TITLE: 40 Hz STEADY STATE EVOKED POTENTIALS (SSEP) DURING ISOFLURANE-N_2O ANESTHESIA

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Introduction

A direct neurophysiologic indicator of anesthetic depth is desired to guide drug administration and thereby avoid awareness or overdosage. The EEG is hard to interpret, and varies widely between agents and patients, a deficiency shared with clinical signs and cortical evoked potentials. Brainstem evoked potentials are refractory to anesthetics in clinical doses and their acquisition is technically demanding. A new technique, the 40 Hz SSEP, is elicited by stimuli presented at a rate such that there is overlap of responses from successive stimuli. The resulting composite waveform is sinusoidal, with greatest peak-to-trough amplitude attained at a stimulus rate of 40 Hz. Composed predominantly of energy from middle latency responses, it is postulated that the 40-Hz SSEP is generated in the rostral reticular formation or thalamus[1]. Sleep and sedation decrease response amplitude by approximately 30%, but the effects of anesthesia are unknown. It was the purpose of this study to determine the sensitivity of the 40-Hz SSEP to isoflurane-N_2O anesthesia.

Methods

Six male volunteers (age $\overline{30}$ yrs.) undergoing knee surgery consented to awake baseline and perioperative SSEP recordings. No effort was made to influence choice of anesthetic agent or technique, and results were blinded to anesthesia personnel. Patients were pre-medicated with morphine and/or midazolam, and glycopyrrolate, and anesthesia was induced with thiopental and succinylcholine. Temperature and end-tidal CO_2 were normal, and SaO_2 was $\geq$ 98%. Intraoperative 40 Hz SSEP were recorded when end inspiratory and expiratory levels of isoflurane and N_2O were equilibrated for a minimum of fifteen minutes (AIMT SARA mass spectrometer).

Stimuli consisted of 200 usec., 65dB nHL alternating polarity clicks delivered binaurally with TDH-49 earphones. The electrode montage was C_z (+) to linked mastoids (-) and Fpz ground. All electrodes had less than 3 kohm impedance. A Pathfinder I (Nicolet Corp.) with a time base of 500 msec. and bandpass of 15-250 Hz was used for signal averaging. Stimulus rate was 39.7 Hz, with a no-stimulus trial also recorded. Each response of 500 averages was replicated. Trials with changes in midde ear compliance due to N_2O diffusion were detected by construction of a BAER latency/intensity function, and were excluded from analysis. An unpaired two-tailed t-test was used, with a significance level of $P<0.05$ adopted for comparison of baseline and intraoperative amplitudes.

Results

Highly replicable 40 Hz SSEPs were readily acquired from all subjects under baseline and anesthetized conditions (Fig.). In most instances the response stabilized after fewer than 150 averages due to underlying component magnitude, and rapid summation of overlapping peaks. There was low inter- and intra-subject variability in the waveform configuration compatible with its far-field derivation. At anesthetic equilibrium (isoflurane $\overline{0.68}$%, N_2O $\overline{60}$%) the amplitude of the 40-Hz SSEP declined a mean of 78% from awake baseline. During emergence the response rapidly returned to normal as end-tidal levels of anesthetics approached zero. Awake postoperative recordings closely resembled the preoperative 40 Hz SSEP.

Discussion

The human 40 Hz SSEP appears altered in a continuum from wakefulness, through sleep and sedation, to surgical anesthesia. Decremental changes with anesthesia confirm that the response is an authentic neuronal component, and not an artifact of stimulation, recording technique (i.e. amplifier 'ringing') or evoked muscle activity. The 40-Hz SSEP is robust, reproducible, and easily quantified. These advantages, coupled with its close correlation with psychophysical thresholds, and presumed origin in regions of the brain responsible for maintenance of consciousness, warrant its further characterization with anesthetic dose response studies, and manipulations known to affect anesthetic depth.

References

1. Galambos R., Makeig S., Talmachoff P.J.. A 40-Hz auditory potential recorded from the human scalp. Proc Natl Acad Sci USA 1981; 78:2643-7.