ORIGINAL ARTICLE

# Effects of Sevoflurane and Halothane on Haemodynamics During Induction of General Anaesthesia using Laryngeal Mask Airway in Children

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## Abstract

**Introduction:** Inhalational anaesthesia is a preferred technique of induction in children. Halothane has been commonly used for inhalational induction. Sevoflurane with low blood gas solubility and pleasant odor allows rapid induction, early and smooth emergence. The study was conducted to observe effects of sevoflurane and halothane on hemodynamics during induction of general anaesthesia using laryngeal mask airway in children.

**Methods:** This prospective, observational study was conducted among 60 ASA PS I children aged 2 - 12 years. The two groups of children undergoing surgery with halothane and sevoflurane induction were compared. Heart rate, mean arterial pressure and complications were observed between two groups.

**Results:** The two groups were comparable in terms of age, weight, sex distribution, ASA status and surgical procedure. There was no significant difference in heart rate and mean arterial pressure during pre - induction, loss of eyelash reflex, immediately after LMA insertion and then 3 mins and 5 mins later. There were two cases of arrhythmia in halothane group and two cases of laryngospasm in sevoflurane group.

**Conclusions:** There was no significant difference in effects of sevoflurane and halothane on hemodynamics during induction of general anaesthesia using LMA in paediatric patients. Hence, both agents can be safely used.



## INTRODUCTION

Inhalational induction is most common and popular method employed in paediatric anaesthesia as the need to secure an intravenous line in an awake child is psychologically traumatic and unpleasant.[1,2] Among various inhalation agents, halothane and sevoflurane has been widely used for inhalation induction.[3,4]

Halothane is easily available and relatively inexpensive inhalational agent that has been commonly used for induction particularly in low to middle income countries. It has sweet non irritating odor but it has propensity to cause bradycardia, hypotension, arrhythmias and halothane hepatitis.[5] Sevoflurane is one of the newer inhalation agents. It has rapid onset due to lower blood gas solubility, lesser cardiac depression, lesser arrhythmogenic property, non-pungent. It has negligible airway irritant effect but it is expensive than halothane. It has side effects like agitation upon awakening, nausea, vomiting and nephrotoxicity.[6-8]

Laryngeal mask airway (LMA) device is a popular device for elective short surgical procedures under general anesthesia in paediatric population.[9,10] Since, cost of sevoflurane is approximately 30 times greater, halothane may be the only affordable potent inhalation agent in resource limited settings. However, there is paucity of evidences regarding effects of these two agents on

hemodynamics during induction of anesthesia using LMA in children.[11] Hence, this study was conducted to observe heart rate, mean arterial pressure and complications in terms of arrythmias, bradycardia, hypotension, apnea, desaturation, involuntary movements and laryngospasm using halothane and sevoflurane for induction in children with and after LMA insertion.

## METHODS

After getting ethical approval from Institutional Review Committee (IRC Reg. No: 268), a prospective observational study was conducted in Shree Birendra Hospital, Chhauni, Kathmandu, Nepal from May 2020 to April 2021. After getting informed written consent from parent, 60 American Society of Anesthesiologist (ASA) physical status class I patients aged 2 - 12 months of either sex were selected by non purposive sampling method. The children weighed 10 - 30 kg undergoing elective orthopedic and general surgeries under general anaesthesia (GA) using LMA were studied. 30 children with halothane and 30 children with sevoflurane were studied. ASA PS II and above, prior exposure to GA within three months, family history of malignant hyperthermia, allergy to study drug and contraindications to LMA insertion (Mouth opening less than 1.5 cm, full stomach patient, airway pressure more than 20 cm of $H_20$) were excluded. Pre-anesthetic check up with thorough history, physical examination and investigations were done a day before surgical procedure. The patients were kept nil per oral for two hours for clear liquid, four hours for breast milk, six hours for infant formula / non-human milk, six hours for light meal and eight hours for heavy meal.[12] All patients were administered glucose water two hours prior to arrival to operating room.[13] Demographic variables including age, gender and weight were recorded. Patients were shifted to operation theatre and attached to ASA standard monitors. Baseline hemodynamic parameters like heart rate, oxygen saturation of hemoglobin and mean arterial pressure was noted. Anaesthesia was induced by principal investigator after priming the circuit for 30 seconds via facemask using Jackson - Rees circuit, using oxygen with a fresh gas flow rate of 4 L / min with incremental concentrations of the studied volatile anesthetic agent. In halothane group, halothane was set at 0.5% initially in the dial setting, followed by stepwise increase of 0.5% every 5 - 7 breath up to 5% until the loss of eyelash reflex. Sevoflurane was set at 1% initially in the dial setting and increased stepwise by 1% up to 7% till loss of eyelash reflex. Appropriate IV access was established and administered 10 ml / kg / hr of Ringer's lactate.[14] Time of loss of eyelash reflex, time of centralization of eyeballs and time of adequate jaw relaxation was noted. Proper size LMA was inserted when eyeballs were centralized and jaw was relaxed. The classic laryngeal mask airway (cLMA) was inserted as per the standard and departmental protocol. LMA placement was confirmed by slight outward movement of the tube upon LMA inflation, presence of a small oval swelling in the neck around the thyroid and cricoid area, no cuff visible in oral cavity and expansion of chest wall on bag compression. Heart rate, mean arterial pressure and oxygen saturation were recorded during this period for both the groups. Any complications such as arrhythmias, apnea, desaturation, involuntary movements, bradycardia and hypotension was noted and treated immediately.[15] After insertion of LMA, anesthesia was maintained on the study inhalational agent and oxygen until the end of surgery. Inj. Fentanyl 2 mcg / kg was administered only when recording was complete. Recordings of HR, $SpO_2$ and MAP was obtained when the eyelash reflex was lost, immediately after LMA insertion, at 3 minutes and 5 minutes after LMA insertion. The study ended at this point. Complications during induction was recorded and managed accordingly. Hypotension was considered significant when MAP was less than 30% below pre-induction valuesand was managed by decreasing the delivery of anesthetic agents, administration of IV fluids 20 ml / kg bolus and ephedrine at 0.1 - 0.3 mg / kg IV with dose increments when it was needed. Bradycardia (HR < 60 beats per minute or HR < 20% pre-induction values was treated with atropine 0.01 - 0.02 mg / kg IV. Tachycardia (HR > 20% pre - induction values) was managed by increasing the anesthetic depth and esmolol 0.1 - 0.5 mg / kg IV.[16] Demographic variables were expressed as frequencies, means and standard deviation for both the groups. Mean value with standard deviation of heart rate, mean arterial pressure and oxygen saturation were compared between sevoflurane and halothane groups at pre induction, during loss of eyelash reflex, immediately after LMA insertion, 3 minutes and 5 minutes after LMA insertion. All the data collected were analyzed statistically using SPSS software version 24.

## RESULTS

The frequency distribution of basic demographic variables is presented in Table 1. Majority of the patients were males in both the groups. The mean age and weight in sevoflurane group were 6.27 years and 19.18 kg while 5.02 years and 17.08 kg in halothane group respectively.

The mean heart rate in every stage was higher in sevoflurane group as compared to halothane group (Table 2). However, the difference of heart rate between these two groups was not statistically significant (P > 0.05). Thus, we could not assert that heart rate between participants in sevoflurane group was different than heart rate of participants in halothane group.

**Table 1:** Distribution of demographic characteristics of the study participants

| Demographic data | Sevoflurane (N = 30) | Halothane (N = 30) |
|---|---|---|
| No. of patients | 30 | 30 |
| Mean age (Years) (Mean ± SD) | 6.27 ± 3.12 | 5.02 ± 2.36 |
| Mean weight (kg) (Mean ± SD) | 19.18 ± 6.12 | 17.08 ± 4.85 |
| Sex (M / F) | 26 / 4 | 27 / 3 |

**Table 2:** Comparison of heart rate (beats / min) between sevoflurane and halothane

| Time | Sevoflurane (N = 30) HR (Mean ± SD) | Halothane (N = 30) HR (Mean ± SD) | P value |
|---|---|---|---|
| Pre induction | 124.6 ± 30.69 | 121.80 ± 28.60 | 0.728 |
| During loss of eyelash reflex | 115.9 ± 20.6 | 109.20 ± 23.48 | 0.211 |
| Immediately after LMA insertion | 115.2 ± 25.06 | 102.70 ± 24.70 | 0.090 |
| 3 mins after LMA insertion | 107.67 ± 24.75 | 99.83 ± 19.60 | 0.295 |
| 5 mins after LMA insertion | 106.4 ± 23.72 | 96.97 ± 17.40 | 0.154 |

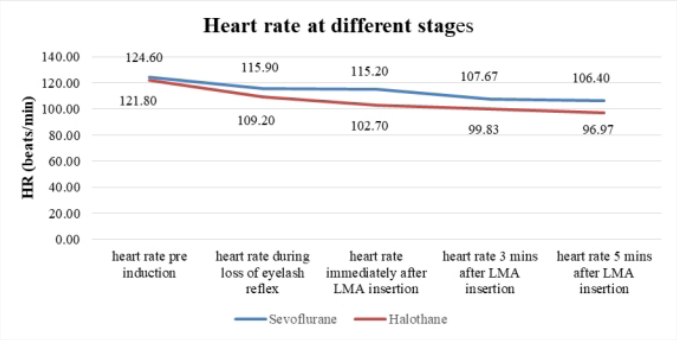


**Fig 1:** Comparison of heart rate between Sevoflurane and Halothane groups at various intervals of time

The distribution of mean arterial pressure at different stages are depicted in Table 3. The mean arterial pressure in every stage was higher in sevoflurane group compared to halothane group. However, the difference of mean arterial pressure between these two groups were not statistically significant (P > 0.05).

**Table 3:** Comparison of MAP (mm Hg) between sevoflurane and halothane groups

| Time | Sevoflurane (N = 30) MAP (Mean ± SD) | Halothane (N = 30) MAP (Mean ± SD) | P value |
|---|---|---|---|
| Pre induction | 92.82 ± 17.9 | 92 ± 14.70 | 0.494 |
| During loss of eyelash reflex | 72.54 ± 16.53 | 70.28 ± 10.32 | 0.609 |
| Immediately after LMA insertion | 68.27 ± 10.32 | 64.28 ± 7.49 | 0.202 |
| 3 mins after LMA insertion | 63.47 ± 8.54 | 61 ± 10.36 | 0.268 |
| 5 mins after LMA insertion | 62.20 ± 7.26 | 60.29 ± 8.14 | 0.180 |

The graphical representation of mean arterial pressure at different stages between sevoflurane and halothane group is shown in Figure 2.

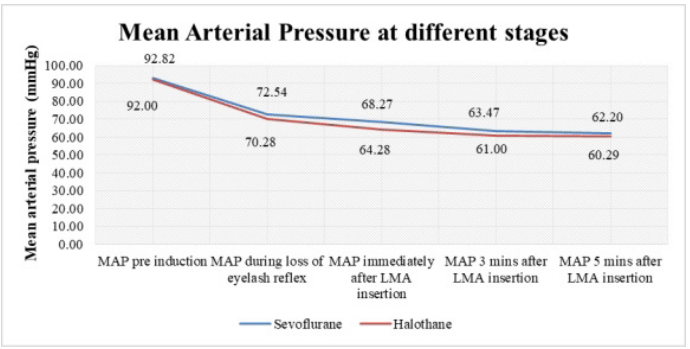


**Fig 2:** Comparison of MAP between sevoflurane and halothane groups

The distribution of mean oxygen saturation ($SpO_2$) at different stages are depicted in Table 4. The mean arterial pressure was higher in sevoflurane group compared to halothane group. However, the difference of $SpO_2$ between these two groups were not statistically significant (P > 0.05), thus we could not assert that $SpO_2$ between participants to whom sevoflurane was used was different than to whom halothane was used.

**Table 4:** Comparison of $SpO_2$ (%) between sevoflurane and halothane groups

| Time | Sevoflurane (N = 30) SPO2 (Mean ± SD) | Halothane (N = 30) SPO2 (Mean ± SD) | P value |
|---|---|---|---|
| Pre induction | 98.52 ± 1.27 | 98.37 ± 1.27 | 0.596 |
| During loss of eyelash reflex | 98.87 ± 1.61 | 98.57 ± 1.45 | 0.172 |
| Immediately after LMA insertion | 99.07 ± 0.98 | 98.30 ± 1.64 | 0.092 |
| 3 mins after LMA insertion | 99.33 ± 0.88 | 98.79 ± 1.37 | 0.135 |
| 5 mins after LMA insertion | 99.33 ± 0.95 | 98.66 ± 1.61 | 0.125 |

The graphical representation of $SpO_2$ at different stages between sevoflurane and halothane group is shown in Figure 3.

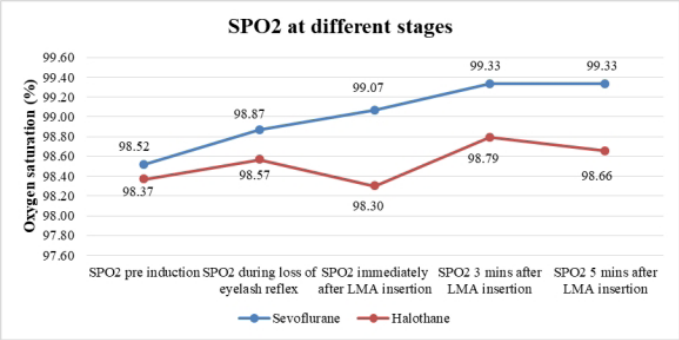


**Fig 3:** Comparison of $SpO_2$ between sevoflurane and halothane groups

There were two cases of arrhythmia observed in halothane group and two cases of laryngospasm observed in sevoflurane group as shown in Table 5.

**Table 5:** Comparison of complications betwen sevoflurane and halothane groups

| | Sevoflurane (N = 30) | Halothane (N = 30) |
|---|---|---|
| Arrhythmias | 0 | 2 |
| Apnea | 0 | 0 |
| Desaturation | 0 | 0 |
| Involuntary movements | 0 | 0 |
| Secretions | 0 | 0 |
| Bradycardia | 0 | 0 |
| Hypotension | 0 | 0 |
| Laryngospasm | 2 | 0 |

## DISCUSSION

In this study, we found that demographic profile was similar in both groups in regard of baseline parameters like age, gender, weight, ASA class and surgical procedure. Among various techniques of inhalational induction, some authors have used rapid inhalational induction[17] while others have used tidal technique of incremental concentrations.[18] The incidence of airway complications such as breath holding and laryngospasm were more frequent with rapid inhalational induction than with incremental technique. Hence in our present study we adapted incremental inhalation induction technique with use of 0.5 - 5% halothane and 1 - 7% sevoflurane that was similar to study done by Piat VQ et al,[18] O'Brein K et al,[19] Ashraf S et al[20] and Lapin S et al.[21]

In the present study, we used non - invasive hemodynamic measurements such as heart rate and blood pressure to evaluate the cardiovascular responses of halothane and sevoflurane. We found a progressive decrease in heart rate in both the groups from pre induction phase to 5 mins after LMA insertion, more in halothane group (121.80 ± 28.60 bpm to 96.97 ± 17.40 bpm) compared to sevoflurane group (124.6 ± 30.69 bpm to 106.4 ± 23.72 bpm). But we could not find a statistically significant difference in heart rate between sevoflurane and halothane at any phase of induction. The findings were similar to the studies done by O'Brien K et al[19] and Bacher A et al[22] which also showed no significant difference in heart rate between two groups. While Sarner JB et al[23] observed that children receiving halothane tended to have a decrease in heart rate during anaesthetic induction, whereas children receiving sevoflurane maintained or increased heart rate. Similarly, Ashraf S et al[20] also found a greater incidence of fall in heart rate in patients receiving halothane compared to patients receiving sevoflurane in whom heart rate was maintained during all phases of induction.

This study showed no significant difference in MAP between halothane and sevoflurane group from pre-induction phase to five minutes after LMA insertion. However, the MAP was greater in the sevoflurane group compared to halothane group which might be due to the myocardial depressant effect of halothane which was similar to the study done by O'Brien K et al[19] and Bacher A et al.[22] However, Sarner JB et al[23] observed a decrease in the MAP during induction with both halothane and sevoflurane probably due to use of higher concentration of halothane up to 5% and sevoflurane up to 8%. Another randomized double blinded study by Greely WJ et al[16] concluded that among children with congenital heart disease, sevoflurane might have hemodynamic advantage over halothane as severe episodes of hypotension was found in patients receiving halothane than in patients receiving sevoflurane. As our study was conducted in healthy individuals with ASA physical status I, this might have caused the difference in findings.

This study showed no difference in oxygen saturation between halothane and sevoflurane group at all phases

of pre-induction, during loss of eyelash reflex, immediately after LMA insertion, 3 minutes and 5 minutes after LMA insertion which was similar to study done by Ashraf S et al[20] O'Brien K et al[19] and Bacher A et al.[22] Thus, all these studies concluded the difference between two drugs in clinical practice to be very small and did not justify the additional cost of sevoflurane.

The complications such as arrhythmia was seen in two patients administered halothane at 4% and 5% concentration respectively during induction and was managed by decreasing concentration of halothane in dial setting during maintenance of anaesthesia. Similarly, two cases in the sevoflurane group had developed laryngospasm which could be the result of inadequate depth of anaesthesia. It was managed by administration of 100% oxygen, Larson's maneuver and application of continuous positive airway pressure (CPAP). There are few limitations of this study. Firstly, the study was limited to ASA PS I only. Secondly it was single centre study hence could not be generalized. Thirdly the sample size was small and lastly since time to onset of induction was not compared, we could not determine which among the two has faster induction.

## CONCLUSIONS

There is no difference on the effects of sevoflurane and halothane on hemodynamics during induction of general anaesthesia using laryngeal mask airway in paediatric patients. Hence, both of these agents can be used safely in children. However, to claim the superiority of sevoflurane over halothane, we recommend for larger and multicenter studies.

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**CONFLICT OF INTEREST:** None

## REFERENCES

1. Mellor J. Induction of anaesthesia in paediatric patients. Update in Anaesthesia. 2000;11(14):27-30 Retrieved from: https://resources.wfsahq.org/wp-content/uploads/uia18-INDUCTION-OF-ANAESTHESIA-IN-PAEDIATRIC-PATIENTS.pdf
2. Whalen FX, Bacon DR, Smith HM. Inhaled anesthetics: an historical overview. Best Pract Res Clin Anaesthesiol. 2005 Sep 1;19(3):323-30
DOI: 10.1016/j.bpa.2005.02.001
PMID: 16013684
3. Hemona Devi S, Potli S, Madhusudhana R, Krishnamurthy D. A Comparative Study of Halothane versus Sevoflurane for Induction of Anaesthesia and Tracheal Intubation in Children. IOSR-JDMS 2017 Nov 12;16(6):90-5
DOI: 10.9790/0853-1606019095
4. Reichert C. Beyond halothane: an update on pediatric anesthesia pharmacology. Can J Anesth. Jun 2003;50:51-54
DOI: 10.1007/BF03018156
5. O'brien HD. The Introduction of Halothane into Clinical Practice: The Oxford Experience. Anaesth Intensive Care. 2006 Jun; 34(1):27-32
DOI: 10.1177/0310057X0603401S03
PMID: 16800225
6. De Hert S, Moerman A, Eckenhoff R, Seeberger M. Sevoflurane. F1000Research. 2015 Aug 4:626
DOI: 10.12688/f1000research.6288.1
PMID: 26380072 PMCID: PMC4560253
7. Delgado HL, Ostroff RD, Rogers SA. Sevoflurane: Approaching the ideal inhalational anesthetic a pharmacologic, pharmacoeconomic, and clinical review. CNS Drug Rev. 2001 Mar; 7(1):48-120
DOI: 10.1111/j.1527-3458.2001.tb00190.x
PMID: 11420572 PMCID: PMC6741648
8. Brioni JD, Varughese S, Ahmed R, Bein B. A clinical review of inhalation anesthesia with sevoflurane: from early research to emerging topics. J Anesth. 2017 Oct; 31(5):764-78
DOI: 10.1007/s00540-017-2375-6
PMID: 28585095 PMCID: PMC5640726
9. Verghese C, Mena G, Ferson DZ, Brain AIJ. Laryngeal Mask Airway. In Benumof and Hagberg's Airway Management. Elsevier. 2013. p. 443-465
DOI: 10.1016/B978-1-4377-2764-7.00022-1
PMCID: PMC4031455
10. Hernandez MR, Klock PA, Ovassapian A. Evolution of the extraglottic airway: a review of its history, applications, and practical tips for success. AnesthAnalg. 2012 Feb; 114(2):349-68
DOI: 10.1213/ANE.0b013e31823b6748
PMID: 22178627

11. Kangralkar G, Jamale P. Sevoflurane versus halothane for induction of anesthesia in pediatric and adult patients. Med Gas Res. 2021 Apr; 11(2):53-57
DOI: 10.4103/2045-9912.311489
PMID: 33818443 PMCID: PMC8130664

12. ASA. Practice Guidelines for Preoperative Fasting and the Use of Pharmacologic Agents to Reduce the Risk of Pulmonary Aspiration: Application to Healthy Patients Undergoing Elective Procedures. Anesthesiology. 2017 Mar; 126(3):376-93
DOI: ALN.0000000000001452
PMID: 28045707

13. Crean Peter. APA Consensus guideline on perioperative fluid management in children v 1.1 consensus guideline on perioperative fluid management in children 2007. APAGBI. 2007;1(1):1-37 Retrieved from: https://www.apagbi.org.uk/sites/default/files/inline-files/PerioperativeFluidManagement2007.pdf

14. Sumpelmann R, Becke K, Brenner S, Breschan C, Eich C, Hohne C, et al. Perioperative intravenous fluid therapy in children: guidelines from the Association of the Scientific Medical Societies in Germany. Paediatr Anaesth. 2017 Jan; 27(1):10-18
DOI: 10.1111/pan.13007
PMID: 27747968

15. Koay CK, Yoong CS, Kok P. A randomized trial comparing two laryngeal mask airway insertion techniques. Anaesth Intensive Care 2001 Dec; 29(6):613-5 DOI: 10.1177/0310057X0102900609
PMID: 11771605

16. Greeley WJ, Russell IA, Hance WCM, Gregory G, Balea MC, Cassorla L, et al. Pediatric anesthesia society for pediatric anesthesia section editor. The Safety and Efficacy of Sevoflurane Anesthesia in Infants and Children with Congenital Heart Disease. Anesth Analg. 2001; 92(5):1152-8
DOI: 10.1097/00000539-200105000-00014
PMID: 11323338

17. Sigston PE, Jenkins AMC, Jackson EA, Sury MRJ, Mackersie AM, Hatch DJ. Rapid inhalation induction in children: 8% sevoflurane compared with 5% halothane. Br J Anaesth. 1997 Apr; 78(4):362-5
DOI: 10.1093/bja/78.4.362
PMID: 9135351

18. Piat V, Dubois MC, Johanet S, Murat I. Induction and recovery characteristics and hemodynamic responses to sevoflurane and halothane in children. Anesth Analg. 1994;79(5):840-4
DOI: 10.1213/00000539-199411000-00004
PMID: 7978397

19. O'Brien K, Kumar R, Morton NS. Sevoflurane compared with halothane for tracheal intubation in children. Br J Anaesth. 1998; 80(4):452-5
DOI: 10.1093/bja/80.4.452
PMID: 9640148

20. Ashraf S, Hassan Y, Salmani UG, Ahmad GB, Saleem B. Comparison of Sevoflurane and Halothane for Induction of Anesthesia and Laryngeal Mask Airway Insertion in Pediatric Patients: A Tertiary Care Experience. Int J Clin Anesthesiol. 2018; 6(2): 1096
DOI: 10.47739/2333-6641/1096

21. Lapin SL, Auden SM, Goldsmith LJ, Reynolds AM. Effects of sevoflurane anaesthesia on recovery in children: a comparison with halothane. Paediatr Anaesth. 1999; 9(4):299-304
DOI: 10.1046/j.1460-9592.1999.00351.x
PMID: 10411764

22. Bacher A, Burton AW, Uchida T, Zornow MH. Sevoflurane or halothane anesthesia: can we tell the difference? Anesth Analg. 1997; 85(6):1203-6
DOI: 10.1213/00000539-199712000-00004
PMID: 9390580

23. Sarner JB, Levine M, Davis PJ, Lerman J, Cook DR, Motoyama EK. Clinical characteristics of sevoflurane in children. A comparison with halothane. Anesthesiology. 1995; 82(1):38-46
DOI: 10.1097/00000542-199501000-00006
PMID: 7832332