Meningitis

Tuesday, November 4, 2025 2:57 PM

Definition

Meningitis is an infection of the meninges — the protective membranes covering the brain and spinal cord.

It can be classified by speed of onset and disease progression:

Type	Duration	Common Causative Agents
Acute	Hours to days	Pyogenic bacteria (*Streptococcus pneumoniae, Neisseria meningitidis*) or viruses (*Coxsackievirus, HSV-2*)
Subacute	Days to weeks	*Mycobacterium tuberculosis, Cryptococcus neoformans*
Chronic	Weeks to months	*Cryptococcus, Coccidioides, Histoplasma, Treponema pallidum, Borrelia burgdorferi*

Viral meningitis is also called aseptic meningitis because routine bacterial cultures are negative.

⚙ Pathophysiology

1. Routes of Spread

i. Hematogenous spread (most common) — organisms enter blood (bacteremia/viremia) → cross blood-brain barrier → infect meninges

ii. Direct spread

↳ From adjacent infections (e.g., otitis media, sinusitis)
↳ From trauma (e.g., skull fracture involving cribriform plate)
↳ From neurosurgical procedures (e.g., shunt placement)

Hematogenous spread is key — hence, conjugate vaccines against S. pneumoniae, N. meningitidis, and H. influenzae type B induce protective IgG antibodies that neutralize bacteria in blood.

2. Mechanism of Acute Bacterial Meningitis

Pathogenesis:

→ Nasopharyngeal colonization
↳ Local mucosal invasion
↳ Entry into bloodstream (bacteremia)
↳ Crossing the blood-brain barrier → Infection of meninges
↳ Intense inflammatory response →

- Cytokine release → Edema → ↑ Intracranial pressure → Headache, vomiting, altered mental status
- Cerebral vasculitis → Infarction → Focal neurologic deficits

Inflammation and raised intracranial pressure are the main causes of clinical manifestations.

Clinical Manifestations

Stage	Key Findings	Explanation
Early (Classic Triad)	Fever, Headache, Neck stiffness (nuchal rigidity)	Due to meningeal irritation
Common Additions	Altered mental status, photophobia, vomiting, seizures	Result of increased ICP and neuronal irritation
Severe / Complicated	Focal neurological deficits, coma	Due to infarction or brain edema

Special Feature (Neisseria meningitidis)

→ Can cause meningococcemia → petechial rash → purpura fulminans (due to endotoxin-mediated vascular

damage)

 Pathogens

A. Acute Bacterial Causes

Age Group / Risk Factor	Common Organisms
Neonates (<1 month)	*Streptococcus agalactiae (Group B), E. coli, Listeria monocytogenes*
Children (1 month–6 years)	*Streptococcus pneumoniae, Neisseria meningitidis, H. influenzae type B* (rare now due to vaccine)
Adolescents / Young Adults	*Neisseria meningitidis*
Adults / Elderly	*S. pneumoniae, Listeria monocytogenes* (esp. in immunocompromised)

 *Less common: Borrelia burgdorferi* (Lyme), *Treponema pallidum* (syphilis).

B. Acute Viral Causes

Virus	Notes
Enteroviruses (Coxsackievirus, Echovirus)	Most common; affects children; peaks in summer/fall 
HSV-2	Causes meningitis (primary genital infection)
HSV-1	More associated with encephalitis
Varicella-Zoster Virus (VZV)	Both primary and reactivation may involve meninges
Arboviruses (West Nile, St. Louis Encephalitis Virus)	Usually cause encephalitis, but meningitis possible
Mumps Virus	Now rare due to vaccination 

C. Subacute and Chronic Causes

Type	Common Organisms	Key Features
Bacterial	*Mycobacterium tuberculosis*	Tuberculous meningitis – gradual onset, base of brain involvement
Fungal	*Cryptococcus neoformans,*	Common in

	Coccidioides immitis, *Histoplasma capsulatum*	immunocompromised (esp. AIDS)
Spirochetes	*Treponema pallidum*, *Borrelia burgdorferi*	Chronic meningitis with neurological involvement
Viral	*HIV*	Most common viral cause of chronic meningitis

💡 Summary Table — Key Etiologic Agents by Category

Category	Typical Pathogens
Acute Pyogenic (Bacterial)	*S. pneumoniae, N. meningitidis, H. influenzae, L. monocytogenes*
Aseptic (Viral)	*Enteroviruses, HSV-2, VZV, Mumps virus*
Subacute / Chronic	*M. tuberculosis, Cryptococcus, Coccidioides, T. pallidum, B. burgdorferi, HIV*

🔬 Diagnosis

1. Specimen Collection

→ Cerebrospinal fluid (CSF) obtained by lumbar puncture
→ Samples also include blood, nasopharyngeal swabs, or biopsy in selected cases

---

2. Microbiological Tests

Diagnostic Method	Description	Interpretation / Use
Gram Stain	Rapid screening test for bacteria	Positive in most bacterial meningitis cases
CSF Culture	Gold standard for bacterial diagnosis	Identifies specific organism & antibiotic sensitivity
PCR (Polymerase Chain Reaction)	Detects bacterial/viral DNA or RNA in CSF	Fast (≈1 hour); high accuracy; detects multiple pathogens
India Ink Preparation	For *Cryptococcus neoformans*	Visualizes encapsulated yeast in CSF
Cryptococcal Antigen Test	Detects capsular polysaccharide antigen	Very sensitive and specific for *Cryptococcus*
Serologic Tests	Detect antibodies against viruses/fungi	Useful when cultures are negative

💡 PCR panels can simultaneously test for 6 common bacteria, 7 viruses, and Cryptococcus — providing a complete result within 1 hour ⏱.

---

3. CSF Analysis — Key Findings 

Feature	Bacterial (Acute)	Viral (Aseptic)	Fungal / Tuberculous (Subacute–Chronic)
Opening Pressure	↑ Increased	Normal / Slightly ↑	↑ Increased
Appearance	Turbid / Purulent	Clear	Slightly turbid
WBC Count	↑↑ (1000–5000/mm³)	↑ (50–500/mm³)	↑ (50–500/mm³)
Cell Type	Neutrophils predominance	Lymphocytes predominance	Lymphocytes predominance
Protein	↑↑ (100–500 mg/dL)	↑ (50–100 mg/dL)	↑↑ (>200 mg/dL)
Glucose	↓ (<40 mg/dL)	Normal	↓ (<40 mg/dL)
Gram Stain / Culture	Positive	Negative	Fungal/TB-specific stains or antigen tests positive

 *Bacterial infections*: Neutrophils + ↓ glucose

 *Viral infections*: Lymphocytes + normal glucose

 *Fungal/TB infections*: Lymphocytes + markedly ↑ protein + ↓ glucose

---

4. Flowchart: Diagnostic Approach to Suspected Meningitis

→ Lumbar puncture → Collect CSF sample

↳ Perform Gram stain & culture → Positive → Identify bacteria → Begin targeted therapy

↳ If Gram stain negative:

→ Perform PCR (for bacteria, viruses, Cryptococcus)
→ Perform India ink / antigen test (if fungal suspected)
→ Perform AFB stain / culture (if TB suspected)

💊 Treatment

1. Principles of Empiric Therapy

- Start immediately after CSF collection (do not delay for results).
- Use bactericidal agents that penetrate the blood-brain barrier (BBB).

- Modify regimen once organism and sensitivities are known.

2. Empiric Therapy Regimens by Age Group / Risk

Patient Group	Empiric Therapy	Notes
Neonates (<1 month)	Ampicillin + (Cefotaxime or Ceftriaxone) ± Gentamicin	Covers *Group B Streptococcus, E. coli, Listeria monocytogenes*
Infants & Children	Ceftriaxone or Cefotaxime + Vancomycin	Vancomycin covers resistant *S. pneumoniae*
Adults	Ceftriaxone or Cefotaxime + Vancomycin	Same rationale as above
Elderly / Immuno compromised	Ampicillin + Ceftriaxone (or Cefotaxime) + Vancomycin	Add Ampicillin to cover *Listeria*
HSV / VZV Suspected	Acyclovir	For viral meningitis caused by herpes viruses

💡 *Vancomycin is crucial for penicillin/cephalosporin-resistant pneumococci.*

3. Flowchart: Empiric Therapy Selection

→ Suspected Bacterial Meningitis

↳ Neonate (<1 month) → Ampicillin + (Cefotaxime / Ceftriaxone) ± Gentamicin
↳ Child / Adult → Ceftriaxone + Vancomycin
↳ >50 years / Immunocompromised → Ceftriaxone + Vancomycin + Ampicillin

↳ If HSV/VZV suspected → Add Acyclovir

Prevention

1. Vaccination

Vaccine	Pathogen Covered	Notes
Pneumococcal Conjugate Vaccine (PCV13, Prevnar 13)	*Streptococcus pneumoniae*	Protects against 13 serotypes
Haemophilus influenzae Type B (Hib) Vaccine	*H. influenzae type B*	Only protects against type B serotype
Meningococcal Conjugate Vaccine (MCV4)	*Neisseria meningitidis* (A, C, Y, W-135)	Does not cover type B
Meningococcal Type B Vaccine	*N. meningitidis* (serogroup B)	Uses factor H binding protein (fHbp) and other surface proteins (fHbp, NadA, NHBA, PorA)

Vaccines prevent the most dangerous pyogenic forms of meningitis.

---

2. Chemoprophylaxis

Target Organism	Indication	Drug of Choice	Notes
Group B Streptococcus (S. agalactiae)	Positive vaginal/rectal cultures (35–37 weeks gestation)	Ampicillin (during labor)	Prevents neonatal infection
N. meningitidis	Close contacts of meningococcal case	Ciprofloxacin (single dose)	Reduces nasopharyngeal carriage
H. influenzae type B	Household / close contacts of Hib case	Rifampin	Prevents spread among children

---

3. Public Health Measures

- Prompt isolation of bacterial meningitis cases.
- Notification to public health authorities.
- Screening and prophylaxis for close contacts.
- Maintenance of herd immunity via immunization

campaigns.

Quick Summary

Aspect	Key Points
Diagnosis	CSF Gram stain, culture, PCR, antigen tests
CSF Findings	Bacterial: Neutrophils + ↓ glucose; Viral: Lymphocytes + normal glucose
Treatment	Ceftriaxone + Vancomycin (± Ampicillin / Acyclovir)
Prevention	Vaccines (PCV13, Hib, MCV4, MenB) + Chemoprophylaxis for contacts