

Guidelines for Fluid Management in Infants and Children on PICU

Introduction

These guidelines apply to infants and children on the paediatric and cardiac intensive care units. They include:

1. Normal maintenance requirements for intravenous and enteral fluids
2. Replacement of pre-existing fluid deficit and ongoing fluid losses
3. Post operative cardiac surgical patients
4. Type of fluid and electrolyte requirements

1. Normal maintenance fluid requirements

(a) Intravenous fluid requirements

A child's maintenance fluid requirement decreases proportionately with increasing age. For practical purposes either of the following calculations may be used to estimate the approximate maintenance requirement of well children according to weight.

	Method 1	Method 2
First 10 kg	100 ml/kg/day	4 ml/kg/hr
Second 10 kg	50 ml/kg/day	2 ml/kg/hr
Subsequent kg	20 ml/kg/day	1 ml/kg/hr

Example calculation for 35 kg child:

Method 1: $(10 \times 100) + (10 \times 50) + (15 \times 20) = 1800\text{ml/day} = 75\text{ml/hr}$

Method 2: $(10 \times 4) + (10 \times 2) + (15 \times 1) = 75\text{ml/hr}$

Quick reference guide:

Kg	4	6	8	10	12	14	16	18	20	30	40	50	60	>70
ml/hr	16	24	32	40	45	50	55	60	65	70	80	90	95	100

(b) Enteral feed requirements

Age >6 months

For children above 6 months of age the enteral requirement is equal in volume to the IV requirement and the above calculation can be used.

Age <6 months

For young infants there is often confusion about the difference between oral and IV fluid requirements. Their water requirement is the same for both routes of administration; however infants need larger volumes of milk (see below) to provide adequate nutrition.

Day 1	60 ml/kg/day	Day 5 (preterms)	180 ml/kg/day
Day 2	90 ml/kg/day	Day 5 to 3 months	150 ml/kg/day
Day 3	120 ml/kg/day	3 to 6 months	120 ml/kg/day
Day 4	150 ml/kg/day (maximum for term infants)		

2. Replacement of pre-existing fluid deficit and ongoing fluid losses

In addition to normal maintenance fluid requirements, unwell children may need:

- Fluid resuscitation for shock
- Replacement of pre-existing fluid losses
- Replacement of ongoing fluid losses

(a) Fluid resuscitation for shock

Give a bolus of 10-20ml/kg of 0.9% sodium chloride, 4.5% Human Albumin Solution (HAS) or commercial colloid (eg. Gelofusin) and reassess. Repeat as necessary.

(b) Replacement of pre-existing fluid losses

The water deficit can be calculated following an estimation of the degree of dehydration as a percentage of body weight. A 10kg child who has lost 1kg due to fluid loss will be 10% dehydrated. To calculate the fluid deficit:

$$\text{Fluid deficit (ml)} = \text{weight (kg)} \times \% \text{ dehydration} \times 10$$

This deficit should be replaced, usually over 24 hours. In some instances replacement of the deficit over 48 hours is more appropriate (such as diabetic ketoacidosis and hypernatraemic dehydration). For specific fluid management issues relating to certain conditions please see separate guidelines (DKA, liver failure).

(c) Replacement of ongoing fluid losses

Nasogastric losses should be replaced ml for ml with 0.9% sodium chloride + added potassium chloride.

Chest drain losses should be replaced with 0.9% sodium chloride or 4.5% Human Albumin Solution (HAS). If there is significant blood loss with a falling haemoglobin post operatively then replace with packed cells.

3. Post operative cardiac surgical patients

After cardiopulmonary bypass there is a tendency for sodium and water retention in conjunction with a systemic inflammatory response that results in increased capillary permeability. Fluid administration in the first 24 hours is aimed at maintaining an optimal haemodynamic state.

Fluid restriction in the immediate post-operative period:

Bypass cases	50% maintenance
Non bypass cases	60% maintenance

Continue this fluid regime until the patient is extubated OR until the cardiothoracic consultant wishes to increase maintenance fluids. They should then be increased by 10% per day.

4. Type of fluid

Wherever possible, enteral feeds should be given. The intravenous fluids listed below are all available for use in PICU patients. Which fluid you use depends on the individual circumstances, the patient's age, serum sodium and glucose. In most situations, 5% Dextrose + 0.45% sodium chloride with potassium chloride 10mmol per 500ml is a safe fluid to start with.

Potassium chloride (10mmol per 500ml) should be added unless the child is hyperkalaemic or in renal failure. This will provide the daily potassium requirement of around 2mmol/kg/day.

0.9% sodium chloride	Suitable for initial volume resuscitation in hypovolaemia, and for ongoing fluid therapy in older children with normal serum glucose. Fluid of choice in patients with head injury.
5% dextrose + 0.9% sodium chloride	Suitable for ongoing fluid therapy in infants and children, including post-operative cardiac patients. Use in head injured patients with hypoglycaemia.
5% dextrose + 0.45% sodium chloride	Suitable for ongoing fluid therapy in infants and children, including post-operative cardiac patients
10% dextrose + 0.45% sodium chloride See page 4 appendix 1: how to prescribe and make up bags	Suitable for ongoing fluid therapy in neonates or older infants who are hypoglycaemic, including post-operative cardiac patients
4% dextrose + 0.18% sodium chloride	Not recommended for routine maintenance. Use with caution after discussion with PICU consultant.

The routine use of 4% dextrose + 0.18% sodium chloride is not recommended. It may be used with caution in exceptional circumstances after discussion with the PICU consultant. This is because the syndrome of inappropriate antidiuretic hormone secretion (SIADH) is common in infants and children who are unwell, and the combination of SIADH plus administration of 0.18% sodium chloride can lead to water retention, cerebral oedema and herniation.

The “neonatal solution” should not be used (10% dextrose + 0.18% sodium chloride + potassium chloride 8mmol/500ml + calcium chloride 3mmol/500ml) because of the risk of extravasation injury when given peripherally.

In children at risk of SIADH (meningitis, encephalitis, respiratory infections, post operative) fluids should initially be restricted to 60-80% maintenance. Once on full enteral feeds, total maintenance should be increased to 100%.

All children on IV fluids should have serum electrolytes, glucose, hydration status and fluid balance monitored and their fluid therapy adjusted accordingly.

Appendix 1: Guideline for the preparation of 10% dextrose + 0.45% sodium chloride intravenous solution at ward level

We do not stock ready made bags of this fluid. To enable its use according to the PICU fluid management guidelines the bags will need to be prepared on the ward. The aim of this guidance is to ensure that this fluid is safely prescribed and prepared at ward level.

(a) 10% dextrose + 0.45% sodium chloride in 500ml

This should be prescribed as **5% dextrose 0.45% sodium chloride 500ml + 50ml 50% dextrose**

To prepare add 50ml of 50% dextrose (from a prefilled syringe) to a 500ml bag of 5% dextrose + 0.45% sodium chloride and mix well.

The final solution will be 10% dextrose + 0.41% sodium chloride in 550ml which can be considered equivalent to 10% dextrose + 0.45% sodium chloride

(b) 10% dextrose + 0.45% sodium chloride + 10mmol potassium chloride in 500ml

This should be prescribed as **5% dextrose 0.45% sodium chloride 500ml +10mmol potassium chloride + 50ml 50% dextrose**

To prepare add 50ml of 50% dextrose (from a prefilled syringe) to a 500ml bag of 5% dextrose + 0.45% sodium chloride + 10mmol potassium chloride and mix well.

The final solution will be 10% dextrose + 0.41% sodium chloride + 10mmol potassium chloride in 550ml (= 9.1mmol potassium in 500ml). This can be considered equivalent to 10% dextrose + 0.45% sodium chloride + 10mmol potassium chloride.

References:

1. Clinical Practice Guidelines, Royal Children's Hospital, Melbourne.
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3. Shafiee M, Bohn D, Hoorn E, Halperin M. How to select optimal maintenance intravenous fluid therapy. QJ Med 2003; 96: 601-10
4. Halberthal M, Halperin M, Bohn D. Acute hyponatraemia in children admitted to hospital: retrospective analysis of factors contributing to its development and resolution. BMJ 2001; 322: 780-2
5. Hoorn EJ, Geary D, Robb M, Halperin M, Bohn D. Acute hyponatremia related to intravenous fluid administration in hospitalized children: an observational study. Pediatrics 2004; 113: 1279-84

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