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Morphological variations of human pulmonary fissures: an anatomical cadaveric study in Sri Lanka

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Abstract

The aim of this study was to identify morphological and morphometric variations of pulmonary fissures. A sample of 50 adult formalin fixed Sri Lankan cadaveric lungs (24 left and 26 right lungs) were observed with the help of magnifying glass and length measurements of the lung fissures were taken using a measuring tape. Complete oblique fissure was seen in 16 (66.67%) left lungs and 11 (42.3%) right lungs. Incomplete oblique fissure was seen in 8 (33.33%) left lungs and 15 (57.69%) right lungs. There was complete absent of horizontal fissure in 4 (15.38%) right lungs whereas rest of the 22 right lungs indicated incomplete horizontal fissure (84.61%). The mean lengths of the left oblique fissure, right oblique fissure and horizontal fissure were 26.88±5.88cm, 27.31±6.04 cm and 8.31±3.61 cm, respectively. Incomplete fissure was the most common variant of the fissures in the analyzed sample. There was a high prevalence of incomplete horizontal fissure of right lung followed by incomplete right and left oblique fissures. Absence of oblique fissure was not found in either left or right lungs. The mean length of right oblique fissure was slightly greater than the mean length of left oblique fissure. The knowledge lung fissures, indeed help clinicians and radiologists to identify alterations of the disease distribution and to reduce the misinterpretation of radiological modalities as well as to arrive at an accurate diagnosis with plan of management of a patient.

Keyword

lung; variant; fissure; morphology; Sri Lanka.

Introduction

Lungs are the vital organs of the body which are responsible for the process of gas exchange called respiration. They are paired organs situated on either side of the heart in the thoracic cavity. Lungs are separated into lobes by the presence of fissures. Presence of fissures are essential for the greater distension of the lungs during the respiration. The fissures allow greater degree of movement of the lobes over one another. Thus, they allow uniform expansion of the whole lung for more volume of air during inspiration (Rosse & Gaddum-Rosse, 1997). The left lung is composed of superior and inferior lobes separated by the oblique fissure whereas right lung has oblique and horizontal fissures separating it into superior, middle, and inferior lobes. The oblique fissure being less vertical on right lung than left lung separates inferior lobe from middle and upper lobe (Sudikshya et al., 2018). Normally fissures cut the

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whole thickness of the lung except at the hilum. The oblique fissure runs obliquely downward and forward. In the right lung, horizontal fissure runs horizontally to the anterior border and separates a middle lobe which is wedge shaped (Sudikshya et al., 2018). Knowledge about the fissures of lungs are clinically important for distribution of bronchopulmonary segments and lobar anatomy (Meenakshi, 2004).

The deviations from normal anatomy of lungs are somewhat common. Main anatomical variations found in the lung fissures are categories as the complete, incomplete, absent and accessory. When there is a complete fissure, the lobes are held together only at the hilum by the bronchi and pulmonary vessels. The fissures are said to be incomplete when there are areas of parenchyma is left in between lobes and the clefts do not reach the hilum. Accessory fissures are the clefts of varying depths lined by visceral pleura. Accessory fissures usually surround the boundaries of bronchopulmonary segments. Accessory fissure, common congenital variant which commonly occurs at the borders of bronchopulmonary segments, as a with clefts of varying depth lined by visceral pleura. The fissures are said to be incomplete when parenchyma is left in between lobes and the clefts do not reach the hilum. Accessory fissure, common congenital variant which commonly occurs at the borders of bronchopulmonary segments with clefts of varying depth. Commonly occurring accessory fissures are the superior accessory fissure (SAF), Left minor accessory fissure (LMF) and the inferior accessory fissure (IAF). SAF separates the basal segment of the lower lobe from the superior segment, which can either be complete or partial. This causes the superior segment to be called as posterior or dorsal lobe. The IAF associate with medial basal segment of the lower lobe. In the left upper lobe, the lingula is separated from the rest of the lobe by the LMF (Sudikshya et al., 2018). Some accessory fissures are not detected on computed tomography because of incompleteness, thick section and orientation related differences (Zareena, 2014).

Normal anatomy is vital for surgical procedures. Variations in anatomy can lead to interpretation difficulties in radiological investigations. In patients with endotracheal lesions, presence of an accessary fissure might alter the usual pattern of lung collapse and leads to difficulty in diagnosing the extent of the lesion (George *et al*., 2014). Usually, pneumonia is confined to the lobes affected by it, but in contrast, when there are incomplete fissures, pneumonia would spread to adjacent lobes due to incomplete parenchymal separation. (Aldur, 1997). There are many researches have been done related to variations in the anatomy of human lung cadavers all over the world (Sudikshya et al., 2018.; Meenakshi, 2004; Zareena, 2014; Aldur, 1997). In another research "Fissural balance" is used to describe the relationship between the pulmonary artery to oblique fissure (Craig & walker, 1997). In a "normally balanced" fissure, the pulmonary artery lies centrally to the oblique fissure. In an "anterior or posterior imbalance fissure", anterior or posterior displacement of the artery occurs. A cadaveric study in Nepal, revealed complete oblique and horizontal fissures in right lung and incomplete oblique fissure in left lung as their common findings (Sudikshya et al., 2018). Another study by indicated that the incomplete fissure predominates in right lungs whereas in few cases the horizontal fissure is classically absent (Radha and Durai, 2015). In an Indian study reported by Meenakshi, 2004 had found out 16.6% absence of horizontal fissure whereas absence of oblique fissure was not reported (Meenakshi, 2004). In a study conducted in Ethiopia had unfolded higher prevalence of 68.42% of incomplete horizontal fissure of the right lung (Gebregziab-

her *et al*., 2015). Although the anatomy of lung fissures and lobar pattern is studied in many populations, there is only one study been reported in Sri Lankan context where authors revealed 66 % of the right lungs had either an incomplete or absent horizontal fissure and the typical fissure pattern was seen less (Ekanayaka *et al*., 2019). In order to widen the Sri Lankan data base related to lung variations, the present study is aimed to analyze the morphological and morphometric variations of human pulmonary fissures and lobes related to local population.

Material and method

The 50 specimens of adult lungs of unknown gender, fixed with formalin and preserved in the dissection hall at the Faculty of Medicine, University of Kelaniya were analyzed in the present study. Overall the specimens were in good condition and their pleura are intact except at the hilum. Lung specimens that were damaged during dissection, undergone surgical procedures, and those that had been identified to be having pathological changes were excluded from the study. Each specimen was given an identification number for convenience in collecting data by observation and assessed under four key parameters; number of fissures, completeness of each fissure, presence or the absence of an accessory fissure and length of each fissure.

Length measurements of the lung fissures were taken using a measuring tape. In addition, magnifying glasses and dividers were used on requirement during the study. Three length measurements on the same fissure were taken from each specimen by the same observer. On data collection, same observer took 3 length measurements on same fissure of each lung. Calculated average length of the 3 recorded measurements was used for statistical inference. The Craig and Walker classification was used to determine the presence and the completeness of fissures; Grade I: Complete fissure with entirely separate lobes, Grade II: Complete visceral cleft but parenchymal fusion at the base of the fissure, Grade III: Visceral cleft evident for a part of the fissure, Grade IV: Complete fusion of lobes with no evident fissure line (Craig & walker, 1997). The collected data was analyzed using the software SPSS 25.0 whereas the significance level was set to $p< 0.05$.

Results

Out of the 50 lungs analyzed in the current study, 24 (48%) lungs were left lungs and 26 (52%) of the lungs were right lungs. Oblique fissure was present in all the left lungs and among those 16 lungs (66.67%) had complete oblique fissures (Figure 1A) whereas 8 (33.33%) had incomplete oblique fissures (Figure 1B). Oblique fissure was present in all the right lungs and it was complete in 11 (42.3%) lungs whereas incomplete oblique fissure was seen in 15 (57.69%) lungs.

Regarding the horizontal fissure of the right lungs, it was present in 22 (84.61%) lungs and absent in 4 (15.38%) lungs (Figure 1C). Engrossing fact is that oblique fissure is present in all the lungs unlike the horizontal fissure (Table 1).

A significant presence of accessory fissure was observed in both lungs (Figure 1D and Figure 1E). Out of the samples analyzed we observed accessory fissures in

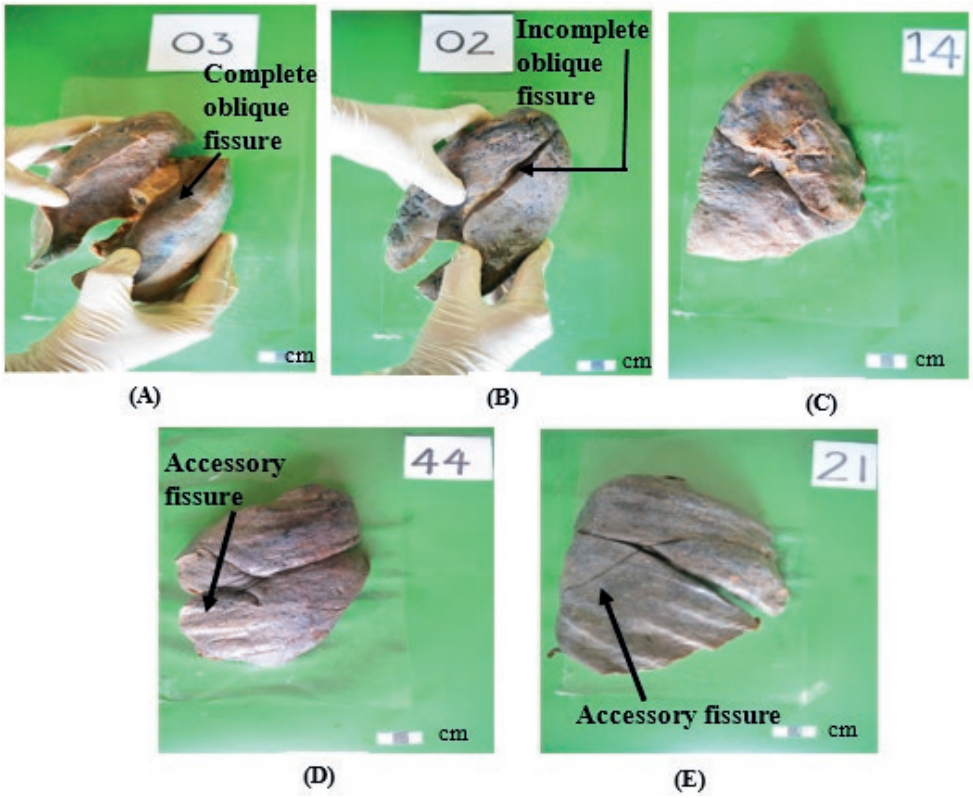

Figure 1. (A)-Left lung with complete oblique fissure, (B)-Left lung with incomplete oblique fissure, (C)-Right lung with absent horizontal fissure, (D)- Left lung with an accessory fissure, (E)- Right lung with an accessory fissure.

Table 1. The fissural pattern and measurements of the Sri Lankan cadaveric lungs.

	Complete (%)	Incomplete (%)	Absent (%)	Length(cm) Mean±SD	Range (cm)
Left oblique fissure	16(66.67)	8(33.33)	00	26.88+/-5.88	8.2-35.5
Right oblique fissure	11(42.33)	15(57.69)	00	27.31+/-6.04	13.2-35.8
Horizontal fissure	00	22(84.61)	4(15.38)	8.31+/-3.61	2.7-16.5

4 left lungs and 3 right lungs and the data pertaining to this variation was given in Figure 2.

The obtained fissural parameters related to oblique fissure of both left and right lungs, and horizontal fissure of right lungs were given in Table 1. Incidence of oblique and horizontal fissures found in the lungs according to Craig and Walker criteria is shown in the Table 2.

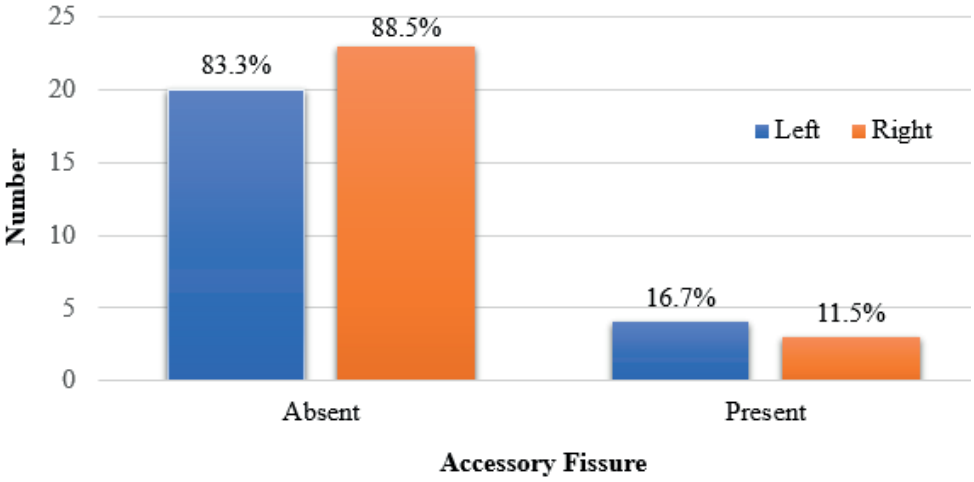

Figure 2. Presence of accessary fissures in left and right lungs.

Table 2. Craig and Walker classification of fissures of the lungs in the present study.

Side of Lung	Fissure	Grade I (%)	Grade II (%)	Grade III (%)	Grade IV (%)
Right	Oblique	11(42.3%)	4(15.4%)	11(42.3%)	0(0%)
Right	Horizontal	0(0%)	3(11.5%)	19(73.1%)	4(15.4%)
Left	Oblique	8(33.3%)	4(16.7%)	12(50%)	0(0%)

Discussion

The importance of understanding the anatomical variation of lobar anatomy in relation to fissures has been overlooked in the Sri Lankan context. Many studies have been conducted in the subcontinent, mainly in India with the objective of enhancing the understanding about this subject area, often widening the study on this anatomical diversity (Meenakshi, 2004; Zareena, 2014; George et al., 2014; Varalakshmi et al., 2014). The lack of similar studies in Sri Lankan population can hinder the future improvements in the field of lung surgery and this study will shed lights to fulfil this lacunae.

The variations in the fissures and lobes of the lungs were due to the defective pulmonary embryological fissures that initially separates individual bronchopulmonary buds. Incomplete or absence of lung fissures could be due to a defect in the obliteration of the prenatal fissures either completely or incompletely. A good understanding about the pulmonary fissural anatomy is helpful not only in surgically but also in radiological and pathological perspectives. Radiological signs can be vary depending on variation on fisural anatomy such as fluid collecting areas (Damor et al., 2012). It has also been identified to be playing a key role in the process of disease spread and progression. The most significant impact lies in the field of pulmonary surgery, where

the fissures demarcate the boundary of lung lobes acting as the landmarks based on, where the surgeons make their incisions. A wide knowledge on possible variations of fissures, both location wise and size wise can improve the outcome of oncological and benign surgical procedures (Standring et al., 2008). Clinically, in cases of endobronchial lesions, diagnosis of type of pneumonia may be altered by presence of an accessary fissure. Pneumonia may spread to adjacent lobes by parenchymal fusion.

Study conducted in India found that 16.7% right oblique fissure was incomplete (Varalakshmi et al., 2014) whereas another study revealed that it was 10.7% (Divya et al., 2015). In the studies conducted by Nishan et al., 2014, Abhilasha & Charulata, 2013, Thapa & Desai, 2016 have found out that incomplete right oblique fissure was present as 24%, 17.25% and 30%, respectively. However, in contrast to that, our study reported higher incidence (57.69%) of incomplete right oblique fissure. Similar results were found by Shivaleela et al., 2018 and they reported 63% of right oblique fissures. Lower incidence of absent oblique fissures of right lung was reported in some studies (Nishan et al., 2014, Shivaleela et al., 2018) but most of studies including our present study does not report, absence in oblique fissure (Meenakshi, 2004; George et al., 2014; Varalakshmi et al., 2014; Divya et al., 2015; Abhilasha & Charulata, 2013; Thapa & Desai, 2016; Mamatha et al., 2016).

Regarding the horizontal fissure of right lungs, the studies conducted by Varalakshmi et al., 2014, Abhilasha & Charulata, 2013, Divya et al., 2015 and Nisha et al. found 30%, 31.03%, 50% and 32% of incomplete horizontal fissures, respectively. Contrasting to these results, Shivaleela et al., 2018 had found higher incidence rate (63%) of incomplete horizontal fissures. However, present study reported remarkably higher incidence rate of 84.61% of incomplete horizontal fissures.

The results of absent horizontal fissures (15.38%) of the current study were comparable to published data by Thapa & Desai, 2016 (20%), Shivleela et al. (26%), Divya et al., 2015 (21.4%) and Varalakshmi et al., 2014 (10%). Considering the incomplete horizontal fissure left lung, very high incidence rate (70%) of incomplete horizontal fissure was reported by the, Shivaleela et al., 2018 and low incidence rate such as 14.8% recorded by Divya et al., 2015. Interestingly, current study revealed a 33.3% Varalakshmi et al., 2014 (29.4%), Nishan et al., 2014 (40%), Abhilasha & Charulata, 2013 (28.8%) and Thapa & Desai, 2016 (25%). Absent of left oblique fissure is the commonest variation observed by many published researches. Its rate varies between 3-15% (Varalakshmi et al., 2014; Divya et al., 2015; Abhilasha & Charulata, 2013; Thapa & Desai, 2016; Shivaleela et al., 2018). However, in the current study, we did not observe any absence in left oblique fissure. Also similar result was reported by Nishan et al., 2014. Variations in formation of lobes and fissures occur due to certain factors affecting fusion of lobes (Brahmbhatt et al., 2013). Accessory lobes developed by non-fusion of the spaces between the bronchopulmonary buds. Some studies had identified variations in the presence of lobes and fissures of the lungs (Sudikshya et al., 2018; Meenakshi, 2004; Zareena, 2014; Brahmbhatt et al., 2013). Accessory fissure may confuse the interpretation of X-rays and CT scans. Clinical conditions such as linear atelectasis, pleural scars or walls of bullae may be misinterpreted due to presence of accessory lobes and fissures (Brahmbhatt et al., 2013; Mayuri et al., 2013).

According to literature review several studies claimed the presence of accessory fissures of the lungs (Esomonu et al., 2013.; Mayuri et al., 2013). In George et al., 2014 reported 3 (4.61%) of right lungs and 2 (2.73%) of left lungs with accessory fissures.

In a study done in South Indian cadavers has found out presence of 4 (13.3%) accessory fissures in right sided lungs and 5 (27.7%) in left sided lungs (Jacob & Pillay, 2013). In our study, we found 4 (16.67%) of left lungs having accessory fissures while 3 (11.53%) of right lungs having accessory fissures.

Craig & walker, 1997 had proposed a classification based on degree of completeness of the fissures. To prevent post-operative hemorrhage and complications in the surgical procedures, it's important to grade the fissures. According to current study, similar percentages in grading of the above classification found as in previous studies, except that we found right horizontal grade 1 percentage is less than usual and grade 3 is more than usual pattern of distribution.

Some research had focused over the length of lung fissures (Gopalakrishna et al., 2017, Dutta et al., 2013). Gopalakrishna et al., 2017 states that the mean length of right oblique fissure is 29.36 ±5.61cm (29) whereas in the study conducted by Dutta *et al.* had found out that the mean length of right oblique fissure is 30.15±6.26 cm. Our results of 27.31±6.04 cm mean length of right oblique fissure was not much differ from the previous studies. The mean length of the left oblique fissure was measured as 26.81 ±8.18 cm by Gopalakrishna et al., 2017 while it was measured as 27. 32 ±7.29 cm by Dutta et al., 2013 In the current study the mean length of the left oblique fissure was 26.88 ±5.88 cm which is in the similar range as previous studies.

Conclusion

In the present study, the commonest variation was the presence of incomplete fissures on both right and left lungs. The prevalence of incomplete horizontal fissure of right lung reported from the Sri Lankan cadavers, probably is the highest reported from such researches all over the world. Incidence of incomplete oblique fissure was found to be greater in the right lung than the left lung. Absence of oblique fissure was not found in both left and right lungs. The similar prevalence of accessory fissure was observed in both right and left lungs. The mean length of right oblique fissure was slightly greater than the mean length of left oblique fissure. The knowledge on morphological and morphometric variations of lungs, indeed help clinicians and radiologists to identify alterations of the disease distribution and to reduce the misinterpretation of radiological modalities as well as to arrive at an accurate diagnosis with plan of management of a patient.

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