



BSPED Recommended Guideline for the Management of Children and Young People under the age of 18 years with Diabetic Ketoacidosis 2015

These guidelines for the management of DKA in children and young people under the age of 18 years are based on the NICE guideline for Type 1 and Type 2 diabetes in children and young people [published August 2015, recommendations 1.4.1 to 1.4.66]. During the development of the NICE guideline the evidence for the diagnosis, investigation and management of DKA was examined for a large number of review questions, for many of which there was only limited evidence. All the information can be found in the full [NICE guideline](#). Dr Julie Edge, who has contributed to the BSPED guideline, was the chair of the DKA Guideline Development Group for the NICE guideline.

These BSPED 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.

The following changes have been made since the last version (2009)

1. Change in the degree of dehydration to be used to calculate fluids; 5% for mild to moderate DKA and 10% for severe DKA, based on pH
2. De-emphasise sodium chloride bolus at the start of treatment apart from the sickest children
3. No more than one 10ml/kg fluid bolus to be given without discussion with a senior doctor
4. Further reduction in maintenance fluid rates, and simpler calculation of fluid rates
5. No longer to subtract any boluses given up to 20 ml/kg from the fluid calculation (as the rate is already reduced significantly from previous guidelines)
6. Continuation of 0.9% sodium chloride (instead of changing to 0.45% sodium chloride) for the full duration of rehydration
7. Option for using an intravenous insulin infusion rate of 0.05 Units//kg/hour OR 0.1 Units/kg/hour

The associated fluid calculation spreadsheet was designed by Dr Andrew Durward. It is recommended that junior doctors use the fluid calculator alongside this full guideline, in order to reduce errors in calculation.

In addition, guidance has been provided for the management of Hyperosmolar Hyperglycaemia States (HHS). This was not reviewed in the NICE guideline, and is based on the ISPAD guidance of 2014.

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

Diabetes Lead, BSPED Clinical Committee, Dr May Ng.

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 slow 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

Guidelines for the Management of Diabetic Ketoacidosis

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A. DIAGNOSIS :

Always accept any referral and admit children in suspected DKA.

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.

Diagnose DKA in children and young people who have

- acidosis (indicated by blood pH below 7.3 or plasma bicarbonate below 18 mmol/litre) and
- ketonaemia (indicated by blood beta-hydroxybutyrate above 3 mmol/litre)

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

Children and young people with a pH of 7.1 or above have MILD or MODERATE DKA

Children and young people with a pH of less than 7.1 have SEVERE DKA

Use a near-patient testing method for blood ketone (beta-hydroxybutyrate) level for the diagnosis and monitoring of the treatment of DKA. If a near-patient testing method is not available, use urinary ketone levels to make the diagnosis, but they are not useful for monitoring.

These guidelines are intended for the management of **children and young people** who have, in addition to the biochemical features above -

- clinical dehydration
- nausea and/or vomiting
- and/or drowsy

They may also have the following clinical features –

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

Always consult with a more senior doctor 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 (>30 mmol/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 4.

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

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.

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

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)
Measure blood pressure and heart rate

Discuss the use of inotropes with a paediatric critical care specialist if a child or young person with DKA is in hypotensive shock

2. Initial fluid bolus:

- Do not give an intravenous fluid bolus to children and young people with mild or moderate DKA (indicated by a blood pH of 7.1 or above).
- Do not routinely give an intravenous fluid bolus to children and young people with severe DKA (indicated by a blood pH of less than 7.1).
- **Only if shocked** (poor peripheral pulses, poor capillary filling with tachycardia, and/or hypotension) **give 10 ml/kg 0.9% sodium chloride** as a bolus. *(There is no evidence to support the use of colloids or other volume expanders in preference to crystalloids)*
- Do not give more than one intravenous fluid bolus of 10 ml/kg 0.9% sodium chloride to a child or young person with severe DKA without discussion with the responsible senior paediatrician.

3. Initial Investigations:

- blood glucose
- urea and electrolytes (electrolytes on blood gas machine give a guide until accurate results available)
- blood gases (venous or capillary)
- near patient blood ketones (beta-hydroxybutyrate) 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. Suspect sepsis if there is fever or hypothermia, hypotension, refractory acidosis or lactic acidosis

At this point explain to the child or young person with DKA and to their family members or carers (as appropriate) about their condition and the care that they may need.

C. FULL CLINICAL ASSESSMENT:

Assess and record in the notes, 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) whether or not 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 8 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**

3. 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.

Consider where the child or young person should be nursed –

Children and young people with DKA should be cared for with one-to-one nursing, either on a high-dependency unit, (preferably a paediatric unit) or on a general paediatric ward if:

- they are younger than 2 years or
- they have severe DKA (blood pH below 7.1).

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, even if on general paediatric wards

D. MANAGEMENT:

1. FLUIDS:

N.B. It is essential that all fluids given are documented carefully, particularly the fluid which is given in the accident and emergency department 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 after a maximum of one bolus of 10 ml/kg 0.9% sodium chloride. If not, **discuss with a consultant whether a second bolus should be given.**

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

$$\text{Requirement} = \text{Deficit} + \text{Maintenance}$$

Deficit –

It is not possible to accurately clinically assess the degree of dehydration to work out the deficit.

Therefore –

**Assume a 5% fluid deficit in children and young people in mild or moderate DKA
(indicated by a blood pH of 7.1 or above)**

**Assume a 10% fluid deficit in children and young people in severe DKA
(indicated by a blood pH below 7.1)**

Maintenance - Calculate the maintenance fluid requirement using the following 'reduced volume' rules:

- if they weigh less than 10 kg, give 2 ml/kg/hour
- if they weigh between 10 and 40 kg, give 1 ml/kg/hour
- if they weigh more than 40 kg, give a fixed volume of 40 ml/hour.

These are lower than standard fluid maintenance volumes because large fluid volumes are associated with an increased risk of cerebral oedema. Do not use other methods of calculating maintenance fluids, for example APLS, as these over-estimate fluid requirement.

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 – If more than 20 ml/kg 0.9% sodium chloride has been given by intravenous bolus, subtract any additional bolus volumes from the total fluid calculation for the 48-hour period ie if 30 ml/kg has been given subtract 10 ml/kg from the calculations

Fluid Calculation -

Calculated the fluid deficit (either 5% or 10% dehydration depending on severity of acidosis), divide over 48 hours and add to the hourly rate of maintenance deficit, giving the total volume **evenly** over the next 48 hours. i.e.

$$\text{Hourly rate} = (\text{deficit} / 48\text{hr}) + \text{maintenance per hour}$$

Examples :

A 20 kg 6 year old boy who has a pH of 7.15, who did not have a sodium chloride bolus, will require

deficit 5 % x 20 kg	=	1000 mls
divide over 48 hours	=	21 ml/hr
plus maintenance 1ml/kg/hr =		20 ml/hr
Total =		41 ml/hour

A 60 kg 16 year old girl with a pH of 6.9, and who was given 30 ml/kg 0.9% sodium chloride for circulatory collapse will require

deficit 10 % x 60 kg	=	6000 mls
minus 10ml/kg resuscitation fluid =	-	600 ml
divide over 48 hours	=	113 ml/hr
plus maintenance fixed rate =		40 ml/hr
Total =		153 ml/hour

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

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 -

Use 0.9% sodium chloride with 20 mmol potassium chloride in 500 ml (40 mmol per litre) until blood glucose levels are less than 14 mmol/l (see below)

Corrected sodium levels should rise as blood glucose levels fall during treatment. Some have suggested that Corrected Sodium levels give an indication of the risk of cerebral oedema. If you wish to calculate this, either do it on the fluid calculator as above, or go to:

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

If corrected sodium levels do not rise during treatment, discuss with the consultant on call.

If the child is becoming hypernatraemic, this is not generally a problem, and is protective against cerebral oedema. Please discuss with the consultant on call.

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. If large volumes of gastric aspirate continue, these will need to be replaced with 0.45% saline with KCl.

2. POTASSIUM:

Ensure that all fluids (except any initial bolus) contain 40 mmol/l potassium chloride, unless there is evidence of renal failure.

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** potassium chloride (**40 mmol per litre**).

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

- think about temporarily suspending 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.

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. Do not give bolus doses of intravenous insulin.

Therefore start an intravenous insulin infusion 1-2 hours after beginning intravenous fluid therapy.

Use pre-filled syringes containing 50 Units of soluble insulin in 50 ml 0.9% sodium chloride.

Use a soluble insulin infusion at a dosage between 0.05 and 0.1 units/kg/hour.

Your local policy may have a particular preference for the dose, but there is no evidence that one dose is superior to the other.

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** (especially insulin glargine (Lantus)), 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.

4. BICARBONATE:

Do not give intravenous sodium bicarbonate to children and young people with DKA.

5. 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.

E. MONITORING:

a) Nursing Observations –

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

- 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 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)
- urine testing for ketones (only needed if blood ketone testing not available)
- hourly BP and basic observations
- hourly level of consciousness initially, using the modified Glasgow coma score
- **half-hourly** neurological observations, including level of consciousness (using the modified Glasgow coma score) and heart rate, in children under the age of 2, or in children and young people with a pH less than 7.1, 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

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

b) 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 -

- glucose (laboratory measurement)
- blood pH and pCO₂
- plasma sodium, potassium and urea
- blood ketones (beta-hydroxybutyrate).

A doctor should carry out a face-to-face review 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 the following:

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

Update the child and young person with DKA and their family members or carers (as appropriate) regularly about their progress.

F. CONTINUING MANAGEMENT:

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

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.

If the blood ketone level is not falling within 6–8 hours, think about increasing the insulin dosage to 0.1 units/kg/hour or greater.

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

If **ketone levels** are less than 3 mmol/l

- change the fluid to contain 5% glucose; use 500 ml bags of 0.9% sodium chloride with 5% glucose and 20 mmol potassium chloride in 500ml which are available from Pharmacy.
- If this fluid is not immediately available, make up a bag on the ward as described in Appendix 2.
- reduce to or maintain at an insulin infusion rate of 0.05 units/kg/hr

If **ketone levels** are above 3 mmol/l

- maintain the insulin infusion rate at 0.05 to 0.1 units/kg/hour to switch off ketogenesis
- change the fluid to contain 10% glucose rather than 5% glucose, in order to prevent hypoglycaemia when the higher dose of insulin is continued
- use 500 ml bags of 0.9% sodium chloride with 10% glucose and 20 mmol potassium chloride in 500ml; to make up this fluid see Appendix 2.

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 6 mmol/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 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.

- Once the pH is above 7.3, ketones are below 3, the blood glucose is down to 14 mmol/l, and a glucose-containing fluid has been started, reduce the insulin infusion rate, to 0.05 units/kg/hour.
- **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.

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, and this can be left to resolve on its own, and does not require any treatment.

G. INSULIN MANAGEMENT ONCE KETOACIDOSIS RESOLVED -

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

Do not change from intravenous insulin to subcutaneous insulin until ketosis is resolving (for example, blood beta-hydroxybutyrate level below 1.0 mmol/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 intravenous insulin.

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 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).

H. 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

- mannitol (20% 0.5-1 g/kg over 10-15 minutes) or
- hypertonic saline (2.7% or 3% 2.5-5 ml/kg over 10-15 minutes).

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

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

treat them Immediately for cerebral oedema using the most readily available of

- mannitol (20% 0.5-1 g/kg over 10-15 minutes) or
- hypertonic saline (2.7% or 3% 2.5-5 ml/kg over 10-15 minutes)

In addition fluids should be restricted to $\frac{1}{2}$ maintenance rates and **inform senior staff immediately.**

After starting treatment for cerebral oedema with mannitol or hypertonic saline 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
- 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

I. 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.

J. EDUCATION AND FOLLOW-UP

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.

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

How to make up special Intravenous Fluids

The following fluid is generally available from Pharmacy

500ml bag of 0.9% sodium chloride / 5% glucose containing 20 mmol potassium chloride (Baxter: FKB 2486)

But this may not be available on every ward. If you need to make it up, please do so as below, rather than waiting for pharmacy – as below

Glucose 5% & Sodium Chloride 0.9% with 20mmol K in 500ml (if this bag is unavailable in the clinical area)

Remove 50ml from a bag of Sodium Chloride 0.9% with 20mmol K in 500ml

Draw up 50ml of Glucose 50% using a syringe and add to the above bag which will make the Glucose concentration 5%

Mix well before administration

This other fluid is not available and MUST be made up if required.

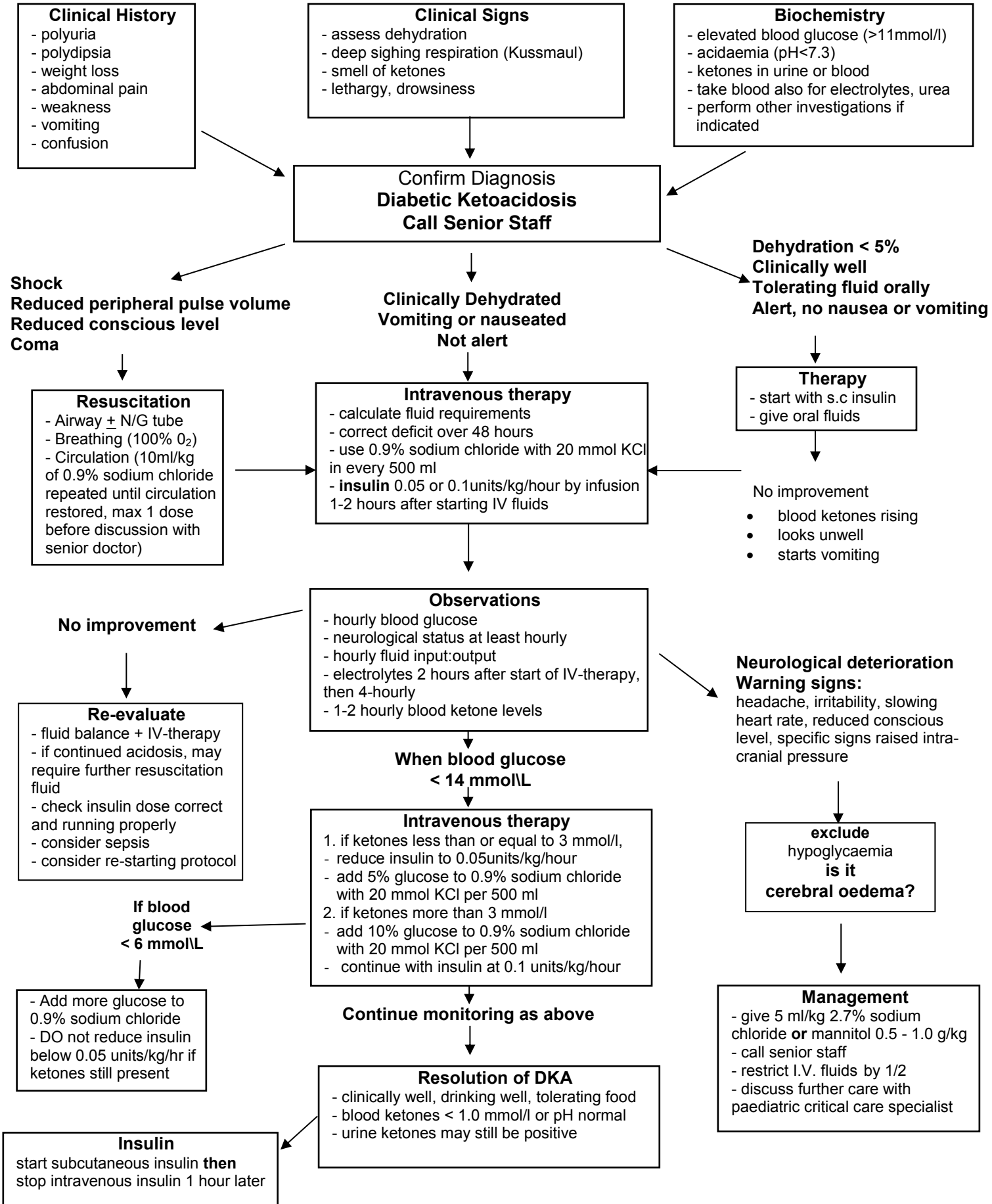
Glucose 10% & Sodium Chloride 0.9% with 20mmol K in 500ml

Remove 50ml from a bag of Glucose 5% & Sodium Chloride 0.9% with 20mmol K in 500ml (FKB2486)

Draw up 50ml of Glucose 50% using a syringe and add to the above bag which will increase the Glucose concentration to 10%

Mix well before administration

Appendix 3 Algorithm for the Management of Diabetic Ketoacidosis



Appendix 4

Initial management of Hyperosmolar Hyperglycaemic State (HHS)

Definition

Features which differentiate it from other hyperglycaemic states such as DKA are:

- Hypovolaemia
- Marked hyperglycaemia (40 mmol/L or more)
- No significant hyperketonaemia (<3 mmol/L) or acidosis (pH>7.3, bicarbonate >15 mmol/L)
- Osmolality usually >320 mosmol/kg or more

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 of HHS 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 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 should be of 20 mL/kg of isotonic saline (0.9% NaCl)
- Assume a fluid deficit of approximately 12–15% of body weight.
- Additional fluid boluses should be given, if necessary, to restore peripheral perfusion.
- Thereafter, 0.45–0.75% NaCl with potassium should be administered to replace the deficit over 24–48 hours.
- 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, 0.5 mmol/L per hour has been recommended for hypernatremic dehydration.

If there is a continued rapid fall in serum glucose (>5 mmol/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 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.

For further information see ISPAD Guidelines 2014 Chapter 11