The role of self-monitoring of blood glucose in the care of people with diabetes: report of a global consensus conference

Richard M. Bergenstal, MD, a James R. Gavin III, MD, PhD, b on behalf of the Global Consensus Conference on Glucose Monitoring Panel

aInternational Diabetes Center, Minneapolis, Minnesota, USA; and
bDepartment of Medicine, Emory University School of Medicine, Atlanta, Georgia, USA.

Self-monitoring of blood glucose (SMBG) is an underutilized but integral part of disease management for patients with both type 1 and type 2 diabetes. Guidelines on the recommended frequency and timing of SMBG vary among international diabetes associations, and patients are often unaware of actions they should take in response to SMBG results. In response to this, a global consensus conference of recognized diabetes experts convened to clarify the role of SMBG as a tool to help optimize glycemic control (e.g., complementing information provided by hemoglobin A1c, detecting postprandial excursions, identifying glucose patterns, and providing patients feedback on lifestyle and medications) while minimizing hypoglycemia and maintaining quality of life. The consensus panel also sought to reinforce the importance of appropriate and systematic patient and provider response to the collected SMBG data. A set of 16 consensus statements was approved by the panel. This article presents the 16 statements together with some brief rationale for their inclusion.
testing to optimize glycemic control. HbA1c is often used as an index of long-term (2- to 3-month) glycemic control and serves as a reliable predictor of microvascular, neuropathic, and macrovascular complications of diabetes. Because the HbA1c value is a time-averaged result, it also has certain limitations as a marker for glycemic control. It does not provide “real-time” feedback to patients or physicians and thus, cannot reveal transient excursions in glycemic control, such as postprandial hyperglycemia or severe hypoglycemia, which may require short-term adjustments in treatment regimens. In contrast, SMBG allows for immediate patient feedback regarding glycemic control. It allows prompt determination of hypoglycemia or hyperglycemia that not only can improve patients’ safety but also can motivate them to make appropriate changes in diet, exercise, and insulin dosing. The effectiveness of oral antidiabetic agents can also be assessed by SMBG, thereby allowing for more timely adjustment of pharmacologic therapy than possible with HbA1c monitoring alone.

Substantial disparity exists between actual and recommended frequency of SMBG testing, especially by patients at highest risk for complications. One factor contributing to this disparity is the lack of a consensus on recommendations for self-monitoring regimens in defined patient groups, a problem driven by a paucity of well-designed clinical studies. Clear, detailed recommendations that describe how often, when, and under what conditions SMBG should be used would help physicians, diabetes educators, and patients establish comprehensive diabetes action plans for attaining and maintaining daily glycemic control.

A global consensus conference on SMBG, hosted by the International Diabetes Center (IDC), a World Health Organization (WHO) Collaborating Center for Diabetes Education and Translation, was convened in Minneapolis, Minnesota, on October 29–30, 2004 to develop just such a consensus. This international panel of recognized experts included representatives of the WHO, the IDC, the American Association of Diabetes Educators (AADE), and the Council for the Advancement of Diabetes Education and Research (CADRE), as well as diabetes specialists from various countries. In addition to their own clinical experience, the participants evaluated new and existing evidence regarding the role of SMBG in improving glycemic control. The panel was charged with the following 4 key tasks: (1) to reach consensus on the role of SMBG in identifying or avoiding glycemic excursions; (2) to provide guidance regarding the most effective method of glucose monitoring and supporting interventions to achieve optimal glycemic control; (3) to evaluate clinical evidence (including new studies) regarding the benefit of SMBG for patients with type 2 diabetes and to provide specific recommendations for testing in this population; and (4) to provide consensus recommendations for specialists, primary care physicians, diabetes educators, and patients with diabetes to guide the successful implementation of SMBG.

The conference produced 16 consensus statements, which are summarized below. Brief explanations of how the panel supported these statements also are provided.

### Consensus statements

#### A call to action

1. Failure to achieve metabolic goals—including glycemic control—is associated with serious consequences and substantial costs.
2. Control of blood glucose has been shown to improve clinical outcomes and quality of life in people with diabetes.
3. Worldwide, optimal glycemic control is not achieved in most people with diabetes; a re-evaluation of our approach to management is needed.

Substantial evidence from controlled clinical trials indicates that improved glycemic control reduces the risk of diabetic complications and attendant healthcare costs, and improves patient quality of life. The Diabetes Control and Complications Trial (DCCT) demonstrated the advantages of improved glycemic control in reducing macrovascular complications. An emerging body of evidence supports the benefit of glycemic control in reducing macrovascular complications. Yet numerous studies, including NHANES 1999 to 2000, have shown that many patients with diabetes still do not achieve good glycemic control. In the NHANES study, for example, only 37% of patients with diabetes achieved glycemic control, as defined by an HbA1c <7%.

### Methods for monitoring glycemic control

4. Both HbA1c and SMBG are essential for assessing glycemic control:
   - HbA1c assesses long-term glycemic control, has been shown to be a predictor of diabetes complications, and reflects the combination of preprandial and postprandial glucose.
   - SMBG is required to determine recent patterns of preprandial and postprandial glucose.

5. SMBG should be recommended to all patients with diabetes as an integral part of an overall diabetes management program because it provides:
   - Real-time, reliable blood glucose concentrations
   - Ability to assess pre- and postprandial hyperglycemia
   - Improved safety through detection of hypoglycemia
   - Possibility of timely therapeutic adjustments

6. SMBG is an essential component for insulin-treated patients with diabetes, both for safety reasons (detection of
SMBG improves a patient’s problem-solving skills for preventing, detecting, or treating out-of-range blood glucose concentrations, especially during illness. In these ways, SMBG facilitates patient self-management while guiding therapeutic decision-making by healthcare professionals. Because it adds significant safety information about daily glucose control, SMBG by all patients with insulin-treated diabetes is recommended by several professional groups.\textsuperscript{12–17}

The level of glucose in a urine sample is a measure of how much glucose was cleared by the kidneys during the interval since the previous urine voiding and is affected by the patient’s renal threshold for glucose. Results will be misleading whenever this threshold is decreased (e.g., pregnancy) or increased (e.g., aging). Urine glucose testing, while historically useful for indicating episodes of hyperglycemia, provides little information about real-time blood glucose control.\textsuperscript{19} Furthermore, urine testing does not differentiate among hyperglycemia, euglycemia, or even mild-to-moderate hyperglycemia; it will give a negative (satisfactory) result in each of these instances.\textsuperscript{19} Urine testing cannot replace SMBG for the goal of achieving tight glycemic control to prevent diabetic complications, and it should only be used when blood glucose testing is not feasible.\textsuperscript{17,19}

### Specific recommendations for SMBG frequency

8. Current guidelines for the use of SMBG testing in glycemic control should contain more specific recommendations regarding frequency, timing, and integration of SMBG into the management strategy of patients, especially those with type 2 diabetes.

9. Recommended frequency of SMBG testing will depend on:
   - Type of therapy
   - Degree of glycemic control

10. Recommended frequencies for SMBG in order to optimize or advance therapy are as follows:
   - For patients at or above target managed with oral agents plus once-daily insulin, once-daily insulin alone,* or oral agents alone: ≥2 times daily
   - For patients at target managed with once-daily insulin alone* or oral agents alone: ≥1 time per day, including a weekly profile
   - For patients at target managed with oral agents plus once-daily insulin: ≥1 time per day, with more frequent profiles
   - For patients at or above target managed nonpharmacologically: ≥1 weekly profile

11. Recommended frequencies should be varied for individual patients especially those not at glycemic target or in the setting of other special clinical circumstances.

Although the importance of frequent SMBG testing is well established for adjusting insulin doses,\textsuperscript{6,37} the value of SMBG among patients with type 2 diabetes not treated with insulin has been more controversial due, in part, to a paucity of well-designed, longitudinal studies. Recent data from randomized controlled trials\textsuperscript{24,25} and a meta-analysis of randomized controlled trials,\textsuperscript{38} together with preliminary results from a large, observational cohort study, support the use of SMBG in these patients. The most current recommendations from various diabetes organizations vary widely in their suggestions for method, technique, timing, and frequency of SMBG by patients with type 2 diabetes not using insulin.\textsuperscript{12–17} More detailed information is also needed for patients with diabetes treated with insulin; current asso-

\*Once-daily insulin alone is generally less effective for achieving target blood glucose than oral agents plus once-daily insulin or multiple daily insulin injections with or without oral agents.
ciation guidelines typically indicate only that SMBG practices should be determined by the needs of the individual patient. No single guideline would be appropriate for all patients. Patients and physicians must work together to set and adjust glycemic targets and self-monitoring practices to reflect the unique situation of each patient. Importantly, the value of SMBG is not only in evaluating glucose control but also in helping patients learn how various medications and/or lifestyle choices affect their glucose levels. Using SMBG values as a teaching tool maximizes their value.

Considerable variation exists in the testing regimens suggested by the various diabetes groups, but after surveying all the available data, the panel reached a consensus. Testing at or above glycemic target, should be considered. Patients managed nonpharmacologically, whether at or above glycemic target, managed with oral agents plus once-daily insulin, once-daily insulin alone, or oral agents alone. For patients at glycemic target and managed with once-daily insulin alone or oral agents alone, self-monitoring at least weekly is recommended to guide nutrition and physical activity, detect postprandial hyperglycemia, and prevent hypoglycemia. The same one-weekly self-monitoring frequency is recommended for patients at glycemic target managed with oral agents plus once-daily insulin. However, more frequent SMBG values should be considered. Patients managed pharmacologically, whether at or above glycemic target, should perform at least weekly profile in order to guide nutrition and physical activity and to trigger the addition of pharmacologic therapy if the patient is consistently above glycemic target. A blood glucose profile should include both pre- and postprandial measurements on at least 1 day of the week.

In special cases, such as preconception and during pregnancy, acute or intercurrent illness, or lack of good glycemic control, the frequency of SMBG should be increased. In other circumstances, such as an elderly patient controlled through lifestyle modifications, this frequent testing may be unnecessarily invasive.

Specific recommendations for SMBG timing

12. SMBG should be performed at various times of the day, including preprandially and 1 to 2 hours postprandially, to obtain glucose profiles.

13. If fasting and preprandial glucose levels are controlled, but HbA1c levels are above target, controlling postprandial glucose should be emphasized.

Profiling of blood glucose through self-monitoring at various times of the day has been recommended to provide an overall view of fasting, preprandial, and postprandial glycemic control. Fasting blood glucose has long been used to assess glycemic control, particularly in patients with type 2 diabetes not treated with insulin, but studies have shown the additional value of postprandial measurements. Although fasting hyperglycemia is more prominent in patients with poor control (HbA1c ≥8.4%), most individuals with HbA1c values between 6.0% and 7.0% have normal fasting glucose levels but abnormal 2-hour postprandial levels. Additional postprandial testing is necessary in these fairly well controlled patients in order to minimize the risk for cardiovascular disease associated with postprandial hyperglycemia. Preprandial measurements also provide valuable information about fluctuations in daily glucose control and can help assess risk of hypoglycemia.

Successful implementation of SMBG

14. In addition to its utility as a tool for evaluation of glycemic control, SMBG is an educational tool to inform patients and healthcare professionals about the effects of lifestyle (including both nutrition and exercise), behavioral, and/or medication changes.

15. Ongoing education and reinforcement regarding the use and interpretation of SMBG by patients and healthcare professionals is essential.

16. SMBG should be used by patients and healthcare professionals in conjunction with a diabetes management action plan.

The majority of evidence and most diabetes guidelines emphasize the importance of SMBG in the management of diabetes. SMBG is a self-care behavior, and patients benefit from ongoing education to help them understand the role that self-monitoring can play in helping attain optimal glycemic control. The AADE had identified monitoring as 1 of the 7 AADE self-care behaviors. Diabetes educators, where available, should be approached for ongoing education to maximize the benefit of self-monitoring. A critical step in achieving optimal blood glucose monitoring behavioral goals is identifying and resolving barriers to blood glucose monitoring. By demonstrating the effects that medications, diet, and exercise have on blood glucose levels, self-monitoring can motivate patients to become active participants in their own care. A comprehensive diabetes management plan is essential in achieving good glycemic control through SMBG. When diabetes self-management education is included as part of the action plan, the patient can learn accurate and reliable monitoring skills, proper interpretation of the results, and how to use the results to adjust medical nutrition therapy, exercise, or pharmacologic therapy to achieve specific glycemic goals. Furthermore, successful implementation of SMBG should include a return demonstration to assess patient technique.

Summary

By presenting these consensus statements, the conference participants hope to provide physicians with timely information to improve glycemic control in all patients with diabetes.
Appendix

Consensus Conference on Glucose Monitoring Panel Members: Mary M. Austin, RD, MA, CDE, American Association of Diabetes Educators and The Austin Group, LLC, Shelby Township, Michigan, USA; Lawrence Blonde, MD, Diabetes Clinical Research Unit, Ochsner Clinic Foundation, New Orleans, Louisiana, USA; Antonio R. Chacra, MD, Endocrine and Diabetes Division, Department of Medicine, Federal University, São Paulo, Brazil; Stephen Colagiuri, MD, Department of Endocrinology, Diabetes and Metabolism, Prince of Wales Hospital, Randwick, New South Wales, Australia; Domenico Cucinotta, MD, Division of Endocrinology and Metabolism, Department of Internal Medicine, University of Messina Medical School, Messina, Italy; Paul Davidson, MD, Atlanta Diabetes Associates, Atlanta, Georgia, USA; Sean F. Dinneen, MD, Department of Diabetes and Endocrinology, Addenbrooke’s Hospital, Cambridge, United Kingdom; John E. Gerich, MD, University of Rochester School of Medicine, Rochester, New York, USA; Steven J. Hurel, PhD, Department of Diabetes and Endocrinology, University College London Hospitals, London, United Kingdom; Linong Ji, MD, Department of Endocrinology and Metabolism, People’s Hospital, Peking University, Beijing, China; Tina Kader, MD, CDE, McGill University, and Department of Endocrinology, Jewish General Hospital, Montreal, Quebec, Canada; Andrew J. Karter, PhD, Division of Research, Kaiser Permanente, Oakland, California, USA; Andreas Liebl, MD, Division of Diabetology, Center for Diabetes and Metabolism, Fachklinik Bad Heilbrunn, Bad Heilbrunn, Germany; Augusto D. Litonjua, MD, Division of Endocrinology, Department of Medicine, Makati Medical Center, Makati, Metro Manila, Philippines; Massimo Massi-Benedetti, MD, Department of Internal Medicine, Endocrine Science and Metabolism, University of Perugia, Perugia, Italy; Gérard Reach, MD, Department of Internal Medicine and Endocrinology, Hospital Avicenne, Bobigny, France; Eric Renard, MD, PhD, Department of Endocrinology, Diabetes, and Metabolism, Montpellier I University, and Lapeyronie Hospital, Montpellier, France; Subhash K. Wangnoo, MD, Department of Endocrinology and Diabetes, Indraprastha Apollo Hospitals, New Delhi, India; Kun-Ho Yoon, MD, PhD, Department of Endocrinology and Metabolism, Kangnam St. Mary’s Hospital, Catholic University of Korea, Seoul, Korea.

References
