Am J Transl Res 2026;18(11):9780-9792
www.ajtr.org /ISSN:1943-8141/AJTR0175275

*Original Article*

# Admission inflammatory indices correlate with liver/kidney function injury in patients with preeclampsia

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Received July 9, 2026; Accepted September 17, 2026; Epub November 15, 2026; Published November 30, 2026

**Abstract:** Background: Preeclampsia (PE) is a pregnancy-specific disorder driven by systemic inflammation and endothelial dysfunction, commonly resulting in liver and kidney injury. The neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), monocyte-to-lymphocyte ratio (MLR), and systemic immune-inflammation index (SII) are cost-effective inflammatory biomarkers, but their relationship with organ function recovery in PE remains unclear. Objective: To evaluate the correlations of admission NLR, PLR, MLR, and SII with recovery of liver and kidney function in PE patients, and to assess their predictive value. Methods: This retrospective case-control study included 100 PE patients and 100 normal pregnant women. Admission inflammatory indices and discharge creatinine (Cr) and alanine aminotransferase (ALT) were analyzed using Spearman correlation, multivariate linear regression, logistic regression, and ROC curve analysis. Results: All four indices were significantly higher in PE patients (all $P<0.001$). NLR and SII correlated positively with discharge Cr ($r=0.400$ and 0.278, respectively) and with discharge ALT ($r=0.418$ and 0.457, respectively). After full covariate adjustment, NLR, PLR, and SII independently predicted discharge Cr, while all four predicted discharge ALT. NLR was an independent predictor of poor renal recovery (OR=0.725, $P=0.006$); NLR, PLR, and SII were predictors of poor hepatic recovery. ROC-AUC values for predicting discharge ALT>40 U/L were 0.708 (NLR), 0.767 (PLR), 0.698 (MLR), and 0.743 (SII). Conclusions: Admission inflammatory indices, especially PLR and SII, are independently associated with liver and kidney recovery and show moderate predictive value for hepatic dysfunction, suggesting they may serve as early prognostic tools for PE patients at risk of poor organ recovery.

**Keywords:** Preeclampsia, inflammatory indices, neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, monocyte-to-lymphocyte ratio, systemic immune-inflammation index, liver function, kidney function, prognosis, predictive value

## Introduction

Preeclampsia (PE) is a multisystem syndrome specific to pregnancy, characterized by new-onset hypertension and proteinuria after 20 weeks of gestation. With a global incidence of 2%-8%, it is one of the leading causes of maternal and perinatal deaths [1, 2]. Although the etiology of PE has not been fully elucidated, placental ischemia, oxidative stress, endothelial dysfunction, and systemic inflammatory response play central roles in its pathogenesis [3, 4]. If not promptly identified and treated, PE can progress to severe preeclampsia, HELLP syndrome, or eclampsia, and even threaten maternal and infant lives. Liver and kidney dysfunction are among the most common serious complications of PE [5].

The liver and kidneys are among the organs most frequently affected by PE. Liver dysfunction is characterized by elevated alanine aminotransferase (ALT), aspartate aminotransferase (AST), and lactate dehydrogenase (LDH), and may progress to subcapsular hematoma or liver rupture in severe cases. Renal dysfunction is characterized by proteinuria, elevated serum creatinine (Cr), and abnormal uric acid (UA) [6, 7]. Currently, the assessment of liver and kidney function impairment in PE patients relies mainly on routine biochemical tests, but these markers usually become significantly abnormal only after organ injury has occurred, offering little early warning value [8, 9]. Therefore, we need simple, cost-effective, and reproducible biomarkers that can identify early liver and kidney function impairment and predict their recovery.

https://doi.org/10.62347/TEKU1808

In recent years, peripheral blood inflammatory indices have received widespread attention due to their convenience, availability, and low cost. The neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), monocyte-to-lymphocyte ratio (MLR), and systemic immune-inflammation index (SII) are composite markers that stably reflect the systemic inflammatory status and are derived solely from routine admission blood counts, incurring no extra cost [5, 10, 11]. Studies have shown that NLR, PLR, and SII have good prognostic predictive value in various cardiovascular diseases, tumors, and inflammatory diseases [12, 13]. In obstetrics, several studies have confirmed that peripheral blood NLR, PLR, and other indices are significantly higher in PE patients than in normal pregnant women and are associated with disease severity [14-16]. However, it remains unclear whether admission inflammatory indices can predict the recovery of liver and kidney function by discharge [17].

Against this background, this study retrospectively analyzed the clinical data of 100 patients with preeclampsia and 100 normal pregnant women to evaluate systematically the associations of admission peripheral blood inflammatory indices (NLR, PLR, MLR, SII) with liver and kidney dysfunction at admission and with functional recovery at discharge. The study aims: (1) to compare the differences in admission inflammatory indicators between the PE group and the normal pregnancy group; (2) to analyze the correlation between admission inflammatory indicators of PE patients and Cr and ALT at discharge; (3) to evaluate the predictive value of admission inflammatory indicators for poor recovery of liver and kidney function. We hypothesized that higher admission inflammatory indices would be associated with poorer recovery of liver and kidney function at discharge, and could be predictors of liver and kidney injury recovery in PE patients, providing a basis for clinical early risk stratification and individualized treatment.

## Materials and methods

### *Research design and ethical review*

This was a single-center retrospective case-control study. The study subjects were pregnant women who delivered in the Obstetrics Department of Zhenhai District People's Hospital from January 2024 to May 2026. All clinical data were retrospectively extracted from the hospital's electronic medical record system. This study was approved by the Ethics Committee of Zhenhai District People's Hospital. All procedures performed in this study involving human participants were in accordance with the Declaration of Helsinki (as revised in 2013).

### *Research subjects*

Inclusion criteria for the PE group: (1) Singleton pregnancy; (2) Age 18-45 years; (3) Met the diagnostic criteria for preeclampsia according to the "Guidelines for Diagnosis and Treatment of Hypertensive Disorders in Pregnancy": (a) new-onset systolic blood pressure (BP) ≥140 mmHg and/or diastolic BP ≥90 mmHg after 20 weeks of gestation, with proteinuria ≥0.3 g/24 h or a random urine protein-to-creatinine ratio ≥30 mg/mmol; or (b) in the absence of proteinuria, presence of liver dysfunction, renal dysfunction, thrombocytopenia, pulmonary edema, or new-onset cerebral or visual disturbances; (4) Completed blood routine, liver and kidney function, and urine protein quantification tests within 24 hours of admission; (5) Completed blood routine and liver and kidney function tests within 24 hours before discharge.

Normal pregnancy group: (1) Singleton pregnancy; (2) Age 18-45 years; (3) Normal pregnant women hospitalized during the same period (e.g., for elective cesarean section or repeat cesarean section); (4) No hypertension (intrapregnancy systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg); (5) No proteinuria (urine protein qualitative test negative); (6) Completed blood routine, liver and kidney function, and urine protein quantification tests within 24 hours of admission; (7) Completed blood routine and liver and kidney function tests within 24 hours before discharge. The study selection process is shown in **Figure 1**.

Exclusion criteria: (1) Multiple pregnancies; (2) History of chronic hypertension or diagnosed hypertension before pregnancy; (3) Chronic kidney disease; (4) Chronic liver disease; (5) Autoimmune diseases; (6) Diabetes during pregnancy or pre-pregnancy diabetes; (7) Clear signs of infection within one week before admission (body temperature ≥38°C, white

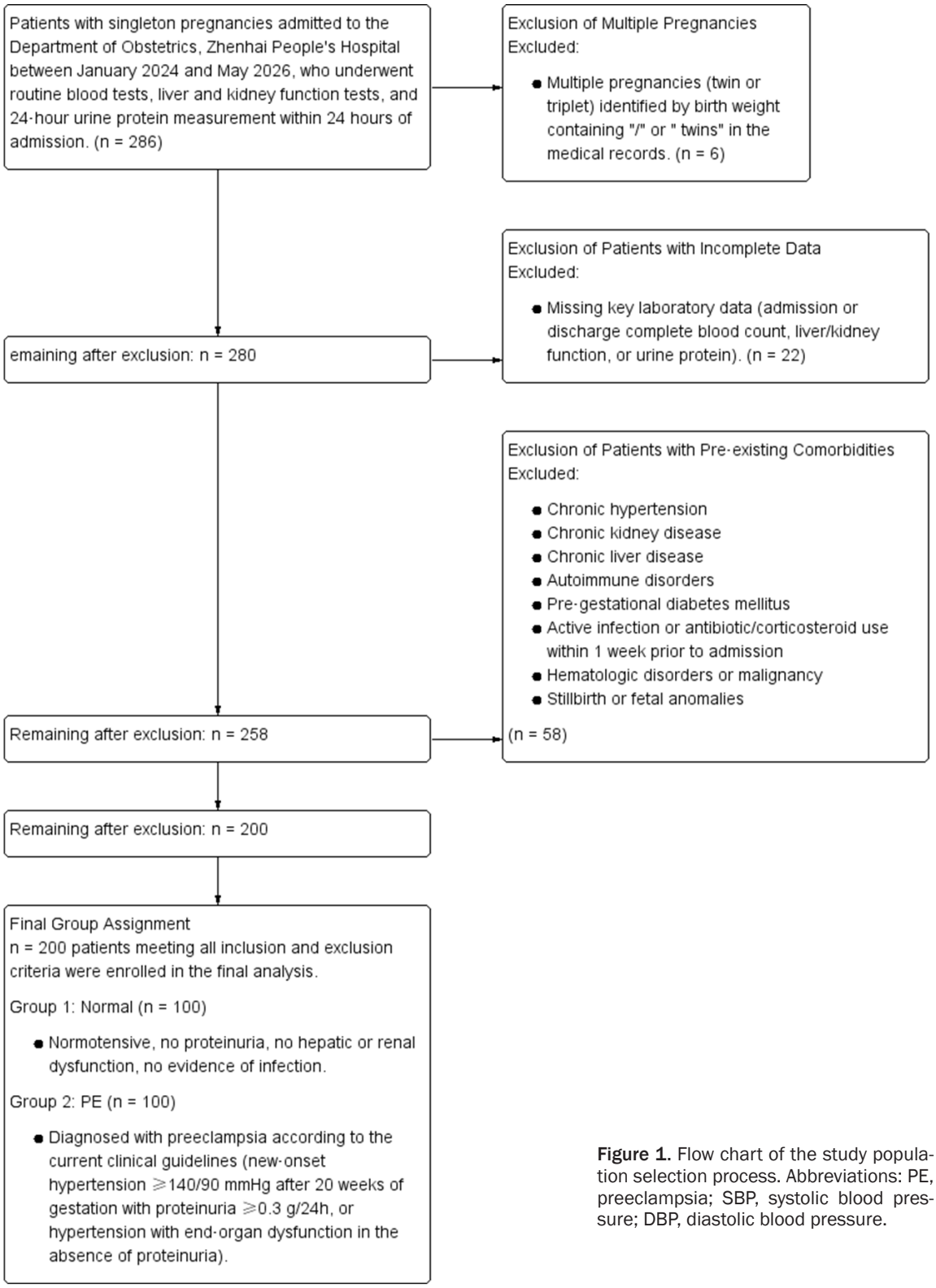



**Figure 1.** Flow chart of the study population selection process. Abbreviations: PE, preeclampsia; SBP, systolic blood pressure; DBP, diastolic blood pressure.

blood cell count >15 × $10^9$/L, or C-reactive protein >10 mg/L); (8) History of antibiotic or glucocorticoid use within one week before admission; (9) Hematological diseases; (10) Malignant

tumors; (11) Congenital fetal malformations or stillbirth; (12) Severe missing clinical data.

*Data collection and variable definition*

All data were uniformly extracted by the researchers from the electronic medical record system and recorded using a standardized data collection form.

*Baseline data:* Age, height, pre-pregnancy weight, pre-pregnancy BMI, gestational weeks at delivery, number of pregnancies, number of deliveries, admission systolic and diastolic blood pressure, use of magnesium sulfate, use of antihypertensive drugs, mode of delivery, newborn birth weight and 1-minute Apgar score. Length of hospital stay was calculated as the difference between discharge and admission dates, extracted from the electronic medical record.

*Laboratory indicators:* Blood routine indicators: White blood cell count (WBC) at admission and before discharge: neutrophil (NEUT), lymphocyte (LYMPH), monocyte (MONO), and platelet (PLT) counts.

Liver function indicators: Alanine aminotransferase (ALT), aspartate aminotransferase (AST), lactate dehydrogenase (LDH) at admission and last test before discharge.

Renal function indicators: Serum creatinine (Cr), urea nitrogen (BUN), uric acid (UA) at admission and last test before discharge.

Urine protein: 24-hour urine protein quantification (g/24 h) and qualitative urine protein test at admission and before discharge.

*Comprehensive inflammatory indicators:* The following inflammatory indices were calculated from admission blood counts: Neutrophil/lymphocyte ratio (NLR) = NEUT/LYMPH; Platelet/lymphocyte ratio (PLR) = PLT/LYMPH; Monocyte/lymphocyte ratio (MLR) = MONO/LYMPH; Systemic immune inflammation index (SII) = PLT × NEUT/LYMPH.

*Paired data:* The Cr and ALT at admission and before discharge were paired for analysis. The change was calculated as discharge value minus admission value. The percentage decrease was defined as (admission value - discharge value)/admission value × 100%.

*Grouping*

Normal pregnancy group (Normal Group): Pregnant women who met the inclusion criteria for normal pregnancy and did not meet any exclusion criteria.

Preeclampsia group (PE Group): Patients who met the diagnostic criteria for preeclampsia and did not meet any exclusion criteria.

*Outcome definitions*

(1) Good renal recovery: discharge Cr decreased by ≥10% from admission; (2) Poor renal recovery: discharge Cr decreased by <10% or increased from admission; (3) Good liver function recovery: The ALT level at discharge decreased by ≥10% compared to that at admission (ALT_drop_pct ≥10%); (4) Poor liver function recovery: The ALT level at discharge decreased by <10% or increased (ALT_drop_pct <10%); (5) Abnormal liver function: The ALT level at discharge was >40 U/L (used for ROC curve analysis).

*Statistical analysis*

Statistical analysis was conducted using SPSS 26.0 and R 4.2.1. Continuous variables were first tested for normality using the Shapiro-Wilk test. Normally distributed variables were presented as mean ± SD and compared using independent t-tests. Non-normally distributed variables were presented as median (IQR) and compared using Mann-Whitney U tests. Paired data (admission vs. discharge) were analyzed using Wilcoxon signed-rank test. Categorical variables were presented as numbers (percentages) and compared using chi-square or Fisher's exact test.

Spearman rank correlation analysis was used to evaluate the correlation between admission inflammatory indicators (NLR_admit, PLR_admit, MLR_admit, SII_admit) and discharge liver and kidney function indicators (Cr_discharge, ALT_discharge).

Multivariate linear regression was performed with discharge Cr and ALT as dependent variables and admission inflammatory indices as independent variables, adjusting for age, pre-pregnancy BMI, and admission SBP. Regression coefficients (β) and 95% confidence intervals

**Table 1.** Baseline characteristics of normal pregnancy and preeclampsia groups

| Variable | Normal (n=100) | PE (n=100) | t/U | *P* value |
|---|---|---|---|---|
| Age (years) | 29.25 ± 4.65 | 32.33 ± 5.79 | -4.153 | <0.001 |
| Pre-pregnancy BMI (kg/m$^2$) | 22.22 ± 2.92 | 24.83 ± 4.20 | -5.098 | <0.001 |
| Admission SBP (mmHg) | 117.56 ± 9.61 | 143.28 ± 13.58 | -15.463 | <0.001 |
| Cr_admit (μmol/L) | 62.97 ± 9.01 | 84.00 ± 14.06 | -12.591 | <0.001 |
| ALT_admit (U/L) | 20.16 ± 8.38 | 44.69 ± 20.67 | -10.998 | <0.001 |
| NLR_admit | 2.64 (2.23-3.44) | 4.72 (3.95-6.55) | 1205.0 | <0.001 |
| PLR_admit | 117.39 (100.92-142.26) | 143.52 (114.78-174.25) | 3400.0 | <0.001 |
| MLR_admit | 0.26 (0.19-0.33) | 0.38 (0.25-0.50) | 2904.0 | <0.001 |
| SII_admit | 624.68 (492.64-816.82) | 1084.04 (803.11-1405.39) | 1961.0 | <0.001 |

Data are presented as mean ± standard deviation for normally distributed variables or median (interquartile range) for non-normally distributed variables. Abbreviations: SBP, systolic blood pressure; Cr, creatinine; ALT, alanine aminotransferase; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index. *P* values were calculated using independent t-test (t) for normally distributed variables and Mann-Whitney U test (U) for non-normally distributed variables.

(95% CI) were calculated. Univariate logistic regression was performed with good renal recovery (Cr decrease ≥10%) and good hepatic recovery (ALT decrease ≥10%) as dependent variables; odds ratio (OR) and 95% CI.

Receiver operating characteristic (ROC) curves were constructed to evaluate the predictive efficacy of admission inflammatory indicators for abnormal liver function at discharge (ALT> 40 U/L), and the area under the curve (AUC) was calculated. All tests were two-sided, and P<0.05 was considered significant.

To validate robustness of the findings, we performed 1:2 propensity score matching using age and pre-pregnancy BMI as matching variables. SBP was not included as it is a diagnostic criterion. The matched analyses are presented in Supplementary Tables 1 and 2.

## Results

### *Baseline data comparison*

This study included 100 patients with preeclampsia (PE) and 100 normal pregnant women. Baseline characteristics of the two groups are shown in **Table 1**. The age (32.33 ± 5.79 years vs. 29.25 ± 4.65 years, P<0.001), pre-pregnancy BMI (24.83 ± 4.20 vs. 22.22 ± 2.92 kg/m$^2$, P<0.001), and admission systolic blood pressure (143.28 ± 13.58 vs. 117.56 ± 9.61 mmHg, P<0.001) of the PE group patients were significantly higher than those of the normal control group. In addition, admission Cr and ALT were significantly higher in the PE group than in the normal control group (Cr: 84.00 ± 14.06 vs. 62.97 ± 9.01 μmol/L, P<0.001; ALT: 44.69 ± 20.67 vs. 20.16 ± 8.38 U/L, P<0.001), suggesting that PE patients already had a certain degree of liver and kidney function impairment upon admission.

In terms of peripheral blood inflammatory indices at admission, the median neutrophil/lymphocyte ratio (NLR_admit) of the PE group was 4.72 (IQR 3.95-6.55), significantly higher than that of the normal control group (2.64 (2.23-3.44)) (P<0.001); the platelet/lymphocyte ratio (PLR_admit) in the PE group was 143.52 (114.78-174.25), also significantly higher than that of the normal control group (117.39 (100.92-142.26)) (P<0.001). The monocyte/lymphocyte ratio (MLR_admit) in the PE group was 0.38 (0.25-0.50), significantly higher than that of the normal control group (0.26 (0.19-0.33)) (P<0.001). The systemic immune inflammatory index (SII_admit) in the PE group was 1084.04 (803.11-1405.39), significantly higher than that of the normal control group (624.68 (492.64-816.82)) (P<0.001). These results indicate that peripheral blood inflammatory indices were significantly elevated in PE patients at admission, confirming the involvement of systemic inflammation in PE pathophysiology (**Table 1**).

### *Changes in liver and kidney function and inflammatory indicators during hospitalization of PE patients*

Paired analysis of PE patients at admission and discharge (**Table 2**) showed that the blood cre-

**Table 2.** Paired changes (discharge - admit) in liver and kidney function markers among preeclampsia patients (n=100)

| Variable | Change (Discharge - Admit) Median (IQR) | Wilcoxon statistic | *P* value |
|---|---|---|---|
| Cr (μmol/L) | -15.58 (-30.58 to -3.39) | 475.0 | <0.001 |
| ALT (U/L) | -16.92 (-29.94 to -1.91) | 905.0 | <0.001 |

Abbreviations: Cr, creatinine; ALT, alanine aminotransferase; IQR, interquartile range. *P* values were derived from Wilcoxon signed-rank test for paired samples.

**Table 3.** Comparison of admission inflammatory indices between good and poor renal recovery subgroups in preeclampsia patients

| Variable | Good Recovery (n=67) | Poor Recovery (n=33) | U | *P* value |
|---|---|---|---|---|
| NLR_admit | 4.43 (3.95-5.54) | 5.90 (4.14-7.83) | 763.0 | 0.012 |
| PLR_admit | 140.03 (114.59-164.08) | 144.93 (118.15-181.64) | 1019.0 | 0.528 |
| MLR_admit | 0.38 (0.28-0.47) | 0.33 (0.23-0.55) | 1139.0 | 0.809 |
| SII_admit | 1044.95 (799.33-1315.41) | 1193.28 (814.70-1622.70) | 936.0 | 0.215 |

Good recovery defined as a decline in creatinine of ≥10% from admission to discharge; poor recovery as a decline <10%. Data are median (IQR). *P* values from Mann-Whitney U test. Abbreviations: NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index; IQR, interquartile range.

**Table 4.** Spearman correlation coefficients between admission inflammatory indices and discharge liver/kidney function markers in preeclampsia patients

| Inflammation marker | Outcome | Spearman r | *P* value |
|---|---|---|---|
| NLR_admit | Cr_discharge | 0.400 | <0.001 |
| NLR_admit | ALT_discharge | 0.418 | <0.001 |
| PLR_admit | Cr_discharge | 0.158 | 0.116 |
| PLR_admit | ALT_discharge | 0.232 | 0.020 |
| MLR_admit | Cr_discharge | 0.121 | 0.232 |
| MLR_admit | ALT_discharge | 0.216 | 0.031 |
| SII_admit | Cr_discharge | 0.278 | 0.005 |
| SII_admit | ALT_discharge | 0.457 | <0.001 |

Abbreviations: Cr, creatinine; ALT, alanine aminotransferase; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index.

atinine (Cr) level of PE patients significantly decreased during hospitalization, with a median change of -15.58 (IQR -30.58 to -3.39), and the Wilcoxon signed-rank test P<0.001; alanine aminotransferase (ALT) also significantly decreased, with a median change value of -16.92 (-29.94 - -1.91), P<0.001. These results suggest that liver and kidney function improved significantly during hospitalization after clinical intervention.

*Predictive value of admission inflammatory indicators for renal function recovery in PE patients*

Based on whether Cr decreased by ≥10% at discharge, PE patients were classified into good recovery (n=67) and poor recovery (n=33) groups. Subgroup analysis (**Table 3**) showed that the median NLR_admit in the poor recovery group was 5.90 (IQR 4.14-7.83), significantly higher than that in the good recovery group (4.43, IQR 3.95-5.54; P=0.012), indicating that higher admission NLR was associated with worse renal recovery. There was no significant difference in PLR_admit, MLR_admit, or SII_admit between the two groups (P=0.528, 0.809, and 0.215, respectively).

Spearman correlation (**Table 4**) showed that admission NLR and SII were significantly positively correlated with discharge Cr (r=0.400, P<0.001 and r=0.278, P=0.005, respectively), whereas PLR and MLR showed no significant correlations. Scatter plots (**Figure 2A-D**) visually confirmed these correlations: higher admission NLR and SII levels were associated with higher discharge Cr, while PLR and MLR showed weak associations.

Logistic regression with good renal recovery as the outcome variable (**Table 5**) showed that each 1-unit increase in admission NLR was associated with a 27.5% decrease in the odds of good renal recovery (OR=0.725, 95% CI 0.577-0.910, P=0.006); PLR, MLR, and SII were

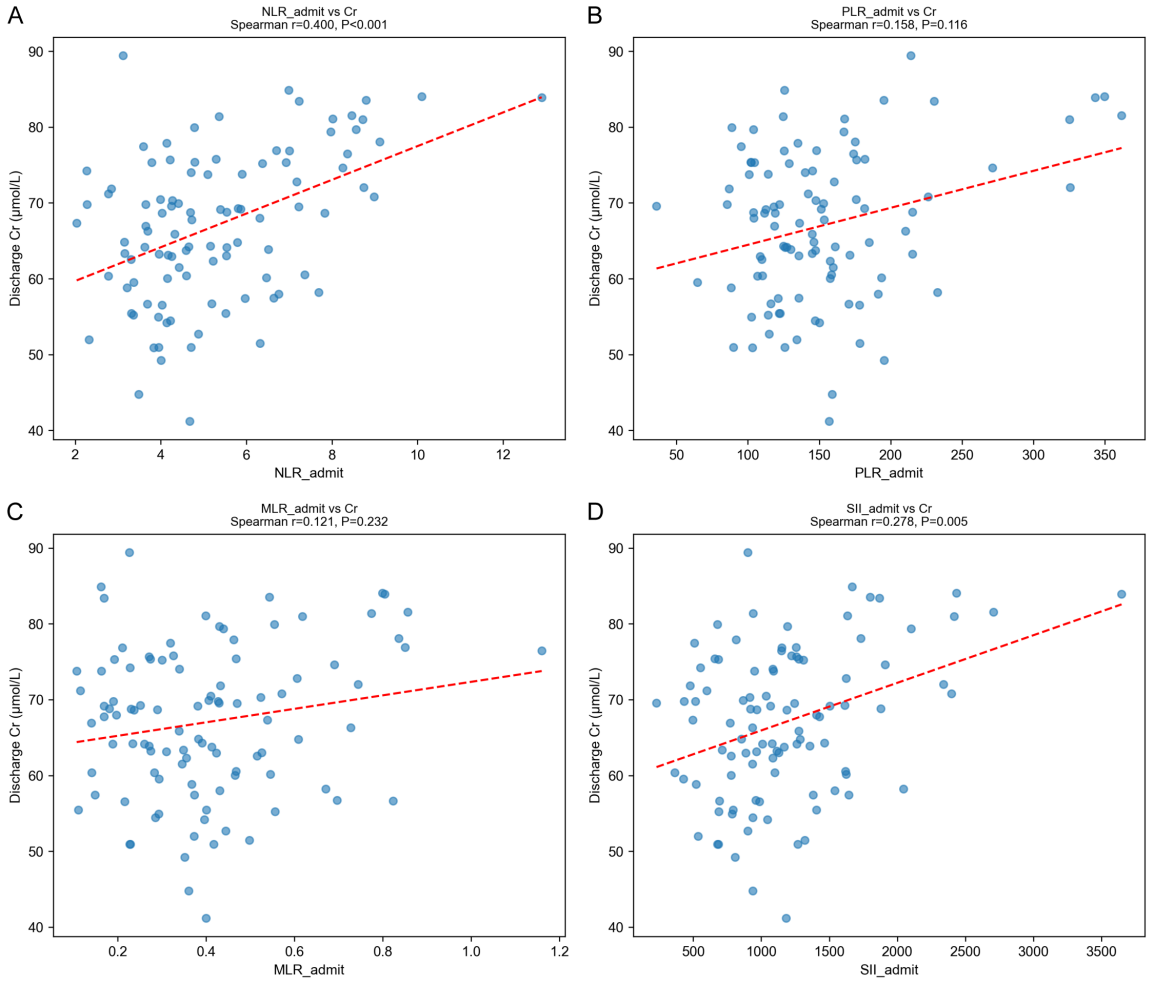



**Figure 2.** Scatter plots of admission inflammatory indices versus discharge creatinine (Cr) in preeclampsia patients (n=100). A. Neutrophil-to-lymphocyte ratio (NLR_admit) vs. discharge Cr. Spearman correlation coefficient r=0.400, P<0.001. B. Platelet-to-lymphocyte ratio (PLR_admit) vs. discharge Cr. r=0.158, P=0.116. C. Monocyte-to-lymphocyte ratio (MLR_admit) vs. discharge Cr. r=0.121, P=0.232. D. Systemic immune-inflammation index (SII_admit) vs. discharge Cr. r=0.278, P=0.005. Solid red lines represent linear regression fits; shaded areas indicate 95% confidence intervals. Abbreviations: Cr, creatinine; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index.

not significant predictors (P=0.436, 0.630, and 0.125, respectively).

*Predictive value of inflammatory markers at admission for liver function recovery in patients with PE*

Based on ALT decrease ≥10% at discharge, patients were classified into good (n=73) and poor (n=27) hepatic recovery groups. Subgroup analysis (**Table 6**) showed that median SII_admit was significantly higher in the poor recovery group than in the good recovery group (1193.28, IQR 883.28-1638.20 vs. 1036.43, IQR 777.91-1284.80; P=0.047). NLR_admit showed a trend towards significance (P=0.085), while PLR and MLR were not significant.

Spearman correlations (**Table 4**) showed that all four admission indices correlated positively with discharge ALT: NLR (r=0.418, P<0.001), PLR (r=0.232, P=0.020), MLR (r=0.216, P=0.031), and SII (r=0.457, P<0.001). Scatter plots (**Figure 3A-D**) visually illustrated positive correlations between each marker and discharge ALT, with NLR and SII showing the strongest associations.

Logistic regression analysis used good liver function recovery as the outcome variable

**Table 5.** Logistic regression analysis for predicting good renal recovery (Cr decline ≥10%) in preeclampsia patients

| Predictor | OR (95% CI) | *P* value |
|---|---|---|
| NLR_admit | 0.725 (0.577-0.910) | 0.006 |
| PLR_admit | 0.997 (0.990-1.004) | 0.436 |
| MLR_admit | 0.606 (0.079-4.647) | 0.630 |
| SII_admit | 0.999 (0.999-1.000) | 0.125 |

Abbreviations: Cr, creatinine; ALT, alanine aminotransferase; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index.

(**Table 7**), and the results showed that for each unit increase in admission NLR_admit, the probability of good liver function recovery decreased by approximately 22.1% (OR=0.779, 95% CI: 0.622-0.975, P=0.029). Each 1-unit increase in PLR was associated with a 0.9% decrease in the odds of good hepatic recovery (OR=0.991, 95% CI 0.983-0.998, P=0.015). Each 1-unit increase in SII was associated with a 0.1% decrease in the odds (OR=0.999, 95% CI 0.998-1.000, P=0.011). The prediction of MLR_admit did not reach statistical significance (P=0.645).

ROC analysis (**Figure 4**) showed AUCs of 0.708, 0.767, 0.698, and 0.743 for NLR, PLR, MLR, and SII, respectively, indicating moderate predictive performance, with PLR and SII showing relatively better discrimination.

*Multivariate linear regression analysis*

After adjustment for age, pre-pregnancy BMI, admission SBP, hospital stay, magnesium sulfate, antihypertensives, 24-hour urine protein, admission Cr, and admission ALT, multivariate linear regression (**Table 8**) showed that NLR, PLR, and SII were independent predictors of discharge Cr (β=2.128, 95% CI 1.197-3.059, P<0.001; β=0.057, 95% CI 0.024-0.091, P= 0.001; and β=0.006, 95% CI 0.003-0.010, P<0.001, respectively). MLR was not significant (β=7.689, 95% CI -2.180 to 17.558, P=0.125).

For discharge ALT, NLR (β=2.908, 95% CI 1.879-3.937, P<0.001), PLR (β=0.079, 95% CI 0.042-0.117, P<0.001), MLR (β=12.975, 95% CI 1.722-24.228, P=0.024), and SII (β=0.011, 95% CI 0.008-0.015, P<0.001) were all independent predictors. These results indicate that the associations between admission inflammatory indices and discharge liver and kidney functions were independent of the above confounding factors.

## Discussion

This study found that admission peripheral blood NLR, PLR, MLR, and SII were significantly higher in PE patients than in normal controls. Admission NLR and SII levels correlated positively with discharge Cr and ALT. After adjusting for age, pre-pregnancy BMI, and admission systolic blood pressure, multivariate linear regression analysis showed that NLR, PLR, and SII were independent determinants of discharge Cr, while all four indices were independent determinants of discharge ALT. Logistic regression confirmed that NLR predicted poor renal recovery, and that NLR, PLR, and SII predicted poor hepatic recovery. ROC curves showed AUCs of 0.708, 0.767, 0.698, and 0.743 for NLR, PLR, MLR, and SII, respectively, indicating moderate predictive ability for abnormal discharge ALT. The above results indicate that the admission peripheral blood inflammatory indices are not only good indicators for reflecting the systemic inflammatory state of PE patients, but also may become biomarkers for predicting the recovery of liver and kidney functions.

The pathophysiology of PE is characterized by extensive systemic inflammation and endothelial dysfunction [18, 19]. Placental ischemia and hypoxia release pro-inflammatory factors into the maternal circulation, activating neutrophils, monocytes, and platelets, leading to an imbalance in peripheral leukocyte subsets [20]. Elevated NLR reflects an imbalance between neutrophil-driven inflammation and lymphocyte-mediated immune regulation, whereas elevated PLR reflects platelet activation coupled with lymphopenia [21]. In this study, the NLR, PLR, MLR, and SII of PE patients were significantly higher than those of normal pregnant women, which was consistent with previous studies [22]. This result not only verified the hypothesis of the inflammatory mechanism in the pathogenesis of PE, but also provided a theoretical basis for subsequent use of these indicators for prognosis assessment.

The key finding of this study is the significant association between admission inflammatory indices and recovery of liver and kidney function at discharge. Cr and ALT are the most com-

**Table 6.** Comparison of admission inflammatory indices between good and poor hepatic recovery subgroups in preeclampsia patients

| Variable | Good Recovery (n=73) | Poor Recovery (n=27) | U | *P* value |
|---|---|---|---|---|
| NLR_admit | 4.68 (3.79-6.31) | 5.22 (4.32-8.19) | 763.0 | 0.085 |
| PLR_admit | 135.56 (114.22-167.17) | 152.80 (125.70-193.24) | 750.0 | 0.068 |
| MLR_admit | 0.37 (0.27-0.50) | 0.38 (0.23-0.49) | 996.0 | 0.938 |
| SII_admit | 1036.43 (777.91-1284.80) | 1193.28 (883.28-1638.20) | 729.0 | 0.047 |

Good recovery defined as a decline in ALT of ≥10% from admission to discharge; poor recovery as a decline <10%. Data are median (IQR). *P* values from Mann-Whitney U test. Abbreviations: NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index; IQR, interquartile range.

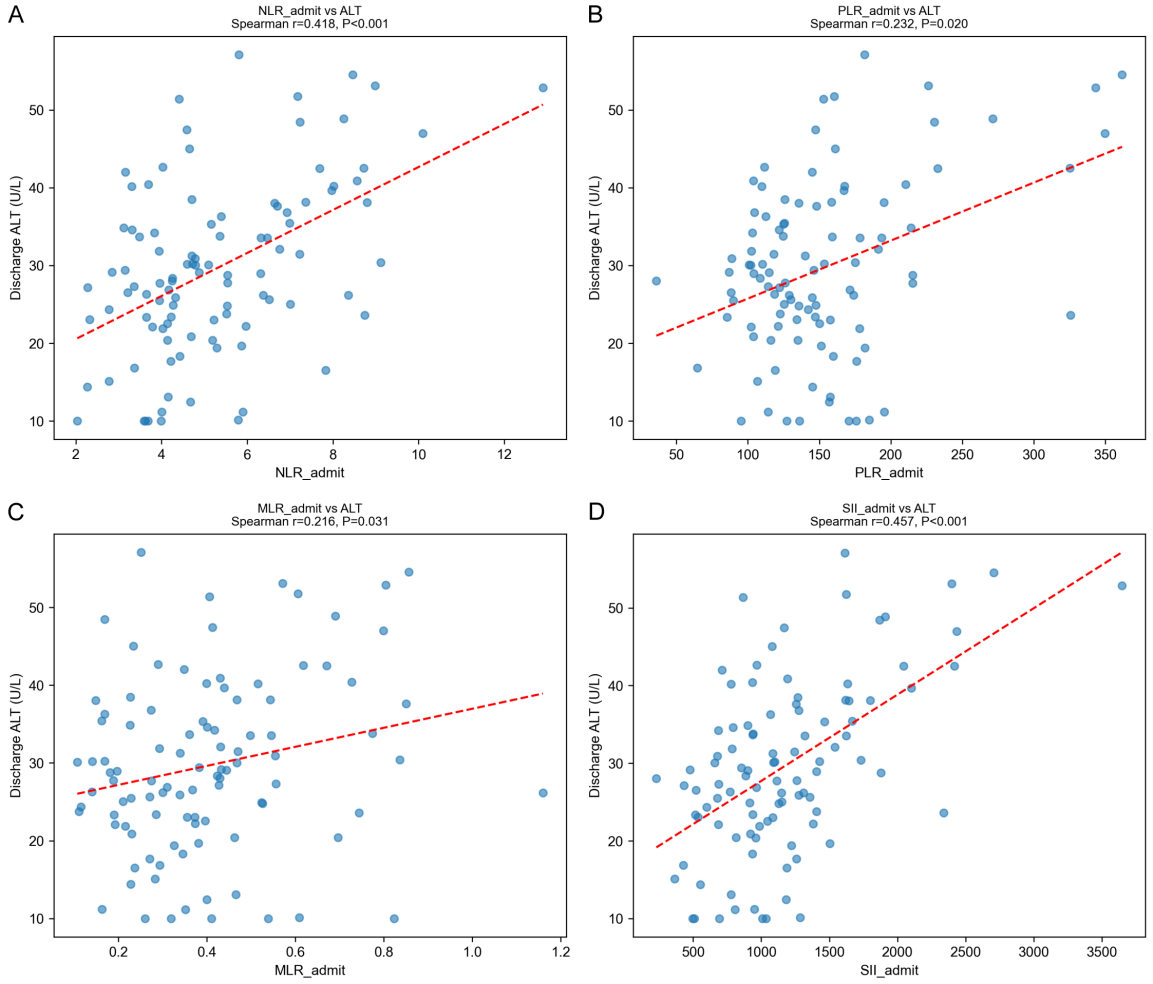



**Figure 3.** Scatter plots of admission inflammatory indices versus discharge alanine aminotransferase (ALT) in preeclampsia patients (n=100). A. Neutrophil-to-lymphocyte ratio (NLR_admit) vs. discharge ALT. Spearman correlation coefficient r=0.418, P<0.001. B. Platelet-to-lymphocyte ratio (PLR_admit) vs. discharge ALT. r=0.232, P=0.020. C. Monocyte-to-lymphocyte ratio (MLR_admit) vs. discharge ALT. r=0.216, P=0.031. D. Systemic immune-inflammation index (SII_admit) vs. discharge ALT. r=0.457, P<0.001. Solid red lines represent linear regression fits; shaded areas indicate 95% confidence intervals. Abbreviations: ALT, alanine aminotransferase; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index.

monly used biochemical indicators for evaluating liver and kidney function in PE patients [23]. In this study, the Cr and ALT of PE patients were significantly elevated at admission and significantly decreased at discharge, suggesting that clinical management was effective. However,

**Table 7.** Logistic regression analysis for predicting good hepatic recovery (ALT decline ≥10%) in preeclampsia patients

| Predictor | OR (95% CI) | *P* value |
|---|---|---|
| NLR_admit | 0.779 (0.622-0.975) | 0.029 |
| PLR_admit | 0.991 (0.983-0.998) | 0.015 |
| MLR_admit | 0.604 (0.071-5.155) | 0.645 |
| SII_admit | 0.999 (0.998-1.000) | 0.011 |

Abbreviations: NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index; OR, odds ratio; CI, confidence interval.

the rate and extent of recovery varied considerably among individuals. This study found that the higher the admission NLR, the lower the odds of good renal recovery, suggesting that admission inflammatory status may be an important determinant of renal recovery. The biological plausibility of this association lies in the fact that admission NLR may reflect not only the current inflammatory level but also the duration and intensity of the inflammatory response [24, 25]. A persistent inflammatory state may aggravate glomerular endothelial and podocyte injury, delay renal tubular repair, and thus impair renal function recovery [26].

From a mechanistic perspective, NLRP3 inflammasome activation and its downstream pyroptosis pathway may serve as a critical bridge linking peripheral inflammatory indices to impaired recovery of liver and kidney function in PE [16, 21]. The NLRP3 inflammasome, as a key sensor of the innate immune system, is activated under placental ischemia-hypoxia conditions, promoting the maturation and release of IL-1β and IL-18, which in turn induce pyroptosis [25]. Neutrophil extracellular traps (NETosis), as a downstream event of NLRP3 inflammasome activation, can further exacerbate vascular endothelial injury and microthrombus formation, thereby delaying recovery of glomerular filtration [27]. The significant positive correlation between admission NLR and discharge Cr in this study partially supports this mechanistic cascade: elevated NLR at admission may reflect the intensity of NETosis and systemic inflammation, whereas sustained pyroptotic signaling may inhibit repair and regeneration of renal tubular epithelial cells. Furthermore, the strongest correlation between SII and discharge ALT suggests that platelets may participate in NLRP3 inflammasome-mediated hepatic microcirculatory disturbances, further aggravating hepatocyte injury and impairing repair [21].

Notably, the four inflammatory indices exhibited differential predictive patterns in this study, which may be attributed to their distinct biological significance. NLR primarily reflects the dynamic balance between neutrophil-mediated inflammatory responses and lymphocyte-mediated immune regulation, with neutrophil NETosis playing a critical role in glomerular endothelial injury; this is consistent with a significant association between NLR and renal recovery [27, 28]. PLR, in contrast, reflects predominantly the combined effect of platelet activation and lymphocyte reduction. Platelets contribute to hepatic injury by promoting microthrombus formation and amplifying inflammatory cascades in the hepatic microcirculation, which aligns with the favorable predictive performance of PLR for hepatic recovery [29]. MLR reflects the degree of monocyte/macrophage infiltration; its lack of predictive value for renal recovery may suggest that monocyte-driven inflammation contributes little to renal recovery in PE, or that other repair mechanisms compensate [14]. SII, as a composite marker, may better reflect the overall inflammatory burden, which explains its strongest correlation with discharge ALT [28].

From a clinical perspective, our findings have potential clinical utility. Currently, assessment of recovery relies mainly on discharge biochemical tests, with no early prediction tools available [29]. We found that admission inflammatory indices showed moderate predictive performance for abnormal discharge ALT (AUC 0.698-0.767), suggesting they may help identify patients at risk of poor organ recovery early during admission. In particular, PLR showed an AUC of 0.767. Although a single marker cannot replace routine tests, it may serve as an adjunct for clinical decisions - for instance, prompting more intensive monitoring or optimized antihypertensive and supportive care in patients with markedly elevated indices [27, 30].

This study has certain limitations. First, this is a single-center retrospective study with a relatively small sample (n=100), and our findings require external validation in larger, multicenter prospective cohorts. Second, discharge timing

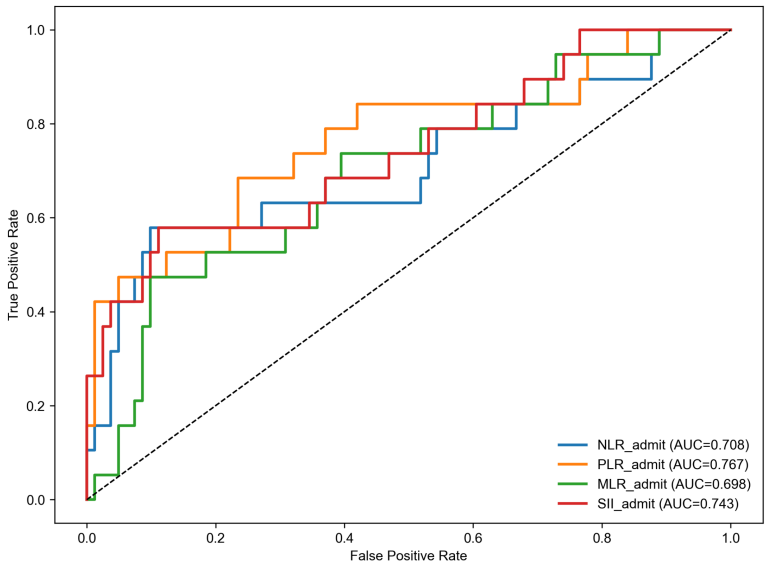



**Figure 4.** Receiver operating characteristic (ROC) curves of admission inflammatory indices for predicting discharge alanine aminotransferase (ALT) >40 U/L in preeclampsia patients (n=100). The area under the curve (AUC) values for NLR_admit, PLR_admit, MLR_admit, and SII_admit were 0.708, 0.767, 0.698, and 0.743, respectively. The diagonal dashed line represents the reference line of AUC=0.5 (no discrimination). Abbreviations: ALT, alanine aminotransferase; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index; ROC, receiver operating characteristic; AUC, area under the curve.

**Table 8.** Multivariate linear regression analysis of admission inflammatory indices with discharge liver and kidney function markers in preeclampsia patients

| Dependent Variable | Independent Variable | β | 95% CI | *P* value |
|---|---|---|---|---|
| Cr_discharge | NLR_admit | 2.128 | (1.197, 3.059) | <0.001 |
| Cr_discharge | PLR_admit | 0.057 | (0.024, 0.091) | 0.001 |
| Cr_discharge | MLR_admit | 7.689 | (-2.180, 17.558) | 0.125 |
| Cr_discharge | SII_admit | 0.006 | (0.003, 0.010) | <0.001 |
| ALT_discharge | NLR_admit | 2.908 | (1.879, 3.937) | <0.001 |
| ALT_discharge | PLR_admit | 0.079 | (0.042, 0.117) | <0.001 |
| ALT_discharge | MLR_admit | 12.975 | (1.722, 24.228) | 0.024 |
| ALT_discharge | SII_admit | 0.011 | (0.008, 0.015) | <0.001 |

Adjusted for age, pre-pregnancy BMI, admission SBP, length of hospital stay, magnesium sulfate use, antihypertensive drug use, 24-hour urine protein, admission Cr, and admission ALT. Abbreviations: Cr, creatinine; ALT, alanine aminotransferase; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; SII, systemic immune-inflammation index; CI, confidence interval.

varied among patients, and some may not have reached stable liver/kidney function by discharge, which could have affected the results. Third, we only measured indices at admission and before discharge, without capturing dynamic changes during hospitalization, which might have stronger predictive value than single measurements [27]. Fourth, although we adjusted for age and BMI, selection and information biases inherent to retrospective designs could not be fully eliminated. Other potential confounders - such as medication regimens, gestational age at delivery, and postpartum blood loss - were not included. Fifth, our definitions of good recovery (≥10% decrease in Cr or ALT) are arbitrary and lack a universally accepted standard, limiting comparability of results. Sixth, our models were based on single-predictor analyses; combined models might have had better performance and should be explored in future studies [31].

In conclusion, this study revealed a significant association between admission inflammatory indices and recovery of liver and kidney function at discharge, offering a new perspective for early prognostic assessment. Future studies should validate these findings in prospective multicenter cohorts, incorporate dynamic monitoring, and develop combined prediction models to improve accuracy and clinical utility.

## Conclusion

In preeclampsia patients' peripheral blood NLR, PLR, MLR, and SII were significantly elevated at admission. Admission NLR, PLR, and SII were independently associated with recovery of liver and kidney function at discharge. Admission inflammatory indices showed moderate predictive value for abnormal liver function at discharge. Routine

peripheral blood inflammatory indices may serve as predictive tools for recovery of liver and kidney function, aiding early identification of high-risk patients and guiding individualized management. Further verification of these conclusions through prospective multicenter studies is needed.

## Disclosure of conflict of interest

None.

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**Supplementary Table 1.** Baseline characteristics before and after propensity score matching (1:2 matching for age and pre-pregnancy BMI)

| Variable | Before PSM | | | After PSM | | |
|---|---|---|---|---|---|---|
| | Control | PE | P | Control | PE | P |
| Age | 29.25 ± 4.65 | 32.33 ± 5.79 | <0.001 | 31.74 ± 5.00 | 32.33 ± 5.79 | 0.267 |
| Pre-pregnancy BMI | 22.22 ± 2.92 | 24.83 ± 4.20 | <0.001 | 24.14 ± 4.52 | 24.83 ± 4.20 | 0.066 |
| Admission SBP* | 117.56 ± 9.61 | 143.28 ± 13.58 | <0.001 | 118.50 ± 9.61 | 143.28 ± 13.58 | <0.001 |

*SBP was not included as a matching variable because it is a diagnostic criterion for PE. Abbreviations: PE, preeclampsia; BMI, body mass index; SBP, systolic blood pressure; PSM, propensity score matching.

**Supplementary Table 2.** Spearman correlations between admission inflammatory indices and discharge outcomes after PSM

| Inflammation marker | Outcome | Spearman r | *P* value |
|---|---|---|---|
| NLR_admit | Cr_discharge | 0.188 | - |
| NLR_admit | ALT_discharge | -0.190 | - |
| SII_admit | Cr_discharge | 0.201 | - |
| SII_admit | ALT_discharge | -0.060 | - |

Data are presented as mean ± SD. *P* values from independent t-test. *P* values for Spearman correlations are not reported because the matched-pair design uses conditional analysis. Abbreviations: NLR, neutrophil-to-lymphocyte ratio; SII, systemic immune-inflammation index; Cr, creatinine; ALT, alanine aminotransferase; PSM, propensity score matching.