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ARTICLE

Prevalence and Risk Factors of Preeclampsia in Pregnant Women With Gestational Diabetes Mellitus

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Abstract

Aims/Background Pregnant women with gestational diabetes mellitus (GDM) are at an increased risk of developing preeclampsia, a condition that not only threatens maternal and fetal safety but also compromises organ function. This study aimed to determine the prevalence of preeclampsia among pregnant women with GDM in China and to identify its associated risk factors.

Methods A total of 212 GDM patients who underwent prenatal care and delivery at Beilun District People's Hospital between September 2020 and September 2024 were included in the study. Participants were divided into a preeclampsia group (PE group) and a non-preeclampsia group (Non-PE group) based on the presence or absence of preeclampsia. Clinical and demographic data were extracted from the medical record system and compared between the two groups. Univariate and multivariate analyses were conducted to identify factors influencing the occurrence of preeclampsia. Receiver operating characteristics (ROC) curves were used to evaluate the predictive efficacy of statistically different indicators.

Results Among the 212 GDM patients, 60 developed preeclampsia (PE group), while 152 did not (Non-PE group), resulting in a preeclampsia prevalence of 28.30% (60/212). Multivariate logistic regression analysis identified high systolic blood pressure (SBP) ($p < 0.001$), high diastolic blood pressure (DBP) ($p = 0.002$), elevated body mass index (BMI) ($p < 0.001$), increased glycated hemoglobin (HbA1c) ($p = 0.007$), and high blood urea nitrogen (BUN) ($p = 0.017$) as independent risk factors for preeclampsia in GDM patients. The predictive value for preeclampsia was assessed using ROC curve analysis. When BMI was $\geq$23.205 kg/m^2, the area under the curve (AUC) was 0.695 [$p < 0.001$, 95% CI (0.612, 0.778)], with a sensitivity of 0.683 and specificity of 0.632. For HbA1c $\geq$5.550%, the AUC was 0.665 [$p < 0.001$, 95% CI (0.583, 0.747)], with a sensitivity of 0.617 and specificity of 0.658. When BUN was $\geq$4.250 mmol/L, the AUC was 0.692 [$p < 0.001$, 95% CI (0.612, 0.772)], with a sensitivity of 0.550 and specificity of 0.763; The combined prediction model of these three parameters yielded an AUC of 0.826 [$p < 0.001$, 95% CI (0.759, 0.892)], with a sensitivity of 0.783 and specificity of 0.803.

Conclusion The prevalence of preeclampsia was significantly higher among patients with GDM. In addition to blood pressure, BMI, HbA1c, and BUN levels are key factors associated with preeclampsia risk and may be used together to assist in predicting GDM patients with preeclampsia. It is necessary to pay more attention to the high-risk groups of preeclampsia and formulate targeted health management strategies to reduce the risk of preeclampsia and improve maternal and neonatal outcomes.

Key words: gestational diabetes; predictive value of tests; preeclampsia; prevalence; risk factors

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Introduction

Preeclampsia is primarily characterized by maternal hypertension and proteinuria and is one of the most common hypertensive diseases during pregnancy. It

is considered a severe obstetric complication (Jung et al, 2022; Rana et al, 2019). Globally, the incidence of preeclampsia ranges from approximately 1.5 to 16.7%, with significant variations across different countries and regions. Additionally, preeclampsia causes approximately 60,000 maternal deaths and over 500,000 preterm births annually, making it one of the leading causes of maternal and neonatal mortality (Ma'ayeh and Costantine, 2020; Overton et al, 2022). With advancing research, our understanding of preeclampsia has significantly improved, and a large number of scholars have investigated its risk factors (Muldoon et al, 2023; Wheeler et al, 2022; Yang et al, 2021). Although some researchers have developed screening algorithms for predicting preeclampsia based on these risk factors, their clinical implementation remains limited (MacDonald et al, 2022). Consequently, effective strategies for the prevention and management of preeclampsia remain challenging (Ives et al, 2020).

Gestational diabetes mellitus (GDM) is a condition characterized by hyperglycemia resulting from abnormal glucose tolerance and impaired insulin secretion during pregnancy. It encompasses diabetes, impaired glucose tolerance, and elevated fasting blood glucose (Sweeting et al, 2022; Al-Rawi et al, 2024). As a common pregnancy-related complication, GDM and preeclampsia are associated with an increased risk of adverse pregnancy outcomes (Weiner et al, 2018; Ye et al, 2022). Recent studies have demonstrated a positive correlation between GDM and preeclampsia (Mistry et al, 2021), with the risk of preeclampsia in pregnant women with GDM being 1.3 times higher than those with normal blood glucose levels (Hornová et al, 2023). When GDM coexists with preeclampsia, it poses a direct threat to maternal and neonatal outcomes and impairs organ functions, exacerbating the physiological burden on mother and child.

While previous studies have confirmed that GDM increases the risk of preeclampsia, they have not explored its risk factors. To address this research gap in China, the present study investigated the prevalence of preeclampsia among 212 GDM patients in China by analyzing their clinical data. Through a retrospective analysis of general characteristics and clinical indicators of GDM patients, this study aimed to identify risk factors associated with preeclampsia in this population to provide a scientific basis for developing health management programs to mitigate preeclampsia risk and improve maternal and neonatal outcomes.

Methods

Study Participants

A total of 212 patients with GDM who underwent antenatal examination and delivery at Beilun District People's Hospital were selected as the study participants from September 2020 to September 2024. Inclusion criteria: (1) Meeting the diagnostic criteria for GDM recommended by the International Association of Diabetes and Pregnancy Study Group (IADPSG) (International Association of Diabetes and Pregnancy Study Groups Consensus Panel et al, 2010). Patients underwent an oral glucose tolerance test (OGTT) between 24 and 28 weeks of gestation, following at least 8 hours of fasting. Fasting blood glucose (FBG), 1-hour fasting blood glu-

cose (1-h FBG), and 2-hour fasting blood glucose (2-h FBG) levels were measured. GDM was diagnosed if FBG ≥5.1 mmol/L, 1-h FBG ≥10.0 mmol/L, or 2-h FBG ≥8.5 mmol/L; (2) Age between 18 and 45 years; (3) Complete general clinical data and laboratory examination records; (4) Non-smoker and no excessive alcohol consumption; (5) Local residents with spontaneous pregnancies.

Exclusion criteria: (1) Other hypertensive disorders during pregnancy; (2) Twin or multiple pregnancies; (3) Fetal malformations; (4) Coexisting rheumatic or immune system diseases; (5) Presence of other severe pregnancy complications; (6) Severe mental illnesses; (7) Diagnosis of malignant tumors.

Procedures

The 212 GDM patients were divided into a preeclampsia group (PE group, n = 60) and a non-preeclampsia group (Non-PE group, n = 152) based on the presence or absence of preeclampsia.

Preeclampsia was diagnosed according to the criteria established by Brown et al (2018): Pregnant women beyond 20 weeks of gestation with systolic blood pressure (SBP) ≥140 mmHg and/or diastolic blood pressure (DBP) ≥90 mmHg for the first time, accompanied by urinary protein ≥0.3 g/24 h, a urinary protein/creatinine ratio >0.3, or random positive urinary protein test. General information such as age, body mass index (BMI), gestational age, gravidity, parity, history of spontaneous abortion, history of recurrent abortion, prenatal examination interval, cardiovascular and cerebrovascular diseases, hypertension, and diabetes, as well as clinical indicators of late pregnancy (>28 weeks) were collected from the medical records of the two groups. The clinical indicators included SBP, DBP, FBG, 2-h FBG, glycated hemoglobin (HbA1c), triglyceride (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), hemoglobin (Hb), hematocrit (Hct), platelet count (PLT), D-dimer (D-D), prothrombin time (PT), activated partial thromboplastin time (APTT), thrombin time (TT), fibrinogen (Fib), alanine aminotransferase (ALT), aspartate transaminase (AST), lactate dehydrogenase (LDH), serum creatinine (Scr), blood urea nitrogen (BUN), and uric acid (UA). These parameters were compared between the two groups. All the biochemical markers were measured using an automatic biochemical analyzer (LABOSPECT 008AS, Hitachinaka, Ibaraki Prefecture, Japan).

Statistical Analysis

Statistical analyses were conducted using SPSS v23.0 (IBM SPSS Corp., Armonk, NY, USA). Categorical variables (gravidity, parity, history of spontaneous abortion, history of recurrent abortion, time interval of prenatal examination, cardiovascular and cerebrovascular diseases, hypertension, and diabetes) were analyzed using the Chi-square test, continuity correction, or Fisher's exact tests, as appropriate, and expressed as counts (n). The Shapiro-Wilk normality test was performed to assess the distribution of continuous variables. Data following a normal distribution (age, BMI, gestational age, SBP, DBP, FBG, 2-h FBG, HbA1c, TG, TC, LDL-C, HDL-C, Hb, Hct, PLT, PT, APTT, TT, Fib, AST, LDH, Scr, BUN, and UA) were expressed as mean ± standard deviation ($\bar{x} \pm s$) and compared using

an independent sample *t*-test. Non-normally distributed data (D-D and ALT) were expressed as median (min, max) and analyzed using the Mann-Whitney U test.

Univariate analysis and multivariate logistic regression analysis were conducted to identify risk factors for preeclampsia in GDM patients. Receiver operating characteristics (ROC) curves were generated to assess the predictive efficacy of statistically significant indicators in GDM patients with preeclampsia. A p-value < 0.05 was considered statistically significant.

Results

Prevalence of Preeclampsia in Patients With GDM

Among the 212 patients diagnosed with GDM in this survey, 60 developed preeclampsia (PE group), while 152 did not (Non-PE group), resulting in a preeclampsia prevalence of 28.30% (60/212).

Univariate Analysis of Preeclampsia in GDM Patients

Participants were categorized into preeclampsia (n = 60) and non-preeclampsia (n = 152) groups based on the presence or absence of preeclampsia. There was no significant difference ($p > 0.05$) between the two groups in terms of baseline characteristics, including age, gestational age, gravidities, parity, history of spontaneous abortion, history of recurrent miscarriage, cardiovascular and cerebrovascular diseases, hypertension, and diabetes. However, the univariate analysis identified BMI, time interval of prenatal examination, SBP, DBP, FBG, HbA1c, TG, Hb, AST, LDH, Scr, BUN, and UA as significant risk factors influencing preeclampsia in GDM patients ($p < 0.05$, Table 1).

Multivariate Logistic Regression Analysis of Preeclampsia in GDM Patients

A multivariate logistic regression model was constructed with preeclampsia prevalence as the dependent variable, while BMI, time interval of prenatal examination (1 week = 0, 2–4 weeks = 1), SBP, DBP, FBG, HbA1c, TG, Hb, AST, LDH, Scr, BUN, and UA were included as independent variables based on their statistical significance in Table 1. The analysis revealed that elevated systolic blood pressure ($p < 0.001$) and higher diastolic blood pressure ($p = 0.002$) were independent risk factors for preeclampsia in GDM patients. Additionally, high BMI ($p < 0.001$), increased HbA1c levels ($p = 0.007$), and elevated BUN ($p = 0.017$) are also independent risk factors for preeclampsia in patients with GDM (Table 2).

Predictive Efficacy of BMI, HbA1c, BUN, and Their Combination for Preeclampsia in GDM Patients

ROC curve analysis revealed that when BMI $\geq$23.205 kg/m^2, the AUC for predicting preeclampsia in GDM patients were 0.695 [$p < 0.001$, 95% CI (0.612, 0.778)], with a sensitivity of 0.683 and a specificity of 0.632, respectively. For HbA1c $\geq$5.550%, the AUC was 0.665 [$p < 0.001$, 95% CI (0.583, 0.747)], with a sensitivity of 0.617 and a specificity of 0.658. For BUN $\geq$4.250 mmol/L, the AUC was 0.692 [$p < 0.001$, 95% CI (0.612, 0.772)], with a sensitivity of 0.550 and specificity of 0.763. When BMI, HbA1c, and BUN were combined for prediction,

Table 1. Univariate analysis of risk factors for preeclampsia in patients with GDM.

Variable	n	PE group (n = 60)	Non-PE group (n = 152)	$t/Z/\chi^2$	*p*-value
Age (years)		31.73 ± 5.06	31.34 ± 4.78	0.528	0.598
BMI (kg/m^2)		25.61 ± 4.89	22.56 ± 3.35	5.208	<0.001
Gestational age (weeks)		38.63 ± 0.99	38.80 ± 1.10	1.025	0.306
Gravidities (n)				2.884	0.089
1–3 times	148	47	101		
4–7 times	64	13	51		
Parity (n)				0.006	0.939
0–1 time	176	50	126		
2–4 times	36	10	26		
History of spontaneous abortion (n)				0.265	0.607
Yes	40	10	30		
No	172	50	122		
History of recurrent miscarriage (n)				-	1.000
Yes	3	1	2		
No	209	59	150		
Time interval of prenatal examination (n)				5.695	0.017
1 week	190	49	141		
2–4 weeks	22	11	11		
Cardiovascular and cerebrovascular diseases (n)				-	1.000
Yes	1	0	1		
No	211	60	151		
Hypertension (n)				0.582	0.445
Yes	26	9	17		
No	186	51	135		
Diabetes (n)				2.278	0.131
Yes	17	8	9		
No	195	52	143		
SBP (mmHg)		148.33 ± 11.20	119.03 ± 10.01	18.557	<0.001
DBP (mmHg)		95.53 ± 7.64	76.18 ± 7.02	17.643	<0.001
FBG (mmol/L)		5.16 ± 0.63	4.85 ± 0.59	3.411	0.001
2-h FBG (mmol/L)		8.53 ± 1.58	8.42 ± 1.44	0.518	0.605
HbA1c (%)		5.85 ± 0.76	5.45 ± 0.50	4.469	<0.001
TG (mmol/L)		4.75 ± 1.84	4.19 ± 1.62	2.169	0.031
TC (mmol/L)		6.10 ± 1.42	5.79 ± 1.11	1.691	0.092
LDL-C (mmol/L)		2.75 ± 1.03	2.83 ± 0.88	0.551	0.582
HDL-C (mmol/L)		1.71 ± 0.45	1.75 ± 0.39	0.645	0.519
Hb (g/L)		119.75 ± 13.77	123.88 ± 11.79	2.186	0.030
Hct (%)		0.36 ± 0.04	0.37 ± 0.03	1.467	0.144
PLT ($\times 10^9$/L)		202.12 ± 58.63	197.39 ± 50.51	0.585	0.559

Table 1. Continued.

Variable	n	PE group (n = 60)	Non-PE group (n = 152)	$t/Z/\chi^2$	*p*-value
D-D (mg/L)		1.808 (1.425, 2.661)	1.640 (1.223, 2.363)	0.156	0.118
PT (s)		10.12 ± 0.76	10.28 ± 0.58	1.624	0.106
APTT (s)		27.07 ± 2.54	27.48 ± 2.04	1.250	0.213
TT (s)		13.51 ± 1.08	13.35 ± 0.95	1.027	0.306
Fib (g/L)		4.63 ± 0.91	4.55 ± 0.76	0.670	0.504
ALT (U/L)		11.000 (8.000, 17.000)	9.000 (8.000, 13.750)	1.807	0.071
AST (U/L)		18.55 ± 6.84	16.32 ± 4.77	2.691	0.008
LDH (U/L)		201.07 ± 44.62	178.39 ± 35.57	3.880	<0.001
Scr (μmol /L)		50.25 ± 12.19	42.93 ± 8.69	4.900	<0.001
BUN (mmol/L)		4.50 ± 1.31	3.65 ± 1.07	4.878	<0.001
UA (μmol /L)		369.41 ± 99.52	318.02 ± 79.91	3.925	<0.001

Notes: GDM, gestational diabetes mellitus; PE, preeclampsia; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; 2-h FBG, 2-hour fasting blood glucose; HbA1c, glycated hemoglobin; TG, triglyceride; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; Hb, hemoglobin; Hct, hematocrit; PLT, platelet count; D-D, D-dimer; PT, prothrombin time; APTT, activated partial thromboplastin time; TT, thrombin time; Fib, fibrinogen; ALT, alanine aminotransferase; AST, aspartate transaminase; LDH, lactate dehydrogenase; Scr, serum creatinine; BUN, blood urea nitrogen; UA, uric acid.

the AUC increased to 0.826 [$p < 0.001$, 95% CI (0.759, 0.892)], with a sensitivity of 0.783 and a specificity of 0.803 (Table 3, Fig. 1).

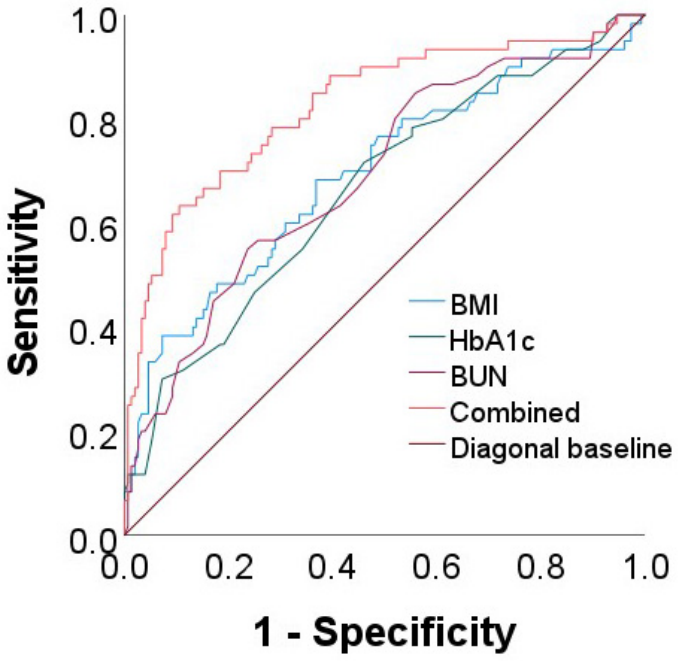

Fig. 1. Receiver operating characteristics (ROC) curve for BMI, HbA1c, BUN, and their combined prediction of preeclampsia in GDM patients.

Table 2. Multivariate logistic regression analysis of preeclampsia in patients with GDM.

Variable	β	Standard error	Wald	*p*-value	Odds ratio	95% CI	
						Lower	Upper
BMI (kg/m^2)	0.168	0.045	14.042	<0.001	1.183	1.084	1.292
Time interval of prenatal examination (n)	0.875	0.512	2.917	0.088	2.399	0.879	6.546
SBP (mmHg)	0.375	0.093	16.112	<0.001	1.455	1.211	1.747
DBP (mmHg)	0.257	0.081	10.026	0.002	1.293	1.103	1.517
FBG (mmol/L)	–0.007	0.023	0.089	0.765	0.993	0.950	1.038
HbA1c (%)	0.956	0.352	7.381	0.007	2.601	1.305	5.184
TG (mmol/L)	0.167	0.099	2.875	0.090	1.182	0.974	1.434
Hb (g/L)	–0.021	0.014	2.045	0.153	0.980	0.952	1.008
AST (U/L)	0.118	0.082	2.089	0.148	1.125	0.959	1.321
LDH (U/L)	0.008	0.014	0.370	0.543	1.008	0.982	1.036
Scr (µmol/L)	0.040	0.020	3.779	0.052	1.040	1.000	1.083
BUN (mmol/L)	0.389	0.163	5.714	0.017	1.475	1.073	2.029
UA (µmol/L)	0.003	0.002	2.499	0.114	1.003	0.999	1.007
Constant	–5.430	0.990	30.079	<0.001	0.004		

Table 3. Predictive efficacy of BMI, HbA1c, BUN, and their combination for preeclampsia in GDM patients.

Variable	AUC	*p*-value	Cut-off	Sensitivity	Specificity	Youden index	95% CI	
							Lower	Upper
BMI	0.695	<0.001	23.205	0.683	0.632	0.315	0.612	0.778
HbA1c	0.665	<0.001	5.550	0.617	0.658	0.275	0.583	0.747
BUN	0.692	<0.001	4.250	0.550	0.763	0.313	0.612	0.772
Combined	0.826	<0.001	-	0.783	0.803	0.586	0.759	0.892

Discussion

In this study, we observed significant differences between the PE group and the Non-PE group in clinical characteristics such as BMI, time interval of prenatal examination, and levels of SBP, DBP, FBG, HbA1c, TG, Hb, AST, LDH, Scr, BUN, and UA. To minimize potential confounding effects, multivariate logistic regression analysis was applied to assess the influence of various independent variables on the occurrence of preeclampsia. First, we examined the influence of basic maternal characteristics on preeclampsia. BMI and time interval of prenatal examination were gradually introduced into the regression model, and the findings showed that BMI is an independent risk factor for preeclampsia in GDM patients. Next, after adjusting for blood pressure, blood glucose and lipid profiles, the analysis demonstrated that SBP, DBP, and HbA1c were independent risk factors for preeclampsia in GDM patients. Subsequently, we evaluated liver and renal function, and after ad-

justing for the above factors, we established that BUN is an independent risk factor for preeclampsia in GDM patients.

At present, multiple studies have investigated the prevalence of preeclampsia across various populations. Yang et al (2021) surveyed Swedish and Chinese pregnant women and reported a preeclampsia prevalence of 2.9% (16,068/555,446) and 2.3% (1803/79,243), respectively. Similarly, Guida et al (2022) conducted a systematic review and found that the prevalence of preeclampsia among Brazilian pregnant women is 6.7%. Ma'ayeh and Costantine (2020) estimated that the prevalence of preeclampsia in pregnant women in the United States ranges from 3 to 8%, whereas Mou et al (2021) reported an overall prevalence of 14.4% in Bangladeshi pregnant women. In Ghana, Anto et al (2023) randomly selected 1174 pregnant women and observed a prevalence of 8.8%. A Norwegian study by Sole et al (2022) documented a decrease in preeclampsia prevalence from 4.3% (1999–2002) to 2.7% (2015–2018). Sutan et al (2022) investigated a maternity hospital in Malaysia, reporting a preeclampsia prevalence of 1.6%, while Kokori et al (2024), through an electronic database search, estimated that preeclampsia prevalence in Nigeria was 4.51%.

Although these studies highlight regional variations in the prevalence of preeclampsia, the prevalence in most countries (except Bangladesh) is relatively low. In this survey, the incidence of preeclampsia in GDM patients was 28.30% (60/212), which is significantly higher than the prevalence rates reported in previous studies, suggesting an increased risk of preeclampsia in GDM patients. Earlier studies have primarily reported a positive correlation between GDM and preeclampsia (Hornová et al, 2023; Mistry et al, 2021), but the specific incidence of preeclampsia in GDM pregnant women was not well documented. Our findings emphasize the importance of early identification and intervention to mitigate preeclampsia risk in GDM patients.

BMI is a widely used indicator for measuring underweight or obesity (Bray, 2023). Robillard et al (2019) reported a linear relationship between increased BMI and the occurrence of delayed preeclampsia. Similarly, Gong et al (2022) investigated 117,738 pregnant women from 150 maternity hospitals in China and found that high pre-pregnancy BMI and rapid gestational weight gain were risk factors for preeclampsia, with a synergistic effect. This conclusion was further confirmed by Shao et al (2017). In the present study, GDM patients with preeclampsia exhibited significantly higher BMI, consistent with the findings of previous research. The underlying mechanisms may be attributed to several factors (Bodnar and Kaufman, 2004; Cnossen et al, 2007; Poorolajal and Jenabi, 2016). Firstly, excessive BMI may disrupt blood lipid metabolism and alter uterine artery hemodynamics, resulting in increased blood pressure. Secondly, a significant increase in excessive BMI may lead to elevated levels of oxidative stress and inflammatory factors in the placenta, which may induce vascular endothelial damage, thereby increasing the risk of preeclampsia. Additionally, high BMI (obesity) is associated with varying degrees of insulin resistance, and studies have demonstrated that hyperinsulinemia can elevate blood pressure through multiple mechanisms. In this study, HbA1c was identified as an independent risk factor for preeclampsia in GDM patients, whereas

FBG and 2-h FBG were not. This discrepancy may be attributed to GDM patients being treated with insulin, making single-time blood glucose detection inadequate for assessing long-term glucose metabolism. However, HbA1c is unaffected by acute changes in blood glucose, meal interval, or insulin use and offers the advantages of high reproducibility and stability. As a result, HbA1c is widely accepted as a reliable indicator for monitoring blood glucose control in diabetes mellitus (Tanaka and Node, 2021).

In recent years, studies have highlighted the critical role of HbA1c in hypertension and related diseases. Heianza et al (2015) investigated a Japanese cohort and found that HbA1c levels can be an independent risk factor for the development of hypertension. Au Yeung et al (2020) observed that HbA1c level was positively correlated with SBP, although its correlation with DBP remained unclear. Mi et al (2020) analyzed 1777 Chinese individuals and reported that the hemoglobin glycosylation index (HGI) was independently correlated with the risk of hypertension. At present, the mechanism underlying the relationship between HbA1c and blood pressure has not been fully elucidated. Han et al (2024) suggested that the influence of increased HbA1c on blood pressure may involve two key mechanisms. First, an increase in HbA1c reflects a persistent hyperglycemic state, which may promote oxidative stress, activate protein kinases, and disrupt the stability and homeostasis of endothelial and smooth muscle cells by inducing the formation of advanced glycation end products (AGEs), leading to an increase in blood pressure. Additionally, higher HbA1c levels often reflect insulin resistance, which may increase the risk of hypertension by promoting the release of inflammatory factors, inducing endothelial dysfunction, and enhancing sympathetic tension. This study is among the first to report such findings in patients with GDM.

BUN reflects renal excretory function and is a routine indicator for evaluating renal function. A previous study reported that, elevated BUN levels are associated with an increased risk of adverse maternal and neonatal outcomes (Wu et al, 2022). Recent studies have also established a strong correlation between BUN levels and preeclampsia. Li et al (2016) observed a significant elevation in BUN levels among preeclampsia patients, while Kavak et al (2025) identified a close association between BUN levels and the presence and severity of preeclampsia. Han et al (2020) analyzed biochemical indicators in 568 pregnant women and found that BUN independently predicted the risk of preeclampsia. Fang et al (2024) investigated GDM patients and identified BUN as an independent risk factor for the occurrence of preeclampsia, a finding consistent with the results of this study.

Limitations: (1) This study is a retrospective, single-center study analysis with relatively small sample size. The study population comprised only GDM patients from a single region in a recent time frame, which may limit the generalizability of the findings due to temporal and geographical factors; (2) The etiology of GDM complicated by preeclampsia is complex. Although the study design accounted for several relevant factors, the potential influence of unmeasured or unknown residual confounding factors, such as lifestyle and dietary habits, cannot be entirely ruled out; (3) The biochemical indicators used in this study were primarily routine indicators such as those related to glucose and lipid metabolism, as well as liver and

kidney function. Other relevant biomarkers, such as inflammatory indicators, were not assessed. In addition, all biochemical indicators were derived from blood samples collected during late pregnancy, and the expression levels of these indicators across different gestational stages were not explored. In future research, we aim to expand the sample size, extend the study period and region, and incorporate additional variables to comprehensively assess the factors contributing to the occurrence of preeclampsia in patients with GDM.

Conclusion

The incidence of preeclampsia among GDM patients was as high as 28.30% (60/212), significantly exceeding the reported prevalence of preeclampsia in the general population. In addition, the occurrence of preeclampsia in patients with gestational diabetes is influenced not only by blood pressure but also by BMI, HbA1c, and BUN levels. The combination of these three factors may serve as a valuable predictor of preeclampsia risk in this population. Therefore, in clinical practice, attention should be given to high-risk groups, especially patients with high BMI, HbA1c, and BUN levels. Preventive measures should include ensuring adequate rest, dietary modifications, appropriate physical activity, regular prenatal examinations, enhanced fetal monitoring, and adherence to prescribed medications when necessary. Additionally, for pregnant women with pre-existing hypertension, chronic kidney disease, or diabetes, it is recommended that these chronic diseases be optimized before conception to reduce the risk of preeclampsia.

Key Points

- The incidence of preeclampsia among GDM patients was significantly higher than the reported prevalence in the general population.
- Univariate analysis identified BMI, time interval of prenatal examination, SBP, DBP, FBG, HbA1c, TG, Hb, AST, LDH, Scr, BUN, and UA as factors associated with preeclampsia in GDM patients.
- Multivariate logistic regression analysis determined that elevated SBP, DBP, BMI, HbA1c, and BUN are independent risk factors for preeclampsia in GDM patients.
- The combination of BMI, HbA1c, and BUN demonstrates high diagnostic efficiency in predicting preeclampsia in patients with GDM.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

YFY and XLY designed the research study and wrote the first draft. LYZ and YGH performed the research. YFY, LYZ and YGH analyzed the data. All authors

contributed to important editorial changes in the manuscript. 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 complies with the relevant principles and regulations of the Declaration of Helsinki, and the study was reviewed and approved by the Beilun District People's Hospital Ethics Committee (No.2024LP031). The subjects were informed of the study content and voluntarily signed the informed consent.

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Conflict of Interest

The authors declare no conflict of interest.

References

Al-Rawi H, Nori W, Salman D, Issa A, Akram W. The Utility of Maternal Adiponectin and Triglyceride-Glycemic Index for Gestational Diabetes Mellitus Screening: A Cross-Sectional Study. Clinical and Experimental Obstetrics & Gynecology. 2024; 51: 262. https://doi.org/10.31083/j.ceog5112262

Anto EO, Boadu WIO, Ansah E, Tawiah A, Frimpong J, Tamakloe VCKT, et al. Prevalence of preeclampsia and algorithm of adverse foeto-maternal risk factors among pregnant women in the Central Region of Ghana: A multicentre prospective cross-sectional study. PLoS ONE. 2023; 18: e0288079. https://doi.org/10.1371/journal.pone.0288079

Au Yeung SL, Luo S, Schooling CM. The impact of glycated hemoglobin on risk of hypertension: a Mendelian randomization study using UK Biobank. Journal of Hypertension. 2020; 38: 38–44. https://doi.org/10.1097/HJH.0000000000002210

Bodnar LM, Kaufman JS. Body mass index and preeclampsia. Epidemiology. 2004; 15: 252–253. https://doi.org/10.1097/01.ede.0000112145.70380.a2

Bray GA. Beyond BMI. Nutrients. 2023; 15: 2254. https://doi.org/10.3390/nu15102254

Brown MA, Magee LA, Kenny LC, Karumanchi SA, McCarthy FP, Saito S, et al. Hypertensive Disorders of Pregnancy: ISSHP Classification, Diagnosis, and Management Recommendations for International Practice. Hypertension. 2018; 72: 24–43. https://doi.org/10.1161/HYPERTENSIONAHA.117.10803

Cnossen JS, Leeflang MMG, de Haan EEM, Mol BWJ, van der Post JAM, Khan KS, et al. Accuracy of body mass index in predicting pre-eclampsia: bivariate meta-analysis. BJOG: An International Journal of Obstetrics and Gynaecology. 2007; 114: 1477–1485. https://doi.org/10.1111/j.1471-0528.2007.01483.x

Fang Y, Liu H, Li Y, Cheng J, Wang X, Shen B, et al. A Prediction Model of Preeclampsia in Hyperglycemia Pregnancy. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy. 2024; 17: 1321–1333. https://doi.org/10.2147/DMSO.S453204

Gong X, Li J, Jiang Y, Yuan P, Chen L, Yang Y, et al. Risk of preeclampsia by gestational weight gain in women with varied prepregnancy BMI: A retrospective cohort study. Frontiers in Endocrinology. 2022; 13: 967102. https://doi.org/10.3389/fendo.2022.967102

Guida JPDS, Andrade BGD, Pissinatti LGF, Rodrigues BF, Hartman CA, Costa ML. Prevalence of Preeclampsia in Brazil: An Integrative Review. Revista Brasileira De Ginecologia E Obstetricia. 2022; 44: 686–691. https://doi.org/10.1055/s-0042-1742680

Han Q, Zheng W, Guo XD, Zhang D, Liu HF, Yu L, et al. A new predicting model of preeclampsia based on peripheral blood test value. European Review for Medical and Pharmacological Sciences. 2020; 24: 7222–7229. https://doi.org/10.26355/eurrev_202007_21874

Han Y, Hai J, Yang X, Lu D, Li J, Yan X, et al. The synergistic effect of triglyceride-glucose index and HbA1c on blood pressure control in patients with hypertension: a retrospective cohort study. Scientific Reports. 2024; 14: 20038. https://doi.org/10.1038/s41598-024-70213-z

Heianza Y, Arase Y, Kodama S, Hsieh SD, Tsuji H, Saito K, et al. Fasting glucose and HbA1c levels as risk factors for the development of hypertension in Japanese individuals: Toranomon hospital health management center study 16 (TOPICS 16). Journal of Human Hypertension. 2015; 29: 254–259. https://doi.org/10.1038/jhh.2014.77

Hornová M, Šimják P, Anderlová K. Preeclampsia and diabetes mellitus. Ceska Gynekologie. 2023; 88: 467–471. https://doi.org/10.48095/cccg2023467

International Association of Diabetes and Pregnancy Study Groups Consensus Panel, Metzger BE, Gabbe SG, Persson B, Buchanan TA, Catalano PA, et al. International association of diabetes and pregnancy study groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. Diabetes Care. 2010; 33: 676–682. https://doi.org/10.2337/dc09-1848

Ives CW, Sinkey R, Rajapreyar I, Tita ATN, Oparil S. Preeclampsia-Pathophysiology and Clinical Presentations: JACC State-of-the-Art Review. Journal of the American College of Cardiology. 2020; 76: 1690–1702. https://doi.org/10.1016/j.jacc.2020.08.014

Jung E, Romero R, Yeo L, Gomez-Lopez N, Chaemsaithong P, Jaovisidha A, et al. The etiology of preeclampsia. American Journal of Obstetrics and Gynecology. 2022; 226: S844–S866. https://doi.org/10.1016/j.ajog.2021.11.1356

Kavak EC, Akcabay C, Demircan M, Batmaz I, Sanli C, Senocak A, et al. The Role of Mid-Trimester BUN and Creatinine Assessment in Predicting Preeclampsia: Retrospective Case-Control Study. Medicina (Kaunas). 2025; 61: 746. https://doi.org/10.3390/medicina61040746.

Kokori E, Aderinto N, Olatunji G, Komolafe R, Babalola EA, Isarinade DT, et al. Prevalence and maternofetal outcomes of preeclampsia/eclampsia among pregnant women in Nigeria: a systematic review and meta-analysis. European Journal of Medical Research. 2024; 29: 482. https://doi.org/10.1186/s40001-024-02086-x

Li XL, Guo PL, Xue Y, Gou WL, Tong M, Chen Q. An analysis of the differences between early and late preeclampsia with severe hypertension. Pregnancy Hypertension. 2016; 6: 47–52. https://doi.org/10.1016/j.preghy.2015.12.003

Ma'ayeh M, Costantine MM. Prevention of preeclampsia. Seminars in Fetal & Neonatal Medicine. 2020; 25: 101123. https://doi.org/10.1016/j.siny.2020.101123

MacDonald TM, Walker SP, Hannan NJ, Tong S, Kaitu'u-Lino TJ. Clinical tools and biomarkers to predict preeclampsia. eBioMedicine. 2022; 75: 103780. https://doi.org/10.1016/j.ebiom.2021.103780

Mi J, Song J, Zhao Y, Wu X. Association of hemoglobin glycation index and its interaction with obesity/family history of hypertension on hypertension risk: a community-based cross-sectional survey. BMC Cardiovascular Disorders. 2020; 20: 477. https://doi.org/10.1186/s12872-020-01762-0

Mistry SK, Das Gupta R, Alam S, Kaur K, Shamim AA, Puthussery S. Gestational diabetes mellitus (GDM) and adverse pregnancy outcome in South Asia: A systematic review. Endocrinology, Diabetes & Metabolism. 2021; 4: e00285. https://doi.org/10.1002/edm2.285

Mou AD, Barman Z, Hasan M, Miah R, Hafsa JM, Das Trisha A, et al. Prevalence of preeclampsia and the associated risk factors among pregnant women in Bangladesh. Scientific Reports. 2021; 11: 21339. https://doi.org/10.1038/s41598-021-00839-w

Muldoon KA, McLean C, El-Chaár D, Corsi DJ, Rybak N, Dagvadorj A, et al. Persisting risk factors for preeclampsia among high-risk pregnancies already using prophylactic aspirin: a multi-country retrospective investigation. The Journal of Maternal-Fetal & Neonatal Medicine. 2023; 36: 2200879. https://doi.org/10.1080/14767058.2023.2200879

Overton E, Tobes D, Lee A. Preeclampsia diagnosis and management. Best Practice & Research. Clinical Anaesthesiology. 2022; 36: 107–121. https://doi.org/10.1016/j.bpa.2022.02.003

Poorolajal J, Jenabi E. The association between body mass index and preeclampsia: a meta-analysis. The Journal of Maternal-Fetal & Neonatal Medicine. 2016; 29: 3670–3676. https://doi.org/10.3109/14767058.2016.1140738

Rana S, Lemoine E, Granger JP, Karumanchi SA. Preeclampsia: Pathophysiology, Challenges, and Perspectives. Circulation Research. 2019; 124: 1094–1112. https://doi.org/10.1161/CIRCRESAHA.118.313276

Robillard PY, Dekker G, Scioscia M, Bonsante F, Iacobelli S, Boukerrou M, et al. Increased BMI has a linear association with late-onset preeclampsia: A population-based study. PLoS ONE. 2019; 14: e0223888. https://doi.org/10.1371/journal.pone.0223888

Shao Y, Qiu J, Huang H, Mao B, Dai W, He X, et al. Pre-pregnancy BMI, gestational weight gain and risk of preeclampsia: a birth cohort study in Lanzhou, China. BMC Pregnancy and Childbirth. 2017; 17: 400. https://doi.org/10.1186/s12884-017-1567-2

Sole KB, Staff AC, Räisänen S, Laine K. Substantial decrease in preeclampsia prevalence and risk over two decades: A population-based study of 1,153,227 deliveries in Norway. Pregnancy Hypertension. 2022; 28: 21–27. https://doi.org/10.1016/j.preghy.2022.02.001

Sutan R, Aminuddin NA, Mahdy ZA. Prevalence, maternal characteristics, and birth outcomes of preeclampsia: A cross-sectional study in a single tertiary healthcare center in greater Kuala Lumpur Malaysia. Frontiers in Public Health. 2022; 10: 973271. https://doi.org/10.3389/fpubh.2022.973271

Sweeting A, Wong J, Murphy HR, Ross GP. A Clinical Update on Gestational Diabetes Mellitus. Endocrine Reviews. 2022; 43: 763–793. https://doi.org/10.1210/endrev/bnac003

Tanaka A, Node K. What Is Behind the HbA1c Value? Journal of the American College of Cardiology. 2021; 78: e117. https://doi.org/10.1016/j.jacc.2021.06.054

Weiner E, Feldstein O, Schreiber L, Grinstein E, Barber E, Dekalo A, et al. Placental Component and Pregnancy Outcome in Singleton versus Twin Pregnancies Complicated by Preeclampsia. Fetal Diagnosis and Therapy. 2018; 44: 142–148. https://doi.org/10.1159/000479737

Wheeler SM, Myers SO, Swamy GK, Myers ER. Estimated Prevalence of Risk Factors for Preeclampsia Among Individuals Giving Birth in the US in 2019. JAMA Network Open. 2022; 5: e2142343. https://doi.org/10.1001/jamanetworkopen.2021.42343

Wu L, Liu Y, Liu Z, Chen H, Shen S, Wei Y, et al. Serum urea acid and urea nitrogen levels are risk factors for maternal and fetal outcomes of pregnancy: a retrospective cohort study. Reproductive Health. 2022; 19: 192. https://doi.org/10.1186/s12978-022-01496-6

Yang Y, Le Ray I, Zhu J, Zhang J, Hua J, Reilly M. Preeclampsia Prevalence, Risk Factors, and Pregnancy Outcomes in Sweden and China. JAMA Network Open. 2021; 4: e218401. https://doi.org/10.1001/jamanetworkopen.2021.8401

Ye W, Luo C, Huang J, Li C, Liu Z, Liu F. Gestational diabetes mellitus and adverse pregnancy outcomes: systematic review and meta-analysis. BMJ (Clinical Research Ed.). 2022; 377: e067946. https://doi.org/10.1136/bmj-2021-067946