International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Website: https://ijmpr.in/

Research Article

A Cross Sectional Study on Correlation Between Bispectral Index, End Tidal Sevoflurane Concentration, Difference in Inspiratory and End Tidal Oxygen Concentration for Anesthetic Depth Monitoring in Pediatric Patients Undergoing Short Surgeries

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Received: 10-08-2025
Accepted: 31-08-2025
Available online: 18-09-2025

ABSTRACT

Abstract
Introduction: Maintenance and monitoring of adequate depth of anesthesia in pediatric population is of utmost importance as it can lead to long term psychological and behavioral effects. There are various modalities for assessing depth of anesthesia. None of them can be claimed the best especially in pediatric population. In this study we evaluated the prevailing indices and correlation between them.
Materials and methods: The present study entitled 'A cross sectional study, conducted in All India Institute of medical sciences, Rishikesh. The primary outcome was to correlate the difference of inspired and end-tidal oxygen concentration [(Fi–Et) O2%] with ETsevo at various predefined time points. We investigated and tried to validate the derived cut-off value of (Fi–Et) O2% which corresponds with lighter
anesthetic plane (MAC<0.6). Secondary outcome was to correlate BIS with ETsevo as well as BIS with (Fi–Et) O2% at similar predefined time points. Data were coded and recorded in MS Excel spreadsheet program. SPSS v23 (IBM Corp.) was used for data analysis
Results: While there was significant difference compared to baseline in each parameter following anesthesia serving as indicators of good depth of anesthesia, neither the correlation of (Fi-ET) O2% was statically significant with ETsevo and BIS, nor the correlation of BIS and ETsevo was statically significant contrary to findings of previous authors.
Conclusion: ETsevo concentration hold their ground and BIS monitoring and monitoring of (Fi-ET) O2% look promising and congruent.

Keywords: *ETsevo, (Fi–Et) O2%, BIS monitoring, depth of anesthesia, pediatric surgery.*

INTRODUCTION

One of the most common concerns of patients about to undergo anesthesia is that they will remember the intraoperative events. It is undesirable to have awareness during surgery. Although the risks associated with anesthesia have progressively decreased, yet awareness during anesthesia remains a serious complication with potential long term psychological sequelae. The preverbal children are not able to express or recall the intraoperative events which may be identifiably elicited in adults. However pediatric population may also face problem of intraoperative awareness (1) and the incidence found to be more in children compared to adults (2).

It is sensible to measure the consciousness during anesthesia, therefore different way to monitor anesthesia depth such as Bispectral index (BIS)(3), End tidal sevoflurane concentration (ETsevo)(4), difference of inspiratory and end tidal (Fi-ET) O2%(5), minimum alveolar concentration (MAC)(6) are used in clinical practice. Specialized monitoring equipment has been developed to assist in the assessment of depth of anesthesia. Such equipment includes BIS, Narcotrend and M-Entropy etc. Although there are several ways to assess the depth of anesthesia, main focus in majority of research and publications recent years are with that of EEG application. BIS monitoring works on an algorithm derived entirely from healthy adults within repeated transitions between consciousness and unconsciousness while using different anesthetic agents. The algorithm processes the EEG in near real time and computes an index value between 0 and 100 that indicates the patient's level of consciousness. A value of 100 corresponds to being completely awake, whereas 0 corresponds to a profound state of coma or unconsciousness that is reflected by an isoelectric or flat EEG. Due to rapidly developing brain in infant and toddlers, also due to their increased neuronal activity, BIS monitoring is not yet authentic for using in children. BIS is unreliable in measuring the depth of anesthesia in toddlers and preschoolers (6).

Real time feedback provided by measurement of end tidal anesthetic gas (ETAG) concentration can facilitate target-controlled titration of volatile anesthetic agents and serve as a reasonable indicator for monitoring anesthetic depth (7). Inhalational anesthetic agents decrease the cerebral oxygen consumption and cerebral metabolic rate (5). A study conducted by R Dias et al had concluded that cerebral oxygen consumption will increase in the light planes of anesthesia when other confounding factors influencing oxygen consumption are kept constant(5). In this study conducted by them, they had measured difference between inspiratory and end tidal (Fi-ET) oxygen concentration and found significant correlation with ETAG at certain time points during anesthesia.

MAC is defined as the minimum alveolar concentration of an inhaled anesthetic at 1 atmospheric pressure in 100% oxygen equilibrium, at which 50% of patients do not produce any apparent purposeful movement in response to a standardized noxious stimuli. It remains the most commonly used measure of anesthetic potency for inhaled drugs. MAC awake, is defined as the minimal alveolar concentration of an inhaled anesthetic at 1 atmospheric pressure in 100% oxygen equilibrium, needed to suppress a voluntary response to verbal command in 50% of patients.

Our study was to find the correlation of (Fi-ET) O2% and ETsevo. A similar study by R Dias et al observed a cut-off value of (Fi–Et) O2 >7, which corresponds to lighter anesthetic plane (MAC <0.6) (5). Our study aimed to validate the above cut-off value derived from the previous study. Correlation between BIS with ETsevo as well as with (Fi-ET) O2% was also checked in this study.

MATERIALS AND METHODS

This observational cross-sectional study was conducted in department of Anesthesiology at All India Institute of Medical Sciences, Rishikesh, over a period of 12 months. The protocol of this study was approved by the institutional ethics committee of AIIMS Rishikesh (India) Letter No- AIIMS/IEC/19/1255 dated 31/12/2019.

Aim of this study was to study on correlation between (Fi-ET) O2% with ETsevo, also to find correlation of BIS with (Fi-ET) O2% and ETsevo in pediatric patients undergoing short surgeries. To correlate difference of inspiratory and end tidal oxygen concentration (Fi-ET) O2% with ETsevo, to correlate BIS with ETsevo, to correlate BIS with difference of inspiratory and end tidal oxygen concentration (Fi-ET) O2% were the other objectives of this study.

The informed written consent was obtained from patient's parent/ guardian. Sample size was estimated based on a previous study[6] in which the correlation between steady-state end-tidal sevoflurane concentration of 3% with (Fi-ET) O2% values in 30 children between 1 and 5 years of age was 0.372. With type 1 error at 5% level of significance and 80% power of study, sample size of 54 was obtained. To compensate for dropouts, we took a sample size of 63. We included ASA I & II patients posted for elective surgeries with duration up to 90 minutes, age between 1 and 5 years.

Parents/Legal guardian's refusal to allow participation. Patients with Neurological disease, Cerebral palsy, Seizure disorders Attention deficit hyperactivity disorder, Sepsis, Anemia with hematocrit less than 30 were excluded. The primary outcome was to correlate the difference of inspired and end-tidal oxygen concentration [(Fi–Et) O2%] with ETsevo at various predefined time points. We investigated and tried to validate the derived cut-off value of (Fi–Et) O2% which corresponds with lighter anesthetic plane (MAC<0.6). Secondary outcome was to correlate BIS with ETsevo as well as BIS with (Fi–Et) O2% at similar predefined time points.

The study protocol was explained to the parents/legal guardians during the pre-anesthetic check and consent was obtained. A total of 63 children between 1 and 5 years of age, posted for short surgical procedures like hydrocele repair, orchidopexy, circumcision, I&D, meatoplasty, dermoid excision, inguinal hernia repair with expected duration of up to 90 min, was recruited from the pre anesthetic clinic.

After confirming adequate nil per oral (NPO) status, all children was pre medicated with intravenous (IV) midazolam 0.1 mg/kg and 1mcg/kg of fentanyl, 5 min prior to induction of general anesthesia. Administration of premedication was under controlled conditions in the preoperative holding area. The children were then wheeled into the operation theatre, and monitors such as pulse oximeter, noninvasive blood pressure (NIBP), electrocardiography, skin temperature, hemoglobin monitor (MASIMO) was attached. BIS electrodes (Aspect Medical systems, Newton, MA, USA) was applied over the patient's forehead after cleaning the forehead thoroughly with an alcohol swab. This was connected to BIS-A-2000 monitor on the Drager Perseus® machine.

Data was collected by the principal investigator. Hence, consistency was maintained. Baseline heart rate, NIBP, noninvasive hemoglobin, O2 saturation, skin temperature and BIS values was noted. Patients were then pre oxygenated with 100% oxygen for 3 min with fresh gas flow of 4L/min using circle absorber. Anesthesia was induced with incremental sevoflurane up to 8 dial setting till MAC of 1–1.3 (MAC- Intubation) was achieved (MAC values were adjusted for age). All children has received IV Inj. fentanyl 2 mcg/kg followed by muscle relaxation was achieved with inj. Atracurium 0.6mg/kg.

Patients were then intubated with appropriately sized endo tracheal tube. 5 minutes after intubation, values of MAC, heart rate, NIBP, O2 saturation , noninvasive hemoglobin, BIS, ETsevo, dial agent concentration, FiO2(%) and ETO2(%) were noted. Intravenous Inj. Paracetamol 15 mg/kg was given for analgesia. Anesthesia was maintained with O2 + N2O (50:50), sevoflurane using the circle absorber and controlled ventilation at flows of 0.5L/min , maintained MAC between 1 and 1.3. Intermittent atracurium 0.2 mg/kg
IV was given when required. Values of MAC, heart rate, NIBP, O2 saturation, BIS, ETsevo, dial agent setting, noninvasive hemoglobin, FiO2(%), and ETO2(%) were noted at the following predefined points of time: maintenance phase of anesthesia (15 and 30 min after noting down intubation values of study parameters),15 min before completion of surgery, completion of surgery (skin closure), extubation and recovery.

At the start of skin closure inhalational agent was shut off and slowly the MAC values tapered down to 0. At the time of skin dressing, fresh gas flow was increased to 4L/min and FiO2 (%) increased to 100%. Residual neuromuscular blockade was reversed with neostigmine 50 mcg/kg and atropine 20 mcg/kg IV and patients was then extubated. 'Extubation' values of parameters were noted then. Recovery was defined as coughing, eye opening and purposeful spontaneous movements. After ensuring adequate recovery patients were shifted to the post anesthesia care unit for further care and management. Data were coded and recorded in MS Excel spreadsheet program. SPSS v23 (IBM Corp.) was used for data analysis.

OBSEVATION AND RESULTS

RESULTS

This study was conducted in the Department of Anesthesiology, All India Institute of Medical Sciences (AIIMS), Rishikesh, over a period of 12 months. The aim of this study was to find out correlation between BIS, ETSevo concentration, (Fi-ET) O2 concentration for anesthetic depth monitoring in pediatric patients undergoing short surgeries. A total of 63 patients were included in the study who met the inclusion criteria.

The mean Age (Years) was 3.09 ± 1.47. 35 (55.6%) of the participants had Gender: Male. 28 (44.4%) of the participants had Gender: Female. 63 (100.0%) of the participants had ASA Status: I. The mean Duration of Anesthesia (Minutes) was 72.78 ± 16.65. The mean Duration of Surgery (Minutes) was 62.70 ± 15.55.

While there was significant difference compared to baseline in each parameter following anesthesia serving as indicators of good depth of anesthesia, neither the correlation of (Fi-ET) O2% was statically significant with ETsevo and BIS, nor the correlation of BIS and ETsevo was statically significant

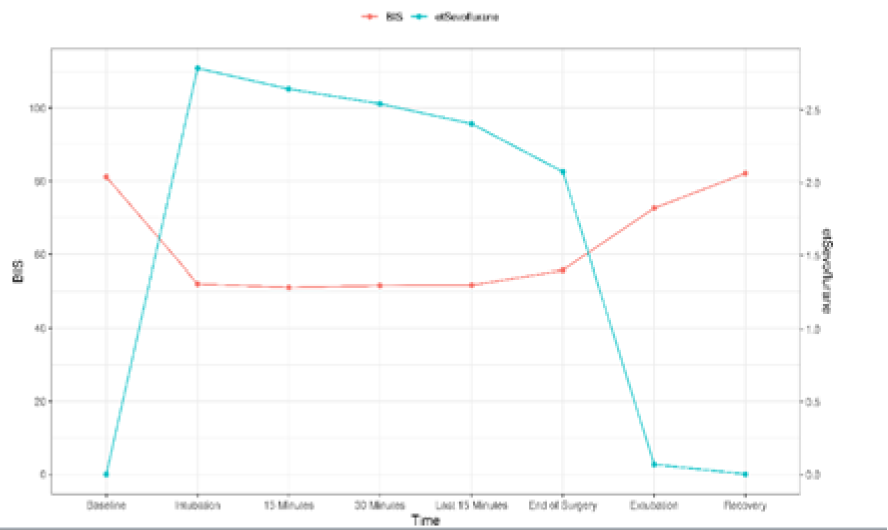

Fig.1 Correlation between BIS and ETsevo

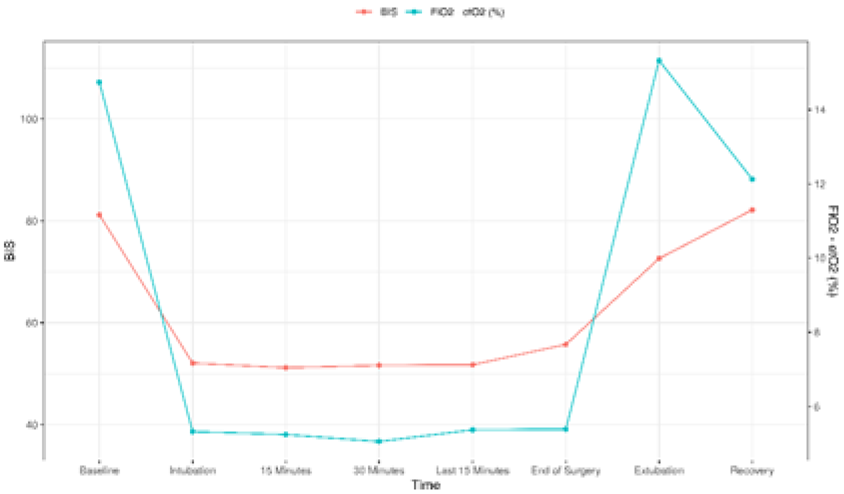

Fig.2 Correlation between BIS and (Fi-ET) O2%

DISCUSSION

The present study was done in 63 pediatric patients, who were ASA 1 category, planned for elective surgery under general anesthesia. The primary outcome of this study was to correlate difference of inspiratory and end tidal oxygen concentration (Fi-ET) O2% with end tidal sevoflurane concentration (ETsevo). The secondary outcomes were to correlate BIS with ETsevo and with the (Fi-ET) O2%.

Depth of sedation influences oxygen consumption (8). Awake patients and those on lighter planes will have more oxygen consumption as the use of anesthetic agents decreases the oxygen consumption, making an increase in (Fi-ET) O2 % >7(5). Apart from anesthetic depth, several factors can contribute in oxygen consumption. It includes adequate muscle relaxation, patient characteristics like age, weight, body temperature, pain, stress, sympathetic stimulation, cardiac output and sepsis (8). Hypo or hyperthermia was ruled out by continuous temperature monitoring. IV paracetamol was also given apart from fentanyl to provide adequate analgesia. Muscle relaxants were repeated as and when needed. We found after eliminating all confounding factors, the mean (Fi-ET) O2% increased from 14.75 at the baseline time point to a maximum of 15.33 at the extubation time point, in agreement with emergence from anesthesia and then decreased to 12.13 at the recovery time point when the patients settled and slept again. From the time of induction to end of surgery the (Fi–ET) O2% was in a median of 5 which can be attributed as within adequate depth of anesthesia. A similar study by Dias et al concluded that (Fi-ET) O2% >7 can be considered as light planes of anesthesia (5). So a median value 5 for (Fi- ET) O2% during maintenance anesthesia in our study can be considered an adequate depth anesthesia. However, we were unable to validate the above cut-off because there was no significant correlation and no ROC curve could be analyzed.

MAC was maintained between 1-1.3 during maintenance phase, this range was found within MAC range for adequate depth based on study by Davidson et al (9). Aranake et al in 2013 concluded that for the measurement of potency of inhaled anesthetics most commonly used is minimum alveolar concentration (6). In our study we found out that MAC value increased significantly as compared to baseline value and remained at equilibrium throughout the procedure till inhalational agent was cut down.

The ETsevo increased from a minimum of 0.00 at the Baseline time point to a maximum of 2.79 at the intubation time point, and then decreased to 0.00 at the recovery time point. During induction of anesthesia dial agent concentration of sevoflurane was increased up to 8% to attain a MAC value between 1-1.3 during intubation time, this could be the reason for high ETsevo value during intubation time point. Sevoflurane was used as inhalational agent as it was observed that sevoflurane based general anesthesia does not have significant adverse effects on the cognitive function of children (10). Sevoflurane is considered safe and maintains stable hemodynamics even in children with CHD (11). Other parameters like BIS, ETsevo, (Fi-ET) O2% also followed the similar trend in agreement with deeper planes of anesthesia. The mean MAC value increased from a minimum of 0.00 at the Baseline time point to a maximum of 1.13 at the intubation time point, and then decreased to 0.00 at the recovery time point.

Among the 63 children between the age group of 1-5 years participated in this study, a statistical significant change in BIS value was noted. The mean BIS decreased from 81.16 at the baseline time point to a minimum of 51.17 at the 15 Minutes time point, and then increased to 82.14 at the recovery time point. Decrease in the BIS value from baseline to time points thereafter can be explained by the deeper planes of anesthesia achieved in the patients. Children were pre medicated before wheeling in to the theatre and this could be the reason for lesser BIS value during baseline time point. A significant increase in BIS from pre arousal to post arousal in children was observed in a similar study (12).

The hemodynamic parameters showed a decrease from baseline after induction of anesthesia and increased at the recovery time point. These changes in hemodynamic parameters can be attributed to adequate depth of anesthesia and adequate analgesic cover. Mild increase from baseline in hemodynamic parameters during intubation can be attributed to laryngoscopy response. Mild excitements were observed in some children during intubation with sevoflurane anesthesia in a study conducted by Piat et al. Author also concluded that comparing with halothane anesthesia hemodynamic effects are minimal in sevoflurane anesthesia(8).

There was a moderate negative correlation between ETsevo (End of Surgery) and BIS (End of Surgery), and this correlation was statistically significant (rho = -0.48, p = <0.001). For every 1 unit increase in BIS (End of Surgery), ETsevo during corresponding time point showed a decrease by 0.03 units. BIS showed statistically significant correlation only in one point may be because of inadequate sample size and non- uniform distribution. Similarly, a statistically significant negative correlation was observed between BIS and ETsevo in a study conducted by McCann et al (13). On the contrary, Schwartz et al, in a study conducted on 240 pediatric patients about the use of bispectral index monitoring in children during maintenance anesthesia, observed that BIS values were variable and high in children unlike adults and concluded BIS is not a reliable monitor of anesthetic depth in children(7). Though BIS values followed the trend with MAC, ETsevo and (Fi-ET) O2% over different time points in sync with depth of anesthesia, the correlation amongst them was statically insignificant barring end of surgery time point in our study. This may be attributed to smaller sample size and non-normally distributed variables. This could also be because BIS is an EEG based indices for brain monitoring whereas (Fi-ET) O2% tells about the oxygen consumption of whole body rather than the oxygen consumption of brain alone.

CONCLUSION

For pediatric population receiving general anesthesia with N2O and Sevoflurane mixture, current methods of monitoring MAC values, ETsevo concentration hold their ground and while BIS monitoring and monitoring of (Fi-ET) O2% look promising and congruent, they need further studies with larger sample size to evaluate their correlation with MAC and ETsevo.

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