Prevalence of electrographic seizures in hospitalized patients with altered mental status with no significant seizure risk factors who underwent continuous EEG monitoring.

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Research Article

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Abstract

Objectives

To evaluate the prevalence of electrographic seizures in hospitalized patients with altered mental status and no significant risk factors for seizures.

Methods

We retrospectively reviewed over a six-year period (2013–2019) the medical records of all adults admitted at Ohio State University Wexner Medical Center (OSUWMC), who underwent cEEG monitoring for ≥ 48 hours. Our primary objective was to identify the prevalence of electrographic seizures in patients with altered mental status and no significant acute or remote risk factors for seizures.

Results

A total of 1966 patients were screened for the study, 1892 were excluded (96.2%) and 74 patients met inclusion criteria. Electrographic seizures were identified in seven of 74 (9.45%). We found a significant correlation between electrographic seizures and history of hepatic cirrhosis, n = 4 (57%), (p = 0.035), acute on chronic hepatic failure during admission, 71% (n = 5), (p = 0.027), and hyperammonemia (p = 0.009).

Conclusion

In this retrospective study of patients with altered mental status and with no significant acute or remote risk factors for seizures who underwent cEEG monitoring for ≥ 48 hours, electrographic seizures were identified in 9.45%. Electrographic seizures were associated with hepatic dysfunction and hyperammonemia. Based on our results, cEEG monitoring should be considered in patients with altered mental status and hepatic dysfunction even in the absence of other seizure risk factors.

Introduction

Continuous electroencephalography (cEEG) is an invaluable tool to detect seizures in patients who are critically ill and have altered mental status as clinical signs (like ictal nystagmus, facial twitching) are often minimal or may not be present. In contrast, some of these patients exhibit abnormal movements that are not seizure related but could be interpreted as such. Without the use of cEEG, these patients may be unnecessarily treated with anti-seizure medications. Notably, patients with electrographic seizures and electrographic status-epilepticus stay longer in the Intensive Care Unit (ICU) and have a greater incidence in hospital mortality, highlighting the importance for early detection and treatment of these seizures. Thus, cEEG provides real-time information of brain function, which is critical to detect electrographic seizures as well as different abnormal non-epileptic movements from epileptic ones. The role of cEEG in identifying seizures has been well established in patients with acute ischemic stroke, intraparenchymal hemorrhage, aneurysmal subarachnoid hemorrhage, brain tumors, moderate to severe traumatic brain injury (TBI), central nervous system infections and inflammation, and anoxic brain injury. Yet, the use of cEEG to evaluate encephalopathy in critically ill patients without apparent brain injury is less well established, although evidence supports its use in such cases. For example, electrographic seizures can occur in patients with sepsis and chronic renal failure. In addition, a retrospective study found that chronic hepatic disease tended to be associated with non-convulsive seizures (NCSZ) in surgical intensive care unit (ICU) patients with altered mental status and without primary acute brain injury. However, it is unclear what symptoms may be indicative of seizure risk and support the use of cEEG to monitor patients.

In the last several years, there has been growing recognition of cephalosporin-related neurotoxicity, most commonly cefepime, as a risk factor for electrographic seizures, especially in patients with renal failure, suggesting that the use of cEEG may be warranted in these patients. The relationship between liver disease and seizures is more complex. Patients with hepatic encephalopathy may present epileptiform abnormalities and seizures with unknown pathophysiology. In contrast, a more recent retrospective cohort study in a large sample of elderly patients suggested that the presence of liver disease was not associated with seizures. In this study, only patients with cirrhosis more frequently exhibited status epilepticus, although these patients also exhibited other risk factors for seizures (e.g., TBI, CNS infections).

In clinical practice, neurologists are commonly consulted on hospitalized patients with altered mental status and must determine whether continuous EEG monitoring would be an appropriate test for diagnostic evaluation. The EEG Taskforce of the American Clinical Neurophysiology Society has established recommendations on the use of video cEEG in critically ill adults with well-defined indications. This includes recommending use in patients with fluctuating mental status, agitation, lethargy, fixed or fluctuating neurologic deficits, obtundation, and coma. To identify at least 88–93% of first seizures, it is recommended that EEG recordings are obtained for 24 to 48 hours. However, given the limited availability and labor-intensive nature of cEEG, it is of paramount importance to determine the cohort of patients most in need of cEEG monitoring due to associated complications that put them at high risk of seizures.

We hypothesized that the prevalence of electrographic seizures would be very low in patients with an altered mental status with no significant acute or remote risk factors for seizures, and that continuous EEG monitoring would not provide data that would warrant a change in clinical management. We
therefore conducted a retrospective chart review to identify the prevalence of electrographic seizures in patients with altered mental status with no known acute or remote risk factors for seizures.

Methods
This is an observational retrospective chart review of a cohort of adult patients ≥ 18 years of age who underwent continuous video electroencephalogram monitoring (cEEG) for ≥ 48 hours between January 1st 2013 and December 31st 2019 at Ohio State University Wexner Medical Center (OSUWMC). The Institutional Review Board (IRB) approved the study with number 2020H0040. The requirement for inform consent was waived because the risk for patients was minimal. We identified electrographic seizures within our Comprehensive Epilepsy Center electronic database which included start time, end time and date documentation of all in-patient electroencephalogram monitoring. We obtained medical information of each patient by reviewing the electronic medical records. Patients were included if they underwent long term cEEG monitoring for evaluation of altered mental status either as primary cause of admission or occurring through the course of their hospitalization.

Patients with the following seizure risk factors were excluded: acute or remote history of ischemic stroke, hemorrhagic stroke/intracerebral hemorrhage, subarachnoid hemorrhage, epidural hematoma, subdural hematoma, severe traumatic brain injury, central nervous system infection, neurosurgical (brain) procedure, cardiac/respiratory arrest, acute or chronic kidney injury and concomitant administration of cephalosporin class of antibiotics, alcohol, or drug dependence, established epilepsy.

Continuous electroencephalography (cEEG) was recorded using 21 standard scalp electrodes according to the International 10–20 System, placed by board certified EEG technologists. cEEG were interpreted by board-certified epileptologists and reviewed by one of the main authors (A.A) who determined whether inclusion criteria were met. Electrographic seizures were defined based on Salzburg criteria (Leitinger et al, 2016). Clinical seizures were defined as clinically observable seizure activity occurring in conjunction with epileptiform abnormalities on cEEG. Data was obtained from consultants and primary team notes, cEEG reports and discharge summaries. Laboratory results, imaging reports and inpatient medication lists were also reviewed. The discharge status of the patient was simply classified as good (either home or rehabilitation) or poor (death during hospital stay).

Statistical analysis
Summary statistics were calculated for the overall study sample and stratified by seizure status. Categorical measures are presented as counts and percentages. Due to non-normal distributions, all continuous variables are presented as medians and interquartile ranges. P-values were generated to compare patients who did and did not experience seizures using Wilcoxon rank sum tests for continuous measures and Fisher's Exact Test for categorical measures. A significance threshold of 0.05 was used for all statistical tests. All analyses were conducted using R, version 4.1.3.

Results
Patient Characteristics
We identified through database search a total of 1966 patients with altered mental status who underwent cEEG monitoring for ≥ 48 hours from January 2013 to December 2019. Of these 1966 patients, 1892 (96.2%) did not meet the inclusion criteria at the time cEEG was ordered (Fig. 1). Seventy-four patients (3.7%) were identified that fulfilled the inclusion criteria. Patient characteristics are presented in Table 1.
| Table 1 | Patients’ baseline characteristics |
|---|---|---|---|---|---|
| Overall, n = 74 | Without Electrographic seizures n = 67 | With Electrographic seizures n = 7 | p-value |
| Age (years) | 62 (54, 70) | 63 (53, 70) | 61 (60, 66) | 0.6 |
| Female gender | 36 (49%) | 33 (49%) | 3 (43%) | > 0.9 |
| Hypertension | 40 (54%) | 37 (55%) | 3 (43%) | 0.7 |
| Diabetes Mellitus | 31 (42%) | 28 (42%) | 3 (43%) | > 0.9 |
| Atrial Fibrillation | 17 (23%) | 15 (22%) | 2 (29%) | 0.7 |
| Coronary Artery Disease | 14 (19%) | 13 (19%) | 1 (14%) | > 0.9 |
| Chronic Renal Failure | 15 (20%) | 14 (21%) | 1 (14%) | > 0.9 |
| Hepatic Cirrhosis | 16 (22%) | 12 (18%) | 4 (57%) | 0.035 |
| Oncologic | 19 (26%) | 17 (25%) | 2 (29%) | > 0.9 |
| End Stage Renal disease (ESRD) | 11 (15%) | 11 (16%) | 0 (0%) | 0.6 |
| Primary Admission Diagnosis | | | | 0.2 |
| Acute Hepatic Failure | 3 (4.1%) | 2 (3.0%) | 1 (14%) | |
| Acute Renal Failure | 1 (1.4%) | 1 (1.5%) | 0 (0%) | |
| Altered Mental Status | 27 (36%) | 24 (36%) | 3 (43%) | |
| Cardiology | 2 (2.7%) | 2 (3.0%) | 0 (0%) | |
| Oncologic | 7 (9.5%) | 5 (7.5%) | 2 (29%) | |
| Others | 6 (8.1%) | 5 (7.5%) | 1 (14%) | |
| Respiratory Failure | 8 (11%) | 8 (12%) | 0 (0%) | |
| Sepsis | 16 (22%) | 16 (24%) | 0 (0%) | |
| Surgical | 4 (5.4%) | 4 (6.0%) | 0 (0%) | |
| Suspected clinical seizures prior cEEG | 16 (22%) | 13 (19%) | 3 (43%) | 0.2 |
| Medical Complications during admission | | | | |
| Acute Kidney Injury | 44 (58%) | 39 (58%) | 5 (71%) | 0.7 |
| Sepsis | 34 (46%) | 31 (46%) | 3 (43%) | > 0.9 |
| Ventilator Associated Pneumonia | 29 (39%) | 26 (39%) | 3 (43%) | > 0.9 |
| Acute Hepatic Failure | 23 (31%) | 18 (27%) | 5 (71%) | 0.027 |
| Mechanical Ventilation | 49 (66%) | 43 (64%) | 6 (86%) | 0.4 |
| Received any type of dialysis | 22 (30%) | 20 (30%) | 2 (29%) | > 0.9 |
| Vasopressors Use | 26 (35%) | 22 (33%) | 4 (57%) | 0.2 |
| Death at hospital discharge | 22 (30%) | 18 (27%) | 4 (57%) | 0.2 |
| Death at hospital discharge OR Death at three months | 27 (36%) | 22 (33%) | 5 (71%) | 0.09 |

1Median (IQR); n (%); 2Wilcoxon rank sum test; Fisher’s exact test; 3including NASH cirrhosis, TIPS; 4including chemotherapy; 5including STEMI, heart failure; 6including Aspiration pneumonia, Acute Respiratory Distress Syndrome, Chronic Pulmonary Disease exacerbation; 7including esophageal fistula, cardiac transplant, lung transplant, exploratory laparotomy, incarcerated hemia; 8including urinary tract infection and septic shock

Of these seventy-four, seven patients were found to have electrographic seizures (9.45%). The median age for patients with electrographic seizures was 61 (60–66) years of age and without electrographic seizures was 63 (53–70) (p = 0.6). At the time cEEG was placed, electrographic seizures were detected in three patients during the first 6 hours, one additional one from 6 to 12 hours, two additional patients from 12–24 h and one additional patient from 24–48 hours. (Table 4). Of patients with electrographic seizures, there was a significantly association with history of chronic liver disease, predominantly cirrhosis, acute hepatic failure during admission and hyperammonemia compared with patients without electrographic seizures (p = 0.035; p = 0.027; p = 0.009, respectively) (Tables 1 and 2)
Table 4
Characteristics patients with electrographic seizures

<table>
<thead>
<tr>
<th>Patient</th>
<th>Primary Cause of Admission</th>
<th>Reason for ordering</th>
<th>Lumbar Punction</th>
<th>Acute Hepatic Failure</th>
<th>Radiologic Findings</th>
<th>EEG Abnormalities (Ictal)</th>
<th>EEG Abnormalities (Inter-Ictal)</th>
<th>Final Neurology Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gastro-Intestinal Bleed</td>
<td>Facial twitching</td>
<td>No</td>
<td>Yes</td>
<td>Head CT: Diffuse brain edema</td>
<td>-</td>
<td>Subclinical seizures of left parietal-occipital and right hemispheric onset</td>
<td>Bi-hemispheric periodic epileptiform discharges</td>
</tr>
<tr>
<td>2</td>
<td>Altered mental Status with Sepsis</td>
<td>Facial twitching</td>
<td>No</td>
<td>Yes</td>
<td>MRI: Hyperintensity, hyperammonemia and inflammatory changes</td>
<td>Yes</td>
<td>Subclinical seizures of multi-focal onset</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>Altered mental Status</td>
<td>New onset seizures</td>
<td>No</td>
<td>Yes</td>
<td>MRI: Hyperintensity, hyperammonemia and inflammatory changes</td>
<td>Yes</td>
<td>Subclinical seizures of left hemispheric onset</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>Altered Mental Status</td>
<td>Altered mental Status</td>
<td>Yes</td>
<td>No</td>
<td>Unremarkable</td>
<td>Yes</td>
<td>3 hertz GPEDS w/triphasic morphology</td>
<td>Bilateral independent sharp and slow waves</td>
</tr>
<tr>
<td>5</td>
<td>Nash Cirrhosis</td>
<td>Seizure like movement and altered mental status</td>
<td>Yes</td>
<td>Yes</td>
<td>Unremarkable</td>
<td>Yes</td>
<td>Subclinical seizures of right temporal onset</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>Altered Mental Status</td>
<td>Altered Mental Status</td>
<td>No</td>
<td>Yes</td>
<td>Unremarkable</td>
<td>Yes</td>
<td>Continuous diffuse spike-wave discharges</td>
<td>Multifocal sharp waves</td>
</tr>
<tr>
<td>7</td>
<td>Chemotherapy CART</td>
<td>Altered mental Status</td>
<td>Yes</td>
<td>No</td>
<td>Unremarkable</td>
<td>Yes</td>
<td>Generalized rhythmic sharp wave activity</td>
<td>Intermittent GPDS w/triphasic morphology</td>
</tr>
</tbody>
</table>

Table 2
Laboratory results in total cohort of patients

<table>
<thead>
<tr>
<th></th>
<th>Total cohort, n = 74</th>
<th>Without seizures, n = 67</th>
<th>With seizures, n = 7</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venous lactate (mmol/L) (Missing)</td>
<td>2.00 (1.40, 4.29)</td>
<td>1.99 (1.35, 4.06)</td>
<td>2.54 (1.82, 6.18)</td>
<td>0.3</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Creatinine (mg/dL) (Missing)</td>
<td>1.22 (0.78, 2.18)</td>
<td>1.27 (0.78, 2.22)</td>
<td>0.86 (0.79, 1.30)</td>
<td>0.3</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Ammonia (Upper limit of normal 60 µmol/L) (Missing)</td>
<td>48 (34, 81)</td>
<td>42 (34, 63)</td>
<td>252 (129, 291)</td>
<td>0.009</td>
</tr>
<tr>
<td>21</td>
<td>20</td>
<td></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

1Median (IQR); n (%); 2Wilcoxon rank sum test; Fisher’s exact test

No differences were seen in other medical complications, such as acute kidney injury, sepsis, need for ventilation or need for vasopressors in patients with or without electrographic seizures (Table 1). There were no differences between the two groups with regards to death at discharge or at 3 months (p = 0.09) (Table 1).

All seven patients with electrographic seizures underwent head CT. In one patient, head CT identified diffuse brain edema and in the remaining six patients was normal. Six patients underwent brain MRI following completion of cEEG, which showed hyperammonemia related changes in two patients (p = 0.2) (Table 3 and Table 4).
Our study has several important limitations. The first is that it was a retrospective cohort study that did not consider other confounding factors, such as selection bias, since only patients who had cEEG ordered by their clinicians were included. Second, the sample size was relatively small; a larger sample size may have demonstrated more robust findings. Third, initial diagnoses of patients upon admission were very heterogenous, and ranged from acute hepatic failure, acute respiratory failure, gastro-intestinal bleed, sepsis, or surgical and oncologic causes. Fourth, we lacked power to perform detailed multivariable analysis of electrographic predictors of seizures. Consequently, our data do not permit firm conclusions to be drawn regarding the clinical predictors of electrographic seizures in this cohort of patients. Fifth, lumbar puncture was not consistently performed in our cohort, therefore some patients may have had undiagnosed CNS infections or inflammatory conditions that could have contributed to their altered mental status or seizures. Sixth, we may have more precisely identified the prevalence of electrographic seizures if patients with liver disease/hepatic encephalopathy had been included.

Table 3

<table>
<thead>
<tr>
<th>Brain Images Results</th>
<th>n (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cohort, n = 74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without seizures, n = 67</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>With seizures, n = 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CT scan results, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>62 (94%)</td>
<td></td>
</tr>
<tr>
<td>Abnormal</td>
<td>4 (6.1%)</td>
<td></td>
</tr>
<tr>
<td>MRI results n, %</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>30 (45%)</td>
<td></td>
</tr>
<tr>
<td>Abnormal</td>
<td>11 (16%)</td>
<td></td>
</tr>
<tr>
<td>No MRI</td>
<td>26 (39%)</td>
<td></td>
</tr>
</tbody>
</table>

Final neurologic diagnosis was hepatic encephalopathy in five patients, CART-neurotoxicity in one patient and one patient no clear etiology was identified, autoimmune encephalitis was a consideration (Table 4). Specific ictal & inter-ictal EEG abnormalities for each individual patient are shown in Table 4.

Discussion

In clinical practice neurologists commonly encounter patients with an altered mental status and must determine whether the use of cEEG would identify findings that would lead to diagnosis and affect clinical management of symptoms. Guidelines help physicians determine which patients may be at an elevated risk for electrographic seizures, but these emphasize known risk factors. In contrast, there is a lack of guidance for patients that exhibit no known risk factors for seizures. Therefore, we performed a retrospective chart review to evaluate the prevalence of electrographic seizures in hospitalized patients with altered mental status and no significant risk factors for seizures.

We found that most patients (96.2%) who underwent cEEG monitoring at Ohio State University Wexner Medical Center (OSUWMC) had at least one acute or remote risk factor for seizures, cEEG was rarely used in patients with an altered mental status who had no significant risk factors for seizure (used 3.7% of the time in this population), presumably due to the low pre-test probability of identifying electrographic seizures in this cohort.

Of patients with altered mental status and no significant seizure risk factors, 9.45% had electrographic seizures. The prevalence of electrographic seizures in our cohort of patients was similar to other studies; however, those studies did not consider many other seizures risk factors that could have contributed to their results. In a cohort of medical ICU patients without acute neurologic injury, electrographic seizures occurred in 10% of patients. Similarly, in a retrospective cohort study of surgical ICU patients without acute brain injury, electrographic seizures were detected by cEEG in 11% of patients. Electrographic seizures occurred in 16% of patients who were admitted to the surgical ICU and underwent cEEG due to unexplained altered mental status.

However, each of these studies included patients with remote risk factors for seizures including a history of seizures, stroke, remote brain injury, and no clear indication that the patients was on cephalosporins at the time of cEEG recording. In contrast to these prior reports, our study is unique because we determined the prevalence of electrographic seizures in hospitalized patients without many acute or remote risk factors for seizures, including those at risk for cephalosporin-related neurotoxicity.

We found an association between patients who had electrographic seizures and a history of chronic liver disease, acute hepatic failure during admission, or elevated ammonia levels at the time of cEEG recording. This is consistent with prior reports that found up to a third of patients presenting with acute liver failure had seizures that were associated with elevated ammonia levels. In addition, there are case reports describing convulsive status epilepticus, epilepsy partialis continua and electrographic seizures among patients with liver disease, and liver cirrhosis was found to reduce the seizure threshold in patients with other seizure risk factors (e.g. TBI and CNS infection), creating a favorable environment for status epilepticus. In patients with chronic hepatic failure in the surgical ICU, NCSZ were observed more commonly. However, this was in contrast with other studies that include surgical and medical ICU patients and found that chronic hepatic failure were not associated with electrographic seizures.

In contrast to these prior reports, our study is unique because we determined the prevalence of electrographic seizures in hospitalized patients without many acute or remote risk factors for seizures, including those at risk for cephalosporin-related neurotoxicity.

Similar to other studies, electrographic seizures were detected in 14% of patients in our cohort within the first hour of cEEG monitoring, in 85.7% of patients during the first 24 hours and in 100% of patients during the first 48 hours. It remains unclear whether electrographic seizures in critically ill patients are markers of severe illness, or if they cause secondary brain injury.

Our study has several important limitations. The first is that it was a retrospective cohort study that did not consider other confounding factors, such as selection bias, since only patients who had cEEG ordered by their clinicians were included. Second, the sample size was relatively small; a larger sample population may have demonstrated more robust findings. Third, initial diagnoses of patients upon admission were very heterogenous, and ranged from acute hepatic failure, acute respiratory failure, gastro-intestinal bleed, sepsis, or surgical and oncologic causes. Fourth, we lacked power to perform detailed multivariable analysis of electrographic predictors of seizures. Consequently, our data do not permit firm conclusions to be drawn regarding the clinical predictors of electrographic seizures in this cohort of patients. Fifth, lumbar puncture was not consistently performed in our cohort, therefore some patients may have had undiagnosed CNS infections or inflammatory conditions that could have contributed to their altered mental status or seizures. Sixth, we may have more precisely identified the prevalence of electrographic seizures if patients with liver disease/hepatic encephalopathy had been excluded.
Conclusions

Implementing cEEG as a standard monitoring method in clinical practice may be controversial. Even when it is clinically considered, it is important to identify which patients may benefit from this procedure based on how potential findings would change the clinical care these patients are otherwise receiving. Previous studies have suggested an association between hyperammonemia and subclinical seizures, which is supported by the findings in our study. We also identified both hepatic dysfunction and hyperammonemia as potential risk factors for electrographic seizures, while also excluding other confounding risk factors. Therefore, we suggest that cEEG monitoring must be considered in patients with altered mental status and concomitant hepatic dysfunction, even in the absence of other risk factors for seizure. Further prospective studies and larger sample sizes may better determine the exact prevalence of electrographic seizures in patients with no apparent seizure risk factors and subsequently provide valuable information on which cohort of patients would most benefit from continuous EEG monitoring.

Declarations

Acknowledgment

We thank Patrick Ten Eyck, Statistician/ Biostatistician Manager and Linder H Wendt, Statistician/ Biostatistician, from Department of Design and Ethics, University of Iowa, Hospital and Clinics, for the statistical analyses.

1. Confirmation that manuscript complies with all instructions to authors.

I confirm that authors comply with all the instructions established to authors by the journal” accordingly.

2. Confirmation that authorship requirements have been met and the final manuscript was approved by all authors.

I attest that all authors met the authorship requirements have been met and the final manuscript was approved by all authors, accordingly.

3. A list of each author's contributions

Dr Adeli

- Substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data.
- Drafting the article or revising it critically for important intellectual content.
- Final approval of the version to be published.
- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Dr Hannawi

- Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
- Drafting the article or revising it critically for important intellectual content.
- Final approval of the version to be published.

Dr Echeverria-Villalobos

- Drafting the article or revising it critically for important intellectual content.
- Final approval of the version to be published.

Dr Fiorda

- Drafting the article or revising it critically for important intellectual content.
- Final approval of the version to be published.

4. Confirmation that this manuscript has not been published elsewhere and is not under consideration by another journal.

“I attest that this manuscript has not been submitted to any other Journal”

5. Confirmation of adherence to ethical guidelines and indicate ethical approvals (IRB) and use of informed consent, as appropriate. Retrospective studies require a statement regarding IRB approval

“I attest that this manuscript has adherence to ethical guidelines. IRB has been approval with number 2020H0040

6. I attest all authors (E.Garrido, A.Adeli, M. Echeverria-Villalobos, J. Fiorda and Y Hannawi) have no conflict of interest
References


Figures

1966 records identified through data base search

74 met inclusion criteria

67 patients no cEEG seizures

1892 excluded:
- 270 acute or remote stroke history
- 215 brain tumor history
- 149 history of seizures on admission
- 57 CNS infection
- 310 hypoxic encephalopathy
- 136 acute or remote history of ICH
- 79 acute or remote history of TBI
- 70 acute or remote history of SAH
- 113 acute or remote history of SDH
- 30 acute or remote history of hydrocephalus
- 45 status epilepticus on admission
- 175 history of epilepsy
- 33 history of cerebral aneurysm
- 22 history of encephalitis
- 102 kidney injury and taking cephalosporins
- 86 other causes, including (brain edema, cerebral palsy, PRES, neurotoxicity, encephalomalacia, AVM, Arnold Chiari)

7 patients with cEEG seizures
Figure 1

Flow diagram detailing eligible patients in the study.