

PERIPROCEDURAL ASPECTS OF PERCUTANEOUS CORONARY INTERVENTIONS ON LEFT MAIN CORONARY ARTERY

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Lesions of the main left coronary artery tend to have worse long-term outcomes and higher mortality rates than lesions of other coronary arteries. The aim of this work was to comprehensively examine clinical, angiographic and procedural factors in patients who underwent percutaneous coronary intervention (PCI) on the left main (LM). The research was conducted as a retrospective study of patients with coronary disease of the left main, who were patients and users of the health services of the Cardiology Clinic of the University Clinical Center Niš. Men made up 85% of all included patients, the average age of the subjects was 66 ± 9 years. PCI LM was the planned intervention in

60% of cases of diseases of the main stem. In total, primary PCI LM was performed in 13% of cases. Only in one case was PCI LM performed as a "bail out" procedure. The average SYNTAX-II score in the entire study population was 26.8 ± 7.2 . Planned intravascular ultrasound-guided PCI LM accounted for 14.55% of cases. Optical coherence tomography was used only in 12.73% of planned PCI LM cases. Predominant was the 1-stent technique, which was performed in 84%. In 12.7% of cases, PCI LM was performed after coronary artery bypass grafting procedures. We found that percutaneous coronary intervention on the left main in chronic coronary syndrome, but also in acute myocardial infarction, is safe and effective during in-hospital follow-up.

Keywords: left main, percutaneous coronary interventions, intravascular ultrasound, optical coherence tomography

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Periproceduralni aspekti perkutanih koronarnih intervencija na glavnom stablu leve koronarne arterije

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Lezije glavnog stabla leve koronarne arterije imaju tendenciju da imaju lošije dugoročne ishode i veće stope smrtnosti od ostalih koronarnih arterija. Cilj ovog rada bio je da sveobuhvatno ispita kliničke, angiografske i proceduralne faktore kod bolesnika kojima je rađena perkutana koronarna intervencija (engl. *percutaneous coronary interventions* – PCI) na glavnom stablu leve koronarne arterije (engl. *Left main* – LM). Istraživanje je sprovedeno kao retrospektivna studija bolesnika sa koronarnom bolešću glavnog stabla leve koronarne arterije, koji su bili pacijenti i korisnici zdravstvenih usluga Klinike za kardiologiju Univerzitetskog kliničkog centra Niš. Muškarci su sačinjavali 85% svih uključenih pacijenata, prosečna starost ispitanika bila je 66 ± 9 godine. PCI LM je u 60% slučajeva bolesti glavnog stabla bila planirana intervencija. Ukupno u 13% slučajeva radjena je primarna PCI LM. Samo u jednom slučaju radjena je PCI LM kao „bail out“ procedura.

Prosečan SYNTAX-II skor u celoj populaciji ispitivanja bio je $26,8 \pm 7,2$. Planirana PCI LM vođena intravaskularnim ultrazvukom sačinjavala je 14,55% slučajeva. Optička koherentna tomografija je korišćen samo u 12,73% slučajeva planirane PCI LM. Predominantna je bila 1-stent tehnika koje je radjena u 84% slučajeva. U 12,7% slučajeva PCI LM radjena je nakon procedura bajpasa koronarnih arterija. Ovim istraživanjem ustanovili smo da je perkutana koronarna intervencija na glavnom stablu leve koronarne arterije u stabilnom hroničnom koronarnom sindromu, ali i u akutnom infarktu miokarda, bezbedna i efikasna tokom intrahospitalnog praćenja.

Ključne reči: glavno stablo, perkutana intervencija, intravaskularni ultrazvuk, optička koherentna tomografija

INTRODUCTION

The left coronary artery (LCA) supplies approximately 75 percent of the myocardium. Lesions of the left main tend to have worse long-term outcomes and higher mortality rates than other coronary arteries. (1, 2)

Coronary artery bypass grafting (CABG) has long been considered the best treatment strategy for coronary artery disease. With the development of stent technology, the usage of intravascular imaging and the optimization of antithrombotic therapy, there is an increasing approach to revascularization by percutaneous coronary interventions (PCI), which are gradually becoming an alternative treatment option. (1)

European and American guidelines list PCI as an alternative (class IIa-IIb) for distal left main disease, as it offers less invasiveness and non-inferior survival to CABG. In complex lesions (SYNTAX score >32), guidelines generally favor CABG, while lower scores are more suitable for PCI. (3, 4)

Given the available data on the potentially promising results of PCI revascularization of left main coronary artery disease, it is understandable that larger trials on the clinical outcomes and periprocedural aspects of PCI are needed.

AIM

The aim of this work was to comprehensively examine clinical, angiographic and procedural factors in patients who underwent percutaneous coronary intervention on the left main.

MATERIAL AND METHODS

The research was conducted as a retrospective study of patients with coronary disease of the left main, who were patients and users of the health services of the Cardiology Clinic of the University Clinical Center Niš.

During the research, the usual methods of data collection were applied, which include complete medical documentation, fluoroscopic images of coronary angiography and PCI procedures, laboratory analyses, as well as findings of echocardiographic examinations. The identity of all persons involved in the research is completely anonymized. In elective patients without

complications, the hospital follow-up of the examined parameters lasted 24 hours, and in patients with ACS without complications, the hospital follow-up of complications lasted an average of 72 hours, while late complications were observed on an outpatient basis.

The study was approved by the institutional review board of University Clinical Center Niš, and written informed consent was obtained from all patients.

Statistical processing of the collected data was performed in the SPSS (Statistical Package for Social Science) program, Statistics for Windows, version 13 (SPSS Inc., Chicago, Ill., USA). Tested parameters are represented as a percentage, and continuous variables are represented by mean value (X) and standard deviation (SD) and minimum and maximum values.

RESULTS

Demographic characteristics and the results of the examined parameters during percutaneous interventions are presented in Table 1. Out of the total number of patients, 13 were presented with ACS-STEMI; 17 with ACS-NSTEMI and 5 with ACS-NAPS, the other 20 presented as stable angina pectoris (Table 1).

Table 1. The demographic characteristic and the statistical results of the investigated parameters

Parameters	Values (N=55)
Men	47 (85%)
Age	66 ± 9 Min 44 Max 84
Clinical presentation	
STEMI	13 (24%)
NSTEMI	17 (31%)
APNS	5 (9%)
SAP	20 (36%)
Ejection fraction (EF)	49 ± 10 % Min 25 Max 74
Diabetes mellitus	Yes-14 (25,5%) Type 2- 11 (79%) Type 1- 3 (21%)
Hypertension	54 (98%)
Smoking	Current 15 (27%) Former 13 (24%) Non-smokers 27 (49%)
Chronic kidney disease	3 (5,5%)
BMI	25,8 ± 2,61
Syntax score	26,8 ± 7,2
Syntax score II	35,4 ± 6,8
Hemodynamic instability	5 (9%)
Success of the procedure	54 (98%)
Vaskular complications	3 (2%)
Access	Radial 15 (27%) Femoral 40 (73%)

IVI guided PCI	16 (29%)
Change of planned technique	6 (11%)
Circulatory support	1 (1.8%)

Men made up 85% of all included patients, the average age of the subjects was 66 ± 9 years.

After coronary angiography, surgical revascularization of the myocardium was indicated in 25.5% of cases, but it was abandoned due to associated comorbidities and high operative risk, and in those cases, percutaneous intervention of the lesion on the left main was also performed.

PCI LM was the planned intervention in 60% of cases of diseases of the left main. In patients presenting as ACS-STEMI, a total of 7 cases (13%) underwent primary PCI LM. Only in one case was PCI LM performed as a "bail out" procedure.

In 73%, the femoral artery was used as an access point, of which 7.5% of cases had vascular complications, none of which were treated operatively.

The proportion of used stent strategies is presented in Figure 1.

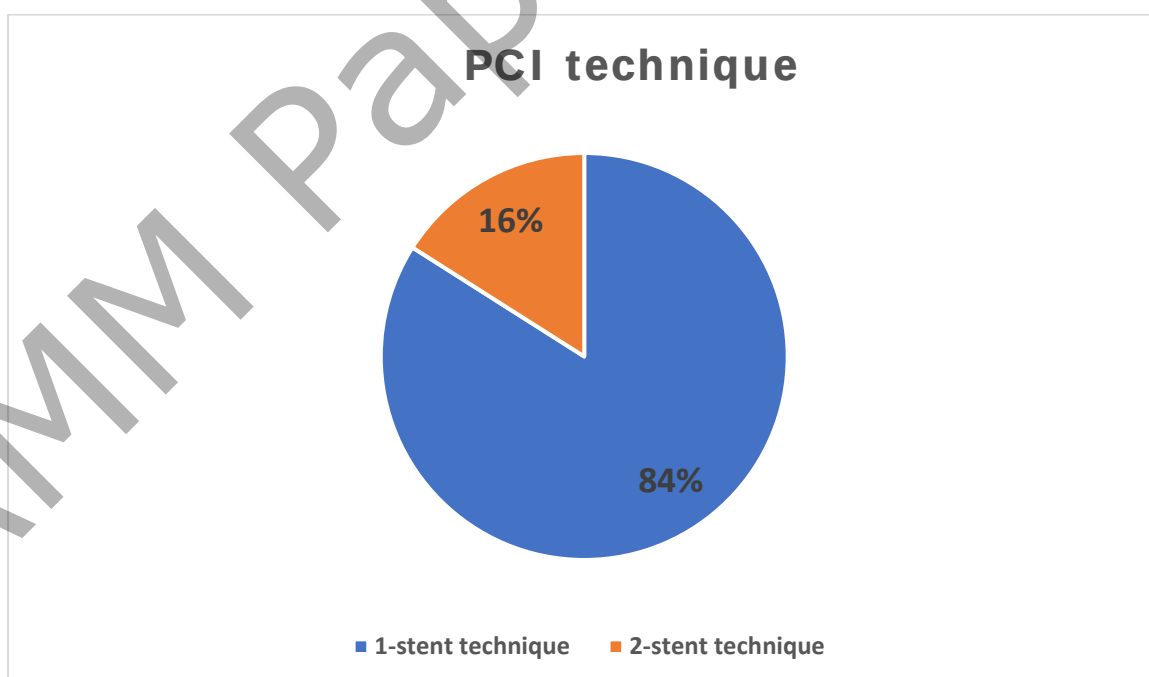


Figure 1. The proportion of stent strategies

The proportion of performed 2-stent strategies is shown in Figure 2.

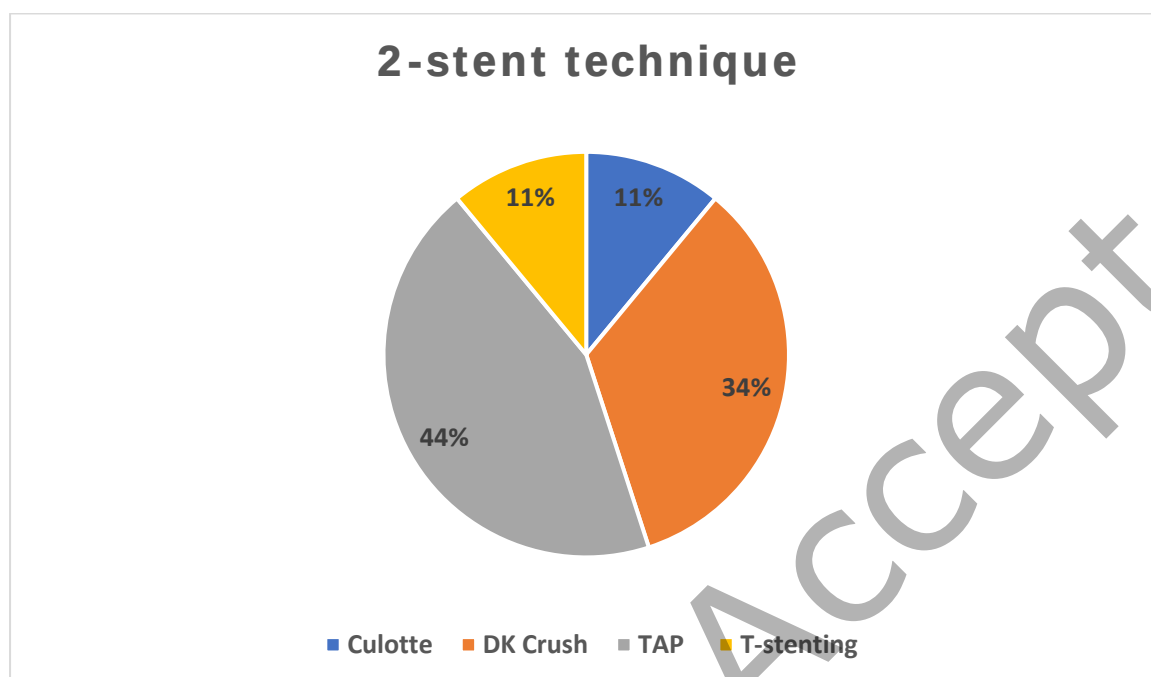


Figure 2. The proportion of 2-stent strategies

DISCUSSION

This research included 55 cases of percutaneous interventions on the left main performed in the cath lab of the Cardiology Clinic of the University Clinical Center in Niš. Procedural characteristics were pooled: stenting techniques, frequency of procedural complications such as coronary artery dissection or perforation, procedural success, patient demographic characteristics and associated comorbidities, as well as composite outcomes of procedures during hospital treatment. A comparison of individual parameters with data obtained from the literature was also made.

The atherosclerotic plaque of the LMCA (left main coronary artery) is qualitatively different from the plaques of other epicardial arteries, due to the minimal content of the necrotic core and a thinner layer of fibro-atheroma than the proximal segments of other coronary arteries, and is more prone to rupture. Conventionally, angiographic stenoses >50% in diameter (equivalent to >75% of the area of other coronary arteries) indicate hemodynamic significance. (5)

Because of the large amount of myocardium at risk, LMCA obstructive disease is associated with a significantly higher risk of cardiovascular morbidity and mortality compared with non-LMCA coronary artery disease. (2, 6, 7)

The development of drug-eluting stents, the evolution of PCI techniques, the widespread use of intravascular imaging and physiologic tools, and the advancement of additional cardiovascular drugs have enabled a state-of-the-art PCI approach for significant LMCA disease. This evolution has allowed PCI to be represented in European and American guidelines as a valid alternative (class IIa-IIb) for distal left vessel disease, especially when equivalent revascularization to CABG is possible, as it offers less invasiveness and non-inferior survival. With high anatomical complexity (SYNTAX score >32), guidelines generally favor CABG, while lower scores are more suitable for PCI. (3, 4)

In the latest American and European Society of Cardiology guidelines, intravascular ultrasound (IVUS) is recommended for procedural optimization in patients with unprotected left main coronary artery (ULMCA) disease. (Class of Evidence IIa/ Level of Evidence B) (3, 4)

The use of IVUS can provide accurate size of reference vessel segments and degree of plaque distribution up to the bifurcation, which allows adequate optimization of PCI with appropriate stent selection and post-stent dilatation. Several studies support the benefit of intravascular imaging for ULMCA, particularly the use of IVUS. The NOBLE (Nordic-Baltic-British Left Main Revascularization) study showed that the use of IVUS to prevent stent underexpansion in ULMCA improved target lesion revascularization rates after 5 years (0% in MSA ≥ 13.4 mm² versus 12.2% in MSA ≤ 10.8 mm², $p=0.002$). (8) The British Cardiovascular Intervention Society (BCIS) registry showed that intravascular imaging-guided PCI for ULMCA was associated with fewer immediate procedural complications and improved 1-month and 12-month survival compared with angiography-guided PCI. (9)

In the large, multicenter, prospective ROLEX registry, the primary incidence of target lesion revascularization failure (a combination of cardiac death, myocardial infarction, and target vessel revascularization-induced ischemia) was significantly lower in patients undergoing IVUS/OCT-guided PCI of LMCA versus angioguided PCI (2.0 vs. 7.6%; HR 0.28 (95% CI): 0.13-0.500) $p<0.500$). (10)

In the EXCEL trial, small final MSA measured by IVUS after PCI of the LMCA was strongly associated with adverse events (death, myocardial infarction, and stent thrombosis) during a 3-year follow-up. MSA values were classified as low (4.4–8.7 mm²), medium (8.8–10.9 mm²), and high (11–17.8

mm2), with the primary end point being all-cause mortality, MI, or stroke. A graded relationship was found between MSA size and improvement in the primary endpoint (19.4%, n=32/172 in the smallest subgroup, 16.1%, n=26/169 in the middle subgroup; and 9.6%, n=15/163 in the largest subgroup; p=0.01 for smallest vs. largest subgroup). (11)

In the EBC MAIN study, the primary outcome did not differ for PCI procedures guided by intracoronary imaging versus angiographic guidance (17% vs. 16%; (OR): 0.92 (95% CI): 0.51-1.63) p = 0.767), nor for IVUS reintervention (14% vs. 16%; (OR) 0.88 (95% CI: 0.51-1.63) p = 0.767). 0.32–2.43) p = 0.803), adjusted according to Syntax score values, lesion calcification and ischemia. With angiographic guidance, primary outcome events were more frequent with the two-stent technique compared to the provisional technique (21% vs 10%; OR: 2.11 (95% CI: 1.04-4.30) p = 0.039). For intracoronary imaging, there were fewer primary outcome events with the two-stent technique compared to the single-stent technique (13% vs. 21%; OR: 0.56 (95% CI: 0.22-1.46) p = 0.220). (12, 13)

OCT-guided PCI for ULMCA has some limitations in assessing the main stem ostium due to difficulty in obtaining an optimal measurement due to the presence of blood. However, a pilot study demonstrated the feasibility and safety of an OCT-guided mid/distal main stem PCI procedure. (14, 15)

Eight cases of planned PCI LM were guided by IVUS (14.55%). Intravascular imaging-OCT (Optical Coherence Tomography) was used only in 7 cases (12.73%) of planned PCI LM, and it is in accordance with European and American recommendations on the performance of interventions on the main stem and data from the literature in which the use of IVI during PCI of multivessel coronary diseases ranges from 30.2-50.2%. (9, 11)

The average SYNTAX-II score in the entire study population was 26.8 ± 7.2 and progressively increased in groups with recommended PCI, i.e. CABG (coronary artery bypass graft surgery), and groups that were not eligible for CABG, and is in accordance with the data from the literature 24.5 ± 7.2 . (10) Patients were rejected from the cardiac surgical council due to associated comorbidities and high operative risk.

In 73%, the femoral artery was used as an access point, of which 7.5% of cases had vascular complications in the form of a hematoma at the puncture site, none of which were surgically treated. Of these, one hematoma was at the LFA puncture site during placement of iVAC 2L circulatory

mechanical support (PulseCath BV, Amsterdam, The Netherlands) through an 18 Fr introducer. All complications were resolved during hospitalization and did not require surgical treatment.

Apart from that one case of using circulatory support, there were 5 more cases of hemodynamically unstable patients presenting with ACS-STEMI and cardiogenic shock who underwent primary PCI LM. In the other stable patients with ACS-STEMI, planned PCI LM was performed within 24 hours of the onset of symptoms. There were two cases of planned PCI LM with known CTO RCA. Those procedures were guided by intravascular imaging, without the use of circulatory support.

"Bail out" PCI LM was performed in only one case, after a complication in the form of LM dissection after primary PCI LAD.

Predominant was the 1-stent technique, which was performed in 36 cases (84%). After POT, kissing with NC balloons was performed in 3 cases (8.34%), while side-POT was performed in 2 cases (5.56%).

In addition to vascular complications, one periprocedural complication was noted in the form of a stent falling off during the TAP technique of stent placement at the LCx ostium, and after LM-LAD stenting. The stent was retracted with a smaller balloon, and the LCx was stented in the second act after 3 weeks.

In 7 cases (12.7%) PCI LM was performed after CABG procedures, after LIMA-LAD graft occlusion, an average of 8 years after bypass surgery. Despite the calcified lesions, these procedures were performed only with prior preparation of lesions with NC balloons, without additional use of rotablation, or IVL.

CONCLUSION

Through this research, we found that percutaneous coronary intervention on the left main in chronic coronary syndrome, but also in acute myocardial infarction, is safe and effective during in-hospital follow-up. Our goal for future research will be to demonstrate favorable long-term outcomes after percutaneous coronary revascularization in patients with left main coronary artery disease: a composite outcome including cardiac mortality, non-fatal target vessel myocardial infarction (NF-TVMI) and target lesion revascularization (TLR) after long-term follow-up.

REFERENCES

1. Liu H, Li D, Gao C, Dai H, Kang L, Zhang M, et al. A Systematic Review and Meta-Analysis of 35,409 Patients Undergoing PCI versus CABG for Unprotected Left Main Coronary Artery Diseases. *Rev Cardiovasc Med* 2024; 25(8): 282. DOI: 10.31083/j.rcm2508282
2. 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. *Journal of the American College of Cardiology* 2016; 68: 1233–1246. DOI:10.1016/j.jacc.2016.05.089. PMID: 27609687
3. Writing Committee Members. Lawton JS, Tamis-Holland JE, Bangalore S, Bates ER, Beckie TM, Bischoff JM, et al. "2021 ACC/AHA/SCAI guideline for coronary artery revascularization: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines". *J Am Coll Cardiol* 2022; 79: e21-e129. DOI: 10.1016/j.jacc.2024.07.010. PMID: 34895950.
4. Byrne RA, Rossello X, Coughlan JJ, Barbato E, Berry C, Chieffo A, et al. "2023 ESC Guidelines for the management of acute coronary syndromes". *Eur Heart J* 2023; 44: 3720-3826. DOI: 10.1093/eurheartj/ehad870. PMID: 37622654.
5. Gould KL, Lipscomb K, Hamilton GW. Physiologic basis for assessing critical coronary stenosis. Instantaneous flow response and regional distribution during coronary hyperemia as measures of coronary flow reserve. *Am J Cardiol.* 1974 Jan;33(1):87-94. DOI: 10.1016/0002-9149(74)90743-7. PMID: 4808557.
6. Wee SB, Ahn JM, Kang DY, Park SJ, Park DW. Contemporary State-of-the-Art PCI of Left Main Coronary Artery Disease. *Circulation: Cardiovascular Interventions* 2024; 17(11): e014026. DOI: 10.1161/CIRCINTERVENTIONS.124.014026. Epub 2024 Nov 19. PMID: 39561238.
7. Kalbfleisch H, Hort W. Quantitative study on the size of coronary artery supplying areas postmortem. *Am Heart J* 1977; 94: 183–188. DOI: 10.1016/s0002-8703(77)80278-0. PMID: 141876.
8. Ladwiniec A, Walsh SJ, Holm NR, Hanratty CG, Mäkikallio T, Kellerth T, et al. Intravascular ultrasound to guide left main stem intervention: a NOBLE trial substudy. *EuroIntervention.* 2020 Jun 25;16(3):201-209. DOI: 10.4244/EIJ-D-19-01003. PMID: 32122821.

9. Kinnaird T, Johnson T, Anderson R, Gallagher S, Sirker A, Ludman P, et al. Intravascular Imaging and 12-Month Mortality After Unprotected Left Main Stem PCI: An Analysis From the British Cardiovascular Intervention Society Database. *JACC Cardiovasc Interv.* 2020 Feb 10;13(3):346-357. DOI: 10.1016/j.jcin.2019.10.007. PMID: 32029252.
10. Tarantini G, Fovino LN, Varbella F, Trabattoni D, Caramanno G, Trani C, et al. A large, prospective, multicentre study of left main PCI using a latest-generation zotarolimus-eluting stent: the ROLEX study. *EuroIntervention.* 2023 Feb 6;18(13):e1108-e1119. DOI: 10.4244/EIJ-D-22-00454. PMID: 36043326; PMCID: PMC9909455.
11. Hunter GW, Sharma V, Varma C, Connolly D. The EXCEL Trial: The Interventionalists' Perspective. *Eur Cardiol* 2021; 16: e01. DOI: 10.15420/ecr.2020.32. PMID: 33708262; PMCID: PMC7941379.
12. Hildick-Smith D, Egred M, Banning A, Brunel P, Ferenc M, Hovasse T, et al. The European bifurcation club Left Main Coronary Stent study: a randomized comparison of stepwise provisional vs. systematic dual stenting strategies (EBC MAIN). *Eur Heart J.* 2021 Oct 1;42(37):3829-3839. DOI: 10.1093/eurheartj/ehab283. PMID: 34002215.
13. Maznyczka A, Arunothayaraj S, Egred M, Banning A, Brunel P, Ferenc M, et al; EBC MAIN (European Bifurcation Club Left Main Coronary Stent study) investigators. Bifurcation left main stenting with or without intracoronary imaging: Outcomes from the EBC MAIN trial. *Catheter Cardiovasc Interv.* 2023; 102(3): 415-429. DOI: 10.1002/ccd.30785. PMID: 37473405.
14. Amabile N, Rangé G, Souteyrand G, Godin M, Boussaada MM, Meneveau N, et al. Optical coherence tomography to guide percutaneous coronary intervention of the left main coronary artery: the LEMON study. *EuroIntervention.* 2021; 17(2): e124-e131. DOI: 10.4244/EIJ-D-20-01121. PMID: 33226003; PMCID: PMC9724912.
15. Kim Y, Kim J, Hong S, Kim H, MD, Lee HJ, MD, Yoon HJ, et al. Widespread Use of Imaging-Guided PCI in Asia: Time for Extended Application. *JACC: Asia.* 2024; 4(9): 639–656.