



Basic Principles of Meningitis & Cerebrospinal Fluid (CSF) Analysis Interpretation

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1. Definition

Meningitis is inflammation of the meninges surrounding the brain and spinal cord, usually caused by infection.

The most important distinction is between:

- **Bacterial meningitis** → medical emergency requiring immediate antibiotics.
- **Viral (aseptic) meningitis** → usually self-limited.
- **Tuberculous and fungal meningitis** → subacute/chronic, requiring specific therapy.

Clinical priority: Never delay treatment while waiting for lumbar puncture (LP) if bacterial meningitis is suspected.

2. Clinical Presentation

Key History

Ask about:

- Fever
- Headache
- Neck stiffness
- Altered mental status
- Vomiting
- Seizure
- Rash (especially petechiae)
- Recent ear infection/sinusitis
- Head trauma/neurosurgery
- Immunodeficiency
- TB exposure
- Vaccination status

Infants may present only with

- Poor feeding
 - Irritability
 - Lethargy
 - High-pitched cry
 - Bulging fontanelle
 - Apnea
 - Hypothermia instead of fever
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Physical Examination

Look for

Classic triad (only ~40–50%)

- ✓ Fever
 - ✓ Neck stiffness
 - ✓ Altered consciousness
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Meningeal signs

- Nuchal rigidity
- Kernig sign
- Brudzinski sign

(Often absent in infants.)

Signs of severe disease

- Hypotension
- Petechial/purpuric rash
- Shock
- Focal neurological deficit
- Cranial nerve palsy
- Papilledema
- Persistent seizures
- Reduced GCS

3. Diagnostic Approach

Step 1

Suspect meningitis if:

- Fever + headache
- Fever + altered consciousness
- Fever + neck stiffness
- Fever + seizure
- Infant with fever + lethargy/irritability

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Assess ABCDE

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Stabilize airway, breathing, circulation

↓

Draw blood cultures

↓

Start empiric antibiotics immediately

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Decide whether LP is safe

Contraindications to Immediate Lumbar Puncture

Delay LP if ANY of the following are present:

- Signs of raised intracranial pressure
- Papilledema
- Focal neurological deficit
- New focal seizure

- Severe impaired consciousness
- Hemodynamic instability
- Respiratory compromise
- Coagulopathy
- Infection over puncture site

Remember

Delay LP—not antibiotics.

When is CT Brain Needed Before LP?

CT is **NOT routinely required**.

Perform CT before LP only if:

- Papilledema
 - Focal neurological deficit
 - New-onset seizures
 - Immunocompromised patient
 - Severe altered mental status
 - Suspected intracranial mass
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4. Differential Diagnosis

Consider:

- Viral encephalitis
 - Brain abscess
 - Migraine
 - Subarachnoid hemorrhage
 - Febrile seizure
 - Sepsis without meningitis
 - Toxic ingestion
 - Autoimmune encephalitis
 - Intracranial tumor
 - Tuberculous meningitis
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5. Investigations

Essential

- ✓ Blood cultures
 - ✓ CBC
 - ✓ CRP $\pm$ Procalcitonin
 - ✓ Electrolytes
 - ✓ Glucose
 - ✓ Renal function
 - ✓ Coagulation profile (if indicated)
 - ✓ Lumbar puncture (if safe)
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CSF Analysis

Always compare CSF glucose with **serum glucose**.

Request:

- Opening pressure
 - Appearance
 - Cell count
 - Differential
 - Protein
 - Glucose
 - Gram stain
 - Culture
 - PCR (viral/bacterial if available)
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CSF Interpretation Table

Finding	Normal CSF	Bacterial	Viral	Tuberculous	Fungal
Opening pressure	Normal	↑↑	Normal/↑	↑	↑
Appearance	Clear	Turbid	Clear	Slightly cloudy	Clear/cloudy
WBC	<5	1,000–5,000	10–500	50–500	20–500
Predominant cells	None	Neutrophils	Lymphocytes	Lymphocytes	Lymphocytes
Protein	Normal	↑↑	Mild ↑	↑↑	↑
Glucose	Normal	↓↓↓	Normal	↓	↓
Gram stain	Negative	Often positive	Negative	Negative	Negative
Culture	Negative	Positive	Negative	TB culture/PCR	Fungal culture

Quick Interpretation Rule

Bacterial

↑ Neutrophils

↑ Protein

↓ Glucose

Viral

↑ Lymphocytes

Normal glucose

Mild protein elevation

TB

Lymphocytes

Very high protein

Low glucose

Fungal

Similar to TB

Usually immunocompromised patients

6. Management Algorithm

Suspected meningitis

↓

ABCDE

↓

Blood culture

↓

Start empiric antibiotics

↓

Dexamethasone (selected patients)

↓

LP if safe

↓

Adjust antibiotics according to culture/PCR

↓

Supportive care

↓

Monitor for complications

7. Drug Summary Table

Drug	Common Indication	Typical Pediatric Dose*	Important Notes
Ceftriaxone	First-line empiric therapy (>1 month)	100 mg/kg/day IV (max 4 g/day)	Excellent CNS penetration
Cefotaxime	Alternative to ceftriaxone	200 mg/kg/day IV divided every 6 hours	Preferred in some neonates
Vancomycin	Add if resistant <i>Streptococcus pneumoniae</i> is possible	15 mg/kg IV every 6 hours (adjust to levels)	Combine with third-generation cephalosporin
Ampicillin	Neonates; suspected <i>Listeria</i>	300 mg/kg/day IV divided every 6 hours	Include in neonates and older adults/immunocompromised
Acyclovir	Suspected HSV encephalitis	10–20 mg/kg IV every 8 hours	Start if encephalitis is suspected
Dexamethasone	Suspected bacterial meningitis	0.15 mg/kg IV every 6 hours for 2–4 days	Ideally before or with the first antibiotic dose

*Typical pediatric doses; always verify with local guidelines and adjust for age, renal function, and institutional protocols.

8. Admission Criteria

All suspected bacterial meningitis

Require hospital admission.

Also admit:

- Neonates
- Altered consciousness
- Persistent vomiting
- Seizures
- Dehydration
- Immunocompromised patients

- Abnormal CSF
 - Need for IV antibiotics
 - Social concerns preventing safe outpatient care
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9. Referral Criteria

Urgent referral to pediatric/infectious diseases/neuroscience services if:

- Septic shock
 - Raised ICP
 - Status epilepticus
 - Focal neurological deficit
 - Need for ICU
 - Persistent altered consciousness
 - Hydrocephalus
 - Brain abscess
 - Suspected TB/fungal meningitis
 - Failure to improve within 48 hours
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10. Follow-up

Monitor for:

- Hearing loss (audiology assessment after bacterial meningitis)
 - Developmental delay (children)
 - Cognitive impairment
 - Seizure disorder
 - Hydrocephalus
 - Cranial nerve deficits
 - School performance and neurodevelopment when appropriate
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11. Clinical Pearls

- **Bacterial meningitis is a medical emergency.**
 - Antibiotics should **never be delayed** for CT or LP if meningitis is strongly suspected.
 - Blood cultures should be obtained **before antibiotics** whenever this does not delay treatment.
 - Normal meningeal signs do **not** exclude meningitis, especially in infants.
 - Compare CSF glucose with simultaneous serum glucose.
 - Neutrophils + low glucose + high protein strongly suggest bacterial meningitis.
 - PCR can remain diagnostic even after antibiotics have been started.
 - Dexamethasone is most effective when given **before or with the first antibiotic dose**.
 - CT does **not** rule out raised intracranial pressure and is not routinely indicated before LP.
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12. Common Mistakes in Exams and Practice

- ✗ Delaying antibiotics until after LP.
 - ✗ Performing LP in an unstable patient.
 - ✗ Ordering CT for every patient before LP.
 - ✗ Interpreting CSF glucose without checking serum glucose.
 - ✗ Assuming viral meningitis cannot have neutrophils early in the illness.
 - ✗ Missing meningitis in infants because neck stiffness is absent.
 - ✗ Failing to obtain blood cultures before antibiotics when feasible.
 - ✗ Forgetting hearing assessment after bacterial meningitis.
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13. Key Take-Home Messages

1. **Suspect meningitis early** in any patient with fever and altered mental status, neck stiffness, severe headache, or seizures.
2. **Stabilize first (ABCDE)** and treat bacterial meningitis as a medical emergency.
3. **Do not delay empiric antibiotics** for LP or neuroimaging when bacterial meningitis is strongly suspected.

4. Perform **lumbar puncture only when there are no contraindications**.
5. **CT before LP is indicated only in selected high-risk patients**, not routinely.
6. **Classic bacterial CSF**: neutrophilic pleocytosis, markedly elevated protein, and low glucose.
7. **Classic viral CSF**: lymphocytic pleocytosis, normal glucose, and mildly elevated protein.
8. Always interpret **CSF glucose alongside serum glucose** and use Gram stain, culture, and PCR to identify the pathogen.
9. **Third-generation cephalosporin plus vancomycin** is appropriate empiric therapy for most children older than 1 month, while **ampicillin** should be added when *Listeria* coverage is required (e.g., neonates).
10. Early recognition, prompt treatment, and monitoring for neurological complications (especially hearing loss) are essential to reduce morbidity and mortality.

High-Yield CSF Interpretation Mnemonic

Type	Cells	Protein	Glucose
Bacterial	↑ Neutrophils	↑↑	↓↓↓
Viral	↑ Lymphocytes	Mild ↑	Normal
Tuberculous	↑ Lymphocytes	↑↑	↓
Fungal	↑ Lymphocytes	↑	↓

Core References (2023–2025 evidence)

- Infectious Diseases Society of America (IDSA). *Practice Guidelines for the Management of Bacterial Meningitis* (with current evidence updates).
- American Academy of Pediatrics (AAP). *Red Book: Report of the Committee on Infectious Diseases* (latest edition).
- National Institute for Health and Care Excellence (NICE). *Meningitis (bacterial) and meningococcal disease: recognition, diagnosis and management*.
- World Health Organization (WHO). *Meningitis: Prevention, Diagnosis and Treatment*.
- European Society for Paediatric Infectious Diseases (ESPID). Guidance on the management of acute bacterial meningitis in children.