Int. J Med. Pharm. Res.
P-ISSN: 2958-3675 | E-ISSN: 2958-3683
Available on: https://ijmpr.in/

International Journal
of Medical and
Pharmaceutical Research

ORIGINAL ARTICLE OPEN ACCESS

Evaluating the Effect of Patient Height on Optimal Endotracheal Tube Depth in Orotracheal Intubation: Insights from a Descriptive Study in India

Dr. Debjyoti Mandal[1]; Dr Subrata Pahari[2]

[1]Senior Resident, Department of Anaesthesiology, Bankura Sammilani Medical College, Bankura
ORCID ID: https://orcid.org/0000-0003-2643-4037
[2]Professor, Department of Anaesthesiology, Bankura Sammilani Medical College, Bankura

OPEN ACCESS

Corresponding Author
Dr. Debjyoti Mandal
Senior Resident, Department of Anaesthesiology, Bankura Sammilani Medical College, Bankura

Received: 19-06-2025
Accepted: 25-07-2025
Available Online: 12-08-2025

ABSTRACT

Background and Aims: Placing an oral endotracheal tube (ETT) accurately is always a challenge; however, achieving proper placement can reduce the risks associated with malposition.
This study aimed to assess the precision of inserting cuffed oral ETTs to the appropriate depth among Indian adults, focusing on how patient height influences this, according to standard guidelines.
Methods: 240 adults aged between 20 to 60 years of both genders who required endotracheal intubation in operating rooms or were already intubated for various reasons and admitted in a tertiary care hospital while excluding individuals with haemodynamic instability or upper airway deformities. Following standard protocols, oral ETT intubation was performed securing ETT at incisors, and ETT tip to Carina distance was measured. The study's power was maintained at 0.95. Microsoft Excel 2016 was used to analyze the collected data using both descriptive and inferential statistical tests.
Results: Only 60% of the ETTs were positioned correctly. Majority of the misplaced ETTs (40%) were positioned too deeply (36%). The equation, depth of ETT placement = [0.22×Height (cm) - 14.5], can aid in ideal placement of oral ETT with the tube tip safely above the carina in Indian adult patients.
Conclusions: Conventional ETT placement guidelines at incisors don't meet Indian community. ETT placement correlates positively with patient height. Placing ETT at 20 cm and 22cm in females and males respectively will meet majority of people in Eastern India. We suggest to implement our equation over diverse demographics to aid in ETT placement to correct depth.

Keywords: *Intubation, Intratracheal, Adult, Incisor, Trachea, Endotracheal Tube*

INTRODUCTION:

Placing a specific tube into the trachea to keep the airway open is known as endotracheal intubation. This method is widely used in anaesthesiology, emergency medicine, and critical care. The "gold standard" for securing and safeguarding a patient's airway [1] to this day is still an endotracheal tube (ETT) with cuff. Every anaesthesiologist in practice must be able to correctly place an oral ETT. Given the serious consequences of improper placement, one of the main issues while securing an oral ETT is ensuring that it is positioned correctly and appropriately. Vocal cord paralysis, endobronchial intubation, accidental extubation, collapsed lung, hypoxaemia, pulmonary barotraumas, [2] and other severe problems might result from improper ETT placement. Black mark(s) given proximal to the cuff and kept at cord level aid in determining the right depth of ETT insertion to avoid the aforementioned issues. The intratracheal ETT insertion at the bedside can be verified utilising an array of clinical measures;[3] however, while these tests are helpful in ruling out oesophageal intubation, they are unable to precisely anticipate the extent of an ETT's placement into the trachea. There appears to be a favourable association between height and airway length, as evidenced by the limited research conducted to establish the proper depth of introduction of ETT both orally and nasally [4-6] There isn't a study that looks into the proper depth of ETT placement in Indians living in the country's eastern region and how it relates to

different physical characteristics, though. Our study aims to assess correctness of depth of tube placement following conventional method and influence of patient height on accurate depth of oral ETT placement among population residing in Eastern Part of India.

Subjects and Methods:

This scientific investigation was therefore carried out to describe the precision of positioning oral cuffed ETTs to the appropriate depth depending on customary procedures and finding out the ideal depth of ETT implantation in the adult Indian population and how it relates to height. The Institutional Ethics Committee granted authorization for this descriptive cross-sectional study to be carried out in a medical college and tertiary care hospital. The study's inclusion and exclusion criteria were used to determine the patients' eligibility. With the exception of patients with haemodynamic instability and anatomical abnormalities of the face, cervical region, or upper airway, this study involved 240 people between the ages of 20 and 60 who required endotracheal intubation in operating rooms or who were previously intubated for whatever reason while in the critical care unit. In this regard, written informed consent was obtained. The patient was placed in the traditional "morning sniffing position" with a tiny pillow beneath the occiput after non-invasive monitors including an ECG, non-invasive blood pressure monitoring, pulse oximetry, and end-tidal CO2 analysis were connected. According to conventional procedures,[7] the ETT of the appropriate size was placed over the central incisors following orotracheal intubation.

Next, the patient was positioned with their head in a neutral posture over the surgical table. Following confirmation of the ETT's intratracheal placement by the presence of mist within it, the breathing circuit with capnography was attached, the chest rise was examined, and the chest and belly were auscultated. Anaesthesia continued while a swivel connector with a fiber optic bronchoscope (FOB) port was connected to the machine end of the ETT. After a few minutes of anaesthetic delivery and haemodynamic variability stabilization, a swivel connector was utilized for inserting the FOB within the ETT and roughly matched with the carina.

The FOB was retracted 5cm from the same, and the tip of the ETT was then examined. ETT stayed the same as such if the tip was either ≤2 cm ahead of the FOB tip or at level and mark on the ETT over the upper incisors was noted. In order to validate Goodman's criteria,[8] the ETT positioned 4 cm from the carina if tip was not glimpsed or more than 2 cm forward of the FOB tip; marking over ETT at incisor level recorded. In a similar manner, for patients in the critical care unit who had previously been intubated for any reason, the ETT was fixed at the midline over the central incisors in accordance with standard protocols, the patient's oral suction was completed thoroughly, and the procedure was carried out under close supervision after the patient's haemodynamic stability was evaluated clinically. The machine end of the ETT had a swivel connector with a fiber optic bronchoscope (FOB) port connected. The remaining processes were identical to those stated previously. An assistant monitored the entire procedure to make sure there was no unwanted movement of the ETT during that time, and the movement of the FOB in either direction was determined by its marking at the swivel adaptor level. The study's power was set at 0.95, and 240 people were chosen, evenly divided between males and females aged 20 to 60, eliminating the need for a control group. Microsoft Office 2016 was used to tabulate the data and analyze it using both descriptive and inferential statistical tests. To check for normality in the distribution pattern of the continuous variables, the Kolmogorov Smirnov test was conducted beforehand. Patient age, patient height, and the distance of the ETT tip above the carina were all continuous variables with normal distribution. The sole continuous variable that did not follow a normal distribution was the ETT marking, as measured at the upper central incisors. Means and standard deviations were used to characterize normally distributed continuous variables, whereas medians and inter-quartile ranges were used to characterize non-normally distributed ones. The p-value was determined using standard tests of significance, with $p<0.05$ being deemed significant. Several linear regression equations were estimated and a Pearson correlation analysis was performed to predict the ETT location at midline with the assurance of a safe ETT tip-carina (TC) distance taking the patient's height into account.

Results:

Among 240 patients who agreed to participate in the study, 120 (50%) were female and 120 (50%) were males. Patient demographics and comparison of the ETT tip distance measured above the carina in the male and female patient groups are described in Table 1.

Table 1.

Variables	Measurement	Males	Females	p-value
Age	Mean ± SD	39.33 ± 11.43	41.25 ± 10.87	0.082487
	Range	20-60	20-60	
Height	Mean ± SD	165.88 ± 4.69	156.41 ± 5.21	1.11698E-35
	Range	154-180	145-173	
ETT tip to carina	Mean ± SD	3.89 ± 1.18	3.14 ± 1.12	3.45262E-07
	Range	1.2-6.9	0.5-5.8	

An unpaired t-test was used for this comparison showing significant difference in distance between Carina to ETT tip. Table 2 describes correctness of depth of tube placement in adults following conventional method and to compare this between male and female patients.

Table 2.

ETT placement	Male	Female	Total	p-value
Correct	80	64	144	
Incorrect	40	56	96	< 0.05
Total	120	120	240	

The accuracy of anaesthetists at placing ETTs to correct depth or in other words describing correctness of depth of tube placement among males and females were compared using a Chi-square test. [χ^2 (1, n=240) =6.9272, P=0.0313] Overall accuracy of placing ETT was 60% (n=144). Of the remaining 40% (n=96) of misplaced ETTs, the majority (91%, n=87) were placed too deep. When number of accurately placed ETT were compared using Chi-square test that showed statistical significance (P=0.0313), it revealed that higher fraction of male patients (67%, n=80) had accurately placed ETT compared to female patients (53%, n=64). The number of deep ETT misplacement was significantly higher in the female group (61%, n=53 vs. 39%, n=34) whereas shallow misplacement occurred mostly in males (67%, n=6 vs. 33%, n=3).

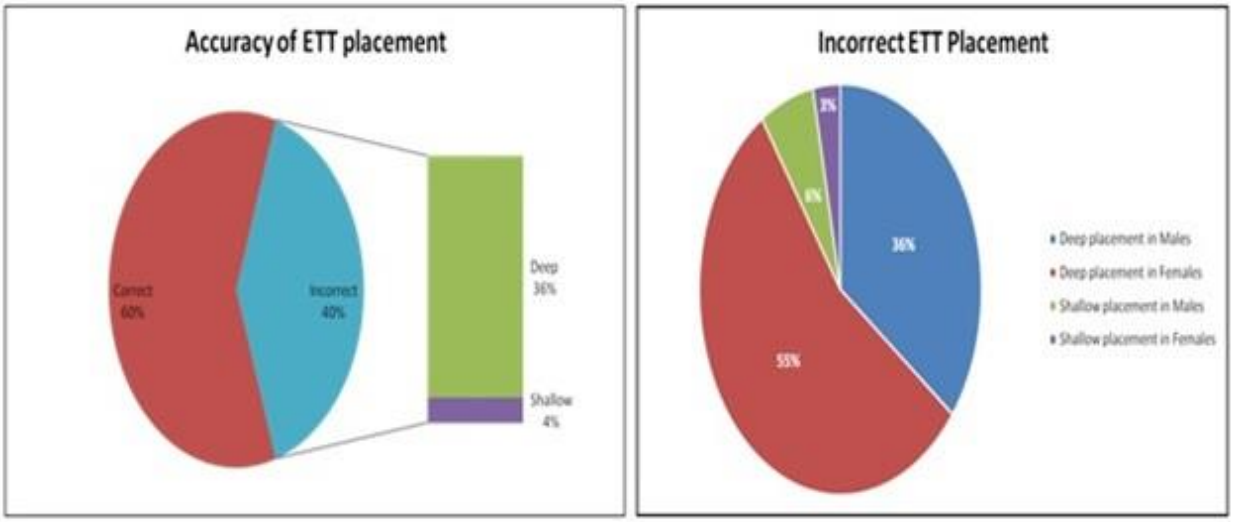

Figure 1. Pie Chart describing accuracy of ETT placement and distribution of Incorrect ETT placement among the study population

Table 3 has been designed to establish influence of patient height on accurate depth of oral ETT placement.

Table 3.

ETT placement	Height/Length(cm)	Tip to Carina distance(cm)	p-value
Correct	163.38 ± 5.53 149 – 176	4.11 ± 0.70 3.0 - 5.0	< 0.05
Deep	156.23 ± 5.41 145 – 168	2.26 ± 0.59 0.5 - 2.9	< 0.05
Shallow	173.55 ± 5.00 164 – 180	5.99 ± 0.54 5.2 - 6.9	< 0.05

Using an ANOVA test, a significant difference was found in the patient heights between the accurate, too deep and too shallow groups. Henceforth, we can say that patient height has significant influence on accurate depth of oral ETT placement.

For the prediction of the length of ETT insertion and fixation over central incisors correlating with the height of the patient irrespective of gender, a Pearson correlation analysis was conducted and positive correlation(r=0.771851368) has been noted.

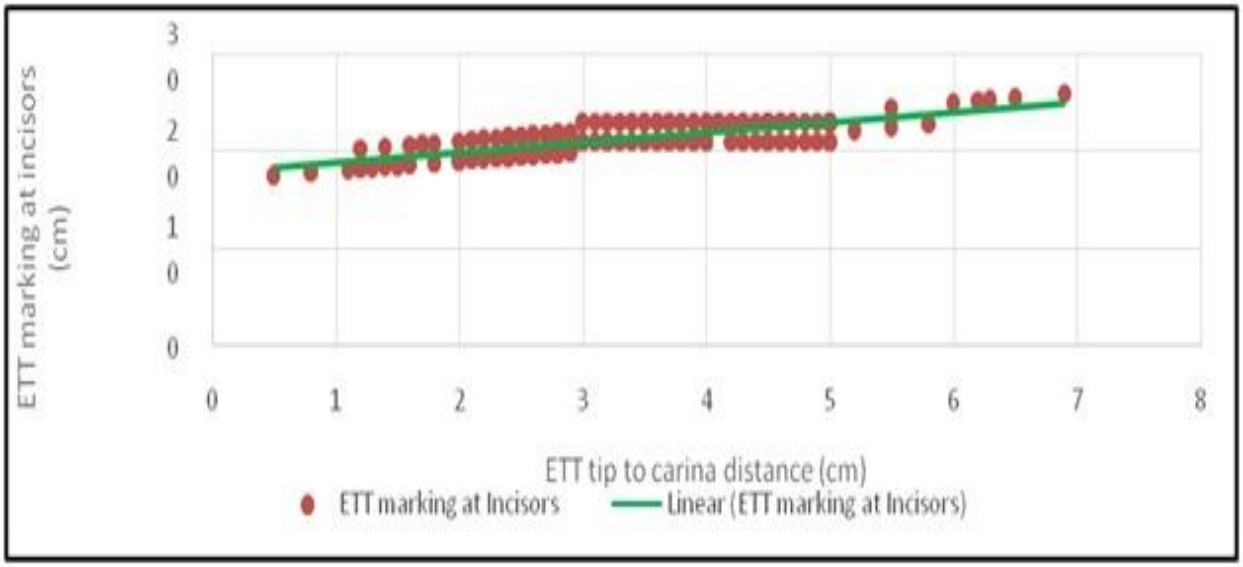

Fig 2. Pearson Correlation analysis between ETT marking at incisors and TC distance

After doing a linear correlation analysis between the airway distance variables and height, a direct and statistically significant correlation was found in all cases, for men and women. Without controlling for age and gender, and using height and ETT tip to carina as the independent variables, the following linear regression model was obtained (Table 4) along with its respective prediction equation.

Table 4.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.885322777
R Square	0.783796042
Adjusted R Square	0.781971917
Standard Error	0.742605701
Observations	240

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	473.8111735	236.9056	429.5945	1.51793E-79
Residual	237	130.6967848	0.551463		
Total	239	604.5079583			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-12.00104814	1.144109551	-10.4894	2.16E-21	-14.25497143	-9.747124857	-14.25497143	-9.747124857
Height(cm)	0.2232888	0.007885329	28.31699	5.2E-78	0.207754512	0.238823088	0.207754512	0.238823088
Corrected TC distance	-0.623036496	0.10001356	-6.22952	2.12E-09	-0.820065609	-0.426007382	-0.820065609	-0.426007382

Prediction equations for optimal depth of ETT placement in Indians residing in the eastern zone of India can be formulated as,

ETT marking over central incisors= 0.22× [Height / length (cm)] - 0.62× TC* distance (cm) – 12; * where TC distance refers to ETT Tip to Carina distance

TC distance has been considered as 4 cm as this corresponds, according to the literature, to the minimum distance that the tube should remain away from the carina.[2,8] The predicted length of insertion of ETT over central incisors can be established from the modified equation as:

ETT marking over central incisors = 0.22× [Height / length (cm)] – 14.5

Discussion:

Analysis of the first 2000 reports from the Australian Incident Monitoring Study (AIMS) showed that problems with the ETT accounted for 9% of all incidents reported by anaesthetists. Of these, endobronchial intubation was the most commonly reported incident (42%) and oesophageal intubation accounted for a further 18% of cases.[9] Thus, the correct placement of the tip of the endotracheal tube thus is a vital element in the practice of anaesthesiology and emergency and critical care medicine. Several formulae are there to process ETT placement to safer depth, although most have been validated only for children. The recommendation that in adults an ETT should be placed from 20 to 21 cm at the upper incisors in females, and 22 to 23 cm in males is a good guideline; when applied on our study population resulted in 60% (n=144) having ETT correctly positioned.

There are many factors (age, gender, height to name a few) which determine tracheal length, ETT depth, and therefore this method is not completely reliable. Although there is no concord relating optimal depth for ETT placement in the existing literature, Goodman et al.[8]suggested that in order to prevent endobronchial insertion and carinal contact, the average distance between the carina and endotracheal tip should be between three to five cms.

The study population considered for our study closely resembles to the population considered by Chong et al. [6], Varshney M et al. [10] and Lal et al. [11] who conducted the study over Chinese, Indian and South-east Asian people respectively. Male patients were significantly taller (P <0.0001) and the mean ETT distance measured above the carina was also significantly greater; 3.89 ± 1.18 cm in male patients compared to 3.14 ± 1.12 cm in females. We detected a

general trend in patient height and ETT implantation depth in our study. Patients with deep ETT placement were shorter, whereas ones with shallow ETT placement were taller, indicating a substantial difference from those who had correct ETT placement. This study supports previous studies [5, 6, 10-12] on the optimum length of endotracheal tube insertion for women and men in various circumstances and demographics.

In an attempt to find out relationship if any, between the depth of ETT placement over the incisors and the height of the patient irrespective of gender, a Pearson correlation analysis was conducted and positive correlation ($r = 0.771851368$) has been noted. Patients with deep ETT placement were found to be significantly shorter (156.23 ± 5.41cm) than those with accurate ETT placement (163.38 ± 5.53 cm) [$P < 0.05$], and those with shallow ETT placement (173.55 ± 5.00cm) were found to be significantly taller than the ones who had deep ETT placement (156.23 ± 5.41cm). [$P < 0.0001$]

Varshney M et al. [10], Lal et al. [11] concluded in their study done in 2011 that, among all the patient factors studied, "height of the patient" best correlates with the "airway length." On the note of existence of positive correlation between ETT placement with the height of the patient irrespective of gender and age, a linear correlation analysis among the airway distance variables and height in connection with ETT positioning was sought for.

The average height in sample population was 165.8 cm in males and 156.4 cm in females. Oral ETT should therefore be fixed at the incisors at an average depth of 21.9 cm for males and 19.9 cm for females. The ETT length was determined using the Chula formula [13] which showed 20.6 cm in males and 19.6 in females respectively. Taking into account the shortest adult of our study, a female extending mere 145 cm had deep intubation when fixed at 21 cm over incisors; adjusted to 18 cm with FOB help, compared to 17.5 cm obtained from our equation. Even if ETT placed according the devised formula, we still would have safe ETT tip to carina distance (4.5cm) and the placement can be easily considered to be correct one. Likewise, the longest adult measuring 180 cm had shallow intubation having ETT tip to carina distance nearing 6.9 cm when fixed at 23 cm over incisors; later corrected to 26 cm aided by FOB. However, our equation predicted 25 cm; 1 cm less than actually found by FOB and on execution would have resulted a safe ETT tip to carina distance (5cm). The equation served the median population quite well thus averting the possible complications of ETT misplacement.

Nonetheless, the midline airway distances have been used to recommend the depth of fixation. Compared to midline [14], ET markings rise by one cm when positioned at the right angle of the mouth, which is a shorter distance. Regardless of gender, the research population's ideal tube insertion length would differ by 0.5 cm when the Chula formula [13] and the equation from this investigation are compared.

In agreement with other reports from the literature, the results of this study did not show differences related to sex in relation with the length of the airway; if a man and a woman of equal heights are considered. So, hereafter we can declare that securing ETT at midline over the upper central incisors in accordance to conventional guidelines doesn't cater our Indian population residing in the eastern zone of the country.

It would be desirable to do a follow-up study using a bigger sample size and the suggested equation .The fact that the included males and females represent individuals who were scheduled for surgery during the time allotted for data collection indicates the study's limitation. No further additions were made once the desired sample population was attained, which might have unintentionally left a large range of body heights and lengths.

Conclusion:

The general trend observed with patient height and ETT placement in our study justifies the positive correlation among themselves. Therefore, we can draw an inference that placing ETT at incisor level at 20 and 22 cm in females and males with meet the requirement in majority of the population residing in the Eastern parts of India. This study came up with a formula that can guide proper depth of ETT insertion to ensure optimal ETT tip placement. Henceforth, we would suggest implementing our equation over a large sample of population with diverse demographical parameters to further strengthen our ability to optimally place ETT to the correct depth thereby avoiding the complications associated beforehand. The equation recommended by this study: Adequate depth of endotracheal tube = [$0.22 \times$ Height (cm) – 14.5]

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