

Hyponatremia

Too much water compared to sodium. The brain swells when sodium drops fast; the brain shrinks itself to survive when sodium stays low for days.

THE ONE-LINE TRUTH

Low sodium (Hyponatremia) means too much water diluting the blood, not too little sodium—the kidney either kept water it should have dumped, or the body lost salt faster than water.

The chain — how it unfolds

1. Blood sodium drops below 135 milliequivalents per liter. — why: Either ADH is high when it should be low (SIADH, nausea, hypothyroid, adrenal failure, post-op), or the body is holding water because it thinks it is dry (heart failure, cirrhosis), or sodium is leaving faster than water (vomiting, diarrhea, thiazides), or free water intake is huge (polydipsia, beer potomania). Blood becomes hypotonic (too watery).
2. Water moves from blood into cells by osmosis. — why: Water always flows toward higher solute concentration to balance. Blood is now more dilute than the inside of cells, so water rushes in. This happens in every cell, but the brain is trapped inside the rigid skull, so swelling there is dangerous.
3. Brain cells swell and intracranial pressure rises (acute low sodium (hyponatremia), under 48 hours). — why: Neurons and glia (brain cells) take in water and expand. The skull cannot stretch, so pressure builds. Cerebral swelling (edema) (brain swelling) squeezes blood vessels, cuts oxygen delivery, and pushes the brainstem down toward the foramen magnum (the hole at the base of the skull), risking herniation. The patient gets headache, nausea, vomiting, confusion, lethargy, seizures, or coma. Sodium under 120 with acute drop is a medical emergency.
4. If sodium stays low for more than 24–48 hours, brain cells start pumping out organic osmolytes (chronic adaptation). — why: The brain cannot stay swollen forever. Astrocytes (support cells) and neurons push potassium, sodium, chloride, glutamate, taurine, and myo-inositol out of the cell into the extracellular space and blood. This lowers the osmotic gradient so water stops flowing in. Cell volume returns toward normal even though blood sodium is still low. Symptoms improve or disappear. This is why chronic low sodium (hyponatremia) (more than 48 hours) is often asymptomatic even with sodium in the 120s.

5. The brain is now adapted to low sodium and vulnerable to fast correction. — why: The brain has dumped its osmolytes and now depends on blood staying hypotonic. It takes days to build those osmolytes back up. If you raise blood sodium quickly, the blood becomes hypertonic (too salty) compared to brain cells, and water is pulled out of cells faster than osmolytes can be replaced.
6. Rapid correction causes brain cells to shrink too fast → osmotic demyelination syndrome. — why: When water leaves neurons and oligodendrocytes (the cells that make myelin) faster than they can adapt, the cells shrivel and the myelin sheath breaks apart. The pons (the brainstem relay station for motor signals) and other deep brain areas are hit hardest. Axons are exposed and stop conducting signals. Damage is often irreversible.
7. Osmotic demyelination syndrome appears 2–6 days after overcorrection. — why: Myelin breakdown takes time to show up clinically. The patient may improve at first as sodium normalizes, then suddenly develops slurred speech (dysarthria) (slurred speech), trouble swallowing (dysphagia) (cannot swallow), flaccid quadriplegia (floppy weak arms and legs), locked-in syndrome (awake, can only blink or move eyes), pseudobulbar palsy (emotional lability, trouble with speech and swallow), or coma. MRI shows hyperintense (bright) lesions in the pons on T2 and FLAIR images, often days after symptoms start.
8. Safe correction prevents this cascade. — why: Limit sodium rise to 6–8 milliequivalents per liter in 24 hours (or 10 in high-risk acute symptomatic cases with seizure or coma, then slow down). Use 3% hypertonic saline in small boluses (100–150 mL over 10–20 minutes) and recheck sodium every 2–4 hours. Stop when symptoms resolve or sodium rises 4–6 milliequivalents per liter, not when sodium is normal. If chronic low sodium (hyponatremia), treat the cause (stop thiazide, give hydrocortisone for adrenal failure, fluid-restrict for SIADH) and let sodium drift up slowly over days. In hypervolemic states (heart failure, cirrhosis), give a loop diuretic plus salt tabs to remove free water without dropping volume too fast. Monitor closely and correct slowly—your patience protects the brain.

Spot it — what you see, and why

- Headache: When sodium in the blood drops, water moves into brain cells to balance the saltiness, making the brain swell slightly and press against the skull.
- Nausea and vomiting: The brain's vomit center (area postrema) becomes irritated when brain cells swell from the sodium drop, triggering the urge to throw up.
- Confusion or trouble thinking clearly: The prefrontal cortex (the front of the brain that handles clear thinking) cannot fire signals normally when its cells are swollen with extra water.
- Muscle cramps or weakness: Muscles need sodium to squeeze and relax in the right rhythm; when sodium is too low, the electrical signals that tell muscles to contract get weak and sloppy.

- Seizures (sudden shaking or blackout spells): Neurons (brain cells that carry electricity) misfire in wild bursts when they are swollen, because the balance of sodium and potassium across the cell wall is out of whack.
- Lethargy or extreme sleepiness: The reticular activating system (the brain's wake-up network in the brainstem) slows down when brain cells are swollen and cannot maintain normal alertness signals.

Red flags — act now

- Seizures or sudden shaking spells
- Coma or cannot be woken up
- Sodium below 120 mEq/L or dropped more than 10 mEq/L in 24 hours
- Severe confusion or inability to speak clearly
- Trouble breathing or very slow heart rate

Treat it — in this order

1. 3% hypertonic saline 100 mL IV bolus over 10 minutes, repeat every 10 minutes up to 3 doses if severe symptoms (seizures, coma, severe confusion) → Adds concentrated salt directly to the bloodstream, raising serum sodium by 4–6 mEq/L in the first hour. The higher sodium outside brain cells pulls water out of the cells, shrinking them and stopping the swelling that causes seizures and brain damage.
2. Fluid restriction to 500–1000 mL per day if SIADH is the cause → Limits the amount of water coming into the body so the kidney's small amount of free-water excretion can slowly raise the sodium-to-water ratio. Works because in SIADH the kidney cannot make dilute urine, so less water in means less dilution.
3. Stop the offending drug: thiazide diuretics, SSRIs, NSAIDs, carbamazepine, or other medications that raise ADH or cause sodium loss → Removes the chemical trigger that either made the kidney lose sodium (thiazides block sodium reabsorption in the distal tubule) or raised ADH when it should be low (SSRIs stimulate ADH release from the hypothalamus). Stops the sodium from dropping further.
4. Normal saline (0.9% NaCl) IV if the patient is volume-depleted (dry skin, low blood pressure, urine sodium <20 mEq/L) → Replaces the salt and water the body lost from vomiting, diarrhea, or sweating. Restores blood volume, which turns off the body's signal to release ADH (the hypothalamus stops seeing 'low volume' and stops making ADH). Sodium rises as the kidney starts making dilute urine again.

5. Treat the underlying disease: levothyroxine if hypothyroid (TSH >10, low free T4), hydrocortisone 50–100 mg IV if adrenal insufficiency, treat cancer or infection if SIADH from those → Fixes the broken hormone or the disease that is keeping ADH high. Thyroid hormone speeds the heart and kidney so they can make dilute urine. Cortisol lets the kidney suppress ADH and hold onto sodium. Treating cancer or infection removes the source of ectopic ADH.

Your top priorities at the bedside

1. Check mental status every 1 to 2 hours and watch for new confusion, sleepiness, or seizure activity — why: When sodium drops below 120 mEq per liter the brain cells swell with water and the patient can have seizures, stop breathing, or go into a coma within hours
2. Start seizure precautions: pad the bed rails, keep suction at bedside, and have 3% hypertonic saline ready at the bedside — why: Severe low sodium (hyponatremia) causes seizures without warning, and the brain needs concentrated salt (3% saline) pushed fast to pull water out of swollen brain cells and stop the seizure
3. Measure and record every milliliter of fluid the patient drinks and every milliliter of urine output each shift — why: Fluid balance tells you if the kidneys are holding too much water or losing it, and strict intake and output numbers guide whether to restrict fluids or give more fluids