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Original Research Article

Haemodynamic stability and incidence of adverse events during tracheal intubation without neuromuscular blockade: comparison of clinical versus bispectral-index monitored depth of anaesthesia

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ABSTRACT

Background: Haemodynamic stability during intubation is influenced by sympathetic response to laryngoscopy and intubation. Furthermore, the incidence of adverse events during intubation without NMB warrants further investigation. BIS-guided anaesthesia has been associated with improved haemodynamic outcomes compared to clinical monitoring alone. Despite these advantages, the utility of BIS monitoring during intubation without NMB remains underexplored.
Methods: This was a randomised, single-blind, controlled clinical study conducted in the Jos university teaching hospital, Jos, Nigeria, among 56 children aged 2 to 6 years with ASA I and II scheduled for adenotonsillectomy. Patients were randomised into two groups, B and C, with patients in group B receiving BIS monitoring while those in group C received clinical monitoring for the depth of anaesthesia with sevoflurane and without a neuromuscular blocking agent. Haemodynamic changes and adverse events associated with laryngoscopy were noted. Data was analysed using SPSS with students' t test and chi-square test being the statistical tests utilised, and the level of significance set at p=0.05.
Results: Systolic blood pressures were slightly higher in group C than group B. Diastolic blood pressures were slightly higher in group B than group C, while differences in mean arterial pressure between group B and group C were not statistically significant (p=0.10). Adverse events were only found in group C, with 10.7% of patients developing laryngospasm.
Conclusions: The monitoring of inhalational induction using clinical signs is an acceptable alternative to BIS and can be used in the absence of BIS.

Keywords: Sevoflurane, Tracheal intubation, Anaesthesia depth, BIS, Clinical monitoring

INTRODUCTION

Haemodynamic stability during intubation is influenced by sympathetic stimulation caused by laryngoscopy and intubation. This results in tachycardia, hypertension, and potentially severe complications such as myocardial ischaemia, arrhythmias, or intracranial pressure elevation, especially in high-risk patients.[1-3] Maintaining an appropriate depth of anaesthesia is essential to attenuate these responses. The traditional approach relies on clinical signs such as heart rate, blood pressure, and movement to estimate anaesthetic depth. However, these parameters may not accurately reflect cerebral anaesthetic effects and can lead to either under- or overdosing.[4,5]

The bispectral index (BIS) monitor, a widely used processed electroencephalographic (EEG) device, provides an objective assessment of anaesthetic depth,

with a numerical range of 0 (complete suppression) to 100 (awake state). BIS-guided anaesthesia has been associated with reduced anaesthetic consumption, faster recovery, and improved haemodynamic outcomes compared to clinical monitoring alone.[6-8] Despite these advantages, the utility of BIS monitoring during intubation without NMB remains underexplored.

Studies comparing clinical versus BIS-monitored anaesthesia have yielded mixed results. While some evidence suggests that BIS-guided anaesthesia reduces the risk of haemodynamic fluctuations and adverse events, other studies have found no significant differences.[9-11] The variability in outcomes may stem from differences in study populations, anaesthetic techniques, and BIS target ranges. Furthermore, the incidence of adverse events such as inadequate anaesthesia, laryngospasm, or airway trauma during intubation without NMB warrants further investigation.[12,13]

This study aims to compare haemodynamic stability and the incidence of adverse events during tracheal intubation without NMB under clinical versus BIS-monitored anaesthesia. Understanding the relative efficacy of these approaches may guide anaesthetic management and improve patient safety in scenarios where NMB is contraindicated or avoided.

METHODS

This was a randomised, single-blind, controlled clinical study conducted at the Jos university teaching hospital, Jos, Plateau State, North Central Nigeria from Dec-2023 toJun-2024. The study was carried out amongst paediatric surgical patients. Inclusion criteria were patients aged 2 to 6 years with ASA physical status of I and II and scheduled for adenotonsillectomy. Exclusion criteria included parental/guardian refusal, recent respiratory tract infection, and patients with anticipated difficult airway or tracheal intubation. The sampling technique employed was purposive sampling. Patients were randomised by means of balloting into groups B and C. Patients in group B had BIS monitoring while those in group C had clinical monitoring for the depth of anaesthesia.

The sample size for this study was estimated from the formula for determination of sample size for experimental study design;[14]

$$n=(Z_\beta + Z\alpha_{/2})^2 \text{ X } 2\dot{P}\ (1 - \dot{P})/E^2$$

Where n=sample size per group, Z_β=desired power of the study, typically 0.84 for 80% power, $Z_{\alpha/2}$=normal deviate for two-tailed alternative hypothesis at a level of significance; for example, 5% level of significance, it is 1.96, $\dot{P}\ (1 - \dot{P})$ is a measure of variability similar to standard deviation, $\dot{P}=P_1+P_2/2$, P_1=proportion of the population with the desired condition, P_2=proportion of the population without the desired condition, $E=P_1- P_2$, which is the effect size, i.e., the difference in proportion. Therefore, for this study, P_1 was assumed from a previous study which was 0.7, and P_2 was 0.3.[15] Assuming the level of significance for this study was set at 5% and the power at 80%, then Z_β was 0.84 and $Z\alpha_{/2}$ was 1.96. Substituting these values into the formula above and assuming an attrition rate of 10% will give a sample size of 28 patients per group and therefore a total sample size of 56 patients.

Informed consent was obtained from the parents/guardians of children recruited into the study before the commencement of the study. All the recruited patients were reviewed a day prior to surgery. Preoperative assessment to create rapport, history of previous anaesthesia, URTI, asthma, and developmental milestones was done. A physical examination, including airway assessment, was carried out, and ASA physical classification was done. All investigations were reviewed and fasting guidelines given. As the patients presented to the modular theatre reception, they were randomised as earlier stated. All patients came to the theatre with an intravenous cannula mildly sedated from the ward and were accompanied by a nurse.

On arrival in the operating room, the theatre was already warmed, and the overhead radiant warmer was used. Drugs and doses appropriate for the patient's weight were calculated and written; tube size=(age in years)/4 + 4 was calculated, tube length in cm=(age in years)/2 + 12 (for an oral endotracheal tube), and standard monitoring, including pulse rate, non-invasive blood pressure NIBP (SBP, DBP) and MAP, pulse oximetry, $EtCO_2$, and electrocardiography, was instituted using the GE DASH 4000 multi-parameter monitor. The BIS monitor (cerebral state monitor model CSM Dan meter) was also connected to the patients in group B to take note of the baseline value of 0.

Premedication was administered to all patients with IV atropine 0.02 mg/kg and IV midazolam 0.20 mg/kg five minutes before pre-oxygenation and induction. The patients were placed on the operating table in the supine position with the head supported with a head ring at the occiput. The primary investigator of this project was the intubating anaesthetist for all the patients in the study to provide for consistency. Pre-oxygenation using 100% oxygen at 6 L/min. via the Ayres T piece with Jackson Ree's modification or Bain's circuit for the children weighing more than 25 kg was then commenced. Induction of anaesthesia was conducted with sevoflurane at 8%. The vital capacity method was employed with the concentration of sevoflurane increased at the rate of 1.5% per three breaths using a TEC7 vaporiser.

For the BIS monitoring group, the skin of the forehead was cleaned with methylated spirit before the application of the BIS sensor strip in accordance with the manufacturer's instructions. The end point of hypnosis was the attainment of a BIS value of 48. Using a Macintosh laryngoscope blade with the left hand, it was introduced into the right side of the mouth and used to deflect the tongue to the left.

The laryngoscope was lifted upwards and forwards with the tip inserted into the vallecula and pressure on the hyoepiglottic ligament to move the epiglottis so as to expose the vocal cords. External laryngeal manipulation was performed to aid visualization of the larynx in cases where difficulties were experienced. An appropriately sized preformed uncuffed endotracheal tube was inserted through the larynx. Confirmation of correct tube placement was carried out via capnography with an end-tidal CO_2 of 35 mmHg. The haemodynamic response (such as PR, SBP, DBP, MAP, and SpO_2 changes) to laryngoscopy and tracheal intubation was noted and recorded at 0, 1, 3, 5, 7, and 10 minutes. Adverse events of laryngoscopy and tracheal intubation (such as limb movement, coughing, laryngospasm, bronchospasm, and airway trauma) were noted and recorded.

For the clinically monitored group, the TEC7 vaporiser (which was also used for the BIS group) was used to administer the incremental concentration of 8% sevoflurane in 100% oxygen at 1.5% every three breaths until there was loss of eyelash reflex, and then patients were manually ventilated. Both pupils were checked with a pen torch every 30 seconds until the pupils became central and fixed, and the jaw relaxed. Tracheal intubation was then done as described earlier. Confirmation of correct tube placement was done via capnography with an end-tidal CO_2 of 35 mmHg. The haemodynamic response (such as PR, SBP, DBP, MAP, and SpO_2 changes) to laryngoscopy and tracheal intubation was noted and recorded at 0, 1, 3, 5, 7, and 10 minutes. Adverse events of laryngoscopy and tracheal intubation (such as limb movement, coughing, laryngospasm, bronchospasm, and airway trauma) were noted and recorded.

Data was collected and temporarily entered and stored in an Excel spreadsheet during the period of data collection. Confidentiality was maintained by storing patient identifiers with alphanumeric codes, and only individuals directly involved with this study had access to collected data. The data was analysed using the statistical package for the social sciences (SPSS version 23). The level of significance was set at p=0.05. The student's t test was utilised for comparison of continuous variables while the Chi-square test was utilized for comparison of categorical variables.

RESULTS

All the 56 patients enrolled in this study were included in the final analysis, having completed the study. The study participants had similar representation of males and females in the study groups (p=0.778). The mean ages were 3.29±1.329 and 3.43±1.425 years for the BIS and clinical groups, respectively (p=0.317). All participants in this study were ASA I (Table 1).

These baseline pulse rates represented the minimum in this study for both study groups. There were, however, increased pulse rates for both study groups at the assessed interval with a later return to near baseline values. No significant statistical differences were found in pulse rates between the study groups (Figure 1).

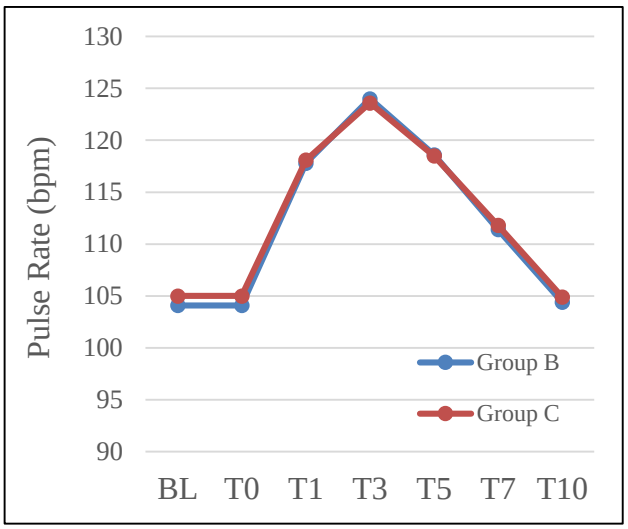

Figure 1: Mean PR at baseline and intervals between study groups.

No significant statistical differences were found in systolic blood pressure between participants of the study groups in the entire duration of the study. Systolic blood pressures were, however, slightly and generally higher in the clinical group than the BIS groups (Figure 2).

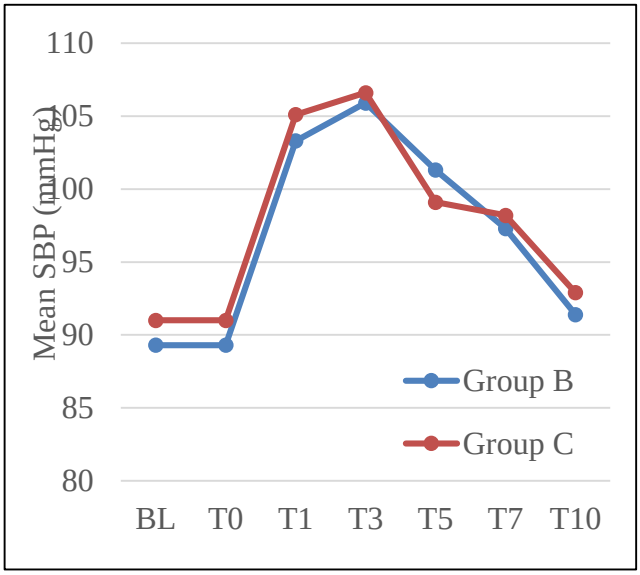

Figure 2: Mean SBP at baseline and intervals between study groups.

No significant statistical differences were found in diastolic blood pressure between participants of the study groups in the entire duration of the study. Diastolic blood pressures were, however, slightly and generally higher in the BIS group than the clinical groups (Figure 3).

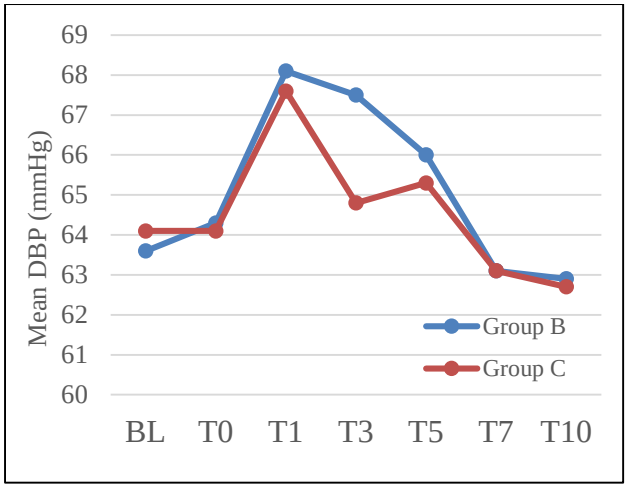

Figure 3: Mean DBP at baseline and intervals between study groups.

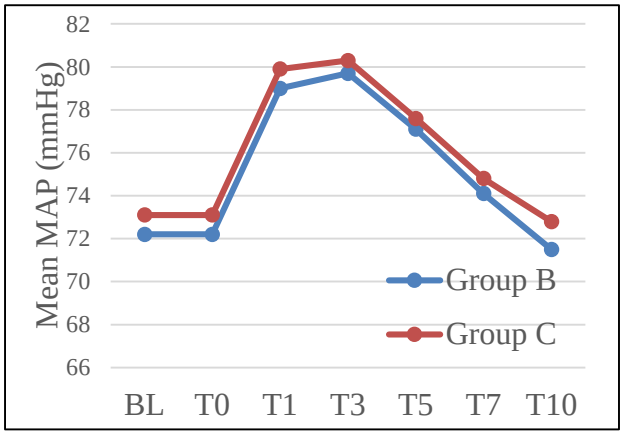

Figure 4: Mean MAP at baseline and intervals between study groups.

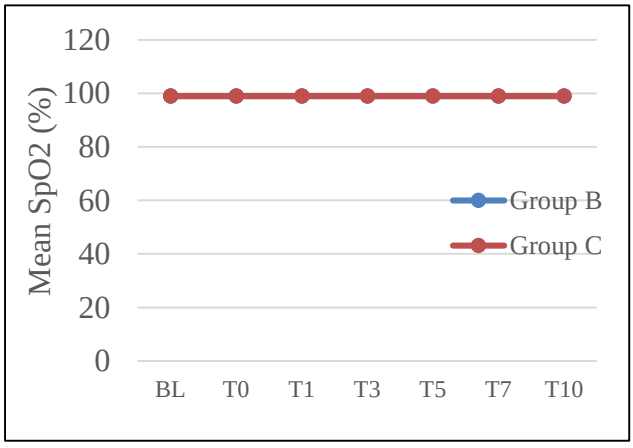

Figure 5: Mean SpO_2 at baseline and intervals between study groups. note: group B has been superimposed under group C.

The mean arterial pressures showed a slightly higher value for the clinical group compared to the BIS groups but were, however, not statistically significant (p=0.997). No significant statistical differences were found in mean arterial pressures between participants of the study groups in the entire duration of the study (Figure 4).

The mean oxygen saturation observed in the entire duration of this study among study participants and between both study groups was 99.00±0.000 percent (Figure 5).

Adverse events were only found in the clinical group and none in the BIS group. Three (10.7%) patients in the clinical group developed laryngospasm. Other adverse events such as cough, bronchospasm, airway trauma, and emergence delirium were not recorded in this study (Table 2).

Table 1: Characteristics of study participants in study groups.

Parameters	BIS	Clinical	P value
Sex (number/percent)			
Male	19	18	0.778
Female	9	10	
Age (Mean±SD) (in year)	3.29±1.329	3.43±1.425	0.317
ASA (number/percent)			
I	28 (100)	28 (100)	
II	0 (00)	0 (00)	

BIS: Bispectral index, ASA: American society of anaesthesiologists, SD: standard deviation.

Table 2: Incidence of adverse events between study groups.

Adverse events (number/ percent)	BIS	Clinical	P value
Cough	0 (0.0)	0 (0.0)	-
Laryngospasm	0 (0.0)	3 (10.7)	0.075
Bronchospasm	0 (0.0)	0 (0.0)	-
Airway trauma	0 (0.0)	0 (0.0)	-

DISCUSSION

Haemodynamic parameters often correlate with the depth of anaesthesia and the autonomic response to anaesthetic and/or surgical procedures. Most of the haemodynamic changes in this study were comparable, with no significant statistical difference in both study groups along the study time. This finding could be attributed to the autonomic (sympathetic) and stressor response to laryngoscopy and tracheal intubation, which probably caused the rise in the haemodynamic parameters and later a fall in the values to almost baseline values after the laryngoscopy and tracheal intubation.

The finding of this study is consistent with that of Singh et al who conducted a randomised controlled study to compare haemodynamic changes in children using fixed high concentration sevoflurane with incremental

concentration of sevoflurane for induction and intubation without muscle relaxants in paediatric patients.[16] Similarly, Emeema et al evaluated and compared the haemodynamic changes associated with the single-breath vital capacity technique with the tidal volume technique in children scheduled to undergo elective surgery using sevoflurane 8% in 100% oxygen.[17] They also demonstrated an initial rise in the haemodynamic parameters and then a gradual fall, but with the SpO_2 remaining the same throughout the study period. These findings are consistent with known effects of noxious stimulation of patients under general anaesthesia.[18]

In contrast to the finding in this study, Koshy and colleagues studied the effects of propofol and sevoflurane on haemodynamic changes in children scheduled for cleft lip/cleft palate/cleft alveolus surgery under general anaesthesia.[19] They found that the haemodynamic parameters decreased following laryngoscopy and intubation. This difference could be as a result of the use of IV lignocaine, IV fentanyl, and IV propofol given before laryngoscopy and tracheal intubation, which blunted sympathetic response to laryngoscopy. These drugs were not used in our study. Abdelhalim et al compared the haemodynamic effects of two different doses of propofol for tracheal intubation during sevoflurane induction without muscle relaxants.[20] They also found that the haemodynamic parameters decreased following laryngoscopy and intubation. This difference might also be due to the use of propofol and fentanyl, which are known to obtund the stressor response to laryngoscopy and intubation.

The incidence of adverse events in this study was low. Only 3 patients in the clinical group had laryngospasm. This finding may be attributed to a reduction of oral secretions by administration of an intravenous anticholinergic agent (atropine), oral suctioning, gentle laryngoscopy, and achieving a deeper plane of anaesthesia in both study groups (the use of a BIS value of 48 in the BIS group and clinical parameters in the clinical group) before laryngoscopy and tracheal intubation. Laryngospasm in the clinical group of this study was effectively managed by increasing the depth of anaesthesia and manually ventilating the patients. Devys and co-workers conducted a study to compare the incidence of adverse events after sevoflurane induction with or without rocuronium or alfentanil in children requiring general anaesthesia.[21] They found the incidence of laryngospasm in 7 (30%), 4 (33%) and 0 (0%) patients in the placebo, alfentanil and rocuronium groups respectively, $p<0.005$. This minimal adverse event is similar to the finding in the clinical group of this current study. This similarity might be because the same concentration of sevoflurane was used in their study.

Soulard et al conducted a study to determine the sufentanil dose needed to facilitate intubation under excellent conditions after induction with various end-tidal concentrations of sevoflurane without neuromuscular block in 63 children aged 2 to 8 years.[22] They found minimal incidence of laryngospasm (4.76%) which was similar to the finding in the clinical group of this current study. Salawu et al reported similar findings of laryngospasm in the sevoflurane group in their study.[23] It was found that 2 (6.1%) patients had laryngospasm in the sevoflurane group against none in the propofol-suxamethonium group in their study. Redhu et al reported no cough, bronchospasm, or limb movement in their study, which is similar to the finding in this current study.[24] Coughing in children from laryngoscopy may occur when adequate depth of anaesthesia is not achieved. Kumar et al and Naziri et al also reported no coughing, limb movements, hypoxia, bradycardia, or laryngospasm or bronchospasm in any of their patients when they conducted tracheal intubation using sevoflurane without muscle relaxant.[25,26]

Imran and colleagues conducted a prospective randomised study to compare high concentration primed circuit technique with single-breath vital capacity technique of induction of anaesthesia using 7% sevoflurane in a 2:1 N_2O; O_2 ratio at flow of 6 L/min for a min and their finding was different from what was found in clinical group in this study.[27] They found no incidence of adverse event. This difference might be due to addition of nitrous oxide to sevoflurane in their study. Consistent with finding of Imran and colleagues is study by Tejesh et al who did comparative randomised study to determine induction and intubation characteristics of sevoflurane and halothane.[28] They reported that none of children had complications like laryngospasm/hypoxia during/ immediately after tracheal intubation in their sevoflurane group.

CONCLUSION

In the absence of muscle relaxant during inhalational induction with sevoflurane, when the depth of anaesthesia was monitored using either clinical signs or BIS in the absence of muscle relaxants during induction with sevoflurane, the haemodynamic changes and incidence of adverse events were similar in both situations. The monitoring of inhalational induction using clinical signs is an acceptable alternative to BIS and can be used in the absence of BIS.

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