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Anatomical variations of the lung fissures assessed by high resolution computed tomography (HRCT) of chest – a cross sectional study at tertiary center of Nepal

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Abstract

Introduction: The lungs are a pair of vital organs of respiration which are divided into lobes by fissures which facilitate the movements and uniform expansion of lobes. The fissure may be complete, incomplete, or absent; knowledge of which is vital for both clinician and surgeons. High Resolution Computed tomography (HRCT) chest can clearly depict the fissural anatomical variation. The objective of this study was to analyze the morphology of lung fissures undergoing HRCT.

Method: This cross-sectional study was done among 247 patients undergoing HRCT in Dept. of Radiology, Patan Hospital. The HRCT images were visually analyzed and categorized. Statistical analysis was performed using SPSS.

Result: Out of 247 patients, classical trilobed right and bilobed left lung was seen in only 69(24.94%) subjects. Rest of the subjects had some anatomical variation of lung fissure. Incomplete oblique fissure was seen in 23(9.31%) and 18(7.28%) on the right and left side respectively. The inferior accessory fissure was seen among 50(20.24%) individuals, followed by left minor fissure among 23(9.31%), superior accessory fissure among 17(6.88%), fissure in right middle lobe among 23(9.31%) and azygyous fissure among six (2.41%). The significant difference was only seen in the completeness oblique fissure with respect to gender ($p < 0.05$).

Conclusion: Classical fissural anatomy was found in only 69(24.94%) patients and common other variations were also noted in our study. Variations in the fissures are not uncommon. This study reinforces the importance of considering anatomical variations of the fissures whenever interpreting the radiographs and plan surgical procedure.

Keywords: Anatomy; Accessory fissure; Anatomical variation; High resolution computed tomography (HRCT)

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Introduction

Pulmonary fissures are double layers of in-folded invaginations of visceral pleura that exist between the various lobes, allowing greater distention and movement of the lobes during respiration.[1,2] Many potential anatomic configurations of lung fissures are frequently unrecognized.[3] High Resolution Computed Tomography (HRCT) is a noninvasive imaging modality for the optimal visualization of the lung fissures.[4] Multiple studies have been carried out for prevalence of various pattern of lung fissures.[5,6] In a study done previously in Nepal, prevalence of incomplete right oblique fissure was 22%, incomplete right horizontal fissure seen in 12.5%, incomplete left oblique fissure was seen in 21%.[7] Preoperative knowledge of variants lung fissures anatomy may reduce extensive exploration during surgery for lung cancer; advanced pulmonary tuberculosis and consequently decrease operative time and complications like bleeding, postoperative air leak, and broncho-pleural fistula.[8] Incomplete fissures can also cause improper lung expansion, which can contribute to hypoxia in patients with intrathoracic illnesses. When a fissure is incomplete or absent, pneumonia and malignancy can easily spread to the adjacent lobes.[7,9] Thus, detailed knowledge of the normal and accessory fissures of the lung on imaging modalities like HRCT is of paramount importance. Most of the previous studies are based on cadavers.[10] There is a lack of similar studies on anatomical variations based on HRCT scans in Nepalese population as seen through a database search on NepJol, PubMed, Sage Wiley, Science Direct and, Springer. This study is aimed at finding the prevalence of different types of anatomical variations of lung fissures in patient undergoing HRCT.

Method

This observational cross-sectional study was conducted in Department of Radiology, Patan Hospital from Feb 2024 to Jun 2024 after ethical clearance from the Institutional Review Committee (IRC) (Ref: drs2402021837) of Patan Academy of Health Sciences (PAHS). A total of 247 patients were included in the study based on inclusion and exclusion criteria using convenience sampling technique. Informed consent was taken from the patients before including them in the study. HRCT studies of patients who have undergone major surgery that would have altered vascular anatomy of lung fissures (e.g. lobectomy, resection of lung and segmental resection) and pathologies such as extensive pneumonia, transfissural mass lesion were excluded. Similarly, suboptimal HRCT study (such as motion artefacts, poor visualization of fissures) were also excluded from the study.

Sample size was calculated based on Cochrane's formula at 95% level of significance and allowable error (e) at 5%.

The tabulated value of Z at 95%level of significance is 1.96, $Z^2 = (1.96)^2 = 3.84$;
prevalence (p)= 0.22[7],
q=100-p=77;
$e^2 = 25$.
The calculated sample size was 247.

Patients undergoing HRCT of chest were scanned with Philips Ingenuity 128 Slice Computted Tomography (CT) in Department of Radiology in coronal, axial and sagittal planes by the radiology technician as per the standard protocol. All scans were performed using 128-Slice Volume CT scanner, with a multidetector CT using 1.25 mm collimation and 0.8 mm reconstruction interval, 140 kVp, and average 300 mA tube current with pitch of 1.375. Scans were routinely obtained at end inspiration with the lungs fully expanded in supine position. Multiplanar reformation (MPR) images and axial images were obtained. Acquired raw data were processed in workstation and images were evaluated for anatomy of lung fissures in Philips Portal software version 11.

The presence or absence of the normal and accessory pulmonary fissures were documented as described in a previous study.[5] These fissures include the normal fissures namely; right major fissure, left major fissure, and right horizontal fissure. Accessory fissures include superior and inferior accessory fissures on both sides, accessory fissures between medial and lateral segments of the middle lobe on right side, accessory fissures between superior and inferior segments of the lingula on left side, accessory fissures between anterior basal and lateral basal segments of the lower lobes on both sides, left horizontal fissure, and azygos fissure. Superior accessory fissure is the accessory fissure between superior and basal segment of the lower lobe. Inferior accessory fissure separates the medial basal segment from the rest of the segments of lower lobe. The left horizontal/minor fissure is an accessory fissure that separates lingula from the rest of the left upper lobe. Azygos fissure occurs only on the right upper lobe, which can have either a vertical or an oblique course.

Result

HRCT of 247 patient were evaluated out of which were 123(49.79%) were males and 124(50.21%) were females. Classical trilobed right and bilobed left lung was seen in only 69(27.94%) subjects. Rest of the subjects had some anatomical variation of lung

fissure; majority of those having multiple accessory fissures in same subject. Our study showed complete oblique fissure in 223(90.28%) on right side and 229(92.71%) on left side. Incomplete oblique fissure was seen in 23(9.31%) and 18(7.29%) on right and left side respectively, while one of the subjects (0.41%) had no oblique fissure at all, Table 1. Two lobes on right side due to the absence of the minor fissure was seen in 15(6.07%), and incomplete minor fissure was seen in 33(13.36%). Azygos fissure happened to occur in six (2.41%) patients. Accessory fissure was seen almost equally on both sides. The most common accessory fissure was inferior accessory fissure seen in 50(20.24%) of the subject followed by superior accessory and left minor fissures in descending order, Table 2. Superior accessory fissure was present in eight (3.24%) in right side and nine (3.64%) on left side whereas inferior accessory fissure was seen in 26(10.53%) on right side and 24(9.70%) on left side. Azygous fissure was present in six (2.41%) subjects. Middle lobe fissure was seen in 11(4.45%) on right side and left minor fissure was seen in 23(9.31%).

Gender wise distribution showed prevalence of incomplete oblique fissure on each side was more in the male when compared with the female gender and was statistically significant (p=0.04). In contrast to incomplete right minor fissure which was seen more in female gender. Accessory fissures and absent right minor fissure were seen equally on both genders. Superior accessory fissure was more common on male subject whereas inferior accessory fissure was more common on left side, Table 3.

Discussion

Our study included 247 patients who underwent HRCT chest examinations from various departments. Among the participants, 123(49.79%) were male and 124(50.21%) were female. Notably, variations

Table 1. Lung fissures and its anatomical variants (N=247)

Variation	Total N(%)	Male N(%)	Female N(%)	Chi-square test (p-value)
Right absent oblique fissure	1(0.41%)	1(0.41%)	0	0.08
Right Incomplete oblique fissure	23(9.31%)	16(6.48%)	7(2.83%)	0.04
Left incomplete oblique fissure	18(7.29%)	13(5.26%)	5(2.02%)	0.04
Right minor fissure incomplete	33(13.36%)	15(6.07%)	18(7.29%)	0.67
Right minor fissure absent	15(6.07%)	7(2.83%)	8(3.24%)	0.79
Right accessory fissure	46(18.62%)	22(8.91%)	24(9.72%)	0.44
Left Accessory fissure	47(19.03%)	25(10.12%)	22(8.91%)	0.54
Total	**178(72.07%)**	**96(38.87%)**	**82(33.20%)**	

Table 2. Frequency of different variants of accessory lung fissures (N=247)

Accessory fissure	Right side	Left side	Total N(%)	Chi square test (p-value)
Superior	8(3.24%)	9(3.64%)	17(6.88%)	0.71
Inferior	26(10.53%)	24(9.72%)	50(20.24%)	0.47
Azygous	6(2.43%)	0	6(2.43%)	
Left Minor fissure	0	23(9.31%)	23(9.31%)	
Fissure in right middle lobe	11(4.45%)	0	11(4.45%)	

Table 3. Gender specific frequency of different variation of lung fissures (N=247)

Accessory fissure	Total number		Chi-square test (p - value)
	Male N(%)	Female N(%)	
Right side	22(8.91%)	24(9.72%)	0.45
Superior accessory fissure	6(2.43%)	2(0.81%)	0.13
Inferior accessory fissure	10(4.05%)	16(6.48%)	0.26
Fissure in right middle lobe	7(2.83%)	4(1.62%)	0.26
Azygous fissure	3(1.22%)	3(1.22%)	0.65
Total	48(32.28%)	49(32.31%)	
Left side	25(10.12%)	22(8.90%)	0.44
Superior accessory fissure	4(1.62%)	5(2.02%)	0.52
Inferior accessory fissure	14(5.67%)	10(4.05%)	0.44
Left minor fissure	13(5.26%)	10(4.04%)	0.55
Total	**56(22.67%)**	**47(19.03%)**	

in fissural anatomy were observed in 178(71.79%) of the subjects, a figure significantly higher than the 18.92% reported in a study done at Navodaya Medical College, India.[4] In terms of gender distribution, 38.87% of the variations were found in males, while 33.16% were noted in females. The remaining 69(27.9%) exhibited normal fissural and lobar patterns. These results indicate that variations in fissural anatomy are relatively common.

Our study showed that variations in fissural anatomy were present in 96(38.87%) right lung and 82(33.16%) left lung. The nearly equal prevalence of variations in both lungs aligns with findings from previous studies conducted in India.[4] The incomplete right minor fissure emerged as the most commonly noted variation, occurring in 13.36% of the cases. This finding contrasts with earlier research, which identified the incomplete right major fissure as the predominant variation, as reported in study done in Czech Republic 35% and Japan 48%.[11,12] Study done in India also noted the incomplete minor fissure as the most frequently observed variation, while another study done in Narayana Medical college, India categorized it as the least common.[13,14] Incomplete fissures accompanied by parenchymal fusion necessitate further dissection during surgical procedures, which can elevate the risk of hemorrhage and postoperative air leaks, particularly following lobectomies and video-assisted thoracic surgery. This condition may also influence the spread of disease and distribution of pleural effusion. Following the incomplete right minor fissure, the right incomplete oblique fissure was noted in 9.31% of cases, while the left incomplete oblique fissure was found in 7.28%. The right minor fissure was absent in 6.07% of cases, and the rarest variation was the right absent oblique fissure, which occurred in only 0.4% of cases.

Different morphologic studies done in India revealed incomplete oblique fissures in the ranges of 20-70%.[15,16,17] Similarly study done in Czech Republic (48% on the right and 43 % cases on the left), University of Michigan, USA (33% on the right and 25% on the left), Turkey (62.5% on the right and 59.7% on the left), Czech Republic (35% on the right and 24% on the left) and India (36.7 % on the right and 27.3% on the left) studies collectively demonstrate a higher prevalence of incomplete major fissures, particularly on the right side.[12,18,19,11,4] In contrast, our research identified incomplete oblique fissures in only 9.31% on the right and 7.28% on the left. This discrepancy may be attributed to the enhanced anatomical resolution provided by the volumetric thin-section MDCT technique, which allows for a more accurate assessment of fissural completeness.

The prevalence of an absent oblique fissure in both lungs is lower than that of an absent minor fissure, with studies reporting a 1% prevalence and another study in Kenya finding it rare.[20,21] Our study observed it in only 0.4% of cases, seen on the right side and in male subject. There was no case of complete absence of the oblique fissures in other studies.[10,19] Other morphologic studies showed absent oblique fissures in the left lung.[15,22,23] The discordance among these studies might be attributed to several factors, including small sample sizes, variability in the presence of incomplete fissures, differences in CT equipment, and technical factors.

The study conducted by Nagasaki University School of Medicine in Japan indicated a higher prevalence of incomplete minor fissures, reported at 63%.[12] In addition, cadaveric research done in India revealed a similar trend, with incomplete right minor fissures occurring in 40-50% of cases.[17,24] Conversely, our findings demonstrate a lower prevalence of 13.36%, with a marginally higher occurrence in females 7.28% compared to males 6.07%, which is somewhat consistent with the study done in India at 2.3%.[4] The right minor fissure was found to be absent in 6.07% of cases, showing a slight variation between genders (2.83% in males and 3.23% in females). Likewise, other studies also reported a lower prevalence of absent right minor fissures in the range of 1.56-2.6%.[4,10] It is noteworthy that thin slices taken at closer intervals tend to provide a more comprehensive view of the fissure compared to thicker sections or those taken at wider intervals. Additionally, factors such as racial diversity and the characteristics of the study population may also impact the results.

The accessory fissure was identified in 16.59% of cases on the right side, with a higher occurrence in females 8.90% compared to males 7.69%. On the left side, the accessory fissure was present in 19% of cases, showing a slightly greater prevalence in males 10.12% than in females 8.90%. Among the various accessory fissures, the inferior accessory fissure emerged as the most prevalent variation in our study, consistent with findings done at Indian Institute of Medical Science and Research, India 12%.[25] Our research indicated a prevalence of 10.5% on the right and 9.7% on the left, which is lower than the autopsy findings that report frequencies between 30% and 50%. Other studies, such as study done at University Faculty of Medicine, Turkey 21%, support these cadaveric observations.[19] However, our results are in agreement with study done at Nagasaki University School of Medicine, Japan, who reported an 8.6% incidence, predominantly in the right lung 80%, and with another study done at Kasturba Medical College,

India who noted a 5.55% occurrence in the right lung and 5% in the left, suggesting a higher prevalence on the right side.[12,26] Study done at Manipal Medical College, India did not observe any inferior accessory fissure in the left lung but recorded a 5% incidence in the right lung.[27] Other studies reported occurrences of 3.9% (2.1% on the right and 1.7% on the left) and 1%, respectively.[4,10] In contrast, study done at GSL Medical College, India found a higher incidence of inferior accessory fissure in the left lung 24% compared to the right 14%.[28] Another study done in Turkey documented a right-to-left inferior accessory fissure ratio of 19:1, while our study, along with study done at University of Michigan revealed a less pronounced ratio of 1.08:1 and 2.1:1, respectively.[29,30] The frequent detection of inferior accessory fissures may be attributed to their sagittal orientation, which facilitates easy visualization on axial HRCT. Conversely, other accessory fissures are oriented horizontally, making them more challenging to visualize and more susceptible to being overlooked in the interslice gap, potentially leading to an underestimation of their frequency. Although this fissure is present in 30–50% of autopsy specimens, we found it in only 10% of subjects in our study.

A fissure dividing the right middle lobe is rarely described. Some anatomic study has revealed such fissures.[31] Our study showed the presence of a fissure in the right middle lobe in 4.5% of cases like the study done at Hacettepe University Faculty of Medicine, Turkey which showed in 2% of cases.[19] In contrast, study done at Japan demonstrated this fissure in large proportion seen in 16 % of the cases.[20]

Superior accessory fissure was found in 5±30% of autopsy specimens and 3% of HRCT series. In agreement with this, the superior accessory fissure was found in 3.2% on the right side and 3.6% of cases on the left in our study. Other studies have shown the similar incidence of SAF in the right lungs in the range of 1-4.6%.[28,27,10,19]

The azygous fissure was the least common, present exclusively on the right side in 2.4% of cases in our study. There were no cases of an azygous fissure on the left side. Azygous fissure occurs in 1% of anatomic specimens and is identified on 0.5% of the chest radiographs. Typically, it is located on the right side, although there have been reports of left-sided azygous fissures where the vein at the base is the superior intercostal vein. Other similar studies have also indicated a low prevalence of azygous fissures, with frequencies in the range of 0.5-1.2%.[12,32,18,19] However, study done in Sweden reported 14(3.7%) cases of azygous fissures among 382 subjects.[10] Studies have shown metastasis and spread to adjacent structure is often rare and delayed in primary malignancy involving the azygos lobe.

The left minor fissure has been identified in 8-9% of high-resolution computed tomography (HRCT) examinations and in 8–18% of anatomical specimens obtained from autopsies. Study done at University of Michigan showed this fissure was the most frequently observed accessory pulmonary fissure, occurring in 16% of the cases, followed by the inferior accessory fissure at 12.7%, with its prevalence aligning with autopsy findings.[18] Similarly, study utilizing CT imaging reported prevalence rates of 1-9%.[25,19,10] In our study, the left minor fissure was noted in 9.3% of the cases. However, a cadaveric study conducted in Tanzania revealed that 2.9% of left lungs exhibited three lobes, suggesting the presence of a left minor fissure.[32] In contrast, other studies have reported higher prevalence rates, such as 26% GSL Medical College, India and 17.5% at Kasturba Medical College, India.[26,28]

In our study, fissures in the right middle lobe were identified in 3.2% of cases. Comparable results were reported in studies done at Turkey 2% and USA 5%.[29,18] Conversely, study done at Japan observed this condition in 16% of cases.[20] Additionally, other similar studies found no accessory fissures.[33,3,34] Godwin and Tarver highlighted that, apart from the superior and inferior accessory fissures, and left minor fissures; other accessory fissures may appear in various anatomical locations.[35]

Identifying accessory fissures is crucial, as they can be misinterpreted on imaging as consolidation, collapse, or pleural effusions. In cases with endobronchial lesions, these fissures can alter pattern of lung collapse, complicating diagnosis.[10] Atypical fissures may also be confused with unusual pleural or pulmonary conditions. It's important to differentiate accessory fissures from fibrotic bands, as the former can limit the spread of pneumonia or malignancy to adjacent lobes.[4] Bronchogenic carcinoma near accessory fissures often show delayed metastasis, potentially keeping the disease localized. Axial imaging may not effectively capture horizontally oriented fissures, such as the right minor, superior accessory, and left minor fissures as these fissures parallel to the scan direction.[19]

Studies have examined fissural variation in different ethnic populations, but there is limited data on comparing the gender-specific differences. Study conducted in India showed variations in fissures were predominant in males than females.[4] Our study

showed males were more likely to have an incomplete oblique fissure, while females showed a higher prevalence of the incomplete right minor fissure, suggesting gender-specific anatomical variations. However, accessory fissures and the absence of the right minor fissure were similarly distributed across gender. Additionally, males exhibited a higher frequency of the superior accessory fissure, while the inferior accessory fissure was slightly higher in female gender in our study.

One limitation of our study is its solo reliance on HRCT images without pathological analysis. Discrepancies with other studies may result from factors like small sample sizes, technical factor and variability of incomplete fissures. Despite its enhanced spatial resolution, HRCT faces challenges such as motion artefacts, incomplete fissure visualization, alignment issues, and in inspiration depth. These limitations may have affected our study's outcomes, and detailed anatomical and pathological investigations could provide a more accurate assessment of fissure variation.

Conclusion

The present study showed a wide range of difference in the lobes and fissures when compared with previous study. Accessory and incomplete fissures are common in lung morphology. Knowledge of such variation may be important for both anatomy and clinical practice as well as correct imaging interpretation. Recognizing this variation prior to pulmonary lobectomy and thoracoscopic segmentectomy could influence the preoperative approach.

Conflict of Interest

None

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None

Author Contribution

Concept, design, planning: SKC, SG ; Literature review: SKC;SG Data collection: SKC,SG; Data analysis: SKC,SG; Draft manuscript: SKC, SG; Revision of draft: SKC,SG ; Final manuscript: SKC,SG; Accountability of the work: SKC, SG.

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