Gestational Diabetes Mellitus in Women of Single Gravidity in Tianjin City, China

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OBJECTIVE — The aim of this study was to investigate the prevalence of gestational diabetes mellitus (GDM) and risk factors for the development of GDM in pregnant women in Tianjin, China, where the prevalence of GDM is still unknown.

STUDY DESIGN AND METHODS — A total of 9,471 pregnant women living in the six urban districts of Tianjin, China, took part in the initial screening between December 1998 and December 1999. The screening test consisted of a 50-g 1-h glucose test. Women with a reading ≥7.8 mmol/l at the initial screening were invited to undergo a 75-g 2-h oral glucose tolerance test (OGTT). GDM was confirmed using the World Health Organization's diagnostic criteria.

RESULTS — At the initial screening test, 888 women had a glucose reading of ≥7.8 mmol/l. A total of 701 (79%) women took a subsequent OGTT. Of these, 174 women were confirmed to have GDM (154 with impaired glucose tolerance [IGT] and 20 with diabetes). The prevalence of GDM was 2.31% (2.03% for IGT and 0.28% for diabetes), adjusting for serum glucose levels at the initial screening test. Independent predictors for GDM were maternal age, stature, prepregnancy BMI, weight gain in pregnancy before screening, diabetes in first-degree relatives, and habitual cigarette smoking during pregnancy. Women who smoked or had a short stature are more likely to develop GDM than their counterparts.

CONCLUSIONS — The prevalence of GDM in pregnant women in the city of Tianjin, China, was 2.31%. Short stature and smoking in pregnancy were additional risk factors for GDM.

Gestational diabetes mellitus (GDM) increases the risk of perinatal morbidity (1–3). Women with prior GDM are also at a higher risk of type 2 diabetes later in life (4,5). The prevalence of GDM in ethnic women in the Western world has been shown to be higher than in women of their host populations (6–10). Separate studies of donor nations, however, showed a much lower prevalence of GDM than those of Western populations. The prevalence of known diabetes and GDM in an Indian population was reported to be 1.19 and 0.56%, respectively (11). Studies on the prevalence of GDM in Chinese women living in China are few and usually not readily accessible in Western literature (12,13). The risk factors for GDM have not been systematically researched in China. This article aims to examine the prevalence of GDM and its risk factors in urban districts of Tianjin city as part of the Tianjin Study of Diabetes in Pregnancy (TSDP).

RESEARCH DESIGN AND METHODS

The TSDP is a prospective population-based study. A total of 9,471 pregnant women living in the six urban districts of Tianjin, China, took part in the GDM screening program between December 1998 and December 1999. Screening was carried out at 26–30 gestational weeks, during which women were under the care of antenatal basic care units (ABCUs). Venous blood was taken 60 min after the ingestion of 200 ml of 25% glucose solution. Women who had a glucose reading ≥7.8 mmol/l were asked to undergo a 75-g 2-h oral glucose tolerance test (OGTT) at the GDM clinic in the city center (the Tianjin Institute for Women's Health). OGTT test results were interpreted based on World Health Organization (WHO) provisional criteria (14). Diabetes is defined as fasting serum glucose ≥7.0 mmol/l or 2-h serum glucose ≥11.1 mmol/l, and impaired glucose tolerance (IGT) is defined as 2-h serum glucose ≥7.8 and <11.1 mmol/l and fasting serum glucose <7.0 mmol/l. Women with a test result confirming either diabetes or IGT are regarded as having GDM.

Women who had any of the following medical conditions were excluded from screening (15): *1*) age <18 years; *2*) multiple gestations; *3*) maternal-fetal ABO blood type incompatibility (titer >1:30); *4*) significant maternal diseases, including chronic hypertension, connective tissue disease, endocrine disorders, and chronic hepatic disease; *5*) prepregnancy diabetes; and *6*) long-term medical treatment that may affect glucose metabolism, such as steroids and β-mimetic tocolytic agents. Ethics clearance was obtained from the Standing Committee on Ethics in Research on Humans of Monash University, Australia, and informed consent was obtained from all subjects.

Obstetricians, gynecologists, endocrinologists, dieticians, and nurses working at the ABCUs were invited to a fieldwork training workshop. The objectives of clinical staff training were to provide data collection guidelines, standardize anthropometric measurements, and minimize variations between ABCUs.

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Table 1—*Comparison of characteristics between women with and without GDM*

	Non-GDM	GDM	P*
n	9,109	177	
Age (years)	26.8 ± 0.033	28.0 ± 0.28	<0.0001
Stature (cm)	161.7 ± 0.049	160.8 ± 0.40	0.0104
Prepregnancy body weight (kg)	55.3 ± 0.084	58.2 ± 0.73	<0.0001
Prepregnancy BMI (kg/m^2)	21.2 ± 0.030	22.5 ± 0.26	<0.0001
Blood pressure (mmHg)			
Systolic	105 ± 0.11	108 ± 0.84	0.0009
Diastolic	68 ± 0.076	70 ± 0.56	0.0011
Body weight gain at initial screening test (kg)	9.7 ± 0.043	10.0 ± 0.35	0.6278
Habitual smoking (one or more cigarettes/day) (%)	15 (0.16)	2 (1.13)	0.0480†

Data are means ± SEM or *n* (%). Two-sided Wilcoxon rank-sum test (normal approximation); †two-sided Fisher's exact test.

Obstetricians at the ABCUs completed the GDM screening questionnaire, which included general and demographic information, GDM risk factors, health status, medical history, anthropometric measurements, and clinical information about the current pregnancy. Stature was measured without shoes, using a standardized procedure, and recorded to the nearest 0.1 cm. Self-reported prepregnancy body weight was obtained. BMI was calculated as body weight in kilograms divided by stature in meters squared and was used to measure overweight and obesity. BMI ≥23 and <26 kg/m^2 was classified as overweight, and BMI ≥26 kg/m^2 was classified as obesity (16). All measurements were taken in the clinical examination rooms of ABCUs.

Questionnaires were collected monthly from the participating ABCUs and centrally processed at the Tianjin Institute for Women's Health. Fieldworkers responsible for quality assurance checked and verified the questionnaires with the obstetrician who was in charge at each ABCU and district institute for women's health before transcribing the data to a computer. The computerized data were checked and verified against the forms by members of the investigating team.

Participating laboratories used the glucose oxidase method (17). Blood samples were processed within 1 h after blood collection. The mean routine coefficient of variance was 3.14 ± 0.82% (range 2.04–4.37) for the Tianjin Institute for Women Health and 4.81 ± 2.43% for the ABCUs. The coefficients of variation were compatible with a large-scale study, the Da Qing IGT and Diabetes Study (18).

Data were entered and stored in personal computers and analyzed using the Statistical Analysis System (SAS) (19). Two-sided Wilcoxon's rank-sum test (normal approximation) using the procedure NPAR1WAY was performed to compare the sampling distributions of continuous variables that were not normally distributed. PROC FREQ was used to obtain descriptive statistics. PROC Logistics stepwise was used to obtain odds ratio (OR) estimates for GDM and 95% confidence limits. The significant level was set at 5%, unless otherwise indicated. Ethics clearance was obtained from the Standing Committee for Research into Humans at Monash University, Australia, and informed consent was obtained from all subjects.

RESULTS — During the 13-month study period, a total of 11,641 gravidas were registered with the participating ABCUs. Of these, 490 (4.2%) women who met one or more exclusion criteria were excluded from the study. A total of 1,675 (14%) women refused to take part in the study. Two women were further excluded from the study due to incomplete data. Three women, who were diagnosed to have diabetes before the 15th gestational week, were excluded from the initial screening. Of the 9,471 pregnant women who took part in the initial screening, 888 had a serum glucose level ≥7.8 mmol/l (a crude rate of 9.4%). Of these 888 women, 187 (21%) refused to have a further OGTT at the centralized GDM clinic. The remaining 701 (79%) women underwent a 75-g 2-h OGTT, and

171 (24%) were diagnosed with GDM. Additionally, three women who had a glucose level <7.8 mmol/l at the initial screening were diagnosed with GDM later in pregnancy. The average gestational week at the screening was 28 ± 0.11 weeks (Table 1). Women with GDM were older, of shorter stature, and had greater prepregnancy body weight (thus higher prepregnancy BMI) and higher blood pressure readings compared with their counterparts. Pregnancy body weight gain before the initial screening did not differ significantly between the two groups.

Women who attended the subsequent OGTT had a significantly higher mean serum glucose level at the initial screening than those who did not attend (9.0 ± 0.05 vs. 8.6 ± 0.08 mmol/l, $P < 0.0001$). The two groups of women did not differ significantly in age, stature, prepregnancy body weight and BMI, pregnancy body weight gain, gestational age at the initial screening, blood pressure, or household income. The expected number of women with IGT and diabetes of the 187 women who refused to attend the OGTT was obtained from the predictive values. Predictive values were estimated from the initial screening glucose levels of the 701 women who completed the OGTT (7.8–9.0 mmol/l, 19%; 9.1–10.0 mmol/l, 26%; 10.1–11.0 mmol/l, 39%; 11.1–12.0 mmol/l, 50%; and ≥12.1 mmol/l, 55%). Had all women with a positive screening result taken the OGTT, an additional 38 with IGT and 4 with diabetes (a total of 42 women) would have been identified (Table 2). The prevalence of IGT, diabetes, and GDM was 2.31% (192 [2.03%] with IGT and 27 [0.28%] with diabetes), adjusting for nonrespondents to the OGTT and case subjects detected in early pregnancy and later in pregnancy.

Factors that significantly increased the risk of GDM were older maternal age, high prepregnancy BMI, undue body weight gain in pregnancy before GCT, history of diabetes in first-degree relatives, and smoking in pregnancy. A tall stature, however, protected women from the development of GDM (Table 3).

CONCLUSIONS — Overseas Asian women have been shown to be more prone to developing diabetes in pregnancy than their Anglo-Celtic counterparts (6–10). Dornhorst (6) reported an

Table 2—*GDM cases using the WHO criteria and prevalence estimates*

	IGT	Diabetes	Total
New cases with glucose level ≥ 7.8 mmol/l at the initial screening and completed OGTT (*n*)	152	19	171
New cases with glucose level <7.8 mmol/l at the initial screening (*n*)	2	1	3
Case subjects with known diabetes (*n*)†	0	3	3
Total cases (*n*)	154	23	177
Crude rates (%)‡	1.63	0.24	1.87
Expected cases in those who refused the OGTT (*n*)§	38	4	42
Adjusted rate (%)‡	2.03	0.28	2.31

*OGTT performed later in pregnancy, GDM was then confirmed; †cases confirmed before the 15th gestational week; ‡*n* = 9,474; §predictive values were estimated from the initial screening glucose levels of the 701 women who completed OGTT and applied to the 187 women who refused the OGTT: 7.8–9.0 mmol/l, 19%; 9.1–10.0 mmol/l, 26%; 10.1–11.0 mmol/l, 39%; 11.1–12.0 mmol/l, 50%; and ≥12.1 mmol/l 55%.

RR of 7.6 (4.1–14.1) in Southeast Asian women and 11.3 (6.8–18.8) in Indian women living in London. In Melbourne, Australia, the prevalence of GDM was significantly greater in women born on the Indian subcontinent (15%) and in Vietnam (7.3%), China (13.9%), and other Asian countries (10.9%) (7). In Sydney, Yue et al. (8) reported an OR of 5.6 in Chinese, 3.6 in Vietnamese, and 6.4 in Indians, compared with their Anglo-Celtic counterparts. In the U.S., the prevalence of GDM was significantly greater for Chinese (7.3%) compared with other ethnic women (20).

There have been, however, few population-based studies of GDM in women living in mainland China. Studies of Chinese women living in Hong Kong, Taiwan, major cities of mainland China, and Singapore suggested a lower rate of GDM than Chinese women in Western countries. Ray et al. (21) reported a prevalence of 4.8% in multiethnic Singaporean women. Lee et al. (12) reported rates of 6.8, 5.5, 7.2, and 8.1% in Beijing, Shanghai, Guangzhou, and Hong Kong women, respectively. The prevalence of IGT and type 2 diabetes was 5.1 and 1.9%, respectively, using a 75-g 2-h OGTT and the WHO 1985 diagnostic criteria (22) in a group of northern (Qingdao) Chinese women (23); 4.2 and 0.6%, respectively, in metropolitan Taipei (24); and 2.51% in Shanghai (13).

This study is the first to introduce the universal screening program for GDM in mainland China. In Tianjin urban areas, the prevalence of IGT and diabetes was 2.31% (2.03% for IGT and 0.28% for diabetes). Thus, the prevalence of GDM in

the current study was at best half of that reported in overseas Chinese women. The prevalence of GDM in Tianjin urban areas was also the lowest among those reported in mainland Chinese women. Other studies of GDM prevalence in mainland China have been of small sample size, with study subjects recruited from tertiary hospitals (23). Tertiary hospitals in China are the referral centers for high-risk pregnancy and thus a nonrepresentative catchment of district or community obstetric populations. The prevalence of diabetes in China is on the increase. It has been attributed to adaptations of modern lifestyle arising from economic development in recent years (25). There is a growing concern of a rapid increase in the prevalence of GDM in the future.

Despite being a cohort of young and lean women with a low prevalence of family history of diabetes, Tianjin women experienced common risk factors for the development of GDM, as reported elsewhere in the literature (9,13,26–30).

Aside from the common risk factors such as maternal age, prepregnancy BMI (i.e., body weight), pregnancy weight gain, and family history of diabetes, this study found a significant association of stature and cigarette smoking in the development of GDM. Previous studies have also noted stature as a risk factor. Jang et al. (28) reported the highest prevalence of GDM in the shortest quartile (≤157 cm) group. In a sample of 2,772 Greek pregnant women, Anastasiou et al. (31) reported an association of short stature with glucose intolerance. This study showed an increased risk for GDM in women with a stature in the lowest quartile (<159 cm). Cigarette smoking as an independent risk factor for GDM (OR 1.43 [95% CI 1.14–1.80]) was also reported in the large U.S. Nurses' Health Study (27). The smoking prevalence in this study was low (0.16 and 1.13% for women without and with GDM, respectively). However, the adjusted OR for smoking was 7.8 (1.73–35.28). The role of smoking in the development of GDM warrants further investigation.

Studies show that the WHO diagnostic criteria may produce a higher estimation of GDM prevalence (32,33) than ADA criteria. It is thus unlikely that GDM prevalence in this population would have been higher if the ADA criteria had been used. GDM has been shown to occur more frequently in women with chronic hypertension (RR 2.03) (30). The exclusion of women with significant diseases, such as chronic hypertension, from the screening would thus lower the estimate of GDM prevalence. If all 490 women who met the exclusion criteria of the study had chronic hypertension and were twice as likely to develop GDM (30), 22 additional GDM cases would have been

Table 3—*Independent predictors for GDM*

Variables*	OR	95% CI	P
Age (years)	1.07	1.03–1.11	0.0007
Stature (cm)	0.96	0.93–0.99	0.0077
Prepregnancy BMI (kg/m²)	1.14	1.09–1.19	<0.0001
Pregnancy weight gain (kg)	1.05	1.01–1.08	0.0085
Diabetes in first-degree relatives (0 = "No", 1 = "Yes")	3.46	2.43–4.93	<0.0001
Smoking status (0 = none or occasional smokers, 1 = one or more cigarettes/day)	7.82	1.73–35.28	0.0075

*Multiple stepwise logistic analysis controlling for age, BMI, weight gain, education attainment, average household income, pregnancy-induced hypertension, gestational weeks at GCT, diabetes in first-degree relatives and in other relatives, maternal GDM, parity, abortion, and a history of serious pregnancy outcomes (birth defect, fetal death, and neonatal death), as well as smoking and alcohol drinking habit.

identified (for a prevalence of 2.43%). Because it is most unlikely that all 490 women who met exclusion criteria had chronic hypertension, the exclusion of women with chronic diseases from the study, in terms of the impact on the estimate of GDM prevalence, was insignificant. Chinese traditional dietary habits (high carbohydrate and low fat) and the use of bicycles as a primary means of transportation (physical activity) are consistent with diabetes prevention guidelines (34). Dietary and physical activity data were not collected in women who took part in the initial screening. Dietary habits and habitual physical activity attributable to a low prevalence of GDM thus cannot be extrapolated from the current study.

Pregnancy-induced hypertension has been shown to be associated with elevated glucose levels (35). Pregnancy-induced hypertension, however, was not a significant and independent predictor for GDM in the current study. Similar findings have been reported in mainland China (13). Previous spontaneous or induced abortion and previous stillbirth have been associated with increased risk for GDM in some studies (30,36). Other studies showed an insignificant relationship (9,13). No associations were found in the current study, when controlling for confounding factors (not shown).

The prevalence of GDM in Tianjin Chinese women is lower than that reported elsewhere outside China (7,20). This study found a consistently low prevalence of common risk factors for GDM. Of the women, 98% were nulliparous, which is attributable to the successful implementation of the "one child policy." Of the total number of women, 88% were <30 years of age. Overweight and obesity were uncommon in local pregnant women (16% overweight and 6.5% obese). Of our study subjects, 8.33% had a family history of diabetes (first-degree relatives), a rate compatible with a national survey in China (25). Habitual cigarette smoking is very uncommon in Chinese women living in China (current study: 0.18%, 17 of 9,287 subjects). The lack of risk factors for GDM in this prevailing nulliparous obstetric population is the single most important protective factor that safeguards Tianjin Chinese woman from the development of diabetes in pregnancy.

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