Original Article

Effects of individual dietary intervention on blood glucose level and pregnancy outcomes in patients with gestational diabetes mellitus: a retrospective cohort study

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Background: Gestational diabetes mellitus (GDM) increases the incidence of adverse outcomes in pregnant women. Individual diet intervention (IDI) was developed in our center through collaboration with nutritionists to treat GDM and prevent further complications. We then aimed to analyze the effects of IDI on the level of blood glucose and pregnancy outcomes in pregnant women with GDM.

Methods: We retrospectively enrolled pregnant women with GDM between April 2016 and March 2020. Participants in the control group received routine GDM care, and those in the study group received extra IDI on the basis of routine GDM care. Demographic and clinical characteristics of participating pregnant women were retrospectively collected. The study outcomes were the status of blood glucose control after 6 weeks of IDI or conventional intervention and pregnancy outcomes. Univariable and multivariable logistic regression analyses were sequentially performed to determine the predictors of proper blood glucose control and risk factors of adverse pregnancy outcomes in the study population.

Results: A total of 817 pregnant women who had been diagnosed as GDM were enrolled in this study, including 435 admitted between April 2016 to March 2018 who received conventional medication and 382 who were admitted between April 2018 to March 2020 and received IDI. Generally, there was no significant difference in baseline characteristics between study and control groups. Glycated hemoglobin (HbA1c) level after intervention was statistically lower in the study group than in the control group (5.6±0.9 *vs.* 5.5±0.7, P=0.006). Multivariable logistic regression analysis revealed that IDI was a predictor of proper blood glucose control in GDM participants (P=0.003). There were more cesarean sections and cases of macrosomia in the control group than the study group, showing statistical difference (35.9% *vs.* 28.5%, P=0.026; 8.7% *vs.* 4.7%, P=0.023, respectively). According to multivariable logistic regression analysis, IDI was identified as playing a protective role against cesarean section in GDM participants (P=0.034) and it could reduce the incidence of macrosomia in GDM participants (P=0.028).

Conclusions: This novel pattern of IDI may not only help stabilize blood glucose levels in pregnant women with GDM, but also reduce the incidence of adverse outcomes to a certain extent.

Keywords: Gestational diabetes mellitus (GDM); individual dietary intervention (IDI); blood glucose level; pregnancy outcomes; retrospective cohort study

Submitted Jul 07, 2021. Accepted for publication Aug 16, 2021.
doi: 10.21037/apm-21-2115
View this article at: https://dx.doi.org/10.21037/apm-21-2115

Introduction

With the improvement of living standards, currently women of childbearing age are often overweight or obese. In western countries, it has been reported that about half of women of childbearing age are overweight or obese (1). In China, the proportion of overweight or obesity in women of childbearing age is relatively small; however, the existence of overweight or obesity will increase the incidence of their pregnancy complications.

Gestational diabetes mellitus (GDM), defined as glucose intolerance at the onset of pregnancy or first recognition during pregnancy, is a common pregnancy complication which is closely related to the weight of pregnant women (2). The diagnostic criteria for GDM are not yet unified, which can be screened and diagnosed according to International Association of Diabetes and Pregnancy Study Groups criteria or some other criteria (3). Generally, the prevalence of GDM ranges from 1.8–17% in all pregnant women and it may vary between different races or ethnicities (4,5). It has been reported that 8.1–11.7% pregnant women experience GDM (6,7). It increases the incidence of adverse outcomes in pregnant women, such as spontaneous abortion, preeclampsia, cesarean delivery, macrosomia, as well as neonatal hypoglycemia (2,8,9). Additionally, pregnant women with GDM are more likely to develop type 2 diabetes mellitus after pregnancy (10).

Dietary restriction and management is one of the main methods to treat GDM and prevent further complications. Some previous studies have indicated that dietary interventions, when initiated early pregnancy, were beneficial to reduce the risk of GDM (11,12). However, obstetricians can only provide medication and offer dietary advice for pregnant women with GDM in China. Pregnant women often consciously reduce their carbohydrate intake in their daily diet. Some studies have revealed that low-carbohydrate dietary intake may not be beneficial to the control of blood glucose and reducing adverse pregnancy outcomes (13,14). In addition, strict dietary control will also provoke irritability in pregnant women, leading to their lack of cooperation.

In the recent 2 years, our center developed a clinical pattern of individual diet intervention (IDI) in pregnant women with GDM with the cooperation of nutritionists, which was a kind of personalized diet management. Herein, we retrospectively collected the data of all pregnant women with GDM admitted to our hospital from 2017 to 2020, and analyzed the effects of IDI on the level of blood glucose and pregnancy outcomes. The results from this study confirmed the positive effects of IDI to control blood glucose level and reduce the incidence of adverse pregnancy outcomes. We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/apm-21-2115).

Methods

Study design

We performed a retrospective cohort study at Liyang People's Hospital between April 2016 and March 2020. The study was approved by the Ethics Committee of Liyang People's Hospital before its commencement (No. 2020-011). The study was performed according to the Declaration of Helsinki (as revised in 2013), but written informed consent was not provided by the enrolled pregnant women due to the retrospective design.

Participant selection and data collection

Pregnant women who visited our hospital between April 2016 and March 2020 for their first prenatal examination before 12 gestational weeks and were expected to deliver at our hospital were initially included in our study. The blood glucose levels of included pregnant women were tested according to a 75-g oral glucose tolerance test (OGTT) at 24–28 weeks of gestation. The diagnosis criteria of GDM were as follows: fasting blood glucose >5.1 mmol/L; 1 h blood glucose >10.0 mmol/L; and/or 2 h blood glucose >8.5 mmol/L. Those pregnant women with GDM were finally included in our study. Participants admitted to our hospital between April 2016 to March 2018 receiving conventional medication and dietary advice were selected as the control group, while those who were admitted between April 2018 to March 2020 receiving IDI were chosen as the study group.

The demographic and clinical characteristics of included pregnant women were collected, such as maternal age at conception, pre-pregnancy body mass index (BMI), gravidity, parity, history of cesarean section, educational status, occupational status, and history of drinking and smoking.

IDI

Participants in the control group received routine GDM care, including appropriate medication, advice on daily diet, guidance for proper exercise, and frequent blood glucose tests. On the other hand, participants in the study group received extra IDI on the basis of routine GDM care, including evaluating the nutritional status of participants during different gestational periods, investigating their dietary structure, formulation of a reasonable diet list by nurses and a nutritionist with the proportion of carbohydrate, fat, and protein in daily diet of 50–60%, 25–30%, and 15–20%, respectively, having 4–6 meals per day, making timely dietary adjustments according to the status of blood glucose level, and guiding patients to use a food exchange method to avoid anorexia and decreased compliance due to monotonous diet.

Study outcomes

All participants were followed up until they were discharged from hospital after delivery. Study outcomes were the status of blood glucose control after 6 weeks of IDI or conventional intervention, such as fasting blood glucose, 1 h blood glucose, 2 h blood glucose and the level of glycated hemoglobin (HbA1c), and pregnancy outcomes, such as gestational week, preterm birth, cesarean section, postpartum hemorrhage, low birth weight, macrosomia, Apgar score <7, and neonatal mortality. If the results of the OGTT in participants with GDM after 6 weeks did not meet any of the GDM diagnosis criteria, the level of blood glucose was considered well controlled.

Statistical analysis

All statistical analysis was performed using the software SPSS 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed using mean with standard deviation (SD) and compared using Student's *t*-test between two groups. Categorical variables were expressed using number with percentage and compared using chi-square test between two groups. Then, univariable and multivariable logistic regression analysis were sequentially performed to ascertain the predictors of proper blood glucose control and risk factors of adverse pregnancy outcomes in the study population. A P value <0.05 was considered significantly different.

Results

Baseline characteristics of GDM pregnant women

The flow chart of our study is shown in *Figure 1*. During the 4-year period, 8,719 pregnant women were admitted to our hospital. A total of 72 pregnant women were transferred to a superior hospital due to excessively high risk pregnancy and 8,647 women were evaluated according to inclusion criteria. Finally, a total of 817 pregnant women diagnosed as GDM were enrolled in this study, including 435 admitted between April 2016 and March 2018 receiving conventional medication and 382 admitted between April 2018 and March 2020 receiving IDI.

Characteristics of the control group are listed in *Table 1*. Maternal age at conception in 94.5% of women was 18–35 years. Regarding pre-pregnancy BMI, 6.7% of pregnant women were underweight, 51.3% were normal weight, 35.4% were overweight, and 6.7% were obese. About one fifth of pregnant women were in their first pregnancy, 66.9% in their second or third pregnancy, and 12.6% in their fourth or more pregnancy. Also, 27.6% of participants had a history of cesarean section and 34.5% had the education level of college or above. About two thirds of participants were currently employed and very few had a history of drinking and smoking.

On the other hand, 359 (94.0%) of participants in the study group were aged 18–35 years, showing no significant difference compared with the control group. Among these participants, 47.9% were normal weight, 5.5% were underweight, and 39.0% were overweight, which was similar to the control group. Meanwhile, the number of gravidity and parity was similar between the two groups (P=0.093 and P=0.751, respectively). There were 102 (26.7%) participants with a history of cesarean section and 142 (37.2%) with an education level of college or above. A total of 273 pregnant women were currently employed. Less than 1% of participants had a history of drinking and smoking. Generally, there was no significant difference in baseline characteristics between the study and control groups.

Changes of blood glucose

The changes in the level of blood glucose of the study population are summarized in *Table 2*. The baseline levels of fasting blood glucose, 1 h glucose, and 2 h glucose were not significantly different between the study and control groups. After the intervention of IDI, it was found that the levels of fasting blood glucose, 1 h glucose, and 2 h glucose decreased more compared with the control group, especially the level of fasting blood glucose (P=0.033). The HbA1c level after intervention was also statistically lower in the study group than the control group (5.6±0.9 *vs.* 5.5±0.7,

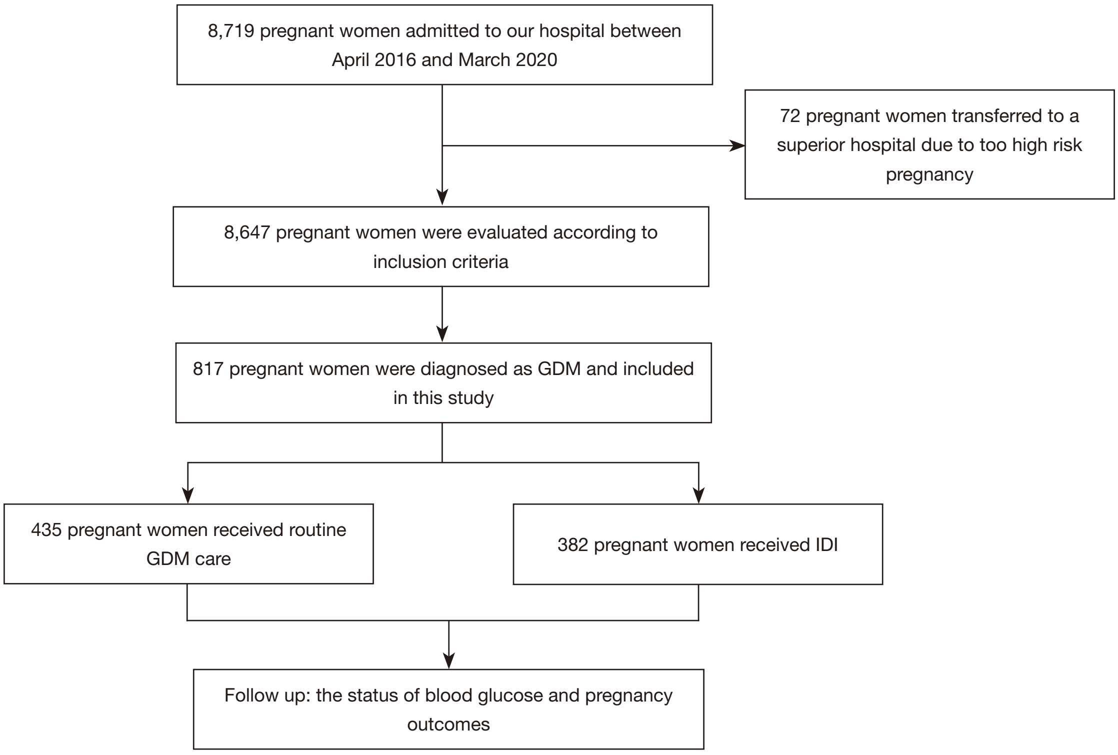

Figure 1 The flow chart of this study. GDM, gestational diabetes mellitus; IDI, individual dietary intervention.

P=0.006). Generally, 94.0% of pregnant women achieved proper blood glucose control in the study group, which was significantly more than in the control group (88.0%, P=0.003). Predictors of proper blood glucose control in the study population are presented in *Table 3*. After adjusting by univariable logistic regression analysis, IDI and higher educational level were identified as predictors of proper blood glucose control in GDM participants [odds ratio (OR) 0.694, 95% confidence interval (CI): 0.559 to 0.862, P=0.001; OR 0.717, 95% CI: 0.574 to 0.895, P=0.003]. On the other hand, older age and higher BMI acted as significant risk factors of improper blood glucose control (OR 3.077, 95% CI: 2.026 to 4.672, P<0.001; OR 1.565, 95% CI: 1.111 to 2.206, P=0.010).

Outcomes and risk factors

The mean follow up period in this study was 16.2±3.5 weeks. Pregnancy outcomes of the study population are summarized in *Table 4*. Gestational week was 38.4±2.1 and 38.3±1.8 weeks in the control group and study group, respectively (0.891). The incidences of preterm birth, postpartum hemorrhage, low birth weight, and Apgar score <7 were similar between the two groups. No newborns died after delivery. There were more cesarean sections and cases of macrosomia in the control group than the study group, showing a statistical difference (35.9% *vs.* 28.5%, P=0.026; 8.7% *vs.* 4.7%, P=0.023, respectively). The risk factors of cesarean section and macrosomia in the study population were determined according to logistic regression analysis (*Table 5*). After adjusting by univariable logistic regression analysis, IDI was identified as having a protective role against cesarean section in GDM participants (OR 0.739, 95% CI: 0.573 to 0.971, P=0.034) and pregnant women with history of cesarean section may have higher incidence of cesarean section (OR 1.621, 95% CI: 1.163 to 2.258, P=0.004). Similarly, IDI could reduce the incidence of macrosomia in GDM participants (OR 0.818, 95% CI: 0.643 to 0.980, P=0.028) and higher BMI may increase the incidence of macrosomia (OR 2.048, 95% CI: 1.303 to 3.219, P=0.002).

Discussion

The occurrence of GDM is related to an increase of adverse pregnancy outcomes, and dietary intervention is very

Table 1 Characteristics of the study population

Characteristics	Control group (N=435) (%)	Study group (N=382) (%)	P value
Maternal age at conception			0.953
<18	1 (0.2)	1 (0.3)	
18–35	411 (94.5)	359 (94.0)	
>35	23 (5.3)	22 (5.8)	
Pre-pregnancy BMI			0.599
<18.5	29 (6.7)	21 (5.5)	
18.5–23.9	223 (51.3)	183 (47.9)	
24–27.9	154 (35.4)	149 (39.0)	
>28	29 (6.7)	29 (7.6)	
Gravidity			0.093
1	89 (20.5)	81 (21.2)	
2–3	291 (66.9)	233 (61.0)	
>3	55 (12.6)	68 (17.8)	
Parity			0.751
0	166 (38.2)	138 (36.1)	
1–2	263 (60.5)	237 (62.0)	
>2	6 (1.4)	7 (1.8)	
History of cesarean section	120 (27.6)	102 (26.7)	0.777
Educational level			0.423
High school or lower	285 (65.5)	240 (62.8)	
College or above	150 (34.5)	142 (37.2)	
Occupational status			0.258
Unemployed	140 (32.2)	109 (28.5)	
Employed	295 (67.8)	273 (71.5)	
History of drinking	2 (0.5)	3 (0.8)	0.439
History of smoking	4 (0.9)	4 (1.0)	0.564

BMI, body mass index.

important for the treatment of GDM. The novel pattern of IDI developed in our study will consume more medical resources because it requires enhanced cooperation between nurses and nutritionists and more frequent follow up. Accordingly, IDI was verified by our study as beneficial to maintaining a stable level of blood glucose and reducing the incidence of adverse pregnancy outcomes. From this point of view, IDI is worthy of clinical promotion for women with GDM.

Based on the results in our study, conventional dietary intervention can provide some benefit to the control of blood glucose. Totally, 383 (88.0%) pregnant women with GDM in the control group obtained proper blood glucose control after receiving conventional dietary intervention. All of fasting blood glucose, 1 h blood glucose, and 2 h blood glucose declined in the control group and the level of HbA1c after intervention maintained stable. Notably, 359 (94.0%) participants with GDM in the study group obtained proper blood glucose control, which was much higher than in control group. The most significant improvement was

Table 2 Changes in the level of blood glucose of the study population

Characteristics	Control group	Study group	P value
Number	435	382	–
Fasting blood glucose, mmol/L			
Baseline	5.3±0.7	5.2±1.0	0.091
After intervention	4.7±0.6	4.4±0.8	<0.001
Change	−0.6±0.9	−0.8±1.2	0.033
1 h blood glucose, mmol/L			
Baseline	9.8±1.6	9.6±1.4	0.086
After intervention	8.4±1.8	8.3±1.5	0.177
Change	−1.3±1.3	−1.3±1.1	0.594
2 h blood glucose, mmol/L			
Baseline	8.3±1.3	8.3±1.7	0.767
After intervention	7.0±1.6	6.8±1.0	0.091
Change	−1.3±1.1	−1.5±1.0	0.181
HbA1c level after intervention, %	5.6±0.9	5.5±0.7	0.006
Proper blood glucose control (%)	383 (88.0)	359 (94.0)	0.003

HbA1c, glycated hemoglobin.

Table 3 Predictors of proper blood glucose control in the study population

Characteristics*	Multivariable logistic regression analysis	
	OR (95% CI)	P value
IDI versus conventional GDM care	0.694 (0.559 to 0.862)	0.001
Maternal age at conception		
18–34	Reference	
<18	1.323 (0.165 to 10.589)	0.792
≥35	3.077 (2.026 to 4.672)	<0.001
Pre-pregnancy BMI		
18.5–23.9	Reference	
<18.5	0.888 (0.599 to 1.316)	0.555
≥24	1.565 (1.111 to 2.206)	0.010
Educational level		
High school or lower	Reference	
College or above	0.717 (0.574 to 0.895)	0.003

*, multivariable logistic regression analysis here was adjusted by univariable logistic regression analysis, including maternal age at conception, pre-pregnancy BMI, gravidity, parity, history of cesarean section, educational status, occupational status, and history of drinking and smoking. IDI, individual dietary intervention; GDM, gestational diabetes mellitus; BMI, body mass index; OR, odds ratio; CI, confidence interval.

Table 4 Pregnancy outcomes of the study population

Characteristics	Control group (%)	Study group (%)	P value
Number	435	382	–
Gestational week	38.4±2.1	38.3±1.8	0.891
Preterm birth	35 (8.0)	37 (9.7)	0.409
Cesarean section	156 (35.9)	109 (28.5)	0.026
Postpartum hemorrhage	15 (3.4)	15 (3.9)	0.717
Low birth weight	18 (4.1)	12 (3.1)	0.450
Macrosomia	38 (8.7)	18 (4.7)	0.023
Apgar score <7	4 (0.9)	2 (0.5)	0.406
Neonatal mortality	0 (0.0)	0 (0.0)	–

Table 5 Risk factors of adverse pregnancy outcomes in the study population

Characteristics*	Multivariable logistic regression analysis	
	OR (95% CI)	P value
Cesarean section		
IDI versus conventional GDM care	0.739 (0.573 to 0.971)	0.034
History of cesarean section	1.621 (1.163 to 2.258)	0.004
Macrosomia		
IDI versus conventional GDM care	0.818 (0.643 to 0.980)	0.028
Pre-pregnancy BMI		
18.5–23.9	Reference	
<18.5	1.653 (0.988 to 2.766)	0.056
≥24	2.048 (1.303 to 3.219)	0.002

*, multivariable logistic regression analysis here was adjusted by univariable logistic regression analysis, including maternal age at conception, pre-pregnancy BMI, gravidity, parity, history of cesarean section, educational status, occupational status, and history of drinking and smoking. OR, odds ratio; CI, confidence interval; IDI, individual dietary intervention; BMI, body mass index; GDM, gestational diabetes mellitus.

observed in the fasting blood glucose of GDM participants receiving IDI. Recently, some studies have also identified fasting blood glucose as the most important marker to diagnose GDM and low fasting blood glucose was related to a low rate of abnormal glucose tolerance and reduced adverse pregnancy outcomes (15). The use of insulin in pregnant women with early GDM can be predicted by fasting blood glucose (16). This study presents an extra option to treat GDM and control the level of blood glucose. Previous studies have also indicated that the living environment of pregnant women also plays an important role in controlling blood glucose. Kang *et al.* reported that PM2.5 exposure during pregnancy was likely to elevate maternal glucose levels and increased the risk of GDM (17). It was also reported that living with green space was significantly associated with low level of blood glucose and low risk of GDM (18). Physical exercise is also beneficial to the control of blood glucose (19). Older age and higher BMI were also identified as important risk factors of blood glucose control in GDM participants, which was similar to some previous studies (20,21). Interestingly, GDM participants with higher educational level in our study achieved much better blood glucose control, which may be explained by these participants being more willing to cooperate with medical staff and having better compliance.

The incidence of cesarean section was higher in pregnant women with GDM according to a previous study. Also, some other risk factors of cesarean section were identified, such as older age, overweight, and gestational hypertension (22-24). However, our study only identified IDI as having a protective role and the history of cesarean section as a risk factor of cesarean section. Similarly, many studies have investigated the risk factors of macrosomia, including age, weight, GDM, and multiparity (25-27). We only included GDM participants in this study, and found that IDI could reduce the incidence of macrosomia while higher BMI may increase the incidence of macrosomia. Age was not identified as a risk factor of adverse pregnancy outcomes in our study, which may be explained by age being the risk factor of GDM and its effects on adverse pregnancy outcomes overlapping with the effects of GDM.

There were some limitations in this study. Firstly, the retrospective design may have led to incomplete data in our study and subsequently some further errors. A prospective study or even a randomized controlled trial could provide more convincing evidence for the application of IDI in pregnant women with GDM. Secondly, the sample size in our study may be not have been adequate for the study of adverse pregnancy outcomes, as the incidence rate of adverse pregnancy outcomes was relatively small. There may have been some errors in the final results when exploring the relationship between IDI and adverse pregnancy outcomes. Thirdly, in previous studies, the incidence of GDM has often been associated with the levels of blood lipid; however, the data of blood lipid level was lacking in our study due to the retrospective design, thus this study did not perform an in-depth discussion on this aspect.

To conclude, the novel pattern of IDI was developed in recent years to improve the control of GDM in pregnant women. This study confirmed that IDI could be effectively beneficial to proper blood glucose control, and reduce the incidence of adverse pregnancy outcomes, including cesarean section and macrosomia. Therefore, the pattern of IDI should be promoted, although it may consume more medical resources.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://dx.doi.org/10.21037/apm-21-2115

Data Sharing Statement: Available at https://dx.doi.org/10.21037/apm-21-2115

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://dx.doi.org/10.21037/apm-21-2115). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was approved by the Ethics Committee of Liyang People's Hospital before its commencement (No. 2020-011). The study was performed according to the Declaration of Helsinki (as revised in 2013), but written informed consent was not provided by the enrolled pregnant women due to the retrospective design.

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(English Language Editor: J. Jones)

Cite this article as: Zhou S, Wang L, Chen J, Liu L, Wu X. Effects of individual dietary intervention on blood glucose level and pregnancy outcomes in patients with gestational diabetes mellitus: a retrospective cohort study. Ann Palliat Med 2021;10(9):9692-9701. doi: 10.21037/apm-21-2115