# Is it effective to monitor intraoperative awareness?

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## Abstract

**To assess if there is a relationship between intraoperative awareness and the use of Sedline® monitor in patients under general intravenous anaesthesia. Observational, descriptive and cross-sectional study performed between 2014 and 2015 in 93 patients. We excluded: patients premedicated with benzodiazepines or opioids, not extubated in the operating room, under 18 years or with a history of neurological or psychiatric alterations.**

**Sedline® obtains the Patient State Index (PSI), which is a value for classifying anaesthetic depth. The reference values are: 100-70: Aware patient.70-50: Sedation.25-50: Ideal Anaesthetic Depth. 0-25: Deep Anaesthetic Plane. We use Brice questionnaire to evaluate intraoperative awareness. The variables are age, sex, weight, ASA, BMI, type and duration of surgery, PSI values at baseline, induction, 5 minutes postinduction, surgical incision and extubation. Statistical significance level p<0.05.**

**The incidence of intraoperative awareness was zero. Seven patients reported intraoperative dreams. With a PSI>39 in induction, 10.2% had dreams, whereas those with a value of less than 39 had only 3.3% dreamed (p>0.05). Of the total sample, at induction, the average PSI value was 49.83 (DS18.70) with values greater than 50 at 37.6%. During extubation, 44.1% of the patients had PSI<70, of which 6.5% woke up with values below 50.**

**There were no cases of intraoperative awareness. Seven cases had dreams, 6 of them had a PSI value at induction greater than 39. It could suggest that values above 39 at induction are related to the possibility of dream recall. In the total sample the average PSI value during induction was very close to 50, which corresponds to the upper limit to be in the optimum state of hypnosis. The PSI value in extubation is below 70 in 44.1%. This value does not assure the reliable awakening state for the patient.**

**Keywords:** Sedline monitor, Intraoperative awareness, Anaesthesia depth, General anaesthesia.

*Accepted on September 06, 2017*

## Introduction

Intraoperative awakening is an incident in which the patient under general anaesthesia remembers surgery events [1,2]. The annual incidence is 0.1-0.02% in adults and in children 0.6-1% [3]. Several factors increase the risk of intraoperative arousal, such as the type of surgery (obstetric, trauma, emergency), ASA III-IV patients, female sex, young people, obesity, alcohol consumption, sedatives or amphetamines, and lack of knowledge in the devices that analyze the anaesthetic depth by the sanitary staff. The variability in the incidence is due to the fact that the problem is minimized, it is not registered, ignorance, lack of methods of detection and controlled studies [4].

Intraoperative awakening is an important complication that can have long-term psychological consequences [5]. Approximately 78% of patients with intraoperative awakening develop early psychological effects that occur in the form of sleep disorders, nightmares, fear to the operating room or diurnal anxiety. Late complications are disabling and poor prognosis such as posttraumatic stress disorder [6,7].

With all this, the measurement of the level of consciousness during the surgery has been a challenge [1]. There are clinical signs such as the variation of hemodynamic parameters that are as guidance but are highly variable in each patient [8,9]. Hemodynamic responses to surgical stimulation and anaesthetic administration have a low prediction of adequate patient anaesthetic depth since numerous factors and high individual variability influence to these responses, which is not a good method of monitoring intraoperative awakening [10].

There are several types of monitors to measure hypnotic depth: BIS, Sedline and Entropy. There are many studies to evaluate the efficacy of BIS [11-13] and Entropia [14-16], but the few are those who value hypnosis with Sedline [17]. The latter is a brain function monitor based on four channels that collect EEG data. For this reason, in the present work we intend to measure the relationship between intraoperative awakening and Sedline use in patients under general anaesthesia.

## Material and Methods

Observational, descriptive and cross-sectional study performed at the Surgical and Reanimation Unit of the Salamanca University Hospital Complex from October 2014 to December 2015. Data were collected from the medical records of 93 patients undergoing different surgeries (Table 1) under total intravenous anaesthesia. We excluded premedicated patients with benzodiazepines or opioids, who were not extubated in the operating room, under the age of 18 years or with a history of neurological or psychiatric disorders.

Sedline is an EEG-based brain function monitor [18]. It obtains the numerical value called the Patient State Index (PSI), which is a clinically validated measure to classify the anaesthetic depth. It is calculated by an algorithm based on EEG registers captured through 4 channels of high resolution [17]. In this study, according to the literature [18], we took the following PSI reference values:

100-70: Awake, response to verbal stimulation.

70-50: Awake, sedation, response to low intensity stimulation.

25-50: Ideal anaesthetic depth to avoid intraoperative awakening.

0-25: Deep anaesthetic plane.

Since its arrival at the operating room all patients were monitored with monitor Sedline to obtain a baseline measurement of the PSI with the patient awake. The following were taken at induction, 5 minutes after induction, at the time of surgical incision and in education. Induction was performed with propofol 2 mg/kg IV, rocuronium 0.6 mg/kg and fentanyl 2 μg/kg. Maintenance was performed with propofol on varying dose in function of patient requirements and PSI values. In addition, remifentanil is given as continuous infusion or fentanyl boluses 1 μg/kg, and rocuronium 0.1 mg/kg. Two investigations were carried out in each case. One of them was responsible for anaesthetizing the patient and the second one collected data on hemodynamic monitoring, PSI and the amount of drugs. The hemodynamic data measured in the study were systolic, diastolic blood pressure and heart rate at different moments: baseline, induction, 5 minutes postinduction, surgical incision and awakening (extubation).

For the evaluation of intraoperative awakening, the Brice questionnaire was used [19]. The patient was questioned at 2-6 hours after the surgery, 24-36 hours after the intervention and a month by phone call. Brice's questionnaire.

Questions for all patients:

What is the last thing you remember before falling asleep?

What is the first thing you remember when you wake up?

Did you have any sleep while you were asleep?

What was the worst experience related to the intervention?

What was the next worst experience?

In those patients in whom we obtained a suspicious response of possible intraoperative awakening in the Brice questionnaire we applied the Michigan Awareness Classification Instrument to specify the type of perception the patient expresses [20]:

Class 0: No memories.

Class 1: Isolated auditory perception.

Class 2: Tactile perception (surgical manipulation, orotracheal tube).

Class 3: Pain.

Class 4: Paralysis (feeling unable to move, speak, or breathe).

Class 5: Paralysis and pain.

Quantitative variables are expressed as means and standard deviations. The qualitative in percentages for the variables relationship we used the chi-square statistic, Student's t-test for paired samples and Pearson's correlation with statistical significance level $p<0.05$ and use of the SPSS 20.0 program. The quantitative variables collected in this study were age, weight, body mass index, duration of surgery, PSI values, systolic blood pressure, diastolic and basal heart rate, at induction, 5 minutes postinduction and awakening. Qualitative variables were type of surgery, gender, ASA, and neurological history

## Results

The demographic and surgical characteristics of patients are shown in Table 1.

**Table 1.** Demographic Characteristics of Patients.

| | N(%) or Average(Sd) |
|---|---|
| Age (years) | 57.58 (17.89) |
| Male sex | 53 (50.5) |
| Weight (Kg) | 72.19 (14.66) |
| Body Mass Index | 25.72 (4.51) |
| ASA I and II | 67 (63.8) |
| Type of surgery | |
| · Visceral and endocrine | 46 (43.8) |
| · Urology | 23 (21.9) |
| · Gynecology | 5 (4.8) |
| · Other Surgeries | 19 (18.1) |
| Time (minutes) | 154.43 (77.32) |

The incidence of intraoperative awakening in this study after applying the Brice questionnaire was cero. Seven patients (6.7%) reported on their postoperative admission to have dreamed during the intervention. Of those who had PSI>39, 10.2% had dreams, whereas those who had a value of less than 39, only 3.3% dreamed. The remaining values showed no differences. Of the total sample of patients, in the induction the mean PSI value was 49.83 (ds 18.70) with values greater than 50 a 37.6%. 44.1% of the patients had PSI<70 at the time of education, of which 6.5% woke up with values below 50.

**Table 2.** PSI and hemodynamic values at different moments of surgery; P value is equivalent to Pearson Correlation in each of the operative times. PSI: Patient State Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate; Lpm: beats per minute.

| | Average (Sd) | | | | statistical significance |
|---|---|---|---|---|---|
| | PSI (ds) | SBP (mmHg) | DBP (mmHg) | HR(bpm) | P value* |
| Basal | 87.24 (6.56) | 138.48 (21.95) | 78.77 (11.92) | 76.46 (14.3) | >0.05 |
| Induction | 49.83 (18.70) | 115.99 (22.81) | 68.69 (14.75) | 69.71 (15.14) | >0.05 |
| 5 minutes postinduction | 35.73 (13.42) | 106.89 (21.56) | 63.98 (13.16) | 65.75 (13.36) | >0.05 |

No statistical association was found between hemodynamic variables and PSI variations, although both follow a similar trend curve.

## DISCUSSION

An anaesthetic depth monitor should maintain a good correlation between the measured values and the physiological response during surgery, regardless of the anaesthetics administered, and there should be little variability between different patients [21]. With the data of this study the values of the PSI upon awakening have a great range of values, thus questions the measurement of this monitor at that moment.

Changes in the EEG have been documented during induction, maintenance and extubation. With the loss of consciousness delta and theta waves increase in anterior regions of the brain [22]. Dreams occur in the REM sleep phase with predominance of theta and beta waves. This phase depends on serotonergic activity present in the wake, which promotes the formation of pituitary hypothalamic peptides that activate the pontine region of the brain stem where the sleep mechanisms are integrated. During the REM phase, there are potential occipital genicles that cause repetitive eye movements, dreams and connect with the limbic system, where emotions and memory reside [23,24]. Recall of intraoperative dreams is related to superficial levels of anaesthesia. That is why we wanted to study and compare the values of PSI in patients who remember having dreamed. Such value is significant in induction by different findings. Firstly, 85.71% of the patients who dreamed reached a value greater than 39. This fact, made us analyze in the total sample the patients with PSI in the induction greater than 39 and in turn with intraoperative dreams. There is not more difference than 30% in patients with intraoperative dreams that obtained values of more than 39 (3.3% *vs.* 10.2%), close to the upper limit value for a good hypnotic state for surgery 50 ($p>0.05$). In order to eradicate the risks of intraoperative awakening, it could be suggested that values above 39 at induction are related to the possibility of remembering dreams during surgery.

It should be noted that the mean value of the PSI during induction is very close to 50, which corresponds to the upper limit for a patient to be in the optimal state of hypnosis and avoid intraoperative awakening. Above 50 it is considered that there may be response with a stimulus. It could be suggested that the upper limit value of the PSI at extubation moment is the average of the value in our patients with which it would be advisable to study this limit.

On the other hand the value of PSI at the induction is below 70 in 44.1%, those values that may not assure the optimum awakening state for the patient.

Although the variation of hemodynamic data is studied in relation to the degree of hypnosis and are not reliable meters [8,9], the degree of relationship between this variation and the PSI values has been determined. A similar modification follows as shown in Table 2, but there is no statistically significant association.

Limitations of our study: Other values given by the same monitor, such as the SEF, which indicates the hertz below which 95% of EEG activity, may help to guide the degree of hypnosis along with PSI . In this case the values range from 0 to 30 Hz, considering that a value lower or around 15 indicates enough anaesthetic depth to avoid intraoperative awakenings [18]. The use in this study of PSI as the only parameter for guidance intraoperative awakening could be completed in future studies adding other values as the SEF.

One limitation of the Brice questionnaire applied in our study is that dreams are not classified according to their content, something that could help in the orientation of the true diagnosis of intraoperative awakening.

Our observational study may need to expand the number of patients and types of surgery to achieve a more complete study and to draw conclusions. More extensive studies are needed to assess the Sedline monitor.

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