Caspian Journal of Neurological Sciences
"Caspian J Neurol Sci"
http://cjns.gums.ac.ir

Ictal and Interictal Electroencephalography of Mesial and Lateral Temporal Lobe Epilepsy; A Comparative Study

Mehvari Jafar (MD)[1], Zare Mohammad (MD)[2], Andami Rooholla (MD)[3], Ghadimi Keyvan (MD)[4], Tabrizi Nasim (MD)[5]*

ARTICLE INFO

Article type:
Original Article

Bullet point:
- ***Surface EEG is not enough powerful to differentiate mesial and lateral temporal epilepsy***

Article history:
Received: 24 May 2017
Accepted: 29 Jul 2017
Available online: 1 Oct 2017
CJNS 2017; 3 (11): 222-230

Corresponding author:
Neurologist, Department of Neurology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

Email: andami61@Yahoo.com

ABSTRACT

Background: Epilepsy is considered as one of the most important disorders in neurology. Temporal lobe epilepsy is a form of epilepsy including two main types of mesial and lateral (neocortex).

Objectives: Determination and comparison of electroencephalogram (EEG) pattern in the ictal and interictal phases of mesial and lateral temporal lobe epilepsy.

Materials and Methods: This cross-sectional descriptive study included 80 patients with mesial and lateral temporal lobe epilepsy who satisfied the inclusion criteria. The patients were monitored using EEG, and then the EEG results were compared between two groups of temporal epilepsies.

Results: There was no significant difference between two groups of patients (mesial and lateral temporal lobe epilepsy) in terms of the type of seizure, history of tumor or trauma or hypoxia, and duration of seizure history ($p>0.05$). The ictal wave onset in 52.5% of the patients was in the left temporal region, and the ictal wave onset in 58.75% of patients was the slow wave. There was no significant difference between the two groups of patients in terms of ictal wave onset and its location.

Conclusions: According to the results, EEG is a good method for detecting temporal lobe epilepsy, but it does not help to differentiate the type of mesial and lateral temporal epilepsy. In order to distinguish between these two types, EEG alone is not helpful, and other diagnostic methods are required.

Keywords: Epilepsy, Temporal Lobe; Electroencephalography

➢ ***Please cite this paper as:***
Mehvari J, Zare M, Andami R, Ghadimi K, Tabrizi N. Ictal and Interictal Electroencephalography of Mesial and Lateral Temporal Lobe Epilepsy; A Comparative Study. Caspian J Neurol Sci 2017; 3(11): 222-230.

1. *Associate professor, Department of Neurology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran*
2. *Professor, Department of Neurology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran*
3. *Neurologist, Department of Neurology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran*
4. *Medical Student, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran*
5. *Epilepsy Fellowship, Department of Neurology, School of Medicine, Mazandaran University of Medical Sciences, Sari, Mazandaran, Iran*

Introduction

Epilepsy characterized by recurrent seizures. Hauser (1) study reported that about 2 million people in the United States have epilepsy and about 44 new cases are found annually in every 100 thousand people. Two-thirds of them had epilepsy in their childhood. In developing countries, about 80% of people who have seizure have never received any treatment. According to the classification by the International League Against Epilepsy (ILAE) in 2017, the next stage after detecting the type of seizure is to determine the diagnosis of epilepsy, i.e., focal, generalized, combined epilepsy, and an unknown type of epilepsy (2). Epilepsy has been described as a condition in which the seizure occurs recurrently due to a permanent or progressive abnormalities in the brain. A focal epileptic seizure is caused by abnormal neural activity in a particular part of the cortex that can extend to other parts. Temporal lobe epilepsy (TLE) is A known case of focal epilepsies and includes seizures, which often originates from the interior of the temporal lobe (3-6). TLE is related to certain structural and metabolic disorders such as hippocampal atrophy or reduced hippocampus metabolism. These structural or metabolic anomalies extend to the outer part of the mesial temporal lobe and several non-limbic regions of the brain, which often includes the outer part of the temporal lobe and the anterior regions of the cerebral cortex. These anomalies are diagnosed through Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) Scan, Magnetic Resonance Spectroscopy (MRS), or pathological studies. However, many patients have normal MRI or PET scan results, even several years after the onset of disease (7,8).

In fact, temporal lobe epilepsy, is one of the main classes of epilepsy, including the mesial temporal lobe epilepsy (mTLE) and lateral or neocortex temporal lobe epilepsy (nTLE). In focal seizures, certain signs and symptoms can indicate the location of the brain, which the seizure originates from. In previous studies (9), the symptoms occurring in epilepsy of the mesial temporal lobe were slightly different from that of lateral temporal lobe epilepsy. For example, early automatism movements in the opposite upper extremity limb were more prevalent in lateral epilepsy, whereas premature mouth automatism was observed more in mesial epilepsy. Studies carried out on the metabolic level during seizure, using the Computed Single Photon Emission Tomography (SPECT) technique, have indicated that, in temporal lobe epilepsy, the mesial part of the temporal lobe is not the only starting point in the seizure impulses, but parts such as lateral part of temporal lobe, insula lobe and even thalamus can be activated quickly (10). mTLE, the most common form of focal epilepsy, has a certain clinical presentation called limbic seizure, which results from specific neurological changes in the limbic structures. mTLE also has an electrographic appearance and distinct pathologic findings. Its most common pathological disorder subclass is hippocampal sclerosis (HS), which involves the destruction of cells in a particular pattern, which encompass mostly the CA1 and hilar neurons sections (11). Using electroencephalogram (EEG), abnormal brain activity can be accurately evaluated; this is considered as an important clinical test for the diagnosis and treatment of brain diseases. EEG is also an important survey and research tool for young people with epilepsy (12,13). The value of EEG for the diagnosis and classification of

epilepsy has been proven well, but its predictive value is still unclear (14). In temporal lobe epilepsy, the EEG provides a limited coverage of different areas of the temporal lobe and can only show some interictal epileptiform discharges (IEDs). However, additional electrode scan helps EEG to assess a much wider area. EEG abnormal findings in TLE often involve a decrease in arrhythmia (slowing down) of the focal point of the brain waves (both theta and delta waves) and focal IEDs, which are limited to temporal anterior regions. In most cases, these abnormal findings are consistent with the starting point of the seizure and structural abnormalities observed in MRI (15). In this study, we tried to compare patients with mesial and lateral temporal lobe epilepsy in terms of EEG parameters, MRI findings, and demographic information. We also attempted to differentiate between these two types epilepsy.

Materials and Methods

This cross-sectional descriptive study is a specialized doctoral dissertation approved with the code 395298 by the Vice Chancellor of Research and technology at the Faculty of Medicine of Isfahan University of Medical Sciences. This study included 80 known cases of mesial and lateral TLE who were selected by non-random available sampling. These patients, diagnosed based on clinical signs, physical examinations, paraclinical results, EEG findings, and MRI findings, were hospitalized from 2006 to 2016 in the epilepsy center of Kashani Hospital. Therefore, in MRI imaging, the cases involving the medial temporal lobe were considered as mesial temporal lobe epilepsy, and the cases involving the lateral temporal lobe (neocortex) were considered as lateral temporal lobe epilepsy (nTLE). The inclusion criteria were as follows: the occurrence of mesial or lateral temporal epilepsy, informed consent of participation in the study, resistant focal epilepsy (refractory cases include uncontrolled, drug-resistant or intractable cases) (2), and completeness of the patients' files. All patients were prevented from seizure-inducing factors such as sleep deprivation, drinking alcohol drinks, seizure-stimulating drugs, intermittent contact with photic stimulation, long-term focus on the computer, and video games during the hospitalization. Patients who did not satisfy the above criteria or suffered from status epilepticus or any neurological disorder in the central nervous system, such as Alzheimer's, Parkinson's, malignant tumors, cerebral stroke, multiple sclerosis, and neuroinfections, were excluded. Patients' demographic data included age (year), sex, duration of illness (year), type of focal seizure (complex or simple), history of tumor or trauma or hypoxia, and febrile convulsion (FC) (based on previous history and childhood information or based on the available evidence). MRI data of all the patients were also collected. The EEG of all patients carried out on the skull surface (scalp) by the routine or standardized method, was continuously monitored and stored during admission. The following machines were used in this study: Nihon Kohden monitoring device made in Japan with 10-20, T1, T2, T9, F9 and T10, F10 system and 0.1-70 filtering and a stellate machine with a 10-20 system and 60-75-15 filtering. A neurologist (fellowship of epilepsy), unaware of the patients' details, recorded the results of EEG reviews. The duration (seconds) of seizures, localization of the starting point of the ictal wave, morphology of the ictal waves

at onset (or PAO), morphology of the ictal late significant pattern (or LSP), secondary generalization, interictal waves, localization of the dominant interictal waves, the patient's condition in terms of sleeping or awaking during the seizure were investigated in EEGs.

Statticis

For statistical analysis, SPSS version 24 was used. Independent T-test was used to compare the quantitative and qualitative variables and the chi-square test was used to compare qualitative variables between two groups. Distribution of data was shown as the number (percent) and mean ± standard deviation (mean ± SD). In addition, the significance level was considered as less than 0.05.

Results

In this cross-sectional descriptive study, 80 patients with mesial and lateral temporal lobe epilepsy participated. 40 patients (17 men and 23 women) suffered from mTLE and 40 patients (22 men and 18 women) suffered from lateral (neocortex) nTLE. The mean age of patients in the lateral and mesial temporal epilepsy groups was 25.02 ± 12.68 and 26.97 ± 11.99 years, respectively. There was no significant difference between the two groups in age and sex (p-value was 0.61 and 0.26, respectively). In patients with treatment-resistant focal epilepsy, 91% had Complex Partial Seizure (CPS), 29% of patients had a history of tumor or trauma or hypoxia. 57.5% of patients in the mTLE group and 52.5% of patients in the nTLE group had a lesion of the left temporal lobe in MRI. The mean duration of seizure history in patients with mTLE and nTLE was 13.15 ± 7.95 and 11.05 ± 8.62 years, respectively. There was not the significant difference in the type of seizure, history of tumor, trauma, or hypoxia, and duration of seizure history between the two groups of patients (mesial and lateral temporal epilepsy) (p>0.05). In 4 cases (10%) of the mTLE group and 2 cases (5%) of the nTLE group, the history of childhood seizure or febrile convulsion was reported. With regards to the type of lesion in MRI, 30%, 25% and 22.5% of mLTE cases had atrophy, sclerosis, and cyst respectively. In the nTLE group, 42.5%, 20% and 15% of the cases had gliosis, cyst, and benign tumor respectively. There was a significant difference between the two groups in terms of the type of lesion present in the MRI (p=0.001) (Demographic information of patients are summarized in table 1).

After performing EEG, the parameters and variables were compared in each group of patients (table 2), and it was found that the mean seizure duration in patients with mTLE and nTLE was 71.37 ± 47.59 and 72.62 ± 36.46 seconds, respectively. There was no significant difference between the two groups in terms of seizure duration (p=0.74). The location of the ictal wave onset in 52.5% of patients was in the left temporal region. The onset ictal wave in 57.5% of patients in the mTLE group and 60% of patients in the nTLE group was slow wave (delta and theta waves). In 22.5% of the mTLE patients and 27.5% of the nTLE patients, the onset ictal waves were alpha and beta waves, respectively. A sharp or spike wave comprised 20% and 12.5% of mTLE and nTLE cases, respectively. There was no significant difference between the two groups of patients in terms of the wave type of the ictal onset wave and location of the ictal onset wave (p-value was 0.57 and 0.89, respectively). In the case of ictal continuation wave in the mTLE group, 42.5% of cases had sharp or spike wave, 17.5% of other cases had

theta, and10% had delta waves. In the nTLE group, 50% had spike or sharp wave, 12.5% had delta wave, and 7.5% had theta wave. There was no significant difference between the two groups in terms of ictal continuation wave (p=0.67). In the case of interictal waves in patients with mTLE, 30% had non-epileptiform abnormal waves, 70% had epileptiform abnormal waves, and in the nTLE group, these ratios were 27.5% and 72.5%, respectively. There was no significant difference between the two groups in terms of intrarectal waves recorded (p=0.80). With regards the predominant location of interictal waves in the mTLE group, 62.5% were unilateral, 22.5% were bilateral, and 15% were contralateral, and in the nTLE group, these locations comprised 75%, 15%, and 10% of the cases, respectively. There was no significant difference between the two groups in terms of the location of interictal waves (p=0.48). The secondary generalization was in 42.5% of patients in the mTLE group and 37.5% in the nTLE group with no significant difference between the two groups (p> 0.05). Sleep seizure in the mTLE and nTLE groups were 32.5% and 62.5%, respectively, and the amount of seizure in sleep was significantly higher in the nTLE group compared with the mTLE group (p=0.007) (table 2).

Table 1. Demographic data of patients in two groups of mesial and lateral temporal lobe epilepsy

Demographic variables		mTLE	nLTE	p-value
Number of patients		40	40	-
Age (mean±SD)		26.97±11.99	25.02±12.68	0.61
Sex	Male	17 (42.5%)	22 (55%)	0.26
	Female	23 (57.5%)	18 (45%)	
Focal seizure type	Complex	37 (92.5%)	36 (90%)	0.69
	Simple	3 (7.5%)	4 (10%)	
History of tumor, trauma or hypoxia	Yes	10 (25%)	13 (32.5%)	0.45
	No	30 (75%)	27 (67.5%)	
History of seizure (year) (mean±SD)		13.15±7.95	11.05±8.62	0.92
Lesion region in MRI	Right temporal lobe	14 (35%)	14 (35%)	0.74
	Left temporal lobe	23 (57.5%)	21 (52.5%)	
	Two-sided	3 (7.5%)	5 (12.5%)	
Lesion type in MRI	Sclerosis	10 (25%)	2 (5%)	0.001
	Atrophy	12 (30%)	3 (7.5%)	
	Cyst	9 (22.5%)	8 (20%)	
	Gliosis	3 (7.5%)	17 (42.5%)	
	Benign tumor	4 (10%)	6 (15%)	
	Heterotrophy	1 (2.5%)	3 (7.5%)	
	Dysplasia	1 (2.5%)	1 (2.5%)	

mTLE: mesial temporal lobe epilepsy, nLTE: neocortex temporal lobe epilepsy, MRI: magnetic resonance imaging

Table 2. Distribution of EEG data in two groups of mesial and lateral temporal lobe epilepsy

EEG information		mLTE	nLTE	*p-value*
Seizure duration (seconds) (mean±SD)		71.37±47.59	72.62±46.36	0.74
Location of ictal wave onset	Right temporal lobe	15 (37.5%)	17 (42.5%)	0.89
	Left temporal lobe	22 (55%)	20 (50%)	
	Two-sided	3 (7.5%)	3 (7.5%)	
Ictal wave onset	Beta and Alpha	9 (22.5 %)	11 (27.5%)	0.57
	Delta	9 (22.5%)	6 (15%)	
	Theta	14 (35%)	18 (45%)	
	Sharp or Spike	8 (20%)	5 (12.5%)	
Ictal continuation wave	Delta	4 (10%)	5 (12.5%)	0.67
	Theta	7 (17.5%)	3 (7.5%)	
	Beta and Alpha	1 (2.5%)	2 (5%)	
	Sharp and Spike	17 (42.5%)	20 (50%)	
	Artifact	11 (27.5%)	10 (25%)	
Secondary generalization	Yes	17 (42.5%)	15 (37.5%)	0.64
	No	23 (57.5%)	25 (62.5%)	
Interictal waves	Nonepileptiform abnormality	12 (30%)	11 (27.5%)	0.80
	Epileptiform abnormality	28 (70%)	29 (72.5%)	
Dominant interictal location	Unilateral	25 (62.5%)	30 (75%)	0.48
	Bilateral	9 (22.5%)	6 (15%)	
	Contralateral	6 (15%)	4 (10%)	
Seizure in sleep	Yes	13 (32.5%)	25 (62.5%)	0.007
	No	27 (67.5%)	15 (37.5%)	

Discussion

The purpose of our study was to evaluate and compare EEG parameters, including seizure duration, ictal onset waves, location of ictal wave onset, ictal continuous wave, secondary generalization, interictal waves, dominant location of interictal waves, seizure in sleep along with the results of MRI imaging, and demographic information in patients with mesial and lateral (neocortex) temporal lobe epilepsy (mTLE and nTLE). In our study, there was no significant difference in EEG of both mesial and lateral temporal lobe epilepsy groups in terms of seizure duration, ictal onset wave, location the ictal onset wave, ictal continuous wave, secondary generalization, interictal waves, and dominant interictal location (p>0.05). Although there was significant difference between the two groups in terms of seizure in sleep in a way that seizure in sleep in lateral temporal epilepsy was significantly more than mesial type (p=0.007). According to the results of our study, EEG with scalp surface electrode is not a suitable method for differentiating mesial and lateral temporal lobe epilepsies, and a more appropriate diagnostic method should be used in this area. In a study conducted by García-Marín and González-Feria, the routine EEG method was not considered as an appropriate method to get

enough information to therapeutic follow-up. They also considered the placement of electrodes in the interactive and deep modes to provide sufficient information in deep temporal epilepsy and mesial regions of the brain (16). The results of this study are in line with our study. It can be concluded that our study findings are not meaningful due to our study limitations including a small number of samples and the absence of sphenoidal electrodes. Perhaps, if we used more aggressive methods such as intracranial and deep electrodes to record EEG, we would obtain different results. In a study by Ebner and Hoppe, the ictal and interictal waves of EEG information in patients with mesial temporal sclerosis were investigated. Their EEG findings were as follows: 50% of spike-wave of patients were in the opposite lobe, and the patterns of the ictal wave onset were rhythmic as delta, theta and alpha waves and were recorded from temporal region of the same or opposite side (17). These results are not consistent with the results of our study in which the ictal wave onset in mesial temporal epilepsy were a spike or sharp waves in 20%, delta type in 22.5%, theta type in 35%, and 22.5% were alpha and beta in 22.5% of cases (table 2). In a study by Ebersole (18), it was concluded that EEG helps in differentiating between the ictal wave onset among patients with neocortex epilepsy or lateral temporal lobe with hippocampus epilepsy; this finding is not consistent with our study. In a study by Terence *et al.* (19), which was similar to our study, mTLE and nTLE were compared in terms of EEG findings and demographic data. In their study, 46 people including 31 cases of mTLE and 15 cases of nTLE participated in the study. The results of this study showed that a history of FC in childhood was higher in the mTLE group, and there was not a significant difference in the area of seizure and interictal waves in the EEG. Also, the automatism movements and hemifacial clonic movement at the beginning of the seizure occurred in 2 cases of the nTLE group. On the other hand, early mouth automatism occurred more in the mesial temporal type, and the alpha and beta and sharp waves were significantly higher in the ictal phase in the mTLE patient group. They concluded that although there were differences in EEG and clinical signs and symptoms between the two groups, but none of them contributed to the definitive distinction between these two sources of epilepsy. It should be noted that their study was not in line with our study. However, according to Raghavendra *et al.* (15), EEG continues to be the most important test for TLE patients among the clinical and non-invasive methods. Biography, clinical examination, neurophysiological tests and MRI should be completed by EEG findings, to make the best treatment decision for patients (15). In the Watanabe study (20), which investigated the bold response in patients with mesial lobe epilepsy, it was concluded that hemodynamic changes in mesial lobe at the time of interictal epileptic discharges are recorded from the temporal region on the scalp, and a small amount of a BOLD response was found in the neocortex lobe on the same side.

Conclusion

This study is one of the first studies in Iran, during in which we investigated and compared two mesial and lateral temporal lobe epilepsies based on EEG results of patients with temporal epilepsy. In addition, there is no study similar to this study, which investigates both the Mesial and Lateral

temporal lobe epilepsies based on EEG data. According to the results of our study, EEG is a good method for detecting temporal lobe epilepsy, but it is incapable of differentiating between the mesial and lateral type of TLE. So that, EEG alone is not helpful to distinguish between these two epilepsies, and other diagnostic methods such as deep and intracranial electrodes, PET and SPECT methods are required. Also considering the symptoms of seizures can get a differential feature. It is also noteworthy that due to the lack of similar studies on determining new diagnostic strategies, further studies are needed in the future.

Acknowledgment

Hereby, we express our sincere gratitude to the personnel of the epilepsy department of Kashani Hospital in Isfahan who helped us in this study. This study is a residency thesis which was approved with the code of 395298 in the Vice Chancellor of Research in Isfahan University of Medical Sciences.

Conflict of interest

The authors have no conflict of interest.

References

1. Pellock JM, Nordli DR, Sankar R, Wheless JW. Pellock's Pediatric Epilepsy: Diagnosis and Therapy. 4th ed. New York, NY: Demos Medical Publishing; 2016.
2. Scheffer IE, Berkovic S, Capovilla G, Connolly MB, French J, Guilhoto L, et al. ILAE classification of the epilepsies: Position paper of the ILAE Commission for Classification and Terminology. Epilepsia 2017;58(4):512-21.
3. Maccotta L, He BJ, Snyder AZ, Eisenman LN, Benzinger TL, Ances BM, et al. Impaired and facilitated functional networks in temporal lobe epilepsy. Neuroimage Clin 2013;2:862-72.
4. Mehvari-Habibabadi J, Zaki B, Badihian S, Manuchehri N, Basiratnia R, Barekatain M, et al. Predictors for Surgical Outcome in Patients with Tumor-Associated Epilepsy. Journal of Isfahan Medical School 2017;34(410): 1466-74. [Text in Persian]
5. Barekatain M, Tavakoli M. Neuropsychological Assessment in Refractory Temporal Lobe Epilepsy. Journal of Isfahan Medical School 2011;29(143): 780-90. [Text in Persian]
6. Najafi MR, Saeidi S, Nematollahi S, Meamar R. Different Characteristics between the Generalized and Partial Epilepsy Based on the Family History of Epilepsy. Journal of Isfahan Medical School 2016;33(360): 2036-42. [Text in Persian]
7. Bernhardt BC, Bernasconi N, Concha L, Bernasconi A. Cortical thickness analysis in temporal lobe epilepsy Reproducibility and relation to outcome. Neurology 2010;74(22):1776-84.
8. Smith AP, Sani S, Kanner AM, Stoub T, Morrin M, Palac S, et al. Medically intractable temporal lobe epilepsy in patients with normal MRI: surgical outcome in twenty-one consecutive patients. Seizure 2011;20(6):475-9.
9. Yoo JY, Farooque P, Chen WC, Youngblood MW, Zaveri HP, Gerrard JL, et al. Ictal spread of medial temporal lobe seizures with and without secondary generalization: an intracranial electroencephalography analysis. Epilepsia 2014;55(2):289-95.
10. Hogan RE, Kaiboriboon K, Bertrand ME, Rao V, Acharya J. Composite SISCOM perfusion patterns in right and left temporal seizures. Arch Neurol 2006;63(10):1419-26.
11. Javidan M. Electroencephalography in mesial temporal lobe epilepsy: a review. Epilepsy Res Treat 2012; Article ID 637430.
12. Marini C, King M, Archer J, Newton MR, Berkovic SF. Idiopathic generalised epilepsy of adult onset: clinical syndromes and genetics. J Neurol Neurosurg Psychiatry 2003;74(2):192-6.
13. Ashtari F, Zare M, Akrami S. Clinical and Paraclinical Findings in Admitted Patients in Epilepsy Ward. Journal of Isfahan Medical School 2011;28(119):1317-23. [Text in Persian]
14. Malter MP, Bahrenberg C, Niehusmann P, Elger CE, Surges R. Features of scalp EEG in unilateral mesial temporal lobe epilepsy due to hippocampal sclerosis: Determining factors and predictive value for epilepsy surgery. Clin Neurophysiol 2016;127(2):1081-7.

15. Raghavendra S, Nooraine J, Mirsattari SM. Role of electroencephalography in presurgical evaluation of temporal lobe epilepsy. Epilepsy Res Treat 2012; Article ID 204693.
16. García-Marín V, González-Feria L. Depth electroencephalography in selection of refractory epilepsy for surgery. Our experience with the suboccipital approach. Neurol Neurochir Pol 2000; 34 Suppl 8:31-9.
17. Ebner A, Hoppe M. Noninvasive electroencephalography and mesial temporal sclerosis. J Clin Neurophysiol 1995;12(1):23-31.
18. Ebersole JS, Pacia SV. Localization of temporal lobe foci by ictal EEG patterns. Epilepsia 1996;37(4):386-99.
19. O'Brien TJ, Kilpatrick C, Murrie V, Vogrin S, Morris K, Cook MJ. Temporal lobe epilepsy caused by mesial temporal sclerosis and temporal neocortical lesions. Brain 1996;119(6):2133-41.
20. Watanabe S, Dubeau F, Zazubovits N, Gotman J. Temporal lobe spikes: EEG-fMRI contributions tothe “mesial vs. lateral” debate. Clin Neurophysiol 2017;128(6):986-91.