Original Article

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Anaesthesia Section

Effect of Head Rotation on Efficiency of Face Mask Ventilation among Apnoeic Patients: A Cross-sectional Study

AMOL SINGAM[1], MATTURU SOUMYA[2], ASHOK CHAUDHARY[3]

ABSTRACT

Introduction: Respiratory function is crucial in the practice of anaesthesia. An in depth understanding of respiratory physiology is a must because it aids in the proper execution of daily general anaesthesia practice. Head and body postures have long been known to affect the patency of the upper airway. Head extension and a lateral recumbent position help to clear the upper airway. Head rotation is known to expand the upper airway's cross-sectional area.

Aim: To determine the effect of head rotation on efficiency of face mask ventilation among apnoeic patients, by measuring expiratory tidal volume.

Materials and Methods: This cross-sectional study was conducted in the Department of Anaesthesiology at Jawaharlal Nehru Medical College, Acharya Vinoba Bhave Rural Hospital, Sawangi, Wardha, Maharashtra, India, from May 2021 to November 2021. Total 40 patients belonging to the age group of 20-40 years, American Society of Anaesthesiologists' (ASA) class I and II, undergoing surgeries requiring general anaesthesia with endotracheal intubation, were selected as study subjects. They were administered inj. fentanyl at a dose of 1-2 µg/kg, inj. propofol at a dose of 1-2 mg/kg, and inj.vecuronium bromide (0.08-0.1 mg/kg). Patients were mask ventilated with pressure-controlled ventilation, for a total of 3 minutes, during which they were ventilated in a neutral head position for 90 seconds and then rotated for another 90 seconds. Following induction, the expiratory tidal volume was measured every 30 seconds in both postures. Software used was Statistical Package for Social Sciences for windows (SPSS Inc., Chicago, IL, USA), version 17.0. A p-value <0.05 was considered statistically significant.

Results: The mean age of patients was 48±8.3 years. The 45° head rotation was beneficial to all patients, the mean expiratory tidal volume was 423±62.5 mL in the rotated head position compared to 397±52.5 mL in the neutral head position (p-value=0.045). It was also observed that some individuals profited more than others. Patients with airway obstruction, for example, had a greater Expiratory Tidal Volume (V_{TE}) at 45° head rotation than in a neutral head position.

Conclusion: The most notable conclusion is that in apnoeic adult patients, a 45° head rotation showed a significant enhancement in V_{TE} when compared to a neutral position of the head.

Keywords: Airway anatomy, Airway patency, End tidal carbon dioxide, Expiratory tidal volume, Posture

INTRODUCTION

In the practice of anaesthesia, respiratory function is critical. A thorough understanding of fundamental respiratory physiology is necessary for performing daily general anaesthetic practice duties such as induction, maintenance, administration of mechanical ventilation, and termination of mechanical ventilation [1]. After the loss of consciousness, gentle mask ventilation is deemed appropriate during rapid sequence induction, minimising the incidence of hypoxia prior to tracheal intubation [2]. Various mechanisms help to improve mask ventilation like muscle relaxation, using a double C-E grip, and jaw thrust. This is especially important for people who have a shorter apnoea time. For resuscitation, an effective breathing strategy and the best equipment selection are critical. Head and body postures have long been known to affect the patency of the upper airway. Head extension and a lateral recumbent position help to clear the upper airway. Head rotation is known to expand the upper airway's cross-sectional area [3].

Edentulous facies, the existence of a beard, and substantial gas leaks surrounding the face mask are all variables that contribute to problematic mask ventilation [4]. Simple treatments include replacing dentures, packing the sides of the face around the facemask, and removing the facial hair.

Aspiration is a frequent mask ventilation hazard that may be avoided by following fasting recommendations or utilising a gastric tube to empty the stomach before airway management. Cricoid pressure can assist minimise stomach distension during mask ventilation, but it should be used with caution because it can make mask ventilation more difficult [5]. Head up position, neuromuscular blockade, using airways such as oropharyngeal and nasopharyngeal airways, and two-handed mask ventilation can help with the inability to oxygenate and ventilate during mask ventilation [6].

Poor mask ventilation techniques, especially during emergency airway management, might have negative physiological repercussions [7]. Hyperventilation, for example, lowers Partial Pressure of Carbon Dioxide ($PaCO_2$) and causes vasoconstriction. Small tidal volumes (6-7 mL/kg) and a one-second inflation time are advised to minimise quick or violent breathing.

Head posture has a considerable effect on the collapsibility and site of the collapse of the passive human upper airway. According to Walsh JH et al., controlling head posture during sleep or recovery from anaesthesia may alter the propensity for airway obstruction [8]. In a study to determine the effects of sleep posture on upper airway stability in patients with obstructive sleep apnea, Neill AM et al., found that in severely affected obstructive sleep apnea patients, upper body elevation, and to a lesser extent lateral positioning, significantly improve upper airway stability during sleep [9].

As stated above, several studies have shown that body posture and head position have an impact on airway anatomy, but it is still unclear if these have a positive impact on mask ventilation efficacy. Considering this, the study aimed to evaluate if head rotation improves the efficiency of mask ventilation in an apnoeic patient, by measuring the expiratory tidal volume.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Anaesthesiology at Jawaharlal Nehru Medical College, Acharya Vinoba

Bhave Rural Hospital, Sawangi, Wardha, Maharashtra, India, from May 2021 to November 2021. The Institutional Ethics Committee had approved the study vide letter number DMIMS(DU)/IEC/2020-21/102.

Sample size calculation: Assuming mean expiratory tidal volume to be 612±68.6 mL, as reported by Itagaki T et al., [10] and keeping power at 80%, alpha of 0.05, a sample size of 40 was calculated to detect a minimum of 20% difference in expiratory tidal volume by head rotation (using www.OpenEpi.com).

Inclusion criteria: A total of 40 patients between the ages of 20 and 60 years of either gender, undergoing surgical procedures (diagnostic laparoscopy, laparoscopic appendectomy, breast lump excision, spine surgeries) under general anaesthesia, willing to give written consent, American Society of Anaesthesiologists' (ASA) Class I and II, Body Mass Index (BMI) less than 24.9 kg/m^2, Mallampati score class I/II, and neck circumference <35.5 cm were included in the study.

Exclusion criteria: Edentulous patients, patients having allergies to drugs, history of neck pain, giddiness on neck head rotation, history of cervical spine pathology, and patients with co-morbidities (cardiac diseases, on thyroid medications) were excluded from the study.

Study Procedure

A complete history of all the patients was taken and a thorough general examination was done for all patients. The procedure was explained to the patients before surgery to win their trust, and a signed agreement was obtained. Prior to the scheduled surgery day, all of the patients were kept fasting overnight. In the preoperative room, patients were assessed for vital factors such as pulse rate, oxygen saturation (SpO_2), blood pressure, and Electrocardiogram (ECG) abnormalities and also for cervical spine pathology.

Patients were briefed on the research methodology prior to the start of the trial. Baseline values of heart rate, blood pressure, and oxygen saturation were noted using non invasive monitoring.

Patients were intravenously administered inj.fentanyl, inj.propofol, at a dose of 1-2 μg/kg and 1-2 mg/kg, respectively and inj.vecuronium bromide 0.08-0.1 mg/kg. Then patients were mask ventilated after attaining apnoea with pressure controlled ventilation using an anaesthesia machine at Inspiratory to Expiratory ratios (I:E) of 1:2, Peak Inspiratory Pressure (PIP) of 15 cmH_2O, and a Positive End-Expiratory Pressure (PEEP) of 0 cmH_2O. Two hands were used to hold the mask in place, and the jaw was positioned to improve the airway.

Every patient was mask ventilated for a total of three minutes, during which they were ventilated in a neutral head position for 90 seconds [Table/Fig-1] and then in an axial head position rotated to right [Table/Fig-2] for another 90 seconds. The trial was ended and normal airway treatment was commenced if there was no breathing possible for a minimum of four breaths, which was shown by the absence of chest wall movement and End tidal carbon dioxide ($EtCO_2$) trace. If the SpO_2 dropped to 92% or below at any point throughout the research, it was stopped and usual airway care continued. Pulse oximetry, electrocardiography, and non invasive arterial blood pressure monitoring were used for routine monitoring.

Following induction, the expiratory tidal volume was noted from the monitor of the ventilator (GE DatexOhmeda 9100c NXT) every 30 seconds in both postures. The occurrence of tongue fall was noted [Table/Fig-3].

STATISTICAL ANALYSIS

Statistical analysis was performed using descriptive statistics such as mean, and standard deviation, as well as inferential statistics such as the Chi-square test and Student's Unpaired t-test. Software used was Statistical Package for Social Sciences for Windows (SPSS Inc., Chicago, IL, USA), version 17.0. A p-value <0.05 was considered statistically significant.

RESULTS

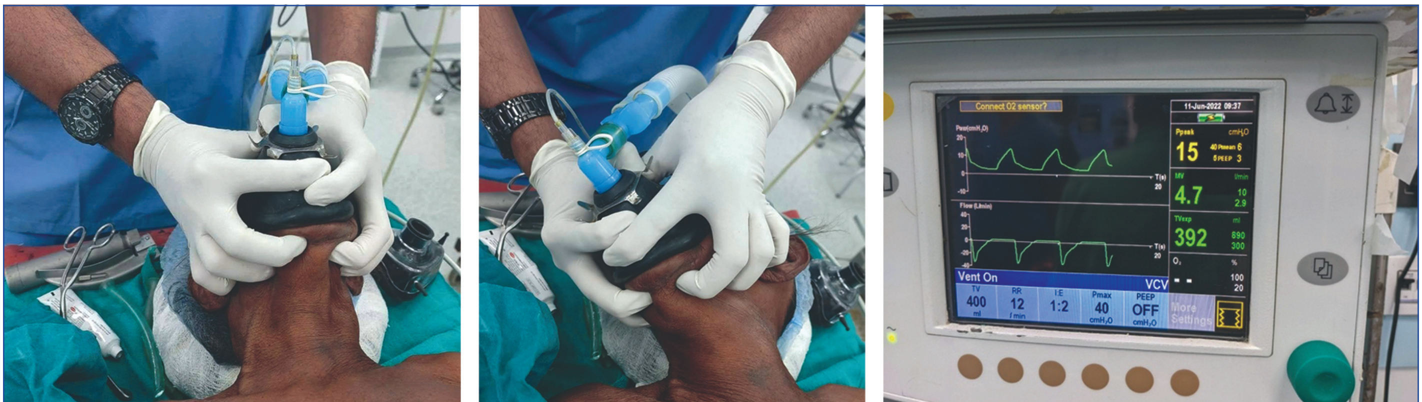
The mean age of patients was 48±8.3 years [Table/Fig-4]. There was no particular damage associated with therapy in any patient, with a SpO_2 of less than 92%. The expiratory tidal volume (V_{TE}) with head rotation was substantially greater 423±62.5 mL than in the neutral position 397±52.5 mL (p-value=0.045) at a 95% confidence interval.

The 45° head rotation was beneficial to all patients, it was found that while switching from a neutral position to 45° head rotation position patients with airway obstruction had a greater benefit. Airway obstruction was seen in 12 patients in total out of which eight patients had tongue fall in the neutral position and four patients in a rotated head position [Table/Fig-5].

DISCUSSION

The most basic technique in airway control is mask ventilation. Mask ventilation is required immediately after intravenous infusion of anaesthetic medications to support ventilation and essentially avoid potential airway blockage. This is the primary mode of ventilation before tracheal intubation or the insertion of any airway device [11]. Its most notable application is as a ventilation rescue method in the event when tracheal intubation fails or becomes difficult, or when multiple attempts are made. The mask ventilation technique generally is based on two fundamental elements: a seal between the face mask and the patient's face is maintained, and the upper airway is not occluded in a subtle way. It may be fairly possible to lessen the morbidity related to mask ventilation if people are informed of the risks. A typical problem of mask ventilation is aspiration, due to insufflation of the stomach. Reflux of stomach contents is caused by high inflation pressures in the ventilation bag. During mask ventilation, damage to the eyes and eyelids can also happen if an improper technique is followed [12].

The present study was aimed to observe if head rotation has an impact on efficacy of mask ventilation, and was planned to measure the tidal volume in both the positions. Furthermore, since a constant PIP was maintained throughout mask ventilation, the V_{TE} could be



[Table/Fig-1]: Showing mask ventilation in neutral head position. **[Table/Fig-2]:** Showing mask ventilation in head rotated position. **[Table/Fig-3]:** Shows V_{TE} on Datex-Ohmeda 9100 NXT monitor. (Images from left to right)

Variable	Findings
Age (years)	48±8.3
Weight (kg)	59±6.9
Height (meters)	1.64±0.12
Body mass index (kg/m^2)	22±1.9
Mallampati class (n)	
Class 1	26
Class 2	14
Neck circumference (cm)	33.4±1.8

[Table/Fig-4]: Representing demographic data of the study population.

Variable	Overall	Patients in neutral position	Patients in rotated position	p-value
Expiratory tidal volume (mL) (V_{TE})	412.1±60.6	397±52.4	423±62.5	0.045
End tidal carbon dioxide ($EtCO_2$) (kPa)	4.7±0.26	4.6±0.24	4.8±0.28	0.623
Tongue fall	12	8	4	0.685

[Table/Fig-5]: Representing the study parameters.

correlated to the patency of the airway directly and to the degree of obstruction of the airway indirectly. It was observed that head rotation has a significant effect on mask ventilation.

Hillman DR et al., described various factors that contribute to upper airway blockage under general anaesthesia, such as the decreased activity of the dilator muscle of pharynx and effects of gravity on airway structures in the supine posture [13]. Weingart SD et al., observed that lateral positioning, as well as the reverse Trendelenburg position, increases the mask ventilation effectiveness [14], suggesting a higher incidence of airway blockage in the supine position, as seen in the present study. It was previously suggested by studies that more effective and better mask ventilation is possible with head rotation but never systematically shown.

Armstrong JJ et al., used imaging and endoscopic methods to investigate the effects of head rotation on upper airway collapsibility [15]. Schwab RJ and Goldberg AN, have conducted MRI studies in normal awake patients and observed that in both head rotation and lateral recumbent position there was a significant increase of retroglossal and retropalatal areas' anteroposterior dimension [16]. Similar findings were present in this study as well, concluding that better mask ventilation was possible with head rotation when compared to supine. Because airway blockage is thought to be caused by a decrease in the length of the pharyngeal tube [16], head rotation may allow the soft tissue to shift out of the submandibular area, improving mask ventilation by reducing airway obstruction [17]. Head rotation caused a significant increase in the upper airway diameter in the neck, as well as an increase in the cross-sectional area in the retroglossal region, according to Ono T et al., [18]. Thus, airway patency is well maintained with head rotated position which was observed in the present study as well.

Zhu K et al., concluded when the head rotated from supine to lateral with the trunk in the supine position, Obstructive Sleep Apnea (OSA) severity decreased dramatically, especially in non obese patients. These findings show that, in patients with OSA, the head position has a significant impact on the Apnea Hypopnea Index (AHI), regardless of trunk posture or sleep stage [19].

Despite the fact that multiple studies have found that head and body posture have a substantial impact on airway structure, there is very limited knowledge available on its impact on mask ventilation. A 45° head rotation has a good effect on mask breathing performance, according to a study by Itagaki T et al., [10], however the results were not statistically significant. The present study also found that head rotation enhances mask ventilation efficacy, and the results were statistically significant. It was observed that head rotation reduced the overall incidence of tongue fall leading to airway obstruction, indicating that head rotation helps to preserve airway patency.

Mask ventilation particularly is an important skill for both airway management and for the facilitation of definitely effective oxygenation as well and proper patient positioning actually is of the actually utmost importance [20] because difficult mask breathing frequently occurs in conjunction with difficult kind of tracheal intubation [21]. The population in the present study, in particular, requires adequate ventilation in order to allow for several or protracted attempts of intubation. The findings of this study show that when an airway blockage is encountered, the most basically effective strategy, for the most part, is to turn the head of the patient to change the position of the tidal volume (VT).

Limitation(s)

Owing to anatomical variations between paediatric and adult airways, the findings cannot be applied to children. The study only evaluated paralysed adult patients. Finally, the study only looked at the effect of head rotation to the right, and not to the left. Though it is not anticipated that rotation in the other direction would change the finding because commonly airway blockage is symmetric.

CONCLUSION(S)

The most notable conclusion of our study actually was that in apnoeic adult patients, expiratory tidal volume increased significantly with a 45° head rotation when compared to the neutral position of the head, basically contrary to popular belief. It also had a definitely lesser incidence of airway obstruction. From the present study, it was ascertain that head rotation specifically has the sort of potential to reduce the occurrence of airway obstruction as in this study we specifically have compared the airway and incidence of tongue fall within a patient in two different positions.

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PARTICULARS OF CONTRIBUTORS:
1. Professor, Department of Anaesthesia, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences, Sawangi (Meghe), Wardha, Maharashtra, India.
2. Resident, Department of Anaesthesia, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences, Sawangi (Meghe), Wardha, Maharashtra, India.
3. Professor, Department of Anaesthesia, Datta Meghe Medical College, Shalinitai Meghe Hospital and Research Centre, Nagpur, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Amol Singam,
Professor, Department of Anaesthesia, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences, Sawangi (Meghe), Wardha, Maharashtra, India.
E-mail: dramolsingam@gmail.com

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