Validation of the EEG Electrode Placement for the Patient State Index (PSI)

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Background

The Patient State Index (PSI) is a dimensionless number derived from quantitative analysis of the electroencephalogram (EEG). It has been found that at loss of consciousness (LOC) EEG power increased in all frequency bands with the exception of gamma and there was anteriorization of power. In addition it was noted that there is a hemispheric relationship with prefrontal and frontal regions of each hemisphere becoming more closely coupled, as well as uncoupling of anterior and posterior regions at LOC. The goal of this study was to determine if the current new electrode placement of the PSI with bilateral and temporal EEG leads could obtain the same amount of clinical information without posterior lead placement as compared to the initial PSI electrode array placement. The use of fewer EEG leads would allow an EEG array with a more convenient application during clinical use.

Methods

After IRB approval, patients undergoing general anesthesia were enrolled. All patients received a combination propofol, alfentanil, N2O anesthetic or a balanced anesthetic with volatile gas and opioid as required. EEG electrodes were applied with electrode gel and Ag/AgCl electrodes at positions Fp1, AFZ, Fpz, Fp2, CZ, PZ, A1, A2, F7 and F8 on the 10/20 layout. The raw EEG and processed parameters were acquired by a modified PSA4000 (Physiometrix Inc) and were continuously recorded to a hard drive. Final choice of electrode placement for calculation of the new PSI with reduced number of electrodes was based on predictive value at prospectively determined endpoints of anesthesia. Comparison of PSI values was performed in a series of tests that included a Z(t) score, Wilcoxon signed rank test on the differences of Z(t), sign test on Z(t), generalized estimating equation (GEE) to fit the regression model, and anesthesiologist assessment.

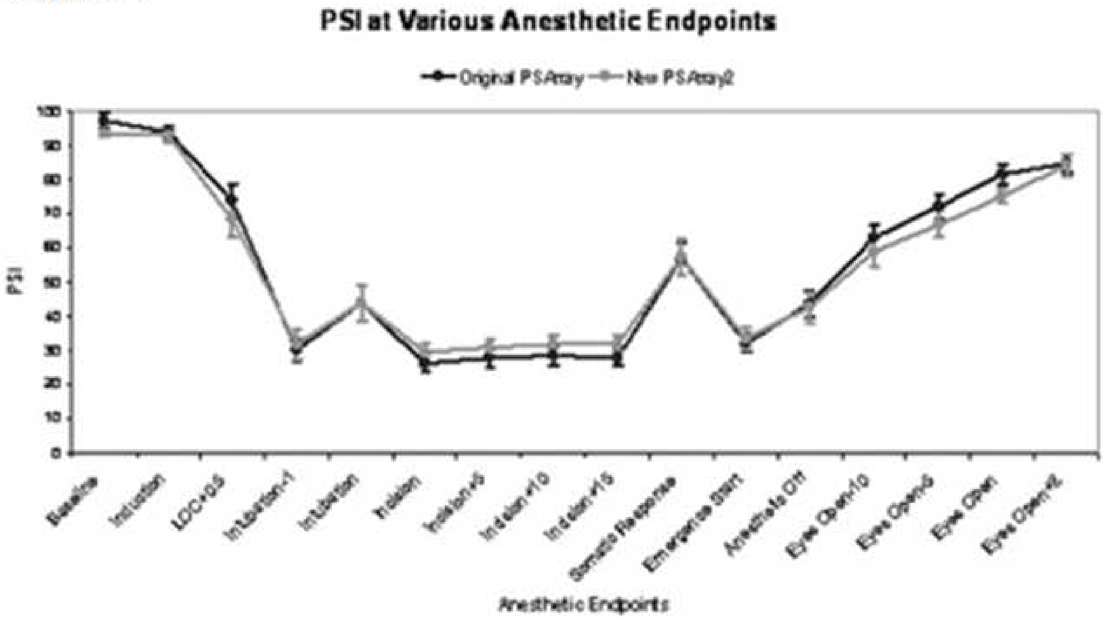
Results

108 patients were enrolled. The original PSI and revised PSI as generated by the new frontal electrode array were calculated off-line and values are presented in the figure (mean 95% CI) for each anesthetic endpoint. Additional statistical analyses were conducted on the individual PSI data points for each patient (about 1000 observations per patient). In addition, a GEE repeated measures model was fit (SAS PROC GENMOD) in order to account for within-subject correlation in the analysis of "offset" difference between original PSI and revised PSI. The final electrode selection was at FP1, FP2, F7 and F8 with reference at AFZ. The PSI had a high predictive value for estimating level of sedation at each anesthetic endpoint.

Conclusion

A new electrode placement choice with 4 leads of bilateral, frontal and temporal location is required to obtain information to accurately predict level of sedation. Regional differences in the EEG are important factors in predicting level of sedation. The major components of the new PSI from 4 leads are calculated from absolute EEG power gradient and changes between frontopolar and anterior temporal regions, total spectral power, absolute power in delta and coherences between regions.

Figure 1



PSI at Various Anesthetic Endpoints
Original PSArray
New PSArray2
PSI
100
90
80
70
60
50
40
30
20
10
0
Anesthetic Endpoints