The European Research Journal 2025;11(2):363-370 Original Article

DOI: https://doi.org/10.18621/eurj.1609129 *Obstetrics and Gynecology*

Evaluation of APRI and FIB-4 indices in early and late-onset preeclampsia

Nazan Vanlı Tonyalı[1], Gülşan Karabay[1], Gizem Aktemur[1], Betül Tokgöz Çakır[1], Zeynep Şeyhanlı[1], Sevinç Çetin[2], Ali Turhan Çağlar[1]

[1]Department of Obstetrics and Gynecology, Division of Perinatology, Ankara Etlik City Hospital, Ankara, Türkiye; [2]Department of Obstetrics and Gynecology, Ankara Etlik City Hospital, Ankara, Türkiye

ABSTRACT

Objectives: This study aimed to evaluate the relationships between maternal and neonatal outcomes and the Fibrosis-4 Index (FIB-4) and Aspartate Aminotransferase-to-Platelet Ratio Index (APRI) in healthy pregnancies, late-onset preeclampsia (LOP), and early-onset preeclampsia (EOP).

Methods: A retrospective study was conducted on 239 pregnant women diagnosed with EOP (n=62), LOP (n=56), and healthy pregnancies (n=121) at Etlik City Hospital. Maternal and neonatal outcomes, as well as APRI, and FIB-4 scores were compared. Statistical analyses included ANOVA, chi-square tests, and ROC curve analysis.

Results: EOP was associated with lower gestational age at birth, lower fetal birth weight, and higher NICU admission rates compared to LOP and control groups. APRI scores were significantly elevated in LOP compared to controls (P=0.012). FIB-4 scores were significantly higher in LOP than controls (P=0.005). ROC analysis showed modest predictive power for APRI (AUC=0.614) and FIB-4 (AUC=0.617) in distinguishing LOP from controls. The best cut-off values for APRI and FIB-4 were 0.2347 and 0.65, respectively.

Conclusions: Elevated APRI and FIB-4 scores in LOP suggest their potential roles as complementary markers in preeclampsia management. However, their moderate predictive performance indicates the need for further studies.

Keywords: Preeclampsia, APRI (Aspartate Aminotransferase-to-Platelet Ratio Index), FIB-4 (Fibrosis-4 Index)

Globally, preeclampsia remains one of the main causes of morbidity and mortality among mothers and newborns [1]. After 20 weeks of pregnancy, it is defined by newly developed hypertension and proteinuria, or in the absence of proteinuria, by the presence of disorders such as thrombocytopenia, poor liver function, or fetal growth limitation. Preeclampsia is broadly classified into early-onset preclampsia (EOP), often presenting before 34 weeks of gestation, and late-onset preeclampsia (LOP), which manifests later. Early-onset preeclampsia is frequently associated with placental dysfunction, leading to severe maternal and neonatal complications [2].

In recent years, studies on biomarkers aimed at predicting preeclampsia have appeared in the literature [3]. Among these, the Aspartate Aminotransferase-Platelet Ratio Index (APRI) emerged as a non-invasive marker that was initially developed to assess liver fi-

Corresponding author: Nazan Vanlı Tonyalı, MD.,
Phone: +90 312 797 00 00, E-mail: nazanvanli@gmail.com

How to cite this article: Vanlı Tonyalı N, Karabay G, Aktemur G, et al. Evaluation of APRI and FIB-4 indices in early and late-onset preeclampsia. Eur Res J. 2025;11(2):363-370. doi: 10.18621/eurj.1609129

Received: December 29, 2024
Accepted: February 10, 2025
Published Online: February 15, 2025

Copyright © 2025 by Prusa Medical Publishing
Available at https://dergipark.org.tr/en/pub/eurj

This is an open access article distributed under the terms of Creative CommonAttribution-NonCommercial-NoDerivatives 4.0 International License

brosis [4]. Elevated APRI scores have been shown to correlate with liver function impairment in various pregnancy-related conditions, including HELLP syndrome (hemolysis, elevated liver enzymes, and low platelets) and intrahepatic cholestasis of pregnancy. FIB-4, like APRI, is a non-invasive biomarker used to evaluate liver fibrosis. The pathophysiology of preeclampsia is believed to be associated with systemic inflammation and endothelial dysfunction. [5]. However, specific studies directly examining the use of FIB-4 in preeclampsia or other pregnancy-related conditions are limited.

Several studies have investigated the utility of APRI in predicting adverse maternal and neonatal outcomes. For instance, Tolunay *et al*. [6] demonstrated that elevated first-trimester APRI scores could predict the development of HELLP syndrome, with high sensitivity and specificity. Similarly, APRI has been explored as a potential predictor of superimposed preeclampsia in pregnancies complicated by chronic hypertension [7]. These results emphasize the potential role of APRI in identifying high-risk pregnancies early, facilitating timely interventions.

The present study aims to evaluate and compare APRI and FIB-4 scores among EOP, LOP and healthy pregnancies, with a focus on their associations with maternal and neonatal outcomes.

METHODS

This retrospective study was carried out at Etlik City Hospital Perinatology Clinic between January 2022 and November 2024. Women diagnosed with preeclampsia (early and late onset) and healthy pregnancies comprised the study group. Ethical approval was obtained prior to the initiation of the study. Ethical principles were followed throughout the study and all necessary precautions were taken to ensure patient privacy and data confidentiality in accordance with institutional regulations.

Clinical and laboratory data of the mothers and newborns were retrieved from the hospital's medical record system. EOP and LOP were defined according to ISSHP criteria [8]. The pregnancies included in the study consisted of three groups: EOP, LOP and healthy pregnancies. Women aged 18-45 who were diagnosed with preeclampsia or have a healthy pregnancy, whose pregnancy follow-up and birth took place in our clinic were included in study. Exclusion criteria included pregnancies with systemic diseases, pregnancies with follow-up or delivery in another center, and pregnancies with fetal anomalies.

Data collection was performed retrospectively and included maternal blood pressure measurements, medications used, and laboratory parameters. The study collected maternal demographic data, preeclampsia-related information, ultrasound measurements, medications, maternal outcomes, complications associated with preeclampsia (e.g., HELLP syndrome, eclampsia, and severe hypertension), delivery methods and indications, birth weight, gestational age, and neonatal intensive care unit (NICU) requirements. The following formula was used to calculate the APRI: (AST / Upper Limit of Normal AST) × 100 / Platelet count, where AST levels were measured in U/L, the upper limit of normal AST was defined based on laboratory reference ranges, and platelet counts were recorded in $\times 10^9$/L. The formula for calculating the FIB-4 index was: (Age × AST) / (Platelet count × √ALT).

Statistical Analysis

For the statistical analysis in this study, the Statistical Package for the Social Sciences (SPSS) software version 23.0 was used. Based on the results, appropriate parametric or non-parametric tests were applied after evaluating the normality of continuous variables. Non-parametric tests, such as the Mann-Whitney U test, were used for skewed data, whereas one-way ANOVA and Tukey post-hoc tests were applied for group comparisons of normally distributed variables. The chi-square test was also used to assess categorical variables. The diagnostic performance of the APRI and FIB-4 scores was evaluated using receiver operating characteristic (ROC) curve analysis. Sensitivity, specificity, and the area under the curve (AUC) were calculated using ROC analysis. The cut-off point was determined as the value that optimized the balance between sensitivity and specificity, ensuring both measures were maximized as much as possible.

RESULTS

The analysis of maternal age across the three groups did not reveal a statistically significant overall differ-

Table 1. Maternal demographic characteristics and laboratory findings

	Early preclampsia (n=62)	Late preclampsia (n=56)	Control (n=121)	P value	Post-Hoc comprasions P value		
					Early-late preclampsia	Early preclampsia-Control	Late preclampsia - Control
Maternal age (years)	30.19±5.84	30.46±6.58	28.48±5.27	0.057	0.965	0.139	0.085
BMI (kg/m$^{2)}$	33.85±6.68	33.91±6.34	29.05±4.30	**0.001**	NA	**0.001**	**0.001**
Gravidity	2±2	2±2	2±2	0.465			
Parity	0±2	1±2	1±2	0.415			
Living children	0±2	1±2	1±1	0.457			
Gestational age at diagnosis (weeks)	30.06±2.26	35.58±1.05		0.001			
Hemoglobin (g/dL)	12.0±1.40	11.69±1.44	11.5±1.32	0.139			
WBC (×10^9/L)	12.0±3.65	10.60±3.06	10.58±3.32	**0.011**	**0.044**	**0.012**	NA
Platelet (×10^9/L)	247.89±69.46	224.59±60.77	246.70±68.11	0.089			
AST (U/L)	18.5±10	18.0±9	16.0±6	**0.020**	NA	**0.050**	NA
ALT (U/L)	11.00±9	11.00±7	10.00 (4)	**0.011**	NA	**0.011**	NA
24-hour proteinuria (mg/24h)	634±2454	530±563		0.348			
APRI	0.22±0.17	0.25±0.12	0.20±0.10	**0.014**	NA	NA	**0.012**
FIB-4	0.66±0.42	0.73±0.53	0.59±0.36	**0.020**	NA	NA	**0.005**

Data are shown as mean±standard deviation or median (IQR). BMI=body mass index, WBC=white blood cell, AST=aspartate aminotransferase, ALT=alanine aminotransferase, APRI=AST to platelet ratio index, FIB-4=fibrosis-4 score.

Table 2. Comparasion of neonatal outcomes among EOP, LOP and control groups

	Early preclampsia (n=62)	Late preclampsia (n=56)	Control (n=121)	P value	Post-Hoc comprasions P value		
					Early-late preclampsia	Early preclampsia-Control	Late preclampsia - Control
Gestational age at birth (weeks)	34.31 ± 2.94	36.75 ± 1.11	38.55 ± 1.69	**0.001**	**0.001**	**0.001**	**0.001**
Fetal birth weight (g)	2073±833	2696±583	3137±476	**0.001**	**0.001**	**0.001**	**0.001**
Apgar 1 minute	8±3	9±1	9±1	**0.001**	**0.001**	**0.001**	NA
Apgar 5 minute	10±1	9±2	10±0	**0.001**	**0.011**	**0.001**	NA
C/S, n (%)	50 (80)	42 (75)	72 (60)	**0.0071**	NA	**0.0042**	0.0458
NICU, n (%)	36 (58.1)	14 (25)	13 (10.7)	**0.001**	**0.044**	**0.012**	NA

Data are shown as mean± standard deviation, median (IOR) or n (%) where appropriate. EOP=early-onset preeclampsia, LOP= late-onset preeclampsia, C/S=cesarean section, NICU=neonatal intensive care unit

ence (P=0.057). Maternal BMI was significantly higher in both preeclampsia groups compared to the control group (P=0.001). Gestational age at diagnosis was significantly earlier in the EOP group than in the LOP group (P=0.001). White blood cell counts (WBC) were significantly elevated in the EOP group compared to both the LOP and control groups (P=0.011). AST and ALT levels were higher in the EOP group compared to the control group (P=0.020 and P=0.011, respectively). Notably, the APRI score was significantly higher in the LOP group compared to the control group (P=0.014). The FIB-4 index showed significant differences among the groups (P=0.020), with post-hoc analysis revealing that the LOP group had significantly higher FIB-4 values compared to the control group (P=0.005) (Table 1).

Neonatal outcomes showed significant differences across the EOP, LOP, and control groups. Gestational age at birth was significantly lower in the EOP group compared to both the LOP and control groups (P=0.001). Similarly, fetal birth weight was lowest in the EOP group and highest in the control group (P=0.001). The 1-minute Apgar scores were significantly lower in the EOP group compared to the other groups (P=0.001), while the 5-minute Apgar scores were also significantly reduced in the LOP group compared to the control group (P=0.011). The rate of cesarean delivery was highest in the EOP group (80%), followed by the LOP (75%) and control groups (60%; P=0.0071). NICU admission rates were significantly higher in the EOP group (58.1%) compared to the LOP (25%) and control groups (10.7%; P=0.001) (Table 2).

According to the ROC analysis results, APRI and FIB-4 demonstrated a statistically significant distinction between late-onset preeclampsia and control groups (APRI AUC: 0.614, P=0.010; FIB-4 AUC: 0.617, P=0.008). The cutoff point for APRI was determined to be 0.2347, with a sensitivity of 61% and a specificity of 60%. For FIB-4, the optimal cutoff point was 0.65, with a sensitivity of 57% and a specificity of 56% (Fig. 1).

Chi-square analysis was performed between the control group and the preeclampsia group based on the cutoff points determined for APRI and FIB-4. The proportion of individuals below the 0.23 cutoff point for APRI was 57.6% in the control group and 42.4% in the preeclampsia group, while the proportion of individuals above the cutoff point was 43.0% in the control group and 57.0% in the preeclampsia group (P=0.024). The rate of individuals below the 0.65 cutoff point for FIB-4 was 56.8% in the control group and 43.2% in the preeclampsia group, whereas the rate of individuals above the cutoff point was 43.9% in the control group and 56.1% in the preeclampsia group (P=0.046) (Table 3, Fig. 2).

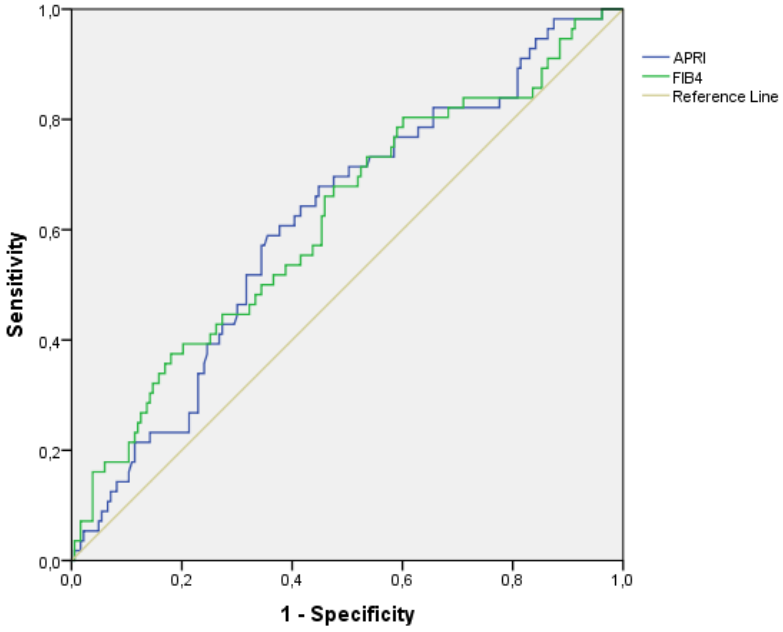

Fig. 1. ROC Curve for diagnostic performance evaluation.

Table 3. Distribution of APRI and FIB-4 according to cutoff values

Category	Group	Control)	Preeclampsia	Total
APRI (<0.23)	<0.23	72 (57.6%)	53 (42.4%)	125 (52.3%)
APRI (≥0.23)	≥0.23	49 (43.0%)	65 (57.0%)	114 (47.7%)
FIB-4 (<0.65)	<0.65	71 (56.8%)	54 (43.2%)	125 (52.3%)
FIB-4 (≥0.65)	≥0.65	50 (43.9%)	64 (56.1%)	114 (47.7%)

Data are shown as n (%). APRI= aspartate aminotransferase to platelet ratio index, FIB-4=fibrosis-4 score

Note: Counts and percentages for control and preeclampsia groups are presented based on the cutoff values for APRI (0.23) and FIB-4 (0.65).

DISCUSSION

Our study identified significant differences in clinical and neonatal outcomes among the EOP, LOP, and control groups. EOP was associated with lower gestational age at birth, lower fetal birth weight, and higher NICU admission rates compared to the LOP and control groups. The APRI score in the LOP group was noticeably higher than that in the control group, while elevated white blood cell counts (WBC) were observed in the EOP group. These findings highlight distinct clinical profiles across the groups and emphasize the importance of these parameters in preeclampsia. Neonatal outcomes showed marked differences among the early-onset, late-onset preeclampsia, and control groups, with the most adverse outcomes observed in the early-onset preeclampsia group, particularly in parameters such as gestational age, birth weight, Apgar scores, and NICU admissions.

Preeclampsia is a pregnancy-specific condition that complicates approximately 5% of all pregnancies [9]. Despite its relatively low prevalence, it holds significant importance among pregnancy complications due to its severe adverse maternal and fetal outcomes [10]. Preeclampsia and its complications account for 10-15% of maternal death. Perinatal morbidity and mortality rates are also markedly higher, especially in preeclampsia that begins before the 34th week [11]. These serious outcomes highlight the need for studies aimed at predicting and managing preeclampsia.

In this study, no statistically significant difference in maternal age was observed among the groups

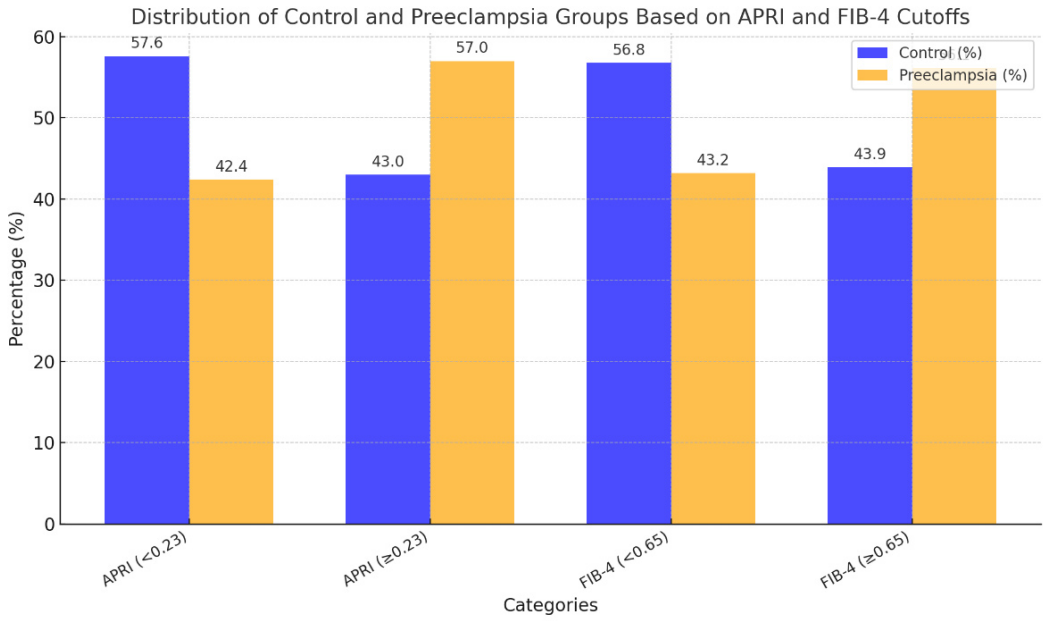

Fig. 2. Distribution of control and preeclampsia groups according to APRI (0.23) and FIB-4 (0.65) cutoff values.

(P=0.057). This finding aligns with existing literature, which identifies advanced maternal age as a risk factor associated with vascular and metabolic changes that predispose individuals to hypertensive disorders in pregnancy [12]. Nulliparity is also recognized as a potential risk factor for preeclampsia [12]. However, in our study, no significant difference was observed between the groups for gravida and parity (P=0.465 and P=0.415, respectively). BMI was significantly higher in both preeclampsia cohorts compared to the control group (P=0.001). High BMI is a known contributing factor to metabolic dysregulation, systemic inflammation, and endothelial dysfunction [13]. The similar BMI observed between the EOP and LOP groups suggests that obesity may contribute to the development of both subtypes, although the severity and onset may vary depending on other factors.

In our study, the WBC level in the EOP group (12.0±3.65) was significantly higher than that in the LOP group (10.60±3.06; P=0.044) and the control group (10.58±3.32; P=0.012), but no significant difference was observed between the LOP and control groups. These findings highlight the role of the inflammatory response in preeclampsia. The literature describes preeclampsia as a systemic inflammatory condition, with leukocytosis considered an indicator of inflammation. Redman and Sargent [14] emphasized the relationship between preeclampsia, maternal immune system activation, and inflammatory processes. The AST and ALT levels in the early preeclampsia cohort were significantly higher compared to the control group (P=0.050 and P=0.011, respectively), but no significant difference was observed in the LOP group. These increases in AST and ALT levels can be considered indicators of liver dysfunction and HELLP syndrome in preeclampsia [15]. Bartal and Sibai [16] stated that preeclampsia may impair liver function, but these changes are generally limited in the early period. İpek *et al*. [17] investigated the efficacy of the APRI score assessed in the first trimester for predicting superimposed preeclampsia. In this retrospective case-control study, APRI scores at two different time points, designated as APRI1 and APRI2, were evaluated. The most appropriate cutoff value for APRI1 in predicting superimposed preeclampsia was determined to be 0.036, with a sensitivity of 65.2% and a specificity of 83.7%. The most appropriate cutoff value for APRI2 was determined to be 0.057; at this threshold, sensitivity was reported as 67.4% and specificity as 52.0%. These findings suggest that APRI scores measured in the first trimester may serve as a potential marker for predicting the development of superimposed preeclampsia [17]. Although the APRI score is primarily used as a biomarker for assessing liver fibrosis, its elevation in preeclampsia patients has been linked to liver dysfunction and inflammation. In our study, APRI scores showed no significant difference between the early and late preeclampsia groups; however, they were significantly elevated in the late preeclampsia group compared to the control group (P 0.012). In the literature, Itakura *et al*. [18] highlighted that the APRI score serves as a non-invasive indicator of liver fibrosis in chronic liver disorders.

Our ROC analysis indicated that APRI and FIB-4 scores provided significant discrimination between late-onset preeclampsia and control groups. These findings suggest that both scores may be useful in evaluating cases of late-onset preeclampsia. However, the use of APRI and FIB-4 in the context of preeclampsia is limited in the literature. For instance, Yen *et al*. reported that APRI offers moderate sensitivity and specificity in diagnosing hepatic fibrosis, suggesting that the score may reflect inflammatory processes [18]. Similarly, there are some studies linking FIB-4 to extrahepatic conditions such as metabolic syndrome and hypertension [19]. Considering the systemic inflammation, endothelial dysfunction, and microvascular damage characteristic of the pathophysiology of preeclampsia, these two scores may provide meaningful discrimination. Nevertheless, given that the AUC values in our ROC analysis (0.614 for APRI and 0.617 for FIB-4) are in the low-to-medium range, these scores alone are insufficient as predictors and should be evaluated alongside other clinical and biochemical parameters.

The similarity in APRI and FIB-4 scores between the EOP and LOP groups suggests that these biomarkers might be more closely linked to liver function and levels of systemic inflammation rather than the timing of preeclampsia onset. However, further research with a larger patient population is necessary to clarify this distinction. Notably, our results show that the APRI and FIB-4 scores in the LOP group (0.25±0.12 and 0.73±0.53, respectively) were higher than those in

both the EOP (0.22±0.17 and 0.66±0.42, respectively) and control groups (0.20±0.10 and 0.59±0.36, respectively), which aligns with the increased systemic inflammation and potential liver fibrosis associated with LOP [20]. Despite these findings, the difference between the LOP and EOP groups did not achieve statistical significance, likely due to the small sample size. In contrast, the difference between the LOP and control groups was statistically significant for both APRI (P=0.012) and FIB-4 (P=0.005). On the other hand, the absence of a difference between the EOP and control groups may be attributed to EOP typically reflecting a scenario limited to local placental dysfunction. The localized effects in EOP may not have led to a significant alteration in APRI and FIB-4, which assess systemic inflammation and liver function. These results underscore the necessity for larger studies to more effectively evaluate the role of APRI and FIB-4 in differentiating between preeclampsia subtypes.

Although APRI and FIB-4 are not sufficient as independent predictors of preeclampsia, they may be useful in risk stratification and management as complementary tools alongside existing clinical and biochemical markers. These scores can play a supportive role, particularly in the early diagnosis and follow-up of preeclampsia. However, larger-scale prospective studies are necessary to fully confirm the diagnostic and prognostic value of APRI and FIB-4 in the context of preeclampsia. Such studies are crucial to clarifying the role of these scores in clinical practice.

CONCLUSION

APRI and FIB-4 may be useful as supplementary tools in risk stratification and preeclampsia management, especially in late-onset cases, even though they are insufficient as stand-alone predictors. To verify their therapeutic usefulness and investigate how they might be integrated with current diagnostic frameworks, larger-scale, prospective investigations are needed.

Ethical Statement

This study was approved by the Ankara Etlik City Hospital Scientific Research Evaluation and Ethics Committee (Decision no: AEŞH-BADEK-2024-1143, and date: 11.12.2024). Ethical principles were followed throughout the study and all necessary precautions were taken to ensure patient privacy and data confidentiality in accordance with institutional regulations.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Authors' Contribution

Study Conception: NVT; Study Design: NVT, GK; Supervision: ATÇ; Funding: GK, ZŞ; Materials: GA, SÇ; Data Collection and/or Processing: GA; Statistical Analysis and/or Data Interpretation: NVT; Literature Review: BTÇ; Manuscript Preparation: NVT; and Critical Review: NVT, ATÇ.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

The authors disclosed that they did not receive any grant during conduction or writing of this study.

REFERENCES

1. Bisson C, Dautel S, Patel E, Suresh S, Dauer P, Rana S. Preeclampsia pathophysiology and adverse outcomes during pregnancy and postpartum. Front Med (Lausanne). 2023;10:1144170. doi: 10.3389/fmed.2023.1144170.
2. Jung E, Romero R, Yeo L, et al. The etiology of preeclampsia. Am J Obstet Gynecol. 2022;226(2S):S844-S866. doi: 10.1016/j.ajog.2021.11.1356.
3. MacDonald TM, Walker SP, Hannan NJ, Tong S, Kaitu'u-Lino TJ. Clinical tools and biomarkers to predict preeclampsia. EBioMedicine. 2022;75:103780. doi: 10.1016/j.ebiom.2021.103780.
4. Leybovitz-Haleluya N, Yahav L, Saban A, Eshkoli T, Hershkovitz R, Weintraub A. The use of aspartate aminotransferase to platelet ratio index as a predictor of obstetrical and neonatal adverse outcomes in patients with preeclampsia toxemia. Authorea. September 13, 2024. doi: 10.22541/au.172621263.32151270/v1.
5. Blanco-Grau A, Gabriel-Medina P, Rodriguez-Algarra F, et al. Assessing Liver Fibrosis Using the FIB4 Index in the Community Setting. Diagnostics (Basel). 2021;11(12):2236. doi: 10.3390/diagnostics11122236.
6. Tolunay HE, Kahraman NC, Varli EN, Reis YA, Celen S, Caglar AT. Can First-trimester AST to Platelet Ratio Index Scores Predict HELLP Syndrome? J Coll Physicians Surg Pak. 2021;31(2):188-192. doi: 10.29271/jcpsp.2021.02.188.
7. Soe MZ, Hayati F, Abdul Rahim SSS. Can First-trimester AST to Platelet Ratio Index Scores Predict HELLP Syndrome? J Coll

Physicians Surg Pak. 2022;32(3):409-410. doi: 10.29271/jcpsp.2022.03.409.
8. Bouter AR, Duvekot JJ. Evaluation of the clinical impact of the revised ISSHP and ACOG definitions on preeclampsia. Pregnancy Hypertens. 2020;19:206-211. doi: 10.1016/j.preghy.2019.11.011.
9. Abalos E, Cuesta C, Grosso AL, Chou D, Say L. Global and regional estimates of preeclampsia and eclampsia: a systematic review. Eur J Obstet Gynecol Reprod Biol. 2013;170(1):1-7. doi: 10.1016/j.ejogrb.2013.05.005.
10. Duley L. The global impact of pre-eclampsia and eclampsia. Semin Perinatol. 2009;33(3):130-137. doi: 10.1053/j.semperi.2009.02.010.
11. Cluver CA, Bergman L, Bergkvist J, et al. Impact of fetal growth restriction on pregnancy outcome in women undergoing expectant management for preterm pre-eclampsia. Ultrasound Obstet Gynecol. 2023;62(5):660-667. doi: 10.1002/uog.26282.
12. Bartsch E, Medcalf KE, Park AL, Ray JG; High Risk of Preeclampsia Identification Group. Clinical risk factors for preeclampsia determined in early pregnancy: systematic review and meta-analysis of large cohort studies. BMJ. 2016;353:i1753. doi: 10.1136/bmj.i1753.
13. Ellulu MS, Patimah I, Khaza'ai H, Rahmat A, Abed Y. Obesity and inflammation: the linking mechanism and the complications. Arch Med Sci. 2017;13(4):851-863. doi: 10.5114/aoms.2016.58928.
14. Redman CW, Sargent IL. Latest advances in understanding preeclampsia. Science. 2005;308(5728):1592-1594. doi: 10.1126/science.1111726.
15. Afroz F, Sultana N, Rahman A, et al. A comparative study of hepatic enzymes between preeclampsia and normal pregnant women. J Dhaka Med Coll. 2020;29(1):18-22. doi: 10.3329/jdmc.v29i1.51137.
16. Bartal MF, Sibai BM. Gestational hypertension, preeclampsia, and eclampsia. In: Spong CY, Lockwood CJ, editors. Queenan's Management of High−Risk Pregnancy. 1st ed. Wiley; 2024. pp. 281-287.
17. İpek G, Tanaçan A, Ağaoğlu Z, Gülçin Baştemur A, Gülen Yıldız E, Şahin D. The role of aspartate aminotransferase to platelet ratio index (APRI) in the first trimester for the prediction of superimposed preeclampsia: A case-control study from a tertiary center. Pregnancy Hypertens. 2024;37:101132. doi: 10.1016/j.preghy.2024.101132.
18. Yen, Y. H., Kuo, F. Y., Kee, K. M., Chang, K. C., Tsai, M. C., Hu, T. H. (2018). APRI and FIB-4 in the evaluation of liver fibrosis in chronic hepatitis C patients stratified by AST level. PloS one, 13(6), e0199760.
19. Itakura J, Kurosaki M, Setoyama H, et al. Applicability of APRI and FIB-4 as a transition indicator of liver fibrosis in patients with chronic viral hepatitis. J Gastroenterol. 2021;56(5):470-478. doi: 10.1007/s00535-021-01782-3.
20. Sumida Y, Yoneda M, Tokushige K, et al, Japan Study Group Of Nafld Jsg-Nafld. FIB-4 First in the Diagnostic Algorithm of Metabolic-Dysfunction-Associated Fatty Liver Disease in the Era of the Global Metabodemic. Life (Basel). 2021;11(2):143. doi: 10.3390/life11020143.