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Electroencephalography findings in patients presenting to the ED for evaluation of seizures☆,,☆☆,,★

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Abstract

Background—Status epilepticus is a life-threatening, time-sensitive emergency. Acquiring an electroencephalogram (EEG) in the emergency department (ED) could impact therapeutic and disposition decisions for patients with suspected status epilepticus.

Objectives—The objective of this study is to estimate the proportion of EEGs diagnostic for seizures in patients presenting to an ED with a complaint of seizures.

Methods—This retrospective chart review included adults presenting to the ED of an urban, academic, tertiary care hospital with suspected seizures or status epilepticus, who received an EEG within 24 hours of hospital admission. Data abstraction was performed by a single, trained, nonblinded abstractor. *Seizures* were defined as an epileptologist's diagnosis of either seizures or status epilepticus on EEG. The proportion of patients with seizures is given with confidence interval$_{95}$ (CI$_{95}$).

Results—Of 120 included patients, 67 (56%) had a history of epilepsy. Mean age was 52 years (SD, 16), 58% were White, and 61% were male. Within 24 hours, 3% had an EEG diagnostic for seizures. Electroencephalogram was obtained in the ED in 32 (27%) of 120 (CI$_{95}$, 19%-35%), and 2 (6%) of 32 (CI$_{95}$, 1%-19%) had seizures. Electroencephalogram was performed inpatient for 88 (73%) of 120 (CI$_{95}$, 65%-81%), and 2 (2%) of 88 (CI$_{95}$, 0.5%-7.1%) had seizures.

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[1]With guidance from WAK and OMA, who conceived the study, designed the trial, and obtained research funding.
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[3]Supervised the conduct of the trial and data collection.
[4]Managed and analyzed the data, including quality control.
[5]Provided input to the design of the study.
[6]Provided statistical oversight.
[7]Takes responsibility for the manuscript as a whole.

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Conclusion—Only 3% of ED patients with suspected seizures or status epilepticus had EEG confirmation of seizures within 24 hours. Early EEG acquisition in the ED may identify a group of patients amenable to ED observation and subsequent discharge from the hospital.

1. Introduction

1.1. Background

An estimated 20 million patients in the United States have epilepsy, and an additional 140000 patients are diagnosed each year [1]. Up to 20% of epilepsy patients develop status epilepticus in their lifetime. Status epilepticus is a life-threatening condition of prolonged seizures for which treatment is time sensitive. The mortality rates for adult episodes of status epilepticus are between 16% and 25% [2]. Aggressive, early treatment is recommended to reduce neurologic morbidity and mortality [2,3].

Patients with status epilepticus are often admitted to the hospital through the emergency department (ED) [1,2]. Approximately 1% to 2% of all ED patients have a chief complaint of seizures, and 7% of these are admitted for suspicion of status epilepticus [4,5]. The definitive diagnosis of status epilepticus is obtained by an electroencephalogram (EEG) study, interpreted by a trained specialist. The results of the EEG frequently guide therapeutic decision making, especially in the absence of overt clinical seizures [6]. However, EEG monitoring is often delayed until after admission to the hospital, and experience suggests few patients receive an EEG in the ED. This delay may result in either protracted periods of unrecognized or untreated status epilepticus with resultant high morbidity and mortality [2] or overutilization of resources, when patients without status epilepticus are admitted.

1.2. Importance

It is unknown if acquisition of an EEG during the ED stay would impact the therapeutic decision making and outcomes for patients with suspected status epilepticus [5]. Potential benefits of obtaining an EEG in the ED include early recognition and treatment of confirmed status epilepticus and the expedited workup and disposition of patients with ruled out status epilepticus. Obtaining an EEG in the ED could therefore help optimize resource utilization and decision making for ED patients with suspected status epilepticus.

1.3. Goals

This study was designed to characterize the pattern of EEG acquisition for patients presenting to the ED with a complaint of seizures who are subsequently admitted to the hospital. We also estimated the proportion of EEGs diagnostic for seizures or status epilepticus as well as the potential impact of obtaining an EEG in the ED on patient outcomes.

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2. Methods

2.1. Study design and setting

This retrospective chart review was conducted at an urban, academic, tertiary care center with greater than 90000 annual adult visits to the ED [7]. This study was approved by the institutional review board.

2.2. Selection of participants

Eligible patients were identified from electronic medical records using *International Classification of Diseases*, *Ninth Revision* (*ICD-9*) and *Current Procedural Terminology* (*CPT*) codes. Potentially eligible patients had a seizure-related *ICD*-9 code (780.97, 780.39, 345.0, 345.1, 345.2, 345.3, 345.4, 345.5, 345.6, 345.7, 345.8, or 345.9) and had a *CPT* code indicating that an EEG had been performed (95812, 95813, 95816, 95819, or 95822). After identification, patients were screened for eligibility. Patients presenting between January 1, 2011, and December 31, 2011 who were aged 18 years or older, admitted to the hospital and received an EEG or continuous EEG within 24 hours of ED presentation, and diagnosed with seizures or status epilepticus during the hospital stay were included. Patients who were transferred from another medical facility, left the ED or hospital against medical advice, or for whom records were missing greater than 10% of abstracted data were excluded.

2.3. Methods and measurements

A data abstraction form and data dictionary with prespecified definitions for all fields and explicitly stated abstraction and coding rules were used. Missing or unknown data points were recorded as such, and every data form had all entries completed.

Data were abstracted from electronic medical records by 1 investigator, PK, who was trained by emergency medicine and neurocritical care physicians on the format and terminology of the ED, floor and intensive care unit (ICU) hospital records, and the abstraction methods to be used for this study. The abstractor was not blinded to the purpose of this study but was not involved in the care of seizure patients at the study site in any capacity.

Five test charts were initially abstracted. These were reviewed by an emergency medicine and neurocritical care–trained physician investigator, WAK, and feedback was provided. An additional 10 charts were then reviewed by the abstractor and independently reviewed and adjudicated by an emergency medicine and neurocritical care–trained physician investigator, WAK or OA. Accuracy of abstraction was considered acceptable, and subsequent chart abstraction was conducted without duplication. Questions regarding variable definitions and charting shortfalls were addressed throughout the data collection period.

Abstracted data included demographics, laboratory results, written EEG reports, and final patient disposition. All EEGs were interpreted by board-certified epileptologists, and these reports were abstracted for the presence of mild, moderate, and severe slowing; epileptiform discharges; focal, myoclonic, and generalized seizures; and status epilepticus and myoclonic status epilepticus. Thirty-day mortality was assessed via review of the Social Security Death Index at least 7 months after patient discharge.

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2.4. Outcomes

The primary outcome was the proportion of EEGs obtained in the ED for patients suspected of having seizures or status epilepticus and the number and proportion that were diagnostic for seizures or status epilepticus according to the clinical determination of the interpreting epileptologist. Secondary outcomes included length of stay, disposition, and 30-day mortality.

2.5. Analysis

Study data were collected on paper case report forms and subsequently entered into a Research Electronic Data Capture database [7]. All analyses were conducted using SPSS 21.0 for Windows (IBM Corporation, Armonk, NY). Continuous data are described using means and SDs or medians and ranges. Categorical data are described using frequencies and percentages. Differences in proportions were calculated, and confidence intervals$_{95}$ (CIs$_{95}$) are presented to indicate precision of the estimates.

3. Results

3.1. Characteristics of study subjects

There were 171 patients with an *ICD-9* code related to seizures and with a *CPT* code for an EEG identified. Of these, 51 were excluded: 20 (39%) patients did not have a documented ED physician diagnosis of status epilepticus or seizure, 13 (25%) were transferred from a different facility, 9 (18%) had no EEG obtained within 24 hours of presentation, 7 (14%) left against medical advice, and 2 (4%) had incomplete records. The Figure summarizes patient inclusion.

The mean age of the 120 included patients was 52 years (SD, 16), 70 (58%) were White, and 73 (61%) were male. A history of seizure disorder or epilepsy was reported in 67 (56%), and 34 (28%) had a history of alcohol abuse. Demographics, medical history, and presenting vital signs are listed in Table 1.

3.2. Main results

Overall, 4(3%) of 120 of patients had findings diagnostic of seizure or status epilepticus on EEG within 24 hours of presentation. An EEG was obtained in the ED for 32 (27%) of 120 (CI$_{95}$, 19%-35%) patients. Of these, seizures were diagnosed in 2 (6%) of 32 (CI$_{95}$, 1%-19%) patients. An inpatient EEG was performed after admission to the hospital for 88 (73%) of 120 (CI$_{95}$, 65%-81%), and of these, 2 (2%) of 88 (CI$_{95}$, 0.5%-7.1%) were diagnostic of seizures. Electroencephalogram findings for those with and without seizures are presented in Table 2. At hospital discharge, 101 (84.2%) of 120 patients were diagnosed with seizures, 7 (5.8%) of 120 were diagnosed with nonepileptic seizures, and 6 (5.0%) of 120 were diagnosed with spells.

The median ED length of stay for patients who received an EEG in the ED was 9 hours (interquartile range (IQR), 12), and it was 6 hours (IQR, 7) hours for those with inpatient EEG; difference in medians was 3 hours (CI$_{95}$, −0.8 to 6.8). The median hospital length of stay for patients who received an EEG in the ED was 2 days (IQR, 3), and it was 2 days

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(IQR, 3) for those with an inpatient EEG; difference in medians 0 days (CI_{95}, −1.6 to 1.6). Among admitted patients, 37% were discharged from the hospital within 24 hours.

Of patients with an EEG in the ED, 1 (2%) of 32 died in the hospital. Of the 88 patients, 2 (2%) who got an inpatient EEG died in the hospital; difference in proportions−0.9% (CI_{95}, −7.6% to 5.9%). No additional patients died within 30 days of discharge.

4. Discussion

4.1. Significance

In patients admitted to the hospital from the ED with suspected seizures or status epilepticus, only 3% with EEG performed within 24 hours had an EEG diagnostic for seizures. Twenty-seven percent of EEGs were performed in the ED. Of these, 6% were diagnostic for seizures, compared with 2% of inpatient EEGs done after admission. Given these rates of occurrence of seizures and status epilepticus after the initial ED course and the finding that 37% of all patients were discharged within 24 hours, an opportunity exists for improving current resource utilization by treating and monitoring appropriate patients with suspected seizures/status epilepticus in an ED observation setting after obtaining an EEG in the ED. This may avoid transfers to specialized hospitals or admission to the ICU.

It is possible that patients who received an EEG in the ED may have presented differently from those patients who received an inpatient EEG during their hospital admission. Increased overall physician level of suspicion or concern for status epilepticus may have led to earlier initiation of EEG in the ED. The low rate of seizure diagnosis by continuous EEG is likely multifactorial. Aggressive prehospital and ED pharmacologic management may have contributed to a low rate of subsequent seizures or status epilepticus on EEG. The rate of final hospital discharge diagnosis of seizures or status epilepticus (84%) suggests that the patient population was at high risk for additional inpatient seizures or status epilepticus. Regardless of any possible differences in ED presentation and workup, the prevalence of seizures diagnosed by EEG was not statistically different between ED or inpatient acquisition of EEG.

The ED length of stay was higher for the ED EEG group compared with those with an inpatient EEG. Any increase in the time spent in the ED has an impact on ED operations and resource utilization. Measures have been proposed to optimize ED resources and obtain a more efficient EEG set up to solve the issue of increased ED length of stay [2,8]. It is also possible to consider the use of observation units; the 24-hour time window for this study was selected, as it may represent a patient population that would benefit from observation status to exclude life-threatening status epilepticus, thus avoiding hospital and potential ICU admission. In our study, more than one-third were discharged within 24 hours and may thus have been observation unit candidates. It is possible that these patients were postictal and did not warrant hospital admission.

4.2. Limitations

We demonstrate that only 3% of EEGs conducted within 24 hours of presentation with a chief complaint of seizures or status epilepticus were diagnostic for seizures. This result

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should be tempered by the limitations inherent in the study design. Although rigorous chart review methods were used, the study is nonetheless limited by the nature of clinical documentation, including missing data, error, and inconsistency. In addition, our study used a single, nonblinded abstractor. The small sample size also suggests the need to replicate these findings. The seizure rates we observed were smaller than some previously published reports, where rates of diagnosis of status epilepticus of between 7% and 37% have been observed for patients admitted from the ED presenting with seizures [2,8-10]. The time course of EEG acquisition was less clear in those studies compared with ours, and extending the time window beyond 24 hours identified additional seizures in our study.

5. Conclusions

Early EEG acquisition in ED patients with suspected seizures or status epilepticus might identify a group of patients amenable to ED observation and subsequent discharge from the hospital. Future studies should assess the potential impact of routine EEG acquisition in the ED on patient outcomes and resource utilization.

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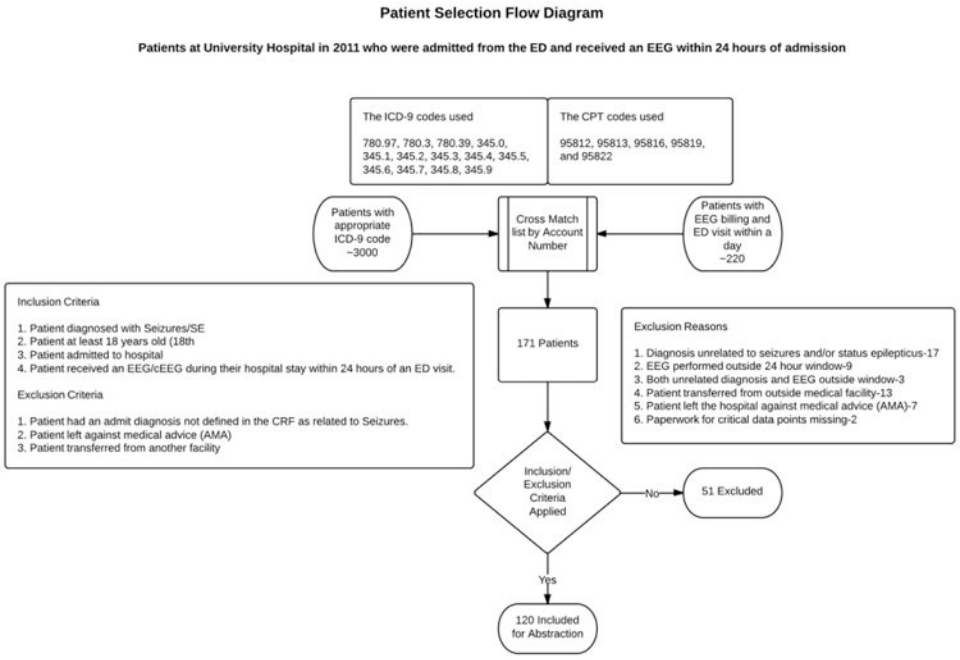

Figure.
Patient selection flow diagram.

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Table 1

Demographics, medical history, and presenting vital signs by EEG obtained in the ED

	Total (n = 120)	No (n = 88)	Yes (n = 32)
Age, mean (SD)	52 (16)	52 (18)	52 (11)
Race, n (%)			
White	70 (58.3)	55 (62.5)	15 (46.9)
African American	48 (40.0)	32 (36.4)	16 (50.0)
Other	2 (1.7)	1 (1.1)	1 (3.1)
Hispanic, n (%)	2 (1.7)	1 (1.1)	1 (3.1)
Male, n (%)	73 (60.8)	52 (59.1)	21 (65.6)
Arrival by EMS, n (%)	93 (77.5)	64 (72.7)	29 (90.6)
Medical history, n (%)			
Seizures/epilepsy	67 (55.8)	48 (54.5)	19 (59.4)
Alcohol use	34 (28.3)	24 (27.3)	10 (31.3)
Drug use	18 (15.0)	11 (12.5)	7 (21.9)
Stroke/trans ischemic attack	17 (14.2)	10 (11.4)	7 (21.9)
Traumatic brain injury	8 (6.7)	7 (8.0)	1 (3.1)
Intracerebral hemorrhage/subarachnoid Hemorrhage	4 (3.3)	4 (4.5)	0 (0.0)
Nonepileptic seizures/pseudoseizures	2 (1.7)	1 (1.1)	1 (3.1)
Status epilepticus	1 (0.8)	1 (1.1)	0 (0.0)
Presenting vital signs, mean (SD)			
Systolic BP	143 (28)	143 (29)	143 (24)
Diastolic BP	85 (14)	85 (15)	85 (11)
Heart rate	95 (22)	95 (22)	96 (21)
Respiratory rate	19 (5)	19 (5)	19 (7)
Oxygen saturation	97 (4)	97 (4)	97 (4)

Abbreviations: *EMS*, emergency medical services; *BP*, blood pressure.

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Table 2

Electroencephalogram finding by seizure on EEG

	No seizure		Seizure	
	n	%	n	%
Generalized seizures	0	0.0	1	25.0
Partial seizures	0	0.0	2	50.0
Status epilepticus	0	0.0	1	25.0
Myoclonic status epilepticus	0	0.0	0	0.0
Myoclonic seizures	0	0.0	0	0.0
Focal seizures	0	0.0	1	25.0
Epileptiform discharges	21	18.1	3	75.0
Slowing	72	62.1	2	50.0