1. Introduction

DKA is a potentially life-threatening medical emergency due to absolute or relative insulin deficiency coupled with counter-regulatory hormones excess.

2. Aim

To provide a guideline for management of the patient presenting with DKA.

The objective of this guideline is to:

- Recognise DKA early
- Correct metabolic disturbances (dehydration, ketoacidosis, hyperglycemia)
- Prevent complications
- Identify and treat precipitating events

3. Parameters of the guideline:

These guidelines are intended for the management of children who present with DKA

4. Definition:

A. DKA: Diabetes Ketoacidosis

Clinical & Biochemical Criteria

<table>
<thead>
<tr>
<th>Clinical history</th>
<th>Clinical signs</th>
<th>Biochemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyuria, polydipsia, polyphagia, wt loss or abdominal pain or vomiting</td>
<td>Varying degree of dehydration, Kussmaul respiration, fruity (acetone) smell, altered sensorium</td>
<td>RBS &gt;11mmol/l, Venous Blood Gas (pH &lt;7.3mmHg, HCO₃ &lt;15 mmol/l), ketonemia or ketonuria and glycosuria</td>
</tr>
</tbody>
</table>

B. CBG – Capillary Blood Glucose

6. Emergency Management:

A. Resuscitation

Airway: If comatose, insert airways & NG tube
Breathing: Give oxygen via face mask (even if O₂ Sat > 95% in RA)
Circulation: Insert IV cannula + IA line & take blood samples (see below)
Cardiac monitor (ECG for hypo/hyperkalemia) + IDC
If in shock, give 10ml/kg normal saline bolus ½-1hr, maximum of 30mls/kg to restore circulation. (N.B. Discuss with the Consultant if the patient has received 30mls/kg)
Immediate assessment

Clinical History
- Polyuria
- Polydipsia
- Wt loss (Weigh)
- Abdominal pain
- Weakness
- Vomiting
- Confusion

Clinical Signs
- Assess dehydration
- Deep sighing respiration (Kussmaul)
- Smell of ketones
- Lethargy/drowsy +/- vomiting

Biochemical features & investigation
- Ketones in urine
- Elevated blood glucose
- Acidaemia
- Blood gases: urea, electrolytes
- Others: investigations as indicated

Diagnosis confirmed
Diabetic Ketoacidosis
Call senior staff/Consultant.

Resuscitation
- Airway + NG tube
- Breathing (100% O₂)
- Circulation (0.9% saline 10-20 ml/kg over 1-2h & repeat until circulation is restored) but do not exceed 30ml/kg

IV Therapy
- Calculates fluid requirement
- Correct over 48 hrs
- Saline 0.9%
- ECG for T wave changes
- Add KCL 40mmol per litre fluid
- Continuous insulin infusion 0.1ml/kg/hr

Clinical observations
- Hourly blood glucose
- Hourly fluids input & output
- Neurological status at least hourly
- Electrolytes at least 2 hourly after start of IV therapy
- Monitor ECG for T-wave changes

Re-evaluate
- IV fluid calculations
- Insulin delivery system & dose
- Need for additional resuscitation
- Consider sepsis

IVF Therapy
- Change to 0.45% saline + 5% glucose
- Adjust sodium infusion to promote an increase in measured serum sodium
- Improvement
- Clinically well, tolerating oral fluids

Transition to SC insulin
- Start SC insulin then stop IV insulin after 30 minutes

Therapy
- Start with SC insulin. Continue oral fluids
- No improvement

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Management
- Give mannitol 0.5-1g/kg, Restrict IV fluids by 1/3, Call senior staff
- Move to ICU, Consider cranial imaging only after patient is stable

Urea & electrolytes (electrolytes from blood gases can be used)
- Blood gases (venous give very similar pH & CO₂ to arterial)
• HbA1c
• Urine ketones and glucose (N.B. Blood ketones is more superior to urine ketones)
• Islet cell antibodies, insulin antibodies, GAD antibodies, antiendomyseal IgA antibodies and TFTs for all newly diagnosed patients.
• Other investigations only if indicated: FBC, Urinalysis, Chest X-Ray and Cultures (blood, urine, throat, CSF) then give appropriate antibiotics

(N.B. leukocytosis is common in DKA and does not necessarily indicates sepsis, unless there is fever)

9. Management

A. Fluids

• Treat shock with bolus 10mls/kg 0.9% saline over 1/2-1hr, (max. of 30mls/kg), (if further fluid boluses required at this stage, discuss with consultant)
• After restoration of BP, all children with DKA and unequivocal signs of dehydration should be given the following amount of IVF (based on maintenance requirements of 80% of normal, and 3-5% of dehydration corrected over 48hrs) irrespective of their apparent degree of dehydration (see table below):

<table>
<thead>
<tr>
<th>Wt (kg)</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ml/hr)</td>
<td>24</td>
<td>28</td>
<td>32</td>
<td>36</td>
<td>40</td>
<td>45</td>
<td>50</td>
<td>55</td>
<td>65</td>
<td>70</td>
<td>75</td>
<td>80</td>
<td>90</td>
<td>95</td>
<td>105</td>
<td>110</td>
</tr>
</tbody>
</table>

(N.B. this fluid rate (ml/hr) includes deficit AND maintenance fluid needs)

• Fluid therapy should be reviewed if oliguria develops due to tubular necrosis caused by severe hypotension before resuscitation may require fluid restriction. But persistent hypovolemia may require extra fluids
• Initial fluids should be 0.9% saline or Lactated Ringers with 40mmol KCL in 1 L for the 1st 48 hrs (see section on Potassium).
• Change IVF to 5% dextrose (add 100mls of D50% in 900mls 0.9 N/S), you can increase the dextrose concentration to as high as 12.5% (discuss with consultant)¹
• Indications of adding glucose in the maintenance fluids:
  ➤ Serum glucose is 14 mmol/l
  ➤ Rapid drop in blood glucose level (>5-8 mmol/l per hr) even if the serum glucose is >14 mmol/l
  ➤ Ketacidosis remains despite correction of hyperglycemia
• Give 2-5ml/kg D10% bolus if CBG 3-4mmol/l
• Do not change the IVF to 0.45% saline if the corrected Na level does not rise ¹
• Start oral fluids when clinically improved. (N.B these oral fluids should be subtracted from IVF if still within 48 hrs)

B. Insulin

• No initial insulin bolus
• Start insulin after 1 hr of initial IVF
• Add 50 units insulin “short acting” (regular) to 49.5mls of 0.9% saline to make 1 units/ml solution. **Prime giving set prior to commencing infusion**
• Run at 0.1 unit/kg/hr, *(N.B. in <5yrs and neonates start with 0.05unit/kg/hr).*
• Correct ketoacidosis **first before** hyperglycemia.
• **Do not reduce or stop insulin infusion, instead add glucose in the IVF** *(see Fluids)*
• Blood glucose fall rate should be 3-5 mmol/l per hour
• Keep blood glucose at 8-12mmol/l
• The best time to change insulin infusion to SC is just before a meal, when the child is alert and metabolically stable (glucose 8-12mmol/l, pH >7.3 & HCO₃ >15). The insulin infusion should only be stopped 30mins after the 1st SC insulin injection.

C. **Potassium**
• Start KCl at a concentration of 40-60mmol/l (40mmol if Body Wt <30kg, and 60mmol if >30kg)
• Extreme care should be taken if the initial serum K is >5.5mmol/l or if the patient is anuric. Check ECG monitor for peak T waves *(Disc. with Consultant)*

D. **Bicarbonate**
• Discuss with the Consult.

E. **Monitoring & Observation**

<table>
<thead>
<tr>
<th>Hourly blood glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hourly fluid input and output</td>
</tr>
<tr>
<td>Neurological status at least hourly</td>
</tr>
<tr>
<td>Electrolytes and blood gases 2 - 4hourly after start of IV therapy</td>
</tr>
<tr>
<td>BP, PR, RR 1-2 hourly &amp; Temperature 4 hourly.</td>
</tr>
<tr>
<td>Urine ketones and glucose 4 hourly or every voids</td>
</tr>
<tr>
<td>Monitor ECG for T-wave changes</td>
</tr>
</tbody>
</table>

F. **Complications of therapy**

• Hypoglycemia
• Hypokalemia
• Aspiration pneumonia
• Cerebral oedema

10. **Cerebral edema**

• If suspected, exclude hypoglycemia and **inform Consultant immediately**.
• **Treatment:**
  1. Keep NBM, give 100% O₂, and elevate the head of the bed by 30°
  2. Reduce the rate of IVF to 2/3 of the calculated IVF
  3. Give mannitol 0.5-1g/kg IV over 20 mins, may repeat if no initial response in 30 mins to 2hrs.
  4. Hypertonic saline (2.7-3%) 5-10 ml/kg over 30mins may be an alternative or a second line of therapy if no initial response to mannitol
  5. Intubation and mechanical ventilation for impending respiratory failure, avoid aggressive hyperventilation (keep PCO₂ at 30-35 mmHg)

11. Transition from Insulin infusion to Subcutaneous:

   **Step1. Determine the Total daily Insulin Requirement using a Sliding Scale**
   - Subcutaneous insulin therapy is initiated with regular (short acting) insulin given in a dose of 0.2U/kg/dose, with the subsequent dose being adjusted every 6 h, depending on the response as judged by the blood glucose levels and ketonuria
   - Monitor CBG 4 times/day (pre-meals & after midnight)
   - Use Table Appendix 2 Column 1, 2 & 5 for calculating and adjusting a sliding scale

   **Step 2. Use Twice Daily Insulin Regimen**
   - Divide the Total daily Insulin Requirement into (2/3 before breakfast, 1/3 before dinner)

   **Step 3. Determine components of each dose**
   - 2/3 of each dose as intermediate-acting (Isophane) insulin.
   - 1/3 as short-acting (Regular)
   - If using mixtard insulin, give 2/3 dose in the morning and 1/3 in the afternoon

**NOTE:**
- CBG can still be fluctuating even after a fixed insulin-meal regimens as calculated above
- First exclude inter-current illness or stress etc.
- Use “10% rule” for insulin dose changes after determining the time at which abnormal CBG occurs.
- Modify insulin doses by 10 %, e.g. *if CBG is persistently out of range before dinner then the dose modification applies only to the morning or lunch time insulin and the amount is determined by 10% of the morning dose.*

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**Appendix 1**

- **Anion gap:** \((12 \pm 2\text{mmol/l}): (\text{Na} + \text{K}) – (\text{Cl} + \text{HCO}_3)\)
• **Osmolality**: \((280 – 300 \text{mmol/l})\): \(2(\text{Na} + \text{K}) + \text{Glucose}(\text{mmol/l}) + \text{Urea}\)

• **Corrected Na**: \(\text{measured Na} + [2(\text{plasma glucose (mmol/l)} - 5.6)] ÷ 5.6\)

• **Fluid calculation**: use this link: [Tools\correctedNA.pdf](Tools\correctedNA.pdf)

**Appendix 2**

**TABLE 1: Subcutaneous Insulin Dosing**

<table>
<thead>
<tr>
<th>AGE (YR)</th>
<th>TARGET GLUCOSE (MMOL/L)</th>
<th>TOTAL DAILY INSULIN (U/KG/D)</th>
<th>BASAL INSULIN, % OF TOTAL DAILY DOSE</th>
<th>Units Added per 5.5mmol/l above Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–5</td>
<td>5.5-11.1</td>
<td>0.6–0.7</td>
<td>25–30</td>
<td>0.50</td>
</tr>
<tr>
<td>5–12</td>
<td>4.4-8.3</td>
<td>0.7–1.0</td>
<td>40–50</td>
<td>0.75</td>
</tr>
<tr>
<td>12–18</td>
<td>4.4-8.3</td>
<td>1.0–1.2</td>
<td>40–50</td>
<td>1.0–2.0‡</td>
</tr>
</tbody>
</table>

* Newly diagnosed children in the “honeymoon” may only need 60–70% of a full replacement dose. Total daily dose per kg increases with puberty.

‡ For finer control, extra insulin may be added in 2.8mmol/l increments.

**TABLE 2: A 6 Hourly Sliding Scale for SC insulin**

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Insulin SC</th>
<th>CBG (mmol/l)</th>
<th>5-10</th>
<th>10-15</th>
<th>15-20</th>
<th>&gt;20</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>Insulin</td>
<td>0.15U/kg/dose</td>
<td>0.15U/kg/dose + 0.5Unit</td>
<td>0.15U/kg/dose + 1Unit</td>
<td>GO BACK TO INSULIN INFUSION</td>
<td></td>
</tr>
<tr>
<td>5-12</td>
<td>Insulin</td>
<td>0.2U/kg/dose</td>
<td>0.2U/kg/dose + 0.75Unit</td>
<td>0.2U/kg/dose + 1.5Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-18</td>
<td>Insulin</td>
<td>0.25U/kg/dose</td>
<td>0.25U/kg/dose + 1Unit</td>
<td>0.25U/kg/dose + 2Units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(N.B. The above Sliding scale table is derived from Table 1)

**Appendix 3: Diagnostic criteria for Cerebral Edema in children with DKA**

1. Diagnostic criteria for cerebral edema
• Abnormal motor or verbal response to pain
• Decorticate or decerebrate posture
• Cranial nerve palsy (especially III, I V and VI)
• Abnormal neurogenic respiratory pattern (e.g. grunting, Cheyne-Stoke respiration, apnea)

2. Major criteria
• Altered mentation/fluctuating level of consciousness
• Sustained heart rate deceleration (decrease of >20 beats/min) not attributing to improved intravascular volume or sleep state.
• Age-inappropriate incontinence

3. Minor criteria
• Vomiting
• Headache
• Lethargy or not easily arousable
• Diastolic BP >90mmHg
• Age <5 years

To diagnose Cerebral Edema, the following criteria has to be met: (N.B. These criteria has 92% sensitivity & 4% false positive rate)

- 1 diagnostic criterion OR
- 2 major criteria OR
- 1 major and 2 minor criteria.

References:
2. Edge JA. BSPED Recommended DKA Guidelines 2009, November 2009
15. http://www.bsped.org.uk/professional/guidelines/

Scope and Application
This CPG is intended for use by all health care workers in their daily care of paediatric patients
<table>
<thead>
<tr>
<th><strong>Effective Date</strong></th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supercedes Policy Number</strong></td>
<td>Not applicable</td>
</tr>
<tr>
<td><strong>Review Responsibilities</strong></td>
<td>The Chairperson of the Paediatric CSN will initiate the review of this guidelines every 3 years from the date of issue or as required.</td>
</tr>
<tr>
<td><strong>Further Information</strong></td>
<td>Paediatric CSN Chairperson</td>
</tr>
</tbody>
</table>

**RESPONSIBILITY:**
**CPG Owner:** National Paediatric CSN

**CPG Writer:** Ministry of Health  
**Date:** 2010

**Endorsed:**
National Medicines & Therapeutic Committee, MOH  
**Date:** 23 November 2010

**Endorsed:**
National Health Executive Committee, MOH  
**Date:** 25 November 2010