Chapter J

Diabetes During Illness - Ketones

J: Diabetes During Illness - Ketones

J1. Understanding Ketones: How to Treat Ketones & Avoid DKA

Insulin acts as a key to allow glucose to move from the blood into the cells, where it is used for energy. If you have diabetes and do not have enough insulin, the body cannot use glucose properly. The body then tries to release more glucose from its own stores and starts breaking down fats for energy. This leads to ketone production. The body will also produce ketones if you starve for more than a few hours as the body will run out of glucose.

Ketones provide the body with energy in the short term but also make your body more resistant to insulin. This means that the body generally needs more insulin than usual to work effectively. Ketones are acids and can make you very ill. If they are not treated they can lead to diabetic ketoacidosis (DKA). Your body will try to get rid of ketones in the urine and in your breath. They smell like Pear Drop boiled sweets but not everyone can smell ketones.

Early identification of rising ketone levels and prompt management supported by the diabetes team can potentially avoid an emergency situation or a hospital admission.

Managing ketones may take up to 24 hours and usually requires extra insulin doses, careful observation of food and fluid intake and regular telephone contact. Individual assessment is essential and in some cases admission to hospital may be unavoidable.

J2. Situations Where The Body May Make Large Amounts of Ketones

Sub-optimal diabetes control with high HbA1c:

When your HbA1c is high, there is regularly not enough insulin in the body and blood glucose levels are high most of the time. Glucose cannot effectively get into the cells from the blood to be used as energy so the body is more likely to produce ketones.

Illness:

Children and young people whose diabetes control is optimised should not experience more illness or infections compared to children and young people without diabetes. However, even routine childhood illnesses (e.g. flu, tonsillitis or chicken pox) can make diabetes management more challenging and increase the risk of DKA. This is because during illness, particularly those associated with high temperatures, the body works much harder and it demands more glucose. Blood glucose levels are also raised due to higher levels of stress hormones, which encourage the body to release more glucose and make it harder for the insulin to work properly. The body then breaks down fat leading to ketones.

Illness associated with vomiting and diarrhoea (e.g. gastroenteritis) may lower blood glucose levels and lead to ketone production secondary to starvation.

Illness can affect glucose levels prior to the onset of the illness, during illness and for several days after and therefore it is extremely important to monitor both blood glucose levels and ketones when unwell.

Starvation:

If you miss food, particularly carbohydrates, the body will naturally form ketones for energy if the blood glucose is low. This can happen more quickly if your child is unwell, particularly if illness is associated with vomiting and/or diarrhoea (e.g. gastroenteritis). .

Stress:

During periods of stress, the stress hormones cause the body to release more of its own stores and make the body more resistant to insulin. If extra insulin is not given to compensate, the body may produce ketones.

Growth and Puberty:

During times of rapid growth and puberty the body needs more insulin as the pubertal hormones make your body less responsive to insulin.

Exercise:

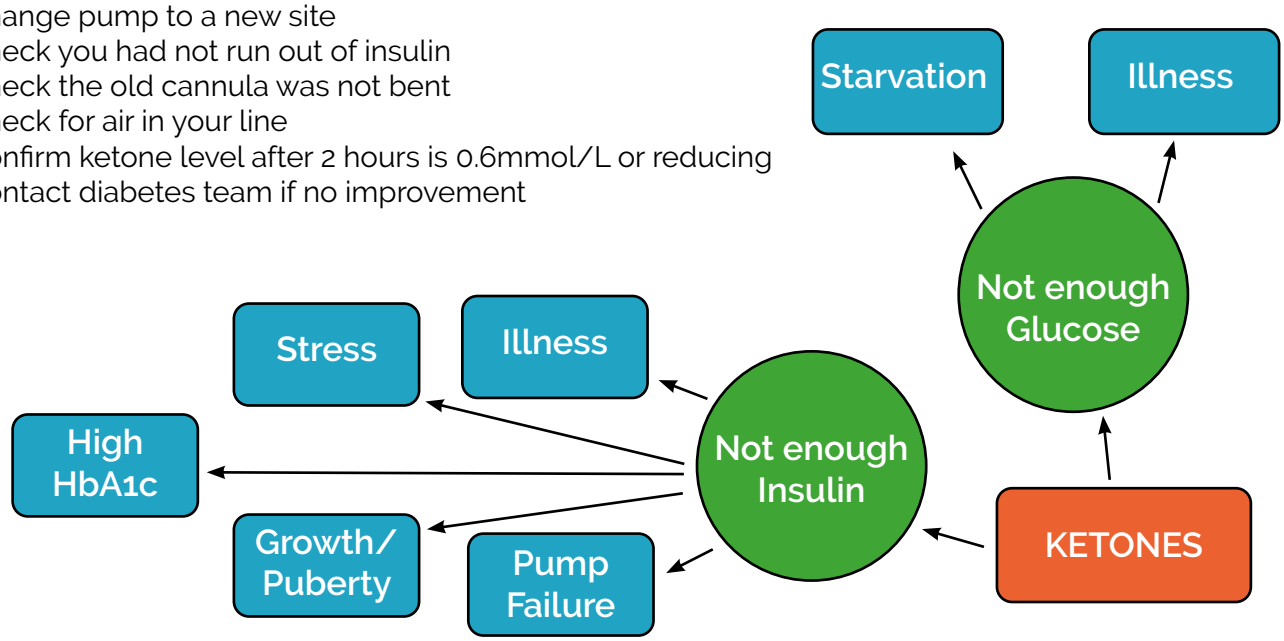
Exercise demands energy and if there is not enough glucose from carbohydrate, more fats will be broken down to form ketones. Exercise is good for you but if your blood glucose is high or low and ketones are present you should not exercise until your ketones have gone and blood glucose normalised.

Pump failure:

When you are on a pump, there is no long acting insulin in the body, only rapid acting insulin. Being on a pump puts you at greater risk for developing ketones and DKA if your pump insulin runs out, your insulin becomes disconnected for too long or the pump is not working properly. If you feel unwell or have high blood glucose with or without ketones, always consider "'is my pump working?"

Pump users must be more vigilant and check for ketones after any raised blood glucose result that has not been resolved by one correction dose by the pump. Pump users should follow these rules:

- Check ketones
- Correction dose by pen injection if ketones are present
- Change pump to a new site
- Check you had not run out of insulin
- Check the old cannula was not bent
- Check for air in your line
- Confirm ketone level after 2 hours is 0.6mmol/L or reducing
- Contact diabetes team if no improvement



J3. Avoiding Ketones

General tips:

- Try to eat a healthy varied diet at regular intervals.
- Accurate carbohydrate counting is essential.
- Try not to forget insulin. You should aim for 4-7 boluses per day, with food or as corrections. Doses should be based on a recent glucose level and accurate carbohydrate value if eating. If your glucose is elevated a correction dose will also be required.
- Aim for an average glucose of 8mmol/L or below over a two week period. If higher than this it is likely that your insulin needs review. Please contact the diabetes team if you are unsure what to do.
- Regular uploading to check for patterns or trends of elevated glucose can indicate if a change to insulin is required.

Illness Management:

If your child is vomiting, has abdominal pain, fast breathing, is drowsy, confused or feels cold you must seek urgent advice.

- Check blood glucose and ketones to establish the specific diabetes action required. During illness blood glucose can be normal or elevated. In some situations, particularly gastroenteritis (vomiting and diarrhoea), the blood glucose can be low due to starvation. This requires slightly different treatment to that described below.
- Drinking plenty of sugar free fluids to flush ketones out of the body and maintain hydration is essential.
- Carbohydrate as food or drink is essential during illness matched with insulin. If your child cannot eat, give your child sugary drinks (e.g. Lucozade, milk or fresh orange) with insulin. If your child is struggling to drink, they can suck glucose tablets or sweets instead .
- **NEVER** stop taking your insulin even if you are not eating. If blood glucose is low, insulin may need reducing but should never be stopped.
- You usually need more insulin when you are unwell. Your usual basal dose may need to be increased and extra fast-acting insulin may need to be given more regularly than usual.
- It may be necessary to adjust your correction dose for the duration of the illness.
- It may be necessary to temporarily increase the basal rate if you are on a pump.
- You may be advised to see your GP depending on your specific symptoms.

J4. Ketone Monitoring

A blood ketone meter should be available at all times. Blood ketones are measured by a finger prick. The result tells you whether the ketone level is normal or elevated. **The higher the result the quicker you need to act.**

Ketones must be checked if:

- Your child is feeling unwell regardless of the blood glucose
- When the blood glucose levels are 14mmol/L and above
- Your child feels sick or has vomited
- Your child is feeling under stress

Levels of blood ketones (traffic light alert):

- Less than 0.6mmol/L (normal)
- 0.6-1.5 mmol/L (small to moderate elevation)
- 1.5-2.9 mmol/L (moderate to large elevation) – needs urgent treatment
- 3 mmol/L or greater (very large elevation) – needs urgent treatment

J5. Ketone Management (Sick Day Rules)

The blood ketone and blood glucose level help to determine the specific treatment advised. The box below highlights the key principles of ketone management with more detailed information in the flow charts and table below. **This advice is based on those using multiple daily injection regimens and insulin pump therapy. For patients on alternative insulin regimens, Fast Acting insulin will need to be used and the diabetes team should be contacted for advice.**

The aim is to achieve:

- Blood glucose levels 4 -10mmol/L
- Blood ketones <0.6mmol/L

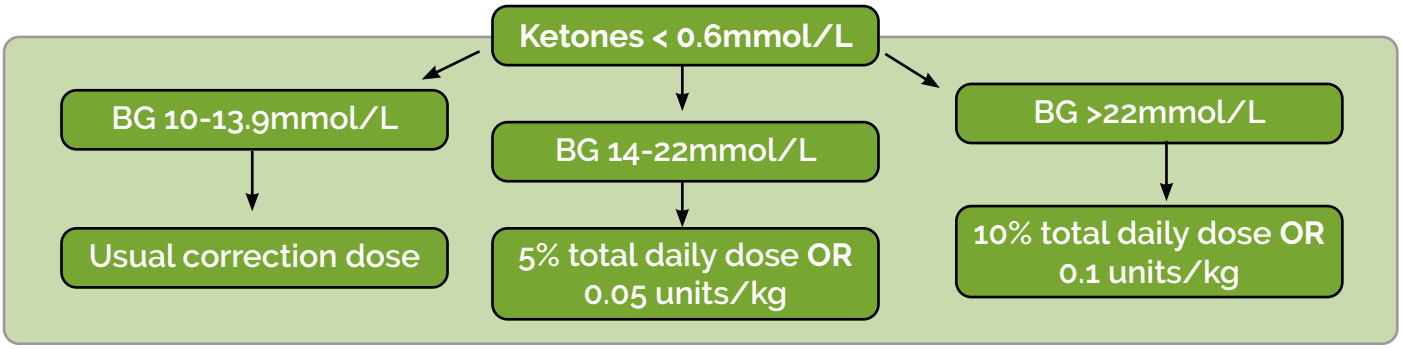
Key Points

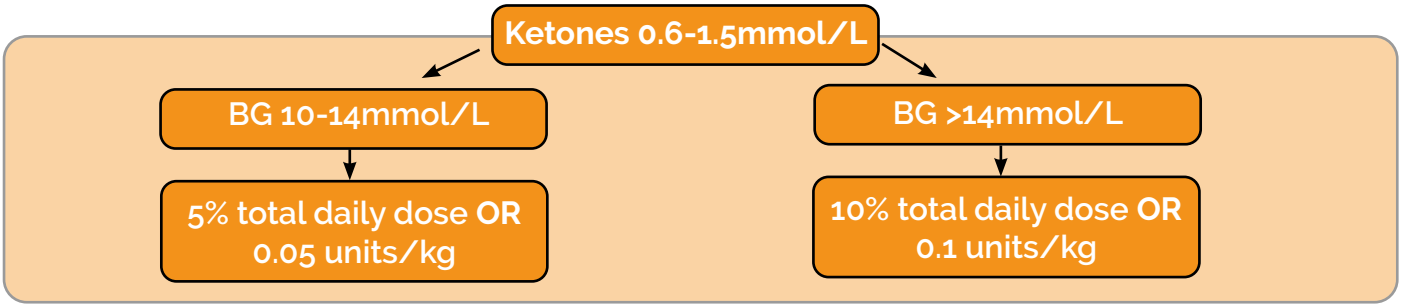
- Ketones must be checked if your blood glucose is 14mmol/L and above **OR** if you feel unwell regardless of your blood glucose level.
- Check your blood glucose and ketones every 1-2 hours.
- Contact the Diabetes team **URGENTLY** if your child is vomiting or you are at all unsure. Vomiting could be a sign of DKA.
- **NEVER STOP INSULIN** even if not eating.
- The body needs food, fluids and insulin to stop ketone production. Drink plenty of sugar free fluids to flush ketones out of the body. Replace food with small amounts of carbohydrate containing liquid if not hungry (e.g. fruit juice, ice cream, yoghurt, sugary drinks) with adequate insulin.
- Additional insulin doses should be given every 2-4 hours by pen injection until glucose is normal and ketones are less than 0.6mmol/L. If you are on a pump you must give the first correction via a pen injection and then change your pump cannula.
- Contact your GP for general care of the illness. Most medications are sugar free. If not, the amount contained is negligible.

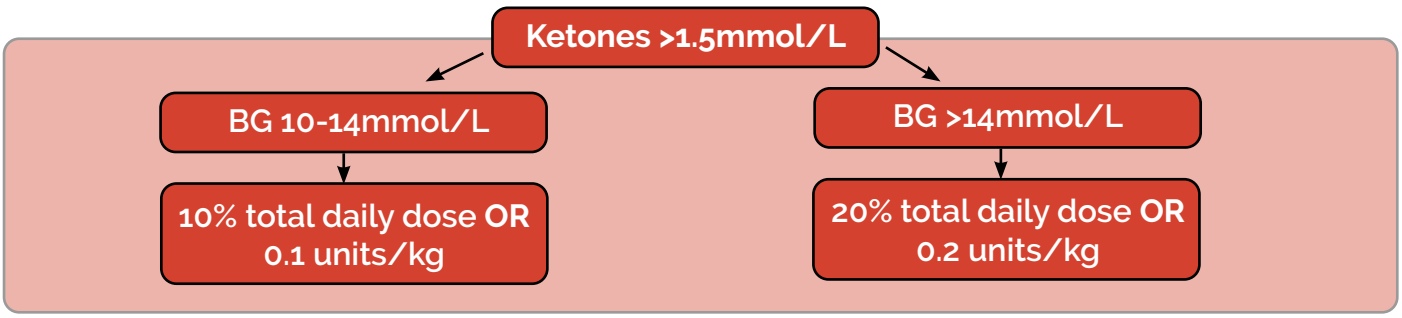
Flowchart for Ketone Management (Sick Day Rules)

General Principles

1. Never stop insulin
2. More frequent BG and ketone monitoring is required. Check ketones if BG 14 or above OR if your child feels unwell.
3. Aim for BG levels between 4-10mmol/L and ketones below 0.6mmol/L
4. Insulin treatment is guided by the BG and ketone numbers as outlined below and corrections should be at least 2 hours apart guided by regular BG and ketone monitoring (ideally 1-2hourly).
5. If you are on a pump, you must assume your pump is not working if you have ketones, and give a pen injection before re-siting the pump.
6. Drink plenty of sugar free fluids to push ketones out of the body.
7. Where possible eat food matched with your usual food insulin. If you cannot eat, replace food with small amounts of carbohydrate containing fluids and match with adequate insulin.
8. Treat underlying illness and symptoms.







If your child is vomiting, has abdominal pain, fast breathing, is drowsy, confused or feels cold, you must seek urgent medical advice.

If ketones remain >1.5mmol/L despite additional insulin and adequate hydration please seek urgent medical advice.

Table for Ketone Management

Blood Glucose (BG) Level	Blood Ketone Level	Recommended Actions
BG 10 – 13.9 mmol/L	Below 0.6 mmol/L (normal)	• Give usual correction dose to get back to your target blood glucose level. • Recheck BG and ketone in 2hrs. • Have food as usual with insulin.
BG 14 - 22 mmol/L	Below 0.6 mmol/L (normal)	• Additional correction dose is needed for high blood glucose level – give 5% of total daily dose OR 0.05units/kg. • Pump users can try to deliver additional insulin via the pump. • Give extra sugar free fluids. • Recheck BG and ketones in 2 hours. • Have food as usual with insulin or liquids if struggling to eat.
BG greater than 22 mmol/L	Below 0.6 mmol/L (normal)	• Additional correction dose is needed for high blood glucose level – give 10% total daily dose OR 0.1 units/kg. • Pump users can try to deliver additional insulin via the pump. • Give extra sugar free fluids. • Recheck BG and ketones in 2 hours. • Have food as usual with insulin or liquids if struggling to eat.
BG 10 – 14 mmol/L	0.6-1.5 mmol/L (moderate)	• Give extra insulin immediately - give 5% total daily dose OR 0.05 units/kg. • Pump users to give additional insulin dose using a pen injection and re-site pump • cannula. • Recheck BG and ketones in 2 hours. If unsure of how much further insulin to give contact the diabetes team for further advice. • Give extra sugar free fluids. Despite these actions your child could deteriorate very quickly into the high-risk category. Any signs of nausea, vomiting or abdominal pain, seek advice immediately or take to the Emergency Department.

BG greater than 14 mmol/L	0.6-1.5mmol/L (moderate)	• Give extra insulin immediately - give 10% total daily dose OR 0.1 units/kg. • Pump users to give additional insulin dose using a pen injection and re-site pump cannula. • Recheck BG and ketones in 2 hours. If unsure of how much further insulin to give contact the diabetes team for further advice. • Give extra sugar free fluids. Despite these actions your child could deteriorate very quickly into the high-risk category. Any signs of nausea, vomiting or abdominal pain, seek advice immediately or take to the Emergency Department.
BG 10-14mmol/L	Greater than 1.5mmol/L (high)	Your child is at risk of developing DKA. Watch for signs of abdominal pain and vomiting. High ketones levels will mean your child will no longer feel hungry but you MUST Give extra insulin - give 10% total daily dose OR 0.1 units/kg. Contact the diabetes team. Recheck BG and ketones in 1 hour. Encourage sips of sugary fluids with insulin. After two hours repeat the higher insulin correction dose if ketones have not decreased. If your child develops DKA symptoms take them to the Emergency Department immediately.
BG greater than 14mmol/L	Greater than 1.5mmol/L (high risk)	Your child is at risk of developing DKA. Watch for signs of abdominal pain and vomiting. If present take your child immediately to the Emergency Department. Your child may not feel hungry. You MUST Give extra insulin - give 20% total daily dose OR 0.2 units/kg. Contact the diabetes team. Recheck BG and ketones in 1 hour. Encourage sips of sugary fluids with insulin. After 2 hours repeat the insulin correction dose if ketones have not decreased.
BG may occasionally be near normal but usually high	Greater than 3.0mmol/L (serious risk)	The ketone level is seriously high. Your child needs insulin immediately and a rapid assessment of severity of DKA. TAKE TO EMERGENCY DEPARTMENT IMMEDIATELY If dehydrated and breathing fast it is very unlikely that further insulin under the skin will work and hospital admission is required. If at night do not wait until the morning but seek advice immediately.

Examples of dose calculations

You can calculate your child's total daily dose in the following way:

- **Multiple daily injections** - add the long acting dose to the average amount of Novorapid your child has for each meal. For example, Levemir 10 units once a day, 4 units Novorapid for breakfast, 3 units for lunch and 3 units for evening meal, the average total daily dose = 10 + 4 + 3 + 3 = 20 units
- **Pump therapy** – the pump will give you an average total daily dose based on the basal rate and boluses given.

If you are not sure about your child's total daily dose, weigh your child in kilograms. Most children need 1 unit insulin per kg of weight. If 40kg = TDD is 40 units.

Please note that if your child has a high HbA1c or often misses insulin doses using their weight will be more accurate than estimating their total daily dose.

Example

Your child has developed a cough and cold symptoms with a temperature of 38 degrees. You check their blood glucose and their ketones.

BG	20 mmol/L
Ketones	2 mmol/L
Total daily dose	50 units
Weight	50 kg

Additional insulin is required via a pen. Novorapid is required 20% of the total daily dose **OR** 0.2 units/kg based on their numbers.

20% of 50 units = 10 units OR 0.2 x 50 kg = 10 units

You would give your child 10 units of Novorapid via pen injection and recheck their blood glucose and ketones in 2 hours. Call diabetes team for advice.

2 hours later....

Your child's temperature has improved and they are feeling a bit better. You recheck their blood glucose and ketones.

BG	16 mmol/L
Ketones	1.2 mmol/L

You would now need to give another correction as the ketones are still elevated. This time the amount of Novorapid required is 10% of total daily dose OR 0.1 units/kg based on their recent numbers.

10% of 50 units = 5 units OR 0.1 x 50 kg = 5 units

You would give your child 5 units of Novorapid and recheck again in 2 hours. Update the diabetes team with the new numbers.

J6. Starvation Ketone Recognition and Management

Starvation ketones can be challenging to manage, particularly if your child has diarrhoea and vomiting. They do not usually rise above 1.5mmol/L. Please call the diabetes team early for advice.

Key Points:

- If your child is hypoglycaemic (BG < 4.0) treat appropriately with fast acting glucose and recheck BG after 15 minutes.
- Give extra carbohydrate as food where able otherwise give your child regular sugary fluids.
- Insulin should not be stopped but it may need reducing.
- If your child is on a pump we may recommend a temporary basal rate reduction.
- BG and ketones should be checked every 2 hours (unless ongoing hypoglycaemia where it should be checked and treated every 15 minutes until hypoglycaemia has resolved).

J7: Diabetic Ketoacidosis (DKA)

DKA is a **VERY SERIOUS** potential complication of diabetes. Ketones are acids and ketoacidosis describes how acidic the blood has become because there is **NOT ENOUGH INSULIN** in the body. Ketoacidosis can develop within a few hours, especially if you are on an insulin pump.

DKA can be life threatening. Early recognition and prompt treatment may avoid hospital admission and the need for intravenous insulin and fluids. Please ring the diabetes team for advice.

Recognising DKA

High ketone levels affect the way the heart, lungs, digestive system and brain function. In the worst situation they can cause coma and death.

EARLY Signs that your child is developing ketoacidosis

- Blood glucose level is rising and typically greater than 14 mmol/L
- Ketones are present (the higher the level the greater the risk of DKA)
- Confusion
- Tiredness
- Increased thirst
- Becoming dehydrated

LATE signs that your child has developed or is developing ketoacidosis
*** Seek Urgent Medical Attention**

- Nausea
- Vomiting
- Headache
- Abdominal pain
- Breath smells of acetone /pear drops (remember not everyone can smell ketones)
- Deep/Sighing breathing