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Original Research Article

Comparative Study of Hematological Parameters Neutrophil to Lymphocyte Ratio Hypertensive and Non-Hypertensive Subjects

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Conflict of interest: Nil

Abstract:

Background: Hypertension is increasingly recognized as a state of chronic low-grade systemic inflammation rather than a purely hemodynamic disorder. The neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR), derived from a routine complete blood count, are simple and inexpensive surrogate markers of systemic inflammation. This study aimed to compare basic hematological parameters, NLR, and PLR between hypertensive and normotensive adults, and to assess the correlation of NLR and PLR with blood pressure.

Methods: This cross-sectional observational study was conducted over 12 months at a tertiary government medical college in Rajkot, Gujarat, India. A total of 160 adults aged 3-70 years were enrolled, comprising 80 hypertensive and 80 normotensive subjects. Hemoglobin, total leukocyte count, neutrophil count, lymphocyte count, and platelet count were obtained using an automated hematology analyzer, and NLR and PLR were calculated from differential counts. Group comparisons were performed using the unpaired Student's t-test, and Pearson's correlation coefficient (r) was used to assess associations between NLR/PLR and systolic and diastolic blood pressure. A p-value <0.05 was considered statistically significant.

Results: Systolic and diastolic blood pressure were significantly higher in the hypertensive group compared with normotensive controls ($p<0.05$). Among hematological indices, total leukocyte count, neutrophil count, and platelet count were significantly higher in hypertensive participants (all $p<0.05$), while hemoglobin and lymphocyte count showed no significant difference between groups ($p>0.05$). The mean NLR was significantly higher in hypertensive participants than in normotensive participants (2.47 ± 0.55 vs. 1.97 ± 0.39; $p<0.05$), whereas the mean PLR, although numerically higher in hypertensives (133.28 ± 37.09 vs. 123.39 ± 26.45), did not reach statistical significance ($p>0.05$). NLR showed a moderate positive correlation with systolic blood pressure ($r = 0.442$) and a weak-to-moderate positive correlation with diastolic blood pressure ($r = 0.381$).

Conclusion: Hypertensive individuals demonstrate significant alterations in basic hematological parameters consistent with a pro-inflammatory state, with NLR emerging as a significantly elevated and blood pressure–correlated marker. As an inexpensive index derived from a routine complete blood count, NLR may serve as a practical adjunctive tool for cardiovascular risk assessment in hypertensive patients.

Keywords: Hypertension; Neutrophil-to-Lymphocyte Ratio; Platelet-to-Lymphocyte Ratio; Hematological Parameters; Systemic Inflammation; Blood Pressure.

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Introduction

Hypertension is one of the most prevalent non-communicable diseases worldwide, affecting an estimated 1.28 billion adults aged 30-79 years, nearly half of whom remain undiagnosed. [1,2] It is a major modifiable risk factor for ischemic heart disease, stroke, chronic kidney disease, and premature mortality, and its burden is disproportionately higher in low- and middle-income countries [1,4]

Beyond its classical hemodynamic basis, hypertension is increasingly recognized as a chronic low-grade inflammatory condition. Endothelial dysfunction, reduced nitric oxide bioavailability, oxidative stress, and activation of innate and adaptive immune pathways contribute to vascular remodellin, arterial stiffness, and sustained elevation of blood pressure. [5,6] Neutrophils contribute to vascular injury through the release of reactive oxygen species and proteolytic enzymes, whereas lymphocytes are involved in immune regulation; an

imbalance between these cell populations is reflected in the neutrophil-to-lymphocyte ratio (NLR).

The NLR is a simple, inexpensive, and readily available marker of systemic inflammation derived from a routine complete blood count (CBC). It has been associated with hypertension, stroke, heart failure, and acute coronary syndromes [7,8,9] Similarly, the platelet-to-lymphocyte ratio (PLR) reflects platelet activation and a pro-thrombotic, pro-inflammatory state and has been proposed as an adjunctive marker of cardiovascular risk.

Most existing data on NLR and PLR in hypertension originate from Western and East Asian populations, with limited comparative data from Indian cohorts. [7,10] Since NLR and PLR can be derived from a standard CBC at no additional cost, establishing their utility in an Indian population could support their integration into routine cardiovascular risk assessment, particularly in resource-limited settings.

The present study was therefore designed to compare basic hematological parameters including NLR and PLR between hypertensive and normotensive adults attending a tertiary care center in Rajkot, Gujarat, and to evaluate the correlation of these indices with blood pressure.

Objectives

- To compare the neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) between hypertensive and non-hypertensive individuals.
- To compare basic hematological indices (hemoglobin, total leukocyte count, neutrophil count, lymphocyte count, and platelet count) between groups.
- To evaluate the correlation of NLR and PLR with systolic and diastolic blood pressure.

Materials and Methods

Study Design and Setting: This cross-sectional observational study was conducted over a 12-month period (August 2024 to July 2025) in the Department of Physiology, in collaboration with the Departments of Medicine and Pathology, at a tertiary government medical college and hospital in Rajkot, Gujarat, India. Participants were recruited from both hospital outpatient departments and the surrounding community. Hematological analyses were performed in the central pathology laboratory of the same institution.

Study Population: A total of 160 adults aged 30–70 years were enrolled, comprising 80 hypertensive and 80 normotensive participants, after obtaining written informed consent. Hypertensive participants were either newly diagnosed or already receiving antihypertensive treatment, while normotensive participants were healthy volunteers with no history of hypertension. A detailed medical and personal history was recorded for each participant using a structured case record form.

Inclusion criteria were age 30–70 years; both sexes; hypertensive individuals with systolic blood pressure (SBP) ≥140 mmHg and/or diastolic blood pressure (DBP) ≥90 mmHg on at least two separate occasions, or currently on antihypertensive medication; non-hypertensive individuals with SBP <140 mmHg and DBP <90 mmHg; and willingness to provide written informed consent.

Exclusion criteria included age <30 or >70 years; pregnancy or lactation; current or recent (within one month) use of corticosteroids, immunosuppressive, or anti-inflammatory drugs; recent acute illness, infection, or hospitalization; known hematological malignancy, chronic kidney disease, or chronic liver disease; current tobacco/smoking use; obesity (BMI ≥30 kg/m²); and any known chronic inflammatory, autoimmune, metabolic, or malignant disease that could independently alter hematological parameters.

Sample Size: The sample size was calculated based on a previously reported weighted mean difference in NLR of 0.40 between hypertensive and normotensive subjects, with a pooled standard deviation of approximately 0.60.[7] Using a two-sample t-test formula with $\alpha = 0.05$ (two-tailed) and 80% power, a minimum of 80 participants per group was determined to be required. A total of 160 participants (80 per group) were enrolled accordingly.

Blood Pressure Measurement: Blood pressure was measured in the seated position using a mercury sphygmomanometer after 5 minutes of rest. Two readings were taken from the dominant arm at 1–2-minute intervals, and the mean of the two was recorded; if the difference between readings exceeded 5 mmHg, a third reading was obtained. Blood pressure was classified according to JNC 7 criteria.[11]

Blood Sample Collection and Hematological Analysis: A 2 mL venous blood sample was collected under aseptic precautions into an EDTA tube and analyzed using an automated hematology analyzer in the central laboratory. All instruments were calibrated daily, and analyses were performed according to standard operating procedures. NLR was calculated as the absolute neutrophil count divided by the absolute lymphocyte count, and PLR as the absolute platelet count divided by the absolute lymphocyte count.

Statistical Analysis: Data were compiled in Microsoft Excel and analyzed using SPSS software (version 25.0). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequency and percentage. Comparisons between hypertensive and normotensive groups

were performed using the unpaired Student's t-test. Pearson's correlation coefficient (r) was used to assess the relationship between blood pressure and the inflammatory indices NLR and PLR. A p-value <0.05 was considered statistically significant.

Ethical Considerations: Approval for the study was obtained from the Institutional Ethics Committee prior to initiation. All participants received an information sheet describing the purpose and procedures of the study and provided written informed consent in their local language. Confidentiality of participant data was maintained, and participants were free to withdraw at any time without prejudice. Only routine venipuncture was performed, with no additional risk or cost to participants.

Results

A total of 160 participants were enrolled, comprising 80 hypertensive and 80 normotensive subjects.

Demographic and Hemodynamic Characteristics: The mean age of the normotensive group was 50.54 ± 8.29 years, compared with 53.05 ± 9.15 years in the hypertensive group; this difference was not statistically significant (p>0.05). The male-to-female ratio was comparable between groups (normotensive 44:36; hypertensive 46:34; p>0.05), indicating adequate matching for age and sex. As expected, both systolic and diastolic blood pressure were significantly higher in the hypertensive group compared with the normotensive group (both p<0.05), confirming clear hemodynamic differentiation between groups (Table 1).

Table 1: Demographic and Hemodynamic Parameters of Study Participants

Parameter	Normotensive (n=80)	Hypertensive (n=80)	p-value	Significance
Age (years)	50.54 ± 8.29	53.05 ± 9.15	>0.05	Not significant
Males : Females	44 : 36	46 : 34	>0.05	Not significant
Systolic BP (mmHg)	119.35 ± 8.22	149.32 ± 9.74	<0.05	Significant
Diastolic BP (mmHg)	77.05 ± 6.76	95.71 ± 6.85	<0.05	Significant

Hematological Indices: Hemoglobin levels did not differ significantly between groups (13.19 ± 1.53 g/dL in hypertensives vs. 13.29 ± 1.27 g/dL in normotensives; p>0.05). Total leukocyte count was significantly higher in hypertensive participants (8.99 ± 1.70 × 10^9/L vs. 7.18 ± 1.47 × 10^9/L; p<0.05), driven primarily by a marked increase in absolute neutrophil count (5826.58 ± 1275.11 vs. 3876.10 ± 631.30 cells/µL; p<0.05). Lymphocyte counts were modestly higher in the hypertensive group (2590.14 ± 665.29 vs. 2164.70 ± 581.20 cells/µL) but did not reach statistical significance (p>0.05). Platelet count was significantly higher in hypertensives (309748.72 ± 74208.53 vs. 244666.48 ± 51369.79 cells/µL; p<0.05) (Table 2, Figure 2).

Table 2: Comparison of Basic Hematological Indices between Normotensive and Hypertensive Groups

Parameter	Normotensive (n=80) Mean ± SD	Hypertensive (n=80) Mean ± SD	p-value	Significance
Hemoglobin (g/dL)	13.29 ± 1.27	13.19 ± 1.53	>0.05	Not significant
Total WBC (×10^9/L)	7.18 ± 1.47	8.99 ± 1.70	<0.05	Significant
Neutrophil count (cells/µL)	3876.10 ± 631.30	5826.58 ± 1275.11	<0.05	Significant
Lymphocyte count (cells/µL)	2164.70 ± 581.20	2590.14 ± 665.29	>0.05	Not significant
Platelet count (cells/µL)	244666.48 ± 51369.79	309748.72 ± 74208.53	<0.05	Significant

Inflammatory Indices (NLR and PLR): The mean NLR was significantly higher in hypertensive participants compared with normotensive participants (2.47 ± 0.55 vs. 1.97 ± 0.39; p<0.05). The mean PLR was also numerically higher in the hypertensive group (133.28 ± 37.09 vs. 123.39 ± 26.45) but did not reach statistical significance (p>0.05) (Table 3, Figure 1).

Table 3: Neutrophil-to-Lymphocyte Ratio (NLR) and Platelet-to-Lymphocyte Ratio (PLR) in Hypertensive and Normotensive Groups

Parameter	Non-Hypertensive (Mean ± SD)	Hypertensive (Mean ± SD)	p-value
NLR	1.97 ± 0.39	2.47 ± 0.55	<0.05
PLR	123.39 ± 26.45	133.28 ± 37.09	>0.05

Correlation of NLR and PLR with Blood Pressure: NLR showed a moderate positive correlation with systolic blood pressure (r = 0.442) and a weak-to-moderate positive correlation with diastolic blood pressure (r = 0.381) (Table 4).

Table 4: Correlation Coefficients between NLR and Blood Pressure Parameters

Correlation Pair	r-value	Interpretation
NLR vs. Systolic BP	0.442	Moderate positive correlation
NLR vs. Diastolic BP	0.381	Weak-to-moderate positive correlation

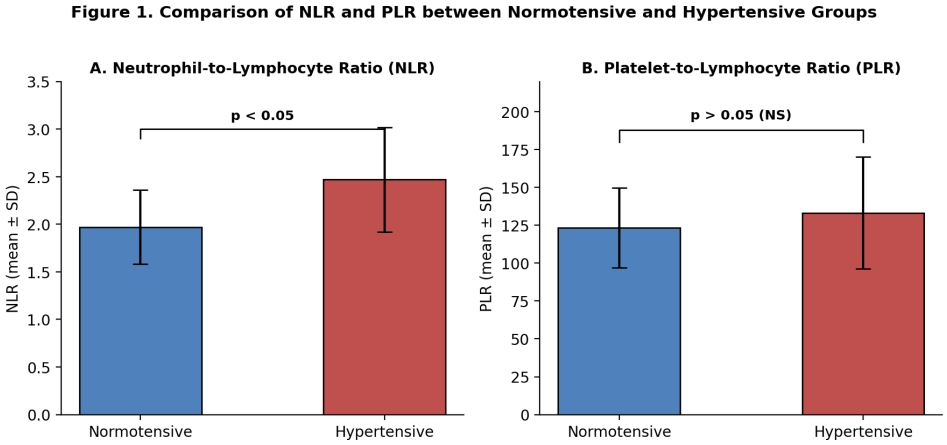

Figure 1: Comparison of (A) Neutrophil-to-Lymphocyte Ratio (NLR) and (B) Platelet-to-Lymphocyte Ratio (PLR) between normotensive and hypertensive groups. Bars represent mean ± SD.

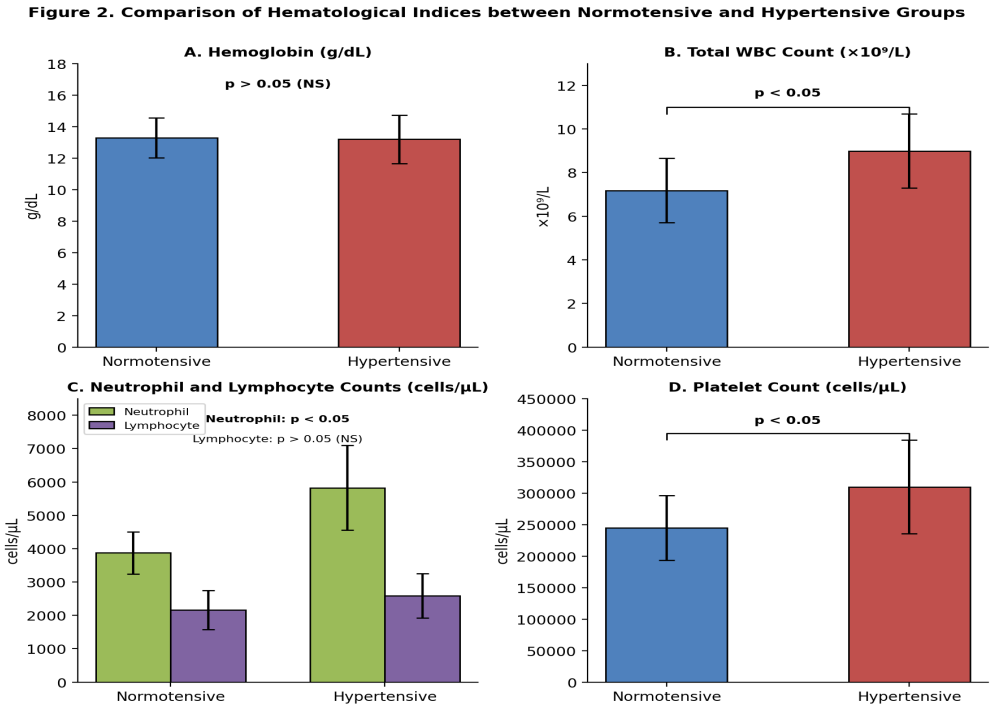

Figure 2: Comparison of (A) hemoglobin, (B) total leukocyte (WBC) count, (C) neutrophil and lymphocyte counts, and (D) platelet count between normotensive and hypertensive groups. Bars represent mean ± SD.

Discussion

This cross-sectional study evaluated basic hematological parameters and the inflammatory indices NLR and PLR in hypertensive versus normotensive adults from western India. The principal finding was a significant elevation of NLR in hypertensive participants, accompanied by significant increases in total leukocyte count, neutrophil count, and platelet count, together with moderate positive correlations between NLR and both systolic and diastolic blood pressure. These findings support the view that hypertension is associated with a measurable systemic pro-inflammatory and pro-thrombotic hematological profile.

Demographic Findings: The two groups were well-matched for age and sex, with no significant differences observed ($p>0.05$), minimizing the likelihood that these variables confounded the comparison of hematological parameters.

Leukocyte and Differential Counts: Total leukocyte count and absolute neutrophil count were significantly higher in hypertensive participants, consistent with prior population-based observations linking elevated leukocyte counts to hypertension risk. [12,13] Neutrophils contribute to vascular injury through release of reactive oxygen species and proteolytic enzymes, which reduce nitric oxide bioavailability and promote endothelial dysfunction—mechanisms considered central to hypertension pathogenesis.[14] Lymphocyte counts were modestly higher, though not significantly, in the hypertensive group; while this is at variance with some reports of hypertension-associated lymphopenia, it is consistent with evidence implicating T-lymphocyte activation, including Th17 cells, in experimental models of hypertension.[14,15]

Platelet Count: Platelet count was significantly elevated in the hypertensive group, in agreement with previous comparative studies reporting platelet hyperreactivity as a marker of vascular inflammation and cardiovascular risk in hypertensive populations. [16,17] This finding reinforces the concept of a pro-thrombotic state accompanying the inflammatory milieu of hypertension.

NLR and PLR: The mean NLR was significantly higher in hypertensive participants (2.47 ± 0.55) than in normotensive participants (1.97 ± 0.39), with a between-group difference of approximately 0.50. This is broadly consistent with the meta-analysis by Sarejloo et al., which reported a pooled weighted mean difference of 0.40 across 21 studies (95% CI 0.22–0.57, $p<0.0001$)[7] The slightly larger difference observed in the present study may reflect differences in population characteristics, ethnicity, and inclusion criteria between cohorts.

The positive correlations observed between NLR and systolic ($r = 0.442$) and diastolic ($r = 0.381$) blood pressure are comparable in direction and magnitude to those reported by Hou et al. in a pediatric hypertensive cohort ($r = 0.344$ and $r = 0.310$, respectively, after adjustment for age, sex, and BMI).[9] Similar associations between NLR and ambulatory blood pressure have also been reported by Çimen et al. [18] Together, these findings support the reproducibility of the NLR–blood pressure association across diverse populations and age groups.

In contrast, although PLR was numerically higher in the hypertensive group (133.28 ± 37.09 vs. 123.39 ± 26.45), this difference was not statistically significant. This is consistent with prior reports of inconsistent or modest PLR elevation in hypertension, with some studies failing to demonstrate independent significance after adjustment for confounders. [16,17] Taken together with the significant NLR finding, this suggests that NLR may be a more sensitive marker of hypertension-related inflammation than PLR in this population.

Clinical Implications: NLR is derived from a routine CBC at no additional cost, making it a practical tool for opportunistic cardiovascular risk assessment, particularly in resource-limited settings. Its significant elevation in hypertensive individuals, together with its positive correlation with blood pressure, suggests that NLR could help identify hypertensive patients with a higher inflammatory burden who may benefit from closer monitoring and more proactive lifestyle or pharmacological intervention.

Strengths and Limitations: This study had a reasonably balanced sample size (n=160), clearly defined inclusion and exclusion criteria, and provided region-specific data from a population that has been underrepresented in the existing literature on NLR and hypertension. However, several limitations should be acknowledged. The cross-sectional design precludes any inference of causality or temporal sequence between inflammation and hypertension. The study was conducted at a single center, which may limit generalizability. Age, although not significantly different between groups, may still have acted as a residual confounder, and multivariable adjustment was not performed. Despite strict exclusion criteria, undetected subclinical infection or inflammation could have influenced hematological parameters.

Conclusion

This cross-sectional study demonstrated that hypertensive individuals exhibit a distinct hematological profile compared with normotensive individuals, characterized by significantly higher total leukocyte count, neutrophil count, platelet count, and NLR. NLR showed a significant elevation in hypertensive participants and a moderate positive correlation with both systolic and diastolic blood pressure, whereas PLR did not differ significantly between groups, suggesting that NLR may be the more sensitive of the two indices in this population.

Given that NLR can be derived at no additional cost from a routine complete blood count, it represents a practical and accessible adjunctive marker for identifying hypertensive individuals with greater systemic inflammatory activity, particularly in resource-limited settings. These findings provide

region-specific evidence supporting the role of systemic inflammation in hypertension and warrant validation through larger, multicentric, and longitudinal studies.

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