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## 6. Monitoring Glycemic Control

Many factors affect the ability of patients to achieve and maintain near-normal blood glucose levels. Collaboratively developed glycemic goals should take into consideration the patient's age, comorbidities, physical limitations, lifestyle, occupation, support system, and financial resources. The patient's ability to recognize and appropriately treat hypoglycemia should be considered as well.

### Self-Monitoring of Blood Glucose

Self-monitoring of blood glucose is the most effective way to assess and manage glycemic control in the short term. Such monitoring provides immediate feedback about the impact that food, medication, stress, and activity have on glycemic control. For a checklist that can help your patients monitor their blood glucose regularly, see *Monitoring Your Blood Sugar* in Chapter 6 of the *Diabetes Care Guide Toolkit*.

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*How often should I recommend that my patients check their blood glucose?*

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The American Diabetes Association (ADA) recommends that persons with type 1 diabetes self-monitor their glucose at least 3 times daily. Patients with type 1 diabetes who use basal-bolus insulin regimens should self-monitor their blood glucose at least four times daily (e.g., before meals and at bedtime) and use the data they gather to adjust insulin dosages on a meal-by-meal, day-to-day basis. Regardless of treatment regimen, patients with type 2 diabetes need to have a blood glucose meter and know how to use it. Self-monitoring of blood glucose should be done frequently enough to provide feedback about progress toward goals and to help patients recognize when glycemic control

is deteriorating, such as during times of illness or stress.

- There is no consensus regarding the frequency of self-monitoring in patients who are not taking insulin.
- Patients with type 2 diabetes who use insulin, insulin secretagogues (sulfonylureas, meglitinides), or one of the new injectable drugs (exenatide or pramlintide) are at risk for hypoglycemia and may need to monitor more frequently (up to four times daily and/or when symptomatic) compared with those using lifestyle modifications, either alone or in combination with nonsecretagogue oral agents.
- Patients with either type 1 or type 2 diabetes may need to monitor their blood glucose more frequently when there are changes in insulin or medication dosages, activity, or meals, or during illness or stressful events.

### Using the Results of Blood Glucose Monitoring

Blood glucose monitoring alone, no matter how frequent, will not lead to improved glycemic control. Improvement in glycemia is rarely achieved unless patients have been shown how to identify glycemic trends and patterns and how to make appropriate adjustments, either independently or with the assistance of a member of the health-care team. It is important that patients understand their role in analyzing self-monitoring blood glucose records regularly (daily or weekly) to identify trends indicating that medication or lifestyle adjustments may be needed.

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*What are the goals for fasting and pre- and postprandial blood glucose levels?*

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The ADA recommends a goal of 90 to 130 mg/dL for preprandial blood glucose levels in adults with diabetes and less than 180 mg/dL for peak

postprandial glucose levels. Similarly, the American Association of Clinical Endocrinologists (AACE) recommends that adults aim for a preprandial blood glucose goal of  $\leq 110$  mg/dL and a postprandial goal of  $\leq 140$  mg/dL.

Establishing *personal* blood glucose targets in collaboration with patients is critically important, however. These personal targets may be the same as those recommended by the ADA or AACE, or they can be modified based on the patient's ability or willingness to achieve this level of glycemic control or on clinical factors, such as the ability to detect hypoglycemia. In patients whose blood glucose and hemoglobin A1C levels are significantly above the recommended values, it is often more effective to set intermediate decrements in blood glucose and A1C targets. Hitting these intermediate targets will then promote a sense of accomplishment and self-efficacy.

### The Role of Postprandial Blood Glucose Monitoring

Epidemiologic studies and preliminary intervention studies have demonstrated that postprandial hyperglycemia is an independent risk factor for cardiovascular disease in patients with type 2 diabetes. Because treatment modalities can now target postprandial blood glucose excursions, assessing how well postprandial blood glucose levels are controlled is important for determining when treatment adjustments are needed. Generally, measuring blood glucose levels 2 hours after a meal approximates the peak postprandial blood glucose concentration in patients with diabetes. It is important to measure postprandial blood glucose levels under the following circumstances:

- If hemoglobin A1C is elevated but fasting glucose levels are within the target range
- To determine the adequacy of the pre-meal insulin dosage when using basal-bolus insulin therapy

- If the patient is using an oral agent that targets postprandial glucose excursions, such as repaglinide (Prandin) and nateglinide (Starlix)
- If the patient is counting carbohydrates
- If the patient is making lifestyle modifications (diet and exercise) to achieve optimal blood glucose control

### Blood Glucose Pattern Management

Pattern management is a systematic method of analyzing self-monitoring blood glucose data to make appropriate adjustments in the treatment plan. Ideally, all patients with diabetes should learn how to use pattern management to prevent extended periods of hyperglycemia.

Patients use pattern management to assess the effectiveness of their treatment regimen and to make treatment modifications, either independently or with the help of a health-care provider, to bring blood glucose levels back into a predetermined target range. Pattern management enables patients with both type 1 and type 2 diabetes to assume more responsibility for their diabetes management and often leads to improved glycemic control by limiting the magnitude and duration of out-of-target blood glucose levels.

For patients with type 1 diabetes and for insulin-treated patients with type 2 diabetes, pattern management provides the data necessary to make self-directed adjustments in insulin dosages, carbohydrate intake, and/or activity. Pattern management is also useful for patients with type 2 diabetes who are not taking insulin but who are using lifestyle modification, oral agents, or exenatide to manage their diabetes. Pattern management helps these patients recognize when their current treatment is ineffective. Relying on pre-established guidelines, patients can use pattern management to understand when to seek advice from their health-care providers.

Pattern management requires patients (or their health-care providers) to:

- Know their individualized blood glucose target range
- Learn how to review blood glucose records regularly (daily or weekly) to identify any pattern of hypo- or hyperglycemia (usually defined as three or more self-monitoring blood glucose values outside the target range)
- Understand which components of the treatment regimen are responsible for the pattern
- Make adjustments, either independently or with the assistance of a health-care provider, to the treatment regimen that address the identified pattern

Blood glucose patterns are affected by many factors:

- Fasting blood glucose concentrations are influenced by medication or basal insulin dosage, the size of an evening meal or snack, and the amount of physical activity during the previous 24 hours.
- The dawn phenomenon, defined as an increase in blood glucose levels during the early morning hours (4 AM–8 AM), can have a pronounced effect on fasting blood glucose concentrations. It is thought to be related to increased levels of growth hormone at this time. The dawn phenomenon is seen more often in patients with type 1 diabetes than in patients with type 2 diabetes. Less commonly, fasting hyperglycemia is attributed to antecedent, nocturnal hypoglycemia (the Somogyi effect or *rebound hyperglycemia*).
- Postprandial blood glucose concentrations are influenced by the dosage of the pre-meal medication (either an oral secretagogue or rapid-acting insulin), the carbohydrate content of the meal, the preprandial blood glucose concentration, and physical activity.

Methods of pattern management for patients on insulin are described in more detail in Chapter 8 (Insulins and New Injectables). Patients using oral medications and those who are unable or unwilling to make insulin adjustments based on self-monitoring blood glucose results need instructions on how frequently to contact their

providers. This is necessary to routinely review their blood glucose records. These patients also may need specific guidelines about out-of-target readings. Patients initiating any changes in their regimen need similar guidelines.

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*What are some of the barriers that prevent patients from monitoring their glycemic control as recommended?*

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#### Financial

- Most test strips cost about 75-80 cents each.
- Some insurance companies limit the number of test strips permitted each month.

#### Fear

- Monitoring is a reminder of the diagnosis and the risk for complications.
- The patient views the results as a judgment of his or her self-management efforts rather than as data.
- The patient fears criticism from his or her health-care provider. (It is very common for patients to want their provider to think well of them.)
- The patient fears that the provider will not provide the same quality of care if the patient is not doing his or her part.
- Elevated results may mean that the diabetes is worse or that insulin is needed.

#### Discomfort associated with fingersticks

- Some patients experience more discomfort than others.
- Alternate-site testing can often eliminate or reduce discomfort.

#### Inconvenience

- Patients who are unwilling or unable to self-monitor blood glucose in public may not be able to find a suitable place to do the monitoring.
- Carrying the needed supplies can be cumbersome.

- Self-monitoring blood glucose interrupts activities of daily life.

Not seen as important

- The patient has not been adequately informed about the utility and importance of self-monitoring blood glucose.
- The patient has not been taught how to use the information from the results.
- The patient views the monitoring as unimportant because the health-care provider does not ask for his or her self-monitoring blood glucose records, does not review them when the patient brings them to an appointment, or uses them to criticize the patient's efforts.
- The patient sees no changes in self-monitoring blood glucose results or hemoglobin A1C values despite making lifestyle modifications and monitoring as often as recommended.

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### *What should I include in my discussions with patients about blood glucose monitoring?*

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There are several things you can do when discussing self-monitoring of blood glucose with patients:

- Stress that the purpose of monitoring is for the patient to use results for daily decision making. Therefore, results should be recorded accurately (see *When Patients' Blood Glucose Logbooks Are Inaccurate*). The results also provide information for providers, but the primary user of the daily information is the patient.
- Ask patients what they think the results mean (rather than just telling them).
- Remind patients that self-monitoring blood glucose results are not used to judge the patient's worth but are simply numbers that help both patient and practitioner know what to do; use words such as *monitor* or *check*, rather than *test*.

- Provide information about how to use the results to make proactive decisions or adjustments and when or how often to contact the provider to review readings.

- Help patients identify and address barriers to monitoring. Ask patients to identify behavioral and psychosocial issues they are likely to encounter. For example:

- How will you handle monitoring in public places or various social situations? How will you handle monitoring at work? How will you handle questions in these situations?

- What kind of support would you like from your family and friends? Do you want them to ask you about your results or wait until you tell them?

- How will you handle it when you are working hard and your results do not reflect your efforts?

- Let patients know you understand that it is frustrating to do the same thing one day to the next and have very different results.
- Stress that there is no such thing as perfection in blood glucose levels. The patient's values are what count the most in most situations.

### **Blood Glucose Meters**

A variety of blood glucose meters are available with differing capabilities. The size of the blood sample needed ranges from 0.3  $\mu\text{L}$  to 10.0  $\mu\text{L}$ , depending on the meter. Most meters have memory capability for storing variable amounts of data, and many have relatively sophisticated data management software that enables the user to enter medication/insulin dosages, carbohydrate intake, and exercise. Some meters can be downloaded using software programs that provide data analysis (blood glucose averages, percent of readings within the target range, etc.). You can use these software programs to download data at the time of the visit. Because patients frequently do not utilize the data management

## When Patients' Blood Glucose Logbooks Are Inaccurate

Studies have shown that patients often add, delete, or alter numbers in their glucose log books. While some of these inaccuracies are likely due to simple recording errors or represent the patient's estimate of their blood glucose, others are deliberately fabricated or changed.

Fear is the most likely underlying cause of this common occurrence. It is human nature to want others to think well of us. Therefore, making the frequency of testing or the results look better than they are often reflects the patients' desire to have us think well of them or their diabetes self-management efforts.

An effective strategy to prevent this from happening is to ask the patient what they think of their glucose readings rather than telling the patient what you think. In addition, teach patients:

- That blood glucose readings are information used by both of you to make decisions, not a judgment of their efforts or worth as a person;
- How to use the information to make the many daily decisions that are needed to manage diabetes effectively and to make adjustments in their medications or other therapies;
- How you will use the information during a visit;
- How to incorporate monitoring into their daily routine, solve problems, and obtain family support.

capabilities of their meters, they should be encouraged to keep a handwritten logbook.

All meters have a toll-free number on the back that patients can call for technical assistance. Most meter companies also have user-friendly Web sites. Whereas blood glucose meters are generally covered by insurance, the number of test strips covered may be limited.

A variety of meters are available that can be used for alternate-site testing, which is reportedly less painful than fingertip testing. Alternate sites include the forearm, the palm of the hand, and the thigh. Blood glucose levels documented via alternate-site testing tend to lag behind fingertip levels. Alternate-site testing should not be used when blood glucose levels are changing rapidly, such as after meals or exercise, or when hypoglycemia is suspected.

All meters are plasma referenced; that is, a fingerstick (capillary) sample should be comparable to a simultaneously obtained venous sample performed in a laboratory. Technique and meter accuracy should be assessed regularly, especially if hemoglobin A1C values do not correlate with self-monitoring blood glucose readings. During initial training and periodic reassessments, patients should be asked to demonstrate their self-monitoring technique.

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### *How can I help patients choose a blood glucose meter?*

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Many insurance companies dictate which meter a patient can use regardless of the needs and abilities of the patient. Whenever possible, however, patients should consider their preferences, technical abilities, and physical limitations when choosing a meter. For example, very small meters or meters with very small strips can be difficult to use for people with visual impairment or problems with manual dexterity. Some meter displays may be more difficult to read than others. In addition, some patients may be intimidated by overly complicated meters and may be less likely to use such a meter.

## Recording Blood Glucose Results

Keeping a written logbook that is updated with every self-monitored blood glucose reading allows patients to get immediate feedback about their treatment regimen and their self-management decisions. This is especially important for patients using basal/bolus insulin therapy, who need to make daily adjustments in their

pre-meal insulin dosages. Most meter companies provide logbooks to providers and patients. By going to a manufacturer's Web site, patients can find out how to obtain additional logbooks. Many Web sites also offer a free, downloadable logbook. Some patients prefer to develop their own logbooks by using a spreadsheet format.

Meters with memory and download capabilities have nearly caused the extinction of handwritten logbooks. Unfortunately, however, most patients do not review the meter memory or download the data often enough—if at all—to make timely treatment adjustments. Even though memory meters can store many blood glucose readings and the meter downloads can provide sophisticated analyses of blood glucose trends, entering blood glucose readings by hand is generally more helpful for using the information. This method gives patients the opportunity to assess their blood glucose levels daily or weekly. Handwritten logbooks also permit easy entry of other important data, including medication dosages, carbohydrate intake, and exercise.

- Patients who do not keep handwritten records need guidelines for how often to download the meter and how to interpret the data from these downloads.
- Software programs are available for patients and practitioners to use to download data from selected meters and perform trend analysis.

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*What do my patients need to know about their blood glucose meters?*

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Some tips you can share with patients about their blood glucose meters include:

- Patients need to know technical aspects of using their meter and how to solve meter-related problems. Point out the toll-free hotline number on the back of the meter.

- Availability of reimbursement for strips and meters is another issue. If none is available, ask if paying for a meter and strips is a problem.
- Remember to point out where to get help choosing a meter (e.g., from a diabetes educator or pharmacist) if one is not prescribed by an insurance or managed care plan.

## Hemoglobin A1C

Hemoglobin A1C measures nonreversible glycosylation of the hemoglobin molecule. The rate of formation of hemoglobin A1C is directly related to blood glucose concentration and reflects a time-weighted mean of the patient's blood glucose level over the previous 2 to 3 months. Hemoglobin A1C is predictive of the risk for micro- and macrovascular complications.

Slightly differing hemoglobin A1C goals have been established by the ADA and the AACE; however, as with blood glucose goals, hemoglobin A1C goals must be individualized for patient safety. Our recommendations are as follows:

- A1C goal:  $\leq 7.0\%$ , individualized for patient safety
- A1C testing interval: twice annually in stable patients; four or more times per year if glycemic control is not achieved or if treatment changes

The evidence for the importance of achieving blood glucose levels that are as close to normal as possible in older adults with diabetes is overwhelming. However, it is less clear what the target A1C levels should be for older adults with a recent diagnosis of diabetes. In other words, an older adult with a recent diagnosis has a far lower risk of developing complications over his or her lifetime than does someone whose diagnosis was made when he or she was much younger. Some geriatrics groups thus argue that for older

adults with a recent diagnosis of diabetes, the A1C targets do not have to be as stringent.

The A1C level is used in assessing the overall effectiveness of the treatment regimen and in adjusting the regimen to improve glycemic control. The ability to obtain in-office, point-of-care hemoglobin A1C measurements has been shown to improve glycemic control by providing immediate feedback on the adequacy of the current treatment regimen. Timely adjustments to the regimen, based on out-of-range hemoglobin A1C values, can be made at the time of the next visit. This facilitates communication between you and patients about regimen changes and encourages a collaborative relationship in which patients actively participate in their diabetes management.

The A1C goals cited by organizations such as the ADA are based on pay-for-performance metrics that include the frequency of testing A1C and the percentage of patients not at their goal. The goals for hemoglobin A1C management listed in the Ambulatory Care Quality Alliance (AQA) starter set of performance measures for diabetes are as follows:

- Management—Percentage of patients with diabetes with one or more A1C test(s) conducted during the measurement year
- Control—Percentage of patients with diabetes with most recent A1C level >9.0% (poor control)

Hemoglobin A1C values should correlate with self-monitoring blood glucose results. The data correlating A1C with serum blood glucose in **Table 6-1** were derived from quarterly, 7-point self-monitoring blood glucose profiles (pre- and post-meal, at bedtime, and at 3 AM) of the Diabetes Control and Complications Trial (DCCT) cohort. The self-monitoring blood glucose average in patients measuring blood glucoses less frequently than these intervals may not correlate with the A1C values listed in the table.

Table 6-1. Correlating A1C with Serum Blood Glucose

Hemoglobin A1C	Mean Blood Glucose
6%	135 mg/dL
7%	170 mg/dL
8%	205 mg/dL
9%	240 mg/dL
10%	275 mg/dL
11%	310 mg/dL
12%	345 mg/dL

Data from: American Diabetes Association. Standards of medical care in diabetes—2006. *Diabetes Care*. 2006;29 Suppl 1:S4-42. [PMID: 16373931]

When A1C levels are higher than expected, given the self-monitoring blood glucose results, consider the following possibilities:

- Blood glucose levels that are outside the target range at times when self-monitoring blood glucose is not being done (e.g., postprandially or overnight)
- Technical problem with the blood glucose meter or strips or faulty technique
- Inaccurate data recorded in patient's logbook (If possible, use meter download or review meter memory to confirm.)
- Hemoglobinopathy or anemia (because A1C is influenced by blood loss and rapid red blood cell turnover)

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### *What do my patients need to know about their A1C results?*

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When reviewing A1C results with patients, the following points are important to include in the discussion:

- Tell them that the results reflect their blood glucose levels over the past 2 to 3 months.
- Explain what their results mean in relationship to recommended target levels. Phrases such as *out of the target range* are more meaningful than *out of control*.

- Point out the importance of these results as a way of understanding their risk for the complications of diabetes.
- Explain what the A1C results mean in relationship to blood glucose levels. (Again, use Table 6-1 as a guide.)
- Emphasize that the results are not a “report card” of their efforts or yours. The A1C is simply additional information to help develop an effective treatment program.

## Fructosamine

Fructosamine (glycosylated protein) levels reflect average blood glucose values over the previous 1 to 2 weeks. These levels are used less frequently than hemoglobin A1C levels but can be useful in situations in which hemoglobin A1C measurement is not reliable (e.g., hemolytic anemia).

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