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 Children & Young People, Edinburgh (RHCYPE)
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 RHCYP, 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 may require transfer to RHCYPE or RHCG.

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.

Review Group - see Appendix 1

INITIAL PATIENT ASSESSMENT AND RESUSCITATION

Date: Patient presented at: : hours

For children and young people on INSULIN PUMP THERAPY, stop the pump: ☐

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%).

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.
This 10ml/kg fluid volume **should** be subtracted from the calculated fluid deficit.

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 dependent 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 15 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 75kg*** 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) 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 RHCYPE/ RHCG PICU to confirm the appropriate care setting (HDU or PICU or ward setting).
- 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. This 10 ml/kg fluid volume **should** be subtracted from the calculated fluid deficit.

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 75kg* or 97th centile weight for age (whichever is lower).

			Initial fluid
Volume to be infused (10 x weight):	10 x ____ Kg = ____ mls		mls
Time commenced:		Time completed:	

For shocked DKA patients:
FLUID REQUIREMENT = DEFICIT+ MAINTENANCE. Use 0.9% Sodium Chloride

For all other patients:
FLUID REQUIREMENT = [DEFECIT minus initial 10mls/kg fluid volume]+ MAINTENENCE.
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 (H+ 62–51 nmol/l) &/or bicarbonate 10–14.9 mmol/l)
- ☐ **2.** Assume a 5% fluid deficit in children and young people in moderate DKA (indicated by a blood pH of 7.1–7.19 (H+ 79–63 nmol/l) &/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 (H+ ≥80 nmol/l) &/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.

Initial 10ml/Kg fluid

This fluid given to the non-shocked patients only SHOULD be subtracted from the calculated deficit.

Calculation for shocked patients

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

Calculation for non shocked patients

Calculated deficit (in ml) **=** (% dehydration _____ **x weight** (in kg) _____ **x** 10) **=** Deficit _____

Deficit _____ – initial 10mls/kg fluid volume _____ **=** Calculated 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 75kg 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:

Please note that staff may wish to check their fluid calculations using the BSPED DKA calculator:
www.dka-calculator.co.uk

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 15-30 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 metabolic acidosis: this may occur following the administration of large amounts of chloride containing fluids (as a result of the preferential renal excretion of ketones instead of chloride). Direct monitoring of ketones will differentiate between persisting acidosis due to ongoing ketosis (this may need adjustment to insulin infusion or fluids) or due to hyperchloraemia. Acidosis due to hyperchloraemia will generally correct spontaneously but always review the clinical situation. Acidosis due to hyperchloraemia need not delay the transition to oral fluids and subcutaneous insulin.
- 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 and check preparation of insulin infusion
- 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)

If the rise in Nacorr is more than 5 mmol/L in 8 hours this suggests too much fluid loss or insufficient replacement. Consider increasing the fluid rate.

If there is a fall in Nacorr by more than 5 mmol/L in 8 hours this suggests too much fluid gain or too rapid replacement. Consider reducing the fluid rate.

Blood glucose <4 mmol/L
(refer to page 10 - 'Management of Intravenous Insulin Infusion')

- If pH ≥7.3 (H^+ 50 nmol/l) give 10g glucose powders orally in 20mls water
- If pH <7.3 (H^+ 50 nmol/l) 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 or medical ward at RHCG or RHCYPE, depending on local policy.

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

- Transfer to the Emergency Department at RHCG or RHCYPE 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.

Known diabetes patients:
Document date, time and dose of last basal insulin.

Name of basal insulin:		DOSE:	DATE:	TIME:

DO NOT administer additional basal insulin, use Actrapid as indicated below.
The local diabetes team will discuss the timing of basal insulin administration at a later stage.

ACTION: INSULIN PRESCRIPTION

1. Prescribe 50 units soluble insulin (Actrapid or Humulin S) added to 49.5ml 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 using an anti-syphon set with Y-connector and anti-reflux valve. Ensure the IV fluids are connected to the valve closest to the patient.**
3. **Once started the insulin infusion should not be stopped for transfer.**

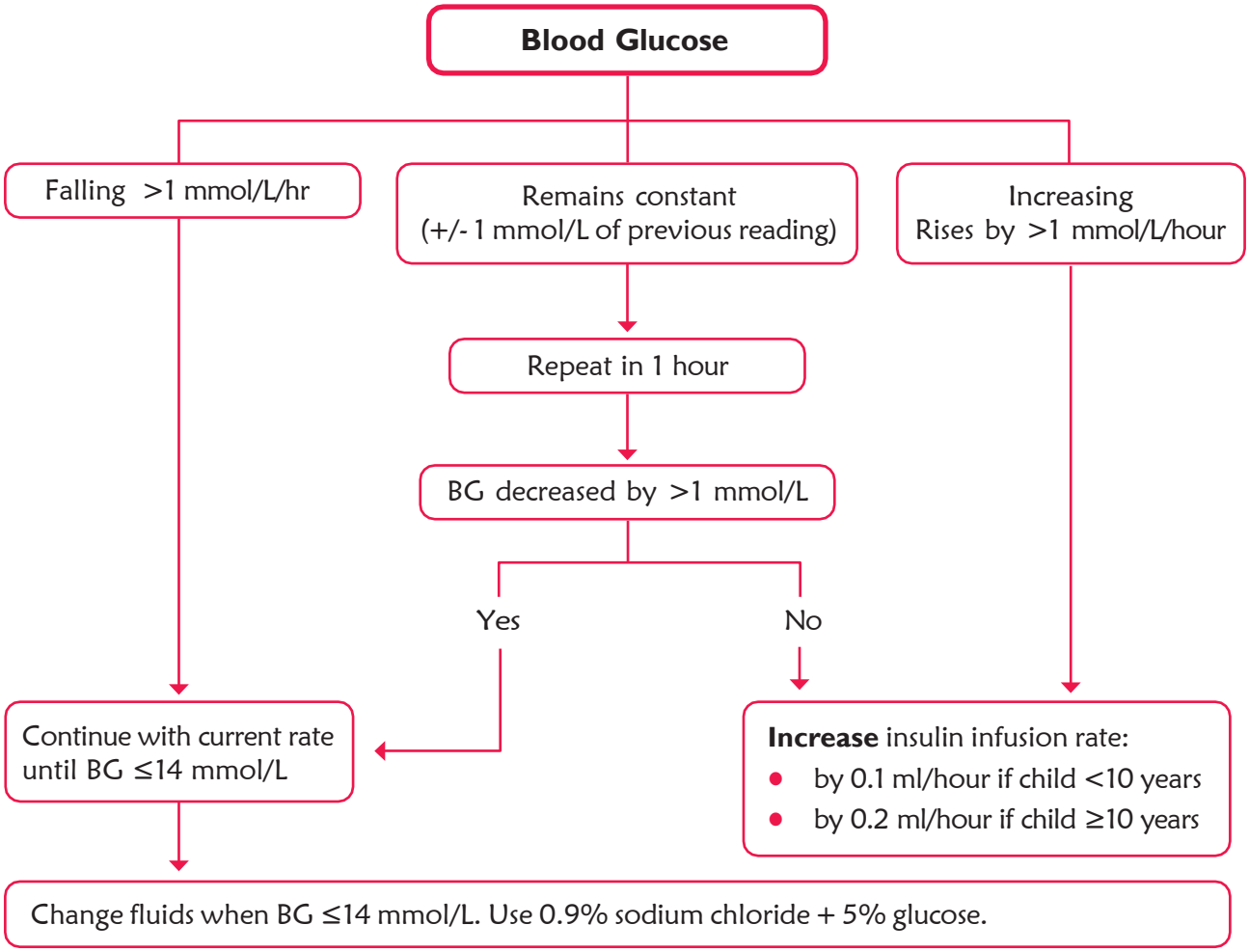
Insulin infusion commenced at:	DATE:	TIME:	INITIALS:

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

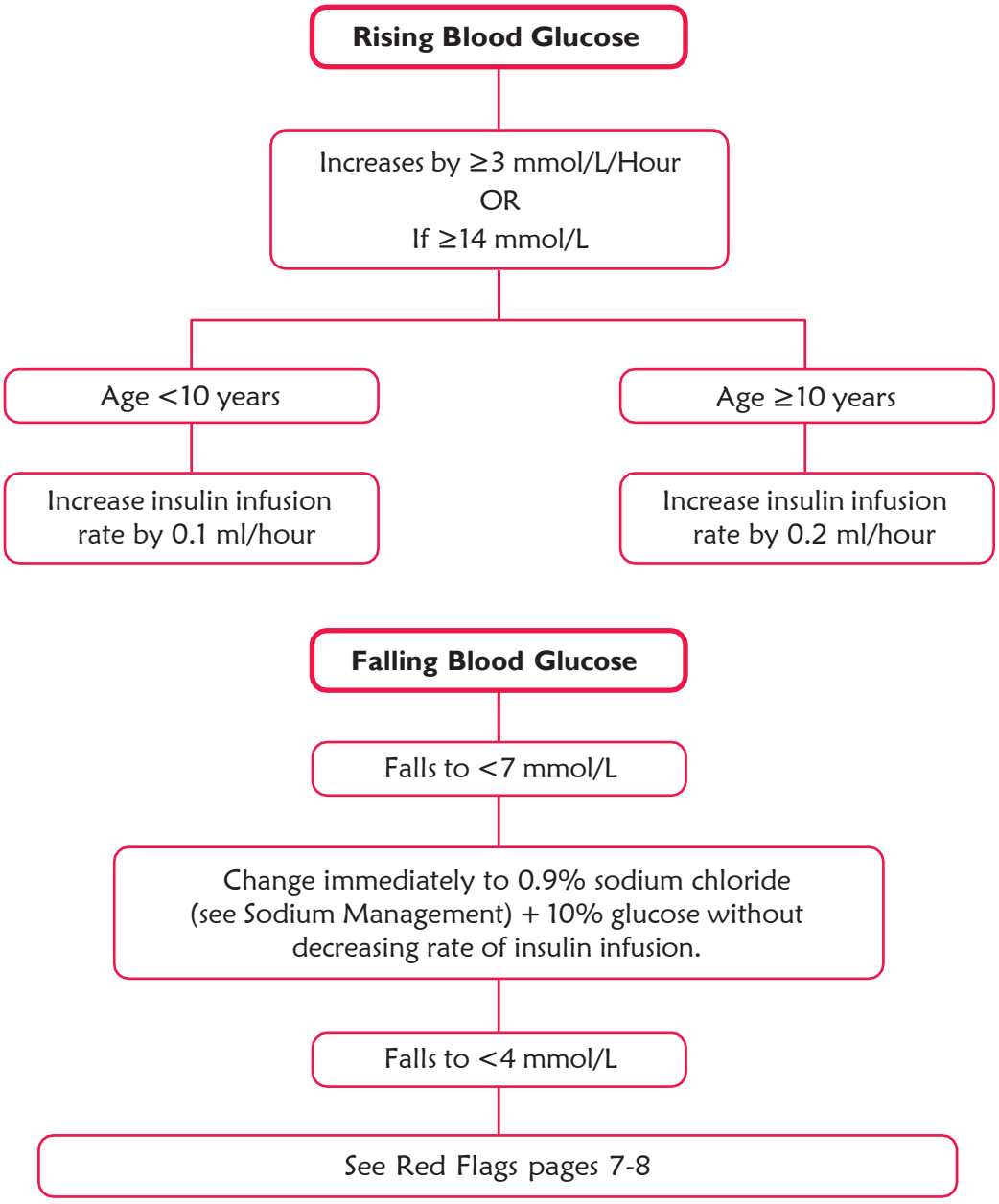
DATE:	TIME:

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.



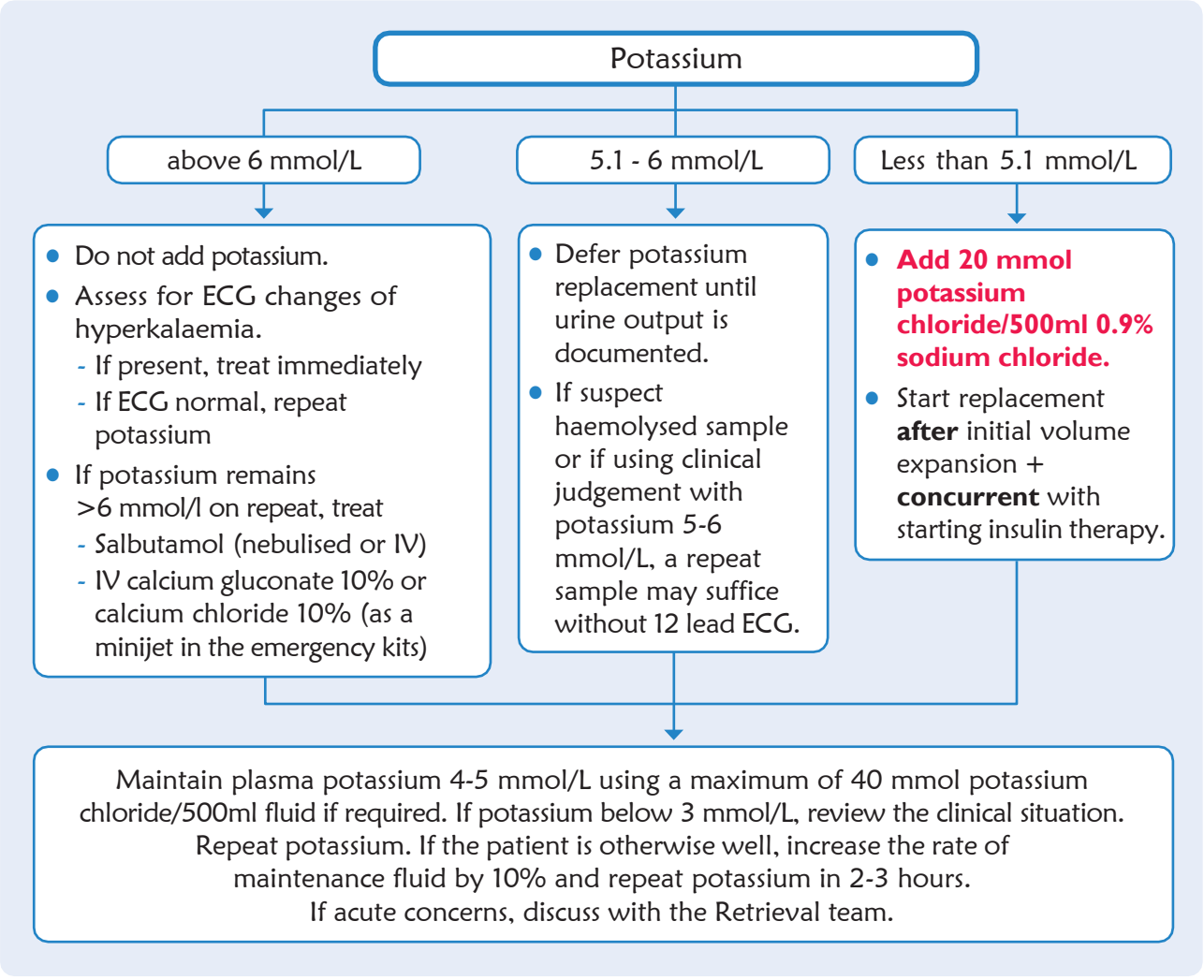
ELECTROLYTE MANAGMENT

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.

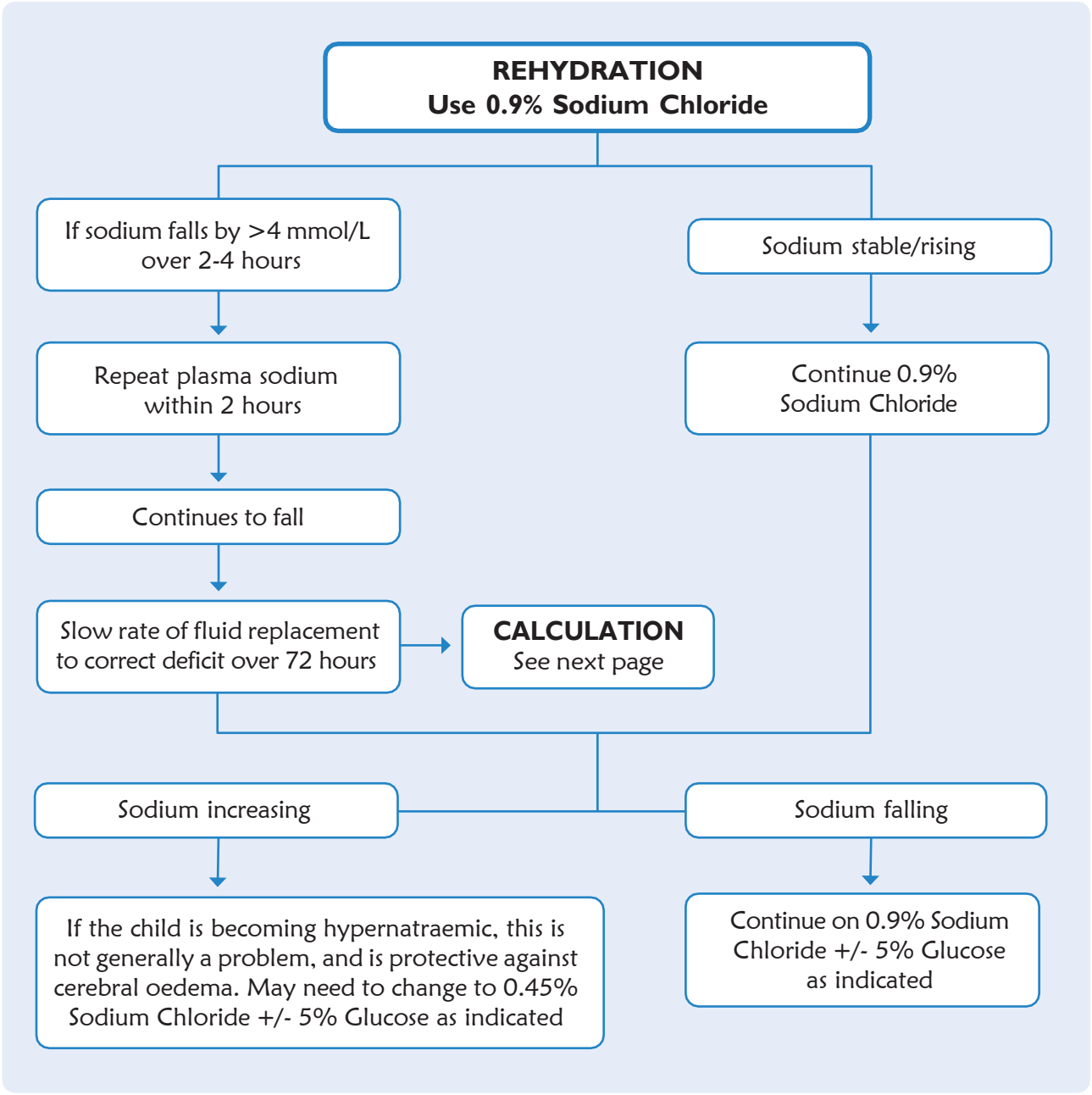
ELECTROLYTE MANAGMENT

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. See Red Flags (page 8).

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.



ELECTROLYTE MANAGMENT (continued)

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

Exclude hypoglycaemia as a possible cause of any behavioural change, then:

Use, [+]Hypertonic (2.7%) sodium chloride (5ml/Kg over 10 mins)

This is the preferred management

Show calculation

If Hypertonic (2.7%) sodium chloride unavailable, use

10% *[+]Mannitol 0.5g-1g/kg (5-10mls/kg over 15 mins)

*Check Mannitol for particles and warm fluid if crystals present

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**

Hypertonic saline has a peak onset of action at 10 minutes, and effects last around 1 hour in total. The preference is for hypertonic sodium chloride first, but if hypertonic sodium chloride is not effective, add mannitol as they may be additive together. IV hypertonic sodium chloride induces a shift of fluid from the intracellular to the extracellular space across the osmotic gradient it generates. It therefore reduces brain water, increases blood volume and increases plasma sodium. Mannitol may precipitate acute renal failure and may not be excreted in oligo-anuria whereas hypertonic sodium chloride is renoprotective.

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: RHCYPE 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 RHCYP 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/1943/bsped-guideline-for-the-management-of-children-and-young-people-under-the-age-of-18-years-with-diabetic-ketoacidosis-2021.pdf

www.ispad.org (under guidelines - DKA)

Review group

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