Original Article

Pulmonary Fissures Including Accessory and Azygos Fissures and their Clinical Significance

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Abstract

Introduction: The lungs are divided into lobes by oblique and horizontal fissures. Knowledge of extent of completeness of fissures is important for surgical planning. This study highlights the variation in Pulmonary fissures including accessory and azygos fissure and their clinical relevance. **Materials and Methods:** The sample consists of fifty (50) lung specimens (25 right and 25 left), collected from formalin fixed cadavers, which were dissected during undergraduate teaching. The lungs were observed for complete, incomplete, and absent fissures. Additional fissures including accessory and azygos fissures were also observed and findings compared with previous studies. **Results:** Accessory fissure was found in 35% right and 40% left lungs. Horizontal fissure was found to be absent in 30% right lungs. Oblique fissure was found absent in 5% right and left lungs. Four right lungs had azygous fissure. Inferior accessory fissures were found in 15% right lungs. 20% left lungs had both inferior accessory and left minor fissures. **Conclusion:** It is important to assess the incompleteness or absence of fissures, when planning any surgical procedure. Lung fissure variations are frequently encountered during surgical procedures and knowledge of pattern of these fissures is important to avoid and reduce associated mortality and morbidity.

Keywords: Horizontal lung fissure, left minor fissure, lung, oblique lung fissure

Introduction

The lungs are vital organs of respiration. Each lung is divided by fissures into lobes. The right lung has one oblique and one horizontal fissure, dividing the right lung into three lobes. On the other hand, the left lung has only one oblique fissure, dividing it into two lobes.[1] Fissures form due to the invagination of visceral pleura. They may be found obliterated to some extent or completely in cases of incomplete or absent fissures. The fissures may be complete, incomplete, cleft like, or absent altogether. Complete fissures reach up to the hilum, while incomplete fissures and cleft fail to reach the hilum because of parenchymal fusion.[2]

An accessory fissure is lined by visceral pleura and commonly found at the margins of the bronchopulmonary segments. The accessory fissures have been described in the literature as left minor fissure (LMF), superior accessory fissure (SAF), and inferior accessory fissure (IAF). The SAF separates the superior segment, while IAF separates the medial basal segment of the lower lobe from the remaining segments. The LMF separates the lingula from the rest of the left upper lobe.[3] In addition to the accessory fissures, azygos fissures are also found, which separates the apical-medial part from the rest of the right upper lobe. Azygos fissure is formed when the right posterior cardinal vein, one of the precursors of the azygos vein, fails to migrate over the apex of the lung and penetrates it instead, carrying along two pleural layers as the azygos fissure, that invaginates into the upper portion of the right upper lobe. Knowledge of the accessory fissures is anatomically and clinically necessary to locate the bronchopulmonary segments.[4] Accessory fissures occur due to the variant anatomy and can mimic lesions. These

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fissures might alter the diagnosis and may affect surgical planning of pulmonary lobectomy and segmentectomy.[5]

Identification of completeness of the fissures is important before lobectomy because individuals with incomplete fissures are more prone to develop postoperative air leaks. Incomplete fissures may spread diseases to adjacent lobes through parenchymal continuation.[6] These anatomical variations are important for radiologists to be able to correctly interpret radiological images and also for clinicians in planning segmental resection or pulmonary lobectomy. The present study was designed with the aim of finding the incidence of variation in fissures, in cadaveric lungs and their implications in clinical practice.

Materials and Methods

Study design

The present study was a descriptive observational type, conducted in the department of anatomy, from March 2022 to June 2023. Ethical clearance was not required as the sample consists of specimens, collected from cadavers of voluntary body donors, donated for teaching and research purposes under the Anatomy Act.

Study settings

The study was conducted in the department of anatomy of a North Indian medical college. Sample was collected from formalin-fixed cadavers, which were previously dissected by medical students in the dissection hall, as part of their undergraduate teaching.

Sample size

Fifty lung specimens (25 right and 25 left) were collected from formalin-fixed cadavers. Inclusion criteria: Lungs with intact visceral pleura were included in the study. Exclusion criteria: All the lungs, which were damaged when removing from cadavers or during preservation and with pathological lesions such as trauma, necrosis, and adhesions, were excluded from the study.

The lungs were observed and photographed for the presence or absence of fissures, variation in fissures, complete or incomplete fissures, and accessory or azygos fissures. The anatomical classification proposed by Craig and Walker[7] was followed to determine the presence of completeness of fissures. As per this classification, complete fissure with entirely separated lobes is categorized under Grade I. Complete visceral cleft but fusion at the base of fissure is Grade II. Visceral cleft evident for a part of fissure Grade III and complete fusion of lobes with no evident fissure line is Grade IV. The data were collected, tabulated, and percentage calculated by using Microsoft excel.

Results

Out of 50 lungs, 20 (80%) right and left lungs had complete oblique fissure. In 25 right lungs, eight (32%) had complete oblique and horizontal fissure [Figure 1]. The observations regarding variations in oblique and horizontal fissures were observed and tabulated [Table 1].

Figure 1: Costal surface of right lung showing complete oblique (marked with red arrow) and complete horizontal fissure (marked with yellow arrow)

Table 1: Incidence of variation in oblique, horizontal, and accessory fissures in the right and left lungs

Lung	Fissures	Number of lungs (%)		
		Complete	Incomplete	Absent
Right (*n*=25)	Oblique	20 (80)	4 (16)	1 (4)
	Horizontal	8 (32)	11 (44)	6 (24)
Left (*n*=25)	Oblique	20 (80)	4 (16)	1 (4)

Incomplete oblique fissure was found in four right and four left lungs (16%) in the present study. Oblique fissure was found to be absent in one each right and left lungs (4%). Furthermore, we found an incomplete horizontal fissure in 11 right lung samples (44%) [Figure 2]. The horizontal fissure was absent in 6 (24%) right lung samples [Figure 3]. The variations in accessory and azygos fissures were observed and tabulated [Table 2].

IAF was found in 4 (16%) left and 5 (20%) right lungs [Figure 4]. SAF was not observed in any of the lungs. LMF was found in 6 (24%) left lungs. Azygos fissure was observed in 5 (20%) right lungs [Figure 5].

Discussion

The respiratory diverticulum (lung bud) develops as an outgrowth from the ventral wall of foregut at 4 weeks. This bud expands into the mesenchyme and bifurcates to form bronchial buds. At the 5th week, the right and left bronchial buds divide into three and two secondary bronchi, respectively. Secondary bronchial buds branch and form tertiary bronchial buds. After several generations of branching, bronchopulmonary segments are formed (10 on both sides).[8] Spaces between the bronchopulmonary segments get obliterated except along the line of division of principal bronchi to form fissures. Along

Figure 2: Right lung showing incomplete horizontal fissure (marked with red arrow)

Figure 3: Costal surface of right lung showing complete oblique and absent horizontal fissure

Figure 4: Left lung showing inferior accessory fissure (marked with red arrow)

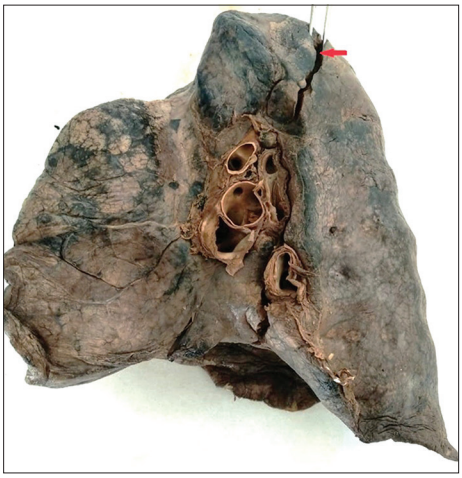

Figure 5: Mediastinal surface of right lung showing azygos fissure (marked with red arrow)

Table 2: Incidence of variations in accessory fissures in the right and left lungs

Accessory fissures	Right lung (%)	Left lung (%)
Superior accessory fissure	0	0
Inferior accessory fissure	5 (20)	4 (16)
Left minor fissure	0	6 (24)
Azygos fissure	5 (20)	0

these fissures, the visceral pleura invaginates and gets reflected to cover each lobe on all sides. Lack of obliteration of these spaces may result in the formation of accessory fissures in the lungs.[9]

The fissures may be complete, incomplete, cleft like, or absent altogether. Complete fissures reach up to the hilum, while incomplete fissures and cleft fail to reach the hilum because of parenchymal fusion. The variations in pulmonary fissures have been reported in various cadaveric studies conducted in the past. Several radiological studies also recognized the extent of fissure completeness. The incidence of incomplete oblique fissure is equally prevalent in both lungs in our study. In previous studies, the incidence of incomplete oblique fissures was considerably varied between the right and left lungs (5.55%–61.54% and 8%–51.85%, respectively) [Table 3].

Oblique fissure was found to be absent in 4% in both right and left lungs in the present study. Absent oblique fissure was also reported in the data of other studies.[10,11] In previous studies, the incidence of incomplete horizontal fissure was widely varied, ranging from 17.0% to 83.4%[4,10-22] as compared to 44% in the present study. The horizontal fissure was absent in 24% of all right lungs in our study. However, its incidence was mostly between 6.6% and 45.2% in previous studies.[4,10-20,22] The highest incidence was reported by Medlar (45.2%),[11] while Mamatha *et al*. did not find horizontal fissure absence in any of the lungs.[21]

Defects in pulmonary development may result in accessory fissures.[9] The accessory fissures reported in the literature are SAF, IAF, and LMF. The SAF partially or completely

Table 3: Comparison of different studies indicating the variations of major and minor fissures

Study	Right lung (%)						Left lung (%)		
	Horizontal fissure			Oblique fissure			Oblique fissure		
	Complete	Incomplete	Absent	Complete	Incomplete	Absent	Complete	Incomplete	Absent
Meenakshi *et al*.[4]	20.1	63.3	16.6	63.4	36.6	0	53.4	46.6	0
Dutta *et al*.[10]	26.49	38.89	36.42	26.92	61.54	11.54	44	48	8
Medlar[11]	37.7	17.1	45.2	69.6	25.6	4.8	82.1	10.6	7.3
Bergman *et al*.[12]	12	67	21	70	30	0	70	30	0
Dhanalakshmi *et al*.[13]	30	52	18	68	32	0	62	38	0
Kalai and Dhivya[14]	36	44	20	72	28	0	68	32	0
Jacob and Pillay[15]	10	83.4	6.6	46.6	50	3.4	61.1	38.9	0
Lattupalli[16]	82	8	10	90	10	0	90	8	2
Prakash *et al*.[17]	42.9	50	7.1	53.6	39.3	7.1	53.6	35.7	10.7
Nene *et al*.[18]	78	08	14	92	6	2	88	12	0
Magadum *et al*.[19]	35	52.5	12.5	30	60	10	50	42.5	7.5
Quadros *et al*.[20]	63.88	25	11.11	94.44	5.55	0	97.5	2.5	0
Mamatha *et al*.[21]	50	50	0	85	15	0	65	35	5
Kc *et al*.[22]	52.18	34.78	13.04	69.57	30.43	0	48.15	51.85	0
Halagatti *et al*.[23]	-	45.94	8.1	-	35	0	-	24.32	0
Mutua *et al*.[24]	47.37	42.11	10.53	63.16	36.84	0	55.26	34.38	0
Ranaweera *et al*.[25]	0	84.61	15.38	42.33	57.69	0	66.67	33.33	0
Present study	32	44	24	80	16	4	80	16	4

separates the superior segment of the lower lobe from the basal segments.[22] The IAF separates the medial basal segment from other segments of the lower lobe. Lingula is separated from the rest of the left upper lobe by LMF. The incidence of accessory fissures was compared with previous studies. IAF was found to be 16% in the left lung and 20% in the right lung, which is close to the findings of Kc *et al*.[22] We did not find SAF in any of the lungs. The incidence of LMF was 24% in our study. However, previous studies reported varied incidence of SAF and LMF [Table 4].[18-20,22]

Table 4: Comparison of different studies indicating the variations of accessory fissures

Study	Right lung (%)		Left lung (%)	
	SAF	IAF	LMF	IAF
Nene *et al*.[18]	4	14	26	24
Quadros *et al*.[20]	8.33	5.55	17.5	5
Magadum *et al*.[19]	2.5	5	7.5	8
Kc *et al*.[22]	4.34	21.73	29.62	3.70
Mutua *et al*.[24]	0	5.26	37.5	
Present study	0	20	24	16

SAF: Superior accessory fissure, IAF: Inferior accessory fissure, LMF: Left minor fissure

In addition to the accessory fissures, azygos fissures have also been reported in the literature. The right posterior cardinal vein (precursor of the azygos vein) penetrates the right lung apex, rather than migrating over it, resulting in the formation of azygos fissure. As a result, the apical-medial portion gets separated from the rest of the right upper lobe to form the azygos lobe. However, it is not a true accessory lobe as it does not have its own bronchus and does not correspond to a specific bronchopulmonary segment. Azygos lobe was first described by Heinrich Wrisberg in 1877. In previous studies, azygos lobe has been reported[25] and in 1% specimen during anatomical dissection.[26,27] Azygos fissures have been reported as an incidental finding in various radiological case reports.[28,29] Azygos fissure was observed in 20% of the right lungs as compared to 4.34% in the study conducted by Kc *et al*.[22]

During lung development, genetic and various environmental factors can cause wide range of variation in occurrence of fissures and can also be found in healthy individuals. The present study as well as the results of previous studies suggests the varied prevalence of fissure anatomy in different individuals. Common findings of the present study are incomplete horizontal fissure and absent horizontal fissure in the right lung. LMF in the left lung, azygos fissure in the right lung, and IAF in both lungs are found to be the most common fissures in our study. Accessory fissures may prevent the spread of diseases in the lung and can also mimic lesions. Most of the studies on variations of the fissures in the cadaveric lung have been done in South India. There is a paucity of similar studies from North India. Our study highlights accessory fissures and azygos fissures which are not reported in most cadaveric studies. Knowledge of accessory and incomplete pulmonary fissures could improve diagnostic accuracy and inform prognosis for pulmonologists and thoracic surgeons.

Conclusion

Lung fissure variations are frequently encountered during surgical procedures and knowledge of pattern of these fissures is important to avoid and reduce associated mortality and morbidity.

An incomplete fissure can also be a cause for postoperative air leakage and may affect the spread of disease within the lung. The knowledge of accessory fissures helps radiologists in correct diagnosis of clinical conditions. Accessory fissures on radiographs and computed tomography scans can mistakenly be interpreted as linear atelectasis, pleural scars, and can alter the diagnosis and hence line of treatment. The azygos fissure helps prevent spread of infection to the azygos lobe of the lung. However, a good knowledge of variation in lung fissures including accessory fissures of the lungs is important for diagnostic imaging techniques and thoracic surgery and for clinicians in general.

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Conflicts of interest

There are no conflicts of interest.

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