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Depth Of Anesthesia

An essay
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ABSTRACT

Anesthetic depth has been defined as the probability of non-response to stimulation, calibrated against the strength of the stimulus. The similarity between sleep and anesthesia is widely argued that these brain states are actually different, sleep being readily reversible, whereas anesthesia is irreversible.

The first section in this essay discusses clinical measures of anesthetic depth that derive directly from the patient. Each discussion begins with a review of the subjective clinical approaches used in anesthetic practice. The second section discusses several electrophysiologic approaches to assessing depth of anesthesia. The BIS® (Aspect Medical Systems Inc., Newton, MA, USA), A-line® (Alaris Medical Systems, Inc., San Diego, CA, USA) devices are designed to monitor the hypnotic state of the patient. There are also both spontane-ous EEG, Evoked potentials and Entropy (GE Healthcare, Helsinki, Finland).

Key words: Depth of anesthesia (DoA), Electroen-cephalogram (EEG), Bispectral Index (BIS), Entropy, Narcotrend, Monitoring anesthetic depth in children, Awareness and Observer's assessment of alertness and sedation (OAAS).

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LIST OF ABBREVIATION

AAI	A-Line Autoregressive Index
ABM	Anesthesia and Brain Monitor
AEP	Auditory-evoked potential
BAEPs	Brain-stem auditory evoked potentials
BIS	Bispectral index
CNS	Central nervous system
Cp50	Steady-state plasma concentration of the drug which will prevent purposeful movement to noxious stimuli in 50% population.
CPB	Cardiopulmonary Bypass
CSA	Clinical signs of anesthesia
CSM	Cerebral State Monitor
CSI	Cerebral State index
DHel-ind	Electronic indices of depth of hypnosis
DHobs	Observed depth of hypnosis
DHreal	Real depth of hypnosis
DoA	Depth of anesthesia
ECG	Electrocardiography
ECoG	Electrocorticogram
ED	Entropy difference
ED50	50% Effective dose
ED95	95% Effective dose
EMG activity	Electromyography (muscle movement)
EPs	Evoked Potentials
FDA	Food and Drug Administration

FEMG	Frontalis electromyogram
HRV	Heart rate variability
IFT	Isolated forearm technique
LOC	Loss of consciousness
LOC	Lower esophageal contractility
LORnoxious	Loss of response to 50Hz noxious stimuli
LORverbal	Loss of Response to a verbal command
NMBA	Neuro Muscular Blocking Agents
MAC	Minimum alveolar concentration
MAP	Mean arterial pressure
MIR	Minimum infusion rate
MOAAS	Modified Observers Assessment of Alertness and Sedation
mLAER	Middle-latency auditory evoked response
OAA/S	Observer’s Assessment of Alertness/Sedation
PACU	Postanesthesia care unit
Pk	Prediction coefficient
PRST	Patient response to surgical stimulus
PRST score	Changes in blood pressure, heart rate, sweating, and tear production
RE	Response entropy
REM	Rapid eye movement
RE2SE	Difference between the entropy readings

RSA	Respiratory sinus arrhythmia
SE	State entropy
SEF95	Spectral Edge Frequency 95%
SEMG	Spontaneous surface electromyogram
SEP	Sensory evoked potential
SLOC	Spontaneous lower esophageal contractions
SSEPs	Somatosensory Evoked Potentials
TIVA	Total intravenous anesthesia
TMN	Tuberomammillary nucleus
VLPO	Ventrolateral preoptic
VEPs	Visual evoked potentials

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Introduction

Anesthetic depth has been defined as the probability of non-response to stimulation, calibrated against the strength of the stimulus, the difficulty of suppressing the response, and the drug induced probability of non-responsiveness at defined effect site concentrations. This definition requires measurement of multiple different stimuli and responses at well-defined drug concentrations [1].

First of all it is important to understand the neuro-physiology of sleep. To appreciate the neural underpinnings of sleep, it is important to view this universal mammalian behavior at multiple levels of its biological organization. Molecularly, the circadian rhythm of sleep involves inter-locking positive- and negative-feedback mechanisms of circadian. Circadian information is integrated with informa-tion on homeostatic sleep need in nuclei of the anterior hypothalamus. These nuclei interact with arousal systems in the posterior hypothalamus, basal forebrain and brainstem to control sleep onset. During sleep, an ultradian oscillator in the mesopontine junction controls the regular alternation of rapid eye movement (REM) and non-REM sleep. Sleep cycles are accompanied by neuromodulatory influences on forebrain structures that influence behavior, consciousness and cognition [2].

Depth of anesthesia monitors might help to individualize anesthesia by permitting accurate drug administration against the measured state of arousal of the patient. In addition, the avoidance of awareness or excessive anesthetic depth might result in improved patient outcomes. Various depth of anesthesia monitors based on processed analysis of the EEG or mid-latency auditory evoked potentials are commercially available as surrogate measures of anesthetic drug effect. However, not all of them are validated to the same extent.

Anesthesia is a balance between the amount of anesthetic drug(s) administered and the state of arousal of the patient. Given that the intensity of surgical stimulation varies throughout surgery, and the haemodynamic effects of the anesthetic drugs may limit the amount that can be given safely, it is not uncommon for there to be critical imbalances between anesthetic requirement and anesthetic drug administration. Underdosing may be because of equipment failure or error may occur [3]. Conversely, inappropriate titration of the hypnotic components, leading to an excessive depth of anesthesia (DoA), might compromise patient outcome [4].

Patient movement in response to noxious stimulation remains an important sign of inadequate DoA, but is unreli-able [5] and is suppressed by paralysis. Traditional clinical signs such as hypertension, tachycardia and lacrimation are unreliable indicators of DoA as they all are subjective methods depending on the anesthetist and his experience and furthermore, it varies from patient to patient [6].

A reliable DoA monitor is keenly sought [7] and several methods have been developed. Early techniques based on real time signal processing such as the raw or summated EEG, and lower esophageal contractility, were unreliable. The isolated forearm technique has had some enthusiasts, [8] but it is cumbersome and has undergone limited evaluation as a DoA monitor and has not been widely adopted; nevertheless, it remains a useful comparator in the evaluation of newer methods [1].

Advances in computer power and miniaturization have allowed the concomitant development of processed electro-encephalographic modalities such as bispectral index (BIS, Aspect Medical Systems, Newton, MA, USA) and Spectral Entropy (GE Healthcare, Helsinki, Finland). Most current proprietary DoA machines use a dimensionless monotonic index as a measure of anesthetic depth, typically scaled from 100 (awake state) to 0 (deep coma). Auditory-evoked potential (AEP) responses have attracted attention since studies in the 1980s demonstrated a clear dose–response with increasing anesthetic administration reducing the AEP amplitude and increasing its latency [9].

What is the real incidence of awareness under anaesthesia?

Sebel and colleagues [10] reported a 0.13% incidence amongst 19 575 patients with risk increased by high ASA physical status score, but no effect of age and sex and others have reported rates of 0.18 and 0.11% [5]. Awareness occurs more frequently among patients who have received neuromuscular blocking drugs, who cannot signal to the medical team that they