A systematic literature study of anatomical variations in human lung fissures and hilar structures

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SUMMARY

This study aimed to examine the anatomical features and variation prevalence of human lung fissures and hilar structures. Anatomical variations can be seen in these structures and morphometrical data are not consistent. Studies in the literature were reviewed using the PubMed, Scopus, and Google Scholar databases. The method of the study was prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis [PRISMA] protocol. Data on the complete, incomplete, absent and accessory fissures, accessory fissure types, number of arteries, veins and bronchi were extracted and included in the analysis. The Anatomical Quality Assessment (AQUA) tool was used in order to examine potential risks of bias within the included studies. Out of 302 studies initially evaluated, 68 were included in the analysis. It was determined that the prevalence of completion of horizontal fissure of the right lung (56,5%) was lower than oblique fissures, while the prevalence of incomplete and absent fissure (43,4%) were higher than oblique fissures. The prevalence of the left horizontal accessory fissure (9,9%) in the left lung and the inferior accessory fissure type (8,9%) in the right lung were found to be the highest. It has been found that the number of arteries and bronchi in the hilum of the right lung are different from the general anatomy. Although studies on lung fissure variations are more common, studies examining accessory fissures and hilar structures are rare. We think that this study will be useful for clinicians in interpreting radiological images, diagnosing lung pathologies, and applying surgical procedures.

Key words: Lung – Fissure – Accessory fissure – Hilum – Variation

INTRODUCTION

On the surfaces of the lungs, there are clefts called fissures separating lobes from each other (Arıncı, 2005). In the right lung, a horizontal fissure (minor fissure) separates the upper and middle lobes, and the right oblique fissure (major fissure) separates the lower lobe from the upper and middle lobes. In the left lung, there is only the oblique fissure (major fissure) that separates the lung into the upper and lower lobe and these fissures are presented in Fig. 1 (Ugalde et

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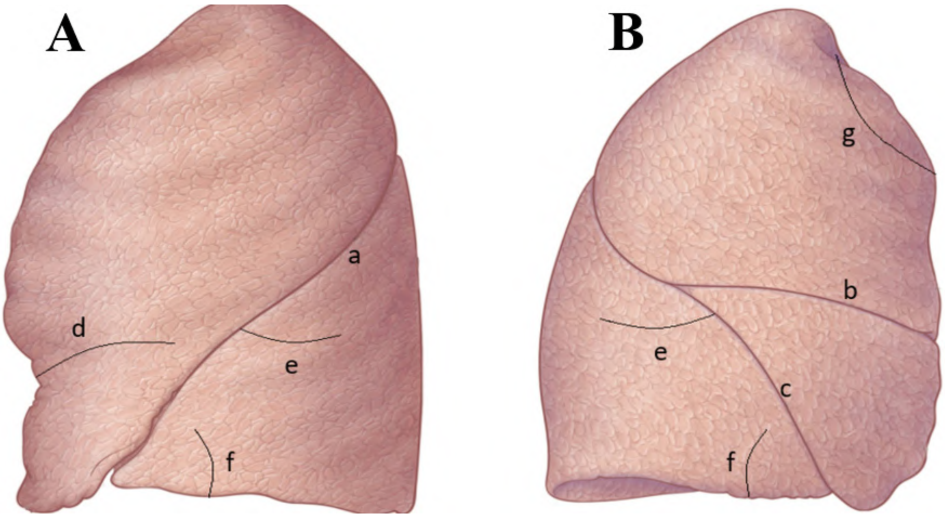

Fig. 1.- Horizontal, oblique and accesory fissures in the right (**B**) and left (**A**) lung. a: Left oblique (major) fissure; b: Right horizontal (minor) fissure; c: Right oblique (major) fissure; d: Left minor fissure; e: Superior accesory fissure; f: Inferior accesory fissure; g: Azygos fissure. Modified from Ugalde et al. (2007).

al., 2007). Fissures in the fully developed lungs embryologically separate the bronchopulmonary segments, which will develop in the next process (Kc et al., 2018). Completed fissures are defined as fissures that are held together only at the hilar level (by bronchi and pulmonary blood vessels), while incomplete fissures are defined as areas of parenchymal fusion between the lobes (Ugalde et al., 2007). Incomplete pulmonary fissures lead to interlobar collateral airway pathologies and common venolymphatic drainage between adjacent lobes or segments, which may influence surgical and endobronchial treatments of the lungs and the treatment outcomes. Although rare, the spread of small cell lung cancer to the adjacent lobe takes place due to incomplete fissures and affects the prognosis negatively (Bayter et al., 2021).

In addition to normal fissures, accessory fissures can also be observed in the lungs. Anatomically, the accessory fissure is a cleft with a varying depth, covered with visceral pleura. They usually appear at the borders between bronchopulmonary segments (Godwin and Tarver, 1985). The inferior accessory fissure that separates the medial basal segment from the rest of the lower lobe, the superior accessory fissure that separates the upper segment of the lower lobe from the basal segment, and the left horizontal fissure (minor fissure) that borders the lingula of the left lung are the most observed accessory fissures in the lungs (Bayter et al., 2021; Godwin and Tarver, 1985). Apart from these, the azygos fissure is frequently observed in the upper lobe of the right lung (Ozan, 2014). Accessory fissures may change the usual pattern of lung collapse in patients with endobronchial lesions and make it difficult to identify the size of the lesion (George et al., 2014). Moreover, the accurate identification of accessory fissures is important since they may be misinterpreted as linear atelectasis, pleural scars, or bullae walls (Manicka et al., 2019).

The hilum of the lung, where the anatomical structures entering and leaving the organ are located, is found on the mediastinal surface of the lungs. The root of the lungs, which is known as the stalk of the lung, is surrounded by the mediastinal pleura of the lung and connects to the hilum of the lung (Arıncı, 2005; Ozan, 2014). The root of the lungs contains a pulmonary artery, 2 pulmonary veins, main bronchus, bronchial vessels, nerves, and lymph nodes (Drake et al., 2020). Having knowledge about arteries and veins can be useful for surgeons to prevent excessive bleeding during pulmonary lobectomy (Manicka et al., 2019). Knowing the variations of hilar structures is important, as they are often associated with misinterpretation of radiography and computed tomography images. (Saha and Srimani, 2019).

Our study aimed to examine the prevalence of variations according to previous studies by reviewing those studies that discussed the variations of fissures in human lungs and structures in the hilum of the lungs. In our literature review, there were many studies on fissure variations in the lungs, but we could not find any systematic reviews examining the variations of lung fissures and hilar structures together.

MATERIALS AND METHODS

Search strategy

Studies in the literature examining the variations of lung fissures and hilar structures were reviewed by two researchers using the PubMed, Scopus, and Google Scholar databases. During the search done in the databases, the keywords "variations", "fissures", "hilum", "human", "lung", "accessory fissures" and search terms such as "variations of fissures in human lung", or "variations of hilum in lung" were used. To prevent any location and interviewer bias during the search, an inclusive search strategy was determined. Furthermore, no date and language restrictions were set during the search, and the search was expanded using the references of the articles suitable for the study. The method of the study was prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis [PRISMA] protocol (Henry et al., 2016).

Eligibility assessment

Inclusion and exclusion criteria of potential articles were determined by 2 different researchers. Regardless of sex, age, and ethnicity, articles involving different populations and different methods, in which no pathologies were found in the lungs, were selected and included in the study. Case reports, letters to the editor, conference proceedings, unpublished articles, and published articles with incomplete or uncertain results were excluded from the study. Studies in languages other than English were translated into English by medical professionals. The review team made a compromise in case of disagreements during the conformity assessment of the studies.

Data extraction

Data extraction of articles that met the inclusion criteria was obtained by two different researchers. Data on lung counts, publication date and location of study, prevalence of variation of lung fissures, prevalence of variation of accessory fissure types, and prevalence of variation of hilar structures were extracted. The authors of the articles were contacted due to inconsistencies in the data of some articles.

Study endpoints

The primary endpoint was to find the prevalence of variation of lung fissures and hilar structures relative to the right and left lungs in the general population. The secondary endpoints included various anatomical variation features associated with the lung fissures and hilar structures: developmental status of fissures (complete, incomplete and absent), types of accessory fissures (superior accesory fissures, inferior accesory fissures, left minor fissures, azygos fissures and other accessory fissures), number of hilar structures (one artery, two arteries or more, one vein, two veins, three veins and more, one bronchus, two bronchi and more).

Quality assessment

Anatomical Quality Assessment (AQUA) Tool was used to evaluate the quality and reliability of anatomical studies. The AQUA tool assesses the risks of study bias in 5 areas (1. Aim and subject characteristics 2. Study design, 3. Characterization of methods, 4. Descriptive anatomy, 5. Results reporting). Each of the fields was set to end with a bias question and rated as "Low", "High" or "Uncertain". Answering "yes" to the questions indicates that the study carries a low risk of bias, and answering "no" indicates that the study carries a high risk of bias. The ''unclear answer was given for studies that contain inconsistent data and cannot be clearly examined (Henry et al., 2017).

Statistical analysis

Statistical analysis was performed by two reviewers (B.A and D.E). The data were analyzed using MetaXL version 5.3 by EpiGear International Pty Ltd (Wilston, Queensland, Australia). The pooled prevalence of the parameters in the studies were represented by grouping them according to the right and left lung. The Chi2 test and Higgins I2 statistics were used in order to investigate the heterogeneity among the included studies. Cochran's Q p value of less than <0.10 (for the Chi2 test), indicates statistically significant heterogeneity between studies. Higgins I2 values between 0-40% were considered as "might not be important"; 30-60% as "might indicate moderate heterogeneity";50-90% as "may indicate substantial heterogeneity";, and 75-100% as "may represent considerable heterogeneity" (Henry et al., 2016).

RESULTS

Study identification

The study identification process is summarized in Fig. 2. The first search of the databases found 275 articles that could potentially meet the inclusion criteria of the study. Further 27 studies were identified during the reference search. A total of 53 studies were duplicates and were excluded. As a result of the detailed examination of the titles and abstracts of the articles, it was decided that 136 articles were not suitable for the study. Of the 113 articles obtained, 45 were excluded due to their being case reports, letters to the editor, conference proceedings, unpublished articles, and published articles with incomplete or uncertain results. Finally, 68 articles were included in this study.

Characteristics of the included studies

Characteristics of the included studies are summarized in Table 1 in detail. Of the 68 articles used in our study, 60 focused on fissures of the lungs (7366 lungs), 20 focused on accessory fissures observed in the lungs (2623 lungs), and 12 focused on the pulmonary hilum (944 lungs). The articles included in our study were published between 2001 and 2022. Lungs were examined on cadavers in 60 articles, CT (computed tomography) images in 6 articles, and medical autopsy in 2 articles. The vast majority of studies belonged to the Indian population (50 studies).

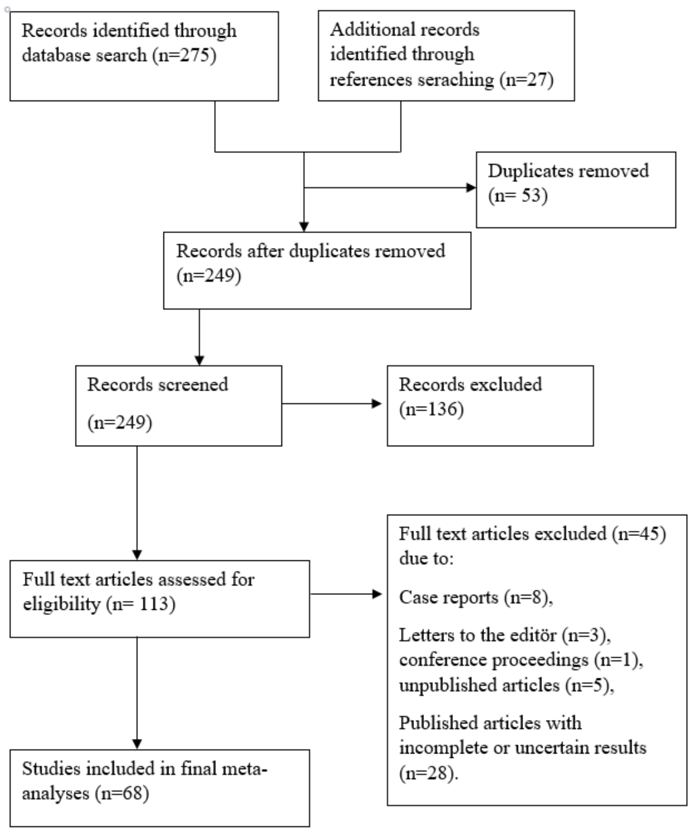

Fig. 2.- PRISMA flow diagram.

Table 1. Characteristics of the included studies & AQUA TOLL- risk of bias. Modified from Henry et al. (2016).

Studies	Method of study	Study population	Number of Lungs	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5
Kc (2018)	Cadaver	Nepalese	Right (23) Left (27)	High	Low	High	Low	Low
George (2014)	Cadaver	Indıa	Right (65) Left (73)	Low	Low	High	Low	Low
Mahmut (2007)	CT	Japan	Right (1000) Left (1000)	Low	Low	Low	Low	Low
Joshi (2022)	Cadaver	Indıa	Right (32) Left (38)	High	Low	High	Low	Low
Manjunath (2021)	CT	Indıa	Right (70) Left (58)	Low	Low	High	Low	Low
Thapa (2016)	Cadaver	Indıa	Right (20) Left (20)	High	Low	High	Low	Low
Bostancı (2019)	Medicolegal autopsy	Turkey	Right (256) Left (256)	High	Low	High	Low	High
Z. Hermanová (2014)	CT	Czech Republic	Right (250) Left (250)	Low	Low	Low	Low	Low
N. U. Dogan (2015)	Medicolegal autopsy	Turkey	Right (210) Left (210)	Low	Low	High	Low	Low
Murlimanju (2012)	Cadaver	Indıa	Right (32) Left (28)	High	Low	High	Low	Low
James (2019)	Cadaver	Indıa	Right (25) Left (25)	High	Low	High	Low	High
Jethva (2019)	Cadaver	Indıa	Right (25) Left (25)	High	Low	High	Low	Low
V. Mutua (2021)	Cadaver	Kenya	Sağ (38) Left (32)	High	Low	High	Low	Low
Khedekar (2017)	Cadaver	Indıa	Right (25) Left (25)	High	Low	High	Low	High
Jacob (2019)	Cadaver	Indıa	Right (47) Left (47)	High	Low	High	Low	High
Devi (2011)	Cadaver	Indıa	Right (22) Left (22)	High	Low	High	Low	Unclear
Wahengbam (2019)	Cadaver	Indıa	Right (42) Left (37)	High	Low	High	Low	Low
Jaiswal (2017)	Cadaver	Indıa	Right (55) Left (0)	High	Low	High	Low	Low
Ranaweera (2022)	Cadaver	Sri Lanka	Right (26) Left (24)	High	Low	High	Low	Low
Anbusudar (2016)	Cadaver	Indıa	Right (25) Left (25)	High	Low	High	Low	Low
Sailaja (2019)	Cadaver	Indıa	Right (30) Sol (30)	High	Low	High	Low	Low
Kumar (2014)	Cadaver	Indıa	Right (50) Left (50)	High	Low	High	Low	Low

Studies	**Method of study**	**Study population**	**Number of Lungs**	**Domain 1**	**Domain 2**	**Domain 3**	**Domain 4**	**Domain 5**
Mamatha (2016)	Cadaver	Indıa	Right (20) Left (20)	High	Low	High	Low	Low
Singh (2014)	Cadaver	Indıa	Right (30) Left (30)	High	Low	High	Low	Low
Quadros (2014)	Cadaver	Indıa	Right (36) Left (40)	Low	Low	High	Low	Low
Vasuki (2019)	Cadaver study	Indıa	Right (40) Left (40)	High	Low	High	Low	High
Shivaleela (2018)	Cadaver study	Indıa	Right (38) Left (46)	High	Low	High	Low	Low
Ughade (2018)	Cadaver study	Indıa	Right (50) Left (50)	High	Low	High	Low	Low
Shinde &Patel (2022)	Cadaver study	Indıa	Right (24) Left (24)	High	Low	High	Low	Low
Agrawal (2018)	Cadaver study	Indıa	Right (40) Left (40)	High	Low	High	Low	Low
Subadha (2019)	Cadaver	Indıa	Right (32) Left (38)	High	Low	High	Low	Low
Dhanalakshmi (2016)	Cadaver	Indıa	Right (50) Left (50)	High	Low	High	Low	Low
Hema (2014)	Cadaver	Indıa	Right (25) Left (25)	High	Low	High	Low	Low
Lakshmi (2018)	Cadaver	Indıa	Right (32) Left (28)	High	Low	High	Low	High
Jacob & Pıllay (2013)	Cadaver	Indıa	Right (30) Left (18)	High	Low	High	Low	Low
Nene (2011)	Cadaver	Indıa	Right (50) Left (50)	High	Low	High	Low	High
Dutta (2013)	Cadaver	Indıa	Right (52) Left (50)	High	Low	High	Low	Low
Magadum (2015)	Cadaver	Indıa	Right (40) Left (40)	High	Low	High	Low	Low
Ambali Manoj (2014)	Cadaver	Indıa	Right (50) Left (50)	High	High	High	Low	Low
Nakhate (2017)	Cadaver	Indıa	Right (40) Left (40)	High	Low	High	Low	Low
Varalakshmi (2014)	Cadaver	Indıa	Right (30) Left (34)	High	Low	High	Low	Low
Divya (2015)	Cadaver	Indıa	Right (28) Left (27)	High	Low	High	Low	Low
Nisha Kaul (2014)	Cadaver	Indıa	Right (50) Left (50)	High	Low	High	Low	Low
Wahane (2015)	Cadaver	Indıa	Right (29) Left (21)	High	Low	High	Low	Low
Radha (2015)	Cadaver	Indıa	Right (30) Left (30)	High	Low	High	Low	Low

Studies	Method of study	Study population	Number of Lungs	Domain 1	Domain 2	Domain 3	Domain 4	Domain 5
Mansur (2019)	Cadaver	Nepal	Right (38) Left (31)	High	Low	High	Low	Low
Ghosh (2013)	Cadaver	Indıa	Right (46) Left (36)	High	Low	High	Low	Low
Gebregziabher (2015)	Cadaver	Ethiopia	Right (23) Left (20)	High	Low	High	Low	Low
Sumalatha (2019)	Cadaver	Saudi Arabia	Right (32) Left (30)	High	Low	High	Low	Low
Gayathri (2016)	Cadaver	Indıa	Right (25) Left (25)	High	Low	High	Low	Low
Sangeetha (2019)	Cadaver	Indıa	Right (25) Left (25)	High	Low	High	Low	Low
Tallapaneni (2016)	Cadaver	Indıa	Right (30) Left (30)	High	Low	High	Low	Low
West (2020)	Cadaver	UK	Right (81) Left (81)	High	Low	High	Low	Low
Kommuru (2013)	Cadaver	Indıa	Right (40) Left (40)	High	High	High	Low	Unclear
Gautam (2021)	Cadaver	Nepal	Right (42) Left (28)	High	Low	High	Low	High
Amin (2020)	Cadaver	Egyptian	Right (21) Left (19)	High	Low	High	Low	Low
Mathangasinghe (2021)	Cadaver	Sri Lanka	Right (12) Left (12)	Low	Low	High	Low	Low
Anjankar (2017)	Cadaver	Indıa	Right (39) Left (38)	High	Low	High	Low	Low
Meenakshi (2004)	Cadaver	Indıa	Right (30) Left (30)	High	Low	High	Low	Low
Zareena SK. (2014)	Cadaver	Indıa	Right (40) Left (40)	High	Low	High	Low	Low
Arıyürek (2001)	CT	Turkey	Right(186) Left (186)	Low	Low	High	Low	Low
Rani (2020)	Cadaver	Indıa	Right (30) Left (30)	High	Low	High	Low	Low
Kılıç (2006)	Cadaver	Turkey	Right (30) Left (30)	High	Low	High	Low	Low
Cronin (2010)	CT	USA	Right(150) Left (150)	Low	Low	Low	Low	Low
Yıldız (2004)	CT	Turkey	Right(115) Left (115)	Low	Low	Low	Low	Low
Kumari (2022)	Cadaver	Indıa	Right (21) Left (26)	High	Low	High	Low	Low
Saha (2019)	Cadaver	Indıa	Right (49) Left (54)	High	Low	High	Low	Low
Ganapathy (2018)	Cadaver	Indıa	Right (36) Left (39)	High	Low	High	Low	Low

Abbreviations: Domain 1: Objective(s) and study characteristics; Domain 2: Study design; Domain 3: Methodology characterization; Domain 4: Descriptive anatomy; Domain 5: Reporting of results.

Quality assessment

Quality assessment are summarized in Table 1. The majority of studies evaluated by the AQUA tool revealed that domain one (Objective(s) and subject characteristics) and domain three (Methodology characterization) were at "High" risk for bias (due to the lack of demographic data of the research group and no information on the experience of the researchers). Most other studies had a 'Low' risk of bias found in field two (study design), field four (descriptive anatomy) and field five (reporting results).

Variations of horizontal, oblique and accessory fissures in the lungs

A total of 7366 lungs, 3738 right and 3628 left lungs, were examined in 60 articles reviewed regarding the variations of fissures observed in them. The completion rate of horizontal fissures in 3738 right lungs examined was 56.5%, whereas the incompleteness rate of fissures was 34.5%, and the absence rate of horizontal fissures was 8.9%. The completion rate of the oblique fissures was 72.9%, the incompleteness rate of oblique fissures was 25.6%, and the absence rate of the oblique fissures was 1.4% in right lungs. The incidence rate of accessory fissures in the right lungs was found to be 10.2%. In 3628 left lungs, the incidence rate of the oblique fissures was 72.6%, the incompleteness rate of fissures was 25.7%, and the absence rate of the oblique fissures was 1.65%. The incidence rate of accessory fissures in the left lungs was 11.2%.

Variations types of accesory fissures in the lungs

In 20 articles on variation types of accessory fissures in the lungs, a total of 2623 lungs, 1341 right lungs and 1282 left lungs, were examined. In the right lungs, the incidence rate of superior accessory fissures was 4.7%, the incidence rate of inferior accessory fissures was 8.9%, the incidence rate of azygos fissures was 0.7%, and the incidence rate of other accessory fissures was 2.1%. In the left lungs, the incidence rate of superior accessory fissures was 3.3%, the incidence rate of inferior accessory fissures was 5.1%, the incidence rate of left horizontal fissures was 9.9%, and the incidence rate of other accessory fissures was 1.5%.

Variations of hilar structures in the lungs

In the 12 reviewed articles on variations of hilar structures in the lungs, a total of 944 lungs, 503 right lungs and 441 left lungs, were examined. The incidence rate of a single pulmonary artery in the right lungs was found to be 26.6%, and the incidence rate of two or more pulmonary arteries was found to be 38.2%. The incidence rate of a single pulmonary vein was 1.6%, whereas the incidence rate of two pulmonary veins was 38.6%, and the incidence rate of three or more pulmonary veins was 30.2%. While the incidence rate of a single bronchus was 3.4%, the incidence rate of two or more bronchi was 63.6%. In the left lungs, the incidence rate of a single pulmonary artery was 49.9%, while the incidence rate of two or more arteries was 12.5%. The incidence rate of a single pulmonary vein was 3.0%, the incidence rate of two pulmonary veins was 47.4%, and the incidence rate of three or more pulmonary veins was 19.5%. Whereas the incidence rate of a single bronchus was 45.1%, the incidence rate of two or more bronchi was 29.9%.

The heterogeneity between the studies

Heterogeneity statistics between studies are presented in table 2. Except for some parameters (superior accesory fissure in the right lung, other accessory fissures in the right and left lungs, azygos fissure in the right lung, single vein and single bronchus in the left lung), the heterogeneity between studies examining other parameters was statistically significant ($p<0.001$). For the I-square test, the heterogeneity of superior accessory fissures observed in the right (58.0%) lung, azygos fissure (56.3%), other accessory fissures observed in the right (40.2%) and left (0%) lungs, single vein (6.0%) and single bronchus (58,5%) in the left lung was found to be lower than in other parameters according to the studies.

DISCUSSION

Our study examined 68 articles on variations of lung fissures and hilar structures. The prevalence of variations of lung fissures and hilar structures differ according to studies. This may be due to the fact that the studies were conducted in different populations and with different methods, or the developmental state of the lungs.

Table 2. Heterogeneity statistics of studies on variations of fissures and hilar structures.

Parameter	Number of studies	Pooled Prevalance % (95% CI)	Chi- Square Test Cochran's Q, p-value	I^2 (Higgins) Test
Complete Horizontal Fissure (R)	60	56,5 (44,0-69,0)	P<0,001	90,3%
Incomplete &Absent Horizontal Fissure (R)	60	43,4 (30,9-55,9)	P<0,001	92,7%
Complete Oblique Fissure (R)	60	72,9 (61,6-84,2)	P<0,001	82,7%
Incomplete &Absent Oblique Fissure (R)	60	27,0 (15,7-38,3)	P<0,001	92,4%
Complete Oblique Fissure (L)	60	72,6 (61,3-83,9)	P<0,001	80,15%
Incomplete &Absent Oblique Fissure (L)	60	27,3 (16,1-38,5)	P<0,001	91,6%
Accesory Fissure (R)	60	10,2 (2,6-17,8)	P<0,001	94,4%
Accesory Fissure (L)	60	11,2 (3,3-19,1)	P<0,001	97,3%
Superior Accesory Fissure (R)	20	4,7 (0,0-13,9)	P>0,001	58,0%
Superior Accesory Fissure (L)	20	3,3 (0,0-11,1)	P<0,001	69,4%
Inferior Accesory Fissure (R)	20	8,9 (0,0-21,4)	P<0,001	76,2%
Inferior Accesory Fissure (L)	20	5,1 (0,0-14,7)	P<0,001	94,6%
Left Minor Fissure	20	9,9 (0,0-23,0)	P<0,001	93,0%
Azygos Fissure (R)	20	0,7 (0,0-4,3)	P>0,001	56,3%
Other Accesory Fissure (R)	20	2,1 (0,0-8,4)	P>0,001	40,2%
Other Accesory Fissure (L)	20	1,5 (0,0-6,8)	P>0,001	0%
One Artery (R)	12	26,6 (1,6-51,6)	P<0,001	95,0%
One Artery (L)	12	49,9 (21,6-78,2)	P<0,001	91,5%
Two Arteries and More (R)	12	38,2 (10,8-65,6)	P<0,001	91,4%
Two Arteries and More (L)	12	12,5 (0,0-31,2)	P<0,001	86,7%
One Vein (R)	12	1,6 (0,0-8,7)	P<0,001	99,7%
One Vein (L)	12	3,0 (0,0-6,1)	P>0,001	6,0%
Two Veins (R)	12	38,6 (11,1-66,1)	P<0,001	90,6%
Two Veins (L)	12	47,4 (19,2-75,6)	P<0,001	92,6%
Three Veins and More (R)	12	30,2 (0,2-60,2)	P<0,001	93,7%
Three Veins and More (L)	12	19,5 (0,0-41,9)	P<0,001	84,9%
One Bronchus (R)	12	3,4 (0,0-13,6)	P<0,001	99,3%
One Bronchus (L)	12	45,1 (17-73,2)	P>0,001	58,5%
Two Bronchi and More (R)	12	63,6 (36,4-90,8)	P<0,001	95,6%
Two Bronchi and More (L)	12	29,9 (4,0-55,8)	P<0,001	83,0%

The epithelium of the lungs starts to develop from the endoderm of the foregut after the 4th week. First, a laryngotracheal groove is formed, and a lung bud develops out of the groove. The laryngotracheal tube is formed when this groove grows longer, and its lower parts form the bronchial cartilage. In the following process, bronchial cartilages branch and form the bronchial tree of the lung (Waschke et al., 2016). After several generations of branching, bronchopulmonary segments start to emerge. Bronchopulmonary segments fuse to form fissures and lobes in fully developed lungs. Incomplete or absent fissures may result from a defect in the obliteration of these fissures (Kc et al., 2018). Accessory fissures may arise from the non-fusion of the spaces between the bronchopulmonary segments. Differences in the formation of lung fissures and lobes during development may result from the presence of any factor that triggers the fusion of bronchopulmonary buds (George et al., 2014).

According to the results of the data in our study, it is seen that the prevalence of the completion of the horizontal fissures of the right lung (56.5%)

was lower compared to the oblique fissures of the right and left lungs. The prevalence of incompleteness of the horizontal fissures of the right lung was found to be 34.5%, which is higher than that of the oblique fissures of right and left lung. In their study, Joshi et al. (2022) stated that the incidence rate of incomplete horizontal fissures was higher. The study by Lakshmi et al. (2018) reported that the development of fissures might be incomplete due to genetic and environmental factors during the development of the lungs. The incidence rate of the absence of the horizontal fissures of the right lung was found to be 8.9%, and the prevalence of the variation was higher than that of oblique fissures. In their study, Kc et al. (2018) stated that the absence of horizontal fissures was a common variation. Ranaweera et al. (2022) reported in their study that the incompleteness or absence of lung fissures might result from a defect due to complete or incomplete obliteration of the fissures before birth. The completion, incompleteness, and absence rates of the right and left oblique fissures were almost close to each other. In addition, the prevalence of accessory fissures in the right and left lungs is similar. The prevalence of oblique and accessory fissures in our study was close to each other, indicating that the number of lungs in the 60 studies examined and the number of variations observed in the fissures were parallel to each other.

As a result of 20 studies investigating the prevalence of variation types of accessory fissures, the inferior accessory fissure had the highest prevalence in the right lung (8.9%), and the left horizontal fissure had the highest prevalence in the left lung (9.9%). In their study, Arıyürek et al. (2001) reported that the incidence of inferior accessory fissure is the most common in the right lungs. Yıldız et al. (2004) and Kılıç et al. (2006) stated in their study that the incidence of left horizontal accessory fissure is common in the left lungs. Accessory fissures are formed as a result of the absence of permanence or obliteration of prenatal fissures. Any change in the structure of prenatal fissures shows that the way the lung develops is different (Sailaja et al., 2019). Knowing the accessory fissures enables the fissure to be distinguished from the other normal and pathological ones. Furthermore, it is helpful for segmental localization in numerous diseases (Hema, 2014). Accessory fissures lead to sharply limited pneumonia by assuming a preventive responsibility against the spread of the infection (Godwin and Tarver, 1985). Accessory fissures may form accessory lobes depending on their localization. This finding is frequently seen in infants (Nene et al., 2011). Moreover, knowing accessory fissures is important, since they are often misevaluated or not identified while the lung is examined on radiographs and CT scans (Magadum et al., 2015).

As a result of 12 studies examining the prevalence of variations in the structures in the lung hilum, the incidence rate of a single pulmonary artery was found to be 49.9%, two pulmonary veins to be 47.4%, and a single bronchus to be 45.1% in the left lungs. The incidence rate of two or more arteries in the right lung was 38.2%, the incidence rate of a two pulmonary vein was 38.6%, and the incidence rate of two or more bronchi was 63.6%. Our findings overlap with the study done by Wahengbam et al. (2019). Murlimanju et al. (2012) stated in their studies that left lung hilum variations were higher than the right lung and the frequency of variation was not clearly explained in the textbooks. In their study, Kc et al. (2018) reported that the variations in the number and model of hilar structures in human lungs were not examined in detail. Also reported a higher incidence of 2 arteries in the right lungs compared with previous studies. The study by Jacob et al. (2019) revealed that almost no studies were conducted on the hilar pattern in the literature. In their study, Wahengbam et al. (2019) explained that, in addition to the shape in lung morphology, fissures and lobes, different variations of hilar structures may appear, and the range of these variations observed within large and different populations and affecting lung development might result from genetic or environmental factors or both. Considering all these facts, knowing the lobar and hilar anatomy of the lungs is of great significance for clinicians, surgeons, and radiologists (Jethva et al., 2019).

This study is limited, as the lungs were mostly studied on cadavers and the majority of the studies were from the Indian population. In addition, while the number of studies examining fissure variations of the lungs is high in the literature, studies examining accessory fissures and hilar structures are rare. In new studies to be conducted with different methods and techniques, lung samples should be examined by considering gender and age differences, and new studies should be performed more comprehensively in different and larger populations, including types of accessory fissures and hilar structures.

CONCLUSION

Our study examined variation types of lung fissures and hilar structures and their incidences. The completion rate of the horizontal fissures of the right lung (56.5%) was lower than that of oblique fissures, and the rates of incompleteness (34.5%) and absence (8.9%) were higher than those of oblique fissures. The completion, incompleteness, and absence rates of the oblique fissures of the right and left lung were close to each other. The incidence rate of accessory fissures was higher in the left lungs (11.2%) than in the right lungs (%10.2), whereas the incidence rates of the horizontal accessory fissure (9.9%) in the left lung and the inferior accessory fissure (8.9%) in the right lung were the highest. While the incidence rates of a single pulmonary artery (49.9%), two pulmonary veins (47.4%) and single bronchus (45.1%) were the highest in the left lungs, the incidence rates of two or more pulmonary arteries (38.2%), two pulmonary veins (38.6), and two or more bronchi (63.6%) were the highest in the right lungs. In this study, will be useful for clinicians in interpreting radiological images, diagnosing lung pathologies, and applying surgical procedures. We think that knowing the variations of lung fissures and hilar structures will be theoretically and clinically beneficial.

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