The segmentation pattern of bronchial tree and its anatomical variations. A bronchoscopy study

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Abstract

Background: Advances in thoracic surgery and respiratory medicine has shown the rising importance of bronchoscopy. This study aimed to describe the prevalence of different bronchial anatomic branching patterns observed during bronchoscopy.

Methods: A total of 104 patients underwent bronchoscopic evaluation for various indications, mostly as a part of malignancy workup. Segmental as well as subsegmental bronchi were properly identified. Data was entered and analyzed using IBM SPSS v25.

Results: Various types branching patterns were observed, namely in right upper lobe(RUL) (four types), right lower lobe(RLL) (six types), upper division of left upper lobe(LUL) (two types) and left lower lobe(LLL) (three types). Presence of Subsuperior(B*) bronchus was noted in 35.8% cases.

Conclusion: Segmental variations of various patterns are not uncommon and improved knowledge of these anatomical variations are important to plan intervention like segmentectomy. Bronchoscopy plays an important role in identifying different segmental variations.

Keywords: *Lungs, Bronchi, Bronchoscopy.*

Introduction

In the field of respiratory medicine and thoracic surgery, bronchoscopy remains an irreplaceable armamentarium for diagnosis as well as therapeutic modality. Expanded diagnostic uses such as biopsy sampling of endobronchial growth, bronchoalveolar lavage, staging of malignancy using endobronchial ultrasound as well as therapeutic procedures such as foreign body removal, airway occlusion using coil implantation and clearing, laser procedures, all have improved the management of thoracic patients.[1]

Variations in the anatomical patterns of the bronchial tree have been studied throughout history. Aeby gave the first description of bronchial anatomy concluding the main bronchi to grow caudally giving rise to branches by monopodial division.[2] In 1932, Krammer and Glass identified bronchopulmonary segments as a unit.[2] In 1949, Boyden reported the most common pattern of RUL and the RLL as trifurcation, in LUL and LLL as bifurcation. He also pioneered the detailed description of the B* in lower lobes providing their prevalence.[3]

According to "Terminologia Anatomica" (TA 2019), the human lung has been divided into 10 bronchopulmonary segments in the right side and 8-9 segments in the left. But, there is no formal recognition of B*.[4]

After the non-inferiority of sublobar resection over lobectomy for peripheral lesions < 2 cm (JACOG 0802 trial and ALLIANCE trial)[5,6], there has been an increasing interest in segmentectomy among thoracic surgeons worldwide. Therefore, knowing of segmental bronchi either by 3D CT, bronchoscopy or mostly by combination of the two methods becomes a prerequisite to surgery. Our study aims to describe the prevalence of the different variation with the help of bronchoscopy.

Methods

A prospective observational study was conducted at B.P. Koirala memorial cancer hospital, Bharatpur,

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Nepal in patients undergoing flexible bronchoscopy for various indications, mostly malignancy. The study was conducted from May 2025 to August 2025 in 104 consecutive patients after an informed consent. Ethical clearance was taken from Institutional Review Committee for conducting the study (Reference no: 081/082/127). Only the cases in which bronchoscopy revealed patent bronchial tree up to the segmental division were included in the analysis.

Patients who were unfit to tolerate bronchoscopy, had massive hemoptysis, history of lung resection in past, or were in severe hypoxemia were excluded from the procedure.

Clinical symptoms and CECT scan of chest were evaluated prior to the procedure. Blood counts, coagulation profile, HIV and Hepatitis viral markers were performed as per the institutional protocol. Patients were advised for fasting at least 6 hours prior to the procedure. Intravenous access was secured for all patients.

Bronchoscopy procedure

All fiberoptic bronchoscopy were done in endoscopy suite under local anesthesia. Patients were explained about the procedure thoroughly. Olympus fiberoptic bronchoscope with 6.4 mm external diameter with a large 2.8mm working channel was used. Procedure was done in supine position. Continuous monitoring of pulse oximetry, electrocardiography and sphygnomanometry were done. Pre oxygenation was done via face mask with oxygen at 2-3 L/min. Local anesthesia was given via transtracheal route or 'spray-as-you-go' technique using 1% lidocaine. 15% lidocaine spray was used to anesthetize oropharynx and laryngopharynx. Distal shaft of bronchoscope was lubricated with 2% lidocaine jelly before insertion. The nasal pathway was preferred, if not feasible, the oral route was used. Bronchoscope was inserted till the vocal cords and as epiglottis was clearly visible, then 2ml of 1% lidocaine was flushed. Bronchoscope was then carefully inserted into the trachea where another 2ml of 1% lidocaine was flushed.

A thorough evaluation of tracheobronchial tree at least up to the level of segmental bronchi was done. Pattern of bronchial division was recorded for each lobe. Any supernumerary bronchus, bronchial diverticulum or bridging pattern of bronchial tree was noted as well.

Data analysis

Data were collected and analyzed using IBM SPSS version 25. Frequency distribution were calculated and to look for statistical significance Chi-square test and Fischer exact test were used whenever necessary.

Results

In this study a total of 104 patients were examined with flexible bronchoscopy. In few of the cases, complete evaluation of bilateral bronchial tree was not possible due to various reasons like occlusion of the lumen by tumor or external compressions. So, the data was separately analyzed for different lobes of the lungs. We studied altogether 55 males (52.9%) and 49 females (47.1%) patients. The results of the observed bronchial segmentation and their frequency are shown in Table 1.

Table 1 Frequencies of the different lobes evaluated in the patients.

		RULB	RMLB	RLLB	LULB	Superior division	Inferior division	LLLB
N=104	Observed	90	92	98	87	82	85	96
	Missing[a]	14	12	6	17	22	19	8

[a]= Incomplete evaluation of segmental bronchi.

Right upper lobe (n=90): In our study we found 4 different anatomic variations in the RUL bronchial segmentations (Table 2). Among the variations, trifurcation of the RUL bronchus into B1, B2 and B3 was noted as the most common (41.1%) (Figure 1a).

Table 2 RUL bronchial branching patterns.

Branching pattern	Frequency
B1, B2; B3	37 (41.1%)
B1 + 2; B3	22 (24.4%)
B1 + 3B2	12 (13.3%)
B2 + 3 and B1	19 (21.1%)
Total	90 (100.0%)

Middle lobe(n=92): The only anatomic pattern noted in the RML was bifurcation into B4 and B5.

Right lower lobe(n=98): In the RLL (Table 3), we noted a total of seven different segmentation patterns. Branching of RLL into B6, B7 and B8 separately with B9 and B10 having a common origin (B6, B7, B8, B9+10) was noted as the most common

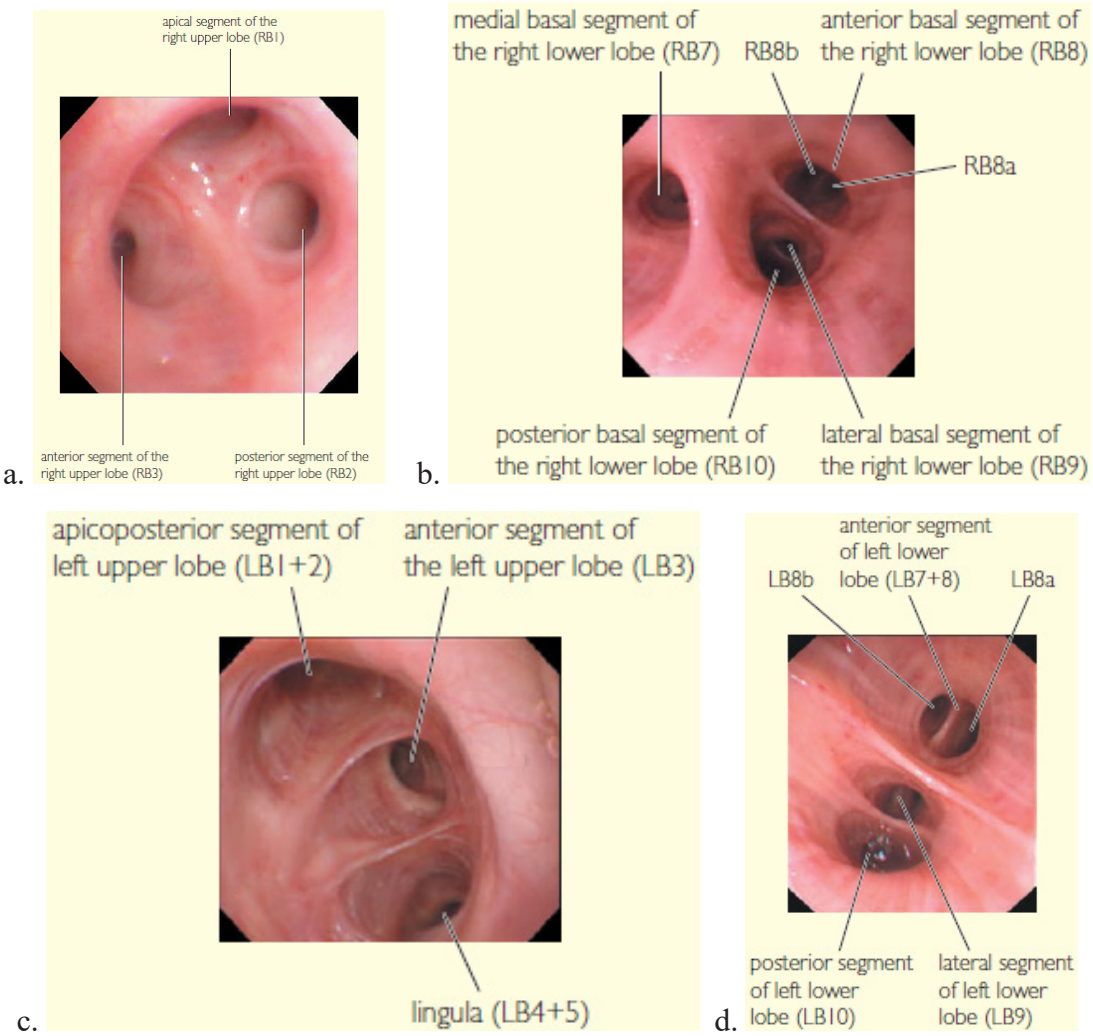

Fig. 1 Common patterns of bronchial division in different lobes.[1] a: Trifurcation of RUL with B1;B2;B3. b: In RLL , B6, B7, B8, B9+10. c: In LUL superior division B1+2 and B3 and inferior division B4;B5. d: In LLL B6;B8;B9+10, B6 is not shown.

segmentation pattern (Figure 1b). The presence of B* on the right side was noted in 18(18.4%) out of 98 cases. Presence of B* in the right lower lobe was most commonly seen with B6, B7, B8, B9+10 pattern.

Table 3. RLL bronchial branching patterns with B*.

Bronchial patterns	Frequency
B6;B7;B8;B9;B10	19 (19.4%)
B6;B7+8;B9+10	7 (7.1%)
B6;B7;B8;B9+10	40 (40.8%)
B6;B7;B8+9;B10	30 (30.6%)
B6;B8;B9+10	1 (1.0%)
B6;B7;B8+9+10	1 (1.0%)
Total	98 (100.0%)
Presence of B*	18(18.4%)

Left upper lobe: In the LUL (Table 4) superior and inferior division were evaluated in 82 and 85 patients, respectively. In our study, only two branching variations in the superior division were noted with most common being the two branches with B1+2 and B3(92%) (Figure 1c). A small number of patients has trifurcation of the superior division (7.3%) was noted. In the lingular lobe we however found only single pattern of two branches if the inferior division into B4 and B5.

Table 4. LUL bronchial branching in superior and inferior division

Branching of LUL		Frequency
Superior division	B1+2;B3	76 (92.7%)
	B1+2a+b,B1+2c,B3	6 (7.3%)
Total		82 (100%)
Inferior division	B4;B5	85 (100%)

Left lower lobe: In the LLL (Table 5) three different distinct anatomic patterns were found. Most common being the pattern with LLL giving off B6, then B8 and then a common origin of B9 and B10 (41.7%)

(Figure1d). The presence of the B* was seen in the 17.5% of the left lungs.

Table 5. Segmentation pattern in LLL.

Branching pattern of LLL	Frequency
B6;B8;B9;B10	27 (28.1%)
B6;B8+9;B10	29 (30.2%)
B6;B8;B9+10	40 (41.7%)
Total	96 (100.0%)
Presence of B*	17(17.7%)

Subsuperior Bronchus(B*): The presence of B* was noted in total of 34(35.8%) out 95 patients in either left or right lung in whom both lungs were evaluated, see Table 6. The right B* bronchus was noted in 18(18.4%) of 98 cases, the left B* bronchus was noted in 17(17.7%) of 96 cases. In one patient B* bronchus was noted bilaterally. However, there was no statistical difference noted in the presence of B* in males and females.

Table 6 Presence of B* among males and females.

	Male	Female	Total	p-value
overall B*	18 (18.9%)	16 (16.8%)	34 (35.8%)	0.796
RB*	12 (12.2%)	6 (6.1%)	18 (18.4%)	0.280
LB*	6 (6.3%)	11 (11.5%)	17 (17.7%)	0.107

Discussion

There is very limited literature about the bronchial segmentation in lungs in Nepal. The present study represents one of the first prospective studies in the Nepalese population with larger sample size which aims to identify the frequency of normal and possible variations in the bronchial tree of both lungs. Different literatures globally vary in the anatomical variations and their prevalence.

With advances in medical and surgical fields, there is widened diagnostic and therapeutic capabilities of flexible bronchoscopy. The advances in surgical intervention with increasing popularity of minimally invasive approach, and few studies showing non-inferiority of segmentectomy over lobectomy for early lung cancer, it is imperative to know the details of segmental variation of the lung lobes.[5,7,8]

We observed four different branching patterns in Right upper lobe in our study. Division of the right upper lobe into three branches with B1, B2 and B3 was the most common (41.1%), similar to the prevalence observed by Nomori(40%).[9] The RML had bifurcation pattern (i.e. B4;B5) which is the predominant pattern in the general population. However, trifurcation of the middle lobe is also an established variation.[10] We did not come across the tracheal bronchus or Accessory Cardiac Bronchus(ACB) during our study. In our study, in the right lobe, RLL had the highest number of variations whereas the RML had no variation. Nomori stated in his book, the most common anatomical pattern of right lower lobe giving rise to B6, B7 and B8 separately with a common trunk giving off B9+10 (86%).[11] In the RLLB we came across a total of six different variations of the segmental bronchi. The most common variation was B6;B7;B8;B9+B10 (40.8%). A similar study done for bronchial variations of right lung by Thapa et al in 60 patients showed the most common pattern to be B6,B7,B8+9,B10 in 30.8% patients.[12] According to the study by Martín-Ruiz et al, RLL had the most variations in right lung similar to our findings. In their study, the frequency of B* in the right side was in 16.4% of the studied cases. This value was close to the presence of B* in right lower lobe(18.4%) in our study.[10] The B* is almost always oriented outwardly and posteriorly and lies between the superior segment (B6) and basal segments (B9+10). Presence of B* was noted between B6 and B9+10 in most cases (10.2%). Rest of them had B* bronchus associated with B6; B7; B8+9; B10; B* However, we did not come across other anatomical variations such as accessory bronchus.

In left lung, the upper lobe is divided into superior division and inferior division. The superior division gives off B1+2 and B3 bronchi as the most common branching pattern.[1,10,13] Our observation noted the same pattern of B1+2,B3 as the most common pattern in 92.7% while small portion of the cases had trifurcation with B1+2a+b,B1+2c and B3 (7.3%). Although other authors have mentioned about other variations such as trifurcation with B1+2,B3a and B3b+c, we did not came across such variation.[13] In the inferior division we observed only one pattern of bifurcation with B4 and B5. Other studies have mentioned about the trifurcation of the inferior division in small proportion of the cases(6%).[10]

The LLL shows more variations, we noted three basic branching patterns of LLL bronchus. Among the different variations, LLL bronchus giving rise to B6, B8 separately and a common trunk giving rise to B9 and B10 was the most common pattern (41.7%). Presence of B* also adds up to the anatomical

variation. On the left lung, B* was present in 17.7% of the cases. Our findings show similar pattern to those observed by Nomori regarding the bronchial patterns and frequency of B*.[13] However, the presence of B* is only 3% in study done by Martín-Ruiz et al.[10]

A similar study by Thakur et al showed the prevalence of B* in Nepalese population with 60 cases evaluated. In that study, B* was found in 21.6% on right side and 10% on left side.[14] Our study with increased sample size showed 18.4% cases and 17.7% cases had B* on RLL and LLL respectively. If we consider prevalence of B* in either lung, this would show about 35.8% of the population may have B* bronchus in any one lung.

Conclusion

Our study showed the prevalence of different bronchial branching patterns in the Nepalese population. The RLL has the highest number of variation in the right bronchial tree followed by RUL. The presence of B* is seen in considerable number of patients. Having knowledge of the branching patterns of the bronchial tree is imperative in addition to the knowledge of segmental arteries and veins in planning advanced surgical intervention such as segmentectomy and bronchoscopic procedures.

Limitations

Our study could have given more information if there was bigger sample size and bronchoscopic findings were correlated with CT- scan images.

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