LRI Children's Hospital

Fluid Electrolyte Management UHL Childrens Hospital Guideline	
Staff relevant to:	Health professionals caring for children and young people aged up to 16 years.
Approval date:	September 2022
Revision due:	September 2025
Written by: Reviewed by:	Fahim Patel Razi Paracha
Version:	4
Trust Ref:	C6/2015

1. Introduction and who this guideline applies to

This guideline is for medical and nursing staff working within UHL Children's Hospital caring for patients requiring fluid and electrolyte management.

Exclusions:

- Condition-specific fluid and electrolyte management including but not limited to:
    - Diabetic ketoacidosis; metabolic conditions; trauma; burns; tumour-lysis syndrome; hyper-hydration regimes; acute kidney injury (stage 2 onwards)
- Patients admitted under surgical specialties
- Patients prescribed total parenteral nutrition (TPN)
- Children in whom a specialist has recommend a specific fluid and electrolyte management plan (e.g. patients under gastroenterology /renal medicine / metabolic medicine)
- Neonates before the initial postnatal diuresis or weight loss

Contents

Related Documents

- **Acute Kidney Injury AKI UHL Childrens Hospital Guideline - UHL C86/2016**
- **Diabetes (Including Diabetic Ketoacidosis) UHL Childrens Hospital Guideline - UHL C10/2019**
- **Gastroenteritis UHL Childrens Guideline - UHL C37/2006**
- **Sickle Cell Disease - Management UHL Childrens Medical Guideline UHL C17/2016**
- **Metabolic Conditions UHL Childrens Medical Guideline UHL C97/2016**
- **Pyloric Stenosis UHL Childrens Hospital GuidelineUHL C159/2016**
- **Infant Feeding Policy UHL LLR and Childrens Centre Services UHL E1/2015**
- **Parenteral Nutrition - Monitoring and Weaning UHL Childrens Hospital Guideline UHL C43/2018**
- **Parenteral Nutrition – Administration by Nurses UHL Childrens Hospital Guideline UHL C45/2018**
- **Parenteral Nutrition - Initiation and Administration UHL Childrens Hospital Guideline UHL C42/2018**
- **Parenteral Nutrition – Supporting Information UHL Childrens Hospital Guideline UHL C44/2018**

Background

This guideline is based on current NICE guidance and it provides a framework for prescribing fluids safely in paediatrics. Fluid prescriptions require careful consideration to provide optimum therapeutic benefits and prevent electrolyte abnormalities. Clinicians must consider the indication for fluid management, choice of fluid, choice of route, calculate a target volume and set the correct delivery rate to prescribe fluids safely.

Broadly speaking there are three main aims of fluid management:

1. Resuscitation - fluids are given for rapid volume expansion in the critically unwell patient.
2. Maintenance plus correction for dehydration- fluids are usually combined with maintenance fluids for patients with detectable dehydration and on-going losses. Careful consideration needs to be given to the type of fluid being lost to account for differences in electrolyte content (see appendix 1).
3. Maintenance- fluids for patients who are refusing feeds, establishing feeds or are nil by mouth awaiting a procedure or sedation.

Unfortunately complications are rife and can be precipitated by poor prescribing and infrequent patient review. We emphasise that enteral rehydration is safer than intravenous fluid (IV), so clinicians should aim to withdraw IV fluids at the earliest opportunity. We also recommend frequent patient review to prevent complications.

2. Clinical assessment

The aim of clinical assessment is to identify patients requiring fluid management and assign a level of clinical risk to guide fluid prescription.

Our guideline identifies three groups: firstly those in clinical hypovolaemic shock; secondly those who have clinically detectable dehydration (but crucially are not in hypovolaemic shock); and thirdly those who examine normally but are at risk of dehydration.

Clinicians categorise the degree of dehydration based on a thorough history, clinical examination and biochemistry. A weight on admission and a weight trend is often useful for assessing dehydration with 1 Kg equivalent to 1 Litre of fluid. A focussed history should identify risk factors for dehydration, co-morbidities and medications that may affect fluid status such as diuretics or laxatives. Patient examination should be centred on determining fluid status.

Figure 1 is a decision-aid to guide patient assessment to stratify their level of dehydration.

Figure 1 – Clinical assessment and categorisation of dehydration

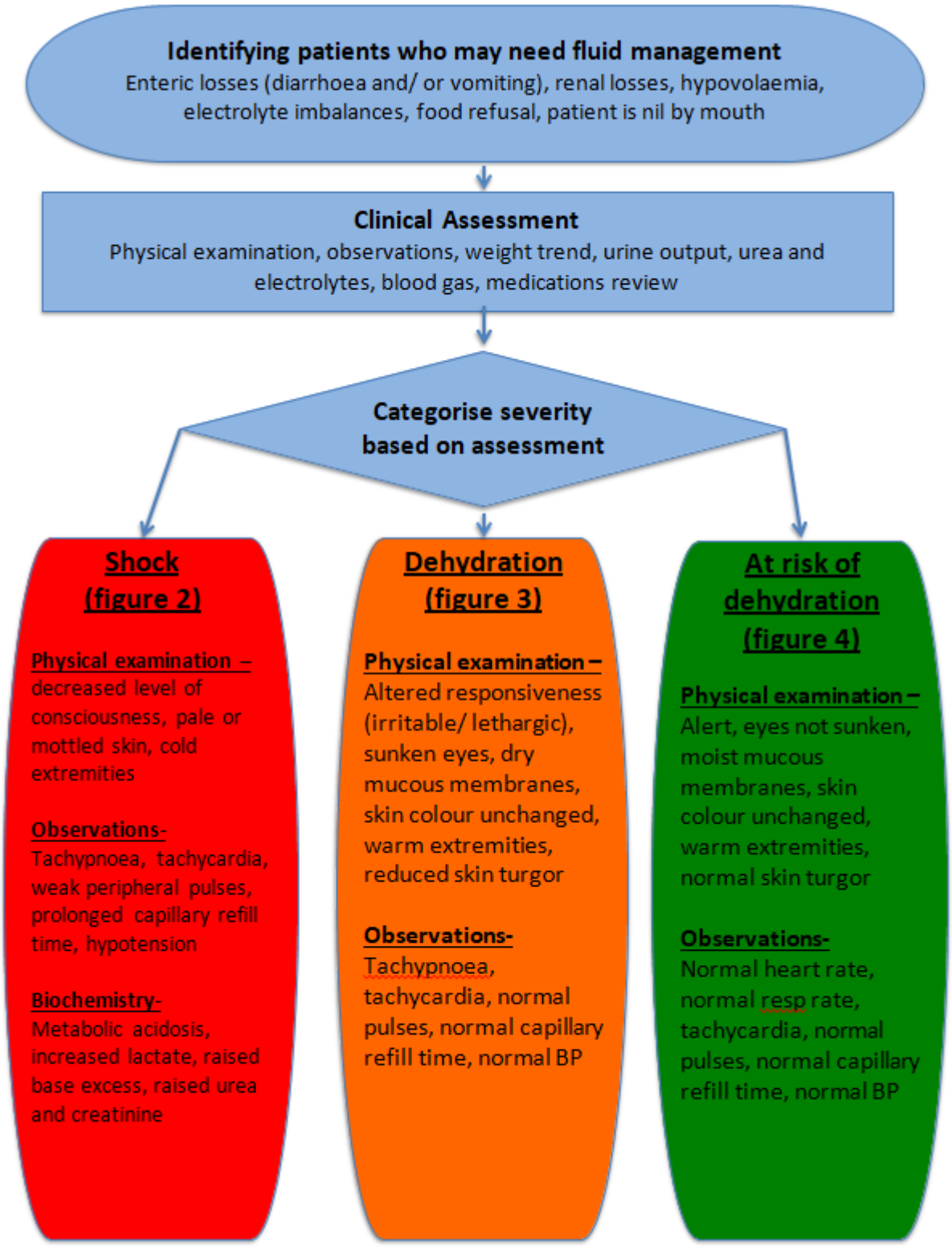
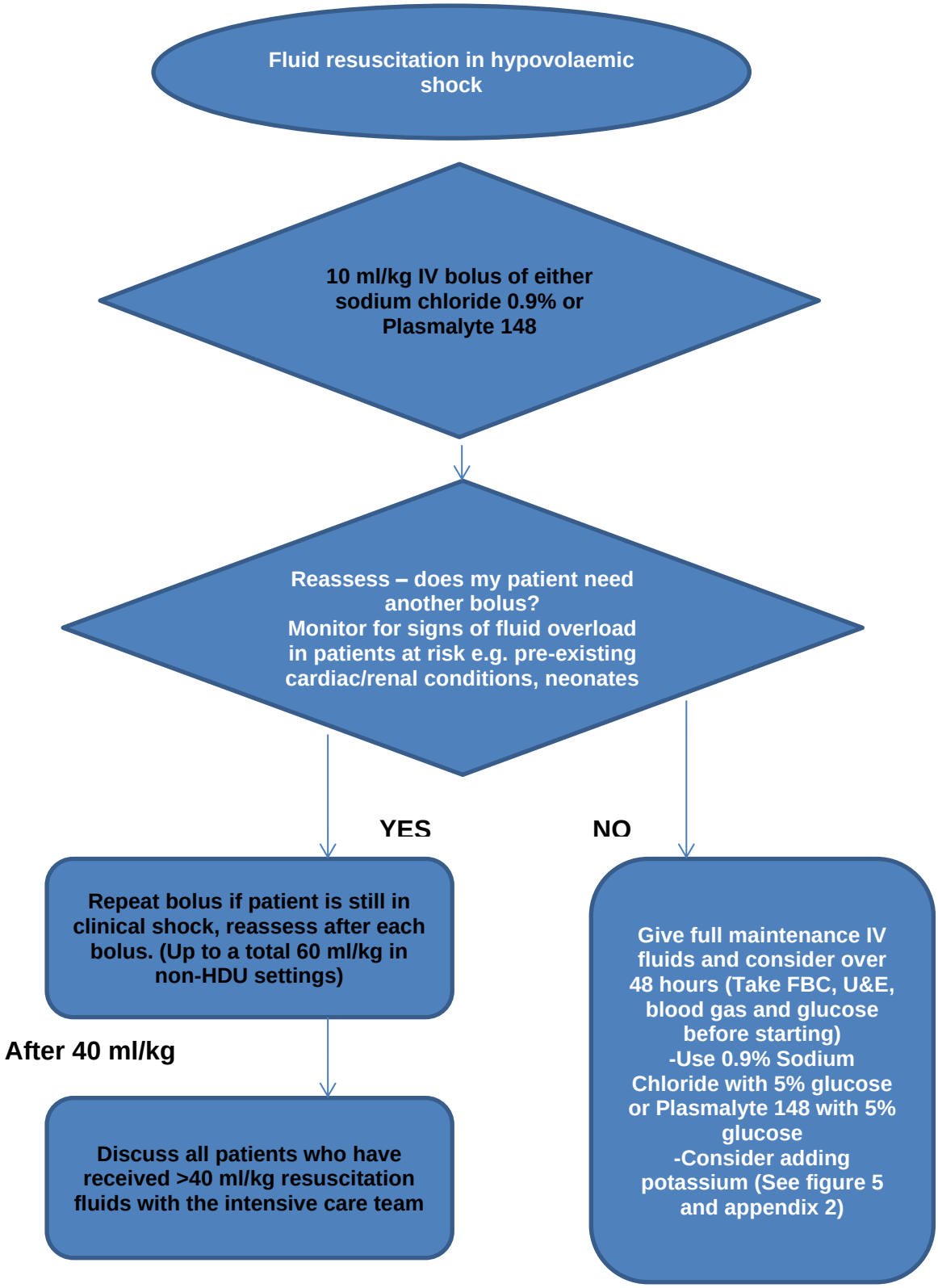


Figure 2 – Initial fluid resuscitation hypovolaemic shock



*Plasmalyte only available on CICU

Figure 3: Management of clinically detectable dehydration (without shock)

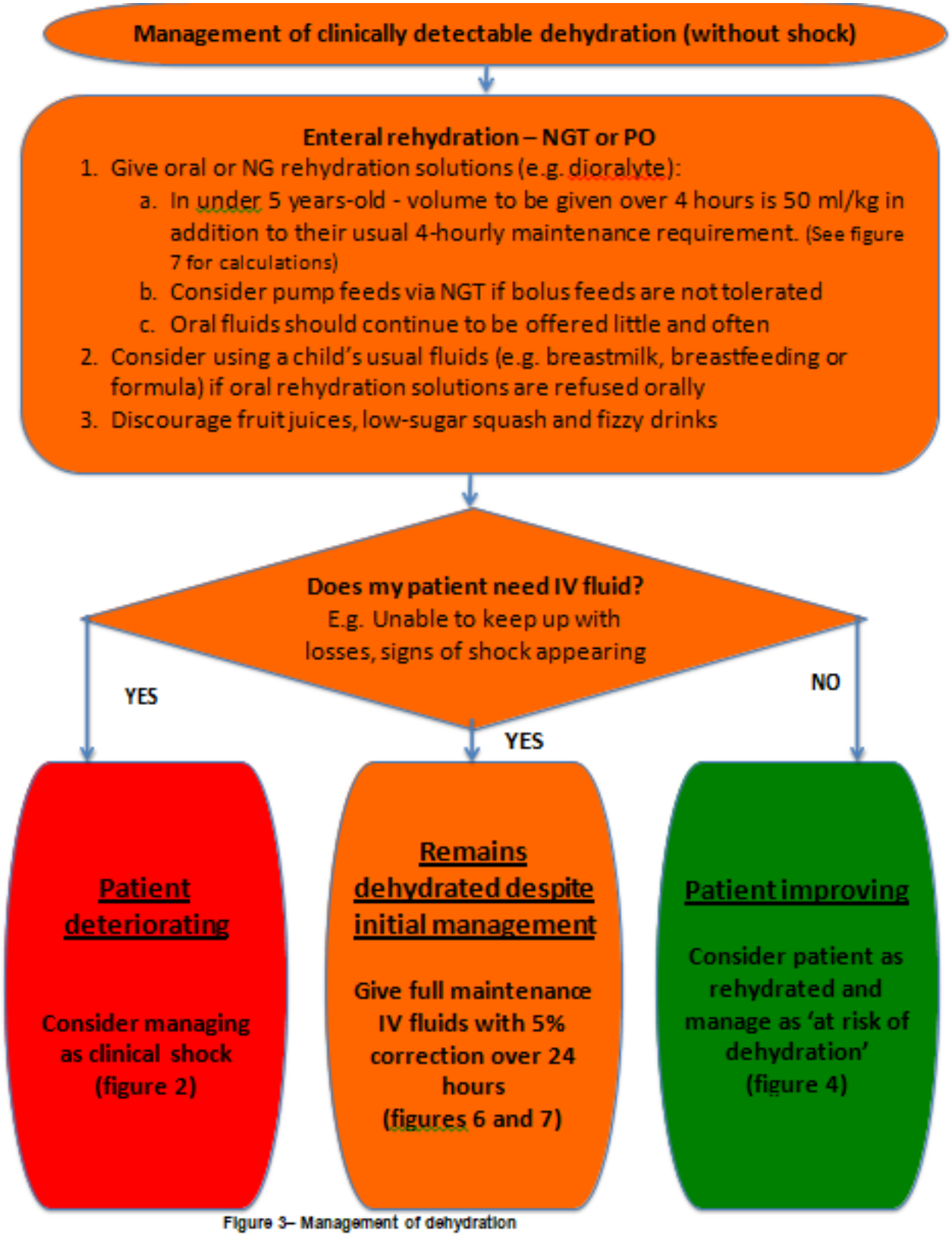


Figure 3– Management of dehydration

Figure 4: Management of patients at risk of dehydration but not clinically dehydrated

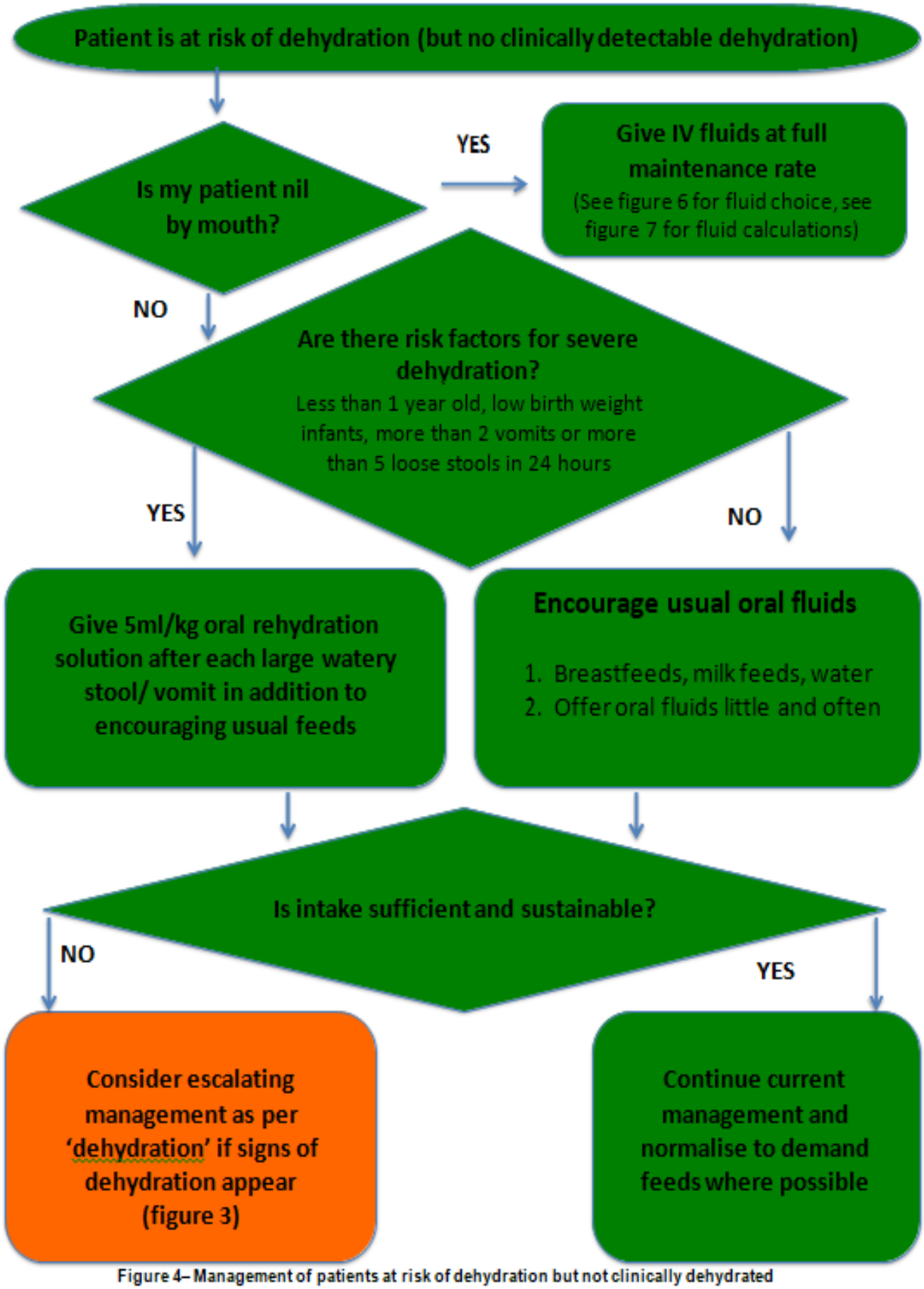


Figure 4– Management of patients at risk of dehydration but not clinically dehydrated

Figure 5: Summary chart on enteral fluid choices and rates

ENTERAL FLUID (NGT or PO) – fluid choice and rate		
	Fluid type	**Rate**
Dehydrated	• Use rehydration solutions such as dioralyte • Use usual feeds/fluids if oral rehydration solution is refused and child does not appear unwell • Discourage fizzy drinks or pure fruit juices	Initially 50 ml/kg oral rehydration solution in addition to 4 hours at full maintenance rate in under 5 year-olds
At risk of dehydration	• Offer usual feeds, water, milk feeds (breast or other milk-containing feeds)	No specific rate - Give little and often If at particular risk of dehydration e.g. infants less than 1 year old, low birth weight infants, more than 2 vomits or 5 loose stools in 24 hours – - Offer 5mls/kg after each loose stool or vomit

Figure 5 – Summary chart on enteral fluid choices and rates

Figure 6: Summary of IV fluids choices and rates

IV FLUID – fluid choice and rate		
	Fluid type	**Rate**
Clinical shock (bolus)	Use glucose-free crystalloid that contains sodium (131-154 mmol/litre) e.g. 'Plasmalyte 148' or 0.9% Sodium Chloride *Do not ADD potassium to any fluids used for bolus*	10 ml/kg over less than 10 minutes Full maintenance plus 10% correction over 48 hours
Maintenance after correction of clinical shock	0.9% Sodium Chloride + 5% dextrose or 'Plasmalyte 148 + 5% dextrose' Glucose-containing crystalloid that contains sodium (131-154 mmol/litre) (For neonates consider 10% dextrose plus bespoke additives in the first 7 days of life)	
Dehydrated	• See maintenance after correction of clinical shock	Full maintenance plus 5% correction over 24 hours
At risk of dehydration	• See maintenance after correction of clinical shock	Full maintenance over 24 hours

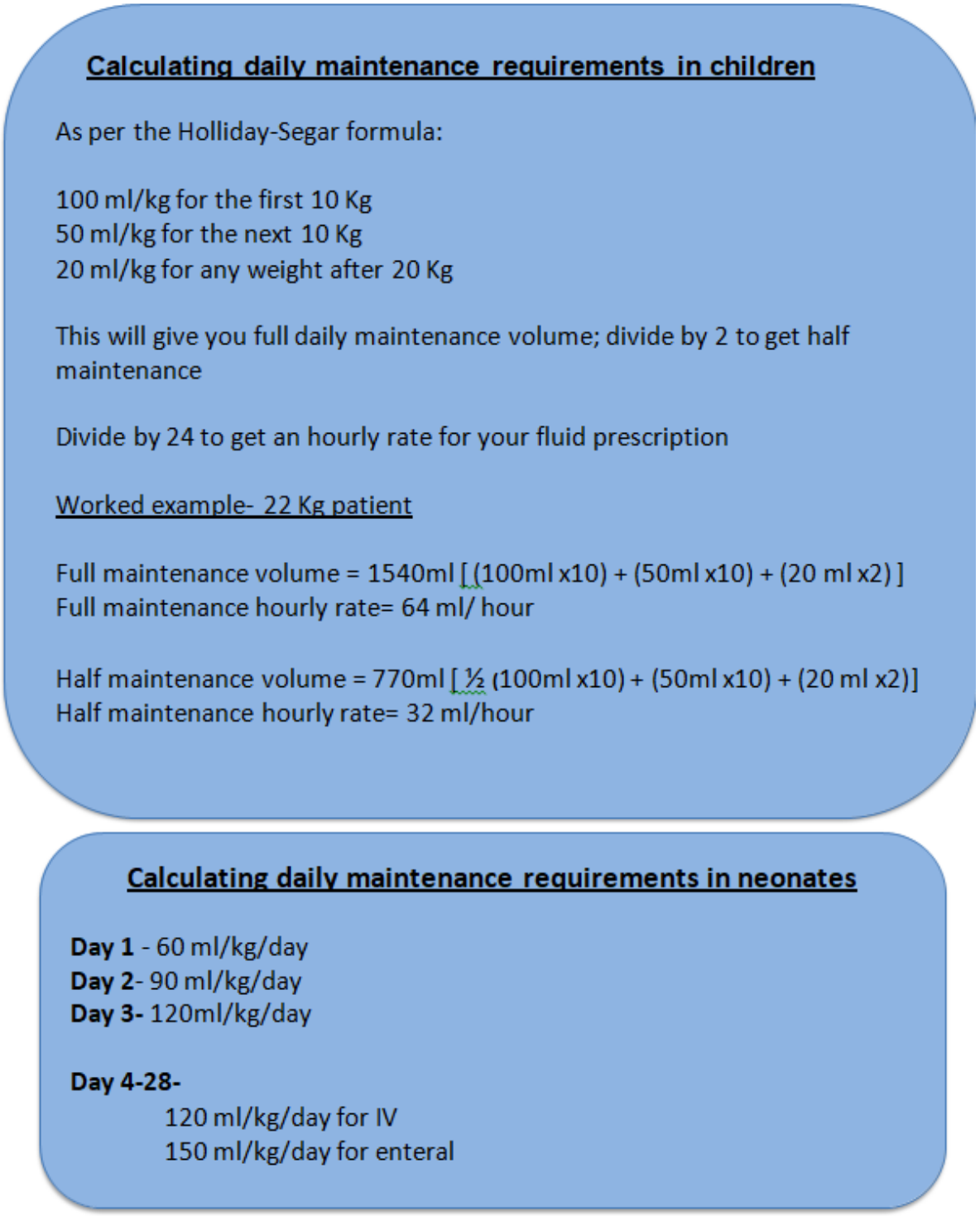
If there is no evidence of hyperkalaemia or renal impairment you should routinely supplement potassium chloride *(except in bolus for shock)*

- **Give 20mmol per 500ml bag in potassium depletion**
- **Give 10mmol per 500ml bag for maintenance**

'Plasmalyte 148' contains 5mmol/ L of Potassium; you **cannot add anything to these bags. If your patient requires more than this, use either 0.9% Sodium Chloride (with or without dextrose) and add Potassium as shown above**

Figure 6– Summary chart on IV fluid choices and rates

Figure 7: Calculating paediatric and neonatal fluid requirements



Calculating correction volumes in children

Remember –these volumes are in ADDITION to daily full maintenance

5% Dehydration volume = 50 ml for every Kg
10% Dehydration volume = 100 ml for every Kg
These volumes are then added to full maintenance to give full maintenance + % correction.

Worked example 1- 22 Kg patient with 5% dehydration (to be given over 24 hours)

- 5% Dehydration volume = 1100ml (5 x 10 ml x 22 kg)
- 5% Dehydration hourly rate over 24 hours = 46 ml/hour

- Full maintenance volume = 1540ml [(100ml x 10) + (50ml x 10) + (20 ml x 2)]
- Full maintenance hourly rate= 64 ml/ hour

-Therefore, full maintenance plus 5% correction (to be given over 24 hours) is:

5% Dehydration volume = 1100ml (5 x 10 ml x 22 Kg) ***PLUS***
Full maintenance volume = 1540ml [(100ml x 10) + (50ml x 10) + (20 ml x 2)]
= 2650 ml (to be given over 24 hours)

- 5% Dehydration (over 24 hours) hourly rate = 46 ml/hour ***PLUS***
Full maintenance hourly rate= 64 ml/ hour
= 110 ml/hour (for 24 hours)

Worked example 2- 22 Kg patient with 10% dehydration (to be given over 48 hours)

-10% Dehydration volume = 2200ml (10 x 10 ml x 22 kg)
-10% Dehydration (over 48 hours) hourly rate = 46 ml/hour

-Full maintenance volume = 1540ml [(100ml x 10) + (50ml x 10) + (20 ml x 2)]
-Full maintenance hourly rate= 64 ml/ hour

-Therefore, full maintenance plus 5% correction (to be given over 48 hours) is:

10% Dehydration volume = 2200ml (10 x 10 ml x 22 Kg) ***PLUS***
Full maintenance volume for the first 24 hours = 1540ml [(100ml x 10) + (50ml x 10) + (20 ml x 2)]
PLUS
Full maintenance volume for the second 24 hours = 1540ml [(100ml x 10) + (50ml x 10) + (20 ml x 2)]
= 5280 ml (to be given over 48 hours)

-10% Dehydration (over 48 hours) hourly rate = 46 ml/hour ***PLUS***
Full maintenance hourly rate= 64 ml/ hour
= 110 ml/hour (for 48 hours)

Figure 7– How to calculate paediatric and neonatal fluid requirements

2.1 Management of hypovolaemic shock

Clinical shock from hypovolaemia is a medical emergency requiring immediate fluid resuscitation. Figure 2 is based on the APLS algorithm for managing hypovolaemic shock. Patients may require repeat fluid boluses until they are no longer in clinical shock. If a patient has received more than 40 ml/kg of resuscitation fluids we recommend urgent discussion with PICU for ongoing management.

2.2 Management of dehydration

Patients who are not in shock but have clinical signs of dehydration need careful and frequent assessment of their hydration status. If oral fluids are not tolerated, pass a nasogastric tube (NGT) to give fluids. If despite this enteral fluids are still not tolerated, IV fluids should be prescribed as maintenance with 5% correction.

Figure 3 gives guidance on how to manage patients who are dehydrated but not in clinical shock.

Figures 5, 6 and 7 will help fluid choice, rate of delivery and fluid calculations respectively.

Management of patients at risk of dehydration

Patients who have no clinical signs of dehydration but their history or clinical presentation suggest they might become dehydrated can be managed as per the algorithm in figure 3. If a patient is to remain nil by mouth for a prolonged period such as for a procedure or pre-sedation, prescribe full maintenance IV fluids that contain glucose and potassium.

If a patient is unable to tolerate fluids orally, for example, secondary to a painful mouth or increased work of breathing, consider a nasogastric tube for fluids.

Figures 5, 6 and 7 will help with fluid choice, rate of delivery and fluid calculations respectively.

Choosing a fluid type and rate

Choosing the correct fluid for the correct indication can prevent electrolyte abnormalities. We advocate early introduction of potassium supplementation, unless there are specific contraindications.

Appendix 2 shows the constituents of prescribed fluids in comparison to plasma.

Fluid rate is variable depending on the clinical scenario. Figures 5&6 summarises the rate of fluid delivery depending on the indication.

Fluid calculations

Fluid requirements in children are calculated based on weight and we seldom prescribe more than 2500ml per day for routine maintenance.

When calculating percentage correction for dehydration, remember that this represents a daily volume that should be ADDED to the daily maintenance volume. It is often helpful to consider the hourly rates for maintenance and for correction as separate; you can then add these to give the rate to be delivered (maintenance + correction). There are worked examples in figure 7.

2.3 Monitoring and ongoing assessment

Indication and requirements

Every child on IV fluids should have their requirement for fluids reviewed twice daily:

- Consider introduction of enteral fluids at the earliest possible opportunity
- The child's fluid requirements should be calculated and recorded on a daily basis.

Fluid balance

Every child on fluid management requires an accurate fluid balance chart documenting:

- All input (including medications)
- All output including on-going losses and urine output
- Sub-total should be recorded every 4 hours and 12 hours
- Total balance recorded over 24 hours

Review fluid balance charts with every fluid prescription.

Biochemistry

Prior to starting IV fluids, patients should have:

- Blood gas
- Glucose
- Urea and creatinine
- Serum electrolytes (sodium, potassium, chloride)
- FBC

Every 24 hours (or sooner if indicated) we suggest:

- Urea and creatinine
- Serum electrolytes (sodium, potassium, chloride)
- Glucose – daily or sooner if indicated

Every 24 hours (or sooner if indicated) we consider:

- FBC
- Urinary electrolytes

Physical examination

- Clinical assessment of fluid status
- Observations trend, blood pressure and heart rate
- Actual or estimated daily body weight

- Record the weight from the current day, the previous day, and the difference between the two. If an estimate was used, the actual weight should be measured as soon as clinically possible.

Electrolyte imbalances

Electrolyte imbalances are commonly encountered in fluid management and the most likely affected are sodium and potassium. As a general rule, electrolyte abnormalities should be corrected slowly to prevent sudden shifts in fluid through concomitant changes in the osmotic gradient. The best cited example is osmotic cerebral demyelination in sudden changes in sodium levels. As such, sodium levels should be corrected no quicker than 0.5 mmol/l per hour (up to maximum of 12 mmol/l in 24 hours).

Here we discuss how to troubleshoot anomalies in potassium and sodium levels in relation to IV fluid management. However please note that these topics are covered in the context of IV fluid prescribing only and the guidance here is not a comprehensive guide in managing all causes of sodium or potassium imbalances.

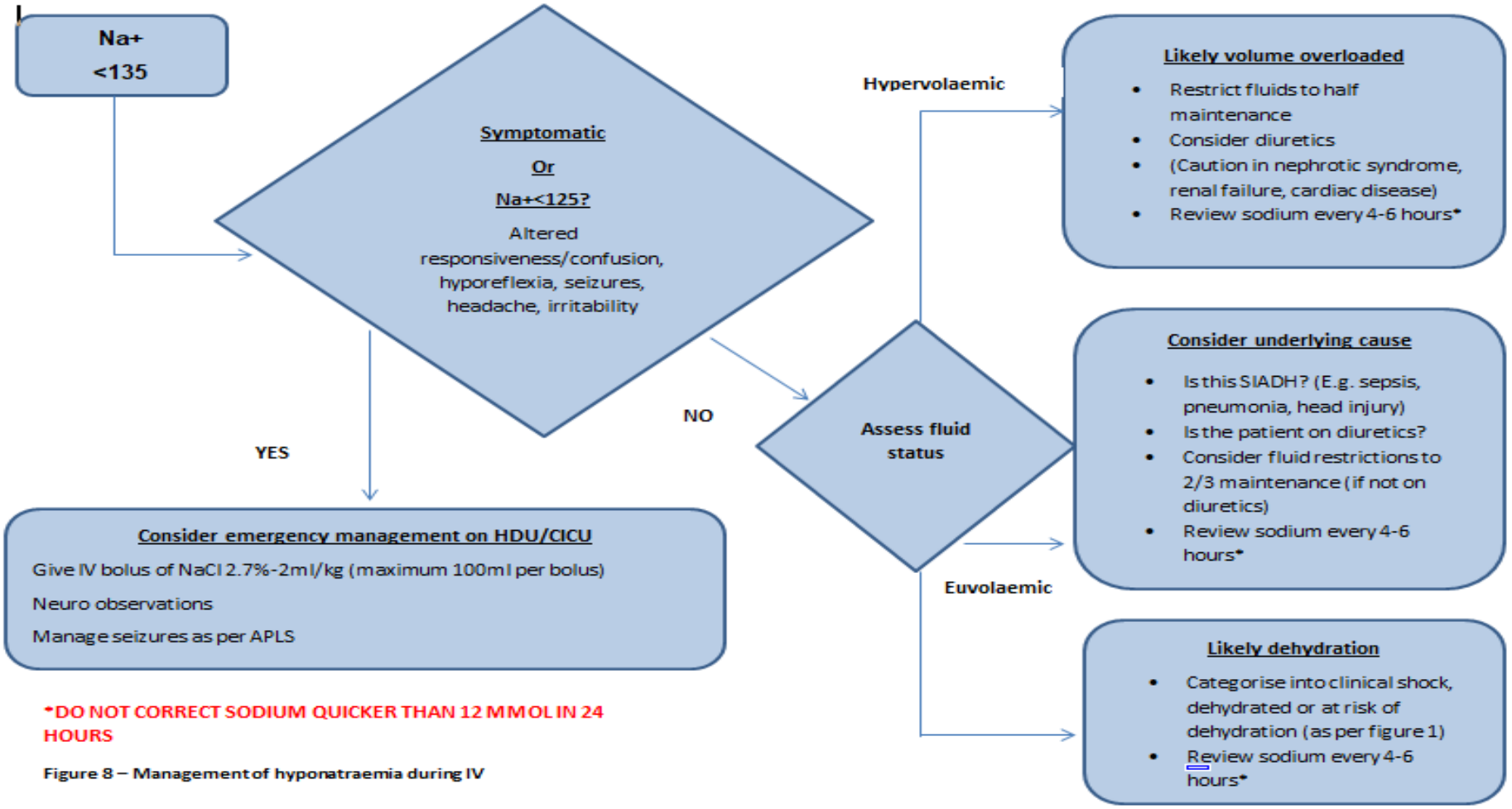
2.4 Hyponatreamia in IV fluid management

A sodium level of less than 135 mmol/l defines hyponatremia. Either sodium <125 mmol/l or <135 mmol/l with symptoms defines severe hyponatraemia. This is rare and patients may exhibit headaches, nausea/vomiting, altered responsiveness, hyporeflexia and seizures. Severe hyponatraemia is a medical emergency that requires a bolus of 2ml/kg (maximum 100ml per bolus) of 2.7% sodium chloride to prevent neurological deterioration. These patients are usually managed in the intensive care setting.

In non-severe hyponatraemia, clinicians must assess the sodium level in-accordance to fluid status.

Figure 8 is a decision-aid for guiding management of fluids in hyponatraemia.

Figure 8: Decision-aid for guiding management of fluids in hyponatraemia



*DO NOT CORRECT SODIUM QUICKER THAN 12 MMOL IN 24 HOURS

Figure 8 – Management of hyponatraemia during IV

Figure 9: management of hypernatraemia during IV fluid management

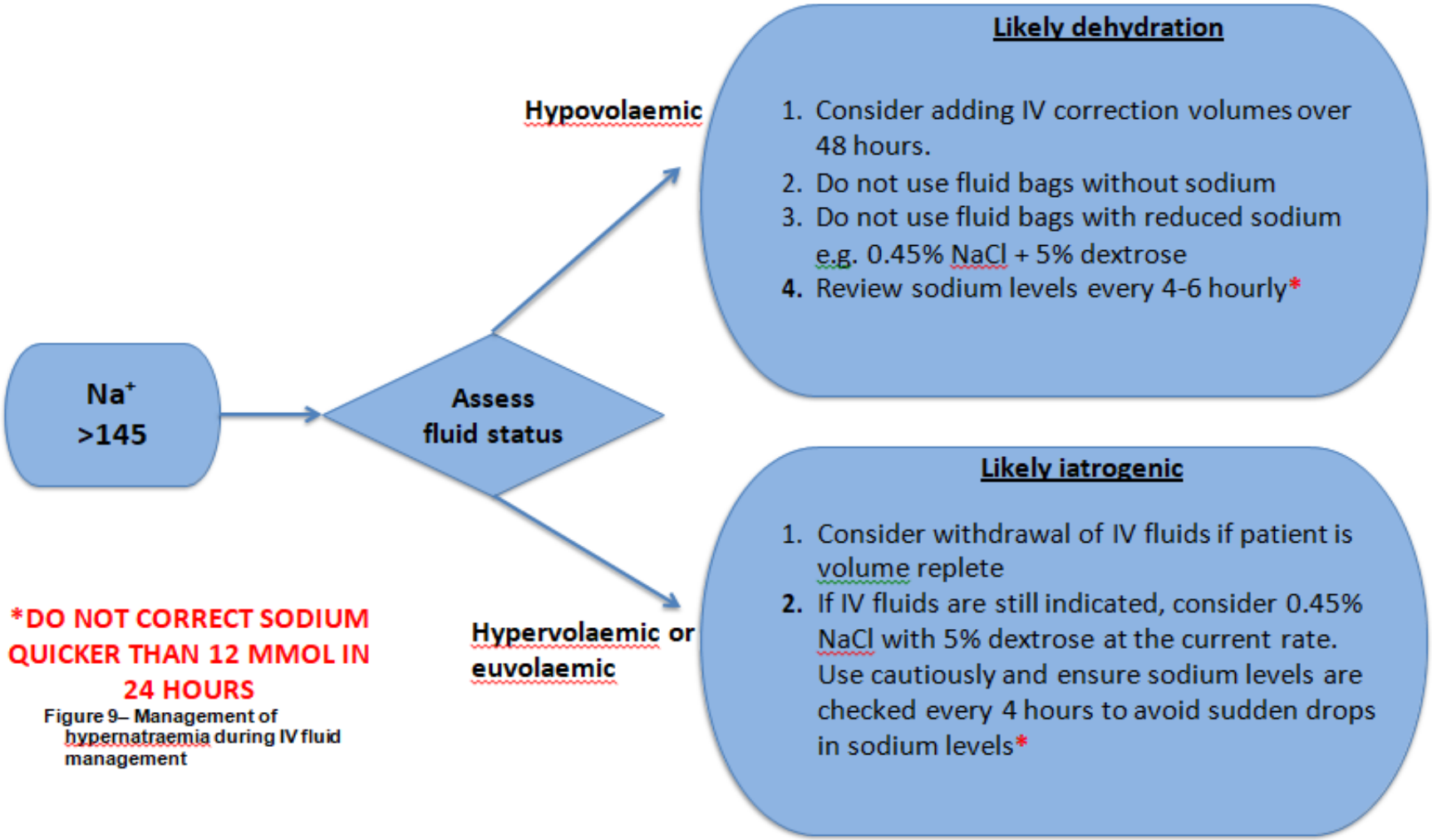


Figure 9– Management of hypernatraemia during IV fluid management

Figure 10: Management of hyperkalaemia during IV fluid management

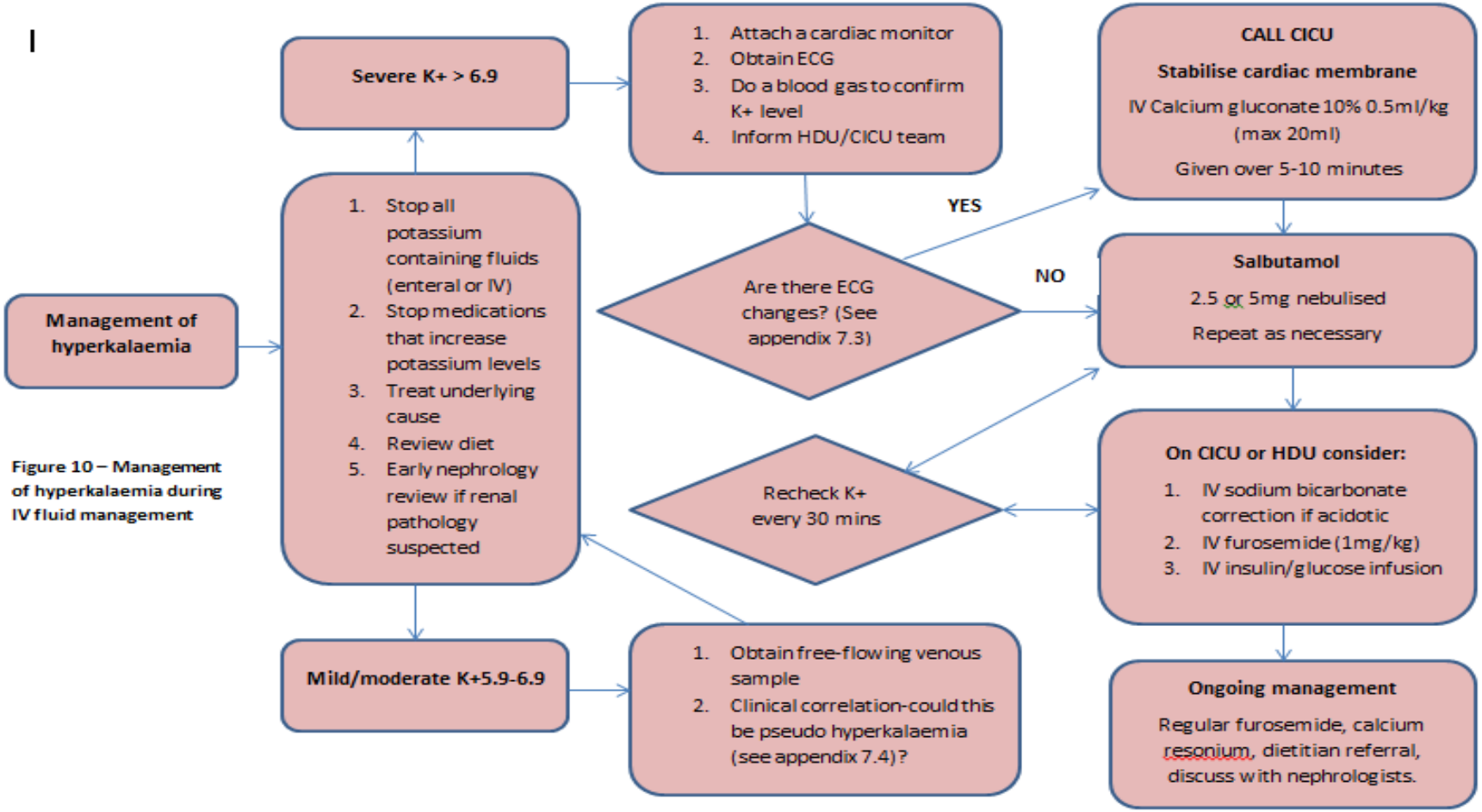


Figure 10 – Management of hyperkalaemia during IV fluid management

Figure 11: Management of hypokalaemia during IV fluid management

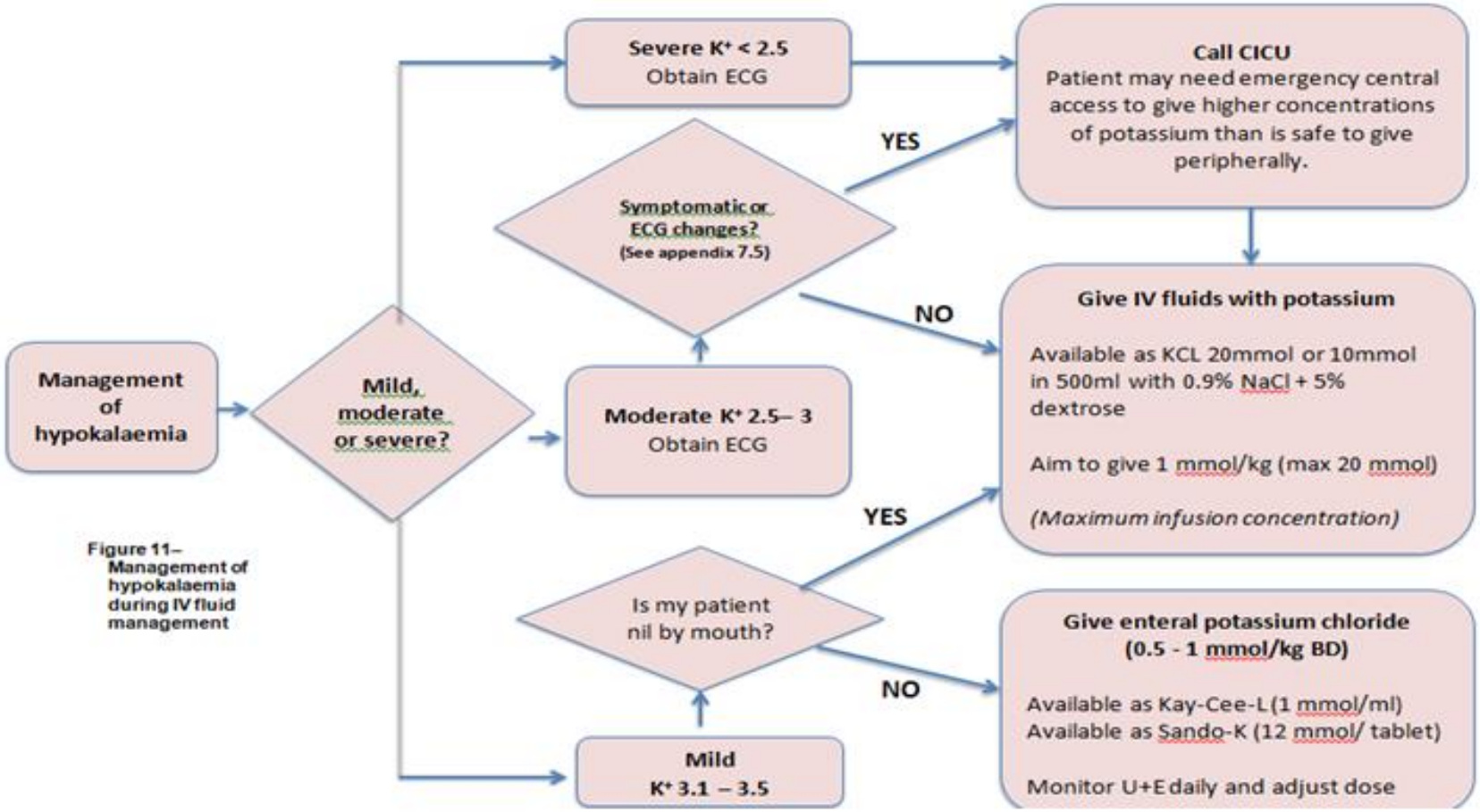


Figure 11– Management of hypokalaemia during IV fluid management

2.5 Hypernatreaemia in IV fluid management

A sodium level of more than 145 mmol/l defines hypernatreamia. The principal cause for this are either dehydration of sodium (and fluid) overload from IV fluids. To differentiate, one must interpret raised sodium level with the patent's fluid status.

A dehydrated patient with hypernatraemia is likely to have a normal total body sodium level but a raised intravascular sodium level due to haemoconcentration. In these patients, you must not reduce the level of sodium delivery in their fluid prescription but instead focus on providing increased fluid volumes to correct the sodium and dehydration simultaneously. Consider full maintenance with correction volumes over 48 hours to reduce the risk of sudden shifts in sodium levels.

A hypervolaemic or euvolaemic patient with hypernatraemia is likely to be sodium overloaded through IV fluid prescribing. Remember that water follows sodium via osmosis so these patients are likely to be volume overloaded too. Withdraw IV fluids where possible in these situations to prevent further supra-physiological delivery of sodium. If IV fluids cannot be stopped, consider prescribing 0.45% Sodium Chloride with 5% dextrose. This must however be used with great caution to prevent any sudden shifts in sodium and therefore osmolality. Remember that sodium levels should be corrected no quicker than 0.5 mmol/l per hour (up to a maximum of 12 mmol/l in 24 hours).

Figure 9 is a decision-aid for guiding management of fluids in hypernatraemia.

2.6 Hyperkalaemia in IV fluid management

Hyperkalaemia can be a life threatening medical emergency that can potentially induce cardiac arrhythmia. There are many causes of apparent hyperkalaemia but true hyperkalaemia is rare. However high potassium levels should always prompt urgent clinical review and consideration of cardiac monitoring and stabilization. Our local network hospital for nephrology has a comprehensive guideline on the management of hyperkalaemia. A copy is available on Nottingham Children's Hospitals website entitled Management of hyperkalaemia (see figure 10 and section 5)

Appendices 3 and 4 show ECG changes in hyperkalaemia and causes of pseudo hyperkalaemia respectively.

2.7 Hypokalaemia in IV fluid management

A potassium level of less than 3.5mmol/l defines hypokalaemia. This is usually caused by gastric losses, reduced dietary intake, medications (such as salbutamol or insulin) or from intracellular shifts secondary to refeeding. Symptoms include muscular dysfunction such as cramping, gastric ileus, fasciculation and in severe cases cardiac arrhythmias.

Figure 11 is a decision-aid for guiding management of fluids in hypokalaemia.

Appendix 4 shows ECG changes in hypokalaemia.

3. Education and Training

Junior doctors local induction

Prescribing intravenous fluids online module provided by e-learning for health. Available at **https://portal.e-lfh.org.uk/Component/Details/443277**

4. Monitoring compliance

What will be measured to monitor compliance	How will compliance be monitored	Monitoring Lead	Frequency	Reporting arrangements
Patients who are prescribed fluids have a documented fluid status including mention of any red flags if present	Audit	Ruth Radcliffe	3-Yearly	
Patients prescribed IV fluids have a documented weight or estimated weight	Audit	Ruth Radcliffe	3- Yearly	
Patients prescribed IV fluids have a correct calculated delivery rate and volume	Audit	Ruth Radcliffe	3- Yearly	
Patients given resuscitation fluids receive either 0.9% Sodium Chloride or 'Plasmalyte 148'	Audit	Ruth Radcliffe	3- Yearly	
Patients who are prescribed IV fluids have had a baseline FBC, U+E, blood gas	Audit	Ruth Radcliffe	3- Yearly	
Patients who are prescribed IV fluids have an accurate fluid balance chart with 4,12 and 24-hourly totals	Audit	Ruth Radcliffe	3- Yearly	
Patients who are prescribed IV fluids should have daily (or sooner) FBC, U+E and glucose	Audit	Ruth Radcliffe	3-Yearly	
Patients who are prescribed IV fluids should have a documented consideration for enteral fluids/ withdrawal of IV fluids	Audit	Ruth Radcliffe	3-Yearly	

5. Supporting Documents and Key References

Intravenous fluid therapy in children and young people in hospital. National Institute for Health and Clinical Excellence. Guideline NG29. December 2015

Diarrhoea and vomiting caused by gastroenteritis in under 5's: diagnose and management. NICE CG84 2009.

Nottingham Childrens hospital hyperkalaemia guidelines
http://www.nuh.nhs.uk/dowload.cfm?doc=docm93jijm4n5732.odf&ver=12066

Nottingham University Hospitals NHS Trust
Guideline for Management of Fluids in Children and Young People with known Renal Disorders Fluid management in renal disorders

Wan J, Xu E, Xiao Y. Isotonic versus Hypotonic Maintenance IV fluids in Hospitalised Children: A Meta-analysis. Journal of American Academy of Paediatrics.2014; 133 (1)

Torres SF, Lolster T, Schnitzler EJ, Serrate AJS, Sticco NA, Rivarola MR. Hypotonic and isotonic intravenous maintenance fluids in hospitalized paediatric patients: a randomized controlled trial. British journal or Medicine Paediatrics Open. 2019; 3 (1)

Allen CH et al. A randomized trial of plasma Lyte A and 0.9% sodium chloride in acute paediatric gastroenteritis. BMC paediatrics. 2016; 16 (117)

Neilson J, O'neil F, Dawoud D et al. Intravenous fluids in children and young people; summary of NICE Guidance. British Medical Journal. 2015; 351

6. Key words

Fluid, Electrolytes, Intravenous fluid, Enteral, Dehydration, hyperkalaemia, hypernatraemia, hypokalaemia, hyponatraemia

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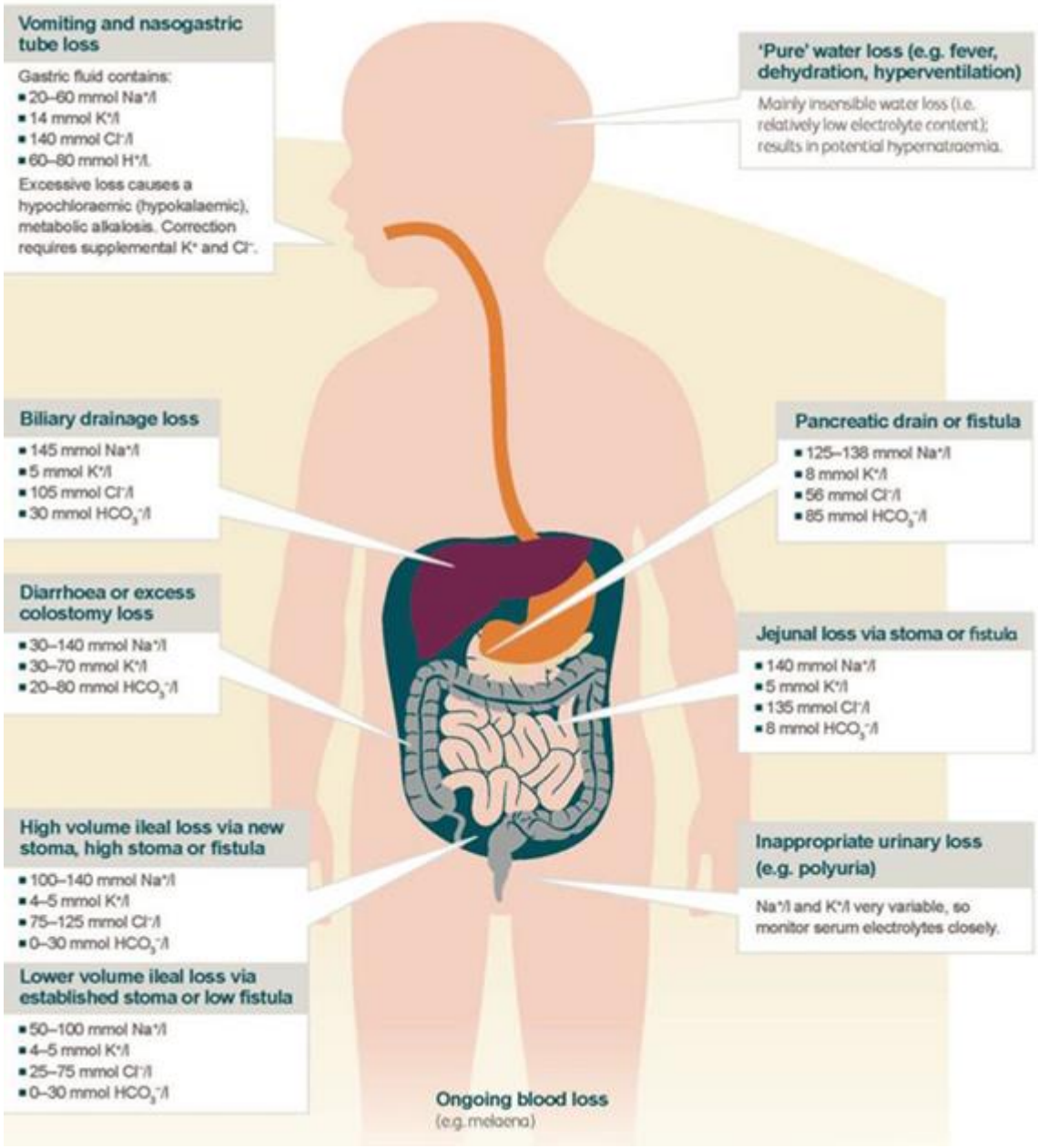
The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs.
As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.

Contact and review details			
Guideline Lead (Name and Title) Razi Paracha - Consultant			**Executive Lead** Chief Medical Officer
Details of Changes made during review:			
Date	**Issue Number**	**Reviewed By**	**Description Of Changes (If Any)**
September 2022	**4**	Razi Paracha – Consultant David Harris – Pharmacist Approved by UHL Children's Hospital Clinical Guidelines Group	**Updated figure 2** – fluid resuscitation in hypovolaemic shock, removed 20ml/kg IV bolus option. Added to monitor signs for fluid overload

Appendix 1: NICE guidelines diagram of ongoing losses



Appendix 2: Composition of crytalloids & dioralyte

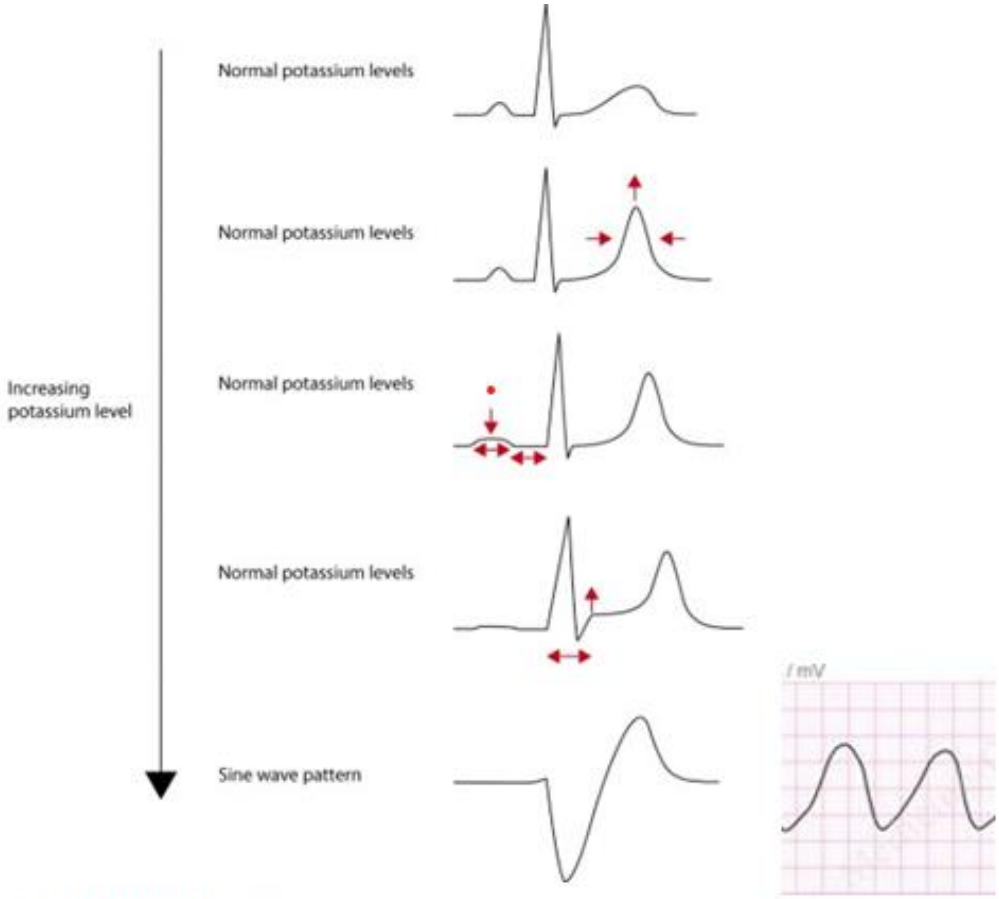
	Na^+ (mmol/l)	K^+ (mmol/l)	Cl^- (mmol/l)	HCO_3^- (mmol/l)	Glucose	Ca^{2+} (mmol/l)	Mg^{2+} (mmol/l)	Others
Normal Plasma	135-145	3.5 - 5	100-110	22-26	N/A	2.2 to 2.6	0.8 - 1	N/A
Glucose-free crystalloid that contains sodium (131-154 mmol/l)								
0.9% Sodium Chloride	154	0 (can add 20 or 40)	154	0	0	0	0	
Plasmalyte 148	140	5	98				3	Gluconate 23mmol/l Acetate 27mmol/l
Glucose-containing crystalloid that contains sodium (131-154 mmol/l)								
0.9% Sodium Chloride + 5% dextrose	154	0 (can add 20 or 40)	154	0	50g per litre	0		
Plasmalyte 148 + 5% dextrose	140	5	98		50g per litre		3	Gluconate 23mmol/l Acetate 27mmol/l
Glucose-containing crystalloid that contains reduced sodium								
0.45% Sodium Chloride + 5% dextrose	77	0 (can add 20 or 40)	77	0	50g per litre	0		

7.3. Composition of dioralyte

	Na^+ (mmol/l)	K^+ (mmol/l)	Cl^- (mmol/l)	HCO_3^- (mmol/l)	Glucose	Ca^{2+}	Mg^{2+}	Citrate (mmol/l)
Normal Plasma	135-145	3.5 - 5	100-110	22-26	N/A	2.2 to 2.6		N/A
Dioralyte	60	20	50	0	3.56g per 200 ml sachet	0	0	10

Appendix 3: ECG changes in hyperkalaemia

(Images from https://ecgwaves.com/)



- Tall peaked t-waves
- QRS widens
- Wide-complex tachycardia (severe hyperkalaemia)
- Sine wave formation (severe hyperkalaemia)

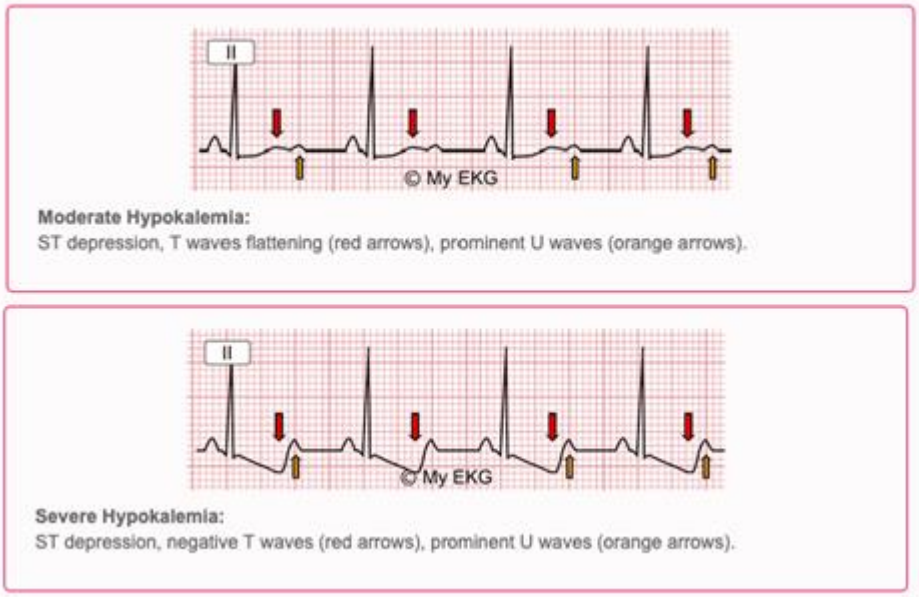
Causes of pseudo hyperkalaemia:

- Sampling error:
  - Haemolysed blood sample
  - Squeezed heel/toe/finger pricks
  - Prolonged tourniquet time
  - A non-free flowing sample
  - EDTA contamination (FBC bottle was taken before U&E bottle)
  - Sampling downstream from a drip-arm or line containing potassium
  - Sampling from a line where TPN, blood or IV fluids containing potassium were given.

- Extreme leucocytosis
- Hereditary spherocytosis
- Familial pseudo hyperkalaemia
- Hyperventilation e.g. due to crying (acute respiratory alkalosis may cause potassium to shift out of cells)

Appendix 4: ECG changes in hypokalaemia

- ST depression
- Negative T-waves (flattened at first)
- Prominent U-waves



(Images – www.my-ekg.com)

Appendix 5: How to prepare 1 litre (1000ml) of Oral Rehydration Solution (ORS)

To prepare ORTS at home using salt, sugar and water;

- Put 1 litre of cool water into a clean jug
- To the water add 6 level teaspoons of sugar (granulated or caster sugar is fine)
- Add half a level teaspoon of table salt
- Gently stir the water to dissolve the sugar and salt
- Give to the patient as directed by the nurse, doctor or pharmacist.

Label and cover the jug of ORS, keeping it in the fridge between uses. Every 24 hours the old solution should be thrown away and a new solution must be made up as directed above.

If you have any questions about this treatment please read any information sheet you have been given, look at the website www.nhs.uk or call 111 for non-emergency medical advice
Source – https://rehydrate.org/index/html