Diabetic Ketoacidosis

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THE STORY IN ONE SENTENCE

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"The tank is full but the key is broken, so the body burns wood in the fireplace — and the smoke poisons the room."

Normal anatomy — the body's job

The pancreas (an organ behind your stomach) makes insulin. Insulin is the key that opens the door on every cell so sugar (glucose) can get inside. Sugar inside the cells fuels the whole body — the brain, the muscles, the heart, everything. When you eat and blood sugar rises, the pancreas releases insulin. When blood sugar drops, insulin drops. The body keeps blood sugar in a tight, safe window all day and night.

BODY'S JOB

Match insulin to the amount of sugar in the blood, so sugar smoothly enters every cell for fuel and blood sugar stays steady.

1. Food is eaten — Carbs (bread, fruit, rice) break down into sugar (glucose) in the gut and enter the bloodstream.
2. Pancreas senses rising blood sugar — Beta cells (tiny factories inside the pancreas) release insulin into the blood.
3. Insulin travels through the bloodstream — It reaches every organ and tissue in the body.
4. Insulin unlocks cell doors — Sugar moves from the blood into the cells (like unlocking a door so fuel can go inside).
5. Cells use sugar for energy — Blood sugar drops back to normal. The cycle repeats with every meal and snack.

What breaks

Insulin is missing or almost missing. Either the pancreas (in type 1 diabetes) does not make any insulin, or a big stress like an infection, missed doses, or sickness makes the insulin the body has stop working well enough. Sugar cannot get into cells. The body panics and thinks it is starving, even though the blood is flooded with sugar.

> **CLINICAL TERM**
> Absolute or severe relative insulin deficiency, combined with a surge of counter-regulatory hormones (glucagon, cortisol, catecholamines) that drive glucose production and fat breakdown.

How the body compensates

Since cells cannot use sugar for fuel, the liver dumps even MORE sugar into the blood to try to help. At the same time, the body starts breaking down fat for emergency fuel. Fat breakdown makes ketones — acids. The kidneys try to pee the sugar and acids out. That works for a while but pulls a huge amount of water with it (like a flood through the pipes). The lungs try to blow off the acid by breathing deep and fast.

1. Cells are starving → they send out stress hormones (glucagon, cortisol, adrenaline) that tell the liver, 'Make more sugar!'
2. Liver dumps sugar into the blood → blood sugar climbs into the 300s, 500s, or higher (normal is 70–100).
3. Kidneys try to flush the extra sugar out in the urine → this pulls a huge amount of water and salt with it (osmotic diuresis — sugar drags water like a sponge soaking up a puddle).
4. Body starts burning fat for emergency fuel → fat breakdown creates ketones (beta-hydroxybutyrate, acetoacetate, acetone) — these are acids.
5. Blood pH drops (becomes more acidic) → lungs respond by breathing deep and fast (Kussmaul respirations) to blow off CO_2 and try to lift the pH back up.
6. Potassium looks normal or even high on the lab, but total body potassium is very low — it has been peeing out. The moment insulin is given, potassium will crash dangerously low (because insulin pushes potassium back into cells).

Domino effect

1. Insulin drops or disappears (missed dose, new undiagnosed type 1 diabetes, insulin pump failure, or illness). — No key, so the cell door stays locked. Sugar cannot enter.

2. Cells starve while blood sugar climbs sky-high. — Sugar is stuck in the blood with nowhere to go.
3. Liver makes even more sugar; body starts burning fat for emergency fuel. — The body thinks it is starving and tries to make fuel any way it can.
4. Ketones (acids from fat breakdown) build up in the blood. — Fat breakdown creates acid by-products faster than the body can clear them.
5. Blood becomes acidic (pH drops below 7.3). — Too many acid molecules, not enough buffer (bicarbonate) left to soak them up.
6. Kidneys pee out sugar and ketones → huge water and salt loss. — Osmotic diuresis — sugar drags water with it like a sponge. The body becomes dehydrated.
7. Dehydration sets in. Fast deep breathing (Kussmaul). Fruity breath (acetone). Belly pain. Confusion. — Every organ feels the acid burn and the fluid loss. The brain gets foggy. The gut cramps. The lungs work overtime.
8. If untreated → shock (dangerously low blood pressure), coma, brain swelling (cerebral swelling (edema)), and death. — The acid and severe dehydration become so extreme the body cannot recover on its own.

Symptoms · what the patient feels, and why

- Extreme thirst: High blood sugar spills into the urine and pulls water out with it like a sponge, so the body loses a lot of water and becomes very dry inside.
- Peeing constantly (polyuria): When blood sugar rises above 180, the kidneys cannot hold it back, so sugar spills into the urine and drags water along with it, making huge amounts of dilute pee.
- Nausea and vomiting: Ketones (acidic chemicals the body makes when it burns fat for fuel) and the acid itself irritate the stomach and trigger the vomit center in the brain.
- Belly pain: The acid irritates nerves in the belly wall and can slow the gut down; sometimes the pain is so sharp it looks like appendicitis or another surgical emergency.
- Deep, fast breathing (Kussmaul breathing): The lungs blow off carbon dioxide (CO_2) to raise the blood pH and fight the acid—this is the body's fastest emergency fix for too much acid in the blood (acidosis).
- Fruity or acetone breath: One of the ketones, acetone, evaporates through the lungs with each breath and smells like nail-polish remover or rotting fruit.
- Confusion, drowsiness, or hard to wake: The brain is very sensitive to acid and to big swings in blood sugar and salt balance; when pH drops or osmolality (concentration of particles in blood) rises, brain cells swell or shrink and stop working well.
- Weakness and fatigue: Without enough insulin, cells cannot take in glucose even though it is high in the blood, so the cells are starving for energy and the person feels exhausted.

- Weight loss: The body breaks down muscle and fat for fuel because cells cannot use glucose, and water weight drops quickly from all the urination.

Focused exam

- Dry mouth and lips, eyes look sunken, skin stays pinched when you lift it (called tenting): The body has lost a huge amount of water — adults can be missing 6 to 10 liters, more than two large soda bottles. High sugar acts like a drain, pulling water out through pee. Replacing this water fast is the first step to saving the organs.
- Deep, fast breathing that sounds like hard work (called Kussmaul breathing): The lungs are working overtime to blow off carbon dioxide (a gas that turns into acid) to protect the blood from getting more acidic. If breathing suddenly gets slow or shallow in a sick DKA patient, the body is getting too tired to keep fighting — that is a red flag the patient may crash and need a breathing tube.
- Breath smells sweet or fruity, like nail polish remover or rotting apples: This smell comes from acetone, one of the ketones (acid chemicals the body makes when it burns fat for fuel because it cannot use sugar). This smell is very specific for ketone buildup — you will not see it in other causes of confusion or fast breathing like infection or stroke.
- Belly is tender when you press on it, sometimes with guarding (muscles tighten up to protect): Acid in the blood irritates the stomach and intestines, causing pain and tenderness. But never assume it is just the acid — you must still rule out real surgical emergencies like appendicitis (inflamed appendix) or pancreatitis (swollen pancreas), because both can trigger DKA and both need different treatment. Missing these can be deadly.
- Confused, sleepy, or hard to wake up: This means the acid is very severe (pH dropping toward 7.0 or below) or the brain is swelling (called cerebral swelling (edema) — most common and most dangerous in children under 5). Brain swelling can happen during treatment if fluids or insulin are pushed too fast. Any worsening confusion after treatment starts is an emergency.
- Heart rate over 100, blood pressure dropping, especially when sitting up: This means the blood tank is so empty that the heart has to race to keep organs alive. A drop in blood pressure when the patient sits or stands (called orthostatic low blood pressure (hypotension)) tells you the body has lost a dangerous amount of fluid. This patient needs IV fluids immediately to prevent shock (organs shutting down from lack of blood).

Diagnostics · every test answers a question

- Blood sugar (glucose) — fingerstick and lab draw from a vein → Is the sugar high enough to cause DKA?

- Venous or arterial blood gas — pH, bicarbonate (HCO_3), and carbon dioxide (pCO_2) → Is the blood turning acidic, and how bad is it?
- Anion gap (calculated from sodium, chloride, and bicarbonate) → Is there hidden acid in the blood, and is it caused by ketones?
- Beta-hydroxybutyrate (blood ketone level) → Are ketones actually in the blood, and how much?
- Basic metabolic panel (BMP) — sodium, potassium, chloride, bicarbonate, BUN, creatinine, glucose → How dry is the patient? What is the potassium doing? Are the kidneys working?
- Urinalysis — ketones, sugar, white blood cells, nitrites, bacteria → Is there an infection (like a bladder infection or kidney infection) that triggered this?
- EKG (electrocardiogram — heart tracing) → Did a heart attack trigger this? Is potassium dangerously high or low?
- Infection and trigger work-up — chest X-ray, blood cultures, urinalysis, troponin, lipase, pregnancy test → What pushed the body into DKA?

Treatment logic

- IV fluids — normal saline (0.9% NaCl), 1 to 2 liters in the first hour, then 250 to 500 mL per hour → Refills the blood tank so organs (brain, kidneys, heart) get blood and oxygen again. Helps kidneys start flushing out the extra sugar and ketones through pee. Starts to improve the acid just by improving blood flow and kidney function. Guideline: give 15 to 20 mL per kilogram in the first hour in adults; 10 mL per kilogram over 1 hour in children (slower to prevent brain swelling).
- Check potassium before starting insulin. If potassium is under 3.3 mEq/L, give potassium chloride (20 to 40 mEq) through the IV over 1 to 2 hours before starting insulin. → Prevents potassium from crashing to a deadly level (under 2.5 mEq/L). Insulin pushes potassium from blood into cells, so if you start with low potassium, insulin will drop it even further and the heart can stop (cardiac arrest). Guideline: do not start insulin until potassium is at least 3.3 mEq/L. Keep potassium between 4.0 and 5.0 mEq/L during treatment.
- IV insulin — regular insulin drip at 0.1 units per kilogram per hour (or 0.14 units/kg bolus, then 0.1 units/kg/hour infusion). Start after fluids are running and potassium is safe. → Turns off the fat-burning that makes ketones. Lets cells open their doors (by activating glucose transporters) and start using sugar again instead of making acid. This is what actually fixes DKA. Guideline: aim for blood sugar to drop 50 to 75 mg/dL per hour and ketones to drop at least 1 mmol/L per hour. If not, increase insulin by 1 unit per hour.

- Add dextrose (sugar) to the IV fluids when blood sugar drops below 200 to 250 mg/dL. Use 5% dextrose in half-normal saline (D5 1/2 NS) or 10% dextrose if sugar keeps dropping. → Keeps insulin running so it can keep clearing the acid and ketones, but prevents blood sugar from crashing too low (hypoglycemia). Acid and ketones clear slower than sugar drops, so you need to give sugar back to safely finish the job. Guideline: goal is to keep sugar between 150 and 200 mg/dL until DKA is resolved (pH over 7.3, bicarbonate over 18, anion gap under 12).
- Treat the trigger — antibiotics for infection (e.g. ceftriaxone for pneumonia or UTI), aspirin and catheterization for heart attack, insulin education and social work for missed doses, etc. → Removes the reason DKA started in the first place. Without treating the trigger, DKA can come right back even if you fix the acid and sugar. For example, if pneumonia triggered DKA and you do not give antibiotics, the infection will keep stressing the body and ketones will keep rising.
- Bicarbonate (sodium bicarbonate 100 mEq in 400 mL sterile water, given over 2 hours) — only if pH is under 6.9 → Buys a little time when acid is so severe that the heart and blood vessels cannot contract or respond to medicines. Raises pH just enough (goal: pH over 7.0) to keep the patient alive while insulin starts working. Guideline: only consider if pH is under 6.9 after initial fluids.
- Transition to subcutaneous (under-the-skin) insulin when DKA is resolved: pH over 7.3, bicarbonate over 18 mEq/L, anion gap under 12, and patient can eat. Give long-acting insulin (e.g. glargine or detemir) 2 hours before stopping the drip, or give rapid-acting insulin (e.g. lispro or aspart) with a meal 30 minutes before stopping the drip. → Prevents DKA from coming back. IV insulin only lasts 15 to 30 minutes in the body, so if you stop the drip without giving longer-acting insulin first, ketones will start building up again within hours. Guideline: overlap is critical — never stop the drip until subcutaneous insulin is on board.

Medications

Regular insulin (IV infusion) · Human insulin, short-acting

The missing key that unlocks the cell's door so sugar can get inside and be used for energy. When you give it into the vein, it tells the body to stop burning fat (which makes ketones, the acid that builds up in DKA). It also turns off the liver's ketone factory.

1. Insulin lands on the insulin receptor, a tiny lock on the outside of the cell.
2. The lock opens. The cell wakes up and moves glucose transporters (doorways called GLUT4) from inside the cell to the surface.
3. Sugar (glucose) flows through those doorways into the cell, where it is burned for energy instead of being left in the blood.

4. The liver gets the signal to stop making new sugar (a process called gluconeogenesis) and to stop breaking fat into ketones (ketogenesis).
5. Ketone production stops. The acid in the blood starts to clear. The anion gap (a lab test that shows how much unmeasured acid is in the blood) closes.

> **SAFETY WATCH**
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> Never start IV insulin if potassium is below 3.3 mEq/L. Replace potassium first. Very low potassium can cause a deadly heart rhythm (arrhythmia). · Add dextrose (sugar) to the IV fluids when blood glucose drops below 200 mg/dL. This stops blood sugar from crashing (hypoglycemia) while the insulin keeps working to clear the acid. The goal is to fix the acid, not just the sugar. · Do NOT stop the insulin drip just because blood sugar looks normal. Keep the drip running until the anion gap closes (usually less than 12 mEq/L) and the blood pH is above 7.3. DKA is about too much acid, not just too much sugar. · The usual starting dose is 0.1 units per kilogram per hour (about 5 to 7 units per hour for most adults). Do not give a large bolus (big shot) of insulin upfront in most cases; current guidelines prefer continuous low-dose infusion. · Check blood sugar every hour. Check electrolytes (especially potassium), anion gap, and blood pH every 2 to 4 hours until the DKA clears.

Potassium chloride (KCl) · Electrolyte replacement

Puts potassium back into the blood before insulin pushes it into cells. In DKA, the body is running low on total potassium (even if the blood test looks normal at first) because of vomiting, peeing a lot, and high acid. Replacing it protects the heart.

1. In DKA, the body has lost a lot of potassium through urine and vomiting. The blood test may look normal or even high at first because acid in the blood pushes potassium out of cells into the bloodstream.
2. As soon as you give insulin, it acts like a broom and sweeps potassium from the blood into the cells. Blood potassium can drop fast.
3. Replacing potassium before or during insulin treatment keeps the blood level safe. It prevents a dangerous drop that can cause a life-threatening heart rhythm (arrhythmia).
4. Potassium is given continuously in the IV fluids (usually 20 to 40 mEq per liter) to match the body's need as insulin pushes it into cells.

SAFETY WATCH

Check potassium level before starting insulin. If potassium is below 3.3 mEq/L, give potassium first and hold insulin until the level is safe. If potassium is above 5.2 mEq/L, hold potassium replacement and recheck in 2 hours. · Check potassium every 1 to 2 hours during the first 4 to 6 hours of DKA treatment. Most patients need 20 to 40 mEq of potassium added to each liter of IV fluid. · Giving potassium chloride faster than 10 mEq per hour through a regular IV (peripheral line) burns the vein and causes pain. If the patient needs more than 10 mEq per hour, use a central line (a larger IV placed in a big vein near the heart). · Watch the EKG (heart tracing). Peaked (tall, narrow, pointy) T waves mean potassium is too high. Flat T waves and a small extra bump after the T (called a U wave) mean potassium is too low. Either can cause a dangerous heart rhythm.

0.9% sodium chloride (normal saline, IV fluids) · Isotonic crystalloid fluid

Replaces the huge amount of water and salt the body has lost through vomiting and peeing. Fills the blood vessels back up so blood pressure stays stable and the kidneys can start clearing ketones and acid.

1. In DKA, high blood sugar acts like a sponge in the blood. It pulls water out of cells and into the urine. The body loses liters of fluid and becomes severely dehydrated.
2. IV fluids (normal saline) are given fast at first (usually 15 to 20 milliliters per kilogram in the first hour, or about 1 to 1.5 liters for most adults) to fill the blood vessels back up.
3. As the blood vessels refill, blood pressure stabilizes. The kidneys get enough blood flow to start filtering and clearing ketones and acid from the blood.
4. After the first hour, fluids are given more slowly (about 250 to 500 milliliters per hour) to continue rehydration without overloading the heart or lungs.

SAFETY WATCH

Start IV fluids before starting insulin. Rehydration is the first step in DKA treatment. · Watch for fluid overload, especially in older adults or people with heart failure or kidney disease. Signs include shortness of breath, crackles (bubbling sounds) when listening to the lungs, and swelling in the legs. · Switch from normal saline to 0.45% saline (half-normal saline) if the patient's sodium level is high or normal and the blood pressure is stable. This prevents too much sodium from building up. · Add dextrose (5% dextrose in the IV fluids) when blood glucose drops below 200 mg/dL. This allows insulin to keep working to clear the acid without causing low blood sugar. · Aim to replace about 3 to 6 liters of fluid in the first 12 to 24 hours, adjusted based on how dehydrated the patient is and how the heart and kidneys are doing.

Sodium bicarbonate (IV, rarely used) · Alkalinizing agent (raises pH by adding base)

Temporarily buffers (neutralizes) the acid in the blood when the pH is dangerously low (below 6.9) and the heart rhythm or breathing is at risk. It does not fix the root cause. Insulin and fluids do the real work.

1. Sodium bicarbonate is a base (the opposite of acid). When you give it into the vein, it combines with hydrogen ions (the acid) in the blood and neutralizes them.
2. This raises the blood pH slightly and may protect the heart from dangerous rhythms when the pH is extremely low (below 6.9).
3. It does not stop ketone production. It does not fix the DKA. Insulin and fluids do that.
4. The effect is temporary. If insulin is not working to stop ketone production, the acid will build up again.

> **SAFETY WATCH**
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> Use only when pH is below 6.9 AND the patient has severe symptoms (such as shock, dangerous heart rhythm, or failing breathing). Current guidelines (ADA 2023) say bicarbonate is NOT helpful and may be harmful in mild or moderate DKA (pH above 6.9). · Can cause a paradoxical drop in brain and spinal fluid pH (the acid in the central nervous system may worsen even as blood pH rises). This can worsen confusion or coma. · Can cause severe low potassium (hypokalemia) by pushing potassium into cells. Check potassium before and after giving bicarbonate. Replace potassium first if it is low. · Can cause fluid overload (too much sodium and water) because it is given as a large-volume infusion. · Can cause overshoot too little acid in the blood (alkalosis) (blood becomes too basic) after DKA clears, which can cause its own problems (such as low calcium and muscle spasms). · Typical dose is 100 mEq (2 ampules) in 400 mL of sterile water, given over 2 hours. Repeat only if pH is still below 7.0 after 2 hours.

Red flags

- Breathing slowing down or becoming shallow in a patient who is still acidotic—the respiratory muscles are tiring out and respiratory arrest may be next
- Sudden severe headache, worsening confusion, vomiting, or decline in mental status during treatment (especially in children under 18)—warns of cerebral swelling (edema), brain swelling that can be fatal
- Blood sugar dropping quickly but the anion gap still wide and bicarbonate still low—ketoacid is still being made or not cleared, do not stop insulin even if glucose is normal

- Chest pain, new trouble breathing, troponin elevation, or signs of heart failure—a heart attack or severe infection may have triggered the DKA and needs urgent treatment alongside DKA care
- Blood pressure staying low or dropping despite fluid—suggests septic shock, cardiogenic shock, or severe volume depletion; needs immediate ICU-level support

Nursing priorities

1. Check potassium BEFORE the first insulin bolus or infusion — Insulin will drop K into cells. If K is already low, that can stop the heart.
2. Titrate fluids and insulin per protocol; hourly finger sticks — Sugar drops fast — need dextrose add-on when it hits 200.
3. Watch mental status every hour, especially in kids — Cerebral swelling (edema) can appear 4–12 hours into treatment.
4. Do NOT stop insulin when glucose normalizes if the anion gap is still open — The acid clears AFTER the sugar. Stopping early relapses the DKA.
5. Look for and treat the trigger — Without fixing why DKA happened, it can come right back.

Sources

- ADA Standards of Care in Diabetes 2024
- ISPAD Clinical Practice Consensus Guidelines: Diabetic Ketoacidosis and Hyperglycemic Hyperosmolar State 2022
- American Diabetes Association: Hyperglycemic Crises in Diabetes (Diabetes Care)
- UpToDate: Diabetic Ketoacidosis and Hyperosmolar Hyperglycemic State in Adults

Last reviewed: 2026-02-28