EXERCISE 12: BEDSIDE GLUCOSE TESTING

Skills: 15 points

Objectives:

1. Define "diabetes mellitus".
2. Compare and contrast: Type 1 Diabetes, Type 2 Diabetes and gestational diabetes.
3. List the limitations of the bedside glucose test procedure.
4. State the normal values for blood glucose levels.
5. Briefly describe the glucose tolerance test including patient instructions.
6. Briefly describe the 2 hour post prandial glucose test including patient instructions.
7. State the purpose of performing bedside glucose testing.
8. State the principle of the reaction which occurs on the glucose test strip.
9. Describe the system for monitoring quality assurance in bedside glucose testing.
10. Perform and record the calibration and normal control solution for the test.
11. Evaluate the calibration and normal control solution using predetermined criteria to determine if the test can be performed on the patient.
12. Perform a capillary puncture using an automatic blood sampler designed for capillary glucose testing.
13. Perform a quantitative measurement of glucose on whole blood using a device manufactured for patient home use and bedside testing.

Discussion

Diabetes mellitus is a disorder of carbohydrate metabolism caused by a lack of insulin or nonfunctional insulin and characterized by high blood glucose levels. This is a complicated disease that may cause more complications for the patient than just an increased blood glucose level. Persons with diabetes mellitus often develop blindness, kidney failure, and/or circulatory problems that result in tissue damage and possible amputation. **Hyperglycemia** is the signal that a person possible has diabetes mellitus. Commonly the patient is deficient in insulin production by the pancreas or in insulin function. Insulin is the hormone primarily responsible for regulating blood glucose levels. When it is absent or nonfunctional the glucose levels in the blood rise dangerously.

Type 1 diabetes was previously called insulin-dependent diabetes mellitus (IDDM) or juvenile-onset diabetes. Type 1 diabetes develops when the body's immune system destroys pancreatic beta cells, the only cells in the body that make the hormone insulin that regulates blood glucose. This form of diabetes usually strikes children and young adults, who need several insulin injections a day or an insulin pump to survive. Type 1

diabetes may account for 5% to 10% of all diagnosed cases of diabetes. Risk factors for type 1 diabetes include autoimmune, genetic, and environmental factors.

Type 2 diabetes was previously called non-insulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes. Type 2 diabetes may account for about 90% to 95% of all diagnosed cases of diabetes. It usually begins as insulin resistance, a disorder in which the cells do not use insulin properly. As the need for insulin rises, the pancreas gradually loses its ability to produce insulin. Type 2 diabetes is associated with older age, obesity, family history of diabetes, prior history of gestational diabetes, impaired glucose tolerance, physical inactivity, and race/ethnicity. African Americans, Hispanic/Latino Americans, American Indians, and some Asian Americans and Pacific Islanders are at particularly high risk for type 2 diabetes. Type 2 diabetes is increasingly being diagnosed in children and adolescents.

Gestational diabetes is a form of glucose intolerance that is diagnosed in some women during pregnancy. Gestational diabetes occurs more frequently among African Americans, Hispanic/Latino Americans, and American Indians. It is also more common among obese women and women with a family history of diabetes. During pregnancy, gestational diabetes requires treatment to normalize maternal blood glucose levels to avoid complications in the infant. After pregnancy, 5% to 10% of women with gestational diabetes are found to have type 2 diabetes. Women who have had gestational diabetes have a 20% to 50% chance of developing diabetes in the next 5-10 years.

The Glucose Tolerance Test

The glucose tolerance test (GTT) is done on individuals who are being screened for diabetes mellitus or *hypoglycemia*. The phlebotomist plays a very crucial role in the administration of this test. Usually the patient receives a set of instructions about what to eat and a warning to avoid stressful exercise in the days leading up to the GTT. However, it is often the phlebotomist who gives the patient instructions about dieting and fasting. The patient should eat a well-balanced diet for 3 days before the test. Generally, the patient is allowed water and is actually encouraged to drink water during the fast and test, but nothing else is allowed, including coffee and tea. Smoking is also discouraged. These instructions must be delivered in a clear and understandable manner. Patients should be encouraged to ask questions if they do not understand the instructions. If the phlebotomist does not perform this patient education function properly, much valuable time may be wasted.

After a patient has fasted for at least 12 hours, a blood sample is collected using routine collection procedures. The blood may be collected in a plain tube or in a tube especially designed to preserve glucose levels. If a plain tube is collected it is critical to get it back to the lab so the serum can be separated from the red blood cells. If the serum is allowed to sit on the cells glycolysis by the cells will occur, causing a falsely decreased glucose level.

After the fasting sample is collected, the patient is directed to consume 100 gm of glucose as quickly as possible, often in liquid form. **It is critical to note the time of glucose consumption and of all subsequent venipunctures.** Blood is then collected 30 minutes, 1 hour, 2 hours, 3 hours, etc., up to 5 hours after consuming the glucose. At each venipuncture a urine specimen may also be collected.

It is very important to collect the specimen at the designated. When labeling the sample include all items routinely collected plus the time in the series "1 hour", "2 hour" and so on.

The laboratory analyzes the glucose level in each specimen and plots the results on a chart. The results help the physician determine whether the patient is suffering from diabetes.

The phlebotomist must be prepared to handle the situation when the patient becomes ill from consuming the glucose or "light headed" from fasting for several hours during the test. Generally, nausea and vomiting occur early in the test, and it is a good idea to have towels and an emesis basin nearby. If the patient vomits within the first 30 minutes, the test should be discontinued and will probably need to be rescheduled for another day. If the patient vomits or becomes faint later in the test, have him or her lie down, and complete the testing. If repeated oral glucose administrations are unsuccessful, intravenously administered glucose is an option. The patient's physician will make this decision.

Postprandial Glucose Test

The 2-hour postprandial glucose test can be used to **screen** patients for diabetes because glucose levels in serum specimens drawn 2 hours after a meal are rarely elevated in normal patients. In contrast, diabetic patients will usually have increased values 2 hours after a meal.

For this test, the patient should be placed on a high carbohydrate diet 2 to 3 days before the test. The day of the test, the patient should eat a breakfast of orange juice, cereal with sugar, toast, and milk to provide an approximate equivalent of 100 g of glucose. A blood specimen is taken 2 hours after the patient has finished eating breakfast. The glucose level on this specimen is then determined. The physician can decide if further carbohydrate metabolism tests are needed, such as the GTT.

Two Hour Post-glucose Drink

Giving a patient a glucose load as in a GTT and then testing their glucose two hours later is more objective than the postprandial glucose. This method standardizes the amount of glucose given and eliminates the variables of time to consume the meal and how fast the meal is absorbed. The patient has the benefit of not being drawn as many times as with a glucose tolerance test.

Home Monitoring of Glucose

Persons with diabetes do not want to go to the laboratory to be tested on a daily basis. Several instruments for home monitoring are available for patient purchase. All the instruments use the same basic principle. Patient's perform a finger stick on themselves and place a drop of blood on a small testing pad. The pad is then inserted into the instrument and at the proper time the glucose value is displayed on the monitoring device. The patient records the value and can even be trained to adjust their insulin dose depending on the glucose values.

The ADA suggests that people with type 1 diabetes and pregnant women taking insulin test their blood glucose levels at least three times a day. There is no official recommendation for daily testing frequency for type 2 diabetes; however the ADA does state that testing should be frequent enough to achieve blood glucose goals, and both type 1 and type 2 patients should test more often when their treatment regimen is adjusted.

Principle of the Test Procedure

Quantitative measurement of glucose in whole blood with an electrochemical biosensor begins when a drop of blood is introduced on the top, tip, or side of the test strip. Plasma from the whole-blood sample diffuses into and solvates the reagent layer, which contains glucose oxidase or glucose dehydrogenase and electrodes. Glucose is catalyzed to form gluconic acid by the glucose dehydrogenase or glucose oxidase reagent. The electrons produced from the reaction form a current. Under the potential provided from the meter, a current is generated from the electrons produced during glucose oxidation. The current is calibrated to measure the glucose concentration in the whole-blood sample.

Sample Collection and Preparation

A small drop of capillary whole blood is collected by skin puncture from the finger or heel (in infants). Fresh blood obtained by venipuncture may also be used. However, venous and capillary blood may differ in glucose concentration by up to 70 mg/dL, depending on time of blood collection after food intake. Be sure to check the manufacturer's recommendations as they relate to anticoagulants. Some procedures require blood without an anticoagulant, other procedures are not affected by anticoagulants. As for any blood collection procedure, appropriate safety procedures must be followed and disposal of contaminated waste must be part of the quality control and safety guidelines. The puncture site should be cleansed and **thoroughly** dried before obtaining the blood sample. These bedside procedures are handy for quick screening in a hospital or outpatient setting.

Always test blood samples as near as possible to the time of sample collection. Blood glucose concentration in whole blood decreases over time, glucose measurements of stored samples will not equate with their concentrations at the time of collection. The blood glucose determination should be performed within 10 minutes of specimen collection to minimize glycolysis.

Quality Control

It is **extremely important** to maintain and provide a rigid quality control and training program prior to implementing these procedure. Variance in methodology and lack of quality control on reagents and equipment can lead to **serious medical consequences** for patients being tested. Careful adherence to manufacturer's instructions as well as a thorough evaluation of the monitoring devices, coupled with strict adherence to daily quality control procedures, will ensure a more accurate and precise screening tool.

Quality control involves testing the equipment by utilizing control solutions of known values. Most manufacturers make a high, low and normal solution. These solutions are tested just as if they were a patient solution. The values are then compared with the manufacturer's values. If the expected values are obtained, patient testing can be done. If the expected values are not obtained the system is not functioning properly and **the equipment cannot be used** until the problem is identified and corrected. Control results that fall outside of the expected range may indicate procedural error, test strip deterioration, meter malfunction, or extremes in testing procedure. Once the problem is identified, the controls must be repeated. If the results are now in range the equipment can be used for patient testing. If controls continue to be out of range, notify the

manufacturer for assistance and possible repair. Documentation of these control results and action taken when problems arise is an integral part of a complete quality assurance program.

Limitations of the Procedure

1. The test strips are designed to be tested with whole blood, serum or plasma ***cannot*** be used.

2. Do not use preservatives that contain fluoride.

3. Extremes in hematocrit can affect results. High hematocrits (above 60%) are known to decrease glucose meter measurements, conversely low hematocrits (below 25%) can cause increased glucose measurements.

4. Check with manufacturer as to whether or not the equipment can be used on neonates. Some equipment is not designed for babies.

5. Blood glucose results obtained may be significantly lower that true concentrations if excessive water loss and dehydration occurs. Severe dehydration can lead to many serious, life threatening medical complications.

> The loss of excessive water upsets the body's chemical balance which affects the blood in many ways. One very important effect is that the liquid (plasma) portion of the blood will be greatly reduced which makes the blood thicker. This may cause the meter to give inaccurately low blood glucose results.

> The following are some of the factors which could lead to dehydration:

> a. vomiting or diarrhea

> b. prescription drugs, e.g., diuretics

> c. inability to recognize ore respond to "thirst" sensations

> d. sustained uncontrolled diabetes

6. Reducing substances such as ascorbic acid, etc. when occurring in normal blood concentrations do not significantly affect the results. However, abnormally high concentrations in blood will cause inaccurately low results for reflectance methods, these do not interfere with biosensor methods.

7. Reagent strips *must not* be used beyond their printed expiration date and vials must be used within a specified period of time after opening.

Expected Values

The target blood glucose value appropriate for the patient should be established by the physician or prescribing healthcare professional. Target blood glucose levels associated with well controlled diabetes are as follows:

* Fasting 60 - 130 mg/Dl

* After meals (1 hour): Less than 180 mg/dL

* After meals (2 hours): Less than 150 mg/dL

EXERCISE 12: BEDSIDE GLUCOSE TESTING

Phlebotomist_____Date_____

Patient Name _____

A Performed

B Needs Improvement

C Not Performed

_____ 1. Appropriately prepares the glucose meter.

_____ 2. States the proper protocol for the performance of quality control procedures.

_____ 3. Reads instructions of appropriate instrument and automatic blood sampler prior to proceeding.

_____ 4. Selects, prepares and organizes equipment.

_____ 5. Washes hands, dons gloves, greets and identifies patient.

_____ 6. Explains procedure to the patient. Interviews patient concerning preparation prior to specimen collection.

_____ 7. Selects puncture site, massages and warms site as necessary, cleanses site, allows site to dry completely and performs puncture.

_____ 8. Appropriately squeezes finger to form first drop of blood.

_____ 9. Appropriately applies the blood drop to the reagent strip according to the manufacturer's directions to initiate timing of the reaction.

_____ 10. Measures the glucose content on the strip according to the instrument manufacturer's directions.

_____ 11. Provides appropriate post-puncture care to the patient.

_____ 12. Disposes of all materials and supplies in the appropriate containers.

_____ 13. Inspects puncture site, applies bandage if necessary.

_____ 14. Removes gloves, washes hands.

Time of patient's last meal	
Calibration strip (place a check if acceptable)	
Normal Control Solution	
Manufacturer's value for normal control solution	
Patient's Glucose results	

Based on the results of the calibration can this machine be used? YES NO

Based on the results of the normal control can this machine be used? YES NO

Are the patient results: NORMAL ABNORMAL

EXERCISE 12: BEDSIDE GLUCOSE TESTING STUDY QUESTIONS

Name_____ Date _____

Points: 25

1. What is the cause of diabetes mellitus (1 point)?

2. What is the function of insulin (1 point)?

3. Describe the difference between Type I and Type II diabetes mellitus (2 points).

4. **Briefly** describe the instructions given to patients to prepare them for the glucose tolerance test (GTT) (2 points).

5. For what period of time does a patient fast before the GTT (0.5 point)?

6. Describe the time intervals of the specimens drawn during a GTT and how these should be labeled (2 points).

7. What must be done if a patients vomits within the first 30 minutes of the GTT (1 point)?

8. Briefly describe the postprandial (PP) glucose test (2 points).

9. Briefly describe the 2 hour postglucose drink test **AND** state the advantages this test has over the PP glucose test (2 points).

10. Describe the advantage for patients to monitor their glucose at home (1 point).

11. What is the time limit for testing blood specimens for glucose after collection. **Why** is this limit set (1 point).

12. Why is quality control of the glucose meter so important (1 points).

13. Briefly describe the quality control testing to be done each day (1 points).

14. List four (4) factors which may cause control results to fall outside of the expected range (2 points).

15. List three limitations of the glucose testing procedure using the glucose meter (1.5 points).

16. List three factors which may lead to dehydration (1.5 points).

17. How will dehydration affect the test results (1 point).

18. List the expected values of the blood glucose for each of the following (1.5 points):

   * Fasting _____

   * One hour after a meal _____

   * Two hours after a meal _____