

FLUID GUIDELINES IN CHILDREN

PERIOPERATIVE FLUIDS

Intravenous fluids are administered perioperatively to maintain homeostasis during this period. Water and electrolytes are required to correct deficits and ensure adequate intravascular volume. Calories in the form of dextrose may be needed to prevent hypoglycaemia.

Unless fasted for a long period of time, most children undergoing minor procedures which allow them to resume feeding soon after surgery do not need intra-operative intravenous fluids.

Children undergoing major surgery, or those who have incurred fluid deficits, and/or are required to remain nil by mouth post-operatively will require intravenous (IV) fluids. Fluids may be given for:

- Resuscitation - to correct pre-existing hypovolaemia or dehydration
- Maintenance - to provide water, electrolytes and glucose during the starvation period.
- Replacement of ongoing losses

PAEDIATRIC ANAESTHESIA

Assessment of Extent of Dehydration

Sign	5% body weight fluid loss 50ml/kg (mild)	10% body weight fluid loss 100ml/kg (moderate)	15% body weight fluid loss 150ml/kg (severe)
Pulse (rate/strength)	Normal/ normal	Increased /weak	Greatly increased/ feeble
Blood pressure	Normal	Normal to low	Reduced and orthostatic
Respiration	Normal	Deep	Deep and rapid
Mucous membrane	Moist	Dry	Very dry
Anterior fontanelle	Normal	Sunken	Markedly sunken
Eyes	Normal	Sunken	Markedly sunken
Skin turgor sunken	Normal	Decreased	Markedly decreased
Sensorium	Normal/ thirsty/ restless	Thirsty/ lethargic but arousable	obtunded
Urine output	<2ml/kg	<1ml/kg	<0.5ml/kg

Resuscitation

This should begin pre-operatively although full resuscitation may not be possible if the child has to undergo surgery without delay. In these unusual situations, resuscitation must continue intraoperatively. It is important to be able to assess the degree of dehydration in a child. This is summarized in the table above. Hypovolaemia (losses from the intravascular space) should be replaced initially with 20 ml/kg boluses of isotonic solutions like normal saline or colloid. Blood should be considered if the haemoglobin is low, or there is ongoing bleeding, or more than 40 ml/kg of fluid is required.

Maintenance

Several formulas are available; the simplest and most commonly used is the one devised by Holliday and Segar (and modified by Oh). Do note though that infants, particularly neonates, have increased maintenance requirements and this is discussed under the chapter Pediatric Medicine Clinical Guidelines For Intravenous Fluids In Children.

Body weight	Holliday and Segar	Oh
1-10kg	4ml/kg/hour	4ml/kg/hour
10-20kg	40ml/hour+2ml/kg/hour above 10 kg	20 + (2x weight in kg) ml/kg/h
>20kg	60ml/hour+1ml/kg/hour above 20 kg	40 + weight in kg ml/kg/h

Intraoperatively, the amount of insensible loss will vary depending on the extent of surgical exposure and trauma. The additional fluid requirements for minimal tissue trauma may range from 0-2ml/kg/hr, moderate surgery 2-4ml/kg/hr and up to 10ml/kg/hr for severe tissue trauma/ major surgery. All this should factor in determining the maintenance fluid rate.

Children given hypotonic fluid may become hyponatraemic. Surgery and anaesthesia cause antidiuretic hormone (ADH) levels to rise, resulting in conservation of water and predisposing patients to hyponatremia. A rapid or profound drop in sodium results in water moving into cells causing swelling and oedema. This can manifest as raised intracranial pressure, brain stem herniation, coning and death. Prepubertal children in particular are susceptible to brain damage associated with postoperative hyponatraemic encephalopathy. As such, the use of hypotonic solutions is avoided during surgery except in patients with hypernatremia.

Ongoing losses:

An estimate of the blood loss can be made by weighing swabs, monitoring suction losses and “eyeballing” drapes. There may also be other sources of fluid losses such as the gastrointestinal tract fluid or cerebral spinal fluid or urine. The type of ongoing loss should determine the type of fluid used to replace the loss.

Monitoring urine output and central venous filling pressures are useful adjuncts in determining the volume status of the child. If surgery is prolonged and there are extensive fluid shifts / blood loss, regular blood gas, haematocrit, electrolyte and serum glucose monitoring should be carried out to optimize fluid management. Point of care tests for hemoglobin is available in the form of i-STAT and Hemocue.

Fluids in the Operating theatre

In the OT, the default fluid used for patients will be Hartmann's Solution except in:

- Neonates- Use Dextrose 5% or Dextrose 10% as maintenance drip, and use Normal Saline or Albumin 5%/ blood /blood products for volume resuscitation / replacement as appropriate to the clinical situation.
- Neurosurgical cases- Normal Saline
- Child on total parenteral nutrition (TPN)- continue TPN during surgery. Do not disrupt the sterility of the line used to administer TPN.

It should be remembered that complications may arise from excessive administration of crystalloids or colloids. Excessive administration of normal saline for example is associated with acidosis.

More recently, balanced salt solutions such as plasmalyte A have become available. These ISOTONIC SOLUTIONS have an electrolyte composition similar to human plasma and are hence less likely to result in electrolyte disturbances.

PAEDIATRIC ANAESTHESIA

The composition of some commonly used crystalloids and colloids are given below.

Fluid Type	Osmolarity (mOsm)	Na (mmol/L)	Osmolality	Tonicity	Others
0.9% saline	308	154	isosmolar	isotonic	
D5% / 0.9% saline	586	150	hyperosmolar	isotonic	
4.5% albumin	275	100-160	isosmolar	isotonic	
Hartmann's solution	278	131	Slightly hyposmolar	Slight hypotonic	K/Ca/ lactate
0.45% saline	154	77	hyposmolar	hypotonic	
D5% / 0.45% saline	432	75	hyposmolar	hypotonic	
D5%	278	0	isosmolar	hypotonic	
D10%	555	0	hyperosmolar	hypotonic	
Sterofundin	309	145	isosmolar	isotonic	K/Ca/Mg/acetate/ malate
Plasmalyte A	294	140	isosmolar	isotonic	Na/K/Ca/Mg/acetate/ gluconate

For more information on Fluid Orders in the General Paediatric Wards, see chapter on Paediatric Medicine Clinical Guidelines - Intravenous Fluids in Children.

Paediatric Medicine Clinical Guidelines for Intravenous Fluids in Children

In the Wards

This set of guidelines is written primarily for fluid orders in the wards, rather than in the OT. However, the principles may be applied in many instances to the OT.

This guideline is applicable to paediatric patients older than 28 days.

Maintenance fluids per day should be calculated using the “100,50,25” rule (also known as the “4,2,1” where the calculation is per hour rather than per day).

100ml/kg/day for the 1st 10kg = 4ml/kg/hr for the 1st 10kg

50ml/kg/day for the 2nd 10kg = 2ml/kg/hr for the 2nd 10kg

25ml/kg/day for every kg thereafter = 1ml/kg/hr for every kg thereafter

Weight (kg)	ml/day	ml/hour	Weight (kg)	ml/day	ml/hour
3	300	12	14	1200	48
4	400	16	16	1300	52
5	500	20	20	1500	60
6	600	24	30	1750	70
7	700	28	40	2000	80
8	800	32	50	2250	90
10	1000	40	60	2500	100
12	1100	44	70	2500	100

There are a number of clinical conditions that will affect the baseline infusion rate:

Consider increasing the infusion rate if:

Fever, hyperventilation, ongoing losses (diarrhoea, polyuria)

Consider decreasing the infusion rate if:

Hypothermia, oliguria, anuria, inactivity, fluid retention, excessive ADH (pneumonia, meningitis)

If the child is dehydrated the water deficit is calculated by multiplying the body weight by the percentage dehydration to obtain the deficit in litres. e.g. 10kg child, 3% dehydration, $10 \times 0.03 = 0.3$ litres = 300ml deficit.

Fluid deficit in mls:

Dehydration (%)→	3	5	10	15
3 kg	90	150	300	450
5 kg	150	250	500	750
10 kg	300	500	1000	1500
15 kg	450	750	1500	2250
20 kg	600	1000	2000	3000
30 kg	900	1500	3000	4500
40 kg	1200	2000	4000	6000
50 kg	1500	2500	5000	7500

The fluid used to rehydrate is the same as the fluid used to provide the maintenance infusion. Rehydration should be carried out evenly over at least 24 hours. If the dehydration is 10% or greater then rehydration should be carried out over a longer period.

e.g. 15 kg child, 5% dehydration

maintenance	1250 ml/day
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deficit	750 mls
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therefore prescribe 2000mls/day (80mls/hr) for the 1st 24 hours, 1250 mls/day thereafter:

e.g. 30 kg child, 10% dehydration

maintenance	1750 ml/day
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deficit	3000 mls
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plan to correct the deficit over 48 hours

Therefore prescribe 3250 ml/day (1500+1750) (135 ml/hr) for the 1st 48 hours, followed by maintenance of 1750 ml/day thereafter.

Fluid composition

A. The standard fluids available in the wards are:

Dextrose 5% + 0.45% saline

Dextrose 5% + 0.9% saline (consider for >10kg, or >1 year)

These two preparations will also be available with pre-added KCL to a concentration of 10mmol per 500ml.

B. 0.9% Normal saline can also be prescribed for volume resuscitation in aliquots of 10 to 20ml/kg.

C. Other fluids available are:

Dextrose 5%

Dextrose 10%

Normal Saline 0.9%

Hartmann's and Ringer's Lactate.

Neonatal fluid orders

Neonates (up to 44 weeks post-conceptual age) should have fluids ordered as per table below. Premature or low birth weight babies have a greater surface area to weight ratio, lose more water by evaporation and consequently require more replacement fluid. The fluid is usually given as 10% dextrose with or without NaCl or K added.

Weight / age	< 1.0 kg	1.0 - 1.5 kg	1.5 - 2.0 kg	> 2.0 kg
	Fluid requirement	ml/kg/day		
Day 1	100 - 120	80 - 100	60 - 80	40 - 60
Day 2	120 - 150	110 - 130	90 - 110	60 - 90
Day 3	150 - 170	140 - 160	120 - 140	80 - 100
Day 4	180 - 200	160 - 180	140 - 160	100 - 120
Day 5	180 - 200	170 - 200	150 - 180	120 - 150

References:

1. Holliday MA, Segar WE. The maintenance need for water in parenteral fluid therapy. *Paediatrics* 1957;19:823-832
2. Oh TH. Formulas for calculating fluid maintenance requirements. *Anesthesiology* 1980; 53:351