Original Article

Evaluation of optimum time for intravenous cannulation after sevoflurane induction of anesthesia in different pediatric age groups

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Abstract

Background and Aims: The ideal time for intravenous (IV) cannulation following inhalational induction in children is debatable. The effect of age on this time has not been studied. We evaluated the optimum time for IV cannulation after sevoflurane induction of anesthesia in different pediatric age groups.

Material and Methods: A prospective interventional study based on Dixon's sequential up and down method was conducted in children of age 1–10 years. They were grouped according to their age – Group 1: 1–3 years, Group 2: >3–7 years, and Group 3: >7–10 years. Anesthesia was induced with 8% sevoflurane in 5 L of 100% oxygen. IV cannulation was attempted at 3.5 min in the first child in each group. The time for cannulation in the next child was stepped up or down by 30 s depending on positive or negative response, respectively, in the previous child. Children were recruited till a minimum of six pairs of failure–success sequence which was obtained in each group. The mean of midpoints of the failure–success sequence was calculated to obtain the time for cannulation in 50% of the children in each group.

Results: Total number of children in Groups 1, 2, and 3 were 24, 23, and 24, respectively. The mean (95% confidence level) time for IV cannulation after sevoflurane induction in Groups 1, 2, and 3 was 53.6 (40.0–67.1), 105 (62.6–147.4), and 143.6 (108.8–178.4) s, respectively. This time was significantly shorter in Group 1 compared to those in Groups 2 and 3.

Conclusion: The optimum time for IV cannulation in 50% of the children after sevoflurane induction of anesthesia was shorter in children of age 1–3 years than in older children.

Keywords: Age group, child, general anesthesia, induction of anesthesia, sevoflurane, venous cannulation

Introduction

Inhalational induction with sevoflurane is the preferred method for anesthetizing children. However, there is limited literature on ideal time for intravenous (IV) cannulation after inhalational induction. Pediatric anesthesiologists use their experience and clinical parameters such as loss of eye lash reflex, heart rate, muscle tone, and centralization of pupils to decide the cannulation time.[1] A previous study has found that the optimum time for IV cannulation after sevoflurane induction is 3.5 min in 95% of the children between 4 and 10 years.[2] We hypothesized that the time for cannulation is not uniform in pediatric population and it varies with age. Therefore, we planned a study with the primary aim to compare the optimum time for IV cannulation after sevoflurane induction in different pediatric age groups.

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Material and Methods

The study was conducted after obtaining the Institutional Ethics Committee's approval and enrollment in the Clinical Trials Registry of India (REF/2014/05/006928). After obtaining assent and parental/guardian consent, children aged 1–10 years scheduled for elective ophthalmic surgery under general anesthesia were included in this study. Those with recent respiratory tract infection (<2 weeks), seizure disorder, congenital syndrome, difficult airway, difficult IV access, American Society of Anesthesiologists Grade 3 or 4, and weight >25 kg were excluded from the study. Those fulfilling the above criteria were grouped according to their age, Group 1: 1–3 years, Group 2: >3–7 years, and Group 3: >7–10 years. No premedication or eutectic mixture of local anesthetics cream was prescribed, and the child was accompanied by one of the parents to the operating room for induction of anesthesia. On arrival to operation room, routine monitors - electrocardiography, SpO_2, and noninvasive blood pressure were attached. Drager Primus (Drager Medical) anesthesia workstation with pediatric circle circuit was used in all cases to maintain the same circuit volume. Anesthesia was induced with 8% sevoflurane dial concentration in 100% oxygen at 5 L fresh gas flow (FGF) with an appropriately sized mask. Once the eyelash reflex was lost, the dial concentration was reduced to 5% and the FGF was maintained at 5 L. These settings were maintained till IV cannula was introduced.

A tourniquet was used to make the vein prominent and an experienced anesthesiologist did all cannulation over one of the dorsum of hands with 22/24 gauge cannula. The first child in each group was cannulated 3.5 min after the loss of eyelash response. A separate observer unaware of the study recorded the response to cannulation as positive (movements, withdrawal, cough, laryngospasm, and breath holding) or negative. Dixon's up and down method was used to determine the cannulation time for the next child.[3] If there was no response to IV cannulation in the previous child in that group, cannulation time for the next child was stepped down by 30 s from the previous time. The cannulation time was stepped up by 30 s from the previous time, if there was any positive response in the previous child during IV cannulation. The study ended after IV cannulation attempt; rest of the anesthetic management was performed according to the discretion of the attending anesthesiologist.

The following parameters were recorded - age, weight, and gender of the child. Time to loss of eyelash reflex, cannulation time, age-corrected minimum alveolar concentration (MAC) at the time of IV cannulation, and response to cannulation were noted. Any need for assisted ventilation before IV cannulation was also noted.

All the collected data were analyzed by statistical software STATA version 11.2. The data were presented as mean (standard deviation) and 95% confidence level. Continuous variables were compared among the groups using one-way ANOVA and postprocess comparison by Bonferroni test. $P < 0.05$ was considered statistically significant. Sample size in each group was decided by Dixon staircase method, according to which there should be at least six pairs of failure–success response. Hence, we recruited children till we obtained a minimum of six pairs of positive–negative sequence in each group. Cannulation time in 50% of the children based on Dixon method was calculated from the mean of midpoints of these failure–success responses.[4]

Results

The total number of children in Groups 1, 2, and 3 was 24, 23, and 24, respectively. Demographic parameters (age, weight, and gender) of the children in each group are presented in Table 1. The time from induction of anesthesia to loss of eyelash reflex in Group 1 was significantly earlier compared to Group 3. However, this time was not significantly different between Groups 1 and 2 or Groups 2 and 3. Children in Group 1 achieved a significantly higher age-corrected MAC of sevoflurane at the time of cannulation compared to the other two groups.

Sequential up and down response to cannulation in consecutive child in each group is given in Figures 1-3. Time for cannulation was significantly less in Group 1, as compared to other two higher age group children. The cannulation time between Groups 2 and 3 was not statistically significant [Table 1].

There was no significant difference in the MAC at the time of cannulation between the children who showed movement and who did not in all the three groups. The MAC of children who reacted to cannulation compared to who did not reacted was

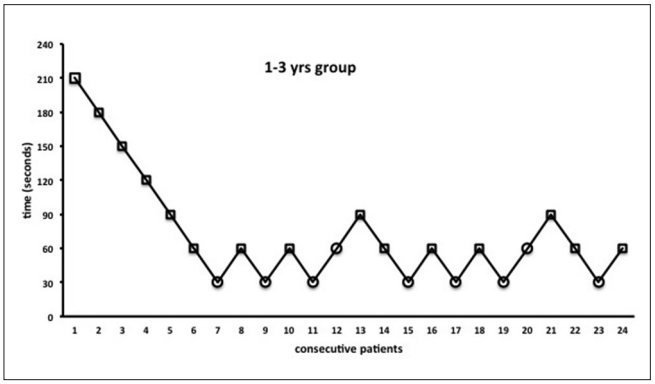

Figure 1: Individual response in 1–3 years age group. Circle represents response to cannulation (movements, withdrawal, cough, laryngospasm, and breath holding) and square represents no response

2.2 versus 2.2 ($P = 0.96$), 1.9 versus 1.8 ($P = 0.46$), and 1.8 versus 2.0 ($P = 0.20$) in Groups 1, 2, and 3, respectively.

Analysis of up and down graph shows that positive response to IV cannulation was observed in all the seven cannulation attempts at 30 s in Group 1 and all the five children cannulated at 60 s in Group 2 [Figures 1 and 2]. The only child cannulated at 60 s and three of the four children cannulated at 90 s in Group 3 showed response to IV cannulation [Figure 3].

Discussion

In the present study, we found that the mean time for IV cannulation in children of age 1–3 years was significantly less (54 s) in comparison to those of age more than 3 years (105 and 144 s). This difference could be attributed to lower lung volumes, higher minute ventilation, and cardiac output in younger children in comparison to older children.[5] These physiological differences along with high FGF (5 L) helped them to achieve a higher MAC (2.2%) compared to older children.

We observed that there was a higher chance for movement during IV cannulation attempt in Groups 1, 2, and 3 at 30, 60, and 90 s, respectively. Few studies have been done to evaluate the optimum time for IV cannulation after inhalational induction. Schwartz *et al*. have observed the readiness for cannulation at 30 and 120 s after loss of eyelash response in age group from 1 to 18 years and concluded that attempting IV cannulation 30 s after loss of eyelash reflex is associated with high incidence of movement, increased difficulty in cannulation, and laryngospasm.[6] Similar study by Joshi *et al*. used Dixon's up and down staircase method in children aged between 4 and 10 years and found that the mean optimal time for cannulation was 1.9 min.[2] Compared to the previous studies, we have included children from 1 to 10 years and divided them into small homogeneous groups. Further, we designed the study to find the optimum time for IV cannulation rather than comparing cannulation at two time points. Unlike Joshi *et al*., we have included 1–3 years age group and found that the time for cannulation is significantly less as compared to higher age groups.

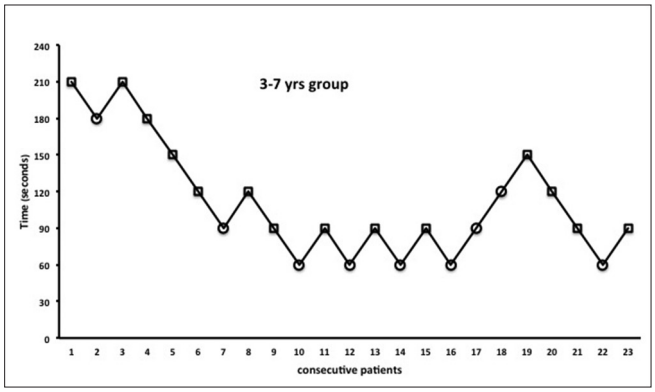

Figure 2: Individual response in 3–7 years age group. Circle represents response to cannulation (movements, withdrawal, cough, laryngospasm, and breath holding) and square represents no response

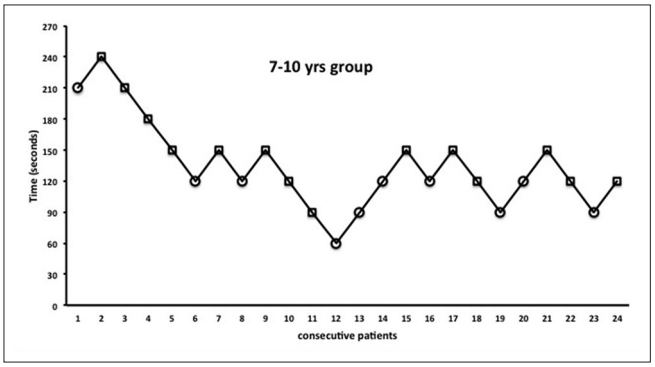

Figure 3: Individual response in 7–10 years age group. Circle represents response to cannulation (movements, withdrawal, cough, laryngospasm, and breath holding) and square represents no response

Table 1: Patient characteristics, time to loss of eyelash reflex, minimum alveolar concentration at cannulation, and time for intravenous cannulation

Parameters	Group 1 (n=24)	Group 2 (n=23)	Group 3 (n=24)	P
Age (years)	1.8 (0.8)	5.1 (0.9)	8.3 (1.2)	
Weight (kg)	9.9 (2.1)	16.1 (3.2)	22.1 (3.2)	
Male/female	18/6	20/3	17/7	
Age-corrected MAC at IV cannulation	2.2 (0.4)	1.8 (0.4)	1.9 (0.5)	Group 1 versus 2: 0.01
				Group 1 versus 3: 0.04
				Group 2 versus 3: 1.0
Time to loss of eyelash reflex (s)	44.3 (41.0-47.5)	49.7 (45.9-53.6)	52.6 (47.0-58.2)	Group 1 versus 2: 0.22
				Group 1 versus 3: 0.02
				Group 2 versus 3: 1.0
Time for IV cannulation (s)	53.6 (40.0-67.1)	105 (62.6-147.4)	143.6 (108.8-178.4)	Group 1 versus 2: 0.041
				Group 1 versus 3: 0.001
				Group 2 versus 3: 0.17

Age, weight, MAC expressed as mean (SD). Time expressed as mean (95% CL). MAC=Minimum alveolar concentration, SD=Standard deviation, CL=Confidence level, IV=Intravenous

Kilicaslan *et al.* found that the optimum time for cannulation after induction with sevoflurane and nitrous oxide in children aged 2–6 years was 1.29 min.[7] Authors attributed premedication with midazolam and addition of nitrous oxide to sevoflurane as the reason for decreased cannulation time (1.3 min) as compared to 1.9 min in the study by Joshi *et al.*[2] The mean age group of children in the study by Kilicaslan *et al.* was 3.7 years whereas the mean age in the study by Joshi *et al.* was 7.4 years. Apart from the use of nitrous oxide, difference in the age groups in these two studies could have contributed to the reduction in cannulation time.[8] Children with younger age group in the study by Kilicaslan *et al.* could be one of the reasons for reduced cannulation time. This supports our finding that younger children require relatively lesser time for cannulation after inhalational induction.

A total of 28 children showed positive response to IV cannulation. Nine children each from Groups 1 and 2 and ten children in Group 3 had positive response to IV cannulation. Mild movements at the level of wrist and elbow were the only positive responses observed in our study. In the present study, none of the child in any group developed laryngospasm or breath holding. Schwartz *et al.* have reported eight cases of laryngospasm in early cannulation group at 30 s after the loss of eyelash reflex.[6] They also found that laryngospasm was more in higher age group and weight. In our study, IV cannulation was attempted at 30 s in Group 1 only, and none of the children developed complications. This could be due to relatively higher MAC (2.2%) achieved in younger children.

We tried to standardize variables which could have effect on the timing such as vaporizer dial setting, inspiratory gas mixture, FGF, circle system volume, and spontaneous/assisted breathing from induction to cannulation. We chose 3.5 min as initial cannulation time in each group based on a previous study, which has calculated the optimal time for cannulation in 95% of children as 3.3 min.[2]

The limitations of the present study include avoidance of nitrous oxide during induction and exclusion of infants. Although addition of nitrous oxide to sevoflurane helps in fast and smooth induction, we avoided nitrous oxide due to increasing concerns of theater and environmental pollution and postoperative nausea and vomiting, especially in squint surgeries and for safety.

Conclusion

The mean cannulation time in 50% of the children after sevoflurane induction in 1–3 years, 3–7 years, and 7–10 years age group was 54, 105, and 144 s, respectively. These timings were arrived when anesthesia was maintained with 5% sevoflurane dial concentration in 5 L of 100% oxygen. Changing this setting could have an effect of cannulation timing.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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