Bacterial meningitis and brain abscess

Andrew Woodhouse

Abstract

Central nervous system infections are associated with a high mortality and morbidity in all population groups. Early diagnosis and treatment of bacterial meningitis and brain abscess leads to improved outcomes. Suspected bacterial meningitis should be considered a medical emergency with an emphasis on early lumbar puncture and prompt initiation of empirical antibiotic therapy together with corticosteroids. The indications for neuroimaging before lumbar puncture are limited, and recently published guidelines should help to discourage unnecessary scans. Conversely, timely diagnosis of brain abscess requires a high index of suspicion and early cerebral imaging. Management requires good cooperation between emergency physicians, radiologists, infection specialists and neurosurgeons to optimize outcomes.

Keywords Adult; bacterial; brain abscess; children; infection; meningitis; MRCP; treatment

Key points

- Bacterial meningitis is a serious infection requiring prompt recognition and early treatment
- Lumbar puncture is the key to diagnosis of meningitis
- Adjunctive corticosteroids may improve outcomes in bacterial meningitis
- Brain abscesses present as space-occupying lesions
- Imaging is the key to diagnosis of brain abscess
- Proper bacteriological diagnosis usually requires needle aspiration of a brain abscess

Bacterial meningitis

Definition

Meningitis is inflammation of the meningeal tissues lining the brain. Although a variety of infectious and non-infectious forms of meningitis are recognized, bacterial meningitis is among the most serious, and, if untreated, results in death in most patients. Mortality rates with treatment can still be as high as 20–30% and, because of this, a diagnosis of bacterial meningitis needs to be considered early and investigation and treatment initiated promptly.

Epidemiology

Bacterial meningitis affects all age groups, but the epidemiology of community-acquired bacterial meningitis has changed over recent years. This has largely occurred because of the introduction of systematic vaccination programmes in many countries. These include vaccines protective against invasive disease resulting from the key organisms causing bacterial meningitis, including *Haemophilus influenzae* type B, *Neisseria meningitidis* serogroup C and *Streptococcus pneumoniae*.

The overall incidence of disease has reduced, and a recent publication from the European Society of Clinical Microbiology and Infectious Diseases (ESCMID) study group for infections of the brain highlights this change in Europe.[1] Table 1 summarizes the relative proportions of causative organisms in different age groups, based on cumulative data from several countries reported by that study group.[1]

H. influenzae is now a rare cause of meningitis across all age groups. Group B streptococci account for a significant majority of neonatal cases, with *Listeria monocytogenes* and *S. pneumoniae* responsible for only a small proportion. In older children, *N. meningitidis* and *S. pneumoniae* now account for similar proportions of cases, with *N. meningitidis* serotype B, rather than C, now dominant. A number of vaccines designed to protect against serotype B disease have been developed for various geographical regions, with apparent benefit.

In adults, *S. pneumoniae* is the predominant cause of bacterial meningitis. In contrast to overall disease incidence, some UK data suggest a recent slight increase in the incidence of meningitis in adults, peaking at around 1.2 cases per 100,000 for the 45–64-year age group.[2]

Meningococcal disease remains mostly an infection of younger adults. *Listeria* meningitis continues to be rare but is more common in older adults and those with predisposing health conditions, including immunodeficiency, alcohol dependency and diabetes mellitus.

In some parts of South-East Asia, notably Vietnam, *Streptococcus suis* is the most common cause of adult meningitis.

Causative organism of bacterial meningitis proportionately by age group – pooled data from European studies[1]

	Neonates	Children	Adults
Streptococcus agalactiae	58%		
Escherichia coli	21%		
Neisseria meningitidis		50%	27%
Streptococcus pneumoniae	4%	37%	53%
Haemophilus influenzae		5%	3%
Listeria monocytogenes	2%		4%
Other	16%	8%	13%

Table 1

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Pathology and pathogenesis

Development of bacterial meningitis requires bacterial invasion of the central nervous system, and survival and replication within the subarachnoid space. In the context of community-acquired bacterial meningitis, the initiating event is colonization of the mucosa of the nasopharyngeal space.

Organisms that successfully evade host mucosal defences can invade locally and cause bacteraemia. Encapsulated bacteria, which represent most organisms causing bacterial meningitis, demonstrate properties that help to evade host defence mechanisms, including relative resistance to phagocytosis and complement-mediated killing.

Sustained bacteraemia can result in meningeal invasion. The exact mechanisms leading to invasion are unknown, but a number of bacterial factors, such as expression of surface components with specificity for receptors on cells of the cerebral capillaries and choroid plexus, are thought to contribute.

Once bacteria have entered the subarachnoid space, replication is relatively rapid and host defence is restricted by low concentrations of immunoglobulin and complement in cerebrospinal fluid (CSF). This limits effective opsonization and phagocytosis.

The presence of replicating bacteria and release of cell wall and soluble components result in initiation of a cytokine-dependent inflammatory cascade. Subsequent alterations in blood–brain barrier permeability, together with subarachnoid inflammation, lead to vasogenic and interstitial oedema with a rise in intracranial pressure and alterations in cerebral blood flow. These physiological abnormalities produce the symptoms seen in patients with bacterial meningitis.

Diagnosis

A high index of suspicion is needed to diagnose meningitis. The typical presentation of bacterial meningitis with a combination of headache, fever, meningism (neck stiffness, photophobia) and altered mental state is not always present. However, no individual feature in isolation is highly predictive of meningitis, although a combination of two or more findings makes the diagnosis more likely. Older children and adults are more likely to have a more classical presentation, but neonates can present non-specifically unwell with irritability, poor feeding, respiratory distress or features of sepsis.

Children <5 years of age also tend to present with less typical symptoms, but fever and vomiting are common. In older children, headache is more likely to be a feature at presentation, and their presentation is more similar to that of adults.

As soon as a diagnosis of meningitis or meningococcal sepsis is suspected, patients should be referred to hospital for urgent evaluation. Initial review should focus on features in the medical history that might predispose to meningitis, contact with individuals with meningitis or sepsis, the time course of illness development and current symptoms, including photophobia. A travel history can be relevant regarding risk of acquisition and possibility of infection with a resistant organism.

Clinical examination should be focused and include evaluation of general haemodynamic state, presence of neck stiffness, level of consciousness, focal neurological deficits or evidence of rash, particularly the purpura seen in meningococcal disease. Patients should be assessed for features of middle ear, mastoid or sinus infections, all of which can precede meningitis.

Investigations

Investigations should be undertaken promptly to confirm a diagnosis of meningitis and avoid delaying initiation of treatment.

CSF evaluation: lumbar puncture (LP) to obtain CSF for evaluation is the most important investigation to confirm bacterial meningitis. It should preferably be performed within an hour of presentation to hospital, ideally before the first dose of antibiotics is given.[2] The opening pressure should be recorded, and CSF sent for biochemical and microbiological analysis. Empirical antibiotics should be administered after CSF sampling (see below). It is important to submit a suitable volume of CSF and 10–15 ml can be removed with minimal risk.

Characteristic CSF parameters suggesting bacterial meningitis include raised protein and low glucose concentration relative to plasma. Elevated CSF white cell count with neutrophil predominance is typical of bacterial meningitis; however, there are variations, including some culture-proven cases of *S. pneumoniae* with minimal cellular response when LP is performed early in the disease course. Microscopy may reveal a positive Gram stain (60–90%), and culture of a bacterial organism confirms the diagnosis. Table 2 illustrates the CSF findings in bacterial meningitis and a number of other types of meningitis that form important differential diagnoses for bacterial meningitis.

In addition to culture, polymerase chain reaction (PCR) testing for *N. meningitidis* and *S. pneumoniae* can be performed on CSF and blood (EDTA tube), and can be useful if cultures fail to grow. This is particularly relevant if CSF is obtained after antibiotic administration as the culture yield is reduced; however, PCR may continue to detect nucleic acid for a number of days.

Imaging: cerebral imaging is not mandatory when evaluating patients with possible bacterial meningitis. Evidence of meningeal enhancement may be seen on contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI) but a normal scan is common.

A common rationale for performing CT is because of concerns about performing a LP in the presence of significantly raised intracranial pressure, which might result in brain shift. The risks tend to be overestimated, and waiting for CT before LP is undertaken has been shown to lead to delays in initiating treatment and poorer outcome.[1]

If CT or other neuroimaging is indicated, treatment should be initiated if delay to LP is likely to extend beyond an hour. Two recently published guidelines provide similar recommendations regarding imaging in the context of investigation for bacterial meningitis and are summarized in Table 3.[1,2] Most patients presenting for evaluation do not require cranial imaging, and LP should not be delayed in most patients.

Additional investigations: blood cultures should be obtained in patients with possible bacterial meningitis as soon as possible after arrival in hospital and before antibiotics are administered. A nasopharyngeal swab should be obtained as this is culture positive in up to 40–50% of patients with meningococcal disease. A serum glucose to compare with CSF glucose should be taken along with other baseline biochemistry, and a full blood count

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