Percutaneous Coronary Intervention Strategy for Bifurcation Lesions

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LEE ET AL.: ***Percutaneous Coronary Intervention Strategy for Bifurcation Lesions.*** *True bifurcation lesion is frequently encountered in percutaneous coronary intervention. Because of the risk of acute closure after dilating the main branch lesion, intervention involving bifurcation lesion is associated with higher complication rate. Meanwhile, it is also associated with higher restenosis rate. Without anticipation and pre-defined intervention strategy, retrieval of compromised side branch after stenting the main branch may be problematic. The "Jailed Guidewire" technique was used in 32 patients with bifurcation lesions. The main branch was stented in all patients. Seven patients had stenting of both the main and side branches. Angiographic success was achieved in all main branches and in 84.4% of side branches. In-hosptial major adverse cardiac event (MACE) was 3.15% and the 6 month repeat revascularization rate was 15.6%. (J HK Coll Cardiol 2003;11:27-32)*

Bifurcation, percutaneous coronary intervention

摘要

在經皮冠狀動脈介入治療中常常會遇到真性動脈分叉處的病變。由於在主幹病變擴張後存在急性閉塞的風險，冠狀動脈分叉處病變的介入治療往往伴有較高併發症發生率。同時還伴有較高的再次狹窄的發生率。沒有預計和介入治療前精確的定位，在主幹放置支架後病損側的恢復可能是會存在問題的。在 32 例真性動脈分叉處病變中應用了“監禁導管”技術。所有病人的冠狀動脈主幹均放置了支架，有 7 位病人的主幹和側支均放置了支架。血管造影在所有主幹支均獲得了成功，而在側支中有 84.4% 的成功率。在住院期間主要心臟不良事件的發生率為 3.15%，6 個月後有 15.6% 的病人血管重建。

關鍵詞：分叉處　經皮冠狀動脈介入

Introduction

Vessel bifurcations are predisposed to atherosclerosis because of turbulent flow and increased shear stress.[1] True bifurcation lesion is defined as the presence of a stenosis >50% involving both the main branch and the ostium of its side branch. It was reported that, in the modern era, true bifurcation was involved in 13% of all intervention procedures.[2] Because of the risk of abrupt closure of the side branch after dilation of the main vessel, bifurcation lesion involving major side branch was considered to be a contraindication for percutaneous coronary intervention (PCI) in the past. Side branches with significant ostial involvement were associated with higher rate (up to 37%) of acute occlusion during angioplasty.[3] With the accumulation of experience and improvement in both techniques and hardwares, PCI of bifurcation lesion is almost a routine to most interventionists, even though it still remains a technical challenge. Our experience with a PCI strategy which had a high success rate in preserving the side branch patency after the procedure was described in this paper.

Methods

Patient Population

From January to October 2002, 32 patients were consecutively included in this observational study. Inclusion criteria comprised all types of bifurcation lesions with sidebranches >2.0 mm and supplying moderate amount of viable myocardium. The "Jailed

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Guidewire technique" described below was used during the intervention.[4] Patients with unstable angina, acute myocardial infarction or post-infarct angina were included in the study.

Procedural Data

Procedures were performed using the transfemoral approach with 6 to 8 Fr guiding catheters. If a 6 Fr guiding catheter was used, the newer generation guiding catheter with larger internal diameter (e.g. 0.07 inch or above) would be needed. After engaging the coronary artery with the guiding catheter, both the main branch and the sidebranch were crossed with a guidewire sequentially. Non-hydrophilic coated wires were used as fracture of hydrophilic coated wire had been reported with this technique. To avoid guidewire crossing, the most difficult branch, which was frequently the side branch, was wired first. Predilation of the main branch lesion and/or the side branch lesion was at the discretion of the operator. The main branch was then stented while the guidewire in the side branch was voluntarily jailed (Figure 2). After confirming there was neither stent edge dissection nor other complication, the guidewire in the main branch was pulled back and used to cross the stent struct into the side branch. The jailed-wire was then retrieved slowly and meticulously to avoid deep intubation of the guiding catheter, which might traumatize the coronary artery. It was than advanced through the stent lumen to the distal part of the main branch. After wire-exchange, high pressure dilation of the stent was performed at the operator's discretion. Finally, kissing balloon inflation (Figure 3) was performed in order to open the stent cell leading to the side branch while maintaining the geometry of the stent in the main branch. Routine stenting of the side branch was discouraged unless there was flow-limiting dissection or significant recoil despite repeated balloon inflations. Bail-out stenting of the side branch however was allowed. Heparin was given during the procedure to maintain an ACT above 250 sec. Aspirin 100 mg once a day and clopidogrel 300 mg loading followed by 75 mg daily for 4 weeks were given after stent implantation. A pre- and postprocedure off-line quantitative coronary angiography (QCA) analysis was subsequently conducted using the QCA-CMS system (Medis, The Netherlands).

Definitions

Angiographic success was defined as final lesion percentage diameter stenosis less than 50%,

Figure 1. *Left anterior oblique view showing critical proximal left anterior descending (LAD) artery bifurcation lesion involving the ostium of first diagonal branch.*

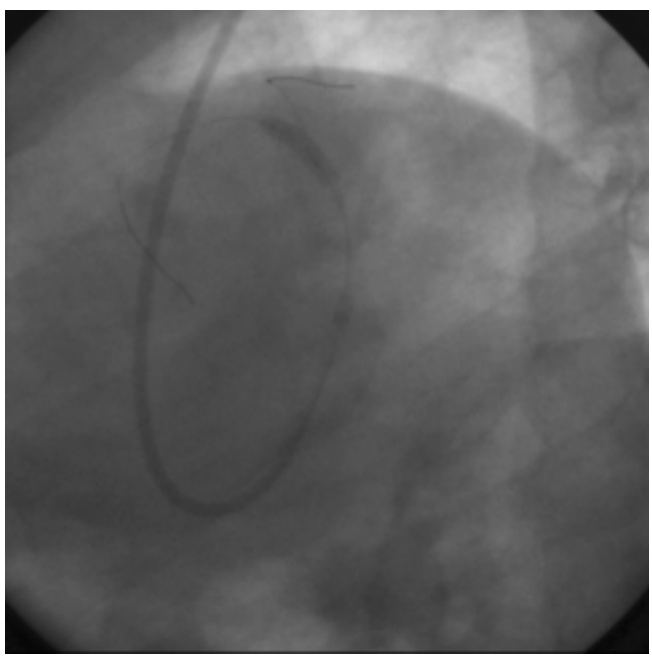

Figure 2. *Stent deployment in proximal LAD across the bifurcation while the guidewire in the first diagonal branch was jailed.*

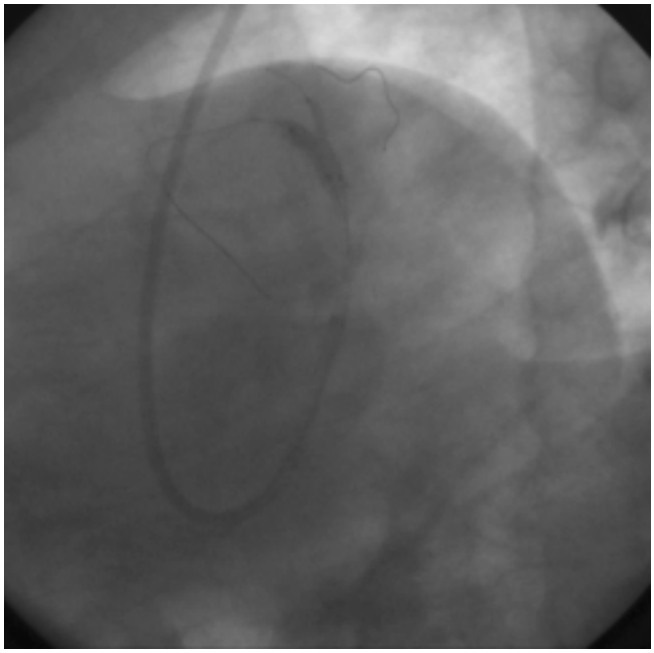

Figure 3. *After exchange of guidewire, final kissing balloon inflation was performed.*

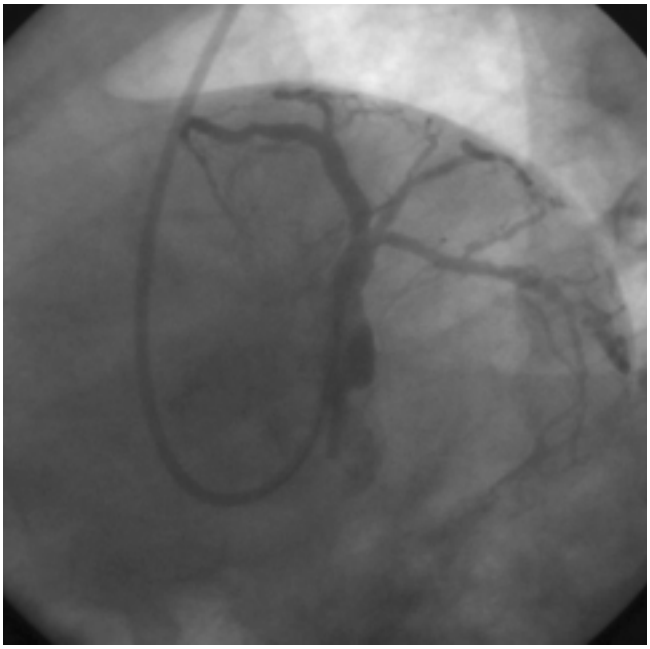

Figure 4. *Final angiogram showing widely patent LAD and first diagonal branch.*

Thrombolysis in Myocardial Infarction (TIMI) III flow and no dissection. All patients had creatine phosphokinase (CPK) determination 12-24 hours after the index procedure. 12-lead electrocardiogram (ECG) was performed 1 hour after PCI and before discharge and in case of chest pain. Myocardial infarction was defined as an elevation of CPK ≥3 times the upper limit of normal value with or without accompanied ECG changes. Major adverse cardiac event (MACE) was defined as death, myocardial infarction and urgent repeat target vessel revascularization.

Results

There were 27 male and 5 female patients (Table 1). Seventy-five percent of these patients had history of diabetes mellitus. Most of the bifurcation lesion involved the left anterior descending artery and a diagonal branch (Table 2). Distal left main coronary artery bifurcation lesion was tackled in two of these

Table 1. Baseline Clinical Characteristics (n=32)

Age (Mean±SD), y	66 ±10
Female, %	16
Diabetes mellitus, %	75
Hypertension, %	75
Hypercholesterolemia, %	81
Smoking, %	47

Table 2. Target lesion distribution

Location	Number (%)
LAD / Diag.	20 (62.5)
LCx / OM	2 (6.25)
PDA / PLV	8 (25)
LM	2 (6.25)

LAD, left anterior descending artery; Diag., diagnoal branch; LCx, left circumflex artery; OM, obtuse marginal branch; PDA, posterior descending artery; PLV, posterolateral branch; LM, left main coronary artery.

patients. According to the Duke classification,[5] there were 4 (12.5%) type C, 16 (50%) type D and 12 (37.5%) type F bifurcation lesions respectively.

Debulking, by rotational atherectomy, before stenting the main branch was performed in 5 patients (15.6%). Because of anatomical difficulty, predilation of the main branch lesion was necessary in 2 patients before successful wiring of the sidebranch. Stenting the main branch was performed in all patients. In 7 patients (21.9%), the side branch was also stented for persistent flow-limiting dissection or significant residual stenosis. Final kissing balloon inflation was performed in 30 patients (93.8%). In this series, all side branches could be preserved by the end of the procedure.

The percentage diameter stenosis of the main branch lesion decreased from 81.41% to 4.22% whereas the minimal lumen diameter (MLD) increased from 0.61 mm to 3.03 mm after stenting. In the meantime, the percentage diameter stenosis of the side branch decreased from 39.69% to 19.06% and MLD increased from 1.49 mm to 2.01 mm after the procedure.

The mean follow up so far was 199±77 days. There was one in-hospital death accounting for the 3.15% in-hospital MACE. The index patient presented with cardiogenic shock after thrombolytic therapy for acute myocardial infarction. PCI to the left main coronary artery bifurcation lesion was successful. However, the patient died 3 days after the procedure with evidence of severe pump failure. Five patients (15.6%) presented with instent restenosis requiring repeated revascularization during the follow up.

Table 3. Procedural data

	Number (%)
Debulking (rotational atherectomy)	5 (15.6)
Predilation before wiring side branch	2 (6.3)
Bifurcation stenting	7 (21.9)
Final kissing balloon inflation	30 (93.8)
Side branch loss	0 (0)
Angiographic success	
Main branch	32 (100)
Side branch	27 (84.4)

Table 4. QCA data

	Pre PCI	Post PCI
Main branch		
Reference (mm)	3.16±0.47	3.05±0.32
MLD (mm)	0.61±0.38	3.03±0.51
Stenosis (%)	81.41±10.41	4.22±6.11
Side branch		
Reference (mm)	2.47±0.43	2.32±0.38
MLD (mm)	1.49±0.92	2.01±0.63
Stenosis (%)	39.69±35.24	19.06±19.07

QCA, quantitative coronary angiography; PCI, percutaneous coronary intervention; MLD, minimal lumen diameter.

Discussion

True bifurcation lesions accounted for 4-16% of all percutaneous intervention.[2,6-8] Despite the advance in hardware and accumulation of experiences, it remained a technical challenge to interventionists. The higher rate of complications after intervention was due to the risk of side branch occlusion secondary to plaque shifting, ostial recoil, propagation of dissection[9,10] and endothelial dysfunction occurring at the site of coronary bifurcation.[11] The presence of ostial lesion in the side branch was associated with higher occlusion rate of the side branch after stenting the main branch.[12]

Side branch occlusion was usually silent. However, depending on the vessel caliber, presence and adequacy of collaterals, other coronary disease and left ventricular function, patient might present with chest pain, haemodynamic instability and malignant arrhythmia. Post-procedure cardiac enzyme leak which was associated with worse long term outcome was not uncommon.[13]

Debulking technique was used to tackle such lesions, including directional atherectomy and rotational atherectomy.[14] Both techniques were shown to be effective in treating bifurcation lesions by achieving high acute procedural success rates. However, there were increased peri-procedural rise in cardiac enzymes.[15,16]

The "jailed guidewire" technique helped to re-enter the side branch by modifying favourably the angle between both branches. It also helped to keep the side branch patent and hence the access to the side branch after main branch stenting is facilitated. Meanwhile, the "jailed guidewire" may serve as a marker of the location

of the side branch enhancing the rewiring procedure. In our series, all side branches were preserved with this technique.

Stenting both the main branch and the side branch were associated with poorer outcome compared to stenting the main branch alone.[17-19] It was also suggested that the use of tubular, instead of coil or multicellular, stents together with the use of final kissing balloon inflation might achieve better outcome. Meanwhile, compared to T stenting or provisional stenting of the side branch, culotte stenting was strongly associated with a poorer outcome.[17] Stenting of the main branch and balloon angioplasty with provisional stenting of the side branch may be a better option.

The availability of drug eluting stent may change the strategy in tackling bifurcation lesions. In the RAVEL study, the use of sirolimus eluting stent was shown to be favourable on the side branch spontaneous recanalization upon follow up.[20] The use of two sirolimus eluting stents in both branches was shown to be feasible in a recent study.[21] However, complete coverage of the ostium of the side branch was essential in reducing restenosis rate. Meanwhile, tailor-made bifurcation stent may also prove to be useful.[22]

Treatment of instent restenosis with bifurcation stenting is difficult. Vascular brachytherapy using manual pullback technique to treat long diffuse disease was reported recently.[23] Using the same concept, bifurcation brachytherapy was performed in some centers. However, no formal report has been published yet. The possible overdose effect in the bifurcation needs to be addressed by future studies.

In our series with the guidewire technique, the procedure success rate was high (100% for main branch and 84.4% for side branch) with low in-hospital complication rate. At 6-month follow-up, the clinically driven repeat revascularization secondary to restenosis was 15.6%, comparing favourably with other studies.

Limitations

It was a non-randomized study with limited number of patients. Selection bias of the patients involved might influence the outcomes. Meanwhile, only patients with recurrent symptoms had repeated angiogram to document restenosis. Thus, the angiographic restenosis rate could not be determined.

Conclusion

In conclusion, the use of jailed guidewire technique during stenting of a bifurcation lesion has a high procedural success rate, low acute complication rate and an acceptable 6-month clinical restenosis rate. However, a prospective randomized study involving larger number of patients would be needed to confirm these findings.

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