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## **Blood glucose monitoring: a key component of diabetes management**

**Abstract:** The global prevalence of diabetes and its impact on patient wellbeing have been raised by several health authorities. Despite the high prevalence of diabetes, it is often detected during routine medical investigation. Diabetes UK (2021) states that diabetes is a serious medical condition affecting one in 15 people in the United Kingdom, including one million with type 2 diabetes that are undiagnosed. The rising prevalence of diabetes and its associated complications in some patients when they are diagnosed presents a major health challenge.

Key words: Diabetes, blood glucose monitoring, glycaemic control, glucose metabolism

**Introduction:** Diabetes can be simply defined as abnormal high blood glucose levels in the blood; hence, constant monitoring of blood sugar levels is essential in diabetes care (Lawal, 2021). A poorly controlled blood glucose level may lead to acute and long-term diabetes-related complications such as hypoglycaemia, diabetes ketoacidosis, blindness, sexual related problems, and lower limb amputation (Brashers, Jones and Huether 2017, WHO 2021). Although most endocrine emergencies occur rarely, diabetic emergencies are witnessed by most nurses caring for patients within the hospital and community settings. Therefore, it is important for nurses and other healthcare practitioners to have a good insight into glucose metabolism and control (NMC 2018) and be aware of the importance of routine monitoring as a key aspect of diabetes management. Thus, this article discusses the clinical importance of blood glucose monitoring in diabetes management and the common techniques used for testing blood glucose level.

### **Glycaemic control**

Blood glucose monitoring is the measurement of blood glucose level in the body, and it is important to ensure that blood glucose levels are within normal range (Waugh and Grant, 2018). The diagnosis of diabetes is based on either a pre-prandial level (before meal) or a post-prandial level (after meal) assessment (Brashers, Jones and Huether 2017). The indications for measuring blood glucose levels include assessing the level of glucose in the blood to ascertain that it is within the normal range, pre- and post-operatively and in diabetes emergencies such as hypoglycaemia (See box 1). Hyperglycaemia increases the risk of other long-term conditions and may precipitate fluctuating blood glucose levels which eventually requires a more frequent blood glucose monitoring (Brashers, Jones and Huether 2017, Waugh and Grant, 2018). The acceptable level for patients with long-standing diabetes may vary slightly and the interpretation of results may be affected by other problems (Box 2).

### **The common methods of assessing glucose level**

In practice, glucose is monitored by using urine or a blood sample and the test can be conducted by using several investigative techniques such as urinalysis, blood glucose monitoring and glycosylated haemoglobin (Box 3). Whatever the clinical procedure employed, registered nurses are personally accountable for their actions (NMC 2018). Some patients with unstable blood glucose levels may require continuous monitoring, however, the recommended frequency would be four times a day for routine blood glucose monitoring (NICE 2021).

#### **Urinalysis:**

In the past, testing urine for glucose and ketones was the only method available for evaluating the management of diabetes (LeMone and Burke 2008). Urine does not normally contain detectable glucose or ketones, therefore, the presence of either substance represent an abnormality in urine

composition. The level required for a positive result is 180mg/dl, however, individual with high renal threshold glucose level may still have a negative test strip result. Urine testing is a simple procedure that is often performed during routine admission, and it involves putting a sensitive glucose -specific reagent test strip in the urine for a few seconds and comparing the colour of the strip with the chart on the container of the strip and recording it on an appropriate chart. Urine testing is a non-invasive technique and is used in clinical practice to detect the presence of glucose, ketones, or protein, however, this is not a conclusive test because the presence of glucose in the urine does not always indicate that a person has diabetes (LeMone and Burke 2008, Alexander et al, 2006, Lawal 2021). Also, a positive test result only indicates the current level, and it cannot detect hypoglycaemia.

### **Blood test**

The normal fasting blood glucose levels are 4 – 7mmol/L, fluctuating to 7–9mmol/L following a meal (Diabetes UK 2021a, American Diabetes Association 2021). Healthcare practitioner often use the fasting plasma test to diagnose diabetes, however, a random plasma glucose test is used in some cases. Random blood glucose test entails random check of plasma glucose concentration regardless of the time of the last meal. On the other hand, fasting blood glucose test involves the measurement of plasma glucose concentration in a blood sample taken after 8 hours of fasting (Diabetes UK 2019, Diabetes UK 2019a). In either case, the results are expressed as a percentage based on DCCT (Diabetes control and clinical trial) unit or as a value in mmol/mol IFCC unit (International federation of clinical chemistry) however, mmol/mol is the current default unit in the UK. There are several methods of blood glucose testing that is available in clinical practice such as oral glucose tolerance test, finger prick test and glycosylated haemoglobin test (ADA 2021, Diabetes UK 2021, National Institute of Diabetes and Digestive and Kidney Diseases 2021).

### **Blood glucose monitoring (Finger prick test)**

Blood glucose monitoring refers to measuring the level of glucose in the blood to show how the body is controlling glucose metabolism (Diabetes UK 2021a). In comparison to urine test, the use of glucose meters to measure blood glucose level is more accurate and indicates both low and high level (LeMone and Burke 2008, Lawal 2021). Evidence shows that the use of glucose meters is the most common and accurate method of testing blood glucose levels used by patients and often done at the patient's bedside. It offers a simple and reliable method to monitor a patient's glycaemic control and this technique also allows competent people to measure their blood glucose at home. Blood glucose level measurement involves pricking the finger with a lancet or special needle to obtain a drop of capillary blood. The blood is placed on a reagent strip, and the glucose concentration is determined visually by using a glucose meter (LeMone and Burke 2008, Lawal 2021).

There are various blood glucose monitoring devices, some of which have computer software packages that offer the benefit of monitoring the trends in blood glucose levels. Being able to see the trend is empowering and patients feel in control as they can see glucose reading over a period of time and able to link the relationship between their glucose level and lifestyle changes made. It is important to use the correct equipment and obtain accurate readings and staff should receive appropriate training because blood glucose testing must conform to safety standards (NICE 2021, LeMone and Burke 2008).

### **Oral and intravenous glucose tolerance test:**

In this test, blood glucose concentration is measured after 8 hours of fasting followed by either ingestion of 75 g anhydrous glucose dissolved in water or an infusion of 50% glucose. A blood sample is taken at intervals of 30 minutes, 1 hour, 2 hours and 3 hours following ingestion of the glucose

solution (LeMone and Burke 2008). This test is used to diagnose diabetes when plasma glucose is above or equal to 200mg/dl (11.1 mmol/L) when repeated after 2 hours of ingesting the glucose (American Diabetes Association 2021). Although, this is not recommended as a routine investigation, NICE (2020a) recommended oral glucose tolerance test (OGTT) to test for gestational diabetes in women with risk factors, for women who have had gestational diabetes in a previous pregnancy, or for early self-monitoring of blood glucose.

### **Glycosylated haemoglobin test:**

Glycosylated haemoglobin (HbA1c) test is an important indicator of long-term glycaemic control of patient. This test measures the amount of glucose bound to haemoglobin, and therefore used to assess the cumulative glycaemic history of patients for the predicted half-life of red blood cells (LeMone and Burke 2008, Waugh and Grant, 2018). Thus, it gives an indication of the blood glucose level for an average of 8–12 weeks, which is the approximate life span of red blood cells. Normal glycosylated haemoglobin (HbA1c) is 48 mmol/mol (6.5%), and diabetes is usually diagnosed beyond the limit of this healthy target (American Diabetes Association (ADA) 2021). A glycosylated test is an effective laboratory test; however, it is a more expensive test in comparison to a urine or blood glucose monitoring test using finger prick test. All the same, it is convenient with no fasting required, hence, it can be done at any time of the day.

### **Flash glucose monitoring**

This new technology presents a way of monitoring blood glucose levels without pricking the fingers and it is associated with positive patient outcomes (Castellana et al 2020, Heald et al 2019). Freestyle Libre which is a process of wearing a small sensor (flash) under the skin to record blood glucose levels continuously during the day and night is used in the United Kingdom. This technique measures the amount of glucose in the interstitial fluid (fluid surrounding the body cells) and therefore, the result may not be exactly the same as the capillary blood glucose (finger prick sample) technique result (Diabetes UK 2021a, Castellana et al 2020). The benefits of a flash glucose monitoring include people with phobia, dexterity problem, type 1 diabetes who need to have multiple tests per day, and people with mental health problem, however, it may not be suitable for people who are allergic to the adhesive, or paranoid about over testing their blood glucose levels. Although, there is increased use of interstitial glucose monitoring using flash glucose monitor (Freestyle Libre), the National Health Service funding criteria for flash prescription are being type 1 diabetes, gestational women, children, people with learning disability who have diabetes, those that are prone to severe hypoglycaemia or people with reduced hypoglycaemia awareness (Diabetes UK 2021).

### **Self-monitoring of blood glucose level**

Diabetes is a self-managed medical condition; therefore, this technique is fundamental to diabetes self-management. The use of glucose meters has helped to increase patient involvement in their glycaemic control. There is evidence to support the benefits of self-monitoring of blood glucose (SMBG) in maintaining tight glucose control in people with type 1 and type 2 diabetes who are on insulin therapy or are unwell or prone to hypoglycaemia or hyperglycaemia for any reason (e.g., vigorous exercise or diet). Although individual capabilities and motivation is required, it is helpful in adjusting medication, physical activity, or food intake in response to test results. Although, SMBG is seen as a beneficial aspect of the day-to-day management of diabetes, self-monitoring of blood glucose (SMBG) is still a debatable issue in diabetes care, particularly, in patients with type 2 diabetes.

## **National diabetic screening**

The aim of screening is to aid early identification of susceptible individuals, provide appropriate diagnostic examination and institute early treatment. There are arguments for and against screening for diabetes. The rising incidence of diabetes and high prevalence of undiagnosed diabetes, and the fact that early detection may reduce the impact of the disease, strengthen the argument for screening. However, case finding must be cost-effective and without any disadvantage to other people. There is also the issue of how often to screen people and highly predictive tests, tend to be expensive compared with urinalysis, and involve venepuncture, which is invasive, although they pose little risk when performed by a competent practitioner.

Like any other nation, economics and politics play a vital role in the delivery of healthcare in the UK. No doubt, the growth in the number of items and cost for blood glucose monitoring agents and devices represents a large component of costs associated with blood glucose control in the UK. Although, considering the use of the least invasive interventions is important to reduce anxiety and pain, however, it must be cost-effective. Consequently, access to continuous blood glucose monitoring systems, flash glucose monitoring and self-blood glucose monitoring differ between various commissioning clusters. In all, balancing the economic cost of blood glucose monitoring with clinical need is essential to provide evidence-based practice.

## **Conclusion**

The rising prevalence of diabetes and the health implications for those affected poses a serious health challenge; therefore, awareness and prevention are crucial to achieve a positive health outcome. The goal of diabetes management is to maintain the patient's blood glucose levels within the normal range of 4–7 mmol/litre, and there are various ways to measure blood glucose levels, including urinalysis and glycosylated haemoglobin. Although diabetes services are improving globally; there is a need for further improvement, particularly in promoting effective and reliable blood glucose monitoring. Blood glucose monitoring is essential in achieving normoglycaemia in patients with diabetes and therefore helps to reduce diabetes related complications. While blood glucose monitoring is crucial in diabetes management, the resource implications of blood glucose monitoring in diabetes for clinical commissioning groups and service providers are huge. Thus, type and frequency of monitoring should be based on individual need to minimize the impact of diabetes and ensure evidence-based care to achieve a good clinical outcome.

## **Key Points**

- ▶ Diabetes is an international public health problem and early diagnosis is essential.
- ▶ Glucose is monitored in clinical practice by using urine or blood samples and this can either be done randomly or while fasting.
- ▶ Blood glucose results are used as part of data for prescription, general management of diabetes and prevention of complications.
- ▶ Blood glucose monitoring has resource implications for NHS commissioners and service providers
- ▶ Health professionals/nurses play a pivotal role in measuring and interpreting blood glucose levels and in ensuring safety.

**2258 words**

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#### Box 1: Indications

- For initial diagnosis of diabetes.
- Monitor patients receiving insulin or hypoglycaemic drugs to adjust the treatment.
- To regularly assess patients with metabolic disorders e.g., hyperinsulinemia.
- To detect abnormal levels -hypoglycaemia, hyperglycaemia, and ketoacidosis.
- Assess suitability of diabetic patients for surgery and to monitor blood glucose level postoperatively.
- In pregnancy, it helps to diagnose gestational diabetes.
- Identify and monitor changes in blood sugar level of a known diabetic patient particularly during illness.
- Routine medical check.

#### Box 2: Factors affecting blood glucose level readings

- Timing of meals
- Fasting, e.g., Muslim during Ramadan period
- Drugs, e.g., corticosteroids
- Underlying disease
- Hyperlipaemia
- Vigorous exercise
- Quality of the meter and test strips
- Use of correct supplies and sample volume
- Clients with high or low haematocrit values e.g., anaemia and sickle cell disease
- Practitioners appropriate training

(LeMone and Burke 2008, Waugh and Grant 2018)

Box 3: Techniques for testing blood glucose levels

- Urinalysis
- Random blood glucose test
- Fasting blood glucose test
- Oral and intravenous glucose tolerance test
- Blood glucose level measurement (Test strip)
- Glycosylated haemoglobin test