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MONITORING BLOOD KETONES IN DIABETES



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The ability to self monitor blood ketone levels is a recent advance in diabetes management that has arisen from Abbott Diabetes Care. The Optium™ or Optium Xceed™ blood glucose meters have the added function of being able to measure blood ketones. However, there are currently no universally adopted guidelines for monitoring blood ketones in the UK. Therefore, the Diabetes Monitoring Forum has undertaken to provide the following information and guidelines.

This work is based on research by Professor David Matthews and his team at the Oxford Centre for Diabetes Endocrinology and Metabolism.*

What are ketones?

- + The ketones, acetoactate, acetone and β -hydroxybutyrate, are naturally occurring acidic products of fat metabolism.
- + Under everyday metabolic conditions ketones do not accumulate in the blood and so are undetectable.
- + Measurable levels of ketones however are found in blood (ketonemia or ketosis) during starvation, after exercise, or in children overnight (when fat is used as an energy source) which is quite normal.

When is ketosis a problem?

- + When there are inadequate amounts of insulin in the blood, metabolism is switched to utilising fats, which produces ketosis.
- + Ketosis is typically accompanied by hyperglycaemia due to the lack of insulin.
- + In people with diabetes, hyperglycaemia and ketosis may be accompanied by acidosis resulting in diabetic ketoacidosis (DKA), which is distinct from simple ketosis.
- + DKA is a major problem in Type 1 diabetes where it can be a life-threatening event.
- + There is also a sub-group of people with Type 2 diabetes who develop ketotic episodes but only rarely.
- + In DKA the major ketone is β -hydroxybutyrate (β -OHB).
- + Episodes of DKA must be treated by giving adequate insulin and fluids until the plasma levels of β -OHB are brought back to within normal limits. (See page 5)

How are ketones measured?

In the urine.

Urinary ketones can be measured using a dipstick with colour matching. Until recently this was the only method for measuring ketones and has been the mainstay of diagnosis of clinical ketosis with clinical symptoms of acidosis.

However, there are serious limitations to measuring urinary ketones with dipsticks:

- + The values are only semi-quantitative and can be difficult to interpret.
- + Ketone sticks do not measure β -OHB.
- + Measurement of urinary ketones is retrospective – i.e. the urine has gathered over some hours before the ketones are measured and urinary ketones can persist after the episode of DKA has resolved.
- + Resolution of the ketoacidotic episode can be difficult to monitor.
- + Urine samples cannot always be easily obtained, especially in the presence of dehydration and altered consciousness.

In the blood.

Blood ketones are measured by monitoring blood β -OHB, the major ketone in DKA.

At present the only meters available to measure blood ketones are the dual glucose/ketone Optium™ and Optium Xceed™ meters. By using two different electrode strips, glucose and β -OHB can be measured in the blood from the same fingerprick test. The ketone strip produces an electrical signal proportional to the whole blood concentration of β -OHB in 30 seconds and this signal is translated into a reading of concentration, which is shown in the display panel.

Notes for secondary care professionals.

- + Blood ketones can be a valuable indicator of adequate resolution of ketotic episodes.
- + The resolution of DKA is more accurately monitored by measuring blood β -OHB than by measuring urinary acetoacetate. This is because β -OHB is metabolised to acetoacetate as acidosis resolves. Thus an increase in urinary acetoacetate, seen with a dipstick, would give the misleading impression that the clinical situation is worsening when in fact it reflects the metabolism of β -OHB and the situation is in fact improving.
- + Patients with high urinary ketones may be kept in hospital inappropriately, when they could safely be sent home if blood ketones are normal.

When should blood ketones be measured?

- + When blood glucose is greater than 15mmol/L in people with type I diabetes who feel unwell.
- + To distinguish between simple hyperglycaemia (which could have a number of causes) and DKA.
- + When there is a clinical suspicion of DKA in anyone with diabetes.
- + In secondary care blood ketones are an indicator of adequate resolution of ketotic episodes.

What action should be taken?

The guidelines on the facing page are also provided as an accompanying blood ketone monitoring advice card for people with Type 1 diabetes.

There are spaces on that card that you or your healthcare professional should fill in.

Guidelines.

▲ Ketone reading on your meter (β - OHB (mmol/L))

0.1
TO
1.0

These are acceptable blood ketone levels

- Treat for elevated glucose appropriately.

1.1
TO
3.0

It is important to reduce your blood ketone levels to below 1.0

Take additional short- or rapid-acting insulin. If you do not have this type of insulin use your usual premix insulin. Take the amount shown below, but if the space below has not been completed take 1/5 of your total daily dose. However, if this dose is above 10 units, just take 10 units and contact your healthcare professionals.

- Insulin type.....Dose.....
- Retest your blood glucose and ketones after 1 hour.
- If your blood glucose and ketones are not falling, contact your doctor or nurse.
- If your blood glucose and ketones are falling retest every hour while ketones remain above 1.0 and continue to follow these guidelines.

OVER
3.0

Much too high. you are at risk of DKA and the ketone level must be reduced urgently

Take additional short- or rapid-acting insulin. If you do not have this type of insulin use your usual premix insulin. Take the amount shown below, but if the space below has not been completed take 1/5 of your total daily dose, but not more than 10 units.

- Insulin type.....Dose.....
- Drink plenty of water
- Seek specialist advice immediately.
- Retest glucose and ketones every hour.

Please remember to drink at least a cupful of sugar-free fluid every 15 mins (about 1 pint or 500 mls per hour) while your blood glucose is high.

Note to healthcare professionals.

β -OHB can rise by 1-2 mmol/L per hour. With adequate treatment of DKA β -OHB levels should fall by about 1 mmol/L per hour. (Wallace et al., Diabetic Medicine, 2001;18: 640-45.)

*Acknowledgements

These guidelines are based on preliminary guidelines developed by Sue Allen, Tim Antrobus, Dawn Cuzner, Maggie Hammersley, Jenny Harper, David Matthews, Janet Sumner, and Tara Wallace.

Disclaimer

The guidelines are based on clinical evidence, but the database of levels of β -OHB that are relevant to DKA is small. Continued accumulation of data will help in refining these guidelines. Special care must be taken when treating children or people with rare metabolic syndromes.

Further copies of this leaflet, and the others in the series, may be obtained from The DMF Secretariat, c/o Innervate Ltd, Golden Cross House, 8 Duncannon Street, London WC2N 4JF. Tel: +44 (0)20 7484 5091. E-mail info@dmforum.org.uk. The leaflets may be photocopied.

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