European Journal of
**Health Sciences**
*(EJHS)*

# Clinical Outcome of Intravascular Ultrasound Guided Percutaneous Coronary Intervention of Isolated Ostial Left Anterior Descending Artery Lesions

*Hany Fayed, Khaled Elgendy, and Ismail R Barrada*

AJPO

European Journal of Health Sciences
ISSN 2520-4645 (online)
Vol.8, Issue 1, pp 1 - 10, 2023
www.ajpojournals.org

# Clinical Outcome of Intravascular Ultrasound Guided Percutaneous Coronary Intervention of Isolated Ostial Left Anterior Descending Artery Lesions

**Hany Fayed[1], Khaled Elgendy[1], and Ismail R Barrada[2]**

[1]M.D. Cardiology, National Heart Institute, Egypt

[2]M.D. Cardiothoracic Surgery, National Heart Institute, Egypt

Corresponding Author's Email: hanyfayed1@gmail.com

**Abstract**

**Purpose**: Despite recent advances in interventional cardiology procedures, isolated ostial left anterior descending (LAD) lesions remain a challenge in cardiology. Due to the probability of left main (LM) affection, an LM bifurcation stenting technique may be required in certain individuals. So, we evaluated result of Intravascular Ultrasound (IVUS) guided percutaneous coronary intervention (PCI) in isolated LAD coronary artery lesions, either by crossing over the ostium or not, with a focus on major adverse cardiovascular events (MACE).

**Methodology**: Our prospective study from January 2021 to November 2022 included 79 isolated ostial LAD patients with Ostial LAD stenting (OS) or LM to LAD cross-over (CO) stenting at the National Heart Institute. As per the recommended guidelines, the participants were divided into two groups: the first one had IVUS guided PCI and Group (2) had Angiography guided PCI. The data was collected and statistically analyzed with SPSS 23.0 program.

**Findings:** No statistically significant difference was present between the groups regarding socio-demographic or clinical data (P-value > 0.05). It was discovered that an increase in Rotablator use, a decrease in Fluoroscopy time (min), a decrease in Contrast volume (ml), and a decrease in PCI duration (min) in patients who had IVUS guided PCI, with statistically significant difference when compared to other group who had Angiography guided PCI (P-value < 0.05). In addition, it was discovered that an increase in the necessity for a cross-over stenting method in group (1), with no statistically significant difference (P-value > 0.05). Low prevalence of mortality and morbidity among IVUS guided PCI patients was present with statistical significance regarding TVR (P-value < 0.05).

**Recommendations**: IVUS can offer valuable information on vascular lumen, plaque features, stent deployment, & device failure causes. As a result, IVUS-guided PCI may enhance clinical impact among participants, particularly those with complicated coronary lesions & those at high risk. Further reduction in IVUS's cost, cardiologists' education and enhancing IVUS use at PCI should be adapted next.

**Keywords**: *PCI, left main coronary disease, ostial disease, CABG, IVUS*

## INTRODUCTION

Regardless of recent advancements in interventional cardiology procedures, isolated ostial LAD lesions remain a difficulty for interventional cardiologists. As there is a probability of (Left Main) LM illness, an LM bifurcation stenting technique may be required in certain individuals. The aim of PCI for ostial LAD diseases is covering coronary ostium plaque while minimizing harm to surrounding bifurcation segments [(1)]. The majority of clinical outcomes data comes from studies comparing PCI of an isolated LAD lesion to CABG. Two meta-analyses of these studies found comparable death rates and MACE with minimally invasive LIMA operations, but much lower revascularization rates and angina recurrence rates with CABG [(2)].

Because of the likelihood of shear stress on the main branch with ostial LAD atherosclerosis, this kind of lesion presented unique technical and procedural challenges during PCI [(3)]. The aim of this research was to investigate clinical result of intravascular ultrasonography-guided percutaneous intervention among isolated LAD artery lesions, either crossing over the ostium or not, with MACE follow-up. It must be remembered that the myocardium is at risk with these operations. This danger may arise during PCI from the connection of LAD to LM and LCX, since atheroma may be established at the distal left main artery and ostial LAD site [(4)]. Instant restenosis and long-term MACE were more common in ostial lesions than in non-ostial lesions [(5)].

Intravascular ultrasonography (IVUS) can detect balloon slippage and dissection extension into the LM, which shows stent struts protruding to left-main versus insufficiently covering ostial lesion, which raises the risk of restenosis and stent thrombosis. Furthermore, ostial LAD stenting may cause damage to the neighboring LCX artery, resulting in ischemia and other negative consequences [(6)]. Rotational atherectomy, the use of cutting balloons, and other wire methods can enhance clinical and angiographic outcomes, as well as reduce the risk of MACE during follow-up. Furthermore, previous literatures showed have shown that stenting ostial LAD with the left main improves results [(7,8)].

The IVUS evaluates LMCA anatomy, and presence and distribution of plaque. Multiple investigations have established that a minimal lumen area (MLA) of 6 $mm^2$ is the cut-off number for assessing severity [(9)]. IVUS could be used to determine the amount of atherosclerosis at coronary ostia of LAD and LCX. Whenever it requires revascularization, IVUS offers information about optimum method according to architecture and calcium amount of proximal LAD/LCX and the LMCA. The IVUS can help to characterize the etiology for in-stent restenosis and risk of stent border damage [(10)]. Furthermore, IVUS may assess the requirement of stent post-dilatation and distal dissection presence, as well as if a side branch is impaired and requires fixing following provisional stent approach [(11)]. Recommendations in clinical practice for European Society of Cardiology propose utilizing IVUS to determine severity of LMCA defects as a class IIa B indication [(12)].

## MATERIALS AND METHODS

From January 2021 to November 2022, 79 participants with isolated ostial LAD illness with OS or LM to LAD (CO) stenting were included at National Heart Institute. The patients were divided into two groups: Group 1 received IVUS guided PCI, group 2 had Angiography guided PCI, and they all had clinical features (risk factors) assessment and evaluation with echocardiogram with focus on LVEF% on admission analysis. Procedural features (location and severity of lesion/s per the SYNTAX score[13] and medina classification[14]). Two qualified interventional cardiologists assessed the coronary angiography findings. All patients were thoroughly informed about the procedure's possible risks and benefits, as well as alternative therapeutic choices prior to the intervention, and obtained signed consent from all participants. Data was gathered during hospital admission and follow-up. In-hospital mortality and morbidity were also documented.

### Exclusion Criteria

1. Patients with acute ST-elevation myocardial infarction (STEMI) had Primary PCI.
2. Those with coronary angiography results such as: (significant disease of the LM more than 20% or serious lesions of the right coronary artery (RCA) and/or LCX greater than 50%).
3. Patients with protected LM.
4. In adherence to a dual antiplatelet regimen by enrolled patients within the first 12 months after the procedure.

### Clinical follow up of MACE in Both Groups

All-cause in-hospital mortality, acute MI, stroke, TVR, and instent restenosis (ISR), ostial LCX reintervention, contrast induced nephropathy (CIN), bleeding, and hospital re-admission (major arrhythmias, heart failure or others). If symptoms or verified myocardial ischemia indicated clinically, angiographic follow-up was advised.

### Definitions

Re-infarction was considered by the following:

1. ST-elevation of 0.1 mv or new pathognomonic Q waves on $\geq$ two contiguous leads, accompanied by a repeated rise in cardiac enzymes, especially when paired with ischemia symptoms lasting 20 minutes. A cTn measurement should be done immediately, and another sample to be obtained after 3-6 hours, with a 20% rise in the cTn value in the second sample.
2. CK-MB (or CK in the absence of MB) > 3 times more than normal and 50% more than the prior value [15].
3. TVR is defined as the re-intervention of any portion of target vessel.
4. Instent restenosis should be done whenever there is a luminal narrowing of more than 50% within 5 mm of the stented segment in angiograph [16].
5. According to least foreshortened angiographic projection view, an ostial LAD defect is described as isolated narrowing (50%) occurring within 3 mm of LAD take off.
6. Bleeding was classified as major, moderate, or minor using the TIMI scale [17].

European Journal of Health Sciences
ISSN 2520-4645 (online)
Vol.8, Issue 1, pp 1 - 10, 2023


7. CIN is defined as a 25% increase in serum creatinine from baseline or a 0.5 mg/dL (44 mol/L) absolute value increase within 48-72 hours of receiving intravenous contrast media **(18)**.
8. Procedural success is a residual stenosis of < 20% by visual inspection when there is TIMI III flow.

**In-hospital Management**

Initial aspirin 300 mg and clopidogrel 600 mg dose were given to all patients prior to the coronary operation. Utilizing quantitative coronary angiographic analysis (QCA), angiograms were assessed and the lesions were assessed using IVUS as indicated subsequently. PCI and coronary angiography were performed via the femoral or radial arteries. Heparin (80-100 IU/kg) was administered intravenously to all patients. The TIMI classification was used to assess coronary artery flow. The decision was made by the operators whether to utilize parenteral inotropes or glycoprotein IIb/IIIa inhibitors. When there was a significant thrombus load, a thrombus aspiration catheter was employed as advised. For 12 months, double antiplatelet medication (aspirin & clopidogrel every day) is suggested.

**IVUS Protocol**

In this study, the Boston Scientific coronary IVUS catheter was used by operator and ≥ IVUS technician in accordance with current standards **(19)**. IVUS images were taken during diastole after 100-200 mg of nitroglycerin administration. IVUS catheter was pushed 10 mm behind defect and back to within 10 mm of it using motorized transducer pullback at 0.5 mm/s. We estimated the lumen cross-sectional area (CSA) using Planimetry at the lesion at many levels, with lowest area was taken. The diameters and areas of the proximal and distal reference lumens **(20)** were also measured manually. AVIO (angiography versus intravascular ultrasound optimal stent implantation) criteria **(21)** have been used to evaluate the area and stenosis. In order to reduce the variability, all IVUS measurements were repeated, and the average of the two results was examined. Pre- and post-stent implantation measurements were taken routinely.

**Basic IVUS Measurement**

The inner layer of the IVUS of coronary arteries typically comprises atheroma, intima, and elastic membrane. Media is intermediate part, which is less echogenic than intima. Outer part which borders external elastic membrane (EEM) is made up of adventitia and periadventitial tissues that are not identified in IVUS images. The following basic measurements may be made with IVUS:

1. Minimum lumen diameter (MLD): the shortest diameter via lumen's center.
2. Minimum lumen area (MLA): the smallest area via the lumen's center.
3. Stenosis area: (reference lumen area - stenosis lumen area)/reference lumen area.
4. Plaque burden: (EEM area − lumen area) / EEM area **(22)**.

**Statistical Analysis**

Data were gathered and analyzed with SPSS 23.0, Quantitative data was given as mean, standard deviation, and ranges. Qualitative factors were given numerically and as percentages. The following tests were carried out: t-test was employed for means' comparison, while the Chi-square test was employed when comparing percentages' difference. CI at 95%, and P-value was deemed significant as follows: Probability P-values less than 0.05: significant; P-values more than 0.001: extremely significant; and P-values greater than 0.05 insignificant.

**RESULTS**

**Table 1: Demographic, clinical data between both groups**

| | **IVUS guided PCI group (39 patients)** | **Angiography guided PCI group (40 patients)** | **Test value** | **P-value** |
|---|---|---|---|---|
| Age (yr) | 63.1±10.9 | 59.9±10.2 | T:0.971 | 0.325 |
| Gender (male) | 29 (74.4%) | 30 (75.0%) | $x^2$: 0.004 | 0.951 |
| Hypertension | 21 (53.8%) | 22 (55.0%) | $x^2$: 0.011 | 0.915 |
| Dyslipidemia | 12 (30.8%) | 16 (40.0%) | $x^2$: 0.721 | 0.396 |
| DM | 18 (46.2%) | 12 (30.0%) | $x^2$: 2.172 | 0.141 |
| Smoking | 14 (35.9%) | 11 (27.5%) | $x^2$: 0.636 | 0.425 |
| +ve Family history of CAD | 7 (17.9%) | 6 (15.0%) | $x^2$: 0.119 | 0.730 |
| Previous MI | 11 (28.2%) | 10 (25.0%) | $x^2$: 0.102 | 0.749 |
| Previous PCI | 14 (35.9%) | 12 (30.0%) | $x^2$: 0.307 | 0.579 |
| LVEF% on admission | 52.2±8.1 | 54.5±7.36 | T: 1.322 | 0.190 |

*Using: t=Independent Sample test; $x^2$: Chi-square test;*

*p-value >0.05 NS; *p-value <0.05 S; **p-value <0.001 HS*

European Journal of Health Sciences
ISSN 2520-4645 (online)
Vol.8, Issue 1, pp 1 - 10, 2023


**Table 2: Procedural characteristics**

| | IVUS guided PCI group (39 patients) | Angiography guided PCI group (40 patients) | Test value | P-value |
|---|---|---|---|---|
| SYNTAX score (mean±SD) | 23.7±6.8 | 24.2±7.1 | T: 0.320 | 0.750 |
| Medina 0,1,0 | 36 (92.3%) | 38 (95.0%) | $x^2$: 0.240 | 0.625 |
| Medina 0,1,1 | 4 (10.3%) | 5 (12.5%) | $x^2$: 0.093 | 0.760 |
| Cross-over stenting | 37 (94.9%) | 35 (87.5%) | $x^2$: 1.324 | 0.250 |
| Rotablator use | 6 (15.4%) | 1 (2.5%) | $x^2$: 4.015 | 0.045* |
| PCI approach Femoral | 38 (97.4%) | 34 (85.0%) | $x^2$: 3.706 | 0.054 |
| PCI approach radial | 1 (2.6%) | 6 (15.0%) | | |
| Fluoroscopy time (min.) | 8.7±6.9 | 12.8±4.6 | T: 3.099 | 0.003* |
| Contrast volume (ml.) | 89.1±12.4 | 100.5±10.8 | T: 4.353 | <0.001 |
| PCI duration (min.) (mean±SD) | 46.4±30.6 | 65.9±35.7 | T: 2.609 | 0.011* |
| Abrupt vessel occlussion | 1 (2.6%) | 3 (7.5%) | $x^2$: 0.971 | 0.325 |
| Procedural success | 38 (97.4%) | 37 (92.5%) | $x^2$: 0.971 | 0.325 |

*Using: t=Independent Sample test; $x^2$: Chi-square test;*

*p-value >0.05 NS; *p-value <0.05 S; **p-value <0.001 HS*

**Table 3: Clinical outcome**

| | IVUS guided PCI group (39 patients) | Angiography guided PCI group (40 patients) | *x2* | P-value |
|---|---|---|---|---|
| In hospital MR% | 3 (7.7%) | 9 (22.5%) | 3.314 | 0.687 |
| Morbidities | | | | |
| AMI | 2 (5.1%) | 5 (12.5%) | 1.324 | 0.250 |
| Stroke | 1 (2.6%) | 4 (10.0%) | 1.796 | 0.180 |
| TVR | 1 (2.6%) | 8 (20.0%) | 5.840 | 0.016* |
| CIN | 2 (5.1%) | 1 (2.5%) | 0.362 | 0.547 |
| Bleeding | 1 (2.6%) | 1 (2.5%) | 0.001 | 0.978 |
| Hospital re-admission | 1 (2.6%) | 2 (5.0%) | 0.306 | 0.580 |
| Reintervention for ostial LCX | 1 (2.6%) | 3 (7.5%) | 0.971 | 0.325 |

*Using: $x^2$: Chi-square test;*

*p-value >0.05 NS; *p-value <0.05 S; **p-value <0.001 HS*

**DISCUSSION**

Isolated LAD ostial lesions were usually handled using techniques which cover angiographic ostium's edge, resulted in possibility of shifting of plaque into LM or incomplete covering of a plaque that may reach LM, with raised possibility for restenosis and stent thrombosis (23). Nevertheless, raised SYNTAX score and frequent requirement for rotablation, our trial demonstrated outstanding performance of cross-over stenting guided by IVUS with a low rate of mortality and MACE. Almost all occurrences of clinically significant restenosis in patients who received angiography-guided PCI for ostial LAD stenting can be attributable to a lack of plaque coverage and stent expansion.

In this research, higher Rotablator use, low Fluoroscopy time (min. ), low Contrast volume (ml. ), and lower PCI duration (min.) were demonstrated at patients who had IVUS guided PCI of isolated LAD lesion with statistically significant difference compared to the other group of patients who had Angiography guided PCI (P-value $< 0.05$), which is consistent with Gianluca et al. (2019) who found that CO group was associated with lower fluoroscopy time and contrast volume despite an higher use of IVUS and Rotablator (24).

Also, among Angiography guided PCI patients, it was found that the prevalence of mortality and morbidities was high, including the need for urgent CABG due to stent fracture and massive pericardial effusion in one case, with a statistically significant difference in groups regarding TVR, which is consistent with Gianluca et al., (2019), who found that CO stenting had better MACE and TVR than OS. In this study, this is attributable to lack of lesion preparation, precise stenting and optimization, which may be assisted by using IVUS for attaining good long-term results among the complicated population (24).

In a series of 162 patients, Capranzano et al. (2010) found that rate of cardiac mortality, nonfatal MI, total TLR, and TLR-LM were 2.6%, 2.1%, 8.3%, and 4.7%, respectively. TLR and TLR-LM were greater among ostial LAD stenting patients than in the LM to LAD stenting guided by IVUS group (25). The results go with Rigatelli et al. (2019), who examined 74 individuals who had ostial LAD lesions. Thirty-six (49%) had IVUS-guided crossover stenting into LM. The crossover group had a numerical decrease in MACE compared to the ostial stent group (10 vs. 21%; P = 0.20). Nevertheless, TVR among crossover approach was much lower (5.6% versus 10.1%; P= 0.04) (26).

A meta-analysis of 8 randomized IVUS-guided VS angiography-guided DES researches found that IVUS had reduced risk of MACE by 41%, mortality by 54%, instent thrombosis by 51%, and ischemia-driven target lesion revascularization by 40% (27). The current study demonstrated that PCI in isolated ostial LAD defects was possible, safe, and efficacious when distal LM is implicated instead of stenting only LAD ostium and is linked with better results. An isolated ostial LAD stenting might be technically challenging, with strong elastic recoil and side branch stent jail. Furthermore, a stenting that is limited to the LAD ostium, risk of plaque transfer in LM / LCX is present, as well as distal LM injury from balloon dilatation, carrying possibility of progressive affection in LM segment proximal to stent. The study proved that atheroma spread of isolated ostial disease to LM is present in 95% of group 1 who assessed by using IVUS and so cross-over stenting strategy was done; this finding agrees with Medina et al., (2009) utilizing OS gave mean protrusion of stent over origin of LCX of 2.48±0.91 mm using IVUS: LCX was damaged among 10% of cases, needed more intervention in one third of patients [28].

## CONCLUSION

IVUS can offer valuable information on vascular lumen, plaque features and stent deployment. As a result, IVUS-guided PCI may enhance clinical impact among participants, particularly those with complicated coronary lesions & those at high risk.

## RECOMMENDATIONS

Further reduction in IVUS cost, continuous cardiologists' education and enhancing IVUS use at PCI should be adapted next.

## REFERENCES

1. Park SJ, Lee CW, Hong MK, et al. Stent placement for ostial left anterior descending coronary artery stenosis: acute and long term (2-year) results. Catheter Cardiovasc Interv 2000;49:2 67-71.
2. Jaffery Z, Kowalski M, Weaver WD, et al. A meta-analysis of randomized control trials comparing minimally invasive direct coronary bypass grafting versus percutaneous coronary intervention for stenosis of the proximal left anterior descending artery. Eur J Cardiothorac Surg 2007;31:69 1–7.
3. Zheng X, Peng H, Zhao D, et al. Optimal revascularization strategy on medina 0,1,0 left main bifurcation lesions in type 2 diabetes. J Diabetes Res 2016; 2016: 1702454.
4. Li L, Dash D, Gai LY, et al. Intravascular ultrasound classification of plaque in angiographic true bifurcation lesions of the left main coronary artery. Chin Med J (Engl) 2016; 129: 1538-1543.
5. Hsieh IC, Chen CC, Chang SH, et al. Acute and long-term outcomes of drug-eluting stent implantations in aorto-ostial, left anterior descending artery-ostial, and nonostial lesions. Catheter Cardiovasc Interv 2013; 82: 727-734.
6. Kang SJ, Ahn JM, Kim WJ, et al. Intravascular ultrasound assessment of drug-eluting stent coverage of the coronary ostium and effect on outcomes. Am J Cardiol 2013; 111: 1401-1407.
7. Lee CH, Choi SW, Hwang J, et al. 5-year outcomes according to ffr of left circumflex coronary artery after left main crossover stenting. JACC Cardiovasc Interv 2019; 12: 847-855.
8. Rigatelli G, Zuin M, Baracca E, et al. Long-term clinical outcomes of isolated ostial left anterior descending disease treatment: Ostial stenting versus left main crossover stenting. Cardiovasc Revasc Med 2019; 20: 1058-1062.
9. Mintz GS, Lefèvre T, Lassen JF, et al. Intravascular ultrasound in the evaluation and treatment of left main coronary artery disease: a consensus statement from the European Bifurcation Club. EuroIntervention. 2018;14: e467-e474.

10. De la Torre Hernández JM, García Camarero T, Baz Alonso JA, et al. Outcomes of predefined optimisation criteria for intravascular ultrasound guidance of left main stenting. EuroIntervention. 2020;16:210-217.

11. Kang SJ, Ahn JM and Kim WJ. Functional and morphological assessment of side branch after left main coronary artery bifurcation stenting with crossover technique. Catheter Cardiovasc Interv. 2014;83:545-552.

12. Stone GW, Kappetein AP, Sabik JF, et al. Five-Year Outcomes after PCI or CABG for Left Main Coronary Disease. N Engl J Med. 2019;381:1820-1830.

13. Sianos G, Morel MA, Kappetein AP, et al. The SYNTAX Score: an angiographic tool grading the complexity of coronary artery disease. Eurointervention 2005; 1: 219-27.

14. Medina A, Suarez de Lezo J and Pan M. A new classification of coronary bifurcation lesions. Rev EspCardiol 2006; 59: 183.

15. Kristian T, Joseph A, Allan J, et al. the Writing Group on behalf of the Joint ESC/ACCF/AHA/WHF Task Force for the Universal Definition of Myocardial Infarction. 2012; 125(21):2613-20.

16. Mehran R, Dangas G and Abizaid AS. Angiographic patterns of in-stent restenosis: Classification and implications for long-term outcome. Circulation 1999;100:1872-1878.

17. Kinnaird T, Strabile E, Mintz G. et al. Incidence, predictors, and prognostic implications of bleeding and blood transfusion following percutaneous coronary intervention. Am J Cardiol 2003; 92(8):930-935.

18. Lakhal K, Ehrmann S, Chaari A, et al. Acute Kidney Injury Network definition of contrast-induced nephropathy in the critically ill: incidence and outcome. J Crit Care 2011; 26(6):593-9.

19. Lotfi A, Jeremias A, Fearon WF, et al. Expert consensus statement on the use of fractional flow reserve, intravascular ultrasound, and optical coherence tomography: a consensus statement of the society of cardiovascular angiography and interventions. Catheter CardiovascInterv 2014; 83: 509-518.

20. Kang SJ, Lee JY, Ahn JM, et al. Validation of intravascular ultrasound-derived parameters with fractional flow reserve for assessment of coronary stenosis severity. CircCardiovascInterv 2011; 4: 65-71.

21. Chieffo A, Latib A, Caussin C, et al. A prospective, randomized trial of intravascular ultrasound guided compared to angiography guided stent implantation in complex coronary lesions: the AVIO trial. Am Heart J. 2013;165:65-72.

22. Mintz GS, Nissen SE, Anderson WD, et al. American College of Cardiology clinical expert consensus document on standards for acquisition, measurement and reporting of intravascular ultrasound studies (IVUS). A report of the American College of Cardiology Task Force on Clinical Expert Consensus Documents. J Am Coll Cardiol 2001;37:1478–92.

23. Golmohamadi Z, Sokhanvar S, Aslanabadi N, et al. One-Year Outcomes After Everolimus-Eluting Stents Implantation in Ostial Lesions of Left Anterior Descending Coronary Arteries.Cardiol Res. 2013;4:192-198.

24. Gianluca R, Marco Z, Enrico B, et al. Long-Term Clinical Outcomes of Isolated Ostial Left Anterior Descending Disease Treatment: Ostial Stenting versus Left Main Cross-Over Stenting. Cardiovascular Revascularization Medicine journal .2019;20: 1058-62.

25. Capranzano P, Sanfilippo A, Tagliareni F, et al. Long-term outcomes after drug-eluting stent for the treatment of ostial left anterior descending coronary artery lesions.Am Heart J. 2010;160:973-8.

26. Rigatelli G, Zuin M, Baracca E, et al. Long-term clinical outcomes of isolated ostial left anterior descending disease treatment: Ostial stenting versus left main crossover stenting. Cardiovasc Revasc Med 2019; 20: 1058-1062.

27. Elgendy IY, Mahmoud A, Elgendy AY, et al. Outcomes With Intravascular Ultrasound-Guided Stent Implantation: A Meta-Analysis of Randomized Trials in the Era of Drug-Eluting Stents. Circ Cardiovasc Interv 2016;9:e003700.

28. Medina A, Martín P, Suárez de Lezo J, et al. Vulnerable carina anatomy and ostial lesions in the left anterior descending coronary artery after floating-stent treatment.Rev EspCardiol. 2009;62:1240-9.