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The Obstetric and Neonatal Implications of a Low Value on the 50-g Glucose Screening Test

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Abstract

Objective—To assess the relationship between a low 50-g 1-hour glucose loading test (GLT) and maternal and neonatal outcomes in women without diabetes.

Study Design—This was a secondary analysis of a multicenter observational cohort from a randomized trial of treatment for mild gestational diabetes. Maternal and neonatal outcomes were compared between women with GLT values < 90 mg/dL and those with results 90 to 119 mg/dL.

Results—Of 436 enrolled women, 297 (68.1%) had a GLT result of 90 to 119 mg/dL and 139 (31.9%) had a result of < 90 mg/dL. There was a lower incidence of neonatal hypoglycemia in those with a GLT < 90 mg/dL (5.7% versus 16.5%, $p = 0.006$). Other outcomes were not associated with test results.

Conclusion—A GLT result < 90 mg/dL compared with 90 to 119 mg/dL is associated with a lower risk of neonatal hypoglycemia, but no other significant findings.

Keywords

low glucose screening test; neonatal hypoglycemia

Gestational diabetes mellitus (GDM) affects 2 to 5% of pregnancies depending on the population; some groups have an incidence as high as 14%.^{1,2} The American College of Obstetricians and Gynecologists states all pregnant women should be screened for GDM either by history, clinical risk factors, or laboratory screening tests.³ Several recent large studies have evaluated the effects of maternal hyperglycemia and pregnancy outcomes. These trials demonstrated treatment of even mild GDM reduced the risks of fetal macrosomia, large-for-gestational-age infants, shoulder dystocia, cesarean delivery, and hypertensive disorders.^{4,5}

There have been fewer research studies examining the impact of maternal hypoglycemia on pregnancy outcomes, but this could potentially impact fetal growth. Several placental hormones including growth hormone, corticotropin-releasing hormone, chorionic somatomammotropin, and progesterone contribute to insulin resistance in pregnancy. Cytokines and tumor necrosis factor- α also contribute to insulin resistance in pregnancy.⁶ Metabolic changes in pregnancy reflect a patient's pregravid metabolic status, and therefore the glucose loading test (GLT) may give insight on metabolic profiles outside of pregnancy.⁷

Altered glucose production and insulin resistance have been studied in hyperglycemic pregnancy states and their relationship to maternal and neonatal outcomes, but less is known about the converse state. Table 1 shows a summary of previous work examining hypoglycemia and the outcomes. Early studies stratified study and control groups by those with intrauterine growth restriction or low-birth-weight infants and then studied their glucose test results.^{8–10} More recent studies have looked at outcomes of those with mild hypoglycemia, but both studies included those with elevated values on the glucose test in their control group.^{11,12} However, women with even a single abnormal value on the glucose tolerance test are at risk for macrosomia, neonatal morbidity, cesarean delivery, and preeclampsia, which could complicate the comparison between a low GLT value and other values.^{13,14} The objective of this study was to evaluate the relationship between a low value (less than 90 mg/dL) on the maternal GLT and maternal and neonatal morbidity outcomes compared with women with a GLT value 90 to 119 mg/dL.

Materials and Methods

Design

This was a secondary analysis of a *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network multicenter observational cohort assembled alongside a randomized controlled trial of treatment for mild gestational diabetes.⁴ Patients were recruited from October 2002 to mid-November 2007.

This cohort included all women between 24 weeks 0 days and 30 weeks 6 days of gestation with a serum value less than 120 mg/dL 1 hour after a 50-g GLT. Ultrasonography was performed in all subjects prior to the oral glucose screening test to confirm gestational age.

In the original study, four populations were studied. The first population consisted of women with a diagnosis of mild GDM who were randomized to treatment of GDM. The second population also had a diagnosis of mild GDM, but instead was randomized to routine prenatal care. The third population consisted of women who had a glucose value between 135 and 200 mg/dL 1 hour after a 50-g GLT but had a normal subsequent 3-hour 100-g glucose tolerance test. These women were matched with the GDM randomized women, with respect to race/ethnicity and body mass index (BMI) dichotomized as less than 27 or 27 and more. The fourth population was an observational cohort that consisted of women with a glucose value less than 120 mg/dL after a 50-g GLT and thus unlikely to have GDM. These women were also matched to the randomized group by race/ethnicity and BMI category, continued routine prenatal care, and did not receive any treatment for GDM. This last population was the cohort studied in the current analysis. Women with values between 120 and 135 mg/dL were not recruited into the original study to limit false-negatives for GDM.

Exclusion criteria were preexisting diabetes, an abnormal result on a glucose screening test prior to 24 weeks of gestation or prior GDM; a history of stillbirth, multifetal gestation, asthma, chronic hypertension, or corticosteroid use; a known fetal anomaly; or if imminent or preterm delivery was likely because of maternal disease or fetal conditions.

The records of all enrolled women and their infants were reviewed at the time of their discharge from the hospital, and information regarding antepartum, intrapartum, and postdelivery complications was recorded.

Data

Maternal demographic characteristics, including maternal age, race, tobacco use, alcohol use, and obesity were examined. Obesity was defined as a prepregnancy BMI greater than or equal to 30 kg/m². Maternal outcomes such as weight gain from the time of study enrollment were recorded. Labor and delivery characteristics such as type of labor (induced, augmentation, or spontaneous) and mode of delivery and maternal morbidity such as presence of preeclampsia, gestational hypertension, or abruption were analyzed. All cases of hypertensive disorders underwent masked central review by two of the authors to ensure that the diagnoses were accurate.

Neonatal blood for glucose determination was collected for all neonates, if possible, within 2 hours of birth and before first feeding. Hypoglycemia was defined as a glucose value less than 35 mg/dL.¹⁵ Small for gestational age was defined as birth weight less than the 10th percentile of a U.S. reference population. Large for gestational age was defined as birth weight above the 90th percentile of a U.S. reference population.¹⁶ Birth weight percentiles were generated using a customized growth standard.¹⁷ Serum bilirubin was determined between 16 and 36 hours after birth for all neonates, if possible. A bilirubin value greater than the 95th percentile was considered to be an elevated level.¹⁸ Data were collected on

gestational age at birth, birth weight, birth length, admission to the neonatal intensive care unit (NICU), and various neonatal morbidities.

Statistical Analysis

Maternal and neonatal outcomes were compared between women with values in the lowest tertile (< 90 mg/dL) and those with higher screening results (90 to 119 mg/dL). The threshold of 90 mg/dL was chosen as there has been previous work suggesting women with GLT values less than 90 mg/dL were at risk for fetal growth restriction and neonatal intensive care admissions.^{11,12} Additionally, subgroup analyses were conducted by 10-mg/dL increments.

Obstetric and neonatal outcomes were compared between groups. Categorical variables were analyzed using the chi-square test or Fisher exact test. Continuous variables were analyzed using the Wilcoxon rank sum test or the Kruskal-Wallis test. The Cochran–Armitage test was used to test for trends between GLT level in 10-mg increments and neonatal hypoglycemia.¹⁹ Receiver operating characteristic (ROC) curves were generated to look at the ability of the GLT to predict outcomes.

A result was considered statistically significant if the p value was less than 0.05 and no adjustments were made for multiple comparisons. Analyses were performed with SAS statistical software (SAS Institute Inc, Cary, NC).

All women who participated in the study provided written informed consent. The primary study was approved by the human subjects committee at each participating center. Institutional Review Board approval was received for this secondary analysis prior to study initiation.

Results

Four hundred thirty-six women were enrolled into the cohort. One hundred thirty-nine women (31.9%) had a GLT result < 90 mg/dL and 297 (68.1%) had a test result of 90 to 119 mg/dL. There were no significant differences in the demographic characteristics between the two groups except GLT value (Table 2, $p = 0.0001$).

There were no significant differences in maternal outcomes between the groups (Table 3). No significant difference in the incidence of gestational hypertension/preeclampsia was seen in those with a GLT < 90 mg/dL compared with those who had a GLT < 90 mg/dL ($p = 0.16$).

The neonatal outcomes are summarized in Table 4. Although not significant, there was a trend toward increased small-for-gestational-age infants ($p = 0.10$) and NICU admissions ($p = 0.11$) in the group with a GLT < 90 mg/dL. Examination of the mean birth weight did not show a difference between the two groups ($p = 0.94$). There was a significantly lower incidence of neonatal hypoglycemia (glucose < 35 mg/dL within 2 hours of birth) in those with a GLT < 90 mg/dL (5.7% versus 16.5%, $p = 0.006$). Examination by 10-mg increments showed a trend of increasing neonatal hypoglycemia with higher GLT value ($p = 0.011$, test for trend, Table 5). There were no differences in neonatal hyperbilirubinemia between the

two groups: GLT < 90 mg/dL or GLT ≥ 90 mg/dL. There were also no differences in hyperbilirubinemia when the cohort was examined in 10-mg increments (Table 6). An ROC curve was generated for further sensitivity analysis to compare whether the GLT could predict neonatal hypoglycemia. The area under the curve was 0.63 (0.54, 0.72), indicating GLT was a modest predictor of neonatal hypoglycemia.

Discussion

Although our study did not find a correlation between a low value on maternal GLT and maternal morbidity, neonatal outcomes were affected. Most significant is the difference between the rates of neonatal hypoglycemia in these groups despite similar rates of large-for-gestational-age infants in both groups. Although we found a trend toward small-for-gestational-age infants in women with a GLT < 90 mg/dL compared with those with a GLT 90 to 119 mg/dL, this was not statistically significant ($p = 0.10$). This trend corroborates previous research indicating neonatal morbidity with maternal hypoglycemia on GLT.^{8,12} In animal studies, maternal hypoglycemia during pregnancy has been associated with a decrease in fetal glucose, an increase in protein breakdown, and an increase in oxidative metabolism. These factors contribute to slower rates of fetal growth and decreased fetal insulin.²⁰

Previous work suggested mildly low GLT values were associated with NICU admissions. However, the etiology of increased NICU admissions was unclear, although it was hypothesized it could be due to an increased rate of neonatal hypoglycemia.¹² Our study did not confirm an increased risk for NICU admissions with a lower GLT value. However, the previous work included women with an abnormal GLT but normal 3-hour 100 g glucose tolerance test, which is not reflective of the population in this study.

The rate of neonatal hypoglycemia is estimated to be 10% in normal term infants.²¹ This is consistent with the overall rate of neonatal hypoglycemia in this cohort (10.1%). It is plausible with a lower GLT value, relative fetal and neonatal hyperinsulinemia is reduced, therefore making neonatal hypoglycemia less common. Divided into 10-mg/dL increments, there was a trend toward increasing rates of neonatal hypoglycemia with increasing GLT value.

These results are similar to the Hyperglycemia and Adverse Pregnancy Outcomes (HAPO) study.⁵ In the HAPO study, participants underwent a 2-hour, 75-g oral glucose tolerance test; glucose values were then compared with maternal and neonatal outcomes. An increasing 1-hour glucose value was associated with an increased risk of clinical neonatal hypoglycemia in the HAPO study. Although the rate of clinical neonatal hypoglycemia in the HAPO trial was 2.1%, which is lower than this study, the trend was similar in both groups.

Our results concerning neonatal hypoglycemia must be interpreted with caution. Despite a difference in rates of neonatal hypoglycemia, there were no significant differences between NICU admissions between the groups, suggesting limited clinical consequences associated with this finding. Additionally, infants had to be tested prior to the neonate's first feeding

and within 2 hours of birth, and therefore not all infants in the cohort were tested for neonatal hypoglycemia. However, routine postnatal care typically only tests neonatal glucose values for a clinical indication and it is recommended to continue this practice until further studies can be performed.

In regards to sample size, if the odds ratio for an adverse outcome associated with hypoglycemia (GLT < 90) was 2.0, and the proportion with the outcome in the group with GLT 90 to 119 was 0.20, then the power is 84%. However, our cohort may have been underpowered for less common outcomes or for more modestly increased odds ratios. Given this cohort was a secondary analysis of an observational cohort, enrollment was fixed and limited to primary study. Additionally, we acknowledge the majority of the cohort studied was Hispanic, and therefore these results may not be applicable or representative of the general population.

In summary, our study revealed that among women with a GLT < 120 mg/dL between 24 and 30 weeks of gestation, a result < 90 mg/dL is associated with a lower risk of neonatal hypoglycemia but not with any adverse maternal or neonatal outcomes. Future studies may determine whether even lower screening glucose values in women without diabetes have a greater impact on neonatal outcomes and possible long-term effects.

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Table 1

Summary of previous work examining the effects of maternal hypoglycemia

Author	Number of study subjects	Study group characteristics	Number of control subjects	GTT test	Outcome	Comments
Khouzami, 1981 ⁸	22	Low birth weight or adequate birth weight with a low Ponderal Index	100	100-g oral GTT for 3 h	No statistically significant differences in hypoglycemia between control and IUGR group	Groups stratified by low birth weight; GTT performed 26–40 wk gestation
Langer, 1986 ⁹	20	Risk factors for intrauterine growth restriction: poor fundal growth, previous small-for-gestation-age infant, hypertension, and/or tobacco use	23	100-g oral GTT for 4 h	Glucose index < 105 mg/dL may predict IUGR	Groups stratified by risk factors for growth restriction; test performed 33–35 wk gestation
Piper, 1996 ¹⁰	36	Risk factors for growth restriction and/or hypertension	49	100-g oral GTT for 3 h	Lower glucose index in patients who were normotensive but had risk factors for growth restriction	Groups stratified by risk factors for growth restriction
Feinberg, 2005 ¹²	334	1-h value < 88 mg/dL	334	50-g glucose loading test	Increased special/neonatal intensive care unit admissions in hypoglycemic group	Control subjects included those with elevated 50-g glucose screening test
Weissman, 2005 ¹¹	51	Fasting, 1-h, 2-h, or 3-h value 50 mg/dL	754	100-g oral GTT for 3 h	Lower incidence of gestational diabetes and neonatal birth weight in hypoglycemic subjects	All subjects with elevated 50-g glucose screening test prior to 100-g GTT

Glucose index = sum of all postglucose values – fasting glucose. Abbreviations: GTT, glucose tolerance test; IUGR, intrauterine growth restriction.

Table 2

Characteristics by maternal GLT value

Characteristics	GLT < 90 mg/dL (<i>n</i> = 139)	GLT 90–119 mg/dL (<i>n</i> = 297)	<i>p</i> Value
Age, y (SD)	25.4 (5.5)	25.0 (5.3)	0.47
Nulliparous, <i>n</i> (%)	45 (32.4)	117 (39.4)	0.16
Race/ethnicity			0.36
African-American, <i>n</i> (%)	13 (9.4)	43 (14.5)	
Caucasian, <i>n</i> (%)	41 (29.5)	77 (25.9)	
Hispanic, <i>n</i> (%)	84 (60.4)	171 (57.6)	
Other, <i>n</i> (%)	1 (0.7)	6 (2.0)	
Smoking, <i>n</i> (%)	9 (6.5)	25 (8.4)	0.48
Alcohol use, <i>n</i> (%)	3 (2.2)	10 (3.4)	0.76
BMI, prepregnancy			0.11
< 18.5 kg/m ² (underweight), <i>n</i> (%)	1 (0.8)	7 (2.5)	
18.5–24.9 kg/m ² , <i>n</i> (%)	64 (49.2)	131 (47.5)	
25–29.9 kg/m ² (overweight), <i>n</i> (%)	47 (36.2)	75 (27.2)	
30–39.9 kg/m ² (obesity), <i>n</i> (%)	16 (12.3)	54 (19.6)	
40 kg/m ² (morbid obesity), <i>n</i> (%)	2 (1.5)	9 (3.3)	
GLT value, mg/dL (SD)	78.9 (8.4)	105.8 (8.5)	0.0001

Abbreviations: BMI, body mass index; GLT, glucose loading test; SD, standard deviation.

Table 3

Maternal outcomes by GLT value

Outcome	GLT < 90 mg/dL	GLT 90–119 mg/dL	<i>p</i> Value
Weight gain, kg (SD)	5.05 (5.0)	5.08 (3.6)	0.69
Spontaneous labor, <i>n</i> (%)	63 (47.4)	116 (40.1)	0.16
Cesarean delivery, <i>n</i> (%)	32 (24.1)	72 (24.9)	0.85
Gestational hypertension/preeclampsia, <i>n</i> (%)	6 (4.5)	24 (8.3)	0.16
Abruption, <i>n</i> (%)	1 (0.75)	4 (1.4)	>0.99 ^a

Abbreviation: GLT, glucose loading test; SD, standard deviation.

^a Fisher exact two-sided test.

Table 4

Neonatal outcomes by GLT value

Outcome	GLT < 90 mg/dL	GLT 90–119 mg/dL	<i>p</i> Value
Gestational age at delivery, wk (SD)	39.5 (1.4)	39.3 (1.6)	0.68
Birth weight, g (SD)	3352 (469)	3332 (459)	0.94
Birth weight percentile ^a	50.3 $\pm$ 9.2	49.4 $\pm$ 8.5	0.76
Large for gestational age, <i>n</i> (%)	11 (8.3)	17 (5.9)	0.36
Small for gestational age, <i>n</i> (%)	12 (9.0)	14 (4.8)	0.10
Ponderal index (SD)	2.71 (0.25)	3.02 (3.34)	0.97
NICU admissions, <i>n</i> (%)	13 (9.8)	16 (5.5)	0.11
Neonatal hypoglycemia, <i>n</i> (%)	6 (5.7)	38 (16.5)	0.006
Neonatal hyperbilirubinemia, <i>n</i> (%)	13 (10.8)	26 (9.4)	0.66

Abbreviations: NICU, neonatal intensive care unit; SD, standard deviation.

^a Gardosi J, Francis A. A customized standard to assess fetal growth in a US population. *Am J Obstet Gynecol* 2009;201:25.e1–7.¹⁷

Table 5Neonatal hypoglycemia stratified by GLT value^a

GLT Value (mg/dL)	Patients (n)	Cases	Rate of Neonatal Hypoglycemia (%)
< 80	50	3	6.0
80–89	56	3	5.4
90–99	65	9	13.9
100–109	84	13	15.5
110–119	82	16	19.5

$p = 0.011$, test for trend. Abbreviations: GLT, glucose loading test.

^aNinety-nine neonates did not have neonatal glucose levels measured.

Table 6Neonatal hyperbilirubinemia stratified by GLT value^a

GLT value (mg/dL)	Patients (<i>n</i>)	Cases	Rate of neonatal hyperbilirubinemia (%)
< 80	53	4	7.5
80–89	67	9	13.4
90–99	75	2	2.7
100–109	103	11	10.7
110–119	98	13	13.3

$p = 0.38$, test for trend. Abbreviations: GLT, glucose loading test.

^aForty neonates did not have neonatal bilirubin levels measured.