Bacterial meningitis (classically, ‘pyogenic’ or polymorphonuclear meningitis) is a much more severe disease than viral meningitis (classically ‘aseptic’ or lymphocytic) and, untreated, is almost always fatal. Even with antibiotic therapy bacterial meningitis remains a serious cause of morbidity and mortality, and is a bacteriological emergency requiring urgent diagnosis and treatment.

Clinical features

**Symptoms:** severe headache with malaise and fever – the onset is often abrupt. Vomiting, photophobia and convulsions are sometimes seen; patients often show irritability and are lethargic, with drowsiness progressing to unconsciousness.

**Signs** of meningeal irritation: neck and spinal stiffness; pain and resistance on extending the knee when the thigh is flexed (Kernig’s sign). ‘Meningism’ (signs of meningeal irritation without meningitis) may be a feature of other types of severe infection: the diagnosis of meningitis has to be differentiated from meningism, subarachnoid haemorrhage and cerebral abscess.

**Age:** although meningitis is largely a disease of infancy and childhood, the disease is encountered throughout life.

**Neonatal meningitis:** the characteristic clinical features of meningitis are usually absent, the only presenting features being that the baby is obviously unwell, with failure to feed and, often, vomiting. The condition is much more common in premature than in full-term babies.
The elderly and the immunocompromised: typical clinical signs and symptoms of meningitis may again be absent; mental confusion is sometimes a prominent feature.

Sequelae

There are extensive pathological changes within the CNS (Fig. 10.1) and, despite appropriate antibiotic therapy, neurological sequelae can follow in survivors. The commonest sequela is deafness; other, rarer, neurological sequelae include encephalopathy, cranial nerve palsies and obstructive hydrocephalus.

CAUSAL ORGANISMS

The most common causal organisms are:

- Neisseria meningitidis (meningococcus)
- Haemophilus influenzae
- Streptococcus pneumoniae (pneumococcus)
- Mycobacterium tuberculosis.

*Neisseria meningitidis* (meningococcus)

The main cause of meningitis in Britain: affects all ages, but most common in infants, children and young adults. In the UK, group B strains are responsible for the majority of infections, but group

![Fig. 10.1](image.png) **Surface of brain in pneumococcal meningitis.** *Note:* Congested meningeal vessels with purulent exudate, best seen within the sulci.
C strains have become more common in recent years. The other serogroups (see Chapter 4) are usually found in carriers rather than in cases. The disease is endemic, and sometimes epidemic.

*Meningococcal septicaemia:* is a dangerous early manifestation of meningococcal meningitis. It has a high mortality rate and is associated with adrenal haemorrhages, causing sudden collapse (Waterhouse–Friderichsen syndrome). During the meningococcaemia a characteristic petechial rash, rare in other types of meningitis, is common (Fig. 10.2).

*Incubation period* of meningitis: short: around 3 days.

*Source:* the reservoir is the human nasopharynx.

*Spread:* via infected respiratory secretions from carriers and cases (i.e. ‘droplet spread’). Carriage rate in normal populations is about 10–25%: this may rise to 50% or more in household contacts of sporadic cases and during epidemics in closed communities, e.g. institutions, military camps.

*Route of infection:* from nasopharynx, probably via the bloodstream, to the meninges.

*Treatment:* penicillin is the drug of choice: cefotaxime or ceftriaxone are alternatives. Chloramphenicol can be used in penicillin-allergic patients.

Fig. 10.2  Meningococcal septicaemia: haemorrhagic rash. (Photograph courtesy of Dr D. H. M. Kennedy.)
Chemoprophylaxis: use for close contacts of a patient, e.g. members of the same household, possibly contacts in school, to eradicate the organism from the nasopharynx. Ciprofloxacin (not for children or pregnant women) and rifampicin are the drugs of choice; an alternative is ceftriaxone (by injection only).

Vaccine: N. meningitidis type B is unfortunately non-immunogenic. Effective vaccines are available for types A and C. The introduction of N. meningitidis type C vaccine in 1999 in UK has reduced the number of cases by over 80%.

Haemophilus influenzae

A cause of meningitis in infants and preschool children aged 1 month to 4 years. The causal strains are capsulated and almost always of serological type b. Spread to the meninges is from the nasopharynx, probably via the bloodstream.

Treatment: Cefataxime or ceftriaxone are the drugs of choice. Chloramphenicol is an alternative.

Chemoprophylaxis of close contacts: rifampicin.

Vaccine: Hib vaccine has now been introduced for the immunization of infants (see Chapter 39) and has caused a dramatic fall in the incidence of the disease.

Streptococcus pneumoniae (pneumococcus)

Although not uncommon in children, this is the usual cause of meningitis in the middle-aged and elderly, especially in patients who are in poor general health. This type of meningitis is often the sequela to pneumococcal infection of the middle ear, sinuses or lungs; fracture of the base of the skull, communicating with the nasopharynx, is another risk factor.

Case fatality rate: is high, despite appropriate antibiotic therapy – around 20%.

Treatment: penicillin: but note that a small proportion of S. pneumoniae are now penicillin resistant: if so, use cefotaxime, ceftriaxone or vancomycin plus rifampicin.

Mycobacterium tuberculosis

Seen in people of all ages – but most common in children – and at any stage after the primary infection. Now rare in developed countries: about 100 cases per year in England and Wales. Typically lymphocytic (aseptic) meningitis, although polymorphs are present in the early stages.
Treatment: triple therapy with isoniazid, rifampicin and pyrazinamide: include ethambutol and streptomycin if resistance suspected. Continue isoniazid and rifampicin for 12 months, with pyrazinamide for the first 2 months. Steroids are given with the antibiotics to reduce the inflammatory response.

Rare causes of meningitis

- *Listeria monocytogenes*: mainly seen in infants, the elderly and immunocompromised patients; often, but not always, a lymphocytic meningitis.
- *Cryptococcus neoformans*: meningitis due to this yeast is rare in previously normal people, but is found in immunocompromised patients, e.g. those with leukaemia or lymphoma.
- *Leptospira* spp.: a lymphocytic meningitis.

Neonatal meningitis: a serious form of meningitis: mainly due to Gram-negative bacilli such as *Escherichia coli*, *Klebsiella* species and *Proteus* species, but also to *L. monocytogenes* and β-haemolytic streptococci of Lancefield group B (usually acquired from the mother’s vagina). Premature (low birthweight) babies are at greatest risk, especially if there has been a prolonged interval between rupture of the membranes and delivery (see chapter 38).

Treatment of neonatal meningitis: if due to coliform bacilli: give cefotaxime or ceftriaxone. If due to listeria, give netilmicin with amoxycillin.

Group B β-haemolytic streptococcal meningitis in babies is best treated with penicillin and netilmicin in combination. Cefotaxime is an alternative.

Diagnosis

Laboratory diagnosis of bacterial meningitis depends on examination of the CSF. Table 10.1 lists the results of CSF examination in meningitis compared to those in the other two most important diseases in the differential diagnosis, subarachnoid haemorrhage and cerebral abscess.

Red blood cells may be present in a normal CSF owing to accidental damage to a blood vessel during lumbar puncture (universally known as a ‘bloody tap’): in such cases the supernatant fluid after centrifugation is clear, whereas in subarachnoid haemorrhage it is stained yellow to orange (xanthochromic).
<table>
<thead>
<tr>
<th>Causal microorganisms</th>
<th>Appearance</th>
<th>Cells/mm³</th>
<th>Microbiology</th>
<th>Protein</th>
<th>Glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>–</td>
<td>Clear, colourless</td>
<td>0–5 lymphocytes</td>
<td>Sterile</td>
<td>150–450 mg per litre</td>
</tr>
<tr>
<td>Bacterial meningitis</td>
<td>Neisseria meningitidis, Haemophilus influenzae, Streptococcus pneumoniae</td>
<td>Turbid</td>
<td>500–20 000, mainly polymorphs, few lymphocytes</td>
<td>Bacteria in Gram-stained deposit. Growth on culture. PCR</td>
<td>Markedly raised</td>
</tr>
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<td></td>
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<tr>
<td>Viral (aseptic) meningitis</td>
<td>Enteroviruses, Mumps virus</td>
<td>Clear or slightly turbid</td>
<td>10–500, mainly lymphocytes</td>
<td>Viruses rarely isolated from CSF. Diagnose by stool culture (enteroviruses) or serology (mumps). PCR</td>
<td>Normal or slightly raised</td>
</tr>
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<tr>
<td>Tuberculous meningitis</td>
<td>Mycobacterium tuberculosis</td>
<td>Clear or slightly turbid</td>
<td>10–500, mainly lymphocytes, polymorphs in early stages</td>
<td>AAFB in ZN-stained deposit – often scanty. Growth on LJ culture. PCR</td>
<td>Moderately raised</td>
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<tr>
<td>Cerebral abscess</td>
<td>Streptococcus milleri, Bacteroides species, Staphylococcus aureus, Proteus species</td>
<td>Clear or slightly turbid</td>
<td>0–500, mainly polymorphs, some lymphocytes</td>
<td>Organisms often not present in CSF</td>
<td>Normal or raised</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Subarachnoid haemorrhage</td>
<td>–</td>
<td>Turbid, often blood-stained; supernatant yellow–orange</td>
<td>Large numbers of red blood cells</td>
<td>Sterile</td>
<td>Markedly raised</td>
</tr>
</tbody>
</table>

Isolation: specimens: CSF obtained by lumbar puncture; blood. 

Examination of CSF:

- In a counting chamber, for white blood cells and erythrocytes
- Gram film of centrifuged deposit, for bacteria and cells
- If indicated, Leishman film of centrifuged deposit, to differentiate polymorphonuclear leukocytes from lymphocytes
- If indicated, Ziehl–Neelsen film of centrifuged deposit, for tubercle bacilli.

Culture of CSF:

- centrifuged deposit on to blood agar and chocolate agar, and into glucose broth and cooked meat broth: incubate plates in air plus 5% CO₂
- if indicated, Löwenstein–Jensen medium, for culture for tubercle bacilli.

Blood culture: positive in over 40% of patients with meningitis due to N. meningitidis, H. influenzae or S. pneumoniae.

Demonstration of bacterial antigen or DNA

Of value when meningitis has been partially treated and no infecting organisms can be seen or cultured: detect immunologically by latex agglutination or Phadebact coagglutination for N. meningitidis, H. influenzae type b and pneumococci: detect DNA by PCR.

Antibiotic treatment: before the results of laboratory tests are available, if meningitis is suspected give high-dose intravenous penicillin immediately: this may be life-saving in the case of meningococcal septicaemia.

The treatment of meningitis of known cause is covered in the corresponding sections above.

Meningitis of unknown cause

When many polymorphs are present in the deposit of the CSF, but no bacteria have been detected and there is no growth on culture, treatment must be empirical. This state of affairs is usually the result of inadequate treatment, given outside hospital before the patient is admitted. Broth cultures may give a positive result after a few days’ incubation when cultures on solid media remain negative.

On a ‘best-guess’ basis, give either benzyl penicillin or cefotaxime or ceftriaxone. Add amoxycillin if Listeria spp. suspected. If history of anaphylaxis to β-lactams give chloramphenicol.