In Brief

Interpretation of self-monitoring of blood glucose (SMBG) results is not routinely practiced in the office and clinic setting. However, such interpretation in the presence of patients may facilitate improved patient-provider discussion, clinical decisions, and ability to manage glycemic patterns. This review outlines key steps in a systematic review of SMBG data, including 1) identifying the degree of blood glucose control using mean and standard deviation or variance, 2) identifying patient safety concerns with regard to hypoglycemia, and 3) understanding the factors influencing blood glucose control by noting trends and patterns. Case studies are provided to illustrate the process for using and interpreting electronic SMBG downloads.

Blood Glucose Monitoring: A Practical Guide for Use in the Office and Clinic Setting

Peggy Soule Odegard, PharmD, BCPS, CDE, and Jennifer Rose Beach, PharmD, CDE

In 1978, the introduction of home blood glucose meters for self-monitoring of blood glucose (SMBG) provided a new window through which people with diabetes could observe and respond to the daily influences on blood glucose affecting their diabetes.1,2 This new vantage point on blood glucose also provided health care providers with a novel and effective way to provide counseling, target therapy, and empower people with diabetes to have more control over management of their diabetes. Since that time, the technology of blood glucose monitoring has developed significantly to facilitate convenience of meter use and interpretation of results.3 Specific developments that have driven the market include substantial reduction in meter size, speed of testing (5 seconds is common now), automated controls and strip coding, minimal need for blood (as low as 0.3 µl), enhanced memory, and the ability to download results. Table 1 displays the key features of several popular meters.

Although technology has advanced to facilitate increased use of home blood glucose meters, published reports describing systematic review and interpretation of this information by health care providers are limited. A major diabetes trial conducted in community pharmacies that involved free distribution of blood glucose monitors, education on use, and ongoing monitoring and consultation with pharmacists on results, demonstrated improved diabetes control.4

In an uncontrolled study conducted at two community pharmacies in Virginia, blood glucose values decreased significantly at 12 months compared to baseline (P < 0.05), while medication adherence was maintained at 90% for those receiving pharmacist review and consultation about their SMBG results.5

Some third-party insurers offer free blood glucose meters through their drug benefit. However, personalized training and instruction of patients or regular monitoring of results does not appear to be linked to these programs. Instead, clients are referred to the meter use instructions available through the blood glucose meter manufacturer’s websites.6,7 The consensus statement developed by people with diabetes at the seventh annual “Taking Control of Your Diabetes” conference indicates that patients desire to have increased participation in decisions and understanding of test results. Systematic review and discussion with patients about SMBG results makes this desire a possibility.8

Whether in a clinic, office, or pharmacy setting, key challenges to systematic and ongoing SMBG consultation and review include poor provider familiarity with meters because of a lack of training and workload limitations precluding more extensive consultation with patients. These limitations in the translation of meter technology into daily practice may negatively affect initial meter education and follow-up monitoring of results. In a clinic or...
Table 1. Selected Downloadable Blood Glucose Meters and Their Features<sup>10</sup>

<table>
<thead>
<tr>
<th>Name</th>
<th>Coding</th>
<th>Blood Volume (µl)</th>
<th>Testing Time (seconds)</th>
<th>Test Range (mg/dl)</th>
<th>Hematocrit Limits (%)</th>
<th>Test Memory</th>
<th>Special Features and Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accu-Chek Compact Plus*</td>
<td>No coding</td>
<td>1.5</td>
<td>5</td>
<td>10–600</td>
<td>25–65</td>
<td>300 glucose readings with time and date; 7-, 14-, and 30-day averages</td>
<td>Strips are housed inside meter. Do not use if on peritoneal dialysis.</td>
</tr>
<tr>
<td>Accu-Chek Advantage*</td>
<td>Snap-in code key</td>
<td>4</td>
<td>26</td>
<td>10–600</td>
<td>20–65</td>
<td>480 glucose readings with time and date; 7-, 14-, and 30-day averages</td>
<td>Strips are curved for ease of use.</td>
</tr>
<tr>
<td>Accu-Chek Aviva*</td>
<td>Snap-in code key</td>
<td>0.6</td>
<td>5</td>
<td>10–600</td>
<td>Not reported in package insert</td>
<td>500 glucose readings with time and date; 7-, 14-, and 30-day averages</td>
<td>Up to four alarms can be set in the meter. Do not use if on peritoneal dialysis.</td>
</tr>
<tr>
<td>Ascencia Contour (new 2007 version)†</td>
<td>Automatic</td>
<td>0.6</td>
<td>5</td>
<td>10–600</td>
<td>0–70 in new meters, 20–60 in old meter version</td>
<td>480 glucose readings with time and date; 14-day average</td>
<td>Optional meal markers with postmeal reminder alarms</td>
</tr>
<tr>
<td>Ascencia Breeze2†</td>
<td>Automatic</td>
<td>1</td>
<td>5</td>
<td>20–600</td>
<td>20–55</td>
<td>420 glucose readings with time and date; 1-, 7-, and 30-day averages</td>
<td>Strips housed in meter. May be better for arthritis sufferers.</td>
</tr>
<tr>
<td>OneTouch Ultra‡</td>
<td>Manual</td>
<td>1</td>
<td>5</td>
<td>20–600</td>
<td>30–55</td>
<td>150 glucose readings with time and date; 14- and 30-day averages</td>
<td>—</td>
</tr>
<tr>
<td>OneTouch Ultra2‡</td>
<td>Manual</td>
<td>1</td>
<td>5</td>
<td>20–600</td>
<td>30–55</td>
<td>500 glucose readings with time and date; 7-, 14-, and 30-day averages</td>
<td>Meal markers and other comments available.</td>
</tr>
<tr>
<td>OneTouch UltraMini (new version)‡</td>
<td>Manual</td>
<td>1</td>
<td>5</td>
<td>20–600</td>
<td>30–55</td>
<td>500 glucose readings with time and date</td>
<td>—</td>
</tr>
<tr>
<td>OneTouch UltraSmart‡</td>
<td>Manual</td>
<td>1</td>
<td>5</td>
<td>20–600</td>
<td>30–55</td>
<td>More than 3,000 records with 7-, 14-, 30-, 60-, and 90-day averages</td>
<td>Electronic logbook options including insulin, exercise, health data, medication, and food</td>
</tr>
</tbody>
</table>

continued on p. 102
provider office setting, interpretation of meter data is often limited to either reviewing patient logbooks or records with infrequent use of the 7- or 14-day blood glucose averaging function or downloading results to evaluate the mean blood glucose and standard deviation (SD).

Software technology that is readily available and easy to use can assist providers in rapid interpretation of SMBG information in the clinic and office setting. In this review, we will discuss, through the presentation of two case studies, these technologies

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<th>Name</th>
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<th>Blood Volume (µl)</th>
<th>Testing Time (seconds)</th>
<th>Test Range (mg/dl)</th>
<th>Hematocrit Limits (%)</th>
<th>Test Memory</th>
<th>Special Features and Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision Xtra (new version)§</td>
<td>Calibrator in each test strip box</td>
<td>0.6</td>
<td>5</td>
<td>20–500</td>
<td>30–60</td>
<td>450 glucose readings with time and date; 7-, 14-, and 30-day averages</td>
<td>Tests blood ketones (strips use 1.5 µl; 10-second results)</td>
</tr>
<tr>
<td>Therasense Freestyle§</td>
<td>Manual</td>
<td>0.3</td>
<td>7–15</td>
<td>20–500</td>
<td>0–60</td>
<td>250 glucose readings with time and date; 14-day average</td>
<td>Up to four daily alarms can be set in meter. Do not use if on peritoneal dialysis.</td>
</tr>
<tr>
<td>Therasense Freestyle Flash§</td>
<td>Manual</td>
<td>0.3</td>
<td>7</td>
<td>20–500</td>
<td>0–60</td>
<td>250 glucose readings with time and date; 14-day average</td>
<td>Up to four daily alarms can be set in meter. Do not use if on peritoneal dialysis.</td>
</tr>
<tr>
<td>Therasense Freestyle Freedom§</td>
<td>Manual</td>
<td>0.3</td>
<td>5</td>
<td>20–500</td>
<td>0–60</td>
<td>250 glucose readings with time and date; 14-day average</td>
<td>Up to four daily alarms can be set in meter. Do not use if on peritoneal dialysis.</td>
</tr>
<tr>
<td>Therasense Freestyle Lite§</td>
<td>Automatic</td>
<td>0.3</td>
<td>5</td>
<td>20–500</td>
<td>15–65</td>
<td>400 glucose readings with time and date; 7-, 14-, and 30-day averages</td>
<td>Up to four daily alarms can be set in meter. Do not use if on peritoneal dialysis.</td>
</tr>
<tr>
<td>Truetrack</td>
<td></td>
<td>Code chip</td>
<td>1</td>
<td>10</td>
<td>20–600</td>
<td>30–55</td>
<td>365 glucose readings with 14- and 30-day averages</td>
</tr>
<tr>
<td>Prodigy Autocode¶</td>
<td>Automatic</td>
<td>0.6</td>
<td>6</td>
<td>20–600</td>
<td>20–60</td>
<td>450 glucose readings with time and date; 7-, 14-, 21-, 28-, 40-, and 90-day averages</td>
<td>Talking meter; value meter option</td>
</tr>
</tbody>
</table>

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*Roche (1-800-858-8072, www.accu-chek.com)
†Bayer (1-800-248-8100, www.BayerDiabetes.com)
‡Lifescan (1-800-227-8862, www.lifescan.com)
||Home Diagnostics (1-800-803-6025, www.homediagnostics.com)
¶Diagnostic Devices, Inc. (1-800-243-2636, www.prodigymeter.com)
and suggest a step-by-step method for same-visit interpretation of SMBG results in the clinic or office setting.

**Case Study 1**

B.T. is an 80-year-old woman with type 2 diabetes, who has come to the clinic for a checkup of her diabetes. She also has congestive heart failure, hypertension, and hyperlipidemia. She is confined to a wheelchair and therefore gets very little physical activity. Her most recent health crisis includes hospitalization for pneumonia. During that time, her blood glucose levels were consistently 300–400 mg/dl. Before this illness, her blood glucose levels were more or less under control. She had been increasing her insulin doses to cover the higher glucose levels related to her illness, but she is now complaining of symptoms of hypoglycemia.

Her usual home regimen is 10 units of lispro insulin twice daily, 10 units of lispro before breakfast, 8 units of lispro before lunch, and 10 units of lispro before dinner. She does not have a logbook or written record of blood glucose results. However, she says that she checks her blood glucose a few times each day. How might a record keeping method of record keeping in diabetes. However, interpretation of SMBG based on handwritten logbook records is dependent on patients’ record-keeping intensity and organization, and these records can vary dramatically in terms of helpfulness in making management decisions. Some patients who bring in a handwritten logbook are very careful to note the time of day, how much insulin or medication was given, what was eaten, and the corresponding blood glucose result. Other patients provide a collection of results, in random order, without indicating the date, time, or reason for taking the blood glucose measurement.

When relying on handwritten SMBG results, it is essential that results are organized, timed, and provide a sense of the influence of medications and lifestyle on blood glucose to allow for meaningful diabetes care decision making. If logbooks are lacking sufficient information to provide feedback on diabetes self-management, patients should be specifically instructed to increase SMBG, including the time of day to test and timing with regard to meals or medications. Follow-up should then be arranged to assess the SMBG information after 1–2 weeks. If there are concerns about the reliability of results, a hemoglobin A1C (A1C) test or random finger-stick check can be performed in the office or clinic to validate the information.

Important considerations when reviewing handwritten SMBG logbooks are to identify hypoglycemic events (safety concerns) and glucose patterns (efficacy of therapy). Table 2 reviews the steps for manual interpretation of SMBG results. Logbooks are commonly organized with columns for time of day and rows for the day of the week (Figure 1), allowing the eye to travel down columns to identify trends at certain times of day and across rows for trends occurring certain days of the week. After reviewing a patient’s logbook, worrisome hypoglycemic events should be immediately discussed with the patient and a plan should be created to avoid future events. Trends in glucose values also should be discussed to provide encouragement for positive trends and identify strategies for reducing negative trends (e.g., weekend high readings because of eating at restaurants). The final step is to provide insight to the patient

![Figure 1. Sample SMBG logbook.](image)

<table>
<thead>
<tr>
<th>DATE</th>
<th>BLOOD GLUCOSE TEST RESULTS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breakfast</td>
<td>Lunch</td>
</tr>
<tr>
<td>Sunday</td>
<td>10:00</td>
<td>11:00</td>
</tr>
<tr>
<td>Monday</td>
<td>11:00</td>
<td>12:00</td>
</tr>
<tr>
<td>Tuesday</td>
<td>12:00</td>
<td>13:00</td>
</tr>
<tr>
<td>Wednesday</td>
<td>13:00</td>
<td>14:00</td>
</tr>
<tr>
<td>Thursday</td>
<td>14:00</td>
<td>15:00</td>
</tr>
<tr>
<td>Friday</td>
<td>15:00</td>
<td>16:00</td>
</tr>
<tr>
<td>Saturday</td>
<td>16:00</td>
<td>17:00</td>
</tr>
</tbody>
</table>

**Methods for Interpreting SMBG Results**

There are several methods for evaluating SMBG results, including manual review of patient diaries or logbooks, use of meter memory histories and computation, and electronic meter downloads with external software analysis. Regardless of method, there are five standard goals for a systematic review:

1. Estimate the degree of blood glucose control and variation throughout the day.
2. Identify patient safety concerns with regard to hypoglycemic trends or events.
3. Understand the factors influencing blood glucose control.
4. Suggest strategies for achieving improved blood glucose control.
5. Provide reinforcement to patients that this information is valuable and useful in their care.

In general, the average or mean blood glucose (using at least a 3-day history) can provide an idea of recent diabetes control and allow for counseling on factors that may have affected blood glucose, including diet, physical activity, and medications.

**Patient Records and Logbook Reviews**

Ideally, interpretation of SMBG should be based on a systematic review or download of meter results because this provides the most objective method for reviewing information and providing feedback to patients. In reality, however, many patients bring only their handwritten records or logbook to office visits.

Logbooks (Figure 1) are distributed with each new meter and are a common method of record keeping in diabetes.
### Table 2. Interpretation of SMBG Results

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
<th>Manual Review of Logbook</th>
<th>Electronic Meter Download</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Connect download cable to meter and cue computer to begin downloading at least 1–2 weeks of data. Select desired report and print.</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>Review at least 1–2 weeks of SMBG results.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>Identify and circle worrisome hypoglycemic events (e.g., SMBG &lt; 70 mg/dl). Ask whether these required the assistance of another individual (i.e., “serious” events) or were manageable by the patient with carbohydrate treatment. Also ask whether they can be explained (e.g., missed a meal or over-treatment of hyperglycemia) or were unexpected.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>Review consistency and timing of SMBG.</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
| 5    | Assess the overall (aggregate) SMBG average and variability throughout the day.  
  • Compare average seen to previous review and to A1C values.  
  • The goal for an acceptable SD is less than half of the average, in the absence of predominant hypoglycemia.  
  • Time frames with a higher SD should be evaluated for reasons of variability. | ✓ Variability must be visually observed as a range. | ✓ Variability is reported as an SD. |
| 6    | Assess the time-specific SMBG averages.                                | ✓ This would have to be done manually or by quick visual glance down logbook columns. | ✓                         |
| 7    | Evaluate trends in basal and prandial control. Note positive and negative trends.  
  • Basal trends: Evaluate fasting blood glucose by comparing bedtime to morning blood glucose values.  
  • Prandial trends: Evaluate postmeal blood glucose; establish patient’s eating time and routines.  
  • Other trends: Review blood glucose records for evidence of insulin stacking, problems with correction doses, or over-treatment of hypoglycemia.  
  • Consider adjusting insulin doses by 10–20%. | ✓                        | ✓                         |
| 8    | Discuss your assessment with patients to get their input on trends and to improve efficacy and safety of therapy.  
  • Set realistic testing goals for the next visit.  
  • Changes that are made may require special testing scenarios (such as recommending a few 3:00 a.m. blood glucose measurements to follow up on a basal insulin adjustment). Discuss these expectations. Decide on follow-up plans. | ✓ Difficult to perform full review of trends at one visit given the need for calculation and manual data analysis. | ✓ Automated reporting facilitates the ability to have this discussion within minutes of a download. Practitioners can review current average tests per day on some download programs to help set future goals. |

on the overall glucose average and degree of variability and to roughly equate these to the expected A1C (Table 3).

**Case Study 1 Update**

_B.T. reveals that she cannot write anymore because she has severe tremors, especially on her right side, which is her dominant hand. She confides that maintaining her logbook has been difficult. She is cared for by her son and daughter-in-law, who are busy during the day and unable to help her with this task._
as well, confirming her reports of hypoglycemia symptoms. Without the information mapped out more succinctly, it is difficult to interpret trends and patterns.

Meter Downloads and Analysis
Downloading SMBG results to an office or clinic computer, secured website, or even a patient’s computer for analysis is a fast, simple, and effective method for evaluating glucose information. Major advantages of electronic SMBG download and analysis include speed of review; instant and accurate calculation of results (versus estimation often used when looking at logbooks); ability to report data in many ways using tables, graphs, charts, or statistics; and ability to show these reports immediately to patients for use in planning care.

Both specialty software and native software offered by the meter company are readily available for downloading. Several programs are able to interface with the popularly used meters (Table 4). One example of specialty software is Clinipro, which can download most commercially available meters into one software program. After using software to download meter readings, a process similar to that described above for manual interpretation of logbook results can be used to interpret the data (Table 2).

The overall mean and SD are key factors to evaluate when using software analysis. The aggregate mean can be a good quick comparison from the last visit to the current visit in terms of diabetes control, assuming the amount of hypoglycemia is approximately equal. The average can be used to compare to recent A1C values so that discrepancies can be identified that may need further investigation (Table 3).

The SD, which is the square root of the variance, indicates the amount of variability among all the meter readings. It has been suggested that the SD value doubled should be less than the aggregate mean as a way to assess safety and efficacy of treatment regimen. Certainly, the higher the SD, the more variability a patient is experiencing, with many possible causes, such as erratic insulin or medication absorption, improper timing of meals with insulin onset, or gastroparesis creating a mismatch between food absorption and insulin action onset.

Case Study 1 Update
B.T.’s meter is downloaded, and her aggregate mean for the past month is 245 mg/dl, reflecting her earlier hospital admission and illness-related hyperglycemia. She has an SD of 131 mg/dl, which is higher than desired. This could reflect that, although she is often hyperglycemic, she is having episodes of hypoglycemia, contributing to a large degree of variability. In her case, it could also be the result of the change in her usual level of control, with better blood glucose levels before pneumonia and higher levels afterward.

Exploring Problems With Basal Glucose Control
Evaluating fasting blood glucose is the best way to diagnose needs for improved basal control. For the majority of individuals, the first morning blood glucose (premeal) is a good proxy for fasting blood glucose (8 hours since last meal). For those taking insulin, preprandial glucose monitoring provides information regarding the efficacy of basal insulin doses (subcutaneous injection or pump basal infusion rate) and can also provide insight into the effectiveness of previously injected prandial coverage. For those taking oral medications, such as sulfonylureas or metformin, fasting blood glucose can provide a sense of basal control with regard to influence on insulin production (sulfonylureas) or inhibition of nighttime glucose output (metformin).

Elevated morning blood glucose levels can also be the result of nighttime snacking that presents as morning hyperglycemia, so it is important to explore reasons for high readings before making a change. Other nighttime routines, such as exercise, medication dosing, and sleep patterns, are also relevant topics to review with patients and can lend evidence or doubt to a given presumption about the patients’ blood glucose patterns.

The blood glucose trend overnight is especially important, and bedtime blood glucose results can help to evaluate this trend. For example, if a patient goes to sleep with a blood glucose level of 120 mg/dl (> 3–4 hours after dinner) and has no bedtime snack, a blood glucose at or just
<table>
<thead>
<tr>
<th>Name (Manufacturer)</th>
<th>Meters Supported</th>
<th>Special Features</th>
<th>System Requirements</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accu-Chek Compass (Roche)</td>
<td>Accu-Chek Advantage, Compact, Compact Plus, Active, Complete, Aviva</td>
<td>Logbook, trend graph, average day, average week, target range, hypoglycemia measurement, 1-page summary</td>
<td>Pentium 90 or higher, Windows 98, Windows NT 4.0, Windows ME, Windows 2000, or Windows XP Home or XP Professional, 32 MB of RAM, 50 MB of available hard disk space, graphics card that supports a resolution of 800 x 600 pixels and 256 colors, serial/COM port, MS Internet Explorer 5.0 or higher</td>
<td>Accu-Chek Compass software = $29.99; cable for Aviva/Compact/Active = $15; cables for Advantage or Complete = $10</td>
</tr>
<tr>
<td>OneTouch Diabetes Management Software version 2.3.1 (Lifescan)</td>
<td>All OneTouch meters with data ports, including Ultra, Ultra2, New UltraMini, UltraSmart</td>
<td>Logbook, 14-day summary, glucose trend, pie chart, average reading, standard day, data list, histogram, insulin log, health checks</td>
<td>Windows-compatible computer with 266 MHz, Intel Pentium 2 or equivalent, minimum 128 MB of RAM, minimum free hard disk space 100–200 MB during installation/100 MB after installation, Microsoft Windows 98 Second Edition, Windows NT 4.0 Workstation (SP6 or above), Windows 2000 Professional (SP4 or above), Windows ME, and Windows XP (SP2 or above) Home and Professional (SP2 or above), 9-pin/25-pin COM or USB port, video monitor at least 800 x 600 pixels and 256 colors, CD-ROM drive</td>
<td>Software kit including cable and CD = $29.99, suggested retail. Visit website <a href="http://www.OnetouchDiabetesSoftware.com">www.OnetouchDiabetesSoftware.com</a> for full details on where to purchase and for download of drivers for UltraMini download</td>
</tr>
<tr>
<td>TrackRecord Data Management Software (Home Diagnostics)</td>
<td>TrueTrack, TrueRead, Prestige IQ</td>
<td>Summary, logbook, conformance, glucose trend, and extended logbook</td>
<td>Microsoft Windows XP Professional with SP2 or Vista, Adobe Acrobat Reader, Intel Pentium III or higher, USB connectivity</td>
<td>Download latest version for free at website <a href="http://www.thesmartchoice.com">www.thesmartchoice.com</a> or call 1-800-342-7226 for free CD; cable $19.99</td>
</tr>
</tbody>
</table>

continued on p. 107
<120 mg/dl would be expected the next morning. If the patient wakes up with blood glucose levels higher than at bedtime, it may be related to inadequate basal medication, reactive hyperglycemia in response to low blood glucose, or the dawn phenomenon.

Reactive hyperglycemia and the dawn phenomenon can be difficult to diagnose without the benefit of continuous glucose monitoring (CGM) or multiple nighttime SMBG values to observe trends. The dawn phenomenon is a natural increase in blood glucose between about 4:00 and 8:00 a.m., presumably as the result of counter-regulatory hormone increases or the release of growth hormone in the early morning hours.13

**Case Study 1 Update**

B.T.’s fasting average in the past has usually been quite good. She maintains that higher readings now are not related to waking or fasting blood glucose levels.

**Exploring Problems With Prandial Glucose Control**

Higher blood glucose attributed to prandial inadequacies can be seen when evaluating peak postprandial blood glucose (determined 1–2 hours after the start of a meal). Because many patients do not test in the period after eating, a good idea of postprandial coverage can be obtained from looking at the preprandial value for...
the next meal. If patients can recall the past 2 days of meals, activity, and medications, their blood glucose control can be evaluated based on the most recent data collection. This can be important not only to interpret the data, but also to obtain a sense of the day-to-day influences on glucose variability. The SMBG averages on the glucose meter can be helpful to get a global sense of how a patient is doing. For example, if the aggregate mean blood glucose level for all predinner blood glucose values is higher than any other time of the day, information about what typically happens at lunch and afterward would be useful. If there is no apparent reason for the hyperglycemia, such as snacking or over-treatment of hypoglycemia, then increasing prandial coverage at lunch would make sense.

Case Study 1 Update
B.T. has begun experiencing hypoglycemia after meals. It is discovered that she has been increasing her prandial insulin recently to cover the high blood glucose levels related to her illness. She has since been treated with antibiotics, and her pneumonia is resolving. She had one blood glucose reading of 40 mg/dl shortly after breakfast. She gave 15 units of aspart for breakfast, and the low glucose level occurred 2 hours afterward. She also had another hypoglycemic reaction after dinner, and although she was unable to test because of the severity of the tremor with the reaction, she treated with candy and the feeling resolved. She had taken 15 units of aspart for dinner.

Other Common Issues Seen When Evaluating SMBG Data
There are more aspects to evaluating glucose control than basal- and prandial-related concerns. A common issue for those using insulin is related to their correction algorithm, an insulin dose used to normalize blood glucose above the preprandial target. If too much insulin is given for correction of hyperglycemia, it may be reflected in the download by hypoglycemia after the correction dose. If an insufficient correction insulin dose is given, the reverse would be true, with continued hyperglycemia after treating.

Another cause of hypoglycemia after a treated hyperglycemia is what is sometimes termed “insulin stacking.” This occurs when insulin correction (using rapid- or short-acting insulin) is layered too heavily on top of the prandial dose of insulin already administered by the patient. There is generally a 4-hour window after the initial injection of rapid-acting insulin when this is most commonly seen, and it can be resolved by reducing the amount of additive correction insulin given when there is already substantial insulin remaining “on board.” For patients who take an oral sulfonylurea or use NPH insulin, hypoglycemia may be related to delayed or skipped meals.

Case Study 1 Update
Figure 2 shows B.T.’s download. Despite higher blood glucose levels from her previous illness, her meter download shows that her blood glucose control is improving, and the temporary increase in insulin is now too much. Review of her SMBG results before the illness also reveals that often her blood glucose levels were lower than ideal. A change is necessary in her prandial insulin regimen. Instead of 10 units before breakfast, 8 units before lunch, and 10 units before dinner, she is asked to use 7 units before each meal, representing a 25% reduction in her daily prandial insulin, and a 15% reduction of her overall daily insulin dose.

Frequency of Testing and Related Testing Challenges
The American Diabetes Association (ADA) Standards of Medical Care in Diabetes recommends that SMBG should be carried out three or more times daily for patients using multiple daily insulin injections or insulin pump therapy. The ADA also states that SMBG may be useful for patients using less frequent insulin injections, noninsulin therapies, or medical nutrition therapy alone.14 This recommendation likely stems from the discrepancy of data supporting the benefit of frequent SMBG on glycemic control for those who are not using intensive insulin regimens. However, from a practical standpoint, it can be difficult to make effective recommendations for change without some idea of how a patient’s blood glucose manifests on a routine basis. Certainly cost considerations are a factor, although most insurance companies will cover their preferred meter strips, and Medicare covers three times daily testing for insulin-treated patients or once-daily testing for patients who do not use insulin.
From the patients’ perspective, one reason testing may not be a priority is health care providers’ lack of enthusiasm at reviewing the data. If there is no feedback to be gained, it is difficult to expect adherence.

An extensive review of blood glucose monitoring data, part of a global consensus conference report on SMBG, included the following five recommendations:
1. SMBG should be initiated in all patients with diabetes as an integral part of an overall diabetes management program.
2. SMBG should be performed ≥3–4 times daily for patients treated with multiple daily insulin injections or using an insulin pump; ≥2 times daily for patients above their glycemic target who are managed with oral agents and once-daily insulin; ≥1 time per day with a weekly profile (to include pre- and postprandial glucose readings) for patients at their glycemic target who are managed with oral agents plus once-daily insulin; and ≥1 weekly profile for patients managed nonpharmacologically, whether they are at or above their glycemic target.
3. Additional SMBG should be performed in certain situations, such as acute illness, intercurrent illness, changes in medications, for patients with impaired awareness of hypoglycemia, and during pregnancy.
4. Postprandial SMBG testing should be used by all patients with diabetes to minimize postprandial excursions and guide lifestyle changes.
5. SMBG should be viewed as an education tool to inform patients about the effects of lifestyle and behavioral changes.

Certainly, barriers to the above recommendations are well recognized, including high out-of-pocket costs or no insurance, language barriers, and lower education levels. However, it is prudent to help patients where possible to overcome these barriers, given the importance of the information.

Case Study 1 Update
B.T. comes back to the clinic convinced that her meter is broken. She is getting such good results from the recent change that she requests validation of accuracy with our clinic meter. The two meters show identical results. Her download summary appears in Figure 3 and shows an improved aggregate mean of 122 mg/dl with an SD of 34 mg/dl.

CGM
CGM devices are now available for home use for patients with diabetes. These devices offer a large amount of blood glucose information, with readings displayed every 5 minutes. Although CGM devices offer another great way for clinicians to help patients with disease management and for patients to have much more data to evaluate daily decision making, they are still not the norm. With many practices still resistant to downloading meters, the time and resources needed to begin CGM downloading and review on a routine basis make it not yet practical for most offices. This emerging technology is described in full elsewhere in this issue (p. 112).

Case Study 2
P.Q. is a 64-year-old woman who presents for a review of glycemic control. She has type 2 diabetes, weight management issues, hypertension, and dyslipidemia. She is now retired from her profession as a school teacher, and she feels that this has allowed her to start paying much more attention to her personal health needs. She states that she is disappointed that today’s weight does not reflect the 10-lb loss she achieved this past fall, but also acknowledges that she was not as careful during the holiday season and therefore has
regained some of the weight she had lost. She feels she is ready to renew her dietary efforts and become much more physically active. She has been quite careful with food choices for the past week.

Her medications include:
- Glargine, 20 units in the morning
- NPH, 8 units at bedtime
- Lispro, 6–8 units at breakfast, 8 units at lunch, and 8 units at dinner (She does not vary these doses with a correction algorithm.)
- Losartan, 100 mg daily
- Ezetimibe, 10 mg daily
- Niacin, 1,000 mg at bedtime
- Aspirin, 81 mg daily

On physical examination, her weight is 225 lb (down 3 lb from her weight 9 months ago). Her blood pressure is 152/70 mmHg, but she has a considerable office component, which we have demonstrated with a 24-hour ambulatory blood pressure monitor. Examination of her lower extremities shows good dorsalis pedis pulses. She has a rather significant fifth metatarsophalangeal on the right foot callus. This is not thick, but it is an area to be monitored, and the clinician draws her attention to it. On a 10-g monofilament challenge, she is able to appreciate the monofilament over all areas checked.

Laboratory values include an A1C of 8.8%, total cholesterol of 237 mg/dl, LDL cholesterol of 140 mg/dl, HDL cholesterol of 82 mg/dl, triglycerides of 75 mg/dl, and all other tests within normal limits.

P.Q.’s meter download chart is shown in Figure 4, and a graph of her blood glucose readings is shown in Figure 5.

Discussion
To interpret the data gathered from P.Q.’s meter, the clinician:
1. Reviews the report, highlighting key data.
   - What is the time period? (It should be at least 2 weeks.): The time period is 1 month with 102 readings.
   - Are there any concerning hypoglycemic events (e.g., SMBG < 70 mg/dl)? Yes, there have been eight events < 60 mg/dl. This is discussed with P.Q., who reveals that these occurred after exercising, although the one episode that occurred in the nighttime is a mystery. She suggests that maybe she gave her NPH shot twice the night before.
   - What are the trends? The highest mean blood glucose average (189 mg/dl) is at night. The highest SD (120.65 mg/dl) is occurring at bedtime, with a mean of 131 mg/dl (based on four values).
The best control is at lunch (132 mg/dl, SD 50.54 mg/dl).

- What are the average blood glucose readings?
  - Morning fasting: 161 mg/dl (SD 71.47 mg/dl); mid-morning 137 mg/dl (SD 68.89 mg/dl); lunchtime 132 mg/dl (SD 50.54 mg/dl); mid-afternoon 164 mg/dl (SD 96.81 mg/dl); dinner 128 mg/dl (SD 77.16 mg/dl); mid-evening 154 mg/dl (SD 72.71 mg/dl); and bedtime 131 mg/dl (SD 120.65 mg/dl).
- What is the aggregate mean blood glucose? 154 mg/dl (SD 80.71 mg/dl).

2. Interpret the data.
- The aggregate blood glucose is acceptable. However, the SD reveals high glucose variability throughout the day. P.Q.'s SD needs to be lower to reduce risk of serious hypoglycemia and hyperglycemic damage.

3. Plans for care.
- Increase glucose management related to exercise to prevent hypoglycemia.
- Because P.Q. maintains that she is careful with her diet and has not been snacking at night, increase her bedtime long-acting insulin to 10 units to manage her nighttime and fasting hyperglycemia. Consolidate the insulin to glargine (basal) and lispro (prandial), to simplify her regimen.
- Review new orders: glargine, 10 units at bedtime and 20 units in the morning. Lispro, 6–8 units before meals (use ~2 units per 15 g of carbohydrate in each meal).
- Instruct P.Q. to use a correction dose of 1 unit of lispro for every 50 mg/dl that her blood glucose rises above 150 mg/dl before meals. This should be given in addition to her usual prandial dose.

Summary
Systematic interpretation of blood glucose data in the office or clinic can provide clinicians with invaluable information for improving diabetes care and promoting self-management for individuals with diabetes. According to surveys, people with diabetes would like increased ability to participate in the decision making for their diabetes care. Because blood glucose interpretation requires discussion with patients to identify reasons for variability and patterns in control, it is a natural way to facilitate integration of the patients’ perspective, needs, lifestyle, and abilities into office-based decision making for diabetes care.

The goals of a review of SMBG results should include: 1) estimating the degree of blood glucose control and variation throughout the day; 2) identifying patient safety concerns with regard to hypoglycemic trends or events; 3) understanding the factors influencing blood glucose control; 4) suggesting strategies for achieving improved blood glucose control; and 5) providing reinforcement to patients with diabetes that this information is valuable and useful in their care. Meter technology should be used to provide the best care possible for patients and should become the minimum requirement for caring for patients with diabetes. Incorporation of this technology into clinical practice should be simple, practical, and, above all, considered necessary for patient care.

References
3Maze RS: Making sense of glucose monitoring technologies: from SMBG to CGM. Diabetes Technol Ther 7:784–787, 2005

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