

Diagnosing type 1 diabetes and diabetic ketoacidosis in children

Fergus Cameron, Gary Kilov, Ralph Audehm

One in three children present in diabetic ketoacidosis (DKA) when they are diagnosed with type 1 diabetes. DKA is a life-threatening complication of hyperglycaemia, therefore avoiding DKA and providing a swift diagnosis of type 1 diabetes is paramount. The authors cover the symptoms and diagnosis of type 1 diabetes and DKA and provide examples to raise awareness with parents, carers and the community.

Globally, 30% of children newly diagnosed with type 1 diabetes present in diabetic ketoacidosis (DKA; Silverstein et al, 2005). DKA is the combination of hyperglycaemia, metabolic acidosis and ketonaemia. It may be the first presentation for a child with previously undiagnosed diabetes. DKA is caused by hyperglycaemia by a total omission of insulin production and secretion. It can develop over a few hours or days. In DKA, as glucose is unable to be used for energy, fat is used and, as a result, ketone bodies are produced. In high levels, ketone bodies are toxic and can ultimately lead to death.

DKA is the leading cause of diabetes-related deaths in children, so it is imperative that clinicians are aware of the symptoms and act fast when type 1 diabetes and DKA is suspected. Delayed DKA diagnosis can lead to a detrimental effect on attention and memory. Cameron et al (2014) used magnetic resonance imaging (MRI) and spectroscopy with cognitive assessment to compare cognitive function in children who had previously had DKA with children who had not (controls). Early brain changes caused by DKA resolved after the first week; however, 6 months later, these brain changes were associated with persisting alterations in attention and memory.

It has been reported that nearly half of children presenting with DKA have seen a GP in the preceding week and were not diagnosed with type 1 diabetes (Bui et al, 2010). In 2013, the incidence of type 1 diabetes in children was 11 per 100 000 of the population

(Australian Institute of Health and Welfare, 2015). This means that many primary care health professionals will rarely see a case of new-onset type 1 diabetes. It is, therefore, understandable that diagnosis of type 1 diabetes is often delayed.

Type 1 diabetes and DKA symptoms

Early identification of type 1 diabetes in children and urgent referral can prevent DKA from developing. According to the Australian arm of the Juvenile Diabetes Research Foundation (2015), the following are a list of type 1 diabetes symptoms can occur in children:

- Extreme thirst.
- Constant hunger.
- Sudden weight loss.
- Frequent urination.
 - Nocturnal enuresis (night time bed-wetting) – especially in a previously dry child.
 - Polyuria (production of abnormally large volumes of dilute urine).
 - Pollakiuria (frequent urination during daylight hours).
- Blurred vision.
- Nausea.
- Vomiting.
- Extreme tiredness.
- Infections.
- Dehydration (sunken eyes, dry skin, dry mucous membranes).

The symptoms of DKA will include the symptoms of type 1 diabetes, as well as the following:

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Article points

1. If left undiagnosed, type 1 diabetes and diabetic ketoacidosis can lead to death.
2. Symptoms can be non-specific so diagnosis can sometimes be delayed for some time even though the diagnostic test is rapid and straightforward.
3. It is imperative to raise awareness of the symptoms of diabetes among parents, carers and healthcare professionals.

Key words

- Children
- Diabetic ketoacidosis
- Type 1 diabetes

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Page points

1. As parents or carers may not mention polyuria or bed-wetting in a previously “dry” child during appointments, a doctor must carefully draw out this information.
2. It is time to raise the profile of type 1 diabetes and ensure it is considered in all children who present unwell.

- Abdominal pain.
- Kussmaul breathing (rapid, laboured breathing).
- Fruity breath – caused by ketone bodies.
- Confusion.
- Flu-like symptoms.

Polyuria and polydipsia are the main symptoms of type 1 diabetes in all age groups. As parents or carers may not mention these symptoms during appointments, a doctor must carefully draw out this information. Bed wetting in a previously “dry” child can be one of the first symptoms of diabetes and was observed in 89% of children over the age of 4 years (Vanelli et al 1999; Roche et al, 2005). However, diagnosing polyuria and polydipsia can be extremely difficult in children under 2 years.

It is important to note that diabetes and DKA symptoms can be non-specific (e.g. nausea and vomiting, and abdominal pain), even though a child can already be pre-comatose and at risk of death.

Interestingly, children who have previously been seen by primary care physicians often present with worse DKA (Lokulo-Sodipe et al, 2013). The reassurance of having seen a healthcare professional or the delay caused by waiting for test results can ultimately delay attendance to the emergency department. In a 3-month study in the UK, 46% of delayed presentations to secondary care of children with new-onset type 1 diabetes and DKA had received non-urgent investigations at primary care (Lokulo-Sodipe et al, 2014).

Diagnosing type 1 diabetes

Given the potentially fatal consequences of undiagnosed and untreated type 1 diabetes, excluding or confirming a diagnosis of type 1 diabetes in an unwell child is important and can be done quickly and easily. All children who are unwell with any of the symptoms above should have a urine or finger-prick blood glucose test (Wolfsdorf et al, 2009). Glucose in the urine or a random blood glucose level ≥ 11.1 mmol/L should alert clinicians to refer the child to the nearest emergency department; this goes to say that all children newly diagnosed with type 1

diabetes should be referred to the emergency department. A fasting blood glucose test, oral glucose tolerance test (OGTT) or HbA_{1c} test are not necessary to make a diabetes diagnosis. Waiting for confirmatory blood tests can delay treatment in children and increase the risk of DKA and death.

Diagnosing DKA in children with established type 1 diabetes

According to the clinical practice guidelines of The Royal Children’s Hospital Melbourne (2016), children with a blood glucose level ≥ 11.1 mmol/L should have blood ketones tested on a capillary sample. If this test is positive (>0.6 mmol/L), assess for acidosis to determine further management. Analysis of urine for ketones can also be used if blood ketone testing is not available. Again, if ketones are detected in a child with new-onset type 1 diabetes, they should be immediately referred to the nearest emergency department.

Raising awareness of type 1 diabetes

It is time to raise the profile of type 1 diabetes and ensure it is considered in all children who present unwell. A new diagnosis of type 1 diabetes is five times more common than meningococcal meningitis (Children with diabetes in the UK, 2012). Primary care physicians are often concerned about missing a diagnosis of meningococcal meningitis, yet missing a diagnosis of type 1 diabetes has equally profound consequences and can also lead to death. Compared to the effort that goes into raising awareness and supporting the early recognition of meningococcal meningitis, raising type 1 diabetes awareness is frequently overlooked (Children with diabetes in the UK, 2012).

Awareness campaigns have been proven to increase early identification of type 1 diabetes in children and reduce the incidence of DKA. Raising parental awareness of the symptoms of type 1 diabetes has been shown to be protective and reduce the likelihood of a child developing DKA (Lokulo-Sodipe et al, 2014). In Parma, Italy, an 8-year awareness campaign was launched providing information on DKA to

teachers, students, parents and paediatricians. Group 1, who had access to information, were compared to group 2, who had no access. In the 4 years prior to the program (1987–1991), the incidence of DKA were 78% in group 1. During the campaign, the incidence of DKA fell to 12.5%. In group 2, the control group, 83% were diagnosed with DKA during the study period. In group 1, after the first 2 years of the campaign, none of the newly diagnosed children with type 1 diabetes were admitted to the diabetes unit with severe or moderate DKA (Vanelli et al, 1999).

A campaign in Gosford, Sydney, has also demonstrated the positive impact of improving DKA education. After a 2-year program to raise awareness of the symptoms of type 1 diabetes, there was a decrease in the presentation of children in DKA by over 60% (King et al, 2012). In the campaign areas, the proportion of children presenting in DKA significantly decreased from 37.5% during the 2-year baseline period to 13.8% during the 2-year intervention. During this time, there was no significant change in the control regions, where no awareness campaign was in place. The programme offered education and provided posters on type 1 diabetes symptoms to childcare centres, schools and doctor's offices, and offered glucose and ketone testing equipment to GP surgeries.

Conclusion

The serious complication of DKA and undiagnosed type 1 diabetes can be averted with rapid diagnosis using a simple glucose test. We recommend sharing this article with colleagues and using resources from successful campaigns and programmes that raise awareness for parents, carers and healthcare professionals (see *Figure 1* overleaf for examples). Although produced overseas, these resources are relevant for the Australian population.

Learning points

- Type 1 diabetes can occur at any age and is easily diagnosed if suspected.
- Polyuria, polydipsia, bed-wetting and weight loss are the usual early symptoms.
- Positive results of glucose in the urine and

a random finger-prick blood glucose level ≥ 11.1 mmol/L in a child with symptoms of diabetes is indicative of diabetes.

- A fasting blood glucose level, OGTT or HbA_{1c} are not necessary when diagnosing diabetes in a child with suspected type 1 diabetes. Carrying out such tests and waiting for results can delay treatment.
- If diabetes is suspected, refer all children immediately, and all children newly diagnosed with type 1 diabetes should be referred to the emergency department.
- Early diagnosis and immediate referral to a doctor experienced in the management of type 1 diabetes in children can prevent DKA. ■

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"Share this article with colleagues and use resources from successful campaigns and programmes that raise awareness for parents, carers and healthcare professionals."

a) **Do you or your child have one or more of these symptoms?**

- Extreme thirst**
- Tiredness, no energy**
- Weight loss**
- Frequent urination**
- Blurred vision**

If so, talk to your doctor. It's possible that you or your child may have type 1 diabetes.

Type 1 diabetes can affect anyone at any age. Type 1 diabetes is not linked to diet or lifestyle and symptoms can come on very quickly. Early diagnosis is important, so discuss your concerns with your doctor as soon as possible. If you or your child has type 1 diabetes, you are not alone. For more information on Juvenile Diabetes Research Foundation and our search for the cure, visit www.jdrf.org.uk/info or call 020 7713 2030

JDRF Juvenile Diabetes Research Foundation
Dedicated to finding a cure.

JDRF works to fund basic research to determine causes of the condition.

b) **COULD YOUR CHILD HAVE TYPE 1 DIABETES?**

Toilet
Thirsty
Tired
Thinner

If your child is going to the toilet a lot, has increased thirst, is more tired than usual or is losing weight, it could be a sign they have Type 1 diabetes. If not diagnosed early enough, Type 1 diabetes can be fatal. Don't delay – if your child is experiencing any of the **4 Ts**, visit your doctor immediately for a test.

www.diabetes.org.uk/The4Ts

DIABETES UK
CARE. CONNECT. CAMPAIGN.
A charity registered in England and Wales (215100) and in Scotland (SC239136).

c) **Type 1 diabetes is the most common childhood chronic illness. Newly diagnosed diabetes in children is a serious and potentially fatal condition. These referrals are emergencies regardless of how well the child looks. Early referral will prevent diabetic ketoacidosis (DKA).**

HISTORY AND EXAM. Look for...		TESTS	ACTION
Symptoms of type 1 diabetes <ul style="list-style-type: none"> <input type="checkbox"/> Polyuria <input type="checkbox"/> Polydipsia <input type="checkbox"/> Weight loss <input type="checkbox"/> Enuresis <input type="checkbox"/> Lethargy 	Symptoms of DKA <ul style="list-style-type: none"> <input type="checkbox"/> Vomiting <input type="checkbox"/> Dehydration <input type="checkbox"/> Nausea <input type="checkbox"/> Abdominal pain 	<ul style="list-style-type: none"> <input type="checkbox"/> Urine glucose (+ ve) or <input type="checkbox"/> Fingerprick blood glucose* (fasting ≥ 7.0mmol/L) or (random ≥ 11.1mmol/L) <p>*Do not send to pathology as this delays result and treatment</p>	Refer to hospital emergency department immediately.

Figure 1. Examples of simple messages that have been developed to raise awareness among parents and healthcare professionals of the symptoms of diabetes: a) Poster produced by the Juvenile Diabetes Research Foundation (available to download at: <http://bit.ly/1Ozljfp> [accessed 18.05.16]); b) The 4Ts campaign from Diabetes UK (available to download at: <https://www.diabetes.org.uk/The4Ts> [accessed 09.06.16]); c) Pathway for clinicians to diagnose type 1 in children (King et al, 2012).