



# Revista Colombiana de Anestesiología

## Colombian Journal of Anesthesiology

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### Review

## The use of cerebral monitoring for intraoperative awareness<sup>☆</sup>



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#### ARTICLE INFO

##### Article history:

Received 1 April 2014

Accepted 27 September 2015

Available online 12 December 2015

##### Keywords:

Consciousness monitors  
Intraoperative awareness  
Anesthesia  
Mental recall  
Review literature as topic

#### ABSTRACT

**Introduction:** the bispectral index monitoring system (BIS) was introduced in the United States in 1994 and approved by the FDA in 1996 with the objective of measuring the level of consciousness through an algorithm analysis of the electroencephalogram (EEG) during general anesthesia.

This novelty allowed both the surgeon and the anesthesiologist to have a more objective perception of anesthesia depth. The algorithm is based on different EEG parameters, including time, frequency, and spectral wave. This provides a non-dimensional number, which varies from zero to 100; with optimal levels being between 40 and 60.

**Objectives:** Perform an analysis of the advantages and limitations of the anesthetic management with the bispectral index monitoring, specifically for the management and prevention of intraoperative awareness.

**Methodology:** A non-systematic review was made from literature available in PubMed between the years 2001 and 2015, using keywords such as “BIS”, “bispectral monitoring”, “monitoreo cerebral”, “despertar intraoperatorio”, “recall” and “intraoperative awareness”.

**Results:** A total of 2526 articles were found, from which only the ones containing both bispectral monitoring and intraoperative awareness information were taken into consideration. A total of 68 articles were used for this review.

**Conclusion:** BIS guided anesthesia has documented less immediate postoperative complications such as incidence of postoperative nausea/vomit, pain and delirium. It also prevents intraoperative awareness and its complications.

Published by Elsevier España, S.L.U. on behalf of Sociedad Colombiana de Anestesiología y Reanimación.

<sup>☆</sup> Please cite this article as: Castellon-Larios K, Rosero BR, Niño-de Mejía MC, Bergese SD. Uso de monitorización cerebral para el despertar intraoperatorio. Rev Colomb Anestesiol. 2016;44:23-29.

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2256-2087/Published by Elsevier España, S.L.U. on behalf of Sociedad Colombiana de Anestesiología y Reanimación.

## Uso de monitorización cerebral para el despertar intraoperatorio

### R E S U M E N

#### Palabras clave:

Monitores de conciencia  
Despertar intraoperatorio  
Anestesia  
Recuerdo mental  
Literatura de revisión como  
asunto

**Introducción:** El índice de monitoreo biespectral (BIS) fue introducido en Norte América en 1994 y aprobado por la FDA en 1996 con el objetivo de medir el nivel de conciencia realizando un análisis algorítmico del electroencefalograma (EEG) durante la anestesia general.

Esta novedad permitió que tanto el cirujano como el anestesiólogo tuvieran una percepción más objetiva de la profundidad anestésica. El algoritmo está basado en diferentes parámetros del EEG, incluyendo tiempo, frecuencia y onda espectral. Esto provee un número no dimensional, que varía desde cero, hasta 100; siendo los niveles óptimos entre 40 y 60.

**Objetivos:** Realizar un análisis de las ventajas y limitaciones del manejo anestésico con el monitor de análisis biespectral, específicamente en el manejo y prevención del despertar intraoperatorio.

**Metodología:** Se realizó una revisión no sistemática de literatura disponible en PubMed entre los años 2001-2015, utilizando palabras clave como "BIS", "bispectral monitoring" "monitoreo cerebral", "despertar intraoperatorio" "recall" y "intraoperative awareness".

**Resultados:** Se encontraron un total de 2526 artículos, de los cuales solo se tomaron en cuenta aquellos que contenían información de tanto monitoria biespectral como despertar intraoperatorio. Un total de 68 artículos fueron utilizados para esta revisión.

**Conclusión:** En la anestesia guiada por BIS se han documentado menores complicaciones postoperatorias inmediatas como la incidencia de náusea/vómito, dolor y delirium. Además de prevenir el despertar intraoperatorio y sus complicaciones.

Publicado por Elsevier España, S.L.U. en nombre de Sociedad Colombiana de Anestesiología y Reanimación.

## Introduction

Measuring anesthetic depth has always been a substantial necessity, even from the beginning of anesthesia with ether in 1847.

Currently, the Bispectral Index (BIS) is the most frequently used technology for monitoring anesthetic depth. Its objective, based on a mathematical algorithm, is to measure the level of consciousness through the use of an EEG of the patient under general anesthesia to thereby evaluate its effects directly at a cerebral level.<sup>1</sup>

Among the advantages of its use are anesthetic titration based on brain activity by which the incidence of intraoperative awareness (IA) and anesthetic consumption are reduced; this leads to quick recovery.<sup>2,3</sup>

BIS values are related to EEG activity. The beta wave ( $\beta$ ) is related to awareness at BIS values between 100 and 80 and to a state of sedation with general anesthesia in the range of 60–40. Deep anesthesia is reflected with delta waves ( $\delta$ ) and a range between 40 and 20 on the BIS monitor, while burst suppression is reflected by a range of 0 and 20. An isoelectric line on the encephalogram corresponds to a value of 0 on the monitor.<sup>4-7</sup>

The meta-analysis carried out by Punjasawadwong et al. compared BIS use to standard anesthetic care in order to determine if there was a reduction in anesthetic consumption, recovery time, incidence of IA, and hospital costs. 12 studies and 4056 patients were considered and it was demonstrated that the use of BIS lowers propofol levels by 1.3 mg/kg/h; minimum alveolar concentration (MAC) by 0.17; extubation time

by 3.05 min; recovery time in the postanesthetic care unit by 6.83 min; and IA by 65.4%.<sup>8</sup> In a later update to this study, a result of equivalency in the reduction of IA was obtained when comparing anesthetic depth guided by BIS monitoring and anesthetic depth guided by the concentration of anesthetic gas at the end of the tidal volume.<sup>9</sup>

Monk et al. researched the relationship between anesthesia management and mortality one year after non-cardiovascular surgery, finding an increase of 24.4% in mortality per hour in which the BIS values were lower than 45 ( $p=0.0121$ ).<sup>10</sup> Similarly, Leslie et al., in their study, "B-Aware", demonstrated that when BIS values did not go below 40 for more than 5 min, there was an increase in survival to 30 days.<sup>11</sup> The importance of monitoring of anesthetic depth with BIS has not been very well explored. Studies like "B-Unaware" and "BAG-RECALL", performed with patients undergoing heart surgery, demonstrated a probable relationship between low BIS values and mortality in the medium term. However, this was not associated with an increase in the total dosage of anesthetics.<sup>12,13</sup>

One of the most important retrospective studies in the United States was developed by Sessler et al. and investigated the relationship between length of hospital stay and mortality after 30 days in patients that presented a "triple low" in values of mean blood pressure ( $<75$  mmHg), BIS ( $<45$ ), and CAM ( $<0.8$ ).

Of the 24,120 patients included in the study, 6% presented "triple low" during the surgery. These patients experienced a prolonged hospitalization and mortality increased by two. It was concluded that mortality after 30 days increased when the duration of the "triple low" was greater than 30 min.<sup>14</sup> Later, however, the results of this study were questioned by

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