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Original Research

Cesarean Section Indication and Perinatal Outcomes of Infants With Macrosomia in Primiparous Women: A Retrospective Cohort Study

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Abstract

Background: This study aims to investigate the delivery modes, indications for cesarean section, and perinatal outcomes of infants with macrosomia in primiparous women, with a particular focus on those with gestational hyperglycemia who have achieved satisfactory glycemic control, as well as those with normal blood glucose levels. **Methods**: A retrospective cohort study was conducted in 269 primiparous women with infants affected with macrosomia at Haidian Maternal and Child Health Hospital in Beijing (2022–2024). These women had no prior history of uterine surgery, breech presentation, placenta previa, or any other conditions that would necessitate a cesarean section. The participants were categorized into two groups based on their blood glucose levels: a hyperglycemic group consisting of 107 cases (after excluding 2 cases due to inadequate blood glucose control) and a normal blood glucose group with 160 cases. This study compared various factors between the two groups, including basic demographic information, mode of delivery, reasons for the cesarean sections, and any complications that arose during delivery. Primary outcomes included cesarean section rates and perinatal outcomes. **Results**: The cesarean section rate was notably higher in the hyperglycemic group compared to those with normal blood glucose levels, while the rate of vaginal deliveries, including those assisted by forceps, was lower in the hyperglycemic group. This difference in delivery methods was statistically significant (χ^2 = 4.132; $p < 0.05$). Additionally, within the hyperglycemic group, babies born via cesarean section due to fetal macrosomia had a significantly greater birth weight than those delivered vaginally (Z = 3.500; $p < 0.05$). A similar trend was observed in the normal blood glucose group, where cesarean section deliveries also resulted in higher birth weights compared to vaginal deliveries (Z = 3.750; $p < 0.05$). Furthermore, the hyperglycemic group exhibited a higher incidence of shoulder dystocia and intrapartum fever compared to the normal blood glucose group, with these differences being statistically significant ($p < 0.05$). **Conclusions**: For primiparous women with infants who possessed macrosomia, the cesarean section rate in the hyperglycemic group was higher than that in the normal blood glucose group, and the incidence of shoulder dystocia in the hyperglycemic group was higher than that in the normal blood glucose group. Therefore, using a fetal weight of ≥4150–4190 g as the cesarean section indication for macrosomia is recommended, whether for pregnant women with normal blood glucose levels or those with gestational hyperglycemia who have good blood glucose control.

Keywords: macrosomia; vaginal delivery; cesarean section; maternal and infant outcomes

1. Introduction

In 2007–2008, the cesarean section rate in Asia was 27.3% [1]. By 2020, this rate in China was 44.5% [2]. Macrosomia, defined as a birth weight exceeding 4000 grams, has an incidence of approximately 7.46% in China [3]. Chinese clinical guidelines [4] suggest that for pregnant women with poor glycemic control during pregnancy and an estimated fetal weight of ≥4000 g as determined by ultrasound examination, the indications for cesarean delivery may be relaxed. However, it does not specify the cesarean section threshold for diabetic women who maintain well-controlled blood glucose levels, nor do it provide a weight threshold for cesarean section in pregnant women with normal blood glucose levels. The American College of Obstetricians and Gynecologists (ACOG) suggests that cesarean sections should be considered when the estimated fetal weight exceeds 4500 grams, particularly in cases of prolonged second stage of labor or arrested descent [5]. However, this criterion may not be suitable for Chinese women. Pregnancies complicated by macrosomia in the presence of diabetes appear to be significantly associated with cesarean delivery [6]. A retrospective study found that the cesarean section rate was significantly higher in patients with gestational diabetes mellitus (GDM) than in non-diabetic patients, particularly when the fetal weight was larger than ≥4000 g [7].

Observational studies are critical for evaluating real-world outcomes in pregnancies complicated by macrosomia. While randomized trials are unethical in this context, cohort studies allow comparison of delivery modes and complications between hyperglycemic and normoglycemic women.

This study aimed to analyze the indications for cesarean section and the perinatal outcomes associated with macrosomia in primiparous women, particularly focusing on those with gestational hyperglycemia who have achieved satisfactory glycemic control.

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2. Materials and Methods

2.1 Clinical Data

This study was a retrospective cohort analysis involving 269 primiparous women who delivered macrosomic infants at Haidian Maternal and Child Health Hospital between January 2022 and February 2024. The inclusion criteria were: ① full-term, singleton pregnancy in primiparous women with cephalic presentation and normal pelvis; ② birth weight ≥4000 g; ③ complete medical records.

The exclusion criteria were: women with placenta previa, vasa previa, or a history of uterine surgery, all of which are indications for cesarean section.

The study was approved by the Ethics Committee of Haidian Maternal and Child Health Hospital (Approval No. 2025LW-14, valid from January 2022 to December 2024).

2.2 Study Design

Data on maternal and neonatal outcomes were gathered, focusing on factors such as maternal age, pre-pregnancy body mass index (BMI), gestational weight gain, gestational hyperglycemia, gestational age at delivery, trial of labor, delivery method, reasons for cesarean section, intrapartum fever, shoulder dystocia, fetal stress, postpartum hemorrhage, neonatal sex, birth weight, and neonatal asphyxia. Among the participants, 160 had normal blood glucose levels, while 109 experienced hyperglycemia. Two participants with poor glycemic control were excluded from the analysis, resulting in a final count of 107 participants with well-controlled blood glucose levels in the hyperglycemic group and 160 participants in the normal blood glucose group. A comparison was made between the 2 groups regarding maternal demographic characteristics, delivery method, reasons for cesarean section (macrosomia, fetal stress, cephalopelvic disproportion) and delivery complications (shoulder dystocia, neonatal asphyxia).

2.3 Definitions

Postpartum hemorrhage and gestational hyperglycemia were defined according to published guidelines [8,9]. The diagnosis of gestational hyperglycemia was consistent with International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria. The diagnostic criteria for neonatal asphyxia are based on the Guidelines on Basic Newborn Resuscitation [10]. Intrapartum fever refers to maternal temperature ≥38 °C during labor, which may indicate complications such as intra-amniotic infection or epidural-related maternal fever [11].

2.4 Fetal Weight Estimation

Our hospital's Ultrasound Department utilizes the Voluson E10 ultrasound equipment (GE Healthcare, Chicago, IL, USA) to assess fetal weight. Instead of relying on a single fixed formula, it automatically matches internationally recognized standardized formulas (such as the Hadlock series formulas, Warsofs formula, etc.) that have been validated through extensive clinical data, based on the fetal biological parameters measured by ultrasound (such as biparietal diameter, head circumference, abdominal circumference, and femur length). The selection of these formulas is usually determined by the fetal growth assessment system preset by the equipment, with the core goal of improving the accuracy of weight estimation through multi-parameter joint calculation. For example, Hadlock II formula may be preferred in early second trimester, while Warsofs formula may be preferred in late pregnancy.

2.5 Sample Size Calculation

We assumed the cesarean section rate in the hyperglycemia group was 57% and the cesarean section rate in the normoglycemia group being 40%, Significance level (α): Typically set at 0.05 for a two-tailed test (corresponding to a critical value $Z_{\alpha/2}$ = 1.96).

Power (1-β): It is recommended to be ≥80% (β = 0.2, corresponding to $Z\beta$ = 0.84).

Two group proportions: p1 = 57% = 0.57 (Group A), p2 = 40% = 0.40 (Group B).

Rate difference: δ = p1 – p2 = 0.17 (17%).

The sample size calculation for comparing the difference in proportions between 2 groups is typically based on the normal approximation method, and its general formula is:

$$n = (Z_{\alpha/2} + Z\beta)^2 \cdot [p1(1 - p1) + p2(1 - p2)] / (p1 - p2)^2$$

The sample size for each group is approximately 132 cases.

This study is a retrospective study, involving the collection of data from 160 pregnant women with normal blood glucose levels and 107 pregnant women with gestational hyperglycemia. Statistical analysis revealed a significant difference in the delivery methods between the two groups. Therefore, the enrolled cases in this study consist of 107 pregnant women with gestational hyperglycemia and 160 pregnant women with normal blood glucose levels.

2.6 Statistical Analysis

Statistical analyses were conducted using SPSS 26.0 software (IBM, Armonk, NY, USA). The assumptions for each test were verified prior to analysis:

Continuous Data:

(1) Normality: Assessed using the Shapiro-Wilk test (for n <50) or Kolmogorov-Smirnov test (for n ≥50).

(2) Homogeneity of Variances: Evaluated with Levene's test for equality of variances.

① Parametric tests (Independent Samples *t*-test):

(a) Assumed normal distribution and equal variances (if Levene's test $p > 0.05$).

(b) Reported as mean ± standard deviation (SD).

② Non-parametric tests (Mann-Whitney U test):

Table 1. Baseline characteristics of participants by glycemic status.

Clinical features	Hyperglycemic group (n = 107)	Normal blood glucose group (n = 160)	Test statistic	p-value
Age ($\bar{x} \pm$ s, years)	30.7 $\pm$ 3.6	30.7 $\pm$ 3.1	t = –0.095	0.924
Pre-pregnancy BMI [$\bar{x} \pm$ s, kg/m^2]	24.6 $\pm$ 3.5	22.5 $\pm$ 3.4	t = 4.925	0.000
Gestational weight gain ($\bar{x} \pm$ s, kg)	14.8 $\pm$ 6.0	15.8 $\pm$ 4.1	t = –1.495	0.137
Delivery weeks [M, IQR, 95% CI, weeks]	39.0, 1.0 [38.9, 39.1]	40.0, 1.0 [39.9, 40.1]	Z = –3.813	0.000
Birth weight [M, IQR, 95% CI, g]	4150.0, 200.0 [4149.9, 4150.1]	4100.0, 197.5 [4099.9, 4100.1]	Z = 2.329	0.020
Male infants (n, %)	69.0 (64.5)	106.0 (66.3)	χ^2 = 0.088	0.766

M, median; BMI, body mass index; IQR, interquartile range; CI, confidence interval.

Table 2. Comparison of trial of labor rates between the two groups.

Trial of labor	Hyperglycemic group (n = 107)	Normal blood glucose group (n = 160)	χ^2	p-value
Trial of labor (n, %)	74.0 (69.2)	125.0 (78.1)		
Elective cesarean section (n, %)	33.0 (30.8)	35.0 (21.9)	2.716	0.099

Table 3. Comparison of delivery methods between the two groups.

Delivery method	Hyperglycemic group (n = 107)	Normal blood glucose group (n = 160)	χ^2	p-value
Cesarean section (n, %)	57.0 (53.3)	65.0 (40.6)		
Vaginal delivery (including forceps) (n, %)	50.0 (46.7)	95.0 (59.4)	4.132	0.042

(a) Applied when data were skewed ($p < 0.05$ for normality) or variances were unequal ($p < 0.05$ for Levene's test).

(b) Reported as median (interquartile range, IQR).

Categorical Data:

Chi-square test:

① Assumed independence of observations and expected cell counts $\geq$5 in $\geq$80% of cells.

② Used to compare proportions between groups (e.g., delivery modes, complications).

③ Fisher's exact test:

(a) Applied when $\geq$20% of cells had expected counts <5 to avoid Type I error inflation.

(b) Reported p-values derived from exact probabilities.

Significance Level:

All tests were two-tailed, with $p < 0.05$ considered statistically significant.

3. Results

3.1 Comparison of General Clinical Characteristics Between the Two Groups

There were no significant differences in maternal age, gestational weight gain, or the proportion of male infants between the 2 groups ($p > 0.05$). However, the hyperglycemic group exhibited a higher pre-pregnancy BMI compared to the normoglycemic group. Furthermore, the gestational age at delivery was lower in the hyperglycemic group, while the birth weight was higher than that of the normoglycemic group. These differences were statistically significant ($p < 0.05$), as indicated in Table 1.

3.2 Comparison of Trial of Labor and Delivery Methods Between the Two Groups

The trial of labor rates did not show a significant difference between the hyperglycemic group and the normoglycemic group ($p > 0.05$) as illustrated in Table 2. However, the cesarean section rate was notably higher in the hyperglycemic group, whereas the rate of vaginal deliveries, including those assisted by forceps, was lower compared to the normoglycemic group. These differences were statistically significant ($p < 0.05$), as shown in Table 3. There was no statistical difference in the indications for cesarean section between the 2 groups, as shown in Table 4.

3.3 Further Comparison of Indications for Cesarean Section and Neonatal Weight Between the Two Groups

Based on the indications for cesarean section, cases involving fetal macrosomia, cephalopelvic disproportion, and arrested labor were selected from both the hyperglycemic and normoglycemic groups. These cases were then compared to vaginal delivery cases in terms of neonatal weight. In the hyperglycemic group, neonates delivered via cesarean section due to these indications had a significantly higher birth weight compared to those delivered vaginally, with a statistical result of $Z = 3.500$ and $p < 0.05$. Similarly, in the normoglycemic group, neonates delivered by cesarean section for the same reasons also exhibited significantly higher birth weights than their vaginally delivered counterparts, indicated by $Z = 3.750$ and $p < 0.05$. However, when examining cesarean section cases specifically for these indications, there was no significant difference in birth weight between the hyperglycemic and normoglycemic groups, as shown by $Z = 1.541$ and $p = 0.123$. Likewise, among the vaginal delivery cases, birth weight

Table 4. Comparison of cesarean indication.

Cesarean indication	Hyperglycemic group (n = 57)	Normal blood glucose group (n = 65)	χ^2	*p*-value
Macrosomia (n, %)	31.0 (54.4)	35.0 (53.8)		
Cephalopelvic disproportion (n, %)	10.0 (17.5)	11.0 (16.9)	8.213	0.145
Fetal stress (n, %)	3.0 (5.3)	5.0 (7.7)		
Arrested labor (n, %)	6.0 (10.5)	13.0 (20.0)		
Chorioamnionitis (n, %)	5.0 (8.8)	0.0 (0.0)		
Preeclampsia (n, %)	2.0 (3.5)	1.0 (1.5)		

Table 5. Comparison of neonatal weight [Median (P25, P75), g] between subgroups.

	Hyperglycemic group (n = 107)	Normal blood glucose group (n = 160)	Test statistic	*p*-value
Vaginal delivery	4115.0 (4050.0, 4172.0) (n = 50)	4090.0 (4020.0, 4160.0) (n = 95)	Z = 1.209	0.227
Cesarean section due to macrosomia	4190.0 (4120.0, 4430.0) (n = 47)	4150.0 (4060.0, 4310.0) (n = 58)	Z = 1.541	0.123
Test statistic	Z = 3.500	Z = 3.750		
p-value	0.000	0.000		

Table 6. Comparison of perinatal outcomes between the two groups.

Items	Hyperglycemic group (n = 107)	Normal blood glucose group (n = 160)	Test statistic	*p*-value
Fetal stress (n, %)	7.0 (6.5)	7.0 (4.4)	χ^2 = 0.606	0.436
Shoulder dystocia (n, %)	8.0 (16.0) (n = 50)	3.0 (3.2) (n = 95)	χ^2 = 7.706	0.006
Neonatal asphyxia (n, %)	1.0 (0.9)	1.0 (0.6)		1.000*
Intrapartum fever (n, %)	16.0 (15.0)	11.0 (6.9)	χ^2 = 4.603	0.032
Postpartum hemorrhage (n, %)	5.0 (4.7)	9.0 (5.6)	χ^2 = 0.117	0.732

*Fisher exact test.

did not differ significantly between the 2 groups, with results of Z = 1.209 and p = 0.227 (Table 5).

3.4 Comparison of Perinatal Outcomes Between the Two Groups

The rates of postpartum hemorrhage, fetal distress, and neonatal asphyxia did not show significant differences between the 2 groups ($p > 0.05$). However, the hyperglycemic group experienced higher incidences of shoulder dystocia (the denominator used in the statistics for shoulder dystocia is the number of vaginal deliveries plus the number of forceps deliveries) and intrapartum fever compared to the normal blood glucose group, with both differences being statistically significant ($p < 0.05$), as illustrated in Table 6.

4. Discussion

4.1 Gestational Hyperglycemia and Macrosomia

GDM has seen a significant rise in incidence globally, attributed to various risk factors including obesity, advanced maternal age, and lifestyle changes. The prevalence of GDM among women with pre-existing obesity is notably higher, with studies indicating that pre-pregnancy BMI is a critical determinant of GDM risk [12,13]. Additionally, advanced maternal age, especially women over 35 years, has been associated with increased risk of GDM [14]. Macrosomia, defined as a birth weight greater than 4000 grams, presents a significant public health challenge. Studies indicate that the prevalence of macrosomia can range from 0.5% in India to as high as 13.9% in China [15,16]. This variation is influenced by factors such as maternal obesity, gestational diabetes, and regional dietary habits. Notably, infants born to mothers with gestational hyperglycemia have a 2–3 times higher risk of macrosomia compared to those born to normoglycemic mothers [12]. The increasing trend of macrosomia is concerning, as it is associated with adverse perinatal outcomes, including higher rates of cesarean delivery and neonatal complications [17].

In accord with these observations, our study found that the hyperglycemic group exhibited a higher pre-pregnancy BMI and cesarean delivery rate, alongside increased neonatal birth weight and a greater incidence of intrapartum fever compared to the normal blood glucose group.

4.2 Delivery Complications of Macrosomia

This study found no significant differences in the rates of fetal stress, neonatal asphyxia, or postpartum hemorrhage between the 2 groups. Both groups included infants classified as macrosomic, and GDM did not appear to elevate the risk of these delivery complications. Previous research indicates that the incidence of shoulder dystocia in infants weighing between 4000 g and 4500 g is approximately 5% [18]. In our study, the incidence of shoulder dystocia in the normal blood glucose group was recorded at 3.2%, aligning with existing literature. However, the hyperglycemic group exhibited a shoulder dystocia incidence of 16%, which is significantly higher than that of the normal blood glucose group. Pregnancies complicated by diabetes result in a macrosomic fetus developing a unique pattern of excessive growth characterized by central fat deposition [19]. Research by Duewel *et al*. [20] identified several independent risk factors for shoulder dystocia, including an estimated fetal weight of 4250 g or more, a difference of 2.5 cm or greater between abdominal circumference and head circumference, and the presence of diabetes. Additionally, another study highlighted that large-for-gestational-age infants, diabetes (both pregestational and GDM), and vacuum-assisted delivery are significant risk factors for shoulder dystocia [21]. Furthermore, a retrospective cohort study involving Chinese women found that a pre-pregnancy BMI of 24 kg/m^2 or higher was linked to an increased risk of GDM, shoulder dystocia, and cesarean delivery [22]. In our study, the average pre-pregnancy BMI in the hyperglycemic group was 24.6 kg/m^2, surpassing the 24 kg/m^2 threshold. Consequently, the elevated incidence of shoulder dystocia in the hyperglycemic group may be attributed to hyperglycemia, a high pre-pregnancy BMI, or a combination of both factors; further investigation is necessary to delineate their individual impacts.

This study found that while the incidence of shoulder dystocia was higher in the hyperglycemic group, there was no significant difference in the rates of neonatal asphyxia between the hyperglycemic and control groups, and notably, no cases of neonatal brachial plexus injury were reported in either group. This aligns with existing literature indicating that, over the past two decades in Sweden, the incidence of shoulder dystocia has risen, whereas the occurrence of neonatal brachial plexus palsy has actually declined [23]. Therefore, the findings from this study imply that even though shoulder dystocia is more common among those with hyperglycemia, it does not appear to elevate the risk of neonatal injuries, including asphyxia or brachial plexus injury.

4.3 Prediction of Macrosomia

In clinical practice, accurately predicting macrosomia is crucial for both maternal and fetal health. Ultrasound measurement plays a significant role in predicting macrosomia prenatally. When the abdominal circumference is $\geq$36 cm, the sensitivity of predicting macrosomia can reach 80–90%, while the specificity is about 70% [24]. Head circumference and femur length are also important ultrasound parameters. However, when using these parameters to estimate fetal weight, the error rate can be as high as 10–15% [25]. Ultrasound technology needs to be continuously updated and improved to enhance the accuracy of prediction. For instance, combining multiple ultrasound parameters with maternal clinical characteristics may help improve the accuracy and reliability of EFW (estimated fetal weight) estimation [26].

In the study of prenatal prediction of macrosomia (fetal weight $\geq$4000 grams), biomarkers play an important role, especially in identifying high-risk populations. Research shows that GDM is one of the main risk factors for macrosomia, especially when fasting blood glucose is $\geq$5.1 mmol/L, with the risk of macrosomia increasing by 2.5 to 3 times [27]. The latest research shows that, A higher TyG index (the triglyceride-glucose index) and a higher TG/HDL-C (triglyceride to high-density lipoprotein cholesterol) ratio in maternal blood in late gestation indicate a metabolic process that causes fetal macrosomia. Physicians should be more cautious about the risk of macrosomic fetuses when the cut-off value for the TyG index (>4.88) and the cut-off value for the TG/HDL-C ratio (>3.63) are available [28].

4.4 Indications for Cesarean Section in Macrosomia

The indication for cesarean section in pregnant patients, whether they have gestational hyperglycemia or normal glucose levels, continues to raise concerns. Research indicates that fetal weight plays a significant role in the likelihood of cesarean delivery, especially in women diagnosed with GDM. Current findings suggest that a fetal weight of 4150 to 4190 grams may be a reasonable threshold for considering a cesarean section in both groups of pregnant patients. However, it is essential to take into account individual pelvic findings and the mother's preferences regarding the mode of delivery when making specific clinical decisions. Additionally, research indicates that the risk of cesarean delivery increases notably in cases of fetal macrosomia, defined as a fetal weight of 4500 grams or more, particularly in pregnancies complicated by diabetes [29]. To mitigate cesarean section rates and minimize the risk of neonatal birth trauma, current evidence underscores the importance of maintaining strict glycemic control and creating individualized delivery plans [30].

In conclusion, while we suggest a weight range of 4150–4190 g as a guideline for considering a cesarean section, it is essential that the decision-making process incorporates a thorough clinical assessment and takes into account the unique circumstances of each pregnant woman. Additionally, future studies should further investigate how varying weight thresholds correlate with cesarean section rates, which will enhance our ability to effectively inform clinical practice.

4.5 Limitation

Our retrospective design may introduce selection bias. Additionally, the generalizability of our findings to multiparous women or non-Asian populations is uncertain. Strengths include the large sample size and detailed ascertainment of perinatal complications using standardized definitions.

5. Conclusions

In summary, among primiparous patients with macrosomia, the rate of cesarean sections is notably higher in the hyperglycemia group compared to those with normal blood glucose levels. Additionally, the incidence of shoulder dystocia is also elevated in the hyperglycemia group relative to the normal blood glucose group. For primiparous patients who maintain normal blood glucose levels, as well as those with gestational hyperglycemia who effectively manage their blood glucose, it is advisable to consider a weight threshold of 4150 to 4190 grams as an indication for cesarean section in cases of macrosomia.

Availability of Data and Materials

All data generated or analyzed during this study are included in this article.

Author Contributions

LC: Corresponding author, designed the research study, analyzed the data and revised the article. The author read and approved the final manuscript. The author has participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the guidelines of the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Haidian Maternal and Child Health Hospital (approval number: 2025LW-14). Informed consent was waived by the Ethics Committee due to the retrospective design of the study.

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Conflict of Interest

The author declares no conflict of interest.

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

In the preparation of this work, the author utilized DeepSeek to check spelling and grammar. Following the use of this tool, the author reviewed and edited the content as necessary, and bears full responsibility for the content of the publication.

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