Analyses of the Prevalence and Risk Factors of Gestational Diabetes Mellitus Using Novel Diagnostic Criteria

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ABSTRACT

Objective: *The aim of this study was to investigate the prevalence of gestational diabetes mellitus (GDM) and analyse its risk factors using the International Association of Diabetes in Pregnancy Study Groups' diagnostic criteria.*

Method: *Pregnant women (n = 650) were selected for our study. The related risk factors of GDM were collected using a questionnaire. The 75 g oral glucose tolerance test was done from the 24th to the 28th week of their gestation. Their blood glucose levels were measured.*

Results: *The GDM prevalence was 32.8%. Age, pre-pregnancy weight, pre-pregnancy body mass index (BMI), gestational weight gain, weight at birth and triglycerides in the GDM group were significantly higher than that of the normal glucose tolerance group (*$p < 0.05$*). The correlation analyses revealed that: age, pre-pregnancy weight, weight gain during pregnancy, the weights of the pregnant women at delivery, family history of diabetes, birth times, previous history of adverse pregnancy and hypertriglyceridaemia, were significantly correlated with the development of GDM (*$p < 0.05$*). Stratified analyses showed that the prevalence of GDM increased gradually with age and increased pre-pregnancy BMI. The pregnant women with a history of multiple pregnancies and previous adverse pregnancy had a significantly increased risk of developing GDM. Multiple stepwise regression analyses data indicated that prepregnancy weight, weight gain during pregnancy, family history of diabetes, previous adverse pregnancy, and hypertriglyceridaemia were the independent risk factors that contributed to the development of GDM in the pregnant women.*

Conclusion: *The use of newly defined criteria has increased the apparent prevalence rate of GDM in the pregnant women we studied. Intervention treatment should be administered if the risk factors for GDM are established in order to reduce the incidence of GDM in pregnant women.*

Keywords: Gestational diabetes mellitus, prevalence, risk factors

Análisis de la Prevalencia y Factores de Riesgo de la Diabetes Mellitus Gestacional con Nuevos Criterios de Diagnóstico

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RESUMEN

Objetivo: *El objetivo de este estudio fue investigar la prevalencia de la diabetes mellitus gestacional (DMG) y analizar sus factores de riesgo usando los criterios de diagnóstico de la Asociación Internacional de Grupos de Estudio de Diabetes y Embarazo.*

Método: *Seis cientos cincuenta mujeres embarazadas (n = 650) fueron seleccionadas para nuestro estudio. Los factores de riesgo relacionados de la DMG se recogieron utilizando un cuestionario. La prueba de tolerancia de glucosa oral de 75 g se realizó de la semana 24 a la semana 28 de la gestación. Se midieron los niveles de glucosa en sangre.*

Resultados: *La prevalencia de DMG fue del 32.8%. La edad, índice de masa corporal antes del embarazo (IMC), peso antes del embarazo, aumento de peso gestacional, peso al nacer y los triglicéridos en el grupo de DMG fueron significativamente mayores que en el grupo de tolerancia normal a la glucosa (*$p < 0.05$*). Los análisis de correlación revelaron que la edad, el peso antes del embarazo, el aumento*

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de peso durante el embarazo, el peso de las mujeres embarazadas en el parto, los antecedentes familiares de diabetes, los tiempos de nacimiento, los antecedentes de embarazo adverso, y la hipertrigliceridemia, se correlacionaban significativamente con el desarrollo de la DMG ($p < 0.05$*). Los análisis estratificados mostraron que la prevalencia de DMG aumenta gradualmente con la edad y el mayor IMC antes del embarazo. Las mujeres embarazadas con antecedentes de embarazos múltiples y embarazos anteriores adversos tenían un riesgo significativamente mayor de desarrollar DMG. Nuestros datos del análisis de regresión múltiple paso a paso indicaron que el peso antes del embarazo, el aumento de peso durante el embarazo, los antecedentes familiares de diabetes, los embarazos adversos anteriores, y la hipertrigliceridemia eran factores de riesgo independientes que contribuían al desarrollo de la DMG en las mujeres embarazadas.*

Conclusión: *El uso de los criterios definidos recientemente aumentó la prevalencia aparente de DMG en las mujeres embarazadas que estudiamos. Si se determina que existen factores de riesgo de DMG, debe administrarse un tratamiento de intervención con el fin de reducir la incidencia de DMG en las mujeres embarazadas.*

Palabras claves: Diabetes mellitus gestacional, factores de riesgo, prevalencia

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INTRODUCTION

Gestational diabetes mellitus (GDM) refers to the occurrence of abnormal glucose tolerance during pregnancy (1). Owing to different diagnostic criteria and screened populations, the reports of the incidence of GDM are highly variable. The development of global rational screening methods and diagnostic criteria are issues of common concern. A hyperglycaemia level even below the diagnostic criteria for GDM has been reported to be closely related to neonatal weight gain at birth and adverse pregnancy outcomes based on the results of hyperglycaemia and adverse pregnancy (HAPO) study (2). Based on the findings of the HAPO study, the International Association of Diabetes Pregnancy Study Group (IADPSG) has proposed new criteria in 2011 for the diagnosis of GDM (3). Herein, we aimed to determine the prevalence rate of GDM in China under the new diagnostic criteria.

SUBJECTS AND METHODS

Study subjects

Six hundred and fifty pregnant women were selected to be in the present study, they were between the 12th and 20th week of gestation at antenatal booking. Women who had been diagnosed with diabetes mellitus before pregnancy were excluded from the study. This study was conducted in accordance with the Declaration of Helsinki and with approval from the Ethics Committee of Henan Technology University. Written informed consent was obtained from all the participants.

Research methods

At the booking clinic, the pregnant patients' weights were measured. A questionnaire relating to GDM was completed by the patients in order to collect data regarding their: age, pre-pregnancy weight, height, increased bodyweight at booking, smoking history, family history of diabetes mellitus, previous history of adverse pregnancy (*eg* pregnancy-induced hypertension, unexplained miscarriages, stillbirth and Caesarean section), birth times and the number of previous pregnancies.

The 75 g oral glucose tolerance test (OGTT) was done from the 24th to the 28th week of the patients' gestation. Each patient's blood glucose level was measured at zero, one and two-hour intervals. The fasting insulin level was also measured, and repeated two hours after the glucose load. The cholesterol and triglyceride levels were also measured and recorded.

The following IADPSG diagnostic criteria were used in the diagnosis of GDM: a glucose level of; 5.1 mmol/L at zero-hours, 10.0 mmol/L at one-hour and 8.5 mmol/L at two-hours. The detected value at any point that exceeded the standard diagnosis of GDM was classified as GDM, and these patients were defined as the GDM group. The pregnant women with normal glucose tolerance were included in the normal glucose tolerance (NGT) group.

Statistical analyses

The SPSS 17.0 software package was used to analyse and process the data. The pregnant women with normal distribution were represented by $\bar{x} \pm s$. The comparisons of the general characteristics between the GDM group and NGT group were done using the *t*-test. The relationships among the patients' between blood glucose levels and other risk factors were analysed using the linear correlation analyses, while the risk factors for GDM were analysed using regression analyses. The difference between the rates was analysed using the Chi-squared test. A *p*-value of $p < 0.05$ was considered to be statistically significant.

RESULTS

Of the 650 pregnant women in this study, 610 of the patients completed the glucose tolerance screening, and 40 pregnant women refused prenatal glucose tolerance screening and were therefore excluded from our analyses. Based on the IADPSG

diagnostic criteria, of the 610 patients, 200 were classified as GDM patients; the GDM prevalence was 32.8% (200/610).

Age, pre-pregnancy weight, pre-pregnancy body mass index (BMI), weight gain during pregnancy (compared with the weight at booking with pre-pregnancy weight), weight at birth, and triglyceride level in the GDM group were significantly higher than that of the NGT group ($p < 0.05$), while no significant difference was observed between the height and blood pressure in the two groups (Table 1). Correlation analyses revealed that age, pre-pregnancy weight, weight gain during pregnancy, pregnant women weight at birth, family history of diabetes, birth times, previous adverse pregnancy history, and hypertriglyceridaemia were significantly correlated with the development of GDM ($p < 0.05$, Table 2).

The GDM prevalence of the patients differed according to their age. The prevalence of GDM gradually increased with an increase in age (Table 3). Pre-pregnancy BMI was correlated with blood glucose level. The higher the BMI, the greater the prevalence of GDM. The prevalence of GDM gradually increased with BMI increase (Table 4).

Table 1: Comparisons of general information between gestational diabetes mellitus group and normal group

	Cases (n)	Age (years old)	Height (m)	Pre-pregnancy weight	Pre-pregnancy BMI	Weight gaining	Weight at birth
GDM group	200	29.87 ± 4.47	1.62 ± 0.04	57.54 ± 9.04	21.78 ± 3.47	3.70 ± 2.93	3.35 ± 0.64
NGT group	410	28.34 ± 3.99#	1.62 ± 0.06	54.55 ± 7.45#	20.86 ± 2.84#	2.83 ± 2.62#	3.21 ± 0.41#

Table 1: Comparisons of general information between gestational diabetes mellitus group and normal group (continues)

	SBP	DBP	TG	TC	0 h blood glucose	1 h blood glucose	2 h blood glucose
GDM group	100.88 ± 10.5	64.35 ± 7.64	3.37 ± 1.33	6.33 ± 1.46	4.93 ± 0.78	10.14 ± 2.55	8.35 ± 1.91
NGT group	100.5 ± 10.89	63.48 ± 7.36	2.76 ± 1.22#	6.48 ± 1.31	4.38 ± 0.46#	7.64 ± 1.29#	6.71 ± 0.92#

Note: Comparison between the two groups; # indicates $p < 0.01$; SBP: systolic blood pressure; DBP: diastolic blood pressure; TC: total cholesterol; TG: triglycerides; GDM: gestational diabetes mellitus; NGT: normal glucose tolerance; h: hours

Table 2: Correlation analyses between risk factors and gestational diabetes mellitus

	Age	Pre-pregnancy weight	Pre-pregnancy BMI	Weight gaining	Weight at birth	Family history of diabetes mellitus	Born times
0 h blood glucose	0.19 (p =0.00)	0.202 (p = 0.00)	0.176 (p = 0.00)	0.179 (p = 0.00)	0.077 (p = 0.06)	0.064 (p = 0.11)	0.236 (p = 0.00)
1 h blood glucose	0.238 (p = 0.00)	0.150(p = 0.00)	0.141 (p = 0.00)	0.160 (p = 0.00)	0.142 (p = 0.00)	0.111 (p = 0.00)	0.119 (p = 0.00)
2 h blood glucose	0.195 (p = 0.00)	0.112 (p = 0.00)	0.109 (p = 0.00)	0.073 (p = 0.07)	0.036 (p = 0.38)	0.031 (p = 0.45)	0.211 (p = 0.00)

Table 2: Correlation analyses between risk factors and gestational diabetes mellitus (continues)

	Caesarean	Pregnancy-induced hypertension	Abortion history	Stillborn	Huge children	TG (mmol/L)	TC (mmol/L)
0 h blood glucose	0.245 (p = 0.00)	0.092 (p = 0.02)	0.038 (p = 0.35)	0.196 (p = 0.00)	0.166 (p = 0.00)	0.233 (p = 0.00)	0.015(p=0.71)
1 h blood glucose	0.399 (p = 0.00)	0.174 (p = 0.00)	0.004 (p = 0.91)	0.115 (p = 0.00)	0.132 (p = 0.00)	0.091 (p = 0.03)	0.022(p=0.61)
2 h blood glucose	0.368 (p = 0.00)	0.108 (p = 0.00)	0.108 (p = 0.01)	0.206 (p = 0.00)	0.155 (p = 0.00)	0.137 (p = 0.00)	0.073(p=0.08)

Table 3: Distribution and prevalence of gestational diabetes mellitus in different age stages

Age	Cases	GDM cases	Total GDM cases	GDM distribution rate	Prevalence of GDM with different age stages
< 25	70	15	200	7.5%	21.42%
25−30	370	111	200	55.5%	30.0%
31−35	117	48	200	24.0%	41.03%
> 35	53	26	200	13.0%	49.06%

GDM: gestational diabetes mellitus

Table 4: χ^2 analyses for the prevalence of gestational diabetes mellitus with different body mass index

BMI	GDM (%)	NGT (%)	Total
< 19	36 (25.4%)	106 (74.6%)	142
19−24	119 (32.2%)	250 (67.8%)	369
> 24	38 (43.7%)	49 (56.3%)	87
> 28	7 (58.3%)	5 (41.7%)	12
χ^2	9.45		
p	< 0.01		

BMI: body mass index; GDM: gestational diabetes mellitus; NGT: normal glucose tolerance

Smoking, polycystic ovarian syndrome (PCOS) and positive hepatitis B virus surface antigen (HBSAg) had no significant contribution to the development of GDM among the two groups. The number of patients with a family history of diabetes mellitus in the GDM group was significantly higher than in the NGT group.

In the GDM group, 10 patients had pregnancy-induced hypertension, 15 patients had a previously unexplained miscarriage, 14 patients had stillbirth, and 20 patients had normal pregnancies and birth, while there were 0, 20, 6, 7 patients, respectively, in the normal pregnancy group. These were collectively classified as adverse pregnancies. In the GDM group, it was the first pregnancy for 52 women, the second for 73 women, the third for 52 women, and the fourth or more for 23 women. In the NGT group, 196 women were pregnant for the first time, 147 for the second time, 43 for the third time, and 24 women were pregnant for at least a fourth time. The patients who had been pregnant at least three times were collectively classified as the multiple pregnancy groups. Chi-squared test analysis was used to analyse the family history, Caesarean section rate, history of adverse birth and pregnancy, and the frequency distribution of diabetes mellitus between the two groups; the results showed significant differences (Table 5, $p < 0.001$).

Stepwise regression analyses

Stepwise regression showed that the pre-pregnancy weight, weight gain during pregnancy and family history of diabetes, previous adverse pregnancy and hypertriglyceridaemia level were independent risk factors in the development of GDM (Table 6).

DISCUSSION

Gestational diabetes mellitus is one of the common complications arising during pregnancy and which results in many adverse effects on pregnant women and fetuses.

The prevalence of GDM was reported to be different in various areas, which was related to the use of different diagnostic criteria and study populations. A number of previous benchmark diagnostic criteria were developed on the basis of the long-term risk of the mothers developing diabetes mellitus but not taking into account perinatal complications. Even pregnant women beyond the diagnostic criteria for GDM had a higher incidence of delivering large babies (2). Based on the findings of the HAPO study, newly defined GDM diagnostic criteria were developed by IADPSG (3).

Table 5: χ^2 analyses and comparisons of the risk factors between the two groups

	Smoking	PCOS	Positive HBSAg	Family history of DM	Cesarean rate	History of adverse pregnancy	Multiple pregnancy history
GDM group	4	7	3	37	73	59	75
NGT group	5	4	8	26	48	33	67
χ^2	0.007	3.298	0.01	18.98	50.42	46.64	35.52
p-value	> 0.5	> 0.05	> 0.9	< 0.005	< 0.001	< 0.001	< 0 .001

PCOS: polycystic ovarian syndrome; GDM: gestational diabetes mellitus; NGT: normal glucose tolerance; DM: diabetes mellitus

Table 6: Gestational diabetes mellitus regression analyses of the risk factors

	B	Standard error	T value	*p*-value	95% credibility interval
Constant	0.143	0.504	0.283	0.777	(-0.848−1.133)
Pre-pregnancy weight	0.007	0.003	2.242	0.025	(-0.014−0.000)
Weight gaining	0.012	0.005	2.459	0.014	(0.000−0.014)
Family history of diabetes mellitus	0.108	0.143	2.510	0.012	(0.002−0.022)
Caesarean	0.417	0.018	23.190	0.000	(0.023−0.193)
Pregnancy-induced hypertension	0.306	0.101	3.027	0.003	(0.381−0.452)
Stillbirth	0.308	0.085	3.619	0.000	(0.141−0.476)
TG	0.029	0.010	2.840	0.005	(0.009−0.087)

The new standard enabled the cut-off point for a diagnosis of GDM to be decreased, which resulted in a significant increase in the number of diagnosed GDM cases.

Our study found that the prevalence of GDM was 32.8% when using the new diagnostic criteria, which was significantly higher than the previously reported prevalence of domestic GDM (8.3–11.6%). By comparison, the GDM prevalence rate in Australia was 13.0% when using the IADPSG standard, with 82% sensitivity and 94% specificity (4). The Oriot *et al* study (5) reported that the GDM prevalence rate ranged from 8–23% according to the IADPSG standard, and these patients required insulin therapy. The prospective studies of Nayak *et al* indicated that the GDM prevalence rate was 27% by applying IADPSG standard screening, and the number of pregnancy complications increased in the GDM group [25% *vs* 12%] (6). Disse *et al* (7) found that of the 75 pregnant women in their study, 55 were diagnosed with GDM (16 with impaired fasting glucose and 39 with impaired glucose tolerance) according to the IADPSG criteria. Furthermore, the fasting glucose level in these patients was significantly associated with large-for-gestational-age infants independently of BMI and a two-hour OGTT. The > 5.1 mmol/L cut-off value for fasting glucose was highly predictive of the delivery of large-for-gestational-age infants.

Age and weight were recognized risk factors in the development of GDM. This study found that GDM prevalence increased with age. Gestational diabetes mellitus prevalence in patients > 35 years of age was 2.29-fold that for patients < 25 years of age. The prevalence of GDM gradually increased with an increase in BMI. This study found that the GDM prevalence rate reached 58.33% in the study population in patients with a BMI > 28, which is consistent with the results of a previous study conducted in China (8).

Certain studies suggested that smoking and positive HBSAg were risk factors for the development of GDM. However, a recent study in Spain indicated that smoking was not related to the development of GDM (9). In the present study, statistical analyses showed no significant difference between the two groups when smoking and positive HBSAg were considered; this result was probably because of fewer numbers of women smokers in North China and a low HBSAg level in the study population. Studies have shown that PCOS was a risk factor for GDM. The present study found no correlation between PCOS and GDM, which may be related to not checking for PCOS and hence only few diagnosed cases. Multiple births, multiple pregnancies, previous unexplained stillbirth, and abortion history were correlated with the pathogenesis of GDM. Multiple pregnancies and an adverse birth history in the GDM group were also observed to be higher than in the NGT group. Regression analyses showed that a family history of diabetes, pre-pregnancy weight, weight gain during pregnancy, and a previous history of adverse pregnancy were independent risk factors in the development of GDM.

The incidence of GDM was significantly higher when using the new diagnostic criteria. Therefore, more GDM patients required intervention therapy. However, the study by Bodmer-Roy *et al* showed that although pregnant women met the IADPSG diagnostic criteria, the Canadian GDM diagnostic criteria were not met, but the pregnancy outcomes were similar to that of the non-GDM group (10).

Therefore, some clinicians have advised that the diagnostic criteria of IADPSG are too strict and may lead to unnecessary treatment, increase in healthcare costs, and maternal psychological stress (11). More randomized, controlled studies examining pregnancy outcomes and economic effectiveness are still needed to re-evaluate the clinical applications of the IADPSG standard.

The incidence of GDM is increasing yearly. Early screening and intervention should be performed for patients with risk factors in order to reduce the incidence of GDM, improve maternal and fetal outcomes, and improve maternal health.

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