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Research Article

Inflammation-Based Risk Assessment in Acute Pulmonary Embolism: Diagnostic and Prognostic Implications of the Neutrophil-to-Lymphocyte Ratio

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Abstract

Objectives: Acute pulmonary embolism (PE) is a serious cardiovascular disorder that may lead to substantial morbidity and mortality if not recognized early. Timely diagnosis and accurate assessment of disease severity are essential for appropriate treatment planning. Although imaging techniques and cardiac biomarkers are commonly used in the diagnostic process, there remains a need for practical laboratory markers that are inexpensive, rapidly obtainable, and easily applicable in routine clinical settings. The neutrophil-to-lymphocyte ratio (NLR), derived from peripheral blood counts, has recently gained attention as an indicator of inflammatory activation. In this study, we investigated the diagnostic significance of NLR in acute PE and examined its association with clinical severity and mortality outcomes.

Methods: A total of 100 patients diagnosed with acute PE by computed tomography pulmonary angiography and 94 healthy individuals were retrospectively evaluated. Patients were categorized according to the 2014 European Society of Cardiology risk stratification model into low/intermediate-low-risk and intermediate-high/high-risk groups. Laboratory data obtained within the first 6 hours after hospital admission were analyzed. Receiver operating characteristic (ROC) curve analysis was used to determine the diagnostic performance of NLR.

Results: Patients with acute PE had significantly higher NLR values compared with healthy controls (5.7±4.3 vs. 2.08±1.6, p<0.001). ROC analysis demonstrated that NLR had favorable diagnostic performance for acute PE, with an area under the curve of 0.855. An NLR threshold above 2.56 provided 76% sensitivity and 84.6% specificity. Moreover, NLR levels were significantly greater in intermediate-high/high-risk patients compared with low/intermediate-low-risk patients (6.82±5.1 vs. 4.93±3.3, p=0.031). Although higher NLR values were observed among patients who died during follow-up, no statistically significant relationship was identified between NLR and short- or long-term mortality.

Conclusion: The present findings suggest that NLR may be a useful supportive biomarker in the early evaluation of acute PE. Elevated NLR levels were associated with increased disease severity. Although its prognostic value for mortality was not clearly demonstrated, NLR may still contribute to clinical risk assessment because of its rapid availability and ease of calculation.

Keywords: Inflammation, pulmonary embolism, mortality, neutrophil-to-lymphocyte ratio, risk stratification

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Acute pulmonary embolism (PE) is a serious cardiovascular condition caused by obstruction of the pulmonary arterial circulation, most commonly secondary to thrombi originating from the deep venous system of the lower extremities. Despite substantial progress in imaging modalities and anticoagulant treatment strategies, PE continues to be associated with considerable morbidity and mortality worldwide.[1–3] Clinical presentation may vary from mild nonspecific symptoms to circulatory collapse and sudden death. Because symptoms such as dyspnea, chest pain, syncope, and tachycardia are not unique to PE, establishing an early diagnosis may be difficult in routine clinical practice.[1,3]

Early identification of high-risk patients is essential for determining treatment strategy and predicting clinical outcomes. Current guideline recommendations support the use of clinical scoring systems, including the Pulmonary Embolism Severity Index (PESI) and simplified PESI (sPESI), together with imaging findings and cardiac biomarkers such as troponin and N-terminal pro-brain natriuretic peptide (NT-proBNP).[1,4] However, some of these approaches may not always be immediately available during the first assessment in emergency settings.

Recent studies have demonstrated that inflammatory mechanisms contribute significantly to the development and progression of venous thromboembolism. Endothelial dysfunction, platelet activation, cytokine release, leukocyte recruitment, and neutrophil extracellular trap formation are believed to participate in thrombus formation and pulmonary vascular injury.[5,6] Therefore, acute PE is increasingly recognized as a disorder involving both thrombosis and systemic inflammatory activation.

The neutrophil-to-lymphocyte ratio (NLR) is a readily available laboratory parameter derived from routine complete blood count measurements. Elevated NLR levels are considered to reflect both inflammatory activity and physiologic stress response.[7] Previous reports have demonstrated associations between increased NLR values and unfavorable outcomes in several cardiovascular and inflammatory diseases, including acute coronary syndromes, heart failure, ischemic stroke, and venous thromboembolism.[7,8]

Several investigators have evaluated the prognostic significance of NLR in acute PE. Higher NLR levels have been associated with greater disease severity, right ventricular dysfunction, and adverse short-term outcomes.[9,10] Nevertheless, evidence regarding its diagnostic value and long-term prognostic role remains limited and somewhat inconsistent. In addition, there is still a need for inexpensive and rapidly obtainable biomarkers that may support clinicians during the early evaluation of patients with suspected PE, particularly in emergency departments and resource-limited healthcare settings.[11,12]

In the present study, we aimed to investigate the diagnostic performance of NLR in patients with acute pulmonary embolism and to evaluate its association with disease severity and mortality outcomes.

Methods

Study Design and Population

We retrospectively evaluated adult patients diagnosed with acute pulmonary embolism (PE) between September 2015 and September 2017 at a tertiary referral center. Demographic characteristics, laboratory findings, and radiologic data were retrieved from institutional electronic medical records and archived patient files. To reduce potential selection bias, all eligible consecutive patients identified during the study period were included in the analysis.

The diagnosis of acute PE was established by computed tomography pulmonary angiography (CTPA). Only patients with segmental or more proximal pulmonary arterial involvement were included. Patients with isolated subsegmental embolism or chronic thromboembolic pulmonary disease were excluded from the study. Cases with missing clinical, laboratory, or imaging data required for statistical evaluation were excluded during the screening process.

Patients aged 18 years or older with laboratory measurements obtained within the first six hours after admission were considered eligible for inclusion. Evaluated laboratory parameters included complete blood count, D-dimer, arterial blood gas analysis, and cardiac biomarkers. Pregnant patients and individuals with incomplete clinical information were not included in the final cohort.

Risk stratification was performed according to the 2014 European Society of Cardiology (ESC) recommendations for acute PE. Clinical evaluation included assessment of the Pulmonary Embolism Severity Index (PESI), simplified PESI (sPESI), hemodynamic status, right ventricular dysfunction, and cardiac biomarker positivity. Echocardiographic findings suggesting right ventricular dysfunction included right ventricular dilatation, an RV/LV ratio greater than 0.9, or increased tricuspid regurgitation. Troponin I and NT-proBNP values obtained at admission were used for biomarker assessment.

A control group consisting of healthy individuals without known thromboembolic or acute inflammatory disease was included for comparison of neutrophil-to-lymphocyte ratio (NLR) values.

Peripheral venous blood samples collected before treatment initiation were analyzed using the hospital central

laboratory system. NLR was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count.

The primary objectives of the study were to evaluate the diagnostic performance of NLR in acute PE and to investigate its relationship with disease severity. Secondary endpoints included 30-day and 1-year mortality. Mortality data were obtained from hospital records and national health databases.

Data analysis was conducted using SPSS version 20.0 (IBM Corp., Armonk, NY, USA) and MedCalc software. Continuous variables are presented as mean±standard deviation, whereas categorical variables are summarized as frequencies and percentages. Group comparisons were performed using the independent samples t-test or chi-square test, where appropriate. Receiver operating characteristic (ROC) curve analysis was applied to assess the diagnostic and prognostic performance of NLR, and cutoff values were determined using the Youden index. A two-sided p-value below 0.05 was considered statistically significant.

Results

Baseline Characteristics

A total of 100 consecutive patients with acute pulmonary embolism (PE) and 94 healthy controls were included in the study. The mean age of the PE group was 71.2±16.4 years, and 56% of the patients were female. The control group consisted of 51 women (54.3%) and 43 men (45.7%), with a mean age of 67.3±13.1 years. There was no statistically significant difference between the groups in terms of age or sex distribution (p>0.05).

The most common comorbid conditions among patients with PE were coronary artery disease (23%), chronic obstructive pulmonary disease (23%), congestive heart failure (23%), hypertension (48%), and diabetes mellitus (23%).

According to the 2014 ESC risk classification, 29 patients were categorized as low risk, 26 as intermediate-low risk, 36 as intermediate-high risk, and 9 as high risk. For further analyses, patients were grouped as low/intermediate-low risk (Group 1, n=55) and intermediate-high/high risk (Group 2, n=45). Baseline demographic and laboratory characteristics according to PE risk groups are summarized in Table 1.

Relationship Between NLR and Disease Severity

Patients in the intermediate-high/high-risk group demonstrated significantly higher NLR values compared with patients in the low/intermediate-low-risk group (6.82±5.1 vs. 4.93±3.3, p=0.031). Detailed laboratory comparisons between PE risk groups are shown in Table 1.

Similarly, D-dimer and NT-proBNP levels were significantly higher among patients with greater disease severity. Neutrophil counts were also significantly elevated in the higher-risk group, whereas lymphocyte counts were lower, although the difference in lymphocyte counts did not reach statistical significance.

ROC curve analysis evaluating the ability of NLR to differentiate low/intermediate-low-risk and intermediate-high/high-risk PE patients is presented in Figure 1.

ROC analysis of NT-proBNP for differentiating PE severity groups is shown in Figure 2.

Patients with higher-risk PE more frequently demonstrated right ventricular dysfunction and elevated cardiac biomarkers.

Although mean NLR values were numerically higher among non-survivors compared with survivors, the difference did not reach statistical significance. ROC analyses evaluating

Table 1. Baseline demographic and laboratory characteristics according to pulmonary embolism risk groups

Variable	Group 1 (n=55)	Group 2 (n=45)	p
Age	69.04±14.2	74.87±10.4	0.024
Female sex, n (%)	37 (67%)	28 (62%)	NS
D-dimer (ng/mL)	2969.64±2626.9	4514.73±4177.2	0.026
NT-proBNP (pg/mL)	313.42±931.2	733.66±1004.8	0.033
Leukocyte count (/mm^3)	9391±4238.1	11585.78±6729.6	0.061
Neutrophil count (/mm^3)	6803.64±3849.4	9215.33±6203.4	0.019
Lymphocyte count (/mm^3)	1728.27±824	1692.71±1195.8	0.861
NLR	4.93±3.3	6.82±5.1	0.031
Hemoglobin (g/dL)	11.22±2.2	10.76±2.5	0.347
Hematocrit (%)	34.05±6.5	32.31±8.8	0.263
Platelet count (/µL)	275056±113118	232435±109643	0.060

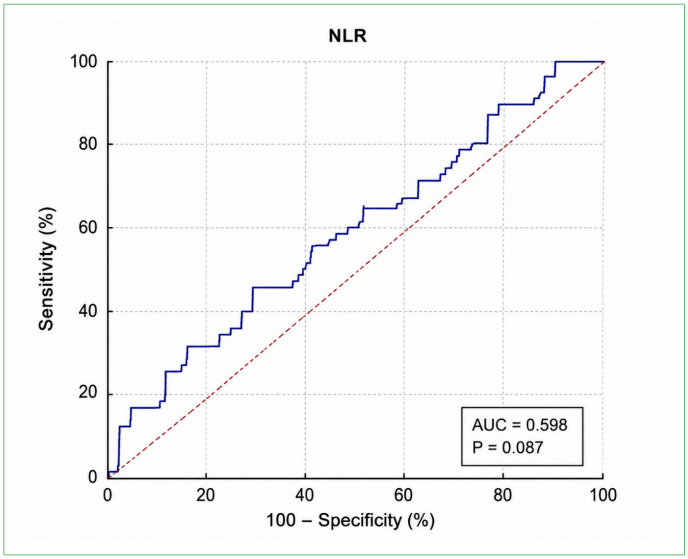

Figure 1. Receiver operating characteristic (ROC) curve of the neutrophil-to-lymphocyte ratio (NLR), showing limited and statistically nonsignificant discriminatory performance (AUC=0.598, p=0.087).

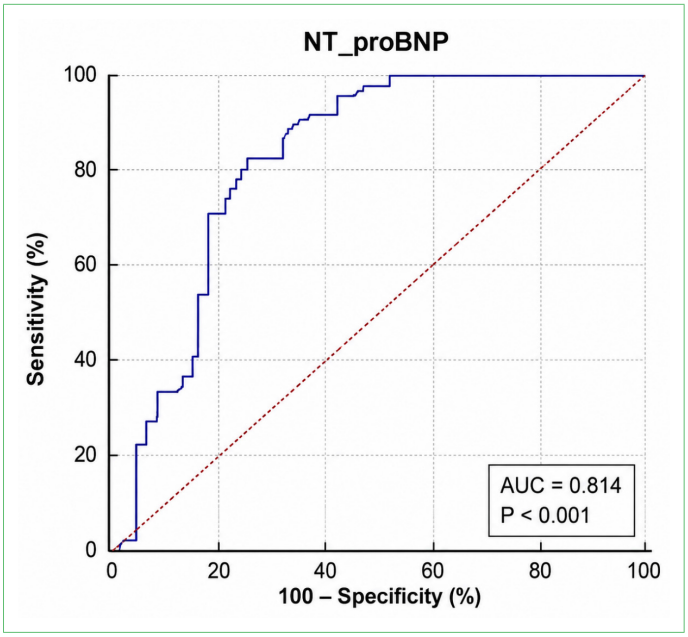

Figure 2. Receiver operating characteristic (ROC) curve of NT-proBNP, showing good and statistically significant discriminatory performance (AUC=0.814, p<0.001).

the prognostic performance of NLR for 30-day and 1-year mortality are presented in Figures 3 and 4, respectively.

Correlation Analyses

Elevated NLR values showed positive correlations with D-dimer and NT-proBNP levels, suggesting an association between systemic inflammatory response, thrombotic burden, and right ventricular strain in acute PE.

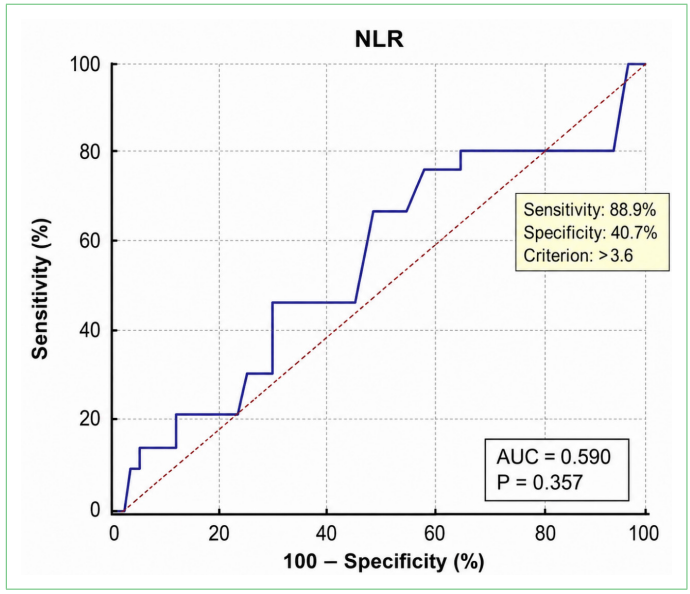

Figure 3. Receiver operating characteristic (ROC) curve of the neutrophil-to-lymphocyte ratio (NLR), showing limited and statistically nonsignificant discriminatory performance at a cutoff value of >3.6 (AUC=0.590, p=0.357).

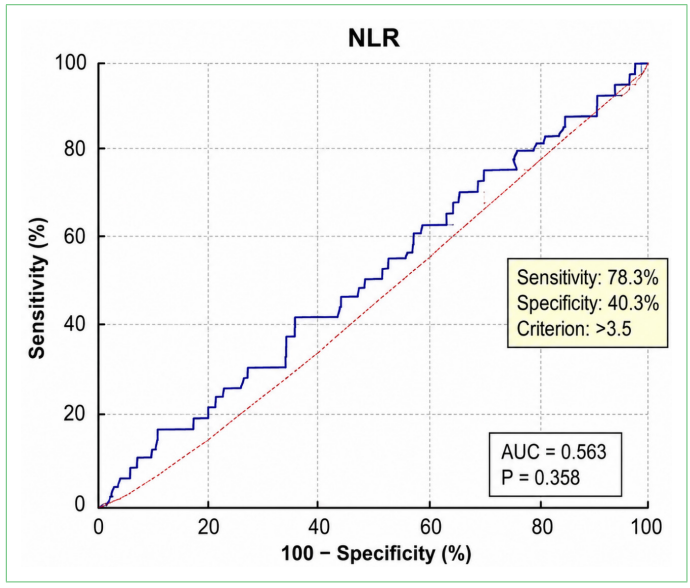

Figure 4. Receiver operating characteristic (ROC) curve of the neutrophil-to-lymphocyte ratio (NLR), showing limited and statistically nonsignificant discriminatory performance at a cutoff value of >3.5 (AUC=0.563, p=0.358).

Laboratory Findings and Diagnostic Performance of NLR

Comparisons of laboratory and demographic variables between low/intermediate-low-risk PE patients and healthy controls are summarized in Table 2.

Comparisons between intermediate-high/high-risk PE patients and healthy controls are summarized in Table 3.

Table 2. Comparison of group 1 pulmonary embolism patients and healthy controls

Variable	Group 1 (n=55)	Healthy Controls (n=94)	p
Age	69.04±14.2	67.3±10.9	0.047
Female sex, n (%)	37 (67%)	62 (66%)	NS
Leukocyte count (/mm^3)	9391±4238.1	6878.13±2099.5	0.032
Neutrophil count (/mm^3)	6803.64±3849.4	3945.27±1586.3	0.006
Lymphocyte count (/mm^3)	1728.27±824	2131.97±676.1	1.000
NLR	4.93±3.3	2.08±1.6	0.014
Hemoglobin (g/dL)	11.22±2.2	13.32±1.56	0.804
Platelet count (/µL)	275056±113118	248075±62337	0.059

Table 3. Comparison of group 2 pulmonary embolism patients and healthy control

Variable	Group 2 (n=45)	Healthy Control (n=94)	p
Age	74.87±10.4	67.3±10.9	<0.001
Female sex, n (%)	28 (62%)	62 (66%)	NS
Leukocyte count (/mm^3)	11585.78±6729.6	6878.13±2099.5	<0.001
Neutrophil count (/mm^3)	9215.33±6203.4	3945.27±1586.3	<0.001
Lymphocyte count (/mm^3)	1692.71±1195.8	2131.97±676.1	0.018
NLR	6.82±5.1	2.08±1.6	<0.001
Hemoglobin (g/dL)	10.76±2.5	13.32±1.56	<0.001
Platelet count (/µL)	232435±109643	248075±62337	0.059

Mean neutrophil-to-lymphocyte ratio (NLR) values were significantly higher in patients with acute PE compared with healthy controls, as shown in Table 4.

Receiver operating characteristic (ROC) analysis demonstrated good diagnostic performance of NLR for acute PE, with an area under the curve (AUC) of 0.855 (95% CI: 0.800–0.909, p<0.001). An NLR cutoff value >2.56 yielded 76% sensitivity and 84.6% specificity. Positive predictive value and negative predictive value were calculated as 40.4% and 96.9%, respectively (Fig. 5).

Mortality Outcomes

Thirty-day mortality was observed in 9 patients, whereas 1-year mortality occurred in 23 patients. Mortality outcomes according to PE risk groups are summarized in Table 5. Detailed mortality distributions between groups are presented in Table 5.

Table 4. Comparison of NLR between pulmonary embolism patients and healthy controls

Variable	PE patients (n=100)	Healthy controls (n=94)	p
NLR	5.7±4.3	2.08±1.6	<0.001

PE: Pulmonary embolism; NLR: Neutrophil-to-lymphocyte ratio.

Discussion

Acute pulmonary embolism (PE) continues to represent a major clinical problem despite advances in diagnostic

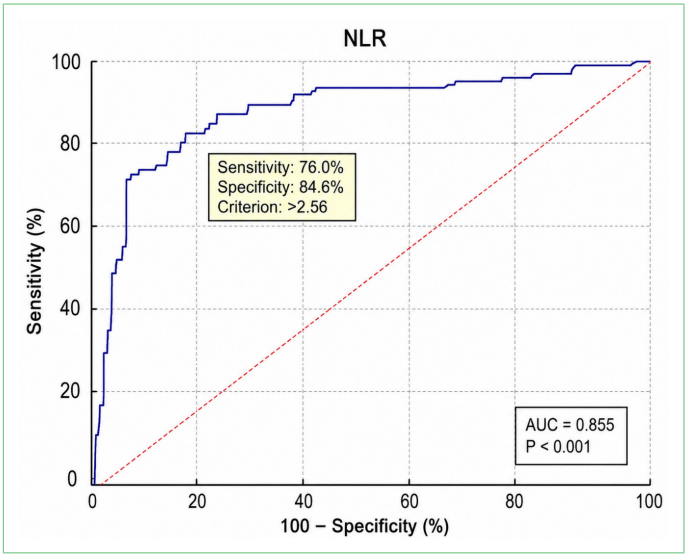

Figure 5. Receiver operating characteristic (ROC) curve of the neutrophil-to-lymphocyte ratio (NLR), showing good and statistically significant discriminatory performance at a cutoff value of >2.56 (AUC=0.855, p<0.001).

Table 5. Thirty-day and one-year mortality according to risk groups

Mortality	Group 1	Group 2	Total
30-day mortality	4	5	9
30-day survivors	51	40	91
1-year mortality	12	11	23
1-year survivors	43	34	77

approaches and anticoagulant therapies. Early identification of patients at increased risk for deterioration remains particularly important, especially among normotensive patients in whom the clinical course may initially appear stable.[1,2] Although patients presenting with hemodynamic instability are generally recognized rapidly, predicting adverse outcomes in clinically stable individuals is often more difficult.

Current risk assessment strategies are mainly based on clinical scoring systems, imaging findings related to right ventricular dysfunction, and cardiac biomarkers.[1,4] While these methods are well established, some may not be immediately accessible during the first evaluation in emergency settings. In addition, conventional biomarkers primarily reflect myocardial stress and may not fully demonstrate the inflammatory processes accompanying acute PE. For this reason, interest in simple laboratory parameters reflecting systemic inflammatory activation has increased in recent years.

Growing evidence suggests that inflammation plays an important role in the pathogenesis of venous thromboembolism. Endothelial injury, platelet activation, cytokine release, leukocyte recruitment, and neutrophil extracellular trap formation have all been implicated in thrombus formation and pulmonary vascular damage.[5,6] Accordingly, acute PE is now increasingly viewed as a condition involving both thrombotic and inflammatory mechanisms.

The neutrophil-to-lymphocyte ratio (NLR) is an easily obtainable marker derived from routine complete blood count analysis. Elevated NLR levels are considered to reflect both inflammatory activation and physiologic stress response.[7] Previous investigations have demonstrated associations between increased NLR values and adverse clinical outcomes in several cardiovascular and inflammatory disorders, including venous thromboembolism.[7,8]

In the present study, patients with acute PE had significantly higher NLR levels than healthy controls. In addition, patients classified in the intermediate-high/high-risk category demonstrated higher NLR values compared with lower-risk patients. These findings support the relationship between systemic inflammatory response and disease severity in acute PE.

Our results are generally compatible with previous reports evaluating the prognostic significance of NLR in PE. Earlier studies demonstrated that elevated NLR levels may be associated with right ventricular dysfunction, more severe clinical presentation, and poorer short-term outcomes.[9,10] Similarly, a recent meta-analysis suggested that inflammatory biomarkers, particularly NLR, may provide prognostic information in patients with acute PE.[12]

Another noteworthy finding of this study was the diagnostic performance of NLR in distinguishing patients with PE from healthy individuals. Although NLR cannot replace imaging modalities used for definitive diagnosis, it may provide supportive information during the early assessment of patients with suspected PE. This may be especially useful in emergency departments or situations in which immediate access to advanced imaging is limited.

We also observed positive correlations between NLR and established laboratory markers such as D-dimer and NT-proBNP. This observation may reflect the relationship between inflammatory activation, thrombotic burden, and right ventricular strain in acute PE. Therefore, NLR may represent a broader marker of physiologic stress associated with pulmonary vascular obstruction.

Unlike some previous studies, we did not observe a statistically significant relationship between NLR and mortality outcomes. Several factors may explain this finding. Mortality in acute PE is influenced by multiple clinical variables, including age, comorbid disease burden, cardiopulmonary reserve, clot extent, and treatment response. In addition, the relatively limited sample size may have reduced the ability to detect mortality-related differences.

This study has several limitations. First, its retrospective and single-center design may limit generalizability. Second, the number of patients included was relatively limited, particularly for mortality analyses. Third, serial measurements of NLR during follow-up were not available. Finally, the potential effects of accompanying inflammatory or chronic comorbid conditions cannot be completely excluded.

Despite these limitations, the study also has important strengths. Consecutive patient inclusion reduced the likelihood of selection bias, and laboratory measurements were obtained early after admission before treatment initiation. Moreover, no missing data were present in the final analytical cohort.

From a clinical perspective, NLR is an inexpensive, easily obtainable, and widely available laboratory parameter. Although it should not replace established diagnostic methods or cardiac biomarkers, it may provide additional support during early risk assessment in patients with acute PE.

Conclusion

The present study demonstrated that neutrophil-to-lymphocyte ratio levels were significantly increased in patients with acute pulmonary embolism and were associated with greater disease severity according to ESC risk categories. These findings support the relationship between inflammatory activation and the clinical presentation of acute PE.

Although NLR should not be used as an isolated diagnostic or prognostic marker, its rapid availability and low cost make it a potentially useful adjunctive parameter during the early assessment of suspected PE.

In routine clinical practice, a simple marker obtained from standard blood counts may provide additional information during the initial evaluation of patients with acute pulmonary embolism.

Disclosures

Ethical Committe Approval: The study protocol was approved by the Haydarpaşa Numune Training and Research Hospital Ethics Committee (Approval No: HNEAH-KAEK 2015/78 [487], Date: September 14, 2015).

Informed Consent: Due to the retrospective nature of the study, the requirement for informed consent was waived.

Conflict of Interest: The authors declare that they have no competing financial or non-financial interests.

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Use of AI for Writing Assistance: The authors declare that no artificial intelligence (AI)–assisted technologies (including large language models, chatbots, or image generation tools) were used in the preparation of this manuscript.

Author Contributions: Concept – BG; Design – FMT; Supervision – FMT; Findings – BG; Materials – BG; Data Collection and/or Processing – BG; Analysis and/or Interpretation – FMT; Literature Review – BÇG; Writing – BG; Critical Review – FMT, BÇG.

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References

1. Konstantinides SV, Meyer G, Becattini C, Bueno H, Geersing GJ, Harjola VP, et al. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J 2020;41(4):543–603.
2. Stein PD, Henry JW. Prevalence of acute pulmonary embolism among patients in a general hospital and at autopsy. Chest 1995;108(4):978–81. [CrossRef]
3. Goldhaber SZ, Bounameaux H. Pulmonary embolism and deep vein thrombosis. Lancet. 2012 May 12;379(9828):1835-46. [CrossRef]
4. Jiménez D, Aujesky D, Moores L, Gómez V, Lobo JL, Uresandi F, et al. Simplification of the pulmonary embolism severity index for prognostication in patients with acute symptomatic pulmonary embolism. Arch Intern Med 2010;170:1383–9. [CrossRef]
5. Martinod K, Wagner DD. Thrombosis: tangled up in NETs. Blood 2014;123(18):2768–76. [CrossRef]
6. Semeraro F, Ammollo CT, Morrissey. Extracellular traps in thrombosis. Semin Thromb Hemost. 2012;38:663–73.
7. Zahorec R. Ratio of neutrophil to lymphocyte counts--rapid and simple parameter of systemic inflammation and stress in critically ill. Bratisl Lek Listy 2001;102(1):5–14.
8. Ma Y, Mao Y, He X, Sun Y, Huang S, Qiu J. The values of neutrophil to lymphocyte ratio and platelet to lymphocyte ratio in predicting 30 day mortality in patients with acute pulmonary embolism. BMC Cardiovasc Disord 2016;16:123. [CrossRef]
9. Kayrak M, Erdogan HI, Solak Y, Akilli H, Gul EE, Yildirim O, et al. Prognostic value of neutrophil to lymphocyte ratio in patients with acute pulmonary embolism: a retrospective study. Heart Lung Circ 2014;23(1):56–62. [CrossRef]
10. Cavus UY, Yildirim S, Sonmez E, Ertan C, Ozeke O. Prognostic value of neutrophil/lymphocyte ratio in patients with pulmonary embolism. Turk J Med Sci 2014;44(1):50–5. [CrossRef]
11. Kabrhel C, Rosovsky R, Channick R, Jaff MR, Weinberg I, Sundt T, et al. A Multidisciplinary pulmonary embolism response team: Initial 30-Month Experience with a novel approach to delivery of care to patients with submassive and massive pulmonary embolism. Chest 2016;150(2):384–93. [CrossRef]
12. Guo J, Wang H, Wang Q. Prognostic value of inflammatory biomarkers in acute pulmonary embolism: a meta-analysis. Thromb Res 2021;198:219–29.