

## An Appropriate Indicator for Diagnosing Gestational Diabetes

Jui-Hung Sun, MD; Lai-Chu See<sup>1</sup>, PhD; Tsung-Hong Chiu<sup>2</sup>, MD;  
T'sang-T'ang Hsieh<sup>2</sup>, MD; Miao-Ju Huang, MD

**Background:** This study was intended to simplify the diagnostic procedure for gestational diabetes mellitus (GDM) through using a single plasma glucose level, after a 100 g oral glucose tolerance test (OGTT), as the most appropriate indicator for diagnosing GDM in pregnant women with a positive 50 g, 1-hour oral glucose challenge test (GCT) in Northern Taiwan.

**Methods:** A total of 973 native Taipei metropolitan pregnant women with a positive GCT, who underwent a 100 g, 3-hour OGTT were retrospectively surveyed. GDM was defined according to the standards of National Diabetes Data Group. Plasma glucose levels, obtained 1 hour following a GCT and at multiple timing following a 100 g oral glucose load, were used to plot receiver operative characteristic curves to determine the most appropriate indicator for diagnosing GDM.

**Results:** In the 973 pregnant women with a positive GCT, a 2-hour plasma glucose level above 165 mg/dl revealed a sensitivity and specificity of 91.2% and 90.3%, respectively.

**Conclusions:** To simplify the diagnostic procedure for GDM, we suggest that a 2-hour plasma glucose level above 165 mg/dl after a 100 g OGTT might be an appropriate indicator for diagnosing GDM in women with a positive GCT. (*Chang Gung Med J* 2005;28:824-8)

**Key words:** Gestational diabetes mellitus, glucose challenge test, ROC curve, Taiwan.

Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance of varying degrees of severity with onset or first recognition during pregnancy.<sup>(1)</sup> The identification of GDM is necessary for the prevention of perinatal complications, such as macrosomia, birth trauma, and metabolic abnormalities for the neonate.<sup>(2-4)</sup> In addition, women with GDM are at higher risk for subsequent development of diabetes.<sup>(5)</sup> Although the importance of diagnosis and management of GDM is widely accepted, there is still uncertainty about the most effective screening

method.<sup>(6-13)</sup> Furthermore, due to the complexity of the oral glucose tolerance test (OGTT), some investigators have reported cheaper and easier methods to diagnose GDM.<sup>(14)</sup>

To simplify the diagnostic procedure for pregnant women with a positive 50 g, 1-hour oral glucose challenge test (GCT), we intended to use a single plasma glucose level at different timing following a 100 g oral glucose load as a standard for diagnosing GDM. Receiver operative characteristic (ROC) curves were constructed to identify the most appro-

From the Division of Endocrinology & Metabolism, Department of Internal Medicine, Chang Gung Memorial Hospital, Taipei; <sup>1</sup>Department of Public health, College of Medicine, Chang Gung University, Taoyuan; <sup>2</sup>Department of Obstetrics and Gynecology, Chang Gung Memorial Hospital, Taipei.

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Correspondence to: Dr. Miao-Ju Huang, Division of Endocrinology & Metabolism, Department of Internal Medicine, Chang Gung Memorial Hospital, 5, Fushing Street, Gueishan Shiang, Taoyuan, Taiwan 333, R.O.C. Tel: 886-03-3281200 ext. 8821 or 8491; Fax: 886-03-3288257; E-mail: huangmj@adm.cgmh.org.tw

ropriate result for assessing alternative and possibly more efficient methods of diagnosing GDM.

## METHODS

We retrospectively surveyed the information from computerized medical records of native Taipei metropolitan pregnant women that were native to Taipei who received screening for GDM at the Taipei Branch of the Chang Gung Memorial Hospital from March 2001 through February 2003. The gestational age was confirmed in all subjects by crown-rump length measurement during the first trimester. Women who either had a personal history of hyperglycemia or received medications known to affect glucose metabolism were excluded from this study.

Each subject underwent a GCT between 24 and 28 weeks of gestation. A venous blood sample for examining the glucose level was drawn 1 hour after intake of 50 g oral glucose load without regarding for the fasting or fed state. A positive GCT was defined as a venous plasma glucose level  $\geq 140$  mg/dl. Subjects with a positive GCT were recruited for a 100 g, 3-hour OGTT. According to the standards proposed by the National Diabetes Data Group, GDM was diagnosed when two or more venous plasma glucose values reached or exceeded the following threshold: fasting, 105 mg/dl; 1 hour, 195 mg/dl; 2 hour, 165 mg/dl; or 3 hour, 145 mg/dl.<sup>(15)</sup> The plasma glucose levels were measured by the glucose oxidase method (AU400, Olympus, Japan).

The demographic characteristics of subjects with GDM and subjects without GDM were compared. Subjects themselves reported their prepregnancy weight. The data were presented as mean  $\pm$  standard deviation and percentages. The continuous variables were analyzed by unpaired Student's *t*-test. Chi-Square or Fisher's exact test were used to evaluate categorical variables. Statistical significance was defined as  $p < 0.05$ .

The aim of this study was to simplify the current diagnostic algorithm for GDM. Therefore, ROC curves were made by plotting sensitivity versus one minus specificity for varied plasma glucose levels. Areas under the ROC curves were used to determine which plasma glucose level was the most appropriate indicator for diagnosing GDM. The statistical analysis was performed using the SPSS win 10.0 (SPSS

Inc, Chicago, Ill).

## RESULTS

A total of 973 subjects with a positive GCT result underwent a 100 g, 3-hour OGTT. The demographic features were as follows: the maternal age was  $32.4 \pm 4.2$  years old, the gestational age at delivery was  $38.4 \pm 1.4$  weeks, and the birth weight was  $3210.9 \pm 447$  g. Two hundred and seventeen cases were diagnosed as GDM, while the other 756 cases had normal glucose tolerance.

Table 1 shows the characteristics of subjects between different diagnostic categories. Cases with GDM were older with heavier prepregnancy weight and body mass index (BMI), and had a higher frequency of family history of diabetes mellitus.

Figure 1 shows the ROC curves of plasma glucose levels of a GCT and at different timing before and after 100 g glucose load. The area under curve was as follows: GCT, 0.725; fasting, 0.685; 1-hour, 0.919; 2-hour, 0.947; and 3-hour, 0.830. Comparison of the predictive ability demonstrated only the 2-hour plasma glucose level to be an adequate standard for diagnosing GDM. A 2-hour plasma glucose level above 165 mg/dl was the most powerful for detecting GDM, which revealed a sensitivity and specificity of 91.2% and 90.3%, respectively.

## DISCUSSION

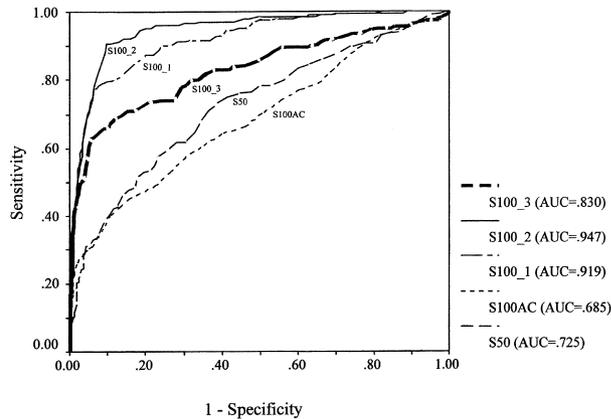
The conclusions from the Fourth International Workshop-Conference on GDM suggested general screening on high-risk populations using either a two-step (a GCT followed by a 100 g OGTT) or one-

**Table 1.** Demographic Characteristics of 973 Subjects with a Positive 50 g, 1-hour Glucose Challenge Test

	GDM (n = 217)	Non-GDM (n = 756)	<i>p</i> -value
Age at delivery (years)	33.6 $\pm$ 4.2	32.1 $\pm$ 4.1	< 0.0001
Body height (cm)	157.7 $\pm$ 5.3	159.4 $\pm$ 5.0	< 0.0001
Prepregnancy weight (kg)	57.4 $\pm$ 10.4	54.7 $\pm$ 8.8	0.014
Prepregnancy BMI (kg/m <sup>2</sup> )	22.9 $\pm$ 4.0	21.5 $\pm$ 3.3	< 0.0001
Parity	1.7 $\pm$ 0.8	1.6 $\pm$ 0.7	0.1
Family history of DM	92 (42%)	187 (24.8%)	< 0.0001

**Abbreviations:** GDM: gestational diabetes mellitus; BMI: body mass index.

The data were presented as mean  $\pm$  standard deviation.



**Fig. 1** The area under receiver operative characteristic (ROC) curve for the ability of plasma glucose in different timing after a 50 g, 1-hour oral glucose challenge test (GCT) and a 100 g, 3-hour oral glucose tolerance test (OGTT). S100\_2 was the most appropriate indicator of GDM with highest area under ROC curve (AUC) of 0.947 (95% confidence interval; 0.930~0.960). The cutoff of S100\_2 was 165 with sensitivity = 91.2% and specificity = 90.3%.

S50: the ROC curve for GCT.

S100AC: the ROC curve for fasting plasma blood glucose level before a 100 g, 3-hour OGTT.

S100\_1: the ROC curve for 1-hour plasma blood glucose level during a 100 g, 3-hour OGTT.

S100\_2: the ROC curve for 2-hour plasma blood glucose level during a 100 g, 3-hour OGTT.

S100\_3: the ROC curve for 3-hour plasma blood glucose level during a 100 g, 3-hour OGTT.

step approach (100 or 75 g OGTT) on all subjects as early in pregnancy as feasible.<sup>(1)</sup> Some researchers recommended that in high-risk populations all pregnancies can be susceptible to GDM and progress directly the diagnostic OGTT.<sup>(16)</sup> However, these steps are difficult in a clinical service setting due to time-consumption and large numbers of laboratory work load. Therefore, this study was designed to search for more practical alternatives to simplify the procedure for diagnosing GDM with satisfactory sensitivity and specificity.

Our result indicated that a 2-hour plasma glucose level above 165 mg/dl was identified as the most appropriate indicator for detecting GDM, which led to failure to diagnose in 8.8% of the cases of GDM in those pregnant women with a positive GCT. With omission of the 3-hour plasma glucose value after a 100 g OGTT, other investigators report-

ed missing of 13% of cases with GDM in pregnant women with a positive GCT.<sup>(14)</sup> Our method does not only have higher sensitivity, but also has a simpler diagnostic procedure. Moreover, a GCT result is more powerful than that of fasting blood glucose for detecting GDM (Fig. 1); therefore, we favor the use of a GCT for screening GDM.

In this research, there were 194 (16.6%) subjects, who failed to perform a 100 g OGTT. The results of another study revealed a similar situation.<sup>(11)</sup> A part of the reason for failure to receive an OGTT was probably due to the amount of time used during the diagnostic procedure. For the traditional two-step diagnostic procedure for GDM, the patient needed to spend at least 3 hours to complete the procedure and three needle punctures were needed for testing blood sugar. On the contrary, our suggestion could accomplish the diagnostic program with less time and fewer blood tests. Therefore, we recommend using a GCT plus a single 2-hour plasma sugar value after a 100 g OGTT to not only save time, but also markedly decrease laboratory workload. Although our method still missed 8.8% of cases with GDM, the rate might be reduced further through promoting the use of the 100 g OGTT after simplifying the diagnostic procedure. However, this inference needs a prospective study to confirm.

In terms of cost, this approach for diagnosing GDM saves about 4 US dollars for each subject. During 2003, 227070 term live births were delivered in Taiwan.<sup>(17)</sup> Although this figure probably underestimates the total pregnancies, more than 880000 US dollars would have been saved for that year through our method as a diagnosing procedure for GDM. Nevertheless, other authors drew attention to the unperceived expenses of the missed cases with morbidity or mortality.<sup>(18-20)</sup> Without prospective data on the undetermined costs of the cases that would have been missed by applying modified criteria to diagnose GDM, it is difficult to estimate such a cost analysis.

In summary, using a positive GCT result in combination with a plasma glucose level 2 hours following a 100 g OGTT to diagnose GDM, has the potential to reduce medical costs and laboratory workload and be more convenient for patients. However, the postpartum status including the maternal and fetal outcome was not reported in this study; therefore, whether such a trial has the beneficial

effects to prevent perinatal risks in GDM should be confirmed through a prospective study in the future.

## REFERENCES

1. Metzger BE, Coustan DR. Summary and recommendations of the fourth international workshop-conference on gestational diabetes mellitus. *Diabetes Care* 1998;21 (Suppl 2):B161-7.
2. Jacobson JD, Cousins L. A population-based study of maternal and perinatal outcome in patients with gestational diabetes. *Am J Obstet Gynecol* 1989;161:981-6.
3. Jang HC, Cho NH, Min YK, Han IK, Oh KS, Jung KB, Metzger BE. Gestational diabetes mellitus in Korea: increased macrosomia and morbidity without maternal obesity or advanced maternal age. *Diabetes* 1994;43 (Suppl 1):136A.
4. Langer O, Levy J, Brustman L, Anyaegbunam A, Merkatz R, Divon M. Glycemic control in gestational diabetes mellitus - how tight is tight enough: small for gestational age versus large for gestational age? *Am J Obstet Gynecol* 1989;161:646-53.
5. Metzger BE, Cho NH, Roston SM, Radvany R. Prepregnancy weight and antepartum insulin secretion predict glucose tolerance five years after gestational diabetes mellitus. *Diabetes Care* 1993;12:1598-1605.
6. Rust O, Bofill JA, Carroll SC, Cowan BD, Martin RW, Morrison JC. Two-hour postprandial test versus one-hour, fifty-gram glucola test as screening tools for gestational diabetes: a critical analysis. *J Perinatol* 1998;18:49-54.
7. Reichelt AJ, Spichler ER, Branchtein L, Nucci LB, Franco LJ, Schmidt MI. Fasting plasma glucose is a useful test for the detection of gestational diabetes. Brazilian Study of Gestational Diabetes (EBDG) Working Group. *Diabetes Care* 1998;21:1246-9.
8. Perucchini D, Fischer U, Spinass GA, Huch R, Huch A, Lehmann R. Using fasting plasma glucose concentrations to screen for gestational diabetes mellitus: prospective population based study. *BMJ* 1999;319:812-5.
9. Agarwal MM, Hughes PF, Punnoose J, Ezimokhai M. Fasting plasma glucose as a screening test for gestational diabetes in a multi-ethnic, high-risk population. *Diabet Med* 2000;17:720-6.
10. Hidar S, Chaieb A, Baccouche S, Laradi S, Fkih M, Milled A, Khairi H. Post-prandial plasma glucose test as screening tool for gestational diabetes: A prospective randomized trial. *J Gynecol Obstet Biol Reprod* 2001;30:344-7.
11. de Aguiar LG, de Matous HJ, de Brito Gomes M. Could fasting plasma glucose be used for screening high-risk outpatients for gestational diabetes mellitus? *Diabetes Care* 2001;24:954-5.
12. Sacks DA, Chen W, Wolde-Tsadik G, Buchanan TA. Fasting plasma glucose test at the first prenatal visit as a screen for gestational diabetes. *Obstet & Gynecol* 2003;101:1197-203.
13. Miyakoshi K, Tanaka M, Ueno K, Uehara K, Ishimoto H, Yoshimura Y. Cutoff value of 1 h, 50 g glucose challenge test for screening of gestational diabetes mellitus in a Japanese population. *Diabetes Res Clin Pract* 2003;60:63-7.
14. Atilano LC, Lee-Parriz A, Lieberman E, Cohen AP, Barbieri RL. Alternative methods of diagnosing gestational diabetes mellitus. *Am J Obstet Gynecol* 1999;181:1158-61.
15. National Diabetes Data Group: Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. *Diabetes* 1979;28:1039-57.
16. Diabetes and pregnancy. In ACOG Technical Bulletin 200. *Int J Gynaecol Obstet* 1995;48:331-9.
17. Department of Statistics, Ministry of Interior, Taiwan, R.O.C. Statistical yearbook of interior 2003, the Republic of China: population analysis 2004:25.
18. Reed BD. Screening for gestational diabetes: Analysis by screening criteria. *J Fam Pract* 1984;19:751-5.
19. Marquette GP, Klein VR, Repke JT, Niebyl JR. Cost-effective criteria for glucose screening. *Obstet Gynecol* 1985;66:181-3.
20. Massion C, O'Connor PJ, Gorab R, Crabtree BF, Nakamura RM, Coulehan JL. Screening for gestational diabetes in a high-risk population. *J Fam Pract* 1987;25:568-75.

# 妊娠糖尿病診斷之適當指標

孫瑞鴻 史麗珠<sup>1</sup> 邱宗鴻<sup>2</sup> 謝燦堂<sup>2</sup> 黃妙珠

**背景：**本研究之主要目的為簡化妊娠糖尿病之診斷程序。我們於台灣北部利用口服 50 公克葡萄糖一小時後血糖值超過 140 毫克/百毫升之懷孕婦女，接受口服 100 公克葡萄糖耐糖測試之結果加以分析，探討能夠診斷妊娠糖尿病之最適當單一血糖值。

**方法：**本研究是利用台北市 973 位口服 50 公克葡萄糖一小時後血糖超過 140 毫克/百毫升之懷孕婦女，同時接受口服 100 公克葡萄糖三小時耐糖試驗之結果，進行回顧性的分析。妊娠糖尿病之診斷以美國國家糖尿病資料群 (National Diabetes Data Group; NDDG) 之建議為基準。我們利用受試者動作特性曲線 (Receiver Operating Characteristic curve; ROC curve) 的方法，就不同時間的血糖 (口服 50 公克葡萄糖 1 小時後血糖值、空腹血糖值、口服 100 公克葡萄糖 3 小時耐糖試驗之血糖值) 加以比較，來決定診斷妊娠糖尿病之最適當單一指標。

**結果：**973 位口服 50 公克葡萄糖 1 小時後血糖超過 140 毫克/百毫升之懷孕婦女，在接受口服 100 公克葡萄糖 3 小時耐糖試驗中，以兩小時的靜脈血漿葡萄糖濃度超過 165 毫克/百毫升時，對妊娠糖尿病的診斷率最為理想，可以達到 91.2% 的敏感度及 90.3% 的專一度。

**結論：**就簡化妊娠糖尿病之診斷程序，我們建議對於一位口服 50 公克葡萄糖 1 小時後血糖超過 140 毫克/百毫升之懷孕婦女，在接受口服 100 公克葡萄糖耐糖試驗中，兩小時的靜脈血漿葡萄糖濃度超過 165 毫克/百毫升，可能是適用於診斷妊娠糖尿病的單一指標。

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**關鍵字：**妊娠糖尿病，葡萄糖耐糖試驗，ROC curve，臺灣。

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長庚紀念醫院 台北院區 新陳代謝科；<sup>1</sup>長庚大學 醫學院 公共衛生學科；<sup>2</sup>長庚紀念醫院 台北院區 婦產科

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通訊作者：黃妙珠醫師，長庚紀念醫院 新陳代謝科。桃園縣333龜山鄉復興街5號。Tel.: (03)3281200轉8821; Fax: (03)3288257; E-mail: huangmj@adm.cgmh.org.tw