

GUIDELINES FOR THE MANAGEMENT OF DIABETIC KETOACIDOSIS

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Approved by the Medicines Governance Group March 2020

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Approved by the Children and Young Person's South East Coast and London Diabetes Network
(Available on Intranet)

These are general guidelines. They may be altered to suit individual situations. They are informed by the British Society of Paediatric Endocrinology and Diabetes Interim Guideline (2020) and the ISPAD Clinical Practice Consensus Guidelines 2014 Compendium - Diabetic ketoacidosis in children and adolescents with diabetes.

**All newly diagnosed Type 1 diabetes patients
MUST be discussed with a member of the
Diabetes team within 24 hours of diagnosis.**

**Contact the diabetes team using numbers
below (leave a message and a member of the
team will call you back within an hour):**

- **In hours – telephone ext. 63140**
- **Out of hours – pager 07623 979815**

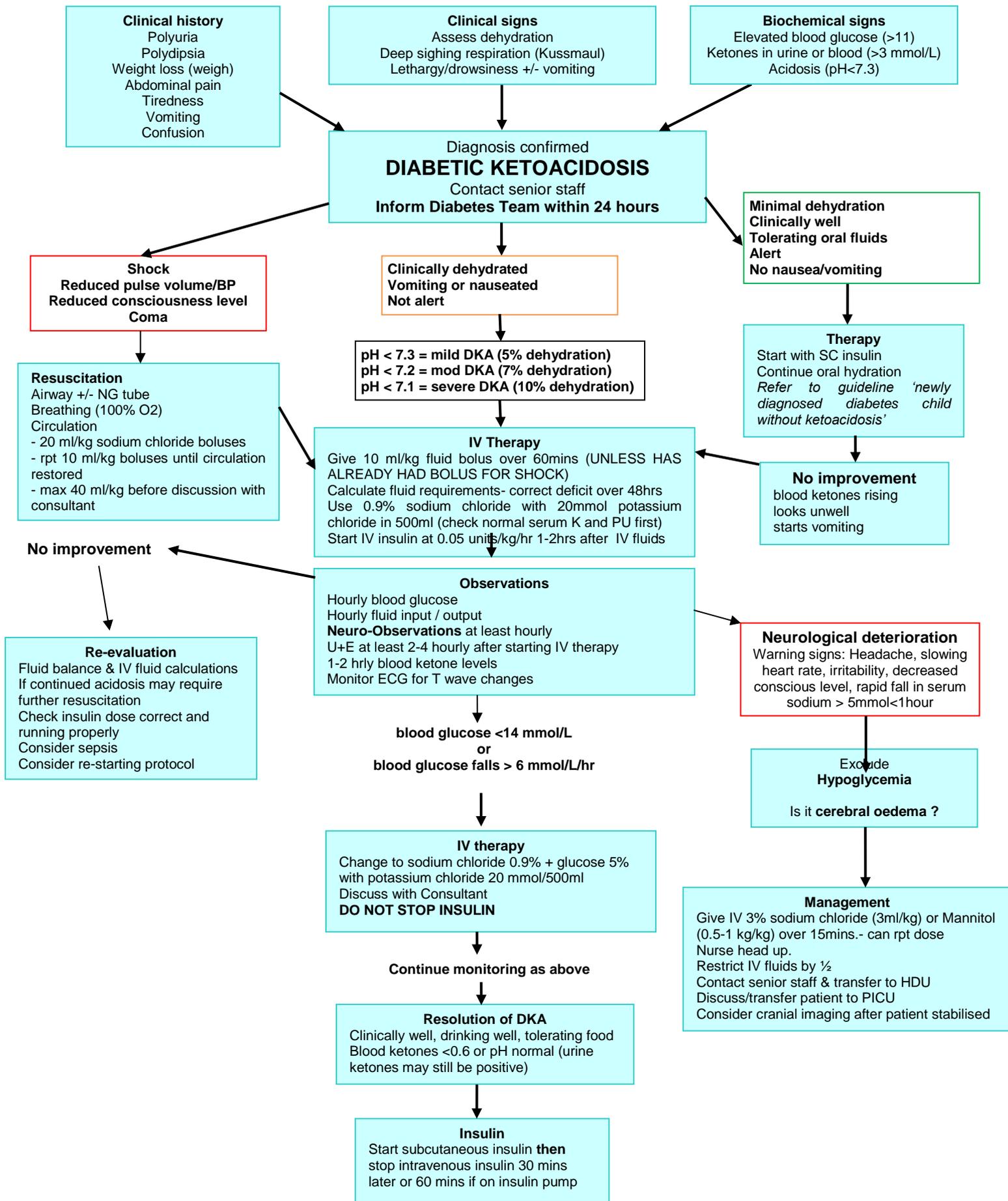
Please note this is not an emergency service. It
may take **up to an hour** to call back.

Please be patient.

For children using an insulin pump and admitted with DKA

- **Discontinue the pump whilst treating for DKA**
- **start IV fluids and IV insulin as per current guidelines**

ALGORITHM FOR THE MANAGEMENT OF DIABETIC KETOACIDOSIS



Diagnosis of DKA

Uncontrolled/poorly controlled diabetes mellitus with acidosis and dehydration:

- **Acidosis** (pH < 7.3 or bicarbonate < 15)
and
- **Ketonaemia** (beta-hydroxybutyrate > 3mmol/L)

Blood glucose levels are usually high (>11)

These guidelines are intended for children who are clinically dehydrated and who may also have vomiting +/- drowsiness.

Severity classification	
Mild DKA	pH 7.2-7.29 &/or bicarb < 15
Moderate DKA	pH 7.1-7.19 &/or bicarb < 10
Severe DKA	pH < 7.1 &/or bicarb < 5

Always consult with the consultant paediatrician on call as soon as you suspect DKA, even if you feel confident of your management. Severe DKA being admitted to HDU to be discussed with HDU consultant. All others should be discussed with COW.

REMEMBER: CHILDREN CAN DIE FROM DKA

They can die from:

- Inhalation of vomit / **aspiration pneumonia**
- **Hypokalaemia**
- **Cerebral oedema.** This is unpredictable, occurs more frequently in younger and in newly diagnosed children.
- **Inadequate resuscitation.** Children who are shocked must receive adequate resuscitation.

Precipitating Factors for DKA

1. Delayed diagnosis and treatment of a new patient.
2. Failure to take adequate insulin or to adequately monitor diabetes.
(Often secondary to teenage rebellion further complicated by unstable endocrine milieu due to pubertal hormonal changes.)
3. Vomiting or unable to drink & maintain hydration.
4. Infection.

Where to admit

Admit to HDU if:

- < 2 years
- Severe DKA – pH < 7.1

A) EMERGENCY Management

1. General resuscitation

Airway – ensure patent airway

If the child is comatose insert an airway

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

Seek urgent anaesthetic review if child unable to protect their airway

Breathing – give 100% oxygen if required by face-mask
(NB: patient often has acidotic breathing)

Circulation - Insert IV cannula – preferably x2 large (take bloods, see point 4 below)
Measure HR, BP and CRT
ECG monitoring (for T waves - peaked in hyperkalaemia)

Shocked patients require adequate fluid volume resuscitation. A fluid bolus of 20ml/kg may be indicated.

2. Initial fluid bolus

- **All** children with mild, moderate or severe DKA **who are not shocked but are felt to require IV fluids** should receive a **10ml/kg 0.9% sodium chloride** bolus over 60 minutes.
- **Shocked patients** should receive a **20ml/kg bolus of 0.9% sodium chloride** over 15 minutes. Shock is defined by the APLS definition of tachycardia, prolonged CRT, poor peripheral pulses and hypotension (though this is a late sign). It is not just poor peripheral perfusion.
- Following the initial 20ml/kg **shocked** patients should be reassessed and further boluses of 10ml/kg may be given if required to restore adequate circulation up to a total of 40ml/kg - at which stage inotropes should be considered and a consultant informed.
- **Shocked patients** should be admitted to HDU.
- Whilst excessive fluid should be avoided because of the risk of cerebral oedema it is important to ensure the circulation is adequate and fluid should be given to support this. Cerebral perfusion is dependent on both perfusion pressure and intracranial pressure; so hypotension/low perfusion pressure will also exacerbate the risk of brain injury.

3. Rapid history and full examination

- Polydipsia, polyuria, weight loss, lethargy, vomiting
- Assess GCS (see below for actions if reduced conscious level).
- Check pupils
- Features of cerebral oedema include headache, irritability, slowing pulse, rising blood pressure, reducing conscious level (papilloedema is a late sign)
- Symptoms/signs of any infection precipitating DKA
- Features of ileus (common in DKA)
- Weight (if unable to weigh calculate expected weight or use recent clinic weight)

4. Investigations

- **Blood glucose** (Capillary blood glucose and also lab glucose)
- **Venous blood gas**
- **U & E, chloride, osmolality**
- **Venous blood ketones** (lab beta-hydroxybutyrate and near patient testing ketone meter)
- **HbA1c**
- **FBC** (↑ WBC common and not always a sign of infection or sepsis)
- Blood cultures and CRP if pyrexia or very unwell. (*Caution* - Septic diabetic patient may not have a high temperature. Suspect sepsis if there is fever or hypothermia, hypotension, refractory acidosis or lactic acidosis)

If newly diagnosed patient admitted with DKA:

- TFTs, Thyroid antibodies (TPO)
- Coeliac screen
- IgA levels
- IA2 antibodies, GAD65 antibodies, ZnT8 antibodies
- Urine analysis
 - glucose and ketones
 - MSU for microscopy, culture and sensitivity if symptoms of UTI or leucocyte / nitrite positive

5. Additional calculations from available results:

- Corrected Sodium (Na) = Measured Na + 0.3 x (Glucose – 5.5)
- Anion Gap = (Na + K) – (Cl + Bicarb)
- Plasma Osmolality = 2 x (Na+K) + blood glucose + Urea

6. Other investigations if indicated:

- CXR
- LP
- Swabs (throat, genital, wounds etc...)
- Viral studies (blood, urine, throat, stool etc...)
- Research bloods – if any

7. Start hourly neuro-obs including GCS, whether or not drowsy on admission.

If conscious level decreased:

- Nil by mouth
- Nasogastric tube to empty stomach contents (acute gastric dilatation may be present) and aspirate hourly or continuous drainage.
- If GCS <8, consider elective intubation and ventilation to protect airway
- Catheterise bladder for accurate urine output
- Hourly or more frequent neuro-observations
- Conscious level is directly related to the degree of acidosis but signs of raised intracranial pressure suggest cerebral oedema that must be managed accordingly
- Inform HDU staff early. Discuss with Anaesthetist on call and STRS team as appropriate.

B) EARLY management

1) FLUIDS

a) Volume of fluid

- By this stage circulating volume should have been restored- children with shock should have been adequately resuscitated with appropriate fluid volume replacement. Other patients should have received a fluid bolus of 10ml/kg as part of routine DKA management
- Once circulating volume has been restored calculate fluid requirements as:

Requirement = Deficit + Maintenance

- **Deficit**
 - It is not possible to accurately clinically assess degree of dehydration to work out the fluid deficit. Instead estimation of fluid deficit should be based on **initial** blood pH:-

Assume a 5% fluid deficit in mild DKA

Assume a 7% fluid deficit in moderate DKA

Assume a 10% fluid deficit in severe DKA

Deficit volume =
% deficit x weight x 10

- **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 SHOULD be subtracted from the estimated fluid deficit.
- The deficit should be replaced over 48 hours alongside appropriate maintenance fluids.

• **Maintenance**

- Maintenance fluid volumes should be calculated by the traditional UK method (Holliday-Segar formula) as:-
 - 100ml/kg/day for the first 10kg of bodyweight
 - 50ml/kg/day for the next 10 to 20kg
 - 20ml/kg/day for each additional kg above 20kg

(NB: neonatal DKA will require special consideration and larger volumes of fluid than those quoted may be required- usually 100-150ml/kg/day)

• **Fluid calculation**

- Calculate the fluid deficit (5%, 7% or 10%), subtract initial 10ml/kg bolus (*not* in shocked patients) then divide over 48hrs and add this to the hourly rate of maintenance fluid
 - i.e. **hourly rate = ({deficit – initial bolus}/ 48hrs) + maintenance/hour**
- **Weight:** wherever possible use actual weight at presentation. To avoid excessive amounts of fluid in overweight children use a maximum weight of 80kg or the 98th centile weight for age (whichever is lower).

Examples:

- A 20kg 6 year old boy who has a pH of 7.15 and is not in shock
 - moderate DKA => 7% dehydrated- will receive a 10ml/kg fluid bolus (200ml) over 60 minutes
 - Ongoing fluids will comprise:

7% deficit (moderate)	=	$7 \times 10 \times 20\text{kg} = 1400\text{ml}$
Subtract initial bolus	=	$1400 - 200 = 1200\text{ml}$ to be replaced over 48hrs
	=	25ml/hr
Maintenance		$10 \times 100 = 1000\text{ml}$ per day for 1 st 10kg
	+	$10 \times 50 = 500\text{ml}$ per day for next 10kg (10-20kg)
	=	1500ml/day total over 24 hrs
	=	62ml/hr
Total fluid		25ml/hr (deficit – bolus over 48hrs)
	+	62ml/hr (maintenance over 24hrs)
	=	87ml/hr

- A 60kg 15 year old girl with a pH of 6.9 who was shocked at presentation.
 - She has received 30ml/kg of 0.9% sodium chloride for **resuscitation** – these fluids are *not* subtracted from her requirement.
 - Ongoing fluids will comprise:

10% deficit (severe)	=	$10 \times 10 \times 60\text{kg} = 6000\text{ml}$
	=	6000ml to be replaced over 48hrs
	=	125 ml/hr
Maintenance		$10 \times 100 = 1000\text{ml}$ per day for 1 st 10kg
	+	$10 \times 50 = 500\text{ml}$ per day for next 10kg (10-20kg)
	+	$40 \times 20 = 800\text{ml}$ per days for next 40kg (20-60kg)
	=	2300 ml total over 24 hrs
	=	96 ml/hr
Total fluid		125 ml/hr (deficit over 48hrs)
	+	96 ml/hr (maintenance over 24hrs)
	=	221 ml/hr

b) Type of fluid

- Use **0.9% sodium chloride with 20 mmol potassium chloride in each 500ml** bag (40 mmol/L) for initial maintenance/rehydration fluids *unless* there is evidence of renal failure or the potassium remains above the upper range of normal following resuscitation fluids (see (2) POTASSIUM below)
- Once blood glucose has fallen to <14 mmol/L change to dextrose containing fluids (see C) ONGOING management below)

c) Oral fluids

- Do not give oral fluids whilst giving IV fluids for DKA until ketosis is resolving and there is no nausea or vomiting.
- An NG tube may be necessary in cases of gastric paresis.
- If oral fluids are given before the 48hr rehydration period is complete the IV infusion needs to be reduced to take into account the oral intake.

d) Fluid losses

- Replace significant ongoing fluid losses with appropriate fluid (e.g. 0.9% sodium chloride with potassium chloride for large gastric aspirates; 0.9% sodium chloride with 5% glucose and potassium chloride for diarrhoea).
- **Urinary losses are not routinely replaced** but if a massive diuresis continues for several hours, then fluid input may need to be increased. Discuss with a consultant.

2) POTASSIUM

- Use potassium containing IV fluids (0.3% potassium chloride which contains 20 mmol in 500 ml) for all fluids following any initial resuscitation boluses *unless*:-
 - There is evidence of renal failure
 - potassium is above the upper limit of normal at presentation- in this case add potassium to IV fluids once child has passed urine **or** potassium has fallen within upper limit of normal (this typically will happen after the first 10ml/kg fluid bolus has been given)
- Monitor serum potassium levels with U&Es every 2-4 hours
- Potassium levels fall once insulin is commenced. If hypokalaemia develops:-
 - Consider reducing the insulin infusion rate
 - Consider whether central venous access is required to give higher concentrations of IV potassium solutions (>40mmol/L)

3) INSULIN

Rehydration fluids are the most essential first line treatment. Once IV fluids are started, blood glucose levels will begin to fall. Insulin is used to switch off ketogenesis.

- **Start an insulin infusion 1-2 hours after beginning intravenous rehydration.**
1. A continuous low-dose infusion of intravenous insulin (usually at **0.05 unit / kg / hr**) via electronic syringe pump is preferred
 2. How to make up insulin infusion:
 - Take 50 ml syringe and syringe pump.
 - Withdraw 2.4 units/kg of soluble insulin (Actrapid or Novorapid)
 - Inject into 50 ml syringe
 - Dilute with 48 ml of 0.9 % sodium chloride
 - Rotate the syringe to mix the insulin and sodium chloride solution
 - Set up an infusion pump at 1 ml/hr via a 3-way tap into drip needle.
 - This will infuse 0.05 units/kg/hr of IV insulin
 - Consider 0.5 ml/hr = 0.025 units/kg/hr for a very young child (< 5 years)
 3. The prescription should record:
 - a) The number of units in the syringe as 2.4 units/kg
 - b) The rate of infusion in ml/hr
 - c) The number of units/kg/hr
 - For known patients who are already on a long acting subcutaneous insulin, continue this alongside IV treatment

4) Bicarbonate

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

If metabolic acidosis is persisting, consider:-

- Insufficient insulin to switch off ketogenesis
 - check blood ketones to ensure falling adequate. If not:-
 - check lines
 - check insulin calculations
 - check infusion pump
 - consider increasing the insulin dosage to 0.1 unit/kg/hour, after discussion with the diabetes team or on call consultant
- Inadequate resuscitation
- Sepsis
- Salicylate or other prescription or recreational drugs
- Hyperchloraemic acidosis from sodium chloride in normal sodium chloride (likely if the above have been excluded - does not require specific treatment)

NB: The anion gap is typically 20-30mmol/L in a patient with ketoacidosis - an anion gap >35mmol/L may suggest concomitant lactic acidosis and should prompt review of the clinical picture.

(In cases of life-threatening hyperkalaemia or severe acidosis with impaired myocardial contractility discuss with an intensivist whether bicarbonate may have a role.)

C) ONGOING Management

1) Monitoring

- Hourly BP, basic observations & neuro obs/GCS (increase frequency if abnormal, young child or pH<7.1)
- Strict fluid balance (urinary catheter may be needed in young/sick children)
- Hourly capillary blood glucose (often inaccurate in presence of poor peripheral circulation/severe acidosis so cross check with lab glucose every 2-4 hrs)
- 1-2 hourly blood ketones using HOSPITAL meter
- **Lab U&Es, glucose, ketones and venous blood gases every 2-4hrs for the first 24hrs** (more often if clinically indicated)
 - Calculate plasma osmolality and corrected sodium (NB sudden drop in plasma osmolality/corrected sodium may be early indicator of impending cerebral oedema and needs careful review of patient condition and management including review of fluids being given - see below)
- Weight at least once daily
- Urine testing of all samples (glucose & ketones)

2) Ongoing management of fluids and IV insulin

- Once the blood glucose has fallen below 14mmol/L, change the intravenous fluids to **0.9% sodium chloride + 5% glucose + 0.3% potassium chloride** (20mmol in 500ml) *and:-*
- *If ketones <3 use 0.9% sodium chloride / 5% glucose / potassium chloride and continue insulin at 0.05 u/kg/hr*

- If ketones >3, consider use of 0.9% sodium chloride / **10% glucose** / potassium chloride and increase insulin to 0.1 u/kg/hr (10% glucose to avoid hypoglycaemia with higher insulin dose)

- **Blood glucose should fall gradually at a rate of 5 mmol/hr or less.**

If rate of glucose fall is more rapid, consider changing to **0.9% sodium chloride + 5% glucose + 0.3% potassium chloride** (20mmol in 500ml) earlier.

- During the recovery phase, if blood sugars increase again to >14 mmol/L, do not restart plain 0.9% sodium chloride, but continue fluids with glucose and potassium chloride. Consider reducing the rate of IV fluids, especially if the child is also drinking orally.
- As blood glucose levels fall, a gradual rise in corrected sodium in the initial phase of treatment is normal, and does not require any correction. As the rehydration progresses, the serum sodium levels will return to normal. Management should also aim to keep the osmolality stable during treatment of DKA.

- **Occasionally an exaggerated increase in corrected sodium occurs (>5 mmol/L in 4-8 hrs).** This suggests too much fluid loss or insufficient replacement.

→ Review the IV fluids being given to the child and consider any additional fluids required for the child after discussion with the consultant on call.

- **A rapid decrease in corrected sodium (>5 mmol/L in 4-8 hrs) suggests too much fluid administered/fluid given too rapidly and may increase the risk of cerebral oedema.**

→ Review IV fluids (including all fluid calculations done and any oral intake) and consider management suitable for cerebral oedema after discussing with a consultant.

- Oral fluids can be introduced when ketosis has begun to resolve, the child is not nauseous or vomiting, and feels ready to drink. If oral fluids are given before the 48 hour rehydration period is completed IV fluids need to be reduced to take account of the oral intake.
- Small amount of urine ketones can persist for 24 to 48 hours and do not reflect ongoing ketogenesis. Blood ketones are more useful in monitoring a trend. Anion gap is also a useful measure to follow resolution of ketogenesis. A normal anion gap of <18 indicates resolution of ongoing ketogenesis.
- Insulin infusion can be stopped (and subcutaneous insulin initiated- see 'Subcutaneous Insulin Therapy' below) when:

- Anion gap <18 mmol/L
- pH >7.3
- Urine ketones – Negative or trace only (or blood ketones <0.6)
- Child drinking / eating well without vomiting

Beware

1. Hypoglycaemia

Hypoglycaemia in diabetes = blood glucose < 3.9 mmol/L

Actions:

- Give 2 ml/kg bolus of 10% Glucose IV. Do not stop the insulin infusion.
- Consider escalating the glucose concentration in the intravenous fluids:-
 - to **0.9% sodium chloride + 5% glucose + 0.3% potassium chloride** (20mmol/500ml)
 - or **0.9% sodium chloride + 10% glucose + 0.3% potassium chloride** (20mmol/500ml) – please refer to the [“prescribing a non-standard glucose infusion”](#) guideline.
- If hypoglycaemia persistent **consider decreasing insulin infusion by half** (i.e. from 1 ml/hr to 0.5 ml/hr which provides just 0.025 units/kg/hr of insulin).

2. Hypokalaemia

Monitor ECG if potassium is high or low:

High potassium → peaked T waves; QRS wide and slurred

Low potassium → low or inverted T waves, ST-depression; U waves

- Increase K content in IV fluids- a central line may be necessary
- If has started oral intake and clinically improving give oral K supplements

3. Cerebral oedema

Cerebral oedema is a major cause of mortality in paediatric diabetic ketoacidosis that can occur at any time.

Early manifestations of cerebral oedema include:-

- Headache
- Agitation/irritability
- Unexpected fall in heart rate
- Increased BP

Later manifestations of cerebral oedema include:-

- Deterioration in consciousness level
- Abnormalities in breathing pattern e.g. pauses
- Oculomotor palsies
- Abnormal posturing/seizures
- Pupillary inequality or dilatation
- Papilloedema

If cerebral oedema is suspected, Consultant on-call & HDU staff should be notified immediately and the following measures should be undertaken:

- a) Maintain airway, breathing, oxygenation, circulation and perfusion.
- b) Exclude hypoglycaemia
- c) Administer “hypertonic saline” = 2.7% sodium chloride - 3ml/kg over 15 minutes. Can be repeated if required.
(Mannitol 20%, 0.5-1g/kg over 15 minutes is alternative to 2.7% sodium chloride, used rarely now).
- d) Restrict rehydration infusion rate to ½ of original rate until situation improves.
- e) Notify and transfer to HDU if patient not there already. Nurse with child’s head elevated (10°) and in midline.
- f) Discuss with STRS and consider intubation and ventilation and transfer to PICU.
- g) Aim to keep CO₂ >3.5 kPa, preferably at 4 to 4.5 kPa. Do not hyperventilate.
- h) Consider repeat boluses of 2.7% sodium chloride* to prevent rebound increase in intracranial pressure (every 2 – 6 hours).
- i) Consider Neuro-imaging (CT or MRI scan) to exclude other diagnoses e.g. thrombosis, haemorrhage or infarction; these can present in a similar way.
- j) Consider Phenobarbital if convulsions.

***The licensed preparation of 2.7% Sodium Chloride (Polyfusor) is available in the Trust**

Subcutaneous Insulin Therapy:

Discuss with the diabetes team (use OOH Diabetes on call bleep number as needed). Confirmation of the following plan is required, as for individual patients this may vary slightly from this guideline:

Use MDI (multiple daily injections) or basal bolus regimen for all patients regardless of age, as the preferred insulin regimen.

MDI regimen

- start basal bolus regimen (4 injection regimen) utilising NOVORAPID before each meal and LEVEMIR usually given at the same time every day at bedtime.

NOVORAPID doses are generally estimated at **0.1 unit/kg** for each meal (with some variation) and LEVEMIR dose at **0.2 units/kg**.

There is no need for mid-morning and mid-afternoon snacks with this insulin regimen.

- Start with (pre meal) subcutaneous fast acting insulin (e.g. Novorapid) at a convenient meal. Leave IV cannula in situ in case diet and fluids are not tolerated. If possible consider going straight from IV insulin to child’s usual regimen.

- Give subcutaneous fast acting insulin (Novorapid) up to 5 minutes before the meal and stop IV insulin 30 minutes after the first s/c injection of insulin (Novorapid) to prevent rebound hyperglycaemia.
- A guide to approximate dose (rounded to the nearest 0.5 units) of insulin (Novorapid) with meals, based on pre-meal blood glucose levels is as follows:
 - Pre meal BM <10 – mealtime insulin 0.1 unit/kg + no additional correction
 - Pre meal BM 10.1-17 – mealtime insulin of 0.1 unit/kg + additional correction of 0.02 units/kg
 - Pre meal BM 17.1-24 – mealtime insulin of 0.1 unit/kg + additional correction of 0.04 units/kg
 - Pre meal BM >24.1 – mealtime insulin of 0.1 unit/kg + additional correction of 0.06 units/kg

NB: Children should be ketone free for at least 24 hours if they are to recommence CSII pump
- The insulin dose needs to be reviewed at least daily.
- Consider extra dose of fast acting insulin if blood sugar >14 with ketones. Additional fast acting insulin for high glucose >14mmol/L and ketones >0.6mmol/L is approximately another 0.02 units/kg (rounded to the nearest 0.5 units)
- Do not add in extra doses of fast acting insulin in between if blood sugars are slightly high and there is no ketonuria. Never wake a child in the night to give insulin unless absolutely necessary.
- Do not advise exercise if blood sugars high with ketonuria.

Please note:

1. In severe cases where whole body potassium depletion is likely, consider oral potassium supplements.
2. Educate new patients and parents. Assess precipitants of ketoacidosis in older patients with established diabetes.
3. Blood glucose monitoring should be done by capillary blood glucose testing using the HOSPITAL meter before 3 main meals of the day and at bedtime as a minimum and should the child appear unwell.
4. Discharge will vary with the family. The aim is to get the child and the family home as soon as the child is well and child / family have been educated about diabetes. Plans for discharge should be made in conjunction with the Diabetes Nurse Specialist, who will be in frequent contact with the family when they go home. Inform the GP of the child's diagnosis, discharge and treatment. Make outpatient appointment in the diabetic clinic for 1 month. There is a TTO prescription guide on the intranet.

Diabetic keto-acidosis – Investigations chart

Name

DOB

Trust ID:

Date									
Time									
pH									
pCO ₂									
Bicarb									
BE									
Na									
K									
Urea									
Creat									
Pl. Osm									
Corr Na									
Cap Gluc									
Lab Gluc									
Hb									
WBC									
N									
Plate									
Hct									
Blood Cult									
Urine Cult									
CRP									
TFTs									
Coeliac screen									
GAD65/IA2/ZnT8/Islet cell antibodies									
HbA1c									

Are research bloods taken? (if any)

Estimated Osmolality = 2(Na+K) + gluc + urea

Corrected Na = Actual Na + 0.3(gluc-5.5)