Role of cEEG as a Predictor of Patient Outcome and Survival

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Background Research

Cranial hemorrhages can devastate lives. This form of stroke is caused by bursts in the brain vasculature and leads to brain bleeds. Though some recover fully from intracranial hemorrhages, others face a loss of brain function as seen through diminished abilities to think, communicate and move. With this study, we plan to analyze the direct correlation between features of the electroencephalographs (EEG) and the functional outcomes of patients with a history of intracranial hemorrhages. Patients and their families want to know what the future holds, whether care ought to be withdrawn or the patient can return with minimal symptoms. Thus, enabling doctors to predict a patient's functional recovery holds great value. Additionally, if an EEG feature looks like a precursor to a poor outcome, doctors can search for a fix to a potential underlying condition to increase the patient's survival chances.

EEG TECHNOLOGY

Electroencephalography is a crucial mechanism used by neurologists to measure and monitor the brain's electrical activity by attaching electrodes to the scalp. A healthy brain has certain EEG features: Posterior Dominant Rhythm, organization (AP gradient), continuity, reactivity, and transition to sleep. There are certain features that are seen in pathological brains, like seizures and rhythmic/periodic discharges. It has not yet been used as the primary source for assessing the outcome of a patient.[1]

MODIFIED RANKIN SCALE

This scale assigns a certain number, 0-6, to patients based on their physical and functional outcome, thus allowing us to numerically categorize these outcomes. While it was initially introduced to assess post stroke functionality, its reliability, feasibility and cost effective nature has allowed for its integration into many other fields of science. [2]

POSTERIOR DOMINANT RHYTHM (ALPHA WAVES)

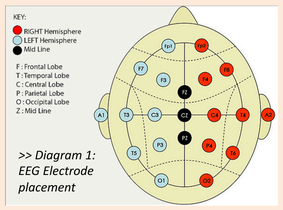
- Pattern seen in normal healthy persons while awake with eyes closed
- Traced by O1 and O2 electrodes on posterior lobes of the brain.

DELTA WAVES

- Seen in sleeping adults in the slow-wave sleep phase
- Notated as GRDA and LRDA

SLEEP SPINDLES

- A cardinal feature of Stage 2 sleep; represents existence of normal brain state transitions.
- Extremely sensitive to any pathology in the brain and tends to disappear[7].



>> Diagram 1: EEG Electrode placement

Research Question

When evaluating an individual's electroencephalograph (EEG), how does the disappearance of normal features (sleep spindles and PDR) and the emergence of abnormal features correlate to a patient's outcome with regards to the Modified Rankin Scale (MRS)?

Hypothesis

When evaluating an individual's electroencephalograph (EEG), I hypothesize that the disappearance of PDR and sleep spindles, and appearance of delta waves and other abnormal features are associated with higher MRS scores.

Methods

- Use the BWH EEG database to construct an array of 200 patients who display diagnoses of hemorrhages (intracranial and other) and have undergone a cEEG
  - Eligibility: Randomly selected/History of Subdural, Subarachnoid, Intracranial or Intraventricular Hemorrhage/Need not be alive today/No 0 score
- Select a cEEG date and analyze the degree of the individual's disability or dependence in daily living activities around the time of the respective cEEG.
  - Patient information found in documents such as patient-care referral forms, physical therapy notes, discharge summaries and progress notes.
- Quantify their abilities using the operational definitions provided by the MRS chart featured to the right
- Read and interpret the individual's EEG's from corresponding dates of assessment
- Evaluate EEG for presence of normal patterns: PDR, sleep spindle frequency, reactivity, organization, continuity[6]
- Evaluate EEG for pathological patterns: GPD[4], LPD, GRDA, LRDA, seizures, epileptiform, paralytic, sleep stages, semiology, slowing, reactivity, attenuation, K-complex
- Statistical Analysis:
  - 1) General demographics (Student's t-test, ANOVA)
  - 2) Correlation of variables vs. MRS (correlation coefficient, chi-square test)
  - 3) Correlation of variables with mortality (Fisher's Exact, chi-square test, logistic regression)

Score	Description
0	No symptoms at all
1	No significant disability despite symptoms; able to carry out all usual duties and activities
2	Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance
3	Moderate disability; requiring some help but able to walk without assistance
4	Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance
5	Severe disability; bedridden, incontinent and requiring constant nursing care and attention
6	Dead

Key Baseline Characteristics

	Dx Subdural Hemorrhage	Dx Subarachnoid Hemorrhage	Dx Intracranial Hemorrhage/Intraventricular Hemorrhage
% Male	61.02%	21.74%	57.44%
Median Age	74.78 (Mean: 71.96)	66.42 (Mean: 66.91)	71.24 (Mean: 67.83)
Age Range	22.05 – 89.98	31.82 – 94.75	22.05 - 93.39
Mean MRS	4.33	4.26	4.213

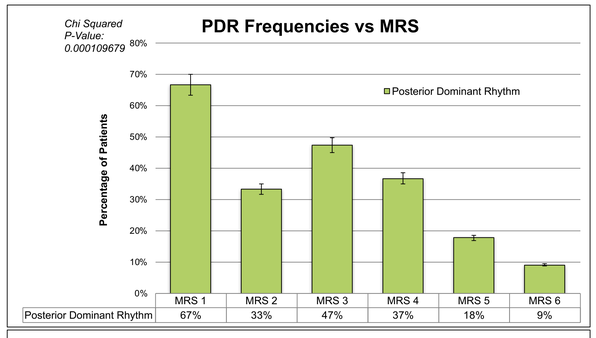
Subdural Hemorrhage-- Bleeding between Dura and the surface of the brain

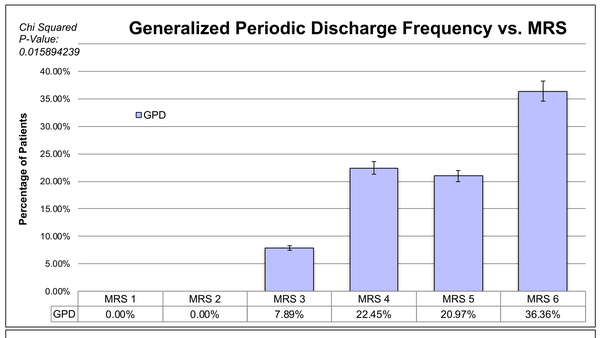
Subarachnoid Hemorrhage-- Bleeding between the brain and the tissues that cover the brain

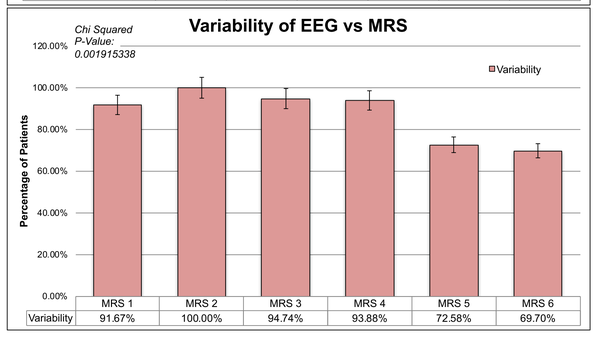
Intraparenchymal Hemorrhage-- Intraventricular Extension. Bleeding into brain tissue

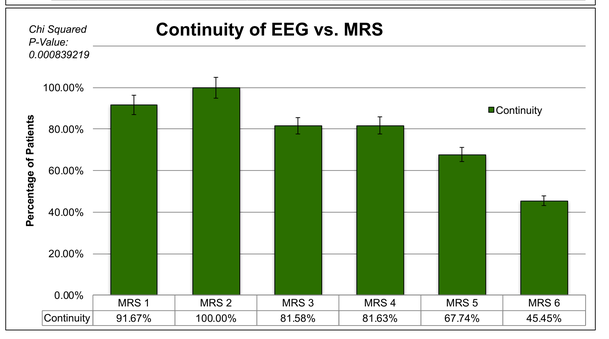
Multivariate Logistic Regression Analysis

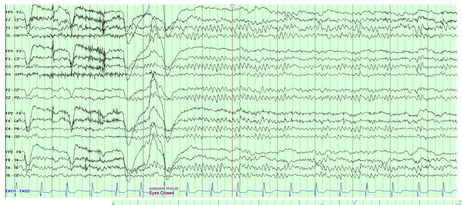
Characteristic	Coefficient	Standard Error	P-Value	Status
Continuity	-0.4463	0.2071	[0.0324]	"In"
AP Gradient	-0.0775	0.2084	[0.7105]	"Out"
Posterior Dominant Rhythm	-0.6438	0.2014	[0.0016]	"In"
Variability	-0.5893	0.2438	[.0165]	"In"
Generalized Periodic Discharges	0.5484	0.2258	[.0160]	"In"



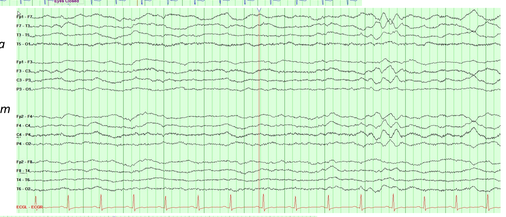




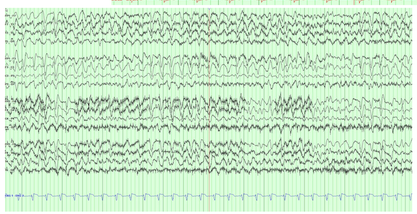




<<Image 1: EEG displaying normal EEG activity with posterior dominant rhythm



>>Image 2: EEG displaying a discontinuous EEG with no posterior dominant rhythm



<<Image 3: EEG displaying Generalized Periodic Discharges

Results

- The three diagnoses groups were found to be similar in age, gender, and MRS score
- EEG variables and MRS Score:
  - The presence of PDR, variability, and continuity were significantly associated with lower MRS
  - The presence of GPDs was significantly associated with higher MRS
- EEG variables and mortality
  - The presence of PDR, variability, continuity, and AP gradient were significantly associated with decreased mortality
  - Only the presence of GPD was significantly associated with increased mortality.
  - After multivariate analysis, continuity, PDR, variability, and GPD's were found to be independently associated with mortality.
- **Univariate Regression Results (all MRS scores)**

Pattern	P-Value	Significant?
Seizure	0.1865	N
Continuity	4.2169e-04	Y
AP Gradient	0.0061	Y
Posterior Dominant Rhythm (PDR)	0.0033	Y
Variability	0.0363	Y
Generalized Rhythmic Delta Activity (GRDA)	0.7929	N
Generalized Periodic Discharges (GPD)	0.0142	Y
Generalized Spike and Wave (GSW)	1	N
Lateralized Rhythmic Delta Activity (LRDA)	0.7568	N
Lateralized Periodic Discharges (LPD)	0.5876	N
Late Slow Wave (LSW)	1	N

Statistically Insignificant:

- Mortality vs. Seizure: Fisher's Exact Test P= 0.099647879
- Diagnosis vs. MRS: X^2 (All MRS Scores) P= 0.099353056
- ANOVA: SDH/SAH/ICH

Conclusions

We have found that several EEG features are associated with functional outcome as well as mortality, without taking into account the severity of the hemorrhage. It may be used in addition to imaging and clinical examination to help neurologists predict the outcome of these patients.

In recognizing such features in their patient's EEG's, doctors will be better versed in what's in store for the patient and their loved ones. Not only can they can relay this information in a timely fashion, but these early indicators allow the luxury for neurologists, cardiologists and other doctors to approach underlying problems from different angles. In effect, it buys more time and knowledge to increase the survival chances of their patients.