A COMPARATIVE STUDY OF HALOTHANE VERSUS SEVOFLURANE FOR INDUCTION OF ANAESTHESIA AND TRACHEAL INTUBATION IN CHILDREN

BY:

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Dr.Sinam Hemona Devi

LIST OF ABBREVIATIONS

ASA - American Society of Anaesthesiologists

BP - Blood pressure

bpm - Beats per minute

CBF - Cerebral blood flow

CI - Cardiac index

CMRO2 - Cerebral metabolic rate for oxygen

CNS - Central nervous system

Da - Daltons

ECG - Electrocardiogram

GSTA - Glutathione transferase alpha

H - Halothane

HFIP - Hexafluoroisopropanol

HR - Heart rate

iv - Intravenous

Kg - Kilogram

kPa - Kilo Pascal

LD50 - Lethal dose 50

MAC - Minimum alveolar concentration

MAP - Mean arterial pressure

mg - Milligram

min - Minutes

mmHg - Millimeters of mercury

µgm - Microgram

μM - Micromole

ppm - Parts per million

S - Sevoflurane

SD - Standard deviation

secs - Seconds

SVI - Stroke volume index

TFA - Trifluroacetyl

Pint - Immediate post intubation

1min pint - 1 minute post intubation

ABSTRACT

BACKGROUND

Inhalational anaesthesia is the most commonly employed technique in paediatric age group since it is associated with rapid induction and emergence. Halothane has been very popular as it non - irritant and well tolerated by the upper airways. However, it has the propensity to cause bradycardia, hypotension and arrhythmias. Sevoflurane, a newer inhalational agent fulfils the advantageous criteria of halothane without the associated side effects and is becoming very popular as the inhalational agent of choice in paediatric surgery

OBJECTIVES

To compare halothane and sevoflurane as inhalational agents in paediatric surgery with respect to

- Induction time
- Intubation time and characteristics
- Haemodynamic responses during induction and intubation

DESIGN

Prospective clinical study

SETTINGS

R.L. Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Tamaka, Kolar.

METHODOLOGY

This clinical study was conducted on 60 paediatric patients (30 each for halothane and sevoflurane group) of ASA grade 1 & 2 in the age group of 1 year to 5 years of either sex posted for elective surgeries under general anaesthesia in the period from June 2009 to September 2011.General anaesthesia was induced and the trachea intubated with either halothane or sevoflurane in 50:50 O_2 and N_2O without the use of any intravenous inducing agents or muscle relaxants. The data collected were statistically analysed.

SUMMARY OF RESULTS

Both halothane and sevoflurane produce acceptable induction and intubation in majority of the patients. Induction and intubation are faster with sevoflurane compared to halothane. Haemodynamic stability during induction and intubation is better with sevoflurane compared to halothane.

CONCLUSION

We conclude that sevoflurane is a better alternative to halothane for induction of anaesthesia in children with a shorter induction and intubation time and with better haemodynamic stability.

KEY WORDS

Paediatric, Halothane, Sevoflurane, Induction, Intubation.

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INTRODUCTION

In adult patients, intubation is generally facilitated by a muscle relaxant. In children, however, we prefer inhalational anaesthetic agents. The continued dominance of inhalational methods of anaesthesia over other techniques is mainly attributed to their inherent safety and almost universal application. Ether was the first agent to be used as a sole inhalational anaesthetic. Taking the patient to a level adequate for intubation took a long time due to its high blood-gas solubility.

Halothane was introduced in the year 1956[1]. It is the main drug for inhalational induction of anaesthesia in children.[3]It is preferred because it is non-irritant and produces a rapid and smooth induction. However, it may cause myocardial depression and cardiac arrhythmias[4] and also the rare, but serious complication of hepatitis and rarely triggers malignant hyperthermia.

Continued effort to manufacture an inhalation agent which would match the induction properties of halothane with minimal side effects led to the introduction of sevoflurane.[5]It has a low blood gas solubility allowing rapid induction and recovery.[7]It is non-irritant and pleasant-smelling with less myocardial depressant action and undergoes minimal metabolism.

Therefore, the present study was undertaken to compare the induction and intubation characteristics of halothane with sevoflurane in paediatric patients.

OBJECTIVES

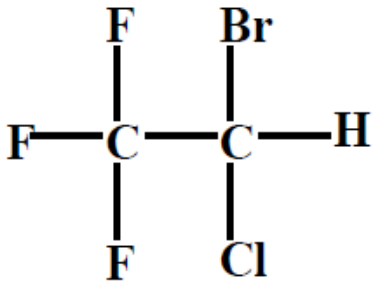
The objectives of the present study is to compare sevoflurane with halothane for induction of anaesthesia and tracheal intubation in children aged 1-5 years, both used in incremental concentrations to a maximum of 8% with sevoflurane and 5% with halothane with respect to their

1. Induction time and intubation time
2. Intubation characteristics
3. Haemodynamic responses during induction and intubation

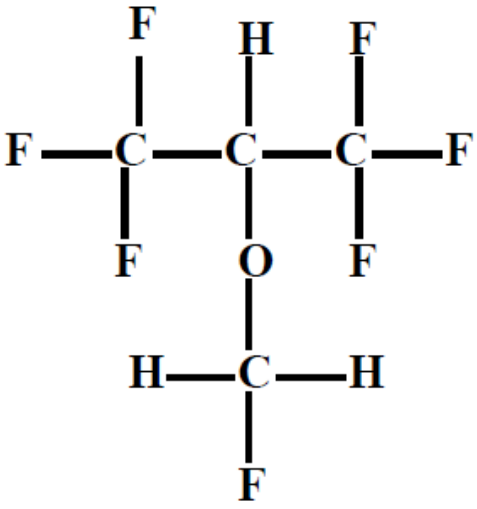
PHARMACOLOGY

Comparative pharmacology of Halothane and Sevoflurane

Halothane was synthesized in the laboratories of Imperial Chemical Industries in 1951 by C.W.Suckling[8] and was first introduced into clinical practice by Michael Johnstone in Manchester in 1956.[8] Halothane is 2-bromo-2-chloro-1,1,1,trifluoroethane.[8] Sevoflurane was first synthesized in 1968 by Regan at Travenol laboratories, Illinois. Sevoflurane is fluoroethyl 2,2,2-trifluoro-1-[trifluoromethyl]ethyl ether.



Structure of Halothane



Structure of Sevoflurane

Table 1: Physical Properties[8,9]

Particulars	Halothane	Sevoflurane
Molecular weight (Da)	197.4	200.5
Boiling point (ºC) at 760mmHg	50.2	58.6
Specific gravity (at 20ºC)	1.86	1.505
Vapour pressure at 20ºC mmHg kPa	 243 32.4	 160 21.3
Appearance	Colourless, clear	Colourless, clear
Odour	Sweet, pleasant	Mild ethereal, Pleasant, non-pungent
Flammability	None	None
Preservatives	Thymol 0.01%	None
Ozone depletion	Marked	No effect
Stability to Alkali UV light	Some Decomposition Decomposes	Degraded by sodalime and Baralyme Stable
Partition coefficients Blood / gas Oil / gas Tissue / gas Brain Liver Kidney Muscle Fat Rubber / gas	 2.3 224 1.9 2.1 1.2 3.4 51 190	 0.69 53.4 1.7 1.8 1.2 3.1 48 29
MAC in O2 (%) in 70% N2O (%)	0.75 0.29	1.7-2.05 0.66

Pharmacokinetics:

Uptake:

Halothane has blood gas solubility of 2.3 and is taken up rapidly from the alveoli. The low blood-gas solubility of sevoflurane compared with halothane produces a rapid uptake and rapid anaesthetic induction by inhalation.[9] Also, sevoflurane is non-pungent, providing a smooth induction, without airway irritation or increased secretions. Sevoflurane is probably the least irritating to the respiratory tract compared to any of the currently used volatile anaesthetics.[9]

Distribution and elimination:

A five compartment model describes the distribution of halothane and sevoflurane.[10] These five compartments comprise the lungs, the vessel rich group of organs, muscle, fat around the vessel rich organs and peripheral fat.[10] The wash out of an anaesthetic agent is influenced by its blood solubility and sevoflurane with its low blood solubility gets washed out quickly from the body. The α cerebral elimination of sevoflurane is twice as fast as that of halothane, but the long term β elimination of both agents are equal.[11]

Metabolism:

Up to 46% of inhaled halothane undergoes primarily oxidative metabolism metabolism in the liver.[12]The major metabolites are chlorine, bromine, and trifluoroacetic acid. Trifluoroacetic acid has been strongly implicated in the etiology of fulminant hepatitis. Halothane also undergoes reductive metabolism at low oxygen tension and this is associated with the production of fluoride ions, although not at the concentration associated with renal toxicity. Metabolism of halothane is catalysed by

cytochromeP_{450}. Drugs acting on cytochromeP_{450}, such as alcohol or isoniazid, which induce this enzyme system, or cimetidine and disulfiram, which inhibit it, may alter halothane metabolism. Up to 1.6%-4.9% [13] of sevoflurane is metabolized mainly in the liver, by cytochromeP_{450}2E1 enzyme.[15] Sevoflurane is broken down into inorganic fluoride ions and the organic fluoride metabolite hexafluroisopropanol (HFIP).[17] HFIP is conjugated with glucuronic acid to form HFIP glucuronide, which is excreted by the kidney.

Sevoflurane and CO_2 absorbents:

Sevoflurane is degraded by the commonly used CO_2 absorbents, sodalime and baralyme. Sevoflurane is degraded to a variety of compounds (compounds A-E), of which two are produced in significant amounts, fluoromethyl-2,2-difluoro-1-(trifluoromethyl) vinyl ether (Compound A) and fluoroethyl-2-methoxy-2,2-difluoro-1-(trifluoromethyl) ethyl ether (Compound B).[19] The rate at which CO_2 absorbents degrade sevoflurane is dependent on the concentration of the anaesthetic (the rate decreases as fresh gas flow rate increases), the temperature of the CO_2 absorbent (which in turn is dependent on the quantity of CO_2 passing through) and the water content of the CO_2 absorbent (faster in dry than in wet sodalime).[20] Sevoflurane is degraded 4-5 fold more rapidly in baralyme than in sodalime.[20] Compound A has been shown to be toxic in rats (LD50 1000ppm after 1hr exposure), causing lung and renal damage, and there are concerns that it may also be toxic to humans.

Pharmacodynamics:

Central nervous system effects:

Halothane causes cerebral vasodilation and increased CBF, provided systemic blood pressure is maintained. A concentration of 1MAC halothane doubles CBF, and 1.6MAC quadruples it.[21] Halothane abolishes CBF autoregulation.[22]The increase in CBF induced by halothane may be prevented or reversed by hypocapnia. Halothane reduces cerebral oxygen consumption by up to 25%. The greatest reduction in oxygen consumption occurs at an inhaled concentration of halothane of 0.5% to 0.8%.

Halothane influences sensory evoked potentials, reducing the amplitude and increasing the latency, but this effect does not interfere with the use of sensory evoked potential used to evaluate CNS function.[23] Sevoflurane causes a minimal increase in CBF and a significant reduction in $CMRO_2$. The cerebrovasular response to carbondioxide and cerebrovascular autoregulation are both preserved under sevoflurane anaesthesia.[25]

Respiratory effects:

Sevoflurane is a more potent respiratory depressant than halothane.[26] Tidal volume with sevoflurane decreases with increasing depth of anaesthesia as it does with halothane.[26]At 1.4MAC, tidal volumes are similar with the two agents. However, respiratory frequency in patients given sevoflurane was found to increase, but not enough to compensate for the reduction in tidal volume.[26] The result is the reduction of minute ventilation seen with sevoflurane.[26] This decrease in minute ventilation differs from halothane anaesthesia, in which the increase in respiratory frequency is enough to offset the reduction in tidal volume.[26] Both sevoflurane and halothane show similar increases in CO_2 elimination and dead space to tidal volume ratio with

increasing depth of anaesthesia.[26] The ventilatory response to carbondioxide is depressed to a slightly greater degree by sevoflurane than with halothane. The ventilatory response to hypoxia is significantly reduced at 0.1MAC of both halothane and sevoflurane.[27] Halothane is a more potent bronchodilator than sevoflurane and is the most potent bronchodilator of the available inhalational agents.[28]

Cardiovascular effects:

The main haemodynamic effect of halothane is a reduction in blood pressure secondary to fall in cardiac output.[29] Halothane produces a reduction in myocardial contractility and a reduction in stroke volume. This reduction in contractility is due to alterations in calcium metabolism. Halothane produces little change in total systemic vascular resistance.

Sevoflurane causes a dose dependent depression of cardiac output and a reduction in systemic vascular resistance, which results in a fall in systemic blood pressure.[30] Sevoflurane has minimal effect on heart rate[31] 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. The reflex tachycardia one would normally expect with hypotension does not occur as halothane inhibits baroreceptor reflex.[32] Sevoflurane does not sensitise the myocardium to epinephrine, while halothane does, resulting in increased incidence of arrhythmias. Renal and hepatic blood flows are well preserved with sevoflurane [33] while it is significantly reduced with halothane.

Neuromuscular effects:

Both halothane and sevoflurane produce significant muscle relaxation, and following inhalational induction laryngoscopy and endotracheal intubation can be accomplished without muscle relaxants.

Toxicity:

Malignant hyperthermia:

Both halothane and sevoflurane can trigger malignant hyperthermia in susceptible individuals.[33]Although, sevoflurane has a lower potential to cause this effect than halothane.

Hepatotoxicity:

A major problem with the use of halothane is hepatotoxicity which can manifest itself in two forms. The first occurs in about one in three patients exposed to halothane and manifests as a subclinical transient increase in liver enzymes shortly after exposure. The etiology unknown and previous exposure is not a prerequisite. The second form of halothane hepatotoxicity is the rare but serious hepatic necrosis (halothane hepatitis). The incidence is 1 in 6000 to 35000 administrations and is immune mediated.[34]The risk increases with repeated exposure. Metabolism of halothane results in the production of trifluroacetyl (TFA) halide, which binds covalently to hepatocytes creating neoantigens, thereby eliciting an autoimmune response against the hepatocyte.[34]

Sevoflurane is not hepatotoxic. Of the halogenated anaesthetic agents currently in use, sevoflurane is the only one not metabolized to trifluroacetic acid, which has been implicated in hepatotoxicity.

Nephrotoxicity:

Metabolism of sevoflurane results in the production of inorganic fluoride ions. Nephrotoxicity has been considered likely when plasma fluoride levels exceed 50μmolL^{-1}. Although serum inorganic fluoride levels greater than 50μmolL^{-1}have been recorded in humans following administration of sevoflurane there have been no reports of renal failure. This is probably because of the low tissue solubility of sevoflurane, as it is rapidly eliminated once anaesthesia is discontinued and hence, high levels of inorganic fluoride are maintained for only a relatively short period of time.[35] Furthermore, the rate of intra-renal defluorination is minimal and therefore, generation of high levels of inorganic fluoride in renal tubular cells would not be expected to occur in patients with sevoflurane.[35] Although fluoride ions are also produced by the reductive metabolism of halothane, this is a minor pathway, and significant amounts are not produced. No evidence of nephrotoxicity exists with the use of halothane.

REVIEW OF LITERATURE

Historical review

Inhaled anaesthetics have been in the picture ever since the discovery of surgical anaesthetics. From the times where diethyl ether was first synthesized, to the modern operating theatres, inhalational anaesthetics have always had a major role in anaesthesia. In the quest for safety, many a different inhaled anaesthetics have been tried and tested and the quest still continues for the perfect agent, one that rapidly induces anaesthesia, smells pleasant and is free of side effects.

Inhalational induction of anaesthesia is frequently the most preferred technique of inducing anaesthesia in paediatric age group. It avoids the potential psychological trauma associated with venepuncture in a child.

America's greatest contribution to 19th century, and perhaps all of mankind, was the introduction of diethyl ether into medical practice by W.T.G.Morton. Ether remained a common inhalational agent for inducing children because of its cardiovascular stability, analgesic property, low cost, wide safety margin, practically no biodegradation and simplicity of administration. Its glory though was short-lived. Its disadvantages like high flammability, explosiveness, irritability, prolonged induction, recovery and high incidence of postoperative nausea and vomiting led to its downfall.

With the progress made in surgical specialities, that is, introduction of cautery, X-rays, and laser in the clinical practice, one of the essential properties needed for an inhalational anaesthetic agent was non- inflammability. Although an agent could be

made non-inflammable by the addition of chlorine, it enhanced toxicity. Chloroform introduced in the year 1847 could not survive because of its deleterious effect on heart and respiration. The development of Manhattan atomic bomb provided the needed economy in fluorine chemistry technology and led to the synthesis of fluroxene, an ethyl vinyl compound that was minimally successful.

Next, the focus was on the alkane series and halothane, which is a member of this series, was developed after 2nd World War by Charles Suckling of Imperial Chemical Industries in UK, in 1951. It was subsequently offered to Michael Johnstone, a respected anaesthetist of Manchester, England. To his credit, Johnstone recognized haolthane's great advantages over other anaesthetics available at that time. His endorsement made halothane very popular across the world in a very short span of time.[36]

Ever since halothane was introduced into clinical practice, it was accepted as one of the ideal inhalational agents in paediatric practice. Halothane with its bronchodilator property, rapid, pleasant induction is an attractive choice for induction in paediatric patients. The introduction of halothane marked a major advance in the quality and safety of anaesthesia care. However, the propensity of halothane to sensitize the myocardium to catecholamines[37] and its potentially serious complication of hepatitis made the researchers continue their quest for a safer agent. As these disadvantages are not seen with diethyl ether, it was realized that an ether derivative that is non-inflammable and less blood soluble could make an ideal anaesthetic agent.

Methoxyflurane and enflurane (fluorinated ethers) were subsequently introduced into clinical practice in the year 1951 by Shukys and in 1966 by Virtue, respectively.

Even though these agents were non-inflammable they showed significant fluorine mediated nephrotoxicity. Enflurane also had an additional side effect of provoking seizures. Hence, they went out of practice. Researchers continued to investigate higher ethers, and isoflurane, which is a methyl ethyl ether which fulfilled these goals of noninflammability and cardiovascular stability without sensitizing the myocardium to catecholamines, was the result. But, the potential to cause "coronary steal" and airway irritant effects were the major drawbacks of this agent.

Sevoflurane was first synthesized in 1968 by Regan at Travenol Laboratories, Illinois, while he was investigating a series of halomehtyl polyfluoroisopropyl ethers. The first volunteer trials, reported by Holaday and Smith in 1981, were encouraging. Maruishi Company released sevoflurane for clinical use in Japan in 1990. By the end of 1993, sevoflurane was administered to an estimated one million patients.

Clinical review

Halothane remains a popular choice for induction of anaesthesia in paediatric age group. This is because of its low blood gas solubility, which produces rapid induction and emergence. Also, it is non-irritant and well tolerated by the upper airways. However, it has the propensity to cause bradycardia, hypotension and arrhythmias.

Sevoflurane fulfils the safety criteria of halothane without the associated side effects. The added advantage of this drug is not only its rapid and pleasant induction but also

its minimal metabolism in the body and its haemodynamic stability and so is rapidly becoming very popular as the inhalational agent of choice in paediatric surgery.

In view of these advantages of sevoflurane over halothane many authors have conducted studies comparing the induction, intubation and haemodynamic profiles of these two commonly used agents.

O'Brein K et al[2] compared tracheal intubation with sevoflurane and halothane in 40 ASA I or II children, aged 3 to10 years, undergoing elective adenotonsillectomy. Children with significant airway, cardiac, respiratory, renal, hepatic or central nervous system diseases, any child with a history of an unusual response to a halogenated anaesthetic and any child who had received a general anaesthetic within the past 2 weeks were excluded from the study. Each child was randomly allocated to undergo inhalation induction with either halothane or sevoflurane. All children received sedative and antiemetic premedication with trimeprazine $2mgKg^{-1}$1-1.5 hours before induction, and EMLA cream was applied 1hr before induction. Each child received inhalation induction with either halothane or sevoflurane and 60% nitrous oxide in oxygen. Incrementally increasing dose of volatile agent every three breaths (an increase of 0.5% for halothane and 1% for sevoflurane) until the child was breathing 8% sevoflurane or 5% halothane. When the pupils were deemed to be small and central, the trachea was intubated. The quality of the intubating conditions was assessed and recorded by a senior intubating anaesthetist who was blinded to the induction agent used.

The intubating conditions were assessed as per the scoring system given below.

Score	Laryngoscopy	Vocal Cords	Coughing	Jaw Relaxation	Limb movement
1	Easy	Open	None	Complete	None
2	Fair	Moving	Slight	Slight	Slight
3	Difficult	Closing	Moderate	Stiff	Moderate
4	Impossible	Closed	Severe	Rigid	Severe

All variables were allocated a score of 1-4, with 1 being ideal conditions. Therefore the best possible score was 5. Intubating conditions were considered unacceptable if a score of 3 or 4 was recorded in any individual category. Intubation was successful in all children at the first attempt. In each group, only one patient had a score of 3 in any one category. Twelve of 20 children who received halothane had ideal intubating scores of 5 compared with only seven of 20 who received sevoflurane. There was no significant difference between mean total intubation score per patient in the two groups (mean score in halothane group 5.5; mean score in the sevoflurane group 5.85). The vocal cords were more likely to be moving or closing in the sevoflurane group. Time to reach the clinical end point for intubation was reached significantly more rapidly in halothane group (200.25secs in halothane and 243.4secs in sevoflurane). All patients remained haemodynamically stable during the study. The authors concluded that higher percentage of patients reach ideal intubating conditions more rapidly with incremental halothane than with incremental sevoflurane induction.

Piat V et al[3] compared the induction, recovery characteristics, and assessed the haemodynamic profile of sevoflurane and halothane in children.

Thirty four children, aged 9 months to 9 years belonging to ASA I-II, scheduled for minor surgical procedures (hernia repair, orchidopexy, hypospadias repair) were randomly assigned to either receive halothane (n=17) or sevoflurane (n=17) in a

mixture of oxygen and nitrous oxide (40:60) for mask induction and maintenance of anaesthesia. Children were fasted overnight and were pre-medicated 30 min before induction of anaesthesia with $0.4mgKg^{-1}$ rectal midazolam. After baseline haemodynamic values were obtained, anaesthesia was induced with the allocated inhalational anaesthetic in a mixture of oxygen and nitrous oxide (40:60). In both groups, inspired concentration was increased every five breaths in the following order: 1%, 2%, 3%, and 3.5% in halothane group, and 2%, 4%, 6%, and 7% in the sevoflurane group. The trachea was intubated after placement of an intravenous line as soon as the depth of anaesthesia was deemed appropriate by the attending anaesthesiologist. After intubation the end-tidal anaesthetic concentration was maintained at 1MAC throughout surgery until skin closure. The following data were recorded: time to loss of eyelash reflex, time to obtain constricted pupils in median position, time to intubation, time to skin incision, and duration of surgery. Arterial pressure, heart rate, SpO_2, and end-tidal gas concentrations ($ETCO_2$, ETN_2O, ETsevo and EThalo) were recorded.

At the end of the case, volatile anaesthetics were abruptly discontinued and the following data were recorded - time to extubation, time to emergence (defined as time at which the patient was opening his eyes on command); time to response to age-appropriate verbal commands; and time to obtain a modified Aldrete score equal to or greater than 8.

The time to loss of eyelash reflex (halothane1.8 ± 0.7min vs sevoflurane 1.5 ± 0.6min),time to obtain central pupils (halothane 4.1 ± 1.0min vs sevoflurane 4.1 ± 1.3min), time to intubation (halothane 6.1 ± 1.9min vs sevoflurane 5.6 ± 1.0min) were

the same between the two groups. No complications were observed in sevoflurane group except for mild excitement during induction in 5 patients. Two complications were observed in the halothane group, one mild laryngospasm and transient haemodynamic deterioration.

From induction to intubation, heart rate did not change in the halothane group, whereas a significant increase in heart rate was observed in the sevoflurane group. During the same time interval, systolic arterial pressure decreased significantly in the halothane group whereas it did not change in the sevoflurane group. When compared to control pre-induction values, heart rate did not change in either group at 1MAC during maintenance. However, systolic arterial pressure was significantly reduced in halothane group, while no significant changes were observed in the sevoflurane group.

Recovery from anaesthesia was significantly faster with sevoflurane than with halothane. Time to extubation (sevoflurane14.6 ± 1.7min Vs halothane 19.2 ± 6.2min), time to emergence (sevoflurane 18.1 ± 5.4min Vs halothane 33.4 ± 10.4min), time to respond to verbal command (sevoflurane 26.9 ± 8.0min Vs halothane 42.2 ± 12.4min), and time to obtain a modified Aldrete score ≥ 8 (sevoflurane 25.3 ± 6.1min Vs halothane 35.9 ± 9.1min) were significantly shorter in sevoflurane group compared to halothane.

Complications were not observed during the recovery period in either group. The authors suggested that sevoflurane is a satisfactory drug for the induction and

maintenance of anaesthesia in children, with a faster recovery compared with halothane.

Black A et al[4] compared the induction characteristics of sevoflurane and halothane in 81 children aged between 6months and 6yrs belonging to ASA I or II, and were having general surgical, urological, plastic or orthopaedic procedures.

Patients with epilepsy were excluded from the study. Children were randomly assigned to receive either halothane or sevoflurane. The study was not blind. Children were pre-medicated with atropine $0.02mgKg^{-1}$orally or intramuscularly and temazepam$0.5mgKg^{-1}$ orally when clinically indicated. The inhalational agent was administered via a Mapleson F breathing system with 66% nitrous oxide in oxygen. Inspired concentrations were steadily increased in increments of 0.5-1% for halothane of 1.5-2% for sevoflurane every three breaths up to a maximum of 5% for halothane and 7% for sevoflurane. As soon as consciousness was lost intravenous cannula was sited. After, or towards the end of the induction period, either a laryngeal mask airway or a tracheal tube was inserted as appropriate for the surgical procedure. Tracheal intubation was accomplished after muscle relaxation with atracurium. The time taken to achieve unconsciousness (loss of eye lash reflex) was recorded for all children. The time taken to complete induction (to achieve steady spontaneous ventilation and small pupils with central gaze) was recorded except in children whose tracheas were intubated. Heart rate and non-invasive blood pressure were measured every minute for the first 10 mins. Any untoward events during induction were noted and scored (1=mild; 2=moderate; 3=severe).

The mean time to achieve loss of eyelash reflex was appreciably and significantly shorter with sevoflurane than with halothane (sevoflurane 1min 41secs and halothane 2min 17secs, $p<0.01$). The mean time taken to complete induction was also shorter in children induced with sevoflurane (sevoflurane 3min 58secs and halothane 4min 50secs).

Sedative premedication did not alter induction time appreciably. The complications noted during induction were cough, breath holding, secretions and excitement. None of them were considered to be severe. Laryngospasm, bronchospasm and vomiting did not occur in both groups. Excitement occurred more frequently and was more often scored as moderate in children who received sevoflurane. Other complications were similar for both groups.

Lowest and highest heart rates and blood pressures recorded during the first 10min of anaesthesia were similar in both groups. Oxygen saturation was never below 90% in either group.

Authors opined that sevoflurane was not associated with any major airway complications and there were few instances of coughing, breath holding and secretions. This smooth induction property suggests that sevoflurane may be as safe as halothane for induction of anaesthesia in children with difficult airways. Only excitement seems to be more common with sevoflurane than with halothane and was not a major problem. They suggested that sevoflurane is nearer to providing ideal inhalational induction than halothane and may therefore be the preferred inhalational induction agent for children.

Swadia VN et al[5] compared the induction and intubation characteristics of sevoflurane and halothane in 50 children 1month-12yrs of ASA I and II undergoing general surgical and urological operations. They also assessed the haemodynamic profile of both anaesthetic agents during induction and intubation.

After 4-6hrs of fasting (according to age), all patients were given combination of midazolam ($0.5mgKg^{-1}$) and atropine ($0.03mgKg^{-1}$) orally 45mins prior to surgery. Patients were allocated randomly to group I (sevoflurane) and group II (halothane). Anaesthesia was induced by face mask using 60% nitrous oxide in oxygen mixture and incremental concentration of studied volatile anaesthetic. The inspired concentration of halothane was initially set at 0.5% followed by stepwise increase of 0.5% every 4 breaths until loss of eye lash reflex (maximum of 5%). Sevoflurane was initially set at 1% and increased stepwise by 1% every 4 breaths to maximum of 7%. After loss of eye lash reflex, an intravenous access was secured. When depth of anaesthesia was adequate, trachea was intubated. Time taken for loss of eyelash reflex and time to intubation were recorded as induction time I and induction time II respectively. Intubating conditions were evaluated as four part scale:

1. Excellent – no vocal cord movement / no coughing.
2. Good – no vocal cord movement / bucking present.
3. Fair – vocal cord partially relaxed and coughing present.
4. Poor – vocal cord not relaxed.

For sevoflurane, induction time I was 97.27 ± 45.68 secs and induction time II was 242 ± 52.67 secs. While for halothane induction time I was 103.67 ± 39.87 secs and induction time II was 246 ± 55.93 secs. All patients from both the groups were

intubated at first attempt. In sevoflurane group, 80% had excellent and 20% good intubating conditions, with none of patients in fair or poor category. While in halothane group though none had poor condition, only 10% had excellent score. 20% had fair intubation conditions and 70% good. Bradycardia occurred in 35% of patients in halothane group compared to 8% in the sevoflurane group ($p<0.001$). As far as blood pressure was concerned, 80% had hypotension in sevoflurane group and 75% had hypotension in halothane group ($p>0.05$). Complications like laryngospasm, bronchospasm or respiratory depression were not observed in any of the patients. The authors concluded, that sevoflurane gives rapid and smooth induction with good intubating conditions keeping stable haemodynamics. This makes sevoflurane a suitable alternative to halothane for induction of anaesthesia in children.

Paris ST et al[7] undertook a study to compare the incidence and type of arrhythmia, and quality of anaesthesia and recovery during sevoflurane and halothane anaesthesia in children undergoing outpatient dental extraction.

100 unpremedicated children belonging to ASA I and II, aged 2-12yrs, undergoing outpatient dental extractions were randomly allocated to receive either halothane or sevoflurane. ECG, SpO_2 and arterial pressures were recorded before induction, during induction, throughout surgery and during recovery from anaesthesia.

Anaesthesia was induced by inhalation of 50% nitrous oxide in oxygen with the selected vapour. The concentration of the agent was increased every 3-5 breaths in increments of 1% to a maximum of 5% halothane, and in increments of 2% to a maximum of 8% sevoflurane. When the child lost consciousness, a nasal mask was

applied and anaesthesia was maintained with 50% nitrous oxide in oxygen with 1-2% halothane or 2-4 sevoflurane. Anaesthetic gases were discontinued at the time of extraction of the penultimate tooth.

Time to loss of eyelash reflex, time to mouth prop insertion were recorded during induction. Times to eye opening and satisfying discharge criteria were recorded during recovery. ECG recordings were analysed by a physician during induction, surgery and recovery. The time between the start of induction and loss of eyelash reflex was significantly shorter in the sevoflurane group (1.5 ± 0.6 min) compared with halothane group (1.9 ± 0.5 min). Time to insertion of the mouth prop was significantly slower after induction with sevoflurane (3.9 ± 1.3 min) than halothane (3.5 ± 0.7 min). In the recovery period, times to eye opening and discharge were similar in both groups. The incidences of complications like intolerance, hypoxaemia, vomiting and shivering were similar between the two groups. The overall incidence of arrhythmia was significantly greater in the halothane group, and was more often of ventricular origin. The authors concluded that sevoflurane has qualities that have made halothane the most used inhalation agent for children, and it is superior to halothane in dental outpatients where cardiac arrhythmias are a particular problem.

Taivainen T et al[39] compared the induction and recovery characteristics of halothane and sevoflurane. They also assessed hepatocellular integrity by measurement of serum glutathione transferase alpha (GSTA) concentration and sevoflurane metabolism by serum fluoride concentration.

Fifty children aged 5-12yrs belonging to ASA I and II, who were undergoing elective general surgery with an anticipated duration of anaesthesia of at least 1hr and anticipated hospitalization of at least 24hr after surgery were randomly allocated to two groups of 25 patients each to receive either sevoflurane or halothane.

None of the children received premedication. Anaesthesia was induced via a face mask by inhalation of 60% nitrous oxide in oxygen and 2% sevoflurane or 1% halothane via Mapleson F breathing system. Both anaesthetic agents were introduced gradually into the breathing system every three to five breaths; successive inspiratory concentrations were 2, 4, 6 and 8% for sevoflurane and 1, 2, 3 and 3.5% for halothane. An i.v. cannula was inserted immediately after the end of induction and sample for baseline laboratory investigation were collected. Thereafter an infusion of Ringer's acetate solution was started. When an adequate depth of anaesthesia was achieved, the trachea was intubated without using a neuromuscular blocking agent. Anaesthesia was maintained using 60% nitrous oxide in oxygen and inhalation of 1-1.2MAC of sevoflurane or halothane. Arterial pressure and heart rate were recorded at 3min intervals from 1min before to 15min after induction. Thereafter arterial pressure and heart rate were recorded at 5min intervals and in the recovery room at 10min intervals. Times from application of the face mask to loss of eyelash reflex, to the end of induction (defined as unconscious child with constricted pupils and regular respirations) and to tracheal intubation were recorded. At the end of operation, the volatile anaesthetic agent and nitrous oxide were discontinued simultaneously and abruptly, and all recovery assessments were timed from this point. The trachea was extubated when spontaneous breathing was adequate. Emergence from anaesthesia was defined as opening of eyes to commands issued at 1min intervals after cessation

of anaesthetic. Thereafter the patient was asked every 1min to squeeze the observer's hand. Modified Aldrete scores were measured at 10min intervals in the recovery room. Blood samples were obtained for measurements of serum GSTA and inorganic fluoride concentrations after induction of anaesthesia (baseline), at the end of anaesthesia (0) and 1, 2, 4, 6, 24 and 48 hr after anaesthesia.

At 24hr a standardized questionnaire was used to enquire about acceptance of induction of anaesthesia, graded as pleasant, indifferent or unpleasant, and if the child would like to have possible future anaesthesia carried out in the same way.

Time from application of the face mask to loss of eyelash reflex (sevoflurane 1 ± 0.3min vs halothane 1.7 ± 0.6min) and to end of induction (sevoflurane 2.4 ± 1min vs halothane 3.3 ± 0.9min) were significantly shorter in the sevoflurane than in the halothane group. Systolic and diastolic arterial pressures decreased in both groups by a mean of 20%, with no differences between groups. Heart rate changed less in the sevoflurane than in the halothane group. Time to emergence (sevoflurane 15.4 ± 12.4min vs halothane 33.0 ± 16.6min), hand squeeze on request (sevoflurane 19.5 ± 12.3min vs halothane 38.4 ± 20.5min) and orientation were significantly shorter in the sevoflurane than in the halothane group. Modified Aldrete scores were significantly greater in the sevoflurane group for the first 30min after anaesthesia.

Significantly more children who were anaesthetised with sevoflurane rated induction of anaesthesia as pleasant compared with those receiving halothane (sevoflurane 56% vs halothane 20%). More children in the sevoflurane than in the halothane group said they would prefer to have another anaesthesia carried out by a similar method

(sevoflurane 76% vs halothane 44%). Serum GSTA concentration at 1 and 2hr after the end of anaesthesia were increased significantly more in halothane than in sevoflurane group. Fluoride concentrations were significantly greater in the sevoflurane group at all times. Symptoms of hepatic or renal disease were not observed in any patient after anaesthesia. The authors concluded that children tolerated sevoflurane better than halothane, with rapid psychomotor recovery after sevoflurane and with no signs of hepatic or renal disturbance.

Sarner JB et al[40] undertook a study to evaluate the clinical characteristics of sevoflurane (with or without nitrous oxide) compared with halothane with nitrous oxide in children.

120 patients belonging to ASA I and II aged 1 to 12yrs having a low to moderate risk elective surgery were studied. Patients were randomly assigned to one of the three study groups: sevoflurane with oxygen (group S, n=40), sevoflurane with nitrous oxide (66%) and oxygen (group SN, n=40), and halothane with nitrous oxide (66%) and oxygen (group HN, n=40). None of the children received premedication. Inhalation induction of anaesthesia was accomplished in all patients using a Mapleson D, F (Jackson-Rees modification of Ayer's T-piece) or Bain's system.

Anaesthetic induction began with face mask application and was achieved using incremental concentration of anaesthetic every three to five breaths. Halothane was begun at 0.5% and increased by increments of 0.5-1% (up to maximum of 4.5%); sevoflurane was begun at 1% and increased by increments of 1.5% (up to maximum of 7%). Intravenous line was secured after loss of eyelash reflex. Blood pressure,

heart rate, ECG, blood oxygen saturation by pulse oximetry and end-tidal concentrations of halothane, sevoflurane and carbondioxide were measured. Vagolytic agents, muscle relaxants, and other anaesthetic adjuvants were avoided before tracheal intubation. The end-tidal concentration of halothane or sevoflurane and the position of the vocal cords (open, midline, or closed) were noted at the time of tracheal intubation. After tracheal intubation, the end-tidal anaesthetic concentration was adjusted to 1.3MAC (1.2% halothane, 3.2% sevoflurane); nitrous oxide and oxygen were continued at the same concentrations used before intubation. End-tidal carbondioxide tension was maintained between 30 and 40mmHg using controlled ventilation. Patients received vecuronium ($70\mu gKg^{-1}$) after intubation when neuromuscular blockade was clinically indicated.

Heart rate, systolic, diastolic, and mean arterial blood pressure, end-tidal carbondioxide, respiratory rate, temperature, and inspired and end-tidal anaesthetic concentrations were recorded every 2min before surgical incision, at 1 min interval for 5mins after incision, and then every 5min until the end of surgery.

During the last 10min of surgery, the end-tidal concentration of inhaled anaesthetic was adjusted to 1MAC (0.9% halothane, 2.5% sevoflurane). If necessary, residual neuromuscular blockade was completely antagonized using neostigmine ($50\text{-}60\mu gKg^{-1}$) and glycopyrrolate ($10\mu gKg^{-1}$) or atropine ($25\mu gKg^{-1}$) before emergence from anaesthesia. At the end of surgery, all anaesthetic agents were discontinued simultaneously. The trachea was extubated when the gag reflex had returned and the patients were breathing spontaneously and making purposeful movements.

The time from face mask application to loss of eyelash reflex (induction time), intubation, surgical incision, and discontinuation of anaesthetic (duration of anaesthesia) were measured. The intervals from discontinuation of the anaesthetic to patient response by hip flexion or bucking (time to hip flexion), extubation (time to extubation), administration of first postoperative analgesic (time to first analgesic), and attaining discharge criteria from the recovery room were recorded. Venous blood was sampled at anaesthetic induction, at the end of anaesthesia, and 1, 4, 6, 12 and 18-24hr after discontinuation of the anaesthetic for determination of plasma inorganic fluoride content.

There was no difference in induction times between three groups (group S 1.9 ± 0.9min, group SN 1.6 ± 0.7min, group HN 1.7 ± 0.6min). Time to intubation was significantly greater in group S when compared with groups SN and HN (group S 6.2 ± 1.8 min, group SN 5.1 ± 1.9 min, group HN 5.2 ± 1.4 min). The distribution of vocal cord positions at intubation was similar between the 3 groups. End-tidal minimum alveolar concentration multiple of anaesthetic at the time of intubation was significantly greater in patients receiving halothane than in patients receiving sevoflurane (group S 2.1 ± 0.2, group SN 2.0 ± 0.3, group HN 3.4 ± 0.7).

During induction, patients in group S and SN maintained significantly higher average heart rates and systolic blood pressures than patients in group HN. Mean and diastolic blood pressures did not differ between groups during the induction period. No significant difference was found between groups in heart rate or systolic, mean or diastolic blood pressures during the intubation or incision periods.

The incidence of excitement during induction of anaesthesia and movement during maintenance of anaesthesia was significantly greater in group S than in groups SN and HN.

Emergence from anaesthesia was significantly faster in patients receiving sevoflurane (with or without nitrous oxide) than in patients receiving halothane and nitrous oxide. Time to extubation and time to attaining discharge criteria from recovery room were significantly less in group S and SN than in group HN. Inorganic fluoride concentrations in group S and SN were significantly greater than those in group HN from initial to final evaluation. The maximum mean concentrations of inorganic fluoride were 15μM in group S, 14.7μM in group SN, and 1.8μM in group HN.

The authors concluded, sevoflurane with nitrous oxide is effective for inhalational induction and maintenance of and emergence from anaesthesia. Emergence from anaesthesia is rapid in children anaesthetised with sevoflurane (with or without nitrous oxide) compared with halothane and nitrous oxide. Haemodynamic stability and low incidence of airway related complications provided during inhalational induction coupled with rapid emergence suggest that sevoflurane may be a reasonable alternative to halothane in children.

Kawana S et al[41] compared the haemodynamic effects of sevoflurane and halothane in paediatric patients.

38 patients aged 1-6yrs of ASA I schedule to undergo adenotonsillectomy were studied. Children were fasted overnight but were allowed free access to clear fluid

until three hours before surgery. They received premedication with bromazepam 1.5-3mg suppository. On arrival in the operating room, their sedation was evaluated by a four grade score:

1. Sleeping or sleepy
2. Sedated
3. Alert and
4. Excited

Patients of grade 4 were excluded from the study. The remaining patients were randomly assigned to four groups, depending on the dose and agent (1 and 2 MAC of sevoflurane: S1 and S2; 1 and 2 MAC of halothane: H1 and H2, respectively).

Anaesthesia was induced with oxygen $2Lmin^{-1}$, nitrous oxide $4Lmin^{-1}$and 1 to 2 MAC of sevoflurane or halothane, depending on the group. After an iv catheter was placed and vecuronium $0.1mgKg^{-1}$was given iv, all anaesthetic agents were discontinued and the lungs were manually ventilated with 100% oxygen until the end-expired concentrations of sevoflurane or halothane were reduced to 0.2 MAC. End-expired anaesthetic agent and carbondioxide concentrations were sampled from oral cavity. The cardiac output, and stroke volume were measured by impedence cardiometry and cardiac index and stroke volume index were calculated. The mean blood pressure and heart rate were recorded. The anaesthetic agent concentrations were then increased to 3% in group S1, 6% in S2, 1.5% in H1 and 2.5% in H2 until the end-expired concentration reached the MAC assigned to the group. Thereafter, the inspiratory concentration was controlled to maintain the assigned end-expired concentrations until the end of the measurement. The measurement was terminated at 15mins.

The mean blood pressure decreased at the end of measurement in all groups ($p<0.05$ in S1 and H1, $p<0.01$ in S2 and H2). Changes in mean blood pressure were not different among the groups.

The SVI decreased at the end of measurement of all groups except group S1. The SVIs in the 2MAC groups were lower than those in 1MAC groups (S1 vs S2, H1 vs H2, $p<0.01$).

The heart rate increased in S1, S2 and H2, but not in H1. The heart rate at the end of measurement was higher in group S2 than in group H2 (135.3 ± 4.2bpm in S2 vs 114.4 ± 4.8bpm, $P<0.01$).

The CI, the product of SVI and HR, tended to decrease in all groups but not significantly and there were no differences among groups.

The authors concluded, both volatile anaesthetics decreased mean BP, SVI and increased HR in a dose-dependent fashion. There were no differences in haemodynamic variables between the sevoflurane and halothane groups except in HR.

Lerman J et al[42] compared the induction, recovery and safety characteristics of sevoflurane in children undergoing ambulatory surgery with halothane.

375 children aged 1-12 yrs belonging to ASA I and II, were randomly assigned in a 2:1 ratio to receive either sevoflurane or halothane, both in 60% nitrous oxide and 40% oxygen. All children were fasting and unpremedicated. After application of standard monitors, including an ECG, pulse oximeter and non-invasive blood

pressure, anaesthesia was induced with 60% nitrous oxide and 40% oxygen followed by stepwise increases in the inspired concentrations of either sevoflurane (1.5-2% increments) or halothane (0.5- 1% increments) every three to four breaths. The maximum inspired concentration of sevoflurane was 7% and that of halothane was 4.3%. Immediately after induction of anaesthesia, intravenous access was established and 2ml of blood sampled for analysis of inorganic fluoride. During the maintenance period, the children breathed spontaneously through a face mask and the inspired anaesthetic concentration was adjusted to produce an end-tidal concentration of 1.3MAC of the inhalational agent in 60% nitrous oxide and oxygen. For a minimum of 10min before the conclusion of surgery, the inspired anaesthetic concentration was adjusted to an end-tidal concentration of 1MAC of the inhalational agent. At the time of placement of the last suture, all anaesthetic agents were discontinued, and 100% oxygen was administered for 1-2min. Induction and emergence characteristics, including coughing, laryngospasm, breath holding, nausea, vomiting, secrections, bronchospasm, excitement, and any other unanticipated events, were recorded.

The induction interval (time from application of face mask until loss of eyelash reflex), duration of anaesthesia (defined as the interval from application of mask until discontinuation of anaesthetics), and duration of surgery (defined as the interval from skin incision until the final skin suture was inserted) were recorded. The times from the discontinuation of anaesthesia until the child responded appropriately to commands or demonstrated purposeful movement and until the first post surgical analgesic was administered were recorded.

The time to loss of eyelash reflex during sevoflurane anaesthesia was minimally but significantly faster than during halothane anaesthesia (sevoflurane1.3 ± 0.79min vs halothane1.6 ± 1.1min). The time to emergence and recovery (sevoflurane12.3 ± 10.8min vs halothane19.9 ± 10.9min) after sevoflurane anaesthesia were significantly more rapid than after halothane anaesthesia. Recovery milestones, including a modified Aldrete score ≥ 8 and time to orientation after sevoflurane, were reached more rapidly than after halothane.

Side effects, including airway reflex responses, vomiting, and excitement, were similar during both induction of and emergence from anaesthesia with sevoflurane and halothane. The plasma inorganic fluoride concentration measured 1hr after discontinuation of sevoflurane anaesthesia was 10.3 ± 3.5μM compared with 2.1± 1.7μM. The authors concluded that the induction recovery and safety characteristics of sevoflurane in children undergoing ambulatory surgery are comparable to those of halothane.

Bithal PK et al[43] compared the intubating conditions and haemodynamic changes with inhalation of sevoflurane and halothane in 29 children belonging to ASA I and II, schedule to undergo adenotonsillectomy.

All children were fasted 4-6hr and no premedication administered. They were randomly allocated to receive either halothane (group I, n=13) or sevoflurane (group II, n=16). Inhalation induction of anaesthesia was accomplished in all patients using Jackson Rees modification of Ayer's T-piece breathing system. Anaesthetic was given in 60% nitrous oxide and 40% oxygen mixture. Anaesthesia was begun with

face mask application and was achieved using incremental concentration of anaesthetic every 4 breaths. Halothane was begun at 0.5% and increased by increments of 0.5% (up to a maximum of 5%); sevoflurane was begun at 1% and increased by increments of 1% (up to a maximum of 8%). When ideal intubation conditions (pupils small and central) was reached, anaesthesiologist blinded to the inducing agent noted the intubating conditions while intubating the patient. The quality of intubating conditions was graded using the scoring system as below:

Score	Laryngoscopy	Vocal Cords	Coughing	Jaw Relaxation	Limb movement
1	Easy	Open	None	Complete	None
2	Fair	Moving	Slight	Slight	Slight
3	Difficult	Closing	Moderate	Stiff	Moderate
4	Impossible	Closed	Severe	Rigid	Severe

The best possible score was 5. Any assessment score greater than 2 in any individual category was taken as indicative of unacceptable intubating condition. After tracheal intubation, the child continued to breathe 1MAC of the volatile agent until all measurements (heart rate, MAP) were complete. HR and MAP were obtained when the eyelash reflex was lost (that is post induction), immediately after intubation, and 1min post intubation. Intubation was successful in all the children at first attempt, without the need for any other intervention. In group I, two patients had a score of 3 while one had a score of 4 in any one category. In group II, there were two patients with a score of 3 in any one category. Thus the overall assessment of acceptable intubating conditions (score of 2 or less) was 76.9% (10/13) in group I and 81.25% (14/16) in group II. Time to reach the clinical end-point for intubation (pupils small and central) was equal in both the groups (group I 330.76 ± 59.79secs and group II 324.93 ± 44.12secs). There was no difference in MAP at any point of time between

the two groups. However, the heart rate was significantly high in the sevoflurane group compared to the halothane group at each point of recording. The authors concluded that in children sevoflurane and halothane inhalational induction provided similar ideal intubating conditions in a comparable time period. However, the propensity of sevoflurane to increase the heart rate gives it an edge over halothane.

Agnor RC et al[56] compared the speed of induction of anesthesia with sevoflurane with and without nitrous oxide with the speed of halothane and nitrous oxide using a single-breath vital capacity induction.

With informed parental consent, 51 healthy unpremedicated children aged 5-12 yr were randomized to inhale a single breath of one of three gas mixtures: 8% sevoflurane in 66% nitrous oxide, 8% sevoflurane in oxygen, or 5% halothane in 66% nitrous oxide. A blinded observer recorded the times to loss of the eyelash reflex, return of conjugate gaze, the presence of airway reflex responses, involuntary movement, and hemodynamic responses.

Forty-two children completed the study. The times (mean ± SD) to loss of the eyelash reflex with sevoflurane/nitrous oxide, 38±8 s, and for sevoflurane-oxygen, 34±12 s, were less than that with halothane-nitrous oxide, 58±17 s ($P < 0.01$). Movement occurred less frequently during sevoflurane than during halothane anesthesia ($P < 0.05$). The times to return of conjugate gaze and the incidence of airway reflex responses were similar among the groups. The incidence of dysrhythmias in the sevoflurane groups was less than that in the halothane group ($P < 0.01$).

It was concluded that induction of anesthesia with a single breath of 8% sevoflurane with or without 66% nitrous oxide is more rapid than with 5% inspired halothane with 66% nitrous oxide in children. The incidence of movement and dysrhythmias during a single-breath induction with sevoflurane are less than they are with halothane.

Baum Victor C et al[48] compared the efficacy and tolerance of paediatric inductions with immediate 8% sevoflurane in 70% nitrous oxide with either incremental sevoflurane or incremental halothane in 70% nitrous oxide.

Forty-six unpremeditated children had anaesthesia induced by immediate 8% sevoflurane (high sevoflurane [HS]; circuit primed with 70% N,O and 8% sevoflurane before application of the face mask), gradual sevoflurane (GS; primed with 70% N,O with increments of sevoflurane), and gradual halothane (HAL; 70% N,O with incremental halothane). Blind video recordings were made, and each child's distress was rated prior to mask application, during mask application, and every 10 s thereafter using a behavioural rating scale. There were no complications. Of those subjects not quiet and cooperative throughout, times to complete quiet were significantly different (P = 0.001): HS 19.8 ± 8 s (range 9-34); GS 52 ±17 s (range 8-73); HAL 43 ± 22 s (range 13-73). Times to eye closure were also significantly different (P < 0.001): HS 37 ± 10 s (range 15-56); GS 70 ±18 s (range 35-114); HAL 815± 34 s (range 55-140). Distress scale scores showed more rapid decrement with HS than with GS or HAL.

The authors concluded that 1) immediate 8% sevoflurane/N_2O results in a significantly faster induction than GS or HAL; 2) in children, HS in N_2O will not result in a single-breath induction under the conditions of the study.

Dedhia KN et al[50] compared sevoflurane and halothane for induction of anaesthesia and laryngeal mask insertion in paediatric patients.

After approval of the ethical committee, sixty children of ASA grade 1 and 2 with age between 1-12 years and weighing between 10-30 kg, undergoing short, general surgical and genitourinary surgeries were enrolled for the study. Patients were excluded if they were predicted to have a difficult airway or ASA grade 3 and above. A written consent was obtained from the parents. After confirming adequate starvation, all the patients were given IM inj. glycopyrrolate 4 $mgkg^{-1}$ and syrup triclofos 60 $mgkg^{-1}$ orally 45 minutes before surgery. After evaluating the effect of premedication, patients were randomly allocated to group I (halothane) and group II (sevoflurane). Anaesthesia was induced by facemask using Jackson- Rees circuit or non- rebreathing circuit as per the weight of the patient, using 50% nitrous oxide in 50% oxygen with incremental concentrations of the studied volatile anesthetic agent.
In group I, inspired concentration of halothane was set at 0.5% initially, followed by stepwise increase of 0.5% every 3- 4 breaths until the loss of eyelash reflex. In group II, sevoflurane was set at 1% initially and increased stepwise by 1%. Struggling score was noted till the loss of eyelash reflex (struggling score: 0 – No movement, 1 – Head movement, 2 – Head and Limb movement, 3 – severe struggle). Time of loss of eyelash reflex, time of onset of regular respiration, time of centralization of eyeballs and time of adequate jaw relaxation were noted. Proper size LMA was inserted when eyeballs were centralised and jaw was relaxed. Pulse, blood pressure, heart rhythm and oxygen saturation were recorded during this period for both the groups at half minute intervals. Any complications were noted and treated immediately. At the time of LMA insertion, the following points were noted – Jaw opening, ease of insertion,

number of attempts, any movement, coughing or phonation at insertion and need for tracheal intubation.

Induction was faster in group II ($p<0.001$). In both the groups, conditions for LMA insertion and patient response were found satisfactory. LMA was successfully placed at the first attempt in 29 patients of group I and 27 patients of group II with adequate jaw relaxation in both the groups. There was a reduction in the mean heart rate in group I while there was an increase seen in group II at 30 seconds followed by a gradual fall. The reduction was more in group I ($p < 0.001$). At time of insertion of LMA, there was a slight increase in mean heart rate in both the groups, but the values remained significantly lower than at 0 second ($p<0.05$). There was a significant fall seen in the mean systolic pressure in both the groups, but the fall was more in group I ($p < 0.001$). At LMA insertion, there was a rise in mean systolic pressure in both the groups, but the values remained significantly lower than at 0 second ($p < 0.05$). There was no significant occurrence of complications in both the groups.

The authors concluded that since sevoflurane is as effective as halothane in providing smooth induction with low incidence of airway related complication and also has a rapid induction with better hemodynamic stability, sevoflurane is a suitable alternative to halothane for inhalational induction of anaesthesia in children.

Redhu S et al[51] conducted a comparative study of induction, maintenance and recovery characteristics of sevoflurane and halothane anaesthesia in paediatric patients (6 months to 6 years).

In a randomized , double blind clinical study, 30 children, aged 6 months to 6 years, were studied to compare halothane and sevoflurane anaesthesia in patients undergoing short surgical procedures under general anaesthesia. All the patients were pre-medicated with atropine 0.02mg $kg^{-1}$and midazolam 0.1mg kg^{-1}body weight intravenously and received inhalation induction using nitrous oxide in oxygen supplemented with either halothane (maximum inspired concentration of 5%) or sevoflurane (maximum inspired concentration of 8%). Induction was by inhalation of increasing concentrations of sevoflurane (1%) or halothane (0.5%) in the vaporizing setting after every three breaths of the patient.

Time to loss of eyelash reflex and tracheal intubation was more rapid using sevoflurane. Cardiac arrhythmias were significantly more frequent during halothane than sevoflurane anaesthesia. Psychomotor recovery was more rapid after sevoflurane anaesthesia. Children who received sevoflurane had comparatively less nausea and vomiting and the incidence of clinically important side effects was significantly less with sevoflurane anaesthesia.

The authors came to the conclusion that, induction with sevoflurane in nitrous oxide and oxygen leads to fast loss of consciousness and provides ideal conditions for managing the airway without supplemental opioids or muscle relaxants with haemodynamic stability and is therefore a reasonable alternative to halothane for paediatric patients.

Epstein RH et al[56] undertook a study to compare the vital signs, induction and emergence of sevoflurane and halothane for general anaesthesia in paediatric patients.

The study was conducted on 40 unpremedicated ASA Physical Status I and II children age 9 months to 16 years undergoing elective inpatient otorhinolaryngologic or orthopedic surgery. Standardized induction of anaesthesia was with sevoflurane (start: 1%, maximum: 7%) or halothane (start: 0.5%, maximum: 5%) in nitrous oxide/oxygen (N_2O/O_2). Intubation was done following vecuronium and 4 minutes of controlled ventilation with 2 minimum alveolar concentration (MAC) drug in O_2; 1.5 MAC drug in N_2O/O_2 delivered for 20 minutes; then 0.75 MAC until the end of surgery. Fentanyl 1 mcg/kg was administered 15 minutes before the anticipated end of surgery, at which time anaesthetics were stopped and mechanical ventilation continued until eye opening (emergence).

Blood pressure, heart rate (HR), oxygen saturation, end-tidal gas concentrations, and temperature were recorded. Induction and emergence times were measured to the nearest second. Induction (loss of eyelash reflex) was faster with sevoflurane (97 ± 31 sec) than halothane (120 ± 36 sec; $p < 0.05$), despite a lower inspired sevoflurane MAC. 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. Following intubation, HR (compared with the pre-induction value in the operating room) was significantly higher in the halothane group (136.8% ± 16.3% vs. 115.0% ± 25.6%), as was mean arterial pressure (113.2% ± 25.5% vs. 87.8% ± 22.6%). This finding corresponded with a higher MAC multiple of end-tidal concentration in the sevoflurane group than in the halothane group.

The authors came to the conclusion that induction of and emergence from anaesthesia was faster with sevoflurane than halothane. Also, airway complications were low in

both groups. Vital signs were stable with sevoflurane during maintenance and that sevoflurane is an excellent drug for inhalation induction in paediatric patients.

Johannesson et al[57] compared sevoflurane with halothane for ENT surgery in children. Altogether 40 children participated in the investigation. In 18 (median age 4.2 years), halothane was used. The remainder (median age 4.0 years) were anesthetized with sevoflurane. After rectal premedication with midazolam and atropine, anaesthesia was induced by mask (the agent in O_2/N_2O, 40/60) using a Mapleson D system. The trachea was intubated without the use of muscle relaxants and the children were then allowed to breathe spontaneously at fresh gas flows set high enough to avoid re-breathing. Hemoglobin oxygen saturation (SpO_2), inspired and expired gas concentrations, respiratory rate (RR), heart rate (HR), ECG and blood pressure were followed. Equi-anesthetic concentrations of the agents were used and induction characteristics were comparable between the two agents. RR and end-tidal CO_2 tensions were similar in the two groups. HR and systolic blood pressures were, however, higher with sevoflurane. Cardiac arrhythmias were seen more frequently with halothane (61%) than with sevoflurane (5%). During emergence, postoperative nausea/vomiting was more frequent after halothane anaesthesia. Initially, postoperative excitement occurred more often after sevoflurane, when paracetamol was given during anaesthesia, which was reduced ($P < 0.01$) when paracetamol was given at the time for premedication.

It is concluded that sevoflurane is an excellent induction agent, and maintains heart rate and systolic blood pressure better than when halothane is used. The incidence of cardiac arrhythmia is lower with sevoflurane than with halothane.

Kern C et al[58] studied the haemodynamic responses to sevoflurane compared with halothane during inhalational induction in children.

They studied the haemodynamic changes during induction of anaesthesia in 50 ASA I and II children (1-12 yrs) undergoing minor elective surgery. The patients were randomly divided into two groups to receive either halothane (n = 25) or sevoflurane (n = 25) in a mixture of O_2 and N_2O (40:60) for mask induction of anaesthesia. Induction of anaesthesia was performed with an overpressure technique by administering rapid increases of gas concentrations, in increments of 1% up to 7% for sevoflurane and of 0.5% up to 3% for halothane. Induction was smooth and rapid in both groups but characterized by increases in heart rate and systolic blood pressure up to 20% especially in the sevoflurane group ($P < 0.05$); these increases in the latter group were significant compared with baseline and the halothane group ($P < 0.05$). No serious complications were observed.

The authors conclude that more children experienced heart rate and blood pressure increases during the early stage of inhalational induction with sevoflurane compared with halothane.

Villani A et al[59] undertook a study with the goal to compare in a prospective and randomized manner, the induction, the maintenance and the recovery characteristics of halothane and sevoflurane when used in paediatric patients.

With the approval of the Ethical Committee and the parental written informed consent, 64 children aged 3-12 years, receiving general anaesthesia for urological, abdominal, and orthopaedic surgery, were studied. After oral flunitrazepam (0.05 mg kg^{-1}), general anaesthesia was randomly induced by either sevoflurane (start: 1%,

maximum: 7%, n = 32) or halothane (start: 0.5%, maximum: 4.5%, n = 32) and a 60% N_2O in oxygen mixture until the loss of eyelash reflex (induction time). Then the trachea was intubated (if necessary, a muscle relaxant was administrated), and the concentrations of the anaesthetic vapours were adjusted in order to maintain cardiovascular stability until the end of surgery. The following times were recorded: time of extubation, time for having purposeful movements, time of eyes opening and readiness for discharge from the recovery area, as well as the occurrence of untoward events during either induction of, maintenance of, or recovery from anaesthesia. Before surgery and 24 hr after the procedure, blood was collected in order to measure serum creatinine and BUN.

No differences in induction time, extubation time, side effects and postoperative renal function were observed between the two groups. Four patients in each group received muscle relaxants to perform intubation (p = NS). When compared to halothane group, children receiving sevoflurane had shorter times of showing purposeful movements (median: 9 min versus 15.5 min, $p < 0.005$), emergence from anaesthesia (median: 12 min versus 18 min, $p < 0.05$) and achieving readiness to be discharged (median: 18 min. versus 30 min, $p < 0.005$). Sevoflurane group also showed a more stable heart rate during the induction period than halothane one ($p = 0.05$).

It was therefore concluded that sevoflurane is as effective as halothane in providing smooth and rapid induction of anaesthesia, while recovery is considerably faster and haemodynamic tolerance is better if compared to halothane suggesting sevoflurane could be an useful substitute for halothane in paediatric patients.

Marochkov AV et al[60] compared sevoflurane and halothane used during general anaesthesia in children.

The investigators made a prospective analysis of the specific features of anaesthesias with sevoflurane and halothane in 70 children aged 1 to 11 years with systemic surgical diseases and assessed their physical status as ASA Class I. The anaesthetics sevoflurane, 3.1 ± 0.7 MAC, and halothane, 2.4 ± 0.3 MAC, were used to induce anaesthesia. Sevoflurane, 1.6 ± 0.6 MAC, and halothane, 1.5 ± 0.4 MAC, were employed to maintain anaesthesia. In children, sevoflurane anaesthesia induction and emergence occurred by 49% more rapidly ($p < 0.001$) than halothane use (the time of induction 2.9 ±0.7 min for sevoflurane versus 5.7 ± 0.5 min for halothane; that of consciousness recovery 3.6 ± 0.7 min versus 7.0 ±1.2 min). After halothane anaesthesia, there was a significant reduction in mean blood pressure (BP) by 24.5% as compared with the baseline values ($p < 0.001$). Sevoflurane use demonstrated a significantly less reduction in systolic BP by 10.2% of the baseline value ($p < 0.001$). In both groups after induction, there was a decrease in tidal volume, but minute volume was insignificantly lower due to higher respiration rate. The level of blood oxygenation was stable (SpO_2 97-99%) in both groups during all observational stages. No severe complications were recorded in both groups during anaesthesia. However, mild or moderate complications were twice fewer in the sevoflurane group.

Considering the results, it was concluded that sevoflurane was better than halothane for use during general anaesthesia in children.

METHODOLOGY

A clinical comparative study of halothane and sevoflurane as inhalational agents for induction of anaesthesia and tracheal intubation was carried out in 60 children aged between 1 to 5 yrs posted for elective surgical procedures at R.L.Jalappa Hospital attached to Sri Devaraj Urs Medical College, Kolar. The study was conducted during the period from June 2009 to September 2011.

Inclusion criteria

1. Paediatric patients of 1-5 years of either sex
2. Posted for elective surgical procedures
3. ASA Grade I and II

Exclusion criteria

1. ASA Grade III and IV
2. Head injury cases
3. History of drug allergy
4. Haemorrhagic diathesis
5. Neurological involvement/diseases
6. Anticipated difficult airway

Pre- Anaesthetic Evaluation

1. Was done a day before the proposed surgery
2. Relevant history taken
3. Physical examination carried out
4. Cardiovascular and respiratory system were assessed for any abnormalities

Investigations

1. Complete haemogram

2. Bleeding time and clotting time

3. Urine Routine Analysis

The children were randomly assigned into 2 groups of 30 each, Group H and Group S.

Group H – Consisting of 30 patients induced and intubated with incremental concentration of halothane 0.5% to 5% in 50% nitrous oxide and 50% oxygen mixture.

Group S – Consisting of 30 patients induced and intubated with incremental concentration of sevoflurane 1% to 8% in 50% nitrous oxide and 50% oxygen mixture.

The ethical committee clearance was obtained for the use of these drugs.

An informed written consent was obtained from the parents or guardians. All the patients were kept fasting for a period of 4-6 hours according to the age.

Premedication: Midazolam 0.1mgKg^{-1} and Atropine 0.03mgKg^{-1} intramuscularly 45 mins before surgery.

On the OT table, patient's base-line pulse, non-invasive blood pressure, SpO_2, ECG were recorded. Induction and tracheal intubation was done in both the groups without the use of muscle relaxants. Inhalation induction of anaesthesia was accomplished in all patients using Jackson-Rees modification of Ayre's T-piece breathing system and an unscented face mask using 50% nitrous oxide and 50% oxygen mixture with incremental concentrations of the study volatile anaesthetic using a Datex-Ohmeda S/5 Aespire anaesthesia work-station equipped with vaporisers for both halothane and sevoflurane.

Figure 1 : Halothane Vaporiser

Figure 2: Sevoflurane vaporiser

In group H, the inspired concentration of halothane was initially set at 0.5% followed by a stepwise increase by 0.5% every 3-4 breaths to a maximum of 5% until the loss of eye-lash reflex. In group S, the inspired concentration of sevoflurane was initially set at 1% followed by a stepwise increase by 1% every 3-4 breaths upto a maximum of 8% till the loss of eyelash reflex. No other drugs were used during the induction period. As soon as the child falls asleep, an intravenous line was secured and EP started. Proper sized oral endotracheal tube was inserted when the eyeballs were centralised and jaw relaxed. After the trachea was intubated, the child continued to breathe 1-1.5% halothane or 1.5-3% sevoflurane until all measurements were complete.

Recordings of heart rate, blood pressure, SpO_2 and were recorded during induction at half minute intervals, at intubation and 1 min post intubation. The HR (heart rate), MAP (Mean Arterial Pressure) and SpO_2 changes were compared between the two groups during induction, at immediate post-intubation and 1 minute post-intubation. The study ended at this point.

During the study the following parameters were taken into consideration:

Induction time – It is the time interval between the placements of facemask to loss of eyelash reflex.

Intubation time – It is the time interval between the placements of facemask to loss of conjugate eye movements (centrally placed mid dilated pupils).

Intubation characteristics were assessed using the following scoring system:[43]

Characteristic	Scores			
	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 movement	none	slight	moderate	severe

As shown above, the variables were given a score of 1-4, 1 being the ideal condition. Therefore, the best possible score was 5. A score of more than 2 was considered unfavourable for intubation. All the observations and measurements were made by the same independent trained observer throughout the study. The results of the study were statistically analysed using Student t-test and Mann-Whitney test.

RESULTS

A comparative study of halothane versus sevoflurane for induction of anaesthesia and tracheal intubation in children was done at R.L.Jalappa Hospital and research Centre, Tamaka, Kolar.

The results of the study are as under.

Table 2: Age distribution of patients studied

Age in years	Group H		Group S	
	No	%	No	%
1-2 years	5	16.7	9	30.0
3-5 years	25	83.3	21	70.0
Total	30	100.0	30	100.0
Mean ± SD	3.70±1.23		3.18±1.29	

Samples are age matched with p=0.118

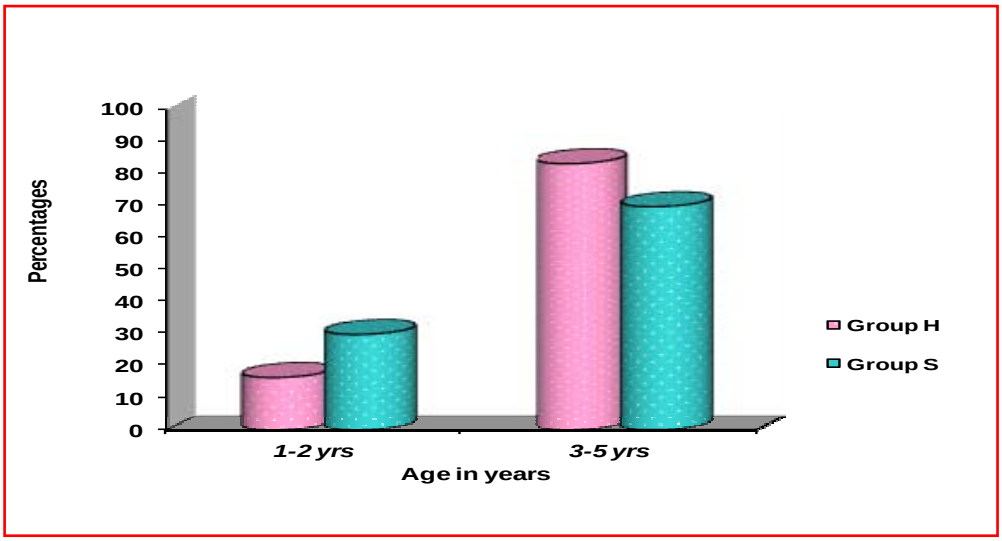


Figure 3: Age distribution

Table 3: Gender Distribution

Gender	Group H		Group S	
	No	%	No	%
Male	21	70.0	20	66.7
Female	9	30.0	10	33.3
Total	30	100.0	30	100.0

Samples are gender matched with p=0.781

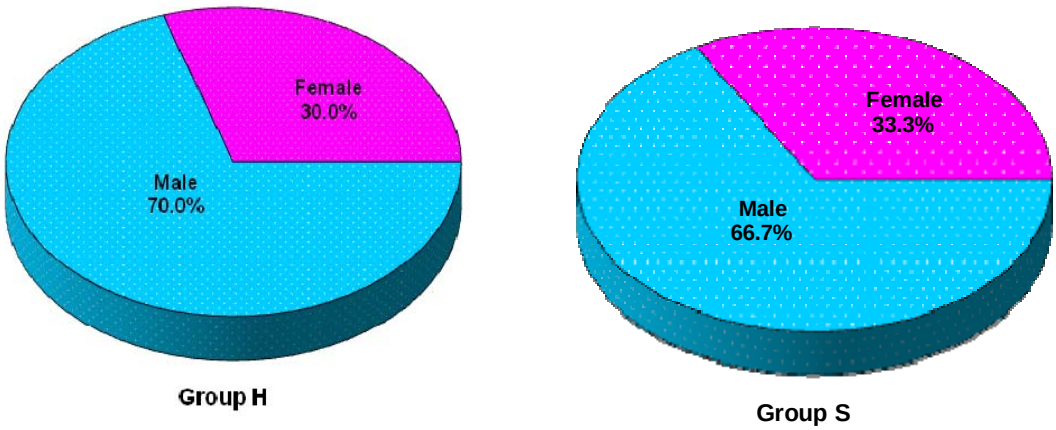


Figure 4: Gender distribution

Table 4: Nature of surgeries undergone by the patients in the two groups

Sl. No.	Nature of surgery	Group H n=30	Group S n=30
1	EUA(rectal polyp)		1
2	Excision of branchial cyst		1
3	SSG		2
4	Excision of M. contagiosum		1
5	Exam (EAC)	1	1
6	Arthroscopy(chronic synovitis)		1
7	Hypospadias repair	1	3
8	Theirsch(rectal prolapse)		1
9	Excision(umbilical granuloma)		1
10	Herniotomy	6	7
11	Cleft palate repair	1	1
12	Release(post- burn contracture)	1	1
13	Implantation of ect.ureteric op		1
14	Debridement	1	6
15	Adenotonsillectomy	3	1
16	Circumcision	1	1
17	Excision(cystic hygroma)	1	
18	Orchidopexy	1	
19	Removal(foreign body)	3	
20	Laparotomy pull through	1	
21	Polypectomy	1	
22	Suturing	2	
23	Oesophagoscopy	2	
24	Corneal tear repair	1	
25	Appendicectomy	1	
26	Excision(lipoma)	2	

Table 5: Comparison of Induction and intubation time (seconds) of the patients studied

	Group H (n=30)	**Group S (n=30)**	**P value**
Induction time(seconds)	98.00±49.22 (40-180)	57.50±22.88 (30-120)	<0.001**
Intubation time (seconds)	244.67±86.10 (90-420)	186.17±87.58 (60-390)	0.012*

*indicates significant value **indicates very significant value

Results are Mean ± SD (Min-Max)

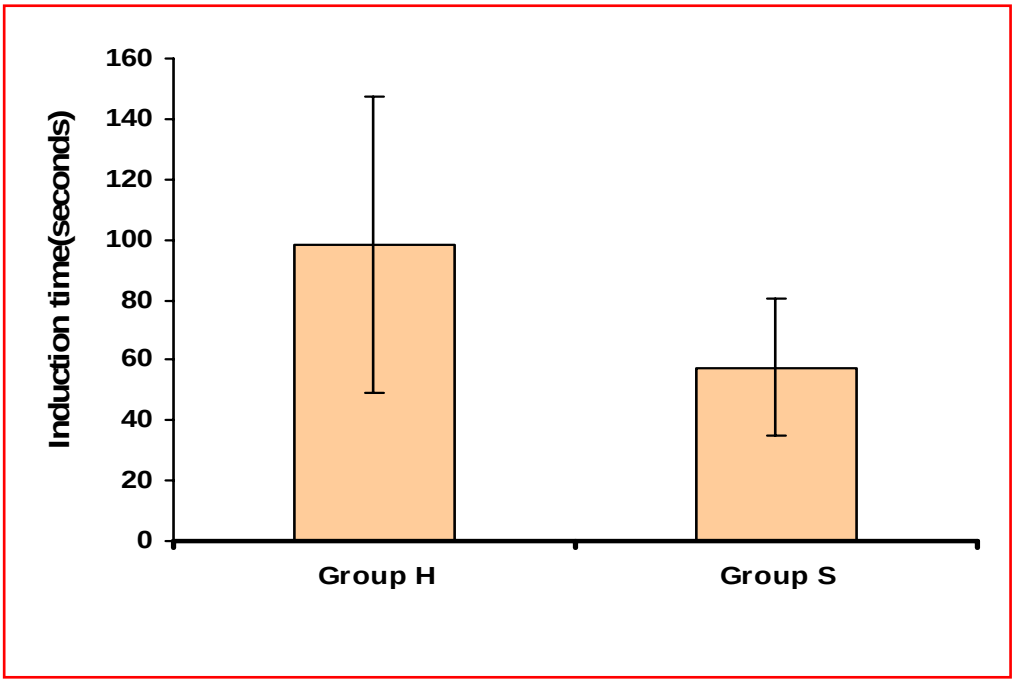


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Figure 5: Induction time

INDUCTION TIME

It is the time interval between placement of face mask and loss of eyelash reflex.

The mean induction time with halothane was 98 secs (SD 49.22secs) while with sevoflurane it was 57.50 secs (SD 22.88secs). As the p value <0.05 i.e. 0.001, it is statistically significant.

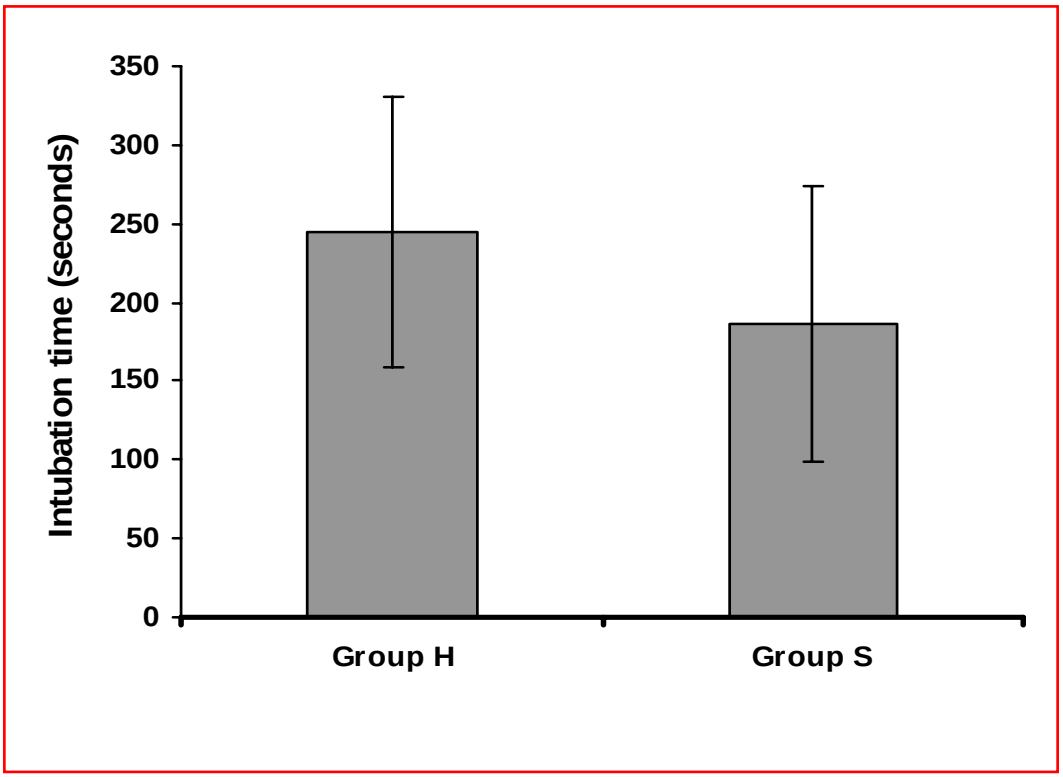

Figure 6: Intubation time

INTUBATION TIME

It is the time interval between the placements of facemask to centrally placed middilated pupils.

Mean intubation time with halothane was 244.67secs (SD 86.1secs) and that with sevoflurane was 186.57secs (SD 87.58 secs). As p<0.05 this was statistically significant.

Table 6: Comparison of Intubation characteristics in two groups of patients

Intubation characteristics	Group H (n=30)	Group S (n=30)	P value
Laryngoscopy			
• Easy	30(100.0%)	30(100.0%)	NS
• Fair	-	-	
• Difficult	-	-	
• Impossible	-	-	
Vocal cords			
• Open	24(80.0%)	20(66.7%)	0.126
• Moving	6(20%)	7(23.3%)	
• Closing	-	3(10.0%)	
• Closed	-	-	
Coughing			
• None	25(83.3%)	23(76.7%)	0.188
• Slight	3(10.0%)	7(23.3%)	
• Moderate	2(6.7%)	-	
• Severe	-	-	
Jaw relaxation			
• Complete	27(90.0%)	25(83.3%)	0.706
• Slight	3(10.0%)	5(16.7%)	
• Stiff	0	0	
• Rigid	0	0	
Limb movement			
• None	28(93.3%)	24(80.0%)	0.254
• Slight	2(6.7%)	6(20.0%)	
• Moderate	0	0	
• Severe	0	0	

Two patients in group H and three patients in group S had a score of 3 in any one category and hence intubating condition was considered unacceptable in these patients. Thus 98% patients in halothane group and 97% patients in sevoflurane group had acceptable intubating conditions. In all the characteristics studied for comparison, the p value was > 0.05, and so was statistically insignificant.

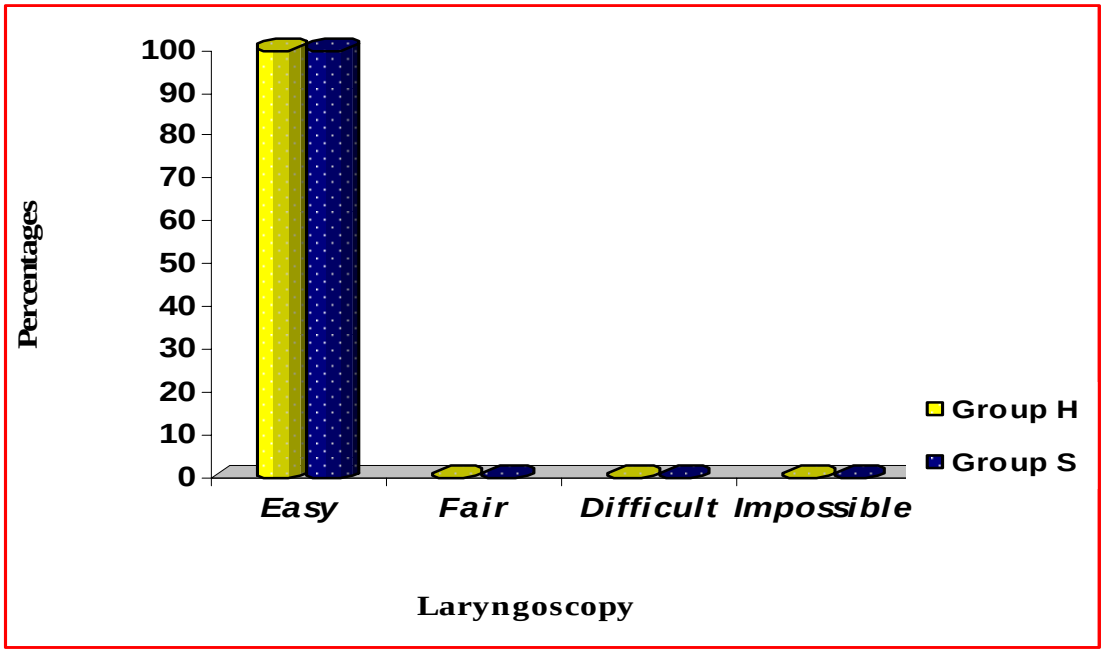

Figure 7: Laryngoscopy grading

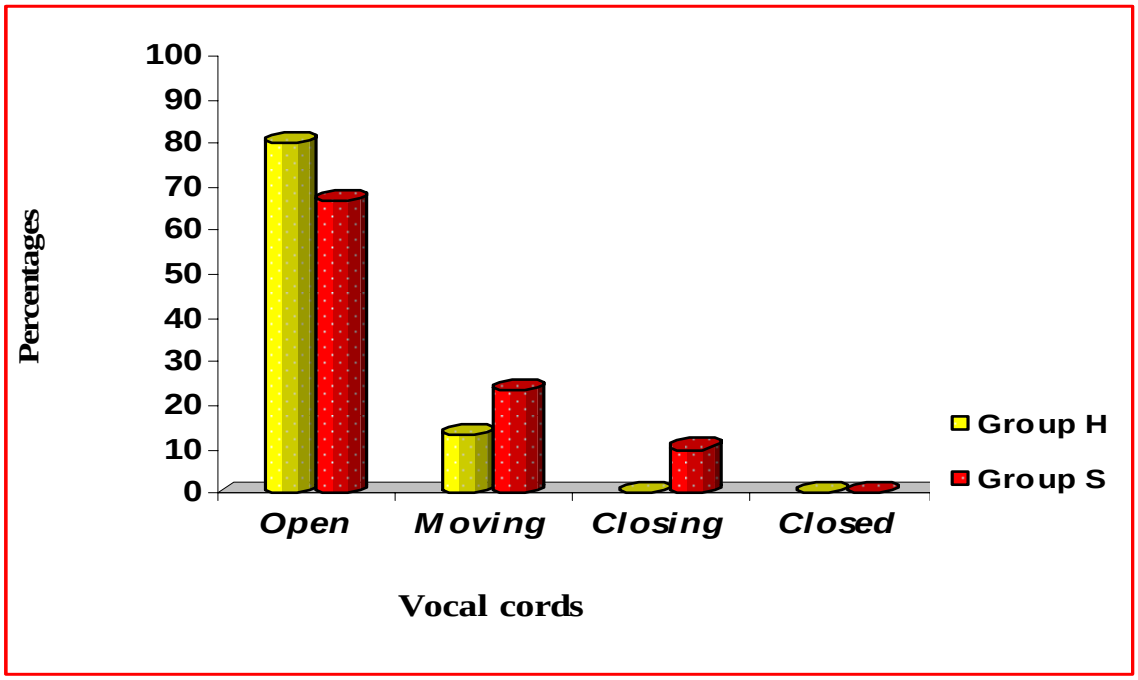

Figure 8: Vocal cords grading

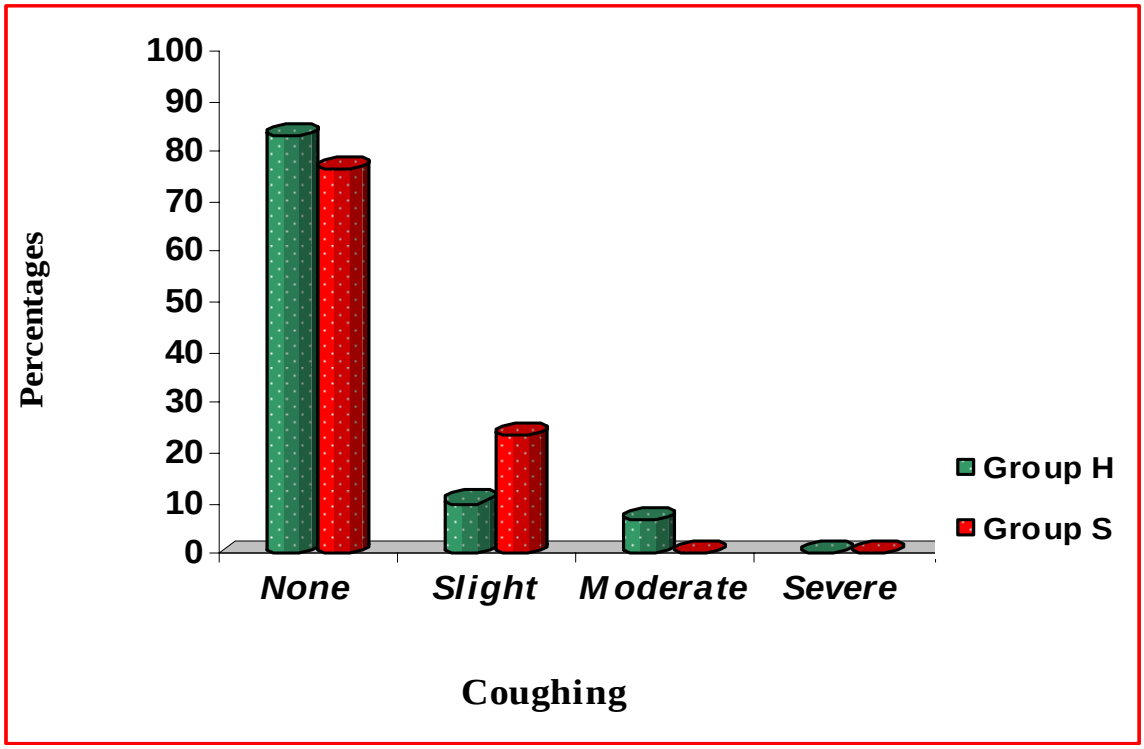

Figure 9: Coughing grading

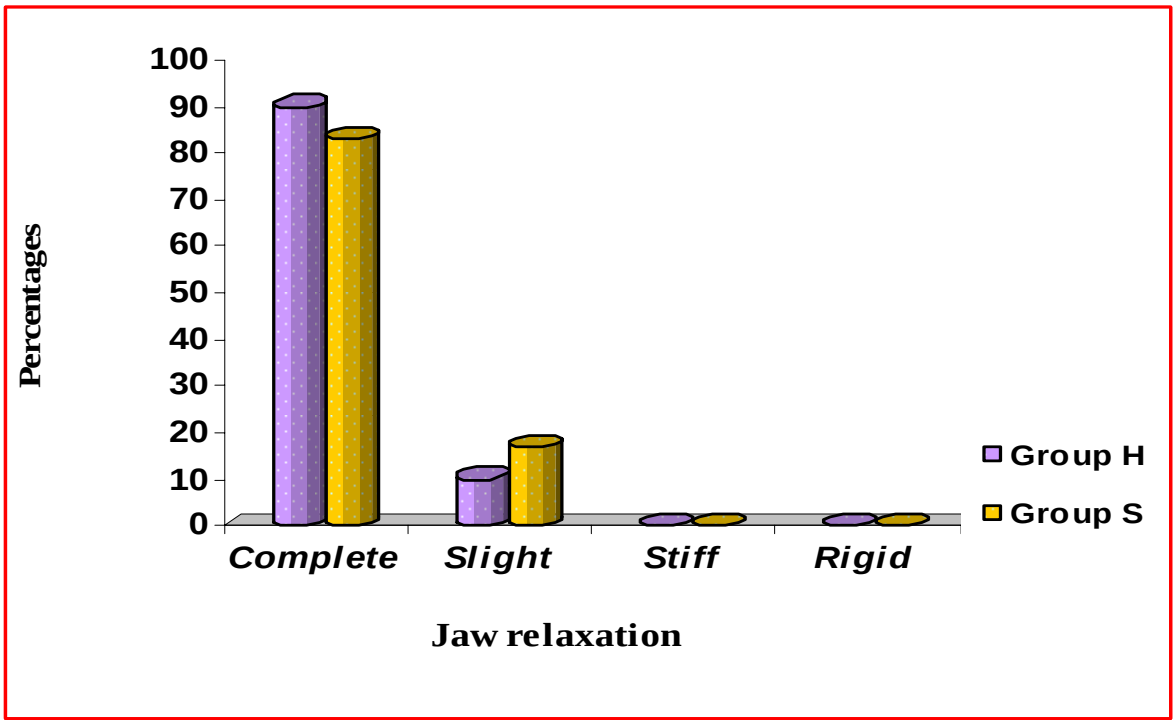

Figure 10 : Jaw Relaxation Grading

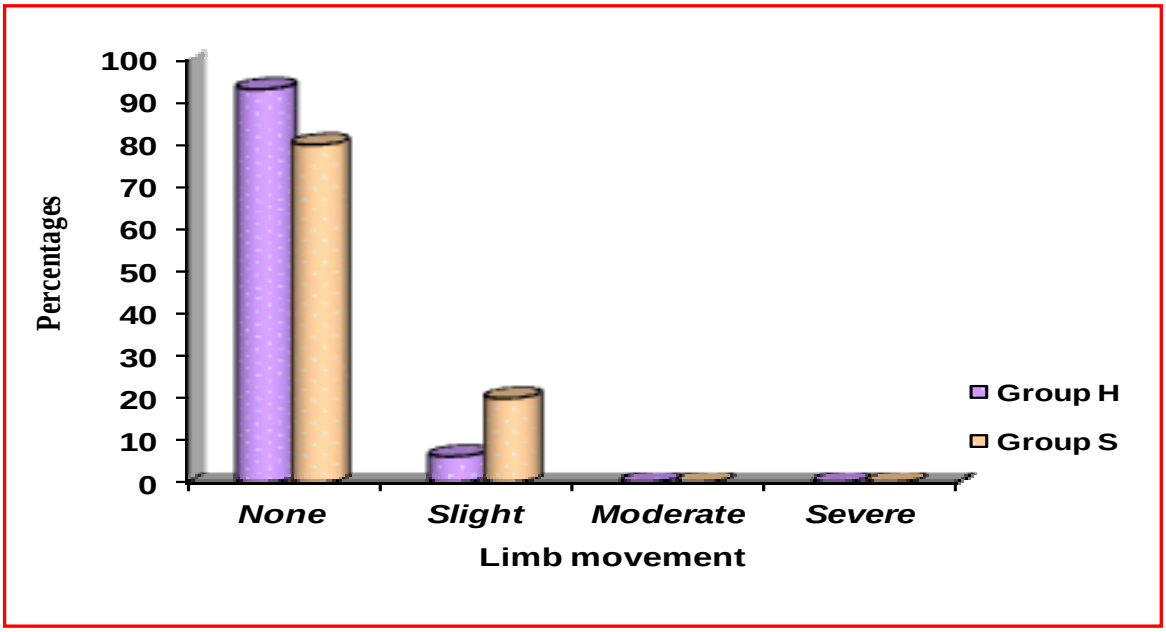

Figure 11: Limb movement grading

Table 7: Comparison of mean heart rate in two groups of patients studied

HR (bpm)	Group H		Group S		P value
	No of patients	Mean ± SD	No of Patients	Mean ± SD	
basal	30	148.27±18.40	30	136.27±19.28	0.017*
0.5min	30	146.30±17.41	30	135.50±19.68	0.028*
1min	30	143.63±15.85	30	135.37±20.44	0.085
1.5min	30	141.70±14.86	29	134.72±23.07	0.171
2min	28	139.21±13.23	27	132.85±23.55	0.220
2.5min	27	136.59±13.36	21	140.76±21.29	0.411
3min	23	135.04±14.58	17	146.06±17.68	0.037*
3.5min	20	134.55±13.10	13	145.23±19.49	0.068
4min	19	133.32±13.80	8	140.38±17.36	0.271
4.5min	13	131.23±14.22	6	134.33±6.19	0.619
5min	10	129.80±16.57	5	135.40±8.82	0.497
5.5min	7	129.00±12.64	4	137.00±11.11	0.321
6min	4	133.50±4.73	1	130.00±0.00	0.555
6.5min	2	134.00±8.49	1	130.00±0.00	0.766
7min	1	125.00±0.00	-	-	-
pint	30	131.30±12.81	30	137.80±25.90	0.223
1minpint	30	139.50±12.33	30	145.40±18.79	0.156

*indicates significant value

Mean ± SD: Student test

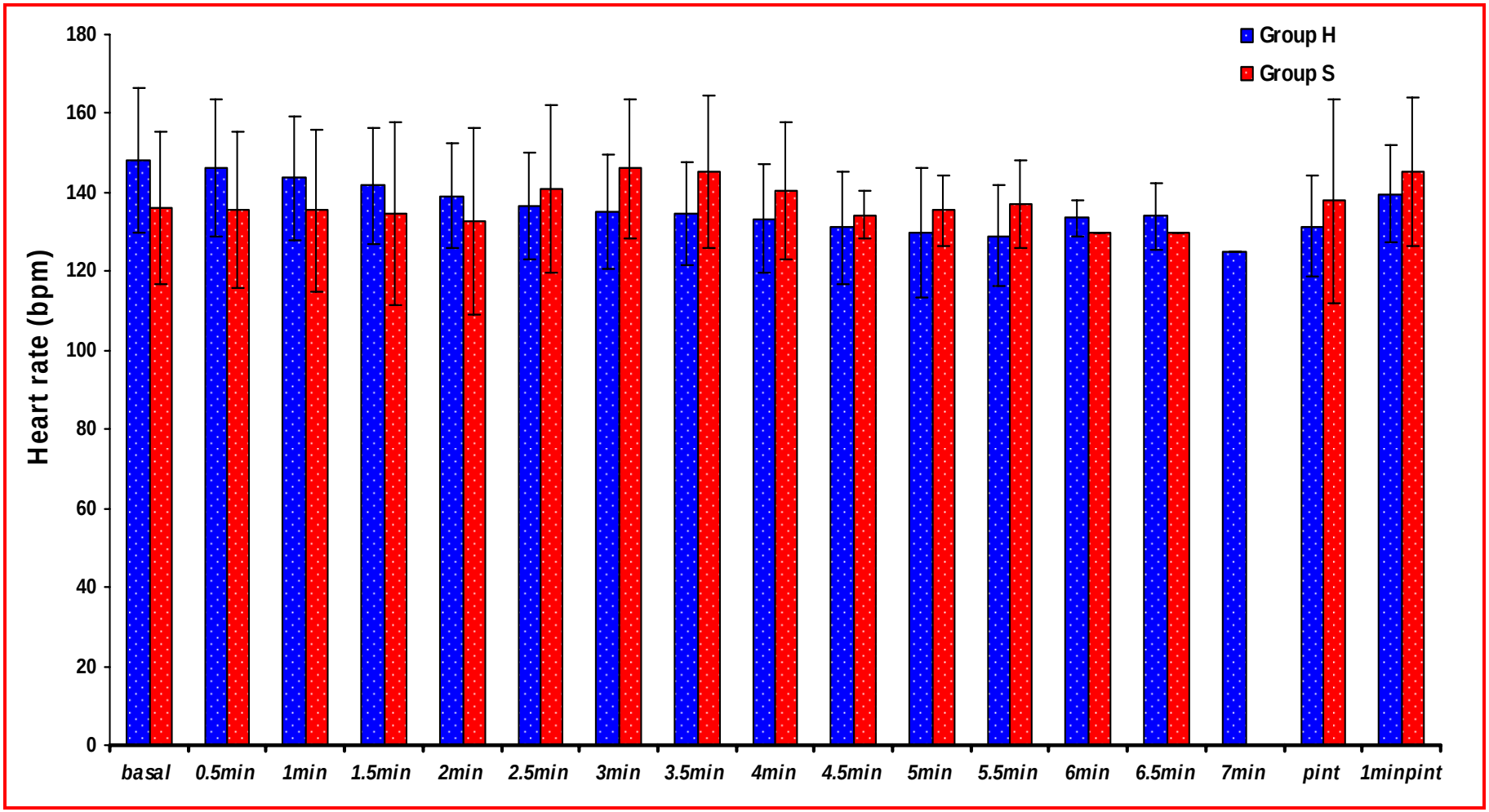

Figure 12: Mean Heart Rate during Induction, Intubation and 1 minute Post-Intubation

Basal heart rate was 148.27 bpm in halothane group and 136.27 in the sevoflurane group. With induction of anaesthesia the heart rate decreased progressively in the halothane group from 141.4bpm to 125.0bpm, at 7 min. Where as, in the sevoflurane group there was a very reduction in the heart rate compared to basal value at 6.5min.

After intubation an increase in heart rate was observed in both the groups. Heart rate increased from 131.30bpm at intubation to 139.50bpm 1min after intubation in the halothane group and from 137.80.bpm at intubation to 145.7bpm 1min after intubation in the sevoflurane group.

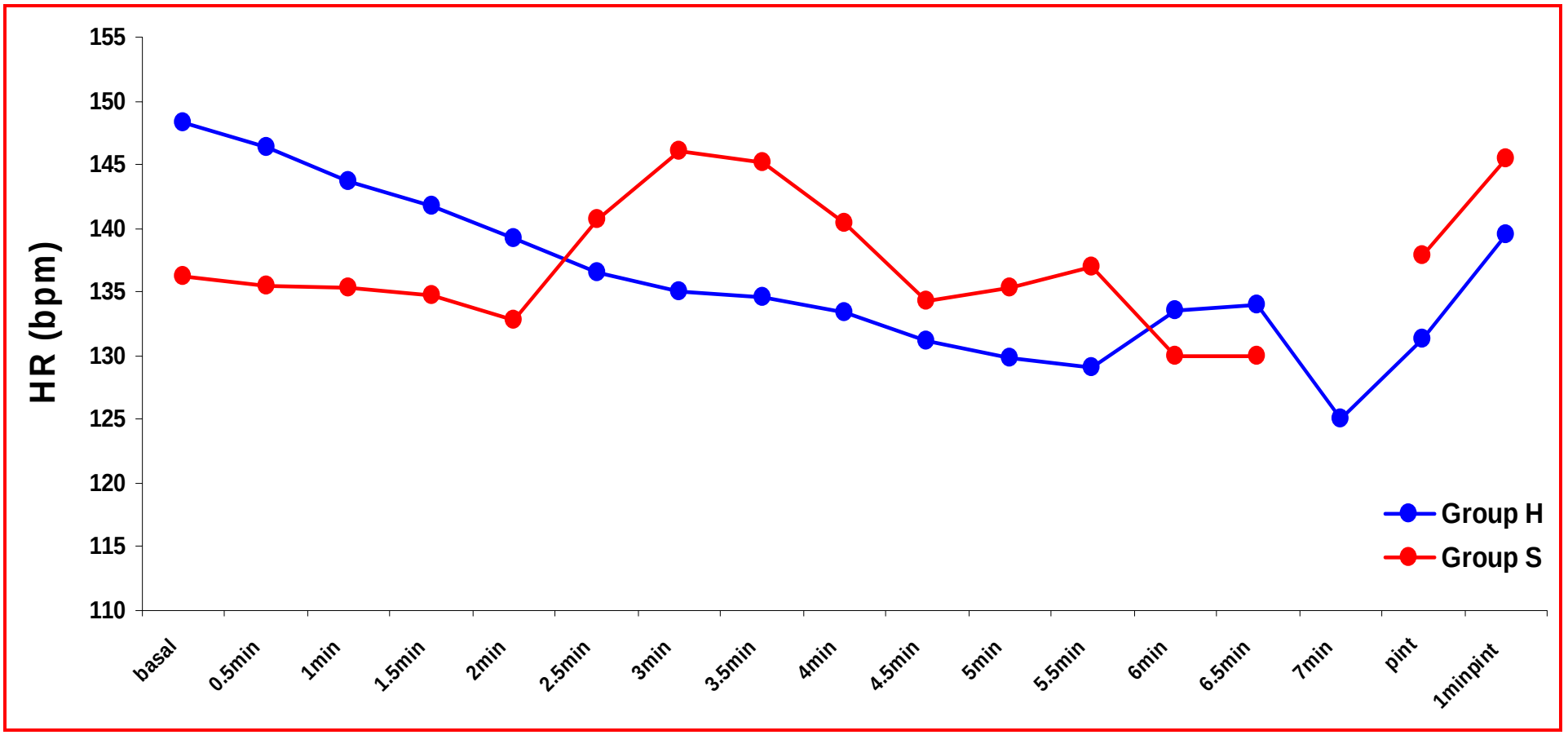

Figure 13: Mean Heart Rate during Induction, Intubation and 1 minute Post-Intubation

Table 8: Comparison of MAP (mm Hg) in two groups of patients studied

MAP (mm Hg)	Group H		Group S		P value
	No of Patients	Mean ± SD	No of Patients	Mean ± SD	
Basal	30	86.30±13.90	30	83.13±14.06	0.384
0.5min	30	83.77±13.70	30	82.30±14.09	0.684
1min	30	81.30±14.24	30	80.60±13.87	0.848
1.5min	30	79.10±14.24	29	79.28±13.92	0.962
2min	28	76.25±15.16	27	77.89±14.14	0.680
2.5min	27	73.00±15.54	21	77.57±15.55	.0.318
3min	23	74.26±14.41	17	78.29±16.98	0.422
3.5min	20	75.05±14.16	13	80.77±20.02	0.343
4min	19	74.63±14.54	8	75.38±14.85	0.905
4.5min	13	73.08±15.93	6	77.83±16.09	0.554
5min	10	70.00±16.01	5	77.60±19.63	0.434
5.5min	7	73.57±15.54	4	77.00±22.24	0.769
6min	4	75.50±11.9	1	91.00±0	0.328
6.5min	2	79.00±12.73	1	91.00±0	0.582
7min	1	88.00	-	-	-
pint	30	70.90±15.41	30	74.40±14.56	0.370
1minpint	30	74.70±16.73	30	78.33±14.6	0.374

Mean ± SD: Student test

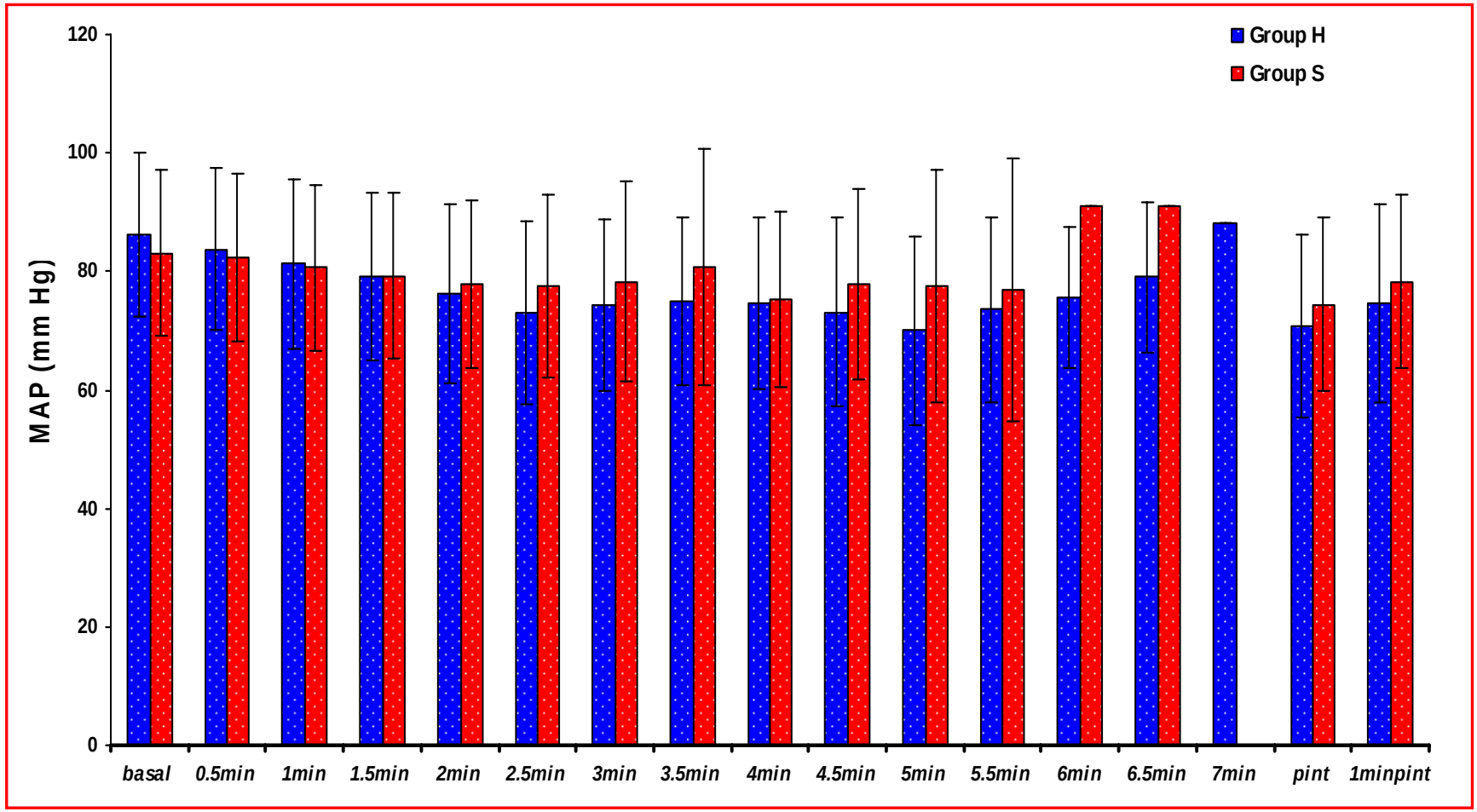

Figure 14: Mean Arterial Pressure during Induction, Intubation and 1 minute Post-Intubation

Basal MAP was 86.3mmHg in halothane group and 83.13mmHg in the sevofluranre group. With induction of anaesthesia there was a progressive decrease in the MAP in both the groups. MAP decreased from 86.3mmHg to 70.0mmHg at 5min in halothane group and from 83.13mmHg to 77.6mmHg at 5min in the sevoflurane group.

After intubation an increase in MAP was observed in both the groups. MAP increased from 70.9mmHg at intubation to 74.7mmHg 1min after intubation in the halothane group and from 74.4mmHg at intubation to 78.3mmHg 1min after intubation in the sevoflurane group.

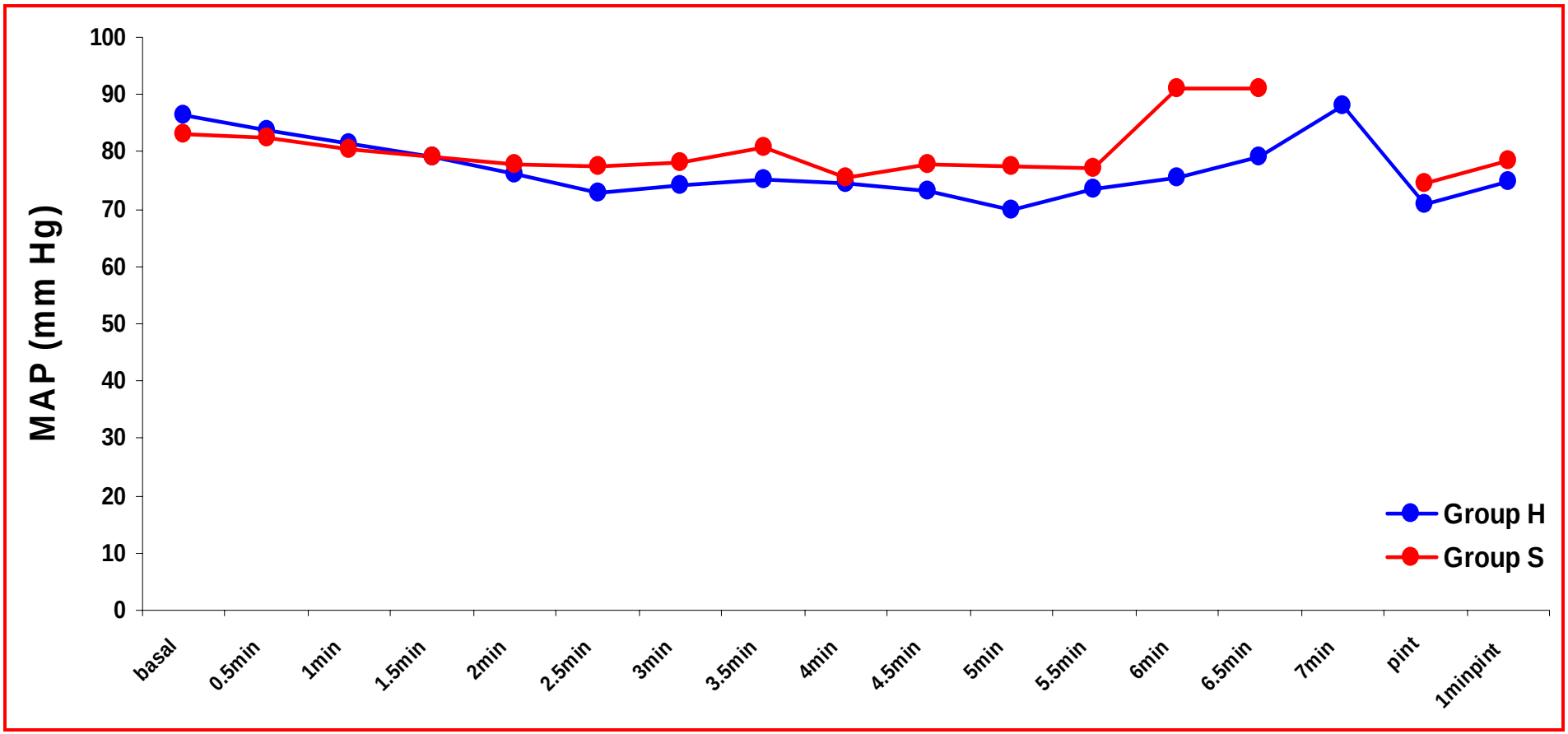

Figure 15: Mean Arterial Pressure during Induction, Intubation and 1 minute Post-Intubation

Table 9: Comparison of SpO_2 (%) in two groups of patients studied

SpO_2 (%)	Group H		Group S		P value
	No of patients	Mean ± SD	No of patients	Mean ± SD	
basal	30	98.77±1.07	30	98.63±1.27	0.783
0.5min	30	98.90±0.71	30	98.7±0.88	0.372
1min	30	98.73±0.91	30	98.63±1.1	0.805
1.5min	30	98.70±0.70	29	98.66±0.94	0.948
2min	30	98.63±0.76	27	98.44±0.97	0.384
2.5min	30	98.10±2.25	21	98.71±1.01	0.329
3min	26	98.46±0.99	17	98.94±0.56	0.063
3.5min	23	98.61±0.99	14	98.86±0.95	0.526
4min	20	98.95±0.69	10	98.5±0.71	0.146
4.5min	15	98.93±0.80	6	98.33±0.52	0.111
5min	12	98.63±0.72	5	99±0.71	0.642
5.5min	7	98.43±0.98	4	99.75±0.5	0.038*
6min	4	98.25±0.50	1	96±0	-
6.5min	2	99±0	1	99±0	-
7min	1	99±0	0	-	-
pint	30	98.17±0.91	30	98.90±0.94	0.004**
1minpint	30	98.8±0.71	30	98.45±1.09	0.146

*indicates significant value

**indicates very significant value

Mean ± SD: Mann Whitney U test

SpO_2 remained stable in both the groups throughout the course of the study.

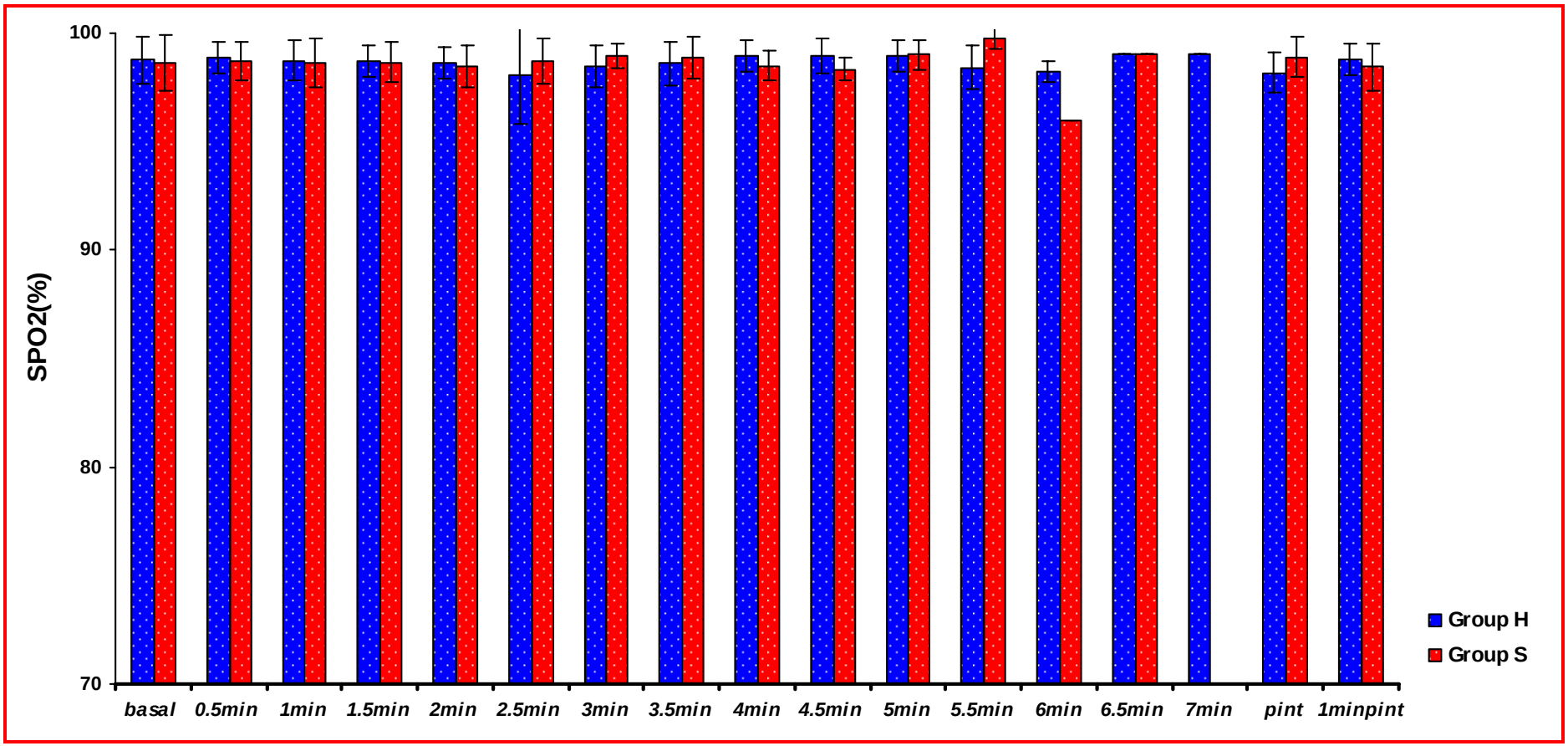

Figure 16: Mean SpO_2 during Induction, Intubation and 1 minute Post-Intubation

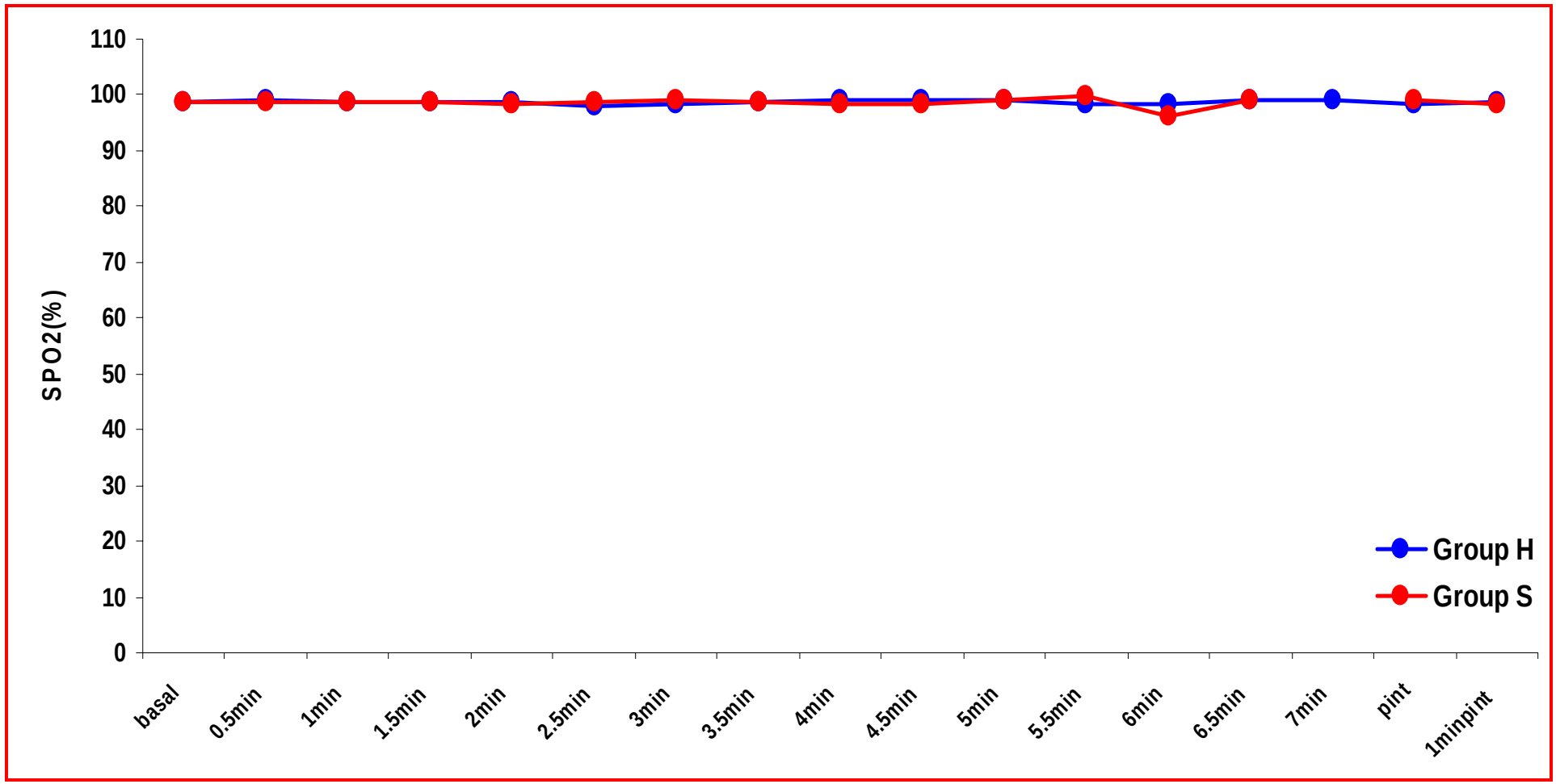

Figure 17: Mean SpO_2 during Induction, Intubation and 1 minute Post-Intubation

DISCUSSION

Inhalational induction of anaesthesia is one of the most common methods of induction employed in paediatric practice.[45]Though intravenous induction has also been employed in children, the need to secure an intravenous line in an awake child which is psychologically traumatic and unpleasant to the child, makes inhalational induction still the commonly used and popular method of induction in paediatrics.

Various inhalational agents like ether, chloroform, cyclopropane, trichloroethylene and methoxyflurane have been used for induction of anaesthesia. Ether had several disadvantages like high inflammability, airway irritability, prolonged induction and recovery, which led to its downfall. Chloroform went into disrepute because of its deleterious effect on heart. Trichloroethylene could not be used in closed circuits and cyclopropane was highly explosive[45] and arrhythmogenic. Methoxyflurane caused high output renal failure.

The characteristics of an ideal inhalational agent are

1. Pleasant odour
2. Rapid and smooth induction and recovery.
3. Non-inflammable.
4. Chemically stable during storage and while in contact with metals used in anaesthesia.
5. Bio-chemically stable and non toxic to parenchymatous organs even with prolonged and repeated use.
6. Excreted as it is with virtually no bio-transformation.
7. Capable of inducing unconsciousness quickly.
8. Allow high inspired oxygen level.
9. Produce muscle relaxation.

10. Low water solubility.
11. Sole anaesthetic.
12. Does not sensitise the heart to exogenous and endogenous catecholamines.

Among the present day inhalational agents, halothane satisfies most of these properties and is the induction agent most commonly employed in children. Because of its pleasant smell and low blood gas solubility coefficient it allows smooth and rapid induction.[45] However, it has disadvantage of myocardial depression, sensitizes myocardium to both endogenous and exogenous catecholamines and is associated with serious complication of halothane hepatitis. Sevoflurane, introduced in the year 1990 by Maruishi Company in Japan is the new inhalational agent which is added to anaesthesiologist's armamentarium. Like halothane, it has low blood gas solubility coefficient allowing rapid induction. Because of its non-pungent odour induction is said to be smooth with this agent. In addition it has no much effect on cardiovascular system. It neither sensitizes the myocardium nor produces myocardial depression. In view of it sevoflurane is gaining in popularity as the inhalational induction agent of choice in paediatric population.

The present study was conducted in 60 paediatric patients aged 1-5yrs. In 30 patients halothane was employed for induction and intubation. And in remaining 30 patients sevoflurane was employed for induction and intubation. The demographic profile was similar in both the groups.

Premedication:

Various authors have employed various premedicant drugs in paediatric patients.

O'Brein K et al[2] have used trimeprazine $2mgKg^{-1}$ 1-1.5hrs before induction.

Piat V et al[3] have used 0.4mgKg^{-1}rectal midazolam 30mins before induction.

Black A et al[4] have used atropine 0.02mgKg^{-1}orally or intramuscularly with temazepam 0.5mgKg^{-1}. Swadia VN et al[5] have used a combination of midazolam 0.5mgKg^{-1}and atropine 0.03mgKg^{-1}orally 45mins before surgery.

As halothane administration is associated with the risk of bradycardia, it is common to administer intramuscular atropine 30-45mins before surgery. However, the question of using atropine premedication for sevoflurane induction is controversial as sevoflurane is said to be cardio-stable. In the present study, to have the common methodology of induction we employed atropine in the dose of 0.03mgKg^{-1} and midazolam 0.1mgkg^{-1} given intramuscularly 45mins before the proposed surgical procedure.

Concentration of halothane and sevoflurane used:

Various techniques of inhalational induction have been adopted by different authors. Some authors have used the rapid inhalational induction (Agnor R et al,[46] Sigston et al,[47] and Baum VC et al[48]) while others have used the tidal technique of incremental concentrations. 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 the incremental technique as used by Piat V et al,[3] Black et al,[4] Swadia VN et al[5] and others.

Various authors have used different concentrations of halothane and sevoflurane.

O'Brein K et al,[2] Swadia VN et al,[5] Black A et al,[4] Paris ST et al[7] and Bithal PK et al,[43]have used 0.5-5% halothane and 1-7 or 8% sevoflurane. Piat V et al[3] have used 1-3.5% halothane and 2-7% sevoflurane. In our present study we have used 0.5-5% halothane and 1-8% sevoflurane.

Induction time:

Piat V et al,[3] Black A et al,[4] Swadia VN et al,[5] Tainvainen T et al,[39] and Naito et al,[49] and have defined induction time as the time interval from the placement of face mask to loss of eye lash reflex. In the present study the above definition was employed for induction time.

Table 10: Induction time by various authors

Author	No. of patients	Induction time (Secs) (Time to loss of eye lash reflex)	
		Halothane	Sevoflurane
Swadia VN et al	H=13 S=16	103.67 ± 39.87	97.27 ± 45.68
Black A et al	H=39 S=42	137 ± 43	101 ± 35
Naito et al	H=15 S=15	198 ± 48	192 ± 84
Lerman J et al	H=125 S=250	96 ± 66	78 ± 47.4
Piat V et al	H=17 S=17	108 ± 42	90 ± 36
Paris ST et al	H=50 S=50	114 ± 30	90 ± 36
Joel BS et al	H=40 S=40	102 ± 36	96 ± 42
Taivainen et al	H=25 S=25	102 ± 36	60 ± 18
Present study	H=30 S=30	98.00 ± 49.22	57.50 ± 22.88 p<0.05

From the above table it is seen that the induction time observed by various authors with increasing concentrations of halothane ranges from 96secs (Lerman J et al[42]) to 198secs (Naito et al[49]). In the present study the induction time of halothane ranged from 40secs to 180secs with a mean of 98secs (SD 49.22secs) which is similar to the studies of Lerman J et al[42]. The induction time of sevoflurane observed by various authors with increasing

concentrations of sevoflurane ranges form 60secs (Taivainen et al[39]) to 192secs (Naito et al[49]). In the present study the induction time of sevoflurane ranged from 30secs to 120secs with a mean of 57.5secs (SD 22.88secs) which is similar to the studies of Taivainen et al[39] and Lerman J et al.[42] Black A et al,[4] Taivainen et al[39] and Lerman J et al[42] noted a significantly rapid induction with sevoflurane when compared to halothane. In the present study the induction with sevoflurane was rapid than halothane (sevoflurane 57.5secs vs halothane 98secs, **p<0.05**), which is similar to that noted by authors above.

Intubation time:

It is the time interval between the placement of face mask to centrally placed mid dilated pupils. The above definition for intubation time is similar to that employed by O'Brein K et al[2], Taivainen et al,[39] and P Bithal PK et al.[43]

Table 11: showing the intubation time observed by various authors

Author	No. of Patients	Intubation time (Secs) (Time to central mid dilated pupils)	
		Halothane	Sevoflurane
Bithal PK et al	H=13 S=16	330.76 ± 59.79	324.93 ± 44.12
Swadia VN et al	H=25 S=25	246 ± 55.93	242.27 ± 52.67
Black A et al	H=39 S=42	290 ± 87	238 ± 68
O' Brien K et al	H=20 S=20	200.25 ± 53.9	243.4 ± 52.9
Piat V et al	H=17 S=17	246 ± 60	246 ± 78
Joel BS et al	H=50 S=50	312 ± 84	306 ± 114
Taivainen et al	H=25 S=25	198 ± 54	144 ± 60
Present study	H=30 S=30	244.67 ± 86.10	186.17 ± 87.58 p<0.05

From the above table it is seen that the intubation time observed by various authors with increasing concentration of halothane ranges from 198secs (Taivainen et al[39]) to 330.76secs (Bithal PK et al[43]). In the present study the intubation time of halothane ranged from 90secs to 420secs with a mean of 244.67secs (SD 86.1), which concurs with the study of Piat V et al[3] and Swadia VN et al[5].

The intubation time observed by various author with increasing concentration of sevoflurane ranges from 144secs (Taivainen et al[39]) to 324.93secs (Bithal PK et al[43]). In the present study the intubation time of sevoflurane ranged from 60secs to 390secs with a mean of 186.17secs (SD 87.58), which is similar to the study of Taivainen et al.[39] Taivainen et al[39] and Black A et al[4] observed that the intubation time was shorter with sevoflurane than halothane. In the present study we noted a significantly shorter intubation time with sevoflurane than halothane (sevoflurane 186.17secs vs halothane 244.67secs $p<0.05$). This observation concurs with the studies of the above authors.

Intubating conditions:

Various authors have assessed the intubating conditions with halothane and sevoflurane as induction agents. In the present study we assessed intubating conditions employing the scale used by O' Brein K et al[2] and Bithal PK et al.[43]

Table 12: showing intubating conditions observed by various authors.

Author	No. of patients	Acceptable intubating condition		Remarks
		Halothane	Sevoflurane	
Bithal PK et al	H=13 S=16	76.90%	81.25%	Vocal cords more likely to be moving or closing in Sevoflurane group
O' Brein K et al	H=20 S=20	95%	95%	Vocal cords more likely to be moving or closing in Sevoflurane group
Present study	H=30 S=30	98%	97%	Vocal cords more likely to be moving or closing in Sevoflurane group

Bithal PK et al[43] noted acceptable intubating conditions in 76.9% patients in halothane group and 81.25% of patients in sevoflurane group. O' Brein K et al[2] noted acceptable intubating conditions in 95% patients in both halothane and sevoflurane group. Both the above authors also noted that the vocal cords were more likely to be moving or closing in sevoflurane group.

In the present study intubating conditions was acceptable in 98% patients in halothane group and 97% patients in sevoflurane group which is close to the study of O' Brein K et al.[2] We

noted that the vocal cords were more likely to be moving or closing in the sevoflurane group, which concurs with the studies of Bithal PK et al[43] and O'Brein K et al.[2]

2 patients in halothane group had a score of 3 i.e. moderate coughing during intubation. 3 patients in sevoflurane group had their vocal cords closing i.e. a score of 3 during intubation. However, we were able to intubate all the patients in both the groups in the first attempt.

Haemodynamic characteristics:

Non-invasive haemodynamic measurements such as heart rate and blood pressure have often been used to evaluate the cardiovascular responses of anaesthetic agents. In the present study also non-invasive measurements like heart beat and blood pressure were used to evaluate the cardiovascular effects of halothane and sevoflurane. Sarner JB et al[40] observed that children receiving halothane tended to have a decrease in heart rate during anaesthetic induction, where as children receiving sevoflurane maintained or increased heart rate. In the present study the heart rate decreased progressively in the halothane group from 148.27bpm (SD 18.40) to 131.30bpm (SD 12.81) at intubation, where as in the sevoflurane group heart rate increased slightly from 136.27bpm (SD 19.28) to 137.80bpm (SD 25.90) at intubation, which concurs with the study of Sarner JB et al.[40] Sarner JB et al[40] observed a decrease in the MAP during induction with both halothane and sevoflurane, but the decrease was greater in patients receiving halothane than in those receiving sevoflurane. In the present study MAP decreased from 86.30mmHg (SD 13.90) to 70.90mmHg (SD 15.41) in the halothane group and from 83.13mmHg (SD 14.06) to 74.40mmHg (SD 14.56) in the sevoflurane at intubation, which concurs with the study of Sarner JB et al.[40]

From the present study it is seen that halothane in gradually increasing concentration of 0.5-5% and sevoflurane in increasing concentration of 1-8% provides rapid and smooth induction with an induction of 98secs for halothane and 57.50secs for sevoflurane. Halothane produces acceptable intubating conditions in 98% of patients in a mean time of 244.67secs. Sevoflurane produces acceptable intubating conditions in 97% of patients in a mean time of 186.17secs. Halothane administration is associated with slight decrease in heart rate and slight reduction in MAP, where as sevoflurane administration is not associated with any significant cardiovascular changes.

The SpO_2 was stable in both the groups throughout the course of the study.

CONCLUSION

From the present study it can be concluded that,

1. Halothane in the concentration of 0.5-5% produces induction in 98secs (SD 49.22secs) and sevoflurane in the concentration of 1-8% produces induction in 57.50secs (SD 22.88secs).Thus sevoflurane produces rapid induction compared to halothane.
2. Intubation time is reached in 244.67secs (SD 86.10secs) with halothane employed in the concentration of 0.5-5% and in 186.17secs (SD 87.58secs) with sevoflurane employed in the concentration of 1-8%. Thus intubation time is achieved earlier with sevoflurane than halothane.
3. Acceptable intubating conditions are obtained with both halothane and sevoflurane.
4. Haemodynamic stability is better with sevoflurane when compared to halothane.

In conclusion, both halothane and sevoflurane produces acceptable induction and intubation in majority of the patients. Induction and intubation are faster with sevoflurane compared to halothane. Haemodynamic stability during induction and intubation is better with sevoflurane compared to halothane. This makes sevoflurane a better alternative to halothane for induction of anaesthesia in children.

SUMMARY

The present study entitled ***"A comparative study of halothane versus sevoflurane for induction of anaesthesia and tracheal intubation in children"*** was carried out at Sri Devaraj Urs Medical College, Tamaka, Kolar after obtaining ethical committee clearance.

The study population consisted of 60 patients aged 1-5yrs divided randomly into two groups of 30 each.

Group H – Consisting of 30 patients induced and intubated with incremental concentrations of halothane 0.5-5% in 50% nitrous oxide and 50% oxygen mixture.

Group S – Consisting of 30 patients induced and intubated with incremental concentrations of sevoflurane 1-8% in 50% nitrous oxide and 50% oxygen mixture.

Table 13: Summary of Results

Sl. no.	Particulars	Group H n=30	Group S n=30
1	Mean age (Years)	3.7 ± 1.23	3.18 ± 1.29
2	Male:Female ratio	21: 9	20:10
3	Mean Induction time (secs)	98 ± 49.22	57.50 ± 22.88
4	Mean Intubation time (secs)	244.67 ± 86.10	186.17 ± 87.58
5	Favourable intubating conditions	98%	97%
6	Heart Rate (bpm) Mean ± SD		
	Basal	148.27±18.40	136.27±19.28
	0.5min	146.3±17.41	135.5±19.68
	1min	143.63±15.85	135.37±20.44
	1.5min	141.7±14.86	134.72±23.07
	2min	139.21±13.23	132.85±23.55

	2.5min	136.59±13.36	140.76±21.29
	3min	135.04±14.58	146.06±17.68
	3.5min	134.55±13.10	145.23±19.49
	4min	133.32±13.80	140.38±17.36
	4.5min	131.23±14.22	134.33±6.19
	5min	129.8±16.57	135.4±8.82
	5.5min	129±12.64	137±11.11
	6min	133.5±4.73	130±0.00
	6.5min	134±8.49	130±0.00
	7min	125±0.00	
	At intubation	131.3±12.81	137.8±25.90
	1 minute after intubation	139.5±12.33	145.4±18.79
7	MAP(mmHg) Mean ± SD		
	Basal	86.3± 13.90	83.13±14.06
	0.5min	83.77±13.70	82.3±14.09
	1min	81.3±14.24	80.6±13.87
	1.5min	79.1±14.24	79.28±13.92
	2min	76.25±15.16	77.89±14.14
	2.5min	73±15.54	77.57±15.55
	3min	74.26±14.41	78.29±16.98
	3.5min	75.05±14.16	80.77±20.02
	4min	74.63±14.54	75.38±14.85
	4.5min	73.08±15.93	75.83±16.09
	5min	70±16.01	77.6±19.63
	5.5min	73.57±15.54	77±22.24
	6min	75.5±11.9	91±0
	6.5min	79±12.73	91±0
	7min	88	
	At intubation	70.9±15.41	74.4±14.56
	1 minute after intubation	74.7±16.73	78.33±14.6

8	SpO_2 (%) Mean ± SD		
	Basal	98.77±1.07	98.63±1.27
	0.5min	98.9±0.71	98.7±0.88
	1min	98.73±0.91	98.63±1.1
	1.5min	98.7±0.70	98.66±0.94
	2min	98.63±0.76	98.44±0.97
	2.5min	98.1±2.25	98.71±1.01
	3min	98.46±0.99	98.94±0.56
	3.5min	98.61±0.99	98.86±0.95
	4min	98.95±0.69	98.5±0.71
	4.5min	98.93±0.80	98.33±0.52
	5min	91.33±0.72	99±0.71
	5.5min	98.43±0.98	96±0.5
	6min	98.25±0.5	96±0
	6.5min	99±0	99±0
	7min	99±0	
	At intubation	98.17±0.91	98.9 ± 0.94
	1 minute after intubation	98.8±0.71	98.45 ± 1.09

In conclusion, both halothane and sevoflurane produce acceptable induction and intubation in majority of the patients. Induction and intubation are faster with sevoflurane compared to halothane. Haemodynamic stability during induction and intubation is better with sevoflurane compared to halothane. This makes sevoflurane a better alternative to halothane for induction of anaesthesia in children.

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ANNEXURE- 1

PROFORMA

A COMPARATIVE STUDY OF HALOTHANE VERSUS SEVOFLURANE FOR INDUCTION OF ANAESTHESIA AND TRACHEAL INTUBATION IN CHILDREN

Investigator: Dr. Sinam Hemona Devi **Guide: Dr. Somasekharam P**

Name: IP No :

Age: Diagnosis:

Sex: Surgery :

Weight: Group I / Group II

(halothane) / (sevoflurane)

Pre-anaesthetic evalution

History:

General physical examination:

Heart rate / Pulse rate:

Cardiovascular system:

Respiratory system:

Oral cavity:

Airway assessment:

Investigations:

Hb% -

BT -

CT -

Urine

Albumin -

Sugar -

Microscopy -

Case accepted under ASA grade _____ physical status.

Premedication: Atropine 0.03mg/Kg intramuscularly and Midazolam 0.1mg/kg intramuscularly 45mins before induction

Baseline :

HR: BP: SpO_2:

Circuit : Jackson Ree's modification of Ayre's T piece

Induction and Intubation time:

1) Time of starting halothane/ sevoflurane :

2) Loss of eye lash reflex (induction time) :

3) Loss of conjugate eye movements/centrally placed mid dilated pupils (intubation time) :

Haemodynamic parameters during induction:

Time	HR	BP	MAP	SpO_2

Haemodynamic parameters after intubation:

Time	HR	BP	MAP	SpO_2
At intubation				
1 min				

Intubation characteristics score:

	Scores			
Characteristic	**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 movement	none	slight	moderate	severe

ANNEXURE- 2

KEY TO MASTERCHART

m - Male

f – Female

Intubation characteristics:

Laryngoscopy – 1 -easy, 2 - fair, 3 - difficult, 4 - impossible

Vocal cords – 1 - open, 2 - moving, 3 - closing, 4 - closed

Coughing – 1 -none, 2 - slight, 3 - moderate, 4 - severe

Jaw relaxation – 1 - complete, 2 - slight, 3 - stiff, 4 - rigid

Limb movement – 1 -none, 2 - slight, 3 - moderate, 4 – severe

bpm - beats per minute

Pint - immediate post intubation

1min pint -1 minute post intubation

GROUP H

Sl.no	Name	Age(yrs)	Sex	Ip. no.	ASA Grade	Diagnosis	Procedure	Induction time(secs)	Intubation time(secs)	INTUBATION CHARACTERISTICS				
										laryngoscopy	vocal cords	coughing	jaw relaxation	limb movement
1	Trishati	6	f	609328	I	cystic hygroma	excision	120	390	1	1	1	1	1
2	Girish	5	m	620385	I	cong.hydrocele	herniotomy	165	345	1	1	1	1	1
3	Chaitanya	1.5	f	516150	I	cleft palate	palatoplasty	150	240	1	1	1	1	1
4	Hajira	5	f	606034	II	adenotonsillitis	tonsillectomy	180	360	1	2	1	1	1
5	Md.Suhel	5	m	634607	I	undescended testis	orchidopexy	180	315	1	1	1	1	1
6	Babu	2	m	544231	I	burns hand	release	110	270	1	1	3	1	1
7	Preetham	1.5	m	472877	I	ing.hernia	herniotomy	135	240	1	1	1	1	1
8	Munendra	5	m	635100	I	fb cricopharynx	removal	180	420	1	1	1	1	2
9	Kumar	3	m	591637	I	hydrocele	herniotomy	75	255	1	2	1	1	1
10	Akram	5	m	595363	I	hirschsprung ds	laparotomy pull-through	120	300	1	1	1	2	1
11	Gangadhar	5	m	579043	I	ing.hernia	herniotomy	105	285	1	1	1	1	1
12	Chandu	5	m	590415	II	adenotonsillitis	tonsillectomy	55	195	1	3	1	1	1
13	Akhila	3	f	672395	I	rectal polyp	polypectomy	90	210	1	1	3	1	1
14	Abbas	4	m	676290	I	laceration soft palate	suturing	180	330	1	1	1	1	1
15	Shravan K	3	m	599334	I	hypospadias	reconstruction	50	225	1	1	1	1	1
16	Reehan	4	m	636557	I	fb oesophagus	oesophagoscopy	120	345	1	3	1	2	1
17	Rubina	3	f	671773	I	congenital hydro	herniotomy	75	300	1	1	1	1	2
18	Abhi	5	m	691664	I	lt.inguinal hernia	herniotomy	60	150	1	1	2	1	1
19	Swathi	3	f	688219	I	f.b.left nostril	removal	60	165	1	1	1	1	1
20	Bharath	3	m	690416	II	f.b cricopharynx	rigid oesophagoscopy	40	180	1	1	1	1	1
21	Karthik	4	m	712378	I	corneal tear with iris prolaps	repair	45	180	1	2	2	1	1
22	Madhan	4	m	668866	I	phimosis	circumcision	135	270	1	1	1	1	1
23	Syed faizaan	4	m	716329	I	appendicitis	appendicectomy	60	180	1	1	1	2	1
24	Gnanesh	2	m	717197	I	lipoma chest	excision	45	120	1	1	1	1	1
25	Uday	2	m	630816	I	micropenis hypospadias	repair	135	240	1	1	1	1	1
26	Dhanlakshmi	3	f	712343	II	cellulitis leg	debridement	40	90	1	1	1	1	1
27	Pavan	3	m	644048	I	tonsillitis	tonsillectomy	45	165	1	1	1	1	1
28	Maya	4	f	668876	I	fb ear	removal	105	240	1	2	1	1	1
29	Divya	5	f	678845	I	lipoma back	excision	50	150	1	1	1	1	1
30	Niraj	3	m	712388	I	lip laceration	suturing	40	105	1	1	2	1	1

GROUP H

HAEMODYNAMIC PARAMETERS DURING INDUCTION AND INTUBATION

	Heart rate(bpm)																	Mean Arterial Pressure(mmHg)															SpO2(%)														
sl.no	basal	0.5min	1min	1.5min	2 min	2.5min	3min	3.5min	4min	4.5min	5min	5.5min	6min	6.5min	7min	p.int	1minp.int	basal	0.5min	1min	1.5min	2min	2.5min	3min	3.5min	4min	4.5min	5min	5.5min	6min	6.5min	7min	p.int	1minp.int	basal	0.5min	1min	1.5min	2min	2.5min	3min	3.5min	4min	4.5min	5min	5.5min	6min	6.5min	7min	pint	1minpint
1	160	155	154	150	148	147	146	145	145	142	142	141	140	140		140	145	78	76	76	75	74	73	73	72	72	71	72	72	70	70		70	75	100	99	98	98	98	97	97	96	98	98	98	98	98	99		99	99
2	136	134	130	125	124	122	124	125	128	128	130	132	130			130	138	78	77	76	74	73	70	68	66	65	64	64	62	62			62	64	99	99	99	98	97	99	98	99	99	98	98	97	98			97	98
3	144	142	142	140	136	134	130	128	126							126	134	74	73	72	70	69	68	67	66	66							66	63	99	100	99	98	98	99	100	100	100							100	98
4	154	153	150	151	149	147	147	145	144	145	140	136	134			134	140	88	87	86	86	85	84	83	84	83	83	82	81	81			81	87	100	99	99	98	99	98	97	98	99	98	99	99	99			99	100
5	120	118	118	116	117	114	110	109	105	104	103	102				102	108	68	68	67	67	65	63	63	61	59	58	57	57				57	82	98	97	97	98	98	98	97	97	98	99	99	98				98	99
6	146	145	143	140	138	137	134	132	131	130						130	136	110	109	108	106	106	104	103	101	101	100						100	104	99	99	100	99	98	99	98	98	99	99						99	98
7	96	120	118	116	114	114	118	125	136							136	140	72	71	71	70	69	66	65	63	62							62	58	98	99	99	98	100	99	98	99	100							98	99
8	146	148	148	150	146	144	144	140	140	136	136	134	130	128	125	125	136	100	99	98	97	97	96	94	92	91	91	90	89	89	88	88	88	93	97	98	97	98	98	98	98	99	99	100	100	100	98	99	99	99	98
9	170	167	167	160	156	154	150	150	145	140						140	160	80	80	79	78	78	76	74	75	74	74						74	78	97	98	98	99	99	87	98	98	99	99						97	99
10	150	154	154	153	150	148	146	146	140	136	130					130	145	72	72	71	70	70	68	67	66	64	63	63					63	65	100	99	98	98	99	97	99	98	99	99	99					99	100
11	132	128	127	126	123	120	118	117	110	105	102					102	124	79	79	78	79	76	75	74	74	72	71	70					70	79	100	99	100	100	99	98	99	99	98	98	98					98	100
12	130	128	126	126	124	122	120	120	118							118	130	100	98	98	94	92	86	82	76	71							71	88	100	100	99	99	98	99	98	99	98							97	99
13	144	142	140	140	139	135	132	130								130	145	97	94	88	86	74	68	64	62								71	69	99	100	100	99	99	97	98	97								98	99
14	138	136	136	136	133	132	130	130	129	128	129	130				130	147	70	68	66	65	64	63	63	62	61	60	58	58				58	64	99	99	98	99	99	98	98	98	99	99	99	98				98	98
15	184	185	183	176	174	172	172	162	160							160	170	88	87	86	84	83	81	80	78	78							78	84	98	99	98	98	99	100	100	99	99							99	100
16	170	168	148	146	140	140	138	137	133	132	130	128				128	136	116	114	113	110	106	105	102	100	99	98	98	96				96	105	97	98	99	98	99	98	98	99	99	98	99	99				99	100
17	160	159	168	168	148	147	151	151	152	154	156					156	151	58	58	57	56	55	54	53	50	48	47	46					46	54	98	99	99	98	98	99	100	100	99	100	100					99	98
18	183	180	160	148	146	143										143	150	86	80	76	64	50	47										47	42	98	99	98	99	99	99										97	99
19	151	149	145	143	136	130										130	126	95	90	82	74	70	63										63	71	99	100	100	99	99	98										96	99
20	150	151	146	145	140	140	139									139	147	72	70	68	66	60	58	56									56	66	99	98	99	98	99	98	99									99	99
21	156	155	154	150	146	140	136									136	150	74	72	70	69	67	66	64									64	67	96	98	98	99	97	99	99									98	98
22	164	156	156	154	146	134	130	126	124	126						126	135	80	78	78	76	72	71	72	70	70	70						70	78	98	99	98	100	99	99	98	100	100	100						97	99
23	118	117	116	116	114	112	110									110	112	94	88	80	74	63	58	57									57	52	99	100	100	99	99	98	100	99	99							97	99
24	149	151	146	144	141											141	139	103	100	98	96	95											95	93	99	99	98	99	97	99	97									98	99
25	153	151	149	149	147	145	143	143	141							141	147	100	99	98	96	95	93	92	91	90							90	92	100	99	100	100	99	100	98	99	100	100	99					99	98
26	140	138	134	132												132	135	86	72	64	62												62	66	100	99	98	99	99	98										98	98
27	151	148	143	143	139	136										139	145	84	80	78	77	76	74										74	72	100	99	100	100	99	98	100	99								98	98
28	164	156	150	152	147	140	138	130	126							126	135	103	100	99	96	95	93	92	92	92							92	90	99	99	99	98	100	100	99	99	98	99	98					98	99
29	149	143	140	136	137	139										139	143	84	76	62	60	56	48										48	42	99	98	99	99	99	99	99	99								99	99
30	140	112	118	120												120	136	100	98	96	96												96	98	99	99	98	99	99	98										98	98

GROUP S

Sl.no	Name	Age(yrs)	Sex	Ip no.	ASA Grade	Diagnosis	Procedure	Induction time(secs)	Intubation time(secs)	INTUBATION CHARACTERISTICS				
										laryngoscopy	vocal cords	coughing	jaw relaxation	limb movement
1	Kavya	3	f	601446	I	rectal polyp	eua	60	330	1	1	1	1	1
2	Kushan	2	m	671156	II	branchial cyst	excision	105	210	1	2	1	1	2
3	Chandrika	3	f	591618	I	ulcer foot	ssg	50	260	1	1	2	1	1
4	Sharifa	3	f	629056	I	m.contagiosum	excision	60	195	1	1	1	2	1
5	Vinay	4	m	618617	II	cellulitis	ssg	55	180	1	2	1	1	2
6	Ashok Kumar	2	m	641356	I	granulation eac	exam	50	340	1	1	1	1	1
7	Babu	5	m	601539	II	chr.synovitis	arthroscopy	30	150	1	1	1	1	1
8	Vinay	1.5	m	618617	I	cellulitis	debridement	40	105	1	3	1	1	1
9	Rohan	3	m	591284	I	hypospadias	repair	45	60	1	1	2	1	1
10	Chandan	4	m	607142	I	rectal prolapse	theirsch	120	300	1	1	2	1	2
11	Sindhushree	5	f	641719	I	umbilical granulom	excision	45	180	1	2	1	1	1
12	Chetanya	1	f	630193	I	dog bite eye	debridement	60	210	1	1	1	2	1
13	Priyanka	3	f	644839	I	suboccipital lesion	excision	120	315	1	1	1	1	1
14	Sujan	5	m	650596	I	cong.hydrocele	repair	40	160	1	2	1	1	1
15	Riyaz	4	m	653732	I	cong.hernia	herniotomy	45	240	1	1	2	1	1
16	Ashok	2	m	650651	I	ear irritation	exam	45	135	1	1	1	1	1
17	Priyamani	3	f	647144	II	cleft palate	repair	50	80	1	1	1	1	2
18	Harish	4	m	591832	I	post burn contract	release	60	180	1	1	1	2	1
19	Swati	3	f	650659	I	ectopic ureteric op	implantation	50	100	1	2	1	1	1
20	Kavya	1	f	650269	I	gangrene	debridement	45	90	1	1	2	1	1
21	Tejas	3	m	642230	I	hypospadias	repair	60	210	1	3	1	2	1
22	Uday	2	m	630816	I	hypospadias	repair	45	240	1	1	1	1	2
23	Lokesh reddy	5	m	676918	I	hydrocele	herniotomy	45	100	1	2	1	1	1
24	Vinay kumar	4	m	673348	II	adenotonsillitis	adenotonsillectomy	50	60	1	1	1	1	1
25	b/o Asha	1	f	673354	I	gangrene	debridement	45	120	1	1	2	1	1
26	Sagar	4	m	671773	I	hydrocele	herniotomy	110	390	1	3	1	2	2
27	Abhi Gowda	5	m	689690	I	phimosis	circumcision	50	105	1	1	1	1	1
28	Sawan Kumar	5	m	690426	I	snake bite cellulitis	debridement	50	150	1	1	1	1	1
29	Prasanna Kumar	3	m	689882	II	chronic adenotonsillitis	tonsillectomy	60	180	1	1	2	1	1
30	Reddy Prasanna	2	m	703070	I	snake bite cellulitis	debridement	45	130	1	2	1	1	1

GROUP S

HAEMODYNAMIC PARAMETERS DURING INDUCTION AND INTUBATION

	Heart Rate(bpm)																	Mean Arterial Pressure(mmHg)															SpO2(%)														
sl.no.	basal	0.5min	1min	1.5min	2min	2.5min	3min	3.5min	4min	4.5min	5min	5.5min	6min	6.5min	7min	p.int	1minp.int	basal	0.5min	1min	1.5min	2min	2.5min	3min	3.5min	4min	4.5min	5min	5.5min	6min	6.5min	7min	p.int	1minp.int	basal	0.5min	1min	1.5min	2min	2.5min	3min	3.5min	4min	4.5min	5min	5.5min	6min	6.5min	7min	pint	1minpint
1	130	120	120	118	130	131	132	132	131	134	136	136				136	132	85	85	83	82	78	72	69	66	65	61	58	56				56	67	100	98	98	96	98	100	99	99	98	99	98	100				100	100
2	163	164	165	165	166	168	170	172								172	170	95	94	93	90	85	83	110	126								100	89	98	97	99	99	98	98	99	98								98	99
3	120	123	124	125	125	130	133	132	137	140						140	143	75	74	73	70	69	77	75	73	72	72						66	95	96	97	98	98	96	97	99	98	97	98						98	96
4	184	150	148	140	135	132	131	171								171	162	96	94	88	75	63	57	58	60								60	62	99	100	99	99	98	100	100	100								100	100
5	154	156	164	165	163	161	157									156	146	81	81	79	75	81	83	86									86	84	98	99	100	100	98	99	99									99	98
6	130	123	121	124	124	127	128	127	128	129	129	130				130	132	96	94	92	88	86	84	80	76	74	66	62	60				60	62	100	99	100	100	98	99	99	98	99	99	100	100				100	99
7	137	137	139	139	110	108										108	117	94	93	93	92	90	90										90	92	100	99	100	99	99	100										100	99
8	112	110	108	99	94											94	132	106	105	100	102	93											93	102	97	97	97	98	98											98	99
9	151	136	138													138	147	70	68	66													64	67	96	98	96													96	98
10	130	132	132	128	126	123	128	129	132	133	134					134	148	75	74	70	69	73	75	77	77	75	73	72					67	93	98	99	98	99	100	100	98	99	99	98	99					99	97
11	163	163	164	165	167	169	170									170	168	74	73	73	72	71	71	70									70	74	98	100	99	99	98	98	99									99	99
12	143	143	130	131	133	135	136	140								140	145	69	69	68	67	66	65	64	64								64	65	100	99	100	100	99	98	99	100								100	97
13	123	126	130	131	133	134	136	136	138	143	150	153				153	160	110	110	108	107	106	104	102	100	100	102	103	100				100	101	98	99	100	100	99	98	99	99	98	98	99	99				99	100
14	158	136	137	145	152	156										156	147	102	101	100	98	97	97										97	100	99	99	98	98	98	99										99	98
15	105	178	176	174	170	174	176	176	178							178	180	69	69	68	67	67	68	67	66	64							64	65	99	98	99	99	98	98	99	97	98							98	97
16	110	109	107	103	100	95										95	130	67	66	65	63	62	61										61	58	98	99	99	98	99	98										98	98
17	148	154	173	182												182	175	73	72	70	67												67	72	97	98	98	98										98	99
18	146	150	151	152	153	153	154									154	156	88	86	85	83	83	84	81									81	84	98	99	97	98	100	98	99	100								100	98
19	150	153	155	156	161	163	164	166								166	170	105	105	104	103	102	101	100	100								92	100	100	99	100	99	99	100	100	99	99							99	99
20	110	112	116	119	120											120	136	96	95	95	94	93	92	90	90								90	94	99	98	98	99	98	99	99	98	99							99	98
21	125	126	129	130	129	129	130	130								130	145	74	73	72	72	70											70	74	97	98	97	98	98											98	99
22	153	160	164	165	167	165	163	153	153							153	145	63	62	61	61	60	60	58	58	58							58	59	99	99	100	97	98	98	99	100	99							99	99
23	130	131	127	126												130	132	80	80	78	77												77	79	100	100	99	99												99	97
24	110	109	105	100	95											95	130	80	78	76	75	75											75	77	100	99	100	99	99											99	98
25	135	100	115	120	132											116	100	69	69	68	66	64											64	67	100	100	99	100	99											99	100
26	130	131	127	126	124	124	125	124	126	127	128	129	130	130		130	132	98	98	97	97	96	95	94	94	95	93	93	92	91	91		91	94	99	98	98	98	96	97	98	99	99	98	99	100	96	99		99	100
27	136	130	124	116	110											110	120	87	87	84	82	77											77	81	100	100	99	99	100											100	98
28	157	158	130	131	131	133										133	168	63	63	62	61	60	60										60	64	100	99	98	98	99	100										100	99
29	130	132	132	136	143	146	150									150	160	65	63	61	60	54	50	50									50	58	99	99	98	99	99	99	98									98	97
30	115	113	110	96	94											94	134	89	88	86	84	82											82	71	97	98	98	98	99											99	98