Bacterial Meningitis

Bacterial meningitis means bacteria have infected the cerebrospinal fluid around the brain and spinal cord. Every hour of delay in treatment increases the risk of death or permanent brain damage.

THE ONE-LINE TRUTH

Bacteria invade the cerebrospinal fluid (the protective liquid cushion around the brain and spinal cord), triggering life-threatening inflammation of the brain's lining.

The chain — how it unfolds

1. Bacteria enter the cerebrospinal fluid (CSF) and multiply. — why: Bacteria cross the blood-brain barrier via bloodstream spread (most common), direct extension from ear, sinus, or mastoid infection, skull fracture, or neurosurgery. Once in the CSF, bacteria face no immune defenses because CSF normally lacks antibodies and complement, so they replicate freely.
2. Bacterial toxins trigger intense inflammation in the meninges (brain lining). — why: Bacterial cell wall fragments (lipopolysaccharide in gram-negative bacteria, peptidoglycan in gram-positive bacteria) activate microglia (brain immune cells) and endothelial cells (blood vessel lining) to release cytokines (TNF-α, IL-1, IL-6). These cytokines cause fever (resetting the brain's thermostat), meningeal irritation (inflamed meninges pull on pain-sensitive structures, causing severe headache and a stiff neck (nuchal rigidity), or stiff neck), and increased permeability of the blood-brain barrier (allowing more white blood cells and protein into the CSF).
3. Cerebral swelling (edema) (brain swelling) and elevated intracranial pressure (ICP) develop. — why: Cytokines cause vasodilation (widening of blood vessels), increased capillary leakage (fluid shifts from blood into brain tissue), and cytotoxic swelling (edema) (neurons swell from injury). Because the skull is rigid, swelling increases ICP, which compresses blood vessels and reduces cerebral blood flow (perfusion) pressure (CPP), starving neurons of oxygen and glucose. This manifests as altered mental status (confusion, lethargy, coma) and, if severe, swelling of the optic nerve (papilledema) (swelling of the optic nerve visible on exam) and herniation (brain tissue shifts, compressing the brainstem).

4. Vasculitis (inflamed blood vessels), clot formation (thrombosis) (clot formation), and blood-starved (ischemic) injury occur. — why: Inflammatory cytokines damage the endothelium (inner lining of blood vessels in the brain), promoting clot formation and vessel narrowing. This causes focal blood-starved (ischemic) strokes (oxygen-starved brain regions stop working, producing focal neurologic deficits such as weakness, speech problems, or vision loss) and increases seizure risk (ischemic neurons fire abnormally).
5. Systemic complications: septic shock, disseminated intravascular coagulation (DIC), and multiorgan failure. — why: If bacteria (especially Neisseria meningitidis) spill into the bloodstream (meningococcemia), they trigger a systemic inflammatory response. Cytokines cause widespread vasodilation and capillary leak, dropping blood pressure (septic shock, where organs do not get enough oxygen). DIC (widespread clotting and bleeding from clotting factor depletion) causes pinpoint bleeding spots (petechiae) and purple bleeding blotches (purpura) (purple skin spots from bleeding into the skin). Waterhouse-Friderichsen syndrome (hemorrhage into both adrenal glands) causes sudden adrenal insufficiency (loss of cortisol and aldosterone), worsening shock and electrolyte imbalances.

Spot it — what you see, and why

- Fever (often above 101°F or 38.5°C): When bacteria invade the meninges (the thin protective layers around the brain and spinal cord), the immune system releases chemicals called pyrogens (like IL-1 and TNF-α). These pyrogens tell the hypothalamus (the brain's temperature control center) to turn up the body's thermostat, making you feel hot and shivery so your immune cells can fight the bacteria better.
- Severe headache: The meninges are swollen and irritated, which stretches the pain-sensing nerve endings in the dura (the tough outer covering of the brain) and nearby blood vessels. When the brain swells, pressure inside the skull goes up, pressing on those nerves even more and causing a pounding, severe headache.
- Stiff neck (nuchal rigidity, hard to bend the neck forward): The inflamed meninges around the spinal cord are so irritated that moving the neck forward would stretch them painfully. To protect you, the muscles in the back of your neck automatically tighten up and resist any forward bending, making your neck feel stiff and locked.
- Confusion, drowsiness, irritability, or coma (altered mental status): When the brain swells, pressure inside the skull rises and squeezes the brain's blood vessels, so brain cells don't get enough oxygen and sugar to work normally. The body's inflammatory chemicals also interfere with how neurons (brain cells) talk to each other, causing confusion, sleepiness, or even loss of consciousness.

- Sensitivity to bright light (photophobia): The inflamed meninges irritate nerves that connect to the eyes, especially the optic nerve (which carries vision signals) and the trigeminal nerve (which senses pain in the face and eyes). When light hits your eyes, these already-irritated nerves send extra-strong pain signals to your brain.
- Nausea and vomiting: Rising pressure inside the skull signals a part of the brainstem called the chemoreceptor trigger zone (the body's nausea alarm). This alarm center also picks up inflammatory chemicals in the bloodstream from the infection and tells your stomach to empty itself by vomiting.

Red flags — act now

- Tiny purple or red spots on the skin that don't fade when pressed (petechiae or purple bleeding blotches (purpura)): this means bacteria are in the bloodstream causing clotting problems and severe sepsis—antibiotics must be given immediately.
- Confusion getting worse or falling into a coma: the brain is swelling dangerously and may be starting to shift inside the skull—urgent brain imaging and ICU care are needed.
- Seizures, especially a seizure that lasts more than 5 minutes or keeps repeating (status epilepticus): the brain is severely inflamed or being damaged by lack of blood flow—emergency brain imaging, seizure medicine, and airway protection are needed.
- Very slow heart rate, high blood pressure, and irregular breathing (Cushing triad), or stiff, abnormal body positions (arms bent inward or legs straight and rigid): the brainstem is being crushed by the swelling brain—death is imminent without immediate treatment.
- Low blood pressure, fast heart rate, weak pulses, cold hands and feet, or little to no urine (signs of septic shock): the infection is overwhelming the whole body—IV fluids, blood pressure medicines, and ICU care are critical.

Treat it — in this order

1. Empiric intravenous antibiotics: vancomycin PLUS third-generation cephalosporin (ceftriaxone 2 grams every 12 hours or cefotaxime 2 grams every 4–6 hours) → These antibiotics kill the three most common bacteria causing meningitis in adults: Streptococcus pneumoniae (pneumococcus), Neisseria meningitidis (meningococcus), and—when ampicillin is added—Listeria monocytogenes. Vancomycin covers drug-resistant pneumococcus strains; ceftriaxone covers meningococcus and susceptible pneumococcus. Both cross the blood-brain barrier (the tight seal between blood vessels and brain tissue) and reach high enough levels in spinal fluid to kill bacteria. Start antibiotics within ONE HOUR of suspecting bacterial meningitis—every hour of delay raises the risk of death by eight percent (Infectious Diseases Society of America, IDSA, guidelines). NEVER wait for lumbar puncture if it cannot be done immediately.

2. Dexamethasone 10 milligrams intravenous, given 15 to 20 minutes BEFORE or WITH the first antibiotic dose → Dexamethasone is a steroid that quiets the immune system's inflammatory response. It blocks the release of cytokines (chemical alarm signals) in the space around the brain, reducing swelling of the meninges and lowering pressure inside the skull. In adults with pneumococcal meningitis, dexamethasone lowers the risk of death, hearing loss, and long-term brain damage (European Dexamethasone in Adulthood Bacterial Meningitis trial). It works best when started early—ideally before or with the first antibiotic dose—so inflammation is controlled from the start.
3. Add ampicillin 2 grams intravenous every four hours if patient is over 50 years old, pregnant, or immunocompromised → Listeria monocytogenes causes meningitis in older adults, pregnant women, newborns, and people with weakened immune systems (chronic steroids, HIV, cancer chemotherapy, organ transplant). Ceftriaxone and cefotaxime do NOT cover Listeria—only ampicillin does. Adding ampicillin ensures all likely bacteria are covered in high-risk groups (IDSA guidelines). Once culture results return and Listeria is ruled out, ampicillin can be stopped.
4. Lumbar puncture with cerebrospinal fluid analysis (cell count with differential, protein, glucose, Gram stain, bacterial culture, PCR if available) → Lumbar puncture confirms the diagnosis by showing bacteria or bacterial DNA in spinal fluid and identifies which bacteria is causing the infection. Once culture and sensitivity results return (24 to 72 hours), antibiotics can be narrowed from broad empiric coverage to targeted therapy against the specific germ, reducing side effects and antibiotic resistance. For example, if Neisseria meningitidis is isolated and is penicillin-sensitive, vancomycin can be stopped and the patient switched to penicillin alone.
5. Supportive care: elevate head of bed to 30 degrees, maintain normal blood volume (euvolemia) with normal saline, avoid hypotonic fluids, monitor for seizures, ensure oxygen saturation above 94 percent, keep carbon dioxide in normal range → Elevating the head promotes blood drainage out of the brain veins, lowering pressure inside the skull. Normal saline (0.9 percent sodium chloride) keeps blood pressure and brain blood flow (perfusion) (blood flow to brain tissue) stable without worsening brain swelling. Hypotonic fluids such as half-normal saline or dextrose 5 percent in water cause water to shift into brain cells, making swelling worse. Seizures raise brain metabolic demand and increase intracranial pressure; treat with antiepileptic drugs such as levetiracetam or fosphenytoin if they occur. Keep oxygen saturation above 94 percent; low oxygen (hypoxia) injures brain cells. Keep carbon dioxide in the normal range (35 to 45 millimeters of mercury); high carbon dioxide (hypercapnia) dilates blood vessels in the brain and raises pressure.

Your top priorities at the bedside

1. Draw blood cultures from two different sites, then start empiric intravenous vancomycin and ceftriaxone within 60 minutes of emergency department arrival, ideally within 30 minutes. — why: Bacterial meningitis kills brain cells every hour antibiotics are delayed; blood cultures taken before antibiotics help identify the exact bacteria later, but treatment cannot wait for culture results because mortality rises 10 to 15 percent for each hour without antibiotics.
2. Give dexamethasone 10 milligrams intravenous 15 to 20 minutes before or with the first antibiotic dose. — why: Dexamethasone (a steroid) reduces inflammation in the subarachnoid space (the fluid-filled area around the brain) and lowers risk of hearing loss, brain damage, and death, especially in pneumococcal meningitis; it works best when given before antibiotics start killing bacteria and releasing inflammatory toxins.
3. Perform hourly neurologic checks including Glasgow Coma Scale (a 15-point score measuring eye opening, speech, and movement), pupil size and reaction to light, and motor strength in all four limbs. — why: Rising intracranial pressure from brain swelling causes herniation (brain tissue pushes through skull openings and compresses the brainstem); early signs include decreasing consciousness, unequal pupils, or new arm and leg weakness, and catching these changes allows immediate imaging and life-saving interventions like hyperosmolar therapy or neurosurgery.