EDITORIAL

Continuous Electroencephalogram—Necessity or Luxury?

Emily J. Gilmore, MD, MS

Before the last decade, the critically ill brain was often neglected with regards to direct monitoring and was subjected to systemic targets driven by broad population-based thresholds. Recently, there has been a concerted push from the critical care community to increase noninvasive (and invasive) monitoring in patients with critical illness, especially those with acute brain injury.[1] With the advent of precision medicine extending beyond the world of oncology, the brain has come into focus as a target for individualizing care with advanced neuromonitoring. Continuous electroencephalogram (cEEG) monitoring is being used widely at major medical centers not only for occult seizure detection, but also targeted interventions aimed at preventing or minimizing secondary brain injury (eg, vasospasm detection in subarachnoid hemorrhage) and elucidating injury severity for neuroprognostication.[2] However, a lack of controlled studies showing actual improvement in meaningful outcomes threatens this emerging field that is already confronted by limitations in expertise, resource availability, and fiscal responsibility. Without compelling outcome data, the adage that an absence of evidence may in fact be evidence of absence has the potential to significantly affect the ability to appropriately use advanced technologies, including cEEG and quantitative EEG, for individual patients who need them most.

Related article

In this issue of *JAMA Neurology*, Rossetti and colleagues[3] report on the CERTA (Continuous EEG Randomized Trial in Adults) trial, which, to my knowledge, is the first randomized clinical trial of intermittent routine EEG (irEEG) vs cEEG. With a prospective cohort of 364 intensive care unit (ICU) and intermediate care patients without a preceding seizure but persistent unexplained decreased level of consciousness, Rossetti and colleagues[3] provide helpful insight into the contribution of irEEG (2 routine; mean, 40 minutes) vs cEEG (mean, 30 hours) on intermediate-term outcomes. Using a design of needs EEG as the inclusion, the study was conducted in 4 Swiss tertiary hospitals and encompassed the spectrum of diagnoses, including secondary to cardiac arrest (approximately 30% of the cohort). The authors concluded that although seizures were detected and antiseizure medications were adjusted at a greater rate with cEEG than with irEEG, the 6-month mortality between the 2 groups was not statistically significant.

To my knowledge, few recent retrospective studies have highlighted the association of cEEG vs irEEG vs no EEG in the acute care setting with seizure detection and outcome. In a recent meta-analysis by Limotai and colleagues,[4] the detection of seizures was particularly higher with respect to cEEG in patients with postconvulsive status epilepticus, central nervous system infection, and post-cardiac arrest. The results for cardiac arrest have been reiterated in a recent 2-center retrospective study of 759 patients in which Elmer and colleagues[5] simulated multiple EEG monitoring scenarios (including no EEG) and showed that cEEG was more sensitive in detecting epileptiform events. But detecting epileptiform abnormalities, including seizures, does not necessarily translate into improved outcomes, a theme that has existed for every monitoring device used in the ICU setting to date.[6] The most commonly used devices have not been evaluated by randomized clinical trials (RCTs), the community's accepted barometer for practice-based evidence. Although to my knowledge no large RCT of intermittent electrocardiogram vs continuous telemetry monitoring or intermittent vs continuous intracranial pressure monitoring has been performed to compare outcomes, we do not question their use as standard of care. Thus, should cEEG monitoring be relegated to the same paradigm of proven efficacy defined by outcome? Should the outcome be mortality or functional and cognitive recovery?

Albeit limited and not isolated to patients with acute brain injury, 2 recent cross-sectional studies using Nationwide Inpatient Sample (NIS) data have been published alluding to the association of improved outcomes with cEEG. Ney and colleagues[7] used NIS data from 2005 to 2009 to convey that cEEG monitoring was associated with higher inpatient survival in patients receiving mechanical ventilation as opposed to those with equal illness severity monitored with irEEG. These findings persisted even for those patients without a primary neurologic diagnosis and when patients with epilepsy and convulsions were excluded from the analysis, suggesting that cEEG monitoring may help guide management decisions even when seizures are not the primary concern. Subsequently, Hill et al[8] used the NIS data from 2004 to 2013 representing 7 million patients receiving ventilation and reported that cEEG monitoring was associated with lower in-hospital mortality. Although cEEG monitoring was more likely to be used in clinically sicker patients than in the Ney et al[7] cohort, its use was associated with lower odds of in-hospital mortality. Although these studies showed that the use of cEEG has grown astronomically during the last 10 to 15 years, compared with the total population of ICU patients, its use remains reserved for only a few patients.

Given the number of patients likely to benefit from cEEG and limited capacity of cEEG monitoring at most hospitals, the goal should not be to use the data from Rossetti et al[3] to debunk the use of cEEG but rather justify the use of irEEG in resource-restricted hospitals for lower-risk patients. Risk stratification tools, like the 2HELPS2B score, which has been validated in an external cohort, can be used to allocate resources

to benefit those at highest risk but also ideally with the greatest potential for recovery.[9,10]

The soft inclusion of needs EEG in the CERTA trial was nonspecific; this has been the challenge with guideline statements that make broad recommendations for specific diseases (eg, traumatic brain injury, status epilepticus, cardiac arrest, and coma).[2] These diagnoses encompass very heterogenous subgroups and, when combined, can lose their effect. Ongoing prospective studies that include patients undergoing cEEG monitoring as part of routine clinical care (eg, BOOST-3 and ICE-CAP) could explore the disease-specific associations of EEG monitoring with meaningful outcomes by creating similar EEG monitoring models as Elmer and colleagues did.[5]

The study by Rossetti and colleagues[3] should make an impression in the critical care monitoring, epilepsy, and neurocritical care worlds, from which many future studies targeting more homogenous subpopulations and neurophysiologic signatures will hopefully emerge. So, is cEEG a necessity or luxury? Well, it is probably a bit of both. Although RCTs are helpful and remain the criterion standard, when they have broad inclusion of heterogenous diseases, it becomes difficult to determine the nuances with which their outcomes apply to an individual patient. Resultantly, questions surrounding the effect of EEG monitoring for which patients, with which diseases and endophenotypes, when in their clinical trajectory, and for what duration and frequency remain. Let this study not support the notion that cEEG should be abandoned or further restricted but rather studied with continued rigor and prioritized for those who need it most. In addition, the findings should reassure those practicing in resource-restricted environments that irEEG is a reasonable alternative to cEEG, as some monitoring is certainly better than no monitoring at all.

ARTICLE INFORMATION

Author Affiliation: Yale School of Medicine, New Haven, Connecticut.

Corresponding Author: Emily J. Gilmore, MD, MS, Yale School of Medicine, PO Box 208018, 15 York St, Bldg LLCI, 8th Floor, Ste 810c, New Haven, CT 06520 (emily.gilmore@yale.edu).

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