Published in final edited form as:

Eur J Emerg Med. 2013 April ; 20(2): 126–129. doi:10.1097/MEJ.0b013e32835473b1.

Electroencephalographic Findings in Consecutive Emergency Department Patients with Altered Mental Status: A preliminary report

Shahriar ZEHTABCHI, M.D.,

Department of Emergency Medicine, State University of New York, Downstate Medical Center & Kings County Hospital Center, Brooklyn, New York, USA

Samah G. ABDEL BAKI, M.D., and

Department of Emergency Medicine, State University of New York, Downstate Medical Center & Kings County Hospital Center, and Bio-Signal Group Corp, Brooklyn, New York, USA

Arthur C. GRANT, MD, PhD

Departments of Neurology and Physiology & Pharmacology, State University of New York, Downstate Medical Center, Brooklyn, New York, USA

Abstract

Background—Electroencephalography (EEG) can help narrow the differential diagnosis of altered mental status (AMS) and is necessary to diagnose non-convulsive seizure (NCS).

Objectives—To identify the prevalence of EEG abnormalities in emergency department patients with AMS.

Methods—Prospective observational study. Inclusion: Patients 13 years old with AMS.

Exclusion: Easily identifiable cause of AMS (e.g. hypoglycemia). A 30-minute EEG with the standard 19 electrodes was performed on each subject. Descriptive statistics (% , 95% confidence interval [CI]) are used to report EEG findings of the first 50 enrolled patients.

Results—Thirty-five EEGs (70%, 57–81%) were abnormal. The most common abnormality was background slowing (46%, 33–60%), reflecting an underlying encephalopathy. NCS was diagnosed in 3 (6%, 1–17%), including one patient in non-convulsive status epilepticus. Nine patients (18%, 10–31%) had interictal epileptiform abnormalities indicating an increased risk of spontaneous seizure.

Conclusions—Patients presenting to the ED with AMS have a high prevalence of EEG abnormalities, including NCS.

Keywords

nonconvulsive seizure; nonconvulsive status epilepticus; altered mental status

Address for Correspondence: Shahriar Zehtabchi, MD, Department of Emergency Medicine, State University of New York, Downstate Medical Center, 450 Clarkson Avenue, Box: 1228, Brooklyn, NY 11203, Tel: 718-245-2973, Fax: 718-245-4799, shahriar.zehtabchi@downstate.edu.

Contribution

All authors have been involved in the study design, data collection, data analysis, drafting, and editing the manuscript.

Conflict of Interest

All authors are collaborating with Bio-Signal Group Corp. (BSG) in conducting a clinical trial of a novel wireless EEG device funded by the National Institutes of Health. SZ and AG receive salary support from the grant through a subcontract with Downstate Medical Center. SGAB is employed by BSG.

INTRODUCTION

Two to ten percent of the 120 million patients evaluated annually in US emergency departments (ED) present with AMS, with the most common underlying etiology being neurological disease.[1,2] EEG findings can often help narrow the differential diagnosis, and may provide valuable prognostic information as well.[3,4] Unfortunately, EEG is not routinely available in EDs, and therefore is rarely part of the acute evaluation of patients with AMS. The absence of the EEG data may delay arrival at the correct diagnosis and lead to unnecessary tests, procedures, admissions, and costs.

METHODS

The main goals of this prospective observational study are to determine the prevalence and type of EEG abnormalities, and to evaluate a novel, miniature, wireless EEG technology in ED patients 13 years old with AMS. Enrolled patients undergo an EEG with the experimental device and a separate EEG with a standard, commercially available EEG machine. Here we report data on EEGs obtained with the standard system (the experimental EEG system is investigational and has not yet been approved for marketing by the FDA). The study was approved by the institutional review board, which waived the requirement for informed consent. The study is being performed in the EDs of two urban academic hospitals in New York with approximately 205,000 ED visits per year combined. These hospitals provide care to an underserved population in a primarily Caribbean-American and African-American community. All patients 13 years old presenting with AMS of any severity are screened for enrollment on a 24/7 basis. Patients whose AMS is due to a rapidly correctable etiology such as hypoglycemia, hypotension, hypothermia, hyperthermia or narcotic overdose are excluded, as are those with severe facial or scalp injuries. Each enrolled patient undergoes a standard 30 minute EEG obtained with a full set of 19 gold-plated cup electrodes applied according to the international 10–20 system, with all electrode impedances ≤ 5 k Ω . Patient demographics, presenting symptoms and other relevant clinical data are also collected. The standard EEG is screened remotely 24/7 by an on-call clinical neurophysiologist who reports the findings to the ED attending physician.

Outcome Measures

Specific EEG findings.

Statistical analysis

The results are presented with descriptive statistics. Continuous variables are described as mean $\pm$ standard deviation and frequencies are reported as percentages with 95% confidence intervals (CI).

RESULTS

The study population consisted of 24 men (48%) and 26 women (52%) with a mean age of 60 ± 20 years (range, 13–92). The EEG findings are shown in detail in Table 1. Most importantly, 35 (70%, 95% CI, 57–81%) of the EEGs were abnormal. Twenty-three (46%, 95% CI, 33–60%) demonstrated slowing of background activities (without additional abnormalities), 3 studies (6%, 95% CI, 1–17%) demonstrated NCS with one of these showing NCSE (Fig. 1), and 9 (18%, 95% CI, 9.5–31%) had epileptiform discharges (i.e. sharp waves, spikes, or spike-wave discharges). These *interictal* epileptiform discharges are not seizure activity, but they reflect cortical irritability and indicate an increased risk of spontaneous seizure. Eight EEGs were normal (16%, 95% CI, 8–29%) and seven (14%, 95% CI, 7–27%) were deemed uninterpretable for technical or other reasons.

The emergency department disposition diagnoses (clinical impression at the time of disposition) for subjects in each EEG category are also presented in Table 1.

DISCUSSION

AMS is a common presenting symptom of ED patients. The differential diagnosis of AMS is broad, even after eliminating easily determined and treatable causes such as hypotension, hypoglycemia, etc. EEG can help to narrow the differential diagnosis, for example by ruling in or out a physiologic encephalopathy based on the presence or absence of pathologic slowing of EEG waveforms. Some diagnoses, such as NCS or severe hepatic encephalopathy, cannot be made without EEG. Despite its clinical utility, EEG is simply not available on an urgent or emergent basis in most EDs. An informal internet-based survey (unpublished data) performed by the authors found that only 2% of EDs are equipped with EEG machines, or have a technologist who can properly apply EEG electrodes, troubleshoot problems, and record a technically adequate study. Thus, ED physicians may not be aware of its value or the prevalence of abnormal EEG findings in AMS patients. The paucity of institutions equipped to perform urgent EEG in the ED on a 24/7 basis has also impeded prior studies of EEG in the ED setting.

In this report we show that EEG abnormalities are very common in a consecutive sample of 50 patients 13 years old presenting with AMS of uncertain etiology. As expected, the most common EEG abnormality was slowing, a finding indicative of encephalopathy, but non-specific as to cause. The presence of diffuse slowing, particularly if it is of at least moderate severity, would rule out a purely psychogenic or psychiatric etiology of the AMS, and thus aids in narrowing the differential diagnosis. In fact, Khan et al. showed that EEG performed emergently in the context of encephalopathy had a major impact on management and prognosis, especially when other specific biochemical and microbiological investigations were unavailable.[5]

Three of the 50 patients had NCS during the EEG, including one in NCSE. This crucial finding, which cannot be diagnosed without an EEG, impacts acute patient management and may obviate the need for additional diagnostic studies. The prevalence of NCS in this cohort is similar to that reported in the only other study that enrolled consecutive ED patients with AMS.[6] Other studies performed in the ED, ICU and / or hospital ward have reported higher rates of NCS, but in each case the pre-test probability of NCS was elevated, i.e. the EEG was requested due to a clinical suspicion of NCS.[7] Some cases of NCS in our population may have been missed, since a seizure may not have occurred during the 30 minute EEG. Detection of NCS increases with repeated or prolonged EEG monitoring.[8,9]

The epileptiform discharges observed in 9 of the recordings indicate increased risk of spontaneous seizure occurrence. They are an interictal finding most commonly seen in patients with epilepsy, but may also occur with acute or subacute structural brain injury, or in specific toxic-metabolic encephalopathies such as lithium overdose.[10]

Although a normal EEG does not exclude all serious cerebral pathologies, it does exclude NCSE, toxic-metabolic encephalopathy, and acute or subacute lesions (tumor, abscess, stroke, etc.) large enough to produce focal slowing of EEG activity.

Seven EEGs were technically limited due to excessive artifact. This is not unexpected in the ED environment, where EEG signals often contain abundant 60 Hz noise due to the high ambient electrical noise level. Also, patients with AMS may accidentally or deliberately remove electrodes during the study due to their confusion, agitation or frank combativeness. In studies of EEG in ED patients with AMS, a 10 – 15% rate of uninterpretable recordings is typical. In this study, EEG readers used a very liberal definition of “uninterpretable”, such

that many EEGs with considerable artifact-free portions were still classified as uninterpretable.

LIMITATIONS

This report describes results from the first 50 patients in a study that is expected to enroll 260 subjects. The final distribution of EEG abnormalities may differ from those presented here, although there is no reason to suspect that the overall prevalence of abnormal findings will substantially change. The EEG findings reported here are those of the individual clinical neurophysiologists who interpreted each study and were not subjected to an analysis of inter-rater reliability. However, all of the interpreters completed clinical EEG/epilepsy fellowships and are board-certified in clinical neurophysiology. As previously mentioned, some cases of NCS may have been missed if a seizure did not occur during the EEG. This limitation is an unavoidable consequence of the limited duration of both seizures and EEGs.

CONCLUSIONS

ED patients 13 years old presenting with AMS have a very high rate of EEG abnormalities. The most common abnormality is background slowing (diffuse or focal), consistent with an underlying encephalopathy. Some patients have clinically unapparent NCS or are in frank

NCSE, diagnoses that can be made only by EEG and that trigger specific treatment protocols. These data support the value of incorporating EEG into the initial evaluation of patients presenting with AMS to the ED.

Acknowledgments

The authors thank Dr. Andre Fenton, Dr. Ahmet Omurtag, Dr. Shweta Malhotra and Vanessa Arnedo for their assistance with the manuscript.

Funding

Supported by grant from National Institutes of Health (N#1RC3NS070658).

References

1. Bastani A, Kayyali H, Schmidt R, Qadir R, Manthana P. Wireless brain monitoring in the emergency department. *Conf Proc IEEE Eng Med Biol Soc.* 2005; 3:2502–05. [PubMed: 17282746]
2. Kanich W, Brady WJ, Huff JS, Perron AD, Holstege C, Lindbeck G, et al. Altered mental status: evaluation and etiology in the ED. *Am J Emerg Med.* 2002; 20:613–7. [PubMed: 12442240]
3. Kaplan PW, Rossetti AO. EEG patterns and imaging correlation in encephalopathy: encephalopathy. *J Clin Neurophysiol.* 2011; 28:233–51. [PubMed: 21633250]
4. Ziai WC, Schlattman D, Llinas R, Venkatesha S, Truesdale M, Schevchenko A, et al. Emergent EEG in the emergency department in patients with altered mental status. *Clin Neurophysiol.* 2011 In Press (full manuscript available online on journal website).
5. Firosh Khan S, Ashalatha R, Thomas SV, Sarma PS. Emergent EEG is helpful in neurology critical care practice. *Clin Neurophysiol.* 2005; 116:2454–9. [PubMed: 16122983]
6. Bautista RE, Godwin S, Caro D. Incorporating abbreviated EEGs in the initial workup of patients who present to the emergency room with mental status changes of unknown etiology. *J Clin Neurophysiol.* 2007; 24:16–21.
7. Zehtabchi S, Abdel Baki SG, Malhotra S, Grant AC. Nonconvulsive seizures in patients presenting with altered mental status: An evidence-based review. *Epilepsy Behav.* 2011; 22:139–43. [PubMed: 21784709]

8. Claassen J, Mayer SA, Kowalski RG, Emerson RG, Hirsch LJ. Detection of electrographic seizures with continuous EEG monitoring in critically ill patients. *Neurology*. 2004; 62:1743–8. [PubMed: 15159471]
9. Friedman D, Claassen J, Hirsch LJ. Continuous electroencephalogram monitoring in the intensive care unit. *Anesth Analg*. 2009; 109:506–23. [PubMed: 19608827]
10. Smith SJM, Kocen RS. A Creutzfeldt-Jacob like syndrome due to lithium toxicity. *J Neurol Neurosurg Psychiatr*. 1988; 51:120–123. [PubMed: 3127546]

Figure 1.

1a. A 5 second segment of EEG from a 48-year-old man who presented with AMS, showing continuous diffuse epileptiform discharges. The discharges evolved in frequency and distribution throughout the recording (not apparent in a 5 second EEG segment).

1b. A 5 second segment of EEG from an 87-year-old man with AMS showing diffuse, relatively high amplitude, frontally predominant 1–1.5 Hz slow waves (down arrow) superimposed on a normal posterior alpha rhythm of 9 Hz (up arrows). The slowing indicates an underlying physiologic encephalopathy and rules out both NCS and a purely psychiatric cause of AMS.

Table 1

Summary of EEG Findings and emergency department disposition diagnosis in the first 50 patients enrolled in the clinical trial.

EEG findings		Subtypes	n	ED disposition diagnosis* (n)
Normal		-	8	Undifferentiated AMS (2), Pseudoseizures (1), Syncope (1), Stroke (1), Acute Psychosis (1), Nonspecific convulsion (1), Brain tumor (1)
Abnormal	Nonconvulsive Status Epilepticus	Focal	0	NCSE and HIV encephalopathy (1)
		Generalized	1	
	Non-convulsive Seizure	Focal	0	NCS (2)
		Generalized	1	
		Focal & Generalized	1	
	Epileptiform or Epileptiform & Slowing	Focal	3	Post-ictal Confusion (6), Sepsis (1), Hepatic Encephalopathy (1), Brain Tumor (1)
		Generalized	3	
		Multifocal	3	
		Focal & Generalized	0	
	Slowing only	Focal	7	Post-ictal confusion (6), Stroke (4), Undifferentiated AMS (3), Dementia (2), Syncope (2), Nonspecific convulsion (2), Sepsis (1), Hyponatremia (1), TBI (1), Uremia (1)
		Diffuse	12	
		Focal & Diffuse	4	
Uninterpretable			7	Undifferentiated AMS (4), Acute Psychosis (2), Stroke (1)

* ED disposition diagnosis indicates the ED attending's clinical impression at the time of disposition.

Abbreviations: NCS: Non-convulsive seizure; NCSE: Non-convulsive status epilepticus; ED: Emergency Department; AMS: Altered mental status; TBI: Traumatic Brain Injury.