

Acid-base

A plain-English guide for you and your family

WHAT IS HAPPENING

Your body keeps a narrow zone of acidity (pH 7.35 to 7.45) using three teams: buffers (instant sponges that soak up or release acid), lungs (blow off or hold CO₂), and kidneys (dump or save bicarbonate over days). When the balance breaks—acid piles up from shock, diabetes, toxins, diarrhea, or kidney trouble, or CO₂ builds up from weak breathing, or hyperventilation blows off too much CO₂—pH swings and the body scrambles to compensate. Too much acid (acidemia) confuses the brain, weakens the heart, and pushes potassium dangerously high. Too much base (alkalemia) drops active calcium and triggers muscle spasms, seizures, and abnormal heart rhythms. Every strange lab value you see (high potassium, deep gasping breaths, confusion) is the body fighting to survive, not the disease itself. Trace every clue backward to the one broken thing upstream, name it, fix it, and the whole cascade reverses.

What you might feel

- Kussmaul breathing (deep, fast, sighing breaths)
- Confusion, drowsiness, or coma
- Nausea and vomiting
- Muscle weakness or paralysis
- Muscle spasms, tingling in fingers and lips, or seizures (tetany)
- Heart racing, fluttering, or dangerous rhythms
- Belly pain
- Fruity or sweet breath smell
- Peeing a lot and feeling very thirsty
- Low blood pressure or shock

Call the doctor right away if...

- pH below 7.20 or above 7.60 — risk of deadly heart rhythms, seizures, or coma

- Potassium above 6.5 mEq/L with peaked T waves or wide QRS on ECG — heart can stop beating any second
- Anion gap above 30 with confusion — think poisoning (methanol, antifreeze) or septic shock with severe lactic acidosis (acid from oxygen-starved tissues)
- Bicarbonate below 10 mEq/L in diabetic ketoacidosis (the acid crisis of missing insulin) — brain can swell if you correct pH too fast; do NOT give bicarbonate unless pH is below 6.9 (ADA 2024)
- Kussmaul breathing with fruity breath and high blood sugar — diabetic ketoacidosis (the acid crisis of missing insulin) until proven otherwise; check blood or urine ketones and start insulin right away

What the care team will do

- Place patient on continuous cardiac monitor and watch for peaked T waves, wide QRS, or arrhythmias every 15 minutes if potassium is above 5.5 mEq/L.
- Check blood glucose immediately with fingerstick, then obtain full metabolic panel, arterial blood gas, and anion gap calculation before any treatment.
- Start high-flow oxygen or prepare for mechanical ventilation if respiratory rate is below 8 or above 35 breaths per minute, or if patient is drowsy and cannot protect airway.
- Establish large-bore IV access (18-gauge or larger) and hang normal saline or lactated Ringer's solution at the rate ordered, preparing to give 1 to 2 liters rapidly if patient is with low blood pressure (hypotensive) or in DKA.
- Hold all bicarbonate administration until the physician reviews the anion gap and identifies the cause, unless pH is below 7.10 in metabolic acidosis (acid building up in the blood) with shock.
- Assess for Chvostek sign (tap cheek, watch for face twitch) and Trousseau sign (inflate blood pressure cuff, watch for hand spasm) every 2 hours if pH is above 7.50.
- Monitor urine output every hour and report if less than 30 mL per hour, while watching for dark brown or tea-colored urine.
- Recheck arterial blood gas 1 hour after any ventilator change, bicarbonate dose, or insulin bolus to verify pH is moving toward 7.35 to 7.45 at a safe speed.

Medicines you may be given — and why

Sodium bicarbonate

Sodium bicarbonate is baking soda given through an IV. It dumps bicarbonate (the body's main base, which soaks up extra acid like a sponge) directly into the blood. When bicarbonate meets hydrogen ions (the particles that make blood acidic), they combine to form water and carbon

dioxide (the gas you breathe out). This raises the blood pH (makes it less acidic) within minutes. The kidneys then filter out the extra sodium and water over the next few hours.

Insulin (regular insulin IV drip)

In diabetic ketoacidosis (the acid crisis of missing insulin), the body has no insulin, so cells cannot use glucose (sugar) for energy. Instead, the liver breaks down fat and makes ketones (acids that pile up in the blood). Regular insulin given through an IV tells cells to open their doors and let glucose in. Once cells have fuel again, the liver stops making ketones. Ketone production shuts off within 1 to 2 hours, and the acids slowly leave the blood through urine and breathing. Blood pH rises as ketones disappear.

Normal saline (0.9% sodium chloride IV fluid)

Normal saline is salt water given through an IV. In metabolic acidosis (acid building up in the blood) from dehydration, vomiting, or diarrhea, the body loses fluid and bicarbonate. Saline replaces blood volume, which improves kidney blood flow. When kidneys get enough blood, they start making new bicarbonate and filtering out acid. Saline also dilutes the acid already in the blood (like adding water to strong lemon juice). In metabolic alkalosis (the blood turning too alkaline) from vomiting or diuretics, saline gives the kidneys the chloride they need to dump the extra bicarbonate into urine and bring pH back to normal.

Oxygen and mechanical ventilation

In respiratory acidosis (acid building up from trapped carbon dioxide), the lungs cannot blow off enough CO₂ (the acid gas made by every cell), so CO₂ builds up in the blood and makes it acidic. Oxygen alone does NOT fix this—you must move more air in and out of the lungs. Mechanical ventilation is a breathing machine that pushes air into the lungs and pulls it out, doing the work the lungs cannot do. By increasing the rate or depth of breaths, the machine blows off extra CO₂, and blood pH rises. In respiratory alkalosis (blowing off too much carbon dioxide), the person is breathing too fast (hyperventilation) and blowing off too much CO₂, making blood too basic. You treat the cause (pain, anxiety, fever, lung disease) so breathing slows down, CO₂ rises, and pH comes back to normal.

Potassium chloride (KCl IV or oral)

Potassium is a charged particle (electrolyte) that every cell needs to work, especially heart and muscle cells. In metabolic alkalosis (the blood turning too alkaline), the kidneys dump potassium into urine while trying to get rid of extra bicarbonate. Low potassium makes too little acid in the blood (alkalosis) worse because the kidneys hold onto hydrogen ions (acid particles) to save potassium, which keeps blood basic. Giving potassium lets the kidneys release hydrogen ions and dump bicarbonate, so pH comes back to normal. In too much acid in the blood (acidosis) treatment (especially with insulin or bicarbonate), potassium shifts from

blood into cells, and blood potassium can drop to dangerous levels. Replacing potassium prevents deadly heart rhythms.

Acetazolamide

Acetazolamide blocks an enzyme in the kidney called carbonic anhydrase, which normally helps the kidney reabsorb bicarbonate from urine back into blood. When you block that enzyme, bicarbonate spills into urine and leaves the body, lowering blood bicarbonate and bringing down a high pH. This is used to treat metabolic alkalosis (the blood turning too alkaline) (blood too basic) that does not respond to saline, or to treat chronic respiratory acidosis (acid building up from trapped carbon dioxide) (like in severe COPD) by lowering bicarbonate so the body tolerates a higher CO₂ without the blood becoming too basic.

Fomepizole (4-methylpyrazole)

Methanol (wood alcohol) and ethylene glycol (antifreeze) are poisons that, by themselves, cause mild intoxication. The danger comes when the liver enzyme alcohol dehydrogenase breaks them down into toxic acids—methanol becomes formic acid (which blinds you and makes blood very acidic), and ethylene glycol becomes glycolic and oxalic acids (which destroy kidneys and make blood acidic). Fomepizole blocks alcohol dehydrogenase so the poison cannot turn into acid. The original alcohol then leaves the body slowly through the kidneys and lungs, without causing too much acid in the blood (acidosis) or organ damage.

Where this information comes from

- ADA Standards of Care in Diabetes 2024
- Surviving Sepsis Campaign 2021
- Berend K et al. N Engl J Med 2014;371:1434
- UpToDate: Approach to the adult with metabolic acidosis, 2024

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