Original Research Article

Indian Journal of Anesthesia and Analgesia
March – April 2020; 7(2): 570–577
DOI: http://dx.doi.org/10.21088/ijaa.2349.8471.7220.19

To Study and Compare Induction Characteristics and Hemodynamic Effects of Sevoflurane with Halothane for Inhalational Anesthesia in Pediatric Patients

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Abstract

Induction: and maintenance of general anesthesia in pediatric patients is often managed with an inhaled anesthetic agent, with various inhalational anesthetic agents available having their pros and cons. In this study, we evaluated and compared sevoflurane with halothane in pediatric patients for induction characteristics and hemodyanamic effects. Sixty patients, aged between 2 and 10 years undergoing various surgeries were randomly divided into two groups of 30 each to receive either sevoflurane or halothane anesthesia, induced by using equipotent incremental doses of either of the inhalational agent upto 3 MAC. Anesthesia was then maintained with either of the inhalational agents at 0.5 MAC with nitrous oxide (60%) in oxygen (40%). Induction time, induction scoring and hemodynamic parameters were recorded and analyzed using appropriate statistical method. *Results:* of our study showed that the induction time of sevoflurane was significantly faster than that of halothane (184 ± 56 secs *vs* 302 ± 62 secs) without any major airway problem (salivation, breath-holding and coughing). Excitement and restlessness during induction was found to be more common with sevoflurane than with halothane but this difference was not statistically and did not interfere with the induction. Heart rate and blood pressure were better maintained during sevoflurane anesthesia than the halothane anesthesia. We did not find any significant incidence of cardiac arrhythmias with either of the agents.

Keywords: Inhalational; Induction; Sevoflurane; Halothane; Pediatric; Anesthesia.

How to cite this article:

Tahir Ali Khan, Surendra Kumar Raikwar, Aditya Agarwal. To Study and Compare Induction Characteristics and Hemodynamic Effects of Sevoflurane with Halothane for Inhalational Anesthesia in Pediatric Patients. Indian J Anesth Analg. 2020;7(2): 570–577.

Introduction

Induction and maintenance of general anesthesia in pediatric patients is often managed with an inhaled anesthetic agent, which should ideally produce rapid and smooth induction, rapid emergence and a short postoperative recovery period with minimal adverse effects. Halothane has traditionally been used as anesthetic agent for inhalational induction in children because it produces less airway irritation, but it is not an ideal induction agent because of its potential to cause bradycardia, hypotension and ventricular ectopy.[1,2] The pleasant, nonpungent odour of sevoflurane, its low-blood – gas solubility along with its cardiostable properties and minimal hepatotoxicity suggests that it has most of the

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Received on 13.12.2020, **Accepted on** 28.01.2020

properties of an ideal inhalational agent and that it may be a suitable alternative to halothane for its use in pediatric anesthesia.[3–6] We designed this study to compare the induction characteristics and hemodynamic effects of sevoflurane with halothane anesthesia in children aged 2–10 years undergoing various commonly performed surgical procedures.

Materials and Methods

Patients in the age group of 2–10 years (ASA Grade 1 & 2), undergoing elective pediatric surgeries under general anesthesia were chosen for the study. Patients with history of any major systemic illness, previous history of hypersensitivity to any anesthetic drug, patients undergoing emergency surgeries were excluded. After a careful preanesthetic checkup, an informed consent was taken from the guardian of the patient. Premedication with oral midazolam 0.5 mg/kg given 1 hour prior to the procedure. The patients were then randomly divided into two groups to receive either sevoflurane or halothane anesthesia.

On reaching the Operation table, the baseline values of PR, BP, SpO_2 were recorded. Intravenous access was established. Anesthesia was then induced with Sevoflurane beginning at 1 MAC (2.5%), increasing by 1% (0.5 MAC) every 3–4 breaths to a maximum of 7.5% (3 MAC) *via* JR circuit using an appropriate sized face mask along with Nitrous oxide (60%) in oxygen (40%). The same protocol was followed during the induction of anesthesia by Halothane.

There again the induction was started at 1 MAC of Halothane (1%) followed by increments of 0.5% (0.5 MAC) every 3–4 breaths to a maximum of 3% (3 MAC). Once the criteria of induction were met with (loss of eyelash reflex, loss of tone, fixed central pupil, automatic respiration), trachea was intubated with an appropriate sized endotracheal tube and oropharyngeal packing done. Anesthesia was maintained with Sevoflurane/Halothane at 0.5 MAC (1.2% and 0.5% respectively) with Nitrous Oxide (60%) in Oxygen (40%). Injection fentanyl 1 μg/kg was given for the intraoperative analgesia. Muscle relaxation was supplemented with Inj. Atracurium besylate 0.2 mg/kg as and when required. In both the groups the volatile anesthetic agent was discontinued at the completion of the last stitch.

The neuromuscular block was then reversed after the dressing with Inj. Neostigmine (0.05 mg/kg) along with Inj. Glycopyrrolate (0.01 mg/kg). A gentle suction was then done under vision followed by removal of oral packing.

The trachea was extubated after the return of the gag reflex, adequate tidal volume, and the return of purposeful movements.

The following parameters were recorded :

1. Heart Rate (HR), Blood Pressure (BP), Oxygen Saturation (SpO_2) were noted at following intervals:
   (a) Preinduction;
   (b) During induction at every 2 min. interval;
   (c) Immediately after intubation;
   (d) 5 mins after intubation;
   (e) Every 10 mins during the maintainance till the recovery.
2. ECG, SpO_2 monitoring was done continuously during the procedure. Any episode of bradycardia (HR < 20% of preinduction level), hypotension (20% of preinduction value), hypoxia (SpO_2 < 90%) were recorded;
3. Induction Time was taken as the time taken from the start of the anesthesia to the loss of eyelash reflex;
4. Induction Scoring was done as follows (Table 1):

The results were compiled and analyzed using the following tests:

Student's t- test: Demographic profile, Systolic blood pressure, Diastolic blood pressure, Induction time, Total Induction scoring.

Chi-square test: Sex ratio, Untoward effects during induction,

Wilcoxan signed rank test: Heart rate.

Results

There was no statistical difference between the two groups with respect to the demographic profile, the number of various surgical procedures done and the mean duration of anesthesia for various procedures, shown in Table 2. There was a statistically significant difference between the two groups with respect to the induction time. The induction time was seconds in sevoflurane group compared to seconds in halothane group. The induction was significantly faster with sevoflurane than with halothane, (Table 3).

Table 1: Symptom

Symptom	Worst (1)	Fair (2)	Best (3)
Salivation	Pouring out	Little wet	None
Coughing	Persistant	Self limiting	None
Breath holding	Persistant	Temporary	None
Laryngospasm	No air entry	Partial air entry	B/L equal air entry
Nausea/Vomiting	Persistant	Temporary	None
Bronchospasm	Unable to ventilate	Wheeze	None
Excitement/Restlessness	Severe	Some problem	None

Table 2: Induction parameters (Induction time)

Parameter	Group H (n = 30)	Group S (n = 30)	p - value*
Induction time (secs)	302 ± 62	184 ± 56	< 0.0001

Table 3: Demographic profile

	Group H (n = 30)	Group S (n = 30)	p - value**
Age (years)*	5.7 ± 21	4.8 ± 3	0.725
Sex (M/F)	20/10	21/9	1
Wt.(kg)*	15.5 ± 3.33	15.2 ± 3.18	0.865
Surgical procedure			
Upper abd Surgery	18	21	
Tonsillectomy	5	2	
Orthopedic surgery	7	7	
Mean duration of anesthesia(min)			
Upper abd surgery	66.71 ± 13.89	75 ± 7.07	0.465
Tonsillectomy	48.27 ± 7.78	48 ± 10.17	0.098
Orthopedic surgery	60.17 ± 22.4	59.28 ± 25.9	0.125

Untoward effects during the induction of halothane anesthesia were seen in the form of salivation (6 pts.), breath holding (3 pts.), cough (3 pts.) and bronchospasm (2 pts.) whereas during sevoflurane anesthesia induction; salivation, breath holding, cough and bronchospasm were observed in 7, 2, 1 and 1 patients respectively, Table 4.

Table 4: Untoward effects during induction

Parameter	Group H (n = 30)	Group S (n = 30)	p - value
N/V	0	0	
Salivation	6	7	1
Breath holding	3	2	1
Cough	3	1	0.612
Laryngospasm	0	0	
Bronchospasm	2	1	1
Excitement/Restlessness	0	2	0.492

Excitement and restlessness which was absent in halothane group was observed in 2 patients in sevoflurane group but this was statistically insignificant, Fig. 1. There was no significant difference between the mean induction scores in the two groups, (Table 5).

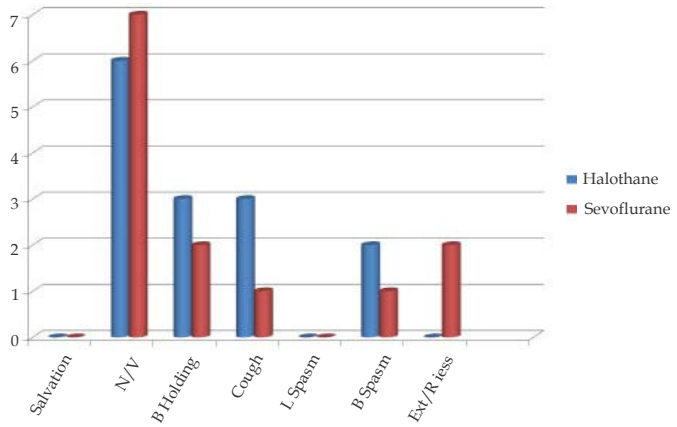

Fig. 1: Untoward effects during Induction

Table 5: Induction score

Score	Group H (*n* = 30)	%	Group S (*n* = 30)	%	*p* - value
21	19	63.33	20	66.66	1
20	8	26.66	8	26.66	1
19	2	6.66	1	3.33	1
18	1	3.33	1	3.33	1
Mean	20.5 ± 0.77		20.5 ± 0.72		0.733

An increase in PR was seen at 2 min during induction in sevoflurane group which is statistically significant. A statistically highly significant increase in the pulse rate was seen immediately after intubation in both the groups which became stable in sevoflurane thereafter. Whereas, in halothane group, fall in pulse rate was seen at 20 mins where it was statistically significant and at 30 min duration it was highly significant in halothane group, (Table 6 and Fig. 2).

Table 6: Heart rate variation

Time	Group H (*n* = 30)	*p* - value* H	Group S (*n* = 30)	*p* - value* S
Preop	110 ± 20.5		114.2 ± 19.08	
At 2 min	115.11 ± 21.2	0.086	120.8 ± 18	0.057
At intubation	125.1 ± 13.3	000	129.57 ± 16.97	000
5 min postintubation	112.7 ± 15.23	0.422	121.6 ± 13.60	0.063
At 10 min	108.4 ± 15.60	0.078	120.2 ± 18.86	0.063
20 min	106.46 ± 13	0.020	119.83 ± 19.44	0.056
30 min	104.2 ± 12.9	0.006	115 ± 15.74	0.750

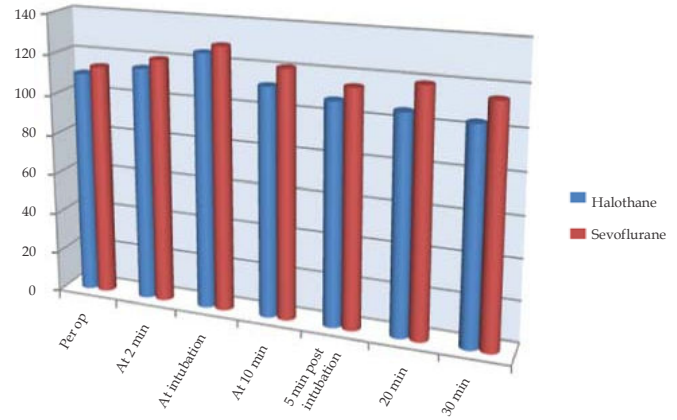

Fig. 2: Heart rate variation.

There was a statistically significant fall in SBP at 2 mins during induction in halothane group. A statistically significant increase in SBP was seen in both the groups immediately postintubation which was more in sevoflurane than in halothane. SBP was stable during rest of the procedure in both the groups, Table 6 and Fig. 3. There was statistically significant increase in Diastolic BP in sevoflurane group which was clinically significant at immediate postintubation time and clinically insignificant at 20 mins, (Table 7 and Fig. 4).

Table 7: Systolic blood pressure variation

Time	Group H (n = 30)	p - value* H	Group S (n = 30)	p - value* S
Preop	108.33 ± 8.20		101.43 ± 8.63	
At 2 min	101.60 ± 12.92	0.05	102.20 ± 8.25	0.514
At intubation	112.8 ± 9.85	0.04	107.40 ± 9.37	0.002
5 min postintubation	107.13 ± 7.24	0.140	103.97 ± 11.05	0.240
At 10 min	108.2 ± 8.08	0.809	103.2 ± 9.76	0.292
20 min	108.13 ± 9.77	0.875	104.66 ± 10.94	0.155
30 min	107.87 ± 9.22	0.822	102.10 ± 8.39	0.698

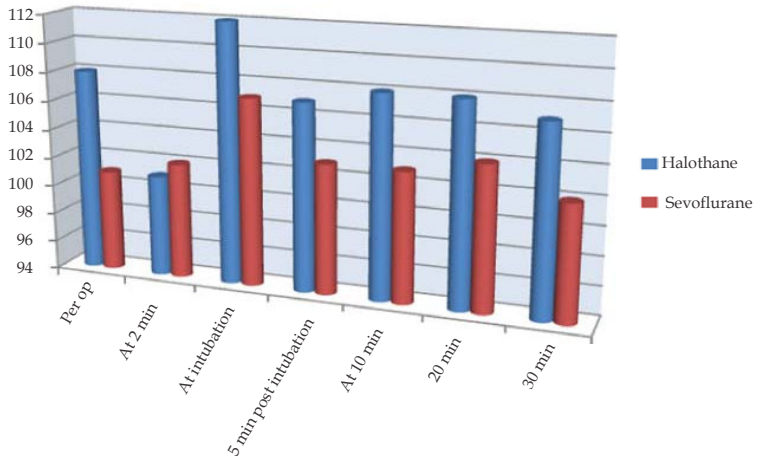

Fig. 3: Systolic blood pressure variation.

Table 8: Diastolic blood pressure variation

Time	Group H (n = 30)	p - Value* H	Group S (n = 30)	p - value* S
Preop	61.13 ± 18.90		54.20 ± 8.24	
At 2 min	54.27 ± 7.59	0.064	55.20 ± 6.40	0.428
At intubation	60.23 ± 7.53	0.800	59.30 ± 9.07	0.012
5 min postintubation	54.77 ± 6.59	0.102	56.23 ± 7.69	0.204
At 10 min	57.47 ± 6.95	0.310	54.70 ± 5.87	0.767
20 min	56.56 ± 6.84	0.219	57.86 ± 8.45	0.049
30 min	54.63 ± 11.91	0.126	56.73 ± 10.86	0.272

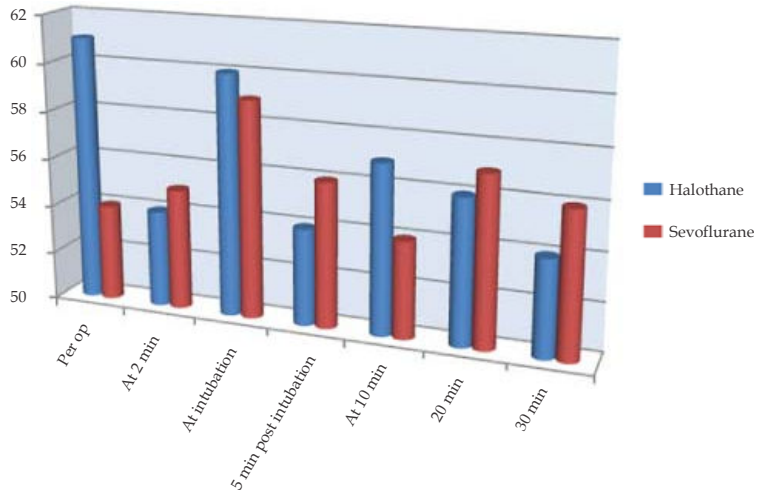

Fig. 4: Diastolic blood pressure variation.

Discussion

We conducted this study to compare the induction and hemodynamic characteristics of sevoflurane and halothane anesthesia in 60 patients of ASA Grade 1 & 2 undergoing various surgeries. Both the groups studied were comparable with respect to the age, sex ratio, weight in kgs, the no. of various surgical procedures done and the mean duration of anesthesia during the various surgical procedures, (Table 2).

In our study the induction was significantly faster in sevoflurane group (184 ± 56 secs) compared to halothane group (302 ± 62 secs), Table 3. This result was found to be statistically significant ($p < 0.05$). This was most probably the consequence of the lower-blood – gas partition coefficient for sevoflurane compared to halothane, particularly since it was a goal to use comparable MAC's for both the agents during the induction as well as the maintenance. Our results were similar to those of PJ Davis et al.[7] GP Johannasson et al.[8] A Black, et al. [9] PE Singston et al.[10] R Muto et al.[11] S Inomoto[12] and Kajal N Dedhia et al.[13] But, Y Naito et al.[14] and Veronique Piat et al.[15] did not find any significant difference between the induction time of sevoflurane and halothane. This difference in result was probably due to the fact that they did not use the equipotent concentrations of the two agents throughout the induction time. The concentration used for halothane was higher compared to the concentration of sevoflurane in all the three studies.

In our study no difference was found between the two groups with respect to the induction score. Untoward effects during induction of halothane anesthesia were seen in the form of salivation (6 patients), breath holding (3 pts.), cough (3 pts.) and mild bronchospasm (2 pts.). Whereas, during sevoflurane induction, salivation, breath holding, cough and bronchospasm were found in 7, 2, 1 and 1 patients respectively, Table 3. These incidences were not statistically significant. Excitement and restlessness which was absent in the halothane group was observed in 2 patients in the sevoflurane group. Though this was clinically significant, it was statistically found to be insignificant. Our results are in accordance with the studies done by Y Naito et al.[14] V Piat,[15] A Black[9] and Kajal N Dedhia. They found no statistically significant difference in the side-effects during the induction of anesthesia in both the groups. PE Singston et al.[10] found a higher incidence of struggling during rapid induction with 5% halothane compared to 8% sevoflurane. This was probably due to the more pleasant odour of sevoflurane which was better tolerated in unpremedicated children. No such observation was made in our study and all our patients were premedicated with oral midazolam. A statistically insignificant incidence of excitement which did not interfere with the course of induction was seen in the sevoflurane group and this was similar to the trend seen in our study. The incidence of breath holding was found in 3 patients in halothane group and 2 in sevoflurane group, whereas cough was observed in 3 patients in halothane group and 1 patient in sevoflurane group. R Muto et al.[11] also found a higher incidence of airway problems in the form of breath holding, coughing and complete refusal in halothane (40%) compared to sevoflurane (7%).

In our study, we found an increase in the heart rate immediately after intubation in both the groups,

Table 5. In sevoflurane group it rose from the baseline value of 114 ± 19.08 per minute to 129.57 ± 16.97 per minute. Similarly, heart rate in halothane group increased from 110 ± 20.5 per minute to 125 ± 13.3 per minute. In both the groups these changes were very highly significant ($p < 0.001$). The increase in heart rate at the time of intubation in both the groups may be due to the stress response to laryngoscopy and intubation. This was also observed by V Piat et al.[15] in sevoflurane group but not in halothane group. The heart rate started returning towards normal in both the groups after intubation and reached the baseline value in halothane group at 5 minutes and in sevoflurane group at 30 minute. A fall in the heart rate below baseline value was observed in halothane group during intraoperative period which was statistically significant at 20 and 30 minutes but was not clinically significant and did not require any treatment. Kajal N Dedhia et al.[13] observed a fall in heart rate in halothane group but no change in sevoflurane group. Our results are similar to other studies. GP Johannasson et al.[8] reported a higher heart rate throughout in the sevoflurane but no change in heart rate was seen in halothane group. This difference in observations may be because of the use of atropine premedication (0.035 mg/kg) in all the patients. In our study, we did not give any atropine to our patients. We gave Inj. Glycopyrrolate only to those patients who had excessive salivation during induction of anesthesia (3 patients in sevoflurane group and 2 patients in halothane group). Studies done by A Black et al. [9] and PE Singston et al.[10] showed no difference in the heart rate between the two groups from the baseline values. Both of them had used atropine premedication in their studies.

In halothane group a fall in systolic and diastolic blood pressure was observed at 2 mins of induction. Thereafter, at intubation, there was an increase in both systolic and diastolic blood pressure. The rise in systolic blood pressure was significant whereas rise in diastolic blood pressure was insignificant. In sevoflurane group, there was a marginal increase in both the systolic and diastolic blood pressures at 2 minutes of induction which increased to significant levels at intubation, Tables 7 and 8. V Piat et al.[15] observed that during the same time interval (induction to intubation) SBP decreased significantly in halothane group whereas it did not change in sevoflurane group. The same results were observed in our study during induction. The increae in blood pressure during intubation found in our study in accordance with the studies done by Kajal N Dedhia et al. [13] and V Piat et al.[15] who also observed an increase in SBP immediately after the insertion of the LMA and after intubation respectively. The systolic and diastolic blood pressures remained stable during intraoperative period, Table 7 and 8, after intubation in our study. Our results are similar to those of A Black et al. [9] who reported stable blood pressure during intraoperative period in both the groups. R Muto et al.[11] and Satoru Tanaka et al.[16] observed a slight decrease in BP in both the groups which was not significant and this was probably due to the use of higher dose of sedative premedication in their study.

No significant arrhythmia, episode of deaturation or any other mishap was observed during the cases in either of the groups.

Conclusion

From our study, we conclude that the induction time of sevoflurane was significantly faster than that of halothane and it was not associated with any major airway problem (salivation, breath-holding and coughing. Heart rate and blood pressure were better maintained during sevoflurane anesthesia than the halothane anesthesia. We did not find any significant incidence of cardiac arrhythmias with either of the agents.

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