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Systematic literature study of trachea and bronchus morphology in children and adults

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ABSTRACT

Understanding the dimensions of the lower airway is critical for performing respiratory surgery, selecting and designing appropriate airway equipment, and removing aspirated foreign bodies via bronchoscopy, anesthesia, and radiography. The purpose of this study was to analyze the trachea and bronchus morphologically in children and adults, as well as to standardize the data for these structures' measurements. Various databases were reviewed for studies on lower airway dimensions. The criteria for inclusion and exclusion were established. Finally, it was agreed to look into 28 studies that took place between 1984 and 2021. The length of the trachea, its anterior-posterior (AP) and transverse dimensions, the lengths and transverse diameters of the right and left major bronchus, and the subcarinal angle were also investigated in the study. In studies where measurements were performed with different methods and procedures; It was revealed that age and gender were effective in the difference in lower respiratory tract dimensions. The mean values of all parameters were greater in adults than in children, the AP diameter of the trachea in adults was greater than the transverse diameter; In

children, it was observed that the transverse diameter was larger than the AP diameter on average, the left main bronchus was longer than the right main bronchus, and the transverse diameter was smaller than the right main bronchus in most of the studies. Was found to be smaller. The articles reviewed for this study revealed that measurements were done using a variety of different procedures and approaches, and the resulting data were inconsistent and could not be standardized. The data collected will be beneficial both conceptually and clinically; we believe that additional comparison research involving children and adults in bigger groups are necessary.

Key words: trachea, bronchus, morphology, adult, child

INTRODUCTION

The trachea is a tubular organ with muscles and membranes that is 10-13 cm long [1,39]. It begins at the lower edge of the C6 vertebra and divides into two bronchus principalis dexter and bronchus principalis sinister at the T4-T5 vertebra level. After giving rise to the superior lobar bronchus, the right main bronchus descends as the intermediate bronchus. The middle and inferior lobar bronchi separate the intermediate bronchus into two lobar bronchi. Two lobar bronchi, bronchus lobaris superior and inferior, split the left main bronchus [29]. The term "normality" in anatomy refers to a variety of morphologies, including the most prevalent, and "variations" are used to describe uncommon anatomical variation [40,43]. In the medical literature, anatomical differences are referred to as anomalies [43]. Variations can influence disease susceptibility, symptomatology, clinical examination, and patient care in operational surgery and can affect any area of the human body [40]. Contrary to its overall anatomical structure, the tracheobronchial tree may also have distinctive characteristics and numerous variations [3]. The accessory cardiac bronchus (ACB) and tracheal bronchus (TB) are frequently major anomalies or variations in the tracheobronchial tree [41]. The accessory cardiac bronchus is an excess bronchus that extends from the inner wall of the right main bronchus or intermediate bronchus to the pericardium [13], whereas the tracheal bronchus is an abnormal or accessory bronchus that primarily arises from the right lateral wall of the trachea [26]. Tracheobronchial abnormalities occur between 0.1% and 2% of the time [41]. Clinical practice should take anatomical

variances into account [43]. Surgeons must have a thorough understanding of anatomical variations in order to appropriately identify anatomical structures during surgery [40]. In anesthesia and respiration, knowing these airway dimensions are critical in conditions such as endotracheal tube, double lumen tube, rigid and flexible bronchoscopes, bronchial blockers, or stent size selection [11]. Furthermore, understanding the standard reference values for airway dimensions in radiology allows for the differentiation of normal and pathological airway findings in various age groups, as well as the design and manufacture of appropriate airway equipment [10]. In surgical approaches to the thoracic cavity, in the application of various airway techniques in anesthesiology, and in the removal of aspirated foreign bodies by bronchoscopy, accurate knowledge of the anatomy and morphology of the tracheobronchial tree is essential [17]. Airways can be measured using CT (computed tomography) scans, cadaver measurements, chest X-ray and 3D (three-dimensional) reconstruction, ultrasound, and bronchoscopy [38].

The purpose of this study was to compare the dimensions of the trachea and bronchus in children and adults using existing data and to standardize the measurement values. Our study of the literature revealed no systematic study comparing the morphological measurements of the trachea and bronchus in children and adults.

MATERIALS AND METHODS

Our study's methodology was developed in accordance with a paper from the Annals of Anatomy journal titled "Methods of Evidence-Based Anatomy: a guide to conducting systematic reviews and meta-analysis of anatomical studies" [16]. After conducting a literature analysis, it was decided that the focus of our study would be a review of the morphological structure of the trachea and bronchi in both children and adults. Our study's objective was to standardize the data and compare the diameters of the trachea and bronchi in children and adults. The inclusion criteria were carefully chosen. Children under the age of 18 and adults over the age of 18, from any ethnic origin, without airway pathology were included study. We used articles that examined CT scans, cadavers, chest radiographs, and 3D reconstructions as the basis for our work. Our study is a retrospective study that clearly defined the anatomical definitions of the

trachea and bronchus. In order to avoid any interviewer bias in our study, care was taken to include articles that presented anatomical data in tabular form. Case reports, letters to the editor, conference summaries, unpublished articles, studies on fetuses, published articles with incomplete or uncertain results, age criteria, and the number of people in the article were excluded from our study. Researchers have identified a broad search strategy to reduce location bias. For literature searches on lower respiratory tracts such the trachea and bronchus, researchers used Google academic, PubMed, and Scopus databases. Searches in these databases returned 45 articles using keywords like "adult," "child," "human," "trachea," "bronchus," "diameter," "dimensions," "bronchial angles," "airway morphology," and their permutations. During the database search, neither historical date nor language restrictions were identified. In addition, the search has been expanded to include additional articles in the study from the journals' websites and by utilizing references from previously selected papers. In deciding the study, the title and abstract of the search-result articles were examined first, followed by the full text of the articles, if relevant to the subject of the study. To reduce the possibility of language and multi-publication bias in the article selection process, we also included data from incomprehensible languages and avoided using duplicate publications of the same study data. 28 articles that were published between 1984 and 2021 were selected for our study after the articles had been examined by the researchers. Table 1 and 2 show general descriptive information gathered from papers, including the articles' authors and the year they were published, the number of participants and age groups, the anatomical structures that were measured, and the methodologies that were used. The length of the trachea, the AP and transverse diameters of the trachea, the subcarinal angle, the lengths of the right and left major bronchus, and their transverse diameters, in both adults (>18 years) and children (under 18 years) are defined independently in the publications included in our analysis.

Analytıcal statistics

The data was analyzed using the SPSS 24.0 software within the scope of this study. For each parameter, the data in the studies were grouped and represented according to child and adult age groups. Minimum and maximum values, range, mean, standard deviation,

median, quartiles, and confidence intervals were generated for each parameter as descriptive statistics (Table III, Table IV). Due to the varying age group distributions in the studies and the fact that the parameter measuring method was not consistent, further statistical analysis of the data was limited.

RESULTS

In the scanned studies, total of 2308 children were examined in 13 and 7148 adults in 18 were examined. 18 of the studies were examined using CT scan, 9 using cadaver examination, 6 using chest X-ray, and 3 using 3D reconstruction method. Table III and IV provide descriptive data for trachea and bronchus measurements in children and adults. In table V and VI, studies that include measurements of trachea and bronchus sizes are presented in detail in children and adults.

As a result of the studies examined, the mean values in children and adults, respectively, trachea length are 7.52 (6.19-9.36) and 10.08 (8.13-13.25) cm; the AP diameter of the trachea is 1.19 (0.78-1.58) cm and 1.75 (1.11-2.14) cm; the transverse diameter of the trachea was found to be 1.28 (0.95-1.74) cm and 1.66 (1.23-2.57) cm. It has been observed that the parameters increase with age. The transverse diameter of the trachea was greater than the AP diameter in children, and the AP diameter was greater than the transverse diameter in adults.

When the mean values in children and adults are compared; length of right main bronchus was 2.05 (1.76-2.47) and 2.93 (1.23-11.35) cm, length of left main bronchus was 4.09 (3.48- 5.17) cm and 5.25 (3.68-10.15) cm, transverse diameter of the right main bronchus was 0.97 (0.73-1.34) cm and 1.40 (1.08-1.91) cm, and the transverse diameter of the left main bronchus was 0.85 (0.68-1.10) cm and 1.26 (0.94-1.69) cm. The mean subcarinal angle was 71.53° (56.1°–83°) and 72.14° (52.48°–82.12°) in children and adults, respectively. It has been observed that the left main bronchus is longer than the right main bronchus in children and adults, and the transverse diameters of the right main bronchus are wider than the left main bronchus. On average, all parameter values were found to be higher in adults than in children.

When the parameters were compared according to gender, all values, except the subcarinal angle, were found to be higher in males than females on average. In 4 of the

6 studies in which the subcarinal angle was measured, the values were higher in women than in men, while it was observed that it was higher in men than in women in 2 studies.

DISCUSSION

28 studies were analyzed in the review of the literature, and lower airway dimensions in children and adults were compared. In both children and adults, measurement values vary. Among the possible explanations for this are the participants' ages, the various assessment methods and procedures performed, gender disparities, and research conducted on various ethnic communities. Due to these discrepancies, standardizing measurement values is difficult.

Length of trachea

The mean value of the length of the trachea was found to be greater in adults than in children (Tables III and IV). In studies on children and adults, it was found that the length of the trachea grows with age (Tables V and VI). Studies in children have shown that the length of the trachea increases with age and is close to each other in males and females. When the studies conducted by Griscom and Wohl (1986) [14] and Kuo et al. (2018) [23] were examined, it was seen that there was no difference between men and women until puberty, and the main difference began to occur after puberty and was higher in men than in women. However, in a study by Chunder et al. (2010) [8], it was found that the length of the trachea is shorter in women than in men, who were aged 0–15 years old. Chunder et al. (2010) [8] stated that this may be due to the puberty of children.

In all studies on adults, the length of the trachea increased with age, and it was found to be greater in males than females. However, in the study conducted by Chunder et al. (2010) [8] in the age groups of 41–55 and over 55 years old, it was stated that the length of the trachea decreased in both men and women depending on age. Chunder et al. (2010) [8] stated that this may be due to excessive contraction of the trachea by fibrous tissue due to aging.

Trachea lengths differ according to the method used in the studies. For example, in studies conducted by examining CT images of children [14,23,25] and adults [19,36], it was found that trachea lengths were higher than studies performed on child [18] and adult [4,18,19,28] cadavers.

AP and transverse dıamaters of trachea

It was noticed in comparative studies of children and adults that the diameters increased with age [5,8,18,37]. In every study that compared men and women, the diameters of men were found to be bigger than those of women.

In studies comparing the AP and transverse diameters of the trachea in children and adults, it was discovered that there were differences (Tables V and VI). The mean value of the transverse diameter of the trachea was found to be greater than the AP diameter in children's studies [6,14,25,37]. While the average value of the diameters was equal in the study by Breatnach et al. (1984) [5], the mean value of the AP diameter of the trachea was found to be larger than the transverse diameter in the study by Jit et al. (2000) [18]. In a study conducted by Chunder et al. (2010) [8] in the 0-15 age group, it was discovered that men had a larger AP diameter and women had a larger transverse diameter. Jit et al. (2000) [18] stated that these differences may be racial, due to the variability of the subjects' height and neck length.

Studies in adults were reviewed and studies were found in which the mean value of the AP diameter of the trachea was larger [4,5,9,18,36,42] and smaller [19,30,37] than the mean value of the transverse diameter.

The trachea's AP and transverse diameters differ depending on how they're measured. The values of the transverse and AP diameters of the trachea measured on CT images were larger than the values measured on cadavers, according to Kamel et al. (2009) [19]. The transverse diameter of the trachea measured on the chest X-ray was found to be higher than the value of the transverse diameter measured on the CT images in studies conducted by Sakuraba et al. (2010) [31].

Lengths of right and left main bronchus

In studies comparing the lengths of the right and left main bronchus in children and adults, the average values of main bronchus lengths in adults were found to be higher

than in children (Tables III and IV). In studies conducted on adults, the lengths of the main bronchus were found to be greater in males than in females [7,18,20,24,27,36]. In studies examining the lengths of the right and left main bronchus in children [18,25] and adults [18,20,21,24,27,37] comparatively, the length of the left main bronchus is compared to the length of the right main bronchus and found to be larger.

The lengths of the main bronchus differ according to the measurement methods. In a study by Lee et al. (2014) [24] in which measurements were made on 2D (two-dimensional) and 3D (three- dimensional) images in adults, it was found that the length of the right main bronchus was larger in 2D images than in 3D images. The length of the left main bronchus was found to be smaller in 2D images than in 3D images.

Transverse diamaters of right and left maın bronchus

The mean values of the transverse diameters of the main bronchus in adults were larger than in children, according to studies comparing the transverse diameters of the right and left main bronchus in children and adults (Tables III and IV). The diameters of the right and left main bronchus were found to be larger in men than in women in all of the studies (Tables V and VI.). All studies measuring the transverse diameters of the right and left main bronchus in children [2,6,18,23,25,33,35] and adults [15,18,20,21,24,27,37,42] found that the right main bronchus was larger than the left main bronchus. The value of the main bronchus' transverse diameter was found to be greater than the transverse diameter of the left main bronchus.

The transverse diameters of the main bronchus vary depending on the method of measurement. Lee et al. (2014) [24] determined that the transverse diameters of the right and left main bronchus were smaller in 3D images than in 2D images in adults.

Subcarinal angle

Considering the studies examining the subcarinal angle in children and adults, it is seen that the mean value of the subcarinal angle is higher in adults than in children (Tables III and IV). In a comparative study by Ulusoy et al. (2016) [37] in children and adult, it was reported that the mean value of the subcarinal angle was higher in adults. In the studies conducted by Jit et al. (2000) [18] and Chunder et al. (2010) [8], the mean value

of the subcarinal angle was found to be higher in children. It was stated by Farrukhabad et al. (2015) [12] that with increasing age, the ossification of the chest wall and ribs is about to be completed, relatively hardening and causing the subcarinal angle to narrow by directing the lower growth of the lungs.

The subcarinal angle varies by gender. It was found to be higher in men than women in some studies [8,20,34], but higher in women in others [18,19,27,37].

Understanding the subcarinal angle is critical in some clinical scenarios. Enlargement of mediastinal structures or pulmonary diseases can dramatically modify the subcarinal angle. Due to the fact that the right main bronchus is almost parallel to the trachea, the right subcarinal angle, which is a component of the subcarinal angle, is smaller than the left subcarinal angle. For this reason, the probability of foreign bodies entering the right lung is higher [12].

CONCLUSIONS

The literature reviews on the trachea and bronchus in children and adults were compared according to age and gender in this study. The mean values of all parameters in the studies increased with age, and gender differences were found to have an impact on the differences in measured parameter values. The AP diameter of the trachea was discovered to be less than the transverse diameter in children, whereas the AP diameter of the trachea was found to be bigger than the transverse diameter in adults. According to studies, the right main bronchus transverse diameter is greater than the left main bronchus transverse diameter in children and adults. Despite the fact that the mean value in subcarinal angle studies is higher in adults than in children, there are research that contradict these findings [8,18]. The data collected from the parameters varies since the measurements were done with varied methods and techniques in the investigations, and it is assumed that standardization is difficult. We believe that the data gained will be valuable in terms of theory and clinic, and that it will be useful to perform additional research in a larger population, including children and adults, in a comparative manner, in conjunction with creating methodologies and procedures.

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Table I: General Descriptive Data on Lower Airway Studies in Children

Studies	Age	Number of people	Parameter	Method
Griscom & Wohl (1986)	0-18 years	119 people (64 men, 55 women)	Trachea length, AP and transverse diameters, cross-sectional area, volume	CT image
Herek D. & Ozkan (2017)	0-18 years	118 children (67 men, 51 women)	SCA, RBA, LBA, IBA	CT image
Breatnach et al. (1984)	10-18 years	48 children (26 men, 22 women)	of trachea AP and transverse diameters	Chest X-ray
Kuo et al. (2018)	0-18 years	240 people (155 men, 85 women)	Trachea length, transverse diameter, right and left main bronchus diameters	CT image
Ulusoy et al. (2016)	0-18 years	41 people (26 men, 15 women)	AP and transverse diameters of trachea, trachea cross-sectional area, RBA, LBA, IBA	Multidetect or CT image
Jit H. & Jit I. (2000)	0- 18 years	60 children (30 men, 30 women)	Trachea length, AP and transverse diameters, right and left main bronchus lengths and transverse diameters, subcarinal angle	Cadaver study

Table I: General Descriptive Data on Lower Airway Studies in Children (continue)

Chalwadi et al. (2021)	0-18 years	110 children (54 men, 56 women)	AP, transverse diameters and cross-sectional areas of trachea, right and left main bronchus	CT image
Tan & Tan-Kendrick (2002)	2 days -16 years	250 children (133 men, 117 women)	Right and left main bronchus transverse diameters	CT image
Luscan et al. (2020)	1 day -14 years	192 children (127 men, 65 women)	Trachea length, AP and transverse diameters, right and left main bronchus lengths, AP and transverse diameters	CT image
Aslan et al. (2015)	0-16 years	520 people (246 men, 274 women)	Trachea diameters of right and left main bronchus	Chest X-ray
Szelloe et al. (2017)	0-16 years	195 people (118 men, 77 women)	Trachea, right and left main bronchus, AP diameter, transverse diameter, cross-sectional area	CT image
Tahir et al. (2009)	<16 years old	156 people (84 men, 72 women)	Trachea, right and left main bronchus transverse diameters, RBA, LBA, SCA	Chest X-ray
Kubota et al. (1986)	0-13 years	259 babies and children	RBA, LBA, SCA	Chest X-ray

Abbreviations: AP: anterior-posterior diameter; RBA: right bronchial angle; LBA: left bronchial angle; IBA: interbronchial angle; SCA: subcarinal angle; CT: computed tomography.

Table: II General Descriptive Data on Lower Airway Studies in Adults

Studies	**Age**	**Number of people**	**Parameter**	**Method**
Breatnach et al. (1984)	20-79 years	760 people (404 men, 356 women)	Trachea length, AP and transverse diameters, cross-sectional area, volume	CT image
Tuncer (2019)	Average: 52 years	150 people (81 men, 69 women)	Trachea length, AP and transverse diameters, right and left main bronchus lengths, lobar bronchus lengths	CT image
Ulusoy et al. (2016)	19-74 years	212 people (116 men, 96 women)	AP and transverse diameters of trachea, cross-sectional area of trachea, RBA, LBA, IBA	Multidetector CT image
Jit H. & Jit I. (2000)	18-75 years	370 people (220 men, 150 women)	Trachea length, AP and transverse diameters, right and left main bronchus lengths and diameters, RBA, LBA, SCA	Cadaver study
Zahedi-Nejad et al. (2011)	20-85 years	200 people (132 men, 68 women)	AP and transverse diameters of trachea, cross-sectional area of trachea, diameters of right and left main bronchus	CT image
Mi et al. (2015)	18-89 years	2107 people (1143 men, 964 women)	Trachea length, AP and transverse diameters, right and left main bronchus lengths and diameters, RBA, LBA, right upper lobe bronchus length and angle	CT image 3D reconstruction
Tamang et al. (2017)	Adult individuals	40 people (20 men, 20 women)	Length and transverse diameter of trachea, SCA	Cadaver study
Sakuraba et al. (2010)	Average age 58	146 people (55 men, 91 women)	Trachea transverse diameter	Chest X-ray CT image

Table: II General Descriptive Data on Lower Airway Studies in Adults (continue)

Chen et al. (2020)	18-89 years	2093 people (1136 men, 957 women)	Length and diameter of right main bronchus, right upper lobe length, diameter and angle of the	CT image

			bronchus, RBA	
Premakumar et al. (2018)	70-96 years	10 people (8 men, 2 women)	Trachea, AP and transverse diameters	Cadaver study
Lee et al. (2014)	21-78 years	160 people (80 women, 80 men)	Right-left main bronchus length, AP and transverse diameters	3D reconstruction CT image
Kim & Song (2017)	47-91 years	48 cadavers (33 males, 15 females)	of right and left main bronchus, AP and transverse diameters, SCA	Cadaver study
Bhandari et al. (2018)	over 18 years	182 cadavers (132 men, 50 women)	Trachea, AP and transverse diameters	Cadaver study
Kamel et al. (2009)	CT image: 22-88 years Cadaver study: 68-101 years old	CT: 60 people (40 men, 20 women) Cadaver: 10 people (7 men, 3 women.)	Trachea length, AP and transverse diameters, tracheal volume, SCA	CT image Cadaver study
Otoch et al. (2013)	18-83 years old male patients	134 people	Trachea, length of right main bronchus	Cadaver study
Datta et al. (2019)	20-65 years	60 cadavers (30 men, 30 women)	Trachea, AP and transverse diameters	Cadaver study
Hampton et al. (2000)	Adult individuals	206 people (130 men, 76 women)	Trachea diameter, right and left main bronchus diameters	Chest X-ray
Kim et al. (2014)	19-80 years	200 people (100 men, 100 women)	Right and left main bronchus lengths, AP and transverse diameters	CT image 3D reconstruction

Abbreviations: AP: anterior-posterior diameter; RBA: right bronchial angle; LBA: left bronchial angle; IBA: interbronchial angle; SCA: subcarinal angle; CT: computed tomography; 3D: three-dimensional reconstruction.

Table III: Descriptive Statistics of Measurements of Trachea and Bronchus in Children

	LMB TR Diamater	**LMB Length**	**RMB TR Diamater**	**RMB Length**	**SCA**	**Trachea AP Diamater**	**Trachea TR Diamater**	**Trachea Length**

Age	0-18	0-18	0-18	0-18	0-18	0-18	0-18	0-18
Min	0.68	3.48	0.73	1.76	56.10	0.78	0.95	6.19
Max	1.10	5.17	1.34	2.47	83.00	1.58	1.74	9.36
Range	0.42	1.69	0.61	0.71	26.90	0.80	0.79	3.17
Mean	0.85	4.09	0.97	2.05	71.53	1.19	1.28	7.52
SD	0.14	0.94	0.20	0.37	10.25	0.29	0.27	1.36
95,0% Lower CL for Mean	0.73	1.77	0.81	1.13	60.77	0.92	1.07	5.36
95,0% Upper CL for Mean	0.96	6.42	1.14	2.97	82.28	1.46	1.49	9.68
Median	0.83	3.63	0.98	1.93	73.12	1.10	1.14	7.27
95,0% Lower CL for Median	0.70	3.48	0.75	1.76	63.25	0.94	1.13	6.19
95,0% Upper CL for Median	0.96	5.17	1.10	2.47	80.56	1.58	1.60	9.36
Percentile 05	0.68	3.48	0.73	1.76	56.10	0.78	0.95	6.19
Percentile 25	0.75	3.48	0.83	1.76	63.25	0.94	1.13	6.56
Percentile 75	0.92	5.17	1.06	2.47	80.56	1.50	1.50	8.48
Percentile 95	1.10	5.17	1.34	2.47	83.00	1.58	1.74	9.36

Abbreviations: LMB: left main bronchus; RMB: right main bronchus; SCA: subcarinal angle; AP: anterior-posterior diamater; TR: transvers diamater; CL: confidence interval; SD: standard deviation; Min: minimum; Max: maximum.

** Values are presented as centimeter and degree.

Table IV: Descriptive Statistics of Measurements of Trachea and Bronchus in Adults

	LMB TR Diamater	**LMB Length**	**RMB TR Diamater**	**RMB Length**	**SCA**	**Trachea AP Diamater**	**Trachea TR Diamater**	**Trachea Length**
Age	18-89	18-89	18-89	18-89	18-89	18-89	18-89	18-89
Min	0.94	3.68	1.08	1.23	52.48	1.11	1.23	8.13
Max	1.69	10.15	1.91	11.35	82.12	2.14	2.57	13.25
Range	0.75	6.47	0.83	10.12	29.64	1.03	1.34	5.12
Mean	1.26	5.25	1.40	2.93	72.14	1.75	1.66	10.08
SD	0.28	2.19	0.27	3.24	10.48	0.25	0.33	1.39
95,0% Lower CL for Mean	1.02	3.22	1.20	0.44	61.14	1.59	1.47	9.09
95,0% Upper CL for Mean	1.49	7.28	1.61	5.42	83.14	1.91	1.84	11.08
Median	1.17	4.59	1.32	1.68	74.44	1.80	1.65	10.20
95,0% Lower CL for Median	1.07	4.29	1.25	1.36	71.37	1.72	1.58	9.20
95,0% Upper CL for Median	1.66	10.15	1.76	3.30	78.00	1.85	1.75	10.38
Percentile 05	0.94	3.68	1.08	1.23	52.48	1.11	1.23	8.13
Percentile 25	1.08	4.29	1.25	1.36	71.37	1.72	1.51	9.20
Percentile 75	1.46	4.83	1.46	2.55	78.00	1.85	1.75	10.38
Percentile 95	1.69	10.15	1.91	11.35	82.12	2.14	2.57	13.25

Abbreviations: LMB: left main bronchus; RMB: right main bronchus; SCA: subcarinal angle; AP: anterior-posterior diamater; TR: transvers diamater; CL: confidence interval; SD: standard deviation; Min: minimum; Max: maximum.
** Values are presented as centimeter and degree.

Table V: Studies Examining the Sizes of Trachea and Bronchus in Children

STUDIES	**PARAMETERS**	**PARAMETERS**
	RMB TR Diamater	**LMB TR Diamater**
Kuo[23]	Male: 1,12 Female: 1,06	Male: 0,87 Female: 0,78
Jit[18]	Average: 0,9	Average: 0,82
Chalwadi[6]	Average: 1,02	Average: 0,96
Tan[35]	Average: 0,75	Average: 0,7
Luscan[25]	Average: 1,01	Average: 0,88

Aslan[2]	Average: 0,94	Average: 0,8
Tahir[33]	Male: 0,77 Female: 0,68	Male: 0,7 Female: 0,67
	RMB Length	**LMB Length**
Jit[18]	Average: 1,93	Average: 3,48
Luscan[25]	Average: 1,76	Average: 3,63
	Trachea AP Diamater	**Trachea TR Diamater**
Griscom[14]	Male: 1,1 Female: 1,08	Male: 1,14 Female: 1,14
Breatnach[5]	Male: 1,54 Female: 1,45	Male 1,55 Female: 1,44
Ulusoy[37]	Male: 1,22 Female: 0,94	Male: 1,37 Female: 0,99
Jit[18]	Average: 1,32	Average: 1,13
Chalwadi[6]	Average: 1,1	Average: 1,16
Luscan[25]	Average: 0,78	Average: 1,02
Szelloe[32]	Average: 0,94	----------
Kuo[23]	----------	Male 1,32 Female: 1,2
Aslan[2]	----------	Average: 1,14
Tahir[33]	----------	Male: 1,02 Female: 0,91
	Trachea Length	**Subcarinal Angle**
Griscom[14]	Male: 9,45 Female: 9,28	----------
Kuo[23]	Male: 7,06 Female: 6,09	----------
Jit[18]	Average: 6,09	Average: 56,10°
Luscan[25]	Average: 7,6	----------
Herek[17]	----------	Average: 80,56°
Ulusoy[37]	----------	Male: 72,55 ° Female: 69,6°
Aslan[2]	----------	Average: 63,25°
Kubota[22]	----------	Average: 83°

Abbreviations: LMB: left main bronchus; RMB: right main bronchus; AP: anterior-posterior diamater; TR: transverse diamater.

** Values are presented as centimeter and degree.

Table VI: Studies Examining the Sizes of Trachea and Bronchus in Adult

STUDIES	**PARAMETERS**	**PARAMETERS**
	RMB TR Diamater	**LMB TR Diamater**
Ulusoy[37]	Average: 1,34	Average: 1,1
Jit[18]	Male: 1,36 Female: 1,1	Male: 1,16 Female: 0,94
Mi[27]	Male: 1,41 Female: 1,21	Male: 1,16 Female: 1,0
Lee[24] (2D)	Male: 1,98 Female: 1,84	Male: 1,82 Female: 1,56
Lee[24] (3D)	Male: 1,56 Female: 1,21	Male: 1,35 Female: 1,01
Kim[21]	Male: 1,89 Female: 1,65	Male: 1,7 Female: 1,44
Kim[20]	Male: 1,51 Female: 1,18	Male: 1,3 Female: 0,99

Hampton[15]	Male: 1,5 Female: 1,38	Male: 1,3 Female: 1,18
Zahedi-nejad[42]	Male:1,16 Female: 0,93	Male:1,02 Female: 0,8
Chen[7]	Male: 1,41 Female: 1,21	----------
	RMB Length	**LMB Length**
Tuncer[36]	Male: 12,56 Female: 10,15	Male: 11,38 Female: 8,71
Ulusoy[37]	Average: 2,47	Average: 5,17
Jit[18]	Male: 2,68 Female: 2,37	Male: 4,81 Female: 4,37
Mi[27]	Male: 1,41 Female: 1,29	Male: 5,0 Female: 4,62
Lee[24] (2D)	Male: 1,38 Female: 1,37	Male: 4,36 Female: 4,19
Lee[24] (3D)	Male: 1,34 Female: 1,18	Male: 4,82 Female: 4,36
Kim[21]	Male: 1,68 Female: 1,69	Male: 3,72 Female: 3,6
Kim[20]	Male: 1,29 Female: 1,17	Male: 4,78 Female: 4,35
Chen[7]	Male: 2,37 Female: 2,15	----------
Otoch[28]	Average: 3,3	----------

** Values are presented as centimeter.

Table VI: Studies Examining the Sizes of Trachea and Bronchus in Adult (continue)

	Trachea AP Diamater	**Trachea TR Diamater**
Breatnach[5]	Male: 2,01 Female: 1,63	Male: 1,92 Female: 1,62
Tuncer[36]	Male: 1,98 Female: 1,55	Male: 1,85 Female: 1,49
Ulusoy[37]	Male: 1,76 Female: 1,35	Male: 1,94 Female: 1,51
Jit[18]	Male: 2,0 Female: 1,62	Male: 1,65 Female: 1,3
Zahedi-nejad[42]	Male: 1,96 Female: 1,47	Male: 1,8 Female: 1,43
Mi[27]	Male: 1,9 Female: 1,49	Male: 1,71 Female: 1,49
Premakumar[30]	Average: 1,72	Average: 1,73
Bhandari[4]	Male: 1,89 Female: 1,58	Male: 1,32 Female: 1,05
Kamel[19] (CT)	Male: 2,26 Female: 1,92	Male: 2,71 Female: 2,29
Kamel[19] (Cadaver)	Male: 2,17 Female: 1,55	Male: 2,13 Female: 1,78
Datta[9]	Male: 1,55 Female: 1,37	Male: 1,29 Female: 1,2
Sakuraba[31] (CT)	----------	Male: 1,74 Female: 1,48
Sakuraba[31] (Chest x-ray)	----------	Male: 1,77 Female: 1,58
Otoch[28]	Average: 1,85	----------
Tamang[34]	----------	Male: 1,85 Female: 1,34
Hampton[15]	----------	Average: 1,79
	Trachea Length	**Subcarinal Angle**
Jit[18]	Male: 8,93 Female: 8,19	Male: 51,2° Female: 54,3°
Tamang[34]	Male: 11,13 Female: 9,58	Male: 72,15° Female: 70,6°
Kamel[19] (CT)	Male: 10,5 Female: 9,83	Male: 76° Female: 81°
Kamel[19] (Cadaver)	Male: 10,26 Female: 9,6	----------
Mi[27]	Male: 10,7 Female: 10,1	Male: 75,2° Female: 80,1°

Tuncer[36]	Male: 14,24 Female: 12,26	----------
Premakumar[30]	Average: 10,38	----------
Bhandari[4]	Male: 8,28 Female: 7,75	----------
Otoch[28]	Average: 9,2	----------
Datta[9]	Male: 10,42 Female: 9,81	----------
Ulusoy[37]	----------	Male: 71,5°; Female: 76,4°
Kim[20]	----------	Male: 83,4°; Female: 79°

Abbreviations: LMB: left main bronchus; RMB: right main bronchus; AP: anterior-posterior diamater; TR: transvers diamater; CT: computed tomography; 2D: two-dimensional image; 3D: three-dimensional image.

** Values are presented as centimeter and degree.

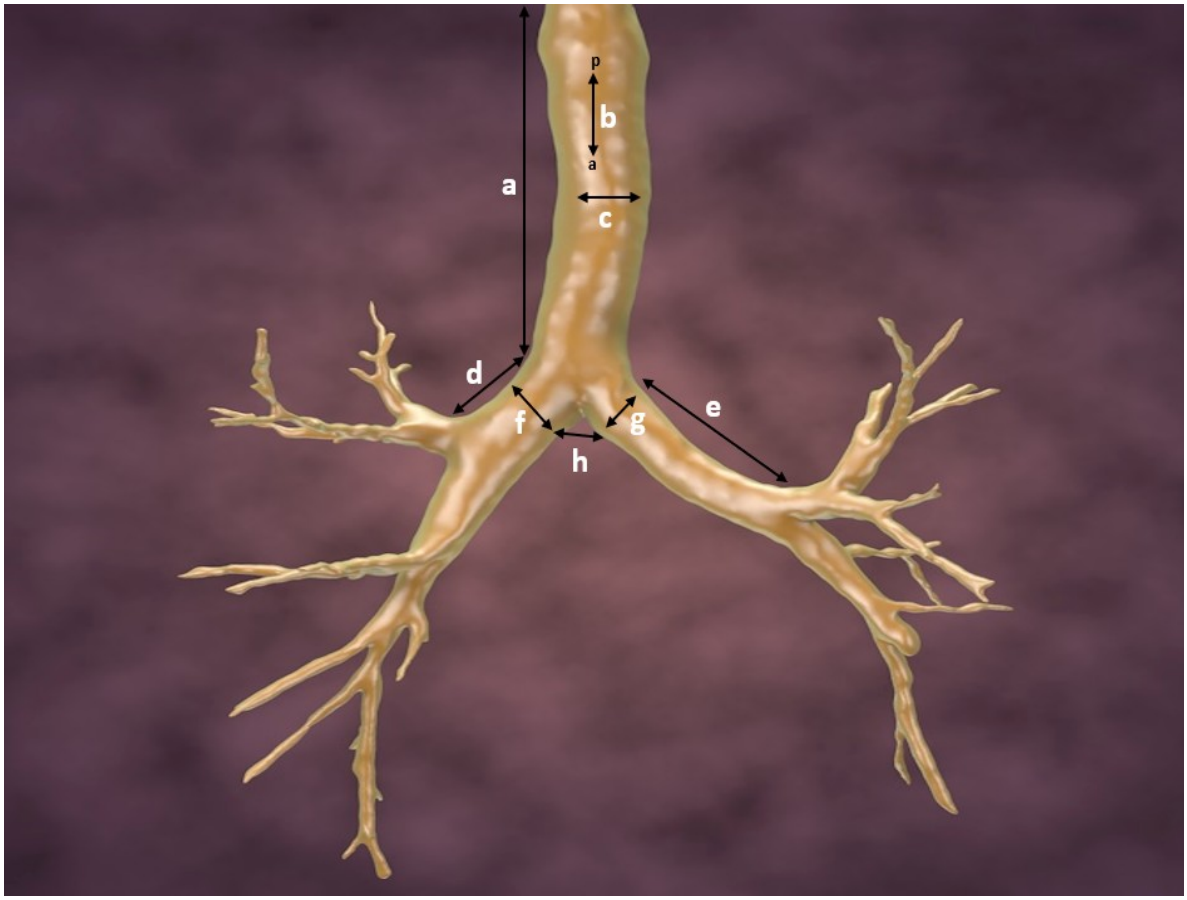


Figure I. Three-dimensional model of tracheobronchial tree; a — Trachea length; b — Trachea AP diamater; c — Trachea transvers diamater; d — RMB length; e — LMB length; f — RMB transvers diamater; g — LMB transvers diamater; h — Subcarinal angle.