

BSPED Recommended DKA Guidelines 2009

These guidelines for the management of Diabetic Ketoacidosis were originally produced by a working group of the British Society of Paediatric Endocrinology and Diabetes. Modifications have been made in the light of the ESPE/LWPES consensus statement on diabetic ketoacidosis in children and adolescents (Archives of Disease in Childhood, 2004, 89: 188-194) and the recent guidelines produced by the International Society for Pediatric and Adolescent Diabetes (Pediatric Diabetes, 2007: 8: 28–43).

These guidelines are believed to be as safe as possible in the light of current evidence. However, no guidelines can be considered entirely safe as complications may still arise. In particular the pathophysiology of cerebral oedema is still poorly understood.

For the evidence-base to the management guidelines, please see the 2007 ISPAD guidelines; http://www.ispad.org/FileCenter/10-Wolfsdorf_Ped_Diab_2007,8,28-43.pdf and Chapter 4 of Evidence-based Paediatric and Adolescent Diabetes, Eds Allgrove, Swift & Greene, Blackwell Publishing, ISBN 978-1-4051-5292-1.

The following changes have been made since the last version (2004)

1. Recommendation to use capillary blood ketone measurement during treatment
2. Reduction in the degree of dehydration to be used to calculate fluids
3. Reduction in maintenance fluid rates
4. Change in the recommendations for PICU/HDU – more emphasis on safe nursing on general wards
5. Continuation of Normal saline for the first 12 hours of rehydration
6. Delay in insulin until fluids have been running for an hour
7. Option to continue insulin glargine during treatment
8. Reminder to stop insulin pump therapy during treatment
9. Reminder to consider anticoagulant prophylaxis in young children, especially those with femoral lines
10. Interpretation of blood ketone measurements if pH not improving
11. Option to use hypertonic saline instead of mannitol for the treatment of cerebral oedema

The associated fluid calculation spreadsheet was designed by Dr Andrew Durward, and the flow-charts for results by Dr Nandu Thalange. The Integrated Care Pathway has been produced by the South West Diabetes Group, with minor modifications to take account of recent changes to the Guidelines (Dr Christine Burren).

Any information relating to the use of these guidelines would be very valuable. Please address any comments to :

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Guidelines for the Management of Diabetic Ketoacidosis

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A. GENERAL :

Always accept any referral and admit children in suspected DKA.

Always consult with a more senior doctor on call as soon as you suspect DKA even if you feel confident of your management.

Remember : children can die from DKA.

They can die from -

Cerebral oedema	This is unpredictable, occurs more frequently in younger children and newly diagnosed diabetes and has a mortality of around 25%. The causes are not known, but this protocol aims to minimise the risk by producing a <u>slow</u> correction of the metabolic abnormalities. The management of cerebral oedema is covered on page 8.
Hypokalaemia	This is preventable with careful monitoring and management
Aspiration pneumonia	Use a naso-gastric tube in semi-conscious or unconscious children.

These are general guidelines for management. Treatment may need modification to suit the individual patient and these guidelines do not remove the need for frequent detailed reassessments of the individual child's requirements.

These guidelines are intended for the management of **children and young people** who have:

hyperglycaemia (BG >11 mmol/l) pH < 7.3 bicarbonate < 15 mmol/l	and who are <ul style="list-style-type: none"> • more than 3% dehydrated • and/or vomiting • and/or drowsy • and/or clinically acidotic
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Children who are 5% dehydrated or less and not clinically unwell (mild acidosis and not nauseated or vomiting) usually tolerate oral rehydration and subcutaneous insulin.

Blood ketone levels are generally over 3.0 mmol/l but some well children who do not fulfil the criteria above for IV fluids may have ketone levels of up to 6.0 mmol/l.

Discuss this with the senior doctor on call.

B. EMERGENCY MANAGEMENT IN A & E :

1. General Resuscitation : A, B, C.

Airway Ensure that the airway is patent and if the child is comatose, insert an airway.

If consciousness reduced or child has recurrent vomiting, insert N/G tube, aspirate and leave on open drainage.

Breathing Give 100% oxygen by face-mask.

Circulation Insert IV cannula and take blood samples (see below).
Cardiac monitor for T waves (peaked in hyperkalaemia)

Only if shocked (poor peripheral pulses, poor capillary filling with tachycardia, and/or hypotension) **give 10 ml/kg 0.9% (normal) saline** as a bolus, and repeat as necessary to a maximum of 30 ml/kg.

(There is no evidence to support the use of colloids or other volume expanders in preference to crystalloids)

2. Confirm the Diagnosis :

History :	polydipsia, polyuria
Clinical :	acidotic respiration dehydration drowsiness abdominal pain/vomiting
Biochemical :	high blood glucose on finger-prick test (>11 mmol/l) blood pH<7.3 and/or HCO ₃ <15 mmol/l finger-prick blood ketones >3.0 mmol/l glucose and ketones in urine

3. Initial Investigations :

- blood glucose
- urea and electrolytes (electrolytes on blood gas machine give a guide until accurate results available)
- blood gases (venous blood gives very similar pH and pCO₂ to arterial)
- near patient blood ketones if available (superior to urine ketones).

± other investigations only if indicated e.g. PCV and full blood count (leucocytosis is common in DKA and does not necessarily indicate sepsis), CXR, CSF, throat swab, blood culture, urinalysis, culture and sensitivity etc.

(DKA may rarely be precipitated by sepsis, and fever is not part of DKA.)

C. FULL CLINICAL ASSESSMENT AND OBSERVATIONS :

Assess and record in the notes, so that comparisons can be made by others later.

1. Degree of Dehydration -

mild, 3%	is only just clinically detectable
moderate, 5%	dry mucous membranes, reduced skin turgor,
severe, 8%	above with sunken eyes, poor capillary return
+ shock	may be severely ill with poor perfusion, thready rapid pulse (reduced blood pressure is not likely and is a very late sign)

Over-estimation of degree of dehydration is dangerous.

Therefore do not use more than 8% dehydration in calculations

2. Conscious Level -

Institute hourly neurological observations including Glasgow Coma Score (see Appendix 1) whether or not drowsy on admission.

If **in coma on admission**, or there is any subsequent deterioration,

- consider transfer to PICU/HDU if available
- consider instituting cerebral oedema management (if high level of suspicion, start treatment prior to transfer) (page 8)
- coma is directly related to degree of acidosis, but signs of raised intracranial pressure suggest cerebral oedema

3. Full Examination - looking particularly for evidence of -

- **cerebral oedema** headache, irritability, slowing pulse, rising blood pressure, reducing conscious level **N.B.** papilloedema is a late sign.
- **infection**
- **ileus**

WEIGH THE CHILD.

If this is not possible because of the clinical condition, use the most recent clinic weight as a guideline, or an estimated weight from centile charts.

4. Consider PICU or HDU for the following, and discuss with a PICU consultant.

- severe acidosis pH<7.1 with marked hyperventilation
- severe dehydration with shock
- depressed sensorium with risk of aspiration from vomiting
- very young (under 2 years)
- staffing levels on the wards are insufficient to allow adequate monitoring

N.B. Where PICU or HDU do not exist within the admitting hospital, transfer to another hospital for such care (unless ventilatory support becomes necessary) may not be appropriate. However, ALL children with DKA are high-dependency patients and require a high level of nursing care, usually 1:1 even if on general paediatric wards

5. Observations to be carried out :

Ensure full instructions are given to the **senior** nursing staff emphasising the need for:

- strict fluid balance (urinary catheterisation may be required in young/sick children)
- measurement of volume of every urine sample
- hourly **capillary blood glucose** measurements (these may be inaccurate with severe dehydration/acidosis but useful in documenting the trends. Do not rely on any sudden changes but check with a venous laboratory glucose measurement)
- **capillary blood ketone** levels every 1-2 hours (if available) – see section E below
- urine testing for ketones (if blood ketone testing not available)
- hourly BP and basic observations
- twice daily weight; can be helpful in assessing fluid balance
- hourly or more frequent neurological observations initially
- reporting **immediately** to the medical staff, even at night, symptoms of **headache**, or slowing of pulse rate, or any change in either conscious level or behaviour
- reporting any changes in the ECG trace, especially T wave changes suggesting hyper- or hypokalaemia

Start recording all results and clinical signs on a flow chart. An example is shown here ([flow chart](#))

D. MANAGEMENT :

1. FLUIDS :

N.B. It is essential that all fluids given are documented carefully, particularly the fluid which is given in Casualty and on the way to the ward, as this is where most mistakes occur.

a) Volume of fluid -

By this stage, the circulating volume should have been restored and the child no longer in shock. If not, give a further 10 ml/kg 0.9% saline (to a maximum of 30 ml/kg) over 30 minutes. **(discuss with a consultant if the child has already received 30 ml/kg).**

Otherwise, once circulating blood volume has been restored, calculate fluid requirements as follows

$$\text{Requirement} = \text{Maintenance} + \text{Deficit} - \text{fluid already given}$$

Deficit (litres) = % dehydration x body weight (kg)

Ensure this result is then converted to ml.

For most children, use **5% to 8% dehydration** to calculate fluids.

Maintenance requirements:

Weight	0 – 12.9 kg	80 ml/kg/24 hrs
	13 – 19.9 kg	65 ml/kg/24 hrs
	20 – 34.9 kg	55 ml/kg/24 hrs
	35 – 59.9 kg	45 ml/kg/24 hrs
	(>60 kg)	35 ml/kg/24 hrs

N.B. Neonatal DKA will require special consideration and larger volumes of fluid than those quoted may be required, usually 100-150 ml/kg/24 hours)

NB APLS maintenance fluid rates over-estimate requirement, particularly at younger ages. Add calculated maintenance (for 48 hrs) and estimated deficit, subtract the amount already given as resuscitation fluid, and give the total volume **evenly** over the next 48 hours. i.e.

$$\text{Hourly rate} = \frac{\text{48 hr maintenance} + \text{deficit} - \text{resuscitation fluid already given}}{48}$$

Example :

A 20 kg 6 year old boy who is 8% dehydrated, and who has already had 20ml/kg saline, will require

$$\begin{array}{rcl} 8\% \times 20 \text{ kg} & = & 1600 \text{ mls deficit} \\ \text{plus } 55\text{ml} \times 20\text{kg} & = & 1100 \text{ mls maintenance each 24 hours} \\ & & \underline{1100 \text{ mls}} \\ & = & 3800 \text{ mls} \\ \text{minus } 20\text{kg} \times 20\text{ml} = & \underline{400} & \text{ mls resus fluid} \\ & & 3400 \text{ mls over 48 hours} = 71 \text{ mls/hour} \end{array}$$

Do not include continuing urinary losses in the calculations at this stage

For a method of calculating fluid rates which can be printed out for the child's medical records, use this link ([Fluid Calculator](#))

b) Type of fluid -

Initially use **0.9% saline with 20 mmol KCl in 500 ml, and continue this sodium concentration for at least 12 hours.**

Once the blood glucose has **fallen to 14 mmol/l** add glucose to the fluid.

A bag of 500 ml 0.9% saline with 5% glucose and 20 mmol KCl should be available from Pharmacy (it can be obtained as an unlicensed bag from Baxter- Code FKB2486). If not, make up a solution as follows - withdraw 50ml 0.9% sodium chloride/KCl from 500ml bag, and add 50ml of 50% glucose (this makes a solution which is approximately 5% glucose with 0.9% saline with potassium).

After 12 hours, if the plasma sodium level is stable or increasing, change to 500ml bags of 0.45% saline/5% glucose/20 mmol KCl.

If the plasma sodium is falling, continue with Normal saline (with or without glucose depending on blood glucose levels). Some have suggested that Corrected Sodium levels give an indication of the risk of cerebral oedema. If you wish to calculate this, go to:

<http://www.strs.nhs.uk/resources/pdf/guidelines/correctedNA.pdf>.

Corrected sodium levels should rise as blood glucose levels fall during treatment. If they do not, then continue with Normal saline and do not change to 0.45% saline.

Check U & E's 2 hours after resuscitation is begun and then at least 4 hourly Electrolytes on blood gas machine can be helpful for trends whilst awaiting laboratory results.

The following solutions should soon be available from pharmacies:

500ml bag of 0.45% saline / 5% glucose containing 20 mmol KCl

500ml bag of 0.9% saline / 5% glucose containing 20 mmol KCl

c) Oral Fluids :

- In severe dehydration, impaired consciousness & acidosis do not allow fluids by mouth. A N/G tube may be necessary in the case of gastric paresis.
- Oral fluids (eg fruit juice/oral rehydration solution) should only be offered after substantial clinical improvement and no vomiting
- When good clinical improvement occurs before the 48hr rehydration period is completed, oral intake may proceed and the need for IV infusions reduced to take account of the oral intake.

2. POTASSIUM :

Once the child has been resuscitated, potassium should be commenced immediately with rehydration fluid unless anuria is suspected. Potassium is mainly an intracellular ion, and there is always massive depletion of total body potassium although initial plasma levels may be low, normal or even high. Levels in the blood will fall once insulin is commenced.

Therefore ensure that **every** 500 ml bag of fluid contains **20 mmol KCl (40 mmol per litre)**. There may be standard bags available; if not, strong potassium solution may need to be added, but always check with another person.

Check U & E's 2 hours after resuscitation is begun and then at least 4 hourly, and alter potassium replacements accordingly. More potassium than 40 mmol/l is occasionally required.

Use a cardiac monitor and observe frequently for T wave changes.

3. INSULIN :

Once rehydration fluids and potassium are running, blood glucose levels will start to fall. There is some evidence that cerebral oedema is more likely if insulin is started early. **Therefore DO NOT start insulin until intravenous fluids have been running for at least an hour.**

Continuous low-dose intravenous infusion is the preferred method. There is no need for an initial bolus.

Make up a solution of 1 unit per ml. of human soluble insulin (e.g. Actrapid) by adding 50 units (0.5 ml) insulin to 50 ml 0.9% saline in a syringe pump. Attach this using a Y-connector to the IV fluids already running. Do **not** add insulin directly to the fluid bags.

The solution should then run at **0.1 units/kg/hour** (0.1ml/kg/hour). There are some paediatricians who believe that 0.05 units/kg/hour is an adequate dose. There is no firm evidence to support this.

- Once the blood glucose level falls to **14mmol/l**, change the fluid to contain 5% glucose (generally 0.9% saline with glucose and potassium, see 1b above for type of fluid). **DO NOT** reduce the insulin. The insulin dose needs to be **maintained** at 0.1 units/kg/hour to switch off ketogenesis.
- Some suggest also adding glucose if the initial rate of fall of blood glucose is greater than 5-8 mmol/l per hour, to help protect against cerebral oedema. There is no good evidence for this practice, and blood glucose levels will often fall quickly purely because of rehydration.
- **DO NOT** stop the insulin infusion while glucose is being infused, as insulin is required to switch off ketone production. If the blood glucose falls below 4 mmol/l, give a bolus of 2 ml/kg of 10% glucose and increase the glucose concentration of the infusion. Insulin can temporarily be reduced for 1 hour.
- If needed, a solution of **10% glucose with 0.45% saline** can be made up by adding 50ml 50% glucose to a 500 ml bag of 0.45% saline/5% glucose with 20 mmol KCl.

- Once the pH is above 7.3, the blood glucose is down to 14 mmol/l, and a glucose-containing fluid has been started, consider reducing the insulin infusion rate, but to no less than 0.05 units/kg/hour.
- If the blood glucose rises out of control, or the pH level is not improving after 4-6 hours consult senior medical staff and re-evaluate (possible sepsis, insulin errors or other condition), and consider starting the whole protocol again.

For **children who are already on long-acting insulin** (especially Glargine (Lantus)), your local consultant may want this to continue at the usual dose and time throughout the DKA treatment, in addition to the IV insulin infusion, in order to shorten length of stay after recovery from DKA.

For children on **continuous subcutaneous insulin infusion (CSII) pump therapy**, stop the pump when starting DKA treatment.

4. BICARBONATE :

This is rarely, if ever, necessary. Continuing acidosis usually means insufficient resuscitation or insufficient insulin. Bicarbonate should only be considered in children who are profoundly acidotic (pH< 6.9) and shocked with circulatory failure. Its only purpose is to improve cardiac contractility in severe shock.

Before starting bicarbonate, discuss with senior staff, and the quantity should be decided by the paediatric resuscitation team or consultant on-call.

5. PHOSPHATE :

There is always depletion of phosphate, another predominantly intracellular ion. Plasma levels may be very low. There is no evidence in adults or children that replacement has any clinical benefit and phosphate administration may lead to hypocalcaemia.

6. ANTICOAGULANT PROPHYLAXIS :

There is a significant risk of femoral vein thrombosis in young and very sick children with DKA who have femoral lines inserted. Therefore consideration should be given to anticoagulating these children with 100 units/kg/day as a single daily dose of Fragmin.

Children who are significantly hyperosmolar might also require anticoagulant prophylaxis (discuss with your local consultant).

E. CONTINUING MANAGEMENT :

- Urinary catheterisation should be avoided but may be useful in the child with impaired consciousness.
- Documentation of fluid balance is of paramount importance. All urine needs to be measured accurately (and tested for ketones if blood ketones are not being monitored). All fluid input must be recorded (even oral fluids).
- If a massive diuresis continues fluid input may need to be increased. If large volumes of gastric aspirate continue, these will need to be replaced with 0.45% saline with KCl.
- Check biochemistry, blood pH, and laboratory blood glucose 2 hours after the start of resuscitation, and then at least 4 hourly. Review the fluid composition and rate according to each set of electrolyte results.
- **If acidosis is not correcting**, consider the following
 - insufficient insulin to switch off ketones
 - inadequate resuscitation
 - sepsis
 - hyperchloraemic acidosis
 - salicylate or other prescription or recreational drugs

Use **near-patient ketone testing** to confirm that ketone levels are falling adequately. If blood ketones are not falling, then check infusion lines, the calculation and dose of insulin and consider giving more insulin.

Consider sepsis, inadequate fluid input and other causes if sufficient insulin is being given.

Insulin management once ketoacidosis resolved -

Continue with IV fluids until the child is drinking well and able to tolerate food. Only change to subcutaneous insulin once blood ketone levels are below 1.0 mmol/l, although urinary ketones may not have disappeared completely.

Discontinue the insulin infusion 60 minutes (if using soluble or long-acting insulin) or 10 minutes (if using Novorapid or Humalog) after the first subcutaneous injection to avoid rebound hyperglycaemia. Subcutaneous insulin should be started according to local protocols for the child with newly diagnosed diabetes, or the child should be started back onto their usual insulin regimen at an appropriate time (discuss with senior staff).

F. CEREBRAL OEDEMA :

The signs and symptoms of cerebral oedema include

- headache & slowing of heart rate
- change in neurological status (restlessness, irritability, increased drowsiness, incontinence)
- specific neurological signs (eg. cranial nerve palsies)
- rising BP, decreased O₂ saturation
- abnormal posturing

More dramatic changes such as convulsions, papilloedema, respiratory arrest are late signs associated with extremely poor prognosis

Management :

If cerebral oedema is suspected **inform senior staff immediately.**

The following measures should be taken **immediately** while arranging transfer to PICU–

- exclude hypoglycaemia as a possible cause of any behaviour change
- give **hypertonic (2.7%) saline** (5mls/kg over 5-10 mins) **or Mannitol** 0.5 – 1.0 g/kg stat (= 2.5 - 5 ml/kg Mannitol 20% over 20 minutes). This needs to be given as soon as possible if warning signs occur (eg headache or pulse slowing).
- restrict IV fluids to 1/2 maintenance and replace deficit over 72 rather than 48 hours
- the child will need to be moved to PICU (if not there already)
- discuss with PICU consultant. Do not intubate and ventilate until an experienced doctor is available
- once the child is stable, exclude other diagnoses by CT scan - other intracerebral events may occur (thrombosis, haemorrhage or infarction) and present similarly
- a repeated dose of Mannitol may be required after 2 hours if no response
- document all events (with dates and times) very carefully in medical records

G. OTHER COMPLICATIONS :

- **Hypoglycaemia and hypokalaemia** – avoid by careful monitoring and adjustment of infusion rates. Consideration should be given to adding more glucose if BG falling quickly even if still above 4 mmol/l.
- **Systemic Infections** – Antibiotics are not given as a routine unless a severe bacterial infection is suspected
- **Aspiration pneumonia** – avoid by nasogastric tube in vomiting child with impaired consciousness

Other associations with DKA require specific management:

Continuing abdominal pain is common and may be due to liver swelling, gastritis, bladder retention, ileus. However, beware of appendicitis and ask for a surgical opinion once DKA is stable. A raised amylase is common in DKA.

Other problems are pneumothorax ± pneumo-mediastinum, interstitial pulmonary oedema, unusual infections (eg TB, fungal infections), hyperosmolar hyperglycaemic non-ketotic coma, ketosis in type 2 diabetes.

Discuss these with the consultant on-call.

APPENDIX 1 Glasgow Coma Scale

Best Motor Response	1 = none 2 = extensor response to pain 3 = abnormal flexion to pain 4 = withdraws from pain 5 = localises pain 6 = responds to commands
Eye Opening	1 = none 2 = to pain 3 = to speech 4 = spontaneous
Best Verbal Response	1 = none 2 = incomprehensible sounds 3 = inappropriate words 4 = appropriate words but confused 5 = fully orientated

Maximum score 15, minimum score 3

Modification of verbal response score for younger children :

2-5 years

- 1 = none
- 2 = grunts
- 3 = cries or screams
- 4 = monosyllables
- 5 = words of any sort

< 2 years

- 1 = none
- 2 = grunts
- 3 = inappropriate crying or
unstimulated screaming
- 4 = cries only
- 5 = appropriate non-verbal responses
(coos, smiles, cries)

Appendix 2. Algorithm for the Management of Diabetic Ketoacidosis

