

# EEG-Derived Indexes for the Depth of Anesthesia and Muscle Relaxants

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**Abstract:** Recently, the depth of anesthesia has become an integral part of the multimodal anesthesia monitoring. The most popular parameters used are the EEG-based indexes - such as BIS, evoked potentials and entropy. Anesthetics have a variable influence on them. The aim of this review is to show the effect of the muscle relaxants on the EEG-derived indexes.

**Keywords:** depth of anesthesia, EEG-derived indexes, muscle relaxants.

## 1. Introduction

It is assumed that due to the frontal muscles' activity, muscle relaxants can interfere with the capacity of the various electroencephalogram (EEG) -based monitors to control the anesthesia depth (4, 5). Most studies (2, 7, 10) reveal that the presence of frontal muscle activity may be responsible for the elevated Bispectral index (BIS) values. The increased value of the electromyography (EMG) signal, which is detected to a certain extent by the BIS monitor, is a likely cause of the false-high BIS values. It should be noted that new studies have found more complex and compound effects of relaxants on the EEG signal and its numeric derivatives.

Ekman A. et al. (1) describe that relaxants do not modify the BIS index or the A-line Autoregression Index (AAI) in the absence of pain but attenuate the EEG activation under the

influence of a pain stimulus. According to the authors, such a phenomenon occurs as a result of the deafferentation syndrome. It is believed that the use of a muscle relaxant may physiologically modify a particular component of the EEG (its derivative digital indexes, respectively), especially in response to a pain stimulus.

Most researchers claim that if the major artefacts caused by the EMG activity of the frontal muscles are ignored, the muscle relaxants' effects on the index values remain with little clinical significance (1, 6, 8). Regarding the BIS monitor, it is possible to identify any artefacts occurring by analyzing the EMG curve and its numeric values displayed on the monitor screen. The BIS values must be carefully interpreted when the EMG signal values are above 30 Hz.

The changes of BIS after the application of muscle relaxants are demonstrated on Figure 1.

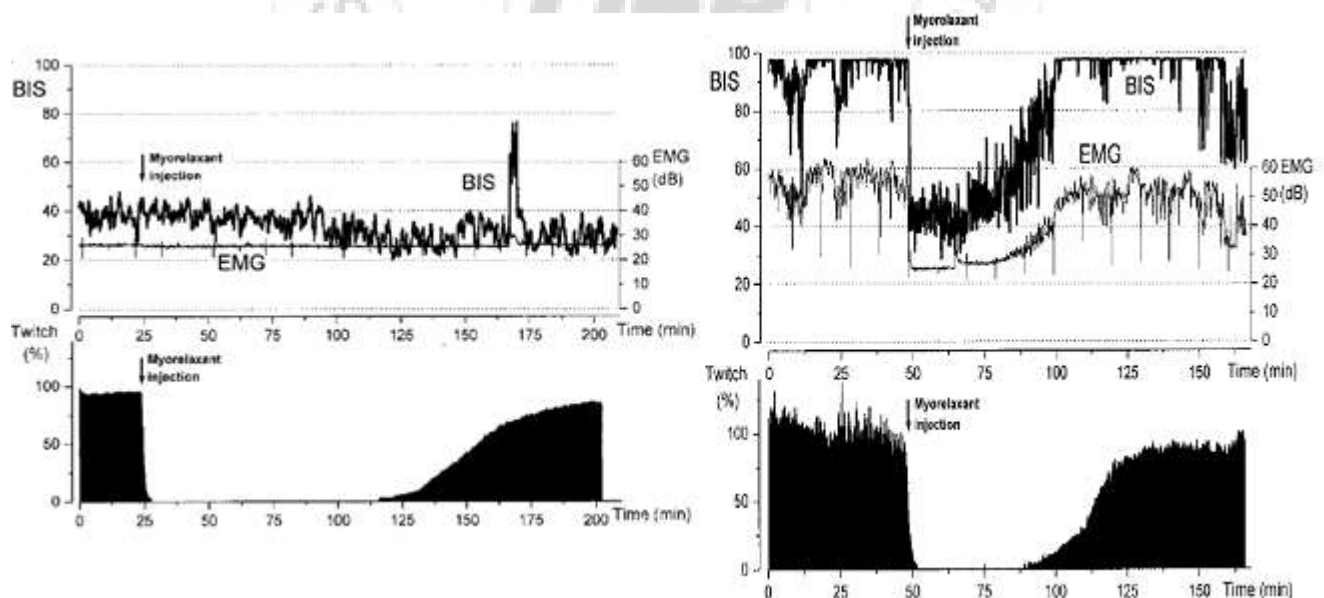


Figure 1: BIS after the application of a muscle relaxant

Spectral entropy is an EEG - derived index, recently introduced into the clinical practice to monitor the depth of anesthesia. The entropy module records two values: SE (State Entropy) and RE (Response Entropy). The SE index covers the range of EEG frequencies predominantly (0.8-32Hz), with values between 0 and 91. It is considered

indicative of the hypnotic component of the anesthesia. The RE index covers a higher spectrum of frequencies (0.8-47Hz), thus including both the EEG activity, and the EMG activity from the frontal muscle; the digital correspondence of the frequencies is from 0 to 100. The RE and RE-SE indexes increase as a numerical value in the presence of a

pain stimulus. They are considered to reflect the balance of pain / antinociception during general anesthesia (3,4, 9)

In the study of Marinova R. et al. (5) the administration of Atracurium 0.6mg / kg does not change the SE-entropy values but significantly changes the RE-entropy and RE-SE gradient values when reaching a stable anesthesia state. The induction dose of Atracurium 0.6mg / kg reduces the RE-SE index values in the absence of pain stimulation. SE entropy is initially considered an indicator of an electrocortical activity. The SE index can be associated with the BIS monitor, which has longer been known in the clinical practice and has much more research done on it. For example, a study conducted in an Intensive Care Unit (ICU) (13) implies a fairly accurate interpretation of the BIS values when a neuromuscular blocker is administered. The patients in this study were sedated with Midazolam and Sufentanil for level 1 of sedation on the Sedation-Agitation Scale. The authors found out that the reduction in BIS values following the administration of the neuromuscular blocker correlated to a large extent with the BIS and EMG values before relaxation. It is considered that the overestimation of BIS in this study is due to the high EMG activity that is present even in the new BIS XP monitor. Another study (11) on patients in the ICU under mild sedation (BIS 65-80) also confirmed that muscle relaxation deepens the level of anesthesia reported by the BIS monitor. A different research (12), however, came out with the statement that it is the antagonism of the neuromuscular block rather than the muscular relaxation that influences the depth of anesthesia monitored by BIS and the middle-latency auditory evoked potentials. In this study, patients undergoing planned surgical operations were anesthetized with Propofol and Remifentanyl injected with target-controlled infusion up to a BIS value of about 55. Actually, this may also be the explanation of the fact that no significant changes in the SE-entropy values were observed in the present study after administration of Atracurium.

The controversial results on BIS and EMG activity in the above-mentioned studies could be explained by the lower sedation levels of patients in the ICU compared to patients undergoing surgery. According to the theory of afferent impact, the neuromuscular blockers affect the electrocortical activity by reducing the proprioceptive afferent activity from the muscles and the afferent signal has a weak central effect (12). It can be concluded that the effect of the neuromuscular blockers on BIS and SE- entropy is present during mild sedation but cannot be detected during general anesthesia.

## 2. Conclusion

Monitoring the depth of anesthesia is an essential component of modern anesthesia. The EEG - based indexes are the most popular in the clinical practice, this is why they have the highest number of studies published on them. The influence of muscle relaxants is insignificant. In terms of the entropy indexes, it seems that the muscle relaxation interferes with the correct interpretation of the entropy values when evaluating the patient's response to pain stimulation.

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