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Original Research Article

Anatomical arrangement of the lobar bronchi, broncho-pulmonary segments and their variations

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ABSTRACT

Background: The segmental concept of lungs was still in dispute in the literature. Although the segments differ considerably in shape and size, they all contain a well-defined area of lung and they are all well demarcated from the neighbouring segments. Therefore, in the present study, an attempt has been made to demonstrate the anatomical arrangement of the lobar bronchi, broncho-pulmonary segments and their variations.
Methods: The study was conducted in fifty human lungs, obtained from autopsies, dissection hall cadavers and full term foetuses. The bronchial tree was investigated by air inflation, dye injection and using dissection, preparation of casts, air inflation, dye injection and bronchographic techniques. The external morphology of lungs and their lobes has been studied and the bronchopulmonary segments are described in detail.
Results: In humans, the right lung is found to consist of ten segments in only 77% cases, and the left lung of ten segments in 84% cases. Thus in the study of 50 human lungs, the classical textbook description has occurred only in 80.5% of cases. Remaining 19.5% showed variations. Among the variations observed, right lung showed (59%) predominance over (41%) on left side.
Conclusions: In man there is an increase in the number of bronchial generations and alveoli after birth. An increase in their size was noted as well. Thus the study of variations in the pattern of bronchopulmonary segments aids the clinician very much. It is necessary for Thoracic Surgeons, Anaesthetists, Chest physicians, Radiologists, Ultrasonologists, Pathologists and Anatomists for investigative procedures, diagnosis and various treatment modalities including surgeries like segmentectomy.

Keywords: Bronchial system, Bronchopulmonary segments, Bronchopulmonary variations

INTRODUCTION

The bronchial system of the lungs serves excellently as a skeleton, partly because the tubular structures of the thorax and the lung parenchyma are supported by it and surround it completely and partly because the recognition and portrayal of this structure is useful for radiological investigations.[1]

A picture of the bronchial network occupying the thorax may be built up from basic knowledge of the ramification of the bronchial system. This problem has been approached from various angles, partly to classify, the fundamental principles of classification of this complicated system, and partly to narrow the difference between anatomical specimens and the routine clinical investigations.[2,3] For a complete topographic anatomical examination of the bronchial system of the living subject by radiographs, contrast material has to be used. Since the entire bronchial system cannot be completely examined at one time in the living subject, examination of the cadaver has to be carried out.

The development of the segmental concept induced the chest physician, thoracic surgeon and radiologist to abandon the two dimensional way of regarding the lung. This has led to the discovery that certain changes are almost specifically confined to certain segments.[4] Curiously enough, lungs that are made up wholly of prevailing patterns are seldom encountered, for a variation in even one zone necessarily modifies the development of adjacent segments, where over twenty variations occur in what are apparently normal right and left lungs For purposes of instruction, therefore, it has become necessary to create a hypothetical pair of lungs that will combine the prevailing patterns of all the principal bronchi.

This segmental concept was until recently, still in dispute in the literature. Although the segments differ considerably in shape and size, they all contain a well-defined area of lung and they are all well demarcated from the neighbouring segments. The apex of the segments usually lies-towards the hilum.[5] The base of their incomplete cone or pyramid is usually well defined at the visceral pleura. Opinions are still divided as to the number, extent, and even the naming of the segments although in recent years the international nomenclature of 1949, by the congress of the Oto - Rhino - Laryngology held in London has become universally accepted, in clinical practice, individual segments are still described in topographic anatomical terms. This nomenclature was later accepted by the Thoracic Society and recorded in Thorax.[6]

Modern methods of examination of the bronchi were linked to the name of Melnikow, working at the beginnings of the 20th century. Melnikow's fundamental work marked the beginning of the discovery of more extensive bronchial anatomy.[7] His investigations are more valuable than those of Aeby and Narath.[8] He showed that the bronchi are so variable that it is not even always possible to find the ten branches on the right and nine on the left as described by previous authors, for their numbers vary and in addition the same area may at times be supplied by branches of a different bronchus.[9] Therefore, in the present study, an attempt has been made to demonstrate the anatomical arrangement of the lobar bronchi, broncho-pulmonary segments and their variations.

METHODS

This study was conducted at the department of Anatomy, Medical College Calicut after the institutional ethical clearance. The study of bronchopulmonary segments of human lungs was undertaken in fifty specimens of various ages ranging from 37-40 weeks of gestation to 65 years. All lungs were obtained in pairs.

Of the fifty human lungs subjected to study, twenty four adult lungs were taken from the embalmed cadavers in the dissection hall; sixteen fresh lungs were collected from Forensic Medicine Department. Out of which one pair of lung belonged to an eight years old boy and ten fetal lungs were taken from full term stillborn babies obtained from the Institute of Maternal and Child Health, Medical College Calicut, India. Ten specimens were female lungs and forty were male lungs. The methods of study of the bronchial tree were the dissection of formalin preserved lungs from the cadavers, dissection of fresh lungs obtained from autopsies, luminal cast study of fresh lungs obtained from autopsies and still born babies using silicon sealant, dye injection using colored gelatin solution, air inflation and post-mortem broncho-graphic studies using Barium sulphate.

Dissection

After removing the lungs from the body, they were examined for congenital anomalies like bronchial atresia, aplasia, hypoplasia, sequestration, congenital lobar emphysema, congenital cysts and acquired conditions like cavities, tumours and cysts. Then they were dissected and bronchopulmonary segments were carefully examined.

Luminal cast study

This is a permanent method of defining the segments of the lungs which was used in freshly isolated 6 pairs of human lungs. Twelve lung casts were obtained by this method. Fresh specimens were used for luminal cast study as alteration during preservation would give a wrong picture of the interior. The principle involves filling up of the lumen with silicon sealant and dissolving the surrounding lung tissue by boiling the specimen.

The lumen of the tracheobronchial tree was cleaned using tap water containing dish washing detergent to remove mucus, blood and secretion. The cleaning was stopped when the fluid coming out was as clean as the ingoing one. Approximate volume of the casting material necessary was calculated by observing the amount of washing fluids used.[1] After cleaning, the excessive amount of fluid in the lumen was drained by tilting the organ and by squeezing. After draining the fluids completely the lungs were made dry using cotton towels and blotting papers.

Once the lungs were made dry, the tracheobronchial tree was injected gently and carefully with silicon sealant, available as readily packed gel. Once filled completely, the entry port was blocked by tying in order to prevent the escape of the material. Canulae, rubber tubes and special injecting gun were used for this procedure. 24 - 48 hours after injection, the lungs were boiled for 2 hours. The lungs were then taken out and the remaining lung tissue was removed piece meal and cleaned the cast using tap water. The cast stands a considerable amount of movement and bending, so that the complicated work of tubes in the lung and their delicate connections to the air sacs could be studied without fear of breaking them. The

cast is soft enough to be cut easily with scissors. The silicon sealant produces an excellent, soft, flexible cast showing an unimaginable three dimensional orientation of the cavity including abnormalities, if any. So this technique is useful to study the dimensions and architecture of the tracheobronchial tree and their variations.

Dye injection

Fresh, unfixed lungs from autopsies were selected. Trachea was cannulated and trachea-bronchial tree was cleaned with tap water. The two lungs were separated by cutting the trachea at the bifurcation and the origin of each of the bronchopulmonary segments was exposed by blunt dissection. Each lung was then injected with two liters of 12% gelatin solution through cannulae.

After that each segment was filled with different colored gelatin of about 50 – l00ml, using 20cc syringe with a wide bored needle. Each segmental bronchus was tied after injection of that particular segment. The lungs were then placed in 4% formalin for a few days to harden the gelatin with which it was partly filled. The pleura were stripped from the surface to show the colors better.

Air inflation

This is a quick, temporary method of defining the segments. Each segment was inflated with air passed under pressure sufficient to produce demarcation, but not to break down the alveoli.

Postmortem bronchography

The isolated fresh, cleaned lungs were injected with 25ml of Barium sulphate. The entry port was tied to prevent the escape of Barium Sulphate. The lungs were then X-rayed. Both AP and PA views were taken. The bronchopulmonary segments were analysed with the help of a radiologist.

RESULTS

The study of human lungs was conducted in fifty specimens. Out of which, twenty four adult lungs from the embalmed cadavers, sixteen fresh lungs from autopsies and ten were feotal lungs (Table 1). They were tabulated according to the different age groups in the two sexes.

Table 1: Number of specimens collected for study.

Age groups	Male	%	Female	%	Total	%
Foetus	4	40	6	60	10	20
Child	2	100	0	0	2	4
Adult	30	79	8	21	38	76
Total	36	72	14	28	50	100

Table 2: Anatomical arrangement of bronchopulmonary segments.

Methods	Source		Foetus	Child	Adult	Total
	Fresh	Preserved				
Dissection	2	20	4	0	18	22
Luminal Cast Study	12	0	4	2	6	12
Post mortem Bronchography	8	0	2	0	6	8
Air inflation	4	0	0	0	4	4
Dye injection	4	0	0	0	4	4
Total	30	20	10	2	38	50

Table 3: Variations in the bronchopulmonary segments of left lung.

Lobes	Number of segments	%
Upper	5	96
	6	4
Middle	0	0
	0	0
Lower	5	72
	6	28

Table 4: Variations in the bronchopulmonary segments of right lung.

Lobes	Number of segments	%
Upper	3	96
	2	4
Middle	2	96
	3	4
Lower	5	40
	6	60

Anatomical arrangement of bronchopulmonary segments on the basis of dissection, luminal Cast Study, Post mortem bronchography, Air inflation and dye injection were explained in Table 2. The number of samples from dissection was 22%, luminal cast study was 12%, Post mortem Bronchography was 8%, air inflation and the dye injection were 4% each.

Table 5: Pattern of distribution of bronchopulmonary segments of the two sides.

Lobe	Right		Left		% of variation		Normal pattern %	
	Number	%	Number	%	Right	Left	Right	Left
Upper	3	96	5	96				
	2	4	6	4				
Middle	2	96						
	3	4			23	16	77	84
Lower	5	40	5	72				
	6	60	6	28				

Table 6: Sidewise distribution of variations.

Normal pattern	Variations observed	Variations	
		Right	Left
80.5%	19.5%	59%	41%

The variations in the bronchopulmonary segments of left lung and right lung are explained in the Table 3 and 4. In the upper and lower lobes of right lung showed 5 and 6 segments each. Whereas, in the upper and middle lobes showed 96% and 4% each, and the lower segment showed 40% and 60% each (Table 5).

Table 7: Details of variations.

Variations	No. of cases seen	%
Bifurcation of right upper lobe bronchus	1	4
Trifurcation of lingular common stem	1	4
Trifurcation of middle lobe bronchus	1	4
Right lower lobe bronchus dividing into six (subapical)	15	60
Left lower lobe bronchus dividing into six (subapical)	7	28

Sidewise Distribution showed 80.5% of normal pattern and 19.5% of variations (Table 6). There was 4% each of bifurcation of right upper lobe bronchus, trifurcation of lingular common stem and trifurcation of middle lobe bronchus and 60% of right lower lobe bronchus divided into six (subapical) and 28% of left lower lobe bronchus divided into six (subapical) segments (Table 7).

DISCUSSION

Segmentectomy is a commonly performed surgical procedure on the lungs. A precise knowledge of the morphology of the lobes and segments is therefore important. The lungs described in this study are being subdivided by fissures or interlobar connective tissue planes into lobes; each lobe is ventilated by a large bronchus arising from the main bronchus.[10] The lobes are then subdivided further into bronchopulmonary segments, the right into ten segments and left into ten segments. The variational pattern of the bronchopulmonary segments have been studied and reported in the literature in different ways by many investigators.[11-13]

An attempt has been made here to compare the results of the earlier workers with those of the present study. The classical textbook description of the anatomical arrangement of the bronchopulmonary segments has occurred in 80.5% of cases only. In the remaining 19.5% cases, variations were observed, 59% on the right side and 41% on the left side. In the present study the oblique fissure was found to be totally absent on the left lung in 4% of cases. On the right lung, the horizontal fissure was found to be incomplete in 4% of cases. Medlar found additional clefts 21 times in the right lower lobe, 3 times in the right upper lobe, twice in the left lower lobe and 18 times in the left upper lobe, and the additional fissures corresponding to the azygos lobe occurred in 7 cases.[14] Such additional clefts were not observed in the present study.

According to Kovats F et al, supernumerary lobes are frequently found on the right side. They observed azygos lobes in 3 - 5% of cases. It is formed when the parietal and visceral layers of the pleura are pushed deeply into the lung parenreyma by the azygos vein, so that a pseudolobe is cut off from the upper lobe.[15] In the present study, no azygos lobe was observed.

Boyden EA has introduced term called Pre-eparterial bronchus to designate any anomalous bronchus which arises above the level of the eparterial or right upper lobe bronchus: namely, from the lateral wall of the right primary bronchus or from the right side of the trachea.[16]

In the present study, such a pre-eparterial bronchus was not observed. Brock and Boyden also describe' a Post-eparterial bronchus, which arises from the right bronchial tree at a level below that of the eparterial bronchus.[16] This also was not observed in the present study.

In the present study all superior (apical) segmental bronchus arose as a single stem. The 60% variation observed in the present study was due to an additional subapical segment. Although a side-wise occurrence of variations have not been highlighted in any preceding study, we observed a right sided variation and were found to be 59 % as opposed to 41 % on the left side.[17] So the present study agrees with the previous studies that the patterns of bronchopulmonary segments are so variable.

CONCLUSION

Thus the study of variations in the pattern of bronchopulmonary segments aids the clinician very much, and it is necessary for Thoracic Surgeons, Anaesthetists, Chest physicians, Radiologists, Ultrasono-logists, Pathologists and Anatomists because it is essential for investigative procedures, diagnosis and various treatment modalities including surgeries like segmentectomy.

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