Bispectral Index System (BIS) Monitoring Reduces Time to Discharge in Children Requiring Intramuscular Sedation and General Anesthesia for Outpatient Dental Rehabilitation

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Abstract

Purpose: Pediatric patients who receive both intramuscular (IM) sedation and general anesthesia (GA) for oral rehabilitation occasionally experience prolonged sedation and delayed discharge. The Bispectral Index System (BIS) is an EEG monitor that measures the level of sedation. The authors compared discharge times of patients who had BIS monitoring to those who did not to determine if the use of BIS speeded discharge.
Methods: After IRB approval, 20 children were enrolled. BIS was monitored continuously from admission until discharge. Each child received ketamine, midazolam, and glycopyrrolate IM. Once sedated, the patient was transferred to the operating room, monitored, and IV access was established. GA proceeded with sevoflurane, rocuronium, and fentanyl. Randomly, in half the patients, the anesthesiologist knew and maintained the BIS at GA level of sedation by adjusting sevoflurane. In the rest, the anesthesiologist did not know BIS. Time from turning of sevoflurane to discharge was noted and compared.
Results: Patients where the BIS was known and used were discharged 60±13 minutes after the end of GA. Patients where BIS was unknown were discharged 90±11 minutes after the end of GA (P<.001).
Conclusions: Based on the data, the authors recommend the use of BIS to facilitate faster discharge of pediatric patients who require IM sedation and GA for oral rehabilitation. (*Pediatr Dent.* 2004;26:256-260)

KEYWORDS: BIS, GENERAL ANESTHESIA, SEVOFLURANE, KETAMINE, MIDAZOLAM, CHILDREN

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Pediatric patients who require general anesthesia (GA) for their dental rehabilitation are usually highly anxious, combative, and, in most cases, ambulatory. The child is usually brought to the ambulatory surgical suite after completing the necessary preanesthesia evaluation. Almost all such children need presedation utilizing intramuscular (IM) or oral sedatives prior to taking them to the operating room and inducing GA. It is not unusual for such patients to experience prolonged sedation with the standard anesthesia techniques thus delaying emergence and discharge time.

The purpose of this study was to evaluate the possible use of the Bispectral Index System (BIS) in reducing time to extubation and speed of Post-Anesthesia Care Unit (PACU) discharge. On occasion, these patients have been transferred to PACU intubated and have even required admission overnight because they were too sleepy to be discharged. This is a hardship for families and a complicated process, as most dentists and anesthesiologists do not have admitting privileges.

The BIS is a monitor (Aspect Medical Systems, Newton, Mass) that derives its data from the electroencephalogram

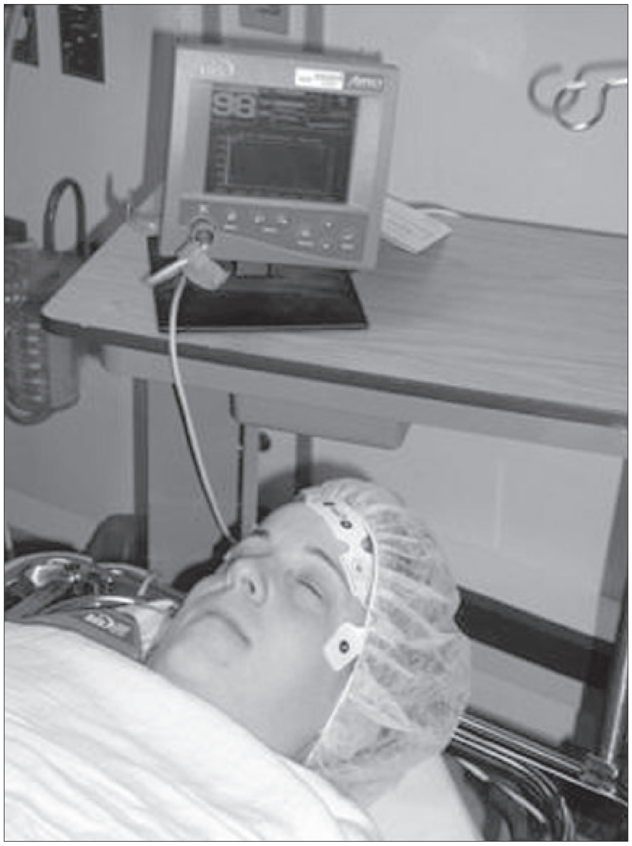

Figure 1. The BIS monitor.

(EEG) utilizing bispectral and time domain parameters[1] (Figure 1). An EEG is the raw wave representing the brain's electrical activity. Small electrodes are placed on the scalp and attached by wires to an EEG machine. Electrical activity (brainwaves) is displayed, collected, and recorded as a complex pattern of waves. The BIS monitor provides information about the degree of sedation by anesthetics. A sensor is placed on a forehead, and this is connected to a BIS monitor. The BIS processes the complex EEG wave form into an absolute number from 100 to 0. At values near 100, the patient is awake. At ranges from 60 to 70 the patient is considered to be in deep sedation or light hypnotic state (ie, the range used to maintain sufficient GA and amnesia). At ranges from 40 to 60, the patient is unconscious and said to be in a moderate hypnotic state. Below 40, the patient is said to be in a very deep hypnotic state.[2,3] The BIS range of 60 to 70 for maintaining sufficient GA is neither gender nor age sensitive.

The clinical validity and data derivation studies conducted on healthy adults suggests the possible benefit of the BIS in optimizing the depth of anesthesia, assuring adequate anesthesia, and reducing the time to extubation and discharge.[5] Reports on BIS utilization in children have emerged in the past 4 years, indicating that the BIS could possibly be used with children with the same benefit found in the adult patient population.

In 1994, Sigl and Chamoun[1] described the basic concept of the BIS monitor as a simplified method for the interpretation of the electroencephalogram. It was described as a possible tool for diagnosing neurological disorders as well as for intraoperative monitoring of anesthetic efficacy and cerebral ischemia.

Since then, numerous articles were published on the use of the BIS monitor in adult anesthesia monitoring and assessment of its clinical utilization. Glass et al[3] reported that in adults the BIS reduced the incidence of free recall and consciousness to 0. Gan et al[5] reported a 36% faster extubation time and 16% faster PACU discharge time in adult patients undergoing propofol, alfentanil, and nitrous oxide anesthesia. Further studies by Guignard[6] et al, Silva et al,[7] and Song et al[8] have reported a significant reduction of isoflurane[6,7] and desflurane[8] requirements when the inhalational anesthetic was titrated based on the BIS number. All the aforementioned studies were done on healthy adult patients or healthy adult volunteers.

Although there has been earlier work done on the correlation between the EEG variations in children under anesthesia,[9] the utilization of BIS in anesthesia monitoring was first published in 1998. These clinical studies took place in a variety of surgical and critical care settings. The question remains whether BIS could be useful in the reduction of time from end of GA to extubation and PACU discharge in children undergoing ambulatory surgery. Berkenbosch[10] et al studied 24 mechanically ventilated children in the ICU. They found that the BIS number correlated with the clinically assessed sedation levels and was useful in differentiating between adequate and inadequate sedation levels.

Choudhry and Brenn[11] compared 21 neurologically healthy children to 20 children with cerebral palsy and mental retardation (CPMR) undergoing sevoflurane anesthesia. They reported that BIS changes in both groups showed similar patterns of change when correlated with the sevoflurane concentration administered. However, they found that CPMR children had a lower BIS baseline value when compared to healthy children. Bannister et al[12] evaluated 202 sevoflurane/nitrous oxide anesthetics, which were randomized between standard practice and BIS utilization. Children ages 0 to 3 were having inguinal hernia surgery, which required a caudal block for postoperative analgesia. Children ages 3 to 18 were undergoing tonsillectomy and/or adenoidectomy. The authors reported that titrating sevoflurane, while utilizing the BIS value as a part of the monitoring criteria, significantly reduced the use of anesthesia and recovery time. This was consistent with earlier data published by Denman et al,[12] showing that BIS monitoring can significantly reduce the end tidal sevoflurane and recovery time in children. They reaffirmed the fact that the baseline minimum alveolar concentration requirement by children less than 1 year of age is generally higher than older children.

Table 1. Demographic Data*

	BIS known	BIS unknown	P
Age (years)	7.4±3	5.5±3	.2
ASA PS†	II (I-III)	II (I-III)	1
Weight (kg)	28±15	21±9	.2
Gender (male:female)	4:6	7:3	.3
Cerebral palsy‡	2/10	2/10	1

*Data=mean±standard deviation.
†ASAPS=American Society of Anesthesiology physical status.
‡Cerebral Palsy incidence/number in group.

Table 2. Time in Minutes of Surgery and Recovery in Patients With BIS Known Versus Unknown During Anesthesia*

	BIS† known	BIS unknown	P‡
Duration of surgery	139±43	162±35	.2
End of general anesthesia —PACU§ discharge	60±13	90±11	<.001
End of general anesthesia —extubation	9±5	13±5	.07
PACU stay	45±8	71±9	<.001

*Data=mean±standard deviation.
†BIS – Bispetral Index System.
‡*P* value was determined by student *t* test between groups. Significance was considered <.05.
§PACU=Post-Anesthesia Care Unit.

Morse and others[14] assessed the use of BIS monitoring in 22 patients undergoing conscious sedation for dental surgery and found that the BIS values remained close to baseline and did not lend further value to the standard monitoring methods. Religa and others[15] reached the same conclusion when they assessed the use of BIS in 21 pediatric patients ages 3 to 6 undergoing oral conscious sedation for dental treatment.

Some studies have suggested that ketamine anesthesia increases brain electrical activity, as evident by EEG monitoring. Kurehara et al[16] reported that the spectral edge frequency 90 of the BIS increased significantly in relation to the beta power. However, this did not change the parameters in a dose-related fashion.

To date, there are no published studies of BIS with IM sedation and inhalational GA. The authors studied pediatric patients who required IM presedation and GA for oral rehabilitation with regard to the effect of monitoring BIS and not monitoring BIS on discharge times.

Methods

The study protocol was approved by the Institutional Review Board Office of Protection of Research Subjects prior to any data collection. This was a prospective, randomized, and observer-blinded study. Twenty children ages 2 to 13 years old who were scheduled to undergo complete dental rehabilitation under GA were recruited to participate in this study. Patients with mild cerebral palsy who did not have significant neurological deficit were also enrolled. Previous studies have shown that the baseline BIS value in cerebral palsy patients is lower but still valuable in predicting the level of sedation in this population. The study protocol was explained to the parents or guardians and the children. Written informed consent was obtained. Assent was obtained for children (ages 7 years and older).

Each child was given a presedative in the form of IM injection of ketamine 3 mg/Kg, midazolam 0.05 mg/Kg and glycopyrrolate 0.2 mg. Subsequently, the patient was taken to the operating room and GA was induced with sevoflurane inhalation. Muscle relaxation was achieved with rocuronium bromide 1mg/Kg. The patients were intubated and ventilated mechanically. Anesthesia was maintained with sevoflurane and fentanyl 1 μg/Kg. Ondansetron 0.15 mg/kg was given near the end of the procedure. The BIS number was recorded at key points: (1) baseline or presedation; (2) induction of GA; (3) end of GA; (4) PACU admission; and (5) PACU discharge.

The patients were randomized to 2 groups. In group I, the anesthesiologist was aware of and used the BIS number throughout the case. In this group in order to maintain deep or general anesthetic levels of sedation, sevoflurane was adjusted to keep the BIS between 60 to 70.[2,3] In group II, the anesthesiologist was not aware of the BIS number; an independent observer recorded the BIS values. Adjustment of inhalation anesthetic in both groups was also determined on the basis of the patient's vital signs (heart rate, blood pressure, surgical stimulation).

However, in group II the BIS number was not utilized. Based on the findings of the anesthesiologist and the independent observer, there was no significant overlap of the BIS readings between the consciousness and unconsciousness state in the population tested. The duration of the surgical procedure, the time between end of general anesthesia or turning off the sevoflurane and extubation, and the time between anesthesia termination and discharge from PACU were noted. The time from injection of the presedation to the start of the surgical procedure was noted but was not analyzed, since the study focused on the use of BIS in reducing the time from the end of GA to extubation and PACU discharge.

Data are presented as mean±SD or median and range. Statistical analysis was performed using Student's *t* test and the Mann-Whitney rank sum test with a significance level of P<.05.

Results

Patients in groups I and II were comparable demographically (age, American Society of Anesthesiology physical status, weight, gender, and history of cerebral palsy). The

Table 3. BIS Values During Anesthesia and Recovery*

	BIS† known	BIS unknown	*P*‡
Baseline	93±6	85±14	.9
Induction of general anesthesia	64±25	61±15	.7
End of general anesthesia	72±9	68±13	.5
Extubation	89±12	88±15	.9
PACU§ admission	92±7	86±18	.4
PACU discharge	94± 6	92±7	.6

*Data=mean±standard deviation.
†BIS – Bispetral Index System.
‡*P* value was determined by student *t* test between groups.
§PACU=Post-Anesthesia Care Unit.

age range of the children in group I was 3 to 13 years. The age range of the children in group II was 2 to 12 years (Table 1.) The distribution of the ASA PS classes was the same in both the groups. The duration of the surgery and the time from the end of anesthesia to extubation were not significantly different between the 2 groups. The level of the surgical care and procedure were similar in all patients. The patients in group I were discharged 60±13 minutes after the end of GA, which was significantly faster than patients in group II who were discharged 90±11 minutes after the end of GA ($P<.001$). Likewise, there was a considerable reduction in PACU stay to 45±8 minutes for patients in group I, as compared to 71±9 minutes PACU stay for patients in group II ($P<.001$; Table 2.) The BIS numbers recorded at key points before, during, and after the surgical and anesthetic procedure in both the groups showed no statistical significance. (Table 3.)

Discussion

Pediatric patients who are admitted to the hospital for outpatient dental rehabilitation under GA are usually highly anxious and sometimes combative children with complex dental and anesthetic needs. Their dental conditions often require prolonged and multiple sessions or GA. In most cases, those children would need presedation prior to the induction of GA. Adding another sedative regimen above the anesthetic agents used during the actual procedure can lead to prolonged postoperative sedation. Presedation is much needed for a smooth transfer to the operating room and safe induction of GA. The level of postoperative home care varies depending on the level of involvement of parents, family members, and caretakers. Use of BIS reduces time to discharge for pediatric patients who required intramuscular presedation and GA for total oral rehabilitation.

The ideal objective is to provide the anesthesia level necessary to carry out the treatment while minimizing postoperative drowsiness and the recovery and discharge time. To make the anesthetics comparable, standard doses of commonly used intramuscular presedative were used in this study. Likewise, a standardized general anesthetic was also given. The GA was based on what is routinely used with children needing this kind of procedure. The investigators are currently evaluating utilizing oral midazolam as the presedation component of this anesthetic technique. No other anesthetic techniques were evaluated as part of this study.

The data revealed a statistically significant reduction in the time between turning off sevoflurane anesthesia or end of GA and PACU discharge as well as the time between PACU admission and discharge. It was observed that patients in which the BIS was known required less time to recover in the PACU compared to patients in which the BIS was not known. In addition, there was a trend toward earlier extubation. This is important in terms of OR utilization, though the actual time did not achieve statistical significance.

BIS values during the surgical procedure did not show a difference between both groups at the critical points. This appears to be inconsistent with the variation in anesthetic depth between the groups producing a longer time to recover in the BIS-unknown group. Observations of BIS during surgery indicated that the BIS-unknown group showed more variation in the rise and fall of the BIS number throughout the surgery. It is likely that this variation was related to using other signs of anesthetic depth (ie, adjustments of sevoflurane were reactions to changing vital signs, not the depth of sedation). Though the authors did not analyze the level of sevoflurane in both groups, it is reasonable to speculate that the level of sevoflurane in the BIS-unknown group was higher than in the BIS-known group.

While Table 3 does not demonstrate great variability between groups I and II during induction and end of GA, the independent observer who recorded the BIS values in both cases noticed those variations during the intraoperative course of the anesthetic procedure. Thus, attempts to control depth of anesthesia based on cardiovascular and other physiological parameters would periodically require greater anesthetic doses. This may have resulted in higher tissue anesthetic levels at the end of the surgical periods.

In summary, children having oral rehabilitation under GA recover more quickly and are able to be discharged sooner if BIS is used to guide their anesthetic. A common occurrence in these cases is that the anesthesia practitioner fails to consider the cumulative effect of the IM presedation, in addition to inhalational anesthetics, intravenous agents, and the local anesthetic. The amount of ketamine and midazolam used plus local anesthetic variably requires reductions in the amount of sevoflurane and fentanyl administered during the surgical procedure. According to the data, use of the BIS to guide the general anesthetic will prevent excessive levels of sedation and anesthesia and, thus, allow for speedier recovery. This benefits not only the facility, but the patient and family. The child's level of sedation will return to baseline sooner so that the child and care provider will have a better perioperative experience.

Conclusions

1. Guiding the level of sedation with BIS during sevoflurane general anesthesia in children facilitates faster recovery and discharge from the PACU.
2. BIS is useful in reducing the recovery and PACU discharge time for pediatric patients undergoing sevoflurane general anesthesia for dental rehabilitation after receiving intramuscular ketamine and midazolam presedation.
3. Despite of the possible effects of ketamine on the brain electrical activity and, hence, on the BIS value, in a standardized anesthetic regimen it should not affect the usefulness of the BIS in assessing the level of anesthesia.
4. Further studies are needed in the pediatric patient population, including studies that evaluate other sedative and anesthetic techniques.

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