Original paper

The impact of ECG at admission and a culprit lesion on 12-month outcomes in acute myocardial infarction – analysis based on the PL-ACS Registry

Wpływ obrazu EKG oraz naczynia dozawałowego na 12-miesięczne rokowanie w ostrym zawale serca – analiza na podstawie Rejestru PL-ACS

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Key words: electrocardiography, culprit lesion, myocardial infarction, ischaemic changes

Słowa kluczowe: elektrokardiografia, naczynie dozawałowe, zawał serca, zmiany niedokrwienne.

Abstract

Introduction: Acute myocardial infarction (MI) is usually associated with ischaemic abnormalities in electrocardiography (ECG). However, a considerable proportion of MI cases present with no ischaemic changes (NIC). The exact impact of the ECG pattern and a culprit lesion on long-term outcomes in the era of routine percutaneous coronary interventions remains unclear.
Aim of the research: To analyse baseline characteristics and 12-month outcomes of MI patients with various ECG patterns on admission as well as the exact impact of a culprit lesion on the long-term prognosis.
Material and methods: Based on PL-ACS Registry data, we analysed patients admitted to Polish hospitals in 2015–2020 due to MI. A total of 111,689 cases who underwent primary percutaneous coronary intervention were included in the study. Based on initial ECG, 5 groups were established: ST segment elevation (STE), ST segment depression (STD), T-wave inversion (TWI), other ST-T abnormalities (STT), and no ischaemic changes (NIC).
Results and conclusions: NIC patients accounted for over 10% of all MI cases. In-hospital mortality in NIC was higher than TWI but lower than in STE, STD, and STT. In 12-month follow-up NIC had worse prognosis than TWI and STE. STT and STD presented with the worst prognosis, which is associated with adverse factors like comorbidities, heart failure, and multi-vessel coronary disease. The impact of a culprit lesion on 12-month outcomes was equal for right coronary artery (RCA), obtuse marginal branch (OM), diagonal (D), and circumflex artery (Cx), i.e. it is negligible except for both LM and LAD.

Streszczenie

Wprowadzenie: Ostry zawał serca (MI) jest zwykle związany z obecnością zmian niedokrwiennych w elektrokardiografii (EKG). Jednak u znaczącej grupy chorych z zawałem serca nie występują zmiany niedokrwienne (NIC). Znaczenie prognostyczne obrazu EKG oraz naczynia odpowiedzialnego za zawał na rokowanie długoterminowe w erze rutynowego stosowania przezskórnych interwencji wieńcowych jest niejasne.
Cel pracy: Określenie charakterystyki klinicznej i 12-miesięcznego rokowania chorych z zawałem serca z różnymi wariantami EKG oraz ocena wpływu naczynia dozawałowego na długoterminową prognozę.
Materiały i metody: Na podstawie danych z Rejestru PL-ACS przeanalizowano chorych z ostrym zawałem serca przyjętych do polskich szpitali w latach 2015–2020. Do badania włączono łącznie 111 689 chorych, którzy przebyli zabieg pierwotnej angioplastyki wieńcowej. Na podstawie obrazu EKG przy przyjęciu wyszczególniono 5 podgrup: uniesienie odcinka ST (STE), obniżenie odcinka ST (STD), odwrócenie załamków T (TWI), inne nieprawidłowości ST-T (STT) i brak zmian niedokrwiennych (NIC).
Wyniki i wnioski: Grupa NIC stanowiła ponad 10% wszystkich przypadków zawału serca. Śmiertelność wewnątrzszpitalna w grupie NIC była niższa niż w TWI, ale wyższa niż w STE, STD i STT. W obserwacji 12-miesięcznej grupa NIC miała gorsze rokowanie niż TWI i STE. STT i STD charakteryzowały się najgorszym rokowaniem, co może się wiązać z niekorzystnymi czynnikami, takimi jak liczne schorzenia współistniejące, niewydolność serca i wielonaczyniowa choroba wieńcowa. Wpływ naczynia dozawałowego na 12-miesięczne rokowanie w przypadku prawej tętnicy wieńcowowej (RCA), gałęzi marginalnej (OM), diagonalnej (D) i gałęzi okalającej (Cx) był podobny w przeciwieństwie do LM i LAD.

Introduction

Acute myocardial infarction (MI) remains one of the most important issues in cardiology. MI is usually associated with typical ischaemic abnormalities presented on electrocardiography (ECG) such as ST-segment elevation, ST-segment depression, and T-wave inversion. Importantly, a substantial fraction of patients with acute MI present with no ischaemic changes (NIC) on ECG. Because ECG still is an essential method in the diagnosis of acute MI, this group of patients might be challenging in a routine medical practice, especially in emergency medicine. In the past NIC was considered to be a predictor of a favourable prognosis. However, the latest studies have revealed that long-term results in this group are comparable to those for other ECG patterns [1–4].

Aim of the research

We conducted an analysis of detailed characteristics as well as outcomes of MI cases with various ECG patterns to determine the impact of both ECG and culprit lesion on long-term prognosis.

Material and methods

Based on PL-ACS Registry data, we analysed 139,465 patients admitted to Polish hospitals in 2015–2020 due to an acute myocardial infarction. Among them, 5 subgroups were established based on initial ECG presentation: ST segment elevation (STE), ST segment depression (STD), T-wave inversion (TWI), other ST-T abnormalities (STT), and no ischaemic changes (NIC). We then selected patients who underwent percutaneous coronary intervention (PCI) of a culprit lesion that was chosen based on both angiographic and clinical features (ECG, echocardiography) [5].

Patients who were not qualified to primary PCI (e.g. non-obstructive coronary artery disease and patients qualified for urgent coronary artery bypass graft) were excluded from further analysis. Finally, a total of 111,689 patients who fulfilled the criteria above were included in the study.

The study was performed in accordance with the Declaration of Helsinki and was approved by the PL-ACS Registry Committee. Ethics Committee approval and informed patient consent were not required for this study. Data were collected from the PL-ACS Registry questionnaires, which that included demographic data (sex and age) and risk factors (smoking, arterial hypertension, hypercholesterolaemia, diabetes mellitus, and obesity); previous coronary incidences and procedures such as MI, percutaneous coronary intervention, coronary artery bypass graft; clinical presentation on admission (Killip class, heart rate, systolic blood pressure, ECG abnormalities, and left ventricular ejection fraction); history of coronary angiography; details of the percutaneous coronary intervention; and in-hospital and post-discharge treatment. The follow-up period included in-hospital and 12-month mortality rates.

Patients were classified into one of the following groups based on their initial ECG pattern: STE, STD, TWI, STT, or NIC, according to the European Society of Cardiology (ESC) guidelines. The clinical profiles, details from coronary angiogram and PCI, as well as outcomes of the cohorts were compared.

Statistical analysis

Continuous variables are expressed as medians and interquartile ranges due to non-normal distributions. The normality of distribution was assessed using the Kolmogorov-Smirnov test. Categorical variables are expressed as numbers and percentages. Continuous variables were compared using the Mann-Whitney test, while categorical variables were compared using the χ^2 test. The Holm-Bonferroni correction was applied for multiple comparisons. Univariate logistic regression analysis was performed to identify potential independent predictive factors of the endpoint for inclusion in the multivariable analysis. Univariable predictors of the endpoint $p < 0.2$ were used in a multivariable logistic regression model with stepwise backward elimination. The results are presented as odds ratios with 95% confidence intervals. Differences were considered statistically significant at $p < 0.05$. Statistical analyses were performed using SAS v9.4 (SAS Institute Inc., Cary, NC, USA).

Results

In the study group NIC patients accounted for over 10% of all cases and were more often encountered than TWI. The baseline characteristics of the ECG groups are presented in Table 1. Patients in the NIC group presented with the most favourable clinical condition (Killip class). In that group, relatively often, diagonal, circumflex, and marginal arteries were confirmed to be a culprit lesion in coronary angiogram.

During the in-hospital observation the mortality rate in NIC patients was higher than for TWI but lower than STE, STD, and STT. Twelve-month follow-up revealed that patients with NIC had worse prognosis than those with TWI and STE (Table 1).

Multivariate analysis showed that STE, STT, and STD were independent predictors of in-hospital mortality whereas TWI was associated with the most favourable outcomes. In 12-month analysis, only STT and STD were independent risk factors in multivariate analysis while the impact of STE and TWI were equal to that of NIC (Table 2).

Univariate analysis of a culprit lesions revealed that into the in-hospital observation, both marginal branch (OM) and diagonal (D), were associated with the most favourable prognosis while right coronary ar-

Table 1. Baseline characteristics of MI with various ECGs

Parameter	*n*	STE *n* (%)	STD *n* (%)	TWI *n* (%)	STT *n* (%)	NIC *n* (%)	*P*-value
Male	74903	32078 (68.3)	15621 (64)	5979 (63.8)	13127 (68.7)	8098 (68.4)	< 0.05
Age [years]:							
< 55	15566	8445 (18)	2500 (10.2)	1152 (12.3)	1980 (10.4)	1489 (12.6)	< 0.05
55–65	32301	15117 (32.2)	6349 (26)	2716 (29)	4961 (26)	3158 (26.7)	
65–75	34526	13376 (28.5)	8010 (32.8)	3000 (32)	6218 (32.6)	3922 (33.1)	
≥ 75	29294	10045 (21.4)	7546 (30.9)	2500 (26.7)	5940 (31.1)	3263 (27.6)	
Hypertension	78589	29888 (66.5)	18522 (78.8)	7284 (79.7)	14266 (77)	8629 (75.9)	< 0.05
Diabetes	30066	10677 (24.1)	7597 (32.7)	2557 (28.2)	5831 (31.6)	3404 (30.5)	< 0.05
Hypercholesterolemia	47133	18340 (42.4)	11294 (49.9)	4617 (52.7)	8079 (45.7)	4803 (44.5)	< 0.05
Current smoking	32784	17237 (41.2)	5882 (27.6)	2491 (29.6)	4378 (26.2)	2796 (26.9)	< 0.05
Obesity	26101	10563 (23.8)	6149 (26.8)	2114 (23.6)	4580 (25.1)	2695 (24.4)	< 0.05
Chr. kidney disease	8764	2389 (5.3)	2572 (11.1)	817 (9)	2010 (10.8)	976 (8.8)	< 0.05
Previous MI	22890	6064 (13.5)	6165 (26.3)	2315 (25.4)	5276 (28.3)	3070 (27.3)	< 0.05
Previous CABG	5040	828 (1.8)	1745 (7.4)	492 (5.4)	1213 (6.5)	762 (6.8)	< 0.05
Previous PCI	21465	5477 (12.2)	5777 (24.7)	2148 (23.6)	4976 (26.7)	3087 (27.5)	< 0.05
Killip class:							
1	92010	37575 (80.2)	20032 (82.2)	8156 (87.1)	15763 (82.6)	10484 (88.6)	< 0.05
2	13584	6116 (13.1)	3105 (12.7)	973 (10.4)	2357 (12.3)	1033 (8.7)	
3	2589	884 (1.9)	772 (3.2)	175 (1.9)	547 (2.9)	211 (1.8)	
4	3294	2263 (4.8)	452 (1.9)	55 (0.6)	420 (2.2)	104 (0.9)	
Culprit lesion:							
LM	2504	602 (1.3)	909 (3.7)	176 (1.9)	542 (2.8)	275 (2.3)	< 0.05
LAD	40253	18745 (39.9)	7435 (30.5)	3762 (40.2)	6430 (33.7)	3881 (32.8)	
D	2903	998 (2.1)	708 (2.9)	261 (2.8)	550 (2.9)	386 (3.3)	
Cx	17755	4938 (10.5)	5578 (22.9)	1480 (15.8)	3453 (18.1)	2306 (19.5)	
OM	5996	1451 (3.1)	1896 (7.8)	514 (5.5)	1192 (6.2)	943 (8)	
RCA	36978	18966 (40.4)	6404 (26.2)	2727 (29.1)	5513 (28.9)	3368 (28.5)	
Bypass	1465	274 (0.6)	566 (2.3)	126 (1.3)	335 (1.8)	164 (1.4)	
TIMI:							
0	33151	22222 (48.6)	4476 (19.1)	1604 (17.5)	3135 (16.8)	1714 (14.9)	< 0.05
1	14067	5365 (11.7)	3021 (12.9)	1625 (17.8)	2800 (15)	1256 (10.9)	
2	15981	5253 (11.5)	4027 (17.2)	1631 (17.8)	3325 (17.8)	1745 (15.2)	
3	45221	12906 (28.2)	11900 (50.8)	4281 (46.8)	9370 (50.3)	6764 (58.9)	
1-vessel CAD	46715	19601 (54.2)	9425 (48.3)	3893 (52.8)	8607 (54.4)	5189 (54.2)	< 0.05
2-vessel CAD	24706	10014 (27.7)	5623 (28.8)	2092 (28.4)	4257 (26.9)	2720 (28.4)	
3-vessel CAD	13826	5375 (14.9)	3548 (18.2)	1142 (15.5)	2422 (15.3)	1339 (14)	
4-vessel CAD	2593	902 (2.5)	759 (3.9)	202 (2.7)	481 (3)	249 (2.6)	
EF:							
35%	10418	4419 (11.1)	2146 (10.5)	685 (8.5)	2312 (14.4)	856 (9)	< 0.05
35–50%	36362	18453 (46.4)	7256 (35.6)	2768 (34.3)	5321 (33.2)	2564 (27.1)	
≥ 50%	46897	16890 (42.5)	10967 (53.8)	4620 (57.2)	8371 (52.3)	6049 (63.9)	
In-hospital mortality	5340	3042 (6.5)	1014 (4.2)	154 (1.6)	815 (4.3)	315 (2.7)	< 0.05
12-month mortality	8954	3292 (7.5)	2230 (9.5)	657 (7.1)	1890 (10.3)	885 (7.7)	< 0.05

CA – cardiac arrest, CABG – coronary artery by-pass graft, CAD – coronary artery disease, Cx – circumflex, D – diagonal, EF – ejection fraction, LAD – left anterior descending, LM – left main, MI – myocardial infarction, NIC– non ischemic changes, OM – obtuse marginal, PCI – percutaneous coronary intervention, RCA – right coronary artery, STD – ST segment depression, STE – ST segment elevation, STT – other ST-T abnormalities, TIMI – thrombolysis in myocardial infarction, TWI – T-wave inversion.

Table 2. Impact of ECG pattern on mortality

Parameter	In-hospital		12-month	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
STE (vs. NIC)	1.43 (1.18–1.72)	< 0.05	1.10 (0.99–1.22)	0.08
STD (vs. NIC)	0.97 (0.79–1.19)	0.77	1.15 (1.04–1.28)	< 0.05
TWI (vs. NIC)	0.60 (0.45–0.81)	< 0.05	0.99 (0.87–1.13)	0.92
STT (vs. NIC)	1.11 (0.89–1.36)	0.34	1.26 (1.13–1.40)	< 0.05

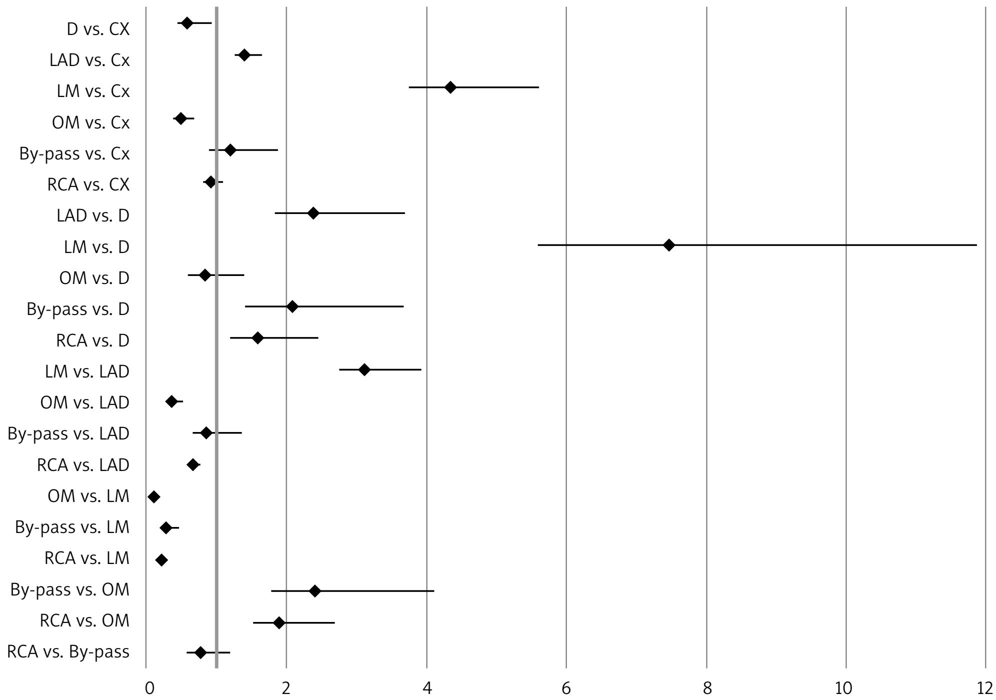

Figure 1. Impact of a culprit lesion on in-hospital mortality (univariate analysis)
Cx – circumflex, D – diagonal, LAD – left anterior descending, LM – left main, OM – marginal, RCA – right coronary artery.

tery (RCA) and circumflex (Cx) presented with an intermediate risk (Figure 1). In 12-month follow-up, OM, D and RCA were associated with the best outcomes whereas Cx and left anterior descending artery (LAD) presented with a moderate prognosis (Figure 2).

Multivariate analysis of culprit lesions revealed that in-hospital observation OM and RCA were associated with better outcomes than Cx, while LAD, D, and by-pass presented with a similar prognosis to Cx. Twelve-month observation showed that only left main (LM) and LAD were associated with worse outcomes when compared to Cx whereas the other vessels (RCA, OM, D, and by-pass) presented with equal results to Cx (Table 3). Other independent predictors of a worse prognosis are age, chronic kidney disease, higher Killip class, and multi-vessel disease (Table 3).

Discussion

Myocardial infarction is usually associated with typical electrocardiographic abnormalities that indicate the ongoing myocardial ischaemia. Nevertheless, a substantial number of MI cases present without the above. NIC accounted for 12.7% [1] to 19.5% [4] of all MI cases in the latest reports.

There are numerous possible underlying conditions that may lead to a lack of ECG abnormalities indicating ongoing ischaemia in MI, e.g. ischaemia of 2 remote segments that mutually cancel the injury vector, transition from subendocardial to transmural is ischaemia, pseudonormalisation of baseline negative T-wave, segments that are not covered by any of the 12 standard ECG leads, etc. [6]. Based on guidelines on chest pain diagnosis, supplemental ECG

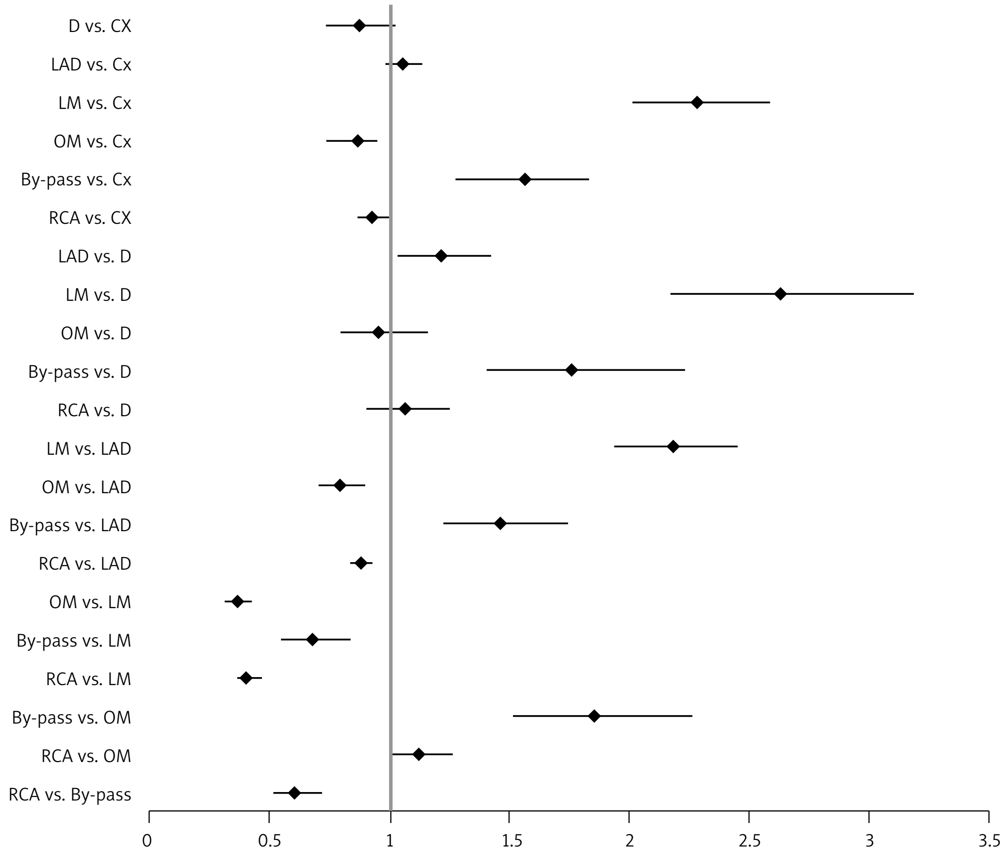

Figure 2. Impact of a culprit lesion on 12-month mortality (univariate analysis)

Cx – circumflex, D – diagonal, LAD – left anterior descending, LM – left main, OM – marginal, RCA – right coronary artery.

leads, e.g. V7-V9 in nonconclusive ECG presentation, are reasonable [7].

Because there are numerous potential causes of cardiac injury (ischaemic, noncoronary, and noncardiac), differential diagnosis of chest pain with concomitant elevated troponin level, especially without ECG abnormalities, might be challenging and misleading [8]. Final confirmation of type 1 myocardial infarction and revealing of a culprit lesion base on a coronary angiography [9]. In routine medical practice, one might also encountered patients with myocardial infarction with non-obstructive coronary arteries (MINOCA) [10].

Analysis of culprit lesions in various ECG patterns showed that in NIC patients marginal (OM), diagonal (D), and circumflex (Cx) are commonly observed. Previous studies revealed that NIC is often associated with a left circumflex lesion [3, 9, 11].

Our study proved that the long-term prognosis in NIC patients is not favourable. Twelve-month mortality is higher than for TWI, and even for STE [4, 10]. Analysis of independent predictors of long-term mortality revealed that a lack of ischaemic abnormalities has the same impact as ST-segment elevation and T-wave inversion [12].

Interestingly, multivariate analysis revealed that the long-term outcomes are similar in OM, D, Cx, RCA, and by-pass lesion, meaning that the impact of a culprit lesion on 12-month outcomes is negligible except for LM and LAD. Irrespective of the culprit lesion, all patients post MI should obtain full spectrum of secondary prevention to improve long-term prognosis.

Our study confirmed again that short- and long-term outcomes in patients with acute myocardial infarction are highly dependent on initial circulatory status (e.g. Killip scale) [13] as well as comorbidities (Table 3).

Conclusions

Long-term prognosis in NIC after primary PCI is not favourable (12-month mortality is worse than for the STE group). STT and STD presented with the worst prognosis, which is associated with adverse factors such as older age, comorbidities, heart failure, and multi-vessel coronary disease. The impact of a culprit

Table 3. Factors influencing on mortality (multivariate analysis)

Parameter	In-hospital		12-month	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
STE (vs. NIC)	1.43 (1.18–1.72)	< 0.05	1.10 (0.99–1.22)	0.08
STD (vs. NIC)	0.97 (0.79–1.19)	0.77	1.15 (1.04–1.28)	< 0.05
TWI (vs. NIC)	0.60 (0.45–0.81)	< 0.05	0.99 (0.87–1.13)	0.92
STT (vs. NIC)	1.11 (0.89–1.36)	0.34	1.26 (1.13–1.40)	< 0.05
Age 55–65 (vs. < 55)	1.38 (1.10–1.74)	< 0.05	2.18 (1.86–2.56)	< 0.05
Age 65–75 (vs. < 55)	2.41 (1.94–3.00)	< 0.05	3.80 (3.25–4.44)	< 0.05
Age ≥ 75 (vs. < 55)	4.63 (3.71–5.77)	< 0.05	7.04 (6.01–8.25)	< 0.05
Chronic kidney disease	1.77 (1.54–2.02)	< 0.05	2.07 (1.92–2.34)	< 0.05
Killip class 2 (vs. 1)	2.81 (2.49–3.16)	< 0.05	1.73 (1.61–1.86)	< 0.05
Killip class 3 (vs .1)	4.91 (4.06–5.93)	< 0.05	2.62 (2.31–2.97)	< 0.05
Killip class 4 (vs. 1)	15.80 (13.45–18.57)	< 0.05	3.16 (2.69–3.71)	< 0.05
OM (vs. Cx)	0.53 (0.38–0.74)	< 0.05	0.90 (0.77–1.04)	0.14
D (vs. Cx)	0.68 (0.46–1.00)	0.05	0.94 (0.75–1.17)	0.56
RCA (vs. Cx)	0.69 (0.59–0.81)	< 0.05	0.97 (0.79–1.18)	0.74
By-pass (vs. Cx)	0.873 (0.58–1.32)	0.52	1.00 (0.92–1.10)	0.95
LAD (vs. Cx)	1.02 (0.88–1.18)	0.79	1.12 (1.03–1.22)	0.01
LM (vs. Cx)	1.70 (1.33–2.17)	< 0.05	1.52 (1.29–1.78)	< 0.05
2-vessel CAD (vs. 1-vessel)	1.05 (0.93–1.19)	0.40	1.00 (0.94–1.07)	0.99
3-vessel CAD (vs. 1-vessel)	1.68 (1.48–1.91)	< 0.05	1.22 (1.13–1.32)	< 0.05
4-vessel CAD (vs. 1-vessel)	2.26 (1.82–2.81)	< 0.05	1.51 (1.31–1.73)	< 0.05

CAD – coronary artery disease, Cx – circumflex, D – diagonal, LAD – left anterior descending, LM – left main, MI – myocardial infarction, NIC– non ischaemic changes, OM – obtuse marginal, RCA – right coronary artery, STD – ST segment depression, STE – ST segment elevation, STT – other ST-T abnormalities, TWI – T-wave inversion.

lesion on 12-month outcomes is negligible except for LM and LAD.

Conflict of interest

The authors declare no conflict of interest.

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