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Why do we do EEG? Experience of two years from a new pediatric neurology center

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Abstract

Electroencephalography (EEG) is very important for pediatric neurologists. The request reasons and results of EEGs from a newly established center were enrolled. Total of 2021 (1299 sleep + awake, 652 sleep, 70 awake) EEGs evaluated. Patients included 1005 girls and 1016 boys. 65% of the EEGs were normal and 30% was epileptic. Electroencephalography was performed due to epilepsy, fainting, first afebrile seizure, febrile seizure, speech retardation, dizziness, headache, movement disorders, gaze abnormalities, behavioral disorders, tremor, sleep disorders, tic, autism spectrum disorders, infantile spasm, encephalopathy, vision loss and abdominal pain in decreasing order. Significantly more common EEGs were performed due to tics (p:0,006), autism spectrum disorders (p:0,04) and speech retardation(p:<0,001) in boys and due to syncope (p:0,001) and dizziness(p:0,038) in girls. When EEG requests were examined by age groups, statistical significance was found. The EEG requests were parallel to the distribution of epileptic and non-epileptic events seen in that age group.

Keywords: electroencephalography, nonepileptic events, seizure

1. Introduction

Electroencephalography (EEG) is an indispensable tool in pediatric neurology practice. Electroencephalography is used to differentiate epileptic and non-epileptic activity, to define epilepsy type and epileptic syndromes, to follow up patients using anti convulsive drugs, and to decide on drug discontinuation1. It may be useful for prediction of long-term outcome or recurrence.

Electroencephalography is a noninvasive, readily available and inexpensive investigation to study the neuronal dysfunction and abnormal cortical excitability in children who present with seizures (1).

Electroencephalography must not be used to exclude epilepsy since epilepsy is a clinical condition or to determine the efficacy of the anti convulsive medication (1).

Who made the EEG request, may cause changes in the reasons of EEG request. As pediatric neurologists working in a newly established center, we wanted to evaluate the reasons and results of the EEGs performed in 2 years.

2. Material and methods

Electroencephalographies taken at the Maternity and Children Hospital between June 2018 and June 2020 were evaluated according to the reasons for request, age, gender and EEG results.

Electroencephalographies were recorded with an 18-channel EEG device (Neurofax QP-112AK ver.07-21 Nihon Kohden Corporation). Electrodes were placed according to the 10-20 international system (Bipolar and reference montage). Sleep, wakefulness and sleep + wakefulness EEG recordings were taken after sleep deprivation. Activation methods of hyperventilation and intermittent photic stimulation were done routinely. For both sleep and wakefulness records of at least 20 minutes were taken. The families were given a written document on what to do before the EEG procedure, and their consents were obtained for the EEG procedure.

2.1 Ethics

Informed consent were taken from the parents/guardians of the patients. The study was conducted in concordance with the Declaration of Helsinki-Ethical Principles for Medical Research Involving Human Subjects. Ethical approval was obtained from the local Clinical Research Ethics Committee for the study (Date: 09.11.2020, Number: 04).

2.2 Statistical analysis

All analyses were performed using IBM SPSS (v22.0) package program. Data are expressed as percentiles, frequencies, mean, standard deviation (SD), median, minimum–maximum values. Pearson chi-square test was used for between-group comparisons. Significance level (p value) was determined to be at the ≤0.05 level.

3. Results

A total of 2021 EEG records were evaluated in the study.

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1299 (64.3%) sleep + awake EEG 652 (32.3%) sleep EEG and 70 (3.5%) awake EEG were performed. Of the patients, 1005 (49.7%) were female and 1016 (50.3%) were male. Electroencephalography results were interpreted as: normal 1321 (65.4%), epileptic 598 (29.6%) and uncertain (suspicious) 102 (5.0%).

Electroencephalographies in which the EEG recording was not completely normal but sharp wave activity not evaluated as epileptic or background slowing was accepted as suspicious EEG and control EEG was requested. There were also repeated EEG records: 2 times for 243 patients, 3 times for 64 patients, 4 times for 13 and 6 times for 3 patients (totally 748 EEG). We found that patients with 3 or more EEG records were patients with refractory epilepsy, status epilepticus, epileptic encephalopathy, and status epilepticus in early sleep (ESES). Only 1.8% of the patients were under the age of 2, the other 20% were under 2 years old, 50% were between 2-12 years old, and 30% were >12 years old (12-18 years).

Electroencephalography was performed most frequently due to epilepsy. Other causes of EEG request and EEG results are given in Table 1. There was a significant difference between the reasons for requesting EEG according to gender and age categories.

Table 1. The indications for EEG request and the EEG results

	No of EEG		EEG results		
	n	%	Epileptic N, (%)	Normal N, (%)	Suspicious N, (%)
Epilepsy	**803**	**39.7**	382 (47.60%)	388 (48.30%)	33 (4.1%)
Syncope	**205**	**10.1**	33 (16.10%)	158 (77.10%)	14 (6.8%)
First afebrile seizure	**190**	**9.4**	42 (22.10%)	135 (71.10%)	13 (6.8%)
Febrile seizure	**143**	**7.1**	25 (17.50%)	111 (77.60%)	7 (4.9%)
Language impairment	**95**	**4.7**	14 (14.70%)	72 (75.80%)	9 (9.5%)
Vertigo	**93**	**4.6**	16 (17.20%)	75 (80.60%)	2 (2.2%)
Breath holding spell	**76**	**3.8**	5 (6.60%)	68 (89.50%)	3 (3.9%)
Headache	**67**	**3.3**	13 (19.40%)	51 (76.10%)	3 (4.5%)
Movement disorder	**49**	**2.4**	7 (14.30%)	41 (83.70%)	1 (2.0%)
Newborn seizure	**48**	**2.4**	8 (16.70%)	38 (79.20%)	2 (4.2%)
Abnormal eye movement	**44**	**2.2**	6 (13.60%)	34 (77.30%)	4 (9.1%)
Behavioural disorder	**35**	**1.7**	9 (25.70%)	22 (62.90%)	4 (11.4%)
Tremor	**34**	**1.7**	8 (23.50%)	24 (70.60%)	2 (5.9%)
Sleep disorder	**32**	**1.6**	3 (9.40%)	29 (90.60%)	0
Tic	**30**	**1.5**	2 (6.70%)	27 (90.00%)	1 (3.3%)
Autism spectrum disorder	**24**	**1.2**	4 (16.70%)	17 (70.80%)	3 (12.5%)
Other	**15**	**0.7**	8 (53.30%)	6 (40.00%)	1 (6.7%)
Infantile spazm	**14**	**0.7**	10 (71.40%)	4 (28.60%)	0
Encephalopathy	**8**	**0.4**	1 (12.50%)	7 (87.50%)	0
Vision loss	**8**	**0.4**	1(12.50%)	7 (87.50%)	0
Masturbation	**4**	**0.2**	0	4 (100.00%)	0
Abdominal pain	**4**	**0.2**	1(25.00%)	3 (75.00%)	0
Total	**2021**	**100%**	598 (29.60%)	1321 (65.40%)	102 (5%)

Table 2. Statistically significant EEG request reasons according to gender

	Total	Male (n, %)	Female (n, %)	P*
Tic	30	23 (76.7%)	7 (23.3%)	0.006
Autism spectrum disorder	24	17 (70.8%)	7 (29.2%)	0.043
Language impairment	95	65 (68.4%)	30 (31.6%)	<0.001
Syncope	205	80 (39%)	125 (61%)	0.001
Vertigo	93	37 (39.8%)	56 (60.2%)	0.038

*Pearson chi-square

Table 3. Statistically significant EEG request reasons according to age categories

	Newborn	1-24 months	2-6 years	6-12 years	12-18 years	P*
Epilepsy	10	92	130	326	244	<0.001
First afebrile seizure	6	49	35	52	48	0.012
Febrile seizure	0	58	49	31	5	<0.001
Breath holding spell	2	46	12	10	6	<0.001
Movement disorder	0	20	7	12	10	0.001
Syncope	0	7	14	60	124	<0.001
Language impairment	0	13	54	20	8	<0.001
Headache	0	1	7	25	34	<0.001
Vertigo	0	1	4	30	58	<0.001
Newborn seizure	16	25	2	4	1	<0.001
Behavioural disorder	0	0	3	15	17	0.008

*Pearson chi-square

4. Discussion

In this article, we aimed to find out the EEGs taken in our center, to whom and why we had EEG and what our rate of epileptic activity.

Epilepsy is a clinical diagnosis. Although EEG is not necessary for the diagnosis of epilepsy, it is useful for classification of epilepsy, determination of the severity of epilepsy and differentiation from non-epileptic paroxysmal events. Epileptiform discharges may be found in EEGs of the healthy people but this does not mean they are epileptic. Epileptiform discharges are found in 5.6% of normal healthy children and 0.5% of adults without any event of seizure (2).

Among children with new onset seizures, 18-56% display epileptiform discharges on initial EEG and 15% will never show abnormal findings (3).

In our study, epileptic activity was detected in 30% of all EEGs and 48% of patients with epilepsy. The rate of epileptic EEGs taken with the suspicion of the first afebrile seizure remained at 22%. In a study from Turkey where EEG recording has been performed for a long time, 38% of 2045 EEGs were found to be epileptic. EEG was epileptic in the 54% of patients with epilepsy and 29% of first afebrile seizures (4).

We determined that our epileptic rates were slightly lower, but there was no significant difference. In another retrospective study from Turkey; in which 1000 patients aged 5-18 years with seizures and seizure-like complaints were examined; 14% of all EEGs was epileptic and this ratio was 39% in the patients who were thought to have seizures (5). We thought the difference was due to study design.

Considering the distribution of EEGs by age group, the group with the highest incidence of epilepsy was school age and the second was adolescents.

The number of EEGs taken on suspicion of seizures was similar in all age groups except newborn period. EEG scan for FS was most common in infants and up to 6 years of age. Most of the EEGs taken for the breath holding spells were infants. Sleep disturbance was distributed to all age groups except newborn. Tic was most common reason for request in the 6-12 age group, tremor was most common in the 12-18 age group. Movement disorders were most common in the infant group and least common in the toddler. Shuddering attack in infancy, migraine equivalent syndromes like benign paroxysmal vertigo and torticollis, Sandifer syndrome and many paroxysmal non-epileptic conditions were in this group. Syncope was most common reason in the adolescent with increasing rate according to ages. Speech retardation was the most common reason for EEG request in the 2-6 age group. Headache, dizziness, disorientation were found to be the reasons for EEG evident in school age children and adolescence. The reason for the statistical difference according to age groups was that the mentioned events were more common in that age group. We did not encounter a different result than expected here.

According to gender, we found that syncope was a statistically significant reason for more EEG requests in girls. Dizziness/vertigo was also higher in girls, but it was not statistically significant. Tic, speech retardation and autism spectrum disorders (ASD) were the causes of EEG requests at a significantly higher rate in males. Since these disorders are seen more frequently in male, it was expected.

In studies on EEG duration and time, it is seen that detection rate of epileptic activity increases as the duration of EEG recording increases (6-8).

In the first 20 minutes, the epileptic activity can be detected by 45-48%. The detection rate increases by 19% after 30 minutes of the interictal EEG8. Ambulatory EEG records of 20-30 minutes seems to be appropriate for the outpatient clinic conditions. Our sleep+wake EEG recordings were taken as minumum 40 minutes (20 minutes for each).

All of our sleep EEGs were taken after sleep deprivation (all night or less depending on the age of the patient (9). In case of difficulty in sleeping due to co-morbidities such as ASD, attention deficit hyperactivity disorder (ADHD), cerebral palsy, mental retardation, chloralhydrate was given to patients for sedation. Many drugs are used for EEG recordings to supply sedation and sleep, chloralhydrate is one of the best known, it is effective and safe (10).

In the study of Orgun et al. (4), when the EEG was evaluated according to the reasons for the request, it was found to be epileptic at a rate of 8.5% in FS, 16% in tic, 15.7% in speech disorder, 44% in learning disability, 20% in sleep disorder, 11% in night terror, 10% in breath holding spells, 8.4% in syncope, and 11.6% in headache.

In the study of Kamaşak et al. (5), EEG abnormalities were found in 8% of speech disorder, 4% of headache, 7% of syncope, 6% of sleep disorder, 10% of movement disorder and 13% of learning disability.

EEG was requested under different headings in different studies for similar patients who applied. For example, sleep disorder can be taken as a single heading, or it can be named as night terror and sleep disorder. Even involuntary movements in sleep can be classified as sleep disorder or movement disorder.

In different clinics, patient distribution may vary and affect these rates. EEG requests are made only by child neurologists in some clinics, and additionally by child and child psychiatry specialists in some clinics. The branch of the requester (child neurologist or pediatrician) may affect these rates. We think that only EEG is requested by a pediatric neurologist in our clinic increases this rate. In the other two studies conducted in Turkey, the rate of finding epileptic in headache is very different from each other, such as 11.6% and

4% (4, 5). In our study, a higher result of 19% was found. We can attribute this not to all headaches, but to EEG request in patients selected by a pediatric neurologist or to the presence of findings suggestive of seizures in the medical history.

From the point of view of speech retardation, things get even more complicated. In a meta-analysis study 33.5% of children with language impairment but without epilepsy were found to have isolated epileptiform activity in sleep EEGs. This corresponded to 6 times greater than for typically developing children. The overall pooled prevalence of epileptiform activity was 27.3%. A wide variation between the prevalence estimates was, to a certain degree, explained by type of impairment such as 8.1% in speech impairments, 25.8% in language impairments, and 51.5% in language regression (11).

In a prospective study in which 24 children with speech disorders were evaluated by sleep EEG, epileptiform activity was found in 7 children and abnormal EEG in 5 children (12). In our study, 14.7% (14/95) of the children had epilepsy, and 9.5% (9/95) had suspicious epileptic activity. The rates were found similar. In another study, 7/54 (13%) of cases with developmental speech-language disorder had an epileptic EEG, compared with 3/45 (6.7%) of healthy controls, yielding an odds ratio of 2.1. They reported a weak association between epileptic EEGs and speech-language disorder but significant association between EEG status and Performance IQ (13). In another recently published study 55 children with developmental language disorders were enrolled, 33 (%61.1) of them also had motor coordination disorders and 39 (70.9%) of them had diagnosis of ADHD. Awake EEG examinations showed epileptiform discharges in 36.4% and nocturnal EEG and polysomnography (PSG) recordings enhanced epileptiform discharges in up to 55.6% of the children (14). The rates are found very high in this study. The comorbidities of the children (ADHD, mental retardation, motor developmental problems) might be the cause of epileptiform discharges. Epileptic activity is observed with a rate of 52% in ASD and 42% in ADHD (15). This issue is still not fully clear (16).

As it can be understood from the publications we mentioned about speech retardation, it is necessary to examine specific groups homogeneously in order to talk about EEG. The differences between the publications are also due to the heterogenous groups. However, our study was found to be compatible with the literature on most subjects.

EEG was performed in 143 patients with febrile seizures, and 17.5% were found to be epileptic. There are no RCTs related to the time of EEG in complicated FS. Electroencephalography was performed to the patients with complicated FS and recurrent FS due to panic states of the families, recurrent FS, and family history of epilepsy in some patients (17).

It has been reported that EEG characteristics in FS can predict the development of epilepsy in the later stages (18). Kanemura et al. (19, 20) stated that epileptic activity in the frontal region had a significantly higher risk for the development of epilepsy than those with focal paroxysms in other regions.

In two studies (18, 20) investigating the development of paroxysmal activity on EEG and epilepsy in FS, 16.8% and 21.8% of epileptic paroxysmal abnormalities detected, respectively, and epilepsy occurred at a rate of 6.7 and 7.6 (18, 20). In our study, epileptic activity was found at a rate of 17.5 %, similar to the literature. We cannot comment on epilepsy since long-term follow-ups have not been performed yet.

Electroencephalography is often misused to justify the need for AED among children with clear history of paroxysmal non-epileptic events, headache, simple febrile seizures and head trauma. An abnormal EEG report should always be interpreted in clinical context.

In the study of Park et al. (21), the patients who underwent video EEG monitorisation (VEM) evatuated and overmedication rate was 27%. Children present age-specific non-epileptic paroxysmal patterns, recognition of the clinical aspects of them according to age plays a key role in diagnose. They recommend long-term VEM in differentiating epileptic from nonepileptic events to prevent overmedication and guide proper treatment. We found that there are differences in the EEG requests according to age and also gender. We used video assisted EEG but unfortunately we were unable to record for long time.

Today, studies are carried out on the EEG maturation and the use of EEG in terms of academic success (22, 23). The effect of anesthesia on the child's brain is another field of research (24). Electroencephalography can be used in patients with hearing loss (25), analysis in perceptional decision making can be made by using EEG (26). Since this study was retrospective, there was no EEG recording for research purposes.

The major limitation of this study is the lack of knowledge about the detailed results of the EEG recordings such as the background activity, hemispheric asymmetry, localization of the epileptic activity. Instead, normal, epileptiform discharges (spike and sharp waves) and suspicious was used.

Another limitation of the study was its retrospective design and lack of homogeneous groups.

Patterns of children in EEG can be mistakenly defined as epilepsy. It is very important to evaluate the EEG by the specialist, knowing the patient's age and clinic. Suspicious abnormalities in EEG can be diagnosed as epilepsy (27, 28).

Common reasons for misinterpretation of EEG include poor expertise, lack of good quality recording, inappropriate

indication, and absence of clinical correlation (29).

In our study, all EEGs were requested and evaluated by two pediatric neurologists. In order to minimize false readings, in cases where clinical information was insufficient or unclear, the expression suspicious was used in EEGs without definite epileptiform anomaly, and patients were referred for re-examination of EEG.

Electroencephalography was also performed for non-epileptic events that could be diagnosed clinically because it is a newly established center and the number of EEG recordings is low. We presented our own EEG request reasons and results by comparing them with the literature.

The answer to the question of why we take the EEG seems to be getting harder. For whatever reason, clinical information is required for EEG recording. Every paroxysmal activity on EEG should not be considered as epilepsy. Sleep EEG recording and activation methods are very valuable in children.

Although EEG is a very valuable auxiliary technique, we think that it would not be very useful to evaluate the results independently from the clinical evaluation. Also pediatric neurologist decision to order an EEG and reporting would lead to better consequences.

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