The Management of Diabetic Ketoacidosis in Adults

Where individuals aged 16-18 are managed by paediatric teams, the paediatric guidelines should be followed: BSPED | BSPE DKA Guidelines

Diagnostic criteria: all three of the following must be present:
- capillary blood glucose above 11 mMOL/L
- capillary ketones above 3 mMOL/L, or urine ketones ++ or more
- venous pH less than 7.3 and/or bicarbonate less than 15 mMOL/L

BOX 1: Immediate management: time 0 to 60 minutes

Give 1L 0.9% sodium chloride over the first 60 minutes. The addition of potassium is likely to be required in this second hour. Potassium replacement should be added as follows:

<table>
<thead>
<tr>
<th>Potassium level (mMOL/L)</th>
<th>Potassium replacement mmol/L of infusion solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 5.5</td>
<td>Nil</td>
</tr>
<tr>
<td>3.5-5.5</td>
<td>40 mmol</td>
</tr>
<tr>
<td>&lt; 3.5</td>
<td>senior review – additional potassium required</td>
</tr>
</tbody>
</table>

If intravenous access cannot be obtained request critical care support immediately.

Action 1: Commence 0.9% sodium chloride solution (use a large bore cannula) via an infusion pump.

See Box 2 for rate of fluid replacement.

Action 2: Commence a fixed rate intravenous insulin infusion (0.1 unit/kg/hr based on estimate of weight). 50 units human soluble insulin (Actrapid® or Humulin R) made up to 500 ml with 0.9% sodium chloride solution. If patient normally takes long acting insulin analogue (glargine, detemir, degludec) continue at usual dose and time.

Action 3: Assess patient.
- Respiratory rate, temperature, blood pressure, pulse, oxygen saturation
- Glasgow Coma Scale
- Full clinical examination

BOX 2: 60 minutes to 6 hours

Aims of treatment:
- Rate of fall of ketones of at least 0.5 mmol/L/hr OR bicarbonate rise 3 mmol/L/hr.
- Maintain normoglycaemia.
- Monitor potassium therapy.
- Avoid hypokalaemia.

Action 1: Re-assess patient, monitor vital signs.
- Hourly glucose levels (lab glucose 8 times: reading 14)
- Hourly blood ketones. If ketones >4 mmol/L consider insulin analogue.
- Venous blood gas for pH, bicarbonate and potassium at 60 minutes, 2 hours and 4 hours thereafter.
- If potassium is outside normal range, re-assess potassium replacement and check hourly. If abnormal after further one week of insulin therapy request senior medical advice.

Action 2: Continuous fluid replacement via infusion pump as follows:
- 0.9% sodium chloride 1L with potassium chloride over next 2 hours.
- 0.9% sodium chloride 1L with potassium chloride over next 2 hours.
- 0.9% sodium chloride 1L with potassium chloride over next 4 hours.
- Add 10% glucose 125ml/hr if glucose falls below 14 mmol/L

Consider reducing the rate of intravenous insulin infusion to 0.05 unit/kg/hr when glucose falls below 14 mmol/L.

More cautious fluid replacement in young people aged 16-25 years, elderly, pregnant, heart or renal failure. (Consider HDU and/or central line).

- Insulin infusion rate may need review if:
  - Capillary ketones not falling by at least 0.5 mmol/L/hr
  - Venous bicarbonate not rising by at least 3 mmol/L/hr
  - Plasma glucose not falling by at least 3 mmol/L/hr
  - Continue FRU II until ketonaemia less than 0.6 mmol/L/hr, venous pH >7.3 and/or venous bicarbonate above 18 mmol/L.

If ketones and glucose are not falling as expected always check the insulin infusion pump is working and connected and that the correct insulin residual volume is present (to check for pump malfunction).

If equipment working but response to treatment is inadequate, increase insulin infusion rate by 0.1 unit/hr increments hourly until targets achieved.

Additional measures:
- Regular observations and Early Warning Score (NEWS2).
- Accurate fluid balance chart, minimum urine output 0.5 ml/kg/hr.
- Consider urinary catheterisation if incontinence or anuria (not passed urine) by 60 minutes.
- Nephrotoxic tubular injury with strenuous hydration if patient obtunded or persistently vomiting.
- Measure arterial blood gases and repeat chest radiograph if oxygen saturation <90%.
- Thrombophlebitis with low molecular weight heparin.
- Consider ECG monitoring if potassium abnormal or concerns about cardiac status.

Additional action:
- Consider reducing the rate of intravenous insulin infusion to 0.05 unit/kg/hr when glucose falls below 14 mmol/L.
- If DKA resolved go to Box 6.

BOX 3: 6 to 12 hours

Aims of treatment:
- Ensure clinical and biochemical parameters improving
- Continue IV fluid replacement
- Avoid hypokalaemia
- Assess for complications of treatment e.g. fluid overload, cerebral oedema
- Treat precipitating factors as necessary.

Action 1: Re-assess patient, monitor vital signs.
- If patient not improving by criteria in Box 3, seek senior advice.
- Continue IV fluid via infusion pump at reduced rate.
- 15% sodium chloride 1L with KCl over 4 hours.
- 0.9% sodium chloride with KCl over 6 hours.
- Add 10% glucose 125ml/hr if glucose falls below 14 mmol/L.

Consider:
- Reducing the rate of intravenous insulin infusion to 0.05 unit/kg/hr when glucose falls below 14 mmol/L.

Reassess cardiovascular status at 12 hours; further fluid may be required.

Check for fluid overload

Action 2: Review biochemical and metabolic parameters.
- At 6 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose.
- Resolution of DKA is defined at ketonaemia <0.6 mmol/L AND venous pH >7.3 (do not use bicarbonate as a marker at this stage).

Ensure a referral has been made to the diabetes team.

If DKA not resolved review insulin infusion (see BOX 3 Action 3).

If DKA resolved go to Box 6.

BOX 4: 6 to 12 hours

Aims:
- Ensure clinical and biochemical parameters improving
- Continue IV fluid replacement
- Avoid hypokalaemia
- Assess for complications of treatment e.g. fluid overload, cerebral oedema
- Treat precipitating factors as necessary.

Action 1: Re-assess patient, monitor vital signs.
- If patient not improving by criteria in Box 3, seek senior advice.
- Continue IV fluid via infusion pump at reduced rate.
- 15% sodium chloride 1L with KCl over 4 hours.
- 0.9% sodium chloride with KCl over 6 hours.
- Add 10% glucose 125ml/hr if glucose falls below 14 mmol/L.

Consider:
- Reducing the rate of intravenous insulin infusion to 0.05 unit/kg/hr when glucose falls below 14 mmol/L.

Restrict fluid overload

Action 2: Review biochemical and metabolic parameters.
- At 6 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose.
- Resolution of DKA is defined at ketonaemia <0.6 mmol/L AND venous pH >7.3 (do not use bicarbonate as a marker at this stage).

Ensure a referral has been made to the diabetes team.

If DKA not resolved review insulin infusion (see BOX 3 Action 3).

If DKA resolved go to Box 6.

BOX 5: 12 to 24 HOURS

Expectation: By 24 hours the ketonaemia and acidosis should have resolved. Request senior review is not improving.

Aims:
- Ensure that clinical and biochemical parameters are continuing to improve or are normal.
- Continue IV fluid replacement if not eating and drinking.
- If ketonaemia has cleared and the patient is not eating or drinking, transfer to a variable rate intravenous insulin infusion (VRIII) as per local guidelines.
- Assess for complications of treatment, e.g. fluid overload, cerebral oedema.
- Continue to treat precipitating factors.
- Transfer to subcutaneous insulin if the patient is eating and drinking normally and biochemistry is normal.

Action 1: Re-assess patient, monitor vital signs.

Action 2: Review biochemical and metabolic parameters.
- At 12 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose.
- Resolution is defined as ketonaemia <0.6 mmol/L, venous pH >7.3 and/or glucose <14 mmol/L.
- If resolved move Box 4 Action 1 and insulin infusion Box 3.

Action 3: If DKA resolved go to Box 6.

BOX 6: Resolution of DKA

Expectation: Patient should be eating and drinking and back on normal insulin.

If DKA not resolved identify and treat the reasons for failure to respond. This situation is unusual and requires senior and specialist input.

Transfer to subcutaneous insulin.

Convert to subcutaneous regime when biochemically stable (capillary ketones <6 mmol/L, AND pH over 7.3 and the patient is ready and goes to eat). Do not discontinue intravenous insulin infusion until 30 minutes after subcutaneous short acting insulin has been given. Conversion to subcutaneous insulin should be managed by the Specialist Diabetes Team. If the team is not available use local guidelines. If the patient is newly diagnosed it is essential they are seen by a member of the specialist team prior to discharge.

Arrange follow up with specialist team.

Represented: Association of British Clinical Diabetologists; British Society for Endocrinology and Diabetes and Association of Children’s Diabetes Clinicians; Diabetes Inpatient Specialist Nurse (DISN) Group; Diabetes UK; Diabetes Network Northern Ireland; Society of Acute Medicine; Welsh Endocrine and Diabetes Society, Scottish Diabetes Group.