



Clinical Guidelines

Diabetic Ketoacidosis

Document Control Information

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As of January 2020 the BESPED Guidelines have changed. This guideline has been updated to reflect these changes. Some key changes include:

1. Stratification into mild, moderate and severe dehydration
2. Resuscitation fluid for shock should **NOT** be subtracted from calculated fluid deficit
3. All children who require IV fluids should receive a 10ml/kg fluid bolus which **SHOULD** be subtracted from the calculated fluid deficit
4. Traditional paediatric formula for maintenance fluid calculation (Holliday-Segar)

1.0 Assessment

Diagnosis requires a combination of hyperglycaemia, acidosis & ketosis. If all three features are not present then an alternative diagnosis should be considered such as:

lactic acidosis, inborn error of metabolism, alcoholic ketoacidosis, salicylate poisoning, or sepsis.

Definition for DKA

1. Acidosis pH < 7.3 **or** $\text{HCO}^3 < 15 \text{ mmol/l}$
2. Ketones > 3.0 mmol/l

1.1 History

- Polyuria
- Polydipsia
- Usual insulin regimen (if known diabetes)
- Any triggers (e.g. Infections, stress)

1.2 Clinical signs

- Acidotic (Kussmaul) breathing pattern
- Abdominal pain / vomiting
- Level of consciousness
 - Assess the GCS
 - Institute hourly neurological observations whether drowsy on admission or not

- Clinical dehydration:

Mild (5%)	pH 7.2- 7.29 or $\text{HCO}^3 < 15\text{mmol/l}$
Moderate (7%)	pH 7.1-7.19 or $\text{HCO}^3 < 10\text{mmol/l}$
Severe (10%)	pH < 7.1 or $\text{HCO}^3 < 5\text{mmol/l}$

1.3 Examination

Look particularly for evidence of

- Infection
- Ileus
- Cerebral oedema
 - Headache / Irritability
 - Reduced level of consciousness
 - Bradycardia & hypertension

Cerebral oedema is the most common cause of mortality

Risk factors for cerebral oedema include:

- Severe hypocapnoea at presentation (<2kPa)
- Younger age
- First presentation
- Elevated serum urea at presentation
- Bicarbonate administration
- Rapid fall in corrected sodium (see section 5.2 below)

If suspected discuss with CATS immediately and give:

1. Hypertonic Saline 2.7% 3mls/kg over 10 – 15 mins **OR** if any delay;
2. Mannitol 20% 0.5g/kg (2.5mls/kg) over 10 – 15 mins **AND**
3. Half maintenance fluid rates and discuss with Paediatric consultant and CATS

1.4 Indications for discussion with CATS

- pH <7.1 with marked hyperventilation
- Severe dehydration with shock
- Depressed level of consciousness
- Headache
- Age <2yrs

2. Resuscitation

2.1 Airway & Breathing

- Ensure airway patency
- Intubation is **rarely** necessary. Hyperventilation is a normal compensatory mechanism for metabolic acidosis
- Give 100% oxygen via face mask
- Insert NGT (if decreased conscious level or recurrent vomiting), and leave on free drainage

2.2 Circulation

- Insert 2 IV cannulae
- Take blood samples
 - Blood glucose
 - U&Es & CRP (can use electrolytes on blood gas until available)
 - Blood gas (venous gives similar values to arterial)
 - Blood ketones if possible (superior to urine ketones)
 - FBC / BC if sepsis suspected

- Initial fluid bolus:

ALL children with mild, moderate or severe DKA who are **NOT** shocked and are felt to require IV fluids should receive 10mls/kg 0.9% NaCl or PlasmaLyte 148 over 60 mins. This **SHOULD** be subtracted from the total calculated fluid deficit.

- **Shocked patients** (tachycardia, poor peripheral pulses, and prolonged CENTRAL capillary refill time, +/- hypotension) require appropriate restoration of their circulating volume.

An initial 20mls/kg bolus of 0.9% NaCl over 15mins and assess for effect. A further 10ml/kg may be given up to a total of 40mls/kg at which stage inotropes should be considered. This resuscitation fluid **SHOULD NOT** be subtracted from the estimated fluid deficit.

- **Do not use capillary refill as an indicator for fluid bolus administration**
 - Hypocarbia causes peripheral vasoconstriction and prolonged CRT
- **Do not give bicarbonate**
- Ensure full cardiac monitoring (look for peaked T waves with hyperkalaemia)

The aim is to slowly correct metabolic abnormalities

3. Management

3.1 Insulin

- There is some evidence that cerebral oedema is associated with early insulin administration
- Start soluble insulin at 0.05 - 0.1 units/kg/hr 1-2 hours after starting IV fluids
- Aim to reduce the blood glucose no faster than 5mmols/hr
- Once blood glucose <14mmol/l add 5% glucose to IV fluids
- If blood glucose falls to <4mmol/l give 2mls/kg 10% glucose & increase glucose content of IV fluids to 10%
- Insulin infusion rate can be temporarily reduced (for 1hr) but should be continued at 0.05 - 0.1 units/kg/hr to switch off ketogenesis

3.2 Fluids

Requirement = (Deficit + Maintenance -> replaced over 48hrs) – 10mls/kg given to NON-Shocked patient.

Resus fluid given to children in shock should NOT be subtracted

Maintenance fluids volumes now to be calculated using the traditional Holiday –Segar formula (BSPED Jan 2020 guidance).

Weight (kg)	Rate (ml/kg/day)
1 st 10 kg	100mls/kg/day
10-20 kg	50mls/kg/day
Each additional kg	20mls/kg/day

Neonates may require larger volumes

Examples

6yo child weighing 20kg, assessed as moderate DKA with pH 7.15, therefore 7% dehydration who received 10ml/kg bolus (200mls fluid) over 60 minutes as part of initial management. His ongoing fluids will comprise:

Deficit 7% x 20kg	= 1400ml
Subtract initial bolus	1400-200 = 1200ml to be replaced over 48 hours = 25ml/hr
Maintenance	10 x 100 = 1000ml per day for 1 st 10kg 10 x 50 = 500ml per day next 10kg (weighs 20kg) = 1500ml per day total (over 24 hours) = 62ml/hour
Total fluid	= 25ml/hour – Deficit of 7% minus bolus over 48 hours + 62 ml/hr – Maintenance fluids = 87ml/hour

15yo child weighing 60kg, pH 6.9 who was shocked at presentation has received 30ml/kg of 0.9 NaCL for **resuscitation**. These boluses are **not** subtracted from ongoing maintenance fluids. Her ongoing fluids will comprise:

Deficit 10% x 60kg	= 6000ml to be replaced over 48 hours = 125ml/hr
Maintenance	10 x 100 = 1000ml per day for 1 st 10kg 10 x 50 = 50ml per day for next 10kg (10-20kg) 40 x 20 = 800ml per day for next 40kg = 2300ml per day total (over 24 hours) = 96ml/hour
Total fluid	= 125ml/hour – Deficit of 10% over 48 hours + 96ml/hr – Maintenance fluids = 221ml/hour

3.3 Type of fluid

- 0.9% NaCl + 20mmol KCL per 500ml (once urine output confirmed)
- PlasmaLyte 148 (additional potassium will need to be added as it only contains 5mmol/l potassium)
- Once blood glucose is < 14mmol/l change to glucose containing fluid
- Calculated deficit replacement fluid must be completed - if tolerating oral fluids before the 48 hr rehydration period is complete, ensure IV rehydration rate is reduced accordingly to account for oral intake.

4. Observations

- Strict fluid balance (catheterise younger patients or those with low GCS)
- Hourly capillary blood glucose measurement
- Hourly BP, HR
- Continuous ECG monitoring
- **Half hourly** (or more frequently) neurological assessment
- 1-2 hourly capillary blood ketones
- 2 – 4 hourly capillary blood gas & U&Es
- Twice daily weights

5. Troubleshooting

5.1 Acidosis:

If acidosis is not correcting, consider:

- Inadequate fluid resuscitation
- Insufficient insulin to switch off ketogenesis
- Hyperchloraemic acidosis
 - If Cl is >80% of Na
 - Base excess due to $Cl = Na - Cl - 32$

5.2 Corrected sodium:

It is recommended the corrected sodium levels are monitored in the management of DKA to assess adequacy of rehydration.

$$\text{Corrected sodium (mmol/l)} = \text{measured sodium} + \frac{(\text{glucose} - 5.6)}{3.5}$$

- If Corrected Na **RISING** >5mmol/l in 4-8 hr – indicates too much fluid **LOSS**
Consider increasing the fluid rate.
- If corrected Na **FALLING** >5mmol/l in 4-8 hr – indicates too much fluid **GAIN**
Consider reducing the fluid rate.

6. Indication for intubation

- Ventilatory failure
- Loss of airway
- Decompensated shock

Intubation & ventilation poses a significant risk with worsening acidosis due an abrupt rise in pCO₂.

References

- British Society for Paediatric Endocrinology and Diabetes. Recommended DKA guidelines Jan 2020.
- NICE Guidelines (2020). Diabetic ketoacidosis in children and young people.