Inappropriate use of intravenous fluids in children may have serious consequences. These include death or permanent neurological injury from hyponatraemia, 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.

This article summarises the most recent recommendations from the National Institute for Health and Care Excellence (NICE).

**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.

**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.

**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.

---

Correspondence to: J Neilson Julie.neilson@rcplondon.ac.uk

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

Contributors: All authors contributed to the conception and drafting of this article, and to revising it critically. They have all approved this version. JN is guarantor.

Funding: Julie Neilson, Frank O’Neill and Dalia Dawoud are employees of the National Clinical Guideline Centre, at the Royal College of Physicians which is commissioned and funded by NICE to develop clinical guidelines.

Competing interests: We declare no competing interests, based on NICE’s policy on conflicts of interests (available at http://www.nice.org.uk/Media/Default/About/Who-we-are/Policies-and-procedures/code-of-practice-for-declaring-and-managing-conflicts-of-interest.pdf). The authors’ full statements can be viewed at www.bmj.com/content/bmj/351/bmj.h6388/related#datasupp.

Provenance and peer review: Commissioned; not externally peer reviewed.


Cite this as: BMJ 2015;351:h6388
© BMJ Publishing Group Ltd 2015
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

Can patient meet his or her fluid and/or electrolyte needs enterally?

No

Does patient need fluid resuscitation?

Yes

Provide fluid and electrolytes enterally

No

See “Fluid resuscitation” section

Is an accurate calculation of insensible losses important? For example:

- Weight above 95th centile
- Acute kidney injury
- Known chronic kidney disease
- Cancer

No

Use body weight to calculate intravenous fluid and electrolyte needs

Yes

Consider using body surface area to calculate intravenous fluid and electrolyte needs

Record assessment and monitoring criteria on fluid balance and prescription chart

Measure plasma electrolyte concentrations using laboratory tests when starting intravenous fluids, and then at least every 24 hours

Measure more often if electrolyte disturbances exist

Risk of hypoglycaemia?

No

Time critical situation? For example:

- Emergency
- Theatre
- Critical care

Yes

Measure blood glucose more often than every 24 hours

No

Measure blood glucose at least every 24 hours

Yes

Consider using point of care testing for plasma electrolyte concentrations and blood glucose

Look for clinical dehydration and hypovolaemic shock

Patient needs fluid for routine maintenance

Patient has complex fluid or electrolyte replacement or abnormal distribution issues

See "Routine maintenance" algorithm (fig 3)

See "Replacement and redistribution" section
<table>
<thead>
<tr>
<th>No clinically detectable dehydration</th>
<th>Clinical dehydration</th>
<th>Hypovolaemic shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert and responsive</td>
<td>Altered responsiveness (for example, irritable, lethargic)</td>
<td>Decreased level of consciousness</td>
</tr>
<tr>
<td>Appears well</td>
<td>Appears to be unwell or deteriorating</td>
<td>–</td>
</tr>
<tr>
<td>Eyes not sunken</td>
<td>Sunken eyes</td>
<td>–</td>
</tr>
<tr>
<td>Moist mucous membranes (except after a drink)</td>
<td>Dry mucous membranes (except for “mouth breather”)</td>
<td>–</td>
</tr>
<tr>
<td>Normal blood pressure</td>
<td>Normal blood pressure</td>
<td>Hypotension (decompensated shock)</td>
</tr>
<tr>
<td>Normal breathing pattern</td>
<td>Tachypnoea</td>
<td>Tachypnoea</td>
</tr>
<tr>
<td>Normal capillary refill time</td>
<td>Normal capillary refill time</td>
<td>Prolonged capillary refill time</td>
</tr>
<tr>
<td>Normal heart rate</td>
<td>Tachycardia</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Normal peripheral pulses</td>
<td>Normal peripheral pulses</td>
<td>Weak peripheral pulses</td>
</tr>
<tr>
<td>Normal skin turgor</td>
<td>Reduced skin turgor</td>
<td>–</td>
</tr>
<tr>
<td>Normal urine output</td>
<td>Decreased urine output</td>
<td>–</td>
</tr>
<tr>
<td>Skin colour unchanged</td>
<td>Skin colour unchanged</td>
<td>Pale or mottled skin</td>
</tr>
<tr>
<td>Warm extremities</td>
<td>Warm extremities</td>
<td>Cold extremities</td>
</tr>
</tbody>
</table>

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 CG96)."
Fig 3 Algorithm for routine maintenance

Measure plasma electrolyte concentrations and blood glucose when starting intravenous fluids (except before most elective surgical procedures) and at least every 24 hours thereafter.

**Term neonate**

- Calculate routine maintenance intravenous fluid rates using the following as a guide:
  - Day 1: 50-60 mL/kg/day
  - Day 2: 70-80 mL/kg/day
  - Day 3: 100-120 mL/kg/day
- Is neonate in a critical postnatal adaptation phase? For example: respiratory distress syndrome, meconium aspiration, hypoxic ischaemic encephalopathy.
  - No
    - Initially use isotonic crystalloids that contain 131-154 mmol/L sodium and 5-10% glucose
  - Yes
    - Give no or minimal sodium until postnatal diuresis with weight loss occurs

**Child or young person**

- Using body weight to calculate intravenous fluid needs?
  - No
    - When using body surface area to calculate needs, estimate insensible losses of 300-400 mL/m²/24 hours plus urinary output.
  - Yes
    - Calculate routine maintenance intravenous fluid rates for children and young people using Holliday-Segar formula:
      - 100 mL/kg/day for first 10 kg of weight
      - 50 mL/kg/day for second 10 kg of weight
      - 20 mL/kg/day for 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

**Risk of water retention associated with non-osmotic antidiuretic hormone secretion?**

- No
- Yes
  - Consider either:
    - Restricting fluids to 50-80% of routine maintenance needs
    - Reducing fluids, calculated on basis of insensible losses of 300-400 mL/m²/24 hours plus urinary output

Base any subsequent intravenous fluid prescriptions on plasma electrolyte concentrations and blood glucose measurements.
Fig 4 Ongoing fluid and electrolyte losses in children. Reproduced with permission from the National Clinical Guideline Centre.