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FLUID AND ELECTROLYTES IN CHILDREN

Standard Operating Procedure (SOP)

Contents

FLUID AND ELECTROLYTES IN CHILDREN 1
FLUID AND ELECTROLYTES IN CHILDREN 1
1) Fluid and Electrolyte Imbalances in Children 1
Table 2.1 Normal fluid requirements 1
Table 2.2 Normal electrolyte requirements 1
2) SIADH (Syndrome of Inappropriate Antidiuretic Hormone Secretion) 2
Following disorders are usually associated with SIADH: 2
Management 2
3) Sodium Disorders 3
Sodium is major cation of the extracellular fluid 3
Hyponatremia 3
Management 3
Hypernatremia 3
Clinical manifestation 4
Management 4
Rehydration phase 4
Mild hypernatraemic dehydration (Na* 146-149 mmol/L) 5
Moderate hypernatraemic dehydration (Na* 150-169 mmol/L) 5
Severe hypernatraemic dehydration (Na*2170 mmol/L) 5
Hypovolemia with hypernatremia 5
4) Potassium Disorders 7
Serum Potassium <3.5 mmol/L 7
Renal losses 7
Clinical feature 7
Investigations 7
Management 7
Note 8
Serum potassium >5 mmol/L 8
Causes 8
Clinical feature 8
Investigation 8
Management 9
5) Calcium Disorders 10

Serum calcium <2 mmol/L 10
Ionized calcium <1 mmol/L 10
Causes 10
Clinical manifestation 10
Management of hypocalcemia 10

FLUID AND ELECTROLYTES IN CHILDREN

1) Fluid and Electrolyte Imbalances in Children

Introduction

Water constitutes 70-80% of body weight in full term and preterm babies and decreasing to 60% by one year of age, intracellular fluid constitutes 30-40% and extracellular fluid (intravascular, interstitial and transcellular) constitutes 20-25% of body weight.

- *Osmolality of plasma-280 mosm/kg of water (275-295 mosm/kg)*
- *Insensible losses-10-30 ml/kg/day*
- *Urinary losses-1-2 ml/kg/hour*

In patients with persistent increase in temperature, there is 10-15% increase in maintenance water needs for each 1ºC increase in temperature above 38ºC due to evaporative losses from skin.

Table 2.1 Normal fluid requirements

Body weight	*Fluid requirement/day*	*Fluid requirement/hour*
First 10 kg	*100 ml/kg*	*4 ml/kg*
Second 10 kg	*50 ml/kg*	*2 ml/kg*
Subsequent kg	*20 ml/kg*	*1 ml/kg*

For example:

Maintenance fluid requirement for 25 kg child is:

For 1st 10 kg-------- 100ml/kg--------- 10 x 100 = 1000 ml

For 2nd 10kg-------- 50 ml/kg-------- 10 x 50 = 500 ml

For the rest kg-------- 20 ml/kg------ 5 x 20 = 100 ml

Total 1600 ml /day

NB. Maximum normal requirement for male is not more than 2.5 L/day and not more than 2 L/day for that of female.

Table 2.2 Normal electrolyte requirements

Sodium	*3-4 mmol/kg*
Potassium	*2-3 mmol/kg*
Chloride	*2-4 mmol/kg*
Calcium	*0.5-1 mmol/kg (200-500 mg/kg calcium gluconate)* *Maximum 2 g/day in infants, and 3-4 g/day in older Children)*
Magnesium	*0.25 mmol/kg*
Phosphate	*2 mmol/kg*

Fluid Replacement in Dehydration
Formula for calculating deficit
Percentage of dehydration x Weight in kg x 10
Example

1. *5% Dehydration (some dehydration) in 6 kg child = 5 x 6 x 10 = 300 ml*
   100 ml/kg for daily maintenance fluid = 600 ml
   Rehydration + maintenance = 900 ml to be replaced in 24 hours
2. *10% dehydration loss in 6 kg child*
   Deficit fluid = 10 x 10 x 6= 600 ml

2) SIADH (Syndrome of Inappropriate Antidiuretic Hormone Secretion)

SIADH causes hyponatremia with water retention due to excessive ADH activity with continues sodium excretion, The urine osmolality is inappropriately high for serum sodium concentration (>100 mosm/kg). Urine Na is greater than 20 mmol/land serum osmolality is less than 280 mosm/kg.*

Following disorders are usually associated with SIADH:

- *CNS*
  - *Bacterial meningitis*
  - *Encephalitis*
- *Pulmonary*
  - *Pneumonia*
- *Cardiac*
  - *Congestive heart failure*
- *Infection*
  - *Sepsis (bacterial/viral)*

Management

- *Treat underlying cause*
- *Fluid restriction to 60% maintenance requirement using 0.45% saline*
- *If Hyponatremia is symptomatic (having seizures) or Serum Sodium <120mmol/L, replacement with 3% Saline (513 mmol/L of Na*) necessary to correct serum Na* to 125 mmol/L over 48 hours*
- *Na* requirement mmol = 0.6 x weight in kg x (140- Sodium measured)*

3) Sodium Disorders

Sodium is major cation of the extracellular fluid

- *Range - 135-140 mmol/L*
- *It is important in maintaining cell turgor, intracellular volume, nerve action potential*
- *Sodium level must be brought back to normal at a rate that does not exceed0.5-1 mmol/L/hour because too rapid correction of hypernatremia may lead to cerebral edema and injury whereas hyponatremia can cause brain damage*

Hyponatremia

Serum Sodium <130 mmol/L
Clinical feature

- *Depend on primary condition*
- *Sign of hypovolemia and dehydration/ fluid overload and edema*
- *Apathy*
- *Headache, nausea, vomiting*
- *Lethargy ataxia*
- *Poor perfusion*
- *Hypotension*
- *Serum sodium <125 mmol/L> confusion, seizure and coma*

Management

- *If in shock, give 20 ml/kg of 0.9% saline (0.9% Normal saline contain 154 mmol/L of sodium)*
- *If serum sodium is less than 120 mmol/L or patient is symptomatic and fitting consider 3% saline till serum sodium level to 125 mmol/L*
- *The rest of the sodium deficit should be replaced over 48 hour with 0.9% saline and after calculating sodium deficit*
- *Dose of sodium (mmol) = Weight in kg x 0.6 x (140-current serum sodium)*

Hypernatremia

Serum Sodium >150 mmol/L
Causes

- *Increased sodium containing fluid*
- *Gastroenteritis: bacterial/viral*

- *Phototherapy*
- *Increased insensible water loss*

Clinical manifestation

If serum osmolality is more than 335 mosm/kg due to hypernatremia, there is increase in frequency of intraparenchymal bleeding and venous thrombosis.

- *irritability*
- *Vomiting*
- *Central nervous system bleeding*
- *Lethargy, confusion*
- *Seizure*
- *Coma*

Management

In general, recommendations for treating hypernatremic dehydration consist of:
Emergency phase

- *Restoration of vascular volume with 10 to 20 ml/kg of isotonic intravenous fluid such as lactated Ringer solution with 130 mEq/L (130 mmol/'L) of sodium or normal saline with 154 mEq/L (154 mmol/ L) of sodium*

Rehydration phase

Fluid management should be based on the initial serum sodium

- *Free water deficit (L)=0.6 x wt (kg) x (1-current sodium/desired sodium)*
- *Start with calculated maintenance fluid volume + estimated rehydration volume (free water deficit) given as constant infusion over 48 hours*
- *During the rehydration phase, 5% dextrose in 0.2% normal saline (31 mEq/L(31 mmol/L)of sodium) is the usual IV fluid composition*
- *If the initial serum sodium level is very high, suggest usually 0.45% saline with5%dextrose is used as starting solution for rehydration*
- *Ideally weight and serum sodium level should be checked every 4 hour and modify the replacement accordingly*
- *The aim is to reduce serum sodium level at a rate not more than 0.5-1 mmol/L/hour*
    - *Monitor fluid status, urine output*
    - *Monitor other electrolytes and blood sugar*
    - *Measure ongoing losses (i.e. vomiting or diarrhoea, excluding urine)*
    - *Careful neurological monitoring*

    Example for 12 Kg child with 5% dehydration:
    - *Maintenance fluid = 1100 ml/24 Hr*
    - *Deficit = 5%of12000gm = 600 ml*

- *Replace deficit over 48 Hr (1100+1100+600) = 2800 ml in 48 Hr*

Mild hypernatraemic dehydration (Na* 146-149 mmol/L)

- *Rarely requires specific management.*
- *Manage underlying cause.*
- *Repeat in 4-6 hours if clinically indicated.*

Moderate hypernatraemic dehydration (Na* 150-169 mmol/L)

- *After initial resuscitation, replace the deficit plus maintenance slowly at a uniform rate over 48 hours.*

Severe hypernatraemic dehydration (Na*2170 mmol/L)

- *Medical emergency*
- *Tertiary referral and contact Intensive care*
- *When the serum sodium is greater than 175 mEq/L (175 mmol/L), IV fluids traditionally considered isotonic actually are hypotonic compared with the patient's serum.*
- *If the serum sodium is 195 mEq/L (195 mmol/L), and is given a large amount of 0.9% normal saline to restore vascular volume, serum osmolality may fall rapidly, leading to cerebral edema and death.*
- *Therefore, if the serum sodium is greater than 175 mEq/L(175 mmol/L) various amounts of 3% normal saline (513 mEq/L [513 mmol/L] sodium) should be added such that the IV fluid sodium concentration is approximately10 to 15 mEq/L (10 to 15 mmol/L) lower than the serum sodium level.*
- *The maximum rate of decrease of the serum sodium level should be (0.5mmol/L) per hour or 12 mEq/L (12 mmol/L) per day.*
- *The free water deficit should be calculated to lower the serum sodium level by 12 mEq (12 mmol)/d and may take longer than 48 hours to correct.*
- *It is important to monitor the patient's electrolytes frequently and adjust the rate or composition of the IV fluid to prevent the serum sodium level from decreasing too rapidly*

Hypovolemia with hypernatremia *(Decreased body weight (BW), much decreased total body water (TBW), and decreased total body sodium)*

- *Managed as hypernatremic dehydration*
- *For example: 7 kg weighed infant with 10% dehydration and measured sodium 165 mmol/L -Fluid and electrolytes are calculated as following table*
  Desired plasma sodium: 135 mmol/L
  Total body water = BW x0.6=7 x0.6 (liter)
  Correct deficit over 48 hours

Maintenance	*Replacement of loss*	*Total requirement*
Water = 100x7x2 = 1400 ml	*Water = 7 x 0.1 x 1000 = 700 ml* *Free water deficit = 580 ml*120 ml loss as isotonic solution*	*Water needed: 1400+700 ml = 2100 ml*
Sodium = 3 mmol/L x 7 x 2 = 42 mmol/L	*Sodium loss = 154 x (700-580) = 18 mmol/l*	*Sodium needed = 42+18 = 60 mmol/l*

**Free water deficit = [(Current Na level in mmol/L÷145 mmol/L)-1] x 0.6 x body weight (kg)*
= [(165 +145)-1] x 0.6 x 7
= 579 ml (580 ml)

Therefore,60 mmol of sodium in 2100 ml water is infused over 48 hours.
Review electrolytes in 4 hours and adjust changes if necessary.

- *If patient is in shock, give 10-20 ml/kg of 5% albumin or normal saline over 30 minutes*
- *If oliguric, give 10-20 ml/kg of 0.45% saline hourly till urine flow is established*
- *Correction of water deficit + maintenance should be done over 48 hours*

Euvolemic hypernatremia (Decreased or normal BW, decreased TBW and normal total body sodium)

- *Calculate water replacement required for tonicity change*

$$\text{Volume of water required to lower sodium} = \frac{(\text{Measured Na}^* \times \text{TBW}^*) - \text{TBW}}{\text{Desired plasma sodium}}$$

**TBW = 0.6 x BW*

Hypervolaemic hypernatremia (increased BW, increased TBW and increased total body sodium)

- *Example in acute salt poisoning*
  - *Furosemide diuresis and replaced urine output with dextrose solution*
  - *Dialysis therapy*

4) Potassium Disorders

Hypokalemia

Serum Potassium <3.5 mmol/L

Causes

Decreased intake/Gastrointestinal losses

- *Vomiting and diarrhoea*
- *Nasogastric drainage*
- *Chemotherapy induced*

Renal losses

- *Diuretics*
- *Tubular diseases e.g. RTA, Bartter's syndrome*
- *Cushing's syndrome*
- *Metabolic alkalosis*

Clinical feature

- *Muscle weakness, cramp, intestinal ileus and gastric dilatation*

Investigations

- *ECG abnormalities-Flatten T wave, T inversion, appearance of U wave*
- *Urea and electrolytes (U & E)*

Management

- *Treat underlying cause*
- *Correction of acid base status and accompanying electrolyte abnormalities*
- *If Serum potassium is <2.5 mmol/L, 0.5 mmol/kg of KCL infusion over one hour with continuous ECG monitoring (Risk-Ventricular fibrillation)*
- *The bolus should not exceed 20mmol and should not be more concentrated than 40 mmol/L KCL*
- *Ideally K* level should be repeated after 2 hour*
- *If Serum K* is more than 2.5, the hypokalemia should be corrected using Potassium Chloride (ORs contain KCL- 1.5 gm/L which 27 mmol)*

- *For DKA Patient, add Potassium Chloride or Potassium Phosphate 20 mmol/Lof fluid to prevent hypokalaemia*

Potassium deficit (mmol) = 0.6 x body wt (kg) x (4-Serum potassium)

Note

- *Absolute maximal 1 hour IV dose is 0.4 mmol/kg*
- *Potassium replacement should only be given when urine output is established*
- *Oral potassium replacement is safer if patient can retain oral feeds*

Hyperkalaemia

Serum potassium >5 mmol/L

Causes

- *Impaired renal excretion*
  - *Renal Failure*
  - *Severe rapid haemolysis*
  - *Haemolytic uraemic syndrome*
- *Latrogenic*
  - *Stored blood, platelet transfusion*
  - *Tumour lysis syndrome*
  - *Metabolic acidosis*
  - *ACE inhibitor*

Clinical feature

- *Paresthesia*
- *Muscle weakness*
- *Flaccid paralysis*
- *Cardiac arrest*

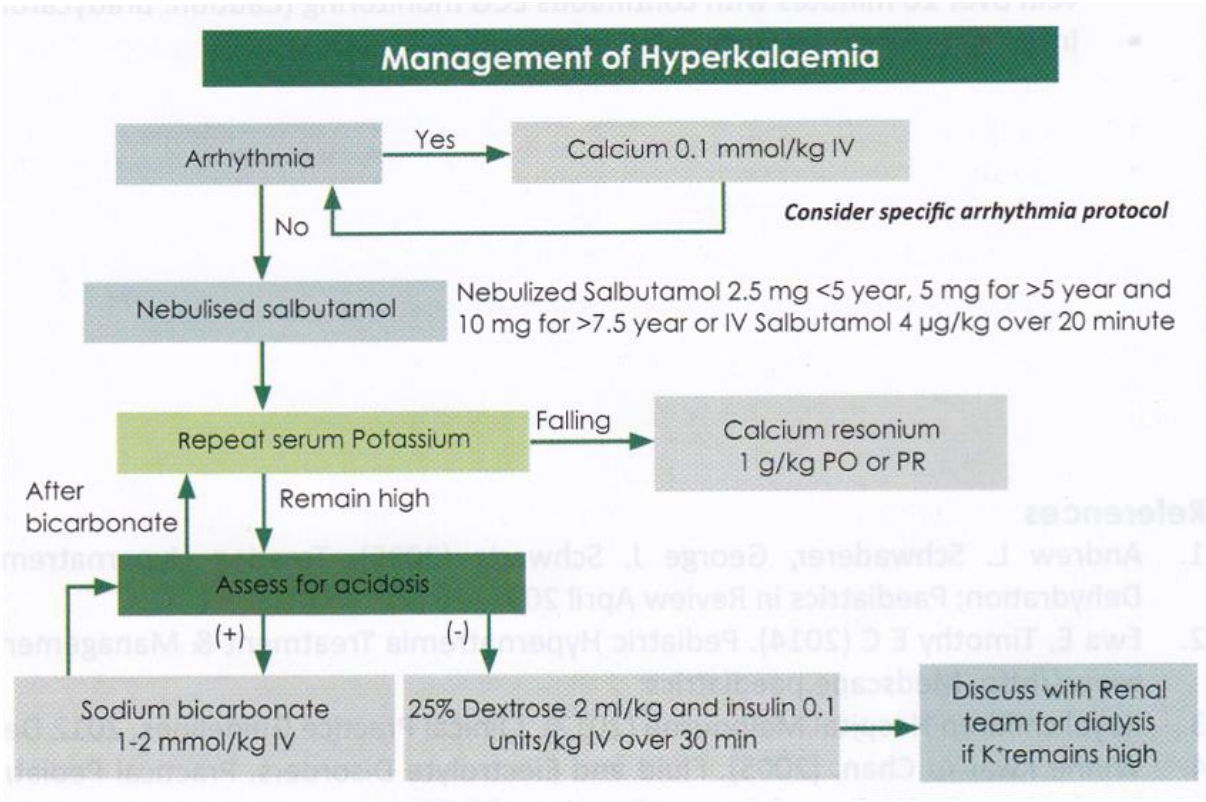
Investigation

- *Urgent U & E*
- *Glucose*
- *ECG - Peaked T wave, lengthen PR interval, widen QRS complex, flatten P, progress to ventricular fibrillation*

Management

(See below algorithm)

- *Stop IV fluid containing K or any contributory medication*
- *Start cardiac monitoring*
- *Protect myocardium with 10% calcium gluconate 1.5-3.0 ml/min and monitor the patient for bradycardia and hypotension*



5) Calcium Disorders

Hypocalcemia (Izonized Hypocalcemia)

Serum calcium <2 mmol/L

Ionized calcium <1 mmol/L

Causes

- *Blood transfusion (chelation)*
- *Sepsis*
- *Burns*
- *Neonatal hypocalcemia*
- *Hyperphosphatemia (due to tumour lysis syndrome, renal failure)*

Clinical manifestation

- *Tetany*
- *Respiratory effect - Stridor, laryngospasm, apnoea*
- *Neuromuscular effect - Muscle cramps, muscle twitching, carpopedal spasm, Chvostek's sign and Trousseau's sign postive*
- *Paresthesia, seizure especially in neonate*
- *Cardiovascular effect - Hypotension, poor myocardial contractility, catecholamine unresponsiveness, dysrhythmias - Prolonged OT interval, T-wave inversion and bradycardia*

Management of hypocalcemia

Emergency treatment

- *10% Ca gluconate 0.5 ml/kg (diluted 1 in 10 with distilled water) IV via major vein over 20 minutes with continuous ECG monitoring (Caution: bradycardia)*
- *Investigate and treat underlying cause*