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CLINICAL APPLICATIONS

Self-Monitoring of Blood Glucose: Practical Aspects

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Abstract

Self-monitoring of blood glucose (SMBG) should be part of a regular management plan for patients with diabetes. Self-monitoring of blood glucose provides information regarding an individual's dynamic blood glucose profile. This information can help with the appropriate scheduling of food, activity, and medication. It is also required for understanding of the timing of blood glucose variations. Lack of regular SMBG predicts hospitalization for diabetes-related complications. Self-monitoring of blood glucose is an essential tool for people with diabetes who are taking insulin or for those who experience fluctuations in their blood glucose levels, especially hypoglycemia. Application of practical aspects that aid in easy management of SMBG makes the task of checking blood glucose more achievable. For patients taking insulin and adjusting their dose, SMBG is needed for self-management. For others receiving oral medication, profiling glucose trends and the confirmation of high or low blood glucose can be a useful addendum to successful management.

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Introduction

Self-monitoring of blood glucose (SMBG) can be a useful tool in the management of diabetes mellitus. Patients with diabetes often measure their blood glucose to detect hypoglycemia and to adjust insulin dose as needed. Others utilize SMBG to help establish a profile of blood glucose levels and response to nutrition and pharmacotherapy. The American Diabetes Association (ADA) initially established guidelines for SMBG in 1987, and current recommendations suggest regular SMBG in persons with diabetes based on each patient's needs.[1,2] Records of SMBG can also be used during consultation with diabetes health care providers to titrate blood glucose-lowering agents and to guide physical activity and food intake.

One objective of *Healthy People 2010* is to increase the number of adults with any type of diabetes who perform SMBG at least once daily.[3] Data from the Behavioral Risk Factor Surveillance System, representing 25 of 38 states in the United States, reported this to be 63.4% among all adults with diabetes and 86.7% among those treated with insulin.[4] For patients with type 1 diabetes mellitus, it is recommended that patients measure their blood glucose at least three times daily.[2] The effectiveness of SMBG has been established for insulin-treated patients.

There is debate over optimal frequency and timing of SMBG for those with type 2 diabetes mellitus (T2DM)

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Abbreviations: (ADA) American Diabetes Association, (CGMS) continuous glucose monitoring system, (DCCT) Diabetes Control and Complications Trial, (A1C) hemoglobin A1c, (SMBG) self-monitoring of blood glucose, (T2DM) type 2 diabetes mellitus

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not taking insulin. Some health practitioners are skeptical about the effectiveness of SMBG as a self-management tool. However, lack of regular SMBG predicts hospitalization for diabetes-related complications.[5] Self-monitoring of blood glucose has also been shown to significantly decrease hemoglobin A1c (A1C).[6,7] The ADA recommends using SMBG as a guide to successful therapy and to achieve postprandial glucose targets.[2]

Self-monitoring of blood glucose by persons with diabetes is an integral part of intensive glycemic treatment and is widely believed to improve the control of blood glucose levels and health outcomes. The results of the Diabetes Control and Complications Trial (DCCT) among persons with type 1 diabetes mellitus showed that intensive glycemic control significantly slowed the progression of diabetes complications.[8] The DCCT protocol required SMBG at least four times each day and multiple injections of insulin. Furthermore, the United Kingdom Prospective Diabetes Study found that a reduction in A1C was associated with a decreased risk of microvascular complications in persons with T2DM.[9]

Specific Goals of Blood Glucose and Documentation

The target for A1C is less than 7%; this correlates with an average blood glucose of approximately 150 mg/dl. Specifically, the ADA recommends that preprandial plasma glucose values range from 70 to 130 mg/dl, and peak postprandial levels are targeted at <180 mg/dl.[2] The use of SMBG by a person with diabetes can be helpful in developing a *longitudinal* glucose profile and as an aid in making day-to-day decisions. *Standards of Medical Care in Diabetes 2010* also recognizes that there is increased risk for diabetes at a fasting plasma glucose of 100 to 125 mg/dl or a 2-hour postprandial glucose that is 140 to 199 mg/dl as well as a A1C level that is 5.7% to 6.4%.[2] Furthermore, the new standards also recognize the use of a A1C ≥6.5% as an option for diagnosis of diabetes if the test is performed by a laboratory using a certified methodology.[2]

It is advisable to have the patient record their SMBG values in a log book. Information about food intake, medication, and exercise can be important for interpreting the SMBG results. Keeping a log will also encourage the patient to acknowledge their SMBG and to contemplate the potential adjustments they can make with activity and nutrition. Accurate data are imperative for the health team to adjust medication, problem solve, and recommend lifestyle (activity, stress, nutrition) modifications for the patient.

Steps for Self-Monitoring of Blood Glucose

There are several necessary steps to assure accurate data from SMBG. To assess a patient's understanding of SMBG knowledge, an explanation of the practical aspects of the procedure is imperative. **Table 1** contains points to consider for successful SMBG and lists several important steps that should be instituted for SMBG.[10–13] Specifically, proper use of the strips and general procedures for meter handling must be understood appropriately in order to obtain useful data. Since there are a multitude of meters available on the market, the information in **Table 1** applies to general aspects of SMBG and user manuals for each individual meter can be consulted for specific functions, error messages, and setting date and time. For some meters, the accuracy can be affected by interfering substances (medication), temperature, hematocrit level, and user technique.[14] In addition, the accuracy of SMBG meters available has been recommended to produce results within a 20% margin of error.[13] Recognition of meter accuracy variability is important, as many patients will retest SMBG, obtaining different results that can create concern.

Table 1.
Strip and Meter Handling for Self-Monitoring of Blood Glucose[10–12]

Meter and test strips should be handled with clean, dry hands.
Test strips are for single use and unique for each meter. Test strips must be kept in the original canister, as any moisture can affect the integrity of the strip, and the containers should be kept closed. Check for expiration date.
Strips can be tested for accuracy with control solution provided initially with each meter and should be checked for expiration date. The control glucose range for the strips appears on the canister.
Some meters require coding with each canister. Many of the newer meters do not require coding.
The amount of blood required is usually very small. Many meters easily pull the blood drop into the end of the strip. Inadequate sample can be a source of error.
Keep meter and supplies in a cool, dry area, not in the car or in sunlight.
Bring meter into office visits with diabetes educator or primary care provider to test the accuracy comparatively.

Lancing procedures for SMBG require the patient to fully understand the appropriate steps for successful blood obtainment (**Table 2**).[15,16] Most SMBG meters come with some type of lancing device. It will be important for the patient to demonstrate how to adjust the depth

of the lancing device to avoid bruising while effectively acquiring an adequate blood sample. Alternative sites other than the finger can be used with many meters; however, blood sample obtainment can often be challenging without instruction. There are also lancing tools that have multiple lancets that are inserted into a device that rotates a cylinder and provides an alternative to handling individual sharps.

Table 2.
Lancing Procedure for Self-Monitoring of Blood Glucose[13,15]

Site preparation: Clean area with warm, soapy water and dry. Food residue can be a source of false high blood sugar values.
Lancet devices to obtain blood can vary and all use a lancet to prick the skin. Thin, sharp lancets are more comfortable. Lancets should not be reused or cleaned, as they quickly become dull.
Depth setting on the lancet device controls the penetration of the stick and can be adjusted for best comfort and size of blood sample. Most meters require very small samples—less than a small teardrop.
Lancet should be applied firmly to the clean, dry finger, but not with force.
Sides of the finger should be used, as there is less pain. Use of the third, fourth, and fifth digits may be preferable to spare index finger and thumb.
Alternate test sites (upper arms and thighs) are approved for many meters. Fingertips or the outer palm are preferred and are more accurate.
Obtainment of blood sample should be a gentle "milking" from the base of the finger to the lanced tip. Pressure directly on the site of lancing is not recommended.
Disposal of lancets and SMBG testing supplies should be done according to local laws for sharps. In many locations, a hard plastic container with a screw top can be disposed of in the household trash.

Choosing a Self-Monitoring of Blood Glucose Device

There are several considerations for pairing a meter with each patient. Assessment of the patient's ability to follow the necessary steps to successfully obtain a SMBG reading will be essential. Dexterity is a very important factor to consider. Some meters facilitate the use of strips that are contained with multiple use containers or "drums" that load much like a roll of film into a camera. Other meters contain multiple blood glucose strips that are in the form of a circulating wheel that rotates and eliminates the need to handle individual test strips. Many SMBG meters have strips that "wick" the blood sample into the end of the strip, allowing visual inspection to assure an appropriate sample is obtained.

Blood sample size can also be a factor for many individuals, especially if there is lancing difficulty or lack of blood flow. Sample size requirement for some meters is as small as 0.3 μl. Newer SMBG devices deliver results very quickly, averaging around five seconds or less. For the vision impaired, the size of the screen will need to be evaluated with a variety of digital output reading font sizes and information that is available. Some meters contain very sophisticated features such as food/medication/activity tracking, premeal and postmeal SMBG "tagging," and low blood glucose alerts. The option of using a talking meter that provides verbal guidance on each step in the SMBG process is also available. A comprehensive guide to SMBG devices including size, weight, sample size required, alternative site testing approval, memory features, warranty, and other meter aspects are available annually at the beginning of each year in a resource guide published by the ADA.[13]

Cost is a major factor for many patients and often times becomes the primary factor for SMBG meter selection. Insurance coverage varies widely in the amount of copay required and whether a deductible has to be met first before a percentage of the supplies are covered. Some insurance companies will only cover a specific SMBG meter and supplies, giving the patient no alternative unless they want to pay for a different device out of pocket. For many insurance coverage plans, mail order can be an option to cover the meter, strips, and lancets as durable medical equipment and will not factor in under the patient's prescription benefit coverage. Documented medical necessity can help reimbursement for exceptions.

Management of Self-Monitoring of Blood Glucose

Management of SMBG depends on the patient's level of diabetes education and/or a person's general ability to understand the necessary basic steps for SMBG. The application of SMBG results for self-management is necessary for successful diabetes outcomes.[17] Goal setting from a health care and patient team approach can also be useful as action items for SMBG results. For example, if the results of SMBG show a consistent pattern of high fasting glucose levels, then medications that target liver output of glucose might be helpful. Postprandial glucose levels (two hours after eating) provide information regarding the impact of food intake on blood sugar. Diet modification or medication (some orals or mealtime insulin) may be useful therapies.

The role of physical activity and diet will be needed to assess how to appropriately adjust self-management. Treatment should be outlined to include goal setting for self-care behavior.[18] Specific schedules for SMBG will vary for each patient. Short periods of intense SMBG, before and after each meal and at bedtime, will provide data to identify glucose patterns. This can be an important adjunct to A1C to distinguish between fasting, preprandial hyperglycemia, and postprandial hyperglycemia. Alternatively, patients may use a staggered schedule of checking at various times of day throughout the week. For example, the use of a preprandial and two-hour postprandial SMBG gives the patient immediate feedback on their food choices for that meal. Postprandial spikes may be an independent risk factor for diabetes complications, even when glycemic control appears to be satisfactory.[19] Useful tips for health care providers and patients are outlined in **Table 3**. Careful consideration should be given to assessing the patient's ability to comprehend and retain the procedure of SMBG that can often be technical. Attention to literacy and numeracy skills will be an equally important step in successful SMBG.[20] Patient demonstration of SMBG to the diabetes educator or health care provider is critical.

Table 3.
Tips for Successful Self-Monitoring of Blood Glucose Teaching

Use simple and specific steps at the patient's level of comprehension.
Be sure the patient can demonstrate the steps for SMBG.
Give your patient written recommendations for frequency and times of testing and desired results.
Observe SMBG procedure at follow-up visits.
Ask the patient to assess the relationship of SMBG with exercise, food, medications, and stress.
Specify which SMBG values are most problematic (especially low blood glucose) and discuss solutions with the patient.
Acknowledge the patient for goals achieved with SMBG.

Tools, such as SMBG, can help patients with glucose regulation. The ADA recommends that patients receive initial instruction for SMBG and routine follow-up to use data obtained to adjust therapy.[2] The frequency of SMBG testing should be clearly outlined with emphasis on testing during illness, preprandial and/or postprandial, and during times of potential low blood sugar. Patients who use carbohydrate counting to adjust insulin doses and postprandial glucose will need SMBG goals set that may be more intensive than for persons who are maintained with good control using oral medications. A dialogue between the patient and the health care provider should be agreed upon to assure periodic assessment of SMBG timing, accuracy of testing, and goals. For example, when medicine dose is being adjusted, more frequent SMBG may be needed to assure response to therapy. Once therapy is established, SMBG can often be altered to accommodate patient schedules. Targeting blood glucose fluctuations around meals or increased activity can provide useful information. There is also the option of a continuous glucose monitoring system (CGMS). Through a sensor that is inserted subcutaneously, the patient wears the CGMS for an extended period of time (usually 3 days) to capture blood glucose levels day and night.[13] While CGMS is an ideal option to monitor blood glucose spikes and potential lows, insurance coverage is variable, and interpretation of the data will be necessary by a qualified individual (diabetologist, certified diabetes educator, or endocrinologist).

Other Summary Points

Diabetes requires self-management and adherence to treatment guidelines such as those recommended by the ADA; among these is regular SMBG to monitor success with the diabetes treatment plan. The cost-effectiveness of SMBG has also been questioned, and insurance coverage or affordability of glucose test strips must be considered.[21] Some research has shown that providing SMBG devices at no charge can improve the rate of testing.[22] Self-monitoring of blood glucose can serve an important role in improving patient knowledge of glucose levels and the effects of different behaviors on blood glucose outcomes.

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Julienne K. Kirk is a diabetes educator/speaker for Novo Nordisk and Lilly. Jane Stegner is a contracted trainer for Abbott, Animas, and Roche.

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