

Title : THE EEG DURING HIGH-DOSE FENTANYL ANESTHESIA  
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**Introduction.** We have used the processed EEG to help judge the level of anesthesia with high-dose fentanyl (F) during open-heart surgery. We wanted to determine if the EEG could predict the depth as assessed by clinical criteria. On the premise that a major advantage of F is its attenuation of undesirable CV responses, we tried to match easily recognized EEG patterns to clinical levels based mainly on CV responses.

**Methods. EEG processing.** We used the Demetrescu method of EEG analysis and display. Each individual wave of the EEG is detected and plotted on a television screen, according to frequency, amplitude, and time. The timespan of the entire plot is 4 min. The combined 3-D effect and color display make patterns extremely easy to interpret; the changes are striking. Furthermore, the display is updated every second, making it easy to see rapid changes in the EEG. **Clinical evaluation.** We divided the clinical status into 5 categories: 1) awake, but premedicated, or response to voice and/or spontaneous movement; 2) no response to voice command and no spontaneous movement, but marked circulatory responses to stimulation; 3) moderate circulatory responses; 4) no or minimal circulatory responses; 5) "too deep". We examined the EEG before and after certain events: the insertion of a Foley catheter, laryngoscopy and spraying of cords, laryngoscopy and endotracheal intubation, leg incision, sternal incision, sawing of sternum, and spreading of sternum. The response which we considered marked, moderate, or minimal varied with the stimulus. Given seven stimuli, three measurements (arterial pressure, heart rate, and beat-to-beat cardiac output by the pulse contour method) and three levels of response, it is too extensive to list the 63 possible combinations in an abstract. The analyzed EEG was stored on a floppy disk. In addition, a strip-chart record was kept of all the CV variables. Time was kept on both records.

**Results.** Figure 1 shows an awake pattern being rapidly converted to a Stage III pattern during a very rapid infusion of F (1,500 mcg total up to that point). Certain EEG patterns were almost invariably present before the clinical levels outlined above. I. High amplitude in the alpha and beta range. II. The high frequency waves decrease in amplitude and begin to spread out, that is, the band is wider. The "poles" are further apart. III. High frequency amplitude decreases, but low frequency amplitude begins to increase. IV. Very little high frequency remains, and the low frequency has begun to decrease. V. No high or midfrequency remains, only scattered theta and widely scattered delta. Out of the 86 possible correlations, the independently determined EEG stages matched the response to stimulus in all but 7 cases (Table). And in only one case did the EEG misjudge by more than 1 level. In addition, there were 4 other instances where the EEG successfully predicted movement or hypertension during surgery.

**Discussion.** The processed EEG can predict clin-

ically relevant levels during F. Thus one need not give it by a formula, but rather by the patient's response. If hypotension occurs before the anesthesiologist has given the calculated dose, the EEG can help decide if enough has been given. If not, F can be slowly titrated, using the EEG as a guide. Most importantly, we have examined only one EEG analysis and display technique. Of all the techniques which we have used, the present one give the most information the most rapidly. Other techniques should be assessed for their ability to judge the level during F.

These studies were approved by the Human Research Committees of the University of California, San Diego, and the VA Hospital, San Diego, and informed consent was obtained. Supported in part by the Medical Research Service, Veterans Administration. I wish to thank the Diatek Co. for the loan of the Neurometrics EEG Monitor.

TABLE

EEG Stage	Clinical Stage				
	I	II	III	IV	V
I	18	1	0	0	0
II	0	6	1	0	0
III	1	0	17	2	0
IV	0	0	2	34	0
V	0	0	0	0	6

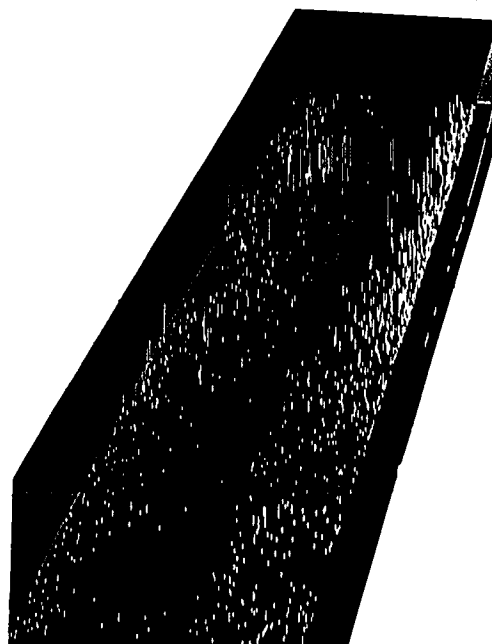


Figure 1. A very rapid transition from level I to level IV, so rapid that it is difficult to follow the transition through each level. Height of box=200 microv, width=0-30Hz (nonlinear scale), depth=4 min. (front=most recent).