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PRACTICE

GUIDELINES

Intravenous fluids in children and young people: summary of NICE guidance

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Inappropriate use of intravenous fluids in children may have serious consequences. These include death or permanent neurological injury from hyponatraemia,[1] hypovolaemia, and poor organ perfusion, as well as the risks of hypervolaemia, oedema, and heart failure. Children have different fluid requirements from adults, for whom specific guidance exists.[2] This article summarises the most recent recommendations from the National Institute for Health and Care Excellence (NICE).[3]

Recommendations

NICE recommendations are based on systematic reviews of best available evidence and explicit consideration of cost effectiveness. When minimal evidence is available, recommendations are based on the guideline development group's experience and opinion of what constitutes good practice. Evidence levels for the recommendations are given in italic in square brackets.

The guidance covers children and young people under 16, including neonates, unless otherwise specified.

Assessment and monitoring (figs 1 and 2)

Fluid resuscitation

- If children and young people need intravenous fluid resuscitation, use glucose-free crystalloids that contain 131-154 mmol/L sodium, with a bolus of 20 mL/kg over less than 10 minutes. Take into account pre-existing conditions (such as cardiac disease or renal disease), as these may require smaller fluid volumes.
- If term neonates need intravenous fluid resuscitation, use glucose-free crystalloids that contain 131-154 mmol/L sodium, with a bolus of 10-20 mL/kg over less than 10 minutes.

[*Based on very low to low quality evidence from randomised controlled trials and the experience and opinion of the Guideline Development Group (GDG).*]

Routine maintenance (fig 3)

Replacement and redistribution

For term neonates, children, and young people:

- Adjust the intravenous fluid prescription (in addition to maintenance needs) to account for existing fluid and/or electrolyte deficits or excesses, ongoing losses (see fig 4⇓), or abnormal distribution (for example, tissue oedema in sepsis).
- Consider isotonic crystalloids that contain 131-154 mmol/L sodium for redistribution.
- Use 0.9% sodium chloride solution containing potassium to replace ongoing losses.
- Base any subsequent fluid prescriptions on plasma electrolyte concentrations and blood glucose measurements.

[*Based on very low quality evidence from one randomised controlled trial and the experience and opinion of the GDG.*]

Hypernatraemia that develops during intravenous fluid therapy

In term neonates, children, and young people who develop hypernatraemia, 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 (such as 0.45% sodium chloride with glucose).
- If dehydration is diagnosed, calculate the water deficit and replace it over 48 hours, initially with 0.9% sodium chloride.

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What you need to know

- Careful assessment and monitoring of body weight, fluid balance, and fluid status are essential during intravenous fluid therapy in children, as is the correct choice of fluid, to avoid serious complications including death and neurological injury
- To reduce anxiety and improve compliance with blood tests, explain their importance to children who are old enough to understand and to their carers; consider distraction techniques and comfort measures in younger children and use topical local anaesthetics before taking blood
- Isotonic crystalloids with a sodium content of 131-154 mmol/L are appropriate for initial maintenance requirements
- In children receiving intravenous fluids, symptoms such as nausea and vomiting, lethargy, confusion, and irritability may indicate hyponatraemia. This is a medical emergency requiring immediate expert advice and treatment

What's new in this guidance

- Intravenous fluids are potentially dangerous; they should be used only when clinically indicated and with close observation and assessment
- Recognise that children are at greater risk than adults of permanent neurological complications and death due to hyponatraemia from inappropriate use of intravenous fluids

- 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 (such as 0.45% sodium chloride with glucose).
- When correcting hypernatraemia, ensure that plasma sodium does not fall by more than 12 mmol/L in a 24 hour period.
- Measure plasma electrolyte concentrations every 4-6 hours for the first 24 hours; after this base the frequency of further plasma electrolyte measurements on the treatment response.

[*Based on the experience and opinion of the GDG.*]

Asymptomatic hyponatraemia that develops during intravenous fluid therapy

Hyponatraemia that develops while receiving intravenous fluids is potentially dangerous and associated with permanent neurological damage and death in children.

- If hyponatraemia develops in term neonates, children, and young people, review the fluid status, and if the child is being prescribed a hypotonic fluid change to an isotonic fluid (such as 0.9% sodium chloride).
- In children and young people who are hypervolaemic or at risk of hypervolaemia (for example, if increased antidiuretic hormone secretion is possible), either:
  -Restrict maintenance fluids to 50-80% of routine maintenance needs, or
  -Reduce maintenance fluids, calculated on the basis of insensible losses within the range 300-400 mL/m^2/24 h plus urinary output.

Acute symptomatic hyponatraemia that develops during intravenous fluid therapy

The following symptoms are associated with acute hyponatraemia during intravenous fluid therapy:

- Headache
- Nausea and vomiting
- Confusion and disorientation
- Irritability
- Lethargy
- Reduced consciousness
- Convulsions
- Coma
- Apnoea.

In term neonates, children and young people who develop acute symptomatic hyponatraemia, do not manage acute hyponatraemic encephalopathy using fluid restriction alone. Instead, review the fluid status, seek immediate expert advice (for example, from the paediatric intensive care team), 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 measurement on the basis of the response to treatment.
- After hyponatraemia symptoms have resolved, ensure that plasma sodium does not increase by more than 12 mmol/L in a 24 hour period.

[*Based on the experience and opinion of the GDG.*]

Overcoming barriers to optimal treatment

Intravenous fluid therapy is a core part of the care of children in hospital. It requires consistent efforts to comply with the recommendations. Identifying adverse events from mismanagement of intravenous fluid therapy and establishing a causal association between the two can be difficult. Because blood tests to guide intravenous fluid therapy can be painful and distressing for the child, it is crucial to explain the importance of these tests to children who are old enough to understand and to their carers. This can reduce anxiety and improve compliance. Use techniques such as distraction and comfort in younger children and apply topical local anaesthetic agents to the skin before venepuncture. Templates for fluid prescribing can facilitate the careful monitoring of children and recording of observations.[5] This may require more staff time

but will help prevent serious complications and reduce current variations in practice and outcome.

The members of the Guideline Development Group were Peter Crean, Jan Dudley, Deborah Evans, Andrew Fitzsimons, Chris Gildersleve, Lyda Jadresic, Ann Kelly, Jayne Kranat, Aung Soe, Stephanie Warne, Andrew Wignell, and Peter Wilson. The members of the technical team were Joanna Ashe, Katie Broomfield, Dalia Dawoud, Elisabetta Fenu, Edward Griffin, Jennifer Hill, Katie Jones, Samantha Jones, Julie Neilson, Frank O'Neill, Gill Ritchie, and Cheentan Singh.

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How patients were involved in the creation of this article

The guideline committee included lay members who contributed to the formulation of the recommendations summarised here.

Further information on the guidance

In response to safety concerns, particularly hyponatraemia from the use of hypotonic intravenous fluids in children, the National Patient Safety Agency has produced a template for intravenous fluid prescription.[5] Children are at higher risk than adults of developing cerebral oedema and neurological complications as a consequence of hyponatraemia. There are many cases in the literature where children have died because of inappropriate hypotonic fluid therapy.[6] Monitoring and assessment of children receiving intravenous fluids are of paramount importance to guide continuing treatment, but this can be challenging for healthcare professionals and distressing for children and their carers. As a result, assessment and monitoring are often suboptimal, with inadequate evaluation of fluid and electrolyte status and inappropriate intravenous fluid prescribing. The guidance was commissioned on the basis of these concerns.

At the time of publication (December 2015), some intravenous solutions did not have a UK marketing authorisation for use in children and young people. Prescribers should follow relevant professional guidance.[7]

Guidelines into practice

- Have the fluid requirements been clinically reassessed at least every 12 hours in any child receiving intravenous fluids?
- Have urea and electrolytes been estimated at least every 24 hours in any child receiving intravenous fluids?

Methods

The guideline was developed using current National Institute for Health and Care Excellence (NICE) guideline methodology (www.nice.org.uk/article/PMG20/chapter/1%20Introduction%20and%20overview). The Guideline Development Group (GDG) comprised consultant paediatric anaesthetists, a consultant paediatric nephrologist, a paediatric nurse practitioner, a paediatric emergency medicine consultant, a consultant paediatrician, an advanced paediatric nurse practitioner, a consultant neonatologist, a locum consultant in paediatric surgery and urology, a specialist clinical pharmacist, a paediatric intensive care consultant, and a patient/carer member.

The GDG developed clinical questions, collected and appraised clinical evidence, and evaluated the cost effectiveness of proposed interventions and management strategies through literature review and economic analysis. The draft guideline went through a rigorous review process, in which stakeholder organisations were invited to comment; the group took all comments into consideration when producing the final version of the guideline. Quality ratings of the evidence for intervention reviews were based on GRADE methodology (www.gradeworkinggroup.org). These relate to the quality of the available evidence for assessed outcomes rather than the quality of the clinical study. One qualitative review in which the views of practitioners were required was included.

NICE has produced two versions of the guideline: a full version (www.nice.org.uk/guidance/ng29/evidence) and a summary version known as the “NICE guideline” (www.nice.org.uk/guidance/ng29). These versions, as well as a pathway (http://pathways.nice.org.uk/pathways/intravenous-fluid-therapy-in-hospital), are available from the NICE website. Updates of the guideline will be produced as part of NICE’s guideline development programme.

Figures

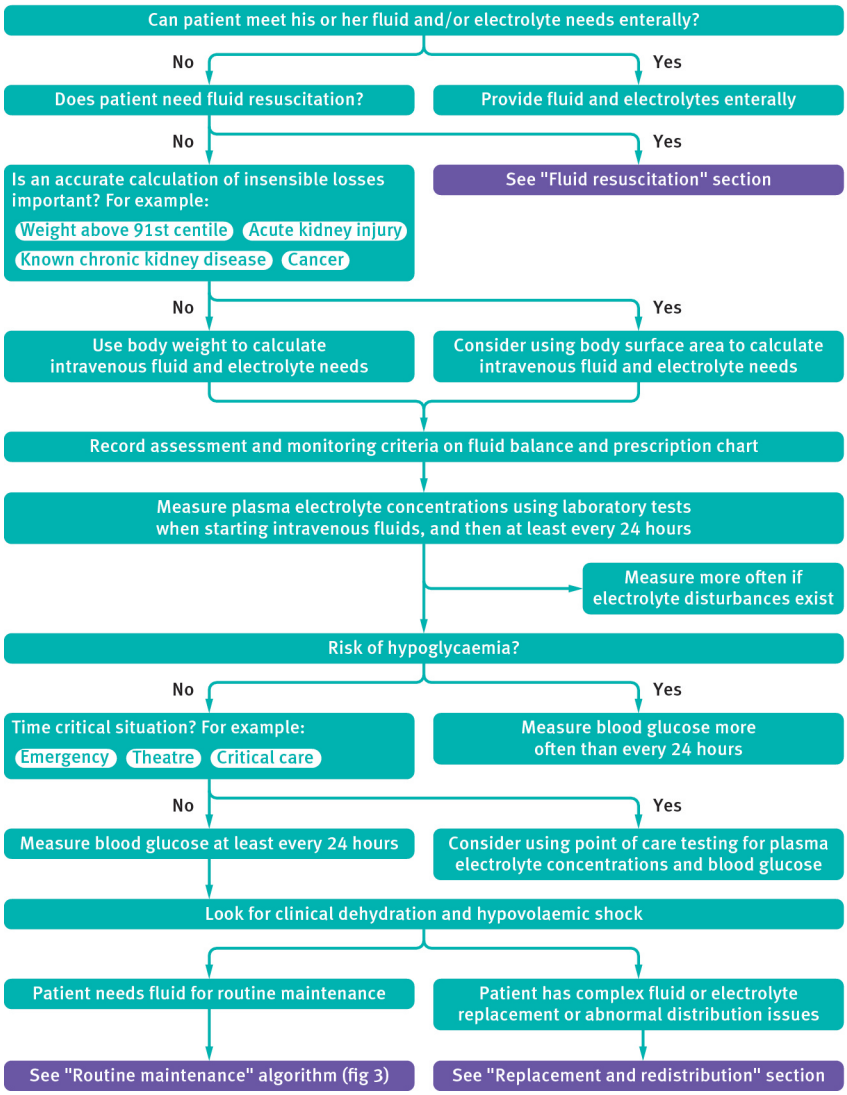

Fig 1 Algorithm for assessment and monitoring

No clinically detectable dehydration	Clinical dehydration	Hypovolaemic shock
Alert and responsive	Altered responsiveness (for example, irritable, lethargic)	Decreased level of consciousness
Appears well	Appears to be unwell or deteriorating	–
Eyes not sunken	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	Tachypnoea	Tachypnoea
Normal capillary refill time	Normal capillary refill time	Prolonged capillary refill time
Normal heart rate	Tachycardia	Tachycardia
Normal peripheral pulses	Normal peripheral pulses	Weak peripheral pulses
Normal skin turgor	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

Within the category of "clinical dehydration" there is a spectrum of severity indicated by increasingly numerous and more pronounced clinical features. For hypovolaemic shock, one 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 figure has been adapted from the assessing dehydration and shock section in 'Diarrhoea and vomiting in children' (NICE guideline CG84)[4]

Fig 2 Red flags for clinical dehydration[4]

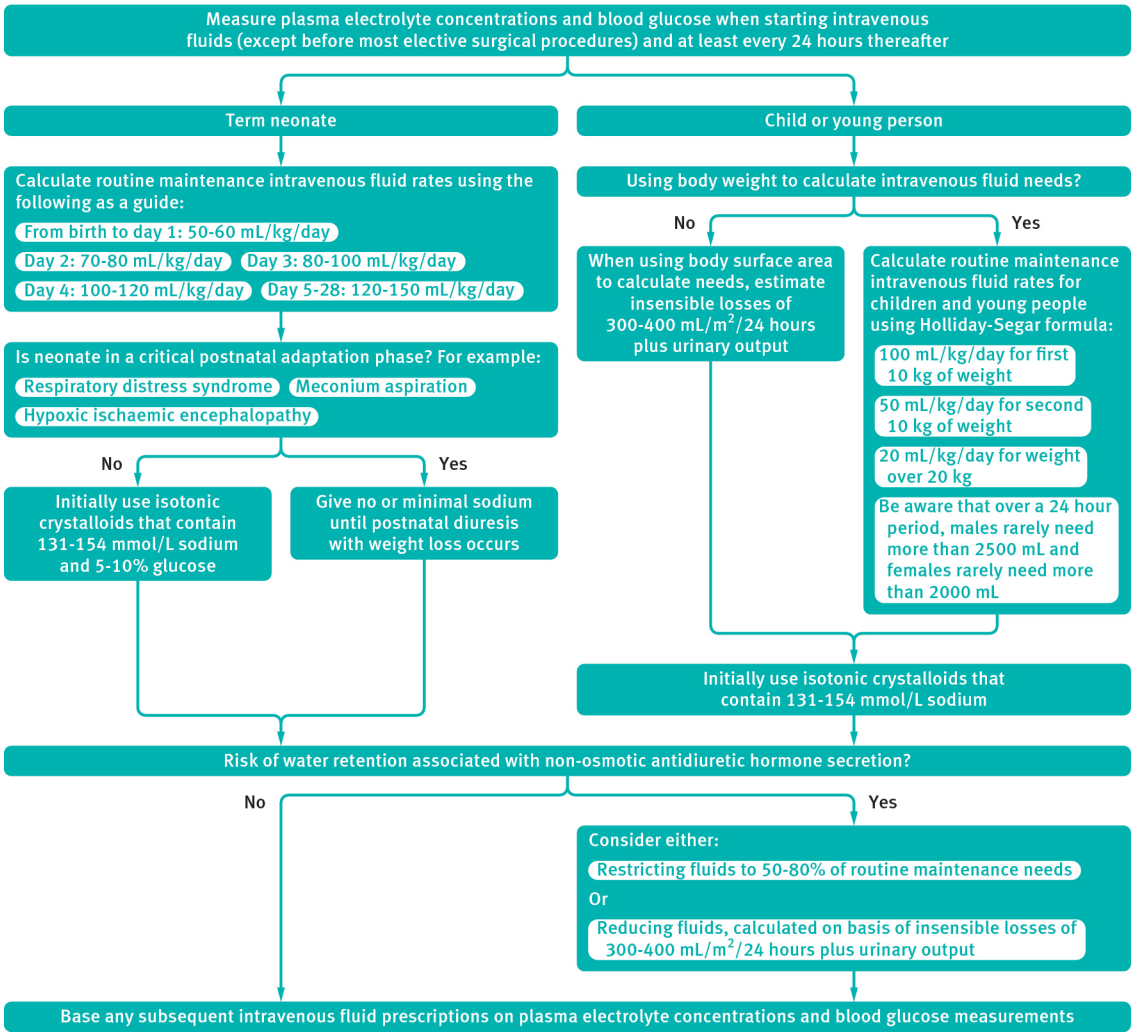

Fig 3 Algorithm for routine maintenance

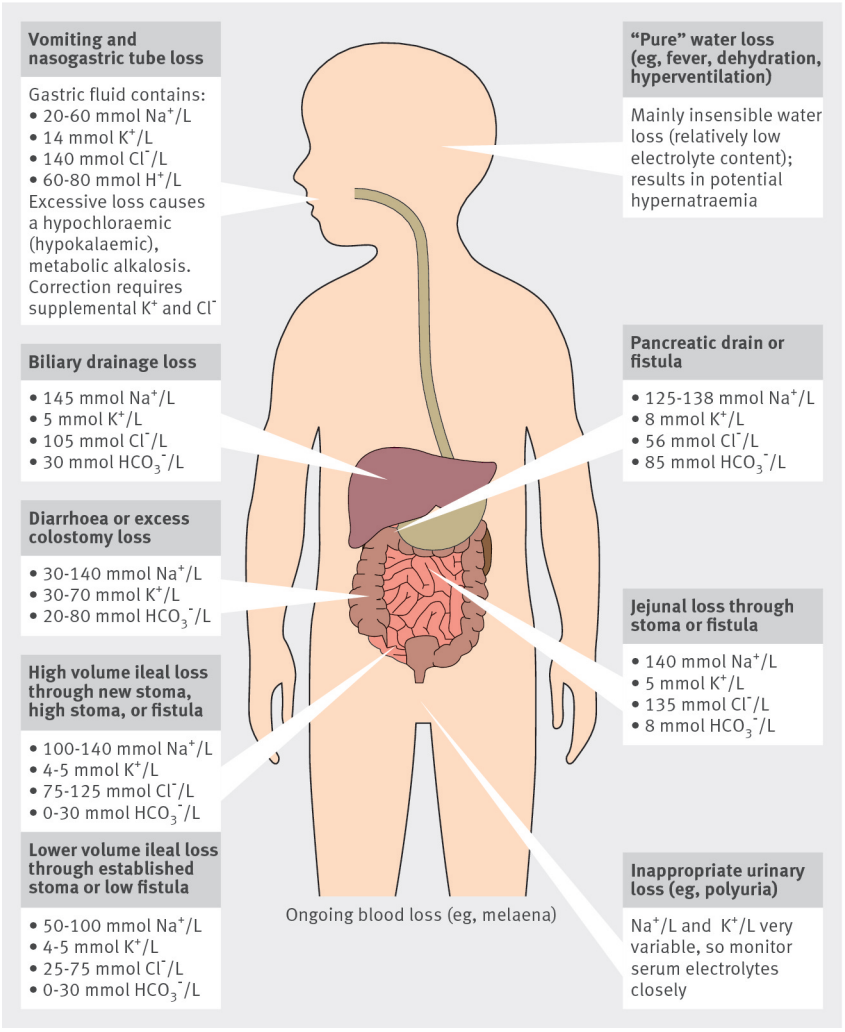

Fig 4 Ongoing fluid and electrolyte losses in children. Reproduced with permission from the National Clinical Guideline Centre