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What has changed in the utility of pediatric EEG over the last decade?

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Background/aim: We evaluated the utility of electroencephalography (EEG) in children with neurological conditions and compared the results with those of our previous study on excessive uses of pediatric EEG, which was published in 2003. We also evaluated the possibility of subsequent EEGs and satisfactory duration of EEG recordings according to EEG type and admission status. We also evaluated the yield of varying durations of EEG recordings.

Materials and methods: All consecutive pediatric EEG records performed at Gazi University EEG laboratory during a 1-year period were retrospectively reviewed. The indications of EEGs, the number of EEGs for each patient, condition and duration of EEG records, and activation techniques were evaluated in terms of detection of abnormalities by EEG.

Results: We reviewed a total of 2045 EEGs in children aged 2 months–20 years. Of these, 776 were repeat EEGs (38%) and 485 recordings were ≥30 min (23.7%); 98% of EEG abnormalities appeared in the first 30 min. Overall, 90.5% of EEGs were ordered by a pediatric neurologist. There were similar requests for numbers of EEGs, but the rate of abnormal EEGs (43.6%) was significantly higher when compared to that of our previous study (36.2%).

Conclusion: The results of this study show that the utility of EEG becomes more selective and interpretation of pediatric EEG improves depending on the increasing number of pediatric neurologists. A duration of 20–30 min of EEG recording is sufficient, on the condition of inclusion of nREM sleep records.

Key words: Childhood, electroencephalogram, duration of EEG, seizure

1. Introduction

Electroencephalography (EEG) is one of the main tools for obtaining electrophysiological information about cerebral function. It is widely used to detect various neurological conditions and to evaluate the differential diagnosis of numerous episodic events that may simulate epilepsy (1,2).

Studies have been published with regard to its utility, and the widespread use of EEG in child neurology has led to increasing concern regarding justification for and optimization of EEG orders (1). Our previous study showed that routine or excessive use of EEG would further lead to increased concern regarding its proper application, and documented the critical need for detailed clinical evaluations of patients before an EEG order (3). Since then, child neurology has developed greatly, and there is a marked increase in the number of child neurologists and their worldwide availability. With a thorough knowledge and understanding of EEG, one can narrow the scope of EEG requests and eliminate unnecessary EEG recording, enabling more efficient management.

A guideline on EEG methodology published by the American Clinical Neurophysiology Society (ACNS) aimed to standardize the EEG procedure. The guideline recommended a minimum of 20 min of artifact-free EEG recording; the optimal duration of routine EEG recording is still a matter of debate (4). In clinical practice, the duration of EEG recordings varies widely amongst different EEG laboratories. These differences are mainly attributed to variable resources and economic constraints. One recent recommendation states that routine EEGs should be performed for 40 min whenever possible, to improve yield in a cost-effective manner (5). However, limited resources and economic considerations affect the recording time and may reduce the duration of EEG recording.

As an extension of our previous study, we aimed to evaluate the EEG findings in children with various acute and chronic neurological conditions, along with comparing changes in EEG requests. In addition, we also evaluated the possibility of stratified duration of EEG recordings according to EEG type and admission status. In

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this extended study, we retrospectively reviewed patients who underwent routine EEGs at Gazi University Hospital to better understand the utility of EEG and factors that may impact it.

2. Materials and methods

2.1. Study design

We retrospectively performed a review of all consecutive EEGs performed at the Gazi University EEG Laboratory during a 1-year period from 1 January 2015 to 1 January 2016. Children aged less than 2 months were excluded. The digital EEGs were recorded from 21 electrodes placed according to the International 10–20 System (6). Additional electrodes were used to facilitate the detection of the electrocardiogram. Total recording time included 3 min hyperventilation (HV) and photic stimulation (PS) from 5 to 20 Hz at the end of the recording.

Demographic and clinical data were obtained from computerized hospital records. All EEG requisitions were reviewed by 2 EEG experts (L.T.O. and T.R.) to identify the referral diagnosis. The following parameters were collected in a database: demographic data (sex, age), specialization field of referring doctors (pediatrician, child psychiatrist, child neurologist, and another specialized pediatrician), indication of suspected diagnosis on EEG request (i.e. the referral diagnosis), history of epilepsy and currently used antiepileptic drugs, and number of EEG recordings.

The referral diagnosis related to the EEG request was defined as one of 6 categories: 1. Established epilepsy; 2. Suspected epilepsy (probable seizure or seizures of new onset); 3. Nonepileptic paroxysmal events (e.g., migraine, syncope, breath holding spells); 4. Acute central nervous system disorders (ACNS) (e.g., toxic, metabolic, infectious, hypoxic encephalopathy); 5. Nonepileptic chronic central nervous system disorders (CCNS) (e.g., mental retardation, autism, attention disorder); 6. Febrile seizure. All EEG recordings were reviewed by 2 of the authors (certified and experienced in pediatric neurology; K.A. and E.A.) while blinded to the demographic and clinical data of the patient. Each EEG was initially evaluated by the reviewers separately; the evaluations were eventually matched with each other. This removed any bias caused by the different reviewers.

The following data were collected: duration of recording, duration of sleep, sleep staging, epileptiform or background abnormalities, while awake, drowsy, or asleep, activation by photic stimulation (IPS) or hyperventilation (HV), photic driving response (PD). EEG findings were classified based on symmetry, reactivity, background (normal, diffuse slowing, focal slowing in Hz), location (generalized, lateralized, bilateral independent, multifocal). EEG abnormalities were grouped as: 1. Focal epileptiform discharges; 2. Multifocal epileptiform discharges; 3. Generalized epileptiform discharges; 4. Focal or diffuse background disturbances.

The duration of EEG recording was considered: long, ≥30 min (as 30 min to 120 min); regular, 20–30 min. Epileptiform activity was defined based on current literature as distinctive waves or complexes, distinguished from background activity (spikes (20–70 ms), sharp waves (70–200 ms), slow waves (>200 ms) (6). Epileptiform activity (spikes, sharp waves, and focal slow activity) was manually counted and the latency was calculated. Long records were grouped according to the latency with the initial interictal activity as within the first 30 min or after >30 min.

The effect of the duration of EEG recording, number of EEG recordings in each patient, and activation techniques (photic stimulation, hyperventilation) were evaluated in terms of detection of EEG abnormality. The presence and the extent of these abnormalities were analyzed during each phase of the awake or sleep-deprived records especially during the transition phases between wakefulness, drowsiness, sleep, and vice versa. The effects of sleep, standard sleep deprivation, spontaneous sleep, and pharmacological sleep capture (chlorohydrate, doxylamine, and hydroxyzine HCl) on the probability of detecting epileptiform abnormalities in EEGs were compared.

Ethical approval for this study was obtained from our institutional ethical committee (77082166-302.08.01-2017-264).

2.2. Statistical analysis

All analyses were performed using IBM SPSS (v22.0). Data are expressed as percentiles, frequencies, mean, standard deviation (SD), median, minimum–maximum values. A chi-square test was used for between-group comparisons of qualitative data, and Student's t-test was used to compare quantitative data between the 2 groups. Significance level (P value) was determined to be at the ≤0.05 level.

3. Results

3.1. Population demographics

We reviewed a total of 2045 consecutive pediatric EEGs of 1604 patients aged between 2 months and 20 years (mean 8.7 years, SD 5.17); 862 were males (53.7%). Two hundred and twenty-five records were excluded (72 records for patient age younger than 2 months, 125 records because of insufficient data, and 28 records due to less than 20 min recording time). Patients in the series underwent routine EEGs; 857 (42%) patients underwent sleep EEGs, 594 (29%) patient had both sleep and awake EEGs, and 594 (29%) had awake EEGs. More than half of the patients (62%) had only 1 EEG recording, whereas 38% underwent repeated EEGs (range of 2–5). Overall, 90.5% (n = 1856) of EEGs were ordered by pediatric neurologists, 2.5% (n =

53) were ordered by pediatricians, 4.6% (n = 94) were ordered by child psychiatrists, and 2% (n = 41) of EEGs were ordered by other specialized pediatricians.

3.2. At the request of referring physicians

EEGs were performed on a wide spectrum of cases including children with unclear spells, first seizure, established epilepsy, intractable epilepsy, headaches, behavior problems, etc. Established epilepsy (61.4%) accounted for the majority of indications for EEG. The detailed clinical features and EEG indications included in this study are presented in Table 1.

Eighty-seven percent of the established epilepsy patients (n = 1100) were receiving at least 1 antiepileptic drug (AED) at the time of screening. The number of AEDs used per patient ranged from 1 to 4 with a mean of 1.36 AEDs. Monotherapy was used for 698 (76.7%) patients.

3.3. Sleep achievement

Of the total 2045 routine EEGs, sleep was obtained in 1451 (70.1%) of these patients; in 536 studies (26.2%), with pharmacotherapy (either chlorohydrate, doxylamine, or hydroxyzine HCl), and in 408 (28.1%), spontaneous sleep; 594 (29.9%) of the EEGs were done while the patient was awake. Sleep deprivation was performed in 488 (23.8%) patients, and 18 (0.8%) patients had been given pharmacotherapy after sleep deprivation. Of these, 29% were awake throughout the recording, whereas 41.9% had achieved sleep during the EEG recording. Sleep occurred in 90% of children younger than 6 years versus 58% of children older than 12 years. The relationship between age, sleep, and abnormal EEG rate in this study is given in Table 2.

Overall, 46.8% of EEG tracings with sleep and 35% of EEGs without sleep showed no abnormalities. Similarly, the probability of abnormalities on EEGs was higher in EEGs with sleep (chi-square (X^2); $P < 0.001$). There is no significant difference between the proportion of EEGs showing abnormalities and sleep protocol (spontaneous 48%, pharmacotherapy 46%, sleep deprivation 48%).

EEG abnormalities were noted in 892 (43.6%) of all EEGs (54.2% of the definite cases of epilepsy, 29.4% of the clinically suspected cases, 9.3% nonepileptic paroxysmal events, 20% nonepileptic chronic central nervous system (CNS) disorder cases, 62.7% acute CNS disorder cases, 8.5% complex and simple febrile patients). Background disturbances (diffuse or focal) were seen in 111 (12.4%) of EEGs. Epileptiform activity was noted in 781 (38.2%) of all EEGs (50.1% of the definite cases of epilepsy, 24.5% of the clinically suspected cases, 6.6% nonepileptic paroxysmal events, 13.5% nonepileptic chronic CNS disorder cases, 73.7% acute CNS disorder cases, 8.5% typical–atypical febrile patients). Of the total epileptiform activities seen in 781 recordings, 531 (67.9%) were focal, 157 (20.6%) were generalized, and 93 (11.9%) were multifocal. The focal epilepsies included temporal lobe (24%), frontal lobe (16.5%), occipital lobe (13%), and parietal lobe (7.5%). Childhood epilepsy with centrotemporal spikes was seen in 214 (40%) patients. The clinical indications and detailed EEG results included in this study are presented in Table 3.

3.4. Effect of duration of EEG recording

A total of 485 (23.7%) EEG recordings were long recordings. Epileptiform activity was seen in 196 of 485 (40.5%) EEG recordings. The EEG results according to the recording time are given in the Figure. Of the 196 abnormal EEGs, 187 (95%) were abnormal, and abnormality was captured within the first 20 min of recording, 5 (2.5%) showed abnormalities only between 20 and 30 min, and only 4 (2%) showed abnormalities over 30 min. All 4 of the recordings that captured abnormalities over 30 min had

Table 1. Relationship between the clinical indications and EEG results (n = 2045).

Clinical indications	Total n (%)	Normal n (%)	Abnormal n (%)				
			Focal spikes	Multifocal spikes	Generalized epileptiform discharges	Focal or diffuse background disturbances	Total
Established epilepsy	1257 (61.4)	576 (45.9)	424 (33.8)	77 (6.1)	128 (10.1)	52 (4.1)	681 (54.1)
Suspected epilepsy	302 (14.7)	213 (70.5)	54 (17.8)	2 (0.7)	18 (5.9)	15 (5)	89 (29.5)
Nonepileptic paroxysmal events	181 (8.8)	164 (90.6)	10 (5.5)	0	2 (1.1)	5 (2.7)	17 (9.4)
Acute CNS disorders	118 (5.8)	44 (37.3)	28 (23.7)	12 (10.2)	2 (1.7)	32 (27.1)	74 (62.7)
Nonepileptic chronic CNS disorders	140 (6.8)	112 (80)	12 (9.7)	1 (0.7)	6 (4.2)	9 (6.4)	28 (20)
Febrile seizure	47 (2.3)	43 (91.5)	2 (4.3)	1 (2.1)	1 (2.1)	0	4 (8.5)
Total	2045	1153 (56.3)	531 (59.5)	93 (10.4)	157 (17.6)	111 (12.4)	892 (43.7)

Table 2. The relationship between age, sleep, and abnormal EEG rate.

Age	Total n (%)	Sleep EEG n (%)	X^2	Abnormal EEG n (%)	X^2
2 months–1 year	122 (6)	119 (97.5)		53 (43.4)	
1–3 years	196 (9.6)	194 (99)		69 (35.2)	
3–6 years	318 (15.5)	289 (90.9)		157 (49.4)	
6–9 years	379 (18.5)	250 (66)		204 (53.8)	
9–12 years	315 (15.4)	184 (58.4)	0.001	153 (48.6)	0.001
>12 years	715 (35)	415 (58)		257 (35.9)	
Total	2045	1451 (70.1)		892 (43.6)	

generalized spike and wave epileptiform activity, especially during sleep. Latency to first spike in these 4 EEGs varied between 32 and 44 min. Three patients already had the diagnosis of epilepsy, but 1 was ordered in a patient with intellectual disability.

3.5. Subsequent EEG recording

More than half of the patients (n = 1269, 62%) had only 1 EEG recording, whereas 776 (38%) underwent repeated EEGs ranging between 2 and 5 times. Four hundred and fifty-two (n = 452/776, 58.2%) of the repeated EEGs showed an abnormality, whereas 442/1269 (34.8%) of the isolated EEG recording group showed abnormalities. There was a statistically significant difference between the 2 groups in the rate of detection of abnormalities. In addition, 11.9% of subsequent EEGs made a contribution to the diagnosis. Twenty-three patients had normal awake EEGs, while their repeated EEG during sleep showed an abnormality: 12 focal, 7 generalized epileptiform discharges, and 4 background disturbances.

3.6. Activation procedure

Photic stimulation was applied in 1467 (71.1%) EEG recordings as an activation procedure. Photoparoxysmal response (PPR) was seen in 16 (1.1%) patients; photic driving was identified in 124 (8.4%) EEGs. Two patients who had a generalized epilepsy diagnosis had clinical seizures during photic stimulation. PD was more common in children older than 12 years (13.1%), while PPR was more common in children in the 6–9-year-old group (1.5%). PPR or PD was rarely found in the 1–3-year-old group (0.66%).

Hyperventilation was applied in 603 (29.4%) EEGs. Slowing of diffuse background activities was seen in 169 EEGs, while focal slowing was seen in 16 patients' EEGs. Generalized epileptiform discharge was observed in 24 of 603 EEGs (3.4%).

4. Discussion

This 1-year retrospective study of the clinical utility of EEG recording in pediatric population demonstrated several important points. In this cohort of 2045 consecutive EEGs, we found that: 1. Sleep EEG is superior to awake EEG in detecting epileptic abnormalities when the clinical suspicion of epilepsy is high; 2. The majority of abnormalities on routine EEG are seen within the first 20 min of recording but increasing EEG duration to 30 min significantly increases the yield of EEGs; and 3. Nearly half of the recorded EEGs showed some kind of abnormality. Our findings expanded on our previous study, which was held for 3 months and consisted of 534 EEGs (3). We previously noted that standard interictal EEG is being overused during evaluation of various neurologic disorders in children and adolescents, and a normal EEG is highly predictable in children with nonepileptic conditions. Overall, 63.8% of the EEG records were normal; epileptiform activity was noted in 37.1% of the definite cases of epilepsy and 13.2% of the clinically suspected cases (3). These findings encouraged us to formally investigate the profile of changes in the use of EEG over years in the pediatric population. To our knowledge, the current study is the largest follow-up report on the utility of EEG in the pediatric population, and it provides physicians with a framework for interpreting the clinical significance of EEG findings in children with various neurological disorders.

We have compared our previously reported data with our recent results in Table 4. While the number of EEG requests were similar in the 2 surveys, the apparent increase in the rate of capturing abnormalities could be explained by improved ascertainment rate and diagnostic accuracy in EEGs (3). The epileptiform abnormalities rates of suspected epilepsy and established epilepsy in this study were noted to be significantly higher than those reported in our previous study ($P < 0.01$). In our previous study, epileptiform activity was not detected in most of the

Table 3. The clinical indications and detailed EEG results.

Clinical Indications	Total n (%)	Normal n (%)	Abnormal n (%)				
			Focal spikes n (%)	Multifocal spikes n (%)	Generalized epileptiform discharges n (%)	Focal or diffused background disturbances n (%)	Total n (%)
Established epilepsy	1257 (61.4)	576 (45.9)	424 (33.8)	77 (6.1)	128 (10.1)	52 (4.1)	681 (54.2)
Suspected epilepsy	302 (14.7)	213 (70.5)	54 (17.8)	2 (0.7)	18 (5.9)	15 (5)	89 (29.4)
NEPO¶							
Headache	60	53 (88.3)	4	-	-	3	7 (11.6)
Syncope	59	54 (91.5)	2	-	2	1	5 (8.4)
Night terror	18	16 (88.9)	1	-	-	1	2 (11.1)
Breath holding spells	10	9 (90)	1	-	-	-	1 (10)
Sleep disorder	10	8 (80)	2	-	-	-	2 (20)
Cyclic vomiting	7	7 (100)	-	-	-	-	-
Dizziness	12	12 (100)	-	-	-	-	-
Psychogenic nonepileptic seizures	5	5 (100)	-	-	-	-	-
Total	181(8.8)	164 (90.6)	10	-	2	5	17 (9.4)
CCNS‡							
ADHD	42	36 (85.7)	2	-	2	2	6 (14.3)
Autism spectrum disorders	16	13 (81.2)		-	1	2	3 (18.7)
Mental–growth retardation	20	15 (75)	2	1	1	1	5 (25)
Learning disability	9	5 (55)	2	-	-	2	4 (44)
Speech–language disorder	19	16 (8.4)	2	-	-	1	3 (15.7)
Tic disorder	12	10	1	-	-	1	2 (16.6)
Enuresis	4	4 (100)	-	-	-	-	-
Obsessive compulsive disorder	7	7 (100)	-	-	-	-	-
Psychiatric disorder organicity	5	4 (100)	-	-	1	-	4 (100)
Visual perception disorder	1	-	-	-	1	-	-
Syndrome	5	2 (40)	3	-	-	-	2 (40)
Total	140(6.8)	112 (80)	12	1	6	9	112 (80)
ACNS†							
Encephalopathy	56	16 (28.5)	16	4	2	18	16 (28.5)
Metabolic disorder	21	10 (47.6)	4	4	-	3	10 (47.6)
Trauma	9	3 (33.3)	1	-	-	5	3 (33.3)
Acute psychosis	2	2 (100)	-	-	-	-	2 (100)
Hallucination	3	3 (100)	-	-	-	-	3 (100)
HIE§	18	6 (33.3)	6	3	-	3	6 (33.3)
Intracranial hemorrhages	9	4 (44.4)	1	1	-	3	4 (44.4)
Total	118(5.8)	44 (37.3)	28 (23.7)	12 (10.2)	2 (1.7)	32 (27.1)	44 (37.3)
Febrile seizures	47(2.3)	43 (91.5)	2	1	1	-	43 (91.5)
TOTAL	2045	1153 (56.3)	531 (59.5)	93 (10.4)	157 (17.6)	111 (12.4)	1153 (56.3)

†: ACNS, Acute central nervous system disorders; ††: ADHD, Attention deficit and hyperactivity disorder; ‡: CCNS, Nonepileptic chronic central nervous system disorders; §: HIE, Hypoxic ischemic encephalopathy; **¶:** NEPO, Nonepileptic paroxysmal events.

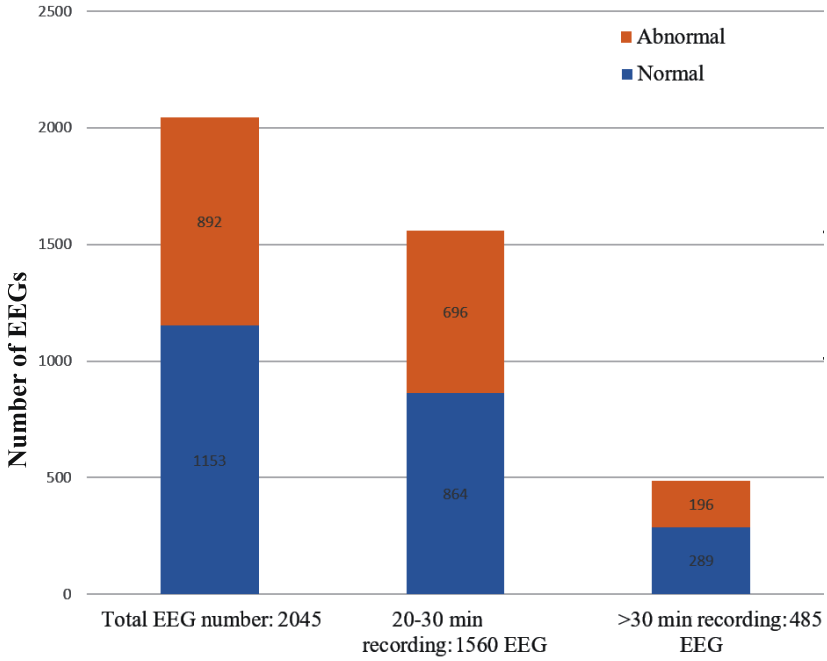

Figure. Results of EEGs according to recording time. A total of 485 (23.7%) EEG recordings were long recordings. Epileptiform activity was seen in 40.5% of long EEG recordings, while it was seen in 44% of EEGs of 20–30 min recording time. There were no significant statistical differences between the 2 groups in capturing EEG abnormalities ($P < 0.05$).

Table 4. The comparison of our previous and current study according to epileptiform activity.

	Present study		Previous study		P-values
	Total; n	Epileptiform activity; n (%)	Total; n	Epileptiform activity; n (%)	
Established epilepsy	1257	681 (54.1)	167	62 (37.1)	0.01
Suspected epilepsy	302	89 (29.5)	181	24 (13.2)	0.01
Febrile seizure	47	4 (8.5)	20	2 (10)	
ADHD	42	4 (9.5)	49	3 (6.1)	
Headache	60	7 (11.6)	43	0	
Syncope	59	5 (2.9)	19	0	
Learning disability	9	2 (22)	11	0	
Tic disorder	12	1 (8.3)	8	1 (12.5)	
Sleep disorder	10	2 (20)	6	1 (16.6)	
Others	245	55 (22)	30	2 (6.6)	
Total	2045	781 (38.2)	534	95 (17.7)	

children with nonepileptic conditions, but the abnormality detection rate has been found to be significantly increased in NEPO and CCNS patients, especially in syncope, headache, and learning disabled patients in our current study. On the other hand, the number of EEG requests for NEPO and CCNS was found to be notably decreased in our recent study. This may depend on the fact that most EEGs are ordered by a pediatric neurologist. Clinical factors may affect the preferred diagnostic approach of the practicing pediatric neurologist or others.

Gastroesophageal reflux disease (GERD) can mimic epileptic seizure and is seen very often among PENS in the clinical pediatric neurology practice. Recently, one Pediatric Neurology Center reported 16 pediatric patients with only GERD who were misdiagnosed as having epileptic seizures. In the present study, we have 7 patients who had complained of cyclic vomiting among 181 patients with paroxysmal nonepileptic events; however, only 1 patient had a GERD diagnosis (6).

The optimal duration of routine EEG recording in children is still a matter of argument. The ACNS guidelines recommend at least 20 min of artifact-free recording as necessary for routine EEG, and the International League Against Epilepsy (ILAE) recommends at least 30 min recording should be performed for baseline EEGs (4,7). Some studies have evaluated the effect of longer recording on the detection of EEG abnormalities, and they have found that most epileptiform abnormalities (37%–89%) are seen in the first 20 min of recording (5,8). On the other hand, some studies have evaluated short EEG recordings, and claim that reducing the recording time of standard EEGs to 15 min may fail to register some abnormalities (9). In our study, 485 (23.7%) of EEGs were recorded for over 30 min. Epileptiform activity was seen in 196/485 (40.2%) of EEG records. The majority of all EEG abnormalities (98%) were detected in the first 30 min, but 4 (2%) of the abnormal EEGs showed first abnormalities only after 30 min. Latency to first spike in these 4 EEGs ranged between 32 and 44 min; all of them had shown a generalized epileptiform activity, especially during sleep. Three patients already had the diagnosis of epilepsy, but 1 of the EEG requests in these patients was mental retardation.

A review of the literature shows that the prevalence rates of interictal epileptiform discharges (IIED) even in children with established epilepsy vary from 29% to 56% (10,11). The higher prevalence rates are observed in repeated EEGs. This is an expected outcome, because patients who still have the same neurological complaint or condition would warrant a repeated referral for EEG, which would increase the rate of IIED. In the study by Mohammed et al., repeated EEGs were found to be a factor that significantly increased the likelihood of abnormal EEGs (1). This is consistent with our previous data, with a 58.2% rate of detecting abnormalities with a repeated EEG.

Clinical practice guidelines recommend a standard sleep–wake recording in neurological disorders (7,12,13). Interictal discharges are seen more commonly during sleep, with the greatest activation seen during nonrapid eye movement sleep (nREM). Sleep deprivation also facilitates both epileptiform abnormalities and seizures (2,14). Recent clinical practice guidelines for EEG have supported subsequent EEG recording with sleep deprivation after a noninformative routine EEG (7,12). A review of the literature demonstrates that EEG laboratories using only awake EEGs as routine EEG recordings report a relatively low prevalence of epileptiform discharges, whereas the higher prevalence of epileptiform discharges is seen in those with more prolonged sleep recordings (14,15). Some studies have found that sleep deprivation is more effective for producing abnormalities in EEG than sleep obtained with pharmacotherapy (15). Sleep EEG was performed in 70% of patients; nearly one-third of recordings were performed with pharmacotherapy and one-third of recordings with sleep deprivation. We did not identify a significant difference between sleep protocols in terms of capturing epileptiform abnormalities. We addressed the use of sleep EEG for evaluating neurological disorders. In line with previous studies that demonstrated the additional diagnostic effect of subsequent sleep-deprived EEGs, we also assessed the clinical utility of the common practice of obtaining an awake EEG first and a subsequent sleep-deprived EEG. Clinical factors may affect the preferred diagnostic approach of the practicing pediatric neurologist or others.

We have some limitations in this study; first, our study was designed retrospectively, and our activation procedures were not applied properly to evaluate the effects of HV and IPS on epileptic discharges. Second, we could not use a strict protocol for sleep deprivation, which changes according to the age of the patient. Third, we evaluated whether IIED was seen in the first 20 min; however, we could not record the exact timing of the first IIED. There is a need for prospective studies in large pediatric case series, which should include established strict protocols to apply on all activation techniques.

In conclusion, we claim that the use of EEG has become more selective and the detection of abnormalities has increased during the last decade due to the increasing number of pediatric neurologists. We think that a careful clinical evaluation by a pediatric neurologist should precede the decision to order an EEG. Subsequent EEG recordings and sleep EEGs may contribute to the yield of EEG results. A duration of 20–30 min of EEG recording is sufficient, with inclusion of nREM sleep records, and may lead to more cost-effectiveness in the use of EEGs.

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