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Tracheal intubation in children using sevoflurane without muscle relaxant. A novel approach using apnea as clinical indicator

[1]N. Kumar, [2]D. Galante, [3]K. B. Shetty

[1]Consultant, Department of Anesthesia and Intensive Care, Naryana Nethralaya Eye Hospital, Narayana Hrudalaya Campus, Bangalore, India.
[2]University Department of Anesthesia and Intensive Care, University Hospital Ospedali Riuniti, Foggia, Italy
[3]Senior Consultant Opthalmologist and Chairman, Naryana Nethralaya Eye Hospital, Narayana Hrudalaya Campus, Bangalore, India.

Corresponding author: [1]N. Kumar, Consultant, Department of Anesthesia and Intensive Care, Naryana Nethralaya Eye Hospital, Narayana Hrudalaya Campus, Bangalore, India. Email: dr.narendra.mehta@gmail.com

Key points

Tracheal intubation based on induction time using sevoflurane supplemeted by low dose propofol showed 100% success without any complications in the age group one year to 6 years, so that it can be commonly used in our clinical practice.

Abstract

Introduction

Many clinical indicators for tracheal intubation in children using sevoflurane without muscle relaxant have been used. None of the study showed 100% excellent intubating conditions. A single large study showing 80% excellent intubating conditions, noticed that persistence of spontaneous ventilation before intubation had very poor intubating conditions. So, our study aimed to achieve apnea based on induction time using sevoflurane before intubation and observe the intubating conditions and hemodynamic variations in one hundred and fifty ASA I and II patients aged between one year to six years posted for ophthalmic procedures under general anaesthesia.

Methods

Based on the results of pilot study, all patients were induced with sevoflurane in 100% oxygen with 7 L/min flow via facemask. Glycopyrrolate 0.06 mg/kg, fentanyl 1 mcg/kg was given intravenously. Induction was done in slow incremental manner upto 8 vol% for 4.5 min (0 vol% to 8 vol% over 2.5 to 3 minutes). Propofol 1 mg/kg was given intravenously at 4.5 min. Ventilation was controlled after achieving apnea on their own based on capnography and respiratory pattern by positive pressure mask ventilation. Laryngoscopy and tracheal intubation was performed at 5.5 minutes. Intubating conditions were assessed using Steyn's modification of Helbo-Hansen scoring system and hemodynamic parameters were measured at 0, 3, 4.5, 5.5 and 6.5 minutes after induction.

Results

96 out of 150 patients achieved apnea at 4.5 min and all 150 patients achieved apnea after giving propofol 1 mg/kg. Intubating conditions were excellent in all the cases without any complications. There was decrease in HR at 5.5 min compared to 3 min. There was decrease in Systolic and Diastolic blood pressure at 3, 4.5 and 5.5 minute intervals when compared to baseline value at 0 min (at 5.5 minutes was 15.58% and 12.75% compared

to baseline respectively.

Conclusions

Apnea was achieved and excellent intubating conditions were observed in all the patients without any complications during induction with sevoflurane of 8 vol% by 5.5 minutes beforelaryngoscopy and tracheal intubation.

Keywords: Pediatric anaesthesia, sevoflurane, airway management, propofol, inhalational, ambulatory anaesthesia.

Introduction

There are many clinical indicators for tracheal intubation in children using sevoflurane without muscle relaxant. It can be based on physical examination[1], changes in blood pressure (BP), heart rate[2] (HR), or respiratory pattern, induction time[3,6], end-tidal (ET) sevoflurane concentration[4] and Bispectral index[5]. Though all the parameters have been used in many studies, none of the study showed 100% percent excellent intubating conditions in tracheal intubation without any complications. The presence of physical examination end points, such as constricted centralized pupils, may frequently result in successful tracheal intubation[1]. But such end points are considerably more subjective than induction time and many patients may be ready for laryngoscopy before clinical criteria are met[1]. Hemodynamic markers of readiness may not be useful with sevoflurane, because HR and BP change minimally[2] and may even increase during sevoflurane induction[7]. Study in adults using BIS monitoring, provided 90% excellent intubating conditions in tracheal inutubation using sevoflurane remifentanil propofol combinations[5]. But, its efficacy in pediatrics, availability and high cost limits its use.

Some studies have determined the ET sevoflurane concentration required for achieving 50 successful intubation of children, waiting for at least 15 min before intubation to allow for equilibration of sevoflurane concentrations[8,9]. Some studies have used sevoflurane, propofol and sevoflurane, high dose opoids, but none of them showed cent percent success without any complications. A single large study[6] based on induction time using sevoflurane showed 80% success in tracheal intubation and noted that persistence of spontaneous ventilation during induction had very poor intubating conditions. So, our study aimed to achieve apnea before intubation using induction with sevoflurane based on induction time supplemented by propofol (1mg/kg) and fentanyl (1 mic/kg) and observe the intubating conditions and hemodynamic variations in the patients aged between one year to six years posted for ophthalmic procedures under general anaesthesia.

Methods

After receiving approval from institutional ethical committee and informed consent, one hundred fifty ASA I and II patients aged one year to six years posted for ophthalmic procedures under general anaesthesia from August 2013 to July 2014 in the hospital were enrolled in the study. All patients were scheduled to receive an endotracheal tube (ETT) during an elective procedure posted for ophthalmic surgeries. Patients having difficult intubation, upper respiratory tract infection, any musculoskeletal disorder, history of malignant hyperthermia and allergic to anaesthetic drug were excluded from the study. Initially a pilot study was done in thirty patients aged one year to six years selected randomly into three groups of five patients each to determine the induction time using sevoflurane required for achieving apnea in atleast 80% of the cases so that it can be later supplemented by propofol (1 mg/kg) to achieve apnea in all patients, reduce the induction time and suppress the laryngeal reflex during laryngoscopy and intubation. Intravenous line was inserted in the preoperative area, glycopyrrolate 0.06 mg/kg and fentanyl 1mcg/kg were given. Patients were induced with sevoflurane in slow incremental manner upto 8 vol % in 100% oxygen of 7L/min (0 vol% to 8 vol% over 2.5 to 3 minutes) via facemask. Patients were allowed to achieve apnea on their own. Respiratory pattern was observed. Subsequent times were allocated for each succeeding group of five patients by using a modification of the allocation scheme used by Dixon and Mood[10]. The algorithm for chan-

ging the induction time was designed to cluster our sample points around the induction time that would achieve apnea in atleast 80% of patients[6]. Rather than following Dixon and Mood's method of increasing or decreasing the induction time after each patient, changes were made in the induction time after each group of five consecutive patients[6], depending on whether an 80% success rate was reached. Therefore, success in exactly four of five patients dictated no change in the succeeding group's induction time, whereas more or lesser success dictated a 30-s decrease or increase, respectively. It was found that 80% of patients achieved apnea in 4.5 minutes. So, 4.5 minutes was made as standard time and propofol (1 mg/kg) was given at 4.5 minutes to facilitate apnea in the next three groups of five patients each aged between one year to six years selected randomly. It was found that, apnea was achieved in all the patients without much hemodynamic alteration after giving propofol. Ventilation was controlled by positive pressure mask ventilation after achieving apnea by the patients on their own. Ventilation was made as uniform as possible with the help of capnography (35-45 cm H_2O). Laryngoscopy and tracheal intubation was done at 5.5 minutes. It was found that the intubating conditions were excellent in all the cases without much hemodynamic alterations and any complications. Because of the encouraging results of the pilot study, it was extended to study the same in one hundred and fifty patients aged between one year to six years posted for ophthalmic surgeries under general anaesthesia. Intravenous line was inserted in the preoperative area. Upon their arrival in theater, all the monitors like pulse oximeter, electrocardiogram, non invasive blood pressure, end tidal carbon dioxide, and alveolar gas monitoring were attached and monitored continuously. All patients were induced with sevoflurane in 100% oxygen with 7 L/min flow) via facemask.. Induction was done in slow incremental manner upto 8 vol% (0 vol% to 8 vol% over 2.5 to 3 minutes) for 4.5 min using Jackson Rees circuit. Glycopyrrolate 0.06 mg/kg, fentanyl 1 mcg/kg were given intravenously. Airways were managed by single anesthesiologist to avoid observer's variability. An oral airway was inserted, if there is an obstruction in the airway. $ETCO_2$ measurements and respiratory pattern were monitored through induction for adequate ventilation. Ventilation was controlled by positive pressure mask ventilation after achieving apnea by the patients on their own. Ventilation was made as uniform as possible with the help ofcapnography (35-45 cm H_2O). Laryngoscopy and tracheal intubation was done at 5.5 minutes. The appropriateness of the uncuffed ETT size was always checked by ananesthesiologist [by using the standard formula. Intubating conditions were assessed by the anaesthesiologsit using a standard 1–4 grading system (Helbo-Hansen scoring system in Table 4) which includes five variables of laryngoscopy, position of vocal cords, degree of coughing, jaw relaxation, and limb movements and scored accordingly. The sum of the scores of these five individual variables was computed as the Helbo-Hansen Steyn's modification. Total score of 5 was considered to be excellent, 6-10 good, 11-15 poor, and 16-20 bad. Total scores were divided into clinically acceptable and not acceptable scores (total score ≤ 10 acceptable, >10 unacceptable). If the score was more than 10, failure of adequate intubating conditions was considered and intubation was performed using succinylcholine. Oxygen saturation, heart rate and noninvasive blood pressure were measured at 0, 3, 4.5, 5.5 and 6.5 minutes. Vitals at 0 minutes were considered as baseline values. The incidence of bradycardia(less than 30% of the baseline), hypotension(less than 30% of the baseline), hypoxia (oxygen saturation of less than 90%), bronchospasm, laryngospasm, coughing and limb movements were noted. The collected data were analyzed using EPI info statistical software. A P value of <0.05 was considered statistically significant. Student t test was used to compare the hemodynamic variables (heart rate, blood pressure and oxygen saturation) from the baseline.

Results

General anaesthesia using sevoflurane was given to 150 patients undergoing were cataract extraction, treatment of retinoblastoma, squint correction, Keratoplasty, electroretinogram, probing and retling intubation, corneal tear, vitrectomy , orbitotomy, enuclaetion, Trabalectomy and Trabaculotomy, membranectom, lid tear, optic nerve sheath decompression, ahmed valve implantation. Age distribution among 150 subjects is described in (Table 1, Figure 1).

		Frequency (n=150)	Percent
Age	1 to 2 yrs	44	29%
	2 to 3yrs	21	14%
	3 to 4 yrs	24	16%
	4 to 5yrs	21	14%
	5 to 6 yrs	40	26%
Sex	Male	78	52%
	Female	72	48%
Weight	Mean ± SD	12.88 ± 5.10	

Table 1. Profile of Subjects. Among 150 subjects, majority were males 52% and mean weight of subjects was 12.88 Kgs

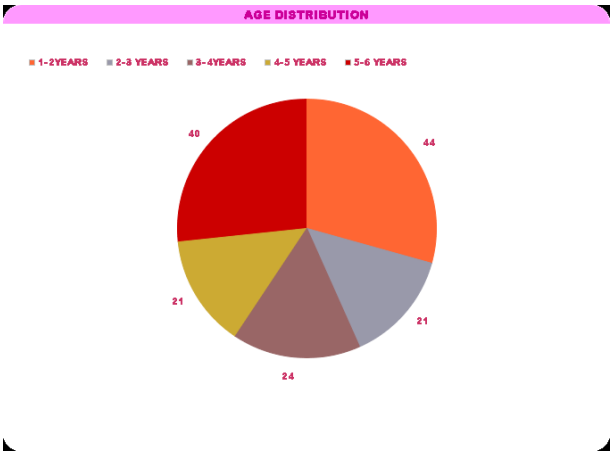

Figure 1. Age distribution

Apnea was achieved in all the patients and hence ventilation was controlled by the time of laryngoscopy in all the patients. 96 patients achieved apnea at 4.5 minutes of sevoflurane exposure. All patients achieved apnea after giving propofol one mg/kg. Airway obstruction during induction occurred in 40 patients and was immediately relieved in each case by placement of an oral airway. Intubation conditions were excellent in all the patients.135 patients were able to intubate in single attempt. 15 patients required second attempt. All 150 patients required second attempt for the exchange of proper sized endotracheal tube. Intubating conditions was excellent in all the cases in the second attempt.There were no coughing, limb movements, hypoxia, bradycardia and laryngo or bronchospasm in any of the patients. There was an increase in heart rate at 3 min compared to 0 min Heart rate ($p < 0.01$) may due to glycopyrrolate administration (Table 2). Similarly, there was decrease in heart rate at 5.5min compared to 3 min heart rate (Figure 2) may be due to propofol administration. There was decrease in systolic and diastolic blood pressure at all the intervals when compared to baseline value at 0 min. The percentage decrease in systolic and diatolic blood pressure at 5.5 min was 15.58% and 12.75% respectively (Table 3, figure 3).

		Mean	SD	p value [0 min with 3,4.4,5.5,6.5 min]	p value [3 min with 4.5,5.5,6.5, min]
Heart Rate	0 min	114.32	14.49		
	3 min	137.97	98.16	0.0038	
	4.5 min	134.40	81.16	0.0031	0.736
	5.5 min	119.84	9.75	0.0001	0.0258
	6.5 min	130.00	12.28	0.0001	0.325

Table 2. Comparison of Heart rate after sevoflurane administration. Heart rate after sevoflurane administration increased significantly at 3 min, 4.5 min, 5.5 min and 6.5 min when compared to 0 min Heart rate ($p < 0.01$). Similarly Heart rate variation was not significant at 4.5 min and 6.5 min but there was significant decrease in HR at 5.5min compared to 3 min HR.

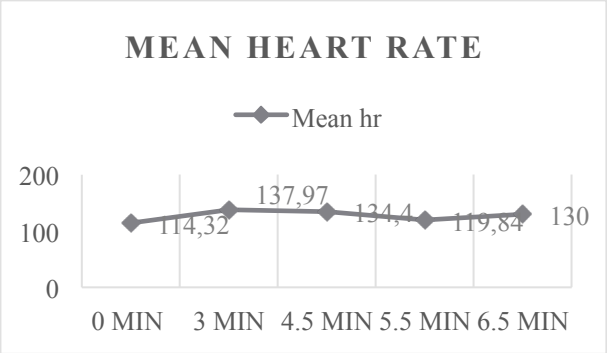

Figure 2. Line diagram representing heart rate variation

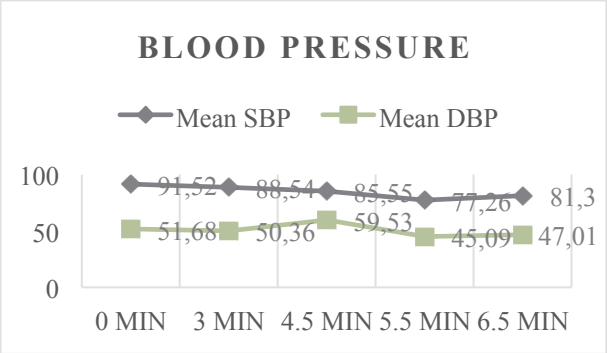

Figure 3. Line diagram systolic and diastolic variation after sevoflurane variation.

		Mean ± SD	p value	P value [3min]
Systolic Blood Pressure	0 min	91.52 ± 8.66		
	3 min	88.54 ± 7.90	0.0020	
	4.5 min	85.55 ± 7.45	0.0001**	0.0008
	5.5 min	77.26 ± 7.15	0.0001**	0.0001
	6.5 min	81.30 ± 7.29	0.0001**	0.0001
Diastolic Blood Pressure	0 min	51.68± 8.78		
	3 min	50.36 ± 7.62	0.1654	
	4.5 min	59.53 ± 86.12	0.2676	0.1959
	5.5 min	45.09 ± 6.71	0.0001**	0.0001
	6.5 min	47.01 ± 6.75	0.0001**	0.0001

Table 3. In the study it was observed that there was significant decrease in Systolic and Diastolic blood pressure at all the intervals when compared to baseline value at 0 min.
Percentage decrease in SBP at 5.5 min = 91.52 – 77.26 / 91.52 = 15.58%. Percentage decrease in DBP at 5.5 min = 51.68 – 45.09/ 51.68 = 12.75%

Points	**1**	**2**	**3**	**4**
Laryngoscopy	Easy	Fair	Difficult	Impossible
Vocal cords	Open	Moving	Closing	Closed
Coughing	None	Slight	Moderate	Severe
Jaw relaxation	Complete	Slight	Stiff	Rigid
Limb movements	None Moderate (jerky)	Slight		Severe

Table 4. Steyns modification of Helbo-Hansen scoring system for tracheal Intubation. Intubating Conditions were considered:
1. Excellent, Score 5 (1 in each item).
2. Good, Score 6-10 (1-2 in each item).
3. Poor, Score 11-15.
4. Bad, Score 16-20
Clinically acceptable a Score ≤ 10
Clinically not accepatable a Score > 10

Discussion

The study showed that apnea was achieved in all the patients. 96 patients achieved apnea at 4.5 minutes of induction with sevoflurane of 8 vol% before propofol. 100% (150) achieved apnea after giving propofol (1mg/kg). Tracheal intubation was done in all the patients at 5.5 minutes.Intubating conditions were excel-

lent in all the patients without any complications. The advantage of this technique are it includes wide range of age group between one year to six years, it is very safe as there were no complications observed, it can be used in day care surgeries, surgeries where muscle relaxant is avoided or not advised and also be tried in cases of anticipated difficult intubations as initial assessment. The dose of propofol or fentanyl used were in very low dose, may not affect the recovery, devoid of any muscle relaxant related side effects and even if intubation could not be performed, recovery is faster. It does not require reversing on neuromuscular blockade, BIS and alveolar gas monitoring. Though intubation time is bit longer in duration (5.5 minutes), it can be very well used for inserting an intravenous line. The limitations of this study are it does not include infant less than one year and children older than six years, the intubating conditions in the second attempts is studied in few cases and hence it cannot be used widely and safely in difficult intubations mandating further studies for intubating conditiondss in second attempt of laryngoscopy. Over past few years, several factors have led researchers to ignore neuromuscular blocking agents for tracheal intubation. The driving force were introduction of propofol, short acting opioid, sevoflurane in clinical practice. Suxamethonium, though provides almost ideal intubating conditions, has been contraindicated in the United States for routine use in children(especially males less than 8 years) due to the increased incidence of fatal or near fatal cardiac arrests following its use[11,12,13]. This is attributed to hyperkalemia, developing especially in patients with undiagnosed muscular dystrophies[11,12,13]. Other side effects include myalgia, prolonged apnea, and rarely precipitation of malignant hyperpyrexia[11,12,13,14]. If difficult airway is anticipated, prolonged neuromuscular blockade and inability to quickly reverse the neuromuscular blockade make the use of nondepolarizing muscle relaxants for intubation less desirable[15]. They too have their share of side effects and complications like development of awareness under general anesthesia, residual paralysis, and allergic reactions[16]

Hence if laryngoscopy and intubation could be performed by avoiding the use of muscle relaxants, without compromising on the ease or success of the procedure, many adverse eventsduring anesthesia can be avoided[17].

Among the inhalational agents which are presently available for clinical use, sevoflurane has merits of a pleasant smell, low airway irritability and low blood gas solubility, thereby facilitating a rapid and smooth induction[18,19]. Because of its stable hemodynamics[19], less potential for myocardial depression and arrhythmogenecity[20], it is considered a safe inhalational agent for induction.

Propofol, one of the most frequently used induction agent, has favorable depressant effect on the pharyngeal and laryngeal reflexes and the muscle tone[15,16]. The induction with propofol is quick and smooth, with rapid awakening during recovery[17]. Propofol along with fentanyl is a good suppressor of stress response to laryngoscopy and intubation. Many used sevoflurane, sevoflurane with propofol or propofol with high dose opioids. None had 100% excellent intubating conditions and those who had close to 90% used high dose opiods[21,22,23,24,25] or propofol. Using either propofol or opoids at high doses can cause significant hemodynamic alterations and affect recovery of patients posted for day care surgeries. Remifentanyl or alfentanyl are still not easily available in many countries, so that it can used for tracheal intubation in even at higher doses. The addition of nitrous oxide to the inhaled gases deepen the plane of anesthesia[17]. It may be disadvantageous in a difficult to ventilate and/or intubate patient, especially a child, as a reduction in the inhaled oxygen concentration will fasten desaturation if intubation somehow gets delayed[17]. Moreover as spontaneous respiration is maintained, these patients will be breathing room air which may cause even faster desaturation due to diffusion hypoxia[17]. So, nitrous oxide was not used as it may influence our results by speeding induction and by the additive effect it

exerts on the amount of sevoflurane required for tracheal intubation without a relaxant[17].

Our study used fentanyl 1mcg/ kg and propofol 1 mg/kg which may not effect the hemodynamic parameters and affect recovery in post operative period significantly.

Through probit analysis[6], it was shown that induction time required to achieve 95% success rate was 189 sec (162-351) and 260 sec (217-614) for age 1-4 and 4-8 years repectively in a single large study of one hundred fifty three patients 6using 8 vol% sevoflurane in 60% nitrous oxide discontinued 1 min after the start of induction6. Since our study included from one year to 6 years, the mean of both i.e, 210 sec (3.5 minutes) was taken as initial induction time. Propofol in the dose of 1 mg/kg at 4.5 minutes was chosen as it was shown that propofol needed to supplement sevoflurane in children can be expected to decrease after 4 minutes of sevofluraneexposur[27]. Minute ventilation during induction may likely affect the induction time required to achieve good intubating conditions. Patients were allowed to achieve the apnea on their own.

Ventilation was controlled after achieving apnea by positive pressure mask ventilation.Ventilation was made as uniform as possible with the help of capnography(35-45 cm H_2O) and single anaesthesiologist to avoid observer variability.

Conclusions

Apnea was achieved in all the patients during induction with sevoflurane of 8 vol% of 5.5 minutes. Tracheal intubation was done in all cases, inutubating conditions were excellent in all the cases. Thus, tracheal intubation using sevoflurane without muscle relaxant with apnea as clinical indicator provided excellent intubating conditions without any complications in all the patients without any complications and can be very well adopted in our routine practice.

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