MANAGEMENT OF DIABETIC KETOACIDOSIS (DKA)

Aetiology
- Complete or near complete lack of insulin, resulting in decreased peripheral glucose utilization and increased gluconeogenesis, lipolysis and ketogenesis
- Can also occur during severe physiologic stress – insulin requirements cannot be met by the diabetic pancreas
- Can occur in IDDM NIDDM or first manifestation of diabetes mellitus

Clinical Features
- Constitutional – malaise, weakness, myalgia
- Abdominal pain, nausea and vomiting
- Polyuria, polydipsia and loss of weight
- Signs of volume depletion and hypoperfusion +/- hypovolaemic shock
- Hyperventilation Kussmaul’s breathing in severe acidosis), ketotic breath, pyrexia
- Pyrexia
- Delirium, reduced conscious level, coma
- Evidence of precipitating causes
  - Sepsis eg UTI, respiratory tract infection, bacterial meningitis, retropharyngeal abscess, hepatobiliary sepsis. Examine for sources of sepsis include “hidden” sites eg scalp, back, auditory meatus, perianal region
  - Noncompliance with diet or insulin therapy
  - Trauma
  - AMI
  - CVA
  - Pancreatitis
  - Drug or alcohol use

Laboratory Findings
- Hyperglycaemia (BSL >15mmol/L)
- Ketosis
  - Serum and urine detection uses nitroprusside reaction
  - Urine ketones positive (+ or more). Standard dipsticks only detect acetoacetate and acetone. Cannot detect $\beta$-hydroxybutyrate
  - $\beta$-hydroxybutyrate:acetoacetate ratio is 3:1 in vivo. Ratio increase >3:1 during tissue hypoperfusion and hypoxia (acetoacetate → $\beta$-hydroxybutyrate) and decreases the apparent ketone detected, even though total ketones may be unchanged
- Metabolic acidosis (pH<7.3)
- High anion gap (25-35 mmol/L)
- Dehydration (urea:creatinine ratio increased)
Renal impairment
- Hypovolemia, pre-renal
- Underlying DM nephropathy
- Lab interference (Jaffe reaction) due to high circulating acetoacetate

HypoK⁺/hyperK⁺
- HyperK⁺ initially, then hypoK⁺ after insulin therapy

HypoNa⁺/hyperNa⁺
- Hyponatraemia may be real (dilutional from osmotic effect of hyperglycaemia initially)
- Or expected as a result of hyperglycaemia (correction factor: \( \Delta Na = -0.016 \times (\text{glucose} - 100) \))

HypoPO₄, hypoMg⁺⁺

Patients with chronic renal failure tend to have milder hyperglycaemia and dehydration, and more severe acidosis

Investigations
- CBC, U/Cr/Na/K/Cl/PO₄/MgGlucose, ABG, serum osmolality
- Urine for ketones may be negative initially in DKA (see above). Repeated hourly for 3 hours if diagnosis is strongly suspected
- Urine microscopy and culture
- Blood culture+/- lumbar puncture in a septic patient
- ECG
- CXR

Principles of Management
1. Aggressive fluid management
2. IV soluble insulin
3. Aggressive K replacement except in renal failure
4. Look for precipitating factors

Treatment
1. Fluid therapy
   - Aggressive fluid replacement about 2 L in 4 h, 1-2 L in the next 4 h; about 4-7 L in total within the first 24 h
   - NS is preferred because it helps to maintain intravascular volume and maintain peripheral perfusion and hence, clearance of ketones. It may also reduce risk of cerebral oedema when sugar is lowered
   - \( \frac{1}{2} \) NS is used if serum Na >150-155mmol/L
   - Change to D5% with additional NaCl when blood sugar is <14mmol/L
   - Avoid alternating NS with dextrose drip as this will cause fluctuations in blood sugar
   - CVP/PCWP monitoring in patient with history of heart failure or renal impairment
2. Insulin therapy

- Continuous IV insulin infusion (CI) through a pump is preferred as it offers smooth control. A more gradual normalization in the first 12-24 h period is preferred to avoid cerebral oedema. Loading dose of IV insulin does not result in better clinical outcome.
- Dilute 50 U of soluble insulin in 50 ml of gelofusine in a syringe and deliver it by an infusion pump.
- The average initial CI rate is about 0.1U/kg/h. It should preferably not exceed 10U/h for patient weight >70kg.
- In severely insulin resistant cases eg morbid obesity, severe sepsis, high dose glucocorticoid treatment and TPN, a sliding scale with an initial rate of >10/h may be required.
- Blood sugar should be monitored at 2-h intervals. Depending on whether the blood sugar improves 4 h later, the sliding scale may be switched to one with a higher initial CI rates (eg scale 1 to scale 3).

<table>
<thead>
<tr>
<th>BSL (mmol/L)</th>
<th>CI Scale 1 (U/h)</th>
<th>Scale 2</th>
<th>Scale 3</th>
<th>Scale 4</th>
<th>Scale 5</th>
<th>Scale 6</th>
<th>Scale 7</th>
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<td>3.0</td>
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<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
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<tr>
<td>&lt; 4</td>
<td>Stop iv insulin infusion and inform doctor</td>
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</tbody>
</table>

3. Potassium replacement

- Aggressive IV K+ infusion should be given in initial phase because of the shift of K+ with glucose into the intracellular compartment with hydration and insulin treatment.
- In presence of ECG changes of hypokalaemia, 30 mmol of K+ diluted in 1 litre NS or ½ NS should be given over 1 h before laboratory confirmation is available. Checking of K+ usually available in our ICU – use ABG machine.
- Replacement may be given according to the scale below:

<table>
<thead>
<tr>
<th>K+ level (mmol/L)</th>
<th>&lt; 3.0</th>
<th>3 -</th>
<th>4 -</th>
<th>5 -</th>
<th>&gt; 5.5</th>
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<tbody>
<tr>
<td>IV K+ (mmol/h)</td>
<td>30</td>
<td>20</td>
<td>10</td>
<td>5</td>
<td>0</td>
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</tbody>
</table>
• Review K⁺ infusion rate when blood sugar is normalizing (<14mmol/L). K⁺ level should be measured every 4 h within the first 24 h

4. Bicarbonate/phosphate/magnesium
   • Most authors do not recommend bicarbonate or phosphate infusion in DKA
   • If measured phosphate or magnesium is low, replacement can be given
   • Mg²⁺ may be considered if arrhythmias occur

5. Venous thromboembolism prophylaxis
   • Look under relevant chapter in the ICU manual

6. Termination of CI
   Continuous insulin infusion can be stopped when:
   • Blood sugar has been stabilized to ≤ 10 mmol/L on a steady insulin infusion rate for 12 h. The usual time frame is about 24-48 h of CI treatment
   • Urine ketones should be negative
   • Dehydration is almost corrected
   • Precipitating factor is under control. If patient is still acutely ill, insulin resistance will be high and rebound in blood sugar is likely