CASE STUDY

IVUS-Guided PCI For Bifurcation Lesion
Bifurcations are complex!
IVUS-guided PCI for bifurcation lesion can improve outcomes

IVUS-guided PCI for bifurcation lesion can improve outcomes


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Abstract
BACKGROUND: although intravascular ultrasound (IVUS) has been widely used for complex lesions during coronary intervention, IVUS for stenting at bifurcation lesions has not been sufficiently assessed. The aim of this study was to investigate the impact of IVUS guidance on long-term clinical outcomes during drug-eluting stent (DES) implantation for bifurcation lesions.

METHODS: the Korean multicenter bifurcation registry enrolled 1,968 patients with non-left main de novo bifurcation lesions who underwent DES implantation between January 2004 and June 2008. Using propensity score matching with clinical and angiographic characteristics, 467 patients with IVUS guidance and 467 patients with angiography guidance were selected. The long-term clinical outcomes were compared between the 2 groups.

RESULTS: baseline clinical and angiographic characteristics were well matched and showed no significant differences between the 2 groups. Two-stent technique and final kissing balloon angioplasty were more frequently performed in the IVUS-guided group. Maximal stent diameters at both the main vessel and the side branch were larger in the IVUS-guided group. Periprostural intimal hyperplasia (0.3 times of upper normal limits) was frequently observed in the angiography-guided group. The incidence of death or myocardial infarction was significantly lower in the IVUS-guided group compared to the angiography-guided group (3.1% vs 7.8%, log rank test P = .03, hazard ratio 0.44, 95% CI 0.12-0.96, Cox model P = .04).

CONCLUSIONS: intravascular ultrasound guidance during DES implantation at bifurcation lesions may be helpful to improve long-term clinical outcomes by reducing the occurrence of death or myocardial infarction.

Long-Term Outcomes of Intravascular Ultrasound-Guided Stenting in Coronary Bifurcation Lesions

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Stenting for bifurcation lesions is still challenging, and the effect of intravascular ultrasound (IVUS) guidance on long-term outcomes has not been evaluated. We evaluated 716 patients with de novo native main coronary bifurcation lesions who underwent stent implantation from January 1996 to February 2004. We compared the adverse outcomes (ie, death, stent thrombosis, and target lesion revascularization) within 4 years, after adjustment using a multivariate Cox proportional hazard model and propensity scoring. IVUS-guided stenting significantly reduced the long-term all-cause mortality (hazard ratio [HR] 0.81, 95% confidence interval [CI] 0.63 to 0.89, p = .008) in the total population and in the patients receiving drug-eluting stents (DESs) (HR 0.84, 95% CI 0.65 to 1.06, p = .13), but not in the patients receiving bare metal stents (HR 0.44, 95% CI 0.13 to 1.24, p = .21). IVUS-guided stenting had no effect on the rate of stent thrombosis (HR 0.98, 95% CI 0.36 to 2.98, p = .96, log-rank test). In patients receiving DESs, however, IVUS guidance reduced the development of very late stent thrombosis (0.4% vs 2.8%, p = .01, log-rank test). In conclusion, in patients receiving DESs, IVUS-guided stenting for treatment of bifurcation lesions significantly reduced the 4-year mortality compared to conventional angiographically guided stenting. In addition, IVUS guidance reduced the development of very late stent thrombosis in patients receiving DESs. © 2010 Elsevier Inc. All rights reserved. (Am J Cardiol 2010;106:412-418)

CONCLUSIONS:
IVUS guidance during DES implantation at bifurcation lesions may be helpful to improve long-term clinical outcomes by reducing the occurrence of death or myocardial infarction.

In conclusion, IVUS-guided stenting for bifurcation lesions significantly reduced the 4-year mortality compared to conventional angiographically guided stenting.
What can be guided by IVUS?

- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting
Precise anatomical lesion assessment

LAD:
- Lumen area: 2.8mm²
- Plaque area: 6.2mm²
- %plaque burden: 69%
- Vessel area: 9.0mm²

Diagonal branch:
- Lumen area: 2.7mm²
- %plaque burden: 46%
- Plaque area: 2.3mm²
- Vessel area: 5.0mm²
Mechanism of side branch stenosis
Important of longitudinal view

- Geometry of bifurcation lesion
- Amount, character and distribution of plaque
- Location, length of carina
- Distance between carina and outer lumen of a side branch
Important of longitudinal view

Will this diagonal branch occluded?
Precise anatomical (=functional) assessment?

LAD:
- Lumen area: 2.8mm²
- Plaque area: 6.2mm²
- %plaque burden: 69%
- Vessel area: 9.0mm²

Diagonal branch:
- Lumen area: 2.7mm²
- %plaque burden: 46%
- Plaque area: 2.3mm²
- Vessel area: 5.0mm²

Diagonal FFR 0.94
LAD FFR 0.89
Diagnostic accuracy of IVUS parameters in pure ostial lesions

Koh JS, Koo BK, et al., JACC Intv, 2012
IVUS-Guided PCI For Bifurcation Lesion

• Pre-intervention
  - IVUS can provide detailed anatomical information which is very helpful to plan the intervention strategy.
  - Longitudinal view is important to predict what will happen in side branch after main branch stent implantation.
  - IVUS parameters have low positive predictive values to predict the presence of ischemia.
What can be guided by IVUS?

- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting
How can these be assessed by IVUS?
Pre-intervention IVUS to predict jailed SB FFR

Mechanism of SB jailing

<table>
<thead>
<tr>
<th>Proximal Main Branch</th>
<th>Distal Main Branch</th>
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<tbody>
<tr>
<td>P-5</td>
<td>D1</td>
</tr>
<tr>
<td>P-4</td>
<td>D2</td>
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<td>P-3</td>
<td>D3</td>
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<td>P-2</td>
<td>D4</td>
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<tr>
<td>P-1</td>
<td>D5</td>
</tr>
</tbody>
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Plaque shift + Carina shift

Graph showing correlation between pre-intervention IVUS and jailed side branch FFR:

1. Proximal main branch plaque: $r=-0.31$, $p=0.047$
2. Distal main branch lumen: $r=0.43$, $p=0.003$

Koo BK, et al., Circ Cardiovasc Interv, 2010
Pre-intervention IVUS to predict jailed SB FFR<0.8

A. MLA within SB ostium

B. Plaque burden within SB ostium

C. MLA within the POC

Kang SJ, et al., Am J Cardiol 2011
IVUS can tell True vs. Pseudo-stenosis

FFR = 0.60

FFR = 0.92
IVUS can tell the mechanism of SB jailing

Complexity of SB jailing: Plaque, Carina, Stent......

Ref: Koo BK, TCT 2008
Different target, different strategy

• **Target: SB plaque**
  - Large balloon, high pressure
  - More injury, more dissection
  - Higher chance of SB stenting
  - More late loss

• **Target: Shifted carina**
  - Relatively small balloon, low pressure
  - Less injury, less dissection
  - Less chance of SB stenting
  - Less late loss
IVUS-Guided PCI For Bifurcation Lesion

- After main branch stent implantation
  - IVUS for jailed side branches is generally not recommended.
  - Main branch IVUS is helpful to define the degree and mechanism of side branch jail and to plan the treatment strategy.
  - Pre-intervention IVUS is not that helpful to predict the functional significance of jailed side branch.
What can be guided by IVUS?

- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting
Anatomical severity vs. Functional significance

- IVUS vs. FFR in SB ostial lesions -

Min Lumen Area: 2.0mm²
MLD: 1.2mm
Reference segment
Assessment of procedural results

Before Kissing balloon inflation

After Kissing balloon inflation
What happened?

After Kissing balloon inflation
What can be guided by IVUS?

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

Modified T  
Kissing  
Crush
Angiographically excellent, but...
Larger post-procedural MSA for larger MLA during follow-up

Under-expansion

Estimated ideal diameter by Finet’s law = 4.4mm

Over-expansion

Estimated ideal diameter by Finet’s law = 3.7mm

Average Diameter: 3.2mm

Average Diameter: 3.4mm

Reference segment
Average diameter: 3.7mm
Eccentricity: 3.51/3.75 = 0.93

Proximal stent
Average diameter: 4.2 mm
Eccentricity: 3.6/5.0 = 0.71
Over-expansion and flow dynamics

Pressure gradient in all segments: < 3mmHg

Koo BK. European Bifurcation Club 2010
• After side branch angioplasty

• After side branch stenting
  - IVUS is helpful to understand the cause of procedural difficulty/complications and to determine the procedural success of side branch PCI.
  - Keeping the natural anatomy is more important than acquiring more than enough lumen area.
PCI For Bifurcation Lesion: What can be guided by IVUS?

**Pre-intervention**
- IVUS can provide detailed anatomical information (especially, longitudinal view) to plan the intervention strategy.
- IVUS parameters have low positive predictive values to predict the presence of ischemia.

**After main branch stent implantation**
- Main branch IVUS is helpful to define the mechanism of side branch jail and to plan the side branch intervention strategy.
- Pre-intervention IVUS is not that helpful to predict the functional significance of jailed side branch.

**After side branch angioplasty/stenting**
- IVUS is helpful to determine the cause of complications and to assess the procedural success (keep the natural bifurcation geometry at the end of a procedure).