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Original Research Article

MRI PROTOCOL FOR EPILEPSY IMAGING IN THE DEVELOPING WORLD: A PRACTICAL PROPOSAL

Nilesh Kumar Sinha[1], Gaurav Raj[1], Rudra Prasad Ghosh[3], Shubhlaxmi Srivastava[4]

[1,3,4]Senior Resident, Department of Radio Diagnosis, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, India.
[2]Professor & HOD, Department of Radio Diagnosis, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, India.

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Corresponding Author:
Dr. Nilesh Kumar Sinha,
Senior Resident, Department of Radio Diagnosis, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, India.
Email: nileshsinha@hotmail.co.in

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ABSTRACT

Background: Epilepsy disproportionately affects low- and middle-income countries (LMICs), where infectious etiologies such as neurocysticercosis and tuberculomas are common. Standard MRI protocols are primarily optimized for non-infectious causes and may reduce diagnostic yield in these settings.
Purpose: To evaluate a modified MRI epilepsy protocol incorporating post-contrast T1-weighted imaging and susceptibility-weighted imaging (SWI) for improved lesion detection in LMICs.
Materials and Methods: In this retrospective study, 102 patients with epilepsy underwent 3T MRI using a protocol including 3D T1, T2, FLAIR, DWI, SWI, and post-contrast T1 sequences. Lesion types and sequence-wise detection were analyzed, and stepwise rank analysis assessed cumulative diagnostic yield.
Results: Inflammatory granulomas were the most common lesions (39.2%). Post-contrast T1-weighted imaging showed the highest standalone detection (45.1%), particularly for infectious and neoplastic lesions. FLAIR and T2 sequences were essential for gliosis, demyelination, and mesial temporal sclerosis, while SWI was critical for detecting calcified granulomas and cavernomas. Combined use of T1+C and FLAIR detected 73.5% of lesions, increasing to 100% with additional sequences.
Conclusion: Inclusion of post-contrast T1 and SWI significantly improves detection of epileptogenic lesions in LMICs. A region-specific MRI protocol enhances diagnostic yield and may improve epilepsy management in resource-limited settings.
Keywords: MRI, epilepsy, granuloma, neurocysticercosis, tuberculoma, epilepsy surgery, epilepsy protocol.

INTRODUCTION

Epilepsy affects an estimated 51.7 million people worldwide, with bulk of the burden residing in low income countries (LICs) and lower middle-income countries (LMICs) with 82.1% incident and 80.4% prevalent.[1] While the core imaging approach to epilepsy has traditionally focused on identifying structural lesions such as mesial temporal sclerosis, cortical dysplasias, and neoplasms, the underlying etiologies of epilepsy can vary significantly between high-income and developing countries.

Infectious causes such as neurocysticercosis, tuberculosis, HIV-associated encephalopathy, and post-infectious gliosis are disproportionately prevalent in low and middle-income countries, including regions of South Asia, sub-Saharan Africa, and Latin America.[2] These infections can result in a wide spectrum of brain lesions such as calcified granulomas, ring-enhancing lesions, tuberculomas, and encephalitic changes that may be missed or mischaracterized using standard epilepsy protocols optimized for non-infectious pathologies.

Magnetic Resonance Imaging (MRI) is the most sensitive modality for identifying structural brain lesions associated with epilepsy. Standardized protocols such as the protocol recommended by the International League Against Epilepsy (ILAE), suggested by appropriateness criteria of American College of Radiology (ACR), and as recommended by European Society of Neuroradiology (ESNR) emphasize high-resolution sequences including 3D T1-weighted imaging, coronal oblique T2-weighted imaging perpendicular to the hippocampus, and fluid-

attenuated inversion recovery (FLAIR) sequences.[3,4,5] These protocols are optimized for detecting common causes of medically refractory epilepsy in upper middle income countries (UMICs) and high income countries (HICs), particularly mesial temporal sclerosis (MTS), focal cortical dysplasias (FCD) and low-grade gliomas.

However, in low and lower middle-income countries, the etiological landscape of epilepsy differs markedly. Numerous studies have shown that infectious and post-infectious etiologies particularly neurocysticercosis, tuberculomas, HIV-associated CNS infections, and post-encephalitic gliosis are disproportionately more common in these settings. For example, a study in India found neurocysticercosis to be the most frequent identifiable cause of epilepsy.[6]

These conditions often present with lesion characteristics that are not optimally visualized on non-contrast standard protocols. Post-contrast T1-weighted imaging is essential for delineating ring-enhancing lesions and distinguishing between active and inactive infections. Likewise, Susceptibility-Weighted Imaging (SWI) or Gradient Echo (GRE) sequences are critical in detecting calcifications, microbleeds, and hemosiderin deposits—hallmarks of chronic infections and post-infectious sequelae.[7]

There is limited literature addressing MRI protocol adaptation based on regional disease epidemiology. This gap underscores the need for a revised epilepsy imaging protocol that integrates sequences sensitive to the most prevalent infectious causes of seizures in the developing world. By aligning imaging strategies with local etiological profiles, such protocols may significantly improve diagnostic yield and influence treatment decisions more effectively.

MATERIALS AND METHODS

This was a retrospective observational study conducted at a tertiary care academic hospital. The study aimed to assess the utility of a dedicated epilepsy MRI protocol in detecting epileptogenic lesions in patients with epilepsy. To determine the optimal MRI protocol for detecting epileptogenic lesions, the study analyzed data of 102 **patients** who were clinically diagnosed with epilepsy and underwent **MRI** for the detection of potential epileptogenic lesions with successful detection of some form of potential epileptogenic lesion. Patients with prior neurosurgical interventions and incomplete imaging datasets were excluded.

This lesion spectrum was used as the foundational dataset to assess the sensitivity of various MRI sequences and to identify which are essential for detecting all common epileptogenic pathologies.

MRI Acquisition Protocol

All MR imaging was performed on a 3 Tesla MRI GE SIGNA OT HDxt- 32 channel MRI machine (WB0427) using an imaging protocol that included the following sequences:

3D T1-weighted BRAVO: isotropic voxel size ≤1 mm.

2D Coronal T2-weighted fast spin-echo (FSE): perpendicular to the long axis of the hippocampus with ≤2 mm slice thickness and no gap.

Coronal FLAIR (fluid-attenuated inversion recovery): identical plane as T2, optimized for mesial temporal lobe assessment.

Axial T2-weighted and FLAIR sequences: to identify neocortical and extra-temporal lesions.

SWI: to detect calcifications, hemosiderin, or cavernomas.

Axial diffusion-weighted imaging (DWI): to rule out acute ischemic changes or diffusion abnormalities.

Post-contrast 3D BRAVO

Each sequence was evaluated for its ability to detect specific lesion types and the sequences which detected even small and subtle lesions were identified. These ratings were informed by the original Wellmer et al. dataset, and expert interpretation from three academic imaging centers as mentioned by Wellmer et al.

RESULTS

Table 1: Epileptogenic lesions and most suitable sequences for their detection

Diagnosis	FLAIR	T2	T1	DWI	SWI	T1 Contrast
Encephalomalacia		+				
Epidermoid		+		+		
Heterotopia			+			
Inflammatory granuloma (Tuberculoma, NCC)						+
Demyelination	+					
DNET		+				
GBM	+					+
Gliosis	+	+				
Focal cortical atrophy	+	+	+			
Calcified granuloma					+	
Meningioma		+				+
Metastasis	+					+
Periventricular leukomalacia		+				
Rasmussen's encephalitis	+					
FCD			+			
Cavernoma					+	
Mesial Temporal Lobe Sclerosis	+	+				

Hemangiopericytoma		+				+
Cortical tubers	+					
Pachygyria			+			
Oligodendroglioma	+	+				

Table 2: Distribution of epileptogenic lesions as detected on MRI

Diagnosis	Number of cases	Diagnosis	Number of cases
Calcified granuloma	9	Inflammatory granuloma (NCC, Tuberculoma)	40
Cavernoma	1	Meningioma	2
Cortical tubers	1	Mesial temporal lobe sclerosis	2
Demyelination	10	Metastasis	2
DNET	2	Nodular heterotopia	1
Encephalomalacia	7	Oligodendroglioma	1
Epidermoid	1	Pachygyria	1
FCD	3	Periventricular leukomalacia	1
Focal cortical atrophy	3	Rasmussen's encephalitis	4
GBM	1	Band heterotopia	1
Gliosis	8	Hemangiopericytoma	1

Table 3: Stepwise rank analysis

	T1+C	FLAIR	T2	SWI	T1
Rank 1	45.1%				
Rank 2		73.5%			
Rank 3			84.3%		
Rank 4				94.1%	
Rank 5					100%

MRI evaluation of 102 patients with epilepsy using the proposed protocol including SWI and T1+conrast revealed multiple structural abnormalities. The most frequent lesion identified was neurocysticercosis (NCC), seen in 28% of patients, followed by demyelinating lesions (10%), gliosis (8%), tuberculomas (8%), and encephalomalacia (7%). Other lesions included calcified granulomas, Rasmussen's encephalitis, meningiomas, focal cortical dysplasia (FCD), and a range of neoplasms such as DNETs, GBM, and metastases.

Tabe 1 shows the MRI sequences which are most suitable to detect specific epileptogenic lesions. Few epileptogenic lesions can be detected by more than one sequences while the rest can be detected by just one sequence. To determine the detection rate of various sequences for epileptogenic lesions, each lesion type was analyzed for its optimal imaging detection pathway. T2 weighted imaging demonstrated the highest overall detection rate, especially for visualizing encephalomalacia, tumors and cystic structures (9/20, 45% of lesion entities). T2-weighted sequence was essential for gliosis, demyelination, mesial temporal sclerosis, and Rasmussen's encephalitis (8/20, 40% of lesion entities) while SWI was indispensable for detecting calcified granulomas, cavernomas, and hemosiderin deposits (2/20, 10% of lesion entities). 3D T1-weighted imaging (BRAVO) contributed primarily to the detection of malformations of cortical development, including FCD, heterotopia, and pachygyria (4/20, 20% of lesion entities) while post-contrast T1 sequences were crucial for identifying tuberculomas, inflammatory granulomas, and enhancing neoplasms (5/20, 25% of lesion entities).

Table 2 shows the frequency of various epileptogenic lesions as detected by MRI in our study. If we take into account the prevalence of various epileptogenic lesions in our dataset then T1+C is able to detect most of the lesions, i.e., 46 out of 102 (45.1%) detected lesions. Second most number of lesions were identified by FLAIR, i.e., 32 out of 102 (31.4%), followed by T2 (29/102, 28.4%), SWI (10/102, 9.8%) and T1 (9/102, 8.8%).

A stepwise rank analysis of the sequences was performed to assess their diagnostic yield. Since post-contrast sequence detected most number of lesions, we kept the T1+C at first position (Rank 1). T1+C imaging alone was able to detect 45.1% of lesions which is nearly half of all the detected lesions. The addition of FLAIR increased the detection rate by 28.4%. Incorporating T2 further elevated this by 10.8%, and SWI brought it up by 9.8%. Finally, with the inclusion of T1 imaging, the lesion detection increased by about 5.9%. Table 3 shows the stepwise rank analysis showing cumulatively increasing detection rate of the epileptogenic lesions with addition of more MRI sequences starting from T1+C.

DISCUSSION

The findings of this study underscore the critical need for tailored MRI protocols in epilepsy imaging, particularly in low- and middle-income countries (LMICs) where infectious etiologies dominate.

In our study of 102 participants, we found that the most commonly detected etiological cause of epilepsy was inflammatory granuloma, comprising of 40 cases (39.2%). This result is consistent with other epidemiological studies carried out at various locations in India such as Rajshekhar V et. al., Devi et. al., Goel et. al.[8,9,10]

Post-contrast T1-weighted sequence emerged as indispensable, detecting 45.1% of lesions in our cohort, particularly inflammatory granulomas (e.g.,

neurocysticercosis, tuberculomas). Its high diagnostic yield highlights the importance of contrast administration in LMIC settings, where active infections are common. This contrasts with protocols from high-income regions (such as in ILAE recommendations), where post-contrast sequence is often reserved for specific scenarios and is considered optional.[3]

SWI proved vital for identifying calcified granulomas and cavernomas, which are frequent sequelae of chronic infections like neurocysticercosis. Its inclusion addressed a limitation of standard protocols, which may miss subtle calcifications or hemosiderin deposits on conventional sequences.

The stepwise rank analysis revealed a cumulative detection rate, with T1+C and FLAIR together identifying 73.5% of lesions. This suggests that even in resource-limited settings, a minimal protocol combining these sequences could offer substantial diagnostic value.

Our protocol diverges from the study done by Wellmer et al. (2013), where FLAIR and non-contrast sequences sufficed for most lesions (84.80% of the lesions were detected by the FLAIR sequence itself, with 99.4% lesions detected by all the sequences other than post-contrast sequence).[11] In our population, post-contrast imaging detected 45.1% lesions with rest of the lesions being detected by non contrast sequences, underscoring the need for post-contrast sequence. This discrepancy calls for context-specific guidelines rather than a one-size-fits-all approach. Our results demonstrate that the inclusion of post-contrast T1-weighted imaging and susceptibility-weighted imaging (SWI) significantly enhances the detection of epileptogenic lesions, addressing a gap left by standard protocols optimized for non-infectious pathologies prevalent in high-income countries.

Limitations

This proposal is derived from a retrospective analysis of lesion frequency and MRI sequence suitability. Prospective validation in LMIC settings—ideally through multicenter studies—is needed to confirm feasibility, diagnostic yield, and clinical outcomes. Additionally, patient throughput, cost of MRI contrast and scan duration must be balanced against resource constraints, though the protocol remains practical within a 35–40 minute time frame on modern 1.5T systems.

CONCLUSION

Incorporating post-contrast T1 and SWI into a modified epilepsy MRI protocol significantly enhances lesion detection in populations where infectious etiologies are common. The proposed protocol provides a cost-effective, high-yield framework for epilepsy imaging in developing countries and may improve early diagnosis and management of structurally mediated epilepsy in low and middle income settings.

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