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Original article

# Trend figures assist with untrained emergency electroencephalogram interpretation

Katsuhiro Kobayashi [a,*], Kosuke Yunoki [b], Kazumasa Zensho [b], Tomoyuki Akiyama [a], Makio Oka [a], Harumi Yoshinaga [a]

[a] *Department of Child Neurology, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences and Okayama University Hospital, Okayama, Japan*

[b] *Okayama University Medical School, Faculty of Medicine, Okayama, Japan*

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**Abstract**

*Objective:* Acute electroencephalogram (EEG) findings are important for diagnosing emergency patients with suspected neurological disorders, but they can be difficult for untrained medical staff to interpret. In this research, we will develop an emergency EEG trend figure that we hypothesize will be more easily understood by untrained staff compared with the raw original traces. *Methods:* For each of several EEG patterns (wakefulness, sleep, seizure activity, and encephalopathy), trend figures incorporating information on both amplitude and frequency were built. The accuracy of untrained reviewers' interpretation was compared with that of the raw EEG trace interpretation. *Results:* The rate of correct answers was significantly higher in response to the EEG trend figures than to the raw traces showing wakefulness, sleep, and encephalopathy, but there was no difference when seizure activity patterns were viewed. The rates of misjudging normal or abnormal findings were significantly lower with the trend figures in the wakefulness pattern; in the other patterns, misjudgments were equally low for the trend figures and the raw traces. *Conclusion:* EEG trend figures improved the accuracy with which untrained medical staff interpreted emergency EEGs. Emergency EEG figures that can be understood intuitively with minimal training might improve the accuracy of emergency EEG interpretation. However, additional studies are required to confirm these results because there may be many types of clinical EEGs that are difficult to interpret.


*Keywords:* aEEG; Frequency; Emergency; Non-expert interpretation

## 1. Introduction

In emergency patients with seizures and/or loss of consciousness, acute electroencephalogram (EEG) findings are important for diagnosis and neurological evaluation [1], particularly in cases of nonconvulsive seizures/status epilepticus [2–4]. The brief EEG examinations made during such emergencies are different from ordinary routine EEG examinations in several aspects. If there may not be enough time to attach a full set of electrodes according to the international 10–20 system, the use of less than 10 electrodes may be accepted, as in cases with continuous EEG (cEEG) monitoring for critical neurological patients [5]. In addition, some emergency patients may have head injuries that preclude the

* Corresponding author. Address: Department of Child Neurology, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences and Okayama University Hospital, Shikata-cho 2-chome 5-1, Kita-ku, Okayama 700-8558, Japan. Tel.: +81 86 235 7372; fax: +81 86 235 7377.

*E-mail address:* k_koba@md.okayama-u.ac.jp (K. Kobayashi).

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attachment of electrodes in certain places. On the other hand, identification of individual epileptic discharges is not always required, and only a quick differentiation between seizure activity patterns, abnormal background patterns, and normal conditions is necessary in brief emergency EEGs.

The most difficult problem in emergency EEG examination may be one of data interpretation [6]. The skill required to interpret EEGs is highly specialized and demands considerable time spent in training. It would be prohibitively difficult for adequate skill in EEG interpretation to be obtained by most medical staff in the emergency department and the intensive care unit (ICU). In addition, consultation with EEG specialists may not be always possible. This is the case in most Japanese hospitals, particularly in local hospitals, although situations may be different depending on countries or institutions. Therefore, a technique that will enable untrained people to interpret emergency EEGs with minimal error needs to be developed.

We hypothesize that it is possible to make a graphical EEG representation that is more intuitively understandable for non-specialists than the traditional raw traces. We herein propose a trend figure of EEG data that shows both amplitude and frequency as well as their changes over time. Because it is challenging for untrained medical personnel to measure the amplitude and frequency in EEG data when relying on calibration alone, we developed our trend figures to be easier for untrained people to interpret compared with raw original EEG traces. The trend figures used in the current study were amplitude-integrated EEGs (aEEGs) that were developed for cEEG monitoring in a previous study [7], and they incorporated frequency information by color-coding. The trend figures were modified in the present study to be suitable for brief EEG examination data. In this study, we evaluated the interpretation accuracy of these prototype figures to show that such graphical EEG representation would have an advantage for non-specialists. Our goal is to make EEG a clinically relevant and useful tool for specialists and all clinicians, similar to electrocardiogram (ECG), in the future.

## 2. Subjects and methods

### 2.1. Patients undergoing EEG

The EEG data were from 44 pediatric/young adult patients who visited the Department of Child Neurology at Okayama University Hospital for various neurological disorders between October 2003 and August 2013. The mean age of these patients was 7.6 years (SD 6.1 years; range: 3 months–25 years). There were 11 subjects exhibiting each of the following EEG patterns: normal wakefulness with bi-occipital dominant alpha rhythms (Pattern W), normal sleep, particularly stage N2 with spindles [8] (Pattern S), ictal seizure activity (Pattern SZ: convulsive seizures in four patients and nonconvulsive seizures in seven), and abnormal background associated with various forms of encephalopathy (Pattern E: high-amplitude slow waves in eight patients, and low-amplitude EEG or electrical cerebral inactivity in three). These EEG patterns were identified through consensus of two experienced neurophysiologists (Table 1).

Table 1
Electroencephalographic (EEG) data.

| EEG pattern | Purpose | No. of patients | Age in years (mean ± SD) | Details of EEG findings (no. of patients) |
|---|---|---|---|---|
| W (wakefulness) | Demonstration | 1 | 8.25 | Bi-occipital dominant 10 Hz alpha rhythms |
| | Test review | 10 | 9.7 ± 4.8 | Bi-occipital dominant 9 Hz alpha rhythms (1) |
| | | | | Bi-occipital dominant 10 Hz alpha rhythms (5) |
| | | | | Bi-occipital dominant 11–12 Hz alpha rhythms (4) |
| S (sleep) | Demonstration | 1 | 13.4 | Stage N2 sleep with bilateral 12 and 14 Hz spindles |
| | Test review | 10 | 10.8 ± 9.2 | Stage N2 sleep with bilateral 12 and 14 Hz spindles (9) |
| | | | | Stage N1 sleep with vertex sharp transients (1) |
| SZ (seizure) | Demonstration | 1 | 4.2 | CPSE |
| | Test review | 10 | 5.6 ± 4.2 | Focal seizure (2) |
| | | | | GTCS (3) |
| | | | | Atypical absence status epilepticus (1) |
| | | | | CPSE (3) |
| | | | | Convulsive status epilepticus (1) |
| E (encephalopathy) | Demonstration | 1 | 5.3 | Acute encephalopathy with excessive HVS |
| | Test review | 10 | 4.5 ± 3.9 | Acute encephalopathy with excessive HVS (5) |
| | | | | Chronic encephalopathy with excessive HVS (1) |
| | | | | Diffuse low amplitude (3) |
| | | | | Angelman syndrome with excessive HVS (1) |

CPSE, complex partial status epilepticus; GTCS, generalized tonic-clonic seizure; HVS, high-voltage slow wave.