TITLE :SPECTRAL EDGE FREQUENCY - A NEW CORRELATE OF ANESTHETIC DEPTH

AUTHORS :I.J. Rampil,M.S.; F.J. Sasse,M.D.; N.T. Smith,M.D.; B.H. Hoff,M.D.; D.C. Flemming,FFARCS

AFFILIATION :Department of Anesthesiology, College of Physicians and Surgeons of Columbia University, New York,N.Y.; Department of Anesthesiology, University of Wisconsin, Madison, Wi.; Department of Anesthesiology, University of California, San Diego, Ca.; Department of Anesthesiology, University of Texas, San Antonio, Tx.

Introduction. Previous workers [1] have attempted, with variable success, to ascertain the depth of anesthesia induced with various agents using the electroencephalogram (EEG). The measurement of depth is confounded by the complexity of the EEG and the fact that different agents create different patterns. In dogs we have observed a common parameter in the disparate EEG changes due to Halothane (H) or Enflurane (E). This common parameter is simply the highest frequency at which a significant amount of energy is present in the EEG. We call this point in the frequency spectrum the 'Spectral Edge Frequency' (SEF).

Methods. Anesthesia was induced in eight mongrel dogs by H-O2 (6 studies) or E-O2 (8 studies). The dogs were mechanically ventilated and the End Tidal CO2 and rectal temperature were maintained within normal limits. The EEG was a unilateral Frontal - Occipital lead. The EEG, Mean Arterial Pressure (MAP), and continuous airway concentrations of CO2 and E or H were recorded on an FM tape recorder and simultaneously analyzed in real time by a PDP-11/34 computer. The EEG was divided into epochs 4 seconds long which were sampled at a rate of 125 Hz. A frequency spectrum of each EEG epoch was calculated by the Fast Fourier Transform technique. Each spectrum was scanned by the computer from 40 Hz down to 0.5 Hz and the SEF located by a pattern matching search which ignored small, isolated bumps in the spectrum. The search emphasized a small region containing the previous SEF, thus increasing immunity to noise.

The dogs were subjected to two protocols to vary anesthetic depth, a step response test and a Pseudo Random Binary Sequence (PRBS) test [2]. The step response test consisted of ascending and descending step changes of .25 MAC inspired concentration with sufficient time between steps to allow equilibration of the MAP response (at least 10 minutes). The PRBS test used a pre-programmed sequence of agent concentrations in order to ascertain the dynamic response of the EEG to the agent. A constant level of 50% N2O was added to the inspired gas and each test then repeated. During these experiments the SEF was observed to be correlated with the MAP, so a phenylephrine drip was given to four dogs to increase the MAP without changing the depth of anesthesia.

Results. The SEF rapidly responds to changes in inspired concentrations of E or H with a decreasing frequency (slowing) shift occurring with increasing depth. Within the therapeutic range of these agents, the SEF is located in the range between 10 - 30 Hz. The SEF responds in a highly repeatable fashion in individual dogs but there are inter-dog variations in sensitivity. The SEF is insensitive to large changes in MAP (60 mmHg) induced by phenylephrine, indicating that the anesthetic - induced fast EEG activity which the SEF tracks is not simply related to pressure - induced cerebral blood flow changes. The addition of 50% N2O did not affect the ability of the SEF to follow changes in E or H. Halothane. The presence of H in dogs creates a distinct band of activity in the EEG spectrum. This band is readily apparent in a compressed spectral array plot and its position in the spectrum is followed by the SEF. Typically, the sensitivity of the SEF to small changes in H was 8 Hz/MAC. Enflurane. The analysis of the EEG with E is more complex due to the absence of distinct spectral features such as the H band. The background EEG activity is more uniformly spread over a wide region of the spectrum but, as with H, the SEF varies with the End Tidal concentration of E. The figure demonstrates a step response in the presence of 50% N2O. The SEF algorithm can be confused by the presence of high frequency spike activity common in E anesthesia, so a de-spiking algorithm was devised which obviated the problem. Typical sensitivity of SEF to small changes in E was 20 Hz/MAC.

Discussion. The SEF provides a simple, rapid and sensitive indication of the relative depth of anesthesia. Its output may be either a simple number or a graphic trend plot. The simplicity and legibility of this technique may in the future permit the routine use of intraoperative EEG monitoring. Further studies are underway to test the applicability of the SEF in humans during surgery.

References. [1] Clark DL, Rosner BS. Neurophysiologic Effects of General Anesthetics. Anesthesiology 38:564-82, 1973.

[2] Rampil IJ,Sasse FJ,Smith NT,et al. A New Method for Testing the Response to an Inhalation Agent. Anesthesiology 51:s26, 1979.