Screening Electroencephalograms in the Emergency Department

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Background

The Problem:

- There currently exists no effective non-invasive neurologic monitor for patients presenting to the Emergency Department (ED).
  1. Current technologies including Bispectral Index (BIS) Monitor, Positron Emission Tomography (PET) Scan and functional Magnetic Resonance Imaging (fMRI) exist as inadequate or impractical instruments for use in the ED.
- Though electroencephalograms (EEGs) are the gold-standard for objectively evaluating the functional neurologic status of patients, they are not performed in the ED due to multiple factors including:
  1. The bulk of the equipment makes it inconvenient to be permanently located in an ED setting.
  2. The cost of equipment at $20,000-$40,000 per unit is very expensive for most ED budgets.
  3. The time and expertise required to set up and monitor an EEG is lacking in the ED.
  4. ED physicians are not trained to read EEGs and neurologists may not be immediately available to read a STAT EEG performed in the ED.

The Harm:

- Patients in whom an EEG is a required aspect of their work-up are:
  1. Admitted to the hospital with their potential disorder undiagnosed and untreated for days, while potentially placed on anti-convulsant medications that they may or may not need.
  2. Discharged home, again with their potential disorder undiagnosed and untreated for days, while potentially placed on anti-convulsant medications that they may or may not need, in hopes that nothing deleterious will happen until they receive follow-up.
- Neither option is acceptable, but at current we are limited by the lack of a technologically feasible alternative.

The Response:

- To address lack of adequate neurologic real-time monitoring the National Institutes of Health (NIH) released PA-04-006, which provides support for the development of new technology to non-invasively monitor a patient's neurologic status.
- The Crystal Monitor: (See Figure)
  1. Under an NIH sponsored Phase II grant a miniature, portable, wireless, screening EEG has been developed specifically for use in the ED.
  2. Using an abbreviated montage, this machine was designed primarily for the ED patient allowing for a screening EEG to be done while minimizing electrode setup time.
- The goal of the screening EEG is to determine:
  1. Whether a patient is having focal vs. diffuse neurologic dysfunction.
  2. Whether the patient has an active subclinical epileptogenic focus.
  3. Telemetry allows the patient to be untethered and moved about freely while still being monitored, an important requirement for any patient being monitored in the ED.
  4. An internet connection allows a neurologic to interpret the EEG from anywhere.

Our Objective: To determine the quality and utility of screening EEGs obtained in the ED.

Study Design/Methods

- We conducted a hypothesis generating, prospective observational study on a convenience sample of patients presenting to the Troy Beaumont ED.
  - Troy Beaumont is a community hospital located in a relatively affluent suburb of Detroit, MI with a yearly ED census of 65,000 patients.
  - Local IRB approval was attained .

Initial Evaluation and Consent:

- Adult (Age > 18 years) patients who met the Inclusion/Exclusion criteria (See Inclusion/Exclusion criteria) were eligible for enrollment in the study.
  - All enrolled patients or their appropriate caregiver completed an informed consent prior to study enrollment.
- Data was extracted from the chart using a preconstructed data extraction sheet.
- EPs were blinded to the results of the screening EEG; however:
  - Emergency Physicians (EPs) were asked on these individual patients whether they felt the results of a screening EEGs would: 1) likely alter 2) possibly alter, or 3) not alter their management decisions.

Attaining the EEG:

- All enrolled patients had a 20 minute screening EEG, utilizing the Crystal Monitor.
  - This process involves the placement of an abbreviated montage gold-cup electrodes with electro-conductive paste ***(See Figure #1)***.

Figure 1

Inclusion Criteria:

1) Suspected and/or new-onset seizure disorder
2) Acute altered mental status not otherwise explained
3) History consistent with partial complex or non-convulsive seizure disorder
4) Head injury with mental status changes that may indicate non-convulsive seizures

Exclusion Criteria:

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

Transmission and Reception:

- After the EEG was completed the data was compressed and password encrypted.
- The study coordinators paged the neurologist with information regarding the case and that an EEG was being sent.
- The EEG was transmitted and read by one of three study neurologists.
- The neurologist then not only interpreted the EEG but also judged the EEG based on quality using a 4-point scale:
  - 4 = Excellent quality/Acceptable
  - 3 = Good quality/Acceptable
  - 2 = Fair quality/Acceptable
  - 1 = Poor quality/Unacceptable
- Patients were followed to either their disposition from the ED.

Results

- 148 patients have been enrolled in the trial.
  - An EEG was completed, transmitted, and interpreted in 146 (98.6%) patients.
- Historical Data
  - 66/148 (44.6%) of the patients were female.
  - The mean age of the patients was 57.6 years old (SD of 21.1).
- Min Age = 18, Max age = 95
  - Racial background of the patients included:
- Caucasian, Non-Hispanic= 128/148 (86.5%)
- Caucasian, Hispanic = 2/148 (1.4%)
- Caucasian, Middle Eastern = 6/148 (4.1%)
- African American = 11/148 (7.4%)
- Asian = 1/148 (0.7%)
- Indication for EEG
  - Witnessed or Suspected seizure disorder = 94/148 (63.5%)
  - Syncope = 35/148 (23.6%)
  - Altered Mental Status not otherwise explained = 16/148 (10.8%)
  - Head Injury with prolonged mental status change = 3 /148 (2.0%)
- EEG quality

EEG Quality	Total
1 = poor quality, unusable	11 (7.4%)
2 = fair quality, acceptable	46 (31.1%)
3 = good quality, acceptable	70 (47.3%)
4 = excellent quality, acceptable	19 (12.8%)
	146 (100%)

  - EEG quality was acceptable, i.e. a screening interpretation was able to be performed, in 135 (92.5%) cases
- EEG interpretation in the remaining cohort identified:
  - 75 (55.6%) normal EEGs
  - 39 (28.9%) Any patient with diffuse cortical slowing
  - 17 (12.6%) Any patient with subclinical persistent epileptogenic foci
  - 13 (9.6%) Any patient with focal cortical slowing
  - 10 (6.1%) patients with a combination of epileptogenic activity, diffuse or focal slowing
  - 1 (0.7%) patient with excess βeta activity
- ED Physician impression regarding the function of a screening EEG to alter ED management (either treatment or disposition) for their individual patient:
  - Data was available on 132 patients:
    - 30 (22.7%) noted a screening EEG would likely would likely alter management
    - 58 (43.9%) noted a screening EEG would possibly alter management
    - 44 (33.3%) noted a screening EEG would not alter management
- **Final Disposition:**
  - Left AMA = 1/148 (0.7%)
  - Discharged = 3/148 (2.0%)
  - Observation = 57/148 (38.5%)
  - Admission = 87/148 (58.8%)

Discussion and Future Considerations

- It is important to note that EEG is an imperfect modality:
  - The result of an EEG must be taken into consideration with the clinical context under which it was performed:
    - For example an EEG with diffuse cortical slowing may indicate the patient to be post-ictal from a recent seizure or be encephalopathic as a side effect of medications.
  - By performing EEGs temporally closer to the event we are able to improve the likelihood of identifying an abnormality.
- We believe that wireless EEG is a feasible in the emergency department.
  - There were 2 patients in whom data could not be collected secondary to software failure.
    - This occurred when we upgraded the machine from the Crystal Monitor 16 to the Crystal Monitor 20.
    - There have been no further malfunctions since the software was revised.
  - Only 11 of 148 (7.4%) patients having unusable EEGs primarily due to combination of muscular artifact and gaps in the data for interference during the wireless transmission.
    - Due to other telemetry based monitoring systems within the hospital finding the optimal bandwidth for transmission of data is an ongoing process.
- Based on this data we also believe that a screening EEG provides valuable information to the ED physician, which can potentially expedite safe medical care.
  - We do not assert that a screening EEG is superior or equivalent to the standard EEG, however:
    - As a screening tool in the ED, provides the emergency physician with the additional information necessary to may provide a more appropriate disposition from the ED.
      - Information that our EPs subjectively indicate may alter management in approximately two/thirds of cases.
    - Utilizing a screening EEG may allow the EPs to identify or exclude disease processes that would otherwise require admission to the hospital.
- Understanding that until the screening EEG is utilized in an unblinded real-time fashion no definite recommendations, the data thus far seems to indicate there is a wealth of objective clinical knowledge being left on the table during our interaction with this cohort of patients.
  - Pending NIH approval, we plan on conducting a follow-up study and unblinding the result of the ED EEG to the ED physician and providing that information in real-time.

Conclusion

Emergency department screening EEGs are not only feasible but also provide objective non-invasive information regarding cortical dysfunction and subclinical epileptogenic activity.

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