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**Title:** EEG PREDICTION OF AROUSAL DURING ANESTHESIA WITH COMBINATIONS OF ISOFLURANE, FENTANYL, AND N2O

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**INTRODUCTION.** To further examine the usefulness of the EEG in detecting arousal in patients during anesthesia, we determined 50-, 80-, and 95%-anesthetized points and quantal response curves (QRCs) for EEG by noting whether patients (Pts) moved with surgical stimulation or not (M/NM) or responded appropriately to verbal requests (VR) or not (R/NR). These maneuvers are methodologically analogous to determinations of MAC and "MAC Awake" and anesthetic dose-response curves (ADRCs) for end-tidal gas concentrations (1).

**METHODS.** The protocol was approved by the hospital IRB, and all Pts gave informed consent. 325 Pts undergoing routine laparoscopy without paralysis after intubation received thiopental (4 mg/kg) and one of six maintenance anesthetic combinations: I (isoflurane), IN (isoflurane/ N2O 70%), INF1 (isoflurane/ N2O 70%/ fentanyl 1 µg/kg), INF2 (isoflurane/ N2O 70%/ fentanyl 2 µg/kg), NF4 (N2O 70%/ fentanyl 4 µg/kg), IF4 (isoflurane/ fentanyl 4 µg/kg). For each Pt, M/NM data were collected for insertion of a trocar (TR) and again during the less noxious closing phase (CL). Also for each Pt, R/NR data were collected for the VR to Pts to open their eyes or to squeeze the investigator's hand. A CDC Cyber 960 Computer computed offline EEG F95 values and QRCs. F95 is the frequency (Hz) below which lies 95% of the power in the EEG power spectrum. QRCs have the familiar sigmoid shape of ADRCs, but show percentage of patients anesthetized vs. EEG, rather than vs. end-tidal gas concentration.

**RESULTS.** The table shows F95 values at the 50-, 80-, and 95%-anesthetized QRC points for all stimuli and anesthetic combinations. Except for 1 Pt in INF1, appropriate responses to verbal requests were not observed unless fentanyl 4 µg/kg was used, allowing elimination of isoflurane or N2O. QRCs were not calculated (NC) for I TR because burst suppression was often present.

**DISCUSSION.** When less isoflurane is required, the QRCs shift to higher values of F95. Less isoflurane is required when fentanyl is increased or N2O added, or when stimulus intensity is reduced from TR to CL. With fentanyl 4 µg/kg, appropriate responses to verbal requests could be obtained in many Pts, even though they were not moving with surgical stimulation. We conclude that a simplified EEG can be used to predict arousal, and that the results of this study can provide guidelines to titrate the administration of anesthesia. The results may be especially useful for the EEG monitoring of patients receiving muscle relaxants and therefore unable to signal arousal by moving.

ANESTHETIC	F95 VALUES FOR EEG QRCs					
	I	IN	INF1	INF2	NF4	IF4
<b>Trocar</b>						
No. Pts	25	73	42	50	42	79
50% F95	NC	23.2±1.4	23.1±0.7	25.8±1.2	25.1±0.5	22.2±0.7
80% F95	NC	19.7±0.8	21.5±0.6	22.4±1.1	23.4±0.8	19.5±0.7
95% F95	NC	15.8±1.8	19.6±1.0	18.5±2.2	21.6±1.3	16.4±1.2
<b>Closing</b>						
No. Pts	25	78	42	49	51	76
50% F95	20.8±2.0	25.3±0.5	26.8±0.8	27.0±0.4	33.8±7.6	25.2±0.6
80% F95	15.9±2.4	23.5±0.5	24.9±0.6	26.1±0.4	25.2±2.6	23.1±0.6
95% F95	10.3±5.6	21.6±0.8	22.7±1.3	25.1±0.7	15.4±1.2	20.7±1.1
<b>Verbal request</b>						
No. Pts	25	78	42	50	52	79
50% F95	NR	NR	Only	NR	32.1±2.0	26.9±0.9
80% F95	NR	NR	1 Pt	NR	29.3±1.2	24.9±0.5
95% F95	NR	NR	Resp.	NR	26.5±0.7	22.6±0.7

± Standard Error of the Estimate.  
NC = Not Computed; NR = No Response

**REFERENCE.**

1. Anesthesiology 42: 384-389, 1975

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**Title:** AUDITORY EVOKED POTENTIALS TO PITCH CHANGE DURING SUFENTANIL ANESTHESIA

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**INTRODUCTION:** There is controversy as to whether opioids reliably produce unconsciousness [1]. The "P3" is a late (~250-500 ms) component of sensory evoked potentials (EPs). The P3 can detect consciousness [2]. To evoke a P3, subjects are asked to identify occasional "oddball" stimuli (ex., high-pitch tones) appearing unpredictably in a sequence of "standard" stimuli (ex., low-pitch tones). Only oddballs detected by the subject evoke a P3. Oddballs missed by the subject and standards evoke no P3 [2]. We have examined the effects of sufentanil on the P3.

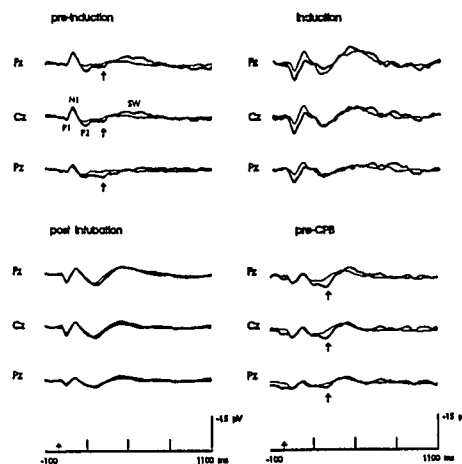
**METHODS:** Informed consent was obtained from all subjects after Ethics Committee approval. Nine patients (8 men, age 56-yrs, SD=8) undergoing cardiac surgery (mostly CABG) were tested. After premedication with diazepam-morphine-scolopamine, anesthesia was induced with sufentanil (6.0-10.0 µg.kg<sup>-1</sup>). After tracheal intubation with vecuronium-pancuronium, the lungs were ventilated with air-O<sub>2</sub> without inhalation agents. Additional sufentanil was given before skin incision (2.0 µg.kg<sup>-1</sup>), sternotomy (1.0 µg.kg<sup>-1</sup>) and aortic-atrial cannulation (1.0 µg.kg<sup>-1</sup>).

The EEG was recorded (0.3-100 Hz) from Fz, Cz and Pz, referenced to right mastoid. Stimuli lasted 50 ms and were presented every 1.5 s. Standards (probability 0.8) were 1 KHz tones; oddballs (probability = 0.2) were 2 KHz tones occurring unpredictably. Conventional averaging was used.

Recordings were obtained before induction (pre-induction); during induction (after loss of responsiveness to verbal commands); post-intubation (after intubation before incision); pre-CPB (during atrial-aortic cannulation, before bypass).

**RESULTS:** The P3 (arrows) was present before induction (Fig.). It disappeared during induction, and was absent during post-intubation. It reappeared during pre-CPB, but in contrast to a typical P3, it was larger at Fz than at Pz. An ANOVA for repeated measures confirmed that during pre-induction and pre-CPB, the P3 was larger for oddballs than for standards (P < 0.01). During pre-CPB, it was larger at Fz than at Pz (P < 0.01). There were no instances of recall.

**DISCUSSION:** The frontally-predominant P3 during pre-CPB indicates that the pitch difference between standards and oddballs was being registered by the brain. This does not prove consciousness however, because the link between consciousness and the P3 is only valid for a typical P3, which is larger at Cz and Pz than at Fz.



**FIG.:** Waveforms for all patients. Thin lines were evoked by standards and thick lines, by oddballs. The P3 (arrows) is seen only for oddballs and only during pre-induction and pre-CPB. Negativity at the active electrode is plotted upward.

**REFERENCES:**

1. Wong KC. Anesth Analg 62; 625-6, 1982.  
2. Flourde G, Picton TW. Anesth Analg 71; 460-8, 1990.