Association of platelet-to-lymphocyte ratio and neutrophil-to-lymphocyte ratio with outcomes in stroke patients achieving successful recanalization by endovascular thrombectomy

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Research Article

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Abstract

Serum inflammatory biomarkers have been found to play crucial roles in the development of acute ischemic stroke (AIS). In this study, we explored the association between inflammatory biomarkers, such as platelet-to-lymphocyte ratio (PLR), neutrophil-to-lymphocyte ratio (NLR), and monocyte-to-lymphocyte ratio (MLR), and functional outcomes in AIS patients who achieved successful recanalization. Patients with AIS who underwent endovascular thrombectomy (EVT) therapy and achieved a modified thrombolysis in cerebral infarction scale of 2b or 3 were screened from a prospective cohort at our institution between January 2013 and June 2021. Data on blood parameters and other baseline characteristics were collected. Unfavorable outcomes were defined as a modified Rankin Scale of 3-6 at 3 months. Multivariable logistic regression analysis was performed to explore the effects of PLR, NLR, and MLR on neurological functional outcomes. We enrolled 796 patients, of whom 331 (41.6%) had favorable outcomes and 465 (58.4%) had unfavorable outcomes. Patients with unfavorable outcomes had higher PLR (median, 168.89 vs. 153.90, p = 0.002), NLR (median, 6.57 vs. 4.85, p < 0.001), and MLR (median, 0.32 vs. 0.28, p < 0.001). After adjusting for confounding variables, a higher NLR (OR, 1.076; 95% confidence interval [CI], 1.037-1.117; p < 0.001) and PLR (OR, 1.001; 95%CI, 1.000-1.003; p = 0.045) were significantly associated with unfavorable outcomes. The area under the receiver operating characteristic curve of NLR and PLR was 0.622 and 0.564, respectively. Overall, our results indicate that higher PLR and NLR were independently associated with unfavorable functional outcomes in AIS patients with successful recanalization after EVT, but the underlying mechanisms remain to be investigated.

Background

Previous randomized controlled trials have demonstrated that patients with acute ischemic stroke (AIS) secondary to large vessel occlusion could benefit from reperfusion therapy with endovascular thrombectomy (EVT).\textsuperscript{1,2} However, approximately half of patients who achieved successful recanalization of the occluded artery post-EVT have unfavorable outcomes at 90 days.\textsuperscript{3–5} The mechanisms underlying the mismatch of successful recanalization and good outcomes are still unclear.\textsuperscript{6}

The neuroinflammatory response has been increasingly recognized to be important in the pathophysiology of AIS.\textsuperscript{7} Activation of leukocytes, platelets, or other pro-inflammatory mediators plays a vital role in AIS neurological prognoses. The potential novel biomarkers of inflammation, platelet-to-lymphocyte ratio (PLR), neutrophil-to-lymphocyte ratio (NLR), and monocyte-to-lymphocyte ratio (MLR), have recently been promoted as critical predictors of unfavorable outcomes in patients with AIS.\textsuperscript{8,9} It has been found that NLR and PLR in AIS patients with National Institutes of Health Stroke Scale (NIHSS) ≥ 6 were significantly higher than in patients with NIHSS < 6, indicating the severity of stroke was related to the value of NLR and PLR.\textsuperscript{10} In addition, higher NLR and MLR have been found to be positively correlated with stroke severity, adverse complications, and death,\textsuperscript{11,12} while higher PLR predicted unfavorable functional outcomes with higher modified Rankin Scale (mRS) and NIHSS scores.\textsuperscript{13} However, few studies support the predictive value of NLR, PLR, and MLR on unfavorable outcomes in AIS patients with
In this study we aimed to explore the association of PLR, NLR, and MLR with functional outcomes in patients with AIS who underwent EVT and achieved successful recanalization.

**Methods**

**Study design**

Data for this study were obtained from a prospective cohort of consecutive patients with AIS who underwent EVT at our hospital between January 2013 and June 2021. Information on the prospective cohort, the processes of EVT for AIS, and imaging evaluations have been described previously. This study was approved by the Ethics Committee of Xuanwu Hospital, and written informed consent was obtained from all patients or their legally authorized representatives.

**Study population**

The inclusion criteria for this study were as follows: (1) age ≥ 18 years, (2) treatment with EVT within 24 h and successful recanalization, defined as a modified Thrombolysis in Cerebral Infarction (mTICI) of 2b or 3. The exclusion criteria were as follows: (1) pre-stroke mRS > 2, (2) absence of blood parameters before EVT, and (3) lack of 3-month follow-up.

**Data collection**

Variables including demographics, vascular risk factors, baseline clinical assessment (admission systolic blood pressure [SBP], diastolic blood pressure [DBP], NIHSS, Alberta Stroke Program Early Computed Tomography Score [ASPECTS], or posterior circulation Alberta Stroke Program Early Computed Tomography Score [pc-ASPECTS]), laboratory tests (fasting blood glucose [FBG], NLR, PLR, MLR), lesion location, stroke etiology, treatment (general anesthesia, time interval from symptom onset to puncture [OTP], time interval from symptom onset to recanalization [OTR], intravenous thrombolysis [IVT]), intracranial hemorrhage (ICH), symptomatic intracranial hemorrhage (sICH), and clinical outcomes were collected from the database and analyzed.

**Assessment of NLR, PLR, and MLR**

Blood samples were collected within 10 min of arrival at the hospital. Parameters including neutrophils, lymphocytes, monocytes, and platelets were analyzed using an automated blood cell counter (MEK-722K, NIHON, KOHEN, JAPAN). The NLR, PLR, and MLR were calculated by dividing the number of neutrophils, platelets, and monocytes by lymphocytes.

**Assessment of clinical outcomes**

A favorable outcome was defined as an mRS of 0–2, whereas an unfavorable outcome was defined as an mRS of 3–6. Any ICH was assessed according to the Heidelberg Bleeding Classification, and sICH was assessed using the European Cooperative Acute Stroke Study III. The sICH was diagnosed as ICH associated with any of the following conditions: (1) NIHSS score increased > 4 points; (2) Clinical
deterioration determined by investigators, or adverse events including drowsiness and increase of hemiparesis, etc.\textsuperscript{17,18}

**Statistical Analyses**

All enrolled patients were divided into the favorable and unfavorable outcome groups according to their clinical outcomes at 90 days, as previously described. Differences in baseline characteristics between the two groups were analyzed. Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range, IQR), and analyzed using the t-test for independent samples or Mann-Whitney U test, respectively. Categorical variables were described as numbers (percentages) and analyzed using the chi-square test. Multivariable logistic regression analysis was performed to explore the effect of NLR, PLR, and MLR on 3-month neurological outcomes, adjusting for age, sex, diabetes, hyperlipidemia, atrial fibrillation, admission DBP, NIHSS, ASPECTS, FBG, lesion location, general anesthesia, and sICH. Receiver operating characteristic (ROC) curves were used to test the discriminative ability of the NLR and PLR for clinical outcomes.

Statistical analyses were performed using SPSS statistical software (version.26; IBM Corp., Armonk, NY, USA). \( P<0.05 \) was realized to be statistically significant.

**Results**

A total of 960 patients with AIS who underwent EVT were screened, and 796 patients who fulfilled the inclusion criteria were included in the study (Fig. 1). The mean age of the patients was 62.89 ± 12.22 years, and 566 (71.1\%) were male. The median baseline NIHSS and ASPECTS/pc-ASPECTS scores were 16 and 9, respectively. Large-vessel occlusion in the anterior circulation was observed in 568 patients (71.4\%). A total of 270 patients (33.9\%) underwent IVT before EVT. The median OTP and OTR were 380 and 458 minutes, respectively. During the follow-up at 90 days, 465 (58.4\%) patients had unfavorable functional outcomes.

**Univariate analyses of patients with favorable and unfavorable outcomes**

A comparison of the detailed characteristics of the patients with favorable and unfavorable outcomes is shown in Table 1. In the univariable analysis, patients with unfavorable outcomes were much older (65.07 ± 11.93 vs. 59.83 ± 11.98, \( p<0.001 \)), had higher proportions of diabetes (34.0\% vs. 21.1\%, \( p<0.001 \)), hyperlipidemia (69.5\% vs. 42.0\%, \( p<0.001 \)), previous stroke (29.5\% vs. 20.2\%, \( p=0.003 \)), posterior circulation lesion (32.9\% vs. 22.7\%, \( p=0.002 \)), general anesthesia (42.2\% vs. 29.9\%, \( p<0.001 \)), ICH (44.1\% vs. 22.7\%, \( p<0.001 \)), and sICH (17.8\% vs. 1.8\%, \( p<0.001 \)). However, there was a lower proportion of current smokers (35.7\% vs. 45.6\%, \( p=0.005 \)).
Table 1
Characteristics of patients with favorable outcome and unfavorable outcome

<table>
<thead>
<tr>
<th>Factors</th>
<th>Total number (n = 796)</th>
<th>Favorable outcome (n = 331)</th>
<th>Unfavorable outcome (n = 465)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
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</tr>
<tr>
<td>Age, y, mean ± SD</td>
<td>62.89 ± 12.22</td>
<td>59.83 ± 11.98</td>
<td>65.07 ± 11.93</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>566(71.1%)</td>
<td>256(77.3%)</td>
<td>310(66.7%)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td><strong>Vascular risk factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>558(70.1%)</td>
<td>220(66.5%)</td>
<td>338(72.7%)</td>
<td>0.059</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>228(28.6%)</td>
<td>70(21.1%)</td>
<td>158(34.0%)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Hyperlipidemia, n (%)</td>
<td>462(58.0%)</td>
<td>139(42.0%)</td>
<td>323(69.5%)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Current smoking, n (%)</td>
<td>317(39.8%)</td>
<td>151(45.6%)</td>
<td>166(35.7%)</td>
<td>0.005</td>
</tr>
<tr>
<td>Atrial fibrillation, n (%)</td>
<td>259(32.5%)</td>
<td>95(28.7%)</td>
<td>164(35.3%)</td>
<td>0.051</td>
</tr>
<tr>
<td>Previous stroke, n (%)</td>
<td>204(25.6%)</td>
<td>67(20.2%)</td>
<td>137(29.5%)</td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Baseline clinical assessment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission SBP (mmHg), mean ± SD</td>
<td>146 ± 33</td>
<td>143.55 ± 22.58</td>
<td>150.67 ± 24.15</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Admission DBP (mmHg), mean ± SD</td>
<td>83 ± 15</td>
<td>83.03 ± 14.43</td>
<td>85.27 ± 14.79</td>
<td>0.033</td>
</tr>
<tr>
<td>Admission NIHSS, median (IQR)</td>
<td>16(9)</td>
<td>13(7)</td>
<td>18(12)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Admission ASPECTS/pc-ASPECTS, median (IQR)</td>
<td>9(3)</td>
<td>9(2)</td>
<td>8(3)</td>
<td>0.006*</td>
</tr>
<tr>
<td><strong>Laboratory test</strong></td>
<td></td>
<td></td>
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<tr>
<td>FBG (mmol/L), median (IQR)</td>
<td>7.37(3.35)</td>
<td>6.89(2.54)</td>
<td>7.96(3.92)</td>
<td>&lt; 0.001*</td>
</tr>
</tbody>
</table>

*P < 0.05. SBP, systolic blood pressure; DBP, diastolic blood pressure; NIHSS, National Institute of Health Stroke Scale; ASPECTS, Alberta Stroke Program Early Computed Tomography Score; pc-ASPECTS, posterior circulation Alberta Stroke Program Early Computed Tomography Score; FBG, fast blood glucose; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; LAA, large artery atherosclerosis; CE, cardio embolism; OTP, time interval from symptoms onset to puncture; OTR, time interval from symptoms onset to recanalization; IVT, intravenous thrombolysis ICH, intracranial hemorrhage; sICH, symptomatic intracranial hemorrhage.
<table>
<thead>
<tr>
<th>Factors</th>
<th>Total number (n = 796)</th>
<th>Favorable outcome (n = 331)</th>
<th>Unfavorable outcome (n = 465)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLR, median (IQR)</td>
<td>5.87 (6.42)</td>
<td>4.85 (4.96)</td>
<td>6.57 (7.21)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>PLR, median (IQR)</td>
<td>161.79 (133.10)</td>
<td>153.90 (113.05)</td>
<td>168.89 (140.10)</td>
<td>0.002*</td>
</tr>
<tr>
<td>MLR, median (IQR)</td>
<td>0.30 (0.21)</td>
<td>0.28 (0.17)</td>
<td>0.32 (0.25)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Lesion location</td>
<td></td>
<td></td>
<td></td>
<td>0.002*</td>
</tr>
<tr>
<td>Anterior circulation, n (%)</td>
<td>568 (71.4%)</td>
<td>256 (77.3%)</td>
<td>312 (67.1%)</td>
<td></td>
</tr>
<tr>
<td>Posterior circulation, n (%)</td>
<td>228 (28.6%)</td>
<td>75 (22.7%)</td>
<td>153 (32.9%)</td>
<td></td>
</tr>
<tr>
<td>Stroke etiology</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>LAA, n (%)</td>
<td>479 (60.2%)</td>
<td>210 (63.4%)</td>
<td>269 (57.8%)</td>
<td>0.088</td>
</tr>
<tr>
<td>CE, n (%)</td>
<td>281 (35.3%)</td>
<td>103 (31.1%)</td>
<td>178 (38.3%)</td>
<td></td>
</tr>
<tr>
<td>Others, n (%)</td>
<td>36 (4.5%)</td>
<td>18 (5.4%)</td>
<td>18 (3.9%)</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General anesthesia, n (%)</td>
<td>295 (37.1%)</td>
<td>99 (29.9%)</td>
<td>196 (42.2%)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>OTP (min), median (IQR)</td>
<td>380 (244)</td>
<td>389 (254)</td>
<td>375 (238)</td>
<td>0.775</td>
</tr>
<tr>
<td>OTR (min), median (IQR)</td>
<td>458 (242.0)</td>
<td>450 (237.0)</td>
<td>465 (249.5)</td>
<td>0.507</td>
</tr>
<tr>
<td>IVT, n (%)</td>
<td>270 (33.9%)</td>
<td>112 (33.8%)</td>
<td>158 (34.0%)</td>
<td>0.967</td>
</tr>
<tr>
<td>Clinical outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICH, n (%)</td>
<td>280 (35.2%)</td>
<td>75 (22.7%)</td>
<td>205 (44.1%)</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>sICH, n (%)</td>
<td>89 (11.2%)</td>
<td>6 (1.8%)</td>
<td>83 (17.8%)</td>
<td>&lt; 0.001*</td>
</tr>
</tbody>
</table>

*P < 0.05. SBP, systolic blood pressure; DBP, diastolic blood pressure; NIHSS, National Institute of Health Stroke Scale; ASPECTS, Alberta Stroke Program Early Computed Tomography Score; pc-ASPECTS, posterior circulation Alberta Stroke Program Early Computed Tomography Score; FBG, fast blood glucose; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; LAA, large artery atherosclerosis; CE, cardioembolism; OTP, time interval from symptoms onset to puncture; OTR, time interval from symptoms onset to recanalization; IVT, intravenous thrombolysis; ICH, intracranial hemorrhage; sICH, symptomatic intracranial hemorrhage.
The results showed that men were more likely to achieve favorable outcomes (77.3% vs. 66.7%, \( p < 0.001 \)). In addition, patients with unfavorable outcomes also had higher baseline SBP (150.67 ± 24.15 mmHg vs. 143.55 ± 22.58 mmHg, \( p < 0.001 \)), higher DBP (85.27 ± 14.79 mmHg vs. 83.03 ± 14.43 mmHg, \( p = 0.033 \)), higher NIHSS score (median, 18 vs. 13, \( p < 0.001 \)), lower ASPECTS/pc-ASPECTS score (median, 8 vs. 9, \( p = 0.006 \)). For laboratory tests, patients in the unfavorable outcome group had higher FBG (median, 7.96 mmol/L vs. 6.89 mmol/L, \( p < 0.001 \)), NLR (median, 6.57 vs. 4.85, \( p < 0.001 \)), PLR (median, 168.89 vs. 153.90, \( p = 0.002 \)), and MLR (median, 0.32 vs. 0.28, \( p < 0.001 \)).

**Effect of NLR, PLR, and MLR on functional outcomes**

After adjusting for potential confounders (age, sex, diabetes, hyperlipidemia, atrial fibrillation, admission DBP, NIHSS, ASPECTS, FBG, lesion location, general anesthesia, and sICH), NLR (OR, 1.076; 95% CI, 1.037–1.117; \( p < 0.001 \)), and PLR (OR, 1.001; 95% CI, 1.000-1.003; \( p = 0.045 \)) were found as independent predictors of unfavorable outcomes. Nevertheless, MLR was not significantly associated with unfavorable outcomes (OR, 1.052; 95% CI, 0.954–2.365; \( p = 0.079 \)) (Table 2).

<table>
<thead>
<tr>
<th>Variable</th>
<th>( \beta )</th>
<th>SE</th>
<th>OR</th>
<th>95% CI</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLR</td>
<td>Unadjusted</td>
<td>0.083</td>
<td>0.016</td>
<td>1.087</td>
<td>1.054</td>
</tr>
<tr>
<td></td>
<td>Adjusted @</td>
<td>0.074</td>
<td>0.019</td>
<td>1.076</td>
<td>1.037</td>
</tr>
<tr>
<td>PLR</td>
<td>Unadjusted</td>
<td>0.001</td>
<td>0.001</td>
<td>1.001</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Adjusted @</td>
<td>0.001</td>
<td>0.001</td>
<td>1.001</td>
<td>1.000</td>
</tr>
<tr>
<td>MLR</td>
<td>Unadjusted</td>
<td>0.482</td>
<td>0.297</td>
<td>1.619</td>
<td>0.905</td>
</tr>
<tr>
<td></td>
<td>Adjusted @</td>
<td>0.407</td>
<td>0.232</td>
<td>1.502</td>
<td>0.954</td>
</tr>
</tbody>
</table>

*\( P < 0.05 \). @ Adjusting for age, sex, diabetes, hyperlipidemia, atrial fibrillation, admission DBP, NIHSS, ASPECTS/pc-ASPECTS, FBG, lesion location, general anesthesia, and sICH.

The areas under the receiver operating characteristic curves (AUC) of NLR, PLR, and MLR were 0.622 (95% CI, 0.583–0.661; \( p < 0.001 \)), 0.564 (95% CI, 0.524–0.604; \( p = 0.002 \)), and 0.576 (95% CI, 0.536–0.616; \( p < 0.001 \)), respectively (Fig. 2).

**Discussion**

In this study, we found that approximately half (58.4%) of the patients with successful recanalization still had unfavorable clinical outcomes at 90 days, and that higher pre-EVT NLR and PLR were significantly associated with unfavorable outcomes in patients with AIS who achieved successful recanalization after EVT.
Currently, EVT has been recognized as the most effective reperfusion therapy for the treatment of patients with AIS secondary to the occlusion of large vessels.\textsuperscript{19} Despite the fact that EVT yields a successful recanalization rate of > 80\% compared with traditional therapies, about half of the patients who achieved successful recanalization still suffer from unfavorable functional outcomes,\textsuperscript{3} as was observed in this study. Recent imaging studies have shown that the no-reflow phenomenon, indicating the tissue suffering incomplete microvascular reperfusion despite successful macrovascular revascularization, provides insights into the mechanisms underlying this unfavorable prognosis.\textsuperscript{20} However, advanced perfusion imaging to evaluate microvascular tissue reperfusion is too time-consuming to guide timely treatment, and is difficult to implement in the clinic. In patients with acute myocardial infarction treated with percutaneous coronary intervention, composite inflammatory biomarkers have been shown to be strong predictors of both the no-reflow phenomenon and unfavorable functional outcomes.\textsuperscript{21} We therefore hypothesized that NLR, PLR, and MLR may also mediate neurological outcomes through the mechanism of microvascular no-reflow in patients with AIS treated with EVT.

Consistent with studies of acute myocardial infarction treated with percutaneous coronary intervention, this study found that NLR and PLR before EVT were significantly associated with unfavorable functional outcomes in patients with AIS after successful recanalization with EVT. Theoretically, ischemic brain tissues can release various kinds of cytokines and chemokines to guide the proliferation and migration of peripheral leukocytes.\textsuperscript{22} Elevated levels of peripheral leukocytes transmigrating and infiltrating to the ischemic tissues may cause thrombosis, aggravate endothelial edema, and lead to microvascular occlusion, thereby participating in the process of microvascular no-reflow phenomenon.\textsuperscript{20} Therefore, composite inflammation indexes such as NLR, PLR, and MLR, easy-to-acquire biomarkers, might serve as potential predictors of the no-reflow phenomenon, and could be associated with unfavorable functional outcomes in successfully recanalized patients with AIS.\textsuperscript{23, 24} In the present study, NLR and PLR were found to be independently correlated with functional outcome, but MLR was not significantly associated with functional outcome. Further investigations are needed to explore the relationship between inflammatory indices, the no-reflow phenomenon, and functional outcomes in human ischemic stroke. Since increased inflammatory indexes have been shown to be related to unfavorable outcomes, therapy targeting microvascular embolism caused by coagulation and inflammatory pathways may help improve the neurological prognosis of patients with AIS.

This study had some limitations. First, the cohort included subjects from only one region of China, which would have introduced selection bias. Further exploration using larger multicenter prospective studies is warranted to substantiate our findings. Second, covariates related to AIS could not be completely collected because of data limitations. Finally, we only evaluated preoperative inflammatory indicators, not postoperative indicators; this will need to be to be dynamically documented in future studies.

Conclusion
This study showed that NLR and PLR before EVT were significantly associated with 3-month functional outcomes in patients with AIS who achieved successful recanalization after EVT. Further studies are needed to confirm these results, and the underlying mechanisms should be explored.

**Abbreviations**

AIS: acute ischemic stroke; PLR: platelet-to-lymphocyte ratio; NLR: neutrophil-to-lymphocyte ratio; MLR: monocyte-to-lymphocyte ratio; EVT: endovascular thrombectomy; mTICI: modified thrombolysis in cerebral infarction; mRS: modified Rankin Scale; CI: confidence interval; AUC: area under the receiver operating characteristic curve; SBP: systolic blood pressure; DBP: diastolic blood pressure; NIHSS: National Institute of Health Stroke Scale; ASPECTS: Alberta Stroke Program Early Computed Tomography Score; pc-ASPECTS: posterior circulation Alberta Stroke Program Early Computed Tomography Score; FBG: fasting blood glucose; LAA: large artery atherosclerosis; CE: cardio embolism; OTP: time interval from symptoms onset to puncture; OTR: time interval from symptoms onset to recanalization; IVT: intravenous thrombolysis; ICH: intracranial hemorrhage; sICH: symptomatic intracranial hemorrhage; SD: standard deviation; IQR: interquartile range; ROC: Receiver operating characteristic.

**Declarations**

**Ethics approval and consent to participate**

This study was approved by the Ethics Committee of Xuanwu Hospital (No. [2017]030), and written informed consent was obtained from all patients or their legally authorized representatives.

**Consent for publication**

Not applicable.

**Availability of data and materials**

The data supporting the findings of this study are available from the corresponding author on reasonable request.

**Competing interests**

The authors declare that they have no competing interests.

**Funding**

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Authors’ contributions

Jin Ma and Wenting Guo conceived of the study idea, collected and analyzed the data, and drafted the manuscript. Jiali Xu, Longfei Wu, and Wenbo Zhao participated in the data collection and analysis. Xunning Ji, Sijie Li, Changhong Ren, Chuanjie Wu, Chuanhui Li, Jian Chen, Jianguang Duan, Qingfeng Ma, Haiqing Song participated in the coordination of the study. Wenbo Zhao and Xunning Ji helped to interpret the data and modify the manuscript. All authors read and approved the final manuscript.

Acknowledgements

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References


Figures

Figure 1

Study flow chart. AIS, acute ischemic stroke; EVT, endovascular thrombectomy; mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction.
Figure 2

Receiver Operating Characteristic Curve of NLR, PLR, MLR.