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Anatomical Variations in Fissure of the Lung on Computed Tomography

Bilgisayarlı Tomografide Akciğer Fissüründeki Anatomik Varyasyonlar

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ABSTRACT

Objective: Lung fissures embryologically separate the bronchopulmonary segments from each other. We aimed to detect anatomical variations in fissures in patients who underwent thoracic computed tomography (CT).

Materials and Methods: All the patients underwent a thoracic CT examination between July 1 - July 15, 2022. The patients' gender, lung fissures continuity, accessory fissures presence, and variation side were recorded. The frequency of fissures was compared between the genders using the chi-square test.

Results: The study included a total of 352 patients (211 men, 141 women). A total of 105 variations were detected in 95/352 (26.99%) of the patients, 61/211 (28.91%) were male, 34/141 (24.11%) were female. The right oblique fissure was incomplete in nine (2.6%), and the right horizontal fissure was incomplete in 14 (4%) patients and absent in 14 (4%). The left oblique fissure was observed to be incomplete in 16 (4.5%) patients. A total of 52 (14.8%) accessory fissures were detected.

Conclusions: In the literature, a wide variety of fissure variations have been reported. Due to this diversity, having good knowledge of the fissure anatomical architecture is essential when performing surgical procedures and interpreting radiological images to clinically identify the location of bronchopulmonary segments.

Keywords: Anatomic variation, computed tomography, lung fissure

ÖZ

Amaç: Akciğer fissürleri embriyolojik olarak bronkopulmoner segmentleri birbirinden ayırırlar. Bu nedenle biz de toraks bilgisayarlı tomografi (BT) çekilen hastalarda fissürlerdeki anatomik varyasyonları bulmayı amaçladık.

Materyal ve Metot: Çalışmamıza 01 -15 Temmuz 2022 tarihleri arasında toraks BT tetkiki çektiren tüm hastalar dahil edilmiştir. Hastaların cinsiyetleri, akciğer fissürlerinin devamlılık durumu, aksesuar fissür varlığı ve varyasyonun tarafı kaydedildi. Cinsiyetler arası fissür sıklığı ki-kare testi kullanılarak değerlendirilmiştir.

Bulgular: Çalışmamıza toplamda 352 hasta (211 erkek, 141 kadın) dahil edildi. hastaların 95/352 (%26,99) tanesinde 105 varyasyon tespit edildi bunların 61/211'i (%28,91) erkek, 34/141'i (%24,11) kadındı. Sağ oblik fissür dokuz (%2,6) hastada inkomplet; sağ horizontal fissür 14 (%4) hastada inkomplet, 14 (%4) hastada ise yoktu. Sol oblik fissür 16 (% 4,5) hastada inkomplet olarak izlendi. Toplamda 52 (%14,8) aksesuar fissür tespit edildi.

Sonuç: Literatürde çeşitli fissür varyasyon sıklığı bildirilmiştir. Bu çeşitlilik nedeniyle, cerrahi işlemler yapılırken ve radyolojik görüntüleri klinik olarak yorumlarken bronkopulmoner segmentlerin yerini tespit etmek için fissür anatomik yapısını iyi bilmek önemlidir.

Anahtar Kelimeler: Anatomik varyasyon, bilgisayarlı tomografi, akciğer

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INTRODUCTION

The lungs are the main respiratory organs covering most of the thoracic cavity. The lungs have a half-conical shape and comprise an apex, a base, three faces, and three borders. The lung consists of three lobes on the right (superior, middle, and inferior) and two lobes on the left (superior and inferior). Lung lobes are separated from each other by fissures on both sides.[1] Lung fissures embryologically separate the bronchopulmonary segments from each other. Fissures show continuity in the interlobar plane in adult life. Horizontal fissures can be detected in 60% of anterior-posterior frontal chest radiographs. The oblique fissure is usually visible on the lateral radiograph. In addition, high-resolution computed tomography (CT) shows this fissure as a curved band from the lateral to the hilum.[1,2]

Anatomically, contrary to classical knowledge, fissures show a wide variety of variations. Accessory fissures are usually detected at the borders between the broncho-segments. Common accessory fissures are the superior accessory fissure (SAF), inferior accessory fissure (IAF), and left horizontal fissure (LHF). SAF separates the superior segment in the lower lung lobe from other lung lower lobes, IAF separates the small infra-cardiac lobe from other lung lower segments, and LHF separates the lingula from the different left upper lobe segments.[3] In addition to the presence of variations, the continuity of existing fissures also varies. Fissures that exist in classical anatomy are sometimes partially present and sometimes absent.[4] With the increasing use of imaging methods, there has also been an increase in the rate of fissure variation detection and identification of fissure types.[5,6] Cadaver studies and imaging studies have reported the presence of lung fissure variations at different rates. The detection of anatomical variations in fissures, especially with CT used for lung imaging, is important in pre-surgical planning. The absence of a fissure or presence of extra fissures may cause technical difficulties in separating the lobes and increase the risk of postoperative air leak, blood loss, and bronchopleural fistula formation.[6,7]

Therefore, in this study, we aimed to identify anatomical variations in fissures in patients who underwent thoracic CT and compare the frequency of these variations between the genders.

MATERIALS AND METHODS

Ethics Committee Approval: The study was approved by the Ethics Committee of the Yıldırım Beyazıt University, Yenimahalle Training and Research Hospital (Date: 31.08.2022, decision no: E-2022-52), and performed by Helsinki Declaration.

Participants: All patients who underwent a thoracic CT examination 16-slice device (Alexion, Toshiba, Tokyo, Japan) for any reason at our hospital between July 1, 2022, and July 15, 2022, were included in the study. Patients whose thoracic CT was not of diagnostic quality and those with a history of lung surgery and or major pulmonary trauma were not included in the study. In all patients, reconstructed images in 1-mm axial, 3-mm coronal and 3-mm sagittal sections were examined. The patients' gender was recorded. In addition, the presence of normal and accessory fissures was noted. Lastly, the sides of the fissures (right oblique, right horizontal, and left oblique) and their continuity (complete, incomplete, and absent) were evaluated.

Data Analysis: Patients' ages were noted as mean and standard deviation. The numbers of different fissure variations in both lungs were recorded, and their percentages within the total population were expressed. The numbers of fissure variations were recorded for both genders. Chi-square tests were used to test the frequency of all fissure variations and the total number of accessory fissures between genders. SPSS (version 23) software package was used for statistical analysis.

RESULTS

During the study period, a total of 368 thorax CT examinations were undertaken. Of these, 14 were not included in the study since they were not of the diagnostic quality to evaluate fissures, one was excluded due to a history of surgery, and another due to previous trauma. The remaining 352 patients, 211 men and 141 women were included in the sample. The mean age was 38.34±13.18 years for all the patients, 37.53±13.06 years for the men, and 39.55±13.31 years for the women. A total of 105 variations were detected in 95/352 (27%) of the patients, of whom 61/211 (28.9%) were male and 34/141'i (24.1%) were female. In six male and four female patients, there were two variations, one in each lobe (Table 1).

Table 1. Distribution of patient information.

	Male	Female	Total
Patient, n (%)	211 (59.9)	141 (40.1)	352 (100)
Age, (year) mean±SD	37.53 ± 13.06	39.55 ± 13.31	38.34 ± 13.18
Fissure Variation, n (%)	61/211 (28.91)	34/141'i (24.1)	95/352 (27)
Accessory Fissure, n (%)	35 (16.6)	17 (12.1)	52 (14.8)

SD: Standard Deviation.

Of all the variations, 71 (67.6%) were on the right side, and 34 (32.4%) were on the left. The right oblique fissure was complete in 343 (97.4%) patients and incomplete in nine (2.6%) (Figure 1), and the right horizontal fissure was complete in 324 (92%) patients, incomplete in 14 (4%) and absent in 14 (4%). The left oblique fissure was complete in 336 (95.5%) patients and incomplete in 16 (4.5%) patients when evaluating the fissure variations in the left lung in detail (Table 2).

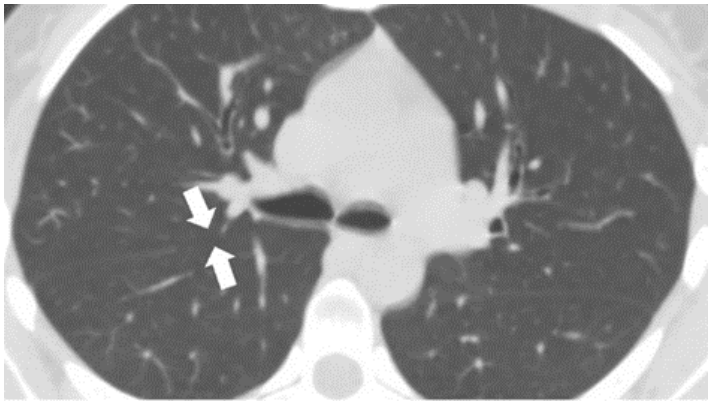

Figure 1: Thorax computed tomography image in the axial section showing an incomplete oblique fissure (arrows) in the right lung.

Table 2. Fissure variations in both lungs.

		Complete	Incomplete	Absent	Accessory
		n (%)	n (%)	n (%)	n (%)
Right	**Oblique**	343 (97.4)	9 (2.6)	0	34 (9.7)
	Horizontal	324 (92)	14 (4)	14 (4)	-
Left	**Oblique**	336 (95.5)	16 (4.5)	0	18 (5.1)

A total of 52 (14.8%) accessory fissures were found when the frequency of these fissures was assessed, with 35 (9.9%) in male patients and 17 (4.8%) in female patients. In 26 patients, an inferior accessory fissure was detected, and in 14 patients, a superior accessory fissure was detected. Both fissures were predominantly found on the right side. In our study, more rarely, the left horizontal fissure, accessory fissure between the right middle lobe medial and lateral segments (Figure 2), and accessory fissure between the right anterobasal and laterobasal segments variations were detected. Accessory fissure variations were found in 34 (9.7%) cases on the right lung and 18 (5.1%) cases on the left lung (Table 3).

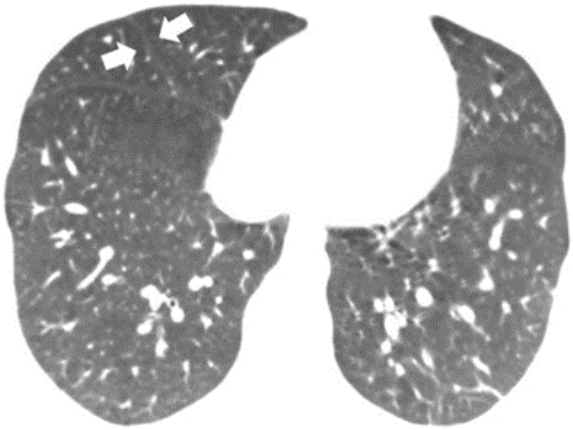

Figure 2: Axial section image showing an accessory fissure (arrows) between the lateral and medial segments in the middle lobe of the right lung.

Table 3. Incidence of accessory fissures.

	Total n (%)	Right n (%)	Left n (%)	Men n (%)	Women n (%)	p- values
Superior accessory fissure	15 (4.3)	14 (4)	1 (0.3)	12 (3.4)	3 (0.9)	0.105
Inferior accessory fissure	26 (7.4)	18 (5.1)	8 (2.3)	16 (4.5)	10 (2.8)	0.556
Left horizontal fissure	9 (2.6)	-	9 (2.6)	6 (1.7)	3 (0.9)	0.677
Accessory fissure between the right antero-basal and laterobasal segments	1 (0.3)	1 (0.3)	0	0	1 (0.3)	-
Accessory fissure between the right middle lobe medial and lateral segments	1 (0.3)	1 (0.3)	0	1 (0.3)	0	-
Total	52 (14.8)			35 (9.9)	17 (4.8)	0.139

DISCUSSION AND CONCLUSION

In the literature, it has been reported that the absence of fissures or presence of incomplete fissures may result from their partial obliteration, and fissures may form due to the non-obliteration of normally obliterated spaces.[8] As the utilisation of current imaging studies continues to rise, our understanding of anatomical variations and incidental findings is expanding.[3,6] However, data on lung fissures are mostly from cadaver studies, and there are fewer studies conducted with CT.[3-7] Technological advancements have made CT scans increasingly valuable in assessing these variations. This is due to their ability to produce thinner sectional images, examine various planes, and enable the evaluation of larger sample sizes.[9-12]

The rates of incomplete fissures reported in radiology studies in the literature show significant variations, ranging from 8.4-85% for right oblique fissures, 6.3-74% for left oblique fissures, and 0.5-90% for horizontal fissures.[6,9-12] In cadaver studies, the frequency of variations in fissure continuity has been shown to range from 6 to 60% for the right oblique fissure, 12 to 42.5% for the left oblique fissure, and 8 to 83.4% for the horizontal fissure.[4,13-15] As seen in both cadaver and CT studies, there are significant differences in the reported rates. It should be kept in mind that these rates may vary according to the population evaluated. In our study, the rate of incompleteness was calculated as 2.6% for the right oblique fissure, 4.5% for the left oblique fissure, and 4% for the right horizontal fissure. These rates are lower than reported in previous studies. One reason for this discrepancy is that the section thickness was 5 mm in previous radiological studies. At the same time, our study used 1-mm and 3-mm sections, which may have provided more accurate results in evaluating fissure continuity. Similar to our study, a recent CT study reported lower rates for incomplete fissures (8.4% for the right oblique fissure, 6.3% for the left oblique fissure, and 0.5% for the right horizontal fissure).[6]

Data on the absence of fissures also vary in the literature. In some studies, the absence of fissures was not mentioned, and the rate was not reported.[5] In other studies reporting these rates, the right oblique fissure was absent in 0-12.5% of cases, the left oblique fissure in 0-10.7%, and the right horizontal fissure in 0-34.62%.[5,16-19] In a CT study, only the right horizontal fissure was found to be absent, and this was detected at a rate of 0.4%.[6] In our study, we did not detect the absence of the right oblique or left oblique fissure in any of the patients, while the right horizontal fissure was absent at a rate of 4%.

In the literature, variations of SAF, IAF, LHF, accessory fissures located between the anterobasal and laterobasal segments (ALAF), those located between the medial and lateral segments of the middle lobe (MLAF), and those located between the superior and inferior lingular segments, and azygos fissures have been described.[20] In our study, accessory fissures were detected in 26.99% of the patients. In two previous CT studies, accessory fissures were reported at a rate of 7.3% and 32%.[6,20] In studies conducted with cadavers, accessory fissures varied between 0 and 66.6%.[16,21,22]

In our study, the most common accessory fissure was IAF with a frequency of 7.4%. The rate of IAF was previously reported as 9.03% by Arıyürek et al.[20], 12% by Yıldız et al.[23], and 3.92% by Manjunath et al.[6], who all noted that this was the most common accessory fissure. In addition, IAF was found more frequently on the right side in all three studies.[6,20,23] These findings support our study. We observed that 5.1% of IAFs were on the right, and 2.3% were on the left. SAF is the second most common variation and can be seen in both lungs. SAF partially or completely separates the lower lobe superior segment from other basal segments, and as a result, the dorsal lobe is formed.[24] In a cadaver study, Deve reported this variation at a rate of 22% in the right lung and 8.7% in the left lung.[25] Similar-

ly, Langlois and Henderson [26] reported the presence of SAF as 17.5% on the right and 2% on the left. In our study, we found the presence of SAF on the right in 4% of the patients and on the left in 0.3%. Similar to the literature, SAF variation was higher on the right, but its frequency was lower than reported in previous studies. Another frequently reported fissure is LHF, which is a common lung fissure form that divides the left upper lobe into two almost equal parts. The lower part of the fissure is called the left middle lobe.[27] LHF has been reported to have a 7.5-29.62% frequency in cadaver studies.[5,13] In our study, we determined the rate of LHF as 2.6%. In another study conducted with CT, the rate of LHF was lower at 1.3%.[6] In our study, the total variation and presence of accessory fissures were higher on the right than on the left. Literature studies also support this finding. In addition to these fissures, one ALAF and one MLAF were found in our study. MLAF divides the right middle lobe into two. This variation has rarely been reported in case reports or some studies. In a study conducted with high-resolution CT, Arıyürek et al.[20] reported this variation in three (2%) patients. In another study, this variation was observed in six (5%) of the 115 patients.[23] In the same study, ALAF was found in one patient.[23] In our study, we did not detect any other subsegmental accessory fissures. In addition, there was no patient with the azygos fissure described in some studies.

Accessory fissures and fissure variations are usually detected incidentally and do not cause any symptoms. However, accessory fissures may not always be reported in CT imaging. Some parts' thickness can sometimes be misidentified due to different morphologies and planar orientations. In imaging methods, lung fissures can be used as a sign, especially to identify pulmonary lesions, and the completeness of a fissure may be important for treatment planning in patients with these lesions. Evaluating our data considering the literature, it is remarkable that fissure variations can be incidentally detected in healthy populations, regardless of the reason for the CT examination. The frequency and types of these variations markedly differ in the literature. Various genetic and environmental factors can be cited as the main reason for these differences.[16] These fissure variations have been reported to represent the side of a spectrum compatible with life. At the other end of the spectrum are various anomalies, such as agenesis and hypoplasia. Advanced levels of these anomalies are seen together with cardiovascular abnormalities.[28,29] Although the exact etiology remains unclear, it has been reported that vitamin A deficiency, viral infections, genetic factors, and embryological neuronal crest damage may cause delays in lung development at various levels, as well as agenesis, hypoplasia, and variations.[27]

In conclusion, the most common variations in our study were the incompleteness of the right horizontal fissure and left oblique fissure, and the absence of the right horizontal fissure. The most common accessory fissure was the right IAF. When evaluated with previous studies, various variations are reported with varying frequencies. Due to this diversity, having good knowledge of the lobar and fissure anatomical architecture is essential when performing surgical procedures and interpreting radiological images to clinically identify the location of bronchopulmonary segments and determine the localization of variations. There are certain limitations to our study, with the most important being the limitations of CT itself. Although we evaluated thin CT sections in three planes, we may have overlooked some fissure variations. Therefore, we may not have been able to make a precise assessment as in cadaver studies. However, our design provided an advantage in terms of reaching more patients than cadaver studies. Another limitation can be considered as the evaluation of CT images by a single radiologist, even if he is experienced in thoracic CT.

Ethics Committee Approval: The study was approved by the Ethics Committee of the Yıldırım Beyazıt University, Yenimahalle Training and Research Hospital (Date: 31.08.2022, decision no: E-2022-52), and performed by Helsinki Declaration.

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