

Original Article**Comparative evaluation of different values of bispectral index in determination of the appropriate level of anesthesia for tracheal intubation during inhalational induction of anesthesia in pediatrics**

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Abstract

BACKGROUND: Induction of anesthesia is the most crucial period of general anesthesia. Inhalational induction is the most commonly used technique in pediatric anesthesia. Tracheal intubation can be done after reaching the deep levels of anesthesia. The depth of anesthesia is often difficult to be judged. Bispectral index is a measure of the effects of anesthesia on brain. This study was designed to evaluate the efficacy of bispectral index (BIS) in clarifying suitable depth of anesthesia for tracheal intubation during inhalational induction of anesthesia.

METHODS: In a clinical trial, ninety patients, ASA I & II, 1 to 6 years old, scheduled for elective surgery were enrolled into the study. After starting BIS monitoring, patients randomly were divided into three groups. Then, anesthesia was induced by gradual increase of halothane in 50% mixture of oxygen (O₂) and N₂O and continued until target BIS (60 ± 2, 50 ± 2 and 40 ± 2) achieved. After tracheal intubation, the duration of laryngoscopy and the presence of laryngospasm, bronchospasm, laryngoscopy failure, the movement of extremities and the changes in SpO₂ and BIS were recorded. The data were analyzed by chi-square and ANOVA at 0.05 level of significance.

RESULTS: BIS could not determine the appropriate level of anesthesia for tracheal intubation in this setting. There were no differences in laryngoscopy duration and the occurrence of laryngospasm, bronchospasm, laryngoscopy failure, extremity movement and awakening time among three groups.

CONCLUSIONS: These results confirmed that there was no significant difference in the incidence of complications related to intubation at different BIS values (from 60 to 40) during inhalation induction, and probably to achieve an adequate or more reliable depth of anesthesia, the lower values of BIS is required.

KEYWORDS: Inhalation Induction, BIS, Pediatric, Anesthesia.

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Induction of anesthesia is the most crucial and stressful period of general anesthesia for the young patient as well as the anesthesiologist.¹ The consequences of this stressful experience by a child become apparent in the immediate postanesthetic period and may persist for weeks or even longer.² Inhalational induction of anesthesia by mask is the most commonly used technique in pediatric anesthesia in the United States.³ Its reason is the fact that this technique is relatively easier, more rapid and less objective for most children in comparing the insertion of the intravenous

catheter.³ Intubation of trachea can be made after reaching the deep levels of anesthesia.

It is often difficult to judge the depth of anesthesia. The most reliable signs of adequate depth of anesthesia for tracheal intubation are centrally fixed pupils, flaccidity of arms and hands, jaw relaxation, apnea and blood pressure lower than the preinduction level.^{4,5} Mistakes in measuring the depth of anesthesia can cause serious problems.⁶

Trying to insert tracheal tube into the trachea at low levels of anesthesia can cause bucking, laryngospasm, bronchospasm,

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movement of patient, traumatization of airway (teeth, palates, tonsils, tonsillar folds, vocal cords, arytenoid cartilages and ...), prolongation of intubation period, sympathetic stimulation and probably desaturation.⁷⁻⁹ Moreover, the delay in intubation can cause overdosage of inhaled anesthetics and their complications such as bradycardia, arrhythmia, hypotension and finally, respiratory arrest and vasomotor collapse.¹⁰

Guedel (1883-1956) in 1937 described a detailed system to separate various stages of anesthesia depth which was generally accepted.¹¹ This classification was designed for use of a sole inhalational anesthetic agent which was Ether. Nowadays, because of the use of intravenous induction agents with muscle relaxants and discontinuation of Ether, Guedel's classification is no longer used in clinical practice and the depth of anesthesia can be measured by using BIS monitoring.^{11,12}

The effects of anesthesia and sedation on the brain are measured by the Bispectral index (BIS). Clinicians are allowed to deliver more précised anesthesia and a better response to the patient's changing condition during surgery by this new vital "sign". The BIS index is a measure of, a new "vital sign".¹³⁻¹⁶

The BIS index is a number between 0 and 100. The "awake" clinical state is represented by a BIS values near 100. While the maximal electroencephalogram (EEG) effect possible (an isoelectric EEG) is denoted by a zero value. At BIS index values less than 40, a greater effect of the anesthesia on the EEG is signified and at a BIS index value of less than 60, an extremely low probability of conciseness is considered. The maintenance of BIS index number between 40 and 60 signifies adequate hypnotic effect during general anesthesia.

Induction of anesthesia with inhalational gases is the most popular method in children and there is no reliable sign or monitoring to find an optimal depth of anesthesia for tracheal intubation in this method. In addition, BIS is a measure of the effects of anesthesia and sedation on the brain that can be used for measuring anesthetic depth.¹⁷ We designed

this study to assess the efficacy of BIS in accurate measuring depth of anesthesia during inhalational induction of anesthesia and introducing a suitable level of BIS for safe tracheal intubation in children.

Methods

After obtaining approval from Institutional Ethics Committee and informed consent from each patient's parent, in a clinical trial, ninety patients, ASA I and II, 1-6 years of age scheduled for elective surgery in Alzahra Hospital were included in this study in a simple sampling manner. Other inclusion criteria were no sign of difficult intubation, no signs, symptoms or history of upper respiratory tract infection in the past 2 weeks and no contraindication for use of halothane. All patients were premedicated with midazolam 0.1 mg/kg intravenously and transferred to operating room. Patients who showed adverse reaction to premedication with midazolam were excluded from this study (18). Routine monitoring of vital signs (pulse oximetry, capnography, electrocardiography, non-invasive blood pressure and temperature) was supplemented by additional BIS monitoring (A-2000 BIS monitor; Aspect Medical Systems, BV, Leiden, The Netherlands). BIS monitoring was started before receiving intravenous atropine (0.02 mg/kg). Then, they were randomly divided into three groups according to suggestions of Randomized Allocation Software (19); group 1 included BIS of 60, group 2 covered BIS of 50 and group 3 involved BIS of 40.

Inhalational anesthesia was induced by gradual increasing of halothane* with a 50% mixture of O₂ in N₂O and continued until target BIS (60 ± 2 for group 1, 50 ± 2 for group 2 and 40 ± 2 for group 3) were achieved. To prevent possible injuries due to inadequate depth of anesthesia, after achieving the desired level of BIS, clinical signs of deep anesthesia (relaxation of extremities, rapid shallow respiration, size and centralization of pupils) were checked and recorded. Then, tracheal intubation was done after 3-5 times inspiring 100% O₂. After tracheal intubation, the concentration of halo-

thane reduced to 0.8% in a 50% mixture of N₂O and O₂. Then, atracurium 0.6 mg/kg were given intravenously and lungs were mechanically ventilated (tidal volume: 10 mg/kg) to maintain EtCO₂ of 30-40 mmHg by regulating suitable respiratory rate. At the end of surgery, halothane and N₂O discontinued and muscle relaxant was reversed by intravenous mixture of prostigmin (0.04 mg/kg) and atropine (0.02 mg/kg). Patients were extubated after full awakening (crying, spontaneous eye opening and trying for self extubation) and then, transferred to recovery room. BIS values, blood pressure, pulse rate and SpO₂ were measured and recorded before induction of anesthesia, before laryngoscopy and immediately after laryngoscopy. In addition, the amounts of change of BIS values, pulse rate and SPO₂ for each patient were calculated by decreasing those values "immediately after laryngoscopy" from the values "before laryngoscopy" and then, the mean change of these three data were used in comparison among three groups (Table 2). Moreover, the time to reach the proposed BIS index (the time interval between placing face mask and initiation of inhalational anesthetics to reach the BIS index of 60, 50 and 40 in groups 1, 2 and 3, respectively), EtCO₂ values after intubation (mean EtCO₂ at first minute after intubation), laryngoscopy duration (the time interval between the insertion of the

blade of laryngoscope and taking it out from the patient's mouth after a successful intubation), responses to laryngoscopy (laryngospasm, bronchospasm, movement of extremities) and the awakening time (the time interval between the discontinuation of inhalational gases and endotracheal extubation) were assessed too.

One way analysis of variance (one way ANOVA) was used for comparison of age, weight, BIS values, duration of intubation, heart rate, SpO₂, EtCO₂ and awakening time. Chi-square was used for comparison of gender and responses to laryngoscopy. Statistical tests performed with SPSS (version of 17) statistical software package at 0.05 level of significance.

Results

Ninety patients including 25 females and 65 males were enrolled into the study. Mean and standard deviation of age and weight were 2.82±1.25 years and 12.13±2.86 kg, respectively (p>0.05).

The mean and SD of age in groups 1 to 3 were 2.77±1.4, 2.53±1.4 and 3.18±0.8, respectively with the p value of 0.122; and these measures for weight were 12.33±2.6, 11.87±3.4 and 12.18±2.6, respectively and the p value for this variable was 0.823.

The relative distribution of male/female ration in groups 1, 2, and 3 were 21/9, 22/8

Table 1. Comparison of time to reach to proposed bispectral index (BIS), duration of laryngoscopy, mean changes of BIS, heart rate, arterial oxygen saturation (SpO₂), end tidal CO₂ (EtCO₂) and an awakening time among three groups.

Variable	Group 1	Group 2	Group 3	p
Time to reach the proposed BIS (min)	3.28±0.76	3.71±0.67	4.4±0.67	0.00
Mean changes of BIS	-1.6 ±11.57	4.5±7.6	9.1±10.8	0.00
Duration of laryngoscopy (min)	7.4±1.0	7.4±1.2	7.2 ±1.4	0.897
Mean changes of heart rate (b/min)	7.1±7.7	12.06±9.7	9.0±12.5	0.174
Mean changes of SpO ₂ (%)	-0.83±1.6	-0.10±1.7	0.36±1.9	0.037
EtCO ₂ after intubation (mmHg)	41.06±9.9	43.2±9.4	49.9±10.8	0.174
Awakening time (min)	9±1.3	8.5±1.3	8.8±1.6	0.520

Table 2. The frequency distributions of responses to laryngoscopy among three groups

	Group 1	Group 2	Group 3	p
Laryngospasm	5	6	3	0.553
Bronchospasm	0	1	0	0.364
Movement of extremity	7	9	9	0.801
Patients with response to laryngoscopy*	10	10	12	0.824

*Some patients showed more than one response.

and 22/8, respectively ($p = 0.946$). There were no significant differences in laryngoscopy duration, laryngospasm, bronchospasm, laryngoscopy failure, extremity movement, awakening time among three groups. ($p < 0.05$) (Tables 1 and 2)

In addition to our findings, it was unpredictably seen that groups who had a lower BIS values (group 2 and 3) showed a significant increase in BIS values due to the laryngoscopic stimuli (Table-3).

Discussion

The aim of the present study was to investigate the efficacy of BIS in evaluating the adequate anesthetic depth for endotracheal intubation during induction of inhalational anesthesia in children. We chose halothane as an inhalation induction agent because it has some priorities on sevoflurane²⁰ including lower speed of induction by halothane and practically it is easier to keep patient at a special level of anesthesia depth with less fluctuations in BIS value.

In spite of using BIS monitoring in children to evaluate anesthesia depth in several studies, no study has been done to use this monitoring to find the suitable anesthesia depth for tracheal intubation during inhalational anesthesia in children.

Our findings showed that although reaching the BIS value of about 40 when compared to 50 and 60 values required more time, no significant difference was seen in the incidence of complications due to inadequate depth of anesthesia among these three groups.

In this study, in two groups patients showed a significant difference in BIS changes due to tracheal intubation; this difference was greater at the lower BIS value. In other words, BIS values were increased significantly in the second and third groups who had BIS values about 50 and 40, respectively. These results are consistent with known effects of noxious stimulation on BIS values of patients under general anesthesia.²¹

But, it is not consistent to the findings of Oda et al.²² who reported that in youngsters in the presence of N₂O, BIS decreased during laryngoscopic stimulation (paradoxical reaction). This difference probably was due to the age of the selected groups in his study (less than 40 years) comparing with our studied groups who were much younger.

Instead, this finding is in the same direction of another study²³ that revealed the painful stimuli in children (1-6 y), even in the presence of N₂O resulted in elevation of BIS values.

In the present study, HR, SpO₂ and EtCO₂

Table 3. The mean bispectral index (BIS) before and immediately after intubation in different groups

		Group 1	Group 2	Group 3
Mean of BIS	Before Intubation	61.63±5.4	50.53±2.9	38.36±7.6
	Immediately After Intubation	60.03±10	55.06±7.7	47.5±9.9
	p	0.455	0.003	0.000

were recorded before and after tracheal intubation and there were no significant differences among the three groups. This finding showed that although the depth of anesthesia was enough to eliminate the pressor response, the BIS values were increased.

Our results further confirmed the inefficacy of BIS monitoring in detecting the adequate anesthetic depth for tracheal intubation which were similar to the findings of Constant and his colleagues.²⁴

Constant et al.²⁴ studied 40 children under inhalational induction of anesthesia with sevoflurane and they concluded that BIS did not reliably predict the depth of anesthesia during inhalational anesthetic induction. However, van Twest et al.²⁵ reported that when comparing two different BIS values (25 and 40), BIS values of about 25 provided a better condition for tracheal intubation during induction of anesthesia with sevoflurane.

With regard to the results of the mentioned studies and the present study, it seems that a lower level of BIS values is needed to provide acceptable condition for tracheal intubation

during inhalation anesthesia induction.

Van Twest et al. also showed that children who had BIS values about 40 had pressor responses.²⁵

In any case, the known paradoxical effect which was explained in the presence of N₂O (laryngoscopic stimulation leading to reduction of BIS) is not confirmed by our findings.

In conclusion, there were no significant difference in the incidence of responses related to intubation at different BIS values (from 60 to 40) during inhalation anesthesia induction, and probably to achieve an adequate or more reliable depth of anesthesia, the lower values of BIS is required.

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The Ethical Committee of Isfahan University of Medical Sciences approved this study (Project number: 18 Center 5012).

Conflict of Interests

Authors have no conflict of interests.

Authors Contribution

MG Primary searches, preparing proposal, producing and providing equipments, collecting data, statistical analysis, writing manuscript. RK collecting data, writing and translating manuscript. All authors have read and approved the content of the manuscript

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