 2004
- Pan 2004
- Steigen 2006
- Ferenc 2007
- Colombo 2007
- Tsuchida* 2007

MACE (%)
Provisional stenting: rationale

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- Why stenting a SB lesion which is already stented?
- Why stent a functionally non significant SB lesion?
- Do we have 1 reason for using 2 DES?
  - Angiographic result yes
  - Deliverability no
  - Efficacy no
  - Safety no
- Why Taking More Risk of ST?
Provisional stenting: rationale

« ... cause of stent thrombosis stent underexpansion, crush technique ... »

Renu Virmani et al, TCT 2004
In most bifurcation lesions one stent is the treatment of choice.

The controversy may exist in “true” bifurcations (both branches have a stenosis).

In these type of bifurcations the advantage of 2 vs. 1 stent depends on:

- size and distribution of the side branch
- extension of the disease into the side branch
One or Two stent?

True Bifurcation?
(significant stenosis on the MB and SB)

- No → Provisional SB stenting
- Yes → The side branch is suitable for stenting

Provisional SB stenting

- No → Stent on MB
  PTCA on SB
- Yes → The disease on the SB extends for more than 3mm from the SB ostium

- No → Provisional SB stenting
- Yes → Elective implantation of two stents (MB and SB)
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<table>
<thead>
<tr>
<th>Technique</th>
<th>French size required</th>
<th>SB ostium coverage</th>
<th>SB jailing</th>
<th>Technical difficulty**</th>
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<tbody>
<tr>
<td>T-stenting</td>
<td>7</td>
<td>+ (if angle &lt;90°)</td>
<td>++</td>
<td>++</td>
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<tr>
<td>TAP</td>
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<td>Step Crush</td>
<td>6</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

*Indicated when a constant access to both branches is preferable, but relatively contraindicated in distal/small bifurcations.
Technique choice: assess the angle and disease

- Bifurcation lesion with no disease proximal to the bifurcation or very short left main
  - V-Stenting

- Bifurcation lesion with MB disease extending proximal to the bifurcation and SB with $\approx 90^\circ$ angle origin
  - T-Stenting

- Bifurcation lesion with MB disease extending proximal to the bifurcation and SB with $\approx 60^\circ$ angle origin
  - Mini-Crush, SKS TAP, Culotte
The categorization of stents as open or closed cell refers to the pattern of metal wires that is used to make up a stent's structure.

- **Open-cell** stents are made of parallel wire loops with few wires that cross these loops. The resulting pattern has lots of open spaces.

- **Closed-cell** stents have many crossing wires, a design that creates much smaller spaces between the wires. In theory, closed cells should do a better job of trapping plaque against the arterial wall and should prevent pieces of plaque from protruding between the stent's struts and into the vessel lumen. Better scaffolding, worse deliverability.
Stent type choice

Cell opening after dilation with a 4.0 mm balloon

Express

Costar

Bx velocity

Select

Libertè

Driver

Vision

Ormiston et al.
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In clinical practice, adequate stent deployment has an important effect on immediate and long term results after percutaneous coronary interventions.

In particular, suboptimal or incomplete stent expansion is associated with increased restenosis and target vessel revascularization rates, and especially with drug eluting stent, may also predispose to stent thrombosis.

Bifurcation lesions are at increased risk of suboptimal stent expansion
Importance of final kissing balloon

Stenting of MB

Effect of SB stenting on MB

Effect of MB post-dilation on SB

Effect of kissing balloon on MB and SB

Ormiston et al. CCI 2004
Importance of “good kissing”

Kissing with balloon diameters smaller than stent balloons

Kissing with balloon diameters equal to stent balloons

Ormiston et al. CCI 2004
Kissing or not using Crush technique

TVR (%)

- Airoldi
- Moussa
- Serruys
- Colombo

Kissing
Not kissing
In bifurcation treated with two stent TLR and TVR are progressively decreasing

Colombo et al. 2005
Final kissing balloon tips and tricks

- Pre-FKI side branch dilatation
- Use balloon with the same size as stent balloons
- Use of non-compliant balloons (high pressures safely)
- High pressure side branch inflation

“Taken together we think that these factors represent our ‘learning curve’ in the treatment of bifurcations with 2 stents”
Conclusion

- Bifurcation lesions are frequent (10-20%)
- Plaque shifting is constant
- The learning phase involves both strategy and technique
- DES are associated with better outcome compared to BMS, but did not change the stenting approach
- In the majority of cases, bifurcation lesions can be treated with a provisional SB stenting approach
- Due to high rate of cross over (up to 50%) and heterogeneity of bifurcation lesions, no statement can be made regarding the most appropriate technique or approach to use.
Conclusion

- In case of SB treatment, technique choice and final kissing balloon are a major issues

- There is no evidence of a significant advantage in 2-stent strategy over one of provisional stenting but.. there is no evidence of a significant disadvantage in 2-stent strategy over provisional stenting

- Restenosis at the SB remains a problem to be solved.

- Uncertainties are still present concerning long term safety of routine double stenting over stenting only the MB with provisional SB stenting.

- Using an indexed approach, acute results are excellent and TVR not so high.
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