Title: EEG POWER SPECTRUM CORRELATES OF AMNESIA

Authors: Warren J. Levy, M.D.

Affiliation: Department of Anesthesia, University of Pennsylvania, School of Medicine, Philadelphia, Pennsylvania 19104

Introduction: Although EEG changes have been correlated with increasing depth of anesthesia, technical considerations, the inconvenience of utilizing standard EEG recording techniques intraoperatively, and the minimal EEG changes associated with light anesthesia have limited the usefulness of the EEG in assessing anesthetic depth in very lightly anesthetized patients. Power spectrum analysis is a powerful technique for quantitating EEG activity and simplifying its presentation intraoperatively, but no studies have determined whether the EEG changes associated with light levels of anesthesia can be identified using power spectrum analysis. Therefore we undertook power spectrum analysis of the EEG during anesthetic induction to determine if this technique allowed the identification of EEG changes which correlated with the onset of amnesia.

Materials and Methods: 14 healthy patients gave informed consent for this study, which was approved by the institutional review committee. Patients received no premedication. After arrival in the OR, a common reference electrode montage of F_{Pl}, F_3, C_3, and T_3 to A_1 with A_2 as ground was established. The EEG bandwidth (3 db) was 4 to 45 hz.

After a 2-minute period of preoxygenation, anesthesia was induced with N_2O, 4 l/min, O_2, 2 l/min and enflurane 0.5%. Every 15 seconds, the subject was told the number of seconds since beginning the induction. Every 30 seconds, the inspired enflurane was increased by 0.5%. Postoperatively (6 to 20 hours), each subject was asked "what was the last number you remember?" The onset of amnesia was defined as the first number not remembered.

Quantitative analysis of the EEG was performed by the calculation of the power spectrum from successive 2-second epochs of data sampled at 128 hz. Average power in the alpha band (8-12 hz) was calculated for two 30-second periods: the mnemonic period, which ended with the last number remembered, and the amnesic period, which began with the first number not remembered.

Results: Although all subjects remembered some of the numbers spoken, two subjects recalled the last number incorrectly. Both had correct recall for the immediately preceding number and had no recall for the immediately following one, indicating incomplete recall for the number in question. These two subjects were considered mnemonic for the number remembered incorrectly. Stable baseline alpha rhythms could not be obtained from 5 patients due to anxiety, shivering, etc. In the remaining 9 subjects, the alpha power during the amnesic period was 27% less than the power during the mnemonic period ($p < .01$ by paired t-test). All subjects showed decreased alpha power either coincident with the amnesic period or immediately subsequent to it ($p < .005$ by paired t-test). No consistent statistically significant pattern of frequency changes was observed when comparing the amnesic and mnemonic power spectra, however new high-frequency activity was observed in all subjects after the first amnesic period.

Discussion: Because it provides trend analysis in a convenient display, power spectrum analysis could be a convenient means for utilizing the intraoperative EEG. It has been utilized for identifying intraoperative ischemia[1] (in which gross EEG changes are often present), but not for identifying the more subtle changes which are associated with minimal anesthetic depth. In this study, the high-frequency activity previously associated with amnesia[2] was identified in all subjects. In addition, quantitative analysis of the alpha band power allowed use of the paired t-test to eliminate interpersonal variability in the EEG. This quantitative analysis demonstrated that a previously unidentified small, but consistent, reduction in alpha band power coincides with the onset of amnesia before the high-frequency activity occurs.

Conclusion: Power spectrum analysis of the EEG has been validated as a technique for analyzing small changes in the EEG. In addition, it has revealed previously undocumented EEG changes coincident with amnesia in patients undergoing induction with N_2O/O_2/enflurane. Further evaluation of these changes and the effects of surgery and other anesthetic agents and adjuvants is appropriate to determine the general applicability of power spectrum analysis as a measure of anesthetic depth.

References:

1. Rampil IJ, Holzer JA, Correll JW, et al: Prognostic value of computerized EEG monitoring during cerebrovascular surgery. Anesthesiology (abstr) 55:A126, 1982.

2. Hosick EC, Clark DL, Adam N, et al: Neurophysiologic effects of different anesthetics in conscious man. J Appl Physiol 31:892-898, 1971.