Original Research Article

Indian Journal of Anesthesia and Analgesia
2018; 5(5): 701-706
DOI: http://dx.doi.org/10.21088/ijaa.2349.8471.5518.1

Placement of Oral Endotracheal Tube and its Possible Determinants in Adult Patients

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Abstract

Aim: This study was conducted with the aim of determining the optimal depth of ET placement in Indian adult population and its relation with vertebral column, height, weight, arm span length. *Materials and Methods:* This was a prospective study which was carried out in 100 ASA grade I and II adult patients who were planning to undergo elective surgery which required orotracheal intubation during general anaesthesia. *Results:* The airway distance from lip to carina was 22.38±2.59 cms in males and 20.92±3.55 cms in females; airway distance from lip to cricotracheal membrane was 13.67 ±0.59 cms in males and 11.99±1.66 cms in females; airway distance from cricotracheal membrane to carina was 9.10±6.58cms in males and 9.37±0.22cms in females; airway distance from endotracheal tube tip-carina was 3.21±1.11 cms in males and 2.22±2.58 cms in females; airway distance from lip to endotracheal tube tip was 21.29±1.08 cms in males and 18.39 ±3.33 cms in females. The various airway distances in males and females were correlated with patient factors separately. The total airway length (L-C), lower airway length (CT-C) were significantly correlated with height, arm span, vertebral column length ($P<0.05$), but the correlation with upper airway length (L-CT) was not statistically significant. In females, both total and upper airway length was significantly correlated with height, arm span, vertebral column length. In case of BMI and airway distances, it was statistically insignificant in both males and females. It was found that the total and upper airway length correlated significantly with height, arm span and vertebral column length ($P<0.01$), when the various patient factors were correlated with airway lengths in all patients (males and females together). The coefficient of correlation was much less suggesting a poor correlation, the lower airway length was also found to have a statistically significant correlation with height, arm span and vertebral column length. BMI and airway distances were not found to be correlated. *Conclusion:* The patient's height correlates the best with the length of the airway. In Indian population, the mean airway distances were smaller so that the average depth of fixation was easier from right angle of mouth.

Keywords: Orotracheal Intubation; Cricotracheal Membrane; Endotracheal Tube.

Introduction

Endotracheal intubation is a medical procedure in which a tube is placed into the windpipe (trachea) through the mouth or nose. In most emergency situations, it is placed through the mouth. Whether you are awake (conscious) or not awake (unconscious), you will be given medicine to make it easier to insert the tube [1]. After endotracheal intubation, you will likely be placed on a breathing machine. If you are awake after the procedure, your health care provider may give you medicine to reduce your anxiety or discomfort. Endotracheal intubation is done to open the airway to give oxygen, medicine, or anesthesia, support breathing in certain illnesses, such as pneumonia, emphysema, heart failure, collapsed lung or severe trauma, remove blockages from the airway, allow the provider to get a better view of the upper airway, protect the lungs in people who are unable to protect their airway and are at risk for breathing in fluid (aspiration) [2]. This

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Received on 27.01.2018, **Accepted on** 26.02.2018

includes people with certain types of strokes, overdoses, or massive bleeding from the esophagus or stomach. Risks include bleeding, infection, trauma to the voice box (larynx), thyroid gland, vocal cords and windpipe (trachea), or esophagus, puncture or tearing (perforation) of body parts in the chest cavity, leading to lung collapse. Intubation is an invasive procedure and can cause considerable discomfort. However, you'll typically be given general anesthesia and a muscle relaxing medication so that you don't feel any pain. With certain medical conditions, the procedure may need to be performed while a person is still awake. A local anesthetic is used to numb the airway in order to lessen the discomfort [3]. EI is usually done in the hospital, where you'll be given anesthesia. In emergency situations, a paramedic at the scene of the emergency may perform EI. In a typical EI procedure, you'll first receive an anesthetic. Once you're sedated, your anesthesiologist will open your mouth and insert a small instrument with a light called a laryngoscope. This instrument is used to see the inside of your larynx, or voice box. Once your vocal cords have been located, a flexible plastic tube will be placed into your mouth and passed beyond your vocal cords into the lower portion of your trachea. In difficult situations, a video camera laryngoscope may be used to give a more detailed view of the airway. The most important and most commonly performed procedures in the field of anaesthesiology, emergency medicine and critical care is endotracheal intubation. Because of the major complications associated with its malplacement, one of the major concerns while securing endotracheal tube (ET) is its correct and appropriate depth of placement.

Placing the tube deeply can cause impingement on the carina and thus sympathetic stimulation leading to tachycardia, hypertension and/or bronchospasm [4]. It may result in the non-ventilated lung might become atelectatic with resultant systemic hypoxemia and thus hyperinflation of the intubated lung, thereby increasing the risk of pneumothorax. The cuff might impinge on the vocal cords on inflation leading to sympathetic stimulation, trauma, recurrent laryngeal nerve compression and increased risk of accidental extubation, if the depth of insertion of ET beyond vocal cords is too less. To confirm the depth of ET placement including cuff palpation in suprasternal notch, various techniques have been described such as chest X-Rays, fibre optic bronchoscopy, etc., with fibre optic bronchoscopy. Because of feasibility and ease of performing it, 5-point auscultation remains the most common method of ascertaining ET position. It is recommended that the depth of placement of ET to be 21 cm and 23 cm in adult females and males, respectively, from central incisors [5]. The tip of ET should be at least 4 cm from the carina, or the proximal part of the cuff should be 1.5 to 2.5 cm from the vocal cords. In some patients, securing ET at a fixed length will result in endobronchial intubation or endolaryngeal placement of the ET cuff, considering that the length of trachea as well as the distance from teeth to vocal cords is variable. This study was conducted with the aim of determining the optimal depth of ET placement in Indian adult population and its relation with vertebral column, height, weight, arm span length.

Materials and Methods

This was a prospective study which was carried out in 100 ASA grade I and II adult patients who were planning to undergo elective surgery which required orotracheal intubation during general anaesthesia. Exclusion Criteria was patients who required preformed tubes or flexometallic tubes, or those who were having altered airway anatomy, i.e. swelling or contractures in the neck, swelling or deformity of pharyngeal, oral, laryngeal region. Recordings of age, height, arm span, weight, length of the vertebral column i.e. from external occipital protuberance to the coccyx tip. The establishment of intravenous line was done and intravenously, pethidine was injected. To facilitate tracheal intubation, thiopentone sodium and vecuronium bromide was administered. By performing direct laryngoscopy, patient's trachea was intubated in sniffing position using cuffed PVC ET . For females, size ET was selected for tracheal intubation, i.e., 7.0 or 7.5 mm ID and for male patients, it was 8.0 to 9.0 mm ID. Below the vocal cords, the tube was placed such that the cuff of the endotracheal tube (ETT) disappeared and the black mark lay between the vocal cords. The head position was made neutral. By tape at the right angle of mouth, the ET was secured. The placement of ET confirmed by 5-point auscultation and capnography, breathing circuit was then attached. To the machine end of the ET, anaesthesia was continued and a swivel connector with a port for fibre optic bronchoscope (FOB) was attached. Following distances were measured using a tape having 1 mm markings, FOB was introduced into the ET through swivel connector. A swivel connector was connected to the lips (L): With the tip of FOB at the level of the lower lip, this distance would be total length of FOB insertion cord minus

length of the FOB insertion cord above the swivel connector. Swivel connector to the carina (end of trachea) (C): With the tip of FOB at the level of tracheal carina, this distance would be total length of FOB insertion cord minus length of the FOB insertion cord above the swivel connector. Swivel connector to the tip of endotracheal tube: With the tip of FOB at the level of tip of the ET, this distance would be total length of FOB insertion cord minus length of the FOB insertion cord above the swivel connector.

Swivel connector to the beginning of trachea (CT): For this last distance, the FOB was withdrawn till the black mark on ETT was just visible through FOB and then FOB light was switched off. At the cricotracheal membrane (the beginning of the proximal end of trachea), a sharp light was then placed externally. For the extratracheal glow to be best visible intratracheally, the depth of FOB (with its light "Off") was then adjusted. The distance between swivel connector and the beginning of trachea (i.e., FOB tip positioned as described above) was recorded. After the measurements, the surgery was allowed to start. Throughout the procedure, controlled ventilation was carried using oxygen-nitrous oxide mixture with isoflurane.

Glycopyrrolate and neostigmine were used to reverse the residual neuromuscular blockade, at the end of surgical procedure. All the patients were monitored using pulse oximetry, Electro-cardiography (ECG), capnography and non-invasive blood pressure measurements.

For correlating various distances and patient factors and Pearson correlation coefficient was calculated, correlation-regression analysis was done. To find out the *P* value, standard tests of significance were applied. $P<0.05$ was considered as significant.

Results

Table 1 shows the demographic distribution in the study; age in years was 32.58±13.89 in males and 30.89±7.77; weight in kgs was 54.29±6.39 in males, 51.82±11.55 in females; height in cms was 153.99±4.21 in males and 150.18±5.87 in females; BMI was 21.59±1.99 in males and 22.55±3.69 in females; arm span in cms was 165.37±5.00 in males and 159.27±6.44; VC length was 70.28±6.35 cms in males and it was 64.66±5.33.

Table 2 shows that airway distance from lip to carina was 22.38±2.59 cms in males and 20.92±3.55 cms in females; airway distance from lip to cricotracheal membrane was 13.67±0.59 cms in males and 11.99±1.66 cms in females; airway distance from cricotracheal membrane to carina was 9.10 ±6.58cms in males and 9.37±0.22cms in females; airway distance from endotracheal tube tip-carina was 3.21±1.11 cms in males and 2.22±2.58 cms in females; airway distance from lip to endotracheal tube tip was 21.29±1.08 cms in males and 18.39±3.33 cms in females.

Table 1: Demographic distribution in the study

Demographics	Male {Mean(SD)}	Female {Mean(SD)}
Age (Years)	32.58 (13.89)	30.89 (7.77)
Weight (Kgs)	54.29 (6.39)	51.82 (11.55)
Height (cms)	153.99 (4.21)	150.18 (5.87)
BMI	21.59 (1.99)	22.55 (3.69)
Arm span (cm)	165.37 (5.00)	159.27 (6.44)
VC length (cm)	70.28 (6.35)	64.66 (5.33)

SD: Standard Deviation; BMI: Body mass index; VC: vertebral column.

Table 2: Airway distances.

Airway distances (cms)	Male {Mean(SD)}	Female {Mean(SD)}
Lip to carina (L-C)	22.38 (2.59)	20.92 (3.55)
Lip to cricotracheal membrane (L-CT)	13.67 (0.59)	11.99 (1.66)
Cricotracheal membrane to carina (CT-C)	9.10 (6.58)	9.37 (0.22)
Endotracheal tube tip-carina (ET-C)	3.21 (1.11)	2.22 (2.58)
Lip to endotracheal tube tip (L-ET)	21.29 (1.08)	18.39 (3.33)

Table 3: Correlation of patient factors with airway distances

Factors of patients (Pearson correlation) P value	Total airway length (L-C)	Upper airway length (L-CT)	Lower airway length (CT-C)
Height (cm)	0.600 (0.000)	0.522 (0.000)	0.231 (0.001)
Weight (Kgs)	0.077 (0.063)	0.118 (0.051)	-0.004 (0.896)
Arm Span (cms)	0.521(0.000)	0.417 (0.000)	0.190 (0.005)
VC length (cms)	0.509 (0.000)	0.450 (0.000)	0.214(0.000)
BMI	-0.201(0.055)	-0.059 (0.366)	-0.110(0.100)

Table 3 shows that various airway distances in males and females were correlated with patient factors separately. The total airway length (L-C), lower airway length (CT-C) were significantly correlated with height, arm span, vertebral column length ($P<0.05$), but the correlation with upper airway length (L-CT) was not statistically significant. In females, both total and upper airway length was significantly correlated with height, arm span, vertebral column length. In case of BMI and airway distances, it was statistically insignificant in both males and females. It was found that the total and upper airway length correlated significantly with height, arm span and vertebral column length ($P<0.01$), when the various patient factors were correlated with airway lengths in all patients (males and females together). The coefficient of correlation was much less suggesting a poor correlation, the lower airway length was also found to have a statistically significant correlation with height, arm span and vertebral column length . BMI and airway distances were not found to be correlated.

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Discussion

In the present study, the demographic distribution in the study; age in years was 32.58±13.89 in males and 30.89±7.77; weight in kgs was 54.29±6.39 in males, 51.82±11.55 in females; height in cms was 153.99±4.21 in males and 150.18±5.87 in females; BMI was 21.59±1.99 in males and 22.55±3.69 in females; arm span in cms was 165.37±5.00 in males and 159.27±6.44; VC length was 70.28±6.35 cms in males and it was 64.66±5.33. The airway distance from lip to carina was 22.38±2.59cms in males and 20.92±3.55 cms in females; airway distance from lip to cricotracheal membrane was 13.67±0.59 cms in males and 11.99±1.66cms in females; airway distance from cricotracheal membrane to carina was 9.10 ±6.58cms in males and 9.37 ±0.22cms in females; airway distance from endotracheal tube tip-carina was 3.21±1.11 cms in males and 2.22±2.58 cms in females; airway distance from lip to endotracheal tube tip was 21.29 ±1.08 cms in males and 18.39 ±3.33 cms in females. The various airway distances in males and females were correlated with patient factors separately. The total airway length (L-C), lower airway length (CT-C) were significantly correlated with height, arm span, vertebral column length ($P<0.05$), but the correlation with upper airway length (L-CT) was not statistically significant. In females, both total and upper airway length was significantly correlated with height, arm span, vertebral column length. In case of BMI and airway distances, it was statistically insignificant in both males and females. It was found that the total and upper airway length correlated significantly with height, arm span and vertebral column length ($P<0.01$), when the various patient factors were correlated with airway lengths in all patients (males and females together). The coefficient of correlation was much less suggesting a poor correlation, the lower airway length was also found to have a statistically significant correlation with height, arm span and vertebral column length . BMI and airway distances were not found to be correlated.

Manu Varshney et al. [6]; conducted a prospective study on 200 ASA I and II patients requiring general anaesthesia and orotracheal intubation. The power of the study is 0.9. Mean (SD) and median (range) of various parameters and Pearson correlation coefficient was calculated. The mean (SD) lip-carina distance, i.e., total airway length was 24.32 (1.81) cm and 21.62 (1.34) cm in males and females, respectively. With black mark of ET between vocal cords, the mean (SD) ET tip-carina distance of 3.69 (1.65) cm in males and 2.28 (1.55) cm females was found to be considerably less than the recommended safe distance. It concluded that fixing the tube at recommended 23 cm in males and 21 cm in females will lead to carinal stimulation or endobronchial placement in many Indian patients. The lip to carina distance best correlates with patient's height. Positioning the ET tip 4 cm above carina as recommended will result in placement of tube cuff inside cricoid ring with currently available tubes.

Juan Camilo Gomez et al. [7]; conducted a study to determine the optimal insertion length of endotracheal tubes in female and male adults

according to their height. Height and mouth-carina distance showed a direct and statistically sig- niûcant correlation. Two equations for estimating optimal endotracheal insertion length were obtained, according to sex: men = 11.413 + (0.072 × height in cm) 3; and women = 13.555 + (0.056 × height in cm) 3.

Techanivate A et al [8]; conducted a prospective study of 100 patients who underwent general anesthesia with oral endotracheal intubation. The cuff of the endotracheal tube was placed 2 cm below the vocal cords. The positions of the endotracheal tube tip and the airway distances of the patients were measured by fiberoptic bronchoscope; OC= the distance from the right upper canine to the vocal cords, NC= the distance from the right external naris to the vocal cords and T= the distance from the vocal cords to the carina. The correlation between the airway distances and patient's factors were analyzed. The proper depth of placement of the endotracheal tube was calculated with the formula OTT = OC+T-2, nasal endotracheal tube NTT= NC+T-2. The mean distance from the endotracheal tube tip to the carina was 3.0 +/- 1.48 cm (ranged 0.7-7.5 cm). The distance from the endotracheal tube tip to the carina of 86 from 100 patients was more than 2 cm. The mean OC was 9.79 +/- 1.27 cm. The mean NC was 15.00 +/- 0.84 cm. The mean T were 13.03 +/- 1.48 cm in males and 11.63 +/- 1.25 cm in females and it also related to the height of the person (Pearson correlation = 0.557, p value < 0.05). These distances did not relate to gender.

Sharma K et al. [9]; Following successful placement of a tracheal tube (TT), it is frequently moved from the midline to the angle of the mouth. This study investigates the tracheal tube tip position in the two fixation positions in 200 adult patients. Following tracheal intubation, a fibreoptic bronchoscope (FOB) was introduced through a swivel connector and the distances from the swivel connector to the lips, carina, tip of TT and the cricotracheal membrane were measured with the TT in the midline and at the right angle of the mouth. The mean (SD) TT tip to carinal distance decreased from 3.60 (1.50) cm to 2.28 (1.55) cm in female patients, and 5.04 (1.43) cm to 3.69 (1.65) cm in male patients on moving the tracheal tube to the angle of the mouth. We conclude that there is a significant movement of the tracheal tube towards the carina on moving the TT from midline to angle of mouth and the depth of insertion of the tube should be adjusted accordingly.

Cherng CH et al. [10]; conducted a prospective study in 293 ASA physical status I and II patients (150 male and 143 female), requiring general anesthesia and orotracheal intubation. The length from carina to vocal cords, vocal cords to right mouth angle (corner), and carina to right mouth angle were measured. The optimal ETT tip was defined as 5 cm above the carina. Patient's height and sternum length were recorded. The correlation between airway length and body height was significant. By linear regression, a formula was obtained to estimate the optimal ETT length in orotracheally intubated patients: the length from 5 cm above carina to right mouth angle (cm) =< body height (cm)/5> - 13.

Conclusion

This study concludes that patient's height correlates the best with the length of the airway. In Indian population, the mean airway distances were smaller so that the average depth of fixation was easier from right angle of mouth. To place the distance markers at 2 and 4 cms from the proximal edge of the cuff, the endotracheal tube manufacturers were requested to shorten the proximal cuff to endotracheal tube tip distance to avoid the tube cuff placement inside the cricoid ring by shortening the tracheal cuff.

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