Machine-learning with QEEG to predict prognosis of coma patients in one month

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Background & Objectives

- Post-cardiac arrest syndrome (PCAS) is a syndrome caused by cardiac arrest that shows brain damage and multi-organs dysfunction.
- PCAS can cause severe neurological disorders due to brain damage.
- Accurate prognosis prediction is crucial to coma patients, but not yet developed.
- We tried to develop EEG-centered machine-learning(ML) algorithm to predict prognosis of coma in one month.

Methods

- Subjects
  - Retrospective study was done for 195 coma patients
  - Prognosis were classified 'Awaken' or 'Non-awaken' 1 month later according to Cerebral Performance Categories(CPC) scale.
  - 49 patients were in Non-awaken group (CPC4-5), and the other patients were in Awaken group (CPC1-3).
- EEG acquisition & analysis
  - 19-channel EEG was measured under the resting state for 4 minutes within 72 hours after Recovery Of Spontaneous Circulation (ROSC).
  - All preprocessing steps with denoising using amICA and sensor level feature extraction were performed on iSyncBrain®.
  - The spectral power of 6 frequency bands, Delta (1-4Hz), Theta (4-8Hz), Alpha1 (8-10Hz), Alpha2 (10-12Hz), Beta1 (12-15Hz), Beta2 (15-20Hz) band and power ratio were analyzed at each channel.
- Machine-Learning algorithm
  - We developed 2 different ML algorithm to predict Non-awaken group : one was only based on EEG, and the other was based on the combination of EEG and clinical features including pupil reflex and Glasgow Coma Scale (GCS).
  - Feature selection and model training were independently done for each ML algorithm.
  - Two algorithms are integrated using the mean probability of Awaken group from each algorithm (Fig1).

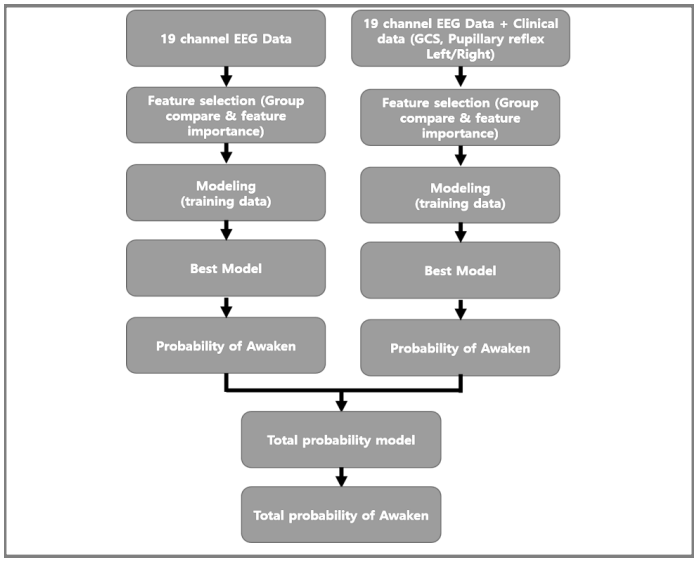

Figure1. Modeling process

Results

For the ML algorithm based only on EEG, 14 features were selected, and 11 features were selected for the ML algorithm based on EEG, pupil reflex, and GCS.
The accuracy of the algorithm based on EEG only was 0.953, that based on EEG, pupil reflex, and GCS was 0.958. Integrated model showed 0.979 (Table1). Integrated model has higher accuracy than the other algorithms.

	Sensitivity	Specificity	Accuracy
Algorithm based on EEG	0.914	1.000	0.953
Algorithm based on EEG, pupil reflex, and GCS	0.931	1.000	0.958
Integrated model	0.966	1.000	0.979

Table1. Performance of each ML algorithms

The probability of Awaken group from Integrated algorithm is strongly correlated with the CPC scale of the patients (r^2: 0.96, p < 0.01) (Fig2).

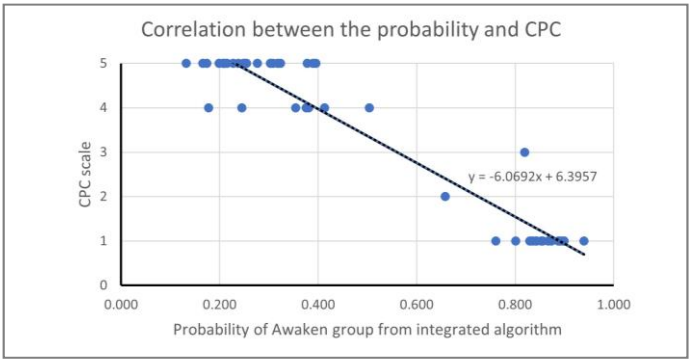

Figure2. Correlation between the probability of Awaken group from Integrated algorithm and the CPC scale

Conclusions

- QEEG features showed big difference between Awaken group and Non-Awaken group.
- Relative increase of Alpha and Beta wave and decrease of Delta and Theta wave has been observed in Awaken group.
- The QEEG features were used as main features to predict the prognosis.
- To achieve higher performance, pupil reflex, and GSC were added to train classification models as well as QEEG features.
- Finally, every classification models showed outstanding performance and it indicated that EEG is an excellent biomarker to predict the prognosis.

Acknowledgement
This study was supported by the fund from the Ministry of Trade, Industry and Energy(no. P0014055) and Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(No.2020R1I1A1A01073396).