

HHS · Hyperosmolar Hyperglycemic State

Hyperosmolar hyperglycemic state (HHS) — extremely high blood sugar with severe dehydration — happens mostly in type 2 diabetes when insulin runs low enough that sugar piles up but just enough remains to stop the body from burning fat for fuel (so no ketones). Always give fluids first to thin the blood, then start insulin slowly.

THE ONE-LINE TRUTH

Blood sugar shoots above 600 mg/dL, blood turns thick like syrup, and the brain gets confused — but no big acid buildup like in DKA.

The chain — how it unfolds

1. Insulin resistance plus a trigger (infection, heart attack, stroke, or missed medicine) causes blood sugar to skyrocket above 600 mg/dL. — why: The pancreas cannot make enough insulin to overcome the resistance, and stress hormones — cortisol and epinephrine — tell the liver to dump even more glucose into the blood while blocking insulin's action, so sugar piles up with nowhere to go.
2. The kidneys try to dump the excess sugar into urine, and sugar drags water with it by osmosis. — why: When blood sugar exceeds the kidney's reabsorption limit (about 180 mg/dL), glucose spills into the urine; because sugar is osmotically active, it pulls water molecules along, causing massive urine output (polyuria) — often 8 to 12 liters of fluid lost over days.
3. Severe dehydration sets in — the person loses so much water that blood volume shrinks and blood becomes thick, concentrated, and syrupy. — why: Water leaves the bloodstream faster than it can be replaced by drinking (especially in elderly, confused, or bed-bound patients who cannot access fluids), so the remaining blood has the same amount of salt, sugar, and protein in far less liquid — like reducing a sauce on the stove.
4. Serum osmolality climbs above 320 mOsm/kg, and brain cells shrink. — why: Osmolality measures the concentration of particles in blood; when it rises, water is pulled out of brain cells by osmosis to try to balance the concentration, shrinking the cells and disrupting electrical signaling — this causes confusion, lethargy, seizures, or coma.

5. The kidneys, now starved of blood flow, can no longer filter effectively, so they trap glucose in the circulation instead of clearing it. — why: Dehydration drops blood pressure and flow to the kidneys (prerenal waste buildup in the blood (azotemia)); the glomerular filtration rate falls, so the kidneys cannot dump glucose into urine anymore — sugar stays in the blood, climbing even higher in a vicious cycle.
6. Despite extreme high blood sugar (hyperglycemia), there is no major acid buildup (pH stays above 7.30) and only trace or absent ketones. — why: Enough insulin is still present to suppress hormone-sensitive lipase in fat cells, so the body does not break down fat into free fatty acids and convert them into ketones (acetoacetate, beta-hydroxybutyrate) — this distinguishes HHS from diabetic ketoacidosis (the acid crisis of missing insulin) (DKA), where insulin is nearly zero and ketoacid production is massive.
7. Thick blood clots easily — risk of a clot in a deep leg vein (deep vein thrombosis) (DVT), pulmonary embolism (a clot lodging in a lung artery) (PE), and stroke spikes. — why: Dehydration raises hematocrit (the fraction of blood that is red cells), increases blood viscosity (thickness), and slows flow, especially in the legs; slow, thick blood plus sticky platelets and clotting factors create the perfect setup for clots to form and break off, traveling to the lungs or brain.
8. Treatment starts with IV normal saline to restore volume and thin the blood, then switches to half-normal saline once blood pressure stabilizes. — why: Fluids must go in gently — 1 to 1.5 liters in the first hour, then 250–500 mL/hr — to avoid cerebral swelling (edema) (brain swelling from water rushing into cells too fast); normal saline (0.9% NaCl) replaces volume without dropping osmolality too quickly, then half-normal saline (0.45% NaCl) replaces free water as osmolality falls.

Spot it — what you see, and why

- Extreme thirst and dry mouth: When blood sugar climbs very high, the kidneys try to flush out the extra sugar by pulling water from the body into the urine. This drains water from tissues and blood, so the body sends a powerful thirst signal to get you to drink and replace what's being lost.
- Peeing much more than usual: The kidneys spill the sky-high sugar into urine, and sugar drags water with it (like salt pulling water through a sponge). This makes huge amounts of urine, sometimes several liters a day, which washes water and salts out of the body.
- Severe dehydration—dry skin, sunken eyes, fast heart rate: Days of heavy urination drain so much water that blood volume drops. The skin loses its bounce, the eyes sink back, and the heart speeds up to try to pump the smaller, thicker blood volume around the body. Blood pressure may fall because there isn't enough fluid in the vessels.

- Confusion, drowsiness, or trouble waking up: The combination of very high blood sugar (often over 600 mg/dL) and severe dehydration makes the blood thick and sludgy. Brain cells shrink when water is pulled out by the high sugar, and the sluggish blood can't deliver enough oxygen and nutrients. This disrupts the brain's electrical signals, causing confusion, sleepiness, or even coma.
- Weakness and fatigue: Without enough insulin, sugar piles up in the blood but can't get into muscle cells to power them. At the same time, dehydration lowers blood pressure and oxygen delivery. Muscles feel heavy and weak, and the whole body runs low on energy—like a car with a full gas tank but a broken fuel pump.
- Warm, flushed skin with no sweating: Severe dehydration shuts down sweat production because the body can't spare any more water. The skin feels warm and dry to the touch, and the person may run a mild fever simply from the stress and dehydration, not from infection.

Red flags — act now

- Confusion, extreme drowsiness, or can't be woken up—the brain is shutting down from dehydration and sky-high sugar; this can lead to coma and death without emergency treatment.
- Blood pressure dropping or heart racing over 120 beats per minute at rest—the blood volume is dangerously low and the heart is struggling to keep organs alive.
- Seizure or one-sided weakness—severe dehydration and thick blood can trigger a stroke or seizure, especially in older adults.

Treat it — in this order

1. IV fluids: Start with 0.9% normal saline 1–1.5 L in the first hour, then 250–500 mL/h; switch to 0.45% half-normal saline once serum sodium is normal or high and blood pressure is stable → Replaces the 8–12 liters of water the body lost, thins out the thick blood, restores kidney blood flow so kidneys can filter glucose, and lowers blood sugar by dilution. Corrects dehydration and hyperosmolarity—the main broken step in HHS.
2. Check potassium before starting insulin; if $K^+ < 3.3$ mEq/L, hold insulin and give IV potassium (20–30 mEq/h) until K^+ is ≥ 3.3 ; maintain K^+ at 4–5 mEq/L during treatment → Prevents fatal cardiac arrhythmias (heart stopping). Insulin drives potassium from the blood into cells, so if you start insulin when potassium is already low, serum K^+ can drop to dangerous levels (< 2.5 mEq/L) and cause ventricular fibrillation or asystole.

3. IV insulin: Start regular insulin infusion at 0.1 units/kg/h (or 0.14 units/kg/h without a bolus) AFTER fluids have started and potassium is ≥ 3.3 ; aim to lower glucose by 50–70 mg/dL per hour → Tells muscle and fat cells to take glucose out of the blood and into cells (via GLUT4 transporters) and stops the liver from making new glucose (blocks gluconeogenesis). Lowers blood sugar slowly and safely—rapid correction can cause cerebral swelling (edema) (brain swelling).
4. Add 5% dextrose to IV fluids once glucose reaches 250–300 mg/dL, and continue insulin to normalize osmolality and mental status → Prevents blood sugar from dropping too low (hypoglycemia) while you continue insulin to fix the hyperosmolality and wake up the brain. The goal is not just lower glucose—it is normal osmolality (< 315 mOsm/kg) and clear thinking.
5. Find and treat the trigger: antibiotics for infection (UTI, pneumonia, sepsis), aspirin and cardiac catheterization for MI, adjust or restart home insulin if doses were missed → Removes the stress that overwhelmed the body's insulin reserve. Infection, heart attack, and stroke all raise cortisol (stress hormone) and epinephrine, which block insulin and raise blood sugar. Treating the trigger stops the vicious cycle.

Your top priorities at the bedside

1. Start two large-bore IV lines and hang normal saline at 1 to 1.5 liters per hour immediately — why: Severe dehydration from osmotic diuresis (sugar pulling water into urine) causes shock and organ damage; rapid fluid replacement expands blood volume, improves blood pressure, and actually lowers glucose by dilution before insulin even starts
2. Check fingerstick glucose and send lab work for basic metabolic panel with sodium and potassium before giving any insulin — why: We must know the potassium level first because insulin pushes potassium into cells; giving insulin when potassium is already low (below 3.3 mEq/L) can cause life-threatening heart rhythms (arrhythmias) and cardiac arrest
3. Monitor mental status and neurologic checks every hour, documenting any confusion, sleepiness, or seizure activity — why: High serum osmolality (concentration of blood) shrinks brain cells and causes altered mental status; tracking changes tells us if treatment is working, and sudden worsening may signal cerebral swelling (edema) (brain swelling) from too-fast correction