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ORIGINAL ARTICLE

Electroencephalogram Spectrum in Children with Neurological Disorders an Experience of Tertiary Care Hospital

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ABSTRACT

Background and Objective: For evaluation of brain function in medical and psychiatric disorders one of the important investigative tool is Electroencephalogram (EEG) . There are limited studies overall related to use of EEG however in pediatric population there is scarcity of standard data related to topic Therefore, the objective of this study is to evaluate the prevalence of abnormal EEG and related neurological disorders in children.

Methods: A retrospective analysis of 664 EEG was done. One year record from 1st October 2020 to 30th September 2021 was reviewed .EEG request forms and reports were retrieved from neurophysiology lab data of the institute. A structured Pre-designed questionnaire used for collection of data information collected include demographics , history and conclusion were noted on the proforma.

Results: Total of 664 childrens has complete Electroencephalogram and bio-demographic records. The Mean age was 5.5 ± 4 SD at presentation was . Males 375(63.5%) and 290(43.6%) were females. Males to female ratio was. Among total ,375 (56%) EEG were normal, while 408(61.4%) patients had history of seizure. whereas 256 (38.5%) had provisional diagnosis other than seizure and 61 (29%) of them abnormal EEG tracing.

Conclusion: In developing countries EEG yet plays an essential role in the evaluation of neurological disorder particularly epilepsy. Therefore efforts needed to establish fully equipped neurophysiology facilities at least in tertiary care pediatric hospitals for early diagnosis and optimum prognosis.

Keywords: Electroencephalogram, Neurological Disorders, patterns

INTRODUCTION

Electroencephalogram (EEG) is one of the basic investigations in neurological disorders, it helps in evaluation of brain function in medical as well as psychiatric disorders. EEG recordings intimate the health states of the brain by means of providing information about its electrical activity on EEG recording paper as wavy lines.[1,2] EEG waves tracing are comprised of excitatory and inhibitory alternating synaptic potentials which is generated in the pyramidal cells of the cerebral cortex.[3] EEG waves are classified according to frequency of waves cycles/sec as Alpha (α), Beta (β), Theta (θ), and Delta (δ). Alpha wave frequencies range between 8 to 12 cycles/sec. Alpha (α) waves are found primarily in healthy person when awake or in resting states of cerebration. Beta waves activity range between 13 to 30 cycles/sec and recorded when an individual is focused towards particular mental activity. Theta wave frequencies are between 4 to 7 cycles/sec. They are mainly found in children below 7 years of age, but can be recorded in adults during states of emotional stress. Theta activity may be suggestive of degenerative brain disorders. Delta wave frequencies are below 3.5 cycles/sec. Delta activity is recorded in normal state of deep sleep and in abnormal conditions like organic brain disease.[4,5]

The conventional EEG is non-invasive comparatively inexpensive technique and main investigative tool in the diagnosis and management of various neurological disorders like brain trauma, dementia, cerebrovascular disease, neurocutaneous disorders, seizures, sleep disorder and tumor etc. It can also be suggested for the evaluation of developmental childhood disorders like autism, behavioral problems as attention deficit hyperactivity disorders (ADHD), learning difficulties, speech and language delay etc. [6,7] Likewise In critically ill children with neurological involvement EEG is vital tool for diagnosis and management of seizure either clinical, subtle and subclinical seizure.[8]

Although, effectiveness of EEG depends on multiple factors, included technical as well as competency of interpreter who must be an experienced neurologist with comprehensive knowledge of neurophysiology. [9,10] Though, there is marginal research on observation of the basic trends of EEG and its use generally either in adults or children while there is dearth of standard data regarding EEG use and its significance in pediatric population. Rational of our study is to fill this gap and review significance of EEG in children with preceding neurological presentation in making final diagnosis and also increase awareness of pediatrician regarding EEG use. Therefore, the objective of this study is to evaluate the prevalence of abnormal EEG and related neurological disorders in children.

METHODS

This study was conducted at the Department of Neurology, the National Institute of Child Health(NICH), which is one of the largest pediatric tertiary care public sector hospital in Karachi, Pakistan. A retrospective analysis of 664 EEG of all attendees was done who referred for their neurological presentation. One year record of EEG were reviewed from 1st October 2020 to 30th September 2021 after approval of study protocol from Institutional Ethical Review Board (IERB :18/2021).

Data retrieved from neurophysiology laboratory of the hospital. However, incomplete EEG, multiple artifacts that affect EEG reading, EEG less than 20 minute duration and EEG done outside of our hospital were excluded from this study. The standard EEG was performed by a trained neurophysiology technologist according to international protocol and reported by a pediatric neurologist.

A structured pre-designed proforma was used for data collection. Proforma encompassed information included demographics (age & gender), relevant history (cerebral palsy, developmental delay, developmental childhood disorder, seizures, learning difficulty, behavioral problem, headache, sleeping disorders and aggression) ,source of referral, clinical details of symptoms, EEG findings, provisional diagnosis made by referring physician, patterns of EEG and conclusion drawn were noted. EEG patterns which were categorized as normal, abnormal with either background slowing or significant abnormal background activity or both, types of seizure were documented. SPSS version 22 was used for data analysis. The descriptive statistics, frequency and percentage were computed for qualitative variables like seizures semiology, EEG abnormal pattern, diagnosis and gender. For quantitative variables like age mean and standard deviation were computed.

RESULTS

Total of 664 children had complete Electroencephalogram and bio-demographic records referred for EEG. The biodemographic characteristics are shown in Table 1. Most of the participants 308 (46.3%) were aged between 5 to 13 years, out of which 375(63.5%) were males and 290 (43.6%) females. Out of total EEG 353(53%) were abnormal, among all abnormal tracings 83% were of patients with history of seizures and 17% of patients without history of clinical seizures. Most commonly observed abnormality in tracing of patients without seizures were mild encephalopathy followed by cortical dysfunction.

The sources of referral for EEG were around 59% by Pediatric Neurologist, 25% from General Pediatrician, 8% from Pediatric Intensivist, 8% from Pediatric Oncologist and 3% from Pediatric Psychiatrist. Provisional diagnosis of generalized seizures were in 158 (38.8%), focal seizure with impairment of consciousness 138 (33.8%), focal seizure without impairment of consciousness were in 83 (20.3%) and epileptic encephalopathy were 29 (7%) of patients as shown in Table 1. While table 2 shows details of abnormal EEG patterns in children with provisional diagnosis of seizure.

EEG findings with provisional diagnosis other than seizure are illustrated in Table 3 and Table 4 illustrates comparison of abnormal EEG in patients with and without history of seizures.

Table 1: Clinical Characteristics of Children (n= 664)

Variable	n (%)
Mean Age (years) ±SD	5.5±4
Age Distribution	
≤ 1 year	132 (19.8)
1-5 year	224 (33.7)
5 to 13 year	308 (46.3)
Gender	
Male	374 (56.3)
Female	290 (43.6)
Male to Female ratio	1.2:1
Reason of EEG	
Seizures History	408 (61.4)
Delayed Developmental Milestones	42 (10.3)
Abnormal Body Movements	38 (9.3)
Pseudoseizure	33 (4.9)
Regression of Milestones	30 (4.5)
First Seizures of Prolong Duration	25 (3.7)
Headache History	23 (3.4)
Head Injury	20 (3)
ADHD	11 (1.6)
Altered Sensorium	11 (1.6)
Autism	08 (1.2)
Learning Difficulty	07 (1)
Narcolepsy or Sleep Related History	06 (0.9)
Aggression	02 (0.3)
EEG Conclusion	
Normal	311 (47)
Abnormal	353 (53)
Source of Referral	
Pediatric Neurologist	392 (59)
General Pediatrician	166 (25)
Pediatric Intensivist	53 (8)
Pediatric Psychiatrist	33 (5)
Pediatric Oncologist	20 (3)
Patient with Provisional Diagnosis of Seizures	408
Generalized Seizure Disorder	158 (38.8)
Focal Seizure with Impairment of Consciousness	138 (33.8)
Focal Seizure without Impairment of Consciousness	83 (20.3)
Epileptic Encephalopathy of Infancy	29 (7.1)

Table 2: Details of an Abnormal EEG Patterens in Children with Provisional Diagnosis of Seizure (n=292)

EEG Findings	n=292	Male (n=159)	Female (n=133)
Focal Seizures	103	51	52
a) Benign rolandic epilepsy (BRE)	06	03	03
b) Occipital	25	15	10
c) Paracentral	10	06	04
d) Hemispheric	11	05	06
e) Temporal Lobe	16	04	12
f) Frontal Lobe	05	01	04
g) Parietal Lobe	03	01	02
h) Other	27	12	15
Generalized Seizures	72	42	30
a) SSPE	16	10	06
b) Hypsarrhythmia	10	03	07
c) Absence seizures	06	04	02
d) Juvenile Myoclonic Epilepsy/ Progressive Myoclonic Epilepsy	07	04	03
e) Other	33	21	12
Cortical Dysfunction	45	26	19
a) Mild Cortical Dysfunction	36	21	15
b) Moderate Cortical Dysfunction	09	05	4
Encephalopathy	43	20	23
a) Mild Encephalopathy	10	06	04
b) Moderate Encephalopathy	22	08	14
c) Severe Encephalopathy	11	06	05
Multifocal Seizure Disorder	14	11	03
Asymmetric Background Activity	09	05	04
Early Infantile Epileptic Encephalopathy(EIEE)	06	04	02

Table 3: EEG Findings with Provisional Diagnosis other than Seizure (n=256)

Provisional Diagnosis other than Seizures	Electroencephalogram	
	Normal	Abnormal
Delayed Developmental Milestones	35	7
Abnormal Movements		
a) Facial Tics	08	0
b) Dystonia	18	05
c) Tremors	03	
d) OMS	04	
Pseudoseizures	28	05
Regression of Milestones	12	18
First Prolong Unprovoked Seizure	21	04
Headache	20	03
Head Injury	16	04
Altered Sensorium	03	08
ADHD	10	01
Autism	06	02
Learning Difficulty	03	04
Sleep Disorder	06	0
Aggression	02	0
Total	195	61

Table 4: Comparison of Abnormal EEG in Patients With and Without History of Seizures

EEG Interpretation	History of Seizures	Without History of Seizures
Focal Seizures	103	0
Generalized Seizures	63	11
Cortical Dysfunction	29	17
Encephalopathy	27	29
Multifocal Seizure Disorder	14	0
Asymmetric Background Activity	05	04
Early Infantile Epilectic Encephalopathy	6	0

DISCUSSION

Our study results show that majority of our patients referred to neurophysiology laboratory for EEG evaluation are from department of pediatric neurology and its outpatient clinic (59%) followed by admitted patients in general pediatric wards and its outpatient clinic (25%), pediatric intensive care unit (8%), psychiatry clinic (5%) and department of pediatric oncology (3%). Zaidi and Khan also reported the highest number of referrals in adult patients from the department of neurology while in our study maximum referrals are from the department of pediatric neurology.[11] This is probably due to a number of reasons. Primarily, the EEG unit of our hospital NICH resides in the

department of pediatric neurology and there is a lot of awareness about its usefulness. Moreover, a high proportion of patients with epilepsy, especially those with generalized seizures, focal seizure with and without impairment of consciousness, developmental delay, children with prominent behavioral symptoms and learning difficulty are referred to the department of pediatric neurology.

Majority of referrals were due to the provisional diagnosis of Seizure Disorders (61.4%), which is similar to Olisah and Zaidi's studies, while it is different from Harmon et al, who reported altered sensorium as the commonest reason for EEG referral.[11-13] Various studies reported EEG has limited sensitivity even for seizure disorders as a screening test, however an abnormal EEG would support the clinical diagnosis. We found around 53% of abnormal EEG among total sample irrespective of history of seizure, which is comparable to Rajper's conclusion. Among abnormal EEG in children with history of seizure, we found focal Seizures (35%) followed by generalized Seizures (24.6%) as most prevalent pattern.

In our study, we observed an important reason for EEG referral among attendees was to diagnose or rule out underlying seizures in children with provisional diagnosis of Developmental delay 42 (10%), abnormal Movements 38 (9%), regression of Milestones 30 (4.5%) and likewise to identify pseudoseizures 33(5%) from true Epileptic Seizures. There is an overall limited available data regarding EEG spectrum in children with Neurodevelopmental Disorders of Childhood (DDC) like Attention Deficit Hyperactivity Disorder (ADHD), Autism, Learning Disabilities etc. Some studies suggest significant electroencephalographic findings of encephalopathy, cortical dysfunction and epilepsy associated with these conditions.[14-16] In this study, 26 patients with ADHA, Autisim and learning difficulty evaluated by EEG and 7 had abnormal EEG and the most common finding is Cortical Dysfunction, which is comparable to Emily at al. However, studies with larger sample size needed to identify the significance of this finding in children with developmental disorders of childhood.

Diagnostic relevance of EEG also encompasses conditions like Cerebrovascular Diseases, traumatic brain injury (TBI), Psychiatric problems and Encephalopathy.[17,18] Psychiatric patients may have abnormal EEG patterns ranges from generalized or focal slowing or paroxysmal epileptiform discharges. These findings are not specific as far as primary psychiatric disorder is concerned but they contribute to variable processes associated or leading to psychiatric illness.

As a result of a variety of conditions in which EEG is used as a diagnostic tool, some studies have questioned the appropriateness of its use. However, in developing countries EEG use is still of relevance in the investigation of neuropsychiatric conditions especially where financial constraints could be a major challenge when it comes to carrying out some neuroimaging procedures on patients.

CONCLUSION

In developing countries, EEG yet plays an essential role in the evaluation of neurological disorder particularly epilepsy. Therefore, efforts are needed to establish fully equipped neurophysiology facilities at least in tertiary care pediatric hospitals for early diagnosis and optimum prognosis.

REFERENCES

1. Noachtar S, Rémi J. The role of EEG in epilepsy: a critical review. Epilepsy behav.. 2009;15(1):22-33.
2. Siuly S, Li Y, Zhang Y. Electroencephalogram (EEG) and its background. In EEG Signal Analysis and Classification 2016 (pp. 3-21). Springer, Cham.
3. Mohammad D, Zaidi S, Fawad B, Fazal MHQ, Abubaker ZJ et al. Frequency of Neurological Disorders and Related EEG Finding in a Tertiary Care Hospital of Karachi. J Biosci Med. 2019; 7(11): 56-64. DOI: 10.4236/jbm.2019.711005
4. Hall, J.E. Guyton and Hall Textbook of Medical Physiology. 13th Edition. Philadelphia(PA): Saunders; 2015.p. 1145.
5. Rosenow, F, Klein, K.M. and Hamer HM. Non-Invasive EEG Evaluation in Epilepsy Diagnosis. Expert Review of Neurotherapeutics .2015; 15(4): 425-444. doi:10.1586/14737175.2015.1025382
6. Rajper SB, Mukhtiar K, Baloch F, Ibrahim SH, Memon AR. Spectrum of electroencephalogram finding in Children with newly diagnosed epilepsy–an Experience at a tertiary care hospital. Pak J Neurological Sci. 2019;14(2):40-3.
7. Khanna, A., Pascual-Leone, A., Michel, C.M. and Farzan, F. Microstates in Resting-State EEG: Current Status and Future Directions. Neurosci Biobehav Rev .2015; 49(2): 105-113. Doi:10.1016/j.neubiorev.2014.12.010
8. Rajper SB, Moazzam M, Zeeshan A, Abbas Q. Acute symptomatic seizures in critically ill children: frequency, etiology and outcomes. J Pediatr Neurosci. 2020; 15(4):375.
9. Khan RL, Lahorgue Nunes M, Garcias da Silva LF,da Costa JC. Predictive value of sequential electroencephalogram (EEG) in neonates with seizures and its relation to neurological outcome. J Child Neurol 2008;23(2):144.
10. Verrotti A, Morresi S, Cutarella R, Morgese G, Chiarelli F. Predictive value of EEG monitoring during drug withdrawal in children with cryptogenic partial epilepsy. Neurophysiol Clin. 2000;30(4):240-5.
11. Zaidi Saba, Khan A. Patterns of eeg (electroencephalogram) findings in patients with neurological disorders, Pak J Neurological Sci.2020;15(1): 38-42
12. Olisah VO, Adekeye O, Okpataku CI, Eseigbe EE. Electroencephalographic findings in patients referred for electroencephalogram in a University Teaching Hospital in Northern Nigeria. Sahel Med J 2015; 18: 78-82. Doi: 10.4103/1118-8561.160805.
13. Harmon LA, Craddock M, Jones E. Effect of inpatient electroencephalography on clinical decision making. J Am Osteopath Assoc. 2013; 113(12): 891-896. Doi: 10.7556/jaoa.2013.067
14. Frye RE, Sreenivasula S, Adams JB. Traditional and non-traditional treatments for autism spectrum disorder with seizures: an on-line survey. BMC pediatrics. 2011 Dec;11(1):1-8.
15. Bolton PF, Carcani-Rathwell I, Hutton J, Goode S, Howlin P, Rutter M. Epilepsy in autism: features and correlates. The British Journal of Psychiatry. 2011 Apr;198(4):289-94.
16. Neuhaus, E., Lowry, S.J., Santhosh, M. et al. Resting state EEG in youth with ASD: age, sex, and relation to phenotype. J Neurodevelop Disord .2021;13(33):90-91. . https://doi.org/10.1186/s11689-021-09390-1
17. Brenner M, Oakley C, Lewis D. The evaluation of children and adolescents with headaches. Current pain and headache reports. 2008 Oct; 12(5):361-6.
18. Verrotti A, Coppola G, Spalice A, Di Fonzo A, Bruschi R, Tozzi E, Iannetti P, Villa MP, Parisi P. Peri-ictal and inter-ictal headache in children and adolescents with idiopathic epilepsy: a multicenter cross-sectional study. Child's Nervous System. 2011 Sep 1;27(9):1419.