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Original Research Article

Intubation without Muscle Relaxants: Sevoflurane Vs Halothane, A Comparison of Intubation Characteristics

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Abstract

Endotracheal intubation is one of the most important procedures undertaken during the induction of general anaesthesia for securing a patent airway. The administration of muscle relaxants has been associated with enormous side effects which include among others hyperkalaemia, raised intraocular and intracranial pressures, malignant hyperthermia, cardiac arrest and even death. Children are at an increased risk of desaturation, laryngospasm and airway obstruction during induction of anaesthesia. Induction in this group of patients is preferred with potent inhalational agents which can be used as an alternative to muscle relaxants to facilitate tracheal intubation and to further avoid the side effects mentioned. A randomized double blinded study conducted on 110 ASA I and II children aged less than five years who were scheduled for elective surgery under general anaesthesia were included and were randomly assigned into (2) groups namely groups S and H. Children in Group S were induced with sevoflurane to an end tidal concentration of 8% while those in group H were induced with halothane to an end tidal concentration of 2%. Laryngoscopy and tracheal intubation were attempted after the end-point was reached in both groups. The intubation conditions were assessed with the Steyn's modification of Helbo-Hansen intubation condition score. A total score of ≤ 10 was considered clinically acceptable while a score > 10 was considered clinically unacceptable. Statistical analysis was performed by using the unpaired t-test and the Chi-square test. Significantly shorter time of induction was achieved in patients in group S compared to those in group H (p = 0.01). The overall intubation conditions were clinically acceptable in 98% and 92.7% in groups S and H respectively with no statistically significant difference, (p = 0.18). The commonest complications observed during this study were breath-holding (7.3%), laryngospasm (5.5%) and cough (3.6%) in group S while, in group H bradycardia (7.3%), breath-holding (5.5%) and hypotension (3.6%) were the commonest complications observed. The induction characteristics, haemodynamic variables and complications observed were comparable among the study groups, however, sevoflurane provided significantly shorter time of induction of anaesthesia compared to halothane.

Keywords: Ease, Safety, Sevoflurane, Halothane, Tracheal intubation

INTRODUCTION

Endotracheal intubation is the placement of an endotracheal tube (ETT) into the trachea to maintain an open airway. It is one of the most important procedures undertaken during the induction of general anaesthesia for securing a patent airway. The need to achieve a smooth and safe intubation in children is very essential due to the fact that they have low respiratory reserve with high basal metabolic rate hence, they can easily become hypoxic (Shaik and Bellagali, 2010). During the process of endotracheal intubation, the patient should be relaxed to allow for an ease of manipulation of cervical, maxillofacial and pharyngeal structures for ease of laryngoscopy and tracheal intubation (Steyn et al., 1994). The ease with which endotracheal intubation is achieved depends on technical proficiency, depth of anaesthesia and degree of muscle relaxation (Bithal et al., 2000).

There are various modalities employed to achieve the above stated goals which among others include the use of a short acting depolarizing muscle relaxant (e.g. suxamethonium), short acting non-depolarizing muscle relaxants (e.g. Mivacurium), intermediate and long acting non-depolarizing muscle relaxants such as atracurium and pancuronium respectively and also without the use of any muscle relaxant but with only inhalation agent or a combination of inhalational and intravenous agents. Suxamethonium is the commonest muscle relaxant in use; however, it is associated with a life threatening allergic reaction, arrhythmia, prolonged respiratory depression or apnoea (Woods and Allam, 2005; Robinson et al., 1996).

The use of a non-depolarizing muscle relaxant may lead to prolonged neuromuscular blockade, potentiate histamine release and inability to quickly reverse the blockade in the event of an unexpected difficult intubation (Robinson et al., 1996).

Halothane, a volatile anaesthetic agent which is cheap, readily available, non-irritant and pleasant to breathe and has rapid loss of pharyngeal and laryngeal reflexes can be the drug of choice for tracheal intubation when the use of a muscle relaxant is not desired (Yakaitis et al., 1977).

Sevoflurane is a volatile anaesthetic agent with a pleasant smell, non-irritant to airway, with fast and smooth induction and also smooth and rapid recovery from anaesthesia. Its use is associated with an acceptably low incidence of postoperative nausea and vomiting (PONV). Sevoflurane when in use maintained the cardiac output well over the normal anaesthetic maintenance doses. It is however expensive, not readily available and also unstable with carbon dioxide absorber (Chawathe et al., 2005; Bordes and Cros, 2006).

Attempts have been made to intubate the trachea without the use of muscle relaxants with some successes and also studies were conducted to determine and compare the ease and safety of tracheal intubation without the use of muscle relaxants but with only induction agents (intravenous and inhalational induction agents) (Bordes and Cros, 2006). This study compared the ease and safety of the use of sevoflurane and halothane for tracheal intubation in children under the age of five years for general anaesthesia.

PATIENTS AND METHODS

This study was a randomized, double-blinded study carried out at the main operating theatre of Federal Teaching Hospital, Gombe state. Ethical approval was obtained from the hospitals ethical and research committee. A total of one hundred and ten (110) ASA I and II children who have not reached their fifth birthday (under-fives) scheduled for elective surgery under general anaesthesia with endotracheal intubation were recruited for the study. Exclusion criteria were ASA III and IV, previous history of difficult airway or anticipated difficult intubation. Family history of malignant hyperthermia, known allergy to drugs used was also considered and all emergency surgeries were also excluded.

Each patient while in the operating theatre was placed supine on the operation table and multi-parameter monitor and precordial stethoscope were attached and baseline vital signs (heart rate, non-invasive blood pressure, arterial oxygen saturation, electrocardiography (ECG)] were taken and recorded. All patients were allowed to breath either 2-3% sevoflurane or 1-2% Halothane in100% oxygen at 5-8 litres/min using facemask connected to Ayres T-piece breathing circuit with main stream capnograph connected to Datex-Ohmeda monitor with pulse oximeter attached until the SpO_2 is 100%. Anaesthetic machines used were the PENLON SIGMA DELTA (Penlon limited, Abingdon Oxon, OX14 3PH, UK) and AEON 7500A (Beijing Aeonmed Co. LTD).

Laryngoscope blade and endotracheal tube (ETT) size was at the discretion of the researcher but was guided by the formula n/4 + 4 in sizing of the ETT, where n is the age of the patient in years. Stylet was placed in all the ETT to provide the researcher with the best opportunity to place the ETT successfully.

Patients in group S were given incremental doses of Sevoflurane to induce sleep and allow for intravenous cannulation on the dorsum of the hand with sizes 24, 22 and 20G depending on the patient's age and visibility of veins. Intravenous fluid 4.3% dextrose in 0.18% saline was used as the maintenance fluid of choice given via a soluset and calculated according to the 4-2-1 formula with $4mlkg^{-1}$ for the first ten kilograms, $2mlkg^{-1}$ for second ten kilograms and $1mlkg^{-1}$ for subsequent ten kilograms. The deficit was calculated by multiplying the maintenance to duration of fasting and half of the deficit was replaced in the first hour of the surgery. The remaining deficit was divided into two equal parts and each half plus the ongoing losses were replaced over an hour. All the patients were premedicated with $0.01mgkg^{-1}$ atropine and $1\text{-}2\mu gkg^{-1}$ fentanyl intravenously at induction. The research assistant administered incremental dose of sevoflurane during induction using the modified patient controlled induction at the rate of 1% increase after every four (4) breath until the 8% mark on the control dial has been reached. Once the end point has been reached, defined by MAC_{EI} concentration of sevoflurane of 8% and end tidal carbon dioxide of 30-35mmHg, the research assistant informed the researcher who has been waiting in the induction room while noting the time taken to reach the end point. Laryngoscopy and tracheal intubation was attempted by the researcher at this point.

Patients in group H on the other hand received incremental doses of Halothane to induce sleep and allow for venous cannulation with similar sizes of

Table 1. Socio-demographic characteristics among the study groups.

Characteristics	Group S n = 55	Group H n = 55	p-value
Age (months)	10.82 ± 3.35	11.41 ± 4.08	0.42
Gender (M/F)	2.67:1	1.89:1	0.41
Weight (kg)	10.12 ± 4.14	10.34 ± 3.94	0.61
ASA I n (%)	38(69.01)	41(74.55)	0.53
II n (%)	17(30.91)	14(25.45)	

Table 2. Time to reach end point in the two study groups

Time (secs)	1-100 n (%)	101-200 n (%)	201-300 n (%)	301-400 n (%)	Total n (%)	Mean ± SD	p-value
Group S	-	16(29.1)	39(70.9)	-	55(100)	250.18±54.73	0.01
Group H	-	11(20)	42(76.4)	2(3.6)	55(100)	281.25±73.54	

cannula as those in group S.

The research assistant administered incremental dose of Halothane during induction using the modified patient controlled induction at the rate of 1% increase after every four (4) breath. Once the end point has been reached, defined by an end tidal concentration of Halothane of 2% and end tidal carbon dioxide of 30-35mmHg, the research assistant informed the researcher while noting the time taken to reach the end point. Laryngoscopy and tracheal intubation was attempted at this point by the researcher.

Laryngoscopic view was assessed using the Cormach and Lehane grading at laryngoscopy.Conditions for endotracheal intubation were assessed by the researcher using the modified Helbo-Hansen scoring system.

Complications arising from induction, laryngoscopy and intubation such as breathe holding bradycardia, hypotension, desaturation, laryngospasm, coughing and vomiting were noted and documented. In the event of difficult laryngoscopy, anaesthesia was deepened with intravenous 2.5mgkg^{-1} propofol and intravenous 2mgkg^{-1} suxamethonium was given to facilitate intubation.

Vital signs such as heart rate, non-invasive blood pressure, oxygen saturation and electrocardiography were recorded. Ten minutes after intubation, all patients were given intravenous 0.5mgkg^{-1} atracurium for muscle relaxation when spontaneous respiration resumed and anaesthesia was maintained with 1-2% Isoflurane in all the groups. Patients were ventilated at 20-25 breathe per minute with a tidal volume of 7-10mlkg^{-1} body weight to maintain end tidal carbon dioxide between 30-35mmHg. Intraoperative analgesic was 10-15mgkg^{-1} Paracetamol (Surex) and 1mgkg^{-1}Diclofenac (Jawa) intravenously.

At the end of the surgery, airway was suctioned, all inhalational agents turned off and residual neuromuscular blockade was reversed with 0.04mgkg^{-1} neostigmine and 0.02mgkg^{-1}atropine. The patients were extubated when spontaneous breathing returned in regular pattern and patient was fully awake. Oxygen was given via facemask to maintain arterial oxygen saturation between 98 – 100%. All patients were transferred to the recovery room and handed over to the recovery nurse for continuous monitoring.

Statistical package for social sciences (SPSS) 19.0 for windows (SPSS Inc., Chicago, IL, USA) installed on a personal computer was used for statistical analysis. All values were expressed ± standard deviation (SD) and were presented in tables and charts. Qualitative data were analyzed by Chi-square test. Quantitative data were analyzed by unpaired t-test. Intra-group analyses were conducted using t-test with repeated measurement. A p-value of less than 0.05 was regarded as significant and p-value less than 0.01 highly significant.

RESULTS

There was no statistically significant difference in the sociodemographic characteristics between the two groups as shown in table 1 The mean time taken to reach the end point was 250.18±54.73s and 281.25±73.54 s in groups S and H respectively and it was statistically significant (p = 0.01) as shown in table 2. The overall intubating conditions were acceptable in 98% and 92.7% of patients in groups S and H respectively. There was no significant difference between the two groups, (P=0.18). In 50(91%) of the patients in group S, excellent intubating condition defined by Helbo-Hensen score of 5 was seen, while 4(7%) had good intubating condition defined by a score ranging between 6 and 10 and only 1(2%) patient had poor score defined by a score of 11-15. In group H, 4(7.3%) patients had a poor score while 42(76%) and 9(16%) had excellent and good intubating condition respectively as shown in tables 3 and 4. There was no statistically significant differences (p = 0.99) between the two groups with respect to Cormach and Lehane grading as shown in table 5. The mean baseline preoperative HR, SBP, DBP, MAP, SpO_2, were comparable in both groups and there was no statistically significant difference

Table 3. Ease of tracheal intubation among the study groups

Parameter	Groups	Easy n (%)	Fair n (%)	Difficult n (%)	p-value
Ease of laryngoscopy	Group S	50(90.1)	5(9.9)	-	0.18
	Group H	44(80.1)	11(20)	-	
Position of vocal cords	Group S	48(87.3)	6(10.9)	1(1.8)	0.18
	Group H	45(81.8)	8(14.5)	2(3.6)	
Degree of coughing	Group S	54(98.2)	1(1.8)	-	0.50
	Group H	53(96.4)	2(3.6)	-	
Limb movements	Group S	51(92.7)	4(7.3)	-	0.09
	Group H	49(89.1)	6(10.9)	-	
Jaw relaxation	Group S	52(94.5)	3(5.5)	-	0.24
	Group H	50(90.1)	5(9.9)	-	

Table 4. Steyn modification of Helbo-Hansen scoring system among the study groups

Group	Excellent n (%)	Good n (%)	Poor n (%)	Bad n (%)	p-value
S	50 (91%)	4 (7%)	1 (2%)	-	0.09
H	42 (76.3%)	9 (16.4%)	4 (7.3%)	-	

Table 5. Complications/side effects observed during induction of anaesthesia among the study groups

Parameters	Group S n (%)	Group H n (%)	p-value
Laryngospasm	3(5.5)	1(1.8)	0.49
Coughing	2(3.6)	1(1.8)	0.99
Breath holding	4(7.3)	3(5.5)	0.50
Hypotension	-	2(3.6)	
Bradycardia	-	4(7.3)	
Desaturation	-	-	
Total n(%)	9(16.4)	11(20.0)	

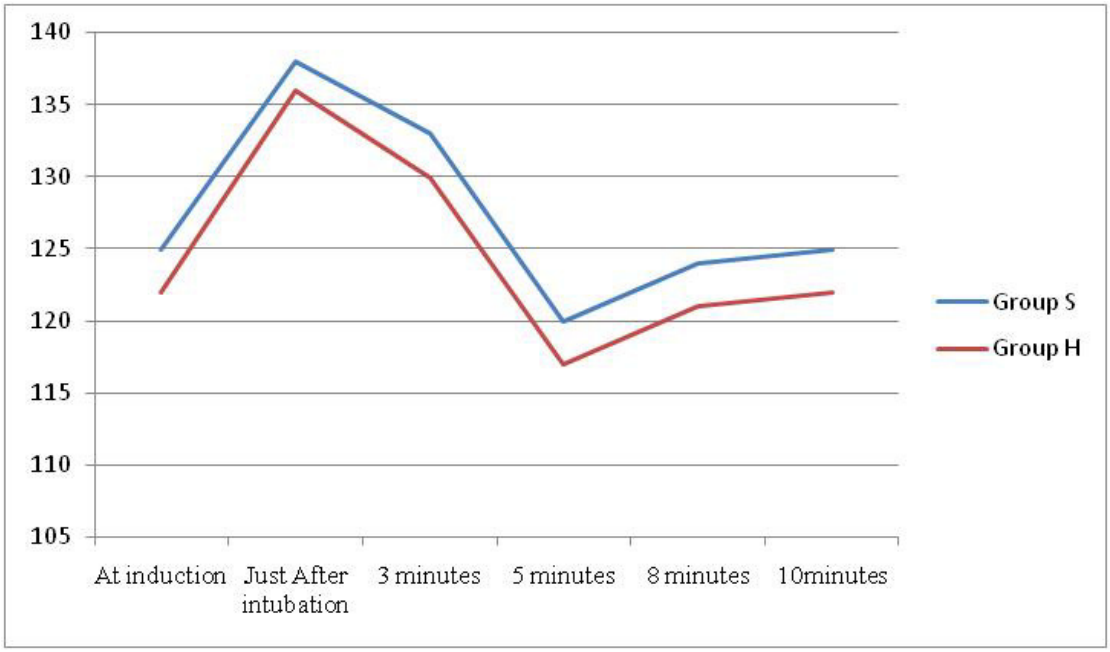

Figure 1. Trends of perioperative mean heart rate (beats/minutes) among the study groups

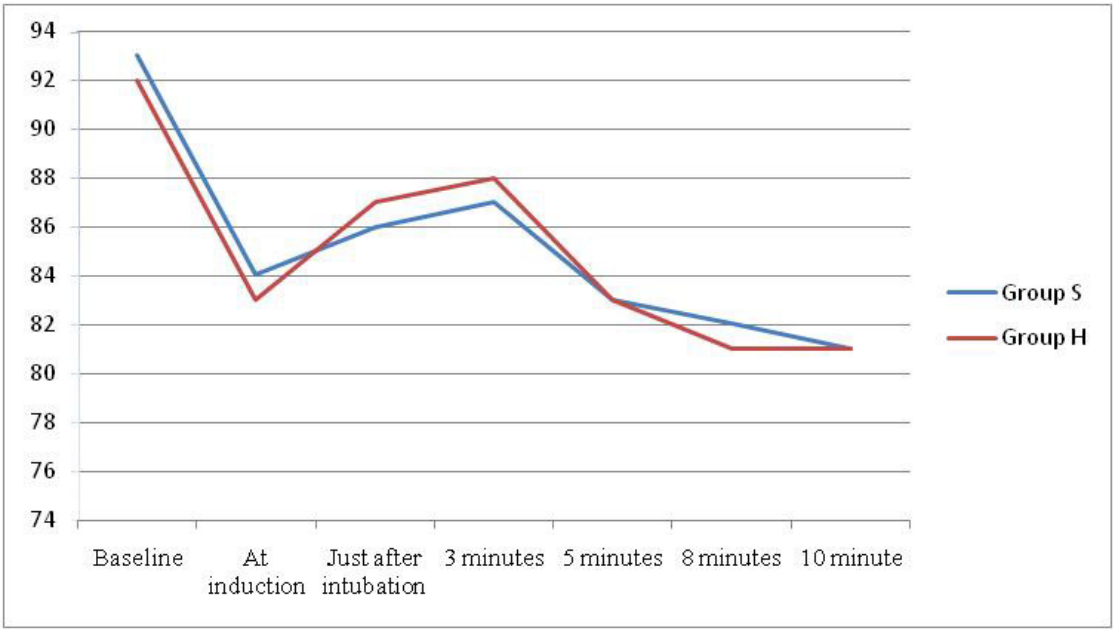

Figure 2. Trends of perioperative mean systolic blood pressure (mmHg) among the study groups

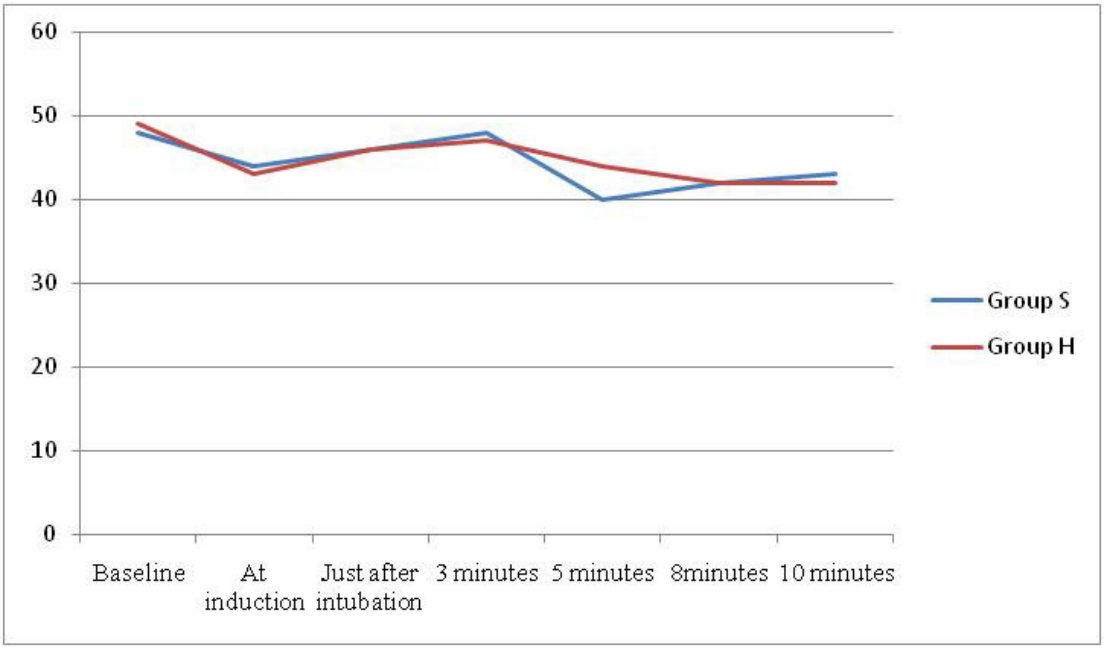

Figure 3. Trend of perioperative mean diastolic blood pressure (mmHg) among the study groups

between the two groups. The mean heart rate during the induction of anaesthesia decreased gradually in both groups with no significant differences but gradually increased immediately after tracheal intubation up to the third minutes in both groups with patients in group S showing slightly higher heart rate but it was not significant, (p = 0.65). However, HR began to return to base line values after the fifth minutes and was maintained up to the tenth minute as shown in figure 1.

The mean SBP and MAP as shown in figures 2 and 4 respectively remained stable and were comparable in both groups. There were no significant differences between the two groups. However, there was significant drop in DBP at the fifth minute in group S (P = 0.04) after intubation which persisted up to the tenth minute as shown in figure 3.

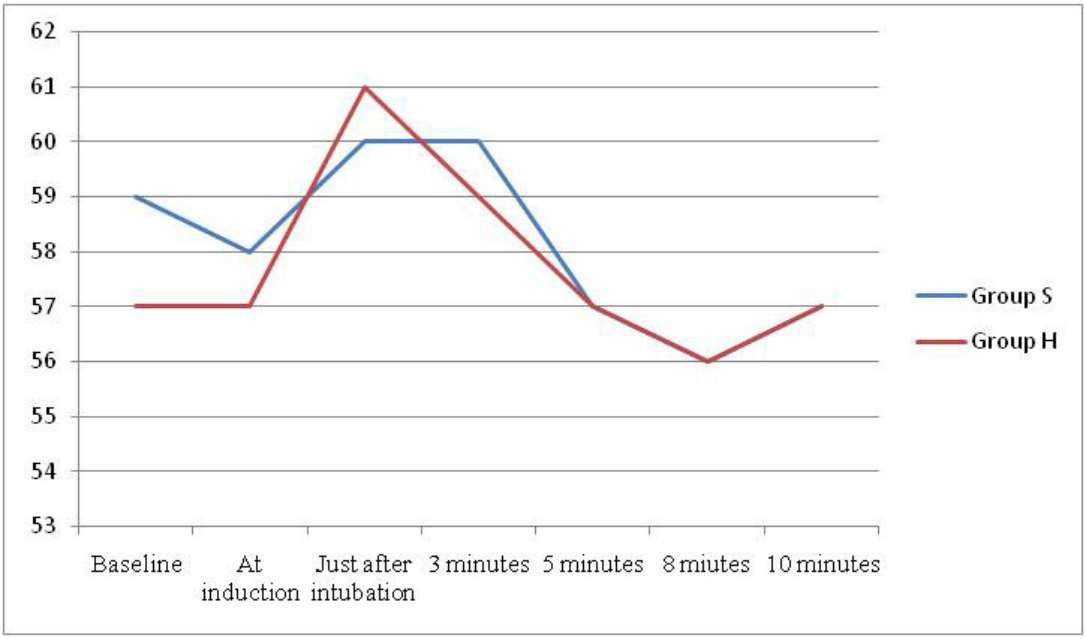

Figure 4. Trend of perioperative MAP (mmHg) among the study groups

The mean oxygen saturation during induction of anaesthesia, tracheal intubation, maintenance of anaesthesia, emergence of anaesthesia and in the immediate post-operative period was 99% in both the study groups. However, there were no changes in ECG seen in all the patients in both groups throughout the research.

Generally, complications/side effects of the procedures were minimal, however, among the two study groups, the commonest complications observed in this study were breath holding with 4(7.3%) and laryngospasm 3(5.5%) in group S, while in group H patients, the commonest complications observed were bradycardia 4(7.3%) followed by breath holding 3(5.5%). However, hypotension and bradycardia were observed only in group H as shown in table VI.

DISCUSION

Induction of anaesthesia using inhalational method is one of the most common methods of induction employed in paediatric practice (Bithal et al., 2000). The need to secure an intravenous line in an awake child is psychologically traumatic and unpleasant to the child making inhalational induction a common and popular method of induction in children (Bithal et al., 2000; O'brien et al., 1998; Paris et al., 1997). The wide availability and cheapness of Halothane in developing countries such as Nigeria makes is the most commonly used agent for induction of anaesthesia in children. However it has been associated with disadvantages such as myocardial depression, sensitization of myocardium to catecholamines, and rarely the serious complication of hepatitis (Yakaitis et al., 1977). Sevofluraneon the other hand has minimal effects on the cardiovascular system and has rapidly gained popularity as the inhalational agent of choice in paediatric anaesthesia despite is cost implication for developing nations.

This study demonstrate that successful tracheal intubation in children aged less than 5 years is achievable by inhalational agents; either Sevoflurane or Halothane without the use of any muscle relaxant.

In this study, the revised Helbo-Hensen-Raule and Trap Anderson's scoring system (Helbo-Hansen et al., 1988) was used to compare the ease of tracheal intubation in patients induced with sevoflurane compared to those induced with halothane. All the five parameters (ease of laryngoscopy, position of vocal cords, degree of coughing, degree of jaw relaxation and limb movement) were assessed individually and there was statistically no significant difference ($p > 0.05$) between the two groups. Although the overall intubation conditions were clinically acceptable in 98.2% and 92.7% of the patients induced with sevoflurane compared to those induced with halothane, visualization of the vocal cords was difficult in 1.8% and 3.6% of patients in groups S and H respectively. This was however statistically not significant ($p = 0.18$). Limbs movement were observed in about 7% and 11% of patients in Sevoflurane and Halothane respectively, this was statistically not significant ($p = 0.09$).

Similar result with this present study was obtained by (Bithal et al., 2000; Sabapathy et al., 2011; Rajan et al.,

2014; Terjesh et al., 2017; Hussein et al., 2011) when they compared the induction characteristics of sevoflurane and halothane. Although Terjesh et al. (2017) encountered significant difficulty ($p < 0.05$) with visualization of the vocal cord and excitation 27% and 40% of patients in the halothane group and sevoflurane group respectively. Excitation was difficult to assess in this present study due to small age group.

In a similar study by O'brien et al., (1998) that used similar methodology with this present study and also other studies, different results were reported. O'brien et al., (1998) found better intubation condition with the halothane group (60%) compared to 35% in the sevoflurane group when they compared the use of sevoflurane or halothane in forty (40) children aged 3-10years. They reported no significant difference between the sevoflurane group and the halothane two groups with respect to laryngoscopy, degree of jaw relaxation, limb movement or jaw relaxation, however, vocal cords were more likely to be moving or closing in the sevoflurane group ($p = 0.01$). Despite the fact that this present study and other previous studies used similar methodology with O'brien et al., (1998), only O'brien et al., (1998) reported superiority of halothane over sevoflurane with regards to ease of tracheal intubation and the reason(s) could not be ascertained.

The commonest complications observed in this study were breath-holding (7.3%), laryngospasm (5.5%) and coughing (3.6%) in patients induced with Sevoflurane however, in those induced with Halothane, the observed complications were Bradycardia (7.3%), breath-holding (5.5%), hypotension (3.6%) and coughing (1.8%). Complications obtained from this study were similar to those obtained by Paris et al, Al-Khraysha et al,Delhia et al and Plastow et al. However, (Sarner et al., 1995; Ariffin et al., 1997) reported excitement as a complication in addition to coughing, breath-holding and laryngospasm. This may not be unconnected with the fact that the study population where older (up to 12 years) compared to 0-5 years in this present study.

CONCLUSION

This study revealed that the ease and safety of tracheal intubation using either sevoflurane or Halothane were comparable among the study groups. Both inhalational agents can be safely used as induction agents especially in children aged less than five years when there is no contraindication to their use.

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