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Oral Glucose Powder Solution versus 50% Intravenous Glucose Solution on Blood Glucose Levels and Satisfaction in the 50-gram Glucose Challenge Test: A randomized controlled trial

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ABSTRACT

Objective: To compare blood glucose levels and patient satisfaction during gestational diabetes screening between two oral glucose formulations: 50 grams of dissolved glucose powder in water versus 50% intravenous glucose solution diluted for oral intake.

Materials and methods: This randomized controlled trial was conducted from July 2024 to July 2025. A total of 208 pregnant women were randomly allocated into two equal groups. Group 1 (n = 104) received 50 grams of glucose powder dissolved in water, while Group 2 (n = 104) received 50% glucose solution intended for intravenous injection, also diluted in water. In both groups, the glucose solutions were prepared to a final volume of 300 mL and administered orally. All participants underwent the glucose screening test by drinking the assigned solution. Blood glucose levels were measured one hour after ingestion. The primary outcome was to compare the mean 1-hour post-load plasma glucose between the two groups. The secondary outcome was to compare patient satisfaction regarding the taste and ease of glucose solution consumption between the groups.

Results: There were no significant differences in baseline characteristics between the two groups. Similarly, there was no significant difference in 1-hour post-load plasma glucose. The mean blood glucose level was 119.22 mg/dL in the distilled glucose powder group and 121.25 mg/dL in the 50% intravenous glucose solution group (mean difference = -1.84, 95% confidence interval (CI) -8.62-4.95). There was no statistically significant difference in the proportion of positive glucose challenge test results between the groups (19.23% vs 24.03%, risk ratio 1.25, 95% CI 0.74-2.11, p = 0.703). However, the satisfaction score was significantly higher in the group that drank distilled glucose powder in water compared to the group that drank 50% intravenous glucose solution (p = 0.005).

Conclusion: The administration of 50 grams of glucose powder dissolved in water and 100 milliliters of 50% injectable glucose solution diluted to a total volume of 300 milliliters resulted in no

significant difference in 1-hour post-load plasma glucose levels. However, the consumption of 50 grams of glucose powder was reported to result in ease of ingestion.

Keywords: glucose challenge test, gestational diabetes mellitus, gestational diabetes mellitus, distilled glucose powder, 50% intravenous glucose solution, blood glucose measurement, patient satisfaction

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การรับประทานสารละลายกลูโคสชนิดผงเทียบกับสารละลายกลูโคสเข้าหลอดเลือดดำความเข้มข้น 50% ต่อระดับน้ำตาลในเลือดและความพึงพอใจระหว่างการทดสอบกลูโคสชนิด 50 กรัม: การทดลองแบบสุ่มมีกลุ่มควบคุม

ไพลิน พิชัยแพทย์, ภูริณัฐ ใจธรรม, เกียรติศักดิ์ คงวัฒนกุล, เมธา ทรงธรรมวัฒน์

บทคัดย่อ

วัตถุประสงค์*: เพื่อเปรียบเทียบระดับน้ำตาลในเลือดและความพึงพอใจของผู้ป่วยระหว่างการคัดกรองเบาหวานขณะตั้งครรภ์ ด้วยสารละลายกลูโคสชนิดรับประทานสองรูปแบบ ได้แก่ กลูโคสผง 50 กรัมละลายในน้ำ กับสารละลายกลูโคสร้อยละ 50 ที่ใช้สำหรับฉีดทางหลอดเลือด*

วัสดุและวิธีการ*: การทดลองแบบสุ่มมีกลุ่มควบคุมนี้ดำเนินการระหว่างเดือนกรกฎาคม พ.ศ. 2567 ถึง กรกฎาคม พ.ศ. 2568 โดยหญิงตั้งครรภ์จำนวน 208 คนถูกสุ่มแบ่งออกเป็นสองกลุ่ม กลุ่มที่ 1 (n = 104) ได้รับกลูโคสผง 50 กรัมละลายในน้ำ ส่วนกลุ่มที่ 2 (n = 104) ได้รับกลูโคสชนิดร้อยละ 50 ที่ผลิตสำหรับฉีดทางหลอดเลือด ซึ่งถูกเจือจางในน้ำเช่นกัน ทั้งสองกลุ่มปรับปริมาตรของสารละลายให้เป็น 300 มิลลิลิตร และให้ดื่มทางปาก จากนั้นวัดระดับน้ำตาลในเลือดหลังจากดื่มครบ 1 ชั่วโมง โดยผลลัพธ์หลักของการศึกษา คือ การเปรียบเทียบระดับน้ำตาลในเลือดหลังรับประทานอาหาร 1 ชั่วโมง โดยเฉลี่ยระหว่างกลุ่มทดลองทั้งสองกลุ่ม ส่วนผลลัพธ์รอง คือ ให้ผู้ป่วยเปรียบเทียบความพึงพอใจของผู้ป่วยต่อรสชาติและความสะดวกในการรับประทานสารละลายน้ำตาลระหว่างกลุ่ม*

ผลการศึกษา*: ไม่พบความแตกต่างอย่างมีนัยสำคัญในลักษณะพื้นฐานระหว่างกลุ่มทั้งสอง นอกจากนี้ ยังไม่พบความแตกต่างอย่างมีนัยสำคัญในระดับน้ำตาลในเลือดหลังรับกลูโคส 1 ชั่วโมง โดยระดับเฉลี่ยของกลูโคสในเลือดอยู่ที่ 119.22 mg/dL ในกลุ่มที่ดื่มกลูโคสผง และ 121.25 mg/dL ในกลุ่มที่ดื่มกลูโคส 50% สำหรับฉีด (ค่าความแตกต่างของค่าเฉลี่ย =-1.84, ช่วงความเชื่อมั่นร้อยละ 95 -8.62-4.95).และไม่มีความแตกต่างอย่างมีนัยสำคัญในสัดส่วนของผลการทดสอบน้ำตาลหลังรับประทานน้ำตาล 1 ชั่วโมงที่เป็นบวกระหว่างกลุ่ม (ร้อยละ 19.23 ต่อ 24.03, risk ratio 1.25, 95% CI 0.74-2.11, p =*

0.703) อย่างไรก็ตาม กลุ่มที่ดื่มกลูโคสผงละลายในน้ำมีคะแนนความพึงพอใจในความง่ายของการดื่มสารละลายสูงกว่าอย่างมีนัยสำคัญเมื่อเทียบกับกลุ่มที่ดื่มกลูโคสร้อยละ 50 สำหรับฉีด (p = 0.005)

***สรุปผล**: การดื่มกลูโคสผงละลายในน้ำและการดื่มกลูโคสร้อยละ 50 ที่ใช้สำหรับฉีด ให้ผลระดับน้ำตาลในเลือดหลัง 1 ชั่วโมงที่ไม่แตกต่างกันในการคัดกรองเบาหวานขณะตั้งครรภ์ด้วยการทดสอบน้ำตาลหลังรับประทานน้ำตาล 1 ชั่วโมง อย่างไรก็ตามการรับประทานกลูโคสผงขนาด 50 กรัมดื่มง่ายกว่า*

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Introduction

Gestational diabetes mellitus (GDM) is a common and important obstetric complication[1]. It is associated with significant short-term and long-term adverse outcomes for both mothers and their offspring. In the short term, GDM increases the risk of complications such as neonatal hypoglycemia, shoulder dystocia, macrosomia, preeclampsia, postpartum hemorrhage, and even intrauterine fetal demise[1]. In the long term, women with a history of GDM are at significantly higher risk of developing type 2 diabetes mellitus, with a relative risk approximately 7.4 times greater than women without GDM[2]. Furthermore, offspring of mothers with GDM are more likely to develop obesity, glucose intolerance, and metabolic syndrome later in life[1].

The prevalence of GDM has been reported to vary across countries. According to the International Diabetes Federation (IDF), approximately 21.1 million women, or 16.7% of pregnancies globally, are affected by hyperglycemia during pregnancy[3]. The prevalence of diabetes in pregnancy differs significantly between regions. For instance, in the United States, GDM occurs in approximately 7.8% of live births[4]. In Thailand, the 2019 IDF report indicated that the country had the highest prevalence of GDM in Southeast Asia, at 24.7%. However, the reported prevalence of GDM in Thailand has varied across studies, ranging from 12.3-21.8%[5-7], largely due to differences in screening criteria and testing methods used during pregnancy.

The glucose challenge test (GCT) and oral glucose tolerance test (OGTT) are standard methods for screening and diagnosing GDM[8]. For these tests, 50 to 100 grams of glucose powder dissolved in 300 milliliters of water is commonly recommended[9]. The new International Federation of Obstetrics and Gynaecology guidelines on GDM recommend the use of anhydrous glucose powder dissolved in a glass of water as part of the one-step screening approach[10]. However, due to the wide availability of 50% glucose solution intended for intravenous injection, many hospitals in Thailand have adopted this preparation as an alternative to glucose powder for both GCT and OGTT. While glucose powder is generally easier to dissolve, the injectable glucose solution is readily available and more convenient for use in most clinical settings. Although the use of intravenous glucose solution for the 50-gram glucose challenge test in GDM screening has been practiced for many years, no studies have confirmed whether the mean plasma glucose levels differ compared with glucose powder. Schwartz, et al[11] previously reported that, despite an equivalent total glucose load, differences in the form of glucose preparation may influence plasma glucose levels. This rationale formed the basis of the present

study.

Despite these practical differences, a review of the existing literature found no published studies comparing the two glucose formulations in terms of their effects on blood glucose levels, the proportion of positive screening results, or patient satisfaction. Therefore, this study was conducted to generate evidence-based recommendations that may help inform and improve GDM screening practices in hospital settings.

Materials and Methods

The present study was a randomized controlled trial conducted at the Department of Obstetrics and Gynecology, Udon Thani Hospital, Udon Thani, Thailand, between July 2024 and July 2025. The study protocol was approved by the Udon Thani Hospital Ethics Committee in Human Research (No. 121/2567) and was registered in the Thai Clinical Trials Registry (TCTR), with the identification number TCTR20241201003.

A total of 208 pregnant women, between 24 and 28 weeks of gestation, who underwent universal GDM screening as recommended by the Royal Thai College of Obstetricians and Gynaecologists, were enrolled[11]. The inclusion criteria were age ≥ 18 years and a singleton pregnancy. Exclusion criteria included pre-existing diabetes mellitus or unwillingness to participate in the study. All participants were informed of the study details prior to undergoing the GCT at the antenatal care clinic, and written informed consent was obtained from each participant.

Randomization was performed using computer-generated numbers. Allocation was concealed in sealed, opaque envelopes prepared by research assistants. Eligible participants were randomly assigned into one of two groups: the first group received 50 grams of glucose powder (n = 104), and the second group received 100 milliliters of 50% intravenous glucose solution (n = 104), both diluted with water to give a total volume of 300 milliliters before oral ingestion.

Pregnant women were randomly assigned to one of two groups, and the patients were blinded to their group allocation, and the medical technologists were also blinded to the group assignments. Group 1 received 50 grams of glucose powder dissolved in water to a final volume of 300 milliliters. Group 2 received 100 milliliters of 50% injectable glucose solution (equivalent to 50 grams of glucose), diluted with water to a total volume of 300 milliliters11. However, the taste of the two glucose formulations differed, with the 50% intravenous glucose solution perceived as sweeter than the glucose powder solution.

Participants in both groups were not required to fast prior to the test. One hour after ingestion of the glucose solution, venous blood samples were collected to measure plasma glucose levels using the hexokinase enzymatic method with the Architect c4000 analyzer (Abbott Laboratories, USA). The secondary outcome was to compare patient satisfaction regarding the taste and ease of glucose solution consumption between the groups, as assessed by the study participants.

The sample size was calculated using the formula for comparing the means of the two independent groups, based on the primary objective of the study. The calculation was performed using the n4Studies application[13,14]. The estimated mean blood glucose level in the control group was 127.40 mg/dL, compared to 114.66 mg/dL (representing a 10% difference) in the treatment group, with a standard deviation of 31.7 mg/dL in both groups15. Allowing for an anticipated dropout rate of 10%, the final required sample size was determined to be 104 participants per group.

Statistical analysis was performed using STATA software version 13 (StataCorp, College Station, TX, USA). Continuous variables were reported as means and standard deviations, while categorical variables were presented as frequencies and percentages. An unpaired t-test was used to compare continuous variables between groups, and results were presented with mean differences and 95% confidence intervals (CIs). A generalized linear model was applied to

estimate relative risks (RRs) and their corresponding 95% CIs. The Pearson chi-square test and Fisher's exact test were used to compare categorical variables. A p value of < 0.05 was considered statistically significant.

Results

A total of 212 pregnant women were enrolled in the study, and 4 were excluded (1 was unwilling to participate and 3 were pre-existing diabetes mellitus). All participants were randomly assigned into two equal groups. Blood samples were collected exactly one hour after ingestion to measure blood glucose. The study flow is shown in Fig. 1.

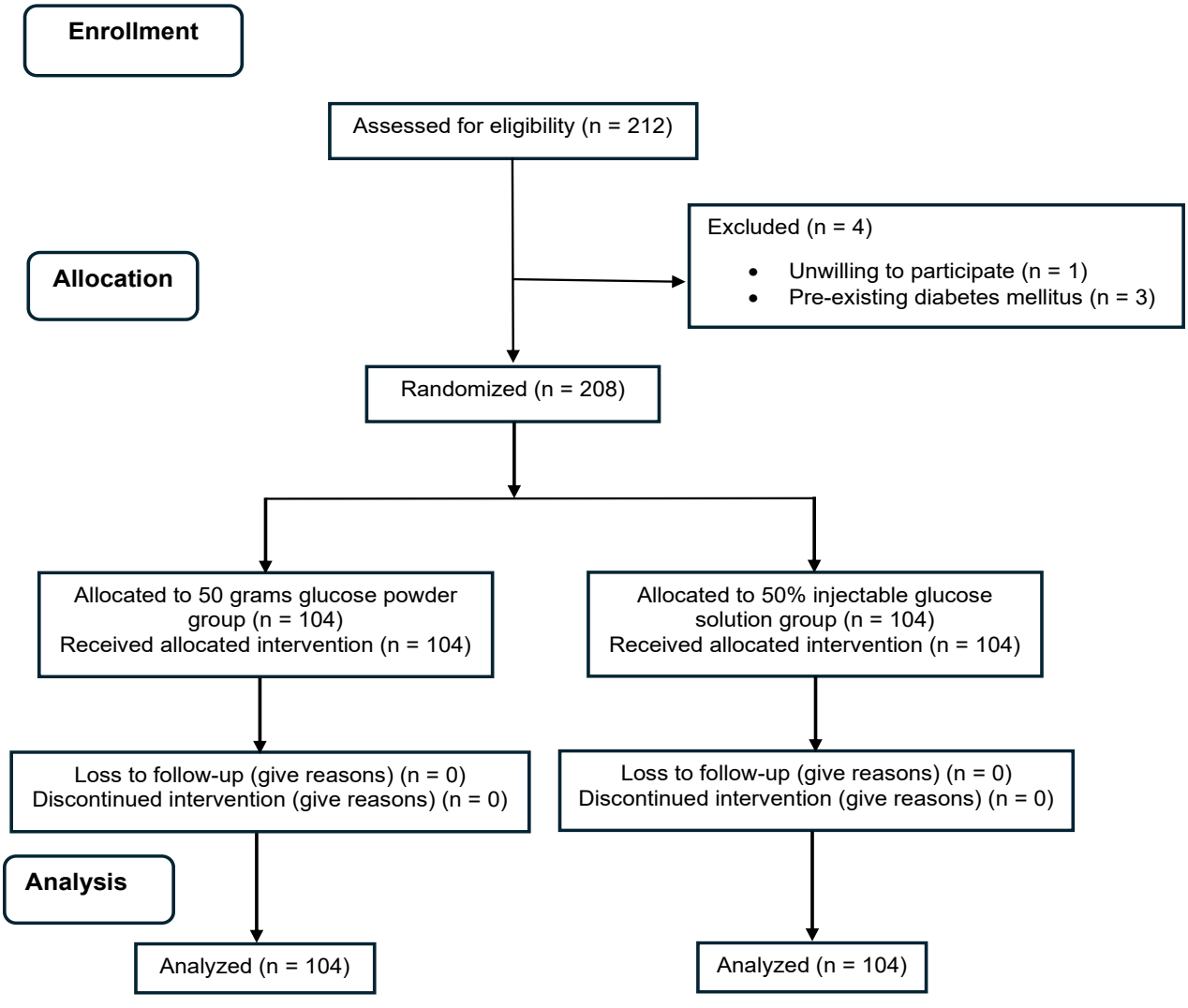

Fig. 1.

There were no significant differences between the two groups in baseline demographic and clinical characteristics, including maternal age, body mass index, parity, and gestational age at the time of testing, as presented in Table 1.

Table 1. Clinical characteristics of oral glucose and group.

	50-gram glucose powder group (n = 104)	50% glucose solution group (n = 104)	p value
Age, mean ± SD (weeks)	25.86 ± 5.62	26.96 ± 5.45	0.151*
Body mass index, mean ± SD (weeks)	22.85 ± 4.78	23.69 ± 4.47	0.195*
Nulliparity, n (%)	46 (44.23%)	40 (38.46%)	0.398**
Gestational age at testing, mean ± SD (weeks)	25.56 ± 1.25	25.59 ± 1.27	0.869*

* Calculated by unpaired t-test, ** calculated by pearson chi square

SD: standard deviation

The GCT results demonstrated that the mean 1-hour post-load plasma glucose were 119.33 mg/dL in the group receiving 50 grams of glucose powder and 121.05 mg/dL in the group receiving 100 milliliters of 50% injectable glucose solution. The mean difference with 95%CI was -1.84 (-8.62 to 4.95) mg/dL, indicating no statistically significant difference between the two groups. The positive GCT rate also showed no significant difference between the two groups. However, the ease of ingestion scores was higher in the 50-gram powder group (Table 2). Nevertheless, no significant differences were observed between the groups in taste satisfaction or in adverse events such as nausea and vomiting.

Table 2. Comparison of primary and secondary outcomes between groups.

	50-gram glucose powder group (n = 104)	50% glucose solution group (n = 104)	Risk ratio (95%CI) or mean difference (95% CI)
Positive GDM screening, n (%)	20 (19.23%)	25(24.03%)	1.25 (0.74 to 2.11) p = 0.703**
Plasma glucose (mg/dL), mean ± SD	119.22 ± 24.13	121.05 ± 25.49	-1.84 (-8.62 to 4.95) p = 0.703**
Satisfaction score (mean ± SD)			
Taste	3.98 ± 0.75	3.82 ± 0.89	0.16 (-0.06 to 0.39) p = 0.076*
Ease of ingestion	4.20 ± 0.84	3.88 ± 0.91	0.32 (0.08 to 0.56) p = 0.005*
Solubilit	4.05 ± 0.81	3.91 ± 0.78	0.14 (-0.08 to 0.35) p = 0.110*
Side effect			
Nausea	3 (2.88%)	4 (3.85%)	1.33 (0.31-5.81) p = 0.500 ***

*Calculated by unpaired t-test, ** calculated by Pearson chi-square, *** calculated by Fisher's extract test

SD: standard deviation

Discussion

This study demonstrated that the 1-hour blood glucose levels following ingestion of 50 grams of glucose powder and 100 milliliters of 50% injectable glucose solution were not significantly different. The incidence of adverse effects, such as nausea and vomiting, was also comparable between the two groups during the 50-gram glucose challenge test for GDM screening. However, ingestion of glucose powder was found to be easier and resulted in higher participant satisfaction.

The present study was conducted to address a practical concern in antenatal care regarding the form of glucose administration during the 50-gram GCT, which is widely used for GDM screening. Although the World Health Organization and other clinical guidelines provide recommendations on the glucose load, they do not specify the exact formulation, thereby allowing healthcare providers to choose between glucose powder and injectable glucose solutions diluted for oral administration[16]. In many clinical settings, particularly in primary and secondary hospitals, glucose powder is not always readily available, and injectable glucose solution is often used as an alternative. Despite this common practice, there has been a lack of direct evidence comparing the efficacy, tolerability, and acceptability of these two formulations in a standardized screening context. To our knowledge, this is the first randomized controlled trial that directly compares 1-hour plasma glucose levels, adverse effects, and maternal satisfaction between these two forms of glucose delivery.

Our findings demonstrated that both formulations produced comparable glycemic responses, with no statistically significant differences in 1-hour blood glucose levels. Moreover, the incidence of adverse effects such as nausea and vomiting was similar between groups, indicating that both methods are equally safe and well-tolerated. Importantly, however, participants who received glucose powder reported greater ease of ingestion and higher satisfaction compared to those who consumed diluted injectable glucose solutions. These results suggested that while both formulations are effective for GCT, glucose powder may be favored due to higher patient acceptability and ease of use.

Previous studies have reported that glucose solution can cause gastrointestinal side effects due to delayed gastric emptying and its intensely sweet taste, particularly when consumed in large volumes[17]. Schwartz et al found that using a more physiologic, lower-osmolarity glucose solution reduced nausea and vomiting without affecting glucose values at 1 hour[11]. Other studies also highlighted that patient satisfaction and perceived tolerability vary depending on glucose formulation, flavoring, and even texture18-19. These findings support the significance of our results and emphasize the importance of patient-centered approaches when selecting GCT methods.

This study had several strengths. It was conducted using a randomized controlled design, which minimizes selection bias and strengthens internal validity. The sample size was adequate to detect meaningful differences in glycemic response and adverse effects, and the study protocol closely reflected real-world clinical practice. Furthermore, patient-reported outcomes, such as satisfaction and ease of ingestion, were included, with patients blinded to which solution they received, providing a more comprehensive and unbiased perspective.

Nevertheless, some limitations should be acknowledged. This study was conducted at a single center, which may limit the generalizability of the findings to other populations or settings. Although both groups received the same total volume of glucose solution, subjective responses may have been influenced by differences in taste and mouthfeel. Furthermore, the study did not evaluate clinical outcomes or the diagnostic accuracy of the GCT results. The sample size calculation was based solely on the primary objective and did not account for patient satisfaction. Additionally, certain variables, such as the time since the last meal and specific risk

factors for GDM, were not included in the analysis of this study.

Given the practical implications of our findings, oral glucose powder is generally more satisfaction in terms of ease of ingestion, however the supply availability in some centers still might be problematic.

Future studies could expand on this work by examining commercial glucose beverages or flavored options, and by testing acceptability in women with conditions such as hyperemesis gravidarum. Multicenter studies in varied clinical contexts would help strengthen generalizability. Cost-effectiveness analysis may also help inform policy decisions regarding which formulations to use in standard GDM screening protocols.

In conclusion, this study supported the interchangeability of glucose powder and diluted injectable glucose for GDM screening in terms of glycemic outcomes and safety. However, glucose powder may be the preferred option due to higher maternal satisfaction, and healthcare providers should consider patient experience in selecting formulations for GCT administration.

Conclusion

The administration of 50 grams of glucose powder dissolved in water and 100 milliliters of 50% injectable glucose solution diluted to a total volume of 300 milliliters resulted in no significant difference in 1-hour post-load plasma glucose blood glucose levels. However, the consumption of 50 grams of glucose powder was preferable due to the higher score of ease of ingestion.

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Potential conflicts of interest

The authors declare no conflicts of interest.

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