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COMPARISON OF SYSTEMIC INFLAMMATORY PARAMETERS WITH ANATOMICAL PATHOLOGY RESULTS IN DIFFERENTIATING BENIGN PROSTATIC HYPERPLASIA WITH AND WITHOUT INFLAMMATION: CROSS-SECTIONAL ANALYTICS

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ABSTRACT
Chronic inflammation plays an important role in pathogenesisbenign prostatic hyperplasia (BPH). Anatomic pathology examination is the standard for detecting prostate inflammation, but it is invasive. Systemic inflammation parameters based on peripheral blood counts have the potential to be non-invasive biomarkers. Comparing inflammatory parameters based on peripheral blood counts NLR, PLR, MLR, SII and SIRI with Anatomical Pathology results in comparing BPH with and without inflammation. This research is an analytical cross-sectional study in BPH patients with and without inflammation based on the results of Anatomical Pathology. A total of 334 patients were included in this study, and the sampling technique used was consecutive sampling. Parametersneutrophil to lymphocyte ratio (NLR), platelet to lymphocyte ratio (PLR), monocyte to lymphocyte ratio (MLR), systemic immune-inflammation index (SII), andsystemic inflammatory response index (SIRI) were analyzed and compared between groups. AnalysisReceiver Operating Characteristic (ROC) is used to determine the valuecut-off optimal. The median age of patients was relatively homogeneous. In the BPH group with inflammation, Total leukocyte count, absolute neutrophil count, and absolute monocyte count were higher, while absolute lymphocyte count was lower. All systemic inflammation parameters (NLR, PLR, MLR, SII, and SIRI) were significantly higher in the inflammation group ($p < 0.001$). SII showed the highest AUC value (0.840), followed by NLR (0.829) and SIRI (0.822). Based on our research, it can be concluded that systemic inflammatory parameters have the potential to be used as non-invasive biomarkers to determine whether a person has BPH with inflammation or not.

Keywords: benign prostatic hyperplasia; hematologic profile; inflammatory biomarkers; neutrophil-to-lymphocyte ratio; systemic inflammation index

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INTRODUCTION

Benign prostatic hyperplasia (BPH) is one of the most common non-malignant conditions affecting older men and remains a major clinical and public health problem worldwide. Histological evidence of prostate enlargement is present in more than half of men over the age of 60 and increases dramatically with age, with up to 80–90% of men over 80 years of age affected (Vuichoud & Loughlin, 2015). As the global population ages and life expectancy increases, the number of individuals with BPH and lower urinary tract symptoms (LUTS) is expected to increase, placing an additional burden on healthcare systems. Beyond direct urinary symptoms, BPH significantly impacts sleep quality, productivity, and overall quality of life, making it an important target for early identification, monitoring, and individualized management (Cai et al., 2019).

Initially, BPH was viewed as a hormonally influenced condition, specifically the balance of testosterone, dihydrotestosterone, and age-related endocrine changes. However, modern evidence suggests that its pathophysiology is much more complex. A growing body of research supports the concept that chronic, low-grade inflammation within prostate tissue plays a key role in the initiation

and progression of hyperplastic changes (Fibbi et al., 2010). Inflammatory infiltrates, consisting of lymphocytes, macrophages, neutrophils, and other immune cells, are frequently found in prostate specimens from symptomatic patients (Xiang et al., 2025). These immune cells release cytokines, chemokines, and *reactive oxygen species* which triggers epithelial proliferation, stromal remodeling, angiogenesis, and fibrosis, thus contributing to prostate enlargement and mechanical obstruction (Robert et al., 2009). Over time, this inflammatory microenvironment becomes self-perpetuating and reinforces local tissue damage.

Because prostate tissue sampling is invasive and impractical for routine monitoring, there is interest in non-invasive biomarkers that can reflect the level of inflammation. Complete blood count (CBC)-based inflammatory biomarkers are attractive candidates because they are inexpensive, readily available, and biologically relevant. These biomarkers *neutrophil-to-lymphocyte ratio* (NLR), *platelet-to-lymphocyte ratio* (PLR), and*monocyte- to lymphocyte ratio* (MLR) - provides insight into the systemic immune balance and the interaction of innate and adaptive immunity (Zahorec, 2021). Meanwhile, composite indexes such as*systemic immune inflammation index* (SII) and*systemic inflammatory response index* (SIRI) provides a broader picture of inflammatory activity (Yang et al., 2023).

Several clinical studies have reported that elevated inflammatory biomarkers may correlate with prostate volume, LUTS severity, risk of acute urinary retention, or comorbid metabolic disorders (Ozer et al., 2017). However, the available evidence remains predominantly analytical, with few studies providing detailed descriptive data on baseline inflammatory biomarker values in BPH populations. Most are from Western countries, and data on Southeast Asian populations are scarce (Ficarra et al., 2014). Without robust data, interpreting biomarker elevations is challenging and lacks appropriate clinical benchmarks (Wang et al., 2024). Therefore, this study was conducted to compare peripheral blood count-based inflammatory parameters (NLR, PLR, MLR, SII and SIRI) with Anatomical Pathology results in comparing BPH with and without inflammation.

METHOD

This study used a cross-sectional analytical design (*cross-sectional*) which aims to compare systemic inflammation parameters with anatomical pathology results in BPH patients at DR KH Idham Chalid Regional Hospital. FrameworkCross-sectional studies were chosen because they allow comprehensive assessment of biomarker levels at a single point in time, depicting each participant's inflammatory status during routine clinical evaluation without the need for longitudinal follow-up. The study was conducted at the Urology Department of Dr. KH Idham Chalid Regional General Hospital from June 2022 to February 2025 using the hospital's clinical database and laboratory information system. All laboratory analyses followed the standard procedures of the institution's accredited clinical pathology laboratory. The research subjects were BPH with total 334 patients who underwent prostate surgery and anatomical pathology examination. Subject selection was carried out using the random sampling method.*consecutive sampling* according to inclusion and exclusion criteria. Inclusion Criteria: 1)Patients with clinical and pathological diagnosis of BPH with or without nflammation; 2)Undergoing prostate surgery (e.g. TURP or open prostatectomy); 3)Have the results of anatomical pathology examination of prostate tissue; 4)Have complete pre-operative blood laboratory data. Exclusion Criteria: 1)Patients with prostate malignancy; 2)History of acute infection, autoimmune disease, or other malignancy; 3)History of use of systemic anti-inflammatory drugs or immunosuppressants; 4)Incomplete clinical or laboratory data. Demographic data were limited to patient age as the sole numeric characteristic collected. Laboratory variables were obtained directly from the CBC results and included hemoglobin, hematocrit, total leukocytes, platelets, leukocyte differential (%), and absolute neutrophil, lymphocyte, and monocyte counts. The inflammatory index is calculated using the following formula:

1. NLR = absolute neutrophil count / absolute lymphocyte count
2. PLR = platelet / lymphocyte absolute count

3. MLR = absolute monocyte count / absolute lymphocyte count
4. SII = platelets × absolute neutrophil count / absolute lymphocyte count
5. SIRI = absolute neutrophil count × absolute monocyte count / absolute lymphocyte count All calculations were performed consistently to ensure uniformity and reproducibility.

Method Laboratory: CBC examination is performed using*analyzer* automated hematology operated by laboratory personneltcertificationThe laboratory follows internal and external quality control procedures. Absolute count units are reported in $\times 10^3/\mu L$ according to hematology convention. No additional chemical or imaging biomarkers were analyzed. Data was analyzed using IBM'sStatistical Package for the Social Sciences (SPSS) version 26.0. Descriptive analysis was performed to describe the characteristics of the study subjects. Comparison tests were used to assess differences in inflammatory parameters between BPH groups with and without inflammation. Numerical data are presented as medians (interquartile ranges (IQR)). Student's t-test was used for continuous variables.distributednormal and Mann-Whitney U test are applied to continuous variables that are notdistributednormal. The diagnostic ability of each inflammatory parameter was evaluated using analysis*receiver operating characteristic* (ROC) to determine the value*area under the curve* (AUC), sensitivity, specificity, and optimal cut-off value. A p-value < 0.05 is considered statistically significant. Ethics approval was obtained from the institutional ethics committee with Ethical Clearance Number 112/KEPK-FK/VI/2026. The study used anonymized secondary data from medical records and laboratory systems, ensuring no patient-identifying information was collected. All procedures complied with the Declaration of Helsinki and the institutional privacy policy.

Table 1.
Baseline demographic characteristics and inflammatory biomarker profiles in patients with BPH

Variable	BPH	BPH with Inflammation	Unit
Demografi			
Usia	68(9)	68(10)	
Parameter Hematologi			
Hemoglobin median (IQR)	13.4(2)	13(2.4)	g/dL
Hematokrit median (IQR)	40(6.4)	39.7(8)	%
Leukosit median (IQR)	7.87(2.78)	10.22(4.10)	x10 /L
Trombosit median (IQR)	268(104)	305(109)	x10 /L
Leukocyte Diffrential (%)			
Neutrofil median (IQR)	58(12)	71(14)	%
Limfosit median (IQR)	28(10)	17(10)	%
Monosit median (IQR)	8(2)	7(3)	%
Eosinofil median (IQR)	4(4)	2(3)	%
Basofil median (IQR)	1(1)	0(1)	%
Absolute Differential Count			
Neutrofil Absolute median (IQR)	4570(2020)	7170(4480)	$x10^3/L$
Limfosit Absolute median (IQR)	2237(1050)	1832(1040)	$x10^3/L$
Monosit Absolute median (IQR)	602(250)	721(360)	$x10^3/L$

Table 2.
Relationship between inflammatory parameters in BPH patients without inflammation and with inflammation.

Inflammation Parameters	BPH median (IQR)	BPH with Inflammation (IQR)	p value
Neutrophil to lymphocyte ratio (NLR)	2.07(1.08)	4.11(3.47)	0.000
Platelet to lymphocyte ratio (PLR)	116.96(57.34)	181.98(112.2)	0.000
Monocyte to lymphocyte ratio (MLR)	0.27(0.13)	0.40(0.35)	0.000
Systemic immune inflammation index (SII)	558.57(367.52)	1364.21(1305.59)	0.000
Systemic inflammation response index (SIRI)	1.29(0.89)	2.82(4.02)	0.000

Table 3.
ROC curve analysis to determine the optimal cutoff level for NLR, PLR, MLR SII and SIRI in BPH patients with inflammation

Parameters	Cut-Off	Sensitivitas	Spesifisitas	AUC	CI	P value
Neutrophil to lymphocyte ratio (NLR)	3.48	61.7%	93.4%	0.829	0.783–0.876	0.000
Platelet to lymphocyte ratio (PLR)	81.19	96.4%	12.6%	0.753	0.701–0.804	0.000
Monocyte to lymphocyte ratio (MLR)	0.355	61.7%	79%	0.749	0.697–0.801	0.000
Systemic immune inflammation index (SII)	665	82%	64.1%	0.840	0.795–0.884	0.000
Systemic inflammation response index (SIRI)	1.80	76.6%	74.9%	0.822	0.776–0.868	0.000

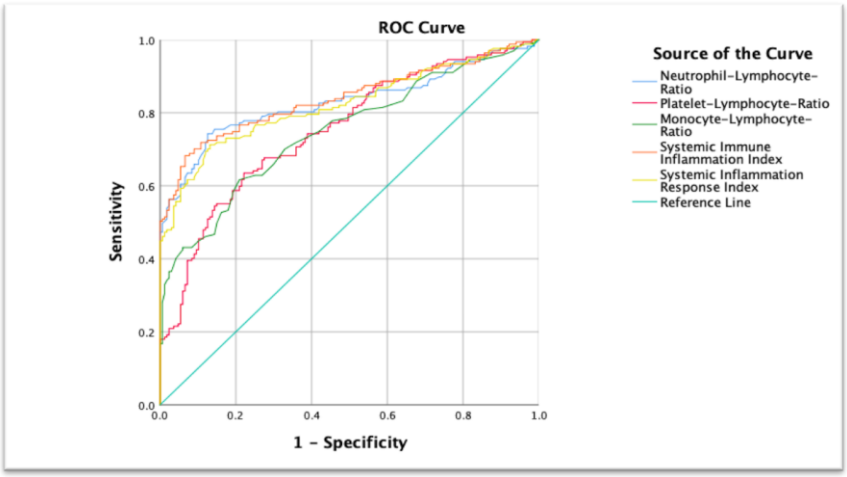

Figure 1 ROC curve analysis for NLR, PLR, MLR, SII, SIRI in BPH patients with inflammation

RESULT

This study involved BPH patients with and without inflammation based on anatomical pathology results. The median age of patients in the BPH group without inflammation was 68 (IQR 9) years, while in the BPH group with inflammation it was 68 (IQR 10) years, indicating relatively homogeneous age characteristics in both groups (Table 1). Baseline hematological parameters, including hemoglobin levels, hematocrit, and platelet counts, showed relatively comparable median values between the two groups. However, the total leukocyte count in the BPH group with inflammation appeared higher than in the group without inflammation. Differential leukocyte analysis showed that BPH patients with inflammation had a higher proportion and absolute number of neutrophils, accompanied by a lower proportion and absolute number of lymphocytes. Furthermore, the absolute monocyte count was also higher in the group with inflammation compared to the group without inflammation (Table 1).

All systemic inflammatory parameters were based on peripheral blood count, namely *Neutrophil to Lymphocyte Ratio* (NLR), *Platelet to Lymphocyte Ratio* (PLR), *Monocyte to Lymphocyte Ratio* (MLR), *Systemic Immune-Inflammation Index* (SII), and *Systemic Inflammation Response Index* (SIRI), showing a significantly higher median value at BPH patients with inflammation compared to BPH patients without inflammation. The difference was statistically significant for all inflammation parameters ($p < 0.001$) (Table 2). Analysis *Receiver Operating Characteristic* (ROC) showed that all systemic inflammation parameters had good discriminatory ability in differentiating BPH with and without inflammation. *Area Under the Curve* The highest (AUC) was obtained in SII

(AUC 0.840; CI 95%: 0.795–0.884), followed by NLR (AUC 0.829; CI 95%: 0.783–0.876) and SIRI (AUC 0.822; 95% CI: 0.776–0.868). The optimal cut-off values determined using the Youden index were 3.48 for NLR; 81.19 for PLR; 0.355 for MLR; 665 for SII; and 1.80 for SIRI. NLR showed the highest specificity (93.4%), while SII had the highest sensitivity (82%) in detecting inflammation in BPH patients (Table 3).

DISCUSSION

The results of this study indicate that systemic inflammatory parameters calculated from peripheral blood counts, such as NLR, PLR, MLR, SII, and SIRI, were significantly higher in BPH patients with inflammation compared to those without inflammation. This finding is consistent with evidence that inflammation plays a key role in the pathogenesis of BPH and can be reflected through non-invasive hematological indicators. Several previous studies support the role of NLR as an indicator of inflammation in BPH (Kang et al., 2021). For example, Kang et al. reported that the value of NLR High NLR levels were significantly associated with the presence of BPH, suggesting a possible effect of inflammation on the development of BPH. A large prospective study by Song et al. also found that higher NLR levels were associated with an increased risk of BPH in a population of adult men, strengthening the link between systemic inflammation and BPH (Shi et al., 2024).

In addition, associations between more complex inflammatory indices such as SII and PLR with BPH have also been reported cross-sectional NHANES data showed that high levels of PLR and SII were positively correlated with the risk of BPH in middle-aged and elderly individuals, which is consistent with our findings that SII and PLR were increased in BPH patients with inflammation. A study by Ahmed et al. also stated that SII, NLR, and PLR are significant inflammatory biomarkers in detecting inflammatory conditions in BPH patients, and can predict symptom severity and therapeutic response (Ahmed et al., 2023). This supports the ROC curve results in this study, which showed good diagnostic performance for these inflammatory parameters. Another study by Wu et al. extended this understanding by showing that NLR, SIRI, and SII were positively correlated with symptom severity. Lower Urinary Tract Symptoms (LUTS)/BPH, confirms that systemic inflammatory markers can reflect the clinical severity of BPH (Wu et al., 2025).

Biologically, the increase in neutrophils and decrease in lymphocytes reflected in the NLR and related indices reflects the activation of the innate immune response and the reduction of the adaptive immune response, which are characteristic of chronic inflammation. This explains the increased ratio of inflammation in the BPH group to inflammation, as it has also been shown in the literature that chronic inflammation can trigger the proliferation of prostatic stromal and epithelial cells that characterize BPH (Song et al., 2023). Thus, the results of this study not only corroborate previous evidence of the role of inflammation in BPH but also confirm that CBC-based systemic inflammatory parameters may be an effective and inexpensive biomarker for indirectly detecting prostate inflammation before histopathological confirmation. However, it is important to note that systemic inflammation has been linked to metabolic syndrome, obesity, insulin resistance, and cardiovascular disease, conditions that commonly coexist with BPH (Jiang et al., 2025). Future studies may explore whether inflammation-based BPH phenotypes overlap with metabolic or cardiovascular risk groups, allowing for a more holistic patient assessment.

CONCLUSION

Systemic inflammatory parameters based on peripheral blood counts, namely NLR, PLR, MLR, SII, and SIRI, were significantly higher in BPH patients with inflammation compared to BPH patients without inflammation. The SII, NLR, and SIRI indices were significantly higher in BPH patients with inflammation compared to BPH patients without inflammation. SIRI showed the best diagnostic ability in differentiating the two groups, with a value *cut-off* optimal biomarkers that can be used as non-invasive biomarkers to support anatomical pathology.

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