Opioid Overdose

Opioids turn off the brain's breathing switch, oxygen drops, and the person stops breathing.

THE STORY IN ONE SENTENCE

Opioids turn off the brain's breathing switch, oxygen drops, and the person stops breathing.

“Opioid overdose shuts down the brain stem's breathing control center, so the body forgets to breathe and runs out of oxygen.”

Normal anatomy — the body's job

The medulla oblongata (the breathing control center at the base of your brain stem) constantly measures carbon dioxide in your blood and sends automatic 'breathe' signals to your lungs to keep oxygen flowing in and waste gas flowing out.

BODY'S JOB

Your medulla senses when carbon dioxide builds up in your blood and fires a signal down the phrenic nerve to your diaphragm (the big breathing muscle under your lungs) and to the muscles between your ribs. Those muscles contract, your chest expands, air rushes in, oxygen enters your blood, and carbon dioxide leaves. This happens twelve to twenty times every minute, awake or asleep, without you thinking about it.

1. Medulla oblongata detects rising carbon dioxide in the blood.
2. Medulla sends 'contract now' signal down the phrenic nerve and intercostal nerves.
3. Diaphragm and rib muscles pull the chest open.
4. Air rushes into the lungs; oxygen crosses into the bloodstream.
5. Carbon dioxide crosses out of the blood into the lungs and is exhaled.
6. Blood oxygen stays high (around 95–100%), carbon dioxide stays low, and every organ—especially the brain and heart—gets the oxygen it needs.

What breaks

Opioids lock onto mu opioid receptors in the medulla oblongata and turn off the automatic breathing signal, so the body stops breathing even though carbon dioxide is piling up in the blood.

> **CLINICAL TERM**
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> Mu opioid receptor agonism in the medulla oblongata causes respiratory depression by suppressing the ventilatory response to hypercapnia (high carbon dioxide) and low oxygen (hypoxia) (low oxygen).

How the body compensates

At first, the heart pumps harder and adrenaline tries to keep blood pressure up, but once breathing slows below eight breaths per minute, oxygen drops too low and all compensation fails—the person collapses, turns blue, and will die without immediate naloxone or rescue breathing.

1. {'step': 'Sympathetic nervous system releases adrenaline to squeeze blood vessels and keep pressure up.', 'limit': 'Adrenaline cannot create oxygen; if the lungs are not moving air, blood pressure will still fall.'}
2. {'step': 'Carotid bodies (oxygen sensors in the neck) try to trigger faster breathing.', 'limit': 'Opioids override this backup signal, so breathing stays dangerously slow.'}
3. {'step': 'Heart rate slows (bradycardia) to save oxygen.', 'limit': 'A slow heart pumps less blood; organs—including the brain—starve faster.'}
4. {'step': 'Skin and lips turn blue or gray (cyanosis) as oxygen drops.', 'limit': 'This is a late sign; brain injury is already starting.'}
5. {'step': "The person becomes unconscious to reduce the brain's oxygen demand.", 'limit': 'Unconsciousness means they cannot protect their airway; vomit or the tongue can block breathing completely.'}

Domino effect

1. Opioids (heroin, fentanyl, morphine, oxycodone) bind to mu opioid receptors in the medulla oblongata. — These receptors normally help dampen pain signals, but when opioids flood them—especially in overdose—they shut down the medulla's automatic breathing rhythm.
2. The medulla stops sending 'breathe' signals to the diaphragm and rib muscles. — Without that signal, the chest does not expand, air does not flow in, and breathing slows to under twelve breaths per minute (normal is twelve to twenty).

3. Blood oxygen drops (hypoxemia) and carbon dioxide climbs (hypercapnia). — The lungs are not exchanging gases, so oxygen cannot enter the blood and carbon dioxide cannot leave; the blood becomes acidic.
4. Pupils shrink to tiny pinpoints (miosis). — Opioids also stimulate the parasympathetic Edinger–Westphal nucleus in the brainstem, which tightens the iris muscle and makes the pupil as small as a pinhead.
5. The person becomes confused, then unconscious. — The brain needs oxygen every second; when the level drops below about 90%, neurons misfire (confusion), then shut down (coma).
6. Heart rate slows and blood pressure falls. — Low oxygen weakens the heart muscle; it cannot pump hard, so pressure drops and organs get even less blood.
7. Skin and lips turn blue or gray (cyanosis). — Hemoglobin in the blood carries less oxygen and looks darker; you see this blue color through the skin, especially at the lips, fingernails, and face.
8. Without naloxone or rescue breathing, the heart stops (cardiac arrest) and the person dies. — The heart cannot run without oxygen; once it stops, brain death begins within four to six minutes unless CPR and naloxone reverse the overdose.

Symptoms · what the patient feels, and why

- Pinpoint pupils (tiny dots for eyes): Opioids turn on mu receptors (special docking spots) in the oculomotor nucleus (the brain's eye-control center in the midbrain), which makes the pupil muscles squeeze tight and stay small — even in dim light when they should get bigger.
- Slow, shallow breathing (often under 12 breaths per minute): Opioids quiet the mu receptors in the medulla (the base of the brain that sets your breathing rhythm), so the brain stops sending strong 'breathe now' signals. The person takes fewer and shallower breaths, and carbon dioxide builds up in the blood.
- Drowsiness or being completely unresponsive (won't wake up to voice or touch): Opioids flood mu receptors across the whole brain, especially in the reticular activating system (the brain's on/off switch for wakefulness), so the person drifts into deep sleep or even coma and cannot stay alert.
- Blue or gray lips, fingernails, or skin (cyanosis): When breathing slows too much, not enough oxygen gets into the blood. Oxygen-poor blood looks dark purple-blue instead of bright red, and you can see that color show through at the lips, nails, and skin — especially in people with lighter skin tones.
- Limp, floppy muscles (low muscle tone): Opioids dampen signals in the spinal cord and motor centers of the brain that usually keep muscles firm and ready. As a result, the person's arms, legs, and head feel loose and heavy, like a rag doll.

- Choking sounds, gurgling, or snoring (noisy breathing): When the brain's breathing drive drops, the person cannot keep their airway muscles tight. The tongue falls back, saliva pools in the throat, or vomit creeps up, so air has to push past all that — making a snore, gurgle, or choke noise.
- Slow heart rate (bradycardia, often below 60 beats per minute): Opioids turn up the vagus nerve (the main calming nerve running from the brainstem to the heart), which puts the brakes on the heart's pacemaker cells in the sinoatrial node and slows each heartbeat down.
- Needle marks or track marks on arms, legs, hands, or feet: Repeated injections into veins leave tiny scabs, bruises, scars, or dark lines along the vein path. These marks are clues that the person has been injecting drugs — often opioids — into their bloodstream.
- Fentanyl patches on the skin (small sticky squares, often on chest, back, or upper arm): Prescription fentanyl patches release opioid medicine slowly through the skin for pain control. If someone uses too many patches, cuts them open, or chews them, a huge dose floods the body all at once and can cause overdose.

Focused exam

- Pinpoint pupils (pupils smaller than 2 mm, like tiny dots): Opioids flood mu receptors in the brainstem (the part of the brain that controls automatic body functions). These receptors normally let the pupil widen in dim light, but the opioid locks them shut. Pinpoint pupils are the single most reliable sign that an opioid is on board.
- Respiratory rate below 12 breaths per minute, or no breathing effort at all: Opioids shut down the respiratory center in the medulla (the breathing control tower at the base of the brain). When breathing slows or stops, the body cannot pull in oxygen or push out carbon dioxide. This is how opioid overdose kills—by suffocating the brain and heart.
- Oxygen saturation (SpO_2) below 90%, or blue lips and fingertips (cyanosis): When breathing stops or slows, oxygen in the blood drops fast. The brain needs a steady oxygen supply every second; below 90% saturation, brain cells start to die. Blue color means the blood is not carrying enough oxygen to keep tissues alive.
- Unresponsive to voice or pain, or deeply asleep and impossible to wake: Opioids lock onto mu receptors throughout the brain, especially in the reticular activating system (the brain's wake-up switch). When these receptors are fully occupied, the person cannot stay awake or respond. Deep unconsciousness means the brain is shutting down.
- Cool, clammy skin and systolic blood pressure below 90 mmHg: Opioids relax blood vessels and slow the heart by acting on the vagus nerve (the main nerve that slows the heart). Low blood pressure means the heart cannot pump enough blood to the brain and kidneys. Cool, sweaty skin is the body's alarm that circulation is failing.

- Track marks (needle scars), skin abscesses, or fentanyl patches found on the body: These are direct evidence that opioids entered the body. Even a used fentanyl patch stuck to the skin can release enough drug to cause overdose. Finding these clues confirms the diagnosis and guides treatment.

Diagnostics · every test answers a question

- Arterial blood gas (ABG) or venous blood gas (VBG) → Is the person holding onto too much carbon dioxide because breathing has slowed?
- Urine drug screen (immunoassay) or serum toxicology panel → Which opioid is in the body, and are other drugs on board?
- Serum glucose (fingerstick or lab) → Is low blood sugar causing the unconsciousness instead of (or along with) opioids?
- Chest X-ray → Is fluid building up in the lungs (pulmonary swelling (edema)) or is there pneumonia from aspirating vomit?
- Electrocardiogram (ECG) → Is the heart rhythm abnormal from the opioid or from low oxygen?
- Creatine kinase (CK) and serum creatinine → Has the person been lying still so long that muscles broke down (rhabdomyolysis) and damaged the kidneys?

Treatment logic

- Bag-valve-mask ventilation with 100% oxygen (or high-flow nasal cannula at 15 L/min if breathing is present but slow) → Forces oxygen into the lungs and raises blood oxygen saturation back above 90%. This keeps the brain and heart alive while you wait for naloxone to kick the opioid off the receptors and restart normal breathing.
- Naloxone 0.4–2 mg IV push (or 4 mg intranasal spray), repeat every 2–3 minutes until breathing resumes or total dose reaches 10 mg → Naloxone is a mu-receptor antagonist—it binds to the same receptors as the opioid but kicks the opioid off and does not activate the receptor. This wakes up the respiratory center in the medulla and restores the brain's own drive to breathe. Breathing usually starts within 2–5 minutes.
- Continuous naloxone infusion (typically two-thirds of the wake-up dose per hour IV) for long-acting opioids (fentanyl, methadone, sustained-release formulations) → Keeps naloxone in the bloodstream at a steady level so it occupies the mu receptors longer than the opioid does. This prevents the opioid from re-binding and shutting down breathing again before the drug leaves the body (fentanyl can last 3–4 hours in fatty tissue, methadone up to 24–36 hours).

- Start buprenorphine 4–8 mg sublingual in the emergency department once the person is awake and in mild withdrawal (COWS score ≥8) → Buprenorphine is a partial mu-receptor agonist—it sits on the receptor just tightly enough to stop cravings and withdrawal, but does not activate the receptor enough to cause overdose or euphoria. This stabilizes the brain's reward circuit and cuts the risk of leaving and overdosing again by 50% (JAMA 2015;313:1636).
- IV normal saline bolus (1–2 liters) if systolic BP below 90 mmHg or creatine kinase is elevated → Restores blood volume and blood pressure so the heart can pump oxygen to the brain and kidneys. Flushes muscle breakdown products (myoglobin) out of the kidneys before they clog the filters and cause acute kidney injury.
- Observe for 4–6 hours after last naloxone dose (longer for methadone or sustained-release opioids); teach naloxone rescue kit use to patient and family before discharge → Catches re-sedation if naloxone wears off before the opioid clears the body. Empowers the patient and loved ones to reverse the next overdose at home, buying time for EMS to arrive. Community naloxone distribution cuts overdose death by 27% (Annals Intern Med 2018;168:241).
- Link to medication-assisted treatment (buprenorphine or methadone program), housing support, mental health care, and harm reduction services before discharge → Removes the social and psychological stressors (homelessness, untreated depression, chronic pain) that drive repeated use. Medication-assisted treatment keeps the mu receptors occupied safely so the craving circuit stays quiet. Harm reduction (clean needles, fentanyl test strips) lowers the risk of infection and accidental fentanyl overdose.

Medications

Naloxone (Narcan) · Opioid antagonist (opioid blocker)

Naloxone kicks opioids off the mu-opioid receptors in the brain and spinal cord (the docking stations where opioids slow down breathing and cause sedation). By blocking these receptors, naloxone reverses the opioid's effects within 2 to 3 minutes, waking the person up and restarting normal breathing.

1. Opioids (like fentanyl, heroin, oxycodone) bind to mu-opioid receptors in the brainstem and slow the breathing center, causing respiratory depression (dangerously slow or stopped breathing).
2. Naloxone is a competitive antagonist—it has stronger binding power than opioids and bumps them off the receptors.
3. Once naloxone occupies the receptors, the opioid signal stops, and the brainstem's breathing center wakes back up.
4. Breathing rate and depth return to normal within 2 to 3 minutes of IV or intramuscular injection, or 2 to 5 minutes with intranasal spray.

5. Naloxone's effect lasts 30 to 90 minutes, shorter than many opioids (especially long-acting ones like fentanyl or methadone), so re-dosing is often needed.

SAFETY WATCH

Watch for acute opioid withdrawal symptoms within minutes: agitation, sweating, rapid heart rate, vomiting, body aches, and severe anxiety. These are uncomfortable but not life-threatening. · Re-dosing: Give 0.4 to 2 mg IV/IM/subcutaneous or 4 mg intranasal every 2 to 3 minutes until breathing improves. For potent synthetic opioids like fentanyl, multiple doses (sometimes 4 to 10 mg total) may be needed. · Observe the patient for at least 4 to 6 hours after the last naloxone dose. For long-acting opioids like methadone or extended-release formulations, observation should extend to 24 hours because re-narcotization can occur once naloxone wears off. · Naloxone does NOT harm someone who has NOT taken opioids—if in doubt, give it. · After stabilization, offer referral to medication for opioid use disorder (MOUD) such as buprenorphine or methadone before discharge. Emergency department-initiated buprenorphine improves engagement in treatment and reduces overdose deaths.

Buprenorphine (Suboxone, Subutex) · Partial opioid agonist (used for opioid use disorder treatment, not acute overdose reversal)

Buprenorphine is a partial agonist at mu-opioid receptors—it activates them gently (reducing cravings and withdrawal) but has a ceiling effect, meaning it cannot produce the dangerous respiratory depression of full opioids. It also blocks other opioids from binding, protecting against overdose if the person relapses. Starting buprenorphine in the emergency department after overdose reversal helps bridge the patient into long-term addiction treatment and lowers the risk of repeat overdose.

1. After naloxone reverses the overdose and the patient is awake, buprenorphine can be started once mild withdrawal symptoms appear (usually 6 to 12 hours after last short-acting opioid use, or 24 to 48 hours for long-acting opioids like methadone).
2. Buprenorphine binds tightly to mu-opioid receptors and activates them partially, relieving withdrawal and cravings without producing a high or dangerous sedation.
3. Because it binds so tightly, it blocks other opioids from attaching, reducing overdose risk if the person uses again.
4. The ceiling effect means that even at higher doses, buprenorphine does NOT slow breathing the way full opioids do, making it much safer.
5. Long half-life (24 to 37 hours) allows once-daily dosing and steady control of cravings and withdrawal.

SAFETY WATCH

Start ONLY after mild withdrawal symptoms appear (watery eyes, sweating, restlessness, elevated heart rate). Starting too soon triggers precipitated withdrawal. · Common initial dose is 2 to 4 mg sublingual (under the tongue), with additional 2 to 4 mg doses every 1 to 2 hours until withdrawal is controlled, up to 8 to 12 mg on day one. Maintenance dose is typically 12 to 16 mg daily. · Avoid combining with benzodiazepines or other sedatives—this raises the risk of respiratory depression, especially early in treatment. · Buprenorphine is safe in pregnancy and is the preferred treatment for pregnant people with opioid use disorder (reduces maternal and fetal complications). · Link the patient to outpatient buprenorphine or methadone maintenance and behavioral support before discharge—this combination dramatically reduces overdose death risk.

Red flags

- Breathing slower than 12 breaths per minute or stopping for more than 10 seconds at a time (apnea)
- Person will not wake up even when you rub their chest hard or shout their name
- Lips, fingernails, or face turning blue or gray
- Choking, gurgling, or gasping sounds — the airway may be blocked
- Heart rate below 50 or no pulse you can feel

Nursing priorities

1. Open the airway with head-tilt-chin-lift or jaw-thrust maneuver, suction any vomit or secretions, and start bag-valve-mask ventilation at 10 to 12 breaths per minute with 100% oxygen if respirations are under 12 per minute or pauses in breathing (apnea) is present. — Opioids bind to mu receptors (special proteins) in the brainstem respiratory center and turn off the automatic breathing drive, so low oxygen (hypoxia) (low oxygen in the blood) kills brain cells within 4 to 6 minutes unless you breathe for the patient.
2. Give naloxone 0.4 to 2 mg IV push or 4 mg intranasal spray immediately, then repeat every 2 to 3 minutes until the patient breathes on their own at a rate above 12 per minute or until you have given a total of 10 mg. — Naloxone is a competitive antagonist (a blocker) that kicks opioids off the mu receptors and reverses respiratory depression, but fentanyl binds so tightly that you often need multiple doses or higher total amounts.

3. Monitor oxygen saturation continuously with pulse oximetry and keep SpO_2 above 94% with supplemental oxygen or bag-valve-mask support. — Even after naloxone wakes the patient up, low oxygen in the blood (hypoxemia) (low oxygen in the blood) can persist because aspiration pneumonitis (lung inflammation from inhaled vomit or stomach acid) or pulmonary edema (fluid flooding the lungs) (fluid in the lungs from opioid toxicity) takes hours to resolve.
4. Place the patient on continuous cardiac and respiratory monitoring, checking respiratory rate and pulse oximetry every 15 minutes for at least 4 hours after the last naloxone dose. — Renarcotization happens when naloxone (half-life 30 to 90 minutes) wears off before the opioid (fentanyl half-life 7 hours, methadone up to 59 hours) is gone, so respiratory depression can come back suddenly and kill the patient.
5. Start a continuous naloxone infusion at two-thirds of the total wake-up dose per hour IV if the patient needed more than 4 mg to reverse or if a long-acting opioid like fentanyl, methadone, or sustained-release morphine was involved. — Long-acting opioids release slowly from fat tissue and keep circulating for many hours, so a one-time naloxone bolus will wear off and the patient will stop breathing again unless you give a steady drip.
6. Draw blood for creatine kinase (an enzyme released when muscles break down), basic metabolic panel (electrolytes and kidney function), and lactic acid if the patient was unresponsive for more than 30 minutes or has dark urine. — Rhabdomyolysis from pressure tissue death (necrosis) (muscle death from lying on one position too long) releases myoglobin (a muscle protein) that clogs kidney tubules and causes acute kidney injury, and you must catch it early to start IV fluid rescue.
7. Check all four limbs for compartment syndrome signs: pain out of proportion to exam, tense swelling, numbness, or inability to move fingers or toes, and call the surgeon immediately if present. — Prolonged immobility cuts off venous drainage (blood return from arms or legs), pressure builds inside the muscle compartments, arterial inflow stops, and the limb dies within 6 to 8 hours unless a fasciotomy (emergency surgery to cut open the tight tissue) is done.
8. Do not leave the patient alone; assign one-to-one observation and place the bed in the lowest position with side rails up, because many patients wake up agitated or try to leave against medical advice. — Naloxone not only reverses overdose but also triggers acute opioid withdrawal (sweating, agitation, vomiting, severe pain), so patients often become combative, pull out IVs, and try to leave to use again, putting themselves at very high risk for repeat overdose and death.

Sources

- ACEP Clinical Policy on Naloxone Administration 2023
- SAMHSA Opioid Overdose Prevention Toolkit

- CDC Guideline for Prescribing Opioids for Chronic Pain 2022
- AMA Opioid Task Force

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