

The Morphometric Study of Main Bronchus in Korean Cadaver

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Abstract : This morphometric study of main bronchus was performed to provide the basic data necessary for anatomists, anesthetists and emergency medical technicians. A total of 48 cadavers, 33 men and 15 women, were used in this study. When it comes to their average age, men were 70 years old (50 to 91 years old), and women were 74 years old (47 to 92 years old). For this study, the length of the left and right main bronchi and the angle between them, and the first bronchial cartilage's each anteroposterior diameter, transverse diameter, vertical height, and distance between posterior ends of cartilage were measured.

As for the length, left length was longer than right length regardless of gender, and there was no significant difference between men and women. When it comes to anteroposterior diameter, transverse diameter, and distance between posterior ends of the first bronchial cartilage in main bronchi, the right side was longer and wider than left side regardless of gender, but statistical significance was shown only in the distance between posterior ends of cartilage. Vertical height of the first bronchial cartilage in main bronchi did not show any difference between the left and right and between men and women, and men cadavers had a very large individual difference from 2.35 mm to 9.22 mm. As for the angle of the main bronchi's separation from trachea's major axis, the left side was larger than the right side in both men and women cadavers and it was larger in men than women, but there was no significant statistical difference. Lastly, as for the length of the main bronchi, the right and left lengths in men were 16.83 ± 1.36 and 37.26 ± 1.42 mm respectively; and the right and left lengths in women were 16.90 ± 2.26 and 36.08 ± 3.39 mm respectively. These results are expected to be used as the basic clinical data useful for medical procedures of emergency care practitioners, anesthetists and emergency medical technicians.

Keywords : Cadaver, Main bronchus, Morphometry

Introduction

In the respiratory tract, cricoid cartilage, tracheal cartilage and bronchial cartilage are the main channels of air.

They are clinically very important areas because tracheotomy, double endobronchial intubation, and cricothyrotomy are conducted to let patients with respiratory disease maintain respiration. The respiratory tract management procedures have been carried out using the image-based measurement data from X-ray photography [1], bronchoscopy [2], computed tomography (CT) [3] and the morphometrical data through cadavers [4]. Recently, the rate of procedures is growing again as the development of respiratory diseases' management and treatment have led to an increase in the number of the patients under long-

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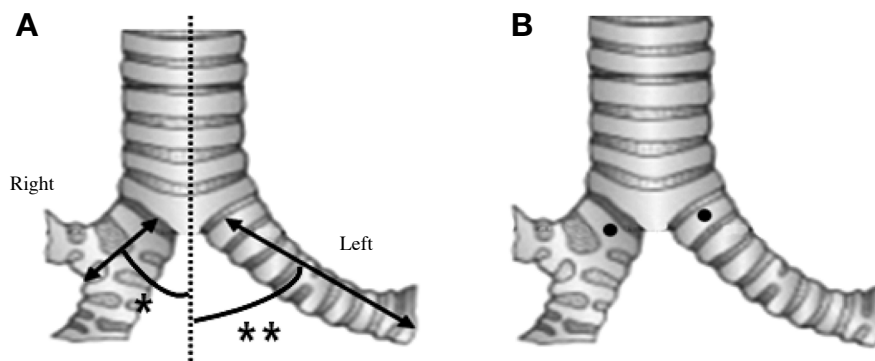


Fig. 1. Measurement method of the main bronchi. (A) Length of main bronchi (arrows) and angle between right (*) and left (**) main bronchi, (B) the first bronchial cartilages (black dots).

term managements of the respiratory tract [5]. The complications coming from the increased rate are frequently caused by inappropriate positioning and distorted anatomical position [6]. Indeed, the complications in the respiratory tract have been often reported [7]. The incidence of complications is high because of the anatomical diversity and emergency situations [8]. The complications in the bronchus, which are the subject of this study, involve many factors including throat pain caused by double endobronchial intubation [9], hypoxemia due to location movement of intubation by positional changes [10], detelectasis and severe hypoxia due to intubation depth and posture change [11], ischemic injury of bronchial mucosa due to the swelling of bronchial air sac [12], and bronchus rupture [13]. However, the management of the respiratory tract has been performed by physicians in different fields of major and mostly by individual physicians [14]. There are many difficulties due to distorted anatomical structures [15]. In that sense, the study on the anatomical morphometry of Koreans' main bronchus is urgently needed to decline complications. The anatomical structure and morphometric length and size of each human organ are greatly different according to race and ethnicity. In particular, the studies on Koreans' respiratory tracts are mostly results using radiography and image photography [4,6-8,16], measured the shape and length of the respiratory tract using cadavers, but have their limits in using them as basic clinical data because the number of cadavers and measuring items was small. The purpose of this study is to provide basic clinical data and advantage of clinical trials for physicians and emergency medical technicians. Therefore, this study was conducted using Korean cadavers to measure the shape

and length of the main bronchus.

Materials and Methods

This study was conducted by targeting 48 cadavers (33 men, 15 women) who have no cartilage-related diseases and no injury to the larynx, trachea, and bronchus among the cadavers used in the training of students at Chonbuk National University Medical School from 2012 to 2014. Some of each thyroid cartilage, cricoid cartilage, trachea and bronchus was harvested from those cadavers. The harvested organs were stored in 10% formalin so that they did not dry out, and then they were washed with water just before measuring their morphologies. The angles between the left and right main bronchi were measured using a protractor, and for other measurement values, a digital caliper (Mitutoyo, Japan) was used to measure the length of the main bronchus up to 0.1 mm (Fig. 1). In the main bronchus of 32 Korean adult cadavers (23 men and 9 women), the length of the left and right main bronchi and the angle between them were measured. In addition, in the main bronchus of 41 Korean adult cadavers (26 men and 15 women), the first bronchial cartilage's each antero-posterior diameter, transverse diameter, vertical height, and distance between posterior ends of cartilage were measured (Fig. 2).

Results

The average age of 48 Korean adult cadavers (33 men

and 15 women) was 70 years old in men and 74 years old in women. The shape of the main bronchi was analyzed as follows (Tables 1, 2): As for the average length of the main bronchus, the right and left bronchi of men were 16.83 ± 1.36 and 37.26 ± 1.42 mm respectively, and those of women were 16.90 ± 2.26 and 36.08 ± 3.39 mm respectively. When it comes to the length of main bronchus, the left length was longer than the right length regardless of gender, but there was no significant difference between men and women (Tables 1, 2).

The analysis results are as follows (Tables 1, 2): As for the mean angle of the main bronchi's separation from the trachea's major axis, the right and left angles were 39.67 ± 2.31 and 43.81 ± 2.67 respectively in men, and were 36.25 ± 3.50 and 42.88 ± 3.41 respectively in women. In fact, the angle 13 of separation of left bronchus was larger than that of right bronchus, but there was no statistical significance between them. In addition, there was

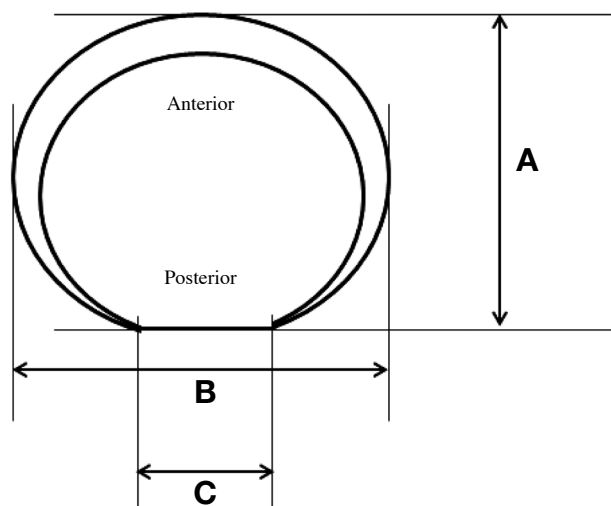


Fig. 2. Measurement method of the first bronchial cartilage in main bronchi. (A) Anteroposterior (A-P) diameter, (B) transverse diameter, (C) distance between posterior ends.

also no significant difference between men and women.

Anteroposterior diameter, transverse diameter, distance between posterior ends of the first bronchial cartilage in men's main bronchi were 17.32, 18.28, and 15.46 mm respectively on the right and 16.43, 17.71, and 12.20 mm respectively on the left (Tables 3-5). Meanwhile, as for women, the measurement values were 13.23, 16.34, and 10.70 mm respectively on the right, and 11.71, 14.45

Table 1. The total data of the main bronchial measurements

Gender	Age	Length (mm)		Bronchial angle (°)	
		Right	Left	Right	Left
Men	50	16.94	38.60	35	55
	51	12.6	35.16	15	25
	51	11.4	34.1	40	40
	51	11.70	36.70	–	–
	54	17.89	29.61	50	55
	55	18.47	28.31	45	55
	59	22.61	41.63	45	45
	59	14.31	35.21	40	30
	59	10.39	32.10	45	65
	62	19.30	40.12	35	50
	66	9.46	30.17	55	50
	66	19.41	41.59	50	40
	67	10.24	40.17	33	45
	67	16.15	32.38	45	45
	67	14.27	37.12	45	40
	77	11.69	36.12	20	20
	78	13.25	32.17	35	30
79	9.03	22.38	45	60	
83	22.36	45.83	25	40	
86	37.63	42.69	30	30	
89	22.47	49.36	50	40	
90	22.49	48.30	50	60	
101	22.94	47.16	–	–	
Women	47	22.36	40.16	40	40
	65	10.63	31.87	50	50
	76	13.33	38.1	25	53
	76	8.16	20.16	45	50
	77	12.48	26.64	25	35
	80	14.36	27.26	40	40
	82	29.39	47.39	25	25
	90	19.93	43.11	–	–
	92	21.5	50.01	40	50

Table 2. Metric values of the main bronchi

		Men	Women	<i>P</i> value*
Length (mm)	Right	16.83 ± 1.36	16.90 ± 2.26	0.9762
	Left	37.26 ± 1.42	36.08 ± 3.39	0.7054
	<i>P</i> value**	<0.0001	0.0002	
Angle (°)	Right	39.67 ± 2.31	36.25 ± 3.50	0.4371
	Left	43.81 ± 2.67	42.88 ± 3.41	0.8480
	<i>P</i> value**	0.2479	0.1971	

Data are mean \pm SEM. **P* value: Men vs Women, ***P* value: Right vs Left

Table 3. The total data of the first bronchial cartilage measurements

Gender	Age	Anteroposterior diameter (mm)		Transverse diameter (mm)	
		Right	Left	Right	Left
Men	50	17.52	15.22	21.88	27.41
	51	15.48	17.81	15.61	15.05
	51	23.00	15.50	16.75	14.12
	51	16.30	13.70	17.48	16.47
	54	15.53	15.69	19.00	18.01
	55	16.53	13.36	19.59	16.92
	59	17.92	18.45	20.77	18.93
	59	24.59	23.42	18.44	16.99
	59	15.76	16.01	20.58	21.74
	62	16.31	—	18.27	—
	66	17.60	—	23.50	23.72
	66	20.68	16.16	19.41	8.17
	67	17.16	15.88	19.00	19.50
	67	17.17	15.10	18.36	17.46
	67	18.20	16.47	21.92	18.37
	76	15.23	13.16	16.68	14.02
	77	26.16	23.63	15.07	15.76
	78	17.89	18.06	18.03	19.74
	79	19.64	16.06	17.63	16.37
	83	18.34	16.83	19.28	19.08
	85	18.09	17.03	16.15	13.49
86	15.15	12.38	16.53	14.04	
87	17.81	20.93	21.99	20.47	
89	14.76	11.33	20.91	20.22	
90	16.38	12.34	20.83	17.64	
101	18.51	20.80	20.45	20.60	
Women	47	11.77	9.29	18.26	14.83
	50	10.14	10.15	11.90	13.21
	53	11.41	9.87	14.08	12.81
	65	8.05	7.64	14.90	11.64
	74	13.38	11.94	19.01	16.95
	76	17.74	16.34	15.21	16.67
	76	11.20	8.76	18.83	16.34
	77	16.00	14.69	21.47	15.80
	80	12.37	11.37	16.92	16.47
	81	16.27	13.48	14.97	11.88
	81	12.41	10.94	22.60	17.38
	82	17.10	16.09	16.11	13.39
	83	13.73	10.24	14.91	10.63
	90	11.99	11.89	14.26	13.35
	92	14.91	13.02	11.71	15.44

and 8.81 mm respectively on the left in the first bronchial cartilage. The right side is longer and wider than the left one regardless of gender, and statistical significance was shown only in distance between posterior ends of cartilage (Table 5). In the right and left anteroposterior diameter, left transverse diameter, and left and right distance between posterior ends of the first bronchial cartilage in main bronchi, men were longer or wider than women (Table 5).

In the first bronchial cartilage in main bronchi, the vertical height showed no difference between the left and the right, and men and women, and men cadavers had a very

large individual difference from 2.35 mm (on the right) to 9.22 mm (on the left) (Tables 4, 5). The rate that the first cartilage's distance between posterior ends in the right and left bronchi accounts for transverse diameter was about 84% and 48% respectively in men, and 65% and 61% respectively in women (Table 6).

Discussion

Tracheotomy of patients with respiratory disease, endo-

Table 4. Metric values of the first bronchial cartilage

Gender	Age	Vertical height (mm)		Distance between posterior ends (mm)	
		Right	Left	Right	Left
Men	50	4.39	3.00	19.21	9.15
	51	4.34	4.39	10.69	8.00
	51	4.15	4.11	15.45	13.83
	51	2.92	4.52	15.94	6.48
	54	3.12	3.21	19.98	13.55
	55	4.23	3.68	13.75	7.46
	59	3.09	2.95	20.23	16.28
	59	6.81	8.87	14.31	14.40
	59	2.90	2.80	19.94	13.31
	62	3.72	–	14.04	–
	66	3.19	2.24	20.57	9.54
	66	6.90	10.16	18.35	17.56
	67	4.15	3.88	12.13	7.49
	67	3.29	3.41	6.95	7.10
	67	4.85	3.48	9.38	13.51
	76	2.57	3.09	10.04	10.10
	77	3.01	4.09	11.97	11.82
	78	9.22	6.40	9.20	9.97
	79	2.73	6.29	20.37	20.71
	83	3.98	5.43	13.78	17.75
85	2.35	3.54	15.87	9.63	
86	3.28	3.75	13.85	10.16	
87	3.42	–	13.12	17.98	
89	4.23	4.43	20.68	21.44	
90	3.85	4.30	19.08	11.36	
101	3.57	3.92	12.08	11.09	
Women	47	2.60	2.70	10.96	5.34
	50	–	–	5.30	4.12
	65	3.27	2.88	14.46	8.58
	74	3.03	2.99	16.50	9.34
	76	4.34	2.84	13.11	8.08
	76	4.24	2.58	15.08	8.10
	77	3.73	4.19	19.01	12.63
	80	3.22	3.63	3.00	8.57
	81	3.54	4.56	2.68	12.96
	81	3.57	3.94	16.09	10.96
	82	3.54	2.86	10.34	10.30
	83	4.87	–	6.00	4.67
	90	2.28	3.01	8.36	3.94
	92	6.77	4.36	8.84	15.84

Table 5. The data of the first bronchial cartilage measurements

		Men	Women	<i>P</i> value*
Anteroposterior diameter	Right	17.32 ± 0.85	13.23 ± 0.70	0.0024
	Left	16.43 ± 0.62	11.71 ± 0.66	<0.0001
	<i>P</i> value**	0.4066	0.1298	
Transverse diameter	Right	18.28 ± 0.76	16.34 ± 0.81	0.1180
	Left	17.71 ± 0.67	14.45 ± 0.56	0.0027
	<i>P</i> value**	0.5782	0.0671	
Vertical height	Right	3.99 ± 0.27	3.76 ± 0.31	0.6346
	Left	4.31 ± 0.35	3.37 ± 0.20	0.0983
	<i>P</i> value**	0.4816	0.3195	
Distance between posterior ends	Right	15.46 ± 0.88	10.70 ± 1.39	0.0046
	Left	12.20 ± 0.79	8.81 ± 0.95	0.0135
	<i>P</i> value**	0.0083	0.2762	

Data (mm) are mean ± SEM. **P* value: Men vs Women, ***P* value: Right vs Left

Table 6. Ratio of the distance between posterior ends of the first bronchial cartilages

Ratio (%)		Men	Women
Distance between posterior ends of cartilages/Transverse diameter	Right	84	65
	Left	48	61

tracheal intubation, and cricothyroid membrane's incision are the most basic skills, but can raise the incidence of complications because of anatomical diversity and frequent emergency situations [8]. Currently, the morphometric figures of anatomical structures which are necessary to secure the respiratory tract of patients with respiratory diseases have been mostly based on Western data [17]. The anatomical structure and morphometric length and size of each human organs are greatly different according to race and ethnicity. In that sense, the studies on the morphometry of trachea, bronchus and cricoid cartilage have been conducted targeting Korean cadavers to examine the anatomical structure and morphometric figures of Koreans. The studies on Koreans' respiratory tracts are mostly results using radiography and image photography [4,6-8], and there have been very few data on the shape and actual measurement of Koreans using cadavers because the number of cadavers and measuring items was small. In this study, several measuring items were selected to understand the anatomical structures necessary for endotracheal intubation, tracheotomy, and cricothyroid incision, by using 48 cadavers. And the currently reported morphometric values were compared and analyzed.

For the main bronchus, 6 items (length, bronchial angle, the first bronchial cartilage's anteroposterior diameter, transverse diameter, distance between posterior ends, and vertical height) were measured by dividing into right and left based on carina. Length of the right and left bronchi were 16.83 mm and 37.26 mm respectively in men, and were 16.90 mm and 36.08 mm respectively in women. The left was two times longer than the right in men and women, but there was no statistical difference between men and women. A report was the study targeting Korean patients using fibroptic bronchoscope and concluded that the length of right and left main bronchi were 22 mm and 53 mm respectively in men and 17 mm and 48 mm respectively in women [2]. The other Chinese report was the study targeting Chinese population using computed tomography (CT) and reported that the mean lengths of the right and left main stem bronchi were 13.6 ± 4.3 and 48.3 ± 6.5 mm,

respectively [18]. This result shows a big difference with our current results. However, it is interpreted that such difference comes from differences in measurement methods.

In this study, the long axis of trachea subcarinal angle was 39.67° and 43.81° in men's right and left bronchi respectively, and 36.25° and 42.88° in women's right and left bronchi respectively. The bronchial angle in combination of each long axis of trachea subcarinal angle of the right and left bronchi was 83.48° in men and 79.13° in women, which was slightly larger than New Zealander's bronchial angle (78° in men, and 81° in women) [19]. In addition, the bronchial angle measured in China was 73.7° and 73.8° in men and women respectively, which was smaller than the bronchial angle in this study [18]. Mi *et al.* [18] were performed on 2107 patients who underwent thoracic CT scans and the sizes of the subcarinal angle were obtained through CT or multi-planar reconstruction imaging.

When it comes to the first bronchial cartilage's anterior-posterior diameter and transverse diameter in this study, right bronchus was larger than left bronchus in men and women, and the difference between right and left bronchi in women was larger than men but there was no statistical significance. However, as for anteroposterior diameter in the right and left bronchi, men were 4.1 mm and 4.73 mm larger than statistically significant difference was shown only in left bronchus's first bronchial cartilage. In particular, the rate that the first cartilage's distance between posterior ends in men's right bronchus accounts for transverse diameter was significantly high, but the causes have not been identified and there have been no reports on the morphometry of the first bronchial cartilage in other populations which can be used for comparison.

In that sense, more studies regarding this are needed to be conducted. This study focused on measuring the shape of main bronchus using Korean cadavers instead of chest X-ray photography and computed tomography, and it is expected to be used as anatomical structure and basic morphometric data of Korean respiratory tract. However, it is needed to improve the way to compare and analyze cadavers' actual measurement values and photographic images' measurement values; measure more cadavers' shapes for comparison by age; and conduct additional studies to calculate the correlation with anthropometric values.

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한국인 시신에서 주기관지의 형태계측학적 연구

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간추림 : 이 연구는 주기관지의 형태를 계측하여 해부학자와 마취의사, 응급구조사들에게 필요한 기초자료를 제공하고자 수행하였다. 연구에는 남자 33구와 여자 15구, 총 48구의 시신을 사용하였다. 시신의 평균 연령은 남자 70세 (50~91세), 여자 74세 (47~92세)였다. 좌우 주기관지의 길이, 기관지들 사이의 각도, 첫째 기관지 연골의 앞뒤지름과 가로지름, 뒷막넓이를 측정하였다. 측정 결과 주기관지의 길이는 남녀 모두 왼쪽이 오른쪽보다 길고 남녀 간의 유의한 차이는 없었다. 첫째 기관지연골의 앞뒤지름과 가로지름, 뒷막넓이는 남자와 여자 모두에서 오른쪽이 왼쪽보다 길고 넓었으나 통계적 유의성은 뒷막넓이에서만 있었다. 첫째 기관지 연골의 높이는 왼쪽과 오른쪽, 남자와 여자 사이에 차이를 보이지 않았고, 남자의 경우 최저 2.35 mm부터 최고 9.22 mm까지 개인적인 차이가 매우 컸다. 주기관지가 기관의 장축으로부터 갈리는 정도는 남녀 모두에서 왼쪽이 오른쪽보다, 남자가 여자보다 컸지만 통계학적으로 유의한 차이는 없었다. 주기관지 길이는 남자에서 오른기관지는 16.83 ± 1.36 mm, 왼기관지는 37.26 ± 1.42 mm, 여자의 오른기관지는 16.90 ± 2.26 mm, 왼기관지는 36.08 ± 3.39 mm이었다. 이상의 결과는 기관지경을 사용하는 응급의사, 마취의사, 응급 구조사들의 시술에 유용한 임상적 기초자료로 활용될 것으로 생각한다.

찾아보기 낱말 : 한국인, 시신, 주기관지, 형태계측