

Title : ANESTHETIC DEPTH TRANSITION BY EEG ANALYSIS

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The alveolar concentration of an anesthetic is often used as an index of the depth of anesthesia in the steady state (MAC). However, when the alveolar concentration is abruptly altered, the change in the brain level of anesthetic is delayed by the circulation time and brain tissue perfusion characteristics. Thus during the transition stage the alveolar concentration is not a reliable index of anesthetic depth. To date, the timing relationship between alveolar and brain tissue concentrations and the associated neural effects has not been characterized.

To identify this relationship, we have implemented a study in dogs with a mass spectrometer to measure the alveolar concentration, and EEG analysis as an index of brain anesthetic level. Autoregressive techniques have been applied for classification of EEG records. This technique has the inherent advantage that the EEG signal is characterized by a model with a small number of parameters. The parameter values effectively summarize the EEG signal and thus can be used for classification in terms of the depth or level of anesthesia in the brain.

The experimental design utilized a mass spectrometer to measure the inspired and end-tidal halothane concentration in an open circuit anesthesia delivery system. Needle electrodes were placed to record bipolar EEG signals from frontal to central areas and from central to occipital areas of both hemispheres. These signals were recorded on an analog tape for later processing.

The procedure consisted of the administration of a muscle relaxant (gallamine) to paralyze the animal so that a baseline record could be obtained. This baseline consisted of EEG records with the animal artificially ventilated and breathing 100% oxygen. Halothane was administered to achieve MAC levels in the range of 0, 1, 1.5, and 2. Data were recorded during both the transition phase and the steady state phase. Time records of the EEG signals and the halothane concentrations were made. These data were analyzed on a laboratory computer system.

The data indicate that the EEG autoregressive model parameters can be used to classify the different levels of anesthesia in the steady state. Twenty-four 4-second

records were used to train an 8-parameter EEG classifier to recognize each of 4 MAC levels (0, 1, 1.5, 2). Selecting 35 additional records at random provided data to test the classifier. On the three separate channels of EEG, the test classification indicated an average probability of .85 for the correct MAC level. Furthermore, these parameters indicate a transition pattern following the change from one alveolar level to another. This pattern indicates an oscillatory behavior during the transition period between the two anesthetic states (MAC 1.5 to 2.0), before finally settling into the new EEG state (See Fig. 1). All three EEG channels showed a similar type of behavior.

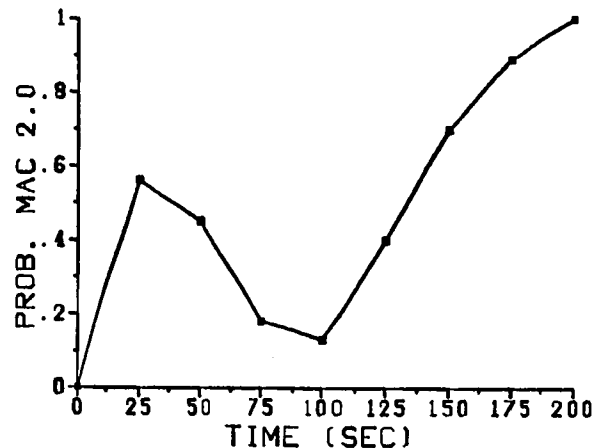


Fig. 1. EEG transition following an abrupt change of alveolar concentration (MAC 1.5 to 2.0). Y-axis indicates the probability that the data came from MAC 2.0.

Theoretically, the classifier should indicate a smooth monotonic transition between two states, since it can distribute the probability between the MAC 1.5 and MAC 2 states. Thus it is surprising to find the oscillatory behavior portrayed in Figure 1. The data suggest that the neural response to a transition in anesthetic concentration is not the smooth monotonic behavior as predicted by the washin characteristics of brain tissue.