Cerebrospinal Fluid (CSF)

Last updated: June 3, 2019

PHYSIOLOGY

CSF functions:
1. Transport media, maintenance of stable chemical environment.
   - CSF is inside BBB, CSF freely communicates with brain interstitial fluid.
2. Hydraulic shock absorber
   - Burstancy reduces in situ weight of brain to ≈ 50 gm.
   - CSF removal during lumbar puncture → brain weight↑ → tension on arachnoid trabeculae, nerve roots and blood vessels → headache.

CSF production:
1. Main amount (70-80%) - CHOROID PLEXUS (vast majority - lateral ventricles).
2. Small amounts - secreted by EPISTEMYMA and brain's capillary bed, metabolic water production.

CHOROID PLEXUS (derived from neural epithelium) is composed of:
1. Choroidal epithelium – specialized ependyma (ependymal lining of ventricular system); microvilli (brush border) are present on apical surfaces of cells.
2. Tela chooroidea - highly vascularized pia mater.
3. Blood vessels and interstitial connective tissue; capillaries have gaps between endothelialcytes (v.s. choroidal epithelium has tight junctions).
   - CHOROID PLEXUS is present in:
     1) 4th ventricle ependymal roof – blood supply from posterior inferior cerebellar artery.
     2) 3rd ventricle ependymal roof - blood supply from branches of posterior cerebral arteries.
     3) medial wall of lateral ventricles (continuous with choroid plexus in roof of 3rd ventricle – main mass!) – blood supply from anterior and posterior choroidal arteries.
   - TOTAL CSF VOLUME 150 ml (62.2-267); = 50 ml in infants; 7.5-70.5 ml in ventricles.
   - CSF flows from ventricles into subarachnoid space.
   - CSF PRODUCTION RATE = 500 ml/d = 20 ml/hr = 0.35-0.40 ml/min.
   - CSF production is affected minimally, if at all, by changes in ICP (i.e. CSF production is independent to ICP), peak production in late evening and early morning.
   - entire CSF volume is turned over 3-4 times each day.
   - CSF volume removed at lumbar puncture is regenerated in 1 hour.

CSF production mechanism – combination of:
1. ULTRAFILTRATION: Due to hydrostatic pressure within plexus capillaries → water and electrolytes move into interstitial space → choroidal epithelium → transfer into ventricular cavity (by traversing tight apical junctions or plasma membrane of apical villus).
   - net secretion of Na, Cl and Mg occurs from plasma to CSF.
   - strong correlation between rate of Na exchange and rate of CSF formation.
   - Na exchange is regulated by bicarbonate permeability (CARBONIC ANHYDRASE is important).
   - ACTINIDEMER (carbonic anhydrase inhibitor) can reduce CSF production significantly.

Active neurogenic control of CSF formation - choroid plexus is innervated by adrenergic and cholinergic nerves:
- adrenergic stimulation → diminished CSF production; cholinergic stimulation may double normal CSF production rate.

CSF flows results from hydrostatic pressure gradient (intraventricular pressure = 180 mmHg, pressure in superior sagittal sinus = 90 mmHg).

CSF reabsorption
- into venous blood by ARACHNOID VILI - protrude from subarachnoid space into lumen of dural sinuses - colagenous trabecular core with associated channels and cap of arachnoid cells on apex (serves as one-way valve) - prevent blood reflux into CSF; opens at Δp = 5 mmHg; CSF reabsorption occurs at ICP > 5 mmHg.
- arachnoid (s, parachorion) granulations – arachnoid outpouchings with collections of ARACHNOID VILI - penetrate gaps of dura mater into SINUS SAGITTALIS SUPERIOR (into lateral venous sinuses -最終 venous lacunae).
- arachnoid villi are also present at veins surrounding spinal nerve roots – drain CSF into EPIDURAL VEINS.
- with age; arachnoid granulations become more numerous and calcify.
- other routes of CSF absorption (via diffusion into veins) - VENTRICULAR EPIDERMYA, ARACHNOID MEMBRANE.

CSF production is independent of ICP.
CSF absorption is proportional to ICP and dural venous sinus pressure (CSF reabsorption is especially highly dependent on dural venous sinus pressure).
**NORMAL**

1. **Opening pressure** 65-200 mmHgO (5-15 mmHg) with patient lying down (or at level of foramen magnum in sitting position).
   - *50 mmHgO in neonates, 85 mmHgO in young children,
   - 250 mmHgO in extremely obese subjects
   - not affected by systemic BP
   - accurate measurement requires patient cooperation. see p. Op/1 >>
   - exquisitely sensitive to blood CO₂ (hyperventilation lowers ICP) and venous pressure.

2. **Clear & colorless** (> 99% water) – indistinguishable from water.

3. Few cellular components (< 5 lymphocytes or mononuclears / mm³); polymorphonuclear (PMN) cells & RBCs are always abnormal (1 PMN is still normal if total cell count ≤ 5).
   - N.B. normal newborn may have up to 19 lymphocytes/mm³ (up to 60% cells may be PMNs); norma in infants 1-2 months old – up to 9 mononuclears/mm³.

4. **Protein** < 60 mg/dL (0.5%), mainly albumin.
   - in lower in children 6 months + 2 yrs; up to 150-170 mg/dL in neonates, esp. premature (immature leaky BBB)
   - majority of CSF protein (esp. albumins) is derived from serum.
   - CSF proteins that arise within intrathecal compartment.
      1) immunoglobulin G (produced by CNS lymphocytes): adults < 15% of total CSF protein children < 14 yrs < 8% of total CSF protein
      2) transthyretin (produced by choroid plexus)
      3) structural proteins (glial fibrillary acidic, tau, myelin basic protein) found in brain tissue.
   - CSF protein concentration increases from cephalad to caudal levels (reflecting different permeability of capillary endothelial cells).

5. **Glucose** (> 60% of plasma amount, i.e. 50-100 mg/dL or 2.8-4.2 mmol/L; values < 50 (40-45 mg/dL) are usually abnormal, and values < 40 (40 mg/dL) are invariably so.
   - ratio is higher in infants.
   - ratio changes proportionately in response to rising or falling plasma glucose with 4-hour lag time (obtain concomitant* serum glucose level at time of CSF sample!).
     - hyperglycemia during 4 hours prior to LP results in CSF glucose↑
     - when CSF glucose is of diagnostic importance, CSF and blood samples ideally should be obtained after 4-hour fast.
     - *phlebotomy should precede lumbar puncture (stress of LP may **arise within intrathecal compartment**
   - the ratio should change in response to rising or falling plasma glucose levels with a 4-hour lag time.
   - reducing ratio of CSF/serum glucose)
   - **linear ratio** (CSF:plasma decreases as plasma glucose exceeds 500 mg/dL).
   - **ventricular CSF glucose** is 6-8 mg/dL higher than in lumbar CSF.

6. **Ions**
   - a) concentration same or greater than in serum - Na, Cl, Mg.
   - b) concentrations lower than in serum - K, Ca, bicarbonate, phosphate.
   - N.B. CSF chloride as diagnostic aid for bc meningitis is no longer clinically relevant!

7. **Acid-base status**
   - higher pCO₂ → slightly lower pH (than arterial blood).
   - pCO₂ is higher and pH lower in lumbar than in cisternal CSF.
   - bicarbonate levels are equal to arterial blood.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Plasma</th>
<th>CSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na (mEq/L)</td>
<td>140</td>
<td>144</td>
</tr>
<tr>
<td>K (mEq/L)</td>
<td>4.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Mg (mEq/L)</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Ca (mg/dL)</td>
<td>8.9</td>
<td>4.6</td>
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<tr>
<td>Cl (mEq/L)</td>
<td>99</td>
<td>113</td>
</tr>
<tr>
<td>Bicarbonate (mEq/L)</td>
<td>23.3-26.8</td>
<td></td>
</tr>
<tr>
<td>Phosphate, inorganic (mg/dL)</td>
<td>4.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Protein (g/dL)</td>
<td>6.8</td>
<td>0.028 (28 mg/dL)</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>110</td>
<td>50-80</td>
</tr>
<tr>
<td>Osmolarity</td>
<td>0.29-0.3</td>
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<tr>
<td>pH</td>
<td>7.4</td>
<td>7.33</td>
</tr>
<tr>
<td>PCO₂ (mmHg)</td>
<td>41.1</td>
<td>50.5</td>
</tr>
<tr>
<td>Urea (mg/dL)</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Uric acid (mg/dL)</td>
<td>5</td>
<td>1.5</td>
</tr>
<tr>
<td>Lactate (mg/dL)</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Cholesterol (mg/dL)</td>
<td>125</td>
<td>0.2</td>
</tr>
</tbody>
</table>

CSF has higher levels of Na, Cl, Mg

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**Figure 32-3.** CSF formation and absorption in humans at various CSF pressures. Note that at 112 mm CSF, formation and absorption are equal, and at 86 mm CSF, absorption is zero.

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*CSF albumin: serum albumin = 1:200*
Six common CSF studies:
1) direct observation for color
2) direct observation for viscosity & turbidity.
3) cell count and differential
4) Gram's stain and culture
5) glucose
6) protein

If cell count, protein, and glucose are all normal, it is highly unlikely that additional studies will be useful (unless special considerations exist).

OPENING PRESSURE

ELEVATED PRESSURE:
A. ICP* (hematoma cerebellar tonsils may occlude foramen magnum and prevent increased ICP transmission to lumbar puncture site!):
1. Acute meningitis (bacterial, fungal, viral).
2. Mass lesions (tumor*, abscess) - LP is dangerous!!
   *N.B. pressure may be normal despite large tumor!
3. Intracerebral bleeding, SAH
4. Brain edema
5. Hydrocephalus - CSF overproduction (choroid plexus papilloma), absorption defect, flow obstruction
6. Pseudotumor cerebri
7. Any coma (slight ICP*) due to hyperventilation and CO2 retention

Systemic causes - congestive heart failure, chronic obstructive pulmonary disease (hypercapnia), superior vena cava or jugular venous obstruction, pericardial effusion.

Falsely elevated pressure:
1) marked obesity
2) tense patient (pressure is not usually measured in struggling or crying child)
3) head elevated above plane of needle
   N.B. opening pressure is artificially elevated with patient in sitting position!

LOW PRESSURE

1) needle obstruction by meninges
2) spinal block (may be verified with \textit{quickened test} see p. 105)
3) CSF leakage:
   - CSF fistula
   - dural nerve sheath tear
   - post-LP drainage
   - post-CNS surgery
4) idiopathic low-pressure syndrome
5) subdural hematomas in elderly patients
6) dehydration-hypovolemia
7) barbiturate intoxication.

COLOR

- Color is observed only in pathological circumstances!
- \textbf{XANTHOCHROMIA} (literally, yellow color) = presence of any color; so state actual color and its magnitude (from 1+ to 4+).
- Yellowish = any cause of \textit{increased protein} (> 100-200 mg/dl).

\textbf{Yellow / pink - hemoglobin}

1) \textit{oxymoglobin} (released with lysis of red cells) becomes pink or yellow when diluted.
   - first detected 2 hours after SAH.
   - maximal within first 24-48 hours.
   - disappears over next 7-14 days.
2) \textit{bilirubin} (produced by leptomeningeal cells) is yellow.
   - first detected 10-12 hours after SAH.
   - maximal at 48 hours.
   - may persist for 2-4 weeks.
3) \textit{methemoglobin} (produced in old hematomas) is brown but seen only spectrophotometrically!

\textbf{Yellow - severe jaundice (> 10-15 mg/dl of total bilirubin), crottenemia, rifampin therapy.}

\textbf{BROWN / GRAY - CNS melanoma.}

\textbf{GREENISH - leukemic meningeal infiltration, pseudomonal meningitis.}

BLOODY CSF

- bloody CSF should be collected in at least three separate tubes ("three-tube test").
- sample of bloody CSF should be \textit{centrifuged} immediately (within 1 hour) and supernatant fluid \textit{compared with tap water} (to exclude xanthochromia).
- *viewing down long axis of tube or holding both tubes against white background

TRAUMATIC TAP

1) CSF clear as sequential amounts are collected (should be \textit{confirmed by cell count} in first and last tubes);
2) no xanthochromia; causes of xanthochromia in traumatic tap:
   - severely traumatic tap (RBC > 150,000,200,000/mm\(^3\)) - xanthochromia is due to serum protein.
   - \textit{oxymeglobin - starts to appear if tube is tested > 1 hour after tap} (RBCs lysis).
3) presence of \textit{clot} in one of tubes strongly favors traumatic tap!
4) immediate* repeat puncture at higher interspinous yield clear CSF.
   *N.B. any lumbar puncture performed several days after especially traumatic puncture, may find some RBCs and xanthochromia!

SAH

1) CSF does not clear with sequentially collected tubes.
   N.B. occasional declining cell count may represent layering of cells in recumbent patient!
2) xanthochromia (only if bleeding occurred before ≥ 2-4 hours), if ≥12 hours passed, virtually all patients CSF will demonstrate xanthochromia!
3) Blood does not clot (blood is defibrinated at site of hemorrhage).
4) positive D-dimer test on CSF (local fibrinolysis); other conditions may produce false-positive test results (e.g. DIC, previous traumatic tap, prior thrombolytic therapy).

\textbf{crenated RBCs (had been used as indication of SAH) are of no distinguishing value - appear both with true bleeding and after traumatic taps.}

Enter red blood cells and protein to CSF, for every 700-1000 RBCs:
1) add 1 WBC
   e.g. if bloody CSF contains 10,000 RBC/mm³ and 100 WBC/mm³, 10 WBC would be accounted for by added blood and corrected WBC count would be 90 WBC/mm³, if patient's hemogram reveals significant anemia or leukocytosis, formula is used to determine number of WBC in CSF before blood was added.

   \[ \text{CSF WBC} = \text{blood WBC} \times \frac{\text{CSF RBC} \times 100}{\text{blood RBC}} \]

2) raise \text{protein} by 1 mg/dl
   e.g. if RBC count is 10,000/mm³ and protein 110 mg/dl, corrected protein level = 104 mg/dl, corrections are reliable only if cell count and total protein are made on same CSF tube!

**VISCOSITY & TURBIDITY**
- \text{viscosity} – most likely explanation is \text{protein} ↑
- \text{turbidity} (detected when tube is twirled in beam of bright light)
  a) \text{lower than normal CSF protein}
  b) \text{very high CSF protein}

**CELLS**

- \text{CSF contamination with blood may significantly elevate IgG index.}
- \text{normal IgG index is < 0.65}

**PROTEIN**

- \text{CSF proteins} – sensitive but nonspecific indicator of CNS disease
- \text{a) increase in endothelial cell permeability (e.g. leaky BBB)}
- \text{b) increased intrathecal synthesis}
- \text{c) release from destroyed neural tissue}

**PROTEIN**

- \text{Neutrophilic pleocytosis is indication for thorough BACTERIOLOGIC INVESTIGATION.}
- \text{Mononuclears – viral, fungal, immunologic or chronic inflammation, tumor, chemical irritation (e.g. myelogram, intrathecal methotrexate)}
- \text{eosinophils – parasites.}

**Tumor Cells** (neoplasms of brain or meninges) → Millipore, cytocyntrifuge, or cytocentrifuge examination.
- \text{cytopathological identification requires large CSF volume (> 20 ml).}
- \text{N.B. initial tap may be negative – serial LPs}
- \text{At least 3 negative cytological evaluations (i.e. 3 separate samplings) are required to rule out leptomeningeal malignancy!}
- \text{sample should be brought immediately to laboratory to minimize cell lysis and morphological changes.}
- \text{after CSF markers may be useful:}
  a) \text{astroglobin (glioblastoma)}
  b) \text{cancerincombinicynthetic antigen, ferritin (cancerous)}
  c) \text{β₂-microglobin (lymphoblastic leukemia and lymphoma)}
  d) \text{α-fetoprotein (germ cell tumors), choriocarcinoma and testicular tumors).}

**GLUCOSE**

- \text{Hypoglycorrhachia – due to hypoglycemia within 4 hours prior to LP.}
- \text{If 50 ml ampule of 50% glucose has been given, 30 minutes is required to influence CSF glucose concentration.}

- \text{see p. Dens5}
CSF cultures

Additional tests

- **CSF glucose** remains ↓ for 1-2 weeks after start of meningitis treatment.
  - **bacterial** (incl. tuberculosis, neurosyphilis)
    - CSF glucose remains ↓ for 1-2 weeks after start of meningitis treatment.
      - **fungals**
      - **certain viral** (mumps, herpes)
      - N.B. in general, aseptic meningitis has normal [glucose] - chemical (that follows intrathecal injection)

- **3 viruses** (cytomegalovirus, trichinosis, anemiasis).
- **SAH** (4-8 days after onset)
- meningeval carcinomatosis
- vasculitis
- sarcoid

**HYPOGLYCORRHACHIA** reflects:
- a) mainly - decreased anerobic glycolysis in adjacent neural tissues*
- b) to lesser degree - increased PMN leukocytes*
- c) [transfer of glucose across BBB]** *invariably accompanied by CSF lactate*  **CSF lactate**

### LACTATE

- **concentration** is dependent on CNS glycolysis.
- helpful in diagnosis of **bacterial meningitis** – [lactate] increases proportionally to **number of PMN cells** in CSF.
- **lactate** > 4.2 mmol/L accurately predicts bacterial meningitis vs. viral meningitis.
- **CSF [lactate] remains elevated for significant time after appropriate therapy is initiated** (vs. [glucose]) - helpful in bacterial meningitis diagnosis when antibiotics had been given before CSF acquisition.
- other causes of [lactate]↑ - cerebral hemorrhage, malignant hypertension, hepatic encephalopathy, diabetes mellitus, hyponglycemic coma.

### LDH

- **elevation** occurs in:
  - 1) bacterial, fungal meningitis (LDH remains elevated for 1-2 days after antibiotic start).
  - vs. viral meningitis – LDH normal.
  - 2) cortical (vs. lacunar) strokes

### pH

- **unreliable indicator** of metabolic CNS state.
- brain injury (and its complications) can alter CSF pH.
- N.B. CSF pH influences pulmonary drive and cerebral blood flow!

**Bacteriologic exam**

Larger amounts of CSF (≥ 10 mL) improve chances of detecting pathogens (esp. rbc, fungi).

- **Gram stain** performed in all cases when CSF WBC count is elevated!
- **CSF analysis** is essential in establishing provisional diagnosis of acute **bacterial meningitis**
  - **CSF must be transported to laboratory immediately (CSF cells begin to lyse* within 1 hour of acquisition.**
  - **Larger amounts of CSF (≥ 10 mL) improve chances of detecting pathogens (esp. tbc, fungi).**
  - **N.B. CSF pH influences pulmonary drive and cerebral blood flow!**

- **use centrifuged sediment.**

1. **Gram stain** indicates initial choice of antibiotic;
- **causes of false-negative Gram stain**
  - *early meningooccal meningitis* or severe leukopenia - CSF protein insufficiently elevated for bacterial adherence to glass slide; H: mix drop of aseptic serum with CSF sediment.
  - too few organisms are present.
  - ongoing a/b therapy - 25-33% positive tests are lost per day in setting of appropriate antimicrobial therapy (it does not significantly affect WBC counts, glucose, protein values)

- Measures to improve yield - acidine orange stain, repeat lumbar puncture.

2. **CSF cultures** - bacteria that commonly cause meningitis grow well on standard preparations:
  - *aerobic* - blood and chocolate agar.
  - *anaerobic* - thiosulfate-iron agar.
  - cultures are examined at 24-48 hours, but plates should be kept for at least 7 days.

3. **Antigen tests**:

- **Bacterial antigens persist in CSF for several days after antibiotic therapy.**
  - **CSF counterimmunoelectrophoresis (CIE)** - wells in two rows of agarose gel; different antigen is placed in each well; current is passed through gel with reactants then moving toward each other by electrophoretic mobilization of antigen, line of precipitation visualized in 1-2 hours represents positive reaction between antigen and antibody.
  - **CSF latex agglutination (LA)** - 10 times more sensitive than CIE - **antibody** on colloid surface combines with antigen binding sites to cross-link colloid-forming antigen bridges (matrix form and appears as macroscopic agglutination).
  - **enzyme-linked immunosorbent assay (ELISA)** - 100-1000 times more sensitive than LA.
  - **counterimmunoelectrophoresis**
  - **PCR** - rapid test with high degree of sensitivity and specificity!!!

  - antigen tests may be falsely-positive for up to 10 days after vaccination (e.g. *H. influenzae* polysaccharide vaccine).
  - **blood and urine** should also be examined for antigen (often antigen may be found only in urine).

4. **Additional tests**

  - **blood cultures** (50-80% positive for etiologic agent)
  - **CSF Ig titers** - important in diseases in which peripheral manifestations fade while CNS symptoms persist (e.g. *syphilis*, Lyme disease).

**[tuberculous meningitis is diagnostic possibility] see p. Inf3 >>
  1) Ziehl-Neelsen acid-fast stain
  2) CSF cultures onto Lowenstein-Jensen medium (wait at least for 8 weeks)
  3) **PCR tests** - likely will replace many of current tests for mycobacteria.

**[fungus meningitis is diagnostic possibility] see p. Inf3 >>
  1) India ink preparation (place cover slip over one drop of CSF on slide; place drop of India ink next to cover slip and allow it to seep under; check at interface for Cryptococcus).
  2) cryptococcal polysaccharide capsular antigen testing
3) **CSF cultures.**

**Viral meningitis.**

1) **CSF cultures.**
   - most commonly isolated viruses are *enteroviruses* (coxsackieviruses, echoviruses) and *mumps* virus; other viruses are seldom isolated from CSF.
   - In known viral CNS disease, stool is more rewarding (85% positive) than CSF (10% positive).
   - cultures in most hospitals are not available and play little role in acute decisions.
   - if CSF cannot be delivered to laboratory in 24-48 hours → refrigerate at 4 °C.

2) **CSF antibody titers** (panels are commercially available) - serial rise (intrathecal production of organ-specific antibodies) - useful only as retrospective diagnostic confirmation.

3) **PCR** (already diagnostic test of choice for herpes simplex meningencephalitis).
## CSF in various disorders

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Pressure (mmHg)</th>
<th>Cells/mm³</th>
<th>Protein (mg/dl)</th>
<th>Glucose (mg/dl)</th>
<th>Additional tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norma</td>
<td>65-200; clear &amp; colorless</td>
<td>≤ 5 mononuclear</td>
<td>&lt; 60</td>
<td>≥ 50 mg/dl (&gt; 60% of plasma [glu])</td>
<td></td>
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<tr>
<td><strong>INFECTIONS</strong></td>
<td></td>
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<tr>
<td>Acute bacterial meningitis</td>
<td>↑↑ (cloudy, straw-colored)</td>
<td>500-20,000; occasionally &lt; 100 (esp. meningococcal or early in disease or immunocompromised); PMN predominate (in partially treated cases - mononuclears)</td>
<td>↑↑↑ 100-500 (occasionally &gt; 1,000)</td>
<td>↓↓↓ 5-40</td>
<td>Gram stain, bacterial Ag, lactate↑, LDH↑</td>
</tr>
<tr>
<td>Viral (aseptic) meningitis</td>
<td>N ÷ ↑ (clear or cloudy, colorless)</td>
<td>5-1000; occasionally &gt; 1,000 (esp. lymphocytic choriomeningitis!); lymphocytes predominate (at onset may be &gt; 80% PMN; repeat tap in 12-24 hours)</td>
<td>↑ &lt; 100 (vs. bacterial meningitis &gt; 100)</td>
<td>N or ↓ (mumps, lymphocytic choriomeningitis virus, herpes, CMV)</td>
<td>PCR</td>
</tr>
<tr>
<td>Brain abscess</td>
<td>↑</td>
<td>5-1000 PMN (esp. early in cerebritis stage; later↓)</td>
<td>↑</td>
<td>N</td>
<td>LP contraindicated</td>
</tr>
<tr>
<td>Viral encephalitis</td>
<td>N ÷ ↑ (clear or cloudy, straw-colored)</td>
<td>5-500 lymphocytes; occasionally &gt; 1000 (Eastern equine encephalitis, California encephalitis, mumps, lymphocytic choriomeningitis); + RBC (herpes)</td>
<td>N ÷ ↑ 50-100</td>
<td>N or ↓ (mumps, lymphocytic choriomeningitis virus, herpes)</td>
<td>PCR</td>
</tr>
<tr>
<td>HIV encephalopathy, myelopathy, neuropathy</td>
<td>N (or &lt; 50 lymphocytes)</td>
<td></td>
<td>↑</td>
<td>N</td>
<td>↑markers of immune activation (neopterin, quinolinic acid, β2-microglobulin)</td>
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<tr>
<td>Cryptococcal meningitis</td>
<td>↑ (cloudy, straw-colored)</td>
<td>≈ 50 (0-500); lymphocytes predominate</td>
<td>↑↑ ≈ 100 (20-500)</td>
<td>↓ 30</td>
<td>cryptococcal Ag, India ink preparation</td>
</tr>
<tr>
<td>Disorder</td>
<td>Pressure (mmH₂O)</td>
<td>Cells/mm³</td>
<td>Protein (mg/dl)</td>
<td>Glucose (mg/dl)</td>
<td>Additional tests</td>
</tr>
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<td>Norma</td>
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<td>≤ 5 mononuclears</td>
<td>&lt; 60</td>
<td>≥ 50 mg/dl (&gt; 60% of plasma [glu])</td>
<td></td>
</tr>
<tr>
<td>Blastomycotic meningitis</td>
<td>↑↑ up to 5000 PMN (!!!)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Tuberculotic meningitis</td>
<td>↑ (cloudy, straw-colored)</td>
<td>↑ 10-500 (rarely &gt; 500); lymphocytes predominate (in early stages may be &gt; 80% PMN)</td>
<td>↑↑ 100-500</td>
<td>↓↓ &lt; 45</td>
<td>± spinal block; acid fast stain, PCR, culture; adenosine deaminase↑</td>
</tr>
<tr>
<td>Neurosyphilis (meningovascular)</td>
<td>N ÷ ↑</td>
<td>↑↑ 25-2000; lymphocytes (rarely PMN)</td>
<td>↑≈100</td>
<td>N (rarely ↓)</td>
<td>VDRL test</td>
</tr>
<tr>
<td>Neurosyphilis (parietic)</td>
<td>N ÷ ↑</td>
<td>↑ 15-2000; lymphocytes</td>
<td>↑ 50-100</td>
<td>N</td>
<td>CSF abnormalities↓ with disease duration</td>
</tr>
<tr>
<td>Neurosyphilis (tabes dorsalis)</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>CSF parameters improve with progression</td>
</tr>
<tr>
<td>Cysticercosis</td>
<td>↑</td>
<td>↑ 50-200 mononuclears &amp; PMN (sometimes with 20-75% eosinophils)</td>
<td>↑≈50-200</td>
<td>N or ↓</td>
<td>(in 20% cases)</td>
</tr>
<tr>
<td>Neuroborreliosis</td>
<td>N ÷ ↑</td>
<td>↑ 5-500 lymphocytes</td>
<td>↑≈100</td>
<td>N or ↓</td>
<td>intrathecal Ig production; CSF normalizes in stage III</td>
</tr>
<tr>
<td>Tetanus</td>
<td>N!!!</td>
<td>♠ 90-150</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poliomyelitis</td>
<td>10-1000 lymphocytes</td>
<td>♠ 50-300</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxoplasmosis</td>
<td>↑ &lt; 100; lymphocytes predominate</td>
<td>♠</td>
<td>N or ↓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HTLV-I</td>
<td>↑ &lt; 100; lymphocytes predominate</td>
<td>(up to 90)</td>
<td>N</td>
<td></td>
<td>IgG↑, oligo-clonal bands</td>
</tr>
<tr>
<td>OTHER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarcoid</td>
<td>N ÷ ↑↑↑</td>
<td>↑ &lt; 100 mononuclears</td>
<td>↑↑ 50-200</td>
<td>↓ 0-30</td>
<td>ACE↑ (in 50% cases)</td>
</tr>
<tr>
<td>Disorder</td>
<td>Pressure (mmH₂O)</td>
<td>Cells/mm³</td>
<td>Protein (mg/dl)</td>
<td>Glucose (mg/dl)</td>
<td>Additional tests</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------------------</td>
<td>----------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Norma</td>
<td>65-200; clear &amp; colorless</td>
<td>≤ 5 mononuclears</td>
<td>&lt; 60</td>
<td>≥ 50 mg/dl</td>
<td>(&gt; 60% of plasma [glu])</td>
</tr>
<tr>
<td>Neoplastic meningitis</td>
<td>N ÷ ↑</td>
<td>0÷several hundred mononuclears, PMN + malignant cells</td>
<td>N ÷ ↑ 50-200 (up to 1200*)</td>
<td>N or ↓↓↓*</td>
<td>*in meningeal carcinomatosis, spinal block</td>
</tr>
<tr>
<td>Pseudotumor cerebri</td>
<td>↑↑↑ 250-600</td>
<td>N</td>
<td>N or ↓</td>
<td>N</td>
<td>CSF removal may be therapeutic</td>
</tr>
<tr>
<td>Normal pressure hydrocephalus</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>High volume LP (40-50 cc), improvement after LP</td>
</tr>
<tr>
<td>SAH</td>
<td>↑ (cloudy, pink)</td>
<td>RBC, ↑ WBC (blood contamination) → RBC↓, WBC ↑↑ (chemical hemic meningitis)</td>
<td>↑↑↑ (blood contamination)</td>
<td>↑ (early) or ↓ (late)</td>
<td>xanthochromia</td>
</tr>
<tr>
<td>Venous thrombosis</td>
<td>↑</td>
<td>↑ RBC; ↑ WBC</td>
<td>N ÷ ↑</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Vasculitis</td>
<td>↑</td>
<td>↑ mononuclears</td>
<td>↑</td>
<td>N or ↓</td>
<td>N</td>
</tr>
<tr>
<td>Guillain-Barré</td>
<td>N ÷ ↑ (clear, yellow)</td>
<td>N!!!</td>
<td>↑↑ 46-400</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>CIDP</td>
<td>↑ 5-50 mononuclears</td>
<td>↑↑ 100÷200</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Kearns-Sayre syndrome</td>
<td>↑↑ 70-400</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>few lymphocytes</td>
<td>↑ &lt; 75-80</td>
<td>N</td>
<td>IgG index↑, oligoclonal bands, MBP</td>
<td></td>
</tr>
<tr>
<td>Myxedema coma</td>
<td>↑↑ 100-300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetic radiculoneuropathy</td>
<td>↑↑ 100-300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generalized seizures</td>
<td>few mononuclears and PMN</td>
<td>N ÷ ↑</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disorder</td>
<td>Pressure (mmH₂O)</td>
<td>Cells/mm³</td>
<td>Protein (mg/dl)</td>
<td>Glucose (mg/dl)</td>
<td>Additional tests</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------</td>
<td>----------------</td>
<td>-----------------</td>
<td>------------------------------------------------------</td>
<td>-----------------------------------</td>
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<td>≤ 5 mononuclears</td>
<td>&lt; 60</td>
<td>≥ 50 mg/dl (&gt; 60% of plasma [glu])</td>
<td></td>
</tr>
<tr>
<td>Lead encephalopathy</td>
<td>↑</td>
<td>0-500 lymphocytes</td>
<td>↑</td>
<td>N</td>
<td></td>
</tr>
</tbody>
</table>

**BIBLIOGRAPHY** for “Cerebrospinal Fluid” → follow this [LINK] >>