Morphometrically Assessment of the Bronchial Tree

Bronş Ağacının Morfometrik Olarak Değerlendirilmesi

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ABSTRACT Objective: Knowledge of the diameter and length of the bronchial tree is important in minimizing complications which may occur during bronchoscopy. The purpose of this study was to estimate the bronchial tree morphometrically. **Material and Methods:** Thirty lungs taken from 15 cadavers (8 males and 7 females) were used in our study. The ages of the subjects were from 37-64 years. The subjects with bronchopulmonary disease were excluded from the study. All lungs were injected with red ink. Then, the bronchial tree was exposed by dissection. The lengths and diameters of tracheae and bronchi; and angles related to main bronchi were measured in all lungs using a caliper. We statistically analyzed the relationship between the data acquired. **Results:** Relations among angles, lengths and diameters of the main bronchi, diameters of the superior lobar bronchi and lengths of the inferior lobar bronchi parameters were statistically significant. Furthermore, the differences among angles, lengths and diameters of the main bronchi; and lengths and diameters of the superior lobar bronchi were significant. **Conclusion:** Our results are conformity with the results of many investigators. The results of this study will provide a great benefit in minimizing the complications which may occur during bronchoscopy and pulmonary surgery. Also, we hope that this study will be helpful for many radiological and anatomical studies.

Key Words: Trachea; bronchi; lung

ÖZET Amaç: Bronkoskopi sırasında ortaya çıkabilecek istenmeyen durumları azaltmak amacıyla bronş ağacının çapı ve uzunluğu hakkında bilgi sahibi olmak önemlidir. Bu çalışmanın amacı bronş ağacını morfometrik olarak değerlendirmekti. **Gereç ve Yöntemler:** Çalışmamızda 15 adet kadavradan (8 erkek, 7 kadın) alınan 30 akciğer kullanıldı. Yaşları 37 ile 64 arasında değişiyordu. Bronkopulmoner hastalığı olan örnekler çalışma dışı bırakıldı. Tüm akciğerlere kırmızı mürekkep enjeksiyonu uygulandı. Sonra bronş ağacı diseksiyon ile ortaya çıkarıldı. Tüm akciğerlerde trakea ve bronkusların uzunlukları ve çapları; ve ana bronkuslarla ilişkili açılar kompas kullanılarak ölçüldü. Elde edilen verilerin birbirleriyle olan ilişkilerini istatistiksel olarak analiz ettik. **Bulgular:** Ana bronkusların açıları, uzunlukları ve çapları; üst lobar bronkusların çapları; ve alt lobar bronkusların uzunlukları arasındaki ilişki istatistiksel olarak anlamlıydı. Ayrıca, ana bronkusların açıları, uzunlukları ve çapları; ve üst lobar bronkusların uzunlukları ve çapları arası farklılık anlamlıydı. **Sonuç:** Bulgularımız birçok araştırmacının bulgularıyla uyumluydu. Bu çalışmanın bulguları bronkoskopi ve akciğer cerrahisi esnasında ortaya çıkabilecek olan istenmeyen durumları azaltmada büyük fayda sağlayacaktır. Ayrıca, birçok radyolojik ve anatomik çalışma için yararlı olacağını ümit ediyoruz.

Anahtar Kelimeler: Trakea; bronkuslar; akciğer

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Trachea is about 100 mm long. Its external diameter is about 20 mm in adult males and 15 mm in adult females. The trachea, bifurcate into the two main bronchi at the level of the sternal angle.[1,2] The right principal bronchus is about 25 mm long. Its point of bifurcation is called to the tracheal bifurcation.[1]

The right superior lobar bronchus arises from the lateral aspect of the right main bronchus. The right superior lobar bronchus commonly divides into three branches designated apical (B1), posterior (B2) and anterior (B3) about 10 mm from its origin.[1-4] Then, the right main bronchus continues as the intermediate bronchus.[2-4] The intermediate bronchus bifurcates to become the bronchi to the middle and lower lobes.[2,3]

The middle lobar bronchus bifurcates into lateral (B4) and medial (B5) segmental branches. The right inferior lobar bronchus; bifurcates into superior (B6), medial basilar (B7), anterior basilar (B8), lateral basilar (B9) and posterior basilar (B10) segmental branches.[1-4]

The left main bronchus is nearly 50 mm long, and divides into the upper and lower lobar bronchi.[1-4] The left superior lobar bronchus bifurcates two divisions. The upper division immediately divides into three segmental branches, B1, B2 and B3. The lower division is the lingular common trunk and divides into superior (B4) and inferior (B5) divisions.[2,3] The left inferior lobar bronchus; bifurcates into B6, B7, B8, B9 and B10 segmental branches.[1-3]

Knowledge of the measurement of the airways is necessary for most of the clinical implications. Thus in our study we aimed to estimate size of the bronchial tree from the trachea to segmental bronchi.

MATERIAL AND METHODS

This study examined 30 lungs from 15 cadavers fixed with formaldehyde. The subjects with a history of the bronchopulmonary disease were excluded from the study. Dissections of all lungs were performed in the Department of Anatomy, Gulhane Military Medical Academy. The protocol for the research project was approved by a suitably constituted Ethics Committee of the institution within which work was undertaken and the study conformed to the provisions of the Declaration of Helsinki in 2008 (as revised in Tokyo 2004). The ages of the subjects were from 37-64 years (8 males and 7 females). Anterior thoracic wall was cut with costotomy and elevated. Then, the lung was removed and placed in 10% formaldehyde for a period of 5-10 days.

All lungs were injected with red ink through the trachea. Then, vessels and lymph nodes in the hilar region were removed. The primary branches of each lobe were dissected from the surrounding parenchyma. Each lobe was also dissected from the anterior surface under the dissecting microscope. Thus the bronchial tree was displayed and photographed (Figure 1). Then, parameters in Table 1 were measured (Figure 2-6) in each specimen using a 0.1 mm sensitive caliper and the data acquired were statistically analyzed.

Data were analyzed with SPSS 11.5 (SPSSFW,

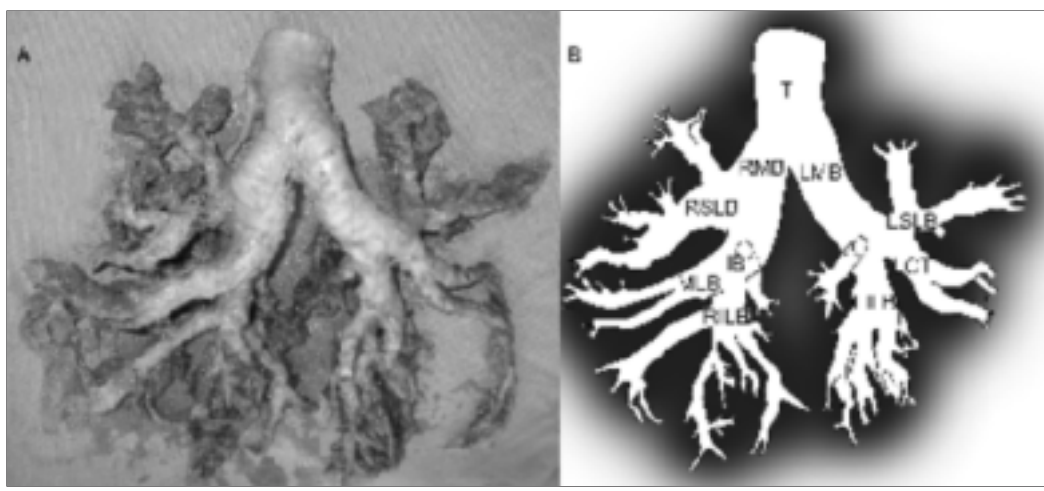

FIGURE 1: A: The bronchial tree (anterior view). **B:** Schematic drawing of the bronchial tree. Trachea (T); right main bronchus (RMB); left main bronchus (LMB); right superior lobar bronchus (RSLB); left superior lobar bronchus (LSLB); intermediate bronchus (IB); middle lobar bronchus (MLB); lingular common trunk (LCT); right inferior lobar bronchus (RILB); left inferior lobar bronchus (LILB).

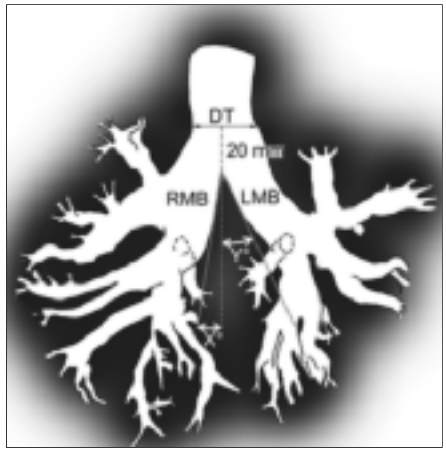

FIGURE 2: The schematic drawing of the bronchial tree (anterior view). Diameter of trachea (DT); angle between vertical line running to tracheal bifurcation and lower border of right main bronchus (X°); angle between vertical line running to tracheal bifurcation and lower border of left main bronchus (Y°); right main bronchus (RMB); left main bronchus (LMB).

FIGURE 3: The schematic drawing of the bronchial tree (anterior view). Length of right main bronchus (LRMB); diameter of right main bronchus (DRMB); length of left main bronchus (LLMB); diameter of left main bronchus (DLMB).

SPSS Inc., Chicago, IL., USA) software. Descriptive statistics of the parameters were given as the mean ± S.D. notation. Left and right values were compared either by a "test for significant of difference between two pairs". Relations among the parameters were investigated by calculating the Pearson coefficient of correlation. $\alpha = 0.05$ was selected as false level. U values less than or equal to p values were evaluated as statistically different.

RESULTS

The measurements with parameters displayed in Table 1 were documented in Table 2. Results of measurements were compared. Relations among X° and Y°; LRMB and LLMB; DRMB and DLMB; DRSLB and DLSLB; LRILB and LLILB parameters were statistically significant (Table 3). Furthermore, the differences between X° and Y°; LRMB and LLMB; DRMB and DLMB; LRSLB and LLSLB; DRSLB and DLSLB; and RB6 and LB6 parameters were significant (Table 4).

DISCUSSION

Several investigators have analyzed the geometry and dimensions of the conducting system by inflating the lungs with plastic, polyester resin or silicone rubber and taking detailed measurements of

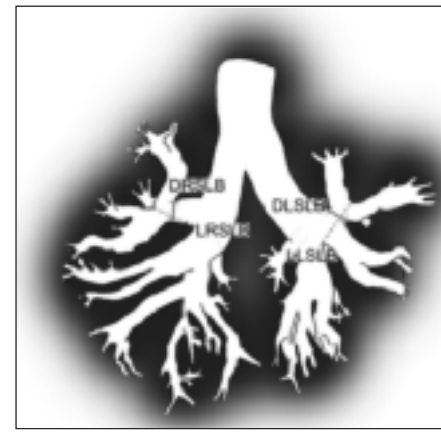

FIGURE 4: The schematic drawing of the bronchial tree (anterior view). Length of right superior lobar bronchus (LRSLB); diameter of right superior lobar bronchus (DRSLB); length of left superior lobar bronchus (LLSLB); diameter of left superior lobar bronchus (DLSLB).

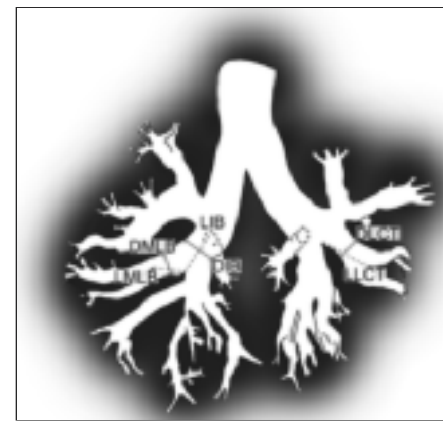

FIGURE 5: The schematic drawing of the bronchial tree (anterior view). Length of intermediate bronchus (LIB); diameter of intermediate bronchus (DIB); length of middle lobar bronchus (LMLB); diameter of middle lobar bronchus (DMLB); length of lingular common trunk (LLCT); diameter of lingular common trunk (DLCT).

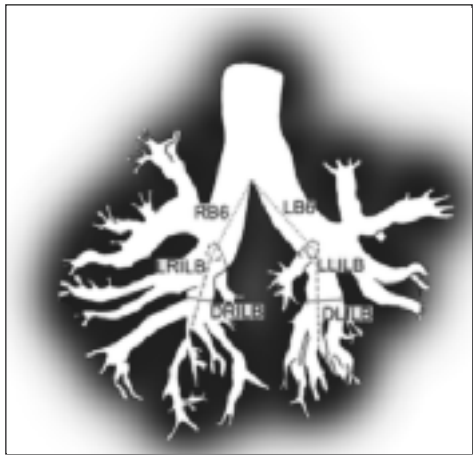

FIGURE 6: The schematic drawing of the bronchial tree (anterior view). Length of right inferior lobar bronchus (LRILB); diameter of right inferior lobar bronchus (DRILB); length of left inferior lobar bronchus (LLILB); diameter of left inferior lobar bronchus (DLILB); distance between arising point of right superior segmental bronchus and tracheal carina (RB6); distance between arising point of left superior segmental bronchus and tracheal carina (LB6).

the resulting casts.[5-7] Although the results of these studies have been extensively used in lung modeling, it is important to note that they come from a very small number of lungs fixed; for example, the data of Horsfield were derived from the lungs of only one subject.[7] Moreover, it take attention that injection-dissection method was performed by few researchers.[5-10]

Reports of other researchers related to DT are summarized in Table 5. In our study, mean diameter of DT was 19.23 ± 2.28 mm. Our results correspond to the results of other researchers.[2,3,11-21] The mean diameters of trachea measured by different methods such as cadaver study, computerized tomography, posteroanterior chest radiography and endobronchial tube are not shown significant differences.

Several investigators found that LLMB and LRMB are about 50 mm, 20-25 mm, respectively. Our results are in conformity with observations of these investigators.[1-4,22] Fraser found that DLMB and DRMB are about 13 mm, 15,3 mm, respectively. Merendino reported that these diameters are about 13 mm, 16 mm, respectively. Our results is in conformity with observations of these researchers.[3,16]

TABLE 1: The abbreviations of measured parameters.

DT	External diameter of trachea 20 mm proximal to the tracheal bifurcation
X°	Angle between vertical line running to tracheal bifurcation and lower border of right main bronchus
Y°	Angle between vertical line running to tracheal bifurcation and lower border of left main bronchus
LRMB	Length of right main bronchus
DRMB	Diameter of right main bronchus
LLMB	Length of left main bronchus
DLMB	Diameter of left main bronchus
LRSLB	Length of right superior lobar bronchus
DRSLB	Diameter of right superior lobar bronchus
LIB	Length of intermediate bronchus
DIB	Diameter of intermediate bronchus
LMLB	Length of middle lobar bronchus
DMLB	Diameter of middle lobar bronchus
LLCT	Length of lingular common trunk
DLCT	Diameter of lingular common trunk
LRILB	Length of right inferior lobar bronchus
DRILB	Diameter of right inferior lobar bronchus
LLSLB	Length of left superior lobar bronchus
DLSLB	Diameter of left superior lobar bronchus
LLILB	Length of left inferior lobar bronchus
DLILB	Diameter of left inferior lobar bronchus
RB6	Distance between arising point of right superior segmental bronchus and tracheal carina
LB6	Distance between arising point of left superior segmental bronchus and tracheal carina

TABLE 2: The means and standard deviations of the measurements (in mm).

Measurement	Mean	Standard deviation
DT	19.23	2.28
X°	18.86	3.46
Y°	30.60	4.44
LRMB	30.30	8.84
DRMB	18.36	2.00
LLMB	47.63	12.65
DLMB	14.45	2.40
LRSLB	20.59	2.67
DRSLB	12.51	2.35
LIB	39.03	3.48
DIB	14.37	2.05
LMLB	24.36	5.40
DMLB	8.81	1.54
LLCT	23.60	3.01
DLCT	9.61	2.14
LRILB	36.35	13.51
DRILB	11.67	1.53
LLSLB	22.53	2.36
DLSLB	11.59	2.15
LLILB	33.95	9.16
DLILB	12.17	1.28
RB6	46.56	4.79
LB6	51.40	6.82

TABLE 3: The results of relations among the parameters.

Parameter	r*	P
X°-Y°	0.778	0.001
LRMB-LLMB	0.706	0.003
DRMB-DLMB	0.678	0.005
LRSLB-LLSLB	0.324	0.239
DRSLB-DLSLB	0.748	0.001
LMLB-LLCT	0.338	0.218
DMLB-DLCT	0.302	0.274
LRILB-LLILB	0.866	< 0.001
DRILB-DLILB	-0.193	0.490
RB6-LB6	0.503	0.056

*The Pearson correlation coefficient.

According to results of X°, Y°, LRMB, LLMB, DRMB and DLMB parameters we found that right main bronchus is slightly larger, shorter than the left one and is oriented more vertically. These results is conformity with classic knowledge.[1,3,4]

Bannister, Naidich, Fraser and Shields reported that LRSLB is about 20 mm, which is in conformity with observations in present study.[1-4] Koshino et al found that DRSLB is about 10 mm, which is in conformity with results in our study.[22]

Naidich and Fraser reported that LIB is about 30-40 mm, which is in conformity with observations in present study.[2,3] However, several researchers reported that LMLB is 10-26 mm. Our results and results of these authors are close.[1-4,22,23]

TABLE 4: The results of comparison of the parameters.

Parameter	t	p
X°-Y°	16.295	< 0.001
LRMB-LLMB	-7.484	< 0.001
DRMB-DLMB	8.399	< 0.001
LRSLB-LLSLB	-2.567	0.022
DRSLB-DLSLB	2.218	0.044
LMLB-LLCT	0.564	0.581
DMLB-DLCT	-1.380	0.189
LRILB-LLILB	1.288	0.219
DRILB-DLILB	-0.890	0.389
RB6-LB6	-3.097	0.008

t = The significance test of differences between two groups.

TABLE 5: The values that researchers reported concerned with DT.

Author	Year	Method	Diameter (mm)
Robbins	2005	PACR	Male ≤26, female ≤23
Ryan	2004	PACR	15-20
Prince	2002	CT	19,97 ± 2,37
Naidich	1999	CT	Male 13±3-25±3, female 10±3-1±3
Fraser	1999	CT	Male 13-25, female 10-21
Schwartz	1999	CT	≤23
Fishman	1998	CT	Male 13-25, female 10-21
Lee	1998	PACR	Male ≤25, female ≤21
Lee	1998	CT	Male ≤21,8±3, female ≤19,4±3
Wallace	1998	CT	19
Brodsky	1996	ET	14-18
Breatnach	1984	PACR	Male ≤25, female ≤21
Vock	1984	CT	≤30
Merendino	1954	CS	19
Present	2009	CS	19.23

PACR: Posteroanterior chest radiography,
CT: Computerized tomography,
ET: Endobronchial tube,
CS: Cadaver study.

Merendino found that DMLB is about 5 mm. This result shorter than ours.[16]

Naidich and Fraser ascertained that LLSLB are about 20-30 mm and 10 mm, respectively. Naidich's result is in conformity with ours.[2,3]

Merendino found that DLSLB are about 10 mm. Our result is longer than this result.[16] Fraser reported that LLCT is 20-30 mm. Our result and result of Fraser are same.[3]

Naidich ascertained that LLILB and LRILB are about 10-20 mm, 5-10 mm, respectively.[2] Shields found that anterior basal segmental bronchus arises from basal stem, approximately 20 mm.[4] Our results with lengths of basal stems and results of other authors are significant differences. Because we assumed that ultimate point of inferior lobar bronchus is division of lateral and posterior basal segmental bronchi in our study.

Merendino found that DRILB is 10 mm. Our result is in conformity with results of this researcher.[16]

Bronchoscopy, flexible bronchoscopy, virtual bronchoscopy and thoracoscopic surgery are important applications for the airways. The bronchial tree can be damaged during many clinical applications such as surgery, anesthesia and bronchoscopy.[24-29] The result of this study will provide a great benefit for clinicians. Also, we hope that this study will be helpful for many radiological and anatomical studies. In addition, we thought that a complete assessment during to bronchoscopy and then saving and collecting of identified variation are need for mapping of bronchial tree and human engineering science.

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