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A comparative study of the glucose challenge test, fasting blood glucose test, and post-prandial blood glucose screening to identify gestational diabetes mellitus

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Abstract

Background: There is currently a scarcity of population-based records related to the prevalence of gestational diabetes mellitus (GDM) in India. There were various recommendations for screening and diagnostic tests for GDM, and no uniform standard has yet been established. Hence, a comparative study was conducted to assess the usefulness of the glucose challenge test (GCT) and fasting blood glucose (FBG)/post-prandial blood glucose (PPBG) test for the screening of GDM in pregnant women attending the prenatal clinic outpatient department.

Methods: This is a comparative observational study involving 300 apparently normal pregnant who were randomly allocated to GCT and FBG/PPBG cohorts of 150 each. The tests were performed at 4 intervals: 8 to 10 weeks, 16 to 20 weeks, 24 to 28 weeks, and 32 to 36 weeks. All diagnosed GDM cases were appropriately handled.

Results: Gestational diabetes mellitus was seen in 2.67% of the FBG/PPBG cohort and 5.34% of the GCT cohort. The GCT test identified 25% of GDM subjects before 24 weeks of gestation, 50% in 24 and 28 weeks, and 25% in > 32 weeks of gestation. The highest prevalence of GDM was noted in the 26–30-year age group. The highest prevalence of GDM was noted in pregnant women with ≥ 26 kg/m2 of body mass index (BMI), with 75% in the FBG/PPBG group and 62.5% in the GCT group. The incidence of GDM was higher in primigravida, 75% in the FBG/PPBG group, and 50% in the GCT group. A higher prevalence was observed in pregnant women of class 4 of socioeconomic status, and it was 75% in the FBG/PPBG group and 75% in the GCT group. A higher prevalence was noted in those with higher secondary education. The majority of GDM cases gave birth at term by labor, and there were no assisted vaginal births in this group. Moreover, 75% of GDM cases in the FBG/PPBG cohort and 62.5% of GDM cases in the GCT cohort had Caesarean section. Besides, 50% of infants from GDM mothers in the FBG/PPBG cohort were hospitalized, while 12.75% were admitted in the GCT cohort. The birth weight of neonates from GDM mothers was 3.09 ± 0.5 kg, 3.11 ± 0.6 kg in normal mothers, 2.98 ± 0.6 kg in the FBG/PPBG cohort, and 2.9 ± 0.5 kg in the GCT cohort.

Conclusion: Irrespective of the last meal, the GCT in all pregnant women is an effective and easy screening approach for 1-step screening for the early diagnosis of GDM for subsequent management at the early gestational pregnancy, which can minimize the adverse obstetric and perinatal outcomes.

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Highlights

What is current knowledge?

Recently, the trend of incidence of gestational diabetes mellitus (GDM) has been on the rise due to various causes. There has been no extensive national assessment research on GDM and its associated socioeconomic and geographic aspects.

What is new here?

The results imply that the glucose challenge test can be done as a 1-step rapid screening process with higher specificity for the early diagnosis of GDM to enable easy management, which helps to reduce the maternal and neonatal risk of diabetes mellitus at later stages.

Introduction

Abnormal maternal glucose regulation occurs in around 3-10% of pregnancies. Ethnically, Indian women are prone to develop glucose intolerance during pregnancy and have an 11-fold increased risk when compared to white Caucasians. (1) Hyperglycemia during pregnancy is associated with various maternal and perinatal adverse outcomes.

Gestational diabetes mellitus (GDM) is a type of glucose intolerance that develops in pregnancy and is considered by onset or detection at pregnancy duration. The American Diabetes Association defines GDM as "diabetes mellitus initially diagnosed at 2nd or 3rd trimester which is not clearly overt diabetes before gestation (2).

Pregnancy, which is a diabetogenic state, is characterized by an exaggerated amount of insulin release, associated with reduced sensitivity to insulin at cellular levels. Together with increased maternal obesity, products of the placenta, including human placental growth hormone and TNF-alpha, play a crucial role in inducing maternal insulin resistance. If compensatory maternal insulin secretion cannot reach the increasing demand, it results in reduced insulin activity and glucose uptake by the skeletal muscle, reduced insulin suppression of lipolysis, and decreased insulin suppression of glucose release by the liver. In this state, if levels of maternal hyperglycemia cross a defined threshold, gestational diabetes is diagnosed (3).

Approximately 50% of women with a history of GDM develop type 2 diabetes within 5 to 10 years after delivery. Gestational diabetes mellitus results in unfavorable pregnancy outcomes for women and their offspring, not only in the short term but also in the long term (4).

All complications associated with GDM are potentially preventable with early recognition of GDM, intense monitoring, and treatment. The number of women with GDM is also rising; hence, an attempt to evaluate the occurrence of GDM and its adverse effect on mother and fetus is made.

Nongenetic variables such as maternal age, obesity, food, and lifestyle are linked to GDM. The international prevalence of GDM continues to rise due to epidemiological causes and updates to GDM definitions and diagnostic processes as per the International Association of Diabetes and Pregnancy Study Groups (IADPSG) (5).

The incidence of GDM was 5% - 7% of pregnancies in high-income countries. (6) In India, it affects 5 million women yearly (7,8). As per a study, GDM prevalence was reported to be 2 - 2.5% in the 16th week, 2.5 - 3% in the 24th week, and 3% in the 32nd week. In India, the prevalence of GDM ranged from < 4% to 18% (9).

Various recommendations to screen tests for GDM were present, but no uniform standard has yet been established.

This comparative study was conducted to assess the role of the glucose challenge test (GCT) and fasting blood glucose (FBG)/post-prandial blood glucose (PPBG) test to identify GDM in pregnant women attending the prenatal clinic outpatient department.

Methods

Type of study: A comparative observational study was conducted by collecting

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the data from the medical records of the outpatient/antenatal clinic of the Department of Obstetrics & Gynecology for the duration of 1 year.

Sampling technique: Simple random sampling method

The sample size was calculated by using the following formula:

$n = 4\ pq/L^2$

n = Minimum sample size

p = Prevalence in percentage

q = 100-p

L = Allowable error in percentage of prevalence

Using the above formula and data,

p = 21; q = (100-p) = 100– 21 = 79

L = 20% of p = 20% of 31 = 6.2

Minimum sample size (n) = 4 x31x79 = 254.84

6.2 x 6.2

After we added an expected + 10% dropout rate, the sample size was 256 + 25 = 281.

The total collected sample size (for 1 year) n = 300.

Sample Size and Sampling Method:

The study group comprised 300 randomly selected pregnant women who met the inclusion criteria.

A total of 300 pregnant women were randomly divided into the GCT cohort and FBG/PPBG cohort (150 each).

They were observed from the time of pregnancy confirmation until 1 week after delivery. The GDM cases were followed up to 6 weeks postpartum when a GCT was performed to determine their glycemic status.

Inclusion Criteria:

Women with singleton gestation, no history of treatment for GDM/DM, including on meal plan, and no history of GDM/DM

Exclusion criteria:

Women with known diabetes mellitus, multiple gestation, thyroid disorders, heart disease, epilepsy, jaundice, auto-immune disorders, and those on long-term medication for any illness

Screening Method:

The pregnant women in the study group were subjected to a detailed history and thorough general and systemic examination. The blood glucose was estimated using the glucose oxidase peroxidase (GOD-POD) method in the laboratory using the MISPA Excel semi-autoanalyzer. Venous blood was collected in fluoride-containing test tubes to prevent glycolysis. Glucose was oxidized by glucose oxidase into gluconic acid and H2O2. In the presence of peroxidase, H2O2 oxidizes the chromogen four amino antipyrine/phenolic compound to a red compound. The intensity of the red compound is proportional to the glucose concentration and is measured at 505 nm. The final color is stable for 2 hours.

The GCT group:

The diabetes in pregnancy study group in India suggested a universal screening approach for gestational diabetes that involves a one-step diagnostic process. This includes assessing blood glucose levels two hours after consuming a 75-gram glucose load, regardless of the last meal, followed by glucose measurement using the glucose oxidase-peroxidase method. Women with a plasma glucose level of 140 mg/dL or more were considered as women with GDM. It is approved by the Ministry of Health Government of India and recommended by the World Health Organization (WHO).

Fasting/Post-prandial Cohort:

The FBG of ⩾ 95 mg% with overnight fasting and PPBG levels of ⩾ 140 mg% at 2 hr post-meal were considered abnormal.

Both GCT and FBG/PPBG testing were conducted in pregnant, and they were grouped into their respective cohorts during 4 visits on 8 - 10 weeks (1st visit), 16 -20 weeks (2nd visit), 24 - 28 weeks (3rd visit), and 32 - 36 weeks (4th visit).

When they were tested for GDM, they were treated accordingly by either a meal plan or insulin administration.

Statistical Analysis:

Categorical variables are expressed as frequency, and continuous variables are expressed as mean and standard deviation (SD). Pearson's correlation coefficient was used to correlate the quantitative descriptive and outcome measures. The chi-square test was applied to analyze the statistical significance between the groups related to maternal/neonatal categorical parameters. Statistical analysis was done in SPSS v. 24.0 (SPSS, IBM Corp., USA). A P-value less than 0.05 was significant.

Results

The mean age was 24.5 ± 4.8 years in the FBG/PPBG cohort and 24.3 ± 4.9 years in the GCT cohort. The highest prevalence of GDM was observed in the age group of 26 - 30 years (P = 0.003). There was a statistically significant rise in GDM incidence when the body mass index (BMI) increased. Women with a BMI of ⩾ 26 kg/m^2 had a higher rate of GDM. Gestational diabetes mellitus prevalence was higher in women with a socioeconomic status of class 4 and those with a higher secondary education.

The distribution of primigravida was higher in this study, and hence, the prevalence of GDM was also higher in primigravida. Table 1 results depict the association between demographics and GDM status in both GCT and FBG/PPBG cohorts. Table 2 depicts the percentage of diagnosed GDM at various visits in both groups.

Table 1. Baseline characteristics in both groups

	GCT cohort (n = 150)		FBG/PPBG cohort (n = 150)		P-value
	Non-GDM (n = 142)	GDM (n = 8)	Non-GDM (n = 146)	GDM (n = 4)	
Age group (y)					
21 to 25	93(65.5%)	2(25%)	98 (67.12%)	1 (25%)	0.02*
26 to 30	30 (21.26%)	3 (37.5%)	26 (17.8%)	3 (75%)	
31 to 35	18 (12.67%)	2 (25%)	21 (14.38%)	0 (0%)	
36 to 40	1 (0.7%)	1(12.5%)	1 (0.7%)	0 (0%)	
BMI range					
< 18 kg/m2	4(2.81%)	0 (0%)	7 (4.8%)	0 (0%)	0.03*
18 - 25 kg/m2	134 (94.36%)	3 (37.5%)	129 (88.3%)	1 (25%)	
> 25 kg/m2	4 (2.81%)	5 (62.5%)	10 (6.85%)	3 (75%)	
Socioeconomic status					
Class 4	34 (23.9%)	6 (75%)	51 (34.93%)	3 (75%)	0.004*
Class 5	108 (76.05%)	2 (25%)	95 (65.06%)	1 (25%)	
Parity					
Primigravida	100 (70.42%)	4 (50%)	110 (75.34%)	3 (75%)	0.001*
2nd gravida	31 (21.83%)	2 (25%)	27 (18.5%)	1 (25%)	
3rd gravida	10 (7.04%)	1 (12.5%)	7 (4.8%)	0 (0%)	
4th gravida	1 (0.7%)	1 (12.5%)	2 (1.36%)	0 (0%)	
Total	142 (100%)	8 (100%)	146 (100%)	4 (100%)	

GCT: Glucose challenge test; GDM: Gestational diabetes mellitus; FBG: Fasting blood glucose; PPBG: Post-prandial blood glucose; BMI: Body mass index. *Chi-square test to find the association between demographic variables with GDM status in both groups

Table 2. Time of diagnosis of GDM in both groups

GDM diagnosed at	GCT group			FBG/PPBG group		
	n	%	% of GDM	n	%	% of GDM
1st visit (8 to 10 weeks)	1	0.67%	12.5%	0	0	0
2nd visit (16 to 20 weeks)	1	0.67%	12.5%	0	0	0
3rd visit (24 to 28 weeks)	4	2.67%	50%	3	1.95	75%
4th visit (32 to 36 weeks)	2	1.33%	25%	1	0.65	25%
Total No. of cases	8	5.34%	100	4	2.67%	100

GCT: Glucose challenge test; GDM: Gestational diabetes mellitus; FBG: Fasting blood glucose; PPBG: Post-prandial blood glucose

In both cohorts, the majority of pregnant women with GDM delivered at term. There was 1 preterm birth among GDM women in the GCT group. Premature membrane rupture may be the cause of preterm labor. The total Caesarean delivery rate in the GCT cohort was 27.34%, while it was 31.34% in the FBG/PPBG group. In the FBG/PPBG group, 31 women had previous CS, while 33 women were in the GCT cohort. The association between gestation age and GDM status was significant (P = 0.003), and the association between gestation type of delivery and GDM status was also significant (P = 0.0002) (Table 3).

Table 3. Gestational age and type of delivery in both groups

	GCT cohort		FBG/PPBG cohort		P-value
	Non-GDM	GDM	Non-GDM	GDM	
Gestational age					
Term	133	7	133	4	0.003*
Preterm	5	1	8	0	
Post-dated	4	0	5	0	
Type of delivery					
Natural labor	98	3	95	1	0.0002*
Assisted vaginal	8	0	7	0	
Cesarean section	36	5	44	3	
Total	142	8	146	4	

GCT: Glucose challenge test; GDM: Gestational diabetes mellitus; FBG: Fasting blood glucose; PPBG: Post-prandial blood glucose. *Chi-square test to find the association between gestational age/type of delivery with GDM status in both groups

Neonatal Outcome:

The birth weight of neonates in the FBG/PPBG cohort was 3.1 ± 0.4 kg, and it was 2.85 ± 0.56 kg in the GCT cohort. There were 3 subjects with macrosomic babies in the non-GDM pregnant women of the FBG/PPBG cohort.

Out of the 4 GDM subjects in FBG/PPBG cases, 3 cases were on meal plans, and 1 case was put on insulin. Among the 8 GDM subjects in the GCT cohort, 5 subjects were kept on meal plans, and 3 were kept on insulin management.

An association between birth weight and GDM status in both GCT and FBG/PPBG cohorts was significant (P = 0.002). The association between neonatal admission and GDM status in both GCT and FBG/PPBG cohorts was

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also significant (P = 0.02).

In our study, there were 4 incidences of hypoglycemia in the FBG/PPBG group and 1 occurrence in the GCT group. All infants born to GDM mothers had their plasma glucose levels checked, and the mothers were advised to begin breastfeeding as soon as possible.

In FBG/PPBG participants who did not have GDM, there was 1 patient with LSCS wound infection and 1 patient with episiotomy wound gaping. On follow-up, GDM cases in both groups had normal plasma glucose levels. One woman in the GCT group remained to have elevated glucose levels even after 6 weeks. Thus, she is being handled after the follow-up (Table 4).

Table 4. Neonatal outcome and management of neonates

	GCT group			FBG/PPBG group			P-value
	Non-GDM	GDM	%GDM	Non-GDM	GDM	%GDM	
Birth weight (kg)							
< 2.5	14	1	12.5%	12	0	0%	0.002*
2.5 to 4	127	7	87.5%	132	4	100%	
> 4	1	0	0%	2	0	0%	
Management							
No treatment	142	0	0%	146	0	0%	0.03*
Meal plan	0	5	62.5%	0	3	75%	
Insulin	0	3	37.5%	0	1	25%	
Neonatal admission							
Not admitted	129	7	87.5%	124	2	50%	0.02*
Admitted	13	1	12.7%	22	2	50%	
Total	142	8	100%	146	4	100%	

GCT: Glucose challenge test; GDM: Gestational diabetes mellitus; FBG: Fasting blood glucose; PPBG: Post-prandial blood glucose; kg: Kilograms. *Chi-square test to find the association between neonatal variables with GDM status in both groups

Discussion

Gestational diabetes mellitus increases the risk of pregnancy problems in both mother and offspring. It has been associated with an increased risk of metabolic diseases, including type 2 diabetes mellitus, arterial hypertension, obesity, and cardiovascular disorders in pregnant women and their neonates later in life (10).

Screening and diagnosing GDM has evolved significantly over the years, and it must be highlighted that an international agreement has yet to be formed in this area of research.

According to the IADPSG recommendations on the diagnosis and classification of hyperglycemia in pregnancy, GDM screening should begin between 24-28 weeks of gestation.

A 75-gram oral glucose tolerance test (OGTT) is suggested for screening for GDM. The FBG levels must be evaluated as soon as possible after conception, during the 1st trimester, in addition to the OGTT performed at the required time of pregnancy (11).

In our study, the mean age was 24.4 ± 4.75 years, the mean BMI was 21.88 ± 3.1 kg/m2, and 30% of the women were multigravida.

In our study, the prevalence of GDM was 2.67% in the FBG/PPBG cohort, and the prevalence of GDM was 5.34% in the GCT cohort.

Various studies in accordance with our study include Magee et al. (1993) (12) (3.2–5%), Dooley et al. (1991) (13) (3.5–5.5%), Berkowitz et al. (1992) (14) (4.6%), Murphy et al. (1993) (15) (5.8%), and Nahum et al. (1990) (16) (7.1%).

Still, some studies show a varied prevalence, such as Abell Beischer et al (17). (0.7%), Ranchod et al (18). (3.8%), Sacks et al (19). (3.4%), Beischer et al. (20) (15%), Mestman et al (21). (12.3%), and Benjamin et al (22). (14.3%).

In India, the overall prevalence of GDM is 7%, with rates greater in urban than rural locations, among older age groups, and among higher socioeconomic level cohorts (23). There is concern about an expected increase in diabetes prevalence and GDM (24).

According to Run Mei MA et al. (2007) (25), the mean age of patients without GDM was 28.4 ±3.6 years and 29.6 ±4.0 years for those with GDM.

According to Kim et al. (2009) (26), the percentage of GDM cases related to overweight, obesity and extreme obesity were 15.4%, 9.7%, and 21.1%, respectively. If women with a BMI of 25 had the same GDM risk as women with a normal BMI, over half of all GDM cases could be avoided. Lifestyle measures to reduce BMI have the potential to lessen the risk of GDM.

As people get older, their chances of developing GDM rise. Similarly, the risk of GDM increases when BMI is 26 kg/m^2.

According to the study by Ogonowski and Miazgowski (2009), the cut-off for BMI as a risk indicator for GDM was 22.8kg/m^2 (27).

In our study, the mean BMI of individuals with GDM was 26.02 kg/m^2 and 21.7 kg/m^2 for those without GDM.

The risk of GDM was inversely related to socioeconomic status. Those with the lowest socioeconomic status had a two-thirds higher risk of GDM than those with the greatest socioeconomic status. Women in the lowest socioeconomic quartile aged > 40 years had a risk of 10.2 times that of women in the highest quartile aged 21-24 years, according to the Anna et al.'s (2008) study (28).

According to Timothy et al.'s (1997) (29) study, obese women with a higher socioeconomic class were at a higher risk of GDM than their lower socioeconomic status peers.

In both groups, the incidence of GDM was high in women with a socioeconomic standing of class 4.

According to Janghorbani et al. (2006) (30), the prevalence of GDM ranged from 1.05% in the least educated neighborhood to 2.1% in the most educated neighborhood.

Gestational diabetes mellitus prevalence was considerably higher in women from socioeconomic class 4 in our study. Gestational diabetes mellitus was prevalent among women with a postsecondary education. In the FBG/PPBG cohort, 2% of patients with upper secondary education and 0.6% of patients with primary and secondary school had GDM, whereas in the GCT cohort, 2.67% of study subjects with graduate degrees and 0.67% of patients with primary and secondary school had GDM.

Gestational diabetes mellitus was less likely in women with a parity of 1 to 2 and 3 to 4 than in grand multiparous women, according to Simmons et al.'s (2006) study (31). According to the findings of Anna et al.'s study, women who reported a previous pregnancy of more than 20 weeks gestation had a slight but substantial lower risk of GDM in subsequent pregnancies. Women who had a previous pregnancy had a 10% lower risk than women who were having their first pregnancy. A similar minor protective effect was observed in women who had 2 previous pregnancies.

In our study, 75% of GDM in the FBG/PPBG cohort and 50% in the GCT group were primigravidas.

Among the GDM women observed in a study, 35.4% were at 24 weeks of gestation, 12.4% were at 16 weeks of gestation, and 64.6% were at> 24 weeks of gestation. According to Seshiah et al. (2008), 2 to 2.5% of pregnant women have GDM in the 16th week, 2.5 - 3% in the 24th week, and around 3% in the 32nd week (32).

In our study, the prevalence of GDM was 25% at 24 weeks, 50% between 24 and 28 weeks, and 25% after 32 weeks. Hence, early detection and treatment of glucose intolerance is expected to reduce some of the hyperglycemia-related problems.

Yariv Yogev et al. (2007) (33) found no difference in the rate of spontaneous preterm delivery (sPTD) in GDM women (10.7%) versus non-GDM women (11.3%) (P = 0.2). Gestational diabetes mellitus individuals with sPTD had greater OGTT glucose levels, as well as higher blood glucose levels (114 ± 16 vs.106 ± 14, P < 0.0001).

According to Moses et al.'s (1998) study (34), the mean neonatal birth weight for women with GDM was 3.293 ± 0.493 kg, which was not statistically different from the matched group (3.315 ± 0.46 kg).

In our study, the mean birth weight of babies born to GDM mothers was 3.09 ± 0.5 kg, while that of normal women was 3.11 ± 0.6 kg in the FBG/PPBG cohort and 2.98 ± 0.6 kg and 2.9 ± 0.5 kg in the GCT group.

According to Silva et al.'s (2006) study (35), there were substantial differences in aspects of delivery, infant weight, hypoglycemia, and hyperbilirubinemia across the various ethnic groups. When compared to other ethnic groups, Chinese women were more likely to have aided vaginal delivery and less likely to have Caesarean section delivery.

In our investigation, no assisted vaginal deliveries occurred in either cohort, while 75% of GDM participants gave birth by Cesarean section and 25% by vaginal delivery labor in the FBG/PPBG cohort and 62.5% and 37.5% in the GCT cohort.

In our study, 50% of diabetes mothers' infants were hospitalized, while 12.75% were admitted in the GCT cohort.

There were no studies available to compare the neonatal outcome of our study results. Hence, it may be the first report of comparison of the 2 GDM diagnosis methods and their associated maternal and neonatal variables.

Conclusion

Screening and subsequent care at the early stages of pregnancy can help to reduce unfavorable obstetric and perinatal outcomes. The GCT, regardless of the previous meal, appears to be a simple and easily repeatable screening strategy as a 1-step screening process for early identification of GDM in all pregnant women.

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Ethical statement

The study followed the guidelines of the Declaration of Helsinki.

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Conflicts of interest

None.

Author contributions

Concept development-A; data collection-B; data analysis- C; research supervision-J; data validation-K; manuscript writing– M; review & editing-N; approval of final version-O.
Dr. Pandala Sravanthi: A, B, C, J, L, M, N, O
Dr. D Shivani: B, C, E, K, M, N, O
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