Bispectral Index Monitoring (BIS) as a Guide for Intubation Without Neuromuscular Blockade in Office-Based Pediatric General Anesthesia: A Retrospective Evaluation

Zakaria S. Messieha, DDS,* Samuel Guirguis, DO,† and Sherine Hanna, MD‡

*Associate Professor of Clinical Anesthesiology, University of Illinois Medical Center at Chicago, Department of Anesthesiology, Chicago, Illinois, †Research Associate and Predoctoral Medical Student, Midwestern University/Chicago College of Osteopathic Medicine, Chicago, Illinois, and ‡Associate Professor of Anesthesiology, Loyola University Medical Center, Department of Anesthesiology, Maywood, Illinois

The Bispectral Index System is a useful guide for timing of adequate intubation conditions in office-based pediatric general anesthesia without neuromuscular blockade. As the number of cases in the office-based setting increase, many clinicians opt to intubate patients without neuromuscular blockade to avoid airway complications associated with skeletal muscle relaxation. Conventionally, this technique is conducted using the traditional monitoring criteria of vital signs, end-tidal inhalation agents, as well as anesthesiologist timing and knowledge of the pharmacodynamics of the anesthetic agent to help determine the proper depth of anesthesia for adequate intubating conditions. This study retrospectively assesses the use of the Bispectral Index System (BIS) as a guide for timing of nonparalytic tracheal intubation in pediatric office-based general anesthesia. Anesthetic records for 168 children, American Society of Anesthesiology physical status I and II, and ranging in age from 18 months to 17 years were retrospectively analyzed. Intubation outcomes were based on 6 preset criteria to reflect the adequacy of the technique. The mean BIS value during the time of intubation was 34.7. There were no complications encountered. A BIS mean value of 34.7 provided adequate intubation conditions without muscle relaxation in office-based pediatric anesthesia without complications.

Key Words: Pediatric general anesthesia; Office-based anesthesia; Intubation without neuro-muscular blockade; BIS applications; Pediatric dental general anesthesia.

Comprehensive dental rehabilitation is an ambulatory procedure that is usually conducted in the office-based environment. General anesthesia is routinely administered to pediatric dental patients due to their lack of cooperation and the complexity of their treatments, particularly for mentally challenged individuals such as those with autism. General anesthesia techniques used for these procedures often include nonintubated open airway, laryngeal mask airway,

and oral or nasotracheal intubation depending on the anticipated length, the nature of the treatment, and the preferences of the dentist anesthesiologist and the treating dentist. The use of paralytic agents prior to endotracheal intubation is the most common practice during surgical anesthesia in the hospital for most adults and also for children if skeletal muscle relaxation is needed for the surgical procedure, especially for abdominal surgery. Otherwise, most children who are intubated are done so under deep general anesthesia without neuromuscular blockade. In the dental office-based environment, muscle paralysis is often omitted because most procedures do not need paralysis and because not doing so adds an additional layer

Received March 9, 2009; accepted for publication July 5, 2010.

Address correspondence to Dr Zakaria Messieha, University of Illinois Medical Center at Chicago Department of Anesthesiology, 1740 W Taylor St UIH3200W, Chicago, IL 60612, M/C 515; messieha@uic.edu.

Anesth Prog 58:3–7 2011

© 2011 by the American Dental Society of Anesthesiology

ISSN 0003-3006/11

SSDI 0003-3006(11)

of safety in case spontaneous ventilation needs to be restored immediately. Forgoing the use of a nondepolarizing muscle relaxant also eliminates the need for reversal agents with their potential adverse parasympathomimetic effects, such as bronchospasm, gastrointestinal cramping, nausea, and bradycardia, which are particularly unwelcome complications in an ambulatory office-based environment, especially for children.

Nonparalytic intubation techniques have been usually conducted by rendering the patient deeply anesthetized at induction and gauging the proper timing for intubation based on changes in the patient's vital signs and other subjective markers of an adequately deep level of anesthesia. If a potent inhalation agent is used, the increase in its end-tidal concentration may also serve as a guide to proper intubating conditions. However, gauging the optimal depth of anesthesia in this manner is highly variable and imprecise. There is always the possibility that inadequate depth of anesthesia during attempted intubation will cause laryngospasm and other airway-related complications such as negative-pressure pulmonary edema or laryngotracheal damage during the intubation phase.

The Bispectral Index System (BIS) is a monitor (Covidien Healthcare, formerly Aspect Medical Systems, Newton, Mass) that derives its data from an electroencephalogram using bispectral and time domain parameters.¹ It is frequently used to monitor the depth of anesthesia in patients undergoing general anesthesia. Studies have shown the value of BIS monitoring in reducing extubation and recovery times in pediatric ambulatory patients.^{2,3} Because the correlation between the degree of intact airway reflexes and BIS values in sevoflurane anesthesia had not been completely validated in the past, Van Twest described the use of the BIS as a guide for timing intubation without neuromuscular blockade during sevoflurane induction of anesthesia in adults.⁴ This same study has not been completed using pediatric patients and especially not in an office-based environment.

PURPOSE

The purpose of this study is to retrospectively evaluate the use of BIS as a guide for the adequacy of the depth of anesthesia for nonparalytic nasotracheal intubation and associated complications in the pediatric patient undergoing office-based ambulatory general anesthesia for dental care. The tabulation of the mean BIS value during the intubations as well as the assessment of complications may serve as a guide for using BIS monitoring for intubation and lay the groundwork for fu-

ture prospective controlled studies to elucidate the BIS threshold for optimization of this technique.

METHODS

Anesthesia records for children aged 18 months to 17 years who underwent office-based dental rehabilitation under general anesthesia with nasotracheal intubation were retrieved. All anesthetics were conducted by the same dentist anesthesiologist using a sevoflurane induction protocol and nonparalytic nasotracheal intubation technique under the guidance of the BIS value as the primary criterion for adequate intubation conditions. An independent chart reviewer tabulated the patient's gender, age, American Society of Anesthesiology physical status classification, induction technique, and the BIS value at intubation. The anesthetic records were reviewed for adequate intubation conditions and for the following possible complications:

1. laryngospasm requiring rescue muscle relaxant or additional intervention,
2. failed intubation,
3. multiple intubation attempts due to light anesthesia or increased muscle tone,
4. SpO₂ drop (desaturation) lower than 95% via pulse oximetry,
5. tissue injury resulting from difficult intubating conditions, and
6. postoperative airway complications that could be attributed to difficult intubation conditions.

Data analysis for anesthesia techniques was limited to sevoflurane induction with or without presedation. The charts documenting intravenous inductions were eliminated from this retrospective study.

The charts of all patients were divided into 3 groups. The first group consisted of patients who received oral midazolam 0.7 mg/kg presedation in the waiting room. A waiting period of 10–15 minutes elapsed prior to induction of general anesthesia. The second group consisted of patients who received intramuscular ketamine 2 mg/kg plus midazolam 0.025–0.05 mg/kg in the waiting room. A waiting period of 5 minutes elapsed prior to induction of general anesthesia. The third group consisted of patients who did not receive a presedative. Each patient was taken to the operator, and monitors were placed including 3-lead electrocardiogram, noninvasive blood pressure, pulse oximetry, capnography, axillary skin temperature probe, and BIS. Induction of general anesthesia was accomplished using 8% sevoflurane and oxygen. Intravenous access was established after induction using an angiocatheter. Lactated Ringers solution was

Table 1. Demographic Data for the Study Population and the 3 Groups Are Displayed as Mean $\pm$ Standard Deviation*

Criteria	Total Population	M	M/K	None
Total (n)	168	133	20	15
Male/female	78/90	62/71	13/7	3/12
Age (years)	5.4 $\pm$ 2.79	4.6 $\pm$ 2.14	8.3 $\pm$ 3.18	8.5 $\pm$ 2.77
ASAPS	I-106, II-61, III-1	I-87, II-45, III-1	I-7, II-13	I-12, II-3
BIS value	34.7 $\pm$ 8.00	35.0 $\pm$ 8.31	35.7 $\pm$ 7.81	31.7 $\pm$ 4.40

* M indicates oral midazolam; M/K, intramuscular midazolam + ketamine; none, no premedication.

administered initially as a fluid bolus of 10 mL/kg and subsequently at an infusion rate that would replenish the fluid deficit and maintenance throughout the duration of the procedure. All patients received intravenous dexamethasone 0.1 mg/kg and glycopyrrolate 0.01 mg/kg prior to intubation. Oxymetazoline nasal spray was administered, and nasopharyngeal airways were serially administered to dilate the nares, allowing the patient to breathe sevoflurane spontaneously between each placement. When the BIS value was observed to be 40 or below and end-tidal sevoflurane did not exceed 6%, nasal-tracheal intubation was initiated. While ketamine is thought to increase brain electrical activity, the BIS value is still reduced proportionate to increased depth of anesthesia. Both the nasal-pharyngeal airways and the tube were lubricated using 2% viscous lidocaine.

The BIS value was recorded immediately prior to the initiation of laryngoscopy and intubation, and any difficulty with the intubation, intubating conditions, or other complications were noted. Postoperative complications attributed to endotracheal intubation were also noted.

RESULTS

Demographic data from a total of 168 patients who qualified for inclusion in this study are detailed in Table 1. Their age range was 1.8–14.9 years. The mean BIS value was 34.7. Table 2 demonstrates the outcomes related to the 6 categories of complications listed above.

Table 2. Complications Related to Intubation

Criteria	N = 168
Laryngospasm requiring rescue muscle relaxant or additional intervention	0
Failed intubation	0
Multiple intubation attempts due to light anesthesia or increased muscle tone	0
SpO ₂ drop (desaturation) lower than 95% via pulse oximetry	0
Tissue injury resulting from difficult intubating conditions	0
Postoperative airway complications that could be attributed to difficult intubation conditions	0

None of the listed potential complications were noted in the charts of any of the study subjects. All patients were discharged to the care of a family member without any complications or the need for intervention or hospitalization.

DISCUSSION

BIS was initially described by Sigl and Chamoun¹ as a simplified method for the interpretation of the electroencephalogram through an absolute number ranging from 0 to 100. It was also described as a possible tool for the diagnosis of neurological disorders as well as intraoperative monitoring of anesthetic efficacy and cerebral ischemia.⁵ Early studies⁶ investigated the use of BIS as a tool to minimize intraoperative surgical recollection in adults. Depth of anesthesia interpretation via BIS was also described,^{6,7} stating that a BIS range of 40–60 provided a moderate hypnotic state while BIS values below 40 were described as deep hypnotic states. The use of BIS as a guide for intraoperative depth of anesthesia and consequently the reduction of extubation and recovery time was extensively studied, showing an advantage in reduction of extubation and recovery time in adults. Messieha et al^{2,3} conducted 2 prospective double-blinded studies evaluating the use of BIS in reducing extubation and recovery time among children undergoing same-day dental rehabilitation under intubated general anesthesia. Results of one study³ showed a statistically significant reduction of both extubation and recovery times, while the other study² showed a statistically significant reduction in recovery time only. Both studies included a nondepolarizing neuromuscular blocking agent (rocuronium) as part of the anesthetic technique.

Office-based ambulatory anesthesia is one of the fastest growing segments of anesthesia care. Patients who undergo office-based anesthesia procedures are usually healthier with fewer anesthesia and surgical risk factors. Reducing the possibility of anesthesia and surgical complications in such an environment is paramount because admission to a hospital for an overnight stay is more problematic than for cases done in the hospital operating room. While general anesthesia in the office is a common practice for both medical and dental procedures, a conservative use of drugs and

techniques for appropriate patients minimizes the chances of perioperative complications. Endotracheal intubation without neuromuscular blockade in office-based anesthesia has several advantages. This technique provides an easier exit strategy in the case of an unanticipated difficult intubation by allowing for the maintenance or rapid restoration of spontaneous ventilation. Flexible fiber-optic intubation scopes and other advanced airway management equipment that permit continuing the anesthesia for difficult airway cases in a hospital are not always available in the office, so rapid awakening of the patient and aborting the procedure can be quickly accomplished if the patient remains spontaneously breathing. If nondepolarizing muscle relaxants were used, too much time would be needed to pharmacologically reverse them if a rapid awakening and return of spontaneous ventilation became necessary. In addition, the previously mentioned side effects attributed to the use of reversal drugs such as neostigmine would be also eliminated. The elective use of the short-acting muscle relaxant succinylcholine is not recommended for children primarily due to its potential to cause cardiac arrest from enhanced muscarinic vagal tone and elevated serum levels of potassium as well as being a triggering agent for malignant hyperthermia.

One of the risks of nonparalytic intubation is that if airway instrumentation and stimulation occurs at an inadequate depth of anesthesia where airway reflexes remain intact, laryngospasm and subsequent loss of the patency of the airway may develop. Lighter depths of anesthesia can also lead to patient movement and tighter muscle tone, which can hamper the intubation effort and possibly result in patient injury. Davidson⁸ studied 62 children scheduled for direct laryngoscopy and bronchoscopy. BIS was used to determine the appropriate time for spraying the vocal cords with lidocaine in 2 groups anesthetized either with halothane or sevoflurane. Complete closure of vocal cords was recorded by the anesthetist as well as subsequent breath holding, desaturation, and coughing. This study showed that BIS correlated better in predicting unwanted airway reflexes with halothane than with sevoflurane.

Oberer et al⁹ found that apnea and laryngospasm occurred more commonly in sevoflurane induction than with propofol among children aged 2–6 years. A BIS-assigned hypnosis level of 40 provided better conditions and lesser laryngeal reflexes in both groups compared with an assigned hypnosis level of 60.

Schneider et al¹⁰ reported that BIS values of 50–60 were inadequate to prevent awareness reaction to intubation during propofol/alfentanil anesthesia in adults.

In studying the advantage of adding remifentanyl 1 µg/kg to sevoflurane induction in children, Weber et al¹¹ used the BIS as a guide for depth of anesthesia at a level of 35 ± 5 .

All the above studies clearly demonstrate that a BIS value higher than 40 may not provide the most ideal conditions for intubation and hence may increase the risk for intraoperative airway complications. Van Twest⁴ studied the use of BIS-guided timing of intubation without neuromuscular blockade during sevoflurane induction in 40 adult patients. This study evaluated 2 assigned BIS values of 25 and 40 among 40 randomized patients. The BIS 25 group demonstrated good to excellent intubating conditions compared with the BIS 40 group.

Our study aimed at retrospectively assessing a BIS-guided intubation technique without the use of neuromuscular blockade in children. This particular approach has not been extensively evaluated or published previously in the literature. Since a deeper hypnotic state has been shown to have less risk of airway reactivity and a lesser risk for complications, the goal of our study was to examine the intubation characteristics after achieving a BIS hypnosis level below 40 prior to the initiation of laryngoscopy and intubation. Producing a BIS value as a guide to depth of anesthesia with a mean target value of 34.7 demonstrated no complications resulting from laryngoscopy and nasotracheal intubation. Most of the patients evaluated received oral midazolam prior to sevoflurane induction. Two smaller groups received either premedication with intramuscular midazolam/ketamine or no premedication. The mean age of the patients included in those 2 smaller groups was clearly higher than the oral midazolam/sevoflurane group, but they nevertheless fared equally well as those in the larger group. In addition, since the BIS reading is known to be not significantly influenced by ketamine, the anesthetic depth of those in the intramuscular ketamine/midazolam group may have been deeper at their BIS level below 40 than those in the other groups with a similar BIS reading. To fully validate this technique, large, prospective, double-blinded controlled studies need to be conducted comparing the use of BIS at differing levels under the above-described conditions with the same intubation approach using the patient's vital signs and monitoring criteria as well as the anesthesiologist's knowledge of the drug pharmacodynamics to determine the threshold of the depth of anesthesia that is ideal for intubation without neuromuscular blocking agents.

CONCLUSION

Producing a level of sevoflurane general anesthesia with a BIS mean value of 34.7 as a guide for adequate depth prior to nasotracheal intubation without the use of neuromuscular blockade during office-based pediatric general anesthesia provided excellent intubation conditions without significant complications.

Further randomized prospective controlled studies need to be conducted to further elucidate the threshold BIS level for ideal conditions for performing this technique.

REFERENCES

1. Sigl JC, Chamoun NG. An introduction to BIS analysis for the EEG. *J Clin Monit*. 1994;10:392–404.
2. Messieha ZS, Ananda RC, Hoffman WE, Punwani IC, Koenig HM. Bispectral Index System (BIS) monitoring reduces time to discharge in children requiring intramuscular sedation and general anesthesia for outpatient dental rehabilitation. *Pediatr Dent*. 2004;26:256–260.
3. Messieha ZS, Ananda RC, Hoffman WE, Punwani IC, Koenig HM. Bispectral Index System (BIS) monitoring reduces time to extubation and discharge in children requiring oral premedication and general anesthesia for outpatient dental rehabilitation. *Pediatr Dent*. 2005;27(5):1–5.
4. Van Twest RM. Bispectral index guided timing of intubation without neuromuscular blockade during sevoflurane induction of anesthesia in adults. *Anaesth Intensive Care*. 2006;34:606–612.
5. Bard JW. The BIS monitor: a review and technology assessment. *AANA J*. 2001;69:477–483.
6. Glass PS, Bloom M, Kears L, Rosow C, Sebel P, Manberg P. Bispectral analysis measures sedation and memory effects of propofol, midazolam, isoflurane, and alfentanil in healthy volunteers. *Anesthesiology*. 1997;86:836–847.
7. Sebel PS, Lange E, Rampil IJ, et al. A multicenter study of bispectral electroencephalogram analysis for monitoring anesthetic effect. *Anesth Analg*. 1997;84:891–899.
8. Davidson A. The correlation between bispectral index and airway reflexes with sevoflurane and halothane anesthesia. *Paediatr Anaesth*. 2004;14:241–246.
9. Oberer C, Von Ungern-Sternberg BS, Frei FJ, Erb TO. Respiratory reflex responses of the larynx differ between sevoflurane and propofol in pediatric patients. *Anesthesiology*. 2005;103:1142–1148.
10. Schneider G, Wagner K, Reeker W, Hanel F, Werner C, Kochs E. Bispectral Index (BIS) may not predict awareness reaction to intubation in surgical patients. *J Neurosurg Anesthesiol*. 2002;14(1):7–11.
11. Weber F, Fussell U, Gruber M, Hobbhahn J. The use of remifentanyl for intubation in pediatric patients during sevoflurane anesthesia guided by Bispectral Index (BIS) monitoring. *Anaesthesia*. 2004;58:749–755.