Original Article

Unsatisfactory Glucose Management and Adverse Pregnancy Outcomes of Gestational Diabetes Mellitus in the Real World of Clinical Practice: A Retrospective Study

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Abstract

Background: Facing the increasing prevalence of gestational diabetes mellitus (GDM), this study aimed to evaluate the management of GDM and its association with adverse pregnancy outcomes.

Methods: The data of 996 inpatients with GDM who terminated pregnancies in our hospital from January 2011 to December 2015 were collected. Treatments during pregnancy and the last hospital admission before delivery were analyzed. Pregnancy outcomes of the GDM patients were compared with 996 nondiabetic subjects matched by delivery year and gestational age. The association between fasting plasma glucose (FPG) and adverse pregnancy outcomes was examined by logistic regression analyses.

Results: The average prevalence of GDM over the 5 years was 4.4% (1330/30,191). Within the GDM patients, 42.8% (426/996) received dietary intervention, whereas 19.1% (190/996) received insulin treatment. Adverse outcomes were more likely to occur in patients with unsatisfactory control of blood glucose such as respiratory distress syndrome (RDS, $\chi^2 = 13.373$, $P < 0.01$). Elevated FPG was identified as an independent risk factor for premature birth (odds ratio [*OR*] = 1.460, $P < 0.001$), neonatal care unit admission (*OR* = 1.284, $P < 0.001$), RDS (*OR* = 1.322, $P = 0.001$), and stillbirth (*OR* = 1.427, $P < 0.001$).

Conclusions: Management of GDM in the real world of clinical practice was unsatisfactory, which might have contributed to adverse pregnancy outcomes.

Key words: Blood Glucose; Disease Management; Gestational Diabetes Mellitus; Pregnancy Outcome; Risk Factors

Introduction

Gestational diabetes mellitus (GDM) is defined as diabetes diagnosed during the second or third trimester of pregnancy that is clearly not pregestational in nature.[1] Previous studies have suggested that GDM was associated with increased risk of maternal and fetal adverse outcomes[2,3] such as gestational hypertensive disorders, stillbirth, congenital anomalies, neonatal hypoglycemia, macrosomia, and respiratory distress syndrome (RDS).[4-6] GDM is also associated with increased risk of obesity, hypertension, impaired glucose tolerance, type 2 diabetes mellitus (T2DM), and neuropsychiatric complications in later childhood and adulthood.[7-10] Notably, the prevalence of GDM keeps increasing over recent years.[2] GDM has become a condition of particular concern worldwide.

There are reports that diet and/or insulin control can reduce the incidence of adverse pregnancy outcomes[11] and the risk of T2DM.[12] However, the effects of these interventions in

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real-world clinical practice have not been examined in depth. Previous studies[13] are mostly focused on the association between adverse pregnancy outcomes and plasma glucose determined by oral glucose tolerance tests (OGTTs). Studies on the relationship between fasting plasma glucose (FPG) immediately before delivery and adverse pregnancy outcomes are few. Herein, the present study aimed to examine the effects of GDM management on pregnancy and neonatal outcomes and the association between adverse pregnancy outcomes and FPG before delivery.

Methods

Ethical approval

The study was conducted in accordance with the *Declaration of Helsinki* and approved by the Medical Research Ethics Committee of the Shandong Provincial Hospital Affiliated to Shandong University (No. 2016-009). As a retrospective study and the data analysis were performed anonymously, this study was exempt from informed consent from patients.

Study population

In this retrospective study, data of 30,191 women who terminated pregnancies in the Department of Obstetrics and Gynecology, Shandong Provincial Hospital Affiliated to Shandong University between January 1, 2011, and December 31, 2015, were initially screened. A total of 302 women were excluded from 1330 GDM patients due to the presence of preexisting diabetes, history of prepregnancy chronic hypertension, congenital heart disease, infectious diseases, and other diseases. Furthermore, 32 women with twin and multiple pregnancies were excluded due to the increased risks associated with twin and multiple pregnancies.[14,15] Eventually, 996 GDM subjects were selected, who were diagnosed by 75 g OGTT at 24–28 weeks of gestation according to the American Diabetes Association (ADA) criteria:[1] FPG ≥92 mg/dl (5.1 mmol/L), 1 h PG ≥180 mg/dl (10.0 mmol/L), or 2 h PG ≥153 mg/dl (8.5 mmol/L). In addition, 996 healthy controls were selected by matching gestational age and delivery year.

Data collection

Electronic medical records of the last hospital admission before delivery were reviewed. General parameters were collected such as age, body mass index (BMI), blood pressure, and parity. GDM-related information was collected including treatments for GDM during pregnancy, in-hospital glycemic control, and FPG within 1 week before delivery. Adverse pregnancy outcomes were recorded including stillbirth, gestational hypertensive disorders, polyhydramnios, placental abruption, cesarean section, and preterm delivery. In addition, neonatal information was collected including birth weight, Apgar scores (at 1, 5, and 10 min postdelivery), neonatal care unit admission, hypoglycemia, hyperbilirubinemia, RDS, macrosomia, congenital malformations, and neonatal death.

Evaluation indicators

The primary end point of this study was the incidence of adverse pregnancy outcomes including both maternal and neonatal adverse outcomes. The secondary end point was the status of glucose management represented by FPG.

Maternal adverse pregnancy outcomes included stillbirth, gestational hypertensive disorders, polyhydramnios, placental abruption, cesarean section, and preterm delivery. Stillbirth was defined as fetal death at or after 20–28 weeks of pregnancy. Gestational hypertensive disorders were defined as preeclampsia or systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg at ≥20 weeks of gestation in a previously normotensive woman, without proteinuria or new signs of end-organ dysfunction. Polyhydramnios was diagnosed by amniotic fluid index (≥2000 ml) determined by ultrasonography. Placental abruption was defined as premature separation of the implanted placenta before delivery of the fetus.

Neonatal adverse outcomes included neonatal care unit admission rate, hypoglycemia, hyperbilirubinemia, RDS, macrosomia, congenital malformations, and neonatal death. Neonatal hypoglycemia was defined as plasma glucose <2.5 mmol/L. Neonatal hyperbilirubinemia was defined as total serum bilirubin higher than the 95th percentile for the patient's age during the 1st week of life. RDS was defined as pulmonary insufficiency that commences at or shortly after birth and aggravates over the first 2 days of life. Macrosomia was defined as a birth weight >4000 g, regardless of gestational age. Congenital malformations were classified according to the European Registration of Congenital Anomalies and Twins (EUROCAT) system. Neonatal death was defined as deaths occurring in live-birth infants during the first 28 days of life. When some neonatal outcomes were compared, certain cases were excluded, such as abortion and induced labor.

We also investigated prevalence of GDM and target-reaching rate of FPG (≤5.3 mmol/L as recommended by ADA[1]). The GDM patients were divided into two groups based on whether they received glycemic control treatments, i.e. the treated group (received dietary advice or/and insulin therapy) and untreated group (received routine care). In addition, the GDM patients were divided into two groups based on whether their FPG reached the targets.

Statistical analysis

All statistical analyses were performed using SPSS version 22 (IBM, Armonk, NY, USA). Continuous variables were presented in the form of mean ± standard deviation and analyzed using independent *t*-test. Categorical variables were presented in the form of percentage and analyzed using the Chi-square test or Fisher's exact test. Multivariable logistic regression analyses were performed to determine the relation between elevated FPG and adverse pregnancy outcomes with gestational age, BMI, primipara, and anemia considered in the model. $P < 0.05$ was considered to be statistically significant. In addition, sample size estimation

was conducted using traditional methods under case control design (supplementary material).

Results

Prevalence and treatment regimens for gestational diabetes mellitus

From 2011 to 2015, the prevalence of GDM in our hospital was 4.4% (1330/30,191). Of the 996 GDM patients, 616 received dietary interventions (426, 42.8%) or insulin treatment (190, 19.1%) and 38.1% (380) received only routine care.

Characteristics of gestational diabetes mellitus patients and healthy controls

Baseline characteristics of the participants are shown in Table 1. GDM patients were more obese, more likely to have higher blood pressure and family history of DM, and more likely to be primipara. Among 996 GDM patients, 27 (2.7%) women did not perform FPG before pregnancy. The proportion of GDM patients whose FPG did not reach target was 60.8% (606/996), and the target-reaching rate of FPG in the GDM patients was only 36.5% (363/996).

Pregnancy outcomes

Women with GDM were more likely to have adverse pregnancy outcomes including gestational hypertensive disorders and polyhydramnios [Table 2]. A higher rate of cesarean delivery was detected in the GDM group (76.0% vs. 56.9%, $P < 0.01$). In terms of neonatal outcomes, the GDM group was at significantly increased risk of having macrosomic neonates, preterm neonates ($P = 0.014$), and Neonatal Intensive Care Unit admission ($P = 0.021$). The incidence of neonatal hyperbilirubinemia, hypoglycemia, and RDS was higher in GDM group ($P < 0.01$ for all).

Based on the FPG within 1 week of delivery, we divided the 969 GDM patients into a good control group (FPG ≤5.3 mmol/L) and a poor control group (FPG >5.3 mmol/L). The incidence of gestational hypertensive disorders, polyhydramnios, stillbirth, cesarean delivery, preterm neonates, and RDS was significantly higher in the poor control group ($P < 0.05$; Table 3). As for neonatal outcomes, Apgar scores at 1, 5, and 10 min were significantly lower in the poor control group.

Table 1: Characteristics of GDM patients and healthy control

Variables	GDM patients (n = 996)	Healthy control (n = 996)	Statistics	P
Age (years)	31.5 ± 4.5	31.3 ± 4.3	1.365*	0.172
BMI (kg/m^2)	30.0 ± 4.3	28.0 ± 3.6	11.683*	<0.01
SBP (mmHg)	123.7 ± 16.2	122.0 ± 17.2	2.689*	<0.01
DBP (mmHg)	81.2 ± 12.3	79.0 ± 12.4	4.452*	<0.01
Primipara	612 (61.4)	555 (55.7)	6.772†	0.01
Positive FHD	155 (15.6)	24 (2.4)	105.337†	<0.01

*t values; †χ^2 values. Values for quantitative data are presented as mean ± SD; values for categorical variables are presented as n (%). GDM: Gestational diabetes mellitus; BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; FHD: Family history of diabetes; SD: Standard deviation.

The results of the comparison of maternal and neonatal outcomes between the GDM patients with and without hypoglycemic therapy are reported in Table 4. Although the rates of adverse pregnancy outcomes, such as gestational hypertensive disorders, stillbirth, neonatal death, and RDS, were higher in the untreated group than the treated group, no significant differences can be observed. In addition, the rates of polyhydramnios, macrosomia, and postpartum hemorrhage tended to be greater in the treated group with no significant differences.

Associations between pregnancy outcomes and fasting plasma glucose

Univariate logistic regression analyses indicated that FPG before delivery was associated with several adverse pregnancy outcomes in the GDM group including gestational hypertensive disorders (odds ratio [OR] = 1.106, $P = 0.045$), stillbirth (OR = 1.431, $P < 0.001$), polyhydramnios (OR = 1.161, $P = 0.004$), premature birth (OR = 1.492, $P < 0.001$), neonatal care unit admission (OR = 1.310, $P < 0.001$), RDS (OR = 1.309, $P < 0.001$), and cesarean section (OR = 1.198, $P = 0.001$) [Table 5].

Multiple logistic regression analyses showed that FPG before delivery was an independent risk factor for stillbirth (OR = 1.427, $P < 0.001$) and RDS (OR = 1.322, $P = 0.001$) [Table 5]. After adjustment for cofounders, the associations remained significant between FPG and polyhydramnios (OR = 1.114, $P = 0.045$), premature birth (OR = 1.460, $P < 0.001$), and neonatal care unit admission (OR = 1.284, $P < 0.001$).

Discussion

The prevalence of GDM keeps elevating over the recent years. With the economic development and improvement of living standards in China, screening and diagnosis of GDM have significantly improved. Based on our sample of GDM inpatients, the prevalence of GDM from 2011 to 2015 was 4.4%, lower than that previously reported in other populations[6,16] and the worldwide prevalence (approximately 14.0% in 2015)[17] reported by the International Diabetes Federation. While ethnic difference might contribute to this discrepancy, we acknowledge that our sample was relatively small.

Although a number of treatments have been proposed for GDM, the effects of these interventions in clinical practice have not been thoroughly reviewed. Indeed, gestational A1C levels and self-monitoring of blood glucose are strongly recommended for GDM by different guidelines.[1,18-20] Notably, the proportion of GDM patients whose FPG before reached target (≤5.3 mmol/L) was only 60.8%, and approximately 38.1% of the GDM inpatients did not receive any treatment for glycemic control, suggesting that

Table 2: Comparison of the maternal and neonatal outcomes between GDM patients and healthy control

Outcomes	GDM patients (n=996)	Healthy control (n=996)	Statistics	P
Maternal				
Stillbirth	15 (1.5)	8 (0.8)	2.155*	0.142
Neonatal death	5 (0.5)	2 (0.2)	1.290*	0.449
Hypertensive disorders	115 (11.5)	73 (7.3)	10.361*	0.001
Polyhydramnios	90 (9.0)	28 (2.8)	32.953*	<0.01
Postpartum hemorrhage	15 (1.5)	9 (0.9)	1.518*	0.305
Placenta previa	34 (3.4)	28 (2.8)	0.599*	0.439
PROM	122 (12.2)	135 (13.6)	0.755*	0.385
Placental abruption	6 (0.6)	3 (0.3)	1.005*	0.504
Method of delivery				
Vaginal delivery	234 (24.0)	413 (43.1)	79.252*	<0.01
Cesarean section	741 (76.0)	545 (56.9)		
Neonatal				
Premature	126 (12.9)	90 (9.4)	6.061*	0.014
Neonatal weight (g)	3.5 ± 0.6	3.3 ± 0.6	5.851†	<0.01
Macrosomia	182 (18.7)	95 (9.9)	31.378*	<0.01
1 min Apgar	9.4 ± 1.0	9.4 ± 1.0	−0.966†	0.334
5 min Apgar	9.9 ± 0.6	9.9 ± 0.7	0.076†	0.939
10 min Apgar	9.9 ± 0.6	9.9 ± 0.5	−0.386†	0.699
1 min Apgar <7	19 (1.9)	17 (1.8)	0.800*	0.777
Admission of neonatal care	86 (8.8)	58 (6.1)	4.319*	0.021
Neonatal complications				
RDS	53 (5.4)	20 (2.1)	7.089*	<0.01
Hyperbilirubinemia	109 (11.2)	35 (3.7)	36.697*	<0.01
Hypoglycemia	13 (1.3)	1 (0.1)	10.150*	0.001
Malformation	30 (3.1)	14 (1.5)	3.464*	0.017

*χ^2 values; †t values. Values for quantitative data are presented as mean ± SD; values for categorical variables are presented as n (%). GDM: Gestational diabetes mellitus; RDS: Respiratory distress syndrome; PROM: Premature rupture of membranes; SD: Standard deviation.

Table 3: Comparison of the maternal and neonatal outcomes between GDM patients with good control and poor control of glucose

Outcomes	Good control (n = 606)	Poor control (n = 363)	Statistics	P
Maternal				
Stillbirth	2 (0.3)	13 (3.6)	15.746*	<0.01
Neonatal death	1 (0.2)	4 (1.1)	3.882*	0.132
Hypertensive disorders	58 (9.6)	54 (14.9)	6.250*	0.012
Polyhydramnios	44 (7.3)	43 (11.8)	5.840*	0.016
Postpartum hemorrhage	9 (1.5)	6 (1.7)	0.042*	0.838
Placenta previa	21 (3.5)	13 (3.6)	0.009*	0.924
PROM	76 (12.5)	43 (11.8)	0.102*	0.75
Placental abruption	3 (0.5)	3 (0.6)	0.405*	0.831
Method of delivery				
Vaginal delivery	158 (26.2)	65 (18.8)	6.796*	0.009
Cesarean section	444 (73.8)	281 (81.2)		
Neonatal				
Premature	51 (8.5)	72 (20.8)	29.619*	<0.01
Neonatal weight (g)	3.51 ± 0.56	3.50 ± 0.68	0.243†	0.808
Macrosomia	102 (16.9)	78 (22.5)	4.479*	0.034
1 min Apgar	9.56 ± 0.67	9.38 ± 0.82	10.573†	<0.01
5 min Apgar	9.95 ± 0.30	9.88 ± 0.48	7.014†	<0.01
10 min Apgar	9.97 ± 0.30	9.93 ± 0.40	5.909†	<0.01
1 min Apgar <7	8 (1.3)	11 (3.2)	3.830*	0.05
Admission of neonatal care	40 (6.6)	46 (13.3)	11.780*	0.001
Neonatal complication				

Contd...

Table 3: Contd...

Outcomes	Good control (n = 606)	Poor control (n = 363)	Statistics	P
RDS	14 (2.3)	25 (7.2)	13.373*	<0.01
Hyperbilirubinemia	62 (10.3)	43 (12.4)	1.011*	0.315
Hypoglycemia	14 (2.3)	16 (4.6)	3.789*	0.052
Malformation	7 (1.2)	2 (0.6)	0.799*	0.585

*χ^2 values; †t values. Values for quantitative data are presented as mean ± SD; values for categorical variables are presented as n (%). GDM: Gestational diabetes mellitus; RDS: Respiratory distress syndrome; PROM: Premature rupture of membranes; SD: Standard deviation.

Table 4: Comparison of the maternal and neonatal outcomes between GDM patients with and without hypoglycemic therapy

Outcomes	With therapy (n = 616)	Without therapy (n = 380)	Statistics	P
Maternal				
Stillbirth	7 (1.3)	8 (1.8)	1.487*	0.223
Neonatal death	1 (0.2)	4 (1.1)	3.684*	0.073
Hypertensive disorders	66 (10.7)	49 (12.9)	1.094*	0.296
Polyhydramnios	63 (10.2)	27 (7.1)	2.787*	0.095
Postpartum hemorrhage	12 (1.9)	3 (0.8)	2.074*	0.150
Placenta previa	18 (2.9)	16 (4.2)	1.183*	0.277
PROM	73 (11.9)	49 (12.9)	0.238*	0.625
Placental abruption	5 (0.8)	1 (0.3)	1.333*	0.416
Method of delivery				
Vaginal delivery	144 (23.8)	90 (24.3)	0.034*	0.853
Cesarean section	461 (76.2)	280 (75.7)		
Neonatal				
Premature	66 (10.9)	60 (16.2)	5.746*	0.017
Neonatal weight (g)	3.51 ± 0.6	3.45 ± 0.65	1.561†	0.119
Macrosomia	115 (19.0)	67 (18.1)	0.123*	0.726
1 min Apgar	9.42 ± 0.9	9.35 ± 1.0	1.119†	0.264
5 min Apgar	9.90 ± 0.6	9.84 ± 0.7	1.457†	0.146
10 min Apgar	9.90 ± 0.5	9.89 ± 0.6	1.214†	0.225
1 min Apgar <7	9 (1.5)	8 (2.2)	0.610*	0.435
Admission of neonatal care	46 (7.6)	40 (10.8)	2.937*	0.087
Neonatal complication				
RDS	29 (4.8)	24 (6.5)	1.280*	0.258
Hyperbilirubinemia	67 (11.1)	42 (11.4)	0.018*	0.894
Hypoglycemia	8 (1.3)	5 (1.4)	0.001*	0.969
Malformation	17 (2.8)	13 (3.5)	0.381*	0.537

*χ^2 values; †t values. Values for quantitative data are presented as mean ± SD; values for categorical variables are presented as n (%). GDM: Gestational diabetes mellitus; RDS: Respiratory distress syndrome; PROM: Premature rupture of membranes; SD: Standard deviation.

glycemic control for GDM patients remains unsatisfactory at the current stage. We have noticed that most of the GDM patients underwent antenatal examinations at local hospitals. These results somehow reflect the need to strengthen GDM management practices at local primary hospitals.

In our study, we also found that more adverse pregnancy outcomes occurred in the GDM group, such as gestational hypertensive disorders, consistent with previous findings.[2,3]

Even mild hyperglycemia in late pregnancy may increase the risk of complications in inpatients with GDM and their newborns. The Hyperglycemia and Adverse Pregnancy Outcome study[4] reported that the risk of adverse pregnancy outcomes increased with maternal glycemic values, as indicated by the results of the OGTT performed at 24–28 weeks. In this study, we found that elevated FPG was associated with increased risk of adverse pregnancy outcomes in women with GDM such as polyhydramnios, preterm birth, and stillbirth. After adjustment for maternal age, BMI, anemia, and other confounders, elevated FPG remained an independent risk factor for these adverse outcomes. These results suggest that FPG might be a convenient and cost-effective indicator to predict adverse maternal and neonatal outcome risk. Women with GDM may be advised not to give birth by cesarean section unless they had a necessary situation. Therefore, association between cesarean section rates and higher fasting blood glucose may be iatrogenic. However, obstetricians usually suggest that they should strengthen glycemic control and cesarean section should be performed after 37–38 weeks of gestation. Thus, rates of early delivery were not iatrogenic, as well as rates of RDS.

Table 5: Association between fasting blood glucose and adverse pregnancy outcomes

Outcomes	Univariate logistic regression		Multivariate logistic regression	
	OR (95% *CI*)	*P*	*OR* (95% *CI*)	*P**
Stillbirth	1.431 (1.24–1.651)	<0.001	1.427 (1.205–1.689)	<0.001
Hypertensive disorders	1.106 (1.002–1.221)	0.045	1.089 (1.036–1.145)	0.207
Polyhydramnios	1.161 (1.050–1.284)	0.004	1.114 (1.002–1.238)	0.045
Premature	1.492 (1.325–1.680)	<0.001	1.460 (1.295–1.647)	<0.001
Admission of neonatal care	1.310 (1.169–1.469)	<0.001	1.284 (1.142–1.443)	<0.001
RDS	1.309 (1.126–1.522)	<0.001	1.322 (1.125–1.552)	0.001
Cesarean section	1.198 (1.044–1.375)	0.001	1.125 (0.985–1.284)	0.082

*Adjusted for age, BMI, primipara, anemia. RDS: Respiratory distress syndrome; BMI: Body mass index; *OR*: Odds ratio; *CI*: Confidence interval.

Prior work has shown that risk factors for adverse pregnancy outcomes can be reduced by diet, exercise, and moderate individualized lifestyle interventions.[11,21-23] In accordance with the results of previous studies, we also found that inpatients with GDM in the treated group had lower rates of certain adverse pregnancy outcomes, including gestational hypertensive disorders and RDS, than in the untreated group. On the other hand, treatment did not improve the rates of polyhydramnios, macrosomia, or postpartum hemorrhage.

In our study, there appeared to be no absolutely better outcomes in GDM with therapy than whom without. As discussed above, imperfect management of GDM, including a lack of medical records on blood glucose monitoring, use of nonstandard glucose monitoring, and low rates of recommended FPG level achievement, might have accounted for the lack of absolutely better outcomes in GDM patients with hypoglycemic therapy. Although inpatients with GDM were given treatment to control glucose immediately after admission to terminate pregnancies, it may be too late to improve pregnancy outcomes.

The limitations of this study are that the data were collected from a single hospital and extracted from records for the last medical visit before delivery. In addition, the study design was retrospective in nature. Data on the follow-up visits that occurred throughout patients' pregnancies could not be extracted from the hospital records. Besides, FPG before delivery was probably incidental to represent the status of glycemic control. Although an independent association between FPG and stillbirth was showed, the 95% confidence interval for this *OR* was relatively large. This may be partly due to the small number of stillbirths.

In this study, we have reported that the current status of GDM management remains to be improved, and the poor glycemic control might have contributed to the adverse pregnancy outcomes observed in inpatients with GDM. These results suggest that pregnant women in China should receive standardized management and that glycemic monitoring efforts should be strengthened, and necessary examinations should be enhanced to improve pregnancy outcomes.

Supplementary information is linked to the online version of the paper on the Chinese Medical Journal website.

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Conflicts of interest

There are no conflicts of interest.

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妊娠期糖尿病患者不理想的血糖管理及不良妊娠结局

摘要

背景：近年来，妊娠期糖尿病（GDM）的发病率不断增长，本文的目的是探讨GDM的管理及其与不良妊娠结局的关系。
方法：本研究收集了996例于2011-2015年在山东省立医院终止妊娠的GDM患者的数据，并对GDM治疗方案及分娩前入院情况进行了回顾性分析，并选择同时期年龄匹配的996例非糖尿病患者作为对照组，比较两组的妊娠结局。同时以Logistic回归分析评价空腹血糖（FPG）水平与不良妊娠结局之间的关系。
结果：5年间GDM平均患病率为4.4% (1330/30,191)。42.8% (426/996)妊娠期糖尿病患者接受饮食干预，19.1% (190/996)接受胰岛素治疗。血糖控制不良的GDM患者比对照组更易发生各种不良妊娠结局，如新生儿呼吸窘迫综合征（$P<0.01$）。升高的血糖水平是早产(OR=1.460, P<0.001)、新生儿呼吸窘迫综合征(OR=1.322, P=0.001)、死胎(OR=1.427, P<0.001)等不良妊娠结局的一个独立的危险因素。
结论：妊娠期糖尿病患者在临床实践中的不完善管理，可能是导致妊娠糖尿病患者发生不良妊娠结局的重要原因。

Supplementary material

Sample size estimation was conducted using the formula: $n = \left(\frac{r+1}{r}\right)\frac{(p)(1-p)\left(Z_{\beta}+Z_{\alpha/2}\right)^2}{\left(p_1-p_2\right)^2}$ We chose α=0.05, 1-β=0.9, *OR*=2, P2=0.3, *r*=1 and estimate the sample size to be 193. In our study, excluding 27 women who did not perform FPG before pregnancy, totally 969 GDM patients were included, among which 409 did not have adverse pregnancy outcomes. It indicated that the sample size was large enough to ensure the power.