It HELPS 2NO When to Stop Continuous EEG Monitoring in Critically Ill Patients

Association of an Electroencephalography-Based Risk Score With Seizure Probability in Hospitalized Patients.

Struck AF, Ustun B, Ruiz AR, Lee JW, LaRoche SM, Hirsch LJ, Gilmore EJ, Vlachy J, Haider HA, Rudin C, Westover MB. *JAMA Neurol* 2017;74:1419–1424.

IMPORTANCE: Continuous electroencephalography (EEG) use in critically ill patients is expanding. There is no validated method to combine risk factors and guide clinicians in assessing seizure risk. OBJECTIVE: To use seizure risk factors from EEG and clinical history to create a simple scoring system associated with the probability of seizures in patients with acute illness. DESIGN, SETTING, AND PARTICIPANTS: We used a prospective multicenter (Emory University Hospital, Brigham and Women's Hospital, and Yale University Hospital) database containing clinical and electrographic variables on 5427 continuous EEG sessions from eligible patients if they had continuous EEG for clinical indications, excluding epilepsy monitoring unit admissions. We created a scoring system model to estimate seizure risk in acutely ill patients undergoing continuous EEG. The model was built using a new machine learning method (RiskSLIM) that is designed to produce accurate, risk-calibrated scoring systems with a limited number of variables and small integer weights. We validated the accuracy and risk calibration of our model using cross-validation and compared its performance with models built with state-of-the-art logistic regression methods. The database was developed by the Critical Care EEG Research Consortium and used data collected over 3 years. The EEG variables were interpreted using standardized terminology by certified reviewers. EXPOSURES: All patients had more than 6 hours of uninterrupted EEG recordings. MAIN OUTCOMES AND MEASURES: The main outcome was the average risk calibration error. RESULTS: There were 5427 continuous EEGs performed on 4772 participants (2868 men, 49.9%; median age, 61 years) performed at 3 institutions, without further demographic stratification. Our final model, 2HELPS2B, had an area under the curve of 0.819 and average calibration error of 2.7%(95%CI, 2.0%-3.6%). It included 6 variables with the following point assignments: (1) brief (ictal) rhythmic discharges (B[I]RDs) (2 points); (2) presence of lateralized periodic discharges, lateralized rhythmic delta activity, or bilateral independent periodic discharges (1 point); (3) prior seizure (1 point); (4) sporadic epileptiform discharges (1 point); (5) frequency greater than 2.0 Hz for any periodic or rhythmic pattern (1 point); and (6) presence of "plus" features (superimposed, rhythmic, sharp, or fast activity) (1 point). The probable seizure risk of each score was 5% for a score of 0, 12% for a score of 1, 27% for a score of 2, 50% for a score of 3, 73% for a score of 4, 88% for a score of 5, and greater than 95% for a score of 6 or 7. CONCLUSIONS AND RELEVANCE: The 2HELPS2B model is a quick accurate tool to aid clinical judgment of the risk of seizures in critically ill patients.

Commentary

Nonconvulsive seizures (NCS) and nonconvulsive status epilepticus (NCSE) occur in approximately 20% of neurologically critically ill patients undergoing continuous EEG (cEEG) monitoring (1, 2). A recent consensus statement recommends that cEEG should be used to detect NCS and NCSE in patients with the following: 1) persistently abnormal mental status following a clinical seizure, 2) altered mental status with an acute supratentorial brain injury, 3) fluctuating or altered mental status without acute brain injury, 4) presence of periodic discharges on routine EEG, 5) requirement for pharmacologic paralysis, and 6) clinical events concerning for seizures (3). There is growing evidence that detecting NCS and NCSE with cEEG monitoring with subsequent treatment is associated with lower morbidity and mortality (4). However, cEEG monitoring is labor intensive, expensive, and has limited availability, even in large centers. The optimal duration for cEEG monitoring that allows capturing seizures but does not excessively drain limited resources remains uncertain.

A recent study by Struck et al. (5) provides "help" in determining how long cEEG monitoring should be continued. After analyzing 5427 cEEGs, they determined the risk of having seizures based on clinical and electrographic variable. Their model has six variables, each with one or two points; the total number of points estimates the seizure risk. The variables and their

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points are encapsulated in the following mnemonic, 2HELPS2B: 1) brief (ictal) rhythmic discharges (BIRDs; 2 points); 2) presence of lateralized periodic discharges (LPDs; 1 point); 3) prior seizure before cEEG monitoring (1 point); 4) sporadic epileptiform discharges (1 point); 5) frequency greater than 2.0 Hz for periodic or rhythmic pattern (1 point); and 6) presence of "plus" features (superimposed rhythmic, sharp or fast activity; 1 point).

The probable risk of seizures for a score of 0 points was 5%, 1 point was 12%, 2 points was 27%, 3 points was 50%, 4 points was 73%, 5 points was 88%, and 6 to 7 points was greater than 95%.

Previous studies have shown that within the first hour of EEG monitoring, only 56% of patients who eventually would have a seizure had a seizure (1). By 24 hours, 88% had a seizure, and by 48 hours 93% had a seizure. A practice analysis survey of neurologists and clinical neurophysiologists showed that most practitioners monitor patients they suspect of having NCS with cEEG for at least 24 to 48 hours (6). This "routine" 24 to 48 hours of monitoring is very resource intensive and may not be necessary. The paper by Struck et al. (5) helps prioritize which patients are most appropriate for prolonged cEEG monitoring and who might be adequately evaluated by a shorter study. Those patients with at least one of the 2HELPS2B features should be considered for cEEG monitoring, while those without any of these features have a very low risk of seizures and may not need cEEG monitoring.

Other investigators have also evaluated whether baseline EEG characteristics can help predict which patients eventually will have seizures. Shafi et al. (7) found that in their population of 242 comatose adult patients that underwent cEEG monitoring, 21% had NCS or NCSE, 9% had periodic discharges, 17% had epileptiform activity, and 10% had generalized periodic discharges with triphasic morphology in the first 30 minutes of recording, while 43% did not have any epileptiform discharges. Excluding those with NCS and NCSE in the first 30 minutes, 17% patients with periodic discharges (including ones with triphasic morphology) and epileptiform activity eventually had seizures. Meanwhile, only 3 patients (3%) without these features in the first 30 minutes of EEG had seizures. All three of these patients had their first seizure within the first 4 hours of cEEG monitoring. Thus, if periodic discharges and epileptiform activity was not seen within the first 4 hours, patients never had seizure for the duration of cEEG monitoring.

A similar study by Swisher et al. (2) noted that when generalized slowing was the only abnormality in the baseline EEG, patients were never found to have seizures on cEEG monitoring. On the other hand, seizures were noted in 53% of patients with LPDs, 50% of those with burst-suppression pattern and generalized periodic discharges (GPDs), 31% of those with focal epileptiform discharges, and 11% with an asymmetric background. Interestingly, of the three patients with a normal EEG background, one (33%) had seizures.

Others have also noted that LPDs and GPDs are associated with seizures. Rodriquez-Ruiz et al. (8) noted that in their study of 4772 patients, 58% of patients with lateralized periodic discharges with "plus" features (described above) had seizures. Patients with generalized periodic discharges and lateralized rhythmic delta activity (LRDA) were also highly likely to have seizures, especially if the frequency of the discharge was greater than 2 Hz and had "plus" features.

Most neurologists and clinical neurophysiologists think of cEEG monitoring in increments of 24 hours. Westover et al. (9) investigated the amount of cEEG monitoring time needed to capture seizures. They noted that the 72-hour risk of seizures declined to less than 5% in the first 2 hours if no epileptiform discharges were present. If such abnormalities were present, 16 hours were needed for the 72-hour risk of seizure to decrease to below 5%. These authors did note, however, that despite low frequency, some patients without epileptiform abnormalities in the initial EEG, do develop seizures.

In aggregate these studies help guide clinicians in determining how much cEEG monitoring is enough. In many cases seizures will be noted in the first 30 minutes of recording. Long-term cEEG monitoring is certainly appropriate in these patients. Those patients with periodic discharges (lateralized or generalized) and epileptiform activity in the baseline recording, should be considered for cEEG monitoring for at least 16 to 24 hours. On the other hand, patients with only generalized slowing without periodic discharges or epileptiform abnormalities in the first 2 to 4 hours of EEG recording, may not need ongoing cEEG monitoring. Clinical history of seizures should also be considered; presence of a seizure prior to presentation should favor longer cEEG monitoring.

However, there remain gaps in our knowledge. Whether the above noted recommendations about who should get long-term cEEG monitoring apply to all age groups is uncertain. Most studies enrolled mostly adult patients. The study by Struck et al. (5) did not specify the age range of their patients. It is possible, even likely, that children and neonates will need a different threshold for ongoing cEEG monitoring than adults. Etiology of encephalopathy likely plays an important role in determining the risk for seizures. Hypoxic-ischemic encephalopathy patients appear to have a high risk of seizures, while those with traumatic brain injury and subarachnoid hemorrhage appear to be less likely to have seizures (7). The relationship of etiologies to baseline EEG characteristic and the risk of subsequent seizures have yet to be fully clarified. Finally, the role of treatment with antiseizure medication and its effect on seizure occurrence is not known.

"2HELPS2B" does indeed help the clinician in deciding how long to continue cEEG monitoring in critically ill patients. It helps objectify risk factors for subsequent seizures that were already recognized, short seizures (BIRDs), periodic discharges (especially those of >2 Hz frequency and with "plus" features), epileptiform abnormalities, and a history of seizures. The more risk factors, the higher the risk. When risk factors are absent, a full 24 hours of cEEG monitoring may not be necessary, and resources may be better used elsewhere. However, it should be remembered that despite the growing evidence of the value of the baseline EEG in determining risk for future seizures, rarely seizures occur without any prior risk factors. Clinical judgment should always supersede any formulaic determination of patient management.

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