Cost Efficacy of Routine Screening for Diabetes in Pregnancy: 1-h Versus 2-h Specimen

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Undetected gestational diabetes mellitus (GDM) is associated with a two- to fivefold increase in perinatal morbidity and mortality. Widespread screening of the obstetric population (resulting in identification and treatment) should reduce these rates. Seven hundred ninety-eight women were examined during a 13-mo period of universal glucose challenge testing (GCT). A total of 2.8% of the population had an abnormal oral glucose tolerance test (OGTT). Thirty percent of those with an abnormal OGTT were <25 yr old. The specificity of a 1-h GCT (50-g carbohydrate load) using a threshold of either 140 or 150 mg/dl was compared with that of a 2-h specimen using a threshold of 118 mg/dl to determine whether the cost of screening could be reduced. One- and 2-h specimens were obtained in 347 of these women. A 34% reduction in the number of follow-up OGTTs required would have been achieved if a 2-h specimen had been used as the index instead of a 1-h specimen ($P < .05$). As a result, the (direct and indirect) cost per patient identified with GDM would have declined 23.5%—from $866 to $662. No comment concerning the actual false-negative rate of either the 1- or 2-h GCT can be made because only select women underwent an OGTT. To assess the validity of the 2-h threshold, an OGTT was performed in an additional 190 women if either the 1- or 2-h screen was abnormal. The results were confirmatory: the 2-h screen would have reduced the cost per case identified by 32% in this small group. Screening on the basis of past medical history clearly lacked sensitivity and cost efficacy in comparison with the GCT and should be abandoned as a practice. DIABETES CARE 1986; 9:255–59.

One to 3% of pregnant women have an abnormal carbohydrate metabolism, commonly termed gestational diabetes mellitus (GDM). Untreated, GDM may be associated with a two- to fivefold increase in perinatal morbidity and mortality.[1-3] The perinatal outcome can apparently be normalized by appropriate maternal treatment and fetal surveillance.[4] Should this prove to be true, widescale screening of the obstetric population could further reduce overall perinatal morbidity and mortality. Screening is not as yet universal. Perhaps the most widely applied screening technique for diabetes during pregnancy is the measurement of a single plasma glucose 1 h after ingesting 50 g of a standardized carbohydrate drink (glucose challenge test, or GCT). Previous reports have shown that the 1-h screen, when applied to all patients between 27 and 30 wk of gestation, both increases the yield and reduces the cost per case of GDM identified compared with that achieved by testing only women with a high-risk history (Table 1).[5] The purpose of our study was to determine whether the specificity of the GCT for diabetes screening during pregnancy could be enhanced by determining a 2-h rather than a 1-h plasma glucose and thus reduce the cost per case identified.

MATERIALS AND METHODS

Each patient receiving prenatal care at the University of Iowa Hospitals and Clinics between March 1984 and April 1985 was screened for carbohydrate intolerance by measuring the plasma glucose concentration 1 h after ingesting 50 g of Trutol (Monoject Scientific, St. Louis, MO). Each woman was instructed to fast for 3 h before the test. In excess of 98% were initially tested between 27 and 29 wk gestation. During the first phase of our investigation, the patients were asked to remain for a 2-h specimen at the time of the GCT. Forty-three percent complied. If the 1-h glucose concentration exceeded 139 mg/dl, the patient underwent a 100-g, 3-h oral

TABLE 1
Historical factors considered high risk for gestational diabetes

General history
Family history (first-degree relative) of diabetes
Previous glucosuria
Recurrent urinary tract infections
Recurrent yeast vulvovaginitis
Obesity
Past obstetrical history
Gestational diabetes mellitus
Recurrent abortion
Unexplained intrauterine fetal demise, stillborn, or neonatal death
Macrosomia, infant ≥4000 g
Congenital birth defect
Polyhydramnios
Previous infant requiring i.v. glucose at birth
Excessive weight gain

glucose tolerance test (OGTT) after 72 h of preparation, consisting of a diet containing ≥100 g carbohydrate per day. During the second phase of the investigation, patients were required to remain for the 2-h sample and a follow-up OGTT performed if either specimen was elevated. Ninety-four percent of the women were white, 80% married, and 72% had completed at least 12 yr of school. Forty-two percent were nulliparous and 80% entered the health care system before 20 wk gestation.

The diagnosis of GDM was made if two or more points of the OGTT exceeded standard threshold values for pregnant women.[6] Each specimen was analyzed in duplicate on an autoanalyzer using the hexose kinase technique. The cost per patient identified with GDM was calculated by:

$$\frac{(\text{cost per screen} \times \text{no. of screens}) + (\text{cost per OGTT} + \text{no. of OGTTs})}{\text{no. of abnormal OGTTs}}$$

The current cost of a 1-h screen at the University of Iowa is $7.25; the cost of an OGTT is $64.00. The latter is comprised of a $24.00 laboratory charge and a $40.00 clinic charge for nursing time. All cost calculations were based on those patients with paired 1- and 2-h specimens. Since both 140 and 150 mg/dl after a 50-g carbohydrate meal have been used as normal limits by previous investigators, yields are also presented in terms of a 140- and a 150-mg/dl threshold to aid comparison with earlier studies.

TABLE 2
Pertinent characteristics of the phase-one population*

N	790
Mean age (yr ± 1 SD)	25.1 ± 5.2
Mean plasma glucose at 1 h (mg/dl ± 1 SD)	121.2 ± 27.8
No. of 1-h screens >139 mg/dl (% of *N*)	176 (22.3)*
No. of positive OGTTs	23
As percent of patients screened	2.9
As percent of patients with 1h > 139 mg/dl	13.0

*Excludes eight women with an elevated value who did not undergo an OGTT.

TABLE 3
Comparison of the 1- and 2-h glucose challenge tests during the first phase of investigation

N	342*
Mean age (yr ± 1 SD)	24.8 ± 5.4
Mean plasma glucose (mg/dl ± 1 SD) at:	
1 h	120.2 ± 29.0
2 h	99.2 ± 21.7
No. of 1-h screens >139 mg/dl (% of *N*)	83 (24.3)†
No. of 2-h screens >115 mg/dl (% of *N*)	69 (20.5)*
No. of 2-h screens >117 mg/dl (% of *N*)	55 (16.3)* †
No. of positive OGTTs	9
As percent of total screened	2.7
As percent 1-h screens >139 mg/dl	10.8†
As percent 2-h screens >114 mg/dl	13.0
As percent 2-h screens >117 mg/dl	16.4†

The 2-h GCT significantly reduced the number of OGTTs required for follow-up to a positive screen and increased the yield of positive OGTTs from positive GCT.
*Excludes five women with a 2-h screen >117 mg/dl who did not have a follow-up OGTT.
†$P < .05$.

RESULTS

Twenty-three percent (184/798) of all women screened had a 1-h plasma glucose value in excess of 139 mg/dl (Table 2). Eight patients with an elevated screen failed to undergo further testing. Twenty-three women (2.9%) had an abnormal OGTT. The mean 1-h value (±1 SD) in the diabetic group was 168 ± 18.1 mg/dl; 13.5% were between 140 and 145 mg/dl. The mean age of the GDM women was greater but not significantly different from the population screened (27.3 ± 5.8 versus 25.1 ± 5.2 yr, respectively).

Both 1- and 2-h specimens were obtained in 347 women who were willing to remain the additional hour (Table 3).

TABLE 4
Cost per case of gestational diabetes identified in the 342 patients who underwent both a 1- and 2-h screen

Method of screening	Cost ($)
1 h >139 mg/dl	866
1 h >149 mg/dl	699*
2 h >114 mg/dl	762
2 h >117 mg/dl	662
History	1805†

Use of a 2-h specimen saves $200 per patient with gestational diabetes identified.
*Misses 17% of gestational diabetic patients identified by using a 140-mg/dl threshold.
†Misses 77.3% of gestational diabetic patients identified by plasma glucose screening.

TABLE 5
Abnormal glucose challenge tests and glucose tolerance tests stratified by patient age and using 140- and 150-mg/dl screen thresholds

Age (yr)	No. of 1-h GCTs	Percent of total screened	No. of 140–149 mg/dl	Percent of group	No. between positive GTTs	Percent of total group	No. ≥150 mg/dl	Percent of group	No. of positive GTTs	Percent of total group	Total No. of positive GTTs in group	Percent positive GTTs in total group by age	No. of 2-h GCTs	Percent of total screened	No. ≥118 mg/dl	Percent of group	No. of positive GTTs	Percent of group
<17	39	4.9	3	7.7	0	0	3	7.7	0	0	0	0	22	6.4	2	9.1	0	0
18–20	127	16.1	15	11.8	1	0.8	16	12.6	1	0.8	2	1.6	60	17.6	14	23.3	1	1.7
21–22	111	14.1	7	6.3	1	0.9	8	7.2	3	2.7	4	3.6	61	17.8	8	13.1	1	1.6
23–24	122	15.4	8	6.6	0	0	17	13.9	1	0.8	1	0.8	60	17.6	8	13.3	0	0
25–26	89	11.3	9	10.1	0	0	20	22.5	4	4.5	4	4.5	37	10.8	10	27.0	3	8.1
27–28	89	11.3	10	11.2	0	0	15	16.9	5	5.6	5	5.6	27	7.9	6	22.2	1	3.7
29–30	82	10.4	6	7.3	1	1.2	11	13.4	0	0	1	1.2	26	7.6	2	7.7	1	3.8
31–32	62	7.8	4	6.4	0	0	15	24.2	3	4.8	3	4.8	19	5.6	5	26.3	1	5.3
33–34	35	4.4	1	2.9	0	0	4	11.4	1	2.9	1	2.9	10	2.9	1	10.0	0	0
35–36	19	2.4	2	10.5	1	5.3	3	15.8	0	0	1	5.3	11	3.2	2	18.2	0	0
37–38	4	0.5	1	25.0	0	0	1	25.0	0	0	0	0	3	8.8	1	33.3	0	0
>38	11	1.4	1	9.1	0	0	4	36.4	1	9.1	1	9.1	6	1.8	1	16.7	1	16.7
Total	790		67	8.5	4	0.5	117	14.8	19	2.4	23	2.9	342		60	17.5	9	2.6

Seventeen percent of women demonstrated to have carbohydrate intolerance were missed using the 150-mg/dl threshold. Of these women 30.4% were under age 25 yr. Excludes eight patients with an abnormal in GCT lost to follow-up.
GCT, glucose challenge test.
GTT, oral glucose tolerance test.

TABLE 6
Prospective comparison of the 1- and 2-h glucose challenge tests

	No. of 1-h tests >139 mg/dl	No. of 1-h tests <140 mg/dl	Total
No. of positive OGTTs	3	1	4
No. of negative OGTTs	33	148	181
Total	36	149	185
	No. of 2-h tests >117 mg/dl	**No. of 2-h tests <118 mg/dl**	**Total**
No. of positive OGTTs	3	1	4
No. of negative OGTTs	15	166	181
Total	18	167	185

One hundred ninety consecutive women had a plasma glucose determination 1 and 2 h after a 50-g carbohydrate drink; an OGTT was obtained if either value exceeded the stated time threshold. Five women with a normal 1-h but an abnormal 2-h screen did not undergo an OGTT and are therefore excluded. The total number of gestational diabetic women represent positive OGTT after either screen. The cost per GDM woman identified was $1215 and $831, respectively.

There were no significant differences between this subgroup and the total group in terms of age (24.8 yr), parity, mean blood glucose at 1 h postingestion (120.2 mg/dl), and frequency of an abnormal OGTT (2.7%). Five patients with an abnormal 1-h screen failed to undergo OGTT and were excluded from analyses. No patient with an abnormal 1-h GCT and subsequent positive OGTT had a 2-h serum glucose <118 mg/dl. Whether a 116- or 118-mg/dl glucose concentration was used as the threshold level for follow-up with an OGTT, the percentage of patients requiring an OGTT was reduced compared with the 1-h screen. The reduction obtained with the 118-mg/dl threshold was significant ($X^2 = 3.9$, $P < .05$). Using this cut-off, 33.7% fewer OGTTs would have been necessary and the cost per case of GDM identified would have been reduced from $866 to $662. If only patients with two or more high-risk historical factors were tested ($N = 141$), then the cost per case identified would have been $1805 and 77% of GDM individuals would be missed (Table 4).

The age breakdown of abnormal screens and OGTTs using either a 140- or a 150-mg/dl threshold for the 1-h and 118-mg/dl for the 2-h GCT are presented in Table 5. Of the total population 17.2% demonstrated to have GDM would not have been identified if the 150-mg/dl threshold had been used. The cost per GDM woman identified using the 150-mg/dl threshold would have been $696. While the greatest yields of positive OGTTs occurred in women aged ≥25 yr, the incidence of GDM in younger women was not insignificant. Thirty percent of patients with an abnormal OGTT were <25 yr of age, although none of these included subjects who were <19 yr old ($N = 59$). Should the latter be excluded from future screening, the cost per case of GDM identified would be further reduced by 6.3% (based on the total population of 790 minus 59 and 10 positive GCTs).

Presumed delayed absorption of the carbohydrate meal, as manifested by a 2-h glucose concentration in excess of the 1 h, was common: 12% of patients screened by both techniques (43/342) had a 2-h value ≥110% of the 1-h value. Twenty-eight women would have been earmarked for an OGTT by the 2-h value but not by the 1-h value.

To assess both the validity of the selected 2-h threshold and the implication of delayed absorption, an additional 190 women were tested. During this phase of investigation, either an abnormal 1- or 2-h value led to a subsequent OGTT. Five women with a normal 1-h but abnormal 2-h result did not undergo an OGTT and are therefore excluded from the pertinent calculations. A total of 19.5 and 9.7% of patients had abnormal 1- and 2-h screens, respectively (Table 6). The 2-h GCT necessitated 50% fewer OGTTs. Four patients had an abnormal OGTT (2.2%), three of whom were detected by each screening technique. The woman with the abnormal 1-h but normal 2-h screen with a positive OGTT had a 2-h value of 114 mg/dl. Ten women with a normal 1-h screen had an abnormal 2-h screen, one of whom had a positive OGTT (her 1-h screen value was 125 mg/dl). The cost per GDM identified in the prospective group would have declined by 32% if the 2-h GCT had been used.

DISCUSSION

We have demonstrated that the measurement of a 2-h plasma glucose concentration after a standard 50-g carbohydrate meal is more specific than a 1-h sample as a screen for GDM. Application of the 118-mg/dl threshold at 2 h would reduce the number of OGTTs needed by at least 34%, and the cost per GDM identified by 23%. These findings confirm the investigation of Merkatz and associates,[7] although our screening technique, study design, and criteria for carbohydrate intolerance differed from those used in their investigation. If an institution currently using a 1-h screen with a 150-mg/dl threshold switched to a 2-h screen, sensitivity would be increased by approximately 17% without increasing the cost per GDM identified. We have further confirmed that clinical history as the basis for performance of an OGTT during pregnancy lacks both sensitivity and specificity and should be abandoned. We are unable to determine the false-negative rate of either the 1- or 2-h GCT in our population because

not all women underwent an OGTT. Thus it is possible that the 2-h GCT using a 118-mg/dl threshold has a lower sensitivity than the 1-h GCT using a 140-mg/dl threshold. Each screening technique missed one patient with an abnormal OGTT in the prospective series.

During the first phase of our study, 13% of our patients had a 2-h glucose concentration at least 10% greater than the 1-h level. A difference as great as 25% was observed. Forty-six percent of these patients would have been screened on the basis of an abnormal 2-h value but were not screened because their normal 1-h level served as our index for further testing. During the second phase of investigation, this category of patients yielded a 10% incidence of carbohydrate intolerance—a rate identical to that found by Merkatz and associates.[7] Should a similar yield hold true for the first-phase population, the cost per case identified would decline to $596.

Previous investigators have concluded that the incidence of GDM in women age 25 yr or younger was too low to warrant routine screening.[8,9] Our findings do not support this conclusion. Approximately 30% of GDM identified were younger than age 25 yr. Fifty-nine patients were ≤18 yr old. None had an abnormal OGTT, although 15.2% had an abnormal 1-h screen. While it is tempting to exclude this age group from future screening, an expanded series is necessary to confirm the absence of GDM in adolescents.

Finally, the cost per patient with GDM identified using the 1-h GCT ($866) may seem disproportionate to the inflationary increases occurring since the report of Lavin and co-workers in 1981,[5] in which the cost per case identified was $329. However, the difference is artifactual. The present study varies in two aspects. First, Lavin and associates based their calculations on direct costs only, whereas we have included indirect costs. Second, they used a threshold of 150 mg/dl. As recommended by others,[9] we chose to enhance the sensitivity of the GCT by lowering the threshold for further testing to 140 mg/dl. Cost efficacy does not appear to have suffered. Applying their 1981 direct costs to our data, the cost per patient with GDM identified by the 1-h GCT was $290; by the 2-h GCT, the cost was $260.

In summary, a 2-h screen significantly reduces the number of OGTT required and the cost per case of GDM identified compared with the 1-h screen. Our experience suggests that the technique can be integrated into routine clinical practice.

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