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Original Research Article

Angiographic determinants for side branch treatment in distal unprotected left main coronary artery bifurcation percutaneous coronary intervention with single stent crossover technique

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ABSTRACT

Background: The aim of this study was to analyze angiographic parameters such as bifurcation angle, diameter at the polygon of confluence (POC) and SYNTAX score in predicting the need for side branch treatment with single-stent crossover technique from distal unprotected left main coronary artery (ULMCA) to the major side branch.
Methods: This was a retrospective and observational study. A total of 83 patients with distal ULMCA lesions were enrolled. Patients who underwent provisional single-stent crossover technique were compared with patients that required side branch treatment though plain old balloon angioplasty (POBA) 5 (6.0%) or stenting 7 (8.4%). Angiographic parameters, bifurcation angle, diameter at the POC and the SYNTAX score were analyzed for their ability to predict the need for side branch treatment.
Results: Mean age of patients was 58.2±5.3 years. Males constituted 61 (73.5%) patients. Post main branch stenting 5 (6.0%) and 7 (8.4%) patients required side branch treatment with POBA and stent implantation, respectively. Binary regression revealed bifurcation angle (Z: 1.15, OR: 0.99, 95% CI: 0.97-1.01, p=0.25), diameter at the POC (Z: 1.1, OR: 0.82, 95% CI: 0.32-2.13, p=0.272) and SYNTAX score (Z: 1.51, OR: 1.18, 95% CI: 0.95-1.45, p=0.132) did not correctly predict the requirement of side branch treatment.
Conclusion: Left main coronary artery to main branch stenting can be performed safely with single-stent crossover technique, irrespective of presence of side branch disease across a wide range of bifurcation angles, diameters at the POC and SYNTAX scores.

Keywords: Bifurcation angle, Coronary artery bypass graft, Left main coronary artery, Percutaneous coronary intervention, Polygon of confluence, Qualitative coronary analysis, SYNTAX score

INTRODUCTION

Previously, coronary artery bypass grafting (CABG) was the recommended treatment strategy for the majority of patients with unprotected left main coronary artery (ULMCA) disease.[1,2] However, the recent introduction of safe and effective stents, new medications and devices and increased operator experience has led to percutaneous coronary intervention (PCI) as an alternative strategy.[3] Clinical studies have proven PCI to be non-inferior to CABG in patients with low or intermediate SYNTAX scores.[4,5] PCI has also been shown to confer high procedural success rates, low procedural complication rates and encouraging long-term outcomes with a low

major adverse cardiac event (MACE) rate at 2-3 year follow up post PCI to ULMCA.[5,6]

Distal ULMCA lesions are consistently involved with ostial left anterior descending coronary artery (LAD) and left circumflex artery (LCX) lesions. These distal lesions are associated with more dismal clinical outcomes than non-distal lesions.[3] The preferred routine treatment is the single-stent crossover technique.[7] In terms of clinical outcomes, the single-stent strategy is superior to the two-stent strategy. However, concerns regarding high-risk side branch compromise exist as the side branch may close abruptly following stenting of the main branch.[8] Side branch occlusions may determine the outcome of the procedure and therefore should not be ignored.[9] Due to consideration of these associated risks, the optimal stenting strategy for distal ULMCA lesions still remains uncertain. In this study, authors have attempted to analyze angiographic parameters that could possibly predict the need of side branch treatment in distal ULMCA bifurcation PCI.

METHODS

Study design and patient population

The study was a retrospective, observational study. A total of 83 patients with distal left main coronary artery (LMCA) bifurcation lesions who underwent single-stent cross-over technique at our tertiary-care centre between 2011 and 2015 were enrolled. The study practiced the provisional approach which was a single-stent cross-over strategy that allowed the positioning of a second stent, if required. Patients who underwent the single-stent crossover technique were compared with those who required side branch treatment with either plain old balloon angioplasty (POBA) or stenting. The study evaluated the ability of angiographic parameters such as bifurcation angle, POC and SYNTAX score to determine the requirement of side branch treatment. The study was approved by the institutional ethics committee. All patients provided written informed consent.

Interventional procedure

All interventions were performed through the femoral route using a 7 Fr sheath, mostly a 7 Fr extra back-up catheter. Guide wire selection was based on lesion nature. The most common guide wire used was Choice Floppy guide wire (Boston Scientific, USA). Other guide wires used included Asahi Sion Blue (Vascular Perspectives, UK) and Choice Intermediate and Choice Extra Support (Boston Scientific, USA). Both LCX and LAD were wired in all patients. The branch with the difficult angle was always wired first, followed by the side branch. The vessel with larger diameter was stented first. Post stenting, proximal optimization technique (POT) was performed, followed by side branch flow assessment. In the case of TIMI III flow, the side branch was left without any further intervention. However, in the case of flow limitation to the side branch (i.e. ≤TIMI II), the side branch was treated through either POBA or stenting. Stenting was performed with subsequent final kissing balloon inflation (FKBI). Post PCI, all patients achieved TIMI III flow in both the main branch and side branch.

Data collection

Data was collected retrospectively from patients who underwent treatment of distal ULMCA between 2011 and 2015. Demographic variables included age, gender, diabetics, hypertensives and left ventricular ejection fraction (LVEF). SYNTAX score is a measure of anatomic complexity. It was calculated using the online SYNTAX calculator to compare baseline anatomical complexity in patients undergoing intervention. The cut-off value was >33. Bifurcation angle was defined as the angle measured between LAD and LCX after the bifurcation at the LMCA. Bifurcation angle was measured using quantitative coronary analysis (QCA) (Syngo, Siemens Healthcare Pvt Ltd, India). The cut-off value was <90°. Majority of the patients had a bifurcation angle >90°. Polygon of confluence (POC) represents the smallest possible independent region that behaves differently from a single vessel segment. It is defined on the 2D radiographic as the area or region that encompasses the start and end of the bifurcation region. The polygon shape is created by connecting begin and end boundaries of the POC by the luminal borders of the vessel. Depending on the type of bifurcation it can have different shapes, such as a pentagon.[10] POC was measured using QCA (Syngo, Siemens Healthcare Pvt Ltd, India). Mean diameter at the POC <3 mm was considered significant.

Study outcomes

Our study evaluated bifurcation angle, diameter at POC and SYNTAX score in the prediction for requirement of the side branch treatment in single-stent crossover technique from distal ULMCA to major side branch. Patients who required side branch treatment either by POBA or stenting due to TIMI II flow were compared with patients who underwent PCI with single-stent crossover technique

Statistical analysis

Continuous variables are presented as mean±standard deviation. Dichotomous variables are reported as percentage with 95% confidence interval in the prediction for requirement of the side branch treatment. Pearson chi-square test was used to compare the dichotomous variables.

Binary regression was used to analyze the ability of bifurcation angle, diameter at POC and SYNTAX score to predict requirement of the side branch treatment in provisional single-stent crossover technique from distal

ULMCA to major side branch. p-value of p<0.05 was considered statistically significant.

RESULTS

Baseline demographics

A total of 83 patients who underwent distal LMCA intervention with provisional stenting strategy were analyzed in this retrospective study. The study population had a mean age of 58.2±5.3 years. Male patients comprised 61(73.5%) of the population. Hypertensives and diabetics contributed 60 (72.3%) and 42 (50.6%) of the patients, respectively. The baseline demographic characteristics are presented in Table 1.

Table 1: Baseline demographic characteristics.

Characteristics	Patients=83
Age, (mean±SD, years)	58.2±5.3
Male, n (%)	61 (73.5%)
Hypertension, n (%)	60 (72.3%)
Diabetes, n (%)	42 (50.6%)
LVEF, n (%)	33 (39.8%)

LVEF-left ventricular ejection fraction

Baseline angiographic and procedural characteristics

The mean vessel diameter for the LMCA, LAD and LCX was 3.6±0.9 mm, 3.2±0.9 mm and 2.5±0.9 mm, respectively. LMCA-LCX crossover stenting performed in 35 (42.2%) patients and LMCA-LAD crossover stenting was performed in 48 (57.8%) patients, respectively. Severity of stenosis observed in the proximal main branch, distal main branch and side branch were 50.3±33.0%, 22.9±34.5% and 66.7±32.8%, respectively. Significant side branch stenosis was prevalent in 75 (90.4%) of patients. Post stenting of the main branch, 12 (14.5%) patients required side branch intervention due to TIMI II flow. Out of these, 5 (6.0%) were treated with POBA and 7 (8.4%) were treated through stent implantation. In 3 (3.6%) patients FKBI could not be performed. The baseline angiographic and procedural characteristics are detailed in Table 2.

Possible predictors for side branch treatment

The bifurcation angle ranged from 45-170° and the mean bifurcation angle was 98.1±37.2°. Mean diameter at POC was 2.7±0.8 mm. Mean SYNTAX score was 26.7±3.7. This score was suggestive of intermediate coronary artery disease.

Analysis of possible predictors for side branch treatment

Binary logistic regression revealed bifurcation angle (Z: 1.15, OR: 0.99, 95% CI: 0.97-1.01, p=0.25), diameter at the POC (Z: 1.1, OR: 0.82, 95% CI: 0.32-2.13, p=0.272) and SYNTAX score (Z: 1.51, OR: 1.18, 95% CI: 0.95-1.45, p=0.132) in the prediction for requirement of the side branch treatment in single-stent crossover technique from distal ULMCA to major side branch.. The possible predictors for side branch treatment are given in Table 3.

Table 2: Baseline angiographic and procedural characteristics of LMCA bifurcation.

Characteristics	Patients=83
Vessel diameter	
LMCA, (mean±SD, mm)	3.6±0.9
LAD, (mean±SD, mm)	3.2±0.9
LCX, (mean±SD, mm)	2.5±0.9
Lesion site	
LMCA-LCX, n (%)	35 (42.2%)
LMCA-LAD, n (%)	48 (57.8%)
Lesion stenosis	
Proximal main branch, (mean±SD, %)	50.3±33.0 (30-90)
Distal main branch, (mean±SD, %)	22.9±34.5 (0-90)
Side branch, (mean±SD, %)	66.7±32.8 (0-100)
Side branch disease, n (%)	75 (90.4%)
Side branch treatment, n (%)	12 (14.5%)
POBA inside branch, n (%)	5 (6.0%)
Stent placement inside branch, n (%)	7 (8.4%)
Final kissing balloon inflation, n (%)	3 (3.6%)
Bifurcation angle, (mean±SD,°)	98.1±37.2 (45-170)
Diameter at POC, (mean±SD, mm)	2.7±0.8 (0.7-4.6)
SYNTAX score, (mean±SD)	26.7±3.7 (21-39)

LMCA-left main coronary artery, LAD-left anterior descending coronary artery, LCX-left circumflex artery, POBA-plain old balloon angioplasty, POC-polygon of confluence.

Table 3: Predictors angiographic and procedural characteristics of LMCA bifurcation.

Predictors	Co-efficient	Odds Ratio	95% CI	p value
Bifurcation angle, (mean±SD, °)	1.15	0.99	0.97-1.01	0.25
Diameter at POC, (mean±SD, mm	1.1	0.82	0.32-2.13	0.272
SYNTAX score, (mean±SD)	1.51	1.18	0.95-1.45	0.132

POC-polygon of confluence.

DISCUSSION

Several factors of bifurcation lesion anatomy can impact the risk of side branch occlusion and influence the outcome of coronary bifurcation intervention. Our findings revealed that angiographic parameters such as bifurcation angle (Z: 1.15, OR: 0.99, 95% CI: 0.97-1.01, p=0.25), diameter at the POC (Z: 1.1, OR: 0.82, 95% CI: 0.32-2.13, p=0.272) and SYNTAX score (Z: 1.51, OR: 1.18, 95% CI: 0.95-1.45, p=0.132) cannot correctly predict the requirement of side branch treatment.

Bifurcation lesions represent a subgroup of complex lesions with varying degree of anatomical features. Some simple lesions may be treated with a single stent, whereas other complex lesions may require treatment with the two-stent technique.[3] The COBIS II multicenter registry of 2044 patients reported higher rates of cardiac death, cardiac death or myocardial infarction (MI), target lesion failure (TLF), target vessel revascularization (TVR) and stent thrombosis (ST) in the two-stent strategy. However, patients in this group had a higher prevalence of previous PCI, acute coronary syndrome, multi-vessel disease, true bifurcation lesions and were older. Similarly, other studies on comparing the provisional one-stent strategy with the two-stent strategy have shown the one-stent strategy resulted in lower rates of cardiac death, MI, major adverse cardiac events, TLR, TVR and ST in patients with bifurcation lesions. Thus, the single-stent strategy should be the preferred approach in the treatment of left main bifurcation lesions.[3,11,12]

Bifurcation angles affect atherosclerosis proliferation, side branch compromise post main branch stenting and long-term clinical outcomes. These angles may therefore represent key factors in the selection of the treatment strategy. Zhang et al. aimed to find the effect of bifurcation angle on side branch occlusion post main branch stenting. Findings revealed side branch occlusion was higher in the high angle group (63/600, 10.5%) than the low angle group (25/600, 4.2%) (P <0.001). The high bifurcation angle group included bifurcation angles >52°, which independently predicted side branch occlusion. In line with this evidence, Zhang et. al. showed mean bifurcation angle in the side branch occlusion group was higher than the no side branch occlusion group (66.7±26.3° vs. 53.5±21.0°). Their explanation suggested lower bifurcation permitted easier flow diversion into the side branch, whereas a higher bifurcation angle increased both pressure drop and flow resistance. Hence, the increase inside branch occlusion. In our study bifurcation angles found ranged from 45-170°. However, the bifurcation angle could not predict the need for side branch treatment. [9,13,14] The POC represents the zone of confluence of the distal left main, ostial LAD and ostial LCX arteries. Kang et al. concluded mean lumen area (MLA) within the POC may serve as a predictor of stenosis in LM disease. They reported that 34 lesions with IVUS-defined stenosis at the LCX carina had a smaller MLA within the POC compared to the 48 lesions that did not have carinal stenosis (4.7±1.9 mm^2 vs. 6.6±3.2 mm^2). The diameters at the POC in our study ranged from 0.7-4.6mm. However, POC was unable to predict side branch stenosis requiring the implantation of a second stent.[4-15] Studies have shown a greater SYNTAX score in patients undergoing the two-stent strategy than in the one-stent strategy in the indication of angiographic complexity in the two treatment groups. Patients in our study included patients at intermediate risk as the mean SYNTAX score was 26.7±3.7 (21-39). In our study a lesser number of patients underwent side branch treatment with POBA or second stent implantation.[3,5,11]

During stenting of the main branch, the side branch may suddenly close. This limits utilization of the provisional one-stent strategy. Identification of predictors for side branch occlusion may aid in the selection of suitable intervention strategies.

Study limitations

The first limitation of the present study was small sample size. A larger population size could have provided better insights. Secondly, this was a non-randomized, observational study. No adjustments were made for confounding factors. Therefore, it is possible unaccountable confounding factors may have affected the results. Thirdly, stenting strategy was left to the discretion of the operator. Also, imaging techniques such as IVUS and OCT were not performed due to logistic and financial constraints. These techniques could have played a role in the determination of the treatment strategy.

CONCLUSION

Angiographic parameters such as bifurcation angle, diameter from the POC and SYNTAX score did not correctly predict the requirement of the side branch treatment in distal LMCA bifurcations. However, the study indicates that provisional stenting with single-stent crossover technique can be performed safely irrespective of SYNTAX score, interpolated diameter and the bifurcation angle.

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REFERENCES

1. Fihn SD, Blankenship JC, Alexander KP, Bittl JA, Byrne JG, Fletcher BJ, et al. ACC/AHA/AATS/PCNA/SCAI/STS focused update of the guideline for the diagnosis and management of patients with stable ischemic heart disease: A report of the American College of Cardiology/American Heart Association Task Force

on Practice Guidelines, and the American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. J Am Coll Cardiol. 2014;64(18):1929-49.
2. Members ATF, Windecker S, Kolh P, Alfonso F, Collet J-P, Cremer J, et al. 2014 ESC/EACTS guidelines on myocardial revascularization: The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). Eur Heart J. 2014;35(37):2541-19.
3. Kim WJ, Kim YH, Park DW, Yun SC, Lee JY, Kang S-J, et al. Comparison of single-versus two-stent techniques in treatment of unprotected left main coronary bifurcation disease. Catheter Cardiovasc Interv. 2011;77(6):775-82.
4. Morice M-C, Serruys PW, Kappetein AP, Feldman TE, Ståhle E, Colombo A, et al. Five-year outcomes in patients with left main disease treated with either percutaneous coronary intervention or coronary artery bypass grafting in the SYNTAX trial. Circulation. 2014Jun10;129(23):2388-94.
5. Stone GW, Sabik JF, Serruys PW, Simonton CA, Généreux P, Puskas J, et al. Everolimus-eluting stents or bypass surgery for left main coronary artery disease. N Engl J Med. 2016;375(23):2223-35.
6. Pavei A, Oreglia JA, Martin G, Tousek P, Sharif F, Farah B, et al. Long-term follow-up of percutaneous coronary intervention of unprotected left main lesions with drug eluting stents: Predictors of clinical outcome. Euro Intervention. 2009;4(4):457-63.
7. Kang S-J, Mintz GS, Kim WJ, Lee JY, Park DW, Lee S-W, et al. Preintervention angiographic and intravascular ultrasound predictors for side branch compromise after a single-stent crossover technique. Am J Cardiol. 2011;107(12):1787-93.
8. Kang SJ, Ahn JM, Kim WJ, Lee JY, Park DW, Lee SW, et al. Functional and morphological assessment of side branch after left main coronary artery bifurcation stenting with cross-over technique. Catheter Cardiovasc Interv. 2014;83(4):545-52.
9. Zhang D, Xu B, Yin D, Li Y-P, He Y, You S-J, et al. Clinical and angiographic predictors of major side branch occlusion after main vessel stenting in coronary bifurcation lesions. Chin Med J. 2015;128(11):1471-8.
10. Tomasello SD, Costanzo L, Galassi AR. Quantitative coronary angiography in the interventional cardiology. Advances in the Diagnosis of Coronary Atherosclerosis: In Tech. 2011:255-72.
11. Song YB, Hahn J-Y, Yang JH, Choi S-H, Choi J-H, Lee SH, et al. Differential prognostic impact of treatment strategy among patients with left main versus non–left main bifurcation lesions undergoing percutaneous coronary intervention: results from the COBIS (Coronary Bifurcation Stenting) Registry II. JACC Cardiovasc Interv. 2014;7(3):255-63.
12. Toyofuku M, Kimura T, Morimoto T, Hayashi Y, Ueda H, Kawai K, et al. Three-year outcomes after sirolimus-eluting stent implantation for unprotected left main coronary artery disease: insights from the j-Cypher registry. Circulation. 2009;120(19):1866-74.
13. Zhang D, Dou K. Coronary bifurcation intervention: What role do bifurcation angles play? J Interv Cardiol. 2015;28(3):236-48.
14. Zhang D, Xu B, Yin D, Li Y, He Y, You S, et al. How bifurcation angle impacts the fate of side branch after main vessel stenting: A retrospective analysis of 1,200 consecutive bifurcation lesions in a single center. Catheter Cardiovasc Interv 2015;85(S1):706-15.
15. Kang S-J, Mintz GS, Oh JH, Park DW, Lee SW, Kim Y-H, et al. Intravascular ultrasound assessment of distal left main bifurcation disease: the importance of the polygon of confluence of the left main, left anterior descending, and left circumflex arteries. Catheter Cardiovasc Interv. 2013;82(5):737-45.

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