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Usage of EpiFinder clinical decision support in the assessment of epilepsy

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ABSTRACT

Background: The diagnosis of epilepsy is at times elusive for both neurologists and nonneurologists, resulting in delays in diagnosis and therapy. The development of screening methods has been identified as a priority in response to this diagnostic and therapeutic gap. EpiFinder is a novel clinical decision support tool designed to enhance the process of information gathering and integration of patient/proxy respondent data. It is designed specifically to take key terms from a patient's history and incorporate them into a heuristic algorithm that dynamically produces differential diagnoses of epilepsy syndromes.
Objective: The objective of this study was to test the usability and diagnostic accuracy of the clinical decision support application EpiFinder in an adult population.
Methods: Fifty-seven patients were prospectively identified upon admission to the Epilepsy Monitoring Unit (EMU) for episode classification from January through June of 2017. Based on semiologic input, the application generates a list of epilepsy syndromes. The EpiFinder-generated diagnosis for each subject was compared to the final diagnosis obtained via continuous video electroencephalogram (cVEEG) monitoring.
Results: Fifty-three patients had habitual events recorded during their EMU stay. A diagnosis of epilepsy was confirmed (with cVEEG monitoring) in 26 patients while 27 patients were found to have a diagnosis other than epilepsy. The algorithm appropriately predicted differentiation between the presence of an epilepsy syndrome and an alternative diagnosis with 86.8% (46/53 participants) accuracy. EpiFinder correctly identified the presence of epilepsy with a sensitivity of 86.4% (95% confidence interval [CI]: 65.0–97.1) and specificity of 85.1% (95% CI: 70.2–96.4).
Conclusion: The initial testing of the EpiFinder algorithm suggests possible utility in differentiating between an epilepsy syndrome and an alternative diagnosis in adult patients.

1. Introduction

Given the varied clinical descriptors and manifestations of epilepsy, the differential is broad, and the diagnostic process is often challenging. Misdiagnosis rates of epilepsy in epilepsy centers have been recorded at 26% [1] and in the community setting at between 20 and 40% [2,3]. This suggests that an accurate diagnosis is often elusive for both neurology and nonneurology providers creating a practice gap where an accurate and early diagnosis of epilepsy is missed or delayed. The consequence of such not only exposes individuals to unwarranted treatments and restrictions but also often prevents investigations that would help in clarifying a true diagnosis [4,5]. As this affects all providers tasked with evaluating patients where epilepsy is a potential diagnosis, it has been recognized that the development of effective screening tools may help streamline the diagnostic process. As a result, the Institute of Medicine has identified the development of such tools as a research priority [6].

To this end, clinical decision support systems (CDSS) have been developed with the goal of improving timely diagnostic accuracy by aiding the process of clinical decision-making [7]. Patterson et al. successfully developed a Bayesian-based 11-question tool to assist in the diagnosis and triage of epilepsy. Their tool was downloaded as a mobile application and successfully administered by nonmedical health workers [8,9]. Given the feasibility of an application-based support tool, further evaluation of non-Bayesian-based CDSS algorithms has yet to be studied.

As such, we tested a novel clinical decision support tool: EpiFinder. This application is designed to take key words from a patient's history and incorporate them into a heuristic algorithm that dynamically produces a list of epilepsy syndromes. The application was developed as a clinical decision support tool to help triage and focus patient encounters with the ultimate goal of improving the diagnostic and therapeutic gap. The objective of this study was to evaluate the usability and diagnostic accuracy of EpiFinder in differentiating between epilepsy syndromes and alternative diagnoses in adult patients.

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2. Methods

2.1. Study population

The study commenced following approval from the Mayo Clinic Institutional Review Board. Subjects were prospectively identified upon admission to the Epilepsy Monitoring Unit (EMU) at Mayo Clinic Arizona, a tertiary epilepsy referral center. Eligible subjects were those over the age of 18 admitted to undergo scalp continuous video electroencephalogram (cVEEG) monitoring for episode classification. Those whose monitoring session was inconclusive because of the lack of recorded events were removed from the study. Subject selection occurred between January 31 and June 30, 2017.

2.2. Data collection

All consecutive adults admitted to the EMU for scalp cVEEG from January through June 2017 were eligible for inclusion in this prospective study. Subjects were asked to describe their events in detail to an trained epilepsy neurologist gathering the admission history. For those unable to provide an account of the event, the information was gathered via a proxy respondent (usually a family or friend) with the subjects' permission. All encounters were timed and included only the history-taking portion of the admission. Physical exam and time taken to review results from prior evaluations were not included. Where applicable, medications were tapered, and provoking maneuvers including hyperventilation and photic stimulation were performed. The final "gold standard" diagnosis was based on video-EEG recording of habitual events.

The EpiFinder application was downloaded as an application and administered to subjects using an iPad. Terms used to describe events in question were entered into the EpiFinder application by an epilepsy-trained neurologist. If the subject had an event during questioning, timing was stopped and resumed only when the subject was able to participate again. Collected terms were submitted to the application, de-identified, and stored on Health Insurance Portability and Accountability Act (HIPPA)-compliant servers.

EpiFinder's algorithm is a form of artificial intelligence that is based on pattern recognition. It utilizes standardized terminology and heuristic algorithms that produce a list of differential diagnoses based on pattern recognition of a cluster or "constellation" of semiology against International League Against Epilepsy (ILAE)-defined epilepsy criteria.

For example, when a patient discusses their symptoms, the semiologic terms (staring/rhythmic eye blinking/loss of awareness) are entered into the application. The application compares the aggregate symptom bundle against a knowledge representation of ILAE recommendations and produces a list of weighted differential diagnoses. These diagnoses included different generalized and localization-related epilepsy syndromes.

The EpiFinder-generated diagnosis for each subject was compared with the final diagnosis obtained via continuous video-EEG monitoring. If the algorithm predicted the presence of epilepsy, it generated a differential of epilepsy syndromes. If the algorithm did not identify an epilepsy syndrome based on the entered descriptors, it would indicate that the information provided was insufficient. Results were considered positive if the EpiFinder application produced a differential diagnosis consistent with a focal or generalized epilepsy syndrome as confirmed by the presence of a habitual event correlating with electrographic changes reflecting seizure on video-EEG monitoring.

3. Results

Subjects were admitted to the EMU at Mayo Clinic Arizona for the purpose of episode classification. All adults identified their preferred language to be English. In total, 57 subjects were enrolled in the study (30 females; 27 males). The mean age of the subjects was 42 (range: 18–78 years). Of the 57 subjects, four had nondiagnostic admissions and were excluded from subsequent analysis (Fig. 1). Average length of stay was 4.7 days (range: 2–8 days).

The EpiFinder algorithm generated differential diagnoses when semiologic terms related to an epilepsy diagnosis were entered. Of the 53 subjects who experienced habitual events, the algorithm predicted the prevalence of an epilepsy syndrome in 35.8% (19/53 subjects) and indicated insufficient information to predict epilepsy in 50.9% (27/53 subjects), suggesting an alternative diagnosis.

The prevalence of those with epilepsy was confirmed with cVEEG in 49.1% (26/53 subjects); 50.9% (27/53 subjects) of subjects were found to have a diagnosis other than epilepsy. This composition was further broken down as follows: 25 subjects were diagnosed with nonepileptic episodes, one subject was found to have a parasomnia, and another was found to have both parasomnia and movement disorder (Table 1).

The algorithm predicted appropriate classification between the presence of pathology and an alternative diagnosis with 86.8% (46/53 participants) accuracy. EpiFinder correctly identified the presence of epilepsy syndrome with a sensitivity of 86.4% (95% confidence interval [CI]: 65.0–97.1) and specificity of 85.1% (95% CI: 70.2–96.4). EpiFinder generated an incorrect outcome in 13.2% (7/53 subjects). Of these, EpiFinder incorrectly identified pathology as being present in four patients and failed to identify pathology in three patients.

Interview time with simultaneous application data entry was recorded and included only the history. Administration of the application, including questioning and data entry, occurred during the initial EMU intake history of present illness. A typical interview averaged 36 min (range: 9–47 min). In patients aged 40 years and under, average task time was 19 min. The timing was stopped during delays and resumed once history-taking began again. The most common cause of delays were subjects having an event while being questioned (4) and needing to use the restroom (3).

4. Discussion

As the differential of episodic neurologic symptoms is broad, symptoms are often first evaluated in a primary care setting, and the diagnosis of epilepsy is made by nonneurologists such as primary care physicians, pediatricians, and emergency medicine physicians [2,10]. One study from the United Kingdom estimated that up to 55% of those receiving treatment for epilepsy had never received subspecialty epilepsy care [11]. As such, the number of patients that actually reach an epileptologist or even a general neurologist is few. Unless physicians initially develop a differential that includes epilepsy or seizures, this possible diagnosis is often eliminated early on, leading to a misdiagnosis [4,12]. Moreover, recent concerns about sudden unexpected death in epilepsy (SUDEP) raise the stakes even higher for an earlier diagnosis [13,14]. The development of clinical decision support tools has been identified as a research priority to help identify patients early on with a seizure diagnosis for earlier intervention with treatment approaches that, for some, include epilepsy surgery and possibly curative resection. By using CDSS technology, we are able to explore a novel way to address a critical practice gap in epilepsy diagnostics and therapy that is faced by neurologists and nonneurologists alike.

This prospective study evaluated a novel clinical decision support tool, EpiFinder. This unique application applies an algorithm to help differentiate between an epilepsy syndrome and epilepsy mimics prior to vEEG. When tested in an adult population, the application's yield in predicting the presence of epilepsy from another nonepilepsy diagnosis was 86%. This has the potential to be a useful tool in the screening of those with transient neurologic events where seizure may possibly be in the differential. Additionally, the algorithm works by recognizing a constellation of semiology compared with standard definitions from the peer-reviewed ILAE proposals rather than individual, internal biases of the clinician. Our initial experience with EpiFinder suggests potential clinical utility at the level of determining the presence of an epilepsy