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Original article

Impact of preeclampsia on maternal and neonatal health: A retrospective cohort study

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Abstract: *Objective* — Understanding the relationship between maternal characteristics of patients with preeclampsia (PE) and disease progression, as well as the impact on neonatal and parturient outcomes, is critical to the development of effective interventions to improve maternal and fetal outcomes in preeclamptic patients.
Material and Methods — This retrospective study analyzed 94 patients with PE and focused on the relationship between maternal characteristics and laboratory findings, as well as on the impact on neonatal and parturient outcomes. Comprehensive laboratory and ultrasound examinations were performed, with primary outcomes classified into antenatal, perinatal and postpartum periods, and secondary outcomes focusing on neonatal health.
Results — Patients with PE requiring maternal intensive care unit (ICU) admission had higher median serum creatinine, AST, and ALT levels vs. non-ICU patients. Patients who required postpartum medications to control blood pressure had elevated median values of urea concentration, systolic blood pressure, and diastolic blood pressure at diagnosis. A notable difference in ALT values was observed when primary cesarean section was indicated (p=0.036). Subgroup analysis revealed higher median birth weight in the Proteinuria 1+ subgroup vs. the Proteinuria 4+ subgroup (p=0.002). Patients with negative proteinuria levels demonstrated less need for neonatal intensive care unit (NICU) compared with higher proteinuria levels. In addition, a higher need for postpartum medical therapy was noted in patients of Proteinuria 4+ subgroup (74.2%).
Conclusion — This study emphasizes the important role of laboratory data and blood pressure monitoring, advocating targeted interventions and clinical approaches to improve maternal postpartum outcomes (need for ICU). It also highlights the utility of urine dipstick testing for effective decision-making in the care of mothers and newborns in the postpartum period.

Keywords: preeclampsia, blood pressure, proteinuria, clinical outcome assessment.

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Introduction

Preeclampsia (PE) is a pregnancy-related disease characterized by increased blood pressure (BP) after the 20th week of pregnancy [1]. PE is a multisystem disease affecting multiple organs and systems. It is responsible for serious maternal and neonatal complications including maternal hypertension, placental abruption, fetal growth restriction and preterm birth [2-4]. Hypertensive disorders of pregnancy (HDP) and PE are significant causes of obstetric pathology in mothers and newborns throughout the world [5]. PE is currently among the leading causes of maternal and fetal loss due to complications of this disease [6]. An important issue for practicing obstetricians is the reduction of maternal mortality rate (MMR) and other serious maternal and fetal complications associated with HDP.

Understanding the relationship of maternal characteristics with pregnancy progress and neonatal outcomes in pregnant women with PE is critical to developing effective interventions to improve maternal and fetal outcomes. The birth of the placenta and child is a radical method of treating PE. However, despite delivery, serious maternal and neonatal complications may occur. MMR remains a problem even after delivery in a patient with PE [7]. Maternal mortality is not only a significant consequence of PE: the need for intensive care unit (ICU) admission is another significant and severe complication. It is notable that hospitalization in the ICU (especially for a long stay) is associated with permanent sequelae [8]. Another detail that should not be ignored is the fact that PE is a multisystem disease that causes multiple organ damage and uncontrolled hypertensive attacks in patients in the prepartum, peripartum, and postpartum periods [9]. Therefore, patients with PE should be referred to (and treated at) tertiary care centers. These centers provide patients with multidisciplinary assessment and have efficient maternal and neonatal ICUs [10-11].

The goal of our study was to examine the relationship between maternal characteristics (obesity, diabetes, gestational diabetes mellitus [GDM], results of maternal laboratory tests and BP) at the time of diagnosis and the course of pregnancy in patients with PE, as well as outcomes of their newborns, in order to identify potential risk factors and specify targeted interventions. In this context, our study aimed at determining which laboratory test

results are capable of predicting adverse effects on postpartum maternal and fetal conditions, thereby improving the accuracy of risk assessment and facilitating the development of more effective intervention strategies. The results of this study may lead to the development of more effective and targeted interventions for the prevention and treatment of PE, which will ultimately lead to a reduction in morbidity and mortality among preeclamptic mothers and their newborns.

This study may also help identify high-risk women who may benefit from early interventions and close monitoring. By understanding the specific characteristics and outcomes of preeclamptic pregnancies, health care providers can develop more effective and individualized care plans for women with PE. Timely detection and the correct choice of treatment regimen can lead to better outcomes for both mother and newborn.

Material and Methods

Study design and setting

This retrospective study included 94 patients with PE. All patients were diagnosed with HDP and were subsequently admitted to the Bursa City Hospital, Bursa, Turkey. The study design was approved by the institutional Ethics Committee at Bursa City Hospital (#2023-11/4). For a retrospective study, formal consent was not required. However, all subsequent procedures were strictly in accordance with the ethical standards of the Human Research Ethics Committee and with the Declaration of Helsinki.

Patients

The study involved 94 patients diagnosed with PE, hospitalized and gave birth in Bursa City Hospital. All patients in this study had their BP measured before pregnancy or in the early stages of pregnancy (first trimester). Pregnant women with symptoms of arterial hypertension were under detailed observation. The patients underwent comprehensive laboratory tests and ultrasonographic examination. Patients were included in the study only if data on maternal demographic characteristics and laboratory or ultrasound screening results were available at the time of diagnosis. Depending on the stability of the maternal and fetal condition and the week of pregnancy, patients were hospitalized and closely monitored. Considering the condition of the mother and fetus, after stabilizing the general condition of the patients and ensuring the maturation of the fetal lungs, the patients gave birth. Antenatal corticosteroids were administered to patients with PE before planned preterm birth to enhance fetal lung maturity at a gestational age of less than 34 weeks (*Table 1*).

The exclusion criteria for the present study were the patients with incomplete maternal demographic or clinical data, as well as patients who did not give birth at Bursa City Hospital (*Figure1*).

Diagnostic criteria

All included patients were diagnosed with HDP. Those with systolic blood pressure (SBP) ≥ 160 mm Hg and/or diastolic blood pressure (DBP)≥110 mm Hg, thrombocytopenia < 100,000/μL, liver enzyme levels in excess of their twofold normal values, HELLP syndrome, renal failure, right upper abdominal pain and/or discomfort, persistent epigastric pain with or without vomiting, visual impairment and neurological symptoms, as well as acute pulmonary edema, were diagnosed as preeclampsia with severe features.

Table 1. Demographic and obstetric characteristics of patients

Characteristics of patients		*n*	*value*
Age		94	29.45±6.19
<35 years		71	26.77±4.42
≥35 years		23	37.69±2.32
Gravida		94	2 (1:7)
Parity		94	1 (0:5)
Abortion		92	0 (0:6)
Initial maternal weight		50	76.86±15.71
Third-trimester weight, kg		45	89 (60:150)
Peripartum period, hour		92	5.5 (0.08:48)
Neonate birth weight, g		92	2547.17±965.62
Neonate length, cm		92	48 (28:56)
Neonate head circumference, cm		92	33 (21:38)
Week of delivery		93	36 (22:40)
Apgar 1 score, pts		93	9 (0:9)
Apgar 5 score, pts		93	10 (0:10)
Follow-up	None	92	51 (55.4%)
	Regular		37 (40.2%)
	Eclampsia at admission		4 (4.4%)
Gestational weight gain, g	≤10	38	18 (47.4%)
	>10		20 (52.6%)
PPP	Present	94	21 (22.3%)
	Absent		73 (77.7%)
GDM	Present	94	14 (15.2%)
	Absent		80 (85.1%)
Urea		84	20.5 (5.8:47)
CR		83	0.59±0.15
AST		88	17 (8.8:222)
ALT		87	11 (5:218)
PLT		86	237.27±73.36
Protein	-	90	15 (16.7%)
	1+		20 (22.3%)
	2+		11 (12.2%)
	3+		13 (14.4%)
	4+		31 (34.4%)
SBP in diagnosis, mmHg		88	150 (110:220)
DBP in diagnosis, mmHg		88	90 (70:120)
Primary C/S	Present	94	15 (16.0%)
	Absent		79 (84.0%)
History of C/S	0	94	79 (84%)
	1		8 (8.5%)
	2		6 (6.4%)
	3		1 (1.1%)
Type of delivery	C/S	94	65 (69.1%)
	V/D		29 (30.9%)
Primary C/S	Other indications	65	11 (16.90%)
	AFD		54 (83.10%)
Gestational age at delivery	< 34 weeks	93	36 (38.7%)
	34–36⁶ weeks		27 (29.0%)
	≥ 37 weeks		30 (32.3%)
Need for NICU	*Level I*	94	5 (5.3%)
	Level III		29 (30.9%)
	No NICU needed		60 (63.8%)
Maternal hospitalization (days)		94	5 (2:18)
Maternal other clinic assessments	Present	94	22 (23.4%)
	More than one		18 (19.1%)
	Absent		54 (57.4%)
Maternal need for ICU	Present	94	7 (7.4%)
	Absent		87 (92.6%)
Postpartum BP	Spontaneous regulation	94	42 (44.7%)
	Medication needed		52 (55.3%)

Data are presented as: mean ± standard deviation, median (minimum: maximum), and n (%). PPP, preeclampsia in a previous pregnancy; GDM, gestational diabetes mellitus; CR, serum creatinine; AST, aspartate aminotransferase; ALT alanine aminotransferase; PLT, platelet count; SBP, systolic blood pressure; DBP diastolic blood pressure; C/S, cesarean section; VD, vaginal delivery; AFD, acute fetal distress; NICU, neonatal intensive care unit; ICU, intensive care unit.

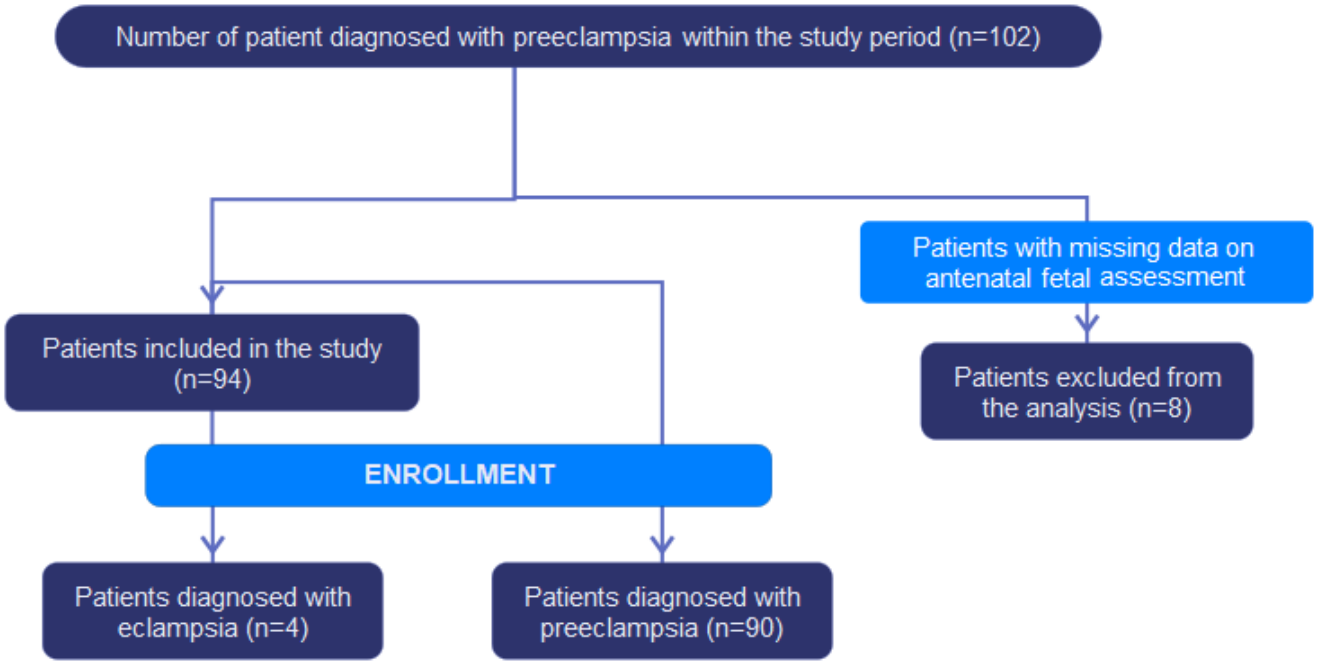

Figure 1. Flowchart of patients included in the study.

Table 2. Correlation between urine dipstick readings and proteinuria

Dipstick reading	*Quantified proteinuria (mg/dL)*
None	None
Trace	15-30
1+	30-100
2+	100-300
3+	300-1000
4+	>1000

Based on [12].

Maternal data

Maternal demographic and obstetric characteristics were examined. Data from patients with PE were assessed by age at diagnosis, as well as by comorbidities, pregnancy, parity, history of cesarean section (C/S), number of C/S the patient had, maternal weight initially and in the third trimester, weight gain during pregnancy, maternal initial (baseline) BP, and BP at diagnosis. Maternal laboratory tests included complete blood count (CBC) with platelets, serum creatinine (CR) and urea levels, and liver enzymes: aspartate aminotransferase (AST) and alanine aminotransferase (ALT). Screening for proteinuria was performed using a urine dipstick test. Correlation between urine dipstick readings and quantitative proteinuria is presented in *Table 2* [12].

Neonatal data

Neonatal assessment included Apgar scores, birth weight, head circumference, neonatal hospitalization rate, and neonatal intensive care unit (NICU) admission.

Primary outcomes

Maternal outcomes were classified into antenatal, perinatal and postpartum periods. In the antenatal period, information was collected on the regularity of antenatal visits during pregnancy (regular follow-up), history of PE, and GDM in the current pregnancy. The patient perinatal period (per hour) in the labor, delivery room, and recovery room, week of labor, type of delivery (vaginal [VD] or C/S), primary C/S rate, and primary C/S indication due to acute fetal distress (AFD) or other indication were assessed. Postpartum assessment included maternal postpartum and puerperal complications caused by HDP, such as length of maternal hospital stay (days) and maternal referral/admission to the ICU. The need for examination by other clinical specialists (internist, cardiologist, neurologist) to stabilize the general condition of patients, as well as the need for medical intervention to control maternal BP in the postpartum period, were also analyzed.

Secondary outcomes

Neonatal outcomes included Apgar scores, neonatal anthropometric parameters (infant birth weight and head circumference), neonatal hospitalization rate, and NICU admissions.

Statistical data processing

The study assessed the compliance of variables with normal distribution using the Shapiro-Wilk test. Continuous variables were presented as mean ± standard deviation and median (min-max). Categorical variables were expressed as n (%). For comparisons between two groups, Student's t-test or Mann-Whitney U test was chosen based on the results of the normality test. More than two groups were compared using Kruskal-Wallis test or one-way ANOVA. The Pearson's chi-squared test and the Fisher-Freeman-Halton exact test were employed to compare categorical variables. Statistical analyzes were performed by IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., released 2017, Armonk, NY: IBM Corp.). All comparisons were set to a significance level of 5%.

Table 3. Association of maternal laboratory results and blood pressure with maternal and fetal outcomes

Variables		*n*	*Urea*	*n*	*CR*	*n*	*AST*	*n*	*ALT*	*n*	*PLT*	*n*	*SBP in diagnosis*	*n*	*DBP in diagnosis*
Peripartum period	r_s	82	-0.143	81	-0.167	86	-0.211	85	-0.313**	84	-0.022	92	-0.126	92	-0.086
	p		0.201		0.136		0.051		0.004		0.845		0.232		0.418
Apgar 1 score	r_s	83	-0.191	82	-0.213	87	-0.090	86	-0.081	85	0.069	93	-0.039	93	-0.157
	p		0.084		0.055		0.407		0.461		0.530		0.708		0.132
Apgar 5 score	r_s	83	-0.172	82	-0.134	87	-0.055	86	-0.079	85	0.161	93	-0.108	93	-0.120
	p		0.119		0.232		0.613		0.470		0.142		0.305		0.252
Infant birth weight, g	r_s	82	-0.376**	81	-0.273*	86	-0.074	85	-0.119	84	0.029	92	-0.133	92	-0.220*
	p		<0.001		0.014		0.500		0.277		0.791		0.205		0.035
Week of delivery	r_s	83	-0.361**	82	-0.242*	87	-0.122	86	-0.151	85	0.026	93	-0.162	93	-0.269**
	p		0.001		0.028		0.259		0.166		0.812		0.121		0.009
Maternal hospitalization	r_s	84	0.002	83	-0.013	88	0.059	87	0.097	86	0.127	94	0.207*	94	0.138
	p		0.985		0.906		0.588		0.371		0.242		0.045		0.184
Follow-up															
None		44	19.7 (10.2:47)	44	0.61±0.16	46	18 (9:222)	46	12 (5:218)	47	238.72±80.81	51	150 (110:220)	51	90 (70:120)
Regular		35	21 (5.8:44.3)	34	0.59±0.12	37	16 (9:55)	36	10 (5:66)	34	227.32±59.65	37	150 (118:190)	37	95 (70:114)
Eclampsia at admission		3	-	3	-	3	-	3	-	3	-	4	-	4	-
p-value			0.441[e]		0.520[d]		0.302[e]		0.546[e]		0.467[d]		0.496[e]		0.431[e]
Type of delivery															
Cesarean section		57	21 (5.8:47)	56	0.61±0.16	61	18 (9:222)	60	11 (5:218)	58	237.6±73.8	65	150 (130:220)	65	100 (70:120)
Vaginal delivery		27	19.7 (10.2:27.1)	27	0.56±0.12	27	16 (9:35)	27	9 (5:50)	28	236.4±73.6	29	150 (110:180)	29	90 (70:110)
p-value			0.156[e]		0.173[d]		0.105[e]		0.105[e]		0.942[d]		0.027[e]		0.008[e]
Primary cesarean section															
Other indications		10	24.5 (14.60:41.5)	10	0.58 (0.28:0.80)	10	16.50 (11:137)	10	8.50 (5:130)	10	240.50 (97:411)	8	125 (107:180)	8	80 (70:110)
Acute fetal distress		47	20.80 (5.80:47)	46	0.61 (0.16:7.40)	51	18 (9:222)	50	12 (5:218)	48	238.50 (103:447)	31	120 (100:140)	31	70 (60:100)
p-value			0.275[e]		>0.999[e]		0.649[e]		0.036[e]		0.877[e]		0.728[e]		0.824[e]
Need for NICU															
Level I		5	21 (10.9:26.3)	5	0.5 (0.36:0.76)	5	16 (14:48)	5	10 (8:25)	5	276 (208:322)	5	160 (140:180)	5	100 (90:110)
Level III		25	20.8 (11.3:34.9)	24	0.56 (0.16:1.0)	25	18 (9:60)	25	12 (5:66)	25	224 (103:381)	29	160 (130:190)	29	100 (90:120)
No NICU needed		54	10.1 (5.8:47)	54	0.59 (0.28:1.1)	58	16 (9:222)	57	10 (5:218)	56	236 (97:447)	60	150 (110:220)	60	90 (70:120)
p-value			0.511[a]		0.250[a]		0.614[a]		0.771[a]		0.162[a]		0.419[a]		0.072[a]
Maternal need for ICU															
Present		5	21 (19.9:25)	5	0.75 (0.69:0.76)	6	42 (16:137)	6	21 (10:130)	5	238 (97:276)	7	150 (140:180)	7	100 (90:120)
Absent		79	20.5 (5.8:47)	78	0.56 (0.16:1.07)	82	16 (9:222)	81	10 (5:218)	81	236 (103:447)	87	150 (110:220)	87	90 (70:120)
p value			0.581[e]		0.004[e]		0.003[e]		0.014[e]		0.455[e]		0.883[e]		0.248[e]
Gestational age at delivery															
<34weeks		32	20.8 (5.8:41.5)	31	0.63±0.14	32	18 (9:92)	32	11.5 (5:71)	30	229.8±73.1	36	155 (118:220)	36	100 (70:120)
34-36^6 weeks		24	22.6 (13.7:47)	24	0.62±0.17	26	17 (11:222)	35	10 (6:218)	26	234.6±67.4	27	150 (130:170)	27	100 (70:114)
≥37 weeks		27	19.7 (10.2:41.5)	27	0.55±0.14	29	16 (9:60)	29	10 (5:43)	29	248.3±80.8	30	150 (110:185)	30	90 (70:110)
p value			0.085[a]		0.100[f]		0.729[a]		0.410[a]		0.615[f]		0.426[a]		0.008[a]
Maternal other clinic assessments															
Present		20	20.6 (5.8:47)	19	0.56 (0.46:1.07)	20	20 (9:222)	20	12 (5:218)	19	256.1±79.8	22	160 (130:220)	22	100 (70:120)
More than one		15	21 (11.3:34)	15	0.53 (0.16:0.76)	17	18 (9:48)	17	13 (5:54)	17	239.1±76.1	18	160 (130:180)	18	95 (80:120)
Absent		49	20.5 (10.2:44.3)	49	0.59 (0.28:0.92)	51	16 (9:137)	50	10 (5:130)	50	229.5±70.1	54	150 (110:180)	54	90 (70:110)
p value			0.874[a]		0.309[a]		0.397[a]		0.255[a]		0.407[f]		0.063[a]		0.085[a]
Postpartum blood pressure															
Spontaneous regulation		38	18.75 (10.2:41.5)	38	0.55 (0.28:0.92)	40	16 (9:137)	40	10 (5:130)	41	235.9±76.2	42	150 (110:180)	42	90 (70:110)
Medication needed		46	22.35 (5.8:47)	45	0.59 (0.16:1.07)	48	18 (9:222)	47	12 (5:218)	45	238.5±71.5	52	160 (130:220)	52	100 (70:120)
p-value			0.010[e]		0.537[e]		0.105[e]		0.339[e]		0.873[d]		0.030[e]		0.003[e]
Gestational weight gain															
≤10		18	19,25 (11.3:44.3)	16	0.56 (0.28:0.80)	181	15.5 (9:55)	18	10 (5:38)	17	238.9±41.4	18	150 (130:160)	18	90 (80:106)
>10		16	20.25 (10.9:34)	16	0.51 (0.41:0.76)	9	16 (9:36)	18	10 (6:24)	18	248.3±68.8	20	155 (118:190)	20	97.5 70:120)
p-value			0.851[e]		0.341[e]		0.408[e]		0.424[e]		0.628[d]		0.141[e]		0.217[e]

Data are given as median (minimum: maximum) and mean ± standard deviation. a, Kruskal Wallis Test; d, Student's t-test; e, Mann-Whitney U test; f, ANOVA test; r_s, Spearman's rank correlation coefficient; CR, serum creatinine; AST, aspartate aminotransferase; ALT alanine aminotransferase; PLT, platelet count; SBP, systolic blood pressure; DBP diastolic blood pressure; NICU, neonatal intensive care unit; ICU, intensive care unit.

Table 4. Association of maternal proteinuria levels with maternal and fetal outcomes

Variables	*n*	*Proteinuria -*	*n*	*Proteinuria 1+*	*n*	*Proteinuria 2 +*	*n*	*Proteinuria 3 +*	*n*	*Proteinuria 4+*	*p-value*
Peripartum period	15	5 (0.5:20)	19	11 (0.3:48)	11	10 (0.08:48)	12	3 (0.25:18)	31	5 (0.83:48)	0.114[a]
Apgar 1 score	15	9 (8:9)	19	9 (3:9)	11	9 (3:9)	13	9 (0:9)	31	9 (1:9)	0.158[a]
Apgar 5 score	15	10 (9:10)	19	10 (8:10)	11	10 (6:10)	13	10 (0:10)	31	10 (4:10)	0.213[a]
Infant birth weight	15	3345 (2010:4345)	19	3120 (1425:4115)	11	2330 (640:4300)	12	2287.5 (940:4340)	31	2070 (535:4110)	<0.001[a]
Week of delivery	15	38 (27:40)	20	37 (23:40)	11	35 (28:39)	13	34 (22:39)	31	35 (24:39)	0.010[a]
Maternal hospitalization	15	4 (2:10)	20	5 (2:18)	11	4 (2:15)	13	5 (2:8)	31	5 (2:10)	0.760[a]
Follow-up											
None		7 (14.6%)		11 (22.9%)		3 (6.3%)		10 (20.8%)		17 (35.4%)	
Regular	14	6 (16.2%)	20	8 (21.6%)	11	8 (21.6%)	13	3 (8.1%)	30	12 (32.4%)	0.360[b]
Eclampsia at admission		1 (33.3%)		1 (33.3%)		0		0		1 (33.3%)	
Type of delivery											
Cesarean section	15	8 (12.9%)	20	12 (19.4%)	11	8 (12.9%)	13	11 (17.7%)	31	23 (37.1%)	0.371[b]
Vaginal delivery		7 (25%)		8 (28.6%)		3 (10.7%)		2 (7.1%)		8 (28.6%)	
Primary cesarean section											
Other indications	12	2 (16.70%)	8	2 (25%)	11	2 (18.20%)	23	3 (13%)	8	1 (12.50%)	0.966[b]
Acute fetal distress		10 (83.30%)		6 (75%)		9 (81.80%)		20 (87%)		7 (87.50%)	
Need for NICU											
Level I		0		1 (20%)		1 (20%)		2 (40%)		1 (20%)	
Level III	15	0	20	5 (17.9%)	11	3 (10.7%)	13	5 (17.9%)	31	15 (53.6%)	0.007[b]
No NICU needed		15 (26.3%)		14 (24.6%)		7 (12.3%)		6 (10.5%)		15 (26.3%)	
Maternal need for ICU											
Present	15	2 (33.3%)	20	0	11	1 (16.7%)	13	2 (33.3%)	31	1 (16.7%)	0.203[b]
Absent		13 (15.5%)		20 (23.8%)		10 (11.9%)		11 (13.1%)		30 (35.7%)	
Gestational age at delivery											
< 34 weeks		3 (8.8%)		5 (14.7%)		5 (14.7%)		6 (17.6%)		15 (44.2%)	
34 – 36^6 weeks	15	3 (11.5%)	20	6 (23.1%)	11	3 (11.5%)	13	4 (15.4%)	30	10 (38.5%)	0.186[b]
≥ 37 weeks		9 (31.1%)		9 (31.1%)		3 (10.3)		3 (10.3%)		5 (17.2%)	
Maternal other clinical assessment											
Present		2 (9.5%)		2 (9.5%)		2 (9.5%)		6 (28.6%)		9 (42.9%)	
More than one	15	4 (22.2%)	20	3 (16.7%)	11	2 (11.1%)	13	2 (11.1%)	31	7 (38.9%)	0.398[c]
Absent		9 (17.6%)		15 (29.4%)		7 (13.7%)		5 (9.8%)		15 (29.4%)	
Postpartum blood pressure											
Spontaneous regulation	15	11 (28.2%)	20	11 (28.2%)	11	5 (12.8%)	13	4 (10.3%)	31	8 (28.2%)	0.023[c]
Medication needed		4 (7.8%)		9 (17.6%)		6 (11.8%)		9 (17.6%)		23 (45.1%)	
Gestational weight gain											
≤10	9	2 (11.1%)	7	3 (16.7%)	7	7 (38.9%)	2	1 (5.6%)	12	5 (27.8%)	0.019[b]
>10		7 (36.8%)		4 (21.1%)		0		1 (5.3%)		7 (36.8%)	

Data are given as median (minimum: maximum) and n (%). a, Kruskal-Wallis test; b, Fisher-Freeman-Halton test; c, chi-squared test; NICU, neonatal intensive care unit; ICU, intensive care unit.

Results

Table 3 presents the association of maternal laboratory test results and blood pressure values with maternal and fetal outcomes.

We observed a significant inverse relationship between urea and CR values, birth weight and week of delivery (p<0.001, p=0.001, p=0.014 and p=0.028). All comparisons between AST and ALT values, birth weight and week of delivery showed no significant difference or relationship (p=0.500, p=0.259, p=0.277 and p=0.166). There was a significant inverse relationship between ALT levels and the perinatal period (p=0.004). We established a significant correlation between diagnosed SBP and duration of maternal hospitalization (p=0.045). Also, there was a statistically significant inverse relationship between DBP at diagnosis, birth weight and week of delivery (p=0.035, p=0.009, respectively). We revealed no significant difference between the laboratory parameters of the patient upon admission in terms of frequency (regularity) of observation (p=0.441, p=0.520, p=0.302, p=0.546, p=0.467, p=0.496, p=0.431), need for NICU (p=0.511, p=0.250, p=0.614, p=0.771, p=0.162, p=0.419, p=0.072), weight gain during pregnancy (p=0.851, p=0.341, p=0.408, p=0.424, p=0.628, p=0.141, p=0.217) and assessments performed by other clinical specialists (p=0.874, p=0.309, p=0.397, p=0.255, p=0.407, p=0.063, p=0.085). SBP and DBP at diagnosis exhibited significant differences depending on the method of delivery (p=0.027, p=0.008, respectively). It was noted that the levels of both SBP and DBP in patients with PE who delivered by C/S were higher than in patients with VD (mean SBP was 155.98±16.31 for C/S and 147.48±15.81 for VD; mean DBP was 96.49±10.1 for CS and 90.86±9.23 for VD). There was a significant difference in ALT values among indications for primary C/S (p=0.036). The median ALT value in patients delivered by C/S based on AFD indications was higher than in the subgroup without AFD. We confirmed significant differences in the values of CR, AST and ALT in maternal need for ICU (p=0.004, p=0.003, p=0.014, respectively). Patients with PE admitted to the maternal ICU had higher median CR, AST, and ALT values than patients who did not require admission to the ICU. A significant difference was found in DBP at diagnosis compared with the preterm birth subgroups (p=0.008). In subgroup analyses, median DBP at diagnosis was higher in those who delivered at <34 weeks and between 34 and 36^6 weeks than in those who delivered at normal gestation (≥37 weeks) (p=0.044, p=0.010 respectively). We observed a significant difference in terms of postpartum need in BP medication for urea, SBP, and DBP values at the time of diagnosis (p=0.010, p=0.030, and p=0.003). Median urea, SBP, and

DBP values at diagnosis were higher in the subgroup with the medication-controlled BP.

Table 4 presents a comparison of clinical data of patients diagnosed with PE based on the level of proteinuria. There were no differences between the proteinuria subgroups in terms of postpartum period, Apgar 1 score, Apgar 5 score and duration of stay in the maternity hospital. There was a significant difference between proteinuria levels depending on birth weight ($p<0.001$). According to subgroup analysis, median birth weight in the Proteinuria 1+ subgroup was higher than in the Proteinuria 4+ subgroup ($p=0.002$). It was observed that the median birth weight of neonates with Protein- was higher than that of newborns with Proteinuria 3+ and Proteinuria 4+ ($p=0.007$, $p<0.001$, respectively). We established a significant difference between proteinuria levels depending on the week of delivery ($p=0.010$). According to subgroup analysis, the median week of delivery was higher in the Protein 1+ subgroup than in the Protein 4+ subgroup ($p=0.037$). The median week of labor in patients with Protein- was higher than in patients with Protein 2+, Protein 3+ and Protein 4+ ($p=0.027$, $p=0.015$, $p=0.001$, respectively). There was a significant difference between proteinuria levels and need for NICU ($p=0.007$). In subgroup analyses, there were no differences between subgroups based on the need for level I NICU, while the need for level III NICU was higher in the Proteinuria 4+ subgroup vs. the Proteinuria- subgroup (48.40% vs. 0%; $p<0.05$). We discovered that the rate of not needing NICU was higher in the patients of the Proteinuria- subgroup compared with patients of Proteinuria 3+ subgroup (100% vs. 46.20%; $p<0.05$) and Proteinuria 4+ subgroup (100% vs. 48.40%; $p<0.05$). We revealed no significant differences in other subgroup analyses ($p>0.05$). There was a significant difference between the level of proteinuria and the medicinal drug required for postpartum BP regulation ($p=0.023$). According to subgroup analysis, it was observed that the need for medical treatment was higher in patients of Proteinuria 4+ subgroup (74.2%), while patients of Proteinuria 1+ subgroup had a higher level of spontaneous regulation of BP (i.e., without drug treatment): 55% and 25.8%, $p=0.035$). We noted that spontaneous BP regulation (73.3% and 30.8%) was higher in patients with negative protein levels than in patients of Proteinuria 3+ subgroup. At the same time, the need for medicamentous treatment was higher in patients of Proteinuria 3+ subgroup (69.2%; $p=0.024$). The need for drug treatment in patients of Proteinuria 4+ subgroup was significantly higher than in patients with negative proteinuria (74.2% vs. 26.7%; $p=0.002$). No significant differences were found in other subgroup analyses in terms of proteinuria levels ($p>0.05$). We also observed that there was a significant difference between weight gain during pregnancy and the level of proteinuria ($p=0.019$). In subgroup analysis, it was noted that all patients of Proteinuria 2+ subgroup exhibited weight gain of 10 kg or less during pregnancy, whereas 58.3% of patients of Proteinuria 4+ subgroup gained over 10 kg ($p=0.017$).

Discussion

PE is a complication observed in 2-5% of all pregnancies [13]. Despite a better understanding of the pathophysiological mechanisms of PE, placental delivery remains the only treatment option. Conservative (medical or observational) treatment does not improve the course of PE, but rather plays a role in preventing maternal complications such as seizures (eclampsia), intracranial hemorrhage and pulmonary edema [14].

In a multicenter study of patients with gestational hypertension, Khan et al. sought to identify risk factors associated with PE and impaired maternal neonatal outcomes [15]. In their study, the researchers found that the majority of patients with PE were younger than 24 years old, belonged to lower socioeconomic classes, and had low levels of education. The authors also found a strong association between a family history of diabetes and chronic hypertension in these patients. Our study showed that 22.3% of patients had PE in previous pregnancies. Our findings indicated that one of the significant risk factors that can lead to PE is the lack of regular antenatal outpatient visits. The share of patients not attending the clinic was noticeably higher and amounted to 55.4% of the study population. Unfortunately, there is evidence that pregnant women are not aware of regular BP monitoring during pregnancy. In a brief review, Brown et al. proposed a recommendation that every pregnant woman with hypertension should be given the opportunity to participate in research, clinical trials, and follow-up studies to better understand and optimally clinically manage the disease [16]. Hence, in our research, we attempted to highlight the importance of HDP and research in this area. As obstetricians, we must raise awareness about HDP through valuable scientific research and emphasize the importance of regular BP measurement during pregnancy to every pregnant woman.

Authoritative organizations, such as the International Society for the Study of Hypertension in Pregnancy (ISSHP) and American Society of Obstetrics and Gynecology (ASOG), have suggested that the classification of mild or severe PE should not be used. According to an authoritative source, “This classification may be erroneous or misleading to less experienced physicians." ASOG excluded the diagnosis of severe PE and instead proposed a classification of PE with or without severe features as a reasonable clinical approach. This approach seems more rational for clinical practice. Given this approach, we used the results of maternal laboratory tests as prognostic markers for assessing the severity of complications in the mother and fetus in the early postpartum period. Mei-Dan et al. noted that elevated ALT levels in the first 20 weeks of pregnancy were significantly associated with mild to severe PE. Elevated AST levels during this period were not associated with mild PE, but were an important indicator of severe PE [17]. Our study showed that the median values of ALT, AST, and CR were higher in patients requiring postpartum maternal ICU admission. On the other hand, there was a significant difference in the ALT value according to the indications of the primary C/S. In our study, the median ALT value was higher in patients delivered by C/S due to AFD indications. These data implied that liver dysfunction did not affect only maternal outcomes but also had a negative impact on fetal outcomes.

Clinical manifestations of pulmonary embolism occurs due to extensive intravascular endothelial damage. These vascular changes in patients with PE result in ischemia of multiple organs, including the kidneys, liver, brain, and placenta. Because PE affects many organs in patients, postpartum maternal monitoring is critical. Most maternal losses associated with pulmonary embolism and due to intracranial hemorrhage caused by poorly controlled hypertension [18, 19]. In our study, the proportion of patients requiring examination by a physician was 42.5%, and the need for medicamentous treatment to regulate blood pressure in the postpartum period was 55.3%. The importance of postpartum care for PE is an important issue in pregnancies complicated by PE. The ISSHP emphasized that, “In the early postpartum period, women

with preeclampsia should be considered at high risk for complications of preeclampsia for at least three days and should have BP and clinical status monitored at least every 4 hours while awake." Our study confirmed a significant difference in postpartum BP medication requirements in terms of urea and BP levels at the time of diagnosis. Median urea levels, SBP, and DBP were markedly higher in the group that required postpartum medicamentous treatment to stabilize BP in the parturient.

During a normal pregnancy, many noticeable changes occur in the vital organs. One of the remarkable changes occurs in the urinary system. Renal blood flow and glomerular filtration rate (GFR) increase as pregnancy progresses. This results in a subsequent reduction in serum CR, urea, and uric acid levels. Increasing GFR also increases urinary protein excretion, with the normal 24-hour urine collection rate in pregnant women being less than 300 mg [20]. Due to endothelial dysfunction, patients with PE experience decreased renal perfusion causing damage to the glomerular basement membrane, which results in protein leakage into the urine.

In the early 2000s, the level of proteinuria was used to determine the severity of the disease, and values above 2 g/24 h were used as a threshold value for deciding on urgent delivery [21, 22]. Proteinuria was an important indicator in the diagnosis of PE until the ASOG in 2013 and the ISSHP in 2014 recommended its exclusion from the main diagnostic criteria [23, 24]. Currently, proteinuria is not a prerequisite for diagnosing PE. However, one study suggests that proteinuria is present in approximately 75% of cases [25]. Currently, proteinuria is not used as a criterion for the diagnosis of PE, but proteinuria levels are used by obstetricians when making decisions about delivery in cases of PE. Some studies demonstrated that a high degree of proteinuria aggravated the course of PE and negatively affected fetal outcomes [26, 27].

Several methods for assessing proteinuria are available in daily practice. These methods include the urine dipstick test, 24-hour urine protein test, and urine protein-to-creatinine ratio. The advantage of the urine dipstick test over the other two tests is that it requires less time. However, the other two test provides quantitative results. Timing is an important issue for patients with PE, as we know that the only effective and definitive treatment for this disease is giving birth at the optimal time in order to minimize adverse effects on the mother and fetus.

However, there is still no reliable evidence of the possible influence of proteinuria on obstetric and perinatal outcomes [21]. Another study reported that the group of PE patients with massive proteinuria had the highest rate of maternal and fetal complications [28]. Dong et al. suggested that the magnitude of proteinuria was not related to the severity of PE once proteinuria was detected, but was related to the severity of PE. The authors also noted that adverse fetal outcomes appeared to be a function of prematurity rather than proteinuria per se [29].

Newman et al. found that massive proteinuria did not affect maternal health. In their study, the authors confirmed that massive proteinuria was associated with earlier onset of PE, earlier gestational age at delivery, and therefore a higher incidence of complications related to prematurity [16]. In contrast, our findings indicated that high levels of proteinuria were associated not only with poor neonatal outcomes but also with poor maternal outcomes. We revealed significant differences between proteinuria levels and medications required to regulate blood pressure in the mother in the postpartum period. Subgroup analysis showed that the need for medicamentous treatment was higher in patients with higher proteinuria levels (proteinuria 4+). This finding suggested that PE patients with high levels of proteinuria required close maternal monitoring. Our study demonstrated a significant difference between proteinuria levels and the need for NICU. The analysis revealed no differences between subgroups in the need for level I NICU, while the need for level III NICU was higher in the Proteinuria 4+ subgroup than in the Proteinuria- subgroup.

In clinical practice, the use and improvisation of urine dipstick results eliminates the difficulty of collecting a 24-hour urine sample and speeds up the decision-making process, especially when the condition of the mother or fetus is unstable. The value of proteinuria should be a parameter to consider when making decisions about the need for NICU and maternal BP management.

Study limitations

The main limitations of this research relate to its design as a retrospective study conducted at a single center, which may limit the generalizability of the results to wider populations or different geographic and socioeconomic contexts. A notable limitation is the lack of longitudinal data, which limits our understanding of the long-term implications of our findings. Moreover, the sample size, although sufficient for preliminary analyses, may not fully reflect the diversity of the at-risk population. These limitations highlight the need for multicenter and possibly multinational studies with larger cohorts of patients to confirm and extend our findings. Future research should also include prospective designs to collect more comprehensive data on patient characteristics, treatment pathways, and long-term outcomes to better understand the complex dynamics of preeclampsia and its management.

Conclusion

This study has important implications for the understanding and treatment of PE by shedding light on the critical importance of laboratory results and BP monitoring in predicting the need for postpartum medications and maternal ICU care. Our study highlights the utility of urine dipstick testing for rapid decision making, facilitating better readiness for maternal and newborn care. Our findings accentuate the potential of targeted interventions to improve outcomes, advocating a nuanced approach to the clinical management of PE.

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Conflict of Interest

None declared by the authors.

Ethical approval

Formal consent is not required for this type of study.

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