KARDIOLOGIA POLSKA
Polish Heart Journal
The Official Peer-reviewed Journal of the Polish Cardiac Society since 1957
Online first
This is a provisional PDF only. Copyedited and fully formatted version will be made available soon
ISSN 0022–9032
e-ISSN 1897–4279

Culprit plaque location within left circumflex coronary artery predicts clinical outcome in patients experiencing acute coronary syndromes with percutaneous coronary intervention — data from ORPKI registry

Authors: Michał Chyrchel, Zbigniew Siudak, Łukasz Rzeszutko, Jan Roczniak, Marcin Piechocki, Wojciech Koziołek, Krzysztof Piotr Malinowski, Rafał Januszek, Stanisław Bartuś, Andrzej Surdacki

Article type: Original article
Received: October 13, 2021
Accepted: June 20, 2022
Early publication date: June 20, 2022

Culprit plaque location within left circumflex coronary artery predicts clinical outcome in patients experiencing acute coronary syndromes with percutaneous coronary intervention — data from ORPKI registry

Short title: Culprit location in LCx predicts clinical outcome of a PCI in ACS

Michał Chyrchel[1, 2], Zbigniew Siudak[3], Łukasz Rzeszutko[1, 2], Jan Roczniak[4], Marcin Piechocki[4], Wojciech Koziołek[4], Krzysztof Piotr Malinowski[5], Rafał Januszek[1, 2], Stanisław Bartuś[1, 2], Andrzej Surdacki[1, 2]

[1]Department of Cardiology and Cardiovascular Interventions, University Hospital, Kraków, Poland

[2]2nd Department of Cardiology, Institute of Cardiology, Faculty of Medicine, Jagiellonian University Medical College, Kraków, Poland

[3]Faculty of Medicine and Health Sciences, Collegium Medicum Jan Kochanowski University in Kielce, Kielce, Poland

[4]Student Scientific Group at the 2nd Department of Cardiology, Jagiellonian University Medical College, Kraków, Poland

[5]Institute of Public Health, Faculty of Health Sciences, Jagiellonian University Medical College, Kraków, Poland

Correspondence to:
Jan Roczniak,
Students' Scientific Group at the 2nd Department of Cardiology,
Institute of Cardiology, Faculty of Medicine,
Jagiellonian University Medical College,
Jakubowskiego 2, 30–688 Kraków, Poland,
phone: +48 12 400 22 51,
e-mail: roczniakjan@gmail.com

WHAT'S NEW?

Data from the Polish national registry (ORPKI) have shown that the location of the culprit plaque has a great impact on the severity of myocardial infarction. Patients with proximal occlusion and non-ST segment elevation myocardial infarction (NSTEMI) are at a greater risk than patients with distal occlusion and ST segment elevation myocardial infarction (STEMI). This correlation indicates how important it is to take other factors alongside the presence of ST-elevation, most importantly Killip score, as a patient with NSTEMI may require more urgent and careful treatment than a patient with STEMI.

ABSTRACT

Background: The left circumflex (Cx) artery is the most challenging of coronary branches in terms of diagnostics because the clinical presentation and electrocardiography (ECG) results do not always suggest critical occlusion despite its presence. Therefore, it is important to determine the factors contributing to the clinical manifestation and outcome, such as culprit location.

Aims: To determine the relation between the location of the culprit plaque and clinical outcomes in the LCx artery.

Methods: Data from the Polish Registry of Invasive Cardiology Procedures (ORPKI) concerning percutaneous coronary intervention (PCI) procedures have been extracted and analyzed using appropriate statistical tests.

Results: Patients with proximal occlusion received a worse grade using the Killip score. Patients with thrombolysis in myocardial infarction (TIMI) score 0 presented worse clinical presentation in each of the occlusion locations. Periprocedural cardiac arrest and death rate was the highest among patients with proximal Cx occlusion. Death rate among patients with proximal occlusion and non ST segment elevation myocardial infarction (NSTEMI) was greater than among patients with distal occlusion and ST segment elevation myocardial infarction (STEMI).

Conclusions: Among patients with proximal occlusions of the Cx artery and TIMI 0 grade flow in initial angiogram, a STEMI-like approach should be undertaken apart from initial ECG findings. This is driven by a higher rate of critical and fatal complications such as cardiac arrest and periprocedural death. Fatal complications occur more often in patients with proximal occlusion of Cx than in medial or distal occlusion. Grade IV according to the Killip score can suggest proximal culprit location.

Key words: culprit lesion, left circumflex artery, acute coronary syndromes, clinical outcomes, Killip classification

INTRODUCTION

Acute coronary syndromes (ACS) encompass ST-segment elevation myocardial infarction (STEMI), non-ST segment elevation myocardial infarction (NSTEMI) and unstable angina (UA). When typical symptoms of myocardial infarction (MI) are associated with STEMI changes on baseline ECG, current guidelines recommend urgent primary percutaneous coronary intervention (PCI) with maximum reduction of door-to-balloon time [1]. In the NSTEMI subgroup, recommendations are not so strict and depend upon clinical and hemodynamic condition of the patient [2]. Moreover, among MI patients, those with occluded or critically stenosed left circumflex coronary artery (Cx) seem to be the most challenging group to identify and immediately qualify for urgent angiography. It could be partially explained by non-conclusive ECG changes at admission and confusing clinical presentation [3–11]. Our investigation has gone further and we focused on assessing whether the different localization of culprit plaque (proximal vs. medial vs. distal segment) within the circumflex artery responsible for MI have any implications on procedural aspects and clinical outcome of these patients. The aim of the present study was to assess the influence of culprit plaque location within the circumflex artery segments (proximal vs. medial vs. distal) on procedural characteristics and clinical outcome in patients with myocardial infarction (both STEMI and NSTEMI) treated using primary PCI. The differences were also referred to preliminary diagnosis and TIMI flow grade within the infarct-related artery at baseline angiography.

METHODS

All data were obtained from the electronic database of the Polish Registry of Invasive Cardiology Procedures (ORPKI), operated by the Jagiellonian University Medical College in Kraków. The ORPKI is a national registry with data compiled from all cardiology percutaneous interventions performed in Poland. Data in the ORPKI registry have been gathered via electronic case report forms at the majority of interventional cardiology centers in Poland since 2004. No personal data is collected in the registry. The presented archive is a single-arm registry of PCIs performed at

Polish cathlabs within years 2014–2019 [12–14]. Corelab assessment was not applied. The MI, STEMI, NSTEMI and UA were defined according to the fourth universal definition of myocardial infarction (2018) [15]. The segmentation assessment was performed on the basis of segmentation visual assessment according to the Coronary Artery Surgery Study (CASS) [16]. Killip-Kimball classification was used to evaluate stage of heart failure among patients with acute myocardial infarction [17]. The thrombolysis in myocardial infarction (TIMI) scale was used to assess coronary artery flow [18].

In the study, patients were included from the ORPKI who were admitted to a cathlab with ACS and underwent a primary PCI of a Cx significant occlusion. The exclusion criterion was a significant lack of documentation. Patients were divided according to the culprit location in the Cx. Primary endpoints compared between the groups were intra- and peri-procedural cardiac arrest and death rate.

The study was provided with ethical principles for clinical research based on the Declaration of Helsinki and appropriate consent was obtained from the institutional review board.

Statistical analysis

Categorical variables are presented as numbers and percentages. The normality of quantitative variables was assessed via the Shapiro–Wilk test. As the distribution of all quantitative data was other from normal, they are expressed as median (interquartile range [IQR]) and were compared using the Kruskal–Wallis ANOVA with post hoc Dunn test. Categorical variables were compared with Pearson χ^2 or Fisher exact test if 20% of cells had an expected count of less than 5 (Monte Carlo simulation for tables larger than 2 × 2). The significance level (α) was set at 0.05. Based on the results of univariate analysis, multivariable logistic regression models were constructed to find predictors of periprocedural deaths, cardiac arrests, and all complications in the analyzed group of patients. We included into the multivariable analysis indices with $P < 0.1$ based on the results of univariate analysis. The best model was obtained using the stepwise regression with minimization of Bayesian Information Criterion as a target. Statistical analysis was performed using the JMP, version 15.2.0 (SAS Institute Inc., Cary, NC, US).

RESULTS

Characteristics

Initially, 97 899 clinical records were analyzed. For the purpose of analyzing all patients, they were divided according to localization of the culprit plaque within the Cx artery: group A — proximal segment (n = 43 444); group B — medial segment (n = 45 363), and group C — distal segment (n = 9092), based on initial angiography. Patient characteristics and data concerning past medical history were presented in Table 1. At admission, patients were assessed according to the Killip–Kimball classification. The patients with proximal occlusion received, on average, the worst score. The results of the assessment on this scale were presented in Table 2.

Clinical status at baseline — whole group (independent on TIMI grade)

On admission, cardiac arrest was observed in 2.31% of patients. The highest rate of cardiac arrest was observed in group A — proximal segment of Cx, followed by group B and C (Table 2). This difference was concordant with the Killip classification — percentage of IV grade in group A was twice as high as in groups B and C. The differences were statistically significant (Table 2).

Hypothermia was introduced extremely rarely in all groups — most commonly in group A, followed by groups B and C — proportionally to the differences in cardiac arrest in analyzed groups (Table 2). In all groups, direct transport to the Cath lab was relatively rare (8.03%).

Clinical status at baseline — patients with TIMI 0 in initial angiogram

At admission, cardiac arrest was observed in 4.89% of patients in the TIMI 0 subgroup, which was over 2 times higher than in the general comparison (Table 2). In the TIMI 0 subgroup, the highest rate of cardiac arrest was also observed in group A — proximal segment of Cx, followed by groups B and C (Table 2). This difference was concordant with the Killip classification — percentage of IV grade was the highest in group A, followed by groups B and C. The differences were statistically significant (Table 2).

Hypothermia was introduced extremely rarely in all groups – most commonly in group A, followed by groups B and C — proportionally to the differences regarding cardiac arrest in analyzed groups (Table 2). In the TIMI 0 subgroup, direct transport to the Cath lab was observed more frequently than in the whole cohort (16.11%).

Initial diagnosis based on ECG and troponin level (STEMI vs. NSTEMI vs. UA)

The most common reason for the procedure in all of the groups was UA. STEMI was most common in group C, followed by groups A and B.

Based on initial diagnosis, cardiac arrest rate was significantly higher in patients with STEMI in the initial ECG, and considering segment division, more frequently in the proximal segments: 1.51% in group A; 0.75% in group B and 0.74% in group C (P <0.001). In NSTEMI, this totaled 0.56% vs. 0.24 % vs. 0.30%, respectively (P = 0.007), while in UA patients, this was 0.17% vs. 0.08% vs. 0.03% (P = 0.015).

Vascular access

The most frequently used access during the procedures in all of the groups was the right radial approach. More specific data concerning vascular access was presented in Supplementary material, *Table S1*.

Angiographic characteristics

Multivessel coronary artery disease (CAD) without left main coronary artery (LMCA) involvement was present in more than half of the performed procedures. Single-vessel CAD was the second most common finding. Specific data concerning the results of the angiograms were given in Table 3.

Advanced morphology and functional assessment

Additional assessment, such as intracoronary ultrasound (ICUS), plaque assessment with optical coherence tomography (OCT) or functional assessment with fractional coronary flow reserve measurement (FFR) were rarely performed in all groups. Further data were presented in Supplementary material, *Table S2*.

Procedural characteristics: amount of contrast and radiation dose

In the whole group, the median contrast volume used during the procedure was 160.00 (120.00–210.00) ml. The smallest amount of contrast was used in group B (medial segment) followed by the C and A groups. In the TIMI 0 subgroup, the median general contrast usage was greater compared to the whole group: 170.00 (135.00–220.00) ml; with the same proportion between segments: significantly higher in group B (medial segment) in comparison to groups A and C. A detailed comparison is provided in Table 4.

Evaluating the contrast volume between assessed segments and stratified by different diagnosis: patients with STEMI were related to the greatest contrast volume use during the procedures and this concerned proximal and distal occlusion; while in NSTEMI — proximal and distal occlusion; in UA — proximal occlusion (Table 4).

The radiation dose received during the procedure was higher in the TIMI 0 subgroup than in the main comparison. In this subgroup, the exposure to radiation was the greatest in C group, followed by groups A and B, whereas in the general comparison, it was greatest in the A group, followed by groups C and B (Table 4).

Comparing the radiation dose in the division according to initial diagnosis: in patients with STEMI, the highest dose of radiation was used during the procedures which concerned distal occlusion; in NSTEMI — distal occlusion; in UA — distal occlusion (Table 4).

COMPLICATIONS

Lesion in the proximal segment of the Cx artery resulted in a significantly greater rate of intra-procedural cardiac arrest and death compared to other locations, both in the TIMI 0 subgroup and in the main comparison. There was no difference in terms of puncture-site bleeding (Table 4).

In division to subgroups according to the initial diagnosis, the results were concordant with the whole group comparison — cardiac arrest and death rate was the highest in the A group (proximal occlusion), followed by the B and C groups. This relation occurred in every subgroup (STEMI, NSTEMI, UA). Death rate in NSTEMI patients with proximal occlusion was comparable to that in STEMI patients with medial occlusion, and was twice as high as the death rate in STEMI patients with distal occlusion (Table 4).

Procedural characteristics: time delays

Time from first contact to inflation or angiogram was the shortest in groups C and A, followed by group B considering the whole group. In the TIMI 0 subgroup, time from first contact to inflation or angiogram was the shortest in the C group (distal), followed by the A and B groups. The results were statistically significant (Table 5).

Regarding the initial diagnosis: in each occlusion location group, patients with STEMI had undergone an angiography much faster than patients with NSTEMI, and even faster than patients with UA. NSTEMI patients had undergone an angiography slightly faster than UA patients (Table 5).

Stenting

Stenting comparison was performed in the TIMI 0 subgroup. In each group, the most commonly used stent type was DES. BVS was used extremely rarely — less than 0.5% of cases. Stents were implanted most commonly in medial location. A substantial percentage of patients did not receive any implant (Supplementary material, *Table S3*).

Risk factors for periprocedural death and complications

Among the risk factors influencing the periprocedural death there is the culprit location (the worst survival in the proximal location), the type of ACS (the worst survival in STEMI, followed by NSTEMI and UA), TIMI flow after the intervention (worse survival in smaller flow) and Killip class (worse survival in higher class) and others. The presence of multi-vessel disease also increased the risk of death. All determined risk factors were presented in Figure 1.

As it comes to periprocedural cardiac death, similar risk factors have been determined. The risk factors include, among others: unsuccessful PCI (TIMI 0 vs. TIMI 3 after PCI), Killip class (worse survival in higher score) and initial diagnosis (STEMI worse than NSTEMI, followed by UA). Surprisingly, intervention on vessel bifurcation has been found to be a protective factor. All determined risk factors have been presented in Figure 2.

In terms of overall complications, the risk factors include, among others: unsuccessful PCI , the Killip class (greater odds of complications in higher score), the initial diagnosis and application of non-standard vascular access (mostly brachial) instead of radial access. The access site was not a risk factor for previously mentioned outcomes (fatal complications). All determined risk factors were presented in Figure 3.

DISCUSSION

The study has shown that culprit location in the Cx artery greatly impacts the clinical manifestation in patients with ACS. Patients with proximal culprit are generally in a worse condition —

considering the Killip class upon admission — and suffer from higher periprocedural mortality. Further multifactorial investigation confirmed these findings, determining culprit location and Killip classification upon admission as independent risk factors for periprocedural death. Other risk factors worth mentioning are the unsuccessful PCI and initial diagnosis (STEMI/NSTEMI/UA).

In comparison to other coronary arteries, the Cx remains the most difficult and challenging to properly diagnose in patients with acute myocardial infarction (AMI) [19]. This may be associated with their location on the lateral and posterior wall of the left ventricle and limited effectiveness of ECG to detect ischemia/infarction in this area [20, 21]. Time delays or failure in the case of Cx artery occlusion diagnosis have serious clinical consequences because it supplies a significant area of the left ventricle myocardium [22]. This is extremely important when the left coronary artery is the dominant one [23]. Delayed treatment of the culprit artery located within Cx results in the worst clinical outcome [3, 24].

The most serious periprocedural complications during primary PCI are cardiac arrest and death. Despite frequent lack of ischemic changes in ECG and less pronounced clinical symptoms, cardiac arrest and death are also observed in patients with AMI from the Cx artery, similarly as in the case of AMI from the RCA, LAD or by-pass grafts. Our study revealed that when the culprit plaque is located in the proximal segment of the Cx, the fatal complications occur more frequently — both at the admission and during the procedure. The location of culprit plaque within the proximal segment also results in a higher rate of left ventricle dysfunction, which could predispose to further fatal complications in these patients. All these findings could be explained by the significantly larger mass of the left ventricle muscle affected by infarct in the case of proximal segment occlusion compared to medial and distal ones.

Surprisingly, ST elevation was present more frequently in patients with distal plaque location. It is hard to explain this phenomenon, however the authors suspect that this difference might be due to the artery thrombosis or embolization, which occurs more likely in a smaller vessel diameter, thus in the distal location [25]. This reduces the myocardial perfusion completely, on the contrary to proximal occlusions where total thrombosis is less likely, and additionally the affected myocardium can be partially supplied by collateral circulation. However, the difference in the occurrence of STEMI between the groups was small, and the authors believe that significant results of the statistical test could be rather caused by the disproportion in NSTEMI and UA, which was greater. Moreover, as previously mentioned, Cx artery supplies an area where ischemia is exceptionally difficult to detect through an ECG [20], which additionally impacts the results. Another consequence of these anatomical conditions was observed in this study, where total occlusion (TIMI 0) did not cause ST-elevation in a substantial percentage of patients, further proving that ST elevation depends on many factors and it's absence can be misleading in regard to the Cx area.

Considering the initial diagnosis (STEMI vs. NSTEMI vs. UA), the fatal complications were more frequently observed in patients with STEMI which may be explained by higher intensification of ongoing ischemia in these subgroups. Regarding both serious complications: cardiac arrest and death — they were more frequently observed in patients with an initially occluded artery during index angiogram — TIMI 0 flow. This is probably justified by the earlier appearance of large-area total necrosis followed by serious rhythm disturbances in this case, compared to arteries with critical stenosis but still preserved flow in the coronary artery.

The median contrast volume in the whole group was high probably due to difficulties with the visualization caused by the spatial conditioning of the Cx artery. The larger contrast volume in the proximal segments could be explained by larger diameter of the vessel and greater area of the distal vascular bed, as well as more difficult procedure, often resulting in complications which prolongs the procedure. In turn, almost the same median volume of contrast used during procedures within the distal segments is most likely due to the difficulties with the infero-basal area visualization, despite smaller vessel diameters.

Regarding initial diagnosis in all comparable segments, the greatest volume of contrast was used in patients with NSTEMI. It was previously shown that total procedural time in NSTEMI is longer than in STEMI [26]. In this subgroup, further difficulty is observed in identifying the culprit plaque in patients with multi-vessel coronary artery disease. Additional tools such as ICUS or OCT, were, unfortunately, applied definitely too rarely during procedures in this registry.

Regarding radiation dose, a smaller dose one used during interventions on the medial segments of the Cx artery. Again, this is probably due to spatial conditioning as proximal and distal segments are more difficult to visualize in the Cx artery.

Regarding time delays, we observed greater delays in the whole group in comparison to the TIMI 0 subgroup when time delays were shorter. This could possibly be explained by more significant clinical symptoms associated with the occluded infarct artery in the TIMI 0 group. This condition could influence the medical staff to make quicker decisions when directing the patient to urgent angiography. Estimating time delays in different diagnoses, we observed smaller delays in STEMI patients in all analyzed segments similarly due to more pronounced ischemia and clinical symptoms in this situation.

In comparison to other coronary vessels (RCA and LAD), the percentage of patients who underwent PCI more than 24 hours from the pain onset is higher in the case of the Cx artery: 30% vs. 20% vs. 17%, respectively, which was explained by lower sensitivity of ST-segment elevation in the detection of acute Cx occlusion [3, 20]. This hypothesis is also consistent with an underrepresentation of the Cx as the culprit artery among patients with STEMI [8, 27].

Determined risk factors prove that VA do not have an impact on serious complications, and thus on the clinical outcome of patients with ACS. However, they do influence overall complications, probably due to the most common, mild complications - puncture-site hematoma, which occurs more often in brachial access [28].

Regarding the therapeutic hypothermia, it was most commonly applied in patients with proximal lesion and TIMI 0. This can be again explained by a greater ischemia, which was associated with a worse Killip score, and therefore worse clinical condition of the patient. This may be an indication for therapeutic hypothermia due to its cardioprotective effect during transport to a cath lab [29, 30]. However, these cases were rare in our study, which can be explained by the fact that the network of cath labs in Poland is dense and highly developed, and the time of patient transport to a cath lab is relatively short [31].

The results show that patients with NSTEMI and proximal occlusion are at a greater risk than patients with STEMI and distal occlusion. However, according to the results of our study, which are concordant with the current guidelines, NSTEMI patients with proximal occlusion would be treated less urgently than a patient with STEMI and distal occlusion [1, 2], as the initial ECG diagnosis greatly impacts time delay. Unfortunately, location of the culprit plaque cannot be taken under consideration in initial diagnosis, as it is known only after performing a coronary angiogram. Therefore, apart from initial ECG diagnosis, it is crucial to make decisions according to the whole clinical presentation, with special emphasis on Killip score, as there is a group of patients with NSTEMI who require as urgent intervention as patients with STEMI.

Limitations

Considering the major limitations, the leading one is the registry nature of the present study. The other one is due to the variability in the area that is supplied with blood by the Cx artery, which affects patients characteristics and clinical outcomes. However, this random bias should be excluded by the large number of patients assessed.

CONCLUSIONS

Among patients with culprit lesions located in the proximal segment of the Cx artery and TIMI 0 grade flow in the initial angiogram, a STEMI-like approach should be undertaken apart from initial ECG findings. This is driven by a higher rate of critical and fatal complications such as cardiac arrest and periprocedural death. Fatal complications occur more often in patients with proximal occlusion of Cx than in medial or distal occlusion. Location of the occlusion should be considered alongside ECG diagnosis as a risk factor for periprocedural cardiac arrest and death. Killip score can be used to predict the suspected culprit location, as patients with proximal occlusion more often receive IV grade.

REFERENCES

1. Ibanez B, James S, Agewall S, et al. et al.. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J. 2018; 39(2): 119–177, doi: 10.1093/eurheartj/ehx393, indexed in Pubmed: 28886621.
2. Collet JP, Thiele H, Barbato E, et al. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: The Task Force for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J. 2021; 42(14): 289–1367, doi: 32860058, indexed in Pubmed: 10.1093/eurheartj/ehaa575.
3. From AM, Best PJM, Lennon RJ, et al. Acute myocardial infarction due to left circumflex artery occlusion and significance of ST-segment elevation. Am J Cardiol. 2010; 106(8): 1081–1085, doi: 10.1016/j.amjcard.2010.06.016, indexed in Pubmed: 20920642.

4. Rasoul S, de Boer MJ, Suryapranata H, et al. Circumflex artery-related acute myocardial infarction: limited ECG abnormalities but poor outcome. Neth Heart J. 2007; 15(9): 286–290, doi: 10.1007/BF03086001, indexed in Pubmed: 18030315.
5. Kim SS, Choi HS, Jeong MHo, et al. Clinical outcomes of acute myocardial infarction with occluded left circumflex artery. J Cardiol. 2011; 57(3): 290–296, doi: 10.1016/j.jjcc.2011.01.014, indexed in Pubmed: 21388789.
6. Stribling WK, Kontos MC, Abbate A, et al. Left circumflex occlusion in acute myocardial infarction (from the National Cardiovascular Data Registry). Am J Cardiol. 2011; 108(7): 959–963, doi: 10.1016/j.amjcard.2011.05.027, indexed in Pubmed: 21820644.
7. Zhan Zq, Wang W, Dang Sy, et al. Electrocardiographic characteristics in angiographically documented occlusion of the dominant left circumflex artery with acute inferior myocardial infarction: limitations of ST elevation III/II ratio and ST deviation in lateral limb leads. J Electrocardiol. 2009; 42(5): 432–439, doi: 10.1016/j.jelectrocard.2009.03.015, indexed in Pubmed: 19446838.
8. Ghanim D, Kusniec F, Kinany W, et al. Left circumflex coronary artery as the culprit vessel in ST-segment-elevation myocardial infarction. Tex Heart Inst J. 2017; 44(5): 320–325, doi: 10.14503/THIJ-16-5905, indexed in Pubmed: 29259501.
9. Morimoto S, Hiasa Y, Hamai K, et al. Electrocardiograms during acute occlusion of the left circumflex artery as compared with that of the right coronary artery [article in Japanese]. J Cardiol. 1989; 19(1): 47–55, indexed in Pubmed: 2530336.
10. Huey BL, Beller GA, Kaiser DL, et al. A comprehensive analysis of myocardial infarction due to left circumflex artery occlusion: comparison with infarction due to right coronary artery and left anterior descending artery occlusion. J Am Coll Cardiol. 1988; 12(5): 1156–1166, doi: 10.1016/0735-1097(88)92594-6, indexed in Pubmed: 3170958.
11. Sohrabi B, Separham A, Madadi R, et al. Difference between outcome of left circumflex artery and right coronary artery related acute inferior wall myocardial infarction in patients undergoing adjunctive angioplasty after fibrinolysis. J Cardiovasc Thorac Res. 2014; 6(2): 101–104, doi: 10.5681/jcvtr.2014.022, indexed in Pubmed: 25031825.
12. Siudak Z, Tokarek T, Dziewierz A, et al. Reduced periprocedural mortality and bleeding rates of radial approach in ST-segment elevation myocardial infarction. Propensity score

analysis of data from the ORPKI Polish National Registry. EuroIntervention. 2017; 13(7): 843–850, doi: 10.4244/EIJ-D-17-00078, indexed in Pubmed: 28606891.

13. Rzeszutko Ł, Tokarek T, Siudak Z, et al. Patient profile and periprocedural outcomes of bioresorbable vascular scaffold implantation in comparison with drug-eluting and bare-metal stent implantation. Experience from ORPKI Polish National Registry 2014-2015. Postepy Kardiol Interwencyjnej. 2016; 12(4): 321–328, doi: 10.5114/aic.2016.63632, indexed in Pubmed: 27980545.
14. Ochała A, Siudak Z, Legutko J, et al. Percutaneous interventions in cardiology in Poland in the year 2014. Summary report of the Association of Cardiovascular Interventions of the Polish Cardiac Society AISN PTK. Postepy Kardiol Interwencyjnej. 2015; 11(3): 177–181, doi: 10.5114/pwki.2015.54009, indexed in Pubmed: 26677356.
15. Thygesen K, Alpert J, Jaffe A, et al. Fourth universal definition of myocardial infarction (2018). J Am Coll Cardiol. 2018; 72(18): 2231–2264, doi: 10.1016/j.jacc.2018.08.1038, indexed in Pubmed: 30153967.
16. Coronary artery surgery study (CASS): a randomized trial of coronary artery bypass surgery. Survival data. Circulation. 1983; 68(5): 939–950, doi: 10.1161/01.cir.68.5.939, indexed in Pubmed: 6137292.
17. El-Menyar A, Zubaid M, AlMahmeed W, et al. Killip classification in patients with acute coronary syndrome: insight from a multicenter registry. Am J Emerg Med. 2012; 30(1): 97–103, doi: 10.1016/j.ajem.2010.10.011, indexed in Pubmed: 21159479.
18. Gibson CM, Cannon CP, Daley WL, et al. TIMI frame count: a quantitative method of assessing coronary artery flow. Circulation. 1996; 93(5): 879–888, doi: 10.1161/01.cir.93.5.879, indexed in Pubmed: 8598078.
19. Niu T, Fu P, Jia C, et al. The delayed activation wave in non-ST-elevation myocardial infarction. Int J Cardiol. 2013; 162(2): 107–111, doi: 10.1016/j.ijcard.2011.05.063, indexed in Pubmed: 21663984.
20. Schmitt C, Lehmann G, Schmieder S, et al. Diagnosis of acute myocardial infarction in angiographically documented occluded infarct vessel: Limitations of ST-segment elevation in standard and extended ECG leads. Chest. 2001; 120(5): 1540–1546, doi: 10.1378/chest.120.5.1540, indexed in Pubmed: 11713132.

21. Dixon WC, Wang TY, Dai D, et al. Anatomic distribution of the culprit lesion in patients with non-ST-segment elevation myocardial infarction undergoing percutaneous coronary intervention: findings from the National Cardiovascular Data Registry. J Am Coll Cardiol. 2008; 52(16): 1347–1348, doi: 10.1016/j.jacc.2008.07.029, indexed in Pubmed: 18929247.
22. O'Keefe JH, Sayed-Taha K, Gibson W, et al. Do patients with left circumflex coronary artery-related acute myocardial infarction without ST-segment elevation benefit from reperfusion therapy? Am J Cardiol. 1995; 75(10): 718–720, doi: 10.1016/S0002-9149(99)80661-4, indexed in Pubmed: 7900668.
23. Knaapen M, Koch AH, Koch C, et al. Prevalence of left and balanced coronary arterial dominance decreases with increasing age of patients at autopsy. A postmortem coronary angiograms study. Cardiovasc Pathol. 2013; 22(1): 49–53, doi: 10.1016/j.carpath.2012.02.012, indexed in Pubmed: 22463919.
24. Pride Y, Tung P, Mohanavelu S, et al. Angiographic and clinical outcomes among patients with acute coronary syndromes presenting with isolated anterior st-segment depression. JACC Cardiovasc Interv. 2010; 3(8): 806–811, doi: 10.1016/j.jcin.2010.05.012, indexed in Pubmed: 20723851.
25. O'Connor NJ, Morton JR, Birkmeyer JD, et al. Effect of coronary artery diameter in patients undergoing coronary bypass surgery. Northern New England Cardiovascular Disease Study Group. Circulation. 1996; 93(4): 652–655, doi: 10.1161/01.cir.93.4.652, indexed in Pubmed: 8640991.
26. Chyrchel M, Gallina T, Szafrański O, et al. Comparison of the characteristics of coronary interventions performed during day and night shifts in patients with acute myocardial infarction. Int J Environ Res Public Health. 2020; 17(15), doi: 10.3390/ijerph17155378, indexed in Pubmed: 32722586.
27. Antoni ML, Yiu KH, Atary JZ, et al. Distribution of culprit lesions in patients with ST-segment elevation acute myocardial infarction treated with primary percutaneous coronary intervention. Coron Artery Dis. 2011; 22(8): 533–536, doi: 10.1097/MCA.0b013e32834c7552, indexed in Pubmed: 21946526.
28. Roczniak J, Koziołek W, Piechocki M, et al. Comparison of access site-related complications and quality of life in patients after invasive cardiology procedures according

to the use of radial, femoral, or brachial approach. Int J Environ Res Public Health. 2021; 18(11), doi: 10.3390/ijerph18116151, indexed in Pubmed: 34200250.

29. Kohlhauer M, Berdeaux A, Ghaleh B, et al. Therapeutic hypothermia to protect the heart against acute myocardial infarction. Arch Cardiovasc Dis. 2016; 109(12): 716–722, doi: 10.1016/j.acvd.2016.05.005, indexed in Pubmed: 27692660.

30. Kang InS, Fumiaki I, Pyun WB. Therapeutic hypothermia for cardioprotection in acute myocardial infarction. Yonsei Med J. 2016; 57(2): 291–297, doi: 10.3349/ymj.2016.57.2.291, indexed in Pubmed: 26847278.

31. Kleczyński P, Siudak Z, Dziewierz A, et al. The network of invasive cardiology facilities in Poland in 2016 (data from the ORPKI Polish National Registry). Kardiol Pol. 2018; 76(4): 805–807, doi: 10.5603/KP.2018.0081, indexed in Pubmed: 29652427.

Table 1. Demographics and characteristics of the analyzed populations

All patients					
Cx narrowing location	**Proximal - A**	**Medial - B**	**Distal - C**	**General**	***P*-value**
Age, years	68.00 (61.00–76.00)	67.00 (60.00–75.00)	66.00 (60.00–75.00)	67.00 (60.00–76.00)	<0.001
Gender	F: 14029 (32.47) M: 29175 (67.53)	F: 14549 (31.11) M: 30759 (67.89)	F: 2659 (29.51) M: 6352 (70.49)	F: 31237 (32.93) M: 66286 (67.97)	<0.001
Weight, kg	80.00 (70.00–90.00)	80.00 (70.00–90.00)	80.00 (73.00–90.00)	80.00 (70.00–90.00)	<0.001
Diabetes	11209 (25.79)	10584 (23.32)	2356 (25.90)	24149 (24.66)	<0.001
Previous MI	13897 (31.98)	12682 (27.94)	2715 (29.85)	29294 (29.91)	<0.001
Previous PCI	15106 (34.76)	14767 (32.54)	3138 (34.50)	33011 (33.70)	<0.001
Previous CABG	3938 (9.06)	2324 (5.12)	477 (5.24)	6739 (6.88)	<0.001
Previous stroke	1663 (3.83)	1442 (3.18)	348 (3.83)	3453 (3.53)	<0.001
Smoking (overall)	9165 (21.09)	10301 (22.70)	2116 (23.26)	21582 (22.04)	<0.001
Psoriasis	175 (0.40)	208 (0.46)	46 (0.51)	429 (0.44)	0.27
Hypertension	30763 (70.78)	31945 (70.39)	6523 (71.71)	69231 (70.68)	0.03
Kidney disease (GRF <60 ml/min/1.73 m^2 or	3164 (7.28)	2374 (5.23)	538 (5.91)	6076 (6.20)	<0.001

renal replacement therapy)					
COPD	1102 (2.54)	991 (2.18)	204 (2.24)	2297 (2.35)	0.002
Initial TIMI 0 patients					
Cx narrowing location	Proximal – A	Medial – B	Distal – C	General	P value
Age, years	65.00 (58.00–73.00)	65.00 (58.00–72.00)	65.00 (57.00–73.00)	65.00 (58.00–73.00)	<0.001
Sex	F: 3054 (30.95) M: 6814 (69.05)	F: 2631 (29.34) M: 6337 (70.66)	F: 697 (30.15) M: 1383 (69.85)	F: 6282 (30.18) M: 14534 (69.82)	0.06
Weight, kg	80.00 (70.00–90.00)	80.00 (70.00–90.00)	80.00 (72.00–91.00)	80.00 (70.00–90.00)	<0.001
Diabetes	2107 (21.28)	1780 (19.83)	449 (22.60)	4336 (20.78)	0.005
Previous MI	2005 (20.25)	1671 (18.61)	374 (18.82)	4050 (19.41)	0.01
Previous PCI	1873 (18.92)	1586 (17.67)	363 (18.27)	3822 (18.32)	0.09
Previous CABG	389 (3.93)	227 (2.53)	57 (2.87)	673 (3.23)	<0.001
Previous stroke	360 (3.64)	287 (3.20)	77 (3.88)	724 (3.47)	0.15
Smoking (overall)	2723 (27.50)	2694 (30.01)	571 (28.74)	5988 (28.70)	<0.001
Psoriasis	41 (0.41)	47 (0.52)	17 (0.86)	105 (0.50)	0.04
Hypertension	6305 (63.67)	5798 (64.58)	1349 (67.89)	13452 (64.47)	0.002
Kidney disease (GRF <60	508 (5.13)	367 (4.09)	107 (5.39)	982 (4.71)	0.001

ml/min/1,73 m^2 or renal replacement therapy)					
COPD	203 (2.05)	175 (1.95)	43 (2.16)	421 (2.02)	0.79

Data presented as median (interquartile range [IQR]) or n (%)

Abbreviations: CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; Cx, circumflex branch of left coronary artery; F, female; M, male; MI, myocardial infarction; PCI, percutaneous coronary intervention

Table 2. Clinical characteristics of the groups

Initial diagnosis based on ECG and troponin level					
	Proximal — A	Medial — B	Distal — C	General	*P*-value
STEMI	11039 (25.41)	11214 (24.72)	2425 (26.67)	24678 (25.21)	<0.001
NSTEMI	15575 (35.85)	14802 (32.63)	2979 (32.76)	33356 (34.07)	
UA	16830 (38.74)	19347 (42.65)	3689 (40.57)	39866 (40.72)	
TIMI 0 without ST elevation	4637 (51.67)	4084 (50.03)	893 (46.22)	9614 (50.59)	0.02
Cardiac arrest on admission	1234 (2.84)	903 (1.99)	132 (1.45)	2269 (2.32)	<0.001
Cardiac arrest on admission (TIMI 0)	575 (5.81)	390 (4.35)	55 (2.79)	1020 (4.89)	<0.001
Therapeutic hypothermia	52 (0.12)	32 (0.07)	1 (0.01)	85 (0.09)	0.001
Therapeutic hypothermia (TIMI 0)	28 (0.28)	11 (0.12)	1 (0.05)	40 (0.19)	0.01
Killip classification					
All patients					
Killip class	Proximal — A	Medial — B	Distal — C	General	*P*-value
I	36814 (84.74)	40654 (89.62)	8145 (89.58)	85613 (87.45)	<0.001
II	3893 (8.96)	3248 (7.16)	706 (7.77)	7847 (8.02)	

III	1208 (2.78)	785 (1.73)	120 (1.32)	2113 (2.16)	
IV	1529 (3.52)	680 (1.50)	121 (1.33)	2330 (2.38)	
Initial TIMI 0					
Killip class	Proximal — A	Medial — B	Distal — C	General	*P*-value
I	7711 (77.88)	7675 (85.52)	1729 (87.04)	17115 (82.04)	<0.001
II	1117 (11.28)	745 (8.30)	173 (8.70)	2035 (9.74)	
III	402 (4.06)	237 (2.64)	35 (1.76)	674 (3.22)	
IV	671 (6.78)	319 (3.55)	49 (2.49)	1039 (4.97)	

Data presented as n (%)

Abbreviations: ECG, electrocardiography; NSTEMI, non ST-segment elevation myocardial infarction; STEMI, ST segment elevation myocardial infarction; TIMI, thrombolysis in myocardial infarction; UA, unstable angina

Table 3. Angiographic characteristics of the groups — results of angiography

All patients					
Result of angiography	Proximal — A	Medial — B	Distal — C	General	*P*-value
No significant stenosis	4 (0.01)	14 (0.03)	1 (0.01)	19 (0.02)	<0.001
No atherosclerotic changes	9 (0.02)	14 (0.03)	5 (0.05)	28 (0.03)	
Single-vessel CAD	12768 (29.39)	17624 (38.85)	3312 (36.43)	33704 (34.43)	

Multi-vessel CAD without LMCA involvement	24802 (57.09)	25576 (56.38)	5378 (59.15)	55756 (56.95)	
Multi-vessel CAD with LMCA involvement	5787 (13.32)	2096 (4.62)	387 (4.26)	8270 (8.45)	
Only LMCA disease	70 (0.16)	41 (0.09)	9 (0.10)	120 (0.12)	
Initial TIMI 0					
Result of angiography	Proximal — A	Medial — B	Distal — C	General	*P*-value
No significant stenosis	0 (0.00)	5 (0.06)	0 (0.00)	5 (0.03)	<0.001
No atherosclerotic changes	2 (0.02)	4 (0.05)	2 (0.10)	8 (0.04)	
Single-vessel CAD	3139 (31.70)	3277 (36.51)	767 (38.61)	7183 (34.44)	
Multi-vessel CAD without LMCA involvement	5802 (58.60)	5241 (58.39)	1128 (56.78)	12171 (58.33)	
Multi-vessel CAD with LMCA involvement	946 (9.55)	441 (4.91)	87 (4.40)	1474 (7.06)	
Only LMCA disease	13 (0.13)	7 (0.08)	2 (0.10)	22 (0.11)	

Data presented as n (%)

Abbreviations: CAD, coronary artery disease; LMCA, left main coronary artery; TIMI, thrombolysis in myocardial infarction

Table 4. Exposition and complications

All patients

	Proximal — A	**Medial — B**	**Distal — C**	**General**	***P*-value**
Contrast volume, ml	170.00 (130.00-220.00)	150.00 (120.00-200.00)	170.00 (130.00-220.00)	160.00 (120.00-210.00)	<0.001
Post hoc test	A vs C: p=0.02	B vs A: p<0.001	C vs B: p<0.001		
Radiation dose, mGy	956.00 (527.00-1630.50)	826.00 (459.00-1407.00)	908.00 (524.00-1557.50)	889.00 (493.00-1518.00)	<0.001
Post hoc test	A vs C: p<0.001	B vs A: p<0.001	C vs B: p<0.001		
Bleeding at the puncture site	70 (0.16%)	68 (0.15%)	18 (0.20%)	156 (0.16%)	0.45
Cardiac arrest during procedure	569 (1.31%)	236 (0.52%)	50 (0.55%)	855 (0.87%)	<0.001
Death during procedure	478 (1.10%)	172 (0.38%)	21 (0.23%)	671 (0.69%)	<0.001
Initial TIMI 0					
	Proximal — A	**Medial — B**	**Distal — C**	**General**	***P*-value**
Contrast volume, ml	180.00 (140.00-220.00)	170.00 (130.00-220.00)	180.00 (140.00-220.00)	170.00 (135.00-220.00)	<0.001
Post hoc test	A vs C: p=0.81	B vs A: p<0.001	C vs B: p<0.01		
Radiation dose, mGy	973.00 (543.00-1668.00)	920.00 (526.00-1547.00)	1000.00 (581.75-1675.50)	952.00 (540.00-1619.00)	<0.001

Post hoc test	A vs C: p=0.85	B vs A: p<0.001	C vs B: p<0.01		
Bleeding at the puncture site	18 (0.18%)	19 (0.21%)	4 (0.20%)	41 (0.20%)	0.90
Cardiac arrest during procedure	308 (3.11%)	123 (1.37%)	20 (1.01%)	451 (2.16%)	<0.001
Death during procedure	264 (2.67%)	90 (1.00%)	8 (0.40%)	362 (1.73%)	<0.001
Exposition compared according to initial diagnosis and location of narrowing					
Diagnosis		Proximal — A	Medial — B	Distal — C	*P*-value
STEMI	Contrast volume, ml	170.0 (130.00–220.00)	150.00 (120.00–200.00)	170.00 (130.00–220.00)	<0.001
	Radiation dose, mGy	957.00 (530.00–1656.00)	825.00 (459.00–1404.50)	922.00 (529.00–1597.50)	<0.001
NSTEMI	Contrast volume, ml	175.00 (130.00–220.00)	160.00 (120.00–200.00)	175.00 (130.00–220.00)	<0.001
	Radiation dose, mGy	974.00 (544.00–1665.75)	850.00 (484.00–1439.25)	949.00 (553.00–1600.00)	<0.001
UA	Contrast volume, ml	170.00 (120.00–220.00)	150.00 (120.00–200.00)	160.00 (130.00–210.00)	<0.001
	Radiation dose, mGy	937.00 (505.75–1593.00)	806.00 (442.00–1391.00)	871.50 (498.00–1484.50)	<0.001

Complications compared according to initial diagnosis and location of narrowing						
Diagnosis		Proximal — A	Medial — B	Distal — C	General	*P*–value
STEMI	Bleeding at puncture site	26 (0.24)	17 (0.15)	6 (0.25)	49 (0.19)	0.27
	Cardiac arrest during procedure	317 (2.87)	132 (1.18)	25 (1.03)	476 (1.93)	<0.001
	Death during procedure	281 (2.54)	110 (0.98)	14 (0.58)	405 (1.65)	<0.001
NSTEMI	Bleeding at puncture site	25 (0.16)	27 (0.18)	3 (0.10)	55 (0.16)	0.61
	Cardiac arrest during procedure	187 (1.20)	75 (0.51)	18 (0.60)	280 (0.83)	<0.001
	Death during procedure	161 (1.03)	44 (0.30)	5 (0.17)	210 (0.62)	<0.001
UA	Bleeding at puncture site	18 (0.11)	22 (0.11)	11 (0.30)	51 (0.13)	0.01
	Cardiac arrest during procedure	66 (0.39)	27 (0.14)	7 (0.19)	100 (0.25)	<0.001
	Death during procedure	36 (0.21)	17 (0.09)	2 (0.05)	55 (0.14)	<0.001

Data presented as median (interquartile range [IQR]) or n (%)

Abbreviations: see Table 2

Table 5. Time from first healthcare contact to inflation or angiogram in minutes. excluding cases over 24 hours

Compared according to location of narrowing					
	Proximal — A	Medial — B	Distal — C	General	*P*-value
All patients	140.00 (70.00–345.00)	150.00 (75.00–355.00)	140.00 (70.00–346.75)	145.00 (72.00–350.00)	<0.001
Post hoc test	A vs. C: *P* = 0.72	B vs. A: *P* <0.01	C vs. B: *P* = 0.59		
Initial TIMI 0	113.00 (60.00–240.00)	117.00 (63.00–240.00)	110.00 (60.00–229.50)	115.00 (60.00–240.00)	0.04
Post hoc test	A vs. C: *P* = 0.60	B vs. A: *P* = 0.16	C vs. B: *P* = 0.10		

Compared according to initial diagnosis and location of narrowing				
	Proximal — A	Medial — B	Distal — C	*P*-value
STEMI	85.00 (59.00–140.00)	90.00 (60.00–145.00)	89.00 (58.00–144.00)	0.002
NSTEMI	240.00 (115.00–512.50)	260.00 (120.00–540.00)	270.00 (120.00–565.00)	<0.001
UA	253.50 (148.50–825.00)	330.00 (72.00–426.00)	629.00 (37.00–1222.50)	0.79

Data presented as median (interquartile range [IQR])

Abbreviations: see Table 2

	OR	95% CI	P-value
Age, years	1.019	1.01-1.029	<0.001
Radiation dose, mGy	1.000098	1.000028-1.000169	0.008
Gender, females vs. males	1.383	1.121-1.706	0.002
COPD, yes vs. no	0.474	0.243-0.921	0.016
Prior MI, yes vs. no	1.595	1.284-1.981	<0.001
Killip class, II vs. I	2.771	2.061-3.726	<0.001
Killip class, III vs. I	6.221	4.493-8.614	<0.001
Killip class, III vs. II	2.244	1.561-3.225	<0.001
Killip class, IV vs. I	13.1	10.051-17.075	<0.001
Killip class, IV vs. II	4.726	3.469-6.438	<0.001
Killip class, IV vs. III	2.105	1.523-2.91	<0.001
TIMI after PCI, 0 vs. 1	1.596	1.117-2.28	<0.001
TIMI after PCI, 0 vs. 2	5.519	4.016-7.584	<0.001
TIMI after PCI, 1 vs. 2	3.456	2.356-5.071	<0.001
TIMI after PCI, 0 vs. 3	38.571	30.052-49.504	<0.001
TIMI after PCI, 1 vs. 3	24.155	17.342-33.643	<0.001
TIMI after PCI, 2 vs. 3	6.988	5.269-9.267	<0.001
STEMI vs. NSTEMI	1.984	1.581-2.489	<0.001
STEMI vs. UA	5.195	3.553-7.597	<0.001
NSTEMI vs. UA	2.618	1.799-3.811	<0.001
Cardiac arrest at baseline, yes vs. no	1.385	1.049-1.829	0.021
Direct transport, yes vs. no	1,385	1.049-1.829	0.002
Cx segment, medial vs. distal	1.714	1.01-2.908	0.045
Cx segment, proximal vs. distal	2.681	1.602-4.486	<0.001
Cx segment, proximal vs. medial	1.564	1.251-1.955	<0.001
MVD vs. SVD	2.44	1.945-3.06	<0.001
MVD + LMCA vs. SVD	3.499	2.601-4.706	<0.001
MVD + LMCA vs. MVD	1.432	1.071-1.92	0.015
PCI + BMS, yes vs. no	1.849	1.369-2.496	<0.001

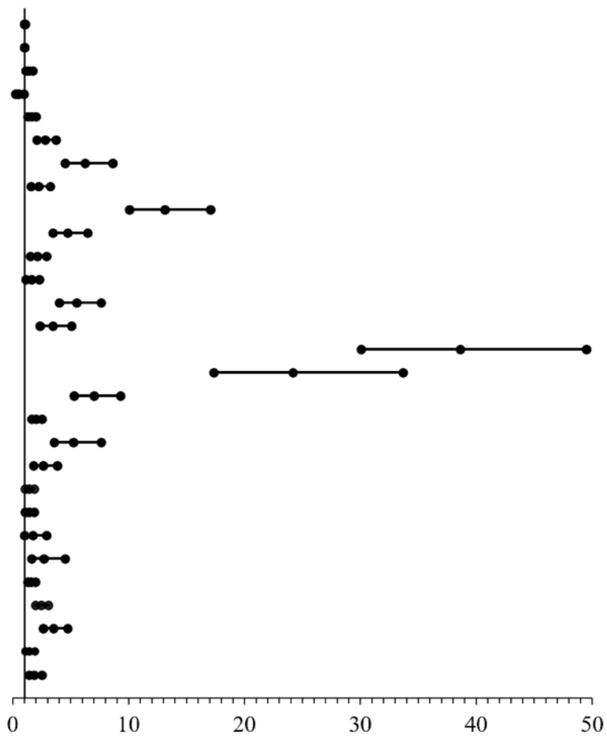

Figure 1. Risk factors for periprocedural death

Abbreviations: BMS, bare metal stent; CI, confidence interval; COPD, chronic obstructive pulmonary disease; Cx, circumflex branch of left coronary artery; LMCA, left main coronary artery; MI, myocardial infarction; MVD, multivessel disease; NSTEMI, non-ST-segment elevation myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction; SVD, single vessel disease; TIMI, thrombolysis in myocardial infarction; UA, unstable angina

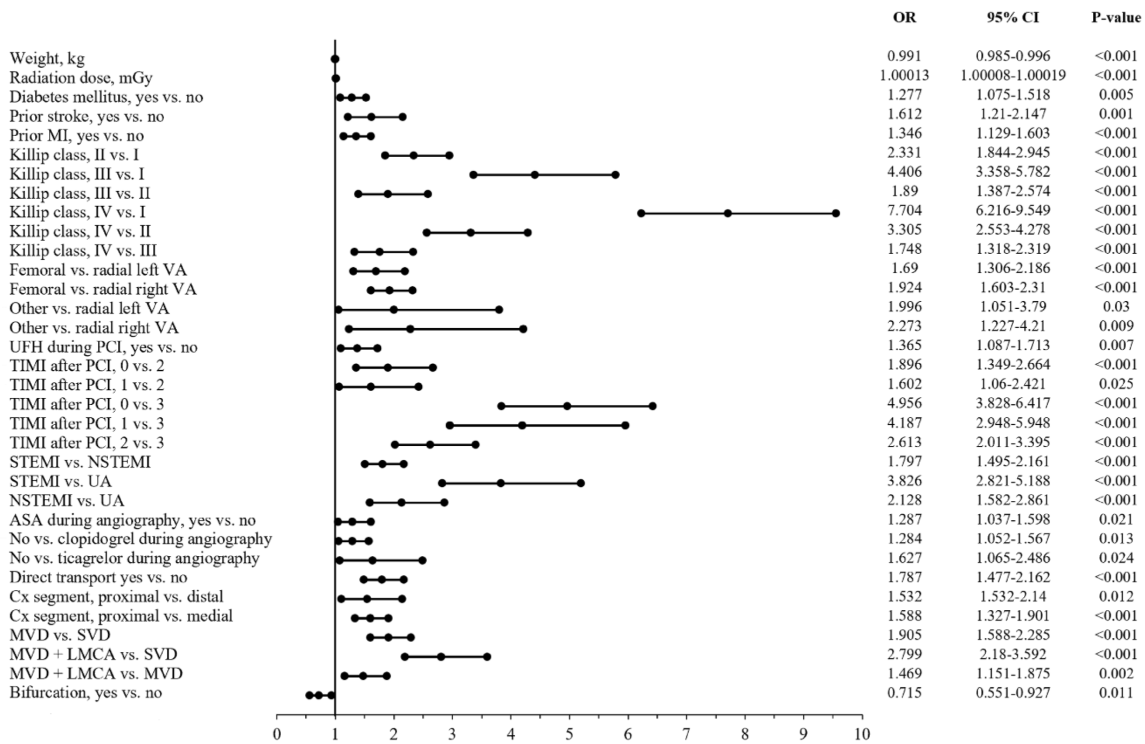

Figure 2. Risk factors for periprocedural cardiac death

Abbreviations: ASA, acetylsalicylic acid; Cx, circumflex branch of left coronary artery; UFH, unfractionated heparin; VA- vascular access; other — see Figure 1

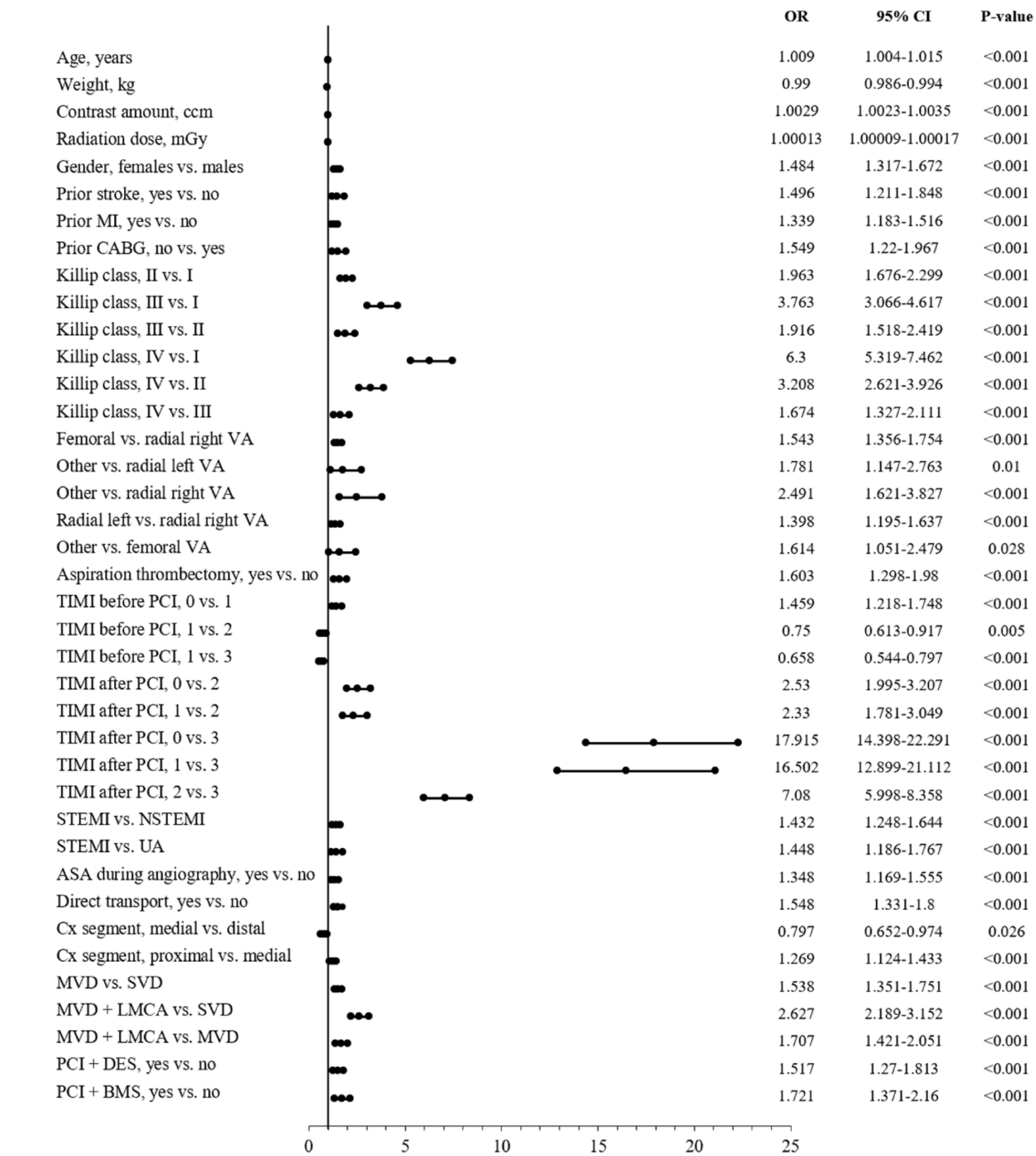

Figure 3. Risk factors for the overall periprocedural complications occurrence

Abbreviations: CABG, coronary artery bypass grafting; DES, drug eluting stent; other — see Figures 1 and 2