

Use of Blood Glucose Meters

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The reliable and accurate use of blood glucose meters within the health care setting and in diabetes self-management is essential to obtaining blood glucose levels to support good diabetes management.

Target Audience

This document is targeted at healthcare professionals whose role includes the use of blood glucose meters and/or the education of others in blood glucose monitoring.

Purpose

The purpose of this document is to:

- Identify where and when it is appropriate to use blood glucose meters.
- Outline appropriate education requirements for the use of blood glucose meters.
- Establish guidance in relation to quality control in the use of blood glucose meters.
- Outline additional methods available to measure glycaemia.

Background

Emerging trends in medical technology have made available blood glucose meters that can provide timely and rapid results in a wide variety of health care settings. The use of these meters assists health care professionals and individuals to make timely therapeutic decisions.¹ Monitoring blood glucose levels using meter technology has become an essential component of the modern management of people with diabetes mellitus.

Self-monitoring of blood glucose (SMBG) levels using blood glucose meters enables the person with diabetes to monitor their own blood glucose levels, and to direct subsequent therapy. Questions have been raised as to the reliability of earlier blood glucose meters, but these issues have largely been resolved by the development of more sophisticated technology.

Large clinical studies such as the Diabetes Control and Complications Trial² and the United Kingdom Prospective Diabetes Study^{3,4} have provided clear evidence of the beneficial effect of intensive therapy in people with diabetes and have emphasised self-blood glucose monitoring (SBGM) as an important component of intensive therapy, particularly for people requiring or dependent on insulin and those taking oral diabetes agents that have a hypoglycaemia risk. However, debate continues as to the utility of SMBG in people who do not use insulin therapy.

Appropriate use of blood glucose meters

Monitoring blood glucose in people with diabetes in the clinical setting.

Modern management of people with diabetes in hospitals and community health services includes the use of capillary blood glucose meters. Results obtained from these meters can facilitate timely therapeutic decision making, which can improve diabetes management and conceivably shorten hospital stays or prevent hospitalisation in some cases. Clinically, blood glucose monitoring may occur in a variety of settings including the hospital inpatient or outpatient services, private medical and diabetes education practices, aged and disability residential care, emergency care, at a community care setting, school, workplace, sporting field, and correctional services or in the person's home. It may assist in the management of all types of diabetes, including in women with gestational diabetes.

Self-monitoring blood glucose in people with diabetes

Unequivocally, tight or optimal glycaemic control helps to reduce the development and progression of diabetes related complications.^{5,6,7} For many people this requires intensive treatment using insulin therapy and active self-management.

The availability of low cost blood glucose meters improves the ability of people with diabetes to intensively monitor their BGL and allows the person to become actively involved in the management of their condition. SMBG may contribute in several ways. It can reinforce beneficial health behaviours and increase adherence with medication. The immediate feedback provided by self-monitoring also helps to establish short term blood glucose patterns and, with appropriate education, assists people with diabetes to make day to day decisions regarding their therapy, such as appropriate adjustment to glucose lowering medication and management of hypoglycaemia and sick days.

Appropriateness of SMBG should be assessed on an individual basis, taking into consideration the person's disease and co-morbidity status, age, culture, dexterity, health literacy level/ability and physical and intellectual capabilities, identified glycaemic targets, current medication regimen, potential confounders that may interfere with the accuracy of results obtained and level of motivation. However, as mentioned previously, there is still debate as to the utility of self-monitoring in people with type 2 diabetes who do not use insulin therapy.^{8,9,10,11} Therefore the decision to undertake SMBG should be determined by the individual in consultation with their health care professional.

Alternate Site Testing

Recent innovations in meter technology allows the measurement of glucose values using small samples of blood, which can be derived from the forearm and sites other than the capillary bed of the fingertip. For some people this has been an alternate strategy to the pain or discomfort experienced when using fingertips to measure blood glucose levels.^{12, 13} However, studies have identified clinically significant variations in blood glucose levels between samples obtained from the fingertips and those from the forearm. Less variation has been found with samples taken from the base of the thumb. These variations appear more apparent with rapid rises and falls in blood glucose levels.^{14,15} Therefore, alternative sites to the fingertips should not be used when blood glucose levels are likely to be fluctuating, for example, post meal or to confirm hypoglycaemia.

Health care professionals must be aware that if patients are using alternate sites, this should be taken into consideration when making management decisions. People with diabetes are encouraged to use sites that are less likely to be subject to variations.

Monitoring blood glucose in people without a confirmed diagnosis of diabetes

Within the acute clinical setting there are medical conditions other than diabetes mellitus where measuring blood glucose levels by health professionals may be warranted, such as intensive care units and special care nurseries. During hospitalisation it may also be appropriate to measure blood glucose levels in people previously diagnosed with impaired fasting glucose (IFG) or impaired glucose tolerance (IGT) to determine any effect of an acute illness on their blood glucose status. Commencement of corticosteroid¹⁶ therapy or total parenteral nutrition¹⁷ will warrant blood glucose surveillance¹⁸.

Inappropriate use of blood glucose meters

Initial screening in asymptomatic individuals should include using the Australian type 2 diabetes risk assessment tool (AUSDRISK).

Screening for type 2 diabetes in asymptomatic individuals

The Australian Diabetes, Obesity and Lifestyle study, AusDiab,¹⁹ showed that type 2 diabetes affects 7.4% of the Australian population in people aged 25 years or older, half of whom are undiagnosed. Unrecognised hyperglycaemia will place individuals at risk of developing long term complications of diabetes before their disease is diagnosed. Screening for type 2 diabetes in asymptomatic individuals has therefore been proposed as one strategy to reduce the diabetes burden.²⁰ However, to date, there have been no published randomised controlled trials on the effects of early

intervention in people with screen-detected diabetes. The current Australian guidelines therefore recommend screening for diabetes only in people deemed to be at high risk of developing the condition.²¹

Capillary blood glucose testing such as at a community event is not recommended unless a medical practitioner or CDE is onsite during the testing.

International standard ISO 22870, *Point-of-care testing (POCT) - Requirements for quality and competence*, defines POCT as: “testing that is performed near or at the site of a patient with the result leading to possible change in the care of the patient.”²² POC tests performed may be dependent upon the capacity and availability of equipment in the individual health care facility.

Currently, fasting plasma glucose, followed by an oral glucose tolerance test in people with an equivocal result, is deemed the preferred screening test for type 2 diabetes. Point of Care (POC) capillary blood glucose testing is not generally recommended for diabetes screening. However, it has been shown to be useful in certain situations, for example, remote areas of Australia where laboratory resources are absent or severely limited in terms of obtaining results in a timely manner to assist with clinical intervention.²³ If an elevated glucose level is found with POC screening, ideally a referral should be made for formal glucose monitoring to confirm a diagnosis of diabetes.

Screening for diabetes in people with impaired fasting glucose (IFG) or impaired glucose tolerance (IGT)

Testing of POC capillary blood glucose is not recommended for screening people for diabetes in those with known IFG or IGT; rather the National Health and Medical Research Council (2001),²⁴ the Australian Diabetes Society and the Australian Diabetes Educators Association (2007)²⁵ and the World Health Organization²⁶ recommend that people with these conditions undergo an annual formal fasting 75gram Oral Glucose Tolerance Test to screen for, and diagnose diabetes.

Self-monitoring of blood glucose in people with IFG or IGT

It is not recommended that people diagnosed with IFG or IGT use blood glucose meters to monitor their blood glucose levels at home, nor are subsidies provided by the National Diabetes Services Scheme to these individuals.²⁷

Appropriate education regarding the use of blood glucose meters

Appropriate education in the use of blood glucose meters and SMBG is essential for the individual with diabetes or their carer, those providing education on SMBG and those performing glucose monitoring in the clinical setting.

In individuals with diabetes:

Individuals using blood glucose meters require access to a health professional deemed competent in the use of the meter. Where meters are sold in pharmacies and other retail environments, it is essential for a health professional staff member who is competent in the use of blood glucose meters and the interpretation of blood glucose results to provide education to the person purchasing the meter.

Maintenance of expertise and certification of ongoing competence are also recommended. Health professionals and pharmacy staff involved in teaching SMBG should receive demonstration and instruction for each brand or type of meter and strip sold, and be certified directly for each meter, either by a company representative or a designated diabetes resource person (for example, a diabetes educator).

Where SMBG is recommended, care is required to ensure an accurate technique, and that self-management behaviours are underpinned by a sound knowledge of how dietary intake, activity, medication, stress and illness interact to affect blood glucose levels. The ability to recognise and interpret clinical signs and symptoms and to know when to access expert advice is also essential. For people with diabetes taking medication that can cause hypoglycaemia, SMBG is essential before driving, regularly during long drives, when operating potentially dangerous equipment or participating in potentially dangerous activities (e.g. alcohol consumption) as well as before, during and after extensive periods of exercise (ADEA SMBG Position Statement, 2011).

Education required:

- Appropriate choice of meter (see page 12)
- Use of an individual meter
- Correct skin preparation of the testing site
- Calibration and checking procedures
- Quality control procedures according to the manufacturer's instructions
- Problem solving of meter action and function
- The recording and interpretation of results

- Specific frequency and times to monitor blood glucose levels, including the reasons for those times, and the circumstances that indicate additional monitoring is required
- Individual target ranges for capillary blood glucose levels to enable the interpretation of results
- What to do and who to notify if blood glucose levels are outside of the target range
- Correct use and safe disposal of used lancets²⁸
- Where and how to purchase blood glucose supplies using the National Diabetes Services Scheme (NDSS). It must also be noted that some blood glucose meters and strips on the NDSS are only available to those with type 1 diabetes
- Additional meter features such as averages and electronic download capabilities
- Information on the completion of the warranty process
- Programming of insulin bolus calculators (in conjunction with a diabetes health care professional)
- Pairing meters/devices to insulin pumps. When and how to contact customer service.

In the clinical setting:

Monitoring of capillary blood glucose levels using blood glucose meters should be limited to experienced and certified staff. Staff using these meters require instruction from a company representative or diabetes educator and need to be able to demonstrate the skilful use of the available blood glucose meter and strip prior to certification. Blood glucose monitoring certification programs will ideally include an audit of the person's technique using the meter, accurate testing with internal quality control solutions and a short answer test on the use of the meter and interpretation of the blood glucose testing results.

Regular re-certification of ongoing competence is recommended and a formal list of accredited staff should be displayed by the employing institution. Accredited personnel will maintain their skill and reliability in the performance of blood glucose monitoring only if this is done with reasonable frequency. Protocols are also required to be readily available, outlining the appropriate action if blood glucose or quality control results are in doubt.

Insulin bolus calculator blood glucose meters

Insulin bolus calculator blood glucose meters, also referred to as 'smart meters', assist those treated with multiple daily injections (MDI) in determining an appropriate rapid-acting insulin dose based on their current blood glucose level (BGL), exercise and planned carbohydrate intake. A variety of clinical information and parameters must be manually entered into the meter. Much of this information is determined together by the multi-disciplinary team and client including:

- Insulin to carbohydrate ratio (ICR)
- Insulin sensitivity factor (ISF), also referred to as a correction factor
- Agreed range of blood glucose targets
- Agreed postprandial rise of blood glucose levels
- Insulin action time.

The ICR, ISF and target BGLs may vary for different time periods across the day.

Several key requirements must be completed prior to any person with type 1 or type 2 diabetes being provided with insulin bolus calculator features. These include:

- A signed medication order by a medical officer or endorsed nurse practitioner that clearly documents the client's insulin to carbohydrate ratio and insulin sensitivity
- Completion of detailed carbohydrate counting education with a dietitian
- Demonstration of an understanding of how the insulin bolus calculator meter calculates recommended doses.

Quality Control

Individuals with diabetes and health professionals need to be confident in the accuracy of test results, irrespective of the setting in which they are performed. Quality control management practices are therefore required to ensure that both the equipment and operators meet high standards of performance and process. Quality control measures should reflect the manufacturer's recommendations as well as local institutional processes and procedures.

Use of a blood glucose meter by health care professionals to monitor an individual's blood glucose level implies legal accountability for the results, as changes in medication and dietary therapy are made based on the blood glucose results obtained. Health care facilities using blood glucose meters therefore require an established quality control program to ensure the accuracy and precision of the blood glucose meters. Internal quality control using control solutions with a known value or simultaneous determinations of venous blood glucose level by the laboratory will assist in checking the integrity of strips and monitor reagents,

operator performance, and device reliability. It is recommended the results be documented and regularly checked, and corrective action taken when necessary. Some companies have external quality control mechanisms, using control solutions with an unknown result, enabling an additional layer of review.

Quality control is best achieved daily in acute care settings. Extra quality control tests need to be performed when a result is significantly abnormal to the one anticipated, after a battery change, when a new packet of strips is to be used, or if there has been the potential for damage to the meter. The general consensus in Australia is that weekly quality control testing regimens are maintained within sub-acute and community/primary care services.

Choice of blood glucose meters

Choice of meter for healthcare services and providers

In-patients with diabetes should have access to blood glucose monitoring. Currently available POC meters have improved accuracy and are able to correct for variation in haematocrit and for other interfering substances. In 2013 the International Organization for Standardization advised blood glucose meter manufacturers that compliance for meter accuracy had tightened from $\pm 20\%$ to $\pm 15\%$.

With advances in technology, blood glucose meters pose few problems if personnel are trained with a specific meter and strip. When more than one meter is used, the responsibility of the operator becomes more complex. It is therefore advisable to designate one type of meter and strip for routine testing throughout a hospital, health care facility or service. The decision process in meter choice should include input from a diabetes educator and laboratory and clinical staff.

Choice of meter for the individual with diabetes

The choice of a blood glucose meter for the person with diabetes will depend on a variety of factors including ease of use, size and portability, type of strip (e.g. canister, individual foil-wrapped strip or strip-free), amount of blood required, suitability for alternate site testing and other additional features such as memory and download capability, alarms and back lights. Individuals with sight or dexterity problems will need a meter that accommodates these issues. Many people with type 1 diabetes use more than one blood glucose meter, and may require a meter to measure blood ketone levels, a smart meter that assists in insulin bolus calculations or a meter that relays blood glucose levels to their insulin pump.

Strip technology

Certain strip technology may be more appropriate than others in certain clinical situations, for example care of patients on peritoneal dialysis using icodextrin (Extraneal®) or intravenous immunoglobulin preparations such as Intragam®.

Diabetes mellitus is now the most common cause of end stage kidney disease in adults.²⁹ Continuous ambulatory peritoneal dialysis is one treatment option for renal replacement therapy. The type of dialysate solution used will depend on various clinical parameters.

Extreme care should be taken when icodextrin (Extraneal®) is used as this solution has been identified as causing falsely elevated blood glucose levels in capillary blood glucose testing in tests strips that use either glucose dehydrogenase pyrroloquinolnequinone or glucose-dye-oxidoreductase-based methods^{30,31}. Intravenous immunoglobulin preparations containing maltose such as Intragam®, CMV Immunoglobulin and Tetanus immunoglobulin (for intravenous use) can also interfere with the readings performed using test strips with glucose dehydrogenase.³²

Blood glucose meters using this technology in these particular clinical situations can result in inaccurate blood glucose determinations. It is therefore essential to consult the product information and/or the manufacturer of the glucose meter and test strip to ensure that icodextrin and maltose do not interfere with the reliability of blood glucose readings.

Hospital blood glucose test strips should not be used in a person with diabetes' meters as some hospital glucometers require calibration while an individual's glucometers do not.

Other methods of measuring glycaemia

Blood glucose levels obtained from a blood glucose meter should not be used as the only evaluation of glycaemic control in people with diabetes.

Glycated haemoglobin testing (HbA1c)

Glycohaemoglobin is formed by a non-enzymatic interaction between glucose and haemoglobin. Formation of glycohaemoglobin, often referred to as glycated haemoglobin or HbA1c, is irreversible and the level in the red blood cell depends on the blood glucose concentration over the life of the cell. The HbA1c is accepted as an important index in diabetes management, reflecting the degree of metabolic glycaemic control over the preceding six to eight weeks,³³ and was the major outcome determinant of the Diabetes Control and Complications Trial. Based on the findings of this trial and others, targets for glycaemic control have been established, which, if met, should minimise the development of diabetes related complications. It is therefore recommended all people with diabetes have an HbA1c estimation at least annually³⁴ in Type 2 diabetes and 3 monthly in people with Type 1 diabetes.^{35,36}

Continuous Glucose Monitoring

Continuous glucose monitoring (CGM) determines blood glucose levels on a continuous basis (every few minutes) and can be a useful adjunct to SMBG in persons with diabetes.

There are two forms of CGM – Real time and retrospective CGM. Real time CGM displays blood glucose levels on a continuous basis. Retrospective devices record blood glucose levels continuously but access to this information is stored until retrieved and can be viewed once the data has been uploaded from the transmitter. Individual use of CGM is an increasing option for people with diabetes with the advancement of smaller, cheaper technology.

Practice Points:

In the clinical setting:

- Blood glucose meters are not generally to be used as a method of screening for diabetes
- Testing at the point of care (POC) for the purposes of screening for diabetes may be appropriate in defined circumstances, such as in remote indigenous communities where laboratory testing is unavailable and postponement of treatment would be potentially harmful for the individual. The meter used at the point of care must have a rigorous quality assurance program in place and confirmation using laboratory testing is required.
- All health services using blood glucose meters develop a well-defined policy and procedure that includes a training program for personnel performing the tests, quality control procedures, regular equipment maintenance, external auditing of meters, and appropriate lancet devices that meet infection prevention and surveillance considerations using standard precautions.
- Patients with diabetes should have access to Point of Care or POC blood glucose monitoring. Currently available POC meters have improved in accuracy and are now more able to correct for variation in haematocrit and for other interfering substances.

In the individual with diabetes:

- Outside the acute clinical setting, blood glucose meters should only be used to monitor blood glucose levels in people with a confirmed diagnosis of diabetes.
- The decision to undertake self-monitoring of blood glucose or SMBG should be assessed on an individual basis, taking into consideration the person's disease and co-morbidity status, age, culture, dexterity and physical and

intellectual capabilities, identified glycaemic targets, current medication regimen, potential confounders that may interfere with the accuracy of results obtained, personal preference and level of motivation.

- All people with diabetes using insulin and sulfonylurea therapy are taught to perform SMBG.
- Individuals performing SMBG should have an understanding of normal or target blood glucose levels, when to report abnormal levels and who they should report to.
- Individuals using blood glucose meters have access to a health professional deemed competent in the use of the meter.
- Diabetes education is essential to ensure self-management behaviours are underpinned by a sound knowledge of how dietary intake, physical activity, medication, physical stress (pain, illness or infection), mental stress all interact to affect blood glucose levels.

In both situations:

- Blood taken from the side of the finger, but avoiding close proximity to the nail bed is the preferred sample, particularly when blood glucose levels are changing rapidly. Some blood glucose meters allow the measurement of glucose levels from small samples of blood from the forearm and other sites.
- Equipment should be used according to the manufacturer's instructions.
- Blood glucose measurement using portable blood glucose meters should not be used in isolation when evaluating the glycaemic control of people with diabetes, but should be used in conjunction with monitoring HbA1c levels (see page 12).
- In certain clinical situations different strip technology may be more appropriate than others, such as in the care of patients using icodextrin dialysate solution e.g. used in peritoneal dialysis, or patients receiving intravenous preparations containing maltose. In these situations it is essential to consult a diabetes health professional and product information and/or the manufacturer of the glucose meter and test strip to ensure appropriate meter/s and test strips are used when icodextrin and maltose containing solutions are in use.
- Blood glucose meters that provide the additional feature of insulin bolus calculators require several additional criteria in terms of training and documentation to be met by health professionals. This includes:
 - that health professionals are thoroughly trained and competent in their use
 - these meters are provided to people with diabetes who have been provided with education by a health care professional competent to

teach carbohydrate counting techniques and the required self-management skills.

Conclusion

Blood glucose monitoring using meters is an important component of current management of diabetes. Used appropriately, including the correct choice of meter, comprehensive education and training and adequate quality control, blood glucose monitoring can assist in timely therapeutic decision making, day to day management of the individual with diabetes, improved glycaemic control and improved quality of life.

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