Effect of Inpatient Electroencephalography on Clinical Decision Making

Laura A. Harmon, MD; Megan Craddock, MD; Elisabeth Jones, MD; Craig W. Spellman, DO; and Donald M. Loveman, MD

From the Department of Internal Medicine and the Center for Diabetes and Metabolic Disorders at Texas Tech University Health Sciences Center-Permian Basin in Odessa, Texas.

Financial Disclosures: None reported.

Support: Texas Tech University Health Sciences Center.

Address correspondence to Donald M. Loveman, MD, Department of Internal Medicine, TTUHSC-Permian Basin, 701 W 5th St, Odessa, TX 79763-4206.

E-mail: donald.loveman@ttuhsc.edu

Submitted February 21, 2013; revision received July 2, 2013; accepted August 5, 3013.

Context: Routine inpatient electroencephalography (EEG) is commonly used as a diagnostic and therapeutic decision-making tool in the care of patients with a wide spectrum of conditions. Previous investigations on EEG use have focused on current guidelines or specific clinical presentations.

Objective: To assess the effect of EEGs on clinical diagnosis and management of disease in adult inpatients in a community hospital.

Methods: Medical records of adult patients who underwent EEG between October 2008 and June 2009 in a single general community hospital were retrospectively reviewed. Data were collected for comorbidities, diagnoses, and management. Findings from EEGs were classified as normal, abnormal, or uninterpretable and according to whether they resulted in a change in diagnosis or management, supported clinical decision making and resulted in no change in diagnosis or management, or did not contribute to diagnosis or management.

Results: A total of 200 medical records were reviewed; 110 (55%) were for male patients and 90 (45%) were for female patients, with a mean (range) age of 60 (18-96) years. The most common pre-EEG diagnoses were altered mental status (52 [26%]) and seizure (48 [24%]). Of all EEGs, 115 (57.5%) had findings that were normal, 83 (41.5%) had findings that were abnormal, and 2 (1%) had findings that were uninterpretable. No EEGs had findings that resulted in a change in diagnosis or management, 8 EEGs (4%) had findings that supported clinical decision making and resulted in no change in diagnosis or management, and 192 EEGs (96%) had findings that did not contribute to diagnosis or management.

Conclusion: In this study, inpatient EEGs rarely contributed to clinical decision making and in no case resulted in a change in diagnosis or management. These findings warrant future research on the effectiveness of inpatient EEGs for a wide breadth of clinical inpatient diagnoses.

J Am Osteopath Assoc. 2013;113(12):891-896
doi:10.7556/jaoa.2013.067

Electroencephalography (EEG) is used as a diagnostic tool for a spectrum of conditions including epilepsy, seizures, cerebrovascular diseases, head injuries, psychiatric diseases, and encephalopathies.[1-3] Because EEG is widely employed, the appropriateness of its use has been called into question by a number of investigators.[3-9] Smith et al[4] found overuse of EEG with respect to the United Kingdom's national guidelines, with up to 40% of EEGs deemed as having been ordered inappropriately.

From country to country, and among professional societies, guidelines for EEG use in specific disorders are highly variable. A search of the literature yielded no formal guidelines in the United States for EEG indications in adults. Previous studies in the United States involving adult EEG use have addressed primarily 3 topics: (1) effectiveness of EEG use in an emergency department (ED) setting[10,11]; (2) relevance of EEG use in specific clinical presentations (ie, syncope or epilepsy)[12,13]; and (3) effectiveness of having neurologists screen nonspecialist EEG referrals before approval.[6] In the present study, we assess the effect of inpatient EEG in the diagnosis and management of disease in adult patients in the community hospital setting.

Methods

Electronic medical records for adult inpatients (ie, aged 18 years or older) who underwent EEG at Medical Center Hospital in Odessa, Texas, from October 2008 to June 2009 were retrospectively and sequentially reviewed. For patients who underwent multiple EEGs during a single hospital stay, only the first EEG was included in study analyses. Records for patients from all hospital inpatient settings (eg, intensive care unit, critical care unit, general medical-surgical) were included.

The EEGs were ordered by consulting neurologists, attending neurologists, or managing (ie, nonneurologist) physicians. All EEGs were standard 23-channel, 30-minute recordings and were interpreted as a standard part of the hospital electrodiagnostic service by 1 of 4 neurologists certified by the American Board of Psychiatry and Neurology.

Records were excluded when they were incomplete or not available for review, when EEGs were used to assess brain death, when only 24-hour EEG monitoring was performed, and when conflicting interpretations existed. Records with video EEGs, ambulatory EEGs, and EEGs performed in the ED were also excluded.

Medical records were evaluated to obtain (1) previous neurologic diagnoses, (2) pre-EEG and discharge diagnoses, (3) management in the ED and during the patient's hospital stay, (4) day of hospital stay when EEG was performed, and (5) findings of EEGs (normal, abnormal, or uninterpretable). Information regarding diagnoses and management was used to assess changes in clinical decision making before and after EEG.

To reduce intraobserver variability, each medical record was reviewed by 2 of 3 independent investigators (L.A.H., M.C., and E.J.). Records that prompted conflicting opinions were reviewed by a quorum of the investigators, which comprised physicians and research scientists. The evaluating team established the working diagnosis and proposed management as of the time when the EEG was ordered. After considering EEGs in the context of the clinical setting, the impact of EEG on patient care was classified in 1 of 3 groups according to the following criteria:

- Group 1: The EEG findings prompted a change in the pre-EEG diagnosis or management.
- Group 2: The EEG findings supported the pre-EEG clinical decision making, and no changes in diagnosis or management occurred as a result of the EEG.
- Group 3: The EEG findings did not contribute to clinical decision making, and no changes in diagnosis or management occurred as a result of the EEG.

Results

A total of 246 medical records were reviewed. Forty-six records met the study's exclusion criteria: 39 records were incomplete or not available for review, 3 had EEGs that were used to assess brain death, 3 had only 24-hour EEG monitoring, and 1 had conflicting interpretations. No records had video EEGs, ambulatory EEGs, or EEGs performed in the ED. Of the 200 records included in study analyses, 110 (55%) were for male patients and 90 (45%) were for female patients, with a mean age (range) of 60 (18-96) years. Records for 125 patients (62.5%)

included a previous neurologic diagnosis, including seizure (38 [19%]), dementia (19 [9.5%]), syncope (3 [1.5%]), and other (65 [32.5%]). The diagnoses that prompted the ordering of an EEG are described in *Table 1*, with the most common diagnoses being altered mental status (52 [26.0%]) and seizure (48 [24.0%]). Discharge diagnoses are also shown in *Table 1*.

The mean (SD) day of the hospital stay that EEG was performed was 2 (3). Results of EEGs were as follows: 115 (57.5%) were normal, 83 (41.5%) were abnormal, and 2 (1%) were classified as poor quality, rendering them uninterpretable. The EEG results were then classified according to their impact on clinical decision making (*Table 2*). No records had EEG findings that resulted in a change in diagnosis or management (group 1). In 8 records (4%), EEG findings supported clinical decision making but resulted in no change in diagnosis or management (group 2). The EEG findings were considered noncontributory to clinical decision making and did not affect diagnosis or management in 192 records (96%) (group 3).

The clinical presentation and course of the 8 patients whose EEG findings were supportive of clinical decision making but did not alter diagnosis or management (group 2) are described in *Table 3*.

Comment

A limitation of the present retrospective study was that it was confined to a single institution and therefore had a limited number of medical records available for analysis. In addition, although we made every effort to understand in detail the working diagnosis (not simply the diagnosis written) and the intended management at the time of the EEG request, we were unable to determine with certainty whether undocumented communication occurred between the EEG interpreter and the care team that may have resulted in any changes in diagnosis or management. It is therefore possible that had this study been performed prospectively, greater benefit of EEG would have been demonstrated. Nevertheless, in the present study, inpatient EEG findings rarely contributed to or resulted in a change in diagnosis or management.

For example, syncope was diagnosed in 3 patients before EEG was administered. In each patient, EEG findings did not alter clinical decision making. These findings mirrored those of Poliquin-Lasnier and Moore,[5] Abubakr and Wambacq,[12] and Davis and Freemon[13]; all 3 studies showed little impact of EEG in the care of patients with syncope.

Table 1.
Pre-EEG and Discharge Diagnoses of Patients Who Underwent EEG in the Hospital Setting (N=200)

	No. (%)	
Diagnosis	**Pre-EEG**	**Discharge**
Altered mental status	52 (26.0)	27 (13.5)
Seizure	48 (24.0)	49 (24.5)
Rule out seizure	38 (19.0)	NA
Syncope	24 (12.0)	21 (10.5)
Encephalopathy	13 (6.5)	15 (7.5)
Dementia	6 (3.0)	9 (4.5)
Abnormal involuntary movement	5 (2.5)	NA
Cerebrovascular accident	4 (2.0)	17 (8.5)
Near syncope	2 (1.0)	NA
Drug overdose	2 (1.0)	7 (3.5)
Traumatic head injury	2 (1.0)	NA
Transient ischemic attack	NA	9 (4.5)
Hematoma	NA	3 (1.5)
Pseudoseizures	NA	3 (1.5)
Other neurologic diagnosis[a]	4 (2.0)	7 (3.5)
Other nonneurologic diagnosis[b]	NA	33 (16.5)

[a] Other neurologic diagnoses include trauma, brain mass, fungal infection, metastatic disease, global amnesia, and hemi-sensory deficit.
[b] Nonneurologic diagnoses were primarily cardiac, respiratory, and renal failure.

Abbreviation: EEG, electroencephalography.

In 2 patients, EEGs were used to support decisions to withhold antiepileptic therapy after the discovery of subdural hematomas. Both EEGs demonstrated abnormal slowing devoid of epileptiform discharge. The literature suggests that most clinicians would either continue antiepileptic therapy for 3 to 6 months regardless of the EEG findings or never initiate treatment in the first place.[14-16] We were unable to find guidelines or studies to support the practice of withdrawing prophylactic antiepileptic medication soon after the injury in a patient with subdural hematoma on the basis of normal EEG results.[17]

Our study had a higher frequency of abnormal EEGs than other comparable studies (41.5% vs 11% to 23%).[5,12,13] One possible explanation for this finding is that our study included all presenting diagnoses rather than a single indication for EEG. In addition, physicians may have ordered repeat EEGs for patients who previously had abnormal EEG findings. Despite the higher frequency of abnormal EEG results in our patient population, we still determined the EEG findings had minimal impact on clinical decision making.

Studies have shown EEG to be beneficial for certain conditions, including conditions with pathognomonic waveforms,[18-20] pediatric epilepsy,[7] and status epilepticus.[21] The findings of the present study suggest, however, that EEG findings may not make an appreciable contribution to clinical decision making, diagnosis, or management in the general patient population. Our findings suggest that a careful clinical evaluation, including a thorough patient history and physical examination, is the most valuable initial approach to patient care. It is also the most cost-effective approach to care—supplemental testing adds to health care costs and should be judiciously considered when the likelihood of benefit is greatest.

It is possible that studies of patient populations in institutions with practice patterns different from ours might reveal different results with regard to EEG use. Further evaluation of EEG use in the general inpatient population is warranted. Specifically, we believe that clearer guidelines for appropriate inpatient use of EEG in general medical practice should be addressed and promulgated.

Table 2.
Effect of EEG Findings on the Care of Hospitalized Adult Patients (N=200)

Effect of EEG Findings	Patients, No. (%)
Group 1: Affected Diagnosis or Management	0
Group 2: Supported Clinical Decision Making and Did Not Affect Diagnosis or Management	8 (4)
Group 3: Did Not Contribute to Clinical Decision Making and Did Not Affect Diagnosis or Management	192 (96)

Abbreviation: EEG, electroencephalography.

Conclusion

In the present study, EEG findings supported clinical decision making in 4% of patients and did not alter diagnosis or management in any case. These results suggest that EEG may fine tune or support diagnostic impressions but rarely leads to a change in medical management. Future research is warranted on the effectiveness of inpatient EEGs for a wide breadth of clinical inpatient diagnoses.

References

1. Krumholz A, Wiebe S, Gronseth G, et al; Quality Standards Subcommittee of the American Academy of Neurology; American Epilepsy Society. Practice parameter: evaluating an apparent unprovoked first seizure in adults (an evidence based review). *Neurology*. 2007;69(21):1996-2007. doi:10.1212/01.wnl.0000285084.93652.43.
2. Nuwer M; American Academy of Neurology; American Clinical Neurophysiology Society. Assessment of digital EEG, quantitative EEG, and EEG brain mapping. *Neurology*. 1997;49(1):277-292. doi:10.1212/WNL.49.1.277.
3. Kapoor WN, Karpf M, Maher Y, Miller RA, Levey GS. Syncope of unknown origin: the need for a more cost-effective approach to its diagnosis evaluation. *JAMA*. 1982;247(19):2687-2691. doi:10.1001/jama.1982.03320440035029.

Table 3.
Clinical Presentation and Course in Patients Who Underwent EEG That Supported Clinical Decision Making

Case by Group	Clinical Presentation	EEG Pattern	Clinical Course
Abnormal EEG Findings With Characteristic Waveforms			
Case 1	Cardiopulmonary arrest DIC	Abnormal Burst suppression pattern	Palliative care
Case 2	Respiratory failure Patient was comatose and receiving ventilation	Abnormal PLEDs	Palliative care
Abnormal EEG Findings With Nonspecific Slowing			
Case 3	Right temporal hematoma	Abnormal slowing Devoid of epileptiform discharge	No seizure activity found AEM discontinued[a]
Case 4	Subdural hematoma	Abnormal slowing Devoid of epileptiform discharge	No seizure activity found AEM discontinued[a]
Normal EEG Findings			
Case 5	Possible seizure activity	Normal	Treatment withheld
Case 6	Seizure, possibly secondary to AICD malfunction	Normal	AEM discontinued[a] Treatment withheld
Case 7	Opioid withdrawal	Normal	Pseudo-seizures suspected Treatment withheld
Case 8	Loss of consciousness Probable vasovagal syncope	Normal	High index of suspicion for vasovagal syncope Treatment withheld

[a] Ambulatory electrocardiographic monitoring (AEM) was started in the emergency department.

Abbreviations: AICD, automatic implantable cardioverter defibrillator; DIC, disseminated intravascular coagulation; EEG, electroencephalography; PLEDs, periodic lateralized epileptiform discharges.

4. Smith D, Bartolo R, Pickles RM, Tedman BM. Requests for electroencephalography in a district general hospital: retrospective and prospective audit. *BMJ*. 2001;322(7292):954-957.
5. Poliquin-Lasnier L, Moore FG. EEG in suspected syncope: do EEGs ordered by neurologists give a higher yield? *Can J Neurol Sci*. 2009;36(6):769-773.
6. Gurbani NS, Gurbani SG, Mittal M, et al. Screening of EEG referrals by neurologists leads to improved health care resource utilization. *Clin EEG Neurosci*. 2006;37(1):30-33. doi:10.1177/155005940603700107.
7. Kwong KL, Chak WK, So KT. Evaluation of paediatric epilepsy care. *KH J Paediatr*. 2002;7:169-172.
8. Primavera A, Folis E, Abbruzzese M. Organic brain syndrome: diagnostic value of the EEG. *JAMA*.1983;250(1):34-35. doi:10.1001/jama.1983.03340010020016.
9. Pearce KM, Cock HR. An audit of electroencephalography requests: use and misuse [published online February 20, 2006]. *Seizure*. 2006;15(3):184-189. doi:10.1016/j.seizure.2006.01.003.

(continued)

10. Ghougassian DF, d'Souza W, Cook MJ, O'Brien TJ. Evaluating the utility of inpatient video-EEG monitoring. *Epilepsia.* 2004;45(8):928-932. doi:10.1111/j.0013-9580.2004.51003.x.

11. Quigg M, Shneker B, Domer P. Current practice in administration and clinical criteria of emergent EEG. *J Clin Neurophysiol.* 2001;18(2):162-165.

12. Abubakr A, Wambacq I. The diagnostic value of EEGs in patients with syncope. *Epilepsy Behav.* 2005;6(3):433-434.

13. Davis TL, Freemon FR. Electroencephalography should not be routine in the evaluation of syncope in adults. *Arch Intern Med.* 1990;150(10):2027-2029. doi:10.1001/archinte.1990.00390210029008.

14. Cameron MM. Chronic subdural hematoma: a review of 114 cases. *J Neurol Neurosurg Psychiatry.* 1978;41(9):834-839. doi:10.1136/jnnp.41.9.834.

15. Sabo RA, Hanigan WC, Aldag JC. Chronic subdural hematomas and seizures: the role of prophylactic anticonvulsive medication. *Surg Neurol.* 1995;43(6):579-582.

16. Cooper PR. Post-traumatic intracranial mass lesions. In: Cooper PR, ed. *Head Injury.* 2nd ed. Baltimore, MD: Williams & Wilkins; 1987:238-284.

17. Chang BS, Lowenstein DH; Quality Standards Subcommittee of the American Academy of Neurology. Practice parameter: antiepileptic drug prophylaxis in severe traumatic brain injury. *Neurology.* 2003;60(1):10-16. doi:10.1212/01.WNL.0000031432.05543.14.

18. Orta DS, Chiappa KH, Quiroz AZ, Costello DJ, Cole AJ. Prognostic implications of periodic epileptiform discharges. *Arch Neurol.* 2009;66(8):985-991. doi:10.1001/archneurol.2009.137.

19. van Putten MJ, van Putten MH. Uncommon EEG burst-suppression in severe post-anoxic encephalopathy. *Clin Neurophysiol.* 2010;121(8):1213-1219. doi:10.1016/j.clinph.2010.02.162.

20. Brown P. EEG findings in Creutzfeldt-Jakob disease. *JAMA.* 1993;269(24):3168.

21. Husain AM, Horn GJ, Jacobson MP. Non-convulsive status epilepticus: usefulness of clinical features in selecting patients for urgent EEG. *J Neurol Neurosurg Psychiatry.* 2003;74(2):189-191. doi:10.1136/jnnp.74.2.189.