cerebrospinal fluid (CSF)

see also:
- meningitis
- subarachnoid haemorrhage (SAH)
- lumbar puncture (LP)

introduction

- CSF volume is 135-150ml and is produced at rate to ~500ml/day
- 50-70% is formed from ependymal cells in the choroid plexus with remainder coming from blood vessels and the ventricle walls
  - the specialized epithelial cell (CPe) layer in the choroid plexus also responds to, synthesizes, and transports peptide hormones into and out of CSF.
  - with an ability to regulate the fate of neural stem/progenitor cells (NSPCs) that lie in the physically adjacent subventricular zone (SVZ) of the ventricular surface, both CPe and ependymal epithelial cells are beginning to be viewed as having a central role in CNS repair
  - trophic factors produced by these epithelial cells could have profound effects on tissue repair and regeneration in the CNS
  - it appears these cells have high levels of Ecrγ4 gene expression which appears to allow production of neuropeptides such as augurin and argilin
- CSF is reabsorbed into the arachnoid granulations in the superior sagittal sinus, in addition, it is thought some may drain via nerve roots into the lymphatic channels.
- CSF has 4 major functions:
  - buoyancy for the brain to allow it to be suspended and thus the lower portions to have adequate blood circulation without compression
  - protection from injury
  - chemical homeostasis
  - prevention of brain ischaemia

normal findings

- CSF pressure ranges from 8-10 cm water
- RBC’s = 0
- WBC’s =< 5 cells/microL (< 20 lymphocytes/microL in neonates)
  - The median CSF WBC count was significantly higher in infants who were aged ≤28 days (3/µL, 95th percentile: 19/µL) than in infants who were aged 29 to 56 days (2/µL, 95th percentile: 9/µL; P < .001)\(^1\)
- protein: < 0.4g/L (< 1g/L in neonates)
- glucose CSF:blood ratio >= 0.6
- glucose >= 2.5mM
traumatic tap

- indicated by high RBC count (often defined as > 400 cells/mm$^3$) which falls in subsequent tubes
- the safest interpretation of a traumatic tap is to count the total number of white cells, and disregard the red cell count. If there are more white cells than the normal range for age, then the safest option is to treat.
- use of fluoroscopic guided LP can reduce the rate of traumatic taps from ~18% to 12% ²)

findings in SAH

- either:
  - an elevated number of red blood cells present equally in all tubes
  - the presence of xanthochromia
    - but xanthochromia takes ~12 hours to develop, hence many delay LP for at least 12 hours from onset to increase its sensitivity

findings in meningitis

- see also RCH CSF interpretation for children
  - the presence of any neutrophils in the CSF is unusual in normal children and should raise concern about bacterial meningitis
  - meningitis can occur in children with normal CSF microscopy.
  - CSF findings in bacterial meningitis may mimic those found in viral meningitis (particularly early on). It may be possible with modest accuracy to judge whether bacterial or viral is more likely based on CSF parameters. However if the CSF is abnormal the safest course is to treat as if it is bacterial meningitis.
  - Recent studies do not support the earlier belief that seizures can increase cell counts in the absence of meningitis

<table>
<thead>
<tr>
<th>meningitis</th>
<th>appearance</th>
<th>neutrophils</th>
<th>lymphocytes</th>
<th>protein</th>
<th>glucose CSF:Blood ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>bacterial</td>
<td>yellowish, turbid</td>
<td>&gt; 100, but may be normal</td>
<td>&lt; 100</td>
<td>often &gt; 1g/L but may be normal</td>
<td>usually &lt; 0.4, but maybe normal</td>
</tr>
<tr>
<td>viral</td>
<td>clear</td>
<td>&lt; 100</td>
<td>10-1000 but maybe normal particularly early</td>
<td>&lt; 1g/L</td>
<td>normal</td>
</tr>
<tr>
<td>TB</td>
<td>yellowish, viscous</td>
<td>&lt; 100</td>
<td>50-1000</td>
<td>usually &gt; 1g/L but may be normal</td>
<td>usually &lt; 0.3, but maybe normal</td>
</tr>
<tr>
<td>fungal</td>
<td>yellowish, viscous</td>
<td>normal or slightly increased</td>
<td>markedly increased</td>
<td>normal or sl. increased</td>
<td>normal or decreased</td>
</tr>
</tbody>
</table>

bacterial meningitis

- some cases have a 10% lymphocyte predominance in CSF, usually infants with gram negative infection, or in Listeria meningitis
• 60-90% positive CSF on gram stain (40-60% if prior antibiotics), although RCH suggest it can be negative in up to 60% of cases of bacterial meningitis even without prior antibiotics.
• neither a normal Gram stain, nor a lymphocytosis excludes bacterial meningitis
• Polymerase chain reaction (PCR) amplification of DNA in blood or CSF ie. N.meningitidis, pneumococcus and for viruses offers a better diagnostic sensitivity than CSF antigen tests which are no longer indicated.

viral meningitis

• polymorphs may exceed lymphocytes in the early phase, even after 24 hours

1) Pediatrics 2009 - Defining Cerebrospinal Fluid White Blood Cell Count Reference Values in Neonates and Young Infants
2) Eskey an CJ et al. AJNR 2001; 22:571-6