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Evaluating predelivery platelet and coagulation indices as predictors of immediate postpartum haemorrhage in low-risk women undergoing vaginal delivery

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Abstract

Background Although monitoring systems for high-risk postpartum haemorrhage (PPH) are well-established, predicting immediate PPH—defined as blood loss ≥ 500 mL within 2 h postpartum, distinct from general PPH (≥ 500 mL within 24 h)—remains challenging in low-risk vaginal deliveries. This case-control study aimed to explore the association between predelivery coagulation profiles and the occurrence of immediate PPH in low-risk parturients, specifically those without severe pregnancy complications and with singleton vertex presentations.

Methods A retrospective analysis was conducted on 409 vaginal deliveries at a tertiary hospital from 2014 to 2019. Of these, 179 cases met the WHO criteria for immediate PPH, while 230 served as controls (blood loss < 500 mL). Thirty clinical and laboratory variables were extracted, including predelivery coagulation parameters—platelet count (PLT), prothrombin time (PT), activated partial thromboplastin time (APTT), and thrombin time (TT)—as well as delivery characteristics such as forceps-assisted delivery and placental retention. Logistic regression was used to identify independent risk factors, and a multivariable prediction model was subsequently developed.

Results Multivariate analysis identified several independent predictors of immediate PPH: Rural residence, Forceps deliveries, Retained placenta and membrane, Newborn birth weight ≥ 3500 g, PLT ≤ 212×10^9/L, PT > 11 s, APTT > 28.8 s, and TT > 13.8 s. (all $P < 0.05$). The combined prediction model demonstrated excellent predictive performance, with an area under the receiver operating characteristic curve (AUC) of 0.854, achieving 82.58% sensitivity and 74.78% specificity.

Conclusions This multidimensional predictive model effectively identifies parturients at elevated risk for immediate PPH in low-risk deliveries, enabling more targeted preventive interventions. Prospective studies are warranted to validate and refine this model in broader clinical settings.

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Keywords Pregnancy, Postpartum haemorrhage, Blood coagulation tests, Platelet (PLT), Risk factor

Introduction

Background

Postpartum hemorrhage (PPH) is defined as blood loss exceeding 500 mL within 24 h of vaginal delivery [1]. Despite advancements in obstetric care, PPH remains a significant cause of maternal mortality, accounting for 4.6% of all maternal deaths even in developed countries [2–3]. Immediate PPH—a subset of PPH characterized by blood loss exceeding 500 mL within two hours after delivery—is most commonly associated with vaginal delivery [4]. Evidence suggests that 91% of women experience 90% of their total blood loss within the first two hours postpartum [5].

Accurate prediction of postpartum haemorrhage (PPH) is vital for timely intervention and reducing maternal mortality. Previous studies have identified high-risk factors for PPH, such as advanced maternal age (≥ 35 years), placenta previa, placental abruption, and severe pre-eclampsia, which can impair uterine muscle contraction and lead to uterine atony [6]. Operative vaginal delivery and macrosomia may cause trauma to the soft birth canal, increasing the risk of haemorrhage. Additionally, conditions like placental abruption, pre-eclampsia, and coagulation disorders can trigger disseminated intravascular coagulation (DIC), resulting in severe postpartum bleeding [7]. These factors often coexist and can act as both causes and consequences of each other. High-risk women with such conditions are typically monitored closely during pregnancy and delivery. However, research indicates that 43% of PPH cases occur in women without identifiable high-risk factors [8]. This highlights the importance of focusing on low-risk parturient women to better understand and prevent postpartum haemorrhage.

During pregnancy, physiological changes result in a hypercoagulable state, but no standardized reference ranges exist for coagulation and fibrinolysis indicators throughout gestation [9–10]. Previous research on hematological and coagulation parameters as potential predictors of PPH has primarily focused on high-risk parturient women, yielding inconsistent results [11–14]. It is noteworthy that severe pregnancy complications may alter coagulation and fibrinolysis functions, complicating the interpretation of these parameters. Consequently, there is a critical need to investigate coagulation indicators and other potential risk factors for PPH specifically in low-risk parturient women without high-risk factors [15–17].

This study addresses this gap by focusing exclusively on low-risk women undergoing vaginal delivery without high-risk factors. The objectives are to identify independent risk factors for immediate PPH, provide insights into its underlying mechanisms, and propose targeted measures to reduce its incidence, thereby improving maternal and neonatal outcomes.

Objectives

This study aims to:

1. Analyse the clinical characteristics of low-risk parturient women and their relationship with immediate PPH.
2. Investigate the predictive value of predelivery coagulation indicators for immediate PPH.
3. Provide evidence-based recommendations to healthcare professionals to enhance preventive strategies for immediate PPH in low-risk parturient women.

Methods

Study design and setting

This retrospective study was conducted with ethical approval from the Institutional Review Board (Approval Number: CYFYLL2023027). Due to the retrospective nature of the analysis, the requirement for informed consent was waived. Data were collected from low-risk parturient women who underwent vaginal delivery at The Fourth Hospital of Shijiazhuang between January 2014 and January 2019.

During the study period, 230 cases of postpartum haemorrhage (PPH) were identified among low-risk women, of which 179 cases were classified as immediate PPH, representing the observation group (79.91% of all PPH cases). Among these cases, 71.8% of the total blood loss within 24 h postpartum occurred within the first two hours of delivery. The control group included 230 parturient women who did not experience PPH during the same period. It was matched with the observation group in terms of baseline characteristics, including age, gestational age, and parity, to ensure comparability between the two groups.

Inclusion and exclusion criteria

According to the Queensland Clinical Guideline 2024: Primary PPH [18], parturient with known risk factors for postpartum haemorrhage were excluded from the study.

Inclusion criteria

1. Vaginal delivery between 37 and 41 weeks of gestation.
2. Singleton foetus in cephalic presentation with a live birth.

3. Vaginal bleeding volume of ≥ 500 mL within two hours postpartum.
4. Maternal age < 35 years.
5. Parity of ≤ 3.

Exclusion criteria

1. Use of anticoagulant or antiplatelet medications.
2. History of severe postpartum haemorrhage (SPPH).
3. Polyhydramnios.
4. Presence of uterine fibroids > 5 cm in diameter.
5. Severe preeclampsia.
6. Use of assisted reproductive technology.
7. Poorly controlled diabetes with abnormal blood glucose levels.
8. Placenta previa.
9. Placental abruption.

Variables

Clinical data collection

Medical records of all parturient women included in the study were meticulously reviewed to extract data on 30 variables. These variables encompassed routine blood indices, coagulation and fibrinolysis parameters, clinical characteristics, duration of labour, and interventions. The selection of risk factors was based on retrospective analysis, incorporating evidence from previous studies, clinical experience, and standardised medical record forms.

Blood loss Estimation

Blood loss was estimated using a combination of volume, area, and weight methods.

Volume method A sterile blood collection tray with a maximum capacity of 500 mL was placed beneath the patient's buttocks immediately after delivery, and the total blood collected was measured.

Area and weight methods The blood absorbed by gauze and delivery pads was assessed based on the stained area and weight measurements.

Laboratory testing

Venous blood samples were obtained from all participants during late pregnancy after overnight fasting. To ensure consistency and comparability of test results, samples were uniformly collected between 8:00 am and 9:00 am. Anticoagulation was performed using a 0.105 mol/L sodium citrate solution. Plasma was separated following centrifugation at 1500 rpm for 15 min and tested for coagulation parameters, including prothrombin time (PT), activated partial thromboplastin time (APTT), thrombin time(TT), and fibrinogen(FIB) levels, using a coagulation analyser. Additionally, 2mL of fasting venous blood was collected and anticoagulated with EDTA-K2. A haematology analyser was used to measure haemoglobin(HB) levels, haematocrit(HCT), and platelet(PLT) counts.

Statistical analysis

Statistical analyses were performed using SPSS 27.0. Missing data were not imputed for the single-factor analysis.

- **Categorical Variables**: Analysed using the chi-square test.
- **Continuous Variables**: Normality was assessed using the Kolmogorov–Smirnov test. Variables not meeting normality assumptions were analysed using nonparametric tests for two independent samples, with results expressed as the median (*P*25, *P*75). For normally distributed data, independent sample t-tests were used, and results were presented as the mean ± standard deviation ($\bar{x} \pm s$). Count data were expressed as frequencies (n) and percentages (%).

Single-factor analysis identified potential risk factors, which were further evaluated using binary logistic regression. A *P*-value < 0.05 was considered statistically significant.

The sensitivity, specificity, optimal cut-off values, and Youden index for each predictive factor and their combinations were calculated. The Hosmer–Lemeshow goodness-of-fit test assessed the calibration of the predictive model, and its predictive accuracy was evaluated using receiver operating characteristic (ROC) curves in MedCalc 20.0. The area under the curve (AUC) was calculated to quantify the model's predictive performance.

Results

This study included 409 low-risk parturient women, of whom 179 (43.8%) were diagnosed with immediate postpartum haemorrhage and formed the observation group. The remaining 230 women (56.2%) who did not experience postpartum haemorrhage during the same period constituted the control group.

Single-Factor analysis

A single-factor analysis was performed to evaluate the included indicators, with the results presented in Tables 1 and 2. The analysis assessed potential associations between clinical characteristics, laboratory parameters, and labour-related factors with the occurrence of immediate postpartum haemorrhage.

Multifactor analysis

Following the single-factor analysis, 13 variables were identified as potential risk factors for immediate

Table 1 Single-factor analysis of categorical variables for immediate PPH

Variable (*n*, %)	Total parturient women (409)		χ^2	*P*
	control group (230)	case group (179)		
Residence				
Urban	194(84.35)	130(72.63)	8.401*	0.004
Rural	36(15.65)	49(27.37)		
Maternal Type				
Primipara	137(59.57)	112(62.57)	0.382	0.537
Multipara	93(40.43)	67(37.43)		
History of induced abortion	77(33.47)	62(34.64)	0.082	0.775
Forceps deliveries	17(7.39)	46(25.70)	26.164*	< 0.001
Retained placenta and membrane	9(3.91)	43(24.02)	34.89*	< 0.001
Artificial rupture of membranes	12(5.22)	14(7.82)	1.146	0.284
Misoprostol induction	2(0.87)	12(6.70)	10.365*	0.001
Newborn birth weight ≥ 3500 g	67(29.13)	99(55.31)	28.604*	< 0.001
Oxytocin induction	46(20.00)	46(25.70)	1.875	0.171
Chronic Hepatitis B Virus Infection	4(1.74)	4(2.23)	0.129	0.72
Uterine fibroid	9(3.91)	7(3.91)	0.000	0.999
Diabetes	21(9.13)	25(14.97)	2.358	0.125
Gestational hypertension	9(3.91)	13(7.26)	2.219	0.136
Hypothyroidism	21(9.13)	11(6.15)	1.244	0.265
Hyperthyroidism	1(4.35)	2(1.12)	0.644	0.422
Placenta Previa	3(1.30)	5(2.79)	1.164	0.281
Premature Rupture of Membranes	3(1.30)	3(1.68)	0.096	0.756

Table 2 Single-factor analysis of metric data for immediate PPH

Variable	Total parturient women (409)		Z	*P*
	control group (230)	case group (179)		
Age (year)	29 (27~32)	29 (27~33)	-0.264	0.792
Prepregnancy BMI (kg/m^2)	22.04 (20.13~24.41)	21.48 (19.56~24.03)	-0.902	0.367
First stage of labor (min)	420 (290~550)	480 (325~665)	-2.649	0.008
Second stage of labor (min)	26 (15~48)	35 (20~87)	-3.966*	< 0.001
Third stage of labor (min)	7 (5~9)	7 (5~9)	-0.636	0.525
Total duration of labor (min)	470 (329~605)	540 (370~730)	-3.29	0.001
HB (g/L)	116 (108.5~123.0)	115 (106~124)	-0.46	0.646
HCT (L/L)	35.1 (33.1~37.3)	34.6 (32.9~36.8)	-1.218	0.223
PLT (× 10^9/L)	219.5 (190~248)	193 (164~224)	-5.279*	< 0.001
PT (s)	10.3 (9.9~10.9)	11.3 (10.3~12.1)	-7.05*	< 0.001
APTT (s)	28.1 (26.8~30.0)	29.3 (27.8~31.4)	-5.009*	< 0.001
TT (s)	13.3 (12.7~14)	14 (13.2~14.7)	-6.054*	< 0.001
FIB (g/L)	4.09 (3.68~4.42)	3.78 (3.23~4.22)	-4.732*	< 0.001

postpartum haemorrhage (PPH). These included Rural residence, forceps deliveries, Retained placenta and membrane, Misoprostol induction, Newborn birth weight ≥ 3500 g, First stage of labor, Second stage of labor, and Total duration of labor, Platelet(PLT) count, Prothrombin time(PT), Activated partial thromboplastin time (APTT), Thrombin time(TT), and Fibrinogen(FIB) levels.

Binary logistic regression analysis was conducted to evaluate these factors, and their associations with the risk of immediate PPH were further examined. The results of the multifactor analysis are summarized in Table 3.

Table 3 presents the results of the multivariable analysis. The analysis identified Rural residence, Forceps deliveries, Retained placenta and membrane, Newborn birth weight ≥ 3500 g, PLT, PT, APTT, and TT as risk factors for immediate PPH. The formula to calculate the combined predictive factor value was derived as follows: L = Rural residence + 1.753 × Forceps deliveries + 3.207 × Retained placenta and membrane + 1.494 × (Newborn birth weight ≥ 3500 g) − 0.017 × PLT + 0.614 × PT + 0.219 × APTT + 0.335 × TT.

Table 3 Multivariable analysis of immediate PPH

Variable	B	*P*	OR	CI 95%
Rural residence	0.753	0.023	2.123	1.109–4.067
Forceps deliveries	1.32	0.001	3.743	1.7-8.241
Retained placenta and membrane	2.415	< 0.001	11.189	4.479–27.953
Misoprostol induction	1.78	0.12	5.927	0.631–55.693
Newborn birth weight ≥ 3500 g	1.125	< 0.001	3.079	1.813–5.228
First stage of labor	-0.034	0.213	0.966	0.916–1.02
Second stage of labor	-0.03	0.284	0.97	0.918–1.025
Total duration of labor	0.035	0.204	1.035	0.981–1.093
PLT ($\times 10^9$/L)	-0.013	< 0.001	0.987	0.982–0.993
PT (s)	0.462	< 0.001	1.588	1.243–2.028
APTT (s)	0.165	0.001	1.179	1.07–1.3
TT (s)	0.253	0.033	1.288	1.021–1.625
FIB (g/L)	-0.032	0.804	0.968	0.749–1.251

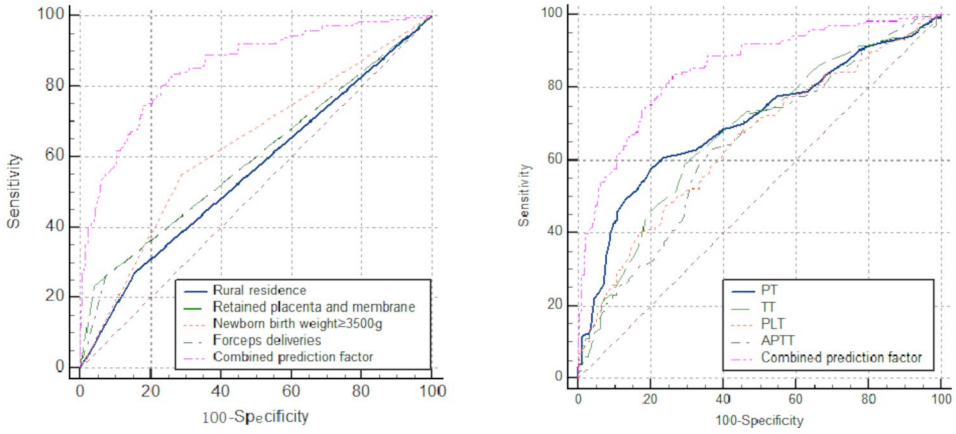

Fig. 1 The ROC curve for the prediction of immediate PPH

Table 4 The area under the ROC curve for the prediction of immediate PPH

Predictor	*P*	AUC (95%CI)	Cut off value	Youden Index	sensitivity	specificity
Rural residence	0.05	0.557 (0.5-0.613)		0.1172	27.37%	84.35%
Forceps deliveries	0.001	0.592 (0.536–0.649)		0.1845	25.84%	92.61%
Retained placenta and membrane	0.001	0.598 (0.542–0.655)		0.2011	24.02%	96.09%
Newborn birth weight ≥ 3500 g	< 0.001	0.63 (0.575–0.685)		0.2618	55.31%	70.87%
PT	< 0.001	0.704 (0.652–0.757)	> 11	0.3754	57.54%	80.00%
APTT	< 0.001	0.644 (0.59–0.698)	> 28.8	0.2661	63.13%	73.48%
TT	< 0.001	0.675 (0.622–0.728)	> 13.8	0.2953	58.66%	70.87%
PLT	< 0.001	0.651 (0.597–0.705)	≤ 212	0.2368	67.60%	56.09%
Combined prediction factor	< 0.001	0.854 (0.817–0.891)	> 16.12	0.5737	82.58%	74.78%

Predictive and diagnostic value

The predictive and diagnostic value of the joint prediction factor was assessed, with the results presented in Fig. 1; Table 4. To evaluate the calibration ability of the prediction model, the Hosmer–Lemeshow test was employed. The results indicated that $X^2 = 7.075$ and $P = 0.529$. Suggesting no statistically significant difference between the predicted values and the actual observed values. This finding demonstrates that the prediction model exhibits good calibration ability.

Rural residence, Forceps deliveries, Retained placenta and membrane, Newborn birth weight ≥ 3500 g, PLT, PT, APTT, and TT were identified as relatively accurate indicators for predicting immediate PPH, with area under the curve (AUC) values exceeding 0.5 for all eight indicators.

The diagnostic accuracy of individual indicators was evaluated:

- **PT > 11 s** demonstrated the highest accuracy for predicting PPH, with a sensitivity of 57.54% and a specificity of 80.00%.

- **APTT > 28.8 s** had a sensitivity of 63.13% and a specificity of 73.48%.
- **TT > 13.8 s** exhibited a sensitivity of 58.66% and a specificity of 70.87%.
- **PLT ≤ 212 × 10^9/L** showed a sensitivity of 67.60% and a specificity of 56.09%.

When the predictive factors were combined, the model demonstrated a high degree of accuracy, achieving an AUC of 0.854 and a Youden index of 0.5737. The sensitivity and specificity of the combined predictive model were 82.58% and 74.78%, respectively, underscoring its robust performance in identifying the risk of immediate PPH.

Discussion

The 2020 World Health Organization (WHO) report on maternal mortality underscores the persistent global challenge of PPH. Nearly 800 parturient women die each day, equating to one maternal death approximately every two minutes, with PPH remaining the leading cause of maternal mortality worldwide. This alarming statistic highlights the critical importance of identifying and mitigating the risk factors associated with PPH.

By exploring the predictors of immediate PPH in low-risk parturient women, this study provides valuable insights for clinicians to identify high-risk cases proactively. Early identification enables the implementation of targeted preventive strategies, potentially reducing the incidence of PPH and improving maternal outcomes.

Clinical characteristics of pregnant women and immediate PPH

Residence

This study identified rural residence as a significant risk factor for immediate PPH. Similarly, Seung Ah Choe et al., in a cohort study of Korean parturient women from 2013 to 2022, observed a higher risk of PPH among women living in underdeveloped areas or with lower income levels [19]. For instance, poor sanitation and inadequate food storage practices in rural areas may heighten pregnant women's exposure to aflatoxin B1, which has been linked to an increased risk of PPH [20]. In addition, this association is likely multifactorial, encompassing socioeconomic factors such as limited economic resources, inadequate healthcare coverage, non-standardized prenatal care, lower levels of formal education [21]. These findings underscore the need for targeted interventions to address healthcare disparities in underserved populations.

Newborn birth weight

Consistent with previous findings, this study demonstrated that a newborn birth weight greater than 3500 g is a significant risk factor for immediate PPH. A secondary analysis from the WHO's CHAMPION trial similarly reported that macrosomia increases the likelihood of intractable PPH following vaginal delivery [22]. Strategies such as promoting a balanced diet, managing maternal weight gain during pregnancy, and improving the accuracy of prenatal ultrasound to estimate foetal weight [23] are crucial for mitigating the risks associated with macrosomia and reducing the incidence of PPH [24].

Pregnancy complications

In this study, the presence of subserosa fibroids smaller than 5 cm in diameter did not significantly increase the risk of immediate PPH in women undergoing vaginal delivery. However, larger fibroids remain a well-documented risk factor for PPH, primarily due to impaired uterine contraction. Effective and standardized management of pregnancy complications is essential for minimizing the risk of PPH and improving maternal and neonatal outcomes [25, 26]. According to WHO estimates, approximately 80% of maternal and neonatal deaths could be averted with sufficient healthcare personnel to implement evidence-based maternal and neonatal health interventions [27].

Predelivery PLT, coagulation indicators, and immediate PPH

In late pregnancy, the blood enters a hypercoagulable state as a physiological adaptation to mitigate blood loss during delivery [28]. This study revealed that decreased PLT counts and prolonged PT, APTT, and TT are independent risk factors for immediate PPH.

During normal pregnancy, the expansion of circulating blood volume, haemodilution, and increased platelet aggregation and clearance in peripheral tissues, such as the placenta, contribute to a relative decrease in PLT counts [29]. This study identified a threshold of ≤ 212 × 10^9/L for PLT with limited sensitivity and specificity in predicting immediate PPH. Consistent with these findings, Van Dijk et al. reported that 10.3% of pregnant women with thrombocytopenia (< 150 × 10^9/L) experienced severe PPH, compared to 7.6% of those with normal PLT counts [13]. The risk of PPH is particularly heightened in women with moderate thrombocytopenia, especially among those with blood group O [14]. Therefore, maintaining adequate PLT levels before delivery is critical for reducing the risk of PPH.

Prolongation of PT, APTT, and TT has been shown to have prognostic value in other conditions, such as sepsis, as demonstrated by Bai et al. [30]. PT and APTT are key indicators of coagulation function, reflecting extrinsic and intrinsic coagulation pathways, respectively. Prolonged PT and APTT are often linked to reduced synthesis of coagulation factors. Chen et al., in a study conducted in Guangxi, China, observed a higher risk of PPH

associated with longer APTT, which may be influenced by prenatal exposure to aflatoxin B1—a risk factor more prevalent among rural women. Their study also indicated that maintaining an APTT of < 38 s could reduce the risk of PPH [21].

Additionally, factors such as pregnancy-induced nausea and vomiting can result in reduced nutrient intake, impairing the synthesis of coagulation factors. This deficiency may disrupt the intrinsic and extrinsic coagulation processes, further contributing to an increased risk of PPH [31].

Duration of labor and interventional measures related to immediate PPH

This study found no significant relationship between the duration of labor and the occurrence of PPH. The obstetric clinicians involved in this research had received Advanced Life Support in Obstetrics (ALSO) training, which emphasizes vigilant observation of labor progression and timely interventions, particularly for prolonged second and third stages of labor.

Although nearly 90% of primiparous women with second-stage labor exceeding three hours may achieve successful vaginal delivery, this prolongation is associated with an increased risk of severe perineal and neonatal injuries [32]. Similarly, prolonged third-stage labor has been strongly linked to an elevated risk of PPH [33].

The study revealed that the rate of forceps-assisted deliveries was 7.36 times higher in the immediate PPH group compared to the non-PPH group. Previous research has demonstrated that forceps-assisted deliveries pose a higher risk of severe maternal and neonatal morbidity, including PPH, compared to caesarean Sect [34]. Therefore, improving the clinical skills of midwives and obstetricians, particularly in the appropriate and effective use of forceps, is a critical strategy for reducing PPH incidence [35].

Combined predictive factors and immediate PPH

Immediate PPH is influenced by various interrelated factors. In this study, key risk factors included Rural residence, Forceps deliveries, Retained placenta and membrane, Newborn birth weight ≥ 3500 g, PLT ≤ 212×10^9/L, PT > 11 s, APTT > 28.8 s, and TT > 13.8 s. While individual factors showed predictive value, their clinical significance was limited. However, combining multiple factors substantially improved predictive accuracy.

The combination of factors achieved an AUC of 0.854, a Youden index of 0.5737, a sensitivity of 82.58%, and a specificity of 74.78%. These results indicate a robust predictive capability, offering valuable evidence for clinical practice.

Given the multifactorial nature of PPH, relying solely on single-factor predictors may compromise sensitivity and specificity. Proactively identifying multiple joint factors during pregnancy and implementing preventive and management strategies during delivery are essential to reducing the risk of PPH in low-risk populations.

Strengths and limitations

Strengths of this study include the robust sample size of low-risk parturient participants and the comprehensive assessment of variables encompassing patient demographics, predelivery laboratory parameters, and labour characteristics, which enhance the reliability of the findings.

However, limitations should be acknowledged. As a retrospective case-control study, it is subject to incomplete historical case records, including data on the duration of latent and active phases in the second stage of labour, timing of third-stage interventions, and specific medication use. Missing data, if systematically related to the outcome and exposure, may introduce bias.

This study is a single-center investigation, and there may be variations in patient populations and medical conditions across different regions and hospitals. Future studies could consider incorporating data from multiple centers to enhance the generalizability of the findings.

Conclusion

Immediate PPH is associated with a variety of risk factors, including Rural residence, Forceps deliveries, Retained placenta and membrane, Newborn birth weight ≥ 3500 g, PLT ≤ 212×10^9/L, PT > 11 s, APTT > 28.8 s, and TT > 13.8 s. While individual factors provide limited predictive value, combining multiple risk factors significantly enhances prediction accuracy and offers strong support for clinical decision-making.

Effective prediction and prevention of immediate PPH require a comprehensive approach, emphasizing the identification of high-risk factors during pregnancy and ensuring adequate preparation for delivery. By focusing on early detection and tailored interventions, the incidence and severity of PPH in low-risk parturient women can be significantly reduced, improving maternal outcomes.

Abbreviations

PPH	Postpartum hemorrhage
PLT	Platelet
PT	Rothrombin time
APTT	Activated partial thromboplastin time
TT	Thrombin time
ROC	Receiver operating characteristic
FIB	Fibrinogen
HB	Hemoglobin
HCT	Hematocrit
BMI	Body mass index
$\bar{x} \pm s$	Mean ± standard deviation

AUC Area under the curve
WHO World Health Organization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12884-025-07427-0.

Supplementary Material 1

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Author contributions
YRP served as the principal investigator of the study, overseeing study design, data interpretation, and drafting the initial manuscript. YW contributed to data collection and interpretation. JYL and PL played key roles in data interpretation and conducted a critical review of the manuscript. YWG and GHZ provided research design guidance, assisted with data collection, and jointly supervised the writing and analysis process. The manuscript has been reviewed and approved by all authors.

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Data availability
The datasets utilized and/or analyzed during the current study can be obtained from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Conducted with obtained ethical approval (Approval Number: CYFYLL2023027) from Chengde Medical University Affiliated Hospital, this retrospective analysis waived the need for informed consent due to its retrospective nature.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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