Journal of Multidisciplinary Healthcare

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Risk Factors and Clinical Features of Peripartum Cardiomyopathy in a Chinese Population

Hui Huang[1–3,*], Qing Ye[1–4,*], Yulan Xu[1–3,*], Baoming Tao[1–3], Junlan Liu[1–3], Tian Xie[1–3], Lingfeng Zha[1–3]

[1]Department of Cardiology, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, People's Republic of China; [2]Hubei Key Laboratory of Biological Targeted Therapy, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, People's Republic of China; [3]Hubei Provincial Engineering Research Center of Immunological Diagnosis and Therapy for Cardiovascular Diseases, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, People's Republic of China; [4]School of Nursing, Wuhan University, Wuhan, People's Republic of China

*These authors contributed equally to this work

Correspondence: Tian Xie; Lingfeng Zha, Department of Cardiology, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, 1277 Jiefang Avenue, Wuhan, 430022, People's Republic of China, Tel +86-15972150162; +86-15827177185, Email xietian@hust.edu.cn; zhalf@hust.edu.cn

Purpose: We investigated the risk factors and characteristic clinical features of peripartum cardiomyopathy (PPCM) to lay the groundwork for early identification, screening, diagnosis, and intervention in high-risk pregnant women.

Patients and methods: A retrospective case-control study was conducted to analyze data from 44 patients with PPCM and 226 normal pregnant women from a Chinese population.

Results: Significant differences were found between the groups in terms of various factors such as age, body mass index (BMI), heart rate, and medical history. Logistic regression models identified abnormal electrocardiography (OR=18.852), upper respiratory tract infection (OR=41.822), gestational hypertension (OR=18.188), and cesarean section (
OR=8.394) as risk factors for PPCM. Common clinical features observed in patients with PPCM included cough, wheezing, and chest tightness (68.18%), left heart enlargement (56.82%) and valvular insufficiency (81.82%). Additionally, cardiotropic virus was detected in a subset of patients (43.18%) and NT-proBNP was elevated ≥ 400 pg/mL (81.82%).

Conclusion: In the Chinese population, the presence of abnormal electrocardiograms during pregnancy, history of upper respiratory tract infection, gestational hypertension, and maternal choice of cesarean section suggest the possibility of PPCM development. Factors such as advanced age, family history of cardiovascular disease, gestational diabetes mellitus, eclampsia, anemia, and hypoproteinemia should be considered. Clinically, patients present with cough, wheezing, chest tightness, enlarged left heart, valvular insufficiency and NT-proBNP elevated ≥ 400 pg/mL. This study could serve as a valuable reference for medical practitioners for the early identification and screening of patients with PPCM.

Keywords: peripartum cardiomyopathy, risk factors, clinical features, early identification

Introduction

Peripartum cardiomyopathy (PPCM) is a form of cardiomyopathy that occurs at the end of pregnancy or within a few months after delivery and is characterized by left ventricular systolic dysfunction (ejection fraction [EF] < 45%) and heart failure in pregnant women without a history of cardiovascular disease.[1–3] Since no specific test to confirm PPCM exists, PPCM still is an exclusion diagnosis after excluding pulmonary embolism or other differential diagnosis that are more common.[4,5] PPCM is global, with the most recent study finding that the incidence of PPCM is 1/4950.[6] However, due to the rarity of PPCM, uncertain definitions, and geographic variations, its incidence varies widely across countries and ethnic groups.[7,8] For example, the incidence ranges from 1/300 in Haiti to 1/4000 in the United States, both of which are located in North America.[9] While, in Asia, the incidence of PPCM ranges from 1/837 in Pakistan to 1/15,533 in Japan.[10] The epidemiology of PPCM in China is poorly understood and data on long-term outcomes are lacking. There

Received: 15 March 2024
Accepted: 30 July 2024
Published: 5 August 2024

are many factors associated with the development of PPCM, including pregnancy-induced hypertensive disorders, multiple births, and genetics, which emphasize its pathophysiological heterogeneity. In addition, regional and geographical differences contribute to the varying risk factors for PPCM across different regions.[11,12] For instance, in the United States, risk factors include advanced age, black ethnicity, preeclampsia, hypertension, multiple pregnancies, anemia, and prolonged use of contraction inhibitors.[13–15] In Korea, the risk factors for PPCM include advanced age, preeclampsia, multiple pregnancies, and gestational diabetes.[16] In China, the PPCM high-risk epidemiological characteristics involve rural patients, 3 months post-delivery, anemia, and hypertension. As the living standards of Chinese residents and fertility technologies advance, researchers have observed additional epidemiological characteristics among patients with PPCM, warranting further investigation and validation.

This study retrospectively analyzed clinical data from 44 patients with PPCM in China, examining their risk factors and distinct clinical presentations to facilitate early identification, screening, diagnosis, and intervention for high-risk pregnant individuals with PPCM.

Materials and Methods

Study Objects

Forty-four patients diagnosed with PPCM were admitted to Wuhan Union Hospital in China between February 2018 and February 2023 and served as the observation group. Parturients without heart disease who were admitted during the same period were selected as the control group. The sample size was determined based on the Logistic regression analysis method, with 20 factors considered in the study (the sample size for the control was 10–15 times the number of covariates. Twenty factors were identified in this study; the sample size for the control was between 200 and 300). To ensure study stability, 226 normal parturients were selected as the control group through convenience sampling.

The inclusion criteria for PPCM patients included being 18 years or older, meeting the diagnostic criteria established by the PPCM Study Group of the Heart Failure Association (HFA) of the European Society of Cardiology (ESC) (that is, i. Heart failure secondary to left ventricular systolic dysfunction; the left ventricular ejection fraction (LVEF) < 45%; ii. It occurs at the end of pregnancy or a few months after delivery; and iii. There were no other identifiable causes of heart failure),[5] and providing informed consent was obtained. The inclusion criteria for normal parturients included delivering a live birth normally, being healthy without systemic diseases, being willing to do Echocardiography examination and Echocardiography examination show normal, as well as the willingness to participate. Exclusion criteria for both patients with PPCM and normal parturients included pre-existing conditions such as hypertension, diabetes, thyroid dysfunction, hypoproteinemia, anemia, history of mental illness, malignant tumors, serious dysfunction of other organs, and missing clinical data.

Our study met the requirements of the World Medical Association Declaration of Helsinki and was approved by the local ethics committee of Wuhan Union Hospital. The patients' basic information and clinical data were kept strictly confidential.

Clinical Data Collection

This study included 44 patients with PPCM and 226 normal parturient individuals from the Wuhan Union Hospital in China (Hubei, Wuhan) between February 2018 and February 2023. The clinical information collected included maternal age at childbirth, heart rate, blood pressure, blood glucose, blood lipids, body mass index (BMI), electrocardiogram (ECG) results, blood biochemical data, childbearing history, antenatal check-up history, gestational diabetes history, gestational hypertension history, eclampsia history, family history of cardiovascular disease, respiratory infection history during pregnancy, and delivery mode, etc.

Statistical Methods

All data were processed using excel tables. Measurement data are presented as means ± standard deviation. For continuous data, normality was checked by the Kolmogorov–test and homogeneity of variance was checked by Hartley test. The *t*-test was used to compare two independent samples with a normal distribution and homogeneity of

variance, while the Mann-Whitney *U*-test was employed for data that exhibited a non-normal distribution or uneven variance. Counting data were described in terms of frequency and percentage, and chi-squared tests were conducted accordingly. Risk factors associated with PPCM were identified using binary logistic stepwise regression analysis (entry criterion = 0.05, removal criterion = 0.10), and the results were presented by odds ratio (OR) and 95% confidence intervals (CI). Statistical analyses were performed using SPSS (version 20; SPSS, Inc., Chicago, IL, USA). All statistical tests were two-sided, with the significance level set at $P < 0.05$.

Results

Comparison of Clinical Data Between PPCM Patient Group and Normal Parturient Group

Upon analysis of clinical data from PPCM patients and normal parturient, statistically significant differences were observed in age, BMI, heart rate, systolic pressure, abnormal ECG, C-reactive protein, hyperlipidemia, upper respiratory tract infection history, gestational diabetes mellitus history, gestational hypertension history, eclampsia history, anemia, hypoproteinemia, multiple pregnancy, multipara, and delivery mode in PPCM patients compared to normal parturients (all $P < 0.05$). However, there were no statistically significant differences in diastolic blood pressure, family history of cardiovascular disease, thyroid dysfunction, or regular birth test results between the two groups (all $P > 0.05$). As detailed in Table 1.

The Risk Factors of PPCM by Logistic Regression Analysis

Sixteen factors with statistical significance identified in the above univariate analysis were assigned values: age, BMI, heart rate, systolic pressure, abnormal ECG, C-reactive protein level, hyperlipidemia, history of upper respiratory tract infection, history of gestational diabetes mellitus, history of gestational hypertension, history of eclampsia, anemia, hypoproteinemia, multiple pregnancies, multipara, and mode of delivery (Table 2). Logistic stepwise regression analysis

Table 1 Comparison of Clinical Data Between PPCM Patient and Normal Parturient Group

	Clinical Index	Normal Parturient (n=226)	PPCM (n=44)	Statistical Magnitude	*P*
General factors	Age (year, $\bar{x} \pm s$)	29.04±3.16	30.89±5.76	2.182[a]	0.029
	BMI (kg/m^2, $\bar{x} \pm s$)	26.21±3.16	25.18±4.50	1.813[b]	0.071
	Heart rate (beats/minute, $\bar{x} \pm s$)	89.31±10.38	96.55±16.09	2.786[a]	0.005
	Systolic pressure (mmHg, $\bar{x} \pm s$)	115.99±10.32	121.00±17.73	2.057[a]	0.040
	Diastolic pressure (mmHg, $\bar{x} \pm s$)	75.54±7.54	74.86±13.14	−1.000[a]	0.317
Non-obstetric factors	Family history of cardiovascular disease (n, %)	19 (8.41%)	4 (9.09%)	0.022[c]	0.536
	Abnormal ECG (n, %)	43 (19.03%)	24 (54.55%)	24.904[c]	<0.001
	Positive C-reactive protein* (n, %)	89 (39.38%)	29 (65.91%)	10.535[c]	0.001
	Thyroid dysfunction (n, %)	71 (31.42%)	14 (31.82%)	0.003[c]	0.544
	Hyperlipidemia (n, %)	219 (96.90%)	29 (65.91%)	47.271[c]	<0.001
	Upper respiratory tract infection history (n, %)	1 (0.44%)	16 (36.36%)	80.548[c]	<0.001
	Anemia (n, %)	29 (12.83)	26 (59.09)	48.587[c]	<0.001
	Hypoproteinemia (n, %)	71 (31.42)	34 (77.27)	32.588[c]	<0.001
Obstetric-related factors	Gestational diabetes mellitus history (n, %)	3 (1.33%)	8 (18.18)	26.771[c]	<0.001
	Gestational hypertension history (n, %)	5 (2.21)	9 (20.45)	24.929[c]	<0.001
	Eclampsia history (n, %)	2 (0.88)	3 (6.82)	7.133[c]	0.032
	Multiple pregnancy (n, %)	5 (2.21)	7 (15.91)	16.269[c]	0.001
	Multipara (n, %)	53 (23.45)	22 (50.00)	12.939[c]	0.001
	Delivery mode (n, %) Eutocia	176 (77.88)	13 (29.55)	40.966[c]	<0.001
	Cesarean	50 (22.12)	31 (70.45)		
	Regular birth tests (n, %)	157 (69.47)	36 (81.82)	2.755[c]	0.066

Notes: [a]Means the statistic is U-value; [b]Means the statistic is t value; [c]Is the chi-square value of the statistic; *Means C-reactive protein > 8mg/L.

Table 2 Assignment of 16 Possible Risk Factors for PPCM

	Risk Factor	Assignment
General factors	Age (year)	<24 year =1, 24~35 year =2, >35 year =3
	BMI (kg/m²)	<24=1, 24~26=2, >26=3
	Heart rate (beats/minute)	<60=1, 60~100=2, >100=3
	Systolic pressure (mmHg)	<90=1, 90~140=2, >140=3
Non-obstetric factors	Electrocardiograph	Normal =1, Abnormal =2
	C-reactive protein (mg/L)	≤8=0, >8=1
	Hyperlipidemia, upper respiratory tract infection history, anemia, hypoproteinemia	No =0, Yes =1
Obstetric-related factors	Gestational diabetes mellitus history, gestational hypertension history, eclampsia history, multiple pregnancy, multipara, cesarean	No =0, Yes =1
Outcome	Outcome of patient	Normal parturient =0, PPCM =1

Table 3 The Risk Factors of PPCM Were Analyzed by Logistic Regression

Risk Factor	β	SE	Wals	*P*	OR	95%CI
Constant term	−1.636	0.165	98.616	<0.001	0.195	——
Abnormal electrocardiograph	2.937	0.841	12.206	<0.001	18.852	3.630–97.912
History of upper respiratory tract infection	3.733	0.851	19.256	<0.001	41.822	7.892–221.619
Pregnancy-induced hypertension	2.901	1.194	5.902	0.015	18.188	1.752–188.856
Delivery mode	2.127	0.367	33.562	<0.001	8.394	4.087–17.241

was used to screen the risk factors, with a significance level of $\alpha = 0.05$ for inclusion and $\alpha = 0.10$ for exclusion. The results indicated that abnormal ECG findings (OR=18.852), history of upper respiratory tract infection (OR=41.822), hypertension during pregnancy (OR=18.188), and caesarean section during delivery (OR=8.394) were identified as risk factors for PPCM. Further details are presented in Table 3.

Characteristic Clinical Manifestations of PPCM Patients

An analysis of 44 patients with PPCM revealed that 68.18% experienced symptoms such as cough, wheezing, and chest tightness. Left heart enlargement was observed in 56.82% of patients, while 81.82% had valvular insufficiency. Furthermore, 47.73% had sinus tachycardia, 43.18% tested positive for cardiotropic virus, and 81.82% had NT-proBNP levels ≥ 400pg/ml. Some patients reported palpitations, dyspnea, chest pain, and other symptoms. More detailed information is provided in Table 4.

Table 4 Characteristic Clinical Manifestations of PPCM Patients

Clinical Characteristics	Symptom	Number (n=44)	Percentage (%)
Cardiac chief complaint	Cough, wheezing, and chest tightness	30	68.18
	Palpitation of breath	15	34.09
	Dyspnea	10	22.73
	Chest pain	2	4.55
	Loss of appetite, nausea and vomiting	2	4.55
Vital signs	Edema of both lower limbs	4	9.09
	Pyrexia	4	9.09
	Facial edema	2	4.55

(*Continued*)

Table 4 (Continued).

Clinical Characteristics	Symptom	Number (n=44)	Percentage (%)
Electrocardiographic examination	Sinus tachycardia	21	47.73
	Atrial fibrillation	2	4.55
	Conduction block	1	2.27
Cardiac imaging	Valvular insufficiency	36	81.82
	Left heart enlargement	25	56.82
	Right heart enlargement	2	4.55
Cardiotropic virus test*	+	19	43.18
Level of NT-proBNP	≥400pg/ml	36	81.82

Notes: *Cardiotropic viruses include coxsackieviruses and enteroviruses. NT-proBNP is the quantitative markers of heart failure.

Discussion

Risk Factors for PPCM Patients

The History of Upper Respiratory Tract Infection is One of the Risk Factors for PPCM

Our research indicated that a history of upper respiratory tract infection was a significant risk factor for the development of PPCM, with approximately 36.36% of the patients with PPCM experiencing upper respiratory tract infections during pregnancy or the postpartum period. These findings align with those of Huang GY's study, where 36.5% of PPCM patients had a history of upper respiratory tract infection, and 25% showed evidence of respiratory tract infection through laboratory tests.[17] However, this study did not investigate the pathogenesis of PPCM caused by respiratory tract infections. Based on our finding, we hypothesized that respiratory infections may contribute to PPCM through tracheal and bronchial constriction, impacting airway ventilation and lung gas exchange, thereby reducing myocardial oxygen supply, constricting the pulmonary vascular bed, and increasing right heart strain. In addition, decreased immunity may facilitate the invasion of cardiotropic viruses, leading to myocardial damage and PPCM. Furthermore, initial PPCM symptoms often mimic congestive heart failure, making it challenging to differentiate them from upper respiratory tract infection symptoms. It is important to note that we did not have data on the pathogens that infected patients in this study, so we could not compare the differences between different pathogens to determine which infections were dominant. Different pathogen infections may trigger different mechanisms. Recent studies have found that residual endothelial damage from COVID-19 infection predisposes pregnant patients to PPCM and should therefore be considered as a risk factor when evaluating symptoms of new heart failure, and suggests that any pregnant woman with cardiomyopathy should consider the possibility of infection with coronavirus.[18,19] Future studies will focus on this data to explore the differences between different pathogens and fully identify the underlying pathophysiology.

Pregnancy-Induced Hypertension is One of the Risk Factors for PPCM

Numerous studies have confirmed an association between pregnancy-induced hypertension and PPCM,[20–23] a relationship that was further supported by our analysis. Pregnant women with PPCM have a 1.5 times higher prevalence of pregnancy-induced hypertension than those with normal blood pressure, with the risk of PPCM being elevated 5–21 times in women with hypertensive pregnancies.[24] Recent advancements in our understanding of PPCM pathophysiology suggest that gestational hypertension contributes to the development of PPCM primarily through myocardial cell apoptosis induced by soluble fms-like tyrosine kinase receptor 1 (sFlt-1) and elevated prolactin levels.[25] Gestational hypertension can also result in perinatal hemodynamic changes, ranging from adaptive myocardial remodeling and left ventricular global diastolic dysfunction in mild cases, to left ventricular hypertrophy and radial artery systolic dysfunction in severe cases, ultimately culminating in PPCM.[26] Eclampsia, a severe complication of high blood pressure during pregnancy, has been shown to directly cause cardiac dysfunction independent of blood pressure levels.[27] However, our study did not find eclampsia to be a significant risk factor for PPCM, possibly because of limitations in sample size, in our study only 3 (6.82%) patients with PPCM had history of eclampsia. Another reason maybe ethnic and

geographic variation, since genetic predispositions exist to eclampsia and PPCM.[28] Some scholars believe that the risk of developing PPCM in pre-eclamptic women is overestimated.

Cesarean is One of the Risk Factors for PPCM

Lee et al conducted a study on the risk factors of PPCM in Korea.[16] They found that 64.5% of patients with PPCM opted for cesarean delivery; however, 62.4% of patients with PPCM were already diagnosed with PPCM before delivery and then chose cesarean. This suggests that cesarean delivery may not be a direct factor for the onset of PPCM. In our study, we found that the proportion of cesarean section in patients with PPCM (70.45%) was significantly higher than that in normal parturients (22.12%), and significantly higher than the average rate of cesarean section in China (46%),[29] which was similar to the results of research from Zhang et al (75%).[30] Through Logistic regression analysis, we found that cesarean delivery was a significant factor in the development of PPCM, with an OR of 8.394 and a 95% CI of 4.087–17.241. This indicates that cesarean delivery poses a risk of PPCM. The increased risk may be attributed to the large volume of fluid infusion during cesarean section, reaching up to 3000ml/day, leading to an increased cardiac load and subsequent heart failure, which could contribute to the development of PPCM. It is also worth noting that we do not know the indications for caesarean section, so there is no way to know the impact of these different indications on this result. Whether cesarean is a risk factor for PPCM and how it affects the occurrence and development of PPCM still need to be verified by various evidence.

Other Risk Factors for PPCM

Previous research has identified perinatal risk factors such as age, family history of cardiovascular disease, C-reactive protein level, thyroid function, gestational diabetes mellitus, eclampsia, anemia, hypoproteinemia, multiple pregnancies, and menstrual status.[16,31,32]

C-reactive protein level increased in 65.91% patients with PPCM, indicated the involvement of inflammation in the pathogenesis of PPCM. 59.09% of patients with PPCM presented with anemia and 18.18% with gestational diabetes, suggesting that anemia and diabetes might promote the development of PPCM. The frequency of multiple pregnancies for patients with PPCM was also higher than normal parturients, suggesting that multiple pregnancies is a risk factor for PPCM.[33] With the release of China's special two-child policy, the number of multiparas in our country has increased overall, so the normal group of multiparas will also have a certain proportion of increase. A meta-analysis of 1097 patients with PPCM in China showed that there were more cases of primipara in PPCM in China than in multipara (53.3% vs 46.7%). Our study also showed a similar proportion, with 50% of multiparas in PPCM compared to 23.45% in the normal group. Although there was a significant difference between these two groups, our subsequent Logistic regression analysis of risk factors for PPCM did not find that multipara was a risk factor for PPCM. This is inconsistent with other countries that have found that multipara are risk factors for PPCM, possibly because of ethnic or geographical differences.

We also observed an interesting phenomenon that a significant proportion of our normal parturients had hyperlipidemia, much higher than patients with PPCM group. We have some explanations for this. The number of overweight pregnant women in China is increasing due to improved living conditions, increased perinatal high-fat diet, and decreased physical activity. About 40% of pregnant women are overweight. In addition, maternal blood lipids will also be affected under the effect of hormones. The pregnant women with PPCM will restrict the diet because of heart failure, so the hyperlipidemia is relatively less. The incidence of hyperlipidemia in the non-PPMC group in this study was 96.90%, which was similar to the results of a study in Cameroon in 2022, where the incidence of hyperlipidemia during pregnancy was 94.23%.[34]

In this study, statistical differences in these factors were observed when compared to the control group (all $P < 0.05$), although they were not included in the regression equation. This omission can be attributed to the small sample size and potential collinearity with other covariables. The correlation between the independent variables and collinear effects was automatically eliminated. Some studies suggest that regression models serve as tools to aid in understanding the real world, and that the selection of independent variables should involve a combination of clinical expertise for analysis and judgment. Although this study suggests a potential relationship between age, family history of cardiovascular disease,

gestational diabetes mellitus, eclampsia, anemia, hypoproteinemia, and the occurrence of PPCM, further research is necessary to confirm this.

Early Identification of Clinical Features of PPCM Patients

Our study revealed that abnormal ECG is an early characteristic of PPCM. ECG examinations are simple and essential for patients with PPCM. The primary abnormal ECG finding in the patients with PPCM was sinus tachycardia (47.73%). Sinus tachycardia in patients with PPCM can be attributed to physiological and pathological factors. Physiologically, increased blood volume at the end of pregnancy leads to higher cardiac output, whereas uterine contractions and fluid absorption during the postpartum period increase cardiac blood return, resulting in sinus tachycardia. Pathologically, patients with PPCM exhibit cardiomyocyte hypertrophy, degenerative changes, myocardial fiber rupture, interstitial edema, and inflammatory cell infiltration, all of which affect the conduction system and cause arrhythmias. Arrhythmias are common in various cardiomyopathies. Simple sinus tachycardia without symptoms or cardiac dysfunction typically does not require specific treatments. However, other arrhythmias such as ST segment changes, Q-T interval prolongation, and malignant arrhythmias indicate cardiac dysfunction and myocardial damage, necessitating targeted treatment based on the underlying cause. Notably, 45.45% of patients with PPCM in our study had normal ECG findings, emphasizing that ECG alone is not sufficient for diagnosing PPCM. Even with a normal ECG, clinical symptoms and additional tests, such as echocardiography, must be considered. In conclusion, ECG changes in PPCM lack specificity and should be interpreted in conjunction with a comprehensive clinical analysis for an accurate auxiliary diagnosis. In addition, as experts recommend that an ECG should be conducted at least in the beginning of the pregnancy to have an ECG for comparison.

The primary symptoms observed in patients with PPCM include cough, wheezing, and chest tightness, which can be mistaken for symptoms resulting from increased blood volume during late pregnancy and hemodynamic changes during the postpartum period, highlighting the importance of differentiation. Cardiac imaging revealed that most patients exhibited left heart enlargement, varying degrees of mitral and tricuspid valve insufficiency, indicating impaired cardiac function. The analysis suggests that factors such as lack of disease awareness and delayed medical treatment may do not facilitate PPCM but contribute to late diagnosis, so patients still need to start seeking medical tests early.[35,36] Cardiotropic viruses were detected in 43.18% of the patients with PPCM, potentially leading to PPCM through direct damage to the myocardium. Considering that a significant proportion of patients with PPCM infected with cardiotropic viruses, routine testing for cardiotropic viruses is recommended for suspected PPCM cases to aid in diagnosis. NT-proBNP levels $\geq$ 400pg/ml are indicative of decompensated heart failure; while a normal increase in blood flow during pregnancy may result in a slight elevation in NT-proBNP, levels typically remain < 400pg/ml. The latest study found that BNP levels were significantly higher in the PPCM group than in the control group (830.21±743.30pg/ml vs 55.27 ±78.78pg/ml).[30] Notably, 81.82% of patients in this study had NT-proBNP levels $\geq$ 400pg/ml, underscoring the importance of immediate cardiac evaluation in perinatal pregnant women with abnormally elevated NT-proBNP levels. There are some limitations to our study, as suggested by the reviewers, multicenter prospective studies should be conducted in the future, if possible, to evaluate the normal value of proBNP in pregnancy and within the course of a pregnancy as well as postpartum. Then we can compare proBNP levels in normal pregnancies with those complicated with PPCM. Only through further investigation can we further clarify the clinical significance of the cutoff value of proBNP.

Currently, specific diagnostic methods for perinatal cardiomyopathy are lacking, and pathological biopsies are limited. Therefore, the initial diagnosis should be based on a combination of medical history, clinical symptoms, and additional tests.[37] With advancements in fertility technology and the relaxation of the two-child policy in China, there has been a significant increase in the number of multiple pregnancies, elderly parturient women, and multiparas, who are at a higher risk of developing PPCM and require increased attention.[38] During perinatal prenatal examinations, healthcare professionals should thoroughly investigate the risk factors for perinatal cardiomyopathy and recommend patients to seek medical evaluation by the cardiology department if any suspicious factors are identified.

Conclusion

Our study made preliminary findings through observational studies that abnormal ECG findings, history of upper respiratory tract infection, gestational hypertension, and caesarean section were potential risk factors for PPCM in the Chinese population. Additionally, factors such as age, family history of cardiovascular disease, gestational diabetes mellitus, eclampsia, anemia, and hypoproteinemia are correlated with the occurrence of PPCM. In the Chinese population, common clinical manifestations of PPCM included cough, wheezing, chest tightness, left heart enlargement, mitral and tricuspid valve insufficiency, presence of cardiotropic virus in blood tests, and elevated levels of NT-proBNP $\geq$ 400pg/ml. This study suggests that early identification, screening, diagnosis, and intervention based on these risk factors can help reduce mortality and improve health outcomes for patients with PPCM. However, it is important to note that this study had a small sample size and was a single-center retrospective case-control study, indicating certain limitations. Future research should focus on conducting large-scale, multi-center, and prospective case-control studies on the risk factors of PPCM.

Data Sharing Statement

All data in the article can be obtained by contacting the corresponding author of the article.

Ethics Approval and Consent to Participate

All recruiters selected signed informed consent. The research meets the requirements of the World Medical Association Declaration of Helsinki and has been approved by the local ethics committee (Wuhan Union Hospital).

Acknowledgments

We want to acknowledge all participants and their supports for this work.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

Our work was funded by the Hubei Provincial Natural Science Foundation of China of Tian Xie [2023AFB1101], Hubei Province health and family planning scientific research project [WJ2023M033].

Disclosure

The authors report no conflicts of interest in this work.

References

1. Regitz-Zagrosek V, Roos-Hesselink JW, Bauersachs J, et al. 2018 ESC Guidelines for the management of cardiovascular diseases during pregnancy. *Eur Heart J*. 2018;39(34):3165–3241. doi:10.1093/eurheartj/ehy340
2. Arany Z. Peripartum Cardiomyopathy. *N Engl J Med*. 2024;390(2):154–164. doi:10.1056/NEJMra2306667
3. Michimata H, Sumi T, Nagayama D, et al. Severe heart failure due to peripartum cardiomyopathy. *Respirol Case Rep*. 2023;11(5):e01137. doi:10.1002/rcr2.1137
4. Davis MB, Arany Z, McNamara DM, et al. Peripartum cardiomyopathy: JACC state-of-the-art review. *J Am Coll Cardiol*. 2020;75(2):207–221. doi:10.1016/j.jacc.2019.11.014
5. Bauersachs J, Konig T, van der Meer P, et al. Pathophysiology, diagnosis and management of peripartum cardiomyopathy: a position statement from the heart failure association of the European society of cardiology study group on peripartum cardiomyopathy. *Eur J Heart Fail*. 2019;21(7):827–843. doi:10.1002/ejhf.1493
6. Jackson AM, Macartney M, Brooksbank K, et al. A 20-year population study of peripartum cardiomyopathy. *Eur Heart J*. 2023;44(48):5128–5141. doi:10.1093/eurheartj/ehad626
7. Ejim EC, Karaye KM, Antia S, et al. Peripartum cardiomyopathy in low- and middle-income countries. *Best Pract Res Clin Obstet Gynaecol*. 2024;93:102476. doi:10.1016/j.bpobgyn.2024.102476

8. Ardissino M, Halliday BP, de Marvao A. The global landscape of peripartum cardiomyopathy: morbidity, mortality, recovery and inequity. *Eur J Heart Fail*. 2024;26(1):43–45. doi:10.1002/ejhf.3097
9. Hilfiker-Kleiner D, Haghikia A, Nonhoff J, et al. Peripartum cardiomyopathy: current management and future perspectives. *Eur Heart J*. 2015;36 (18):1090–1097. doi:10.1093/eurheartj/ehv009
10. Bala R, Mehta S, Roy VC, et al. Peripartum cardiomyopathy: a review. *Rev Port Cardiol*. 2023;42(11):917–924. doi:10.1016/j.repc.2023.01.029
11. Karaye KM, Ishaq NA, Sa'idu H, et al. Incidence, clinical characteristics, and risk factors of peripartum cardiomyopathy in Nigeria: results from the PEACE Registry. *ESC Heart Fail*. 2020;7(1):235–243. doi:10.1002/ehf2.12562
12. Goli R, Li J, Brandimarto J, et al. Genetic and phenotypic landscape of peripartum cardiomyopathy. *Circulation*. 2021;143(19):1852–1862. doi:10.1161/CIRCULATIONAHA.120.052395
13. Arany Z, Elkayam U. Peripartum Cardiomyopathy. *Circulation*. 2016;133(14):1397–1409. doi:10.1161/CIRCULATIONAHA.115.020491
14. Afana M, Brinjikji W, Kao D, et al. Characteristics and in-hospital outcomes of peripartum cardiomyopathy diagnosed during delivery in the United States from the Nationwide Inpatient Sample (NIS) database. *J Card Fail*. 2016;22(7):512–519. doi:10.1016/j.cardfail.2016.02.008
15. Ersboll AS, Johansen M, Damm P, et al. Peripartum cardiomyopathy in Denmark: a retrospective, population-based study of incidence, management and outcome. *Eur J Heart Fail*. 2017;19(12):1712–1720. doi:10.1002/ejhf.882
16. Lee S, Cho GJ, Park GU, et al. Incidence, risk factors, and clinical characteristics of peripartum cardiomyopathy in South Korea. *Circ Heart Fail*. 2018;11(4):e004134. doi:10.1161/CIRCHEARTFAILURE.117.004134
17. Huang GY, Zhang LY, Long-Le MA, et al. Clinical characteristics and risk factors for peripartum cardiomyopathy. *Afr Health Sci*. 2012;12 (1):26–31.
18. Yaniv-Salem S, Dym L, Nesher L, et al. Post-COVID-19 peripartum cardiomyopathy: experience from a large tertiary referral center. *Isr Med Assoc J*. 2023;25(8):533–537.
19. Nejadrahim R, Khademolhosseini S, Kavandi H, et al. Severe acute respiratory syndrome coronavirus-2- or pregnancy-related cardiomyopathy, a differential to be considered in the current pandemic: a case report. *J Med Case Rep*. 2021;15(1):143. doi:10.1186/s13256-021-02751-3
20. Kao DP, Hsich E, Lindenfeld J. Characteristics, adverse events, and racial differences among delivering mothers with peripartum cardiomyopathy. *JACC Heart Fail*. 2013;1(5):409–416. doi:10.1016/j.jchf.2013.04.011
21. Behrens I, Basit S, Lykke JA, et al. Hypertensive disorders of pregnancy and peripartum cardiomyopathy: a nationwide cohort study. *PLoS One*. 2019;14(2):e0211857. doi:10.1371/journal.pone.0211857
22. Behrens I, Basit S, Lykke JA, et al. Association between hypertensive disorders of pregnancy and later risk of cardiomyopathy. *JAMA*. 2016;315 (10):1026–1033. doi:10.1001/jama.2016.1869
23. Kolte D. Understanding the association between hypertensive disorders of pregnancy and peripartum cardiomyopathy. *Eur J Heart Fail*. 2017;19 (12):1721–1722. doi:10.1002/ejhf.941
24. Rana KF, Saeed A, Shamim SA, et al. The association between hypertensive disorders of pregnancy and peripartum cardiomyopathy. *Cureus*. 2019;11(10):e5867. doi:10.7759/cureus.5867
25. Haghikia A, Podewski E, Libhaber E, et al. Phenotyping and outcome on contemporary management in a German cohort of patients with peripartum cardiomyopathy. *Basic Res Cardiol*. 2013;108(4):366. doi:10.1007/s00395-013-0366-9
26. Melchiorre K, Sharma R, Thilaganathan B. Cardiovascular implications in preeclampsia: an overview. *Circulation*. 2014;130(8):703–714. doi:10.1161/CIRCULATIONAHA.113.003664
27. Bello N, Rendon ISH, Arany Z. The relationship between pre-eclampsia and peripartum cardiomyopathy: a systematic review and meta-analysis. *J Am Coll Cardiol*. 2013;62(18):1715–1723. doi:10.1016/j.jacc.2013.08.717
28. Gumilar KE, Rauf KBA, Akbar MIA, et al. Connecting the dots: exploring the interplay between preeclampsia and peripartum cardiomyopathy. *J Pregnancy*. 2024;2024:7713590. doi:10.1155/2024/7713590
29. Liu Y, Wang X, Zou L, et al. An analysis of variations of indications and maternal-fetal prognosis for caesarean section in a tertiary hospital of Beijing: a population-based retrospective cohort study. *Medicine*. 2017;96(7):e5509. doi:10.1097/MD.0000000000005509
30. Zhang Z, Zheng W, Chen M, et al. A new risk score for the assessment of outcomes for Chinese patients with peripartum cardiomyopathy. *Heart Lung*. 2023;60:81–86. doi:10.1016/j.hrtlng.2023.02.021
31. Van Tintelen JP, Pieper PG, Van Spaendonck-Zwarts KY, et al. Pregnancy, cardiomyopathies, and genetics. *Cardiovasc Res*. 2014;101(4):571–578. doi:10.1093/cvr/cvu014
32. Altun I, Akin F, Biteker M. Peripartum cardiomyopathy and triplet pregnancy. *Anatol J Cardiol*. 2015;15(1):85–86. doi:10.5152/akd.2014.5693
33. Kolte D, Khera S, Aronow WS, et al. Temporal trends in incidence and outcomes of peripartum cardiomyopathy in the United States: a nationwide population-based study. *J Am Heart Assoc*. 2014;3(3):e001056. doi:10.1161/JAHA.114.001056
34. Dabou S, Ongbayokolak NS, Fonkeng Sama L, et al. Metabolic syndrome during pregnancy: prevalence and determinants among pregnant women followed-up at the dschang district hospital, west region of Cameroon. *Diabetes Metab Syndr Obes*. 2022;15:743–753. doi:10.2147/DMSO.S348040
35. Elkayam U, Shmueli H. Peripartum cardiomyopathy: one disease with many faces. *Eur Heart J*. 2020;41(39):3798–3800. doi:10.1093/eurheartj/ehaa564
36. Koziol KJ, Aronow WS. Peripartum cardiomyopathy: current understanding of pathophysiology, diagnostic workup, management, and outcomes. *Curr Probl Cardiol*. 2023;48(8):101716. doi:10.1016/j.cpcardiol.2023.101716
37. Eggleton EJ, McMurrugh KJ, Aiken CE. Perinatal outcomes in pregnancies complicated by maternal cardiomyopathy: a systematic review and meta-analysis. *Am J Obstet Gynecol*. 2023;228(3):283–291. doi:10.1016/j.ajog.2022.09.025
38. Hu J, Ye Y, Lu A, et al. Pregnancy outcomes in patients with heart disease in China. *Am J Cardiol*. 2020;125(11):1718–1724. doi:10.1016/j.amjcard.2020.02.043