Original Article

Usefulness of the 50-g Glucose Challenge Test for Screening of Patients with Gestational Diabetes Mellitus and an Analysis of the Timing of Administration of the Test

Keiko KOHNO1), Kazuhiko HOSHI1), Motoi TAKIZAWA1), Takashi KANEKO2), and Shuji HIRATA1)
1)Department of Obstetrics and Gynecology, Faculty of Medicine, University of Yamanashi, 1110 Shimokato, Chuo-shi 469-3898, Yamanashi
2)Yamanashi Occupational Hygiene Center, 860 Ochiai, Yamanashi-shi 405-0033, Yamanashi, Japan

Abstract: Objective We determined whether performing the glucose challenge test (GCT) during early pregnancy is an effective screening method for gestational diabetes mellitus (GDM).

Methods The subjects included 201 pregnant Japanese women on whom a GCT was performed in early and mid-pregnancy, and an oral glucose tolerance test (OGTT) was performed 2–3 weeks after the GCT. The cut-off level for GCT determination was set at 130 mg/dL. The results of the OGTT that indicated the GDM type were displayed as the “GDM pattern.” The present study identified the cases as GDM only if they exhibited a GDM pattern based on the results of OGTT conducted during mid-pregnancy.

Results Based on the results of the GCT with respect to GDM detection during mid-pregnancy, the sensitivity and specificity of the test were found to be 100% (3/3) and 88% (174/198), respectively. During early pregnancy, the sensitivity and specificity of GCT with respect to detection of cases exhibiting a GDM pattern in an OGTT were 63% (5/8) and 84% (63/193), respectively. The 3 cases that were diagnosed as GDM during mid-pregnancy were found to be GCT-positive during early pregnancy, and a GDM pattern was observed based on the results of an OGTT that was conducted during early pregnancy. Thus, the sensitivity and specificity of GCT during early pregnancy for GDM-detection during mid-pregnancy were 100% (3/3) and 84% (166/198), respectively.

Discussion GCT performed during early pregnancy is an effective screening method for detecting GDM during mid-pregnancy.

Key words: Gestational diabetes mellitus, Glucose challenge test, Oral glucose tolerance test

INTRODUCTION

In Japan, the number of cases of impaired glucose tolerance is increasing. According to the 2002 survey on Diabetes in Japanese population by the Japanese Ministry of Health, Labor and Welfare, the diabetic population exceeded 7 million, and it exceeded 16 million when potential diabetics (individuals with impaired glucose tolerance) were included3).

The effects of gestational diabetes mellitus (GDM) on the mother and fetus are similar to those observed during pregnancy that is complicated by diabetes; the effects on the mother include ketoacidosis, toxemia during pregnancy, hypertension, and polyhydramnios; effects on the fetus include an abnormally large fetus and malformation; and neonatal effects include hypoglycemia, hypocalcemia, plethora, hyperbilirubinemia, hypertrophic cardiomyopathy,
and infantile respiratory distress syndrome. In Japan, the increase in the number of diabetics is particularly sharp among the younger population\(^2\). Early diagnosis and treatment is associated with a decreased incidence of abnormally large fetuses, and birth trauma. However, the long-term prognosis of the mother with glucose intolerance including impaired glucose tolerance (IGT) and diabetes is not good; GDM, if untreated, is frequently known to develop into conventional type 2 diabetes mellitus\(^3\). Thus, early treatment is associated with the prevention of onset of type 2 diabetes mellitus. Therefore, it is important to screen for diabetes as early as possible during gestational periods to obtain preferable outcome.

In 2002, the Japan Society of Obstetrics and Gynecology (JSOG) suggested estimation of the 2-hr post-prandial blood glucose level (casual blood glucose) and 50 g glucose challenge test (GCT) as a screening method for GDM; they recommended that either could be performed during the appropriate period for the detection of GDM\(^4\). Estimation of casual blood glucose level is simpler to perform, while GCT is more sensitive and specific for detecting GDM.

The present investigation was performed on pregnant Japanese women who underwent a GCT and 75-g OGTT during their early and mid-pregnancy periods, and it confirmed whether impaired glucose tolerance manifested during gestation. The study investigated whether GCT is an effective screening method for GDM in early pregnancy.

**SUBJECTS AND METHODS**

The subjects included 201 pregnant Japanese women who consulted The Obstetrics Department at the University of Yamanashi Hospital from December 2002 to December 2003. Informed consent was obtained from all the subjects, and a GCT was performed during early pregnancy (9th–15th week of gestation) and mid-pregnancy (21st–26th week of gestation). Fifty gram oral glucose tolerance test (GLT) is performed without regard to time of last meal or time of day, and followed 1 hr later by a plasma glucose concentration. Two to three weeks after performing the GCT, an OGTT was performed to assess the status of glucose tolerance. Subjects who were diagnosed as diabetes mellitus before pregnancy were excluded from the study. Thus, GCT was performed on all subjects during 11.2 ± 1.5 weeks (early pregnancy) and 23.0 ± 3.8 weeks (mid-pregnancy) of gestation. The baseline characteristics of the subjects were as follows (mean ± SD): age, 31.2 ± 4.4 years; weight, 54.5 ± 9.3 kg; height, 157.0 ± 6.0 cm; BMI, 21.0 ± 3.8 kg/m\(^2\); weight gain until to mid-pregnancy was 4.2 ± 3.1 kg.

According to the recommendations of the American Diabetes Association (ADA)\(^5\), a cut-off level of 130 mg/dl (7.2 mmol/l) for GCT determination would result in identification of 90% cases of GDM; therefore, this value was set as the cut-off level for GCT in the present study. GDM was determined according to the criteria stipulated by the JSOG. The results of the OGTT indicating the GDM type were displayed as the “GDM pattern.” Only those cases exhibiting a GDM pattern based on the OGTT results during mid-pregnancy were classified as GDM. The OGTT results during early pregnancy served merely as a diagnostic reference; therefore, even if the subjects displayed a GDM pattern during early pregnancy, they were followed up, and therapeutic intervention was not performed.

Also, the subjects were interviewed with regard to their food intake (including dinner and between-meal snacks) from 4 PM to 10 PM.
on the day prior to the OGTT. The food intake was quantified by using food models including 169 types of food.

Based on the OGTT results obtained during both early and mid-pregnancy, the subjects were classified into 3 groups (X group demonstrated a GDM pattern during early and mid-pregnancy, Y group demonstrated a GDM pattern during early pregnancy only, and Z group demonstrated normal pattern during early and mid-pregnancy). We investigated the difference of the food intake between X, Y, and Z group.

Statistical results are represented as mean ± SD. The student’s t test was used to test for a significant difference, and results with p < 0.05 were considered to be statistically significant.

The approval for the present investigation was obtained from the ethics committee of the University of Yamanashi School of Medicine.

**RESULTS**

Table 1 shows the results of a 75-g OGTT that was performed in early and mid-pregnancy. The GDM pattern was observed in 3 cases in early and mid-pregnancy; 5 cases, during early pregnancy; and 193 cases were determined to be normal during early and mid-pregnancy. The present investigation classified only those cases exhibiting the GDM pattern during mid-pregnancy.

Table 2 shows the results of GCT performed during mid-pregnancy. According to the OGTT results, GDM was detected in 3 of the 27 cases that were GCT-positive, while it was not detected in 174 cases that were GCT-negative. The sensitivity and specificity of GCT with respect to detection of GDM were 100% and 88%, respectively. No false positives results were noted.

Table 3 demonstrates the relationship between the results of GCT (conducted during early pregnancy) and OGTT (conducted during mid-pregnancy).
mid-pregnancy. The sensitivity and specificity of GCT with respect to detection of GDM were 100% and 84%, respectively.

Table 4 demonstrates the relationship between the results of GCT (conducted during early pregnancy) and OGTT (conducted during early pregnancy). Of the 35 GCT-positive, 5 displayed a GDM pattern during early pregnancy. Of the 169 GCT-negative cases, 3 cases displayed a GDM pattern during the early pregnancy. The sensitivity and specificity of GCT with respect to detection of the GDM pattern during early pregnancy were 63% and 84%, respectively.

There were 5 cases that displayed a GDM pattern only during early pregnancy. Therefore, it would be ineffective to use GCT as a screening method during early pregnancy for detection of GDM pattern. The OGTT results of such cases obtained during early pregnancy may be inappropriate as a screening method.

Thus, the OGTT results during early pregnancy were re-examined. In addition, there are reports that suggest that carbohydrate intake prior to the test affects the responses of OGTT5); therefore, food intake prior to OGTT was studied.

Table 5 shows the data regarding total food intake and carbohydrate intake on the day prior to the test. Based on the OGTT results obtained during early and mid-pregnancy, the subjects were classified into 3 groups (X, Y, Z).

With regard to the total food intake and carbohydrate intake during early and mid-pregnancy, no significant difference was noted for the X and Z groups. However, in the Y group the total food intake and carbohydrate intake were both lower during early pregnancy than during mid-pregnancy, and this difference was statistically significant. That is, in cases demonstrating a GDM pattern only during early pregnancy, the total food intake and carbohydrate intake decreased significantly prior to conducting OGTT during early pregnancy. In addition, analyzing the total food intake and carbohydrate intake on the day prior to OGTT testing for individual groups classified by early/mid-pregnancy OGTT results.

Table 4. Results of GCT and OGTT performed during early pregnancy (number of individuals)

<table>
<thead>
<tr>
<th>GCT (early-pregnancy)</th>
<th>OGTT (early pregnancy)</th>
<th>No. of cases</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive predictive value</th>
<th>Negative predictive value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>GDM</td>
<td>30</td>
<td>5</td>
<td>84% (163/193)</td>
<td>14% (5/35)</td>
<td>98% (163/166)</td>
</tr>
<tr>
<td>Negative</td>
<td>GDM</td>
<td>193</td>
<td>3</td>
<td>63% (5/8)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Status of food intake on the day before OGTT testing for individual groups classified by early/mid-pregnancy OGTT results

<table>
<thead>
<tr>
<th>OGTT results</th>
<th>Total food intake (kcal)</th>
<th>Carbohydrate intake (kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early pregnancy</td>
<td>Mid-pregnancy</td>
</tr>
<tr>
<td>X group</td>
<td>GDM pattern</td>
<td>GDM</td>
</tr>
<tr>
<td>Y group</td>
<td>GDM pattern</td>
<td>Normal</td>
</tr>
<tr>
<td>Z group</td>
<td>Normal</td>
<td>Normal</td>
</tr>
</tbody>
</table>

(mean □ SD)*p < 0.05 **p < 0.01 vs. early pregnancy
intake of Y and Z groups during early pregnancy using an ROC curve indicated that the area under the curve were 0.772 and 0.835, respectively. The cut-off levels for total food intake and carbohydrate intake with acceptable sensitivity and specificity during early pregnancy were 488 kcal (sensitivity 75%, specificity 80%) and 245 kcal (sensitivity 75%, specificity 75%), respectively.

**DISCUSSION**

In this study, the effectiveness of performing GCT during early pregnancy as a screening method for GDM was investigated. According to previous reports, performing GCT during mid-pregnancy is a useful screening method for GDM. As shown in Table 3, GCT during early pregnancy enabled 100% detection of GDM, and it was as effective as GCT performed during mid-pregnancy.

The present study detected 3 GDM cases; performing OGTTs revealed that these cases demonstrated a GDM pattern during early pregnancy as well. Our data obtained by repeated OGTTs indicated that all GDM cases displayed a GDM pattern during early pregnancy. However, 5 cases displaying a GDM pattern only during early pregnancy were noted. As stated previously, worsening of glucose tolerance during pregnancy can be a possible reason for this pattern; however, improvement in glucose tolerance during mid-pregnancy in cases that demonstrated impaired glucose tolerance (a GDM pattern) during early pregnancy without any therapeutic intervention appears implausible. Thus, this study was performed to determine whether GDM diagnosis during early pregnancy is appropriate in such cases.

There are scattered reports regarding the effect of carbohydrate intake on GTT responses on the day prior to testing. In 1935, Himsworth performed studies on healthy males and clarified that glucose tolerance worsened with decreased carbohydrate intake, and he reported that “intake of carbohydrates” was the sole dietary factor determining glucose tolerance and insulin sensitivity in healthy individuals. Kaneko et al. prescribed two types of diets (a high-carbohydrate diet containing 80% carbohydrates and a low-carbohydrate diet containing 10% carbohydrates) with equal number of calories to healthy adults and subsequently performed an OGTT. The study revealed that all the subjects in the high-carbohydrate group demonstrated a normal pattern; in contrast, the glucose tolerance in the low-carbohydrate group worsened significantly; therefore, they warned that individuals consuming a “low-carbohydrate diet” prior to OGTT may be mis-diagnosed with impaired glucose tolerance. Takizawa et al. performed a similar study during pregnancy. We also studied whether the OGTT results are affected by the dietary content on the day prior to testing. It was apparent that the GDM pattern that was only observed during early pregnancy and prior to OGTT was attributable to the significantly low intakes of total food and carbohydrate. We speculate that the 5 cases demonstrating a GDM pattern only at early pregnancy would have displayed a normal pattern as seen at mid-pregnancy. Since the carbohydrate intake on the day prior to OGTT during early pregnancy was abnormally low, it is likely that these cases were mis-diagnosed. During early pregnancy the appetite, which results in an inadequate diet, often decreases due to factors such as physical discomfort and morning sickness.

The 3 cases diagnosed as that of GDM during mid-pregnancy exhibited a GDM pattern in early pregnancy as well. For these cases the car-
bohydrate intake on the day prior to the OGTT did not affect the OGTT responses; therefore, the OGTT results during early pregnancy are likely to be appropriate. Moreover, it also indicated that GDM diagnosis is possible during the early stages of pregnancy. This, however, requires accurate diagnosis by OGTT during early pregnancy. We suggest that if OGTT is to be performed during early pregnancy, pregnant women would have to take plenty of food (and over 488 kcal) and carbohydrate (and over 245 kcal).

REFERENCES


