Urgent Continuous EEG (cEEG) Monitoring Leads to Changes in Treatment in Half of Cases

How Seizure Detection by Continuous Electroencephalographic Monitoring Affects the Prescribing of Antiepileptic Medications. Kilbride RD, Costello DJ, Chiappa KH. *Arch Neurol* 2009;66(6):723–728. OBJECTIVES: To assess the effect of continuous electroencephalographic monitoring on the decision to treat seizures in the inpatient setting, particularly in the intensive care unit. DESIGN: Retrospective cohort study. SETTING: Medical and neuroscience intensive care units and neurological wards. PATIENTS: Three hundred consecutive nonelective continuous electroencephalographic monitoring studies, performed on 287 individual inpatients over a 27-month period. MAIN OUTCOME MEASURES: Epileptiform electroencephalographic abnormalities and changes in antiepileptic drug (AED) therapy based on the electroencephalographic findings. RESULTS: The findings from the continuous electroencephalographic monitoring led to a change in AED prescribing in 52% of all studies with initiation of an AED therapy in 14%, modification of AED therapy in 33%, and discontinuation of AED therapy in 5% of all studies. Specifically, the detection of electrographic seizures led to a change in AED therapy in 28% of all studies. CONCLUSIONS: The findings of continuous electroencephalographic monitoring resulted in a change in AED prescribing during or after half of the studies performed. Most AED changes were made as a result of the detection of electrographic seizures.

COMMENTARY

Prolonged continuous digital video and electroencephalographic monitoring (abbreviated as continuous EEG or cEEG) for critically ill patients is becoming standard practice in many locations and is rapidly spreading in use. This shift in practice is primarily because many encephalopathic patients with a variety of underlying diagnoses who undergo cEEG are found to have electrographic seizures (Table 1). Most of these seizures have no obvious clinical correlate and are commonly referred to as "subclinical" or "nonconvulsive" seizures. Neither term is ideal, as mental status is altered (hence, there may or may not be some clinical effect) and subtle clinical findings, such as twitching, eye deviation, or nystagmus, occasionally can be seen on video or examination. In addition, other seizure types (e.g., absence and complex partial) are "nonconvulsive" as well but have obvious clinical features. Therefore, these so-called nonconvulsive seizures discovered during cEEG in the critically ill will be referred to as "clinically unrecognized electrographic seizures" or CLUES.

CLUES appear to be far more common than previously recognized (see Table 1). Furthermore, there is expanding animal and human data suggesting that these seizures are potentially harmful, particularly in the setting of acute brain injury and if the diagnosis is delayed (1). For example, carefully controlled experiments in rodents with acute infarcts have shown that nonconvulsive seizures are independently associated with larger infarcts and higher mortality (2). In humans, nonconvulsive seizures are independent predictors of worse outcome in a variety of patient populations, from acute traumatic brain injury (3) to sepsis-associated encephalopathy (4). Nonconvulsive seizures have been shown to cause or be associated with elevations in intracranial pressure, metabolic crisis (based on cerebral microdialysis data, including elevated lactate/pyruvate ratio, glutamate, and glycerol), elevated neuron-specific enolase (a marker of neuronal injury), increased mass effect and shift on serial imaging after intracerebral hemorrhage, and growth of intracerebral hemorrhage (1). Thus, there is great clinical interest in recognizing electrographic seizures and either preventing or quickly treating them. Since seizures become more difficult to stop and more likely to cause injury as they continue, the goal is rapid recognition.

Performing cEEG is quite labor-intensive and the infrastructure can be expensive. Hence, many healthcare providers have asked if it is really necessary and suggested that this question should be addressed soon, before clinicians become addicted to using cEEG and are unwilling to practice without it—even without proof of its benefit. This situation may have developed with some other (more invasive) diagnostic tools, such as pulmonary artery catheters.

Although Kilbride et al. could not directly address whether cEEG benefited their patients, they have taken an important first step in showing that performing cEEG quite frequently does affect treatment—in just over half of cases in this series. Their study is also further evidence of the expansion of cEEG and confirms the high prevalence of electrographic seizures. Three hundred patients (240 adults) underwent nonelective cEEG over a 27-month period in the investigators' single academic hospital, with 189 studies performed in an intensive care unit, lasting a mean of 52 hours (median 24 hours). They excluded those patients undergoing elective epilepsy monitoring evaluations. Seizures were defined as carefully as possible, and periodic epileptiform discharges were not considered seizures.

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TABLE 1. *Prevalence of Electrographic Seizures and Percent That Are Clinically Unrecognized*

STUDY POPULATION	EEG TYPE	DESIGN	*N*	% OF PATIENTS WITH ANY SEIZURES WHILE ON cEEG	% OF PATIENTS WITH PURELY NONCONVULSIVE SEIZURES	REFERENCES
Altered consciousness or suspected subclinical seizures anywhere in medical center undergoing urgent routine EEG	Routine*	Prospective	198	37	100 (32% had no subtle clinical signs)	Privitera et al. (8)
Neuro-ICU	cEEG	Retrospective	124	35	74	Jordan (9)
Prior convulsive status eptilepticus, altered consciousness without clinical seizure activity	cEEG	Prospective	164	48	100 (by definition)	DeLorenzo et al. (10)
Moderate-to-severe traumatic brain injury, Neuro-ICU	cEEG	Retrospective	94	22	52	Vespa et al. (11)
ICU, coma, without evidence of prior or current clinical seizures	Routine*	Retrospective	236	8	100 (by definition)	Towne et al. (12)
Neuro-ICU with infarct or ICH	cEEG	Prospective	109	19% overall (Lobar ICH: 34% Deep ICH: 21%)	79	Vespa et al. (13)
All inpatients undergoing nonelective cEEG	cEEG	Retrospective	570	19	92	Claassen et al. (14)
Neuro-ICU	cEEG	Retrospective	105	27	68	Pandian et al. (5)
Under 18 years old, in an ICU	cEEG	Retrospective	117	44	75	Jette et al. (15)
ICH	cEEG	Retrospective	102	31	58	Claassen et al. (16)
Medical ICU patients without known acute brain injury	cEEG	Retrospective	201	10 (Sepsis: 16%)	67	Oddo et al. (4)
All inpatients undergoing nonelective cEEG	cEEG	Retrospective	300	28	"most"	Kilbride et al. (current study)

Abbreviations: ICH, intracerebral hemorrhage; ICU, intensive care unit; cEEG, continuous EEG monitoring; Routine*, routine EEG with 30–45 minutes of recording with or without video.

Adapted from Friedman D, Hirsch LJ (17). Diagnosing and monitoring seizures in the ICU: The role of continuous EEG for detection and management of seizures in critically ill patients. Table 2-1: Summary of Studies Using EEG Monitoring to detect nonconvulsive seizures in critically ill patients, page 23. In: *Seizures in Critical Care: A guide to Diagnosis and Therapeutics* 2nd ed. (Varelas P, ed.). New York: Humana Press, 2010:21–47.

The authors found electrographic seizures in 28% of all studies. Although exactly how many electrographic seizures were recognized clinically is not stated, the authors noted that most were nonconvulsive. cEEG led to a change in antiepileptic drugs (AEDs) in one-third of cases, new use of an AED in one-seventh, and discontinuation of AEDs in one-twentieth. The discovery of the nonepileptic nature of spells previously thought to be epileptic seizures in the critically ill is an underappreciated benefit of cEEG that has been noted by others. For instance, in one prior series, 9.5% of patients on cEEG turned out to have nonepileptic spells (5).

Jordan reported similar results over a decade ago after reviewing cEEG in 200 patients in a neuroscience intensive care unit (6). He retrospectively investigated whether cEEG findings

had an effect on the decision to obtain imaging, AED prescribing, or hemodynamic manipulation for cerebral perfusion. He reported that cEEG had a "decisive" impact on clinical management in 54% of patients and contributed to decisions in another 32%. A small German study, also from a decade ago, reported that cEEG affected management on just under 50% of monitoring days (7).

A fundamental question, which is more important but harder to address than whether cEEG affects management, is if it benefits patients. There are several points to keep in mind, summarized in Figure 1, when assessing the answer. First, cEEG is a diagnostic test and cannot improve outcome by itself. Second, cEEG is usually reviewed intermittently (i.e., continuously recorded, but intermittently reviewed), though a handful of centers are now performing true, real-time cEEG monitoring 24 hours/day. Intermittent reviewing can result in significant delay in identification of events. Third, automated cEEG interpretation, with setting of alarms, is now feasible, but infrequently utilized and far from ideal in its current commercially available forms. Fourth, it is unclear which EEG patterns (including intermittent nonconvulsive seizures) require patient treatment or how these individuals would be best treated. Fifth, cEEG with real-time monitoring (or "neurotelemetry," akin to cardiac telemetry) can detect many brain events in addition to seizures, including ischemia, hemorrhage, hydrocephalus, and even systemic events, such as respiratory failure, hypotension, and low cardiac output (1). These and other diagnostic applications of cEEG need to be assessed. Hence, the full potential of cEEG has certainly not been approached.

The perfect time to study cEEG use may be as centers are gaining the ability to perform real-time neurotelemetry but cannot yet do so in all patients who could potentially benefit. In such a situation, randomizing patients to cEEG versus no cEEG would be a reasonable approach to examine the effects on clinical outcome, including cost, subsequent epilepsy, and cognition. Standardized EEG terminology for patterns encountered in the intensive care unit is being developed and validated, and a multicenter research consortium is currently in existence—both of which should help enable large-scale studies.

With regard to cost, one center presented their nonpeer–reviewed financial projections on the costs of cEEG. They estimated that performing cEEG saved money by shortening intensive care unit length of stay in those found to have nonconvulsive seizures—this savings more than offset the overall cost of performing cEEG (18). In addition, in at least one case, failure to make a timely diagnosis of nonconvulsive status epilepticus led to a $1.5 million judgment against a hospital because of long-term cognitive impairment in the patient (6). Although improving care is obviously the main goal of performing cEEG, these financial aspects could help convince hospital

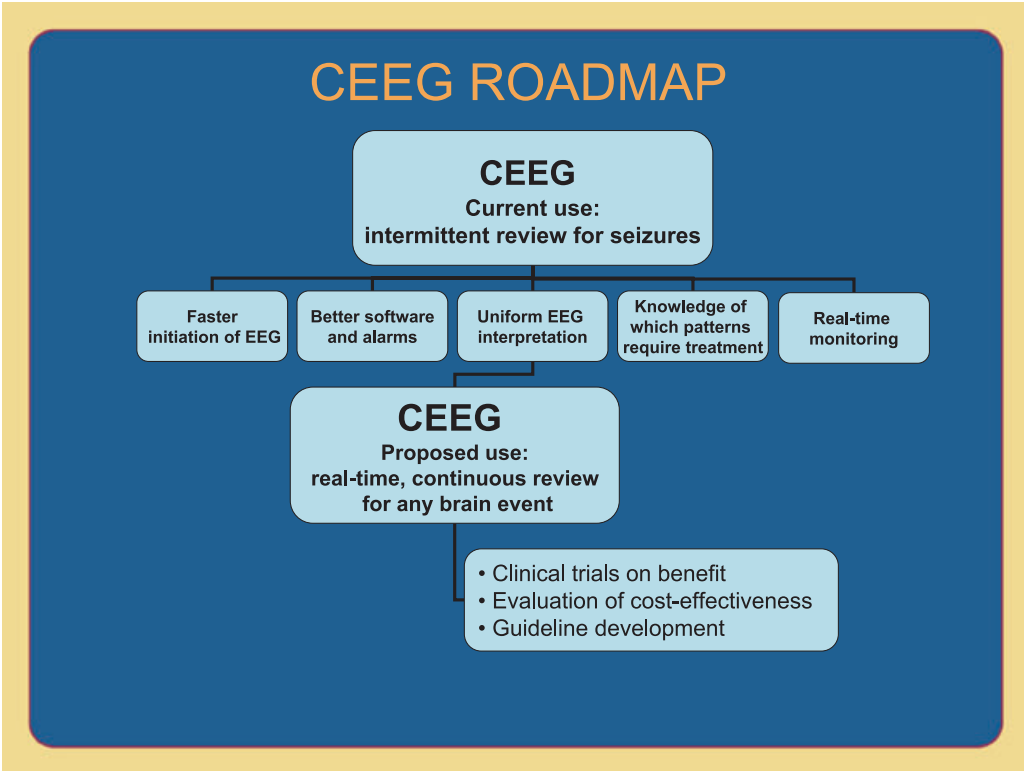

FIGURE 1. CEEG Roadmap.

administrations to provide financial support for a cEEG program.

Progress in this area is proceeding rapidly, so stay tuned!

by Lawrence J. Hirsch, MD

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