A Review of Blood Glucose Self-Monitoring Practices Among Pregnant People with Gestational Diabetes Mellitus

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Abstract

In the context of diabetes, the term "gestational diabetes mellitus (GDM)" refers to glucose intolerance of varied degrees that is identified for the first time during pregnancy. Glucose levels in the blood return to normal quite quickly following the delivery of the baby. On the other hand, the women have a lifelong chance of developing overt diabetes during the next five years. Medical nutrition therapy, physical activity, careful weight management, and "*Self-Monitoring Of Blood Glucose Levels* (SMBG)" are the main treatment pillars for GDM. Of all the management components, SMBG is the one that gets the least amount of attention, particularly among pregnant women who have GDM. Empowering patients and providing them with accurate evidence concerning SMBG may be useful in managing GDM and achieving better outcomes for both the mother and the unborn child. In general, the application of SMBG in developing nations like India falls short of expectations as a practise.

Key words: Gestational Diabetes, Blood Glucose, Self-Monitoring, Pregnancy, India

INTRODUCTION

A frequent pregnancy medical issue called "*Gestational Diabetes Mellitus* (GDM)" can have a detrimental effect on both the mother's and the unborn child's health. GDM is defined as the first-ever identification of high blood sugar levels in pregnant women who have never had Type-1 or Type-2 diabetes. When the baby is delivered, the elevated blood sugar in GDM normally returns to normal.[1-4] "*Self-Monitoring of Blood Glucose (SMBG)*" is the practise of a patient, carer, and/or healthcare professional testing and checking their blood glucose levels throughout the day, whether at home or in a medical facility. It is essential to the management of diabetes. It enables regulating glucose levels and reducing the risk of complications from diabetes to be done in the most effective way possible.[5-7] SMBG plays a crucial part in maintaining the exact blood glucose control needed during pregnancy. Women with GDM should aim for 2-hour post-prandial glucose values of less than 120 mg/dL and fasting blood glucose readings of less than 95 mg/dL, according to recently revised guidelines for the diagnosis and management of GDM. The initial stages to a successful SMBG during pregnancy are patient education and acknowledgment of the need for SMBG in decreasing medical concerns during and after pregnancy. It is crucial that the patient receives thorough instructions on how to operate the glucometer's many functions. It is crucial to inform people about how their diet's glucose content may alter test outcomes. It is critical to remember that simply keeping track of one's daily blood glucose levels is insufficient if no action is taken with the data. Daily glucose monitoring is part of "*Structured* SMBG (sSMBG)", which is done at specified intervals.[8] Patients and doctors can understand the daily trend in blood glucose levels thanks to this methodical approach to blood glucose monitoring, which also enables them to make the required changes to the management strategy. Together with monitoring their blood glucose levels, patients also need to keep track of their dietary consumption and exercise. Patients should receive instruction on how to perform SMBG, alter their insulin dosage, and make relevant lifestyle modifications depending on their results, as well as the necessity of maintaining blood glucose levels within the recommended ranges and the significance of doing so.[9] The doctor is in charge of analysing SMBG data and going over the findings with the patient at each follow-up visit. sSMBG is effective when both the patient and the

doctor are committed to following the instructions, motivated to do so, knowledgeable regarding how to interpret glucose levels, able to spot patterns, and willing to take the necessary steps to attain ideal glycemic control.[8-10] It is crucial to monitor postmeal glucose levels throughout pregnancy. Postprandial hyperglycaemia after the 16th week of pregnancy is a major predictor of foetal macrosomia, according to multiple studies. Postprandial capillary blood glucose monitoring decreased the incidence of preeclampsia and the newborn's triceps skinfold thickness as compared to pre-meal monitoring. The highest plasma glucose levels in pregnancy occur 60 to 90 minutes after a meal. To detect any changes in food content and/or insulin dosage, it is advised that SMBG be conducted an hour following a meal. In some circumstances, including as in women with delayed stomach emptying, after a high-fat meal, or in women who take regular insulin for a prandial bolus, using SMBG two hours after meals rather than one may be advantageous. To detect and prevent nocturnal hypoglycemia, night-time glucose monitoring is required.[2,11-15]

Guidelines for blood glucose self-monitoring in diabetic pregnancy

The traditional management of diabetes must include SMBG. It makes it possible for pregnant women and their healthcare providers to select the most effective therapeutic strategy for regulating glucose levels and reducing the likelihood of diabetic complications. The number of daily tests required to accurately monitor blood glucose levels vary depending on the patient's requirements and the doctor's advice.[14,15] Every pregnant woman has a unique set of characteristics. The type of therapy, the amount and type of exercise, and the risk of hypoglycemia are a few examples. Also, patients feel more secure and at ease administering insulin because SMBG permits early diagnosis of hypoglycemic symptoms.[16] When a pregnant woman is not receiving insulin treatment, the frequency and indications for SMBG must be personalised. It's important to teach patients how to combine their physical activity frequency, intensity, and timing with their dietary consumption. The effectiveness of SMBG in improving glycaemic control in patients with type 2 diabetes who are not receiving insulin is uncertain. There is no information on pregnant women who also have GDM.[17] To guarantee accuracy and that the patient is aware of any changes to the recommended course of therapy, measured glucose readings must be verified often. SMBG is advised ≥3 times per day for the vast majority of insulin-using patients. Women who have type 1/2 pre-gestational diabetes should follow a more rigorous SMBG protocol. The objective is to achieve safe HbA1c levels that are appropriate without causing hypoglycemia.[15,16]

IN THE INDIAN CONTEXT

The way that SMBG is now practised in India appears to be rather random and unorganised. It is a crucial part of managing diabetes, although it isn't given much weight. In other areas of the world, it is a common practise; but, in India, it is less common. "*The SMBG International Working Group"* conducted a survey of the in 2008. Suggested treatment and restricted care for how often and when to use SMBG during pregnancy for diabetes Patients undergoing lifestyle changes patients taking insulin or OADs preferred treatment minimal care preferred treatment minimal care once weekly fasting blood glucose profile & three post-meal values, perhaps scattered throughout the week or at least once per week. Every week, one fasting blood glucose and one post-meal value are taken daily blood glucose measurement and three post-meal measurements Use of SMBG is done daily in thirteen nations, including India, before and after breakfast on the 1st day, before and after lunch on the 2nd day, before and after dinner on the 3rd day, and so on. India was said to practise the least SMBG. (0.2%).[2] According to research conducted in Delhi in 2006 by Nagpal J et al., 77.4% of patients were performing the SMBG as directed, and 28.4% of those with diabetes had glucometers at home.[18] In Chennai, India, a study was piloted in 2016 to evaluate patients with type 2 diabetes mellitus' knowledge of and use of SMBG at home. Only a quarter of the study's participants had a thorough comprehension of and were correctly applying the SMBG method.[19] There is however a dearth of information on the use of SMBG among expectant mothers with gestational diabetes in India.

Diabetes-related concerns that impact SMBG during pregnancy

Precision

The precision of a blood glucose metre reflects how closely the measured number is to the actual value. Meters must be correct and exact over a range of values in order for SMBG to be successful. The "*Mean Absolute Relative Error* (MARE)" is the most effective single indicator of both accuracy and precision. The average of all individual absolute errors in relation to a reference value is used to calculate MARE.[20] "*The International Standards*

Organization (ISO)" established criteria to assess the accuracy of blood glucose metres in collaboration with global regulatory bodies, healthcare providers, and equipment manufacturers. The American Diabetes Association states that for a glucose metre to be deemed accurate, 5% of its values for glucose should be lower than 75 mg/dl. The most accurate metre now only has 63% acceptable values in the 5% error range, according to data currently available.[20] As a result, it may be challenging for patients and healthcare professionals to evaluate the precision of instruments. Significant mistakes that are frequently present in SMBG are typically not understood by patients or clinicians. By locating the error source and devising strategies for prevention and repair, healthcare professionals can assist patients in achieving better results.[20,21]

Diabetes complicating pregnancy blood glucose self-monitoring accuracy

Instrument factors

Blood glucose levels may be inaccurate due to minute strip-to-strip variations. The size of each reaction well and variations in the amount of enzyme coverage on some types of glucose strips may affect reading accuracy. Measurements made using an electrochemical process may not be accurate if the mediator is reduced. Typically, glucose oxidase converts glucose to gluconic acid. Hydrogen peroxide is produced as a result of this reaction involving the reduced form of glucose oxidase, oxygen, and water. The first and second processes on a strip are identical, but in the second step, the glucose oxidase pushes electrons to the oxidised mediator, causing its reduction rather than oxygen plus water, which would result in hydrogen peroxide. The mediator is oxidised by the electrode, which produces the glucose signal.[20] Due to the oxidised mediator's relative instability and susceptibility to reduction, especially at high temperatures, inaccurate blood glucose readings are obtained.[22] Blood glucose strips have a limited shelf life, typically 2 years under ideal storage circumstances, and are dependent on complicated metabolic interactions to function properly. The lifespan of the strips can be shortened by storing them in an open vial, at high temperatures or levels of humidity, or both. The failure rates of various glucose test strip brands vary. Some brands understate the glucose numbers during a failure, while others overstate them. In both situations, the inaccuracy can be significant, and metres frequently fail to identify defective strips.[20,22]

Physical aspects

Altitude and temperature are the two physical variables that affect blood glucose strip accuracy the most frequently. Oxygen concentrations are easily detected by glucose oxidase biosensor strips. As oxidants of the reduced form of glucose oxidase, the mediator and oxygen can both compete. As the electrode can only detect the mediator, too much oxygen steals electrons from the mediator, causing the electrode to underreport glucose levels. In contrast, metres will overstate blood glucose readings at lower oxygen concentrations. [20,22] As a result, capillary blood is typically used to calibrate glucose oxidase biosensor strips, and capillary blood is also the blood type that gives the best results. Altitude has less of an impact on strips that use glucose dehydrogenase as the enzyme since oxygen has less of an impact on them. Temperature has a less predictable impact. Extreme temperature errors are brand-specific and independent of technology. The inaccuracies could range from 5 to 7 percent, but they could also be positive or negative. Low temperatures reduce skin circulation. Since the fingers' arteriovenous shunts remain open, this has little impact on glucose readings from the tips of the fingers. Yet, there is a significant reduction in blood flow to the skin on the forearm. Alternative site testing, which generally has a latency of 15 to 30 minutes, can have a lag of up to an hour when the arm is exposed to an exceptionally low temperature. [20,23]

Patient-related variables

The accurateness of a blood glucose quantity can be significantly impacted by a patient's ability to use her metre correctly. The majority of blood glucose metres require coding. One of the most frequent errors made by patients is improper coding, and the consequences of incorrect coding vary depending on the blood glucose range.[20] Meters that don't need coding are easier to find and more precise when used by patients. Anomalies in the hematocrit can also influence the outcomes of SMBG. Less than 30% hematocrit may overstate blood glucose levels, whereas more than 55% hematocrit may understate readings.[1] All metres employ capillary-derived whole blood concentration. Blood glucose levels in venous blood taken in labs are assessed in relation to plasma rather than whole blood. Whole blood's glucose content is 10% to 15% lower than plasma's due to erythrocyte density. Nonetheless, the majority of modern metres translate whole-blood values into data calibrated for plasma.[24] Those with a normal

hematocrit have plasma glucose levels that are 11% higher than whole blood levels (venous or capillary). Instead of providing whole blood values, "*the international federation of clinical chemistry and laboratory medicine (ifcc)"* suggests expressing plasma glucose measurements. Expression of plasma glucose readings makes it easier to compare them to laboratory-based measures. Whole blood glucose concentration is multiplied by 1.1 to produce plasma readings. Many glucose metres already translate plasma data from blood values. If a glucose metre automatically transforms a whole blood measurement to a plasma measurement, the manufacturer should explicitly indicate this. SMBG devices often update their models, styles, and technological capabilities. Systems are improving in accuracy while also becoming simpler for patients to utilise correctly. Since many more recent metres employ microsamples, even minute levels of contamination can significantly change readings.[20]

Hand cleaning has long been an issue. Triglycerides, oxygen, and uric acid are a few of these. Due to the displacement of glucose in the capillary volume by high triglyceride levels, blood glucose levels are underestimated. Particularly in the third trimester, many pregnant women present with high triglyceride levels, which could result in inaccurate SMBG readings. Because oxygen competes with the mediator to collect electrons from reduced glucose oxidase, high oxygen levels, such as those found in arterial blood or in patients utilising oxygen, will understate glucose concentrations.[25] Patients with severe chronic obstructive pulmonary disease or low oxygen levels in venous blood may overestimate glucose levels. Very high uric acid concentrations can result in falsely high results. Only in patients with uric acid levels high enough to cause severe gout are uric acid levels troublesome. Since glucose dehydrogenase is a less selective enzyme, it can compete with some naturally occurring sugars. High concentrations of these additional sugars can lead to an overestimation of the glucose level because they compete with glucose for binding sites on glucose dehydrogenase. While less sensitive to changes in oxygen concentration, glucose dehydrogenase sensors still exist.[26,27]

Therapeutic variables

Many drugs may have an impact on SMBG results. Electrochemical glucose oxidase systems involve interactions between the electrode and ascorbic acid, L-dopa, tolazamide, and acetaminophen.[26] Thankfully, the mistake caused by these drugs is typically minimal. Several different carbohydrates can obstruct glucose dehydrogenase. Icodextrin can have a significant impact compared to maltose and xylose. Certain peritoneal dialysis fluids contain icodextrin, which can cause the glucose reading on the metre to rise by more than 100 mg/dl. Manufacturers of metres typically don't list the compounds that affect their particular product. When practicable, nevertheless, doing so would increase the precision of SMBG readings made by patients and ultimately therapy efficacy.[1]

OBSTACLES FOR SMBG DURING PREGNANCY

Patient education and comprehension of the value of SMBG in decreasing difficulties during and after pregnancy are the first steps for a successful SMBG during pregnancy. All facets of metre use must be carefully explained to the patient. She must be aware of the proper ways to code her metre, wash her hands prior to the test, and add the appropriate volume of blood to the test strip. It's important to explain to patients how dietary glucose can affect test outcomes and to remind them to use test strips no later than 90 days after the vial was opened and before the expiration date. Finally, it is essential to instruct patients on how to properly store strips and dispose of them if they are exposed to high humidity or temperatures. Costs of the metres and strips, lower socioeconomic level, fewer HbA1c tests, obesity and other comorbidities, inadequate glycemic management, stigmas associated with testing in public areas, pain, and annoyance are additional prevalent obstacles to SMBG.[28,29] Even minor variations in glucose levels during pregnancy may have therapeutic significance. Knowing how accurately the glucose metre readings can represent the patient's actual plasma glucose level is crucial for clinical practise. Perera et al., recently demonstrated variations between SMBG and plasma glucose readings of up to 15%. Diabetes-afflicted pregnant women showed variations of up to 15 mg/dl.[29] However, Kong et al., discovered a link between the SMBG and plasma glucose levels in 90% of the measurements made on GDM-affected women who only received nutritional treatment until they reached normoglycemia.[30]

CONCLUSIONS

Pregnancy complications can be decreased by treating hyperglycemia. Patient adherence to SMBG is the first step to strict glucose management in pregnancy. With SMBG, a number of obstacles and

sources of inaccuracy exist. Doctors, diabetes educators, and healthcare workers in general have a special window of opportunity during pregnancy to inform and educate patients about diabetes and SMBG. It is an occasion to teach women about error prevention and accurate results interpretation, in particular. They can also help to overcome obstacles to receiving optimal diabetic care and offer long-term advantages to the mother and foetus.

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