Bifurcation Approaches: A Step By Step Refresher

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Background

- Bifurcation lesions are commonly encountered in clinical practice (up to 30% of PCIs)
- In the DES era, clinical outcomes of bifurcation PCI are very good
- Various 2-stent techniques have been devised to effectively treat bifurcations lesions
- The savvy interventional cardiologist needs to be familiar with all techniques since there are certain advantages and disadvantages to each
PCI for Bifurcation Lesions

A. V Stenting
B. Y Stenting
C. Kissing Stents
D. T Stenting
E. Culottes
F. Crush
Why Do Bifurcation Lesions Pose Such a Challenge?

• When treating the main vessel, shift of plaque or thrombus can lead to sidebranch occlusion, particularly if:
  ▪ The ostium of the sidebranch itself is diseased
  ▪ The sidebranch is of small diameter
  ▪ Thrombus from ACS is present

• Clinical consequences of loss of the sidebranch are dependent on vessel size and amount of myocardium
Bifurcation Intervention:
The Problem of Plaque Shift ("Snow Plow")
Commonly Used Bifurcation Techniques

- Provisional Stent Technique
- Crush Techniques
- Simultaneous Stent Techniques
- T Stent Techniques
- Culotte Technique
Provisional Stent Technique:

The ‘simplest’ way to treat a bifurcation lesion

- Wire both vessels (if needed)
- Pre-dilate as needed
- Stent main branch
- Rewire and balloon side branch (+/- kissing balloon inflation)
Side branch closure after PCI

A. Prebranch <5%
B. Postbranch <5%
C. Parent vessel only 5-10%
D. Bifurcation 15-20%
   Cause: Plaque shift, Spasm, Dissection
E. Ostial <5%
F. Prebranch and ostial 10-15%
Provisional Stent Technique: Plan B

- If a second stent is needed after provisional stenting is performed (ie: dissection or compromise of the sidebranch) the following techniques can be used:
  - Culotte Technique
  - Reverse Crush Technique
  - TAP Technique
Provisional Stent Technique

ADVANTAGES:
- Simple
- Less Metal
- Potentially easier to treat restenosis
- Less thrombosis?

DISADVANTAGES:
- Residual stenosis at side branch
- If side branch stent needed, it can be more difficult to insert it through first stent
If I Use a One Stent Strategy, Do I Need to do a Final Kissing Inflation?

Published online 2018 Jun 27. doi: 10.1371/journal.pone.0197580

Should kissing balloon inflation after main vessel stenting be routine in the one-stent approach? A systematic review and meta-analysis of randomized trials

Ming Zhong, Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing, Biao Tang, Data curation, Methodology, Qiang Zhao, Methodology, Jian Cheng, Investigation, Supervision, Qiangsong Jin, Supervision, and Shenwen Fu, Conceptualization, Project administration, Writing – review & editing

Meta-analysis of all published studies that included kissing balloon inflation vs. no kissing balloon inflation when using a single stent strategy

Kissing balloon inflation was associated with a higher restenosis rate of the main branch and no difference in overall clinical outcome

PLoS One. 2018; 13(6)
Commonly Used Bifurcation Techniques

• Provisional Stent Technique
• Crush Techniques
• Simultaneous Stent Techniques
• T Stent Techniques
• Culotte Technique
The Classic Crush Technique

Wire both vessels
Pre-dilate as needed
Position stents
Deploy side branch stent, remove balloon/wire
Deploy main branch stent- ‘crushes’ side branch stent
Rewire side branch and perform kissing balloon inflation
The Crush Technique

Main br stent

Crushed side-br stent
The Evolution of the ‘Crush’ Technique: Post-Crush Kissing Balloon Inflation

Before Kissing Balloon Inflation

After Kissing Balloon Inflation
Crush Technique: Variations

- Classic Crush
- Mini Crush
- Double Kissing Crush (DK Crush)
- Reverse Crush
- Step Crush
Classic Crush Technique

Mini Crush Technique
DK Crush Technique

- Position sidebranch stent as if performing a Mini Crush, in conjunction with a balloon in the mainbranch.
- Deploy sidebranch stent, withdraw sidebranch stent balloon slightly, then reinflate to high pressures to “flare” the proximal sidebranch stent.
- Remove sidebranch balloon and wire.
- Crush sidebranch stent with mainbranch balloon.
- Rewire sidebranch and perform a kissing balloon inflation.
DK Crush Technique

- Remove sidebranch wire and balloon
- Position stent in the mainbranch and deploy it
- Rewire sidebranch and perform final kissing balloon inflation
Reverse Crush Technique

Performed as a bailout strategy if provisional stenting of the main branch is suboptimal.
Crush Stent Technique

ADVANTAGES:
• Assures coverage of side branch ostium
• Prevents loss of side branch
• Can be used if side branch and main branch are of significantly different sizes

DISADVANTAGES:
• More complex
• Time consuming
• More costly (additional wires/balloons)
• Sometimes unable to perform the final kiss-desired for a worse outcome
• More difficult to treat restenosis
Commonly Used Bifurcation Techniques

• Provisional Stent Technique
• Crush Techniques
• Simultaneous Stent Techniques
• T Stent Techniques
• Culotte Technique
The Simultaneous Kissing Stent (SKS) Technique

- Wire both vessels
- Pre-dilate as needed
- Position stents
- Deploy stents simultaneously
- Perform kissing balloon post-dilatation
Simultaneous Kissing Stent Technique (SKS)

ADVANTAGES:
- Simple
- Maintain wire access to both branches at all times
- Minimal ischemic time

DISADVANTAGES:
- Can be difficult to rewire/retreat later due to neocarina
- Requires larger vessels of similar size
- Higher restenosis rates reported
Simultaneous V Stenting Technique

- Identical to the SKS technique, but without the creation of a new carina
# Simultaneous V Stenting Technique

**ADVANTAGES:**
- Simple
- Maintain wire access to both branches at all times
- Minimal ischemic time

**DISADVANTAGES:**
- Only works if proximal main branch is free of disease
- Plaque shift more proximally can be difficult to treat:
  
  *Add a stent proximally and potentially leave a gap vs. convert to SKS*
Commonly Used Bifurcation Techniques

• Provisional Stent Technique
• Crush Techniques
• Simultaneous Stent Techniques
• T Stent Techniques
• Culotte Technique
Almost NEVER is there a perfect 90 degree angle between main branch and side branch!

Use of the traditional T stent technique is associated with high risk of missing the side branch ostium.
The TAP Technique

**T stent And Protrusion**

Wire both vessels

Pre-dilate as needed

Position and deploy main branch stent

Rewire side branch and balloon dilate

Position side branch stent so proximal edge protrudes slightly into main branch, ‘backstop’ balloon in main branch

Deploy side branch stent first, then inflate main branch balloon to kiss
TAP Technique

ADVANTAGES:
- Relatively simple
- Assures coverage of side branch ostium
- Less metal at side branch ostium compared to Crush technique
- Works when vessels are different sizes

DISADVANTAGES:
- Excessive stent protrusion can lead to trouble accessing distal main branch in the future
Commonly Used Bifurcation Techniques

- Provisional Stent Technique
- Crush Techniques
- Simultaneous Stent Techniques
- T Stent Techniques
- Culotte Technique
The Culotte Technique

Wire both vessels
Pre-dilate as needed
Position and deploy stent in most angulated branch
Remove first wire, wire second branch and balloon dilate
Position second branch stent so proximal portion equal with previous stent edge and deploy
Rewire initially stented branch and perform kissing post-dilatation
Culotte Technique

ADVANTAGES:
• Assures side branch ostium coverage
• Excellent radial strength in main branch

DISADVANTAGES:
• Complex
• Vessels must be of similar size
• Somewhat time consuming
What is POT?

**Proximal Optimization Technique**

Dilatation of the stent within the proximal vessel to an appropriate size to achieve proper apposition to avoid rewiring behind the stent and causing inadvertent crush or distortion of the stent.
A registry of unprotected left main bifurcation lesions treated with T-stenting, mini-crush, and Culotte techniques.
# Long-Term Outcomes of Different Two-Stent Techniques With Second-Generation Drug-Eluting Stents for Unprotected Left Main Bifurcation Disease: Insights From the FAILS-2 Study

## Table 3. Long-term outcomes (median follow-up, 2.27 years).

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Long-term follow-up (years)</td>
<td>2.2 ± 1.5</td>
<td>2.1 ± 1.4</td>
<td>2.2 ± 1.5</td>
<td>.90</td>
</tr>
<tr>
<td>Planned angiographic follow-up</td>
<td>32 [50.0%]</td>
<td>69 [68.0%]</td>
<td>54 [79.5%]</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Major adverse cardiac events</td>
<td>14 [22.0%]</td>
<td>27 [26.0%]</td>
<td>21 [31.0%]</td>
<td>.50</td>
</tr>
<tr>
<td>Death</td>
<td>6 [9.3%]</td>
<td>9 [9.0%]</td>
<td>3 [4.5%]</td>
<td>.48</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>1 [1.5%]</td>
<td>1 [1.0%]</td>
<td>1 [1.4%]</td>
<td>.93</td>
</tr>
<tr>
<td>TVR</td>
<td>9 [14.0%]</td>
<td>20 [19.5%]</td>
<td>17 [25.0%]</td>
<td>.28</td>
</tr>
<tr>
<td>Angio-driven TVR</td>
<td>5 [7.8%]</td>
<td>9 [8.7%]</td>
<td>10 [14.7%]</td>
<td>.34</td>
</tr>
<tr>
<td>Ischemia-driven TVR</td>
<td>4 [6.0%]</td>
<td>11 [10.6%]</td>
<td>7 [10.3%]</td>
<td>.60</td>
</tr>
<tr>
<td>TLR</td>
<td>8 [12.5%]</td>
<td>18 [17.5%]</td>
<td>14 [20.5%]</td>
<td>.41</td>
</tr>
<tr>
<td>Angio-driven TLR</td>
<td>5 [7.8%]</td>
<td>8 [7.7%]</td>
<td>7 [10.3%]</td>
<td>.82</td>
</tr>
<tr>
<td>Ischemia-driven TLR</td>
<td>3 [4.7%]</td>
<td>10 [9.7%]</td>
<td>6 [8.8%]</td>
<td>.49</td>
</tr>
<tr>
<td>TLR on left main</td>
<td>2 [3.0%]</td>
<td>6 [6.0%]</td>
<td>2 [3.0%]</td>
<td>.63</td>
</tr>
<tr>
<td>TLR on left anterior descending</td>
<td>4 [6.2%]</td>
<td>4 [4.0%]</td>
<td>2 [3.0%]</td>
<td>.62</td>
</tr>
<tr>
<td>TLR on circumflex</td>
<td>6 [9.3%]</td>
<td>16 [15.5%]</td>
<td>11 [16.0%]</td>
<td>.44</td>
</tr>
<tr>
<td>Stent thrombosis [definite/probable]</td>
<td>0 [0.0%]</td>
<td>0 [0.0%]</td>
<td>0 [0.0%]</td>
<td>N/A</td>
</tr>
<tr>
<td>Possible stent thrombosis</td>
<td>1 [1.5%]</td>
<td>3 [3.0%]</td>
<td>0 [0.0%]</td>
<td>.47</td>
</tr>
</tbody>
</table>

TLR = target-lesion revascularization; TVR = target-vessel revascularization;
DK Crush vs. Provisional Stenting for Left Main Bifurcation Lesions

Double Kissing Crush Versus Provisional Stenting for Left Main Distal Bifurcation Lesions: DKCRUSH-V Randomized Trial

Shao-Liang Chen MD, a, 3, Jue-Jie Zhang PhD, a, Yaling Han MD b, Jing Kan MBBS a, Lianglong Chen MD 3, Chunguang Qiu MD d, Tiemin Jiang MD e, Ling Tao MD f, Hesong Zeng MD g, Li Li MD h, Yong Xia MD i, Chuanyu Gao MD j, Teguh Santos MD k, Chootopol Paiboon MD l, Yan Wang MD m, Tak W. Kwan MD n, Fei Ye MD o, Nailiang Tian MD o ... Gregg W. Stone MD aa, 3, 3

482 patients from 26 centers in 5 countries with true distal LM bifurcation lesions (Medina 1,1,1 or 0,1,1) randomized to provisional stenting (n = 242) or DK crush stenting (n = 240)

Chen et al. JACC Volume 70, Issue 21, 28 November 2017, Pages 2605-2617
DK Crush vs. Provisional Stenting for Left Main Bifurcation Lesions

**CENTRAL ILLUSTRATION: Stenting for LM Bifurcations**

- **Simple Lesions**
  - Lesion Length <10mm
  - 50% < Diameter Stenosis <70%

- **Complex Lesions**
  - Lesion Length ≥10mm
  - Diameter Stenosis ≥70%

- **Plus Any Two of:**
  - Multiple Bifurcations
  - Thrombus-Containing
  - MV RVD ≤2.5 mm
  - MV Lesion Length ≥25 mm
  - Severe Calcification
  - Bifurcation Angle ≥70° or
  - Bifurcation Angle ≤45°

**1-Year TLF**

- Provisional: 8.0% (HR: 0.68, 95% CI: 0.31-1.49)
- DK Crush: 3.9%

- Provisional: 18.2% (HR: 0.27, 95% CI: 0.05-0.54)
- DK Crush: 7.0%

Conclusions

• Multiple techniques have been developed to effectively treat bifurcation lesions
• Each has unique advantages and disadvantages
• Being proficient with multiple techniques will assure that you are able to perform PCI regardless of varying patient anatomy with excellent technical success
Thank You