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PREDICTIVE UTILITY OF SYSTEMIC INFLAMMATORY MARKERS IN PATIENTS WITH CARDIAC AND CEREBROVASCULAR EVENTS AT A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Cardiovascular and cerebrovascular diseases are major contributors to global morbidity and mortality. Increasing evidence suggests that systemic inflammation plays a critical role in the development, progression, and prognosis of vascular events. Hematological inflammatory markers such as neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and systemic immune-inflammation index (SII) have emerged as potential predictors of adverse cardiovascular and cerebrovascular outcomes.

Objectives: To evaluate the role of systemic inflammatory markers in predicting both cardiac and cerebrovascular events and to assess their association with disease severity and in-hospital outcomes among patients admitted to a tertiary care hospital in Gujarat.

Methods: A hospital-based observational analytical study was conducted from March 2025 to November 2025 among 120 adult patients diagnosed with acute cardiac or cerebrovascular events. Consecutive sampling was used for participant recruitment. Demographic details, clinical characteristics, comorbidities, and laboratory parameters were recorded using a structured case record form. Inflammatory markers including NLR, PLR, SII, total leukocyte count, and C-reactive protein were assessed at admission. Statistical analysis was performed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. Chi-square test, independent t-test, and logistic regression analysis were applied. A p-value <0.05 was considered statistically significant.

Results: Among the 120 study participants, 68 patients had cardiac events and 52 had cerebrovascular events. The mean age of participants was 59.6 ± 11.8 years, with male predominance. Hypertension was the most common comorbidity. Patients with cerebrovascular events demonstrated significantly higher mean values of NLR, PLR, SII, and CRP compared to cardiac event patients. Elevated inflammatory markers were significantly associated with severe vascular events and adverse in-hospital outcomes. Patients with unfavorable outcomes had markedly elevated mean NLR, PLR, and SII values along with longer hospital stay. Multivariate logistic regression analysis identified elevated NLR, PLR, and SII as independent predictors of adverse outcomes, with SII showing the strongest association.

Conclusion: Systemic inflammatory markers, particularly NLR, PLR, and SII, are valuable predictors of severity and adverse outcomes in patients with cardiac and cerebrovascular events. These inexpensive and readily available biomarkers may serve as useful tools for early risk stratification and prognostication in routine clinical practice.

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Keywords*: Systemic inflammatory markers; Neutrophil-to-lymphocyte ratio; Platelet-to-lymphocyte ratio; Systemic immune-inflammation index; Cardiac events; Cerebrovascular events; Prognosis.*

INTRODUCTION

Cardiovascular and cerebrovascular diseases remain the leading causes of morbidity and mortality worldwide, accounting for a substantial proportion of premature deaths and long-term disability. Acute coronary syndrome, ischemic stroke, and transient ischemic attacks are increasingly recognized as manifestations of a common underlying atherosclerotic and inflammatory process. Chronic low-grade systemic inflammation contributes significantly to endothelial dysfunction, plaque instability, thrombogenesis, and vascular remodeling, thereby playing a central role in the pathogenesis of both cardiac and cerebrovascular events.[1]

In recent years, inflammatory biomarkers derived from routine hematological investigations have gained increasing clinical importance because of their low cost, easy availability, and prognostic utility. Traditional inflammatory markers such as C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and total leukocyte count have long been associated with vascular inflammation and adverse cardiovascular outcomes.[2] However, novel hematological indices including neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and systemic immune-inflammation index (SII) have emerged as promising predictors of vascular events and disease severity.[3]

Inflammation accelerates the progression of atherosclerosis through activation of leukocytes, release of pro-inflammatory cytokines, and endothelial injury. Neutrophilia reflects active inflammatory response and oxidative stress, whereas lymphopenia is associated with impaired immune regulation and physiological stress. Elevated platelet counts contribute to thrombus formation and vascular occlusion. Consequently, composite inflammatory indices such as NLR and PLR provide a more integrated reflection of the inflammatory and thrombotic milieu associated with cardiovascular and cerebrovascular diseases.[4]

Several international studies have demonstrated a significant association between elevated inflammatory markers and adverse outcomes in patients with acute myocardial infarction and ischemic stroke.[5] Increased NLR has been linked with higher mortality, larger infarct size, poor neurological recovery, and recurrent vascular events.[6] Similarly, elevated PLR and SII have shown predictive value for major adverse cardiovascular events and poor functional outcomes after stroke.[7] These markers have also been investigated for their role in risk stratification, prognostication, and guiding therapeutic decision-making in emergency and critical care settings.[8]

In developing countries such as India, the burden of non-communicable diseases is rapidly increasing due to urbanization, sedentary lifestyle, dietary changes, and rising prevalence of diabetes mellitus, hypertension, obesity, and tobacco consumption.[9] Gujarat, being one of the rapidly urbanizing states, has witnessed a notable increase in hospital admissions related to ischemic heart disease and stroke. Despite advancements in diagnostic modalities, there remains a need for simple, economical, and readily available biomarkers that can help clinicians identify high-risk patients at an early stage, especially in resource-constrained tertiary care settings.

Although multiple studies have evaluated individual inflammatory markers in either cardiac or cerebrovascular disorders separately, limited literature from western India has comprehensively assessed their role in predicting both cardiac and cerebrovascular events within a single clinical framework. Furthermore, variability in patient demographics, comorbidities, and healthcare infrastructure necessitates region-specific evidence to establish the clinical utility of these markers in the Indian population. Identification of reliable inflammatory predictors may contribute to improved early risk assessment, timely intervention, and reduction in disease-related complications and mortality.

Therefore, the present study was undertaken to evaluate the role of systemic inflammatory markers in predicting both cardiac and cerebrovascular events among patients admitted to a tertiary care hospital in Gujarat. The objectives of the study were to assess the association of inflammatory markers with the occurrence and severity of cardiac and cerebrovascular events and to determine their predictive utility in clinical practice.

METHODOLOGY

Study Design: The present study was a hospital-based observational analytical study conducted to evaluate the role of systemic inflammatory markers in predicting both cardiac and cerebrovascular events among patients admitted to a tertiary care hospital.a

Study Setting: The study was conducted in the Department of General Medicine in collaboration with the Departments of Cardiology, Neurology, and Central Laboratory Services at a tertiary care teaching hospital in Gujarat, India. The hospital caters to a large population from both urban and rural areas and serves as a referral center for acute cardiovascular and neurological emergencies.

Study Duration: The study was conducted over a period of nine months from March 2025 to November 2025.

Study Population: The study population comprised adult patients admitted with confirmed cardiac or cerebrovascular events during the study period. Cardiac events included acute coronary syndrome (ST-elevation myocardial infarction, non-ST-elevation myocardial infarction, and unstable angina), while cerebrovascular events included ischemic stroke and hemorrhagic stroke confirmed clinically and radiologically.

Inclusion Criteria

1. Patients aged ≥18 years.
2. Patients diagnosed with acute cardiac events confirmed by clinical evaluation, electrocardiography, cardiac biomarkers, and/or echocardiography.
3. Patients diagnosed with acute cerebrovascular events confirmed by neurological assessment and neuroimaging (CT/MRI).
4. Patients willing to provide written informed consent.

Exclusion Criteria

1. Patients with active infections or sepsis.
2. Patients with chronic inflammatory or autoimmune disorders.
3. Patients with hematological malignancies or known immunological disorders.
4. Patients receiving corticosteroids, chemotherapy, or immunosuppressive therapy.
5. Patients with chronic liver disease, end-stage renal disease, or active malignancy.
6. Pregnant women.
7. Patients unwilling to participate in the study.

Sample Size: The sample size was calculated using the formula for estimation of proportion in observational studies:

$$n = \frac{Z^2 \times p \times q}{d^2}$$

Where:

- n = required sample size
- Z = standard normal deviate at 95% confidence interval (1.96)
- p = anticipated prevalence of elevated inflammatory markers among vascular event patients taken as 50% due to variable prevalence in previous studies
- q = 1 − p
- d = allowable error of 9%

$$\text{Using the above formula: } n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.09)^2} \approx 119$$

The calculated sample size was approximately 119. Considering feasibility and complete data availability, a final sample size of 120 patients was included in the study.

Sampling Technique: A consecutive sampling technique was employed. All eligible patients admitted during the study period who fulfilled the inclusion criteria were enrolled until the desired sample size was achieved.

Data Collection Tools and Procedure: After obtaining approval from the Institutional Ethics Committee, eligible patients were recruited following written informed consent. Detailed demographic information, clinical history, risk factors, comorbidities, presenting symptoms, and examination findings were recorded using a predesigned and pretested case record form. Routine laboratory investigations including complete blood count, fasting blood glucose, renal function tests, lipid profile, and inflammatory markers were performed at the time of admission. Systemic inflammatory indices including neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and systemic immune-inflammation index (SII) were calculated from hematological parameters. Electrocardiography, echocardiography, cardiac enzyme assays, computed tomography, and magnetic resonance imaging were performed wherever clinically indicated. Patients were categorized into cardiac event and cerebrovascular event groups, and inflammatory marker levels were compared with clinical outcomes and disease severity.

Study Variables: Independent variables included age, sex, smoking status, alcohol consumption, hypertension, diabetes mellitus, dyslipidemia, obesity, type of vascular event, laboratory inflammatory markers (total leukocyte count, neutrophil count, lymphocyte count, platelet count, NLR, PLR, and SII), and relevant biochemical parameters. Dependent variables included occurrence of cardiac and cerebrovascular events, severity of disease, duration of hospitalization, complications, and in-hospital outcome.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 26.0. Continuous variables were expressed as mean ±standard deviation, while categorical variables were represented as frequencies and percentages. Independent sample *t*-test or Mann–Whitney *U* test was used for comparison of continuous variables depending on data distribution. Chi-square test or Fisher's exact test was applied for categorical variables. Correlation and logistic regression analyses were performed to determine the predictive role of inflammatory markers for vascular events and adverse outcomes. A *p*-value of less than 0.05 was considered statistically significant.

Ethical Considerations: Written informed consent was obtained from all study participants or their legally authorized representatives prior to enrollment. Confidentiality and anonymity of patient information were strictly maintained throughout the study. The study adhered to the ethical principles outlined in the Declaration of Helsinki for biomedical research involving human participants.

RESULTS

A total of 120 patients with vascular events were included in the study, of whom 68 patients had cardiac events and 52 had cerebrovascular events. The mean age of the study population was 59.6 ±11.8 years, and males constituted the majority of participants. Hypertension was the most common comorbidity observed among the study subjects (Table 1).

Table 1. Baseline Sociodemographic and Clinical Characteristics of Study Participants (n=120)

Variable	Cardiac Events (n=68)	Cerebrovascular Events (n=52)	Total (n=120)
Mean age (years)	58.4 ± 11.2	61.1 ± 12.5	59.6 ± 11.8
Male sex, n (%)	46 (67.6)	33 (63.5)	79 (65.8)
Hypertension, n (%)	39 (57.4)	36 (69.2)	75 (62.5)
Diabetes mellitus, n (%)	31 (45.6)	19 (36.5)	50 (41.7)
Dyslipidemia, n (%)	28 (41.2)	17 (32.7)	45 (37.5)
Smoking/tobacco use, n (%)	34 (50.0)	21 (40.4)	55 (45.8)
Obesity (BMI ≥25 kg/m²), n (%)	24 (35.3)	16 (30.8)	40 (33.3)

Systemic inflammatory markers were elevated in both cardiac and cerebrovascular event groups. Patients with cerebrovascular events demonstrated significantly higher mean values of NLR, PLR, SII, and CRP compared to patients with cardiac events (Table 2).

Table 2. Comparison of Systemic Inflammatory Markers Between Cardiac and Cerebrovascular Events

Inflammatory Marker	Cardiac Events (n=68) Mean ± SD	Cerebrovascular Events (n=52) Mean ± SD	p-value
Total leukocyte count (cells/mm³)	11,420 ± 2,310	12,180 ± 2,640	0.08
Neutrophil-to-lymphocyte ratio (NLR)	4.8 ± 1.9	5.9 ± 2.3	0.01*
Platelet-to-lymphocyte ratio (PLR)	152.4 ± 48.6	171.8 ± 55.2	0.04*
Systemic immune-inflammation index (SII)	1,245 ± 402	1,468 ± 438	0.02*
C-reactive protein (mg/L)	12.8 ± 5.1	15.2 ± 6.4	0.03*

*Statistically significant ($p<0.05$)

Elevated inflammatory markers were significantly associated with increased severity of vascular events. Higher proportions of severe cases had NLR >5, PLR >160, elevated CRP levels, and raised SII values compared to mild-to-moderate cases (Table 3).

Table 3. Association of Elevated Inflammatory Markers with Severity of Vascular Events

Variable	Mild–Moderate Events (n=71)	Severe Events (n=49)	p-value
NLR >5, n (%)	24 (33.8)	31 (63.3)	0.002*
PLR >160, n (%)	21 (29.6)	27 (55.1)	0.006*
Elevated CRP (>10 mg/L), n (%)	29 (40.8)	33 (67.3)	0.005*
Elevated SII (>1400), n (%)	18 (25.4)	24 (49.0)	0.01*

*Statistically significant ($p<0.05$)

Patients with adverse in-hospital outcomes showed significantly higher inflammatory marker levels and longer duration of hospital stay. Mean NLR, PLR, and SII values were markedly elevated among patients with complications, prolonged hospitalization, or mortality (Table 4).

Table 4. Inflammatory Markers and In-Hospital Outcomes Among Study Participants

Outcome Variable	Favorable Outcome (n=92)	Adverse Outcome (n=28)	p-value
Mean NLR	4.5 ± 1.8	7.1 ± 2.5	<0.001*
Mean PLR	149.2 ± 46.1	188.7 ± 59.4	0.002*
Mean SII	1,198 ± 376	1,682 ± 452	<0.001*
Mean duration of hospital stay (days)	5.8 ± 2.1	8.6 ± 3.4	0.001*

*Statistically significant (p<0.05)

On multivariate logistic regression analysis, elevated NLR, PLR, and SII emerged as independent predictors of adverse outcomes after adjusting for major comorbidities. Elevated SII demonstrated the strongest association with adverse clinical outcomes (Table 5).

Table 5. Multivariate Logistic Regression Analysis for Predictors of Adverse Outcomes

Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
NLR >5	2.9	1.3–6.5	0.01*
PLR >160	2.1	1.0–4.8	0.04*
Elevated SII (>1400)	3.4	1.5–7.7	0.003*
Hypertension	1.6	0.7–3.8	0.21
Diabetes mellitus	1.4	0.6–3.3	0.29

*Statistically significant (p<0.05)

DISCUSSION

The present hospital-based observational study evaluated the role of systemic inflammatory markers in predicting cardiac and cerebrovascular events among patients admitted to a tertiary care hospital in Gujarat. The findings demonstrated that inflammatory indices such as neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), systemic immune-inflammation index (SII), and C-reactive protein (CRP) were significantly elevated among patients with vascular events and were associated with disease severity and adverse in-hospital outcomes. Among these markers, elevated SII and NLR showed the strongest predictive association with unfavorable clinical outcomes.

The mean age of the study population was approximately 60 years, with male predominance and a high prevalence of hypertension and diabetes mellitus. These findings are consistent with the established epidemiological profile of cardiovascular and cerebrovascular diseases in India and globally.[9] The coexistence of traditional vascular risk factors with elevated inflammatory markers further supports the concept that inflammation and metabolic dysfunction collectively contribute to endothelial injury and accelerated atherosclerosis.[1]

In the present study, patients with cerebrovascular events demonstrated significantly higher NLR and PLR values compared to patients with cardiac events. Similar findings were reported by Wang et al., who observed that elevated NLR was independently associated with increased mortality and poor neurological outcomes in acute ischemic stroke patients.[5] Tokgoz et al. also reported that higher NLR values were strongly correlated with stroke severity and functional disability.[6] The probable explanation lies in the intense inflammatory response triggered by cerebral ischemia, leading to activation of neutrophils, cytokine release, oxidative stress, and blood–brain barrier dysfunction.

The observed association between elevated inflammatory markers and severity of vascular events is biologically plausible. Neutrophils contribute to plaque destabilization through proteolytic enzyme release and endothelial injury, whereas lymphopenia reflects physiological stress and impaired immune regulation.[4] Platelet activation further amplifies thrombotic risk by promoting platelet aggregation and microvascular occlusion. Consequently, composite markers such as NLR and PLR provide a more comprehensive representation of systemic inflammatory and thrombotic status than isolated hematological parameters alone.

The present study also demonstrated that patients with adverse in-hospital outcomes had significantly higher mean values of NLR, PLR, and SII. These findings are comparable to those reported by Adamstein et al., who identified NLR as a significant predictor of incident atherosclerotic events and vascular complications.[8] Similarly, Azab et al. observed that elevated NLR was associated with increased short-term and long-term mortality in patients with non-ST-elevation

myocardial infarction.[4] Elevated inflammatory markers may reflect greater plaque burden, ongoing vascular inflammation, larger infarct size, and impaired tissue recovery, thereby contributing to worse prognosis.

Multivariate logistic regression analysis in the current study identified elevated SII, NLR, and PLR as independent predictors of adverse outcomes. Among these, SII demonstrated the highest adjusted odds ratio. SII integrates neutrophil, lymphocyte, and platelet counts into a single index and therefore may better represent the balance between inflammatory activation and immune response. Recent studies have similarly highlighted the prognostic utility of SII in cardiovascular and cerebrovascular disorders.[10,11] These markers are advantageous in clinical settings because they are inexpensive, rapidly obtainable, and routinely available even in resource-limited healthcare facilities.

From a clinical and public health perspective, incorporation of systemic inflammatory markers into routine evaluation protocols may facilitate early identification of high-risk patients requiring closer monitoring and aggressive management. In tertiary care hospitals with high patient burden, simple hematological indices may serve as practical adjunctive tools for prognostication and risk stratification. Their use may also help optimize resource allocation and improve clinical decision-making in emergency care settings.

The strengths of the present study include simultaneous evaluation of both cardiac and cerebrovascular events within a unified inflammatory framework and the assessment of multiple hematological inflammatory indices in an Indian tertiary care setting. The study also utilized routinely available laboratory investigations, thereby enhancing the applicability of findings in real-world practice.

However, certain limitations should be acknowledged. Being a single-center observational study, the findings may have limited generalizability to broader populations. The relatively modest sample size and short-term follow-up restricted evaluation of long-term outcomes and mortality predictors. Inflammatory markers were assessed only at admission, and serial measurements were not performed. Additionally, residual confounding due to unmeasured variables cannot be completely excluded.

Overall, the present study supports the growing evidence that systemic inflammatory markers, particularly NLR, PLR, and SII, are valuable predictors of severity and adverse outcomes in patients with cardiac and cerebrovascular events.

CONCLUSION

The present study demonstrated that systemic inflammatory markers, particularly neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, and systemic immune-inflammation index, were significantly associated with both cardiac and cerebrovascular events and showed strong predictive value for disease severity and adverse in-hospital outcomes. Patients with elevated inflammatory indices had a greater likelihood of severe clinical presentation, prolonged hospitalization, and unfavorable outcomes. These findings highlight the important role of inflammation in the pathogenesis and progression of vascular diseases. As these markers are inexpensive, routinely available, and rapidly obtainable from standard hematological investigations, they may serve as practical adjunctive tools for early risk stratification and prognostication in tertiary care settings, particularly in resource-constrained environments. Early identification of high-risk patients using systemic inflammatory markers may facilitate timely intervention, closer monitoring, and improved clinical decision-making. Further multicentric studies with larger sample sizes and long-term follow-up are recommended to validate these findings and establish standardized cut-off values for routine clinical application.

DECLARATIONS

Funding: No external funding was received for this study.
Conflict of Interest: The authors declare no conflict of interest.
Consent: Written informed consent was obtained from all participants or their legally authorized representatives prior to enrollment.

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