

Opportunistic Infections in Immunocompromised Patients

HIV (CD4-driven), transplant (time-based), neutropenic (low white cells), complement (body defense), B-cell.

THE STORY IN ONE SENTENCE

HIV (CD4-driven), transplant (time-based), neutropenic (low white cells), complement (body defense), B-cell.

“OI (infection) in weak immune people — depends on what type of weakness and what you see.”

Normal anatomy — the body's job

Layered immunity prevents OIs. Keep that picture in your head, because the weird findings only make sense as a change from it. When this normal job fails, weak immunity by type shows certain infection patterns — that is the upstream break we are about to trace.

BODY'S JOB

If you don't know the normal job first, the weird findings seem confusing.

What breaks

Usually one broken thing explains all the weird findings together.

CLINICAL TERM

Weak immunity by type shows certain infection patterns. That break does not stay local. The downstream signal you will actually see at the bedside is HIV/AIDS: PJP, Toxo, CMV, MAC, cryptococcal bugs. Read all the weird findings backwards from there — they all point to this one broken thing upstream.

How the body compensates

Vital signs can look good while the body is trying hard to cope. The job is to see the bad crash point coming.

1. The body keeps vital signs steady for a while.
2. That is the dangerous middle, because it lets the team miss where the patient really is on the curve.
3. The crash point to watch for is: Big danger: miss OI (infection); disease spreads everywhere.
4. Watch for the crash point before it happens, because once it tips, the window to get better closes fast.
5. Look at how things are getting worse or better, not just one moment in time.
6. A stable patient on a downhill slope is not really stable.

Domino effect

1. HIV/AIDS: PJP, Toxo, CMV, MAC, cryptococcal bugs. — HIV destroys CD4 cells (the body's quarterback), so the immune army loses its orders and cannot rally against rare bugs like PJP, Toxo, CMV, MAC, and Cryptococcus.
2. Transplant: times above. — After transplant, doctors give immune-killing drugs to prevent organ rejection, so the body loses its ability to fight even common bugs—the timing of infection tells you which drug broke which defense.
3. Neutropenic: bacterial, fungal bugs. — Low neutrophils (young white cell soldiers) means no first-line defenders to stop bacteria and fungi from setting up camp in the blood and lungs.
4. No spleen: covered bacteria (*S. pneumo*, *H. flu*, *N. meningitidis*). — No spleen means losing the main filtration station and IgG factory for covered bacteria, so *S. pneumo*, *H. flu*, and *N. meningitidis* run wild.
5. Complement low: *Neisseria* bugs. — Low complement (the body's chemical alarm and tag-marking system) means *Neisseria* bacteria do not get tagged or killed, so they slip through to cause meningitis.
6. B-cell low: covered bugs, *Giardia*. — Low B-cells (the antibody factory) means no IgA or IgG shields against covered bacteria and *Giardia* parasites, so these bugs colonize gut and blood.
7. None of this is random. — No single broken step is random—each type of immunity loss opens the door to a specific set of bugs, so reading the bug list backwards tells you exactly which defense is down.

Symptoms · what the patient feels, and why

- Fever that won't go away or keeps coming back: Germs that a healthy immune system would stop easily now grow unchecked because the body's defense army (white blood cells and antibodies) is too weak or too few to fight them off, so the body stays on high alert and keeps raising its temperature to try to slow the invaders.
- Pneumonia with cough, shortness of breath, and low oxygen: Fungi like *Pneumocystis* or viruses like CMV can settle deep in the lungs' air sacs, where they cause swelling and fill the sacs with fluid and debris, making it harder for oxygen to cross into the blood—healthy lungs would clear these germs before they took hold.
- White patches or sores in the mouth or throat (thrush): *Candida*, a yeast that normally lives quietly in the mouth, overgrows into thick white coatings when the immune system can't keep its numbers in check, turning the mouth's lining red and sore underneath.
- Diarrhea that lasts for weeks: Parasites like *Cryptosporidium* or bacteria like *Salmonella* invade the intestine's lining and damage the cells that absorb water and nutrients, so the gut leaks watery fluid constantly because the immune system can't clear the infection.
- Blurry vision or floating spots in one or both eyes: Cytomegalovirus (CMV) can infect the retina—the light-sensing layer at the back of the eye—and cause patches of dead tissue that blur vision or create blind spots because the immune system can't stop the virus from spreading there.
- Painful blisters or rash on the skin, often in a strip along one side of the body: Varicella-zoster virus (the chickenpox virus) hides in nerve roots and wakes up when the immune system weakens, traveling down the nerve and causing painful blisters along the skin that nerve supplies (shingles).
- Severe headache, stiff neck, confusion, or seizures: Fungi like *Cryptococcus* or viruses like JC virus can invade the brain or the fluid-filled spaces around it (meninges), causing swelling and pressure that disrupt normal brain function, because the immune system can't guard the nervous system properly.
- Night sweats that drench clothes and sheets: *Mycobacterium tuberculosis* or atypical mycobacteria release toxins that reset the body's temperature control center in the hypothalamus (the brain's thermostat), causing fever spikes at night followed by heavy sweating as the body tries to cool down.
- Weight loss without trying: Chronic infection triggers the release of inflammatory chemicals like tumor tissue death (necrosis) factor (TNF) and interleukins that break down muscle and fat for energy, suppress appetite, and speed up the body's metabolism, so weight drops steadily even if eating stays the same.

- Swollen lymph nodes that stay enlarged: Lymph nodes—small filters in the immune system—swell as they fill with white blood cells trying to trap and fight the infection, but because the immune system is weak, the nodes stay swollen and can't clear the germs.

Focused exam

- CD4 count below 200 cells/mm³: The CD4 count tells you how many helper T-cells (the quarterback cells that tell the rest of the immune system what to attack) are left. Below 200 means the body's defenses are so weak that bugs like Pneumocystis (a fungus that attacks the lungs), Toxoplasma (a parasite that hides in the brain), and CMV (a virus that can blind you) can take over without a fight.
- Fever with cough and shortness of breath: In someone with CD4 below 200, this pattern screams PJP pneumonia—Pneumocystis jirovecii, a fungus that fills the air sacs in the lungs with fluid and foam because the immune system cannot clear it. The person drowns slowly in their own lungs.
- Headache, confusion, or seizure: When CD4 drops below 100, parasites like Toxoplasma gondii or fungi like Cryptococcus neoformans can invade the brain and cause swelling, abscesses (pockets of infection), or meningitis (infection of the brain's protective lining). This can kill or leave permanent brain damage.
- Vision changes, floaters, or eye pain: CMV retinitis—cytomegalovirus attacking the retina (the screen at the back of the eye that catches light)—happens when CD4 is below 50. The virus kills retinal cells, creating blind spots that grow and can lead to total blindness if not treated fast.
- Chronic diarrhea, belly pain, and weight loss over weeks: Bugs like MAC (Mycobacterium avium complex, a cousin of tuberculosis) or Cryptosporidium (a parasite) attack the gut lining when CD4 is very low. The intestines cannot absorb food, so the person wastes away even if they eat.
- Thrush—white patches inside the mouth or throat: Oral candidiasis (yeast overgrowth caused by Candida fungus) is a warning flag that CD4 is probably below 300. It tells you the immune system is failing and other, deadlier opportunistic infections may be coming soon.

Diagnostics · every test answers a question

- CD4 count → How many helper T-cells are left to direct the immune system?
- HIV viral load (if HIV is the cause) → Is the virus actively copying itself and killing CD4 cells?
- Chest X-ray or chest CT → What pattern of lung damage do we see?
- Serum cryptococcal antigen (CrAg) → Is Cryptococcus neoformans (a fungus) in the bloodstream or spinal fluid?

- Toxoplasma IgG antibody → Has this person ever been exposed to Toxoplasma, so it could reactivate now?
- CMV PCR (blood) or fundoscopic eye exam → Is CMV replicating in the blood or damaging the retina?
- Coughed-up mucus (Sputum) or bronchoalveolar lavage (BAL) with special stains → What bug is growing in the lungs?
- Blood cultures for bacteria, fungi, and mycobacteria → Is there a bug spreading through the bloodstream?

Treatment logic

- Start or optimize antiretroviral therapy (ART) immediately → ART stops HIV from killing CD4 cells (the helper T-cells that run the immune system). Over weeks to months, the CD4 count rises and the body regains the ability to fight infections on its own. This is the only way to truly fix the broken immune system in HIV patients.
- Give TMP-SMX (trimethoprim-sulfamethoxazole) prevention (prophylaxis) when CD4 <200 → TMP-SMX blocks two enzymes that *Pneumocystis jirovecii* (the PJP fungus) and *Toxoplasma gondii* (the brain parasite) need to survive. This prevents these bugs from causing pneumonia or brain abscesses before the immune system can recover.
- Give azithromycin (or clarithromycin) prevention (prophylaxis) when CD4 <50 → Azithromycin stops *Mycobacterium avium* complex (MAC) from spreading through the blood and gut. MAC is a slow, tough bacterium that the immune system at CD4 <50 cannot control, and it causes fevers, night sweats, diarrhea, and wasting.
- Start valganciclovir (oral) or ganciclovir (IV) for active CMV disease → These antiviral drugs block the enzyme CMV uses to copy its DNA, stopping the virus from destroying the retina (causing blindness), colon (causing bloody diarrhea), or esophagus (causing painful swallowing). They halt disease progression until the immune system recovers.
- Give amphotericin B (induction) then fluconazole (consolidation and maintenance) for cryptococcal meningitis → Amphotericin B punches holes in the fungal cell wall of *Cryptococcus neoformans*, killing it in the brain and spinal fluid. Fluconazole then keeps levels low and prevents relapse. This stops the fungus from causing brain swelling, coma, and death.
- Reduce or temporarily hold immunosuppressive drugs (if transplant, autoimmune disease, or cancer patient) when safe → Lowering steroids, chemotherapy, or anti-rejection drugs lets the patient's own immune cells wake up and fight the infection. The body can clear bugs faster when the brakes are released, as long as the transplant or underlying disease stays stable.

- Give high-dose TMP-SMX plus prednisone for moderate-to-severe PJP ($\text{PaO}_2 < 70$ mmHg or A-a gradient ≥ 35) → High-dose TMP-SMX kills *Pneumocystis* in the lungs. Prednisone (a steroid) dials down the inflammation explosion that happens when the fungus dies, preventing oxygen levels from crashing further. Together they save lives in severe PJP.

Medications

Trimethoprim-sulfamethoxazole (TMP-SMX) · Folate synthesis inhibitor (antibiotic combination)

This drug blocks two different steps bacteria use to build folate (a vitamin-like molecule bacteria need to copy their DNA and grow). By hitting two steps at once, it stops bacteria from multiplying. It protects against *Pneumocystis jirovecii* (the fungus that causes PJP pneumonia) and *Toxoplasma gondii* (the parasite that causes brain infections in people with weak immune systems).

1. Trimethoprim blocks dihydrofolate reductase (the enzyme that makes active folate from its inactive form).
2. Sulfamethoxazole blocks dihydropteroate synthase (an earlier enzyme in the folate-building pathway).
3. Without folate, the bug cannot copy its DNA or make new proteins.
4. The bug stops dividing and dies.

SAFETY WATCH

Rash and allergic reactions (including Stevens-Johnson syndrome, a serious skin reaction) · Low blood counts (especially white cells and platelets) · High potassium (hyperkalemia), especially in people with kidney problems or on ACE inhibitors · Kidney injury in some patients · Nausea and mouth sores

Azithromycin · Macrolide antibiotic

This drug locks onto the ribosome (the protein-making factory inside bacteria) and stops it from building new proteins. Without proteins, the bacteria cannot grow or survive. It prevents *Mycobacterium avium* complex (MAC), a slow-growing germ that spreads through the blood and organs when CD4 counts drop below 50.

1. Azithromycin binds to the 50S subunit of the bacterial ribosome.
2. It blocks the exit tunnel where new proteins leave the ribosome.
3. Protein synthesis stops.
4. The bacteria cannot make the enzymes and structures they need to live, so they die.

SAFETY WATCH

Nausea, stomach cramps, and diarrhea · QT prolongation (a heart rhythm change that can lead to dangerous arrhythmias, especially when combined with other QT-prolonging drugs) · Hearing loss (rare, usually with high doses or long-term use) · Liver enzyme elevation

Valganciclovir (or IV ganciclovir) · Antiviral (nucleoside analog)

This drug is a fake building block for viral DNA. Cytomegalovirus (CMV) uses it to build new DNA, but once the fake piece is inserted, the DNA chain stops growing and the virus cannot make copies of itself. It prevents CMV reactivation (eye, gut, and lung infections) in transplant patients and people with advanced HIV.

1. Valganciclovir is converted to ganciclovir in the intestine and liver.
2. Inside infected cells, cellular and viral enzymes add phosphate groups to activate it.
3. The active form looks like guanosine triphosphate (a normal DNA building block).
4. CMV DNA polymerase (the enzyme that copies viral DNA) inserts it into the growing DNA chain.
5. Once inserted, the chain cannot grow any further, so viral replication stops.

SAFETY WATCH

Bone marrow suppression (low white cells, red cells, and platelets) · Kidney damage (adjust dose for kidney function) · Infertility risk (can harm sperm production) · Birth defects (teratogenic; use contraception) · Nausea and diarrhea

Fluconazole (or other azole antifungals) · Azole antifungal

This drug blocks an enzyme fungi use to make ergosterol, a fat molecule that keeps the fungal cell membrane strong and flexible. Without ergosterol, the membrane becomes weak and leaky, and the fungus dies. It prevents Candida infections (mouth, throat, and bloodstream) and Cryptococcus (brain and lung infections) in people with weak immune systems.

1. Fluconazole enters the fungal cell.
2. It binds to lanosterol 14-alpha-demethylase, an enzyme in the ergosterol-making pathway.
3. Ergosterol production stops.
4. The fungal cell membrane becomes unstable and leaks.
5. The fungus dies.

SAFETY WATCH

Liver enzyme elevation (monitor liver function) · QT prolongation (heart rhythm change) · Drug interactions (inhibits CYP450 enzymes, raising levels of many other drugs) · Nausea and headache · Rash

Acyclovir (or valacyclovir) · Antiviral (nucleoside analog)

This drug is a fake building block for viral DNA. Herpes simplex virus (HSV) and varicella-zoster virus (VZV) use it to copy their DNA, but once the fake piece is inserted, the DNA chain stops and the virus cannot multiply. It prevents HSV and VZV reactivation (cold sores, shingles, disseminated disease) in immunocompromised patients.

1. Acyclovir enters infected cells.
2. Viral thymidine kinase (an enzyme only in infected cells) adds the first phosphate group, activating the drug.
3. Cellular enzymes add two more phosphates, making acyclovir triphosphate.
4. The active form looks like deoxyguanosine triphosphate (a normal DNA building block).
5. Viral DNA polymerase inserts it into the DNA chain and the chain stops growing.
6. Viral replication halts.

SAFETY WATCH

Kidney injury (especially with IV acyclovir; keep the patient hydrated) · Confusion and tremor (more common in elderly or kidney-impaired patients) · Nausea · Injection-site irritation (if IV)

Isoniazid (INH) · Antimycobacterial (cell wall synthesis inhibitor)

This drug blocks the enzyme that bacteria use to build mycolic acid, a waxy fat that makes the outer shell of *Mycobacterium tuberculosis* tough and hard to penetrate. Without mycolic acid, the bacteria cannot build their protective wall and they die. It prevents active tuberculosis (TB) in people with latent infection (positive TB test but no symptoms) when their immune system is about to be weakened.

1. Isoniazid enters the bacterial cell.
2. A bacterial enzyme (catalase-peroxidase, KatG) activates isoniazid.
3. The active form binds to InhA, blocking mycolic acid synthesis.
4. Without mycolic acid, the bacterial cell wall cannot form properly.
5. The bacteria die.

SAFETY WATCH

Liver damage (hepatotoxicity; monitor liver enzymes, especially in people who drink alcohol or take other liver-toxic drugs) · Peripheral neuropathy (nerve damage causing numbness and tingling; give vitamin B6 [pyridoxine] to prevent this) · Drug interactions (inhibits some CYP enzymes) · Rash

Red flags

- New or worsening confusion, seizures, or severe headache—may signal brain infection (meningitis or encephalitis)
- Shortness of breath with low oxygen levels—may be life-threatening pneumonia from *Pneumocystis*, CMV, or fungi
- Sudden vision loss or blurry vision—may be CMV retinitis that can cause permanent blindness if not treated fast
- High fever with very low blood pressure or fast heart rate—may be sepsis (infection in the bloodstream spreading everywhere)
- Severe abdominal pain or blood in the stool—may be invasive gut infection or perforation (a hole in the intestine)

Nursing priorities

1. Place patient in private room with contact precautions if neutropenic (absolute neutrophil count below 500) or standard precautions if HIV alone, and enforce strict handwashing for all visitors and staff — Neutropenic patients cannot fight bacteria from unwashed hands or shared surfaces; even normal skin bacteria can cause fatal bloodstream infections when neutrophil count (infection-fighting white cells) is very low; handwashing is the single best way to prevent hospital-acquired infections in immunocompromised patients
2. Monitor temperature every 4 hours and notify provider immediately if temperature rises above 100.4°F (38°C), even without other symptoms — Immunocompromised patients cannot mount normal inflammatory response (body swelling and pus), so fever may be the only sign of life-threatening infection; neutropenic fever needs blood cultures and broad-spectrum antibiotics within 1 hour because bacterial sepsis (bloodstream infection) can progress to shock and death in hours

3. Assess respiratory rate, oxygen saturation, and work of breathing every 4 hours; report respiratory rate above 20, oxygen below 92 percent, or new shortness of breath immediately — PJP pneumonia causes progressive low oxygen in the blood (hypoxemia) (low blood oxygen) that can drop suddenly; patients may have clear lungs on exam but severe oxygen need; early recognition and oxygen support prevents respiratory failure; PJP is the most common serious opportunistic infection in AIDS patients
4. Check neurological status every shift: orientation to person-place-time, pupil reaction, strength in arms and legs, and ask about headache or vision changes — Toxoplasma encephalitis causes focal deficits (weakness on one side, speech problems) from brain abscesses; cryptococcal meningitis raises intracranial pressure (pressure inside skull) causing headache and confusion; CMV retinitis causes vision loss; early detection allows imaging and treatment before permanent brain or eye damage
5. Verify medication adherence by watching patient swallow all HIV medicines and prevention (prophylaxis) antibiotics; use pill counts and teach about consistent daily timing — Viral replication (HIV copying itself) happens within hours of missed doses and destroys more CD4 cells; inconsistent antiretroviral levels allow drug resistance mutations that make HIV untreatable; stopping prevention (prophylaxis) antibiotics allows breakthrough infections; directly observed therapy improves adherence and treatment success
6. Inspect mouth, skin folds, and perianal area daily for white patches, ulcers, rashes, or new lesions; document size and appearance with photos if available — Oral thrush signals esophageal candida and need for systemic antifungals; herpes ulcers and Kaposi sarcoma (cancer lesions) appear on skin; perianal ulcers may be CMV or resistant herpes; early treatment of mucosal infections (mouth and skin surface infections) prevents spread to internal organs
7. Maintain strict sterile technique for all IV lines, change dressings per protocol, and remove central lines as soon as not needed — Central line-associated bloodstream infections are leading cause of death in neutropenic patients because bacteria enter directly into blood; immunocompromised patients cannot wall off infections with white cells so local line infections become systemic sepsis quickly
8. Coordinate with dietitian to provide high-calorie, high-protein meals; weigh patient daily and track intake-output closely; hold all raw fruits, vegetables, and undercooked foods — Wasting syndrome (severe weight loss) from chronic infections increases mortality; adequate protein helps rebuild immune cells when antiretroviral therapy raises CD4 count; raw foods carry bacteria and parasites that healthy people fight off but cause severe diarrhea in immunocompromised patients; neutropenic diet prevents foodborne infections

Sources

- IDSA Clinical Practice Guidelines for Opportunistic Infections

- CDC Guidelines for Prevention and Treatment of Opportunistic Infections in HIV
- NEJM review on infections in immunocompromised hosts
- ATS/IDSA Guidelines on Healthcare-Associated Pneumonia

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