Variations in the Morphology of Human Lungs and its Clinical Implications

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Abstract

Objective To observe variations in the fissures, in the lobes, and in the hilar pattern of lungs and correlate these findings with clinical implications.

Materials and Methods The present study was performed on random lung specimens available in the Department of Anatomy. A total of 96 lungs (47 right and 49 left) were studied for variations in the fissures and lobes, and 92 lungs (45 right and 47 left) for variations in the hilar pattern.

Results Among the right-sided lungs, 70% presented incomplete horizontal fissure, 15% with absence of the horizontal fissure, and 51% with incomplete oblique fissure. Accessory fissures were also seen, but incomplete, and accounted for 17% of the total number of right lungs.

Among the left-sided lungs, 62% presented incomplete oblique fissures, and 4% with absence of the oblique fissure. Accessory fissures accounted for 6% of the total number of left lungs.

Regarding hilar pattern variations, 11% of the right-sided lungs showed > 2 bronchi, 69% showed > 2 pulmonary veins, and 37% showed > 1 pulmonary artery.

Among the left-sided lungs, 57% showed > 1 bronchi, 21% showed > 2 pulmonary veins, and 17% showed > 1 pulmonary artery.

Conclusion The field of pulmonary surgery is now highly advanced, with well-developed radiological and endoscopic techniques. Hence, a proper understanding and knowledge of these morphological variations of lung fissures and of the hilar pattern would be advantageous for surgeons, as well as for radiologists.

Keywords

► accessory fissure
► horizontal fissure
► lung hilum
► oblique fissure

Introduction

The right and left lungs normally present only the main fissures, which are usually complete with their lobes connected by the lobar bronchi and vessels at the hilum. The right lung is divided by the horizontal and oblique fissures, and the left only by the oblique fissure. These fissures enable the movement of the lobes against each other, thus allowing greater distention and movement of the lower lobes during respiration and, therefore, assisting in a more uniform expansion of the whole lung.¹

The position of the lung fissures are useful landmarks in citing lesions within the thorax as a whole and within the lungs specifically.² Considering the clinical importance, we took keen interest to look for any variations in the normal anatomy of lungs, which were removed from cadavers embalmed with 10% formalin and were being used for routine dissection in our department. We had performed a pilot study on the same
lungs, and had observed many variations, such as incomplete-
ness of the main fissures, and the presence of accessory
fissures that are normally obliterated. In addition to these,
in the present study, we have also encountered variations in
the hilar pattern of the lungs, contradictory to the hilar pattern
mentioned in the standard textbooks of anatomy.
In the clinical practice, radiologists and clinicians often
misinterpret these kinds of variations present in the lungs.
Each lobe segregates a definite number of bronchopulmon-
ary segments and, with this knowledge, clinicians approach
further with preoperative planning and strategy for pulmon-
ary lobectomy and segmental resection. But their strategy
may have to change when confronted with a variation in the
lung. Hence, it is important for the clinicians to have
detailed knowledge of these variations before performing
any pulmonary surgery concerned with the diseases of the
lungs. Knowledge of these anatomical variations is also of
utmost importance for radiologists to correctly interpret X-
rays and computed tomography (CT) scans.

Materials and Methods
The present study was performed on intact lung specimens
in good condition available at the Department of Anatomy.
Diseased and mutilated specimens were excluded from the
study. The lungs were removed from cadavers embalmed
with 10% formalin, which were utilized for routine dissec-
tion, during the course of undergraduate and postgraduate
medical training. A total of 96 lungs (47 right and 49 left)
were studied for variations in fissures and lobes, and 92 lungs
(45 right and 47 left) for variations in the hilar pattern. Only
those lungs in which the fissures were clearly visible and
those in which the hilar pattern was intact were considered
for the study. These were examined carefully for the presence
of any variant fissure as well as for variable hilar pattern. It
was not possible to do gender differentiation of the lung
specimens as the study was performed on specimens already
removed from the cadavers during the course of routine
dissection and were available at the Department of Anatomy.

Results
Among the 96 lungs, the prevalence of variation in the hor-
izontal and oblique fissures of 47 right-sided lungs, and in the
oblique fissure of 49 left-sided lungs was tabulated (Table 1).
A higher prevalence of variation was observed in the incom-
pleteness of the horizontal and oblique fissures of right lungs, of
which 70% had incomplete horizontal fissure and 51% had
incomplete oblique fissure (Fig. 1). The same is the case with
left lungs, in which a higher prevalence of variation was
observed in the incompleteness of the oblique fissure (62%).

The presence of accessory fissures in both right and left
lungs was also tabulated (Table 2). The accessory fissures
observed in almost all of the lung specimens were incom-
plete, with the exception of one left lung having a complete
accessory fissure separating an accessory lobe (Fig. 2).

The hilar pattern of right and left lungs showed a varying
percentage of variations regarding the number of bronchi, of
pulmonary veins, and of pulmonary arteries, as tabulated in
Tables 3 and 4. Of the right lungs, 11% showed > 2 bronchi (normal pattern), of which the highest number was
6, in 2% of the lungs (Fig. 3); 69% showed > 2 veins
(superior and inferior pulmonary veins), the highest being
4 in 13% of the lungs (Fig. 4), and 37% with > 1 pulmonary
artery, the highest being 3 in 4% of the lungs (Fig. 5).

Among the left lungs, 57% showed > 1 bronchus (normal
pattern) of which the highest number was 3 in 8% of the

Table 1 Distribution of main lung fissures

| Category | Right Lungs | | | Left Lungs | | |
|----------|-------------|-------------|-------------|----------|-------------|-------------|-------------|
|          | Oblique Fissure | Horizontal Fissure | | Oblique Fissure | | |
| Number of lungs | Percentage | Number of lungs | Percentage | Number of lungs | Percentage |
| Complete | 23 | 49% | 7 | 15% | 16 | 34% |
| Incomplete | 24 | 51% | 33 | 70% | 29 | 62% |
| Absence | NA | NA | 7 | 15% | 2 | 4% |
lungs; 21% showed > 2 pulmonary veins, the highest being 5 in 2% of the lungs, and 17% with > 1 pulmonary artery, the highest being 2 in 17% of the lungs.

**Discussion**

Lungs begin to develop during the embryonic period, initially arising as a lung bud from the ventral wall of the foregut as early as in the 4th week of gestation. This gives rise to two bronchial buds; each one enlarges to form the right and left primary bronchi, which differentiate into secondary and
tertiary bronchi consecutively. As they expand, they come to
occupy the narrow pericardioperitoneal canals that lie on
either side of the foregut. Eventually, they come in contact
with the splanchnic mesoderm that later develops into the
visceral pleura. The pleura lines each bronchopulmonary
segment of both lungs, which remain separated by fissures.

Most of these lung fissures obliterate, leaving only the
main fissures intact, that is, the horizontal and the oblique
fissures. Generally, they form the normal pattern in
humans, with the right lung exhibiting both the horizontal
and the oblique fissures, and the left lung exhibiting only
the oblique fissure. They are usually complete, with the lobes
connected only by the hilum.

In the present study, we have observed that the preva-
ience of incomplete lung fissures and of accessory fissures
are not uncommon. It has also been observed that the
prevalence of incomplete lung fissures on both sides appears
to be higher than that of accessory fissures.

Table 5 is a comparison of data collected from studies
conducted by various authors with those of the present study
based on different parameters, including the prevalence of
incomplete lung fissures and of accessory fissures.

In an analysis of the data tabulated by various authors,
including the present study, it is observed that a higher
prevalence of variation is in the incompleteness of the
normal fissures in both right and left lungs. The prevalence
of accessory fissures reported is comparatively low, as is the
absence of normal fissures.

Among the right-sided lungs, a higher prevalence of
incomplete horizontal fissure was observed. The highest
percentage was reported by our earlier study3 (83.4%) fol-
lowed by the present study (70%), and by the study by
Meenakshi et al8 (63%). The prevalence of incomplete obli-
que fissure in the right-sided lungs is low when compared
with that of the incomplete horizontal fissure, and this is
seen in the present study (51%), followed by other stu-
dies.5,8,9,11,12 However, according to Magadum et al,10 the
prevalence of incomplete oblique fissure was higher than
that of the incomplete horizontal fissure.

The absence of the oblique fissure in right lungs is reported
by Jacob et al3 (3.4%), by Prakash et al9 (7%), and by Magadum
et al10 (10%), whereas other authors have not reported the same,
as is the case in the present study. The prevalence of the absence
of the horizontal fissure of right lungs is quite low, the highest
being reported by Meenakshi et al8 (17%), followed by the
present study (15%), and the lowest being reported by George
et al5 (3%). Mamatha et al11 did not observe any absence of
horizontal fissure in her study.

The presence of accessory fissures among right lungs is
interestingly found to be high in the study by Prakash et al9
(39%) when compared with studies by other authors,5,8,10–12
which vary from 3% to 17%. The presence of complete
accessory fissures results in accessory lobes.

Azygos lobe is rarely encountered in the right lung, its
prevalence ranging from 0.4 to 1%. During development, the
posterior cardinal vein from which the thoracic portion of
the azygos vein develops penetrates the upper lobe of the
right lung along with the parietal and visceral pleura, creat-
ing an accessory fissure along the depth of which passes the
azygos vein, which is suspended from the thoracic wall by
the mesoazygous, a fold of the parietal pleura. This results in
the detachment of the upper and of the medial portion of the
upper lobe of the right lung located medial to the accessory fissure just above the hilum, resulting in the azygos lobe. However, we did not encounter an azygos lobe in our study.

Among the left-sided lungs, the prevalence of incomplete oblique fissure is comparatively high, with the highest reported prevalence in the present study (62%), followed by Meenakshi et al (47%). The prevalence of absence of the oblique fissure was reported low in the present study (4%), the highest being 11%, reported by Prakash et al. The absence of the oblique fissure has not been reported by Jacob et al by Meenakshi et al, and by George et al. The presence of accessory fissures among left lungs is found to be high in the study by Jacob et al (27.7%), followed by Prakash et al (18%). The present study has reported only 6% of accessory fissures in left lungs, which is comparatively similar with what has been reported by Arora et al (7%). In one of the left sided specimens, a complete accessory fissure that was obliquely oriented, separating a separate lingular lobe, was observed. The fissure probably separates the anterior segment of the left upper lobe from the lingular segments. There is mention by Bergman of a common fissure that separates the superior segment of the right or left lower lobe, which is also referred to as the dorsal lobe of Nelson. Dewe found it bilaterally in 12 cases, in the right lower lobe in 40 cases, and in the left lower lobe in 14 cases. They referred to the separated part as the "posterior lobe." Parenchymal fusion occurs between major lung lobes, which may be partial or complete, leading to incompleteness of the normal lung fissures or to their absence. This fusion is usually seen towards the mediastinal side of the lung. Such a fusion between lung lobes paves way to the spread of disease and collateral air drift. The usual patterns of collapse seen in patients with endobronchial lesions can alter and may also give rise to an atypical type of pleural effusion. A thorough understanding of the appearance and of the implications of an incomplete fissure is significant for planning of lobar resection due to the possibility of a higher prevalence of air leak in lobar fusion. Another variant lung fissure is the accessory fissure, which usually occurs at the boundaries between bronchopulmonary segments. Anatomically, an accessory fissure is a cleft of varying depth lined by visceral pleura. Accessory fissures could be the result of the nonobliteration of spaces that are normally obliterated. An accessory fissure may cause misinterpretation of an infection as apleural effusion causing a sharply marginated pneumonia. Radiologically, an accessory fissure can be mistaken for a lung lesion.

Along with the study of variant lung fissures, an attempt has also been made to study the hilar pattern of lungs as they presented variability in the number of structures forming the root of the lung, contrary to what is mentioned in the standard textbooks, but their significance is yet unknown. Hardly any studies have been done on the hilar pattern as revealed by our literature search. A similar study has been reported by George et al. A comparison between our study and the study by George et al is depicted in Tables 3 and 4.

### Conclusion

In the present study, a high prevalence of incomplete horizontal and oblique fissures were observed amongst right lungs, and this was also the case with left lungs regarding the oblique fissure. The horizontal fissure was absent in 15% of the right lungs, whereas the oblique fissure was absent in 4% of the left lungs. Accessory fissures, mostly incomplete, were observed in right (17%) and left (6%), lungs, with the exception of a single left lung with a complete accessory fissure separating an accessory lobe.

The hilar pattern demonstrated a wide range of variations regarding the pulmonary artery, vein and bronchi, both in their number and arrangement, unlike what is mentioned in the standard textbooks of anatomy. As is evident from the present study, it is imperative for surgeons to be aware of the variant morphology of lungs, which is quite common, in order to plan effectively their surgical procedures, and for radiologists to accurately interpret the radiological images.

### Conflicts of Interests

The authors have no conflicts of interests to declare.

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References
3 Jacob SM, Pillay M. Variations in the inter-lobar fissures of lungs obtained from cadavers of South Indian origin. Int J Morphol 2013;31(02):497–499