

# Inhalation Induction Using Sevoflurane in Children, The Single Breath Vital Capacity Technique Compared to Tidal Volume Technique

Bandrapalli Emeema<sup>1</sup>, Kunda Mary Uma Manjula<sup>2</sup>

## ABSTRACT

**Introduction:** The low solubility as well as the absence of pungency facilitates rapid induction by facemask, making sevoflurane the anesthetic of first choice for inhalational induction in children. The aim of our study was to compare the efficacy and tolerance and to compare the induction characteristics of sevoflurane by vital capacity and tidal volume techniques.

**Material and methods:** Our study included 30 patients each in both group's i.e. single breath vital (VC) capacity and tidal volume groups (TV). The mean age in VC group was 8.76 years and in TV group was 8.86 years. We mainly compared the Induction time, hemodynamic changes and adverse events in both the techniques using sevoflurane.

**Results:** The heart rate, systolic blood pressure, diastolic blood pressure and the mean arterial pressure were compared between both the groups. All these parameters were taken before induction, after loss of eyelash reflex and up to 10 minutes at 2 minute intervals. There were minimal changes between the two groups but clinically, they are not statistically significant in view of mean blood pressure whereas we observed statistically significant difference in heart rate at 8minutes in the post induction period which resolved later. In our study, we observed an increased incidence of cough and involuntary movements in T V. group compared to V C group but statistically, there is no significant difference.

**Conclusion:** Sevoflurane Induction improved the speed of induction when compared to tidal volume technique and reduced the incidence of induction complications

**Keywords:** Inhalation Induction, Sevoflurane in Children, Single Breath Vital Capacity Technique, Tidal Volume Technique

salivation and even laryngospasm. Sevoflurane is an inhalation anesthetic agent with a lower solubility<sup>3</sup> in blood than other substances like isoflurane or halothane. sevoflurane produced the least change in respiratory pattern, the least cough (none), and the least subjective airway irritation. The single vital capacity breath (VCB) technique improved the speed of induction when compared with gradually increasing the inspired concentration of the anesthetic gas during tidal volume breathing and reduced the incidence of induction complications, such as coughing, movement, and laryngo spasm. The ideal agent for this technique should meet the following requirements. It should be non pungent, non irritant odour and should have low solubility. It should also produce smooth rapid induction, with no additional side effects. Sevoflurane is a compound with a low blood/gas partition coefficient of 0.69, with a fast onset of action and early recovery after anesthesia. Haemodynamic variables including heart rate are stable even if concentrations of sevoflurane as high as 8% are used. The low solubility as well as the absence of pungency facilitates rapid induction by facemask, making sevoflurane the anesthetic of first choice for inhalational induction in children. The sevoflurane was very well tolerated, as indicated by high haemodynamic stability. The incidence of airway-related induction side effects with sevoflurane was low, even with the use of 8% with vital capacity induction [VCI] making it as an ideal agent for this technique. Doi and kazuyuki<sup>4</sup> reported in 1993 that sevoflurane was the least irritant of four inhalational anesthetic agents when administered to adult male volunteers using tidal breathing of standardized inhaled concentrations. Hall JE et al<sup>5</sup> concluded that Induction with sevoflurane carried in nitrous oxide and oxygen was quicker than in oxygen alone when a vital capacity technique was used. With this background, we tried to evaluate the efficacy of single breath vital capacity induction with 8% sevoflurane by observing the induction time. We are also comparing this

## INTRODUCTION

Volatile anaesthetics are very important in pediatric anaesthesia, although intravenous anaesthetic methods are also used. The advantages of mask induction of anaesthesia over intravenous induction were avoidance of apnea, anaphylaxis, hypotension, hangover effect. The aim of induction is to render the patient unconscious as rapidly as possible. Sevoflurane is more suitable than Isoflurane for single- breath induction; because it produces a smoother induction with a lower incidence of complications and better patient acceptance.<sup>1</sup> sevoflurane is the least irritant of all inhalation anesthetic agents when administered to adult male volunteers using tidal breathing of standardized inhaled concentrations. Single breath induction was first introduced by Bourne.<sup>2</sup> Induction of anesthesia with inhalation agents may be limited by the effects of anesthetic vapor on the patient's airway, in particular irritation resulting in coughing, excessive

<sup>1</sup>Assistant Professor, Department of Anaesthesiology, <sup>2</sup>Assistant Professor, Department of Anaesthesiology, Government Medical College, Ongole, Andhra Pradesh, India

**Corresponding author:** Kunda Mary Uma Manjula, c/o B. Elizabeth, D. No.4-8-172, Near Rama Buildings, Amaravathi Road, Arundhati Nagar, Guntur

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technique with incremental rise in concentration i.e. tidal volume method. We further tried to evaluate and compare the haemodynamic changes and adverse events associated with these techniques.

The aim of our study was to compare the efficacy and tolerance between single breath vital capacity method with 8% sevoflurane and tidal volume method with incremental increase of concentration. Study objectives were to compare the induction characteristics of the single breath vital capacity induction using 8% sevoflurane to the standard gradual incremental increase in concentration called the tidal volume method, to compare the hemodynamic effects with the two methods and to see if this method of induction causes any untoward effects in children and to compare with tidal volume method.

## MATERIAL AND METHODS

The present study was designed to compare the efficacy and tolerance between the two induction techniques i.e. single breath vital capacity method and tidal volume method using sevoflurane in oxygen in pediatric age group. Studies were performed after approval of our institutional review board and after obtaining written, informed consent from parents. Our study included patients, 30 each in both groups i.e. single breath vital capacity (VC Group) and tidal volume (TV Group).

**Inclusion criteria:** Sixty children aged between 7-12 years of either sex who comes under ASA I and II were chosen for the study. At PAC clinic, routine pre anesthetic checkup of all the patients was done to assess ASA grading to exclude coexisting medical conditions and to assess the airway to detect possible difficult airway who were posted in elective surgery list in paediatric theatre.

**Exclusion criteria:** Included patients with history of asthma, eczema, allergic rhinitis, acute respiratory infections, allergic reactions to drugs and bad anesthetic history, patients with major cardiovascular, pulmonary, hepatic, renal haematological or metabolic diseases or those who are mentally retarded, gastroesophageal reflux, myopathy or familial history of malignant hyperthermia, epilepsy, neurological disease, were not included in the study. Routine investigations like complete blood picture, blood grouping, RH typing, clotting time and bleeding time were done. Patients had anesthesia assigned by one of the two methods as assigned by means of table of random numbers. vital capacity method [GR VC] or tidal volume method.[GR TV] During the pre-operative anaesthetic visit at PAC clinic at least 48 h prior to surgery, children were instructed in the vital capacity technique in a playful manner to blow out birthday candles and then to inflate the lung and stop to breathing for as long as possible as if you had to dive into a swimming-pool. Instructions were repeated until the child had mastered the three steps of the technique, to avoid stressing the child. Immediately following the arrival of the child in the anaesthetic room, the children were asked to verify whether they remembered the three steps of the vital capacity

technique. Standard pre operative preparation consisted of N.P.O. status [overnight fasting for solid food], patient was given milk before 5am (minimum of 5 hours before procedure) on the day of surgery if desired and an IV line was secured before shifting the patient to the operation theatre.

## EQUIPMENT

The Boyles Anesthesia machine, sevoflurane vaporizer, breathing system, with appropriate sized mask, and endotracheal tubes, a working laryngoscope, a working suction apparatus and instruments are kept ready before the procedure started.

### Drug trolley consists of

Emergency drugs [dopamine, adrenaline,  $\text{NaHCO}_3$ ], atropine Glycopyrrolate ampoule Midazolam vial Intravenous cannula with isolyte p drip Paracetamol suppository.

**Premedication:** Inj Glycopyrrolate 0.01mg/kg, inj. midazolam 0.1mg/kg was given intramuscularly at least 20 minutes before induction.

### Technique of anesthesia

After confirming the N.P.O status, the patient was shifted to operating room and transferred onto operating table. An iv line was connected to an isolyte p drip. A blood pressure cuff of appropriate size was tied to left upper arm and connected to non invasive multiparameter monitor. pulse oximeter probe was connected to a finger. After the child calms down from the fear and anxiety of the surroundings, the procedure was started.

### Techniques of induction

Patients are breathing room air before induction of anesthesia. In vital capacity group induction was performed after priming the circuit with 8% sevoflurane in 100% oxygen. Before gently applying the mask, the patients in vital capacity group were instructed to breath out to a residual volume and take a vital capacity breath and hold their breath as long as possible and take regular breaths until unconscious. A successful vital capacity breath was defined as a complete expiration followed by a complete inspiration and an immediate period of apnoea with inflated lungs. Apnoea was defined as breath holding lasting at least for 10s. Patients in tidal volume group were instructed to maintain regular breathing even after application of mask, sevoflurane begun at 1% and increasing the concentration with increments of 1% every 3 breaths until unconscious. Immediately after loss of eye lash reflex, induction time, blood pressure and heart rate were noted and continued upto 10 min for every 2 min intervals. Induction time is defined as time interval between the applications of mask to the point of loss of eyelash reflex. End tidal sevoflurane analyzer was not available in our study. Therefore concentrations refer to delivered concentrations of sevoflurane as indicated in the vaporizer dial setting. The study was concluded, and the anesthetic technique was converted to any technique of attending anesthesiologist's choice. No attempt was made to analyze later factors such as time to awakening. Adverse

events such as cough, laryngospasm, bronchospasm, breathholding, involuntary movements, excessive salivation if any were observed. Results were analyzed using student's T test. P value <0.05 was considered to be significant.

**RESULTS**

The present randomized comparative study was designed to compare the efficacy and tolerance between the two induction techniques i.e. single breath vital capacity method and tidal volume method using sevoflurane. Studies are performed after approval of our institutional review board and after obtaining written, informed consent from parents. Pediatric patients scheduled for elective ambulatory surgery under general anesthesia were selected, whose age ranged between 7-12 years belonging to ASA grade I and II of either sex. our study included 30 patients in each group. The results and analysis of our study were presented below. They were analyzed using students T-test. P value <0.05 is considered to be significant. The parameters we studied were Induction time, hemodynamic changes and adverse events.

**Demographic Data**

**Age:** Each group ranged from 7-12 years with a mean age of 8.76 years and S.D 1.94 in VC group and mean age of 8.86 years and S.D 1.77 in TV group. Both groups were comparable

**Sex:** Our study included 22 males and 8 females each in both groups.

**Weight:** Weight of the patients in VC group ranged from 15-25 with a mean weight of 18.8 Kgs with S.D 3.078. and in TV group, weight of the patients ranged between 16-24 Kgs with a meanweight of 19.5 Kgs and S.D 2.63. Both groups were comparable in as per demographic data.

**SURGICAL PROCEDURES**

All the above procedures were short surgical procedures of varying duration. 46% of patients in vital capacity group were posted for herniotomy while 43% patients in tidal volume group. Other procedures were circumcision, high ligation of sac, I and D, urethral calibration, debridement, secondary suturing and lymphnode biopsy.

**Induction time**

**Induction Time:** Induction Time is the time interval between the point of application of mask to the point of Loss of eye lash reflex. The mean Induction in Vital capacity group was 37.36 sec SD 4.845. Mean Induction in Tidal Volume group was 65.66 Sec, SD 4.49. The ranges were 28-42 sec and 58-72 sec in groups VC and TV respectively. The table shows that there was clinically significant difference in induction time between groups VC and group TV. P Value is 0.001 which is highly significant.

**Comparison of Mean Pulse Rate between Group Vital capacity and Group Tidal Volume in mm hg**

**Heart rate** Heart rate was noted before induction, on loss of eyelash reflex and post induction from 2 minutes to 10 Min at 2 Minute intervals in both groups and standard deviation was calculated and depicted in the table 1. In both groups that is Vital capacity group and Tidal Volume group, we observed a rise in heart rate following induction. During pre induction period, the mean value of the heart rate was 111.03 beats / min (bpm) and SD is 6.50 in vital capacity group. In tidal volume group, the mean values are 110.53 and SD 6.6 before induction.

Baseline values of both the groups were comparable. Following induction, heart rate increased from 111.03[baseline] SD (6.5) to 118.10 SD(7.24) beats/minute in vital capacity group After 2 Min of Induction in group VC, the heart rate was 120.2 bpm SD(7.13) and at 4 Mints

Heart rate	Group I Vital capacity		Group II Tidal Volume		t- Value	SD	P-Value
	Mean	SD	Mean	SD			
Before induction	111.03	6.5	110.53	6.6	-0.586	6.61	0.95
On loss of eyelash reflex.	118.1	7.24	117.6	6.009	0.488	6.62	0.63
Post ind 2 Min	120.2	7.13	117.53	6.09	1.55	6.66	0.13
4 Min	121.13	7.16	119.76	6.3	0.784	6.75	0.44
6 Min	117.33	6.9	119.03	6.85	-0.92	6.88	0.36
8 Min	113.16	6.78	117.43	6.44	-2.45	6.64	0.01*
10 Min	111.03	6.24	116	6.25	-3.08	6.25	0.0032*

\* P Value Significant.

**Table-1:** Mean pulse rate

Group	Apnoea	Cough	Laryngospasm	Bronchospasm	Secretions	Involuntary Movements	Seizures
Gr VC	0	1	0	0	0	2	0
%		3.33%				6.66%	
Gr TV	1	4	0	0	0	5	0
%	3.33%	13.30%				16.66%	
P value	0.3215 not significant	0.1666 not significant				0.2347 not significant	

**Table-2:** Comparison of adverse events

it raised to 121.13 bpm SD(7.16) and slowly decreased to 117.33 bpm, SD(6.9) 113.76 bpm SD(6.78) and 111.03 bpm SD(6.24) at 6, 8 and 10 mins respectively. In TV group, heart rate increased from 110.53 SD (6.6)[baseline] to 117.6 beats/min SD (6.00) following induction. After 2 minutes of induction in tidal volume group, the mean pulse rate noted was 117 bpm SD 6.09, it increased to 119.76 bpm SD 6.3 at 4 mins and remained so at 6 mins and slowly decreased to 117 bpm SD 6.4 and 116 bpm at the end of 8 and 10 mins respectively. The heart rates in both the groups increased up to 4 minutes after induction, but upto 6 mins the difference is statistically not significant and became significant only after 8 mins, the P value is considered to be significant.

#### Comparison of systolic arterial pressure between vital capacity group and tidal volume

In vital capacity group, the base line mean systolic arterial pressure was 99.6 mm of Hg (SD 4.14) before induction. It decreased to 99.4 mm Hg (SD 4.49) following induction., the mean systolic arterial pressure at 2 Minutes was 99 mmHg (SD 4.38) and increased to 100.4 mmHg (SD 4.18) and slowly decreased to 99.26 mmHg (SD 4.01) at 6 Min and further decreased to 98.26 mmHg (SD 3.62) and 97.06 mmHg (SD 2.21) at 8 Minutes and 10 Minutes respectively. In Tidal Volume, Mean systolic arterial pressure was 100.53 mmHg before induction (SD 5.11) and it decreased to 99.46 mmHg (SD 6.58) immediately after induction. Following induction at 2 minutes it was observed as 100.13 mmHg (SD 6.38) and it decreased to 99.86 (SD 5.79) at 4 Minutes and gradually decreased to 98.73 mmHg (SD 5.23), 98.13 mmHg (SD 4.89) and 98.2 mmHg (SD 4.96) at 6, 8 and 10 Minutes respectively. Both the groups were comparable with regards to hemodynamic variables. The difference is statistically not significant with p value greater than 0.05.

#### Group

The table 2 depicts that no patients developed Apnoea in VC group, one out of 30 patients had Apnoea in TV group, apnoea resolved spontaneously. One out of 30 patients developed cough in VC group and 4 out of 30 patients developed from cough in group TV. Both groups were free from laryngospasm and bronchospasm. 2 out of 30 Patients had involuntary movements in VC group and 5 out of 30 patients developed involuntary movements in TV group. None of the patients in both the groups developed seizures. The above table depicts that there is increased incidence of cough and involuntary movements in TV group. Based on the above results, adverse effects were less in vital capacity group than tidal volume group.

#### DISCUSSION

Safe and short induction and especially the full recovery after general anesthesia have become increasingly important. Previously, intravenous induction is the standard method of induction but the recent introduction of newer inhalation agents has made inhalation induction of anesthesia an attractive alternative. The sevoflurane was very well tolerated, as indicated by high haemodynamic stability. The incidence

of airway-related induction side effects with sevoflurane was low, even with the use of 8% with VCI technique making it as an ideal agent for this technique. Victor C. Baum, Terrence A. Yemen, and Lora Baum,<sup>6</sup> compared the efficacy and tolerance of pediatric inductions with immediate 8% sevoflurane in 70% nitrous oxide with either incremental sevoflurane or incremental halothane in 70% nitrous oxide in forty-six unpremeditated children. Based on results, they observed that, immediate 8% sevoflurane in 70% N<sub>2</sub>O results in a significantly faster induction. Masaki Yurino, and Hitomi kimura,<sup>7</sup> in their study of Comparison of Spontaneous Ventilation and Vital Capacity Rapid Inhalation Induction (VCR II 4.5%) with sevoflurane in a mixture of nitrous oxide and oxygen, in a

ratio of 2:1 in unpremedicated volunteers, found that the mean time required for induction of anesthesia with sevoflurane was significantly shorter with the VCR II technique (53.8 ± 9.6 s) than with the conventional inhalation technique (107.5 ± 19.1 s). In a study conducted by Wappler<sup>8</sup>, induction of anaesthesia was accomplished using an inspiratory concentration of sevoflurane 8% in a nitrous oxide and oxygen mixture. It is found 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. Matin Iarrauri R et al<sup>9</sup> in their study of comparison of methods of inhalation induction with sevoflurane in adults observed that the speed of induction was subjectively felt to be faster with vital capacity group 8% [68sec] than tidal volume group [118sec] and concluded that The vital capacity rapid inhalation group primed with sevoflurane 8% was the fastest method with no relevant side-effects. Epstein RH, Marr AT, Lessin JB<sup>10</sup> in their study of High concentration versus incremental induction of anesthesia with sevoflurane in children, reported that, the induction time can be significantly shortened in high concentration group [42sec] than incremental group [66sec]. It was against this background, the present randomized prospective study was initiated in order to evaluate the efficacy of single breath vital capacity induction method with 8% sevoflurane; further this was compared with tidal volume induction method. In addition to this, we tried to evaluate and compare the tolerance in both induction techniques by observing hemodynamic changes. 60 subjects were taken from age group of seven to twelve years of either sex who comes under ASA class I or II. Among them, thirty were included in vital capacity group and thirty in tidal volume group. Inj Glycopyrrolate 0.002mg/kg Inj. midazolam 0.1mg/kg iv were given as premedication. In vital capacity group, we primed the circuit with 8% sevoflurane in 6 ltr oxygen before gently applying the mask. VC Group were instructed to exhale completely and take a vital capacity breath and hold their breath as long as possible and take regular breaths until the patient becomes unconscious. Patients in TV Group were instructed to maintain regular breathing even after application of mask. Here, we used an unprimed circuit starting with 1% sevoflurane in 6 ltr O<sub>2</sub> and increasing the

concentration by 1% for every 3 breaths until they become unconscious. In present study, the mean induction time observed in VC group was 37 sec and in TV group it is 65 sec. In our study we found that induction time was significantly shorter in VC group than TV group with p value >0.05. The induction times we achieved in our study were very near to the studies conducted by Baum et al and Epstein et al. In present study induction time was much shorter than the induction time observed in Martin et al's who did their study in adults, while we compared in children. Who have smaller functional residual capacity when compared to adults. The vital capacity technique produced a more rapid induction of anaesthesia, as assessed by the loss of the eyelash reflex, and was also better tolerated by the children. Despite avoiding N<sub>2</sub>O, the time to loss of eyelash reflex in the vital capacity group is the shortest than that has been reported in the above studies, this may be due to the better memory associated with the single-breath vital capacity technique due to the selected age group of patients [7 to 12] and active participation in the anesthetic induction that is requested from the child, the use of midazolam premedication and the priming of the circuit with 8% sevoflurane. Despite avoiding N<sub>2</sub>O in the present study, We achieved faster induction times [37 vs 65sec] as we used 8% sevoflurane for induction. However, in the present study, Vital capacity Induction could not be achieved in single breath as the children were not able to hold their breath completely. Heart rates did not change significantly over time in group VC (approximately 66 beats/min) but did significantly in group C TV]when measured at intervals of 2 min (68 to 64beats / min). Finally they reported that sevoflurane is useful for the induction of anesthesia and can be used without premedication or supplemental agents. In a study conducted by Yurino et al, they observed significant decrease in mean systolic and diastolic pressures, which might be due to the effect of nitrous oxide. In present study baseline values of both groups VC and TV were comparable and clinically there is no statistical significant decrease in blood pressure values in both the groups, P value >0.05. We observed transient rise in heart rate in both the groups following induction which resolved over a period of time. Inhibition of parasympathetic control of heart rate by sevoflurane may be responsible for the transitory tachycardia. And also on arrival the children were anxious and this might be having some baring cause for the increase in heart rate in both the groups. However, there was a reduction in blood pressure and systemic vascular resistance compared to baseline values in both the groups. Clinically we observed no significant difference in the incidence of adverse effects between groups Vital capacity and Tidal volume, P value >0.05. Sloan et al 1 reported that several patients developed cough, laryngospasm, breath holding, airway obstruction, or prolonged Stage 2. A limitation of the above study was might be due to the unavailability of a sevoflurane vaporizer that could deliver 8% sevoflurane. Finally we have observed higher incidence of excitatory movements in group in group VC than group TV [6.6% vs. 16.66%] which is statistically not significant (P value >0.05). In our study there is no

incidence of bronchospasm or laryngospasm. Only one patient in tidal volume group developed breath holding which resolved spontaneously. While one patient from VC group developed cough, four patients developed cough in TV group. But statistically, no significant difference was found in the incidence of adverse effects in both the groups P value>0.05. Present study shows that single breath vital capacity method with 8% sevoflurane is a safe and effective technique when compared to tidal volume technique. The induction time required for single breath vital capacity method is far less when compared to tidal volume method. Haemodynamic changes observed are similar in both the groups, while the incidence of side effects like cough, involuntary movements were higher in tidal volume group.

## CONCLUSION

Each of the two techniques single breath vital capacity method and tidal volume method were found acceptable by most of the volunteers studied. single breath Vital capacity induction with 8% Sevoflurane offers several advantages over the conventional tidal volume method including a more rapid induction of anesthesia and a decreased incidence of excitatory phenomena. These features, when combined with its favorable cardiovascular profile makes single breath vital capacity induction with sevoflurane favorable in pediatric age group. We conclude that the single breath vital capacity induction technique with 8% Sevoflurane Induction improved the speed of induction when compared to tidal volume technique and reduced the incidence of induction complications, such as coughing, movement, and apnea as it provides enough overpressure to allow the subject to pass reliably and rapidly through the initial stages of excitement while maintaining the haemodynamics in pediatric age group. However it is not possible in our study to evaluate accurately and assess the single breath vital capacity induction time in early pediatric age group as they may not co operate to perform vital capacity maneuver.

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