https://doi.org/10.3329/jicc.v6i2.93326

ORIGINAL ARTICLE

Outcome of Percutaneous Coronary Intervention in Left versus non-left Main Coronary Artery in Acute Coronary Syndrome: A Comparative Study

S M Mamun Iqbal[1], A.M Shafique[2], Neuton Mondal[3], Mohammad Jahid Hasan[4]

Abstract

Introduction: Acute coronary syndromes (ACS), particularly those affecting the left main coronary artery (LMCA), are associated with high morbidity and mortality. The objective of the present study was to investigate long-term outcomes in patients who underwent percutaneous coronary intervention (PCI) for ACS affecting the LMCA compared to those with non-LMCA involvement.

Methods: This interventional study was conducted at the Department of Cardiology of M.H. Shamorita Medical College Hospital in Dhaka, Bangladesh, from January 2023 to June 2024, including a number of 101 patients with ACS who underwent PCI (51 in LMCA group and 50 in non-LMCA group). Follow-up assessment was done at 3rd, 6th, and 12th months, focusing on major adverse cardiovascular events (MACE) as the primary endpoint and persistent symptoms, repeat revascularization and stent thrombosis as secondary endpoints

Results: The mean age of LMCA and non-LMCA group was 56 and 54 years, respectively, with higher female proportion in LMCA group. The patients in LMCA group presented with more complex lesions, with a mean SYNTAX score of 23.6. The MACE rate was notably higher in the LMCA group at 6%, compared to 2% in the non-LMCA group (p=0.013). Myocardial infarction (MI) occurred in 4% of the LMCA group, with no events in the non-LMCA group. Persistent symptoms and repeat revascularization were also more prevalent in the LMCA group (6% and 4%, respectively, p-value <0.05).

Conclusions: Patients with ACS involving the LMCA experienced higher rates of adverse outcomes, particularly MI and repeat revascularization, following PCI compared to non-LMCA cases.

Keywords: Acute coronary syndromes (ACS), Left main coronary artery (LMCA), Percutaneous coronary intervention (PCI), Major adverse cardiovascular events (MACE), Cardiac death

J Inv Clin Cardiol 2024; 6(2): 35-42

Introduction

Acute coronary syndrome (ACS) represents a spectrum of cardiovascular conditions such as ST-segment elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), and unstable angina characterized by a sudden compromise in blood flow to the heart due to blockage or narrowing of coronary arteries secondary to ruptured atherosclerotic plaque and thrombus formation.[1] Among the coronary arteries, the left main coronary artery (LMCA) supplies a significant area of left ventricle through left anterior descending (LAD) and circumflex arteries.[2] Hence, occlusion of the LMCA often leads to more extensive myocardial infarctions, causing severe ischemia and left ventricular dysfunction. As a result, ACS involving the LMCA

1. Professor & Head, MD (Cardiology), Department of Cardiology, M H Samorita Hospital and Medical College, Tejgaon, Dhaka-1208, Bangladesh.
2. Senior Consultant, MD (Cardiology), Department of Cardiology, Continental Hospital PLC.
3. Senior Cathlab Technician, MPH, Department of Cardiology, M H Samorita Hospital and Medical College, Dhaka-1208, Bangladesh.
4. MBBS, MPH, Tropical Disease and Health Research Center, Dhaka-1100, Bangladesh.

Address of Correspondence: Dr. S M Mamun Iqbal, Professor & Head, MD (Cardiology), Department of Cardiology, M H Samorita Hospital and Medical College, Tejgaon, Dhaka-1208, Bangladesh, Email: kironk56@yahoo.com, Cell: +8801715498482
Mohammad Jahid Hasan, MBBS, MPH, Tropical Disease and Health Research Center, Dhaka-1100, Bangladesh, Cell: +8801757818973; Email: dr.jahid61@gmail.com

typically carries a worse prognosis than ACS involving non-LMCA coronary arteries and accounts for a significant proportion of fatal cardiac events.[3]

The high mortality in LMCA-related ACS is primarily attributed to the rapid deterioration of cardiac function, leading to multisystem organ failure if left untreated. Immediate and effective intervention is paramount in managing these cases. Historically, surgical revascularization through coronary artery bypass grafting (CABG) was the mainstay treatment for LMCA disease.[4] However, with the advancement of percutaneous coronary intervention (PCI), this less invasive approach has become a viable and increasingly preferred option for many patients, especially in the acute setting of ACS.[5]

Current clinical guidelines for the management of ACS, including both ST-elevation myocardial infarction (STEMI) and non-ST-elevation ACS, recommend emergency revascularization through primary PCI, particularly for patients presenting with cardiogenic shock.[6] In fact, PCI has become the main modality of reperfusion therapy in ACS, offering rapid restoration of coronary blood flow and reducing myocardial damage. The benefit of PCI in patients with cardiogenic shock is clear—emergency coronary reperfusion through this method is supported by robust evidence as a lifesaving intervention.[7]

Patients undergoing PCI for LMCA disease often face more complex interventions due to the anatomical and clinical challenges associated with the artery. The bifurcation of the LMCA into the LAD and circumflex arteries introduces technical difficulties, which can complicate stenting and increase the likelihood of restenosis or stent thrombosis.[5] Furthermore, LMCA lesions are often more calcified and diffuse, requiring advanced PCI techniques, such as rotational atherectomy or intravascular imaging guidance.[5,6] These complexities make PCI for LMCA disease a high-risk procedure, and concerns remain about long-term complications such as repeat revascularization, restenosis, and mortality.[8]

However, there is scarcity of evidence regarding the long-term outcomes of PCI in patients with ACS involving LMCA in comparison to non-LMCA, particularly in the context of a resource-constrained setting like in Bangladesh. The objective of the present study was to investigate the long-term outcomes in patients undergoing PCI for ACS affecting the LMCA compared to those with ACS affecting non-LMCA.

Methods

Study design and setting

The present one was an interventional study conducted in the Department of Cardiology of M. H. Samorita Medical College and Hospital, a tertiary care hospital situated in Dhaka, Bangladesh from January 2023 to June 2024.

Participants

All patients admitted to the study hospital during the specified time period with a diagnosis of ACS, including STEMI, NSTEMI, and unstable angina, constituted the population for the present study. From this population, participants were selected based on predetermined inclusion and exclusion criteria and divided into two distinct groups. The first group comprised patients diagnosed with ACS with suspected culprit lesion involving the LMCA who underwent PCI. The second group included those diagnosed with ACS and suspected culprit lesion in coronary arteries other than the LMCA (non-LMCA) and also underwent PCI. Patients who did not undergo PCI were excluded from the study, either because they did not meet the PCI eligibility criteria or declined consent for the procedure. In total, 101 patients were included in the study, with 51 in the LMCA group and 50 in the non-LMCA group. A convenience sampling method was employed, in accordance with the inclusion and exclusion criteria, to select participants for the study.

Study procedure

Upon admission, all patients with ACS were screened for eligibility to undergo PCI. Those who met the criteria and consented to the procedure were recruited into the study after providing written informed consent. Prior to PCI, patients were given aspirin (300-325 mg) at least two hours before the procedure, followed by a maintenance dose of 75 mg daily indefinitely. A loading dose of an ADP antagonist (clopidogrel, prasugrel, or ticagrelor) was also mandatory, with continued therapy for at least one year after PCI. Statin pre-loading, either 80 mg of atorvastatin or 40 mg of rosuvastatin, was administered to minimize periprocedural myocardial injury. Unfractionated heparin was preferred for anticoagulation, though Bivalirudin or low molecular weight heparin were acceptable alternatives. PCI was performed according to standard protocols.[3] All PCI

were done by single operator. In left main group, if the patient also had disease in the left anterior descending (LAD) or left circumflex (LCX) arteries, these were treated first, from distal to proximal, unless the left main coronary artery (LMCA) stenosis exceeded 90% or the patient's clinical condition was unstable, in which case the LMCA was treated first. Critical LMCA lesions were addressed with balloon angioplasty and subsequent stenting to ensure patient safety. Lesion preparation, particularly in heavily calcified vessels, included pre-dilatation with compliant or scoring balloons. For distal LMCA bifurcation lesions, a provisional stenting approach was preferred, where one stent was initially deployed and, if needed, a second stent was added using techniques like T-stenting. Upfront two stent strategy such as mini-crush, T and small protrusion (TAP) and V-stenting were planned in some patients based on anatomy of bifurcation. Following any two-stent procedure, kissing balloon inflation was done to ensure optimal stent expansion and vessel patency. After PCI, patients were prescribed aspirin at 75 mg daily indefinitely for secondary prevention of coronary artery disease, and either clopidogrel or prasugrel or ticagrelor was continued for at least one year to prevent stent thrombosis.[9]

Follow-Up

All patients were closely monitored following their PCI, with follow-up evaluations scheduled at 3 months, 6 months, and 12 months after the procedure. These follow-up assessments were conducted either through in-person clinic visits or via telephone interviews, depending on the patient's circumstances and clinical needs. Data regarding symptoms like persistent angina and shortness of breath or dyspnea as well as other outcome variables were collected.

Endpoints

The primary endpoint of the present study was occurrence of major adverse cardiovascular events (MACE). MACE was defined as a composite of myocardial infarction (MI), stroke, and sudden cardiac death.[10] Additionally, persistent angina, persistent shortness of breath or dyspnea, requirement of target vessel revascularization and stent thrombosis were considered as secondary endpoints of the present study.

Statistical Analysis

The statistical analysis was performed using IBM SPSS software. Appropriate statistical tests were carried out to assess the differences in baseline characteristics and outcomes between the LMCA and non-LMCA groups. Continuous variables were expressed as mean with standard deviation (SD) and compared using either the Student's t-test or the Wilcoxon rank test, depending on the distribution of the data. Categorical variables were expressed as percentages and compared using the chi-squared test or Fisher's exact test. For all statistical analyses, a two-sided p-value of <0.05 was considered to indicate statistical significance.

Results

The average age was 56 years for the LMCA group and 54 years for the non-LMCA group. Notably, the LMCA group had a higher prevalence of female patients (31% vs. 14%) and comorbidities, including hypertension (76% vs. 54%) and family history of coronary artery disease (27% vs. 4%) (Table 1).

Among the groups, STEMI was more prevalent in the non-LMCA group (24% vs. 16%), while unstable angina was more common in the LMCA group (55% vs. 42%). The mean SYNTAX score was significantly higher in the LMCA group (23.6 vs. 7.8). Higher number of patients in the LMCA group had multiple-vessel disease (39% vs. 22%), and lesions were more likely to be classified as type B (53% vs. 16%). The proportion of patients with severe calcification was notably higher in the LMCA group (49% vs. 20%). However, left ventricular ejection fraction (LVEF) and serum creatinine levels did not significantly differ between groups (Table 2).

The choice of access route significantly differed between the groups, with femoral access used in 47% of LMCA patients versus only 8% in non-LMCA patients. The majority of patients with multivessel disease in both groups underwent procedures without staged interventions. In terms of procedural strategy, most patients received a single stent strategy (82% for LMCA vs. 94% for non-LMCA). When double stents were considered for bifurcation lesion, several techniques of stenting were utilized, including mini crush (7.84% for LMCA), T and small protrusion (TAP) (5.88% for LMCA vs. 3.00% for non-LMCA), and V-stenting (1.96% for LMCA), but no significant differences were observed in their application (Table 3).

Table-I

Baseline characteristics of the patients (n = 101)

Characteristics	LMCA, n = 51	Non-LMCA, n = 50	p-value
Age	56.06 (11.23)	54.14 (10.58)	0.069
Age group			
<60	27 (52.94)	30 (60.00)	0.078
>60	24 (47.06)	20 (40.00)	
Sex			
Female	16 (31.37)	7 (14.00)	0.014
Male	35 (68.63)	43 (86.00)	
Comorbidities			
Type 2 diabetes mellitus	29 (56.86)	23 (46.00)	0.061
Hypertension	39 (76.47)	27 (54.00)	0.026
Dyslipidemia	8 (15.69)	5 (10.00)	0.102
Chronic kidney disease	7 (13.73)	4 (8.00)	0.045
Chronic respiratory diseases	3 (5.88)	4 (8.00)	0.095
Family history of coronary artery disease	14 (27.45)	2 (4.00)	0.003
Smoking tobacco	4 (8.00)	0 (0.00)	0.193
Smokless tobacco consumption	2 (4.00)	0 (0.00)	0.392
Previous history of PCI	5 (9.80)	1 (2.00)	0.001
Left ventricular failure	8 (16.67)	4 (8.00)	0.024

Table-II

Clinical presentations of the patients (n = 101)

Characteristics	LMCA, n = 51	Non-LMCA, n = 50	p-value
Diagnosis			
STEMI	8 (15.68)	12 (24.00)	0.032
NSTEMI	15 (29.41)	17 (34.00)	
UA	28 (54.90)	21 (42.00)	
SYNTAX score	23.56 (7.08)	7.78 (5.29)	<0.001
Unprotected LMCA	51 (100.00)	-	-
Number of vessel involved			
Single	30 (60.78)	39 (78.00)	0.017
Multiple	20 (39.22)	11 (22.00)	
Type of lesion (AHA/ACC classification)			
A	4 (7.84)	26 (52.00)	0.003
B	27 (52.94)	8 (16.00)	
C	20 (39.22)	16 (32.00)	
Pre-procedure TIMI flow			
0	16 (31.37)	13 (26.00)	0.321
1	31 (60.78)	27 (54.00)	
2	3 (5.88)	8 (16.00)	
3	1 (1.96)	2 (4.00)	
LVEF %	53.90 (11.02)	55.26 (9.71)	0.154
Severe calcificaion	25 (49.02)	10 (20.00)	0.027
Serum creatinine level	1.10 (0.72)	1.00 (0.22)	0.751

Improved TIMI flow was achieved in 67% of the patients with LMCA disease comparable to 64% of the patients with non-LMCA disease (p = 0.467). However, total revascularization was notably different; 45% of the patients with LMCA disease achieved complete revascularization, whereas a higher percentage of 68% was reported in the non-LMCA group (p = 0.028) (Figure 1).

The primary endpoint of the study, major adverse cardiac events (MACE), occurred in 5.9% of LMCA patients compared to 2% in the non-LMCA group (p = 0.013). Myocardial infarction was notably higher in the LMCA group, occurring in 4% patients compared to none in the non-LMCA group. Both groups reported no event of stroke, and cardiac death was similar between groups at 2%. Regarding secondary endpoints, persistent angina was reported in 5.9% of the patients with LMCA versus 4% in the non-LMCA group. Persistent dyspnea was also comparable at 4% in both groups. Stent thrombosis occurred in 2% of LMCA patients, while none were reported in the non-LMCA group. Additionally, repeat revascularization was significantly higher in the LMCA group, with 4% compared to none in the non-LMCA group (Table 4).

Table-III

Procedural characteristics of the patients (n = 101)

Characteristics	LMCA, n = 51	Non-LMCA, n = 50	p-value
Route of procedure			
Femoral	24 (47.06)	4 (8.00)	<0.001
Radial	27 (52.94)	46 (92.00)	
Staged procedure			
No	48 (94.12)	44 (88.00)	0.372
yes	3 (5.88)	6 (12.00)	
Type of procedure			
Double stent Strategy	9 (17.65)	3 (6.00)	0.034
Single stent strategy	42 (82.35)	47 (94.00)	
Double stent Technique			
Mini Crush	4 (7.84)	0 (0.00)	0.376
TAP	3 (5.88)	3 (6.00)	
V-Stenting	1 (1.96)	0 (0.00)	

Table-IV

12-month outcome of the patients (n = 101)

Endpoints	LMCA, n = 51	Non-LMCA, n = 50	p-value
Primary endpoints			
MACE	3 (5.88)	1 (2.00)	0.013
Myocardial infarction	2 (3.92)	0 (0.00)	0.003
Stroke	0 (0.00)	0 (0.00)	-
Cardiac death	1 (1.96)	1 (2.00)	0.752
Secondary endpoints			
Persistent angina	3 (5.88)	2 (4.00)	0.082
Persistent dyspnea	2 (3.92)	2 (4.00)	0.854
Stent thrombosis	1 (1.96)	0 (0.00)	0.091
Repeat revascularization	2 (3.92)	0 (0.00)	0.042

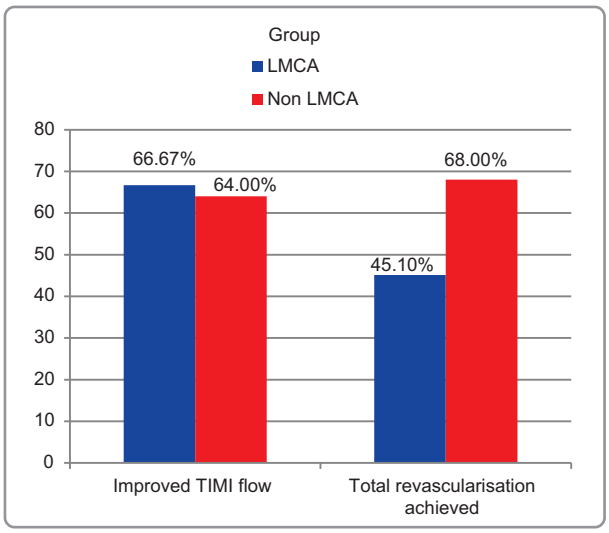


Figure 1: *Procedural outcome of the patients (n = 101)*

Discussion

Our study investigated the outcomes of PCI in patients with ACS involving the LMCA compared to those with ACS related to non-LMCA lesions, revealing variations in morbidity and mortality associated with PCI following LMCA-related ACS.

We found that the occurrence of MACE during the one-year follow-up period after PCI, the primary endpoint of our study, was markedly higher in patients with LMCA disease compared to those with non-LMCA lesions. In our operational definition, MACE included MI, stroke, and sudden cardiac death. We observed an increased rate of MI in the LMCA group, though incidence of stroke and mortality was comparable in both groups. These findings align with existing evidence highlighting the poor prognosis after PCI associated with LMCA lesions.[8,11,12] This poor prognosis might be attributable to the extensive myocardial territory at risk and the complex nature of these lesions, which often involve multivessel disease and more severe coronary artery pathology.[12,13] In our study, we also observed that a higher proportion of patients in the LMCA group had multiple artery involvement and a higher SYNTAX score on admission, indicating a more severe and complex presentation of disease. Besides, the rate of successful total revascularization was significantly lower in the LMCA group (45%) compared to the non-LMCA group (68%) in our study. Incomplete revascularization may be associated with poorer outcomes and increased rates of MACE.[14,15,16,17] The higher prevalence of multivessel disease and severe calcification in the LMCA group in our study could explain the challenges faced in achieving complete revascularization, as complex lesions often necessitate more intricate procedural strategies and may be less amenable to standard approaches followed in vulnerable and high risk ACS patients.[18] In terms of secondary outcomes, persistent angina and dyspnea were reported at comparable rates across both groups. However, the presence of persistent symptoms after PCI may indicate inadequate myocardial perfusion or complications related to the procedure, particularly in the LMCA group, where the risk of restenosis or stent thrombosis may be heightened.[11] This phenomenon was also observed in our study participants, where the incidence of stent thrombosis and repeat revascularization was notably higher in the LMCA group. These findings emphasize the importance of meticulous procedural techniques and intensive post-procedural monitoring and management as well as long-term adherence to dual antiplatelet therapy.[19,20,21]

Though, our study provided valuable insights into the outcomes of PCI for LMCA versus non-LMCA disease, it is important to recognize several limitations. First, we conducted the study in a routine clinical practice setting using convenience sampling, which resulted in differences in baseline characteristics among the groups that could affect the outcomes. Second, the relatively small sample size from a single center may restrict the generalizability of our results. Lastly, the follow-up period was limited to 12 months, which may hinder our ability to assess longer-term outcomes for the patients. Moreover, multivessel disease in this setting requires staged procedure which cannot always be possible due to the socioeconomic condition of most patients in Bangladesh. Considering the procedural aspect, it is now preferred to use IVUS (Intra-vascular ultrasound) in every cases of Left main PCI to assess the adequacy of lesion preparation, measuring precise vessel size and to ensure optimum expansion and apposition of stents. However, in our country most patients cannot bear the extra cost of IVUS in acute clinical settings and we could not use it widely.

Future research involving larger, multicenter cohorts is needed to validate our findings and investigate the effects of various procedural techniques on long-term outcomes.

Conclusion

In conclusion, our study highlighted the comparative outcome of PCI in LMCA and non-LMCA related ACS. We observed higher rates of major adverse cardiovascular events, particularly myocardial infarction, as well as requirement of repeat revascularization after PCI in patients with ACS involving the LMCA.

Abbreviation

ACS- Acute Coronary Syndrome

CABG- coronary artery bypass grafting

LAD- Left Anterior Descending

LCX- left circumflex

LMCA- Left Main Coronary Artery

LVEF- left ventricular ejection fraction

MACE- major adverse cardiovascular events

NSTEMI- Non-ST-Elevation Myocardial Infarction

PCI- Percutaneous Coronary Intervention

SD- Standard Deviation

STEMI- ST-Segment Elevation Myocardial Infarction

Declarations:

Ethics approval and consent to participate: The study protocol was reviewed and approved by the Institutional Ethical Review Board of M H Samorita Hospital and Medical College (MHSHMC/IERB-03-22). The all authors declare no human subjects were harmed and the procedures followed were in accordance with the ethical standards and regulations established by the Helsinki Declaration of the World Medical Association. Informed written consent was obtained from the participants involved in the study.

Consent for publication: Not Applicable.

Availability of data and materials: Patient-level data will be available on request from the corresponding author.

Conflict of interest: The authors declare that they have no competing interests.

Funding: The study did not have specific funding.

Author Contributions: Conceptualization, S.M.M.I., A.M.S., N.M., and M.J.H.; formal analysis, S.M.M.I., and A.M.S., investigation, S.M.M.I., N.M., and M.J.H.; methodology, A.M.S., and M.J.H.; resources, S.M.M.I., A.M.S., N.M., and M.J.H.; supervision, A.M.S., and M.J.H.; writing – original draft, S.M.M.I., and M.J.H.; writing – review & editing, A.M.S., N.M., and M.J.H.; All authors have read and agreed to the published version of the manuscript.

Acknowledgments: The authors would like to express their sincere gratitude to Pi Research & Development Center, Dhaka, Bangladesh (www.pirdc.org), for their help in manuscript revision and editing.

References

1. Fajadet J, Capodanno D, Stone GW. Management of left main disease: an update. *Eur Heart J*. 2019;40(18):1454–66. DOI:10.1093/eurheartj/ehy238
2. Bhatt DL, Lopes RD, Harrington RA. Diagnosis and Treatment of Acute Coronary Syndromes: *A Review. Jama*. 2022;327(7):662–75. DOI: 10.1001/jama.2022.0358
3. Aimo A. Surgical Anatomy of Coronary Arteries: Morphogenesis, Normal and Pathological Anatomy. In: Ischemic Heart Disease: From Diagnosis to Treatment. *Springer*, 2023. p. 1–13. DOI:10.1007/978-3-031-25879-4_1
4. Park S, Park SJ, Park DW. Percutaneous coronary intervention for left main coronary artery disease: present status and future perspectives. *JACC Asia*. 2022;2(2):119–38. DOI: 10.1016/j.jacasi.2021.12.011
5. Armstrong PW, Bates ER, Gaudino M. Left main coronary disease: evolving management concepts. *Eur Heart J*. 2022;43(44):4635–43. DOI: 10.1093/eurheartj/ehac542
6. Kuchulakanti PK. Left Main PCI—Current Evidence, Techniques, and Triumph. *Indian J Clin Cardiol*. 2020;1(2):86–93. DOI:10.1177/2632463620933526
7. Hoole SP, Bambrough P. Recent advances in percutaneous coronary intervention. *Heart*. 2020;106(18):1380–6. DOI: 10.1136/heartjnl-2019-315707
8. Kappetein AP, Serruys PW, Sabik JF, Leon MB, Taggart DP, Morice M-C, et al. Design and rationale for a randomised comparison of everolimus-eluting stents and coronary artery bypass graft surgery in selected patients with left main coronary artery disease: the EXCEL trial. *EuroIntervention*. 2016;12(7):861–72. DOI: 10.4244/EIJV12I7A141
9. Jia SD, Yao Y, Song Y, Tang XF, Zhao XY, Gao RL, et al. Two Year Outcomes after Left Main Coronary Artery Percutaneous Coronary Intervention in Patients Presenting with Acute Coronary Syndrome. *J Interv Cardiol*. 2020;2020(1):6980324. DOI: 10.1155/2020/6980324
10. Bosco E, Hsueh L, McConeghy KW, Gravenstein S, Saade E. Major adverse cardiovascular event definitions used in observational analysis of administrative databases: a systematic review. *BMC Med Res Methodol*. 2021;21(1):241. DOI: 10.1186/s12874-021-01440-5
11. Lee PH, Ahn JM, Chang M, Baek S, Yoon SH, Kang SJ, et al. Left main coronary artery disease: secular trends in patient

characteristics, treatments, and outcomes. *J Am Coll Cardiol*. 2016;68(11):1233–46. DOI: 10.1016/j.jacc.2016.05.089

12. Jia S, Xu N, Yao Y, Yang Y, Xu B, Gao R, et al. TCTAP A-010 Long-term Outcomes After Left Main Coronary Artery Percutaneous Coronary Intervention in Patients Presenting with Acute Coronary Syndrome. *J Am Coll Cardiol*. 2019;73(15S):S6–S6.
13. Nishihira K, Kojima S, Takegami M, Honda S, Nakao YM, Takahashi J, et al. Clinical Characteristics and In-Hospital Mortality According to Left Main and Non-Left Main Culprit Lesions—Report From the Japan Acute Myocardial Infarction Registry (JAMIR). *Circ Reports*. 2019;1(12):601–9. DOI: 10.1253/circrep.CR-19-0056
14. Azzalini L, Candilio L, Ojeda S, Dens J, La Manna A, Benincasa S, et al. Impact of incomplete revascularization on long-term outcomes following chronic total occlusion percutaneous coronary intervention. *Am J Cardiol*. 2018;121(10):1138–48. DOI: 10.1016/j.amjcard.2018.01.033
15. Nagaraja V, Ooi S, Nolan J, Large A, De Belder M, Ludman P, et al. Impact of incomplete percutaneous revascularization in patients with multivessel coronary artery disease: a systematic review and meta analysis. *J Am Heart Assoc*. 2016;5(12):e004598. DOI: 10.1161/JAHA.116.004598
16. Armstrong EJ, Graham LA, Waldo SW, Valle JA, Maddox TM, Hawn MT. Incomplete revascularization is associated with an increased risk for major adverse cardiovascular events among patients undergoing noncardiac surgery. *JACC Cardiovasc Interv*. 2017;10(4):329–38.
17. Garcia S, Sandoval Y, Roukoz H, Adabag S, Canoniero M, Yannopoulos D, et al. Outcomes after complete versus incomplete revascularization of patients with multivessel coronary artery disease: a meta-analysis of 89,883 patients enrolled in randomized clinical trials and observational studies. *J Am Coll Cardiol*. 2013;62(16):1421–31. DOI: 10.1016/j.jacc.2013.05.033
18. Brener SJ, Serruys PW, Morice MC, Mehran R, Kappetein AP, Sabik JF, et al. Optimal duration of dual antiplatelet therapy after left main coronary stenting. *J Am Coll Cardiol*. 2018;72(17):2086–7. DOI: 10.1016/j.jacc.2018.07.084
19. Gaba P, Gersh BJ, Ali ZA, Moses JW, Stone GW. Complete versus incomplete coronary revascularization: definitions, assessment and outcomes. *Nat Rev Cardiol*. 2021;18(3):155–68. DOI: 10.1038/s41569-020-00457-5
20. Cho S, Kang DY, Kim JS, Park DW, Kim IS, Kang TS, et al. Dual antiplatelet therapy after percutaneous coronary intervention for left main coronary artery disease. *Rev Española Cardiol (English Ed)*. 2023;76(4):245–52. DOI: 10.1016/j.rec.2022.07.007
21. Cho S, Kim JS, Kang TS, Hong SJ, Shin DH, Ahn CM, et al. Long-term efficacy of extended dual antiplatelet therapy after left main coronary artery bifurcation stenting. *Am J Cardiol*. 2020;125(3):320–7. DOI: 10.1016/j.amjcard.2019.10.046