Chapter 42

Suggested Protocols for Self-Monitoring of Blood Glucose in India

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INTRODUCTION

Tight control of blood glucose, focusing on maintenance of glucose levels as close to normal as possible, is now universally accepted as a basic tenet of diabetes care. In-clinic measurement of blood glucose levels, along with assessment of glycated hemoglobin (HbA_{1c}), has been widely used as the most convenient means of assessing glycemic control in patients with diabetes. However, clinic-based measurements of blood glucose may not give a true picture of the pattern of glycemia for a particular patient, since the conditions under which the test is conducted are quite different from those obtaining at the patients home. Also, most of these tests are done in the morning hours, leaving clinicians none the wiser as to what happens to the glucose levels after the other two main meals (lunch and dinner). While the HbA_{1c} does give information as to the long-term control of blood glucose, it too is found wanting when it comes to assessing the day-to-day glycemic variations of any given patient. Therefore, measurement of the blood glucose values by the patient at home becomes vitally important. This process is termed as self-monitoring of blood glucose (SMBG).

CONCEPT OF GLYCEMIC VARIABILITY

Of late, the concept of glycemic variability as the fourth component of dysglycemia in diabetes (in addition to fasting and postprandial hyperglycemia and elevated HbA_{1c}) has received a great deal of attention. It has been postulated that the upward and downward swings of blood glucose around a mean value are more important in activating oxidative stress, and by extension, causing diabetes complications, than the absolute value of the mean (HbA_{1c}) itself.[1] For formal assessment of glycemic variability, more sophisticated techniques like continuous glucose monitoring (CGM) are required, but for practical purposes, regular SMBG should give the clinician a general idea of the swings in blood glucose level in a particular patient. Such information cannot be obtained by a monthly estimation of blood glucose in the clinic or, for that matter, quarterly estimation of the HbA_{1c}.

BENEFITS AND USES OF SELF-MONITORING OF BLOOD GLUCOSE

Several randomized controlled trials have demonstrated the efficacy of SMBG. In type 1 diabetes patients, SMBG has been shown to be associated with improved health outcomes.[2] Moreover, increased frequency of SMBG has been shown to be linearly correlated with reductions in HbA_{1c} levels. Similar results have been obtained in insulin-treated type 2 diabetes patients as well.[3] However, results have been mixed in type 2 diabetes patients not on insulin, probably because of the differences in study design, populations studied and outcomes measured. Certain authors have even called into question the cost-effectiveness of SMBG in this population.[4] Nevertheless, most diabetologists today recommend SMBG as part of the diabetes treatment plan to the majority of their patients.

The following are the benefits of SMBG:

- It helps in planning antidiabetic drug regimens and in optimizing existing regimens.
- If performed with adequate frequency, it gives an idea about the magnitude of glycemic variability and can alert patients and physicians to the risk of diabetes complications, even in patients whose HbA_{1c} levels are within acceptable limits.
- It helps in the recognition of hypoglycemic and hyperglycemic episodes and improves quality of life.
- It serves as a motivational and educational aid to patients by encouraging them to adhere to the lifestyle and drug prescription.

WHO SHOULD DO SELF-MONITORING OF BLOOD GLUCOSE?

The following categories of patients might be expected to benefit the most from SMBG:

- Type 1 diabetes patients
- Type 2 diabetes patients on multiple daily doses of insulin
- Pregnant diabetic patients on insulin
- Patients on insulin pump therapy.

In a developing country like India, other factors like affordability and availability of glucose meters and strips should also be considered before recommending SMBG. Fortunately, the advent of less expensive meters and a reduction in the cost of the strips has considerably brightened the scenario of late.

HOW OFTEN SHOULD ONE PERFORM SELF-MONITORING OF BLOOD GLUCOSE?

The American Diabetes Association[5] recommends that patients on multiple doses of insulin or on insulin pumps should test three or more times daily. Similar considerations apply for pregnant women on insulin. There is no consensus as to how often patients on less intensive insulin regimens or on oral antidiabetic drugs should perform SMBG. Guidelines have also been promulgated by various other national and international agencies and bodies on the optimal frequency of SMBG in various patient groups.[6,7] Based on these guidelines, the authors offer below some practical tips for the use of SMBG in patients on various treatment regimens. However, it needs to be emphasized that the frequency and pattern of SMBG in any patient needs to be individualized.

Type 1 Diabetes Patients

Patients with type 1 diabetes, whether on multiple daily doses of insulin or insulin pump therapy, should perform SMBG at least thrice a day. At the time of initiation of insulin therapy, it would be more practical to check the before-meal values (fasting, prelunch and predinner) **(Table 1)**. This will help one to fix the dose of the intermediate or long-acting insulin (or the basal infusion rate in case of the insulin pump). Once the preprandial values are at target, one can concentrate on the postmeal values. This, in turn, will help in setting the dose of the rapid-acting insulin (or the bolus dose in the case of insulin pump) **(Table 2)**.

Once a stable insulin regimen is established, the three point testing schedule can be continued, now with a judicious mixture of preprandial and postprandial readings. As a useful rule of thumb, individuals with and HbA_{1c} of less than 8.4% need to check their postprandial glucose levels more often, since these contribute disproportionately to the dysglycemia in this situation.[8] If HbA_{1c} is more than 8.4%, one should concentrate on normalizing the fasting and preprandial values before attempting control of postprandial hyperglycemia.

Checking of the blood glucose levels at 3 AM is often of use in patients with type 1 diabetes, particularly if nocturnal hypoglycemia is suspected or the patient exhibits the Somogyi phenomenon (unexplained fasting hyperglycemia).

More frequent monitoring is indicated in case of hypo- or hyperglycemic symptoms, hypoglycemia unawareness, intercurrent illness, gastroparesis, pregnancy, use of drugs like steroids, changes in antidiabetic regimen and strenuous physical activity.

Type 2 Diabetes Patients

Patients on intensive multiple dose insulin regimens should follow the same guidelines as type 1 patients for SMBG, since these individuals often have absolute insulin deficiency and behave similar to their peers with type 1 diabetes.

Patients on less intensive therapy can usually manage with less frequent testing. If the HbA_{1c} is above target, one should monitor at least two times daily. Ideally the two tests should consist of one premeal and one postmeal reading; the exact timings may be varied from day-to-day **(Table 3)**.

Patients whose HbA_{1c} value is at target need to check preferably daily, but at least four times a week. They can check their sugars at different times on each day, thereby enabling them to build up a 24-hour glucose profile over the course of a week or so **(Table 4)**. Conversely, they can check all the values (fasting, postbreakfast, prelunch, postlunch, predinner and postdinner) on the same day on a weekly basis[9] but this involves multiple pricks on a single day and may not be acceptable to most patients **(Table 5)**. The above regimen can also be used in non-insulin treated type 2 diabetes.[6]

TABLE 1 | Sample self-monitoring of blood glucose (SMBG) regimen—type 1 diabetes initial phase

Days	Fasting	After breakfast	Before lunch	After lunch	Before dinner	After dinner	3 AM
Monday	√		√		√		
Tuesday	√		√		√		√
Wednesday	√		√		√		
Thursday	√		√		√		
Friday	√		√		√		
Saturday	√		√		√		√
Sunday	√		√		√		

TABLE 2 | Sample self-monitoring of blood glucose (SMBG) regimen—type 1 diabetes optimization phase

Days	Fasting	After breakfast	Before lunch	After lunch	Before dinner	After dinner	3 AM
Monday	√	√		√			
Tuesday	√			√		√	
Wednesday	√	√				√	
Thursday		√		√			√
Friday	√			√		√	
Saturday	√	√				√	
Sunday		√		√			√

TABLE 3 | Sample self-monitoring of blood glucose (SMBG) regimen—type 2 diabetes HbA_{1c} above target

Days	Fasting	After breakfast	Before lunch	After lunch	Before dinner	After dinner	3 AM
Monday	√	√					
Tuesday	√			√			
Wednesday	√					√	
Thursday	√	√					
Friday	√			√			
Saturday	√					√	
Sunday	√	√					

Source: Modified from IDF Clinical Guidelines Task Force. Guideline on Self-Monitoring of Blood Glucose in Non-Insulin Treated Type 2 Diabetes. Brussels: International Diabetes Federation; 2009

TABLE 4 | Sample self-monitoring of blood glucose (SMBG) regimen—type 2 diabetes test staggered over a week

Days	Fasting	After breakfast	Before lunch	After lunch	Before dinner	After dinner	3 AM
Monday	√						
Tuesday		√					
Wednesday				√			
Thursday	√						
Friday		√					
Saturday				√			
Sunday	√						

Source: Modified from IDF Clinical Guidelines Task Force. Guideline on Self-Monitoring of Blood Glucose in Non-Insulin Treated Type 2 Diabetes. Brussels: International Diabetes Federation; 2009

TABLE 5 | Sample self-monitoring of blood glucose (SMBG) regimen—type 2 diabetes multiple test per day

Days	Fasting	After breakfast	Before lunch	After lunch	Before dinner	After dinner	3 AM
Monday							
Tuesday	√	√	√	√			
Wednesday							
Thursday							
Friday							
Saturday							
Sunday							

Source: Modified from IDF Clinical Guidelines Task Force. Guideline on Self-Monitoring of Blood Glucose in Non-Insulin Treated Type 2 Diabetes. Brussels: International Diabetes Federation, 2009

Pregnant Diabetes Patients

Tight control of blood glucose is the key to a successful outcome in both gestational diabetes mellitus (GDM) as well as pregestational diabetes. There is sufficient evidence to show that macrosomia and other adverse pregnancy outcomes are directly proportional to the levels of maternal glycemia, even at levels below those conventionally considered to be suggestive of diabetes.[10] SMBG allows the pregnant woman and her treating physician the opportunity to promptly alter the antidiabetic regimen in response to the rapid hormonal-metabolic alterations that occur during pregnancy, even before changes in long-term indicators like HbA_{1c} occur.

There is some evidence to show that treatment decisions based on postprandial glucose readings result in fewer complications, particularly macrosomia as compared to decisions taken based on premeal readings.[11] Another study showed that treatment based on 1 hour, rather than 2 hours postmeal glucose values resulted in better obstetric outcomes.[12] This has led to several authorities recommending the 1 hour postprandial glucose level as the preferred monitoring tool during pregnancy. Nonetheless, most of the currently accepted guidelines state that pregnant women with insulin-treated diabetes should check their blood glucose at least four times daily—in the fasting state as well as after the three main meals—during the initial stages following diagnosis.[13] Once the glucose levels stabilize, the woman can check her sugars less frequently.

USING SELF-MONITORING OF BLOOD GLUCOSE IN CLINICAL PRACTICE

The accuracy of SMBG is both instrument and user-dependent. Therefore, the patient's testing technique should be monitored at the time of initiation of SMBG as well as at frequent intervals thereafter, to ensure that errors are not being made. Care should also be taken to ensure that the meter strips are stored properly and are not past their expiry date. In addition, it is important to appreciate that the glucose values obtained from capillary blood approximate the venous (laboratory) glucose values only in the fasting state; in the postprandial state, the capillary values may be higher by around 10–20%.

For a patient to obtain maximum benefit from SMBG, the data so obtained should be recorded, analyzed and acted upon in the form of alterations in the medications as well as non-pharmacological therapies. Several of the newer glucose meters have memory functions and data analysis software, which help in storing and graphically representing the collected data. Patients using older glucose meters should maintain a diary in which records of the SMBG are entered and these should be presented to the clinician at the time of follow-up. The clinician's role is to carefully study the reports and to ascertain patterns, if any, in the readings. The importance of this cannot be overemphasized; it is most disheartening for a patient to have reams upon reams of his SMBG data, obtained at much pain and expense, summarily dismissed by a busy physician without even as much as a second glance.

If the blood sugars or HbA_{1c} seem not to be at target, the SMBG patterns will assist the clinician in altering the antidiabetic regimen rationally in order to smoothen out the patient's blood glucose profile.

Depending on the comprehension level and motivation, patients can also be trained to look for patterns and can be encouraged to make minor alterations in their antidiabetic regimens by themselves.

CONCLUSION

Self-monitoring of blood glucose is an effective adjunct to the management of type 1 diabetes and insulin-treated type 2 diabetes. Its utility in non-insulin treated type 2 diabetes is less clear, but may be indicated in certain situations. Used properly, SMBG provides a wealth of information regarding the blood sugar profile of the patient and helps in improving glycemic control by reducing hyperglycemic

peaks and hypoglycemic troughs and by minimizing glycemic variability. The optimal regimen for SMBG has to be individualized for the particular patient and is a function of many variables including personal preference and affordability. To derive maximal benefit from SMBG, the patient and clinician should work in tandem to analyze the information obtained and take action based on the information, whenever indicated.

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