Interpreting CSF Analysis

What Is CSF Analysis?

Cerebrospinal fluid (CSF) analysis is a test we do when someone has fluid taken from around their brain and spinal cord using a needle (a procedure called a lumbar puncture, or LP). We send the fluid to the lab to figure out what's going on in the brain or spinal cord. This helps us find causes of problems like infections (e.g., meningitis), brain bleeding, or diseases like multiple sclerosis. This guide makes it easy to understand how to interpret CSF analysis, with helpful tips (clinical pearls) and examples to guide you in the hospital.

Why Do We Analyze CSF?

CSF surrounds the brain and spinal cord, so it can tell us a lot about what's happening in the nervous system. We analyze CSF to:

- Find the cause of symptoms like headache, fever, confusion, or seizures (e.g., meningitis, brain bleed).
- Check for emergencies like bacterial meningitis or bleeding in the brain (subarachnoid hemorrhage).
- Decide how to treat the patient (e.g., antibiotics for infection, surgery for a bleed).
- Look for diseases like multiple sclerosis or cancer that has spread to the brain.

Step-by-Step Guide to Interpreting CSF Analysis

Let's break it down into simple steps to make it easy to understand.

Step 1: Look at the Appearance of the CSF

When you first get the CSF, check how it looks:

- **Clear and Colorless:** Normal CSF looks like water. This usually means there's no big problem.
- **Cloudy or Turbid:** Could mean an infection (like meningitis) because of lots of white blood cells (WBCs) or bacteria.
- **Bloody or Pink:** Might be a brain bleed (subarachnoid hemorrhage) or just blood from the needle poke (called a traumatic tap). If the fluid clears up from the first tube to the last, it's likely a traumatic tap.

- **Yellow or Orange (Xanthochromia):** Suggests an old brain bleed (happened a few hours or days ago), because red blood cells break down and turn yellow.

Step 2: Check the Opening Pressure

When doing the LP, we measure the pressure of the CSF (in cmH2O):

- **Normal:** 10-20 cmH2O (adults).
- **High (>25 cmH2O):** Could mean brain swelling (e.g., from meningitis), a brain tumor, or a condition like pseudotumor cerebri (high pressure in the brain).
- **Low (<6 cmH2O):** Might mean a CSF leak or dehydration.

Step 3: Look at the Cell Count (White Blood Cells and Red Blood Cells)

- The lab will count the cells in the CSF:
- **White Blood Cells (WBC):**
  - **Normal:** 0-5 WBC/µL.
  - **WBC >10/µL with Neutrophils Predominant:** Suggests bacterial meningitis (e.g., Streptococcus pneumoniae). Start antibiotics right away!
  - **WBC >10/µL with Lymphocytes Predominant:** Think about viral meningitis (e.g., enterovirus), TB meningitis, or fungal meningitis.
  - **WBC >100/µL with Lymphocytes:** Could be cancer (leptomeningeal metastases) or chronic infections (e.g., TB, cryptococcal meningitis).
- **Red Blood Cells (RBC):**
  - **Normal:** 0 RBC/µL (or very few from a traumatic tap).
  - **RBC >1,000/µL and Xanthochromia:** Suggests a subarachnoid hemorrhage (SAH). Order a CT scan to confirm.
  - **RBC Present but Decreasing Across Tubes:** Likely a traumatic tap (not a real brain bleed).

Step 4: Check Glucose and Protein Levels

- **Glucose:**
  - **Normal:** 40-70 mg/dL (about 2/3 of blood glucose).
  - **Low (<40 mg/dL):** Suggests bacterial meningitis, TB meningitis, fungal meningitis, or cancer (leptomeningeal metastases). The infection or cancer "eats up" the glucose.
  - **Normal or High:** Seen in viral meningitis or no infection.
- **Protein:**
  - **Normal:** 15-45 mg/dL.

- **High (>50 mg/dL):** Suggests infection (bacterial, TB, fungal), cancer, or a brain bleed (SAH). The worse the infection or bleed, the higher the protein.
- **Very High (>200 mg/dL):** Think about serious infections like TB meningitis or cancer.
- **Low (<15 mg/dL):** Can happen with a CSF leak or in pseudotumor cerebri.

Step 5: Check for Infection (Culture, Gram Stain, and Specific Tests)

- **Gram Stain:** Shows bacteria in bacterial meningitis (e.g., Gram-positive cocci for Streptococcus pneumoniae), but it's often negative (low sensitivity).
- **Culture:** If bacteria, TB, or fungi grow, it confirms the infection. Common bacteria in meningitis are Streptococcus pneumoniae, Neisseria meningitidis, or Haemophilus influenzae.
- **Specific Tests:**
  - **PCR:** Tests for viruses (e.g., HSV, enterovirus), TB, or fungi.
  - **Cryptococcal Antigen:** High in cryptococcal meningitis (common in HIV patients).
  - **India Ink Stain:** Shows Cryptococcus in HIV patients.
  - **AFB Smear/Culture:** For TB meningitis.

Step 6: Look at Other Tests (If Needed)

- **Cytology:** Looks for cancer cells (e.g., leptomeningeal metastases from lung cancer or lymphoma).
- **Oligoclonal Bands:** High in multiple sclerosis (MS), showing inflammation in the brain.
- **IgG Index:** High in MS (>0.7), compares IgG in CSF to blood.
- **Beta-2 Transferrin:** Confirms a CSF leak (specific marker for CSF).

Helpful Clinical Pearls

- **Pearl 1:** Always Check the Opening Pressure
  - The opening pressure can give you a big clue. If it's high (>25 cmH2O), think about meningitis, brain swelling, or pseudotumor cerebri. If it's low (<6 cmH2O), suspect a CSF leak.
- **Pearl 2:** Neutrophils Mean Act Fast for Bacterial Meningitis
  - If the CSF has lots of neutrophils (WBC >10/µL, mostly neutrophils), assume bacterial meningitis until proven otherwise. Start antibiotics (like ceftriaxone) right away, even before cultures come back.

- **Pearl 3:** Xanthochromia Confirms a Brain Bleed
  - If the CSF is yellow (xanthochromia) and RBCs are high (>1,000/µL), it's likely a subarachnoid hemorrhage (SAH). Order a CT scan of the head to confirm, and consult neurosurgery.
- **Pearl 4:** Low Glucose Is a Red Flag
  - A CSF glucose <40 mg/dL usually means a bad infection (bacterial, TB, fungal) or cancer. Start antibiotics or antifungals and order more tests (like PCR or cryptococcal antigen).
- **Pearl 5:** Traumatic Tap vs. Real Bleed
  - If the CSF is bloody but clears up from the first tube to the last (e.g., Tube 1: 5,000 RBC/µL, Tube 4: 500 RBC/µL), it's probably just from the needle (traumatic tap). If it stays bloody and has xanthochromia, it's a real brain bleed (SAH).
- **Pearl 6:** High Protein Means Something Serious
  - A CSF protein >50 mg/dL suggests infection, cancer, or a bleed. If it's >200 mg/dL, think about TB meningitis or cancer and order specific tests (e.g., TB PCR, cytology).

Table: Interpreting CSF Analysis Results

Test	Result	What It Means	Next Steps
Appearance	Clear, colorless	Normal or viral meningitis	Check cell count, glucose, protein
	Cloudy/turbid	Infection (bacterial meningitis)	Start antibiotics, culture, Gram stain
	Bloody/xanthochromic	Subarachnoid hemorrhage (SAH)	CT head, consult neurosurgery
Opening Pressure	>25 cmH2O	Meningitis, brain swelling, pseudotumor	Brain imaging (CT/MRI), treat cause
	<6 cmH2O	CSF leak, dehydration	Look for leak (beta-2 transferrin), fluids
WBC/ Neutrophils	WBC >10/µL, Neutrophils predominant	Bacterial meningitis	Antibiotics (ceftriaxone), culture
	Lymphocytes predominant	Viral, TB, fungal meningitis, cancer	PCR, TB tests, cryptococcal antigen, cytology
Glucose	<40 mg/dL	Bacterial, TB, fungal meningitis, cancer	Antibiotics/antifungals, further tests
Protein	>50 mg/dL	Infection, cancer, SAH	Culture, cytology, specific tests (e.g., PCR)

Table: Common Causes of Abnormal CSF Findings

Cause	Appearance	WBC	Glucose	Protein	Other Findings
Normal CSF	Clear	0-5/μL	40-70 mg/dL	15-45 mg/dL	None
Bacterial Meningitis	Cloudy	>100/μL, neutrophils	<40 mg/dL	>50 mg/dL	Positive Gram stain, culture
Viral Meningitis	Clear	10-100/μL, lymphocytes	Normal	50-100 mg/dL	PCR (e.g., HSV, enterovirus)
TB Meningitis	Cloudy	100-500/μL, lymphocytes	<40 mg/dL	>200 mg/dL	AFB smear, TB PCR
Subarachnoid Hemorrhage	Bloody, xanthochromic	RBC >1,000/μL	Normal	>50 mg/dL	CT head positive, neurosurgery consult
Multiple Sclerosis	Clear	5-50/μL, lymphocytes	Normal	50-100 mg/dL	Oligoclonal bands, high IgG index

Clinical Scenarios

Scenario 1: Young Adult with Bacterial Meningitis

- Presentation: A 25-year-old male presents with fever, headache, neck stiffness, and confusion. Exam shows T 39°C, BP 110/70 mmHg, HR 120 bpm, RR 20/min, GCS 14, positive Kernig's sign.
- CSF Analysis: **Appearance:** Cloudy, opening pressure 30 cmH2O, WBC 1,200/μL (90% neutrophils), glucose 20 mg/dL, protein 150 mg/dL, Gram stain: Gram-positive cocci, culture pending.
- Interpretation: Cloudy fluid, high opening pressure, neutrophils predominant, low glucose, high protein (bacterial meningitis).
- Management: Admit to ICU (meningitis, altered mental status). Start ceftriaxone 2 g IV q12h + vancomycin 15 mg/kg IV q12h. Dexamethasone 10 mg IV q6h (before antibiotics). Consult ID: Culture grows Streptococcus pneumoniae, antibiotics continued for 14 days. After 3 days, fever resolves, GCS 15, discharged with follow-up.

Scenario 2: Elderly Female with Subarachnoid Hemorrhage

- Presentation: A 70-year-old female presents with sudden severe headache and nausea. Exam shows T 37°C, BP 160/90 mmHg, HR 80 bpm, RR 18/min, GCS 15, neck stiffness, no focal deficits.

- CSF Analysis: **Appearance:** Bloody, xanthochromic, opening pressure 22 cmH2O, RBC 5,000/µL (no clearing across tubes), WBC 50/µL (corrected for RBCs), glucose 60 mg/dL, protein 80 mg/dL.
- Interpretation: Bloody fluid, xanthochromia, high RBCs (SAH).
- Management: Admit to ICU (SAH). CT head confirms SAH, CTA shows cerebral aneurysm. Consult neurosurgery: Aneurysm clipped. Nimodipine 60 mg PO q4h (vasospasm prevention). Monitor for rebleeding, vasospasm. After 7 days, stable, discharged with neurosurgery follow-up.

Scenario 3: Middle-Aged Male with TB Meningitis

- Presentation: A 45-year-old male with HIV (CD4 80) presents with 2 weeks of headache, fever, and confusion. Exam shows T 38°C, BP 110/70 mmHg, HR 100 bpm, RR 18/min, GCS 13, neck stiffness.
- CSF Analysis: **Appearance:** Cloudy, opening pressure 28 cmH2O, WBC 300/µL (80% lymphocytes), glucose 25 mg/dL, protein 220 mg/dL, AFB smear positive, TB PCR pending.
- Interpretation: Cloudy fluid, high opening pressure, lymphocytes predominant, low glucose, high protein, AFB positive (TB meningitis).
- Management: Admit to isolation unit (TB). Start RIPE therapy (rifampin, isoniazid, pyrazinamide, ethambutol). Dexamethasone 0.4 mg/kg/day IV (reduce inflammation). Consult ID: Continue ART, monitor LFTs. After 5 days, GCS 15, TB PCR confirms Mycobacterium tuberculosis, discharged on RIPE therapy.