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Original Research Article

A MORPHOMETRIC STUDY OF HUMAN ADULT TRACHEA & LEFT MAIN STEM BRONCHUS AND ITS CLINICAL IMPLICATION

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Abstract

Background: Within the same age group, there is a significant difference in the trachea's various diameters. The study of these morphometric variances is of great therapeutic significance in addition to anthropometry since it may aid pulmonologists & thoracic surgeons in understanding the aetiology of numerous pulmonary disorders, such as bronchitis, emphysema, pulmonary fibrosis, and TB. The study aimed to conduct a morphometric analysis of both sexes' human trachea and left main bronchus and determine the clinical ramifications. **Materials and Methods:** This prospective study used twenty-one male and nineteen female adult human cadavers that had been embalmed and assigned to the Institute of Anatomy at Madras Medical College for regular dissection, dissected using the conventional dissection procedure. Measurements were collected after dissecting the trachea, larynx, and main bronchi. The acquired morphometric values were computed statistically by comparing means and standard deviation (SD). **Result:** Mean tracheal length was 10.1 cm, with average width, depth and width: depth of 1.5, 1.8 and 1.2 cm, respectively. The mean left bronchial length was 4.5 cm, with average width, depth and width: depth of 1.5, 1.3 and 1.1 cm, respectively. Degrees of mean subcranial and LMB angles were 54.2 and 40.5. Mean tracheal rings were 15.8. The morphometric measurements of the trachea were higher in males and statistically insignificant only in the width: depth of LMB and LMB angle values. **Conclusion:** The study reveals significant variance in tracheobronchial tree parameters, such as length, diameter, height, depth, and tracheal rings. Understanding these variations is crucial for reconstructive surgery and airway management.

INTRODUCTION

The trachea is a centrally positioned membrane-cartilaginous unpaired hollow organ that continues the larynx downward from a superficially exposed location deep inside the well-protected centre of the mediastinum.[1] The trachea runs from the lower edge of the cricoid cartilage next to the C6 vertebra up to the higher edge of the T5 vertebra, where it divides into the right and left main bronchi, which supply the right and left lungs, respectively. The trachea's various diameters vary greatly between individuals of the same age group and those of other age groups in both sexes.[2] The diameters of the trachea stated in various textbooks and by various writers in various periodicals vary greatly. The adult trachea measures 10 and 11 cm in length, has an exterior transverse diameter of 2 cm in adult males and 1.5 cm in adult females, and an average transverse diameter of 12 mm for the lumen.[3]

Understanding the trachea, major bronchi, and carinal angle is crucial since it has several clinical and interventional uses. There is a significant difference between individuals of the same age group as well as those of other age groups in both sexes in terms of length, transverse and anteroposterior diameters, a width-depth ratio of the lumen of the trachea and major bronchi, and the subcarinal angle.[4] In addition to anthropometry, understanding morphometric differences is crucial since it may aid pulmonologists in comprehending the aetiology of various pulmonary disorders.[5] The pattern of the lower respiratory tract, including changes in the width-depth ratio of the tracheobronchial tree's lumen, is currently regarded as the most important risk factor for various respiratory disorders, including emphysema and chronic bronchitis.[6]

The study of morphometric differences is crucial for surgeons who deal with tracheobronchial tree excision and rebuilding since it helps doctors better

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understand the causes of various airway disorders.[7] Studies in pulmonary physiology and anesthesiology may benefit from this information to expertly and skillfully carry out procedures like endotracheal intubation and bronchoscopy. Inflammation in the trachea can cause scarring and structural constriction, which results in stenosis. In chronic obstructive pulmonary disease (COPD) and bronchial asthma, airway inflammation changes normal anatomy and causes bronchospasm.[8] Food ingested and passed down the oesophagus enters the trachea, which can cause major lung issues in people with a Tracheoesophageal fistula. The trachea or one of its branches may become blocked by the aspiration of a foreign body. Since the right main bronchus is shorter, broader, and more aligned with the trachea than its left counterpart and has a smaller divergence angle, it is more prevalent on the right side. Asphyxia may quickly result in death if the foreign body is big enough to clog the airway completely.[9]

Williams-Campbell syndrome, tracheobronchomegaly, Saber-sheath trachea, and malignancy are further tracheal abnormalities.[10] The left main bronchus' has more horizontal course, narrow thin lumen, and constrained peribronchial space are likely to impede the secretion's ability to drain, which might result in Left bronchus syndrome.[11] The tracheal abnormality is diagnosed and treated via bronchoscopy, endotracheal stenting and tracheostomy. It is vital to understand typical tracheobronchial anatomy to conduct management practices thoroughly. With the factors mentioned earlier in mind, the current study was undertaken to measure various dimensions in different age groups of both sexes, including length, transverse and anteroposterior diameters, the width-depth ratio of the lumen of the trachea and left principal bronchi, and the sub-carinal angle, which may have a bearing on the development of respiratory diseases.

MATERIALS AND METHODS

Twenty-one male and nineteen female adult human cadavers that had been embalmed and assigned to the Institute of Anatomy at Madras Medical College for regular dissection were dissected using the traditional procedure. The study used adult human cadavers between the ages of 20 and 70. Cadavers older than 70 years and younger than 20 years, disfigured cadavers, cadavers with sternal and tracheal abnormalities, HIV-positive cadavers, and cadavers with corona positivity were eliminated from this investigation.

Conventional Dissection Method

Each embalmed corpse is recognised and documented for its gender before being supine on the dissecting table. The skin is cut from the chin to the sternum in the midline, and the skin flap is reflected inferolateral to reveal the platysma fibres. The deep cervical fascia is made visible by the upward reflection of the platysma. The infrahyoid muscle is exposed by making a transverse incision in the deep fascia just above the sternum and extending it upward. The pretracheal fascia is made visible by the midline separation of these muscles. This fascia is cut below the thyroid isthmus to reveal the trachea and inferior thyroid veins descending on it.[12]

It is possible to see and identify the cricoid cartilage. The thoracic cage is then sliced open to reveal the trachea's major bronchi and thoracic portion. The left principal bronchus is measured from the angle of the tracheal bifurcation to the point of its division into the secondary bronchi, and the length of the trachea is measured from the lower border of the cricoid cartilage to the point of the tracheal bifurcation. Vernier callipers measure the trachea's exterior transverse diameter (Width) and the left major bronchus' anterior-posterior diameter (Depth). Calculations are made for the left major bronchi's width/depth ratio and the trachea's. Each specimen's inferior margins of the two major bronchi are measured using a goniometer to determine the angle between them (the subcarinal angle). The angles created by the main bronchi are measured using a goniometer from the central axis travelling through the trachea to the axis of the main bronchi. Serial counting of the tracheal rings was done, and any differences in the trachea and main stem bronchus were sought after.

Statistical Method

Following independent recording and tabulation of all measurements for each gender, statistics package for social sciences (SPSS) software analysis was performed.

RESULTS

Among forty cadavers, 21 males and 19 women were dissected, and the specimens were then collected and examined for the different morphometric characteristics. The length of the tracheas is measured from the point of tracheal bifurcation to the lower border of the cricoid cartilage, yielding mean tracheal lengths of 10.4 cm for men and 9.7 cm for women, respectively [Figure 1]. The lengths varied significantly between genders ($p<0.001$).

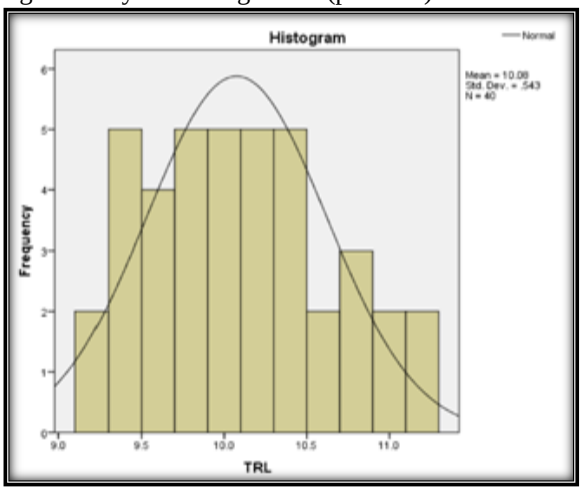

Figure 1: Length of tracheas (cm)

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Figure 2: Length of the trachea, which is measured from the lower border of the cricoid cartilage to the bifurcation

Figure 3: The transverse diameter (width) of the trachea

Figure 4: The anteroposterior diameter (Depth) of the trachea

Figure 5: The length of the left main bronchus, which is measured from the angle of bifurcation to the point of its division into the secondary bronchi

Figure 6: The transverse diameter (width) of the left main bronchus

Figure 7: The anteroposterior diameter (Depth) of the left main bronchus

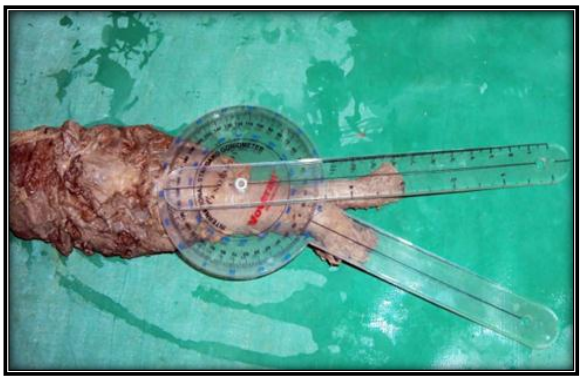

Figure 8: The angle between the two main bronchi (subcarinal angle)

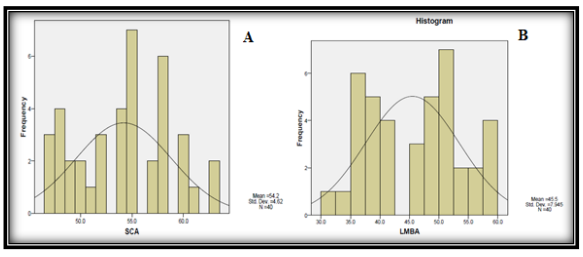

Figure 9: Degrees of A) Subcranial and B) LMB angles

The average exterior transverse diameter of the tracheas in male specimens was 1.9 cm, while the average in female specimens was 1.6 cm. The mean of the tracheal depth of the female specimen is 1.4 cm (Table 1). The male specimens' anterior-posterior diameter (Depth) of the tracheas is determined to be

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1.6 cm. The tracheas' mean width/depth ratio in male specimens is 1.2 cm, while the mean in female specimens is 1.1 cm. P value determined using a t-test demonstrated significance between males and females regarding average exterior transverse diameter, anterior-posterior diameter and mean width/depth ratio [Table 1].

The total length of the left major bronchi was 5.0 cm in males and 4.0 cm in females. Male specimens were found to have a mean exterior transverse diameter (Width) of 1.6 cm, whereas female specimens had a mean of 1.3 cm [Table 1]. Male specimens were found to have an average Anteroposterior diameter (Depth) of 1.4 cm. In contrast, female specimens had an average of 1.2 cm and 0.2, and a p-value determined using a t-test demonstrated significance between males and females regarding the mean total length of the left major bronchi and Anteroposterior diameter (Depth). The mean width/depth ratio of males' and females' left principal bronchi was 1.1 cm (p=0.431). Similar statistical insignificance was also observed among LMB angle values, with 40.0 degrees for males and 41.0 for females [Table 1].

Subcarinal angle among both sexes proved to be statistically significant, with a mean degree of 56.1 in males and 52.1 in females (p<0.05) (Figure 9). Tracheal rings in females were lesser, 15 compared to males, 16.6 with a significant statistical difference (p<0.05) [Table 1].

Table 1: Morphometric parameters

Morphometric parameters	Male	Female	Average	P value
Trachea				
Length (cm)	10.4 ± 0.4	9.7 ± 0.3	10.1 ± 0.5	<0.001*
External transverse diameter /Width(cm)	1.9 ± 0.2	1.6 ± 0.2	1.8 ± 0.3	<0.001*
Anteroposterior diameter /Depth(cm)	1.6 ± 0.2	1.4 ± 0.1	1.5 ± 0.2	<0.05*
Width-Depth ratio	1.2 ± 0.1	1.1 ± 0.1	1.2 ± 0.1	<0.05*
Left main bronchi (cm)				
Length	5.0 ± 0.5	4.0 ± 0.2	4.5 ± 0.6	<0.001*
Width	1.6 ± 0.3	1.3 ± 0.2	1.5 ± 0.3	<0.05*
Depth	1.4 ± 0.2	1.2 ± 0.2	1.3 ± 0.2	<0.05*
Width/Depth ratio	1.1 ± 0.1	1.1 ± 0.1	1.1 ± 0.1	0.431
Sub cranial angle (degrees)	56.1 ± 3.8	52.1 ± 4.6	54.2 ± 4.6	<0.05*
LMB angle (degrees)	40.0 ± 4.9	41.0 ± 5.0	40.5 ± 5.0	0.249
Tracheal rings	16.6 ± 1.6	15 ± 1.2	15.8 ± 1.6	<0.05*

DISCUSSION

In order to perform certain manoeuvres, such as endotracheal intubation and diagnostic and therapeutic bronchoscopic procedures, with finesse and expertise, the present study was undertaken to quantify the various dimensions of the trachea. Although researchers are measuring the trachea's diameters from various sections, few studies are specifically linked to this topic. Therefore, the current study determined how the human trachea's size varied among cadavers in Southern India between the ages of 20 and 70.

In the current study, the average trachea length was around 10.4 cm in men and 9.7 cm in women, respectively, and this finding was statistically very significant, which was in line with earlier research conducted.[13,14] The values in the lower range, 4.2 and 6.18 cm, respectively, were provided in studies.15-17 This needs to be kept in mind when creating prosthetics.

The exterior transverse diameter, often known as the trachea's width, ranges from 1.5 to 2.4 cm with a mean of 1.9 cm in males and 1.4 to 2.0 cm with a mean of 1.6 cm in females. This range was statistically highly significant. When the trachealis muscle contracts at its posterior side, its diameter shrinks in living creatures. When doing interventional procedures like bronchoscopy or endotracheal intubation, it is important to remember this. Only a few studies had examined the morphometry of the anteroposterior diameter of the trachea, and they reported values in the range of 0.7 to 3.2 cm. In the current study, the values were 1.2-2.0 with a mean of 1.6 cm in males and 1.3-1.6 with a mean of 1.4 cm in females, comparable to the study conducted by Chunder R et al. and slightly lower than the values of overseas studies.14 This must be considered, especially when selecting endotracheal tubes and artificial airway stents.

Major airways typically have a width-to-depth ratio of less than 1.5; however, this ratio rises in COPD and Saber-sheath trachea patients. Values decline due to diffuse constriction of the major bronchi or trachea brought on by numerous reasons. The width/depth ratio of the trachea was calculated in the current study, and it was found that the mean values were 1.2 and 1.1 in male and female specimens, respectively. These mean values were statistically significant, fell within the normal range, and are comparable to those reported by Chunder R et al.[14]

Average left main stem bronchus lengths appear almost identical to many previous studies.[13-15] It was statistically highly significant (p-value 0.001) that the length of the left major bronchus was between 3.6 and 5.5 cm with a mean of 5.0 and between 3.5 and 4.0 cm with a mean of 4.0 cm in male and female individuals, respectively. Clinicians must use this morphometric parameter to select the best double-lumen endotracheal tube and airway stents.

The external transverse diameter, or width, of the left main stem bronchus, ranges from 1.2 to 2.0 cm in the present study, with a mean of 1.6 cm in males and

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1.0-1.6 cm in females. This difference was statistically significant and almost identical to other studies. According to Chunder R et al14., the anteroposterior diameter or depth of the left main stem bronchus ranges from 1.5-1.7, 1.0-1.4 cm in males and females, while in the current study, it is 1.1-1.8 with a mean of 1.4 cm in males and 1.0-1.5 and a mean of 1.2 cm in females, which was statistically significant and is nearly identical to the above study.[14] It is important to keep this in mind when doing interventional procedures.

The bigger airways typically have a width-to-depth ratio of less than 1.5; however, this ratio rises in individuals with COPD with Saber-sheath bronchi. Values decline due to diffuse constriction of the left main stem bronchus or its counterpart secondary to different reasons. The width/depth ratio of the left main stem bronchus is calculated in the current study, and it has been observed that the mean value is 1.1 for both male and female specimens respectively. This ratio is significantly lower than the previous study's but was not statistically significant (p=0.431). The primary bronchi's sizes must be properly understood to choose the appropriate tubes for each gender.

No significant differences in subcranial angles were found in the current study; the male angle ranges from 51 to 63 degrees with a mean of 56 degrees, and the female angle ranges from 47 to 63 degrees with a mean of 52 degrees. These subcranial angles are comparable to those found in the Chunder R et al.[14] Bronchoscopic procedures need clinically significant knowledge of the subcarinal angle, and any growth in the mediastinal structures, or any pathology of the lung or pleura, or any cardiac diseases may significantly change the subcarinal angle.

In the current study, the LMB angle ranged from 32 to 48 degrees for men and 33 to 49 degrees for women. However, neither LMB angle was statistically significant (p=0.249). In various studies, the mean length of the left main stem bronchus is almost similar, except in Mrudula C, the value is slightly on the lower limit.18 The right main bronchus comprises a tiny portion of the subcarinal angle, and the left main bronchus provides the majority since it is practically parallel to the trachea. This significantly longer, narrower, more horizontal course makes it more susceptible to blockage, likely influencing the outflow of secretions and resulting in left bronchus syndrome.[19] It also implicates that the peribronchial region in the left lung is also under strain.[20]

In the current research, tracheal rings ranged from 15-20 in males to 13-18 in females, comparable to Kamel KS et al. and Rosen FS et al. and statistically significant (p-value 0.05).[3,21] The largest number of 24 rings was recorded by Mrudula C and Kavuru MS et al.[18,22] This has therapeutic significance since the 'C'-shaped tracheal rings keep the trachea stiff, and any structural imperfection (acquired or congenital) will cause aberrant tracheal collapse during respiration.[23]

CONCLUSION

Significant differences between male and female cadavers were found in various metrics, including length, transverse and anteroposterior diameters, mean height, depth, and width, as well as the number of tracheal rings. The study of these morphometric differences has significant clinical value since it may assist clinicians in understanding the aetiology of various lung disorders and assist surgeons in managing tracheobronchial tree excision and repair. Knowing the trachea's length and width also aids medical professionals in selecting the appropriate endotracheal tube and tracheostomy tube size in emergencies. Understanding the pathogenesis and treatment of various airway problems requires an accurate anatomical understanding of the differences.

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