
Clinical Guidance

Paediatric Critical Care: Diabetic Ketoacidosis (DKA)

Summary

This guideline is for staff to use when treating children with Diabetic Ketoacidosis. It gives advice on treatment, medications, risk factors and resuscitation as well as rehydration and neurological implications.

Document Detail	
Document type	Clinical Guideline
Document name	Paediatric Critical Care: Diabetic Ketoacidosis
Document location	Evelina London website
Version	3
Effective from	Jan 2018
Review date	Jan 2021
Owner	Clinical Lead, Sara Hanna
Author(s)	Jon Lillie, PICU Consultant
Approved by, date	ELCH Sep 2017, DTC Jan 2018
Superseded documents	
Related documents	
Keywords	Evelina, child, Paediatric, intensive care, STRS, Retrieval, Paediatric critical care, Diabetes, Diabetic Ketoacidosis, DKA, PICU.
Relevant external law, regulation, standards	
<p>This clinical guideline has been produced by the South Thames Retrieval Service (STRS) at Evelina London for nurses, doctors and ambulance staff to refer to in the emergency care of critically ill children.</p> <p>This guideline represents the views of STRS and was produced after careful consideration of available evidence in conjunction with clinical expertise and experience. The guidance does not override the individual responsibility of healthcare professionals to make decisions appropriate to the circumstances of the individual patient.</p>	

Key Abbreviations: NaCl = Sodium chloride,
Na = sodium, K = Potassium, Cl = Chloride

Change History		
Date	Change details, since approval	Approved by

Diabetic Ketoacidosis

Risk factors for cerebral oedema:

- Younger age
- $p\text{CO}_2 < 2 \text{ KPa}$ at presentation¹
- $\text{pH} < 7.1$ at presentation^{2,3}
- $> 40 \text{ ml/kg}$ IV Fluid in first 4 hours^{2,3}
- Rapid falls in corrected Sodium²
- NaHCO_3 therapy¹ or raised urea¹
- Hyperventilation post-intubation

Principles of therapy (same as NICE)*:

- Treat shock (Do not treat capillary refill)
 - Correction of keto-acidosis (insulin + glucose)
 - SLOW rehydration over 48 hours reduces risk of cerebral oedema (max risk first 24 h)
 - Start insulin 1 hour after rehydration fluid
 - Continue insulin until ketosis resolves
 - Replacement of K^+
- CONTINUOUS CAREFUL MONITORING!**

Presume cerebral oedema if :

Patient drowsy, obtunded, confused or unrousable.

Use Osmotherapy: Hypertonic NaCl
Dose: 3 to 5 ml/kg of 2.7% NaCl

Risk of cerebral oedema : first 24 h

Monitoring therapy (avoid rapid falls in plasma osmolality to reduce the risk of cerebral oedema)⁴

- Catheter and NG tube should be placed for accurate fluid balance (DO NOT chase urine output!)
- **Half hourly:** GCS and neuro-observations, hourly blood glucose, **2 hourly** blood gas (venous / arterial: not capillary), Electrolytes, phosphate and blood ketones (if available)

1. RESUSCITATION Max 10-20ml/kg 0.9% NaCl bolus initially (Hypotension is rare in paediatric DKA)

- Avoid fluid boluses after initial 20ml/kg unless hypotensive (**$>40 \text{ ml/kg}$ in 1st 4 hours: ↑risk of cerebral oedema**)
- Use inotropes (Dopamine) if hypotensive despite 20ml/kg Fluid bolus.
- Consider hypertonic sodium chloride (3 to 5ml/kg 2.7% sodium chloride) if refractory hypotension
- Antibiotics if sepsis suspected. Suspect if fluid refractory shock.
- Anuria is rare in DKA: limits ketone excretion with persisting acidosis: may need dialysis

2. REHYDRATE OVER 48 h (Assume max of 10% dehydration)

- Prescribe hourly **TOTAL FLUID RATE** according to table (N.B. max 120ml/h) (assumes 10% dehydration and includes 60% maintenance without urine replacement)
- Initially use 0.9% sodium chloride without glucose (do not use hypotonic fluid e.g. 0.45% NaCl)
- If $>40 \text{ ml/kg}$ fluid given in 1st 4 hours, then reduce total fluid rate by a further 1ml/kg/h
- When glucose $< 15 \text{ mmol/L}$ use 2 bag system (add 0.9% NaCl with 10% glucose in 2nd bag) & adjust ratio of two bags to keep glucose at 7 to 10 mmol/L **without** changing insulin rate
- As glucose changes adjust ratio of Bag1 (glucose free) vs Bag2 (10% glucose+0.9% sodium chloride)
- DO NOT replace urine output (polyuria will reduce as glucose and ketone induced diuresis improves)
- Add 40mmol/litre KCl to all fluid bags unless $[\text{K}^+]$ is $> 5.5 \text{ mmol/l}$
- DO NOT routinely supplement phosphate unless very low ($< 0.3 \text{ mmol/L}$)

Adjust total fluid rate using **corrected Na (Na_{corr})⁶**

Rise in $\text{Na}_{\text{corr}} > 5 \text{ mmol/L}$ in 4-8 h = too much fluid LOSS = **increase fluid rate by 1ml/kg/hour**

Fall in $\text{Na}_{\text{corr}} > 5 \text{ mmol/L}$ in 4-8 h = too much fluid GAIN = **reduce fluid rate by 1 ml/kg/hour**

If corrected Na falling or not increasing, consider hypertonic NaCl if signs of cerebral oedema

Try to ensure Corrected Na does not fall with therapy (minimise risk cerebral oedema)

3. KETOACIDOSIS (note: insulin is used to inhibit ketone production from fat cells)

- Low dose insulin (0.05 units/kg/h) adequate in most cases. Delay insulin till 1 hr after initial fluid resus⁶
- 0.1units/kg/h is occasionally needed if insulin resistance (typically adolescents)
- Rarely higher dose insulin (0.2 units/kg/h) if blood ketones remain elevated despite 0.1units/kg/h (usually in association with sepsis. Lactate is also usually high ($> 2 \text{ mmol/L}$). Discuss with STRS)
- DO NOT STOP INSULIN if glucose falls: insulin only when blood ketones $< 1 \text{ mmol/L}$ or Anion Gap $< 18 \text{ mEq/L}$
- Blood ketosis usually resolves by 12 h ($< 1 \text{ mmol/L}$). Should correlate with anion gap ($< 18 \text{ mEq/L}$)
- Urine ketones usually persist for 24 to 48 hours and *do not* reflect serum ketonaemia.
- Base deficit misleading as all DKA have hyperchloraemic acidosis. Quantify base deficit due to chloride
- Hyperchloraemic acidosis if $\text{Cl}:\text{Na}$ ratio > 0.8 or Base deficit chloride > -10 . This may take 24 h to resolve⁷

4. DEPRESSED LEVEL OF CONSCIOUSNESS: ASSUME CEREBRAL OEDEMA

- Discuss with the consultant on call. Highest risk for cerebral oedema in first 8 to 12 h
- Use OSMOTHERAPY: **3 to 5 ml/kg 2.7% hypertonic NaCl** (even if plasma Na sodium high)
- Mannitol 0.5g/kg (2.5 ml/kg of 20% Mannitol) only if hypertonic NaCl not available
- Expect rapid response within 10-15 minutes of administering hypertonic NaCl
- If response, dose can be repeated 2 to 3 times if required (track corrected Na changes)
- **If the patient does not respond to osmotherapy or is not protecting the airway:** intubate and ventilate
- Aim for $p\text{CO}_2$ 4 to 4.5Kpa if ventilated (avoid further cerebral ischaemia from hypocapneic vasoconstriction)
- Ensure patient not hypovolaemic on anaesthetic induction (use hypertonic NaCl as volume and consider inotropes)
- Obtain CT scan to identify cause of coma. Discuss with STRS

NOTE: 1) Hyperosmolar Hyperglycaemic State: rare in children: can present with hyperglycaemic coma without ketoacidosis. May require higher fluid rehydration rates and careful adjustment of insulin as usually not ketotic

Corrected Na =
Plasma Na + (0.4 x (Glucose – 5.5mmol/L))

Anion gap (mEq/L)=
Na + K – Cl – Bicarb

Base deficit chloride*
= Na - Cl - 32

TOTAL IV fluid requirements

Weight (kg)	Total fluid rate
0 to 9.9	4ml/kg/h
10 to 39.9	3 ml/kg/h
40 to 60	2 ml/kg/h
>60kg	120ml/h (max)

Corrected Na⁶
should rise by approx
3 to 5mmol/L in 12 h

Blood ketones
(βOH butyrate sticks):
usually **3 to 6 mmol/L**
in severe DKA
by 12 hours:
should be $< 1 \text{ mmol/L}$

Insulin (Actrapid)
2.5 x weight (kg) units
in 50 ml of 0.9% NaCl
1ml/h=0.05 units/kg/h
DO NOT BOLUS⁵

Hypertonic sodium Chloride (NaCl)
If 2.7% commercial solution not available, see [separate guideline](#) on making up 3% NaCl

*BSPED/ NICE 2015 guidelines have similar principles. We recommend using this guideline if referring patients to STRS with severe DKA
References: 1. Glaser NEJM 2001: 344(4): 264-265 2. Mahoney Pediatr Neurol 1999: 21; 721-727; 3. Roberts Ped Diabetes 2001: 2; 109-114 4. Hoorn J Pediatr 2007 150:455-6 5 Edge. Diabetologia. 2006 49(9):2002-9 6.Durward. Arch Dis Child Oct 2010 7.Taylor Intensive Care Med. 2006 32(2) :295-301