Epileptiform activities in the EEG of Children with Attention Deficit Hyperactivity Disorder

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Abstract:

Introduction: Attention deficit hyperactivity disorder (ADHD) is characterized by heightened impulsivity, inattention, and hyperactivity.

One of changes in EEG of ADHD children is epileptiform activity (EA), characterized by recording of excessive neuronal discharge.

Objectives: identifying encephalographic epileptiform activity in (ADHD) children and its relation to types of ADHD.

Methodology: All ADHD cases from the Centre of special need children in the year of 2015 were examined (4 days / week), 50 cases were enrolled and EEG epileptiform abnormalities were recorded.

Ethical aspects: Approval from the ethical committee of the Faculty of childhood postgraduate studies, Ain Shams University.

Limitations: refusal of the caregiver to perform the EEG.

Results:

A total of 4 cases (8%) presented with generalized epileptiform activities and 23 (46%) presented with focal epileptiform activities.

There was a statistical significant correlation between type of epileptiform activity and ADHD severity (r=-0.467) (p=0.014).

There was a statistical significant difference between age groups and background abnormalities where (75.9% of >7group) compared to (28.6% of < or = 7 group) had

abnormal background ($\chi2=12.052$, $p=0.002$), ADHD severity and generalized epileptiform activity ($\chi2 = 8.269$, $p=0.016$), where 40% of mild, compared to (10% moderate and 2.9% of the marked) type of ADHD cases had generalized activity. And a highly statistical significant difference between speech problems and ADHD severity ($\chi2 = 19.179$, $p=0.004$), where all reversal group was of moderate, and (75%) of delayed group was of the marked type.

Conclusion: Epileptiform activities were detected in ADHD children with the focal (46%) and generalized (8%) type with the marked combined type mostly presented in the focal group.

Recommendations: Further studies for focusing on treatment of epileptiform activity and its control of symptoms. Future Detection of seizures, especially those on stimulants.

Keywords: Attention Deficit Hyperactivity Disorder (ADHD), Electroencephalography (EEG), Epileptiform activity (EA).

النشاط الصرعي في رسم المخ عند الأطفال

الذين يعانون من اضطراب نقص الانتباه و فرط الحركة

الخلاصة

مقدمة: يتميز اضطراب نقص الانتباه وفرط الحركة بالاندفاع ، عدم الانتباه ، وفرط النشاط. من التغييرات في رسم المخ في هؤلاء الأطفال هو نشاط صرعي ، وتتميز بتسجيل الإفرازات العصبية المفرطة.

الأهداف: تحديد النشاط الصرعي الدماغي عند أطفال اضطراب نقص الانتباه وفرط الحركة وعلاقته بأشكال الاضطراب.

المنهجية: تم فحص جميع حالات ADHD (4 2015 عام في الاحتياجات الخاصة ذوي الأطفال مركز من ايام / أسبوع) ، وتم تسجيل 50 حالة ، و تسجيل تشوهات صرعية في التخطيط الدماغي.

الجوانب الأخلاقية: موافقة اللجنة الأخلاقية للدراسات العليا بكلية طب الطفولة ، جامعة عين شمس.

القيود: رفض مقدم الرعاية لأداء فحص رسم المخ.

النتائج : 4 حالات (8 ٪) قدمت مع أنشطة صرعية معممة و 23 (46 ٪) قدمت مع أنشطة صرعية بؤرية. (p = 0.014) (r = -0.467) كان هناك ارتباط معنوي إحصائي بين نوع النشاط الصرعي وشدة نقص الانتباه وفرط الحركة ADHD ، شدة (p = 0.002)، (χ2 = 12.052) (28.6٪ من اقل أو = 7 مجموعة) كان لها خلفية غير طبيعية ، حيث 40٪ من معتدل ، مقارنة بـ (10٪ معتدل و (p = 0.016)، (χ2 = 8.269) وداء صرعي معمم النشاط = χ2) كان لها نشاط معمم. وفرق إحصائي كبير بين مشاكل الكلام وشدة ADHD 2,9٪ من الشديد) من حالات حيث كانت جميع المجموعات العكسية معتدلة ، وكانت (75٪) المجموعة ((p = 0.004، ADHD (19.179 المتأخرة من النوع الشديد.

نوع بؤري (46 ٪) و معمم (8 ٪) مع النوع , ADHD)) الخلاصة: وجود أنشطة صرعية في الأطفال المركب الملحوظ في الغالب في المجموعة البؤرية.

التوصيات: دراسات للتركيز على علاج النشاط الصرعي ومكافحته للأعراض. الكشف المستقبلي عن النوبات ، خاصة مع المنبهات.

الكلمات المفتاحية: اضطراب فرط نشاط الانتباه (ADHD) ، تخطيط كهربية الدماغ (EEG) ، نشاط صرعي (EA).

Introduction:

ADHD consists of three primary symptoms: inattention, hyperactivity, and impulsivity. These symptoms can vary in severity from individual to individual, and individually over time, but to meet a diagnostic threshold they must present to a degree that is inconsistent with the youth's developmental level and cause significant impairment (DSM V, 2013)

Since ADHD is considered to be the result of a brain dysfunction and the electroencephalogram (EEG) assesses brain function, it is natural that this method be examined with respect to this clinical condition. Various research studies have assessed the

value of quantitative EEG in ADHD diagnosis. In a previous study it was affirmed that quantitative EEG data allow for differentiation between ADHD children and normal children with a specificity of 94% and sensitivity of 90%. Other studies indicate the value of qEEG in ADHD diagnosis (Magee et al., 2005).

The definition of Epileptiform wave activity or also called interictal epileptiform discharge (IED); is given in Chatrian's glossary of terms as "distinctive waves or complexes, distinguished from background activity and resembling those recorded in a proportion of human subjects suffering from epileptic disorders" These waves or complexes can appear as isolated focal spikes or sharp waves, generalized polyspikes, spike and wave or paroxysmal fast activity, and sometimes as abrupt rhythmic evolution of the background that heralds seizures. And also occur without evident clinical signs of epileptic seizure (Socanski, 2016).

Higher rates of interictial epileptiform discharges are observed among neurologic inpatients and outpatients without a seizure history, but the risk of subsequent unprovoked seizures or epilepsy is low in healthy volunteers and patients. An exception is the patients with autism spectrum disorders, attention deficit/hyperactivity disorder, or cerebral palsy, who are predisposed to epilepsy development (Elson, 2010).

EEG studies in children with attention deficit hyperactivity disorder are searching for data with respect to various brain function aspects. A greater recording of epileptiform activity has been described in attention deficit hyperactivity disorder children than in normal children (Richer et al., 2002).

Epileptiform activity could be a factor in the origin of the attention deficit, and thus pharmacotherapy with the objective of reducing EA could eventually produce benefit with respect to this behavior (Boutros et al., 2005)

Aim of the study:

To identify the encephalographic epileptiform activity in the electroencephalography of children with attention deficit hyperactivity disorder and its relation to different types of attention deficit hyperactivity disorder.

Design of study: Cross-sectional study, of ADHD children presented to Child psychiatry clinic of the Faculty of postgraduate childhood studies, child psychiatry clinic of

the Centre of special need children and private specialized centers over the period from January to December 2015.

Subjects and methods:

Subjects: A- Patients: All ADHD cases presented to the Centre of special need children over the period from January to December 2015 were examined (2 days per week), 50 ADHD children were enrolled in this study and EEG epileptiform abnormalities were recorded. These Children with ADHD, according to the diagnosis of DSM V were chosen from Child psychiatry clinic of the Faculty of postgraduate childhood studies, child psychiatry clinic of the Centre of special need children and private specialized centers over the period from January to December 2015.

All children from the age of 4 to 14 years, both sexes, with an average IQ of not less than 90 assessed by Stanford–Binnet Intelligence Scale V5were enrolled in this study.

All children with IQ below 90, psychiatric disorders, with past history of epileptic fits or those with inborn errors of metabolism, or major cardiac problems were excluded from this study.

B- Ethical aspects: Approval was obtained from the ethical committee of the Faculty of childhood postgraduate studies, Ain Shams University.

Informed written consent was obtained from the care giver of the patients.

Limitations: Refusal of the care givers to perform EEGexamination.

Methods: All patients were subjected to:

1. History taking: full psychiatric history with focusing on the symptoms of the ADHD diagnosed according to the DSM V for the diagnosis of ADHD (DSM-5, 2013).

2. Examination: Medical clinical examination for excluding any inborn errors of metabolism, or major cardiac problems.

3. Psychological assessment:

A) IQ test: using Stanford–Binnet Intelligence Scale V5 (SB5), the Arabic version conducted by a trained licensed psychologist it is used to assess intellectual ability in individuals between the ages of two and 89 years, is individually administered, and contains 10 subscales. The three areas assessed by the SB5 are: general cognitive functioning, verbal and non-verbal intelligence and five factors formed into groups along

verbal/nonverbal measures: Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory. Together, the ten subtests yield an overall estimate of cognitive functioning, which is the Full Scale Intelligence Quotient (Abu El Neil, 2011).

B) Conner's parent rating Scale (CRS): It was completed by parents to asses in evaluation of the severity of ADHD patients, it included fourteen items(oppositional, cognitive problems(IA), hyperactive, anxious/shy, perfectionism, social problems, psychosomatic, Conner's ADHD index total, Conner's global index(restless, impulsive), Conner's global index(emotional lability), Conner's global index (total), DSMIV (IA), DSMIV(HA-IM), DSMIV(Total) (Conner, 1997).

4. Investigations: All ADHD patients were subjected to electroencephalographic examination. Where any encephalographic epileptiform abnormalities were detected and recorded in each electroencephalography performed.

It was performed using the10-20 international system of electrodes placement method. Twenty electrodes will be applied to the scalp surface using paste. The site of electrode placement is standardized.

EEG examination was analyzed for:

A- Background activity over both hemispheres

B- Presence of abnormal focal or generalized slowing

C- Presence of epileptiform activity (focal or generalized)

Statistical analysis: Statistical analysis was performed using statistical package for social sciences (SPSS) computer software (version 22), IBM software, USA. Chi square test is used to elucidate significance between different variables (All are qualitiative variables). Differences were considered statistically significant at $p < 0.05$ and detailed significance is tested using adjusted residual where residual > +/-1.96. Independent t test (2 groups) and one way anova (>2groups) are used to test association or significance between quantitative variables and qualitative variables.

Results:

Table (1) frequency and percent of sex distribution among ADHD cases.

Sex	Frequency	Percent

Male	43	86
Female	7	14
Total	50	100

Table (2) frequency and percent of postnatal events distribution among ADHD cases:

Postnatal events	Frequency	Percent
Negative	40	80
Jaundice	8	16
RD	2	4

Table (3) frequency and percent of speech problems distribution among ADHD cases:

Speech problems	Frequency	Percent
Negative	34	68
Positive	16	32

Table (4) : Conner's ADHD Index among ADHD cases (ADHD severity)

Conner's ADHD Index	Frequency	Percent
Mild	5	10
Moderate	10	20
Marked	35	70

Table (5): DSM V Classification among ADHD cases.

DSM V Classification	Frequency	Percent
Hyperactive	3	6
Inattentive	9	18
Combined	38	76

Table (6) Frequency of EEG epileptiform activity findings among different types and severity of ADHD cases:

Type of Epileptiform activity	Frequency	Percent within group	Percent within total	Types of ADHD	Severity of ADHD
Generalized					
	1	25	2	Inattentive	Mild
	1	25	2	Hyperactive	Mild
	1	25	2	Combined	Moderate
	1	25	2	Combined	Marked

Focal					
	1	4.3	2	Hyperactive	Mild
	3	13	6	Inattentive	Marked
	1	4.3	2	Inattentive	Moderate
	3	13	6	combined	Moderate
	15	65.4	30	Combined	Marked
Total	27	100	54		

Table (7): Epileptiform activity, centrotemporal activity and slowing in the studied cases.

	Frequency	Percent
Generalized	4	8
Focal	23	46
Centrotemporal	8	16
Slowing	12	24
Abnormal background	28	56

Table (8) Frequency of EEG epileptiform activity findings among ADHD cases:

Type of Epileptiform activity	Frequency	Percent
Frontal Right	17	34
FrontaL left	16	32
Central Right	17	34
Central Left	14	28
Temporal Right	19	38
Temporal Left	27	54
Focal Right	5	10
Focal Left	18	36
Generalized	4	8

Table (9) correlation between types of epileptiform activity with ADHD types performed by DSM V and ADHD severity performed by the Conner's parent rating scale.

Variables	r.value	p-value
Type of epileptiform activity (generalized or focal) and ADHD type	0.253	0.203
Type of epileptiform activity (generalized or focal) and ADHD severity	-0.467	0.014*

There is a statistical significant negative correlation between Type of epileptiform activity (generalized or focal) and ADHD severity performed by the Conner's parent rating scale ($p=0.014$), however there was no statistical significance between the type of epileptiform activity (generalized or focal) and ADHD type performed by DSM V.

Table (10): Comparison of background activity in the EEG of ADHD cases between the two groups of age category.

		Age category		χ2	P value
		7or less	More than 7		
		N(%)			
Background activity	Normal	5(23.8)	4 (13.8)	12.052	0.002**
	Sleep	10(47.6)	3(10.3)		
	Abnormal	6(28.6)	22(75.9)		

There is a statistical significant difference between age category and background activity with a P-value of (P=0.002), where 75.9% of children with 7 or more years compared to 28.6% of 7 or less years had abnormal background activity.

Table (11): relation between Speech problems with background activity and left central epileptiform activity of ADHD cases.

		Speech problems			χ2	P value
		Stuttering	Reversal	Delayed		
		N(%)				
Background activity	Normal	2(33.3)	0(0)	1(12.5)	14.195	0.028*
	Sleep	1(16.7)	0(0)	6(75)		
	Abnormal	3(50)	2(100)	1(12.5)		
Left central	Absent	2(33.3)	2(100)	8(100)	8.372	0.039*
	Present	4(66.7)	0(0)	0(0)		

There is a statistical significant difference between speech problems and background activity with a P-value of (P=0.028), and there is a statistical significant difference between speech problems and left central epileptiform activities with a P-value of (P=0.039).Where all cases of reversal speech showed abnormal background activity and 66.7% of the ADHD cases presented with stuttering had left central activity.

Table (12): comparison of different types of Speech problems in relation to DSMV and Conner's scale of ADHD cases.

		Speech problems			χ2	P value
		Stuttering	Reversal	Delayed		
		N(%)				
DSM V	Hyperactive	1(16.7)	0(0)	1(12.5)	13.051	0.042*
	Inattentive	1(16.7)	2(100)	0(0)		
	Combined	4(66.7)	0(0)	7(87.5)		
Conner's	Mild	2(33.3)	0(0)	1(12.5)	19.179	0.004**

	Moderate	3(50)	2(100)	1(12.5)		
	Marked	1(16.7)	0(0)	6(75)		

There is a statistical significant difference between speech problems and ADHD diagnosis with DSM V with a P-value of (P=0.042), and a highly statistical significant difference between severity of ADHD with the Conner's parent rating scale of ADHD and speech problems with a P-value of (P=0.004), where all cases suffering from reversal speech were classified as the moderate inattentive type of attention deficit hyperactivity disorder. Also (66.7%) of the stuttering speech group and (87.5%) of the delayed speech group were classified as the combined type of attention deficit hyperactivity disorder.

Table (13): comparison between ADHD diagnosis by DSM V in relation to postnatal events, and right frontal activity in EEG of ADHD cases.

P value	χ2	DSM.V				
		Combined	Inattentive	Hyperactive		
		N(%)				
0.019*	7.925	25(65.8)	8(88.9)	0(0)	Absent	Right frontal
		13(34.2)	1(11.1)	3(100)	Present	
P value	χ2	DSM.V				
		Combined	Inattentive	Hyperactive		
		N(%)				
0.039*	10.099	29(72.5)	9(22.5)	2(5)	Negative	post natal events
		8(100)	0(0)	0(0)	Jaundice	
		1(50)	0(0)	1(50)	RD	

There is a statistical significant difference between ADHD diagnosis by DSM V and right frontal epileptiform activities with a P-value of (P=0.019), where all cases of hyperactive ADHD had right frontal abnormality and a statistical significant difference between ADHD diagnosis by DSM V and post natal events with a P-value (P=0.039). Where all cases of jaundice were of the combined type while the (50%) of the respiratory distress cases were of the combined type and the other (50%) were of the hyperactive type of ADHD.

Table (14): relation between Conner's parents rating scale of ADHD, with generalized epileptiform activity.

P value	χ2	Conner's ADHD Index				
		Marked	Moderate	Mild		
		N (%)				
0.016*	8.269	34(97.1)	9(90)	3(60)	Absent	Generalized

		1(2.9)	1(10)	2(40)	Present	

Chi square (X^2) test was used for statistical analysis where* P- value is significant at <0.05, Statistical insignificant at P > 0.05, p <0.01= statistical highly significant

There is a statistical significant difference between ADHD severity with the Conner's ADHD parent scale and the generalized epileptiform activities with a P-value of (P=0.016), where 40% of mild ADHD cases had generalized epileptiform activity.

Discussion:

Attention-deficit/hyperactivity disorder (ADHD) is the most common neurobehavioral disorder of childhood and is one of the most frequently encountered conditions in primary care (French, 2015).

This current study included 50 cases of children with ADHD where the study showed a frequency of 43 cases (86%) of boys and 7 cases (14%) of girl with a ratio of 6:1 (male: female) ratio. All of the hyperactive cases were boys and this was in agreement but showed higher levels than a study by Curran et al., 2000 who found that boys are 2–3 times more frequently affected with ADHD than girls. And by (Fayyad et al., 2001), who found that the boys to girls ratio of ADHD was 3:1.

In this current study ,it was observed that children with ADHD were suffering from language and speech problems (stuttering, reversal or delayed language) in 16 cases(32%) of ADHD cases, this showed lower values than the Study that was performed as an observational prospective method done in the period from October 2009 to October 2012 and composed of 53 children diagnosed as ADHD where they were screened for delayed language development (DLD). 36(67.9%) children were found to have ADHD, DLD (El sady et al., 2013).

Moreover ,the total number of epileptiform activity within the cases of ADHD was 27(54%), of which generalized epileptiform activity was present in 4 cases(8%), focal epileptiform activity was present in 23 cases (46%), centrotemporal activity 8 cases(16%), and slowing was present in 12 cases (24%) of the 50 children with ADHD, this was in agreement with but with higher levels than, a previous study performed on ADHD children that reported the occurrence of focal paroxysmal abnormality (PA) during sleep recording in (24%) of 176 children with ADHD (Hughes et al., 2000).

Also this study showed higher levels than a pervious study that stated that a total of 121 patients were included (93 males, 28 females, mean age 6.9±2.5 years), of whom 28 (23.1%) had electroencephalographic abnormalities, including three (10.7%) with generalized epileptiform discharges and 25 (89.3%) with focal epileptiform discharges. The focal epileptiform discharges were most prevalent from the rolandic (centrotemporal) area (15/25 focal epileptiform activity), followed by the parietal area (5/25 focal epileptiform activity), frontal area (4/25 of the focal epileptiform activity) and occipital area (1/25 focal epileptiform activity). Fourteen (50%) of the 28 patients with epileptiform activity had abnormal electroencephalographic findings only during sleep recordings (Li et al., 2018).

Furthermore, there was a statistical significant difference between speech problems and background activity with a P-value of (P=0.028), a statistical significant difference between speech problems and left central epileptiform activities with a P- value of (P=0.039), and (66.7%) of ADHD cases presented with occasional stuttering showed left central activities but with no statistical significance.

That's why this current study results were in agreement with a previous study that showed that The frequency of abnormal EEG findings was significantly ($p < 0.05$) higher in ADHD with language impairment group than specific language impairment (SLI) group where Focal EEG abnormalities either frontal or frontotemporal were detected in 16.7% of the ADHD children (Kaddah and Abdel Raouf, 2011).

Also our results showed that 28 cases (56%) had abnormal background activity and 12(24%) had localized slowing in their EEG and this was slightly higher than the study performed by Fonseca et al that found that epileptiform Discharges were found in 10% of ADHD patients. The ADHD group showed significantly greater absolute delta and theta powers and also greater absolute beta power and smaller relative alpha 1 and beta powers at some electrodes when compared to the controls in addition to the increased slow-wave and reduced fast-wave activity commonly reported in the ADHD literature (Fonesca et al., 2008).

References:

Boutros N, Fraenkel L, Feingold A (2005): A four-step approach for developing diagnostic tests in psychiatry: EEG in ADHD as a test case. J. Neuropsychiatr. Clin. Neurosci ; 17: 455-464.

Conner C keith (1997): Conner's Rating Scales Technical Manual.North Tonawada, NY: Multi-Health Systems Inc.

Curran S, Newman S, Taylor E, Asheron Hyperscheme P (2000): an operational criteria checklist and minimum data set for molecular genetic studies of attention deficit hyperactivity disorders Am J Med Genetics, 96 pp. 244-250.

Diagnostic and Statistical Manual of Mental Disorders, 5th edition. (2013): American Psychiatric Association Arlington, VA., American Psychiatric Association, cited at CDC, 2014.

Elson L So (2010): Interictal Epileptiform Discharges in Persons Without A History of Seizures: What Do They Mean? J Clin Neurophysiol ; 27: 229–238.

Fatma Alzahraa Kaddah,and Mervat abdelRaouf(2011): ADHD: Linguistic abilities and EEG findings compared to specific language impairment. Egyptian journal of ear nose and throat allied sciences. Volume 12 issue 1 p; 53-59.

Fonseca LC, Tedrus GM, Moraes C, Vicente Machado A, Almeida MP, Oliveira DO (2008): Epileptiform abnormalities and quantitative EEG in children with attention-deficit/ hyperactivity disorder. Arquivos de neuro-psiquiatria; 66(3A):462–7.

Hughes JR, DeLeo AJ, Melyn MA (2000): The Electroencephalogram in Attention Deficit-Hyperactivity Disorder: Emphasis on Epileptiform Discharges. Epilepsy Behav 1: 271-277.

Fayyad J, Sadek M, Cordahi C (2001): Attention deficit hyperactivity disorder (ADHD) Images of psychiatry An Arab perspective, 8 pp. 167-174 WPA Press, Publisher Scientific Book House.

Magee CA, Clarke AR, Barry RJ, McCarthy R, Selikowitz M (2005): Examining the diagnostic utility of EEG power measures in children with attention deficit/hyperactivity disorder. Clin Neurophysiol; 116:1033-1040.

Richer LP, Shevell MI, Rosenblatt BR (2002): Epileptiform abnormalities in children with attention deficit hyperactivity disorder. Pediatr Neurol; 26:125-129.

Safaa Refaat El Sady , Ahlam Abdel-Salam Nabeih , Eman Mohamed A. Mostafa , Abdelrahim A. Sadek (2013): Language impairment in attention deficit hyperactivity disorder in preschool children The Egyptian Journal of Medical Human Genetics Ain Shams University Language impairment in attention deficit hyperactivity disorder in preschool children14(4), 383–389.

Socanski Dorbrinko (2016): Attention Deficiet Hyperactivity Disorder and occurrence of epilepsy, interictial epileptiform discharges and two year follow up in children.

Wei Li, Hui-Ju Chen, Kun-Long Hung (2018): Electroencephalographic Abnormalities in Non-epileptic Children with Attention-Deficit /Hyperactivity Disorder Yi Neuropsychiatry (London) 8 (2), 677–683.

William P French (2015): Assessment and Treatment of Attention-Deficit/Hyperactivity Disorder: Part 1 Pediatric Annals; 44(3):114-120.

محمود السيد ابو النيل (2011): مقياس ستانفورد بينية للذكاء–الصورة الخامسة–, المؤسسة العربية لاعداد و تقنين و نشر الاختبارات النفسية,القاهرة,مصر.