ORIGINAL ARTICLE

Assessment of Predictors of Side Branch Occlusion after Main Vessel Stenting in Coronary Bifurcation Lesions in Patients Undergoing Percutaneous Coronary Intervention

Muhammad Mohsin[1], Hamid Sharif Khan[1], Muhammad Saleem[1] and Aamir Afzal[2]

Abstract

Objective: To determine the frequency of side branch (SB) occlusion during percutaneous coronary intervention (PCI) with stenting of bifurcation lesions and to assess the predictors of side branch occlusion in local population.

Study Design: Cross-sectional study.

Place and Duration of Study: Cardiac Catheterization Lab, Rawalpindi Institute of Cardiology, Rawalpindi, from July 2016 to January 2017.

Methodology: A total of 200 patients fulfilling the inclusion criteria were included in the study with non-probability consecutive sampling technique. Variables like diameters and lesion lengths of main vessel and side branch were recorded using quantitative coronary analysis software (QCA). The SB occlusion was defined as <3 TIMI score following main vessel PCI with stenting. The data was analysed using SPSS version 21.0.

Results: Mean age (years) of the study population was 52.27 ±13.33 including 180 (90.0%) male and 20 (10.0%) female patients. SB occlusion was observed in 15 (7.5%) of cases. Mean SB diameter was significantly larger in cases without SB occlusion than those with SB occlusion (2.06 ±0.09 vs. 2.17 ±0.26, p=0.003). Similarly, SB lesions were significantly shorter in length in those without SB occlusion than those with SB occlusion (3.53 ±0.51 and 4.66 ±3.11, p<0.001). However, mean MV diameter (mm) and mean MV lesions length (mm) in both the groups were statistically not significant.

Conclusion: Mean SB diameter and lesion length are useful predictors of SB occlusion during stenting of bifurcation lesions in the local population.

Key Words: *Bifurcation stenting, Side branch occlusion, Bifurcation lesions, Percutaneous coronary intervention.*

INTRODUCTION

Atherosclerosis frequently occurs at branching points due to higher turbulence and shear stress.[1] This is the reason why lesions at bifurcation sites are common. Approximately 15-20% of coronary stenotic lesions treated with percutaneous coronary interventions (PCIs) involve treatment of bifurcation lesions.[2-4] They, however, are challenging because of a relatively lesser procedural success and higher rate of complications.[2,3,5-9] Currently, one stent with provisional side-branch stent implantation/balloon dilatation is the preferred strategy during treatment of bifurcation lesions.[5,6,8-12]

Nonetheless, side branch (SB) occlusion occurs in about 20% of cases after main-vessel (artery) stent implantation.[5,8,10-12] It could be associated with rewiring failure, peri-procedural MI, higher incidence of stent thrombosis in the first month post-stenting and an increase in the incidence of major adverse cardiac events (MACE) in patients with persistently occluded SB.[5,6,8-12] Various predictors have been studied that may increase the risk of SB occlusion during main branch stenting. Firstly, SB with ostial lesions was observed to occlude more than those without such lesions.[2,3] Secondly, SB lesion length is an important factor for occlusion as it occurs frequently in SB with longer (>5 mm), diffuse lesions.[3] Thirdly, plaque shift is another mechanism of SB occlusion. Greater plaque burden in the proximal main vessel segment is predictive of SB occlusion. However, plaque burden in the distal segment of the main branch does not seem to have an effect on occlusion of the SB. Additionally, unstable plaques, such as those seen in ACS, with a higher thrombus burden are more likely to cause thrombus shift and SB occlusion at the ostium. This is also known as the snow-plow effect.[5,6,12]

One study conducted in China showed that 4.9% patients had SB occlusion, the difference in predictors between SB occluded and non-occluded patients was insignificant, *i.e.* SB diameter (2.3 ±0.2 mm *vs*. 2.3 ±0.3 mm, p=0.14), Lesion length (3.9 ±2.2 mm *vs*. 3.6 ±2.1 mm, p=0.45), MV diameter (3.2 ±0.4 mm *vs*. 3.1 ±0.5 mm, p=0.20) and MV lesions length (10.0 ±4.6 mm *vs*. 12.3 ±7.3 mm, p=0.07).[13] But another study conducted in Korea has shown that whether patients have SB

[1] *Department of Cardiology, Rawalpindi Institute of Cardiology (RIC), Rawalpindi, Pakistan.*

[2] *Statistician, Foundation University Islamabad (FUI), Islamabad, Pakistan.*

Correspondence: Dr. Muhammad Mohsin, Rawalpindi Institute of Cardiology (RIC), Rawalpindi, Pakistan.
E-mail: mohsin.doctor21@gmail.com

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occlusion or not, the difference in predictors was significant, i.e. SB diameter [2.3 (2.3-2.4) mm *vs*. 2.4 (2.3-2.7) mm, p<0.001], Lesion length [4.3 (0.6-9.7) mm *vs*. 0.0 (0.0-5.5) mm, p<0.001], MV diameter [3.2 (2.9-3.6) mm *vs*. 3.4 (3.0-3.8) mm, p<0.001] and MV lesions length [19.5 (12.2-26.9) mm *vs*. 15.6 (10.0-24.2) mm, p<0.001].[12]

There is an ongoing debate about stenting strategy in coronary bifurcation lesions. Literature shows controversial results, and no local study has been conducted on SB occlusion during bifurcation stenting so far in Pakistan. Since there is difference in sizes of coronary vessels of Asians and European populations, the rationale of this study was to confirm how these predictors of side branch occlusion affect local population as compared to international studies. This will help in proper risk stratification of patients undergoing PCI and reduce morbidity and mortality.

The objective of this study was to assess the frequency of side branch occlusion during stenting of main coronary vessel in patients undergoing percutaneous coronary intervention for bifurcation lesions, and to compare the predictors of side branch occlusion like SB diameter, SB lesion length, main vessel diameter and main vessel lesion length in patients with or without SB occlusion.

METHODOLOGY

It was a cross-sectional study conducted at the Cardiac Catheterization Lab, Rawalpindi Institute of Cardiology (RIC), Rawalpindi, from July 2016 to January 2017. Sample size of 200 cases was calculated with 95% confidence level, 3% margin of error and taking expected percentage of SB occlusion, *i.e.* 4.9%,[12] in patients undergoing PCI for bifurcation lesions.

Inclusion criteria were age 35-75 years, either gender of patients undergoing PCI with stenting for coronary bifurcation lesion with at least 2.0 mm main vessel size and treated with drug eluting stents.

Exclusion criteria were left main stem disease, RCA-RV bifurcation (on angiography), in-stent restenosis (on medical record), deranged renal function tests (creatinine >1.2 g/dl), a history of contrast allergy and patients with acute coronary syndrome (unstable angina, non-ST elevation myocardial infarction and ST elevation myocardial infarction).

Patients fulfilling selection criteria were enrolled in the study from angiography ward of RIC, Rawalpindi. They were briefed about the study, and informed consent was taken. Demographic information (name, age, gender, type of ACS) was obtained. A bifurcation lesion was defined as atherosclerotic coronary artery narrowing occurring adjacent to and/or involving, the origin of a significant side branch (at least 1.5 mm). The disease at bifurcation may involve the proximal main vessel, the distal main vessel and/or the side branch. Side branch occlusion after main branch stenting was defined as Thrombolysis in Myocardial Infarction (TIMI) flow grade <3. All patients underwent coronary angiography by using Toshiba Infinix-8000V single plane angiography machine by a senior consultant cardiologist having 4 years' residency experience. Predictors were measured as SB diameter, SB lesion length, MV diameter, MV lesion length, recorded in millimeters using QCA software. The patients underwent stenting of main vessel and provisional stenting of side branch. Post procedure the status of side branch was reassessed and two groups were formed, *i.e.* group I with SB occlusion and group II without SB occlusion. The information was recorded on a structured proforma.

Data was entered and analysed in SPSS version 21.0. Mean and standard deviation was calculated for numerical variables like age and BMI. Frequencies and percentages were calculated for categorical variables like gender, type of ACS, bifurcation lesion, SB occlusion and predictors (SB diameter, lesion length, MV diameter and MV lesions length). Independent sample t-test was applied to compare the means. The p-value $\leq$0.05 was considered as significant.

RESULTS

Data was entered and analysed in SPSS version 21.0. A total of 200 patients were included according to the inclusion criteria of the study. Mean age (years) in the study was 52.27 $\pm$13.33 with ranges from 35 to 75 years; whereas, mean body mass index was 24.35 $\pm$2.93 kg/m^2. Mean SB diameter (mm), SB lesion length (mm), MV diameter (mm) and MV lesions length (mm) were 2.16 $\pm$0.25, 4.57 $\pm$3.01, 3.16 $\pm$0.48 and 15.76 $\pm$7.93, respectively. There were 180 (90.0%) male and 20 (10.0%) female patients.

Distribution of bifurcation lesions were 125 LAD (62.5%), was 35 LCX (17.5%) and was 40 RCA (20.0%) lesions. Frequency of side branch occlusion during stenting of main branch in patients undergoing percutaneous coronary intervention for bifurcation lesions was 15 (7.5%).

Mean values of predictors were compared in patients with or without side branch occlusion. Mean SB diameter was significantly larger in cases without SB occlusion than those with SB occlusion (2.06 ±0.09 *vs*. 2.17 ±0.26, p=0.003). Similarly, SB lesions were significantly shorter in length in those without SB occlusion than those with SB occlusion (3.53 ±0.51 and 4.66 ±3.11, p<0.001). However, there was no significant difference in the mean MV diameter (mm) in both the groups (3.26 $\pm$0.46 *vs*. 3.15 $\pm$0.49, p=0.394) and difference in mean MV lesions length (mm) in both the groups was also not statistically significant (15.26 $\pm$2.47 *vs*. 15.80 $\pm$8.22, p=0.541) summarised in Table I.

Table I: Comparison of predictors in both the groups.

Predictors	Two groups	Mean ±SD	p-value*
SB diameter (mm)	SB occlusion	2.06+0.09	0.003
	No SB occlusion	2.17+0.26	
SB lesion length (mm)	SB occlusion	3.53+0.51	0.000
	No SB occlusion	4.66+3.11	
MV diameter (mm)	SB occlusion	3.26+0.46	0.394
	No SB occlusion	3.15+0.49	
MV lesions (mm)	SB occlusion	15.26+2.47	0.541
	No SB occlusion	15.80+8.22	

**P<0.05 was taken as level of significance.*

DISCUSSION

Side branch (SB) occlusion is one of the major complications associated with percutaneous coronary intervention (PCI) of bifurcation lesions. 15-20% cases of percutaneous coronary intervention involved bifurcation coronary lesions.[14,15] In interventional cardiology, coronary bifurcation lesion stenting is still one of the most challenging fields and the treatment is still debatable. Provisional stenting as a routine bifurcation stenting technique has been recommended in several randomised clinical trials.[16,17]

During bifurcation stenting, side branch (SB) occlusion is a common PCI related complication. In many previous studies, it was documented that presence of SB ostial disease was an independent predictor of SBC occlusion after PCI, but now it has been proven that multiple clinical and angiographic factors increase the risk of side branch occlusion. The risk of SB occlusion is the most important factor affecting the selection of an optimal intervention strategy in coronary bifurcation intervention. Previous studies have reported that the risk of SB occlusion could be affected by numerous factors like bifurcation lesion anatomy and the PCI procedure.[18,19]

Atherosclerotic disease in coronary artery leads to turbulent blood flow, this develops atherosclerosis in side branches of main coronary arteries resulting bifurcation coronary lesions. The frequency of side branch occlusion (SBO) is reported about 12-41% in different studies.[20] The occlusion of side branches with smaller diameter is mostly well tolerated,[21,22] however occlusion of branches of larger diameter is associated with serious complications during PCI.[20,23] Multiple factors increase the risk of SBO during PCI. The anatomy and morphology of atheromatous plaque as well as plaque burden are the major predictors of SBO during PCI. Snow plow effect of plaque burden at the bifurcation site compromises the side branch, even if there is no significant disease of ostium of the SB. However, the plaque volume in the main vessel as well as in side branch is the main determinant of the fate of the side branch.

In this study, mean age (years) was 52.27 ±13.33. Similarly, the results of another study[24] showed that the mean age in years was 50.2 ±12.8 which is almost similar to our results. Mean body mass index was 24.35 ±2.93; whereas, in a study conducted by Dou *et al*.[25] the body mass index was 26.1 ±3.1, which is comparable to this study. In the present study, there were 180 (90%) male and 20 (10%) female patients included. Similarly, another study,[24] showed that 70% patients were male and 30% were female. In this study, the mean SB diameter (mm) in both the groups (with or without side branch occlusion) was 2.06 ±0.09 and 2.17 ±0.26, which was statistically significant (p-value 0.003); whereas, mean SB lesion lengths (mm) in both the groups were 3.53 ±0.51 and 4.66 ±3.11, which was statistically significant (p<0.001). Similarly, mean MV diameters (mm) in both the groups were 3.26 ±0.46 and 3.15 ±0.49 which was not statistically significant (p-value 0.394); whereas, mean MV lesions lengths (mm) in both the groups were 15.26 ±2.47 and 15.80 ±8.22. These results were similar to a study conducted in China[13] in which the differences in predictors were compared between SB occluded and non-occluded patients, i.e. the SB diameter (2.3 ±0.2 mm *vs*. 2.3 ±0.3 mm, p=0.140), SB lesion length (3.9 ±2.2 mm *vs*. 3.6 ±2.1 mm, p=0.45), MV diameter (3.2 ±0.4 mm *vs*. 3.1 ±0.5 mm, p=0.200) and MV lesion length (10.0 ±4.6 mm *vs*. 12.3 ±7.3 mm, p=0.070).[13] Frequency of side branch occlusion during stenting of main branch in patients undergoing percutaneous coronary intervention for bifurcation lesions was 15 (7.5) in this study; whereas, another study showed that 4.9% patients had side branch occlusion.[13]

CONCLUSION

The study concludes that mean values of SB diameter and SB lesion length are important predictors for SB occlusion while stenting of the main branch during percutaneous coronary intervention for bifurcation lesions in the local population. These factors have to be taken into account for proper risk stratification of patients undergoing PCI and reduce morbidity and mortality.

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REFERENCES

1. Pyle AL, Young PP. Atheromas feel the pressure: biomechanical stress and atherosclerosis. *Am J Pathol* 2010; **177**:4-9.
2. Colombo A, Al-Lamee R. Bifurcation lesions an inside view. *Circ Cardiovasc Interv* 2010; **3**:94-6.
3. Koo BK, Waseda K, Kang HJ, Kim HS, Nam CW, Hur SH, *et al*. Anatomic and functional evaluation of bifurcation lesions undergoing percutaneous coronary intervention. *Circ Cardiovasc Interv* 2010; **3**:113-9.
4. Kervinen K, Niemelä M, Romppanen H, Erglis A, Kumsars I, Maeng M, *et al*. Clinical outcome after crush versus culotte stenting of coronary artery bifurcation lesions: the Nordic Stent Technique Study 36-month follow-up results. *Circ Cardiovasc Interv* 2013; **6**:1160-5.
5. Romagnoli E, De Servi S, Tamburino C, Colombo A, Burzotta F,

Presbitero P, *et al*. Real-world outcome of coronary bifurcation lesions in the drug-eluting stent era: results from the 4,314 patients Italian Society of Invasive Cardiology (SICI-GISE) Italian Multicenter Registry on Bifurcations (I-BIGIS). *Am Heart J* 2010; **160**:535-42.

6. Athappan G, Ponniah T, Jeyaseelan L. True coronary bifurcation lesions: meta-analysis and review of literature. *J Cardiovasc Med* 2010; **11**:103-10.
7. Serruys PW, Morice MC, Kappetein AP, Colombo A, Holmes DR, Mack MJ, *et al*. Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease. *New Eng J Med* 2009; **360**:961-72.
8. Hildick-Smith D, De Belder AJ, Cooter N, Curzen NP, Clayton TC, Oldroyd KG, *et al*. Randomized trial of simple versus complex drug-eluting stenting for bifurcation lesions the British Bifurcation Coronary Study: old, new, and evolving strategies. *Circulation* 2010; **121**:1235-43.
9. Yang JH, Song YB, Song PS, Hahn JY, Choi SH, Choi JH, *et al*. Impact of coronary bifurcation angle on clinical outcomes after percutaneous coronary intervention in real-world practice: results from the COBIS registry. *Cardiology.* 2012; **122**:216-24.
10. Iakovou I, Kadota K, Papamentzelopoulos S, Pavlides G, Mitsudo K. Is there a higher risk of stent thrombosis in bifurcation lesion or is it related to the technique? *EuroIntervention* 2010; **6**:J107-11.
11. Park TK, Park YH, Song YB, Oh JH, Chun WJ, Kang GH, *et al*. Long-term clinical outcomes of true and non-true bifurcation lesions according to medina classification-results from the COBIS (Coronary BIfurcation Stent) II Registry. *Circ J* 2015; **79**:1954-62.
12. Hahn JY, Chun WJ, Kim JH, Song YB, Oh JH, Koo BK, *et al*. Predictors and outcomes of side branch occlusion after main vessel stenting in coronary bifurcation lesions: results from the COBIS II Registry (Coronary BIfurcation Stenting). *J Am Coll Cardiol* 2013; **62**:1654-9.
13. Zhang D, Xu B, Yin D, Li YP, He Y, You SJ, *et al*. Clinical and angiographic predictors of major side branch occlusion after main vessel stenting in coronary bifurcation lesions. *Chin Med J* 2015; **128**:1471.
14. Iakovou I, Schmidt T, Bonizzoni E, Ge L, Sangiorgi GM, Stankovic G, *et al*. Incidence, predictors, and outcome of thrombosis after successful implantation of drug-eluting stents. *JAMA* 2005; **293**:2126-30.
15. Latib A, Colombo A. Bifurcation disease: what do we know, what should we do? *Cardiovasc Interv* 2008; **1**:218-26.
16. Colombo A, Bramucci E, Saccà S, Violini R, Lettieri C, Zanini R, *et al*. Randomized study of the crush technique versus provisional side-branch stenting in true coronary bifurcations the CACTUS (Coronary Bifurcations: Application of the Crushing Technique Using Sirolimus-Eluting Stents) study. *Circulation* 2009; **119**:71-8.
17. Ferenc M, Gick M, Kienzle RP, Bestehorn HP, Werner KD, Comberg T, *et al*. Randomized trial on routine *vs*. provisional T-stenting in the treatment of de novo coronary bifurcation lesions. *Eur Heart J* 2008; **29**:2859-67.
18. Hayashi S, Tohyama S, Shindo T, Fukui K, Shiba K, Nakao M, *et al*. Risk of side branch occlusion after coronary Palmaz-Schatz stenting. *J Cardiol* 1997; **29**:261-6.
19. Kralev S, Poerner TC, Basorth D, Lang S, Wolpert C, Haghi D, *et al*. Side branch occlusion after coronary stent implantation in patients presenting with ST-elevation myocardial infarction: clinical impact and angiographic predictors. *Am Heart J* 2006; **151**:153-7.
20. Takebayashi H, Haruta S, Kohno H, Ichinose H, Taniguchi M, Shimakura T, *et al*. Immediate and 3-month follow-up outcome after cutting balloon angioplasty for bifurcation lesions. *J Interven Cardiol* 2004; **17**:1-7.
21. Melikian N, Mario CD. Treatment of bifurcation coronary lesions. *J Interven Cardiol* 2003; **16**:507-13.
22. Timurkaynak T, Ciftci H, Ozdemir M, Cengel A, Tavil Y, Kaya M, *et al*. Side branch occlusion after coronary stenting with or without balloon predilation: direct versus conventional stenting. *J Invasive Cardiol* 2002; **14**:497-501.
23. Cho GY, Lee CW, Hong MK, Kim JJ, Park SW, Park SJ. Effects of stent design on side branch occlusion after coronary stent placement. *Catheter Cardiovasc Intern* 2001; **52**:18-23.
24. Ali L, Asghar N, Nazim M. Clinical and angiographic predictors of major side branch occlusion after main vessel stenting in coronary bifurcation lesions. *Annu Pak Inst Med Sci* 2016; **12**: 151-5.
25. Dou K, Zhang D, Xu B, Yang Y, Yin D, Qiao S, *et al*. An angiographic tool for risk prediction of side branch occlusion in coronary bifurcation intervention: the RESOLVE score system (risk prediction of side branch occlusion in coronary bifurcation intervention). *Cardiovas Interv* 2015; **8**:39-46.