Detection of electrographic seizures with continuous EEG monitoring in critically ill patients

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In the Neuro-ICU, up to 34% of patients undergoing continuous EEG (cEEG) monitoring have non-convulsive seizures (NCS), and up to 8% of comatose patients as well as 27% of patients with altered consciousness have NCS even without a prior history of seizures. NCS associated with acute insults can lead to continued brain injury after the insult, so early identification and treatment of NCS via cEEG monitoring is critical. However, at the time of this study, it remained unclear as to how long one should monitor patients with cEEG, in order to reasonably exclude on-going NCS. As such, the goal of this study was to identify both the risk factors for seizure detection on cEEG (in both the acute and prolonged (>24hrs) phases), and the patient populations that may require >24hrs of cEEG to capture seizures.

Experimental design and statistics: This was a retrospective study completed at New York Presbyterian Hospital, which identified all patients in whom cEEG monitoring had been completed from June 1996 and December 2002. The indication for cEEG was first identified and later classified as either 1) for the detection of NCS or for the evaluation of unexplained encephalopathy/coma, 2) for titrating IV AEDs in refractory SE, or 3) for titrating IV sedation in patients with elevated ICP. For the purpose of this study, the authors included only those patients in category #1. Data from these patients was then collected via chart review, including EEG reports, discharge summaries, and progress notes. Study neurologists determined the state of the patient at the time of cEEG initiation, the initial ICU admission criteria and indication for cEEG monitoring, the presence of any convulsive seizures prior to cEEG monitoring, and their overall outcome at discharge. EEG reports were also reviewed for the presence of convulsive[1] or non-convulsive seizures, and the time needed to record a first seizure on cEEG was categorized based on duration of monitoring[2]. In addition to evaluating for the first recorded seizure, EEGs were also evaluated for the presence of periodic epileptiform discharges (PEDs, Table 1). Statistically, a univariate analysis was used to identify associations between the presence of seizures recorded on cEEG and the associated, patient-specific variables from the cohort as well as the need for >24hrs of cEEG monitoring to document a first seizure. Patient variables that were found to be significant for seizure detection were further analyzed to determine those that were independent predictors for identifying seizures on cEEG, and the need for >24hrs of cEEG to record a first event.

Results: A total of 603 patients underwent cEEG monitoring during the study time frame, though data from 570 were included here. Within this patient cohort, the most common admission diagnoses associated with cEEG monitoring included unexplained encephalopathy and subarachnoid hemorrhage (Table 2) and most were in the Neuro-ICU (61% vs. 8% in other ICUs). Of the 570 patients analyzed, seizures were recorded in 19% (110 patients); most of the recorded events were NCS and 88% were detected within the first 24hrs of cEEG, with most of the remaining events captured by 48hrs of cEEG (Fig 1). More specifically, a comatose state at the start of cEEG monitoring was the most significant variable associated with the need for >24hrs of cEEG for seizure detection (OR 4.5, $p = 0.018$); 20% of comatose, vs. 10% of non-comatose patients, required >24hrs to detect a first seizure (Fig 2, Table 3). Otherwise, seizure detection on cEEG was more likely, overall, in those with epilepsy-related seizures, CNS infections, brain tumors, or those post-op from neurosurgical procedures (Table 2). Other independent predictors of a cEEG-detected seizure included a comatose state (OR 7.7), age <18yrs old

[1] Convulsive seizures were any seizures described (via chart review) with the following terminology: generalized tonic-clonic, grand-mal, convulsions, rhythmic jerking, rhythmic twitching

[2] cEEG time categories: present at cEEG start or within 1hr, 1-6hrs, 6-12hrs, 12-24hrs, on day 2, between days 2-7, or > 7 days

(OR 6.7, consistent after excluding those <2yrs old), a h/o epilepsy (OR 2.7), and convulsive seizures prior to the start of cEEG (OR 2.4). Finally, in terms of EEG patterns, patients with eventual cEEG-recorded seizures were more likely to have PLEDs (40%), GPEDs (17%), and burst suppression (32%) as compared to those patients without seizures recorded on cEEG (11%, 6%, and 3% respectively).

Conclusions: Overall, this study showed that a large majority of cEEG-detected seizures, in patients who will eventually have a seizure, are recorded within 24hrs of monitoring, though depending on the patient state. Namely, most seizures will be detected within 24hrs in non-comatose patients, but comatose patients may require up to 48hrs of monitoring. As such, the study authors note that their data may inform decisions on when to discontinue cEEG monitoring if ictal activity is absent, but not necessarily how long to monitor individual patients in order to detect a seizure. Individual cases may require prolonged periods of monitoring but this should be left to clinical discretion. Further, comatose patients should be approached with extra caution, as 56% of comatose patients in this study had subclinical seizures, and prolonged monitoring (>24hrs) was often needed for seizure detection in this subgroup. Ultimately, despite the limitations inherent to this study (i.e., the retrospective study design), the data can be readily applied to patients undergoing prolonged cEEG monitoring.

Additional Reading, if interested:

1) Towne, A.R., et al., **Prevalence of Nonconvulsive status in comatose patients**. Neurology (2000); 54: 340 - 345.