CLINICAL EEG AND CORTICAL EVENT-RELATED POTENTIAL (ERP) TRACKING TECHNIQUES FOR TBI NEUROMODULATION INTERVENTIONS. BENEFITS OF ADVANCED COMPUTER ALGORITHMS.

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Synopsis

Objective baselines are important prior to neuromodulation interventions.
These range from neuropsych and functional performance tests to complex MRI and SPECT analysis. Newer quick EEG and EP data coupled with computer algorithms produce quite relevant physiological markers. EEG data can consistently track neuromodulation induced physiologic changes. The EEG and EP both track and help predict functional improvement in ABI patients. Clinically, we have seen brain physiologic activity shift in the desired direction weeks prior to functional improvement, helping to guide rehabilitation.
New EEG systems are inexpensive, quickly applied and data is analyzed by advanced algorithms. EEG includes P300, coherence, frequency spectrum, AI clustering and basic EEG frequency and amplitude.

Background

Neurological Rehabilitation requires consistent and quantitative baselines before therapy. Patients and families want to know progress and 3rd parties require improvement tracking. Baseline testing can be straight forward such as performance tests including the Fugl Meyer or speech language cognitive and output testing. Neuropsych evaluations are more extensive and require patient endurance and cooperation. MRI and SPECT scans help with lesion and connectivity identification. They are excellent initially, but often costly and complex for follow-up tracking.
Clinically, with neuromodulation interventions, patients typically improve and eventually plateau. The functional tests likewise plateau. Families often request additional therapy; practitioners follow 3rd party guidelines and suggest transition to a lower level of care. MRIs and costly tests are rarely recommended.
Newer computer-based EEGs are much less expensive and show physiological changes.
They are easier to apply than traditional systems and not looking for epilepsy but rather for coherence improvement, increases in P300 amplitude and speed, left – right lateralization changes as well as shifts in frequency spectra. These are physiological baseline markers that change with cortical improvement.
AI based cluster analysis can be used to identify the relative severity of the patient's

brain dysfunction compared with controls and others with similar neurologic conditions. Machine learning protocols such as Eigenvector mapping produce 3-dimensional clustering that separate controls from pathologic conditions. Subjects can be evaluated, and their data can be displayed on the spectrum of the two groups. As interventions improve patient brain activity, there is an expected migration of patient data points toward the control cluster. Examples are shown here.

Methods

EEG with audio P300 was collected as part of a health screening exam through the Colorado Univ, Boulder, Boone Heart Institute, Denver, and researchers from WAVi Inc. Boulder.
2,025 subjects aged 13-90 were evaluated for baseline both for pre-season sports in the younger groups and prior to engaging in rehabilitation interventions for the 54 patients who had sustained a closed head injury from blunt trauma or blast exposure.
The equipment included WAVi Inc. Boulder, CO headset and computer algorithms. The international 10/20 montage of 19 active EEG electrodes was used. The standard auditory EP "odd ball" paradigm, eyes closed EEG for 4 min. produced the cortical P300 test.
Computer analysis of the EEG produced peak alpha frequency, background and target response cortical coherence at 3 frequency clusters, brain processing delay, physical response delay and P300 amplitudes for each electrode.
Individual subjects EEG were analyzed using Eigenvector clustering that display the positions of individual vector scores within 3D group clustering of a cohort of 150 known TBI patients in comparative relation to uninjured control subjects.
As the patients progressed in rehabilitation, EEG and P300 testing was repeated, monthly or at clinically relevant times

Results

Validity of the tests were substantiated because of the test-retest consistency. The P300 amplitudes and cortical delays demonstrated a standard deviation (SD) of 12%.
Pre-post concussion amplitudes changed (declined) over 40% (-28% to - 64%) at 24 hrs. following mTBI. As the subjects improved clinically, the EEG signals improved in 70% at 2 weeks and 90% returned to within 1 SD at 2 months. Upon repeat testing, individual alpha frequency peak activity remained stable over the course of 0.25 - 2 years in a test-retest dataset.

For subjects with histories of head injuries due to MVA, advanced algorithm cluster analysis Eigenvector mapping showed clear separation between controls and subjects with histories of head injuries.
Three subjects in the control group of 100 subjects showed their individual clustering to be located at the intersection between normal controls and the head injured group. Over the course of 2 to 3 years all 3 previously normal individuals were diagnosed with dementia.

Discussion

These studies demonstrated the benefit of within-person tracking using EEG coupled with advanced computer analysis. P300 testing showed TBI injuries produce effects far exceeding the testing variance.
As subjects improved there was a corresponding increase in P300 amplitude. Improvement in speed or detected delay showed a strong trend. Other clustering AI techniques provide stable within-person long term tracking. If coherence was skewed following injury, even after long periods, it also demonstrated improvement following intervention.
Also noted was the trend of improved P300 amplitude occurring multiple weeks prior to functional improvement.
All these EEG computer-based data points help track patient improvement in response to medication, cognitive and physical based therapies as well as from neuromodulation. The data help with decision making as we assess the optimal application of our interventions. It assists in decisions such as time course of therapy and decisions relating to the intensity, frequency, and location of interventions.

Disclosures

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References

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