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Spectrogram Comparison Between Total Intravenous Anesthesia and Balanced General Anesthesia During Spinal Surgery

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Abstract: Electroencephalographic monitoring is a modality that should currently be recommended in all patients undergoing General Anesthesia. The use of Bispectral index (BIS) maintains special functions such as electromyography (EMG) and electroencephalogram (EEG) waves. The electroencephalogram has the capacity to provide information directly from the cerebral cortex and it can guide us to avoid the presence of suppression bursts, therefore the anesthesiologist should be familiar with the electroencephalogram. Electroencephalographic waves are classified by their frequency range, and their characteristics are highly dependent on the degree of activity of the brain's cerebral cortex. The Delta waves which include all the waves in the EEG below 3.5 Hz, the Theta waves have frequencies between 4 and 7 Hz, the Alpha waves are rhythmic waves occurring at a frequency range between 8 and 13 Hz, the Beta waves are very low amplitude, and high frequency range between 13 and 30 Hz. In this study we analyze the presence of the spectrogram in patients under Total Intravenous Anesthesia (TIVA) and Balanced General Anesthesia (BGA) through the BIS device in spinal surgery. Eighteen patients were analyzed, assessing the spectrogram to find the "fill in" phenomenon, 9 of the patients who were managed with Sevoflorane had this phenomenon, with a total predominance of "alpha theta and delta" waves, while the rest of the patients, who had TIVA, remained with a predominance of "alpha and delta" waves but with lower intensity. The drugs used in the transanesthetic such opioids, hypnotics, and others anesthetics can cause alterations unrelated to the surgical event.

Keywords: Spectrogram, Electroencephalogram, TIVA, BIS

1. Introduction

Electroencephalographic monitoring is a modality that should be recommended in all patients undergoing General Anesthesia. EEG can provide important information about the cerebral cortex during the perioperative period, including detection of cerebral insults and depth of anesthesia. Gibbs and Lenox demonstrated that systematic changes occur in the electroencephalogram of patientes in awake state with ether or pentobarbital use [1].

One of the main concerns of patients undergoing general anesthesia is the presence of intraoperative awareness. The NAP5 is the largest study that has been responsible for the detection of intraoperative awakening where they specify that the misuse of muscle relaxants is the factor that has been most associated with this adverse event. It is also mentioned that the most common type of surgery associated with intraoperative awareness is cardiac surgery [2]. This is why brain monitoring is essential for all patients undergoing surgery under general anesthesia.

The EEG records the bioelectrical activity of the neurons that form the pyramidal cell layer of the cerebral cortex. This bioelectric activity is produced by the exchange of ions between the cytoplasm and the extracellular medium around neurons. The voltage travels to the different structures until it reaches the electrodes placed in the frontal region of the patient, capturing, amplifying and analyzing the EEG signal. Each wave is made up of a frequency and an amplitude. Frequency is the number of waves per second and it is measured in hertz (Hz) or cycles/second, and amplitude is the height the wave reaches from baseline and it is measured in microvolts. Waves are grouped according to frequency. (Figure 1).

The Delta waves which include all the waves in the EEG below 3.5 Hz, occur in deep sleep, in childhood, and in serious organic brain disease. The Theta waves have frequencies between 4 and 7 Hz, these occur mainly during the childhood, but they also occur during emotional stress in some adults. The Alpha waves are rhythmic waves occurring at a frequency range between 8 and 13 Hz, which are found in all normal persons when they are awake in a quiet, resting state of cerebration. The Beta waves are very low amplitude, and high frequency range between 13 and 30 Hz. They are affected by mental activity.

In turn, we have tools such as SEF95 (SEF: Spectral Edge Frequency) or also called spectral limit, which is the frequency below where 95% of the spectral power is found. An SEF less than 12-14 Hz indicates that 95% of the frequency is below 12-14 Hz, indicating that the patient is adequately anesthetized relative to the surgical stimulus.

The spectrogram shows us the oscillations of the electroencephalogram over the time. It is maintained as a three-dimensional structure, which is drawn with a two-dimensional representation, placing time on the "x" axis, frequency on the "y" axis, and power on the "z" axis, which is encoded in a color scale ranging from red (higher proportion of waves or "high power") to blue (electroencephalographic activity hardly detected, or "low power) [3, 15]. (Figure 2).

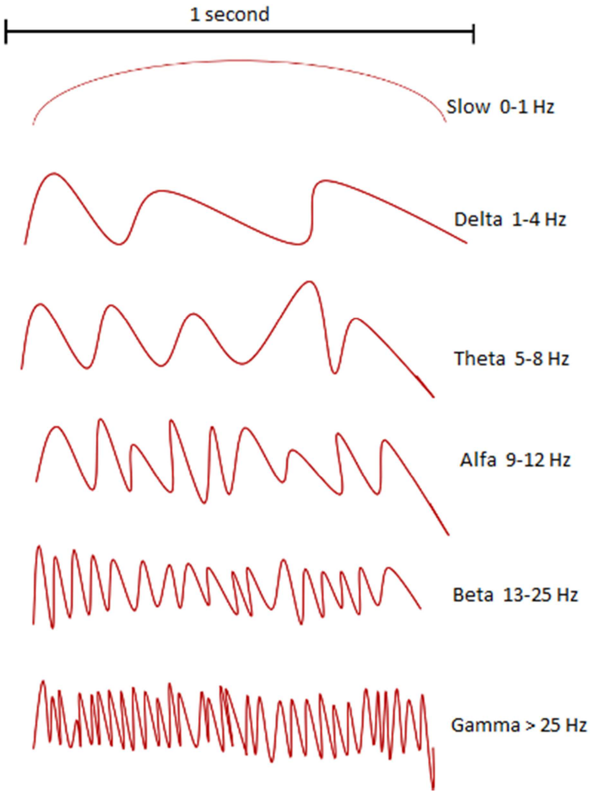

Figure 1. *Electroencephalographic waves classified by their frequency range. Modified from Purdon PL, Sampson A, Pavone KJ, Brown EN. Clinical Electroencephalography for Anesthesiologists: Part I: Background and Basic Signatures. Anesthesiology. 2015; 123 (4): 937-60.*

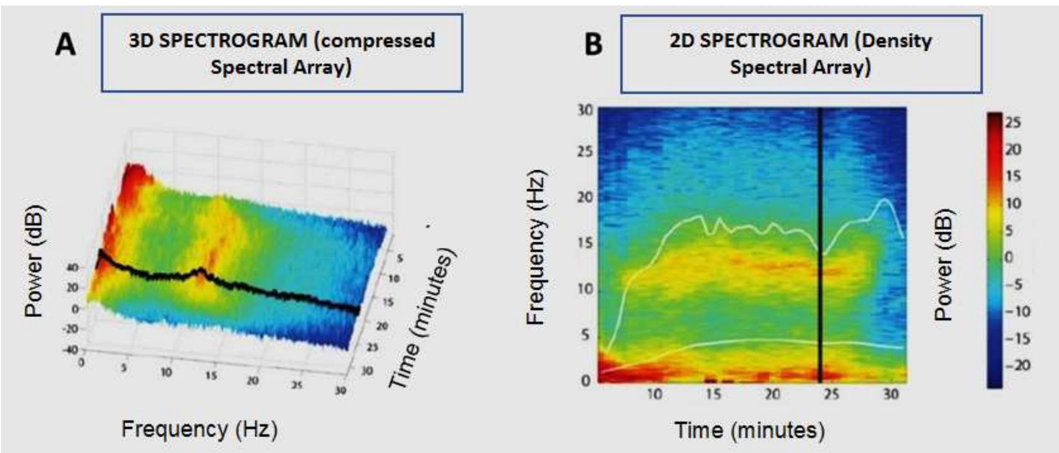

Figure 2. *A. three-dimensional graphs of spectrogram. B. two-dimensional graphs of spectrogram. Modified from Purdon PL, Sampson A, Pavone KJ, Brown EN. Clinical Electroencephalography for Anesthesiologists: Part I: Background and Basic Signatures. Anesthesiology. 2015; 123 (4): 937-60.*

Anesthesiologists must be familiar with the reading of the electroencephalogram since the drugs used in the transanesthetic can cause alterations unrelated to the surgical event. If we consider that the electroencephalogram has the capacity to provide information directly from the cerebral cortex and it can guide us to avoid the presence of suppression outbreaks. This should be a standard measurement such as an electrocardiogram during transanesthesia [4].

The BIS monitor was introduced in 1994 in North America and was approved by the Food and Drug Administration (FDA) in 1996. Its objective is the measurement of the level of consciousness by means of an electroencephalogram. The bispectral analysis is performed on a Fourier transform (FT) based on the decomposition of any signal into a set of sinusoidal signals for a reconstruction of the original signal. The BIS engine processes EEG data from a single-channel EEG signal, measured from the patient's forehead according to an algorithm that combines select EEG features to produce a single dimensionless number, which is the 'BIS index. This numerical result ranges from 0 (equivalent to EEG silence) to 100. A BIS value between 40 and 60 indicates an appropriate level for general anesthesia, with a low probability of consciousness. In turn, it also shows an electromyography (EMG) bar graph, used to help to determine whether the BIS index values are reliable [5, 6].

Shee Jin and Hee Jung Baik assessed the influence of neuromuscular relaxants on BIS and entropy, concluding that electromyography in BIS depends mainly on the patient's awake state. Patients under sedation did not have a decrease in electromyography when using the muscle relaxant, but these changes were not observed when the patient was under general anesthesia [7].

Gaszynski and Wieczorek compared the BIS registry with propofol versus sevoflorane in obese patients looking for intraoperative awareness data. They observed that the registry in both groups of BIS was greater than 60 during the transanesthetic, but no patient presented intraoperative awakening. They concluded that the administration of Midazolam could help to avoid this memory, which is why they recommend it as a preventive measure [8].

There are other devices used for neuromonitoring that have been shown to be useful during transanesthesia. All those parameters derived from the Electroencephalogram are useful to avoid inappropriate effects in the face of inadequate anesthetic depth and to have a quick and better recovery in the postoperative period [9].

Lisbeth A. Evered and Matthew T. V. Chan conducted a randomized study analyzing depth of anesthesia with postoperative delirium in major surgery. They made two groups with different measurements, one with BIS 50 and the other with BIS 35. They observed that postoperative delirium was associated with admission to an intensive care therapy unit and the suppression outbreak remained linked to the BIS 35 group [10].

Maintaining anesthesia under BIS parameters between 40-60 has been a way of keeping the patient in the anesthetic plane for a long time. Currently, as more drugs are used during the transanesthetic, the electroencephalogram patterns may vary, altering the classic BIS reference, which indicates that our monitoring should be directed to the waves of the electroencephalogram [11, 14].

In 2015, the British Journal of Anesthesia compared the effects of propofol versus sevoflorane in different age groups using an electroencephalogram. It is known that the inhibition of GABA at the thalamocortical level induces the presence of alpha waves. Sevoflorane and propofol produce very similar oscillations, but the "fill in" phenomenon associated with theta waves has been observed, creating a pattern of evenly distributed power from the slow oscillation range to the alpha range. P. L. Purdon mentions that propofol appears to act selectively at B3-$GABA_A$ while inhaled anesthetics act at various sites [12].

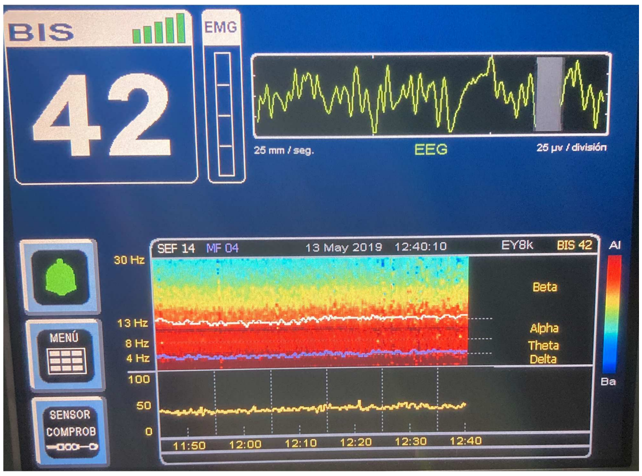

Figure 3. *In BIS monitoring we observe the BIS scale, the EMG, the predominant waves of the Electroencephalogram and the Spectrogram. This patient is under general anesthesia with sevoflurane and fentanyl. We can appreciate the predominance of alpha, theta and delta waves with the present phenomenon of fill in.*

2. Methods

In a hospital of Mexicali: ISSSTECALI, was approved this observational study. A total of 18 patients undergoing spinal surgery with general balanced anesthesia and total intravenous anesthesia were analyzed (BGA: 9, TIVA: 9). All patients were kept under unilateral two-channel BIS monitoring with the exploring electrode in the FT9 and FT10 position (fronto-temporal) and the reference electrode in the FPz position (Fronto-polar). (Figure 4).

Figure 4. *Patient undergoing spinal surgery with unilateral placement of 2 channels of BIS.*

The most performed surgical procedure was cervical discectomy with a total of 11 patients, followed by lumbar laminectomy with a total of 4 patients, 2 patients underwent lumbar discectomy and 1 patient underwent lumbar posterolateral instrumentation (Figure 5). The mean age of all patients was 52.5 years, 10 were female and 8 male. All patients were premedicated with Paracetamol, Ketorolac, Dexamethasone and Ondansetron. A total of 9 patients were managed with Sevoflurane as a hypnotic, maintaining CAM 0.6-1.0 and Fentanyl as a narcotic, while the rest of the patients were maintained with Propofol under target controlled infusion (TCI) (Schinder model) with doses of 3-5 ug/ml and with Fentanyl as a narcotic.

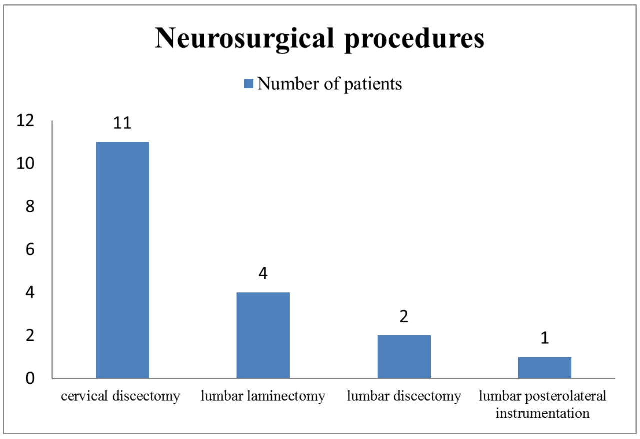

Figure 5. *Bar graph representing the number of patients undergoing neurosurgical procedures.*

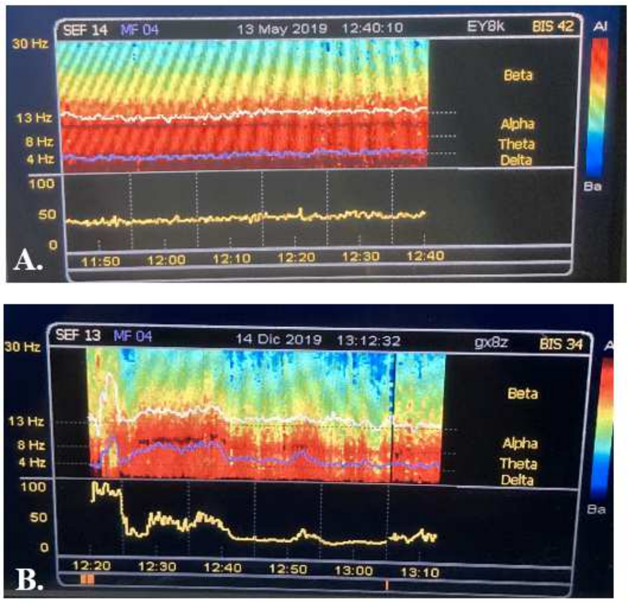

Figure 6. *A. Patient under Balanced General Anesthesia. B. Patient under Total Intravenous Anesthesia. The predominance of Alpha, theta and Delta waves can be seen in the patient under sevoflorane as opposed to the patients under Propofol.*

Within the 9 patients under balanced general anesthesia with sevoflurane, a pattern of predominance of alpha, theta and delta waves was observed throughout the neurosurgical procedure. It is worth mentioning that no intraoperative awakening event was obtained and the minimum alveolar concentrations remained approximately 0.6-1.0. The presence of the "fill in" phenomenon was observed in all the spectrogram records. While the rest of the patients managed with propofol (TIVA patients) maintained the same pattern of alpha and delta waves and the intensity was decreased with theta waves and the fill-in phenomenon was not observed. (Figure 6).

Francisco A. Lobos and Susana Vacas mention in a case report the loss of alpha waves during spinal surgery in a patient undergoing total intravenous anesthesia with propofol. It was shown that the cause was due to technical failure in the TCI perfusions, concluding that an adequate monitoring of the spectrogram helps us to prevent catastrophes and intraoperative awakenings [13].

3. Results

Within the 18 patients undergoing spinal surgery, a pattern of predominance of alpha and delta waves was observed. It was possible to appreciate the intensity reflected in the spectrogram and the presence of theta waves was observed in 9 patients, appreciating the phenomenon of "fill in" in those who were managed under balanced general anesthesia with Sevoflurane. The rest of the patients had only the presence of alpha and delta waves. This may indicate that Propofol appears to act selectively on B3-$GABA_A$ while Sevoflurane would act on more sites.

4. Conclusion

The use of neurophysiological monitoring is elementary in all patients under general anesthesia for spinal surgery. It has been shown that the balanced general anesthesia technique such as total intravenous anesthesia can be used without any problem. We can see how there is a difference between the spectrogram with the patient under different anesthetic techniques, however there have been no postoperative or transanesthetic changes that define which technique is better than another.

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