Title: A COMPARISON OF MEDIAN FREQUENCY, SPECTRAL EDGE, FREQUENCY BAND RATIOS, TOTAL POWER, AND DOMINANCE SHIFTS IN THE DETERMINATION OF DEPTH OF ANESTHESIA

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INTRODUCTION: Several univariate descriptors derived from the processed EEG have been proposed as useful in determining depth of anesthesia. Median frequency was found to effectively differentiate between the intraoperative and "recovery" periods in patients anesthetized with isoflurane (**Iso**) and N2O[1]. "Spectral edge frequency" has been reported to predict the hemodynamic response to laryngoscopy[2]. An EEG shift to "anterior dominance" has been proposed as an index of loss of awareness[3]. In addition, total EEG power[4] and various frequency band power ratios[5,6] have been reported to correlate well with recovery of responsiveness. However, all of these investigations entailed tightly controlled anesthetic techniques and conditions. The present study further examined the ability of these indices to differentiate the anesthetized and awake states by means of a simultaneous comparison in a more commonplace clinical setting.

METHODS: The study was approved by the institutional review board and informed consent was obtained. Fifteen ASA I-II patients undergoing breast, abdominal, pelvic, and peripheral orthopedic procedures were enrolled. Following induction with thiopental, anesthesia was maintained with Iso, 50% N2O and oxygen. Premedication, muscle relaxants and reversal agents were given at the discretion of the anesthetist who was also allowed to choose from a list of optional supplements including: IV lidocaine prior to intubation, droperidol up to 1.25 mg, morphine up to 0.1 mg/kg, and fentanyl up to 2.5 ug/kg (although no supplement was allowed within 30 min of the procedure's anticipated end). Platinum needle electrodes (Grass) were placed at F3, F4, C3, 1 cm lateral to O1 and O2, and at FPz (ground). The EEG was acquired, processed (Fast Fourier Transform) and stored with a Tracor-Northern NOMAD. Band pass filters were set at 1.0 and 30 Hz. Epoch length was four seconds. EEG recording began shortly after induction and continued until wake-up. Prior to the conclusion of the surgical procedure, with the patient receiving Iso and 50% N2O, spontaneous ventilation was re-established using capnometry as a guide. The Iso concentration was chosen by the anesthetist on the basis of clinical requirements. After application of the dressing, Iso and N2O were discontinued and the patient breathed 100% O2 (fresh gas flow: 5 L/min). The patient remained undisturbed (no verbal stimuli, suctioning, etc.) until the first manifestation of arousal (coughing, spontaneous movement, eye opening). The data quantitation function of the NOMAD was used to determine median frequency (**MF**), the "spectral edge" 90% (**SEF90**), and the ratio of power in the 8-20 Hz/0-4 Hz bands (**å+ß/∂**) from both bi-frontal and frontal-occipital montages. Total power (**TP**) was measured in the bi-frontal and bi-occipital leads. The ratio of frontal to occipital power (**F/O TP**) was calculated manually. Each of the five derived parameters was determined by averaging the data from 10 consecutive epochs. Where the value for an individual epoch was more than two standard deviations from the mean it was omitted and replaced by an additional epoch. The present analysis compares data obtained immediately prior to arousal (PRE-AROUSAL) with data obtained 15 min earlier (INTRAOPERATIVE) during the conclusion of the procedure and prior to discontinuation of Iso and N2O.

RESULTS: Five of the 15 patients were excluded for protocol violation or technical error. The remaining 10 (4 male, 6 female) were of mean age 36.1 yrs (range 20-67). Five of the 10 patients received benzodiazepine pre-medication; nine received iv narcotic supplementation; and three received iv droperidol. The EEG data are summarized in the Table. All five descriptors changed significantly ($p<.05$, paired t-tests) between the "Intraoperative" and "Pre-arousal" periods except F/O TP ($p<.06$). There was no apparent difference between data obtained in bi-frontal and frontal-occipital derivations.

DISCUSSION: These data indicate that median frequency, spectral edge, total power, and power band ratios change predictably as depth of anesthesia decreases during emergence from anesthesia with Iso and N2O with iv supplementation. The data do not confirm the occurance of a loss of frontal dominance during emergence in this situation. While MF, SEF90, (å+ß/∂), and TP almost uniformly demonstrated obvious changes during the course of emergence, the absolute values observed varied considerably (note SD's in Table) thus reducing the predictive value in individual patients. MF best differentiated the two conditions (see Figure). Only one patient had an "anesthetized" MF value that fell within the range of "pre-arousal" values, and with this exception an MF of 4.7 served to reliably differentiate the "anesthetized" and "pre-arousal" conditions.

REFERENCES: 1. Schwilden et al., Br J Anaesth 59:738-745, 1987. 2. Rampil et al., Anesthesiology 67:139-142, 1987. 3. Tinker et al., Anesthesiology 46:252-259,1977. 4. Bührer et al., Anesthesiology 67:A658, 1987. 5. Cooke et al., Anesthesiology 65:A541, 1986. 6. Shah et al., Anesth Analg 67:S206, 1988.

	MED FREQ*		SEF 90*		å+ß/∂
	F3-F4	F3-O1	F3-F4	F3-O1	F3-F4
INTRA	4.2±1.1	4.5±1.7	12.8±2.6	11.2±2.6	0.7±0.5
AROUS	9.4±2.8	8.6±2.2	16.2±2.0	15.1±1.4	2.9±2.1

	å+ß/∂	TOTAL POWER†		TOT POWER	
	F3-O1	F3-F4	O1-O2	F/O	
INTRA	0.6±0.5	342±148	202±92	1.95±1.12	*=Hz
AROUS	2.7±1.5	113±75	96±65	1.39±0.72	†=μV2

Table. Descriptors derived from the processed EEG intraoperatively (INTRA) and immediately prior to arousal (AROUS). å+ß/∂=total power 8-20 Hz/total power 0-4 Hz

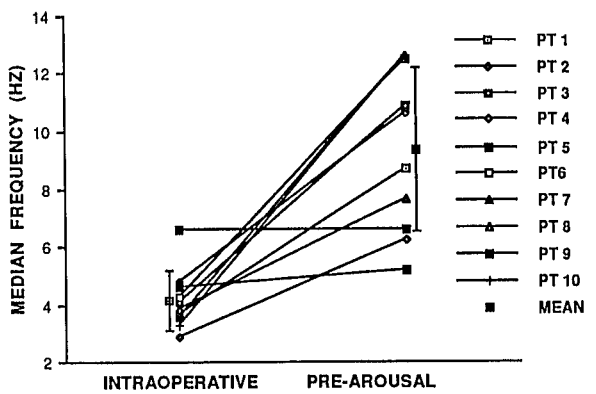

FIGURE: Median frequency in 10 patients (PT) during the INTRAOPERATIVE and immediate PRE-AROUSAL periods. The group MEAN values (±SD) are indicated.

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