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Original Research

Clinical Characteristics and Maternal-Neonatal Outcomes of Thrombocytopenia in Pregnancy: A Retrospective Study

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Abstract

Background: Pregnancy complicated with thrombocytopenia (PT) is the second most common hematologic disorder during gestation and poses notable clinical challenges. This study aims to investigate the effects of thrombocytopenia severity and etiology on clinical characteristics and maternal-neonatal outcomes. **Methods:** A retrospective analysis was conducted on 517 pregnant patients with PT who delivered at the Affiliated Hospital of Nantong University between January 2012 and October 2020. Based on the lowest platelet count (PLT), patients were classified into three groups: mild (50×10^9/L $\leq$ the lowest PLT $< 100 \times 10^9$/L), moderate (30×10^9/L $\leq$ the lowest PLT $< 50 \times 10^9$/L), and severe (the lowest PLT $<30 \times 10^9$/L). Based on etiology, they were classified into four groups: gestational thrombocytopenia (GT), immune thrombocytopenia (ITP) in pregnancy, hypertensive disorder complicating pregnancy (HDCP), and other etiologies. Clinical characteristics and maternal-neonatal outcomes were compared across groups. **Results:** GT was the most common etiology of mild thrombocytopenia (76.06%), whereas ITP was the most frequent cause of severe cases (50.00%). Regarding the impact of disease severity on maternal and neonatal outcomes, the severe group had the highest rates of cesarean delivery, blood product transfusion, and neonatal intensive care unit (NICU) admission. Regarding the impact of etiology on outcomes, the HDCP group had the highest rates of maternal referral, postpartum hemorrhage volume, birth asphyxia, NICU admission, and full-term low birth weight (LBW) infants. The ITP group required blood product transfusion most frequently. In contrast, the GT group was associated with the least adverse maternal-neonatal outcomes. **Conclusions:** GT is a benign condition, whereas both ITP and HDCP are associated with higher risks of adverse maternal-neonatal outcomes. In the management of PT, both the etiology and severity should be evaluated simultaneously.

Keywords: pregnancy; thrombocytopenia; retrospective analysis; maternal-neonatal outcomes

1. Introduction

Pregnancy complicated with thrombocytopenia (PT), defined as a platelet count (PLT) below 150×10^9/L, is the second most common hematologic disorder in pregnancy after anemia, with a reported incidence of approximately 10% [1,2,3,4]. The etiology of PT is heterogeneous. Gestational thrombocytopenia (GT) is the most common cause, accounting for approximately 75% of cases, followed by hypertensive disorder complicating pregnancy (HDCP), and immune thrombocytopenia (ITP) in pregnancy [5,6]. Other etiologies are relatively rare and include conditions such as acute fatty liver of pregnancy, thrombotic thrombocytopenic purpura, atypical hemolytic uremic syndrome, aplastic anemia (AA), systemic lupus erythematosus (SLE), leukemia, and viral infections [7].

GT is typically mild, occurs predominantly in the third trimester of pregnancy, and usually does not require active treatment beyond regular platelet monitoring, as it does not significantly increase the risk of maternal or neonatal bleeding [8]. Although GT may recur in subsequent pregnancies, its course and severity are usually similar to those in prior pregnancies [9]. Compared with GT, ITP in pregnancy is less common but is associated with more adverse outcomes, such as an increased risk of maternal postpartum hemorrhage and neonatal thrombocytopenia [10,11]. The timing of thrombocytopenia onset (most commonly occurring before or during early pregnancy) and PLT (significantly decreased) are independent predictors of ITP in pregnancy [12]. However, these features alone are insufficient to reliably differentiate ITP from GT. Hemolysis, Elevated Liver enzymes, and Low Platelet count (HELLP) syndrome is characterized by hemolytic anemia, elevated liver enzymes, and a PLT below 100×10^9/L [13,14]. Severe preeclampsia, occurring in 8% to 24% of cases, may progress to eclampsia or HELLP syndrome and is associated with considerable perinatal mortality. The only definitive treatment remains delivery [1,13].

Given the complex etiology of PT, its clinical diagnosis and management present significant challenges. Therefore, this study used a large clinical dataset to analyze the impact of both the severity and etiology of PT on clinical features, delivery modes, and maternal-neonatal outcomes.

This provides obstetricians with an evidence-based foundation for the perinatal management of these patients, aiming to prevent adverse pregnancy outcomes.

2. Methods

2.1 Data Collection

This retrospective cohort study included pregnant patients delivered at the Department of Obstetrics and Gynecology, Affiliated Hospital of Nantong University, between January 1, 2012, and October 1, 2020. This study was reviewed and approved by the Ethics Committee of the Affiliated Hospital of Nantong University (2022-K049-01) and was conducted in accordance with the Declaration of Helsinki. Inclusion criteria were: (1) at least two recorded PLT below 100×10^9/L during pregnancy, and (2) delivery at or beyond 28 weeks of gestation. Patients were excluded if they had incomplete clinical data precluding complete case analysis, irregular antenatal examinations, or severe pre-existing cardiopulmonary, hepatic, or renal diseases. Finally, 517 pregnancies in 500 women were enrolled. Of these, 3.4% (17/500) involved two separate eligible pregnancies during the study period; each pregnancy was analyzed as an independent case. All the data were extracted from the electronic medical records and the postpartum follow-up of PLT recovery.

The following variables were systematically extracted:

(1) General patient characteristics: maternal age, predelivery body mass index (BMI), gravidity, parity, number of miscarriages, and gestational age at delivery.

(2) Laboratory parameters: lowest PLT during pregnancy, last PLT before delivery, and platelet parameters (PLT, mean platelet volume [MPV], platelet distribution width [PDW], and plateletcrit [PCT]), measured 1–3 days prior to delivery.

(3) Maternal outcomes: timing of PT diagnosis (preconception, first trimester [<14 weeks], second trimester [14–27^{+6} weeks], third trimester [≥28 weeks]), mode of delivery, indications for cesarean section, intrapartum and postpartum hemorrhage volumes, incidence of postpartum hemorrhage (for vaginal delivery, cutoffs for hemorrhage are typically over 500 mL of blood loss and for cesarean section over 1000 mL), use of carboprost, performance of B-Lynch suture or uterine artery embolization (UAE), requirement for maternal transfer to an intensive care unit (ICU) or other specialty service, and need for platelet or other blood product transfusion.

(4) Neonatal outcomes: birth weight, incidence of full-term low birth weight (LBW) infants, Apgar score (1- and 5-min), neonatal thrombocytopenia, birth asphyxia, cephalhematoma, intracranial hemorrhage, and admission to the neonatal intensive care unit (NICU).

2.2 Grouping Criteria

The 517 PT patients were stratified in two ways. First, based on the lowest PLT during pregnancy, they were categorized into three severity groups: mild (50×10^9/L ≤ the lowest PLT < 100×10^9/L), moderate (30×10^9/L ≤ the lowest PLT < 50×10^9/L), and severe (the lowest PLT <30×10^9/L). Second, based on the etiology, the patients were categorized into four groups:

GT, defined as: (1) no history of thrombocytopenia before pregnancy (except in prior pregnancies); (2) PLT returning to normal within 1–2 months postpartum; and (3) exclusion of other causes of thrombocytopenia [15,16].

ITP, diagnosed according to the Chinese guideline on the diagnosis and management of adult primary ITP (version 2020) [17]: (1) at least 2 consecutive PLT <100×10^9/L, with peripheral blood smear showing no significant abnormalities in blood cell morphology; (2) absence of splenomegaly in most cases; (3) bone marrow examination showing increased or normal megakaryocytes with maturity disorders; and (4) exclusion of other etiologies of thrombocytopenia, including GT, preeclampsia, HELLP syndrome, secondary ITP, infection-related thrombocytopenia, drug-related thrombocytopenia, and AA.

HDCP: HDCP included gestational hypertension, chronic hypertension, preeclampsia/eclampsia, and HELLP syndrome. Thrombocytopenia is one of the diagnostic criteria for severe preeclampsia and HELLP syndrome [18]. In this study, patients with thrombocytopenia caused by HDCP were included.

Other etiologies: this group comprised patients with thrombocytopenia due to other identified causes or of unknown origin.

2.3 Statistical Analysis

Data were analyzed using SPSS v23.0 (IBM® SPSS® Statistics, Armonk, NY, USA). For continuous variables, normally or approximately normally distributed data were expressed as mean ± standard deviation (SD) and compared using one-way analysis of variance (ANOVA), whereas non-normally distributed data were expressed as median (Q1, Q3) and analyzed using the Kruskal-Wallis test. Categorical variables were expressed as *n* (%) and compared using the chi-squared test or Fisher's exact test. Variables showing significance in univariate analyses were further evaluated using multivariate regression to control for potential confounders, with multivariate linear regression applied for continuous outcomes and logistic regression for binary outcomes. A two-sided p-value < 0.05 was considered statistically significant. No formal statistical adjustments for multiple comparisons were applied. The primary reason is that this is an exploratory, hypothesis-generating observational study, and our analyses were aimed at describing associations and patterns rather than confirming a single prespecified primary hypothesis.

Table 1. Relationship between etiology and severity of thrombocytopenia.

	Total	GT	ITP	HDCP	Other etiologies
Mild	284	216 (76.06%)	6 (2.11%)	20 (7.04%)	42 (14.79%)
Moderate	149	70 (46.98%)	24 (16.11%)	6 (4.03%)	49 (32.89%)
Severe	84	9 (10.71%)	42 (50.00%)	1 (1.19%)	32 (38.10%)
Total	517	295 (57.06%)	72 (13.93%)	27 (5.22%)	123 (23.79%)

GT, gestational thrombocytopenia; ITP, immune thrombocytopenia; HDCP, hypertensive disorder complicating pregnancy.

To assess the robustness of our findings to potential clustering due to multiple pregnancies in the same women (3.4% of the cohort), a sensitivity analysis was performed by restricting the dataset to the first eligible pregnancy per woman (n = 500 pregnancies). All primary multivariate regression models were repeated on this restricted cohort using the same covariate adjustments.

3. Results

3.1 Relationship Between the Etiology and Severity of Thrombocytopenia

As shown in Table 1, among the 517 cases, GT was the most prevalent etiology (57.06%), followed by ITP (13.93%), HDCP (5.22%), and other etiologies (23.79%). The other etiologies group comprised unexplained etiology (n = 102, where n is the number of patients), AA (n = 6), Sjögren's syndrome (n = 5), SLE (n = 4), undifferentiated connective tissue disease (n = 2), myelodysplastic syndromes (n = 1), hypersplenism (n = 1), Bernard-Soulier syndrome (n = 1), and chronic nephritis (n = 1). Analysis by disease severity showed that GT was the leading cause of mild thrombocytopenia (76.06%), whereas ITP predominated in severe cases (50.00%). The prevalence of HDCP across the mild, moderate, and severe groups was 7.04%, 4.03%, and 1.19%, respectively.

3.2 Clinical Characteristics of Patients

Tables 2,3 present the clinical characteristics of the pregnancies according to the severity and etiology of thrombocytopenia, respectively. Compared with the mild and moderate groups, the severe group exhibited significantly lower maternal age, gestational age at delivery, gravidity, parity, and number of miscarriages (all $p < 0.05$; Table 2). The timing of onset also differed markedly: mild thrombocytopenia primarily occurred in the third trimester (67.60%), whereas 45.24% of severe cases were present prior to pregnancy ($p < 0.001$).

Analysis by etiology revealed significant differences in maternal age, gestational age at delivery, pre-delivery BMI, gravidity, and time of diagnosis ($p < 0.05$; Table 3). The HDCP group had higher maternal age, higher pre-delivery BMI, and lower gestational age at delivery compared with the other three groups. The onset of thrombocytopenia was predominantly in the third trimester for both the GT (68.47%) and HDCP (96.30%) groups, whereas it mainly occurred before pregnancy in the ITP group (66.67%).

3.3 Platelet Parameters

Table 4 presents the platelet parameters (PLT, MPV, PDW, and PCT) across different etiologies of thrombocytopenia, revealing statistically significant intergroup differences ($p < 0.05$). Table 5 further summarizes these differences based on multivariate regression analysis. All the platelet parameters in the ITP group were lower than those in the GT group ($p < 0.05$), whereas no significant differences were observed between the HDCP group and the GT group ($p > 0.05$).

To evaluate the diagnostic performance of the platelet parameters for identifying the ITP in pregnancy, receiver operating characteristic (ROC) curves were constructed (Fig. 1). For PLT, the area under the curve (AUC) was 0.846 (95% confidence interval [CI]: 0.783–0.909; $p < 0.001$) with a sensitivity of 80.6%, specificity of 79.0%, and a cutoff value of $\leq 57.9 \times 10^9$/L. For MPV, the AUC was 0.669 (95% CI: 0.581–0.758; $p = 0.001$), with a sensitivity of 92.5%, specificity of 36.9%, and a cutoff value of $\leq$12.95 fL. For PDW, the AUC was 0.629 (95% CI: 0.541–0.717; $p = 0.012$), with a sensitivity of 65.0%, specificity of 58.6%, and a cutoff value of $\leq$17.25%. For PCT, the AUC was 0.818 (95% CI: 0.727–0.909; $p < 0.001$), with a sensitivity of 77.5%, specificity of 78.3%, and a cutoff value of $\leq$0.065 %.

3.4 Maternal Outcomes

Patients with severe thrombocytopenia presented significantly higher rates of cesarean section and required platelet or other blood product transfusion more frequently than those in the mild and moderate groups ($p < 0.05$; Table 6). However, thrombocytopenia severity was not significantly associated with intrapartum hemorrhage volume, postpartum hemorrhage volume, postpartum hemorrhage incidence, or the need for B-Lynch sutures or UAE ($p > 0.05$). After adjustment for confounders (maternal age, pre-delivery BMI, gestational age at delivery, gravidity, parity, and number of miscarriages), the significant associations between thrombocytopenia severity and adverse perinatal outcomes (cesarean delivery and transfusion requirement) remained unchanged (Table 7).

Table 2. Clinical characteristics according to the severity of thrombocytopenia.

Characteristics		Mild (n = 284)	Moderate (n = 149)	Severe (n = 84)	p-value
Maternal age (years)		29.00 ± 4.60	27.54 ± 4.65	27.08 ± 4.08	<0.001
Pre-delivery BMI (kg/m^2)		27.58 ± 3.62	27.55 ± 3.18	27.70 ± 3.74	0.944
Gestational age at delivery (weeks)		38.88 ± 1.63	38.73 ± 1.16	38.21 ± 1.63	0.002
Gravidity	1	110 (38.73%)	72 (48.32%)	49 (58.33%)	0.016
	2	86 (30.28%)	39 (26.18%)	21 (25.00%)	
	≥3	88 (30.99%)	38 (25.50%)	14 (16.67%)	
Parity	0	157 (55.28%)	96 (64.43%)	59 (70.24%)	0.023
	≥1	127 (44.72%)	53 (35.57%)	25 (29.76%)	
Number of miscarriages	0	168 (59.15%)	90 (60.40%)	63 (75.00%)	0.028
	≥1	116 (40.85%)	59 (39.60%)	21 (25.00%)	
Time of diagnosis	Preconception	18 (6.34%)	34 (22.82%)	38 (45.24%)	<0.001
	First trimester	14 (4.93%)	13 (8.72%)	13 (15.48%)	
	Second trimester	60 (21.13%)	46 (30.87%)	21 (25.00%)	
	Third trimester	192 (67.60%)	56 (37.59%)	12 (14.28%)	

BMI, body mass index; n, number of patients.

Table 3. Clinical characteristics according to the etiology of thrombocytopenia.

Characteristics		GT (n = 295)	ITP (n = 72)	HDCP (n = 27)	Other etiologies (n = 123)	p-value
Maternal age (years)		28.63 ± 4.42	26.81 ± 3.97	29.26 ± 5.22	28.05 ± 5.05	0.014
Pre-delivery BMI (kg/m^2)		27.43 ± 3.56	27.14 ± 3.32	29.77 ± 3.18	27.75 ± 3.44	0.006
Gestational age at delivery (weeks)		39.02 ± 1.24	38.32 ± 1.50	37.15 ± 2.53	38.63 ± 1.63	<0.001
Gravidity	1	119 (40.34%)	32 (44.44%)	14 (51.85%)	66 (53.66%)	0.020
	2	89 (30.17%)	27 (37.50%)	3 (11.11%)	27 (21.95%)	
	≥3	87 (29.49%)	13 (18.06%)	10 (37.04%)	30 (24.39%)	
Parity	0	165 (55.93%)	51 (70.83%)	16 (59.26%)	80 (65.04%)	0.077
	≥1	130 (44.07%)	21 (29.17%)	11 (40.74%)	43 (34.96%)	
Number of miscarriages	0	176 (59.66%)	43 (59.72%)	19 (70.37%)	83 (67.48%)	0.360
	≥1	119 (40.34%)	29 (40.28%)	8 (29.63%)	40 (32.52%)	
Time of diagnosis	Preconception	0 (0.00%)	48 (66.67%)	0 (0.00%)	42 (34.15%)	<0.001
	First trimester	17 (5.76%)	10 (13.89%)	0 (0.00%)	13 (10.57%)	
	Second trimester	76 (25.77%)	8 (11.11%)	1 (3.70%)	42 (34.15%)	
	Third trimester	202 (68.47%)	6 (8.33%)	26 (96.30%)	26 (21.13%)	

Table 4. Platelet parameters according to the etiology of thrombocytopenia.

Characteristics	GT (n = 295)	ITP (n = 72)	HDCP (n = 27)	Other etiologies (n = 123)	p-value
PLT (×10^9/L)	70.46 ± 17.04	40.22 ± 27.23	69.52 ± 25.66	50.15 ± 20.56	<0.001
MPV (fL)	12.10 ± 1.57	11.13 ± 1.59	11.60 ± 1.78	11.43 ± 1.77	0.001
PDW (%)	17.44 ± 3.37	15.94 ± 2.75	17.12 ± 3.59	16.61 ± 2.76	0.034
PCT (%)	0.09 ± 0.03	0.05 ± 0.03	0.08 ± 0.04	0.06 ± 0.03	<0.001

PLT, platelet count; MPV, mean platelet volume; PDW, platelet distribution width; PCT, plateletcrit.

Significant differences were observed across thrombocytopenia etiology groups in cesarean delivery rates, maternal transfer treatment rates, and the need for platelet or other product blood transfusion ($p < 0.05$; Table 8). These associations were further evaluated by multivariate regression analysis (Table 9). The cesarean section rate was significantly lower in the GT group (76.95%) than in the ITP group (93.06%) ($p = 0.004$). Compared with the GT group (0.68%), maternal transfer rates were significantly higher in the HDCP and ITP groups (11.11% and 5.56%, respectively; $p < 0.05$ for each comparison). The need for platelet and other blood product transfusion was also significantly greater in the ITP group than in the GT group ($p < 0.05$).

A total of 9 patients required transfer. Of these, 3 were HDCP-related (2 transferred to the ICU after cesarean delivery for HELLP syndrome, and 1 transferred to ophthalmology department after discharge for retinal detachment secondary to severe preeclampsia); 3 were ITP-related (2 transferred to the ICU post-cesarean delivery, and 1 to hematology department after discharge); 1 GT patient was

Table 5. Multiple linear regression analysis of platelet parameters according to the etiology of thrombocytopenia.

Characteristics	ITP (Ref. GT)			HDCP (Ref. GT)		
	β	95% CI	*p*-value	β	95% CI	*p*-value
PLT ($\times 10^9$/L)	–28.84	–34.11 to –23.56	<0.001	1.87	–6.50 to 10.23	0.661
MPV (fL)	–0.92	–1.50 to –0.34	0.002	–0.28	–1.09 to 0.53	0.501
PDW (%)	–1.49	–2.60 to –0.37	0.009	–0.37	–1.94 to 1.20	0.642
PCT (%)	–0.04	–0.04 to –0.03	<0.001	0.00	–0.01 to 0.02	0.731

Adjustment covariates: maternal age, pre-delivery BMI, gestational weeks at delivery, gravidity, parity, number of miscarriages. β: regression coefficient.
CI, confidence interval.

Table 6. Maternal outcomes according to the severity of thrombocytopenia.

Maternal outcomes	Mild (*n* = 284)	Moderate (*n* = 149)	Severe (*n* = 84)	*p*-value
Cesarean section	221 (77.82%)	126 (84.56%)	78 (92.86%)	<0.001
Maternal transfer treatment	4 (1.41%)	1 (0.67%)	4 (4.76%)	0.078
Postpartum hemorrhage	11 (3.87%)	4 (2.68%)	2 (2.38%)	0.790
Intrapartum hemorrhage volume (mL)	200.00 (150.00, 250.00)	200.00 (150.00, 200.00)	200.00 (150.00, 250.00)	0.200
Postpartum hemorrhage volume (mL)	293.00 (248.00, 398.75)	305.00 (245.50, 360.50)	306.50 (262.25, 391.25)	0.647
Use of carboprost	29 (10.21%)	12 (8.05%)	15 (17.86%)	0.061
B-Lynch sutures	5 (1.76%)	9 (6.04%)	3 (3.57%)	0.051
UAE	3 (1.06%)	0 (0.00%)	0 (0.00%)	0.739
Transfusion of platelet	82 (28.87%)	110 (73.83%)	75 (89.29%)	<0.001
Transfusion of other blood products	13 (4.58%)	8 (5.37%)	21 (25.00%)	<0.001

UAE, uterine artery embolization.

Table 7. Logistic regression analysis of maternal outcomes according to the severity of thrombocytopenia.

Maternal outcomes	Moderate (Ref. Mild)			Severe (Ref. Mild)		
	OR	95% CI	*p*-value	OR	95% CI	*p*-value
Cesarean section	1.72	1.00 to 2.96	0.049	3.60	1.47 to 8.33	0.005
Transfusion of platelet	6.95	4.40 to 10.97	<0.001	21.64	10.17 to 46.03	<0.001
Transfusion of other blood products	1.29	0.51 to 3.26	0.587	6.92	3.14 to 15.27	<0.001

Adjustment covariates: maternal age, pre-delivery BMI, gestational weeks at delivery, gravidity, parity, number of miscarriages. OR, odds ratio.

Table 8. Maternal outcomes according to the etiology of thrombocytopenia.

Maternal outcomes	GT (*n* = 295)	ITP (*n* = 72)	HDCP (*n* = 27)	Other etiologies (*n* = 123)	*p*-value
Cesarean section	227 (76.95%)	67 (93.06%)	26 (96.30%)	105 (85.37%)	<0.001
Maternal transfer treatment	2 (0.68%)	4 (5.56%)	3 (11.11%)	0 (0.00%)	<0.001
Postpartum hemorrhage	12 (4.07%)	2 (2.78%)	2 (7.41%)	1 (0.81%)	0.342
Intrapartum hemorrhage volume (mL)	200.00 (150.00, 250.00)	200.00 (150.00, 200.00)	200.00 (150.00, 300.00)	200.00 (150.00, 200.00)	0.790
Postpartum hemorrhage volume (mL)	291.00 (246.00, 395.00)	310.00 (263.00, 372.00)	326.00 (250.00, 386.00)	300.00 (246.00, 381.00)	0.572
Use of carboprost	32 (10.85%)	6 (8.33%)	4 (14.81%)	14 (11.38%)	0.814
B-Lynch sutures	8 (2.71%)	3 (4.17%)	1 (3.70%)	5 (4.07%)	0.765
UAE	2 (0.68%)	0 (0.00%)	1 (3.70%)	0 (0.00%)	0.244
Transfusion of platelet	115 (38.98%)	58 (80.56%)	11 (40.74%)	83 (67.48%)	<0.001
Transfusion of other blood products	15 (5.08%)	12 (16.67%)	4 (14.81%)	11 (8.94%)	0.006

transferred to the ICU for acute respiratory failure due to bronchitis post-cesarean delivery; 1 patient with acute fatty liver of pregnancy (AFLP) was transferred to the ICU post-operatively; and 1 patient was transferred to the rheumatology department after discharge for Sjögren's syndrome.

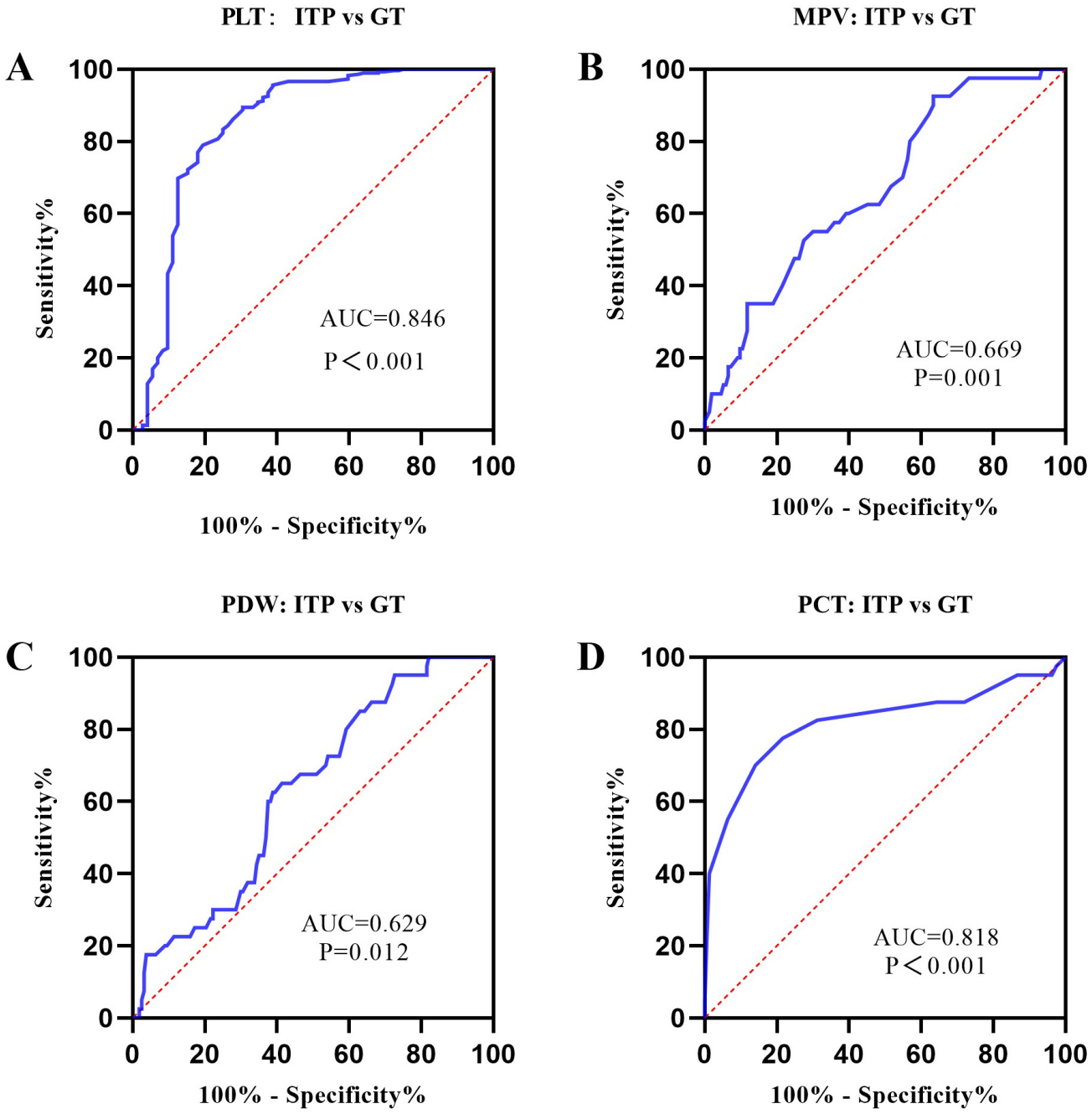

Fig. 1. ROC analysis of the platelet parameters for the diagnosis of ITP in pregnancy. ROC analysis was performed for (A) PLT, (B) MPV, (C) PDW, and (D) PCT to evaluate their potential to distinguish ITP from GT. ROC, receiver operating characteristic; AUC, area under the curve; PLT, platelet count; MPV, mean platelet volume; PDW, platelet distribution width; PCT, plateletcrit; GT, gestational thrombocytopenia; ITP, immune thrombocytopenia.

3.5 Neonatal Outcomes

A total of 540 neonates were born to the 517 mothers. Neonatal outcomes according to the severity and etiology of maternal thrombocytopenia are presented in Tables 10,11, respectively. Notably, 2 adverse outcomes were recorded within the GT group: 1 intrauterine demise at 28 weeks of gestation due to premature rupture of membranes and oligohydramnios, and 1 full-term neonate experienced intracranial hemorrhage.

First, neonatal outcomes were analyzed according to the severity of maternal thrombocytopenia (Table 10). A statistically significant intergroup difference in birth weight was observed ($p < 0.05$), with the lowest mean weight recorded in the severe group (3106.82 ± 527.86 g). NICU admission rates differed significantly across groups ($p < 0.001$), with an overall rate of 16.88% (91/539), and the highest rate in the severe group at 30.68%. While the rates of preterm infants, full-term LBW infants, and birth as-

Table 9. Multivariate regression analysis of maternal outcomes according to the etiology of thrombocytopenia.

Maternal outcomes	ITP (Ref. GT)			HDCP (Ref. GT)		
	β or OR	95% CI	p-value	β or OR	95% CI	p-value
Cesarean section [b]	OR = 4.13	1.56 to 10.92	0.004	OR = 4.43	0.57 to 34.37	0.155
Maternal transfer treatment [b]	OR = 9.37	1.53 to 57.34	0.015	OR = 13.09	1.46 to 117.38	0.022
Transfusion of platelet [b]	OR = 6.45	3.38 to 12.31	<0.001	OR = 0.90	0.39 to 2.20	0.862
Transfusion of other blood products [b]	OR = 3.96	1.69 to 9.24	0.001	OR = 1.96	0.53 to 7.23	0.310

Adjustment covariates: maternal age, pre-delivery BMI, gestational weeks at delivery, gravidity, parity, and number of miscarriages. The superscript [b] means the dichotomous outcomes which were analyzed by the logistic regression model.

Table 10. Neonatal outcomes according to the severity of maternal thrombocytopenia.

Neonatal outcomes	Mild (n = 299)	Moderate (n = 153)	Severe (n = 88)	p-value
Birth weight (g)	3315.27 ± 605.88	3317.32 ± 511.62	3106.82 ± 527.86	0.007
1-min Apgar score	10 (10, 10)	10 (10, 10)	10 (9, 10)	0.209
5-min Apgar score	10 (10, 10)	10 (10, 10)	10 (10, 10)	0.565
Preterm infants	32 (10.70%)	18 (11.76%)	14 (15.91%)	0.414
Full-term LBW infants	6 (2.01%)	4 (2.61%)	4 (4.55%)	0.360
Birth asphyxia	3 (1.00%)	4 (2.61%)	3 (3.41%)	0.166
Neonatal thrombocytopenia	3 (1.00%)	4 (2.61%)	2 (2.27%)	0.293
Admission to NICU	33 (11.00%)	31 (20.26%)	27 (30.68%)	<0.001

NICU, neonatal intensive care unit.

Table 11. Neonatal outcomes according to the etiology of maternal thrombocytopenia.

Neonatal outcomes	GT (n = 308)	ITP (n = 75)	HDCP (n = 31)	Other etiologies (n = 126)	p-value
Birth weight (g)	3366.56 ± 508.69	3130.00 ± 522.14	2688.71 ± 730.83	3311.23 ± 606.96	<0.001
1-min Apgar score	10 (10, 10)	10 (10, 10)	10 (8, 10)	10 (10, 10)	0.006
5-min Apgar score	10 (10, 10)	10 (10, 10)	10 (10, 10)	10 (10, 10)	0.442
Preterm infants	28 (9.09%)	12 (16.00%)	12 (38.71%)	12 (9.52%)	<0.001
Full-term LBW infants	3 (0.97%)	4 (5.33%)	3 (9.68%)	4 (3.17%)	0.006
Birth asphyxia	2 (0.65%)	3 (4.00%)	2 (6.45%)	3 (2.38%)	0.017
Neonatal thrombocytopenia	5 (1.62%)	2 (2.67%)	0 (0.00%)	2 (1.59%)	0.879
Admission to NICU	36 (11.69%)	24 (32.00%)	13 (41.94%)	18 (14.29%)	<0.001

LBW, low birth weight.

phyxia demonstrated a positive correlation with increasing thrombocytopenia severity, these correlations were not statistically significant (p = 0.414, 0.360, and 0.166, respectively). Furthermore, no significant differences were observed among groups in 1-min and 5-min Apgar scores, or in the incidence of neonatal thrombocytopenia (p = 0.209, 0.565, and 0.293, respectively).

After adjustment for confounders, the birth weight did not differ significantly among the three groups (Table 12). In contrast, NICU admission rates remained significantly different (p = 0.001).

Next, neonatal outcomes according to the etiology of maternal thrombocytopenia were analyzed (Table 11). Significant differences were observed across the GT, ITP, HDCP, and other etiology groups in birth weight, 1-min Apgar score, and the rates of preterm infants, full-term LBW infants, birth asphyxia, and NICU admission (all p < 0.05). In contrast, the 5-min Apgar score and the incidence of neonatal thrombocytopenia did not differ significantly (p = 0.442 and 0.879, respectively).

After adjustment for confounders (Table 13), both ITP and HDCP were associated with significantly lower birth weight, with a more pronounced reduction observed in the HDCP group. Moreover, HDCP predicted lower 1-min Apgar scores (p < 0.001), whereas no significant association was observed for ITP (p = 0.458). Both conditions independently increased the odds of full-term LBW infants, birth asphyxia, and NICU admission (all p < 0.05).

3.6 Sensitivity Analysis for Multiple Pregnancies

To address potential non-independence of outcomes from women with two eligible pregnancies during the study period (n = 17, 3.4%), all primary multivariable analyses were repeated after excluding the subsequent pregnancy of each such woman, leaving 500 unique women and 523 neonates.

Table 12. Multivariate regression analysis of neonatal outcomes according to the severity of maternal thrombocytopenia.

Neonatal outcomes	Moderate (Ref. Mild)			Severe (Ref. Mild)		
	β or OR	95% CI	*p*-value	β or OR	95% CI	*p*-value
Birth weight [a]	β = 36.80	–50.73 to 124.34	0.409	β = –49.41	–157.64 to 58.82	0.370
Admission to NICU [b]	OR = 2.85	1.52 to 5.35	0.001	OR = 3.29	1.66 to 6.54	0.001

Adjustment covariates: maternal age, pre-delivery BMI, gestational weeks at delivery, gravidity, parity, number of miscarriages. The superscript [a] means the continuous outcomes which were analyzed by multiple linear regression model, and the superscript [b] means the dichotomous outcomes which were analyzed by the logistic regression model.

Table 13. Multivariate regression analysis of neonatal outcomes according to the etiology of maternal thrombocytopenia.

Neonatal outcomes	ITP (Ref. GT)			HDCP (Ref. GT)		
	β or OR	95% CI	*p*-value	β or OR	95% CI	*p*-value
Birth weight [a]	β = –218.98	–356.75 to –81.21	0.002	β = –762.82	–965.95 to –559.68	<0.001
1-min. Apgar score [a]	β = –0.07	–0.26 to 0.12	0.458	β = –0.55	–0.83 to –0.27	<0.001
Full-term LBW infants [b]	OR = 5.79	1.21 to 27.65	0.028	OR = 27.51	4.22 to 179.58	<0.001
Birth asphyxia [b]	OR = 7.52	1.16 to 48.94	0.035	OR = 19.31	2.07 to 180.57	0.009
Admission to NICU [b]	OR = 3.86	2.09 to 7.12	<0.001	OR = 4.42	1.94 to 10.09	<0.001

Adjustment covariates: maternal age, pre-delivery BMI, gravidity, parity, and number of miscarriages. The superscript [a] means the continuous outcomes which were analyzed by multiple linear regression model, and the superscript [b] means the dichotomous outcomes which were analyzed by the logistic regression model.

The sensitivity analysis yielded results highly consistent with the primary analysis. All statistically significant associations identified in the primary models remained significant, with adjusted odds ratios (aOR) and regression coefficients closely approximating those in the full cohort (Appendix Table 14). For example, the aOR for platelet transfusion in severe versus mild thrombocytopenia was 21.64 (95% CI: 10.17–46.03) in the primary analysis and 25.80 (95% CI: 11.20–59.40) in the sensitivity analysis; for NICU admission in the ITP group versus GT group, the OR was 3.86 (95% CI: 2.09–7.12) in the primary analysis versus 4.12 (95% CI: 2.20–7.73) in the sensitivity analysis.

The only exception was the association between moderate thrombocytopenia and cesarean section, which was borderline significant in the primary analysis (OR = 1.72, 95% CI: 1.00–2.96, $p = 0.049$) and became nonsignificant after excluding multiple pregnancies (OR = 1.57, 95% CI: 0.92–2.70, $p = 0.101$). This change is likely attributable to the slight reduction in sample size and the marginal nature of the original finding. Importantly, the association with severe thrombocytopenia remained strongly significant (OR = 4.04, 95% CI: 1.53–10.63, $p = 0.005$), and the etiological analysis consistently showed significantly higher cesarean rates in the ITP group compared with the GT group (OR = 3.67, 95% CI: 1.40–9.66, $p = 0.008$). Thus, the core conclusions regarding delivery mode were not materially altered. Overall, these sensitivity analyses confirm the robustness of our main findings and indicate that inclusion of a small number of women with two pregnancies did not bias our primary conclusions.

4. Discussion

This study analyzed the clinical characteristics and maternal-neonatal outcomes from two perspectives: the severity of thrombocytopenia and its etiology.

Consistent with a prior study [19], this study demonstrated that GT is the most common cause of PT. It typically presents in the second or third trimester (94.24%), is predominantly mild (76.06%), and lacks specific clinical signs. However, as GT can also occur in the first trimester or present as severe thrombocytopenia, neither timing of onset nor PLT alone is sufficient for a definitive diagnosis. Consequently, GT remains a diagnosis of exclusion, mainly confirmed by the normalization of PLT after delivery [20,21].

ITP is the most common cause of severe thrombocytopenia and of thrombocytopenia presenting in early pregnancy, with 2/3 of cases having a pre-pregnancy history of ITP [6]. In this study, 66.67% of ITP cases occurred before pregnancy, and 50.00% were severe, consistent with previously reported characteristics [6]. However, the proportion of ITP in pregnancy in this study was 13.93%, which was higher than previously reported estimates (3%) [22]. This discrepancy is likely attributable to referral bias, as our institution is a provincial referral center for the treatment of critical and severe maternal conditions, attracting more complex ITP cases. Furthermore, pregnant individuals with ITP in our study were the youngest, consistent with the findings of Lee [23]. To the best of the authors' knowledge, no pathognomonic marker exists for the diagnosis of ITP in pregnancy. Kwon et al. [12] reported that PLT was an independent predictor of ITP in pregnancy, and that PCT pri-

marily changed with the PLT. In this study, the ROC analysis indicated that both PLT and PCT had good diagnostic performance, with AUCs of 0.846 and 0.818, respectively. Using optimal cutoffs (PLT $\leq 57.9 \times 10^9$/L, PCT ≤ 0.065 %), the sensitivity values were 80.6% and 77.5%, and the specificity values were 79.0% and 78.3%, respectively. Therefore, values below these thresholds should raise strong clinical suspicion of ITP in pregnancy.

Although HDCP is reported as the second most common cause of PT [24], it accounted for only 5.22% of cases in this study, the lowest proportion among etiologies. This may be explained by the fact that some HDCP pregnancies were terminated early for maternal-fetal safety before thrombocytopenia developed. Previous studies [25,26,27] have shown that advanced maternal age, obesity, and nulliparity are risk factors for HDCP. In this study, the HDCP group indeed had significantly higher maternal age, pre-delivery BMI, and rates of first pregnancy compared with the other groups. Thrombocytopenia in HDCP typically manifests in the third trimester and resolves rapidly postpartum. As termination of pregnancy (often via preterm delivery) remains the definitive treatment for severe HDCP [1], this explains the significantly lower gestational age at delivery observed in this group.

While current guidelines often consider a PLT $<50 \times 10^9$/L an indication for cesarean section, with vaginal delivery deemed safe at PLT $\geq 50 \times 10^9$/L [17,28], one study has challenged this threshold, suggesting that thrombocytopenia alone may not be an indication for cesarean delivery [29]. Consistent with this latter view, our data show that despite an overall trend toward higher cesarean delivery rates with lower PLT, 11 patients with a pre-delivery PLT between 20 and 50×10^9/L successfully underwent vaginal delivery without adverse maternal or neonatal outcomes. Therefore, a PLT $<50 \times 10^9$/L alone does not determine the safest delivery mode. Clinical decision-making should instead be individualized, based on the treating institution's capacity, blood product availability, and comprehensive obstetric factors, including bleeding tendency, parity, fetal weight and presentation, as well as cervical status. Notably, among these 11 patients, etiologies included 5 cases of GT, 1 case of ITP, 2 cases of AA, and 3 cases of unknown etiology. Consequently, the applicability of this observation to HDCP patients remains limited.

The impact of PT on maternal outcomes was evaluated in three aspects: postpartum hemorrhage, blood product transfusion, and need for referral. First, regarding the postpartum hemorrhage, contrary to prior suggestions that lower PLT increases the risk [30], our study found no correlation between the thrombocytopenia severity and hemorrhage volume or incidence. Postpartum hemorrhage was mainly caused by obstetric factors, such as uterine atony and placental abnormalities. Although no statistically significant differences were observed among etiological groups in intrapartum hemorrhage volume or the incidence of postpartum hemorrhage, the HDCP group showed the highest postpartum hemorrhage volume. However, this association likely reflects the broader pathophysiology of HDCP, such as coagulopathy and endothelial dysfunction, rather than thrombocytopenia alone. Consequently, this observational analysis cannot isolate the independent causal role of thrombocytopenia in the risk of postpartum hemorrhage. Second, regarding the blood product transfusion, the strong inverse relationship between PLT and transfusion requirement was expected; however, the marked difference between ITP and other etiologies warrants further interpretation. ITP patients received platelet and other blood product transfusions far more frequently than those with GT or HDCP, even after multivariable adjustment. This is likely attributable to several converging factors: (1) ITP is characterized by antibody-mediated platelet destruction, resulting in lower baseline PLT and poorer response to transfused platelets [31]; (2) many ITP patients in our cohort received antenatal corticosteroids, which may raise PLT but also introduce uncertainty regarding peripartum hemostatic reserve; and (3) the perceived bleeding risk in ITP—whether or not fully justified—may lower the threshold for prophylactic transfusion among physicians. Finally, the need for referral treatment was unrelated to thrombocytopenia severity but was strongly associated with its etiology. Specifically, referral rates were significantly higher in the ITP and HDCP groups than in the GT group, indicating that these conditions require multidisciplinary management in tertiary care settings.

The impact of PT on neonatal outcomes was evaluated in three aspects: neonatal thrombocytopenia, asphyxia, and birth weight. First, the incidence of neonatal thrombocytopenia showed no association with the severity of maternal thrombocytopenia, consistent with Hachisuga et al. [32]. Second, the rate of neonatal asphyxia was higher in the ITP group than in the GT group. This may be associated with maternal factors in ITP, such as potential anemia, a point which requires further investigation. Therefore, neonates born to mothers with ITP should have an umbilical cord platelet count obtained at delivery and undergo serial platelet-count monitoring after birth [33]. Third, neonates in the HDCP group had the lowest birth weight and the highest rate of full-term LBW infants, consistent with Wang et al. [34]. This may be attributable to the systemic vasospasm in HDCP, which reduces placental perfusion, resulting in chronic fetal hypoxia that ultimately impairs intrauterine growth and leads to lower birth weight [35].

Limitations

The retrospective design may introduce unmeasured or unobserved biases and confounders: (1) the inclusion criteria of ≥ 28 weeks may have influenced the distribution of thrombocytopenia etiologies; (2) potential variations in surgeon experience was not accounted for and may have affected surgical outcomes; (3) the diagnostic performance

Table 14. Sensitivity analysis excluding women with multiple pregnancies: comparison of adjusted effect estimates and *p*-values between the full cohort and the cohort restricted to the first pregnancy per woman.

Outcomes & Subgroups	Primary analysis			Sensitivity analysis		
	β or OR	95% CI	*p*-value	β or OR	95% CI	*p*-value
Maternal outcomes						
Cesarean section [b] (by severity)						
Moderate (Ref. Mild)	1.72	1.00 to 2.96	0.049	1.57	0.92 to 2.70	0.101
Severe (Ref. Mild)	3.60	1.47 to 8.33	0.005	4.04	1.53 to 10.63	0.005
Cesarean section [b] (by etiology)						
ITP (Ref. GT)	OR = 4.13	1.56 to 10.92	0.004	OR = 3.67	1.40 to 9.66	0.008
HDCP (Ref. GT)	OR = 4.43	0.57 to 34.37	0.155	OR = 4.97	0.64 to 38.55	0.125
Maternal transfer treatment [b] (by etiology)						
ITP (Ref. GT)	OR = 9.37	1.53 to 57.34	0.015	OR = 16.58	1.75 to 157.50	0.014
HDCP (Ref. GT)	OR = 13.09	1.46 to 117.38	0.022	OR = 51.85	3.90 to 689.69	0.003
Transfusion of platelet [b] (by severity)						
Moderate (Ref. Mild)	6.95	4.40 to 10.97	<0.001	6.86	4.35 to 10.83	<0.001
Severe (Ref. Mild)	21.64	10.17 to 46.03	<0.001	25.80	11.20 to 59.40	<0.001
Transfusion of platelet [b] (by etiology)						
ITP (Ref. GT)	OR = 6.45	3.38 to 12.31	<0.001	OR = 6.10	3.15 to 11.81	<0.001
HDCP (Ref. GT)	OR = 0.90	0.39 to 2.20	0.862	OR = 0.93	0.39 to 2.18	0.859
Transfusion of other blood products [b] (by severity)						
Moderate (Ref. Mild)	1.29	0.51 to 3.26	0.587	1.23	0.49 to 3.06	0.663
Severe (Ref. Mild)	6.92	3.14 to 15.27	<0.001	7.02	3.17 to 15.55	<0.001
Transfusion of other blood products [b] (by etiology)						
ITP (Ref. GT)	OR = 3.96	1.69 to 9.24	0.001	OR = 3.55	1.50 to 8.40	0.004
HDCP (Ref. GT)	OR = 1.96	0.53 to 7.23	0.310	OR = 2.13	0.59 to 7.70	0.247
Neonatal outcomes						
Birth weight [a] (by severity)						
Moderate (Ref. Mild)	β = 36.80	–50.73 to 124.34	0.409	β = 55.03	–34.17 to 144.23	0.226
Severe (Ref. Mild)	β = –49.41	–157.64 to 58.82	0.370	β = –65.00	–178.73 to 48.74	0.262
Birth weight [a] (by etiology)						
ITP (Ref. GT)	β = –218.98	–356.75 to –81.21	0.002	β = –222.92	–366.49 to –79.36	0.002
HDCP (Ref. GT)	β = –762.82	–965.95 to –559.68	<0.001	β = –768.94	–974.51 to –563.36	<0.001
1-min. Apgar score [a] (by etiology)						
ITP (Ref. GT)	β = –0.07	–0.26 to 0.12	0.458	β = –0.11	–0.31 to 0.08	0.262
HDCP (Ref. GT)	β = –0.55	–0.83 to –0.27	<0.001	β = –0.55	–0.83 to –0.27	<0.001
Full-term LBW infants [b] (by etiology)						
ITP (Ref. GT)	OR = 5.79	1.21 to 27.65	0.028	OR = 6.39	1.32 to 30.87	0.021
HDCP (Ref. GT)	OR = 27.51	4.22 to 179.58	<0.001	OR = 26.23	4.01 to 171.41	<0.001
Birth asphyxia [b] (by etiology)						
ITP (Ref. GT)	OR = 7.52	1.16 to 48.94	0.035	OR = 17.79	1.70 to 186.34	0.016
HDCP (Ref. GT)	OR = 19.31	2.07 to 180.57	0.009	OR = 41.07	2.79 to 604.33	0.007
Admission to NICU [b] (by severity)						
Moderate (Ref. Mild)	OR = 2.85	1.52 to 5.35	0.001	OR = 2.83	1.50 to 5.34	0.001
Severe (Ref. Mild)	OR = 3.29	1.66 to 6.54	0.001	OR = 3.57	1.76 to 7.25	<0.001
Admission to NICU [b] (by etiology)						
ITP (Ref. GT)	OR = 3.86	2.09 to 7.12	<0.001	OR = 4.12	2.20 to 7.73	<0.001
HDCP (Ref. GT)	OR = 4.42	1.94 to 10.09	<0.001	OR = 4.33	1.89 to 9.92	<0.001

The superscript [a] means the continuous outcomes which were analyzed by multiple linear regression model, and the superscript [b] means the dichotomous outcomes which were analyzed by the logistic regression model.

analysis of platelet indices (PLT, MPV, PDW, PCT) was based on measurements obtained within 1–3 days prior to delivery. While this reflects a clinically relevant peripartum assessment point, it may not capture the dynamic changes in these indices earlier in gestation, when ITP typically manifests; and (4) our study did not systematically account for

the potential confounding effects of treatments aimed at elevating PLTs, such as corticosteroids, which are commonly administered to patients with ITP. These treatments may attenuate the observed differences between the ITP and GT groups. Consequently, the diagnostic performance of the platelet indices reported here may represent a conservative estimate. Future prospective studies controlling for treatment exposure are needed to establish more precise and generalizable diagnostic thresholds.

All data were sourced from a single tertiary care center, which may limit the generalizability of the findings to other settings. For example, the overall cesarean section rate was high across all groups (ranging from approximately 77% to 96%), likely reflecting institutional practice patterns in our tertiary care referral center. This practice pattern may have attenuated the true effect size of thrombocytopenia severity or etiology on the decision to perform a cesarean delivery. Consequently, both absolute rates and the magnitude of the difference should be interpreted with caution when generalizing to other clinical settings.

Although the sample size was relatively large, the applicability to broader populations remains to be validated. Future studies incorporating more diverse and comprehensive datasets are warranted to ensure the robustness of these findings.

5. Conclusions

In conclusion, a PLT of $\leq 57.9 \times 10^9$/L and a PCT of ≤ 0.065 % demonstrate good diagnostic performance for identifying ITP in pregnancy. Additionally, while a lower PLT is associated with a higher cesarean delivery rate, a PLT level $<50 \times 10^9$/L does not necessarily determine the safest mode of delivery; therefore, clinical decisions should always be individualized. Furthermore, the occurrence of postpartum hemorrhage is not related to the severity of thrombocytopenia, but may instead be influenced by systemic pathophysiological changes related to obstetric factors (such as uterine atony) and specific etiologies (such as HDCP). Finally, compared with those with GT, patients with ITP in pregnancy have higher probabilities of requiring platelet and other blood product transfusions, maternal transfer to other departments, neonatal asphyxia, and neonatal admission to the NICU.

Abbreviations

PLT, platelet count; GT, gestational thrombocytopenia; ITP, immune thrombocytopenia; HDCP, hypertensive disorder complicating pregnancy; NICU, neonatal intensive care unit; LBW, low birth weight; PT, Pregnancy complicated with thrombocytopenia; AA, aplastic anemia; SLE, systemic lupus erythematosus; BMI, body mass index; MPV, mean platelet volume; PDW, platelet distribution width; PCT, plateletcrit; UAE, uterine artery embolization; ICU, intensive care unit; ROC, receiver operating characteristic; AUC, area under the curve; CI, confidence interval.

Availability of Data and Materials

The datasets supporting the conclusions of this study are included in the article, further inquiries can be directed to the corresponding author.

Author Contributions

YZ and MS designed the research study. YZ and JZ contributed to data acquisition. YZ and JY contributed to data analysis and interpretation. YZ and JZ wrote the manuscript. JY and MS provided help and advice on the manuscript review and editing. 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

This study was reviewed and approved by the Ethics Committee of the Affiliated Hospital of Nantong University (2022-K049-01), and was conducted in compliance with the Declaration of Helsinki. Owing to the retrospective nature of the study, the requirement for informed consent was waived by the Ethics Committee of the Affiliated Hospital of Nantong University.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work the authors used ChatGpt-3.5 in order to check spell and grammar. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Appendix

See Table 14.

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