

Association between Neutrophil-Lymphocyte Ratio and Functional Outcomes of Stroke using the Berg Balance Scale and Manual Function Test in Patients at a Tertiary Care Hospital

Dr. Vishalakshi Jorepalli^{1*}, Dr Ramachandran V², Dr. Vignesh³ and Dr. Hemanth⁴

¹Junior Resident, Department of General Medicine, Sree Balaji Medical College & Hospital, Chrompet, Chennai-600044, Tamil Nadu.

²DNB Professor of Medicine, Department of General Medicine, Sree Balaji Medical College and Hospital, Chennai, India

³Senior Resident, Department of General Medicine, Sree Balaji Medical College & Hospital, Chrompet, Chennai-600044, Tamil Nadu.

⁴Senior Resident, Department of General Medicine, Sree Balaji Medical College & Hospital, Chrompet, Chennai-600044, Tamil Nadu

*Corresponding Author
Dr Vishalakshi Jorepalli

Article History

Received: 04/08/2025

Revised: 19/08/2025

Accepted: 09/09/2025

Published: 26/09/2025

Abstract: *Background:* Stroke is a leading cause of long-term disability worldwide, with residual motor and balance impairments contributing significantly to poor functional outcomes. The neutrophil-lymphocyte ratio (NLR), an inexpensive marker of systemic inflammation, has been associated with stroke severity and prognosis. However, limited data exist regarding its predictive value for functional outcomes measured with validated tools such as the Berg Balance Scale (BBS) and Manual Function Test (MFT). *Objective:* To evaluate the association between NLR at admission and functional outcomes of stroke, assessed using BBS and MFT, in patients admitted with acute ischemic stroke at a tertiary care hospital. *Methods:* This prospective observational study included 120 patients with first-ever acute ischemic stroke. Baseline demographic and clinical details were recorded. NLR was calculated from complete blood counts at admission and categorized as low (<3) or high (≥3). Functional outcomes were assessed using the BBS and MFT at discharge. Statistical analyses included independent t-tests, chi-square tests, correlation analysis, and multivariate regression. *Results:* Among 120 patients, 55 (45.8%) had high NLR and 65 (54.2%) had low NLR. Patients with high NLR had significantly lower mean BBS scores (22.5 ± 8.4 vs. 37.8 ± 9.2 , $p < 0.01$) and lower MFT scores (40.3 ± 10.6 vs. 56.7 ± 11.1 , $p < 0.01$) compared to the low NLR group. Pearson's correlation showed a strong negative relationship between NLR and both BBS ($r = -0.49$, $p < 0.001$) and MFT ($r = -0.52$, $p < 0.001$). Multivariate regression confirmed that NLR was an independent predictor of poor functional outcome after adjusting for confounders. *Conclusion:* Elevated NLR at admission is independently associated with worse functional outcomes, including impaired balance and manual function, among patients with acute ischemic stroke. Given its simplicity and accessibility, NLR may serve as a useful adjunct to clinical tools for predicting recovery potential and planning rehabilitation strategies in stroke care.

Keywords: Stroke, Neutrophil-Lymphocyte Ratio, Berg Balance Scale, Manual Function Test, Functional Outcome, Inflammation.

INTRODUCTION

Stroke is a major contributor to long-term disability worldwide, significantly impacting patients, families, and healthcare systems. Annually, nearly 15 million individuals are affected globally, with five million deaths and an equal number experiencing permanent disability^{1,2}. Stroke remains the second leading cause of mortality and the third leading cause of disability-adjusted life years (DALYs) lost worldwide³.

In India, the incidence of stroke has increased due to demographic transitions, urbanization, and lifestyle changes. Current estimates indicate 119 to 145 cases per 100,000 population, with a higher proportion among younger adults compared to Western countries^{4,5}. This trend results in substantial socioeconomic consequences because stroke frequently affects individuals during their most productive years. Post-stroke disability remains a significant issue, as persistent motor impairment, balance dysfunction, and reduced upper-limb function limit independence and diminish quality of life⁶.

Reliable assessment of functional recovery is crucial in stroke rehabilitation. The Berg Balance Scale (BBS) is widely used to evaluate postural control and balance, with lower scores indicating impaired stability and higher risk of falls⁷. Similarly, the Manual Function Test (MFT) objectively measures upper limb motor function, including grasp, pinch, and coordinated arm movements⁸. Together, these tools provide valuable insights into recovery potential and guide individualized rehabilitation strategies.

The role of systemic inflammation in stroke pathophysiology and recovery is increasingly recognized. Neutrophils infiltrate the ischemic brain early, releasing proteolytic enzymes and reactive oxygen species that amplify tissue damage. Lymphocyte counts decline because of stress-related immunosuppression^{9,10}. The neutrophil-lymphocyte ratio (NLR), derived from routine complete blood counts, combines these parameters into a single inflammatory index¹¹. Previous studies have shown that elevated NLR is associated with greater initial stroke severity and poorer functional

outcomes^{12,13}. A persistently high NLR may reflect ongoing inflammatory activity that interferes with neuroplasticity and limits recovery in areas such as balance and manual dexterity¹⁴.

Although international studies have established the prognostic value of the neutrophil-to-lymphocyte ratio (NLR), there is a paucity of Indian data, particularly concerning validated functional outcome scales such as the Berg Balance Scale (BBS) and the Manual Function Test (MFT). This research gap is especially significant in low-resource settings, where access to advanced biomarkers and imaging modalities is often limited.

This study evaluates the association between admission neutrophil-lymphocyte ratio and functional outcomes, measured by the Berg Balance Scale and Manual Function Test, in patients with acute ischemic stroke at 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.
- Haematological malignancies or patients with systemic steroids/immunosuppressants
- End-stage renal, hepatic, or malignant disease.

Clinical Assessment

Baseline characteristics

A total of 120 patients with acute ischemic stroke were enrolled in the study. The mean age of the cohort was 60.5 ± 13.6 years, with a male predominance (69.2%). Hypertension (45.8%) and diabetes mellitus (46.7%) were the most frequent comorbidities. Other vascular risk factors included smoking (22.5%) and alcohol consumption (20%).

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:

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

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

- **Low NLR:** <3
- **High NLR:** ≥ 3

Functional outcome measures

Functional recovery was assessed at discharge using two validated tools:

1. Berg Balance Scale (BBS): A 14-item scale that evaluates static and dynamic balance through common tasks such as standing, sitting, and transfers. Scores range from 0 to 56, with higher scores indicating better balance and functional independence⁸.
2. Manual Function Test (MFT): An assessment of upper limb motor function including arm movements, grasp, and pinch activities. The test is scored from 0 to 100, with higher values reflecting better manual function and independence in daily activities⁹.

Both assessments were administered by trained physiotherapists blinded to NLR values to reduce observer bias.

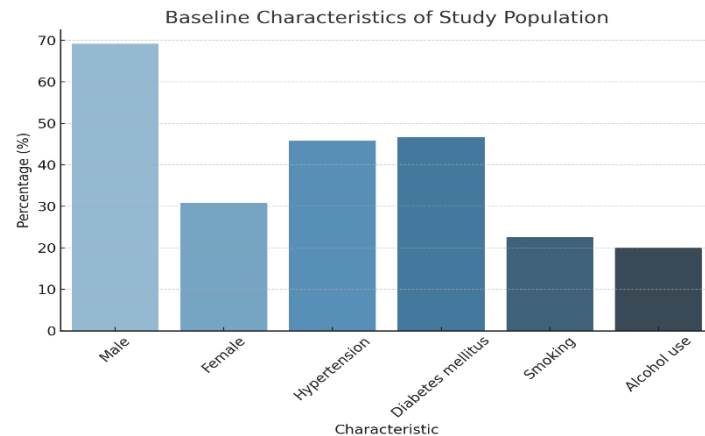
Statistical analysis

Continuous variables were expressed as mean $\pm$ standard deviation (SD), and categorical variables as frequencies and percentages. Comparisons between low and high NLR groups used the independent t-test for continuous variables and the chi-square test for categorical variables. Correlations between NLR and functional scores (BBS, MFT) were analyzed using Pearson's correlation coefficient. Multivariate regression analysis determined whether NLR was an independent predictor of functional outcomes after adjusting for confounders such as age, sex, hypertension, and diabetes mellitus. A p-value <0.05 was considered statistically significant. Statistical analysis used SPSS version 22 (IBM Corp., USA).

RESULTS

Characteristic	Value
Age, mean $\pm$ SD (years)	60.5 $\pm$ 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)

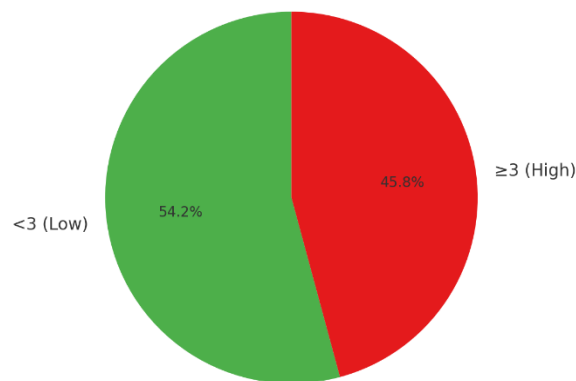
Table 1. Baseline characteristics of the study population (n = 120)



NLR distribution

The mean NLR in the study population was 4.29 ± 2.98 . Using a cut-off value of 3, 65 patients (54.2%) were classified into the low NLR group (<3) and 55 patients (45.8%) into the high NLR group (≥ 3).

Distribution of Patients by NLR Group



Functional outcomes and NLR

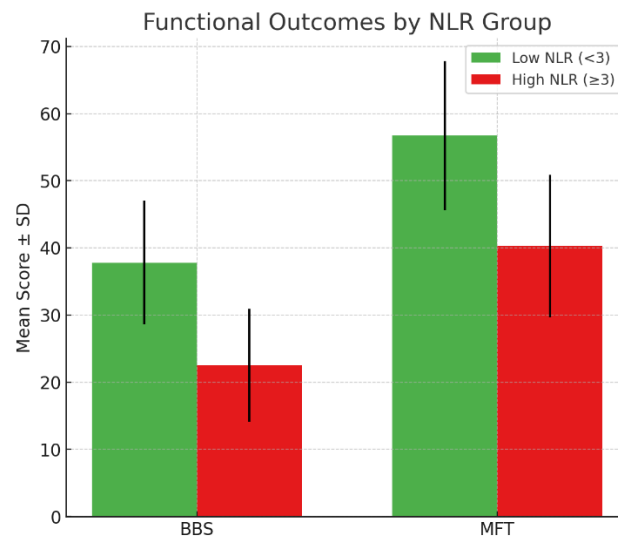
At discharge, patients with low NLR demonstrated significantly better functional recovery compared to those with high NLR.

- The mean BBS score was 37.8 ± 9.2 in the low NLR group versus 22.5 ± 8.4 in the high NLR group ($p < 0.01$).
- The mean MFT score was 56.7 ± 11.1 in the low NLR group versus 40.3 ± 10.6 in the high NLR group ($p < 0.01$).

Functional outcome	Low NLR (<3) (n = 65)	High NLR (≥ 3) (n = 55)	p-value
BBS (mean $\pm$ SD)	37.8 $\pm$ 9.2	22.5 $\pm$ 8.4	$<0.01^*$
MFT (mean $\pm$ SD)	56.7 $\pm$ 11.1	40.3 $\pm$ 10.6	$<0.01^*$

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

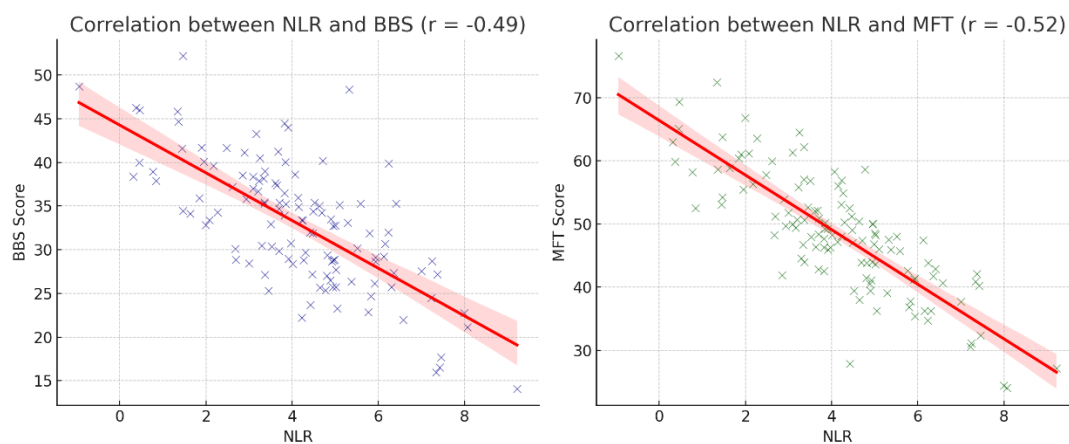
Table 2. Comparison of functional outcomes between low and high NLR groups



Correlation analysis

- BBS: $r = -0.49$, $p < 0.001$
- MFT: $r = -0.52$, $p < 0.001$

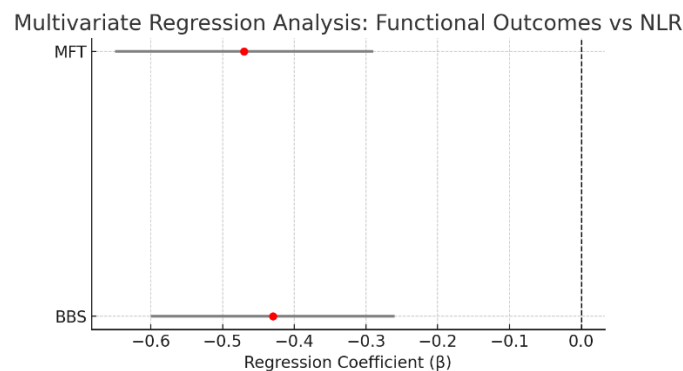
Both plots show a downward trend with increasing NLR, indicating poorer functional outcomes with higher inflammatory burden.



Multivariate Regression analysis

Outcome measure	β coefficient	p-value
BBS	-0.43	<0.001
MFT	-0.47	<0.001

Table 3. Multivariate regression analysis of NLR and functional outcomes



DISCUSSION

Principal findings

This study shows that elevated neutrophil-lymphocyte ratio (NLR) at admission is significantly associated with poorer functional outcomes in patients with acute ischemic stroke. Patients with higher NLR had lower Berg Balance Scale (BBS) and Manual Function Test (MFT) scores at discharge, reflecting impaired postural control and reduced upper limb function. Correlation analysis confirmed a strong negative association between NLR and both outcome measures, and multivariate regression established NLR as an independent predictor after adjusting for age, sex, and vascular risk factors. These findings highlight the potential of NLR as an accessible biomarker for predicting functional recovery in stroke patients.

Biological plausibility

The biological basis of these findings is the dual role of inflammation in ischemic stroke. Neutrophils infiltrate ischemic brain tissue within hours, releasing proteolytic enzymes, reactive oxygen species, and pro-inflammatory cytokines. These mediators exacerbate neuronal damage and impair neurovascular repair mechanisms⁹. Concurrently, stroke-induced stress results in lymphopenia, which reflects reduced adaptive immune regulation¹⁰. An elevated neutrophil-to-lymphocyte ratio (NLR) thus indicates both increased inflammatory injury and compromised immune response.

These biological processes are critical for functional recovery. Persistent inflammation impairs neuroplasticity, axonal sprouting, and synaptic reorganization, which are necessary for restoring balance and fine motor skills¹¹. Consequently, patients with elevated neutrophil-to-lymphocyte ratio (NLR) are more likely to experience residual deficits in postural control and manual dexterity, as indicated by lower Berg Balance Scale (BBS) and Manual Function Test (MFT) scores.

Comparison with previous studies

Our findings align with previous reports linking NLR to post-stroke disability. Xue *et al.* found that higher NLR was associated with unfavorable outcomes on the modified Rankin Scale, suggesting systemic

inflammation affects functional recovery¹³. Graça *et al.* also reported that patients with elevated NLR had worse neurological recovery, supporting NLR as a prognostic marker beyond initial stroke severity¹⁴.

Indian data also support this association. Anusha *et al.* demonstrated that NLR correlated with both severity and short-term functional outcomes, highlighting its value in predicting recovery in resource-limited settings¹⁵. Combined with our findings, these studies suggest that NLR is a reliable prognostic marker across diverse populations, including Indian patients.

Clinical implications

The findings of this study have significant clinical implications. The Berg Balance Scale (BBS) and Manual Function Test (MFT) are validated instruments for assessing balance and manual function in stroke rehabilitation. Early identification of patients at risk for poor performance on these assessments at admission enables clinicians to individualize rehabilitation programs, prioritize physiotherapy interventions, and provide informed prognostic counselling to families.

NLR offers a practical advantage because it is derived from a routine complete blood count, which is inexpensive and widely available. In resource-limited settings, where advanced imaging or molecular biomarkers may not be accessible, NLR provides a useful tool for early risk stratification. Integrating NLR into rehabilitation planning can help ensure that high-risk patients receive more intensive therapy and closer follow-up.

Strengths and limitations

This study's strengths include its prospective design, use of standardized functional outcome measures such as the Berg Balance Scale (BBS) and Manual Function Test (MFT), and adjustment for potential confounders through multivariate analysis. Excluding patients with comorbid conditions that could alter leukocyte counts minimizes bias in interpreting the neutrophil-to-lymphocyte ratio (NLR).

However, several limitations exist. The single-centre setting and modest sample size may limit the generalizability of the findings. Functional outcomes

were assessed only at discharge, without evaluation of long-term recovery. Repeated NLR measurements over time would have provided a more complete understanding of its association with functional recovery. Because NLR can be affected by unrecognized infections, medications, or physiological stress, its interpretation should be integrated with clinical evaluation and functional assessments.

Future directions

Further research is needed to validate these findings in larger, multicenter cohorts and diverse patient populations. Longitudinal studies assessing changes in NLR over time and their relationship with long-term outcomes would provide valuable insights. Combining NLR with established functional scales and imaging biomarkers may help develop robust predictive models for recovery. Exploring targeted interventions to modulate post-stroke inflammation may also open new avenues to improve functional outcomes.

CONCLUSION

An elevated neutrophil-lymphocyte ratio (NLR) is independently associated with poorer functional outcomes, including impaired balance and reduced manual function, in patients with acute ischemic stroke. As an inexpensive and widely available biomarker, NLR can complement established clinical tools such as the Berg Balance Scale (BBS) and Manual Function Test (MFT) to predict recovery and inform individualized rehabilitation strategies.

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