Is there a correlation between right bronchus length and diameter with age?

José Pinhata Otoch, Hélio Minamoto, Marcos Perini, Fred Olavo Carneiro, Everson Luiz de Almeida Artifon

Department of Surgery, Sao Paulo Medical School, Sao Paulo, Brazil

ABSTRACT

Objective: Right main bronchial anatomy knowledge is essential to guide endoscopic stent placement in modern era. The aim is to describe right bronchial anatomy, cross-area and its relation with the right pulmonary artery and patient's age.

Methods: One hundred thirty four cadaveric specimens were studied after approval by the Research and Ethics Committee at the University of São Paulo Medical School and Medical Forensic Institute of São Paulo. All necropsies were performed in natura after 24 hours of death and patients with previous pulmonary disease were excluded. Landmarks to start measurement were the first tracheal ring, vertex of carina, first right bronchial ring, and right pulmonary artery area over the right main bronchus. After mobilization, the specimens were measured using a caliper and measurement of distances was recorded in centimeters at landmarks points. All the measures (distances, cross sectional area and planes) were performed by three independent observers and recorded as mean, standard error and ranges. Student t test was used to compare means and linear regression was applied to correlate the measurements.

Results: From 134 specimens studied, 34 were excluded (10 with previous history of pulmonary diseases, surgery or deformities and 24 of female gender). Linear regression showed proportionality between tracheal length and right bronchus length; with the area at first tracheal ring and carina and also between the cross sectional area at these points. Linear regression analysis between tracheal length and age ($R=0.593$ $P<0.005$), right bronchus length and age ($R=0.523$, $P<0.005$), area of contact between right bronchus and right pulmonary artery and age ($R=0.35$, $P<0.005$).

Conclusions: We can conclude that large airways grow progressively with increasing age in male gender. There was a direct correlation between age and tracheal length; as has age and right bronchus length. There was a direct correlation between age and the area of the right bronchus covered by the right pulmonary artery.

KEY WORDS Anatomy; right bronchus; trachea; gender; age; human

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Introduction

Knowledge of a patient's mainstem right bronchial anatomy would provide a useful guide to choosing the appropriate endoluminal stents length and diameter (1,2) in benign (3) and malignant lesions (4-6). Recently, many radiological techniques has been used to measure tracheal size and diameters (7). As the right pulmonary artery lies over the right bronchial tree, tumors arising in this area can erode into the artery and be a cause of massive bleeding. So in order to correctly place an endoluminal stent, size and diameter does matter (8). Right bronchus length and diameter can be altered by many different causes, such as age, previous history of pulmonary disease and patients' height (1,2,9-11).

Objective

The main objective is to describe the right bronchial anatomy, cross-area and its relation with the right pulmonary artery and patient's age.

Material and methods

One hundred thirty four specimens were studied after approval by the Research and Ethics Committee at the University of São Paulo Medical School and Medical Forensic Institute of São Paulo. All necropsies were performed in *natura* after 24 hours of death and patients with previous pulmonary disease were excluded.

Corresponding to: Everson Luiz de Almeida Artifon. Rua Guimarães Passos 260/121, Vila Mariana, São Paulo-SP, Brazil -04107-030. Email: eartifon@hotmail.com.

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Table 1. Distance (cm) between different tracheal and bronchial landmarks.

	First tracheal ring to carina verge	First tracheal ring to last tracheal ring	Last tracheal ring to first right superior bronchial ring	Carina verge to first inferior bronchial ring	Right bronchial length
Mean	9.2	7.9	1.2	2.8	3.3
SEM	1.0	0.9	0.4	0.5	0.4
Max	11.7	10.4	2.5	3.9	4.5
Min	6.9	5.8	0.3	1.8	2.3
N	100	100	100	100	100

En bloc resection of the trachea, esophagus, heart and lung were performed through a sternotomy and the bloc was displaced over a dissection table. Landmarks to start measurement were the first tracheal ring and the vertex of carina. After mobilization, the specimens were measured using a caliper and measurement of the following distances was recorded in centimeters.

- First tracheal ring: distance from the left lateral to right lateral border (latero-lateral), distance from medial anterior point to the posterior medium point (antero-posterior) and cross sectional area;
- Last tracheal ring: distance from the left lateral to right lateral border (latero-lateral), distance from medial anterior point to the posterior medium point (antero-posterior) and cross sectional area;
- Tracheal length: distance between the first and the inferior point of carinal verge;
- Right main bronchus: distance between the right lateral border of the first bronchial ring to the carina verge, medially (latero-lateral) and antero-posteriorly and cross sectional area at this point;
- Right main bronchus length: distance between the first right bronchial ring until the last right bronchial ring until the right superior or inferior bronchial segmentation;
- Left main bronchus: distance from the left lateral to border of the first bronchial ring to the carina verge (medially) and cross sectional area at this point;
- Right superior bronchus: distance (at the first bronchial ring) between the superior border of the right superior bronchus to the inferior border of it and cross sectional area at this point;
- Right inferior bronchus: distance (at the first bronchial ring) between the superior-lateral border of the right inferior bronchus to the infero-medial border of it and cross sectional area at this point.

Cross sectional area measurement was performed as follows: the tracheal ring was excised from the specimen embedded in black ink and laid down over a white digital paper. The area under the specimen was recorded and processed in a computer after digitalization (Jandel Scientific, Sigmascan Inc., USA).

The right pulmonary artery impression over the right main bronchus was recorded in a similar fashion but using the right artery to perform the measurement. Four different points were demarcated and the area under these points was measured.

Right bronchus area was recorded in order to analyze the amount of area covered by the right pulmonary artery. In order to do so, a cross sectional line was demarcated superiorly by the first right bronchial ring and inferiorly by the last right bronchial ring before the emergency of the right superior and right inferior bronchus. The impression of these points over the cartoon was recorded digitally as previous reported.

All the measures (distances, cross sectional area and planes) were performed by three independent observers and recorded as mean, standard error and ranges. Student t test was used to compare means and linear regression was applied to correlate the measurements.

Results

From 134 specimens studied, 34 were excluded (10 with previous history of pulmonary diseases, surgery or deformities and 24 of female gender). Only male patients were studied and age ranged from 16 to 83 years old (mean 38.2±17.6).

In Table 1, the distance between different tracheal and bronchial landmarks is depicted as mean and range. Tables 2 and 3 show airway width and cross sectional area respectively. In Table 4, the area (cm^3) of contact between the right main bronchus and right pulmonary artery and percentage of right bronchus covered by the right pulmonary artery are shown.

Linear regression showed proportionality between tracheal length and right bronchus length; with the area at first tracheal ring and carina and also between the cross sectional area at these points. Linear regression analysis between tracheal length and age ($R=0.593$, $P<0.005$), right bronchus length and age ($R=0.523$, $P<0.005$), area of contact between right bronchus and right pulmonary artery and age ($R=0.35$, $P<0.005$) showed significance correlation.

Discussion

Anatomical landmarks and topographic relationship are essential

Table 2. Antero-posterior width (cm) at different landmarks.

	First tracheal ring	Last tracheal ring	First right bronchial ring	First right superior bronchial ring	First right inferior bronchial ring	First left bronchial ring
Mean	1.9	1.8	1.5	0.9	1.0	1.4
SE	0.6	0.2	0.2	0.1	0.2	0.2
Max	2.7	2.4	1.9	1.3	1.5	1.9
Min	1.3	1.3	0.9	0.6	0.6	1.0
N	100	100	100	100	100	100

Table 3. Cross sectional area (cm^3) at different levels.

	First tracheal ring	Last tracheal ring	First bronchial ring of the Right bronchus	First bronchial ring of the right superior bronchus	First bronchial ring of the right inferior bronchus	First ring of the Left main bronchus
Mean	3.2	3.5	2.2	1.0	1.2	2.1
SE	0.6	0.9	0.5	0.3	0.3	0.5
Max	5.1	5.8	1.4	1.6	1.9	3.5
Min	1.5	1.8	1.1	0.5	0.6	1.1
N	100	100	100	100	100	100

Table 4. Area (cm^3) of contact between the right main bronchus and right pulmonary artery and percentage of right bronchus covered by the right pulmonary artery.

	Area of superposition (cm^3)	Right bronchus surface area covered by the right pulmonary artery (%)
Mean	7.2	44.3
SE	2.2	10.3
Max	13.6	82.3
Min	2.3	20.2
N	100	100

for the general surgeon dealing with trauma patients and even more for the thoracic surgeon (2). When facing oncological resections in which the normal anatomical landmarks are missing, topographic knowledge is even more important (4,5). Nowadays, laparoscopic lung and esophageal resections are increasing in number and importance. In laparoscopy, where tactile sensation is missing, the more anatomy the surgeon knows, the more precise are the movements.

Airway proportion measurements from cadaver studies suggest that the airways progressively and proportionately reduce size from the central to peripheral airways in both children and adults (9,10,12-14). However the numbers in these studies were small. Our study with far greater numbers of subjects shows that the large airway proportions remains constant across ages, as shown by the constant relationship with tracheal length and right bronchus length and its respective cross sectional area.

When comparing length and diameters, landmarks should be well established and easily assessed (10,12). We used the cricoid as the comparator as it is easily accessible and identifiable, has a relative resistance to distortion with pressure change, and has a relatively constant shape at its outlet. The importance of a comparator is also evident when one describes measurements of tracheomalacia, bronchomalacia and or airway stenosis. In order to avoid such bias, we exclude patients with any pulmonary disease.

The fact that endoluminal stent can be used in the treatment of bronchial leaks (15), perforations or bleeding does not mean that patients' anatomy is standard (16,17). The assumption of rigid measurements in different population subsets can lead to failure (4,6,8,16-18). Age should always be a factor that should be raised due to its correlation with tracheal and right bronchus length, as shown.

Finally, there is a correlation between age and the cross sectional area in the right bronchus covered by the right pulmonary artery. This can be due the more plasticity of the right pulmonary artery in old people and the fact that they also have a greater bronchial cross sectional area.

Conclusions

We can conclude that large airways grow progressively with increasing age in male gender. The cricoid area is a suitable reference point for comparisons of lower airway sizes. There was a direct correlation between age and tracheal length; as has age and right bronchus length. There was a direct correlation between age and the area of the right bronchus covered by the right pulmonary artery.

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