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Evaluation of lateralization and localization value of hand postures in Pediatric Epilepsy

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ABSTRACT

Introduction: Identifying epileptogenic zone is essential for selecting patients for epilepsy surgery and understanding seizure pathophysiology. This study aimed to evaluate the role of ictal hand postures in localization and lateralization value in children.

Material and methods: We conducted a retrospective evaluation of 628 individuals utilizing long-term video EEG recordings of Gazi University Video EEG Monitoring Unit (VEMU) between 2013 and 2022. Distinct hand postures were identified in fifty-six patients. The localization and lateralization value of the hand postures identified in these patients were assessed.

Results: A total of 91 seizures from 56 patients were analyzed, and hand postures were categorized as fist, thumb upside fist (TUF), fanning, holding, index-finger pointing (IFP), and pincer grasp. Fist posture was most frequently observed in frontal lobe seizures, while TUF was dominant in temporal lobe seizures. Fanning was primarily associated with generalized seizures. Lateralization analysis revealed that ipsilateral postures were more common in frontal lobe seizures, whereas contralateral postures were prevalent in temporal lobe seizures ($p < 0.05$).

Conclusion: In conclusion, ictal hand postures may serve as a straightforward and accessible tool for identifying seizure onset zones in children, especially in resource-limited settings. Semiological classification plays a crucial role in the interpretation of video EEG. Accurate identification of semiological manifestations can facilitate timely referral of patients with suspected drug-resistant focal epilepsy for presurgical evaluation.

1. Introduction

Determining the epileptogenic zone is crucial for both therapeutically optimizing patient selection for epilepsy surgery and for comprehending the pathophysiology of ictal processes. Despite all advances in clinical epilepsy, seizure semiology analysis is still the only method available for studying and predicting the epileptogenic zone. It is the initial step in evaluating individuals with epilepsy [1–4]. The literature documents an extensive variety of semiologic findings supporting lateralization and localization. The lateralization and localization of the symptomatogenic zone and the epileptogenic zone (EZ) have been well documented, and many seizure components, such as auras and motor symptoms, have been thoroughly researched [5,6].

The EZ represents a broader theoretical framework that includes the brain regions essential for the generation and propagation of seizures. The seizure onset zone (SOZ) is the brain region where seizures initiate, as determined by electrophysiological recordings. The term "SOZ" is preferable for discussing findings derived from direct ictal recordings, as it circumvents the broader implications associated with "EZ," which are generally inferred during surgical evaluations [7,8]. However, semiological description requires standardization among epileptologists. Particularly when observers are from various epilepsy centers, which may define symptoms and indications differently, there is a great deal of inter-rater heterogeneity. This may occur even when highly qualified epileptologists and a methodical manner are used to study the seizure semiology utilizing video recordings.

Several reliable semiologic signs have been described. Signs like head and eye variation, tonic and clonic activities, and unilateral dystonic posture suggest the contralateral hemisphere of the seizure origin, while blinking, automatisms, and postictal nasal cleaning indicate the

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ipsilateral hemisphere [9,10]. However, specific hand postures have not been extensively studied, aside from dystonic posturing. The usefulness of hand postures in determining the epileptogenic zone has only been the focus of a few studies to date, all of which involved adult patients [11–13]. To our knowledge, though, no effort has been made to employ hand postures in the pediatric age group.

The first objective of this study is to examine the hand posture patterns of children with epilepsy during ictal activities and ascertain their usefulness in lateralizing and localizing the SOZ. Second, in order to prevent inconsistency between evaluators, the videos were evaluated by 3 epileptologists at our Video EEG Monitorization Unit to prevent interrater heterogeneity. We attempted to estimate the IR between three distinct epileptologists and determine the causes of any discrepancies in agreement.

2. Methods

This study involved a retrospective analysis of video EEG recordings performed between 2013 and 2022 of children with drug-resistant epilepsy at Gazi University. Video EEG Monitorization Unit (VEMU). Patients who had a habitual seizure during video EEG monitorization in the VEMU were 18 years of age or younger, had a conclusive final diagnosis based on concordant lines of evidence, and had technically competent video-EEG during the episode to assess hand postures were all eligible to participate. Patients were excluded if any of these requirements were not met or if they refused to participate generally in future research projects.

Assessing hand postures and determining if they may be utilized as lateralizing and localizing signs was the primary goal of this investigation. The seizure onset zones were identified through patients' semiology, the analysis of ictal EEG data from long-term video EEG monitoring, in conjunction with brain magnetic resonance imaging (MRI) and FDG-PET/MRI. Epilepsy type were categorized into two primary groups: localized and generalized. Localization-related epilepsy was further divided into three subtypes: temporal, frontal, and parietal–occipital lobe epilepsies, depending on where the seizure began. Only patients with primary generalized epilepsy were included in the study. Seizures that initiated in either one of the hemispheres and spread throughout the entire hemisphere during ictal activity were classified as generalized onset.

Based on a preliminary assessment of patients in VEMU and technically adequate recordings of at least one event, the first author (D.M.) identified six basic hand positions. Following the detection of dystonic hand postures, three experienced epileptologists (EA, TH, and ES), who were blind to the patients' clinical history and long-term video EEG monitorization results, independently examined each video recording and classified the hand postures into six subcategories based on Ferando et al.'s and Siegel et al.'s research [11,12]. The inter-rater reliability was determined to be 94 % following the initial assessment using the kappa test. The investigators evaluated hand posture inconsistently in five patients at the initial assessment. The investigators were asked to reassess these cases, and an agreement was reached concerning the same posture.

The patient's hand postures during ictal activity were clearly visible in the video recordings and lasted a minimum of 5 s, according to the criteria determined by Ferando I et al. [11]. The evaluation did not include the hand positions of the patients during secondary generalization. The following hand postures were evaluated: fist, thumb-upside fist (TUF), index-finger pointing (IFP), fanning, pincer grasp, and holding. Fist posture is all metacarpophalangeal (MCP) and interphalangeal (IP) joints flexed, the thumb adducted, and the thumb opposed. The thumb IP joint extends in the TUF posture, setting it apart from the fist. In the IFP posture, the index finger joints extend while the other hand finger joints flex. Fanning posture is a completely extended hand with abducted fingers. The pincer grasp posture requires the flexion and adduction of the thumb and index finger, while the other fingers remain extended. The holding posture flexes the MCP joints and extends the IP joints. Hand postures are shown in Fig. 1.

We conducted an analysis on demographic data, clinical data, physical examination findings, neuroimaging examinations, any epilepsy surgeries performed, and clinical follow-up data after video EEG monitoring.

Statistical analyses were performed using the NCSS 2007 program (Kaysville, Utah, USA). The data distribution was assessed using the Shapiro-Wilk test in addition to descriptive statistical methods (mean, standard deviation, median, frequency, ratio, minimum, and maximum). The Kruskal-Wallis test was employed to compare quantitative data between three or more groups, while the Mann-Whitney U test was employed to compare data between two groups. In order to ascertain the correlation between qualitative data, chi-square analysis was implemented. Significance was assessed at the $p < 0.05$ levels. The Kappa test was utilized to calculate inter-rater reliability.

3. Result

Between 2013 and 2024, 628 children were monitored for prolonged video EEG monitorization at Gazi University VEMU in order to define clinical seizures and do presurgical workup. A total of 1373 ictal activity recordings from 628 patients were examined. There were 197 patients with generalized, 165 with frontal-lobe seizures, 171 with temporal-lobe seizures, and 95 with parietal and/or occipital-lobe seizures. All of the patients who fulfilled the inclusion criteria of the study were included. Out of 628 patients, 56 individuals (8,9 %) met the inclusion criteria. A total of 91 seizures were recorded in 56 patients, with each patient having at least one seizure. All individuals had a single hand posture throughout their seizures (Fig. 2).

Table 1 displays the demographic data, seizure onset zones, and distribution of hand postures among the patients. 60.7 % of the patients were male, with a mean age of 12,06 ± 4,23 years. Within the age distribution, there were three patients less than three years, four between three and six years, ten between six and ten years, and forty between ten and eighteen years.

There were no abnormal findings on neuroimaging in 20 patients. In terms of seizure onset zones and hand postures, the 'MR negative' and 'MR positive' groups exhibited comparable ratios. The designation of the patient as 'MRI negative' does not preclude the possibility of their candidacy for epilepsy surgery. Consequently, it may be advisable to reassess the hemisphere lobe with seizure onset zone in MR-negative patients and to conduct neuroimaging again after a specific period of time.

In the acquired group, the temporal lobe accounted for 75 % of the seizure onset zone, whereas in the congenital structural abnormality group, it was 80 % frontal and 20 % temporal. In patients with DNET, seizures originate in the temporal lobe.

We then classified the included patients as either "temporal lobe" (21 patients, 37.5 %), frontal lobe" (20 patients, 35.7 %), or generalized (15 patients, 26.8 %) based on where the detected SOZ is. Upon evaluating the SOZs by age, the frontal lobe was the predominant lobe in individuals under 10 years, whereas the temporal lobe was the predominant lobe in those above 10 years.

The most frequently observed postures were the fist and TUF, with 30,4 % and 28.6 %, respectively. The frequencies of fanning, holding, IFP, and pincer grasp were 17.8 %, 14.2 %, 5.4 %, and 3.6 %, respectively. All patients under the age of six displayed a fist posture; however, in the 6–10 year age group, a holding posture started to emerge alongside the fist posture. The group under 10 years of age did not exhibit any other hand postures.

Table 2 displays the distribution of hand postures based on SOZ. When assessing the association between postures and SOZs, it was found that the fist posture most commonly originated from the frontal lobe, whereas the TUF posture most commonly originated from the temporal lobe. Fist posture was most frequently observed in frontal lobe seizures,



Fig. 1. Hand postures.

while TUF was dominant in temporal lobe seizures. We noticed that the pincer grasp in seizures originated from the frontal cortex and the IFP in seizures originated from the temporal lobe. Fanning was most frequently demonstrated in seizures with a generalized onset.

Out of 56 patients, 22 (39.2 %) underwent epilepsy surgery. Complete seizure freedom was achieved in 11 cases. Focal cortical dysplasia was identified as the aetiology in all three patients within this small group, with the seizure onset zone located in the frontal region. One patient exhibited holding, one extended, and one pincer hand posture. Hippocampal sclerosis and TUF posture were observed in 4 out of 8 patients with a temporal seizure zone. FCD and TUF posture were observed concurrently in one patient. DNET was identified in the etiology of the remaining three patients, one exhibiting a fist posture, another an IFP, and the third a TUF posture.

As per our evaluation of the lateralization of hand postures, 22 patients' hand postures originated from the contralateral hemisphere, while 19 patients' hand postures originated from the ipsilateral hemisphere. Patients with frontal lobe SOZ developed hand posture from the

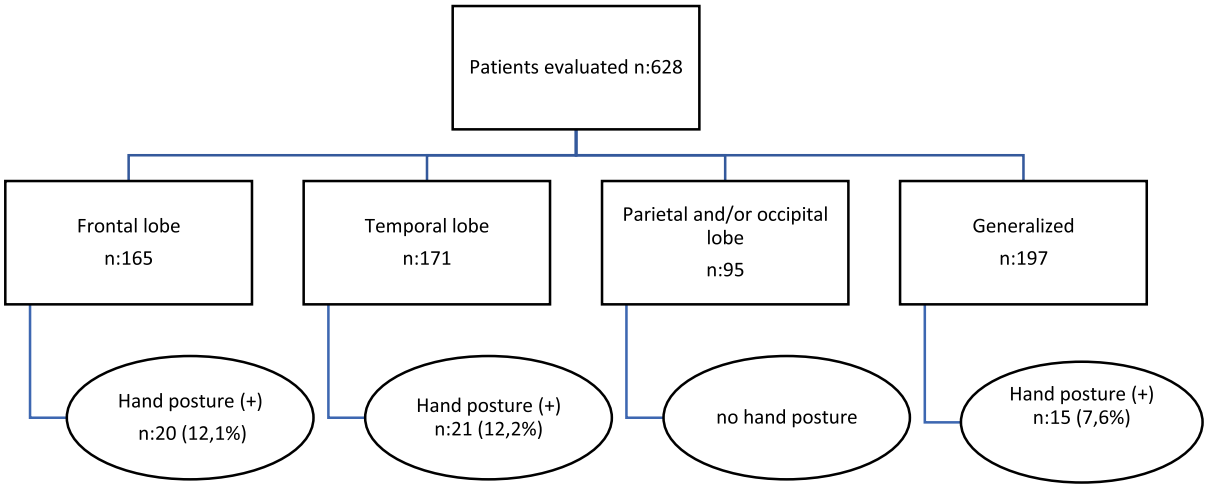


Fig. 2. Study flow.

Table 1
Demographic characterics.

Gender (n; %)	34 male (60,7 %), 22 girl (39,3 %)
Age (years, mean ± SD, range)	12,06 ± 4,23 (1,5–18)
Epilepsy duration (years, mean ± SD, range)	7,69 ± 4,53 (2–16)
Seizure onset zone (n;%)	
Temporal	21(37,5 %)
Frontal	20(35,7 %)
Generalised	15(26,8 %)
Unilateral hemisphere*	6(10,7 %)
Bilateral hemisphere	9(16,1 %)
Hand posture (n;%)	
Fist	17 (30,4 %)
Thumb upside fist	16 (28,6 %)
Fanning	10 (17,8 %)
Holding	8 (14,2 %)
Index finger pointing	3 (5,4 %)
Pincer grasp	2 (3,6 %)
Lateralization (n;%)	
Contralateral	22 (53,6 %)
İpsilateral	19 (46,4 %)
Neuroimaging findings (n;%)	
Normal	20 (35,7 %)
Abnormal	36 (64,3 %) **23 structural anomaly ->15 congenital *8 FCD:* 5 frontal, 2 temporal, 1 frontotemporal *7 migration anomaly:* 2 temporoparietal, 1 parietooksipital, 2 frontoparietal, 2 frontotemporal -> 8 acquired **8 hipocampal sclerosis **5 tumour (4 temporal DNET, 1 multiple hamartoms)
Epilepsy surgery (n;%)	
Yes	22 (39,2 %)
No	34 (60,8 %)
Post surgery seizure freedom (n;%)	
Engel class I	11 (19,3)
Engel class II	4 (7)
Engel class III	7 (12,3)

Abbrevations: FCD: focal cortical dysplasia SD: standard deviation DNET: disembrioplastic neuroepitelial tumor.
* In the generalised group, ictal seizure onset in 6 patients started in one hemisphere and spread to the other hemisphere.

Table 2
Seizure onset zone and hand posture association.

	Seizure onset zone			
Hand posture	Generalize	Frontal	Temporal	Total
Fist	3	10	4	17
Thumb upside fist	2	3	11	16
Fanning	6	3	1	10
Holding	4	2	2	8
Index finger pointing	0	0	3	3
Pincer grasp	0	2	0	2
Total	16	20	21	**56**

Table 3
Seziure onset zone and lateralization.

	Frontal	Temporal
Ipsilateral*	14 (34,1 %)	5 (12,1 %)
Contralateral*	6 (14,6 %)	16 (39,2 %)

* $p < 0{,}05$.

ipsilateral hemisphere, whereas those with temporal lobe SOZ developed it from the contralateral hemisphere. ($p < 0.05$) (Table 3).

4. Discussion

In this study, we assessed the ictal hand postures of pediatric refractory epilepsy patients who underwent long-term video EEG monitoring for presurgical evaluation. Although ictal hand postures have been studied in adult patients in the literature, pediatric patients have not been the subject of similar assessments to date [11–13]. Our results showed that specific SOZs were associated with more frequent observations of specific hand positions. We discovered that hemispheric lateralization is lobe-specific in localization-related epilepsy.

Long-term video EEG is the definitive criterion for assessing a patient's eligibility for surgical intervention in refractory epilepsy cases. Presurgical assessment employs MRI, PET, neuropsychiatric evaluation, and video EEG together [14–16]. The global community of pediatric patients with refractory epilepsy has restricted access to long- term video EEG monitoring. Semiological classification is an integral part of video EEG interpretation. Correct recognition of semiological manifestations can contribute to a decision to refer any patient with presumed drug-resistant focal epilepsy for presurgical evaluation early. In another aspect, semiology is the initial and easiest approach to identifying the seizure onset zone; however, it can occasionally be restrictive due to the

rapid generalization and anatomical network connectivity [2]. Simultaneously, semiology can direct us to reassess neuroimaging or do more comprehensive evaluations in MR-negative individuals [10,17,18]. Thus, we hypothesized that ictal hand positions might be a simple supplementary technique for determining the epileptogenic or seizure onset zone.

Out of 628 people, only fifty-six (8,9 %) had hand postures that satisfied the requirements during seizures. This rate was found to be lower when compared to studies that included adults. There may be two explanations for this situation. Owing to the young brain's ontogeny, ictal posturing distal to the extremities becomes more common as people age; even in youngsters, ictal activity that starts focally quickly spreads throughout the hemispheres, leading to secondary generalization [19–22].

The smallest distribution of people under three in our cohort and the presence of a child who is 1.5 years old point to limited access to VEM units in our country. Studies show that patients' long-term prognosis is positively impacted by early epilepsy surgery. The damage that seizures cause to the developing brain is often irreversible [23–26].

The predominant hand postures identified in our study were the fist and TUF. Fist predominantly came from the frontal cortex, while TUF originated from the temporal lobe. The predominant postures of fist and TUF, along with their originating lobes, were. Unlike the study by Ferando et al., seizures from the frontal and temporal lobes were observed to exhibit pincer grasp and IFP postures, respectively [11]. The fanning posture was predominantly observed in generalized onset seizures. Fanning posture was primarily seen in patients with primary generalized seizures in Siegel and Tatum's study [12]. Holding was first seen in individuals aged 6 years and older.

Our research showed a correlation between advanced age and more complex hand posture. The average age of the fist was 9.8 years, whereas the average ages of the pincer and IFP were 15 and 16 years, respectively. This has been noted in ontological research concerning seizure semiologies [19,20,27].

We evaluated the lateralization of the hand postures of patients in the focal epilepsy cohort. With statistical significance, ipsilateral hand posture was more commonly found in frontal lobe seizures, whereas contralateral hand posture was more common in temporal lobe seizures ($p < 0.05$). This result was found to be in line with studies examining the seizure semiologies of the frontal and temporal lobes in children [17,18,28,29].

The limitations of our study include a limited patient population and unequal subgroups, the inability to conduct invasive EEG on the patients, the localization determinations based on scalp EEG, and the low rate of surgical resection in the cohort.

5. Conclusion

This study investigated hitherto unassessed ictal hand postures in children with intractable epilepsy. Due to restricted access to VEM units and long-term monitoring in numerous countries, including ours, ictal lateralization and localization findings are beneficial for pediatric neurologists. In the real world, pediatric neurologists routinely assess seizure documentation provided by families during outpatient clinic evaluations. Hand postures in ictal recordings can contribute to the clinical diagnosis of focal epilepsy and, therefore, identify individuals suitable for presurgical evaluation.

Declaration of competing interest

None of the authors has any conflict of interest to disclose.

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