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Original Article

Immediate Small Side Branch Occlusion after Percutaneous Coronary Intervention

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Abstract

Background: *Small side branches, albeit less important than their larger counterparts, have not yet received due attention in the literature. Nor has there ever been a comparison between drug-eluting stents and bare metal stents apropos side branch occlusion. The aim of this study was to compare the patency of small (≥0.5 and ≤1.5 mm in diameter) side branches with respect to bare metal vs. drug-eluting stents immediately after their deployment.*

Methods: *This prospective bi-center study, conducted between June 2005 and January 2007, enrolled 82 patients treated with ≥1 of two stents (TAXUS™ Liberte™ or Liberte™). Side branches ≥0.5 and <1.5 mm in diameter arising from the main vessel at the lesion site were evaluated.*

Results: *Thirty-eight patients were treated with 42 Liberte™ stents (58 side branches) and forty-four patients with 50 TAXUS™ Liberte™ (102 side branches). The rate of small side branch occlusion was 35.3% (36) in the TAXUS™ Liberte™ group compared to 29.31% (15) in the Liberte™ group (P-value= 0.7). The presence of type 1 side branch morphology (Lefevre classification) was the most powerful predictor of small side branch occlusion (P-value=0.03).*

Conclusion: *This study shows that drug-eluting stents are not inferior to bare metal stents as regards small side branch occlusion during coronary stenting.*

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Keywords*: Side branch angioplasty • Coronary occlusion • Stent*

Introduction

Despite its widespread use and relative success in the treatment of ischemic coronary artery disease, percutaneous coronary intervention (PCI) is associated with a number of well-known risks, the most notable of them being iatrogenic occlusion (nipping) of the side branches in the proximity of the stenosis for which stent insertion has been attempted. PCI of the lesion in the territory of a side branch is linked with an increased risk of procedure-related myocardial infarction, chest pain, cardiac enzyme elevation, and restenosis.[1] It is important that the diameter of both branch vessels be taken into account when describing a bifurcation lesion. If one branch is ≤1.5 mm in diameter, it is generally considered to be small and not suitable for PCI. In such situations, the small branch can be ignored and stenting is performed in the larger vessel only.[2, 3]

For all the studies into the risks of large side branch occlusion during PCI,[4-6] there is a paucity of data regarding the fate of small side branches during PCI. This study was conducted to compare the direct immediate effect of two stents (with similar stent design), namely TAXUS™ Liberte™ and

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Liberte™, on the risk of small side branch occlusion during PCI. We sought to investigate whether or not the presence of polymers on the stent struts, a smaller cell-surface area, and higher metal (stent)-to-artery ratio in drug-eluting stents (DES) could compromise the ostium of tiny side branches by comparison with bare metal stents (BMS) (Liberte™) [Boston Scientific announces Liberte design.

http://www.bostonscientific.com/med_specialty/deviceDetail.jsp?task=tskBasicDevice.jsp&sectionId=4&relId=2,74,75,76&deviceId=11044&uniqueId=MPDB4399 & clickType=endeca (accessed 25 July 2007)].[7]

Methods

Patient selection

This prospective bi-center study was carried out between June 2005 and January 2007 on 82 consecutive patients treated at Shahid Faghihi and Kowsar Hospitals with two stents: TAXUS™ Liberte™ and Liberte™. Side branches ≥0.5 and ≤1.5 mm in diameter arising at the lesion site from the main vessel were assessed. Thirty-eight patients were treated with Liberte™ stents and 44 patients with TAXUS™ Liberte™ stents. Patients were eligible if they had been diagnosed with symptomatic ischemic heart disease: stable or unstable angina and/or objective evidence of myocardial ischemia. Additionally, the luminal diameter of the lesion had to have a stenosis of at least 51%.The exclusion criteria were myocardial infarction (MI) within 72 hours preceding the index procedure, angiographic evidence of thrombus within the target lesion, poor distal run-off, and presence of total occlusion. Side branches that were compromised or lost during balloon predilatation were excluded. Written informed consent was obtained from each patient for the utilization of data in this study, and the study protocol was approved by the hospital ethics committees.

Stents

The TAXUS™ Liberte™ Paclitaxel-Eluting coronary stent system (Boston Scientific Corporation, Natic, MN) is a device/drug combination product comprised of two regulated components: a device (TAXUS™ Liberte™ stent mounted onto the Liberte delivery system) and a drug product (a formulation of Paclitaxel contained in a polymer coating). On the other hand, Liberte™ Monorail stent (Boston Scientific Corporation, Natic, MN) is a balloon expandable Liberte™ stainless steel stent premounted on Maverick™ catheter technology. Both stents have a Liberte™ stent design (both have small open cell areas). TAXUS™ Liberte™ stents have a lower cell-surface area (2.65 vs. 2.75 mm^2), with the polymer thickness of 0.0006 inch, higher crossing profile (0.047 vs.0.041 inch), and higher metal-to-artery ratio (percentage of artery wall covered by the outer surface of the stent) (22.3% vs. 17%).[7]

Study procedures

Premedication treatment included chronic treatment (>5 days) of aspirin (75-100 mg/day) and clopidogrel (75 mg/day) or ticlopidine (250 mg bd). In the non-pretreated patients, a loading dose of clopidogrel 300 mg the day before or 600 mg (if given <8 hours from PCI) was administered. During the procedure, the patients received 10,000 U bolus of heparin with a repeat bolus of 5000 to maintain the activated clotting time ≥250 seconds. The lesions were treated with the use of contemporary techniques and manufacturer's instruction for use. Predilatation and high pressure stent post dilation (≥14 atm) was advised but direct stenting was also allowed. After the stent was implanted, further dilatation was performed to ensure that the residual stenosis was ≤20% as assessed with the Siemens Koroscope viewer 1997 (Siemens Medical Imaging, Germany).

Coronary angiographic data management

Coronary angiograms were obtained in multiple views after the intracoronary injection of nitrate (solution 1/40%). The analyses of all the angiographic data before, during, and after the procedure were performed with the use of the Siemens Koroscope viewer 1997 (Siemens Medical Imaging, Germany) by two independent interventionists blinded to the stent type. Visual assessments included main vessel lesion type according to the American College of Cardiology/ American Heart Association (ACC/AHA) classifications and side branch type according to the Lefevre classification[7] (practical and easily applicable classification among many bifurcation classifications).[3,7-9] The diameter of the normal segment proximal to the traced area in the parent vessel was used to determine the parent reference diameter (RD), and the side branch RD was determined from the diameter of the traced area in the normal segment distal to the lesion in the branch. The minimal luminal diameter (MLD), RD, and the percent of stenosis were calculated as the mean values from two projections. The lesion length was defined as the distance from the proximal to the distal shoulder of the lesion. The angle between the distal main vessel and side branch was defined as the distal angle and was measured by joining the two centerlines of the daughter vessels in the middle of the bifurcation using the angiographic projection with the widest opening of the two branches.

Study endpoints

Primary end point was comparison of immediate small Side branch (SB) compromise during PCI with two stents. SB compromise was divided into two groups: 1) Side branch occlusion (SBO) was defined as abrupt loss or TIMI flow grade ≤II in SB during the procedure, 2) SB compromise without occlusion was defined as abrupt decrease in the diameter during the procedure without any decrease in the SB

TIMI flow grade. Secondary endpoints were determination of predictors of small SBO.

Study statistical analysis

The continuous data were presented as mean±standard deviation and discrete data as frequencies. The continuous variables were compared using the independent sample t-test, and the categorical variables were compared with the Pearson Chi-square or Fisher exact test. The Fisher exact test was employed when any expected cell count was <5 (not resulting from missing rows or columns in a larger table). P-value ≤0.05 was considered statistically significant. All the analyses were performed using SPSS 13 for Windows.

Results

Thirty-eight patients were treated with Liberte™ stents and forty-four patients received TAXUS™ Liberte™ stents. As is shown in Table 1, there were no significant differences between the two groups in terms of baseline clinical characteristic. The angiographic and procedure–related characteristics of the 92 main vessel lesions and 160 side branches are summarized in Tables 2, 3, and 4, respectively. Lesions treated with TAXUS™ Liberte™ stents were longer than those treated with Liberte™ stents. Meanwhile, the baseline MLD and RD and post-procedure MLD of the main vessel lesions were matched in the two groups. Overall, there were 33.12 % (53) side branch compromises: 10.62 % (17) of the side branches were completely occluded, whereas 22.5% (36) were compromised without complete occlusion. The rate of side branch compromise was 35.3% (36) in the TAXUS™ Liberte™ group compared to 29.31% (15) in the Liberte™ group (P-value= 0.7).

Side branch compromise primarily developed in the side branches with type 1 Lefevre classification morphology (24/52; 46.15 %). However, other morphologies, DES, and Y angle of the side branches were not related to side branch occlusion.

Table 1. Baseline demographics and clinical characteristics*

	TAXUS Liberte (44)	Liberte (38)
Age (y) (mean±SD)	61.9±9.6	62.1±9.4
Male	72.72(32)	65.79(25)
Medically Treated diabetes	27.27(12)	26.31(10)
Insulin requiring	9.09(4)	7.90(3)
Non-insulin requiring	18.18(8)	18.41(7)
Medically treated hyperlipidemia	68.18(30)	65.79(25)
Medically treated hypertension	56.82(25)	55.26(21)
Current smoking	34.09(15)	28.94(11)
Renal failure	6.82(3)	7.90(3)
Prior myocardial infarction	34.09(15)	31.58(12)
Unstable angina	27.27(12)	26.31(10)
2 vessel disease	13.63(6)	10.52(4)

*All the p values were non significant
The numbers in the parenthesis show the number of cases, and the numbers out of the parenthesis show the related percentage

Table 2. Baseline angiographic characteristics of the main vessel lesions*

Variables	TAXUS ™ Liberte™ (n=50)	Liberte™ (n=42)
Length** (mm) (mean±SD)	24.16±6.17	14.96±5.55
Reference dimension (mm)	2.85±0.40	2.92±0.64
Minimal luminal diameter (mm)		
Base line	0.99±0.83	1.25±1.02
Finial	2.76±0.45	2.82±0.55
Calcification % (n)	28 (14)	28.57 (12)
Infarct related artery % (n)	14 (7)	11.90 (5)
Lesion location % (n)		
LAD	56 (28)	47.62 (20)
LCX	20 (10)	28.57 (12)
RCA	24 (12)	23.81 (10)
Lesion Type % (n)		
A	10 (5)	9.52 (4)
B_1	20 (10)	26.20 (1)
B_2	30 (15)	28.57 (12)
C	40 (20)	35.71 (15)

*All p values were non significant except for** which was 0.001
LAD, Left anterior descending artery; LCX, Left circumflex artery; RCA, Right coronary artery

Table 3. Procedural characteristics*

Variables	TAXUS Liberate (n=50)	Liberate (n=42)	p value
Stent			
Length (mm)	28.08±4.67	16.81±4.44	0.001
Diameter (mm)	2.87±0.17	3.03±0.38	0.009
Number of stents per patient	1.13	1.10	NS
Maximal balloon inflation (atm)	13.5±0.8	13.3±1	NS
Balloon to artery ratio	1.03±0.04	1.01±0.05	NS

*Data are presented as mean±SD
NS, Non significant

Table 4. Baseline angiographic characteristics of 160 side branches*

Variables	TAXUS Liberate (n=102)	Liberate (n=58)	p value
Minimal luminal diameter (mm)	0.77±0.34	0.80±0.36	0.56
Reference diameter (mm)	0.90±0.46	0.88±0.33	0.71
Angle Y % (n)	49.02 (50)	51.72 (30)	0.43
Morphology			
Type 1 % (n)	28.43 (29)	32.76 (19)	0.37
Type 2 % (n)	39.21 (40)	34.48 (20)	0.37

*Data are presented as mean±SD

Table 5. Predictors of small side branch occlusion

Variables	Odds ratio	95%CI	p value
Morphology			
Type 1	4.266	1.12-16.25	0.03
Type 2	0.55	0.12-2.56	0.45
Angle Y	1.37	0.67-2.82	0.38
Taxus™ Liberte™	1.29	0.6-2.47	0.51

CI, Confidence interval

Discussion

Despite the fact that there have been many studies focusing on the fate of side branches in bifurcation lesions after coronary stenting,[4,10,11] no published report exists concerning the destiny of small side branches during main vessel PCI. Experimental evidence suggests although the metal struts of the stent do not completely cover the orifices of a side branch, the blood flow into the side branch after stenting may be compromised. Fishman et al.,[12] reporting the outcome of side branches in patients with the Palmaz-Schatz stent, demonstrated that 5% of the side branches were occluded immediately after stenting. Mazur et al.[13] reported the results of Gianturco-Roubin stenting for the treatment of acute or threatened closure after balloon angioplasty. They reported that side branch occlusion developed in 6% of the major side branches after stenting. Cho et al.[4] found 10% side branch occlusion during PCI with three different BMSs. In our series, 33.12% of the side branches were compromised: 10.6% were occluded completely and 22.5% were just compromised without occlusion. These differences could be interpreted in multiple ways: the criterion for side branch occlusion in the Cho et al.,[4] Fishman et al.,[12] and Mazur et al.[13] studies was a persistent reduction in the thrombolysis in myocardial infarction (TIMI) flow grade <1. They did not consider side branches that developed TIMI flow grade II as side branch occlusion, and nor did they take into account side branches that were compromised during stenting but had a normal TIMI flow. In the aforementioned studies, fewer than 20% of the side branches had a type D morphology (equivalent to type 1 Lefevre classification in our study), which is important to consider because this was the most important predictor of side branch occlusion in their study.[4] The other interesting finding in our study was that the small side branches were compromised more than they were occluded totally (22.5 % vs. 10.6%).

Side branches originating from a stenosed segment of a coronary artery are indeed in some jeopardy during the PCI of the segment. The possible mechanism of side branch occlusion after stenting is 'the snow plow effect', where atheroma is shifted into the ostium of the small side branch from the parent vessels.[14] Other mechanisms may include the spasm of the side branch, embolization of atherosclerotic material, thrombus formation, and stent material itself.

In our series, the presence of ostial narrowing that arose from within or just beyond the diseased portion of the parent vessel (type 1 Lefevre classification morphology) was the most powerful predictor of side branch compromise immediately after stenting. This finding suggests that the plaque volume of the parent vessel and the side branch is a major determinant of the fate of a side branch (as was confirmed for larger side branches).[4,15] It is also deserving of note that in the present study, other lesions and side branch characteristics (angel, RD, MLD) had no correlation with side branch compromise.

This study demonstrated that despite a lower cell-surface area, presence of polymer, higher metal-to-artery ratio, and crossing profile, normally associated with a higher chance of spasm and side branch occlusion,[16] there was no statistically significant difference between the two groups regarding small side branch compromise. It seems that these differences are less important than was previously assumed.[3,17]

Although the occlusion of small side branches are less important than that of their larger counterparts, it can occasionally lead to clinically important events such as prolonged chest pain, ECG changes, MI, or hemodynamic instability (esp. if such occlusion leads to right ventricular infarction or papillary muscle dysfunction).[3,15,16]

Conclusion

This study demonstrated that with respect to small side branches (≥0.5 and ≤1.5 mm in diameter), TAXUS Liberte™ stents showed no immediate inferiority to BMSs (Liberte™) after stent insertion: the rate of small side branch occlusion was 35.3% (36) in the TAXUS™ Liberte™ group and 29.31% (15) in the Liberte™ group (P-value= 0.7). The presence of type 1 side branch morphology (Lefevre classification) seems to be the most important predictor of small side branch compromise (including total occlusion and compromise only) during PCI.

Our study had some limitations. First, it was relatively underpowered by the inclusion of a small number of patients. If the trend remains constant (P-value=0.7), there is a need for at least 1300 side branches to compare side branch compromise more precisely. It should also be noted that our study did not randomize the patients into one of the two treatment strategies. Another point that the present study omitted to address was the difference between the two groups in terms of the stent diameter and length.

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