

Original article

MRI imaging in meningeal diseases

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Abstract:

Meninges are the outer coverings of the neuraxis. A variety of diseases can affect the meninges. Contrast enhanced MR imaging is the non invasive investigation of choice in the evaluation of these diseases. We conducted a retrospective study of meningeal diseases detected on MR images, We hereby describe the MR imaging findings in meningeal disease.

Introduction:

Meninges are the membranous coverings of brain and spinal cord. Mutlitude of diseases can affect the meninges , different diseases may affect different parts of the meninges. The pattern of contrast enhancement on MR images also differs in various diseases. In this article, we discuss the MR appearance and enhancement pattern of various meningeal diseases.

Methodology :

Gadolinium enhanced MR images of head were reviewed and the scans of 25 patients in whom abnormal enhancement of the meninges was seen were studied retrospectively. We studied the amount and pattern of meningeal enhancement in various disease processes. Axial short TR and long TR sequences were acquired prior to the administration of contrast material. Gadolinium DTPA was given intravenously in a concentration of 0.1mmol/kg and short TR sequences acquired in all three planes.

Results:

Out of the 25 patients with meningeal abnormalities, 7 patients had meningeal carcinomatosis, 8 patients had primary meningeal tumors,

6 patients had infectious/inflammatory diseases, 4 patients had abnormal meningeal enhancement related to other causes like subacute cerebral infarcts and previous surgery. All the patients with meningeal carcinomatosis had known primary tumors – breast carcinoma (n= 4), adenocarcinoma colon (n= 2) , nasopharyngeal carcinoma (n= 1). Dural enhancement was seen in 12 patients, out of which 8 patients had primary meningeal tumors, two post operative patients and two patients had dural metastasis (primary breast carcinoma). Leptomeningeal enhancement was seen in 13 patients, out of which 5 patients had leptomeningeal carcinomatosis, 6 patients had infectious/inflammatory diseases and 2 patients had subacute cerebral infarcts.

Discussion:

The cranial meninges comprise the dura mater, the arachnoid and the pia mater. The dura mater has two layers. The outer layer composed of fibroblasts is closely applied to inner table of skull and corresponds to periosteum. The inner layer composed of epithelial cells is closely applied to arachnoid. Within the arachnoid is the CSF. The pia mater is the innermost layer which is closely

applied to the brain surface and invests itself into the sulci. The piamater and the arachnoid together are referred to as leptomeninges. [1]

MR imaging is more sensitive than CT in the evaluation of meningeal disease processes. A typical protocol consists of unenhanced short TR and long TR axial sequences followed by contrast enhanced short TR sequence. Various pathological conditions can affect the meninges and produce abnormal meningeal enhancement. Two types of meningeal enhancement have been noted. Pachymeningeal enhancement (or dura –arachnoid enhancement) appears as smooth, linear enhancement adjacent to the inner table of skull or may involve dural reflections of falx cerebri, tentorium cerebelli, falx cerebelli, and cavernous sinus. Leptomeningeal enhancement, also described as gyriform or serpentine appearance, follows along the pial surface of brain and fills the subarachnoid spaces of sulci and cistern. [2] Meninges can be involved in various disease processes such as infectious/ inflammatory conditions, primary and secondary tumors, cerebral infarction and iatrogenic conditions. The imaging findings in these conditions are discussed in the subsequent paragraphs.

Primary tumors:

The most common primary dural neoplasm is meningioma. It is a slow growing, WHO grade I tumor arising from meningothelial cells. Meningiomas typically appear as extraxial masses with a broad dural base, that are homogenous, well circumscribed, T1 isointense, T2 hyperintense and show intense homogenous contrast enhancement (figure. 1). The dural tail is a curvilinear region of dural enhancement seen adjacent to a meningioma, which may be secondary to infiltration by the tumor or may be caused by a reactive process. [3, 4]

Certain meningioma subtypes are associated with more aggressive clinical behaviour and less favourable outcomes. Atypical meningioma is a WHO grade II tumor with indistinct tumor margins and inhomogenous contrast enhancement. Malignant meningiomas typically invade brain and may exhibit a mushrooming configuration. Other less common primary tumors of the meninges include sarcomas (of many histologic types), hemangiopericytomas, solitary fibrous tumors, primary melanocytoma.

Hemangiopericytoma is a primary malignant mesenchymal nonmeningothelial neoplasm thought to arise from the blood vessel pericytes. On MR imaging, they appear as dural based masses that are isointense on T1, of variable intensity on T2 with prominent flow voids and show avid, heterogenous contrast enhancement. Melanocytomas are low grade tumors. The paramagnetic properties of melanin cause T1 shortening, so hyperintensity on T1 and hypointensity on T2 is characteristic. [5].

Meningeal carcinomatosis:

Meningeal carcinomatosis is an important diagnosis to make. Untreated meningeal carcinomatosis decreases the survival time and hence specific therapy for leptomeningeal disease must be initiated to slow down progression of disease. Imaging plays a key role in the diagnosis and management of leptomeningeal metastases.

Primary CNS tumors that commonly metastasise to the meninges include medulloblastomas, ependymomas in children and glioblastoma multiforme in adults. Non CNS malignancies that spread to meninges include breast, lung, melanoma, gastrointestinal, genitourinary and haematological malignancies. [6]

Contrast enhanced T1 weighted MR imaging has been the technique of choice for assessing leptomeningeal disease with a reported sensitivity as high as 71% . [7] Meningeal carcinomatosis may

involve the dura mater, the leptomeninges or both (figures 2,3). Leptomeningeal carcinomatosis appears as thin lines of contrast enhancement following the convolutions of gyri or as small nodular deposits on the surface of brain. [8]

Infectious and inflammatory diseases:

Meningitis may be caused by bacteria, fungi, viruses, and granulomatous agents. Bacterial and viral meningitis is usually associated with leptomeningeal enhancement that is thin and linear (figure 4). [2] Fungal meningitis may produce thicker, nodular enhancement of the meninges. However nodular enhancement is more specific for leptomeningeal carcinomatosis. [9][10]

In granulomatous infections, intracranial contrast enhancement is often confined to the basal cistern and may be associated with other findings such as hydrocephalus, ischemia/infarct, subdural fluid collection or brain parenchymal lesions (figure 5).[11]

Sarcoidosis may involve the meninges. Usually the leptomeninges are involved, and contrast enhancement usually follows the contour of the brain, extending into sulci. Other findings include periventricular multifocal white matter lesions,

enhancing granulomas and enhancing cranial nerve lesions. [1]

Iatrogenic conditions and others:

Post operative meningeal enhancement can be dural or leptomeningeal. In some cases this decreases while in others it may persist for a long duration. It can be either due to meningeal irritation caused by blood in the subarachnoid space as a result of the craniotomy. Longer-term localized enhancement at the operative site may result from fibrotic meningeal changes. [1][6]

Meningeal contrast enhancement may be seen in subarachnoid hemorrhage, vasculitis, Sturge Weber syndrome, idiopathic pachymeningitis, idiopathic intracranial hypotension and various other conditions. [6]

Conclusion:

A variety of diseases can affect the meninges. Contrast enhanced MR imaging with its superior spatial resolution is an excellent non invasive technique for the diagnosis of these conditions. Knowledge of the normal MR anatomy of the meninges and patterns of meningeal enhancement in various diseases improves image assessment and differential diagnosis.

Figure 1: Coronal and sagittal contrast enhanced T1 weighted MR images showing a suprasellar meningioma with associated dural enhancement along the floor of anterior cranial fossa.

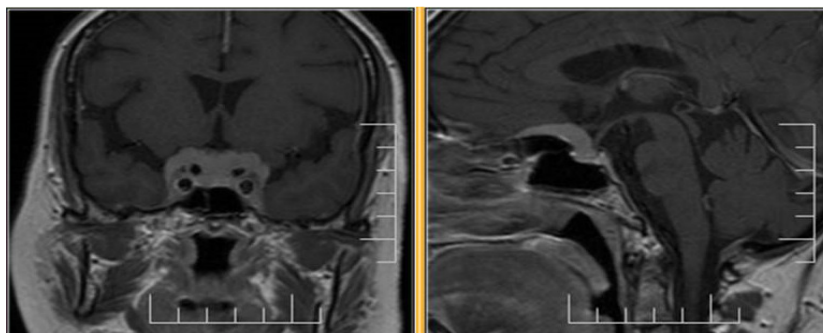


Figure 2: Axial contrast enhanced MR images of brain showing abnormal dural enhancement in the left frontal region.

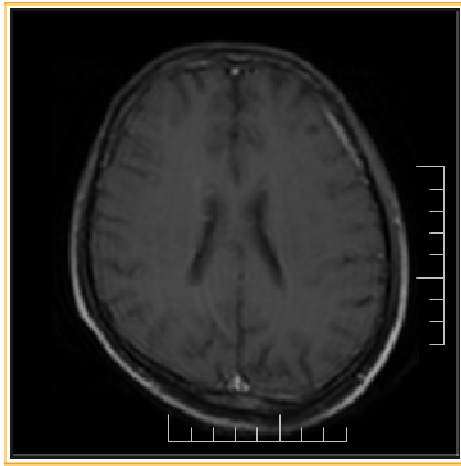


Figure 3 (a,b):

Axial contrast enhanced T1 weighted MR images in two patients of leptomeningeal carcinomatosis with positive CSF cytology and known primaries. Figure a showing abnormal thick and irregular meningeal enhancement in the posterior fossa in a patient with left breast carcinoma . Figure b showing diffuse leptomeningeal enhancement and enhancement of ventricular margins in a case of right frontoparietal astrocytoma.

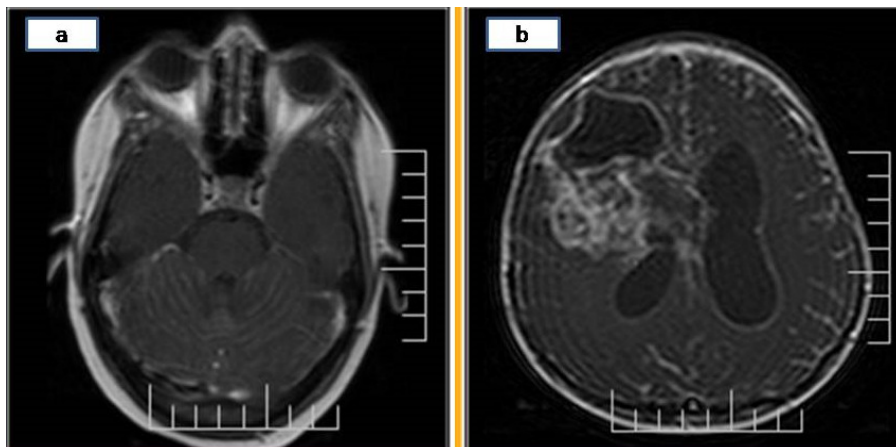


Figure 4: Axial contrast enhanced T1 weighted MR in a patient with meningitis showing thin linear diffuse leptomeningeal enhancement.

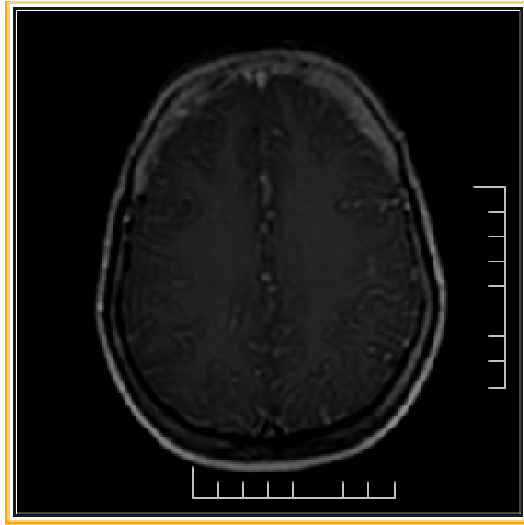
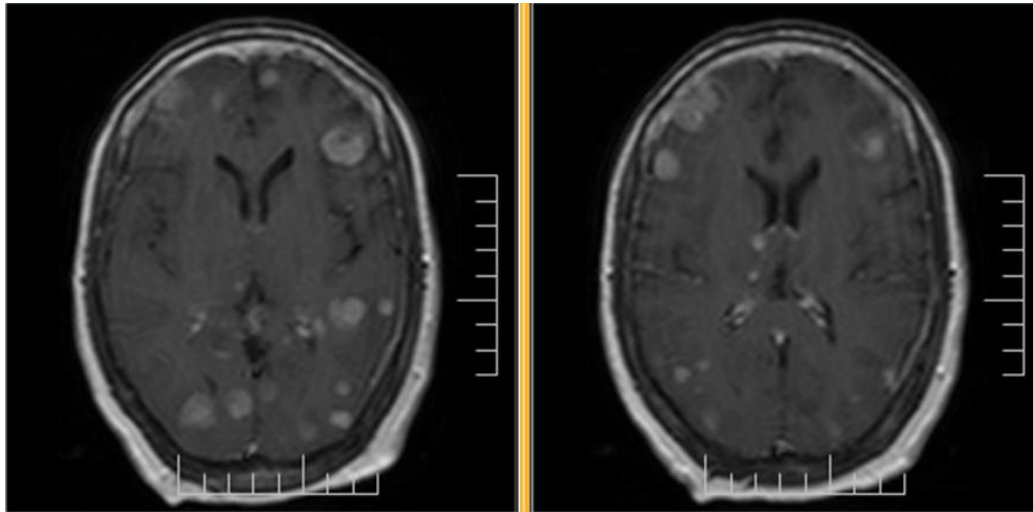


Figure 5: Axial contrast enhanced T1 weighted MR images in a patient with Tuberculosis showing multiple enhancing granulomas in cerebral parenchyma with abnormal dural enhancement in the left parietal region.



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