ABSTRACT

Objective: To screen for gestational diabetes mellitus in outpatients, with 50 g oral glucose load, comparing capillary (reflectance) and venous plasma (enzymatic) glucose. Methods: A cross-sectional clinical trial was conducted on 325 pregnant women, between 24 and 28 weeks gestation. The screening cutoff value was \( \geq 130 \) mg/dl and, at this value or greater, the oral glucose tolerance test with 100 grams glucose was performed. This test was interpreted according to the National Diabetes Data Group and Carpenter and Coustan criteria. A control group of 92 pregnant women with the diagnosis of gestational diabetes mellitus was the reference for comparing the time elapsed between screening and diagnosis. For the statistical analysis, the Pearson correlation coefficient and the Student’s \( t \) test were utilized. Results: The 50 g glucose screening tests using venous and capillary blood were correlated. Capillary blood glucose screening yielded a greater number of diagnoses, with a significant increase in false positive results. Mean capillary blood glucose was 11% greater than mean venous plasma glucose in 82.7% (269/325) of the pregnant women. The time elapsed between screening and diagnosis ranged from 2 to 72 days, and the mean time elapsed when capillary blood glucose was utilized was 15.4 days, while that for the control group when venous plasma glucose was used was 32.5 days (\( p < 0.05 \)). Conclusion: Utilization of capillary blood glucose, maintaining the cutoff point of 130 mg/dl, increased the number of diagnoses of gestational diabetes mellitus, although it yielded greater number of false positive results. The time elapsed between screening and diagnosis was reduced by the use of capillary blood glucose.

Keywords: Diabetes mellitus; Diabetes, gestational; Public health; Diagnosis

RESUMO

Objetivo: Rastreamento do diabete melito gestacional em nível ambulatorial, com sobrecarga de 50 gramas de glicose, comparando a dosagem da glicemia capilar por reflectância com a glicemia plasmática venosa por método enzimático. Métodos: Realizou-se um estudo clínico transversal com 325 gestantes preferentemente entre 24 e 28 semanas de gestação. Rastreamento com valor de corte para positividade \( \geq \) 130 mg/dl, solicitou-se para diagnóstico o teste oral de tolerância à glicose com sobrecarga de 100 gramas de glicose, interpretado segundo o critério do National Diabetes Data Group e o de Carpenter e Coustan. Um grupo controle de 92 gestantes com diagnóstico de diabete melito gestacional foi referência para comparar o tempo decorrido entre o rastreamento e o diagnóstico. Para a análise estatística foi utilizado o coeficiente de correlação de Pearson e o teste \( t \) de Student. Resultados: O rastreamento com sobrecarga, realizado com a glicemia venosa e com a glicemia capilar, mostrou que existe correlação entre elas. Ao utilizar o rastreamento com a glicemia capilar, mais diagnósticos foram feitos, com aumento significativo dos falsos-positivos. A média da glicemia capilar foi 11% maior que a glicemia plasmática venosa em 82,7% (269/325) das gestantes. O tempo decorrido entre o rastreamento e o diagnóstico variou de dois a 72 dias, sendo que a média de dias quando se usou a glicemia capilar foi de 15,4 dias, e a média no grupo controle ao se utilizar a glicemia plasmática venosa foi de 32,5 dias (\( p < 0,05 \)). Conclusão: A utilização da glicemia capilar pelo método da reflectância, com manutenção do ponto de corte de 130 mg/dl, aumenta o número de diagnósticos do diabete melito gestacional, embora determine um número maior de falsos-positivos. O tempo decorrido entre o rastreamento e o diagnóstico foi reduzido com a utilização da glicemia capilar.

Descritores: Diabetes mellitus; Diabetes gestacional; Saúde pública; Diagnóstico
INTRODUCTION

Gestational diabetes mellitus (GDM) corresponds to approximately 90% of cases of diabetes in pregnancy and refers to carbohydrate intolerance of different intensities, which starts or is first recognized during pregnancy (1).

Taking into account the possibility of perinatal harm due to GDM, most of which is preventable when the diagnosis is timely made, its systematic surveillance has become necessary in Perinatal Public Health.

Screening and diagnosing GDM have controversial points. For this reason, the different services rendering obstetric and neonatal care have diverse approaches regarding the problem, which generates unequal reporting on the prevalence of GDM and frequency of fetal morbidity.

The method for screening should, ideally, be simple, inexpensive, with high sensitivity and reproducibility, and allow the early referral for definitive diagnostic procedures.

Screening may be universal (2), done in every pregnant woman, or selective, targeted to the pregnant women having any risk factor for diabetes (3).

It may be done at the first prenatal visit, especially when there are risk factors, or between the 24th and the 28th weeks of gestation (4), when insulin resistance is major and, diagnosing it and beginning treatment then, seem to optimize beneficial outcomes for the mother and the fetus.

Screening by measuring fasting glucose levels is controversial (5-7). Some authors recommend measuring glucose levels after an oral glucose load of 75 grams, with what screening and diagnosing are achieved in a single step (8). However, the most widely used screening test measures blood glucose one hour after a 50 g oral glucose load. This test does not require fasting, despite the oral glucose load (9). Some controversy exists on what the cutoff point should be. The lower the cutoff point, the higher the sensitivity and lower the specificity.

Measuring glucose in capillary blood by the reflectance method using a glucometer is accepted for assessing the glucose profile during the follow-up of pregnant women with diabetes (10). As it is a mixture of arterial and venous bloods, capillary blood glucose levels are 10 to 15% higher than the venous plasma levels after a glucose load or post-prandially (11). The fasting values are similar.

OBJECTIVE

The objective of this study is to compare capillary blood and venous plasma glucose levels in GDM screening done on the same day of the routine prenatal visit.

METHODS

The study was conducted at the Prenatal Outpatient Clinic of Hospital do Servidor Público Estadual Francisco Morato de Oliveira (HSPE), in São Paulo, Brazil, between May 2002 and February 2003. This clinical trial involved 325 pregnant women screened for diabetes with a 50 g glucose load after their routine prenatal visit.

The age of the pregnant women ranged between 13 and 46 years, 12% younger than 20 years; 50% between 20 and 30 years; 36% between 30 and 40 years, and 1% older than 40 years. Most were Caucasian (76%), and 43.6% were primigravida.

Pregnant women in prenatal follow-up, with gestational ages ranging from 24 and 28 weeks, were referred by their physicians to a previously designated room for interviewing and enrollment in the study. Whenever risk factors for GDM were identified, the referral was made irrespective of the gestational age.

Thus, 310 (95.3%) 24-28 week pregnant women and 15 (4.6%), less than 24 week composed the sample. Those with prior diagnosis of diabetes were excluded.

The following were considered as risk factors: obesity, family history of diabetes mellitus, history of glucose intolerance, fetal macrosomy in previous pregnancies, glycosuria, fetal malformations and fetal loss (12).

After being told about the importance of the project, each pregnant woman read and signed an informed consent. A study protocol form was then started. All tests were done in the morning.

For the screening test, glucose was measured in blood drawn one hour after the ingestion of 50 g of anhydrous glucose, diluted in 100 ml water with a small amount of citric acid to improve the taste. Fasting was not required.

The women were told not to leave the area, not to eat or drink and not to smoke. One hour later, venous blood was drawn from the left antecubital region into vacuum tubes and stored in sodium fluoride. After labeling, the sample was forwarded to the Central Laboratory, where venous plasma glucose was determined by the hexokinase enzymatic method (13).

Capillary blood was obtained by finger-pricking with an insulin needle the right middle finger, previously washed with water and soap. A drop of blood was placed on the reagent strip and capillary blood glucose was read immediately in the Accu-Chek II (Roche-Advantage®) glucometer by the reflectance method (14).

Whenever the capillary blood and/or the venous plasma glucose levels were ≥130 mg/dl, an oral glucose tolerance test (OGTT) with 100 g glucose load was done, ordered on the day the capillary blood test was done and later, when the venous plasma results were available.
The women needing an OGTT were instructed, at the Central Laboratory, to eat a carbohydrate-rich diet in the three days preceding the test and to observe fasting for at least 8 hours before it was performed. After the fasting venous blood sample was drawn, they ingested 100 g of glucose, and blood was drawn at 1, 2 and 3 hours thereafter. Glucose was assayed by the hexokinase enzymatic method.

GDM is diagnosed when two or more values in the OGTT are greater than the reference ones, according to the 1979 National Diabetes Data Group (NDDG) criteria and to the 1982 Carpenter and Coustan criteria, both recognized by the American College of Obstetricians and Gynecologists (chart 1). The prevalence calculations took the two criteria into consideration.

Of the pregnant women with abnormal screening tests, that is, with blood glucose $\geq 130$ mg/dl (7.2 mMol/L) one hour after a 50 g oral glucose load, 25 did not undergo the 100 g glucose OGTT and were excluded from the final sample. Among the remaining 300 patients, 93 underwent OGTT. The results were stored in a database.

The time elapsed between screening and performing the diagnostic test was compared between the study group and a control group composed of 92 pregnant women who had GDM diagnosed at this hospital in the previous period (1997-1998), when routine screening was done after the prenatal visit, at the laboratory. When abnormal, the OGTT was ordered, also in a routine visit.

The Pearson correlation coefficient and the Student’s $t$ test, when necessary, were used to compare both methods.

**RESULTS**

Three hundred and twenty-five pregnant women underwent screening, and 118 had capillary blood glucose and/or venous plasma glucose levels $\geq 130$ mg/dl (7.2 mMol/L). Twenty-five of them did not return to get an OGTT and were excluded from the analysis (figure1).

Of the 93 women who underwent an OGTT, 62 (66.7%) had both abnormal, capillary blood and venous plasma glucose levels on screening ($\geq 130$ mg/dl); 30 (32.2%) had only abnormal capillary blood glucose and one (1.1%), abnormal venous plasma glucose.

In 82.8% (269/325) of women, the capillary blood glucose levels were higher than the venous plasma ones; in 15.1% (49/325), the venous plasma glucose levels were higher and in 2.1% (7/325) the values were alike.

Mean capillary blood glucose measured with glucometer was 11% higher than mean venous plasma glucose assayed by the hexokinase enzymatic method (120.5 ± 27.3 mg/dl and 108.5 ± 26.6 mg/dl, respectively).

Comparing the two screening methods interpreted according to the NDDG and the Carpenter and Coustan criteria, the OGTT identified DGM as plotted in figure 1.

Regarding risk factors, 19.3% (58/300) of women had one or more risk factors. Of these, 51.7% (30/58) underwent the 100 gram OGTT. In 63.6% (7/11), GDM was diagnosed according to the NDDG criteria, and in 59.1% (13/22), according to the Carpenter and Coustan criteria.

The mean number of days elapsed between screening and the definitive diagnosis was 15.4 days in the study group and 32.5 days in the control group ($p < 0.05$).

With this study design, 71% of women underwent the screening and diagnostic tests with up to 20-day interval. In the control group, 85% of women performed the two tests with an interval greater than 20 days (figure 2).

In the present study, the prevalence of GDM ranged as below:

- 2.6% with venous plasma glucose screening and the NDDG criteria
- 5.6% with venous plasma glucose screening and the Carpenter and Coustan criteria;
- 3.6% and 7.3%, respectively, with capillary blood glucose screening.

Positive correlation existed between capillary blood glucose measured with reflectance and venous plasma glucose measured by the hexokinase enzymatic method (figure 3).

With capillary blood glucose, there were 27.0% false positive results (81/300) by the NDDG criteria and 23.3% (70/300) by the Carpenter and Coustan criteria. Screening with venous plasma glucose assayed by the hexokinase enzymatic method, there were 18.3% (55/300) and 15.3% (46/300) false positive results, according to the NDDG and the Carpenter and Coustan criteria, respectively (figure 1).
Outpatient screening for gestational diabetes mellitus

The purpose of this study, performed in pregnant women undergoing a 50 g glucose load screening for GDM, was to assay blood glucose by the reflectance method using the Accu-Chek II glucometer, as outpatients, and to verify the possible advantages and/or disadvantages relative to the venous plasma glucose screening test.

Of notice, 63.6% (207/325) of the screening tests were negative. Dacus et al. found 86.8% (205/236) of 236 pregnant women with negative screening tests, using the cutoff point of 140 mg/dl. If this cutoff point were employed in the present study, 70.8% (245/325) negative screenings would have been found. It is worth emphasizing that 21.1% (25/118) of women with abnormal screening tests did not undergo the 100 g glucose OGTT. The above quoted authors found 12.9% (4/31).

Mean capillary blood glucose was 11% higher than mean venous plasma glucose, similar to what was found by Murphy et al., that is, 12% (18). After glucose load, the capillary blood glucose not always surpassed venous plasma glucose, although this was true in 82.7% of cases.

When screening with capillary blood glucose in 300 pregnant women, a 32.2% excess diagnostic tests (OGTT) were performed compared to those performed after venous plasma glucose screening, that is, 92 versus 63 exams. By using the cutoff point of 140 mg/dl, Carr et al. performed 29.2% excess diagnostic tests (19).

In contrast to what was found by Weiner et al. (20), who missed a few diagnoses in pregnant women with slight glucose intolerance through capillary blood screening, in the present sample, GDM was diagnosed in three additional women (27%) according to the NDDG and in five additional ones (22.7%) according to the Carpenter and Coustan criteria (16) (figure 1). Dacus et al., when using the cutoff point of 140 mg/dl, had 82.6% sensitivity and 98.1% specificity. (17) Murphy et al., when using the cutoff point of 155 mg/dl, found 81% sensitivity and 74% specificity, with 9% false positive results (18).

DISCUSSION

Figure 1. Results of GDM screening and diagnosis by capillary and venous glucose levels

Figure 2. Time elapsed between screening and diagnosis of GDM in the Study group (n = 93) vs. Control group (n = 92)

Figure 3. Graphic distribution (plotting) of venous and capillary glucose levels of 325 pregnant women. Pearson correlation coefficient
The cutoff point of 155 mg/dl is also suggested by Meriggi et al. when using the reflectance method\(^{(21)}\).

Weiner et al.\(^{(20)}\) calculated, by means of regression analysis, the equivalence of the venous plasma and capillary blood glucose cutoff points, of 140 mg/dl and 150 mg/dl, respectively. They observed high sensitivity (89%), and concluded it was a feasible and cost effective method.

In the present study, the cutoff point of 130 mg/dl was used, but it could be observed that capillary blood glucose was higher than venous plasma glucose, pointing to the importance of increasing such cutoff point and thus reducing the number of false positive results.

On the other hand, the number of false positive results was higher with the reflectance method compared to the venous plasma method, of 27% and 18.3%, respectively, according to the NDDG\(^{(15)}\) criteria and of 23% and 15.3%, according to the Carpenter and Coustan\(^{(16)}\) criteria.

These two diagnostic criteria were compared, to assess the significance of the differences found, because if in the one hand such criteria are recognized and used according to the experience or convenience of the health service, on the other hand, the difference in prevalence and in incidence in a certain population may be significant.

By screening at the prenatal routine visit and obtaining instant results, the OGTT may also be ordered immediately, thus promoting earlier diagnosis (figure 2).

One may infer, by analyzing these data, that early diagnosis is more likely when screening is done at the first visit. Also, one must consider the practical aspects of the reflectance method.

As fasting blood glucose is the screening method recommended by the Ministry of Health\(^{(22)}\) and as fasting capillary and venous blood glucose levels are equivalent, outpatient screening with capillary blood glucose may be a tool for the early, low cost and highly reproducible diagnosis of GDM.

Although not an objective of this study, it was observed that most of the screening tests (95.3%) were carried out in the second trimester of pregnancy, between 24-28 weeks of gestation. Of notice, the proportion (4.7%) of pregnant women screened in the first trimester was smaller than the proportion of pregnant women having any risk factor (19.6%). This occurred because pregnant women with risk factors were not referred for screening in the first trimester.

Early diagnosis of GDM is important for follow-up and intervention during pregnancy, and the maternal-fetal morbidity is reduced in normoglycemic pregnant women\(^{(23)}\).

Due to the ease of screening with capillary blood glucose, this procedure is relevant for the obstetric follow-up conducted at the Public Health Outpatient Clinics.

Another favorable aspect is that it avoids missed days from activities for a new test.

Dillon et al., aimed to assess the cost-benefit ratio of screening using the reflectance method and determined that capillary blood glucose screening is a feasible method, of low cost and immediate information to the patient\(^{(24)}\).

Thus, the proposed screening has positive socioeconomic impact, especially in regards to pregnant women in the labor market.

### CONCLUSION

Outpatient screening utilizing capillary blood glucose is a feasible, simple and reproducible method. It correlates positively with that done with venous plasma glucose. The diagnosis is faster, and early intervention is possible. The best cutoff point must be determined, because using that of 130 mg/dl, the number of false positive results increases. Capillary blood glucose measured by reflectance is usually higher than the venous plasma glucose measured by the hexokinase enzymatic method. The currently accepted diagnostic criteria, despite their widespread use, reveal significantly different prevalence rates of GDM.

### REFERENCES

Outpatient screening for gestational diabetes mellitus


