Management of Diabetic Ketoacidosis (DKA) in Children and Young People – Full Paediatric Guideline – Joint Derby and Burton

Aim and Purpose

To safely manage the care of children and young people in University Hospitals of Derby and Burton NHS Foundation Trust (both Derby and Burton sites) with diabetic ketoacidosis.

Main Body of Guidelines

Introduction

These guidelines have been revised based upon guidance from the BSPED special interest group in diabetic ketoacidosis (Nov 2021), which itself was updated in light of NICE (Dec 2020) and UK resus council recommendations (May 2021).

For many aspects of the management of DKA the evidence base is limited and where there is limited evidence, consensus recommendations have been consolidated. 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 and specific treatment tailored to those requirements.

The BSPED Integrated Care Pathway (with edits to incorporate local guidelines) is on pages 18-34. Please use this rather than printing the online version as that will not include our local variations. It is recommended that you print these and fill them out to aid management and documentation. **Please file this in the medical notes**.

Current BSPED guideline: https://www.bsped.org.uk/clinical-resources/bsped-dka-guidelines

***Key points*:**

1) Where young people aged 16-18 years are managed by adult medical teams, it is considered appropriate for them to be managed using local adult guidelines that the teams are familiar with rather than using potentially unfamiliar paediatric guidelines. Where individuals aged 16-18 are managed by Paediatric teams the Paediatric guidelines should be followed.

2) The ISPAD **definition for DKA** with blood glucose >11mmol/l, acidosis with a bicarbonate of <15mmol/l or pH <7.3, and ketones of >3.0mmol/l has been adopted.

3) This guideline uses pH to categorise the severity of DKA and to determine the degree of dehydration.
    - Mild DKA – venous pH 7.2-7.29 (or bicarbonate 10.1 - 15mmol/l). Assume 5% dehydration
    - Moderate DKA – venous pH 7.1-7.19 (or bicarbonate 5.1 - 10mmol/l). Assume 5% dehydration
    - Severe DKA – venous pH less than 7.1 (or bicarbonate < 5mmol/l). Assume 10% dehydration

4) **Careful management of fluid administration remains an important part of the management of diabetic ketoacidosis** because of the risk of cerebral oedema but there is increased emphasis on the importance of treating shock and restoring appropriate circulatory volume:

- Patients presenting with **shock** should receive a **10 ml/kg bolus of 0.9% saline over 15 minutes** as soon as possible. Shock is defined as the APLS definition of tachycardia, prolonged central capillary refill, low volume peripheral pulses and hypotension (though this is a late sign of shock). Note poor peripheral perfusion with prolonged peripheral capillary refill, tachycardia and tachypnoea are common in moderate to severe DKA as signs of vasoconstriction due to metabolic acidosis and hypocapnia and would not be considered as shock. Following the initial 10 ml/kg bolus patients should be reassessed and further boluses of 10 ml/kg after discussion with the responsible senior paediatrician may be given if required to restore adequate circulation up to a total of 40 ml/kg at which stage inotropes should be considered. Boluses given to treat shock should NOT be subtracted from the calculated fluid deficit.

- All patients with DKA (mild, moderate or severe) in whom intravenous fluids are felt to be indicated, even if **not shocked**, should receive an initial **10 ml/kg bolus of 0.9% saline over 30 minutes**. This bolus SHOULD be subtracted from the calculated fluid deficit.

5) The calculation of maintenance fluids should be based on the traditional formula used in paediatrics in the UK: 100 ml/kg/day for the first 10 kg body weight, plus 50 ml/kg/day for 10 to 20 kg and 20 ml/kg/day for each additional kilogram above 20 kg.

6) A maximum weight of 75kg should be used for the calculation of fluid replacement and deficit as this ensures that excessive volumes of fluids are not given

7) For insulin infusion we use **0.1 units/kg/hour for children aged 5 and above** in both Derby and Burton, and in **children younger than 5 years we recommend 0.05units/kg/hr** (consensus recommendation) to reduce the incidence of hypoglycaemia. The dose can be increased to 0.1units/kg/hour if acidosis is not resolving.

8) Where **potassium** is above the upper limit of the normal range at presentation it is recommended that potassium is only added to Intravenous fluids after the patient has passed urine or until after the potassium has fallen to within the upper limit of the normal range

9) In patients already on **long acting insulin** this should be continued and in new patients, consideration should be given to starting long acting subcutaneous insulin alongside intravenous insulin.

Please see page 17 for summary of management.

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 uncertain, and evolution of cerebral oedema can be unpredictable. The management is covered within the guideline.

Hypokalaemia . This is preventable with careful monitoring and management

Aspiration pneumonia. Use a nasogastric tube in semi-conscious or unconscious children

Inadequate resuscitation. Ensure that children with DKA receive adequate resuscitation if they are shocked. Inadequate resuscitation is likely to increase the risk of brain injury. Cerebral perfusion is influenced both by the blood pressure and the intracranial pressure in incipient cerebral oedema.

WHERE TO ADMIT AND WHO TO REFER TO

Derby

All children and young people with DKA in Derby should be **admitted to Dolphin PCCU** – ideally with one-to-one nursing.

If **PICU** is felt to be required, senior discussion with QMC PICU and COMET is required.

Derby - In Hours

- Inform CED senior (registrar or above) immediately of attendance
- Inform paediatric registrar of admission
- Inform service consultant of admission
- Inform diabetes team of admission
- **Escalation**: registrar > service consultant > Derby diabetes specialist consultant

Derby - Out of Hours

- Inform CED senior (registrar or above) immediately of attendance
- Inform on call paediatric registrar of admission (if different to above)
- **Escalation**: registrar > on call consultant > on call QMC endocrine consultant
- Handover for day team to inform diabetes team of admission

Burton

If the child is < 2 years of age or has a pH <7.1, they should be transferred to **PCCU in Derby** after stabilisation.

If the child is ≥ 2 years of age and has a pH ≥7.1, they can be transferred to **ward 1** after stabilisation and discussion with nursing staff on the ward. They should be nursed with close observation with one- to-one nursing.

If **PICU** is felt to be required, senior discussion with QMC PICU and COMET is required.

Burton - In Hours

- Inform paediatric registrar immediately of attendance
- Inform paediatric service consultant of admission
- Discuss with Derby paediatric registrar +/- COMET if transfer to Derby PCCU is indicated
- **Escalation**: registrar > service consultant > Burton diabetes specialist consultant
- Inform Burton diabetes team of admission (and Derby diabetes team if transferring to Derby)

Burton - Out of Hours

- Inform paediatric registrar immediately of attendance
- Discuss with Derby paediatric registrar +/- COMET if transfer to Derby PCCU is indicated
- **Escalation**: registrar > on call consultant > on call QMC endocrine consultant
- Handover for day team to inform Burton diabetes team of admission (and Derby diabetes team if transferred to Derby)

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A. DIAGNOSIS

Diagnose DKA in children and young people who have:

- acidosis (blood pH below 7.3 *or* plasma bicarbonate below 15 mmol/litre)
  and
- ketonaemia (indicated by blood ketones above 3 mmol/litre)

Blood glucose levels are generally high (above 11mmol/l) but children and young people with known diabetes may develop DKA with normal blood glucose levels.

pH 7.2 - 7.29 and/or **bicarbonate 10.1 - 15** = **mild DKA**

pH 7.1 - 7.19 and/or **bicarbonate 5.1 - 10** = **moderate DKA**

pH less than 7.1 and/or **bicarbonate < 5** = **severe DKA**

Use a near-patient testing method for blood ketone level for the diagnosis and monitoring of the treatment of DKA.

They may also have the following clinical features:

- acidotic respiration
- drowsiness
- abdominal pain/nausea/vomiting

Always consult with the consultant paediatrician on call as soon as you suspect DKA even if you feel confident of your management.

IMPORTANT NOTES – PLEASE READ

1. Children, who are alert, not clinically dehydrated, not nauseated or vomiting, **do not always require IV fluids**, even if their ketone levels are high. They usually tolerate oral rehydration and subcutaneous insulin but do require monitoring regularly to ensure that they are improving and their ketone levels are falling.

2. If a child is hyperosmolar with a very high BG level (>30mmol/l), with little or no acidosis or ketones, this is a Hyperosmolar Hyperglycaemic State and requires DIFFERENT treatment. Discuss this with the senior doctor– these children can be very difficult to manage. There are starting instructions in Appendix 5 (page 35).

Discuss both groups of children and young people with the responsible senior paediatrician.

B. EMERGENCY MANAGEMENT

1. GENERAL RESUSICTATION: ABC

Airway — Ensure that the airway is patent and if the child is comatose, insert an airway. If consciousness reduced or child has recurrent vomiting, consider inserting N/G tube, aspirate and leave on open drainage.

Seek urgent anaesthetic review and discuss with a paediatric critical care specialist if the child has a reduced level of consciousness and is unable to protect their airway.

Breathing — Give 100% oxygen by face mask (unless child is very well)

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

2. WEIGH THE CHILD

To avoid excessive amounts of fluid in overweight and obese children it is recommended using a **maximum weight of 75kg or 97th centile weight for age (whichever is lower)** when calculating both deficit and maintenance requirements.

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

3. INITIAL FLUID BOLUS

- All children and young people with mild, moderate or severe DKA who are **not shocked** and are felt to require IV fluids should receive a **10 ml/kg 0.9% sodium chloride bolus over 30 minutes.**

- Patients **with shock** require appropriate restoration of their circulation and circulatory volume. Shocked patients should receive a **10 ml/kg bolus of 0.9% saline over 15 minutes**. Shock is defined by the APLS definition of tachycardia, prolonged central capillary refill, weak, thready (low volume) peripheral pulses and hypotension (though this is a late sign of shock). Poor peripheral perfusion with prolonged capillary refill, tachycardia and tachypnoea are common in moderate to severe DKA as signs of vasoconstriction due to metabolic acidosis and hypocapnia and would not be considered as shock.

- Following the initial 10 ml/kg bolus shocked patients should be reassessed and further boluses of 10 ml/kg may be given if required after discussion with the responsible senior paediatrician to restore adequate circulation up to a total of 40 ml/kg at which stage inotropes should be considered.

- Whilst excessive fluid should be avoided because of the risk of cerebral oedema, it is important to ensure that the circulation is adequate and fluid should be given to support this. Cerebral perfusion is dependent on both perfusion pressure and intracranial pressure and hypotension will exacerbate the risk of brain injury.

4. INITIAL INVESTIGATIONS

- Blood glucose
- Blood gases (venous or capillary)
- Ketones - near patient blood ketones testing should be used.
- FBC
- U&Es (electrolytes on blood gas give a guide until U&Es available).
- HbA1c
- Thyroid function tests and coeliac serology in new patients

- In Derby, see “Diabetes - Newly Diagnosed” guideline
- In Burton, see “Diabetes - Newly Diagnosed - Check List For Child/Young Person” guideline. For initial bloods, please use the V6 orderset: PAED.NEW DIABETIC along with blood gas, ketones and glucose as above.

Other investigations should be done only if indicated e.g. CRP, CXR, CSF, throat swab, blood cultures, urinalysis etc. (A raised white blood cell count is common in DKA and does not necessarily indicate sepsis). There is no need to check diabetes antibodies.

DKA may be precipitated by sepsis or intercurrent infection, and fever is not part of DKA. Infection may co-exist with DKA. Suspect sepsis if there is fever or hypothermia, hypotension, refractory acidosis or lactic acidosis. A high lactate should increase concern about possible infection or sepsis.

5. FULL CLINICAL ASSESSMENT

Assess and record (so that comparisons can be made by others later) the following:

1) Conscious Level:
Institute hourly neurological observations including Glasgow Coma Score (see Appendix 1 – page 31) whether or not they are drowsy on admission.

If reduced conscious level on admission, or there is any subsequent deterioration,
- seek urgent anaesthetic review if the airway cannot be protected
- discuss with the responsible senior paediatrician
- discuss with a paediatric critical care specialist to decide the appropriate care setting (paediatric HDU or PICU)

Conscious level is directly related to degree of acidosis, but signs of raised intracranial pressure suggest cerebral oedema - if cerebral oedema is suspected, go to page 15 for details on urgent management.

2) 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 (which is common in DKA)

6. FLUID MANAGEMENT

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

Use of the **BSPED Integrated Care Pathway** (pages 18-34) is the recommended way to work out and document fluid management. It should be printed and kept in the medical notes.

a) Volume of fluid:
By this stage, the circulating volume should have been restored. Once circulating blood volume has been restored and the child adequately resuscitated, calculate fluid requirements as follows:

Calculate the fluid deficit (either 5% or 10% dehydration depending on whether the patient has mild, moderate or severe DKA), subtract the initial 10ml/kg bolus in children without shock (**do not** subtract boluses given to treat shock), then divide this over 48 hours and add to the hourly rate of maintenance fluid volume, giving the total volume **evenly** over the next 48 hours. i.e.

Requirement (over 48 hours) = Deficit – Non-shocked resus bolus + (Maintenance x2)

Hourly rate = ({Deficit – Non-shocked resus bolus} / 48hr) + Maintenance per hour

Fluid Deficit:
Estimation of the fluid deficit should be based on the initial blood pH. Therefore:

Assume **a 5% fluid deficit** in children and young people with **mild DKA**
(indicated by a blood pH 7.2-7.29 &/or bicarbonate 10.1 - 15) and **moderate DKA**
(indicated by a blood pH of 7.1- 7.19 &/or bicarbonate 5.1 - 10)

Assume **a 10% fluid deficit** in children and young people **in severe DKA**
(indicated by a blood pH <7.1 &/or bicarbonate <5)

Maintenance fluid:
Maintenance fluid volumes should be calculated using the traditional method of calculating fluid volume in children in the UK:

- 100 ml/kg/day for the first 10 kg of body weight
- 50 ml/kg/day for the next 10 kg
- 20 ml/kg/day for each additional kilogram above 20 kg

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

Resuscitation fluid:
The volume of any fluid boluses given for resuscitation in children **with shock** should **NOT** be subtracted from the estimated fluid deficit.

The initial 10ml/kg bolus given to all **non-shocked patients** requiring IV fluids **SHOULD be subtracted** from total calculated fluid deficit.

Fluid Calculation Examples:

i. A 20kg 6 year old who has a pH of 7.15 (Moderate DKA = 5% dehydrated) will receive a 10ml/kg bolus (200mls fluid) over 30 minutes as part of his initial management. Their ongoing fluids will comprise:

Deficit 5 % x 20 kg	=	5/100 x (20 x 1000) = 1000 ml
Subtract initial bolus		1000 - 200 = 800ml to be replaced over 48 hours
	=	17 ml/hr
Maintenance		10 x 100 = 1000 ml per day for 1st 10 kg
		10 x 50 = 500ml per day for next 10 kg (weighs 20kg)
	=	1500 ml per day total (over 24 hours)
	=	62 ml/hour
Total fluid		17ml/hour (Deficit of 5% minus bolus over 48 hours)
	+	62ml/hr (Maintenance fluids)
	=	**79 ml/hour**

ii. A 60kg 15 year old with a pH of 6.9 (Severe DKA = 10% dehydrated) who was **shocked** at presentation has received 30ml/kg of 0.9% saline for resuscitation. These boluses are **not subtracted** from ongoing maintenance fluids. Their ongoing fluids will comprise:

Deficit 10 % x 60kg	=	10/100 x (60 x 1000) = 6000 ml to be replaced over 48 hours
	=	125 ml/hr
Maintenance		10 x 100 = 1000 ml per day for 1st 10 kg
		10 x 50 = 500ml per day for next 10 kg (10-20kg)
		40 x 20 = 800ml per day for next 40kg
	=	2300 ml per day total (over 24 hours)
	=	96 ml/hour
Total fluid		125 ml/hour (Deficit of 10 % over 48 hours)
	+	96 ml/hr (Maintenance fluids)
	=	**221 ml/hour**

iii. A 95kg 15 year old with a pH of 7.23 (Mild DKA = 5% dehydrated) will receive a 10ml/kg bolus (750mls fluid as recommend **maximum weight of 75kg**) over 30 minutes as part of their initial management. Their ongoing fluids will comprise:

Deficit 5 % x 75 kg	=	5/100 x (75 x 1000) = 3750 ml
Subtract initial bolus		3750 - 750 = 3000ml to be replaced over 48 hours
	=	62 ml/hr
Maintenance		10 x 100 = 1000 ml per day for 1st 10 kg
		10 x 50 = 500ml per day for next 10 kg (10-20kg)
		55 x 20 = 1100ml per day for next 55kg (up to max 75kg)
	=	2600 ml per day total (over 24 hours)
	=	108 ml/hour
Total fluid		62ml/hour (Deficit of 5 % minus bolus over 48 hours)
	+	108ml/hr (Maintenance fluids)
	=	**170 ml/hour**

Do not give additional intravenous fluid to replace urinary losses. Urinary catheterisation should be avoided but may be useful in the child with impaired consciousness.

b) Type of fluid:

Bolus fluids: 0.9% saline

Maintenance fluids: use **0.9% sodium chloride with 20mmol potassium chloride in 500 ml** (40mmol per litre) until blood glucose levels are less than 14mmol/l (see below section 13 – When Blood Glucose Falls).

c) Oral Fluids:

- Do not give oral fluids to a child or young person who is receiving intravenous fluids for DKA until ketosis is resolving and there is no nausea or vomiting.
- A nasogastric tube may be necessary in the case of gastric paresis.
- If oral fluids are given before the 48hr rehydration period is completed, the IV infusion needs to be reduced to take account of the oral intake.

d) Fluid Losses:

If a massive diuresis continues for several hours fluid input may need to be increased; this should be isotonic to the urine. If large volumes of gastric aspirate continue, these will need to be replaced with 0.45% saline with Potassium Chloride.

7. POTASSIUM

Ensure that **every** 500 ml bag of fluid, except any initial boluses, contains **20mmol** potassium chloride (**40mmol per litre**) unless there is evidence of renal failure. Hypokalaemia can occur up to 48 hours after starting DKA treatment.

Potassium is mainly an intracellular ion, and there is always 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.

Where potassium is above the upper limit of the normal range at presentation, it is recommended that potassium is only added to IV fluids after the patient has passed urine (to confirm they are not becoming anuric) **or** after the potassium has fallen to within the upper limit of the normal range (which it typically will have done after the initial 10ml/kg bolus has been given). **Inform the prescriber once the child or young person has passed urine.**

If the child or young person with DKA develops hypokalaemia (potassium below 3mmol/litre):

- think about further reducing the insulin infusion
- discuss urgently with a critical care specialist, because a central venous catheter is needed for intravenous administration of potassium solutions above 40 mmol/litre.

8. 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. Do not give bolus doses of intravenous insulin.

Start intravenous insulin infusion 1-2 hours after beginning intravenous fluid therapy.

In Derby, use pre-filled syringes containing 50 units of soluble insulin in 50ml 0.9% sodium chloride. In Burton, add 50 units (0.5mls) of soluble insulin (e.g. Actrapid) to 49.5ml of 0.9% sodium chloride in Burton. Both solutions provide 1 unit of insulin per ml.

We start with an insulin infusion rate of 0.1units/kg/hour in both Derby and Burton, **except in children younger than 5 years** where we recommend 0.05units/kg/hr.

Soluble insulin infusion dosage:

Children 5 and older: 0.1units/kg/hour.

Children under 5: 0.05units/kg/hour

Other insulin management:

- For children and young people on **continuous subcutaneous insulin infusion (CSII) pump therapy,** stop the pump when starting intravenous insulin.
- For **children who are already on long-acting insulin**, you may wish to continue this 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 with newly diagnosed diabetes, starting an appropriate dose of long acting background insulin alongside the intravenous infusion on the night of admission should be considered, unless clinically very unwell (see our local guideline for the management of newly diagnosed diabetes available on the intranet).

9. BICARBONATE

Do not give IV sodium bicarbonate to children and young people with DKA. Only consider bicarbonate if there is life threatening hyperkalaemia or in severe acidosis with impaired myocardial contractility. It is anticipated that this would only ever be done following discussion with an Intensivist.

10. RISK OF VENOUS THROMBOSIS

Be aware that there is a significant risk of femoral vein thrombosis in young and very sick children with DKA who have femoral lines inserted. Lines should be in situ as short a time as possible. Thromboembolic prophylaxis should be considered in young people >16 years (in line with NICE guidance), in young women taking the combined oral contraceptive pill and sick patients with femoral lines, following discussion with an Intensive Care Specialist.

11. MONITORING – NURSING OBSERVATIONS

- strict fluid balance including oral fluids and urine output, using fluid balance charts (urinary catheterisation may be required in young/sick children)
- **hourly** capillary blood glucose measurements (these may be inaccurate with severe dehydration/acidosis but are 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
- hourly BP and basic observations
- hourly level of consciousness initially, using the modified Glasgow coma score
- in children under the age of 2, or in children and young people with a pH less than 7.1: half-hourly neurological observations, including level of consciousness (using the modified Glasgow coma score) and heart rate, because they are at increased risk of cerebral oedema

- 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 signs of hypokalaemia, including ST-segment depression and prominent U-waves
- twice daily weight; can be helpful in assessing fluid balance (do not alter fluid calculations with new weight)

12. MONITORING – MEDICAL REVIEWS

At **2 hours after starting treatment, and then at least every 4 hours**, carry out and record the results of the following **blood tests** -

- blood gas (for pH and pCO2)
- finger-prick blood ketones
- plasma glucose (laboratory measurement)
- plasma U&E – **ensure samples are sent URGENTLY to laboratory** – and calculate corrected sodium

A doctor should carry out a **face-to-face review** at the start of treatment and then **at least every 4 hours**, and more frequently if:

- children are aged under 2 years
- they have severe DKA (blood pH below 7.1)
- there are any other reasons for special concern.

At each face-to-face review, assess and document the following:

- clinical status, including vital signs and neurological status
- results of blood investigations
- ECG trace
- cumulative fluid balance record.

Please see Appendix 4 (page 33) for further information on the calculation and interpretation of corrected sodium, acidosis, and other electrolytes.

13. WHEN BLOOD GLUCOSE FALLS

Continue with 0.9% sodium chloride containing 20mmol potassium chloride in 500ml until blood glucose levels have fallen to 14mmol/l.

Once the **blood glucose** has **fallen to 14mmol/l** add glucose to the fluid and think about the insulin infusion rate, as follows -

- Change the fluid to contain 5% glucose; use 500 ml bags of 0.9% sodium chloride with 5% glucose and 20mmol potassium chloride in 500ml which are available from Pharmacy (or see Appendix 3, page 32)
- If blood glucose level is still dropping, continue 0.1 units/kg/hour insulin infusion and change the fluid to 10% glucose rather than 5% glucose, in order to prevent hypoglycaemia (use 500 ml bags of 0.9% sodium chloride with 10% glucose and 20mmol potassium chloride in 500mol)
- If blood glucose level is still dropping, reduce insulin infusion rate to 0.05 units/kg/hour from 0.1 Units/kg/hour
- **Once ketones are <1.0mmol/l**, consider switching from IV to subcutaneous insulin

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 6mmol/l**:

- increase the glucose concentration of the intravenous fluid infusion, and
- if there is persisting ketosis, continue to give insulin at a dosage of least 0.05 units/kg/hour

If the **blood glucose falls below 4mmol/l**, give a bolus of 2ml/kg of 10% glucose and increase the glucose concentration of the infusion.

14. IF DKA IS NOT RESOLVING

If the blood glucose does not improve; or after initial improvement rises > 5mmol/ hour; or the pH level is not improving after 4-6 hours consult senior medical staff and re-evaluate (possible sepsis, insulin dosage errors, blocked or leaking lines, excessive urine loss, fluid calculation error or other conditions) and consider starting the whole protocol again.

If acidosis is not correcting, consider the following

- insufficient insulin to switch off ketones (including incorrectly made insulin infusion)
- inadequate resuscitation
- fluid calculation error
- 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.
Once all these causes of acidosis have been excluded, and if ketones are falling gradually, then residual acidosis is likely to be due to hyperchloraemia; this can be left to resolve on its own and does not require any treatment.

15. WHEN KETOACIDOSIS RESOLVES (STOPPING IV TREATMENT)

Think about stopping IV fluid therapy when ketosis is resolving and oral fluids are tolerated without nausea or vomiting.

Do not change from IV insulin to subcutaneous insulin until ketosis is resolving (for example, blood ketones below 1.0mmol/litre) and the child or young person with DKA is alert and is tolerating fluids without nausea or vomiting.

Start **subcutaneous** insulin **at least 30 minutes** before stopping IV insulin, usually with a meal.

For a child or young person with DKA who is using **insulin pump** therapy, restart the pump **at least 60 minutes** before stopping intravenous insulin. Change the insulin cartridge and infusions set, and insert the cannula into a new subcutaneous site.

Subcutaneous insulin should be started according to local guidelines for the child with newly diagnosed diabetes, or the child should be started back onto their usual insulin regimen at an appropriate time.

C. EDUCATION AND FOLLOW-UP

Ensure the diabetes team are aware of the admission as the child or young person requires a specialist review by the diabetes team within 24 hours of admission.

Contact numbers:

Ext 86963 - RDH paediatric diabetes nurses (if out of hours can leave a message)

Ext 4670 or 5680 - Burton paediatric diabetes office

The paediatric diabetes specialist team can also be contacted directly via switchboard.

After a child or young person **with known diabetes** has recovered from an episode of DKA, discuss with them and their family members or carers (if appropriate) the factors that may have led to the episode.

D. COMPLICATIONS

1. CEREBRAL OEDEMA

Immediately assess a child or young person with DKA for suspected cerebral oedema if they have any of these early manifestations:

- headache
- agitation or irritability
- unexpected fall in heart rate
- increased blood pressure.

If cerebral oedema is suspected in these children or young people, treat immediately with the most readily available of:

- hypertonic saline (2.7% or 3% 2.5-5 ml/kg over 10-15 minutes) *or*
- mannitol 10% contains 10g per 100mls (0.5-1 g/kg over 10-15 minutes)

Ideally, give hypertonic saline. As 20% mannitol has a tendency to crystallise, we use 10% mannitol if needed but this provides a higher volume than 2.7% saline. The key point is that treatment should not be delayed sourcing either – so give what is available.

If a child or young person develops any of these signs –

- deterioration in level of consciousness
- abnormalities of breathing pattern, for example respiratory pauses &/or drop in SaO2.
- oculomotor palsies
- abnormal posturing
- pupillary inequality or dilatation.

treat them **immediately** for cerebral oedema using either:

- hypertonic saline (2.7% or 3% 2.5-5 ml/kg over 10-15 minutes) *or*
- mannitol 10% contains 10g per 100mls (0.5-1 g/kg over 10-15 minutes)

In addition, fluids should be restricted to **⅔ maintenance** rates (and stop fluids prescribed for deficit) and **inform senior staff immediately.**

After starting treatment for cerebral oedema with, immediately seek specialist advice on further management, including which care setting would be best for the child or young person.

- 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. Treatment of suspected cerebral oedema should not be delayed through pending imaging.
- The effect of hypertonic saline should be apparent within 15 minutes and typically lasts for 120 minutes. If there is no improvement with hypertonic saline within 30 minutes a repeated dose of hypertonic saline (mannitol) may be given. Treatment may promote a brisk diuresis due to its osmotic effect and renal excretion.
- If hypertonic saline was given initially and there is no response to treatment within 15-30 minutes, then mannitol may also be given and there is some suggestion that the effect of hypertonic saline and mannitol may be additive.

2. 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 4mmol/l.

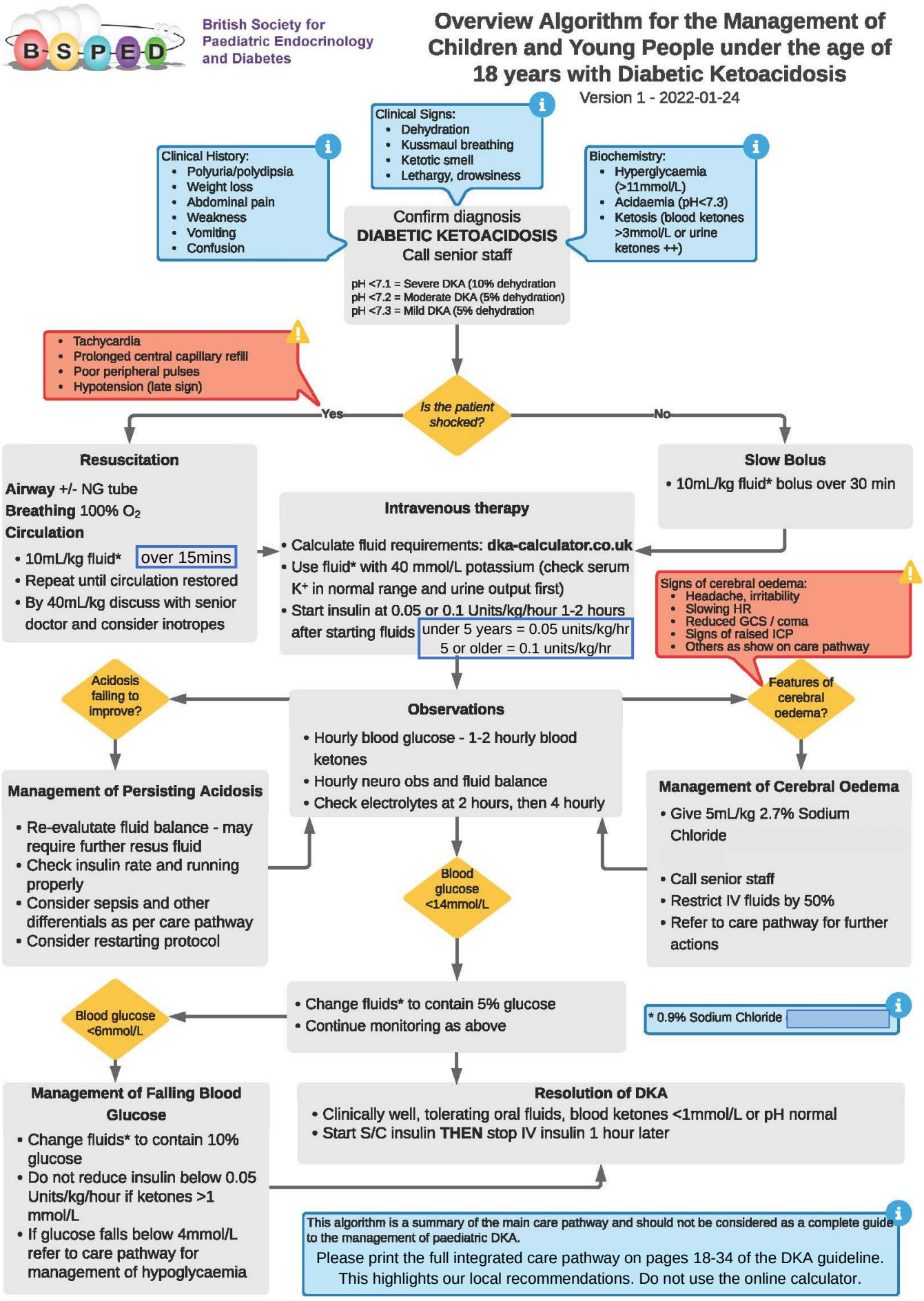
- **Systemic infections** – Antibiotics are not given as a routine unless a severe bacterial infection is suspected. Fever, raised lactate and raised inflammatory markers may all indicate possible concomitant infection.
- **Aspiration pneumonia** – avoid by nasogastric tube in vomiting child with impaired 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 (e.g. TB, fungal infections), hyperosmolar hyperglycaemic non–ketotic coma, ketosis in type 2 diabetes.

E. Overview Algorithm



F. BSPED DKA Integrated Care Pathway with Local Guidance Incorporated – PRINT THIS FOR MEDICAL NOTES (PAGES 18-34)

British Society for Paediatric Endocrinology and Diabetes

Integrated care pathway for the management of children and young people with

Diabetic Ketoacidosis

Updated with the latest changes to the BSPED DKA Guideline 2021

If you are not experienced in managing children in DKA, ask for senior help now.

Affix sticker or complete patient demographics below

Name

Date of Birth

Hospital / NHS Number

DKA protocol started at:

hh:mm

dd/mm/yyyy

IMPORTANT SAFETY NOTES:

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 patient's requirements and specific treatment tailored to those requirements.

This integrated care pathway (ICP) is designed to be used by, or under the supervision of, clinicians experienced in the management of paediatric DKA. It should be used in conjunction with the full BSPED DKA 2021 guideline on which it is based which can be found at: https://www.bsped.org.uk/clinical-resources/bsped-dka-guidelines/

This is part of the official patient care record and should be filed in the patient's notes. All professionals involved must document any intervention carried out. When filling out a flow chart, you must complete the box in the lower right corner of the chart with your signature, name, and the date and time. Any variation from the care plan must be documented.

There is an online DKA calculator available however we do not advise using this as our local recommendations may be overlooked.

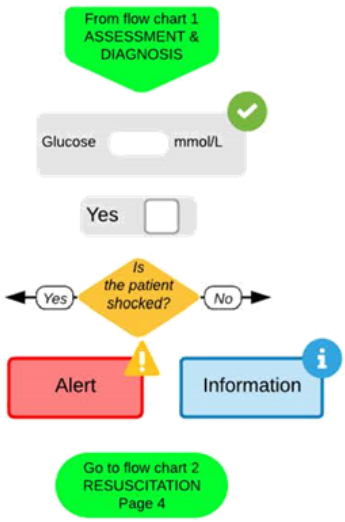
Instead, please print the full integrated care pathway from here (pages 18-34) as our local recommendations are highlighted on this. **Please file this in the medical notes**.

Patient Name:
Date of Birth:
Hospital / NHS Number:

INTRODUCTORY NOTES

This ICP is designed to be worked through and completed to aid with management decisions and to record important events. You should start with flow chart 1 - ASSESSMENT & DIAGNOSIS - on page 3, and proceed as shown in the guidance below. Remember to refer to the additional guidance in the appendicies if you are not already familiar with it.

The flow charts are structured in a systematic way as follows:



Indicates the start of a flow chart, showing how it was reached.

The blank space indicates an entry to be completed by the clinician. A green tick icon indicates that an entry is part of the national DKA audit programme.

Indicates a tick box option.

Indicates a decision point. Follow the appropriate arrow to continue.

Shows additional critical or useful guidance.

Indicates the end of a flow chart sequence, showing which flow chart to use next.

The ICP is divided into sections which are identified by coloured borders at the side of each page.

MAIN PROTOCOL SECTION

COMPLICATIONS SECTION

APPENDICIES SECTION

FLOW CHART 1 – ASSESSMENT & DIAGNOSIS

Patient Name:
Date of Birth:
Hospital / NHS Number:

START HERE

Clinical History:
- Polyuria/polydipsia
- Weight loss
- Abdominal pain
- Weakness
- Vomiting
- Confusion

Clinical Signs:
- Dehydration
- Kussmaul breathing (deep, sighing)
- Ketotic smell
- Lethargy, drowsiness

Biochemistry:
- Hyperglycaemia (>11mmol/L)
- Acidaemia (pH<7.3)
- Ketosis (blood ketones >3mmol/L or urine ketones ++)

Suspect DKA

Ask for senior support

Check:
Blood Glucose
Blood Ketones
Blood Gas

Record initial values:
Glucose ____ mmol/L
pH ____
Ketones ____ mmol/L
Bicarb. ____ mmol/L

Raised blood glucose, pH >7.3 AND bicarbonate >15mmol/L → Consider new diabetes not in DKA Use local guidelines

Very high blood glucose (>33.3mmol/L), No significant ketosis (<3mmol/L) OR acidosis (pH>7.3, bicarb. >15mmol/L) → Go to flow chart 12 HYPEROSMOLAR HYPERGLYCAEMIC STATE Page 13

pH <7.3 or bicarbonate <15mmol/L AND Blood ketones >3mmol/L → **Diagnose DKA**

Blood glucose levels are generally high (above 11mmol/L) but children and young people with known diabetes may develop DKA with normal blood glucose levels.

Perform rapid emergency assessment

Record your initial assessment here and use this to guide your management on the following page

Airway
- Maintaining own airway? Yes ☐ No ☐

Breathing
- RR ____ /min
- SpO_2 ____ %
- Acidotic pattern? Yes ☐ No ☐

Circulation
- HR ____ /min
- CRT ____ secs
- BP ____ /
- Clinically shocked? Yes ☐ No ☐
- See also page 4

Disability
- GCS ____ /15
- M: ____ /6 V: ____ /5 E: ____ /4
- See also appendix 1 page 14

Further details:

Children who are alert, not clinically dehydrated, not nauseated or vomiting, do not always require IV fluids, even if their ketone levels are high. They usually tolerate oral rehydration and subcutaneous insulin but do require monitoring regularly to ensure that they are improving and their ketone levels are falling. This decision should be made in consultation with the responsible paediatrician.

Go to flow chart 2 RESUSCITATION Page 4

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

Page 4

FLOW CHART 2 – RESUSCITATION

Patient Name:
Date of Birth:
Hospital / NHS Number:

From flow chart 1 ASSESSMENT & DIAGNOSIS

A: Establish airway: Seek urgent anaesthetic review if unable to protect airway.
If child comatose: Insert NG tube on free drainage.

B: Give O_2 100% via face mask with reservoir bag (only omit if child very well).

C: Establish IV access (consider 2nd cannula for later blood samples), take bloods (see box).
Commence cardiac monitoring (peaked T waves may indicate hyperkalaemia).

For estimated weight:
- Refer to appendix 2, page 14
- Ensure an accurate weight is obtained before starting maintenance fluids

Weight: ____ kg
Actual / Estimated / Recent ☐ ☐ ☐

Initial bloods:
- Blood gas and ketones
- FBC, HbA1c
- UEs
- If new diabetes: TFTs, coeliac serology
- (CRP only if infection concerns)

Is the patient shocked?

- Tachycardia
- Prolonged central capillary refill
- Poor peripheral pulses
- Hypotension (late sign)

Shocked patients should be discussed with the most senior paediatrician or intensivist at the earliest opportunity.

Yes / No

Shocked patients: 10 ml/kg bolus of 0.9% saline ~~or plasmalyte~~ over 15 minutes
Volume: ____ ml
Started: hh:mm dd/mm/yyyy

Reassess: if still shocked further boluses of 10ml/kg (up to total of 40ml/kg) may be given
Volume: ____ ml hh:mm dd/mm/yyyy
Volume: ____ ml hh:mm dd/mm/yyyy
Volume: ____ ml hh:mm dd/mm/yyyy

If still shocked consider inotropes and critical care escalation

All non-shocked children with mild, moderate or severe DKA should receive a 10ml/kg bolus of 0.9% saline over 30 minutes
Volume: ____ ml
Started: hh:mm dd/mm/yyyy

Whilst excessive fluid should be avoided because of the risk of cerebral oedema, it is important to ensure that the circulation is adequate and fluid should be given to support this. Cerebral perfusion is dependent on both perfusion pressure ***and*** intracranial pressure, and hypotension will exacerbate the risk of brain injury.

A bolus given on this arm is later subtracted from the calculated fluid deficit, whereas boluses for shocked patients are not. See page 6 for details.

Do NOT give IV sodium bicarbonate to patients with DKA. See appendix 4, page 16, for more information.

Consider placing NG tube to reduce the risk of aspiration in patients with reduced conscious level

D: Consider if cerebral oedema may be present
Early manifestations: headache, agitation/irritability, unexpected fall in heart rate, rise in blood pressure
Additional manifestations: deterioration in conscious level, abnormal breathing pattern, oculomotor palsies, abnormal posturing, pupil inequalities or dilatation

Features of cerebral oedema?

No → Go to flow chart 3 SECONDARY REVIEW Page 5

Yes → Go to flow chart 8 CEREBRAL OEDEMA Page 11

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

Page 5

FLOW CHART 3 – SECONDARY REVIEW

Patient Name:
Date of Birth:
Hospital / NHS Number:

From flow chart 2
RESUSCITATION

History:

Consider features including:
- Polyuria/polydipsia/wetting
- Weight loss
- Vomiting/abdominal pain
- Headache
- Recent infection

Past medical history:

If pre-existing diabetes ask about previous DKA episodes.

Drug history:

If pre-existing diabetes include usual insulin regimen details, adherence.

Allergies:

Family and social history:

Ask about family history of diabetes, thyroid disease, coeliac disease and other auto-immune conditions.

Examination:

Including general status, cardiovascular, abdomen, respiratory/ENT, neurology... Consider signs as shown on ASSESSMENT & DIAGNOSIS flow chart 1

DKA may be precipitated by sepsis or intercurrent infection, and fever is not part of DKA. Infection may co-exist with DKA. Suspect sepsis if there is fever or hypothermia, hypotension, refractory acidosis or lactic acidosis. A high lactate should increase concern about possible infection or sepsis.

Go to flow chart 4
FLUIDS
Page 6

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

FLOW CHART 4 - FLUIDS

Patient Name:
Date of Birth:
Hospital / NHS Number:

From flow chart 3 SECONDARY REVIEW

To avoid excessive amounts of fluid in overweight and obese children it is recommended that consideration be given to using a **maximum weight of 75kg or 98th centile weight for age** (whichever is lower) when calculating both deficit and maintenance requirements. Please refer to the full BSPED guidelines for further information.

Decide DKA severity

- pH <7.1 and/or bicarb. <5 SEVERE DKA → Assume 10% dehydration
- pH 7.1-7.19 and/or bicarb. <10 MODERATE DKA → Assume 5% dehydration
- pH 7.2-7.29 and/or bicarb. <15 MILD DKA → Assume 5% dehydration

Fluid calculations

Fluid deficit = Patient weight kg × % Dehydration × 10 = _____ mL

e.g. 24kg × 5% × 10 = 1200mL

Subtract ONLY the 10mL/kg bolus given over 30 minutes to non-shocked patients. DO NOT subtract rapid resuscitation boluses given to shocked patients.

Fluid deficit (less bolus volume) = Fluid deficit mL - 10ml/kg bolus volume mL = _____ mL

e.g. 1200mL − 240mL = 960mL

Deficit replacement rate = Fluid deficit (less bolus volume) mL ÷ 48 hours = _____ mL/hour

e.g. 960mL ÷ 48hours = 20.0mL/hour

Use Holliday-Segar formula: i.e. 100mL/kg for first 10kg; 50mL/kg for next 10kg; 20mL/kg thereafter.

Note: deficit is replaced over 48 hours, maintenance rate is calculated over 24 hours.

Maintenance rate = Daily fluid requirement mL ÷ 24 hours = _____ mL/hour

e.g.(for 24kg) (1000mL+500mL+80mL) ÷ 24hours = 65.8mL/hour

STARTING FLUID RATE (after bolus complete) = Maintenance rate mL/hour + Deficit replacement rate mL/hour = _____ mL/hour

e.g. 65.8mL/hour + 20.0mL/hour = 85.8mL/hour

Plasmalyte 148 can be used as an alternative to 0.9% Sodium Chloride but must have added potassium.

If potassium is above normal range add potassium to fluids only after the patient has passed urine **or** after the Potassium has fallen to within the normal range.

Once initial bolus is complete:
Start 0.9% Sodium Chloride + 20mmol Potassium Chloride in 500mL at STARTING FLUID RATE as above

Fluid start time / date: hh:mm dd/mm/yyyy

Go to flow chart 5 INSULIN Page 7

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

FLOW CHART 5 - INSULIN

Patient Name:
Date of Birth:
Hospital / NHS Number:

From flow chart 4 FLUIDS

Starting insulin early may increase the risk of cerebral oedema

Wait for 1-2 hours after starting IV fluid treatment before starting insulin

If potassium <3.0mmol/L defer insulin until potassium >3.0mmol/L. If expected to cause significant delay discuss with intensivist regarding options including central access or oral potassium.

Insulin hourly rate = 0.05-0.1 Units/kg /hour × Patient weight kg = Units /hour

e.g. 22kg × 0.05 Units/kg/hour = 1.1 Units/hour

Aged 5 or older: start at 0.1 units/kg/hr
Under 5s: start at 0.05 units/kg/hr

Use pre-filled syringes containing 50 Units of soluble insulin in 50mL 0.9% Sodium Chloride where available. If pre-filled syringes are not available, add 50 Units of soluble insulin (e.g. Actrapid) to 49.5mL 0.9% Sodium Chloride.

Start at INSULIN HOURLY RATE as calculated above:

Insulin start time / date: hh:mm dd/mm/yyyy

Pre-existing diabetes?

Yes

Patients on insulin pumps (CSII) should have their pump stopped once IV insulin is started.

Pump stopped? Yes ☐ N/A ☐

For patients already on long-acting insulin consider continuing 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.

Long-acting insulin continued? Yes ☐ No ☐ N/A ☐

No

If supported by your local guidelines, consider starting an appropriate dose of long acting background insulin alongside the intravenous infusion.

Long-acting insulin started? Yes ☐ No ☐

Go to flow chart 6 MONTORING & REVIEWS Page 8

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

FLOW CHART 6 – MONITORING & REVIEWS

Patient Name:
Date of Birth:
Hospital / NHS Number:

From flow chart 5 INSULIN

From flow chart 7 ONGOING MANAGEMENT

N.B. Where PICU or HDU do not exist within the admitting hospital, transfer to another hospital may not be appropriate (unless ventilatory support becomes necessary).

However, ALL children with DKA are high-dependency patients and require a high level of nursing care.

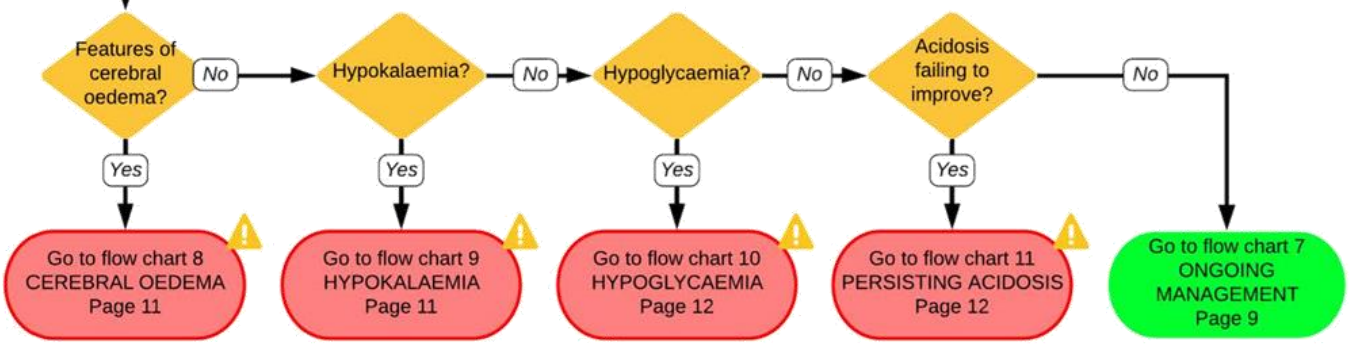
Consider where the child or young person should be nursed:
Patients with DKA should be cared for with one-to-one nursing if:
- they are younger than 2 years or
- they have severe DKA (blood pH below 7.1)

If one-to-one nursing cannot be provided on HDU/general paediatric ward, consider transfer to PICU.

Nursing Observations - ensure full instructions are given to nurse responsible including:
- Strict fluid balance including oral fluids and urine output, using fluid balance charts (urinary catheterisation may be necessary in young/sick children)
- Hourly capillary blood glucose measurements
- Capillary blood ketone levels every 1-2 hours
- Hourly BP and basic observations
- Hourly level of consciousness initially, using the modified Glasgow Coma Score
- In children < 2 years of age and in those with a pH <7.1 (at increased risk of cerebral oedema): Half-hourly neurological observations including the modified Glasgow Coma Score and heart rate
- Report immediately to medical staff:
  - symptoms of headache, or slowing of heart rate, or any change in either conscious level or behaviour
  - any changes in the ECG trace, especially signs of hypokalaemia, including ST-segment depression and prominent U-waves
- Twice daily weight; can be helpful in assessing fluid balance

Medical Reviews
- At 2 hours after starting treatment and then at least every 4 hours carry out and record the results of the following blood tests on the SERIAL DATA SHEET (page 10):
  - Glucose (Laboratory measurement)
  - Blood gas (for pH and pCO_2)
  - Plasma U+Es - ensure samples are sent urgently to the lab
  - Blood ketones
- A doctor (or equivalent practitioner) should carry out a face-to-face review at the beginning of treatment, at 2 hours after starting treatment, and then at least every 4 hours and more frequently if:
  - child is aged under 2 years
  - has severe DKA (pH<7.1)
  - there are any other reasons for special concern
- At each face-to-face review, provide an update on progress to the child or young person and their family and carers (as appropriate), and assess the following:
  - Clinical status, including vital signs and neurological status
  - Results of blood investigations
  - ECG trace (especially signs of hypokalaemia, including S-T segment depression and prominent U-waves)
  - Cumulative fluid balance record
- Ensure that each review is documented in the patient's medical notes, including the components described above.
- Consider adjusting the total fluid rate using corrected sodium (Na_{corr}) (see also appendix 4, page 15) taking into account the circulation and patient's general condition and state of hydration:
  - If the rise in Na_{corr} is >5mmol/L in 4-8 hrs it suggests too much fluid loss or insufficient replacement. Consider increasing the fluid rate
  - If there is a fall in Na_{corr} by more than 5mmol/L in 4-8 hrs it suggests too much fluid gain or too rapid replacement. Consider reducing the fluid rate

At each review confirm monitoring is compliant with the requirements above. Give specific consideration to the issues below. Address these in order of clinical priority.



FLOW CHART 7 – ONGOING MANAGEMENT

Patient Name:
Date of Birth:
Hospital / NHS Number:

From flow chart 6 MONITORING & REVIEWS

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 dosage errors, blocked or leaking lines, excessive urine loss, fluid calculation error or other conditions), and consider starting the whole protocol again.

If the blood ketone level is not falling within 6–8 hours then get senior help and advice and consider increasing the insulin infusion rate to 0.1 Units/kg/hour or greater.

Blood glucose fallen to <14mmol/L?

No → Return to flow chart 6 MONITORING & REVIEWS Page 8

Yes

If local policy is to maintain 0.1 Units/kg/hour insulin infusion rate or if a higher insulin infusion rate is thought necessary then change the fluid to contain 10% Glucose rather than 5% Glucose, in order to prevent hypoglycaemia when the higher rate is continued (use 500mL bags of 0.9% Sodium Chloride with 10% Glucose and 20mmol Potassium Chloride in 500mL).

Change the fluid to contain 5% Glucose
i.e. 0.9% Sodium Chloride + 5% Glucose + 20mmol Potassium Chloride in 500mL

Time / Date fluids changed to contain glucose: hh:mm dd/mm/yyyy

For guidance on preparing glucose containing fluids refer to appendix 3, page 15.

Continue the insulin infusion at 0.05 Units/kg/hour
i.e. reduce the rate from 0.1 Units/kg/hour if this rate was required prior to this point

DO NOT stop the insulin infusion while glucose is being infused, as insulin is required to switch off ketone production.

If at any time the blood glucose falls below 4mmol/L immediately follow flow chart 10 HYPOGLYCAEMIA Page 12

Blood glucose fallen to <6mmol/L?

Yes → **Change the fluid to contain 10% glucose**
i.e. 0.9% Sodium Chloride + 10% Glucose + 20mmol Potassium Chloride in 500mL

Time / Date fluids changed to contain 10% glucose: hh:mm dd/mm/yyyy

No

Blood ketones fallen to <1mmol/L?

No → Return to flow chart 6 MONITORING & REVIEWS Page 8

Yes

Consider switching from intravenous to subcutaneous insulin

Start **rapid-acting** subcutaneous insulin **at least** 30 minutes before stopping intravenous insulin.

Time / Date SC insulin started: hh:mm dd/mm/yyyy

Time / Date IV insulin stopped: hh:mm dd/mm/yyyy

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).

For a child or young person with DKA who is using insulin pump therapy, restart the pump at least 60 minutes before stopping intravenous insulin. Change the insulin cartridge and infusion set, and insert the cannula into a new subcutaneous site.

Ongoing education and management as per local guidelines.

If blood glucose and ketones are not controlled following switch to SC insulin, consider re-starting DKA pathway.

Do not change from IV insulin to SC insulin until ketosis is resolving (i.e. blood ketones below 1.0 mmol/L) and the patient is alert and tolerating oral fluids without nausea or vomiting.

Could this episode of DKA have been prevented? (i.e. earlier presentation not managed correctly?)

Yes ☐ No ☐

If YES then feedback appropriately such as completing incident form or contacting GP.

End of DKA Pathway

Chart completed by:
GMC number:
Signature:
Time / Date:

Patient Name:

Date of Birth:

Hospital / NHS Number:

TABLE 1 - SERIAL DATA SHEET

Time since protocl start (hrs)	Date/time (hh:mm dd/mm/yyyy)	Blood glucose (mmol/L)	Blood ketones (mmol/L)	pH	Base Excess	Bicarbonate (mmol/L)	Sodium (mmol/L)	Corrected sodium (mmol/L)	Potassium (mmol/L)	Urea (mmol/L)	Fluid balance (±mL)	Initial
0												
+2												
Changes:												
+6												
Changes:												
+10												
Changes:												
+14												
Changes:										Weight:		
+18												
Changes:												
+22												
Changes:												
+26												
Changes:										Weight:		
+30												
Changes:												
+34												
Changes:												
+38												
Changes:										Weight:		
+42												
Changes:												

After entering data values at each timeslot record any changes made on the following line. Record your clinical review and detailed plans in the patient notes. Remember to initial after completing each timeslot entry. Corrected sodium levels should typically rise as blood glucose levels fall during treatment. Corrected sodium levels may give an indication of the risk of cerebral oedema with a falling corrected sodium indicating an excess of free water and an increased risk of cerebral oedema. If corrected sodium levels fall during treatment, discuss with the consultant on call. See appendix 3, page 15.

$$Na_{corr} = Na_{measured} + \left(\frac{Glucose - 5.6}{3.5}\right)$$

Reference no: CH CLIN D 03/March 2023/v016

Page 11

FLOW CHART 8 – CEREBRAL OEDEMA

Patient Name:
Date of Birth:
Hospital / NHS Number:

From MAIN PROTOCOL section

Earlier signs of cerebral oedema:
- headache
- agitation or irritability
- unexpected fall in heart rate
- increased blood pressure

Suspicion of cerebral oedema

Later signs of cerebral oedema:
- deterioration in level of consciousness
- abnormalities of breathing pattern, for example respiratory pauses and/or drop in SaO_2
- oculomotor palsies
- abnormal posturing
- pupillary inequality or dilatation

Choose option most readily available

Hypertonic saline 2.7% or 3%
(2.5 - 5 mL/kg over 10-15 minutes)

Time / Date treatment started: hh:mm dd/mm/yyyy

- The effect of mannitol should be apparent within 15 minutes and typically lasts for 120 minutes. If no improvement within 30 minutes dose may repeated (or hypertonic saline may be preferred)
- If mannitol given initially and there is no response within 15-30 minutes then hypertonic saline may also be given as the effect of mannitol and hypertonic saline may be additive

Mannitol 10%
(2.5 - 5 mL/kg over 10-15 minutes)

Time / Date treatment started: hh:mm dd/mm/yyyy

Be aware that other intracerebral events may occur (thrombosis, haemorrhage or infarction) and present similarly, however treatment of suspected cerebral oedema should not be delayed pending imaging.

- Inform senior staff
- Restrict fluids:
  - ½ maintenance rates
  - Replace deficit over 72 hours, rather than 48 hours
- Seek specialist advice on further management, including which care setting would be best for the patient
- Do not intubate and ventilate until an experienced doctor is available
- Once the patient is stable, exclude other diagnoses by CT scan

Return to MAIN PROTOCOL section

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

FLOW CHART 9 – HYPOKALAEMIA

From MAIN PROTOCOL section

- Following resuscitation, commence potassium immediately in rehydration fluid unless anuria is suspected or there are peaked T waves on ECG
- If initial K^+ level > upper limit of normal range, especially if biochemical evidence of renal impairment, temporarily omit KCl but re-check frequently (e.g. after 1-2 hours) and add KCl to IV fluids once the patient has passed urine or as soon as K^+ level fallen to within upper limit of normal range
- There is always massive depletion of total body K^+, 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** 500mL bag of fluid contains **20mmol** potassium chloride (**40mmol/L**)

Hypokalaemia (K^+ <3mmol/L)

- Use a cardiac monitor and observe frequently for T wave changes
- Consider temporarily reducing insulin infusion rate
- Discuss urgently with PICU as a central line is needed for K^+ solutions >40mmol/L

Return to MAIN PROTOCOL section

FLOW CHART 10 – HYPOGLYCAEMIA

Patient Name:
Date of Birth:
Hospital / NHS Number:

From MAIN PROTOCOL section

Hypoglycaemia (Blood glucose <4mmol/L)

Give a bolus of **2 mL/kg of 10% Glucose**

Volume: _____ ml

Started: dd/mm/yy hh:mm

- Increase concentration of glucose in fluids to 10% if not already done
- Reduce insulin infusion rate to 0.05 Units/kg/hour if currently running at a faster rate
- If insulin infusion already running at 0.05 Units/kg/hour, consider temporarily reducing this for 1 hour

Return to MAIN PROTOCOL section

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

FLOW CHART 11 – PERSISTING ACIDOSIS

From MAIN PROTOCOL section

- Consideration should be given to calculating the anion gap
- The anion gap is typically 20-30mmol/L in a patient with ketoacidosis. An anion gap >35mmol/L may suggest concomitant lactic acidosis due to sepsis or poor perfusion and should prompt a review of the overall clinical picture
- It is not required for routine monitoring but may be helpful if the clinical picture or biochemistry is not improving

Acidosis, ketones or clinical status not improving as expected

Check infusion lines, and the calculation and dose of insulin

Anion gap = Sodium - (Chloride + Bicarbonate) = _____ mmol/L

e.g. 130 - (95 + 10) = 25mmol/L

If acidosis is not correcting, consider the following:

- Insufficient insulin to switch off ketones
- Inadequate resuscitation
- Sepsis
- Salicylate or other prescription or recreational drugs

Once all these causes of acidosis have been excluded, and if ketones are falling gradually, then residual acidosis is likely to be due to hyperchloraemia. This can be left to resolve spontaneously, and does not require any treatment. Acidosis due to hyperchloraemia need not delay the transition to oral fluids and subcutaneous insulin. It needs differentiating from ongoing ketosis.

Return to MAIN PROTOCOL section

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

Page 13

FLOW CHART 12 - HYPEROSMOLAR HYPERGLYCAEMIC STATE

Patient Name:
Date of Birth:
Hospital / NHS Number:

From MAIN PROTOCOL section

Features which differentiate HHS from other hyperglycaemic states such as DKA are:
- Hypovolaemia
- Marked hyperglycaemia (33.3mmol/L or more)
- No significant hyperketonaemia (<3mmol/L) or acidosis (pH>7.3, bicarbonate >15mmol/L)
- Osmolality usually 320mosmol/kg or more
- Often altered consciousness

Suspicion of Hyperosmolar Hyperglycaemic State (HHS)

Discuss with the responsible senior paediatrician – these children can be very difficult to manage.

Fluid therapy

The goal of initial fluid therapy is to expand the intra and extravascular volume and restore normal renal perfusion.
The rate of fluid replacement should be **more rapid** than is recommended for DKA.

Give an initial bolus of 20 mL/kg of 0.9% Saline

Volume: _____ mL

Started: hh:mm dd/mm/yyyy

Additional fluid boluses should be given, if necessary, to restore peripheral perfusion.

Volume: _____ mL

Started: hh:mm dd/mm/yyyy

Volume: _____ mL

Started: hh:mm dd/mm/yyyy

- The goal is to promote a gradual decline in serum sodium concentration and osmolality
- As isotonic fluids are more effective in maintaining circulatory volume, isotonic saline should be restarted if perfusion and hemodynamic status appear inadequate as serum osmolality declines
- Serum sodium concentrations should be measured frequently and the sodium concentration in fluids adjusted to promote a gradual decline in corrected serum sodium concentration
- Mortality has been associated with failure of the corrected serum sodium concentration to decline with treatment, which may be an indication for haemodialysis
- Although there are no data to indicate an optimal rate of decline in serum sodium, 0.5mmol/L per hour has been recommended for hypernatraemic dehydration

Thereafter, 0.45–0.75% Saline with potassium should be administered to replace the deficit over 24–48 hours. Assume a fluid deficit of approximately 12–15% of body weight.

Rate: _____ mL/hour

Started: hh:mm dd/mm/yyyy

Further management considerations:
- If there is a continued rapid fall in serum glucose (>5mmol/L per hour) after the first few hours, consider adding 2.5 or 5% Glucose to the rehydration fluid. Failure of the expected decrease of plasma glucose concentration should prompt reassessment and evaluation of renal function
- Unlike treatment of DKA, replacement of urinary losses is recommended. The typical urine sodium concentration during an osmotic diuresis approximates 0.45% Saline; however, when there is concern about the adequacy of circulatory volume, urinary losses may be replaced with a fluid containing a higher sodium concentration
- **Insulin therapy**
  - Blood glucose levels will fall with fluid alone and insulin is NOT required early in treatment
  - Insulin administration should be initiated when serum glucose concentration is no longer declining at a rate of at least 3mmol/L per hour with fluid administration alone
- **Potassium**
  - Patients with HHS also have extreme potassium deficits; a rapid insulin-induced shift of potassium to the intracellular space can trigger an arrhythmia. Therefore potassium MUST be included in all fluids
- For further information see ISPAD Guidelines:

Return to MAIN PROTOCOL section

Chart completed by: _____
GMC number: _____
Signature: _____
Time / Date: _____

Patient Name:
Date of Birth:
Hospital / NHS Number:

APPENDIX 1 – GLASGOW COMA SCORE

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 (with modification for younger patients)

>5 years	2-5 years	<2 years
1 = none	1 = none	1 = none
2 = incomprehensible sounds	2 = grunts	2 = grunts
3 = inappropriate words	3 = cries or screams	3 = inappropriate crying or unstimulated screaming
4 = appropriate words but confused	4 = monosyllables	4 = cries only
5 = fully orientated	5 = words of any sort	5 = appropriate non-verbal responses (coos, smiles, cries)

APPENDIX 2 – ESTIMATED WEIGHT TABLE

Age	Guide weight (kg)	
	Male	Female
6 months	8	7
12 months	9.5	9
18 months	11	10
2 years	12	12
3 years	14	14
4 years	16	16
5 years	18	18
6 years	21	20
7 years	23	22
8 years	25	25
9 years	28	28
10 years	31	32
11 years	35	35
12 years	43	43
14 years	50	50
Adult	70	70

Adapted from Advanced Paediatric Life Support, version 6, 2016

Patient Name:
Date of Birth:
Hospital / NHS Number:

APPENDIX 3 – MAKING UP IV FLUIDS

In Burton, please use the V6 orderset: **Paediatric DKA** which lists the fluids you may need to prescribe.

The fluids below should be available from Pharmacy in Derby or from the children's ward, Emergency Department or Pharmacy Out of Hours (POOH) cupboard in Burton. Please check the stock cupboard in Dolphin paediatric critical care unit (PCCU) before making any fluids up in Derby. If however you cannot find a bag please make it up as below rather than waiting for Pharmacy.

Sodium Chloride 0.9% and Glucose 5% with 20mmol Potassium Chloride in 500ml

- Remove 50 ml from a bag of Sodium Chloride 0.9% with 20 mmol Potassium Chloride in 500 ml
- Draw up 50 ml of Glucose 50% using a syringe and add to the above bag - this will make the Glucose concentration 5%
- **Mix well before administration**
- Please be aware that this will reduce the ACTUAL sodium chloride concentration to 0.81% and the potassium to 18 mmol in 500 ml

Sodium Chloride 0.9% and Glucose 10% with 20mmol Potassium Chloride in 500ml

- Remove 100 ml from a bag of Sodium Chloride 0.9% with 20 mmol Potassium Chloride in 500 ml
- Draw up 100 ml of Glucose 50% using a syringe and add to the above bag - this will make the Glucose concentration 10%
- **Mix well before administration**
- Please be aware that this will reduce the ACTUAL sodium chloride concentration to 0.72% and the potassium to 16 mmol in 500 ml

ALTERNATIVE METHOD FOR 10% GLUCOSE BAG:

Sodium Chloride 0.9% and Glucose 10% with 20mmol Potassium Chloride in 500ml

- Remove 50 ml from a bag of Sodium Chloride 0.9% and Glucose 5% with 20 mmol Potassium Chloride in 500 ml
- Draw up 55 ml of Glucose 50% using a syringe and add to the above bag - this will make the Glucose concentration 10%
- **Mix well before administration**
- Please be aware that this will reduce the ACTUAL sodium chloride concentration to 0.8% and the potassium to 18 mmol in 500 ml

Patient Name:
Date of Birth:
Hospital / NHS Number:

APPENDIX 4 – EXPLANATORY NOTES

Corrected Sodium, Anion Gap, Hyperchloraemic Metabolic Acidosis, Albumin & Phosphate

1) Corrected Sodium (NaCorr)

If the child is becoming hypernatraemic, this is not generally a problem, and is probably protective against cerebral oedema. Hyponatraemia occurs in DKA as with hyperglycaemia the extracellular osmolality rises resulting in water movement from the intracellular space into extracellular space causing dilution of extracellular sodium and a low serum sodium. However, **when glucose begins to fall** through hydration and insulin, and the plasma glucose concentration is reduced, water leaves the extracellular space entering intracellular space raising the extracellular sodium concentration again and **the serum sodium typically rises**.

It is recommended that the corrected sodium levels are monitored during the management of DKA. The corrected sodium (NaCorr) represents the expected serum sodium in the absence of hyperglycaemia.

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

Corrected sodium levels should be calculated on laboratory sodium results not on blood gas results and would typically be monitored **every 4 hours when U&Es are checked** Corrected sodium levels should typically rise as blood glucose levels fall during treatment. Some have suggested that corrected sodium levels give an indication of the risk of cerebral oedema with a falling corrected sodium indicating an excess of free water and an increased risk of cerebral oedema.

If corrected sodium levels fall during treatment, discuss with the consultant on call.

Consider adjusting the total fluid rate using corrected Sodium (NaCorr) taking into account the circulation and patient's general condition and state of hydration:

- If the rise in NaCorr is >5mmol/L in 4-8 hrs it suggests too much fluid loss or insufficient replacement. Consider increasing the fluid rate
- If there is a fall in NaCorr by more than 5mmol/L in 4-8 hrs it suggests too much fluid gain or too rapid replacement. Consider reducing the fluid rate

2) Anion gap

The anion gap is typically 20-30 mmol/l in a patient with ketoacidosis. However an **anion gap >35 mmol/l** may suggest concomitant lactic acidosis due to sepsis or poor perfusion and should prompt a review of the overall clinical picture.

3) Hyperchloraemic metabolic acidosis

Hyperchloraemic metabolic acidosis may occur following the administration of large amounts of chloride-containing fluids given during the management of DKA.

The preferential renal excretion of ketones instead of chloride can result in hyperchloraemia. The acidifying effect of chloride can mask the resolution of ketoacidosis if base deficit alone is used to monitor progress as there may appear to be a continuing base deficit with a continued low bicarbonate due to the chloride component rather than due to ketosis.

Base excess due to **Chloride** = (Sodium – Chloride) – 32 (ISPAD formula)

Direct monitoring of ketones and calculation of the component of the base deficit due to chloride will help differentiate whether persisting acidosis is due to ongoing ketosis that may need additional treatment (adjustment to insulin infusion or fluids) or due to hyperchloraemia. **Acidosis due to hyperchloraemia will correct spontaneously** and doesn't need specific treatment. Acidosis due to hyperchloraemia need not delay the transition to oral fluids and subcutaneous insulin. It needs differentiating from ongoing ketosis.

4) Phosphate and Hypophosphataemia

Phosphate is lost during DKA due to the osmotic diuresis and serum phosphate is often low in the recovery phase of severe DKA. Supplements or replacement, for example potassium acid phosphate, are not required unless there is severe hypophosphataemia associated with metabolic encephalopathy, reduced myocardial contractility, myopathy, dysphagia or ileus. Clinicians should be aware that administration of phosphate can precipitate hypocalcaemia.

5) Albumin

A low serum albumin can also contribute to a persisting acidosis which may be erroneously attributed to persisting ketosis. Some intensivists also recommend partitioning the component of apparent acidosis due to the reduced albumin to avoid it being inappropriately attributed to persisting ketosis.

Base excess component due to **Albumin** = 0.25 x (42 - Albumin)

END OF INTEGRATED CARE PATHWAY

Appendix 5 - Initial management of Hyperosmolar Hyperglycaemic State (HHS)
For further information see ISPAD Guidelines

Definition
Features which differentiate it from other hyperglycaemic states such as DKA are:
- Hypovolaemia
- Marked hyperglycaemia (glucose 33mmol/L or more)
- No significant ketones (<3mmol/L) or acidosis (pH>7.3, bicarbonate >15mmol/L)
- Osmolality usually 320mosmol/kg or more
- Often altered consciousness

This picture usually occurs in Type 2 diabetes, especially where there are learning difficulties or other factors preventing proper hydration. It has a high mortality rate.

Goals of treatment
The goals of treatment are to treat the underlying cause and to gradually and safely:
- Normalise the osmolality
- Replace fluid and electrolyte losses
- Normalise blood glucose

Other goals include prevention of arterial or venous thrombosis and other potential complications e.g. cerebral oedema/ central pontine myelinolysis

Fluid therapy
The rate of fluid replacement should be **more rapid** than is recommended for DKA.
- Give an initial bolus of 20mL/kg of 0.9% saline.
- Assume a fluid deficit of approximately 12–15% of body weight.
- Further fluid boluses should be given if needed until peripheral perfusion is restored.
- Thereafter, 0.45–0.75% NaCl with (with 20mmol potassium per 500ml bag) should be administered to replace the deficit over 24–48 hours. In Derby, we would **use alternating bags of 0.45% and 0.9%** saline if more than 0.45% saline needed.
- The sodium concentration in the IV fluids should be adjusted depending on the rate of plasma sodium decline. The goal is a gradual decline in serum sodium concentration and osmolality.
- Mortality has been associated with failure of corrected serum sodium concentration to decline with treatment, which may be an indication for haemodialysis.
- An optimal rate of decline in serum sodium of 0.5mmol/L per hour has been recommended for hypernatraemic dehydration.

Plasma glucose should fall by around 4 - 6mmol/L per hour with adequate rehydration
- If plasma glucose decreases by more than 5mmol/L per hour after the first 4 hours, add 5% glucose to the rehydration fluids.
- Failure of the expected fall in plasma glucose should prompt reassessment and evaluation of renal function.

Unlike treatment of DKA, **replacement of urinary losses is recommended**. The typical urine sodium concentration during an osmotic diuresis approximates 0.45% saline; however, when there is concern about the adequacy of circulatory volume, urinary losses may be replaced with a fluid containing a higher sodium concentration.

Insulin therapy
- Blood glucose levels will fall with fluid alone and **insulin is NOT required early** in treatment – it should be initiated when serum glucose concentration is no longer declining at a rate of at least 3 mmol/l per hour with fluid administration alone.

Potassium
Patients with HHS also have extreme potassium deficits; a rapid insulin-induced shift of potassium to the intracellular space can trigger an arrhythmia. Therefore, potassium MUST be included in all fluids.

G. References

- BSPED DKA guidelines landing page https://www.bsped.org.uk/clinical-resources/bsped-dka-guidelines/
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H. Documentation Control

Reference Number CH CLIN D03	**Version:** CH CLIN D03		**Status** Final	
Version / Amendment History	Version	Date	Author	Reason
	16	August 2022	Tracy Tinklin	Update in BSPED guidance – local guidelines updated to align
Intended Recipients: State who the Clinical Guideline is aimed at – staff groups etc. Paediatric medical and nursing staff				
Training and Dissemination: How will you implement the Clinical Guideline: cascade the information and address training				
Development of Guideline: **Job Title:** Tracy Tinklin, Consultant Paediatrician				
Consultation with: Paediatric diabetes MDT has been consulted, recent version updated by Isabel Perry ST1.				
Linked Documents: NA				
Keywords: diabetes, DKA, diabetic ketoacidosis, hyperglycaemia				
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Divisional Sign Off	**Group: Women and Children's Clinical Governance Group** **Date: Feb 2023**			
Date of Upload	March 2023			
Review Date	March 2026			
Contact for Review	Dr Tracy Tinklin, Consultant paediatrician, RDH Dr Julie Smith, Consultant paediatrician, RDH Dr Kiran Kumar, Consultant paediatrician, RDH Dr Pooja Vasista, Consultant paediatrician, QHB Dr Richard Lloyd-Nash, Consultant paediatrician, QHB			