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Evaluation of Lateral Head Rotation on Eficacy of Face Mask Ventilation during Induction of Anesthesia in Children

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ABSTRACT

Background: The head's position during mask ventilation on the time of anesthesia induction in children may improve the lung ventilation.
Aim: Current study was designed to verify whether lateral head rotation improves face mask ventilation efficiency during anesthesia induction in children.
Methods: Fifty-six patients aged 1-4 years, candidate for elective surgery, were randomly divided into two equal groups. During induction of general anesthesia, face mask lung ventilation of patients continued with pressure-controlled mode, at a peak pressure level of 10 cmH2O for children 13-24 months and 14cmH20 for children 24-48 month. In patients in the N group, the head position during ventilation was initially in the neutral position for one minute, then the head was axially rotated 45-degree to the right position for one minute and pulmonary ventilation continued in this position, then the head was rotated again to the neutral position and ventilation continued for one minute. In group R patients, mode and time of ventilation was the same, but the order of head placement was first in the lateral rotated to the right, then neutral and then lateral rotated to the right. The primary outcome was the measurement of expiratory tidal volume in each position.
Results: Generally, the mean measured expiratory tidal volume did not change in the neutral position compared to laterally rotated head position, 256.6 vs. 233.5 ml: difference -23.1 [95% confidence interval: 10.8 to 39.4 ml]. Also, the change of head position from lateral to neutral position did not show a significant change in the mean expiratory tidal volume, 232.28 vs.247.86 ml: difference -15 .82 (p= 0.4).
Conclusion: The rotation of the head to the lateral position during induction of anesthesia in apnoeic children 1-4 years old could not improve the efficiency of mask ventilation relative to the neutral head position.

At the time of induction of anesthesia in pediatric patients, the upper airway is often obstructed , and, mask ventilation become difficult and sometimes impossible. In these critical moments, applying the appropriate skill in lung ventilation is very important in airway management. Healthy children usually do not have difficult airway. The occurrence of unpredicted difficult bag mask ventilation in pediatric patients is 7% [1]. According to previous studies, there is no connection between the difficult mask ventilation and the rate of difficult intubation, as the incidence of difficult direct laryngoscopy in these patients varies from 0.06% to 3% [2-3]. To optimize mask ventilation, physicians typically use the oropharyngeal airway, extending the

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patient's head and using several maneuvers such as chin lift, jaw thrust, lateral position, and two hands to improve mask ventilation [4-5].

The axial head rotation has been the subject of many studies to improving the mask ventilation.

In adult apnoeic anesthetized patients, head rotation significantly improved mask ventilation efficiency compared with the neutral head position [6]. In children with obstructive sleep apnoea due to adenotonsillar hypertrophy, placing patients in a lateral position and applying the necessary airway maneuvers improves airway management during induction of anesthesia [7].

Theoretically, turning the head to one side may open the airway by moving the tongue and epiglottis. This study intends to investigate the efficacy of lateral head rotation on mask ventilation in 1-4-year-old pediatric patients without an underlying problem during apnea at anesthesia induction.

Methods

This interventional study was conducted from December 2019 to February 2020 in the Children's Medical Center, Tehran, Iran. The Ethics Committee of the Tehran University of Medical Sciences had approved the study protocol (protocol number: IR.TUMS.CHMC.REC.1398.100). Informed consent was received from the parents. The investigators adhered to Helsinki's declaration- ethical principles for medical research involving human subjects - throughout the study.

Study Design: This is a randomized clinical crossover study.

Inclusion criteria: This study was conducted on 56 patients ASA I, age 1-4 years old, candidates for elective Urologic and Orthopedic surgery under general anesthesia.

Exclusion criteria: Children with difficult airway such as limited head rotation or neck extension, a full stomach, history of tracheal or laryngeal injury, any anatomical abnormality in the chest, skull, and cervical spine myopathies, were excluded.

Eligible patients were randomly divided into N and R groups. Randomization was performed by creating a series of envelopes containing group assignments. Papers containing "Group N" or "Group R" were placed in a sealed envelope. Immediately before the induction of anesthesia, the envelope was opened. Thus, the study staff did not know the group assignment before induction of anesthesia. Standard monitoring (EKG, blood pressure, ETCo2 and pulse oximetry) were applied for all patients. Peripheral intravenous access was provided for all children in the ward. Initially, pre-oxygenation by flow rate of 6L min1 was started for all patients through a circular breathing system and anesthesia face mask until the expired oxygen fraction reached 0.9. For all patients, induction of anesthesia was performed with midazolam (0.05 mg / kg), fentanyl (1 to 2 μg / kg), thiopental sodium (4 mg/ kg) and then atracurium (0.5 mg / kg). Four minutes after muscle relaxant injection, general anesthesia was maintained in the supine position without any shoulder roll with inhaled sevoflurane.

After induction of anesthesia and the onset of apnea, which is evident by the cessation of airflow and respiratory effort, mask ventilation with pressure-controlled ventilation (PCV) by an anesthesia ventilator with ten breaths per minute, inhalation to exhalation ratio 1: 2 was performed. Peak inspiratory pressure (PIP) was set at 10 cmH2o for children 13-24 months and 14 cmH2ofor children 2-4 years, with no positive expiratory end pressure. The patient mask was held in place by an experienced anesthesiologist (with more than 20 years of experience) with both hands in such a way as to maintain airway optimization throughout the ventilation protocol. The mask ventilation was performed in group N, in the neutral head position for 1 minute (step 1), then the head was rotated axially to the right and ventilation continued in this position for 1 minute (step 2) and finally the head was returned to the neutral position, mask ventilation continued for another 1 minute (Step 3). In group R patients, the setting of ventilator and the mask ventilation method were similar to group N patients, except that the order of head placement was first turned to the right, neutral, and then turned to the right position. If ventilation of the lungs was not possible for at least four consecutive breaths, as proven by the lack of movement in the chest wall and the disappearance of the capnographic wave, the next position of the head would be applied. Then, if lung ventilation is not possible in the next four consecutive breaths in the next position, the study in these patients is terminated and airway management continues routinely. If lung ventilation is detected in the next position of the head, the study protocol continued as planned. At any time during the study, if the patient's Spo2 decreases to 94% or the patient's ETCo2 increases to more than 50 mm Hg, the study is terminated and routine airway management resumes.

For each head position, expiratory tidal volume was recorded, and the mean of these volumes was intended for analysis.

Statistical analysis

To calculate the sample size, we used the study of Park HS et al. [8] with considering the error level of 5%, power of 80%, and effect size =35%, the sample size was estimated to be 28 patients in each of the two groups.

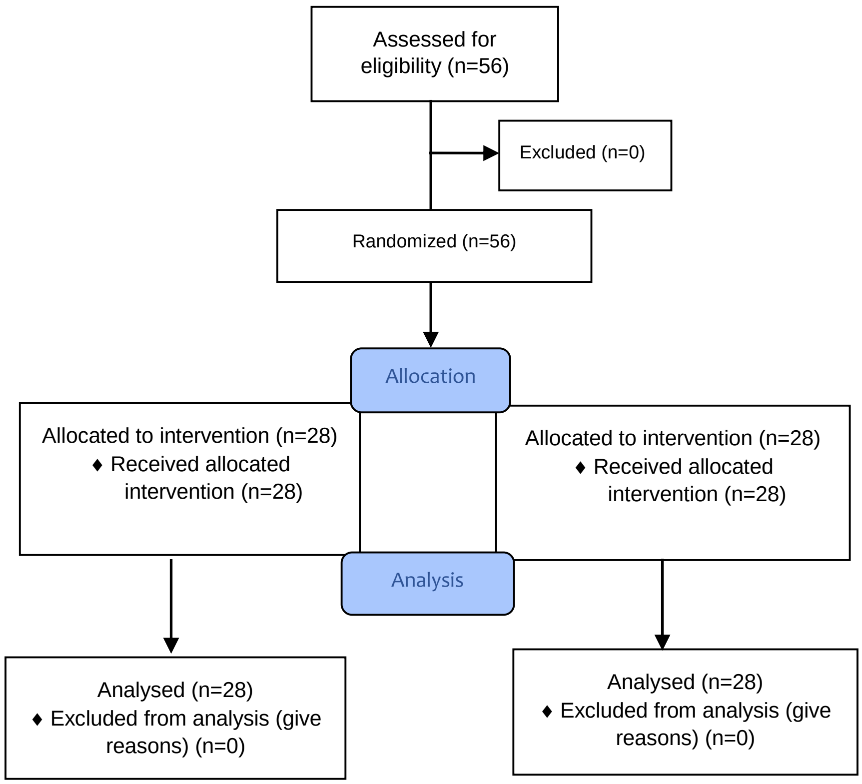
Means and standard deviations (SD) were calculated for continuous variables and frequency and percentage for categorical variables.

Variables were tested for normal distribution and the paired t-test. All analyses were performed at 0.05 significance levels using SPSS ver. 22.0 for Windows (SPSS, Chicago, IL, USA).

Results

At the end of the study, the data of fifty-six pediatric patients who were randomly assigned to the R or N group from December 2019 to February 2020 were collected and analyzed (Figure 1).

Figure 1- Flow chart of the eligible patients



During this study, none of the patients had Spo2 less than 94% or ETCo2 more than 50 mmHg. None of the patients had any specific complications associated with the treatment protocol in this study. The mean age of children included in the study was 32.67±9.68 months (range 14 to 48) months.

Basic characteristics of patients described in (Table 1).

Table 1- Demographic Data of patients

variable	overall	Group N	Group R
Male/female	28/28	28	28
Age13-24 mo	16	7	9
Weight, kg	9.3±1.2	8.6±1.5	9.2±1.4
Height, cm	73.9±5.2	72.7±5.1	71.9±4.6
Age25-48 mo	40	21	19
Weight, kg	14.6±3.2	14.7±2.4	14.5±3.1
Height, cm	95.5±6.2	95.3±4.7	96.2±5.7

N, neutral; R, lateral head rotation

Because there is a difference in the anatomy of the airways, resistance, and compliance of the respiratory system between 12-24-month-old children and 24-48-month-old ones, thus data for children between 1 to 2 years old was evaluated separately, and children aged 2-4 years were examined together.

Correlation of expiratory tidal volume in Neutral and Rotated position with age and gender was presented in (Table 2-3).

Table 2- Correlation of mean expiratory tidal volume with age and gender in group N

Variable	N_1	R_0	N_2	R_0-N_2	P value
V_{TE} ml	242.68±97.9	233.46±89.1	256.57±93.7	-23.9±9.1	0.9
male	265.20±54.61	254.87±66.32	268.07±87.56	-14.2±8.2	0.8
Female	243.31±65.34	230.31±54.65	243.31±62.19	-11.3±8.4	0.5
Age Group					
Age< 24 mo.	170.14±17.24	176.14±28.79	190.71±18.34	-26.6±8.5	0.6
Age>24 mo.	266.86±21.67	265.90±36.49	278.52±45.23	-13.4±7.8	0.4

N, neutral; R, lateral head rotation, VTE, expiratory tidal volume (mean ± SD); mo., month

Table 3- Correlation of mean expiratory tidal volume with age and gender in group R

Variable	R_1	N_0	R_2	R_1-N_0	P value
ETV ml	232.28±97.9	247.86±89.1	237.86±53.7	-15.2±8.2	0.4
male	221.20±54.61	234.87±66.32	230.07±87.56	-13.4±9.3	0.8
Female	242.51±65.34	256.31±54.65	249.32±62.19	-14.7±9.1	0.5
Age< 24 mo.	172.22±17.24	186.14±38.49	168.71±18.34	-14.3±9.1	0.4
Age>24 mo.	246.86±27.67	262.72±46.49	258.42±45.23	-24.7±18.1	0.3

N, neutral; R, 45-degree head rotation, VTE, expiratory tidal volume (mean ± SD); mo., month

According to table 2&3, the VTE changes from a neutral position to a rotated position are minimal. As the forty-five degrees' head rotation even reduces the expiratory tidal volume slightly.

We also investigated the effects of lateral rotation of the head on the rate of VTE changes according to the sex and age of patients, which with the intervention of these variables, no significant change in the rate of VTE was observed.

Discussion

In this clinical study, the effect of lateral head rotation during mask ventilation on expiratory tidal volume was evaluated, and we found that 45° degree head rotation slightly reduced VTE compared to the neutral head position in apnoeic paediatric patients.

Upper airway obstruction at the beginning of general anesthesia induction is one of the most common problems that cause difficult mask ventilation. In apnoeic patients with supine position, the mechanisms of upper airway obstruction are reduced muscle activity of the oropharyngeal structure and their gravitational effects on the anterior structures of the upper airway [9]. The effect of body position and head rotation in adult patients with and without obstructive sleep apnea on the shape, size and the upper airway collapsibility has been studied by imaging techniques [10-11]. These studies' essential findings indicate that, head rotation and lateral position had increased circularity of the upper airway shape and anteroposterior dimensions of the retro-glossal and retro-palatal region.

In 2017, Itagaki et al, evaluate the effect of 45-degree right-head rotation on the performance of facial mask ventilation in adults patients with apnoea under general anesthesia, and found that rotating the head from neutral to lateral position significantly increased VTE [7]. We do a similar study in anesthetized apnoeic children 1-4 years, but VTE slightly decreased in head rotation. An initial study of 17 healthy infants between 1 and 4 months of age showed no significant improvement in tidal respiration parameters in head rotation [12]. Due to this physical structure, children's airways are prone to dynamic airway changes when the head rotates laterally [13]. In addition, the larynx of children is very narrow and funnel-shaped, and in terms of anatomical position that is higher than the larynx of adults and it is at level C2-C4. The epiglottis cartilage is relatively long and stiff at this age, with rotation of the head and neck to the sides, the airway in the pharynx and larynx may predispose to collapse.

The patients in this study all received general anesthesia and muscle relaxants and underwent ventilation with PCV mode. The use of a muscle relaxant will minimize the breathing resistance of the anesthesia machine and make the measurement of respiratory volumes more accurate.

In the case of PCV breathing mode with fixed peak inspiratory 14 CmH2o pressure for children 2-4 years old, this pressure is lower than peaked airway pressure in children, and we are worried about gastric insufflation during ventilation. According to JH Lee et al, during mask ventilation under general anesthesia the median inspiratory pressure that lead to gastric insufflation in age 1-5 year is 16-18 CmH2o, so in this pressure, the probability of gastric insufflations decreases. However, it cannot be ignored, and this complication has not been investigated in this study [14].

Finally, it should be noted that structural and anatomical differences between children and adults in the upper airways increase the likelihood of children's upper airway obstruction in lateral head rotation.

Conclusion

As a result, forty-five degrees of head rotation in anesthetized 1 to 4-year-olds did not increase expiratory tidal volume and could not improve mask ventilation efficiency relative to ventilation at neutral position.

Limitation

We only studied paralyzed patients at the beginning of anesthesia. Therefore, the results of this study cannot be applied to non-paralyzed patients in whom head rotation may open the upper airway and improve ventilation.

We just studied children without any difficulties in the upper airway; therefore, our findings cannot be applied to pediatric patients who have difficulty in upper airway and cervical neck movement.

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