

Benefits of Routine Inpatient EEG in Practice: Experience from a Level 4 University Hospital

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Received date: January 10, 2023, **Accepted date:** March 13, 2023

Citation: Snehal I, Kumari K, Schissel M, Swaminathan A, et al. Benefits of Routine Inpatient EEG in Practice: Experience from a Level 4 University Hospital. J Exp Neurol. 2023;4(1):37-42.

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Abstract

Purpose: Routine inpatient EEGs have been part of epilepsy practices for years. We aim to improve current routine EEG practices by studying their role at a large university hospital. **Methods:** Inpatient routine EEGs from January-July 2021 were included and patients <5 yrs., EEGs repeated on the same patient were excluded. Indications, floor status, abnormality, day of study, neurology consultation, results, treatment changes, discharge status, and prior AED use were analyzed using SAS 9.4. **Results:** The mean age for 250 patients was 57.27 yrs., where 54.22% were males and 45.78% were females. Indications listed were 26.5% altered mental status, 59.83% seizures, and 13.65% others. 87.36% of ICU patients had abnormal EEG vs 73.75% of floor patients. A significant association ($p=0.0147$) was found between floor status and EEG results. Abnormalities were 44% generalized slowing, 23.6% focal slowing, 9.2% epileptiform activity, and 23.2% others. Treatment was changed in 21.03% with abnormal vs 5.56% with normal EEG. AEDs were added in 18.46% with abnormal vs 3.7% with normal EEG. A significant association ($p=0.014$) was found between Neurology consultation and treatment change and with AED addition respectively. EEG result was associated with treatment change and AED addition. "Abnormal EEG" was significantly associated with further study. A significant association ($p=0.0351$) was found between EEG results and discharge status. 53.82% of patients were not on AED before EEG vs 46.18%. Prior AED had no association with EEG results. **Conclusions:** It is helpful to consult Neurology. Longer duration of routine EEGs may not show abnormalities. Routine EEG facilitates discharges and guides further workup.

Keywords: Routine EEG, Epilepsy research, Quality improvement, Clinical practice, Hospital practice

Abbreviations: rEEG: Routine EEG; cEEG: Continuous EEG; AED: Antiepileptic Drug; IRB: Institutional Review Board

Introduction

EEG is a non-invasive and benign tool, that detects electrical activity in the brain. The minimum duration of EEG recording should be 20 min [1]. EEG is not only used to confirm or rule out seizures, but it is also indicated in the evaluation of cognitive change, syncope, psychiatric presentations, movement disorders (e.g., myoclonus, tremors), or unexplained unresponsiveness [2].

Interestingly, EEG can provide important information even when CT and MRI findings are normal [3]. EEG also helps in diagnosing status epilepticus as a cause of altered mental

status or even when the patient is alert. Routine EEG in comatose patients after cardiac arrest helps in determining prognosis at the same time rules out seizures [4].

Routine EEG plays an important role in making a treatment plan, it has been studied to assess the effectiveness of anti-epileptic drug therapy and seen to help in safely weaning off anti-epileptic drugs in patients. It can assist in classifying seizure types as a result and adds to the appropriate selection of AED [5]. The yield of routine EEG increases with video monitoring and when used in an appropriate setting with provocation measures. It is also more helpful when performed sooner rather than later [6,7].

It is a reasonable alternative option over continuous EEG in resource-limited centers [8]. There are certain limitations to the use of routine EEG which included a short duration of recording and due to that, it may not record epileptiform discharges. There can also be inter-observer variability.

We felt the need to re-evaluate the relevance of routine EEG in inpatient settings as in current practices there are new and several modalities coming up to screen seizures. It has been found as a great screening tool previously but also it is important to evaluate its utility in disposition and treatment plans and the contributory factors.

Methods

It is a retrospective, observational study. Patients who underwent inpatient routine EEGs from January to July 2021 were included and those patients who were less than 5 years old and repeat studies on patients during the 6-month period were excluded. IRB approval was waived as this was a quality improvement project.

Included patient charts were reviewed for indications, floor status (ICU vs floor), neurology consultation (whether Neurology was involved or not), day of study (whether it was a weekday vs weekend, findings of the study, if any further workup was pursued if routine EEG was repeated within 10 days or not, if treatment was changed, whether an AED was added on the basis of the findings, if routine EEG helped in expediting discharge, total duration of the studies, and if patient was on prior AED at the time of the study.

Appropriate statistical analyses using SAS 9.4 were performed.

Results

From over 285 records found between January to July 2021, 250 patients were included. The mean age was noted to be 57.27 ± 19.05 years, and 54.22% were males and 45.78% were females. Among the listed indications during ordering the test, 26.5% of studies indicated altered mental status, 59.83% listed seizures and 13.65% listed a mix of other indications. The median duration of routine EEG was 37 minutes.

ICU vs floor status

The majority (64.52%) of study participants were on the floor while 35.48% of them were in the ICU. There was a significant ($p=0.0147$) association between ICU/Floor location and EEG results (**Table 1**). Of those who were in the ICU, 87.36% of them had an abnormal EEG versus 73.13% of those who were on the Floor.

Abnormal EEG

Among abnormalities reported, 44% were noted to have

generalized slowing, 23.6% showed focal slowing, 9.2% showed some epileptiform activity and 23.2% included other findings. Out of the studies reporting abnormal EEGs, only 4.66% were found to record seizures. There was a significant ($p=0.0085$) association of abnormal EEG results with the addition of an AED (**Table 1**). Treatment was changed in 20.92% with abnormal EEG while only 5.66% with normal EEG had a change in treatment. AEDs were added in 18.46% of patients with abnormal EEG vs 3.7% with normal EEG.

Neurology consultation

There was a significant ($p=0.014$) association between the treatment change and a neurology consultation. 97.73% of the study subjects who had a treatment change, also had a neurology consultation. 84.39% of those who did not still have a neurology consultation. Regarding AED addition for management, 18.37% of the participants that received abnormal EEG results had an addition of an AED. Only 3.77% percent of the individuals who had normal EEG results, had an addition of an AED. It was noted that there was a significant ($p=0.037$) association between the addition of an AED and neurology consultation (**Table 1**).

97.37% of the participants who had an AED added, also had a neurology consultation. For those who did not have an AED added, 84.83% of them received a neurology consultation. Significant association was found between Neurology consultation with treatment change and AED addition respectively.

Further workup and AED use

Some patients needed workup beyond routine EEGs. We broadly categorized them into continuous EEGs, MRI Brain, or lumbar punctures. It was noted that further studies were done in 21.94% of patients with abnormal EEG and 9.43% with normal EEG.

Day of the week and discharges

There was no significant association between the day of the week and discharge status. However, of the participants who were discharged, the majority (27.69%) were discharged on a Monday. Very few were discharged on Saturdays or Sundays.

There was a significant ($p=0.0351$) association between EEG results and discharge status. 37.74% of individuals with a normal EEG were able to be discharged compared to only 22.96% of those with an abnormal EEG (**Figure 1**).

Use of AEDs prior to the study

There was a relatively even number of individuals who were on an AED prior to the EEG. 53.82% of individuals were not on an AED, while 46.18% of them were on an AED prior to the EEG. There was no significant association between prior use of AED and abnormal EEG results.

Table 1. Summary of the results of the study. It compares the association of the results of the study with various factors and outcomes.		
Variables	Normal EEG n (%)	Abnormal EEG n (%)
Floor n (%)	42 (26.25)	118 (73.75)
ICU n (%)	11 (12.64)	76 (87.36)
Two-sided p value = 0.0147, missing=3		
Further diagnostics done	5 (9.43)	43 (21.94)
Further diagnostics not done	48 (90.57)	153 (78.06)
Two-sided p value = 0.034, missing=1		
Seizures present	0 (0.00)	9 (4.66)
Seizures absent	56 (100.0)	184 (95.34)
Two-sided p value = 0.211, missing=4		
Treatment changed	3 (5.66)	41 (20.92)
Treatment not changed	50 (94.34)	155 (79.08)
Two-sided p value = 0.008, missing=1		
Addition of AED	2 (3.77)	36 (18.37)
No addition	51 (96.23)	160 (81.63)
Two-sided p value = 0.0085, missing=1		
Discharged early	20 (37.74)	45 (22.96)
Discharged later	33 (62.26)	151 (77.04)
Two-sided p value = 0.035, missing=1		
Prior AED use	19 (35.85)	96 (48.98)
No prior AED use	34 (64.15)	100 (51.02)
Two-sided p value = 0.120, missing=1		
	Neurology consulted	Neurology not consulted
Treatment changed	43 (97.73)	1 (2.27)
Treatment not changed	173 (84.39)	32 (15.61)
Two-sided p value = 0.0139, missing=1		
Addition of AED	37 (97.37)	1 (2.63)
No addition	179 (84.83)	32 (15.17)
Two-sided p value= 0.036, missing =1		
	Normal EEG	Abnormal EEG
Duration of rEEG (min)	37 ± 12.75	37 ± 18.37
p value = 0.659		

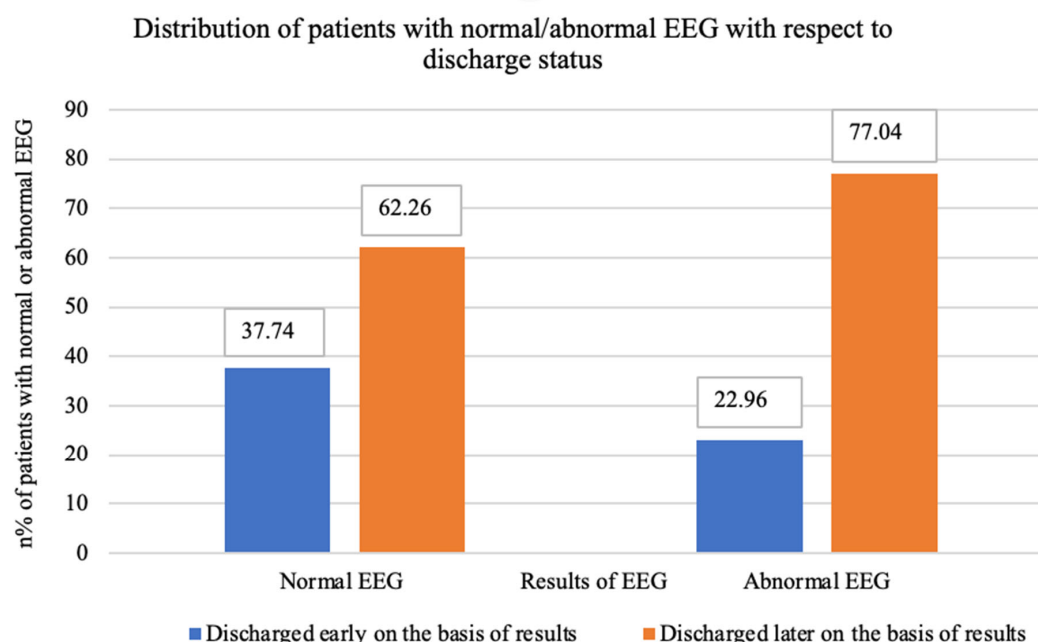


Figure 1. Distribution of patients with normal/abnormal EEG with respect to discharge status.

Duration of the EEG

We found that there was no significant association between the duration of routine EEG with abnormalities on EEG.

Discussion

Routine EEGs have been in use since the 1930s [10]. However, due to the presence of more complex testing and the increased ability of large hospitals to run continuous EEGs, it is helpful to revisit the indications for which routine EEGs are being ordered, the yield of the procedure and what are the best practices.

We found that most indications used were for “seizures” and the next most cited indication was “altered mental status”. Per American Epilepsy Society guidelines there is level B evidence to evaluate for new-onset seizures [11].

In our sample, 78% of the EEGs were abnormal. Out of the abnormal studies, only 9.2% showed epileptiform activity and only 4.6% recorded seizures. When EEG was ordered for an indication of new-onset seizure, Neufeld et al. showed that over 69% of their sample was abnormal, and over 21% showed epileptiform activity, and similar findings have been found in other studies [2,12].

However, we observed that there was a statistically significant association of higher abnormalities with ICU status, this suggests that there is a higher chance of having abnormal EEG in the ICU. This can be attributed to the fact that most

patients in the ICU are likely to be more encephalopathic and may develop epileptogenesis due to secondary causes than the ones on the floor. This could give EEG results that show associated findings. Scozzafava et al. have described the inadequacy of a standard 20-minute routine EEG in ICU patients resulting in a low seizure detection rate and no association with outcomes. We extended research to all inpatient studies done, and all routine EEGs (standard or extended) to find the yield of the study overall and our sample size was relatively bigger [13].

Mussavi et al. have described the importance of abnormal CT and US findings for the cause of neonatal seizures and their use simultaneously with EEG in diagnosing seizures. We tried to further describe how routine EEGs were helpful as a screening tool and in changing management by itself and when further studies such as imaging were required. We also described the further use of MRI in our study [14].

The yield of routine EEG by itself may or may not help in determining the course of treatment, however involving Neurology opinion early may help in determining further treatment and workup.

Previous studies do not describe the importance of Neurology consultation for routine EEG. We found that regardless of abnormalities Neurology consults helped in changing treatment or adding AEDs. Currently, the hospital policy is to compulsorily consult Neurology when ordering a continuous EEG, but not necessarily for

a routine EEG. However, it may save more time later, and expedite contingency plans if Neurology is involved earlier. Only over 22% of patients who had abnormal findings received further testing. Multiple studies show that additional tests can help in increasing the yield of findings in patients [15].

Routine EEG results helped in the addition of an AED. It also helped in expediting discharge. One would think that continuous EEG studies than routine EEGs would expedite the discharge due to more findings and appropriate treatment plans, but it has been studied before that there is no difference in discharge between the two [16,17].

In our sample, the median study duration was 37 minutes, although there was no significant association of the duration with abnormalities on EEG. However, this duration is close to other studies that have found 40 minutes an optimal duration for a routine EEG [18].

The limitations of our study were that we did not compare the yield of a continuous EEG with the routine EEGs on the same patient. The duration of hospital stay was not accounted for, and disposition to rehab centers and skilled nursing were not considered. However, many of these patients had other problems which may or may not have contributed to the discharge status, confounders being socioeconomic reasons, age, primary disease, and other factors impending discharge.

Conclusion

Routine EEG still holds a lot of value in clinical practice. It helps in expediting discharges, and even changing management or adding AEDs. It also helps more when neurology is involved as a consulting team.

Conflicts of Interest

There are no conflicts of interest.

Funding Statement

There is no funding to be disclosed.

Authors Contribution

The principal Author has full access to the data and has the right to publish this data. All authors participated in a meaningful way in the preparation of the manuscript (in the design or conceptualization of the study, interpretation of data, or drafting manuscript).

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