

Heat Stroke

Heat stroke means the body's cooling system has completely failed. Every minute of delay burns organs from the inside. Cool first, ask questions later.

THE ONE-LINE TRUTH

Body temperature climbs above 104°F (40°C) and the brain stops working right — cooling within minutes can save the person's life.

The chain — how it unfolds

1. Core temperature climbs above 104°F (40°C) and the hypothalamus fails — why: The hypothalamus (the brain's thermostat, a small cluster of cells deep in the center of the brain) is damaged by the extreme heat. Its own cells start to die — proteins inside them unfold, membranes leak, and the chemical signals it uses to control sweating and blood vessel widening stop working. The thermostat goes offline, so the body can no longer cool itself. At the same time, heat causes the blood-brain barrier (the tight seal around blood vessels in the brain) to become leaky, and fluid seeps into brain tissue. The brain swells. Swelling pushes on brain cells and squeezes blood vessels, cutting off oxygen. The person becomes confused, then has seizures, then loses consciousness.
2. Liver cells die (acute hepatic injury), and liver enzymes skyrocket — why: The liver (the organ under your right ribs that cleans the blood and makes clotting factors) has huge blood flow — about 25% of all the blood your heart pumps. But in heat stroke, two things kill liver cells. First, direct heat damage: when blood temperature is above 104°F, the heat itself makes liver cell membranes fall apart and mitochondria (the cell's power plants) stop making energy. Second, low blood flow (ischemia): as blood pressure drops and the body diverts blood to the brain and heart, the liver does not get enough oxygen. Liver cells burst open and dump their enzymes — AST and ALT — into the blood. You see AST and ALT levels in the thousands (normal is under 40). If cooling is delayed, the liver completely fails — it stops making clotting factors (so the person bleeds) and stops cleaning toxins (so ammonia builds up and poisons the brain further).

3. Muscle cells burst (rhabdomyolysis), releasing myoglobin and potassium into the blood — why: In exertional heat stroke, hard exercise plus heat makes muscle cells work so hard they run out of energy (ATP). Without ATP, the pumps that keep calcium out of the cell stop working, calcium floods in, and the muscle cell's proteins clump together and the cell membrane tears open. In classic heat stroke, direct heat damage does the same thing. Either way, dying muscle cells dump their contents into the bloodstream: myoglobin (the oxygen-carrying protein inside muscle, which is dark red and turns urine tea-colored or cola-colored), creatine kinase (CK, an enzyme — you see levels in the tens of thousands), and potassium (a lot of it, because muscle cells are packed with potassium). Myoglobin travels to the kidneys and clogs the tiny filters (the glomeruli and tubules), causing acute kidney injury. Potassium floods the blood (hyperkalemia) and poisons the heart — it makes the heart's electrical signals go haywire, causing peaked T-waves on the EKG and dangerous rhythms like ventricular a fast heart rate (tachycardia) or cardiac arrest.
4. Blood clotting system goes haywire (disseminated intravascular coagulation, DIC) — why: Heat damages the endothelium (the smooth inner lining of all blood vessels). Normally, this lining is slippery and keeps blood flowing smoothly. But when it is injured by heat, it becomes sticky and sends out chemical alarms that activate the clotting cascade (the body's emergency repair system). Tiny clots (microthrombi) form in blood vessels everywhere — brain, lungs, kidneys, liver. These clots use up all the platelets (the sticky cell fragments that plug holes) and all the clotting factors (proteins like fibrinogen that glue clots together). Once they are used up, the person cannot clot anymore, so bleeding starts — from IV sites, gums, in the brain (hemorrhagic stroke), in the lungs, in the gut. You see platelets dropping (thrombocytopenia), PT and PTT climbing (clotting times get longer), fibrinogen falling, and D-dimer skyrocketing (a marker that clots are forming and breaking down all at once). This is DIC — clotting and bleeding at the same time — and it is a sign of extreme, life-threatening illness.
5. Lungs fill with fluid (acute respiratory distress syndrome, ARDS) — why: Heat and the flood of inflammatory chemicals (cytokines like IL-1, IL-6, TNF- α released by injured cells) damage the capillaries (the tiniest blood vessels) in the lungs. Normally, the walls of these capillaries are tight, so fluid stays in the blood and air stays in the alveoli (the tiny air sacs where oxygen crosses into the blood). But in heat stroke, the capillary walls become leaky. Fluid, proteins, and even red blood cells seep out of the blood and flood the alveoli. The alveoli collapse and fill with fluid, so oxygen cannot cross into the blood. The person's oxygen level (SpO₂) drops. They breathe faster and faster, but it does not help. You see white patches (infiltrates) all over both lungs on chest X-ray. This is ARDS — the lungs are drowning from the inside — and the person needs a ventilator (breathing machine) to survive.

6. Kidneys fail (acute kidney injury, AKI) — why: Three things kill the kidneys in heat stroke. First, myoglobin released from dying muscles travels through the blood to the kidneys, clogs the tiny tubules (the plumbing inside each kidney that filters waste), and is directly toxic to kidney cells — the tubules die and stop making urine. Second, low blood pressure (shock) means the kidneys do not get enough blood flow to filter waste, so they shut down to protect themselves. Third, tiny clots (from DIC) block blood vessels inside the kidneys. The person stops making urine (oliguria or no urine output (anuria) — less than 400 mL per day or none at all). Creatinine (a waste product normally filtered by the kidneys) climbs in the blood. Potassium, acid, and fluid build up. Without dialysis (a machine that filters the blood), these toxins poison the heart and brain and the person dies.
7. Heart fails (myocardial injury and arrhythmias) — why: The heart muscle itself is damaged by heat — just like any other muscle, when heart cells (cardiomyocytes) get too hot, their proteins unfold, their membranes leak, and they stop contracting well. You see troponin (a protein that leaks out of dying heart cells) rise in the blood. The heart cannot pump hard enough, so blood pressure drops (cardiogenic shock). At the same time, electrolyte chaos — high potassium (from muscle breakdown), low calcium, low magnesium — disrupts the heart's electrical system. The EKG shows wide QRS complexes, peaked T-waves, and then ventricular a fast heart rate (tachycardia) or ventricular fibrillation (the heart quivers uselessly instead of pumping). The person goes into cardiac arrest and dies unless the team cools them, shocks the heart (defibrillation), and fixes the electrolytes immediately.
8. Death occurs within minutes to hours without aggressive cooling — why: Once the domino effect is in motion — brain swelling, liver failure, rhabdomyolysis, DIC, ARDS, kidney failure, and cardiac arrest — the body cannot recover unless core temperature is brought down fast. Every minute above 104°F (40°C) causes more cells to die. The standard teaching is: cool first, ask questions later. The goal is to drop core temperature below 102°F (38.9°C) within 30 minutes. Methods include ice-water immersion (the fastest), evaporative cooling (misting the skin with water and blowing air over it), ice packs on the neck/armpits/groin (where big blood vessels are close to the skin), and cold IV fluids. If cooling is delayed even 30 to 60 minutes, the chance of permanent brain damage or death climbs steeply. Survival depends on how fast you cool, not on what drugs you give — there is no medicine that reverses heat stroke; only cooling works.

Spot it — what you see, and why

- Core body temperature over 104°F (40°C): The body's cooling system (sweating and blood flow to the skin) can't keep up with the heat load, so temperature climbs dangerously high and starts cooking the brain and other organs.
- Confusion, strange behavior, or trouble thinking clearly: The overheated brain—especially the cerebral cortex (the thinking and decision-making layer)—can't work properly when it gets too hot, like a phone that starts glitching in the sun.

- Seizures (sudden jerking or stiffening of the body): Extreme heat disrupts the electrical signals in the brain—especially in the hippocampus and cortex—triggering uncontrolled firing, like a short circuit.
- Loss of consciousness or coma: When the brain's temperature control center (the hypothalamus) and the rest of the brain overheat, they shut down to try to protect themselves, and the person can no longer stay awake.
- Hot, dry skin (classic form) or hot, sweaty skin (exertional form): In classic heat stroke (often in older adults during heat waves), sweating stops because the sweat glands are overwhelmed. In exertional heat stroke (young people exercising hard), sweating may still happen but can't cool the body fast enough.
- Fast, pounding heartbeat: The heart races to pump blood to the skin to try to dump heat and to keep blood pressure up as vessels widen; it's working overtime like a fan on high speed.

Red flags — act now

- Core body temperature above 104°F (40°C)
- Confusion, bizarre behavior, or not making sense
- Seizures or loss of consciousness
- Stopped sweating in a very hot person (classic heat stroke)
- Rapid deterioration—getting worse by the minute

Treat it — in this order

1. Immediate rapid cooling: ice water immersion (if no cardiac arrest) or evaporative cooling (mist water on skin + fans) → Drops core temperature as fast as possible to stop brain cells, liver cells, and other tissues from cooking. The goal is to reach 38.5–39°C (101.3–102.2°F) within 30 minutes. Every minute of delay increases the risk of permanent brain damage and multi-organ failure.
2. Stop active cooling at 38.5–39°C and monitor temperature every 15–30 minutes → Prevents overcooling (hypothermia) which can cause dangerous slow heart rate (bradycardia), low blood pressure, and abnormal heart rhythms. The body's own cooling system takes over from here if it is recovering.
3. Large-bore IV lines (14- or 16-gauge) with cold normal saline bolus (1–2 liters rapidly, then titrate) → Replaces lost fluid from sweating and leaky blood vessels. Restores blood volume so the heart can pump effectively and deliver oxygen to organs. Cold fluid also helps cool the core. Prevents shock and supports the kidneys as they try to filter muscle breakdown waste.

4. Benzodiazepines (lorazepam 2–4 mg IV or midazolam 2–5 mg IV) for seizures or severe shivering → Stops seizures by calming overactive neurons (brain cells) that are misfiring due to heat damage. Stops shivering, which generates extra heat and works against cooling. GABA (the brain's main calming messenger) is boosted by benzodiazepines, which quiets the brain's alarm signals.
5. Aggressive IV hydration + urine alkalinization (sodium bicarbonate to keep urine pH > 6.5) if rhabdomyolysis is confirmed → Flushes myoglobin (muscle protein) out of the kidneys before it clogs the nephrons (tiny kidney filters). Alkaline urine (pH > 6.5) keeps myoglobin dissolved so it does not crystallize and block the kidney tubules. Prevents acute kidney injury and the need for dialysis.

Your top priorities at the bedside

1. Start immediate whole-body cooling with ice water immersion up to neck level or evaporative cooling using water mist spray and high-powered fans while taking rectal or esophageal temperature every 5 to 10 minutes — why: Every minute above 40°C kills more brain cells and damages organs through protein destruction (denaturing). Core temperature must drop to 39°C within 30 minutes to prevent permanent brain damage and death. Rectal or esophageal temperature is the only accurate core temperature; skin, oral, and ear temperatures are wrong during heat stroke.
2. Stop all cooling measures when core temperature reaches 38.5°C to 39°C and watch for temperature rebound every 15 minutes for the next 2 hours — why: Overcooling causes dangerous shivering that makes more body heat and can drop temperature too low (hypothermia below 36°C), which causes heart rhythm problems. The body's temperature control center (hypothalamus) stays broken for hours after heat stroke, so temperature can climb back up without warning.
3. Insert two large-bore IV lines (18-gauge or bigger) and give cold normal saline bolus 1 to 2 liters fast while monitoring lung sounds and checking for leg swelling — why: Heat stroke causes massive fluid loss through sweating and fluid leaking from blood vessels into tissues (third-spacing). Dehydration makes blood pressure drop and reduces blood flow to kidneys, brain, and organs. Cold IV fluids help cool from inside while replacing volume, but too much fluid floods the lungs (pulmonary swelling (edema)), especially in elderly or heart failure patients.