

Carbon Monoxide Poisoning

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THE STORY IN ONE SENTENCE

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“Carbon monoxide is invisible and grabs onto hemoglobin (the part of blood that carries oxygen) 200 times tighter than oxygen does. We give oxygen right away and use special high-pressure oxygen chambers for severe cases.”

Normal anatomy — the body's job

Hemoglobin is a protein inside red blood cells that picks up oxygen in your lungs and releases it to every cell in your body. Picture it like a delivery truck that loads oxygen, drives through blood vessels, and unloads where cells are hungry.

BODY'S JOB

Hemoglobin must grip oxygen tightly enough to carry it but let go easily when cells need it. Your brain, heart, and muscles burn oxygen constantly to make energy, so oxygen delivery must never stop.

1. Air enters your lungs and oxygen crosses into tiny blood vessels (capillaries).
2. Hemoglobin inside red blood cells grabs four oxygen molecules per hemoglobin molecule.
3. Your heart pumps oxygen-loaded blood through arteries to every organ.
4. When blood reaches hungry cells, hemoglobin senses low oxygen and releases its cargo.
5. Cells use oxygen inside their mitochondria (power factories) to burn sugar and make energy (ATP).
6. Blood picks up waste carbon dioxide and carries it back to the lungs to breathe out.

What breaks

Carbon monoxide from fires, car exhaust, broken heaters, or generators sticks to hemoglobin 200 times tighter than oxygen does and refuses to let go. At the same time, it poisons the power factories inside cells so they cannot use oxygen even if some arrives.

CLINICAL TERM

Carbon monoxide (CO) binds hemoglobin with 200–250 times higher affinity than oxygen, forming carboxyhemoglobin (COHb) and blocking oxygen transport. CO also inhibits mitochondrial cytochrome c oxidase, impairing cellular respiration independent of low oxygen (hypoxia). This dual mechanism causes tissue low oxygen and direct cellular energy failure.

How the body compensates

Your body tries to deliver more blood and breathe faster to make up for poisoned hemoglobin, but these tricks cannot fix the real problem. Vital signs may look normal while cells are dying, so the danger is easy to miss until the patient crashes.

1. {'what': 'Heart beats faster (tachycardia)', 'why': 'Pumping blood faster tries to deliver more trips of oxygen, even though each trip carries almost none.'}
2. {'what': 'Breathing gets faster and deeper (tachypnea)', 'why': 'Your brain senses low oxygen and orders faster breathing, but the problem is not in the lungs—it is in the blood, so faster breathing does not help.'}
3. {'what': 'Blood pressure may stay normal or even rise slightly', 'why': 'Your body squeezes blood vessels to keep pressure up and tries to push blood harder to starving organs.'}
4. {'what': 'Skin may look normal or even pink (cherry-red in severe cases)', 'why': 'Carboxyhemoglobin is bright red, so skin color does not turn blue (cyanotic) like typical low-oxygen states. This fools caregivers into thinking oxygen is fine.'}
5. {'what': 'Pulse oximeter reads normal (falsely reassuring)', 'why': 'Standard pulse oximeters cannot tell carboxyhemoglobin from oxyhemoglobin, so the reading looks good even when oxygen delivery is terrible.'}
6. {'what': 'Brain and heart begin to fail (confusion, chest pain, arrhythmias)', 'why': 'Compensation runs out. The brain cannot think, and the heart cannot pump reliably when energy production stops.'}
7. {'what': 'Patient crashes suddenly—seizures, coma, cardiac arrest', 'why': 'Once cells burn through their last energy reserves, organs shut down fast. The window to reverse damage closes quickly.'}

Domino effect

1. Carbon monoxide enters the body (inhaled from fire, exhaust, faulty heater, generator). — CO is colorless, odorless, and tasteless, so you breathe it without knowing. It crosses from lungs into blood instantly.
2. Carbon monoxide binds hemoglobin 200 times tighter than oxygen, forming carboxyhemoglobin. — Hemoglobin mistakes CO for oxygen. Once CO is stuck, hemoglobin cannot pick up or release real oxygen, so blood circulates but delivers almost nothing.
3. Brain cells starve first—headache, nausea, dizziness, and confusion appear. — Your brain burns 20% of your body's oxygen but is only 2% of your weight. When oxygen stops, brain cells scream for help by causing headache and dizziness.
4. Heart muscle starves—chest pain (angina), fast or irregular heartbeat (arrhythmias), and shortness of breath develop. — Your heart never rests and needs constant oxygen. Without it, the heart muscle hurts (chest pain) and its electrical rhythm becomes chaotic.
5. Severe poisoning causes fainting (syncope), seizures, and coma. — As brain oxygen debt grows, the brain cannot keep you conscious or control your body. Seizures are the brain's electrical system misfiring; coma is complete shutdown.
6. Heart stops (cardiac arrest) or breathing stops (respiratory arrest). — The heart and breathing centers in the brainstem run out of energy and quit. Without CPR and oxygen, the patient dies in minutes.
7. Even after rescue, delayed brain damage (delayed neurologic after-effects (sequelae)) appears days to weeks later. — Oxygen-starved brain cells swell, release toxic chemicals, and die slowly. This causes memory loss, personality changes, trouble walking, and parkinsonism in 10–40% of survivors.
8. In pregnant patients, fetal brain damage or fetal death occurs even when the mother recovers. — Fetal hemoglobin holds CO tighter and clears it slower than adult hemoglobin. The baby stays poisoned longer, and fetal brain cells are extremely sensitive to oxygen loss.

Symptoms · what the patient feels, and why

- Headache that feels dull and throbbing: Carbon monoxide sticks to hemoglobin (the part of red blood cells that carries oxygen) about 250 times better than oxygen does, so less oxygen reaches your brain. Your brain complains with pain when it is not getting enough fuel.
- Feeling dizzy or lightheaded: The brain needs a steady supply of oxygen to keep you balanced and aware. When carbon monoxide crowds out oxygen on your red blood cells, your sense of balance and clear thinking start to fade.
- Nausea or throwing up: The stomach and gut are sensitive to low oxygen. When tissues do not get enough fuel, the stomach can feel queasy and even reject food.

- Confusion or trouble thinking clearly: Your brain is the first organ to struggle when oxygen drops. Carbon monoxide keeps oxygen off the hemoglobin in your blood cells, so your thoughts get foggy and decisions become hard.
- Chest pain or a tight feeling in the chest: The heart muscle needs lots of oxygen to pump blood. When carbon monoxide blocks oxygen delivery, the heart may ache or squeeze, especially in people who already have heart disease or clogged arteries.
- Shortness of breath or feeling like you cannot get enough air: Even though your lungs are breathing fine, the blood cannot carry enough oxygen because carbon monoxide is hogging the seats on hemoglobin. Your body feels starved for air even when you are breathing normally.
- Weakness or tired muscles: Muscles run on oxygen. When carbon monoxide takes up space on hemoglobin in red blood cells, muscles get less fuel and feel heavy, weak, or exhausted.
- Passing out or losing consciousness: If the brain's oxygen supply drops too low, it shuts down to protect itself. This is a sign of severe poisoning and means the body is in real danger.
- Cherry-red skin or lips (rare and not reliable): Carbon monoxide makes blood look bright cherry-red instead of the usual darker red when it is low on oxygen. This color can sometimes show through the skin, but it happens in very few people and should never be used to rule out poisoning.
- Multiple people in the same place getting sick at the same time: Carbon monoxide is an invisible, odorless gas that fills a room. If a heater, stove, generator, or car is leaking the gas, everyone breathing that air will start to feel fuzzy, weak, or sick together—a big clue that it is not just a virus.

Focused exam

- Ask about the exposure source: house fire, car or generator running in a closed garage, gas furnace or water heater that smells strange or has a yellow flame instead of blue, charcoal grill burning indoors, or portable generator inside a shed or camper: Carbon monoxide is an invisible, odorless gas made when anything burns fuel (gas, oil, wood, charcoal) without enough air. You can only be poisoned if the gas got into the air you breathed. If there is no plausible source, the diagnosis is likely wrong and you need to think of other causes for the headache or confusion—migraine, viral infection, or other poisoning.
- Ask if multiple people in the same enclosed space—house, car, tent, boat, or camper—developed headache, nausea, dizziness, or confusion at the same time: Carbon monoxide spreads evenly through the air, so everyone breathing that air together gets sick together. One sick person suggests a stomach virus or food poisoning. Five people from the same house all dizzy at once strongly suggests environmental poisoning—carbon monoxide until proven otherwise.

- Check mental status: Is the person confused, sleepy, slow to answer questions, slurring words, hard to wake, or having a seizure?: Carbon monoxide sticks to hemoglobin (the oxygen-carrying protein in red blood cells) about 200 times more tightly than oxygen does, so oxygen cannot get off the truck and reach the brain. Confusion, drowsiness, seizure, or coma means the brain is starving for oxygen right now and the poisoning is severe.
- Check for chest pain, shortness of breath, or abnormal heart rhythm; get a 12-lead ECG and troponin blood test in anyone over age 50, anyone with known heart disease, or anyone with chest symptoms: The heart muscle is like an engine that never stops—it needs oxygen every second. Carbon monoxide poisoning can trigger a heart attack or dangerous rhythm (like ventricular a fast heart rate (tachycardia) or heart block) even if the arteries were healthy before. Troponin above 0.04 ng/mL or new rhythm changes on ECG mean the heart muscle is injured and the poisoning is severe.
- Ask if the patient is pregnant (or do a urine pregnancy test in all women of childbearing age) and ask how many hours the exposure lasted: A developing baby has fetal hemoglobin, which grabs carbon monoxide even more tightly than adult hemoglobin and lets go of it more slowly. The baby can suffer serious brain injury even when the mother has only mild symptoms. Exposures lasting hours allow more carbon monoxide to build up in the blood than exposures lasting minutes.
- Ask about delayed symptoms that appeared days to weeks after the exposure: new trouble remembering things, trouble concentrating, difficulty walking, personality changes (irritability, apathy, impulsiveness), depression, or Parkinsonism (tremor, stiffness, slow shuffling steps): Carbon monoxide can damage the deep brain structures (the basal ganglia, which control movement, and the white matter, which connects different brain regions) even after the person seemed to recover. This delayed injury happens in 10 to 30 percent of moderate-to-severe poisonings. Catching it early allows physical therapy, occupational therapy, and cognitive rehabilitation to start before the damage becomes permanent or the person loses their job or independence.

Diagnostics · every test answers a question

- Carboxyhemoglobin level (CoHb) on arterial or venous blood gas → How much of the hemoglobin is blocked by carbon monoxide right now, and does this match the severity of symptoms?
- Arterial blood gas (ABG) with pH, PaO₂, and lactate → Is the oxygen pressure in the blood normal, and is the body switching to backup energy production (anaerobic metabolism) because oxygen is not reaching the cells?
- Troponin I or troponin T → Is the heart muscle dying from lack of oxygen?
- 12-lead electrocardiogram (ECG) → Is the heart's electrical system unstable, and is there evidence of starved blood flow (ischemia) (the heart muscle not getting enough oxygen)?

- Pregnancy test (urine or serum hCG) in all women of childbearing age → Is there a fetus that needs protection from brain injury?
- Pulse oximetry (SpO₂) → Can we trust the oxygen saturation reading on the finger probe?
- Brain MRI with diffusion-weighted imaging (DWI) and T2/FLAIR sequences if delayed neurologic symptoms appear days to weeks after exposure → Is there structural brain damage in the areas that control movement, memory, and thinking?
- Complete blood count (CBC) with hemoglobin → Does the patient have enough red blood cells to carry oxygen once the carbon monoxide is cleared?

Treatment logic

- 100% oxygen via tight-fitting non-rebreather mask at 15 liters per minute, continued for at least 4 to 6 hours or until CoHb drops below 5% and symptoms resolve → Oxygen molecules compete with carbon monoxide for the binding sites on hemoglobin. Breathing 100% oxygen cuts the half-life of carbon monoxide (the time it takes for half of it to leave the body) from 4 to 5 hours on room air down to about 60 to 90 minutes, so carbon monoxide gets pushed off hemoglobin and exhaled much faster. This rapidly restores oxygen delivery to the brain and heart.
- Hyperbaric oxygen (HBO) therapy at 2.5 to 3 atmospheres of pressure for 90 minutes, sometimes repeated once or twice over the next 24 hours in severe cases → High pressure forces oxygen to dissolve directly into the blood plasma (the liquid part of blood, not just the hemoglobin), cuts the carbon monoxide half-life to about 20 minutes (three times faster than 100% oxygen at normal pressure), and helps repair damaged mitochondria faster than regular oxygen alone. Studies suggest HBO reduces the risk of delayed neurologic injury (memory problems, personality changes, movement disorders that appear weeks later) from around 25 to 30 percent down to 10 to 15 percent in severe poisoning.
- Hyperbaric oxygen is recommended (per current guidelines from the American Heart Association and the Undersea and Hyperbaric Medical Society) if any of these are present: loss of consciousness at any point during or after exposure, CoHb > 25%, pregnancy with CoHb > 15% or any neurologic symptoms (even mild confusion or headache), evidence of heart starved blood flow (ischemia) (chest pain, ECG changes, or troponin elevation), or persistent moderate-to-severe neurologic symptoms (confusion, seizure, focal weakness, vision changes) despite 4 to 6 hours of 100% oxygen at normal pressure → These criteria identify patients at highest risk for permanent brain or heart damage. Using HBO in these patients lowers the chance of delayed neurologic injury and speeds recovery of thinking and movement. It also protects the fetus in pregnant patients, whose babies are at high risk even when the mother feels better.

- Treat coexisting cyanide poisoning with hydroxocobalamin 5 grams IV over 15 minutes (may repeat once) if the exposure was from a structural fire, enclosed-space fire, or burning plastics, synthetic materials, or foam → Fires release both carbon monoxide (from incomplete burning of any fuel) and hydrogen cyanide gas (from burning plastics, polyurethane foam, wool, silk, nylon, and rubber). Cyanide blocks cytochrome c oxidase (the final enzyme in the mitochondria that uses oxygen to make energy), so cells suffocate even when oxygen is present. Hydroxocobalamin (a form of vitamin B12) binds cyanide tightly in the blood and turns it into cyanocobalamin (safe vitamin B12), which the kidneys excrete in urine.
- Treat smoke inhalation lung injury with humidified oxygen, nebulized albuterol 2.5 to 5 mg every 4 hours as needed for wheezing, and close monitoring of the airway; intubate early (within the first 2 to 4 hours) if a high-pitched noise on breathing in (stridor) (high-pitched breathing sound), severe face or mouth burns, soot in the nose or throat, or rapidly worsening breathing are present → Smoke and heat burn the lining of the airway (throat, windpipe, and bronchi), causing swelling that can close off the windpipe within hours, like a straw pinched shut. Albuterol (a bronchodilator) relaxes the muscles around the small airways and opens them up. Humidified oxygen soothes the inflamed tissue and loosens thick secretions. Early intubation (putting in a breathing tube) before the airway swells completely shut prevents the need for emergency cricothyrotomy (cutting the front of the neck to restore breathing).
- Remove the patient and everyone else from the contaminated environment immediately, ventilate the space, and contact the fire department or gas company to inspect the source (furnace, water heater, generator) and measure carbon monoxide levels in the air → Ongoing exposure keeps adding carbon monoxide to the blood, so symptoms will worsen and treatment will fail until the source is shut off and the air is cleared. Measuring the air confirms the diagnosis and identifies the specific equipment that failed so it can be repaired or replaced, preventing re-poisoning when the patient goes home.
- Arrange neurology or neuropsychology follow-up 4 to 6 weeks after discharge to screen for delayed neurologic after-effects (sequelae) (problems with memory, attention, executive function, mood, and movement) → Delayed neurologic injury appears in 10 to 30 percent of moderate-to-severe poisonings, sometimes weeks after the person felt completely better. Early detection allows cognitive rehabilitation, physical therapy, occupational therapy, and psychiatric support to start before deficits become permanent or before the person loses their job, driver's license, or relationships. Some deficits (like mild memory problems) are subtle and only show up on formal testing.

Medications

Normobaric oxygen (100% oxygen through a tight-fitting mask) · First-line supportive therapy

Carbon monoxide sticks to hemoglobin (the protein inside red blood cells that carries oxygen) about 200 times more tightly than oxygen does. When carbon monoxide grabs hemoglobin, it forms carboxyhemoglobin — a locked pair that cannot carry oxygen. Your tissues start to starve. Breathing 100% oxygen floods your lungs with pure oxygen molecules. Because there are so many oxygen molecules rushing in, they slowly push the carbon monoxide off hemoglobin and take its place. The carbon monoxide that gets pushed off leaves your body when you breathe out. This speeds up the clearance: instead of taking about 5 hours (on room air), half the carbon monoxide leaves in about 90 minutes.

1. You breathe in 100% oxygen through a tight non-rebreather mask (a mask with a bag attached that makes sure almost pure oxygen reaches your lungs).
2. The high amount of oxygen in your lungs creates a strong push — like a crowd of oxygen molecules all trying to get onto hemoglobin at once.
3. Oxygen gradually shoves the carbon monoxide off hemoglobin, freeing up the hemoglobin so it can carry oxygen again.
4. The carbon monoxide that gets bumped off leaves your body when you breathe out.
5. As more hemoglobin becomes free to carry oxygen, your brain, heart, and other organs get the oxygen they need, and your symptoms start to improve.

SAFETY WATCH

Use a tight-fitting non-rebreather mask with a reservoir bag to make sure the patient gets close to 100% oxygen — a nasal cannula (the little nose prongs) does not deliver enough. · Keep giving oxygen until the carboxyhemoglobin level (the lab test that measures how much hemoglobin is stuck to carbon monoxide) drops below 5% AND the patient's symptoms are completely gone. Do not stop early. · Watch for oxygen toxicity if treatment goes on for more than 24 hours (very rare, but breathing pure oxygen for a very long time can irritate the lungs). · If the patient is pregnant, treat even harder and faster — fetal hemoglobin (the baby's version) grabs carbon monoxide even more tightly than adult hemoglobin, so the baby is at higher risk. Start oxygen right away and consider hyperbaric oxygen.

Hyperbaric oxygen (HBO, 100% oxygen breathed inside a high-pressure chamber) · Advanced supportive therapy

Hyperbaric oxygen therapy puts the patient inside a sealed chamber that is pressurized to 2.5 to 3 times normal air pressure, like being 60 to 90 feet underwater. While inside, the patient breathes 100% oxygen. The high pressure forces much more oxygen to dissolve directly into the liquid part of the blood (plasma), even without needing hemoglobin to carry it. This extra dissolved oxygen reaches starving tissues faster. The pressure also speeds up the release of carbon monoxide from hemoglobin — the half-life (time for half the carbon monoxide to leave) drops from 90 minutes on regular oxygen down to about 20 to 30 minutes. Most importantly, hyperbaric oxygen may lower the risk of delayed brain problems (memory loss, personality changes, trouble walking) that can appear days to weeks after the poisoning.

1. The patient enters a hyperbaric oxygen chamber (a sealed tube or room) and breathes 100% oxygen while the chamber is pressurized to 2.5 to 3 times normal air pressure.
2. The high pressure forces many more oxygen molecules to dissolve directly into the blood plasma — like carbonation forcing bubbles into soda.
3. This dissolved oxygen reaches tissues that are starving for oxygen, even though their hemoglobin is still stuck to carbon monoxide.
4. The increased oxygen pressure also speeds up the release of carbon monoxide from hemoglobin, cutting the clearance time down to 20 to 30 minutes.
5. Hyperbaric oxygen may also calm down the swelling and chemical stress that carbon monoxide causes inside brain cells, which may reduce the chance of delayed brain damage.
6. A typical session lasts 90 to 120 minutes at pressure. Depending on how severe the poisoning is, the session may be repeated once or twice in the first 24 hours.

SAFETY WATCH

Indications (when to use hyperbaric oxygen): the patient passed out at any point, has brain symptoms now (confusion, seizure, weakness on one side, trouble speaking), has signs of heart damage (chest pain, abnormal heart tracing on EKG, elevated troponin blood test), is pregnant with a carboxyhemoglobin level above 15%, or has a carboxyhemoglobin level above 25% (some centers use 20% or 40% — the exact cutoff varies, but most agree on the other indications). · Risk of barotrauma (injury from pressure changes) — ears or sinuses can hurt or tear if pressure does not equalize. Patients must be able to pop their ears. Unconscious patients or young children may need special care or ear tubes. · Risk of oxygen toxicity seizures if the pressure is too high or the treatment lasts too long — hyperbaric centers follow strict time and pressure limits to keep this risk very low. · Contraindications (when NOT to use): untreated pneumothorax (a collapsed lung with air leaking into the chest, because pressure changes can make it worse), recent treatment with bleomycin or doxorubicin (certain chemotherapy drugs), and some types of ear surgery. · If the patient meets the criteria and a hyperbaric center is within a few hours, transfer is reasonable — but do NOT delay starting 100% oxygen on a regular mask while arranging the transfer. Start oxygen immediately, then call for transfer.

Red flags

- Passing out or becoming unresponsive
- New confusion or trouble thinking clearly
- Chest pain or feeling like the heart is squeezing
- Seizures or jerking movements
- Multiple people in the same building getting sick at the same time

Nursing priorities

1. Remove the patient from the carbon monoxide source immediately and make sure rescuers wear protective gear if the source is still active — Carbon monoxide keeps building up in the blood as long as the patient breathes it, so stopping exposure is the first step before any treatment can work, and rescuers can become victims themselves in high-concentration areas
2. Apply 100% oxygen using a tight-fitting non-rebreather mask at 15 liters per minute right away, making sure the reservoir bag stays inflated — High-flow oxygen floods the blood with oxygen molecules that compete with carbon monoxide for hemoglobin binding sites, and this speeds up the removal of carbon monoxide from the body by cutting the half-life from 5 hours on room air down to about 90 minutes

3. Place the patient on continuous cardiac monitoring and get a 12-lead ECG within the first 10 minutes — Carbon monoxide starves the heart muscle of oxygen, which can cause dangerous heart rhythms called arrhythmias or even a heart attack, and the heart damage may not cause obvious chest pain so monitoring catches silent problems
4. Draw blood for carboxyhemoglobin level (CoHb), troponin (a heart enzyme), basic metabolic panel, and lactic acid (a marker of oxygen starvation) before giving oxygen if possible, but never delay oxygen to get labs — The CoHb level tells how much hemoglobin is poisoned and helps decide if hyperbaric oxygen is needed, troponin shows heart damage, and lactic acid proves the cells are not getting enough oxygen, but treatment must start immediately because brain damage happens fast
5. Check neurological status every 15 minutes using Glasgow Coma Scale or a similar tool, watching for confusion, drowsiness, or any decline in thinking — The brain uses 20% of the body's oxygen even though it is only 2% of body weight, so brain cells die quickly without oxygen, and worsening confusion means the patient may need hyperbaric oxygen to prevent permanent memory loss or personality changes
6. Keep the patient lying flat or with head of bed at 30 degrees and avoid sudden position changes that might drop blood pressure — Carbon monoxide poisoning dilates blood vessels throughout the body which lowers blood pressure, and the brain is already oxygen-starved so any drop in blood flow from standing up too fast can cause passing out or more brain injury
7. Notify the physician immediately if CoHb is above 25%, if the patient is pregnant, if there was loss of consciousness, or if chest pain or confusion is present, because these findings require hyperbaric oxygen consultation — Hyperbaric oxygen at 2.5 to 3 atmospheres pressure forces much more oxygen into the blood plasma and tissues than a regular mask can, which prevents delayed neurological problems that show up 3 to 240 days later in up to 40% of serious poisoning cases
8. Continue 100% oxygen for at least 4 to 6 hours or until the CoHb drops below 5% and all symptoms resolve, rechecking CoHb every 2 to 4 hours — Carbon monoxide releases slowly from hemoglobin even with oxygen therapy, and stopping oxygen too early lets levels climb back up from carbon monoxide still stored in muscle tissue, which can cause symptoms to return or worsen

Sources

- CDC Carbon Monoxide Poisoning Prevention
- American College of Medical Toxicology (ACMT)
- Undersea and Hyperbaric Medical Society (UHMS)
- New England Journal of Medicine

Last reviewed: 2026-07-07