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Branching Pattern Of Lobar Bronchi In Human Cadavers In Tripura: A Cross Sectional Study

Malin Debbarma[1], Sarma HP[2], Pranab Debbarma[3], Pranab Deb[4]
[1](Post Graduate Trainee, Anatomy Department, Agartala Govt Medical College, India)
[2](Professor, Anatomy Department, Agartala Govt Medical College, India)
[3](Associate Professor, Anatomy Department, Agartala Govt Medical College, India)
[4](Assistant Professor, Anatomy Department, Agartala Govt Medical College, India)

Abstract:
Background*: Various Literatures Were Available In Different Part Of World And India Regarding Holistic Study Of Lung Pattern And Their Branches And Its Clinical Importance However, There Is Limited Data In This Part Of India.*
Materials And Methods*: 38 Pairs Of Adults And 11 Pairs Of Fetus Lungs Are Examined By Conventional Dissection Method At Dissection Hall, AGMC, Agartala, Tripura. The Branching Pattern Of Lobar Bronchi Was Identified, Named And Observed Its Variation And Compared With The Previous Data Of Various Author's. Data Were Collected In Performa And Descriptive Statistics Were Used To Analyze The Data.*
Result: *The Upper And Middle Lobes Of The Right Lung Had Varieties Variation Of Bronchial Pattern And The Most Common Pattern Was B_1,B_2,B_3 And In Right Inferior Lobe The Most Common Pattern B_{7+8}, B_{9+10}. The Upper Lobes Of The Left Lung Also Had Varieties Variation Of Branching Pattern And The Most Common Pattern Was B_{1+2}, B_3 And In Left Inferior Lobe The Most Common Pattern Was B_{7+8},B_{9+10}.*
Conclusion: *Branching Pattern Of Lobar Bronchi Is Very Variable. This Study Also Showing The Variation In Lobar Bronchial Branching Pattern. Hence, Anatomical Knowledge About Variation In Branching Pattern Of Lobar Bronchi Is Important Not Only For Anatomist, Physician, Surgeon And For Cardio-Thoracic Surgeon While Planning And Performing The Process Like Pneumonectomy And Lung Transplantation And It Will Give The Higher Success Rate In Curative Aspect.*
Key Word*: Human Cadaver, Lung, Lobar Bronchi, Branching Pattern*

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I. Introduction

The lungs are vital organs of respiration and are situated in the thoracic cavity on either side of the mediastinum. The lungs are divided by fissures into lobes which facilitate movements of lobes in relation to one another during respiration. The arrangement of lung tissue into lobes helps in uniform expansion of the whole lung in inspiration.[1,2]. The Trachea through which air enters the lung, is divided into principal bronchus which further divides into lobar bronchi, three for right lung and two left lungs. There in it was given that the right lung has got superior, middle and inferior lobes with horizontal and oblique fissures in which the superior lobe has apical (B1), posterior (B2) and anterior (B3) segments, middle lobe the lateral (B5) and medial (B4) segments and the inferior lobe superior [apical] (B6), medial basal (B7), anterior basal (B8), lateral basal (B9) and posterior basal (B10) segments. The left lung has got superior and inferior lobes with an oblique fissure only in which the superior lobe has apical (B1), posterior (B2), anterior(B3), superior lingular (B4) and inferior lingular (B5) and the inferior lobe has superior [apical](B6), medial basal (B7), anterior basal (B8), lateral basal (B9) and posterior basal (B10) segments. Finally, each lung consists of ten segmental bronchi.[1] When the embryo is approximately 4 weeks old, the respiratory diverticulum (lung bud) appears as an outgrowth from the ventral wall of the foregut. The appearance and location of the lung bud are dependent upon increase in retinoic acid (RA) produced by adjacent mesoderm. This increase in RA causes up regulation of the transcription factor TBX4 expressed in the endoderm of the gut tube at the site of the respiratory diverticulum. TBX4 induces formation of the bud and the continued growth and differentiation of the lungs. Hence, epithelium of the internal lining of the larynx, trachea, and bronchi, as well as that of the lungs, is entirely of endodermal origin. The cartilaginous, muscular, and connective tissue components of the trachea and lungs are derived from splanchnic mesoderm surrounding the foregut. Initially, the lung bud is in open communication with the foregut. When the diverticulum expands caudally, however, two longitudinal ridges, the trachea-esophageal ridges, separate it from foregut. Subsequently, when this ridges fuse to form the trachea-esophageal septum, the foregut is divided into a dorsal portion. The esophagus, and a ventral portion, the trachea and lung bud. The respiratory primordium

maintains its communication with the pharynx through the laryngeal orifice. During its separation from the foregut, the lung bud forms the trachea and two laterals out pocketing's, the bronchial bud. At the beginning of the fifth week, each of these buds enlarges to form right and left main bronchi. The right then forms three secondary bronchi, and the left, two, thus foreshadowing the three lobes on the right side and two on the left side. With subsequent growth in caudal and lateral directions, the lung buds expand into the body cavity. The spaces for the lungs, the pericardioperitoneal canals, are narrow. They lie on each side of the foregut and are gradually filled by the expanding lung buds. Ultimately the pleuroperitoneal and pleuropericardial folds separate the pericardioperitoneal canals from the peritoneal and pericardial cavities, respectively, and the remaining spaces form the primitive pleural cavities. The mesoderm, which covers the outside of the lung, develops into the visceral pleura. The somatic mesoderm layer, covering body wall from the inside, becomes the parietal pleura. The space between the parietal and visceral pleura is the pleural cavity. During further development, secondary bronchi divide repeatedly in a dichotomous fashion, forming ten tertiary (segmental) bronchi in the right lung and eight in the left, creating the broncho-pulmonary segments of the adult lung. By the end of sixth month, approximately 17 generations of subdivisions have formed. Before the bronchial tree reaches its final shape, however, an additional six divisions form during postnatal life. Branching is regulated by epithelial mesenchymal interactions between the endoderm of the lung buds and splanchnic mesoderm that surround them. Signals for branching, which emit from mesoderm, involve members of the fibroblast growth factor family. While all of these new subdivisions are occurring and the bronchial tree is developing, the lung assume a more caudal position, so that by the time of birth, the bifurcation of the trachea is opposite the fourth thoracic vertebra.[3] Though various studies on lobar bronchi had been carried out in different parts of the World and India but not a single study on variation of lobar bronchi has been carried out in Tripura. Hence the present study has been undertaken and to find out variations exist in this region of cadaveric lung and its branching pattern.

II. Material And Methods

A descriptive cross-sectional study was carried out between Dec 2020 to Nov 2022 in dissection hall Department of Anatomy, AGMC & GBP Hospital, Agartala Tripura which a teaching hospital among human cadavers available at Department of Anatomy, AGMC & GBP Hospital and still born fetus was obtained from Obstetrics and Gynecology Department of same hospital after ethical approval from Institutional ethics board. A full-term fetus (>37weak) to adult Intact human cadaveric lungs irrespective of their sex were included in the study. A mutilated specimens with malformation and deformities and postoperative lung specimens were excluded. A data collection tool (proforma) and dissection set were used to abstract valuable information. Maintaining proper aseptic condition in good illumination light conventional dissection method was carried out in the department and necessary findings from lung's gross specimen such as lobar pattern, branching pattern, additional lobe, segments were noted in the Performa. Data were entered in Microsoft excel. Results were expressed in frequency and percentage manually.

III. Results

38 pairs of the adult lungs and 11 pairs of the fetal lungs were observed. Branching pattern of the bronchial tree is studied by Conventional dissection method in total 49 pair lung specimens. In the present study, right main bronchus after giving rise to superior lobar bronchus reaches the hilum of right lung where it divides into middle and inferior lobar bronchi were observed in 49 of right lung specimens. The left primary bronchus, enters the hilum of the left lung and divides into a superior and an inferior lobar bronchus normally which were observed in 49 of left lungs. The left superior lobar bronchus arises from the anterior lateral aspect of its parent stem, curves laterally and soon divide into two bronchi and one is distributed to the left upper lobe and the other to the lingula. The left inferior lobar bronchus descends postero-laterally and divides to five sub-apical lobes to supply the lower lobe.

Table 1: The incidence of branching patterns of lobar bronchi in right upper, middle and lower lobes.

Sl No	Lungs	Bronchial Pattern Of Lobar Bronchi	No.	Percentage
1	Upper Lobes	B_1, B_2, B_3	48	97.96 %
		B_1, B_2, B_3, X	1	2.04 %
2	Middle Lobes	B_4 – Superior and B_5 - Inferior	4	8.16 %
		B_4 - Lateral and B_5- Medial	45	91.84 %
		Tree Bronchi In The Middle Lobe	Nil	Nil
3	Lower Lobes	B_6	49	100 %
		B_7 Absent	Nil	Nil
		B_7, B_8, B_9, B_{10}	25	51.02%
		B_{7+8}, B_{9+10}	9	18.37%
		B_7, B_8, B_{9+10}	15	30.61
		B_{7+8}, B_9, B_{10}	Nil	Nil

Table 2: The incidence of branching patterns of lobar bronchi in superior division of left upper, inferior division (lingular) of left upper lobes and left lower lobes

Sl. No	Lungs	Bronchial Pattern Of Lobar Bronchi	No	Percentage
1	Superior Division Of Upper Lobes	B_1, B_2, B_3	18	36.73 %
		B_{1+2}, B_3	31	63.27 %
2	Lingula	B_4 – Superior and B_5 - Inferior	48	97.96
		B_4 – Lateral and B_5 – Medial	Nil	Nil
		Three bronchi in the lingula	1	2.04 %
3	Lower Lobes	B_6	49	100 %
		B_7 Absent	Nil	Nil
		B_7, B_8, B_9, B_{10}	15	30.61%
		B_{7+8}, B_{9+10}	34	69.39%
		B_7, B_8, B_{9+10}	Nil	Nil
		B_{7+8}, B_9, B_{10}	Nil	Nil
		B_7, B_{8+9+10}	Nil	Nil

In present study out of 49 right lungs, in 48 specimens (97.96 %), the right superior lobar bronchus divides into three segmental (B_1, B_2, B_3 patterns) bronchi - the apical (B_1), posterior (B_2) and anterior (B_3) [Fig 6]. The apical (B_1) segmental bronchus continues supero-laterally towards the apex of the lung, which it supplies and divides into sub-segmental bronchi. The posterior (B_2) segmental bronchus supplies the postero-inferior part of the superior lobe, passes postero-laterally and slightly superiorly and divides. The anterior (B_3) segmental bronchus runs antero-inferiorly to supply the rest of the superior lobe. In 01 specimens (2.04%), the right superior lobar bronchus divides into four segmental bronchi - the apical, posterior, anterior and an accessory bronchi (B_1,B_2,B_3,X) [Table 1 & 3]. The apical (B_1) segmental bronchus continues supero-laterally towards the apex of the lung, which it supplies and divides into sub-segmental bronchi. The posterior(B_2) segmental bronchus supplies the postero-inferior part of the superior lobe, passes postero-laterally and slightly superiorly and divides. The anterior (B_3) segmental bronchus runs antero-superiorly part of the superior lobe. The accessory (X) segmental bronchus runs antero-inferiorly to supply the rest of the superior lobe.

Table 3: The incidence of branching patterns of lobar bronchi in right upper lobes.

Sl No	Right Lungs	Bronchial Pattern Of Lobar Bronchi	No	Percentage
1	Upper Lobes	B_1, B_2, B_3	48	97.96%
2	Upper Lobes	B_1, B_2, B_3,X	1	2.04%

Right middle lobar bronchi:Out of 49 right lung specimens, in 45 specimens (91.84%), the middle lobar bronchus divided into medial (B_4) and lateral (B_5) segmental bronchi [Fig8 & 9] and in 4 specimens (8.16%), the middle lobar bronchus divided into superior (B_4) and Inferior (B_5) segmental bronchi [Table 1 & 4]

Table 4: The incidence of branching patterns of lobar bronchi in right middle lobes.

Sl No	Right Lungs	Bronchial Pattern Of Lobar Bronchi	No	Percentage
1	Middle lobes	B_4 – Superior and B_5 - Inferior	4	8.16%
2	Middle lobes	B_4 – Lateral and B_5-Medial	45	91.84%
3	Middle lobes	Tree bronchi in the middle lobe	Nil	Nil

Right lower lobar bronchi: In 49 right lung specimens (100%), a little below the origin from the primary bronchus, the right inferior lobar bronchus gives off a large superior (apical basal) segmental (B_6) bronchus posteriorly. This runs posteriorly to the upper part of the inferior lobe. After giving off the superior segmental branch, the right inferior lobar bronchus descends postero-laterally. Out of 49 right lung specimens 25 right lung specimen (51.02%) the inferior lobar bronchus continues downwards and then divides into B_7, B_8, B_9, B_{10} patterns, a medial basal segmental (B_7) bronchus, an anterior basal segmental (B_8) bronchus, a lateral basal segmental (B_9) bronchus and a posterior basal segmental (B_{10}) bronchus [Fig 9]. Nine right lung specimen (18.37%) showed B_{7+8}, B_{9+10} patterns, a common origin of the segmental bronchus of antero-medial (B_{7+8}) which subsequently divides into anterior basal (B_8) and medial basal (B_7) segmental bronchi instead of arising separately from the inferior lobar bronchus and the segmental bronchus of postero-lateral (B_{9+10}) which subsequently divides into posterior basal (B_{10}) and lateral basal (B_9) segmental bronchi instead of arising separately from the inferior lobar bronchus. In 15 right lung specimen (30.61%) [Fig 8] showed B_7, B_8, B_{9+10} patterns, a medial basal segmental (B_7) and anterior basal segmental (B_8) bronchus directly arising from inferior

lobar bronchus and a common origin of the segmental bronchus of postero – lateral (B_{9+10}) which subsequently divides into posterior basal (B_{10}) and lateral basal (B_9) segmental bronchi instead of arising separately from the inferior lobar bronchus (Table 1 & 5).

Table 5: The incidence of branching patterns of lobar bronchi in right lower lobes.

Sl. No	Right Lungs	Bronchial Pattern Of Lobar Bronchi	No	Percentage
1	Lower lobes	B_6	49	100%
2	Lower lobes	B_7 Absent	Nil	Nil
3	Lower lobes	B_7 , B_8 , B_9, B_{10}	25	51.02%
4	Lower lobes	B_{7+8} , B_{9+10}	9	18.37%
5	Lower lobes	B_7 , B_8 , B_{9+10}	15	30.61%
6	Lower lobes	B_{7+8} , B_9 , B_{10}	Nil	Nil

Superior division of left upper lobar bronchi:

Out of 49 left lung specimens, 18 left lung specimens (36.73%) show B_1, B_2, B_3 patterns, the upper division of the left superior lobar bronchus directly divides into an apical segmental (B_1), a posterior segmental (B_2) and an anterior segmental (B_3) bronchus [table 2 & 6]. In 31 left lung specimens (63.27%) the superior division of the left upper lobar bronchus shows B_{1+2}, B_3 patterns, gives off an anterior segmental (B_3) bronchus and an apico- posterior segmental (B_{1+2}) bronchus and then divides into apical (B_1) and posterior (B_2) branches [table 2 & 6]

Lingular lobes:

The inferior descends antero-laterally to the antero -inferior part of the left superior lobe (the lingula) and forms the lingular bronchus, which divides into superior (B_4) and inferior (B_5) lingular segmental bronchi. In the present study out of 49 left lung specimens, 48 left lung specimens (97.96%) shows superior (B_4) and inferior (B_5) lingular segmental bronchi pattern. In one specimen (2.04%) shows three bronchi in the lingula, there was an accessory lingular segmental (X) bronchus which arises from at the junction of superior (B_4) and inferior (B_5) lingular segmental bronchi [Table 2 & 6].

Table 6: The incidence of branching patterns of lobar bronchi in left upper lobes.

Sl No	Right Lungs	Bronchial Pattern Of Lobar Bronchi	No	Percentage
1	Upper lobes	B_1 , B_2 , B_3	18	36.73%
2	Upper lobes	B_{1+2} , B_3	31	63.27%
3	Upper lobes	B_4 -Superior and B_5 - Inferior	48	97.96%
4	Upper lobes	B_4 - Lateral and B_5 - Medial	Nil	Nil
5	Upper lobes	Three bronchi in the lingula	1	2.04%

Left lower lobar bronchi:

In present study the inferior lobe, the superior (apical basal) segmental (B_6) bronchus arises from the inferior lobar bronchus posteriorly from its origin in 49 left lung specimens (100%). In 15 left lung specimens (30.61%) the inferior left lobar bronchus shows B_7, B_8, B_9, B_{10} patterns, which divides into medial basal (B_7), anterior basal (B_8), lateral basal (B_9) and posterior basal (B_{10}) segments. In 34 left lung specimens (69.39%) shows B_{7+8}, B_{9+10} patterns, the inferior lobar bronchus divides into an antero - medial (B_{7+8}) and a postero-lateral (B_{9+10}) stem. The antero-medial (B_{7+8}) stem divides into medial (B_7) and anterior (B_8) basal segmental bronchi. The later divides into posterior (B_{10}) and lateral (B_9) basal segmental bronchi [Table 2 & 7]

Table 7: The incidence of branching patterns of lobar bronchi in left lower lobes of lungs.

Sl. No	Left Lungs	Bronchial Pattern Of Lobar Bronchi	No	Percentage
1	Lower lobes	B_6	49	100%
2	Lower lobes	B_7 Absent	Nil	Nil
3	Lower lobes	B_7 , B_8 , B_9 , B_{10}	15	30.61%
4	Lower lobes	B_{7+8} , B_{9+10}	34	69.39%
5	Lower lobes	B_7 , B_8 , B_{9+10}	Nil	Nil
6	Lower lobes	B_{7+8} , B_9 , B_{10}	Nil	Nil
7	Lower lobes	B_7 , B_{8+9+10}	Nil	Nil

Image 1: Shows B_1,B_2,B_3 patterns in upper lobe, B_4 superior and B_5 inferior in middle lobe and B_{7+8},B_{9+10} pattern in lower lobe of bronchial tree of right adult lung.

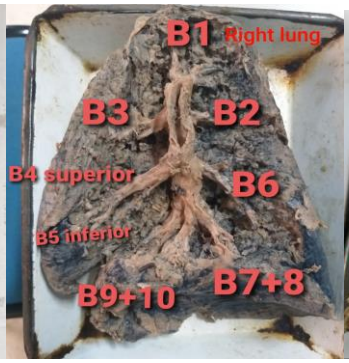

Image 2: Shows B_1, B_2, B_3 patterns in upper lobe, B_4 Superior and B_5 inferior in middle lobe and B_{7+8}, B_{9+10} pattern in lower lobe of right adult lung.

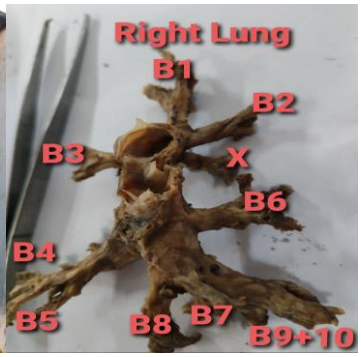

Image 3: Shows B_1, B_2, B_3, X patterns in upper lobe, B_4 lateral and B_5 medial in middle lobe and B_7 ,B_8, B_{9+10} pattern in lower lobe of bronchial tree of right adult lung.

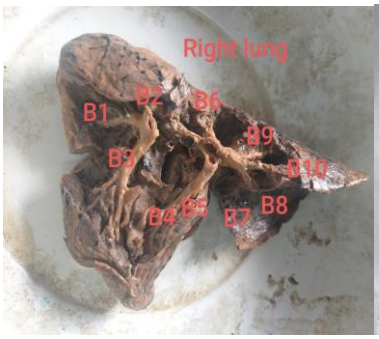

Image 4: Shows B_1, B_2, B_3 patterns in upper lobe, B_4 lateral and B_5 medial in middle lobe and B_7 ,B_8, B_9, B_{10} pattern in lower lobe of right adult lung.

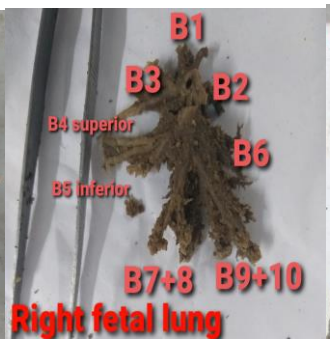

Image 5: Shows B_1, B_2, B_3 patterns in upper lobe, B_4 Superior and B_5 inferior in middle lobe and B_{7+8}, B_{9+10} pattern in lower lobe of bronchial tree of right fetal lung.

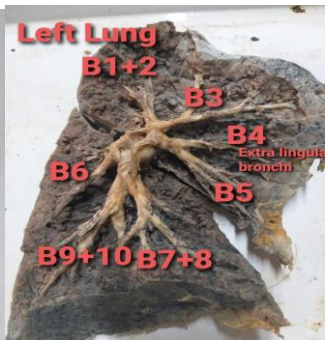

Image 6: Shows B_{1+2}, B_3 patterns in upper division of upper lobe, B_4 Superior and B_5 inferior with an accessory segmental bronchus in inferior division of upper lobe and B_{7+8}, B_{9+10} pattern in lower lobe of left adult lung.

Image 7: Shows B_{1+2}, B_3 patterns in upper division of upper lobe, B_4 Superior and B_5 inferior with an accessory segmental bronchus in inferior division of upper lobe and B_{7+8}, B_{9+10} pattern in lower lobe of bronchial tree of left adult lung.

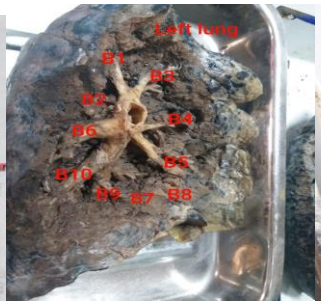

Image 8: Shows B_1, B_2, B_3 patterns in upper division of upper lobe, B_4 Superior and B_5 inferior in inferior division of upper lobe and B_7, B_8, B_9, B_{10} pattern in lower lobe of left adult lung.

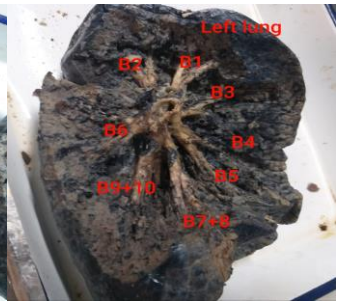

Image 9: Shows B_1, B_2, B_3 patterns in upper division of upper lobe, B_4 Superior and B_5 inferior in inferior division of upper lobe and B_{7+8}, B_{9+10} pattern in lower lobe of left adult lung.

IV: Discussion:

In previously studies many authors reported on branching pattern of lobar bronchi. With due respect, I compare and quote the present study on 49 pairs of lung specimens with those of the eminent workers.

In the present study, the right principal bronchus gives rise to superior lobar bronchus and continues as the intermediate stem bronchus which in turn divides into middle and inferior lobar bronchi in 49 specimens (100%) [Table 8]. Gray (2005)[1] and Keith L Moore (2006)[39] say that right principal bronchus gives rise to superior lobar bronchus and continues as the intermediate stem bronchus. This intermediate stem bronchus after giving rise to the middle lobar bronchus continues as the inferior lobar bronchus. They also say that the superior lobar bronchus gives rise to apical (B_1), posterior (B_2) and anterior (B_3) segmental bronchi. The middle lobar bronchus divides into lateral (B_4) and medial (B_5) segmental bronchi. The inferior lobar bronchus gives origin to apical basal (B_6), medial basal (B_7), anterior basal (B_8), lateral basal (B_9) and posterior basal (B_{10}) segmental bronchi.

Table 8: Shows the incidence of variation in branching pattern of right upper lobar bronchi in different authors.

Authors	Right Upper Lobar Bronchi		
	B_1,B_2,B_3	B_{1+2}, B_3	B_1,B_2,B_3,X
Boyden & Scannell (1948)[7]	46%	54%	14%
Bloomer W E et al (1960)[15]	52%	48%	-
Ghaye (2001)[32]	30%	-	-
Cenk killic (2010)[41]	86.7%	-	13.33%
Umesh S N et al (2019)[50]	100%	0%	0%
Present Study (2022)	97.96%	0%	2.04%

In this study, the superior lobar bronchus divides into three segmental bronchi (B_1, B_2, B_3 patterns) namely the apical (B_1), posterior (B_2) and anterior (B_3) segmental bronchi (trifurcation) in 97.6% of cases which is higher than the study of Boyden E A, and Scannel T G, [1948][7] and Bloomer W E, Ziebow D A, and Hales M R [1960][15] and synonyms with the study by Umesh N S et al (2019)[50] [Table no 8]. And an accessory (X) segmental bronchus along with apical (B_1), posterior (B_2) and anterior (B_3) segmental bronchi (B_1, B_2, B_3, X) in right upper lobar bronchus seen in 2.04% cases. Cenk kilic (2010)[41] reported B1, B2, B3, X pattern in 13.33% in right upper lobar bronchi. Boyden E A and Scannell T G [1948][7] reported that the manner of branching of superior lobar bronchus was found to be a bifurcation (B_{1+2}, B_3 patterns) in 54%, Bloomer W E, Ziebow D A, and Hales M R [1960][15] found bifurcation (B_{1+2}, B_3 patterns) in 48% of cases. In present study, no specimen apical (B_1) and posterior (B_2) segmental bronchi arise by a common stem (B_{1+2}) instead of arising separately from the superior lobar bronchus and this pattern is bifurcation as reported by Boyden E A and Scannell T G. Boyden E A and Scannel TG [1948][7] revealed that the right upper lobar bronchus gives rise to three segmental bronchi (B_1, B_2, B_3 patterns) known as trifurcation about 46% of cases. Bloomer W E, Zeibow D A, and Hales M R, [1960][15] reported trifurcation (B_1, B_2, B_3 patterns) in 52% Ghaye (2001)[32] revealed that the right upper lobar bronchus gives rise to three segmental bronchi (B_1, B_2, B_3 patterns) about 30%, Cenk killic (2010)[41] reported trifurcation (B_1, B_2, B_3 patterns) in 86.7%, Umesh N S et al[50] reported trifurcation (B_1, B_2, B_3 patterns) in 100%.

Table 9: Shows the incidence of variation in branching pattern of right middle lobar bronchi in different authors.

Authors	Right Middle Lobar Bronchi		
	B_4-Superior B_5-Inferior	B_4 - Lateral B_5 -Medial	Three bronchi
Boyden & Scannell (1948)[7]	0%	100%	0%
Hamre C J et al (1951)[12]	18%	80%	2%
Umesh S N et al (2019)[50]	0%	100%	0%
Present Study(2022)	8.16%	91.84%	0%

In this study the middle lobar bronchus dividing into lateral (B_4) and medial (B_5) segmental bronchi in 45 right lung specimens [91.84%] which was a normal pattern as described by Gray [2005][1] and Keith L Moore [2006][39] and the right middle lobar bronchus dividing into superior (B_4) and inferior (B_5) segmental bronchi in 4 right lung specimens [8.16%], Boyden E A, and Hamre C J [1951][12] say that in 2 % of cases trifurcation occurs instead of bifurcation into lateral and medial segmental bronchi of the right middle lobar bronchus[Table no.10]. In the present study, the middle lobar bronchus divides bifurcation into superior (B_4) and inferior (B_5) segmental bronchi instead of the lateral and medial in 8.16% specimens, Hamre C.J. [1951][12] reported the right middle

lobar bronchus divides bifurcation into superior (B_4) and inferior (B_5) segmental bronchi instead of the lateral and medial in 18% [Table no.9]. In this study, the inferior lobar bronchus giving rise to superior (B_6), medial (B_7), anterior (B_8), lateral (B_9) and posterior (B_{10}) basal segmental bronchi (B_7,B_8,B_9,B_{10}) was found in 18.37% specimens which is the normal pattern observed by Gray [2005][1] and Keith L Moore[2006][39]. Ghaye (2001)[32] reported B_7,B_8,B_9,B_{10} patterns in 6%, Cenk Kilic (2010)[4] reported B_7,B_8,B_9,B_{10} patterns in 20% and Umesh S N et al (2019)[50] reported B_7,B_8,B_9,B_{10} patterns in 76.6% cases. In this study, in 51.02% specimens found B_{7+8}, B_{9+10} patterns, a common origin of anterior (B_7) and medial (B_8) basal segment and lateral based (B_9) was arising from the posterior basal (B_{10}) segments in right lower lobes, Ghaye (2001)[32] reported B_{7+8}, B_{9+10} patterns in 3%, Cenk Kilic (2010)[41] reported B_{7+8}, B_{9+10} patterns in 6.7% which was very less from present study incidence. Berg R M, Boyden K A, and Smith F R, [1949][9] found that in addition to a sub-superior bronchus proper arising posteriorly from the left inferior lobar bronchus, an accessory sub-superior, arising as a single bronschus of the posterior basal in 71% and as two branches in 13% and an accessory sub-superior from the lateral basal in 67%, Fierry R M Jr and Boyden E A, [1951][11] in 100 cases investigated by them, found the superior segment of right lower lobe to be supplied exclusively by a Sub-superior(B_6) bronchus proper in 16% and in 39% exclusively by one or more accessory sub-superior bronchi from the posterior basal bronchus. D J Du Plessis [1975][20] describes a super-numerary bronchus found in 50% of cases which is called the sub-superior bronchus. Gray [2005][1] says that in more than half of all right lungs a sub-superior (B_6) (sub-apical) segmental bronchus arises posteriorly from the right inferior lobar bronchus 1.3cm below the superior segmental bronchus, and is distributed to the region of lung between the superior and posterior basal segments. The present study also shows the presence of sub-superior segmental bronchus arising posteriorly from the right inferior lobar bronchus in 9.4% coinciding with Berg, Boyden and Smith, and Gray in the occurrence but for the side, this study coincides with gray as he says that the sub-superior arises posteriorly from the right inferior lobar bronchus. (Table No.11). Thus, the present study is in lesser incidence when compared to the above authors whereas on the left side it is not reported B_7, B_8, B_{9+10} patterns of right lower lobe in 68%, found in the present study.

Table 10: Shows the incidence of variation in branching pattern of right lower lobar bronchi in different authors.

Authors	Right Lower Lobar Bronchi					
	B_7 Absent	B_7,B_8,B_9,B_{10}	B_{7+8},B_{9+10}	B_7,B_8,B_{9+10}	B_{7+8} ,B_9, B_{10}	B_7,B_{8+9+10}
	R	R	R	R	R	R
Smith & Boyden (1949)[8]	14%	-	-	-	-	-
Ferry & Boyden (1951)[11]	20%	-	-	-	-	-
Ghaye (2001)[32]	10%	6%	3%	68%	-	10%
Cenk Kilic (2010)[41]	13.33%	20%	6.7%	53.33%	-	6.7%
Umesh S N et al (2019)[50]	16.7%	76.6%	0%	0%	0%	6.7%
Present Study (2022)	0%	18.37%	51.02%	28.57%	0%	2.04%

In this study, the incidence of B_7, B_8, B_{9+10} patterns in right lower lobe in 28.57% specimens, Ghaye (2001)[32] reported B_7, B_8, B_{9+10} patterns of right lower lobe in 68%, Cenk Kilic (2010)[41] reported B_7, B_8, B_{9+10} patterns of right lower lobe in 53.33%. In this study, the incidence of B_7, B_{8+9+10} patterns in right lower lobe in 2.04% cases, Ghaye (2001)[32] reported B_7, B_{8+9+10} patterns of right lower lobe in 10%, Cenk Kilic (2010)[41] reported B_7, B_{8+9+10} patterns of right lower lobe in 6.7%, Umesh S N et al (2019)[50] reported B_7, B_{8+9+10} patterns of right lower lobe in 6.7%. Bailey and Love [1977][21] say that failure of a main bronchus to develop, results in unilateral agenesis whilst failure of a lobar bronchus to develop produces lobar agenesis. I B Singh [2001][30] says that one lung or one of its lobes and associated bronchi may fail to develop or may remain under developed. Atwell [1967][17] described the absence of four lobar bronchi, one of the right upper lobes and three of the left upper lobes in a series of 1200 consecutive, complete, and bilateral bronchograms – an overall incidence of 0.16%. In the present study, absence of upper, middle or lower lobar bronchus was not observed in any of the right lung specimens.

In this study in 63.27% specimens, incidence shows B_{1+2}, B_3 pattern in superior divisions of left upper lobes, the apical (B_1) and posterior (B_2) segmental bronchi arise by a common stem and anterior (B_3) segmental bronchi and 36.73% specimens shows B_1, B_2, B_3 patterns. Hartman J. F et al (1946)[6] have shown the variants in the upper division of the upper lobar bronchus of the left lung as a single bifurcation of the superior division branches into apical-posterior (B_{1+2}) and anterior (B_3) segmental bronchi, about 74% and B_1, B_2, B_3 pattern in 26% specimens, Ghaye(2001)[32] had reported B_{1+2}, B_3 pattern in 17% specimens and B_1, B_2, B_3 pattern in 83% specimens, Savkovic et al (2004)[36] had reported B_{1+2}, B_3 pattern in 26% specimens and B_1, B_2, B_3 pattern in

74% specimens, Gonlugur U et al (2005)[37] had reported B_{1+2}, B_3 pattern in 27.7% specimens, Cenk killic (2010)[41] had reported B_{1+2}, B_3 pattern in 60% specimens and B_1, B_2, B_3 pattern in 40% specimens and Umesh S N et al (2019)[50] had reported B_{1+2}, B_3 pattern in 6.7% specimens and B_1, B_2, B_3 pattern in 93.3% specimens in the superior divisions of left upper lobes [Table no 11]. According to Gray [2005][1] and Keith L. Moore (2006)[39], the left primary bronchus divides into superior and inferior lobar bronchi. The superior lobar bronchus divides into upper and lower divisions. The upper division gives rise to anterior (B_3) segmental bronchus and apico posterior (B_{1+2}) division which in turn gives rise to apical (B_1) and posterior (B_2) segmental bronchi. The lower division divides into superior (B_4) and inferior (B_5) lingular segmental bronchi. The inferior lobar bronchus gives origin to apical (B_6), antero-medial (B_{7+8}) stem and postero-lateral (B_{9+10}) stem where these divide into medial basal (B_7) and anterior basal (B_8), lateral basal (B_9) and posterior basal (B_{10}) segmental bronchi respectively.

Table 11: Shows the incidence of variation in branching pattern of upper divisions of left upper lobar bronchi in different authors.

Authors	Upper division of left upper lobar bronchi	
	B_1,B_2,B_3	B_{1+2}, B_3
Hartman J. F et al (1946)[6]	26%	74%
Ghaye(2001)[32]	83%	17%
Savkovic et al (2004)[36]	26%	74%
Gonlugur U et al (2005)[37]	-	27.7%
Cenk killic (2010)[41]	40%	60%
Umesh S N et al (2019)[50]	93.3%	6.7%
Present Study (2022)	36.73%	63.27%

Chummy S. Sinnathamby [1999][30] presents that there are typically ten broncho pulmonary segments in each lung in which same segmental bronchi may share a common stem i.e. apico-posterior (B_{1+2}) in left upper lobe. In the left lower lobe, the medial (B_7) and anterior (B_8) basal segments and the lateral (B_9) and posterior (B_{10}) basal segments arise from common stem bronchi (B_{7+8}, B_{9+10}) which subsequently subdivide. T S Ranganathan (2003)[35] explains that the left lung has the apico posterior (B_{1+2}) segment thus reducing the number of total segments from 10.

In this study in 97.96% specimen, incidence shows B_4 superior and B_5 inferior pattern and three bronchi in the lingual shows in 2.04% in inferior divisions (lingular) of left upper lobes. Ghaye(2001)[32] had reported B_4 superior and B_5 inferior pattern in 100% specimens, Cenk killic (2010)[41] had reported B_4 superior and B_5 inferior pattern in 60% specimens and also reported three bronchi in lingual in 46.7%. Umesh S N et al (2019)[50] had reported B_4 superior and B_5 inferior pattern in 83.3% specimens and also reported three bronchi in lingual in 46.7% [Table 12]. According to Gray [2005][1] and Keith L. Moore (2006)[39], the left primary bronchus divides into superior and inferior lobar bronchi. The superior lobar bronchus divides into upper and lower divisions. The upper division gives rise to anterior (B_3) segmental bronchus and apico posterior (B_{1+2}) division which in turn gives rise to apical (B_1) and posterior (B_2) segmental bronchi. The lower division divides into superior (B_4) and inferior (B_5) lingular segmental bronchi. The inferior lobar bronchus gives origin to apical (B_6), antero-medial (B_{7+8}) stem and postero-lateral (B_{9+10}) stem where these divide into medial basal (B_7) and anterior basal (B_8), lateral basal (B_9) and posterior basal (B_{10}) segmental bronchi respectively. In this study, the B_4 superior and B_5 inferior pattern of lingular division of left superior lobar bronchus which is similar to the study of Ghaye(2001)[32], Cenk killic (2010)[41], Umesh S N et al (2019)[50] was observed in 97.96% cases [Table 12].

Table 12: Shows the incidence of variation in branching pattern of lingular division of left upper lobar bronchi in different authors.

Authors	Lingular division of left upper lobar bronchus			
	An extra bronchus	B_4-Superior B_5-Inferior	B_4 - Lateral B_5 –Medial	Three bronchi
Ghaye(2001)[32]	-	100%	-	-
Cenk Kilic(2010)[41]	13.33%	60%	-	46.70%
Umesh S N et al (2019)[50]	6.7%	83.3%	-	10%
Present Study (2022)	0%	97.96%	0%	2.04%

In this study, the inferior lobar bronchus after giving superior (B_6) (apical basal) segmental bronchus divides into antero-medial (B_{7+8}) and posterolateral (B_{9+10}) divisions which in turn divide into medial basal (B_7), and anterior basal (B_8), and lateral basal (B_9) and posterior basal (B_{10}) segmental bronchi in 34 specimens (69.39%) and B_7,B_8,B_9,B_{10} pattern in 30.61% specimens. Berg (1949)[9] had reported B_{7+8},B_{9+10} pattern in 67%,

B_{7+8} ,B_9,B_{10} pattern in 13% and 3% cases B_7 absent, Ghaye(2001)[32] had reported B_{7+8}, B_{9+10} pattern in 76% specimens and B_{7+8}, B_9, B_{10} pattern in 10% specimens, Cenk Kilic (2010)[41] had reported B_{7+8}, B_{9+10} pattern in 53.33% specimens and B_{7+8}, B_9, B_{10} pattern in 26.66% and B_7 pattern absent in 6.7% specimens, Umesh S N et al (2019)[50] had reported $B_{7+8,}B_{9+10}$ pattern in 6.7%, B_7,B_8,B_9,B_{10} pattern in 43.3%, B_7,B_8,B_{9+10} pattern in 13.3% and B_{7+8},B_9,B_{10} pattern in 36.7% specimens in left lower lobe [Table 13].

Table 13: Shows the incidence of variation in branching pattern of left lower lobar bronchi in different authors.

Authors	LEFT LOWER LOBAR BRONCHI					
	B_7 Absent	B_7,B_8,B_9,B_{10}	$B_{7+8,}B_{9+10}$	B_7,B_8,B_{9+10}	B_{7+8} ,B_9,B_{10}	B_7,B_{8+9+10}
	L	L	L	L	L	L
Berg (1949)[9]	3%	0%	67%	0%	13%	0%
Ghaye (2001)[32]	0%	0%	76%	0%	10%	0%
Cenk Kilic (2010)[41]	6.7%	0%	53.33%	0%	26.66%	0%
Umesh S N et al (2019)[50]	0%	43.3%	6.7%	13.3%	36.7%	0%
Present Study (2022)	0%	30.61%	69.39%	0%	0%	0%

In this study, B_7, $B_{8,}$ B_{9+10} pattern, B_{7+8}, B_9, B_{10} pattern and medial basal segmental bronchus (B_7) absent not observed. Thus the present study coincides with the study of Gray[1], Keith L.Moore[39], Chummy S. Sinnathamby[30], Boyden and Hartmann[6] and T S Ranganathan[35]. Fierry R M, Jr, and Boyden E A[11] state that in 20% of 50 specimens, the medial basal (B_7) segmental bronchus was absent as such, its anterior branch arising from the anterior (B_8) basal and its posterior branch from a sub-superior or posterior basal stem. Davidson[22] points out that, there is no medial basal bronchus on the left side and hence only 9 segments on left side. T S Ranganathan[35] states that the left lung has 8 segments having the apico-posterior and anterior in the upper lobe and absence of medial basal segment in its lower lobe.

V. Conclusion

The branching pattern of tracheobronchial tree is not constant and knowledge of variability is useful for interventional radiologist and cardiothoracic surgeons. In this study, irregular pattern was found to be more on right side. The patterns like B_1, B_2, B_3, X pattern in 2.02%, B_4 superior, B_5 inferior in 8.16%, B_{7+8}, B_{9+10} patterns in 18.37% and B_7, B_8, B_{9+10} patterns in 30.61% was seen only in the right lungs, whereas the patterns three bronchi in the lingual (2.04%), was seen only on left side. In the right upper lobe trifurcation occurred in 97.96%, accessory segmental bronchi in 2.04%. In the right middle lobe bifurcation occurred in 100%, trifurcation not observed. In the right lower lobe, the subsuperior bronchus was present in 100%. In the right lower lobe, the branching pattern of basal trunk was bifurcation in 18.37% and trifurcation in 30.61% of the specimens and B_7, B_8, B_9, B_{10} pattern in 51.02%. In the left upper lobe branching pattern was bifurcation in 63.27%, trifurcation in 36.73%. In the left lower lobe subsuperior bronchus was present in all lungs. In the left lower lobe, the branching pattern of basal trunk was bifurcation in 69.39% and B_7, B_8, B_9, B_{10} pattern in 30.61%. An understanding of bronchial tree structure can be achieved only by effort. In planning operative procedures that will serve to remove disease, while preserving useful tissue, this effort will be well expended. An attempt at application of the anatomical data is very useful to the planning of the surgical approach. Pulmonary functions show exactly how essential is the amount of pulmonary tissue for good and efficient functioning of lungs. This study is presented to shed more light on normal anatomy of bronchial tree.

References

[1]. Shah P, Johnson D, Standring S. Thorax. In: Standring S, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 39th ed. Edinburgh: Churchill Livingstone; 2005, 1068-9.
[2]. Rosse C, Gaddum Ross P. Hollinshead's, textbook of anatomy. Philadelphia: Lipincott Williams & Wilkins; 1997, 441-61.
[3]. Sadler T W. A text book of Langman's Medical Embryology-11th edition: 2010, 201-3
[4]. Boyden E A. The Intrahilar and related segmental anatomy of the lung surgery 1945; 18: 706.
[5]. Brock R C. The anatomy of the bronchial tree with special reference to the surgery of lung abscess-New York, Oxford University press, 1946.
[6]. Boyden E A and Hartmann J F. An analysis of variations pulmonary segments of the left upper lobes of fifty lungs. Am. J. anat. 1946; 79: 321-60.
[7]. Boyden E A and Scannel J G. An analysis of variations in the bronchovascular pattern of the right upper lobe of fifty lungs. Am. J.anat.1948; 82: 27-72.
[8]. Smith F R and Boyden E A. An analysis of variations of the segmental bronchi of the right lower lobe of fifty injected lungs. J thoracic surg. 1949; 18: 195.

[9]. Berg R M, Boyden E A and Smith F R- An analysis of variations of the segmental bronchi of the left lower lobe of fifty dissected and ten injected lung. J thoracic surg.1949; 18:216-37.
[10]. Boyden E A. Cleft left upper lobes and the split anterior bronchus. Surgery1949; 26: 167
[11]. Ferry R M and Boyden E A. Variations in the bronchovascular patterns of the right lobe of fifty lungs. J thorac surg.1951; 22: 188-201.
[12]. Boyden E A and Hamre C J. An analysis of variations in the bronchovascular pattern of the middle lobe in fifty dissected and twenty injected lungs. J.thoracic surg.1951; 21: 171.
[13]. Bradley M P. Human Embryology – II edition; 1953, 487–98.
[14]. Storey C F, Marranooni A G. Lobar agenesis of the lung. J thorac surg. 1954; 28: 536.
[15]. Bloomer W E, Liebow A A and Hales M R. Surgical anatomy of the bronchovascular segments. Springfield III, Thomas-1960.
[16]. Boyden E A. The nomenclature of the bronchopulmonary and their blood supply. Dis Chest.1961; 39: 1.
[17]. Atwell S W- Major anomalies of the trachea bronchial tree: With a list of the minor anomalies. Dis Chest.1967; 52: 611.
[18]. Gray S W, Skandalakis J L. Embryology for surgeon, the embryological basis for the treatment of congenital defects. Philadelphia, W D Saunders.1972; 2: 307.
[19]. Mariano S.H, Di Fiore, Robert E. Mancini, Eduardo, D.P. De Roberts. New Atlas of Histology, Light Microscopy, Histo Chemistry & Electron Microscopy; 1973, 208-20.
[20]. Plessis D J D. A synopsis of Surgical Anatomy: 11th edition; 1975, 42–51.
[21]. Henry H B. Bailey and love's short practice of surgery: 17th edition; 1977, 688–9.
[22]. Davidson, Stanley, Macleod and John. Davidson's Principles and Practices of Medicine: A Textbook for Students and Doctors: 12th edition. Elsevier Science; 1977, 248–63.
[23]. Starshak R J, Sty J R, Woods G et al. – Bridging bronchus: a rare airway anomaly. Radiology.1981; 140; 95-6.
[24]. T.W. Sadler PhD. Langman's Medical Embryology: 5th edition; 1983, 215–23.
[25]. Keith H, Wian G, Sally P et al. Growth of the bronchial tree in man. Thorax. 1987; 42: 383-8.
[26]. Woodring J H, Howard R S and Rehm S R. Congenital tracheobronchomegaly (mounier- Kuhn syndrome): a report of ten cases and review of the literature. J thorac image. 1991; 6: 1-10.
[27]. Mori M, Kidogawa H, Moritaka T et al. Bronchial atresia: report of a case and review of the literature. Surg today.1993; 23: 449-54.
[28]. Sealy W C, Connally S R, and Dalton M L. Naming the bronchopulmonary segments and the development of pulmonary sutgery. Ann thorac surg. 1993; 55(1): 184-8.
[29]. Richard G. Kessel. Basic Medical Histology: The Biology of Cells, Tissues and Organs: 1st edition ; 1998, 354-71.
[30]. 30.Chummys S Sinnathamy, R J Last -editor. Last's Anatomy- regional & applied: 10th edition; 1999, 206–10.
[31]. I B Singh. Human Embryology: 7th edition; 2001, 197-202.
[32]. Ghaye B, Szapiro D, Fanchams J M, and Dondelinger R F. Congenital bronchial abnormalities revisited. Radiographics. 2001; 21(1): 105-19.
[33]. Warren M Glid MD, John F Murray MD DSc(Hon) FRCP, Jay A Nadel MD DSC (Hon). Atlas of Procedures in Respiratory Medicine – a companion to Murray and Nadel's Textbook of Respiratory Medicine; 2002, 36–73.
[34]. William I Larsen, PhD. Anatomy development function clinical correlations; 2002, 125-43.
[35]. T S Ranganathan. A textbook of human anatomy: 6th edition; 2003, 436-45.
[36]. Savkovic A et al. The ventilator patterns of the left upper lobe of lung. Coll Antropol. 2004; 28(2): 701-9.
[37]. Gunlugu U, Efeoglu T, Kaptanoglu M, Akkurt I. Major anatomical variation of the tracheobronchial tree: Bronchoscopic observation. Anato sci Int. 2005; 80: 111-5.
[38]. Thomas W, Shields M D, D Sc [hon], Joseph lo Cirero III, M D , Ronald B P, M D, Valeric W R, M D. General Thoracic Surgery: volume I, 6th edition; 2005, 03–65 & 70–73.
[39]. Keith L Moore. Clinically oriented anatomy: 5th edition; 2006, 120-128 & 135.
[40]. Frechette E, Deslauriers J. Surgical anatomy of the bronchial tree and pulmonary artery. Semin Thorac Cardiovasc Surg. 2006; 18(2): 77-84.
[41]. Kilic C, Kerici Y, Ozan H, Aday B. Variations in pattern of bronchial tree. J. clin. Anat.med. 2010; 1(3): 34-38.
[42]. Vishnu Sharma et al. Major anatomical variation in the division of tracheobronchial tree as visualized by fiberoptic bronchoscopy. Capsula Eburnea. 2011; 6(7): 33-6.
[43]. Vassios K, Kotrogianni F, Lavadas E, Ulychou M, Fanariotis M, Arvanitis, et al Tracheobronchial variations evaluated by multidetector computed tomography, and virtual bronchoscopy. OA case report. 2013; 2(3): 23.
[44]. Jadhav B K, Kulkarni Y, Sant S M. Study of common patterns of the segmental bronchi in right and left human lungs on their variations. Ind J of public health research and development. 2015; 3(6).
[45]. Weidong M, Changsheng Z, Tie Y et al. Measurement and Analysis of the tracheobronchial tree in Chinese population using computed tomography. PLoS ONE. 2015; 10(4): 1371.
[46]. Shaik Z, Venkata R M, Hanimann K S. A study an anatomical dimension of bronchial tree. Int J Res Med Sci. 2016; 4(7): 2761-6.
[47]. Sathidevi V K. Anatomical arrangement of the lobar bronchi, bronchopulmonary segments and their variations. Int J Res med Sci.2016; 4(11): 4928-32.
[48]. Guillaume C, Baptiste M, Dominique S et al. Tracheobronchial branching abnormalities: lobe-based classification scheme. Radiographics.2016; 36: 2.
[49]. Heamnth K, Jeyaraman H P, Swaya M, Raj J D, Deeptha V N. Morphological study of the fissure, lobes and bronchial pattern in the lung- A cadaveric study with emphasis on surgical and radiological implications. Int J anat Radiology and surg 2018; 7(3): A001-A006.
[50]. Umesh S N, Hassam K, Afroze M, Sangeeta M. Variations in pattern of segmental bronchi in lungs using conventional dissection method. Int J anat Res 2019; 7(3.3): 6901-05.
[51]. Rodrigo R A, Catarine C M, Francisco P R et al. Anatomical and morphometric study of tracheobronchial angles in human fetuses. M O J Anat and Phy. 2020; 7(6): 308.