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MORPHOMETRIC STUDY OF HILAR ANATOMY, FISSURES AND LOBES OF HUMAN LUNG – A CADAVERIC STUDY

Gomathi Ramakrishnan*[1], Dhivyalakshmi Gnanasekaran[2], Aruna S.[3] and Murugesa Bharathi O.[4]

[1]Third Year Post Graduate Resident, Indira Gandhi Medical College & Research Institute, Puducherry-605009.
[2]Assistant Professor, Indira Gandhi Medical College & Research Institute, Puducherry-605009.
[3]Professor & Head, Department of Anatomy, Indira Gandhi Medical College & Research Institute, Puducherry-605009.
[4]Associate Professor, Department of Forensic Medicine, Indira Gandhi Medical College & Research Institute, Puducherry-605009.

***Corresponding Author: Dr. Gomathi Ramakrishnan**

Third Year Post Graduate Resident, Indira Gandhi Medical College & Research Institute, Puducherry-605009.

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ABSTRACT

Background: The lungs situated in the thoracic cavity on either side of the mediastinum are the vital organs of respiration. Knowledge about the fissures, lobes, and hilar anatomy of the lung is essential for surgeons during the resection of lung segments in lung cancer, for radiologists to avoid misinterpretation of the normal anatomical variations of lungs as lung pathologies. The knowledge of dimensions of principal bronchi is of significant use in bronchoscopy and also in evaluating the etiology of severe pulmonary diseases. **Objectives:** To study the variations in lobes, fissures, and hilar structures and to measure the luminal diameters of the principal bronchus at the bifurcation and the hilum in both lungs. **Method:** It is a cross-sectional descriptive study. Twenty-five lung specimens along with trachea & principal bronchus from the routine autopsy were studied. Variations in the lung, principal bronchi, and hilar structures were noted. Vertical and anteroposterior diameters of principal bronchi were taken at the tracheal bifurcation and hilum. **Result:** Among the fifty specimens, 10% had an accessory fissure, and 8% of right lungs had an absent horizontal fissure. In 14% of specimens, there was bifurcation of the pulmonary artery and in 22% there was bifurcation of the pulmonary vein just before entering the hila. In 12% of lung specimens, the principal bronchus is divided into lobar bronchi either at the level of tracheal bifurcation or just before entering the hilum. There was no progressive narrowing of principal bronchi on both sides but the luminal diameter of the left side bronchus was less compared to the right side. **Discussion:** The knowledge of these variations is essential to diagnose the site of lesions and the luminal diameter of bronchi is useful in diagnostic and therapeutic bronchoscopic procedures. **Conclusion:** This study will be helpful for clinicians, surgeons, and radiologists for diagnostic procedures using bronchoscopy, diagnosis & planning of treatment modalities like lung or segmental or lobar resection surgeries in various lung diseases.

KEYWORDS: *lung, principal bronchus, pulmonary artery, pulmonary vein.*

INTRODUCTION

The lungs are the vital organs of respiration situated in the thoracic cavity. Generally, the right lung has two fissures and three lobes, and the left lung has one fissure and two lobes. The arrangement of hilar structures differs on both sides. On the left side, they are arranged from above downwards as a pulmonary artery, principal bronchus, and pulmonary vein, whereas, on the right as eparterial bronchus, pulmonary artery, hyparterial bronchus, and pulmonary vein.[1] Variations in lobes, fissures, and hilar structures possess great challenges in the accurate diagnosis and management of various lung conditions. Pneumonia in most instances will be restricted to the affected lobe but in case of an incomplete fissure, it may spread to the adjacent lobe and can also cause post-operative air leaks after lung surgeries.[2] The presence of extra lobes may be misinterpreted for possible lesions in radiography.[3] Accessory fissures may be mistaken for areas of linear atelectasis or pleural scars and it can alter the usual pattern of lung collapse in any endobronchial lesion.[4] Variations in hilar structures may increase the risk of injury to the hilar vessels during surgery. Variation in the pulmonary veins may act as a source of ectopic depolarization because of its proximity to the right atrium and can initiate atrial fibrillation. The diameter of bronchi is useful in diagnostic and therapeutic bronchoscopy procedures.[5] Many authors have studied the variation of fissures, lobes, and hilar anatomy in different populations of India like Gujarat, Mumbai, Manipur, Imphal, etc.[2,3,4] but only very few studies have been reported in the population of Puducherry, and Chunder R et al[5] has measured the morphometry of trachea and principal bronchi of different age groups in

both sexes but no one has measured the relation of the dimension of principal bronchi at tracheal bifurcation to its entry point at hilum which will be of significant use during bronchoscopy. Hence this present study was taken up to study the morphometry of hilar anatomy, fissures, lobes, and diameters of principal bronchi at the bifurcation and the point of entry into the hilum of human lungs in the Puducherry region.

MATERIALS AND METHODS

It was a cross-sectional descriptive study. A total of 50 fresh autopsied lung specimens of both genders were taken up for the study. Lung specimens with preserved hilar anatomy and completely covered with visceral pleura were included and those that are damaged, diseased, and or striped of the parietal pleura were excluded from the study. After giving the serial number and identifying the side, the variations in fissures such as numbers, completeness, and variation in lobes were noted. Type of fissures was graded using Craig and Walker's anatomical classification[6] Grade 1: complete fissure with entirely separate lobes Grade 2: complete visceral cleft but parenchymal fusion at the base of the fissure Grade 3: visceral cleft evident for a part of the fissure Grade 4: complete fusion of lobes with no evident fissure line. Variations in the important hilar structures such as the pulmonary artery, pulmonary vein, and principal bronchus in terms of numbers and their arrangements from above downwards and from anterior to posterior were observed. The luminal diameter of the left and right principal bronchi at the hilum was measured along the anteroposterior and vertical axis and the same was measured at the tracheal bifurcation using Mitutoyo digital vernier caliper with the precision of 0.01mm. The results were analyzed using SPSS software and results are expressed in percentage and mean and standard deviation. The study was taken up after obtaining clearance from the institute's research and ethical committees.

RESULTS

Among twenty-five right lungs, a complete oblique fissure (Criag and Walker's Grade 1) was observed in 84%, and an incomplete oblique fissure (Criag and Walker's Grade 2 & 3) in 16%. Lung with total absence of oblique fissure was not seen in any specimens. Forty eight percent had complete horizontal fissures, 36% had incomplete horizontal fissures and 16% had absent horizontal fissures. Twelve percent had accessory fissures (one upper and two lower lobes). (Table.1)

Table 1: Incidence of fissures of lungs based on Craig & Walker's classification.

Side	Fissures	GRADE 1	GRADE 2	GRADE 3	GRADE 4
Left side (n=25)	Oblique fissure (n=25)	60%(15)	24%(6)	12%(3)	4%(1)
	Accessory fissure (n=2)	4%(1)	-	-	4%(1)
Right side (n=25)	Oblique fissure (n=25)	84%(21)	8%(2)	8%(2)	-
	Horizontal fissure (n=25)	48%(12)	16%(4)	20%(5)	16%(4)
	Accessory fissure (n=3)	4%(1)	-	4%(1)	4%(1)

At the hilum normal order of hilar structures from above downwards and from anterior to posterior was observed in 52%, two pulmonary arteries were observed in 20% (Fig.1), three pulmonary veins in 28%, and three hilar bronchi in 4%. (Table.2)

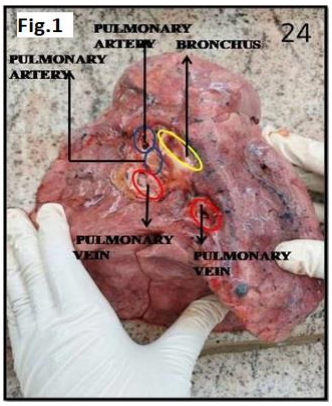

Fig. 1: Two pulmonary arteries at the hilum of right lung.

Table 2: Variations in lung hilar structures.

Side	Number of Artery		Number of Vein			Number of hilar bronchus		
	1	2	1	2	3	1	2	3
Right (n=25)	80%(20)	20%(5)	-	72%(18)	28%(7)	44%(11)	52%(13)	4%(1)
Left (n=25)	92%(23)	8%(2)	4%(1)	84%(21)	12%(3)	92%(23)	8%(2)	-

Among twenty-five left lungs, a complete oblique fissure (Criag and Walker's Grade1) was observed in 60%, incomplete oblique fissure (Criag and Walker's Grade 2&3) in 36%, absent oblique fissure (Criag and Walker's Grade 4) in 4%. Eight percent had accessory fissures (one upper and one lower lobe). (Table.1) (Fig.2) At the hilum normal order of hilar structures from above downwards and from anterior to posterior was observed

in 76%, two pulmonary arteries were observed in 8%, three pulmonary veins in 12% (Fig.3), a single pulmonary vein in 4%, and two hilar bronchi in 8%. (Table.2)

Fig. 2: Accessory fissure in left lung.

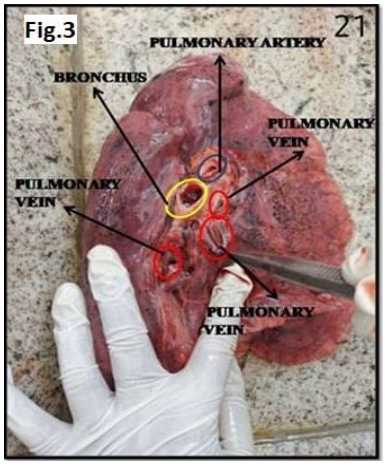

Fig.3 Three pulmonary veins at the hilum of left lung.

The mean vertical and anteroposterior luminal diameters of the left and right principal bronchus are given in Table 3. Paired t-test analysis for the diameter of the principal bronchus of 19 matched pairs shows the luminal diameter of the left side bronchus is less compared to the right side. Analysis of luminal diameter shows that there is no progressive narrowing of the principal bronchus on both sides.

Table 3: Morphometry of principal bronchi expressed in Mean ± Standard deviation (mm).

Side	Luminal Diameter	At Bifurcation	At the hilum	p value
Left (n=21)	Anteroposterior	9.21±0.24	8.73±0.31	0.357
	Vertical	13.78±0.28	13.69±0.35	0.882
Right(n=23)	Anteroposterior	11.76±0.22	8.76±0.25	0.000
	Vertical	18.14±0.27	18.57±0.40	0.573

Among 50 lung specimens, the principal bronchus divided into lobar bronchi either at the level of tracheal bifurcation or just before entering the hilum in 12%. (Fig.4)

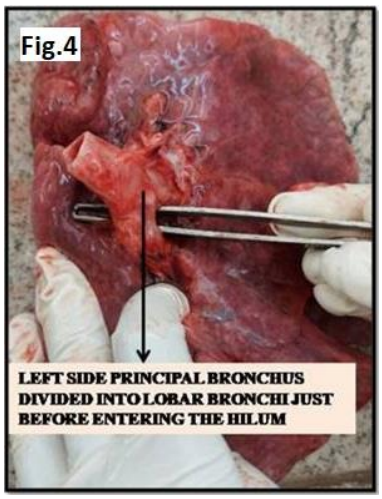

Fig. 4: Variation in principal bronchus.

DISCUSSION

The lung bud appears as an outgrowth from the foregut ventral wall at 4 weeks of embryonic development. The right bronchial bud divides into three secondary bronchial buds and the left bronchial bud divides into two at 5 weeks of life. The secondary bronchial buds divide into tertiary bronchial buds at 6 weeks and form the bronchopulmonary segments.[11] The spaces between bronchopulmonary segments are obliterated except the one along the line of principal bronchi which forms the deep complete fissure alone remains. These fissures are horizontal and oblique in the right lung dividing it into 3 lobes and only oblique in the left lung dividing it into 2 lobes.[12] The visceral pleura gets reflected along these fissures and covers the lobes individually on all sides. The oblique or major fissure lies at the level of the T3 spine or fifth rib or in line with the vertebral border of the scapula when the arm is placed above the head.[13] In the present study 16%(4) right lungs and 36%(9) left lungs showed incomplete oblique fissure and 4%(1) left lung showed absent oblique fissure. The horizontal or minor fissure lies at the level of the fourth costal cartilage.[13] Incompleteness is more common in minor fissures which can be attributed to environmental and genetic factors during lung development.[14] In the present study, 36%(9) showed incomplete horizontal fissures and 16%(4) showed absent horizontal fissures in the right lung.

In the present study, the incomplete horizontal fissure was high which correlates with the previous studies done

by Meenakshi et al and George BM et al.[7,8] (Table.4) This incomplete horizontal fissure leads to fluid tracking within the fissure in pleural effusion, alters the pattern of lung collapse in endobronchial lesions, and spreads pneumonia to adjacent lobes and odd lobar carcinoma.[15]

Table 4: Comparison of incidences of variations of fissures with previous studies.

Authors	Right				Left	
	Oblique fissure		Horizontal fissure		Oblique fissure	
	Incomplete	Absent	Incomplete	Absent	Incomplete	Absent
Meenakshi et.al (2004)	36.60%	0%	63.30%	16.60%	46.60%	0%
George BM et.al (2014)	3.07%	0%	35.38%	23.05%	5.06%	0%
Present study (2022)	4%	0%	28%	8%	8%	0%

Anatomical and functional communications between the lobes explain the relationship between incomplete interlobar fissures and interlobar collateral ventilation.[16] Perioperative identification of the completeness of fissures is needed before lobectomy procedures to prevent postoperative air leaks.[17] The accessory fissures and lobes seen in the adult lung are due to the monopodial branching pattern of stem bronchi.[18] The accessory fissures are clefts of varying depths lined by visceral pleura which are mistaken for interlobar fissures, the wall of a bulla, scar, or pleural line in pneumothorax.[18,19]

The most common accessory fissures are the azygos, inferior and superior accessory fissures, and the left minor fissure.[20] The azygos fissure is formed by the invagination of the azygos vein through the apical region of the right upper lobe which is more common.[20,21] The inferior accessory fissure separates the medial basal segment from the rest of the lower lobe which demarcates the cardiac lobe (medial basal segment)[19,20] in the present study 8%(1-right and 1-left) lung specimens showed inferior accessory fissure. The superior accessory fissures separate the superior segment of the lower lobe from the basal segments and demarcate the posterior or dorsal lobe.[21] In the present study, 8%(1-right and 1-left) lung specimens showed superior accessory fissures.

In comparison, previous studies done by Nane et al[IX] showed a higher incidence of inferior accessory fissure in the left lung (24%) and a study done by Quadros et al[10] showed a higher incidence of superior accessory fissure in the right lung (8.33%)(Table.5). In the present study, both superior and inferior accessory fissures of both lungs showed equal incidence (4%).

Table 5: Comparison of incidences of accessory fissures with previous studies.

Authors	Right Lung		Left Lung	
	SAF	IAF	SAF	IAF
Nene et al (2011)	4%	14%	0%	24%
Quadros et al (2014)	8.33%	5.55%	0%	5%
Present study (2022)	4%	4%	4%	4%

SAF – Superior Accessory Fissure IAF – Inferior Accessory Fissure

Variations in fissures and lobes could be due to defective pulmonary development. Defects in the obliteration of oblique and horizontal fissures could lead to incomplete or absence of these fissures.[22] The accessory fissures are mistaken for linear atelectasis or pleural scars. In the present study hilar anatomy variations were noted in 20%(5) right and 8%(2)left showing two pulmonary arteries, 28%(7) right and 12%(3) left lung showing three pulmonary veins, 4%(1) right lung showing three hilar bronchi and 8%(2) left lung showing two hilar bronchi which correlate with previous studies done by Khedekar et al and George BM et al.[2,8] 4%(1) left lung showing a single pulmonary vein was seen in the present study which correlates with the study done by Khedekar et al.[2] (Table.6)

Table 6: Comparison of variations of hilar structures with previous studies.

Variations in Hilar structures		George BM et al. 2014 (n= 65 right & 73 left)	Khedekar D et el. 2017 (n=25 right & 25 left)	Present study
Right	1 artery	29.23%	4%	80%
	2 artery	67.69%	84%	20%
	3 artery	3.07%	12%	-
	1 vein	-	4%	-
	2 vein	63.07%	88%	72%
	3 vein	32.30%	8%	28%
	1 bronchus	-	4%	44%

	2 bronchus	98.46%	96%	52%
	3 bronchus	1.53%	-	4%
Left	1 artery	94.52%	92%	92%
	2 artery	5.47%	8%	8%
	1 vein	-	4%	4%
	2 vein	80.82%	92%	84%
	3 vein	19.17%	4%	12%
	1 bronchus	78.08%	76%	92%
	2 bronchus	21.91%	24%	8%

The knowledge of variations in lung hilar structures is important because pulmonary veins are the dominant source of ectopic depolarization which initiates atrial fibrillation in cases of paroxysmal atrial fibrillation.[23] Patients with separate ostium for the right middle lobar vein show a higher incidence of atrial fibrillation.[24] The variation of the opening of the middle lobar vein into the inferior pulmonary vein should be noted during lobectomy procedures to avoid hemorrhage.[25]

The luminal diameter of the left principal bronchus was less compared to the right side in the present study which correlates with a previous study done by Chunder R et al.[5] (Table.7) The knowledge of the luminal diameter of principal bronchi is essential in diagnostic and therapeutic bronchoscopy.

Table 7: Comparison of AP diameter of principal bronchi with previous study.

Authors	AP diameter	
	Right principal bronchi	Left principal bronchi
Chunder R et al (2010)	16mm	15mm
Present study (2022)	11.76mm	9.21mm

CONCLUSION

The knowledge of normal anatomy is essential for surgical procedures. Anatomical variation may be misinterpreted in radiological scans as lung pathologies, such as cases of extra lobes which may be diagnosed as lung lesions.[3,4] The accessory fissure can alter the usual pattern of lung collapse in endobronchial lesions. In cases of pneumonia, infection will be restricted to the affected lobes, but in patients with incomplete fissures, it may spread to adjacent lobes.[3,4,5,6,7] Hence knowledge about the variations of fissures and lobes in lungs and their hilar structure arrangements and luminal diameters of principal bronchus will be helpful for clinicians, surgeons, and radiologists for diagnostic procedures using bronchoscopy, diagnosing the etiology of several lung diseases and also for planning lung resection surgeries.

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