Central nervous system infections in intensive care patients

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Abstract

A wide variety of microorganisms may cause infections of the central nervous system. Infection causes well defined illnesses which may be generalized (meningitis, encephalitis), or focal (cerebral abscess, subdural empyema). This article discusses the aetiology, bacteriology, presentation and management of these conditions. They all carry serious morbidity and mortality and most patients are cared for in the critical care setting.

Keywords Cerebral abscess; encephalitis; meningitis; subdural empyema

Royal College of Anaesthetists CPD matrix: 2C01; 2C03; 3C00

Learning objectives

After reading this article, you should be able to:

- list the different types of infections affecting the central nervous system
- list the likely causative organisms in meningitis, encephalitis and cerebral abscesses
- describe the clinical presentation of different central nervous system infections
- understand the methods of diagnosing infections of the central nervous system
- outline the initial management principles of patients with infections of the central nervous system

Infections affecting the central nervous system (CNS) are relatively uncommon but not new, with descriptions of meningitis dating back to the 16th century. Such infections are caused by a wide variety of microorganisms and result in distinct syndromes including meningitis, encephalitis and brain abscess. These conditions can be life threatening and often require admission to the intensive care unit (ICU), where appropriate identification and early management are vital in determining outcome.

Pathogenesis

Microorganisms gain access to the CNS by direct extension from local infected sites such as the sinuses or bone *or* by haematogenous spread. Movement of microorganisms from the systemic circulation to the CNS is prevented in health by the blood–brain and blood–cerebrospinal fluid barriers; these may be disrupted by inflammation and trauma. Having gained access, the presence of microorganisms results in an inflammatory response, mediated in part by nitric oxide and excitatory amino acids; these molecules are responsible for some of the neural damage seen. The beneficial effect of corticosteroids in meningitis is largely due to modulation of this host response. If infective organisms reach the subarachnoid space (SAS), conditions are favourable for replication because of the immunological deprived nature of the SAS.

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Aetiology

CNS infections may be bacterial, viral, mycobacterial or fungal (Table 1). Focal infections within the CNS initially lead to cerebritis or myelitis which then evolve into parenchymal abscesses. Veins and venous sinuses may be involved and can lead to septic venous thrombosis. Host defences play a vital role in determining the signs and symptoms of CNS infections and explains the occurrence of different syndromes in patients infected with the same organism.

Generalized CNS infections

Meningitis

Incidence: meningitis is an important and often fatal infectious disease worldwide. In England and Wales, the mean annual incidence is 1.62 per 100,000 population, with 37% of confirmed cases affecting children. The incidence of bacterial (1.44/100,000), fungal (0.09/100,000) and mycobacterial (0.09/100,000) meningitis has remained relatively stable across most age groups except in children <3 years, who have experienced an annual increase of 7.4%, mostly due to an increase in group B Streptococci (GBS) infections.

Causative organisms: in the UK, five types of microorganisms are responsible for approximately 60% of cases of bacterial meningitis. *Neisseria meningitides* continues to be the most prevalent, accounting for 22% of cases, followed by *Streptococcus pneumoniae* (18%), *Staphylococcus aureus* (10%), GBS (5%), and *Escherichia coli* (5%). However, the prevalence of these microorganisms is age-dependent (Table 2). In children <2 years, GBS accounts for 86% of cases, whereas in patients >18 years, *S. pneumonia* is the causative organism in approximately 70% of cases.

Viral meningitis is commonly caused by enterovirus species, herpes simplex virus (HSV1 or 2), human immunodeficiency virus (HIV), varicella zoster virus (VZV) or the Epstein–Barr virus (EBV).

Clinical presentation: classically, meningitis presents with the triad of fever, neck stiffness and altered mental status; however, in practice, only 45% of patients display all three. Fever is commonly absent in patients who are immunocompromised, elderly or those who have been partially treated with antibiotics. Other features include photophobia, phonophobia and seizures; the latter occur in up to 25% of cases and are an independent

Central nervous system infections

Organism	Syndrome	Common host characteristics
Bacteria		
Streptococcus pneumoniae	Meningitis	Adults
Neisseria meningitidis	Meningitis	Adolescents
Haemophilus B	Meningitis	Children
Listeria monocytogenes	Meningitis	Infants/Immunocompromised adults
Escherichia coli	Meningitis	Newborns
Staphylococcus aureus	Meningitis/Brain abscess	Haematogenous dissemination/osteomyelitis
Streptococcus agalactiae (GBS)	Meningitis	Newborns/older adults/colonization during delivery
Staphylococcus epidermidis	Brain/epidural abscess	After neurosurgical procedures
Streptococcus milleri	Brain abscess	
Treponema pallidum	Meningitis/encephalitis	Accelerated course in HIV patients
	Parenchymal neurosyphilis	Older adults/Accelerated course in HIV patients
	Congenital neurosyphilis	Neonates/Accelerated course in HIV patients
Viruses		
HSV	Encephalitis	
CMV	Encephalitis	Immunocompromised patients
VZV	Encephalitis	Immunocompromised/HIV patients
enterovirus	Encephalitis	Children
Mycobacteria		
M. tuberculosis	Meningitis/brain abscess	
	Epidural abscess (Pott's)	
M. avium complex	Meningitis/encephalitis	HIV patients commonly affected
Fungi		
Aspergillus spp	Meningitis/brain abscess	Granulocytopenic patients
Cryptococcus neoformans	Meningitis/brain abscess	HIV patients/Cell mediated immune deficiency
Coccidioides immitis	Meningitis/brain abscess	Geographically limited

Table 1

predictor of mortality, presumably because they reflect cortical irritation or complication (e.g. cerebral oedema, empyema, stroke or venous thrombosis).

Systemic complications such as septic shock and disseminated intravascular coagulation can also rapidly develop in meningitis.

Causative organisms in bacterial meningitis by age

Age	Common bacterial pathogens
<1 month	GBS
	Escherichia coli
	Listeria monocytogenes
	Klebsiella pneumoniae
1 month—2 years	GBS
	Escherichia coli
	Haemophilus influenzae
	Streptococcus pneumoniae
	Neisseria meningitidis
2—50 years	*Streptococcus pneumoniae*
	Neisseria meningitidis
>50 years	*Streptococcus meningitidis*
	Neisseria meningitidis
	Listeria monocytogenes
	Gram negative organisms

Table 2

Other manifestations may provide clues as to the causative organism. A petechial or puerperal rash may suggest meningococcal meningitis, whilst a history of ataxia or labyrinthitis may point towards *Haemophilus influenzae* infection. A history of cough, weight loss, night sweats and meningism may suggest tuberculous meningitis.

Investigations

CSF findings — lumbar puncture (LP) and cerebrospinal fluid (CSF) analysis is the principal method of diagnosing meningitis. As the presenting symptoms of meningitis may mimic those with a cerebral space occupying lesion, it is essential to perform a CT scan before LP to exclude raised intracranial pressure.

In bacterial meningitis, CSF analysis shows an increased neutrophil count, a low glucose concentration (<30% plasma glucose) and an elevated protein concentration. Gram staining may suggest a likely organism. Both analysis and Gram staining may be unhelpful if antibacterial agents have been started. Tuberculous and fungal meningitis is characterized by a high CSF lymphocyte count. Typical CSF findings are shown in Table 3.

Treatment: early empiric antimicrobial treatment is essential and must be started as soon as meningitis is suspected. A wide-spectrum antibacterial agent with good penetration into the CSF must be used. Ceftriaxone (2 g IV BD) is an effective agent. In the immunocompromised patient, pregnant women, and alcoholic