Welcome to our program: Blood Glucose Monitoring

This program has been sponsored through an unrestricted educational grant from Novo Nordisk Pharmaceuticals, Inc.
The following program is a presentation by Jerry Meece. Mr. Meece is a pharmacist and Certified Diabetes Educator who is owner and Director of Clinical Services of Plaza Pharmacy And Wellness Center in Gainesville, Texas. Mr. Meece has written many articles on diabetes care and insulin use in the patient with diabetes. He has also spoken across the country on the subject of diabetes and disease state management in the pharmacy setting. Mr. Meece currently serves on the Board of Directors for the American Association of Diabetes Educators and is also chairman of the Public Affairs Committee for that organization.
This presentation focuses on the role of blood glucose monitoring in the management of diabetes mellitus.

At the end of this presentation, participants should be able to:

- Discuss the prevalence of diabetes and the increased risk of complications and mortality in patients with diabetes.
- Describe the history of glucose testing, including urine testing, the development of self-monitoring of blood glucose (SMBG), and monitoring of glycosylated hemoglobin.
- Explore key findings of studies evaluating the benefits of reducing blood glucose levels.
- State the importance of empowering patients to achieve glycemic goals.
- Identify and discuss the key features of many currently marketed glucose monitors.
- Discuss the importance of pattern management in tracking trends in blood glucose levels.
According to the Centers for Disease Control and Prevention, as of the year 2000, there were 17.0 million Americans, or 6.2% of the population that had diabetes, with about a third of that number, or 5.9 million people, that remained undiagnosed. Statistics show that the incidence of diabetes is on the rise.

From 1990 to 1998, the prevalence of diabetes rose by about 33%, with this increase occurring in both men and women, and across all sociodemographic groups.

The trends in diabetes risk factors indicate that these numbers will only get larger. The increase in obesity and sedentary lifestyle, the aging of the U.S. population, and the increases in certain U.S. racial and ethnic groups suggest that diabetes will become even more prevalent in the future. An even more disturbing picture emerges as we consider the problem of type 2 diabetes in children and adolescents, a condition considered extremely uncommon just a decade ago.
Diabetes Mellitus
Mortality, Complications, and Costs

♦ Higher risk of death and lower life expectancy
  » 1.5-3.6 times higher mortality rate
♦ Complications contribute to major morbidities
  » 2-4 times greater risk of atherosclerotic disease
  » Single greatest cause of adult blindness, chronic renal failure, and nontraumatic amputations
♦ Three-fold greater healthcare costs

People with diabetes face substantially higher risk of death and a lower life expectancy compared with people who do not have diabetes. In a representative national sample of U.S. adults followed from 1971 to 1993, the mortality rate for people with diabetes was 1.5-3.6 times greater than for those without diabetes, a pattern that persisted for men and women and across all racial and ethnic groups. The median life expectancy was 8 years lower for adults with diabetes 55 to 64 years old.

The complications of diabetes are also major morbidities, resulting in micro and macrovascular complications. People with diabetes have 2-4 times greater risk of atherosclerotic disease and also have the highest incidence of adult blindness, chronic renal failure, and nontraumatic amputations in the country.

The financial burden of diabetes is also substantial. The World Health Organization (WHO) estimates that the total healthcare costs of a person with diabetes in the U.S. are three times those for individuals without the condition.
In the 1960s and 1970s, urine glucose testing was the principal method of monitoring day-to-day glucose levels. At that time, monitoring was used primarily to guide changes in therapy in order to relieve symptoms of hyperglycemia and was not used to normalize glucose levels. Urine testing has several limitations:

The renal threshold varies from patient to patient and increases with age. Another problem is that the glucose level in a urine sample only reflects a blood glucose concentration from several hours before the urine sample was taken, or to put it another way, from the last time urine was passed. The results of any urine test will be negative unless a patient's renal threshold for conserving glucose is exceeded. Another big disadvantage with urine testing is that since a positive test only occurs if the blood glucose level surpasses the renal threshold, hypoglycemia will not be detected in patients using insulin in an attempt to maintain glycemic control. And last of all, urine testing is often impractical and the results may take several minutes to obtain.
By the early 1990s, self-monitoring of blood glucose replaced urine glucose testing as the recommended method of day-to-day testing and the methods and goals of monitoring changed dramatically. SMBG is now the chief yardstick by which to evaluate day-to-day treatment. It is particularly important for patients using insulin so that they can identify highs and lows of blood glucose levels, enabling them to make appropriate adjustments in their treatment. With current blood glucose monitors, results are available in seconds from a very small blood sample. These results can then be used to make adjustments in diet, exercise, and medication to achieve optimal blood glucose control.

Assessment of glycosylated hemoglobin has also become an effective means of routinely monitoring average glycemia over the prior 2 to 3 months. Measurement of glycosylated hemoglobin, principally A1c (formerly known as HbA1c), is now a standard for long-term glycemic control and has been shown to predict the risk for the development of many of the chronic complications in diabetes. Assay of fructosamine as a marker of glucose homeostasis is also becoming an increasingly common short-term evaluation of the pregnant patient with diabetes.
Glycemic Control
Reduce Risk of Complications

Diabetes Control and Complications Trial
Type 1 Diabetes (n=1,441)
(Intensive vs. Conventional Therapy)
ΔA1c=1.8%
♦ Intensive therapy markedly reduced risk of long-term complications
  » Retinopathy 76%
  » Nephropathy 54%
  » Neuropathy 60%

Two large-scale, long-term, prospective, randomized, controlled trials, the Diabetes Control and Complications Trial (known more commonly as the DCCT) and the United Kingdom Prospective Diabetes Study (known more commonly as the UKPDS), underscored the importance of intensive therapy to obtain optimal blood glucose control. The DCCT involved 1,441 patients with type 1 diabetes (formerly known as insulin-dependent diabetes mellitus [IDDM]) who received either intensive or conventional treatment for an average of six and a half years. Intensive therapy consisted of insulin administered three or more times a day (or by insulin pump) guided by SMBG readings at least four times a day.

Results from the DCCT demonstrated that intensive therapy, which resulted in an average A1c of 7.2%, reduced the risk of retinopathy by up to 76%, nephropathy by up to 54%, and clinical neuropathy by up to 60% as compared with conventional therapy, which was reflected by an A1c of 9.0%. The reduction in risk of complications was directly correlated with the reduction in A1c levels. Improved glycemic control also reduced cardiovascular events.
The largest and longest (10 years) study of type 2 patients was the United Kingdom Prospective Diabetes Study. The UKPDS followed 3,867 patients who had been treated with either intensive or conventional treatment. There were many patient cohorts in the UKPDS, but overall, the rate of microvascular complications in intensively treated patients, whose treatment resulted in an average A1c of 7.0%, was decreased by 25% over conventional therapy, which resulted in an A1c of 7.9% in conventionally treated patients. This reduction occurred regardless of whether the primary treatment for intensive therapy was insulin or oral antidiabetic drugs (sulphonylureas or metformin).

Epidemiological analysis of the UKPDS data also showed a continuous relationship between the risk of microvascular complications and glycemia, such that for every 1% decrease in A1c there was a 35% reduction in the risk of microvascular complications. Similarly, for every 1% decrease in A1c there was a 25% reduction in diabetes-related deaths. One very important aspect of the study is that it showed that any improvement in glycemic control would decrease the risk of diabetes complications, even if the level of control was not ideal.
Although the reduction in risk of complications is correlated continuously with the reduction in A1c levels, glycosylated hemoglobin values in patients with diabetes represent a continuum. General guidelines can be suggested. Analysis of results from the DCCT indicates that each 1% increase in A1c is related to a 30-mg/dL increase in average blood glucose. Thus, multiplying A1c levels (measured in %) by 23 approximates the average blood glucose level (measured in mg/dL). Afternoon and evening plasma glucose levels (postlunch, predinner, postdinner, and bedtime) show higher correlations with A1c than morning measurements (prebreakfast, postbreakfast, and prelunch).
The findings of the DCCT and UKPDS have underscored the fact that onset and progression of diabetic complications can be substantially delayed by improving and maintaining glycemic control. In fact, the American Diabetes Association (ADA) now recommends that treatment of all individuals with diabetes should be aimed at lowering blood glucose to normal or near-normal levels. The American Association of Clinical Endocrinologists (AACE) makes similar recommendations, the numbers shown here in brackets, to maximize glycemic control and minimize hypoglycemia. Current ADA guidelines for individuals with diabetes recommend whole blood glucose levels between 80-120 mg/dL before a meal and 100-140 mg/dL at bedtime, with a goal of A1c <7%.

Plasma glucose values are 10-15% higher than whole blood glucose values; therefore, it is crucial that patients with diabetes know whether their glucose levels are referenced to whole blood or plasma results.

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Glycemic Control
Intensive Management

♦ Trend toward intensive treatment
♦ Intensive Management
  » SMBG
    • Type 2 — Daily with insulin/oral antidiabetic agents
    • Type 1 — ≥3-4 times per day
  » A1c Testing
    • Twice annually for “stable” patients
    • Quarterly for patients not meeting goals

The trend toward intensive therapy is growing in the United States. The ADA recommends that the frequency of blood glucose testing in patients with type 2 diabetes "should be sufficient to facilitate reaching glucose goals" which is seen as daily for those treated with insulin or oral antidiabetic drugs to monitor and prevent asymptomatic hypoglycemia. In addition, expert opinion recommends A1c testing at least twice a year in patients who are meeting treatment goals and more frequently, every quarter, in patients whose therapy has changed or who are not meeting glycemic goals. According to the ADA, most type 1 patients should perform frequent blood glucose testing at least three or four times per day.
Self-monitoring of blood glucose is an essential component of diabetes care and a powerful tool in preventing or delaying long-term complications. SMBG provides both the patient and the healthcare team with feedback to continually adjust the therapeutic regimen. SMBG also empowers patients by tailoring diabetes care to individual situations and allows for greater flexibility in daily life. For example, SMBG can minimize glucose fluctuation by providing accurate blood glucose values to adjust insulin dose, medication, caloric intake, and activity levels. SMBG also aids in the recognition and even prevention of hypoglycemia and can help patients detect hyperglycemia related to stress. In addition, use of SMBG in pregnancy aids in achieving good glycemic control and normal fetal outcomes.

Frequent SMBG allows increased flexibility and empowers the patient to assess glycemic control and adjust therapy to achieve targeted glycemic goals. This may lead to a positive effect on clinical outcome.
Managed care organizations increasingly recognize the importance of optimal glycemic control in patients with diabetes, not only financially but also in terms of quality of life. These benefits have prompted an increased focus on patient screening. According to data from the National Committee for Quality Assurance (NCQA), average A1c screening rates increased from 73% in 1998 to 78.5% in 2000.

According to results from a historical cohort study conducted from 1992-1997 in a health maintenance organization (HMO), a sustained reduction in A1c level among adult diabetic patients was associated with significant cost savings within 1 to 2 years of improvement.
Blood Glucose Monitors
Reimbursement

♦ Medicare (Part B)
  » Recently added coverage for lancets, meters, and test strips
  » Both insulin-treated and non-insulin-treated patients are eligible
♦ Medicaid
♦ Private Health Plans

Third party coverage for blood glucose monitoring, both monitors and supplies, has also expanded in recent years.

Originally, Medicare only covered SMBG for people who used insulin. However, as of July 1998, Medicare Part B expanded coverage to include all Medicare beneficiaries with diabetes for a variety of diabetes monitoring and testing supplies, including blood glucose monitors, lancets, and test strips. 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 and testing supplies. Patients having trouble obtaining this coverage can call their local Medicaid representative. Many states require private health plans to cover monitors and test strips. However, health plans may encourage or provide a financial incentive to use a particular brand and limit coverage to a certain number of strips per month. If a health plan does not pay for a particular monitor and test strips, the patient can speak with the plan's representative about obtaining coverage. Up-to-date information about coverage in individual states can be obtained by calling the ADA at 1-800-DIABETES.
The benefits of blood glucose monitoring to achieve glycemic goals are significant. There is a large variety of blood glucose monitors available which may be suitable for individual patients. With so many choices, selection of a blood glucose monitor can be individualized to meet patient needs.

For example, while all monitors provide results in anywhere from 5 seconds to under a minute, they vary in areas such as the sample size needed and in the test ranges they can record. In addition, some monitors are calibrated to whole blood, while others are referenced to serum or plasma. Plasma calibration is usually more desirable because laboratory results are expressed as plasma mg/dL. It is especially important for patients to know which calibration standard is used. This information is usually listed in the meter's instruction booklet and is available from the manufacturer.

Some monitors are easier to use than others, with fewer steps to operate. Others have data-management systems that can make the job of tracking blood glucose levels easier. When selecting a monitor, 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 on some meters.

Financial considerations are also important, both for the monitor purchase and for the strips. In general, it is more important to evaluate the cost of reagent strips as these are an ongoing expenditure.

Lifestyle considerations, including the appearance and size of the meter, the ability to shut off any audible signals for privacy, and the need for memory and logging of events, should also be considered.
There are about two dozen models of blood glucose monitors currently marketed in the United States. Because these monitors have a variety of features, it is useful to review some of the models.
Abbott Laboratories (MediSense Products) features several models of blood glucose monitors, including:

- MediSense® Precision Xtra™ (pictured here)
- MediSense® Precision QID®
- MediSense® Sof-Tact™

All three monitors are calibrated to whole blood and give a blood glucose reading in 20 seconds. The Precision Xtra and Precision QID use a sample size of 3.5 microliters and measure a blood glucose range from 20-600 mg/dL. (The Precision Xtra also measures ketones and gives those results in 30 seconds).

The sample size of the Sof-Tact monitor is 2-3 microliters and has a test range from 30-450 mg/dL. The Sof-Tact has an additional feature in that it is approved for use with blood taken from the forearm and upper arm as well as the fingertip.

The Precision Xtra features a 450-test memory with time and date along with weekly and monthly averaging. The Precision QID stores 125 results for data downloading, and has on-screen recall of the last 10 results. The Sof-Tact can store up to 450 blood glucose test results, displays average glucose readings for up to 4 weeks, and features a data management software program.
Bayer Corporation Diagnostics markets several models of blood glucose monitors, including:

- Glucometer Elite® XL (pictured here)
- Glucometer Elite®
- Glucometer DEX® 2

All three of these meters feature a test time of 30 seconds. The Glucometer Elite XL and Glucometer Elite both use a sample size of 2-4 microliters, measure a blood glucose range from 20-600 mg/dL, and are calibrated to serum or plasma. The Elite XL features a 120-test memory with date, time, and 14-day average. The Glucometer Elite provides only a 20-test memory.

The Glucometer DEX2 has a sample size of 3-4 microliters, has a test range listed at 10-600 mg/dL, and is referenced to serum or plasma. The Glucometer DEX2 stores up to 100 results with time, date, and averages. The DEX model as well as the Glucometer XL can also download information to a personal computer for data management and tracking of trends.
Hypoguard USA, Inc. manufactures blood glucose monitors, including: Supreme II®, Assure®, and Select GT®.

The Supreme II is designed for use by nursing staff in healthcare facilities, particularly long-term care, where the same meter is used to test the blood glucose levels of more than one patient. Blood can be applied to the test strip outside of the meter to minimize the risk of cross-contamination. Up to 100 test results can be stored. The Supreme II uses a sample size of 9 microliters and provides test results within 50 seconds. It has a test range of 30-600 mg/dL. Results can be reported in serum or plasma, or in whole blood values.

The Assure monitor, which has a 3-microliter-sample size, provides test results within 30 seconds, and has a test range of 30-550 mg/dL referenced to plasma. This monitor stores up to 180 test results with a time and date stamp so data can be downloaded to a personal computer.

The Select GT uses a 9-microliter-sample size, provides test results within 50 seconds, and has a test range of 30-600 mg/dL referenced to serum or plasma or whole blood values. It automatically stores up to 100 test results.
LifeScan, Inc.'s line of blood glucose monitors include:

- One Touch® Ultra (pictured here)
- One Touch® Profile®
- One Touch® SureStep®

The OneTouch Ultra requires a very small sample size of 1 microliter, delivers results in 5 seconds, and is approved for use with blood taken from the forearm or fingertip. The OneTouch Ultra can measure plasma calibrated blood glucose values in a range from 20-600 mg/dL and has a warning message that prompts the patient to check ketone levels when blood glucose levels are between 240-600 mg/dL. The OneTouch Ultra, as well as the One Touch SureStep, features a 150-test memory as well as 14- to 30-day test averaging. All three meters can download data to a personal computer for graphing and trending. The One Touch Profile and SureStep models use a sample size of 10 microliters and have test times of 45 and 15-30 seconds, respectively.

The One Touch Profile measures blood glucose levels in a range from 0-600 mg/dL and is referenced to whole blood. The test range for the SureStep is 0-500 mg/dL, calibrated to plasma. Other features of the One Touch Profile model include a 250-test memory with date and time, and 14- to 30-day test averaging.
LXN Corporation offers several models of blood glucose monitors, including:

- Duet® (pictured)
- In Charge™
- ExpressView™

Two models, the Duet and the In Charge, combine blood glucose monitoring and glycosylated protein (fructosamine) testing.

For glucose testing, the Duet uses a sample size of 10 microliters and has a test time of 8-30 seconds. By comparison, the In Charge and ExpressView models both have a sample size of 6 microliters and a test time of 5-20 seconds. These monitors measure a blood glucose range from 20-600 mg/dL; however, results for the Duet are whole blood calibrated while the In Charge and ExpressView provide results referenced for serum or plasma. The memory of all three models holds 200 glucose test results with date and time. The In Charge and ExpressView models are also data management capable.
Roche Diagnostics Corporation's line of monitors include:

- **Accu-Chek Active™** (pictured here)
- **Accu-Chek® Advantage®**
- **Accu-Chek® Complete®**

All three models measure a blood glucose range from 10-600 mg/dL, and results are plasma calibrated. The Accu-Chek Advantage and Accu-Chek Complete use a sample size of 4 microliters with Comfort Curve strips and test times of 26-40 seconds. The Accu-Chek Active uses a sample size of 1 microliter, with a test time of 5 seconds in meter and 10 seconds out of the meter. The Active model can use blood from alternate sites such as the forearm, upper arm, or thigh, in addition to the fingertip.

As for other features, the Accu-Chek Complete can collect, store, and analyze up to 1,000 values for full-range analysis. The Accu-Chek Advantage features a 100-value memory with date and time and has download capability for trend analysis.
Several other manufacturers currently market blood glucose monitors.

Home Diagnostics, Inc. markets the Prestige LX™ and more recently the Prestige IQ™ blood glucose monitor. The Prestige LX and Prestige IQ models use a sample size of 5-7 microliters and have a test time of 10-50 seconds. They measure a blood glucose range from 25-600 mg/dL, referenced to either plasma or whole blood. The Prestige IQ model also features a 365-test result memory with date and time along with 14- or 30-day averaging. Data can be uploaded to a free internet site that allows users to track and share results with healthcare professionals.

TheraSense, Inc. manufactures the FreeStyle™ monitor, which uses a 0.3-microliter-sample size and provides test results in 15 seconds. It has a test glucose range of 20-500 mg/dL and is calibrated for plasma. The FreeStyle has been approved to use blood drawn from the upper arm, thigh, calf, or anywhere on the hand. A companion computer program is also available with this meter and allows users to upload blood glucose readings to a personal computer to analyze trends.
QuestStar Medical produces the CheckMate Plus® monitor, which uses an 8 microliter sample size, provides test results in 15-70 seconds, and has a test range of 25-500 mg/dL. The reference method is selected by the user for either whole blood or plasma. The CheckMate Plus can store up to 255 results with date and time as well as insulin type and dosage.

Wal-Mart Stores, Inc. markets the ReliOn blood glucose monitor. It uses a 10-microliter-sample size, provides test results in 20 seconds, and has a test glucose range of 20-600 mg/dL. Results are whole blood calibrated.
One of the more unique blood glucose monitoring systems is the Induo™, which features an integrated blood glucose monitor and insulin delivery system. It is marketed by a partnership of LifeScan, Inc. and Novo Nordisk Pharmaceuticals, Inc.

The integrated blood glucose monitor uses a sample size of 1 microliter, and delivers results in 5 seconds using blood taken from the forearm or fingertip. The Induo system also has automatic 14- and 30-day averaging with 150-test memory and the results can be downloaded using software for graphing and trending.

The insulin delivery system can be dialed in 1-unit increments to inject a dose from 1-70 units and contains a built-in memory that records the amount of the last insulin dose and the hours since the last dose was administered. 3-mL insulin cartridges are available in Regular, NPH, and 70/30 formulations, as well as a rapid-acting insulin analog.
Recently, non-invasive tests for blood glucose have become available. The FDA recently approved the GlucoWatch® Biographer, manufactured by Cygnus, Inc., as a prescription device for adults 18 years and older with diabetes in the United States. This device is intended to be used as a complement to standard blood glucose monitoring.

The GlucoWatch Biographer is worn like a watch and takes glucose readings through the skin every 20 minutes for up to 12 hours. An extremely low electric current pulls glucose through the skin, which is collected in gel discs where electrodes measure the glucose level. It can be calibrated for either whole blood or plasma values. The GlucoWatch Biographer provides supplemental information about glucose changes and is designed to detect trends and patterns in glucose levels. Although the manufacturer states that most readings are similar to finger stick results taken around the same time, they caution that some results may differ. Therefore, GlucoWatch Biographer should not be used as a substitute for conventional blood glucose monitoring.
The quality assurance of blood glucose monitors is maintained by several regulatory agencies and should be incorporated into any testing program including self-monitoring by the patient. The initial approval of any medical device is by the FDA's Center for Device and Radiological Health (CDRH).

The Joint Commission for the Accreditation of Health Care Organizations (JCAHO) and the Center for Medicare and Medicaid Services (CMS) require hospitals to have quality assurance programs for bedside blood glucose monitoring.

The Clinical Laboratory Improvement Act, (better known as CLIA) of 1988 placed additional requirements on blood glucose monitoring performed outside the hospital. In the physician's office, blood glucose testing can be approved if test accuracy is verified, and paperwork and fees are submitted. For more complex testing, additional requirements must be met.

For self-monitoring, it is also important that meter instruction emphasize not only the use of proper procedures in obtaining a good blood glucose sample, but also how to obtain the correct control solutions and appropriate supplies to ensure accurate testing.
“Tips” for Obtaining Accurate Results

♦ Testing technique
  » Clean hands
  » Proper protocol for lancing finger
  » Adequate blood sample
♦ Follow manufacturer’s instructions
♦ Equipment handling and maintenance
  » Regular cleaning
  » Proper storage — temperature, humidity, etc.

Current blood glucose monitors are capable of providing very accurate results. However, for the most accurate readings, appropriate technique has to be employed. For example, hands should be carefully washed with warm water before obtaining blood samples because some substances that accumulate on the skin can affect blood glucose readings. Patients should also follow proper protocol for lancing the finger or alternate test sites.

Examples of this would be:

• To shake the hand as if shaking a thermometer.

• Briefly tourniquet the finger with either a disposable tissue or by grasping with the fingers of the other hand.

• Prick the finger with firm pressure using a lancet device.

• Squeeze the finger gently while holding the hand down below the waist.

While the sample size is dependent on the specific blood glucose meter, obtaining an adequate size drop of blood is critical to assure accurate results. For alternate site testing, the user should refer to the manufacturer's instructions.

The manufacturer’s instructions for timing and technique should also be followed. Additionally, the manufacturer’s recommendations for maintenance and cleaning should be followed carefully. An example of this is that cleaning the monitor window with alcohol can damage the window in some monitors. Proper storage is also important for both the monitor and reagent strips as each manufacturer’s blood glucose strips have exacting criteria for temperature and humidity control. High temperatures (>86 degrees F) can give false readings and shorten the reagent life of the strips.
Some patients who use blood glucose monitors have found that certain techniques can facilitate the lancing procedure. Some of these "tips for fingertips" include:

• **Thorough clotting** -- Immediately after putting blood on the test strip, patients should apply firm pressure, using a tissue, directly over the fingerstick site for at least 10 seconds.

• **Shallow penetration** -- The trick is to lance the finger as superficially as possible to get just enough blood for an adequate sample. Vigorously "milking" blood out of the finger will obtain the maximum amount of blood with as shallow a fingerstick as possible but compressing the tissue immediately around the sample site could result in intrastitial fluid being mixed with the blood and an inaccurate sample being obtained. If the patient needs to "milk" the finger for a larger sample of blood, have her do it from the proximal end of the finger (the area closest to the hand).

• **Site rotation** - It is better to use as many sites as possible rather than traumatizing one spot excessively. The sides of the fingertips may be more comfortable to lance because they have fewer nerve endings. Additionally, the thumbs can be used as another fingerstick location.

**Lancing device selection** -- Lancing devices differ in the way they stabilize the lancet and drive the lancet through the skin, while the lancets themselves vary in size and shape. Many patients will find that the thinner (higher gauge) lancets are less painful.

**Warm water and lotion** -- Whenever the situation permits, patients should wash their hands (and other test sites) with warm, soapy water before a fingerstick instead of using alcohol. The warmth of the water has the advantage of bringing additional blood into the fingers. Regular use of a lotion can also help soften and soothe the fingertips.
In addition to proper technique, it is important for patients to know when to test to determine the effects that daily activities have on their blood glucose levels. This slide shows several activities or conditions that could affect blood glucose. So what would be the best time for someone to test to determine the effects of each of these conditions on their blood glucose?

To determine the effects that medications would have on lowering our blood glucose, testing before meals and bedtime would be useful. For the effect that food has on our blood sugar, testing 2 hours after meals is helpful. Exercise can be tricky in its effects on blood glucose. Are we doing short bursts of exercise with high intensity, or is this a leisurely walk for a longer period of time? Have we been exercising for a long time and are in good condition, or is this a new exercise program?

All these factors play a big role in determining the effects of exercise on our blood glucose. The best way to see how it specifically affects us is to test before, during, and after exercise, and even more closely if prolonged periods of activity take place. Testing at bedtime can help the patient check for effects of delayed hypoglycemia due to missed meals, medication, or prolonged exercise that day or other to see if other factors could play a role in lowering of blood glucose. Checking blood glucose levels at 3 to 4 AM is important when trying to determine if an early morning rise in blood glucose is due to rebound hyperglycemia or the dawn phenomenon.
Team Management

- Patients
- Nurse
- Physician
  - Primary Care
  - Endocrinologist
- Pharmacist
- Diabetes Counselor
- Dietitian
- Podiatrist
- Optometrist

Diabetes management benefits from a team approach, making the patient the central member of a healthcare provider team in a caring environment. It helps if health professionals know the likes, dislikes, and lifestyles of patients and plan with them to change behaviors that negatively impact blood glucose control. There should be an ongoing process, which leads patients with diabetes to take responsibility for their daily decisions and to communicate the necessary information to their healthcare team in order to best manage the treatment plan. This partnership helps empower the patient to try to improve glycemic control and thus reduce complications in order to ameliorate the impact of diabetes on patients' lives.
Trends and Patterns

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

With accurate results, the data obtained from glucose monitors can be helpful in detecting trends and patterns in glucose levels. Specifically, this information can be used to accomplish several things:

- To establish baseline patterns for the patient.

- To identify patterns in fluctuation in response to therapy and lifestyle. A good example of this would be testing before meals and averaging before-meal results (at breakfast, lunch, dinner and snack), which then would provide valuable feedback regarding current oral medications or insulin dosing. Using this information, the clinician could then identify needed interventions and treatment. She could adjust the dosage of medication or, according to the results obtained, address specific lifestyle situations.

“Information is power” and the information provided by blood glucose monitoring provides patients with increased flexibility. With proper monitoring, patients feel more empowered and are more compliant, which can lead to better glucose control.
In simple terms, "pattern management" is a retrospective assessment of blood glucose levels in order to adjust treatment under the guidance of healthcare providers. However, to effectively perform "pattern management", there are certain requirements that have to be met:

- The first rule is to keep from making adjustments based on a single value. Other than hypoglycemia, assessments are based on several numbers or a "pattern" that forms with several tests.

- Secondly, review all aspects of treatment and adjustment as indicated. Meals and activity have to be scrutinized just as closely as medication.

- Goals and target ranges for blood glucose values need to be discussed with the patient. Clear guidelines for reporting abnormal results should be established and mutually agreed upon by patient and clinician.

- Patient understanding, buy-in, and commitment are essential in obtaining the readings and keeping the records that are necessary for pattern management.

- Communication of all information concerning the patient is important for the team approach to diabetes management and ensures consistency of care. Having the patient vary testing times during the day for several days at a time when certain patterns are already known helps the team to gain the most complete information possible for making decisions. Both patterns are required for the best possible care of the patient.
"Pattern management" is one of the powerful tools available for patients and their healthcare providers in finding the cause of irregularities in blood glucose levels.

The problem-solving starts by asking the following three questions:

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

Examples of common problems encountered in blood glucose management include high fasting glucoses, high glucose levels after breakfast, low glucose levels after breakfast, hypoglycemia or hyperglycemia occurring in the afternoon or hypoglycemia occurring during the night. Some potential causes of abnormal glucose levels are rebound hyperglycemia, caused by a counter-regulatory response to hypoglycemia, the "Dawn phenomenon", brought on by a surge of hormones (mainly growth hormone) that occurs in the early morning hours (3-4 AM) and results in an elevated blood glucose upon awakening. An inadequate or excessive food intake, delayed or missed meals, a change in the level of activity or exercise, illness or stress, which can often be the cause of high blood glucose levels, inadequate or excessive doses of insulin or oral medication, an improper insulin type or timing of the insulin injection are other potential causes of abnormal blood glucose levels.

Possible solutions to the above would be an adjustment in diet, in the types of foods consumed, timing of the meals, exercise, insulin and/or oral medications.
First, look at the trend across several days. When evaluating blood glucose patterns, patients will often look at how the levels varied throughout the day. But just as important as the daily rise and fall of blood glucose levels are consistent patterns in each time slot over at least 3 days.

Do you see any apparent problems or patterns? In this case, a pattern of hyperglycemia occurring in the afternoon prior to dinner stands out. The next step is to determine the possible cause of the hyperglycemia in this time period. Causes could be inadequate insulin, either produced by the patient or injected, an excessive amount of carbohydrates taken in at the noon meal or during a snack in the afternoon, or a decrease in activity level after lunch or during the afternoon.

The final step is to look for potential solutions to any problem that we have uncovered. These could be adjusting the morning or pre-lunch dose of insulin, decreasing calories in the meal or omitting snacks, assessing the calorie source in the meal, such as carbohydrate or fat content, or increasing the level of activity after lunch.
HW is a 55-year-old male, treated for type 2 diabetes for 10 years and for hypertension for the last 5 years. He has taken a long-acting secretagogue for 8 years and a sensitizer was added about a year ago because of deteriorating control and weight gain. He has lost some weight, but is not at his ideal weight. He now has reached the maximum dose of the sensitizer; his morning blood glucose (BG) levels are usually between 150 and 175 mg/dL, and his latest A1c value was 8.7%. HW checks his blood glucose in the morning (fasting) and at bedtime, when it varies between 150 and 200 mg/dL. He plays golf on the weekends. He states that he does not want to take insulin.

The Problem(s): HW has a high A1c and high fasting blood glucose levels. He was advised to check his blood glucose at varying times during the day for three days, including several 2-hr postprandial (PPG) tests.
In looking at his daily log entries or downloads from his blood glucose monitor, we see the following grid. What stands out in any pattern? Are his blood glucose levels within target range? Are his postprandial glucose results too high? This might account for the high A1c. What would solve his problem? Would a fast-acting secretagogue be an option?

Taken before each meal, it could be effective in lowering the postprandial glucose surges, but it might also not be as effective due to the time he has spent already on the long-acting secretagogue.

Would a bedtime dose of intermediate-acting insulin be an option? A discussion of his reluctance to use insulin might turn up some issues that could be solved with an alternate delivery system. For example, if using a syringe and vial at work is a problem, an easy-to-use insulin pen or doser might be useful. Some clinicians have found that once an individual tries insulin, the barrier is broken and the problem is resolved.

Should there be a discussion about his meal plan and a regular activity program? Certainly. A short walk after lunch might help with PPG surges. Any look at blood glucose patterns needs to be done with activity, diet, AND medications in mind.
Case study #2

♦ RW is a 25 year old white female
♦ Height 5’7”, weight 120
♦ Type 1 diabetes for 12 yrs
♦ Regular human insulin before breakfast and the evening meal
♦ NPH before breakfast and bedtime

RW is a 25-year-old active female who has had type 1 diabetes for 12 years. She has been trying to improve her glycemic control and is on a regimen of NPH and Regular insulin before breakfast, Regular before dinner, and NPH at bedtime. She has a full-time job and jogs about 3 miles after dinner several times a week. She checks her blood glucose (BG) before breakfast and before dinner, and sometimes at lunch, but does not check postprandial BG.

Because her fasting BG levels have been high (140-170 mg/dL), she increased her bedtime NPH, but has begun to have episodes of nocturnal hypoglycemia. Her roommate has had to help her with glucose intake two or three times. Her A1c is 7%.

Problems: RW has high fasting blood glucose levels and nocturnal hypoglycemia. RW was advised to check her blood glucose at various times during the day, including at 3 am and 2 hrs postprandial for several days, and also to record exercise times and insulin doses in order to discern patterns, especially those related to strenuous exercise.
Again, look for patterns in each time slot over the 3 day period. What stands out as we look at the grid? Does the pattern show low glucose levels late in the day? What could be a solution?

RW might respond to substitution of a rapid-acting insulin analog for her Regular human insulin. This faster but shorter acting insulin would be leaving the system before the NPH began to work, therefore reducing the potential for hypoglycemia. She also might want to lower her pre-meal insulin dose on the days she jogs. She will have to monitor more often and keep in touch with her healthcare professional(s) as she makes adjustments in her insulin regimen.

To alleviate the nocturnal hypoglycemia and rebound hyperglycemia, could another strategy be to try to lower her NPH insulin dose at bedtime or have a bedtime snack on the days she jogs? She may have a delayed reaction to exercise; some patients have reported a 4-6 hour delay or more in the drop of blood glucose levels after exercise. If so, she might be advised to jog at an earlier time of day, possibly in the morning.

Her roommate should be taught how to use glucagon, to treat severe nocturnal hypoglycemia, in case that is ever required.
Thank you for participating in our program.

Please proceed now to the post-test.

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