

Original Research

Risk Factors Associated with Low Apgar Scores in Pregnancies Complicated by Severe Preeclampsia: A Case–Control Study

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Abstract

Background: Neonates born to women with severe preeclampsia (PE) exhibited lower Apgar scores. The purpose of this study was to evaluate the association between low Apgar scores and maternal, prenatal, and intrapartum variables in patients with severe PE. **Methods:** A retrospective case–control study was conducted in a public teaching hospital from January 2016 to June 2022. Cases included patients with severe PE and an Apgar score below 7 at 1 or 5 minutes, while controls had severe PE with an Apgar score of 7 or higher. A total of 125 cases and 303 controls were included. Fisher's exact test, logistic regression and receiver operating characteristic (ROC) analysis were used as appropriated. **Results:** 22 potential risk factors were assessed, of which 12 were significantly associated with changes in outcome. Multivariate analysis identified gestational age at delivery (GAD) (odds ratio [OR], 0.570; 95% confidence interval [CI], 0.420–0.774; $p < 0.001$), intravenous anesthesia (OR, 12.889; 95% CI, 3.820–43.486; $p < 0.001$) and PE onset weeks (OR, 0.937; 95% CI, 0.879–0.999; $p = 0.047$) as independent risk factors for low Apgar scores in neonates with severe PE. The accuracy of predicting low Apgar scores in newborns of PE patients was high based on GAD (area under the curve [AUC], 0.868; 95% CI, 0.832–0.905; $p < 0.001$) and PE onset weeks (AUC, 0.785; 95% CI, 0.741–0.828; $p < 0.001$). **Conclusion:** The GAD (< 30.5 weeks) and PE onset weeks (< 28.5 weeks) are identified as risk factors for low Apgar scores in newborns of patients with severe PE, and general anesthesia is suggested to be avoided during delivery.

Keywords: severe preeclampsia; low Apgar score; gestational age at delivery; PE onset weeks

1. Introduction

Preeclampsia (PE) is a pregnancy-specific disorder characterized by hypertension and proteinuria, significantly affecting the health of both the mother and the fetus. It is estimated that 4.6% of pregnancies worldwide are affected by PE [1,2]. The pathophysiological changes in PE involve vasoconstriction and endothelial dysfunction throughout the body, resulting in reduced perfusion to various organs and posing risks to both mother and fetus [3]. Inadequate remodeling of uterine spiral arteries leads to decreased placental perfusion, a reduced mean diameter of these vessels, and endothelial injury, which impairs placental function and results in fetal distress. PE is closely related to adverse outcomes such as cesarean delivery, placental abruption, small for gestational age (SGA) infants, preterm birth, and a 5-minute Apgar score < 7 [4,5]. PE is associated with an increased risk of neonatal asphyxia [6] and serves as an independent prognostic factor for low Apgar scores and asphyxia in newborns [7,8]. Neonates born to women with severe early-onset PE exhibited lower Apgar scores than those born to women with late-onset disease [9]. The factors contributing to low Apgar scores in preg-

nant women with PE and strategies for preventing neonatal asphyxia in this population have been rarely addressed in the existing literature. We conducted a retrospective case-control study to evaluate the correlation between low Apgar scores and maternal, prenatal, and intrapartum variables in pregnant patients with severe PE, aiming to identify potential risk factors of low Apgar scores in newborns delivered by these women.

2. Materials and Methods

We conducted a retrospective case–control study at Shandong Provincial Hospital, affiliated with Shandong First Medical University. We reviewed the database for patients diagnosed with severe PE or chronic hypertension complicated by severe PE, between January 2016 and June 2022 (Fig. 1). Of the 968 cases, 70 were discharged after treatment, and 84 underwent labor induction. Ultimately, 814 pregnant patients eventually gave birth, and the Apgar scores of their newborns were assessed. Exclusion criteria included fetal anomalies, fetal distress, abnormal fetal positioning during delivery, chorioamnionitis, and prolonged or rapid vaginal delivery. A total of 772 cases were included in



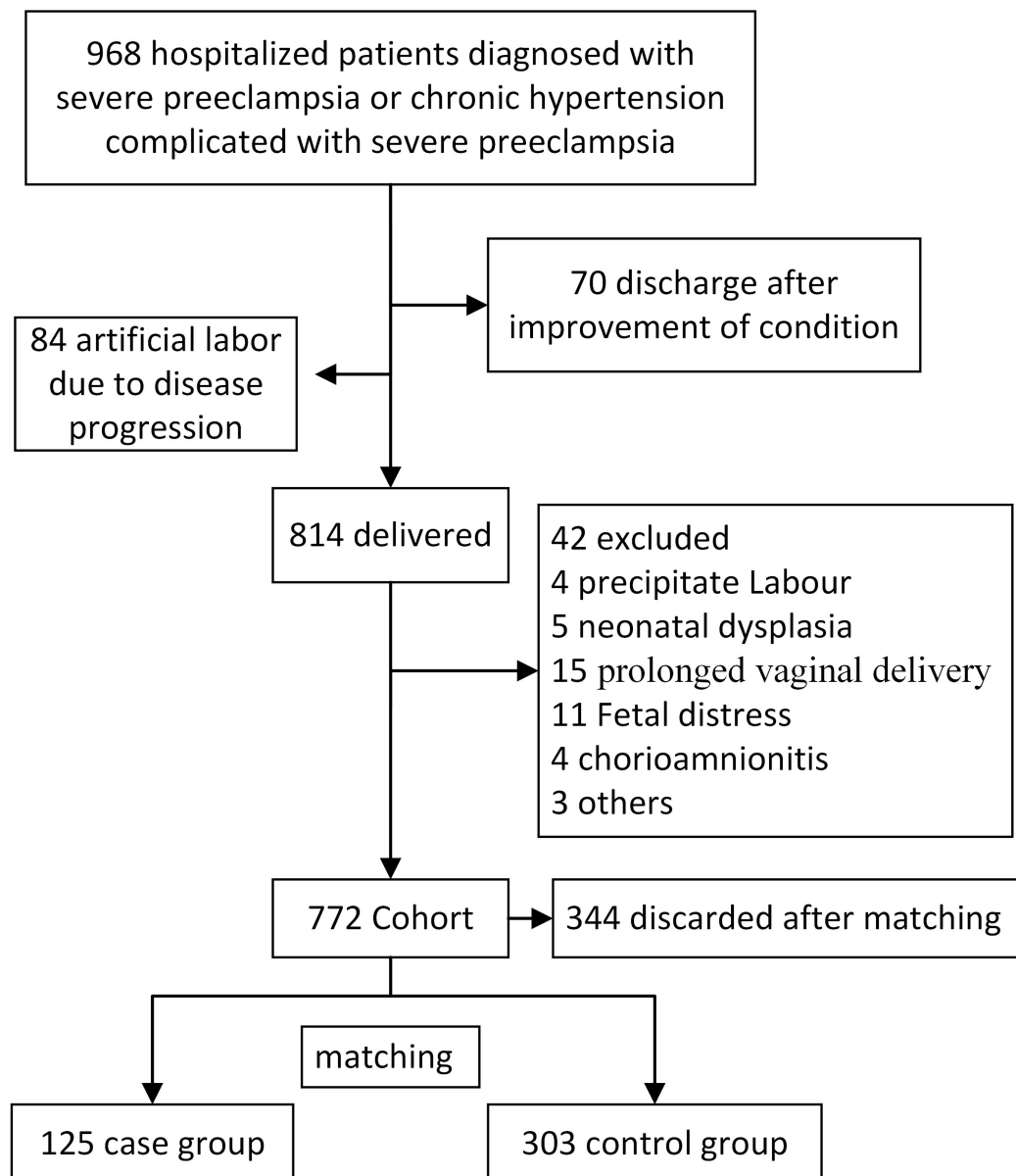


Fig. 1. Patient flow diagram. A representation of the process involved in the inclusion, exclusion, and grouping.

this study, from which 125 cases with Apgar scores <7 at 1 or 5 minutes were selected as the case group. Additionally, 303 cases with Apgar scores ≥ 7 were randomly selected as the control group, maintaining a ratio of 1:2–1:3 between the case and control groups.

3 obstetricians conducted an additional clinical evaluation of the patients and confirmed the diagnosis of PE. Chronic hypertension combined with PE: patients with chronic hypertension present with evidence of new-onset proteinuria, additional maternal organ dysfunction, or uteroplacental dysfunction. PE: gestational hypertension (systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg at ≥ 20 weeks of gestation), accompanied by one or more new conditions; proteinuria (assessed by: test paper proteinuria $\geq 1+$, protein/creatinine ratio ≥ 30 mg/mmol, albumin/creatinine ratio ≥ 8 mg/mmol, or pro-

tein ≥ 300 mg/24 h). Other maternal terminal organ dysfunctions included: neurologic complications; pulmonary edema; hematologic complications; impaired liver function; and renal insufficiency.

Severe PE: systolic blood pressure ≥ 160 mmHg and/or diastolic blood pressure ≥ 110 mmHg at ≥ 20 weeks of pregnancy; renal insufficiency; thrombocytopenia (platelet count $<100 \times 10^9/L$); serum creatinine >1.1 mg/dL or twice the serum creatinine sacrifice; pulmonary edema; liver function impairment. Liver impairment is indicated by elevated liver enzymes (more than twice the upper limit of normal) or severe, persistent pain in the right upper quadrant or epigastric region that does not respond to analgesics. Additional symptoms may include the onset of persistent headaches unresponsive to medication treatment or visual disturbances. Hemolysis, elevated liver enzymes

and low platelets (HELLP) syndrome: lactate dehydrogenase (LDH) ≥ 600 IU/L; elevated levels of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) to more than twice the upper limit of normal; platelet count $< 100 \times 10^9/L$ [10].

Abnormal pregnancy history includes previous history of pregnancy loss, recurrent pregnancy loss, stillbirth, neonatal death, or fetal development abnormalities. We defined SGA as a birth weight below the 10th percentile on the Fenton growth chart or fetal weight of less than 2500 g at or beyond 37 weeks of gestation [11]. Premature rupture of membranes is defined as the spontaneous rupture of the fetal membranes prior to the onset of labor [12]. Clinical evaluation of placental abruption was based on the presence of prenatal uterine tenderness and vaginal bleeding, with confirmation through placental examination following delivery [13]. The diagnostic criteria of antiphospholipid syndrome (APS) followed the Sydney criteria [14], and pregestational diabetes mellitus (PGDM), gestational diabetes mellitus (GDM) according to the recommendations of the International Association of Diabetes in Pregnancy Study Groups [14,15]. Abnormal fetal umbilical artery flow was defined as the absence of end-diastolic blood flow or the presence of reversed end-diastolic flow. Anesthesia for cesarean sections included both intraspinal and general anesthesia. This research was approved by the Biomedical Research Ethics Committee of Shandong Provincial Hospital prior to its initiation (Approval No. SWYX-21).

Statistical analyses were performed using IBM SPSS 22.0 (IBM Corp., Armonk, NY, USA). Comparisons of categorical variables were performed with Fisher's exact test, and continuous variables with Mann-Whitney U test. Logistic regression model was used to analyze the risk factors associated with low Apgar scores. A receiver operating characteristic (ROC) curve analysis was used to determine cutoff values. Statistical significance was set at $p < 0.05$.

3. Results

Of the 772 patients with severe PE, 125 (16.19%) delivered infants with low Apgar scores. A total of 22 variables were assessed, encompassing potential risk factors such as maternal clinical variables, complications during pregnancy, and both maternal and neonatal variables during delivery. As presented in Table 1, a total of 12 variables were found to be significantly associated with changes in the outcome. The gestational weeks at which PE occurred was significantly lower in the case group compared to the control group (median 27.0 weeks [interquartile range (IQR), 24.0–28.0] vs. median 31.0 weeks [IQR, 28.0–34.0], $p < 0.001$), with a higher incidence of history of PE among their mothers (15.2% vs. 8.3%, $p = 0.036$). Additionally, differences were observed in the occurrence of GDM or PGDM between the two groups. The case group had a higher incidence of dexamethasone use and a significant increase in the incidence of HELLP syndrome during preg-

nancy (18.4% vs. 5.3%, $p < 0.001$), placental abruption (8.0% vs. 3.3%, $p = 0.045$), SGA infants (65.6% vs. 39.6%, $p < 0.001$), and abnormalities in end-diastolic cord blood flow (23.2% vs. 6.9%, $p < 0.001$) compared to the control group. Plasma creatinine levels were higher in the case group (median, 63.32 $\mu\text{mol/L}$ [IQR, 52.3–77.4]) compared to the control group (median 60.15 $\mu\text{mol/L}$ [IQR, 50.0–69.2], $p = 0.007$).

GAD in the case group was significantly lower than the control group (median 29.0 weeks [IQR, 28.0–30.0] vs. 34.0 weeks [IQR, 31.0–36.0], $p < 0.001$). Additionally, neonatal birth weight was also significantly lower in the case group compared to the control group (median 980.0 g [IQR, 850.0–1320.0] vs. 1980.0 g [IQR, 1400.0–2610.0], $p < 0.001$). Among the patients who underwent cesarean section delivery, a greater proportion in the case group received general anesthesia (35.2% vs. 5.3%, $p < 0.001$).

The 14 variables with $p < 0.1$ listed in Table 1 were included in the multivariate analysis. The results demonstrated that the PE onset weeks (odds ratio [OR], 0.937; 95% confidence interval (CI), 0.879–0.999; $p = 0.047$), GAD (OR, 0.570; 95% CI, 0.420–0.774; $p < 0.001$), and the use of general anesthesia (OR, 12.889; 95% CI, 3.820–43.486; $p < 0.001$) were identified as independent risk factors for low Apgar scores in neonates born to mothers with severe PE (Table 2).

ROC analysis results demonstrated high accuracy in predicting low Apgar score based on GAD (area under the curve [AUC], 0.868; 95% CI, 0.832–0.905; $p < 0.001$). The optimal diagnostic cutoff point was determined as 30.5 weeks of gestation, with a sensitivity of 76.6% and a specificity of 84.1%. Utilizing PE onset weeks to predict low Apgar scores yielded moderate predictive accuracy (AUC, 0.785; 95% CI, 0.741–0.828; $p < 0.001$). The optimal diagnostic cutoff point was determined as 28.5 weeks of gestation, with a sensitivity of 78.2% and a specificity of 72.4% (Table 3, Fig. 2).

4. Discussion

Pregnant patients with PE often undergo early termination of pregnancy due to factors such as placental hypoperfusion, elevated maternal blood pressure, disease progression, and other related complications. Consequently, their newborns exhibit a higher incidence of low Apgar scores compared to those born to mothers without complications. In univariate analysis, patients with low Apgar scores in newborns exhibited higher rate of a history of PE, earlier onset of PE, shorter GAD, and lower birth weight compared to those with high Apgar scores. This association is thought to be related to premature termination of pregnancy in patients with PE. Patients with low Apgar scores also exhibited an increased rate of dexamethasone administration, likely due to the earlier delivery time. Additionally, the incidence of HELLP syndrome, abnormal umbilical cord blood flow, placental abruption, and SGA infants

Table 1. Baseline characteristics and data of the patients with severe PE.

	Score ≥ 7 (n = 303)	Score < 7 (n = 125)	p
Age, median (year, IQR)	33.0 (29.0, 36.0)	33 (30.0, 36.0)	0.433
PE onset weeks (week)	31.0 (28.0, 34.0)	27.0 (24.0, 28.0)	< 0.001
History of PE	25 (8.3%)	19 (15.2%)	0.036
Abnormal pregnancy history	48 (15.8%)	30 (24.0%)	0.054
BMI, median (kg/m ² , IQR)	31.5 (28.2, 35.0)	29.9 (27.3, 33.5)	0.059
GDM or PGDM	84 (27.7%)	15 (12.0%)	< 0.001
APS	6 (2.0%)	3 (2.4%)	0.724
LWMH	22 (7.3%)	8 (6.4%)	0.838
LDA	17 (5.6%)	4 (3.2%)	0.338
Magnesium sulfate application	201 (66.3%)	81 (64.8%)	0.823
Dexamethasone application	165 (54.5%)	85 (68.0%)	0.010
Serum creatinine ($\mu\text{mol/L}$)	60.15 (50.0, 69.2)	63.32 (52.3, 77.4)	0.007
Serum uric acid (mmol/L)	414.5 (344.0, 476.9)	421.0 (367.5, 593.2)	0.102
HELLP	16 (5.3%)	23 (18.4%)	< 0.001
Premature rupture of membrane	10 (3.3%)	2 (1.6%)	0.522
Placental abruption	10 (3.3%)	10 (8.0%)	0.045
SGA	120 (39.6%)	82 (65.6%)	< 0.001
Abnormal fetal umbilical artery blood flow	21 (6.9%)	29 (23.2%)	< 0.001
Gestational weeks at delivery (week)	34.0 (31.0, 36.0)	29.0 (28.0, 30.0)	< 0.001
Vaginal delivery	7 (2.3%)	0 (0.0%)	0.111
Birth weight of neonates (g)	1980.0 (1400.0, 2610.0)	980.0 (850.0, 1320.0)	< 0.001
General anesthesia	16 (5.3%)	44 (35.2%)	< 0.001

PE, preeclampsia; IQR, interquartile range; BMI, body mass index; GDM, gestational diabetes mellitus; PGDM, pregestational diabetes mellitus; APS, antiphospholipid syndrome; LMWH, low molecular weight heparin; LDA, low-dose aspirin; HELLP, Hemolysis, elevated liver enzymes and low platelets; SGA, small for gestational age.

Table 2. Binary logistics regression analysis of risk factors for low Apgar scores in patients with severe PE.

	B	S.E.	Wald	p	Exp(B)	95% CI	
						Lower	Upper
PE onset weeks	-0.065	0.033	3.960	0.047	0.937	0.879	0.999
GAD	-0.561	0.156	12.999	0.000	0.570	0.420	0.774
General anesthesia	2.556	0.620	16.975	0.000	12.889	3.820	43.486
SGA	0.836	0.464	3.251	0.071	2.308	0.930	5.729

PE, preeclampsia; CI, confidence interval; GAD, gestational age at delivery; SGA, small for gestational age; B, regression coefficient; S.E., standard error; Exp(B), the exponent of B.

Table 3. The accuracy of GAD and PE onset weeks in identifying low Apgar scores associated with PE.

Factor	AUC	95% CI	Cutoff values	Sensitivity%	Specificity%	p
GAD	0.868	0.832–0.905	30.5 weeks	76.6	84.1	< 0.001
PE onset weeks	0.785	0.741–0.828	28.5 weeks	78.2	72.4	< 0.001

GAD, gestational age at delivery; PE, preeclampsia; CI, confidence interval; AUC, area under the curve.

increased during pregnancy. This group of patients also exhibited elevated creatinine levels and an increased rate of general anesthesia use.

In this study, multivariate analysis revealed that the GAD was an independent risk factor for low Apgar scores in cases of PE. The risk of low Apgar score decreased with increasing GAD, highlighting that gestational age is a crucial determinant of newborn Apgar scores. Santos *et al.* [16] found a positive association between low Apgar scores

and GAD of less than 37 weeks pregnant patients without PE. Svenvik *et al.* [17] reported that 62% of preterm infants younger than 28 weeks had a 5-minute Apgar score of 7. The sensitivity and specificity for predicting low Apgar score at 1 minute in gestational age ≤ 28.5 weeks were determined to be 52.1% and 64.4%, respectively [18]. We aimed to identify the optimal threshold value for predicting low Apgar scores in PE, a value that has not been reported in previous literature. ROC analysis demonstrated that a cut-

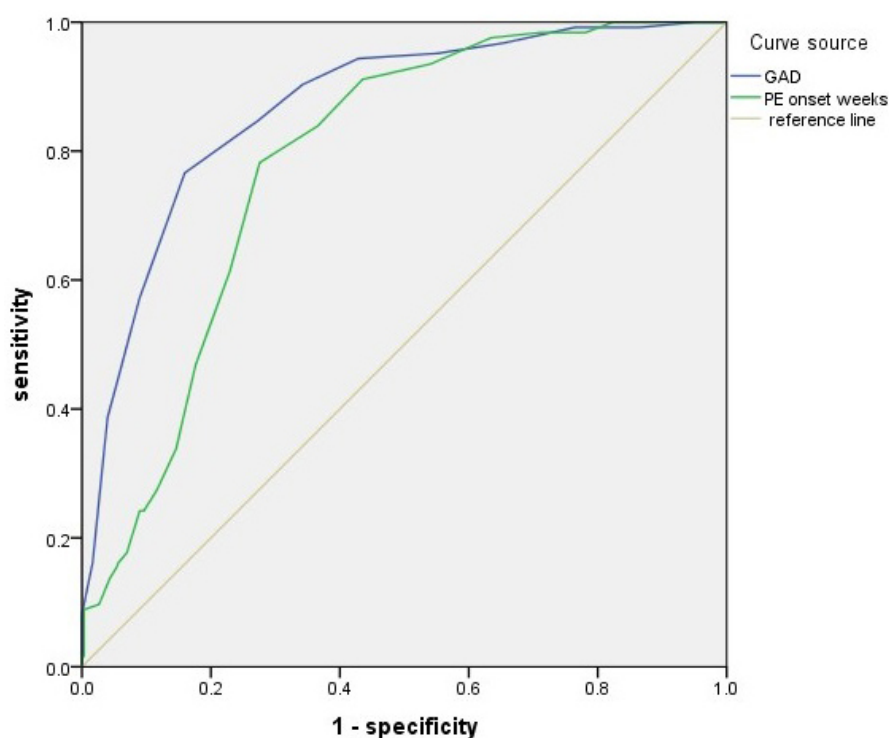


Fig. 2. ROC curve analysis for GAD (AUC, 0.868; 95% CI, 0.832–0.905; $p < 0.001$) and PE onset weeks (AUC, 0.785; 95% CI, 0.741–0.828; $p < 0.001$) as predictors of low Apgar score in PE. AUC, area under the curve; ROC, receiver operating characteristic; GAD, gestational age at delivery; PE, preeclampsia; CI, confidence interval.

off value of 30.5 weeks' gestation accurately predicted low Apgar scores with high precision. Considering the higher probability of SGA infants due to placental hypoperfusion in preeclamptic patients compared to those without complications, pregnancy termination should be delayed until at least 30.5 weeks of gestation. This approach aims to minimize the risk of adverse Apgar outcomes while ensuring maternal safety.

Patients with early onset PE experienced significantly unfavorable perinatal outcomes, including lower 5-minute Apgar scores [2]. This study demonstrated that the gestational week at which PE onset occurs has good accuracy in predicting low Apgar scores. The optimal diagnostic cut-off point was determined as 28.5 weeks of gestation, with a sensitivity of 77.3%, and a specificity of 69.9%. The probability of low Apgar scores in neonates with gestational age greater than 28.5 weeks was significantly reduced.

Pregnant patients with diabetes mellitus are at an increased risk of developing PE. Many of these patients also have longer diabetes duration, poor glycemic control, and microvascular complications, such as type I diabetes, diabetic nephropathy, and retinopathy [19–21]. In this study, while some patients with GDM and PGDM were included, these conditions were not identified as independent risk factors for the delivery of infants with low Apgar scores. The short duration of diabetes and glycemic control may not significantly increase the risk of low Apgar scores in cases of severe PE.

In this study, the cesarean section rate was found to be as high as 98%. Previous studies have reported higher cesarean section rates among pregnant patients with PE compared to vaginal delivery [22,23]. This disparity is believed to be attributed to maternal factors and an immature cervix in these individuals. Pregnant patients who underwent general anesthesia for cesarean sections had a significantly higher risk of low Apgar scores compared to those who underwent intraspinal anesthesia [24–26]. Additionally, a significantly elevated incidence of birth asphyxia was observed in infants born to mothers with severe PE who received general anesthesia [27]. Our data demonstrated that general anesthesia affected neonatal Apgar scores in cases of PE, which is consistent with previous findings. In pregnant patients diagnosed with PE, particularly those who undergo preterm delivery, the use of intraspinal anesthesia may help to reduce the occurrence of this condition.

Previous literature has reported that newborns delivered from patients with severe PE have lower birth weight and higher neonatal asphyxia rate [9,28]. In this study, the incidence of neonatal SGA in neonates born to pregnant patients with PE was significantly increased, consistent with previous literature reports. Some researchers found in their univariate analysis that the incidence of neonatal mild asphyxia increased in pregnant patients with PE combined with fetal growth restriction (FGR) [29]. Kovo *et al.* [30] compared the Apgar scores of pregnant women with gestational hypertension combined with FGR and to those with

normal blood pressure, finding no significant difference between the two groups. Multifactor analysis in this study demonstrated that SGA was not an independent risk factor for low Apgar scores, despite a p -value of 0.071.

The limitation of this study is that it is a single-center study, and due to the low incidence of severe PE, the data for the case group is small. Some very low birth weight neonates were not followed up, and the long-term neonatal outcomes were not included in the study. In the future, we will focus on improving follow up, expanding the data volume, and obtaining more comprehensive neonatal outcome data.

5. Conclusion

The GAD (<30.5 weeks) and PE onset weeks (<28.5 weeks) are important risk factors for low Apgar scores in newborns of patients with severe PE, suggesting that general anesthesia should be avoided when possible.

Availability of Data and Materials

The data are available from the corresponding author on reasonable request.

Author Contributions

YW, JM, BC, JZ and SY designed the research study. YW and JM drafted the work. BC, JZ and SY reviewed it critically. YG and CW acquired, analyzed data and reviewed content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Biomedical Research Ethic Committee of Shandong Provincial Hospital before commencing (approval number: NO. SWYX-21). Our study was retrospective with data from the medical record system, and it was approved for waivers of informed consent.

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Conflict of Interest

The authors declare no conflict of interest.

References

- [1] Abalos E, Cuesta C, Grosso AL, Chou D, Say L. Global and regional estimates of preeclampsia and eclampsia: a systematic review. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*. 2013; 170: 1–7.
- [2] Teka H, Yemane A, Abraha HE, Berhe E, Tadesse H, Gebru F, *et al*. Clinical presentation, maternal-fetal, and neonatal outcomes of early-onset versus late onset preeclampsia-eclampsia syndrome in a teaching hospital in a low-resource setting: A retrospective cohort study. *PLoS ONE*. 2023; 18: e0281952.
- [3] Lal AK, Gao W, Hibbard JU. Eclampsia: Maternal and neonatal outcomes. *Pregnancy Hypertension: An International Journal of Women's Cardiovascular Health*. 2013; 3: 186–190.
- [4] Shen M, Smith GN, Rodger M, White RR, Walker MC, Wen SW. Comparison of risk factors and outcomes of gestational hypertension and pre-eclampsia. *PLoS ONE*. 2017; 12: e0175914.
- [5] Wang YW, Chen Y, Ming YH, Zhang JW, Sun K, Zhang J, *et al*. Epidemiology and region-specific risk factors for low Apgar scores in China: a nationwide study. *World Journal of Pediatrics*. 2022; 18: 135–141.
- [6] Gebregziabher GT, Hadgu FB, Abebe HT. Prevalence and Associated Factors of Perinatal Asphyxia in Neonates Admitted to Ayder Comprehensive Specialized Hospital, Northern Ethiopia: A Cross-Sectional Study. *International Journal of Pediatrics*. 2020; 2020: 4367248.
- [7] Bouzada MCF, Nogueira Reis ZS, Brum NFF, Penido Machado MG, Rego MAS, Anchieta LM, *et al*. Perinatal risk factors and Apgar score ≤ 3 in first minute of life in a referral tertiary obstetric and neonatal hospital. *Journal of Obstetrics and Gynecology*. 2020; 40: 820–824.
- [8] Ahmed R, Mosa H, Sultan M, Helill SE, Assefa B, Abdu M, *et al*. Prevalence and risk factors associated with birth asphyxia among neonates delivered in Ethiopia: A systematic review and meta-analysis. *PLoS ONE*. 2021; 16: e0255488.
- [9] Ali S, Mohammed N, Nuruddin R, Azam I. 85 Comparison of maternal characteristics and perinatal outcomes of early and late onset preeclampsia in a tertiary care hospital of Pakistan: Preeclampsia in low and middle income countries. *Pregnancy Hypertension*. 2016; 6: 218–219.
- [10] Koulouraki S, Paschos V, Pervanidou P, Christopoulos P, Gereide A, Eleftheriades M. Short- and Long-Term Outcomes of Preeclampsia in Offspring: Review of the Literature. *Children*. 2023; 10: 826.
- [11] Alda MG, Holberton J, MacDonald TM, Charlton JK. Small for gestational age at preterm birth identifies adverse neonatal outcomes more reliably than antenatal suspicion of fetal growth restriction. *The Journal of Maternal-Fetal & Neonatal Medicine*. 2023; 36: 2279017.
- [12] Meller CH, Carducci ME, Ceriani Cernadas JM, Otaño L. Preterm premature rupture of membranes. *Archivos Argentinos De Pediatría*. 2018; 116: e575–e581.
- [13] Oyelese Y, Ananth CV. Placental abruption. *Obstetrics and Gynecology*. 2006; 108: 1005–1016.
- [14] Miyakis S, Lockshin MD, Atsumi T, Branch DW, Brey RL, Cervera R, *et al*. International consensus statement on an update of the classification criteria for definite antiphospholipid syn-

- drome (APS). *Journal of Thrombosis and Haemostasis*. 2006; 4: 295–306.
- [15] Coustan DR. Diagnosis of gestational diabetes. *Scandinavian Journal of Clinical and Laboratory Investigation. Supplementum*. 2014; 244: 27–33; discussion 32–33.
 - [16] Santos NCP, Vogt SE, Duarte ED, Pimenta AM, Madeira LM, Abreu MNS. Factors associated with low Apgar in newborns in birth center. *Revista Brasileira De Enfermagem*. 2019; 72: 297–304.
 - [17] Svenvik M, Brudin L, Blomberg M. Preterm Birth: A Prominent Risk Factor for Low Apgar Scores. *BioMed Research International*. 2015; 2015: 978079.
 - [18] Shuping, H. Risk factors for low Apgar score at 1 minute after birth in very low/extremely low birth weight infants: a retrospective multicenter study. *Zhongguo Dang Dai Er Ke Za Zhi*. 2023; 25: 909–914. (In Chinese)
 - [19] Do NC, Vestgaard M, Nørgaard SK, Damm P, Mathiesen ER, Ringholm L. Prediction and prevention of preeclampsia in women with preexisting diabetes: the role of home blood pressure, physical activity, and aspirin. *Frontiers in Endocrinology*. 2023; 14: 1166884.
 - [20] Hornová M, Šimják P, Anderlová K. Preeclampsia and diabetes mellitus. *Ceska Gynekologie*. 2023; 88: 467–471.
 - [21] Castiglioni MT, Valsecchi L, Cavoretto P, Pirola S, Di Piazza L, Maggio L, *et al*. The risk of preeclampsia beyond the first pregnancy among women with type 1 diabetes parity and preeclampsia in type 1 diabetes. *Pregnancy Hypertension*. 2014; 4: 34–40.
 - [22] Wu SW, Zhang WY. Effects of Modes and Timings of Delivery on Feto-Maternal Outcomes in Women with Severe Preeclampsia: A Multi-Center Survey in Mainland China. *International Journal of General Medicine*. 2021; 14: 9681–9687.
 - [23] Amorim MMR, Katz L, Barros AS, Almeida TSF, Souza ASR, Faúndes A. Maternal outcomes according to mode of delivery in women with severe preeclampsia: a cohort study. *The Journal of Maternal-Fetal & Neonatal Medicine*. 2015; 28: 654–660.
 - [24] Bao Y, Zhang T, Li L, Zhou C, Liang M, Zhou J, *et al*. A retrospective analysis of maternal complications and newborn outcomes of general anesthesia for cesarean delivery in a single tertiary hospital in China. *BMC Anesthesiology*. 2022; 22: 208.
 - [25] Gori F, Pasqualucci A, Corradetti F, Milli M, Peduto VA. Maternal and neonatal outcome after cesarean section: the impact of anesthesia. *The Journal of Maternal-Fetal & Neonatal Medicine*. 2007; 20: 53–57.
 - [26] Gwanzura C, Gavi S, Mangiza M, Moyo FV, Lohman MC, Nhemachena T, *et al*. Effect of anesthesia administration method on apgar scores of infants born to women undergoing elective cesarean section. *BMC Anesthesiology*. 2023; 23: 142.
 - [27] Ajuzieogu OV, Ezike HA, Amucheazi AO, Enwereji J. A retrospective study of the outcome of cesarean section for women with severe pre-eclampsia in a third world setting. *Saudi Journal of Anaesthesia*. 2011; 5: 15–18.
 - [28] Kongwattanakul K, Saksiriwuttho P, Chaiyarach S, Thepsuthammarat K. Incidence, characteristics, maternal complications, and perinatal outcomes associated with preeclampsia with severe features and HELLP syndrome. *International Journal of Women's Health*. 2018; 10: 371–377.
 - [29] Huang KH, Chen FY, Liu ZZ, Luo JY, Xu RL, Jiang LL, *et al*. Prediction of pre-eclampsia complicated by fetal growth restriction and its perinatal outcome based on an artificial neural network model. *Frontiers in Physiology*. 2022; 13: 992040.
 - [30] Kovo M, Schreiber L, Elyashiv O, Ben-Haroush A, Abraham G, Bar J. Pregnancy outcome and placental findings in pregnancies complicated by fetal growth restriction with and without preeclampsia. *Reproductive Sciences*. 2015; 22: 316–321.