EXERCISE 8: BEDSIDE GLUCOSE TESTING

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 control solution(s) for the test.
11. Evaluate the control solution(s) using predetermined criteria to determine if the test can be performed on the patient.
12. Perform a capillary puncture for glucose determination and use the first drop of blood for analysis.
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 possibly 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 insulin is absent or nonfunctional, the glucose levels in the blood rise dangerously.

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 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 may account for about 90% to 95% of all diagnosed cases of diabetes. 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. Often the phlebotomist is the individual who gives the patient instructions about dieting and fasting. The instructions should be given verbally and in writing. Instructions given to the patient should include:

1. The patient should eat a well-balanced diet for 3 days before the test.
2. 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.
3. Smoking is also discouraged.
4. Avoid stressful exercise in the days leading up to the GTT.

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 fasting 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 time. When labeling the sample include all routine labeling (name, number, etc.) plus the time in the series “fasting”, “30 minutes”, "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.

**Test Procedure:** 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

**Test Procedure:** Patient is given a glucose drink as in a GTT. Two hours later their blood is drawn. The advantages of this procedure are:
1. It is more objective than the postprandial glucose as it standardizes the amount of glucose given.
2. It eliminates the variables of time to consume the meal and how fast the meal is absorbed.
3. 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. The patient performs a finger stick to obtain a drop of their blood for testing. The manufacturer’s instructions for their specific meter are followed. When testing is complete, 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 – Point of Care Glucose Monitor

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). The first drop of blood expressed is used for the test. **DO NOT** wipe away the first drop of blood. 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 this procedure. Lack of quality control on reagents and equipment or variance in methodology and 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

1. Procedural error,
2. Test strip deterioration,
3. Meter malfunction, or
4. 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. DO NOT use serum or plasma. The test strips are designed to be tested with whole blood.
2. Never test samples that have been collected / preserved with fluoride. Fluoride suppresses the chemical reaction on the strip.
3. Extremes in hematocrit can affect results.
   a. High hematocrits (above 60%) are known to decrease glucose meter measurements. High hematocrits are seen with dehydration (See #5 below).
   b. Low hematocrits (below 25%) can cause increased glucose measurements. Low hematocrits are seen in anemia or recent hemorrhage.
4. Some meters are not designed for newborns. Check the manufacturer’s recommendations before using to test infants and small children.
5. Patient dehydration can falsely reduce results.
   A comparison of glucose test results obtained by glucose meter and by conventional chemistry analysis has demonstrated that patients who are dehydrated may have falsely decreased glucose results when tested using a glucose meter. With less liquid (plasma), the blood is thicker which 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 or respond to "thirst" sensations
   d. sustained uncontrolled diabetes
6. Falsely decreased results due to ascorbic acid (Vitamin C). Ascorbic acid (and other reducing substances) suppresses the glucose strip’s chemical reaction. Patients who take increased amounts of vitamin C (ascorbic acid) can have falsely decreased glucose results when tested using a glucose meter (reflectance methodology). Biosensor methods may not be affected. Check specific manufacturer’s product insert.
7. Reagent strips must not be used beyond their printed expiration date and vials must be used within a specified period after opening.

**Expected Values**
The target blood glucose value appropriate for the patient should be established by the physician or prescribing healthcare professional.

<table>
<thead>
<tr>
<th>Target levels</th>
<th>Blood Glucose</th>
<th>Non-diabetic individuals</th>
<th>Well-controlled diabetic</th>
<th>Diagnostic of Diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting</td>
<td>99 mg/dL or less</td>
<td>60 – 130 mg/dL</td>
<td>126 mg/dL or more</td>
<td></td>
</tr>
<tr>
<td>1 hour after meal</td>
<td>---------------------</td>
<td>Less than 180 mg/dL</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>2 hours after meal</td>
<td>Less than 140 mg/dl</td>
<td>Less than 150 mg/dL</td>
<td>200 mg/dL or more</td>
<td></td>
</tr>
</tbody>
</table>

**Hemoglobin A1c**
Another test that has become commonly ordered on diabetics is Hemoglobin A1c (Hgb A1c). When glucose binds to hemoglobin, glycated hemoglobins are formed and are proportional to the concentration of the patient’s glucose. Since red blood cells last an average of 120 days, measurement of glycated hemoglobin indicates the average blood glucose level during the previous 2-3 months. Hemoglobin A1c has become the standard glycated hemoglobin that is measured for tracking glucose control in diabetics. In normal healthy individuals, about 4% to 6% of hemoglobin is bound to glucose. The American Diabetes Association (ADA) recognizes a Hgb A1c level greater than or equal to 6.5% as one of the indicators of diabetes, and recommends a target range for most diabetics of less than 7%.

In the clinical setting, this test requires the collection of an EDTA sample (Lavender stopper tube). The patient does not need to be fasting. Hemoglobin A1c is most often tested at 3 month intervals.
EXERCISE 8: BEDSIDE GLUCOSE TESTING STUDY QUESTIONS

Name___________________________   Date _____________________ Points: __________/27

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)
   Type 1 Cause-
   Patient type(s)-
   Type 2: Cause -
   Patient type(s)-

4. Briefly describe the instructions to give 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 and labeling requirements of the specimens drawn during a 3 hour GTT. (2 points)
   a. Time intervals:
   b. Sample labeling BE SPECIFIC:
7. What must be done if a patient vomits within the first 30 minutes of the GTT? (1 point)

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

9. Briefly describe the 2 hour post-glucose drink test procedure **AND** state the advantages this test has over the PP glucose test. (2 points)
   a. Procedure:
   b. Advantages

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).
   a. 
   b. 

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

13. Briefly describe the quality control testing to be done each day **and** the expected results. (1 point)
   a. 
   b. 

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

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

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

17. How will dehydration affect the results of glucose testing? (1 point)

18. List the target blood glucose level for patients with well controlled diabetes for each of the following: (1.5 points)
   a. Fasting __________________
   b. One hour after a meal __________________
   c. Two hours after a meal _________________

19. List the target blood glucose levels for non-diabetic patients for each of the following: (1 point)
   a. Fasting________________________
   b. Two hours after a meal____________________

19. List the glucose level which may indicate a patient is diabetic: (1 point)
   a. Fasting__________________________
   b. Two hours after a meal________________
Quality Control

<table>
<thead>
<tr>
<th>Testing of Controls</th>
<th>Expiration Date</th>
<th>Expected Range</th>
<th>Value Obtained (mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control Solution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot #</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Low Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot #</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. High control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot #</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the results of the control solutions, can this device be used for testing? (Circle One)  Yes  No

Sample collection and Testing (Check P for performed, NP for Not Performed)

5. Performs quality control procedures and verifies that equipment can be use for patient testing.
6. Introduces self to patient.
7. Properly identifies patient. Records patient name and ID number in the appropriate space below.
8. Washes hands, dons gloves
10. Selects, prepares and organizes equipment.
11. Selects puncture site, massages and warms site as necessary.
12. Cleanses site. Allows site to dry completely.
13. Appropriately prepares the glucose meter.
15. Appropriately squeezes finger to form first drop of blood.
16. Appropriately applies the FIRST blood drop to the reagent strip according to the manufacturer's written directions to initiate testing.
17. Applies gauze or Biowipe to puncture site, asks patient to apply pressure.
18. Reads and records results in designated area below.
19. Provides appropriate post-puncture care: inspects puncture site, applies bandage if necessary.
20. Disposes of all materials and supplies in the appropriate containers.
21. Thanks patient. If outpatient, allows patient to leave.
22. Disinfect work area after patient has left work area.
23. Removes gloves, washes hands.

Patient Name | ID Number | Time of last meal | Results mg/dL
--------------|-----------|-------------------|----------------

24.

25. Based on the time of the patient’s last meal are these results considered normal? (Circle one.)
YES  NO

Grading Notes:
Every line worth 1 point
Count off .25 for each space where correct units are not used for lines 1, 2, 3 and 24.