

**TITLE:** A COMPARISON OF EEG DETERMINANTS OF NEAR-AWARENESS DURING ISOFLURANE AND FENTANYL ANESTHESIA: SPECTRAL EDGE, MEDIAN POWER FREQUENCY AND DELTA RATIO.

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**Introduction:** Awareness during light general anesthesia is always a concern; its detection by EEG criteria would be a major clinical advance. Spectral Edge Frequency (SEF), Median Power Frequency (MPF) and ratio of power in the alpha and beta frequencies to that of the delta frequency (Delta Ratio) have been suggested for this purpose.(1,2,3) This study compares the utility of SEF, MPF and Delta Ratio for identifying near-consciousness during emergence from a light Isoflurane or Fentanyl anesthetic.

**Methods:** 14 ASA class I patients undergoing general surgical procedures were studied with IRB approval and informed consent. EEG electrodes were placed in a fronto-mastoid array at F3-A1 and F4-A2. Impedances were always below 3000 ohms. EEG spectral analysis was performed on-line with a Tracor Northern Nomad processor. Epoch length was 4 sec; low and high pass filters were at 1 HZ and 30 HZ, respectively. The EEG power spectrum was recorded throughout anesthesia and saved on disc. SEF, MPF and Delta Ratio were computed using Nomad data quantification software.

Patients were anesthetized with a thiopental, nitrous oxide-oxygen and vecuronium sequence, supplemented with either Isoflurane (1% inspired) or Fentanyl (1.5 µg/kg/hr after an initial bolus of 5 µg/kg IV). N<sub>2</sub>O was discontinued as surgical closure began; Isoflurane and Fentanyl were terminated during skin closure. End-tidal CO<sub>2</sub> (Criticare POET), N<sub>2</sub>O and Isoflurane concentrations (Perkin-Elmer mass spectrometer) were recorded: 1) as anesthesia ended and 2) as patients opened their eyes in response to repeated verbal commands.

The mean value for each EEG variable was computed off-line over 5 epochs as follows: 1) just before the anesthetic was discontinued, 2) just before and 3) just after a "shift" in EEG pattern occurred, and 4) just before patients awoke (time "0"). The time between awakening and the other data points was tabulated in seconds. For each anesthetic EEG data obtained at the above times were subjected to statistical analysis using Wilcoxon's rank-sum test for paired data. P<.01 was regarded as significant.

**Results:** The table summarizes our EEG findings during emergence from both anesthetic techniques. All three EEG parameters demonstrated a shift-point indicative of imminent awakening from both Isoflurane and Fentanyl. In the case of Fentanyl, these changes occurred within a minute of eye-opening; with Isoflurane there was always at least 4 minutes between the EEG shift-point and awakening. The magnitude of the "Delta Ratio" shift was always much greater than that observed with SEF or MPF (figure 1).

No significant change in P<sub>ET</sub>CO<sub>2</sub> occurred during emergence from either anesthetic regimen. End-tidal Isoflurane concentration was 0.90%±0.11SE when the agent was turned off and 0.16%±0.02SE when eye-opening occurred. End-tidal N<sub>2</sub>O was always <5% during emergence from anesthesia.

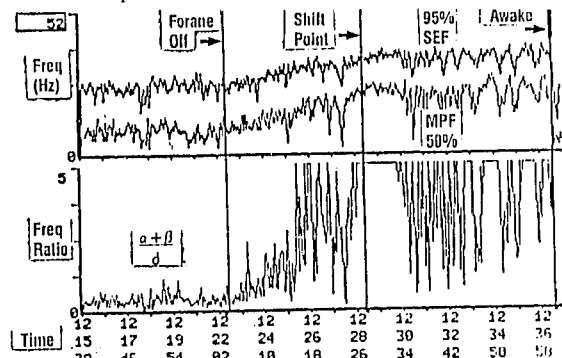
**Discussion/Conclusions:** Both Isoflurane and Fentanyl cause EEG power in the delta range to increase markedly, coincident with decreases in alpha and beta

power.(1,2) Computation of the ratio of these frequency spectra magnifies these EEG changes and gives an endpoint indicative of near-awareness. SEF and MPF, however, change far more gradually during anesthetic induction or emergence.

Isoflurane is the more amenable anesthetic for evaluation of near consciousness by EEG criteria, since several minutes intervene between recognizable EEG changes and awakening. In contrast, the brief interval between awakening from light Fentanyl anesthesia and an identifiable change in the EEG power spectrum means that there is a greater risk of awareness occurring before a clinician could react by deepening the level of anesthesia.

FORANE EMERGENCE		SEF	MPF	"DELTA RATIO"	TIME (sec)
END-POINT					
Agent Off		13.1±0.4	5.5±0.4	1.5±0.3	-984±103
Pre-Shift		15.5±0.3*	8.2±0.4*	1.8±0.2	
EEG-Shift					-639±71
Post-Shift		16.3±0.3*	9.2±0.4*	4.1±0.5*	
Awake		17.9±0.2*	10.1±0.5	4.7±0.5	0
FENTANYL EMERGENCE		SEF	MPF	"DELTA RATIO"	TIME (sec)
END-POINT					
Agent Off		13.5±0.6	4.1±0.4	0.6±0.1	-214±34
Pre-Shift		13.6±0.6	4.1±0.4	0.9±0.2	
EEG-Shift					-51±33
Post-Shift		15.6±0.6*	6.9±0.6*	2.1±0.4*	
Awake		15.7±0.6	6.1±0.7	2.0±0.3	0

\* = P<.01 vs previous value



**Figure 1:** Delta Ratio, SEF and MPF during emergence from Isoflurane anesthesia, showing shift in EEG parameters occurring before awakening.

**References:**

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3. Shah NK, Long CW, Bedford RF: "Delta shift": an EEG sign of awakening during light Isoflurane anesthesia. *Anesth Analg* 67:S206, 1988.

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