ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

Morphological and morphometric analysis of lung: A cadaveric study

Savita Kanaujea[1], Arvind Kumar Pankaj[2], Kaweri Dande[3], Sehra Jabeen[4], Navneet Kumar[5]

[1,4]Junior Resident, [2,5]Professor, Department of Anatomy, King George's Medical University, Lucknow, [3]Assistant Professor, Department of Anatomy, Hind Institute of Medical Sciences, Barabanki, Uttar Pradesh, India

Submission: 08-11-2023 Revision: 23-01-2024 Publication: 01-03-2024

ABSTRACT

Background: The lung is a respiratory organ in which steady development begins during the embryonic period at 0–7 weeks' gestation and continues into early childhood. Cardiothoracic surgeries and procedures such as lobectomy, segmental resection of bronchoscopy, require a thorough knowledge of the anatomy of the lung. Study of length, fissures and lobes of the lung can guide the surgeons for the above procedures and help them to prevent undue complications during surgery. Many variations are noted by researchers till date in both the lungs in regards to length, breadth, fissures, and lobes. In the current study, we have also observed variations in fissures of lung. **Aims and Objectives:** To study the normal length, breadth, and thickness of both sides of lungs, variations in the length, breadth, and thickness of both sides of the lungs. To study the normal fissures, lobes and their variations, of both right and left lungs, and also to study the number of bronchi, pulmonary artery, and pulmonary vein. **Materials and Methods:** 50 Right and 50 left lungs were obtained from embalmed cadavers, used for dissection in the Department of Anatomy, King George's Medical University, Lucknow, UP, by using measuring tape and measuring scale. Photography was done by a DSLR camera. **Results:** The left lung shows maximum variations in the hilum. Out of 50 left lungs, 6 showed the absence of oblique fissures, 2 lungs had 2 arteries, 2 lungs had 2 Veins, and 1 had 2 bronchi. Out of 50 right lungs, 2 lungs showed 2 arteries, 2 lungs had 2 veins, and 2 had 3 bronchi. **Conclusion:** Knowledge of normal measurements of both sides of the lungs and their variations may help cardiothoracic surgeons avoid complications during surgery and it may help radiologists resolve uncertain radiographic findings.

Key words: Lung; Fissure; Bronco-pulmonary segment; Artery; Vein; Bronchi

Access this article online

Website: http://nepjol.info/index.php/AJMS

DOI: 10.3126/ajms.v15i3.59845

E-ISSN: 2091-0576

P-ISSN: 2467-9100

INTRODUCTION

In 4th week of intrauterine life, the respiratory diverticulum (lung bud) appears in the form of an outgrowth from the ventral wall of the foregut, grows caudally, and bifurcates into right and left bronchial buds. The right bronchial bud divides into three secondary bronchi and the left bronchial bud divides into two secondary bronchi then development of each lung occurs by a process of repeated dichotomous branching of the secondary bronchi. Bronchopulmonary segments are formed after several generations of branching. These bronchopulmonary segments are separated by spaces in the fetal period which get obliterated later, except along the line of division of principal bronchi, and produce fissures (oblique and horizontal) in completely developed lung. During the embryonic period up to the 7th weeks of gestation, the development of the lung starts and continues into early childhood.[1,2]

The two lungs are organs of respiration, situated on either side of the mediastinum surrounded by the right and left pleural cavities. Each lung has a base that sits on the diaphragm, apex which is project above the first rib, two surfaces are the costal surface and mediastinal surface. Mediastinal surface contains the comma-shaped hilum of the lung, structures enter and leave via this hilum. Generally, the pulmonary artery is superior, pulmonary veins are inferior at the hilum and bronchi are slightly posterior in position.[3]

Address for Correspondence:
Dr. Arvind Kumar Pankaj, Professor, Department of Anatomy, King George's Medical University, Lucknow, Uttar Pradesh, India.
Mobile: +91-8004872858. **E-mail:** drarvindpankajcsmmu@yahoo.com

The right lung has three lobes namely upper lobe, middle lobe, and inferior lobe and two fissures are oblique fissure and horizontal fissure. The oblique fissure separates the lower lobe from the upper lobe and middle lobe of the right lung. The horizontal fissure separates the upper lobe from the middle lobe. The left lung is smaller than the right lung and two lobes of the left lung are separated by an oblique fissure. The oblique fissure of the left lung is slightly more oblique than the oblique fissure of the right lung.[4,5]

The prior knowledge of the anatomy of the fissures, lobes of the lungs helps the surgeon to correlate the radiological imaging and surgical procedures, thus ensuring that the excellent medical treatment is attain. Cardiothoracic surgeries and procedures such as lobectomy, segmental resection, and bronchoscopy. requires detail knowledge of anatomy of lung and their variations. The study of length, fissures and lobes of the lung can help the surgeons for these procedures. The fissure helps in uniform expansion of the entire lung during respiration for more air intake. As the fissures form boundaries for lobes of the lungs, knowledge of the position of fissure is essential to understand lobar anatomy and locating the broncho-pulmonary segments which is important both anatomically and clinically. The radiologists should have an idea about variations of fissures of both lungs. More variations are noted by researchers till date in both right and left lung in respect to length, breadth, fissures, and lobes. Knowledge of variations of lung is required by clinicians for interpretation on different imaging techniques.[1-6] Thorough knowledge of the anatomical variations in fissures and radiological identification of these variations is essential for locating the intrathoracic and lung parenchymal lesions, to determine the the disease.[7]

Aims and objectives

The aim of the study is to observe the morphology and morphometry of both right and left lungs.

1. To study the normal length, breadth, and depth of both right and left lungs
2. To study the normal fissures, lobes and their variations, of both right and left lung
3. To study the number of bronchi, pulmonary artery, and pulmonary vein.

MATERIALS AND METHODS

One hundred (50 left and 50 right lungs) adult formalin-fixed cadaveric lungs were observed in the dissection hall of King George's Medical University, Lucknow, Uttar Pradesh. Only those lungs that were covered all over by pleura except at the hilum were included in the study. In this study, no gender difference of the lungs was made. Diseased lung and any part of the lung was cutoff during its removal, was excluded from this study.

Each lung was washed with water and carefully measured length, breadth, and depth using a measuring tape and measuring scale. Length and depth of fissures (both horizontal and oblique fissures in case of the right lung and oblique fissure in case of the left lung) were measured and recorded. Uncommon variations were photographed using a DSLR camera. The ethical clearance was obtained by the Institutional Ethical Committee at KGMU UP, Lucknow (Order No. 1513/Ethics/2023).

Inclusion criteria

Inclusion criteria were as follow: lungs which were covered all over by pleura except at the hilum.

Exclusion criteria

Exclusion criteria were as follows: no gender difference of the lungs was made, diseased lung and any part of the lung was cutoff during its removal, were excluded from this study.

RESULTS

Right lungs

Among the 50 right lungs, 2 lungs (4%) showed absence of horizontal fissure. Two (4%) lungs had 2 pulmonary arteries, two lungs (4%) had 2 pulmonary veins, two of them (4%) showed 3 bronchi in the hilum.

Left lungs

Among the 50 left lungs, 6 (12%) showed the absence of oblique fissure, 2 (4%) lungs showed 2 pulmonary arteries, 2 (4%) of the lungs had 2 pulmonary veins, one of them (2%) had 2 bronchi in the hilum. Photographs of the specimens with some of the major variations are shown in Figures 1-8. Percentage statistics is given in Table 1 and the incidence of variation is shown in Table 2.

DISCUSSION

The fissures separate individual broncho-pulmonary segments during development, and become obliterated except along two planes, which is evident in the fully developed lungs as oblique or horizontal fissures. Absence or incomplete oblique or horizontal fissures could be due to obliterated fissures that can occur complete or incomplete.[8,9]

Cadavers are the best means to understand the variant anatomy of any organ. Many researchers have recorded the anomalous anatomy of the lungs in human cadavers.

Figure 1: Measurement of the length of the lung using a measuring tape

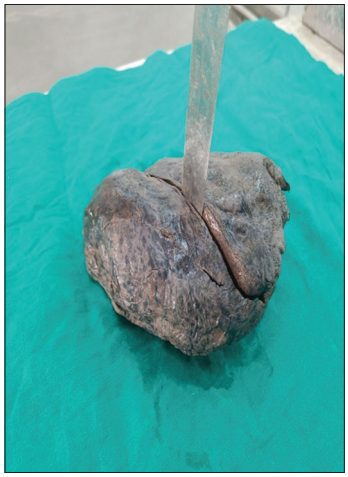

Figure 2: Measurement of depth of right lung using a measuring scale

Figure 3: Left lung hilum showing absence of oblique fissure

Figure 4: Lung hilum showing absence of horizontal fissure

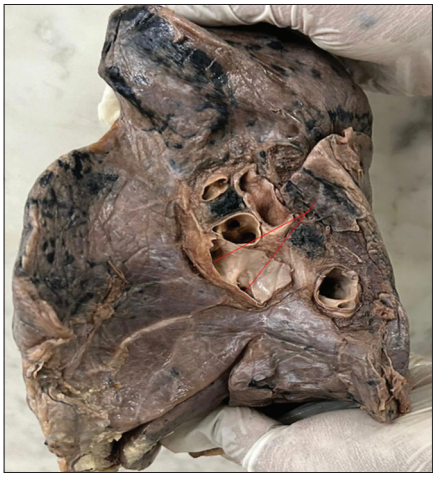

Figure 5: Right lung hilum showing two superior pulmonary vein

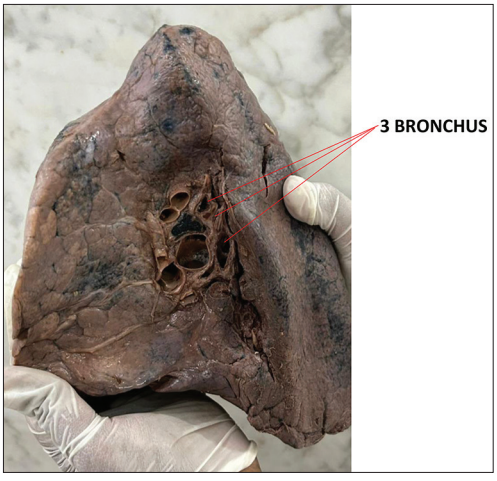

Figure 6: Right lung hilum showing three bronchi

During the development of the lungs, numerous bronchopulmonary buds are formed and later they fuse completely except at the sites of fissure formation. This results in the formation of lobes and fissures. If there is any factor affecting the fusion in the developmental stage, there will be variations in the formation of lobes and fissures of the lung.

Table 1: Paired sample statistics

Pair	Parameters	Mean	n	SD	P-value
Pair 1	Right side length (cm)	19.06	50	2.99	<0.001
	Left side length (cm)	21.10	50	2.02	
Pair 2	Right side breadth (cm)	19.39	50	2.45	0.838
	Left side breadth (cm)	19.28	50	2.52	
Pair 3	Right side fissure length (cm) oblique	15.73	47	4.44	0.014
	Left side fissure length (cm) oblique	18.15	47	4.07	
Pair 4	Right side fissure number	1.89	44	0.32	<0.001
	Left side fissure number	1.00	44	0.00	
Pair 5	Right side fissure depth (cm) oblique	3.58	47	1.63	0.243
	Left side fissure depth (cm) oblique	3.26	47	1.17	

Table 2: The variations seen in the right and left lungs

Right lung (n=50)	Left lung (n=50)
Feature No. (%)	Feature No (%)
Absence of horizontal fissure 2 (4)	Absence of oblique fissure 6 (12)
Two arteries in the hilum 2 (4)	Two arteries in the hilum 2 (4)
Two veins in the hilum 2 (4)	Two veins in the hilum 2 (4)
Three bronchi in hilum 2 (4)	Two bronchi in hilum 1 (2)

Knowledge of the development of minor lung segments and pulmonary veins is also clinically important. When we compared to the previous studies then we got higher case of absence of oblique fissures in the left lung.[4]

The mean length of the right lung and left lung was 19.06 and 21.10, respectively. The mean breadth of the right lung and left lung was 19.39 and 19.28 respectively. The mean length of the oblique fissure of the right lung and left lung was 15.73 and 18.15, respectively. The mean depth of the oblique fissure of the right lung and left lung was 3.58 and 3.26, respectively (Table 1).

The mean of number of fissure of the right lung and the left lung was 3.58 and 3.26 respectively. We applied paired *t*-test and the length and fissure number were statically significant, length of oblique fissure was statistically just significant in the current study (Table 1).

Measurements of fissures of both left and right lungs are given in Table 1 and incidence of variations in Table 2.

We did not find even a single case of incomplete fissure which was reported by previous researchers as 31.25% for the right and 21% for left lung, respectively and We did not find a single case of absence of oblique fissure in the right lung which was reported by previous researchers as 2% for right lung.[4-6]

Prakash et al., found one accessory lobe on the inferior aspect in 27.2% of lungs but in the present study, there was no accessory lobe.[10]

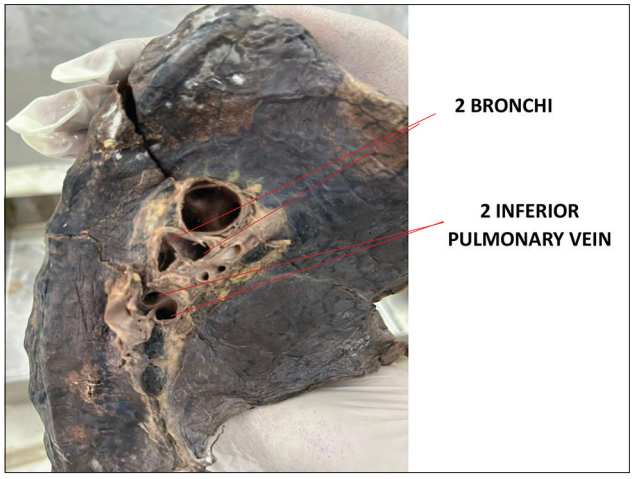

Figure 7: Left lung hilum showing two pulmonary vein and two bronchi

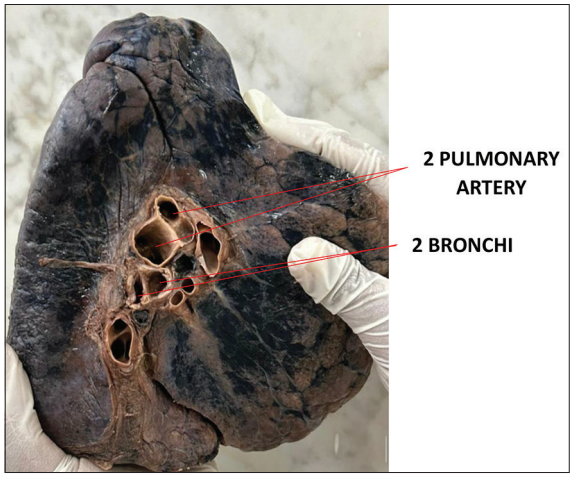

Figure 8: Left lung hilum showing two pulmonary arteries and two bronchi

Twelve percent of left lungs in the current study showed the absence of oblique fissure, whereas the earlier researcher found the incidence of this variation as 10.5–47%.

In our study horizontal fissure was absent in 2 cases (horizontal fissure divides the lung into 2 lobes. The

Table 3: Summary of discussion

Author	Year	Sample size	Study place	Type of study	Findings
George et al.	2014	138 Right-65 Left-73	Manipal	Cadaveric Study	Right lung-2 (3.07%)-absence of horizontal fissure 3 (4.61)-3 fissures 2 (3.07%)-3 arteries 14 (19.17%)-3 vein
Sharma and Kattimuthu	2014	27 Lungs Right - 13 Left - 14	Rajasthan	Cadaveric Study	Right lungs-1 (7.69%)-absence of transverse fissure Left lungs-2 (14.28%)-absence of oblique fissure
Thapa et al.	2016	40 Right-20 Left - 20	North Karnataka	Cadaveric Study	Right lung-4 (20%)-absence of horizontal fissure Left lung-3 (15%)-absence of oblique fissure
Joshi et al.	2022	70 Right- 32 Left- 38	Greater Noida (Uttar Pradesh)	Cadaveric Study	Right lung- 4 (12.5%)- absence of oblique fissure 8 (25%)- absence of horizontal fissure Left lung- 4 (10.7%)- absence of oblique fissure
Present Study	2023	100 Right - 50 Left - 50	Lucknow (Uttar Pradesh)	Cadaveric Study	Right lung- 2 (4%)-absence of horizontal fissure 2 (4%)-2 Pulmonary Vein 2 (4%)-2 pulmonary arteries 2 (4%)-3 bronchi Left lung- 6 (12%)-absence of oblique fissure 2 (4%)-2 arteries 2 (4%)-2 veins 1 (2%)-2 bronchi

oblique fissures were absent in 6 lungs (12%), out of 50 left lungs. Whereas a previous study has shown only 3.6%. Yet another researcher found only 10.7%. We have seen that the left lung shows maximum variations of fissures. This anatomical knowledge and variations may be helpful for clinicians, surgeons, and radiologists.[4]

In this study, we have measured the length and breadth of both right and left lungs, their variations, and the length and depth of horizontal and oblique fissures of both right and left lungs (Table 1). Previously such measurements were done by only Sharma and Kattimuthu Knowledge of normal measurements of lungs, their fissures, and their variations helps cardiothoracic surgeons avoid postoperative complications and also helps in guiding the lung surgery without any confusion regarding lung anatomy. Furthermore, it helps radiologists to interpret MRI and CT in case of lung pathologies. Being aware of these variations before the pulmonary lobectomy and thoracoscopic segmentectomy may alter the preoperative strategy.[11,12] A summary of the discussion is shown in Table 3.

Limitations of the study

The study should be conducted in more than 100 sample size to get more effective result. In present study cadaveric lung could be dissected deep in hilum region.

CONCLUSION

Knowledge and their variations help cardiothoracic surgeons and radiologists. Knowledge of the normal measurements of fissures and lobes of the lungs and their variations is necessary to plan various surgical procedures to avoid post-operative complications such as air leakage, pneumothorax, and bronchopleural fistula.

Thus this study may help cardiothoracic surgeons and radiologists. Results of the present study and their comparison with the previous studies show that many variations can occur at the hilar structures, fissures, and lobes of the lungs in humans. Thus this study adds a database for the same.

ACKNOWLEDGMENT

Authors extend their gratitude towards all non-teaching staff for their immense support to conduct the study. Authors also acknowledge Scholars/Editors/Publishers of all those research articles from where literature for current study has been discussed and review.

REFERENCES

1. Kc S, Shrestha P, Shah AK and Jha AK. Variations in human pulmonary fissures and lobes: A study conducted in Nepalese cadavers. Anat Cell Biol. 2018;51(2):85-92.
https://doi.org/10.5115/acb.2018.51.2.85
2. Smith LJ, McKay KO, van Asperen PP, Selvadurai H and Fitzgerald DA. Normal development of the lung and premature birth. Paediatr Respir Rev. 2010;11(3):135-142.
https://doi.org/10.1016/j.prrv.2009.12.006
3. Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 41st ed. Amsterdam: Elsevier; 2016. p. 956-958.
4. George BM, Nayak SB and Marpalli S. Morphological variations of the lungs: A study conducted on Indian cadaver. Anat Cell Biol. 2014;47(4):253-258.
https://doi.org/10.5115/acb.2014.47.4.253

5. Mpolokeng KS, Madolo MY, Louw GJ and Gunston G. Anatomical variations in lung fissures leading to supernumerary lobes in the lungs. Transl Res Anat. 2022;28:100209.
https://doi.org/10.1016/j.tria.2022.100209
6. Murlimanju BV, Prabhu LV, Shilpa K, Pai MM, Kumar CG, Rai A, et al. Pulmonary fissures and lobes: A cadaveric study with emphasis on surgical and radiological implications. Clin Ter. 2012;163(1):9-13.
7. Joshi A, Mittal P, Rai AM, Verma R, Bhandari B and Razdan S. Variations in pulmonary fissure: A source of collateral ventilation and its clinical significance. Cureus. 2022;14(3):e23121.
https://doi.org/10.7759/cureus.23121
8. Sreenivasulu K, Anilkumar P and Gaiqwad MR. Morphological anatomy of accessory fissures in lungs. Indian J Tuberc. 2012;59(1):28-31.
9. Manjunath M, Sharma MV, Janso K, John PK, Anupama N and Harsha DS. Study on anatomical variations in fissures of lung by CT scan. Indian J Radiol Imaging. 2021;31(4):797-804.
https://doi.org/10.1055/s-0041-1741045
10. Prakash, Bhardwaj AK, Shashirekha M, Suma HY, Krishna GG and Singh G. Lung morphology: A cadaver study in Indian population. Ital J Anat Embryol. 2010;115(3):235-240.
11. Sharma H, Prabhakaran K and Jain LK. Morphometric analysis of human cadaveric lungs. Int J Curr Pharm Rev Res. 2014,6(22):34-36.
12. Yildiz A, Gölpinar F, Calikoğlu M, Duce MN, Ozer C and Apaydin FD. HRCT evaluation of the accessory fissures of the lung. Eur J Radiol. 2004;49(3):245-259.
https://doi.org/10.1016/S0720-048X(03)00137-2

Authors Contribution:
SK- Writing original draft, data management, validation; **AKP-** Conceptualization, methodology, supervision; **KD-** Manuscript writing, review and editing; **SJ**- Literature survey and preparation of figures; **NK-** Review manuscript.

Work attributed to:
King George's Medical University, Lucknow, Uttar Pradesh, India.

Orcid ID:
Savita Kanaujea - https://orcid.org/0000-0002-0380-0594
Arvind Kumar Pankaj - https://orcid.org/0000-0002-4270-0756
Kaweri Dande - https://orcid.org/0000-0003-0450-3484
Sehra Jabeen - https://orcid.org/0000-0001-9237-2159
Navneet Kumar - https://orcid.org/0000-0002-8960-3531

Source of Support: Nil, **Conflicts of Interest:** None declared.