

UNVEILING CNS SECRETS IN HIV PATIENTS THROUGH MRI BRAIN

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ABSTRACT

Background: Human immunodeficiency virus (HIV) is associated with a wide spectrum of central nervous system (CNS) manifestations, ranging from opportunistic infections and neoplasms to chronic neurocognitive disorders. Early and accurate diagnosis using neuroimaging, particularly magnetic resonance imaging (MRI), is essential for timely intervention and improved outcomes. **AIMS and OBJECTIVES :** This study aimed to evaluate the role of MRI in detecting CNS abnormalities in HIV-positive patients, analyze the spectrum of MRI findings, and correlate them with clinical features and demographic data. **Materials and Methods:** A retrospective observational study was conducted in the Department of Radiology at Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation. MRI brain data from 48 HIV-positive patients presenting with neurological symptoms were analyzed using a 1.5 Tesla Philips D Stream MRI scanner. Patients with contraindications for MRI were excluded. Data on age, gender, clinical presentation, and MRI-based diagnoses were recorded and analyzed. **Result:** The highest proportion of patients (58.3%) belonged to the 35–44 years age group, with a male-to-female ratio of 2:1. Fever with headache was the most common presenting symptom (27%), followed by headache with vomiting and seizures. MRI findings revealed that opportunistic infections predominated: toxoplasmosis (27.08%) was the most common, followed by CNS tuberculosis (20.83%) and progressive multifocal leukoencephalopathy (14.58%). Less frequent but clinically significant conditions included CNS lymphoma and vasculitis. Only 2.08% of patients had normal MRI findings. **Conclusion:** MRI plays a pivotal role in early diagnosis and management of CNS complications in HIV-positive patients, especially in resource-limited settings. Early neuroimaging helps in timely initiation of therapy, improves patient outcomes, and reduces morbidity.

INTRODUCTION

The human immunodeficiency virus (HIV), a member of the lentivirus family of retroviruses, exerts a devastating impact not only on the immune system but also on the central nervous system (CNS). Globally, around 39 million individuals are living with HIV as of 2022, with the highest disease burden concentrated in sub-Saharan Africa and South Asia. Although significant strides have been made in antiretroviral therapy (ART), neurological complications associated with HIV remain a

persistent cause of morbidity and mortality. These manifestations result from the early infiltration of the virus into the CNS, where it persists and establishes a viral reservoir behind the protective barrier of the blood-brain barrier (BBB). The virus enters the CNS via infected monocytes and macrophages, initiating a cascade of inflammation and neuronal injury that contributes to a wide array of neurological syndromes over the disease course.^[1-4]

Neurological involvement in HIV-infected individuals ranges from opportunistic infections and

neoplasms to chronic neurocognitive impairment. These include HIV-associated neurocognitive disorders (HAND), encephalitis, toxoplasmosis, cryptococcal meningitis, progressive multifocal leukoencephalopathy (PML), and primary CNS lymphoma. In low-resource settings, delayed diagnosis and limited access to specialized imaging or laboratory tools often lead to late detection and increased severity of these conditions. While ART has led to a decline in the incidence of certain opportunistic infections, the prevalence of chronic and insidious neurological impairments has grown, reflecting both the longer survival of patients and the complexity of long-term viral-host interactions within the CNS.^[5-7]

The importance of MRI in this clinical context becomes even more apparent in resource-limited environments, where laboratory confirmation of CNS infections—such as through cerebrospinal fluid polymerase chain reaction—is not always feasible. In such cases, imaging findings offer an invaluable diagnostic clue, enabling clinicians to start empiric therapy while awaiting further tests. MRI also aids in monitoring treatment response, evaluating for complications such as immune reconstitution inflammatory syndrome (IRIS), and guiding further management decisions, including the need for biopsy or neurosurgical intervention.^[8,9]

It is critical to interpret MRI findings along side clinical history, symptomatology, and immunological status, particularly CD4 T-cell counts. While there is no absolute radiological pattern unique to a specific CD4 threshold, general trends are recognized. For instance, opportunistic infections like toxoplasmosis and cryptococcal meningitis are commonly seen at CD4 counts below 100 cells/mm³, while cerebrovascular diseases and lymphoma may be diagnosed at higher counts. However, considerable overlap exists, emphasizing the multifactorial nature of neuro-HIV, which involves host factors, viral strain, co-infections, and ART adherence. Therefore, MRI must be considered one component of a holistic diagnostic approach.^[8-10]

With increased life expectancy due to antiretroviral therapy, the neurological profile of HIV is shifting toward chronic conditions like HAND, cerebrovascular disease, and ART-related neurotoxicity. Advanced imaging techniques such as diffusion tensor imaging and functional MRI are enabling detection of subtle brain changes, including white matter disruption and atrophy, even in asymptomatic individuals. Despite progress in care, the neurological burden remains significant, especially in resource-limited settings. MRI plays a critical role in diagnosing, monitoring, and researching neuro-HIV. Routine use of brain MRI can improve early detection, guide timely interventions, and enhance outcomes in patients with HIV-related CNS complications.^[11-13]

This study aims to assess the role of MRI in evaluating CNS manifestations in HIV-infected patients and to describe associated imaging findings. It seeks to identify and characterize the spectrum of MRI-detectable CNS abnormalities, correlate findings with clinical presentation and disease stage. Additionally, it evaluates the utility of advanced MRI techniques in differentiating various pathologies, assesses the prevalence of subclinical abnormalities, and explores MRI's role in guiding early treatment decisions and monitoring therapeutic response.

MATERIALS AND METHODS

This retrospective observational study was conducted in the Department of Radiology at Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation using MR imaging data from 48 brain studies. A 1.5 Tesla Philips D Stream MRI scanner was employed for all imaging. The study included HIV-positive individuals presenting with neurological symptoms such as headache, altered sensorium, or focal deficits. Patients were excluded if they had ferromagnetic implants, pacemakers, aneurysm clips and claustrophobia. Ethical clearance was obtained prior to the commencement of the study to ensure adherence to institutional research guidelines.

RESULTS

Table 1: Age and Gender Distribution of HIV-Positive Patients Undergoing MRI Brain Evaluation

Age group	Total patient population	Males	Females
<35 yrs	7	5	2
35–44 yrs	28	18	10
>44 yrs	13	9	4
Total	48	32	16

The table shows that the highest proportion of patients (58.3%) falls within the 35–44 years age group, indicating a peak incidence in middle-aged individuals. Males outnumber females in all age categories, with an overall male-to-female ratio of

2:1. This gender disparity may reflect differences in exposure risks, healthcare-seeking behaviour, or disease progression. The data suggests targeted neurological screening in middle-aged HIV-positive males could be especially relevant.

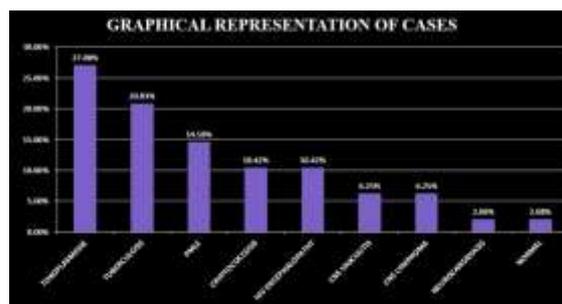
Table 2: Distribution of Neurological Symptoms Among HIV-Positive Patients Undergoing MRI Evaluation

Symptoms	No. of Patients
Fever with headache	13
Headache with vomiting	10
Seizures	8
Altered sensorium	6
Hemiparesis	5
Involuntary movements	3
Aphasia	2
Visual symptoms	1

The table shows that Fever with headache was the most common presenting symptom, affecting 13 patients, followed by headache with vomiting and seizures. These findings indicate that meningoencephalitic and intracranial pathologies are prominent in HIV-related neurological presentations. Less frequent symptoms like aphasia and visual disturbances suggest focal neurological involvement in select cases. Early neuroimaging is essential in symptomatic HIV patients to identify underlying CNS pathology.

Figure 1 shows Toxoplasmosis (27.08%) emerged as the most common CNS pathology, followed by tuberculosis (20.83%) and progressive multifocal leukoencephalopathy. Opportunistic infections predominate, reflecting the immunocompromised status of HIV-positive patients. Conditions like CNS lymphoma and vasculitis were less frequent but

clinically significant. A small fraction (2.08%) showed normal MRI, underscoring the importance of imaging even in ambiguous clinical presentations.

**Figure 1: Graphical Distribution of MRI-Based Diagnoses in HIV-Positive Patients with Neurological Symptoms.****Table 3: MRI-Based Diagnostic Distribution in HIV-Positive Patients with Neurological Manifestations**

Diagnosis	Number of Patients (n)	Percentage (%)
Toxoplasmosis	13	27.08%
CNS Tuberculosis	10	20.83%
Progressive Multifocal Leukoencephalopathy (PML)	7	14.58%
Cryptococcosis	5	10.42%
HIV Encephalopathy (HIV-associated dementia)	5	10.42%
Vasculitis	3	6.25%
CNS Lymphoma	3	6.25%
Neurocandidiasis	1	2.08%
Normal Study	1	2.08%
Total	48	100%

The table reveals that opportunistic infections dominate the neurological diagnoses in HIV-positive patients, with toxoplasmosis (27.08%) and CNS tuberculosis (20.83%) being most common. Viral and fungal infections like PML, cryptococcosis, and HIV-associated dementia collectively account for a significant proportion, reflecting profound immunosuppression. Less frequent but serious conditions include CNS lymphoma and vasculitis. Only 2.08% had normal MRI findings, emphasizing that neuroimaging often detects pathology in symptomatic HIV patients.

DISCUSSION

Our study shows that 58.3% of patients fall within the 35–44 years age group, indicating a peak incidence in middle-aged individuals, with a male-to-female ratio of 2:1. This finding is consistent with

the study by Nyundo AA (2023), where 59.1% met criteria for HIV-associated neurocognitive disorder (HAND), and 58.2% were classified as asymptomatic neurocognitive impairment (ANI) or mild neurocognitive disorder (MND), closely mirroring our proportion. Although Nyundo's study did not provide detailed age stratification, the reported mean age and impairment distribution suggest a similar middle-aged concentration. Male predominance was also noted, aligning with our gender distribution, likely reflecting differences in exposure risks and healthcare access. Similarly, Diaz MM et al. (2021) reported a mean age of 51.6 ± 7.7 years and found that only 15% of participants were female, indicating a strong male predominance. They also noted a 28.5% prevalence of neurocognitive impairment, especially in attention and working memory, supporting the need for targeted neurological screening.^[14,15]

Our study found that fever with headache was the most common presenting symptom in HIV-positive patients with neurological involvement, affecting 13 individuals, followed by headache with vomiting and seizures. These symptoms suggest a predominance of meningoencephalitic and intracranial pathologies. Less frequent manifestations such as aphasia and visual disturbances indicate focal neurological involvement. These findings align closely with those of Bhagwat K et al. (2024), who reported headache in 42%, vomiting in 28%, seizures in 13%, and altered sensorium in 33% of cases, along with meningitic signs and focal deficits. Similarly, Sharma SR et al. (2017), in their study of 91 HIV-positive adults, observed headache and seizures in 25% of patients each, with TB meningitis (43.9%) and cryptococcal meningitis (14.2%) being the leading causes of neurological presentations. These correlations reinforce the need for prompt neuroimaging and diagnostic evaluation in symptomatic HIV patients to identify and manage underlying central nervous system pathology effectively.^[16,17]

Our finding shows that toxoplasmosis (27.08%) was the most common CNS pathology, followed by tuberculosis (20.83%) and progressive multifocal leukoencephalopathy (PMLE), underscoring the predominance of opportunistic infections in HIV-positive patients due to their immunocompromised state. Less frequent but clinically significant conditions included CNS lymphoma and vasculitis, while 2.08% of patients had normal MRI findings, emphasizing the value of neuroimaging even in ambiguous cases. These results align with Maharani K et al. (2024), who reported cerebral toxoplasmosis (41%) as the most common CNS infection, followed by CNS TB (19%) and other OIs such as neurosyphilis (15%) and cryptococcal meningitis (10%), supporting early neuroimaging in symptomatic PLHIV. Similarly, Gams Massi D et al. (2022) observed cerebral toxoplasmosis (24.5%) as the leading cause and highlighted the role of neuroimaging combined with CSF testing, reinforcing that CNS opportunistic infections dominate HIV-related neurological presentations.^[18,19]

In HIV-positive patients, CNS complications such as cerebral tuberculosis, toxoplasmosis, PML, and cryptococcal meningitis are frequently observed. In HIV patients, toxoplasmosis is the most common opportunistic CNS infection, showing multiple T1 hypointense, T2 hyperintense ring-enhancing lesions with marked surrounding edema and the characteristic eccentric target sign (nodule within the enhancing rim) or concentric target sign on T2W; lesions most commonly involve the basal ganglia, thalami and corticomedullary junction.^[23] Primary CNS lymphoma typically presents as solitary or few avidly/peripherally enhancing masses with diffusion restriction and relatively less edema,

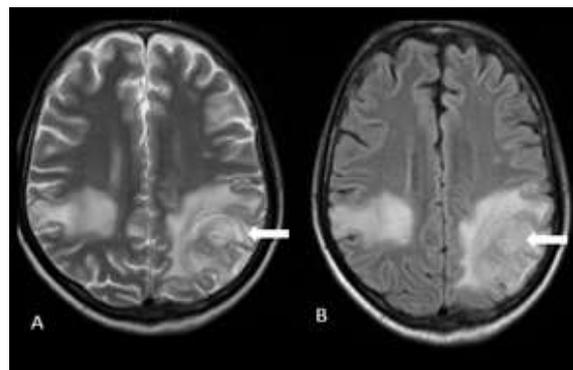
favoring the periventricular white matter, corpus callosum, and deep gray nuclei.

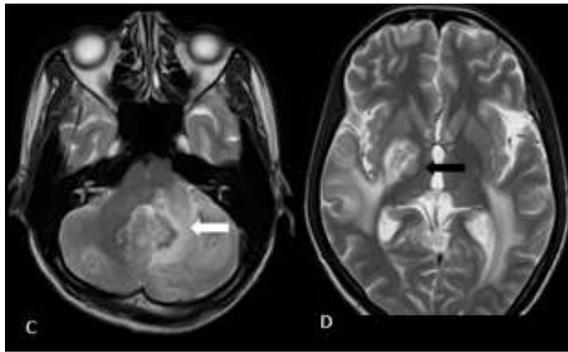
Progressive multifocal leukoencephalopathy (PML) demonstrates asymmetric, non-enhancing T2/FLAIR hyperintense lesions without mass effect, predominantly in the parieto-occipital subcortical white matter and U-fibers. Cryptococcal infection shows dilated Virchow–Robin spaces and gelatinous pseudocysts in the basal ganglia and thalami with minimal enhancement, while CMV encephalitis causes periventricular T2 hyperintensity with ependymal enhancement. CNS tuberculosis appears as ring-enhancing T2W hypo-intense tuberculomas and basal meningitis, commonly involving the basal cisterns, brainstem, and cerebellum.^[24] MRI with diffusion-weighted imaging and spectroscopy aids in distinguishing these entities by assessing lesion morphology, cellularity, and metabolic profiles for accurate diagnosis.^[20-22]

With increased life expectancy due to antiretroviral therapy, the neurological profile of HIV is shifting toward chronic conditions like HAND, cerebrovascular disease, and ART-related neurotoxicity. Advanced imaging techniques such as diffusion tensor imaging and functional MRI are enabling detection of subtle brain changes, including white matter disruption and atrophy, even in asymptomatic individuals. Despite progress in care, the neurological burden remains significant, especially in resource-limited settings. MRI plays a critical role in diagnosing, monitoring, and researching neuro-HIV. Routine use of brain MRI can improve early detection, guide timely interventions, and enhance outcomes in patients with HIV-related CNS complications.^[11,12]

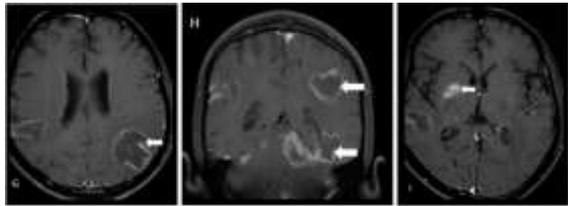
Image gallery:

1)A 45-year-old HIV female presents with headache and vomiting:





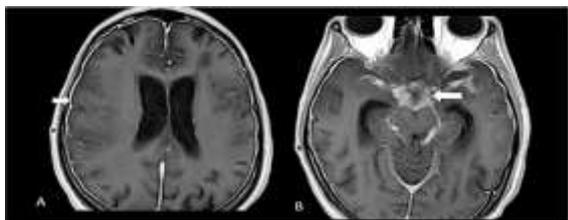
A, B: Axial T2WI and FLAIR shows lesions with alternating concentric zones of hyper and hypointensity with marked perilesional edema (target sign) (white arrows) in left parietal region. Another T2 and FLAIR hyperintensity is seen involving the right parietal region & C. D: T2WI shows heterogenous hyperintense lesion with striking peripheral edema (black arrow) involving right basal ganglia, as well as a large "tumefactive" lesion (white arrow) involving the left cerebellar hemisphere



G: Axial T1 C+ FS image demonstrates ring-enhancing lesions in bilateral parietal regions. H: Coronal T1 C+ FS image demonstrates ring-enhancing lesions in bilateral parietal, left temporal and left cerebellar hemisphere with few of them showing eccentric target sign & I: Axial T1 C+ image demonstrates a hyperintense area – Possible hemorrhage.

**Imaging features are consistent with CNS Toxoplasmosis

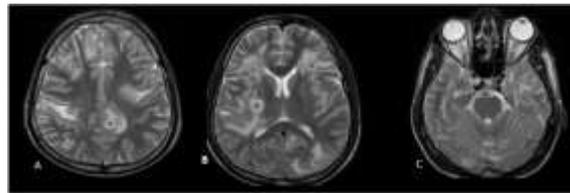
2) A 39-year-old female with HIV presents with headache and fever.



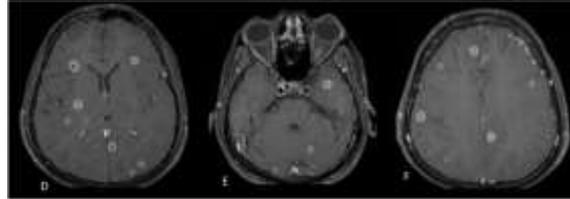
A: Axial postcontrast T1-weighted brain MRI showing strong Pachymeningeal enhancement B: Axial T1 post contrast images show enhancing exudates (white arrow) throughout the basal cisterns.

**Imaging features likely suggestive of CNS tubercular meningitis.

3) A 45-yr old male with k/c/o HIV, presents with seizures.



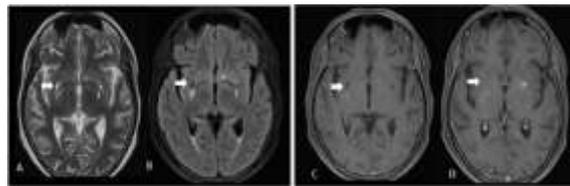
A, B, C: Axial MRI images showing Multiple T2 central hypointense lesions with surrounding edema involving bilateral cerebral and cerebellar hemispheres – Possible tuberculomas.



D, E, F: Series of axial Contrast enhanced T1 weighted images showing multiple rings enhancing lesions in bilateral cerebral and cerebellar hemispheres (Tuberculomas) and leptomeningeal enhancement in left frontal region – meningitis.

**Imaging features likely suggestive of CNS tuberculosis.

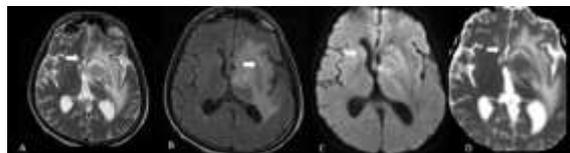
4) A 41-year-old female with HIV, presents with fever and headache.



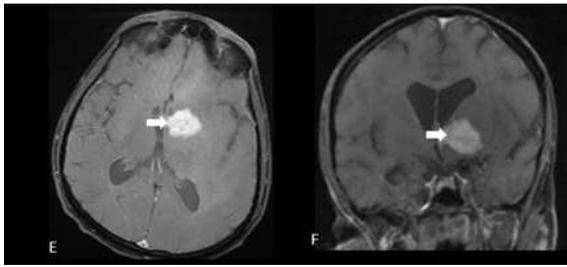
A, B: Axial T2WI shows multiple hyperintense foci in both lenticular nuclei with suppression on FLAIR images – Likely gelatinous pseudocysts & C, D: Axial T1 post contrast images show no enhancement of the pseudocysts.

**Imaging features likely suggestive of CNS Cryptococcosis

5) 53-year-old female with HIV, presents with right hemiplegia:



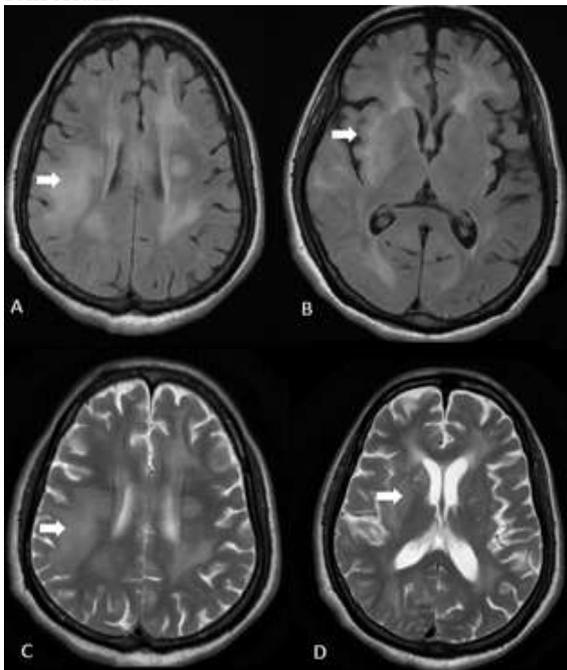
A, B: Axial T2WI and FLAIR shows hypointense lesion in the left basal ganglia and thalami with surrounding intense perilesional edema. This is causing mass effects like midline shift to right and effacement of frontal horn of ipsilateral lateral ventricle & C, D: Axial DWI and ADC images showing restriction of diffusion.



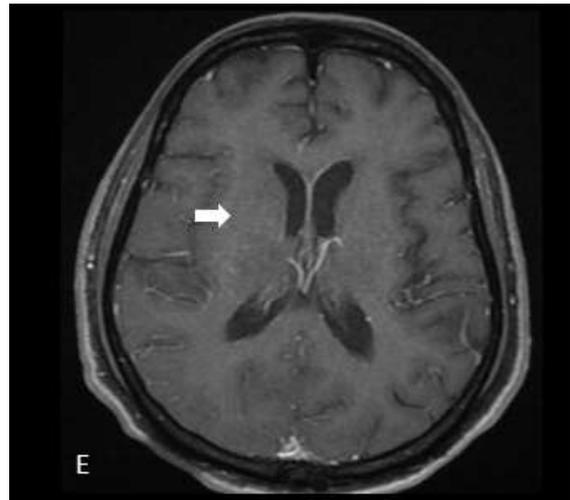
E, F: Axial and coronal T1 post contrast image shows well defined strongly enhancing lesion (black arrow) involving the left basal ganglia with compression of ipsilateral frontal horn of lateral ventricle.

**Imaging features likely suggestive of CNS lymphoma.

6)A 58-year-old HIV male presents with altered sensorium.



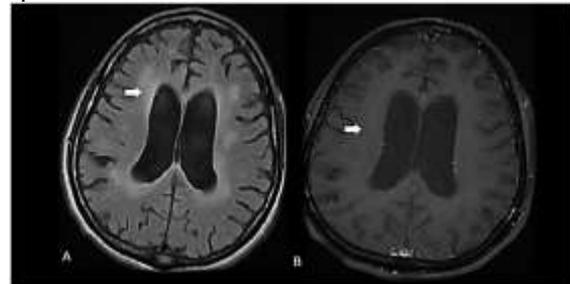
A, B: Axial FLAIR image shows multifocal, confluent, bilateral but asymmetric irregularly shaped hyperintense areas (white arrow) involving periventricular and subcortical white matter reaching upto the subcortical U fibers but sparing the cortex. C, D: Axial T2W image shows multifocal, confluent, bilateral but asymmetric irregularly shaped hyperintense areas (white arrow) involving periventricular and subcortical white matter reaching upto the subcortical U fibers but sparing the cortex.



E: Axial T1 post contrast image shows no significant enhancement of the above.

**Imaging features likely suggestive of Progressive Multifocal Leukoencephalopathy.

7)A 35-year-old male with dementia and slurred speech.



A: Axial T2WI shows volume loss, reflected by the enlarged lateral ventricles and sulci. Symmetric confluent hyperintensities have developed in the periventricular cerebral white matter. Subcortical U-fibers are spared & B: Axial T1 post contrast image shows no enhancement.

**Imaging features likely suggestive of HIV encephalopathy.

CONCLUSION

This study highlights the crucial role of MRI in evaluating central nervous system manifestations in HIV-positive patients. Opportunistic infections such as toxoplasmosis, tuberculosis, and PML were the predominant findings, reflecting the profound immunosuppression in this population. Middle-aged males constituted the majority of cases, and fever with headache emerged as the most common presenting symptom. MRI not only aids in early diagnosis but also guides timely management and treatment monitoring, even in resource-limited settings. Incorporating neuroimaging as a standard diagnostic tool can significantly improve outcomes and reduce morbidity associated with HIV-related neurological complications.

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