Gestational Diabetes Mellitus

Influence of Race on Disease Prevalence and Perinatal Outcome in a U.S. Population

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We explore whether racial differences in a United States population influence disease prevalence and perinatal outcome in gestational diabetes mellitus (GDM). The data presented are based on 3744 consecutive patients who underwent universal screening at 24–28 wk gestation; those with a 1-h plasma glucose ≥7.2 mM underwent a 100-g 3-h oral glucose tolerance test (OGTT). The overall prevalence of GDM was 3.5 cases/100 with the standard O'Sullivan-Mahan diagnostic criteria derived for plasma, whereas use of the Carpenter-Coustan modification of the O'Sullivan-Mahan criteria yielded a prevalence of 5.5. The population was 39.1% white, 37.7% black, 19.8% Hispanic, and 3.4% Oriental/other. For those patients with a nondiagnostic test, mean plasma glucose at each time point of the OGTT was similar for all racial groups. Because of demographic and phenotypic heterogeneity between different racial groups, the influence of these different variables on the prevalence of GDM was tested by multiple logistic regression. Black and Hispanic race, maternal age, and percentage ideal body weight were found to have significant independent effects on the prevalence of GDM ($P < 0.05$, 0.001, 0.001, and 0.001, respectively). The adjusted relative risk of GDM was significantly higher in black (1.81, 95% confidence interval [CI] 1.13–2.89, $P < 0.05$) and Hispanic (2.45, 95% CI 1.48–4.04, $P < 0.001$) patients compared with whites. The influence of race on infant birth weight was examined in the 92 patients with GDM controlled with diet. Despite comparable degrees of carbohydrate intolerance across racial groups, mean birth weight was found to be highest in Hispanics and lowest in blacks and Orientals. By analysis of covariance, race was found to have a significant independent effect on birth weight ($P = 0.017$), with maternal percentage ideal body weight a significant covariate ($P = 0.009$). These results suggest that race as well as maternal age and degree of obesity must be taken into account when comparing the prevalence of GDM in different populations and assessing the impact of specific therapeutic interventions on perinatal outcome.

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Efforts to understand the influence of racial/ethnic differences on disease prevalence and perinatal outcome in gestational diabetes mellitus (GDM) have been hampered by the lack of agreement at the international level in both testing methodology and diagnostic criteria. At the Second International Workshop-Conference on Gestational Diabetes Mellitus, Hadden (1) reviewed the marked racial and geographic variation in reported prevalence of GDM from a low of 0.15% to a high of 12.3%. Whether this represents true differences in prevalence is obscured by a remarkably variable approach to diagnosis across different studies, including different methods for screening, different oral and even intravenous glucose loads, and different diagnostic oral glucose tolerance test (OGTT) criteria. Hadden also raised an intriguing question: to whatever extent there are racial differences in GDM, do immigrant populations express their native prevalences of GDM, and/or are these native prevalences influenced by other changes incurred in the course of immigration, such as altered diet? One example of this phenomenon is the well-described increased prevalence of cardiovascular disease in Japanese immigrating to the United States related to increased dietary fat consumption (2).

All of these issues are relevant to us in the U.S. in that, depending on the region of interest, the population studied may have a considerable racial mix influenced by prior immigration patterns, e.g., Oriental groups on the west coast and Hispanics in the southwest. Studies published since the last international workshop-conference suggest that Oriental and Hispanic populations indeed may have different preva-

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lences of GDM. A report by Doery et al. (3) on a small sample of patients revealed a very high prevalence of GDM in immigrant Vietnamese (14.3%) and Cambodians (16.1%) compared with native Australians (2.4%). In a larger series in Hong Kong, Li et al. (4) found a prevalence of 15.8% in a population of women tested directly with 100-g OGTT because of risk factors for diabetes. Forsbach et al. (5), in a program of universal screening in Mexico, found a prevalence of 3.9% with the standard O'Sullivan-Mahan criteria derived for plasma. Unfortunately, 40% of patients with a positive screen failed to report for OGTT, suggesting that the true prevalence may have been greater. Even at 3.9%, this is somewhat higher than the 2–3% reported in most U.S. studies. There has been little systematic study of heterogeneous U.S. populations. In Loma Linda, CA, Jacobson and Cousins (6) found a disproportionate representation of Hispanics in their GDM population compared with control subjects, whereas blacks and whites were represented in expected proportions. In San Francisco, Green et al. (7) found a high prevalence of GDM in the Chinese-American population (7.3%) despite a high screen threshold of 8.3 mM after a 50-g oral load. Whites and blacks had similar prevalences at 1.6 and 1.7%, respectively, and Hispanics were intermediate at 4.2%.

When considering racial differences, it is important to take into account the factors of maternal age and obesity, which were demonstrated to influence GDM prevalence nearly 20 yr ago by O'Sullivan et al. (8). This has been confirmed by several investigators (6,7,9,10). The point was well illustrated at the last international workshop-conference by Freinkel et al. (11), who showed not only differences in age and obesity between control subjects and those with GDM but also a significant trend of increasing obesity with progressively higher fasting glucose at OGTT.

We have been interested in exploring whether racial differences in a U.S. population influence disease prevalence and perinatal outcome while taking into account other variables such as maternal age and obesity and to what extent differing diagnostic criteria may impact on prevalence. Our program of universal screening in a large heterogeneous obstetric population in Chicago has permitted us to examine these issues.

RESEARCH DESIGN AND METHODS

The data in this report, which have been previously reported in part (12), are based on 3744 consecutive patients with a negative history for prior diabetes screened over 3 yr at Prentice Women's Hospital of Northwestern Memorial Hospital (Chicago, Il). The protocol used was that recommended at the Second International Workshop-Conference on Gestational Diabetes Mellitus. Patients underwent universal screening at 24–28 wk with a 50-g oral load. We have modified this recommended protocol only by the designation of 7.2 mM as the threshold value for the 1-h plasma glucose screening test rather than 7.8 mM. Those patients with a positive screen were recalled for a 100-g OGTT after carbohydrate loading of 150 g/day for 3 days. The OGTTs were performed in an outpatient setting after an overnight fast, with patients encouraged to sit quietly for the duration of the test. The diagnostic criteria used were the standard O'Sullivan-Mahan values derived for plasma, as recommended by the National Diabetes Data Group (13), the American College of Obstetricians and Gynecologists (14), and the last international workshop-conference (15). At screening, the following data were prospectively recorded: maternal race, age, prepregnant weight, height, and category of care provider (private versus nonprivate). Maternal prepregnant percentage ideal body weight (PIBW) was then calculated on the basis of norms from the Metropolitan Life Insurance tables. Perinatal data collected included gestational age at delivery, based on menstrual dates confirmed by ultrasound, and birth weight.

The data were analyzed by multiple logistic regression, χ^2 test, analysis of covariance (ANCOVA), and the Wilcoxon rank-sum W test where appropriate. $P < 0.05$ was considered significant.

RESULTS AND DISCUSSION

Of the 3744 patients screened, 22.8% (852) had a screen value of ≥7.2 mM, and 15.3% (130) of these had a diagnostic OGTT, with 97.5% of patients reporting for OGTT. The overall GDM prevalence was thus 3.5 cases/100 screened. To assess the influence of choice of diagnostic criteria on prevalence, two sets of criteria were applied to the study data: the standard O'Sullivan-Mahan criteria derived for plasma (fasting, 5.8 mM; 1 h, 10.6 mM; 2 h, 9.2 mM; 3 h, 8.1 mM; 13) and the O'Sullivan-Mahan criteria as modified by Carpenter and Coustan (fasting, 5.3 mM; 1 h, 10 mM; 2 h, 8.6 mM; 3 h, 7.8 mM; 16). Use of the latter criteria would have ascertained an additional 75 patients for a total of 205, yielding a prevalence of 5.5/100 screened. These additional 75 patients, whose OGTT values met the lower Carpenter-Coustan criteria but not the stricter standard criteria, thus had a milder degree of carbohydrate intolerance. Note that a significantly greater proportion of these 75 patients were ascertained from lower screening levels than the 130 patients meeting the standard criteria (Fig. 1). Therefore, despite universal screening and a uniform methodology, prevalence could be heavily influenced by the choice of diagnostic criteria. This finding underscores the difficulties in

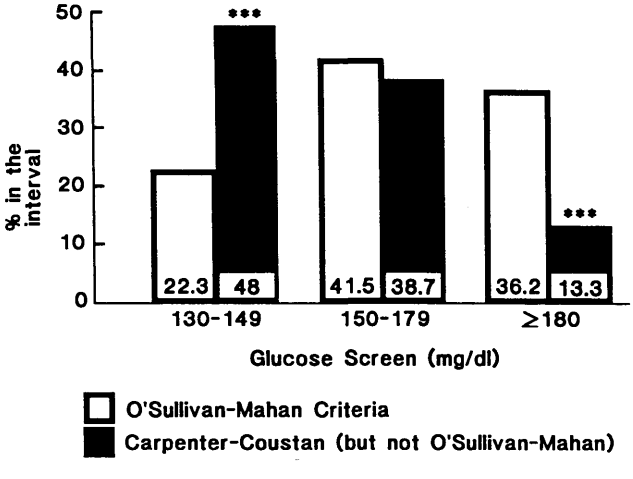

FIG. 1. Distribution of diagnostic oral glucose tolerance test results by grouped levels of glucose screen. Glucose, 1 mM = 18 mg/dl. ***$P < 0.001$.

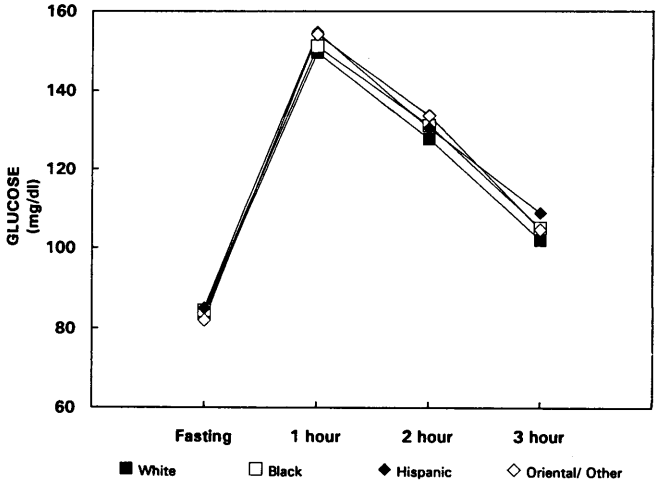

FIG. 2. Oral glucose tolerance test results for patients with nondiagnostic test. Glucose, 1 mM = 18 mg/dl.

comparing results from study to study and does not even address the potential impact of variations in screening techniques and methodological differences.

The racial distribution of the population studied was as follows: white, 39.1%; black, 37.7%; Hispanic, 19.8%; and Oriental/other, 3.4%. We have been cautious in interpreting results from the Oriental/other group because this comprised a small proportion of our population and represented an admixture of various Far Eastern and Pacific island groups. Mean glucose levels at each time point of the OGTT for those patients with a nondiagnostic test were compared across racial groups (Fig. 2). Although the difference between Hispanics and whites at 3 h achieved significance ($P < 0.05$), these curves are more impressive for their similarities across racial groups. Adjusting for maternal age and PIBW did not influence this observation. The data suggest that within the confines of the study design, i.e., without the benefit of OGTT data from those with a screen of <7.2 mM, pregnant nondiabetic women of these different racial groups residing within the same culture do not have fundamental differences in carbohydrate metabolism.

The prevalence of GDM for each racial group is shown in Table 1. With white as the reference, Hispanics had a significantly higher prevalence of GDM, with blacks being intermediate. Although representing only 124 patients, the Oriental/other group demonstrated a very high prevalence of GDM. These raw data suggest racial differences in GDM prevalence, but the study population at large was found to be heterogeneous for other variables that may impact on

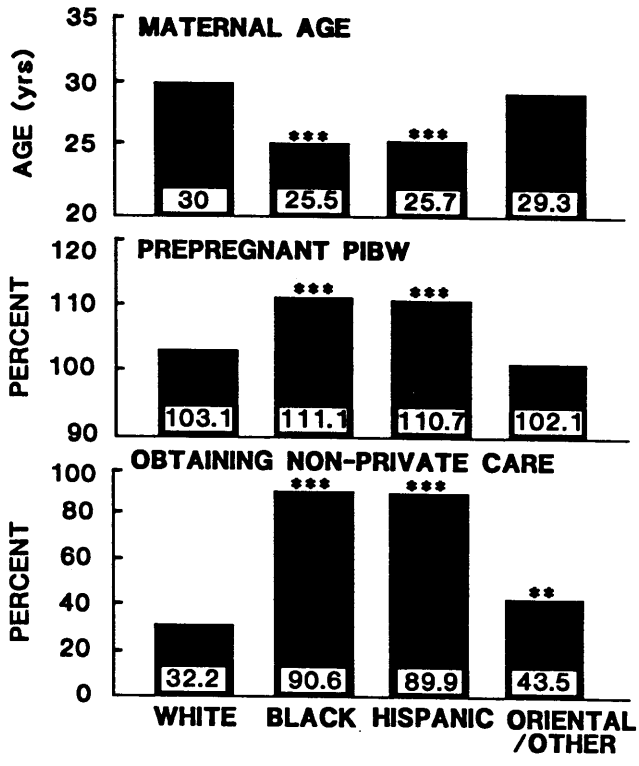

FIG. 3. Demographic and phenotypic features of population screened. PIBW, percentage ideal body weight. **$P < 0.01$, ***$P < 0.001$, vs. white.

prevalence. Black and Hispanic patients were found to be younger than whites, whereas Orientals were similar in mean maternal age (Fig. 3). Body habitus also differed among racial groups, with blacks and Hispanics having a significantly higher PIBW. The proportions of patients obtaining nonprivate care differed significantly in all racial groups compared with whites. Accordingly, the data were analyzed by multiple logistic regression. The Oriental/other group was not included in this analysis because of the small sample size. With white as the reference, black and Hispanic race, maternal age, and PIBW were found to have significant independent effects on the prevalence of GDM ($P < 0.05$, 0.001, 0.001, and 0.001, respectively). Only category of care provider, a gross measure of socioeconomic status, failed to influence disease prevalence ($P > 0.05$). The relative risk of GDM for blacks and Hispanics is shown in Table 2. Adjusting for maternal age and PIBW emphasizes the marked independent effect of race on GDM prevalence. The reasons for these observed racial differences in GDM prevalence remain to be determined.

TABLE 1
Prevalence of gestational diabetes mellitus by race

	Positive OGTT/cases	Prevalence (%)
White	39 of 1430	2.7
Black	46 of 1379	3.3
Hispanic	32 of 723	4.4*
Oriental/other	13 of 124	10.5†

OGTT, oral glucose tolerance test.
*$P < 0.05$, †$P < 0.001$, vs. white.

TABLE 2
Relative risk of gestational diabetes mellitus adjusted for maternal age and percentage ideal body weight

	Relative risk*	95% Confidence interval	P
Black	1.81	1.13–2.89	<0.05
Hispanic	2.45	1.48–4.04	<0.001

*Compared with white.

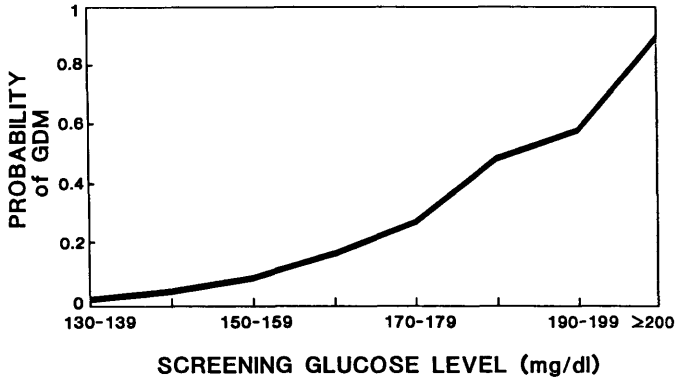

FIG. 4. Probability of gestational diabetes mellitus (GDM) adjusted for maternal age and percentage ideal body weight. Glucose, 1 mM = 18 mg/dl.

The probability of GDM by level of screening glucose, adjusted for maternal age and PIBW, is shown in Fig. 4. The currently recommended threshold for the standard 1-h screen is 7.8 mM. The probability of GDM at a screen level of 7.2–7.7 mM was found to be only 5%. However, ~10% (15 of 130) of our GDM population were ascertained from this screen level, as was found by Sacks et al. (17) and Coustan et al. (18), and these patients manifested typical morbidity, with 2 of 15 requiring insulin therapy, 3 of 15 delivering infants in the >90th percentile for birth weight, and 4 of 15 infants suffering from hypoglycemia. Furthermore, the probability of GDM does not decline to zero at 7.2 mM, indicating that the sensitivity of a 7.8-mM threshold is <90%. Nonetheless, this is a good performance for a screening test. The decision to use a cutoff less than the currently recommended 7.8 mM must be weighed against the cost and inconvenience of a larger proportion of patients requiring OGTTs, many of which will prove nondiagnostic. At the other extreme, performance of a confirmatory OGTT for those with a screen value of >11.1 mM is warranted, because some of these individuals will not be confirmed to have GDM, at least on the basis of a single test. This is true even for Hispanic and black patients who manifest a higher probability of GDM at all screen levels.

The heterogeneity of our population and the observed racial differences in GDM intrigued us to look for any effects on perinatal outcome. Observations were limited to the 92 patients whose control was maintained with diet, because there was marked variation in clinical characteristics and the duration of insulin treatment in the 38 patients who failed diet therapy. Although this is a relatively small sample, it permitted us to gain some insights into the influence of race on birth weight in patients with GDM. All patient groups were similar in mean level of glucose screen and mean levels of plasma glucose at OGTT, with the only significant difference being fasting glucose in whites versus Hispanics (Table 3). However, whites were screened at a significantly later gestational age than blacks or Hispanics. As in the study population at large, there were differences in maternal age and PIBW (Table 4). Not all of these differences achieved statistical significance, but the trends were the same as those seen in the general study population. All racial groups were predominantly parous, with the exception of the Oriental/other group. Mean gestational age at delivery was nearly identical. Despite comparable degrees of carbohydrate intolerance across racial groups, mean birth weight was greatest in Hispanics and lowest in blacks and Orientals, although the data in the Oriental/other group should be interpreted cautiously because of the small number of infants. Our data suggest that factors that mediate birth

TABLE 3
Screening and oral glucose tolerance test (OGTT) results by race for patients with diet-controlled gestational diabetes mellitus

	White	Black	Hispanic	Oriental/other
n	31	28	23	10
Screen (mM)	9.2 ± 0.9	9.3 ± 1.5	9.5 ± 1.2	9.4 ± 1.1
Gestational age (wk)	29.2 ± 3.9	27.1 ± 1.9*	27.1 ± 2.5*	27.4 ± 2.9
OGTT (mM)				
Fasting	5.1 ± 0.6	5.2 ± 1.1	5.4 ± 0.6*	5.2 ± 0.7
1 h	11.4 ± 1.5	11.2 ± 1.2	10.9 ± 1.4	11.3 ± 1.0
2 h	10.2 ± 1.2	10.6 ± 1.1	10.6 ± 1.9	10.4 ± 1.5
3 h	7.9 ± 1.7	7.7 ± 2.2	8.6 ± 1.9	8.5 ± 1.2

*$P < 0.05$ vs. white.

TABLE 4
Maternal characteristics and perinatal outcome in patients with diet-controlled gestational diabetes mellitus

	White	Black	Hispanic	Oriental/other
n	31	28	23	10
Maternal age (yr)	33.2 ± 6.1*	29.9 ± 5.5	30.3 ± 5.2	31.7 ± 4.7
Percentage ideal body weight	110.6 ± 23.8	118.9 ± 29.7	118.2 ± 25.2	104.8 ± 11.5†
Parous	23 (74%)	17 (63%)	21 (91%)	2 (20%)
Gestational age (wk)	38.6 ± 1.5	38.3 ± 1.9	38.8 ± 1.0	38.0 ± 2.4
Birth weight (g)	3452 ± 499	3240 ± 543	3637 ± 494	3211 ± 528†

*$P < 0.05$ vs. black.
†$P < 0.05$ vs. Hispanic.

weight differences are not obscured by glucose intolerance, which would be expected to increase birth weight in GDM. It is known that the birth weight of black infants is less than that of whites in the general population (19). Whether the higher birth weight seen in Hispanics also represents a racial difference is uncertain. We are not aware of normal birth weight curves for U.S. Hispanics and suggest that there is a need for such data. Of the many factors that potentially influence birth weight, we were able to test the following: race, maternal PIBW, maternal age, and parity. Gestational age at the time of screening was also tested, because whites were screened an average of 2 wk later than the other racial groups. The data were analyzed by ANCOVA. The only significant independent effect in this analysis was race ($P = 0.017$), with maternal PIBW a significant covariate ($P = 0.009$). Neither maternal age, parity, nor gestational age at screen had significant effects ($P > 0.05$).

In summary, our results suggest that race as well as maternal age and degree of obesity must be taken into account when comparing the prevalence of GDM in different populations. Also, we may need to carry over our expectations of a racial difference in birth weight to those patients with GDM. It may be important to establish the race-specific frequency of different perinatal complications to assess the impact of specific therapeutic interventions.

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