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Original Article

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The Relationship Between Malnutrition Defined by Prognostic Nutritional Index and Hematological Inflammatory Markers (Neutrophil-to-Lymphocyte Ratio, Platelet-to-Lymphocyte Ratio, and Systemic Immune–Inflammation Index): A Cross-Sectional Study in Patients with Chronic Kidney Disease

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ABSTRACT

Background: Chronic kidney disease (CKD) is often accompanied by systemic inflammation and malnutrition. This study aimed to evaluate whether hematological inflammatory markers—the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and systemic immune–inflammation index (SII)—are associated with nutritional status, as determined by the prognostic nutritional index (PNI) and to explore their potential predictive value in identifying patients at risk of malnutrition.

Methods: A total of 267 adult patients admitted to the nephrology outpatient clinic were included in this cross-sectional study. Malnutrition was defined using a PNI cut-off value of <42.3. Inflammatory markers were calculated from complete blood count parameters. Statistical analyses included group comparisons and correlation analyses between nutritional and inflammatory indices.

Results: Albumin levels were higher in females than males ($P = .031$), while other parameters did not differ by sex. No significant differences were observed among age groups. Anemic patients had higher white blood cell, NLR, PLR, and SII levels and lower albumin and PNI values compared with non-anemic patients (all $P < .001$). In multivariable linear regression, NLR and PLR were negatively associated with PNI, whereas SII showed a positive association (all $P < .001$). Logistic regression analysis showed that PLR was significantly associated with malnutrition (odds ratio (OR) = 1.015, $P = .003$). Receiver operating characteristic analysis demonstrated the highest discriminative ability for PLR (area under the curve (AUC) = 0.842), followed by NLR (AUC = 0.789) and SII (AUC = 0.717).

Conclusion: Inflammatory indices, particularly PLR and NLR, are significantly associated with nutritional status in CKD patients. These simple hematological markers may help identify patients at risk of malnutrition in routine clinical practice.

Keywords: Inflammation, malnutrition, neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, prognostic nutritional index, systemic immune–inflammation index

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INTRODUCTION

Chronic kidney disease (CKD) is a prevalent clinical condition characterized by the progressive and irreversible loss of kidney function and leads to increased morbidity and mortality. Controlling systemic inflammation in the early stages is crucial for slowing disease progression and extending life expectancy.[1] Furthermore, individuals suffering from chronic kidney failure need regular assessments for associated complications, including anemia, cardiovascular disease, bone mineral metabolism disorders, electrolyte and acid-base imbalances, dyslipidemia, and endocrine dysfunction.[2]

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Malnutrition is defined as a systemic condition characterized by changes in body composition due to inadequate nutrient intake. This can result in physical and cognitive impairment. The consequences of malnutrition can be significant, including immune deficiency, delayed wound healing, and an elevated risk of infection. In many cases, it can be a determining factor in the prognosis of chronic diseases. Serum albumin levels serve as an indirect indicator of protein reserves within the body. A deficiency in albumin has been shown to be clinically significant, particularly with regard to malnutrition and infection. Research conducted on hemodialysis patients has demonstrated that low albumin levels are significantly associated with mortality.[3]

The prognostic nutritional index (PNI) is a salient parameter in clinical practice, as it is a straightforward metric that can concurrently assess immune response, inflammation, and nutritional status. The PNI has been associated with survival in various diseases, particularly malignancies, and has begun to be evaluated as a supportive tool in clinical decision-making processes.[4]

However, indices such as the systemic immune–inflammation index (SII), neutrophil-to-lymphocyte ratio (NLR), and platelet-to-lymphocyte ratio (PLR), which are calculated based on common laboratory data such as complete blood count, are among the simple biomarkers reflecting systemic inflammation. The potential of such indices to predict the severity of inflammatory processes has attracted attention in recent years and has been the subject of research in various clinical fields.[5]

There is an increasing demand for non-invasive, rapid, cost-effective biomarkers in CKD. Index-based hematological parameters derived from routine blood tests may provide practical insights into inflammatory and nutritional status in clinical settings. The present study aims to investigate the relationship between PNI levels and systemic inflammatory parameters (NLR, PLR, and SII) in assessing malnutrition in adults, to reveal the effects of these indices on PNI, and to evaluate the potential of inflammation-based biomarkers in identifying patients at risk of malnutrition.

MAIN POINTS

- This study evaluated the relationship between prognostic nutritional index (PNI) and inflammatory indices (neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and systemic immune–inflammation index (SII) in chronic kidney disease patients.
- The PNI showed significant negative correlations with NLR, PLR, and SII.
- The PLR showed a significant association with malnutrition in logistic regression analysis.
- In receiver operating characteristic analysis, PLR showed the highest diagnostic performance for identifying malnutrition.

MATERIAL AND METHODS

Study Design, Ethical Approval, and Sample Size Calculation

This retrospective observational study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Clinical Research Ethics Committee of Tokat Gaziosmanpaşa University, Faculty of Medicine (project no: 23-KAEK-305 / document no: 83116987-047 / date: December 21, 2023). Written informed consent was obtained from all participants prior to data use. Chronic kidney disease was diagnosed by a board-certified nephrologist based on the KDIGO 2021 criteria, which define the disease as a estimated glomerular filtration rate (eGFR) below 60 mL/min/1.73 m^2 and/or persistent markers of kidney damage for at least 3 months.

To estimate the required sample size and statistical power, G*Power software (version 3.1.9.7; University of Düsseldorf, Germany) was used. The calculation, based on a previous study by Ercan et al,[6] determined that with an effect size of 0.40, an α error probability of 0.05, and a power (1–β) of 0.80, a minimum of 200 participants would be required to adequately test the study hypothesis.

Patient Population and Data Collection

Data were retrospectively collected from the hospital information management system and electronic medical records for patients who presented to the Internal Medicine Outpatient Clinic between February 1 and May 30, 2024. All laboratory values and clinical data were extracted from patient files by researchers independently. Those with acute infections, malignancies, decompensated cardiac or pulmonary diseases, recent major surgery, or missing/incomplete data were excluded from the analysis. Only patients who fully met the inclusion criteria were analyzed.

Clinical Outcome Data

Hematological parameters including white blood cell (WBC), red blood cell (RBC), hemoglobin (HGB), platelet (PLT), neutrophil (NEU), lymphocyte (LYM), and serum albumin levels were assessed, along with derived indices such as NLR, PLR, SII, and PNI. Hematological analyses were performed using the DYMIND DH-800 automated hematology analyzer, with all reagents and kits from the same manufacturer. Biochemical parameters, including albumin, were analyzed using the Alinity-c series automated analyzer (Abbott, USA). All measurements were conducted following standard laboratory protocols.

Hematological inflammatory parameters, including the NLR, PLR, and SII, were evaluated as potential indicators of clinical status. In addition, HGB levels were assessed to determine anemia. Anemia was defined according to World Health Organization (WHO) criteria as a HGB concentration of <13.0

g/dL in men and <12.0 g/dL in women, and participants were accordingly classified as anemic or nonanemic.

Nutritional status was evaluated using the PNI, calculated based on serum albumin concentration and total LYM. Malnutrition was defined as a PNI score <42.3, in line with the threshold proposed by Chen et al[7]iAccordingly, patients were categorized as malnourished or well-nourished, and these classifications were used in subsequent statistical analyses.

Statistical Analysis

Statistical analyses were performed using SPSS software (version 22.0; IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation, and categorical variables as frequency and percentage. Normality was assessed using the Kolmogorov–Smirnov test. Group comparisons were made using independent samples *t*-tests or 1-way analysis of variance, depending on the number of groups. Chi-square tests were used for categorical variables.

Correlations between the PNI and inflammatory markers (NLR, PLR, SII) were assessed using Pearson's correlation. Multiple linear regression was used to identify independent predictors of PNI.

To evaluate the diagnostic performance of NLR, PLR, and SII for malnutrition, receiver operating characteristic (ROC) curve analysis was performed. The area under the curve (AUC), cut-off values, sensitivity, and specificity were reported. Binary logistic regression was also used to assess the association of these markers with malnutrition, and results were expressed as odds ratios (ORs) with 95% CIs. A *P* value <.05 was considered statistically significant.

RESULTS

Among the 267 participants, 50.6% (n = 135) were female and 49.4% (n = 132) were male. Regarding age distribution, 24.7% (n = 66) were under 45 years, 69.3% (n = 185) were between 45 and 64 years, and 6.0% (n = 16) were 65 years or older. In terms of anemia status, 47.6% (n = 127) of the patients were anemic, whereas 52.4% (n = 140) were nonanemic. According to the PNI classification, 6.7% (n = 18) of the patients were identified as malnourished, while 93.3% (n = 249) were considered well nourished.

Table 1 presents the descriptive statistics of the continuous variables included in the study. The mean age of the participants was 51.56 ± 11.72 years (range: 17–65 years). The mean values of the hematological parameters were as follows: WBC 8.25 ± 2.63 $\times10^9$/L, RBC 4.49 ± 0.71 $\times10^{12}$/L, HGB 12.59 ± 2.04 g/dL, PLT 269.09 ± 78.26 $\times10^9$/L, NEU 5.27 ± 2.12 $\times10^9$/L, and LYM 2.21 ± 0.89 $\times10^9$/L. The mean serum albumin level was 41.66 ± 4.78 g/L, and the mean PNI was 52.7 ± 6.84. Among the inflammatory markers, the mean values were 2.72 ± 1.50 for NLR, 137.94 ± 62.65 for PLR, and 700.85 ± 363.8 $\times10^9$/L for SII.

Table 1. Descriptive Statistics and Distribution Characteristics of Laboratory and Clinical Variables

	Mean ± SD	Minimum-Maximum	Skewness	Kurtosis
Age (years)	51.56 ± 11.72	17-65	−0.969	0.139
WBC ($\times10^9$/L)	8.25 ± 2.63	1.86-21.92	1.087	1.950
RBC ($\times10^{12}$/L)	4.49 ± 0.71	2.49-6.67	−0.138	−0.007
HGB (g/dL)	12.59 ± 2.04	7.4-17.6	0.099	−0.349
PLT ($\times10^9$/L)	269.09 ± 78.26	74-587	0.912	2.007
NEU ($\times10^9$/L)	5.27 ± 2.12	0.4-17.5	1.665	2.010
LYM ($\times10^9$/L)	2.21 ± 0.89	0.43-6.92	1.139	1.781
Albumin (g/L)	41.66 ± 4.78	21.77-53	−1.410	1.642
PNI	52.7 ± 6.84	29.07-74.6	−0.489	1.353
NLR	2.72 ± 1.5	0.53-10.18	1.884	1.994
PLR	137.94 ± 62.65	41.18-450.64	1.947	1.837
SII ($\times10^9$/L)	700.85 ± 363.8	144.76-1799.15	0.943	0.393

Albumin, serum albumin level; HGB, hemoglobin; LYM, lymphocyte count; NEU, neutrophil count; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; PLT, platelet count; PNI, prognostic nutritional index; RBC, red blood cell count; SII, systemic immune–inflammation index; WBC, white blood cell.

Table 2 presents the comparison of hematological and inflammatory parameters according to sex, age group, and anemia status. Among the evaluated variables, serum albumin levels were significantly higher in females compared with males (*P* = .031), while no significant sex-related differences were observed for WBC, PNI, NLR, PLR, or SII. When stratified by age group, none of the parameters showed statistically significant differences. In contrast, anemia status was significantly associated with all evaluated variables. Anemic patients had significantly higher WBC, NLR, PLR, and SII levels, while albumin and PNI values were significantly lower compared with non-anemic patients (all *P* < .001).

Pearson correlation analysis demonstrated statistically significant negative correlations between PNI and NLR (r = −0.533), PLR (r = −0.567), and SII (r = −0.388) (*P* < .001 for all). Correlation coefficients were calculated using Pearson's method, and a *P* value less than .05 was considered statistically significant. Correlation results were not presented in a table.

According to the multiple linear regression analysis (Table 3), NLR, PLR, SII, and anemia status were significantly associated with PNI. Both NLR (β = −0.568, *P* < .001) and PLR (β = −0.453, *P* < .001) showed significant negative associations with PNI, indicating that higher values of these inflammatory markers were related to lower PNI scores. In contrast, SII demonstrated a positive association with PNI (β = 0.366, *P* < .001). Additionally, the presence of anemia was independently associated with lower PNI values (β = −0.119, *P* = .016). Sex and age groups were not significantly associated with PNI in the adjusted model. Overall,

Table 2. Comparison of Hematological and Inflammatory Parameters According to Sex, Age Group, and Anemia Status (n = 267)

		WBC (×10⁹/L)	Albumin (g/L)	PNI	NLR	PLR	SII (×10⁹/L)
Gender	Female	8.31 ± 2.68	42.29 ± 4.81	53.09 ± 6.95	2.84 ± 1.68	134.19 ± 65.42	696.02 ± 380.22
	Male	8.2 ± 2.58	41.02 ± 4.67	52.3 ± 6.73	2.6 ± 1.29	141.77 ± 59.7	705.79 ± 347.58
P		.719	**.031***	.342	.194	.324	.827
Age, years	Under 45	8.14 ± 3.07	42.65 ± 4.1	53.05 ± 5.95	2.81 ± 1.55	150.06 ± 72.25	704.61 ± 323.35
	45-64	8.25 ± 2.51	41.42 ± 4.82	52.67 ± 6.97	2.66 ± 1.44	131.97 ± 53.34	689.68 ± 363.93
	65 and over	8.72 ± 2.06	40.36 ± 6.3	51.56 ± 8.84	3.08 ± 1.98	156.93 ± 103.09	814.45 ± 503.86
P		.730	.108	.735	.473	.060	.420
Anemic	Anemic	8.39 ± 2.4	40.43 ± 5.08	50.4 ± 6.77	3.06 ± 1.65	158.33 ± 74.54	780.77 ± 383.65
	Not anemic	8.11 ± 2.86	42.78 ± 4.19	54.78 ± 6.23	2.41 ± 1.28	119.45 ± 41.84	628.35 ± 329.73
P		**<.001***	**<.001***	**<001***	**<.001***	**<.001***	**<.001***

Values are presented as mean ± standard deviation (SD). *P* values were calculated using the independent samples *t*-test or ANOVA. Statistically significant results ($P < .05$) are indicated with an asterisk (*).
Albumin, serum albumin level; WBC, white blood cell; BC, bladder cancer; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; PNI, prognostic nutritional index; SII, systemic immune–inflammation index.

the regression model explained 45.6% of the variance in PNI (R^2 = 0.456; adjusted R^2 = 0.441, $P < .001$).

In the binary logistic regression analysis evaluating predictors of malnutrition (Table 4), PLR was identified as an independent predictor (OR = 1.015, 95% CI: 1.005-1.025, $P = .003$). In contrast, NLR, SII, sex, age groups, and anemia status were not significantly associated with malnutrition risk in the multivariable model.

As shown in Tables 5 and 6and Figure 1, PLR demonstrated the highest diagnostic performance in predicting malnutrition, with an AUC of 0.842. NLR also showed good discriminative ability (AUC = 0.789), whereas SII showed a lower predictive performance (AUC = 0.717). The optimal cutoff values determined by the Youden index were >133.17 for PLR, >2.6 for NLR, and >886.96 for SII. In the DeLong test comparing the ROC curves, no statistically significant differences were observed between the AUC values of NLR and PLR ($P = .137$), NLR and SII ($P = .160$), or PLR and SII ($P = 0.066$).

DISCUSSION

The present study demonstrated that hematological inflammatory indices particularly the NLR and PLR—are significantly

Table 3. Results of the Multiple Linear Regression Analysis Examining the Association Between Inflammatory Markers and PNI, Adjusted for Sex, Age, and Anemia Status

Model	B	SD	β (Beta)	*t*	*P*	CI (95%) Lower	CI (95%) Upper	VIF
NLR	−2.585	0.376	−0.568	−6.876	**<.001***	−3.325	−1.845	3.246
PLR	−0.049	0.007	−0.453	−7.212	**<.001***	−0.063	−0.036	1.881
SII	0.007	0.002	0.366	4.149	**<.001***	0.004	0.01	3.708
Gender	−0.955	0.644	−0.07	−1.482	.140	−2.223	0.314	1.06
Age (Under 45)	1.094	1.433	0.069	0.764	.446	−1.727	3.915	3.903
Age (45-64)	−0.457	1.339	−0.031	−0.341	.733	−3.093	2.18	3.899
Anemic	−1.623	0.67	−0.119	−2.423	**.016***	−2.942	−0.304	1.144
Intercep	63.019	1.549		40.678	<.001	59.968	66.069	
$R = 0.675$	$R^2 = 0.456$		Adj. $R^2 = 0.441$		DurbinWatson: 2.089		F (7.266) = 31.038 $P < .001$*	

B, unstandardized coefficient; β, standardized coefficient; VIF, variance inflation factor.
P values were obtained from the multiple linear regression model. A *P* value less than .05 was considered statistically significant.
Reference categories: Female (for sex), age 65 and over years (for age), and non-anemic (for anemia status).

Table 4. Binary Logistic Regression Analysis of Factors Associated with Malnutrition Defined by PNI (n = 267)

Parameters	B	S.E.	*P*	Exp(B)	95% CI for Exp(B)	
					Lower	Upper
NLR	0.285	0.245	.245	1.330	0.822	2.151
PLR	0.015	0.005	**.003***	1.015	1.005	1.025
SII	-0.001	0.001	.475	0.999	0.997	1.001
Gender	0.207	0.587	.724	1.231	0.389	3.89
Age (45-64), years	1.952	1.026	.057	7.043	0.942	52.65
Age (65 and over), years	2.476	1.279	.053	11.892	0.969	145.981
Anemic	0.999	0.712	.161	2.714	0.672	10.96
Intercept	-5.669	1.009	<.001	0.003		
R^2 = 0.119 (Cox & Snell R Square) R^2 = 0.305 (Nagelkerke)			χ^2 (7) = 33.838; *P* < .001* (Omnibus)		χ^2 (8) = 4.699; *P* = .789 (Homers & Lemeshow)	

B, Regression coefficient; S.E., standard error; Exp(B), odds ratio.
P values were calculated using binary logistic regression analysis, and a *P* value <.05 was considered statistically significant.
Malnutrition was defined as a PNI score <42.3. The dependent variable was nutritional status (1 = malnourished, 0 = well-nourished).
Independent variables included NLR, PLR, SII, sex, age group (under 45, 45–64, 65 and over), and anemia status.
Reference categories were female (for sex), age under 45 years (for age group), and non-anemic (for anemia status).

associated with malnutrition, as defined by the PNI, in patients with CKD. Among these markers, PLR demonstrated the highest diagnostic accuracy (AUC = 0.842), followed by NLR (AUC = 0.789) and SII (AUC = 0.717), as shown by ROC curve analysis. However, DeLong test comparisons showed that the differences between the AUC values of NLR, PLR, and SII were not statistically significant. In comparison, SII exhibited lower discriminative capacity, suggesting that its predictive performance may be limited when used in isolation for the assessment of nutritional risk.

Malnutrition is a known and clinically significant complication among patients with CKD. Its reported prevalence varies considerably depending on the diagnostic criteria and the study population. The condition is characterized by a multifactorial etiology, involving inadequate nutrient intake, metabolic alterations, and chronic inflammation, all of which contribute to protein–energy wasting. Numerous studies have demonstrated that malnutrition is closely linked to adverse clinical outcomes, including higher morbidity, cardiovascular events, and all-cause mortality in CKD populations.[8] Given its profound impact on disease progression and patient survival, the accurate recognition and assessment of nutritional status in CKD are essential components of comprehensive care aimed at improving quality of life and long-term prognosis.[9]

Notwithstanding its clinical importance, there is currently no universally accepted gold standard for the assessment of malnutrition in patients with CKD. According to the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative guidelines, an accurate evaluation of nutritional status requires a comprehensive interpretation that integrates both clinical and biochemical parameters. A comprehensive clinical assessment should encompass a meticulous medical history and physical examination, a thorough evaluation of dietary intake, anthropometric measurements, and body composition analysis. Furthermore, laboratory markers such as plasma protein concentrations, serum cholesterol levels, blood urea nitrogen, and serum creatinine play a crucial role in reflecting metabolic and nutritional status.[10] However, these traditional methods can be time-consuming and resource-intensive, leading to the need for simpler and more accessible indices that combine inflammatory and nutritional components to provide a holistic view of patient health.

Table 5. ROC Analysis

Variable	AUC	SE	95% CI	Youden Index J	Cut-off	Sensitivity	Specificity
NLR	0.789	0.0381	0.735-0.836	0.5710	>2.6	94.44	62.65
PLR	0.842	0.0405	0.793-0.884	0.5509	>133.17	94.44	60.64
SII	0.717	0.0693	0.659-0.771	0.4418	>886.96	66.67	77.51

AUC, area under the curve; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SE, standard error.

Table 6. DeLong Test

AUC-1	AUC-2	DBA	SE	95% CI	*P*
NLR	PLR	0.053	0.036	−0.0171-0.124	.137
NLR	Sİİ	0.072	0.051	−0.0284-0.171	.160
PLR	Sİİ	0.125	0.068	−0.0085-0.258	.066

AUC, area under the curve; AUC-1, area under the curve for the first variable; AUC-2, area under the curve for the second variable; DBA, difference between areas; NLR, neutrophil-to-lymphocyte ratio; P, DeLong's test; PLR, platelet-to-lymphocyte ratio; SE, standard error; SII, systemic immune–inflammation index.

The evidence that has been accumulated thus far underscores the intricate bidirectional relationship between inflammation and malnutrition in CKD. The prevailing concept in the field is that chronic, low-grade inflammation plays a pivotal role in the development of protein–energy wasting and the deterioration of clinical outcomes.[11] The PNI—calculated as [10 × serum albumin (g/dL)] + [0.005 × total LYM (/mm^3)]—offers a practical and integrative measure that reflects both immunological and nutritional dimensions. However, because serum albumin levels may also be influenced by inflammatory processes, PNI should be interpreted with caution when used as a nutritional indicator in CKD populations. Nevertheless, recent studies have indicated an association between lower PNI values and adverse kidney and cardiovascular outcomes, underscoring its potential relevance for risk stratification in nephrology practice.[12] Collectively, these observations reinforce the concept that inflammation and malnutrition represent interconnected processes that should be evaluated concurrently in CKD management. Importantly, PNI cut-off values are not standardized and may vary across different clinical populations and study settings; therefore, the threshold applied in individual studies should be interpreted within the context of the specific patient population being evaluated.[13]

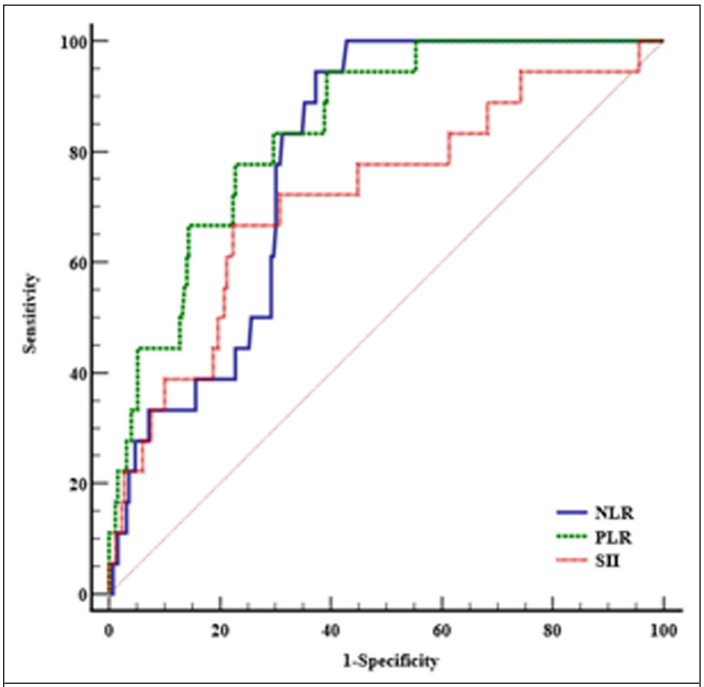

Figure 1. Receiver operating characteristic (ROC) curves illustrating the diagnostic performance of neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and systemic immune–inflammation index (SII) for malnutrition in patients with chronic kidney disease. PLR showed the highest area under the curve (AUC = 0.842), followed by NLR (AUC = 0.789) and SII (AUC = 0.717). NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SII, systemic immune–inflammation index.

Our study's findings indicate that hematologic ratios derived from routine blood counts provide valuable insight into the inflammatory and nutritional dynamics of CKD. Qiu et al[14] identified the monocyte-to-lymphocyte ratio (MLR) as an independent predictor of short-term mortality in CKD patients, thereby reinforcing the prognostic significance of inflammation-based hematologic indices. Similarly Elangovan et al[15] discovered that all significant inflammatory indices, encompassing NLR, PLR, MLR, SII, and the systemic inflammation response index (SIRI), exhibited a progressive escalation across CKD stages, thereby reflecting an escalating inflammatory burden concomitant with the progression of kidneydysfunction. Collectively, these results emphasize the importance of integrating simple yet sensitive hematological indices into the clinical assessment of CKD patients, as they offer an accessible means of capturing the dual impact of inflammation and nutritional deterioration.

In the present analysis, inverse correlations were observed between PNI and inflammatory indices such as NLR, PLR, and SII, suggesting that higher inflammatory activity is closely associated with poorer nutritional status in CKD patients. This negative relationship serves to reinforce the prevailing concept that inflammation and malnutrition represent 2 interdependent processes within the spectrum of kidney dysfunction. Zhou et al[16] demonstrated that an elevated MLR was independently associated with higher levels of inflammatory markers, including high-sensitivity C-reactive protein (hsCRP) and interleukin-6, as well as with reduced eGFR. The present findings highlight the close association between systemic inflammation and declining kidney function, wherein chronic immune activation may contribute to protein catabolism and deterioration of nutritional reserves. These results underscore the importance of hematological indices such as the NLR and the PLR in not only reflecting systemic inflammation but also serving as accessible surrogate markers for identifying patients at risk of inflammation-induced malnutrition in CKD. The present findings contribute to the mounting corpus of evidence that systemic inflammation is closely linked to the development of malnutrition in CKD populations.[17,18]

Anemia showed a significant association with nutritional status, with anemic patients demonstrating lower PNI values compared with non-anemic individuals. This finding is consistent with previous studies reporting poorer nutritional status among patients with CKD who have anemia.[19,20] The coexistence of anemia and

malnutrition in CKD may reflect shared underlying mechanisms, including chronic inflammation, impaired erythropoiesis, and metabolic disturbances. Petrović et al[21] reported that hematologic inflammatory indices, including NLR, PLR, SII, and SIRI, were associated with the severity of kidney dysfunction and correlated with anemia, phosphorus, and calcium abnormalities. Likewise, Li et al[22] demonstrated that the SIRI was independently associated with CKD prevalence, albuminuria, and reduced eGFR in a large population-based study. These findings suggest that inflammation-related hematological indices may reflect multiple overlapping metabolic and inflammatory disturbances in CKD. Collectively, these observations support the concept that systemic inflammation may represent a shared pathophysiological mechanism linking nutritional impairment, anemia, and metabolic dysregulation in patients with CKD.

Limitations

It is imperative to acknowledge the limitations of this study when interpreting the findings. Firstly, the cross-sectional design precludes the establishment of causal relationships between inflammatory markers and nutritional status, as the directionality of these associations cannot be determined. Secondly, the study was conducted in a single center with a limited sample size, which may affect the generalizability of the results to broader CKD populations. Furthermore, potential confounding variables, including CKD stage, body mass index, comorbidities, CRP levels, medication use, dietary intake, and socioeconomic factors, were not thoroughly evaluated, which could have influenced both inflammatory and nutritional parameters. Finally, the assessment of inflammatory markers was based on single laboratory measurements, which may not adequately capture temporal changes in systemic inflammation. In addition, the PNI cut-off value used to define malnutrition was derived from previous studies and may not fully reflect stage-specific nutritional risk across different CKD populations. Notwithstanding these limitations, the present results are consistent with the expanding body of evidence indicating that hematological indices provide useful insights into the relationship between inflammation and nutritional status in CKD patients.

The present study demonstrated that hematologic inflammatory markers, particularly NLR and PLR, are significantly associated with malnutrition as defined by PNI in patients with CKD. Among the indices evaluated, NLR demonstrated the highest diagnostic accuracy, while PLR was identified as an independent predictor of malnutrition in logistic regression analysis. The findings indicate that an elevated inflammatory burden is closely linked to impaired nutritional and immune balance in CKD, reflecting the interaction between chronic inflammation, metabolic alterations, and protein–energy wasting. Consequently, NLR and PLR may provide useful and easily obtainable indicators for identifying patients who may be at increased risk of malnutrition, especially in clinical settings where comprehensive nutritional assessments are not feasible.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Artificial Intelligence Usage Statement: This study used DeepL Translate for language editing during the preparation of the manuscript. The authors take full responsibility for the accuracy, interpretation, and integrity of the content.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Tokat Gaziosmanpaşa University (Approval no: 83116987-047, Date: December 21, 2023).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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