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Anatomical Variations in Lung Fissures and Lobes: A Study of Indigenous Cadaveric Findings

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ABSTRACT

Background: The consistent enlargement of lungs is caused by pulmonary fissures. Lobar variance can be caused by complete, partial, or missing fissures. It takes a thorough understanding of the differences between classical and accessory fissures to properly interpret pulmonary radiographs.

Objective: To study the Indigenous Cadaveric Variations in Lung Fissures and Lobes.

Methodology: A cross-sectional observational study, including 100 cadaveric lung specimens from Department of Anatomy, Multan Medical and Dental College, Multan, was carried out. The study duration was six months from June 2020 to January 2021. The study samples were preserved according to standard procedure and lung lobes and fissures were examined. Data were compiled and categorized according to international grading classification system. All data entered into SPSS V 20 for analysis and level of $p < 0.05$ was considered statistical significance.

Results: 73% of the right lung and 75% of the left lung were normal out of 100. When compared to oblique fissure, horizontal fissure had demonstrated greater variability among the variants. Horizontal cracks were found to be partial in 20% of the specimens from the right side and completely missing in 5% of the specimens. Incomplete oblique fissures were present in 16% of the specimens on the left side and just 3% of the specimens on the right. In comparison to specimens on the right side, accessory fissures were more prevalent in specimens on the left side.

Conclusion: When conducting radiological or surgical procedures, it's crucial to recognize that anatomical variations in lung fissures and lobes are common. Awareness of these morphological differences can enhance diagnostic accuracy, refine surgical planning, and improve patient outcomes. By considering possible deviations from typical anatomy, clinicians can ensure safer, more precise, and effective care.

Keywords: Indigenous; Cadaveric Variations; Lung Fissures; Lobes

Introduction

The human respiratory system is a complex and vital structure, essential for the exchange of gases and sustaining life. Among its components, the lungs are particularly critical, consisting of distinct lobes separated by fissures. Anatomically, the right lung is typically divided into three lobes, upper, middle, and lower, separated by the oblique and horizontal fissures. The left lung, owing to the space occupied by the heart, has two lobes, the upper and lower, separated by an oblique fissure. However, variations in the anatomy of lung fissures and lobes are not uncommon and have significant clinical implications. Pulmonary fissures are thin, folded layers of visceral pleura that divide the lungs into many lobes. Major Fissure (MF) or lobar fissure and Accessory Fissure (AF) are the two types of fissures.[1] The oblique and horizontal fissures are part of the MF. The superior and inferior lobes of the left lung are separated by the oblique fissure. This fissure extends below and above the hilum from the costal to the lung's mediastinal surface. This fissure appears to start in the postero-superior region of the hilum and climb obliquely backward before crossing the posterior boundary. It continues to fall forward over the costal surface, almost reaching the anterior end of the lower border.

Ten percent of individuals have the normal version of the left horizontal fissure.[2] The right lung is divided into the superior, middle, and inferior lobes by the oblique and horizontal fissure.[3] The inferior lobe is divided from the middle and upper lobes by the oblique fissure, which is closely related to the left oblique fissure. The superior and middle lobes are separated by a brief horizontal fissure. The structure runs laterally from the oblique fissure, located at the midaxillary line, to the front border of the lung at the level of the sternal end of the fourth costal cartilage. It then moves in the opposite direction towards the mediastinal surface, where it locates the hilum. The oblique fissure is often seen on a lateral radiograph and a high-resolution CT scans as a curved line extending from the side to the hilum. In contrast, the horizontal fissure is often observed on a frontal chest radiography. Anatomical variance is the term used to describe any discovery that deviates from this.[4] Prenatal persistence fissures manifested as pulmonary accessory fissures. In lobectomies and bronchopulmonary resections, postoperative air leaking may be caused by an incomplete fissure. A thorough understanding of morphological variances is essential to prevent postoperative problems. There are several lobes depending on whether the fissure is entire, partial, or even auxiliary.[5] Only at the hilum do the bronchi and pulmonary arteries hold the lobes together in a full fissure. A fissure is considered partial and occasionally the whole fissure may be gone when parenchymal fusion takes place between the lobes.

Understanding the anatomical variations in lung fissures and lobes is crucial for several medical disciplines, including radiology, thoracic surgery, and pulmonology.[6] Accurate knowledge of these variations aids in the interpretation of imaging studies, surgical planning, and the diagnosis of various pulmonary diseases. For instance, variations in fissures can lead to misinterpretation of radiological images, potentially resulting in diagnostic errors. Moreover, surgeons rely on precise anatomical knowledge to perform lobectomies or segmentectomies, making the understanding of such variations essential for safe and effective surgical interventions.

The development of lung fissures and lobes begins in the embryonic stage, where the lungs form from the endodermal layer of the foregut.[7] During development, the lungs undergo a process of branching morphogenesis, leading to the formation of lobes and fissures. Incomplete or atypical development of these fissures results in anatomical variations, which may include incomplete fissures, accessory fissures, or additional lobes. These variations are of interest not only for their clinical relevance but also for their embryological implications, providing insights into the developmental biology of the respiratory system.

Studies on cadaveric findings have revealed a considerable prevalence of anatomical variations in lung fissures and lobes across different populations.[8] These variations may present as incomplete or absent fissures, which can have clinical consequences. For example, incomplete fissures may lead to difficulties in accurately staging lung diseases or in achieving complete resection during surgery. Additionally, variations in lobar anatomy can affect the spread of infections, tumors, and other pathological processes within the lungs.

Focusing on indigenous cadaveric findings provides a unique opportunity to explore population-specific anatomical variations, which may differ from those reported in global studies. Such research is particularly valuable in regions where genetic, environmental, and lifestyle factors contribute to distinct anatomical characteristics. Understanding these variations is essential for tailoring medical education, improving diagnostic accuracy, and optimizing surgical outcomes in local healthcare settings.

Anatomical variations in lung fissures and lobes can significantly impact clinical practice, particularly in diagnosing and managing pulmonary diseases.[9] These variations, such as incomplete or accessory fissures, may lead to misinterpretation in radiological imaging and pose challenges during surgeries like lobectomies.

Most studies focus on non-indigenous populations, but genetic and environmental factors may result in distinct anatomical patterns in indigenous groups. Documenting these variations is crucial for improving diagnostic accuracy, surgical outcomes, and medical education tailored to local populations. Additionally, understanding these variations provides insights into lung development and enhances the overall knowledge of respiratory

Table 1. Morphological fissure variations among study samples

Side	Fissure	Type	Present Study
Right Lungs Total: 5	Oblique	Complete	36
		Incomplete	01
		Absent	02
	Horizontal	Complete	24
		Incomplete	15
		Absent	03
	Accessory Fissure	Present	02
Left Lung Total: 35 Oblique	Oblique	Complete	24
		Incomplete	07
		Absent	04
	Accessory Fissure	Present	03

anatomy. This study aims to address these gaps by analyzing indigenous cadaveric findings, contributing valuable data to clinical practice and education.

Objective

To study the Indigenous Cadaveric Variations in Lung Fissures and Lobes.

Methodology

Study Design and Duration

This study employed a cross-sectional observational design to assess anatomical variations in cadaveric lung specimens. The research was carried out over a period of six months, from June 2020 to January 2021, at the Department of Anatomy, Multan Medical and Dental College, Multan.

Sample Size Determination

The sample size was determined using the OpenEpi program, with a 5% margin of error and a 95% confidence level. Based on an anticipated 16% variance in the right lung's oblique fissure, the calculated sample size was 160 specimens. This was the final number of cadaveric lungs selected for the study using a non-probability sampling technique.

Inclusion and Exclusion Criteria

Cadaveric lungs from individuals with intact pleura, irrespective of age or sex, were included in the study. Specimens were sourced from cadavers that had been dissected in the dissection hall or from those preserved and stored following dissection. Lungs from cadavers with prior thoracic injuries were excluded to avoid bias from anatomical alterations caused by such injuries.

Data Collection and Assessment

Each lung specimen was thoroughly examined to assess the normalcy and any variations in lung fissures and lobes. The study focused on identifying complete, incomplete, or absent fissures, as well as any accessory fissures or lobes. The findings were categorized according to the Craig and Walker classification system to ensure standardized data recording and analysis.

Results

The present cross-sectional study was conducted with the objective of anatomically study the Indigenous Cadaveric Variations in Lung Fissures and Lobes Out of 100 lungs studied, 65 were right lungs and 35 were left lungs (Figure 1).

After examination of the right lungs, it was observed that 36 lungs were having complete oblique fissures and 24

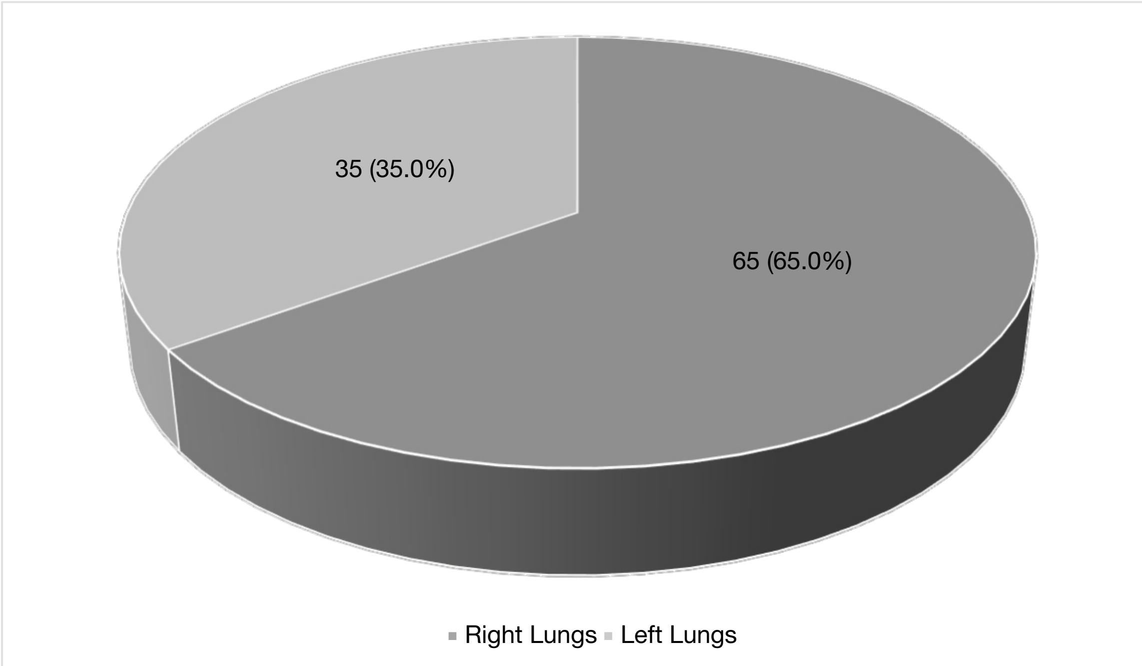

Figure 1. Lungs involved in study

were having complete horizontal fissures. Among lungs having complete horizontal fissures, 15 lungs were found to have incomplete horizontal fissures and in 3 lungs horizontal fissure were entirely absent. The detailed results were listed in Table 1.

The observations regarding variation in the oblique, horizontal, and accessory fissures in both the right and left lungs are summarized in Figure 2 & 3.

Table 2 compares the prevalence of incomplete and absent fissures in the right and left lungs across various studies from 1999 to 2021. For the right lung oblique fissure, the 2021 study reports 2.2% incomplete and 6.0% absent fissures, which is notably lower than studies like Meenakshi et al. (2004), who reported 36.6% incomplete fissures, and Prakash et al. (2010), with 39.3%. These variations may be due to differences in study populations, methodologies, or imaging techniques. Mote (2014) is an outlier, reporting 100% incomplete fissures, which is unusual compared to other studies. For the right lung horizontal fissure, the 2021 study found 20% incomplete fissures but no absent ones. This is lower than studies such as Meenakshi et al. (2004) and Bergman et al. (2010), who reported higher rates of incompleteness (63.3% and 67%, respectively). Nene et al. (2011) reported much lower rates, with only 8% incomplete fissures, suggesting regional or methodological differences.

Regarding the left lung oblique fissure, the 2021 study shows 2.2% incomplete and 7% absent fissures, which is lower than Meenakshi et al. (2004), who found 46.6% incomplete fissures, and Prakash et al. (2010), with 35.7%. Nene et al. (2011) reported lower rates (12%) of incomplete fissures, and Mote (2014) found no cases of incomplete or absent fissures.

Discussion

The study of cadavers remains one of the most effective and accurate methods for understanding the complex anatomy of human organs. This is especially true for the lung, which has a highly variable structure. Cadaveric studies allow researchers to observe first-hand the structural variations and potential anomalies that can occur. Numerous investigators have noted and meticulously documented these anatomical variations, including deformities and anomalies in lung structure, across different populations. This research builds on these foundational observations, focusing on the variations in lung fissures and lobes, which are crucial for understanding both typical and atypical lung anatomy.

The most effective way to learn about an organ's varied anatomy is through cadavers. Numerous investigators have seen and documented the deformity of the lung structure in human cadavers. Multiple bronchopulmonary buds form throughout the development of the lungs, and finally they completely merge together except in the areas where fissures appear. Lobes and fissures are formed as a consequence of this. The incomplete formation of fissures may be attributed to the partial disappearance of these fissures. Failure of the bronchopulmonary buds to fuse and subsequent destruction of the spaces between them might lead to the

Table 2. Comparative studies and their findings

Years	Authors	Right Lung – Oblique fissure		Right Lung – Horizontal fissure		Left Lung – Oblique fissure	
		Incomplete	Absent	Incomplete	Absent	Incomplete	Absent
1999	Lukose R et al[10]	-	-	21%	10.5%	21.0%	-
2004	Meenakshi S et al[11]	36.6%	-	63.3%	16.6%	46.6%	0.0%
2010	Bergman RA et al[12]	30.0%	-	67.0%	21.0%	30.5%	-
2010	Prakash et al[13]	39.3%	7.1%	50.0%	7.1%	35.7%	10.7%
2011	Nene AR et al[14]	6.0%	2.0%	8.0%	14.0%	12.0%	0.0%
2014	Mote D[15]	100%	0%	0%	0.0%	0.0%	13.0%
2021	Present Study	2.2%	6.0%	20.0%	-	2.2%	7.0%

formation of accessory fissures. If there is a factor that affects the fusion during the development stage, it will lead to variations in the formation of lung fissures and lobes.

During lung development, multiple bronchopulmonary buds form, eventually merging to shape the lung's lobes and fissures. These buds begin as individual structures and then fuse completely, except in specific areas where fissures are designed to remain. As a result, lobes and fissures form in a predictable pattern for typical anatomy. However, the incomplete formation or obliteration of these fissures can lead to anatomical variations. This incomplete fissure formation could stem from the partial or failed disappearance of certain fissures that typically close. Moreover, any disruptions in the fusion process of bronchopulmonary buds or partial destruction of the spaces between them may lead to accessory fissures. Thus, factors influencing fusion during the developmental stage could result in significant variation in the formation of lung fissures and lobes. This variability not only affects

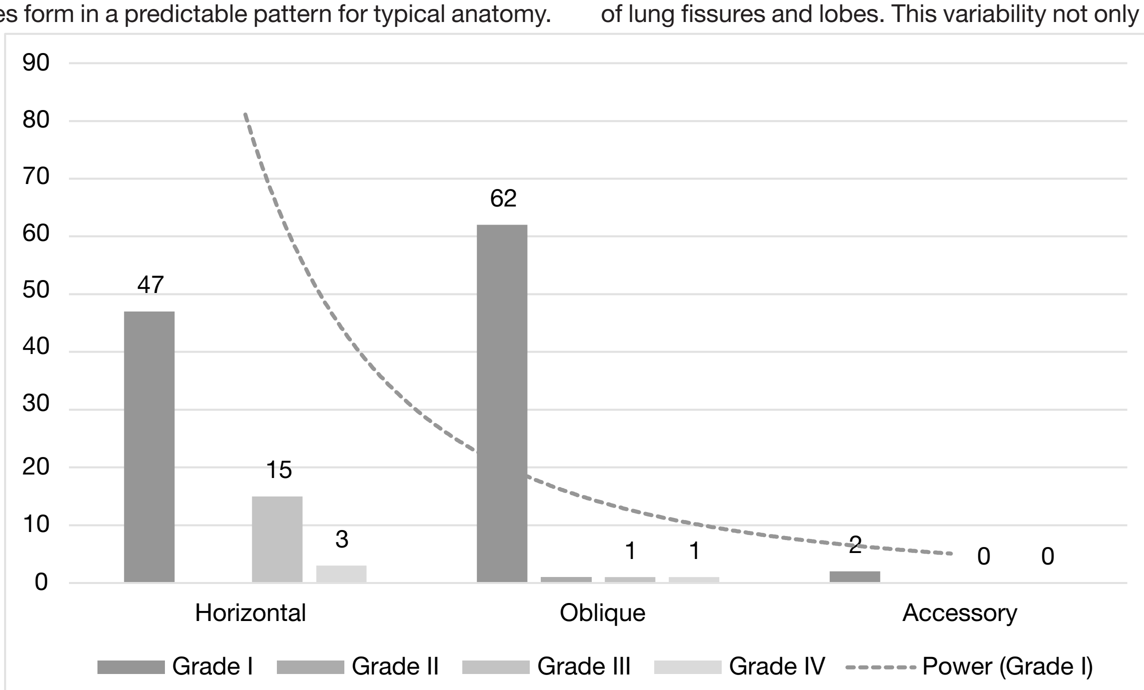

Figure 2. Right Lung grading of completeness of fissure “Craig and Walker classification”

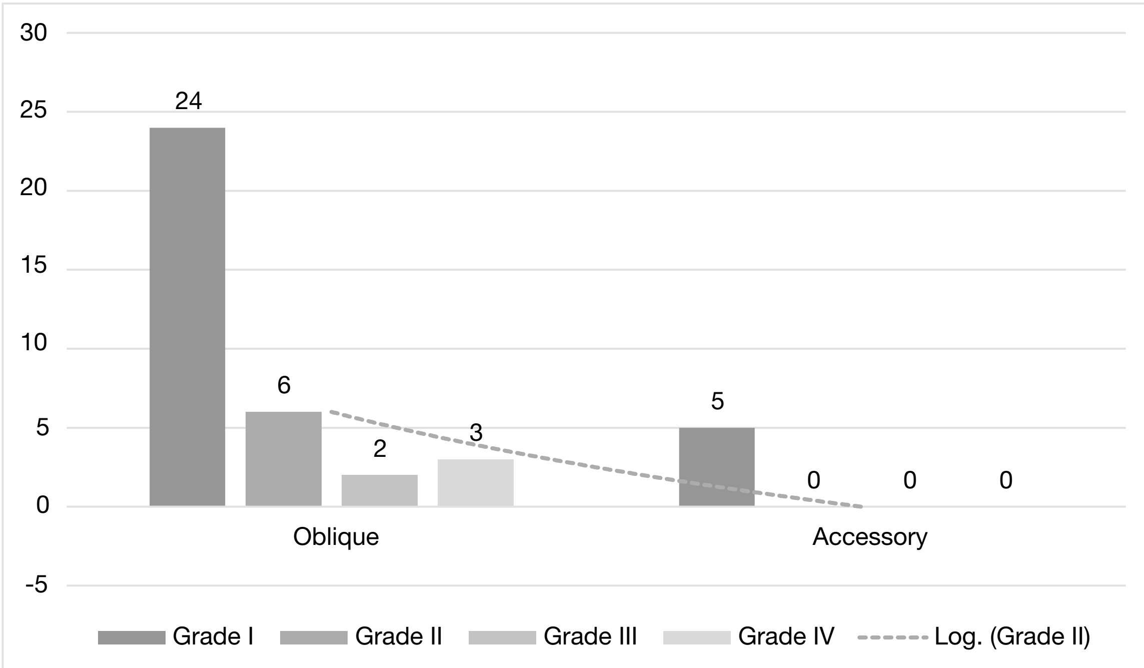

Figure 3. Left Lung grading of completeness of fissure “Craig and Walker classification”

Complete:	(Grade I)	“Complete fissure with entirely separated lobes”
Incomplete:	(Grade II)	“Complete visceral cleft but parenchymal fusion at the base of fissure”
	(Grade III)	“Visceral cleft evident for a part of fissure”
Absent:	(Grade IV)	“Complete fusion of lobes with no evident fissural line”

the structural layout of the lungs but also has clinical implications, particularly when diagnosing and treating respiratory conditions.

According to the findings of this research, the lung does deviate in its ability to obliterate prenatal fissures, which results adult fissures either incomplete or absent. A previous study done by Bush almost similar results and reported that defect in the obliteration of prenatal fissures is done by lung.[16] In another study by Singh et al, stated that presence of accessory lobe was due to monopodial branching of stem bronchi.[17] Such findings underscore the diversity in lung architecture across individuals and populations, contributing valuable insights into typical anatomical variations as well as potential anomalies.

In our study, out of 100 lungs studied, 65 were right lungs and 35 were left lungs. After examination of the right lungs, it was observed that 36 lungs were having complete oblique fissures and 24 were having complete horizontal fissures. Among lungs having complete horizontal fissures, 15 lungs were found to have incomplete horizontal fissures and in 3 lungs horizontal fissure were entirely absent. The current investigation found that the right lung has more incomplete horizontal fissures than incomplete oblique fissures. In comparison to the right lung, a higher proportion of the left lung's oblique fissure was incomplete. Accessory fissure with extra lobe was more pronounced on the left lung. The results of the current study were consistent with earlier research conducted in many regions of the globe.[10-15] Findings of these studies are consistent with the findings of our study. When the current study's findings are compared to those of earlier research, it becomes clear that human lungs may vary widely in terms of their form, fissures, and lobes, in addition to their hilar architecture.

A comparative analysis of our results with previous studies highlights that human lungs can vary not only in terms of fissure completeness but also in their form, lobe configuration, and hilar structures. The presence or absence of fissures, along with their completeness, has important implications in both health and disease. Anatomical variations in the lung, such as accessory fissures, may complicate the clinical assessment of certain conditions, particularly when imaging is used as a diagnostic tool.

For instance, in patients with endobronchial lesions, an accessory fissure can alter the typical presentation of lung collapse, making it more challenging to pinpoint the lesion's exact location and extent. This is because an accessory fissure can mask or obscure the lesion, misleading radiographic interpretations or leading to underestimation of the affected area.[18] Additionally, conditions like pneumonia typically remain confined to a specific lobe if the fissures are complete, as the fissures act as natural barriers. However, incomplete fissures allow infections to spread more easily across lobes through the connecting lung tissue, complicating the localization and treatment of the primary infection. This anatomical variance can potentially mask the primary site of infection, resulting in more diffuse presentations of respiratory disease, which can hinder precise diagnosis and potentially delay appropriate treatment.

The implications of such findings extend beyond just clinical observation. From a surgical perspective, knowing the precise location and structure of fissures and lobes is essential, especially for procedures like lobectomies or segmentectomies where preservation of specific lung regions is necessary. In cases where incomplete fissures are present, surgical planning becomes more challenging due to the increased risk of injuring adjacent lobes. Moreover, understanding these variations is crucial for interpreting imaging studies accurately. In radiology, anatomical inconsistencies can lead to misinterpretations unless radiologists are thoroughly aware of these potential deviations from the norm.

The anatomical diversity of lung fissures and lobes, as observed in our study and supported by prior research, emphasizes the importance of detailed anatomical knowledge for healthcare providers. Recognizing variations in fissure completeness and accessory lobe presence is particularly vital in pulmonology, thoracic surgery, and radiology, where accurate interpretation of lung anatomy directly influences patient outcomes. This study contributes to the growing body of evidence highlighting how individual differences in lung structure can have substantial clinical significance, impacting both diagnosis and treatment strategies.

Conclusion

Understanding the variations in lung morphology is crucial for accurately assessing the spread of pleural effusion, pneumonia, and postoperative complications like air leakage and collateral air drift in cancer. Accessory fissures, more commonly observed on the right lung, hold particular significance in radiology, where their atypical appearance can easily be mistaken for pathological lesions. Recognizing these developmental anomalies and their radiographic presentation improves diagnostic accuracy, enabling more effective management of respiratory diseases and minimizing misinterpretation of imaging findings.

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