The Utility and Feasibility of 4-Channel EEG in the Emergency Department

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Objective

To evaluate the feasibility, quality and utility of a telemetry four-channel Electroencephalogram (EEG) on selected patients presenting to the Emergency Department.

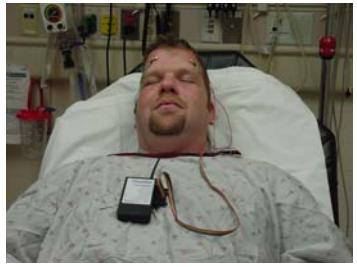
Background

Many modalities such as Bispectral Index (BIS), Cerebral Oximetry, or Positron Emission Tomography (PET) exist to evaluate neurologic status of patients. Despite some optimistic trials in the Emergency Department (ED) to evaluate the neurologic status of patients, none has supplanted the need for Electroencephalogram (EEG). EEG is the gold-standard for objectively evaluating the functional neurologic status of patients. However, EEG's are typically not performed in the Emergency Department (ED) due to multiple factors including machine size / cost, and time / expertise to setup and interpret the recordings.

Subsequently, patients in whom an EEG is required are admitted to the hospital with their potential disorder undiagnosed and untreated for days.

This group currently makes up 10% or 14 million of the 140 million yearly ED visits in the U.S.

Patient with Crystal Monitor 16 attached:



The Crystal Monitor 16:

Guided by NIH recommendations and support, Cleveland Medical Devices Inc. (CleveMed) has created a portable telemetry multi-channel EEG monitor. A four-channel montage (Fp1-C3, Fp2-C4, C3-O1, C4-O2, Gnd FpZ) was used to maximize EEG coverage while minimizing electrode set-up time.

Telemetry allows the patient to be un-tethered and moved about freely while still being monitored, an important requirement for any patient being assessed in the ED. An internet connection allows a neurologist to interpret the EEG from anywhere.

"Crystal Monitor" is a Registered Trademark of Cleveland Medical Devices Inc. of Cleveland, Ohio.

Study Design/Methods:

We conducted a prospective observational study on a sample of patients presenting to the Troy Beaumont ED. Troy Beaumont is a community hospital with a yearly ED census of 65,000 patients. All data was analyzed using descriptive statistics. The enrollment of each patient was broken down into three separate stages:

- Initial Evaluation and Consent
- Attaining the EEG
- Transmission, Reception and Interpretation

Inclusion/Exclusion Criteria:

Inclusion Criteria:

1. Patients with known seizure disorder of any type, but with prolonged (> 1 hr.) post-ictal mental status change.
2. Patients with status epilepticus who have received a muscle relaxant for intubation to determine the presence of sub clinical seizures.
3. Patients with brief alteration of mental status of unknown origin. This group includes new onset seizure disorder, syncope, "spells," "blackouts," etc.
4. Patients with behavioral changes that may indicate non-convulsive seizures (impaired consciousness, violent outbursts, unusual behaviors, etc.).
5. Acute head injury patients with mental status changes that may indicate non-convulsive seizures.
6. Patients with a history of previous head injury presenting with new onset mental status changes. Head injured patients are at risk for post-traumatic seizures.
7. Patients with neurological exams that may be consistent with focal or partial non-convulsive seizures (Ex: aphasia, Todd's paralysis, etc.).

Exclusion Criteria:

1. Patients who are convulsing.
2. Medically or surgically unstable patients.
3. Family member or other authorized representative unable to give informed consent.
4. Patients with a head injury incompatible with the use of EEG (ex: gunshots, severe scalp abrasions, etc.)

Attaining the EEG:

All enrolled patients had a 20-minute EEG, utilizing the Crystal Monitor 16. This process involved the placement of seven gold-cup electrodes with electroconductive paste. The EEG was performed by one of two study investigators. The study investigators were trained by CleveMed as well as EEG technicians from Troy Beaumont in the correct method to attach the electrodes.

As this was only a feasibility study, the ED physician and patient were blinded to the results of this EEG; therefore neither specific care nor inpatients EEG were mandated by inclusion into the trial.

Transmission and Reception:

- After EEG was completed, the data was password encrypted and transmitted to one of two study neurologists.
- The neurologist would then provide a real-time read for the EEG via telephone conversation or email.
- The neurologist also subjectively evaluated the quality of the EEG utilizing the following four point scale:
  - 4 = Excellent quality/Acceptable
  - 3 = Good quality/Acceptable
  - 2 = Fair quality/Acceptable
  - 1 = Poor quality/Unacceptable
- Patients were followed to either attain their discharge diagnosis from the ED or the hospital in the case of admission.

Results

77 patients have been enrolled in the trial.

Demographic data:

- 33.7 % of the patients were female
- The mean age of the patients was 59.7 years old (SD of 19.7)

Racial background of the patients:

- Caucasian, Non-Hispanic= 64/77
- Caucasian, Hispanic = 1/77
- Caucasian, Middle Eastern = 5/77
- African American = 7/77

Indication for EEG:

- Witnessed or suspected seizure disorder = 64/77 (83.1%)
- Syncope = 10/77 (13.0%)
- Head Injury with prolonged symptoms = 3 /77 (3.9%)

EEG quality:

Mean score = 2.52 (99% CI 2.30 to 2.74)

EEG Quality	Total
1 = poor quality, unusable	5 (6.5%)
2 = fair quality, acceptable	32 (41.6%)
3 = good quality, acceptable	35 (45.5%)
4 = excellent quality, acceptable	5 (6.5%)
	77 (100%)

EEG interpretations (5 unusable EEG's were not included):

- 37/72 (51.4%) EEG's were interpreted as normal
- 2/37 were diagnosed as pseudoseizure by the ED physician
- 28/72 (38.9%) EEG's were interpreted as slowing
- 11/28 were patients who clinically appeared post-ictal
- 7/72 (9.7%) EEG's identified a sub clinical epileptogenic foci

Correlation with Standard Inpatient EEG:

- 24/77 (31.1%) patients with EEG had an inpatient EEG
- 18/24 (75%) were equivalent to the study EEG
- The six dissimilar results are described below

Patient #	Study EEG result	Inpatient Result
14	Left sided seizure activity	Post-Ictal State
21	Sharp waves bi-frontopolar channels, possible artifact	Normal
30	Mostly wake EEG	Slightly beyond normal limits, suggestive of mild diffuse cerebral irregularity
50	Mostly wake with movement artifact	Diffuse slowing consistent with mild to moderate encephalopathy
57	Mild slowing bilaterally – consistent with mild sedation	Normal EEG
61	Poor Quality EEG	Normal EEG

Discussion and Future Considerations

Understanding that EEG is a time-sensitive modality, it is important that we perform EEG's when they can be most useful, i.e. in the acute setting.

No enrolled patient failed to complete an EEG. Only 5 of 77 patients had unusable EEG's primarily due to combination of muscular artifact and gaps in the data for interference during wireless transmission.

An improved radio that can re-transmit lost packets has been developed (Crystal Monitor Model 20) and will be used for the second half of this study.

Based on this data we believe that ED EEG provides valuable information to the ED physician, which can expedite safe medical care. We do not assert that a four-channel EEG is superior or equivalent to the standard EEG.

We do believe its use as a screening tool in the ED provides the ED physician with the additional information necessary to make a more appropriate disposition from the ED.

Conclusions

Four-channel telemetry EEG used in the ED is feasible, provides good quality screening EEG's and was able to diagnose underlying seizure in a significant number of patients.

Acknowledgments

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