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Bacterial Infections of the Brain and Spine

The fact that delay in diagnosis of CNS infections may lead to irreversible neurological deficits increases the responsibility of radiologists to promptly recognize different infections in the brain and also in the spinal canal. Magnetic resonance imaging (MRI) is the primary imaging method for the evaluation and monitoring of infection. Newer imaging techniques, such as diffusion-weighted MR imaging (DWI) diffusion-weighted imaging), diffusion-tensor MR imaging (diffusion tensor imaging (DTI)), and pperfusion, MR and MR spectroscopy (MRS) show promising results in the differentiation between infectious and neoplastic diseases.

Based on location of the brain involved bacterial infections can divided into: a) bacterial meningitis, b) encephalitis and brain abscess, c) ventriculitis, and d) subdural / epidural empyema. In the spinal canal bacterial infections can be located in the extradural (spondylitis, discitis, epidural phlegmone/abscess), intradural-extramedullary (arachnoiditis, polyradiculitis) and intramedullary (spinal cord abscess, myelitis) compartments.

Cerebritis is characterized by nonspecific features on CT scans (ill-defined low density area with peripheral enhancement) and cannot reliably be distinguished from neoplasms.

Cerebral abscess account for up to 1-2% of all intracranial mass lesions in developed countries, with potentially high mortality rate. After the formation of a collagenous capsule, a thin-walled, markedly hypointense ring on T2-weighted MR images, with prominent surrounding edema will be recognized on MRI. Pyocephalus is an

inflammation of the ependyma of the ventricular system with the accumulation of suppurative fluid in the ventricles.

The worldwide increase in incidence of tuberculosis is due to the increase of AIDS, spread of tuberculosis among the homeless, and the expanding immigrant population. CNS tuberculosis may have variety of forms: tuberculous meningitis, tuberculous abscess, cerebritis, and tuberculoma.

When analyzing brain images of a patient with ring-enhancing lesions three questions will usually occur: a) abscess or necrotic neoplasms, b) bacterial or fungal abscesses, c) tuberculomas or bacterial abscesses? On conventional MR images the differentiation between bacterial / tuberculous / neoplastic lesions is difficult. Advanced MR imaging techniques are proven to be useful in answering those questions.

Diffusion-weighted MR imaging (DWI) is a proven and reliable method for evaluation of cranial infections. Pyogenic brain abscesses are known to show restricted diffusion with low ADC values due to the highly viscous content in the abscess cavity. Fungal abscesses also show diffusion restriction, although slightly higher ADC values have been measured. ADC measurements have also been helpful in differentiation between toxoplasmosis and lymphoma. Epidural and subdural empyemas can be distinguished from sterile fluid collections using DWI (purulent fluid in empyemas will cause diffusion restriction). Similar to the brain, DWI will be helpful in evaluation of epidural spinal abscesses. In spondylodiscitis elevated diffusivity has been found due to the inflammatory bone edema. This pattern is very different than found in metastatic bone lesions where restricted diffusion will be present (increased tumor cell packing).

In addition to DWI, *perfusion MRI* can be used to differentiate between pyogenic abscesses and neoplastic lesions, especially those presenting as a solitary ring-like enhancing mass. Brain abscesses will show low or minimally increased regional cerebral blood volume (rCBV) in the abscess capsule. Metastatic lesions and necrotic high-grade gliomas will demonstrate high rCBV in the solid tumor parts.

On MR spectroscopy (MRS), the main brain metabolites (NAA, creatine, and choline) are usually not detectable in abscesses, while the spectra characteristically reveal peaks of acetate (1.92 ppm), succinate (2.4 ppm), and other amino acids (0.9 ppm), as well as lactate (1.3 ppm). Furthermore, aerobic organisms show spectra with the resonances of amino acids and lactate, while only anaerobic bacteria demonstrate the presence of additional acetate and succinate peaks.

The occurrence of bacterial spinal cord abscess formations is rare, with only a few cases described in the literature. *Staphylococcus aureus* and *Streptococcus* are the most common bacterial organisms to invade the spinal cord with hematologic spread as the most common source of infection. High signal on T2-weighted MR images with poorly defined enhancement are the typical MR imaging findings in the early stage. Clearly defined peripheral enhancement with surrounding edema is present in the late stage of myelitis, corresponding to capsular formation and inflammatory changes in the late stage of cerebritis. Intramedullary spinal tuberculosis infection remains an extremely rare disease entity. Only 148 cases have been reported in the world literature, although numerous recent reports from developing countries, and on HIV-positive patients, have increased this number. Swelling of the cord, hypo- or isointensity on T2-WI with

surrounding hyperintense edema, and solid or ring-like enhancement have been described on MR. Tuberculous involvement of the subdural and intramedullary compartment is uncommon.

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