Estimation of Depth of Anesthesia: A review

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Received: 16 March 2020 Revised and Accepted: 16 June 2020

Abstract: Anesthesia is a medical treatment that protects patients from feeling pain during surgery. It enables individuals to have processes that lead to longer and healthier life. Physicians use drugs called anesthetics to create anesthesia. Scientists have developed a collection of anesthetic drugs with different effects. These drugs include general, regional and local anesthetics. General anesthetics put patient to sleep during the procedure while local and regional anesthetics just numb part of the body and allow patients to remain awake during the procedure. The indicators of anesthesia for estimating the depth of anesthesia are electrical parameters, physiological & biochemical parameters and mechanical parameters.

Keywords: *General Anesthesia, Local and regional anesthesia, Anesthesiologists, Respiratory Sinus Arrhythmia (RSA), Electroencephalogram (EEG), Evoked Potentials.*

1. Introduction

Anesthesia means loss of sensation. The three types of anesthesia are local, regional and general.

1.1. General Anesthesia: It affects the whole body, making patients unable to move and remain unconscious. When operating on internal organs and other invasive or time- consuming processes such as back surgery, surgeons use it. Without general anesthesia, many important life-saving procedures, including open-heart surgery, brain surgery and organ transplantation, would not be feasible. General anesthetic is provided by doctors either directly into the bloodstream or as an inhaled gas [1]. Directly provided anesthetics will act quickly and disappear rapidly from the body on the other hand inhaled anesthetics may take longer to wear off. Typically, general anesthetics are very secure but they can pose risk to some patients, such as elderly or people with chronic illnesses such as diabetes.

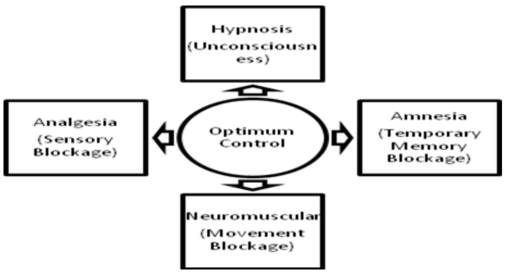

Figure 1. General Anesthesia

1.2. Local and Regional Anesthesia:

To block pain in part of the body doctors use local and regional anesthetic. Patients stay aware and comfortable with these anesthetics [1]. Patients can usually go home shortly after surgery. A tiny portion of the body is affected by local anesthetics, such as a single tooth. They are often used in dentistry for eye surgery such as removal of cataracts and removal of tiny skin growth including warts and moles. Regional anesthetics influence bigger region, like an arm, a leg, or anything under the waist.

2. How Anesthesia Works

We have known very little about how anesthetics operate until recently. Scientists can now study how particular molecules within cells are affected by drugs. Most scientists agree that the drugs target nerve cell proteins in the membranes. Because anesthetics inhaled have distinct impacts than those intravenous, researchers suspect that the two distinct kinds of drugs target distinct protein sets.

3. What Anesthesiologists Do?

Anesthesiologists use digital equipment to monitor the vital signs of patients throughout the operation. They use extremely sophisticated electronic equipment that constantly show the blood pressure, blood oxygen levels, cardiac function, and respiratory pattern of patients. For less invasive processes, such as those used to examine blood vessels and endoscopy, anesthesiologists also provide pain relief [2].

4. Methods for Evaluating Anesthesia Depth

4.1. Subjective Methods

4.1.1. Autonomic Response: These are frequently used as clinical indices of anesthesia depth in daily exercise. Sudden hypertension and tachycardia, sweating, tearing or mydriasis may result in anesthesia lightening. Patient response to surgical stimulus (PRST) score is a poor indicator of anesthesia depth based on autonomic changes in response to surgical stimulus.

Table 1. Methods

A. SUBJECTIVE METHODS
1.Autonomic Response
• Hemodynamic Changes
• Lacrimation
• Sweating
• Pupillary dilation
2. Isolated forearm technique
B. OBJECTIVE METHODS
1.Spontaneous Surface Electromyogram (SEMG)
2.Lower Oesophageal Contractility (LOC)
3.Heart Rate Variability (HRV)
4.Electroencephalogram and derived indices
• Spectrual edge frequency
• Median frequency
• Bispectral Index
5. Evoked Potentials
• Auditory Evoked Potentials
• Visual Evoked Potentials
• Somatosensory Evoked Potentials
• Auditory Evoked Potential Index

4.1.2. Isolated Forearm Technique (IFT): A purposeful movement shows light anesthesia in reaction to verbal command. In this method, a tourniquet is placed on patient's arm before administration of a muscle relaxant and inflated above systolic pressure to exclude its effect. Thus, the arm can move freely during anesthesia.

4.2. Objective Methods

4.2.1. Spontaneous Surface Electromyogram (SEMG): In patients who are not completely paralyzed spontaneous electromyogram (SEMG) can be recorded from various muscle groups, particularly facial, abdomial and neck muscles. Frontalis muscle is innervated by a branch of the facial nerve and is less affected by the neuromuscular blockage.

4.2.2. Lower Oesophageal Contractility (LOC): Even after complete skeletal muscle paralysis by neuromuscular blockers, the non-striated muscle in the lower half of oesophagus maintains their potential activity.

4.2.3. Heart Rate Variability (HRV): Kiode [2] examined Heart Rate Variability and noted that it could provide data that would be helpful for tracking anesthesia depth. HRV special analysis revealed three parts:

a) Low frequency fluctuations; considered circadian

b) Medium changes in frequency; ascribed to the reflex baroreceptor

c) Fluctuations in high frequency

RSA can be readily seen on an ECG monitor. Pomfrett and colleagues [3] recorded a decrease in RSA during anesthesia and an increase in RSA during recovery, using on-line analysis of RSA. Different studies [4] [5] have shown that the RSA level represents an aesthetic depth level.

4.2.4 Electroencephalogram and derived indices: The raw EEG is a tiny complicated voltage deflection (1-50V) that does not correlate with particular underlying occurrences. The level of brain activity is indicated by the EEG electronic Filtering with the embedded EEG waveform amplitude. The cerebral function monitor (CFM) provides a single trace of the integrated EEG amplitude, increasing cerebral activity appears as an expansion of the trace ranging 5-18V peak to peak amplitude. Several numerical single-figures indicators were obtained from EEG's power spectral analysis.

This includes:

a) Spectral Edge Frequency (SEF)

b) Median Frequency (MF)

c) Bispectral Index (BIS)

Using various anesthetic, SEF and MF were linked to clinical indications [6] [7]. The median 5 Hz frequency was used as an empirical guide with closed loop propofol anesthesia to provide appropriate surgical anesthesia.

Bispectral Index (BIS)

A statistically oriented, empirically derived complicated parameter consisting of mixture of time domain, frequency domain and high order spectral sub parameters. The BIS correlates well with the rate of responsiveness and provides an outstanding forecast of awareness rate with propofol [8], midazolam and isoflurane anesthesia [9]. Various studies have shown that BIS also correlates with the haemodynamic response to intubation, the response of patients to skin incision and verbal control during inhalation and total intravenous anesthesia [10][11]. BIS<40 patients had a reaction level of 12%, while BIS>60 patients had a reaction of 25% [12]. It decreases cost by saving anesthetic use and staying in PACU and provides a helpful manual for titration of anesthetic agents in heart surgery, elderly and Paediatric patients [13] [14].

BIS have some deficiencies despite its great usefulness. A confounding factor in interpreting the BIS value may be the existence of senile dementia. In some cases, the use of N2O and ketamine has increased BIS [15] [16].

4.2.5. Evoked Potentials (EPs): Evoked Potentials demonstrate the response of more localized areas of the brainstem, mid-brain and cerebral cortex to specific stimuli. Three kinds of EPs are frequently used for intraoperative monitoring depending on sensory stimulus.

.a) Auditory Evoked Potential (AEP): In reactions to auditory canal stimulation, AEP is recorded in the primary auditory cortex by audible clicks. It is most frequently used for anesthetic drug impact assessment.

b) Visual Evoked Potential: VEP is recorded over occipital cortex in reaction to photic stimulation of the eyes.

c) Somatosensory Evoked Potentials: In response to tibial, peroneal or median nerve stimulation, SEP is recorded over the somatosensory cortex.

Auditory Evoked Potential Index: This was derived from auditory evoked potential and represent as a single numerical variable for monitoring anesthesia depth [17]. The auditory evoked potential index represents the morphology of the AEP models and is calculated from the distinction in amplitude between consecutive curve sections. A moving time average index of AEP is obtained at intervals of 3 sec. The 37 AEP index was 100% precise and 52% susceptible to unconsciousness. It was better associated with BIS to differentiate awake from sleep state. Gajraj et al contrasted the auditory evoked potential (AEP) index, 95% spectral edge frequency (SEF), median frequency (MF) and the spectral index (BIS) during alternating periods of awareness and unconsciousness produced by target-controlled propofol infusions. They discovered that the AEP index was the best and most susceptible of the four readings to distinguish the shift from unconsciousness to consciousness.

Table 2: Bispectral Index (BIS) Spectral Edge Frequency (SEF) and Medium Frequency (MF) values of Auditory Evoked Potential

	Threshold	**Sensitivity (%)**	**Specificity**
Unconscious			
AEP index	37 44	52 85	100 87
BIS	55 76	15 86	100 83
SEF	16.0 21.0	9 85	100 92
MF	1.4 10.7	0 85	100 55
Conscious			
AEP index	56 45	60 87	100 85
BIS	95 75	14 88	100 80
SEF	26.6 21.9	15 84	100 92
MF	13.8 7.9	18 85	100 25

5. Conclusions

Measuring anesthesia depth is one of the most controversial and subjective aspects of modern anesthesia, introducing the concept of balanced anesthesia with multiple drugs and muscle relaxants. For all patients and all anesthetic agents, it is unlikely that any single technique will be found to reliably assess the scope of anesthesia. All methods used to determine anesthesia depth have some potential criteria for exclusion. It can therefore be more accurate to use more than one technique at a moment. The fast progress in microcomputer technology and our knowledge of fundamental basics will enable us to understand our observations of the anesthetic state in near future.

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