

Tuberculosis

Tuberculosis is a chronic infection where the body walls off bacteria but cannot kill them. Active disease needs isolation and four drugs together (RIPE: rifampin, isoniazid, pyrazinamide, ethambutol) for at least six months.

THE ONE-LINE TRUTH

M. tuberculosis is a slow-moving bacteria that hides inside immune cells, causing lung sickness and sometimes spreading to other organs.

The chain — how it unfolds

1. Macrophages cannot kill M. tuberculosis — why: The bacteria's waxy coat (mycolic acid) protects it from the acid and enzymes inside alveolar macrophages, so the bacteria survive and multiply slowly inside the cells instead of dying.
2. Granulomas form to trap bacteria but cannot kill them — why: The body sends CD4+ T cells and more macrophages to surround infected macrophages and build a granuloma—a walled pocket with a dead, cheesy center (caseous tissue death (necrosis)). This stops bacteria from spreading but keeps them alive inside the walls. Most people stay in this latent state for life.
3. Weakened immunity lets bacteria escape and multiply — why: If CD4+ T cell function drops (HIV, TNF-alpha blockers, steroids, diabetes, malnutrition, very young or old age), the granuloma walls crumble, bacteria spill out, and active TB begins.
4. Lung tissue damage causes chronic cough, coughing up blood (hemoptysis), weight loss, night sweats, fever — why: Multiplying bacteria destroy alveoli (air sacs), trigger inflammation, and form cavities (hollow pockets where lung tissue has died). The lungs produce infected mucus and the body coughs for more than three weeks. Blood vessels break, so blood mixes with coughed-up mucus (sputum) (hemoptysis). The immune system runs hot, causing fever and night sweats. Fighting the infection burns calories, causing weight loss.

5. Bacteria spread through bloodstream and lymphatics to distant organs — why: Infected macrophages travel through lymph vessels and blood vessels, carrying bacteria to lymph nodes (scrofula—painless neck swelling), the meninges (TB meningitis—headache, stiff neck, confusion), the spine (Pott disease—back pain, spinal collapse), the kidneys, the stomach lining, the heart lining (pericarditis), and throughout the lungs (miliary TB—countless tiny nodules, looking like millet seeds on chest X-ray).
6. Cavitory disease risks massive coughing up blood (hemoptysis) — why: Large cavities erode into pulmonary arteries, causing sudden, life-threatening bleeding (coughing up more than 200 mL of blood at once). This is a medical emergency.
7. Miliary TB and meningitis are the final crash points — why: Miliary TB (bloodstream spread seeding every organ) causes respiratory failure and multi-organ failure. TB meningitis (bacteria invading the brain's protective layers) causes seizures, stroke, coma, and death if not treated immediately with four-drug therapy and steroids.
8. Every finding traces back to the same upstream break — why: Chronic cough, coughing up blood (hemoptysis), weight loss, night sweats, fever, cavities, lymph node swelling, meningitis, spine collapse, and miliary spread all follow logically from one failure: macrophages cannot kill *M. tuberculosis*, so the bacteria multiply, damage tissue, and spread wherever macrophages and blood travel.

Spot it — what you see, and why

- Cough that lasts three weeks or longer: The TB bacteria (*Mycobacterium tuberculosis*) settle in the lungs and trigger swelling (inflammation) and tissue damage. Your body tries to cough out the mucus and debris, but the infection keeps feeding the cycle, so the cough lingers for weeks.
- Coughing up blood or rust-colored coughed-up mucus (sputum) (hemoptysis): The TB infection eats into lung tissue and small blood vessels, letting blood leak into the airways. You then cough up coughed-up mucus (sputum) tinged pink, red, or rust-brown.
- Fever, often with chills: Your immune system releases chemical messengers called cytokines (like interleukin-1 and tumor tissue death (necrosis) factor) that reset the brain's thermostat (the hypothalamus) higher, raising your body temperature to fight the bacteria.
- Drenching night sweats: The fever breaks overnight as your body tries to cool down. Hormones (like norepinephrine) signal sweat glands to open wide, soaking your sheets—this is the body's way of dumping extra heat.
- Unintentional weight loss and loss of appetite: Cytokines (especially tumor tissue death (necrosis) factor-alpha, once called 'cachectin') ramp up metabolism and suppress hunger signals in the hypothalamus. Meanwhile the infection burns extra calories, so you lose weight even without trying.

- Fatigue and general weakness: Fighting a chronic infection drains energy: cytokines tell muscles to break down protein for fuel, and chronic inflammation keeps your body in overdrive, leaving you exhausted.

Red flags — act now

- Coughing up blood (hemoptysis)
- Severe trouble breathing or shortness of breath at rest
- Confusion, stiff neck, or severe headache (signs of meningitis)
- Rapid weight loss (more than 10% of body weight in weeks)
- Known contact with someone who has active TB and new symptoms

Treat it — in this order

1. RIPE regimen: rifampin, isoniazid, pyrazinamide, ethambutol — all four drugs daily for the first 2 months (intensive phase) → These four drugs work together to kill *M. tuberculosis* hiding inside macrophages and in oxygen-poor pockets of the lung. Rifampin stops the bacteria from copying their DNA. Isoniazid punches holes in the bacterial cell wall. Pyrazinamide works in acidic, low-oxygen areas where the bacteria sleep. Ethambutol blocks the bacteria from building their protective waxy coat. Using all four at once kills the bacteria fast and stops them from becoming resistant.
2. Continuation phase: rifampin plus isoniazid daily (or 3 times per week) for 4 more months after the first 2 months → Kills the remaining slow-growing bacteria hiding in cavities, scar tissue, and low-oxygen corners of the lung where they multiply very slowly. This extended phase prevents relapse — without it, the bacteria wake up and the disease comes back.
3. Pyridoxine (vitamin B6) 25–50 mg daily, given with isoniazid → Prevents peripheral neuropathy (nerve damage causing numbness, tingling, and burning pain in hands and feet) caused by isoniazid, which depletes vitamin B6. Pyridoxine replaces what isoniazid uses up.
4. Airborne isolation (negative-pressure room, N95 respirators for staff) until coughed-up mucus (sputum) AFB smears are negative on 3 consecutive samples (usually after 2 weeks of treatment) → Stops the patient from breathing tuberculosis bacteria into the air where nurses, family, roommates, and other patients can breathe them in. This breaks the transmission chain and protects others.
5. Directly observed therapy (DOT): a healthcare worker or trained observer watches the patient swallow every dose → Ensures the patient actually takes the medicine every single day for the full 6 months — missing doses lets bacteria survive and become drug-resistant. DOT prevents treatment failure and stops the creation of multidrug-resistant tuberculosis (MDR-TB).

Your top priorities at the bedside

1. Place patient in airborne isolation room (negative pressure room with door closed) and wear N95 respirator mask before entering — why: TB bacteria travel through tiny airborne droplets (droplet nuclei) that stay floating in air for hours. Standard surgical masks do not filter particles this small. Negative pressure keeps contaminated air from escaping the room. This protects staff, other patients, and visitors from infection.
2. Collect three coughed-up mucus (sputum) samples (morning is best) for acid-fast bacilli smear and culture before first antibiotic dose — why: Coughed-up mucus (Sputum) (mucus coughed from deep lungs) testing confirms diagnosis and identifies drug resistance. The acid-fast stain shows TB bacteria within hours. Culture grows bacteria to test which medicines work, but takes 6 to 8 weeks. Starting treatment before collection makes test results falsely negative.
3. Administer all four RIPE medicines (rifampin, isoniazid, pyrazinamide, ethambutol) together at the same time each day, and watch the patient swallow every pill — why: Directly observed therapy (DOT) prevents patients from skipping doses or stopping early, which creates drug-resistant bacteria. Taking all four drugs together kills bacteria faster and stops resistance from developing. Consistency in timing keeps blood levels steady for best killing power.