NHS Lothian

NHS Greater Glasgow and Clyde

# Support Document for Emergency Assessment + Management of Diabetic Ketoacidosis (DKA) in children & young people who require transfer to:

## Royal Hospital for Sick Children, Edinburgh (RHSCE)
## or
## Royal Hospital for Children, Glasgow (RHCG)

**Purpose of document:**

**For use for all children and young people less than 16 years of age requiring retrieval or transfer to RHSC, Edinburgh or RHC, Glasgow for management of DKA**

**All calls to go through ScotSTAR:**

**www.snprs.scot.nhs.uk tel: 03333 990 240**

**ScotSTAR support is for children and young people in DKA who require transfer to RHSC, Edinburgh OR RHC Glasgow.**

**In certain clinical scenarios there will be a lower threshold for requiring a transfer by ScotSTAR, depending on the child's age, clinical situation and transfer distance involved.**

**ScotSTAR can task the paramedic team for support as appropriate.**

**CONFIRM THE DIAGNOSIS**
ENSURE involvement of Senior Medical Staff and Paediatric Staff if available

→ Immediate venous blood gas →

**DIAGNOSIS**

- Blood gas pH $<7.3/H^+$ $>50$ nmol/l **or**
- Standard bicarbonate $<15$ mmol/L **and**
- NPT blood ketones $>3$ mmol/l

**REMEMBER: Children can die from DKA**

**Appropriate DKA management aims to minimise the risk of cerebral oedema and prevent hypokalaemia and aspiration pneumonia.**

**Admit all patients up to their sixteenth birthday to a paediatric inpatient facility.**



See Appendix for Review Group details and document guidance

# INITIAL PATIENT ASSESSMENT AND RESUSCITATION

Date: Patient presented at: : hours

## For severe DKA expect consultant review

**RESULTS:**

pH/$H^+$

POCT* glucose

$pCO_2$

POCT*/Urinary Ketones

Standard $HCO_3$

**Tick**

**Severity of DKA is categorized by degree of acidosis**

- ☐ **Children and young people with a pH 7.2–7.29 ($H^+$ 62–51 nmol/l) &/or bicarb 10–14.9 mmol/l have MILD DKA**
- ☐ **Children and young people with a pH less than 7.1–7.19 ($H^+$ 79–63 nmol/l) &/or bicarb 5–9.9 mmol/l have MODERATE DKA**
- ☐ **Children and young people with a pH less than 7.1 ($H^+$ ≥80 nmol/l) &/or bicarb <5 mmol/l have SEVERE DKA**

**If GCS <12 or 'P' on AVPU scale immediately involve the local Anaesthetic Team. Reassess regularly – if deteriorating see 'Red Flags' pages 7-8.**

**WEIGH CHILD IF POSSIBLE** → Actual Kg Estimated Kg

## 1. Airway

- ☐ Ensure airway is patent
- ☐ If child comatose, insert an airway and seek urgent anaesthetic review and urgent support from critical care specialist.
  *Intubation and ongoing ventilatory management must be discussed with ScotSTAR team prior to undertaking.
  Attempting to manage the acidosis and metabolic derangements in these patients can be very challenging.
- ☐ Nil by mouth
- ☐ If vomiting or drowsy pass NG tube
- ☐ Aspirate and leave on open drainage

## 2. Breathing

Give 100% oxygen by face mask, as indicated by PEWS chart (Titrate $O_2$ to target $SpO_2$ >92%).

# INITIAL PATIENT ASSESSMENT AND RESUSCITATION

## 3. Circulation

☐ Insert I.V. cannula(e) and take blood samples as per local team guidance.

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

**See Fluid Management page**

### FLUID RESUSCITATION ONLY IF SHOCKED:

☐ poor peripheral pulses ☐ **AND** poor capillary filling with tachycardia ☐ **AND/OR** hypotension

- Patients with shock require appropriate restoration of their circulation and circulatory volume.
- 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 dependant on both perfusion pressure and intracranial pressure and hypotension will exacerbate the risk of brain injury.

**ACTION:** Volume expansion with 0.9% sodium chloride **10ml/kg** over 30 minutes.

**Do not give more than one intravenous fluid bolus of 10ml/kg 0.9% sodium chloride to a child or young person with severe DKA without review by the responsible senior paediatrician.**

**Further boluses of 10mls/kg may be given if required to restore adequate circulation up to a maximum of 40ml/kg, at which stage inotropes should be considered.**

**If ongoing concerns regarding persisting physiological derangement see Red Flags pages 7-8.**

Actual Weight: ☐ Kg or Estimated Weight: ☐ Kg or Working Weight*: ☐ Kg

To avoid excessive amounts of fluid in overweight and obese children it is recommended that consideration be given to using a **maximum weight of 80kg*** or 97th centile weight for age (whichever is lower).

| | **Initial fluid bolus** | **2nd fluid bolus** | **3rd fluid bolus** | **4th fluid bolus** |
|---|---|---|---|---|
| Volume to be infused (10 x weight)<br>10 x ☐ Kg = ☐ mls | mls | mls | mls | mls |
| Time Commenced | | | | |
| Time Completed | | | | |

## 4. Disability (neurology)

Conscious level and Neurological Observations as per age appropriate PEWS chart. ☐

If reduced conscious level on admission, or there is any subsequent deterioration:

- Seek urgent anaesthetic review if the airway cannot be protected (suggested by GCS <12 or P on the AVPU scale) See page 2 & discuss with ScotSTAR team*
- Discuss with the responsible senior paediatrician.
- Discuss with ScotSTAR retrieval team, who will contact RHSCE / RHCG PICU to confirm the appropriate care setting (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, see 'Management of Cerebral Oedema' pages 15-16 for details of clinical features and urgent management of cerebral oedema.

# FLUID MANAGEMENT

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

Actual Weight: ____ Kg or Estimated Weight: ____ Kg or Working Weight*: ____ Kg

**To avoid excessive amounts of fluid in overweight and obese children it is recommended that consideration be given to using a maximum weight of 80kg* or 97th centile weight for age (whichever is lower).**

| | **Initial fluid** |
|---|---|
| Volume to be infused (10 x weight)<br>10 x ____ Kg = ____ mls | mls |
| Time Commenced | |
| Time Completed | |

**Once circulating blood volume has been restored as outlined in severe SHOCKED DKA patients, or the initial 10mls/kg 0.9% sodium chloride has been given to all other patients, calculate fluid requirements as follows:**

**FLUID REQUIREMENT = DEFICIT + MAINTENANCE Use 0.9% Sodium Chloride**

## Fluids (it is essential to document all fluids carefully)

### 1. DEFICIT (Use the INITIAL blood pH)

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

- ☐ **1.** Assume a 5% fluid deficit in children and young people in mild DKA (indicated by a blood pH 7.2–7.29 &/or bicarbonate 10–14.9 mmol/l)
- ☐ **2.** Assume a 7% fluid deficit in children and young people in moderate DKA (indicated by a blood pH of 7.1–7.19 &/or bicarbonate 5–9.9 mmol/l)
- ☐ **3.** Assume a 10% fluid deficit in children and young people in severe DKA (indicated by a blood pH <7.1 &/or bicarbonate <5 mmol/l)

### Resuscitation fluid

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

Do **NOT** subtract the 10mls/kg fluid given to the non shocked patients.

**Calculation**

**Deficit** (in ml) = % dehydration ____ x **weight** (in kg) ____ x 10 = **Deficit** ____ ml

## 2. MAINTENANCE

**Calculate the maintenance fluid requirement using the following standard formula:**

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

**Weight ≤10kg** Tick if using: ☐

**100mls x** (weight in kg) **=** ml/24 hour

**Therefore, hourly volume = 24 hour total ÷ 24 =** ml/hour

**Weight 10.1 to 20kg** Tick if using: ☐

**100ml/kg/day for first 10kg =** 1000 ml/24 hour

+

**50ml/kg/day for next 10-20kg = 50 x** (remaining weight in kg) **=** ml/24 hour

**Total =** ml/24 hour

**Therefore, hourly volume = 24 hour total** ☐ **÷ 24 =** ml/hour

**Weight >20kg** Tick if using: ☐

(to a maximum weight of 80kg or 97th centile weight for age – whichever is lower)

**100ml/kg/day for first 10kg =** 1000 ml/24 hour

+

**50ml/kg/day for next 10-20kg =** 500 ml/24 hour

+

**20ml/kg/day for each kg >20kg = 20 x** (remaining weight in kg) **=** ml/24 hour

**Total =** ml/24 hour

**Therefore, hourly volume = 24 hour total** ☐ **÷ 24 =** ml/hour

**Neonatal DKA** will require special consideration and larger volumes of fluid that those quoted may be required – usually 100-150ml/kg/24 hours.

## 3. FINAL HOURLY INFUSION RATE (ml) FOR FIRST 48 HOURS

**(Deficit divided by 48) + maintenance/hour = hourly rate (ml)**

Give this volume **evenly** over the next 48 hours.
Do not give additional intravenous fluid to replace urinary losses.

**Show calculations in the boxes below**

( Deficit ÷ 48 ) = mls + Maintenance/hour ml/hr = **Hourly volume** ml/hr

To prescribe potassium in fluids see 'Electrolyte Management - Potassium'.

**IF** 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 (to confirm they are not becoming anuric) or after the Potassium has fallen to within the upper limit of the normal range (expect this to happen after the initial 10ml/kg IV sodium chloride has been given).

| | | | |
|---|---|---|---|
| Commence 0.9% sodium chloride within 1 hour of presentation: | SIG: | DATE: | TIME: |
| I.V. fluids commenced: | SIG: | DATE: | TIME: |

# RED FLAGS

## SIGNS of cerebral oedema:

- Change in neurological status – a falling GCS is abnormal
- ALONG WITH rising blood pressure
- AND a slowing heart rate

With further deterioration the following may occur:

- focal neurological signs
- decreasing oxygen saturation
- abnormal posturing

**ACTION:**

**Immediate request for Retrieval team support as per 'Management of Cerebral Oedema' pages 15-16.**

## SIGNS of persisting circulatory compromise:

- Persistent tachycardia
- Persistent hypotension
- No improvement in peripheral perfusion (time of capillary refill)
- Poor urine output

**ACTION:**

**Immediate request for:**

- **Local consultant support & clinical review**
- **Retrieval team support**

**Additional fluid bolus 0.9% sodium chloride 10mls/kg over 30 mins to be given in addition to hourly fluid replacement.**

## Acidosis

Acidosis should correct with correction of fluid balance. Remember pH is a log scale and therefore small improvements in pH are significant.

**Static or worsening pH despite resolving ketonaemia**

**ACTION:**

**Immediate request for consultant support & clinical review.**

If acidosis is not correcting, consider the following:

- Insufficient insulin to switch off ketones
- Inadequate resuscitation
- Sepsis
- Hyperchloraemic acidosis: consider the use of plasmalyte with appropriate glucose concentration
- Salicylate or other prescribed or recreational drugs

**Continued on next page**

# RED FLAGS

## Rising insulin requirements with persisting hyperglycaemia >14 mmol/L

**(Greater than 0.1 units/kg/hour)**

Indicates significant insulin resistance as a consequence of potential additional pathology: e.g. sepsis, intracerebral event.

**ACTION:**

**Immediate request for consultant support & clinical review.**

## Blood Ketones

Expect blood ketone levels to fall as insulin therapy switches off ketogenesis.

However at presentation it may take several hours to begin to see a fall in levels.

If levels not falling:

- check infusion lines
- check the calculation and dose of insulin
- consider sepsis and inadequate fluid input if sufficient insulin is being given

## Corrected Sodium levels

**Note:** a failure to increase the corrected sodium level = a risk of cerebral oedema

**Simplified corrected sodium formula:**

**Corrected sodium = plasma sodium plus (0.3 x (glucose – 5.5))**

**Corrected sodium should rise with therapy (0.5 – 1 mmol/hr)**

## Blood glucose <4 mmol/L

**(refer to page 10 - 'Management of Intravenous Insulin Infusion')**

- If pH ≥7.3 give 10g glucose powders orally in 20mls water
- If pH <7.3 give IV 10% glucose 2ml/Kg bolus
- Ensure IV insulin running at correct rate
- Ensure IV fluids appropriate and running correctly
- Decrease insulin infusion rate by 20% if no issues identified

# INTRAVENOUS INSULIN INFUSION

**Remember: Insulin is essential to switch off ketogenesis and reverse the acidosis**

- Transfer to Critical Care at at RHCG or RHSCE;

**If the need for a critical care bed not agreed/confirmed:**

- Transfer to the Emergency Department at RHCG or RHSCE for medical/diabetes team review.

The insulin infusion is to commence 1-2 hours after starting fluid replacement therapy.
There is some evidence that cerebral oedema is more likely if insulin is started early.

## ACTION: INSULIN PRESCRIPTION

1. Prescribe 50 units soluble insulin (Actrapid or Humulin S) added to 50ml 0.9% sodium chloride (a solution of 1 unit per ml).
2. Calculate insulin infusion rate, as below.

**0.05 units insulin x weight (kg)/hour =**

| 0.05 | x | | kg | = | | units/hr |
|---|---|---|---|---|---|---|

Note: units/hour also equals mls/hour

| SIGNATURE: | DATE: | TIME: |
|---|---|---|
| | | |

## ACTION: INSULIN INFUSION

1. **Start insulin infusion 1-2 hours after starting fluid replacement therapy.**
2. **Attach this using a Y-connector to the IV fluids already running (to ensure both run together on the same cannula).**
3. **Once started the insulin infusion should not be stopped for transfer.**

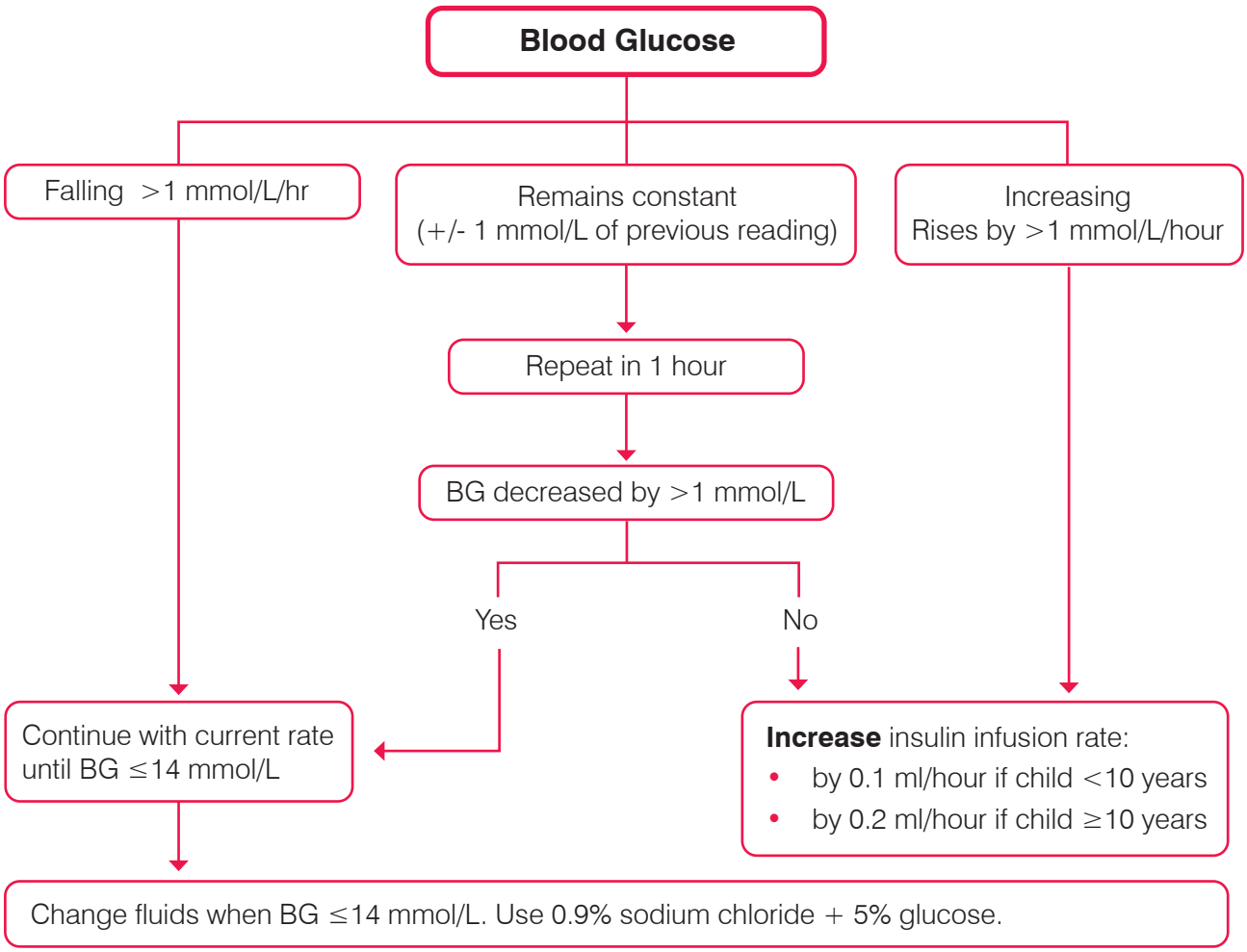
| Insulin infusion commenced at: | DATE: | TIME: |
|---|---|---|
| SIGNATURE: | DATE: | TIME: |

# MANAGEMENT OF INTRAVENOUS INSULIN INFUSION

## Step 1: To Reach Blood Glucose Value of 14 mmol/l

Blood glucose levels will often fall quickly initially simply because of rehydration.

**Small increments in insulin can make a significant difference but may take an hour for the effect to be observed.**




**Target BG ≤14 mmol/L reached**

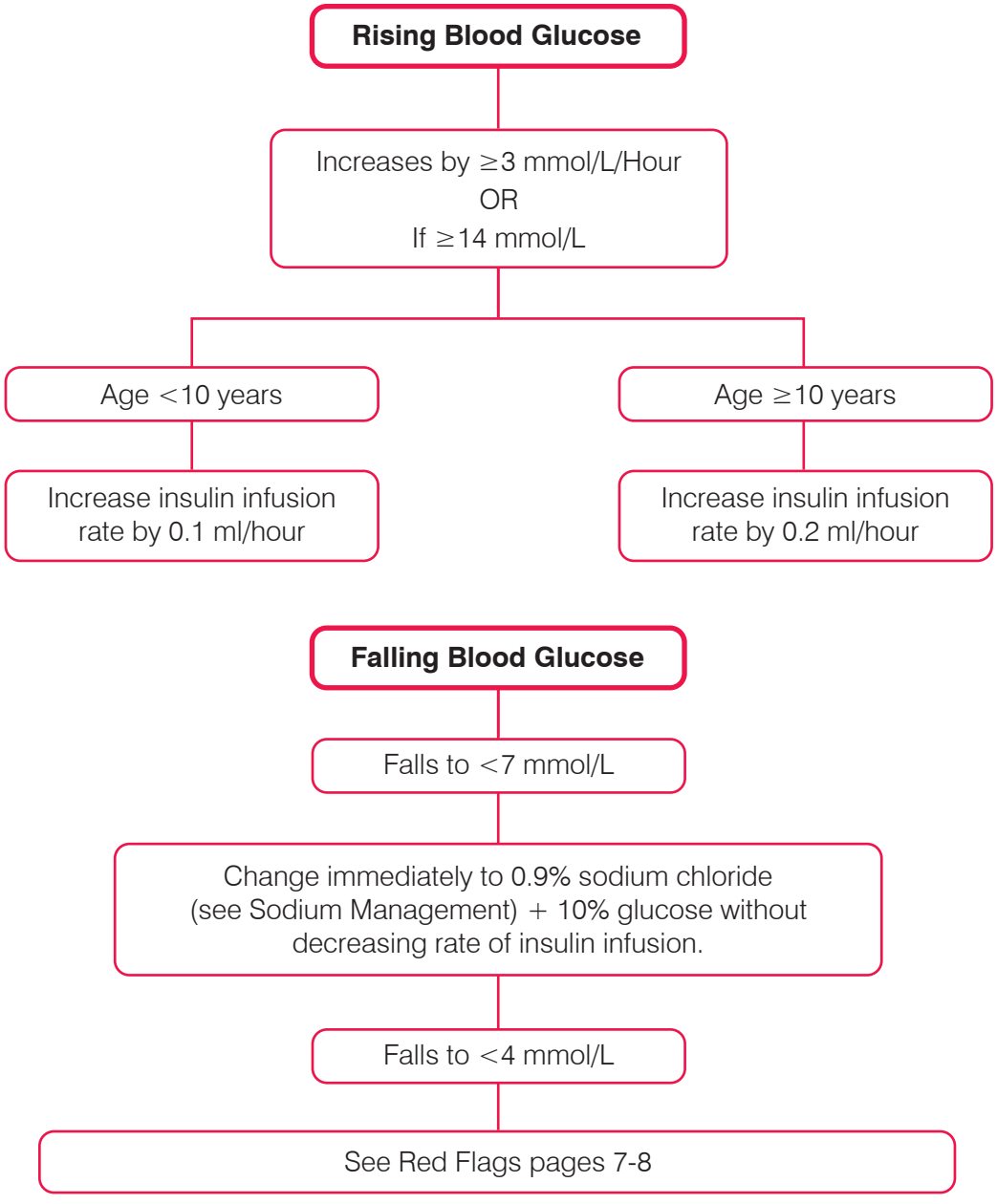
| DATE: | TIME: |
|---|---|
| | |

**Move on to Step 2 (and do not return to Step 1)**

# MANAGEMENT OF INTRAVENOUS INSULIN INFUSION

## Step 2: To Maintain Blood Glucose Target Levels of 7-14 mmol/L

**Remember** that when IV fluids change to include glucose, the blood glucose will rise.
**Do not** reduce glucose content of IV fluids in response to this.



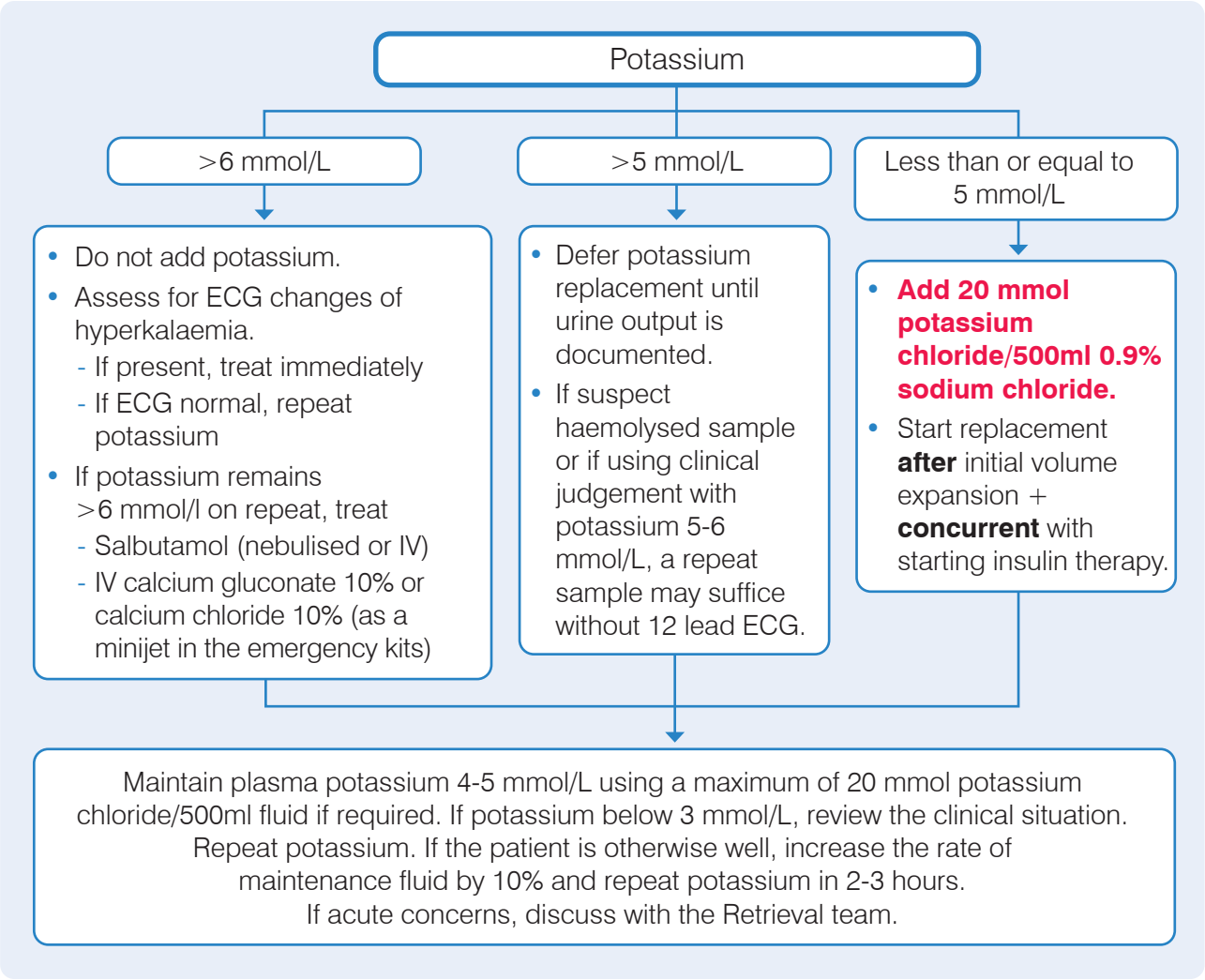
# ELECTROLYTE MANAGMENT

**Check U+E's 2 hours after resuscitation is initiated and then at least 4 hourly.**

## Potassium

- There is always massive depletion of total body potassium, although initial plasma levels may be low, normal, or even high.
- Potassium levels in the blood will **fall** once insulin is commenced.
- Maintain plasma potassium 4–5 mmol/l.
- Observe cardiac monitor for T wave changes.

**ACTION:**




## Phosphate

- There is always depletion of phosphate, another predominately intracellular ion.
- Plasma levels may be very low.
- There is no evidence in adults or children that replacement has any clinical benefit and phosphate administration may lead to hypocalcaemia.
- Severe hypophosphatemia should be treated if associated with either metabolic encephalopathy or impaired myocardial contractility.

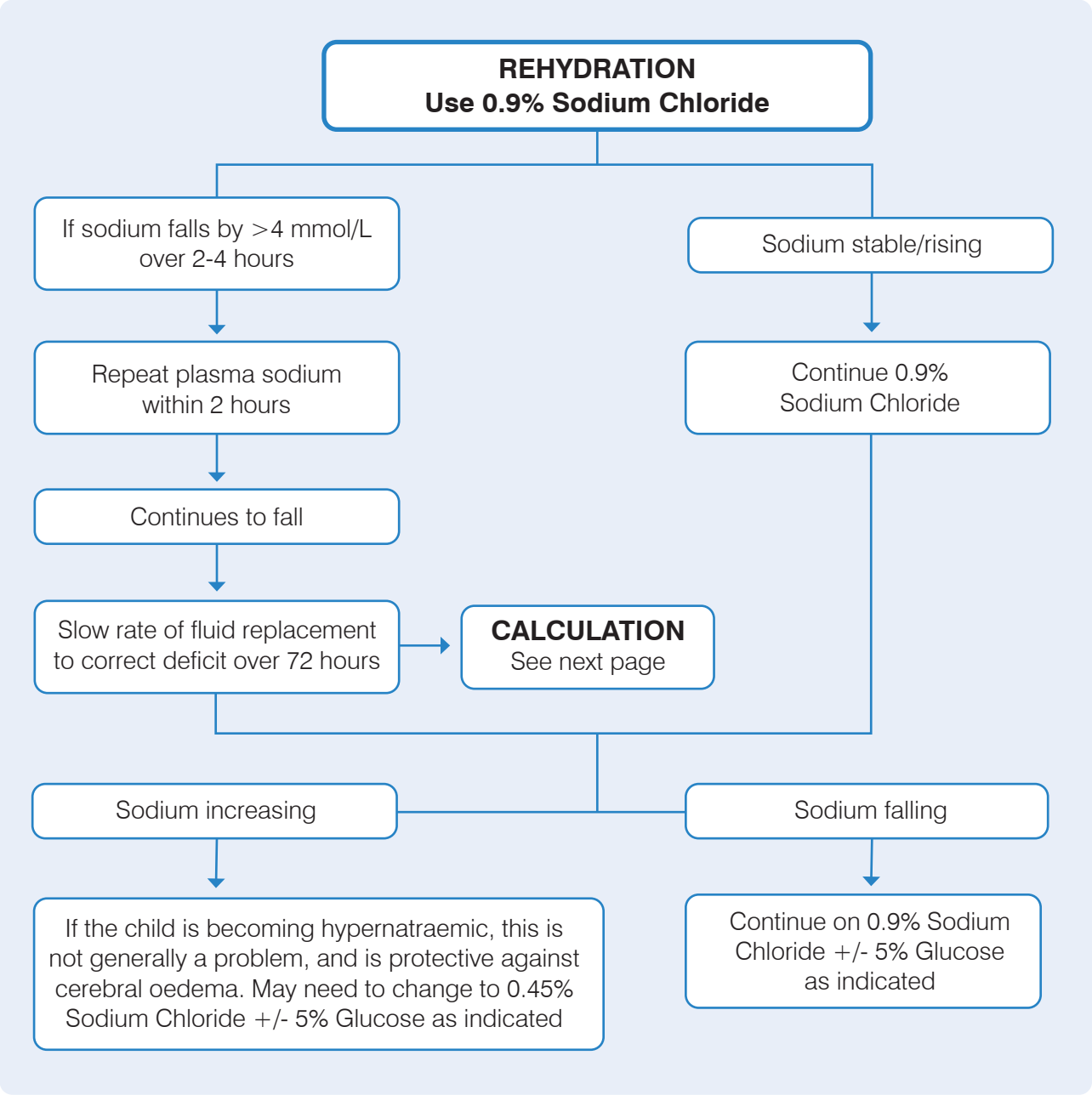
# ELECTROLYTE MANAGMENT

## Sodium

- Plasma sodium should **rise** as DKA is treated and as blood glucose falls.
- A falling plasma sodium is a risk factor for cerebral oedema.

**Corrected sodium = plasma sodium plus (0.3 x [glucose – 5.5])**

Calculate the corrected sodium initially to identify if the patient is hyponatraemic. If not, thereafter monitor plasma sodium and base decision making on plasma sodium values.



## Calculation of fluid replacement to correct deficit over 72 hours –
### ONLY use as indicated on flow chart for 'falling' sodium (see page 13)

**(Deficit divided by 72) + maintenance/hour = hourly rate (ml)**

Give this volume **evenly** over the next 72 hours.

Do not give additional intravenous fluid to replace urinary losses.

**Show calculations in the boxes below**

( Deficit ÷ 72 ) = mls + Maintenance/hour ml/hr = **Hourly volume** ml/hr

# MANAGEMENT OF CEREBRAL OEDEMA

Warning signs and symptoms of cerebral oedema include:

- Change in neurological status – a falling GCS is abnormal
- ALONG WITH rising blood pressure
- AND a slowing heart rate

With further deterioration the following may occur:

- focal neurological signs
- decreasing oxygen saturation
- abnormal posturing

More dramatic changes (convulsions, papilloedema, respiratory arrest) are late signs associated with an extremely poor prognosis.

**Exclude hypoglycaemia as a possible cause of any behavioural change.**

## Management

**If suspected inform local on-call medical paediatric consultant and liaise with ScotSTAR team immediately and initiate treatment with their advice**

**Use**, [+]Hypertonic (2.7%) sodium chloride (5ml/Kg over 5-10 mins)
**This is the preferred management**

OR

**if Hypertonic (2.7%) sodium chloride unavailable, use**
10% *[+]Mannitol 0.25-1.0g/Kg (2.5-10ml/Kg over 20 mins)
*Check Mannitol for particles and warm fluid if crystals present

| Show calculation |
| --- |
| |

| Show calculation |
| --- |
| |

Elevate head of bed.

Restrict IV fluids to 50% maintenance and replace deficit over 72 hours instead of 48 hours.

After child is stable consider CT scan to exclude other intracerebral events (thrombosis, haemorrhage or infarction).

[+] **CAUTION: Confirm patency of IV access as risk of extravasation with these fluids**

| CT scan report |
| --- |
| |

# CEREBRAL OEDEMA

## Restrict IV fluids to 50% maintenance and replace deficit over 72 hours instead of 48 hours

**(Deficit divided by 72) + 50% of maintenance/hour = hourly rate (ml)**

**Show calculations in the boxes below.**

### STEP 1

**Hourly maintenance =** _____ **ml** **50% hourly maintenance =** _____ **ml**

### STEP 2

( Deficit _____ ÷ 72 ) = _____ mls + 50% hourly maintenance _____ ml/hr = **Hourly volume** _____ ml/hr

Give this volume **evenly** over the next 72 hours.

Do not give additional intravenous fluid to replace urinary losses.

| DATE: | TIME PRESCRIBED: | CALCULATION CHECKED BY: |
|---|---|---|
| | | |

# APPENDIX 1

## Support Document for Emergency Assessment + Management of Diabetic Ketoacidosis (DKA) in children & young people who require transfer to: RHSCE or RHCG

**THIS DOCUMENT MUST NOT BE COPIED**

### 1. Purpose of this document

To ensure that all staff have clear guidance to follow when a child or young person up to 16 years of age presents in diabetic ketoacidosis (either newly diagnosed patient or patient with known diabetes) and requires transfer to either RSHSC Edinburgh or RHC Glasgow by ScotSTAR.

### 2. Who should use this document

All medical and nursing staff, and professionals allied to medicine within Children's Services throughout Scotland involved in the care of diabetes patients.

### 3. Further reference

https://www.bsped.org.uk/media/1745/bsped-dka-guidelines-no-dka-link.pdf
www.nice.org.uk/guidance/ng18/chapter/1-Recommendations#diabetic-ketoacidosis-2
www.ispad.org (under guidelines - DKA)

### Review group

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