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Research Article

LOBES AND FISSURES IN FETAL LUNG AT DIFFERENT GESTATIONAL AGES: ANATOMICAL STUDY WITH CLINICAL SIGNIFICANCE

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A R T I C L E I N F O

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A B S T R A C T

Objectives: lungs are divided into various lobes by oblique and horizontal fissures. The fissures can be complete, incomplete or accessory depending on the partial obliteration or due to the non-fusion of spaces between the bronchopulmonary buds. The fissures help in the movement of lobes in relation to one otherresulting in greater distention and movements of lower lobes during respiration. The knowledge of fissures and lobes of the lungs are important to plan various surgical procedures.

Background: The current research paper helps us to know the earliest appearance of fissures, as the study was done on the fetal lung of varying gestational ages, earliest being 10 weeks of gestation. The partial or complete obliteration of prenatal fissures results in absence or incompleteness of fissure. Any variation in morphological pattern of fissures indicates variations from normal pattern of development of lung. The knowledge of the fissures and lobes are important to plan various surgical procedures and also to avoid post-operative complications like air leakage. Various radiological appearances of lobar anatomy of lungs and the position of the interlobar fluid helps the cardiothoracic surgeons during surgical resection of individual lung segments. Post-operative air leakage is most commonly due to an incomplete fissure and accessory fissure, might act as a barrier to spread in the tissue creating a sharply demarcated pneumonia, which could be misinterpreted in the radiograph as atelectasis or consolidation.

Results: Variation in the appearance of lobes and fissures were noted. There was absence and incomplete horizontal fissure in the right lung. 23 cases presented with complete fissure and 14 fetuses presented with incomplete horizontal fissure. In the left lung complete oblique fissure was observed in 38 specimens and 2 specimens presented with incomplete oblique fissure.

Conclusion: Study of lobes and fissures is important to know the anatomical variations in the lobulation of lungs during segmental or lobar resections of lungs. There can be misinterpretation of accessory lobes and fissures on X-rays and CT scans.

INTRODUCTION

Lung maturation and achievement of functionality is primarily a biochemical process and is under the control of a number of different hormones. The right lung is divided into three lobes- superior, middle and the inferior by oblique and horizontal fissures. The left lung is divided into two lobes- superior and inferior by the oblique fissure (Standring 2016). Incomplete fissure can be formed due to partial obliteration of these fissures and accessory fissure results from the of non-fusion of spaces between the bronchopulmonary buds which normally are obliterated. Any factor affecting the fusion in the developmental stage results in various variations in the lobes and fissures of the lung.

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The fissures help in movement of lobes in relation to one other, which results in greater distention and movements of lower lobes during respiration.

The fissures separate the individual broncho-pulmonary segments. All the fissures gradually get obliterated, but the fissures along the inter-lobar planes persist and give rise to major (oblique) and minor (horizontal) fissures (Sudikshya *et al*., 2018). Partial or complete obliteration of prenatal fissures results in absence or incompleteness of fissure. Non obliteration or persistence of prenatal fissures results in accessory lobes and incomplete fissures indicate partial fusion between lobes. Any variation in the morphological pattern of fissures indicates variations from normal pattern of development of lung (Amit *et al*, 2015).

The morphogenesis of lungs at molecular level is controlled by a signaling pathway regulated by temporal and sequential expression of highly conserved HOX genes. A study (Kappan

1996)suggested the role of HOX transcription factor in regional specification and tissue specific cell differentiation in lung development. A loss of HOX a-3 function affects development of lungs and surrounding tissues (Nisha *et al*., 2014). Similarly transforming growth factor (TGF b) and fibroblastic growth factor (FGF) plays important roles in pulmonary morphogenesis, functions and pathogenesis of lung diseases(Nisha *et al*., 2014). A wide range of variation in occurrence of oblique, horizontal and accessory fissures might be due to genetic and environ- mental factors during its development (Sudikshya *et al*., 2018).

A fissural classification based on the degree of completeness of fissures and the location of the pulmonary artery at the base of oblique fissure was proposed (Craig *et al*., 1997). Four stages have been described: Grade 1- complete fissure with entirely separate lobes, Grade 2- complete visceral cleft but parenchyma fusion at the base of the fissure, Grade 3- visceral cleft evident for a part of the fissure and Grade 4- complete fusion of lobes with no evident fissure lines.

Accessory fissure is a cleft of varying depth lined by visceral pleura. The accessory fissures usually occur at the boundaries of the bronchopulmonary segments. The accessory fissures are superior accessory fissure (SAF), inferior accessory fissure (IAF), and left minor fissure (LMF). The SAF is seen in the territory of lower lobe which partially or completely separates the superior segment of the lower lobe from the basal segments. If present, the superior segment is been called the posterior or dorsal lobe. The IAF is seen around the medial basal segment of the lower lobe. LMF separates the lingula from the rest of the left upper lobe. These accessory fissures alter the diagnosis and presence of incomplete fissures may spread diseases to adjacent lobes through parenchymal continuation (Sudikshya *et al*., 2018).

Authors (Meenakshi *et al*., 2004) quoted that the presence of fissures in a normal lung enhances uniform expansion and their position can be used as a reliable land mark in specifying lesions within the thorax. Study (Sharma *et al*., 2014) done on the morphometric analysis of the human cadaveric lungs observed maximum variations in the fissures of the left lung as they showed an extra transverse fissure. Out of 14 left lungs, 5 of them had transverse fissures. The author also stated that the knowledge of normal fissures of the lungs and their variations helps the cardiothoracic surgeon to avoid undue complications during surgery and the radiologist to make accurate diagnosis is case of lung pathologies and an incomplete fissure may lead to post-operative air leakage[8]. Study (Meenakshi *et al*., 2004) done on 30 pairs of lungs observed absence of horizontal fissures in 5 right sided lung and therefore middle lobe was not appreciable. In 19 lungs horizontal fissure was incomplete and there was incomplete oblique fissure in 11 lungs and hence lobulation was imperfect. The author also stated that the accessory fissure especially in the infants of varying depth could be seen in abnormal locations of the lung delimiting the anomalous lobes which corresponded to the normal bronchopulmonary segment and sometimes an accessory fissure could be mistaken for a lung lesion radiologically. An incomplete fissure may also alter the spread of disease within the lung (Meenakshi *et al*., 2004). Another study (Zareena 2014) done on lungs of adult and fetuses observed that out of 6 right sided fetal lungs normal pattern of oblique fissure was observed in 4 lungs, incomplete horizontal fissure in 6 and incomplete oblique fissure in 2 lungs. Out of 6 left sided lungs normal pattern of complete oblique fissure was seen and no accessory fissure or lobe was noted.

The knowledge of lung lobulation can predict the atrial situs. It is important to know the anatomical variations in the lobulation of lungs during segmental or lobar resections of lungs. There can be misinterpretation of accessory lobes and fissures on X-rays and CT scans and can be confused with certain clinical conditions like linear atelectasis, pleural scars or walls of bullae (Craig *et al*., 1997).

The knowledge of the fissures and lobes of the lungs are important to plan various surgical procedures and also to avoid post-operative complications like air leakage. It can also be helpful in explaining various radiological appearances of lobar anatomy of the lungs and the position of the interlobar fluid and is also useful to cardiothoracic surgeons during surgical resection of individual lung segments Post-operative air leakage is most commonly due to an incomplete fissure and the accessory fissure, might act as a barrier to spread in the tissue creating a sharply demarcated pneumonia, which could be misinterpreted in the radiograph as atelectasis or consolidation (Craig *et al*., 1997).

The fissures delimit the lobes and are helpful in locating the bronchopulmonary segments, and knowledge of their position is necessary both anatomically as well as clinically for planning lobectomies & surgical resections & also in the interpretation of radiological images (Dandy 1978). Gradation of fissures is important surgically to ease the approach in surgical procedure and to prevent postoperative haemorrhage and complications (Sudikshya *et al*., 2018). In cases of incomplete fissures where parenchymal fusion is present more dissections is needed to reach the bronchi and pulmonary arteries during surgical resections, leading to more haemorrhage and postoperative complications (Sudikshya *et al*., 2018).

Studies on the lobes and fissures of the developing lung were not available, however few studies were available on the fissures of the adult lung. The present study will add to the knowledge on the development of fissures and lobes in the fetal life at the earliest.

MATERIAL AND METHOD

The present study was carried on 40 autopsied human fetuses of varying gestational ages between 10-30^{+}weeks from 2014-2016 in the Department of Anatomy, Government Medical College and Hospital. The fetuses were obtained from the Department of Obstetrics and Gynaecology which were sent for routine autopsy. Consent was taken from the parents to perform autopsy and to carry out any additional studies. Macerated fetuses, fetuses with congenital malformation and fetuses with maternal history of infection such as rubella, hepatitis, CMV, HIV were excluded from the study.

The lungs with trachea were dissected out en masse from the thoracic cavity and observed for any congenital abnormality. The specimen was examined carefully to observe any gross anomaly such as number of fissures and lobes or presence of any accessory lobes.

RESULTS

For the present study, 80 lungs (of 40 fetuses) were removed en masse and the fetuses were divided according to the gestational age and grouped as shown in Table 1.

Table 1 Distribution of fetuses according to gestation and number of cases with sex.

Gestational age	Groups	Male	Female	Number of cases
10-15 weeks	A	8	1	9
15^{+}-20 weeks	B	7	2	9
20^{+}-25 weeks	C	4	4	8
25^{+}-30 weeks	D	4	5	9
30^{+} weeks	E	2	3	5
Total		25	15	40

The appearance of fissures and lobes were observed and noted in both right and left lung in 40 fetuses and tabulated as shown in Table 2.

Table 2 Gross appearance of fetal right lung.

Lobes	2 lobes	3
	Incomplete 3rd lobe	14
	Complete 3 lobes	23
Oblique fissure	Presence	40
	Absence	0
Horizontal fissure	Absence	3
	Incomplete	14
	Complete	23
Presence of extra fissure		1(one vertical fissure starting from the middle of the horizontal fissure dividing the middle lobe into 2)
Presence of accessory lobe		0

As observed in Table 2 and 3 the lobulation of lung appeared as early as 10 weeks of intrauterine life. However, in some fetuses there was absence and incomplete horizontal fissure in the right lung. Out of 40 right lung observed, 23 cases presented with complete fissure which contributed to 57.5% of cases. Incomplete horizontal fissure was observed in 14 fetuses which contributed to 35% of the total cases taken. Absence of horizontal fissure was also noted in 7.5% of the total cases. Out of the 40 fetuses observed there was presence of one extra lobe in single fetus. There was no appearance of accessory lobe in the right lung. Incomplete horizontal fissure was observed in all age groups. Absent horizontal fissure was observed in age group A, B and D.

In the left lung complete oblique fissure was observed in 38 out of the 40 lungs observed which contributed to 95%. Incomplete oblique fissure was observed in 2 fetuses one in age group C and one in age group E. Presence of horizontal fissure was noted in 3 fetuses in age group A, B and D which contributed to 7.5% of the total cases observed. Accessory lobe was present in one fetus in the age group B.

Incomplete horizontal fissure in the right lung observed in right lung was present in all age group, maximum of 4 each in group B and D but only one case in group A, 3 cases in group C and only 2 cases in group E. Absent horizontal fissure was observed in A, B, and D with single cases in each group.

In the left lung a single case of incomplete oblique fissure was noted in group C and E whereas presence of a single case horizontal fissure was noted each in group A, B and D.

DISCUSSION

The gross development of fetal lung has been a subject of interest for many embryologists, as gross examination gives us an indication of gestational age, lobulation of lung and development at different ages.

The studies done on fetal lung about the appearance of lobes and fissures were very few. Indian studies regarding the lobulation and formation of fissures of the fetal lung were few for comparison with the data of present study. Most of the studies done were on the adult lung after cadaveric dissection. Study (Zareena 2014) done on fetal lungs on 6 specimens in which the age group of the fetuses were not defined showed normal oblique fissure in 4 right lungs and incomplete oblique fissure in 2 which accounted for 22.7%. But on the left side oblique fissure was present in all 6 specimens. Incomplete horizontal fissure of right lung was observed in all the 6 specimens examined in the study. Another study (Meenakshi *et al*., 2004) done on 22 male adult lungs appreciated absent horizontal fissure (16.6%) and incomplete horizontal fissure (63.3%) on the right side. Incomplete oblique fissure of the right side accounted for 36.6%, whereas on the left side the incidence was 46.6%.

In the present study when the lobes and fissures were noted it has been seen that oblique fissure was complete in all the 40 right lung, but on the left side 2 specimens had incomplete oblique fissure which accounted for only 5% of the total 40 cases examined. Incomplete horizontal fissure was present in 14 cases of right lung which accounted for 35% of the total cases. Absence of horizontal fissure in the right lung was also noted in 3 cases which accounted for 7.5% of the total cases. Presence of complete horizontal fissure was present in 3 cases of the left lung which made 7.5% of the total cases (Table 2 & 3).

Table 3 Tabulation of fissures of right lung according to gestational age.

Groups	Complete horizontal fissure	Incomplete horizontal fissure	Absent horizontal fissure	Presence of oblique fissure	Absent oblique fissure	Extra fissure
A	7	1	1	9	0	0
B	4	4	1	9	0	0
C	5	3	0	8	0	1
D	4	4	1	9	0	0
E	3	2	0	5	0	0

In the present study complete 3 lobes were observed in 23 cases of right lungs. Incomplete 3 lobes observed in 14 and 2 lobes in 3 cases which accounted for 35% and 7.5% of the total cases observed. Whereas on the left side only 2 cases had complete 3 lobes, rest 38 cases presented with 2 lobes. There was presence of accessory lobe in the left lung from the inferior border to the inferior surface in one case. There was also presence of 4 lobes in the right lung which was formed by a vertical fissure which extended from the middle of the horizontal fissure, which was noticed in only one right lung. This anomaly has not been mentioned earlier in any of the previously published literature.

Table 4 Gross appearance of fetal left lung.

Lobes	2 lobes	38
	Incomplete 2nd lobe	2
	3 lobes	3
Oblique fissure	Complete	38
	Incomplete	2
Horizontal fissure	Presence	3
Presence of accessory lobe		1

In the present study maximum cases of incomplete horizontal fissure in the right lung was present between age group 15^{+}-20 weeks and 25^{+}-30 weeks ie, 4 cases in each group and minimum of 1 case in 10-15 weeks. Single case each of absent

horizontal fissure was present in 10-15 weeks, 15^{+}-20 weeks and 25^{+}-30 weeks.

Table 5 Tabulation of fissures of left lung according to gestational age.

Groups	Complete oblique fissure	Incomplete oblique fissure	Absent oblique fissure	Horizontal fissure	Presence of Accessory lobe
A	9	0	0	1	0
B	9	0	0	1	1
C	8	1	0	0	0
D	9	0	0	1	0
E	4	1	0	0	0

Observation of the left lung showed presence of single case of horizontal fissure each in age group of 10-15 weeks, 15^{+}-20 weeks and 25^{+}-30 weeks. Maximum of 2 cases showed incomplete oblique fissure one in each age group of 20^{+}-25 weeks and 30^{+} weeks.

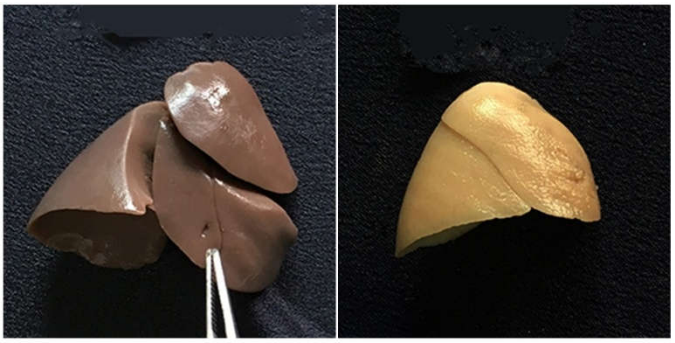

Fig 1 **Fig 2**

Figure 1 Right lung with four lobes.
Figure 2 Right lung with absent horizontal fissure.

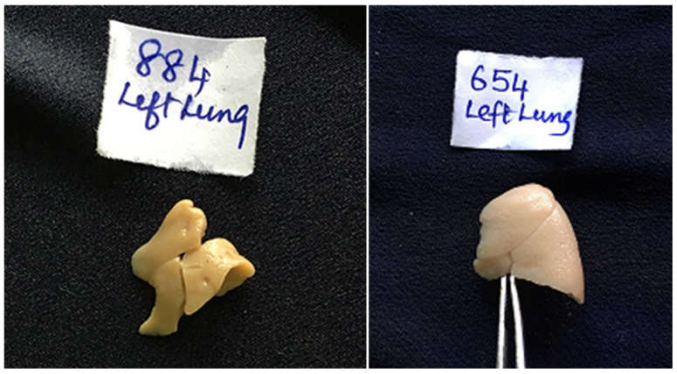

Fig 3 **Fig 4**

Figure 3 & 4 Left lung with three lobes.

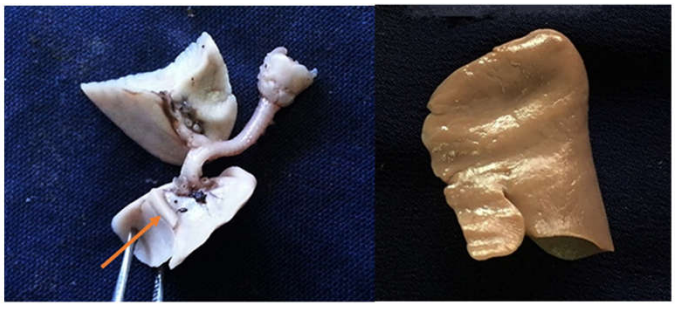

Fig 5 **Fig 6**

Figure 5 Left lung with an accessory lobe (Arrow indicating accessory lobe).
Figure 6 Left lung with incomplete oblique fissure.

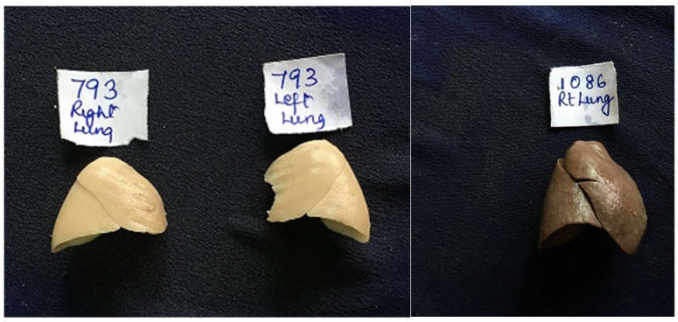

Fig 7 **Fig 8**

Figure 7 Right & left lung with two lobes.
Figure 8 Right lung with incomplete horizontal fissure.

The bronchopulmonary segments are separated by spaces which later gets obliterated except along the line of division of principal bronchi giving rise to major (oblique) and minor (horizontal) fissures in a fully developed lung. The visceral pleura is reflected along these fissures and covers individual lobes on all the sides. Incomplete or absence of oblique and horizontal fissures could be due to a defect in the obliteration of these fissures either completely or incompletely (Sudikshya *et al*., 2018).

Defective pulmonary development can result in variations in the lobes and fissures of lung. These fissures, oblique or horizontal may be complete, incomplete or absent depending upon the partial or complete obliteration (Lattupalli 2014).

SUMMARY AND CONCLUSION

In the present study the appearance of fissures and lobes of the lungs were observed and it was found that complete lobulation of the lungs appeared as early as 10 weeks of gestation. However, there werepresence of incomplete lobulation of right as well as left lung in all the age groups.

Thus, the present study will add to the knowledge of the earliest appearance of fissure and lobulation of the lungs.

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