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# Evaluation of the diagnostic value of the HALP score, uric acid value, and uric acid-creatinine ratio in preeclampsia

## Hodnocení diagnostické hodnoty skóre HALP, hodnoty kyseliny močové a poměru kyselina močová-kreatinin u preeklampsie

**Y. Dal[1], S. G. Karaca[1], F. Akkuş[2], Ş. Karagün[1], A. Z. Nessar[1], A. Coşkun[1]**

[1] Department of Obstetrics and Gynecology, Division of Perinatology, Mersin University Faculty of Medicine, Mersin, Turkey
[2] Department of Obstetrics and Gynecology, Division of Perinatology, Necmettin Erbakan University Meram Faculty of Medicine, Konya, Turkey

**Summary: Objective:** In this study, we aimed to evaluate the diagnostic value of the HALP score, serum uric acid value, and uric acid-creatinine ratio, which are inflammatory markers, in the diagnosis of preeclampsia (PE). **Materials and methods:** One hundred sixty-six pregnant women who met the inclusion and exclusion criteria were included in the study. They were divided into two groups: 81 pregnant women diagnosed with PE (PE group) and 85 pregnant women with healthy pregnancies (control group). Demographic and obstetric stories of the groups; weeks of pregnancy at diagnosis; hematological and biochemical parameters; hemoglobin, albumin, lymphocyte, and platelet (HALP) score and serum uric acid-creatinine ratio (sUA/sCr); and the results of the newborns were recorded and compared between groups. **Results:** There was no significant difference between the groups in terms of age, gravidity, parity, and body mass index (P values = 0.533, 0.188, 0.085, 0.915, resp.). Mean gestational age, mean birth weight, 1st and 5th minute Apgar scores, and mean umbilical cord pH values were lower in the PE group compared to the control group (P values = 0.0001 for all). Percentage of NICU admissions was higher in the PE group (P = 0.0001). HALP score of the PE group was significantly lower than the control group (2.2 vs. 3.2; P = 0.0001). Uric acid and sUA/sCr ratios were significantly higher in the PE group compared to the control group (for uric acid, 6.2 ± 1.7 vs. 4.5 ± 1.2; P = 0.0001; for sUA/sCr, 12.0 ± 4.0 vs. 9.9 ± 3.1; P = 0.0001). In diagnosing PE, serum uric acid had a sensitivity of 82.7% at values of 4.7 and above, 58% sensitivity at values of sUA/sCr ratio of 10.9 and above, and 3.7% sensitivity at HALP score values of 6.6 and above (P values = 0.0001, 0.001, 0.001, resp.). **Conclusion:** In our study, we found that the HALP score in PE was significantly lower than in healthy controls, and the uric acid value and sUA/sCr ratios were significantly higher. Diagnostic value of the serum uric acid value and then the sUA/sCr ratio were higher in PE. However, we found that the HALP score was insufficient for diagnosing PE.

**Key words:** HALP score – uric acid – uric acid-creatinine ratio – preeclampsia

**Souhrn: Cíl:** V této studii jsme se zaměřili na zhodnocení diagnostické hodnoty skóre HALP, hodnoty kyseliny močové v séru a poměru kyselina močová-kreatinin, což jsou zánětlivé markery v diagnostice preeklampsie (PE). **Materiál a metody:** Do studie bylo zařazeno 166 těhotných žen, které splnily kritéria pro zařazení a vyloučení. Byly rozděleny do dvou skupin: 81 těhotných žen s diagnózou PE (skupina PE) a 85 těhotných žen se zdravým těhotenstvím (kontrolní skupina). Demografická a porodnická historie skupin: týdny těhotenství při diagnóze; hematologické a biochemické parametry; skóre hemoglobinu, albuminu, lymfocytů a destiček (HALP) a poměr kyselina močová-kreatinin v séru (sUA/sCr); a výsledky novorozenců byly zaznamenány a porovnány mezi skupinami. **Výsledky:** Mezi skupinami nebyl signifikantní rozdíl z hlediska věku, gravidity, parity a indexu tělesné hmotnosti (p = 0,533; 0,188; 0,085; 0,915). Průměrný gestační věk, průměrná porodní hmotnost, 1. a 5. min Apgar skóre a průměrné hodnoty pH pupečníku byly nižší ve skupině PE ve srovnání s kontrolní skupinou (p = 0,0001 pro všechny). Procento přijetí na NICU bylo vyšší ve skupině PE (p = 0,0001). Skóre HALP u skupiny PE bylo významně nižší než u kontrolní skupiny (2,2 vs. 3,2; p = 0,0001). Poměry kyseliny močové a sUA/sCr byly významně vyšší ve skupině PE ve srovnání s kontrolní skupinou (pro kyselinu močovou 6,2 ± 1,7 vs. 4,5 ± 1,2; p = 0,0001; pro sUA/sCr 12,0 ± 4,0 vs. 9,1 ± 3,0; p = 0,0001). V diagnostice PE měla sérová kyselina močová senzitivitu 82,7 % při hodnotách 4,7 a vyšších; 58% senzitivitu při hodnotách poměru sUA/sCr 10,9 a vyšších a 3,7% senzitivitu při hodnotách HALP skóre 6,6 a vyšších (p = 0,0001; 0,001; 0,001; v tomto pořadí). **Závěr:** V naší studii jsme zjistili, že skóre HALP u PE bylo významně nižší než u zdravých kontrol a hodnota kyseliny močové a poměry sUA/sCr byly významně vyšší. Diagnostická hodnota sérové hodnoty kyseliny močové a poté poměr sUA/sCr byly vyšší u PE. Zjistili jsme však, že skóre HALP bylo pro diagnózu PE nedostatečné.

**Klíčová slova:** HALP skóre – kyselina močová – poměr kyselina močová-kreatinin – preeklampsie preeklampsie

## Introduction

Preeclampsia (PE) is a hypertensive disease that affects 2% to 5% of pregnancies and is associated with serious maternal morbidity and mortality [1]. The exact cause of PE remains unclear. It is shown in many theories that events occurring during the placental implantation and trophoblastic invasion phases are triggers [2,3]. An excessive systemic inflammatory response is also thought to have an impact on pathogenesis [4]. Abnormal placentation, syncytiotrophoblast ischemia, and endothelial dysfunction may result from an increased inflammatory response [5]. These activated inflammatory cells can enter vascular areas with endothelial damage. As a result, it may cause thrombotic and metabolic disorders and increased endothelial dysfunction [6].

In 2015, Chen et al. defined the hemoglobin, albumin, lymphocyte, and platelet (HALP) score [7]. The HALP score, a new score that combines the concepts of inflammation and nutritional deficiency, has been found to increase the predictive accuracy of various cancer prognoses [7–9]. There is increasing knowledge regarding the effects of uric acid on the endothelium, oxidative stress, and inflammation. It may play a direct role in the pathogenesis of PE by increasing inflammation, oxidative stress, and endothelial dysfunction. The prognostic importance of uric acid and serum uric acid-creatinine ratio (sUA/sCr) in the pathogenesis of PE has also been demonstrated in various studies [10,11]. The prognostic importance of the HALP score has been studied only in preterm birth and hyperemesis gravidarum in obstetrics [12,13]. However, there is no study in the literature on the importance of this index in the diagnosis of PE, which is caused by inflammation.

Investigating new markers for diagnosing PE may benefit the early diagnosis of patients at a high risk of PE and the provision of more effective secondary prevention. Timely diagnosis and effective management of PE greatly affect both maternal and fetal outcomes. In developing countries and in pregnancies with inadequate care, PE cannot be diagnosed until major complications occur. Practical and inexpensive new markers may make it easier to reduce the negative consequences of preeclampsia. In this study, we aimed to investigate the diagnostic value of the HALP score, serum uric acid value, and sUA/sCr ratio, which are inflammatory markers and can be easily calculated with a complete blood count and biochemistry parameters, in PE.

## Materials and methods

### Study design

This retrospective study was conducted based on electronic records of pregnant women included in the study between January 2019 and August 2023 in our hospital, which is a tertiary care center for high-risk pregnancies. The Mersin University Clinical Research Ethics Committee approved the study (Decision No. 2023/559), and informed consent was obtained from all participants.

### Patient selection

Inclusion criteria for this study are a singleton pregnancy after the 20$^{th}$ week of gestation, meeting the diagnostic criteria for PE, no complications other than PE, and not receiving any medication before admission. After meeting the inclusion criteria, patients were divided into two groups: PE group and healthy pregnant women (control group). The control group consisted of healthy pregnant women in the same period and gestational age range without any history of obstetric pathology, autoimmune disorders, or medical complications. Exclusion criteria are multiple pregnancies, rupture of membranes, infections, pregnancies resulting from assisted reproductive techniques, smoking, alcohol or substance use, fetal anomalies, and additional chronic diseases such as diabetes, chronic hypertension, thromboembolism, thrombophilia, and a history of liver or renal disease.

### Diagnostic criteria

Gestational weeks were calculated according to the last menstrual dates or fetal ultrasonography measurements in the 1$^{st}$ trimester. American College of Obstetricians and Gynecologists (ACOG) criteria published in 2020 were used to determine the diagnosis of preeclampsia. For diagnosing preeclampsia, systolic blood pressure should be ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg in two measurements 4 hours (h) apart after the 20$^{th}$ week of pregnancy in a woman who has not previously had high blood pressure, and various multisystem disorders (platelet count below 100,000 × 10$^{9}$/liter (L) with or without new-onset proteinuria; liver enzymes should be elevated to twice the upper limit of normal concentration); have unexplained severe persistent right upper quadrant or epigastric pain; have renal failure (serum creatinine ≥ 1.1 milligrams per deciliter (mg/dL) or doubling of serum creatinine concentration in the absence of renal disease); have pulmonary edema; or have an unexplained new onset headache unresponsive to acetaminophen [14].

### Data and measurements

Baseline data collected for analysis from electronic medical records included age and obstetric histories; body mass index (BMI); gestational age at diagnosis; hemoglobin, hematocrit, leukocyte, neutrophil, lymphocyte, monocyte, and platelet counts; mean platelet volume (MPV), platecrit (PCT), alanine aminotransferase (ALT), aspartate aminotransferase (AST), lactate dehydrogenase (LDH), creatinine, albumin, and uric acid levels; HALP score and sUA/sCr ratio; spot urine proteinuria levels; and birth weights of the newborns, 1$^{st}$ and 5$^{th}$ minute Apgar scores, fetal umbilical cord pH value, and admission to the

neonatal intensive care unit (NICU) were recorded. The formula hemoglobin × albumin × lymphocyte/platelet was used to calculate the HALP score [7]. No medication was administered before laboratory data were taken for evaluation. These data for the study and control groups were obtained from hospital records and are laboratory data for the gestational age at diagnosis. Complete blood count parameters were determined using ADVIA 2120i (Siemens Healthcare), and biochemical parameters were determined using Beckman Coulter AU680 and AU480 devices.

### Statistical analysis

It was carried out using SPSS version 26. Continuous variables were tested for normality using Kolmogorov-Smirnov, Shapiro-Wilk tests, and histograms. Independent sample t-test was used to compare variables with a normal distribution between two groups, and a Mann-Whitney U test was used to compare variables that were not normally distributed between two groups. Data are presented as mean ± standard deviation (SD) for normally distributed variables and median (Min.–Max.) for non-normally distributed variables. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. Data are presented as frequency (percentage) for categorical variables. Receiver operating characteristic (ROC) analysis was performed to evaluate the diagnostic performance of the parameters used for preeclampsia diagnosis. For each parameter, the optimal cutoff point, sensitivity, specificity, and area under the curve (AUC) with a 95% confidence interval (CI) were calculated. P value of less than 0.05 was considered statistically significant.

**Tab. 1. Comparison of demographic, clinical characteristics and neonatal outcomes between groups.**
Tab. 1. Porovnání demografických, klinických charakteristik a neonatálních výsledků mezi skupinami.

| | PE group (N = 81) | Control group (N = 85) | P value |
|---|---|---|---|
| Age (year) | 29.9 ± 7.3 | 29.2 ± 6.4 | 0.533* |
| Gravidity | 2 (1–10) | 2 (1–5) | 0.188** |
| Parity | 1 (0–9) | 1 (0–4) | 0.085** |
| BMI (kg/m$^2$) | 26.4 ± 4.5 | 26.3 ± 4.3 | 0.915* |
| Gestational week | 34.2 ± 3.2 | 37.5 ± 1.9 | **0.0001*** |
| Birth weight (g) | 2,182.5 ± 844.9 | 2,993.7 ± 572.4 | **0.0001*** |
| Apgar 1$^{st}$ min | 6.2 ± 2.0 | 7.4 ± 1.2 | **0.0001*** |
| Apgar 5$^{st}$ min | 8.0 ± 1.6 | 8.9 ± 0.8 | **0.0001*** |
| Umbilical cord pH | 7.25 ± 0.12 | 7.33 ± 0.54 | **0.0001*** |
| NICU admission | 63 (77.8%) | 25 (29.4%) | **0.0001***** |

BMI – body mass index, N – number, NICU – neonatal intensive care unit
*Independent T-test, **Mann-Whitney U test, ***Chi-square test.
A value of P < 0.05 is significant. Bold P values indicate statistically significant.

## Results

According to the inclusion and exclusion criteria, 166 pregnant women were included in the study. The PE group consisted of 81 pregnant women, and the control group consisted of 85 pregnant women. Comparing demographic and clinical characteristics and neonatal outcomes between groups (Tab. 1), it was found that there was no significant difference between the two groups in terms of age, gravidity, parity, and BMI (P values = 0.533, 0.188, 0.085, and 0.915, resp.). These findings indicate that age, gravidity, parity, and BMI are not associated with the development of PE in this study population. We observed that the PE group had significantly worse neonatal outcomes compared to the control group. While the mean gestational week of the PE group was 34.2 ± 3.2 weeks, the mean gestational week of the control group was 37.5 ± 1.9 weeks (P = 0.0001). While the mean birth weight of the PE group was 2,182.5 ± 844.9 grams (g), the mean birth weight of the control group was 2,993.7 ± 572.4 g (P = 0.0001). While the mean Apgar score of the PE group at the 1$^{st}$ minute (min) was 6.2 ± 2.0, the mean Apgar score of the control group at the 1$^{st}$ min was 7.4 ± 1.2 (P = 0.0001). While the average Apgar score of the PE group at the 5$^{th}$ min was 8.0 ± 1.6, the average Apgar score of the control group at the 5$^{th}$ min was 8.9 ± 0.8 (P = 0.0001). While the mean umbilical cord pH value of the PE group was 7.25 ± 0.12, the mean umbilical cord pH value of the control group was 7.33 ± 0.54 (P = 0.0001). While the NICU admission percentage of the PE group was 77.8%, the control group's NICU admission percentage was 29.4% (P = 0.0001). These findings indicate that PE is associated with significant adverse effects on neonatal health, such as premature birth.

Tab. 2 shows that there were significant differences between the two groups in most of the parameters except hemoglobin, hematocrit, leukocyte, neutrophil, and MPV (P values = 0.725, 0.822, 0.213, 0.649, and 0.515, resp.). The results show that the platelet, monocyte, lymphocyte, PCT, creatinine, albumin, and HALP score values of the PE group were significantly lower than those of the control group. While the median platelet count of the PE group was 202,000 × 10$^3$/microliter (µl) (13,400–473,000), the median platelet count of the control group was 217,000 × 10$^3$/µl (122,000–439,000) (P = 0.012). The mean monocyte count of the PE group was 0.590 ± 0.351 × 10$^3$/µl, while the mean monocyte count of the control group

**Tab. 2. Comparison of haematological and biochemical parameters between groups.**
Tab. 2. Porovnání hematologických a biochemických parametrů mezi skupinami.

| | PE group (N = 81) | Control group (N = 85) | P value |
|---|---|---|---|
| Hemoglobin (g/dL) | 10.8 ± 1.6 | 10.7 ± 1.3 | 0.725* |
| Hematocrit (%) | 31.4 ± 4.3 | 31.5 ± 3.4 | 0.822* |
| Leukocytes (× $10^3$/μL) | 10.330 (0.942–42.950) | 11.850 (4.710–34.270) | 0.213** |
| Platelets (× $10^3$/μL) | 202.000 (13.400–473.000) | 217.000 (122.000–439.000) | **0.012**** |
| Neutrophil (× $10^3$/μL) | 8.200 (1.960–38.260) | 8.800 (2.970–28.330) | 0.649** |
| Monocytes (× $10^3$/μL) | 0.590 ± 0.351 | 0.817 ± 0.394 | **0.0001*** |
| Lymphocytes (× $10^3$/μL) | 1.628 ± 0.584 | 2.099 ± 0.798 | **0.0001*** |
| Platecrit (%) | 0.22 (0.01–0.51) | 0.26 (0.12–0.51) | **0.004**** |
| MPV (fL) | 11.2 ± 1.2 | 11.1 ± 0.9 | 0.515* |
| Uric acid (U/L) | 6.2 ± 1.7 | 4.5 ± 1.2 | **0.0001*** |
| Creatinine (mg/dL) | 0.6 ± 0.2 | 0.5 ± 0.1 | **0.009*** |
| LDH (U/L) | 258 (156–1,971) | 207 (105–364) | **0.0001**** |
| AST (U/L) | 24 (6–1,572) | 18 (5–339) | **0.0001**** |
| ALT (U/L) | 17 (4–684) | 13 (3–592) | **0.006**** |
| Albumin (g/dL) | 2.6 ± 0.4 | 3.7 ± 0.5 | **0.0001*** |
| Proteinuria | 2 (0–4) | 0 (0–2) | **0.0001**** |
| HALP score | 2.2 (0.4–9.8) | 3.2 (1.3–9.6) | **0.0001**** |
| sUA/sCr ratio | 12.0 ± 4.0 | 9.9 ± 3.1 | **0.0001*** |

ALT – alanine aminotransferase, AST – aspartate aminotransferase, HALP – hemoglobin, albumin, lymphocyte, and platelet, LDH – lactate dehydrogenase, MPV – mean platelet volume, N – number, sUA/sCr – serum uric acid-creatinine ratio
*Independent T-test, **Mann-Whitney U test.
A value of P < 0.05 is significant. Bold P values indicate statistically significant.

was 0.817 ± 0.394 × $10^3$/μl (P = 0.0001). The mean lymphocyte count of the PE group was 1.628 ± 0.584 × $10^3$/μl, while the mean lymphocyte count of the control group was 2.099 ± 0.798 × $10^3$/μl (P = 0.0001). The mean PCT value of the PE group was 0.22% (0.01–0.51), while the mean PCT value of the control group was 0.26% (0.12–0.51) (P = 0.004). While the mean creatinine level of the PE group was 0.6 ± 0.2 mg/dL, the mean creatinine level of the control group was 0.5 ± 0.1 mg/dL (P = 0.009). While the mean albumin level of the PE group was 2.6 ± 0.4 grams per deciliter (g/dL), the mean albumin level of the control group was 3.7 ± 0.5 g/dL (P = 0.0001). While the median HALP score of the PE group was 2.2 (0.4–9.8), the median HALP score of the control group was 3.2 (1.3–9.6) (P = 0.0001). The results show that uric acid, sUA/sCr ratio, LDH, AST, ALT, and proteinuria values in the PE group were significantly higher compared to the control group. While the mean uric acid level in the PE group was 6.2 ± 1.7 mg/dL, the mean uric acid level in the control group was 4.5 ± 1.2 mg/dL (P = 0.0001). The mean sUA/sCr ratio of the PE group was 12.0 ± 4.0, while the mean sUA/sCr ratio of the control group was 9.9 ± 3.1 (P = 0.0001). While the median LDH level of the PE group was 258 U/L (156–1,971), the median LDH level of the control group was 207 U/L (105–364) (P = 0.0001). While the median AST level of the PE group was 24 U/L (6–1,572), the median AST level of the control group was 18 U/L (5–339) (P = 0.0001). While the median ALT level of the PE group was 17 U/L (4–684), the median ALT level of the control group was 13 U/L (3–592) (P = 0.006). While the median proteinuria level of the PE group was 2+ (0–4), the median proteinuria level of the control group was 0 (0–2) (P = 0.0001). These findings indicate that PE is associated with significant changes in hematological and biochemical parameters, reflecting systemic inflammatory responses, endothelial dysfunction, oxidative stress, and organ damage.

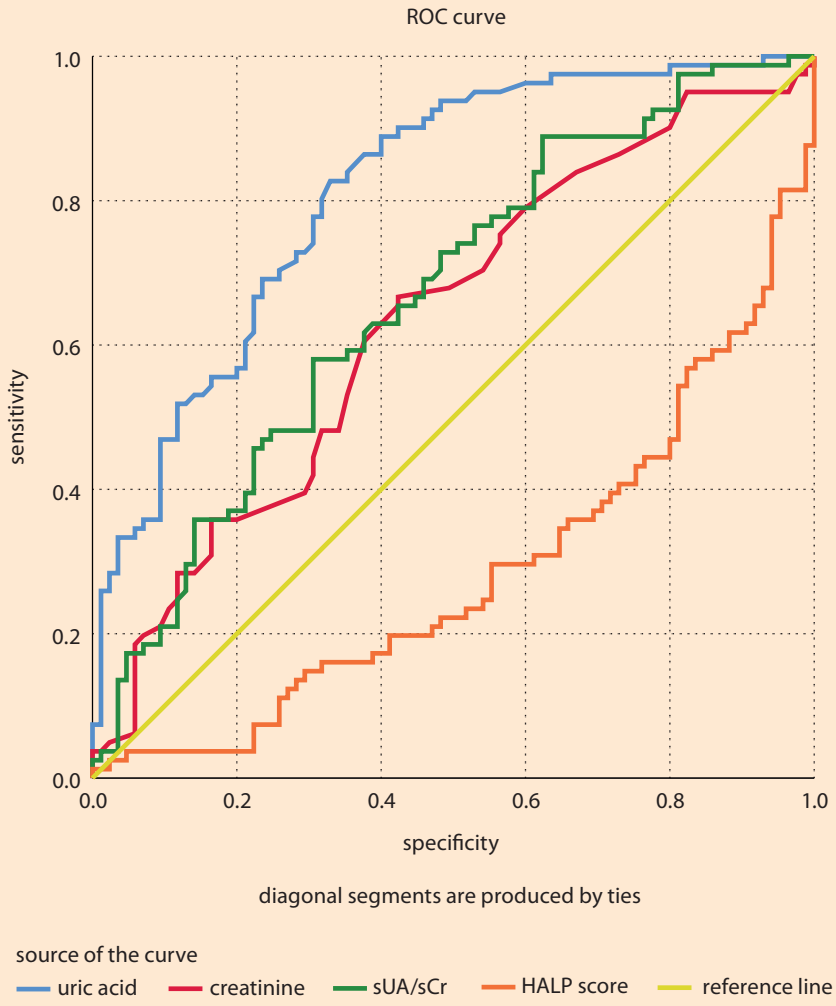
Tab. 3 shows the results of the ROC analysis for the four parameters used to diagnose PE (Fig. 1). It shows that uric

**Tab. 3. Determination of the diagnostic value of uric acid, creatinine, sUA/sCr ratio and HALP score in preeclampsia.**
Tab. 3. Stanovení diagnostické hodnoty kyseliny močové, kreatininu, poměru sUA/sCr a skóre HALP u preeklampsie.

| | Cut-off | Sensitivity (%) | Specificity (%) | AUC (CI 95%) | P value |
|---|---|---|---|---|---|
| Uric acid | 4.7 | 82.7 | 67.0 | 0.812 (0.748–0.877) | **0.0001** |
| Creatinine | 0.47 | 66.6 | 57.6 | 0.632 (0.548–0.717) | **0.003** |
| sUA/sCr ratio | 10.9 | 58.0 | 69.4 | 0.666 (0.584–0.748) | **0.001** |
| HALP score | 6.6 | 3.7 | 95.2 | 0.285 (0.207–0.362) | **0.001** |

AUC – area under the curve, CI – confidence interval, HALP – hemoglobin, albumin, lymphocyte, and platelet, sUA/sCr – serum uric acid-creatinine ratio
A value of P < 0.05 is significant. Bold P values indicate statistically significant.

acid has the highest AUC value (0.812), followed by sUA/sCr ratio (0.666), creatinine (0.632), and HALP score (0.285). All parameters had a significant P value (0 < 0.05). However, only uric acid had high sensitivity (82.7%) and specificity (67%) at the optimal cut-off point (4.7 mg/dL), suggesting that it was the most accurate parameter among the parameters examined for the diagnosis of PE. Other parameters had either low sensitivity or low specificity, indicating a high rate of false positives or false negatives. These results suggest that uric acid is a useful biomarker for preeclampsia and can be used as a screening tool or as an aid for clinical diagnosis. Other parameters may have value in combination with uric acid or other clinical factors but are not reliable enough to be used alone.




HALP – hemoglobin, albumin, lymphocyte, and platelet, ROC – receiver operating characteristic, sUA/sCr – serum uric acid-creatinine ratio

**Fig. 1. ROC analysis of uric acid and creatinine values, sUA/sCr ratio and HALP score for the diagnostic value of preeclampsia.**
Obr. 1. ROC analýza hodnot kyseliny močové a kreatininu, poměr sUA/sCr a skóre HALP pro diagnostickou hodnotu preeklampsie.

## Discussion

PE remains the most common cause of maternal and fetal morbidity and death. Although some factors causing PE are known, the etiopathogenesis is not fully known. New research is also being conducted on this subject. It is known that inflammation causes the emergence of many diseases. Preeclampsia is also thought to be an inflammatory and antiangiogenetic condition [15,16]. Serum uric acid value, sUA/sCr ratio, and HALP score, a new marker, are inflammatory markers that can be easily accessed and provide results. This study is the first to investigate the HALP score in PE. In our study, we found that the HALP score was significantly lower and the uric acid and sUA/sCr ratio were significantly higher in PE compared to healthy controls. We observed that the serum uric acid value and, subsequently, the sUA/sCr ratio had a higher diagnostic value in PE. However, we found that the HALP score has insufficient diagnostic value for the diagnosis of PE.

Pregnancy is a successful semi-allograft reaction [17]. The balance between inflammatory and immune responses is very important in maintaining pregnancy. Blastocyst implantation, trophoblast cell proliferation and differentiation, and placental development occur by maintaining this balance [17]. In PE, this balance is eliminated and an overactive inflammatory response occurs [18]. An increased inflammatory response causes endothelial dysfunction, which is thought to be the main cause of the pathogenesis of PE [19]. When the inflammatory response increases, inflammatory cells accumulate in the vascular space, and vascular functions are impaired [20]. The result is accompanied by high serum levels of inflammatory parameters [21].

The HALP score, which consists of a combination of hemoglobin, albumin, platelet, and lymphocyte counts, has been frequently used in recent years to predict various types of cancer and strokes [22]. This newly discovered score is an important biomarker that indi-

cates nutritional status and level of systemic inflammation [23]. Its diagnostic and prognostic value has also been investigated in several studies in obstetrics and gynecology. A study found that the HALP score was associated with recurrence in endometrial cancer patients. They observed that in these patients, those with lower HALP scores had a worse prognosis [24]. In a prospective study of Njoku et al. conducted on 439 endometrial cancer patients, it was shown that the HALP score was not associated with cancer-specific or relapse-free survival [25]. A study investigating the optimal HALP score value to predict cervical cancer recurrence found that survival was lower at low HALP scores, but the predictive value of the HALP score used alone to predict cervical cancer recurrence was unclear [26]. In another study, it was observed that a low HALP score was associated with a higher stage and tumor size in advanced cervical cancer [27]. In a study investigating the diagnostic value of the HALP score in preterm births, it was found that the HALP score was significantly lower in the preterm birth group. They stated that a HALP score above 24 has a significant diagnostic value for preterm birth, but even if it has statistical significance, it has a weak diagnostic value [12]. In the study of Bayram et al., it was observed that the HALP score had a significant effect on hyperemesis gravidarum. They found that each 1-unit decrease in the HALP score could increase the presence of hyperemesis gravidarum by 2.16-fold and that a HALP score of 3.5 or lower could predict the presence of hyperemesis gravidarum with 78.1% sensitivity and 77.6% specificity [13].

Although the HALP score is shown to be a negative prognostic factor in many clinical cases, it is not known how it affects the prognosis of PE. To explain this, we can analyze the four components of the HALP score. The inflammatory condition reduces the life of the erythrocytes, suppresses bone marrow activity, and causes a decrease in hemoglobin concentration [12]. PE is also known to be an inflammatory condition, and studies have shown an increased incidence of anemia in pre-eclamptic pregnancies [28]. Serum total proteins and their levels indicate inflammation and nutritional status. It is accepted that the serum albumin level is a strong indicator of disease severity in pregnancy-induced hypertension and is a valuable measure in predicting disease severity and pregnancy outcomes [29]. Lymphocytes are one of the most important members of the immune system and an important indicator of inflammation [30]. It is believed there is an agent of inflammation in platelets [31], and thrombotic changes are among the most important indicators of organ retention in PE. Therefore, a lower HALP score consisting of hemoglobin × albumin × lymphocytes/platelets may be related to the pathogenesis of PE. In our study, we concluded that a low HALP score is associated with PE. However, we found that although it is an inflammatory marker, it does not reach sufficient diagnostic value on its own. This result may have been caused by the fact that the severity of the inflammation occurring in PE is not fully known or that the inflammation may intensify in a later period.

Serum uric acid is the end product of purine catabolism and has been implicated in the development of PE since 1925 [32]. Hyperuricemia resulting from increased activity of xanthine oxidase produces reactive oxygen species [33]. The resulting oxidative stress and inflammation trigger endothelial and vascular dysfunction [34]. This pathogenetic mechanism may have an important role in the development and severity of PE. In the study of Ibrahimi et al., they stated that there were higher uric acid levels in PE and that they had excellent prognostic value in the development of PE with a sensitivity of 96.6 and a specificity of 48.8% [35]. The sUA/sCR ratio in PE has recently been investigated and suggested as a better marker than uric acid alone [36]. One study found a higher sUA/sCR rate in preeclamptic pregnant women than in normotensive women [37]. Another study found that the sUA/sCr ratio was significantly higher in PE women compared to hypertensive but non-PE, and normotensive women [38]. In the same study, a higher sUA/sCr ratio in the 3rd trimester was significantly associated with an increased likelihood of developing PE and was associated with an increased likelihood of poor neonatal outcomes, including low birth weight, NICU need, and neonatal death [38]. In our study, we evaluated uric acid and sUA/sCr ratio in PE patients and tested their diagnostic power. We found that uric acid and sUA/sCr ratio were significantly higher in the PE group than in healthy controls. We found that there was an 82.7% sensitivity for serum uric acid values of 4.7 and above and a 58% sensitivity for the sUA/sCr ratio of 10.9 and above in PE. We think that uric acid, in particular, has high diagnostic power and that these two biomarkers may be useful in the diagnosis of PE.

Limitations of our study: This was a retrospective study conducted in a single center. Therefore, the results may not be generalizable to other populations. An important feature of the study is that it was conducted in a center where tertiary and high-risk pregnancies are followed, and data from a single laboratory were used. Other strengths are the multitude of study variables, application of standard protocols for all patients, and homogeneity of the study groups.

## Conclusion

Considering that inflammation is an important factor in the development of PE, evaluation of inflammatory markers may benefit early diagnosis. Since the HALP score, serum uric acid value, and sUA/sCr ratio are easily accessible and calculated markers, their evaluation in preeclamp-

tic patients can guide appropriate follow-up and treatment. We think that the serum uric acid value and sUA/sCr ratio may help in the diagnosis when used together with other biochemical parameters. However, it may be useful to conduct prospective studies with a sufficient sample size to determine the exact threshold values of the HALP score, which can predict pregnancy complications with high sensitivity and specificity in preeclamptic patients.

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## Authorship

YD, AC: concept, author, design, data processing, analysis, and interpretation
YD, FA: analysis and interpretation, design, statistical analysis
ŞK, SGK, AZN: data collection, processing, analysis
YD, SGK: audit, statistical analysis, design
YD, AC, FA: control, concept

## ORCID authors

Y. Dal 0000-0001-7162-4644
S. G. Karaca 0000-0003-1595-2621
F. Akkuş 0000-0001-7037-9165
Ş. Karagün 0000-0003-2339-1609
A. Z. Nessar 0000-0003-2985-0212
A. Coşkun 0000-0002-2887-9649

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*Yusuf Dal, MD*
*Department of Obstetrics and Gynecology*
*Perinatology Department*
*Mersin University Faculty of Medicine*
*TR-33110, Mersin*
*Turkey*
*dryusufdal@gmail.com*

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