

# The role of electroencephalogram in childhood neurological disorders

Çocukluk çağı nörolojik bozukluklarda elektroensefalogramın rolü

Wael Hayel Khreisat<sup>1</sup>

<sup>1</sup>Queen Rania Al-Abdullah Hospital for Children, King Hussein Medical Center, Royal Medical Services, Amman

## Abstract

The aim of this study was to obtain a baseline for clinical application of electroencephalography (EEG) in children and to evaluate the EEG findings in children with various acute and chronic central nervous system disorders and nonepileptic events. EEG records of 250 patients were studied in Neurophysiology Departments of Queen Rania Al-Abdullah Hospital for Children in Jordan. For each patient who had undergone EEG the following data were recorded: age, sex, source of referral (inpatient or outpatient department), reason for EEG, diagnostic impressions, clinical presentation, the result of the EEG examinations and clinical correlation between the seizure type and EEG finding. Males (55%) were slightly outnumbered than females. The majority of cases were between 6-12 years. Total of 63.2% of all referrals for EEG were from outpatient clinics while inpatients accounted for 36.8% of referred cases, with Pediatric Neurology Department referrals being the highest (28.8%). Majority of diagnosis at referral were suspected epilepsy (80%) with epileptiform EEG abnormalities in 32%. Over all 64% the EEG records were normal, including all EEG records of children with syncope and headache. We conclude that there are many unnecessary routine EEG recordings in children. Investigation of epilepsy and acute encephalopathies appear to be the most valuable indications for routine pediatric EEG. EEG can be helpful in classification of seizures. Finding a way to reduce EEG requests is recommended.

**Keywords:** Electroencephalography; epilepsy; paroxysmal event

## Özet

Bu çalışmanın amacı, çocuklarda elektroensefalografinin (EEG) klinik uygulaması için temel sağlamak ve çeşitli akut ve kronik santral sinir sistemi bozuklukları ve epileptik olmayan olaylarda çocuklarda EEG bulgularını değerlendirmektir. Ürdün'deki Queen Rania Al-Abdullah Çocuk Hastanesi Nörofizyoloji Bölümleri'nde 250 hastanın EEG kayıtları incelendi. EEG yapılan her bir hasta için şu veriler alındı: yaş, cinsiyet, sevk kaynağı (yatan veya ayakta tedavi edilen), EEG için sebep, teşhis izlenimleri, klinik gösterge, EEG incelemelerinin sonucu, nöbet tipi ve EEG bulgusu arasında klinik korelasyon. Erkekler (%55) az da olsa bayanlardan daha fazla sayıdaydı. Hastaların büyük çoğunluğu 6-12 yaş arasındaydı. EEG için sevk edilen tüm hastaların %63.2'i ayakta tedavi yapan kliniklerden iken Pediatrik Nöroloji Anabilim Dalı sevkleri en yüksek (%28.8) olmak üzere sevk edilen hastaların %36.8'i yatan hastalardı. Sevkte teşhisin büyük çoğunluğu, %32'inde epileptiform EEG bozukluklarının olduğu epilepsi (%80) şüphesiydi. Senkop ve baş ağrısı olan bütün çocukların EEG kayıtlarının tümü dahil olmak üzere bütün EEG kayıtlarının %64'ü normaldi. Çocuklarda birçok gereksiz rutin EEG kayıtları olduğu sonucuna vardık. Epilepsi ve akut ensefalopatilerin araştırılması, rutin pediatrik EEG için en değerli endikasyonlar olduğu görülmektedir. EEG nöbetlerin sınıflandırılmasında yardımcı olabilir. EEG taleplerinin azaltılması için bir yol bulunması önerilmektedir.

**Anahtar kelimeler:** Elektroensefalografi; epilepsi; paroksizmal olay

## Introduction

A large number of publications have documented the type and frequency of electroencephalography (EEG) abnormalities in many different childhood disorders (1). EEG is very important in investigating children with various neurological disorders, particularly epilepsy. EEG is also a sensitive marker of diffuse cortical dysfunction as seen in toxic, metabolic or hypoxic encephalopathies (2).

Although the diagnosis of seizures and epileptic syndromes is primarily clinical, EEG often provides supportive evidence and helps in seizure classification (3). Many episodic events may simulate epilepsy including breath holding spells, syncope, tics, migraine related phenomena (e.g. benign paroxysmal vertigo), and psychogenic seizures (4). These events are associated with normal neurological examination and interictal EEG. However, although EEG is requested, complete description of the event can accurately identify the nature of these events in most cases (5).

**İletişim/Correspondence to:** Wael Hayel Khreisat, Queen Rania Al-Abdullah Hospital for Children, King Hussein Medical Center, Royal Medical Services, Amman, JORDAN  
Tel: +962 777 406777 wael\_khreisat@yahoo.com

Practice parameters endorsed by the American Academy of Pediatrics, recommended use of EEG after non febrile seizure in children, as standard of care (6). However, non-neurologist physicians differ in their expertise in clinically identifying seizures and many of them have a tendency to exclude almost any paroxysmal events such as syncope, tics or staring spells in attention deficit hyperactivity disorders in their definition of seizure (7). Moreover, EEG is now easily accessible because of its safety and low cost-benefit ratio (about 100 US dollars in Jordan) (8), this has led to an indiscriminate overuse of EEG in clinical practice decreasing the yield of clinical useful information. In one study, up to 40% of EEG requests were considered to be unnecessary (9). New software has been developed which facilitates interpretation of EEG results, though they are in the primitive stages and have not gained clinical acceptance yet.

The present study was done to obtain a baseline for clinical application of EEG in children who visit pediatric departments of Queen Rania Al-Abdullah Hospital regularly, to evaluate EEG findings in children with various acute and chronic central nervous system

(CNS) disorders, to assess relationship between clinical indications and EEG abnormalities and the predictability of a normal EEG result.

#### **Patients and Methods**

This retrospective study included 250 consecutive EEG records, which had been requested by pediatricians, child neurologists, and family doctors. All EEGs were performed in Neurophysiology Unite of Queen Rania Al-Abdullah Hospital for Children at Jordan.

For each patient who had undergone EEG, the following data were recorded: age, sex, source of referral (inpatient department or outpatient), reason for EEG, diagnostic impressions, clinical presentation, the result of EEG examinations and clinical correlation between the seizure type and EEG finding.

All EEGs were recorded digitally and reviewed according to standard clinical practices at the clinical neurophysiology laboratory of Queen Rania Al-Abdullah Hospital for Children. All studies utilized both bipolar and average referential montages performed by using an 8-16-channel digital recording with electrodes placed according to the international 10-20 systems. Routine EEG consisted of a normal recording of 20-30 minutes, including three minutes of hyperventilation and intermittent photic stimulation at various frequencies.

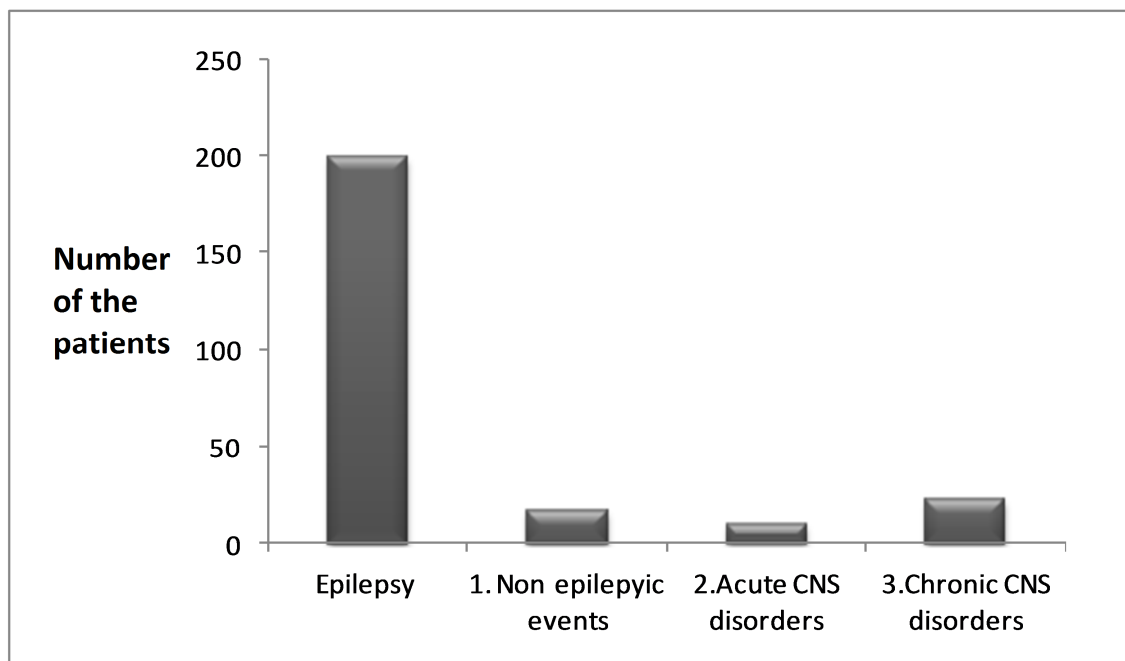
EEG abnormalities were classified to: focal or multifocal spike waves, generalized epileptiform

discharges, focal or diffuse background disturbance, burst suppression pattern and spindle coma. Requests for EEG were written requisitions, indicating the indication of the request. Clinical indications responsible for requesting the EEG can be divided into the following categories: (1) established epilepsy; (2) non-epileptic paroxysmal events (e.g. migraine, syncope, breath holding spells); (3) acute CNS disorders (e.g. toxic metabolic, infectious, or hypoxic encephalopathy); and (4) non-epileptic chronic CNS disorders (e.g. mental retardation, autism, attention disorder).

In patients with both clinical and EEG evidence of epilepsy, seizures were classified according to international classification of the International League Against Epilepsy (ILAE) (10). At the end of each assignment, the EEG requisitions were reviewed for clinical correlation. At this stage, the relationship between the clinical indication and EEG result was recorded for further studies.

#### **Results**

A total number of 250 recorded EEGs were studied. Among these, males slightly outnumbered females (55% males). The patients ranged in age between four months and 14 years with patients less than 10 years constituted more than 50% of the study populations and with majority of cases between 6-12 years. The age distribution of all patients is as shown in Table 1.



**Figure 1.** Reason for referral electroencephalography. 1. Such as syncope, breathe holding, staring migraine; 2. like: toxic metabolic, infectious, or hypoxic encephalopathy; 3. like: autism, attention disorder, learning disability.

**Table 1.** Age range in all patients compare with normal EEG.

Age (years)	Number (%)	Normal EEG (%)
> 1	38 (15.2)	26 (10.4)
1-3	48 (19.2)	24 (9.6)
3-6	42 (16.8)	29 (11.6)
6-9	52 (20.8)	31 (12.4)
9-12	38 (15.2)	23 (9.2)
12-14	32 (12.8)	27 (10.8)
Total	250 (100.0)	160 (64.0)

Total of 63.2% of all referrals for EEG were from outpatient clinics while inpatients accounted for 36.8% of cases. Referrals were from various specialties like, pediatrics, psychiatry, neurosurgery and intensive care unit, with pediatric neurology department having the highest referral rate (28.8%). The source of referrals of patients for EEG is as shown in Table 2.

**Table 2.** Source of patients referral for EEG.

Department	In patient	Out patients	Total
Neurology	25 (10.0)	47 (18.8)	72 (28.8)
Neurosurgeon Intensive Care Unit	18 (7.5)	20 (8.0)	38 (15.2)
Emergency	-	32 (12.8)	32 (12.8)
Psychiatric General pediatrician	6 (2.4)	17 (6.8)	23 (9.2)
Others	6 (2.4)	12 (4.8)	18 (7.2)
Total	20 (8.0)	30 (12.0)	50 (20.0)
Total	92 (36.2)	158 (63.2)	250 (100)

The majority of diagnoses at referral was suspected epilepsy (80%) with epileptiform EEG abnormalities detected in 32% of cases. The diagnoses at referral are shown in Figure 1.

**Table 3.** Clinical and Electroencephalography classification in patients with seizures confirmed by EEG.

Seizure type	Number of patients	%
Primary generalized		
Tonic-clonic	12	18.6
Petit mal	6	9.3
Myoclonic	10	15.6
Partial		
Simple	18	28.2
Complex partial	14	21.9
With secondary generalization	4	6.3
<b>Total</b>	<b>64</b>	<b>32</b>

**Table 4.** EEG results.

EEG finding	No (%)
Normal	160 (64.0)
Focal or multifocal spikes	36 (14.4)
Generalized epileptic activity	28 (11.2)
Focal background disturbance	8 (3.2)
Diffuse background disturbance	11 (4.4)
Others	7 (2.8)
Total	250 (100)

The seizure types in patients with history of epileptic seizures and epileptiform EEG abnormalities are shown

in the Tables 3 and 4; the majority of seizures was partial seizure with secondary generalization. Primary generalized seizures were uncommon, with petit mal absences accounting for only 9.3% of total seizures. The majority of patients with epilepsy was referred for EEG to confirm the diagnosis; 5.5% were referred because of poor seizure control and 1.6% were referred to exclude any space occupying lesion.

### Discussion

This study highlights certain important issues in the utility of EEG in children. EEG was very helpful in diagnosing epileptic syndrome and in seizure classification. EEGs of some patients with epilepsy also revealed completely unexpected findings that strongly influenced their management. This highlights the very important role of EEG in patients with epilepsy.

The age distribution of patients in this study, showing patients under 8 years constituting 50% of the study population, probably reflects the fact that majority of cases with epilepsy belong to this age group. A progressive increase in the proportion of patients with normal EEG with increasing age is well known in patients with epilepsy (11,12), who make up some 65% of our patients.

Two thirds of our referrals were outpatients, similar to findings for neurophysiology investigations in developed countries (13).

Most children (98%) with non-epileptic paroxysmal events (e.g. migraine, syncope, and breath holding spells) had a normal EEG. Other investigators found normal EEGs in up to 87.5% of adults with non-epileptic paroxysmal events (headache, syncope, and vertigo) (14). We think that there should be some special reasons that lead to EEG request for non-epileptic disorders. The first reason is to exclude epilepsy. It is well known that a small percent of children without any neurologic disorder have EEG abnormalities (15). As well, children with epilepsy may not show interictal EEG abnormalities (16). Second reason may be a lack of knowledge in the limits of EEG recording and interpretation (14). Therefore, EEG is not helpful in these children and a complete event description will accurately identify the nature of these events in most cases rather than EEG (16). More than 10% of normal population may have non-specific EEG abnormalities and approximately 1% may have 'epileptiform paroxysmal activity' without seizures (17). The prevalence of these abnormalities is higher in children, with 2-4% having functional spike discharges.

In a review of EEGs in people with epilepsy, it was revealed that 30% of patients' EEGs, contained epileptiform discharges which is close to our study (18). Taken together, these studies suggest an 80% chance of showing epileptiform activity in a first wake-and-sleep EEG in people with epilepsy. Provided there is no other evidence of cerebral disease, epileptiform activity is rare in those who are and will remain free of epilepsy. This policy reduces costs and inconvenience to patients in an

epilepsy service but is inappropriate for patients with a low chance of having epilepsy, and therefore requires some discrimination by doctors (19).

EEG has many applications in epilepsy but it may also be misused. The situations in which the EEG can contribute to the diagnosis of epilepsy are rare. Once the diagnosis of epilepsy is established EEG is probably the most important tool in helping to define the type of epilepsy, the prognosis, and the initial approach to therapy. In partial seizures, EEG is our first choice for localization and is an important part of the work-up for few patients who come for epilepsy surgery (20).

Some investigators found that hyperventilation and intermittent photic stimulation contributed little to the final EEG report (14). Many of our children with focal or generalized epileptiform discharges had spike activation on photic or hyperventilation (19%). Hyperventilation was particularly helpful in children with absence epilepsy, which is consistent with the findings of other investigators (21).

In a recent review of EEG studies of children with attention deficit hyperactivity disorder (ADHD), it was concluded that 30% to 60% of these children showed abnormal EEG findings, including generalized and/or intermittent slowing. Furthermore, there was some evidence that EEG abnormalities decreased with age, with contradictory reports of poor or no correlation between abnormal EEGs and treatment response (22).

However, some children with ADHD were found to have an abnormal EEG in a recent study in which the authors conclude that routine EEG screening is of limited value in childhood behavioral problems (23), because in accordance with previous reports there is comorbidity between ADHD and epilepsy (24).

We conclude that there are many unnecessary routine EEG recordings in children. Investigation of epilepsy and acute encephalopathies appear to be the most valuable indications for routine pediatric EEG. A way should be found to reduce EEG requests. After EEG is requested, the effect of cancelling the test may undermine the patient's confidence in their physician. So physician education seems more palatable.

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