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Retrospective Study

Relationship between gestational body mass index, blood pressure variability, and postpartum depression in pregnant women with pre-eclampsia

Wu FF *et al*. PPD in preeclampsia

Abstract

BACKGROUND

Pre-eclampsia has long been proven to be an independent risk factor for postpartum depression (PPD). Excessive increase in body mass index (BMI) during pregnancy is an important factor inducing pre-eclampsia. Increased blood pressure is the main symptom of patients with pre-eclampsia. However, whether there is a correlation between BMI and blood pressure variability during pregnancy and PPD occurrence in pregnant women with pre-eclampsia remains unclear.

AIM

To investigate the relationship between BMI, blood pressure variability, and PPD in pregnant women with pre-eclampsia.

METHODS

Using a cross-sectional survey research, 201 pregnant women with pre-eclampsia who were treated and delivered in Suzhou Ninth People's Hospital from May 2016 to June 2024 were selected as this study's subjects. At 42 days after delivery, the subjects were re-examined in the hospital's outpatient department. The Edinburgh Postnatal Depression Scale (EPDS) was used to evaluate whether PPD symptoms, divided the subjects into two groups: The PPD and non-PPD groups. We analyzed clinical data, changes in BMI during pregnancy, and blood pressure variability in the two groups. The Pearson method was used to test the correlation between BMI increase, blood pressure variability during pregnancy, and EPDS score in patients with pre-eclampsia. Logistic regression analysis was performed to explore whether increased BMI and blood pressure variability during pregnancy are influencing factors for PPD occurrence in patients with pre-eclampsia.

RESULTS

Of the 201 pre-eclamptic women who underwent an outpatient review 42 days after delivery, 37 had PPD symptoms based on the EPDS scale evaluation, resulting in an incidence rate of 18.41% (37/201). The differences between the PPD and non-PPD groups in terms of age, educational level, place of residence, reproductive history, gestational age, mode of delivery, newborn gender, and newborn birth weight were not statistically significant ($P > 0.05$). The gestational BMI increase, 24-hour systolic blood pressure (SBP) variability, and 24-hour diastolic blood pressure (DBP) variability in the PPD group were significantly higher than those in the non-PPD group; the differences were statistically significant ($P < 0.001$). Pearson correlation analysis showed that BMI increase, SBP variability, and DBP variability during pregnancy correlated positively with the EPDS score of pregnant women with pre-eclampsia ($r = 0.349$, 0.336, and 0.241; $P < 0.001$). Logistic regression analysis showed that a high increase in BMI during pregnancy [odds ratio (OR) = 4.614, 95% confidence interval (CI): 1.749-12.170, $P = 0.002$], large variability in 24-hour SBP (OR = 2.910, 95%CI: 1.322-6.404, $P = 0.008$), and large variability in 24-hour DBP (OR = 2.347, 95%CI: 1.138-4.831, $P = 0.021$) were factors affecting PPD occurrence in patients with pre-eclampsia.

CONCLUSION

Increased BMI and blood pressure variability during pregnancy can increase the risk of PPD in patients with pre-eclampsia. Strengthening pregnancy guidance and controlling fluctuations in BMI and blood pressure variability during pregnancy within a reasonable range can help reduce the risk of PPD in patients with pre-eclampsia.

Key Words: Pre-eclampsia; Pregnancy; Body mass index; Blood pressure variability; Postpartum depression

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Core Tip: Postpartum depression (PPD) is a mental illness that affects family and social harmony. This study found that increased body mass index and blood pressure variability during pregnancy can increase the risk of PPD in patients with pre-eclampsia. This suggests that controlling body mass index increase and blood pressure fluctuations during pregnancy in patients with pre-eclampsia is crucial to prevent these factors from negatively affecting their psychological well-being. Additionally, it plays an important role in reducing the overall incidence of maternal PPD.

INTRODUCTION

Postpartum depression (PPD) is a puerperium mental syndrome characterized by sadness, anxiety, and difficulty in emotional control[1]. It can cause adverse effects on maternal physical and mental health, neonatal feeding, and even negative behaviors, including self-mutilation and suicide, thereby affecting family and social harmony. In addition to common social and physiological factors such as age, parity, and economic status[2], the individual health factors of pregnant women during pregnancy are closely linked to PPD occurrence. The International Academy of Medicine has promoted the ideal range of weight gain during pregnancy based on body mass index (BMI). Several studies have investigated the relationship between pregnancy-related psychiatric symptoms and BMI[3]. Some studies have found that pre-pregnancy obesity is a risk factor for PPD[4]. However, there are few reports on the relationship between BMI and PPD during pregnancy. Pre-eclampsia is a common pregnancy-specific disease. Overweight/obesity is an important trigger for its onset[5,6], with elevated blood pressure being the primary clinical feature of pre-eclampsia. Some studies have suggested a correlation between changes in dynamic blood pressure rhythm and organ diseases in various body systems and that blood pressure variability is closely linked to negative emotions[7]. Given that the primary clinical features of pre-eclampsia are new-onset hypertension and proteinuria after 20 weeks of pregnancy, which can lead to multi-system and organ involvement of varying severity, and the condition can

progress and worsen unpredictably, the risk of adverse pregnancy outcomes is high[8]. Consequently, pregnant women with pre-eclampsia often experience psychological stress during pregnancy, which is significantly higher than that in normal pregnant women, making them more susceptible to PPD. Therefore, understanding the relationship between BMI, blood pressure variability, and PPD during pregnancy in the context of pre-eclampsia is crucial for guiding clinical measures to reduce overall maternal PPD. However, to date, there is little to no literature exploring the mechanisms linking pregnancy BMI, blood pressure variability, and PPD in patients with pre-eclampsia. This study explored the relationship between changes in BMI, blood pressure variability, and PPD in pregnant women with pre-eclampsia to provide a reference for the prevention and treatment of PPD in pregnant women with pre-eclampsia.

MATERIALS AND METHODS

Research subjects

A cross-sectional survey was conducted involving 201 pregnant women with pre-eclampsia who received treatment and successfully gave birth at Suzhou Ninth People's Hospital from May 2016 to June 2024. These women were the research subjects. The Edinburgh Postnatal Depression Scale (EPDS) was used to assess the presence of PPD symptoms at 42 days postpartum. Based on the results, the women were categorized into PPD and non-PPD groups.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) 20-40 years of age; (2) All prenatal checkups were conducted in our hospital; (3) Met the diagnostic criteria for pre-eclampsia in the "Guidelines for the Diagnosis and Treatment of Pregnancy-induced Hypertension (2020)"[9] namely: After 20 weeks of pregnancy, systolic blood pressure (SBP) ≥ 140 mmHg (1 mmHg = 0.133 kPa), diastolic blood pressure (DBP) ≥ 90 mmHg, and elevated proteinuria; (4) No major life changes during pregnancy; (5) The newborn survived, and

no deformity was observed; and (6) Informed of this study, and signed informed consent.

The exclusion criteria were as follows: (1) Other than pre-eclampsia, other pregnancy complications existed; (2) Pre-pregnancy or lineal relatives had a history of mental illness; (3) Pregnancy *via* assisted reproductive technology; and (4) During pregnancy and before delivery, a depression screening questionnaire (PHQ-9) was used to identify individuals who were already depressed[10].

Research methods

General information collection: A general information collection form was created. The collected information included age, pre-pregnancy BMI, educational level, place of residence, birth history, gestational age, delivery mode, newborn gender, and birth weight of the subjects.

Changes in BMI during pregnancy: The height and weight of the subjects were measured. BMI was calculated according to the following formula: BMI = [weight (kg)/height (m^2)]; changes in BMI during pregnancy = pre-delivery BMI - pre-pregnancy BMI[11].

Pregnancy blood pressure variability: Because blood pressure exhibits certain physiological fluctuations and circadian rhythm changes, its dynamic adjustments to these changes are one of the most basic physiological characteristics of the human body. Therefore, we selected the third trimester (28-30 weeks) to observe the 24-hour ambulatory blood pressure (diastolic and SBP) in pregnant women with pre-eclampsia using a non-invasive portable ambulatory blood pressure monitor. To obtain accurate blood pressure values while considering physiological fluctuations and circadian rhythm changes, we selected 6:00 a.m. to 21:59 p.m. as the daytime, measured once every 15 minutes. The night period was from 22:00 p.m. to 5:59 a.m., measured once every 30 minutes. We ensured that monitoring frequency of patients was > 80%

effective, otherwise, we re-measured. The blood pressure variability of patients with pre-eclampsia was calculated based on the daily average blood pressure and standard deviation: Blood pressure variability = standard deviation/mean blood pressure × 100%.

PPD diagnosis: The EPDS was used to assess whether pregnant women with pre-eclampsia who went to the hospital's outpatient department for follow-up 42 days after delivery had PPD symptoms. This scale comprises 10 items, each of which is rated on four levels: Never scored; 0: Occasionally scored; 1: Frequently scored; 2: And always scored; 3: The total score is 0-30 points. PPD symptoms are present when EPDS score is ≥ 9 points in women with pre-eclampsia[12].

Statistical analysis

SPSS 25.0 statistical software was used for data analysis. The measurement data were first verified using the S-W method to conform to a normal distribution expressed as mean ± SD. The two groups were compared using an independent *t*-test. The utilization rate and composition ratio of count data [n (%)] were expressed. The two groups were compared using the χ^2 test. Pearson's correlation method was used to analyze the correlation between BMI increase during pregnancy, blood pressure variability, and EPDS score in patients with pre-eclampsia. Multiple logistic regression analysis was used to investigate the effects of changes in BMI and blood pressure variability during pregnancy on PPD in patients with pre-eclampsia. $P < 0.05$ indicates statistically significant differences.

RESULTS

Occurrence and general information of PPD in patients with pre-eclampsia

Among the 201 pregnant women with pre-eclampsia who attended outpatient follow-up on the 42nd day after delivery, 37 were found to have depressive symptoms based on the EPDS scale evaluation (PPD group), with an incidence rate of 18.41% (37/201) and

an EPDS score of 17.23 ± 3.65. The remaining 164 women had no depressive symptoms (non-PPD group), with an EPDS score of 6.93 ± 1.58. The differences between the PPD and non-PPD groups in terms of age, educational level, place of residence, reproductive history, gestational age, delivery mode, newborn gender, and newborn birth weight were not statistically significant ($P > 0.05$) (Table 1).

Comparison of BMI increase and blood pressure variability during pregnancy

BMI increase, 24-hour SBP variability, and 24-hour DBP variability during pregnancy in pregnant women with pre-eclampsia in the PPD group were significantly higher than those in the non-PPD group, difference was statistically significant ($P < 0.05$) (Table 2). This suggests that increased BMI and blood pressure variability during pregnancy are associated with PPD in pregnant women with pre-eclampsia.

Pearson correlation analysis

The increase in BMI, SBP variability, and DBP variability during pregnancy in pregnant women with pre-eclampsia correlated positively with their EPDS scores (r = 0.349, 0.336, and 0.241; $P < 0\ 001$) (Figure 1). This indicates a positive linear trend between BMI change and blood pressure variability during pregnancy and PPD in pregnant women with pre-eclampsia.

Logistic regression analysis of the factors influencing PPD in patients with pre-eclampsia

PPD occurrence in pregnant women with pre-eclampsia after delivery was used as the dependent variable (0 = no; 1 = yes). The statistically significant indicators presented in Table 2 were used as the independent variables (original value input). Logistic regression analysis showed that a high increase in BMI during pregnancy, large variability in 24-hour SBP, and large variability in 24-hour DBP were the influencing factors of PPD in patients with pre-eclampsia ($P < 0.05$) (Table 3).

DISCUSSION

Pre-eclampsia is a common complication of pregnancy. Srajer *et al*[13] reported that pre-eclampsia is associated with increased risk and severity of cognitive impairment, psychological stress, and mental disorders, including depression, anxiety, and post-traumatic stress disorder. Holland and Richmond[14] reported that pregnant women diagnosed with pre-eclampsia have a significantly higher risk of PPD. This emphasizes that pre-eclampsia can exacerbate the risk of PPD development because it may involve multiple systems and organs to varying degrees, thereby affecting fetal development and causing adverse psychological effects on patients with pre-eclampsia, making them more prone to PPD. A meta-analysis showed that the overall rate of depression in healthy pregnant women without a history of depression is 17%[15]. This study found that the incidence of PPD in pregnant women with pre-eclampsia at 42 days postpartum was 18.41%, slightly higher than that in the abovementioned report. It may be that the pathogenesis of pre-eclampsia or its symptoms increases the risk of PPD in pregnant women. Therefore, for the study of PPD in patients with pre-eclampsia, it is necessary to explore the relationship between PPD and the etiology and symptoms of pre-eclampsia in pregnant women to take early clinical measures to reduce PPD incidence in pregnant women with pre-eclampsia.

Being overweight and obese are important factors in pre-eclampsia pathogenesis[16]. They can lead to complications in pregnant women, including hyperlipidemia, hyperinsulinemia, pathological and physiological changes in the placenta, causing systemic vascular endothelial damage, systemic small artery spasm, and, ultimately, pre-eclampsia. This is evidenced by the fact that most patients with pre-eclampsia were overweight or obese before pregnancy. Furthermore, high BMIs before pregnancy often lead to weight gain during pregnancy that exceeds the reasonable range. Wu *et al*[17] found that an excessive increase in BMI during pregnancy is an important influencing factor of PPD. Howard *et al*[18] reported that the BMI of postpartum women correlates positively with PPD. Qiu *et al*[19] found that excessive weight gain during pregnancy is significantly associated with a high risk of developing PPD. This study found that the

gestational BMI increase in patients with pre-eclampsia in the PPD group was significantly higher than that in the non-PPD group. BMI increase during pregnancy correlated positively with the EPDS score of patients with pre-eclampsia in the PPD group, suggesting that BMI increase during pregnancy is a contributing factor to PPD occurrence in patients with pre-eclampsia, consistent with the abovementioned report. The reason may be that the excessive increase in BMI in pregnant women with pre-eclampsia can cause endocrine disorders, increase the incidence of macrosomia, affect normal vaginal delivery, increase cesarean section and forceps rates, and may adversely affect newborns[20]. Therefore, it significantly affects the psychological state of pregnant women, leading to tension and fear before delivery. This exacerbates the condition, hinders postpartum recovery, and creates a vicious cycle that can ultimately trigger PPD. Second, an excessive increase in BMI during pregnancy can easily lead to postpartum weight and fat retention[21], affecting the mother's body shape and worsening her psychological burden, thereby making them prone to PPD. Additionally, the psychological state of postpartum women is more sensitive compared to the sensitive period. Will pay more attention to postpartum body shape recovery. However, excessive weight gain during pregnancy is associated with many endocrine problems[22]. It often leads to difficulty in restoring weight and body shape after childbirth to the pre-pregnancy state[23]. This can cause the mothers to become prone to negative emotions, increasing their risk of PPD.

Elevated blood pressure is the main clinical manifestation of pre-eclampsia[24]. Harskamp and Zeeman[25] reported that pregnant women with pre-eclampsia are more likely to develop cardiovascular and cerebrovascular diseases than those with normal blood pressure. This may be due to elevated blood pressure variability in pregnant women with pre-eclampsia, which can easily trigger several cardiovascular and cerebrovascular diseases[26]. This will undoubtedly cause a greater physical and psychological burden on pregnant women. When the psychological state is relatively fragile during pregnancy, PPD is often prone to occur[27]. Artinian *et al*[28] reported that the higher the blood pressure level in women, the greater the risk of developing

depression. This study found that the 24-hour SBP and DBP variabilities in patients with pre-eclampsia in the PPD group were significantly higher than those in the non-PPD group. The 24-hour SBP and DBP variabilities correlated positively with the EPDS score of patients with pre-eclampsia in the PPD group. These findings suggest that the 24-h SBP and DBP variabilities are influencing factors for PPD occurrence in patients with pre-eclampsia, consistent with the abovementioned conclusion. Blood pressure variability and PPD occurrence in patients with pre-eclampsia are related. The reason may be the increased blood pressure variability during pregnancy in patients with pre-eclampsia, causing small artery spasms in some cerebral blood vessels[29], damaging the endothelial function of the blood-brain barrier, and leading to long-term structural and functional brain changes. These changes may lead to subsequent mental health damage and increase the risk of PPD. Additionally, blood pressure variability during pregnancy may trigger several cardiovascular and cerebrovascular diseases, which can cause psychological stress[30] and stimulate negative emotions such as tension, fear, and anxiety. These negative emotions can cause sympathetic nervous system excitement, elevated blood pressure, exacerbate blood pressure fluctuations, and induce a relatively stable hypertension level for a long time. This forms a vicious cycle that causes certain mental and psychological abnormalities, thereby increasing the risk of PPD occurrence.

CONCLUSION

In summary, the BMI and blood pressure variability of pregnant women with pre-eclampsia during pregnancy were closely related to their PPD occurrence. In other words, increased BMI and high blood pressure variability during pregnancy can increase the risk of PPD in patients with pre-eclampsia. Although an increasing number of researchers are paying attention to the psychological problems of postpartum women, the clinical management system for these problems remains imperfect. Therefore, we suggest the monitoring of BMI and blood pressure fluctuations during pregnancy in patients with pre-eclampsia during routine prenatal checkups and the

importance of health education and guidance during pregnancy to take proper measures to control the increase in BMI and blood pressure fluctuations in pregnant women with pre-eclampsia, thereby reducing the risk of PPD. We also strongly urge pregnant women to maintain a healthy weight through a reasonable diet and appropriate exercise, to maintain a comfortable mood as much as possible, and to avoid blood pressure stimulation by psychological tension. Furthermore, medical workers need to strengthen prenatal health education, control the weight gain of pregnant women during pregnancy while ensuring the nutritional needs of the mother and fetus, and do a good job in psychological counseling during pregnancy to alleviate tensions in pregnant women. Nevertheless, this study has some limitations. First, this study is a single-center survey data analysis with a limited sample size and representativeness. Second, there may be some residual confounding factors affecting the variable analysis. Therefore, it is necessary to improve and expand the sample size in future research to validate our conclusions.

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