

Salicylate Toxicity

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THE STORY IN ONE SENTENCE

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“When you take too much aspirin, it uncouples mitochondria (your cell power plants), so they burn energy as heat instead of storing it. Your brain screams 'breathe faster!' to blow off acid, which makes your blood too alkaline at first, then too acidic as more poison builds up. Doctors give you IV sodium bicarbonate to make your pee alkaline so your kidneys can dump the aspirin faster, and they use hemodialysis to clean your blood if the level is dangerously high.”

Normal anatomy — the body's job

Aspirin (acetylsalicylic acid) is absorbed in the stomach and small intestine, broken down by enzymes in the liver, and then filtered out of the blood by the kidneys. At normal doses, the liver keeps the drug from building up, and the kidneys flush it out in your pee. This balance keeps aspirin safe.

BODY'S JOB

The liver uses special enzymes (called glycine and glucuronide conjugation pathways) to turn aspirin into harmless pieces. The kidneys then filter those pieces out of the blood and send them into the urine. At the same time, the mitochondria inside every cell use oxygen and glucose to make ATP, the stored energy your body runs on. This process is tightly controlled so energy is stored, not wasted as heat.

1. You swallow aspirin → it dissolves in your stomach and small intestine.
2. Aspirin enters your bloodstream and travels to the liver.
3. Liver enzymes break aspirin into smaller, safer pieces (salicylic acid, then conjugated metabolites).
4. The kidneys filter these pieces out of the blood and send them into the urine.

5. At safe levels, aspirin leaves the body faster than it builds up, so your cells stay healthy and your mitochondria make energy the right way.

What breaks

When you take too much aspirin, the liver's enzyme system gets overwhelmed and can't keep up. Aspirin starts piling up in the blood. It crosses into your cells and poisons the mitochondria, the tiny power plants that make energy. Instead of storing energy as ATP, the mitochondria start burning fuel as pure heat. The brain senses the acid and heat building up and triggers fast, deep breathing to try to blow off carbon dioxide and cool the blood. At first, that hard breathing makes the blood too alkaline. But aspirin keeps dumping acid into the blood, so eventually the blood turns acidic. Now you have both acid and alkaline problems at the same time, plus your cells are overheating and running out of fuel.

CLINICAL TERM

Salicylate toxicity occurs when aspirin (acetylsalicylic acid) saturates hepatic conjugation pathways, causing zero-order kinetics—meaning the liver can no longer clear the drug at a constant rate. Salicylate accumulates and uncouples oxidative phosphorylation in the mitochondria, so the electron transport chain pumps protons without making ATP. Energy is released as heat instead. Salicylate also directly stimulates the respiratory center in the medulla, causing hyperventilation and respiratory alkalosis (blowing off too much carbon dioxide). At the same time, salicylate is an organic acid that causes primary metabolic acidosis (acid building up in the blood). Uncoupling also leads to anaerobic metabolism, lactic acidosis (acid from oxygen-starved tissues), and impaired gluconeogenesis, causing low blood sugar (hypoglycemia). The result is a mixed acid-base disorder (respiratory too little acid in the blood (alkalosis) plus high anion-gap metabolic acidosis), hyperthermia, CNS toxicity, and multi-organ damage.

How the body compensates

The body tries to fix the acid and heat by breathing faster and sweating, but those tricks only work for a little while. Once the aspirin level climbs too high, compensation fails and the patient crashes fast. The danger is that vital signs can look okay in the middle zone, so the

team misses how close the patient is to the edge. Once the brain swells, the lungs fill with fluid, or the kidneys fail, the window to save the patient closes quickly.

1. {'what': 'The medulla (the breathing control center in the brainstem) detects rising CO₂ and acid, so it cranks up the breathing rate.', 'whyItHelps': 'Fast, deep breathing blows off CO₂ and makes the blood more alkaline (respiratory too little acid in the blood (alkalosis)). This buys time by partly offsetting the acid load from the aspirin.', 'whyItFails': 'Salicylate keeps dumping acid into the blood faster than breathing can blow it off. Eventually, metabolic acidosis (acid building up in the blood) overwhelms the respiratory compensation, and the blood pH drops.'}
2. {'what': 'The body sweats and vasodilates (opens blood vessels in the skin) to try to dump the extra heat from uncoupled mitochondria.', 'whyItHelps': 'Sweating and flushed skin cool the body down a little and prevent immediate heat stroke.', 'whyItFails': 'If the aspirin level stays high, mitochondria keep making heat faster than the body can dump it. The patient becomes hyperthermic (dangerously hot), and proteins in the brain and other organs start to break down.'}
3. {'what': 'The kidneys try to filter out salicylate and buffer the acid by holding onto bicarbonate.', 'whyItHelps': 'In alkaline urine (pH > 7.5), salicylate stays charged (ionized) and gets flushed out instead of being reabsorbed. This is why doctors give IV sodium bicarbonate—it alkalinizes the urine and speeds up salicylate clearance.', 'whyItFails': 'If the patient is volume-depleted (from vomiting or sweating), the kidneys can't make enough urine. If the urine stays acidic, salicylate gets reabsorbed back into the blood (ion trapping), and the level climbs even higher.'}
4. {'what': 'The liver tries to keep making glucose to feed the brain, but mitochondrial uncoupling blocks gluconeogenesis.', 'whyItHelps': 'For a short time, stored glycogen can be broken down to release glucose.', 'whyItFails': 'Once glycogen runs out, the liver can't make new glucose. Blood sugar drops (hypoglycemia), and the brain starves. This is especially dangerous in children.'}
5. {'what': 'The heart pumps faster to try to deliver oxygen and clear acid from the tissues.', 'whyItHelps': 'A fast heart rate (Tachycardia) (fast heart rate) keeps blood pressure up and moves blood quickly to the lungs and kidneys.', 'whyItFails': 'If the patient becomes volume-depleted or develops pulmonary edema (fluid flooding the lungs) (fluid in the lungs), the heart can't keep up. Blood pressure drops, and organs fail.'}

6. {'what': 'The point of no return: Once the brain swells (cerebral swelling (edema)), the lungs fill with fluid (non-cardiogenic pulmonary edema (fluid flooding the lungs)), or the kidneys fail, compensation collapses and the patient crashes.', 'whyItMatters': 'Vital signs can look stable in the middle zone—normal or even high blood pressure, fast breathing, alert mental status—but the patient is sliding toward the cliff. The team must treat aggressively (IV fluids, sodium bicarbonate, hemodialysis if needed) before the crash, not after. Once too much acid in the blood (acidosis) is severe ($\text{pH} < 7.1$), intubation becomes extremely dangerous because stopping hyperventilation (even for a few minutes) lets CO_2 rise and pH drop further, which can cause cardiac arrest.'}

Domino effect

1. Aspirin saturates the liver's enzyme pathways and starts piling up in the blood. — At toxic doses, the liver can't break down aspirin fast enough. The drug switches to zero-order kinetics, meaning even a small extra dose causes a big jump in blood level.
2. Salicylate crosses into cells and uncouples mitochondria, so they burn energy as heat instead of storing it as ATP. — Salicylate makes the inner mitochondrial membrane leaky to protons. The electron transport chain keeps running, but no ATP is made. All the energy comes out as heat, so the patient gets hot (hyperthermia) and cells run out of fuel.
3. The medulla (brainstem breathing center) is directly stimulated by salicylate, triggering fast, deep breathing (hyperventilation). — Salicylate acts like a chemical alarm in the medulla. It makes you breathe hard even before CO_2 or oxygen levels change. This blows off CO_2 and causes respiratory alkalosis (blowing off too much carbon dioxide) (blood becomes too alkaline).
4. At the same time, salicylate dumps acid (H^+) into the blood and uncoupling causes lactic acid to build up, so you develop high anion-gap metabolic acidosis (acid building up in the blood). — Salicylate is an organic acid. When mitochondria can't make ATP the normal way, cells switch to anaerobic metabolism (burning glucose without oxygen), which makes lactic acid. Now you have two sources of acid flooding the blood.
5. You end up with a mixed acid-base disorder: respiratory alkalosis (blowing off too much carbon dioxide) (from hyperventilation) and metabolic acidosis (acid building up in the blood) (from salicylate and lactic acid) at the same time. — This is the hallmark of salicylate toxicity. Your blood gas shows low CO_2 (because you're breathing it off) and low bicarbonate (because acid is eating it up). The pH can be high, normal, or low depending on which problem is winning at that moment.
6. Your ears ring (tinnitus) and you may have trouble hearing. — Salicylate poisons the hair cells in the cochlea (the hearing organ in your inner ear) and damages the eighth cranial nerve (the hearing and balance nerve). This causes a high-pitched ringing and temporary hearing loss.

7. You feel sick to your stomach, throw up, and may have belly pain. — Salicylate directly irritates the lining of the stomach and triggers the vomiting center in the brainstem (area postrema). Vomiting makes you lose fluids and electrolytes, which worsens dehydration and kidney function.
8. Your blood sugar drops (hypoglycemia), especially in young children. — Uncoupling increases the cells' hunger for glucose, but it also blocks the liver from making new glucose (gluconeogenesis). Once stored glycogen runs out, blood sugar crashes and the brain starves.
9. Your thinking gets confused, you may see or hear things that aren't there (hallucinations), and in severe cases you can have seizures or slip into a coma. — The brain is extremely sensitive to acid, heat, and low glucose. Salicylate crosses the blood-brain barrier and poisons neurons directly. Cerebral swelling (edema) (brain swelling) can develop, which raises pressure inside the skull and damages brain tissue.
10. Your lungs can fill with fluid (non-cardiogenic pulmonary edema (fluid flooding the lungs)), making it hard to breathe. — Salicylate damages the lining of the tiny air sacs in the lungs (alveolar-capillary membrane), so fluid leaks out of the blood vessels and floods the air spaces. This is not from heart failure—it's direct lung injury from the poison.
11. In the worst cases, your heart rhythm becomes unstable, your blood pressure drops, and you can go into cardiac arrest. — Severe too much acid in the blood (acidosis) ($\text{pH} < 7.1$) makes the heart muscle irritable and less responsive to its own electrical signals. High potassium (from cells dying and leaking their contents) and low calcium (from acid shifting the balance) can trigger deadly arrhythmias. If the brain swells or the lungs fail, oxygen delivery collapses and the heart stops.

Symptoms · what the patient feels, and why

- Breathing very fast and deep: Aspirin directly tickles the breathing center in the brainstem (the control tower at the base of the brain), forcing you to take big, fast breaths. This blows off carbon dioxide and makes the blood turn basic (alkaline), like adding too much baking soda.
- Ringing in the ears (tinnitus): Aspirin builds up in the fluid of the inner ear and irritates the tiny hair cells that sense sound, making them fire off false signals that you hear as ringing or buzzing.
- Nausea and throwing up: Aspirin irritates the stomach lining directly and also triggers the vomiting center in the brainstem (the part of the brain that controls the urge to throw up).
- Confusion or acting strange: High levels of aspirin cross into the brain and interfere with how nerve cells make energy, slowing their signals and scrambling thinking.

- Very high body temperature (hyperthermia): Aspirin uncouples oxidative phosphorylation in mitochondria (the tiny power plants inside cells). Energy that should become fuel instead leaks out as pure heat, like a car engine revving without moving forward.
- Blood that is both too basic and too acidic (mixed acid-base disorder): Early on, fast breathing blows off carbon dioxide and makes the blood basic (respiratory too little acid in the blood (alkalosis)). At the same time, aspirin itself is an acid and also blocks cells from burning fuel cleanly, so lactic acid and ketones pile up, making the blood acidic (metabolic too much acid in the blood (acidosis)). Both happen at once.
- Sweating a lot: The body tries to cool itself as aspirin forces cells to waste energy as heat. Sweat glands open wide to let heat escape through the skin.
- Low blood sugar (hypoglycemia): Aspirin blocks the liver from making new glucose and also ramps up how fast cells burn glucose for energy, so blood sugar drops, especially in young children.
- Seizures: Very high aspirin levels in the brain disrupt the balance of excitatory and inhibitory neurotransmitters (the chemical signals that turn nerve cells on and off), and low blood sugar or swelling in the brain can trigger uncontrolled electrical storms.

Focused exam

- Ringing in the ears (tinnitus): Aspirin directly harms the cochlea (the hearing part deep in your ear). Ringing is often the first clue that aspirin levels are climbing into the danger zone.
- Fast, deep breathing (tachypnea and hyperpnea): Aspirin directly tickles the breathing center in the brainstem, forcing you to breathe fast and deep even when your lungs are fine. This creates respiratory alkalosis (blowing off too much carbon dioxide) (blood becomes too basic from blowing off CO₂).
- High fever (hyperthermia): Aspirin uncouples oxidative phosphorylation — cells still burn fuel but make heat instead of usable energy. High fever means the poison is overwhelming the body's cooling system.
- Confusion, agitation, or lethargy: Aspirin crosses into the brain and causes cerebral swelling (edema) (brain swelling) and direct neurotoxicity. Any altered mental status is a red flag for severe poisoning and warrants immediate hemodialysis.
- Wet lung sounds (crackles) or pulmonary edema (fluid flooding the lungs) on chest X-ray: Salicylates increase capillary permeability (blood vessel walls become leaky), letting fluid spill into the lungs. This is non-cardiogenic pulmonary edema (fluid flooding the lungs) and can be fatal.

- Low blood sugar (hypoglycemia), especially in young children: Aspirin increases glucose use and decreases glucose production in the liver. The brain runs on glucose — low sugar worsens confusion and can cause seizures.

Diagnostics · every test answers a question

- Serum salicylate level → How much aspirin is in the blood right now, and is it rising or falling?
- Arterial blood gas (ABG) → Is the patient compensating, or is acidemia (blood becoming too acidic) winning?
- Serum electrolytes with anion gap calculation → Is there a hidden acid building up, and is potassium dangerously low?
- Serum glucose → Is the brain getting enough fuel?
- Serum creatinine and blood urea nitrogen (BUN) → Are the kidneys still able to clear the poison?
- Chest X-ray → Is fluid leaking into the lungs?
- Urine pH → Is the urine alkaline enough to trap salicylate and flush it out?

Treatment logic

- Activated charcoal 1 g/kg (max 50 g) by mouth or nasogastric tube if patient presents within 1–2 hours of ingestion and airway is protected → Charcoal binds aspirin still sitting in the stomach and gut, blocking absorption into the bloodstream.
- IV normal saline bolus (20 mL/kg, repeat as needed) then continuous infusion at 1.5–2× maintenance, PLUS IV dextrose 5% or 10% to keep glucose > 100 mg/dL → Fluid expands blood volume so kidneys can flush salicylate into urine. Dextrose feeds starving cells and prevents brain glucose depletion.
- Sodium bicarbonate 1–2 mEq/kg IV bolus, then continuous infusion (150 mEq NaHCO₃ in 1 L D5W at 1.5–2× maintenance rate) to achieve serum pH 7.45–7.50 and urine pH 7.5–8.0 → Alkalinizes blood and urine, which traps salicylate in its ionized form — it cannot cross back into cells and gets stuck in urine for excretion. Also directly buffers metabolic acidosis (acid building up in the blood).
- Potassium chloride 20–40 mEq/L added to IV fluids, titrated to keep serum K⁺ 4.0–4.5 mEq/L (higher than usual target) → Replaces potassium lost in urine during alkalinization. Adequate potassium is essential for bicarbonate to work — without it, cells stay acidic even when you give bicarbonate.

- Hemodialysis: start urgently if (1) salicylate > 100 mg/dL acute or > 60 mg/dL chronic, (2) altered mental status, (3) pulmonary edema (fluid flooding the lungs), (4) refractory too much acid in the blood (acidosis) (pH < 7.20 despite treatment), (5) acute kidney injury, or (6) seizures → Physically removes salicylate and toxic metabolites from blood. Corrects severe too much acid in the blood (acidosis) and electrolyte chaos faster than any other treatment.
- Avoid intubation if possible; if mechanical ventilation is unavoidable, set rate and tidal volume to match patient's baseline hyperventilation (prevent hypoventilation) → Preserves the patient's compensatory respiratory alkalosis (blowing off too much carbon dioxide). Slowing breathing allows CO₂ to rise, which worsens acidemia and drives more salicylate into the brain — this can be fatal.
- Continuous monitoring: vital signs, mental status, urine output, and repeat blood gas, salicylate level, electrolytes, glucose every 2 hours until stable and salicylate falling → Catches deterioration early (rising salicylate, worsening too much acid in the blood (acidosis), falling potassium) so treatment can be escalated before the patient crashes.

Medications

Activated charcoal · Gastrointestinal decontaminant (a substance that binds poison in the stomach so it can't get into the blood)

Charcoal is a super-sticky powder that grabs onto salicylate molecules (the aspirin or aspirin-like drug) sitting in the stomach and intestines, trapping them like velcro so they can't cross into the bloodstream. Once trapped, the charcoal and poison leave together in a bowel movement.

1. Aspirin or salicylate pills dissolve in the stomach and upper small intestine.
2. Charcoal particles have millions of tiny pores (like a sponge) that chemically stick to salicylate molecules.
3. The bound salicylate can't be absorbed through the intestinal wall into blood.
4. The charcoal-salicylate bundle moves down the gut and exits in stool, removing poison from the body.

SAFETY WATCH

Do NOT give charcoal if the person is vomiting uncontrollably, drowsy, or unconscious — they could breathe it into their lungs (aspiration), which can cause serious lung injury. · Do NOT use if the person has a hole in the intestine (perforation) or a blocked gut. · Charcoal turns stool black, which is harmless but can be alarming. · Multiple doses of charcoal can cause constipation or, rarely, a dangerous gut blockage. · Charcoal will bind and inactivate other medicines taken by mouth at the same time, so timing matters if the patient needs other drugs.

Intravenous (IV) dextrose (sugar solution) · Carbohydrate replacement / energy substrate

Salicylate poisons the mitochondria (the tiny power plants inside every cell that turn sugar and oxygen into energy). Even though blood sugar may measure normal, the cells can't USE that sugar properly, so the brain and body act as if they are starving. Giving dextrose through an IV floods the blood with extra sugar, pushing more fuel into cells to partly make up for the poisoned energy factories and prevent dangerous low blood sugar (hypoglycemia), especially in the brain.

1. Salicylate uncouples oxidative phosphorylation in mitochondria, meaning cells burn fuel without making usable energy (ATP); instead, the energy is wasted as heat.
2. Cells try to compensate by consuming glucose much faster than normal, which can drop blood sugar dangerously low.
3. The brain is especially vulnerable because it depends almost entirely on glucose for fuel and has very little stored energy.
4. IV dextrose raises blood glucose quickly, ensuring a steady supply of sugar to the brain and other organs.
5. Even though mitochondria are still poisoned, the extra glucose helps keep critical processes running until salicylate is cleared from the body.

SAFETY WATCH

Giving too much dextrose too fast can cause high blood sugar (hyperglycemia), which in salicylate poisoning can actually worsen brain injury because the poisoned mitochondria produce even more harmful byproducts. · Monitor blood glucose frequently (every 1–2 hours) and adjust the infusion to keep glucose in a safe range (typically 100–150 mg/dL). · Watch for fluid overload, especially in children and patients with heart or kidney problems, because IV fluids add volume to the circulation. · If the patient has low potassium (common in salicylate toxicity), dextrose can drive potassium further into cells and worsen the low level in the blood, which can cause dangerous heart rhythms.

Intravenous (IV) sodium bicarbonate · Alkalinizing agent (a substance that makes blood and urine less acidic / more basic)

Salicylate is a weak acid. When blood and urine are acidic, salicylate stays in a form that easily crosses cell membranes, letting it pile up inside the brain and other organs where it does the most harm. Sodium bicarbonate makes the blood and urine more alkaline (higher pH). In alkaline urine, salicylate gets trapped in an ionized (charged) form that cannot cross back out of the kidney tubules, so it is flushed out in the urine much faster. Alkaline blood also helps keep salicylate out of the brain and reduces the dangerous acid build-up (metabolic too much acid in the blood (acidosis)) caused by the poison.

1. Salicylate is a weak acid that exists in two forms: un-ionized (uncharged, can cross membranes) and ionized (charged, cannot cross membranes).
2. In acidic conditions (low pH), most salicylate is un-ionized, so it easily enters the brain, heart, and other organs.
3. Sodium bicarbonate is a base (alkaline substance) that raises the pH of blood and urine.
4. Higher pH shifts the balance so more salicylate becomes ionized (charged).
5. Ionized salicylate in the blood cannot cross into brain cells, reducing brain toxicity.
6. Ionized salicylate in the kidney tubules cannot be reabsorbed back into the blood, so it stays in the urine and is peed out, lowering the total body load of poison.
7. This process is called ion trapping or alkaline diuresis.

SAFETY WATCH

Alkalinization FAILS if potassium is low — you must replace potassium aggressively (often 20–40 mEq per liter of IV fluid) to allow the kidneys to excrete acid and raise urine pH. Check potassium levels frequently. · Monitor arterial blood pH and urine pH every 1–2 hours. Target blood pH 7.45–7.50 and urine pH 7.5–8.0. Do NOT make blood pH go above 7.55, which can cause dangerous side effects. · Giving too much bicarbonate can cause volume overload (too much fluid in the blood), worsening lung fluid (pulmonary swelling (edema)) or heart failure. · Rapid alkalinization can drop ionized calcium in the blood, causing muscle spasms or seizures; monitor calcium. · High sodium load from bicarbonate can worsen swelling (edema) in patients with heart or kidney disease. · If urine pH does NOT rise despite bicarbonate and potassium replacement, suspect severe poisoning or kidney failure — dialysis may be needed.

Intravenous (IV) potassium chloride or potassium phosphate · Electrolyte replacement

Salicylate poisoning causes the body to lose large amounts of potassium in the urine because the kidneys are trying to balance the acid-base disturbance and the fast breathing (which

blows off carbon dioxide and makes blood temporarily alkaline). Low potassium (hypokalemia) prevents the kidneys from making urine alkaline — even if you give sodium bicarbonate, the urine pH will not rise because the kidneys hold onto hydrogen ions (acid) to conserve potassium. Replacing potassium allows alkalinization to work, speeds salicylate elimination, and prevents dangerous heart rhythms caused by low potassium.

1. Salicylate toxicity causes respiratory alkalosis (blowing off too much carbon dioxide) (fast breathing lowers blood carbon dioxide and raises blood pH) followed by metabolic acidosis (acid building up in the blood) (salicylate and other acids build up).
2. The kidneys respond by excreting bicarbonate and potassium in the urine to balance pH, leading to severe potassium loss.
3. When potassium is low, the kidneys prioritize saving potassium over excreting acid (hydrogen ions).
4. This means that even if you give sodium bicarbonate, the kidneys reabsorb hydrogen ions instead of putting them in the urine, so urine pH stays low and salicylate is reabsorbed instead of eliminated.
5. Giving IV potassium refills the body's stores, allowing the kidneys to switch back to excreting hydrogen ions.
6. Urine pH then rises to the target of 7.5–8.0, trapping salicylate in the urine and flushing it out.
7. Normal potassium also prevents dangerous heart rhythms (arrhythmias) that can occur with low potassium, especially when the heart is already stressed by poisoning.

SAFETY WATCH

Potassium **MUST** be given through a secure IV line, never as a rapid push, because a sudden high level in the blood can stop the heart (cardiac arrest). · Typical safe infusion rate is 10–20 mEq per hour through a peripheral IV, or faster (up to 40 mEq/hour) through a central line under close cardiac monitoring, because salicylate toxicity often requires aggressive replacement. · Monitor serum potassium every 2–4 hours; target is usually 4.0–5.0 mEq/L, sometimes higher (4.5–5.0) to ensure adequate kidney function for alkalinization. · Watch the heart rhythm on a monitor — low potassium causes a flattened T wave, U waves, and can trigger life-threatening arrhythmias like ventricular a fast heart rate (tachycardia). · Do NOT give potassium if the patient has severe kidney failure and is not urinating (anuria), because potassium can build up to dangerous levels. · Potassium chloride can worsen metabolic acidosis (acid building up in the blood) slightly (because chloride is acidifying), so some clinicians prefer potassium acetate or potassium phosphate in this setting, though chloride is most commonly used and well tolerated.

Hemodialysis · Extracorporeal blood purification (a machine-based treatment that filters the blood outside the body)

Hemodialysis is a procedure where blood is pumped out of the body through a special filter (dialyzer) that removes salicylate and other toxins, then returns the cleaned blood. The dialyzer contains thousands of tiny hollow fibers; blood flows through the fibers while a cleansing fluid (dialysate) flows around them. Salicylate, which is a small molecule, crosses from the blood into the dialysate and is discarded. Dialysis is the FASTEST way to remove salicylate when the poisoning is life-threatening and the kidneys cannot eliminate it quickly enough, even with alkalinization.

1. Blood is drawn from a large vein (or artery) through a catheter and pumped into the dialysis machine.
2. Inside the dialyzer, blood flows on one side of a semi-permeable membrane and dialysate (a special fluid) flows on the other side.
3. Salicylate and other small waste molecules move from the blood (high concentration) across the membrane into the dialysate (low concentration) by diffusion.
4. The dialysate, now carrying salicylate and other toxins, is discarded.
5. The cleaned blood is returned to the patient's body through another catheter.
6. This process continues for several hours (typically 4-6 hours or longer) until the salicylate level drops to a safe range and the patient's acid-base balance and mental status improve.

SAFETY WATCH

Dialysis requires placing a large catheter into a central vein (usually the internal jugular, subclavian, or femoral vein), which carries risks of bleeding, infection, collapsed lung (pneumothorax), or hitting an artery. · During dialysis, blood pressure can drop suddenly (hypotension), especially if the patient is already dehydrated or in shock from the poisoning. · Hemodialysis removes potassium, calcium, and other electrolytes along with salicylate, so these must be monitored and replaced carefully during and after the procedure. · Anticoagulation (blood thinners like heparin) is usually needed to prevent blood from clotting in the dialysis circuit, which increases bleeding risk. · Dialysis is physically stressful and requires specialized equipment and trained staff — not all hospitals can provide it immediately, so transfer to a dialysis-capable center may be necessary. · Continue to monitor salicylate levels after dialysis — they can rebound as salicylate redistributes from tissues back into the blood.

Intravenous (IV) normal saline or lactated Ringer's solution · Isotonic crystalloid fluid (a balanced salt-water solution that expands blood volume)

Salicylate poisoning causes fluid loss through sweating (from high fever and increased metabolism), vomiting, and fast breathing. This dehydration reduces blood flow to the kidneys, which slows the elimination of salicylate. IV fluids restore blood volume, improve kidney blood flow, and help the kidneys flush out salicylate, especially once urine is alkalinized with bicarbonate. Fluids also dilute the salicylate concentration in the blood and support blood pressure.

1. Salicylate uncouples mitochondria, generating excess heat and raising body temperature, which causes sweating and fluid loss.
2. Vomiting (common in salicylate toxicity) and rapid breathing also deplete fluids.
3. Dehydration reduces the amount of blood reaching the kidneys, slowing the filtration and excretion of salicylate.
4. IV crystalloid fluids quickly expand blood volume, raising blood pressure and increasing kidney blood flow.
5. Better kidney blood flow (perfusion) allows more salicylate to be filtered into the urine.
6. When combined with sodium bicarbonate (to alkalinize urine), adequate IV fluids ensure a good urine flow rate (target 2–3 mL/kg/hour or more), maximizing salicylate elimination.

SAFETY WATCH

Giving too much IV fluid too fast can cause fluid overload, leading to pulmonary edema (fluid flooding the lungs) (fluid in the lungs) or worsening cerebral swelling (edema) (brain swelling), both of which are already risks in severe salicylate poisoning. · Monitor lung sounds, oxygen levels, and work of breathing closely — if the patient develops crackles (a rattling sound when breathing), shortness of breath, or low oxygen, slow or stop fluids and consider dialysis. · Balance is key: give enough fluid to support kidney function and urine output, but not so much that you flood the lungs or brain. · Normal saline contains a lot of chloride, which can worsen metabolic acidosis (acid building up in the blood) (hyperchloremic too much acid in the blood (acidosis)) if given in very large volumes; some clinicians prefer lactated Ringer's or a mix of fluids. · Lactated Ringer's contains potassium (4 mEq/L), which is helpful in salicylate toxicity but must be accounted for when calculating total potassium replacement. · Check urine output, blood pressure, and central venous pressure (if available) to guide fluid administration.

Red flags

- Confusion, slurred speech, or not responding normally
- Body temperature above 104°F (40°C)

- Seizure or uncontrolled shaking
- Very fast or very slow breathing, or gasping for air
- Heart racing or blood pressure dropping (shock)

Nursing priorities

1. Place patient on continuous cardiorespiratory monitor and pulse oximetry; obtain venous or arterial blood gas immediately — Salicylate causes mixed respiratory alkalosis (blowing off too much carbon dioxide) (fast breathing lowers CO₂) and metabolic acidosis (acid building up in the blood) (aspirin itself is acid plus cells make lactic acid) at same time; blood gas shows pH and helps calculate anion gap (measures unmeasured acids); falling pH below 7.35 despite fast breathing means severe toxicity
2. Start two large-bore IV lines; give normal saline bolus 10 to 20 mL/kg over 1 hour, then continuous infusion at 200 to 300 mL/hour — Aspirin causes fluid loss through vomiting, sweating, and fast breathing; dehydration makes kidneys hold onto aspirin instead of removing it in urine; IV fluid reverses shock and supports high urine output needed to wash aspirin out through kidneys
3. Check fingerstick blood sugar immediately and repeat every 1 to 2 hours; give dextrose 1 amp (25 grams D50) IV push if glucose under 60 mg/dL, then add dextrose to all IV fluids — Aspirin blocks cells from using glucose for energy even when blood sugar looks normal; brain glucose drops critically low causing confusion and seizures; dextrose in IV fluid prevents neuroglycopenia (brain starvation) which can happen even with normal blood glucose number
4. Draw blood for salicylate level, complete metabolic panel with potassium, and lactate; repeat salicylate level every 2 to 4 hours until level is dropping — Salicylate level over 30 mg/dL confirms poisoning; level over 100 mg/dL means hemodialysis needed; potassium drops dangerously low during treatment and blocks sodium bicarbonate from working; lactate over 4 shows cells are dying from aspirin toxicity
5. Give sodium bicarbonate 1 to 2 mEq/kg IV push over 5 minutes, then start continuous drip at 150 mEq in 1 liter D5W at 150 to 200 mL/hour; check urine pH every 2 hours with goal 7.5 to 8.0 — Bicarbonate makes blood and urine basic (alkaline) which traps aspirin in urine as charged particles that cannot go back into blood; this forces kidneys to remove aspirin 20 times faster; urine pH over 7.5 is required—blood pH goal is 7.45 to 7.50
6. Add potassium chloride 20 to 40 mEq to each liter of IV fluid; recheck potassium every 2 to 4 hours with goal 4.0 to 4.5 mEq/L — Alkalinization with bicarbonate pushes potassium from blood into cells causing low potassium (hypokalemia) (low potassium); when potassium drops below 3.5 kidneys cannot make alkaline urine no matter how much bicarbonate you give; urine stays acidic and aspirin stays in blood

7. Measure temperature every 30 minutes; apply cooling blankets and ice packs to groin and armpits if temperature over 102°F; never give acetaminophen for fever — Aspirin uncouples mitochondria (cell powerhouses) so cells burn energy and make only heat instead of ATP (energy currency); hyperthermia (very high fever) over 104°F causes brain damage and multi-organ failure; acetaminophen does not work because fever comes from cell poison not infection
8. Call nephrology (kidney doctor) immediately if salicylate level over 100 mg/dL, pH under 7.20, kidney injury with creatinine over 2.0, pulmonary edema (fluid flooding the lungs) (fluid in lungs), seizures, or coma — These findings mean aspirin removal by kidneys has failed and dialysis is only treatment; hemodialysis pulls aspirin directly out of blood and corrects acid-base problems within 4 hours; waiting too long causes death from brain swelling or heart failure

Sources

- EXTRIP (Extracorporeal Treatments in Poisoning) Workgroup 2015 Salicylate Guideline
- American Academy of Clinical Toxicology
- UpToDate Clinical Decision Support
- Poisoning and Drug Overdose, 7th Edition (Olson)

Last reviewed: 2026-07-07