

# Clinical Guidance

## Paediatric Critical Care: Diabetic Ketoacidosis (DKA)

### Summary

This guideline is for staff to use when treating critically ill children with Diabetic Ketoacidosis. BSPED guidance advises giving more fluid than STRS based on a large trial showing no difference between faster and slower rehydration regimes in a population with an average pH of 7.16. However for the sickest patients (pH<7.1), STRS still advises to follow our guidance<sup>1</sup>.

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<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: Na = sodium, K<sup>+</sup> = Potassium, Cl = Chloride**

Change History		
Date	Change details, since approval	Approved by
17/11/20	Acknowledged differences in fluid manage with BSPED guidance Added monitoring sheet and improved clarity of information Added target for glucose once sugar less than 15mmol/L	

# Paediatric critical care: Diabetic Ketoacidosis (DKA)

BSPED guidance advises more fluid than STRS based on a trial showing no difference between faster/ slower rehydration in a population with an average pH of 7.16. However, for the sickest patients (pH<7.1) please follow our guidance<sup>1</sup>

<p><b>Risk factors for cerebral oedema:</b></p> <ul style="list-style-type: none"> <li>o Younger age</li> <li>o pCO<sub>2</sub> &lt;2KPa at presentation<sup>2</sup></li> <li>o pH &lt;7.1 at presentation<sup>3,4</sup></li> <li>o &gt;40mL/kg IV fluid in first 4 hours<sup>3,4</sup></li> <li>o Rapid falls in corrected sodium<sup>3</sup></li> <li>o NaCO<sub>3</sub> therapy<sup>1</sup> or raised urea<sup>2</sup></li> <li>o Hyperventilation post intubation</li> </ul>	<p><b>Principles of therapy (same as NICE):</b></p> <ul style="list-style-type: none"> <li>o Treat shock (Do not treat capillary refill)</li> <li>o Correction of ketoacidosis (insulin + glucose)</li> <li>o SLOW rehydration over 48 hours reduces risk of cerebral oedema (max risk first 24 hours)</li> <li>o Start insulin 1 hour after rehydration fluid</li> <li>o Continue insulin until ketosis resolves</li> <li>o Replacement of K<sup>+</sup></li> </ul> <p><b>CONTINUOUS CAREFUL MONITORING</b></p>	<p><b>Cerebral oedema:</b></p> <ul style="list-style-type: none"> <li>o Presume if patient confused or decreased GCS</li> <li>o Greatest risk in first 24hrs</li> <li>o <b>Use osmotherapy: Hypertonic sodium chloride</b></li> <li>o <b>Dose:</b> 3-5mL/kg of 2.7% sodium chloride</li> </ul>
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**MONITORING THERAPY: (avoid rapid falls in plasma osmolality to reduce the risk of cerebral oedema)<sup>4</sup>**

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

<p><b>Corrected Na:</b>          Plasma Na + (0.4 x (Glucose – 5.5))</p> <p><b>Anion Gap (mEq/L):</b>          Na + K – Cl – Bicarb</p> <p><b>Base Deficit chloride:</b>          Na – Cl – 32</p>
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**RESUSCITATION: Max 10-20mL/kg 0.9% sodium chloride bolus initially (Hypotension is rare in paediatric DKA)**

- o **Shock:** assess usual markers of shock – pulses, BP, lactate. Capillary refill time is not useful as low CO<sub>2</sub> causes vasoconstriction
- o Avoid fluid boluses after initial 20mL/kg unless hypotensive (**>40mL/kg in 1<sup>st</sup> 4 hours: increased risk of cerebral oedema**)
- o Use inotropes (dopamine) if hypotensive despite 20mL/kg fluid bolus
- o Consider hypertonic sodium chloride (3-5mL/kg 2.7% sodium chloride) if refractory hypotension
- o Antibiotics if sepsis suspected e.g. hypotension
- o Anuria is rare in DKA: limits ketone excretion with persisting acidosis – may need dialysis

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

**REHYDRATE OVER 48 hours:** (Assume max of 10% dehydration)

- o Prescribe hourly **TOTAL FLUID RATE** according to table (N.B. max 120mL/h) - (assumes 10% dehydration and includes 60% maintenance without urine replacement)
- o Initially use 0.9% sodium chloride without glucose (do not use hypotonic fluid e.g. 0.45% sodium chloride)
- o If >40mL/kg fluid given in 1<sup>st</sup> 4 hours, then reduce total fluid rate by a further 1mL/kg/h
- o When glucose <15mmol/L: add glucose to fluid aiming for blood glucose 6-14mmol/L. Ideally use **2 bag system**
- o Add 40mmol/L (20mmol/500mL) KCl to all fluid bags unless K<sup>+</sup> >5.5mmol/L
- o **Do not** routinely supplement phosphate unless very low (<0.3mmol/L)
- o **Do not** replace urine output (polyuria will reduce as glucose and ketone induced diuresis improves)

<p><b>Blood ketones</b>  <b>(βOH butyrate sticks):</b>          Usually <b>3 to 6 mmol/L</b>          in severe DKA</p> <p><b>By 12 hours:</b>          Should be &lt;1 mmol/L</p>
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<p><b>Corrected Na<sup>7</sup></b></p> <p><b>Expected rise:</b>          3-5mmo/L in 12 hours</p>
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<p><b>Adjust total fluid rate using corrected Na (Na<sub>corr</sub>)<sup>7</sup></b>          Rise in <b>Nacorr</b> &gt;5mmol/L in 4-8 hrs = too much fluid LOSS = <b>increase fluid rate by 1mL/kg/h</b>          Fall in <b>Nacorr</b> &gt;5mmol/L in 4-8 hrs = too much fluid GAIN = <b>reduce fluid rate by 1mL/kg/h</b></p> <p><b>If corrected Na falling or not increasing, consider hypertonic sodium chloride if signs of cerebral oedema, try to ensure corrected Na does not fall with therapy to minimise risk cerebral oedema</b></p>
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<p><b>Insulin (Actrapid)</b></p> <p>2.5 units x weight          in 50 ml of 0.9%          sodium chloride</p> <p>1mL/h =          0.05 units/kg/h</p> <p><b>DO NOT BOLUS<sup>5</sup></b></p>
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**KETOACIDOSIS: (note: insulin is used to inhibit ketone production from fat cells)**

- o Low dose insulin (0.05 units/kg/h) adequate in most cases. Delay insulin until 1h after initial fluid resus<sup>7</sup>
- o 0.1units/kg/h may be needed if insulin resistance (typically adolescents)
- o 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 mmol/L). Discuss with STRS.
- o **DO NOT STOP INSULIN** if glucose falls: ↓insulin only when blood ketones <1 mmol/L or Anion Gap <18 mEq/L
- o Blood ketosis usually resolves by 12hrs (<1mmol/L). Should correlate with anion gap (<18mEq/L)
- o Urine ketones usually persist for 24 to 48 hours and do not reflect serum ketonaemia
- o Base deficit can be misleading as all DKA have hyperchloraemic acidosis. Quantify base deficit due to chloride
- o Hyperchloraemic acidosis if Cl:Na ratio >0.8 or base deficit chloride >-10. This may take 24hrs to resolve<sup>8</sup>

**DEPRESSED LEVEL OF CONSCIOUSNESS: ASSUME CEREBRAL OEDEMA**

- o Discuss with the consultant on call. Highest risk for cerebral oedema in first 8 to 12 hrs
- o Use **OSMOTHERAPY: 3 to 5 mL/kg 2.7% hypertonic sodium chloride** (even if plasma Na high)
- o Expect rapid response within 10-15 minutes of administering hypertonic sodium chloride
- o If response, dose can be repeated 2 to 3 times if required (track corrected Na changes)
- o **If the patient does not respond to osmotherapy or is not protecting the airway:** intubate and ventilate
- o Aim for pCO<sub>2</sub> 4-4.5Kpa if ventilated (avoid further cerebral ischaemia from hypocapnic vasoconstriction)
- o Ensure patient not hypovolaemic on anaesthetic induction (hypertonic sodium chloride as volume/ consider inotropes)
- o Obtain CT scan to identify cause of coma. Discuss with STRS
- o **Note:** If hypertonic sodium chloride is unavailable or cannot be made up then use mannitol 0.5g/kg (2.5mL/kg 20% mannitol)

<p><b>Hypertonic sodium chloride can be made if not available</b></p>
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**NOTE: 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.

BSPED/NICE 2020 guidelines have similar principles. We recommend using this guideline if referring patients to STRS with severe DKA  
 References: 1. Kuppermann, N et al, Clinical Trial of fluid infusion rates for pediatric diabetic ketoacidosis, N Engl Med 2018; 378:2275-87 2. Glaser NEJM 2001; 344(4): 264-265 3. Mahoney Pediatr Neurol 1999; 21; 721-727; 4. Roberts Ped Diabetes 2001; 2; 109-114 4. Hooorn J Pediatr 2007 150:455-6 5. Edge. Diabetologia. 2006 49(9):2002-9 7. Durward. Arch Dis Child Oct 2010 8.Taylor Intensive Care Med. 2006 32(2) :295-301

