NICE National Institute for Health and Care Excellence

NICE guideline

Intravenous fluid therapy in children and young people in hospital

NICE guideline

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Contents

Key priorities for implementation

The following recommendations have been identified as priorities for implementation. The full list of recommendations is in the recommendations section.

Assessment and monitoring

- In term neonates, children and young people who are receiving IV fluids, assess and document the following:
    - 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.
    - Fluid input, output and balance over the previous 24 hours.
    - Any special instructions for prescribing, including relevant history.
    - An assessment of the fluid status.
    - The results of laboratory and point-of-care assessments, including:
        - full blood count
        - urea
        - creatinine
        - plasma electrolyte concentrations (including chloride, sodium and potassium; see recommendation 1.2.4)
        - blood glucose (see recommendation 1.2.5)
        - urinary electrolyte concentrations.
    - Details of any ongoing losses (see recommendation 1.5.1 and the diagram of ongoing losses).
    - Calculations of fluid needs for routine maintenance, replacement, redistribution and resuscitation.
    - The fluid and electrolyte prescription (in ml per hour), with clear signatures, dates and times.

- Types and volumes of fluid input and output (urine, gastric and other), recorded hourly and with running totals.
- 12-hourly fluid balance subtotals.
- 24-hourly fluid balance totals.
- 12-hourly reassessments of:
    - the fluid prescription
    - current hydration status
    - whether oral fluids can be started
    - urine and other outputs.

Fluid resuscitation

- If children and young people need IV fluid resuscitation, use glucose-free crystalloids[1] that contain sodium in the range 131–154 mmol/litre, with a bolus of 20 ml/kg over less than 10 minutes. Take into account pre-existing conditions (for example, cardiac disease or kidney disease), as smaller fluid volumes may be needed.
- If term neonates need IV fluid resuscitation, use glucose-free crystalloids[1] that contain sodium in the range 131–154 mmol/litre, with a bolus of 10–20 ml/kg over less than 10 minutes.

Routine maintenance

- If children and young people need IV fluids for routine maintenance, initially use isotonic crystalloids[2] that contain sodium in the range 131–154 mmol/litre.
- Measure plasma electrolyte concentrations and blood glucose when starting IV fluids for routine maintenance (except before most elective surgery), and at least every 24 hours thereafter.
- If there is a risk of water retention associated with non-osmotic antidiuretic hormone (ADH) secretion, consider either:
    - restricting fluids to 50–80% of routine maintenance needs **or**
    - reducing fluids, calculated on the basis of insensible losses within the range 300–400 ml/m^2/24 hours plus urinary output.

Replacement and redistribution

- Consider isotonic crystalloids[2] that contain sodium in the range 131–154 mmol/litre for redistribution.

Managing hyponatraemia that develops during intravenous fluid therapy

- If asymptomatic hyponatraemia develops in term neonates, children and young people, review the fluid status and take action as follows:
  - If a child is prescribed a hypotonic fluid, change to an isotonic fluid (for example, 0.9% sodium chloride).
  - Restrict maintenance IV fluids in children and young people who are hypervolaemic or at risk of hypervolaemia (for example, if there is a risk of increased ADH secretion) by either:
    - restricting maintenance fluids to 50–80% of routine maintenance needs **or**
    - reducing fluids, calculated on the basis of insensible losses within the range 300–400 ml/m^2/24 hours plus urinary output.
- Be aware that the following symptoms are associated with acute hyponatraemia during IV fluid therapy:
  - Headache.
  - Nausea and vomiting.
  - Confusion and disorientation.
  - Irritability.
  - Lethargy.
  - Reduced consciousness.
  - Convulsions.
  - Coma.
  - Apnoea.

[1] At the time of publication (December 2015), some glucose-free crystalloids did not have a UK marketing authorisation for use in children and young people. The prescriber should follow relevant professional guidance, taking full responsibility for the decision. Informed consent should be obtained and documented. See the General Medical Council's Prescribing guidance: prescribing unlicensed medicines for further information.

[2] At the time of publication (December 2015), some isotonic crystalloids with 5–10% glucose did not have a UK marketing authorisation for use in children and young people. The prescriber should follow relevant professional guidance, taking full responsibility for the decision. Informed consent should be obtained and documented. See the General Medical Council's Prescribing guidance: prescribing unlicensed medicines for further information.

Recommendations

People have the right to be involved in discussions and make informed decisions about their care, as described in your care.

Making decisions using NICE guidelines explains how we use words to show the strength (or certainty) of our recommendations, and has information about prescribing medicines (including off-label use), professional guidelines, standards and laws (including on consent and mental capacity), and safeguarding.

1.1 Principles and protocols for intravenous fluid therapy

1.1.1 For guidance on the principles and protocols for intravenous (IV) fluid therapy, see the principles and protocols for intravenous fluid therapy section in intravenous fluid therapy in adults (NICE guideline CG174; recommendations 1.1.1, 1.1.2, 1.1.3, 1.1.5, 1.1.6, 1.1.7 and 1.1.8 apply to all ages).

1.1.2 Offer IV fluid therapy as part of a protocol (see algorithms for IV fluid therapy in children and young people in hospital):

- Assess fluid and electrolyte needs following algorithm 1: Assessment and monitoring.
- If term neonates, children and young people need IV fluids for fluid resuscitation, follow algorithm 2: Fluid resuscitation.
- If term neonates, children and young people need IV fluids for routine maintenance, follow algorithm 3: Routine maintenance.
- If term neonates, children and young people need IV fluids to address existing deficits or excesses, ongoing abnormal losses or abnormal fluid distribution, follow algorithm 4: Replacement and redistribution.
- If hypernatraemia develops, follow algorithm 5: Managing hypernatraemia that develops during IV fluid therapy.
- If hyponatraemia develops, follow algorithm 6: Managing hyponatraemia that develops during IV fluid therapy.

1.2 Assessment and monitoring

1.2.1 Use body weight to calculate IV fluid and electrolyte needs for term neonates, children and young people.

1.2.2 Consider using body surface area to calculate IV fluid and electrolyte needs if accurate calculation of insensible losses is important (for example, if the weight is above the 91st centile, or with acute kidney injury, known chronic kidney disease or cancer).

1.2.3 In term neonates, children and young people who are receiving IV fluids, assess and document the following:

- 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.
- Fluid input, output and balance over the previous 24 hours.
- Any special instructions for prescribing, including relevant history.
- An assessment of the fluid status.
- The results of laboratory and point-of-care assessments, including:
  - full blood count
  - urea
  - creatinine
  - plasma electrolyte concentrations (including chloride, sodium and potassium; see recommendation 1.2.4)
  - blood glucose (see recommendation 1.2.5)
  - urinary electrolyte concentrations.
- Details of any ongoing losses (see recommendation 1.5.1 and the diagram of ongoing losses).

- Calculations of fluid needs for routine maintenance, replacement, redistribution and resuscitation.
- The fluid and electrolyte prescription (in ml per hour), with clear signatures, dates and times.
- Types and volumes of fluid input and output (urine, gastric and other), recorded hourly and with running totals.
- 12-hourly fluid balance subtotals.
- 24-hourly fluid balance totals.
- 12-hourly reassessments of:
  - the fluid prescription
  - current hydration status
  - whether oral fluids can be started
  - urine and other outputs.

1.2.4 Measure plasma electrolyte concentrations using laboratory tests when starting IV fluids, and then at least every 24 hours or more frequently if there are electrolyte disturbances.

1.2.5 Measure blood glucose when starting IV fluids, and then at least every 24 hours or more frequently if there is a risk of hypoglycaemia.

1.2.6 Consider point-of-care testing for measuring plasma electrolyte concentrations and blood glucose in time-critical situations when IV fluids are needed (for example, during emergency situations and in A&E, theatre and critical care).

1.2.7 Diagnose clinical dehydration and hypovolaemic shock using the clinical features listed in table 1, but be aware that it can be difficult to identify the clinical features in term neonates.

Table 1 Clinical features of dehydration and hypovolaemic shock

No clinically detectable dehydration	Clinical dehydration	Hypovolaemic shock
Alert and responsive	**Red flag** Altered responsiveness (for example, irritable, lethargic)	Decreased level of consciousness
Appears well	**Red flag** Appears to be unwell or deteriorating	–
Eyes not sunken	**Red flag** Sunken eyes	–
Moist mucous membranes (except after a drink)	Dry mucous membranes (except for 'mouth breather')	–
Normal blood pressure	Normal blood pressure	Hypotension (decompensated shock)
Normal breathing pattern	**Red flag** Tachypnoea	Tachypnoea
Normal capillary refill time	Normal capillary refill time	Prolonged capillary refill time
Normal heart rate	**Red flag** Tachycardia	Tachycardia
Normal peripheral pulses	Normal peripheral pulses	Weak peripheral pulses
Normal skin turgor	**Red flag** Reduced skin turgor	–
Normal urine output	Decreased urine output	–
Skin colour unchanged	Skin colour unchanged	Pale or mottled skin
Warm extremities	Warm extremities	Cold extremities

Notes:

Within the category of 'clinical dehydration' there is a spectrum of severity indicated by increasingly numerous and more pronounced clinical features. For hypovolaemic shock, 1 or more of the clinical features listed would be expected to be present. Dashes (–) indicate that these features do not specifically indicate hypovolaemic shock. This table has been adapted from the assessing dehydration and shock section in diarrhoea and vomiting in children (NICE guideline CG84).

1.3 Fluid resuscitation

1.3.1 If children and young people need IV fluid resuscitation, use glucose-free crystalloids[3] that contain sodium in the range 131–154 mmol/litre, with a bolus of 20 ml/kg over less than 10 minutes. Take into account pre-existing conditions (for example, cardiac disease or kidney disease), as smaller fluid volumes may be needed.

1.3.2 If term neonates need IV fluid resuscitation, use glucose-free crystalloids[3] that contain sodium in the range 131–154 mmol/litre, with a bolus of 10–20 ml/kg over less than 10 minutes.

1.3.3 Do not use tetrastarch for fluid resuscitation.

1.3.4 For guidance on using IV fluids for fluid resuscitation in children and young people with diabetic ketoacidosis, see the diabetic ketoacidosis section in diabetes (type 1 and type 2) in children and young people (NICE guideline NG18).

1.3.5 Reassess term neonates, children and young people after completion of the IV fluid bolus, and decide whether they need more fluids.

1.3.6 Seek expert advice (for example, from the paediatric intensive care team) if 40–60 ml/kg of IV fluid or more is needed as part of the initial fluid resuscitation.

1.4 Routine maintenance

1.4.1 Calculate routine maintenance IV fluid rates for children and young people using the Holliday–Segar formula (100 ml/kg/day for the first 10 kg of weight,

50 ml/kg/day for the next 10 kg and 20 ml/kg/day for the weight over 20 kg). Be aware that over a 24-hour period, males rarely need more than 2500 ml and females rarely need more than 2000 ml of fluids.

1.4.2 Calculate routine maintenance IV fluid rates for term neonates according to their age, using the following as a guide:

- From birth to day 1: 50–60 ml/kg/day.
- Day 2: 70–80 ml/kg/day.
- Day 3: 80–100 ml/kg/day.
- Day 4: 100–120 ml/kg/day.
- Days 5–28: 120–150 ml/kg/day.

1.4.3 If children and young people need IV fluids for routine maintenance, initially use isotonic crystalloids[4] that contain sodium in the range 131–154 mmol/litre.

1.4.4 Measure plasma electrolyte concentrations and blood glucose when starting IV fluids for routine maintenance (except before most elective surgery), and at least every 24 hours thereafter.

1.4.5 Be aware that plasma electrolyte concentrations and blood glucose are not routinely measured before elective surgery unless there is a need to do so, based on the child's medical condition or the type of surgery.

1.4.6 Base any subsequent IV fluid prescriptions on the plasma electrolyte concentrations and blood glucose measurements.

1.4.7 If term neonates need IV fluids for routine maintenance, initially use isotonic crystalloids[4] that contain sodium in the range 131–154 mmol/litre with 5–10% glucose.

1.4.8 For term neonates in critical postnatal adaptation phase (for example, term neonates with respiratory distress syndrome, meconium aspiration, hypoxic ischaemic encephalopathy), give no or minimal sodium until postnatal diuresis with weight loss occurs.

1.4.9 If there is a risk of water retention associated with non-osmotic antidiuretic hormone (ADH) secretion, consider either:

- restricting fluids to 50–80% of routine maintenance needs **or**
- reducing fluids, calculated on the basis of insensible losses within the range 300–400 ml/m^2/24 hours plus urinary output.

1.4.10 When using body surface area to calculate IV fluid needs for routine maintenance (see recommendation 1.2.2), estimate insensible losses within the range 300–400 ml/m^2/24 hours plus urinary output.

1.5 Replacement and redistribution

1.5.1 If term neonates, children and young people need IV fluids for replacement or redistribution, adjust the IV fluid prescription (in addition to maintenance needs) to account for existing fluid and/or electrolyte deficits or excesses, ongoing losses (see the diagram of ongoing losses) or abnormal distribution, for example, tissue oedema seen in sepsis.

1.5.2 Consider isotonic crystalloids[4] that contain sodium in the range 131–154 mmol/litre for redistribution.

1.5.3 Use 0.9% sodium chloride containing potassium to replace ongoing losses (see the diagram of ongoing losses).

1.5.4 Base any subsequent fluid prescriptions on the plasma electrolyte concentrations and blood glucose measurements.

1.6 Managing hypernatraemia that develops during intravenous fluid therapy

1.6.1 If hypernatraemia develops in term neonates, children and young people, review the fluid status and take action as follows:

- If there is no evidence of dehydration and an isotonic fluid is being used, consider changing to a hypotonic fluid (for example, 0.45% sodium chloride with glucose)[5].

- If dehydration is diagnosed, calculate the water deficit and replace it over 48 hours, initially with 0.9% sodium chloride.
- If the fluid status is uncertain, measure urine sodium and osmolality.
- If hypernatraemia worsens or is unchanged after replacing the deficit, review the fluid type and consider changing to a hypotonic solution (for example, 0.45% sodium chloride with glucose).

1.6.2 When correcting hypernatraemia, ensure that the rate of fall of plasma sodium does not exceed 12 mmol/litre in a 24-hour period.

1.6.3 Measure plasma electrolyte concentrations every 4–6 hours for the first 24 hours, and after this base the frequency of further plasma electrolyte measurements on the treatment response.

1.7 Managing hyponatraemia that develops during intravenous fluid therapy

1.7.1 If asymptomatic hyponatraemia develops in term neonates, children and young people, review the fluid status and take action as follows:

- If a child is prescribed a hypotonic fluid, change to an isotonic fluid (for example, 0.9% sodium chloride).
- Restrict maintenance IV fluids in children and young people who are hypervolaemic or at risk of hypervolaemia (for example, if there is a risk of increased ADH secretion) by either:
  - restricting maintenance fluids to 50–80% of routine maintenance needs **or**
  - reducing fluids, calculated on the basis of insensible losses within the range 300–400 ml/m^2/24 hours plus urinary output.

1.7.2 Be aware that the following symptoms are associated with acute hyponatraemia during IV fluid therapy:

- Headache.
- Nausea and vomiting.
- Confusion and disorientation.

- Irritability.
- Lethargy.
- Reduced consciousness.
- Convulsions.
- Coma.
- Apnoea.

1.7.3 If acute symptomatic hyponatraemia develops in term neonates, children and young people, review the fluid status, seek immediate expert advice (for example, from the paediatric intensive care team) and consider taking action as follows:

- Use a bolus of 2 ml/kg (maximum 100 ml) of 2.7% sodium chloride over 10–15 minutes.
- Use a further bolus of 2 ml/kg (maximum 100 ml) of 2.7% sodium chloride over the next 10–15 minutes if symptoms are still present after the initial bolus.
- If symptoms are still present after the second bolus, check the plasma sodium level and consider a third bolus of 2 ml/kg (maximum 100 ml) of 2.7% sodium chloride over 10–15 minutes.
- Measure the plasma sodium concentration at least hourly.
- As symptoms resolve, decrease the frequency of plasma sodium measurements based on the response to treatment.

1.7.4 Do not manage acute hyponatraemic encephalopathy using fluid restriction alone.

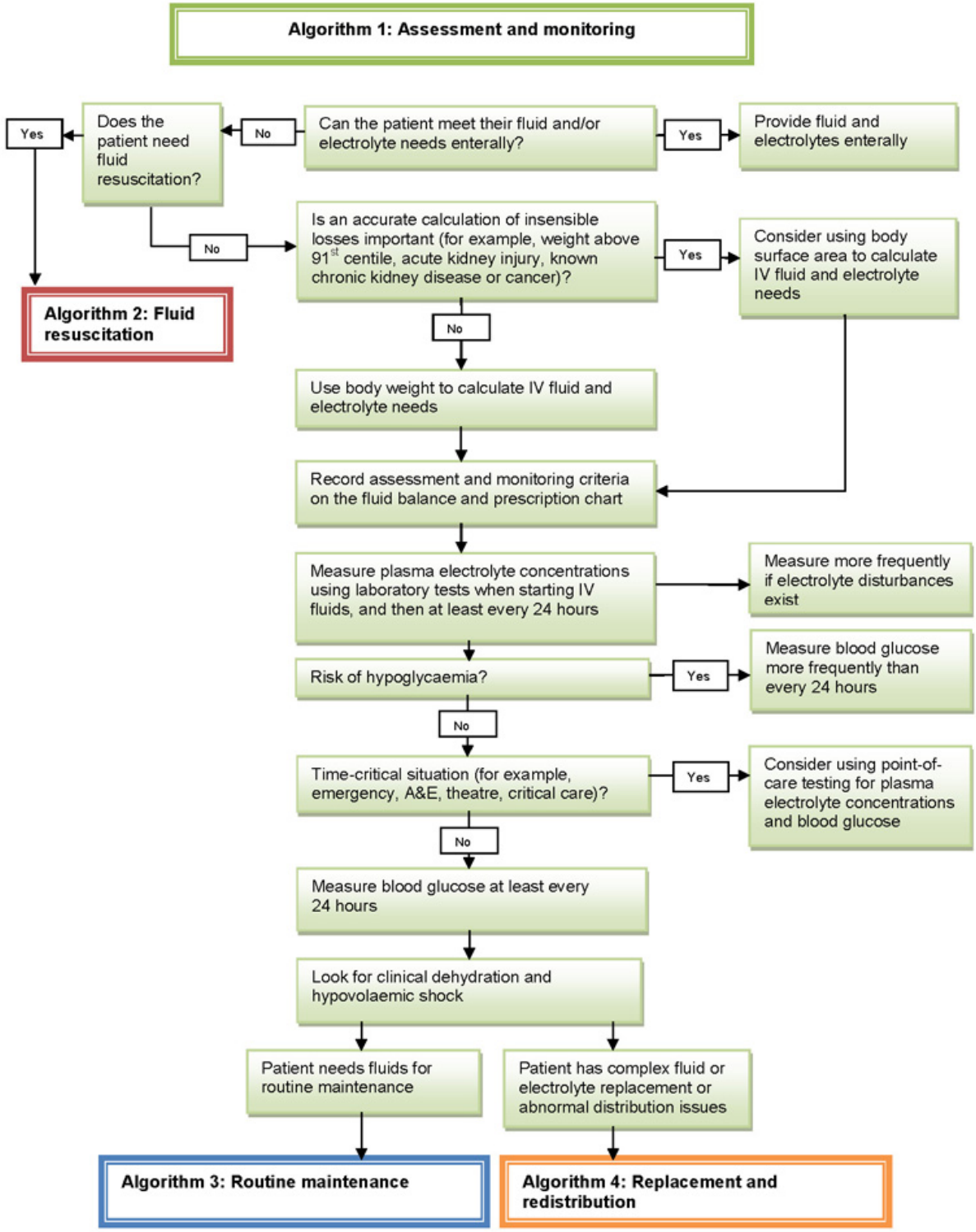
1.7.5 After hyponatraemia symptoms have resolved, ensure that the rate of increase of plasma sodium does not exceed 12 mmol/litre in a 24-hour period.

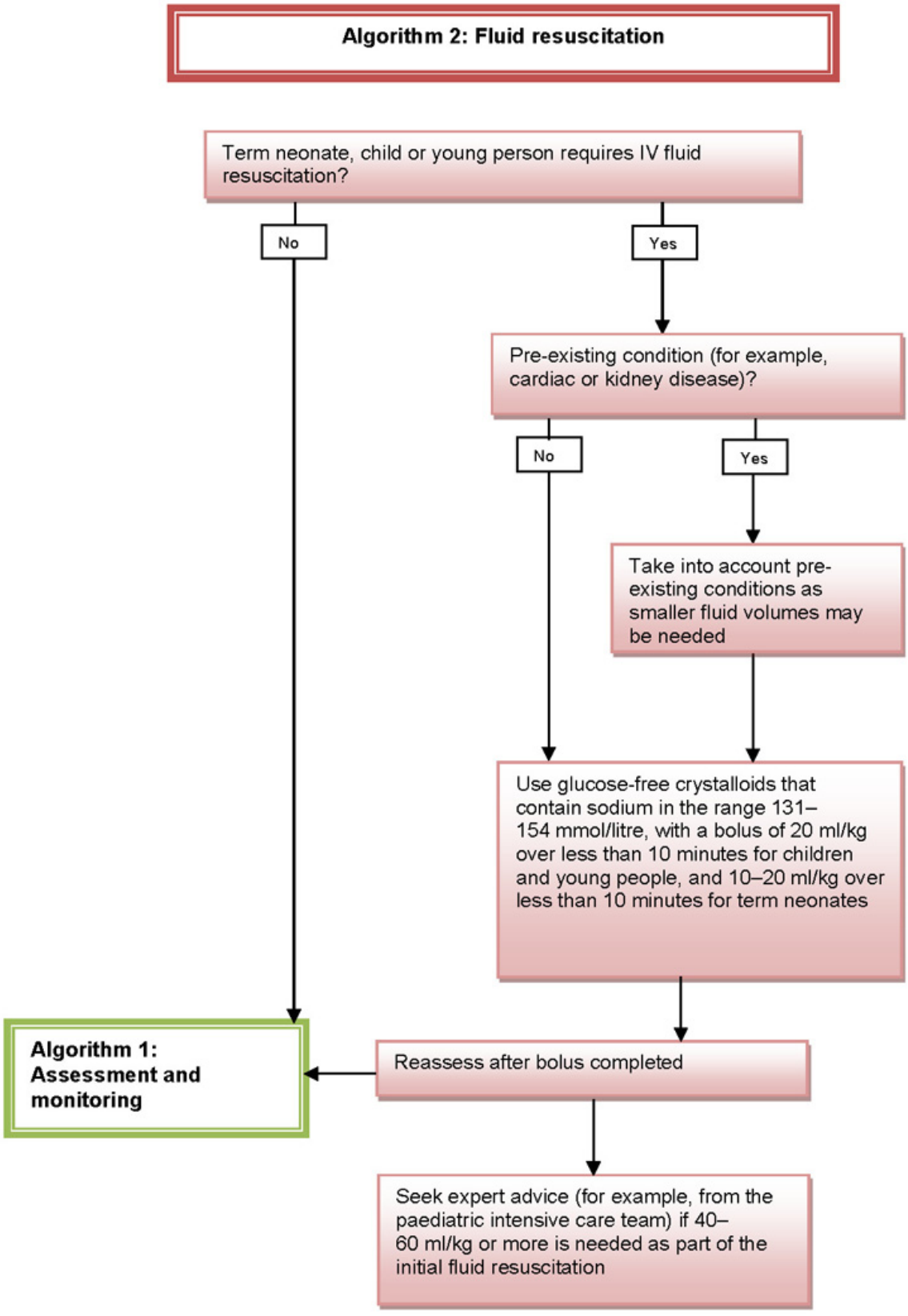
1.8 Training and education

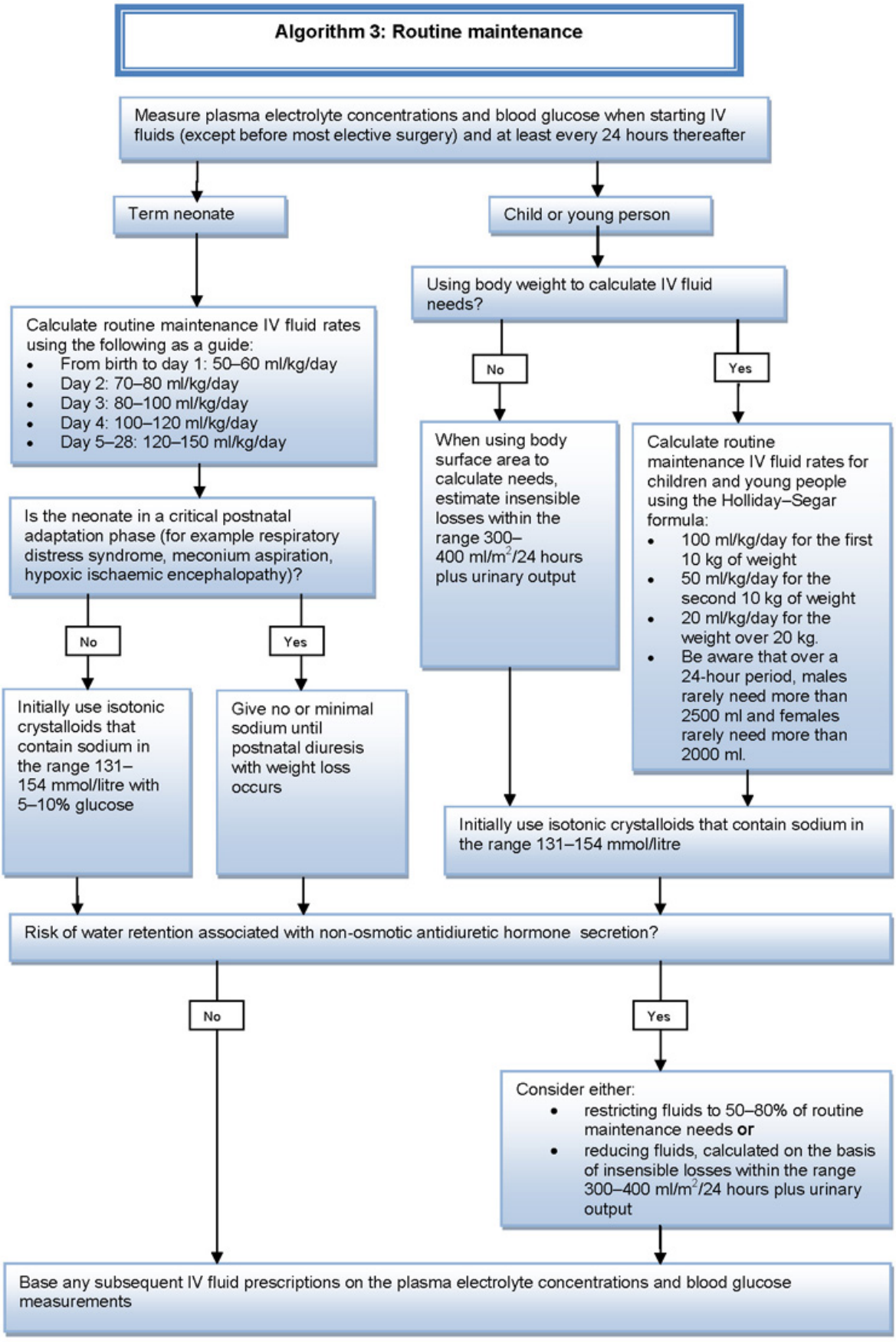
1.8.1 For guidance on training and education for healthcare professionals involved in prescribing and delivering IV fluid therapy, see the training and education section in intravenous fluid therapy in adults (NICE guideline CG174).

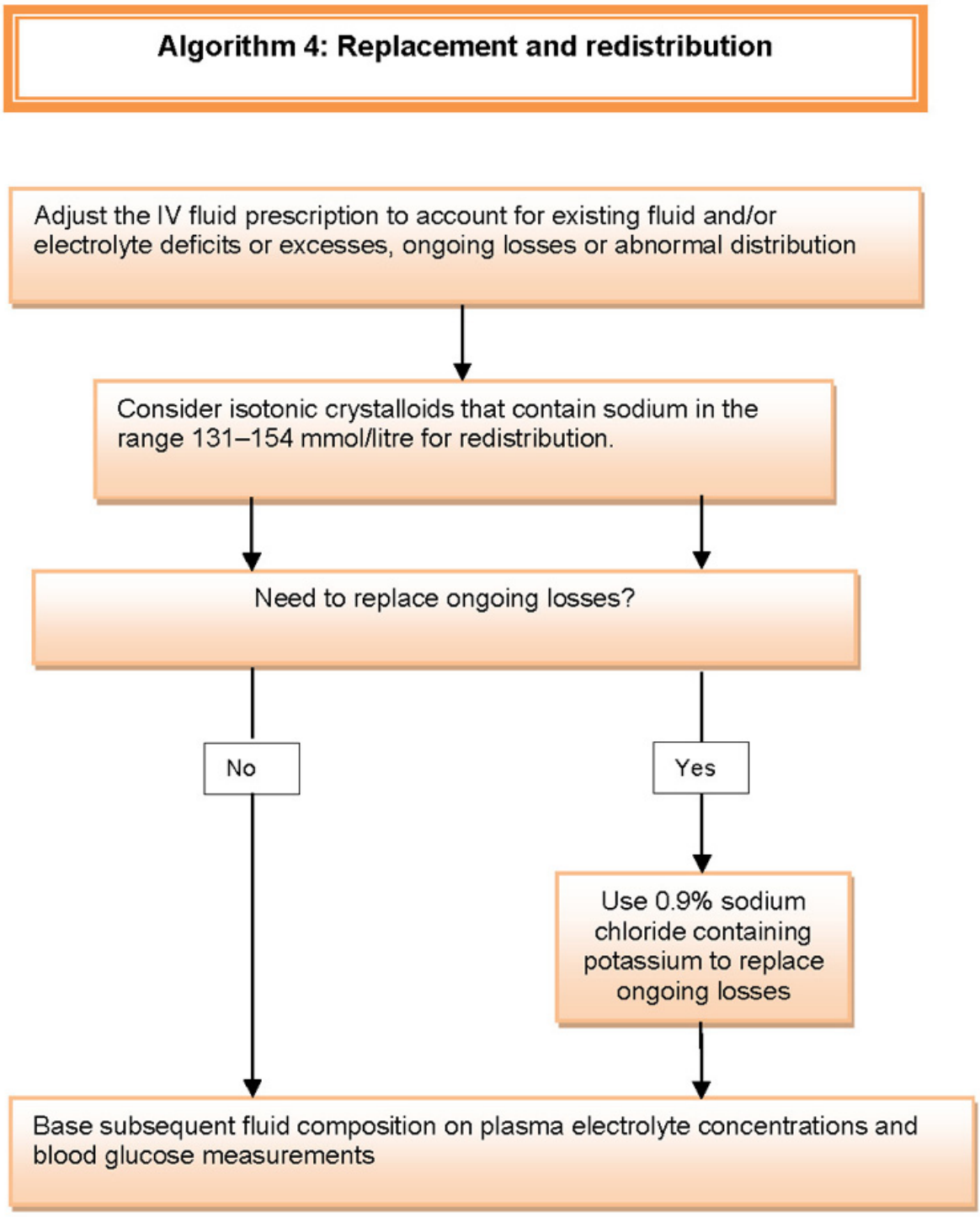
Algorithms for IV fluid therapy in children and young people in hospital

Download a PDF here containing all 6 algorithms.

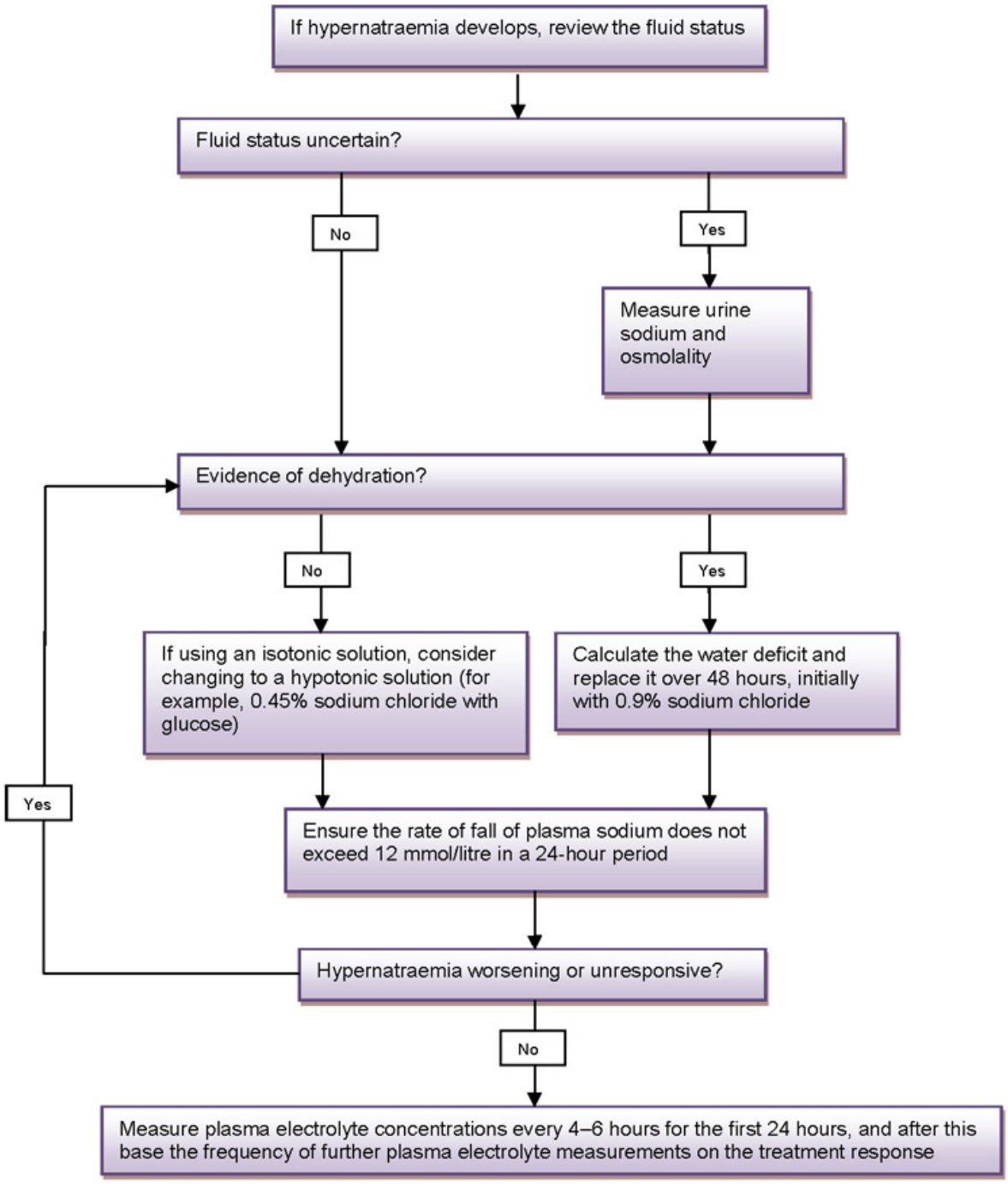








Algorithm 5: Managing hypernatraemia (plasma sodium more than 145 mmol/litre) that develops during IV fluid therapy



Algorithm 6: Managing hyponatraemia (plasma sodium less than 135 mmol/litre) that develops during IV fluid therapy

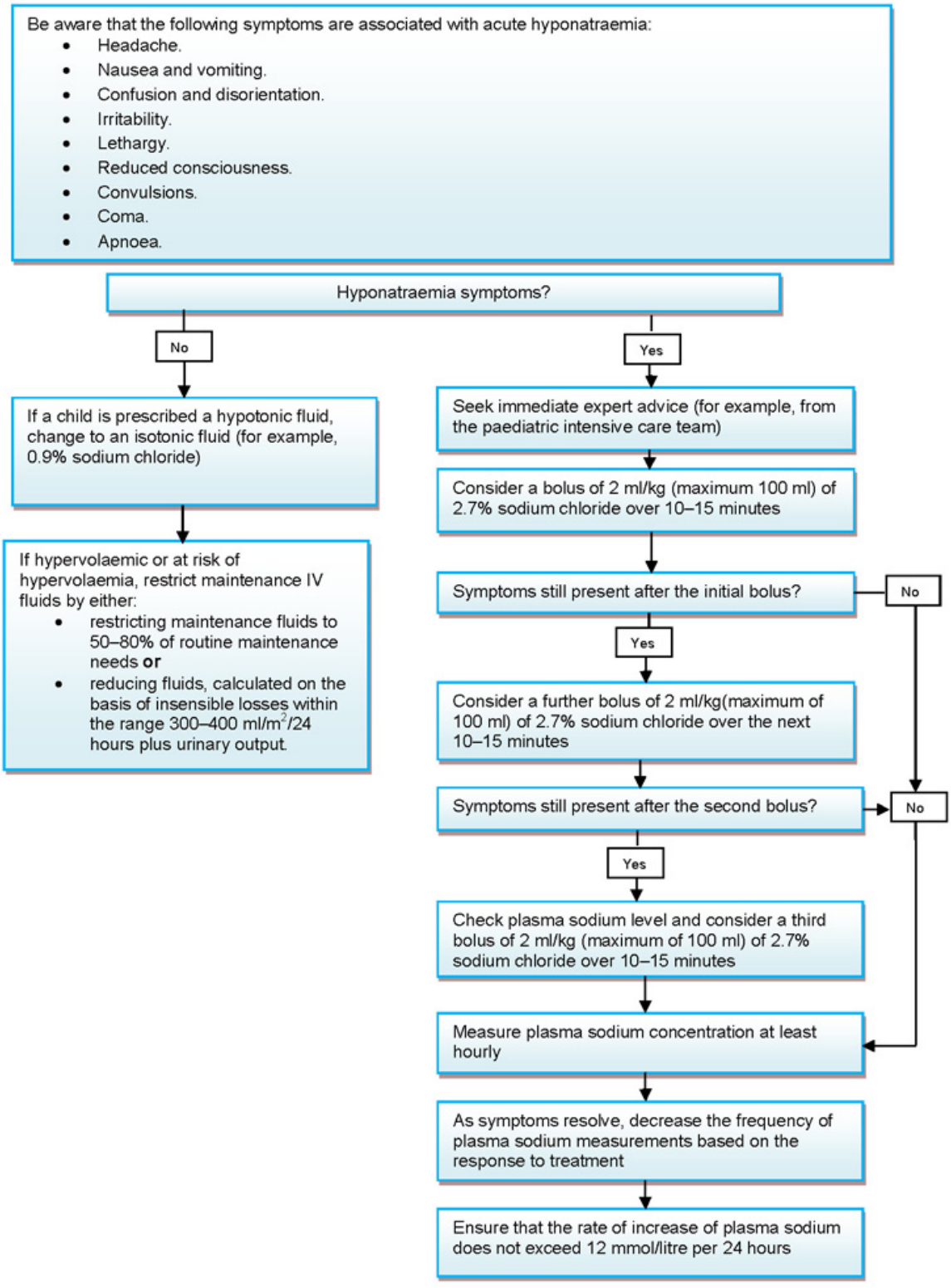
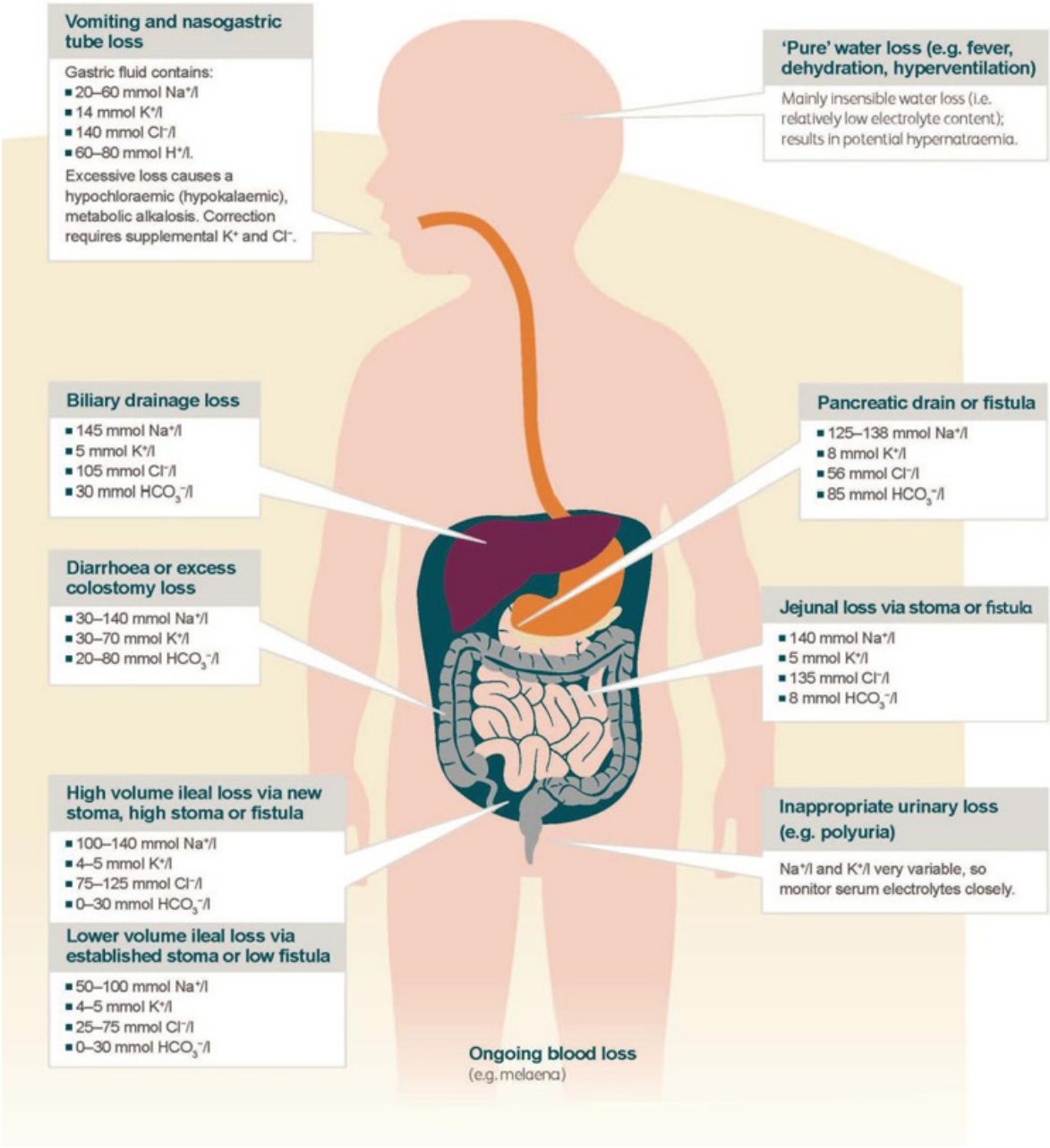


Diagram of ongoing losses for children and young people

Download a PDF here.



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Intravenous fluid types for children and young people

Download a PDF here.

Fluid with recommendation reference	Fluid type[a]	Osmolality (compared with plasma)	Tonicity (with reference to cell membrane)	Sodium content (mmol/ litre)	Potassium content (mmol/ litre)
Isotonic crystalloids that contain sodium in the range 131–154 mmol/litre [1.3.1, 1.3.2, 1.4.3, 1.5.2, 1.6.1, 1.7.1]	0.9% sodium chloride	Isosmolar	Isotonic	154	0
	Hartmann's solution	Isosmolar	Isotonic	131	5
Isotonic crystalloids with glucose that contain sodium in the range 131–154 mmol/litre [1.4.7]	0.9% sodium chloride with 5% glucose	Hyperosmolar	Isotonic	150	0
Hypotonic fluids [1.6.1, 1.7.1]	0.45% sodium chloride with 5% glucose	Hyperosmolar	Hypotonic	75	0
	0.45% sodium chloride with 2.5% glucose	Isosmolar	Hypotonic	75	0
	0.45% sodium chloride	Hyposmolar	Hypotonic	75	0
	5% glucose	Isosmolar	Hypotonic	0	0
	10% glucose	Hyperosmolar	Hypotonic	0	0

[a] Fluids given are examples of appropriate fluids; for further details, see the British national formulary for children.

Terms used in this guideline

Neonates, children and young people are defined as follows:

- neonates: infants aged 28 days and under (born at term; or born prematurely who have a corrected age of term or more)
- children: 29 days to under 12 years
- young people: 12 to under 16 years.

You can also see this guideline in the NICE pathway on intravenous fluid therapy in hospital.

To find out what NICE has said on topics related to this guideline, see our web pages on children and young people, hospital settings, acute and critical care, and trauma.

See also the guideline committee's discussion and the evidence reviews (in the full guideline), and information about how the guideline was developed, including details of the committee.

[3] At the time of publication (December 2015), some glucose-free crystalloids did not have a UK marketing authorisation for use in children and young people. The prescriber should follow relevant professional guidance, taking full responsibility for the decision. Informed consent should be obtained and documented. See the General Medical Council's Prescribing guidance: prescribing unlicensed medicines for further information.

[4] At the time of publication (December 2015), some isotonic crystalloids with 5–10% glucose did not have a UK marketing authorisation for use in children and young people. The prescriber should follow relevant professional guidance, taking full responsibility for the decision. Informed consent should be obtained and documented. See the General Medical Council's Prescribing guidance: prescribing unlicensed medicines for further information.

[5] At the time of publication (December 2015), some hypotonic solutions did not have a UK marketing authorisation for use in children and young people. The prescriber should follow relevant professional guidance, taking full responsibility for the decision. Informed consent should be obtained and documented. See the General Medical Council's Prescribing guidance: prescribing unlicensed medicines for further information.

Intravenous fluid therapy in children and young people in hospital implementation: getting started

This section highlights 3 areas of the IV fluid therapy in children and young people guideline that could have a big impact on practice and improve quality of care. We identified these with the help of stakeholders and guideline committee members (see section 9.4 of the manual). The section also gives information on resources to help with implementation.

The challenge: assessment and monitoring

See recommendation 1.2.3 (KPI).

> To ensure that children and young people receiving IV fluid therapy are prescribed the appropriate fluids, precise measurement of fluid and electrolyte status is essential. Measuring and documenting key components on an IV fluid balance and/or prescription chart enables clinical staff to monitor changes in patients' fluid balance and helps to ensure the appropriate prescribing of fluids. The guideline specifies the minimum information needed on these charts, and provides clarity on when weight or body surface area is the most effective way to calculate routine maintenance needs.

Recording fluid and electrolyte status to ensure appropriate prescribing

Currently there is no standard fluid balance and prescription chart in the NHS that is used to record fluid and electrolyte status. In addition, there is variation in what is recorded and documented on a patient's chart between hospitals and between units within hospitals. This can make it difficult for clinicians to determine an accurate fluid balance for a patient when they are moving between hospitals and within hospital departments, and when there is more than 1 clinician involved in a patient's care.

Including all the recommended measurements on a chart may mean a change in practice. Using a chart that encompasses all of the aspects considered important in monitoring, prescribing and safely administering IV fluid therapy for children and young people may support implementation.

What can clinicians and department managers do to help?

- Access and share examples of fluid balance and prescription charts that include all the recommended measurements, such as those produced by the Department of Health, Social Services and Public Safety (DHSSPS) in Northern Ireland.

- Enable roll out of a trust-wide standard chart for children and young people by, for example, adapting the DHSSPS standard chart for use in local trusts and disseminating to ward staff.

The challenge: identifying fluids for fluid resuscitation and routine maintenance

See recommendations 1.3.1 (KPI), 1.3.2 (KPI), 1.4.3 (KPI) and 1.4.7.

> Information for prescribers about the most appropriate intravenous fluid to use in specific circumstances can help ensure that the amount of fluid or electrolytes given restore and maintain fluid balance.

Using appropriate intravenous fluids for resuscitation and routine maintenance

The guideline specifies the use of glucose-free crystalloids that contain sodium in the range 131–154 mmol/litre for fluid resuscitation, and isotonic crystalloids that contain sodium in the range 131–154 mmol/litre, with and without glucose, for routine maintenance, but does not specify which isotonic fluid to use as there was a lack of evidence to recommend one isotonic crystalloid over another. There are a range of IV fluids available to most healthcare professionals, and some staff who prescribe IV fluids may not know the specific composition of the choices available to them. A table highlighting examples of commonly used IV fluid types and their compositions has been included in the guideline.

What can clinicians and department managers do to help?

- Display the table showing the IV fluid types for children and young people on wards and share it with doctors in training.

The challenge: lack of training and education in IV fluid therapy in children and young people

See recommendation 1.8.1.

> Ensuring education and training for all healthcare professionals involved in prescribing and delivering IV fluid therapy for children and young people is important for patient safety.

Raising awareness of training and education resources

Prescribers are not always aware of the most appropriate IV fluid to use in specific circumstances and as such, the amount of fluid or electrolytes provided can be either too high or too low to

restore and maintain fluid and electrolyte balance. The assessment, prescription and administration of IV fluids in children and young people are complex responsibilities involving clinical and biochemical assessment and a good understanding of the principles of fluid physiology. Failures in education and training which contribute to poor fluid management include:

- poor understanding of the basic principles of fluid balance and a lack of knowledge about fluid management
- poor fluid balance (chart) documentation
- poor interpretation of laboratory results
- inadequate involvement of senior clinicians in fluid management and delegation of fluid prescription to junior members of the team.

There is little formal training and education in IV fluid management to support correct prescribing. Accessible training and education for all clinicians responsible for fluid management can help ensure that morbidity and mortality is minimised.

What can organisations and department managers do to help?

- Make sure clinicians responsible for IV fluid management are given time to undertake training and education, and that they are assessed and reassessed at regular intervals.
- Make sure the organisation has access to existing online training, such as the NICE online learning tool.

Need more help?

Further resources are available from NICE (including shared learning examples) that may help to support implementation.

- The NICE baseline assessment tool can be used by organisations to evaluate whether their practice is in line with the recommendations in this guideline. It can also help organisations to plan activity to meet the recommendations.
- Uptake data about guideline recommendations and quality standard measures are available.

Context

Correct fluid and electrolyte balance is essential to maintain physiological function. Normally, children and young people get the fluid they need by drinking. Many children and young people admitted to hospital may be too ill to drink so may need intravenous (IV) fluid therapy to correct or maintain their fluid and electrolyte balance.

Children and young people may need IV fluids to account for losses of red blood cells, plasma, water or electrolytes beyond the usual losses in urine, stools and sweat. These losses can come from burns, diarrhoea, vomiting or leakage of fluid into the interstitial space. In these cases the aim is to replace any depleted fluids and restore electrolyte balance. Conditions such as cardiac dysfunction, liver disease, inappropriate antidiuretic hormone secretion and nephrotic syndrome can result in an excess of fluids in the body, known as fluid overload. If this happens, the aim is to rebalance and redistribute fluids and ensure the correct levels of electrolytes.

Whether IV fluid therapy is needed for fluid resuscitation, routine maintenance, replacement or redistribution, it is vital that the correct composition, volume and timing of IV fluid therapy is used. IV fluid types include colloids[6], crystalloids and combinations of fluids, and different types of fluids are appropriate for different situations. Errors in prescribing or administering IV fluids can result in inadequate or excessive provision, leading to hypovolaemia and poor organ perfusion, or hypervolaemia, oedema and heart failure. Failing to correct imbalances in electrolytes can lead to disturbances in intracellular or extracellular electrolyte balance, particularly in children and young people with reduced liver or kidney function. Failing to deliver correct fluids can therefore have a significant impact on morbidity and mortality.

Surveys have shown that many staff who prescribe IV fluids know neither the likely fluid and electrolyte needs of individual patients, nor the specific composition of the many choices of IV fluids available to them. There is little formal training and education in IV fluid management to support correct prescribing.

There is also a wide variation in the charts used to prescribe fluids and to record fluid and electrolyte status. Monitoring children and young people is often challenging: it may be difficult to assess urine output accurately, and blood tests can be painful, distressing and difficult to repeat. Assessment and monitoring is often suboptimal, and fluid and electrolyte status may not be recorded accurately. Changes in patients' fluid needs may not be reassessed appropriately or at the correct intervals, which can lead to fluids being prescribed incorrectly. Clinical staff need to ensure that appropriate identification, treatment and monitoring of changes in fluid and electrolyte status is maintained and documented. There is a need for a standardised approach to assessing patients'

fluid and electrolyte status and prescribing IV fluid therapy in the NHS. This guidance represents a major opportunity to improve patient safety for children and young people having IV fluid therapy in hospital.

[6] Please see the MHRA Drug Safety Alert for hydroxyethyl starch intravenous infusions.

Recommendations for research

The guideline committee has made the following recommendations for research. The committee's full set of research recommendations is detailed in the full guideline.

1 Complications of IV fluid therapy

What is the incidence of complications during, and as a consequence of, IV fluid therapy in children and young people?

Why this is important

Every day, children and young people are prescribed IV fluid therapy for a variety of reasons. However, there is little evidence on IV fluids in children and young people, and the limited evidence available is of very poor quality.

Complications of IV fluid therapy can lead to mortality and significant morbidity for the patient. This, in turn, represents a cost burden for the NHS in terms of critical care admissions, prolonged inpatient stays or the potential need for long-term follow-up and care by medical and allied healthcare professionals.

2 Glucose concentration

What is the most appropriate glucose concentration in IV fluids for children and young people of different ages?

Why this is important

In recent years, the use of glucose-containing hypotonic IV fluids in children and young people has been questioned, because of the risk of hyponatraemia. Many children and young people are now prescribed non-glucose-containing isotonic IV fluids for maintenance. However, there are several groups of children and young people, in particular, neonates and some children in the perioperative period (for example, those who underwent prolonged fasting preoperatively, and those who had central blocks during anaesthesia), who may benefit from glucose-containing IV solutions to prevent hypoglycaemia. A blanket prescription of 5 or 10% glucose solution for all may result in hyperglycaemia in some children and young people. However, the use of IV fluids containing lower concentrations of glucose may be sufficient to prevent hypoglycaemia and also avoid unnecessary hyperglycaemia. This may have a clinical application across all age groups, including neonates.

3 Fluid balance charts

For children and young people receiving IV fluids, does the use of a standardised national fluid balance chart reduce the rate of complications arising as a result of prescription and/or administration errors?

Why this is important

The National Confidential Enquiry into Perioperative Deaths reports in 1999 and 2009 identified problems in fluid management in patients in the UK. A lack of consistency in prescribing and recording IV fluids may contribute to this. A lack of familiarity of 'mobile' medical and nursing staff with fluid balance charts in different hospital settings may further increase the likelihood of prescription and administration errors.

A prospective cohort of children and young people receiving IV fluids, prescribed and documented on a standardised national fluid balance chart, or a case–control study comparing the use of a standardised national fluid balance chart with non-standard 'local' fluid balance charts is needed to assess the clinical and cost effectiveness of using a standardised national fluid balance chart. Outcomes should include complications of IV fluid therapy (hypovolaemia, hypervolaemia, electrolyte abnormalities, neurological complications and hypoglycaemia) and incidence of prescription errors. If using a standardised national fluid balance chart resulted in better fluid prescription and clinical outcomes in children and young people, this could potentially lead to significant cost savings for the NHS.

4 Training and education of healthcare professionals

Does ensuring that all hospital healthcare professionals involved in prescribing and delivering IV fluids for children and young people are appropriately trained in the principles of fluid prescribing and IV fluid therapy-related complications lead to a reduction in IV fluid-related complications and associated healthcare costs?

Why this is important

Assessing patients' IV fluid needs, as well as prescribing and delivering IV fluids, are essential daily tasks on most paediatric wards. These are complex responsibilities that entail careful clinical assessment, good understanding of the physiology of fluid homeostasis both in health and disease, and appropriate supervision and training. There is currently no standard training provided for healthcare professionals working in the UK. Any teaching at both undergraduate and postgraduate level is currently delivered ad hoc, and in many cases may be limited. If fluid management in

hospitalised children and young people is to improve, standardised training is likely to be needed. Any educational interventions made would need to be evaluated to assess whether practice had subsequently improved.

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Accreditation