

Blood Glucose Testing at the Bedside

What is Testing Blood Glucose at the Bedside?

- › Nurse-directed **point of care (POC) blood glucose (BG)** testing refers to the process of obtaining a capillary blood specimen and using a portable BG meter, commonly called a glucometer or glucose meter, at the bedside to evaluate the specimen glucose concentration. This topic addresses use of a portable BG meter, the most common method of POC BG testing in a healthcare facility; POC BG testing using an intravascular continuous glucose monitor (typically limited to critically ill patients with central venous access) is beyond the scope of this topic. For information on patient-managed continuous BG measurement associated with an insulin pump (i.e., continuous measurement of interstitial glucose using a subcutaneously implanted sensor), see *Nursing Practice & Skill ... Blood Glucose Monitoring, Continuous: Assisting with*. BG testing can also be performed in clinical laboratory using arterial or venous specimens
- *What:* Glycemic levels are routinely monitored in hospitalized patients because of the increased physiological stress that can cause BG levels to fluctuate widely, particularly those who are receiving **parenteral nutrition (PN)** and patients with **diabetes mellitus (DM)**. Glycemic levels are also monitored for nonhospitalized patients with medical conditions such as those with symptoms of pre-DM, pregnant women with gestational diabetes, and patients who use steroids following organ transplantation
 - *How:* Although the most accurate BG measurements are obtained from venous specimens that are analyzed in a clinical laboratory, bedside BG testing of capillary blood (obtained from cut capillaries in the dermis, commonly referred to as capillary blood or fingerstick blood) is frequently used when multiple measurements are required throughout the day. (Note: Regardless of the method [capillary fingerstick, interstitial cannula, venipuncture, arterial puncture] or the type of blood sample, it is critical to use a consistent method and blood source to evaluate the trend of BG levels.) The process of testing BG levels in capillary blood generally involves
 - programming the glucose meter with the patient’s information
 - using aseptic technique to obtain a blood sample from the dermis using a lancet or automated puncture device
 - applying a drop of blood to a BG testing strip
 - inserting the strip into the glucose meter
 - noting the results of the glucometer analysis
 - evaluating the test results against the ‘action range’ (i.e., range of BG levels that require action on the part of the nurse clinician [e.g., administering or holding insulin or oral diabetic medications as prescribed, notifying the treating clinician]) and performing the appropriate intervention
 - *Where:* BG testing using a portable BG meter is performed in all healthcare settings (e.g., acute care and extended care facilities, outpatient clinics) and by patients in the home setting who self-manage their glycemic levels
 - *Who:* Generally, when POC BG testing is ordered, a licensed clinician assumes the responsibility for monitoring changes in the patient’s BG level, implementing standing orders regarding action ranges, and reporting abnormal findings to the treating clinician. Depending on regulatory policy governing the practitioner’s scope of responsibility and the facility policy, it can be possible to delegate the two tasks of performing the capillary fingerstick and using the glucometer to test the BG level to appropriately

Authors

Kathleen Walsh, RN, MSN, CCRN
Cinahl Information Systems, Glendale, CA

Carita Caple, RN, BSN, MSHS
Cinahl Information Systems, Glendale, CA

Reviewers

Eliza Schub, RN, BSN
Cinahl Information Systems, Glendale, CA

Lee Allen, RN, MS
Glendale Adventist Medical Center,
Glendale, CA

Nursing Practice Council
Glendale Adventist Medical Center,
Glendale, CA

Editor

Diane Pravikoff, RN, PhD, FAAN
Cinahl Information Systems, Glendale, CA

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trained assistive staff members. Outside of the inpatient setting, patients and their caregivers are taught to perform BG measurements and administer prescribed diabetes medication

What is the Desired Outcome of Testing Blood Glucose at the Bedside?

› The desired outcome of testing the BG level in a capillary blood sample is to aid in the management of glucose metabolism

Why Is Testing Blood Glucose at the Bedside Important?

- › Routine BG testing helps to guide treatment decisions directed toward maintaining BG levels within an appropriate range, as determined by the treating clinician (for information about normal BG levels in patients with and without DM, see *What You Need to Know Before Testing a Patient's Blood Glucose at the Bedside*, below). Routine BG testing helps prevent hypoglycemia (i.e., < 70 mg/dL) and hyperglycemia (i.e., > 140 mg/dL), potentially life-threatening conditions, and is essential to maintaining a high **quality of life (QoL)** and increasing life expectancy in patients
 - Severe hyperglycemia (i.e., BG level > 240 mg/dL) can lead to **diabetic ketoacidosis (DKA)** and **hyperglycemic hyperosmolar nonketotic syndrome (HHNS)**, life-threatening medical conditions (for more information, see *Quick Lesson About ... Diabetes Mellitus, Type 2*). Sustained hyperglycemia is associated with widespread vascular damage; long-term complications of DM include neuropathy, retinopathy, and renal failure. Hyperglycemia is associated with increased morbidity and mortality in patients. Although the mechanism of injury to various organ systems due to hyperglycemia is not well understood, hyperglycemia is known to
 - alter the activity of phagocytes, impairing neutrophil and monocyte activity
 - increase production of inflammatory cytokines and oxidative stress. Increased oxidative stress impairs
 - the immune, nervous, and cardiovascular systems
 - endothelial cell function
 - hemostasis
 - inflammatory response
 - promotes apoptosis (i.e., programmed cellular death)
 - Hypoglycemia can lead to unconsciousness if the brain does not receive sufficient glucose to function. Severe hypoglycemia (i.e., BG level < 40 mg/dL) can lead to seizures, coma, and death

Facts and Figures

- › BG levels are often elevated in hospitalized patients primarily due to physiologic stress. Hyperglycemia is estimated to occur in 40% of hospitalized patients, and it is not unusual for critically ill patients to have BG levels > 200 mg/dL (Qaseem et al., 2011)
- › Guidelines published by the **American Diabetes Association (ADA)** confirm the policy of promoting moderate glycemic goals for patients within the hospital setting. Prior to this time, glycemic goals were targeted to a stringent range 80–110mg/dL; however, investigators who published a 2009 meta-analysis of > 26 studies concluded that tightly controlled glycemic levels were associated with increased rates of severe hypoglycemia and mortality (NICE-SUGAR Study Investigators et al., 2009). The 2016 ADA guidelines recommend that insulin therapy be initiated for persistent hyperglycemia > 180 mg/dL (ADA, 2016)
- › A number of factors can contribute to inaccurate BG readings when using the fingertip method of blood sampling (Hirose et al., 2011). For example,
 - low skin temperature can lead to underestimation of BG levels
 - neglecting to wash hands after peeling fruit prior to fingertip blood sampling can lead to overestimation of BG levels
- › Researchers reported that glucose measurements were not significantly different between patients receiving continuous glucose monitoring and those undergoing traditional (preprandial [i.e., before meals] and at bedtime) BG testing, but that fewer postprandial (i.e., 2 hours after meal intake) episodes were detected using the traditional method. The investigators concluded that fingerstick BG monitoring provides a reasonable estimate of mean BG concentration but might underestimate the prevalence of postprandial hyperglycemia (Burt et al., 2013)

What You Need to Know Before Testing a Patient's Blood Glucose at the Bedside

- › Prior to testing a patient's BG, become familiar with the following:
 - Anatomy of the skin
 - The layers of skin, in descending order from external to internal, are epidermis, dermis (the layer from which capillary blood is obtained), and subcutis/hypodermis

- Indications for BG testing, which include
 - DM. In the acute care setting, patients with DM typically undergo BG tests several times daily depending on their diet and exercise patterns, insulin production, and the type of antihyperglycemic medication used (e.g., oral antihyperglycemic, insulin)
 - Enteral and PN (also called hyperalimentation) feedings. Glycemic control for patients receiving enteral and parenteral feedings should be maintained using a **basal-bolus regimen (BB)** insulin regimen. For more information, see *Nursing Practice & Skill ... Parenteral Nutrition: Administering -- an Overview*
 - critical illness (e.g., infection, sepsis, burns, respiratory failure). Critically ill patients are more likely to be hyperglycemic due to the increase in metabolic energy resulting from stress hormones released in response to injury or illness. In general, the ADA recommends a target BG of 180 mg/dL for most critically ill patients and, after insulin is initiated, maintaining a range of 140–180 mg/dL for all patients (critically ill and noncritically ill). More stringent goals (100–140 mg/dL) can be appropriate for selected patients (e.g., cardiac surgery patients, patients with acute ischemic cardiac or neurological events) if the target can be reached without significant hypoglycemia (i.e., < 70 mg/dL). Higher targets can be acceptable for patients who are terminally ill, patients with severe comorbidities, and those in patient care settings where frequent glucose monitoring is not available(ADA, 2016)
 - fasting(e.g., due to loss of appetite or ordered prior to surgery). Fasting increases the risk of symptomatic hypoglycemia
 - changes in medication
- Sliding scale insulin control. The 2016 ADA guidelines strongly discourage *sole* use of sliding scale insulin to manage glycemic levels and recommend glycemic control be achieved with use of a BB regimen (i.e., a method of glycemic control that involves use of longer acting insulin to maintain stable BG levels throughout the day and during periods of fasting [sleep], shorter acting insulin is used to control elevated BG levels resulting from meals). Typically, the patient using the BB regimen receives a minimum of four subcutaneous injections daily: one (of shorter acting insulin) before each meal and one (of longer acting insulin) at bedtime. Unexpected fluctuations in BG levels (based on POC BG testing before meals and at bedtime) are managed using a “correction scale.” The correction scale is not comparable to the sliding scale because the correction scale is designed to manage unexpected changes in BG levels only, not to fully manage glycemic levels. The BB insulin regimen promotes more even insulin coverage by providing baseline insulin coverage for periods of fasting and regularly scheduled insulin injections throughout the day. The sliding scale was often used alone without baseline coverage. The BB regimen permits increased flexibility with meals (e.g., timing and carbohydrate intake). A disadvantage of a BB regimen is the need for more insulin injections. The ADA recommends the BB regimen for all patient groups
- Target glucose levels

Type of Patient	Target Glucose Level
Perioperative	80–180 mg/dL
Non-critical	140–180 mg/dL; 100–140 mg/dL for select patients if significant hypoglycemia can be avoided
Critical	140–180 mg/dL; 100–140 mg/dL for select patients if significant hypoglycemia can be avoided
Enteral/parenteral feeding recipients	140–180 mg/dL using basal-bolus insulin dosing

- Normal goals and target levels for BG in patients with and without DM

Normal Blood Glucose Levels in Nondiabetic Patients	Blood Glucose Goals for Patients with Diabetes Mellitus
Fasting (upon awakening from overnight sleep): < 100 mg/dL	Fasting (upon awakening from overnight sleep): < 100 mg/dL

Preprandial: 70–99 mg/dL	Preprandial: 80–130 mg/dL
Postprandial: < 140 mg/dL	Postprandial: < 180 mg/dL
Bedtime: < 120 mg/dL	Bedtime: 90–150 mg/dL

- BG testing in patients with DM
 - POC BG testing using provides immediate feedback that is used to adjust insulin dosing. Typically, for patients who require insulin, BG testing is performed 4 or more times daily—before each meal, prior to bedtime, and after exercising. For insulin- and non-insulin-dependent individuals who self-manage their insulin, if BG levels remain stable, the treating clinician can reduce the frequency with which BG checks be performed (e.g., once or twice daily)
 - BG checks should be performed more frequently than usual when eating patterns are altered or when medication regimens are adjusted
- BG meters used in an acute care setting are required to adhere to a higher performance standard than meters approved for personal use in the home setting
 - No BG meter manufacturer has United States Food and Drug Administration (FDA) approval for blood glucose testing of capillary blood specimens in critically ill patients receiving intensive medical therapy. Currently only one manufacturer of POC BG meters (Nova StatStrip Glucose and StatStrip Xpress2 Glucose meters) has FDA approval and has received CLIA-waiver (Clinical Laboratory Improvement Amendments) for use with all patients in hospitals with the stipulation that only venous or arterial blood specimens are used in critically ill patients ([Video 1](#) ; [Figure 2](#))
 - Identification of the manufacturer Nova is for educational purposes only and does not constitute an endorsement of this manufacturer of POC BG meters
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 - Hand-held meter with keypad, display screen, and blood sample port. The patient’s identification information is programmed into the meter prior to testing. Some meters include a barcode scanner that can be used to scan the patient’s ID bracelet to automatically enter patient-specific data prior to testing
 - Glucose test strips (also called reagent strips) are meter model-specific and cannot be arbitrarily exchanged among different models of glucometers. The blood sample is applied to the target area on the test strip containing the chemical reagent. The nurse clinician should refer to the manufacturer’s instructions for the procedure for applying blood samples to test strips because variations exist with regard to the size of the blood sample (average is ≤ 0.5 microliters; StatStrip devices require 1.2 microliter sample), and whether to apply the sample prior to or after the strip is inserted into the sample port. Each container of test strips is labeled with a lot number and expiration date. The test strip expiration date should be checked prior to use and the lot number programmed into the meter. Glucose test strips should be stored in a cool, dry location because prolonged exposure to air, light, and/or humidity can discolor test strips and reduce the accuracy of BG results
 - Quality control (QC) checks are performed according to facility/unit-specific protocol (typically once every 24-hour period, not before each use) using solution with high and low glucose content. Typically, each bottle of control solution is stable for 90 days after opening or until the expiration date printed on the label, whichever comes first
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 - Data management system, which permits data from multiple patients to be tracked. The data from the meter can be uploaded to the facility data management system when connected via a docking station
 - Prior to testing, the glucose meter must be programmed with the patient’s information—entered manually or using a barcode scanner included in some glucose meter devices—and programmed with the glucose test strip lot number
- Use of a lancet or skin puncture device, and knowledge of preferred sites for puncture in infants, children, and adults
 - Lancets and other skin puncture devices are designed on single use and should be discarded in a biohazard/sharps container
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 - The puncture site should be highly vascular, but not highly innervated. The preferred puncture sites in children (other than infants) and adults are the lateral aspect of the fingertip or the earlobe. The nurse clinician should avoid pricking the tips of fingers to reduce the incidence of soreness on the most frequently used surfaces of the fingers
 - In infants,
 - the lateral or medial aspect of the heel should be used, and the puncture should be no deeper than 0.01 in/2.0 mm to avoid osteochondritis (i.e., inflammation of bone and cartilage)
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- avoid puncturing the fingers and toes, which can cause nerve damage (see *Nursing Practice & Skill ... Blood Sampling in the Newborn or Infant: Heel Puncture --Performing*)
- avoid puncturing the fingers and toes, which can cause nerve damage (see *Nursing Practice & Skill ... Blood Sampling in the Newborn or Infant: Heel Puncture --Performing*)
- In all patients, avoid previous puncture sites; areas of inflammation, bruising, edema, or infection; cyanotic or poorly perfused tissue; and sites with superficial peripheral arteries
- Puncture site rotation is necessary to reduce tissue damage. If a single location is used repeatedly, the skin at that site can become discolored and thickened. Good blood flow on the initial puncture can be achieved by
 - choosing an appropriate and well-perfused site
 - using the correct technique (i.e., precisely following the manufacturer's instructions for use) for the skin puncture device
 - arterializing the site (i.e., increasing the arterial composition of capillary blood by warming the site to increase circulation) ; **(Figure 5)**



Figure 5: Example of use of an activated heel warmer used to increase circulation. Copyright© 2014, EBSCO Information Services.

- A microcollection device (e.g., preheparinized pipette, capillary collection tube, miniature suction bulb) is required by some facilities to promote the collection of an adequate sample of capillary blood
- › Preliminary steps that should be performed before initiating BG testing at the bedside include the following:
 - Review the facility/unit-specific protocol for BG testing, if one is available
 - Note facility or unit-specific action ranges for high or low BG levels
 - Review the treating clinician's order for BG testing
 - Note the frequency and timing (e.g., before/after meals) of BG checks and applicable action ranges (if different from the facility/unit-specific protocol)
 - Review the manufacturer's instructions for the glucometer to be used. Confirm the QC tests for the glucometer are current and the equipment is in good working order
 - Confirm the test strips are appropriate for the type of glucometer to be used and
 - the expiration date of the test strips has not passed
 - the glucometer has been programmed for the specific batch of strips to be used (if using a meter that requires coding)
 - the strips are functioning properly (Note: Most routine QC checks performed per facility/unit-specific protocol include use of unexpired control solutions to test the functionality of test strips)
 - Verify completion of facility informed consent documents. Typically, the general consent for treatment executed by patients at admission to a healthcare facility includes standard provisions that encompass BG testing
 - Review the patient's medical history/medical record for any allergies (e.g., to latex, medication, or other substances); use alternative materials, as appropriate
- › Gather the supplies necessary to test BG at the bedside, which typically include the following:
 - Nonsterile gloves; additional **personal protective equipment (PPE)**; e.g., gown, mask, eye protection) can be necessary depending on the need for special precautions and the potential for exposure to body fluids
 - Facility-approved antiseptic wipes (e.g., **chlorhexidine gluconate [CHG]** with isopropyl alcohol, povidone-iodine, 70% alcohol)

- Cotton ball or small gauze pad
- Small adhesive bandage (optional)
- 2.0 mm/0.01 inch long lancet or skin puncture device. Note: Lancets/puncture devices are available in varying gauges ranging from 21 to 30
- Glucose meter
- Glucose test strips
- Microcollection device (e.g., preheparinized pipette, capillary collection tube, miniature suction bulb), if indicated
- Hospital-grade disinfectant
- Patient identification label (to enter patient identification information)
- Written information, if available, to reinforce verbal education

How to Test a Patient's Blood Glucose at the Bedside

- › Perform hand hygiene and don PPE
- › Identify the patient using two unique identifiers or according to facility protocol
- › Establish privacy by closing the door to the patient's room and/or drawing the curtain surrounding the patient's bed
- › Introduce yourself to the patient and family member(s) and explain your clinical role
- › Assess the patient and family for knowledge deficits and anxiety regarding BG testing
- › Determine if the patient/family requires special considerations regarding communication (e.g., due to illiteracy, language barriers, or deafness); make arrangements to meet these needs if they are present
 - Use a professional certified medical interpreter when a communication barrier exists
- › Assess the patient's understanding of and previous experience with the procedure; explain the procedure for BG testing and its purpose; answer any questions and provide emotional support as needed
- › Observe standard precautions and aseptic non-touch technique (ANTT; i.e., the skin should not be touched after it has been prepared with antiseptic cleanser and any item introduced into the patient is sterile prior to insertion) throughout the procedure
- › Power on the glucose meter
- › Program the hand-held meter with the patient's identification information (name, medical record number, room/bed number) per facility/unit-specific protocol, and wait until the meter indicates its readiness for testing
- ›
- › Obtain verbal consent for the procedure
- › Remove a glucose test strip from the container and recap the container tightly
- › Obtain the capillary blood sample
- ›
- Select an appropriate puncture site as explained in *What You Need To Know Before Testing a Patient's Blood Glucose at the Bedside*, above
- Wash the patient's hands thoroughly and *gently* massage the finger to stimulate blood flow
- Cleanse the selected site using facility-approved antiseptic in accordance with facility/unit-specific guidelines. If using a CHG wipe, allow the solution to air dry completely prior to puncture. If using 70% alcohol, wipe the site clean using a sterile gauze pad
- Remove the cover of the skin puncture device and adjust the depth to which the device will pierce the skin (if the adjustable option is available)
- Warn the patient that he/she will feel a sharp prick as the device punctures the skin. Advising the patient of the impending injection will allow him/her to mentally prepare for the injection so he/she can remain still
- Place the device firmly against the puncture site, typically the side of a finger, and push the release button to pierce the skin
- Immediately discard the puncture device in the biohazard/sharps container
- Gently massage the skin around the puncture site until a "hanging drop" of blood has formed. A hanging drop is commonly described as a true drop of blood instead of an amount adequate to smear against the target area of the meter strip, which is often an insufficient sample size—it is important to completely cover the entire target area to avoid the necessity of repeating the puncture. If dictated by facility/unit-specific protocol, wipe away the first droplet of blood—the first drop of blood generally contains a significant amount of interstitial fluid—and allow a second drop to form (A 2014 study reported that the value obtained from the first drop of blood is close to that of venous blood when the BG level < 180 mg/dL or 10 mmol/L; when BG level > 360 mg/dL or > 20 mmol/L, the second drop was more accurate [Li et al., 2014])

- The blood should flow freely. It is acceptable to apply light, intermittent pressure to the puncture site to encourage blood flow, but **do not milk the site** which can cause the red blood cells to hemolyze and result in the sample having a disproportionate percentage of interstitial fluid
- Cover the target area of the test strip with the blood sample using the technique recommended by the manufacturer. Some strips are designed so that blood should drop or fall onto the target area, other strips are used by allowing the blood to be “wicked” from the side. Ensure the entire target area is covered—avoid touching the skin
 - Some facilities require the blood sample be first collected in a microcollection device (e.g., capillary tube, pipette, or miniature suction bulb) and then applied to the glucose test strip
- › Insert the glucose test strip into the meter (some devices require that the test strip be inserted prior to obtaining the blood sample) and allow the meter to perform the BG analysis. Do not remove or disturb the test strip while the meter is completing the analysis
- ›
- › Apply pressure to the skin puncture site using a cotton ball or a gauze pad. Inspect the puncture site to verify that bleeding has stopped. Apply a small adhesive bandage to the puncture site if necessary
- › Note the BG result when it appears on the meter display screen
- › Remove the test strip and dispose it and other used supplies in the appropriate receptacles
- › Power off the meter
- › Disinfect the glucose meter and return it to the appropriate storage location
 - The importance of disinfecting the glucose meter after each use is critical. The Centers for Disease Control and Prevention (CDC) has cited POC BG testing in health care facilities as presenting an “underappreciated risk” for exposure to bloodborne viruses (e.g., hepatitis B virus [HBV], hepatitis C, and human immunodeficiency virus [HIV]) due to the practicing of sharing monitoring equipment among patients (CDC, 2012)
 -
- › Dispose of used materials in proper receptacles; perform hand hygiene
- › Update the patient’s plan of care, as appropriate, and document bedside BG testing in the patient’s medical record, including the following information:
 - Date and time BG was measured
 - BG level and action performed (e.g., medication administered or withheld)
 - Location of the puncture site
 - Patient’s tolerance of the procedure
 - Any unexpected patient events or outcomes, interventions performed, and if the treating clinician was notified
 - Patient/family member education, including topics presented, response to education provided, need for follow-up education, any barriers to communication, and/or techniques that promoted successful communication

Other Tests, Treatments, or Procedures that Can Be Necessary Before or After Testing Blood Glucose at the Bedside

- › Medication can be adjusted by the treating clinician to provide more effective glycemic control
- › BG levels will be retested if a false reading is suspected or if the reading is unexpectedly abnormal
- › In addition to BG testing with capillary blood using a portable glucometer, BG is also tested using venous blood analyzed by a clinical laboratory. Venous blood is also tested for glycosylated hemoglobin (**HbA1c**; i.e., a form of hemoglobin that indicates the average plasma glucose concentration over the previous 60–90 days) to detect the extent of chronic hyperglycemia and to evaluate the patient’s control of BG levels over a prolonged period
 - The ADA recommends the HbA1c test be performed for all patients admitted to an acute care facility with DM or hyperglycemia if the test has not been completed in the previous three months (ADA, 2016)

What to Expect After Testing Blood Glucose at the Bedside

- › An accurate analysis of capillary BG levels is obtained
- › Results of the testing will guide appropriate diagnosis and treatment

Red Flags

- › Consider retesting or the use of conventional laboratory blood testing for plasma glucose if the patient’s clinical presentation does not correspond with the BG reading
- › Multiple punctures in the same location increase risk for thickening and scarring of the skin

- › Do not use *capillary* whole blood specimens for BG monitoring in critically ill patients receiving intensive medical therapy due to the possibility of collection error particularly in patients with decreased peripheral perfusion. Only venous or arterial blood specimens are used in critically ill patients
- › Potential errors in BG testing can be the result of the meter hardware (e.g., electronic failure, depleted battery), the meter system (e.g., incorrect calibration, inadequate user training), or the clinical condition of the patient (e.g., dehydration, hypoxia)

What Do I Need to Tell the Patient/Patient's Family?

- › Explain the importance of glucose control in preventing serious long-term complications
- › If the patient and/or caregiver(s) will be performing BG monitoring in the home setting,
 - provide instruction on self-monitoring of BG levels in the home setting; offer written materials if available, to reinforce verbal education
 - educate on healthy BG parameters
 - explain how to contact the treating clinician if hypo- or hyperglycemia is suspected
- › If BG values are consistently elevated, explore issues of nonadherence with medication and diet and lifestyle guidelines; counsel the patient appropriately

Note

- › Recent review of the literature has found no updated research evidence on this topic since previous publication on August 19, 2016

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