

# Morphological Study of Fissures, Lobes and Bronchial Pattern in the Lungs-A Cadaveric Study with Emphasis on Surgical and Radiological Implications

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## ABSTRACT

**Introduction:** Lungs are divided into lobes by the oblique and the transverse (horizontal) fissures. Knowledge about these fissures is necessary for the appreciation of lobar anatomy and for locating the bronchopulmonary segments which is significant both anatomically and clinically. In the past, 1-12% of patients who underwent bronchography or bronchoscopy demonstrated some form of congenital tracheobronchial variations.

**Aim:** To study the variations regarding the fissures, lobes of the lungs and segmental bronchi pattern in the lungs

**Materials and Methods:** In the present study 30 right and 30 left sided lung specimens were utilised. According to the presence of fissures they were grouped into four groups. The specimens were dissected to trace the segmental

bronchi and found out the variations.

**Results:** The upper and middle lobes of the right lung had the normal bronchial pattern and the most common pattern was B1, B2, B3. In the normal left lung the most common bronchial pattern was B1+3, B2, B4, B5. In the inferior lobe of the right lung the most common pattern was (B6c, B6a+b) B7, B8, B9+B10. In the Inferior lobe of left lungs B6a, B6b+c, B7+8, B9+10 is the most common. Accessory bronchus was 100% in the accessory lobes.

**Conclusion:** Segmental bronchial pattern variations in upper lobe of right lungs showed B1+2, B3 and B1, B2, B3, Bx patterns in 49% of specimens and 56.7% of left lung specimens inferior lobe showed B6, B7+8, B9+10 and irregular patterns. The presence of accessory bronchus was more common in the left sided lungs.

**Keywords:** Bronchopulmonary segments, Segmental bronchus, Tracheobronchial variations

## INTRODUCTION

The oblique and the transverse fissures divide the lungs into lobes. The oblique fissure at the level of 4<sup>th</sup> or 5<sup>th</sup> thoracic spine cuts the vertebral border and ends above the hilum of the lung [1]. Horizontal fissure is present only in the right lung and passes transversely across costal surface to anterior margin after starting from the oblique fissure and separate middle lobe from the upper lobe [2]. As the fissures form the boundaries for the lobes of the lungs, knowledge of their position is necessary for the appreciation of lobar anatomy and thus for locating the bronchopulmonary segments which is significant both anatomically and clinically. The fissures may be complete, when the lobes remain held together only at the hilum by the bronchi and pulmonary vessels, or they may be incomplete when there are areas of parenchymal fusion between the lobes, or, they may be absent altogether [3]. The knowledge of fissures is important for knowing the lobar

anatomy and bronchopulmonary segments position which were significant both anatomically and clinically. Knowledge of variation in patterns of bronchial tree is necessary for diagnosis and surgery of pulmonary diseases. The segmental bronchial pattern in the right lung, the right superior lobar bronchus arises from the right main bronchus [4].

The main bronchus of the right lung divides into superior lobar bronchus and intermediate bronchus. The superior lobar bronchus gives three branches namely apical (B1), posterior (B2) and anterior (B3) to the corresponding bronchopulmonary segments. The intermediate bronchus divides into the middle and lower lobar bronchus. The middle lobar bronchus divides into lateral (B4) and medial (B5) segmental bronchus to the bronchopulmonary segments. The right inferior lobar bronchus divides into superior (B6), medial basilar (B7), anterior basilar (B8), lateral basilar (B9) and posterior basilar (B10) segmental branches.

The main bronchus of the left lung divides into the upper and lower lobar bronchi. The upper lobar bronchus bifurcates into upper and lingular divisions. Upper division gives three segmental branches B1, B2 and B3 and the lower division is the lingular gives superior (B4) and inferior (B5) divisions and the left inferior lobar bronchus bifurcates into B6, B7, B8, B9 and B10 segmental branches [5-8].

Tracheobronchial structures are developed from the median bulge on the ventral wall of the pharynx at the age of 24-26 days of embryonic period and this bulge will give rise to right and left lung buds at the age of 26-28 days. In the past, 1-12% of patients who underwent bronchography or bronchoscopy demonstrated some form of congenital tracheobronchial variations [9]. Nowadays, anomalies of the lobes and the bronchial tree are diagnosed with increasing frequency as a result of their most common variants and refinements in modern imaging. Hence, the awareness of their variations is essential in performing lobectomies and in segmental resection involving individual segments and also in interpreting radiological images. Thus, this study was done to study the variations regarding the fissures, lobes of the lung, segmental bronchial pattern in normal lungs and in lungs containing variations regarding the fissures and lobes.

## MATERIALS AND METHODS

This observational study was conducted in Shri Sathya Sai Medical College and Research Institute in 2015 for the duration of 1 year. Total 60 lungs were utilised, out of 60 lungs 30 lungs were of right side and the remaining 30 lungs were of left side and the specimens were collected from the cadavers during regular dissection for 1<sup>st</sup> year MBBS students were utilised for the study. Specimens of right and left lungs of male and female were used and lungs which appeared healthy with normal morphological features were included in the present study. Lungs which were diseased, adherent to the chest wall and lost their morphology during removal from the cadaver were excluded. Institutional Ethical Committee approval was taken before proceeding to the work.

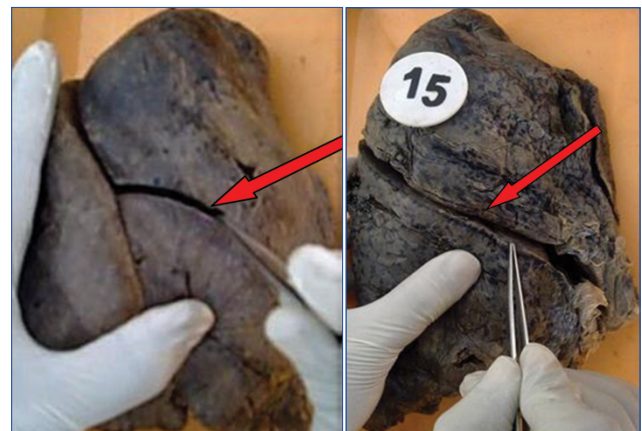
The 60 lung specimens collected from the cadavers were categorised into four groups. Group I includes lungs containing complete normal fissures, Group II includes lungs containing incomplete fissures, Group III includes lungs containing absence of fissures, and Group IV includes lungs containing accessory fissures. Segmental bronchi were traced by removing the lung parenchyma with careful dissection procedure. Segmental bronchial pattern of all the lung specimens were studied, the normal patterns were segregated from abnormal patterns. For the right lung B1, B2, B3 was from superior lobar bronchus, B4, B5 from middle lobar bronchus and B6, B7, B8, B9, B10 from inferior lobar bronchus. For the left lung the normal pattern was B1+2, B3 from superior lobar bronchus, B4, B5

from ligular division of superior lobar bronchus and B6, B7+8, B9, B10 from inferior lobar bronchus were taken as normal bronchial patterns.

## RESULTS

In the present study, 30 right lungs 16 lungs were normal regarding the fissures and lobes and the remaining 14 lungs showed variations in the fissures and lobes. Out of these 14 right lungs, nine lungs showed the presence of incomplete horizontal [Table/Fig-1], three lungs showed incomplete oblique fissure and the remaining two lungs showed the absence of horizontal fissure [Table/Fig-2]. Out of 30 left lungs nine showed variations in fissure and lobes. In these nine lungs, there was absence of oblique fissure in two specimens, in one lung incomplete oblique fissure [Table/Fig-3] and in the remaining six lungs accessory fissures and lobes were observed [Table/Fig-4].

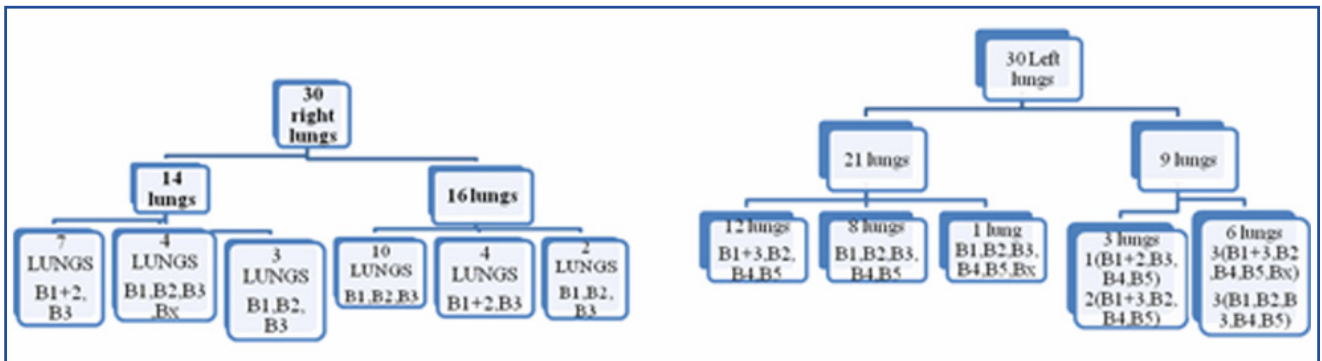
Dissection was done and the segmental bronchii of all the lungs were compared with normal bronchial pattern. In 16 right lungs normal B1, B2, B3 pattern was observed in 12 specimens and in four specimens (B1+2, B3) bronchial pattern was seen. The lungs which showed variations in the fissures were 14. Out of these 14 specimens B1+2, B3 segmental bronchial pattern



[Table/Fig-1]: Incomplete horizontal fissure in right lung. [Table/Fig-2]: Absence of horizontal fissure in right lung.



[Table/Fig-3]: Left lung with incomplete oblique fissure. [Table/Fig-4]: Left lung with accessory oblique fissure.



[Table/Fig-5]: Segmental bronchii patterns in the right and left lungs upper lobes.

was observed in 7 specimens, in 4 specimens B1, B2, B3, Bx (Bx-Accessory segmental bronchus) and in 3 specimens B1, B2, B3 segmental bronchial pattern was observed.

In 21 left lung specimens which didn't show any fissure variations the following segmental bronchial patterns were observed. In 12 lungs B1+3, B2, B4, B5 pattern, in 8 lungs B1, B2, B3, B4, B5 pattern and in 1 specimen accessory bronchus was observed (B1+2, B3 , B4 , B5 , Bx). In the remaining 9 left lungs the bronchopulmonary segments had the following pattern. In 3 lungs which had incomplete oblique fissure showed B1+3, B2, B4, B5. In the remaining 6 lungs which showed accessory fissure the segmental bronchial pattern was B1+2, B3, B4, B5 and in 3 lung specimens accessory bronchus was observed [Table/Fig-5].

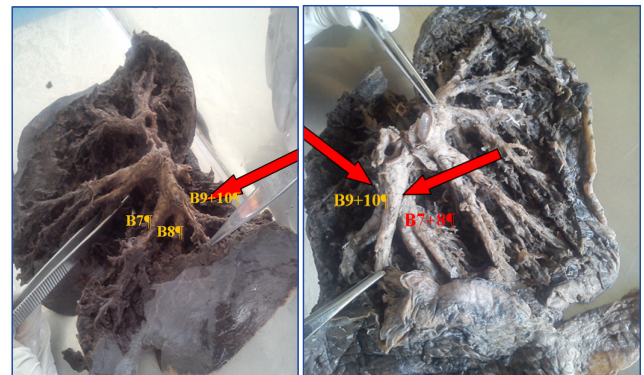
Trifurcate pattern of the segmental bronchi was observed in middle lobe of the right lung, similar pattern of segmental bronchi was observed in the lingular region of the left lung [Table/Fig-6, 7],

In the inferior lobe of right and left lungs, different patterns of segmental bronchi were observed and the findings were tabulated [Table/Fig-8]. In the inferior lobe of the right lungs the most common pattern was B6, B7, B8, B9+B10 [Table/Fig-9] and the second most common pattern was B6, B7, B8, B9, B10). In the Inferior lobe of left lungs B6, B7+8, B9+10 [Table/Fig-10] is the most common pattern and B6, B7, B8, B9+10 is second most common. The left lungs which were containing accessory lobes, the most common segmental

pattern was B7+8, B9+10, Bx and the second most common pattern was B7+8, B9, B10, Bx [Table/Fig-11]. Accessory bronchus was present in all the left lung specimens which had accessory fissures with accessory lobes [Table/Fig-12].

Fissures	Right Lung		Left Lung	
	Incomplete	Absent	Incomplete	Absent
Horizontal fissure	2	9	-	-
Oblique fissure	-	3	1	2
Accessory fissures	1		6	

[Table/Fig-8]: Right and left lungs fissures details.



[Table/Fig-9]: B7, B8, B9+10 pattern in the right lung inferior lobe.

[Table/Fig-10]: B(7+8), B(9+10) bronchial pattern in inferior lobe of left lung.



[Table/Fig-6]: Accessory segmental bronchus in the middle lobe of right lung. [Table/Fig-7]: Trifurcate bronchial pattern in lingular region of the left lung.

	Right Lung		Left Lung
B6, B7, B8, B9+10	53%	B6, B7+8, B9+10	50%
B6, B7, B8, B9, B10	40%	B6, B7, B8, B9+10	40%
B6, B7+8, B9+10	3.5%	B6, B7, B8, B9, B10	3.3%
B6, B7, B8+9+10	3.5%	Irregular	6.7%
		Left lung (with accessory lobe)	
		B7+8, B9+10, Bx	67%
		B7+8, B9, B10, Bx	33%

[Table/Fig-11]: Segmental bronchial pattern of inferior lobes of the right and left lungs.





**[Table/Fig-12]:** Accessory segmental bronchus (Bx) for the accessory lobe in left lung inferior lobe.

## DISCUSSION

As the lung buds elongate, the trachea is separated from the oesophagus by lateral in growth of the mesoderm, forming the tracheo-esophageal septum. At 28-30 days, the lung buds elongate into primary bronchi; at 30-32 days, the five lobar bronchi appear as a monopodial outgrowth of the primary bronchi. The lobar bronchi elongate at 32-34 days and then rapidly branch to form all the segmental bronchi by 36 days. The variations in the fissures and lobes of the lungs were due to the defective pulmonary development [10].

Medlar EM, observed 1200 pairs of lungs and reported, the horizontal fissure was absent in 45.2% and incomplete in 17.1% of the right lungs [11]. Lukose R et al., observed incomplete and absence of horizontal fissure was 21% and 10.5% respectively [12]. Bergman RA et al., reported incomplete and absence of horizontal fissure as 67% and 21% respectively in right lungs [13]. Meenakshi S et al., reported that the horizontal fissure was absent in 16.6% and was incomplete in 63.3% of right lungs [3]. According to Prakash et al., the horizontal fissure was absent in 7.1% and incomplete in 50% of the right lung specimens and supernumerary fissures was most common in right lower lobes and it was detected in 35% [4]. In the present study it was absent in 6.6% and

incomplete in 30% of the specimens and the supernumerary fissure was observed only in one specimen.

Medlar EM [11], Lukose R et al., [12] and Bergman RA et al., [13] reported 10.6%, 21% and 30% of left lungs had incomplete oblique fissures and in the present study it was observed in 3.3% of the cases. Non obliteration of spaces which are normally obliterated could result in accessory fissures [14]. The bronchopulmonary segments having accessory fissure in varying depth and in CT-scan the superior fissure which demarcates the superior segment and the inferior accessory fissure which demarcates the medial basal segment are the most common accessory fissures observed [15]. In the present study, presence of accessory fissures were observed in six left lung specimens (20%) which demarcated the medial basal segment. Ariyurek OM et al., observed that in X-ray the incomplete fissure always give an atypical appearance of pleural effusion and the accessory fissure fail to be detected on CT scans because of their incompleteness, thick sections and orientation in relation to a particular plane [16].

Segmental bronchial pattern of upper lobes of right and left lungs were compared with the previous studies [Table/Fig-13].

Shields TV, suggested that the most common variation in left upper lobe is the presence of three bronchi in the lingular division [17]. In the present study 13.3% of cases showed the presence of three bronchii in the lingula. Trifurcate pattern of the bronchus in middle lobe of the right lung was observed by Boyden EA et al., [18] and Gonlugur U et al., [19]. In the present study also the same was observed in 16.6%. Beder S et al., observed in his findings the common variations regarding the upper lobes of the lungs, being left upper lobe with three segments and the right upper lobe with two segments [20]. In the present study also in 27.7% cases left upper lobe showed three segmental bronchii and in 36.6% cases right lungs upper lobe showed two segmental bronchii. Variations in the ramification of superior segmental bronchii were compared with the previous studies [Table/Fig-13] Variations in the ramifications of right basal stem and left basal stem were compared with the previous studies [Table/Fig-14],

Previous Studies	Right Lung				Left lung		
	B1, B2, B3	B1, B2, B3, Bx	B1+2, B3	Middle lobe	B1, B2, B3	B1+2, B3	B4, B5, Bx
Gonlugur U et al., [19]		5%					
Kilic C et al., [20]	86.6%	13.3%			40%	60%	
Ghaye B et al., [21]	30%				83%	17%	
Koshino T et al., [22]	45%	2.6%					
Boyden EA et al., [23]	46%	14%					
Present study	50.1%	13.3%	36.6%	16.6%	27.7%	60%	13.3%

**[Table/Fig-13]:** Comparison of the upper lobe segmental bronchial patterns of both lungs with the previous authors.

Previous Studies	Segmental Bronchial Pattern			
	B6, B7, B8, B9, B10	B6, B7+8, B9+10	B6, B7, B8, B9+10	B6, B7, B8+9+10
Naidich DP et al., [7]	15%	-	60%	
Ghaye B et al., [21]	6%	3%	68%	10%
Kilic C et al., [24]	20%	6.66%	53.33%	6.66%
Present Study	40%	3.5%	53%	3.5%

**[Table/Fig-14]:** Comparison in the ramifications of right basal stem of the inferior lobe with the previous authors.

Previous Studies	Segmental Bronchial Pattern			
	B6, B7, B8, B9+10	B6, B7+8, B9+10	B6, B7+8, B9, B10.	Irregular
Naidich DP et al., [7]	-	45%	15%	
Bergman R et al., [13]	8%	67%	13%	9%
Ghaye B et al., [21]	14%	76%	10%	
Kilic C Et Al., [24]	13.33%	53.33%	26.66%	6.66%
Pitel M et al., [25]	42%	32%	2%	6%
Present Study	40%	50%	-	67%

**[Table/Fig-15]:** Comparison in the ramifications of Left basal stem inferior lobe with previous studies.

15]. According to Ghaye B et al., [21], Naidich DP et al., [7] and Kilic C et al., [24] the most common pattern in the inferior lobe of the right lung was 6a+b, c, 7, 8, 9+10. In the present study also we observed the same. Various studies reported the most common pattern in the inferior lobe of the left lungs was 6a, b+c, 7+8, 9+10 pattern [7,13,21,24,25,23] [Table/Fig-15]. In the present study also we observed the same. Beder S et al., suggested that the tracheo-bronchial variations increase linearly with the number of lobes [20], in the present study out of 6 lungs 5 lungs (83%) had accessory bronchus to the accessory lobes.

## LIMITATION

Sample size is low and the study was done only in 60 lung specimens. We did not observe the radiological appearance of accessory lobe and accessory bronchus to compare with the normal gross anatomy.

## RECOMMENDATIONS

Comparing the gross anatomical appearance of the accessory lobes and segmental bronchus with radiological images.

## CONCLUSION

In the present study the presence of incomplete horizontal fissure in right lungs and accessory fissures in the left lungs were the most common variations. Segmental bronchial pattern variations were more common in upper lobe of right sided lungs, and inferior lobes of the left sided lungs. The presence of accessory bronchus was more common in the left sided lungs when compared with the right lungs which had the normal lobular pattern.

The lungs which had the accessory lobes almost all of them (83%) had accessory bronchus to the accessory lobes. The awareness of the variations regarding fissures, lobes and segmental bronchi are essential in performing lobectomies and in segmental resection. Bronchial pattern variations are asymptomatic and are more prone for infections. Precise knowledge of bronchial anatomy and its variations is needed to distinguish the pathological findings and is important for the radiologist in reporting CT findings.

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