Neuroimaging of Infectious Disease

Patrick M. Capone, MD, PhD[a,b,c,*], Joseph M. Scheller, MD[b,c]

KEYWORDS

• Central nervous system • Infection • Magnetic resonance imaging
• Computerized tomography • Abscesses • Meningitis

KEY POINTS

- Fifty percent of neuroimaging studies of acute meningitis show no specific abnormalities.
- Imaging is warranted to exclude space-occupying lesions, provide evidence of the source of infection, and better categorize the specific organism.
- Several sources of encephalopathy such as human immunodeficiency virus, JC virus, toxoplasmosis, and Creutzfeldt-Jakob disease have distinct imaging features that can be diagnostic.
- Properly tailored protocols are vital for imaging studies such as short tau inversion recovery or other fat-saturation sequences to properly visualize disorders.
- Metastatic disease, tumefactive demyelinating disease, resolving cerebral hemorrhages, subacute infarctions, and gliomas can appear similar to cerebral abscesses on standard T1-weighted and T2-weighted scan sequences but can generally be distinguished with advanced imaging modalities including diffusion, magnetic resonance (MR) perfusion, and MR spectroscopy.

The modalities of modern neuroimaging are invaluable tools for the diagnosis and treatment of patients with infectious diseases of the central nervous system (CNS). These modalities supplement the clinical assessment of patients as to the type and specific anatomic location along with providing objective measures of the response to antibiotic therapy or the need for other modalities such as surgical intervention. There are a myriad of infectious diseases that invade the CNS. A detailed review of the multitude of CNS infections is beyond the scope of this article. However, there are a limited number of cellular responses that can be produced.[1]

Disclosures: None.
[a] Virginia Commonwealth University, Richmond, VA, USA; [b] Department of Neurology and Medical Imaging, Winchester Medical Center, 1840 Amherst Street, Winchester, VA 22601, USA; [c] Winchester Neurological Consultants, Inc, 125-A Medical Circle, Winchester, VA 22601, USA
* Corresponding author. Winchester Neurological Consultants, Inc, 125-A Medical Circle, Winchester, VA 22601.
E-mail address: pcapone@winchesterneurological.com

Neurol Clin 32 (2014) 127–145
http://dx.doi.org/10.1016/j.ncl.2013.07.009 **neurologic.theclinics.com**
0733-8619/14/$ – see front matter

Infections can be classified by the location within the CNS, the pattern of cellular response, type of infectious organism, and severity.[2,3] These features overlapping for several disease causes such as with pyogenic or fungal abscesses. At times imaging shows more specific disease features that may allow an exact diagnosis, as in cases of herpes simplex encephalitis or neurocysticercosis.[4–9]

In the approach to treatment of patients who present with symptoms suggesting a CNS infection, such as intractable headache, altered sensorium, fever, and/or seizures, the primary modalities of modern neuroimaging are computed tomography (CT) and magnetic resonance imaging (MRI). These modalities provide exquisite anatomic detail along with providing differing but complementary information. These modalities can provide information that may preclude a lumbar puncture as a result of a significant space-occupying lesion or provide an alternative cause for the patient's presentation. CT has the advantage of rapid availability, easier access than MRI, and little to no contraindications if studies are provided without contrast. MRI has significantly better anatomic detail along with imaging features that better show the pathophysiologic changes that may significantly decrease the differential diagnosis and that are at times pathognomonic.[10] Familiarity with the imaging findings for CNS infections on CT or MRI is vital for neurologists who treat these patients.

This article describes our approach to using these imaging modalities and illustrates their findings with several selected clinical examples. An imaging overview is provided of several of the common CNS infections as organized by broad disease location and classifications.

MENINGITIS

Meningitis is the most frequent infection of the CNS.[3,11,12] Patients with the cardinal features of meningitis (headache, fever, altered sensorium, and meningismus) are presumed to have meningitis until proved otherwise. Approximately half of the imaging studies of acute meningitis show no specific imaging abnormalities.[13] Nevertheless, imaging is indicated to exclude space-occupying lesions; to exclude an alternate cause such as a subarachnoid hemorrhage; to assess for hydrocephalus; and to evaluate the potential sources of infection that might necessitate intervention beyond medical therapy, such as sinusitis, mastoiditis, or an empyema.[13]

The normal leptomeninges have a pattern of light and discontiguous enhancement along with the enhancing cortical vasculature. Familiarity with the normal range of contrast enhancement is essential for recognition of what are often subtle abnormalities that may prove diagnostic. Viral causes are the most common, with most being enteroviruses, herpes viruses, arboviruses, and human immunodeficiency virus (HIV). The most common bacterial organisms are *Streptococcus pneumoniae*, *Neisseria meningitides*, *Listeria monocytogenes*, group B streptococci, and *Haemophilus influenzae*.[3,11]

Fig. 1 shows examples of 2 separate patients with pneumococcal meningitis.

Imaging studies of patients with meningitis as in **Fig. 1** frequently show a normal pattern of contrast enhancement in spite of markedly abnormal cerebrospinal fluid (CSF) findings and cultures or may show increase signal on the fluid-attenuated inversion recovery (FLAIR) view and contiguous meningeal enhancement with similar CSF findings.[13–15]

Fig. 2 shows a more markedly abnormal dural enhancement in a patient with multiple episodes of recurrent bacterial meningitis. **Fig. 2** gives an example of FLAIR views, showing the thickened meninges and inflammatory changes to a high degree of sensitivity. These changes are however nonspecific and can be seen in conjunction