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RESEARCH ARTICLE

Association between Neutrophil-Lymphocyte Ratio and Stroke Severity using the NIHSS among Patients in a Tertiary Care Hospital

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Abstract: ***Background***: Stroke is a leading cause of morbidity and mortality worldwide. Early severity assessment is essential for accurate prognosis and effective management. Inflammation plays a critical role in ischemic brain injury, and the neutrophil-lymphocyte ratio (NLR) is recognized as a straightforward and cost-effective biomarker. ***Objective***: To assess the relationship between neutrophil-to-lymphocyte ratio (NLR) and stroke severity, as measured by the National Institutes of Health Stroke Scale (NIHSS), in individuals diagnosed with acute ischemic stroke. ***Methods***: This prospective study included 120 consecutive patients experiencing their first acute ischemic stroke, all admitted within 72 hours of symptom onset. The neutrophil-to-lymphocyte ratio (NLR) was determined from blood samples collected at admission. Stroke severity was evaluated using the National Institutes of Health Stroke Scale (NIHSS). The relationship between NLR and NIHSS scores was examined using Pearson correlation coefficients and regression analyses. ***Results***: Among the 120 patients studied, 65 (54.2%) exhibited a low neutrophil-to-lymphocyte ratio (NLR) below 3, whereas 55 (45.8%) had an elevated NLR above 3. Patients with elevated NLR showed significantly higher National Institutes of Health Stroke Scale (NIHSS) scores, indicating greater stroke severity (11.37 ± 4.76 compared to 5.21 ± 2.68; $p < 0.01$). There was a strong positive correlation between NLR and NIHSS ($r = 0.57$, $p < 0.0001$). Regression analysis identified NLR as an independent predictor of stroke severity. ***Conclusion***: Elevated neutrophil-lymphocyte ratio (NLR) is significantly associated with increased National Institutes of Health Stroke Scale (NIHSS) scores in patients with acute ischemic stroke. Given its accessibility and low cost, NLR represents a valuable biomarker for early risk stratification and management of individuals experiencing ischemic stroke.

Keywords: National Institutes of Health Stroke Scale, National Institutes of Health Stroke Scale, Ischemic stroke.

INTRODUCTION

Stroke is one of the leading causes of mortality and long-term disability worldwide. According to the World Health Organization, nearly 15 million people suffer from stroke annually, of whom five million die and another five million become permanently disabled[1,2]. Globally, stroke remains the second leading cause of death and the third leading cause of disability-adjusted life years (DALYs) lost[3,4].

In India, stroke incidence has increased due to demographic shifts, urbanization, and lifestyle changes. The annual incidence is estimated at 119–145 per 100,000 population[5]. Indian patients often experience strokes at a younger age than those in Western countries, typically during their most productive years, which intensifies the socioeconomic impact [6]. The high prevalence of risk factors such as hypertension, diabetes, smoking, and alcohol use further exacerbates the issue[7,8]. Limited access to acute care and rehabilitation in resource-constrained settings underscores the need for simple and cost-effective prognostic markers[9].

Accurate assessment of stroke severity at admission is essential for predicting outcomes and guiding management. The National Institutes of Health Stroke Scale (NIHSS) is the most widely used tool for this purpose. It provides a standardized neurological assessment, with higher scores indicating more severe neurological impairment[10,11]. The NIHSS score reliably predicts functional outcomes and mortality and is therefore integral to early stroke evaluation[12].

Systemic inflammation is a key contributor to ischemic brain injury. Neutrophils infiltrate the ischemic brain early and release proteolytic enzymes and reactive oxygen species, which aggravate tissue damage. Lymphopenia indicates stress-induced immunosuppression[13,14]. The **neutrophil-lymphocyte ratio (NLR)**, calculated from routine blood counts, serves as a clinically accessible index of systemic inflammation[15].

Elevated neutrophil-to-lymphocyte ratio (NLR) has been associated with larger infarct volumes, increased stroke severity, and poorer clinical outcomes. Several studies have demonstrated a positive correlation between NLR

and National Institutes of Health Stroke Scale (NIHSS) scores, indicating that NLR may function as a surrogate marker for stroke severity [16-19]. Due to its low cost, accessibility, and rapid measurement, NLR offers practical advantages compared to more complex inflammatory biomarkers, especially in resource-limited environments.

However, evidence from India on the role of NLR in predicting stroke severity is limited. Given the unique characteristics of Indian patients, validating NLR in this group is essential.

This study investigated the relationship between the neutrophil-lymphocyte ratio and stroke severity, as assessed by the National Institutes of Health Stroke Scale (NIHSS), in patients with acute ischemic stroke admitted to a tertiary care hospital.

METHODOLOGY

Study Design and Setting

A prospective observational study was conducted in the Department of General Medicine at Sree Balaji Medical College and Hospital, Chennai, from 2022 to 2025. The Institutional Ethics Committee approved the study protocol prior to commencement. All participants provided written informed consent.

Study Population

A total of 120 consecutive patients aged 18 years or older who presented with a first-ever acute ischemic stroke were enrolled in the study. The diagnosis of stroke was established based on clinical assessment and confirmed using non-contrast computed tomography (CT) neuroimaging.

Inclusion criteria:

- First-time acute ischemic stroke.
- Presentation within 72 hours of symptom onset.
- Age ≥18 years.

Exclusion criteria:

- Hemorrhagic stroke.
- History of prior stroke or transient ischemic attack.
- Active infection, sepsis, autoimmune or chronic inflammatory disease.
- Haemtological malignancies or patients with systemic steroids/immunosuppressants
- End-stage renal, hepatic, or malignant disease.

Clinical Assessment

Baseline demographic and clinical characteristics, including age, sex, comorbidities, and vascular risk factors, were systematically collected. Stroke severity upon admission was evaluated using the National Institutes of Health Stroke Scale (NIHSS)[20].

Laboratory Analysis

Venous blood samples were collected within 24 hours of admission. Complete blood counts were analyzed automatically. The **neutrophil-lymphocyte ratio (NLR)** was calculated as follows:

$$NLR = \frac{Absolute\ Neutrophil\ count}{Absolute\ Lymphocyte\ count}$$

Based on prior literature, patients were categorized into two groups:

- **Low NLR:** <3
- **High NLR:** ≥3

Statistical Analysis

Continuous variables were reported as mean and standard deviation, while categorical variables were presented as frequency and percentage. The independent t-test was applied to compare continuous variables, and the chi-square test was used for categorical variables. The correlation between neutrophil-to-lymphocyte ratio (NLR) and National Institutes of Health Stroke Scale (NIHSS) scores was evaluated using Pearson's correlation coefficient. Multiple regression analysis was performed, adjusting for age, sex, hypertension, and diabetes as potential confounders. Statistical significance was defined as a p-value less than 0.05. All analyses were conducted using SPSS version 22 (IBM, USA).

RESULTS

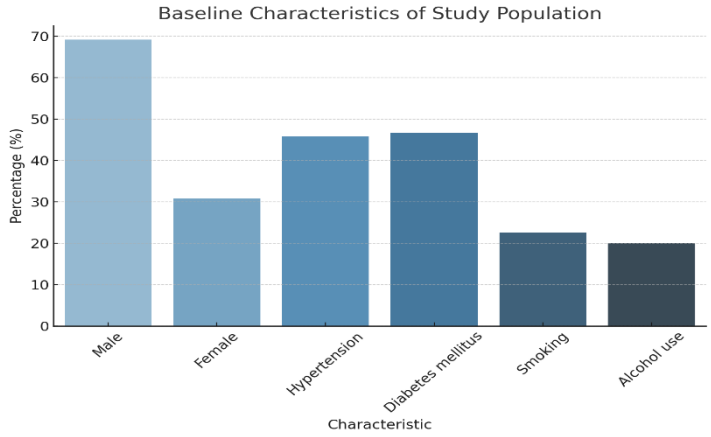
Baseline Characteristics

The study included 120 patients diagnosed with acute ischemic stroke. The cohort had a mean age of 60.5 years with a standard deviation of 13.6 years. Males comprised 69.2% of the participants. The most prevalent comorbidities were hypertension (45.8%) and diabetes mellitus (46.7%), followed by smoking (22.5%) and alcohol consumption (20%).

Table 1. Baseline characteristics of the study population (n = 120)

Characteristic	Value
Age, mean ± SD (years)	60.5 ± 13.6
Male sex, n (%)	83 (69.2)
Female sex, n (%)	37 (30.8)
Hypertension, n (%)	55 (45.8)
Diabetes mellitus, n (%)	56 (46.7)
Smoking, n (%)	27 (22.5)

Alcohol use, n (%)	24 (20.0)

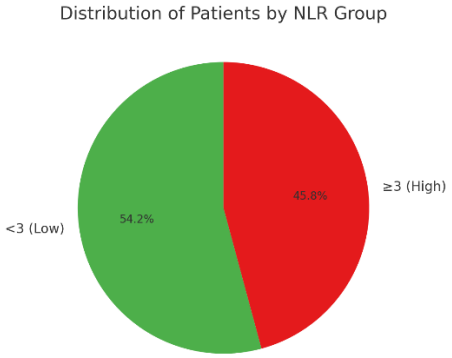


Neutrophil-Lymphocyte Ratio (NLR) Distribution

Among the study population, 65 patients (54.2%) had **low NLR (<3)**, while 55 patients (45.8%) had **high NLR (≥3)**. The overall mean NLR was 4.29 ± 2.98.

Table 2. Distribution of patients according to NLR values

NLR Group	Frequency (n)	Percentage (%)
<3 (Low)	65	54.2
≥3 (High)	55	45.8

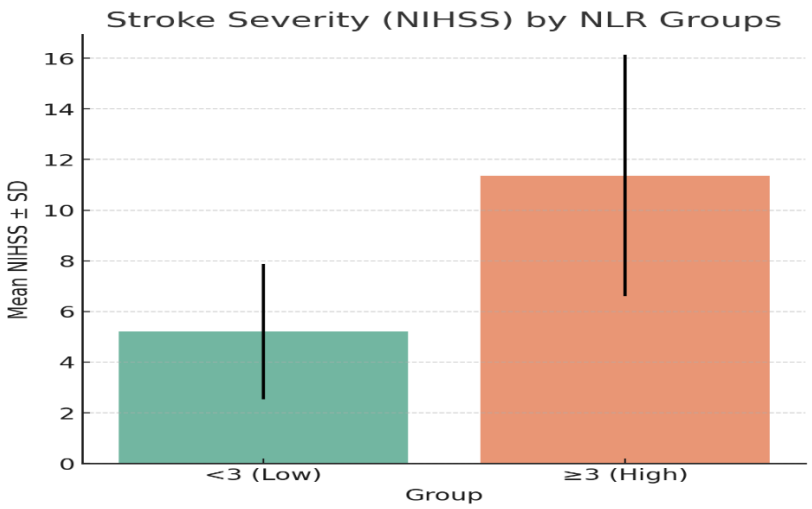


Stroke Severity by NLR Groups

The mean NIHSS score for the entire cohort was 7.01 ± 5.04. Patients in the **high NLR group** had significantly higher NIHSS scores (11.37 ± 4.76) compared to the **low NLR group** (5.21 ± 2.68), p < 0.01.

NLR Group	Mean NIHSS ± SD	p-value
<3 (Low)	5.21 ± 2.68	<0.01*
≥3 (High)	11.37 ± 4.76	

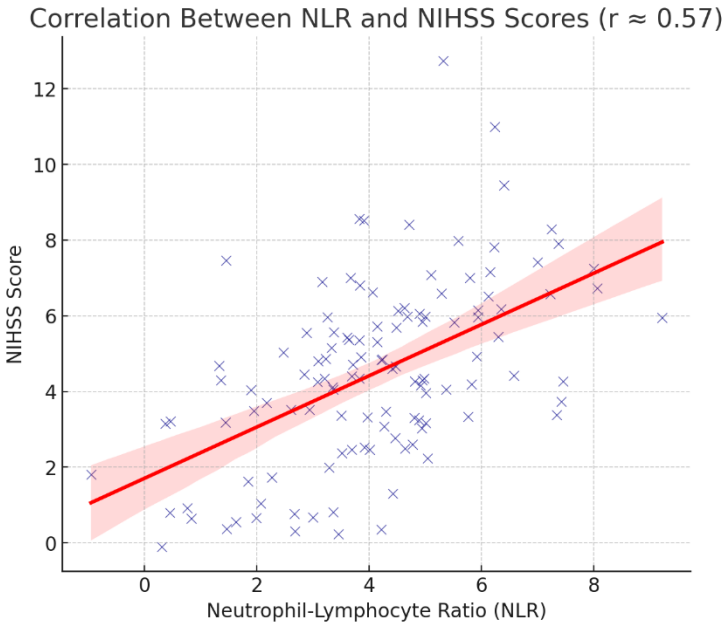
*Independent t-test, p < 0.05 considered statistically significant.



Correlation Analysis

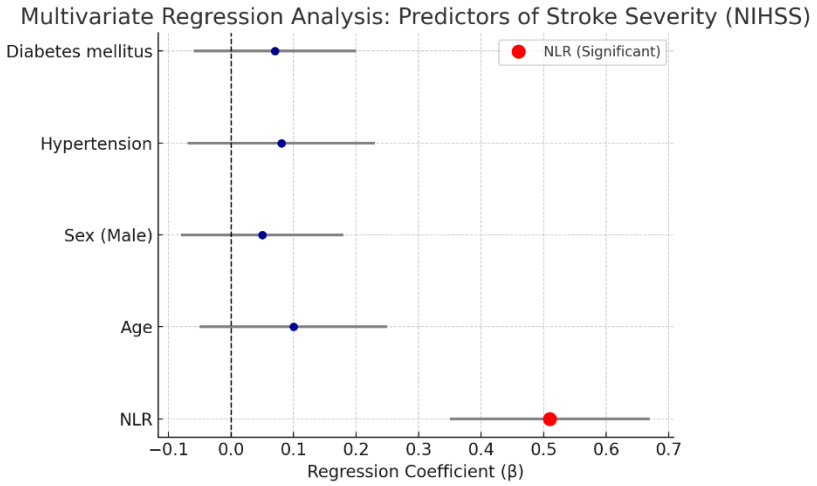
Pearson's correlation analysis revealed a strong positive correlation between NLR and NIHSS scores ($r = 0.57$, $p < 0.0001$), suggesting that higher NLR was associated with more severe neurological deficits at admission.

Scatter plot showing correlation between NLR and NIHSS scores



Multivariate Regression Analysis

After adjusting for confounding factors such as age, sex, hypertension, and diabetes mellitus, NLR remained an **independent predictor** of stroke severity as assessed by NIHSS ($\beta = 0.51$, $p < 0.001$).



DISCUSSION

Principal findings

This study demonstrates a strong association between the neutrophil-lymphocyte ratio (NLR) and stroke severity in patients experiencing their first acute ischemic stroke. Patients with elevated NLR values (≥3) exhibited significantly higher NIHSS scores compared to those with lower NLR. Correlation analysis indicated a moderate-to-strong positive relationship between NLR and stroke severity. Multivariate regression analysis showed that NLR remained an independent predictor of NIHSS after adjustment for conventional risk factors. These results highlight the prognostic utility of NLR as a cost-effective biomarker for early assessment of stroke severity in clinical practice.

NLR and stroke severity

Our findings align with a growing body of literature indicating that neutrophil-to-lymphocyte ratio (NLR) is a significant predictor of acute ischemic stroke severity and outcomes. Graça et al. demonstrated that higher NLR levels within the first 72 hours were associated with significantly greater deficits on the National Institutes of Health Stroke Scale (NIHSS)[11]. Similarly, Iyigundogdu et al. reported a linear correlation between NLR and NIHSS, with elevated NLR predicting longer hospital stays and more severe neurological impairment[12]. Additionally, Pikija et al. found that elevated NLR predicted higher in-hospital mortality, further supporting its association with severe neurological deficits[13].

Evidence from Indian studies adds further weight. Anusha et al. observed a significant relationship between elevated NLR and NIHSS, underscoring its utility in predicting acute stroke severity in the Indian context[14]. A meta-analysis by Xue et al. also demonstrated that higher NLR tertiles were consistently associated with greater initial severity, early neurological deterioration, and poorer outcomes[15]. Collectively, these findings highlight NLR as a reproducible biomarker across diverse populations, including our cohort.

Biological plausibility

The relationship between NLR and stroke severity is biologically plausible given the central role of inflammation in ischemic brain injury. Neutrophils infiltrate ischemic tissue early, releasing reactive oxygen species, proteolytic enzymes, and proinflammatory cytokines that exacerbate neuronal damage and compromise the blood–brain barrier[16]. Excessive neutrophil activation is also associated with microvascular obstruction and secondary ischemic injury[17]. Conversely, lymphopenia is a common feature after acute stroke and reflects stress-induced immunosuppression, which impairs adaptive immune responses and predisposes patients to infections[18].

Thus, a high NLR simultaneously represents increased pro-inflammatory activity and decreased immune regulation. This dual imbalance contributes to larger infarct volumes, greater edema, and ultimately more severe neurological deficits[19]. The integration of NLR into clinical decision-making therefore offers not only prognostic value but also mechanistic insights into the inflammatory basis of ischemic stroke.

Clinical implications

The practical advantages of NLR cannot be overstated. It is calculated from a routine complete blood count, a test that is inexpensive, rapid, and universally available, including in resource-limited settings. Unlike advanced neuroimaging techniques or inflammatory cytokine assays, NLR requires no additional infrastructure. Its incorporation into the acute assessment of stroke patients could enhance early risk stratification, guide monitoring intensity, and inform discussions with families about prognosis.

Importantly, NLR should be viewed as complementary to — rather than a replacement for — validated clinical scales such as NIHSS. Together, they provide a more holistic assessment of stroke severity. In addition, patients with high NLR values may represent a subgroup at particular risk of poor outcomes, for whom more aggressive monitoring and secondary prevention strategies could be prioritized.

Strengths and limitations

The strengths of this study include its prospective design, inclusion of consecutive patients, and standardized assessment of severity using NIHSS. Potential confounding factors such as infections, autoimmune disease, or malignancy were carefully excluded, strengthening the reliability of leukocyte counts as markers of systemic inflammation.

However, some limitations merit consideration. First, this was a single-center study with a modest sample size, which may limit generalizability. Second, the analysis was restricted to baseline NLR values; dynamic changes in NLR over time and their prognostic significance were not assessed. Third, functional recovery outcomes were not analyzed in this study, although they are addressed separately in a companion analysis. Finally, as NLR is influenced by factors such as stress, medications, and subclinical infections, it should be interpreted cautiously and always within the broader clinical context.

Future directions

Future research should aim to validate these findings in larger, multicentric cohorts across different regions of India, where stroke demographics and risk factors vary widely. Longitudinal studies assessing changes in NLR during the acute and subacute phases may provide additional insights into its prognostic utility. Furthermore, integrating NLR into multimodal predictive models alongside imaging biomarkers and clinical scales could enhance precision in prognostication. Given its biological basis, studies exploring targeted modulation of the inflammatory response may also clarify whether interventions that alter NLR could improve outcomes.

CONCLUSION

Elevated NLR is independently associated with higher stroke severity as assessed by NIHSS in acute ischemic stroke patients. Given its simplicity, cost-effectiveness, and availability, NLR represents a valuable adjunct to clinical assessment in the acute setting. Incorporating NLR into routine practice may strengthen early risk stratification and guide clinical decision-making, particularly in resource-constrained healthcare systems.

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