Coll. Antropol. **28** (2004) 2: 701–709
UDC 612.21:611.24
Original scientific paper

The Ventilatory Patterns of the Left Upper Lobe of Lung

Admedina Savković[1], Vasilije Nikolić[2], Jasmin Delić[1] and Eldar Isaković[1]

[1] Department of Anatomy, Medical Faculty, University of Tuzla, Tuzla, Bosnia and Herzegovina
[2] »Josip Juraj Strossmayer« University of Osijek, School of Medicine, Department of Anatomy, Osijek, Croatia

A B S T R A C T

Having knowledge on models of the bronchial tree branching, is of a special interest for clinical and surgical pulmology, because the hemilobectomy, segmentectomy and subsegmentectomy are always determined by intralobar, intrasegmental and intrasubsegmental bronchial ramification. Investigations were performed on 100 lungs of children and adults of both sexes, one day to 85 years old, randomly chosen. There are two main types of branching of the left upper lobe bronchus: the bifurcation pattern as dominant model in 74% and the trifurcation model found in 26%. Out of 100 lungs studied, 21 lungs had the ventilatory variations of the bronchopulmonary segments. The classification and categorization of the ventilatory of bronchopulmonary segments of the left upper lobe of lung were made. This classification contains 5 categories and 8 subcategories.

Key words: *bronchus lobaris superior sinister, variations, ventilations.*

Introduction

Bronchial tree has not a united system of pattern, but different types of organization exist in mammals lungs, what is a result of adaptation to the thoracic structures, respiratory needs, locomotive organization, etc.[1,2]. The exact knowledge of anatomy about the areas of dominant distribution of bronchi enables identification of the variable bronchi distribution areas, as well as the establishment of their identification criteria. The knowledge of anatomy on the variations of the trachea-bronchial tree enables and makes easier to recognize a clinical picture and a pathology of human lungs, as well as the application of therapeutic and diagnostic methods (bronchoscopy and bronchography). That also enables researches on function, especially on the lobar spirometry, tubus selection for bronchoscopy, etc[3].

Foster-Carter[4] gave the first complete, clinical-anatomic description of the hu-

Received for publication November 20, 2004

man bronchial tree. Surgeon Jackson and anatomist Huber[5] published the studies whose three main properties are: description of anatomical structure of bronchus and segments, correlation with bronchoscopic findings and selection of the terminology accepted widely. So, for the first time, the terms for bronchi and the segments belonging to human lungs were used, that were accepted in the international terminology. The list of the segment terminology was published by Huber[6].The term »basalis« was introduced by Churchill and Belsey[7]. Brock[8] published the study titled »Anatomy of the Bronchial Tree with a Particular Review on the Lung Abscess Surgery«. The author determined the accurate lesion localization on the lung segments and thoracic wall, what was of a great importance, particularly in resolving drainage canals, because antibiotics have not been in use yet. The terms for the lung blood vessels were given by the respectable names like Herrnheiser and Kubat[9]. In that way, bronchi, arteries and veins were given a uniform enumeration. The authors emphasized that the clinical problems insoluble on the segmental level should be decided on the subsegmental level.

Milishnikova and Monaenkova[10] were researching the role of anatomical bronchi and lungs substrate in some chronic lung diseases occurrence (bronchitis and pneumoconiosis). The authors concluded that in 78% patients the disease coincides with abnormal segmental division bronchi.

Official anatomic nomenclature of the bronchi and pulmonary arteries include segmental bronchi and some subsegmental branches. However, progress in clinical medicine requires as well as the bronchi generation created by the ramification of subsegmental bronchi as well as their branches, to be included into nomenclature. In recent literature that issue is put as a demand[11]. The author established five, even six bronchi generations lines created by the ramification of subsegmental bronchi.

Recheis et al[12] described that theirs approach in lung volume matching is necessary to get quantitative information of healing-disease process in the lung or therapy outcomes seems to be a feasible and fast way compared to other techniques described in literature. Theirs very preliminary and experimental results though suggest the usefulness of this approach in clinical enviroment.

Material and methods

This research was performed on 100 lungs of children and adults, aged from one day to 85 years, both sexes, by randomized trial.

The first group of the organs removed by means of autopsy were fixed in 4% buffered formalin for 7 to 10 days, and then the anatomical macrodissection and microdissection were done stereoscopically (60 lungs, 40 adults, 20 children). The second group of the organs was injected by mixture of plastic mass and dye, then exposed to corrosion in 30% NaOH (20 lungs, 7 adults, 13 children). The third group were clinical bronchograms (20 adults).

Criterium of bifurcation and trifurcation existence was determined, (because of uniformity), by the position of the openings and fork points that separate the openings, which correspond to carina bronchialis. The bifurcation is determined by two openings and one carina, all situated in the same line. Trifurcation is determined by three openings, two carinas, all lying in the same line, or in the same, slightly arched line. To determine the common tree, the principle of the tree dichotomous branching (bifurcation) was used and its division into two segmental bronchi according to the nomenclature.

Results

A dominant branching model of the left upper lobe bronchus is bifurcation and trifurcation is rarer model, i.e. it is a variation (Figure 1, 2).

Variations in ventilation of bronchopulmonary segments, systematized in 5 categories and 8 subcategories.

I category – variations in the bronchus segmentalis apicoposterior (B^{1+3})

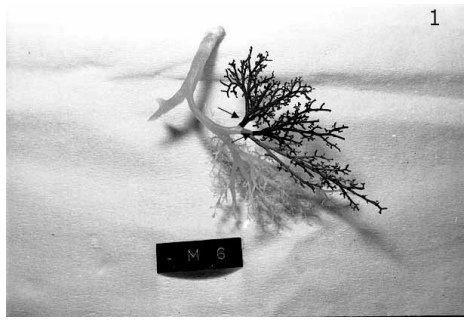

Fig. 1. Bifurcation of the bronchus lobaris superior sinister.

That category has two subcategories:

a) variations of the ramus anterior (B^1b) and

b) variations of the ramus posterior (B^3b).

a) Out of the bronchus segmentalis anterior an upper-front branch goes and enters the segmentum apicoposterius. That is ramus anterior accessorius (BX^1b) in 33,6%, (Figure 3).

b) The upper tree of the bronchus lobaris superior sinister according to the type trifurcation branches into: the bronchus segmentalis apicoposterior, the bronchus segmentalis anterior and the bronchus segmentalis »posterior«. That last is ramus posterior accessorius (BX^3b) in 9,5% (Figure 3).

II category – variations in the bronchus segmentalis anterior

That category has two subcategories:

a) variations of the ramus anterior (B^2b) and

b) variations of the ramus posterior(B^2a).

Fig. 2. Trifurcation of the bronchus lobaris superior sinister.

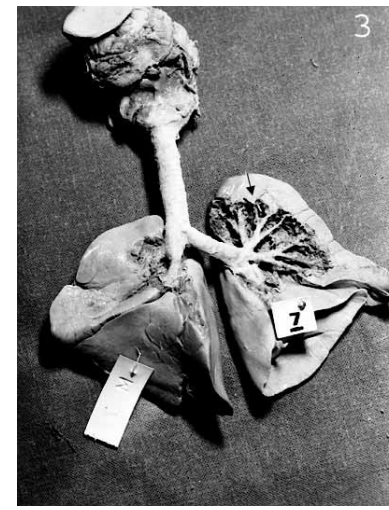

Fig. 3. Out of the bronchus segmentalis anterior an upper-front branch goes and enters the segmentum apicoposterius. That is ramus anterior accessorius (BX^1b).

a) The bronchus segmentalis anterior gives a lower branch which goes to the segmentum lingulare superius. That is ramys anterior accessorius (BX^2b) in 33,3%.

b) Out of the bronchus lingularis superior a smaller branch enters in the lower part of the segmentum anterius. That is ramus posterior accessorius (BX^2a) in 14,3%.

III category – variations in the lingular bronchi

That category has two subcategories:

a) variations of the ramus posterior (B^4a) and

b) variations of inferior limit of the lingular segments (S^4, S^5).

a) Out of the back side of the lingular tree a strong back lingular branch goes and serving for the ventilation of the middle part of the segmentum lingulare superius. That is ramus posterior accessorius (BX^4a) in 14,3%.

Fig. 4. The bronchus lingularis inferior gives two larger branches, an upper and a lower. The little branch out of the lower branch goes to the segmentum basale mediale lobi inferioris (small arrowheads).

b) The bronchus lingularis inferior gives two larger branches, an upper and a lower. The little branch out of the lower branch goes to the sebmentum basale mediale lobi inferioris in 4,8%, (Figure 4).

Out of the bronchus lingularis inferior a smaller branch goes and enters the segmentum basale anterius lobi inferioris in 9,6%.

IV category – anomaly of the bronchus lobaris superior sinister

That category contents two subcategories:

a) absence of the bronchus lobaris superior sinister and

b) anomaly in ramification of the bronchus lobaris superior sinister.

a) The joint bronh for bronchus segmentalis apicoposterior and bronchus segmentalis anterior 5,5 mm long, ramifies at distance of 8,1 mm from the tracheal crest. Out of the bronchus segmentalis anterior an upper branch ramifies and enters the frontal portion of the segmentum apicoposterius. That is ramus anterior accessories (BX^1b). The bronchus principalis sinister goes downward (16,8 mm) giving an upper and a lower tree. The upper tree represents the bronchus lingularis »communis« which ramifies into the bronchus lingularis superior and inferior. The upper branch out of the bronchus lingularis superior enters the lower portion of the segmentum anterius. That represents the ramus posterior accessories, (BX^4a). The bronchus lingularis inferior ventilates the segmentum lingulare inferius. The lower tree of the bronchus principlais sinister, represents the bronchus lobaris inferior in 4,8%.

b) The bronchus lobaris superior sinister to the type of bifurcation is divided into an upper and a lower tree. The upper tree is only the bronchus segmentalis apicoposterior. The lower tree is

joint for the bronchus segmentalis anterior and the bronchus lingularis »communis«. Out of the bronchus segmentalis anterior a lower branch goes and enters the segmentum lingulare superius. That is ramus anterior accessories, (BX^2b). The bronchus ligularis »communis« gives two lingular branches, a front and a back branch (bronchus lingularis »anterior« and »posterior«), the both for ventilation of the segmentum lingulare inferius in 4,8%, (Figure 5).

V category – »Three-lobe left lung«

The bronchus principalis sinister according to the type of bifurcation is divided into: an upper lobar and a lower lobar tree. The bronchus lobaris superior sinister according to the type of trifurcation is divided into: bronchus segmentalis apicoposterior, the bronchus segmentalis anterior and the bronchus lingularis »communis«. The bronchus segmentalis apicoposterior and the bronchus segmentalis anterior ventilate the lobus superior. The bronchus lingularis »communis« ventilates the »lobus medius« (lingular segments)

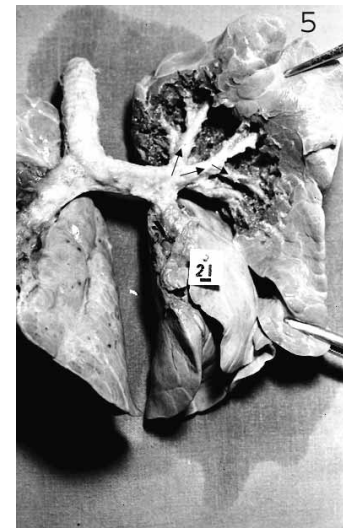

Fig. 5. Anomaly in ramification of the bronchus lobaris superior sinister. The upper tree is only the bronchus segmentalis apicoposterior. The lower tree is joint for the bronchus segmentalis anterior and the bronchus lingularis »communis«. Out of the bronchus segmentalis anterior a lower branch goes and enters the segmentum lingulare superius. That is ramus anterior accessorius (BX^2b).

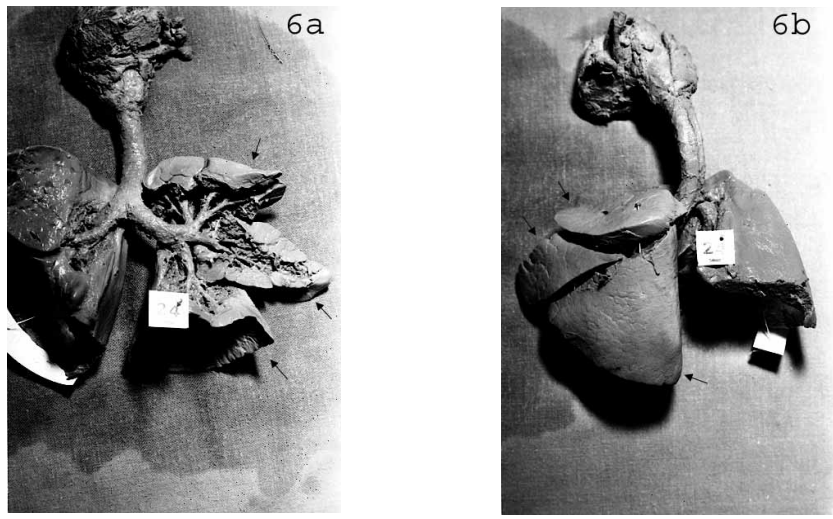

Fig. 6. Three-lobe left lung. The bronchus lingularis »communis« ventilates the »lobus medius« (lingular segments); a) front side and b) back side.

and the bronchus lobaris inferior ventilates the lobus inferior. In concluding it is clear that is the real so-called »middle lobe« of the left lung. That is three – lobe left lung in 4,8%, (Figure 6).

Discussion

A dominant branching model of the left upper lobe bronchus is bifurcation. These results are identical to the findings of the authors as: Brock[13], Boyden[14], Le Roux[15] and Lubkin and Murray[16].

Since the subsegmental bronchi of the left upper lobe are so variable in origin, it is nesessary to define their usual zones of distribution in order to establish criteria of identification (Boyden and Hartmann)[17].

The results obtained in this research are completely identical with researches of above mentioned authors.

Variations in the bronchus segmentalis apicoposterior

The ramus anterior (B^1b) of the bronchus subsegmentalis apicalis displaces to »slide down« onto the bronchus segmentalis anterior. This displaced bronchus is called designated BX^1b now. The effect of the displacement is to increase the size of the segmentum anterius and to permit a lesion of the apex to drain into the bronchus segmentalis anterior. The downward displacement of B^1b is correlated primarily with the presence of a trifurcate pattern, and the variation comprises the 11% of specimens in which the displaced ramus anterior of the bronchus subsegmentalis apicalis originates from the bronchus segmentalis anterior[18].

In our results the seven cases of this type are present (33,6% of the 21 lungs which were variable).That is variation of the cranial limit of the segmentum anterius.The results of this research are compatible with researches of above mentioned author.

The posterior ramus (B^3b) of the bronchus subsegmentalis posterior slides downward on the posterior side of the trunk. In two of specimens, it is one of three stems into which the superior division bronchus trifurcate. That is the shifting ramus posterior of the bronchus subsegmentalis posterior[14,19].

In our research the two cases of this type are present (9,5%) and our results are compatibile with results made by Scannell and Boyden.This variation is correlated primarilly with the presence of a bifurcate pattern.

Variations of the bronchus segmentalis anterior

Boyden[14] described three type if variations of the bronchus segmentalis anterior.

The tendency for B^2 to be represented by two bronchi of separate origin is pronounced, by appearance of accessory anterior ramus (BX^2). From this condition it is only a step to complete separation of the two halves, that is, for two buds to arise embryologically at different places but to grow into the territory usually occupied by a single anterior bronchus. In all, three types of splitting have been encountered in 33%.

The third type is rare and newly recognised. That is connected to occurrence of the left eparterial bronchus and ectopic left pulmonary artery. In three out of five such anamalous specimens, the left eparterial bronchus bifurcated into B^{1+3} and bronchus segmentalis anterior accessorius (BX^2) and the next bronchus then gave rise to anterior (B^2) and lingular bronchi $B^4 + B^5$. At this point, one may logically ask on what basis has the bronchus labeled B^2 and been identified as the main anterior segmental bronchus. Why, for instance, should it not have been called the superior lingular bronchus (B^4).

Our results show on the anatomical dissected section that in 30,3% the ramus anterior BX^2 enters the segmentum lingulare superius. This is completely opposite and different in comparison to available literature, where authors have a dilemma about interpretation of the results of variations named »split« bronchus segmentalis anterior.

When the ramus poster B^2a is absent, its territory is provided for in at least two ways: either B^4a or B^3b expand, or both together or more spectacularly, a bronchus arises from the lingular trunk to supply this territory (BX^2a). The latter is the displaced B^2a. Its surgical importance may be understood from the interlobar side, BX^2a, stretches across the intersegmental line which separates the anterior (B^2) from the lingular segments (B^{4+5}). Therefore, if the operator were to follow the usual plan of separating the lingular segments from the rest of the lung, he would sever BX^2a and its artery (AX^2a), thus comprimising the blood supply to what is usually the interlobar portion of the anterior segment. This is one of the anatomical hazards lingulectomy. BX^2a was found to occur in 12% of 100 specimens[14].

In our results the of this type are present in 14,3%. The results obtained in this research are completely identical to Boyden's findings.

Variations of the lingular bronchi

Atypically (15% of 100 specimens), the ramus posterior B^4a, may arise directly from the lingular trunk. In such cases the orientation of the lingular segments changes from a superior-inferior to a lateral-medial pattern B^4a forming the lateral, $B^b + B^5$ the medial component[14,20].

Our results are opposite to the Boyden's results. Bronchus lingularis »posterior« appears on the back side of the lingular tree, but its distribution is different: in 4,8% cases it enters the segmentum lingulare superius; in 9,6% cases it enters the segmentum lingulare inferius together with bronchus lingularis inferior; in 4,8% cases it enters segmentum lingulare inferius, and in 4,8% cases it enters both lingular segments.

Variations of inferior limit of the lingular segments are partly congruent with other author's findings. We found variations that have not been described in literature yet. Boyden and Hartmann[17] described that left upper lobus bronchi enter the area of lobus inferior sinister (4 %). The authors do not precisely write about the bronchi origin.

Our study ascertains that out of bronchus lingularis inferior (or of its branches) one branch goes to the segmentum basale mediale in 4,8 % cases. In 9,6 % cases, one branch from the bronchus lingularis inferior goes to the segmentum basale anterius lobi inferioris. In 4,8% one branch from the bronchus lingularis inferior goes to the segmentum lingulare superius.

Variations of the left upper lobe

In the literature available, cleft of the left upper lobe, systematized into three types, is described as the major variation[14].

This research detected a complete three-lobe left lung. Lobus medius »sinister« (lingular segments) is completely separated by fissura horizontalis, while the lingular segments are of normal size. This finding is partly congruent to the first type of the left upper lobe variations described by Boyden[14], because the author did not describe the left upper lobe bronchus distribution. This research found that: lobus superior is ventilated by bronchus segmentalis apicoposterior and bronchus segmentalis anterior, created from the upper tree of the left upper lobular bronchus. Lobus inferior ventilates bronchus lobaris inferior.

In 9,6% cases the left upper lobular bronchus anomalies were found. In 4,8% cases the anomaly is partly congruent to the anomaly described in literature as the left eparterial bronchus. In 4,8% cases it was established that just the bronchus segmentalis apicoposterior is created as the upper tree out of the upper lobular bronchus. The lower tree is joint for the bronchus segmentalis anterior and lingular tree. One branch from the bronchus segmentalis anterior goes to the segmentum lingulare superius. Both lingular branches enter the segmentum lingulare inferius. This anomaly is not described in literature.

Maciejewski et al [21] studied relationships between divisions of the lingular bronchi and vascularization patterns in the lingula. Authors concluded that atypical bronchial divisions were almost always associated with unusual types vascularization. Patterns of bronchial division showed complete concordance with those of arterial vascularization of the lingula.

The exact topography of the segmental bronchi in lungs is necessary in diagnostics and surgical procedures[22,23].

Generally, the data of the human bronchial system variations have been very deficient since 1960 year. Sometimes exactitude of the data found in literature is not credible, because authors do not give photos of the anatomical section (preparation) or of radiogram, but show variations of the human bronchial system in schemes.

Conclusion

There are two types branching of the left upper lobe bronchus, bifurcation as a dominant and trifurcation as a rare model, that is a variation.

Very different variations in the ventilation of the bronchopulmonary segments of the left upper lobe are evident. Some variations were not described in the scientific literature, either. Three categories of anomaly were evident.

Acknowledgement

The photographs of the human bronchi were done by Mr. Izet Čanić, who is manager of »FOTO TUZLA«. We would like to thank Mr. Izet Čanić and it has been a great pleasure to collaborate with the competent staff of »FOTO TUZLA«.

REFERENCES

1. EWART, W.: The bronchial and pulmonary blood vessels: Their anatomy nomenclature; with a criticsm of Professor Aeby´s views on the bronchial tree of mammalia and man. (Tindal and Cox, London Baillere, 1889). — 2. HUNTINGTON, C. S., Am. J. Anat., 27 (1920) 99. — 3. FEARON, B., J. S. WHALEN, Am. Otol. Rhinol. Laryngol., 76 (1967) 964. — 4. FOSTER-CARTER, A. F., C. HOYLE, Dis. Chest, 11 (1945) 511. — 5. JACKSON, C. L., F. J. HUBER, Dis. Chest, 9 (1943) 319. — 6. HUBER, J. F., J. Nat. Med. Assoc., 41 (1949) 49. — 7. CHURCHILL, E. D., R. BELSEY, Ann. Surg., 109 (1939) 481. — 8. BROCK, R. C.: Observations on the anatomy of the bronchial tree, with. special reference to the surgery of lung abscess. (Oxford University Press, London, 1942–1944). — 9. HERRNHEISER, G., A. KUBAT, Ztschr. F. Anat. u Entwklngsgesch., 105 (1936) 570. — 10. MILISHNIKOVA, V. V., A. M. MONAENKOVA, Med. truda i Promys. Ekol., 8 (1995) 1. — 11. TOPOL, M., Folia Morphol. (Warsz.), 57 (1998) 241. — 12. RECHEIS, W., M. STRAUB, J. TSCHIRREN, D. NEDDEN, Coll. Antropol., 28 (2004) 103. — 13. BROCK, R. C.: The Anatomy of Bronchial Tree. (Oxford University Press, London, 1954). — 14. BOYDEN, E. A.: Segmental Anatomy of the Lungs. (Mc-Graw-Hill, New York, 1955). — 15. LE ROUX, B. T., J. Thorac. Cardiovasc. Surg., 49 (1962) 216. — 16. LUBKIN, S. R., J. D. MURRAY, J. Math. Biol., 34 (1995) 77. — 17. BOYDEN, E. A., F. J. HARTMANN, Am. J. Anat., 79 (1946) 321. — 18. BOYDEN, E. A., Am. J. Surg., 89 (1955) 79. — 19. SCANNELL, J. G., J. Thorac. Surg., 16 (1947) 530. — 20. BOYDEN, E. A., Surg., 20 (1946) 828. — 21. MACIEJEWSKI, R., S. JABLONKA, Z. WOJTOWICZS, Scand. J. Thorac. Cardiovasc. Surg., 30 (1996) 35. — 22. CONNOLY, J. F., Surg. Clin. North Am., 60 (1980) 1481. — 23.TAPINSKIJ, L. S., A. N. ANDREICEW, Grudn. Chir., 4 (1977) 59.

A. Savković

Department of Anatomy, Medical School, University of Tuzla, Muharema Fizovića 6, 75000 Tuzla, Bosnia and Herzegovina

VENTILATORNI SUSTAV LIJEVOG GORNJEG REŽNJA PLUĆA

S A Ž E T A K

Poznavanje modela grananja bronhijalnog stabla je od posebnog interesa za kliničku i operativnu pulmologiju jer su hemilobektomija, segmentektomija i subsegmentektomija uvijek određene intralobarnom, intrasegmentalnom i intrasubsegmentalnom ramifikacijom. Istraživanja su obavljena na 100 pluća djece i odraslih osoba, oba spola, starosti od jednog dana do 85 godina života, metodom slučajnog izbora. Dva su glavna tipa u grananju lijevog gornjeg lobarnog bronha: bifurkacija kao dominantan model u 74% i trifurkacija kao model u 26%. Od 100 proučavanih pluća, 21 pluće je imalo varijacije u ventilaciji bronhopulmonalnih segmenata. Izvršena je klasifikacija i kategorizacija u ventilaciji bronhopulmonalnih segmenta lijevog gornjeg lobusa pluća. Ova klasifikacija sadrži 5 kategorija i 8 subkategorija.