INTRAVENOUS FLUIDS

PRINCIPLES

- Postnatal physiological weight loss is **approximately** 5-10%
- Postnatal diuresis is delayed in Respiratory Distress Syndrome (RDS)
- Preterm babies have limited capacity to excrete sodium in first 48 hr
- Liberal sodium and water intake before onset of natural diuresis is associated with increased incidence of patent ductus arteriosus (PDA), necrotising enterocolitis (NEC) and chronic lung disease (CLD)
- After diuresis, a positive sodium balance is necessary for tissue growth
- Preterm babies, especially if born <29 weeks’ gestation, lose excessive sodium through immature kidneys
- Babies <28 weeks have significant transepidermal water loss (TEW)
- TEW loss leads to hypothermia, loss of calories and dehydration, and causes excessive weight loss and hypernatraemia

MONITORING

**Weigh**
- On admission
- Once daily: twice daily if fluid balance is a problem
- Use in-line scales if available

**Serum sodium**
- Daily for intensive care babies
- If electrolyte problems or ≤26 weeks, measure twice daily
- Admission electrolytes reflect maternal status: need not be acted upon but help to interpret trends
- Serum urea not useful in monitoring fluid balance: reflects nutritional status and nitrogen load

**Serum creatinine**
- Daily for intensive care babies
- Reflects renal function over longer term
- Trend is most useful
- Tends to rise over first 2-3 days
- Gradually falls over subsequent weeks
- Absence of postnatal drop is significant

**Urine output**
- Review 8 hrly for intensive care babies
- 2-4 mL/kg/hr normal hydration
- <1 mL/kg/hr requires investigation
- >6-7 mL/kg/hr suggests impaired concentrating ability or excess fluids

NORMAL REQUIREMENTS

**Humidification**
- If <29 weeks, humidify incubator 80%
- If ventilated or on CPAP ventilator, set humidifier at 39°C negative 2 to ensure maximal humidification of inspired gas
Normal fluid volume requirements

<table>
<thead>
<tr>
<th>Day of life</th>
<th>&lt;1000 g</th>
<th>≥1000 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>120</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>150</td>
<td>120</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>

- **Day 1**
  - glucose 10%
- **Day 2**
  - glucose 10% and potassium 10 mmol in 500 mL
  - if birth weight <1000 g, use TPN (with potassium 2 mmol/kg/day)
  - add sodium only when there is diuresis, or weight loss >6% of birth weight
- **Day 3**
  - glucose 10%, sodium chloride 0.18% and potassium 10 mmol in 500 mL
    or TPN (with potassium 2 mmol/kg/day and sodium 4 mmol/kg/day)
- **After Day 4**
  - glucose 10% (with maintenance electrolytes adjusted according to daily U&E)
    or TPN

**HYPONATRAEMIA (<130 mmol/L)**
Response to treatment should be proportionate to degree of hyponatraemia

**Causes**
- **Excessive free water**
  - reflection of maternal electrolyte status in first 24 hr
  - failure to excrete fetal extracellular fluid will lead to oedema without weight gain
  - water overload: diagnose clinically by oedema and weight gain
  - excessive IV fluids
  - inappropriate secretion of ADH in babies following major cerebral insults, or with severe lung disease
  - treatment with indometacin or ibuprofen
- **Excessive losses:**
  - prematurity (most common cause after 48 hr of age)
  - adrenal insufficiency
  - GI losses
  - diuretic therapy (older babies)
  - inherited renal tubular disorders
- **Inadequate intake**
  - preterm breast fed infants age >7 days

**Management depends on cause**

**Excessive IV fluids and failure to excrete fetal ECF**

**Management**
- Reduce fluid intake to 75% of expected

**Inappropriate ADH**

**Clinical features**
• Weight gain, oedema, poor urine output
• Serum osmolality low (<275 mOsm/kg) with urine not maximally dilute (osmolality >100 mOsm/kg)

Management
• Reduce fluid intake to 75% of expected
• Consider sodium infusion only if serum sodium <120 mmol/L

Acute renal failure
Management
• Reduce intake to match insensible losses + urine output
• Seek advice from senior colleague

Excessive renal sodium losses
Management

| If possible, stop medication (diuretics, caffeine) that causes excess losses |

• Check urinary electrolytes
• Calculate fractional excretion of sodium (FE Na⁺ %):
  • FE Na⁺ = [(urine Na × plasma creatinine)/(urine creatinine × plasma Na)] × 100%
  • normally <1% but in sick preterm infants can be up to 10%
  • affected by sodium intake: increased intake leads to increased fractional clearance
  • if >1%, give sodium supplements
• Calculate sodium deficit
  • = (135 – plasma sodium) × 0.6 × weight in kg
  • replace over 24 hr unless sodium <120 mmol/L or symptomatic (apnoea, fits, irritability)
• initial treatment should bring serum sodium up to about 125 mmol/L
• Use sodium chloride 30% (5 mmol/mL) diluted in maintenance fluids

Adrenal insufficiency
Clinical features
• Hyperkalaemia
• Excessive weight loss
• Virilisation of females
• Increased pigmentation of both sexes
• Ambiguous genitalia

Management
• Seek consultant advice

Inadequate intake
Clinical features
• Poor weight gain and decreased urinary sodium

Management
• Give increased sodium supplementation
• If taking diuretics, stop or reduce dose

Excessive sodium intake leading to water retention
Clinical features
• Inappropriate weight gain

Management
• Reduce sodium intake
HYPERNATRAEMIA (>145 mmol/L)

Prevention
- Prevent high transepidermal water loss
- Use plastic wrap to cover babies of <30 weeks' gestation at birth
- Nurse in high ambient humidity >80%
- Use bubble wrap
- Minimise interventions
- Humidify ventilator gases

Causes
- Water loss
- Transepidermal water loss
- Glycosuria
- Excessive sodium intake
- Sodium bicarbonate
- Repeated boluses of sodium chloride
- Congenital hyperaldosteronism/diabetes insipidus (very rare)

Management depends on cause

Hypernatraemia resulting from water loss
Clinical features
- Leads to weight-loss with hypernatraemia

Management
- Increase fluid intake and monitor serum sodium
- If undergoing phototherapy, increase fluid intake by 10 mL/kg/day in preterm babies

Osmotic diuresis

Management
- Treat hyperglycaemia with an insulin infusion (see Hyperglycaemia guideline)
- Rehydrate with sodium chloride 0.9%

Hypernatraemia resulting from excessive intake

Management
- If acidosis requires treatment, use THAM instead of sodium bicarbonate
- Reduce sodium intake
- Change arterial line fluid to sodium chloride 0.45%
- Minimise number and volume of flushes of IA and IV lines

PRESCRIBING ELECTROLYTE ADDITIVES TO IV FLUIDS
- Use birth weight of baby until birth weight regained

Daily electrolyte requirements
- Sodium 2-4 mmol/kg/day (5 mmol = 1 mL sodium chloride 30%)
- Infants <30 weeks may need more than this to overcome renal tubular loss
- Potassium 2 mmol/kg/day (2 mmol = 1 mL potassium chloride 15%)
- Calcium 0.45 mmol/kg/day (0.45 mmol = 2 mL calcium gluconate 10%) if supplementation required

Calculate daily fluid requirement
- Include volumes of any additional infusions (e.g. IA line, sedation) in calculations of intake

Calculate hrly infusion rate of maintenance
- Volume of IV fluid to be infused over 24 hr (V) = total to be infused – other fluids

**Calculate amount of calcium gluconate**
- Amount of calcium gluconate 10% to be added per 24 hr = 2 mL/kg calcium gluconate 10% (Y mL) per V mL of fluid
- Amount of calcium gluconate 10% to be added to a 500 mL bag (X) = Y × (500) divided by V mL

**Worked example in a 2 kg baby on 120 mL/kg with UAC at 1 mL/kg**
Y (calcium gluconate 10 %) = 2 mL/kg × 2 = 4 mL
V = (120 mL/kg × 2 = 240 mL) – (UAC at 1.0 mL/hr = 24 mL) = 216 mL
X mL (calcium gluconate 10%) = 4 mL (Y) × 500, divided by 216 (V) = 9.3 mL
(round to nearest 0.5) = 9.5 mL

**Calculate amount of potassium**
- Use standard potassium-containing infusates
  - 10 mmol/500 mL should meet daily maintenance requirements;
  - for correction of hypokalaemia, use bag containing 20 mmol/500 mL

> **Avoid addition of potassium to existing infusates wherever possible**

**IV FLUIDS: some useful information**
- Percentage solution = grams in 100 mL (e.g. glucose 10% = 10 g in 100 mL)
- One millimole = molecular weight in milligrams

**Compositions of commonly available solutions**

<table>
<thead>
<tr>
<th>FLUID</th>
<th>Na mmol/L</th>
<th>K mmol/L</th>
<th>Cl mmol/L</th>
<th>Energy kCal/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium chloride 0.9%</td>
<td>150</td>
<td>-</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Glucose 10%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>400</td>
</tr>
<tr>
<td>Glucose 10% / sodium chloride 0.18%</td>
<td>30</td>
<td>-</td>
<td>30</td>
<td>400</td>
</tr>
<tr>
<td>Albumin 4.5%</td>
<td>150</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sodium chloride 0.45%</td>
<td>75</td>
<td>-</td>
<td>75</td>
<td>-</td>
</tr>
</tbody>
</table>

**Useful figures:**
- Sodium chloride 30% = 5.13 mmol/mL each of Na and Cl
- Sodium chloride 0.9% = 0.154 mmol/mL each of Na and Cl
- Potassium chloride 15% = 2 mmol/mL each of K and Cl
- Calcium gluconate 10% = 0.225 mmol/mL of Ca
- Sodium bicarbonate 8.4% = 1 mmol/mL each of Na and bicarbonate
- Sodium chloride 0.9% 1 mL/hr = 3.7 mmol Na in 24 hr

**Osmolality**
- Serum osmolality = 2(Na + K) + glucose + urea (normally 285–295 mOsmol/kg)
- Anion gap = (Na⁺ + K⁺) (Cl⁻ + HCO₃⁻) normally 7–17 mmol/L
- Normal urine: osmolality 100-300 mOsmol/kg, specific gravity 1004-1015
- Neonates can dilute urine up to 100 mOsmol/kg, but can concentrate only up to 700 mOsmol/kg

**Glucose**
- To make glucose 12.5%, add 30 mL of glucose 50% to 470 mL of glucose 10%
- To make glucose 15%, add 60 mL of glucose 50% to 440 mL of glucose 10%
- Glucose 20% is commercially available
• Glucose 10% with sodium chloride 0.18% and 10 mmol potassium chloride is not commercially available but can be made up using 3 mL sodium chloride 30% and a 500 mL bag of glucose 10% with 10 mmol potassium chloride