Original Article

Comparison of the Qualities of Sevoflurane and Halothane in Paediatric Anaesthesia

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Abstract

Background: Inhalational anaesthetics are used for the induction and maintenance of general anaesthesia in children. More agents are evolving in an effort to discover the agent of choice in this age group, considering the safety margin, availability, affordability, and accessibility of the anaesthetics. **Aim:** The aim of our study was to compare the qualities of halothane and sevoflurane in paediatric patients. **Materials and Methods:** This was a prospective randomised study of 100 children within the age group of 5–12 years, scheduled for elective surgery in Ahmadu Bello University Teaching Hospital, Zaria, from January to October 2022, and satisfied the study inclusion criteria. The following variables (heart rate, blood pressure, arrhythmias, and complications) were recorded and analysed using IBM SPSS version 25 (Chicago) USA. $P \leq 0.05$ was considered statistically significant. **Results:** The incidence of tolerability at induction of anaesthesia, hypoxaemia (SpO_2 <90%), and airway responses (laryngospasm, coughing, and breath holding) was similar in both the groups. However, at induction of anaesthesia, the degree of muscle rigidity in the sevoflurane group was statistically significant compared with the halothane group ($P = 0.028$), but the difference was not statistically significant at the recovery period ($P = 0.59$). More so, the incidence of arrhythmias was higher in the halothane group than in the sevoflurane group. **Conclusion:** The overall qualities of halothane were commensurate with that of sevoflurane. However, where available and affordable, sevoflurane will be a better agent of choice in paediatric anaesthesia.

Keywords: Halothane, paediatric patients, quality of anaesthesia, sevoflurane

Introduction

Halothane is a halogenated hydrocarbon used for the induction and maintenance of general anaesthesia, due to its sweet smell, and it provides smooth induction and emergence. However, it is arrhythmogenic and causes myocardial depression. Sevoflurane, which is also a halogenated ether, is used for the induction and maintenance of general anaesthesia. It has a relatively pleasant smell with a rapid onset and offset of action due to its low blood–gas solubility.[1] It is said to be the induction agent of choice in the paediatric age group.[1,2] Other inhalational agents such as enflurane and isoflurane are less arrhythmogenic[2,3] but inferior to halothane in terms of ease of induction and quality of anaesthesia.[2-4] This is due to the latter's sweet smell and higher potency.

This study was designed to compare the qualities of anaesthesia using either the commonly available halothane or sevoflurane in children.

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Materials And Methods

Consent was sought and obtained from all patients through written informed consent by the parents.

Approval for publication was obtained from the Ethical Committee of Ahmadu Bello University Teaching Hospital, Zaria, with Ref. No. ABUTH/HREC/F30/2022. The calculated sample size was 100 and the study ended at emergence, thus attrition was not added to the sample size.

Inclusion criteria were patients in the American Society of Anaesthesiologists (ASA) physical classification status I and II, patients aged between 5 and 12 years, and patients booked

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for elective surgeries under general anaesthesia. Patients were allocated randomly using a computer-generated method into either the sevoflurane or halothane group. A thorough but focused preanaesthesia evaluation was carried out a day before surgery.

Before the induction of anaesthesia, the following monitors were instituted: electrocardiography (ECG), paediatric pulse oximetry, thermocouple to monitor the electrical activity of the heart (lead II selected), oxygen saturated (SpO_2), and patients' temperature, respectively, with a multiparameter monitor B125 (produced by GE Medical Systems Information Technologies Inc., Freiburg, Germany, 2012). All these devices were used to monitor the patients continuously and throughout the surgery. Paediatric cuff was used for noninvasive arterial blood pressure at induction and throughout the surgery. The measurement was initially done every three minutes and after 20 min of anaesthesia; the blood pressure measurement was done every five minutes and recorded. To avoid bias, patient variables were recorded by a resident doctor not taking part in the study. These variables includes: the time of induction and emergence from anaesthesia, heart rate, blood pressure, arrhythmias (heart rate >170 b/min), incidence of complications throughout the study period. The complications were on the scale of 4 (from 0-3). where 0 mean no complication; 1 mean there is complication but not troublesome; 2 mean complication is present and requiring treatment and 3 mean complication is present and the surgery need to be postponed.

The complications assessed were tolerability of the agents, breath holding, reduced oxygen saturation (SpO_2 of <90%), coughing, laryngospasm, rigidity, and shivering. Anaesthesia was administered by two consultants, and all patients were preoxygenated for five minutes.

The induction of anaesthesia was done by introducing the selected agent (sevoflurane or halothane) in an incremental dose of 1% to a maximum of 5%. The concentration of each agent was increased every 3–5 breaths. The deliveries of these agents were through a Drager vapourizer. The vapour was delivered through Bain's delivery circuit for patients whose weight was >25 kg and Ayre's T piece was used for patients whose weight were <25 kg. All patients were intubated with polyvinyl chloride (PVC) endotracheal tube size appropriate for the age of the patients. The fresh gas flow rates were calculated and delivered throughout the anaesthesia period and maintained on a mixture of respective agents and 100% of oxygen throughout the surgery. The maintenance of anaesthesia was at a concentration of 0.78%–2% in both halothane and sevoflurane depending on the hemodynamics of the patient. All patients had atracurium for muscle paralysis, and pethidine was administered for pain management. All patients were manually ventilated.

At emergence, both agents were turned off, and patients were given 100% oxygen for 10 min, extubated on meeting criteria for extubation, and were taken to recovery room where oxygenation and close monitoring continued till the patient was discharged to the ward.

The recorded variables were analysed, and data were presented as mean and standard deviation (SD). Student's *t*-test and Chi-square analysis were done using IBM SPSS version 25 (Chicago) USA

Results

All the recruited patients took part in the study. The recorded variables were analysed and presented in the table below [Table 1].

It was observed that the ratio of the age group was 1:1.1. It was also observed that female were more in both halothane and sevoflurane group. The duration of anaesthesia was more in halothane group (2 hours and 45 minutes) compared to sevoflurane group (2.5 hours).

In Table 2, it was observed that there was an increase in heart rate in both group at induction, as well as at emergence from anaesthesia. However, the highest heart rate in the halothane group (166 b/min) was statistically significant compared with the sevoflurane group (142 b/min) with $P < 0.001$ at induction of anaesthesia. The increase in heart rate at emergence was statistically significant ($P<0.001$).

In Table 3, the systolic blood pressure was statistically significant in both group with a mean (SD) of 108 mmHg, (-+6.05) and 115 mmHg (-+7.81) in the halothane and

Table 1: Patient biodata and duration of anaesthesia

	Sevoflurane ($n=50$)	Halothane ($n=50$)
Age	7 (±2.8)	8 (±4.1)
Sex (male/female), *n* (%)	19 (38)/31 (62)	23 (46)/27 (54)
Weight (kg)	25 (±3.1)	23 (±4.4)
Duration of anaesthesia (h)	2.45 (±9)	2.30 (±1.7)

Table 2: Heart rate in mean (standard deviation) at various stages of anaesthesia

	Baseline mean (SD)	Induction	Emergence
Halothane	122 B/min (±8.8)	154 B/min (±5.5)	137 B/min (±6.1)
Sevoflurane	118 B/min (±11.1)	121 b/min (±6.8)	124 b/min (±5.3)
P	0.049	<0.001	<0.001

SD: Standard deviation

Table 3: Blood pressure in mean (standard deviation)

	Baseline (mmHg)	At induction	At emergence
Halothane			
Systolic	126 (±2.43)	108 (±6.05)	120 (±12.10)
Diastolic	68 (±1.03)	55 (±3.55)	63 (±9.8)
Sevoflurane			
Systolic	121(±16.40)	115 (±7.81)	123 (±8.14)
Diastolic	71 (±11.58)	60 (±4.24)	59 (±6.33)
P			
Systolic	0.088	<0.001	0.149
Diastolic	0.293	<0.001	0.017

Table 4: Induction and recovery time (n=50)

Agents	Induction time (min) from turning the vapour on up to the loss of eyelash reflex	Recovery time (min) after turning off the vapour to eye-opening
Halothane	1.6 (±0.35)	9.7 (±2.30)
Sevoflurane	1.4(±0.20)	7.8(±2.15)
P	0.003	0.012

Table 5: Graded complications of halothane versus sevoflurane at induction and emergence

Complications	Grade	At induction			During recovery		
		Sevoflurane	Halothane	*P*	Sevoflurane	Halothane	*P*
Tolerability of the agent	0	38	45	0.145	-	-	-
	1	11	4		-	-	
	2	1	1		-	-	
Breath holding	0	49	48	-	50	50	-
	1	0	2		0	0	
	2	1	0		0	0	
SpO_2 (<90%)	0	50	50	-	50	50	-
	1	0	0		0	0	
	2	0	0		0	0	
Coughing	0	43	48	0.146	45	48	0.387
	1	6	1		4	1	
	2	1	1		1	1	
Laryngospasm	0	48	48	-	49	50	-
	1	1	1		1	0	
	2	1	1		0	1	
Muscle rigidity	0	40	48	0.028	46	48	0.59
	1	9	1		1	1	
	2	1	1		3	1	
Shivering	0	-	-	-	50	49	0.32
	1	-	-		0	1	
	2	-	-		0	0	
Abnormal movement	0	49	48	0.54	41	48	0.001
	1	1	1		9	2	
	2	0	1		0	0	

SpO_2: Oxygen saturation

sevoflurane groups respectively ($P<0.001$); similarly, observation was seen in the diastolic blood pressure with *P* value less than 0.001.

However, there was no statistically significant difference in the systolic blood pressure at emergence ($P > 0.05$), but a significant difference was observed in the diastolic blood pressure ($P = 0.017$).

According to the Table 4, the induction onset and loss of eyelash reflex were shorter in Sevoflurane group with a mean of 1.4min and SD -+ 0.20 compared with the halothane group with a mean of 1.6 (SD-+0.35). This difference is statistically significant ($P=0.003$). Similarly, the eye-opening in the recovery period was lower in the sevoflurane group compared with the halothane group 7.8 (±2.15) and 9.7 (±2.30), respectively. The difference was also statistically significant ($P = 0.012$).

According to Table 5, the incidence of tolerability at induction of anaesthesia, hypoxaemia (SPO_2 less than 90%), and airway responses (laryngospasm, coughing and breath holding) was similar in both groups.

However, at induction of anaesthesia, the degree of muscle rigidity in the sevoflurane group was statistically significant compared with the halothane group ($P = 0.028$), but the difference was not statistically significant at the recovery period ($P = 0.59$).

Similarly, the incidence of abnormal movement was similar at induction ($P = 0.55$) but more with the sevoflurane group at the recovery period compared with the halothane group. This difference is statistically significant ($P = 0.026$).

Shivering was not observed in the two groups at induction but similar at the recovery period ($P = 0.32$).

Discussion

Inhalational anaesthetics are used for both induction and maintenance of general anaesthesia in paediatric surgery.[5,6]

The use of halothane in the developed world is becoming obsolete due to the emergence of newer agents such as desflurane and sevoflurane. In the developing world, halothane remains the agent of choice due to its availability, affordability, and accessibility of the agent and its vapourizer. Although, halothane has a sweet smell, it is more arrhythmogenic than isoflurane, enflurane, desflurane, and sevoflurane.[7-8] Frequent exposure to halothane can cause fulminant hepatitis, though this unwanted effect is very rare.[9]

Sevoflurane, on the other hand, is becoming the agent of choice in paediatric anaesthesia due to its high quality of anaesthesia obtained using this agent such as low incidence of arrhythmias, fast onset, and offset time.[10,11]

Cardiac autonomic changes associated with halothane may cause complete parasympathetic blockade in the paediatric age group with a reported increase in heart rate from a mean of about 120 b/min to about 175 b/min.[11,12]

This present comparative study to evaluate the qualities of halothane and sevoflurane at induction of anaesthesia, maintenance, and emergence reveals that the overall induction and intubation characteristics were observed to be better in the sevoflurane group as compared to halothane. This was similar to the study conducted by Redhu *et al*.[10]

In our study, the mean induction time of halothane was significantly longer when compared to the sevoflurane group. Other studies have similarly reported differences in the induction time between the halothane and sevoflurane groups to be statistically significant.[2,6,9,10] Similar observations were also seen during the recovery period of the two agents.[2,6,9,10]

In our study, it was observed that there was an increase in heart rate in both the halothane and sevoflurane groups at induction and emergence. However, this increase in heart rate was more in the halothane group, and the increase was statistically significant ($P < 0.001$). Shareena *et al*.[8] reported a significant difference in the mean elevated heart rate between the halothane and sevoflurane groups during induction; however, Redhu *et al*.[10] reported a significant reduction in the heart rate in the halothane group, whereas no changes were noted in the sevoflurane group during the induction period. The incidence of arrhythmias at induction of anaesthesia was similar in both the groups.[12,13] The incidence of arrhythmias at emergence was statistically significant in our study. Similar findings were seen in another study.[14] The overall incidence of arrhythmias in our halothane group was statistically significant in our study ($P < 0.00001$). Similar finding was seen in the study conducted by Niimi *et al*.[15]

In our study, the effects of blood pressure changes in the two groups were similar at induction as well as at emergence of anaesthesia.[16]

At the time of emergence from anaesthesia, recovery was significantly faster in the sevoflurane group compared to halothane. Similar results were reported by Redhu *et al*.[10] with significantly rapid recovery in the sevoflurane group compared to the halothane group. The faster recovery of sevoflurane could be attributed to its lower blood–gas solubility.[1,10]

The incidence of muscular complications (muscle rigidity and abnormal muscle movement) was more in the sevoflurane group. This was statistically significant. A study conducted by Ira *et al*. showed similar findings.[17]

Limitation of the study

Local studies were not cited to compare our findings. This would have given us a platform to compare and reference.

Conclusion

Sevoflurane provides a rapid and smooth induction and emergence from general anaesthesia. Therefore, it can be considered a suitable alternative to halothane in children. More so, sevoflurane is an effective agent for inhalational induction of anaesthesia with better stability and low incidence of airway-related complications. However, halothane has lesser musculoskeletal complications and remains an agent of choice in the developing world.

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Conflicts of interest

There are no conflicts of interest.

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