Original Research Article

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To Evaluate the Efficacy of Ultrasound in Assessing Subglottic Tracheal Diameter for Endotracheal Intubation

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Abstract

Introduction: This study was conducted to assess the accuracy of ultrasound for estimation of appropriate sized endotracheal tube. *Methods:* Patients underwent preoperative ultrasound examination during pre-anesthetic check up by an Anaesthesia Resident under guidance of an experienced ultra-sonologist. Ultrasound assessment of various diameters of trachea was done and the size of endotracheal tube inserted during surgery was noted. The data was compared with clinically used endotracheal tube size to assess the sensitivity and specificity of ultrasound. Patients were monitored post-operatively over 24 hours for the post-operative complications such as sore throat, laryngeal edema, laryngospasm, nerve injury and aspiration of gastric contents. *Results:* A significantly higher tracheal diameter and ETT size was observed for males than females. The complications reported were Sore throat (8%) and Hoarseness of voice (4%). *Conclusion:* Ultrasonography, is trusted, non-invasive method for pre-anesthetic estimation of the subglottic tracheal diameter selection for clinical use and validated the reliability of ultrasound for subglottic diameter avoiding complications of either trauma or inefficient ventilation.

Keywords: Endotracheal Intubation; Ultrasonography; Subglottic Diameter.

Introduction

Endotracheal intubation, is necessary, for maintenance of airway and adequate ventilation for performing various surgical procedures, without any avoidable complications [1]. The proper size of endotracheal tube is assessed by cricoid cartilage level having narrowest diameter in upper airway [2].

Tracheal tube has been reported to having mechanical burden among spontaneously breathing subjects [3,4,5]. This has additional resistance, and is considered as an important factor for the determination of the work of breathing than the breathing system [6]. The internal diameter (ID) of the tube and its connector is an important factor, which determines the resistance to gas flow [7].

The ideal tube as determined in one of the studies, for a average adult, is 7.5-and 8.5 mm-ID tube for females and males respectively [8]. Correct size of the endotracheal tube is an important aspect among patients because an inappropriately sized tracheal tube can lead to damage to the airway. These complications frequently occur in this area because of the diameter of the upper airway is smallest at cricoid cartilage level [9,10]. Although larger tubes have lesser risk of occlusion and tend to provide lower resistance but they have higher chances of postoperative sore throat, might cause damage to the tracheal mucosa, leads to airway edema, post-extubation stridor, subglottic stenosis because of the pressure of the inflated cuff [11].

Routinely Cuffed tubes are used in adults [12-17]. The cuffed tubes have been improved for

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monitoring the end-tidal gases, tidal volume, compliance, oxygen consumption precisely and are associated with a decreased risk for aspiration; giving capability for using the higher inflation pressures and lower flow of fresh gas; leads to reduction in the pollution of the operating room (OR); lesser fire risk; and requiring lesser tube changes [18-22]. The tracheal tube size is said to be right when the leakage of air around the tracheal tube is determined to be 10–30 cm H_2O [23].

Ultrasonography is a useful non-invasive technique. Among adults [24] and children [25], the visualization of transverse diameter of the trachea can be done by ultrasound. The measurement of the laryngeal lumen by ultrasound during the morphometric measurements have confirmed it to reliable [26,27].

For estimation of the constricted transverse diameter at the subglottic region, ultrasonography could be a relatively much safer, more reliable and non-invasive pain free treatment much more useful for right endotracheal tube size selection [23-28]. Ultasound has the capacity of the detection of the position of the ET tube along with intubation or immediately after the intubation, which is faster than any other method [29]. Therefore, this study was conducted to assess the accuracy of ultrasound for estimation of appropriate sized endotracheal tube.

Materials and Methods

The study was conducted to evaluate the efficacy of ultrasound in assessing subglottic tracheal diameter for endotracheal intubation at Department of Anaesthesiology, Teethankar Mahaveer Medical College & Research Institute, Moradabad for pre-anesthetic checkup for elective surgeries after taking due written informed consent.

The ultrasound examination of these patients was performed at the time of pre-anesthetic check up by an Anesthesia Resident under guidance of an experienced ultra-sonologist. Ultrasound assessment of various diameters of trachea was done and the size of endotracheal tube inserted during surgery was also be noted.

The patients were asked to lie down supine with active maximal head tilt-chin lift (the sniffing position). The probe was then placed in the submandibular area in the midline and the standard scanning plane was predetermined.

A slow inspiration at constant flow was instructed to the patients during the period of measurement for minimization of the respiratory-induced changes in the dimensions of the upper airway dimensions. Ultrasonography began with location of the true vocal cords, seen as paired hyper echoic linear structures with mobility during respiratory movements and swallowing and then moved caudally for visualization of the cricoid arch for avoiding the confusion between cricoid and tracheal ring.

The transverse air column diameter is narrower at cricoid cartilage (cephalic half), and thus was considered as diameter of the trachea. The larynx, was located below the hyoid bone with ring-shaped trachea inferior to the cricoid cartilage with ultrasound in vertical or transverse section.

The intubation was done by the experienced senior anesthesiologist who had an experience of at least 100 intubations. He was also kept unaware of the diameter assessed by the radiologist, intubation was done with the standardized Portex endotracheal tubes designated for the required study as to avoid the bias because of variations in wall thickness, tubes having the same Internal Diameters may have different External Diameters [30-32].

Cuff leak test- 'Best fit': by the attending anesthesiologist is if air leakage was satisfactory at a 15-20 cm H_2O airway pressure. For this purpose, air leak measurement, positions of the head and body were standardized; the patient was asked to lay supine with the head to be kept in a neutral position to limit any impact on the leak test. It was performed after proper suctioning of oral and endotracheal secretions and ventilator set on assisted control volume cycled ventilation we initially recorded inspiratory and expiratory tidal volumes. After deflation of the cuff, the expiratory tidal volume was directly recorded over the next six breathing cycles so as for the expiratory tidal volume to reach a plateau value. Afterwards 3 lowest values were averaged.

The difference between the inspiratory tidal volume (before the cuff was deflated) and the averaged expiratory tidal volume (after cuff deflation) was observed.

The ETT was changed to a 0.5 mm larger tube when air leak was excessive or if a leak occurred at an inflated pressure <10 cm H_2O. Alternatively, when there was resistance to the passage of the ETT into the trachea or when air leak was not detected, the tube was exchanged with one that was 0.5 mm smaller.

The patients were monitored post-operatively over 24 hours for the post-operative complications

such as sore throat, laryngeal edema, laryngospasm, nerve injury and aspiration of gastric contents.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were as follows:

Inclusion Criteria

- Only ASA class I-II patients
- Aged 18-60 years
- Undergoing elective surgery requiring General Anaesthesia with Direct Laryngoscopy (Macintosh blade) and endotracheal intubation was included in the study.

Exclusion Criteria

- Patients with mouth opening too small to pass Macintosh blade 4,
- Anticipation of difficult airway,
- The presence of an unstable cardiopulmonary condition,
- Patients undergoing emergency surgeries,
- Edentulous patients,
- Patients having head and neck anatomical pathologies that may have unpredictable effect on the ultrasound assessment of the airway was excluded from the study.
- The patients who are not able to extend their neck >30 degrees were excluded.

Statistical Analysis

Data was entered in Microsoft Excel sheet and analyzed using the SPSS software version 17 (IBM Inc, Chicago) for analysis. The Qualitative data assessed in terms of frequency and percentages and analyzed using chi-square test of fisher's exact test for 2x2 tables. Numerical data was presented as mean and Standard Deviation, which was, compared by unpaired t-test. p-value < 0.05 was taken as level of significance.

Results

The most common age group amongst study population was 20 to 30 years (32%) and 31 to 40 years (32%) followed by 41 to 50 years. The mean age was 36.44±11.13 years. There was male predominance (74%) in our study. ASA grade I and II was present in 80% and 20% of study population (Table 1).

Most of the study population in female population was 31 to 40 years (46.2%) followed by 20 to 30 years (30.8%) while in male population was 20 to 30 years (32.4%) followed by 31 to 40 years (27%). There was no statistically significant difference between age group and different gender (p value > 0.05).

The mean tracheal outer diameter on ultrasonography of male and female population was 7.8±0.82 and 6.9±0.66 respectively and this difference was statistically significant. The mean tracheal inner diameter on ultrasonography of male and female population was 7.5±0.91 and 6.5±0.54 respectively and this difference was statistically significant. The mean ETT size clinically used for Intubation of male and female population was 7.5±0.43 and 6.5±0.22 respectively and this difference was statistically significant (Table 2).

Table 3 shows the mean Tracheal outer diameter on ultrasonography and ETT size with different age group amongst study population. The most common complications amongst study population was Sore throat (8%) and Hoarseness of voice (4%) (Table 4).

Table 1: Demographic data of the population

		Frequency	Percent
Age group	20 to 30 years	16	32.0
	31 to 40 years	16	32.0
	41 to 50 years	12	24.0
	More than 50 years	6	12.0
Sex	Female	13	26.0
	Male	37	74.0
ASA	ASA grade 1	40	80.0
	ASA grade 2	10	20.0
	Total	50	100.0

Table 2: Comparison between Tracheal outer diameters on ultrasonography and ETT size with different gender amongst study population

	Male	Female	P Value
Tracheal outer diameter on USG	7.8 ± 0.82	6.7 ± 0.66	0.0008
Tracheal inner diameter on USG	7.5 ± 0.91	6.5 ± 0.54	0.0001
ETT size clinically used for Intubation	7.5 ± 0.43	6.5 ± 0.22	0.003

Table 3: Comparison between Tracheal outer diameters on ultrasonography and ETT size with different age group amongst study population

Age group	Tracheal outer diameter on USG	Tracheal inner diameter on USG	ETT size clinically used for Intubation
20 to 30 years	7.3 ± 0.89	7.2 ± 0.91	**7.0**
31 to 40 years	7.8 ± 0.90	7.5 ± 0.89	**7.5**
41 to 50 years	7.8 ± 0.92	7.6 ± 0.90	**7.5**
more than 50 years	7.8 ± 0.94	7.6 ± 0.92	**7.5**

Table 4: Various complications amongst study population

Complications	Frequency	Percent
Sore throat	4	8
Hoarseness of voice	2	4

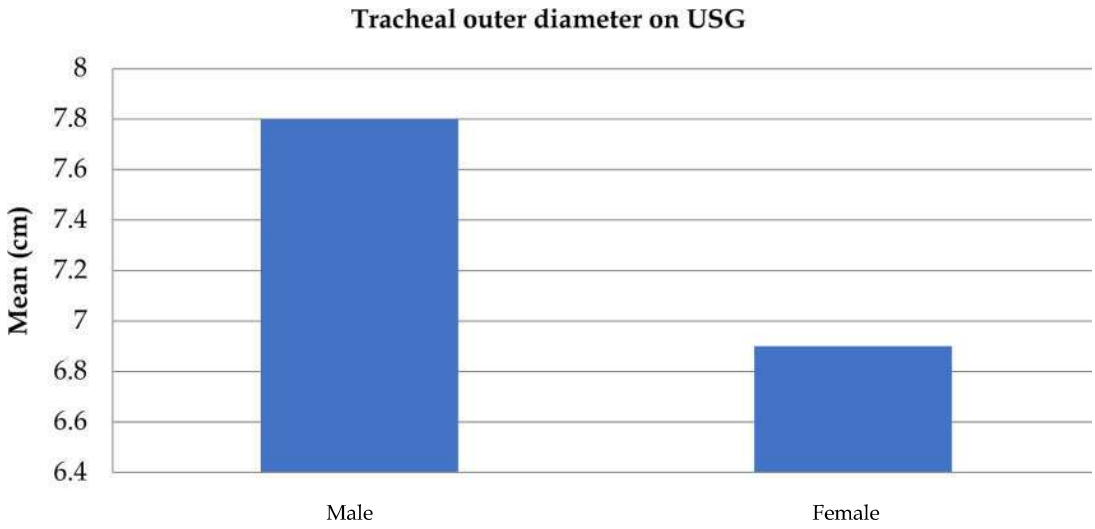

Fig. 1: Tracheal outer diameters on ultrasonography amongst study population

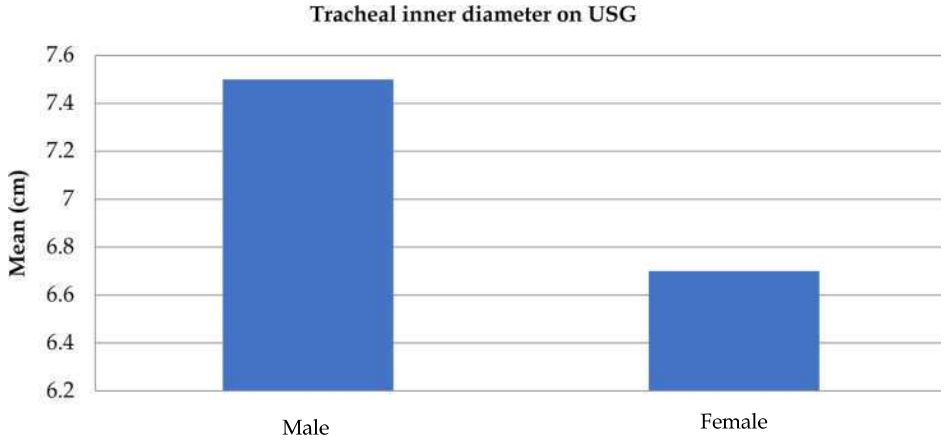

Fig. 2: Tracheal inner diameters on ultrasonography amongst study population

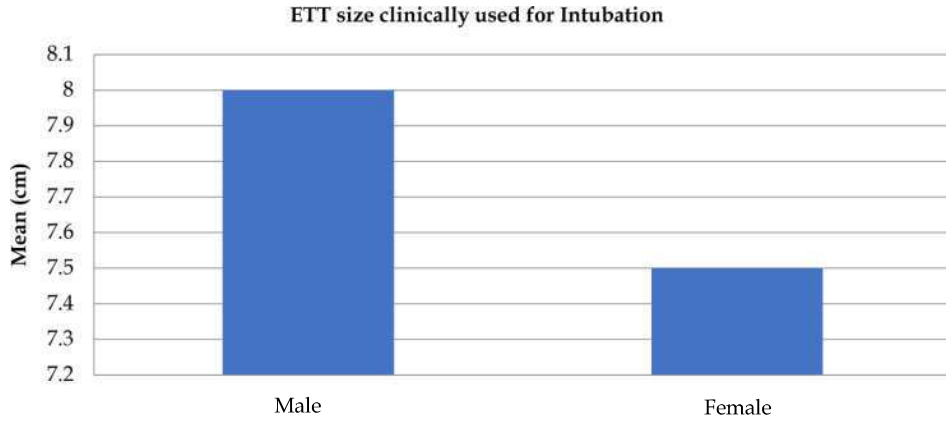

Fig. 3: ETT size clinically used for Intubation amongst study population

Discussion

There could be a large variation in sizes and shapes of tracheas in adults as the transverse dimensions increases with age, but in general there is a poor correlation with age, race, height, weight, body surface area, and tracheal shape or size.

ETs are manufactured in sizes according to internal diameter in increments of 0.5 mm, ranging between 2.5 and 10.0 mm.

For adult females and males, a tube of 7.5-8.0 mm and 8.5- 9.0 mm size respectively, are required. For routine use, a tube of 7.0 to 7.5 mm for females and 7.5 to 8.0 mm for males is appropriate.

Increase in airway resistance with a small-diameter ET associated with accidental positive end-expiratory pressure (PEEP) which increases the risk of barotrauma and circulatory compromise.

When devices like fibre-optic bronchoscopes are passed through ETT of any size there occurs further restriction of the gas flow.

Larger tubes are more associated with trauma to laryngeal structures and the tracheal mucosa [33]. Laryngeal trauma more frequent with prolonged intubation [34], and women, more frequently than men [35].

Arytenoids and cricoid cartilage vocal processes are at major risk. Trauma can occur due to shape discrepancy of round ET with glottic opening [36], also, due to, direct contact and pressure on structures and tube movement, leading to erosion [37]. Mucosal injury, is, because of irregular surfaces, due to wrinkling and folding of ET cuff. This is more likely to occur when large tubes are used and little cuff volume is required to seal the airway [38].

Sore throat and Hoarseness of voice (8 and 4% respectively) were the most prominent complications in the current study.

In the present study, the most common age group amongst study population was 51 to 60 years (42%) followed by 61 to 70 years (38%). The mean age of the study participants was 36.44±11.13 years and male predominance (74%) in our study.

In the present study, the mean tracheal outer diameter on ultrasonography of male and female population was 7.8±0.82 and 6.9±0.66 respectively and this difference was statistically significant.

The mean tracheal inner diameter on ultrasonography of male and female population was 7.5±0.91 and 6.5±0.54 respectively and this difference was statistically significant.

The mean ETT size clinically used for Intubation of male and female population was 7.5±0.43 and 6.5±0.22 respectively and this difference was statistically significant.

This concurs with the ûndings in literature, which, have shown that ultrasonography is useful for assessment of the subglottic diameter in the clinical setting [26]. However, after using ultrasonography, selection of the correct tracheal tube size is done in 60% cases.

In the present study, the mean tracheal outer diameter on ultrasonography in 20-30 years, 31-40 years, 41-50 years and more than 50 years was 7.5±0.43, 7.4±0.42, 7.4±0.41 and 7.4±0.43, the mean ETT size clinically used for intubation in 20-30 years, 31-40 years, 41-50 years and more than 50 years was 7.6±0.91, 77.5±0.89, 7.6±0.90 and 7.6±0.92.

We deûned the correct size of tracheal tube as that allowing an air leak at an inspiratory airway pressure of 15–20 cm H_2O with the head and neck

in a neutral position. The appropriate size of the tube of trachea was evaluated by use of the cuff leak test, which has its limitations in terms of the determination of appropriate size of tube; for example, the incidence of inter-observer variations for the assessment of leak pressures is high [39], and leak pressure has dependence on the position of the head and neuromuscular blockade degree. However, there are no other feasible practical methods for conûrming the correct tracheal tube size after intubation.

As Raphael PO et al. observed that there was higher correlation between ETT determined by ultrasound and ETT used clinically as compared to ETT used clinically and ETT determined by age based formula. Proper size ETT was determined by the air column size which was in turn considered to be the inner diameter of trachea. They preferred to measure the subglottic diameter as this was the narrowest part of trachea thus preventing trauma due to insertion of a large sized endotracheal tube [40].

The limitations of the present study were: Our study is time bound over the period of one year and thus its effect over the larger patient group cannot be deduced, Smaller sample size, the technique of Trans-Tracheal Ultrasonography to verify ET tube placement has its own limitations.

Conclusion

Ultrasonography, is trusted, non-invasive method for pre-anesthetic estimation of the subglottic tracheal diameter selection for clinical use and validated the reliability of ultrasound for subglottic diameter avoiding complications of either trauma or inefficient ventilation.

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