

## Research Article

# A study on anatomical dimensions of bronchial tree

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### ABSTRACT

**Background:** The principle of minimal work requires that the conducting airways of human lungs should have a maximum radius for minimal resistance to gas flow. Malpighi et al said that the trachea terminated in dilated vesicle. The study of bronchial tree and their dimensions is useful in various aspects as to know the entry of foreign particles, to maintain posture for patients suffering from suppurative lung disorders. For anaesthetist to know the caliber of trachea for intubation, bronchoscopy. Bronchial anatomy is essential knowledge for thoracic surgeons in various surgical maneuvers.

**Methods:** The study of bronchial tree is done in 20 pairs of lungs and the following are observed. Various dimensions like tracheal length, width, sub carinal angle, Length and diameter of principal bronchi from the level of bifurcation of trachea is noted with digital Vernier calipers and scale.

**Results:** Though dimensional analysis of bronchi was studied, it shows no significance from earlier studies. In the present study all the dimensions are within normal limits. Out of 20 pairs 6 specimens showed variations in the branching patterns.

**Conclusions:** The results suggests that there are limited variations in the dimensional study, now a days bronchoscopy procedures are widely used in diagnostic and therapeutic purposes. The sub carinal angle indirectly helps in diagnosis of cardiovascular problems and for surgical resection of segments

**Keywords:** Trachea, Angle, Bronchial tree, Branching pattern

### INTRODUCTION

In the light of increase in incidence of pulmonary diseases, there is a concomitant increase in study of lungs and bronchial tree morphological and clinically.

The exchange of respiratory gases is the basic essentiality of life process in all the living organisms. This system has greatly evolved from unicellular to mammalian airway passage. In the late years Diemerbroack identified the bronchial tree pattern.<sup>1,2</sup> The study of this bronchial tree and their dimensions is useful in various aspects as to know any abnormalities of airways like pneumonia, bronchial obstructions, foreign bodies, mediastinal

masses, to maintain posture for patients suffering from suppurative lung disorders; for anesthetist to know the caliber of trachea for intubation, bronchoscopy.

Bronchial anatomy is essential knowledge for thoracic surgeons in various surgical maneuvers. Bronchoscopy procedures are widely used in diagnostic and therapeutic purposes.

Bronchial pattern of pulmonary diseases is characterized by alterations in bronchial wall thickness and lumen diameters. To study the normal morphology of divisions of bronchial tree quantitatively and qualitatively, to know the anatomical dimensions of principal bronchi, to note the morphological variations, to note angle of carina. The

knowledge of this study is of immense value in endoscopic procedures for diagnostic and therapeutic purposes. The principal bronchus plays a major role in transmitting air to and from the lungs. The sub carinal angle indirectly helps in diagnosis of cardiovascular problems and for surgical resection of segments or lobes in diseases of lungs.

The principle of minimal work requires that the conducting airways of human lungs should have a maximum radius for minimal resistance to gas flow. The dimensions of branched structures such as airways bronchial tree is important factor in determining the efficiency of physiological process.

The carina located about 25cm from the incisor teeth and 30cm from the external nares. It lies at the level of T5 vertebrae at expiration and T6 in inspiration.

The proximity of the carina to the vertebral column widens the bifurcation angle; measurement of carina position in relation to tracheal midline. This data may be useful for calculating dead space. The Bronchial tree is aptly name for its resemblance to the branches of a tree, as larger tubes perpetually concede to smaller tube in an intricate framework of branches.

Right around the level of sternal angle, just posterior to manubrium. The trachea splits off into the right and left principal bronchi surrounding the lumen of each extending principal bronchi, rings of cartilage keep the larger airways open as they branch off into smaller tubes.

The right primary branch lies at a more upright angle, which increases the chances of foreign particles slipping through the tubular formation. Each principal bronchi is then segregated off once again as it descends into the lungs, forming lobar and then segmental bronchi also known as secondary and tertiary bronchi. Usually the bronchial segment of interest will be the left, as the length is twice that of right.

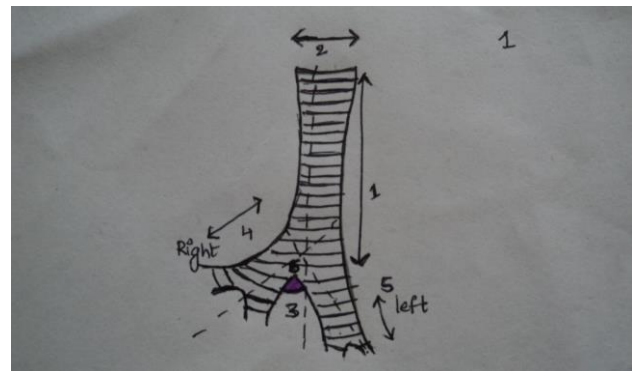
The larger diameter of bronchi optimizes gas flow during ventilation. The right bronchi lies more upright angle so increase in more chance of foreign particle slipping into it. The study of bronchial tree is done by both invasive and non-invasive techniques like bronchoscopy, computed tomography scan, magnetic resonance imaging scan. In the present study 20 pairs of lungs are taken and dissected out till the level of terminal bronchi and various parameters are calculated.

**METHODS**

A gross anatomical dissection of embalmed cadavers was conducted from the department of anatomy, Viswabharathi medical college, Kurnool, Andhra Pradesh, India. Instruments used are forceps, scalpel, and rectangular trays, wooden blocks, measuring tape, Digital calipers, measuring scale are used in the present study.

An incision was done on either side of sternum, ribs, clavicle were cut with the bone cutter, sternopericardial ligaments were ligated and cut, pericardium is incised to view the pulmonary vessels entering the lung are cut, and separated. The trachea is cut at the lower end of the cricoid cartilage and separated from oesophagus posteriorly.

The lungs are removed enmass from the thoracic cavity and washed thoroughly with water, soaked in 10% HCl. Later the parenchymal tissue is scraped with the scalpel and blunt forceps. The bronchial tree is cleaned up to the third generation, dried in air and kept on paper for outline the margins. The study of measurements as follows:



1-Tracheal length, 2-width of trachea, 3-subcarinal angle, 4-length of right bronchus, 5-length of left bronchus, 6-angle formed between right and left principal bronchus.

**Figure1: Measurements of the study.**

**RESULTS**

Tracheal length: It is ranging between 5.8cm and 9.2cm and on average was 7.8cm, Tracheal diameter- on average was 1.47cm and ranging from 1.0cm to 2.4cm, number of tracheal rings-these are c-shaped hyaline rings ranged between 10 and 18 on average 12 rings.

**Table 1: Dimensions of trachea.**

	Tracheal length	Tracheal diameter
In adults	7.4-9.2cm	12mm-20mm
In fetuses	3.0-4.6cm	2mm-4mm

Average range of tracheal length - 7.87cm, Tracheal diameter-16mm, The incidence of different shapes at the upper end of trachea was studied and analyzed in fetuses based on crown-rump length, the length and diameter of trachea steadily increasing in fetus.

The average mean length of right main bronchus from the level of bifurcation is right bronchus length 2.0-2.2cm, Left bronchus length 3.8-4.6cm.

The average mean diameter of right main bronchus is 14mm-18mm and left is 11mm-13mm. The relationship of diameters of both right and left main bronchi of males

and females was correlated in a linear fashion but not precise enough to be clinically evaluated.

**Sub carinal angle**

The angle between two principal bronchi varied between 40degrees and 78 degrees. The mean angle is 53.45 degrees.

**Variations in branching pattern**

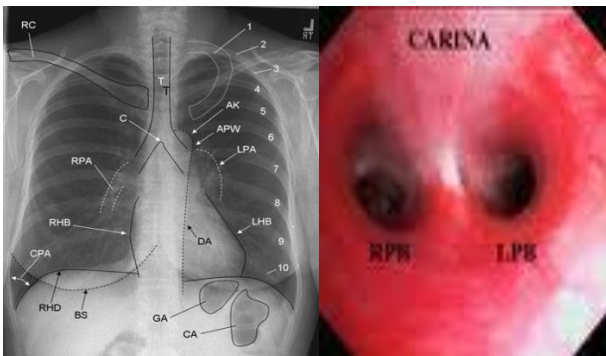
Right lung- In 2 specimens the upper lobar bronchus took origin at the level of carina. In 2 specimens the middle lobar bronchus originated from antero medial surface of main bronchus and ran downwards medially instead of being lateral in direction. Left lung-In 1 specimen the upper lobar bronchus divided into apical and antero-posterior segmental bronchi.

**Table 2: Dimensions of principal bronchi.**

Right bronchus		Number of specimens	Left bronchus		Number of specimens
Length	Diameter		Length	Diameter	
1.6-2.0cm	10-12mm	6	2.6-3.0cm	9-10mm	5
2.0-2.2cm	12-14mm	4	3.0-3.6cm	10-12mm	7
2.2-2.4cm	14-16mm	8	3.6-4.0cm	12-14mm	4
2.4-2.6cm	16-18mm	2	4.0-4.5cm	14-16mm	4

**Table 3: Dimensions of bronchial tree.**

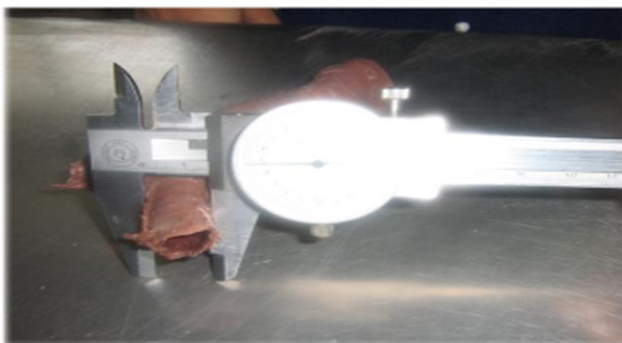
	Trachea			Sub carinal angle	Right main bronchus	Left main bronchus
	Length	Width	No. of rings			
Range	5.8-9.2	1-2.4	10-18	40-70	1.6-2.6	2.6-4.6
Average	7.87	1.6	12	53 degrees	2.0-2.2	3.8-4.6



**Figure 2: Radiographic view and bronchoscopic view of angle of carina.**



**Figure 4: Dissection of bronchial tree.**



**Figure 3: Measuring with Vernier calipers.**

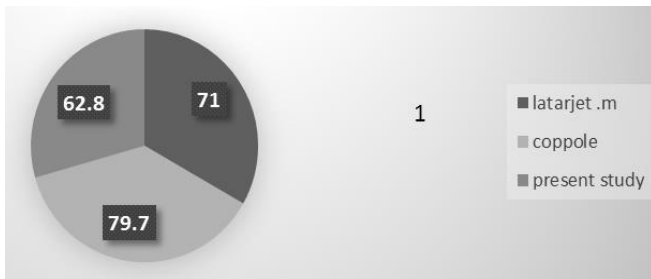
**DISCUSSION**

The occurrence of variations in the length and diameters of main bronchi is fairly common and there are not many variants. The present aimed, In order to find an objective method for measuring narrowing of small airways. The lengths and diameters have a lot of endoscopic importance and studied by many authors (Hannallah, Romanes GJ, Sahni D, Harjeet, Gray H, Hampton T, Horsefield K, Cumming H et al).<sup>3-8</sup> According to Gray H the average length of right main bronchus -2.2cm and that of left -5cm.<sup>6</sup> The present study supports the above statement as the average

length was as more than 1/2 of specimens fall under this range. The review of literature revealed measurements of bronchial tree done by dissection of specimens, chest X-rays, CT-scan. In the present study various parameters are measured and compared with literature. Murray et al reported that the tracheal bifurcation angle refers to the both inter bronchial and sub carinal angles.<sup>9</sup> Normal ranges between 40 degrees to 70 degrees with a mean value of 60-65 degrees.

**Sub carinal angle**

Latarjet M studied CT scans of 129 cases and found the angle 71 degree and the range between 40-108 degrees.<sup>10</sup> Coppole V examined CT scans of 500 patients and found the angle as 79.7 degrees and varied between 37-105 degrees.<sup>11</sup> The present study shows the angle 53.4degrees and the range is between 40-70 degrees.



**Figure 5: Study of subcarinal angle by authors.**

**Tracheal Diameter**

Breatnach studied x rays of 808 patients and found the diameter to be 2.5-2.7 cm in males and 2.1-2.3 in females.<sup>12</sup> Sternberg S in his text book of diagnostic surgical pathology described as the tracheal diameter as 2-2.5cm.<sup>13</sup> The present studies shows the diameter as 1.69cm on average and varied between 1.2 and 2.5cm.

**Table 4: Dimensions of trachea in adults.**

Name of author	Average length	Average diameter
Standring S et al	10-11cm	12mm
Romanes GJ et al	10-12cm	11mm
Sinnatamby et al	10cm	20mm
Datta AK et al	10-11cm	12mm
Present study	7.8-9.6cm	16mm

**Tracheal length**

Sternberg S in his textbook of diagnostic surgical pathology 3<sup>rd</sup> edition described the tracheal length to be 11 cm long.<sup>13</sup> Rosen FS studied 50 specimens al pathology 3<sup>rd</sup> edition described the tracheal diameter as 2.0- 2.5 cm.<sup>14</sup> A CT scan study by leader JK studied in 43specimens and found length to be 7.0-8.9cm.<sup>19</sup> The present study shows the length on average 7.8-9.6cm.

**Number of tracheal rings**

Michael G told that for every 2 cm there are 2 rings.<sup>15</sup> Rosen FS studied 50 specimens and observed that trachea on average contains 13.3 rings.<sup>14</sup> In the present study there are 14 rings.

**Right main bronchus**

**Length-** Snell RS et al in text book of clinical anatomy 7<sup>th</sup> edition describes the length as 2.5 cm.<sup>16</sup> Present studies show the length to be 2.28 cm on average.

**Angle-** Miller studied by gross dissection and found the angle as 20 degrees.<sup>17</sup> Boyd E studied 100 cases and found the angle between 27-30 degrees.<sup>18</sup> In the present study the angle is 43.4 degrees on average.

**Table 5: Dimensions of principal bronchi.**

Previous studies	Present study
Mean length RMB-2.2cm	Mean length RMB-2.0cm
Mean length LMB-5cm	Mean length LMB-4.2cm
Mean diameter RMB -13 to 15mm	Mean diameter RMB-11 to 12mm
Mean diameter LMB-11 to 13mm	Mean diameter LMB-11 to 13mm

Many attempts of variations in the diameters of main bronchi given in the range of RMB-13 to 15mm and that of LMB-11 TO 13mm.

**Left main bronchus**

**Length-**Richard S Snell in text book of clinical anatomy 7<sup>th</sup> edition describes the length as 4.5 cm.<sup>16</sup> Present studies show the length to be 3.86 cm on average.

**Angle-**Miller studied by gross dissection and found the angle as 40 degrees.<sup>17</sup> Boyd E studied 100 cases and found the angle between 43.5 – 46 degrees.<sup>18</sup> In the present study the angle is 39.68 degrees on average.

**CONCLUSION**

Prior knowledge of possible anatomical variants may help the surgeons to reduce the risk of accidental damage for cardiothoracic surgeons, ENT specialists, and anaesthetists; increasing opportunities to enlighten radiological importance with CT.

Scan, X-rays, systematic identification of endobronchial anatomy during bronchoscopy procedures. The present study was done in 20 pairs of lungs and observed .The diameters and lengths are determined in a linear fashion in present study. The tracheal bifurcation angle has a wide range in normal subjects and the absolute measurement of the carina angle is of little diagnostic value.

Variations in branching pattern are observed in right lung. In 2 specimens the upper lobar bronchus took origin at the level of carina. In 2 specimens the middle lobar bronchus originated from anteromedial surface of main bronchus and ran downwards medially instead of being lateral in direction. Left lung-In 1 specimen the upper lobar bronchus divided into apical and antero-posterior segmental bronchi.

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