DIABETIC KETO-ACIDOSIS

Guidelines, incorporating flowsheet, for hospital management

Patient Name: ___________________________    Folder Number: ____________
Completed by: ___________________________     Date: _____________

Diagnosis

Signs and symptoms
- newly diagnosed diabetes
- known diabetes with _______ previous admissions for DKA

Precipitating cause(s)
- infection;
- psychosocial;
- omission of insulin;
- deficient patient/parent/school education
- health service problems;
- other________________

Potential pitfalls in diagnosis
- Children may appear well despite gross metabolic imbalance
- Abdominal symptoms may mimic an acute abdomen DKA can occur without pronounced hyperglycaemia
- Hyperglycaemia may cause false hyponatraemia
- Creatinine assay may be falsely elevated by ketones (i.e. aceto-acetate)
- Outdated reagent strips may not show ketones

Red flags: factors which indicate a need for increased vigilance
- multiple admissions
- toddler / adolescent
- significant weight loss
- educationally disadvantaged

Assessment of severity (circle applicable)

<table>
<thead>
<tr>
<th>Airway</th>
<th>Critical</th>
<th>Narrow</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breathing</td>
<td>Needs IPPV</td>
<td>Needs oxygen</td>
<td>Hyperventilation</td>
</tr>
<tr>
<td>Circulation</td>
<td>Shock (cap refill&gt;3s)</td>
<td>Hypovolaemia</td>
<td>Hypervolaemia</td>
</tr>
<tr>
<td>Consciousness (AVPU)</td>
<td>Unconscious</td>
<td>Response to Pain</td>
<td>Response to Voice</td>
</tr>
<tr>
<td>Dehydration</td>
<td>In hospital</td>
<td>Before arrival</td>
<td>Past</td>
</tr>
<tr>
<td>Acidosis</td>
<td>PH &lt; 7.1</td>
<td>pH &lt; 7.3</td>
<td>PH ≥7.3</td>
</tr>
<tr>
<td>Infection</td>
<td>SIRS (“toxic shock”)</td>
<td>Needs IV agent</td>
<td>Needs oral agent</td>
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Management principles

Phase 1 (acute): correct the DKA

Fluid management is the most important initial intervention (before insulin therapy)

- correct hypovolaemic shock immediately
- correct dehydration slowly over 24 - 48 hours
- correct glucose changes over 24 hours with insulin
- avoid hypokalaemia, hyponatraemia, hypoglycaemia

Be aware of the risk of cerebral oedema, which usually occurs 6-24 hours after initiation of therapy; rehydration, which is too rapid, has been implicated

Phase II: transition

- establish oral feeds and change to subcutaneous insulin, aiming for reasonable in-hospital control

Phase III: achieve ‘normality’

- devise a ‘life plan’ involving the family and the diabetes service (see ‘Looking after Children with Diabetes’)
Management: Phase I: Keto-acidosis and hypovolaemic shock

1) Fluid therapy

a. Resuscitation
- Oxygen 100% by facemask
- Normal saline 0.9% 10ml/kg over 10-30 minutes. Repeat if peripheral pulses remain poor, until shock corrected
- Insert nasogastric tube if there is vomiting, impaired consciousness
- If the referral centre is more than 1 hour away, 0.9% saline should continue at 10 ml kg/hr for 1-2 hours, then at a rate of 5 ml kg/hr

b. Rehydration and maintenance requirements = Maintenance + Deficit + excess urine losses (if known)

Maintenance (continue NORMAL SALINE in most cases)

<table>
<thead>
<tr>
<th>Weight</th>
<th>Maintenance Rate (ml/kg/24 hrs)</th>
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<tbody>
<tr>
<td>&lt; 20 kg</td>
<td>80 ml/kg/24 hrs</td>
</tr>
<tr>
<td>20-30 kg</td>
<td>60 ml/kg/24 hrs</td>
</tr>
<tr>
<td>&gt; 30 kg</td>
<td>50 ml/kg/24 hrs</td>
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</table>

Deficit (Review_6 hourly)

<table>
<thead>
<tr>
<th>Dehydration Level</th>
<th>Deficit Rate (ml/kg over 24-48 hrs)</th>
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<tbody>
<tr>
<td>5%</td>
<td>50 ml/kg over 24-48 hrs = 2.1 – 1.0 ml/kg/hr</td>
</tr>
<tr>
<td>10%</td>
<td>100 ml/kg over 24-48 hrs = 4.2 – 2.1 ml/kg/hr</td>
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Excess urine losses
Replace urine losses in excess of 2 ml/kg/hour = urine output (ml/kg/hr)

Reassess patient and review fluid therapy calculations frequently

Note: Children < 5% dehydrated, with a pH > 7.3, who are clinically well, may tolerate oral rehydration and soluble insulin.

2) Potassium
- Start K+ replacement as soon as resuscitation is completed. Make sure the ECG does not show elevated T-waves and serum K+ is not > 4.5 mmol/l. If initial K+ is elevated, wait until it reaches < 4.5 mmol/l before giving K+ replacement
- Concentration of KCl in IV solutions should be 40 mmol/l (40 mmol KCl = 20 ml of 15% KCl)
- In the presence of oliguria, delay K+ supplements for 30-60 minutes; monitor K+ levels & ECG T-waves
- Potassium phosphate is preferable in severe DKA, but it is not essential (if unavailable, use KCl instead)
- For the 1st 6 hours add equal volumes of KCl and potassium phosphate to IV solutions; after 6-12 hours of phosphate supplementation use KCl only
- Calculation:
  - 1ml KCl 15% = 2mmol K+; 1gram KCl = 13mmol K+
  - 1ml K2HPO4/KH2PO4 = 2 mmol K+ & 1.4 mmol PO4

3) Insulin: use soluble insulin e.g. Actrapid HM or Humulin R
- Start insulin when shock has been corrected and the child is on a fluid regime (see above)
- If a prolonged delay in arrival in a high care unit is anticipated, the responsible doctor must discuss with the receiving doctor possible commencement of insulin therapy. Insulin should NOT be given in transit
- Optimal method: Continuous low-dose IV insulin infusion by syringe pump, not by gravity controller
  - 0.1 units/kg/hour (0.05 units/kg/hour if < 5 years old); for 0.1 units/kg/ml, mix 25 units Insulin solution in 100ml 0.9% saline; run this at (0.4 x patient's mass in kg) ml/hr to give 0.1 units/kg/hr
  - (alternatively – for 0.1 units/kg/hr – 10 units for every 100ml of fluid i.e. 0.1 unit/ml, run at patient's body weight in ml/hr to give 0.1units/kg/hr)

Notes
- if the patient weighs > 25kg, double the concentration of insulin and halve the rate of infusion
- run about 20 ml of the saline-insulin mixture through tubing before connecting to patient
- If a syringe pump is not available, the following methods may be used:
  1) Mix 50 units soluble insulin in 500ml normal saline (i.e. 1 unit insulin / 10 ml saline) and use infusion rate = 0.1 units/kg/hr (=1ml/kg/hr). Change the bag every 24 hr to avoid insulin inactivation
  OR
  2) Give hourly bolus injections of Actrapid HM 0.1 units/kg/hour into the IV line
Adjustments to insulin and glucose therapy

1) Continue insulin infusion at 0.1U/kg/hr until acidosis and ketonuria much improved

**WARNING:** severe keto-acidosis will NOT improve if the insulin infusion rate is < 0.08-1U/kg/hr

2) Once acidosis corrected and ketonuria mild, reduce insulin to 0.03-0.06U/kg/hr
3) When blood glucose (BG) falls to 12- 15 mmol/l, change to rehydration fluid (5% dextrose in 0.45% normal saline)
4) Maintain the BG at 8 - 12mmol/l
5) If BG rises again above 15 mmol/l, increase insulin infusion by 25%
6) If BG falls to < 8 mmol/l and the child remains ketonuric, increase the concentration of glucose to 7.5-10%), maintaining the insulin infusion at 0.03-0.06U/kg/hr. **The infusion rate should only be decreased if the BG remains below 8 mmol/l despite glucose supplementation**

4) Sodium therapy
   - If serum sodium does not increase, or if it falls, increase the concentration of the saline from 0.45% - 0.9 %; observe carefully for signs of cerebral oedema. (Certain studies have correlated a fall in serum sodium with impending cerebral oedema.)
   - If initial Na⁺ > 150mmol/l change to 0.45% saline; consider slower rehydration (>48 hours)
   - Hypoglycaemia may cause false hyponatraemia:
     \[\text{Corrected Na}^+ = \text{Na}^+ + 2 \times (\text{BG} - 5.5)/5.5\]

5) Oral Fluids
   - In severe dehydration and acidosis, allow only sips of water
   - Oral fluids should only be offered after substantial clinical improvement and no vomiting
   - Subtract oral fluid volumes from IV calculations

6) Sodium bicarbonate: consult critical care service before use
   - Sodium bicarbonate therapy is controversial. It should not be used in the initial resuscitation. There is no evidence that it is necessary or safe in DKA

<table>
<thead>
<tr>
<th>Persistent acidosis is likely to be caused by inadequate resuscitation, inadequate insulin, or sepsis</th>
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<tbody>
<tr>
<td>• NaBic may be considered for impaired myocardial contractility in persistent severe shock</td>
</tr>
<tr>
<td>◦ Give NaBic 1-2mmol/kg over 1 hour</td>
</tr>
<tr>
<td>• Discontinue sodium bicarbonate infusion when pH &gt; 7.15 or standard bicarbonate &gt; 8 mmol/l</td>
</tr>
</tbody>
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7) Magnesium
   - If magnesium is low, add 2ml MgSO₄ to each litre of intravenous fluid, for 6 hours. Monitor Mg levels closely

8) Antibiotic therapy
   - As indicated clinically. Remember that infection may precipitate DKA

9) Management of stomach and bladder
   - If patient is unconscious or persistently vomiting aspirate stomach & leave naso-gastric tube on free drainage
   - If patient is unable to pass urine after 4 hours of volume replacement and bladder is full/ palpable, insert a catheter

Monitoring in phase I

- Ward glucometer: monitor hourly
- Blood glucose, ketones: every 2-4 hours
- Blood U&E, creatinine, acid-base, phosphate, magnesium every 2-4 hours until acidosis reversed
- Urine volume (consider catheter)
- Urine glucose, ketones

| Level of consciousness (Children's Coma Scale) |
| Heart rate, blood pressure, hydration hourly |
| Respiratory rate, pattern hourly |
| ECG monitoring: assess T-waves |
| Treatments prescribed and given: fluids, electrolytes, insulin (at every change or new order) |

Discharge planning:

- start planning discharge on admission - see page 5

Complications to watch for

1) Cerebral oedema
   - Cause remains unclear; however, too rapid a reduction in intravascular osmolality may aggravate the process
   - It usually develops in the 1st 24 hours, as patient seems to be improving

Signs: headache, change in level of consciousness (e.g. restlessness, irritability, drowsiness, incontinence), bradycardia, increasing BP, decreasing oxygen saturation. Convulsions, papilloedema and respiratory arrest are late signs with very poor prognosis.
Treatment of cerebral oedema:
1) exclude hypoglycaemia
2) mannitol 1 g/kg IV immediately over 20 minutes (i.e. 5ml/kg 20% solution), then repeat boluses 0.5-1g/kg 4-6 hourly
3) halve rehydration rate
4) elevate head
5) call senior staff, move child to ICU as soon as possible
6) consider cranial imaging only after patient stabilised

2) Technical
   - Insulin drip "tissues", blocks, leaks or infusion rate is uncontrolled

3) Recurrence of keto-acidosis due to prematurely stopping insulin infusion
   - When changing to intermittent therapy, stop the insulin infusion 30 minutes after subcutaneous insulin has been given

4) Hypoglycaemia and hypokalaemia
   - Avoid by careful monitoring and adjustment of infusion rate

5) Hyperkalaemia
   - Risk is increased with oliguria and K+ treatment

6) Aspiration pneumonia
   - Avoid by inserting nasogastric tube in vomiting child with impaired consciousness

Management phase II - the transitional period post keto-acidosis
1) Goals
   - blood glucose of 6-10 mmol/l (5-15mmol/l in hospital is satisfactory)
   - establish oral feeds while adjusting subcutaneous insulin, aiming for reasonable in-hospital control

2) Fluids and food
   - Start oral fluids when there is a clinical improvement and nausea has settled
   - Begin with water or flavoured oral "cell repair fluid" (50g glucose + 4g K2HPO4 in 1l water); then milk, reducing IV fluids accordingly
   - Add solids - diabetes diet! - when fluids tolerated

3) Subcutaneous Insulin
   - Types include:
     - Clear (regular, soluble) Insulin: Actrapid HM, Humulin R.
     - Intermediate (milky) Insulin: Monotard HM, Protophane HM, Humulin N
   - Technique:
     - Change to intermediate SC insulin on clinical recovery and resolution of ketonaemia. make the switch to SC insulin at a mealtime, preferably breakfast
     - Stop the insulin infusion after SC insulin has been started.

4) Calculation of insulin requirements

Adjust insulin therapy cautiously according to blood sugar; aim to keep blood glucose at 5-15mmol/l (in hospital). Use “mop-up” ACTRAPID 0.5-2U SC if BG > 15mmol/l
Monitor BG pre-meals and bedtime
Monitor urine glucose and ketones before breakfast and supper

If not newly diagnosed:
   - Go to insulin doses as for pre-DKA admission and adjust according to response. If cause for DKA was poor control, you may need to increase dose.

Usually cause is transient (eg. Infection) and pre-DKA doses will be sufficient to control sugar before discharge.

If newly diagnosed:

TDD = Total daily dose insulin = 0.6 units x weight (kg)

a. 4 per day regimen (for severe cases)
   - Give 20% TDD as clear insulin with each meal and 40% TDD as intermediate insulin at 10pm

b. 3 per day regimen (for moderate cases)
   - Give ⅔ TDD as clear + intermediate insulin mixed 1:2 at breakfast, ⅓ TDD as clear insulin at early supper, ⅓ TDD as intermediate insulin at bed time

c. 2 per day regime (or mild cases)
   - Mix regular and intermediate insulin 1:2, give ⅔ TDD at breakfast, ⅓ TDD at supper
Discharge Planning - Criteria for discharge

Complete on discharge, but fill in as much as possible on admission!

- Patient well and stable on the SC insulin regime that will be used at home
  - injection technique
  - dose accuracy
  - monitoring blood glucose; urine glucose, ketones
- Parents and/or child and/or school teacher proficient in
  - injection technique
  - dose accuracy
  - monitoring blood glucose; urine glucose, ketones
- Diabetes service has been consulted
- Follow-up appointment has been made with diabetes clinic
- Medic-Alert badge ordered & inscribed: “diabetes on insulin- give sugar if confused”

Address: Medic-Alert Foundation of South Africa, PO Box 4841, Cape Town 8000

- managing diet and exercise
- avoiding, recognising and treating hypoglycaemia
- avoiding, recognising and treating ketoacidosis

Management phase III - long term

Empowerment to maintain metabolic control, with normal development, normal activity and normal education

1) Medical/Dietary / Psychological/Social/Educational support
   - Refer to a diabetic education centre
   - Address: SA Diabetes Association, National Office, PO Box 3943, Cape Town 2000
   - Greys Hospital: 033 897 3185 (working hours) 033 8973014 (after hours)

2) Dietary advice for parents and child
   - arrange consultation with dietician
   - avoid hypoglycaemia with snacks between meals, before exercise, and at bedtime
   - teach patient, family and teachers the warning signs and management of hypoglycaemia and ketoacidosis
   - treat hypoglycaemia with glucose polymer or sweets orally or with GLUCAGON 0.5 - 1mg SC

3) Dietary calculations
   - Energy needs in kJ = 4200 + 420 x (age in yrs - 1)
     - Complex carbohydrates 50% total energy; restrict simple carbohydrates
   - Fat = 30% total energy; poly-unsaturated/saturated fatty acid (P/S) ratio increased to 1.2: 1 protein = 20% total energy