

Factors Related to the Diagnostic Yield of Flexible Bronchoscopy without Guidance in Bronchoscopically Invisible Peripheral Lung Lesions

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Background: We aimed to analyze the factors predicting the diagnostic performance of flexible bronchoscopy without guidance in peripheral lung lesions that are endoscopically invisible.

Methods: This was a retrospective study conducted in St. Paul's Hospital, The Catholic University of Korea, between January 2007 and March 2013. We included all patients who received bronchoscopy during this period. The analyzed variables were age, sex, the etiology of the lesion, lesion size, distance from the pleura, and presence of the bronchus sign. We used multiple logistic regression analysis to identify the significant independent factors associated with diagnostic yield.

Results: We included 151 patients in this study. The overall diagnostic yield was 58.3%. The sensitivity was 43.2% for malignant disease and 78.1% for benign disease. The benign lung lesions ($p<0.001$), lesion size ($p=0.015$), presence of the exposed type of bronchus sign ($p<0.001$), and presence of cavitary lung lesions ($p=0.005$) were factors influencing the yield of flexible bronchoscopy by univariate analysis. In a multivariate logistic regression analysis, the exposed type of bronchus sign and benign lung lesions were independent predicting factors (odds ratio [OR]: 27.95; 95% confidence interval [CI], 7.56–103.32; $p<0.001$ and OR, 4.91; 95% CI, 1.76–13.72; $p=0.002$).

Conclusion: The presence of the exposed type of bronchus sign and benign lung lesions are determining factors of the diagnostic yield in flexible bronchoscopy in evaluating peripheral lesions that are not endoscopically visible.

Keywords: Bronchoscopy; Lung; Bronchi; Multidetector Computed Tomography

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Introduction

Flexible bronchoscopy is commonly performed to evaluate peripheral lung lesions. Several diagnostic innovations, including ultrathin bronchoscopy, virtual bronchoscopy, electromagnetic navigation, and radial endobronchial ultrasound, have been established to increase the diagnostic yield of bronchoscopy¹⁻⁴. However, these modalities are costly and limited to specialized centers, causing difficulty of application in routine clinical practice. Although flexible bronchoscopy under fluoroscopic guidance is a widely accepted method and increases the diagnostic yield of nonendobronchial lung lesions, it has the disadvantages of causing radiation exposure

in patients and clinicians^{5,6}.

Many studies have analyzed the factors that affect the diagnostic performance of flexible bronchoscopy in the evaluation of peripheral lesions. These studies have demonstrated that the size, presence of the bronchus sign, and nature of the lesion are determinants of the diagnostic yield in bronchoscopy when evaluating peripheral lung lesions^{7,9}. However, few studies have reported the diagnostic performance of conventional bronchoscopy without fluoroscopic guidance.

In a previous study, we demonstrated that the size and nature of the lesion were significant predictive factors for a higher diagnostic performance of flexible bronchoscopy without fluoroscopic guidance⁹. However, the bronchus sign, one of the reported predictors of the outcome of flexible bronchoscopy, was not included, and multivariate analytical techniques were not used. Therefore, we performed this study to analyze factors that influence the diagnostic performance of flexible bronchoscopy without fluoroscopic guidance in evaluating peripheral lung lesions.

Materials and Methods

1. Study subjects

This was retrospective study conducted in St. Paul's Hospital, The Catholic University of Korea between January 2007 and March 2013. All patients received bronchoscopy during this period were included. Initially, 204 patients with peripheral lesions without endobronchial lesions who underwent conventional bronchoscopy were enrolled in the study. The nondiagnostic results of bronchoscopy were confirmed from following percutaneous transthoracic needle aspiration (TTNA) or surgical resection. Twelve patients with inactive lung lesions, 24 patients lost to follow-up, and 17 patients with lesions not confirmed by any diagnostic methods were excluded. The remaining 151 patients diagnosed with active lung lesions were registered for the final analysis (Figure 1). All data were collected from the medical records. The requirement for informed consent was waived by the ethical review board. This study was approved by the Institutional Review Board of St. Paul's Hospital (Seoul, Korea) (IRB No. PC16OA-SI0022).

2. Bronchoscopic procedures

Bronchoscopic examinations were performed without fluoroscopic guidance by five full-time faculty staffs with clinical experience of bronchoscopy at least 1 year in the pulmonology division. Before the procedure, the patient was given 0.5 mg of atropine sulfate to reduce oral secretions and bronchospasm, and 50 mg of pethidine hydrochloride to provide pain relief and suppress coughing intramuscularly, and took

nebulized lidocaine (10 mL of 2% solution) for 5 minutes. The heart rates and saturation of peripheral oxygen (SpO₂) were continuously monitored. Oxygen was applied via nasal cannula or mask and adjusted to keep saturation above 90%. Bronchoscopy (models BF-1T260; Olympus, Tokyo, Japan) was used for brushing, washing, and biopsy. Bronchoscopy was performed via the transnasal or transoral approach. Midazolam was administered to achieve moderate sedation. When the vocal cord is inspected, 2 mL of 4% lidocaine was sprayed to anesthetize the upper airway as well as the tracheobronchial tree. All segments of the bronchus were observed. Next, the bronchoscope was moved to the bronchial segment of a targeted lesion located on computed tomography (CT). The specimen obtained by cytology brush was smeared on three slides. These were air-dried and alcohol-fixed, and sent for acid-fast bacilli and Papanicolaou stain, respectively. At least three 1- to 3-mm-sized adequately sized specimens from transbronchial lung biopsies (TBLBs) were processed by first incubating in formalin and then sending to an external vendor for hematoxylin and eosin stain. About 15 mL of saline was instilled through the bronchoscope and aspirated at least three times after biopsy. A sample from bronchial washing (BW) was prepared for routine cytology, cell block cytology, acid-fast bacilli and gram staining, and bacterial and fungal culture. For benign pulmonary lesions, cytologic findings associated with infectious etiologies such as inflammatory cells and/or microbial organisms and resolution of radiologic findings with antibiotics were considered pneumonia. Pulmonary lesion with the presence of necrotic debris or pus was diagnosed of abscess.

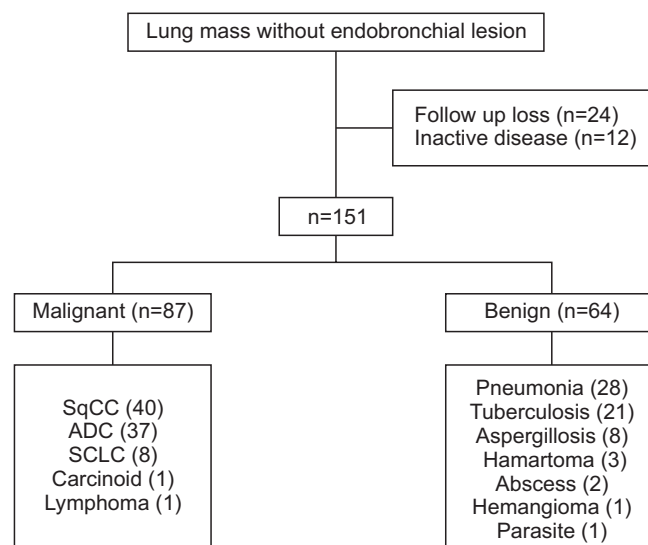


Figure 1. Study patients. SqCC: squamous cell carcinoma; ADC: lung adenocarcinoma; SCLC: small cell lung cancer.

3. Radiographic assessments

Chest CT were performed in most patients within one month before flexible bronchoscopy. The radiologic findings were analyzed by a radiologist, and the size of the lesion was defined as the measurement of the longest dimension. The CT bronchus sign was divided into the exposed and unexposed types according to the definition of Tsuboi et al.¹⁰: (1) the bronchial lumen is exposed to the tumor and cut off or contained within the tumor, or (2) the bronchus is compressed by the tumor or constricted by peri-mucosal tumor spread, causing either smooth or irregular narrowing. When two or more bronchus signs were identified, the order of the more proximal bronchus was prioritized.

4. Definition of bleeding

There is no exact definition of minor and major bleeding. In our study, minor bleeding was defined as bleeding which stopped spontaneously or was controlled with local epinephrine. Major bleeding was defined when additional interventions such as embolization of blood vessel, surgical intervention or transfusion were required.

Table 1. Patient demographics and characteristics of the pulmonary lesions

Characteristic	No. (%) (n=151)
Male sex	100 (66.2)
Age, yr	64.69±13.74
Lesion size, cm	3.68±1.92
Lesion location	
LUL	32 (21.2)
LLL	29 (19.2)
RUL	42 (27.8)
RML	18 (11.9)
RLL	30 (19.9)
Type of lesion	
Malignancy	87 (57.6)
Benign	64 (42.4)
Presence of cavity	29 (19.2)
Presence of bronchus sign	69 (45.7)
Exposed/unexposed	55/14
Distance from the pleura, cm	1.02±1.09

LUL: left upper lobe; LLL: left lower lobe; RUL: right upper lobe; RML: right middle lobe; RLL: right lower lobe.

5. Statistical analysis

Statistical analysis was performed using the Pearson's chi-square test and Fisher exact test for discrete variables, and the Mann-Whitney U test for continuous variables. McNemar's test was performed as a test of univariate association between diagnostic method and the outcomes. Multiple logistic regression analysis was used to identify the significant independent factors associated with diagnostic yield of conventional bronchoscopy. Two-sided p-value of less than 0.05 was considered statistically significant. Statistical analyses were performed using SPSS software (IBM SPSS Statistics 20.0; IBM Corp., Armonk, NY, USA).

Results

One hundred fifty-one patients were included in the study. Among the lesions of these patients, 87 were malignant (40 squamous cell carcinomas, 37 adenocarcinomas, eight small cell carcinomas, one carcinoid, and one lymphoma), and 64 were benign (28 related to pneumonia, 21 to tuberculosis, eight to aspergillosis, three to hamartoma, two to an abscess, one to sclerosing hemangioma, and one to parasite infestation) (Figure 1). In patients with pneumonia, microorganism was isolated in 11 (35.7%) patients. Pathogens detected with bronchoscopic cultures were *Klebsiella pneumoniae* (6) and *Streptococcus pneumoniae* (1), *Enterobacter aerogenes* (1), *S. aureus* (1), and *Proteus mirabilis* (1). The mean patient age was 65±14 years. The mean size of the pulmonary lesions was 3.68±1.92 cm. The mean distance from the lesions to the pleural surface was 1.02±1.09 cm. Most of the lesions were located in the upper lobes (44.3%, 67/151) and lower lobes (39.0%, 59/151) (Table 1).

The overall diagnostic yield of bronchoscopy was 58.3%. The sensitivity was 43.2%, 78.1% in malignant and benign disease, respectively. All patients received TBLB, bronchial

Table 2. Diagnostic yield of the three different diagnostic modalities

Variable	TBB*†	BB	BW
Benign	42/64 (65.6) [‡]	7/64 (10.9)	14/64 (21.9) [§]
Malignant	35/87 (40.2)	11/87 (12.6)	3/87 (3.4)
Total	77/151 (51.0)	18/151 (11.9)	17/151 (11.3)

Values are presented as number (%).

*p<0.001, McNemar's test between diagnostic yields of TBB vs. BB. †p<0.001, McNemar's test between diagnostic yields of TBB vs. BW. ‡p=0.003, chi-square analysis between diagnostic yields for malignant vs. benign lesions. §p=0.001, chi-square analysis between diagnostic yields for malignant vs. benign lesions.

TBB: transbronchial biopsy; BB: bronchial brushing; BW: bronchial washing.

brushing (BB) and BW. The diagnostic performance from TBLB was higher than that from BB and BW. In malignant lesions, the diagnostic yield from TBLB was 40.2% (35/87), and the yield from BB and BW was 12.6% (11/87) and 3.4% (3/87), respectively. A similar tendency was seen in benign lesions. However, the diagnostic yield from TBLB and BW was higher in the benign lesions (Table 2). There was no inconsistency in diagnostic results among TBB, BB, and BW. Sixty-two patients were non-diagnostic with bronchoscopy. These patients received additional diagnostic method (one pleural biopsy, eight surgical biopsies, and 53 TTNA).

As shown in Table 3, the diagnostic yield of bronchoscopy in peripheral lung lesions was associated to the presence of the bronchus sign and cavity, lesion size, and etiology of the lung lesion by univariate analysis. The size of lesion >3 cm was based on dividing point between mass and nodule. The distance from pleura >2 cm was defined according to the previous study, and the lesion >2 cm from the pleura was known to be risk factor of pneumothorax after TTNA^{11,12}.

The location of lesion and distance from the pleura did not affect the diagnostic performance of bronchoscopy. Multivariate analysis after adjusting for sex, age, lesion size,

distance from pleura, and the presence of cavity identified the exposed type of bronchus sign ($p<0.001$) and benign lung lesions ($p=0.002$) as the variables conditioning the diagnostic yield of bronchoscopy with an odds ratio (OR) of 27.95 (95% confidence interval [CI], 7.56–103.32) and 4.91 (95% CI, 1.76–13.72), respectively.

Bronchoscopy was diagnostic in 92.7% of cases (51/55) in which the exposed type of bronchus sign was identified on chest CT but in only 39.0% (32/82) without an identifiable bronchus sign and in only 35.7% (5/14) with an unexposed type of bronchus sign. The unexposed type of bronchus sign was not different from the absence of the bronchus sign in affecting the diagnostic yield of bronchoscopy for peripheral lung lesions (OR, 1.5; 95% CI, 0.4–5.7; $p=0.544$).

During the study period, life threatening major complications did not occur. Sixteen patients (10.6%) had minor bleeding, and five patients (3.3%) had pneumothorax following bronchoscopy. Of patients with pneumothorax, four patients recovered by oxygen therapy and one patient required chest tube insertion.

Table 3. Logistic regression analysis of factors influencing the diagnostic yield of conventional bronchoscopy

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Sex				
Male	1.09 (0.55–2.16)	0.801	0.73 (0.29–1.84)	0.503
Female				
Age	0.96 (0.94–0.99)	0.005	0.97 (0.94–1.01)	0.091
Etiology				
Malignant				
Benign	4.61 (2.22–9.54)	<0.001	4.91 (1.76–13.72)	0.002
Size, cm				
≤3				
>3	2.3 (1.17–4.37)	0.015	1.32 (0.52–4.94)	0.565
Distance from pleura, cm				
≤2				
>2	0.96 (0.30–1.91)	0.556	1.53 (0.47–4.94)	0.478
Cavity				
Presence	4.35 (1.56–12.15)	0.005	1.14 (0.27–4.82)	0.861
Absence				
Bronchus sign				
Exposed type	19.9 (6.56–60.46)	<0.001	27.95 (7.56–103.32)	<0.001
Unexposed type	0.87 (0.27–2.82)	0.814	1.77 (0.45–6.94)	0.414
Absent				

OR: odds ratio; CI: confidence interval.

Discussion

The present study analyzed factors that influence the diagnostic performance of flexible bronchoscopy without guidance in evaluating peripheral lung lesions not visible endoscopically. Benign lung lesions, a lesion size of >3 cm, and the presence of a bronchus sign were determining factors increasing the yield of flexible bronchoscopy by univariate analysis. In multivariate logistic regression analysis, the exposed type of bronchus sign and benign lung lesions were predicting factors.

The diagnostic performance of flexible bronchoscopy in peripheral lung lesions without endobronchial lesions was not high, varying from 19% to 77% in malignant lesions and 27% to 74% in benign lesions¹³⁻¹⁵. Many researchers have sought to determine factors that improve the diagnostic yield of bronchoscopy. Several factors that affect the diagnostic yield of conventional bronchoscopy in patients with peripheral lung lesions without endobronchial lesions have been suggested: the CT bronchus sign, size of the lesion, etiology of the lesion, and location of the lesion¹⁶⁻²⁰. A point that claims our attention is that most of the studies routinely used fluoroscopy as guidance to increase the sensitivity of bronchoscopy. Few studies were conducted with non-guidance conventional bronchoscopy, and these were conducted for the cases confined to malignancies, those mixed with peripheral lung lesions visible bronchoscopically, and those performed with only brushing or washing^{8,21-24}.

The bronchus sign on CT denotes the presence of a bronchus leading directly to a peripheral lung lesion¹⁸. The bronchus sign is grouped into two categories according to the presence or absence of exposure of the tumor mass to the bronchial lumen¹⁰. In a previous prospective study, there was no difference in the diagnostic yield between TBLB and TTNA in lesions with the exposed type of CT bronchus sign²⁵. In a study of the determinants of diagnostic BW in peripheral lung cancers, the exposed type of bronchus sign was the most important factor⁸. Our results correspond with these earlier studies^{8,25}. A revealing fact is that the unexposed type of bronchus sign was not different from the absence of the bronchus sign in affecting the diagnostic yield of bronchoscopy for peripheral lung lesions. A study by Gaeta et al.¹⁸ supports this result: in the unexposed type of bronchus sign, tumor cells could not be obtained by TBLB or BB in evaluating peripheral carcinoma of the lung.

The diagnostic yield from TBLB for benign lesions is generally known to be lower than that for malignant lesions^{17,26,27}. However, these studies used results from fluoroscopy-guided bronchoscopy. Fluoroscopy-guided TBLB significantly increases the diagnostic yield of non-endobronchial lung masses⁶. According to Labbe et al.²¹, the sensitivity of non-guided bronchoscopy for the diagnosis of peripheral malignant lesions is limited. In our study, the higher diagnostic

yield in benign lesions than in malignant lesions may be due to the frequency of positive culture findings for tuberculosis obtained from BW (11/21, 52.4%) and BB (5/21, 23.8%) in our study. Additionally, in general, benign lung lesions present diffuse infiltrates, whereas malignant lung lesions present localized infiltrates²⁸. Descombes et al.²⁹ reported that the diagnostic yield of TBLB was better for lung lesions with diffuse pulmonary infiltrates than those with localized lung lesions or peripheral neoplasia.

Although the diagnostic yield of conventional bronchoscopy without guidance does not provide the highest performance, this procedure has some advantages. First, conventional bronchoscopy without guidance can be performed relatively safely without additional expenses^{16,26}. Fluoroscopy has been used to identify the position of the sheath and forceps, confirm that the biopsy was conducted as planned, and check for complications such as pneumothorax. However, this method has the shortcomings of radiation exposure, a longer procedure time, and occupying a large amount of space^{8,30}. According to a registry-based study, an advanced diagnostic technique such as electromagnetic navigation or radial endobronchial ultrasound does not improve the diagnostic yield compared with conventional bronchoscopy³¹. Second, the incidence rates of complications such as bleeding or pneumothorax are lower with conventional bronchoscopy than with TTNA³².

Our study has limitations inherent in a retrospective research. Additionally, our study was based on a single center; thus, broad application of our results is limited. Finally, direct comparison of the diagnostic yield was not possible because there was no fluoroscopy-guided control group. However, current study is meaningful in that few studies concerning the diagnostic performance of bronchoscopy without guidance have been conducted for peripheral lung lesions that are invisible endoscopically, and predicting factors for diagnostic yield of conventional bronchoscopy has clinical importance in deciding the diagnostic modalities for peripheral lung lesions.

In conclusion, we documented that the exposed type of bronchus sign and benign lung lesions were influencing factors in the diagnostic performance of conventional bronchoscopy without guidance in evaluating peripheral lung lesions that are invisible bronchoscopically. Thus, detailed analysis of pre-procedure radiologic findings is needed for peripheral lesions, and non-guidance conventional bronchoscopy could be considered when the exposed type of bronchus sign is present and a benign lesion is suspected.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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