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The Diagnostic Efficacy of MRI Dedicated-Epilepsy Protocol in Evaluation of Seizures

Rawa Saad[1*], Fawaz Baddour[1] and Hala Saeed[2]

[1]Department of Medical Imaging and Diagnostic Radiology, Tishreen University Hospital, Lattakia, Syria.
[2]Department of Neurology, Tishreen University Hospital, Lattakia, Syria.

Authors' contributions

This work was carried out in collaboration among all authors. Author RS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript, managed the analyses of the study and managed the literature searches. Author FB was supervisor professor. Author HS was assistant supervisor doctor. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aims of this study were to identify the diagnostic efficacy of dedicated epilepsy protocol in detecting possible structural abnormalities that underlie seizure disorders, and compare the diagnostic yields of MRI and electroencephalogram individually and in combination.
Study Design: This was a cross-sectional analytic study.
Place and Duration of Study: Medical Imaging and Diagnostic Radiology Department at Tishreen University Hospital, Lattakia, Syria; between July 2019 and July 2020.
Methodology: Our study included 100 cases (58 females, 41 males, age range 13-77 years) who presented with seizure over 18 months. Patients underwent complete neurological examination, EEG, and MRI with a standard and dedicated epilepsy protocol.
Results: We found epileptogenic lesions in MRI in 55.5%. MRI detected epileptogenic lesions in 74.5% patients who had focal onset seizures. Mesial temporal lobe sclerosis was the most common epileptogenic lesion (45.5%). The diagnostic efficacy of MRI had increased with dedicated

**Corresponding author: E-mail: rawa.saad91@gmail.com, rawasaad14@gmail.com;*

epilepsy protocol compared to standard protocol. Abnormal MRI and EEG were compatible in 21%.
Conclusion: Dedicated epilepsy protocol increased the diagnostic efficacy of brain MRI in detecting a structural epileptogenic lesion, with 100% of mesial temporal sclerosis, the most common lesion in our study, was detected only in dedicated epilepsy protocol and missed in standard protocol.

Keywords: Brain MRI; dedicated-epilepsy protocol; routine electroencephalogram; seizures; standard protocol.

1. INTRODUCTION

Seizures are a common condition. About 8 to 10 percent of the population will have a seizure at some point in their lifetime [1,2].

We can diagnose a specific epilepsy syndrome by the combination of detailed medical history, electroencephalography findings and magnetic resonance imaging results [3, 4]. This complete evaluation will determine the likelihood that a patient will have additional seizures; greatly facilitate early management decisions.

The diagnosis of epilepsy is primarily clinical, but MRI can have a high impact on diagnosis and therapeutic planning [5].

The diagnostic efficacy of neuroimaging in detecting epileptogenic lesions in patients with seizures ranges from 1% to 47% [6].

Epilepsy occurs when an individual has a seizure along with abnormal MRI and/or abnormal EEG, so he/she has probability of at least 60% of having recurrent seizure within the next 10 years [7].

Classification systems of seizure have been used since the 1970s. Over the years, multiple revisions have been implemented. The most recent of which is the International League Against Epilepsy (ILAE) classification 2017 [8,9].

Seizures classified into focal-onset, generalized-onset, or unknown-onset; depending on the initial manifestations [10].

There are multiple potential causes for seizures and can be divided into structural, genetic, infectious, immune, and unknown causes. Some of these are acquired and able to be identified in 30 percent of patients [11]. The remaining causes have no neuroimaging manifestations, such as genetically generalized epilepsy syndromes.

In our study, we will focus on the structural causes of seizures.
The main aims of this study were to determine the role of brain MRI in evaluating patients with seizures, to investigate whether there is any increase in the diagnostic efficacy by using the dedicated-epilepsy protocol, then to compare the diagnostic yields of MRI and electroencephalogram.

2. METHODOLOGY

2.1 Participants

Our study included 100 cases, between the ages of 13 and 77 years. They presented to Neurology department at Tishreen University Hospital, Lattakia, Syria with a seizure over the previous 18 months. Type of seizure was determined according to the criteria of International League Against Epilepsy 2017) 2017. After MRI scan and results, the patients were referred to a specialized neurologist for starting the appropriate management.

2.2 Selection of Patients

The following inclusion criteria were established: 1) all patients aged 13 years or more. 2) patients presenting with seizures over the previous 18 months.

The following exclusion criteria were established and applied to all participants: 1) 12 years of age or younger; 2) non-central nervous system disorders susceptive to cause seizures; 3) any contraindications to MRI; 4) seizures related to metabolic disorders; 5) pseudo-seizures; 6) drug-induced seizures, and 7) head trauma. According to our exclusion criteria, one patient was excluded from the study due to a contraindication for MRI scan, so the study included 99 newly diagnosed patients.

Table 1. Sequences of MRI used at Tishreen University Hospital

Sequence	TR (ms)	TE (ms)	Slice thickness (mm)
T1 sagittal	550	8.9	5
T2 axial	4000	120	5
FLAIR axial, coronal	7100	81	3
DWI/ADC	5600	129	5
GRE	968	25	4
T1 IR	4000	372	1
MPRAGE	2200	2.8	1

2.3 Investigations

All patients have undergone a complete physical and neurological examination.

Magnetic Resonance Imaging was done to all participants, using a device with field strength of 1.5 T (Magnetom Essenza, 16 channel; Siemens, Germany) after the onset of seizure. All patients underwent routine EEG obtained before or after the MRI as soon as possible. Two 10 years expert radiologists, one of them is a pediatric radiologist, interpreted MRI images. The MRI findings was judged by at least one neurologist and one pediatrician.

2.4 Magnetic Resonance Imaging

Standard protocol and dedicated-epilepsy protocol were done to all participants. Standard protocol includes: T1WI in sagittal plane, axial plane T2WI, and axial plane FLAIR. Dedicated epilepsy protocol includes: FLAIR in coronal oblique plane perpendicular to the long axis of hippocampus, 3D acquisition isotropic T1, 3D acquisition isotropic IR, axial T2 GRE, DWI/ADC map, and post-contrast MRI study if required (Table 1).

MRI findings were then classified into three categories: 1) structural lesions potentially related to seizure “epileptogenic lesion”, 2) nonspecific structural lesions unlikely to be related to seizure “non-epileptogenic lesion”, and 3) no lesion detected on MRI “normal MRI”.

For the purpose of study, the epileptogenic lesions were subdivided into seven categories as: infection and inflammation, mesial temporal lobe sclerosis, ischemia, gliosis and encephalomalacia, malformations of cortical development, tumors and tumor-like lesions associated with epilepsy, and vascular malformations.

2.5 EEG Protocol

EEG was done as soon as possible before or after the onset of seizure. Digital EEG systems using electrodes according to the international 10–20 system was done.

For the purpose of study, the EEG results were classified into three categories: 1) epileptic discharges “focal or generalized”, 2) slowing “focal or generalized”, or 3) “normal EEG”.

2.6 Statistical Analyses

This was a cross-sectional study performed during 13 months from July 2019 to July 2020. It was performed using IBM SPSS statistics (version 2020). Descriptive statistics including proportions, median and range were estimated. We studied the correlation between MRI and EEG using McNemer test with significance level $P< 0.05$ was performed.

3. RESULTS

We studied 100 cases of patients who presented to Tishreen University Hospital in Lattakia, Syria with a seizure over the previous 18 months.

3.1 Clinical Characteristics of Patients

The age of the participants was between 13 and 77 years (five patients were < 18; three females and two males) with the mean age of 39 years. 20-35 years was the most common age group. There were 58 females (58.6%) and 41 males (41.4%).

Among our participants, 53 (53.5%) patients presented with focal-onset seizure. The rest presented with generalized-onset seizure in 41 (41.4%) patients, and unknown-onset seizure in 5 (5.1%) patients.

3.2 MRI Evaluation

MRI was abnormal in 71 (71.7%) cases. Among those abnormal scans, we determined a potentially epileptogenic lesion in 55 (55.5%) and a non-epileptogenic lesion in 16 (16.2%) patients (Table 2).

In our study, the diagnostic yield of MRI in detecting epileptogenic lesion was 55.5%. Out of those epileptogenic lesions“ (Table 3)”, mesial temporal lobe sclerosis “(Fig. 1)” was the most common. It was found in 25 (45.5%) patients, followed by eight (14.5%) patients with tumors and tumor-like lesions associated with epilepsy “(Fig. 2)”.

Malformation of cortical development was detected in six (10.9%) patients. Out of those six cases, focal cortical dysplasia FCD was the most common “(Fig. 3)”.

Infection and inflammation group had 6 (10.9%) patients. We found gliosis in 5 (9.1%) patients “(Fig. 4)”, and ischemic lesions in 4 (7.3%) patients.

Table 2. The diagnostic yield of magnetic resonance imaging

MRI*	Number of patients (n= 99)	Percentage (%)
Normal	28	28.3
Abnormal		
Epileptogenic lesion	55	55.5
Non-epileptogenic lesion	16	16.2
Total	99	100

MRI; Magnetic Resonance Imaging

Table 3. Frequency of potentially epileptogenic lesions on MRI

MRI* epileptogenic lesions	Number of patients (n= 55)	Percentage (%)
Mesial temporal lobe sclerosis	25	45.5
Tumors and tumor-like lesions associated with epilepsy	8	14.5
Malformations of cortical development	6	10.9
Infection and inflammation	6	10.9
Gliosis	5	9.1
Ischemia	4	7.3
Vascular malformations	1	1.8

MRI; Magnetic Resonance Imaging

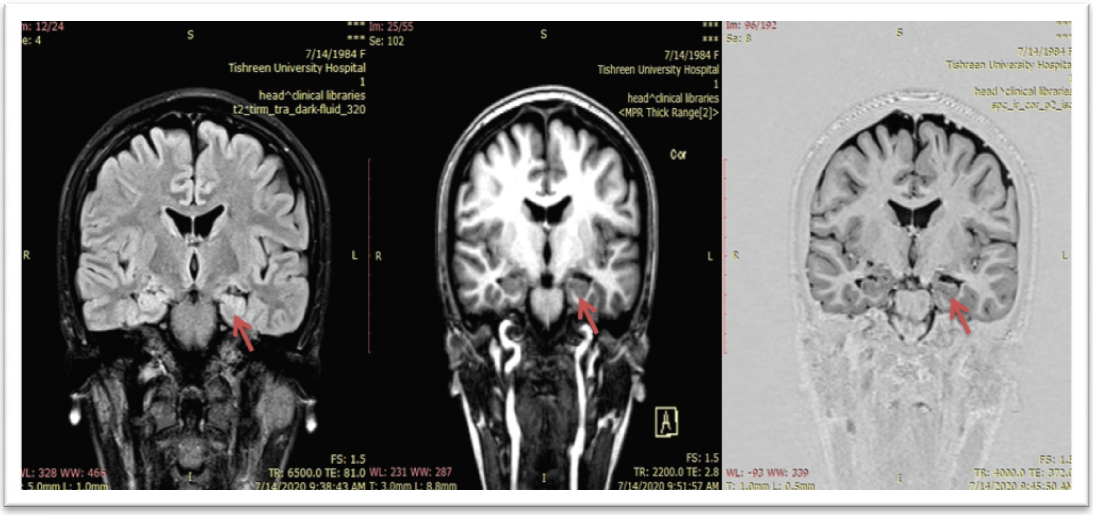

Fig. 1. A 36-year-old female was clinically diagnosed with focal-onset seizure. FLAIR with coronal oblique plane, 3D acquisition isotropic T1, and 3D acquisition isotropic IR. There is increased signal with loss of volume of the left hippocampus (red arrow) suggestive of left mesial temporal sclerosis. Left temporal epileptiform discharges were recorded on EEG

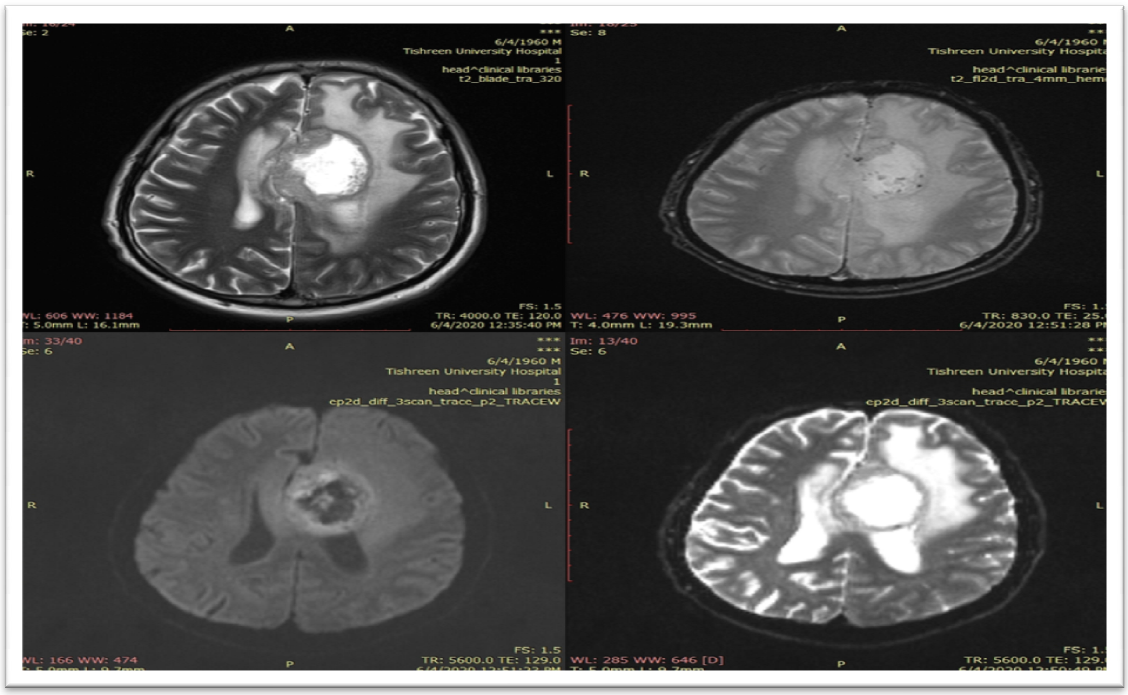

Fig. 2. A 60-year-old male was clinically diagnosed with generalized-onset seizure. Axial T2, GRE, and DWI/ADC map sequences show necrotic mass associated with finger-like vasogenic edema and invasive characteristics suggestive of right glioblastoma multiform (GBM)

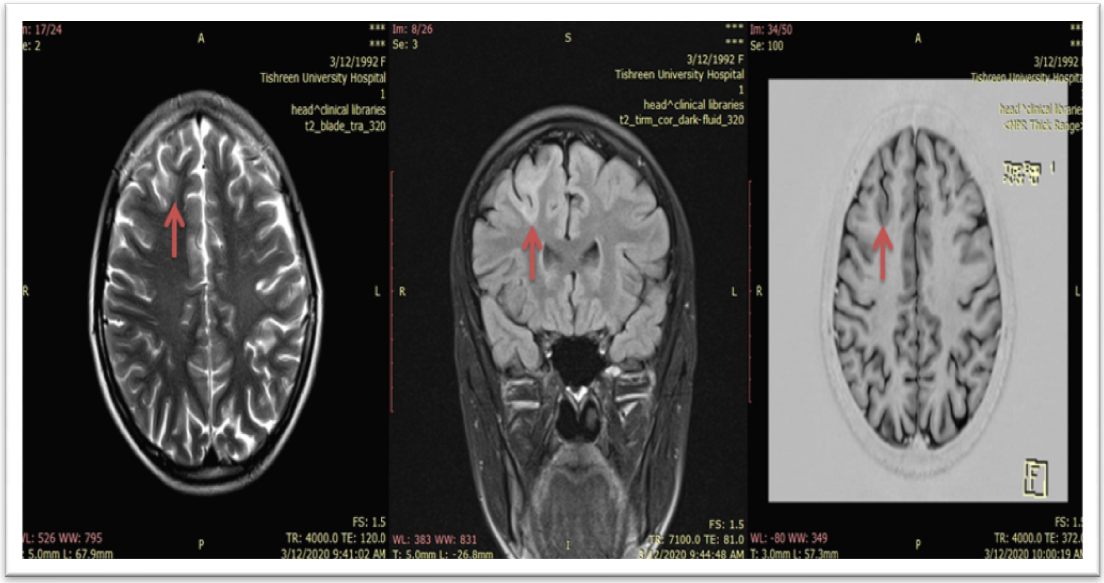

Fig. 3. A 28-year-old female was clinically diagnosed with focal-onset seizure. T2WI in axial plane, FLAIR with coronal oblique plane, and 3D acquisition isotropic IR. There is a region of high T2 signal associated with blurring of the grey white matter junction is seen on the right (red arrow), suggestive of right focal cortical dysplasia

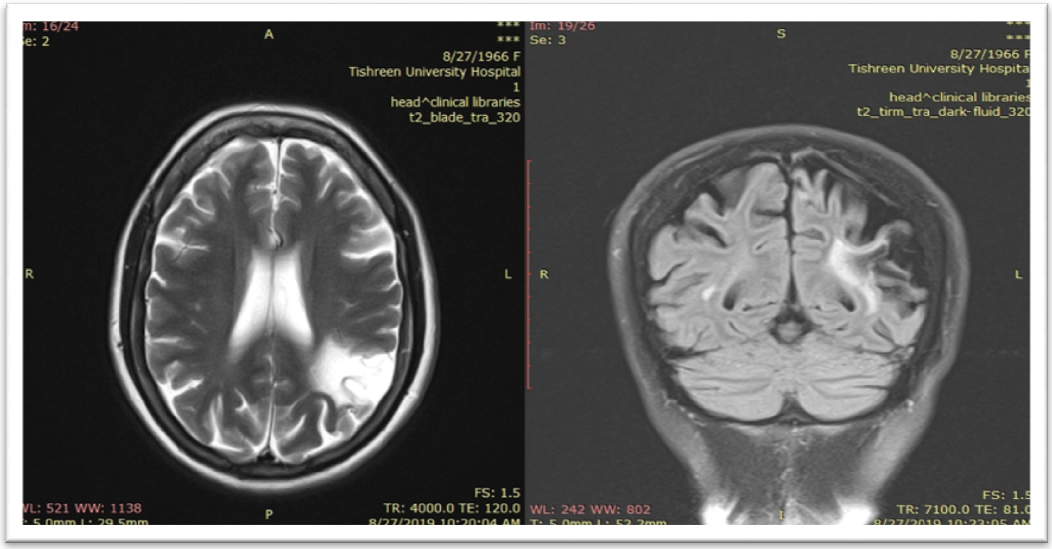

Fig. 4. A 53-year-old female was clinically diagnosed with unknown-onset seizure. T2WI in axial plane, FLAIR with coronal oblique plane, and 3D acquisition isotropic IR. Findings are consistent with left gliosis and encephalomalacia

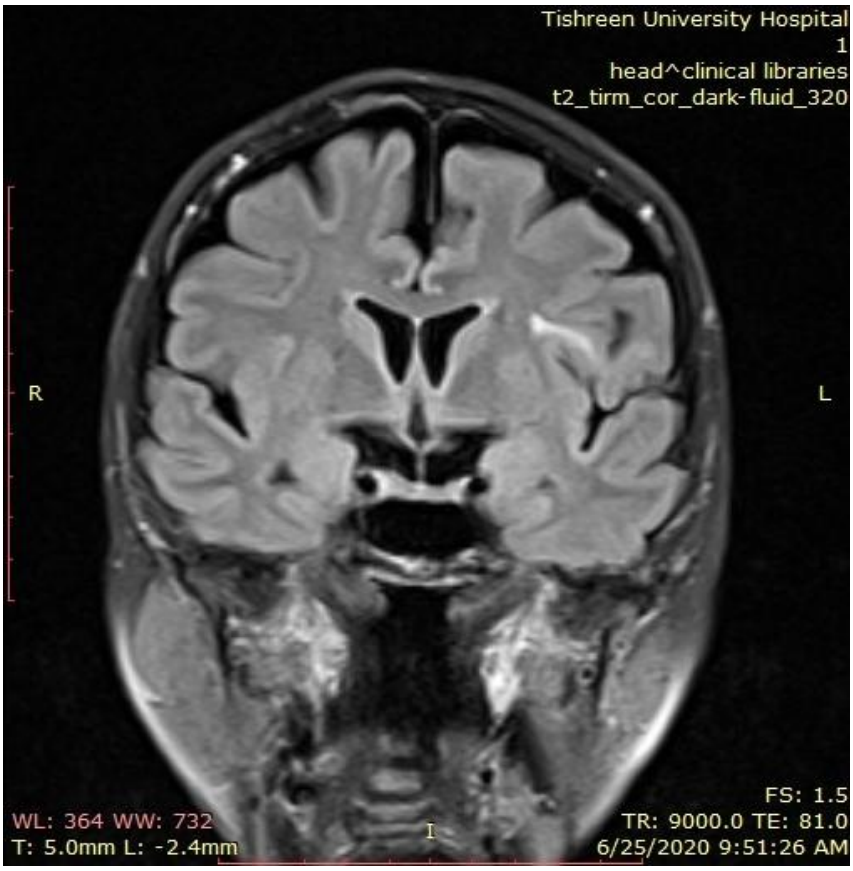

Fig. 5. A 17-year-old female was clinically diagnosed with focal-onset seizure. FLAIR with coronal oblique plane. Findings are suggestive of left focal cortical dysplasia

Vascular malformation group had only one patient, and hence was the least common lesion.

3.3 Differentiation between Dedicated-Epilepsy Protocol and Standard Protocol in MRI

In our study, we detected 55 (55.5%) epileptogenic lesions on MRI. Out of those findings, we found 23 (41.8%) epileptogenic lesions using "standard protocol" while the remaining 32 (58.2%) epileptogenic lesions were found by using "dedicated epilepsy protocol" (Table 4). Standard protocol was normal in 32 patients whose result of "dedicated-epilepsy protocol" MRI was abnormal with significant epileptogenic lesions. According to our results, dedicated epilepsy protocol increased the diagnostic efficacy of detecting epileptogenic lesions.

Out of the 55 epileptogenic lesions, we found 25 patients with mesial temporal lobe sclerosis. Those 25 (100%) cases were missed by using "standard protocol" MRI which would have been detected only by adding "dedicated-epilepsy protocol".

3.4 Correlation between MRI Results and Seizure's Type

We found a potentially epileptogenic lesion in 41 (74.5%) patients who clinically diagnosed with focal-onset seizure, while we found an epileptogenic lesion in 13 (23.6%) patients diagnosed with generalized-onset seizure, and one (1.8%) patient with unknown-onset seizure (Table 5). Among those 41 patients who diagnosed with focal onset seizure and had epileptogenic lesion on MRI, 25 (60.1%) epileptogenic lesions were detected by using "dedicated-epilepsy protocol" and had missed with "standard protocol".

3.5 Electroencephalogram Results

We recorded abnormal EEG in 34 (34.3%) cases and normal EEG in 65 (65.7%) cases. Out of the 34 abnormal findings, 19 (55.9%) showed epileptic discharges, 11 (32.4%) showed generalized slowing and 4 (11.8%) showed focal slowing (Table 6).

3.6 Correlation between EEG Results and Seizure's Type

Our study recorded abnormal EEG in 16 (30.3%) patients who diagnosed with focal-onset seizures. Abnormal EEG was recorded in 15 (36.6%) patients who diagnosed with generalized-onset seizures, and 3 (60%) patients with unknown-onset seizures (Table 7).

3.7 MRI Findings and EEG Results

There were 21 patients (21.2%) with abnormal MRI and abnormal EEG. A compatibility between abnormal MRI and abnormal EEG has been observed in 21% of patients (Table 8). We recorded normal EEG in 50 patients (50.5%) with an abnormal MRI. Among those 50 patients, epileptogeic lesions were detected in 39 (39.4%) cases. Out of these 39 patients, dedicated-epilepsy protocol was able to detect 22 (22.2%) cases.

Table 4. Differentiation between standard protocol and dedicated-epilepsy protocol in magnetic resonance imaging

Epileptogenic lesions	Number of patients (n= 55)	Percentage (%)
MRI* with standard protocol	23	41.8
MRI* with dedicated-epilepsy protocol	32	58.2

MRI; Magnetic Resonance Imaging.

Table 5. Relationship between the seizures' type and findings on magnetic resonance imaging

Seizure's type	MRI*		
	Normal	Epileptogenic lesion	Non-epileptogenic lesion
Focal-onset seizure	9 (32.1%)	41 (74.5%)	3 (18.7%)
Generalized-onset seizure	15 (53.6%)	13 (23.6%)	13 (81.3%)
Unknown-onset seizure	4 (14.3%)	1 (1.8%)	0 (0%)

MRI; Magnetic Resonance Imaging.

Table 6. Results of electroencephalogram

EEG*	Number of patients (n= 99)	Percentage (%)
Normal	33	33.3
Abnormal		
Epileptiform discharges		
Focal	23	23.2
Diffuse	17	17.2
Slowing		
Focal	15	15.2
Diffuse	11	11.1

EEG; Electroencephalogram.

Table 7. Relationship between seizures' type and findings on electroencephalogram

EEG*	Seizure's type		
	Focal-onset	Generalized-onset	Unknown-onset
Normal	37 (69.8%)	26 (63.4%)	2 (40%)
Focal epileptiform discharges	8 (15.1%)	1 (2.4%)	1 (20%)
Generalized epileptiform discharges	3 (5.7%)	5 (12.2%)	1 (20%)
Focal slowing	2 (3.8%)	2 (4.9%)	0 (0%)
Generalized slowing	3 (5.7%)	7 (17.1%)	1 (20%)

EEG; Electroencephalogram.

Table 8. Compatibility between MRI and EEG

MRI*	EEG**	
	Normal	Abnormal
Normal	15 (15.1%)	13 (13.1%)
Abnormal	50 (50.5%)	21 (21.2%)
Epileptogenic lesions	39	16
Non-epileptogenic lesions	11	5

*MRI; Magnetic Resonance Imaging, **EEG; Electroencephalogram*

4. DISCUSSION

Our study showed that the age of the patients was between the ages of 13 and 77 years with the mean age 39 years. These results were nearly similar to the Indian study done in 2018 and Australian study done in 2013 [12,13].

According to our results, the diagnostic yield of MRI in detecting epileptogenic lesion was (55.5%). This result was almost similar to a German study done in 2013 by Jorg Wellmer et al. [14]. In contrast, the diagnostic efficacy of CT and/or MRI was lower (14%) in an earlier Australian study done in 1998 by M A king et al. [15]. The diagnostic efficacy was greater in another Australian study by Hakami et al. in 2013 [13].

Mesial temporal lobe sclerosis was the most common epileptogenic lesion in our study, as we found it in 25 (45.5%) patients; in comparison to other studies [16 17].

According to our study shows, we found a significant increase in the diagnostic value of finding epileptogenic lesions by using "dedicated epilepsy protocol". We detected 100% of mesial temporal sclerosis only by adding epilepsy protocol. Standard protocol alone failed to detect significant findings. These results were similar to a German study done in 2002 studying 123 patients [18].

MRI showed a greater likelihood of detecting potentially epileptogenic lesions (74.5%) in patients who were clinically diagnosed with focal onset seizures. This result was nearly similar to the Australian study done in 2013 by Hakami et al. [13].

Our study showed that the diagnostic efficacy of EEG was 34.3%. These results were nearly similar to the Indian study done in 2018 and an Australian study by King et al. [15].

Our study showed that MRI using dedicated epilepsy protocol was compatible with EEG in 21.2%, whereas standard protocol was compatible with EEG in 10.1% only (Table 9). These results was almost similar to the Indian study done in 2018 and Australian study done in 2013 [12,13].

Table 9. Correlation between magnetic resonance imaging with standard protocol and electroencephalogram

MRI* (standard protocol)	EEG**	
	Normal	Abnormal
Normal	36 (36.4%)	24 (24.2%)
Abnormal	29 (29.3%)	10 (10.1%)
Epileptogenic lesions	17	6
Non-epileptogenic lesions	12	4

*MRI; Magnetic Resonance Imaging, **EEG; Electroencephalogram

5. CONCLUSION

Mesial temporal lobe sclerosis was the most common epileptogenic lesion in our study. MRI has shown great importance in evaluating patients with seizures. All patients with seizure must undergo MRI. All patients who diagnosed with focal-onset seizure should be examined using dedicated epilepsy protocol. MRI has allowed detecting structural brain lesions early in the course of seizure evaluation, positively affecting the early and correct management, especially in patients who diagnosed with focal-onset seizures.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors. In the case of children, written informed consent was obtained from their parent or guardian.

ETHICAL APPROVAL

As per international standard or university standard, written ethical permission has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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