

# SECTION 5

## Monitoring diabetes control

The purpose of monitoring diabetes is to evaluate progress and to adjust therapy. Monitoring diabetes includes aspects of diet, activity, clinical signs and symptoms as well as blood glucose and ketones.

Controlling diabetes is important for:

- health and a sense of well being for the individual
- normal growth and development in children and adults
- normal outcomes of pregnancy
- lowering the incidence of illness and hospitalisation
- prevention of long term complications.

Although glucose can be measured in both blood and urine, blood glucose measurement is preferable for the following reasons:

- blood glucose measurement gives more accurate information about the present state of the blood glucose
- urine glucose is variable due to changes in renal threshold, therefore blood glucose levels are usually not less than 10mmol/L before they register in the urine
- urine glucose monitoring cannot detect hypoglycaemia.

**All methods are potentially inaccurate and the reliability of any test also depends upon the quality of the equipment, basic quality assurance (QA) systems and the skill and experience of the person performing the test. Only staff trained and competent in the use of blood glucose meters for blood glucose monitoring should perform the tests.**

People with diabetes should be encouraged to perform their own blood glucose monitoring if they have access to a meter they can use at home. A health professional trained and accredited in meter operation should assess the person's technique before they perform their own tests in hospital. However, due to the increasing numbers of meters and various techniques, hospital staff may not be familiar with the person's particular meter. Meter company representatives can provide information to assist.

### Remember

Many factors may affect the accuracy of test results. Strategies for reliable blood glucose measurements include:

- obtaining the appropriate sized drop of blood as recommended by the meter company
- precise timing according to manufacturer's instructions where relevant
- routine maintenance of equipment and performance of quality control
- correct storage and avoidance of extremes in temperature.

# Blood glucose monitoring for inpatients

## Indications

Measuring blood glucose during hospitalisation is appropriate for all patients who have diabetes. Results will guide management decisions and should inform patient education.

Blood glucose measurements with hospital meters can only be performed by staff with current accreditation. Information is available from your diabetes educator or meter company representative about quality assurance programs.

## Universal precautions

Follow universal precautions for all blood glucose monitoring. Remember when handling body fluids, treat all fluids as potentially infective. Ensure that blood testing technique does not increase the risk of infection from blood products.

The following guidelines in addition to universal precautions are recommended:

1. Wear disposable gloves when performing or teaching blood glucose monitoring.
2. If possible, do not squeeze the patient's finger to produce an adequate drop of blood. Allow the patient to do this.
3. Dispose of all materials that have been contaminated with blood **immediately**.
4. Dispose of all sharps into sharps container.
5. When teaching, ensure personal lancing device is always left unloaded (dispose of used lancet immediately after use).
6. Professional use lancing devices must be disposable, single use and have retractable lancet.
7. Wash your hands before and after procedure.
8. Ensure work area and surfaces are cleaned and all traces of blood removed.

Soap and water is recommended as a safe and effective cleansing agent. Allow to dry.<sup>1</sup>

## Blood glucose meters

There are increasing numbers of blood glucose meters now available. Each manufacturer provides instruction leaflets and quality control recommendations specific to the meter. The manufacturer's recommendations must be followed for reliability of results.

Hospital blood glucose monitoring must be accurate and reliable to guide management decisions. A hospital accreditation program is essential to ensure accuracy and to maintain ongoing review of blood glucose monitoring techniques / results performed by staff.

## Quality assurance

When using a blood glucose meter to test a person's blood glucose, health professionals are accountable for the results obtained.

To ensure that each operator is competent in using a blood glucose meter, we need a method of checking that the equipment and operator performance meet pre-set standards. This is achieved through the implementation of a quality assurance program.

Involvement in a quality assurance program is an important part of any blood glucose monitoring system. The following terms are frequently used when defining quality assurance and blood glucose monitoring.

**Accuracy:** agreement between result obtained for the sample and its true value.

**Precision:** agreement between repeated tests on the same sample.

**Acceptability:** when a test result lies within acceptable intervals (usually + or - 10% of true value).

Quality assurance aims to improve management of the person with diabetes by providing a confident basis to support blood glucose results. This is essential for accurate adjustment of a patient's diet and medication.

### Recommended hospital standards of practice

Blood glucose meters can only be used by staff members who have successfully completed an annual meter education and accreditation program.

Staff cannot operate blood glucose meters if accreditation status has lapsed.

Ideally an internal quality control test should be performed:<sup>2</sup>

- Every 24 hours
- Each time a new bottle of strips is opened
- If the meter is dropped
- When the batteries are changed
- If the BGL is questionable.

Quality control solutions are available for each type of meter and they contain a set amount of glucose. The test result must be within the range specified for the meter and strips being used. The test should be documented and records of quality control records should be kept for 7 years.<sup>3</sup>

## **Components of an accreditation program**

### **Teaching method**

The clinical teaching method of explanation and demonstration, complemented by audio-visual aids, shall be applied in teaching the following:

1. The functional range of the instrument.
2. Detailed functions.
4. Practical procedures of reagent strip, control checks, blood glucose measurement and cleaning the instrument.
5. The application of results in self care.

### **Learner participation**

Under supervision all participants will have the opportunity to practise reagent strip control checks, blood glucose measurement and cleaning the instrument.

### **Evaluation method**

1. Theoretical knowledge will be evaluated by means of a staff questionnaire.
2. Staff will be evaluated in the practical procedure of blood glucose measurement.

### **Accreditation**

Staff should be accredited after successful completion of the program and evaluation procedures.

### **Program evaluation**

Staff should also evaluate the effectiveness of the program.

### **Annual re-accreditation**

Re-accreditation of technique should occur annually. An audit process can be used for review of procedure and technique (Appendix 1).

### **How can operators become accredited**

Consult with your regional diabetes educator. In most cases this person is accredited to conduct accreditation activities. Otherwise, hospital staff can be accredited directly by meter company representatives. An example of an accreditation tool can be seen in Appendix 2.

## When to test?

Fasting values reflect overnight blood glucose control and is affected by how sensitive the liver and body cells are to insulin (insulin resistance). Pre lunch and pre evening meal blood glucose are affected by factors such as diet, activity and medication. Fasting and pre-meal testing is recommended as first line monitoring as other (eg post-prandial) readings will automatically be elevated if fasting and pre-meal readings are high.

Values at two hours post-prandial would reflect peak glycaemia which is affected by factors such as the food eaten, gastric emptying, insulin resistance, medications and illness.

Indications for extra blood glucose monitoring outside of pre-prandial (particularly before breakfast and evening meal):

- Type 1 diabetes.
- A1c being lower or higher than expected from the existing blood glucose profile (because of possible hidden hypo or hyperglycaemia).
- Unstable blood glucose, particularly those tending to hypoglycaemia before the next meal.
- Hypoglycaemia, particularly in those with hypoglycaemic unawareness.

The appropriate times to test will vary with each individual and will often be the result of a joint decision of the individual and their general practitioner / medical officer / diabetes educator.

## Glucose levels – understanding the numbers

Blood samples are taken under defined conditions and at set times.

### Times

Fasting	-	usually taken after an overnight fast of about 8-12 hours
Random	-	taken at any time during the day
Pre-prandial	-	taken directly before meals usually written as 'before meals'
Post-prandial	-	usually taken approximately two hours after a meal.

### Samples

Whole Blood	-	has 10-15% lower glucose values than plasma because the sample contains blood cells which have low glucose levels
	-	capillary whole blood samples are taken for ward or self blood glucose monitoring tests.
Plasma	-	is obtained by centrifugation of anticoagulated whole blood and has a 10-15% higher glucose value than whole blood because there are no cells
	-	venous plasma is usually tested in laboratories.

### Summary

- Fasting and pre-prandial  $\leq$  random or post prandial.
- Whole blood  $<$  plasma.
- Venous plasma  $\leq$  capillary plasma.

## Monitoring glucose and ketones when in hospital

Aim for target blood glucose levels (BGL) 5.0 - 10.0mmol/L.<sup>4</sup> Blood glucose levels as close to normal as possible improves in-hospital morbidity and mortality rates. Refer to *Hospitalisation* – Section 4 for information about monitoring blood glucose and ketones in a hospital setting.

## Self blood glucose monitoring at home

Self monitoring of blood glucose for people with non-insulin treated diabetes may lead to improved glycaemic control and it is commonly recommended. However the evidence to support this theory remains inconclusive.<sup>5-8</sup> An AADE systematic review and a Cochrane review have both concluded that self blood glucose monitoring for people who are not using insulin may be effective in improving glycaemic control but further research is needed.<sup>6,7</sup> It is important that health care professionals have an individualised and targeted approach to SBGM.

Strategies that can be used to enhance the effectiveness of SMBG include the following.<sup>8</sup>(p1012)

- Stress the importance of SBGM as data needed by the person for decision making, not as something done primarily for the benefit of the provider.
- Emphasise that the results are not a judgment of the persons' self-management efforts but simply a number they can use to make informed decisions.
- Assist the person to identify blood glucose targets and actions to take to achieve those targets.
- Identify strategies for overcoming barriers to monitoring.
- Assist the person in dealing with the impact of results.
- Help the person to identify strategies to obtain the support they need for SBGM from members of their families and health care team.
- Role-play responses to negative comments about the results from members of their family and health care team.

## Important principles

1. Self blood glucose monitoring in the usual work and home environment can be helpful assessing day to day glucose control.
2. Self blood glucose monitoring should be used in the management of all pregnant women with diabetes and all people on insulin therapy.
3. Self blood glucose monitoring is recommended for all people at risk of hypoglycaemia eg taking sulphonylureas or insulin.
4. People who are diet controlled or on metformin alone can be provided with the option of blood glucose monitoring. If they choose not to self monitor then it is important that they are informed of the need for 3 monthly HbA1c tests as this will be the only measure of control.
5. Quality control solutions are recommended for use by people who self monitor with a meter, to ensure reliable and accurate results. Support and resources must be provided to encourage the person to maintain monitoring standards. Alternatively people may be able to go to their local Diabetes Service Pharmacy or Diabetes Australia to have their meter quality control checked.
6. Participation by the person has potential to increase self-responsibility therefore self care.
7. It is important to ensure that the person has the correct technique when using their meter and that the meter is providing accurate results.

## When to test

The targets and frequency of testing will depend on what type of diabetes the person has, the type of treatment they are on (diet, tablets or insulin) and the intensity of their regimen. For example a person who is on a basal bolus regimen (4 injections a day) will need to test at least 3 - 4 times a day whereas a person who is only having a basal insulin regimen (1 to 2 injections) will be able to test less often. People need to be able to adjust the times and frequency based on their current situation.

<b>EXAMPLE: HOME BLOOD GLUCOSE TESTING</b>					
<b>DAY</b>	<b>FASTING</b>	<b>BEFORE LUNCH</b>	<b>BEFORE DINNER</b>	<b>BEFORE BED</b>	<b>2-3am</b>
Monday	X	X			
Tuesday	X		X		
Wednesday	X			X	
Thursday	X				
Friday	X	X			
Saturday	X		X		
Sunday	X			X	

## **Remember the following points when working with people who are monitoring at home**

- Monitoring is only meaningful if the person knows what the target is.
- Monitoring is only useful as a self management tool if people can interpret their results and work out what has caused high / low BGLs so they can take remedial action to bring BGLs back into target.
- The person needs to understand that how they feel is not an accurate estimate of BG levels and not good enough evidence on which to base self management decisions.
- Any self monitoring must be meaningful to the person doing it – that is they are doing it for a reason or to find out the effect of their diabetes management (food, activity, medication) and make management decisions.
- Unfortunately some health professionals, no matter how well intentioned, use 'blaming' language. High or low BG levels should be just another problem to solve.
- Reassure that out of target BG levels are manageable – even if it takes a while to figure out what to do.

## **Assessment of long term glycaemia**

### **Glycated haemoglobin**

Glucose attaches to blood protein. The blood protein that carries oxygen is called haemoglobin and has a life of about 120 days. Haemoglobin that normally has glucose attached to it is called glycated (glycos = glucose). The quantity of glycated haemoglobin is expressed as a percentage of the total haemoglobin.

A regular monitoring schedule for glycated proteins provides information which helps to assess overall control.

A Glycated Haemoglobin Test is a laboratory test used to check control of blood glucose levels by reflecting long term diabetes control. Since haemoglobin stays in the body for some time this measurement reflects all the 'highs' and 'lows' of blood glucose levels over the past 8-12 weeks. The higher the glycated haemoglobin, the higher the average blood glucose.<sup>9</sup>

The test can be done every 3-6 months to check overall control.

### **Glycated plasma protein (Fructosamine)**

Normal proteins, particularly albumin, are also modified by the continual exposure to blood glucose. The plasma levels of these products are therefore elevated in people with diabetes.

Since the lifetime of plasma proteins is approximately 2 weeks, measurement of glycated proteins reflects average plasma glucose levels over the preceding 2 weeks. Fructosamine is an indirect measure of glycosylated albumin. This type of assay allows assessment over the short term.

Glycated haemoglobin is the preferred measurement.

## Ketones

Testing for ketones is necessary in people with type 1 diabetes and should be performed if the person has an infection, is unwell, nauseous or blood glucose values exceed 15mmol/L. Tests should be performed before meals and at bedtime, with the number of tests decreasing as glucose control improves.<sup>10</sup>

Ketones can indicate impending acidosis. Ensure the medical officer is notified if ketones are detected in urine or blood.

For more information about the monitoring of ketones and its role in sick day management see *Unstable Diabetes* – Section 11 or [www.adea.com.au](http://www.adea.com.au).

**Note:** Ketone testing is only routinely performed if the person has type 1 diabetes.

## Microalbumin

Proteinuria is the hallmark of diabetic nephropathy. The appearance of proteinuria during the routine review of people with diabetes is common. The time of onset of proteinuria and the rate of increase is variable. However, once clinical proteinuria occurs (dip stick positive, >500mg/L) progressive renal damage is likely<sup>11</sup>. Initially intermittent low grade proteinuria occurs (microalbuminuria, 20-200µg/min). A laboratory microalbuminuria test is recommended to detect early changes in renal function. Evidence of microalbuminuria usually precedes the macro proteinuria that is detected with dipstick methods. Microalbuminuria can also be detected using Micral-Test®. This strip test can be used outside the central laboratory and is an immunological reagent carrier as opposed to a chemical dipstick. It uses a monoclonal antibody test to give a semi quantitative measurement in the range 0-100mg/L of albumin in urine.

People with diabetes may develop overt clinical manifestations of renal disease, generally termed nephropathy. Eventually a proportion of these people will either require dialysis or kidney transplantation. Microalbumin is also an indicator of blood vessel disease and therefore a marker for cardiovascular disease. Monitoring people with diabetes for microalbuminuria is therefore important if a protocol is to be implemented which can detect and possibly reverse ultimate renal damage or cardiovascular disease.

## Assessment

- Test for microalbuminuria. This can be done using a first morning voided spot urine or an overnight collection.
- Test urine with 'multistick' to ensure the absence of infection. Infections will reduce the reliability of the result. Retest once the condition has improved.
- If microalbuminuria present, perform up to two additional measurements in the next 6 weeks. Diagnosis of microalbuminuria is established if 2 of the 3 measurements are abnormal.

## Interpretation of results<sup>9</sup>

Category	Timed Urine Sample Albumin (ug/min)	First Morning Sample	
		Albumin: Creatinine Ratio Female	Male
Normal	<20	0-3.5	0-2.5
Microalbuminuria	20-200	3.6-35	2.6-25
Macroalbuminuria	>200	>35	>25

## **What to do**

### **If microalbuminuria only present:**

- review diabetes control and improve if necessary
- consider treatment with ACE inhibitor
- consider referral to a physician experienced in the care of diabetic renal disease
- the STENO 2 Study studied inpatients with type 2 diabetes. More active intervention and improved management of risk factors reduced the incidences of cardiovascular events and renal failure by approximately 50%.<sup>11</sup>

### **If macroalbuminuria:**

- quantitate albuminuria by measuring 24 hour urinary protein
- refer to a physician experienced in the care of diabetic renal disease.

### **If macroalbuminuria and hypertension are present:**

- hypertension should be treated actively and BP maintained at lower levels. (<130/80, <125/75 if proteinuria >1g/d exists) in order to slow the progression of nephropathy.

### Blood Glucose Meter Audit

Ward:

Date:

Name:

Does the operator	Yes	No
1. wash hands	<input type="checkbox"/>	<input type="checkbox"/>
2. ensure all equipment is available	<input type="checkbox"/>	<input type="checkbox"/>
3. confirm meter cleanliness and function (date and time)	<input type="checkbox"/>	<input type="checkbox"/>
4. confirm meter is correctly calibrated	<input type="checkbox"/>	<input type="checkbox"/>
5. ensure strips have not expired/deteriorated	<input type="checkbox"/>	<input type="checkbox"/>
6. perform control test	<input type="checkbox"/>	<input type="checkbox"/>
7. identify the person correctly	<input type="checkbox"/>	<input type="checkbox"/>
8. give clear and relevant explanation to the person	<input type="checkbox"/>	<input type="checkbox"/>
9. advise the person of possible discomfort	<input type="checkbox"/>	<input type="checkbox"/>
10. put on gloves when appropriate	<input type="checkbox"/>	<input type="checkbox"/>
11. ensure patient's skin area is clean	<input type="checkbox"/>	<input type="checkbox"/>
12. correctly prepare finger pricking device using aseptic technique	<input type="checkbox"/>	<input type="checkbox"/>
13. correctly choose site for blood sample	<input type="checkbox"/>	<input type="checkbox"/>
14. correctly load strip into meter (if appropriate)	<input type="checkbox"/>	<input type="checkbox"/>
15. correctly commence meter operation (as appropriate)	<input type="checkbox"/>	<input type="checkbox"/>
16. correctly prick finger (use side of finger, not tip)	<input type="checkbox"/>	<input type="checkbox"/>
17. correctly obtain a drop of blood	<input type="checkbox"/>	<input type="checkbox"/>
18. correctly ensure accurate timing (if appropriate)	<input type="checkbox"/>	<input type="checkbox"/>
19. correctly read test result	<input type="checkbox"/>	<input type="checkbox"/>
20. correctly record result on blood glucose monitoring record	<input type="checkbox"/>	<input type="checkbox"/>
21. correctly interpret result and take appropriate action	<input type="checkbox"/>	<input type="checkbox"/>
22. terminate the procedure suitably	<input type="checkbox"/>	<input type="checkbox"/>
23. clean, replace, dispose of equipment appropriately	<input type="checkbox"/>	<input type="checkbox"/>
24. wash hands	<input type="checkbox"/>	<input type="checkbox"/>

Comments:



## REPATRIATION GENERAL HOSPITAL

### Capillary Blood Glucose Monitoring Competency Practical



All nursing staff must be accredited to use the hospital nominated blood glucose meter.

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Theory Accreditation complete: YES / NO

Accredited by: \_\_\_\_\_ Designation: \_\_\_\_\_

**OBJECTIVE:** The Registered/Enrolled nurse will be able to demonstrate the use and maintenance of the hospital nominated blood glucose meter, according to listed criteria.

The nurse will:

1. **Assemble the necessary equipment**
2. **Ensure sensor electrodes and control solutions are within expiry date.**
3. **Calibrate the meter.** (*Nurse to perform calibration*)
  - State when the sensor should be calibrated.
  - The sensor was calibrated with the calibrator.
  - Check that the 5 digit lot number on the calibrator, the meter, the electrode packet and electrode insert sheet correspond
  - State where the lot number is recorded.
4. **Perform a quality control** (*Nurse to perform control test*).
  - States when control checks are performed
  - The expiry date on the control solution and electrodes is checked.
  - The calibration code and lot number match
  - Inserts electrode into meter correctly
  - Follows visual prompts on the meter display to proceed to next step.
  - Correctly applies control solution to target area of sensor electrode.
  - Compares the result to the control range on the electrode insert sheet
  - Records the result in Quality Assurance log
  - Can state the action to be taken if result is outside the acceptable range.
5. **Perform a capillary blood glucose test.** (*Nurse to perform procedure*)
  - Procedure explained to patient.
  - Universal precautions used due to potential for blood exposure.
  - Appropriate site prepared for capillary blood sample.
  - Electrode inserted into meter correctly.
  - Lancet device was used correctly.
  - Blood applied correctly to target area of sensor electrode.
  - Follows visual prompts on the meter display to proceed to next step.
  - Instruction to patient following collection of blood sample.
  - Disposable components of lancet device disposed of correctly.
  - The electrode was removed as per infection control guidelines and disposed into general waste.
  - BGL result was documented in patients file.
6. **Be able to state:**
  - The range of the meter
  - The meaning of displayed symbols
  - Appropriate action to be taken if BGL outside patient's target range.

Comments: \_\_\_\_\_

Reference: Metropolitan hospitals BGM package, updated Sept 08.

# References

1. The Queen Elizabeth Hospital (2008) *Infection prevention & control & community based care*. The Queen Elizabeth Hospital, Adelaide.
2. Royal Adelaide Hospital, Modbury Hospital, The Queen Elizabeth Hospital, and Repatriation General Hospital (2009) *Quality assurance for blood glucose meters: Personal communication*. Diabetes Outreach, Adelaide.
3. SA Pathology (Flinders Medical Centre) (2009) *Record keeping for quality control: Personal communication*. 27 April, Diabetes Outreach, Adelaide.
4. Griesdale D E G, de Souza R J, van Dam R M, Heyland D K, Cook D J, Malhotra A, Dhaliwa R, Henderson W R, Chittock D R, Finfer S, and Talmor D (2009) Intensive insulin therapy and mortality among critically ill patients: A meta-analysis including NICE-SUGAR study data. *Canadian Medical Association*, 180(8): p821-827.
5. Farmer A, Wade A, Goyder E, Yudkin P, French D, Craven A, Holman R, Kinmonth A L, and Neil A (2007) Impact of self monitoring of blood glucose in the management of patients with non-insulin treated diabetes: open parallel group randomised trial. *British Medical Journal*, 335(7611): p132-138.
6. McAndrew L, Schneider S H, Burns E, and Leventhal H (2007) Does patient blood glucose monitoring improve diabetes control? A systematic review of the literature. *The Diabetes Educator*, 33(6): p991-1011.
7. Welschen L M C, Bloemendal E, Nijpels G, Dekker J M, Heine R, Stalman W A B, and Bouter L M (2005) Self-monitoring of blood glucose in patients with type 2 diabetes mellitus who are not using insulin (Review). *Cochrane Database of Systematic Reviews* (2): p1-25.
8. Funnell M M (2007) Self-monitoring of Blood Glucose: A commentary. *The Diabetes Educator*, 33 (6): p1012-1014.
9. Harris P, Mann L, London J, Phillips P, and Webster C (2009/10) *Diabetes management in general practice: Guidelines for type 2 diabetes*. Diabetes Australia and Royal Australian College of General Practitioners, Canberra.
10. Australian Diabetes Educator Association (2006) *Guidelines for sick day management for people with diabetes*, ADEA, Canberra.
11. Harris P, Mann L, Marshall P, Phillips P, and Webster C (2008/09) *Diabetes management in general practice: Guidelines for type 2 diabetes*. Royal Australian College of General Practitioners and Diabetes Australia, Canberra.