

**Abstract:**

Central nervous system infections in children can be life threatening. It is imperative to suspect and identify these early in their course to manage them appropriately and improve outcomes. This article will focus on the clinical definitions, etiologies, and pathogenic mechanisms of some of the most common central nervous system infections in childhood. In addition, key parts of the initial evaluation including physical examination, laboratory investigations, and neuroimaging as well as treatment and outcomes are discussed.

**Keywords:**

meningitis; encephalitis; central nervous system; children

# Approach to Central Nervous System Infections in the Emergency Department

Rebecca García Sosa, MD\*,  
Leon Epstein, MD†

The clinical signs of infections of the central nervous system (CNS) depend on the causative organism, the mechanism of invasion, anatomical structures involved, and the host affected. Emergency care providers are often the first to encounter these patients within the first days of symptoms. Early recognition and management of these life-threatening diseases are key to achieving better outcomes. Supportive care can prevent complications and diminish morbidity and mortality even when there is no specific infectious agent identified or available targeted therapy.

Central nervous system infections should be considered whenever a child presents with fever in the presence of an unexplained neurologic finding or change in mental status. A focused history and thorough neurologic examination remain the foundation to formulate an accurate differential diagnosis and treatment plan in the child with fever and an abnormal neurologic examination. [Table 1](#) summarizes important details of the history that should be obtained at presentation and will aid in establishing a differential diagnosis.

## MENINGITIS

Meningitis refers to isolated inflammation of the meninges. Usually, children present with fever and some degree of headache with or without nuchal rigidity, photophobia, and the classical Brudzinski and Kernig signs. Brudzinski sign is used to describe a

\*Child Neurology Fellow, Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL; †Division Head of Neurology, Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL.

Reprint requests and correspondence: Rebecca García Sosa, MD, Division of Neurology, Ann & Robert H. Lurie Children's Hospital of Chicago, 225 E Chicago Ave, Box 51, Chicago, IL 60611-2991.  
[rgarciasosa@luriechildrens.org](mailto:rgarciasosa@luriechildrens.org)

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**TABLE 1. Important details from history and pathogens to consider.**

Key Factors	Pathogens to Consider
Immunosuppression	<i>Klebsiella pneumoniae</i> , Enterobacteriaceae, <i>Pseudomonas aeruginosa</i> , <i>Salmonella</i> , <i>Proteus</i> , <i>Citrobacter</i> , cytomegalovirus, Epstein-Barr, herpes simplex, human polyomaviruses
Unvaccinated status	<i>Streptococcus pneumoniae</i> , <i>H aemophilus influenzae</i> , varicella zoster, measles, mumps
Season	Enterovirus, respiratory syncytial virus, parainfluenza, influenza, rotavirus
Animal contact	<i>Pastereulla multocida</i> , <i>Francisella tularensis</i> , <i>Bartonella</i> , rabies, lymphocytic choriomeningitis
Ingestion	<i>Toxoplasma</i> , <i>Listeria monocytogenes</i>
Camping or travel	Arboviruses, <i>Borrelia burgdorferi</i>
Living status/housing conditions/sick contacts	<i>Mycobacterium tuberculosis</i> , <i>Neisseria meningitides</i> , <i>Treponema pallidum</i>
Recent illnesses and/or chronic sinus infections	Group A <i>Streptococcus</i> , <i>Moraxella</i>
Rashes	Measles; varicella zoster; herpes simplex; human herpesvirus types 6, 7, and 8; <i>Borrelia burgdorferi</i>
Devices: shunts, cochlear implants, intrathecal pumps	<i>Staphylococcus aureus</i> , <i>Staphylococcus epidermidis</i> , <i>Propionibacterium acnes</i>

patient's response to passive flexion of the neck during an examination, which results in flexion at the hips and knees. Kernig sign refers to stiffness noted when the examiner attempts to extend the knees while the hips are flexed. Unfortunately, these signs are not always present, especially in younger children and infants. Such patients may present with nonspecific symptoms such as irritability, decreased feeding, and vomiting.

One of the proposed mechanisms for meningitis consists of nasopharyngeal colonization followed by invasion of mucosa and entry into the bloodstream. Bacteremia can then result in destruction blood brain barrier and invasion into the subarachnoid space.<sup>1</sup> Less commonly, meningitis can be a result of direct pathogen invasion from infected adjacent structures such as the mastoid and frontal sinuses or from neurosurgical procedures or traumatic injuries, all of which should be suspected from the child's history.<sup>1</sup>

### Epidemiology

A recent epidemiological study looked at both children and adults in the United States presenting to the emergency department (ED) from 1993 to 2008. The burden of meningitis in this cohort was found to be 62 per 100 000 visits, and children were more likely than adults to visit the ED for meningitis.<sup>2</sup> Although the numbers appear to have decreased and the most common organisms have evolved since vaccinations for *Haemophilus influenzae* and *Streptococcus pneumoniae* were implemented in the last decades, meningitis continues to be a

devastating disease worldwide.<sup>3</sup> Morbidity and mortality from bacterial meningitis can be extremely high despite optimal treatment, but prompt identification of these patients and aggressive management should still be the goals to decrease or prevent devastating neurologic sequelae.<sup>4,5</sup>

Neonatal meningitis is typically recognized and treated early given well-recognized guidelines and pathogens causing fever in the newborn. Such infections will, therefore, not be discussed in detail in this article. *S pneumoniae* is the most common causative pathogen for meningitis in the United States, but *Neisseria meningitidis*, group B streptococcus, *Escherichia coli*, nontypeable *H influenzae*, *Listeria monocytogenes*, and Group A *Streptococcus* account for a large number of serious infections of the CNS in infants and children.<sup>4</sup> Age at presentation and vaccination status can guide empiric antimicrobial therapies. It is also crucial to identify other potential risk factors including sick contacts and potential portals for pathogen entry, such as cochlear implants or ventriculoperitoneal shunts.<sup>6</sup>

### Differential Diagnosis and Mimics

Aseptic meningitis refers to meningismus caused by agents such as enterovirus (EV) or mycobacterial infections as opposed to pyogenic bacteria described above. Although these patients often have cerebrospinal fluid (CSF) pleocytosis, bacterial cultures are usually negative. Iatrogenic aseptic meningitis can result from certain medications such as intravenous, intramuscular, or subcutaneous immunoglobulins; nonsteroidal anti-inflammatory

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