Hypernatremia

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A 75-year-old male patient, a case of chronic obstructive pulmonary disease (COPD), was transferred from another hospital with complaints of fever, increased breathlessness for 5 days, and altered sensorium since 1 day. He also had an episode of seizure 1 day. He was being managed on the lines of acute exacerbation of COPD with cor pulmonale with pneumonia. He received antibiotics and diuretic therapy in the previous hospital. On evaluation, his laboratory values showed hemoglobin 13 g/dL, packed cell volume of 38.5%, serum sodium 160 mEq/L, serum potassium 3.0 mEq/L, serum urea 146 mg/dL, and serum creatinine of 1 mg/dL.

Hypernatremia is a common problem characterized by a rise in serum sodium above 145 mEq/L. This is a hyperosmolar condition caused by a decrease in total body water relative to the sodium content. Hypernatremia is caused by impaired thirst and restricted water intake which is often exacerbated by conditions leading to increased fluid loss. The goal of management involves identification of hypernatremia and correction of volume disturbances and hypertonicity.

Step 1: Initiate Resuscitation (Refer to Chap. 23, Vol. 2)

- Assess and secure the airway and provide ventilatory support when required.
- Differentiate between Hypovolemia which is due to water and sodium loss and dehydration which is predominantly due to water loss.
- Infuse isotonic sodium chloride in hypovolemic patients.

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Step 2: Take History and Do Physical Examination

- This should be done to assess the etiology of hypernatremia and severity of the problem.
- Look for symptoms suggestive of hypernatremia (Table 2.1). These are nonspecific and may even mimic rapid fall of serum sodium.
- History should be taken focusing on of the following problems:
  - Extrarenal fluid losses (e.g., burns, vomiting, diarrhea, fever, high minute ventilation in mechanically ventilated patients)
  - Decreased fluid intake
  - Polyuria (i.e., signs of diabetes insipidus [DI] or osmotic diuresis)
  - Review drug chart (drugs causing DI, osmotic diuretics, osmotic laxatives)
  - Review previous sodium levels to assess chronicity
  - Hypertonic solution infusion (sodium bicarbonate, hypertonic saline, total parenteral nutrition)
  - Hypertonic feed (high-protein formula, concentrated formula)

Step 3: Assess Volume Status

- This is important to understand the underlying pathophysiology of hypernatremia (Table 2.2) and plan the treatment strategy.
- Volume status can be assessed by clinical means, hemodynamic monitoring, and urine biochemistry (Table 2.3).

Step 4: Send Investigations

- Arterial blood gases and serum electrolytes
- Blood glucose, blood urea, and serum creatinine
- Serum uric acid
- Hematocrit
- Serum osmolality and urine osmolality
- Urinary sodium and chloride
- If indicated do imaging studies: Head CT scan or MRI

Table 2.1 Clinical features suggestive of hypernatremia

Central nervous system			
Anorexia	Restlessness	Confusion	Weakness
Lethargy	Seizure	Respiratory failure	Coma
Musculoskeletal symptoms			
Twitching	Hyperreflexia	Ataxia	Tremor

Table 2.2 Pathophysiology of hypernatremia

Hypovolemic (i.e., water deficit > sodium deficit)
Extrarenal losses—diarrhea, vomiting, fistulas, significant burns
Renal losses
Osmotic diuretics
Diuretics
Postobstructive diuresis
Intrinsic renal disease(renal tubular disease)
Adipsic hypernatremia is secondary to decreased thirst
Damaged hypothalamic thirst centers
Hypervolemic (i.e., sodium gain > water gain)
Hypertonic saline
Sodium bicarbonate administration
Accidental salt ingestion (e.g., error in preparation of infant formula)
Mineralocorticoid excess (Cushing's syndrome)
Euvolemic
Extrarenal losses—increased insensible loss (e.g., hyperventilation)
Renal losses—central DI, nephrogenic DI
Mostly free water loss is from intracellular and interstitial spaces

Table 2.3 Assessment of low volume status

A. Clinical
Increasing thirst
Dry tongue, sunken eyes, reduced skin turgor on forehead and sternal skin
Orthostatic tachycardia (>20/min rise of pulse rate)
Orthostatic hypotension (>20 mmHg fall in systolic BP or >10 mmHg fall in diastolic BP)
Resting tachycardia and hypotension
Low urine output, concentrated urine (extrarenal loss)
B. Hemodynamic
Low central venous pressure
Arterial pressure variation (in ventilated patients)
Rising arterial pressure on passive leg raising (spontaneously breathing patients)
C. Biochemistry
Rising hematocrit
Rising albumin
Raised urea in proportion to serum creatinine
High serum uric acid
High urine osmolarity
Low urine sodium (extrarenal loss)
Low urine chloride (metabolic alkalosis)

Step 5: Make a Diagnosis

- Serum osmolality is always increased in patients with hypernatremia.
- Urine osmolality of less than 300 mOsmol/kg with high serum osmolality or, urine osmolality <100 mOsmol/kg with normal serum osmolality may be due to DI (central or nephrogenic), which can be distinguished by response to vasopressin.
- Urine osmolality of more than 600 mOsmol/kg could be due to unreplaced gastrointestinal or insensible loss (urine sodium <20 mEq/L) or excess sodium administration by enteral or parenteral route (urine sodium >40 mEq/L).
- Urine osmolality of 300–600 mOsmol/kg may be due to osmotic diuresis (check for glycosuria), partial central or nephrogenic DI.
- Calculate total solute excretion (urine osmolality × urine volume); if more than 1000 mOsmol per day—osmotic diuresis.

Step 6: Treatment

- Aim for symptom resolution, 10–15% improvement in sodium levels in first 24 h.
- Correction in chronic (>48 h) settings:
  - Total less than 10–12 mEq/24 h
- Rapid correction will cause rapid shift of water inside the brain causing cerebral edema and seizures.

Step 7: Calculate Water Deficit

$$\text{Water deficit}\left(\text{L}\right)=\text{total body water}\left(\text{TBW}\right)\times\left[\left(\text{measured Na}/140\right)-1\right]$$

$$\text{TBW}=\text{body weight}\left(\text{kg}\right)\times\text{" Y"}$$

Y = children	Adult men	Adult women	Elderly men	Elderly women
0.6	0.6	0.5	0.5	0.45

(Y= This is percentage of water of the total body weight.)
For example:

- 60 kg adult woman with serum sodium of 160 mEq/L.
- Free water deficit = [(0.5 × 60)] × [(160/140) − 1] = 4.2 L.
- This can be given as 5% dextrose or free water by the nasogastric tube or orally.
- Free water deficit = 4.2 L (see above).
- Thus, 4.2-L positive water balance must be achieved to get serum sodium down from 160 to 140 mEq/L or by 20 mEq.
- Rate of correction = 0.5 mEq/h.

- 4.2 L of free water to be given over 40 h at a rate of approx.100 mL/h.
- Insensible water loss (30 mL/h) should be added.
- Thus, 130 mL/h of free water needs to be replaced for 40 h.
- This can be done with IV 5% dextrose, 0.45% saline or water by the nasogastric tube or orally.
- Large volume of 5% dextrose will lead to hyperglycemia, and if needed, insulin should be given to prevent glycosuria, otherwise osmolar diuresis can worsen hypernatremia.
- Sodium and/or potassium can be added to the intravenous fluid as necessary to treat concurrent volume depletion and/or hypokalemia (e.g., due to diarrhea).
- The addition of solutes decreases the amount of free water that is given.
- If potassium is also added, then even less free water is present and a further adjustment to the rate must be made.
- Repeat sodium level and entire calculation every 12 h and replan infusion rate. (This is because the urinary free water loss is not taken into account and it keeps on changing.)
- In general a net positive balance of 3 mL of electrolyte free water per kg body wt will decrease serum sodium by 1 mEq/L.
- Initially 5% dextrose at the rate of 3–5 mL/kg/h should be infused which should be reduced to 1 mL/kg/h once serum sodium normalises.
- These calculations are only approximations and frequent sodium and glucose measurement very 4–6 h should be performed till serum sodium is 146 mEq/L.

Step 8: Manage Specific Hypernatremic States

Hypovolemic hypernatremia	Volume deficit always takes precedence over correcting water deficit
	Correct volume deficit initially by isotonic saline until improvement of orthostasis, tachycardia, and urine output
	Calculate and correct water deficit
	Treat the etiology of volume loss
	After correction of volume deficit, administer 0.45% saline, 5% dextrose, or oral water, replacing deficit and ongoing losses
Euvolemic hypernatremia	Correct water deficit
	Administer 0.45% saline, 5% dextrose, or oral water, replacing deficit and ongoing losses
	Follow serum [Na] carefully to avoid water intoxication
	Central DI—treat underlying disease, long-term nasal pitressin
	Nephrogenic DI—correct calcium, potassium; remove offending drugs; low-sodium diet
Hypervolemic hypernatremia	Remove the source of extra sodium
	Correct the cause
	Loop diuretics alone can worsen hypernatremia. Thus combining with metolazone or thiazide diuretics will be a better choice
	Hemodialysis may be performed in renal failure

Suggested Reading

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