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Comparison of Induction of Anesthesia Using High Concentration vs. Incremental Doses of Sevoflurane in Children

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Abstract

Background and aim: Three different strategies are used by anesthetists for inhalation induction with sevoflurane- Incremental Induction technique, High concentration primed-circuit technique, and Single Breath Vital Capacity technique. Although first two important techniques of induction have been used quite effectively and safely in children, yet most anesthetists prefer the incremental induction technique while ignoring the quick yet safe method of using high concentration sevoflurane. Considering this fact, we conducted this study to find out the best and safe method of induction among these two techniques.

Methods: A prospective, randomized study was conducted in Dr. RML Hospital .80 children of 2-12 years were randomly allotted into 2 groups of 40 each. Group A- High concentration primed-circuit; Group B- Incremental induction. The primary objective was to determine whether the induction time could be significantly shortened using sevoflurane with a high concentration primed-circuit method as compared to an incremental induction technique. Statistical testing was conducted with the statistical package for the social science system version SPSS 17.0.

Results: The time for induction of anesthesia could be significantly shortened using sevoflurane with a high concentration primed-circuit technique as compared to an incremental induction technique. The effect of both these techniques on hemodynamic and respiratory parameters is statistically insignificant and there is no significant difference in the change in the vital parameters with the use of high initial concentration of sevoflurane when compared to low initial concentrations.

Keywords: Sevoflurane; High concentration primed circuit; Incremental induction; Eyelash reflex; Inhalational induction; Pediatric

Introduction

Sevoflurane causes rapid induction, by virtue of low blood/gas solubility. It also lacks pungency and airway irritation [1]. Hemodynamic parameter remains stable even when high concentrations of sevoflurane, as much as 8% are used along with the advantage that it has minimal effects on the end-organs and on the cerebral blood flow [2,3]. Therefore, can be considered to be closest to an "ideal inhalational induction agent anesthetic" [4,5]. Inhalation induction is preferred in neonates, infants, and young children as they have higher Minute Ventilation to FRC ratio with a relatively higher blood flow to vessel-rich organs like (lungs and brain) contributes to a rapid rise in alveolar anesthetic concentration and speeds inhalation induction [6]. Three different strategies are used by anesthetists for inhalation induction with sevoflurane- Incremental Induction technique, High concentration primed-circuit technique, and Single Breath Vital Capacity technique [7,8].

In the Incremental induction technique, the induction is started with a low concentration of sevoflurane and is slowly increased till the patient loses consciousness. In the high concentration primed-circuit technique, the circuit is first primed with high concentration of sevoflurane and the mask is then immediately applied on the patient till he loses awareness [9]. In the Single Breath Vital Capacity technique, patient is advised to take a deep vital capacity breath immediately as the high concentration primed circuit is applied on him [10]. Comparisons between induction using tidal volume and vital capacity breathing in high sevoflurane concentration (8%) have shown that vital capacity breathing is rapid [11] and is associated with a lower incidence of involuntary movements and coughing [12].

This vital capacity breath induction is primarily limited to adults only because initiation of vital capacity breathing on demand by the anesthesia provider cannot be achieved in the pediatric population [8]. So, in children, it is convenient to use the tidal volume techniques only. Although these two important techniques of induction have been used quite effectively and safely in children, yet most anesthetists prefer the incremental induction technique while ignoring the quick yet safe method of using high concentration sevoflurane. Considering this fact, we conducted this study to find out the best and safe method of induction among these two techniques [13,14].

Materials and Methods

After obtaining ethical committee approval this prospective, randomized study was conducted in Dr. R.M.L. Hospital, New Delhi. In total, 80 children of 2-12 years having ASA I physical status scheduled to undergo elective surgery and were randomly allotted into 2 groups of 40 each. Informed consent was taken from their parents after explaining to them the details of the procedure along with any risks associated with it. Children with gastro esophageal reflux, myopathy, or familial history of malignant hyperthermia, impaired cardiac function, epilepsy, neurological disease, surgery involving oral

cavity asthma and with severe or acute respiratory illness during the previous 5 weeks were excluded from study.

Patients were randomized into two groups: (Group A- High concentration primed-circuit;

Group B- Incremental induction). Randomization was done using the sealed envelope

technique where the patients, after giving their consent, were asked to pick up one envelope from many opaque envelopes containing the group name (either Group A or Group B). In this way, it was decided as to which technique was used for which patient.

All children in both groups were pre-medicated with midazolam, 0.5 mg/kg orally, about 30 minutes before the induction of anesthesia. A parent or guardian accompanied the child into the operating room to allow the child to remain calm and cooperative for inhalation induction. Before induction, pulse oximeter, electrocardiogram and blood pressure monitors were attached. All patients were anaesthetized using an anesthesia workstation (Draeger Primus) and a vaporizer (Draeger Vapor 2000) was used to deliver sevoflurane.

In Group A- After priming the circuit with 7% sevoflurane in a 2:1 nitrous oxide oxygen mixture at a flow of 6 L for 1 minute, inhalation induction was initiated. After loss of eyelash reflex, the sevoflurane dial concentration was reduced to 4%. An IV line was secured by a resident assisting the anesthesia provider, and an optimal-sized Proseal LMA was inserted after miosis of pupils. The total duration until miosis of pupils were noted in seconds.

In Group B- The sevoflurane vaporizer dial initially was set at 1% (in a 2:1 nitrous oxide oxygen mixture) with a fresh gas flow of 6 L/min for 1 minute. The sevoflurane concentration was increased by 1% every 3 breaths. This was done until the vaporizer setting reached 7%. After loss of eyelash reflex, the sevoflurane concentration setting on the vaporizer was decreased to 4%. An IV line was secured by a resident physician assisting the anesthesia provider, following which an optimal sized LMA was 14 inserted after the miosis of pupils. The total duration until miosis of pupils was noted in seconds.

Eyelash reflex was checked every 3 seconds in each patient until it was lost. After insertion of the LMA, the concentration of sevoflurane was set so as to achieve a MAC between 1.0 to 1.2. Ventilation was assisted or controlled wherever required. Clinical parameters recorded were time to loss of eyelash reflex, time to miosis of pupils, heart rate, blood pressure, respiratory rate, SpO_2 at the time of initiation of induction and at intervals of 1 minute, 5 minutes and 10 minutes.

Airway problems (if any) like cough, stridor, laryngospasm and increased secretions, dystonic reactions. The speed of induction of anesthesia was judged clinically as the time for loss of eyelash reflex and miosis of pupils. With this drug, we were expecting adverse events like change in vitals, airway problems and dystonic reactions. Dystonic reactions were characterized as involuntary contractions in opposing flexor and extensor muscles that produced sustained and fixed abnormal postures, such as oculogyric crisis, trismus, torticollis or bizarre positions of the limbs and the trunk. Before the end of the surgical procedure, an intravenous injection of Ondansetron 0.15 mg/kg body weight to prevent nausea and vomiting. All children were then reviewed post operatively in the post-op ward and enquired whether they had nausea and vomiting. The vital parameters were also noted.

Statistical Analysis

Statistical testing was conducted with the statistical package for the social science system version SPSS 17.0. Continuous variables are presented as mean ± SD, and categorical variables are presented as absolute numbers and percentage. The comparison of normally distributed continuous variables between the groups was performed using Student's t test. For within the group comparisons, paired t test was used to see the change at different time points from Baseline. Nominal categorical data between the groups were compared using Chi-square test or Fis Resultsher's exact test as appropriate. $P<0.05$ was considered statistically significant.

Results

Both the groups were comparable in terms of demographic profile: age, sex and weight (Tables 1-3). In Group A, the mean time for the loss of eyelash reflex was 44.83 ± 6.46 seconds, whereas in Group B, the mean time for the loss of eyelash reflex was 84.15 ± 10.29 seconds.

	Group A		Group B		p Value
Sex	Frequency	%	Frequency	%	
F	15	37.50%	10	25%	
M	25	62.50%	30	75%	
Total	40	100%	40	100%	0.228

Table 1: Sex distribution.

	Group A		Group B		p Value
Age Groups	Frequency	%	Frequency	%	
<5 years	13	32.50%	14	35%	
5-8 years	20	50%	20	10%	
9-11 years	7	17.50%	6	15%	
Total	40	100%	40	100%	0.945
Mean ± SD	5.93 ± 2.55		5.81 ± 2.63		0.850

Table 2: Age distribution (in years).

	Group A (n=40)	Group B (n=40)	
	Mean ± SD	Mean ± SD	p Value
Weight (kg)	19.01 ± 7.27	18.50 ± 8.55	0.778

Table 3: Weight distribution in kilograms.

In Group A, the mean time for the miosis of pupils was 186.03 ± 15.74 seconds, whereas in Group B, the mean time for miosis of pupils was 211.82 ± 23.25 seconds. Table 4 shows the comparison of time to loss of eyelash reflex and miosis of pupils between the two groups. In both the above cases, the p value being<0.001, the data was statistically significant.

	Group A (n=40)	Group B (n=40)	
	Mean ± SD	Mean ± SD	p value
Time to loss of eyelash reflex (sec)	44.83 ± 6.46	84.15 ± 10.29	<0.001
Time to Miosis of Pupils (sec)	186.03 ± 15.74	211.84 ± 23.25	<0.001

Table 4: Time for induction of anesthesia (in seconds).

Tables 5-9 show intergroup comparison of HR, SBP, DBP, RR, SPO_2 respectively between Group A and B at the start of induction 1 min, 5 min and 10 min after the start of induction. All the parameters at different points of time during the process in the 2 groups are comparable. Also, there was no significant statistical difference in any parameter (p value>0.05).

HR	Group A (n=40)	Group B (n=40)	
	Mean ± SD Per Minute	Mean ± SD Per Minute	p value
Baseline	108.30 ± 14.93	112.10 ± 14.01	0.244
1 min	105.55 ± 21.25	109.95 ± 17.28	0.313
5 min	92.80 ± 13.14	93.54 ± 12.55	0.799
10 min	93.93 ± 10.73	94.79 ± 8.65	0.693

Table 5: Intergroup comparison of HR.

SBP	Group A (n=40)	Group B (n=40)	
	Mean ± SD Per Minute	Mean ± SD Per Minute	p value
Baseline	98.58 ± 8.26	98.73 ± 10.26	0.943
1 min	93.23 ± 10.72	94.35 ± 17.28	0.639
5 min	89.43 ± 6.46	89.10 ± 12.55	0.829
10 min	90.55 ± 5.63	90.46 ± 6.29	0.948

Table 6: Intergroup comparison of SBP.

DBP	Group A (n=40)	Group B (n=40)	
	Mean ± SD Per Minute	Mean ± SD Per Minute	p value
Baseline	56.93 ± 8.75	58.20 ± 9.59	0.536
1 min	53.13 ± 9.48	54.25 ± 10.82	0.622
5 min	49.63 ± 7.92	50.13 ± 7.32	0.770
10 min	49.50 ± 5.70	50.31 ± 5.81	0.535

Table 7: Intergroup comparison of DBP.

SpO_2	Group A (n=40)	Group B (n=40)	
	Mean ± SD Per Minute	Mean ± SD Per Minute	p value
Baseline	99.98 ± 0.16	99.95 ± 0.22	0.562
1 min	100 ± 0	100 ± 0	-
5 min	100 ± 0	99.97 ± 0.16	0.314
10 min	100 ± 0	100 ± 0	-

Table 8: Intergroup comparison of SpO_2.

RR	Group A (n=40)	Group B (n=40)	p value
	Mean ± SD Per Minute	Mean ± SD Per Minute	
Baseline	22.53 ± 3.37	23.60 ± 3.33	0.156
1 min	24.98 ± 6.44	25.28 ± 4.91	0.815
5 min	21.40 ± 4.53	20.62 ± 4.26	0.431
10 min	18.88 ± 2.38	19.13 ± 2.69	0.658

Table 9: Intergroup comparison of RR.

Table 10 shows intergroup comparison of Post-operative HR, SBP, DBP and RR between Group A and B. The parameters at different points of time during the process in the 2 groups are comparable and the difference is not statistically significant (p>0.05).

Post-Op	Group A (n=40)	Group B (n=40)	p value
	Mean ± SD	Mean ± SD	
HR (Per Min)	102.97 ± 13.26	103.25 ± 13.13	0.927
SBP (mm Hg)	96.11 ± 6.69	95.28 ± 6.03	0.567
DBP (mm Hg)	54.03 ± 6.58	53.20 ± 7.32	0.605
RR (Per Min)	21.54 ± 4.07	22.43 ± 3.50	0.309

Table 10: Intergroup comparison of Post Op parameters.

Table 11 shows the comparison of the incidence of airway problems and dystonic reactions between the two groups. Two patients in Group A and one patient in group B had significant cough. The difference is not statistically significant (p>0.05).

Adverse Reactions	No. of patients in Group A	No. of patients in Group B
Cough	2	1
Stridor	0	0
Laryngospasm	0	0
Increased Secretions	0	0
Dystonic Reactions	0	0

Table 11: Intergroup comparison of airway problems and dystonic reactions.

Discussion

Inhalational induction using sevoflurane in a mixture of nitrous oxide and oxygen without additional muscle relaxation provides sufficiently good conditions for a smooth endotracheal intubation and insertion of LMA [15].

Three different strategies are used by anesthetists for inhalation induction with sevoflurane- Incremental Induction, High concentration primed-circuit technique, and Single Breath Vital Capacity technique [7,8]. Vital capacity breath induction is primarily limited to adults only because initiation of vital capacity breathing on demand by the anesthesia provider cannot be achieved in the pediatric population [8].

Also, it has been demonstrated by Lee et al in 2013 [4] that the induction times could be significantly reduced by using a mixture of N_2O:O_2 in a ratio of 2:1 with high concentration of sevoflurane than with O_2 alone (53.6 sec vs. 63.5 sec). The incidence of excitatory movements were also found to be reduced with the use of N_2O. In our study, in Group A, the time to loss of eyelash reflex was 44.83 ± 6.46 seconds while in Group B it was 84.15 ± 10.29 seconds. The time for miosis of pupils in Group A was 186.03 ± 15.74 sec while in Group B it was 211.82 ± 23.25 sec (p<0.001). So, there was statistically significant difference between the two techniques in terms of time taken for induction. This was also within the range of times observed in other studies. Martín-Larrauri et al., [16] in 2004 compared three methods of inhalation induction with sevoflurane in adult patients. Where 125 adult patients of ASA I-II were scheduled for short elective surgical procedures (<90 min) under general anesthesia with spontaneous ventilation via a laryngeal mask airway. They found that the time to loss of eyelash reflex in the group induced with the incremental induction technique was 118 ± 6 seconds (P<0.0001). The incidence of side effects was not significant. The time taken for the loss of eyelash reflex was slightly longer than in our study. Dedhia et al., [17] while using the incremental induction technique, recorded a time to loss of eyelash reflex at 69.26 ± 27.85 sec, while centralization of pupils was achieved at 206.56 ± 29.73 sec. These results are in agreement with our study where we recorded the time to loss 51 of eyelash reflex as 84.15 ± 10.29 sec and time to centralization of pupils as 211.82 ± 23.25 sec.

The time to loss of eyelash reflex and the time to miosis of pupils were significantly reduced when we used the high concentration technique. In Group A, the time to loss of eyelash reflex was 44.83 ± 6.46 sec and time to miosis of pupils was 186.03 ± 15.74 sec. This is much shorter than the results we got for Group B and this difference is statistically significant (p<0.001).

Lejus et al. [7] in 2006, conducted a randomized trial in 73 children comparing tidal volume and vital capacity techniques of induction of anesthesia using a circuit primed with 7% sevoflurane in a N_2O:O_2 ratio of 50:50. The time to loss of eyelash reflex was 35 sec in the tidal volume group and the time to miosis of pupils was 193 sec. The results are similar to current study along with the hemodynamic stability Baum et al., [13] findings collaborated with our study, they 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. They concluded that immediate 8% sevoflurane with N_2O results in a significantly faster induction (37 sec) than with graded doses (70 sec) in children (p<0.001).

Singh et al 8 in 2014 conducted a trial on 100 pediatric patients where they compared the fixed 8% method and the incremental method. They also reported a significant decrease in the induction time using the high concentration prime-circuit technique when compared to the incremental induction technique (p<0.001).

The SBP and DBP at different points of time during the study were comparable among both the groups. Also, the decrease was not statistically significant. We observed an initial rise in the respiratory rate after 1 min from the start of induction which was followed by gradual decrease in both the groups. This is in accordance with the study conducted by Yamakage et al. [18] in 1994. The saturation of oxygen in both the groups, as measured by pulse oximetry probe, did not change significantly in any group.

Two patients coughed during induction in group A while one patient coughed in group B. However, the induction was carried on as usual. Martin-Larrauri et al. [16] and other studies [7,15] have demonstrated that there is coughing often present while using inhalational anesthesia. This can slow down the induction and interfere with the results.

No other airway problem was observed in any of the patients. Dystonic reactions were also not seen. Induction was smooth in all the patients. Post-operative complaint of nausea and vomiting was not seen in any patient because before the completion of the procedure, in all the patients, we gave injection ondansetron IV in a dose of 0.15 mg/kg body weight.

Conclusion

Thus, our study revealed that both the techniques of inhalational induction using sevoflurane (high concentration and incremental

induction) are equally effective, reliable and safe and not associated with significant hemodynamic changes or respiratory events. The high concentration technique provided early loss of consciousness and early conditions for LMA insertion, thereby making the task of induction an easier process for the anesthetist in an anxious child. This randomized control prospective study showed that the high concentration primed circuit technique with sevoflurane (8%) is a quick and safe method and is not associated with clinically significant hemodynamic response or respiratory complications. Induction using this technique offers the advantage of smooth and rapid loss of consciousness as compared to the incremental induction technique.

While comparing the results of the two techniques used in our study, we found significant difference in the induction times between the two, although the incidence of change in the hemodynamic and respiratory parameters and adverse effects was similar in both the groups. Furthermore, there was no incidence of arrhythmia in any child, and there was no episode of bradycardia requiring atropine.

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