



Continuous EEG in ICU: Not a Luxury After All

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Continuous vs Routine Electroencephalogram in Critically Ill Adults With Altered Consciousness and No Recent Seizure: A Multicenter Randomized Clinical Trial

Rossetti AO, Schindler K, Sutter R, Rüegg S, Zubler F, Novy J, Oddo M, Warpelin-Decrausaz L, Alvarez V. *JAMA Neurol.* 2020;77(10):1-8. doi:10.1001/jamaneurol.2020.2264

Importance: In critically ill patients with altered consciousness, continuous electroencephalogram (cEEG) improves seizure detection but is resource-consuming compared with routine EEG (rEEG). It is also uncertain whether cEEG has an effect on outcome. **Objective:** To assess whether cEEG is associated with reduced mortality compared with rEEG. **Design, Setting, and Participants:** The pragmatic multicenter Continuous EEG Randomized Trial in Adults was conducted between 2017 and 2018, with follow-up of 6 months. Outcomes were assessed by interviewers blinded to interventions. The study took place at 4 tertiary hospitals in Switzerland (intensive and intermediate care units). Depending on investigators' availability, we pragmatically recruited critically ill adults having Glasgow Coma Scale scores of 11 or less or Full Outline of Responsiveness score of 12 or less, without recent seizures or status epilepticus. They had cerebral (eg, brain trauma, cardiac arrest, hemorrhage, or stroke) or noncerebral conditions (eg, toxic-metabolic or unknown etiology), and EEG was requested as part of standard care. An independent physician provided emergency informed consent. **Interventions:** Participants were randomized 1:1 to cEEG for 30 to 48 hours versus 2 rEEGs (20 minutes each), interpreted according to standardized American Clinical Neurophysiology Society guidelines. **Main Outcomes and Measures:** Mortality at 6 months represented the primary outcome. Secondary outcomes included interictal and ictal features detection and change in therapy. **Results:** We analyzed 364 (33% women; mean [SD] age, 63 [15] years) patients. At 6 months, mortality was 89 of 182 in those with cEEG and 88 of 182 in those with rEEG (adjusted relative risk [RR]: 1.02; 95% CI: 0.83-1.26; $P = .85$). Exploratory comparisons within subgroups stratifying patients according to age, premorbid disability, comorbidities on admission, deeper consciousness reduction, and underlying diagnoses revealed no significant effect modification. Continuous EEG was associated with increased detection of interictal features and seizures (adjusted RR: 1.26; 95% CI: 1.08-1.15; $P = .004$ and 3.37; 95% CI: 1.63-7.00; $P = .001$, respectively) and more frequent adaptations in anti-seizure therapy (RR: 1.84; 95% CI: 1.12-3.00; $P = .01$). **Conclusions and Relevance:** This pragmatic trial shows that in critically ill adults with impaired consciousness and no recent seizure, cEEG leads to increased seizure detection and modification of anti-seizure treatment but is not related to improved outcome compared with repeated rEEG. Pending larger studies, rEEG may represent a valid alternative to cEEG in centers with limited resources.

Commentary

The use of continuous electroencephalogram (cEEG) in the neuro-intensive care unit has become a widespread practice over the last 2 decades. The Critical Care cEEG taskforce of the American Clinical Neurophysiology Society (ACNS) recommends its use for the detection of secondary injury in critically ill patients with altered mental status (AMS). The ACNS guidelines highlight its use for diagnosis of nonconvulsive seizures and status epilepticus as well as for the assessment of the efficacy of the treatment for these conditions. It also suggests its use for detection of secondary ischemia, the

evaluation of patients under pharmacological sedation, and prognostication of patients after cardiac arrest.¹

The prevalence of seizures in the ICU population with AMS has been described to be 15% to 30%.^{2,3} Up to 90% of these seizures have no, or only subtle, clinical signs detected only with EEG.^{4,5} The probability of diagnosing seizures with cEEG increases with the duration of the recording with over 87% to 93% of seizures captured within 48 hours² as well as with increased frequency of seizures. A study aimed to predict the performance of repetitive short-term routine EEGs (rEEG) in comparison to cEEG reported that rEEGs repeated every 6



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hours could match the performance of cEEG in regards to seizure detection when seizure frequency was higher than 6 per day.⁶ Some EEG patterns which are not definitely ictal have been described as predictive of seizures. These include lateralized periodic discharges and regional rhythmic slow with sharply contoured morphology, interictal epileptiform discharges, and intermittent fast frequencies.^{5,7,8} Some EEG findings in the critically ill population are described as part of an “Ictal-interictal Continuum” which may be epileptic in nature but only prolonged EEG, response to medications or advanced neurophysiological evaluations are able to clarify.⁹

Unfortunately, the ability to provide cEEG is limited by both technology and personnel. It requires live remote capabilities and an EEG technologist available to start, adjust, monitor, and interpret live EEG. It also requires the interpretation and storage of large amounts of data in a limited amount of time. The presence of seizures in cEEG lengthens hospital stay and increases health care cost.^{8,10} These resources are mostly available at hospitals with high level of complexity and are often absent in community hospitals, developing countries, or rural communities.

With Continuous EEG Randomized Trial in Adults (CERTA), Rossetti et al¹¹ aimed to assess the impact of performing rEEG as compared to cEEG in patients with AMS secondary to acute brain injury or systemic conditions. The primary outcome was mortality at 6 months and secondary outcomes were reported seizures and medication changes at 4 and 6 weeks following randomization. It is important to highlight this study specifically excluded patients with known or reported seizures as the team recognized these patients have a clear indication for cEEG. Patients were randomized to a 30 to 48 hours cEEG or to two 20- to 30-minute rEEGs over 48 hours.

The study found no difference in mortality (48.9% vs 48.4%) between the 2 groups and an increased frequency of reported interictal epileptiform discharges, seizures, and anti-seizure medication changes in the cEEG group. Length of stay, need for additional EEG, use of sedation, duration of mechanical ventilation, and time to death did not differ between the groups. The cEEG group recorded 29 (15.7%) patients with seizures while the rEEG group had 8 (4.3%); this difference may not have swayed the mortality outcome but certainly seems clinically relevant.

Is mortality at 6 months the right outcome when evaluating the performance of short- versus long-term EEG recordings? One may argue that a diagnostic test should be primarily measured by its sensitivity and specificity, whether it changes management, and ultimately whether this management change improves meaningful outcomes. The goals of using EEG in the ICU could be better measured by functional outcome, destination at discharge (home vs inpatient rehab, nursing home, or long-term ventilation facility), cognitive performance, quality of life, development of epilepsy, or even seizure burden. Mortality is predominantly related to the nature and severity of the acute injury. A recent study confirms that seizures are not a predictor of in-hospital mortality in critically ill patients.^{8,12}

Anoxic encephalopathy accounted for about 30% of patients included in CERTA. The study patients had an overall mortality rate of 48.6%, much higher than the one reported by other observational studies evaluating the impact of cEEG in critical care population with AMS.^{13,14} Most studies evaluating the use of cEEG exclude patients post cardiac arrest as the interpretation of the findings in this group of patients is particularly challenging. When cardiac arrest patients were excluded in the CERTA group, the cEEG study group did show a tendency toward lower mortality rate at 6 months, but that difference did not reach statistical significance.

The value of the initial minutes to the first hour of EEG recording has been proposed as a predictor for the need of extended monitoring. A clinical tool designed to guide clinicians in the decision of which critically ill patients to monitor with cEEG based on their probability of having seizures was recently published and validated.^{15,16} The 2HELPS2B model includes 6 variables and assigns points to each one: Brief rhythmic discharges (2 points), lateralized periodic discharges, lateralized rhythmic delta activity or bilateral independent periodic discharges (1 point), previous seizure (1 point), sporadic epileptiform discharges (1 point), periodic or rhythmic pattern >2 Hz (1 point), and superimposed rhythmic or sharp activity (1 point). The final score correlates with the probability of seizures to happen. A score of 6 predicts a seizure risk greater than 95%. The study team recommends applying the model to the EEG data acquired within 1 hour of rEEG and if the score is >2 or if the patient has had prior seizures extending the recording for at least 24 hours.

The patients described in CERTA can be divided in 3 groups. One group of anoxic brain injuries which often have a poor outcome regardless of EEG findings, a group of patients with non-seizure-related concerns which may not benefit from cEEG once seizures have been ruled out and a third group of patients who are seizing and you don't know unless you do cEEG. This third group likely benefits from informed anti-seizure management. Continuous EEG is a diagnostic tool and not a treatment intervention and as such it is helpful only to the extent the information it provides is used to make decisions.

The study by Rossetti et al helps in validating the use of short-term EEGs for critical care units with limited access to cEEG for patients with anoxic injury and in the absence of seizures. Short-term rEEG should be used to identify patterns indicating high risk for seizures and can help to prioritize available resources or transfer patients to a higher complexity level of care. The study shows that we should not underestimate the value of rEEGs for the care of critical care patients. Keeping with Dr Gilmore's editorial discussing the original publication, cEEG may feel like a luxury but it is indeed a necessity our patients should not live without.¹⁷

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