Despite successful vaccination campaigns in many parts of the world, bacterial meningitis in children remains a serious healthcare challenge. Worldwide, it is the cause of over 125,000 deaths every year and neurological sequelae occur in some 18–47% of survivors.

Meningitis is defined as inflammation of the membranes covering the brain and spinal cord (meninges). This can be caused by a wide variety of different microorganisms, including viruses, bacteria and fungi. In children in the UK, bacterial meningitis is most commonly caused by one of three bacteria: Streptococcus pneumoniae, Neisseria meningitidis or Haemophilus influenzae. Neonatal meningitis can be caused by gram-negative bacteria or group B streptococci and may be accompanied by overwhelming sepsis.

Meningitis can also occur following head trauma with a basal skull fracture, which allows bacteria more ready access to the subarachnoid space. Children with ventriculo-peritoneal shunts (for hydrocephalus) are also at risk of meningitis from staphylococcal species.

Some diseases may present in a similar way to meningitis cases, among which are malignant infiltration of the meninges, drug-induced meningitis (for example, caused by non-steroidal anti-inflammatory drugs or intravenous immunoglobulin) and focal central nervous infections (for example, a cerebral or subdural abscess); these will not be discussed further in this article.

Children who contract meningitis during the first year of life have a 15.6% chance of developing a permanent, severe or moderately severe disability by the time they reach five years of age. These include learning and neuromotor disabilities, seizure disorders, hearing problems, ocular or visual disturbances, speech or language difficulties and behavioural problems.

**Pathophysiology**

Bacterial meningitis is a serious infection; although fatality rates can be as low as 2% for infants and children, they can be 20–30% among neonates and adults. Bacteria are usually carried to the brain in the bloodstream. After they penetrate the blood-brain barrier, they release endotoxins.
Signs and symptoms

The classic symptoms of meningitis are fever, headache, photophobia and neck stiffness. However, in the early stages of meningitis, and particularly in young children, the symptoms of meningitis can be variable or non-specific and the classic symptoms may well be absent, making meningitis difficult to diagnose. Children may have fever and vomiting associated with irritability, drowsiness and confusion. They may become suddenly ill with a fever and rigors, which can be mistaken for fitting — although actual fits can be a presentation of meningitis, especially in younger children. Muscle and joint aches can occur, which can be responsible for children being restless and miserable. Vomiting, nausea and poor appetite (poor feeding in babies) are common. Abdominal pain and diarrhoea are less common. Meningitis caused by atypical organisms (for example, tuberculosis) will have a more subtle onset.

Meningitis causes a rise in ICP. In babies and young children who have an open fontanelle, the fontanelle may be full or bulging. In children without open fontanelle, other features of raised ICP (eg, systemic hypertension with bradycardia, leading on to irregular breathing) may be seen. Children may have abnormal tone, have jerky movements or be floppy.

Older children are more likely to have the classic features of meningitis: fever, vomiting and headache, stiff neck and photophobia. Teenagers may present with other features of raised ICP (eg, systemic hypertension and bradycardia, leading on to irregular breathing) may be seen. Children may have abnormal tone, have jerky movements or be floppy.

Diagnosis

Early diagnosis and prompt initiation of treatment is imperative to decrease the morbidity and mortality associated with meningitis. Diagnosis is usually based on history, examination and blood tests, including full blood count, blood film, C-reactive protein, blood culture, serology and polymerase chain reaction (PCR) analysis (which amplifies minute amounts of bacterial DNA). Microbiological testing of a CSF sample, obtained by lumbar puncture, is the gold standard to diagnose meningitis. Nevertheless, the procedure is contraindicated for patients who exhibit features of raised ICP (see below).

During a lumbar puncture, CSF is drained from the back below the level of termination of the spinal cord. If meningitis is present the CSF will usually be turbid and under higher pressure than normal. Samples are sent to microbiology for microscopy and culture.

The causative organism and its antibiotic sensitivity should be established from the CSF sample culture. This is especially important if an atypical meningitis is suspected (eg, a slow onset of illness suggests an atypical meningitis, or recent contact with tuberculosis patients may indicate tuberculous meningitis). In the UK, the commonest causative organisms are sensitive to third-generation cephalosporins (see accompanying article, p311). However organisms originating from other countries might have developed cephalosporin resistance, meaning CSF culture is essential to determine the appropriate antibiotic therapy.

Bacteria may be visible under a microscope and gram-staining can help with early identification of the likely causative organism (S pneumoniae being gram-positive cocci, H influenzae being gram-negative rods and N meningitidis being gram-negative diplococci). Samples of CSF will be cultured to grow bacteria but the results of this, and any PCR tests, will take several days to become available.

It is important to be aware that, during the early stages of bacterial meningitis, the results of microscopic and biochemical investigations of the CSF may be normal. Nonetheless, if the diagnosis of bacterial meningitis is supported by strong clinical evidence, treatment should not be withheld because of normal biochemistry and microscopy.

Although a lumbar puncture can provide useful information, it does have some disadvantages:

- Bacteria may not be cultured if antibiotics have already been administered (the CSF is sterile in 90–100% of patients within 24–36 hours of antibiotic administration); however, PCR testing can be used and is a more sensitive technique than culturing.
Children with meningitis are at increased risk of developing “coning” (where raised ICP causes the brainstem to herniate out of the base of the skull through the foramen magnum). This potentially fatal complication is more common after a lumbar puncture, presumably because the pressure in the spinal cord is lowered by the removal of fluid.

A lumbar puncture should not be performed on patients with haemodynamic instability because the condition can deteriorate when the patient is moved into position for the procedure. It should also not be performed on those with clotting abnormalities or thrombocytopenia because they are at risk of developing epidural haematoma.

Determining the cause It can be difficult to distinguish viral from bacterial meningitis based on clinical symptoms alone, so patients with viral meningitis are often treated as if they have the bacterial form.

Children with meningitis will usually have a raised white cell count (polymorphs in bacterial meningitis and lymphocytes in viral meningitis). Also, in bacterial meningitis CSF protein levels will be raised and CSF glucose will be low (relative to blood glucose levels measured at the same time).

Causative organisms The most common cause of bacterial meningitis among children and young adults in the UK and Ireland is N meningitidis. The term “meningococcal disease” (MD) encompasses both meningitis and septicaemia caused by N meningitidis. In the UK, 15% of MD cases involve meningitis alone, 25% involve septicaemia alone and the remainder involve both. Patients with pure septicaemia have the worst prognosis and maximum effort must be made to identify them early.

Although few patients with meningitis will die as a result of raised ICP, most deaths from MD are caused by septic shock and multi-organ failure. N meningitidis species are divided into serogroups based on antigenic differences in their capsular polysaccharides. At present, 13 subgroups are recognised. Serogroups A, B, C, W135 and Y account for most cases of meningococcal disease. In the UK, 85% of cases are due to serogroup B, while most of the remainder are due to serogroup C.

Other bacteria S pneumoniae is the second most common cause of bacterial meningitis in the UK and Ireland. It usually affects children under two years of age. Minor complications, such as earache and pneumonia, are more likely with this type of meningitis than serious complications, such as septicaemia.

H influenzae type b (Hib) used to be the most common cause of meningitis among children under five years of age. However, since the introduction of the Hib vaccination programme in 1992, that incidence has reduced by over 90%.

Also known as Streptococcus agalactiae, group B streptococci are the main cause of meningitis in neonates. Although group B streptococci can cause septicaemia and pneumonia, up to 90% of infected babies survive with no significant after-effects.

Certain strains of Escherichia coli can cause meningitis, especially in newborn babies and children with other chronic illnesses.

Meningitis caused by Listeria monocytogenes occurs mainly in babies and those with deficient immune systems. It is usually associated with maternal infection acquired from contaminated dairy products.

Tuberculous meningitis (TM) causes around 0.7% of all reported cases of tuberculosis. In areas where tuberculosis prevalence is high, TM is most common among children up to four years of age. In areas where tuberculosis prevalence is low, most cases of TM affect adults. In the UK, TM is rare.

Viral meningitis Viral meningitis is usually a self-limiting illness with no serious sequelae, although infants and immunocompromised patients are more likely to have complications. The most common causes of viral meningitis are enteroviruses, although herpes simplex virus (HSV) 1 and 2, Varicella zoster, mumps virus and HIV are all possible causes.

HSV meningo-encephalitis is the most serious form of viral meningitis. Mumps has recently re-emerged as a public health problem among young adults in the UK (meningitis is a severe potential complication of mumps).

Fungal meningitis Fungal meningitis is a rare, life-threatening disease. It can be caused by a variety of fungi although the most likely are Cryptococcus neoformans and Candida albicans. Fungal meningitis usually only occurs in immunocompromised patients.

References