Meningitis

Bacterial meningitis is an infection in the fluid around the brain. Antibiotics cannot wait.

THE ONE-LINE TRUTH

Bacteria have crossed into the subarachnoid space and turned the cerebrospinal fluid into an abscess.

The chain — how it unfolds

1. Bacteria enter the cerebrospinal fluid (CSF) through the bloodstream, a nearby infection, or a break in the skull or spine. — why: Common bacteria like Streptococcus pneumoniae, Neisseria meningitidis, and Listeria monocytogenes ride the bloodstream from pneumonia or skin infections, or crawl through from ear or sinus infections. Trauma or surgery can also open a direct path. Once inside, bacteria find a space with almost no immune defenses.
2. Bacteria multiply rapidly in the CSF, doubling every 20–30 minutes. — why: CSF normally has fewer than 5 white blood cells per microliter and low levels of antibodies and complement proteins (immune tools that tag and kill germs). Without these defenses, bacteria grow unchecked and spread through the subarachnoid space (the fluid-filled gap around the brain and spinal cord).
3. The body detects bacteria and floods the meninges (the protective layers around the brain) with neutrophils (bacteria-eating white blood cells) and releases inflammatory chemicals like TNF-alpha and interleukin-1. — why: This immune storm tries to kill bacteria and wall off the infection, but the flood of cells and chemicals inflames the meninges, causing severe headache, light sensitivity (photophobia) (light hurts the eyes), and a stiff neck (nuchal rigidity) (stiff neck from irritated meningeal lining pulling on neck muscles).
4. Inflammation makes blood vessels in the brain leaky and swollen, causing vasogenic swelling (edema) (brain swelling from fluid leaking out of vessels) and vasculitis (inflamed, narrowed blood vessels). — why: The brain tissue swells and presses against the rigid skull, raising intracranial pressure (ICP). Blood flow is reduced in inflamed vessels, causing starved blood flow (ischemia) (tissue starving from lack of oxygen). This leads to confusion, lethargy, and eventually coma as brain cells struggle.

5. Pus clogs the normal flow and drainage of CSF, causing obstructive hydrocephalus (backup of fluid in the brain's chambers). — why: CSF is made continuously in the choroid plexus and drains through tiny valves into the bloodstream. When pus blocks these pathways, pressure inside the skull climbs even higher, squeezing the brainstem (the control center for breathing and heart rate) and risking herniation (the brain pushes down through the skull opening, which is fatal).
6. Neurons fire chaotically under the stress of inflammation, low oxygen, and metabolic chaos, triggering seizures. — why: Seizures are the brain's circuits short-circuiting, not a direct infection of neurons. Cytokines (inflammatory chemicals), low glucose in the CSF, and starved blood flow (ischemia) all lower the seizure threshold and cause abnormal electrical storms in the cortex (the brain's outer layer).
7. If bacteria spill heavily into the bloodstream, they trigger septic shock: blood vessels leak, blood pressure crashes, and organs are starved of oxygen. — why: Endotoxins (toxins released when bacteria die) activate the immune system everywhere, causing widespread inflammation. Blood vessels dilate and leak fluid into tissues, blood pressure drops, and the heart cannot pump enough oxygen to the brain, kidneys, and liver. In meningococcemia (Neisseria meningitidis in the blood), this can also cause purple bleeding blotches (purpura) fulminans (massive clotting and bleeding in the skin and organs) and Waterhouse-Friderichsen syndrome (hemorrhage into both adrenal glands, causing sudden loss of stress hormones and fatal shock).
8. Every symptom — fever, headache, stiff neck, confusion, seizures — is the body's emergency response trying to wall off infection and keep the brain alive, not the infection itself. — why: The treatment must break the chain at multiple points: antibiotics (like ceftriaxone or vancomycin) kill the bacteria (the root cause), dexamethasone (a steroid) dampens the inflammatory overreaction and reduces hearing loss, and careful fluid management and ICP monitoring protect the brain from swelling and herniation. Each targets a different domino to stop the cascade before permanent damage or death.

Spot it — what you see, and why

- Fever: Bacteria or viruses in the meninges (the thin protective layers around the brain and spinal cord) trigger the immune system to release chemicals called pyrogens that reset the brain's thermostat higher, raising body temperature to try to fight the infection.
- Severe headache: The infection causes the meninges to swell and stretch, and extra fluid builds up in the tight space around the brain, pressing on pain-sensitive tissues and nerves.
- Stiff neck (cannot bend the neck forward comfortably): Inflamed meninges along the spinal cord tighten the muscles in the back of the neck reflexively to protect the irritated tissue, making it painful and difficult to flex the neck.

- Altered mental status (confusion, sleepiness, hard to wake up, or acting unlike themselves): Infection and swelling disrupt normal brain function, and toxins from bacteria or an overactive immune response interfere with the neurons (nerve cells) that control thinking, attention, and awareness.
- Petechial or purpuric rash (tiny red or purple spots that do not fade when you press on them): Neisseria meningitidis bacteria (meningococcus) can damage blood vessel walls and trigger clotting problems, causing blood to leak into the skin in small spots; this is a sign of meningococcemia (the bacteria spreading in the bloodstream).
- Light sensitivity (Photophobia) (eyes hurt or water in bright light): Inflamed meninges make the brain and nerves extra sensitive, so normal light levels feel painful because the optic nerve (the nerve that carries signals from the eye to the brain) and surrounding tissues are irritated.

Red flags — act now

- Altered mental status, confusion, or hard to wake up
- Seizure
- Petechial or purpuric rash that does not blanch (does not turn white when pressed)
- Signs of shock (very low blood pressure, fast heart rate, cold hands and feet, pale or mottled skin)
- Focal neurologic deficits (weakness, numbness, or vision loss on one side)

Treat it — in this order

1. Ceftriaxone 2 grams IV every 12 hours PLUS vancomycin 15–20 mg/kg IV every 8–12 hours, started within 30 minutes of suspicion (ideally before lumbar puncture if any delay) → Kills Streptococcus pneumoniae (the most common cause, a tough bacteria that hides in a thick capsule), Neisseria meningitidis (the one that causes the purple rash and septic shock), and covers drug-resistant strains that shrug off weaker antibiotics. Stops bacteria from multiplying in the cerebrospinal fluid before the infection triggers unstoppable brain swelling.
2. Ampicillin 2 grams IV every 4 hours added to the regimen if the patient is over 50 years old, pregnant, or has a weakened immune system → Covers Listeria monocytogenes, a bacteria that hides in deli meats and soft cheeses and sneaks into the brain in older adults and people with weak immune systems. Ceftriaxone and vancomycin completely miss Listeria.

3. Dexamethasone 10 mg IV given 15–20 minutes before or at the same time as the first antibiotic dose → Blocks the inflammatory cascade triggered when antibiotics break open bacterial cell walls and spill toxins into the cerebrospinal fluid. Reduces swelling of the meninges and brain (cerebral swelling (edema)), lowers pressure inside the skull, and cuts the risk of hearing loss and brain damage. Interrupts the second domino (the immune overreaction) without touching the first (the bacteria themselves).
4. Acyclovir 10 mg/kg IV every 8 hours if herpes simplex encephalitis cannot be ruled out yet (e.g., focal neurologic signs, temporal lobe changes on imaging, or CSF red blood cells) → Stops herpes simplex virus from copying itself inside brain cells. Herpes encephalitis looks identical to bacterial meningitis at first but needs a completely different drug. Covers this dangerous look-alike while waiting for CSF PCR results.
5. Elevate the head of the bed 30 degrees, keep carbon dioxide in the normal range ($PaCO_2$ 35–40 mmHg by adjusting the ventilator if intubated), treat fever aggressively, and give sedation or pain control as needed → Lowers pressure inside the skull (intracranial pressure) by improving blood flow out of the brain, preventing the brain from herniating (getting squeezed down through the skull opening). Buys time for antibiotics to work and prevents secondary injury from swelling.

Your top priorities at the bedside

1. Obtain blood cultures and ensure antibiotics start within 30 minutes of arrival, before any imaging or lumbar puncture — why: Every hour of antibiotic delay increases mortality by 8 percent; blood cultures before antibiotics help identify the bacteria later but treatment cannot wait for test results
2. Administer dexamethasone 10 mg IV before or with the first antibiotic dose — why: Dexamethasone (a steroid) reduces inflammation in the subarachnoid space and decreases hearing loss and death in bacterial meningitis, but only works if given early before antibiotics
3. Monitor neurological status every 1 to 2 hours using Glasgow Coma Scale and pupil response — why: Rising intracranial pressure (ICP) from brain swelling and pus in CSF causes herniation (brain pushes through skull openings), which kills patients; early signs include decreased alertness and unequal pupils