

# Updated guidelines for the management of fluid and electrolytes in children

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## Abstract

Safe intravenous fluid management in children is important and requires an understanding of the basic science of fluids and electrolytes. NICE guidelines issued in December 2015 update an NPSA alert of 2007 which aimed to reduce the serious risks of hyponatraemia. Hyponatraemia most commonly arises from the inappropriate administration of fluids with low concentrations of sodium during resuscitation or when given for the replacement of deficits or when given in inappropriately large volumes. Electrolyte abnormalities and their correction are summarized in this paper.

**Keywords** Children; intravenous fluid; neonates; NICE; perioperative; young people

The advice in this article is based on a multidisciplinary consensus opinion generated by the Association of Paediatric Anaesthetists, on the March 2007 National Patient Safety Agency (NPSA) recommendations entitled 'Reducing the risk of hyponatraemia when administering intravenous infusions to children' and on National Institute of Health and Care Excellence (NICE) guidance 2015. To this has been added advice from the Birmingham Children's Hospital fluid policy. The overall recommendations are that perioperative maintenance fluid administration in the majority of children should be based upon solutions containing 0.9% saline or Hartmann's. Solutions containing 0.18% saline have now been withdrawn from non-specialist areas. In spite of the 2007 recommendations one commonly sees prescriptions for 0.45% saline in glucose, which may be physiologically appropriate, but this should be prescribed acknowledging that it is not in line with the national guidance.

## National Patient Safety Agency 2007: the dangers of 4% glucose/0.18% saline

The NPSA reminded clinicians of the dangers of the use of fluids with low concentrations of sodium, such as 0.18% saline with 4% glucose. This fluid has always been inappropriate when used for resuscitation or to replace most fluid and electrolyte deficits, or when given at excessive rates when maintenance fluids were intended. The risk is one of precipitating hyponatraemia, which can be fatal. Historically many surgeons used the isosmolar fluid 0.18% saline/4% glucose as a maintenance fluid when given at

appropriate rates in well children based on their weight. This, or 0.45% saline/5% glucose, has traditionally been given at reduced rates in the postoperative period. The NPSA document resulted in the term 'isotonic' being limited to the tonicity of the electrolyte components of fluids. Thus 0.18% saline/4% glucose and 0.45% saline with 5% glucose are now considered to be *hypotonic* because the glucose is ignored. These fluids remain isosmolar, but since the glucose is metabolized to free water it is ignored in the tonicity. In 2007, all stocks of 0.18% saline/4% glucose were removed from non-specialized areas.

## Postoperative fluid prescriptions – new guidance

The headline statement is that neither the NPSA nor the NICE guidance recommends the currently popular 0.45% saline/5% glucose, and outside the neonatal period, only the following fluids are recommended:

- 0.9% saline
- 0.9% saline/5% glucose
- Ringer's lactate/Hartmann's solution
- 4.5% albumin.

For neonates 0.18% saline/10% glucose and 0.45%/5% glucose remain options.

## Prescribing intravenous fluids

Intravenous fluids should be prescribed with the same care and attention as given to other drugs. No one prescribes analgesics when antibiotics are needed, and no one should prescribe maintenance fluids when replacement fluids are intended.

Fluids are given intravenously for four reasons:

- circulatory support in resuscitating vascular collapse
- replacement of previous fluid and electrolyte deficits
- maintenance
- replacement of on-going losses.

Practice should be determined locally and our trust recommends that intravenous fluids should be prescribed daily by the team involved, either at the morning round or in the early evening before handover. Fluids should not be prescribed by the night team, who may not be as familiar with the patient, unless the fluid management requires fine tuning in response to the clinical situation or as a result of investigations. Such a patient would then have had a detailed and specific handover.

## Potassium

Potassium 20 mmol/litre (0.15%) (10 mmol in each 500 ml bag) should be included in maintenance fluids and in replacement fluids unless there are specific reasons against it. If there are special reasons not to give potassium, these should be detailed clearly in the notes. Potassium is not included in the first 24 hours of life nor traditionally in the first 24 hours after surgery.

However, it will be given if Hartmann's is prescribed. Remember that most potassium is intracellular and so a slightly lower serum level than normal indicates marked potassium depletion.

## Monitoring fluid balance

Monitoring of the patient's weight is important and particularly helpful in managing rehydration. Urinary specific gravity is also a good but underused guide to hydration status. Pure water has a

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specific gravity of 1. If there is 30 g of solute in a litre of urine the specific gravity is 1.030 – this is concentrated urine. If there is 10 g of solute in a litre of urine the specific gravity is 1.010 – this is dilute urine.

Daily electrolyte measurements are recommended strongly in those receiving solely intravenous fluids for more than a day. The electrolytes should be looked at in the context of previous results and not simply in relation to the normal values. Typically, fluid restriction is appropriate when the serum sodium falls and fluid rates can be increased when it rises. This is particularly relevant in managing fluids in the postoperative period. A falling sodium level is usually a sign of over-administration of fluid and not of giving too little sodium.

### Circulatory support in shock

The following fluids are appropriate for bolus administration at 10 or 20 ml/kg given over periods up to 20 minutes:

- 0.9% saline
- Ringer's lactate or Hartmann's solution
- blood
- 4.5% albumin
- colloid or blood.

It is inappropriate to use fluids containing low sodium in these situations; 0.18% saline or 0.45% saline in glucose are not to be used for circulatory resuscitation. Hyponatraemia can result and this can be fatal.

Monitoring is typically based on clinical responses, including blood pressure, capillary refill and blood gases. Serum electrolytes should be checked in anyone needing circulatory resuscitation.

### Correcting previous fluid and electrolyte deficits

However estimated, previous losses are typically between 5% and 15% of body weight. Sometimes the weight loss is known accurately. The fluid used to replace this deficit should be isotonic 0.9% sodium chloride (NaCl) or Ringer's lactate/Hartmann's solution.

A 15 kg child who is 5% dehydrated has a water deficit of 750 ml. It is not an uncommon misconception that 10% dehydration can be corrected by increasing maintenance fluid rates by 10%. This is clearly incorrect. Hypovolaemia should be corrected with an initial fluid bolus of 10–20 ml/kg of an isotonic fluid or colloid, repeated as necessary, followed by a slower correction of residual dehydration with an isotonic fluid, taking into account ongoing losses, serum electrolytes and urine output.

### Maintenance fluid requirements in children

Maintenance fluid requirements are still to be calculated according to the recommendations of Holliday and Segar (Table 1). Alternatively surface area can be used (see NICE guidance online).

Table 1 is a starting point only and the individual child's response to fluid therapy should always be monitored and appropriate adjustments made. In children outside the neonatal period 0.45% saline in glucose, or Hartmann's or 0.9% saline are options supported by the NPSA. However, in the postoperative period the NPSA recommends not using 0.45% saline. These

fluids give more than the daily requirements of sodium but the risks of this are considered to be less than the risks of hyponatraemia if hypotonic fluids are used. Our preferred fluid is Hartmann's because this gives less chloride ( $\text{Cl}^-$ ) (Table 2).

In term neonates, during the first 48 hours of life, 10% glucose should be given at a rate of 60 ml/kg/day unless there is a clinical indication for increased or decreased fluid administration and sodium added to intravenous fluids on days 2–3 depending on renal function, serum sodium and weight. From day 3 of life maintenance fluid should be 0.18% saline/10% glucose given at a rate of 4 ml/kg hourly or 100–120 ml/kg daily.

Preterm babies or those weighing less than 2 kg may require higher rates of fluid administration, and should be assessed at least daily by measurement of weight and electrolytes.

Maintenance fluid requirements may need to be increased in children with pyrexia, excess sweating, hypermetabolic states such as burns, or when radiant heaters or sometimes when phototherapy is used.

There is no consensus about whether maintenance fluid requirements should be reduced in children being treated in the paediatric intensive care unit (PICU) who are sedated and ventilated with humidified gases.

### Fluids given during operations

During surgery most children may be given fluids without glucose and so blood glucose should be monitored. Maintenance fluids used during surgery should be isotonic, such as 0.9% NaCl or Ringer's lactate/Hartmann's solution. Neonates in the first 48 hours of life should be given glucose during surgery. Preterm and term infants already receiving glucose-containing solutions should continue with them during surgery.

Infants and children receiving parenteral nutrition before surgery should continue with parenteral nutrition during surgery, or change to a glucose-containing maintenance fluid with monitoring of blood glucose. Children of low body weight (below the 3rd centile) or having prolonged surgery should receive a glucose-containing maintenance fluid (1–2.5% glucose) or have their blood glucose monitored during surgery. Children having extensive regional anaesthesia with a reduced stress response should receive a glucose-containing maintenance fluid (1–2.5% glucose) or have their blood glucose monitored. All losses during surgery should be replaced with an isotonic fluid such as 0.9% saline, Ringer's lactate/Hartmann's solution, a colloid or blood, depending on the child's haematocrit. In children over 3 months of age the haematocrit may be allowed to fall to 25%. Children with cyanotic congenital heart disease may need a higher haematocrit to maintain oxygenation.

### Postoperative fluid management

Some preoperative surgical conditions such as empyema, sepsis and shock, are associated with increased antidiuretic hormone (ADH) production. Operative trauma, pain, nausea and vomiting also contribute to ADH release. The guidance recommends restricting the choice of postoperative fluids to:

- 0.9% saline
- 0.9% saline/5% glucose
- Ringer's lactate/Hartmann's solution
- 4.5% albumin.

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