

which microbes enter the nervous system. *Hematogenous spread* is the most common; infectious agents ordinarily gain access through the arterial circulation, but retrograde venous spread can occur via anastomoses with veins of the face. *Direct implantation* of microorganisms is most often traumatic or is sometimes associated with congenital malformations (e.g., meningocele) that provide ready access for microorganisms. *Local extension* can originate from infected adjacent structures, such as air sinuses, teeth, skull, or vertebrae. Viruses also may be transported along the *peripheral nervous system* as occurs with rabies and herpes zoster virus. General aspects of the pathology of infectious agents are discussed in Chapter 8; distinctive forms of CNS infections are described herein (Table 28-2).

## Acute Meningitis

**Meningitis is an inflammatory process of the leptomeninges and CSF within the subarachnoid space, usually caused by an infection.** *Meningoencephalitis* refers to inflammation of the meninges and brain parenchyma. Although infections are the most common causes of meningitis and meningoencephalitis, this reaction may also occur in response to a nonbacterial irritant introduced into the subarachnoid space (*chemical meningitis*). Based on the etiology and clinical evolution of the illness, infectious meningitis is broadly classified into *acute pyogenic* (usually bacterial), *aseptic* (usually acute or subacute viral), and *chronic* (usually tuberculous, spirochetal, or cryptococcal). Each type is accompanied by characteristic changes in the CSF.

### Acute Pyogenic (Bacterial) Meningitis

Distinctive microorganisms cause acute pyogenic meningitis in various age groups: *Escherichia coli* and the group B streptococci in neonates; at the other extreme of life, *Streptococcus pneumoniae* and *Listeria monocytogenes* are most common; and *Neisseria meningitidis* in adolescents and in young adults, with clusters of cases raising public health concerns. The introduction of immunization against *Haemophilus influenzae* has markedly reduced the incidence of this infection in the developed world, particularly among infants, who used to be at high risk.

Affected individuals typically show systemic signs of infection superimposed on clinical evidence of meningeal irritation and neurologic impairment, including headache, photophobia, irritability, clouding of consciousness, and neck stiffness. A spinal tap yields cloudy or frankly purulent CSF, under increased pressure, with as many as 90,000 neutrophils per cubic millimeter, an increased protein concentration, and markedly reduced glucose content. Bacteria may be seen on a smear or may be cultured, sometimes a few hours before the neutrophils appear. Untreated pyogenic meningitis can be fatal, while effective treatment with antibiotics markedly reduces mortality. The Waterhouse-Friderichsen syndrome results from meningitis-associated septicemia with hemorrhagic infarction of the adrenal glands and cutaneous petechiae (Chapter 24). It occurs most often with meningococcal and pneumococcal meningitis. In the immunosuppressed individual, purulent meningitis may be caused by several other infectious agents, such as *Klebsiella* or anaerobic organisms, and may have an atypical clinical course and

**Table 28-2** Common Central Nervous System Infections

Type of Infection	Clinical Syndrome	Common Causative Organisms
<b>Bacterial Infections</b>		
Meningitis	Acute pyogenic meningitis	<i>Escherichia coli</i> or group B streptococci (infants) <i>Neisseria meningitidis</i> (young adults) <i>Streptococcus pneumoniae</i> or <i>Listeria monocytogenes</i> (older adults)
	Chronic meningitis	<i>Mycobacterium tuberculosis</i>
Localized infections	Abscess	Streptococci and staphylococci
	Empyema	Polymicrobial (staphylococci, anaerobic gram-negative)
<b>Viral Infections</b>		
Meningitis	Acute aseptic meningitis	Enteroviruses Measles (subacute sclerosing panencephalitis) Influenza species Lymphocytic choriomeningitis virus
Encephalitis	Encephalitic syndromes	Herpes simplex (HSV-1, HSV-2) Cytomegalovirus Human immunodeficiency virus JC polyomavirus (progressive multifocal leukoencephalopathy)
	Arthropod-borne encephalitis	West Nile virus Eastern equine encephalitis virus Western equine encephalitis virus St. Louis encephalitis virus La Crosse encephalitis virus Venezuelan equine encephalitis virus Japanese encephalitis virus Tick-borne encephalitis virus
Brainstem and spinal cord syndromes	Rhombencephalitis	Rabies
	Spinal poliomyelitis	Polio West Nile virus
<b>Rickettsia, Spirochetes, and Fungi</b>		
Meningitic syndromes	Rocky Mountain spotted fever	<i>Rickettsia rickettsii</i>
	Neurosyphilis	<i>Treponema pallidum</i>
	Lyme disease (neuroborreliosis)	<i>Borrelia burgdorferi</i>
	Fungal meningitis	<i>Cryptococcus neoformans</i> <i>Candida albicans</i>
<b>Protozoa and Metazoa</b>		
Meningitic syndromes	Cerebral malaria	<i>Plasmodium falciparum</i>
	Amebic encephalitis	<i>Naegleria</i> species
Localized infections	Toxoplasmosis	<i>Toxoplasma gondii</i>
	Cysticercosis	<i>Taenia solium</i>

uncharacteristic CSF findings, rendering timely diagnosis more difficult.

### Acute Aseptic (Viral) Meningitis

**Aseptic meningitis is a clinical term that applies to a situation where there is an absence of organisms by**