Int. J. Morphol.,
43(3):732-736, 2025.

Bilateral Variation of Human Pulmonary Fissure: A Study in Korean Cadaver

Variación Bilateral de la Fisura Pulmonar Humana: Un Estudio en un Cadáver Coreano

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JEONG, E.-A.; BAE, A.-N.; PARK, J.-H.; LEE, J-H. & HEO, Y.-R. Bilateral variation of human pulmonary fissure: A study in Korean cadaver. *Int. J. Morphol., 43(3)*:732-736, 2025.

SUMMARY: The purpose of this study is to elucidate the variations in human lung fissures for clinical benefits. The lungs are a pair of respiratory organs located on either side of the chest cavity. The right lung is typically divided into three lobes by the oblique fissure and horizontal fissure, while the left lung is divided into two lobes by the oblique fissure. In this study, variations in lung fissures were observed in both lungs of a 96-year-old formalin-preserved Korean male cadaver. These lung fissures were observed as additional, complete, incomplete, or absent. The right lung observed an absent horizontal fissure and an incomplete accessory fissure, while the left lung showed an incomplete oblique fissure and an accessory fissure known as the left minor fissure. From a clinical perspective, it is important for clinicians to be aware of these variations in lung fissures. Incomplete lung fissures, for example, have the potential to facilitate the spread of diseases like pneumonia to adjacent lobes. Additionally, accessory fissures can sometimes be mistaken for other conditions such as pleural scars or blisters, requiring careful differentiation.

KEY WORDS: Fissure of the lung; Anatomical variation; Accessory fissure; Incomplete fissure; Korean cadaver.

INTRODUCTION

The lungs are paired respiratory organs located on either side of the heart within the thoracic cavity. The right lung is larger and heavier than the left. The right lung is subdivided into superior, middle, and inferior lobes by oblique and horizontal fissures, while the left lung is divided into superior and inferior lobes by oblique fissures (Jeong *et al*., 1994; Joshi *et al*., 2022). The oblique fissure runs obliquely in a downward and forward direction and is more vertical in the left lung compared to the right. The horizontal fissure is located along the 4th intercostal space and intersects the oblique fissure at the 5th rib.

In a previous study, accessory fissures were defined as additional fissures in the lungs that are not part of the normal anatomical fissures. During fetal development, the lung bud expands into the pleural cavity and forms lung fissures. Most of these fissures disappear over time, except for the oblique and horizontal fissures. If a fissure remains unfused, it becomes an accessory fissure (Nene *et al*., 2011). Common accessory fissures include the superior accessory fissure (SAF), inferior accessory fissure (IAF), and left minor fissure (LMF). The SAF partially or completely separates the lower lobe into two segments, which are referred to as the superior and basal segments, respectively. The IAF separates the medial basal segment from the lower lobe, and the LMF separates the lingula from the remaining left upper lobe (Kc *et al*., 2018).

In lung embryology, the visceral pleura covers the lungs and folds during embryonic growth, forming lung fissures. These fissures separate the lobes and facilitate uniform expansion of the entire lung, enhancing air intake during respiration (Manjunath *et al*., 2021; West *et al*., 2021). A complete fissure is defined as the attachment of the pulmonary lobe to the hilum with only the bronchi and pulmonary blood vessels. In contrast, an incomplete fissure is defined as a cleft that fails to reach the hilum or an area of parenchymal fusion between the lobes. When the parenchyma is completely fused, fissures are absent. According to Godwin & Tarver (1985), the fissures can vary in length and depth, ranging from a few centimeters to complete absence (Godwin & Tarver, 1985; Koenigkam-Santos *et al*., 2012).

Clinically, accessory fissures can complicate diagnosis, and incomplete fissures may alter the course of

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Received: 2024-01-08 Accepted: 2025-03-02

disease spread within the lungs. Therefore, it is essential for clinicians to be aware of variations in lung fissures to ensure accurate diagnosis and effective surgical planning.

Here, we report a case of bilateral pulmonary fissure variation in human lungs collected from cadavers. No prior studies have investigated variations in bilateral lung fissures.

MATERIAL AND METHOD

We identified bilateral accessory fissures and incomplete fissures during a routine lung dissection at Keimyung University School of Medicine in 2023. This observation was made in a 96-year-old formalin-fixed Korean male cadaver. Following the removal of the skin from the thorax, the origins of the pectoralis major and minor muscles were removed. Ribs 2nd–6th were vertically incised into lateral thirds, extending from the clavicle. The manubrium and the 6th intercostal space were horizontally severed. Subsequently, the parietal pleura was excised to reveal the lungs, which were extracted by cutting the pulmonary artery and vein connected to the heart.

RESULTS

In this study, the main and accessory fissures were found in each pair of lungs, categorized as complete, incomplete, or absent. The right lung exhibited a complete oblique fissure but lacked a horizontal fissure, featuring an incomplete accessory fissure. The length of the oblique fissure on the medial lung surface measured 55 mm. A horizontal fissure represents parenchymal fusion between lobes with no evident fissure lines. The accessory fissure extended from the hilum to the lower lobe. On the medial surface of the lung, the fissures had lengths of 62 mm and 95 mm for the accessory and lower lobe, respectively (Fig. 1).

The left lung had an incomplete oblique fissure and a minor fissure. The oblique fissure indicated parenchymal fusion between the lobes on the costal surface of the lung. On the medial lung surface, the distance between the inferior part of the hilum and the margin of the lung was normal at 90 mm, whereas the superior part lacked oblique fissures. The length of the left minor fissure was 53 mm on the medial surface and reached the hilum of the lung. When observing the left minor fissure on the costal surface of the lung, the length of a virtual line was measured from the starting point of the left minor fissure to the oblique fissure. The total length of this virtual line was 119 mm, of which 37 mm (31.1 %) was incomplete and failed to reach the oblique fissure (Fig. 2). The hilum of the lungs appeared normal, and all other structures were also normal.

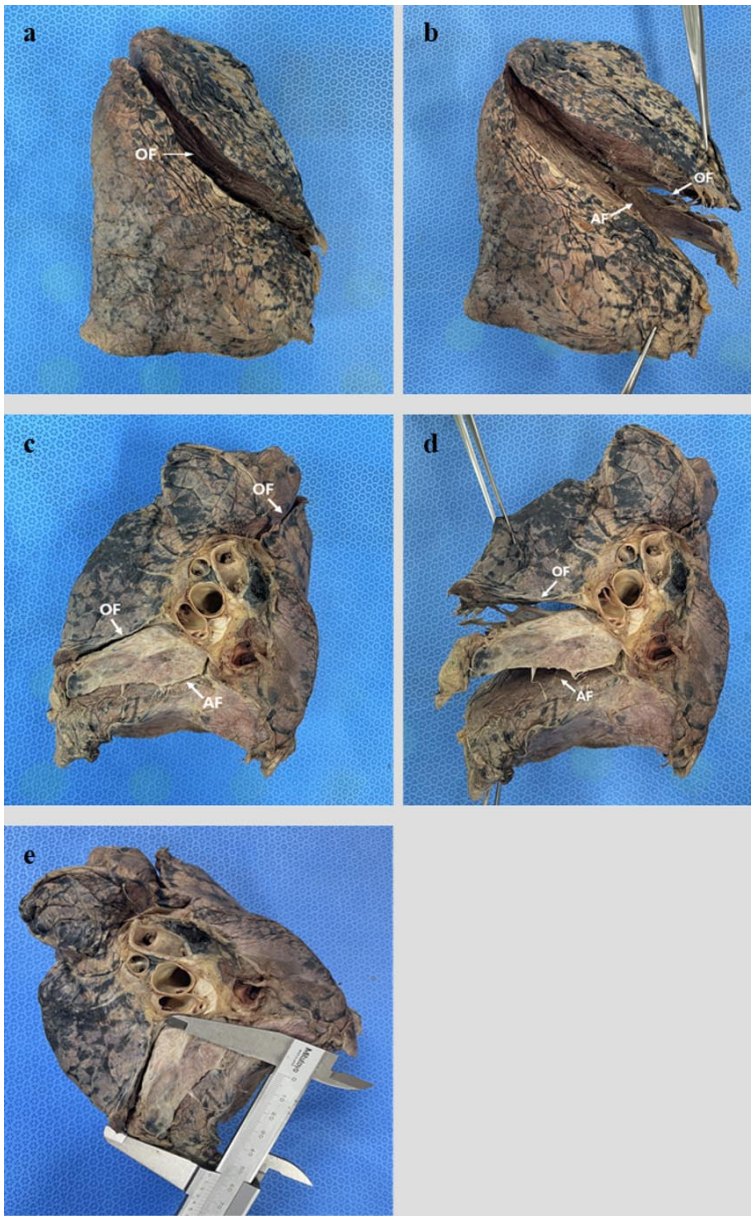

Fig. 1. The image of the right lung with incomplete accessory fissure, complete oblique fissure, and absent horizontal fissure. (a) Costal Surface with Complete Oblique Fissure. (b) Costal Surface with Incomplete Accessory Fissure. (c) Medial Surface with Oblique and Incomplete Accessory Fissure. (d) Medial Surface with Oblique and Incomplete Accessory Fissure. (e) Medial Surface with 55 mm Accessory Fissure. (OF: Oblique Fissure, AF: Accessory Fissure)

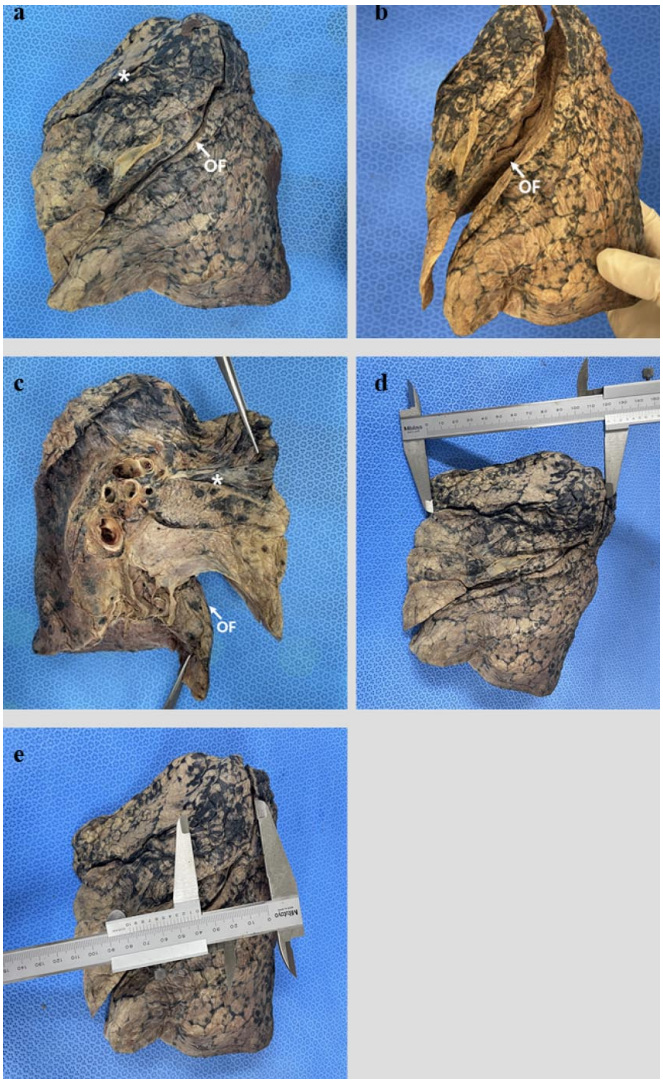

Fig. 2. The image of the left lung has incomplete left minor fissure and incomplete oblique fissure. (a) Costal surface with incomplete oblique and left minor fissures. (b) Degree of incomplete oblique fissure on the costal surface. (c) Medial surface with incomplete oblique and left minor fissures. (d) Costal surface with a 119 mm virtual line of the left minor fissure. (e) Costal surface showing a 37 mm incomplete left minor fissure. (OF: Oblique Fissure, *: Left Minor Fissure)

DISCUSSION

We observed accessory fissures and complete and incomplete fissures during routine dissection. The right lung exhibited a complete oblique fissure, the absence of a horizontal fissure, and an incomplete accessory fissure. Meanwhile, the left lung displayed an incomplete oblique fissure and a minor left fissure. We propose that embryological effects cause variations in pulmonary fissures.

This study examined bilateral lung fissure variations using a formalin-fixed Korean cadaver model. Notably, the anatomy of lung fissures may vary owing to study methods and ethnic differences. Although earlier observations suggested that variations in the number of lobes in the right and left lungs were responsible, we now report that these variations are associated with differences in the pulmonary fissures. This study is significant since most prior research focused on unilateral lung fissure variations.

Typically, the right lung consists of three lobes, separated by an oblique and horizontal fissure, while the left lung has two lobes, separated by an oblique fissure .

Previous research classifies lung variations into accessory fissures (additional fissures other than normal fissures), incomplete fissures, and absent fissures based on the degree of fissure fusion. Table I summarizes the literature on RHF, Right IAF, Incomplete LOF, and Incomplete LMF. As a result of averaging studies with more than 60 cadavers or patients, the probability of RHF being ABSENT was 6.63 % and the probability of finding the right inferior accessory fissure was 6.3 %. Additionally, the probabilities of LOF and LMF are 9.93 % and 8.65 %, respectively (Medlar, 1947; Cronin *et al*., 2010; Murlimanju *et al*., 2012; George *et al*., 2014; Unver Dogan *et al*., 2015; Manjunath *et al*., 2021; West *et al*., 2021).

Table. I. Percentage of fissure observations in the literature.

Study		RHF absent	Right IAF	LOF incomplete	LMF
West *et al*., 2020	United Kingdom—FFC	9/81 (11.1 %)		13/81 (16.0 %)	
Murlimanju *et al*., 2012	India—UC	6/60 (10 %)		2/60 (3.33 %)	
George *et al*., 2015	India—FFC	2/65 (3.08 %)		11/73 (15.1 %)	
Unver Dogan *et al*., 2015	Turkey—AS	4/210 (1.90 %)		2/210 (0.95 %)	
Medlar, 1947	United States of America—AS	160/1200 (13.3 %)		215/1200 (17.9 %)	
P. Cronin *et al*., 2010			13/150 (8.7 %)		24/150 (16 %)
Manjunath *et al*., 2022		2/560 (0.4 %)	22/560 (3.9 %)	35/560 (6.3 %)	7/560 (1.3 %)

RHF: right horizontal fissure, IAF: inferior accessory fissure, LOF: left oblique fissure, LMF: left minor fissure.

During fetal development, a pleural cavity, covered by a mesothelial membrane, forms (Bayter *et al*., 2021). The visceral pleura extends into the interlobar spaces between the developing lobe bronchi, forming lung fissures that separate the lobes. As lung development progresses, most fissures are obliterated, except for the oblique and horizontal fissures (Sarma & Islam, 2014; Kc *et al*., 2018). Accessory fissures may result from the persistence of prenatal fissures due to their failure to obliterate as expected. Incomplete or absent fissures may be due to defects in the fissure obliteration process, while incomplete fissures may be caused by partial fusion. Complete absent fissures occur when prenatal fissures fuse entirely (Mamatha *et al*., 2016; Mutua *et al*., 2021). Previous research has shown that these fissures variations can have varying depths and lengths, influenced by a range of factors including genetic and environmental factors. However, fissure completeness remains unaffected by age, sex, number of pack years of smoking, or maternal smoking during pregnancy van der Molen *et al*. (2021).

Clinically, lung variations present challenges for radiologists and clinicians. Incomplete fissures can facilitate the spread of diseases such as pneumonia to adjacent lobes. Additionally, complete fissures are separated between lobes and are important for the compartmentalization of pulmonary disease, the presence of accessory lobes and fissures may be discovered incidentally during preoperative planning for lobectomy or segmentectomy (Bayter *et al*., 2021). Radiologists may misinterpret accessory fissures as other conditions, such as pleural scars, blisters, or linear collapsed areas Muttikkal & Deng (2012). According to Ranka and collaborators in 2022, the presence of incomplete or accessory fissures may alter the diagnosis of pneumonia (Ranaweera *et al*., 2022). Pneumonia typically remains confined to affected lobes, but in patients with incomplete fissures, it may spread to adjacent lobes (Gebregziabher *et al*., 2015; Ranaweera *et al*., 2022). In addition, patients with incomplete fissures experience prolonged air leakage after major lung resection, leading to extended hospital stays, chest tube usage, and increased postoperative side effects such as hospital costs (Decaluwe *et al*., 2015; Stamenovic *et al*., 2016; Bayter *et al*., 2021). Therefore, knowledge of lung morphological variations is beneficial for clinicians as it aids in identifying alterations in disease distribution, reducing misinterpretation of radiographic modalities, and enabling efficient surgergical planning.

In conclusion, this study identified variations in the lungs with accessory and incomplete fissures. This study aimed to shed light on these variations for the benefit of radiologists and clinicians. It is important to recognize that these accessory and incomplete fissures are affected by lung embryology, although the precise cause of these variations remains unclear. Further studies are needed to confirm this hypothesis.

CONCLUSION

In this study, we observed the presence of accessory fissures, incomplete fissures, or the absence of fissures in bouth lungs. These variations in lung fissures may be attributed to environmental or genetic factors. The variability in lung fissures can potentially complicate the diagnostic process for radiologists and clinicians. A comprehensive understanding of these variations in lung fissures holds significant value for radiologists and clinicians, enabling them to make precise diagnoses and plan surgical procedures. Therefore, it is crucial for radiologists and clinicians to have knowledge of the diverse anatomy of lung fissures.

ACKNOWLEDGEMENTS. The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge that can then improve patient care. Therefore, these donors and their families deserve our highest gratitude.

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RESUMEN: El propósito de este estudio fue dilucidar las variaciones en las fisuras pulmonares humanas para obtener beneficios clínicos. Los pulmones son un par de órganos respiratorios ubicados a ambos lados en la cavidad torácica. El pulmón derecho se divide típicamente en tres lóbulos por la fisura oblicua y la fisura horizontal, mientras que el pulmón izquierdo se divide en dos lóbulos por la fisura oblicua. En este estudio, se observaron variaciones en las fisuras pulmonares en ambos pulmones de un cadáver masculino coreano de 96 años, conservado en formalina. Estas fisuras pulmonares se observaron como adicionales, completas, incompletas o ausentes. En el pulmón derecho se observó una fisura horizontal ausente y una fisura accesoria incompleta, mientras que en el pulmón izquierdo se observó una fisura oblicua incompleta y una fisura accesoria conocida como cisura menor izquierda. Desde una perspectiva clínica, es importante que los profesionales clínicos conozcan estas variaciones en las fisuras pulmonares. Por ejemplo, las fisuras pulmonares incompletas pueden facilitar la propagación de enfermedades como la neumonía a los lóbulos adyacentes. Además, en ocasiones, las fisuras accesorias pueden confundirse con otras afecciones, como cicatrices pleurales o ampollas, lo que requiere una diferenciación meticulosa.

PALABRAS CLAVE: Fisura pulmonar; Variación anatómica; Fisura accesoria; Fisura incompleta; Cadáver coreano.

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