Acute Bacterial Meningitis: Causes, Pathophysiology and Treatment

Acute bacterial meningitis is a **life-threatening purulent infection of the subarachnoid space (SAS)** , leading to inflammation of the meninges and potentially the brain parenchyma (**meningoencephalitis**). It can cause **altered mental status, seizures, elevated intracranial pressure (ICP), and stroke** .

Etiology

Pathogen	Key Risk Groups
Streptococcus pneumoniae	Most common in adults; risk increased with alcoholism, DM, sinusitis, otitis media, splenectomy, complement deficiency
Neisseria meningitidis	Common in children and young adults; risk ? with complement deficiencies (esp. properdin, C5–C9)
Listeria monocytogenes	Neonates, elderly (>60), pregnant women, immunocompromised
Haemophilus influenzae type b (Hib)	Unvaccinated children, older adults
Gram-negative bacilli (e.g., E. coli, Klebsiella)	Diabetics, cirrhosis, UTIs, elderly
Staphylococcus aureus / coagulase-negative staph	Post-neurosurgical procedures (e.g., shunts, trauma)

Pathophysiology

1. **Colonization** : Bacteria colonize the **nasopharynx** and penetrate mucosal barriers.
2. **Hematogenous Spread** : Bacteria evade phagocytosis via **polysaccharide capsules** and enter bloodstream.
3. **Invasion of CNS** : They infect **choroid plexus epithelium** , gaining access to CSF.
4. **Replication in CSF** : CSF is immune-privileged (low immunoglobulins, complement), allowing bacterial proliferation.
5. **Inflammatory Response** :
    - Bacterial lysis releases **cell wall components** (e.g., LPS, peptidoglycan, teichoic acid).
    - Inflammatory cytokines (TNF-?, IL-1?) disrupt the **blood-brain barrier** , causing **vasogenic edema** .
    - ? CSF proteins, leukocytosis, and ? CSF glucose.
6. **Complications** :
    - **Cerebral edema** (cytotoxic, vasogenic, interstitial) ? **? ICP, herniation** .
    - **Vascular inflammation** ? vasculitis, thrombosis ? ischemia, infarction.
    - **Hydrocephalus** : obstructive & communicating due to exudate and impaired CSF resorption.

Clinical Features

Symptom/Sign	Description
Fever, headache, neck stiffness	Classic triad (but present in ~50%)
Altered mental status	Occurs in >75% of patients
Photophobia, nausea, vomiting	Common constitutional symptoms
Seizures	Focal (due to infarction) or generalized (e.g., hyponatremia)
Signs of raised ICP	Papilledema, Cushing reflex, CN VI palsy, decerebrate posturing
Kernig & Brudzinski signs	Positive in meningeal irritation
Petechial rash	Seen in meningococcemia (Neisseria meningitidis)

Diagnosis and Investigations

Initial Assessment

- Immediate **neuro exam** for signs of ?ICP.
- If **no focal signs or papilledema**, perform **lumbar puncture (LP)** immediately.
- If **focal deficits, altered consciousness, or immunocompromised**, obtain **CT/MRI before LP**.

CSF Analysis – Classic Findings in Bacterial Meningitis :

Parameter	Typical Finding
Appearance	Turbid
Opening Pressure	? (>180 mmH?O)
WBC Count	? (?1000/?L), PMN predominant
Protein	? (>0.45 g/L)
Glucose	? (<2.2 mmol/L or <40 mg/dL)
CSF/Serum Glucose Ratio	<0.4 (highly suggestive)

- **Gram stain and culture** : Most definitive.
- **Latex agglutination (LA)** : High specificity for *S. pneumoniae* and *N. meningitidis*.
- **Blood cultures** : Always before antibiotics if LP delayed.
- **MRI with gadolinium** : Detects cerebral edema, infarcts, meningeal enhancement better than CT.

Complications

- **Cerebral herniation** (life-threatening)
- **Hydrocephalus**
- **Seizures**
- **Cranial nerve palsies**

- **Sensorineural hearing loss**
- **Vascular infarcts**

Management Overview

Empirical Antibiotic Therapy (Immediately after cultures):

- **Adults <50 years** : Ceftriaxone + Vancomycin
- **Adults >50 or immunocompromised** : Add **Ampicillin** (for Listeria)
- Consider **Dexamethasone** : Reduces neurological sequelae, especially in pneumococcal meningitis

Supportive Measures :

- Monitor for **ICP** (head elevation, hypertonic saline, mannitol).
- Treat **seizures** , maintain **normovolemia and oxygenation** .
- Admit to ICU if unstable.

Key High-Yield Points

- **CSF glucose <2.2 mmol/L** and **CSF/serum glucose ratio <0.4** = strong indicator.
- **Do NOT delay antibiotics** for neuroimaging in unstable patients.
- **Most common cause in adults** : *Streptococcus pneumoniae* .
- **Meningococcal rash** = petechiae, purpura, can lead to DIC.
- **Immunocompromised or elderly** : Always consider **Listeria** .
- **Dexamethasone** should be given **before or with first dose** of antibiotics.