

Prognostic Evaluation of Acute Ischemic Stroke Patients After Mechanical Thrombectomy Incorporating Imaging, Inflammatory, and Rehabilitation Aspects

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AIM: We aimed to perform a prognostic evaluation for patients with acute ischemic stroke after mechanical thrombectomy (MT) incorporating imaging, inflammatory, and rehabilitation aspects.

METHODS: A retrospective cohort analysis of patients with acute ischemic stroke (AIS) after mechanical thrombectomy (MT) was conducted, systematically evaluating baseline demographics, neuroimaging features, hematological inflammatory indices, and time to start rehabilitation. Prognostic correlations were examined using multivariate logistic regression, with poor functional outcome defined as 90-day modified Rankin Scale (mRS) >2. Model discrimination was assessed via receiver operating characteristic (ROC) analysis of the composite prediction framework.

RESULTS: The analytical cohort comprised 144 subjects. Five independent predictors of unfavorable outcomes emerged: pre-existing hypertension (adjusted Odds Ratio [aOR] 6.48, 95% Confidence Interval [CI] 1.03–40.80), lower baseline Alberta Stroke Program Early CT Score (ASPECTS) (aOR 0.18, 95% CI 0.06–0.49), elevated NLR (aOR 1.27, 95% CI 1.11–1.46), extended onset-to-reperfusion time (OTR) (per minute aOR 1.01, 95% CI 1.01–1.02), and delayed starting rehabilitation (aOR 2.30, 95% CI 1.52–3.46). The multivariable model demonstrated excellent discriminative capacity (area under the curve [AUC] 0.964, 95% CI 0.940–0.988).

CONCLUSIONS: Beyond successful recanalization (modified Thrombolysis in Cerebral Infarction [mTICI] 2b–3), functional outcomes in patients with acute ischemic stroke treated with mechanical thrombectomy were independently influenced by factors across the three core domains of our prognostic framework: imaging (baseline ASPECTS), inflammation (elevated neutrophil-to-lymphocyte ratio, NLR), and rehabilitation (delayed starting rehabilitation). Additional significant clinical variables included pre-existing hypertension and longer onset-to-reperfusion time (OTR). These findings support the potential value of a multidimensional prognostic assessment integrating imaging, inflammatory, and rehabilitation aspects in patients with acute ischemic stroke after mechanical thrombectomy.

Keywords: acute ischemic stroke; mechanical thrombectomy; NLR; rehabilitation; prognosis

Introduction

Acute ischemic stroke (AIS) remains a global health priority as a predominant contributor to acquired disability and mortality, with large vessel occlusion (LVO) cases demonstrating particularly unfavorable clinical trajectories. The advent of mechanical thrombectomy (MT) as first-line intervention for LVO-AIS [1] has revolutionized care paradigms, yielding substantially enhanced recanalization rates and functional outcomes. Nevertheless, contemporary

registry data reveal persistent challenges, as nearly 60% of patients fail to attain functional independence (modified Rankin Scale [mRS] ≤2 at 90 days) despite successful revascularization (modified Thrombolysis in Cerebral Infarction [mTICI] 2b–3) [2]. Beyond recanalization status, emerging evidence highlights the prognostic significance of neuroimaging biomarkers and systemic inflammatory responses in predicting long-term functional recovery. While the Alberta Stroke Program Early CT Score (ASPECTS) provides a valuable assessment of early ischemic changes [3], its conventional implementation presents notable constraints: it cannot quantitatively reflect the degree of cerebral tissue ischemia and hypoxia, and patients with the same scores may have significant heterogeneity. For these reasons, our investigation builds upon ASPECTS by incorporating quantitative computed tomography (CT) density measurements to enable precise volumetric assessment of ischemic edema formation [4], offer-

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ing potential advantages over the traditional scoring system alone. Concurrently, systemic inflammation plays a critical role in post-stroke outcomes. Following successful recanalization, ischemia-reperfusion injury triggers a cascade of innate immune activation, characterized by elevated neutrophil-to-lymphocyte ratio (NLR), C-reactive protein (CRP), and pro-inflammatory cytokines such as interleukin-6. These inflammatory mediators can exacerbate blood–brain barrier disruption, promote hemorrhagic transformation, and impede neuroplasticity.

While MT has transformed AIS management, significant variability persists in post-procedural rehabilitation practices, particularly regarding intervention timing. The critical interplay between early rehabilitation and neurological recovery is often complicated by the severity of post-thrombectomy conditions, and evidence-based guidance on timing selection remains limited [5]. Collectively, imaging characteristics, inflammatory status, and rehabilitation timing all influence prognosis after acute ischemic stroke. Leveraging a multidimensional approach, we retrospectively analyzed imaging biomarkers, inflammatory profiles, and rehabilitation initiation data to identify temporal thresholds associated with improved prognosis. The findings of this study may provide clinically relevant insights to tailor rehabilitation strategies, ensuring timely intervention without compromising patient safety.

Methods

Patients

We consecutively enrolled adults (age ≥ 18 years) who underwent mechanical thrombectomy for anterior circulation LVO-associated AIS between October 2023 and January 2025. Inclusion Criteria included: (1) Radiologically confirmed LVO in the internal carotid artery territory; (2) Achieved endovascular reperfusion (mTICI 2b-3); (3) Comprehensive baseline neurovascular imaging protocol including CT angiography with intracranial/extracranial coverage and Whole-brain CT perfusion (RAPID-processed datasets); and (4) availability of baseline hematological profiling.

Exclusion Criteria included: (1) Posterior circulation (vertebrobasilar system) infarction; (2) Pre-stroke functional impairment (modified Rankin Scale [mRS] >2); (3) Suboptimal imaging analysis (non-RAPID software processed CT Perfusion [CTP] datasets); (4) Incomplete 90-day outcome documentation; and (5) patients with underlying hematologic or hepatic diseases, or malignancies.

Clinical Information

Demographic characteristics (sex, age), medical history (prior stroke, hypertension, hyperlipidemia, diabetes mellitus, atrial fibrillation, and smoking history), and baseline clinical parameters were retrospectively obtained from the electronic medical records of North China University of Science and Technology Hospital. Stroke severity was as-

sessed using the NIHSS upon admission. Data on inflammatory biomarkers (NLR, monocyte-to-lymphocyte ratio [MLR] and platelet-to-lymphocyte ratio [PLR]) and treatment details, including the use of intravenous thrombolysis, time from symptom onset-to-reperfusion time (OTR, minutes), and recanalization success (mTICI), were recorded. Intravenous thrombolysis was performed with either rt-PA (recombinant tissue plasminogen activator, 0.9 mg/kg, maximum dose 90 mg) or TNK (tenecteplase, 0.25 mg/kg, maximum dose 25 mg). Peripheral venous blood samples for NLR, MLR, and PLR were collected before mechanical thrombectomy and analyzed using routine automated hematology methods. NLR, MLR, and PLR were calculated from the corresponding absolute neutrophil, monocyte, lymphocyte, and platelet counts. Rehabilitation mainly included individualized bedside mobilization, limb motor training, and functional activity training according to each patient's neurological and clinical condition. The frequency, intensity, and duration of rehabilitation were adjusted individually based on patient tolerance and clinical status. For patients who did not initiate rehabilitation during hospitalization, the time to start rehabilitation was assigned as 14 days, corresponding to the predefined maximum value used in the analysis. Functional outcomes were evaluated at 90 days using the modified Rankin Scale (mRS), where a score of 0–2 indicated a favorable outcome and >2 denoted an unfavorable outcome. The 90-day mRS was assessed by trained neurologists through outpatient visits or telephone follow-up. Assessors were blinded to the baseline imaging and laboratory results.

Image Acquisition

All enrolled patients underwent standardized neurovascular imaging evaluation for acute cerebrovascular events following institutional protocol, utilizing a 128-slice multidetector computed tomography system (Revolution HD, GE Healthcare). The NCCT was performed using a tube current of 100–300 mAs, a tube voltage of 120 kV, and a reconstructed slice thickness of 5 mm. For CTP, imaging was performed at a tube current of 200–250 mAs and a tube voltage of 80 kV, with 5-mm slice reconstruction and a temporal sampling interval of 1.33–1.50 s during the 45–60 s acquisition. CTA was acquired at a tube current of 150–200 mAs and a tube voltage of 100–120 kV, and images were reconstructed as both 1.25 mm axial sections and 5-mm maximum intensity projections. All studies employed a standardized contrast protocol: 50 mL of iodinated contrast medium administered at 5 mL/s, followed by a 30 mL saline chaser at an identical flow rate. All imaging data underwent automated processing using the latest-generation RAPID AI platform (v5.0, iSchemaView, Menlo Park). RAPID was routinely integrated into the hospital's clinical imaging workflow, and the present retrospective study used the automatically generated results without reprocessing the original images specifically for research purposes. The ischemic

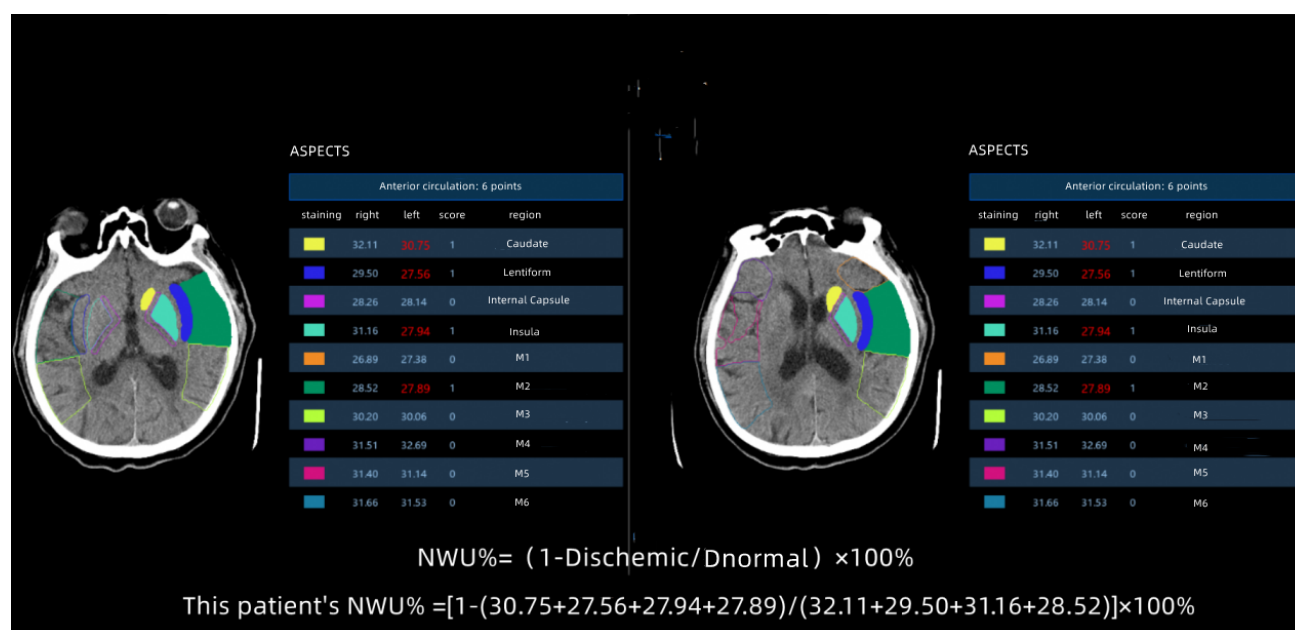


Fig. 1. NWU calculation methodology. NWU, net water uptake; ASPECTS, Alberta Stroke Program Early CT Score.

core was defined using an relative Cerebral Blood Flow (rCBF) threshold of <30%, where the ischemic penumbra was defined by Tmax of >6 seconds. Quality control was performed by two board-certified neuroradiologists.

Image Analysis

Automated volumetric analysis (RAPID v5.0, iSchemaview) computed interhemispheric hypodensity gradients by comparing mean attenuation values (Hounsfield units) in ASPECTS-defined ischemic territories against their contralateral homologs, with results standardized as a hypoperfusion ratio: $\text{Dischismic}/\text{Dnormal} \times 100\%$. Based on predefined relative Hounsfield Unit (HU) difference thresholds, ischemic hemisphere regions were dichotomously classified as either affected (demonstrating RAPID-identified ischemic changes) or unaffected. Density measurements (Dischismic and Dnormal) were obtained from voxels within the 20–80 HU range. Net water uptake (NWU) was computed using the formula: $\text{NWU}\% = (1 - \text{Dischismic}/\text{Dnormal}) \times 100\%$. All NWU measurements underwent blinded verification by both neuroradiologists and stroke physicians. The NWU calculation methodology is illustrated in Fig. 1.

Mechanical Thrombectomy Standard Procedure

The anesthetic approach (general anesthesia or local anesthesia) was selected based on the patient's condition and the characteristics of vascular occlusion. Using the modified Seldinger technique, a femoral artery puncture was performed, and an 8F arterial sheath was inserted. A single-curve pigtail catheter was then advanced through the sheath to perform digital subtraction angiography (DSA) of the entire cerebral vasculature. Subsequently, an 8F guiding

catheter was introduced and positioned in the responsible artery. Under microguidewire guidance, a microcatheter was navigated into the true lumen of the occluded artery. The Solitaire FR stent retriever system was subsequently delivered through the microcatheter to the occluded cerebral artery segment, and the stent was accurately deployed. Recanalization was assessed by angiography. The stent was left in place for 5 minutes before being retrieved. During retrieval, simultaneous aspiration was applied through the guiding catheter, and the thrombus was withdrawn together with the stent from the microcatheter. Angiography was repeated to confirm recanalization. If severe residual stenosis was present or post-procedure flow was graded as mTICI 2a or lower, the above steps were repeated. Depending on the angiographic findings, balloon angioplasty or stenting may be performed. The procedure was concluded when blood flow through the occluded site reached an mTICI grade of 2b or higher. All endovascular procedures were performed by experienced neurointerventionists. Decisions regarding stent retriever thrombectomy, aspiration thrombectomy, stenting, and antithrombotic therapy were made jointly by the operating physician and senior neurologists at the associate chief physician level or above.

Statistical Analysis

Data analysis was performed using SPSS (version 23.0, IBM Corp.) and RStudio (version 4.3.0, Posit Software, PBC, Boston, MA, USA). Distributional properties of metric variables were rigorously assessed through the Lilliefors-corrected Kolmogorov-Smirnov procedure. Normal distributions were summarized as arithmetic centrality measures (mean $\pm$ SD), whereas non-normally distributed variables were characterized by robust location estimators

[Mdn (IQR)]. Discrete clinical covariates were tabulated using absolute frequencies with proportional estimates (n, %). Between-group comparisons were performed using the independent-samples *t*-test or Mann–Whitney U test for continuous variables, as appropriate, and the chi-square test or Fisher’s exact test for categorical variables. No missing data were present in the variables included in the final analysis. The study population was divided into two groups based on 90-day functional outcomes: the favorable outcome group (mRS score 0–2) and the unfavorable outcome group (mRS score 3–6). Comparative analyses of baseline characteristics between these groups were conducted to identify potential prognostic factors. Candidate variables were selected for multivariable modeling based on both statistical significance ($\alpha = 0.05$ in univariate testing) and clinical relevance to identify independent predictors. The predictive performance of significant variables was assessed through receiver operating characteristic (ROC) curve analysis, with optimal cutoff values determined by maximizing Youden’s index ($J = \text{sensitivity} + \text{specificity} - 1$). All statistical tests were two-tailed, with statistical significance set at $p < 0.05$.

Results

Baseline Characteristics

The final analytical cohort comprised 144 eligible patients, with detailed enrollment illustrated in Fig. 2. Comparative analysis revealed significant differences between the outcome groups (favorable outcome [mRS 0–2]: $n = 69$, 47.9%; unfavorable outcome [mRS 3–6]: $n = 75$, 52.1%). Those in the unfavorable outcome group (90-day mRS 3–6) were older (mean age, 65.72 vs. 60.78 years; $p = 0.029$) and had higher baseline stroke severity (median NIHSS score, 17.00 [IQR, 13.00–20.00] vs. 15.00 [10.00–18.00]; $p = 0.004$). The unfavorable outcome group had lower ASPECTS scores (7.00 [6.00–8.00] vs. 8.00 [7.00–9.00]; $p < 0.001$), greater net water uptake (7.00 [5.00–9.80] vs. 4.90 [1.30–7.40]; $p < 0.001$), and larger ischemic core volumes (10.40 [4.20–50.90] vs. 7.00 [0.00–20.0] mL; $p = 0.004$). Systemic inflammatory markers (NLR: 6.60 [2.80–12.30] vs. 3.40 [2.00–10.50]; $p = 0.007$; MLR: 0.34 [0.24–0.44] vs. 0.24 [0.19–0.25]; $p = 0.003$) were elevated in the unfavorable outcome group. Onset-to-reperfusion time (OTR) was longer (619.00 [458.00–750.00] vs. 617.00 [400.00–698.00] min; $p = 0.046$), and time to start rehabilitation was extended (14.00 [13.00–14.00] vs. 7.00 [5.00–14.00] days; $p < 0.001$). Hypertension prevalence was higher in the unfavorable outcome group (80.00% vs. 52.17%; $p < 0.001$), while intravenous thrombolysis was less frequent (20.0% vs. 34.8%; $p = 0.046$). No between-group differences were observed in sex distribution, stroke history, hyperlipemia, diabetes mellitus, atrial fibrillation, or smoking history ($p \geq 0.077$ for all) (Table 1).

Univariate and Multiple Logistic Regression Analysis

Univariate logistic regression revealed significant differences between prognosis groups in age ($p = 0.031$), hypertensive history ($p < 0.001$), intravenous thrombolysis administration ($p = 0.048$), admission NIHSS scores ($p = 0.012$), ASPECTS ($p < 0.001$), net water uptake ($p < 0.001$), ischemic core volume ($p = 0.003$), neutrophil-lymphocyte ratio ($p = 0.002$), onset-to-reperfusion time (OTR) ($p = 0.004$), and rehabilitation initiation timing ($p < 0.001$) (Table 2).

The multivariate regression model incorporating these significant univariate predictors demonstrated five independent prognostic factors: hypertension (adjusted Odds Ratio [aOR] 6.48, 95% Confidence Interval [CI] 1.03–40.80; $p = 0.047$); ASPECTS (aOR 0.18, 95% CI 0.06–0.49; $p < 0.001$); NLR (aOR 1.27, 95% CI 1.11–1.46; $p < 0.001$); OTR (per minute aOR 1.01, 95% CI 1.01–1.02; $p = 0.001$); Time to start rehabilitation (per day aOR 2.30, 95% CI 1.52–3.46; $p < 0.001$) (Table 2).

Predictive Models for Poor Prognosis

Through integrative ROC analysis, we developed a multidimensional predictive model incorporating five critical prognostic indicators (hypertensive status, ASPECTS evaluation, NLR levels, onset-to-reperfusion time (OTR), and rehabilitation initiation timing). This combined model demonstrated excellent predictive performance (AUC 0.964, 95% CI 0.940–0.988) (Supplementary Material, Table 3, Fig. 3).

The cumulative ROC modeling strategy showed progressively higher AUC values from Model 1 (ASPECTS alone; AUC 0.686, 95% CI 0.601–0.771) to Model 5 (ASPECTS, hypertension, NLR, OTR, and time to start rehabilitation; AUC 0.964, 95% CI 0.940–0.988) (Table 3, Fig. 3). The cumulative ROC modeling strategy was designed to assess the incremental predictive value of each additional variable. Cutoff values were identified for ASPECTS score ≤ 6 (44% sensitivity, 91% specificity) and rehabilitation delay > 7 days (65% sensitivity, 84% specificity).

Discussion

This research evaluated prognostic determinants in AIS patients receiving MT, with particular emphasis on neuroimaging characteristics, systemic inflammatory markers, and rehabilitation initiation windows. Multivariable analysis identified five independent predictors of unfavorable outcomes: pre-existing hypertension, reduced ASPECTS scores, elevated neutrophil-lymphocyte ratio (NLR), prolonged onset-to-reperfusion intervals, and delayed rehabilitation commencement. The integrated predictive model achieved outstanding discriminative capacity (AUC 0.964, 95% CI 0.940–0.988).

Mechanical thrombectomy (MT) now represents the standard of care for acute ischemic stroke (AIS) caused by large vessel occlusion (LVO). Current guidelines support MT in-

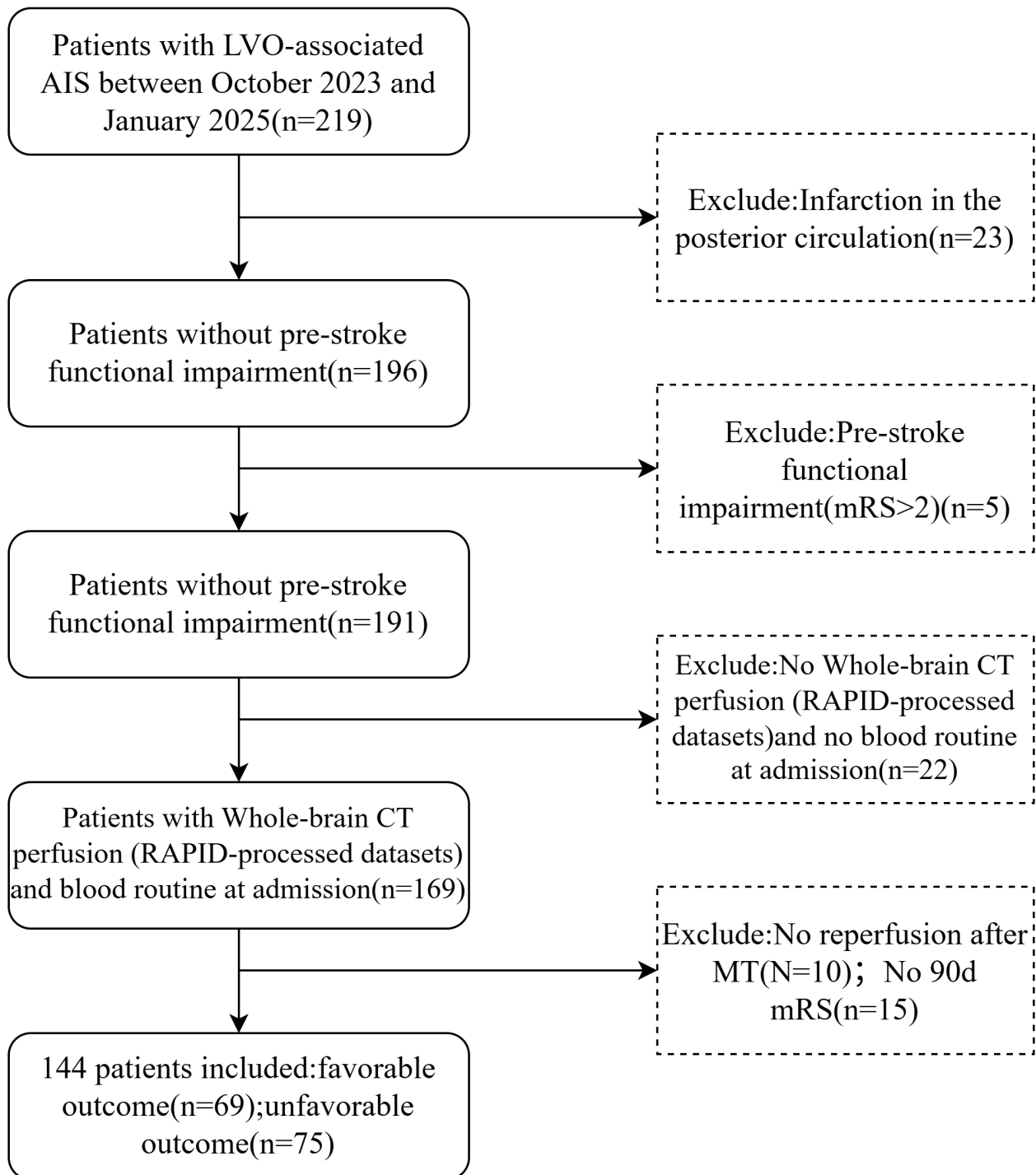


Fig. 2. Flow chart of patient enrollment. LVO, large vessel occlusion; AIS, acute ischemic stroke; CT, computed tomography; mRS, modified Rankin Scale; mTICI, modified Thrombolysis in Cerebral Infarction.

tervention in eligible patients within 24 hours of symptom onset when meeting clinical (NIHSS ≥ 6) and imaging (ASPECTS ≥ 6) eligibility criteria [6]. Recent clinical trials, such as Endovascular Therapy in Acute Anterior Circulation Large Vessel Occlusive Patients With a Large Infarct Core (ANGEL-ASPECT) [7,8,9], have broadened the eligibility criteria for MT, showing therapeutic benefits even

in cases with substantial baseline ischemic changes. While ASPECTS remains a cornerstone imaging selection tool for MT candidates [10], our study additionally explored net water uptake (NWU) quantification—a novel imaging parameter [11] that may allow for voxel-level assessment of cytotoxic edema based on CT density analysis. Existing literature suggests potential clinical utility of NWU, both

Table 1. Baseline characteristics.

Variables	Total (n = 144)	90-day mRS 0–2 (n = 69)	90-day mRS 3–6 (n = 75)	<i>p</i>
Age, Mean ± SD	63.35 ± 13.59	60.78 ± 12.95	65.72 ± 13.81	0.029
Male, n (%)	96 (66.67)	51 (73.91)	45 (60.00)	0.077
Stroke history, n (%)	42 (29.17)	18 (26.09)	24 (32.00)	0.435
Hypertension, n (%)	96 (66.67)	36 (52.17)	60 (80.00)	<0.001
Hyperlipemia, n (%)	27 (18.75)	12 (17.39)	15 (20.00)	0.689
Diabetes mellitus, n (%)	51 (35.42)	21 (30.43)	30 (40.00)	0.231
Atrial fibrillation, n (%)	30 (20.83)	12 (17.39)	18 (24.00)	0.329
Smoking history, n (%)	54 (37.50)	27 (39.13)	27 (36.00)	0.698
IVT, n (%)	39 (27.08)	24 (34.78)	15 (20.00)	0.046
NIHSS at admission, M (Q ₁ , Q ₃)	15.50 (12.00, 20.00)	15.00 (10.00, 18.00)	17.00 (13.00, 20.00)	0.004
ASPECTS, M (Q ₁ , Q ₃)	8.00 (6.00, 9.00)	8.00 (7.00, 9.00)	7.00 (6.00, 8.00)	<0.001
NWU, M (Q ₁ , Q ₃)	5.95 (4.57, 8.40)	4.90 (1.30, 7.35)	7.00 (5.00, 9.80)	<0.001
Ischemic core volume, M (Q ₁ , Q ₃), mL	7.95 (3.92, 23.80)	7.00 (0.00, 20.00)	10.40 (4.20, 50.90)	0.004
NLR, M (Q ₁ , Q ₃)	4.88 (2.08, 10.50)	3.40 (2.00, 10.50)	6.60 (2.80, 12.32)	0.007
MLR, M (Q ₁ , Q ₃)	0.25 (0.21, 0.38)	0.24 (0.19, 0.25)	0.34 (0.24, 0.44)	0.003
PLR, M (Q ₁ , Q ₃)	132.00 (76.40, 254.00)	152.20 (75.20, 182.90)	124.60 (80.75, 254.00)	0.304
OTR, M (Q ₁ , Q ₃)	618.00 (450.00, 742.50)	617.00 (400.00, 698.00)	619.00 (458.00, 750.00)	0.046
Time to start rehabilitation, M (Q ₁ , Q ₃), days	14.00 (7.00, 14.00)	7.00 (5.00, 14.00)	14.00 (13.00, 14.00)	<0.001

IVT, intravenous thrombolysis; NIHSS, National Institutes of Health Stroke Scale; ASPECTS, Alberta Stroke Program Early CT Score; NWU, net water uptake; NLR, neutrophil-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; OTR, onset-to-reperfusion time.

Table 2. Logistic regression analysis.

	Univariable analysis			Multivariable analysis		
	OR	95% CI	<i>p</i>	aOR	95% CI	<i>p</i>
Age	1.03	1.01–1.05	0.031	1.02	0.96–1.09	0.485
Hypertension	3.67	1.75–7.66	<0.001	6.48	1.03–40.80	0.047
IVT	0.47	0.22–0.99	0.048	0.68	0.10–4.81	0.700
NIHSS at admission	1.07	1.02–1.13	0.012	0.99	0.84–1.17	0.935
ASPECTS	0.61	0.48–0.77	<0.001	0.18	0.06–0.49	<0.001
NWU	1.15	1.07–1.24	<0.001	0.97	0.72–1.31	0.837
Ischemic core volume	1.02	1.01–1.04	0.003	0.98	0.95–1.02	0.412
NLR	1.08	1.03–1.13	0.002	1.27	1.11–1.46	<0.001
OTR	1.01	1.01–1.01	0.004	1.01	1.01–1.02	0.001
Time to start rehabilitation	1.28	1.16–1.40	<0.001	2.30	1.52–3.46	<0.001

OR, Odds Ratio; CI, Confidence Interval; aOR, adjusted Odds Ratio.

Table 3. The area under the ROC curve of different models.

Test result variable(s)	Area	S.E	<i>p</i>	95% CI
Model1 ASPECTS	0.686	0.042	0.001	0.601–0.771
Model2 ASPECTS + Hypertension	0.759	0.039	<0.001	0.683–0.835
Model3 ASPECTS + Hypertension + NLR	0.802	0.036	<0.001	0.731–0.873
Model4 ASPECTS + Hypertension + NLR + OTR	0.842	0.033	<0.001	0.778–0.906
Model5 ASPECTS + Hypertension + NLR + OTR + Time to start rehabilitation	0.964	0.012	<0.001	0.940–0.988

S.E, standard error.

as a prognostic indicator following successful reperfusion [12,13] and as a potential metric for a “tissue window” in patients with ischemic stroke of unknown onset time; however, these findings are preliminary and require further con-

firmation. In our analysis, NWU was not established as an independent predictor of 90-day functional outcomes (mRS 3–6) in the MT population [14]. In our analysis, NWU was not established as an independent predictor of 90-day

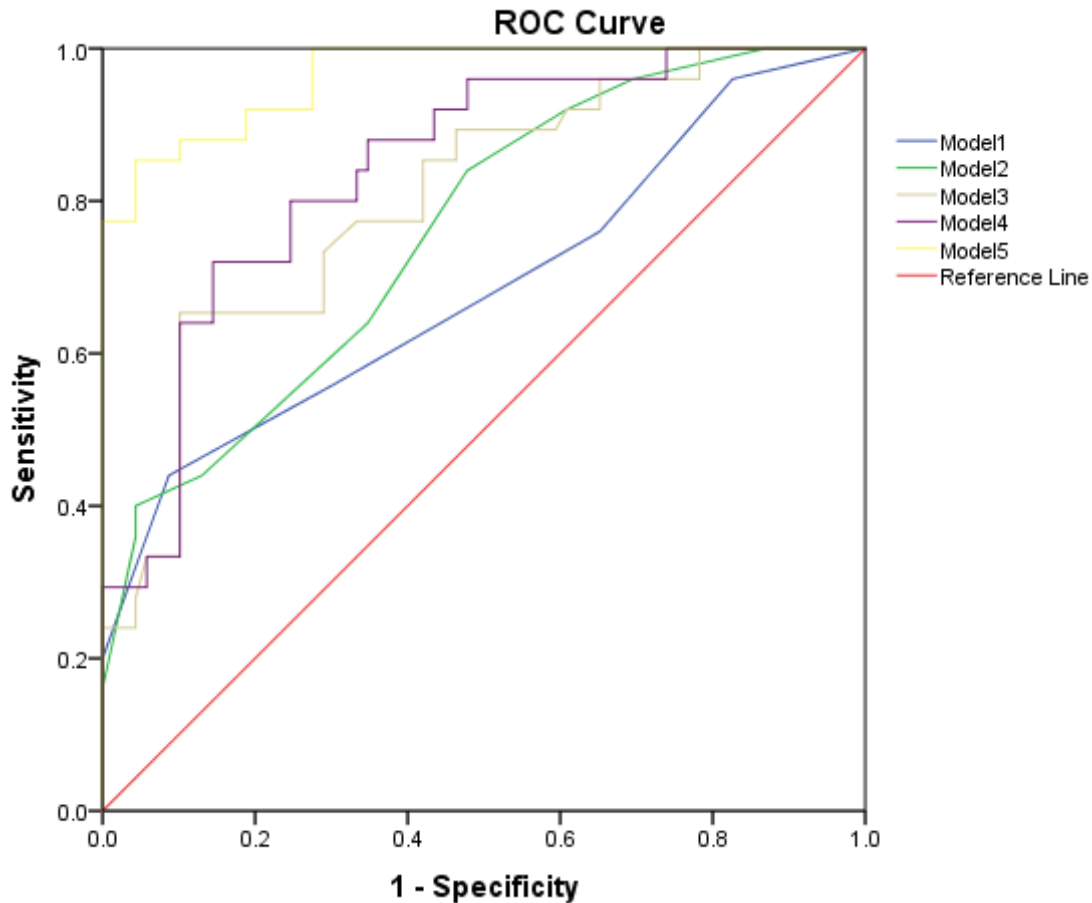


Fig. 3. ROC curve of different models. ROC, receiver operating characteristic.

functional outcomes. Further studies are needed to clarify its prognostic value in patients undergoing mechanical thrombectomy.

From a pathophysiological perspective, the inflammatory cascade and immune regulation significantly influence ischemic stroke progression [15,16]. Both hyperinflammation during the acute phase and subsequent immunosuppression may exacerbate neurological damage and impair long-term recovery [17]. The NLR serves as an integrated inflammatory indicator that better captures systemic inflammatory-immune interactions post-AIS compared to isolated hematologic parameters [18,19]. Our findings demonstrate that elevated baseline NLR independently predicts unfavorable 90-day outcomes in MT-treated patients. Emerging evidence further suggests NLR trajectory may predict revascularization success, hemorrhagic transformation, and mortality [20,21], prompting our planned prospective study to serially monitor inflammatory markers during hospitalization for enhanced prognostic evaluation. Regarding rehabilitation strategies, MT patients present unique clinical challenges in determining optimal intervention timing [5,22]. Our study, the first to incorporate rehabilitation initiation time, identified this parameter as an independent prognostic factor, with a rehabilitation

delay >7 days representing the identified cutoff. While retrospective design limitations exist (potential selection bias toward earlier rehabilitation in milder cases), our longitudinal data suggest early rehabilitation initiation was associated with better functional outcomes—a finding requiring prospective validation. In this study, we included variables such as medical history, imaging, and inflammation in patients with AIS undergoing mechanical thrombectomy, analyzed the independent risk factors associated with patients' prognosis through multifactorial logistic regression, and predicted the prognosis of patients with AIS undergoing mechanical thrombectomy by incorporating rehabilitation timing into a multidimensional predictive framework, which provides an evidence-based basis for accurate assessment of patients' outcomes and selection of the timing of individualized interventions and supports decision-making in clinical practice. We provide an evidence-based basis and decision-making support for precise assessment of patient prognosis and selection of individualized intervention timing in clinical practice.

Several study limitations warrant consideration. First, the observational nature of this analysis may lead to inherent selection biases, requiring confirmation in future prospective, multi-institutional cohort studies. In addition, reha-

bilitation initiation timing may have been influenced by patients' clinical severity and recovery status, introducing potential confounding by indication and reverse causation. Moreover, assigning a value of 14 days to patients who did not initiate rehabilitation during hospitalization may have affected the observed association; therefore, the prognostic role of rehabilitation timing should be interpreted cautiously. Second, while rehabilitation timing was tracked longitudinally, other parameters (imaging and inflammatory markers) were only assessed at baseline, limiting the assessment of their dynamic changes. Future research will expand the sample size on this basis and incorporate multiple time points to monitor the data changes, so as to dynamically evaluate the relationship between the relevant indicators and patients' outcomes, and support the development of more predictive models.

Conclusions

In addition to successful recanalization, multidimensional factors—including hypertension, baseline ASPECTS, NLR, onset-to-reperfusion time, and timing of rehabilitation initiation—were significantly associated with functional outcomes in acute ischemic stroke patients after mechanical thrombectomy.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

SSM designed and performed the research and wrote the paper; CXW designed the research and supervised the study; HL designed the research and contributed to the analysis; YanW designed the research protocol; ZML, YangW and BQL collected the data. BQL contributed to statistical analysis of the data. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study adhered to the guidelines outlined in the Declaration of Helsinki and received ethical approval from the Ethics Committee of the Tianjin Medical University General Hospital (Approval Number: IRB2025-YX-141-01). Given the retrospective nature of the study, the requirement for informed consent was waived by the Ethics Committee.

Acknowledgment

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.62713/ai.c.4672>.

References

- [1] Majoie CB, Cavalcante F, Gralla J, Yang P, Kaesmacher J, Treurniet KM, et al. Value of intravenous thrombolysis in endovascular treatment for large-vessel anterior circulation stroke: individual participant data meta-analysis of six randomised trials. *Lancet* (London, England). 2023; 402: 965–974. [https://doi.org/10.1016/S0140-6736\(23\)01142-X](https://doi.org/10.1016/S0140-6736(23)01142-X)
- [2] Siegler JE, Koneru M, Qureshi MM, Doheim M, Nogueira RG, Martinez-Majander N, et al. CLEAR Thrombectomy Score: An Index to Estimate the Probability of Good Functional Outcome With or Without Endovascular Treatment in the Late Window for Anterior Circulation Occlusion. *Journal of the American Heart Association*. 2024; 13: e034948. <https://doi.org/10.1161/JAHA.124.034948>
- [3] Nie X, Leng X, Miao Z, Fisher M, Liu L. Clinically Ineffective Reperfusion After Endovascular Therapy in Acute Ischemic Stroke. *Stroke*. 2023; 54: 873–881. <https://doi.org/10.1161/STROKEAHA.122.038466>
- [4] Cheng X, Shi J, Wu H, Zhu W, Lu G. Review of net water uptake in the management of acute ischemic stroke. *European Radiology*. 2022; 32: 5517–5524. <https://doi.org/10.1007/s00330-022-08658-x>
- [5] Li S, Lu Y, Fang S, Wang L, Peng B. Inpatient rehabilitation therapy in stroke patients with reperfusion therapy: a national prospective registry study. *BMC Neurology*. 2023; 23: 146. <https://doi.org/10.1186/s12883-023-03144-3>
- [6] Olthuis SGH, Pirson FAV, Pinckaers FME, Hinsenveld WH, Nieboer D, Ceulemans A, et al. Endovascular treatment versus no endovascular treatment after 6–24 h in patients with ischaemic stroke and collateral flow on CT angiography (MR CLEAN-LATE) in the Netherlands: a multicentre, open-label, blinded-endpoint, randomised, controlled, phase 3 trial. *Lancet* (London, England). 2023; 401: 1371–1380. [https://doi.org/10.1016/S0140-6736\(23\)00575-5](https://doi.org/10.1016/S0140-6736(23)00575-5)
- [7] Chinese Stroke Association. Guidelines for reperfusion therapy in acute ischemic stroke (2024). *Chinese Journal of Stroke*. 2024; 19: 1460–1478.
- [8] Huo X, Ma G, Tong X, Zhang X, Pan Y, Nguyen TN, et al. Trial of Endovascular Therapy for Acute Ischemic Stroke with Large Infarct. *The New England Journal of Medicine*. 2023; 388: 1272–1283. <https://doi.org/10.1056/NEJMoa2213379>
- [9] Yoshimura S, Sakai N, Yamagami H, Uchida K, Beppu M, Toyoda K, et al. Endovascular Therapy for Acute Stroke with a Large Ischemic Region. *The New England Journal of Medicine*. 2022; 386: 1303–1313. <https://doi.org/10.1056/NEJMoa2118191>
- [10] McDonough R, Elsayed S, Faizy TD, Austein F, Sporns PB, Meyer L, et al. Computed tomography-based triage of extensive baseline infarction: ASPECTS and collaterals versus perfusion imaging for

- outcome prediction. *Journal of Neurointerventional Surgery*. 2021; 13: 869–874. <https://doi.org/10.1136/neurintsurg-2020-016848>
- [11] Brooks G, Flottmann F, Scheibel A, Aigner A, Faizy TD, Hanning U, et al. Quantitative Lesion Water Uptake in Acute Stroke Computed Tomography Is a Predictor of Malignant Infarction. *Stroke*. 2018; 49: 1906–1912. <https://doi.org/10.1161/STROKEAHA.118.020507>
- [12] Minnerup J, Brooks G, Kalkoffen J, Langner S, Knauth M, Psychogios MN, et al. Computed tomography-based quantification of lesion water uptake identifies patients within 4.5 hours of stroke onset: A multicenter observational study. *Annals of Neurology*. 2016; 80: 924–934. <https://doi.org/10.1002/ana.24818>
- [13] Nawabi J, Flottmann F, Kemmling A, Kniep H, Leischner H, Sporns P, et al. Elevated early lesion water uptake in acute stroke predicts poor outcome despite successful recanalization - When “tissue clock” and “time clock” are desynchronized. *International Journal of Stroke : Official Journal of the International Stroke Society*. 2021; 16: 863–872. <https://doi.org/10.1177/1747493019884522>
- [14] Lu SS, Wu RR, Cao YZ, Xu XQ, Lin SS, Liu S, et al. ASPECTS-based net water uptake predicts poor reperfusion and poor clinical outcomes in patients with ischemic stroke. *European Radiology*. 2022; 32: 7026–7035. <https://doi.org/10.1007/s00330-022-09077-8>
- [15] Mechtouff L, Debs N, Frindel C, Bani-Sadr A, Bochaton T, Paccalet A, et al. Association of Blood Biomarkers of Inflammation With Penumbra Consumption After Mechanical Thrombectomy in Patients With Acute Ischemic Stroke. *Neurology*. 2022; 99: e2063–e2071. <https://doi.org/10.1212/WNL.0000000000201038>
- [16] Bani-Sadr A, Mechtouff L, De Bourguignon C, Mauffrey A, Bouteiller T, Cho TH, et al. Blood-Brain Barrier Permeability and Kinetics of Inflammatory Markers in Acute Stroke Patients Treated With Thrombectomy. *Neurology*. 2023; 101: e502–e511. <https://doi.org/10.1212/WNL.0000000000207460>
- [17] Basic Kes V, Simundic AM, Nikolac N, Topic E, Demarin V. Pro-inflammatory and anti-inflammatory cytokines in acute ischemic stroke and their relation to early neurological deficit and stroke outcome. *Clinical Biochemistry*. 2008; 41: 1330–1334. <https://doi.org/10.1016/j.clinbiochem.2008.08.080>
- [18] Li R, Yin Y, Cai X, Zhu Y, Feng S, Sun J, et al. Effect of routine inflammatory markers on clinical outcomes in acute basilar artery occlusion after endovascular thrombectomy: Results from ATTENTION registry. *International Journal of Stroke : Official Journal of the International Stroke Society*. 2023; 18: 976–985. <https://doi.org/10.1177/17474930231176948>
- [19] Wang J, Zhang X, Tian J, Li H, Tang H, Yang C. Predictive values of systemic inflammatory responses index in early neurological deterioration in patients with acute ischemic stroke. *Journal of Integrative Neuroscience*. 2022; 21: 94. <https://doi.org/10.31083/j.jin2103094>
- [20] Cao W, Song Y, Bai X, Yang B, Li L, Wang X, et al. Systemic-inflammatory indices and clinical outcomes in patients with anterior circulation acute ischemic stroke undergoing successful endovascular thrombectomy. *Heliyon*. 2024; 10: e31122. <https://doi.org/10.1016/j.heliyon.2024.e31122>
- [21] Ferro D, Matias M, Neto J, Dias R, Moreira G, Petersen N, et al. Neutrophil-to-Lymphocyte Ratio Predicts Cerebral Edema and Clinical Worsening Early After Reperfusion Therapy in Stroke. *Stroke*. 2021; 52: 859–867. <https://doi.org/10.1161/STROKEAHA.120.032130>
- [22] AVERT Trial Collaboration group. Efficacy and safety of very early mobilisation within 24 h of stroke onset (AVERT): a randomised controlled trial. *Lancet (London, England)*. 2015; 386: 46–55. [https://doi.org/10.1016/S0140-6736\(15\)60690-0](https://doi.org/10.1016/S0140-6736(15)60690-0) Erratum in: *Lancet (London, England)*. 2015; 386: 30. [https://doi.org/10.1016/S0140-6736\(15\)61204-1](https://doi.org/10.1016/S0140-6736(15)61204-1) Erratum in: *Lancet (London, England)*. 2017; 389: 1884. [https://doi.org/10.1016/S0140-6736\(17\)31213-8](https://doi.org/10.1016/S0140-6736(17)31213-8)

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