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A STUDY ON MORPHOLOGICAL VARIATIONS OF FISSURES AND LOBES OF HUMAN LUNGS.

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ABSTRACT
The fissures in lung enhance uniform expansion. These fissures may be complete, incomplete or absent. Knowledge of these variations is necessary for proper radiological interpretation and performing segmental lung resections. Hence, the present study aimed to study the morphological variations of fissures and lobes of lungs. 41 formalin fixed human lungs (20 right and 21 left lungs) irrespective of gender were obtained from the department of Human anatomy, BPKIHS. The lungs were observed and photographed for presence or absence of fissures and lobes; variations in fissures (incomplete or absent); and accessory fissures, if any were recorded. Among the 20 right lungs, 40% of the specimen had incomplete oblique fissure. The horizontal fissure was absent in 20% of the lungs and 50% had incomplete horizontal fissure. Among the 21 left lungs, 52.4% of the specimen had incomplete oblique fissure. 45% of the right lungs had accessory fissure with 35% present in the upper lobe where as 38.1% of the left lungs had accessory fissure with 28.6% present in the upper lobe. The present study showed a wide range of variations in fissures and lobes of lungs. The knowledge of variations in morphology of lungs would be helpful for clinical diagnosis and pulmonary surgical procedures.

KEYWORDS: Variations, Lobes, Fissures, Accessory Fissures.

INTRODUCTION

The lungs are the essential organs of respiration situated on either side of the heart. Fissuresforms an integral part of human lung. The right lung is divided into superior, middle and inferior lobe by an oblique and a horizontal fissure. The oblique fissure separates the inferior lobe from the middle and superior lobe and the horizontal fissure separates the superior and middle lobe. The left lung is divided into a superior and an inferior lobe by an oblique fissure.[1]

The oblique fissure runs through the vertebral border of both the lungs at the level of 4th or 5th thoracic spine. Traced downwards on the medial surface it ends above the hilum; traced downwards on the costal surface, it continues across the diaphragmatic surface and turn upward on to the medial surface to end just below the lower end of the hilum.[2] Horizontal fissure is seen only in the right lung and it begins laterally at the oblique fissure and runs almost transversely across the costal surface to the anterior margin and around this margin back to the hilum.[2]

The lung fissures ease the movement of the lobes, which helps in greater distention and movement of the lobes during respiration.[3] Thus, they help in the uniform expansion of the whole lung. The fissures may be complete, when the lobes remain held together only at the hilum by the bronchi and pulmonary vessels, or they may be incomplete when there are areas of parenchymal fusion between the lobes, or, they may be absent altogether.[3]

Absence or incompleteness of a fissure could be due to obliteration of these prenatal fissures either completely or partially. Incomplete fissures indicate partial fusion between lobes. Accessory fissures may be as a result of non-obliteration or persistence of the prenatal fissures. Any variation in the pattern of the fissures indicates variations from normal pattern of development of lung.[4]

In the region of an incomplete fissure, the adjacent lobes are connected by a sizeablechunk of pulmonary tissue as the cleft fails to reach the hilum. Parenchymal fusion of varied extent along the floor results in incomplete fissures.[1] Accessory fissures of the lung are commonly observed in lung specimens, but are often unappreciated or misinterpretedon radiographs and computerized tomographic (CT) scans.[5] Radiologically, an accessory fissure appears as a thin

white line.[5] Sometimes the accessory fissures are failed to be detected on computed tomography (CT) scans, because of their incompleteness, thick sections and orientation in relation to a particular plane.[6] The accessory fissures might alter the diagnosis[7] and incomplete fissures may spread diseases to adjacent lobes through parenchymal continuation.[8] Knowledge of lungs fissures and lobes, and their variations helps cardiothoracic surgeons to avoid undue complications during surgery. Also, it helps radiologist to make accurate diagnosis in case of lung diseases.

Hence, the awareness of their variations is essential for surgeons to exactly diagnose, plan and perform lobectomies and in segmental resection involving individual segment. It could also be of significance in interpreting radiological images[9] as the accessory fissures frequently fail to be detected on computed tomography scans, because of their incompleteness.[10] Thus, the following study aimed to find out the anomalous fissures and lobes along with their patterns, in human lungs; collected from cadavers.

5. MATERIALS AND METHODS

The study was done at the dissection hall of Department of Human anatomy, BPKIHS. Of the total 43 lungs present in the department, 2 lungs were excluded and only 41 human lungs were taken for the study which consisted of 20 right lungs and 21 left lungs.

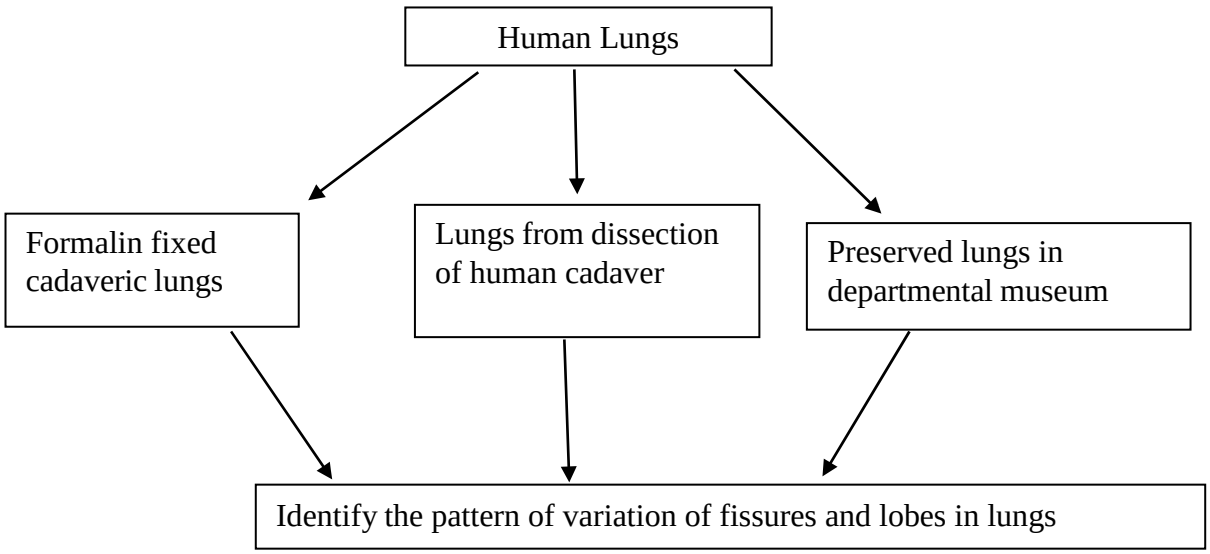
Ethical clearance was taken from IRC of the Institute before commencing the study. Those lungs with intact visceral pleura covering all over it except at hilum were included in the study and those lungs damaged during removal and preservation, marks of previous surgery and with pathological lesions i.e. fibrosis and necrosis were excluded from the study. The lungs were observed and photographed for presence or absence of fissures and lobes; variations in fissures (complete, incomplete and absent), accessory fissures and accessory lobes, if any. The anatomical classification based on the degree of completeness of the fissures proposed by Craig and Walker[11] was followed to determine the presence and completeness of fissure.

Grade I: Complete fissure with entirely separated lobes.

Grade II: Complete visceral cleft but parenchymal fusion at the base of fissure.Grade III: Visceral cleft evident for a part of fissure.

Grade IV: Complete fusion of lobes with no evident fissural line.

Conceptual Framework



The lungs were meticulously observed and photographed during collection of the data. The data were then entered in Microsoft excel and percentage of variation was calculated. The results obtained were compared with other studies.

RESULTS

The study was done to study the morphological variations of fissures and lobes of human lungs. The samples were taken from cadavers and formalin fixed lungs specimen from the Department of Human Anatomy, BPKIHS.

Right Lungs

Among the 20(n) right lungs, the oblique fissure (OF) was present in all the lungs. Incomplete oblique fissure (IOF) was observed in 8(40%) lungs whereas 12(60%) lungs had complete oblique fissure (COF). The horizontal fissure (HF) was absent in 4(20%) lungs, 10(50%) lungs had incomplete horizontal fissure (IHF) and 6(30%) lungs hadcomplete horizontal fissure (CHF).

Accessory fissures were observed in 9(45%) lungs out of which in 7(35%) lungs, it was observed in the upper lobe and in 2(10%) lungs in the lower lobe. No accessory fissures were observed in middle lobe. In 5(25%) lungs, accessory fissures were observed in sternocostal surface,

2(10%) lungs had in the mediastinal surface, 1(5%) at the apex and in 1(5%) lung it was observed in the diaphragmatic surface. Only two lobes were observed in 4(20%) lungs and 3 lobes in 16(80%) lungs.

Left Lungs

Among the 21 left lungs, the oblique fissure was present in all the lungs with COF in 10(47.6%) lungs and IOF in 11(52.4%) lungs.

The accessory fissures were observed in 8 (38.1%) lungs, where in 6(28.6%) lungs it was present in the upper lobe and in 2(9.5%) lungs, it was present in the lower lobe. Most of theaccessory fissures were observed in the upper lobe of the mediastinal surface i.e. in 4 (19%) lungs, and on the costal surface of the upper lobe i.e. 2 (9.5%) lungs and only in 2 (9.5%) lungs, accessory fissures were observed in the diaphragmatic surface. Two lobes were observed in 20 (95.2%) left lungs whereas three lobes were observed in only 1 (4.8%)lung.

The variations of oblique fissure, horizontal fissure, accessory fissures and lobes of lungs are shown in table 1 and 2.

Table 1: Variations in oblique and horizontal fissure of right and left lungs.

Lungs	Fissures	Complete	Incomplete	Absent
Right (20)	Oblique	12(60%)	8(40%)	0
	Horizontal	6(30%)	10(50%)	4(20%)
Left (21)	Oblique	10(47.6%)	11(52.4%)	0

Table 2: Variations in accessory fissures and lobes of right and left lungs.

Features	Right Lung	Left lung
Accessory fissures observed	9(45%)	8(38.1)
Accessory fissures inlobes	Upper lobe:7(35%)Lower lobe: 2(10%)	Upper lobe:6(28.6%)Lower lobe: 2(9.5%)
Number of lobe	2 lobes: 4(20%) 3 lobes: 16(80%)	2 lobes: 20(95.2%) 3 lobes: 1(4.8%)
Accessory fissureson lungs surfaces	Costal surface 5(25%)	Costal surface- 2(9.5%)-
	Mediastinal surface- 2(10%)	Mediastinal surface- 4(19%)
	Diaphragmatic surface - 1(5%)	Diaphragmatic surface- 2(9.5%)
	Apex-1(5%)	-

The anatomical classification based on the degree of completeness of the fissures proposed by Craig and Walker[11], in relation to right lungs, 7 (35%) lungs had grade I oblique fissure,5(25%) lungs had grade II oblique fissure and 8 lungs (40%) had grade III oblique fissure. For horizontal fissure, 3 (15%) lungs had grade I horizontal fissure, 3 (15%) lungs had grade II horizontal fissure, 10 (50%) lungs had grade III horizontal fissure, 4 (20%) lungs had grade IV horizontal fissure. For left lungs, 7 (33.3 %) lungs had grade I oblique fissure, 3(14.3%) lungs had grade II oblique fissure and rest 11 (52.4 %) lungs had grade III oblique fissure as shown in table 3.

Table 3: Grading of horizontal and oblique fissures of lungs according to "Craig andWalker's classification.[11]

Lungs	Fissures	Grade I	Grade II	Grade III	Grade IV
Right(20)	Oblique	7(35%)	5(25%)	8(40%)	-
	Horizontal	3(15%)	3(15%)	10(50%)	4(20%)
Left(21)	Oblique	7(33.3%)	3(14.3%)	11(52.4%)	-

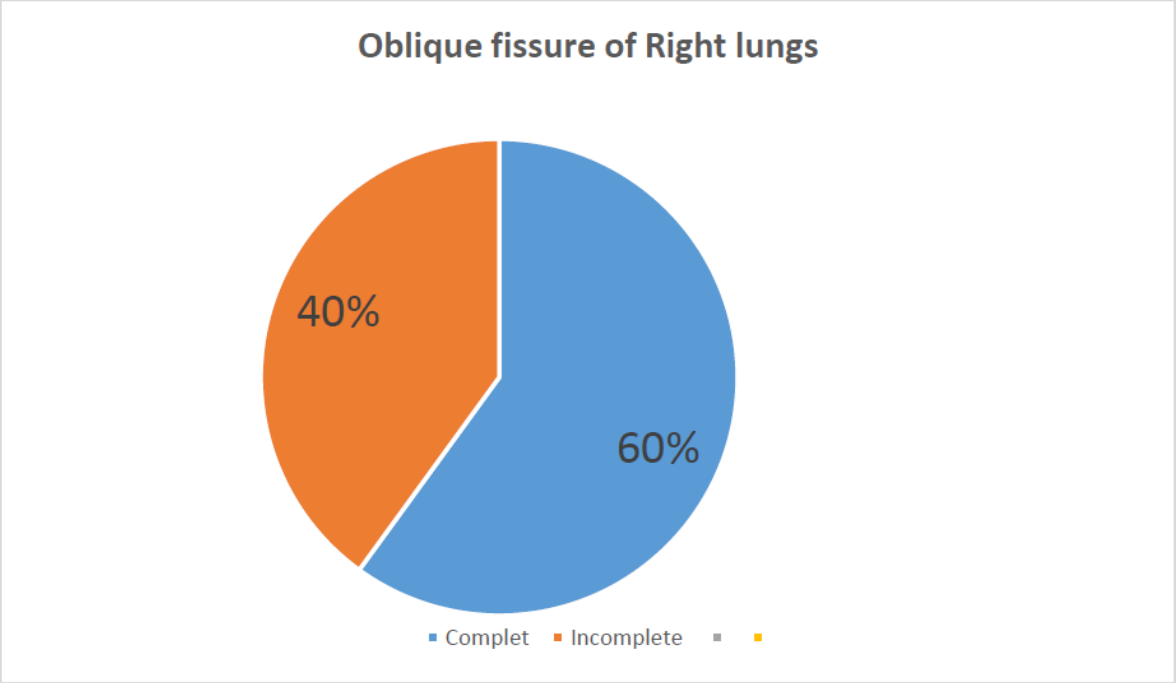


Fig 1: Pie chart showing variations in oblique fissure of right lungs.

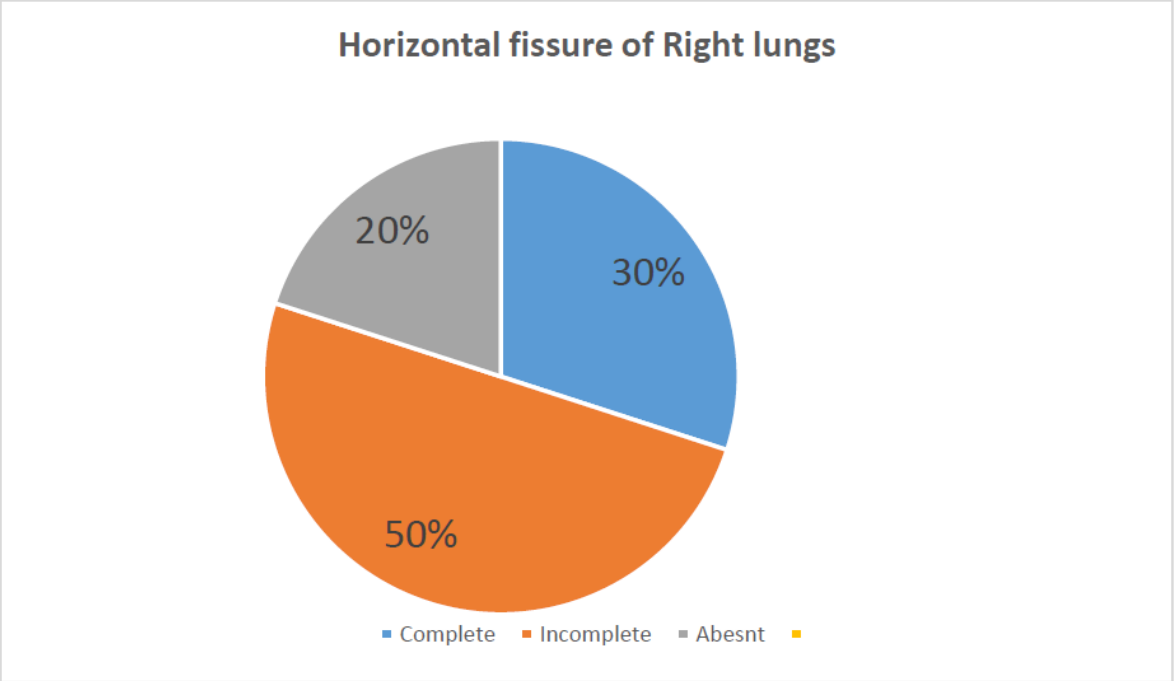


Fig 2: Pie chart showing variations in horizontal fissure of right lungs.

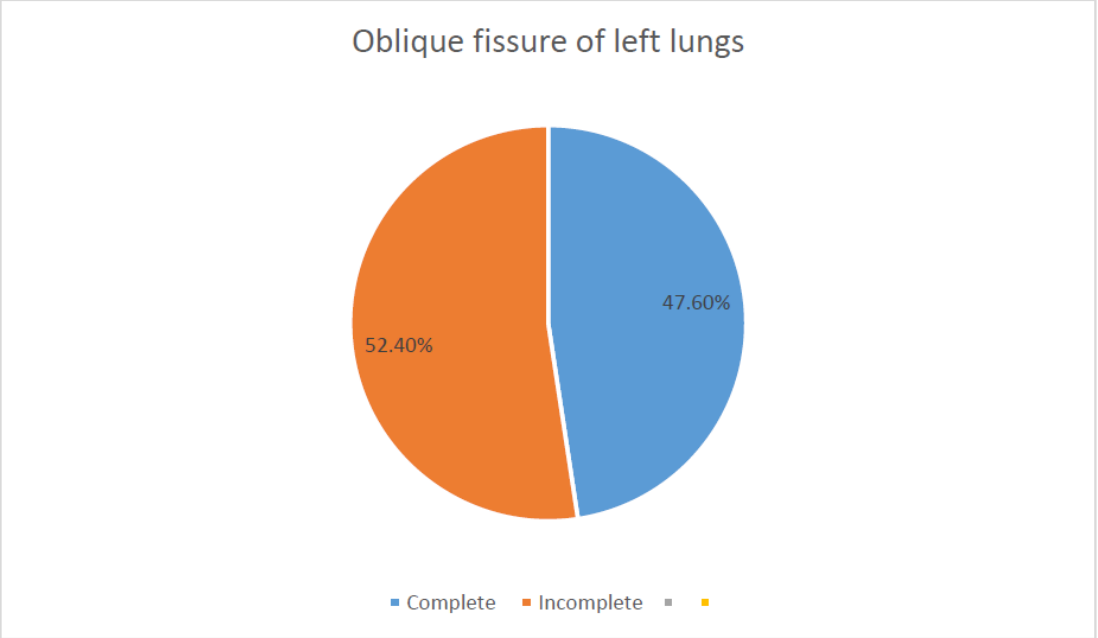


Fig 3: Pie chart showing variations in oblique fissure of left lungs.

Fig 4: Morphological variations in lobes and fissures of right and left lungs.

DISCUSSIONS

The fissures divide the lungs into lobes and help in its uniform expansion. Any variations in the architecture of the fissures may vary the lobar and segmental patterns of the lung. Lobes that remain intact at the hilum by bronchi and pulmonary vessels suggest a complete fissure, whereas the occurrence of parenchymal fusion between lobes suggests an incomplete fissure.[8]

It is necessary to understand the normal development of the organs in order to understand their malformations.[12] Lungs fissure develop in intrauterine life. The development of the lungs begins on day 22nd with the formation of a ventral outpouching of the endodermal

foregut called the respiratory diverticulum (lung bud). This bud grows ventro-caudally through the mesenchyme surrounding the foregut, and on days 26th to 28th, it undergoes a first bifurcation, splitting into right and left primary bronchial (or lung) buds. During 5th to 28th week, the primary bronchial buds undergo about 16 rounds of branching to generate the respiratory tree of the lungs. The first round of branching of the primary bronchial buds occurs early in the 5th week. This round of branching is highly stereotypical and yields three secondary bronchial buds on the right side and two on the left. The secondary bronchial buds give rise to the lung lobes: three in the right lung and two in the left lung. During the 6th week, a more variable round of branching typically yields 10 tertiary bronchi or bronchopulmonary segment on both sides.[13]

In fetal period these bronchopulmonary segments are separated by spaces which later on gets obliterated except along the line of division of principal bronchi to give rise to oblique and horizontal fissures in fully developed lung. Along these fissures the visceral pleura is reflected and covers individual lobes on all sides.[14] Defective pulmonary development will give rise to variations as encountered in fissures and lobes.[4] Incomplete or absence of oblique and horizontal fissures could be due to a defect in the obliteration of these fissures either completely or incompletely.[15] The monopodial branching of stem bronchi accounts for accessory bronchi and lobes often found in adult lung.[16]

The anatomy of fissures and their completeness have been studied by CT and also on postmortem cases and cadavers. Cadavers and formalin fixed specimen are still the best source to study human anatomy. Many researchers have reported their findings done on cadaver and specimen.

Right lungs

In the present study, oblique fissure was complete in 60% and horizontal fissure was complete in 30%. Similar findings were observed by Meenakshi et al. where they reported complete oblique fissure (COF) in 63.4% and complete horizontal fissure (CHF) in 20.1%.[15] Dhanalaxmi et al. reported similar findings with CHF in 30% and COF in 68%.[17] In contrast to the present study, Nene et al.[9] (92% COF and 78% CHF), George et al.[18] (96.93% COF and 61.55% CHF), Lukose et al.[19] (100% COF and 68.5% CHF), Lattupali et al.[20] (90% COF and 82% CHF), Quadros et al.[21] (94.44% COF and 63.88% CHF) and Mamatha et al.[22] (85% COF and 50% CHF) reported the incidence of completeness of fissure much higher than the present study. Few studies Dutta et al.[23] (26.92% COF and 26.49% CHF) and Jacob and Pillay[10] (46.6% COFand 10% CHF) reported the incidence of completeness of fissure less than the present study. Magadum et al.[24] (30 % COF and 35% CHF) and Prakash et al.[25] (53.6% COF 42.9% CHF) reported lower incidence of COF and higher incidence of CHF than the present study. In the present study, the oblique fissure was incomplete in 40%. These findings were supported by studies from Prakash et al. (39.3%)[25] and Meenakshi et al. (36.6%).[15] While, Dutta et al. (61.54%)[23], Magadum et al. (60%)[24] and Jacob and Pillay (50%)[10] reported higher incidence of IOF and in contrast Lukose et al. (0%)[19], Nene et al. (3.07%)[9] and Tallapaneni (6.66%)[26] reported lower incidence of this fissure than the present study. The incidence of absent oblique fissure was 0% in the present day. In accordance to the present study, Mamatha et al.,[22] Kalia and Dhivya[27] and Dhanalakshmi et al.[17] reported 0% incidence of absent oblique fissure. While Medler (4.8%),[28] Dutta et al. (11.54%)[23] reported higher incidence of absent oblique fissure than the present study.

The horizontal fissure was complete in 30% specimen in the present study. Similar findings were observed by Dhanalakshmi et al. (30%)[17] and Mote et al. (33.4%).[29] In contrast with the present study Lukose et al. (68.5%)[19], Nene et al. (78%)[9], Quadros et al. (63.88)[21] and Mamatha et al. (50%)[22] reported higher incidence of CHF. While Jacob and Pillay (10%)[10] showed lower incidence than the present study. The horizontal fissure was absent in 20% in the present study. In accordance with the present study, Kalia and Dhivya[27] reported 20% specimen had no horizontal fissure. In contrast with the present study, Mamatha et al.[22] reported no (0%) specimen showed absence of horizontal fissure. Medler (45.2%)[28] and Dutta et al. (34.62%)[23] reported higher incidence of absent horizontal fissure. While, Jacob and Pillay (6.6%)[10], Prakash et al. (7.1%)[25] and George et al. (3.07%)[18] reported lower incidence of absent horizontal fissure.

In the present study, the accessory fissures were observed in 45% of right lungs. Among which, 35% were found in the upper lobe, 10% in the lower lobe. While 25% of the accessory fissure were seen in sternocostal surface, 10% in the mediastinal surface, 5% in diaphragmatic surface and 5% at the apex. Similar findings with the present study was observed by, Mansur et al.[30] They found 10.53% in the lower lobe. Lower prevalence of accessory fissure was reported by Quadros et al. (5.55%)[21] and Magadum et al (5%)[24] than the present study. of While Meenakshi et al.[15], Prakash et al.[25], and, Kalia and Dhivya[27] did not report any accessory fissures. Mansur et al.[30] reported 2.08% in the middle lobe but no accessory fissures were observed in the middle lobe the present study.

The right lungs usually have three lobes which are separated from each other by horizontal and oblique fissure. In the present study, in 80% of the lungs three lobes were observed andin 20% specimen, the horizontal fissure was absent and only two lobes were observed. Mansur et al.[30] reported 7.89% specimen with two lobes whereas Nene et al.[9] reported 16% with two lobes.

Left Lung

Among the 21 left lungs, the oblique fissure was present in all the lungs with 10 (47.6%) lungs with COF and 11 (52.4%) lungs with IOF In the present study, Complete oblique fissure was observed in 47.6% of the specimen. Similar findings were observed by Sudikshya et al.[31] and Magadum et al.[19], they reported 48.15% and 50% of complete oblique fissure respectively. In contrast to the present study, Nene et al.[9] Lukose et al.[19] and George et al.[18] reported 88%, 79% and 84.94% complete oblique fissure. While Dutta et al.[23] reported 44% of complete oblique fissure.

Incomplete oblique fissure was observed in 52.4% in the present study. In accordance to the present study, Sudikshya et al. reported 51.85% incomplete oblique fissure in their study[31], whereas few other authors[19],[28],[9],[10] 21%, 30%, 12% and 8.9% incomplete oblique fissure respectively which are lower than the present study. In the present study, absence of oblique fissure was not observed in any of the left lung specimen. Similar findings were reported where oblique fissure was present in al specimen.[19],[28],[9],[10] In contrast to the present study, Mamatha et al.[18], Magadum et al.[24], Prakash et al.[25] reported absence of oblique fissure in 5%, 7.5% and 10.7% respectively.

In the present study, the accessory fissures were observed in 38.1% of left lungs. Among which, 28.6% were found in the upper lobe, 9.5% in the lower lobe. While 19% of the accessory fissure were seen in the mediastinal surface, 9.5% in the diaphragmatic surface and 9.5% in the sternocostal surface. In contrast to the present study, Mansur et al.[30] reported 6.45% of accessory fissure in the upper lobe and no accessory fissures were observed in the lower lobe. Similar to the present study, Nene et al.[9] also reported 6% of lungs with three lobes.

The fissures in the lung help even expansion of lung tissue and serve as a reliable landmark on the lung. Accessory fissures when present at abnormal locations in the lungs give rise to abnormal lobes of the lung aerated by normal bronchus. Such finding is more common in infants.[2] From a radiological point of view, an accessory fissure may commonly be misinterpreted as a lung lesion.[7] In patients with endobronchial lesion, an accesssory fissure might alter the usual pattern of lung collapse and pose difficulty in diagnosing a lesion and its extent by giving an unusual appearance. An incomplete major fissure causes the odd appearance of fluid tracking within the fissure. Incomplete fissures may also alter the spread of disease within the lung. Pneumonia in a particular lobe is contained within the confines of the lobe by complete and normal fissure. In patients with incomplete fissures, pneumonia may spread to adjacent lobes through the parenchymal continuation. Lobar involvement with carcinoma of the lung may be explained on a similar basis.[8] Many diseases require accurate segmental localization of the lesion and the knowledge of accessory fissure is of much clinical importance to the clinician. Preoperative planning for segmental resection or pulmonary lobectomy may also change during presence of such accessory fissure. An incomplete fissure is also a cause for postoperative air leakage. Often these accessory fissures act as a barrier to spread of infection, creating a sharply marginated pneumonia which can wrongly be interpreted as atelectasis or consolidation.[5] The knowledge of anatomy of fissures of lung may help clarifying confusing radiographic findings like extension of fluid into an incomplete major fissure or spread of various diseases through different pathways.[32]

SUMMARY AND CONCLUSIONS

The present study showed that morphological variations in fissures and lobes were more in right lungs as compared to left lungs. The present study showed that 40% of the right lung had IOF and 50% had IHF. Horizontal fissure was absent in 20% of the right lungs. 45% ofthe right lungs showed accessory fissure of which 35% was seen in upper lobe and 10% in the lower lobe. The left lungs showed 52.4% IOF. Accessory fissures were seen in 38.1%of the left lungs of which 28.6% seen in the upper lobe and 9.5% in lower lobe. Regarding lobes, only 2 lobes were seen in 20% of the right lungs where as 4.8% of the left lung showed 3 lobes.

The results of present study and their comparison with the previous works show that there is a wide range of variations in the occurrence fissures, accessory fissures and lobes between and among different populations. This implies that genetic and environmental factors might affect development of these fissures. Knowledge of such variations might explain unusual presentation of certain clinical cases pertaining to lung pathologies. Also knowing the frequency of variations of fissures and lobes in a particular population might help the radiologist and clinician to make correct diagnosis. Similarly, it might help the surgeon to plan, execute and modify a surgical procedure depending on the merit of the case. This will overall help to reduce the morbidity and mortality associated with lung surgeries.

Abbreviations

COF: Complete oblique fissure IOF: Incomplete oblique fissure CHF: Complete horizontal fissure IHF: Incomplete horizontal fissureAF: Accessory fissure.
BPKIHS: B.P. Koirala Institute of health sciences IRC: Instituitional review committee.

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