Hyponatremia

- Serum sodium concentration <135 mEq/L
- Severe hyponatremia <120 mEq/L
- Disorder of water, not salt
- Occurs in ~15% of all hospital inpatients
- Increased morbidity and mortality
- Symptoms depend on rate of fall
**Total Body Water**
(60% of Body Weight)

**Intracellular**

**Interstitial**

**Intravascular**

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**Normal Water Regulation via ADH**

- **Sosm**
  - Water load, causing decreased serum osmolality

- **ADH**
  - Leading to suppressed ADH (vasopressin)

- **Uosm**
  - Leading to water excretion in dilute urine (decreased Uosm)

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**Impaired Renal Water Excretion**

1. Inability to suppress ADH
   - True hypovolemia: low Sosm, low arterial blood volume
   - Effective arterial blood volume depletion: cirrhosis, CHF
   - Endogenous stimuli: nausea, pain
   - Thiazide diuretics: reabsorb water, less NaCl reabsorption in distal tubule
   - SIADH

2. Suppressed ADH but overwhelmed excretory capacity of kidney
   - Advanced renal failure
   - Primary polydipsia
   - Beer potomania
Renal Na+ reabsorption (low Una) → Extracellular volume expansion

Renin release

Angiotensin I → Angiotension II → Aldosterone

Hypotension or hypovolemia → Renal hypoperfusion

When should I worry a lot?
1. Symptoms:
   - Headache
   - Muscle cramps
   - Reversible ataxia
   - Psychosis
   - Lethargy
   - Apathy
   - Agitation
   - Seizures
   - (Coma, respiratory arrest, death)
2. Duration:
   - Last sodium level
   - If it’s not broke, don’t fix it quickly
3. Clinical history:
   - Adrenal crisis (hypotension, weakness, shock)
   - Hypothyroidism/ myxedema coma (altered mental status, hypothermia, bradycardia, hypotension)
   - Cerebral salt-wasting syndrome (head injury, intracranial surgery, subarachnoid hemorrhage, stroke, brain tumor)
   - Marathon runner

Evaluation of Hyponatremia
- History
  - Urgent indication
  - Fluid loss
  - Free water intake
• Medications
• Other medical problems
• Small cell carcinoma
• CNS disease

Physical Exam:
• Volume status
• Pulmonary
• Neurologic
• Stigmata of chronic illness

Labs:
• Serum osmolality
  • Compared to calculated
  • \( \text{Sosm} = 2(\text{Na}) + \text{glu}/18 + \text{BUN}/28 \)
  • Difference should be less than 20, or unmeasured osmols present
• Urine sodium: marker of intravascular volume status and ability of kidney to reabsorb Na
  • \(<20 \text{ mEq/L} = \) low effective circulating volume
  • \(>20 \text{ mEq/L} = \) no hypovolemia and/or renal salt-wasting
• Urine osmolality: marker of ADH level
  • \(<100 \text{ mOsm/kg} = \) suppressed ADH
  • \(>300 \text{ mOsm/kg} = \) inability to suppress ADH

Before You Can Call it SIADH
You Must Find:
• Low serum osmolality
• High urine sodium
• High urine osmolality (high ADH)
• Normal creatinine
• Normal acid-base and K
• Normal adrenal and thyroid function

SIADH
• CNS process
• Lung process
• Cancer
• Medications
  • SSRI’s
  • Desmopressin
  • NSAID’s
  • Tricyclics
  • Nicotine
  • Other
• Idiopathic
Hyponatremia Treatment:
Normal or high serum osmolality

Hyponatremia: Normal/High $S_{osm}$

Normal/High $S_{osm}$
- Normal: pseudohyponatremia
- Hypertriglyceridemia
- Cholestatic and obstructive jaundice
- Hyperproteinemia

High, >295 mOsm/Kg H2O = redistributive
- Hyperglycemia
- Mannitol, maltose, sucrose, glycine, or sorbitol administration
- Azotemia
- Alcohol intoxication

- Correct underlying problem
  - Lipids, multiple myeloma, bilirubin
  - Hyperglycemia
    - Need to correct if indirect potentiometry
    - Add 1.6-2.4 mmol/L to Na for every 100 mg/dL glu above 100 mg/dL
  - Remove other solutes, toxins
  - Dialysis
**Hyponatremia: Low Sosm**

<table>
<thead>
<tr>
<th>Hypovolemic Una &lt; 20 mEq/L</th>
<th>Hypovolemic Una &gt; 20 mEq/L</th>
<th>Euvolemic Una &gt; 20 mEq/L</th>
<th>Hypervolemic Uosm &gt; 300 mOsm/kg</th>
<th>Hypervolemic Uosm &lt; 100 mOsm/kg</th>
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<td>5. Endurance exercise</td>
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|                            |                            | 6. Glucocorticoid deficiency | 4-6 mEq/L increase in serum sodium level enough to reverse most severe manifestations of acute hyponatremia

**Central Pontine Myelinolysis**
- Osmotic demyelination syndrome

**General Principles**
- If it’s not broke, don’t fix it quickly
- Treat if acute
- Treat if symptomatic
- If not acute or symptomatic, consider etiology and trending
- Actual correction often exceeds what is intended
- If replacing potassium, likely will raise serum sodium level
- Go slow and check often
- Do not exceed 1-2 mEq/L/hour or 12 mEq/L in 24 hours
- Actual correction often exceeds what is intended
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- If replacing potassium, likely will raise serum sodium level
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- 4-6 mEq/L increase in serum sodium level enough to reverse most severe manifestations of acute hyponatremia
Hyponatremia corrected too rapidly
Mental status changes, seizures, horizontal gaze paralysis, spastic quadriplegia
Do not exceed 1-2 mEq/L/hour or 12 mEq/L in 24 hours
Risk increased if Na<121, alcoholism, liver disease, malnutrition, severe hypokalemia, goal 4-6 mEq/L per 24 hours, do not exceed 9 mEq/L in 24 hours

Low Sosm: Hypovolemia
1. Hypovolemia:
   - Isotonic saline (Na 154 mEq/L)
     - Corrects hyponatremia a little
     - Removes stimulus for ADH release
   - Fix underlying reasons

Low Sosm: Euvolemia
2. Euvolemia: SIADH, psychogenic polydipsia, beer potomania, endocrine, medication
   - Fluid restriction to below level of urine output, usually <800 mL/day
   - Urine to serum electrolyte ratio (Una + Uk)/Sna
   - Hyponatremia likely to improve with fluid restriction alone if <0.5
   - Fluid restriction alone may be insufficient if >1
   - Loop diuretic +/- oral salt tablets in SIADH if urine to serum electrolyte ratio >1
   - Isotonic saline likely to worsen hyponatremia

Low Sosm: Hypervolemia
3. Hypervolemia with effective circulating volume depletion: heart failure, cirrhosis, nephrotic syndrome
   - Fluid restriction to below level of urine output, usually < 800 mL/day
   - If very concentrated urine (>500 mOsm/kg), fluid restriction alone may be insufficient
   - May require diuresis with loop diuretic
   - Advanced renal failure (renal failure with hypervolemia and Una>20) may require hemodialysis for hypervolemia

Hypertonic Saline: Emergencies Only
100 mL of 3% (hypertonic) saline bolus, only in patients with severe symptoms
May repeat 1-2 more times at 10 min intervals
ER or ICU setting

While Treating in Inpatient Setting
Monitor electrolyte levels every:
   - 2 hr minimum if giving saline
   - If fluid restriction alone, depends on change
Monitor serum osmolality, urine sodium, and urine osmolality as needed to evaluate for:
   - Suppression of ADH release and renin release after fluid resuscitation in true hypovolemia
   - Response to diuretics in CHF, cirrhosis
Summary

- Diagnosis of hyponatremia: History, Physical, SosmUnaUosm
- Treatment of hyponatremia:
  - Normal/high serum osmolality
    - Treat underlying etiology
  - Low serum osmolality
    - Hypovolemia: isotonic saline
    - Euvolemia: fluid restrict + correct underlying etiology
    - Hypervolemia: fluid restrict
- Monitor closely
- Do not exceed 1-2 mEq/L/hour or 12 mEq/L in 24 hours (or max 9 mEq/L in 24 hr in high risk patients)
- 4-6 mEq/L improvement to reverse severe manifestations

References:

- Wakil A, Ng JM, Atkin SL. Investigating hyponatraemia. BMJ. 2011; 342:d1118.