

The Role of Blood Glucose Monitoring in Diabetes

Supported by an educational grant from Novo Nordisk Inc.

The Role of Blood Glucose Monitoring in Diabetes is supported by an educational grant from Novo Nordisk Inc. It has been accredited by the American Association of Diabetes Educators (AADE) for nurses, pharmacists, and dietitians.

Karmeen Kulkarni, RD, MS, BC-ADM, CDE



**Coordinator, Diabetes Center
St. Mark's Diabetes Center
Salt Lake City, Utah**

The following program is a taped presentation by Karmeen Kulkarni.

Karmeen Kulkarni, RD, MS, BC-ADM, CDE, is a member of the diabetes team for the Diabetes Center at St. Mark's Hospital in Salt Lake City, Utah. In addition, to holding a Master of Science degree in Food and Nutrition from Eastern Michigan University, Ms. Kulkarni is a certified diabetes educator and registered dietitian. She has more than 20 years' experience in the areas of nutrition and diabetes, and is recognized nationwide for her clinical expertise. Ms. Kulkarni has published numerous articles, studies, and nutritional guides for both professional and lay audiences. She has held numerous local, state, and national leadership positions including: Executive Board Member and Vice-President for the American Association of Diabetes Educators (AADE) as well as co-chair for the 1997 AADE Annual Meeting, Executive Board Vice-President for the American Diabetes Association (ADA) Utah Affiliate, Chair and Newsletter Coordinator for Diabetes Care and Education (a practice group of the American Dietetic Association), a past member of the National Board of Directors, of the ADA, and a past Associate Editor of *Diabetes Spectrum*.

Ms. Kulkarni was a member of the 2001–2002 AADE program planning committee and a faculty member of both the AADE's professional education programs and the ADA's Clinical Education Program on Nutrition. Currently, Ms. Kulkarni is serving as a member on the Content Expert Panel on Advanced Practice.

We will now join Ms. Kulkarni.

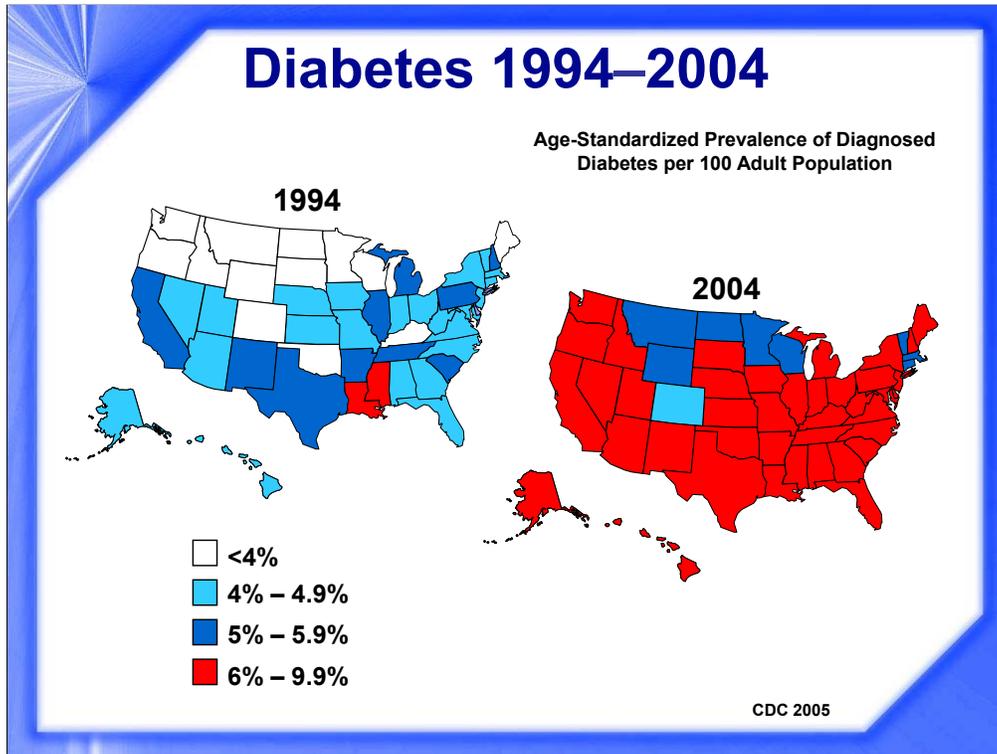
Objectives

- Cite the history behind glucose testing in diabetes and the development of blood glucose meters
- Identify the impact of glycemic control on the risk of complications in diabetes
- Describe the recommended frequency of blood glucose monitoring for the different types of diabetes and patients
- Critique the key features and considerations of the various consumer-marketed glucose meters
- Examine the importance of routine blood glucose monitoring and pattern management in maintaining glycemic control

This presentation focuses on the role of blood glucose monitoring in the management of diabetes mellitus.

Participants should be able to:

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- Identify the impact of glycemic control on the risk of complications in diabetes
- Describe the recommended frequency of blood glucose monitoring for the different types of diabetes and patients
- Critique the key features and considerations of the various consumer-marketed glucose meters
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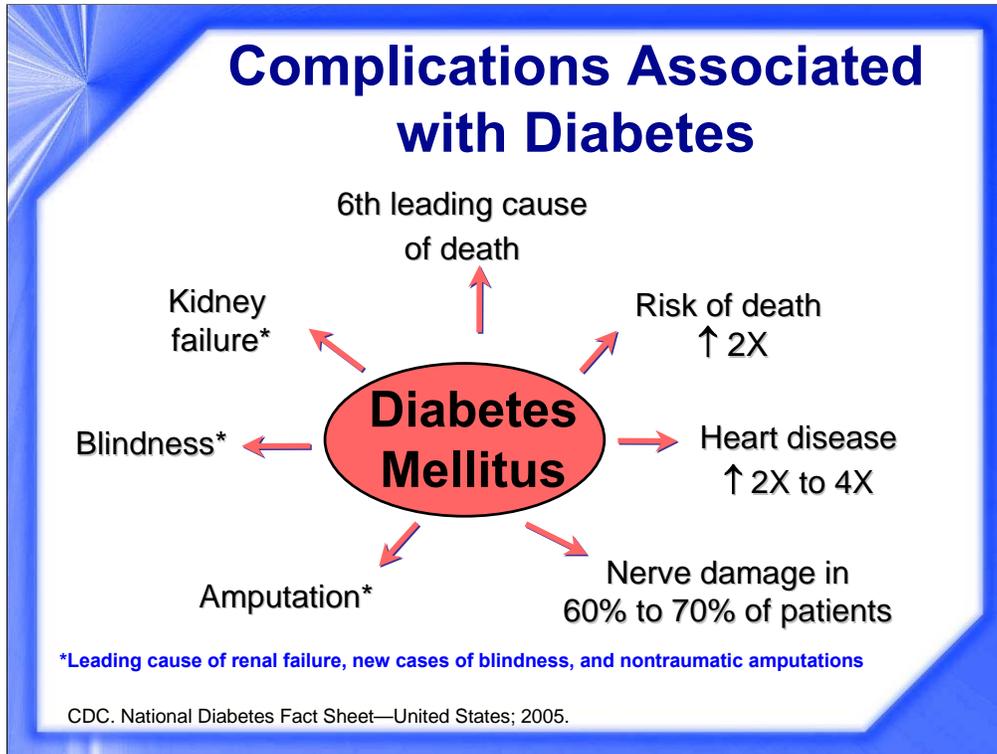


Diabetes is a debilitating and costly disease that is reaching epidemic proportions. Its prevalence has been increasing steadily in the United States over the last few years. The number of individuals aged 20 years or older diagnosed with diabetes each year is estimated to be over 1 million.

In 1994, the Centers for Disease Control and Prevention statistics showed that only 2 states had a 6% or greater prevalence rate; in 2004, 40 states reported a 6% or greater prevalence rate.

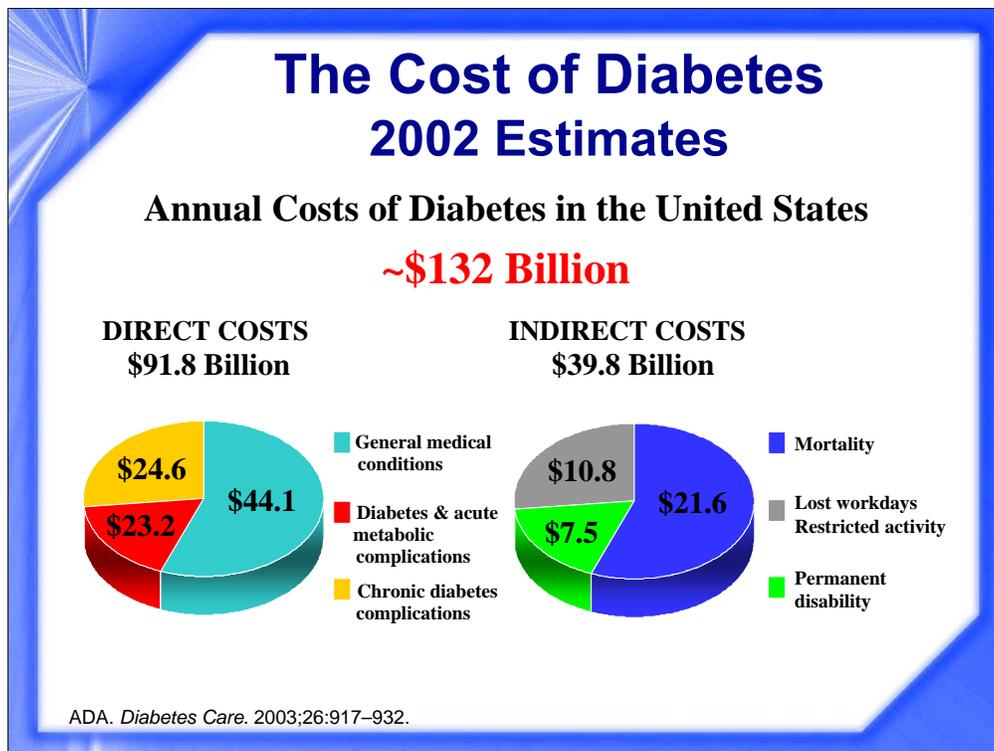
According to 2005 estimates, 20.8 million Americans have diabetes, which includes approximately 6.2 million who are undiagnosed.

In 2004, 41 million Americans were estimated to have prediabetes, which is defined as fasting plasma glucose (FPG) >100 to ≤ 125 mg/dL.



The complications associated with diabetes have a huge impact on health and well-being. Fifty percent of patients with type 2 diabetes will have some type of macrovascular or microvascular complication by the time they are diagnosed with overt diabetes. The disease is the 6th leading cause of death, and mortality in patients with type 2 diabetes is most often due to cardiovascular disease. Indeed, heart disease deaths are 2 to 4 times higher in people with diabetes than in people without diabetes, and people with diabetes are 2 to 4 times more likely to have a myocardial infarction or stroke compared with nondiabetics.

Diabetes is the most common cause of end-stage renal failure and new onset blindness in adults. Peripheral neuropathy, which is present in up to 70% of individuals, impairs sensation and increases the risk for foot amputation; in fact, diabetes is the leading cause of foot amputations not related to trauma.



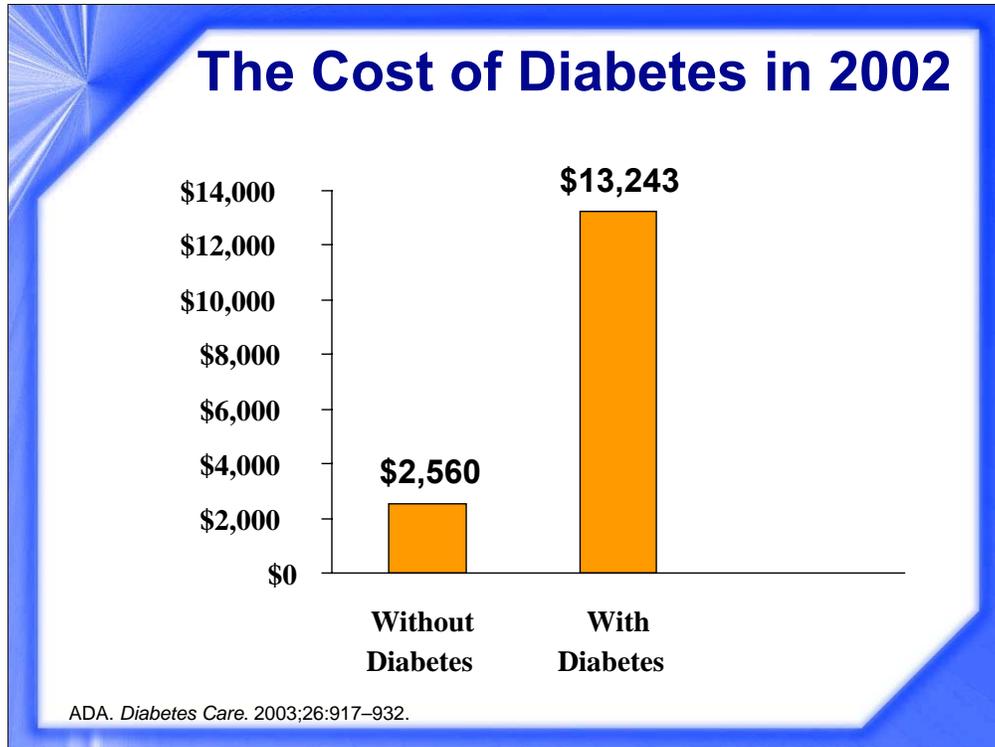
Not surprisingly, diabetes also has a substantial economic impact. Indeed, the management of diabetes accounts for 10% of US health care costs.

Based on 2002 estimates, the total direct and indirect costs attributable to diabetes were estimated to be \$132 billion. Direct costs (eg, those associated with hospitalization, medications) were estimated at \$91.8 billion annually. These costs can be broken down as follows:

- \$23.2 billion for diabetes care and acute metabolic complications
- \$24.6 billion for managing chronic complications attributable to diabetes
- \$44.1 billion for excess prevalence of general medical conditions

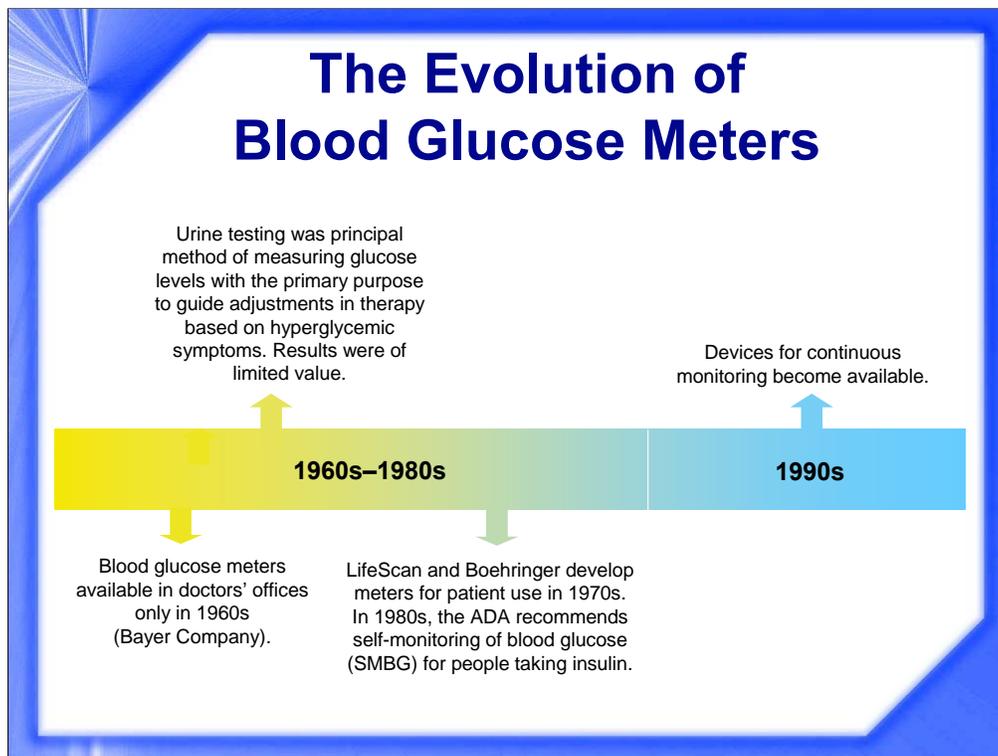
Indirect costs (eg, lost productivity due to disability and early mortality) in 2002 dollars are estimated at \$39.8 billion:

- \$10.8 billion for lost work and restricted activity days
- \$21.6 billion for mortality
- \$7.5 billion for permanent disability



Using data from 2002, researchers calculated that the average annual medical costs for a person with diabetes were \$13,243. This is in contrast to an average annual cost of \$2,560 for a person without diabetes. These researchers also indicated that, after adjusting for differences in age, sex, and race/ethnicity, the medical expenditures of people with diabetes were 2.4 times higher than would be incurred by the same group in the absence of diabetes.

The Evolution of Blood Glucose Meters

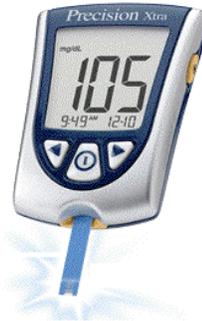


Until the 1980s, urine glucose testing was the principal method of monitoring day-to-day glucose levels. At that time, the primary purpose of monitoring was to guide changes in therapy to relieve symptoms of hyperglycemia. Results were of limited value for several reasons. The renal threshold for glucose excretion into the urine varies from patient to patient and increases with age. Results will be negative unless a patient's renal threshold for conserving glucose is exceeded (for most patients this is 180 mg/dL). The glucose level in a urine sample does not reflect a current specific blood glucose concentration; it is an estimate of the mean blood glucose during the period of collection (4–24 hr). The urine test only detects excess glucose; it cannot detect hypoglycemia. The first blood glucose meter was developed in the mid-1960s by Ames Company (now Bayer Corporation) for use in physicians' offices.

In the 1970s, LifeScan and Boehringer developed meters for use by patients. In the late-1970s, a large symposium, "Diabetes in the '80s," was held in New York City, disseminating information about self-monitoring of blood glucose (SMBG) to healthcare professionals for the first time. The ADA recommended SMBG in the mid-1980s for people with diabetes taking insulin. In the 1990s, devices for continuous blood glucose monitoring became available.

Measuring Glucose Levels Today's Options

- Self-monitoring of blood glucose (SMBG): random tests by patient in 24-hr period
- A1C: 6- to 8-week measurement of glycosylated hemoglobin
- Allows patient to make informed decisions regarding insulin adjustments, food choices, medication, and activity



By the 1990s, SMBG had virtually replaced urine glucose testing as the recommended method of day-to-day testing.

SMBG is now one of the main yardsticks by which to evaluate the effectiveness of a diabetes treatment plan. SMBG allows the patient to make informed decisions regarding insulin adjustments, food choices, diabetes medications, and activities so that hypoglycemia is prevented, and hyperglycemia is minimized. The ADA suggests that SMBG is the only way for patients to achieve and maintain blood glucose levels as close to normal as possible. The American Academy of Family Physicians (AAFP) recommends that all patients with diabetes should own a glucose meter and know how to use it, and that patients whose diabetes is not well controlled should test multiple times per day for several days to produce sufficient data for clinical decision making.

Current blood glucose monitors are small and convenient to use; results are available in seconds.

Measurement of A1C (formerly known as HbA1c) is now a standard measure of long-term glycemic control, and has been shown to predict the risk for the development of many of the chronic complications in diabetes. While A1C is the standard for long-term glycemic control, it does not take into account fluctuations in blood glucose that occur throughout the day, and thus is a mean indicator of glucose levels over the 6- to 8-week period measured.

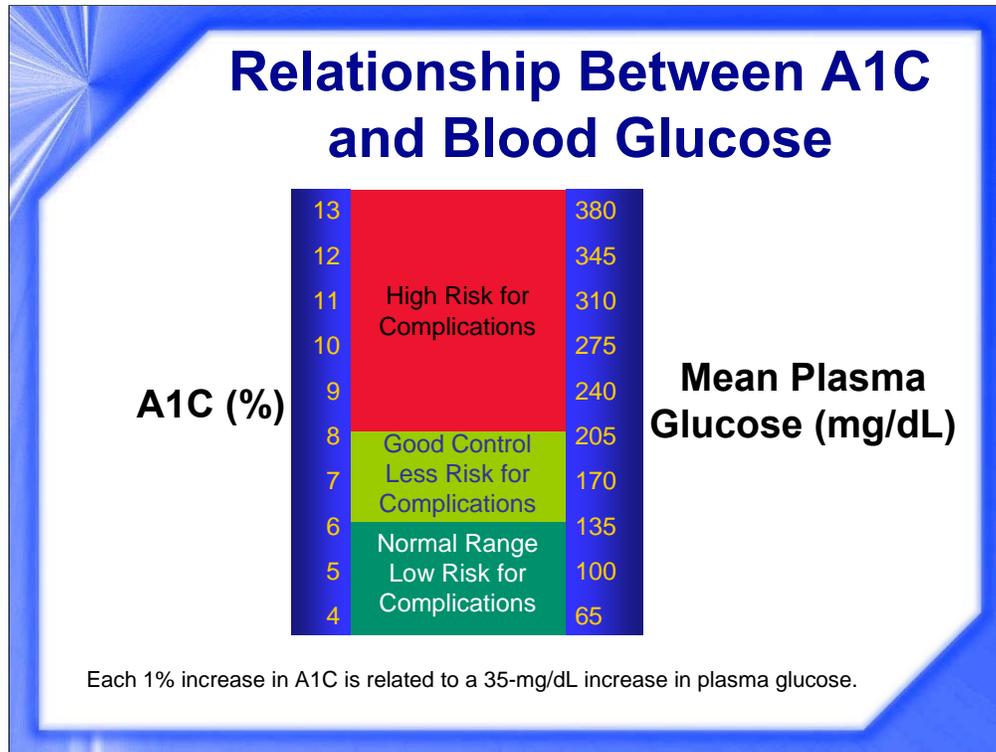
Lowering A1C Reduces Complications

	DCCT (Type 1)	Kumamoto (Type 2)	UKPDS (Type 2)	DCCT/EDIC (Type 1)
A1C	9% → 7%	9% → 7%	8% → 7%	9% → 8%
Retinopathy	↓63%	↓69%	↓17–21%	↓72–87%
Nephropathy	↓54%	↓70%	↓24–33%	↓53–92%
Neuropathy	↓60%			
Macrovascular	↓41%*		↓16%*	↓42–57%

*Not significant because of small number of events.

The randomized clinical trials displayed on this slide have studied the impact of intensive therapy on the incidence of long-term diabetes-related complications. The Diabetes Complications and Control Trial (DCCT) evaluated complications in patients with type 1 diabetes, whereas the Kumamoto study and the United Kingdom Prospective Diabetes Study (UKPDS) were focused on type 2 diabetes.

In all the studies, a reduction of the A1C was associated with a statistically significant reduction of microvascular complications including reduced incidence of retinopathy, neuropathy, and nephropathy. The DCCT, Kumamoto, and UKPDS did not elucidate a statistically significant reduction in macrovascular complications. This may have been due to the small number of events that occurred over the 6- to 10-year follow-up period. More recently, however, a significant reduction in macrovascular complications with intensive therapy in type 1 diabetes was observed in the DCCT/Epidemiology of Diabetes Interventions and Complications (EDIC) study, which was a long-term (17 year) follow-up to the DCCT.



The reduction in risk of complications is correlated directly with the reduction in A1C levels, which can be matched to average blood glucose levels.

General guidelines can be suggested. Analysis of results from the DCCT indicate that each 1% increase in A1C is related to a 35-mg/dL increase in average plasma glucose.

The normal range of A1C with a low risk of complications is between 4% to 6%, the range with a reduced risk of complications is 6% to 8%, and the high risk of complications is 9% or higher.

Afternoon and evening plasma glucose levels (postlunch, predinner, postdinner, and bedtime) show higher correlations with A1C than morning measurements (before and after breakfast and before lunch).

Many experts recommend A1C testing quarterly for all patients initially, and subsequently at least twice a year in patients who are meeting treatment goals, and more frequently (quarterly) in patients whose therapy is being adjusted or who are not meeting glycemic goals.

ADA and AACE Guidelines

	ADA	AACE
FPG (mg/dL)	90–130	<110
PPG (mg/dL)	<180 (1 hour)	<140 (2 hour)
A1C (%)	<7.0	≤6.5

These guideline values are for plasma glucose; whole blood values are ~12% lower. Conversion tables are available.

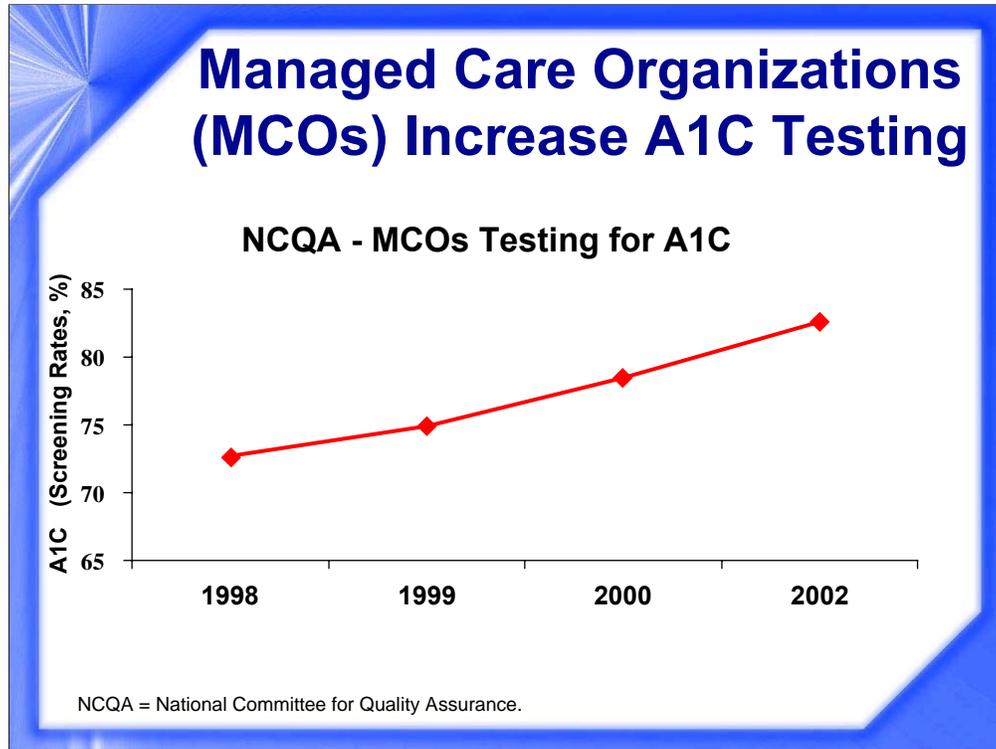
FPG = fasting plasma glucose.
PPG = postprandial glucose.

The results of landmark trials demonstrated that the onset and progression of diabetes-related complications can be substantially delayed by improving and maintaining optimal glycemic control. The ADA and the American Association of Clinical Endocrinologists (AACE) have issued guidelines for optimizing glycemic control for adults with type 1 or type 2 diabetes. Special populations (eg, elderly, children, pregnant/lactating women) may require different goals.

As you can see, the ADA and the AACE have slightly different guidelines for FPG, postprandial glucose (PPG), and A1C. However, they both recommend that treatment for all individuals with diabetes should be aimed at lowering blood glucose to normal or near-normal levels.

The normal value for postprandial blood glucose is <140 mg/dL, normal A1C is <6%.

Aggressive efforts in the diagnosis and treatment of both prediabetes (FPG 100–125 mg/dL) and diabetes (FPG ≥126 mg/dL) can affect the course of the disease. For example, findings from the Diabetes Prevention Program (DPP) provided evidence that treatment involving lifestyle changes had a profound impact on those with prediabetes, reducing risk for diabetes development by 58%.



Managed care organizations are increasingly recognizing the importance of optimal glycemic control in patients with diabetes—both financially and in terms of quality of life.

These benefits have prompted an increased focus on improving glycemic control. According to data from the National Committee for Quality Assurance (NCQA), average A1C testing increased from 73% in 1998 to 82.6% in 2002.

According to results from an historical cohort study conducted in 1992–1997 in a health maintenance organization (HMO), a sustained reduction in A1C level among adult patients with diabetes was associated with significant cost savings within 1 to 2 years of improvement. Total annual healthcare costs were \$685 to \$950 lower in the “improved” versus the “unimproved” cohort: total costs for a 3-year period were 50% to 60% higher in individuals with A1Cs >10% compared to those with A1Cs ≤8%. Improvement in glycemic control also reduced the number of physician visits.

When, Why, How

- ADA
 - Adults with type 1 diabetes: ≥ 3 times daily
 - Children with type 1 diabetes: ≥ 4 times daily
 - In general, frequency dictated by needs and goals of individual patient
- ADA recommends postprandial testing for patients whose FPG levels are within targets, but whose A1C results are high
 - Children with type 1 diabetes: periodically check postprandial, before and after exercise, and nocturnal glucose levels
- AAFP
 - Oral antidiabetic drug–treated patients: 2 to 4 times daily
 - Patients using multiple daily injections: ≥ 3 times daily

According to the ADA, the timing and frequency of SMBG is dictated by the individual needs and goal of the patient; however, for most patients with type 1 diabetes, this is at least 3 times daily. The ADA-recommended frequency for children with type 1 diabetes is at least 4 times daily.

Fasting (at least 8 hr after eating) and bedtime testing are routinely recommended. Intensive insulin therapy requires premeal testing, with an estimate of carbohydrate content in meal, to determine dose. A 3 AM to 4 AM check is used to identify the “dawn phenomenon” (hyperglycemia caused by a surge of counterregulatory hormones at that time) and nocturnal hypoglycemia.

Postprandial results have been linked to risk of complications, and at least 1 postprandial check is usually included in the daily schedule. The ADA recommends postprandial testing for patients whose FPG levels are within target, but whose A1C results are high.

The ADA recommends that the frequency of SMBG in patients with type 2 diabetes should be sufficient to facilitate reaching glucose goals—at least daily for those treated with oral antidiabetic drugs (OADs) to monitor and prevent asymptomatic hypoglycemia.

The AAFP recommends monitoring 2 to 4 times daily for patients with type 2 diabetes who take OADs and at least 3 times per day in patients using multiple daily injections.

When, Why, How

- SMBG is a method for identifying the effect of food, activity, and medication on blood glucose on a daily basis
- Meters are usually convenient to carry and use, providing flexibility for testing
- Intensive insulin therapy is a challenge without SMBG

SMBG is a method for identifying the effect of food, activity, and medication on blood glucose on a daily basis.

Meters are usually convenient to carry and use, providing flexibility for testing.

Intensive insulin therapy is difficult without relatively easy methods for blood glucose monitoring.

When, Why, How

- The wide variety of meters permits a choice according to individual needs and capabilities
- Capillary blood sample is usually taken from fingertip, although alternate sites have been approved in some meters (eg, upper arm, forearm, palm, abdomen, thigh, calf)
- Manufacturers' instructions should be carefully read and followed

The person with diabetes has a variety of meters to select from and this choice allows them to make a selection based on their needs and capability to use the machine. A capillary blood sample is usually taken from the fingertip, although alternate sites have been approved in some meters (eg, upper arm, forearm, palm, abdomen, thigh, and calf).

Manufacturers' instructions should be carefully read and followed.

Selection of a Meter

Features and considerations

- Sample size
- Test range
- Test time
- Calibration (whole or plasma)
- Ease of use
- Insurance coverage
- Lifestyle considerations
 - Appearance and size
 - Privacy shutoff
 - Reminder alarms
 - Memory features

The use of blood glucose monitoring to achieve glycemic goals has increased significantly in the last decade, and manufacturers are continuously adding more sophisticated meters to their product lines. With so many choices, selection of a blood glucose monitor can be individualized based on the following considerations:

- Whole blood sample size
- Different test ranges
- Test times: All monitors provide results in less than 1 minute, varying from a few to 50 seconds.
- Some monitors are calibrated to whole blood only, but most of the newer models are plasma calibrated as well. Information about calibration is available from the manufacturer and is usually described in the instruction booklet.
- Ease of use: Some meters are easier to use than others. Some have data management systems that can make the job of tracking blood glucose levels easier. When selecting a meter, its complexity and the patient's ability to use it should be assessed, and physical limitations that may interfere with testing should be considered. Audio prompts are available for some meters.
- Insurance coverage
- Lifestyle considerations, including the appearance and size of the meter, ability to shut off any audible signals for privacy, reminder alarms, the need for memory and event recording, and download capacity.

Alternate Site Testing

- Some meters have been approved for testing at sites other than fingertips: forearm, upper arm, palm, thigh
 - Manufacturer's instruction booklet should be read carefully
 - If blood glucose changes rapidly (eg, hypoglycemia, postprandial, exercise, illness), fingertip and base of thumb testing is recommended

As mentioned earlier, some meters have been approved for testing at sites other than fingertips; forearm, upper arm, palm, and thigh. For the alternative sites the manufacturer's instruction booklet should be read carefully. If blood glucose changes rapidly (eg, due to a hypoglycemic episode, PPG, exercise, or illness), the fingertip or base of the thumb is recommended. The alternate sites are not recommended for these situations.

Manufacturer's instruction booklet should be carefully followed.

Insurance Coverage

- Medicare (Part B)
 - Coverage for lancets, meters, and test strips
 - Both insulin-treated and noninsulin-treated patients are eligible
- Medicaid
- Private health plans

Insurance coverage for blood glucose monitoring, both meters and supplies, has expanded in recent years.

In July 1998, Medicare Part B added coverage for a variety of diabetes monitoring and testing supplies, including blood glucose meters, lancets, and test strips, even if the patient does not use insulin. Medicare Part B also will cover group diabetes self-management training. Medical Nutrition Therapy training may also be reimbursed for some patients.

All Medicare beneficiaries with diabetes are eligible for reimbursement. Patients pay 20% of the Medicare-approved amount after the annual Part B deductible. Patients can call the Medicare Hotline at 1-800-638-6833 with questions about this coverage.

Medicaid also usually pays for monitoring supplies (meters, test strips, lancets). Patients with questions about this coverage can call their local Medicaid representative.

Many states require private health plans to cover monitors and test strips. Health plans may limit coverage to a certain number of strips per month, or for a specific brand of meter. To obtain more information about coverage, patients can speak with the plan's representative. Up-to-date information about coverage in individual states can be obtained by calling the ADA at 1-800-DIABETES.

Abbott Laboratories

Meters

- FreeStyle®
- FreeStyle Flash®
- Precision Xtra™

Features

- Sample size: 0.3–0.6 μL
- Test time: 5–7 sec
- Number of results stored: 250–450



<http://www.abbottdiabetescare.com>

Abbott Laboratories markets the FreeStyle and Precision blood glucose self-monitoring systems.

These meters use a sample size between 0.3 and 0.6 microliters, provide results in 5 to 7 seconds, and store up to 450 results.

The Precision Xtra minimizes the effects of agents such as acetaminophen, vitamin C, and uric acid for glucose-specific results.

Bayer HealthCare

Meters

- Ascensia® BREEZE®
- Ascensia® CONTOUR®
- Ascensia ELITE®
- Ascensia ELITE® XL



Features

- Sample size: 0.6–3.5 μ L
- Test time: 15–30 sec
- Number of results stored: 20–240

<http://www.ascensia.com>

All the Ascensia meters are approved for multiple-site testing. Diabetes management software is available for all meters except the ELITE.

The Ascensia meters utilize a sample size of 0.6 to 3.5 microliters, provide test results in 15 to 30 seconds, and can store up to 240 readings.

Home Diagnostics, Inc.

Meters

- **Prestige IQ®**
- **Sidekick Testing System™**
- **TrackEASE Smart System®**
- **TrueTrack Smart System®**



Features

- Sample size: 1.0–7.0 μ L
- Test time: 10–50 sec
- Number of results stored: 50–365

<http://www.homediagnostics.com>

The TrueTrack Smart System of Home Diagnostics, Inc., is also sold under retailer names, including Walgreens, CVS, and Eckerd.

Home Diagnostics meters use a sample size of 1.0 to 7.0 microliters, have a test time of 10 to 50 seconds, and store 50 to 365 results.

Pictured above is the Sidekick. It is a vial of 50 test strips with a blood glucose meter on top. The unit is discarded when the vial is empty. It can test on the fingertip or the arm.

Hypoguard USA, Inc.

Professional Meters

- **Assure® Pro**
- **Assure® 3**

Features

- Sample size: 1–3 μL
- Test time: 10 sec
- Number of results stored: 10–250



<http://www.hypoguard.com>

Hypoguard USA manufactures the Assure brand blood glucose meters. They feature a sample size between 1 to 3 microliters, a test time of 10 seconds, and the storage of 10 to 250 results.

Hypoguard USA, Inc.

Consumer Meters

- **Advance Intuition®**
- **Advance Micro-draw®**
- **QuickTek®**

Features

- Sample size: 1.5–3.5 μL
- Test time: 10–30 sec
- Number of results stored: 10–250



<http://www.hypoguard.com>

The Advance and QuickTek meters are produced by Hypoguard USA, Inc. These meters have a sample size of 1.5 to 3.5 microliters, produce results in 10 to 30 seconds, and will store up to 250 results.

LifeScan, Inc.

Meters

- OneTouch® Basic®
- OneTouch® Ultra®
- OneTouch® Ultra®2
- OneTouch® UltraSmart®



Features

- Sample size: 1.0–10.0 μL
- Test time: 5–45 sec
- Number of results stored: 75–3000

<http://www.lifescan.com>

LifeScan, Inc. manufactures the OneTouch line of blood glucose meters. OneTouch features a sample size of 1.0 to 10.0 microliters, a test time of 5 to 45 seconds, and stores up to 3,000 results.

Roche Diagnostics

Meters

- ACCU-CHEK® Active
- ACCU-CHEK® Advantage
- ACCU-CHEK® Aviva
- ACCU-CHEK® Compact Plus
- ACCU-CHEK® Voicemate

Features

- Sample size: 0.6–4.0 μL
- Test time: 5–26 sec
- Number of results stored: 100–500



<http://www.accu-chek.com>

ACCU-CHEK meters are sold by Roche Diagnostics. They use a sample size of 0.6 to 4.0 microliters, complete testing in 5 to 26 seconds, and store up to 500 results.

The ACCU-CHEK Voicemate has a voice synthesizer that speaks the readings. This may be useful to people with impaired vision.

Wal-Mart Stores, Inc. QuestStar Medical, Inc.

Meter

- ReliOn NewTek®
- ReliOn Ultima®

Features

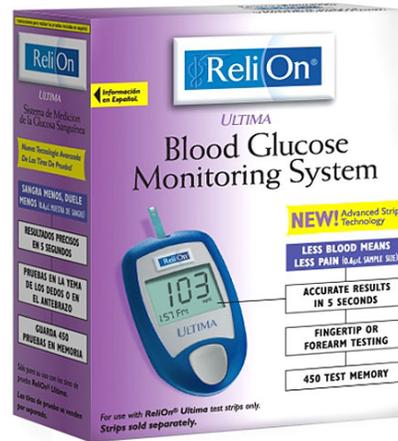
- Sample size: 0.6–4.0 μ L
- Test time: 5–15 sec
- Number of results stored: 100–450

Meter

- Focus™

Features

- Sample size: 7.0 μ L
- Test time: 35–50 sec
- Number of results stored: 150



http://www.relion.com/diabetes/blood_glucose_testing.asp

The ReliOn meters are manufactured by Hypoguard and sold by Wal-Mart as store-brand meters. These meters use a sample size of 0.6 to 4.0 microliters, produce results in 5 to 15 seconds, and store up to 450 results.

The Focus meter uses a 7.0 microliter sample, has a test time of less than 50 seconds, and stores 150 results.

Animas Technologies, LLC.



BGM = blood glucose monitoring.

www.glucowatch.com

- GlucoWatch® G2™ Automatic Biographer
 - Complements BGM (not a substitute)
 - Blood glucose readings through skin every 10 minutes for 13 hours
 - Detects trends and patterns

GlucoWatch G2 Biographer, by Animas Technologies, is a prescription device for adults and children with diabetes (7 years and older). It is intended as a supplement, not as a substitute, for standard blood glucose monitoring.

GlucoWatch is worn like a watch and takes glucose readings through the skin every 10 minutes for up to 13 hours. An extremely low electric current pulls glucose through the skin. The glucose is collected in gel discs, and electrodes measure the level. It can be calibrated for either whole blood or plasma values. It has a storage capacity of over 8,500 data points.

Users can set personal alert levels so that an alarm will sound if readings are too high or too low.

Some disadvantages may include skin irritation and difficulty of use.

Analyzer software is also available to download glucose readings to a personal computer.

Medtronic Minimed, Inc. Guardian® RT Continuous Glucose Monitoring System



- Glucose reading every 10 seconds, average every 5 minutes (288 per day)
- Values similar to fingertip samples
- Readings not affected by age, race, gender, illness, type of diabetes
- Not intended to replace fingertip testing

www.minimed.com

The Guardian RT provides data for retrospective analysis.

The rationale for its development was to improve glycemic control and reduce the risk of hypoglycemic events.

The unit performs a glucose reading every 10 seconds and provides an average every 5 minutes (288 per day). The values obtained are similar to fingertip samples and the results are not affected by age, race, gender, illness, or type of diabetes.

The Guardian system consists of a sensor (which is inserted under the skin and uses interstitial fluid to measure glucose), a transmitter, and a monitor (which is worn on a belt or in a pocket).

Testing by the Guardian RT is not intended to replace fingertip testing and the unit must be calibrated with a glucose meter at least every 12 hours.

Polymer Technology Systems, Inc.

Meter

- CardioCheck™
 - Combination blood glucose meter, lipid, and ketone test

Features

- Sample size: 15–40 μL
- Test time: 30–60 sec, depending on test for glucose, cholesterol (total, triglycerides, and HDL), and ketones
- Number of results stored: 30 of each test



www.ptspanels.com

HDL = high-density lipoprotein.

The Cardiocheck is a portable whole blood analyzer that measures several laboratory values, including glucose as well as lipid values and ketones. It uses a sample size of between 15 to 40 microliters, produces results in 30 to 60 seconds, and can store 30 results.

Principle Sources of Error During SMBG

- Expired or improperly stored test strips
- Inadequate amount of blood on test strip
- Meter in need of cleaning
- Meter not calibrated
- Temperature or hematocrit outside testing range
- Alcohol used on finger and not allowed to dry
- Finger not washed or clean and sample contains contaminants

Current blood glucose monitors are capable of providing very accurate results; however, the patient and clinician must be aware of possible sources of error during SMBG.

Some of these sources include:

- Expired or improperly stored test strips
- Inadequate amount of blood on test strip
- Meter in need of cleaning
- Meter not calibrated (not required by many meters)
- Temperature or hematocrit outside testing range
- Alcohol used on finger and not allowed to dry
- Finger not washed or clean and sample contains contaminants

Tips for Obtaining Accurate Results

- Testing technique
 - Clean area
 - Proper protocol for lancing
 - Adequate blood sample
- Follow manufacturer's instructions
- Equipment handling and maintenance
 - Regular cleaning, if necessary
 - Calibration
 - Proper storage
 - Control testing

To obtain the most accurate readings, proper technique must be employed. The AADE recommends the following protocol for lancing the finger:

- If possible, wash area with warm water.
- Hold hand at side, then briefly shake it.
- Prick the finger with firm pressure.
- Site rotation is recommended to as many sites as possible; the sides of the fingertips may be more comfortable to lance because they have fewer nerve endings.
- Amount of blood required is dependent on the specific blood glucose meter; newer meters require only 0.3 to 5.0 microliters.

The manufacturer's instructions for timing and technique should be used. Additionally, the manufacturer's recommendations for maintenance and cleaning should be followed carefully. For example, cleaning with alcohol can cause the window to be damaged in some monitors.

Proper storage is also important for both the monitor and reagent strips. High temperatures (>86°F) can give false readings and shorten the reagent life, and carrying strips outside of the packaged vial can cause erroneous results.

Trends and Patterns

- Establish baseline patterns
- Assess pattern fluctuations in response to therapy and lifestyle
- Identify the need for intervention
- Empower patients

Data obtained from glucose monitors can be helpful in detecting trends and patterns in blood glucose levels. Specifically, this information can be used to:

- Establish baseline patterns.
- Assess pattern fluctuation in response to therapy and lifestyle; for example, testing before meals and averaging before-meal results (at breakfast, lunch, dinner, and snack) provides valuable feedback regarding current medication/insulin dose.
- Identify need for interventions and treatment. The efficacy of dose can be measured and dose adjustments (titrations) made according to results. For example, if readings are consistently high, additional insulin may be required to get to goal.

“Information is power” and the data provided by blood glucose monitoring can empower patients to manage their diabetes properly, to feel more in control of their treatment plan, and, hopefully, to attain optimal glycemic control.

Pattern Management

- Test glucose several times/day before and after meals
- Assess pattern, not a single value
- Balance medication, meals, activity, other factors
- Establish mutually agreed target ranges
- Identify clear guidelines for reporting out-of-range results
- Empowerment of individual in self-management
- Ensure team approach and communication

Pattern management is a tool used by the patient and the healthcare team to review blood glucose levels, observing if there are trends of hypoglycemia or hyperglycemia. The pattern of readings is assessed, with the recognition that the blood glucose levels are impacted by medication, meals, activity, and other lifestyle issues. The patient and the healthcare team should work together and agree on target blood glucose ranges and identify clear guidelines for reporting the out-of-range results. This approach promotes the empowerment of the person managing their own diabetes and facilitates a team approach and good communication.

See the Pattern, Solve the Problem

- What is the problem?
- What could be the cause?
- What are possible solutions?

Pattern management can be a powerful tool for patients and their healthcare providers if it is used to problem-solve when irregularities in the pattern of blood glucose levels are detected.

Problem-solving starts by asking the following 3 questions:

- What is the problem?
- What is the cause?
- What are possible solutions?

Examples of common problems include:

- High fasting glucose
- High glucose after breakfast
- Low glucose after breakfast
- Hypoglycemia in afternoon
- Hyperglycemia in afternoon
- Hypoglycemia at night

Some potential causes of abnormal glucose levels are:

- “Dawn phenomenon” - Surge of hormones (mainly growth hormone and cortisol) that occurs in the early morning hours (3 AM to 4 AM) and results in an elevated blood glucose level
- Inadequate/excessive food intake
- Delayed or missed meal
- Varying carbohydrate content of meals
- Change in activity/exercise
- Illness/stress
- Inadequate/excessive insulin or oral medication dosing
- Improper insulin type

Possible solutions include adjustment in meal plans, timing of meals, exercise, insulin, and/or oral medication.

Pattern Management

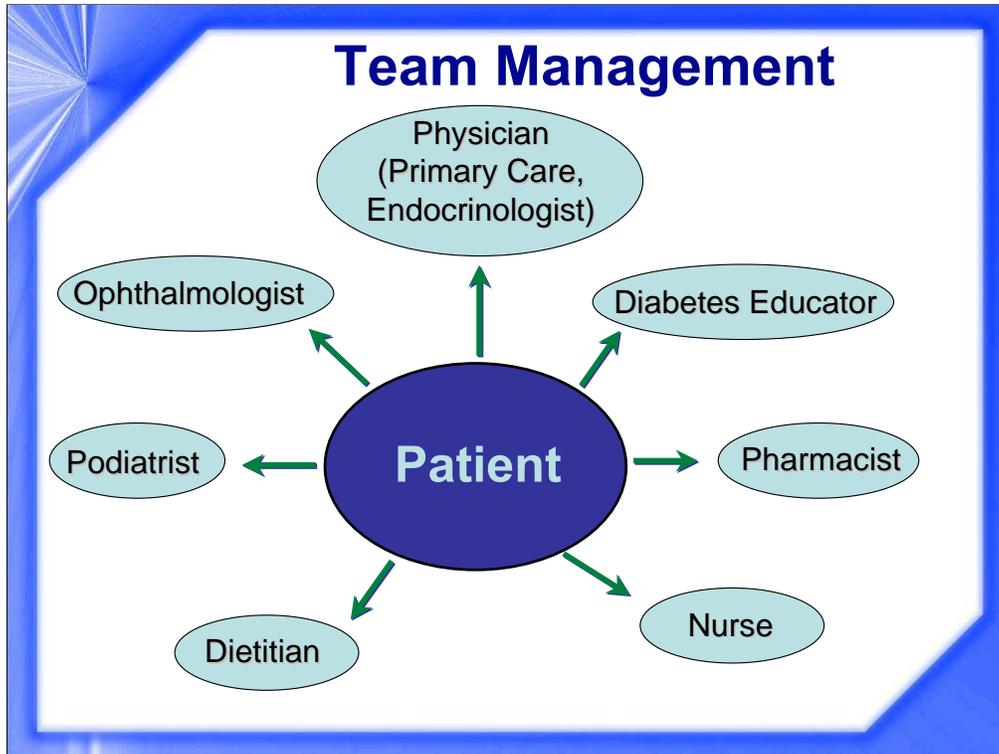
Assumes food/carbohydrate intake and activity are similar each day

Day	Fasting	2 hours post-breakfast	Prelunch	2 hours post-lunch	Predinner	2 hours post-dinner
Thursday	110	250	151	229	140	252
Friday	125	261	148	241	142	277
Saturday	131	284	167	250	137	261
Sunday	119	247	153	262	149	258

Values in mg/dL.

This is an example of pattern management and problem-solving. When evaluating blood glucose patterns, patients may look at how the levels varied throughout the day, but more telling than the daily rise and fall, are consistent patterns in the blood glucose levels over at least 3 days. We see that the fasting blood glucose levels are generally good and the postprandial values are high. Based on these readings, we need to review the daily food/carbohydrate intake and timing and amount of insulin doses.

Some possible solutions include reducing carbohydrate intake if high, especially at breakfast; increasing the prandial insulin dose before meals; or recommending the use of an insulin analog to manage postprandial excursions.



Diabetes management benefits from a team approach, as patients and their healthcare providers work as a team in a caring environment.

If health professionals know the likes, dislikes, and lifestyles of patients, they may be able to help them change behaviors that negatively impact blood glucose control.

An ongoing process that leads patients with diabetes to take responsibility for their daily decisions and to communicate necessary information to their healthcare team can result in optimal management of the treatment plan.

As a member of this type of team, the patients may feel empowered to try to improve glycemic control and thus reduce complications.

Future Developments

- Several companies are developing new continuous glucose monitoring systems
 - Abbott Navigator (under review at US FDA)
- An artificial pancreas created by an implantable pump with a continuous glucose monitoring system is in development
- Several companies are working on noninvasive blood glucose monitoring devices

Several companies are developing new continuous glucose monitoring systems that can detect glucose levels through impedance spectroscopy, skin permeation, ultrasonic waves, or a polymer that glows in the presence of glucose.

An artificial pancreas created by an implantable pump with a continuous glucose monitoring device is in development.

Several noninvasive blood glucose monitoring devices are in development, although development of an effective system has been an elusive goal for many years.

Summary

- SMBG and A1C are now routinely incorporated into treatment plans
- Checking blood glucose levels and making appropriate adjustments can help optimize glycemic control
 - Reduced risk of diabetes-related complications

In the last decade, SMBG and A1C testing have been routinely incorporated into treatment plans for individuals with type 1 and type 2 diabetes as critical elements in the management of the disorder.

The ability to identify the effects of food and activity on blood glucose has been an important advance in patients' efforts to achieve glycemic control.

The ability to determine that an individual is not achieving good glycemic control is beneficial for healthcare professionals so that adjustments can be made quickly and carefully in treatment plans.

Summary

- There are numerous options for SMBG available to fit patient's needs
- Manufacturers have added to their product lines and refined functionality
- Pattern management can be important for therapy adjustment and lifestyle changes

Companies have added new meters to their product lines, as well as such new functions as alternate-site testing and both whole blood and plasma calibration, and there are now a wide variety of monitors available to meet individual needs and capabilities. Computer software is also available for tracking records and using pattern management.

Pattern management is an important tool in identifying causes for high and low blood glucose readings, and can be very useful in treatment adjustment and lifestyle changes.



**Thank you for participating
in the activity**

***The Role of Blood Glucose
Monitoring in Diabetes.***

Thank you for participating in the activity, The Role of Blood Glucose Monitoring in Diabetes.

Please proceed to the post-test.