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Type 1 diabetes in children

Emergency management

Background
Fifteen to sixty-seven percent of patients with new onset type 1 diabetes mellitus (T1DM) present in diabetic ketoacidosis (DKA), of which approximately 79% initially see their general practitioner. Diabetic ketoacidosis is the most common cause of diabetes related deaths, mainly due to cerebral oedema that occurs in 0.4–3.1% of patients.

Objective
The aim of this review is to provide information to improve the early recognition of DKA and to provide guidelines for the initial management of DKA in the nonspecialist setting.

Discussion
Recognition of DKA can be improved by increasing the awareness for early clinical symptoms such as polyuria and polydipsia. It is important to include urinalysis and 'fingerprick' blood glucose and ketone measurements in the early assessment of patients with suspected T1DM and known T1DM, particularly if risk factors for DKA are present, to minimise serious complications and prevent fatal outcomes. Urgent referral to specialist centres for suspected new onset T1DM/DKA is required. Specific steps should be followed to ensure successful initial management of DKA in the nonspecialist setting before transfer.

Keywords: diabetes mellitus, type 1; child health; diabetic ketoacidosis

CPD

The aim of this review is to provide information to improve the early recognition of diabetic ketoacidosis (DKA) and to provide guidelines for the initial management of DKA in the nonspecialist setting. Questions to be answered are:

- Is the patient at risk of DKA?
- Are there clinical symptoms suggestive of DKA?
- What are the initial investigations needed?
- What is the initial therapy?
- Who needs to be contacted?
- What does the specialist treatment include?
- How will the patient be followed up?

Two typical scenarios are described in *Case study 1* and *2*.

Fifteen to sixty-seven percent of patients with new onset type 1 diabetes mellitus (T1DM) present in DKA.[1] About 79% of these patients initially present to their general practitioner.[2] Following an international trend,[3] an increase in the rate of hospital admissions was also reported in Australia.[4] Diabetic ketoacidosis is the most common cause of diabetes related deaths, mainly due to cerebral oedema that occurs in 0.3–1.0% of patients.[5,6]

It is important to achieve early recognition of diabetes to reduce the morbidity and mortality associated with DKA. A public awareness campaign in Italy was shown to be effective in reducing the incidence of DKA as the first presentation of T1DM in children.[7,8]

In established T1DM, the risk of DKA is as high as 10% per patient per year.[5,9,10] Risk factors for DKA in this group are: a higher mean HbA1c level, higher reported insulin dose, puberty, female gender, lower socioeconomic status, and the coexistence of psychiatric disorders.[9] It is controversial whether continuous subcutaneous (SC) insulin infusion ('insulin pump therapy'), predisposes patients to an increased risk of DKA. It has been emphasised that this group must carry needles and syringes and an emergency plan with insulin doses in case of pump malfunction.[5]

At diagnosis of T1DM, DKA is more prevalent in children less than 5 years of age.[5] Interestingly, in the week before presenting in DKA, patients had an increased frequency of doctor visits compared to patients presenting without DKA.[11]

Case study 1

A girl, 15 years of age, with known T1DM, presented to a rural hospital after she had spent the night with friends. She could not answer questions correctly and did not remember the day of the week. She vomited twice and had abdominal pain. There was no information on her regular insulin regimen.

Physical examination

- Glasgow Coma Scale (GCS) score 12
- 10% dehydration
- Blood pressure 90/60 mmHg
- Oxygen saturation 98%
- Weight 50 kg

Investigations

- Urinalysis-glucose ++++, ketones large
- Glucometer: blood glucose level (BGL) high, blood ketones 5 mmol/L

Management

- Rehydration was started with an intravenous (IV) 500 mL bolus of 0.9% normal saline (10 mL/kg) that was repeated 1 hour later. After contacting the specialist team, 5 units Actrapid (0.1 units/kg) were given SC. Transfer to the paediatric intensive care unit (PICU) was arranged via the Rural Flying Doctor Service. During the flight, IV 0.9% normal saline was continued at maintenance plus 10%; 5 hours after presentation another 5 units Actrapid were given SC
- On admission to PICU, the girl was clinically stable but still drowsy. An arterial blood gas (BGA) revealed pH 6.9, HCO_3 6 mmol/L, BGL 29 mmol/L, sodium (Na) 140 mmol/L, potassium (K) 3.5 mmol/L
- Therapy was continued with 0.1 unit/kg/hour of Actrapid IV and IV rehydration with 0.9% normal saline and potassium chloride (KCl) 40 mmol/L at maintenance.
- The girl stabilised and GCS score improved to 15/15. She was transferred to a general ward after 36 hours. A fixed combination of 30% short and 70% long insulin in insulin pens was chosen for regular therapy
- A case conference was initiated and a case manager was assigned. The patient was discharged 1 week later.

Case study 2

A boy, 7 years of age, presented to the GP with a 3 week history of weight loss, polyuria and polydipsia. He woke up with a sore throat and started breathing heavily. Both past medical and family history were unremarkable.

Physical examination

- The boy was stable and alert
- GCS score 15/15
- Kussmaul breathing present
- >5% dehydration
- Weight 30 kg

Investigations

- Capillary blood gas: pH 7.23, bicarbonate (HCO_3) 14 mmol/L, BGL 25 mmol/L, Na 134 mmol/L, K 4.9 mmol/L
- Urinalysis: glucose ++++, ketones small/moderate
- Glucometer: BGL 19 mmol/L, blood ketones 1.2 mmol/L

Management

- The diabetes specialist team was contacted
- IV rehydration was started with an initial bolus of 400 mL of 0.9% normal saline (10 mL/kg) and continued at maintenance plus 5%
- 3 units of Actrapid (0.1 unit/kg) were given SC
- The patient was admitted to a PICU for IV insulin and rehydration and started on twice daily SC Protaphane and Novorapid 24 hours later
- The family received diabetes education and the child was discharged after 4 days. The family stayed in daily contact with the hospital for insulin adjustments and reassurance. Education was completed by a multidisciplinary team at outpatient visits before regular clinics were continued on a 3 monthly basis.

Pathophysiology

Diabetic ketoacidosis results from decreased effective insulin concentration and can be associated with insulin resistance and an increased production of counter regulatory hormones. Hyperglycaemia results from increased hepatic and renal glucose production and impaired peripheral glucose utilisation which leads to osmotic diuresis and electrolyte imbalance. Ketonaemia, or metabolic acidosis, are the consequence of increased lipolysis and ketoacid production as the body tries to generate energy.[5]

Criteria for the definition and classification of DKA include plasma blood glucose, pH and bicarbonate levels (*Table 1*).

Clinical symptoms

A history of polyuria and polydipsia is common. Nocturnal enuresis in a child previously dry by night should raise suspicion of diabetes. There may be a history of recent weight loss. As a symptom of respiratory compensation, patients may show a pattern of deep and slow breathing (Kussmaul breathing) and they may have chest pain. Some patients present with abdominal pain and vomiting. In the presence of cerebral oedema, consciousness can be altered.[5,6,10]

Management

Both the Australasian Paediatric Endocrine Group (APEG) and the International Society for Paediatric Diabetes (ISPAD) recommend immediate referral to specialist centres for suspected new onset T1DM/DKA to prevent fatalities. The following recommendations are based on APEG and ISPAD guidelines.[5,10]

Assessment

Medical history asking for the presence of polyuria and polydipsia, nocturnal enuresis and weight loss. In patients with known diabetes it is essential to know their regular therapeutic regimen and whether insulin has been omitted.

Full physical examination with assessments of weight, blood pressure, level of consciousness using the GCS and level of dehydration is recommended. (See the article 'Minor head injuries in children' by Luckoff and Starr, this issue, for GCS parameters and use in children.)

Biochemical investigations include BGL, urinalysis and ideally, a blood gas analysis (BGA) with bicarbonate, sodium and potassium levels. Bedside urinalysis and glucometer measurements are of exceptional value for both first diagnosis of T1DM and follow up of patients with known T1DM. Measurements allow differentiation between starvation ketones and DKA to guide initial management (*Table 2*).[12]

One study showed that the DKA rate of patients who had bedside analyses was significantly lower compared to those who had only formal blood tests or no investigations. A possible explanation was a delay in diagnosis and appropriate management while waiting for confirmation of blood test results.[2]

Resuscitation

Airway patency and breathing must be assessed and maintained. Patients with vomiting or impaired consciousness need a nasogastric tube. Severely shocked patients might require oxygen supplementation. In circulatory shock, IV fluid administration using 0.9% normal saline is indicated at a rate of 10–20 mL/kg over 1–2 hours. This may be repeated. Initial fluid supplementation lowers the BGL even before starting insulin therapy because of increased urinary glucose excretion.[13] There are no data to support the use of colloid solutions or bicarbonate in the treatment of DKA.[5,10]

Table 1. Classification of diabetic ketoacidosis

	Blood glucose (mmol/L)	Venous pH	Bicarbonate (mmol/L)
Mild	>11	<7.3	<15
Moderate	>11	<7.2	<10
Severe	>11	<7.1	<5

Monitoring

Monitoring is essential to assess changes in the patient's metabolic status and the risk for cerebral oedema.

Biochemical investigations consist of hourly BGL measurements and laboratory confirmation with venous glucose, sodium, potassium and blood gases at least every 4 hours. Monitoring of clinical signs includes hourly heart rate, respiratory rate, blood pressure and neurological assessment using the GCS.

Warning signs for cerebral oedema are headache, inappropriate slowing of heart rate, recurrence of vomiting, change in neurological status, rising blood pressure or decreased oxygen saturation. An electrocardiogram might be indicated to look for signs of potassium imbalance.

Rehydration

It is recommended to keep the patient nil per mouth. Fluids should be used cautiously and clearly documented. Intravenous rehydration is based on the use of 0.9% normal saline not exceeding 1.5–2.0 times the usual daily requirement. This includes IV or oral fluids that were given before the start of hospital management, but does not include urinary losses. If the BGL is lower than 15 mmol/L, 5% dextrose in 0.45% normal saline has to be used to ensure continuation of insulin therapy. This is to avoid further ketone production and keep the patient in an anabolic state. The infusion rate should to be adjusted to stabilise BGLs of 5–10 mmol/L.

Sodium

Pseudohyponatraemia can be caused as a dilutional effect of hyperglycaemia. The corrected sodium concentration can be calculated by adding 2 x (glucose –5.5)/5.5 to the sodium value (all values in mmol/L). A simpler approach is to add 2.0 mmol/L of sodium for every 5.5 mmol/L of glucose above 5.5 mmol/L.

Hypernatraemia is present at sodium levels >150 mmol/L. In this context, 0.45% normal saline is the preferred solution for IV rehydration and treatment should be extended to 48–72 hours.

Table 2. Interpretation of blood and urine analyses for ketones with suggestions for the initial management[12]

Blood ketones (mmol/L)	Urine ketones	Interpretation and initial management
<0.6	Negative/trace	• If BGL <5.5 mmol/L: implies – starvation – give CHO + fluids • If BGL >10 mmol/L: implies – increased risk of DKA – give CHO + fluids plus extra insulin
0.6–0.9	Trace/small	
1.0–1.4	Small moderate	
1.5–2.9	Moderate/large	
>3.0	Large	• EMERGENCY: always high risk of DKA – follow DKA protocol – contact specialist team

BGL = blood glucose level; CHO = carbohydrate unit

Potassium

At the time of presentation, serum potassium might be reduced, normal or elevated. Insulin therapy and correction of acidosis will increase intracellar potassium levels and lead to hypokalaemia. A common replacement dose is 5.0 mmol/kg/day or 40 mmol potassium chloride (KCl) per litre of IV fluid after the patient has passed urine. The maximum potassium infusion rate is 0.5 mmol/kg/hour. Cardiac monitoring is recommended.

Insulin therapy

The standard first insulin dose is 0.05 units/kg for preschool aged children; 0.1 units per/kg

for older children. Ideally, therapy will be commenced intravenously in a PICU or on a specialised diabetes ward. Depending on the setting, SC therapy may be preferable (in consultation with the diabetes specialist team) to stabilise the patient until IV therapy can be started. Short acting insulin (Actrapid) or insulin analogs (Novorapid, Humalog) can be used.

Cerebral oedema

There is no consensus on the pathophysiology of cerebral oedema. Contributing factors are lower partial pressure of arterial CO_2, higher serum urea nitrogen concentration at presentation, treatment with bicarbonate and a smaller increase in the sodium concentration during treatment.[1] Patients must be referred to an intensive care unit. Therapeutic options include fluid restriction, 0.45% normal saline and mannitol.

Recovery and follow up

Regular SC insulin therapy should be started and regular meals recommenced. After further stabilisation and completion of diabetes education, management should be continued on an outpatient basis and integrated into a specialist clinic that includes a multidisciplinary team consisting of diabetes educators, dieticians, psychologists, social workers and doctors. This will also allow follow up of results and confirmation of the diagnosis of T1DM.

Conclusion

Recognition of DKA can be improved by increasing the awareness for early clinical symptoms such as polyuria and polydipsia. It is important to include urinalysis and 'fingerprick' blood glucose and ketone measurements in the early assessment of patients with suspected T1DM and known T1DM, particularly if risk factors for DKA are present, to minimise serious complications and prevent fatal outcomes. Specific steps, as outlined in this article, must be followed to ensure successful initial management of DKA in the nonspecialist setting. Contact with a specialist team should be established early and maintained.

Resources

- Australian Paediatric Endocrine Group A. Guidelines on the management of diabetes in children and adolescents. National Health and Medical Research Council of Australia, 2005: www.nhmrc.gov.au/publications/synopses/cp102syn.htm
- Glasgow Coma Scale proforma: www.strokecenter.org/Trials/scales/glasgow_coma.pdf.

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