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Original Research Article

A Comparative Study of Induction, Maintenance and Recovery Characteristics of Halothane and Sevoflurane in Pediatric Patients

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Abstract:

Introduction: Methods for induction of general anaesthesia in children include inhalational agents as well as intravenous agents. Children are reluctant to have a needle to put them into sleep. So inhalational induction becomes preferable and is used more commonly in children as compared to adults. Desflurane, sevoflurane, isoflurane, enflurane, halothane, nitrous oxide are amongst the most popular inhalational agents used. Of these sevoflurane and halothane are used for induction owing to their non pungent nature.

However, all of these products are airway irritants to varying degree and can cause laryngospasm, breath holding, coughing, and salivation in children.

Halothane has a high solubility in tissues and is therefore associated with a slow onset and termination of effect and recovery. Patients receiving halothane have an increased risk of arrhythmias and hepatotoxicity.

Sevoflurane has low blood gas partition coefficient and low issue solubility. In addition, sevoflurane appears to have fewer hemodynamic effects than halothane.

Purpose of this study is to compare sevoflurane and halothane for induction, maintenance and recovery in general anaesthesia in pediatric patients.

Our primary aim is to compare the induction time produced by halothane and sevoflurane in pediatric patients.

Materials and Methods: After approval from proforma review board this comparative study of halothane and sevoflurane for induction, maintenance and recovery in pediatric patients was carried out in general operation theatre, S.N. Medical College, Agra. Using computer generated random number table patients were randomly allocated into two groups of 30 patients each according to the volatile anaesthetic to be used:

Group-H: Included children who received halothane + nitrous oxide + Oxygen.

Group-S: Included children who received sevoflurane + nitrous oxide+ Oxygen.

Time gap between cessation of the inhalational agent and when child first open his/her eyes was recorded as recovery time 1. Respective time gap till child showed purposeful movements or obeyed commands were taken as recovery time 2.

Statistical analysis: It was done using SPSS 20.0 version for windows. A study population of 30 patients for each group was determined to have 90% power at a =0.05. Data were presented as mean (±SD). After the study, analysis of data was done by chi square test and t- test for parametric data and Mann-whitney for nonparametric data. P value<0.05 was considered as statistically significant.

Results: In the comparative study we compared the induction, maintenance and recovery characteristics of halothane and sevoflurane in pediatric patient of 1 to 10 years of age undergoing elective surgeries of approximately 1 hour duration (ASA grade 1 & 2).

In present study, the time to loss of eyelash reflex (induction time) was significantly shorter in the sevoflurane group, p<0.05 (88.23+19.129 sec) compared to halothane group (165.63+40.372 sec). This can be explained by low blood gas solubility of sevoflurane as compared to halothane.

In our study we compared the two groups for intraoperative complications like cough, bucking, breath holding and oxygen desaturation on the basis of airway hyperreactivity score and found that there was no statistically significant difference (p-value is>0.05). It was because both sevoflurane and halothane are non-irritant and provide smooth induction with minimal secretions. sevoflurane is least airway irritant among all inhalational agents and halothane is most potent bronchodilator among these.

In our study emergence phenomenon were compared among two groups on the basis of emergence agitation score and it was found that children who received sevoflurane were more agitated and restless at the time of emergence than the children who received halothane. The most likely explanation is that patients experienced rapid

emergence as sevoflurane is eliminated rapidly while chidren who received halothane appeared sedated and calm due to slow elimination as compared to sevoflurane. Limitations of this study include lack of blinding due to study design and inability to assess arrhythmogenic properties of both the agents and high cost of sevoflurane. We conclude that induction with sevoflurane and oxygen leads to faster loss of consciousness, provides ideal conditions for managing airway with haemodynamic stability and rapid recovery from anaesthesia. Therefore, it can be a reasonable alternative to halothane for pediatric patients aged 1-10 years.

Conclusion: Time to loss of eyelash reflex (induction time) was compared between two groups and it was significantly shorter in children. Baseline pulse rate was comparable between two groups. There was decline in pulse rate in both groups but this decline was more with children who received halothane anaesthesia than the children who received sevoflurane anaesthesia and difference was statistically significant ,p value<0.05.

Mean arterial blood pressure was comparable between two groups. There was decline in mean arterial blood pressure in both groups but this decline was more with children who received halothane anaesthesia than the children who received sevoflurane anaesthesia and difference was statistically significant, p value <0.05.Time to open eyes and time to follow commands was shorter in sevoflurane group than halothane group and on comparison the difference was statistically significant, p value <0.05.

In our study emergence phenomenon were compared among two groups on the basis of emergence agitation score and it was found that children who received sevoflurane were more agitated and restless at the time of emergence than the children who received halothane.

So, we conclude that the anaesthesia with sevoflurane provided rapid induction and rapid recovery with more stable hemodynamics than halothane in pediatric patients of age group 1-10 years. However, more frequent emergent phenomenon and higher cost may be factors limiting its popularity.

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Introduction

Broadly induction of anaesthesia in children is achieved with the same anaesthetic agents and techniques as that of in adults. The technical difficulties that are associated with small size and the psychological and behavioural issues may make induction of anaesthesia more challenging in a child compared to the adult.

Methods for induction of general anaesthesia in children include inhalational agents as well as intravenous agents. Children are reluctant to have a needle to put them into sleep. So inhalational induction becomes preferable and is used more commonly in children as compared to adults. Desflurane, sevoflurane, isoflurane, enflurane, halothane, nitrous oxide are amongst the most popular inhalational agents used. Of these sevoflurane and halothane are used for induction owing to their non pungent nature.

The advantages of the volatile anaesthetics include rapid onset, rapid offset, and convenient route of delivery. Additionally, some agents may provide analgesia and amnesia. However, all of these products are airway irritants to varying degree and can cause laryngospasm, breath holding, coughing, and salivation in children.

Halothane has a high solubility in tissues and is therefore associated with a slow onset and termination of effect and recovery. Patients receiving halothane have an increased risk of arrhythmias and hepatotoxicity.

Sevoflurane has low blood gas partition coefficient and low issue solubility. In addition, sevoflurane appears to have fewer hemodynamic effects than halothane.

Purpose of this study is to compare sevoflurane and halothane for induction, maintenance and recovery in general anaesthesia in pediatric patients.

Aims and Objectives

1. To compare the induction time produced by halothane and sevoflurane in pediatric patients.
2. To compare the maintenance, characteristics and depth of anaesthesia produced by two drugs.
3. To compare the adverse effects of both drugs.
4. To compare the recovery time produced by both drugs.

Material and methods

After approval from proforma review board this comparative study of halothane and sevoflurane for induction, maintenance and recovery in pediatric patients was carried out in general operation theatre, S.N. Medical College, Agra.

Inclusion Criteria:

Pediatric patients of ASA grade 1 and 2, age group 1 to 10 yrs undergoing elective surgeries of approximately 1 hour duration.

Exclusion Criteria:

1. Prior history of any bleeding disorder.
2. Patients with intracranial lesions and head injury.

3. Patients with significant cardiac, respiratory, hepatic, renal, neuromuscular disease.

Procedure:

All the patients were examined day before surgery and advised nil per oral 6 hour for solids and 4 hour for liquids. After reexamination preoperatively an informed written consent was taken from the guardians of patients. Using computer generated random number table patients were randomly allocated into two groups of 30 patients each according to the volatile anaesthetic to be used:

Group-H: Included children who received halothane + nitrous oxide + Oxygen.

Group-S: Included children who received sevoflurane + nitrous oxide+ Oxygen.

All patients were premedicated with inj atropine (0.02 mg/kg) iv and inj fentanyl 2 ug/kg iv. Inhalational induction of anaesthesia was accomplished in all patients using a mapleson F or Anaesthetic Bains (Mapleson D) breathing system and a face mask. Halothane was begun at 0.5% and increased by increments of 0.5% (upto a maximum inspired concentration of 5%) with 100% oxygen. Sevoflurane was begun at 1% and increased by increments of 1% (upto 8%maximum inspired concentration) with 100% oxygen. Time taken for loss of eyelash reflex since start of the respective inhalational agent is noted and taken as induction time. Pulse oximeter saturations, heart rate and non-invasive mean blood pressure measurements were recorded just after induction.

Now inj succinylcholine 1.5 mg/kg iv was given and tracheal intubation was done.

After induction halothane administration was continued at concentration of 2% to 3% or in case of sevoflurane concentration for maintenance was 3 to 4% in a mixture of 60% nitrous oxide and 30% oxygen. Patient was manually ventilated using mapleson F or D circuit.

Hemodynamic parameters - pulse rate, blood pressure, oxygen saturation were monitored during maintenance at every 10 minutes interval upto 40 minutes and at extubation.

Time gap between cessation of the inhalational agent and when child first open his/her eyes was recorded as recovery time 1. Respective time gap till child showed purposeful movements or obeyed commands were taken as recovery time 2.

cough, buking, breathholding or oxygen desaturation if occurred, were recorded and graded according to **Airway Hyperactivity score:**

Airway hyperreactivity score-table 1

	SCORE				
Parameter	**0**	**1**	**2**	**3**	**4**
1)cough/bucking	None	Occasional	Frequent	continuous	Larynospasm
2)breathholding	None	<15 sec	15-30 sec	>30 sec	Ippv
3)oxygen saturation	>98%	94-97%	90-94%	<90%	<85%

GRADING

MILD ≤3, MODERATE = 4-8, SEVERE ≥9

At the time of emergence restlessness, crying, irritability were noted and graded on the basis of **Emergence agitation score:**

Emergence Agitation Score

Score	symptoms
1	Obtunded with no response to stimulation
2	Asleep but responsive to movement or stimulation
3	Awake and calm, nonirritating to touch
4	Awake and irritating to touch
5	Crying
6	Thrash behaviour that requires restraint

Occurrence of nausea and vomiting, if any, at the time of extubation and at 30 min after extubation, was noted and compared between two groups on the basis of following score:-

Postoperative Nausea and Vomiting Grading

Symptoms	Score
1) None	0
2)Mild (Nausea But No Vomiting)	1
3) Moderate (Nausea And Occasional Vomiting)	2
4)Severe (Nausea And Frequent Vomiting)	3

Statistical Analysis: It was done using SPSS 20.0 version for windows. A study population of 30 patients for each group was determined to have 90% power at a =0.05. Data were presented as mean (+- SD). After the study, analysis of data was done by chi square test and t- test for parametric data and Mann-whitney for nonparametric data. P value<0.05 was considered as statistically significant.

Observation

On the basis of sample size of the study, 60 patients were selected. Patients were divided into two groups, Group H (Halothane) and Group S (Sevoflurane). There were no dropouts in this study. Depending on the results of randomization process, patients received Halothane or Sevoflurane for induction maintenance and recovery-

Table 2: Mean induction and recovery time (rt-iand 2) in both groups

	GROUP-S(n=30)	GROUP-H(n=30)	P value
Mean induction Time +S.D.(in sec)	88.23+19.129	165.63+40.327	0.000
Mean RT1+S.D.(insec)	133.57+28.582	365.37+38.642	0.000
Mean RT2+S.D.(inSec)	333.03+47.177	664.33+139.640	0.000

Above table shows that mean induction time for sevoflurane was less (88.23+19.129 sec) than that of halothane (165.63+40.372 sec) which was **statistically significant, (p= 0.000) .** Both recovery time 1 (time for eye opening) and recovery time 2 (time for purposeful limb movements) were significantly shorter **(p=0.000)** with patients who received sevoflurane than those who received halothane.

Table 3: mean pulse rate in both groups at Different time interval

Mean Pulse Rate	Group-S (N=30)	Group-H (N=30)	P Value
Baseline	117.17+16.129	109.63+14.822	0.065
At induction	109.37+12.139	101.73+12.900	**0.022**
At10 min	110.63+14.445	103.37+12.181	**0.040**
At 20 min	112.60+13.475	94.70+10.993	**0.000**
At 30 min	112.80+16.898	96.73+13.038	**0.000**
At 40min	112.50+17.017	100.73+12.725	**0.004**
At extubation	113.20+13.800	96.40+10.785	**0.000**

Above table shows that baseline pulse rate of two groups was comparable, and both groups showed decline in pulse rate after induction, and this decline was more with children who received halothane and **statistically significant (p<0.05)**

Table.4: mean blood pressure (map) at different time interval in both groups

Map	Group-S (N=20)	Group-H (N=20)	P Value
Baseline	76.83+6.513	78.33+8.087	0.432
At Induction	76.00+6.000	72.10+6.354	**0.018**
At 10 min	14.90+8.197	68.97+5.366	**0.002**
At 20 min	75.77+6.771	71.10+4.626	**0.003**
At 30 min	72.73+4.975	69.57+5.630	**0.025**
At 40 min	75.40+5.405	70.53+5.728	**0.001**
At extubation	73.00+7.764	68.97+6.896	**0.038**

Above table shows that baseline mean blood pressure of two groups was comparable and both groups showed decline in mean blood pressure and this decline was more with halothane group and was **statistically significant (p< 0.05).**

Table 5: airway hyper-reactivity score and emergence agitation score in both groups

Score	Group S(N=30)	Group S(N=30)	P Value
AHS SCORE	26.90	34.10	0.097
EA SCORE	35.63	25.37	**0.016**

Above table shows that incidence of airway complications was low in both groups. It was lower in children receiving Sevoflurane than those receiving Halothane, but the difference was **statistically insignificant (p=0.097, >0.05).**

Emergence phenomenon was found to be more common in group sevoflurane than halothane and was **statistically significant (p=0.016, ＜0.05)**

Discussion

Inhalational induction remains the most preferred technique for pediatric age group because of difficult venous access.

In the comparative study we compared the induction, maintenance and recovery characteristics of halothane and sevoflurane in pediatric patient of 1 to 10 years of age undergoing elective surgeries of approximately 1 hour duration (ASA grade 1 & 2).

Our study included 60 children divided into two groups (of 30 Patients in each group)

Group-S- who received oxygen+ nitrous oxide+ sevoflurane Group-H- who received oxygen+ nitrous oxide + halothane.

In present study, the time to loss of eyelash reflex (induction time) was significantly shorter in the sevoflurane group, p<0.05 (88.23+19.129 sec) compared to halothane group (165.63+40.372 sec). This can be explained by low blood gas solubility of sevoflurane as compared to halothane.

Sarner et al (1995) [1] also compared sevoflurane with or without nitrous oxide vs halothane in children (1-12years of age). They found that induction times, vocal cord position at intubation, time to incision, duration of anesthesia and Mac - hour duration were similar in the three groups.

Paris ST and coworkers [2] (1997) compared halothane and sevoflurane for outpatient dental anaesthesia in paediatric patients. They found that time to achieve loss of eyelash reflex was more rapid using sevoflurane although time to achieve adequate anaesthesia (to allow insertion of mouth prop) was slower in the sevoflurane group.

They suggested that limitation of induction time for sevoflurane may be a function of the vaporizer used. The maximum concentration of the agents that they could deliver was 5 % halothane and 8% sevoflurane which corresponded to 5 MAC and 4 MAC respectively.

Similar result were shown by shruti redhu et al (2010). They found that time to loss of eylash reflex and tracheal intubation was more rapid using sevoflurane than with halothane.

In present study, analysis of heart rate and blood pressure trends during induction, maintenance and recovery showed that there is fall in pulse rate and blood pressure in both groups but this decline is greater with halothane group and statistically significant.

Halothane produces a reduction in myocardial contractility and a reduction in stroke volume.

Sevoflurane has minimal effect on heart rate, while heart rate often falls during halothane anaesthesia. The decrease in heart rate with halothane may be due to a reduction in sympathetic activity or a direct effect on the rate of discharge of the sinoatrial node and inhibition of baroreceptor reflex.

Sarner JB et al (1995) studied sevoflurane and halothane characteristics in 1-12 yrs children and found that mean heart rate and systolic blood pressure decreased during induction in halothane group but not in sevoflurane group.

Richard H Epstain [3] (1995) compared sevoflurane and halothane in 9 month to 16 yrs children. They started their induction with sevoflurane 1%and increased upto 7% maximum or halothane 0.5% and 5% maximum in nitrous oxide and oxygen(60:30). Under 1.5 MAC drug delivered for 20 minutes, the intubation was done following vecuronium and then 0.75 MAC was continued until the end of surgery. They found that post intubation heart rate as well as mean arterial pressure was significantly higher in halothane group compared with preinduction value in operating room. This finding corresponded with a higher MAC multiple of end tidal concentration in the sevoflurane group than in the halothane group.

Richard H. Epstein [4] (1995) compared sevoflurane and halothane for general anaesthesia in pediatric patients and found that emergence was faster with sevoflurane (9.9 ‡2.9 min vs 12.5‡4.7 min, p <0.05), despite a higher MAC multiple of end tidal sevoflurane concentration at the end of surgery.

Villani A et al [5] (1998) did randomized, prospective clinical comparison of sevoflurane (7%) and halothane(5%) in children aged 3-12 years. They showed that sevoflurane group maintained a more stable heart rate during induction period than halothane group (p=0.05).

In our study comparison of recovery time among two groups showed that time to open eyes (recovery time-1) and time to follow commands (recovery time-2) was significantly less in sevoflurane group (133.57 sec vs 365.37 sec) than in halothane.

Chin CL et al [6] (1999) compared halothane and sevoflurane in a children (1-10 years old) and found that emergence from anaesthesia was faster in children receiving sevoflurane than in those receiving halothane (mean 9 min vs 21 min), p < 0.001.

In our study we compared the two groups for intraoperative complications like cough, bucking, breath holding and oxygen desaturation on the basis of airway hyperreactivity score and found that there was no statistically significant difference (p-value is>0.05). It was because both sevoflurane and halothane are non irritant and provide smooth induction with minimal secretions. sevoflurane is least airway irritant among all inhalational agents

and halothane is most potent bronchodilator among these.

In our study emergence phenomenon were compared among two groups on the basis of emergence agitation score and it was found that children who received sevoflurane were more agitated and restless at the time of emergence than the children who received halothane. The most likely explanation is that patients experienced rapid emergence as sevoflurane is eliminated rapidly while children who received halothane appeared sedated and calm due to slow elimination as compared to sevoflurane.

Limitations of this study include lack of blinding due to study design and inability to assess arrhythmogenic properties of both the agents and high cost of sevoflurane.

We conclude that induction with sevoflurane and oxygen leads to faster loss of consciousness, provides ideal conditions for managing airway with haemodynamic stability and rapid recovery from anaesthesia. Therefore, it can be a reasonable alternative to halothane for pediatric patients aged 1-10 years.

Summary and conclusion

The present study was carried out in the general operation theatre, S.N. Medical College. This study was done to compare the induction, maintenance and recovery characteristics of sevoflurane and halothane in pediatric patients of 1-10 years of age, ASA grade 1 & 2 undergoing surgeries under general anaesthesia of approximately 1 hour duration. It included 60 chlidren, which were divided into two groups of 30 children in each group. One group received sevoflurane and one received halothane for induction maintenance and recovery.

1. Time to loss of eyelash reflex (induction time) was compared between two groups and it was significantly shorter in children.
2. Baseline pulse rate was comparable between two groups. There was decline in pulse rate in both groups but this decline was more with children who received halothane anaesthesia than the children who received sevoflurane anaesthesia and difference was statistically significant ,p value<0.05.
3. Mean arterial blood pressure was comparable between two groups. There was decline in mean arterial blood pressure in both groups but this decline was more with children who received halothane anaesthesia than the children who received sevoflurane anaesthesia and difference was statistically significant, p value <0.05.
4. Time to open eyes and time to follow commands was shorter in sevoflurane group than halothane group and on comparison the difference was statistically significant, p value <0.05.
5. In our study emergence phenomenon were compared among two groups on the basis of emergence agitation score and it was found that children who received sevoflurane were more agitated and restless at the time of emergence than the children who received halothane.

So, we conclude that the anaesthesia with sevoflurane provided rapid induction and rapid recovery with more stable hemodynamics than halothane in pediatric patients of age group 1-10 years. However, more frequent emergent phenomenon and higher cost may be factors limiting its popularity.

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