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DETERMINANTS OF ORAL ENDOTRACHEAL TUBE PLACEMENT: A CROSS SECTIONAL STUDY

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ABSTRACT

Introduction: Finding the best depth of endotracheal tube (ET) placement has been a challenge because of the complications caused due to its malposition.

Aims: To find the best depth of placement of oral ET in Indian adult patients.

Methods And Design: This study was conducted in 125 ASA I and II patients requiring general anaesthesia and orotracheal intubation.

Methods: After placing the ET with the designated black mark at vocal cords, various airway distances were measured from the right angle of mouth using a fibre optic bronchoscope.

Statistical Analysis: Mean (SD) and median (range) of various parameters and Pearson correlation coefficient was calculated.

Results: The mean lip-carina distance, i.e., total airway length was 23.52±1.72 cm and 22.11±1.26 cm in males and females, respectively. With black mark of ET between vocal cords, the mean ET tip-carina distance of 4.19±1.60 cm in males and 2.78±1.52 cm females was found to be less than the recommended safe distance.

Conclusions: Height has the best correlation to lip to carina distance. Fixing the tube at recommended distances in both male and female will lead to carinal stimulation or endobronchial placement in many Indian patients. The formula "(Height in cm/7) -2.5." gives us an idea about the approximate depth of ET placement.

KEYWORDS : Carina, endotracheal intubation, general anaesthesia, tracheal length

INTRODUCTION

In the field of anaesthesiology, endotracheal intubation is perhaps the most significant and usually performed procedure. It is also considered as the most common procedure in emergency medicine and critical care. One of the significant concerns while inserting an ET is its correct and appropriate depth of placement to avoid major complication related to misplacement.[1] If the ET tube is too deeply placed, it can cause intrusion into the carina and thus sympathetic stimulation leading to hypertension, tachycardia and/or bronchospasm. Besides this endobronchial intubation can cause hyperinflation of the intubated lungs, thereby increasing the vulnerability to pneumothorax.

Simultaneously, collapse leading to hypoxemia may be caused due to poorly ventilated lungs and if the length of ET post vocal cord is too short, this may cause intrusion of the cuff on the vocal cord during inflation. This can cause sympathetic stimulation such as trauma, increased risk of accidental extubation and reiteration of laryngeal nerve compression.[2,3]

Different procedures have been portrayed to affirm the extent of ET placement constituting cuff palpation in suprasternal notch, chest X-rays, fibre optic bronchoscopy etc. Out of this, fibre optic bronchoscopy is most reliable. Due to viability and ease of execution, 5-point auscultation is the most commonly used in securing ET positions.[4,5,6]

Standard textbooks of anaesthesia, it has been considered that the length of ET placement from focal incision should be 23 cm and 21 cm in adult males and females respectively.[7,8] Conventional method of ET placement suggests that the proximal part of the cuff should be at least 1.5 to 2.5 cmaway from the vocal cord or the tip should be 4 cm away from the carina.[8] Some researches have been carried out over the correct depth of placement of ET, as the length of trachea and distance from teeth to vocal cord varies in population.

Considering a fixed length of ET placement can cause endobronchial intubation or endolaryngeal placement of cuff in the patients.[9-11] Hence, there is no proper study or investigation which can state the correct depth of placement of ET in Indian population and its interconnection with in numerous physical parameters. Consequently, this logical investigation was led with the point of deciding the standard depth of ET placement in Indian population and its relation with variation in body, size and length.

Methods

A study was carried out over 125 ASA grade I and II adults who were assigned for elective surgery under general anaesthesia necessitating orotracheal intubation. Written informed consent was obtained from the patients, and approval was obtained from the institutional board. Patients with any anatomical airway defects such as swelling or deformity in the oral, pharyngeal, laryngeal region and swelling or contractures in the neck or needed the use of flexo metallic or performed tubes were excluded from the study. The patient's physical status, such as height, weight, age, arm span, and vertebrae column length (from the external occipital protuberance to the tip of the coccyx), was recorded. 0.5 mg/kg pethidine was administered after securing the intravenous line, and then induction of general anaesthesia was done by using 0.5 mg/kg thiopentone sodium I.V. 0.1 mg/kg vecuronium bromide was administered to facilitate tracheal intubation. The standard size of ET was selected for tracheal intubation that is 8.0 - 9.0 mm I D for male patients and 7.0 or 7.5 mm I D for female patients.

The tube of ETT was placed in such a way that the cuff disappeared after passing the vocal cords, and the black mark lay between the vocal cords. The ET was secured by tape at the right angle of the mouth, and the head position was made neutral. Appropriate placement of ET was confirmed by 5-point auscultation and capnography after securing the breathing circuit. As the anaesthesia was continued, and swivel connector with a port for fibre optic bronchoscopy (FOB) was attached to the machine end of ET. After introducing FOB into the ET through a swivel connector, the following distances were measured using a tape having 1 mm markings:

(a) Swivel connector to the carina (end of trachea) (C):- The tip of the FOB was kept at the level of tracheal carina, this distance was calculated subtracting the length of FOB insertion cord above the swivel connector from the total length of the FOB insertion cord.

(b) Swivel connector to the tip of endotracheal tube:- This distance was calculated by subtracting the length of FOB insertion cord above the swivel connector from the total length of the FOB insertion cord as it is taken from the tip of FOB at the level of the tip of ET.

(c) Swivel connector to the lips (L):- This distance was calculated by subtracting the length of FOB insertion cord above the swivel connector from the total length of the FOB insertion cord as it is taken from the tip of FOB at the level of the lower lip.

(d) Swivel connector to beginning of trachea (CT):- FOB was pulled out of trachea till the black mark on ETT was just seen through FOB for the measurement of the distance. Then the FOB light was switched off. A sharp light was then placed externally at the cricotracheal membrane

(the beginning of the proximal end of trachea). As the light was off, the length of FOB was adjusted to see extratracheal light which can be best seen intratracheally. As the surgery was started, after measurement of distance between the swivel connector and the beginning of trachea (i.e. FOB tip positioned as described above), oxygen - nitrous oxide mixture with isoflurane was used for ventilation throughout the procedures. For inversion of residual neuromuscular blockade at the endof the surgical procedures, glycopyrrolate (10 µg/kg) and neostigmine (50 µg/kg) were used. For sharp light Trachlight™ Laerdal Medical AS from Norway was used.

A controlled environment was provided to all the patients and they were carefully monitored using electrocardiography (ECG), capnography, pulse oximetry and non-invasive blood pressure measurements.

The sample size of 125 was determined. The data were analysed using statistical software "SPSS 12.0" and mean (SD) and median (range) of various parameters were calculated. Correlation analysis was done for correlating various distances and patient factors and Pearson correlation coefficient was calculated. Standard tests of significance were applied to find out the P value. P<0.05 was considered as significant.

RESULTS

The study group of 125 adult patients comprised of 95 females and 30 males. The mean (SD) age was 41.37 (15.16) years and 39.21 (7.51) years for males and females, respectively. The mean height (SD) was 164.30 (6.90) cm and 151.49 (5.95) cm for males and females, respectively. The mean weight (SD) for males and females, respectively was 54.54 (8.02) kg and 51.24 (11.21) kg. Arm span was 167.78 (4.82) cm and 155.19 (6.10) cm for males and females, respectively. Mean vertebral column length was 71.90 (4.33) cm for males and 66.63 (4.51) cm for females [Table 1].

The Airway distances measured in males and females are shown below [Table 2]. Patient factors were correlated with various airway distances in males and females separately. In males, total airway length (L-C) and lower airway length (CT-C) were found to be significantly correlated with height, arm span and vertebral column length (P<0.05), but the correlation with upper airway length (L-CT) was not statistically significant. However, in females, both the total as well as upper airway length were found to be significantly correlated with height, arm span and vertebral column length (P<0.05).

The correlation between body mass index (BMI) and airway distances was statistically insignificant in both the genders. When the various patient factors were correlated with airway lengths of the total subject pool, it was found that the total and upper airway length correlated significantly with arm span, length of vertebral column and height (P<0.01). The lower airway length was also found to have a statistically significant correlation with height, arm span and vertebral column length.

Pearson's correlational coefficient had low values suggesting a poor correlation [Table 3]. BMI and airway distances were not found to be correlated.

Table 1

Patient statistics		
Patient factors	Male mean ±SD	Female mean ±SD
Age (yrs)	41.37 ±5.16	39.21±7.51
Weight (kg)	54.54±8.02	51.24±11.21
Height (cm)	164.30±6.90	151.49±5.95
BMI	20.26±2.39	21.80± 4.49
Arm span (cm)	167.78±4.82	155.19±6.10
VC length (cm)	71.90±4.33	66.63±4.51

SD: Standard deviation; BMI: Body mass index; VC length: Vertebral column Length

Table 2

Airway distances among males and females		
Airway distances (cm)	**Male mean ±SD**	**Female mean ±SD**
Lip to carina (L−C)	23.52±1.72	22.11±1.26
Lip to cricotracheal membrane (L−CT)	13.94±1.45	12.05±1.37
Lip to endotracheal tube tip (L−ET)	20.98±1.44	19.30±1.04
Endotracheal tube tip−carina (ET−C)	4.19±1.60	2.78±1.52
Cricotracheal membrane to carina (CT−C)	10.45±1.16	9.15±0.99

SD: Standard deviation; L-C: Total airway length; L-CT: Upper airway length; L-ET: Lip to endotracheal tube tip; CT-C: Lower airway length

Table 3:

Correlation Of Patient Factors With Airway Distances In All Patients			
Patient factors	Total airway length (L−C)	Upper airway length (L−CT)	Lower airway length (CT−C)
Height (cm)	0.591**	0.613**	0.332**
Arm span (cm)	0.459**	0.410**	0.321**
VC length (cm)	0.511**	0.312**	0.156**
Weight (kg)	0.082	0.165	-0.0161
BMI	-0.285	-0.090	-0.115

**Correlation is significant at the 0.01 level (2-tailed); BMI: Body mass index; VC length: Vertebral column length

DISCUSSION

The cuff of the ET should be distal to the cricoid ring to prevent damage to vocal cords and inadvertent extubation.[12,13] The best placement of an ET aims to achieve a situation where the tip of the tube is at some distant from carina. This is done to avoid endobronchial intubation, especially during movement of head and neck.[14]

In this study the measurement is the anatomical distance between the crirotrachea to the carina along the trachea. The cricotracheal membrane provides a good reference point to measure the true tracheal length in the study population. It was also aimed that the cuff of the endotracheal tube should be beyond cricoid to protect the recurrent laryngeal nerve and vocal cords from damage.

Cricoid being a complete ring structure mucosal ischemia due to pressure could be much higher. Most of the previous works have taken vocal cords as reference for measuring tracheal length. This could be attributed to either the ease of measuring the distance from vocal cords or because therewas no practical method of locating cricotracheal membrane.[9,11,12] Ina study be Chong et al. gave some reason of choosing vocal cord carina distance as that it is this part of the airway which accommodates the ET from black mark(s) to the tip and thus is important during clinical airway management.[11]

Previous works and textbooks give us an idea that the mean distance from lip to carina and the trachea in Indian population is shorter. The practice of placing the ET at 23 cm in males and 21 cm in females results in impingement of the carina and endotracheal intubation in Indian patients. ET is usually fixed at the right angle of mouth a shorter distance, as compared to the midline recommendation which has been used to measure this depth.[15] Thus, the use of this recommendation increases the chances of endotracheal intubation.

Goodman et al. have recommended that the mean endotracheal tip to carina distance that prevents carinal impingement and endobronchial intubation is to be 4 cm (a range of 3–5 cm).[16] This is also recommended in different anaesthesia textbooks that the ET tip to carina distance should be a minimum of 4 cm. [7,8] Result analysis of this study shows that even with our current depth of fixation being 20.98 cm in males and 19.30 cm in females, the ET tip to carina distance was 4.19 cm and 2.78 cm in males and females, respectively. The ET tip was endobronchial in 5/95 female patients at this depth of fixation. This implies that a considerable number of patients may have been prone to endobronchial shift or carinal impingement of the tube.

Various patient factors were correlated to airway distances. The lip to carina distance correlates best with patient's height [Table 3]. The lip to carina distance also correlates with the vertebral column length and arm span. In females, however, the correlation between upper airway length and patient factors was found to be best with height followed by vertebral column length followed by arm span. Techanivate et al. found poor correlation between height and upper airway length and a moderate correlation between height and vocal cords to carina distance.[10] They also discussed about "Chula formula" based on height

to estimate adequate depth of insertion of ET. The upper airway length seems to have moderate correlation with patient's height in the male subjects. The could due to the small sample size of male patient. A larger sample size could predict the degree of correlation better.

Chong et al. found statistically significant correlation between vocal cord to carina distance and patient's height and thyrosternal distance in their study.[11] They developed a formula to predict this distance. The differences in the way the airway distances are measured in our study as compared to the previous studies it will be unrealistic to use the same formule or even compare them. This is also due to the difference between the races in the study.

The earlier discussion that the depth of placement of ET is better when the tip of endobronchial tube rests approximately 3-5 cm proximal to carina.[7,8,16] This is recommended keeping in mind to keep sufficient distances to prevent injuries and complications associated with movement of head, neck and patient position. The adequate depth of ET tip in Indian patients from right angle of mouth can be estimated by the following formula (simplified):
Adequate depth of endotracheal tube = {Height (cm)/7} – 2.5

This formula can guide optimal depth of placement of oral ET with tube tip 3 cm above carina in adult Indian population. The mean height in sample population was 164.30 cm in males and 151.49 cm in females. Accordingly, the average depth of fixation of oral ET should be 19.85 cm in males and17.70 cm in females from right angle of mouth. Other studies have also reported various formulae.[2,17]

The cuff should be below cricoid for its better placement. It seems prudent to avoid the cricoid as this part of the airway is a complete ring as opposed to the trachea which has a membranous posterior wall that may act to relieve the pressure of an over-inflated tracheal tube cuff. To understand the association between the position of proximal edge of the cuff and the cricoid, tracheal tubes considered in this study, i.e., 7.0, 7.5, 8.0, 8.5 mm ID (Romsons Surgical Ltd., Agra, India), were studied. It was found that the proximal edge of the cuff was at 6.0 cm from the ET tip. This was same for every size used (7.0-8.5 mm ID). The size used in this study are the commonest sizes used in adult in India for orotracheal intubation. If the tip of ET is placed 4 cm above carina, then the proximal part of the cuff will lie 10 cm above carina. But, the mean tracheal length of our study subjects was found to be 10.45cm in males and 9.15 cm in females. This gives us an idea that the cuff would be lying within the cricoid ring in most of the patients. The recommendation is to place the proximal part of the cuff 1.5 to 2.5 cm from vocal cords.[8] Cavo recommended placement of a guide mark on ET at 1.5 cm above the proximal end of cuff to prevent damage to vocal cords and anterior branch of recurrent laryngeal nerve.[13] Mehta et al suggested to place the depth mark at 2.5 cm for males and 2.25 cm for females above the proximal end of cuff.[14] In a study done by Hartrey and Kestin they recommended that this guide mark be placed 3 cm above proximal end of cuff and approximately 8 cm from ET tip.[18] This placing of the tube will ensure the correct and safe placement of the tip of ET tip and will avoid carinal impingement and endobronchial migration, especially during head and neck movement, creation of pneumoperitoneum and Trendelenburg position.

However, this might lead to a higher risk of pressure on cricoid by the proximal part of cuff due to “tip to proximal edge of cuff distance” given on the available tubes. [19,20]

CONCLUSION

The height of the subject has the best correlation with the length of the airway among the subjects of this study. There is also evidence that mean airway distances are smaller in the Indian population as compared to previous studies. Thus, manufacturers should modify the device used to a smaller length.

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