

# Study of EEG pattern of children with status epilepticus at tertiary health care center

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## Abstract

**Background:** An epileptic seizure is a transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain. Electroencephalography (EEG) is a non-invasive, readily available and inexpensive investigation to study the neuronal dysfunction and abnormal cortical excitability in children who present with seizures. Present study was aimed to study clinical profile, neurological outcome, EEG pattern and neuroimaging of children with status epilepticus at a tertiary health care center. **Material and Methods:** Present study was single-center, prospective, observational study conducted in children of age 1month to 12 years who presented with status epilepticus underwent EEG examination. **Results:** In present study, mean age of patients was  $3.75 \pm 2.43$  years and male to female ratio was 1.38: 1 and it was not statistically significant. In present study, most common etiology associated with status epilepticus in children was seizure disorder (44%), followed by acute CNS infection (34%), fever provoked seizures (24%) and Quadriplegia (19%). Majority of children had abnormal epileptiform activity (73%) while 27% had normal EEG. Common EEG patterns noted were focal waveform abnormalities (17 %), periodic discharges (16 %), diffusely slow background activity (15 %) and low voltage recording (14 %). Out of 20 children with abnormal neuroimaging, 7 children had refractory status epilepticus (RSE). Among the structural abnormality, most common was cystic encephalomalacia (6%), followed by porencephaly (4%), space occupying lesion-DNET (4%), polymicrogyria cortex (4%), and arachnoid cyst in temporal region (2%). The mortality associated with SE was greatest (46%) in children between 2 to 5 years of age followed by 5 to 10 years (28%), less than 2 years (20%) and in children between 10 to 12 years of age (6%). This age difference was statistically significant. **Conclusion:** EEG can help in diagnosis and management of epilepsy by assessing risk of recurrence after an unprovoked seizure, selection of antiepileptic treatment, likelihood of seizure relapse if medication is withdrawn.

**Keywords:** EEG, status epilepticus, focal waveform, recurrence.

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## INTRODUCTION

An epileptic seizure is a transient occurrence of signs and/or symptoms due to abnormal excessive or synchronous neuronal activity in the brain. Epilepsy is a

disease characterized by an enduring predisposition to generate epileptic seizures and by the neurobiological, cognitive, psychological, and social consequences of this condition.<sup>1</sup> Many problems can cause due to seizure which include high fever, brain infections, abnormal sodium or blood sugar levels, or head injuries. A seizure that lasts longer than 5 minutes, or having more than 1 seizure within a 5 minutes period, without returning to a normal level of consciousness between episodes is called status epilepticus. This is a medical emergency that may lead to permanent brain damage or death.<sup>2</sup> Electroencephalography (EEG) is a non-invasive, readily available and inexpensive investigation to study the neuronal dysfunction and abnormal cortical excitability in children who present with seizures.<sup>3,4</sup> Electroencephalogram (EEG) has been instrumental in

helping define, classify, and elucidate basic mechanisms in Status epilepticus.<sup>5</sup> Present study was aimed to study clinical profile, neurological outcome, EEG pattern and neuroimaging of children with status epilepticus at a tertiary health care center.

### MATERIAL AND METHODS

Present study was single-center, prospective, observational study conducted in Department of Paediatrics, Vilasrao Deshmukh Government Medical College, Latur, India. Study duration was of 2 years (1st November 2018 to 31st October 2020). All consecutive cases of status epilepticus-those admitted during the study period. Study was approved by institutional ethical committee.

**Inclusion criteria:** Children of age 1 month to 12 years who presented with status epilepticus

**Exclusion criteria:** Child with status epilepticus with head injury. Children less than 1 month and more than 12 years of age. Patients whose parents do not give consent.

Study was explained and an informed consent was obtained from the concerned parents/guardian. A detailed history in all cases was taken with emphasis on the onset of seizure, duration of seizure, number of convulsion, type of seizure, antenatal, natal and post-natal risk factors.

Thorough clinical examination was done – vitals, general physical examination and systemic examination with special reference to central nervous system. All cases underwent surfaces calp EEG recording (conventional short-term cording of 30 minutes) under a digital EEG machine with simultaneous video recording. EEG was done after stabilization. All relevant investigations to arrive at the diagnosis and further management performed; children were followed up to evaluate their immediate outcome. i.e., till discharge or death. Data entered in Microsoft-Excel sheet and its analysis performed by the statistical software SPSS. Chi square test and Fischer test are used for nominal data. ‘P’ value less than 0.05 was considered statistically significant.

### RESULTS

In present study, mean age of patients was  $3.75 \pm 2.43$  years and maximum numbers of male and female patients were in the age group of 2 to 5 years (46%) followed by 5 to 10 years (28%) then less than 2 years (20%) and 10-12 years (6%). In present study 58% patients were males and 42% were females, with male to female ratio of 1.38: 1 and it was not statistically significant.

**Table 1:** Distribution of the Study subjects according to Age and gender

Age group (in years)	Males	Females	Total	Percentage
<2	13	07	20	20%
2 to 5	26	20	46	46%
5 to 10	15	13	28	28%
10 to 12	04	02	06	6%
<b>Total</b>	<b>58</b>	<b>42</b>	<b>100</b>	<b>100%</b>

History of iron deficiency anaemia was observed in 5% cases, Stroke in 11%, space occupying lesion in 6%, CNS Malformation 6%, Immunization appropriate in 96%, milestones appropriate for age in 73% and delay in 27%. History of failure to thrive observed in 24% and vitamin/micronutrient deficiency was observed in 20%.

**Table 2:** Distribution of study subjects according to Past history

Past history	No. of Cases	Percentage
H/O Iron deficiency anaemia	5	5%
H/O Stroke	11	11%
space occupying lesion	6	6%
CNS Malformation	6	6%
Appropriate	96	96%
Not appropriate Immunization as per national immunization programme	04	4%
Delayed milestones	27	27%
H/O failure to thrive	24	24%
Vitamin/Micronutrient deficiency	20	20%

In present study prehospital resuscitation was done in 31% cases. Most common symptom was vomiting (35%) followed by fever with URI (22%) and ALOC (20%) while the commonest sign was pallor (70%) followed by abnormal skull shape in 19% and syndromic appearance (10%). Majority of patients had- CBG in the ranged from 120 to 200 mg/dl (50%) followed by from 54 to 120 mg/dl. Sodium, potassium and calcium were low in 18%, 21% and 33% of cases respectively. Ongoing NCSE was present in 66% patients and intracranial pressure in 36%, clinical meningeal signs in 31%, involuntary movements was seen in 38%, Cerebellar signs in 6%. Sensory system activity involved in all i.e. 100% cases of status epilepticus which may have an important role in both generation and inhibition of seizures. Urinary incontinence (Incontinence bowel/bladder) occurs in 38% child with status epilepticus

**Table 3: Clinical examination profile of study population**

Clinical Examination	No. of Cases	Percentage
Prehospital resuscitation	31	31%
Predominant post ictal presentation		
Vomiting	35	35%
Fever	8	8%
Acute watery diarrhea	18	18%
Abdominal pain	10	10%
Lethargy	13	13%
Crying during micturation	05	5%
Fever + Upper respiratory infection	22	22%
Fever + Urinary tract infection	01	1%
Fever + Acute gastro-enteritis	03	3%
Altered Level of Consciousness	20	20%
Oliguria	01	1%
Clinical signs		
Pallor	70	70%
Icterus	03	3%
Clubbing	01	15%
Lymphadenopathy	00	0.0%
Oedema	01	1%
Abnormal skull shape	19	19%
Syndromic appearance	10	10%
Cutaneous markers	01	1%
Others	06	6%
capillary blood glucose (mg/dl)		
<54	01	1%
54-120	40	40%
120-200	50	50%
>200	09	9%
Nonconvulsive status epilepticus	66	66%
intracranial pressure clinical features	36	36%
Clinical meningeal signs	31	31%
Involuntary movements	38	38%
Cerebellar signs	06	6%
Sensory system	100	100%
Incontinence bowel/bladder +	38	38%

In present study, most common etiology associated with status epilepticus in children was seizure disorder (44%), followed by acute CNS infection (34%), fever provoked seizures (24%) and Quadriplegia (19%).

**Table 4: Etiology and diagnosis profile**

Diagnosis	No. of Cases	Percentage
Seizure disorder	44	44%
Fever provoked seizures	24	24%
Unprovoked seizures	09	9%
Toxic encephalopathy	03	3%
Autoimmune encephalitis	04	4%
Acute CNS infection	34	34%
Stroke	08	8%
Quadriplegia	19	19%
Other - Systemic illness	03	3%

Majority of children had abnormal epileptiform activity (73%) while 27% had normal EEG. Common EEG patterns noted were focal waveform abnormalities (17%), periodic discharges (16%), diffusely slow background activity (15%) and low voltage recording (14%).

**Table 5: EEG of study population**

Parameters	No. of patients (n=73)	Percentage
Normal	27	27.0
Focal Waveform Abnormalities	17	17.0
Periodic Discharges	16	16.0
Diffusely Slow Background Activity	15	15.0
Low Voltage Recording	14	14.0

Out of 20 children with abnormal neuroimaging, 7 children had refractory status epilepticus (RSE). Among the structural abnormality, most common was cystic encephalomalacia (6%), followed by porencephaly (4%), space occupying lesion-DNET (4%), polymicrogyria cortex (4%), and arachnoid cyst in temporal region (2%).

**Table 6: Neuroimaging of children with status epilepticus**

Neuroimaging	No. of Patients	Percentage
Normal	80	80%
Structural abnormality	20	20%
Cystic encephalomalacia	06	6%
Porencephaly	04	4%
Space occupying lesion-DNET	04	4%
Polymicrogyria cortex	04	4%
Arachnoid cyst in temporal region	02	2%

Maximum number of cases required 2 to 4 anti-epileptics drugs for the treatment of status epilepticus. 20% of cases required 4 to 6 anti-epileptics drugs.

**Table 7: Anti-epileptics drugs (AEDs) required**

No of AEDs required	No. of patients	Percentage
<2	07	7%
2-4	70	70%
4-6	20	20%
6-8	03	3%

Out of 100 cases, 76 cases (76%) recovered. Among those recovered, 6 cases (6%) recovered with new neurological sequelae; 13 cases (13%) died and 5 cases (5%) discharged against medical advice (AMA).

**Table 8: Final outcome**

Outcome	No. of Patients	Percentage
Recovered without sequel	76	76%
Recovered with sequel	06	6%
Death	13	13%
AMA	05	5%

The mortality associated with SE was greatest (46%) in children between 2 to 5 years of age followed by 5 to 10 years (28%), less than 2 years (20%) and in children between 10 to 12 years of age (6%). This age difference was statistically significant with p value of 0.039.

**Table 9: Age Distribution and Final Outcome**

Age group (in years)	Survived	Expired	Total
<2	19 (95%)	01 (5%)	20 (20%)
2 to 5	41 (68.75%)	05 (31.25%)	46 (46%)
5 to10	22 (78.57%)	06 (21.42%)	28 (28%)
10 to12	05 (83.33%)	01 (16.66%)	06 (6%)

## DISCUSSION

Electrocorticography (ECoG) or intracranial EEG is useful for invasive recording of cortical electrical activity by use of electrodes directly on the surface of brain (subdural grids or strips) or deep inside the brain (depth electrodes).<sup>6</sup> It helps to localize the epileptogenic zone and to map cortical functional areas in drug-resistant epilepsy. Traditional analog EEG machines are being replaced by digital EEG with simultaneous video recording. Surface

scalp EEG recording can be conventional short-term recording (30 minutes) or long-term video EEG record (for witnessing and localizing seizure activity). A convenient formulation of non-convulsive status epilepticus (NCSE) is the alteration of consciousness or behavior from baseline state for at least 30 minutes without convulsive movements, and the presence of one or more of the following epileptic form patterns:<sup>7</sup>

1. Repetitive focal or generalized epileptic form activity (spikes, sharp waves, spike-and-wave, sharp-and-slow wave complexes) or rhythmic theta or delta activity at more than two per second.
2. The above EEG patterns at less than one per second, but with improvement or resolution of epileptic activity and improvement in the clinical state following intravenous (IV) injection of a rapidly acting anti-epileptic drug (AED), such as a benzodiazepine.
3. A temporal evolution of epileptiform or rhythmic activity at more than 1 Hz with change in location or frequency over time.

EEG can help in diagnosis and management of epilepsy by assessing risk of recurrence after an unprovoked seizure, selection of antiepileptic treatment, likelihood of seizure relapse if medication is withdrawn, identification of epileptogenic region in epilepsy surgery candidates, investigation of cognitive decline, detection of non-convulsive status and monitoring in convulsive status.<sup>6,7</sup> Amonkar *et al.*,<sup>8</sup> studied children aged 1 month to 16 years who presented with seizures were evaluated. EEG was performed during hospital stay in 59 (37.5%) patients and 28 (47.4%) patients had abnormal recordings. EEG abnormalities included focal waveform abnormalities (7), multifocal waveform abnormalities (4), diffusely slow background activity (7), periodic discharges (6) and low voltage recording (4). Similar findings were noted in present study. Narayanan and Murthy<sup>9</sup> reported abnormal EEG in 56% patients, mostly nonspecific, either diffuse symmetric or focal theta or delta activity. None of the EEG showed spike or sharp wave activity and periodic discharges. There were no specific EEG features that could predict the recurrence seizures and SE. A study conducted by Singh and Suryavanshi<sup>10</sup> in 331 children with seizure revealed that in patients with generalized seizures 49% had abnormal EEG while 51% had normal EEG pattern whereas in patients with focal seizures 42% had normal EEG while 48% had abnormal EEG and there was no significant difference in EEG abnormalities in both groups. Alakkodan D<sup>11</sup> studied 218 children with first - time seizures. Abnormal neuro-radio imaging findings were gliosis in 46 - (21.10%), demyelination in 22 - (10.09%), hemorrhage in 20 (09.17%), brain atrophy in 8 - (3.66%), dysgenesis in 6 - (2.75%), infarction in 5 - (2.29%), and encephalomalacia in 4 (1.83%) children, abnormal EEG in 67/218 (30.73%) children. The abnormal recordings in EEG noted in this study were temporal shortwave discharges in 34 (15.59%), centrottemporal spikes in 19 (8.71%), occipital spikes/spike-waves in 17 (7.78%), generalized slowing in 17 (7.78%), focal slowing in 9 - (4.12%), frontal sharp wave discharge in 5 (2.29%), Neuroimaging of children with status epilepticus showed

that out of 20 children with abnormal neuroimaging, 7 children had refractory status epilepticus (RSE). In Purusothaman and Kumar<sup>12</sup> study Structural abnormality was seen in 10 (18.5%) cases of them 7 children (12.2%) presented with refractory status epilepticus. The frequency of refractory seizures is low compared to other published reports the frequency varies from 25-50%.<sup>13,14,15</sup> Refractory seizures were observed more with structural abnormality. In current study, it was observed that among the structural abnormality, most common was cystic encephalomalacia seen in 30% cases followed by porencephaly 20%, space occupying lesion-DNET 20%, polymicrogyria cortex 20 and arachnoid cyst in temporal region seen in 10% cases. This is in accordance with the study done by Purusothaman and Kumar.<sup>12</sup>

Similarly, focal or unilateral SE, as well as lateralized periodic discharges detected by EEG are associated with focal diffusion restriction and increased T2 or FLAIR signal that may persists for days to weeks.<sup>16,17</sup>

However, the EEG has a number of limitations. Electrical activity recorded by electrodes placed on the scalp or surface of the brain mostly reflects summation of excitatory and inhibitory postsynaptic potentials in apical dendrites of pyramidal neurons in the more superficial layers of the cortex. Spatial/temporal sampling in routine scalp EEG is incomplete, as significant amounts of cortex, particularly in basal and mesial areas of the hemispheres, are not covered by standard electrode placement. Limited and relatively short duration of routine interictal EEG recording are common reasons, why patients with epilepsy may not show interictal epileptiform discharge (IED) in the first EEG study.<sup>18</sup> Proper prehospital therapy, early referral, proper care while transporting, anticipating risk factors involved, and protocol based approach uniformly at all hospital can reduce the mortality due to status epilepticus in children. Also considering the large number of referrals, upgradation of intensive care facilities even in tertiary care hospital is much sought to improve the overall outcome of SE.

## CONCLUSION

In status epilepticus commonest type of seizure was a generalized tonic-clonic seizure. Seizure disorder, acute CNS infections, and febrile seizures were commonest etiological reasons. CSF analysis, Neuroimaging and EEG have the most important role in diagnosis of seizures. EEG can help in diagnosis and management of epilepsy by assessing risk of recurrence after an unprovoked seizure, selection of antiepileptic treatment, likelihood of seizure relapse if medication is withdrawn.



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