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Efficacy of continuous electroencephalogram for the management of altered mental status in the neurosurgical intensive care unit

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ABSTRACT

Background: Continuous electroencephalograms (cEEGs) are often used in the neurosurgical intensive care unit (NSICU) to detect subclinical seizures (SCSs) in patients with altered mental status (AMS). This retrospective study evaluated the efficacy of this approach for improving patient outcomes.

Methods: We reviewed the records of 100 patients admitted to the NSICU between 2015 and 2020 who underwent continous electroencephalograms (cEEG) during workup of unexplained AMS. Patient outcomes were classified as positive (discharged), neutral (transfer of care), or negative (dead). Incidence of SCSs on cEEG and association with patient outcomes was analyzed with Chi-square analysis and relative risk (RR).

Results: For the 99 included patients, median age was 62 years and 43% were female. About 15.2% had a known or newly diagnosed brain tumor. Outcomes were positive in 22 patients, neutral in four, and negative in 73. SCSs were detected in 15 patients, of whom 12 died, two were discharged, and one whose care was transferred. Chi-square association between SCS and outcome ($P = 0.59$) and RR of death associated with SCS diagnosis (1.1) was not significant.

Conclusion: We found a lower incidence of SCSs (15.2%) than reported in the literature. In the absence of clinically evident seizures, continous cEEGs performed in the NSICU to determine the etiology of AMS did not yield an improvement in patient outcomes, and patients diagnosed and treated for SCS did not have statistically decreased risk of death. In summary, electroencephalogram monitoring for SCS is important but should not delay diagnosis and treatment of other, potentially life-threating etiologies of AMS.

Keywords: Altered mental status, Electroencephalography, Outcome, Subclinical seizures, Treatment

INTRODUCTION

Altered mental status (AMS) is common in patients presenting to the emergency department, admitted to the hospital,[11,14] and in those admitted to the neurosurgical intensive care unit (NSICU).[1,3] Although the exact definition of AMS is vague, its presence necessitates evaluation to determine etiology. Because the differential diagnosis of AMS is broad and can include life-threatening causes, it is important to approach the workup systematically.[2] Current initial, standardized measures for determining the etiology of AMS include ensuring the stability of the patient (adequate airway, breathing, and circulation), checking vital signs and blood glucose

levels, performing a thorough neurological examination, ruling out infection, ordering laboratory tests, and acquiring urgent neuroimaging.[6,12]

When these standard evaluations have been exhausted yet AMS persists, continuous electroencephalogram (cEEG) can be used to rule out nonconvulsive seizures, otherwise known as subclinical seizures (SCSs).[5] SCSs are defined as electrographic seizure waveforms that present without the usual correlating clinical symptoms of convulsions and stereotyped movements. They are likely to be missed by health-care professionals unless the patient is being actively monitored with cEEG, which currently is considered the gold standard for both diagnosing and ruling out SCSs.[9] Although this appears to be a straightforward etiology for persistent, unexplained AMS, the actual incidence of SCSs in the NSICU has ranged from 18% to 48% in the previous studies.[4,7,10] What remains unclear is the frequency with which cEEG monitoring in the hopes of detecting SCSs actually influences treatment plans and improves clinical outcomes.

While previous studies have looked at the general use of cEEG for NSICU patients and detecting SCSs, none have questioned how either the administration or results of cEEGs in these patients have affected patient outcomes. We hypothesize that an over-reliance on and prioritization of cEEG results may lead to other causes of AMS being missed or necessary treatment being delayed with no actual improvement in patient outcomes.

MATERIALS AND METHODS

Patient selection

This is a retrospective chart review that was approved by the Northwell Health Institutional Review Board after expedited review (IRB 20-0546) and informed consent was waived. Patients who were admitted to the North Shore University Hospital NSICU between 2015 and 2020 were identified using the Sunrise electronic health record and screened for eligibility. We included adult patients with AMS of no apparent cause documented on their medical record, and who underwent cEEG in their workup. Patients were excluded if they did not receive cEEG monitoring, had clinical seizure activity, or lacked an official EEG report or documented results. The hospital course of these patients was then tracked for any changes in treatment and their ultimate outcome.

Statistical analysis

Patient outcomes were stratified into three categories: positive, neutral, and negative. Positive outcomes were discharges to home or to a lower acuity rehabilitation center; neutral outcomes involved the transfer of care to another hospital; and negative outcomes included death or decision for palliative care during hospitalization. A Chi-square test was performed to determine any association between the presence of the SCSs and treatment outcomes with a statistical level of $P = 0.05$. Positive and neutral outcomes were combined to formulate a 2×2 table to calculate the relative risk (RR) of a negative outcome in patients with and without SCSs.

RESULTS

Our initial search resulted in 100 eligible patients. One patient was excluded for a diagnosis of generalized tonic clonic seizures without SCSs. The final cohort of 99 patients had a median age of 64 ± 16. About 43.4% of patients were female and 56.6% were male [Table 1]. About 16.2% of patients had a brain tumor either diagnosed previously or during their hospital course. About 22% of patients were discharged, 4% were transferred to another hospital, 2% were discharged to palliative care, and 71% died. SCSs were detected in 15 patients. Nonconvulsive status epilepticus (NCSE) was not confirmed in any patient. Of these 15 patients with SCSs, 12 (80%) died, 1 (6%) was transferred, and 2 (12%) were discharged [Figure 1].

Table 1: Baseline characteristics of patients.

Characteristics	Value
Age (year)	64±16
Sex	
Male (%)	56.6
Female (%)	43.4
Brain tumor	
Yes (%)	16.2
No (%)	83.8
Patient outcomes	
Positive (%)	22.2
Neutral (%)	4
Negative (%)	73.7

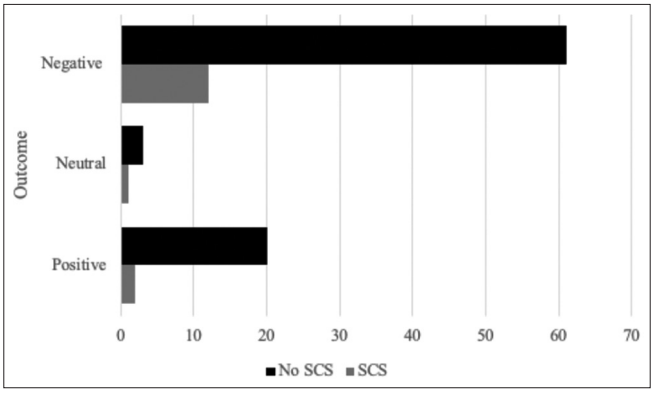

Figure 1: Number of outcomes in patients with and without detected subclinical seizures (SCS).

The association between the presence of a SCS and treatment outcome was not significant (χ^2 [2] = 1.024, P = 0.599). Of the 15 patients who had SCS detected, three had a brain tumor, 10 had a hemorrhage (either traumatic or nontraumatic), one had a stroke, and one had a history of epilepsy. Per standard of care for our institution, 14 patients (excluding stroke patient) would have received an anti epileptic drug (AED) regardless of seizure detection. The RR of a negative outcome in all patients who were diagnosed with SCS compared to those who had no seizure activity was 1.102 (CI 0.828–1.465), which was not statistically significant. One patient was identified in whom a mistaken diagnosis of NSCE led to a critical delay in management.

Case illustrations

Delay in care due to cEEG

A 48-year-old woman with metastatic ovarian carcinoma was admitted to the NSICU after a left medial frontal metastasis was resected through a transfalcine approach. She remained neurologically intact postoperatively and for the next 24 h. She then developed progressively decreasing level of consciousness necessitating intubation for airway protection. Her EEG, although appropriately ordered by the neurointensive care team, was prematurely read as showing NCSE. Subsequently her AED dosages were increased and she remained on cEEG. Despite this change in management, there was no improvement in her mental status. After discontinuation of the cEEG, subsequent imaging was acquired and showed significant bifrontal swelling. She underwent emergency bifrontal craniectomy and experienced complete neurological recovery, with cranioplasty 2 weeks later. Official interpretation of the cEEG by the attending neurologist, read 1 day after the craniectomy, described no seizure activity. After discharge, this patient lived 3 more years before dying of progressive ovarian cancer.

Positive SCS and discharged patient

A 78-year-old man 3-week post burr hole evacuation of a left frontal subdural hemorrhage was found to have stable reaccumulation of his subdural hematoma (SDH) without symptoms. Two days later, he presented with new-onset dysarthria and global aphasia. There had been no head trauma, falls, headaches, vomiting, vision problems, or seizures since his surgery. Noncontrast computed tomography (CT) demonstrated a stable SDH unchanged from his most recent CT 1 day prior. The next day, he received a cEEG showing a SCS and was started on lacosamide without significant change in mental status. The following day, repeat noncontrast CT of the head demonstrated an increased left subacute SDH now with a 6 mm midline shift and mass effect on lateral ventricles. He subsequently underwent a craniectomy followed by interval cranioplasty several days later. His mental status improved, he was deemed clinically stable and was discharged to an acute rehab facility.

DISCUSSION

The two aims of this study were (1) to determine the actual incidence of SCSs in our institution's NSICU and (2) to evaluate whether the detection of an SCS with a cEEG played any significant role in the treatment and outcomes of those patients. The 15.2% incidence of SCSs in our sample was lower than previously reported in the literature.[4,7,10]

Even with a lower incidence of SCSs than expected, we found no significant association between the presence of SCSs and patient outcome. This suggests that in a patient with unexplained AMS, diagnosis and treatment of SCS did not correspond with patient outcome, whether it was improvement or death. Fourteen of the 15 patients with SCSs had either a tumor, an intracranial hemorrhage, or a history of epileptic seizures. It is worth noting that AED use is routine for 1 week after craniotomy for any reason, for patients with SAH, and patients who have sustained a head injury. The one patient with a stroke, AMS, and SCS died during their hospitalization. In addition, one of the hemorrhage patients, despite being treated appropriately for SCS, did not improve until after neurosurgical intervention for worsening SDH.

Another consideration that accompanies the diagnosis of a SCS is subsequent pharmacological management. Using intravenous anticonvulsants to treat SCSs and NSCE in patients with AMS is currently controversial due to the adverse effects of these drugs.[13] Given that sedation and decreased awareness are known possible side effects of both levetiracetam (an AED) and lorazepam (often used to treat patients with status epilepticus), their use as a treatment or prophylactic regimen in patients could also contribute to decreased mental status. There also is a paucity of evidence establishing the benefits of treatment of patients with SCSs with AEDs due to the absence of large-scale prospective studies.[8]

Furthermore, there are a multitude of other causes of AMS in patients in the NSICU. These can be both life-threatening and acute in onset. Persistent AMS may not always be attributed to one, continuous cause. For example, a patient that presents with AMS and is diagnosed with a SCS (Illustrative case 2) is not precluded from experiencing other new or concurrent etiologies of AMS. Patients in the NSCU, as the name indicates, are in a critical and constantly changing condition. While cEEG is vital to diagnosing SCS, this should not occur at the expense of ceasing investigation into other causes and potentially delaying the diagnosis of a life-threating condition due to an overly high reliance on cEEG monitoring.

Limitations

Limitations of this study include it being a retrospective review that may have missed other patients who during this time period had cEEG or excluded patients who did not have complete EEG reports. Our ability to confirm the true incidence was limited by the number of patients with available and complete cEEG monitoring data. Due to the varying sample sizes and heterogeneous populations from the studies reported in the literature, a more conclusive large-scale study may be necessary to determine the true incidence of SCSs in NSICUs. Furthermore, it should be noted that a cEEG is a noninvasive test and the direct downsides of doing this test are primarily added time and cost, with generally lower risk then surgical or endovascular interventions.

CONCLUSION

Overall, our findings in this study challenge priorities in the standard workup of AMS in the NSICU. At present, cEEGs in the NSICU are commonly used to rule out SCSs in patients with AMS. Our results show that patient outcome was not affected by detection of a seizure and in some cases definitive treatment was actually delayed due to the prioritization of completing and reading EEG studies. We emphasize that focusing on cEEG as both a "knee-jerk" reaction and "end-all."

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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