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"VIRAL ENCEPHALITIS: A PICTORIAL ESSAY OF RADIOLOGICAL FINDINGS"

Radiology

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ABSTRACT

Aims: This study aims to elucidate distinct radiological findings associated with various types of viral encephalitis through a detailed analysis of MRI and CT imaging. By examining characteristic imaging patterns specific to each viral pathogen, the objective is to enhance diagnostic precision and facilitate prompt therapeutic interventions, thereby improving clinical outcomes. **Materials and Methods:** A retrospective review was conducted at the Department of Radiodiagnosis, Bapuji Hospital, JJM Medical College, Davangere, Karnataka. MRI scans were performed using a PHILIPS 1.5T MRI MACHINE, and relevant CT scans were included where available. Imaging data from patients diagnosed with viral encephalitis, including dengue, herpes simplex, Japanese encephalitis, varicella zoster, progressive multifocal leukoencephalopathy (PML), acute disseminated encephalomyelitis (ADEM), and Rasmussen's encephalitis, were analyzed for characteristic features. **Conclusion:** MRI emerges as the preferred imaging modality for assessing viral encephalitis, showcasing distinctive features such as T2 hyperintensity in specific brain regions and patterns of diffusion restriction and contrast enhancement. These findings play a pivotal role in differentiating between viral etiologies and guiding appropriate clinical management strategies for optimizing patient care and outcomes.

KEYWORDS

Viral encephalitis, Dengue encephalitis, herpes simplex encephalitis, Japanese encephalitis, varicella zoster encephalitis, progressive multifocal leukoencephalopathy (PML), acute disseminated encephalomyelitis (ADEM), Rasmussen's encephalitis

INTRODUCTION

Viral encephalitis occurs when a human virus infects the brain, sparing the meninges. It can affect any age group, with severity varying based on the viral agent and the host's immune response. Other manifestations include meningitis and meningoencephalitis [1]. Common clinical manifestations of viral encephalitis include disorientation, speech disturbances, and behavioral changes. Additionally, about one-third of patients experience seizures, highlighting the varied and significant impact of this condition on affected individuals [2]. The advent of CSF PCR has enabled the recognition of more subtle manifestations of viral encephalitis. While most cases present acutely, subacute and chronic forms can occur with CMV, VZV, and HSV, especially in immunocompromised patients [3]. Distinguishing ADEM from acute infectious encephalitis, acute non-infectious encephalitis, and acute metabolic or toxic encephalopathy is crucial. Accurate differentiation ensures appropriate treatment and management for these varied conditions, which can present with similar symptoms [4]. Acute encephalitis is a medical emergency requiring early diagnosis for effective management. MRI is the preferred imaging modality, essential for diagnosing and predicting the cause of encephalitis. Confirmation is achieved through PCR testing of the virus in the CSF. A CT scan is often performed before lumbar puncture to assess intracranial pressure. MRI findings can be either specific or nonspecific, playing a crucial role in identifying the type of encephalitis. This pictorial essay reviews MRI and CT findings of common viral encephalitis types.

MATERIALS AND METHODS

The study was conducted retrospectively at the Department of Radiodiagnosis, JJM Medical College, Davangere, Karnataka. Imaging of patients with viral encephalitis was performed using a "PHILIPS 1.5T MRI MACHINE" for MRI scans. MRI was preferred over CT due to its superior ability to provide detailed imaging of brain structures and pathology associated with encephalitis, including T2-weighted, FLAIR, and diffusion-weighted sequences. This modality allowed for comprehensive assessment of the characteristic radiological findings of viral encephalitis. Imaging data from patients diagnosed with viral encephalitis, including dengue, herpes simplex, Japanese encephalitis, varicella zoster, progressive multifocal leukoencephalopathy (PML), acute disseminated encephalomyelitis (ADEM), and Rasmussen's encephalitis, were analyzed for characteristic features.

DISCUSSION

Dengue encephalitis:

Dengue, known for causing dengue fever and hemorrhagic fever, can also lead to dengue encephalitis despite not being traditionally considered neurotropic. The virus can infect neural tissues, highlighting the importance of serological testing and MRI in diagnosis. MRI, conducted following serology, reveals distinctive features such as T2 hyperintensity in the bilateral thalami and globus pallidus. Other affected areas may include the hippocampus, temporal lobe, and pons. Additional MRI findings may show restricted diffusion, and blooming on gradient echo sequence involving thalamus giving characteristics "Dough-nut sign" [Figure 1]. It may also show varying degrees of contrast enhancement [5].

The identification of these MRI patterns specific to dengue encephalitis, particularly involvement of deep gray matter structures and other specified brain regions, facilitates differentiation from other viral encephalitis. This underscores the importance for clinicians and radiologists to consider dengue virus as a potential cause of encephalitis in patients presenting with neurological symptoms, particularly in endemic regions.

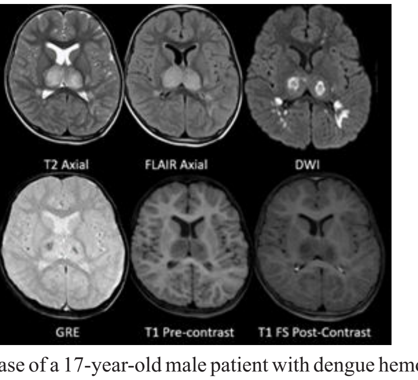

Figure 1: Case of a 17-year-old male patient with dengue hemorrhagic fever, MRI shows T2W/FLAIR hyperintensity with corresponding T1W hypointensity and diffusion-restriction in the bilateral thalamus with blooming on the GRE sequence with surrounding edema, manifesting as the characteristic "**Double Doughnut Sign**."

Herpes simplex encephalitis:

Herpes simplex encephalitis (HSE) Types 1 and 2 represent the most frequent cause of sporadic necrotizing viral encephalitis, with an incidence of approximately two cases per million annually. HSE is associated with high mortality and morbidity in the absence of prompt treatment. It manifests in two main forms: neonatal HSE and adult HSE. In adults and older children, HSE typically affects the temporal and frontal lobes, primarily caused by HSV-1. Neonatal cases, often caused by HSV-2 acquired during delivery, exhibit more diffuse brain involvement [6].

Diagnosis typically relies on CSF analysis and PCR, while MRI plays a crucial role in aiding diagnosis. HSV-1 accounts for over 95% of HSE cases, entering the brain via the trigeminal nerve following initial mucosal infection. Clinical presentation includes fever, headache, seizures, and neurological deficits. MRI findings include T2 hyperintensity in bilateral temporal and frontal lobes, with associated diffusion restriction and gyral swelling [Figure 2]. Treatment with acyclovir is essential for improving outcomes. Differential diagnoses include stroke and status epilepticus, each presenting distinct imaging characteristics [7].

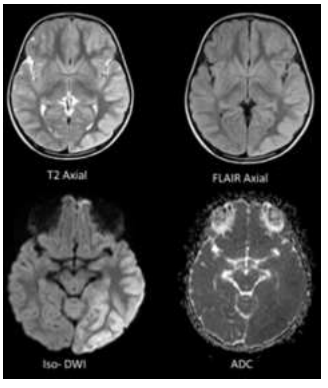

Figure 2: Case of a 28-year-old female patient with HSV Encephalitis, MRI shows gyral edema with T2/FLAIR hyperintensities in the cortical grey matter, diffusely involving the left cerebral hemisphere, predominantly in the parieto-temporal lobes. These areas show true diffusion restriction on DWI sequences.

Japanese encephalitis:

The virus, transmitted by mosquitoes and primarily affecting the South-Asian population, causes symptoms such as fever, rigors, headache, and focal neurological deficits, often with fatal outcomes. Survivors may experience permanent neurological or psychiatric sequelae. MRI typically reveals T2/FLAIR hyperintensity in bilateral thalami and other regions like basal ganglia, substantia nigra, and hippocampus. Hemorrhagic transformation, especially in the thalami, may occur without contrast enhancement [8].

On CT imaging, involvement of the bilateral thalami manifests as enlargement and central hypodensity, leading to mass effect with compression of the aqueduct and resulting in mild ventricular dilatation [Figure 3]. This imaging pattern aids in distinguishing this viral encephalitis from other conditions, including herpes simplex virus encephalitis, which may present with similar clinical features but different radiological findings.

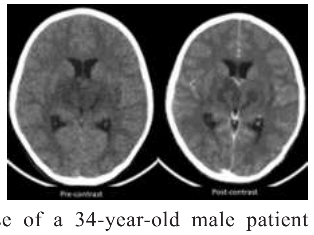

Figure 3: Case of a 34-year-old male patient with Japanese Encephalitis, CT shows enlarged bilateral thalami with central hypodensity (pre-contrast HU: 12) and no contrast uptake (post-contrast HU: 12.8) in comparison to the periphery (HU: 20).

Varicella zoster encephalitis:

Varicella-zoster virus (VZV), despite a decline in incidence due to vaccination, still causes CNS disease, particularly varicella-zoster encephalitis affecting immunocompetent individuals. Symptoms typically manifest around 10 days post-chickenpox rash or vaccination, with meningitis in over 50% and encephalitis in 40% of cases. MRI reveals cerebellitis and myelitis with T2/FLAIR hyperintensities, often showing diffusion restriction. In varicella-zoster vasculopathy with stroke, T2 hyperintensities are observed in the cerebral cortex, basal ganglia, and deep white matter, sometimes accompanied by hemorrhages and necrosis. Contrast enhancement, when present, is patchy and mild [Figure 4]. These findings underscore the diverse neurological manifestations of VZV infection, highlighting the importance of MRI in diagnosis and management, particularly in patients presenting with characteristic clinical symptoms post-varicella infection or vaccination [9].

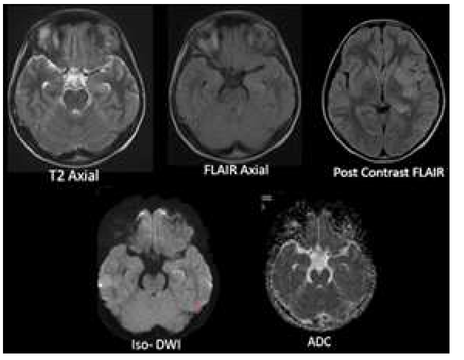

Figure 4: Case of an 18-year-old male patient with Post-Varicella Encephalitis, MRI shows multifocal FLAIR hyperintensities in the left lentiform nucleus, left insular cortex, bilateral thalami, left parietal gyrus, and left hippocampus, with subtle diffusion restriction. Additionally, subtle sulcal FLAIR hyperintensities are noted in the bilateral fronto-parietal regions.

Progressive multifocal leukoencephalopathy:

Progressive multifocal leukoencephalopathy (PML), caused by JC polyomavirus reactivation, poses significant diagnostic challenges, particularly in immunocompromised populations like HIV patients and those treated with immunomodulatory drugs such as natalizumab and rituximab. MRI plays a pivotal role in diagnosing PML, revealing classic findings of white matter lesions with decreased T1 and increased T2 signals, often without enhancement and minimal mass effect. Variations in MRI patterns between HIV-associated PML and Natalizumab associated PML include inflammatory signs like contrast enhancement and a distinct perivascular distribution [Figure 5]. Understanding these nuances is crucial for timely diagnosis and management, emphasizing the role of MRI in differentiating PML from other conditions presenting with similar neurological symptoms in high-risk populations [10].

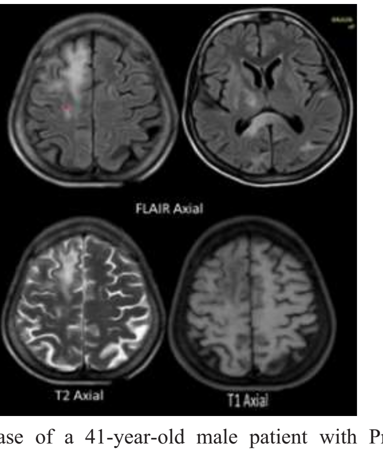

Figure 5: Case of a 41-year-old male patient with Progressive Multifocal Leukoencephalopathy (RVD positive), MRI shows bilateral asymmetrical multifocal and confluent areas of T1 hypointensity and T2/FLAIR hyperintensities in the subcortical white matter of the bilateral cerebral hemispheres. There is also involvement of the subcortical U-fibers and the corpus callosum.

Acute disseminated encephalomyelitis (ADEM):

Acute disseminated encephalomyelitis (ADEM), an autoimmune disorder of the central nervous system, predominantly affects children but also occurs in adults. Characterized by demyelination in response to preceding infections or vaccinations, ADEM is diagnosed clinically with support from MRI, which typically shows multiple, widespread, asymmetric lesions throughout the brain's white and grey matter. These lesions often lack clear margins, distinguishing them from multiple sclerosis lesions [Figure 6]. While MRI is pivotal in diagnosis, some cases may initially show no abnormalities, necessitating repeat imaging. Computed tomography (CT) is less

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sensitive but may be used to rule out urgent conditions. CSF analysis can show lymphocytic pleocytosis and elevated myelin basic protein, aiding in diagnosis [11].

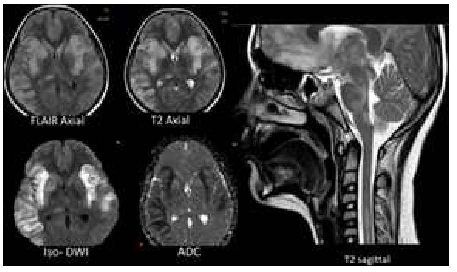

Figure 6: Case of a 13-year-old male patient with Acute Disseminated Encephalomyelitis (ADEM), MRI shows extensive areas of T2/FLAIR hyperintensities involving the bilateral parieto-occipital lobes, with a few areas showing diffusion restriction. Additionally, there are T2/FLAIR hyperintensities involving the bilateral insular cortex and basal ganglia. The T2-weighted sagittal image reveals hyperintensities in the brainstem and cervical spinal cord.

Rasmussen's encephalitis:

Rasmussen's encephalitis presents as a chronic focal or localized encephalitis primarily affecting children between 14 months and 14 years, with peak incidence around 6 years old. The exact cause remains unknown, with viral infection and glutamate toxicity proposed as potential etiologies. Initial MRI scans may appear normal, but over time, hypersensitivity on T2-weighted and FLAIR images becomes evident in the cortical and subcortical white matter of the affected hemisphere. Minimal or no enhancement is typically observed, although other areas like the basal ganglia may also be affected. Cortical atrophy develops in advanced stages, emphasizing the progressive nature of the disease [Figure 7] [12].

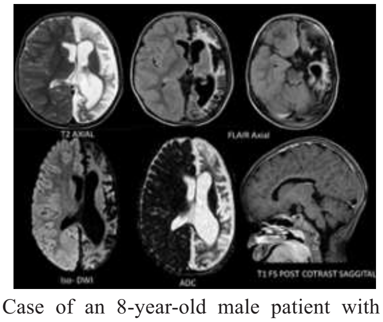

Figure 7: Case of an 8-year-old male patient with Rasmussen Encephalitis, Axial T2 and FLAIR sections reveal significant diffuse atrophy throughout the left cerebral hemisphere, affecting the cortex, white matter, and deep grey matter, associated with encephalomalacia, marked gliotic changes, and subcortical cystic alterations in the frontal and parieto-occipital lobes with patchy areas of cortical diffusion restriction. Wallerian degeneration in the left hemi-midbrain, along with diffuse thinning of the corpus callosum.

CONCLUSION:

In conclusion, this study underscores the critical role of MRI in diagnosing and characterizing viral encephalitis. Each viral pathogen demonstrates unique radiological signatures, such as the bilateral thalamic involvement in Japanese encephalitis or the temporal lobe predilection in herpes simplex encephalitis. These distinctive imaging patterns facilitate accurate differentiation from other neurological conditions, guiding timely therapeutic interventions. By leveraging MRI's capability to visualize specific brain lesions and their evolution, clinicians can effectively tailor treatment strategies, ultimately improving prognosis and patient outcomes in viral encephalitis cases.

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