Predictive value of peripheral neutrophil count on admission for in- hospital adverse events in young patients with acute coronary syndrome

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Abstract

Background: In recent years, the incidence of acute coronary syndrome (ACS) in young people has been increasing gradually. Although the reperfusion strategy has improved the therapeutic effect, the prognosis of ACS is still not satisfactory. The relationship between neutrophil level and cardiovascular adverse events and left heart function during hospitalization in young patients with ACS has been rarely reported. This study explored the relationship between neutrophil count at admission and in-hospital major adverse cardiac and cerebrovascular events (MACEE) and left ventricular ejection fraction (LVEF) in young ACS.

Methods: This study included 207 young ACS patients (≥ 45 years old) who underwent coronary angiography. According to the median neutrophil count at admission, the patients were divided into two groups. The relationship between neutrophil count and MACEE and LVEF during hospitalization was analyzed by univariate and multivariate regression, and receiver operating characteristic (ROC) curve analysis was adopted.

Results: Neutrophil count was an independent risk factor of in-hospital MACEE (OR: 1.446, 95% CI: 1.136–1.842, $P = 0.003$) and LVEF $\leq 50\%$ (OR: 1.381, 95% CI: 1.117–1.708, $P = 0.003$). The cutoff value of neutrophil count for predicting the occurrence of in-hospital MACEE was $6.94 \times 10^9/L$ with a sensitivity of 93% and specificity of 54% (AUC: 0.798, 95% CI: 0.714–0.881, $P < 0.001$), and for identifying the LVEF $\leq 50\%$ was $8.36 \times 10^9/L$ with a sensitivity of 70% and specificity of 76% (AUC: 0.748, 95% CI: 0.648–0.848, $P < 0.001$).

Conclusion: Peripheral blood neutrophil count at admission is an independent predictor of MACEE and LVEF in young ACS patients during hospitalization, providing important information for predicting the poor prognosis of young ACS patients.

Introduction

Acute coronary syndrome (ACS) including ST-segment elevation myocardial infarction (STEMI), non-ST-segment elevation myocardial infarction (NSTEMI), and unstable angina (UA) [1], has emerged as a major public health issue. It is also the leading cause of morbidity and mortality worldwide [2]. Although the elderly are prone to the occurrence of ACS, the incidence of ACS is gradually increasing in Chinese young people less than 45 years old [3]. The incidence of myocardial infarction (AMI) in young patients in China has doubled in the past 10 years [4]. Some studies have shown that compared with elderly patients, young patients with ACS have different risk factor characteristics, the frequency of overweight, obesity, and diabetes has risen, particularly among the young ACS. [5]. Young patients also have different clinical symptoms, angiographic outcomes, and prognoses than senior ones. [6]. Although the therapeutic effect of reperfusion strategy has improved in patients with ACS, the prognosis is still unsatisfactory. Within 2.4 years, about one out of every ten young AMI patients died or had a new cardiovascular incident. [7]. Early risk stratification and appropriate intervention are crucial for improving the prognosis of young ACS.

patients. Therefore, it is very important to find biomarkers that can predict cardiovascular adverse events in young ACS patients to guide clinical treatment.

ACS is associated with coronary atherosclerotic plaque rupture and thrombosis[8]. The pathological basis for the formation of lesions is the enhancement of the inflammatory response and the activation of inflammatory cells. Therefore, understanding the inflammatory response can help monitor atherosclerosis[9]. Plaque rupture causes an increase in the number of neutrophils, which interact with the myocardium by releasing pro-inflammatory cytokines (such as IL-1 β and TNF- α) and chemokines (such as CCL2 and CXCL), degrade the extracellular matrix by releasing matrix metalloproteinases and myeloperoxidase, and produce reactive oxygen species that cause irreversible cardiac damage[10, 11]. Previous studies have shown that elevated baseline neutrophil count or NLR is an independent predictor of adverse cardiac events in patients with ACS[12]. Middle-aged and elderly patients accounted for a large proportion of patients included in previous studies. Given the differences in case characteristics between young and elderly ACS patients, as well as the increasing prevalence of young ACS in recent years, only young ACS patients were included in this study. The purpose of this study was to investigate the correlation between baseline neutrophil count and MACE events and left ventricular ejection fraction (LVEF) during hospitalization in young ACS patients.

Methods

1. Patients

A retrospective study was conducted on 207 young ACS patients (aged < 45 years) who underwent coronary angiography in our hospital from January 2017 to August 2020. The ACS diagnostic criteria satisfied the requirements outlined in the American College of Cardiology/American Heart Association and European Society of Cardiology guidelines for the management of patients with non-ST-elevation and ST-segment elevation ACS[13, 14]. Exclusion criteria included: 1. Patients who have had an AMI or have had coronary revascularization (coronary artery bypass surgery or percutaneous coronary intervention). 2. At admission, there were cardiac insufficiency, infection, hyperthyroidism, liver and kidney insufficiency, any blood system diseases, and cerebrovascular diseases. 3. Patients with other heart diseases (including severe congenital heart disease, valvular heart disease, cardiomyopathy, and myocarditis). 4. Patients who have not undergone PCI in our hospital. 5. Patients with incomplete clinical and ultrasound data.

2. Clinical data collection

Clinical data such as age, sex, smoking history, history of hypertension, history of diabetes, and family history, blood pressure on admission, heart rate, laboratory tests including neutrophil count, lymphocyte count, white blood cell count, triglyceride, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, blood glucose, urea nitrogen, creatinine, myocardial troponin, creatine kinase isoenzyme were collected, neutrophil/lymphocyte ratio calculation. Blood samples were taken at admission. The occurrence of in-hospital MACE (defined as cardiac death, recurrent myocardial

infarction, stroke (including hemorrhagic and ischemic stroke), and cardiogenic shock during hospitalization) in patients was collected.

3. Angiographic examinations

All patients were subjected to selective coronary angiography using the standard Judkin's technique. The severity of CAD was determined using the GS. The angiography results were read by two experienced cardiovascular interventional experts who were unaware of the patient's clinical and laboratory data. According to the number of coronary artery lesions, the enrolled patients were divided into single, double, and three or more (the left main lesion was calculated by two branches) coronary artery lesions. The calculation of the Gensini score system is shown in Table1.

Table 1. Gensini score system

The degree of stenosis (%)	Score	Lesion location	Score
1-25	1	The left main coronary artery	5.0
26-50	2	The proximal segment of left descending branch or circumflex branch	2.5
51-75	4	The middle portion of the left anterior descending	1.5
76-90	8	The distal segment of the left anterior descending artery	1.0
91-99	16	The middle and distal segment of the left circumflex artery	1.0
100	32	Right coronary artery	1.0
		Small branches	0.5

4. Echocardiography

All patients were measured and recorded by experienced physicians within 48-72 hours after hospitalization, including LVEF and other cardiac structure and function indicators, using philips IE33 echocardiography.

5. Statistical analysis

Data analysis was performed using SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). The continuous variables with a normal distribution are shown as $\pm S$ and were analyzed using Student's t-test. The continuous variables without a normal distribution are expressed as median (quartile 25, quartile 75) and the Mann–Whitney U test was used. The categorical variables are presented as number (n) and proportion (%) and were compared using Chi-square or Fisher's exact test. The risk factors for in-hospital MACE and LVEF $\leq$ 50% were studied using univariate and multivariate regression analyses. The predictive value of peripheral neutrophil count for the occurrence of MACE and LVEF50 percent was

evaluated using receiver operator characteristic (ROC) curves. Differences were considered statistically significant at $P<0.05$.

Results

Baseline clinical characteristics

A total of 207 ACS participants were enrolled in this study. The mean age of all subjects was 37 [33-40] years. The incidence of MACEE during hospitalization was higher in the high neutrophil group than in the low neutrophil group [23.5% vs 4.8%] ($P=0.001$). The left ventricular ejection fraction of patients in the high-neutrophil count group was significantly lower than that in the low-neutrophil count group (56% [49.75%, 60%] vs 60% [55.5%, 60%] ($P<0.001$)). Patients with Killip class $\geq$ II accounted for 15%. Blood pressure in the high neutrophil group was lower than that in the low neutrophil group ($P=0.05$). Gender, hypertension, diabetes, family history, smoking, heart rate at admission were not significantly different between the two groups ($P>0.05$). Further information on the characteristics of the study subjects is shown in Table 2.

Table 2. Baseline clinical characteristics of patients

Characteristics	All Patients n=207	High neutrophil Count n=102)	Low neutrophil Count (n=105)	P
Age (years) median [IQR]	37[33-40]	37[33-39]	37[34-40]	0.483
Male sex, n (%)	200[96.6]	97[95.1]	103[98.1]	0.233
Hypertension	62[30.0]	33[32.4]	29[27.6]	0.457
Diabetes mellitus	32[15.5]	10[9.8]	22[30.0]	0.027
Smoking	149[72.0]	77[75.5]	72[68.6]	0.268
family history	45[21.7]	17[16.7]	28[26.7]	0.081
SBP, mmHg, mean±SD	136.73±24.12	132.62±26.10	140.72±21.41	0.015
DBP, mmHg, mean±SD	88.43±17.84	84.19±19.09	92.54±15.54	0.001
HR, beats/min, mean±SD	76.92±15.80	77.48±16.31	76.38±15.34	0.618
Killip class				0.001
I	176[85.0]	93[91.2]	83[79.0]	
II	23[11.1]	3[2.9]	20[27.6]	
III	2[1.0]	2[2.0]	0	
IV	5[2.4]	4[3.9]	1[1.0]	
LVEF(%) [IQR]	58[53-60]	56[49.75-60]	60[55.50-60]	0.001
MACEE	29[14.0]	24[23.5]	5[4.8]	0.001

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; LVEF, left ventricular ejection fraction; MACEE , major adverse cardiac and cerebrovascular events.

The laboratory data and angiographic characteristics of the two groups are presented in Table 3. There were no significant differences in blood lipid, blood glucose, creatinine, urea nitrogen, and uric acid between the two groups (all $P > 0.05$). The white blood cell (WBC) count and NLR values were significantly higher in the high-neutrophil count group than in the low-neutrophil count group (11.78[10.67-13.30] vs 8.71[7.74-10.19], $P < 0.001$ and 4.98[3.30-7.34] vs 2.17[1.51-3.06], $P < 0.001$), while the lymphocyte count was significantly lower in the low-neutrophil count group than in the high-neutrophil count group (1.96 [1.73, 2.65] vs.2.35 [1.77, 3.36], $P < 0.001$).

Table 3. Comparison of laboratory results and severity of coronary stenosis

Characteristics	All	High Ceutrophil Count	Low Ceutrophil Count	<i>P</i>
WBC($\times 10^9/L$)	10.44[8.65-12.30]	11.78(10.67-13.30)	8.71(7.74-10.19)	≤ 0.001
Neutrophil($\times 10^9/L$)	7.05[5.57-9.02]	9.02(7.86-10.21)	5.59(4.67-6.36)	≤ 0.001
Lymphocyte($\times 10^9/L$)	2.16[1.47-3.02]	1.96(1.37-2.65)	2.35(1.77-3.36)	≤ 0.001
NLR	3.19[1.99-5.44]	4.98(3.30-7.34)	2.17(1.51-3.06)	≤ 0.001
TG (mmol/L)	2.05[1.41-3.47]	1.94(1.36-2.65)	2.47(1.50-3.58)	0.082
LDL (mmol/L)	3.37[2.74-4.02]	3.49(2.86-4.05)	3.18(2.65-4.01)	0.256
HDL (mmol/L)	0.94[0.79-1.06]	0.92(0.79-1.10)	0.94(0.82-1.04)	0.702
TC (mmol/L)	5.05[4.21-5.81]	5.10(4.32-5.80)	4.89(4.12-5.83)	0.488
blood glucose (mmol/L)	6.71[5.39-9.20]	6.77(5.89-9.29)	6.45(5.30-9.24)	0.398
Scr (umol/L)	76.00[68.00-85.31]	76.00(68.68-86.68)	75.51(67.00-84.34)	0.798
BUN(mmol/L)	5.11(4.27-5.86)	5.12(4.21-6.03)	5.11(4.27-5.83)	0.856
uric acid(umol/L)	373.90(304.25-458.60)	370.40(303.43-462.53)	375.40(307.95-452.63)	0.799
cTnl($\mu g/L$)	0.35(0.03-2.21)	0.48(0.10-6.85)	0.25(0.02-1.29)	0.005
CK-MB U/L	4.80(1.50-24.35)	8.25(2.18-49.25)	2.75(1.30-11.75)	≤ 0.001
Gensini	44.50(32.00-70.75)	53.50(32.00-80.00)	41.00(29.50-58.75)	0.013
number of coronary lesions				
One-vessel disease	77[37.2]	34[33.3]	43[41.0]	
double vessel disease	51[24.6]	26[25.5]		0.51
Triple vessel disease	79[38.2]	42[41.2]	37[35.2]	

In addition, cTnl (0.48[0.10-6.85] vs 0.25[0.02-1.29], $P=0.005$) and CK-MB (8.25[2.18-49.25] vs 2.75[1.30-11.75], $P<0.001$) were significantly higher in the high-neutrophil Count group. In the case of angiography, The Gensini score was significantly higher in the high-neutrophil Count group than in the low-neutrophil Count group (53.50[32.00-80.00] vs 41.00(29.50-58.75), $P=0.013$, There was no significant difference in the number of diseased vessels.

Univariate and multivariate analyses

We investigated the risk factors for in-hospital MACEE and LVEF50% using univariate and multivariate logistic regression analyses (Tables 4 and 5).Multivariate regression analysis showed that neutrophil

count ,GS, and killip classification were independent risk factors of in-hospital MACEE (odds ratio [OR]: 1.446, 95% confidential interval [CI]: 1.136-1.842, P = 0.003; OR: 1.026, 95% CI: 1.011–1.041, P = 0.001; and OR: 5.363, 95% CI:1.907–15.076, P = 0.001, respectively). While, Neutrophil count, GS, were independent risk factors of LVEF≤50%(OR: 1.381, 95% CI: 1.117–1.708, P = 0.003; and OR: 1.018, 95% CI:1.005–1.031, P = 0.006, respectively).

Table 4. Univariate and multivariate logistic regression analysis of variables on in-hospital MACEE

Variable	Univariate		Multivariate	
	OR[95%CI]	P	Adjusted OR (95% CI)	P
Age	0.981[0.902-1.067]	0.655		
Hypertension	1.76[0.679-4.561]	0.245		
Diabetes mellitus	1.167[0.377-3.611]	0.789		
Smoking	1.425[0.619-3.283]	0.405		
family history	1.076[0.409-2.826]	0.883		
Neutrophil	1.346[1.167-1.552]	0.001	1.446(1.136-1.842)	0.003
NLR	1.134[1.019-1.262]	0.021	0.845(0.675-1.058)	0.141
Gensini	1.027(1.015-1.039)	0.001	1.026(1.011-1.041)	0.001
number of coronary lesions	1.096(0.697-1.724)	0.692		
Killip Class	3.491(1.896-6.429)	0.001	5.363(1.907-15.076)	0.001
cTnl	1(1.000-1.000)	0.129		
CK-MB	1.007(1.003-1.012)	0.002	1.002(0.996-1.009)	0.509

Table 5. Univariate and multivariate logistic regression analysis of variables on LVEF≤50%

	Univariate		Multivariate	
Variable	OR[95%CI]	P	Adjusted OR (95% CI)	P
age	1.017(0.936-1.104)	0.696		
Hypertension	0.957(0.415-2.203)	0.917		
Diabetes mellitus	2(0.572-6.995)	0.278		
Smoking	1.672(0.606-4.613)	0.321		
family history	2.136(0.834-5.4670	0.114		
Neutrophil	1.386[1.197-1.605]	0.001	1.381[1.117-1.708]	0.003
NLR	1.183[1.067-1.313]	0.001	0.958[0.807-1.137]	0.624
Gensini	1.023[1.012-1.035]	0.001	1.018[1.005-1.031]	0.006
number of coronary lesions	0.774[0.501-1.194]	0.247		
Killip Class	1.812[1.079-3.043]	0.025	1.842[0.929-3.651]	0.08
cTnl	1[0.999-1.000]	0.673		
CK-MB	1.005[1.000-1.009]	0.046	0.999[0.992-1.005]	0.656

ROC curve analysis

The results of the ROC curve analysis of neutrophil count for predicting in-hospital MACEE and LVEF $\geq$ 50% are shown in Figures 1 and 2. The neutrophil count cutoff value for predicting the occurrence of in-hospital MACEE was $6.94 \times 10^9/L$ with a sensitivity of 93% and specificity of 54% (AUC: 0.798, 95% CI: 0.714-0.881, $P < 0.001$). The cutoff value of neutrophil count for predicting the LVEF $\geq$ 50% was $8.36 \times 10^9/L$ with a sensitivity of 70% and specificity of 76% (AUC: 0.748, 95% CI: 0.648-0.848, $P < 0.001$), as shown in Table 6.

Table 6 Receiver-operating characteristic curve analysis of neutrophil count for predicting in-hospital MACEE and L

Outcome Variable	AUC	95%CI	P	Sensitivity	Specificity	Cutoff
LVEF	0.748	0.648-0.848	0.001	70	76	8.36
MACEE	0.798	0.714-0.881	0.001	93	54	6.94

Abbreviations: LVEF, left ventricular ejection fraction; MACEE , major adverse cardiac and cerebrovascular events

Discussion

This study investigated the relationship between neutrophil count and MACEE and LVEF during hospitalization in young Chinese ACS patients. The study showed that peripheral blood neutrophil count at admission, Gensini score and Killip class were independent predictors of MACEE during hospitalization, and neutrophil count and Gensini score were independent predictors of LVEF < 50%. Although our regression models incorporate classic risk factors for coronary heart disease (hypertension, age, smoking, diabetes, etc.), we can still find the independent predictive effect of appeal variables on poor outcomes of young ACS patients during hospitalization.

The age at onset of ACS is decreasing due to lifestyle changes, especially the increase in obesity and lack of physical activity. 4%-10% of an acute myocardial infarction occurs in young people[15], which poses a serious burden on families and society. Compared with elderly patients, young patients may have different coronary artery risk factors[16], MACE is less likely to occur during hospitalization, the prognosis is better than elderly patients and have a lower cumulative mortality 12 months after discharge[17]. Many previous studies have shown that white blood cell count or its differential cell count can be used as independent predictive markers for adverse outcomes[18, 19], there are few reports on whether it has a certain predictive effect on adverse outcomes in young ACS patients.

At present, the prognostic assessment of acute coronary syndrome such as Thrombolysis In Myocardial Infarction (TIMI)[20] Platelet glycoprotein IIb/IIIa receptor antagonist for acute coronary syndrome risk Score(PURSUIT)[21] and Global Registry of Acute Coronary Events (GRACE)[22] has been adopted to stratify disease risk for acute coronary syndromes. However, the risk scores described above are too complex to predict early severity and require continuous or multiple measurements to determine the severity. As a necessary test for emergency patients, blood routine can be convenient, economical, and quick to obtain patients' neutrophil numbers. In this study, baseline neutrophil count was found to be accurate in predicting MACEE events during hospitalization in young patients with acute ACS AUC= 0.754. In a study of STEMI patients undergoing thrombolytic therapy, baseline neutrophil counts > $9.7 \times 10^9/L$ were associated with a more than a five-fold increased risk of cardiovascular death[23]. Coronary artery stenosis has also been associated with high neutrophil counts in patients with chronic stable angina[24]. The neutrophil count is not only a prognostic marker in the cardiovascular system but also a prognostic value in peripheral artery disease[25, 26]. In conclusion, neutrophils reflect systemic inflammatory response and are reliable markers of the inflammatory response, which can supplement the risk assessment system for the prognosis of young ACS patients.

In this study, it was found that neutrophil count was an independent predictor of MACEE during hospitalization in young ACS patients, and the incidence of MACEE events during hospitalization was higher in the high neutrophil group than in the low neutrophil group. Neutrophils are considered to be markers of inflammation and are closely related to the formation and rupture of atherosclerotic plaques, directly participating in the inflammatory and pathophysiological processes of ACS. Several studies have shown that increased circulating indicators of the inflammatory response, such as peripheral blood neutrophil count, peripheral blood white blood cell count, c-reactive protein, and other markers, are linked to ACS. [27]. Increased activation of peripheral neutrophils may lead to atherosclerotic lesions by

increasing endothelial adhesion and injury and secreting destructive components[28]. In Julia's study, a prospective multicenter observational study of 1125 patients with acute myocardial infarction symptoms was conducted, found that the diagnostic value of neutrophil count and white blood cell count was significantly higher than that of NLR, what is more interesting is that white blood cell and neutrophil counts are independent predictors of short - and long-term mortality[29], not NLR. O'Donoghue et al. found that baseline neutrophil count was a strong independent predictor of cardiovascular death and heart failure risk in a large number of STEMI patients receiving concurrent fibrinolytic and antithrombotic therapy, this could be explained by the fact that an increased neutrophil count was associated with a lower likelihood of early successful reperfusion and late myocardial microvascular perfusion[23]. The mechanism may be that neutrophils migrate to the vascular wall and microvessels after ischemia and reperfusion, resulting in microvascular obstruction[30]. In fact, neutrophil blockage of microvessels is the most critical cause of major cardiac adverse events after PCI[12]. It may also be caused directly by the absence of refluxes mediated by aggregates of neutrophils and platelets in the microvessels[31]. The results of this study also found that neutrophil count was associated with the occurrence of MACE during hospitalization, which was consistent with the results of previous studies.

Some studies suggest that NLR is a new but readily available inflammatory marker and may be a prognostic factor for ACS patients. NLR was found to be significantly associated with in-hospital mortality in a study of 636 STEMI patients[32]. In addition, NLR was related with an elevated risk of long-term mortality in patients with AMI complicated by left main and/or three-vessel illness, according to a post hoc analysis[33]. In Wang et al. 's study, NLR was also found to have a certain predictive effect on the risk of MACE events in NSTEMI patients within 1 year[10]. However, in a recent retrospective cohort study of 737 ACS patients, no significant association was found between high NLR and poor outcomes in these patients[34]. No predictive value of NLR for adverse outcomes was found in this study. According to current research results, the predictive value of NLR for adverse cardiovascular events is controversial, and the specific mechanism needs to be further explored.

This study also found that neutrophil count was an independent predictor of LVEF reduction, and LVEF was lower in the high neutrophil count group than in the low neutrophil count group. Left ventricular dysfunction after ACS is detrimental to the patient's prognosis. Although several biomarkers associated with heart failure have been well studied and widely accepted in routine clinical practice, their significance in predicting early left ventricular systolic dysfunction (LVSD) after ACS remains uncertain[35]. For example, brain natriuretic peptide is a sensitive marker of heart failure but is not an independent predictor of LVSD. However, brain natriuretic peptide levels were significantly elevated in LVSD patients

[36]. In the study of Taka et al., neutrophil and leukocyte counts were found to be predictors of severe microvascular injury and LVSD[37]. Rajic et al[36] also found that white blood cell count and neutrophil count were independent predictors of early LVSD after STEMI. On the one hand, neutrophils release various inflammatory cytokines, which have adverse inotropic effects and cause myocardial dysfunction [38]. On the other hand, neutrophils and platelets obstruct coronary microcirculation capillaries and impair endothelial function during myocardial ischemia-reperfusion [39]. In addition, neutrophils release

pro-inflammatory cytokines, resulting in impaired microvascular blood flow[40], Microvascular integrity is a major factor in the recovery of left ventricular function. A recent study [41] suggested that neutrophils calcium sensing receptor (CaSR) may activate NLRP3 inflammasome through the PLC-IP3 pathway and ER-Ca²⁺ to induce neutrophils to release IL-1 β release after AMI. It eventually leads to apoptosis, fibrosis, and inflammation of myocardial cells. Neutrophilia at admission is associated with impaired left ventricular function, which can also be explained by the association between neutrophils and microvascular injury. In this study, neutrophilic increase at admission was associated with a decrease in LVEF during hospitalization, which is consistent with previous studies.

Limitations

(1) This study has a small sample size, and larger prospective clinical studies with a larger sample size are needed to confirm the research findings.(2) We did not continuously measure the level of the neutrophil count, so we could not dynamically evaluate the potential value of diagnosis (3) there was no long-term follow-up, and the long-term prognosis of ACS patients needed further study.

Conclusions

In this study, peripheral blood neutrophil count at admission was an independent predictor of MACEE and LVEF in young ACS patients during hospitalization. Given that, rapid and economic characteristics of neutrophils, this provides important information for predicting adverse outcomes in young ACS patients.

Abbreviations

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; LVEF: left ventricular ejection fraction; MACEE : major adverse cardiac and cerebrovascular events, WBC: white blood cell NLR: neutrophil to lymphocyte ratio; TG: triglycerides; LDL-C: low-density lipoprotein cholesterol; HDL-C: high-density lipoprotein cholesterol; TC: total cholesterol; Scr: creatinine BUN: urea nitrogen cTnI: cardiac troponin I CK-MB: creatine kinase isoenzyme;

Declarations

Acknowledgments

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Ethical approval and consent to participate

This study adhered to the Helsinki Declaration and was approved by the institutional Ethics Committee of Tianjin First Central Hospital. All participants provided written informed consent prior to study enrollment.

Consent for publication

Not applicable.

Authors' contributions

(1) Study design: CL and TL (2) Data collection: TL and XZ. (3) Data analysis: TL, QL and XL. (4) Manuscript writing: TL, ZL and XY. (5) Final approval of the manuscript: CL. All authors have read and approved the manuscript.

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Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

Competing interests

The authors declared that there was no conflict of interest.

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Figures

Figure 1

Receiver-operating characteristic (ROC) curve of neutrophil for predicting in-hospital MACE

Figure 2

Receiver-operating characteristic (ROC) curve of neutrophil for predicting LVEF $\geq$ 50%

Supplementary Files

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