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Original Article

Anatomy Section

Anatomical Study of Lobes and Fissures of Lungs and its Clinical Significance-A Cadaveric Study

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ABSTRACT

Introduction: The human lungs are divided by fissures into lobes which permit movements of lobes to one another. The fissures act as barriers to avoid the spread of the diseases. Knowledge of variations in the lobes and fissures of the lungs is important for the Radiologists to interpret the radiological images and for the cardiothoracic surgeons to plan for segmental resection or lobectomy.

Aim: To study the patterns of fissures and lobes of the lungs and their variations and to find their clinical implications and to compare with the previous studies.

Materials and Methods: Forty pairs of lungs were used for the study. They were obtained from formalin fixed cadavers. The patterns of lobes, fissures and hilar anatomy of lungs and its variations were noted and specimens were photographed.

Results: In the present study, incomplete horizontal fissure was found to be in 23(57.5%) right lung specimens and incomplete oblique fissure was observed in 20(50%) left lung specimens. Absence of horizontal fissure was about 10(25%) and oblique fissure was about six (15%) in right lung specimens. Absence of oblique fissure was about four (10%) in left lung specimens. According to Craig and Walker classification, Grade 1 and Grade 3 fissures were found to be more in both the lung specimens. Accessory fissure was observed in 5 (12.5%) specimens in the right lung and 10 (25%) specimens in the left lung. Single lobe was observed in both the lungs, 7.5% in the right lung and 5% in the left lung.

Conclusion: Variations of fissures and lobes and of hilar anatomy is of great significance. Knowledge of these variations is important for Radiologists and Cardiothoracic surgeons for interpreting the data and to plan for the surgeries.

Keywords: Accessory fissure, Hilar anatomy, Lobectomy

INTRODUCTION

The lungs are a pair of essential organs of respiration located within the thoracic cavity, on either side of heart and other mediastinal contents. Each lung is half-conical in shape, divided into lobes by fissures. Anatomically, left lung is divided into upper and lower lobes by oblique fissure whereas right lung is divided into upper, middle, lower lobes by oblique and horizontal fissures. In each lung, the oblique fissure begins from mediastinal surface above and behind the hilum and cuts the posterior border of the lung about 2.5 cm lateral to the junction of the T3 & T4 spine. Then, it runs along the costal surface, cuts the inferior border of the lung and will reappear on the mediastinal surface and ends at the lower end of the hilum. The horizontal fissure begins at the oblique fissure, courses along the costal surface, cuts the anterior border and appears to end at the hilum [1].

Finding of an accessory fissure in lung specimens is not uncommon but appreciating them on radiographs and Computed Tomography (CT) scans is difficult and hence, they are not appreciated as distinct entities or are completely misinterpreted. They usually occur at the boundaries between bronchopulmonary segments [2]. The commonly found accessory fissures are superior accessory fissure, inferior accessory fissure and left minor accessory fissure. The superior accessory fissure separates superior segment from the rest of the segments of lower lobe of lung, the inferior accessory fissure separates small infracardiac lobe from other segments of lower lobe of lung on the diaphragmatic surface and the left minor fissure separates the lingula from the other segments of upper lobe of left lung [2].

The fissures may vary in the degree of completeness and tend to divide the lobe into smaller divisions. Complete fissures have continuity of lobes at their bottom. The adjacent lobes are connected by a small portion of pulmonary tissues because of clefts it fails to reach the hilum in the incomplete fissures. The fissure may be absent altogether. The fissures are important for uniform expansion of lobes. They allow movements of lobes in relation to each other. This is more involved in the lower lobes at the time of breathing [3].

The appearance of accessory lung fissure may be seen as in relation to its completeness or its depth and that varies with X–ray and CT scan [4].

Knowledge of classical accessory lobes and fissures is necessary for radiological interpretation. This gives proper guidance to Cardio thoracic surgeons in performing segmental lung resection and lobectomies to have an uncomplicated perioperative outcome.

To assess the patterns of lobes and fissures of lung and to find out any variations in the fissures and lobes and hilar structures of the lungs in human cadavers and to find their clinical significance and to compare with them with the previous studies.

MATERIALS AND METHODS

Forty pairs of lung specimens (32 lung specimens from male cadavers and 8 lung specimens from female cadavers) free from pathological lesions, removed at the time of teaching for first year of MBBS from the 10% formalin fixed human cadavers from the Department of Anatomy, PSG Institute of Medical Sciences and Research, Coimbatore were included in the study. The study was conducted in the month of November 2016 to April 2017 after Ethical clearance (Proposal Number.16/291). The lung specimens were observed and were photographed for:

1. The patterns of lobes and fissures;
2. Variations in fissures, complete or incomplete;
3. Accessory fissure if any;
4. Hilar structures and its variations.

The anatomical classification proposed by Walker WS et al., was followed to determine the presence of completeness of fissures [5].

Walker WS et al., proposed criteria for classification of fissures for describing operative techniques and also for comparing different surgical series [5]. The criteria used to classify the lung fissures were based on the degree of completeness of fissure and the location of pulmonary artery at the base of oblique fissure.

Four grades of fissures have been described.

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 the part of the fissure

Grade 4- Complete fusion of the lobes with no evident fissure line

RESULTS

According to Craig and Walker various grades of fissures were found [Table/Fig-1,2].

Side of the lung	Fissure	Grade 1	Grade 2	Grade 3	Grade 4
Right lung	Horizontal fissure	7	12	11	10
Right lung	Oblique fissure	17	7	9	7
Left lung	Oblique fissure	13	8	13	7

[Table/Fig-1]: Incidence of major and minor fissures of lungs according to Craig and Walker's Criteria.

Grades	Parameter	Fissure/Lung	Craig and Walker	Present study
Grade 1	Complete	Oblique fissure Right lung Left lung	 53.3% 13.3%	 42.5% 32.5%
		Horizontal fissure Right lung	 20%	 17.5%
Grade 2	Partial incomplete	Oblique fissure Right lung Left lung	 Nil	 7.5% 15%
		Horizontal fissure Right lung	 Nil	 30%
Grade 3	Incomplete	Oblique fissure Right lung Left lung	 36.6% 46.6%	 42.5% 32.5%
		Horizontal fissure Right lung	 63.3%	27.5%
Grade 4	Absent	Oblique fissure Right lung Left lung	 0% 0%	 17.5% 17.5%
		Horizontal fissure Right lung	 16%	 25%

[Table/Fig-2]: According to Craig and Walker.

Right lungs-Incomplete horizontal fissure [Table/Fig-3-5] was observed in 23 lungs. The horizontal fissure was absent in 10 lungs. The oblique fissure was absent in six lungs [Table/Fig-4]. Incomplete oblique fissure [Table/Fig-6] was seen in 13 lungs. Both fissures were absent in three lungs [Table/Fig-6]. The presence of accessory fissure was observed in five lungs [Table/Fig-7,8].

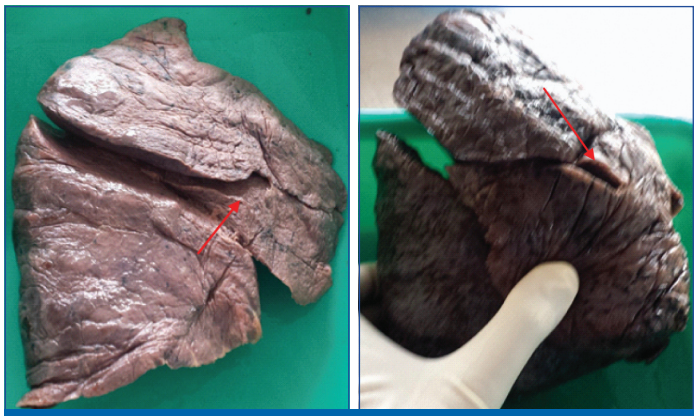
[Table/Fig-3]: Incomplete horizontal fissure- Right lung.

Side of the lung	Fissure	Complete	Incomplete	Absent
Right lung	Horizontal fissure	7	23	10
Right lung	Oblique fissure	21	13	6
Left lung	Oblique fissure	16	20	4

[Table/Fig-4]: Incidence of anatomical variations of fissures in the right and left lungs.

Serial number	Description	Number of specimens
1.	Complete oblique fissure with complete horizontal fissure	4
2.	Complete oblique fissure with incomplete horizontal fissure	20
3.	Incomplete oblique fissure with incomplete horizontal fissure	7
4.	Incomplete oblique fissure with absent horizontal fissure	6
5.	Absent oblique fissure and absent horizontal fissure	3

[Table/Fig-5]: Variant relationship between oblique and horizontal fissures of right lung.

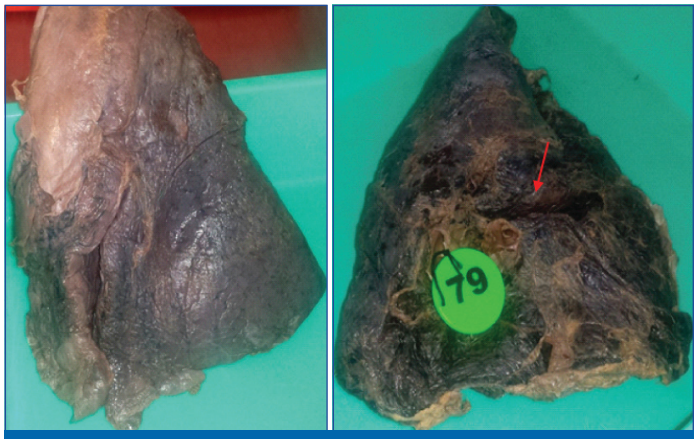


[Table/Fig-6]: Incomplete oblique fissure- Right lung. (left)
[Table/Fig-7]: Accessory fissure- Right lung. (right)

Side of the lung	Superior accessory fissure	Inferior accessory fissure	Left minor fissure
Right lung	3	2	-
Left lung	4	5	1

[Table/Fig-8]: Incidence of lung accessory fissures.

Left lungs- Incomplete oblique fissure [Table/Fig-4,9] was observed in 20 lungs. Oblique fissure was absent in four lungs [Table/Fig-4]. Ten lungs showed the presence of accessory fissure [Table/Fig-8,10].



[Table/Fig-9]: Incomplete oblique fissure- Left lung. (left)
[Table/Fig-10]: Accessory minor fissure- Left lung. (right)

In the present study, morphological variations involving the horizontal fissure of right lungs were observed according to Walker WS et al., as Grade 3 was about 11 (32.5%) specimens which were found to have more common [5]. The variations involving the oblique fissure of right lung was found as Grade 1 was about 17 (42.5%)

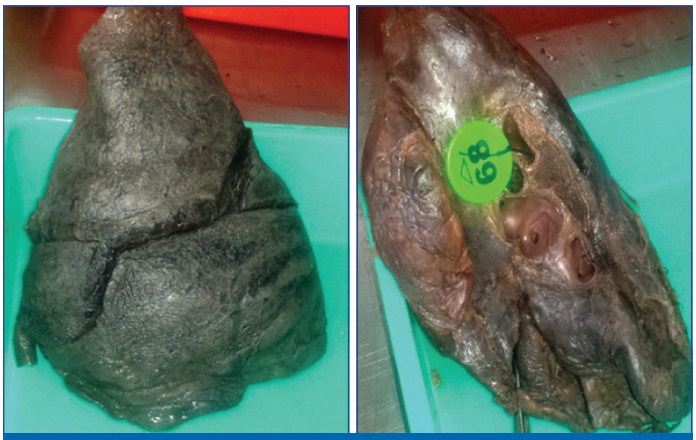
specimens which were found to have more common. The variations involving oblique fissure of left lung was observed as Grade 1 was about 13 (32.5%) specimens and Grade 3 was about 13 (32.5%) specimens were found to be common.

Presence of number of lobes has variations in both the lungs in the present study. Single lobe was found in three right lungs and two left lungs [Table/Fig-11-13]. Four lobes were observed in one specimen of both right and left lung [Table/Fig-9,14,15].

Number of lobes	Right lung	Left lung
Single lobe	3	2
Two lobes	1	35
Three lobes	35	2
Four lobes	1	1

[Table/Fig-11]: Number of lobes in both the lungs.

[Table/Fig-12]: Single lobe-Right lung. (left)
[Table/Fig-13]: Single lobe-Left lung. (right)



[Table/Fig-14]: Four lobes-Right lung. (left)
[Table/Fig-15]: Four lobes-Left lung. (right)

Two bronchi were found in eight specimens of Left lung [Table/Fig-16,17] and Single bronchus with more than three veins was found in three specimens of right lung [Table/Fig-16,18]. Single bronchus with more than three veins were observed in 11 specimens of left lung [Table/Fig-16,19].

Serial number	Parameters	Right lung	Left lung
1.	No arteries	-	1
2.	One artery below the bronchus	-	3
3.	Two arteries in the hilum	4	2
4.	Three arteries in the hilum	2	0
5.	One vein in the hilum	1	-
6.	Two veins in the hilum	12	23
7.	Three veins in the hilum	18	11
8.	More than three veins in the hilum	9	3
9.	One bronchi	3	32
10.	Two bronchi	28	8
11.	Three bronchi	4	Nil
12.	Artery in the oblique fissure	Nil	Nil

[Table/Fig-16]: Other variations in the hilum noticed in both lungs.

[Table/Fig-17]: Two bronchi- Left lung. (left)
[Table/Fig-18]: Single bronchus with more than three veins- Right lung. (middle)
[Table/Fig-19]: More than three veins- Left lung. (right)

Comparison of fissures, accessory fissures of lung with previous authors was tabulated. Comparison of lung lobe variation and hilar structures were tabulated.

DISCUSSION

Ontogenetically the lung is a composite of endodermal and mesodermal tissues. The endoderm of lung bud gives rise to the mucosal lining of the bronchi and to the epithelial cells of the alveoli. The vasculature of the lung and the muscles and cartilages supporting the bronchi are derived from the foregut splanchnopleuric mesoderm, which covers the bronchi as they grow out from the mediastinum into pleural space [6]. When the embryo is approximately four weeks old, the respiratory diverticulum (Lung bud) appears as an outgrowth from the ventral wall of the foregut, on day 22. It bifurcates into two primary bronchial buds between day 26 and day 28 [7]. Early in the fifth week, the right bronchial bud branches into three secondary bronchial buds, while the left one branches into two. By the sixth week, secondary bronchial buds branch into tertiary bronchial buds–ten (on both sides) to form broncho pulmonary segments.

The line of division of principal bronchi makes the right lung into three lobes and left lung into two lobes. These fissures are oblique and horizontal in position in right lung whereas oblique in position in left lung. The reflected visceral pleura cover the individual lobes at the line of fissures. The abnormal branching of stem bronchi accounts for accessory bronchi and lobes in adult lung [7]. Any defect in the lung development may have variations in fissures and lobes of the lung [8].

Accessory fissure could be result of non-obliteration of spaces which normally are obliterated [9]. Any variation in the morphological pattern of the fissures indicates variations from the normal pattern of development of lung. Detection of any accessory fissure is indicative of persistence of prenatal fissure [10] [Table/Fig-20-23].

The identification of the completeness of the fissures is important prior to lobectomy because incomplete fissures in individuals are more prone to develop postoperative air leaks [23]. These patients may require further procedures such as stapling and pericardial sleeves. Incomplete fissure may give rise to atypical appearance of pleural effusion in X-ray and causes the odd appearance of fluid tracking within the fissure. An incomplete fissure may alter the spread of the disease within the lung. If there is an incomplete fissure, pneumonia and carcinoma of lung may spread through the incomplete fissures of the lung to other lobes [23].

Surgically the gradation of fissure is important. The surgeon approaches to ligate the vessels and bronchi through the depth of the fissure. Grade 1 oblique fissure facilitates the approach while doing lobectomy and Video-assisted thoracoscopic surgery [24]. But otherwise lung parenchyma has to be dissected to reach these structures leading to intraoperative haemorrhage and more post-operative complications [25].

Author name	Incomplete horizontal fissure-Right Lung (%)	Incomplete oblique fissure-Right Lung (%)	Incomplete oblique fissure-Left Lung (%)	Absence of horizontal fissure-Right Lung (%)
Radha K et al., study [11]	40	17	23	17
Quadros LS et al., study [12]	25	5.5	2.5	4
Nene AR et al., study [13]	8	6	12	14
Varalaxmi [14] et al., study	30	30	29.4	10
Magadum A et al., study [15]	52.5	-	42.5	12.5
Gebregziabher A et al., study [16]	-	-	35	17.3
Wahane A et al., study [17]	31	17.2	28.5	6.8
George BM et al., study[18]	35	-	15	3
Divya C et al., study [19]	50	10.7	14.8	21.04
Zareena SK [20] study	50	13.6	31.8	13.6
Ghosh E et al., study [21]	5	4	-	2.17
Devi NB et al., study [22]	18	9	36	9
Present study	57	32.5	50	25

[Table/Fig-20]: Comparison of fissures of lungs with previous authors [11-22].

Author name	Superior accessory fissure-Right lung	Inferior accessory fissure-Right lung	Superior accessory fissure-Left lung	Inferior accessory fissure-Left lung	Left minor fissure-Left lung
Quadros LS et al., [12]	8.3	5.5	5	-	17.5
Nene AR et al., [13]	4	14	12	24	26
Varalaxmi et al., [14]	20	-	14	-	-
Magadum A et al., [15]	2.5	5	7.5	-	-
Gebregziabher A et al., [16]	8.6	-	15	-	-
Wahane et al., [17]	19	-	-	-	-
Divya C et al., [19]	11	-	-	-	-
Zareena SK [20]	5	-	-	-	-
Devi NB et al., [22]	4.5	-	-	-	-
Present study	7.5	5	10	12.5	2.5

[Table/Fig-21]: Comparisons of accessory fissures of lungs with previous authors [12-17,19,20,22].

Author name	Four lobes in right lung	Four lobes in left lung	Single lobe in right lung	Single lobe in left lung
George BM et al., [18]	4.61	2.73	-	-
Devi NB et al., [22]	-	-	-	9
Present study	2.5	2.5	7.5	5

[Table/Fig-22]: Comparisons of lobe variation of lungs with previous authors [18,22].

On the other hand, while performing right upper lobectomy, middle lobe has the chance of undergoing torsion if the oblique fissure is of Grade 1 variety. So, preventive fixation of middle lobe is essential to avoid this complication [26].

Accessory fissure may be misinterpreted as linear atelectasis, pleural scars or walls of bullae and hence identification of the accessory fissures is important.

Author name	Arteries	Veins	Bronchus
George BM et al., [18]	Right lung: 3 arteries-3%, Left lung: one artery below bronchus-29% and 2 arteries-5.4%	Right lung:3 veins-32%, >3 veins-4.6% Left lung: 3 veins-19%	Right lung: 3 bronchus-1.5% Left lung: 2 bronchus-21%, 4 bronchus-1.4%
Present study	Right lung:2 arteries-10%,3 arteries-5% Left lung: 2 arteries-5%, one artery below bronchus-7.5%%	Right lung:1 vein-2.5%, 3 veins-45%, >3 veins-4.6% Left lung: %, 3 veins-27.5%,>3 veins-7.5%	Right lung: 3 bronchus-10% Left lung: 2 bronchus-20%

[Table/Fig-23]: Comparison of hilar structures of lungs with previous authors [18].

Knowledge of the arteries and veins might be useful for surgeons to avoid excessive bleeding during pulmonary lobectomy.

Comparison of anatomical variations of lung fissures were observed with previous Author's studies both in Cadaver and High resolution Computed tomographic studies [Table/Fig-20].

A comparison work done by previous authors regarding the prevalence of pulmonary fissures is made with the present study was shown in [Table/Fig-24]. Analysis and comparative Cadaveric data revealed that in the CT scan and radiological studies, there were more prevalence of variations in the fissures of lungs than the whole cadaver and isolated lung studies.

Author	Method of study	Prevalence of incomplete or absent horizontal fissure of right lung (%)	Prevalence of incomplete or absent oblique fissure of right lung (%)	Prevalence of incomplete or absent oblique fissure of left lung (%)	Prevalence of accessory fissures of right and left lung (%)
Medlar EM et al., [27]	Cadaver and Specimen	62.3	25.6-30	10.6-18	-
Lukose R et al., [28]	Cadaver and Specimen	31.5	-	21	-
Bergman RA et al., [8]	Cadaver and Specimen	67	30	30	-
Prakash et al., [29]	Cadaver and Specimen	57.1	39.3	35.7	-
Bhimai devi et al., [22]	Cadaver and Specimen	18	9	6	-
Varalaxmi et al., [14]	Cadaver and Specimen	30/10	16.7/-	29.4/3	14.7/20
Wahane A et al., [17]	Cadaver and Specimen	31.03/6.8	17.2/-	28.5/4.7	24.1/19.04
Present study	Cadaver and Specimen	75	82.5	82.5	12.5/25

[Table/Fig-24]: Comparative prevalence of anatomical variations of lung fissures [8,14,17,22,28,29].

LIMITATION

Limitation of the study was small sample size with a limited period.

CONCLUSION

It was observed that there are many variations in the lung-incomplete, absent fissures, lobar variation-single lobe and four lobes and hilar structures variations which may be useful for the Physicians and Cardiothoracic surgeons while interpreting the radiological images and performing the surgical procedures to avoid post-operative complications like air leakage.

Prior anatomical knowledge and high index of suspicion for probable variations may be crucial for the clinicians, surgeons and radiologists. They have to keep the variations in mind, before planning for a surgical procedure. This may reduce the morbidity and mortality in lung surgeries.

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