Episode 14 - Diabetic Ketoacidosis in Adults and Children

Diabetic ketoacidosis can occur in type 1 or type 2 diabetes mellitus. There is either an absolute or a relative insulin deficiency; relative meaning that the effects of counter-regulatory hormones, levels of which are raised in illness or injury, overwhelm the effects of insulin. This is especially true if insulin production is limited or there is a degree of baseline insulin resistance, i.e. type 2 diabetes. Mortality is still 0.5% (1:200 patients).

Metabolism

There are two important metabolic processes. The first is the breakdown of fatty acids to form ketoacids (acetone, acetoacetate, beta-hydroxybutyrate). This leads to an anion gap metabolic acidosis. The second is production of glucose which leads to an osmotic diuresis and loss of water, sodium and potassium.

Lipid metabolism = acidosis; carbohydrate metabolism = osmosis.

Potassium

Regulation of body potassium is affected by both these metabolic derangements - i) Total body potassium levels are low because it is being excreted in the urine. Especially in the context of dehydration where the body will produce aldosterone in an attempt to maintain intravascular volume; ii) plasma potassium levels are normal or high since potassium moves across cell membranes in exchange for hydrogen ions in the context of metabolic acidosis. Insulin administration can result in a sudden fall in plasma potassium levels as the ion re-enters cells.

Body fluid status

Estimation, measurement and management of: body fluid volume, osmolality and composition.

Diagnosis

Glucose - above 11 mmol/L
Acidosis - pH < 7.30 or a bicarbonate < 15 mmol/L
Ketones - greater than 3 mmol/L.

All of these can be measured at the bedside. If there is no ketone meter to measure betahydroxybutyrate, then urine ketone of greater than 2+ on a dipstick will do.

Main problems

Dehydration and cardiovascular compromise
Acidosis and cellular glucose utilisation (impaired) - cellular dysfunction

Fluid resuscitation

Rapid changes in volume or osmolality can lead to the main cause of death in DKA, which is cerebral oedema. This is especially relevant in children. Do not initiate insulin until initial fluid resuscitation has taken place. Only provide what is necessary to compensate for significant cardiovascular compromise. Plan full fluid resuscitation to take place over 48 hours (it has probably taken at least 24 hours for the patient to reach the state that they are in). Titrate to effect. Close monitoring (specialist ward or high dependency unit).

Estimating deficit

In severe DKA fluid deficit is quoted as being about 10% of total body weight - about 100 ml/kg. So for a 70 kg adult, this would mean a 7 litre fluid deficit, to be replaced over 48 hours. Clinical examination is useful but urine output is not a useful marker of intravascular volume status due to ongoing osmotic diuresis. Serial body weight measurements and comparison to historical values is useful.

Intravenous fluid administration

Two distinct phases: 1) initial resuscitation and 2) ongoing deficit replacement and maintenance (including other medical or surgical causes of fluid loss). Commence treatment of the underlying pathology that has precipitated the crisis.

Initial resuscitation	Balanced crystalloid solution (no glucose, no potassium). 10 ml/kg bolus + review + 10 ml/kg bolus No more than 20 ml/kg in the first 4 hours of treatment. Commence inotropes or vasopressors to achieve haemodynamic stability.
Ongoing replacement	Balanced crystalloid solution. Rate based on deficit calculation with volume given over 48 hours. Addition of potassium 20-40 mmol/L (if plasma potassium < 5 mmol/L). No more than 20 mmol/hr through peripheral line. Addition of glucose 5% (if blood glucose < 15 mmol/L) or 10% glucose (if blood glucose < 6 mmol/L)

Insulin

Fixed rate infusion of 0.1 units/kg/hr. This is made up as a prefilled syringe of 50 units in 50 ml with a concentration of 1 unit/ml. Continued (at fixed rate) until blood ketones < 0.6 mmol/L and acidosis has resolved. It normally takes less than 24 hours. Hourly monitoring of glucose, ketones and potassium, and osmolality.

Changes to the fixed rate

If during treatment the ketones fail to fall by about 0.5 mmol/L/hr then this is considered to be a failure of treatment. Likewise, the bicarbonate should increase by about 3 mmol/L/hr and the glucose should fall by about the same amount (3 mmol/L/hr). If it is not working then the insulin can be increased by 1 unit/hr every hour, up to a maximum of 15 units per hour.

Cerebral oedema

Change in neurological status
Change in cardiovascular status (slowing of heart rate)

Treatment aims to raise the osmolality of the plasma to draw fluid away from the central nervous system.

3 ml/kg NaCL 3% (or 5 ml/kg NaCl 2.7%) - this will raise the plasma sodium by about 3 mmol/L
0.5 g/kg Mannitol (= 5 ml/kg Mannitol 10% or 2.5 ml/kg Mannitol 20%)

Sodium concentration should be increased at no more than 0.5 mmol/L/hr (12 mmol/L over 24 hours) with a target of 150 mmol/L.

Note: hypertonic saline is a better choice than mannitol. Sodium concentrations can be measured it will not be excreted in the same way that mannitol is, i.e. it should have a more prolonged effect.