

## Research Article | Araştırma Makalesi

# FROM REQUEST TO RESULT: THE CLINICAL SIGNIFICANCE OF EEG IN A TERTIARY HOSPITAL IN TURKEY

## İSTEMDEN SONUCA: TÜRKİYE'DE ÜÇÜNCÜ BASAMAK BİR HASTANEDE EEG'İNİN KLİNİK ÖNEMİ

 Dilek Agircan<sup>1\*</sup>,  Mehmet Bal<sup>1</sup>,  Murat Çekiç<sup>1</sup>,  Tulin Gesoglu Demir<sup>1</sup>,  Adalet Gocmen<sup>2</sup>,  Ozlem Ethemoglu<sup>1</sup>

<sup>1</sup>Harran University, Harran Faculty of Medicine, Department of Neurology, Sanliurfa, Türkiye. <sup>2</sup>Sanliurfa Training and Research Hospital, Department of Neurology, Sanliurfa, Türkiye.



### ABSTRACT

**Objective:** This study aimed to assess the clinical and demographic profiles of patients undergoing electroencephalography (EEG) over one year, evaluate EEG's impact on patient management, and ascertain the appropriateness of EEG requests.

**Methods:** A retrospective analysis was conducted in the neurophysiology department at Harran University Faculty of Medicine over 12 months from October 2022 to October 2023. The study included the EEG request to the neurophysiology department; pediatrics and the cases that had artifacts or technical issues were excluded. Age, gender, imaging characteristics, EEG findings, and the reasons for EEG requests were recorded. The contribution of EEG to patient management was analyzed.

**Results:** The study included 1217 patients with a mean age of 34.4±16.5 years, ranging from 18 to 90 years. Of these, 656 were female and 561 male. A history of epilepsy was reported in 821 patients. Neurology outpatient clinics, inpatient wards, and intensive care units requested the majority of EEGs. Epilepsy (48%), presyncope/syncope (13%), and psychogenic non-epileptic seizures (PNES) (5%) were the top reasons for EEG requests. Among the newly diagnosed epilepsy patients, 13 (65%) showed abnormal EEG results. Out of the 202 patients with magnetic resonance imaging (MRI) abnormalities, 39 exhibited focal epileptiform anomalies on EEG, with 32 of these cases (82%) showing concordance between MRI and EEG results. The EEG influenced patient management in 577 (46.5%) cases by confirming diagnoses, guiding drug adjustments, directing further diagnostics, and differentiating between epilepsy and PNES, highlighting its crucial role in clinical decision-making.

**Conclusion:** This study emphasizes the critical role of EEG in patient management, noting that although it is effective for confirming epilepsy, it is not reliable for excluding the diagnosis, thus stressing the need for careful clinical evaluation and prudent use of EEG in diagnostics.

**Keywords:** Electroencephalography (EEG), epilepsy, seizure, patient management, diagnostic utility

### Öz

**Amaç:** Bu çalışmanın amacı, bir yıl boyunca elektroensefalografi (EEG) çekilen hastaların klinik ve demografik verilerini incelemek, EEG'nin hasta yönetimi üzerindeki etkisini ve EEG taleplerinin uygunluğunu değerlendirmektir.

**Yöntem:** Bu çalışma Ekim 2022 ve Ekim 2023 tarihleri arasında Harran Üniversitesi Tıp Fakültesi'nde retrospektif olarak gerçekleştirildi. Çalışmada, nörofizyoloji laboratuvarına gelen EEG talepleri tarandı ve pediatrik vakalara ek olarak artefakt veya teknik sorunlar nedeniyle değerlendirilemeyen EEG'ler çalışmadan dışlandı. Hastaların yaşı, cinsiyeti, görüntüleme özellikleri, EEG bulguları ve EEG taleplerinin nedenleri kaydedildi. EEG'nin hasta yönetimine katkısı analiz edildi.

**Bulgular:** Çalışmaya yaş ortalaması 34,4±16,5 yıl olan ve yaşları 18 ile 90 arasında değişen 1217 hasta dahil edildi. Bunların 656'sı kadın ve 561'i erkekti. Hastaların 821'inde epilepsi öyküsü mevcuttu. EEG'lerin çoğu nöroloji poliklinikleri, nöroloji yatan hasta servisleri ve yoğun bakım ünitelerinden istenmişti. Epilepsi (%48), presenkop/senkop (%13) ve psikojenik epileptik olmayan nöbetler (PNES) (%5) EEG taleplerinin en önemli nedenleriydi. Yeni tanı konulan 20 epilepsi hastasının 13'ünde (%65) anormal EEG bulguları saptandı. MR görüntüleme anormallikleri olan 202 hastanın 39'unda EEG'de fokal epileptiform anormallikler görüldü ve bu vakaların 32'sinde (%82) MR ve EEG sonuçları arasında uyum bulundu. EEG, 577 vakada (%46,5) tanıları doğrularak, ilaç doz ayarına rehberlik ederek, ileri tanıya yönlendirerek ve epilepsi ve PNES arasında ayırıcı tanıya katkı yaparak hasta yönetimini etkilemiş ve klinik karar verme sürecindeki önemli rolünü vurgulamıştır.

**Sonuç:** EEG'nin özellikle epilepsi ve diğer nörolojik hastalıklarda tanıya katkısı önemini korumaktadır. Uygun EEG taleplerinin teşvik edilmesi ve hekimlerin nöbetler hakkındaki bilgilerinin artırılması hasta bakımını ve kaynak kullanımını optimize edebilir.

**Anahtar Kelimeler:** Elektroensefalografi (EEG), epilepsi, nöbet, hasta yönetimi, tanısal yarar

## Introduction

Electroencephalography (EEG) is an essential tool in diagnosing and following neurological disorders affecting the brain, especially epilepsy. It is used to diagnose, classify, and characterize interictal epileptiform abnormalities in people with epilepsy. Besides epilepsy, it is very supportive in the differential diagnosis, especially in confusional states, metabolic or toxic encephalopathies, or nonconvulsive status epilepticus. It is also valuable in central nervous system infections such as Creutzfeldt-Jacobs disease, Herpes simplex encephalitis, and subacute sclerosing panencephalitis.<sup>1,2</sup> In addition to all these diseases, its use is frequent in psychiatric practice to differentiate neurological disorders from psychiatric disorders, as well.<sup>3</sup>

In addition to the misdiagnosis of epilepsy, the abuse of EEG has been an issue for years. In a community-based investigation specifically targeting the adult population, the misdiagnosis rate was identified as 23%. Furthermore, it was discerned that among the cases referred to an adult neurologist for "refractory epilepsy," 26% were erroneously diagnosed, revealing the absence of epilepsy.<sup>4,5</sup> In another study, only 22% of performed EEGs were considered 'useful', meaning they confirmed diagnoses or influenced the management of patients, all of which were requested by only neurologists.<sup>6</sup>

In the present study, our objective was to assess the clinical and demographic profiles of patients who underwent EEG over the past year, along with evaluating the impact of EEG on patient management. Furthermore, we aimed to determine the appropriateness of EEG requests

## Methods

The present study consisted of a retrospective analysis spanning one year, conducted at Harran University Faculty of Medicine between October 2022 and October 2023. All cases being requested EEG from the Department of Neurology were screened for inclusion. EEGs that were affected due to artifacts or technical issues were excluded from the analysis. Pediatric EEGs were omitted from the study. All EEG assessments were conducted ensuring a minimum duration of 20 minutes, and scalp electrodes adhered to the international 10-20 system, including T1 and T2 electrodes. Standard activation protocols, encompassing eye opening-closing, hyperventilation, and photic stimulation, were administered, unless medically contraindicated.

Parameters such as age, gender, clinical manifestations, imaging characteristics, and EEG findings and types were recorded. The EEGs were reviewed by the same neurologist experienced in interpreting EEGs and epilepsy. Each patient's reason for requesting EEG, final neurological diagnosis, and department for EEG requisition were documented. EEG outcomes were categorized into the following groups: normal, focal epileptiform activity, generalized epileptiform activity,

and non-epileptiform abnormalities (such as slow activity). Normal variants were encompassed within the normal EEG classification. The rationale for the EEG request was categorized into several classifications, including epilepsy, patients with a first seizure, syncope/pre-syncope, psychogenic non-epileptic seizures (PNES), altered consciousness, transient global amnesia (TGA), central nervous system (CNS) infection, sleep disorders, movement disorders, and others. In instances where patients underwent multiple EEGs, each recording was documented separately if the reasons for EEG demands varied. The EEG's contribution to the patient's management was deemed significant if it resulted in a modification to the patient's diagnosis or treatment regimen. This included instances where the EEG confirmed or modified diagnoses, guided treatment adjustments such as the adaptation of antiepileptic drug regimens, directed further diagnostic investigations, particularly when MRI abnormalities were present, or differentiated between epileptic and non-epileptic events such as psychogenic non-epileptic seizures (PNES), thus guiding appropriate therapies.

The MRI scans were performed using a standard 1.5 Tesla MRI machine at the Radiology Department of Harran University Faculty of Medicine. The MRI results were evaluated by an experienced radiologist who interpreted the images in a blinded manner. The MRI abnormalities identified in our cohort encompassed gliotic changes, mesial temporal sclerosis, focal cortical dysplasias, intracranial masses (including meningiomas and other tumors), cerebrovascular diseases such as intracranial hemorrhages, infarcts, subdural and subarachnoid hemorrhages, as well as sequelae of previous cerebrovascular events, EEG and MRI were deemed concordant if both detected pathological abnormalities in matching areas.

Ethical approval for this study was granted by the local ethics committee of Harran University Medical Faculty in 2024, with the assigned protocol number being HRÜ/24.02.01.

Data acquisition was facilitated through Microsoft Excel, while statistical analyses were conducted utilizing SPSS statistical software version 25 (IBM Inc., NC, USA). Categorical variables were expressed as frequencies with accompanying percentages, with statistical comparisons performed using the Pearson Chi-square and Fisher exact tests. A significance threshold of  $p < 0.05$  was applied to determine statistical significance.

## Results

During the study period, 1626 patients underwent EEG. After excluding EEGs with artifacts or repetitive EEGs, 1217 patients were included in the study. 656 EEGs were obtained from female patients, whereas 561 were from male patients. The mean age was  $34.4 \pm 16.5$  years and ranged from 18 to 90 years. EEGs were performed as routine, sleep deprived, and sleep EEGs. 1103 were routine EEGs, 32 were sleep-deprived and 82 were sleep

EEGs. While 936 EEGs were reported as normal and 83 as slow, 136 had focal, and 62 had generalized epileptiform activity. 821 patients had a history of epilepsy. A total of 1217 EEGs, including 1053 from neurology outpatient clinics, 75 from neurology inpatient wards, and 39 from neurology intensive care units, were directly requested by the neurology department. 13 EEGs were requested from the emergency department, 25 from other inpatient wards, and 12 from other intensive care units (Table 1).

When the reasons for requesting EEG were analyzed, the 3 most common reasons were epilepsy, presentation with presyncope/syncope, and PNES respectively (Table 2). Of the 43 patients who had a first seizure, 18 were diagnosed with symptomatic seizure and 20 were diagnosed with epilepsy in the following period. 4 patients were diagnosed with PNES and 1 patient with presyncope/syncope. Of the 20 patients newly diagnosed with epilepsy, 7 had normal EEG and abnormal EEG results were detected in 13 patients.

**Table 1.** Comparative Analysis of EEG Patterns by EEG Type, Epilepsy History, and Requesting Departments

		EEG Patterns			
		Normal	Non Epileptiform Abnormalities	Focal Epileptiform Activity	Generalized Epileptiform Activity
EEG Type	Routine	845	82	120	56
	Sleep Deprived	24	0	5	3
	Sleep	67	1	11	3
Epilepsy History		580	57	130	54
The Department EEG was Requested	Neurology Outpatient Clinic	841	55	113	44
	Neurology Inpatient Clinic	43	13	13	6
	Neurology ICU	17	7	8	7
	Emergency Department	10	1	0	2
	Other Inpatient Clinic	16	5	2	2
	Other ICU	9	2	0	1

EEG: Electroencephalography, ICU: Intensive Care Unit

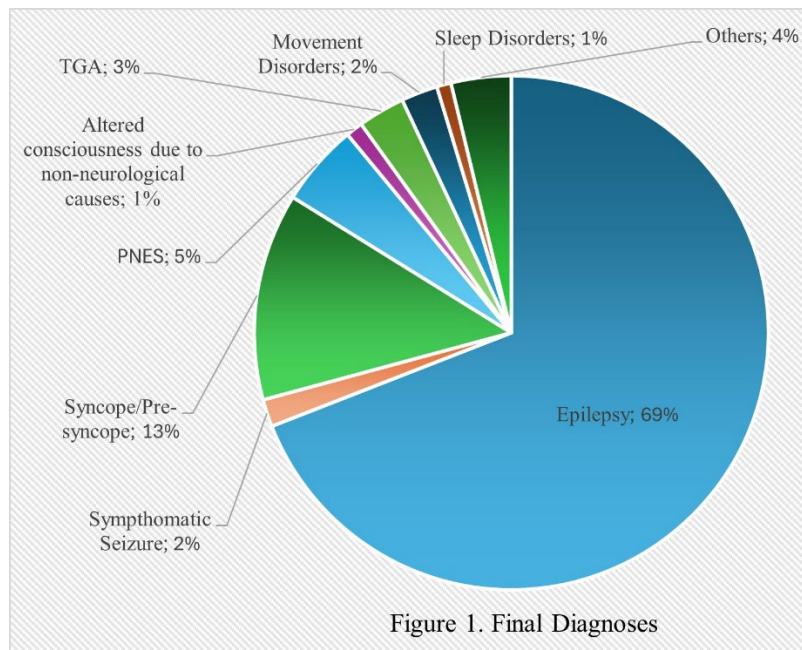
**Table 2.** EEG Patterns According to the Reason for Requesting an EEG

		EEG Results			
		Normal	Non Epileptiform Abnormalities	Focal Epileptiform Activity	Generalized Epileptiform Activity
The Reason for Requesting an EEG	Epilepsy patients	579	57	130	56
	Patients with a first seizure	28	8	3	4
	Syncope/Pre-syncope	158	3	0	0
	PNES	57	0	1	0
	Altered consciousness	17	5	0	1
	TGA	35	1	0	0
	CNS Infection	4	3	1	1
	Sleep Disorders	10	1	0	0
	Movement Disorders	28	0	0	0
	Other	20	5	1	0

CNS: Central Nervous System, EEG: Electroencephalography, PNES: Psychogenic Non-Epileptic Seizures, TGA: Transient Global Amnesia

Out of the 202 patients with MRI abnormalities, 39 exhibited focal epileptiform anomalies on EEG, with 32 of these cases (82%) showing concordance between MRI and EEG results. 577 (46.5%) of EEG's contribution to patient management was deemed significant. EEGs from the neurology service influenced the clinical course of patients in 70.7% of cases, while those from the

neurology intensive care unit impacted 69.2%. In the emergency department, EEGs contributed to patient management in 53.8% of instances. However, EEGs from the neurology outpatient clinic had a lower contribution rate, at 44.3%. The most common final diagnosis was epilepsy (Figure 1).



**Figure 1.** Final Diagnoses

PNES: Psychogenic Non-Epileptic Seizures, TGA: Transient Global Amnesia

## Discussion

Over eight decades since its discovery, the standard EEG has persisted as a secure, non-invasive, cost-effective, and bedside method for assessing neurological function. In the clinical management of epilepsy, the timing for conducting a standard EEG is vital for ensuring superior patient care. Although advancements in neuroimaging have enhanced the detection of structural abnormalities within the central nervous system, EEG remains indispensable in offering crucial diagnostic information that influences therapeutic decisions.<sup>2</sup> EEG plays a pivotal role in diagnosing epilepsy, guiding the selection of antiepileptic medications, assessing treatment efficacy, conducting initial evaluations for alternative invasive therapies, and gauging seizure recurrence risk following medication cessation.<sup>7-10</sup> Epilepsy patients constitute the most commonly evaluated group in routine EEG laboratories.<sup>11,12</sup> In the present study, epilepsy was the leading cause of EEG requests.

In our investigation, the majority of referrals originated from neurologists, particularly those from outpatient clinics. Our study revealed that only 15% of routine neurology outpatient EEGs exhibited epileptiform changes. These results are consistent with those reported by Monif et al.<sup>13</sup> In routine EEG laboratories, roughly half or sometimes even more of the EEG recordings may yield normal results.<sup>12</sup> In this investigation, 77% of EEGs exhibited normal findings. This aligns with Monif et al.'s study, which reported that 67% of routine EEGs were normal. The elevated rate of normal EEGs is influenced by patient selection, especially with many referrals for syncope, presyncope, and psychogenic non-epileptic seizures. This occurrence was attributed to the predominant referral of our patients from outpatient clinics, where the available time for each patient was restricted. Additionally, The sensitivity of EEG for

diagnosing epilepsy is low, ranging from 25% to 56%, whereas its specificity is much higher, between 78% and 98%. The differences in case selection, EEG recording techniques, antiepileptic drug usage, and definitions of epilepsy account for these varied ranges. Overall, findings from these studies, including ours, suggest that EEG is effective for confirming ("ruling in") but not excluding ("ruling out") the diagnosis of epilepsy.<sup>13</sup> These findings highlight the importance of careful clinical consideration and appropriate EEG requests to enhance diagnostic utility.

EEG has been shown to have prognostic utility in assessing the likelihood of seizure episodes following an initial unprovoked seizure event.<sup>14</sup> In patients newly diagnosed with epilepsy, the initial EEG test revealed that 53% exhibited abnormal brain activity patterns, specifically epileptiform abnormalities. However, it is noteworthy that following a first unprovoked seizure episode, a normal interictal EEG is frequently observed, indicating that a single normal EEG does not rule out the diagnosis of epilepsy.<sup>15</sup> Patients presenting with an unprovoked first seizure have a 21-45% risk of recurrent seizures within the first two years after the first seizure.<sup>2</sup> In our cohort, 65% of patients with newly diagnosed epilepsy had abnormal EEG findings and seizures recurred in the following period in approximately 47% of patients with a first seizure.

Differentiating epileptic seizures from paroxysmal non-epileptic events continues to be a critical and challenging task in the routine clinical practice of neurologists and epileptologists.<sup>16</sup> While the utility of EEG for this patient cohort remains a subject of debate, it is commonly used in clinical practice for differential diagnosis. Azman-İste and colleagues reported that the highest frequencies of normal EEG findings were associated with patients experiencing non-epileptic paroxysmal attacks and individuals referred for EEG due to other conditions,

including sleep disorders, movement disorders, and headaches.<sup>12</sup> Similar to their study, the highest occurrences of normal EEG outcomes were detected in patients for whom EEG testing was conducted based on preliminary diagnoses of movement disorders, PNES, and syncope or presyncope episodes in our research.

Although neuroimaging techniques have become the dominant approach for detecting intracranial lesions, EEG maintains a vital role in the diagnostic toolkit, especially during the presurgical examination of epilepsy patients.<sup>11</sup> In the present study, magnetic resonance imaging (MRI) abnormalities were identified in 202 participants, with concordance between EEG findings and MRI observations present in roughly 82% of the patients with focal epileptiform activity.

Our investigation ascertained that EEG conducted on 46.5% of the subjects played a pivotal role in patient care management. The literature demonstrated that confirmed diagnoses or influenced the management of patients in half of performed EEGs. The notion prevails that the appropriateness of EEG requests would be enhanced if they were exclusively made by neurologists.<sup>6,17</sup> In addition to solutions in the literature, such as publishing guidelines, making it easier for the doctor requesting to communicate with the neurologist, and including sufficient information in EEG request forms<sup>6</sup>, we believe that increasing the time allocated per patient in outpatient clinics and the level of knowledge of physicians about seizures will be helpful to prevent unnecessary requests in our country.

In conclusion, the present study demonstrates the essential role of EEG in patient management and underscores the importance of its careful application. Our findings highlight that while EEG is effective for confirming a diagnosis of epilepsy, it is not reliable for excluding it, underscoring the need for careful clinical evaluation and judicious use of EEG in diagnostics.

### Compliance with Ethical Standards

The study was approved by the local ethics committee of Harran University Medical Faculty in 2024 (Protocol number: HRÜ/24.02.01).

### Conflict of Interest

The authors declare no conflicts of interest.

### Author Contribution

DA, MB, TGD, OE: Concept; DA, MB, MC, TGD, OE: Design; MB, MC, AG: Data Collection or Processing; DA, OE: Analysis or Interpretation; DA, TGD, MC, AG: Literature Search; DA, AG, OE: Writing.

### Financial Disclosure

Null.

### References

1. Tatum WO, Rubboli G, Kaplan PW, et al. Clinical utility of EEG in diagnosing and monitoring epilepsy in adults [published correction appears in *Clin Neurophysiol*. 2022 Sep;141:160]. *Clin Neurophysiol*. 2018;129(5):1056-1082. doi:10.1016/j.clinph.2018.01.019
2. Hasan TF, Tatum WO. When should we obtain a routine EEG while managing people with epilepsy? *Epilepsy Behav Rep*. 2021;16:100454. Published 2021 May 3. doi:10.1016/j.ebr.2021.100454
3. Jefsen OH, Nielsen JRW, Christensen J, Hjerrild S. The clinical use of electroencephalography in a general psychiatric setting. *Nord J Psychiatry*. 2023;77(6):560-565. doi:10.1080/08039488.2023.2189300
4. Scheepers B, Clough P, Pickles C. The misdiagnosis of epilepsy: findings of a population study. *Seizure*. 1998;7(5):403-406. doi:10.1016/s1059-1311(05)80010-x
5. Smith D, Defalla BA, Chadwick DW. The misdiagnosis of epilepsy and the management of refractory epilepsy in a specialist clinic. *QJM*. 1999;92(1):15-23. doi:10.1093/qjmed/92.1.15
6. Pearce KM, Cock HR. An audit of electroencephalography requests: use and misuse. *Seizure*. 2006;15(3):184-189. doi:10.1016/j.seizure.2006.01.003
7. Panayiotopoulos CP. *The Epilepsies: Seizures, Syndromes and Management*. Oxfordshire (UK): Bladon Medical Publishing; 2005.
8. Smith SJ. EEG in the diagnosis, classification, and management of patients with epilepsy. *J Neurol Neurosurg Psychiatry*. 2005;76 Suppl 2(Suppl 2):ii2-ii7. doi:10.1136/jnnp.2005.069245
9. Wirrell EC. Prognostic significance of interictal epileptiform discharges in newly diagnosed seizure disorders. *J Clin Neurophysiol*. 2010;27(4):239-248. doi:10.1097/WNP.0b013e3181ea4288
10. Perucca E, Tomson T. The pharmacological treatment of epilepsy in adults. *Lancet Neurol*. 2011;10(5):446-456. doi:10.1016/S1474-4422(11)70047-3
11. Fowle AJ, Binnie CD. Uses and abuses of the EEG in epilepsy. *Epilepsia*. 2000;41 Suppl 3:S10-S18. doi:10.1111/j.1528-1157.2000.tb01529.x
12. Azman-Iste F, Oge DD, Tezer-Filik FI, Saygı S. The EEG Profile of an Outpatient Adult EEG Laboratory of one of the Reference Epilepsy Center in Turkey. *EPILEPSI*. 2020;26(2):108-114. doi:10.14744/epilepsi.2020.09815
13. Monif M, Seneviratne U. Clinical factors associated with the yield of routine outpatient scalp electroencephalograms: A retrospective analysis from a tertiary hospital. *J Clin Neurosci*. 2017;45:110-114. doi:10.1016/j.jocn.2017.08.014
14. Krumholz A, Wiebe S, Gronseth GS, et al. Evidence-Based Guideline: Management of an Unprovoked First Seizure in Adults: Report of the Guideline Development Subcommittee of the American Academy of Neurology and the American Epilepsy Society. *Epilepsy Curr*. 2015;15(3):144-152. doi:10.5698/1535-7597-15.3.144
15. Baldin E, Hauser WA, Buchhalter JR, Hesdorffer DC, Ottman R. Yield of epileptiform electroencephalogram abnormalities in incident unprovoked seizures: a population-based study. *Epilepsia*. 2014;55(9):1389-1398. doi:10.1111/epi.12720
16. Parra J, Iriarte J, Kanner AM. Are we overusing the diagnosis of psychogenic non-epileptic events? *Seizure*. 1999;8(4):223-227. doi:10.1053/seiz.1999.0285
17. Smith D, Bartolo R, Pickles RM, Tedman BM. Requests for electroencephalography in a district general hospital: retrospective and prospective audit. *BMJ*. 2001;322(7292):954-957. doi:10.1136/bmj.322.7292.95