Guidelines for management of

Hypernatremia

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Hypernatremia

Hypernatremia (HRN), defined as serum sodium >145 mmol/l, represents hyperosmolality. Although it reflects a deficiency of water relative to sodium, total body sodium may be high, normal or low. HRN is mirror image of hyponatremia.
Serum sodium (Na) level (hence osmolality) is tightly controlled within a narrow range despite wide variations in Na and water intake, by regulation of urine concentration (via *ADH secretion*) and regulation of *thirst response* (more effective). HRN is extremely rare in an alert patient with intact thirst mechanism and having free access to water. The two mechanisms that result in HRN are loss of water in excess of Na & gain of Na in excess of water.

HRN induced osmotic gradient result in water movement out of the cells into ECF (ECF volume relatively well maintained, hence the less evident signs of hypovolemia). This cellular dehydration in brain cells ('cerebral dehydration' result in local hyperosmolality and reduced `brain volume`) is responsible for the neurological symptoms seen in HRN.
Partial restitution of brain volume occurs by intracellular accumulation of electrolytes (within few hours - '*rapid* adaptation') and organic osmolytes (over several days-'*slow* adaptation'). However they can dissipate only *slowly* out of the cells when HRN is corrected, hence *rapid* correction carries the risk of cerebral edema.

Table 1. Causes of hypernatremia – (Hypovolemic HRN is the commonest)

Hypovolemic :ECF volume contraction (Total body water ↓↓, Total body Na ↓)	**Euvolemic : ECF volume normal (Total body water ↓, total body sodium ↔)**
GI(diarrhea, vomiting) Evaporative(high ambient temp/pyrexia) Diabetes insipidus (central/nephrogenic) Head trauma/ Sheehan's syndrome Tumours/ histiocytosis Degenerative brain diseases/infections Chronic renal failure Hypokalemia/ hypercalcemia Sickle cell disease Renal medullary damage/papillary necrosis Chronic pyelonephritis Nephronophthisis Ineffective breast feeding Osmotic/loop diuretic therapy	Unconscious patients/infants Lack of access to water Primary adipsia Essential hypernatremia (osmoreceptor destruction/malfunction) **Hypervolemic ; ECF volume expansion (total body water ↑, total body sodium ↑↑)** Inappropriate IV fluid therapy (with high Na) Salt poisoning /improperly mixed formula Seawater/sodium chloride ingestion Minaralocorticoid excess (Cushing`s/Conn`s synd)

Signs & Symptoms:

1. Of underlying problem (e.g. suggestive of DI)
2. Most have symptoms of volume depletion (common cause), but are less symptomatic initially as they have better preservation of intravascular volume.
3. CNS symptoms- Severity of the neurological symptoms is related to both the *degree* and, more importantly, the *rate* of rise in the serum Na. Hence patients with chronic HRN may be relatively asymptomatic.
   The symptoms include high pitched cry, irritability, lethargy, weakness which can progress to twitching, seizures, coma and death in severe cases.

Consequences of hypernatremia

1. Brain haemorrhage- Due to tearing of intracerebral veins and bridging blood vessels resulting from decrease in brain volume. This could take the form of subarachnoid, subdural, parenchymal and intraventricular hemorrhage, presenting clinically as seizures and coma.
2. Central pontine and extra pontine myelinolysis
3. Thrombotic complications- stroke, dural sinus thrombosis, peripheral including renal vein thrombosis.
4. Hyperglycemia and hypocalcaemia

Table 2. **Investigations**

In addition to the appropriate tests to **confirm the underlying disorder**, the following investigations are essential (also refer Polyuria for DI)

Blood	**Urine**
Osmolality Sodium, potassium, chloride, bicarbonate Urea, creatinine, glucose, calcium, Ph, Glucose Blood gas if bicarbonate is abnormal	Osmolality Sodium, potassium, chloride Urea, creatinine Calculate-Fractional excretion of sodium (**FENa** = UNa / PNa x PCr / UCr) -Fractional excretion of water (**FEH_2O** = PCr / UCr)

Management of hypernatremia

Basic principles-

1. Identify and treat the underlying cause
2. **HRN should be corrected slowly (particularly if HRN is of unknown duration or chronic)** as rapid correction can induce cerebral edema, seizures, permanent neurological damage and death (rate of correction of Na should be <0.5 mmol/l/hour or <12 mmol/l/day). It is usually corrected over 48 hours but over 72 hours if serum Na is > 170 mmol/l.
3. Those with chronic HRN tend to be the least symptomatic and are at higher risk of cerebral edema if rapidly corrected. If serum Na drops fast during correction and the patient is symptomatic, hypertonic saline might be needed (4-6ml/kg of 3% sodium chloride). Acute HRN can be corrected relatively rapidly.
4. Monitor (paired) osmolality and electrolytes in both serum & urine frequently (6 hourly) to make necessary adjustments to IV therapy.
5. Fluids (dioralyte, water or diluted feeds-based on etiology) can be administered orally. However it is advisable to use IV route if HRN is severe or GI intake or absorption is disturbed (e.g. vomiting or diarrhea)
6. Strict I/O chart, twice daily wt and strict control over Na administered in any form.
7. HRN impairs insulin and PTH release and hence patients should be monitored for

hyperglycemia and hypocalcaemia during correction period. Hyperglycemia in these patients is usually not treated with insulin as it may precipitate cerebral edema.

8. It is important to **keep the possibility of diabetes insipidus** in mind if the history or assessment is suggestive, as even hypotonic fluid administrated in error might significantly increase serum sodium levels

Hypovolemic HRN-

The basic principal of fluid replacement do not differ from those in hypotonic or isotonic dehydration.

1. If the patient is in shock or haemodynamically compromised (significant ECF volume. depletion) administer enough normal saline till ECF volume is restored. More dilute solutions (0.45% saline or 0.18% saline with dextrose) can be substituted once tissue perfusion is adequate.

2. Ongoing losses (urinary or GI) must be included in the replacement calculations. If the patient is loosing pure water (e.g. DI), administer free water orally or IV (as 5% Dextrose). Use hypotonic saline if Na depletion is also present (e.g.vomiting, diarrhea).

Amount and type of IV fluids used for further management of HRN-

It is done using one of the two methods.

A. First approach (preferred)-

1. Calculate insensible loss (400ml/sq.m/day) and total deficit volume (based on % of dehydration –to be corrected over 48-72 hours)
2. Keep a close eye on urine output (catheterize if needed) and ongoing losses.
3. Measure serum and urine U& E 4-6 hourly
4. Use 0.45% or 0.18 % saline with dextrose till urine & blood results are ready

IV fluid (2 drips given via Y connector)

Drip 1. Replace insensible loss ml for ml with 5% dextrose

Drip 2. Replace urine output, deficit and ongoing losses ml for ml as dextrose saline with sodium content about 10-15 mmol (per litre) less than urine sodium (Table 3)

Table 3. **Sodium concentration in different IV fluids**

Urine sodium (mmol/l)	**IV fluid to be used**	**Sodium content (mmol/l)**
165	Normal saline	154 mmol/l
90	0.45% saline	75 mmol/l
45	0.18% saline	30 mmol/l
15	5% dextrose	nil
Other values	Prepare a solution with Na content about 10- 15 mmol (per liter) less than urine Na in 5%dextrose using 3% Nacl	

Review frequently and change IV fluid as suggested by urine sodium.

Example- 15 kg child with hypovolemic dehydration and ser Na of 165 mmol/l. The estimated insensible loss (based on surface area of 0.6) is 240 ml/day. Estimated deficit is 200 ml, ongoing losses around 150 ml/day and passing 30 ml/hour urine with 42mmol/l of sodium. Plan for IV fluids should be

Drip 1- 10 ml/hour (240/24) of 5 % dextrose (insensible loss)
Drip 2- [30+ (150/24) + (200/48)] mls/hour
(hourly urine output + ongoing loss +deficit)
= 40ml/hour of 0.18% saline (with dextrose)

B Second approach-

1. Calculate total body water (**TBW) = *0.6 × (Wt in Kg)***
2. Select the IV fluid you want to use and identify the amount of Na in mmol/l (Table 3)
3. Calculate the effect of one liter of your selected IV fluid (IVF) on serum sodium (in mmol/l) according to the formula-

Change in serum Na for 1 Lit of IVF= [IVF Na-serum Na] ÷ [TBW+1]
= x mmol

If you are also giving potassium in IVF, modify the formula as follows;

Change in serum Na for 1 Lit of IVF= [(IVF Na+ IVF K)-serum Na] ÷ [TBW+1]
= x mmol

4. Decide how quickly you want to correct.
The normal rate of sodium correction is around 10 mmol/l/day

Amount of IVF needed in next 24 hours = 10 ÷ x
= y litres

5. Account for insensible losses (***z mls/day***) and ongoing loss ***(w mls/day***)

6. Add ***y liters*** *(convert to mls)* **+ *z mls* + *wmls* and divide by 24 to get hourly rate of IVF**

Euvolemic HRN

1. As above
2. In some instances of HRN due to pure water loss (resulting usually in euvolemic HRN), the following formula is used to calculatethe amount of pure water loss.

Pure water deficit = TBW × (1-[140 ÷serum sodium])

Hypervolemic HRN (salt excess)

HRN in this setting will correct spontaneously if renal function is normal (excess Na is rapidly excreted in urine).

1. Loop diuretics are sometime used to facilitate the diuresis.
2. Acute severe HRN- Is usually secondary to excessive sodium administration or intoxication and can be corrected relatively rapidly. But it may be impossible to administer enough water to rapidly correct the HRN without worsening volume overload. Peritoneal dialysis (dialysis fluid with high glucose & low Na concentration) is useful in this setting to remove excess Na.

3. Dialysis (PD or HD) is also useful if patients with Hypervolemic HRN also have concurrent renal insufficiency.

Management of Diabetes insipidus

See the section on polyuria

Table 4. **Differences between hypertonic dehydration and salt overload (e.g. salt poisoning)**

Features	Hypertonic dehydration	Salt overload
Weight	↓	Normal or ↑
History of diarrhea	Present	Absent
Signs of dehydration	Present	Absent
Urea & Creatinine	May be ↑	Normal
Fractional excretion of Na (FeNa)	Normal or ↓	↑ (> 3%)
Fractional excretion of water (FeH2O)	Often <1 %	>1 %
Metabolic Acidosis	Non-discriminatory	Non-discriminatory
Urine sodium concentration	Non-discriminatory	Non-discriminatory

Approach to a child with Hypernatremia