ORIGINAL ARTICLE

Safety of endobronchial ultrasound-guided transbronchial needle aspiration in patients with lung cancer within a year after percutaneous coronary intervention

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Abstract

Background: Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) may be necessary for patients with incidental lung cancer during or after coronary intervention. Although EBUS-TBNA is quite safe, the safety in patients who recently received percutaneous coronary intervention (PCI) has not been demonstrated. The aim of this study was to assess the safety of EBUS-TBNA in patients with lung cancer who underwent PCI within one year.

Methods: We retrospectively reviewed the medical records of 24 patients who underwent EBUS-TBNA within one year after PCI between May 2009 and June 2017. Cardiovascular complications (death, myocardial infarction, arrhythmia, and acute heart failure) were assessed as primary outcomes. Procedural-related complications were assessed as secondary outcomes.

Results: The coronary artery diseases requiring PCI were: myocardial infarction ($n = 10$), unstable angina ($n = 10$), stable angina ($n = 2$), and silent ischemia ($n = 2$). The median interval between PCI and EBUS-TBNA was 125 days (interquartile range: 66–180). Atrial fibrillation with a rapid ventricular response temporarily occurred in one patient after EBUS-TBNA. No other significant cardiovascular complications were encountered. Fifteen patients were administered an anti-thrombotic agent the day of EBUS-TBNA, while four had ceased taking the agent < 4 days before EBUS-TBNA, however, there was no significant bleeding among those patients.

Conclusion: EBUS-TBNA was safe and did not cause serious adverse events in patients with lung cancer who required tissue confirmation or mediastinal staging within one year after PCI. Incidental lung cancer found during or after a coronary intervention should be actively evaluated by EBUS-TBNA.

Introduction

Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) has become an important procedure for diagnosing lung cancer, particularly when evaluating mediastinal lymph node (LN) status. The American Thoracic Society and European Respiratory Society have emphasized the roles of pulmonary physicians in the diagnosis and staging of lung cancer using techniques such as bronchoscopy with EBUS-TBNA.[1] Previous studies have found that EBUS-TBNA is less invasive and at least as accurate as mediastinoscopy (area under the summary receiver operating characteristic curve 0.99, 95% confidence interval [CI] 0.96–1.00; pooled specificity 1.00, 95% CI 0.92–1.00; and pooled sensitivity 0.88, 95% CI 0.79–0.94).[2]

EBUS-TBNA also exhibits superior diagnostic performance compared to mediastinoscopy for mediastinal LN staging of clinical N1–3 non-small cell lung cancer.[3]

Although EBUS-TBNA is known to be a safe (major complication rate 0–1.2%) and highly accurate method,[4–7] it is a delicate procedure requiring more attention and training than conventional flexible bronchoscopy (FB). It requires intense training and practical experience because the anatomic structures of the mediastinum are comparatively complex, and the EBUS image planes may be oblique and very different from conventional radiological images. Accordingly, trainees should perform at least 50 procedures in a supervised setting to establish basic competency, and operators should perform at least 20 examinations per year.[8]

Although EBUS-TBNA is recognized as a minimally invasive and highly safe procedure, there is no clear evidence of the safety of EBUS-TBNA in patients with cardiovascular disease, especially those who have undergone recent PCI as a result of coronary disease. According to the British Thoracic Society FB guidelines, close consultation with a cardiologist should be considered when bronchoscopy is indicated in high-risk patients with cardiac disease, and FB should ideally be delayed four weeks after myocardial infarction (MI).[9] However, no guidelines or studies have been published about EBUS-TBNA in patients with coronary artery disease. Additionally, a bleeding complication is a significant issue because dual antiplatelet therapy (DAPT) is recommended to prevent stent thrombosis after PCI and insertion of a coronary stent. Discontinuing an antiplatelet agent prior to EBUS-TBNA to prevent bleeding could be harmful to patients with a recent PCI history.

The aim of this study was to assess the safety of conducting EBUS-TBNA in patients with lung cancer within a year after PCI. We hypothesized that EBUS-TBNA could be performed safely under appropriate sedation and monitoring with the consultation of a cardiologist.

Methods

Patient selection

This was a retrospective single-center based study. We reviewed the Samsung Medical Center EBUS-TBNA registry, which includes 5073 cases of EBUS-TBNA from May 2009 to June 2017. Most of the EBUS-TBNA procedures were performed for the purpose of mediastinal node staging, diagnosis of lung cancer, extrathoracic malignancies, mediastinal lymphoma, or benign disease, such as tuberculous lymphadenitis and sarcoidosis. Patients with suspected or diagnosed non-small cell lung cancer who had undergone PCI with insertion of a coronary stent and then EBUS-TBNA less than a year later were included in the analysis (Fig 1). A radiologist reviewed chest computed

tomography (CT) scans and integrated positron emission tomography-CT images were routinely checked prior to EBUS-TBNA.

All patients underwent cardiac echocardiography and a cardiology consultation to determine their exact clinical heart status. The benefits and risks were assessed after completion of the cardiology and lung cancer evaluation. In general, we did not perform EBUS-TBNA in cases of contraindication for bronchoscopy, such as inadequate oxygenation during the procedure, uncontrolled arrhythmia, unstable cardiac status, refractory hypoxemia, or coagulopathy.

The institutional review board of the Samsung Medical Center approved this study (IRB No. SMC 2018–02-144).

Procedure

Patients who underwent EBUS-TBNA were moderately sedated using midazolam alone or a combination of fentanyl and midazolam with 2% topical lidocaine. Blood pressure, electrocardiogram (ECG), oxygen saturation (SpO_2), and respiratory rate were monitored, and oxygen was supplied via a nasal prong during the procedure in all patients. Real-time guidance with a curvilinear probe was used for all procedures. Six bronchoscopists performed EBUS-TBNA in 24 patients, and all were well trained and had experience of more than 200 EBUS-TBNA cases. All patients in our study underwent EBUS-TBNA for the diagnosis or staging of lung cancer.

Antiplatelet strategy

All patients underwent a cardiologic evaluation before EBUS-TBNA. We identified the drugs they were taking and the date they had undergone PCI. Most of the patients who had undergone PCI within 12 months were on DAPT, but some were only taking aspirin or clopidogrel alone. One patient was taking DAPT and a novel oral anticoagulant together because of atrial fibrillation.

In patients who had undergone PCI < 3 months previously, we decided to continue the anti-thrombotic agents they were already taking. Most were on DAPT, but one patient was taking clopidogrel alone for an unknown reason. As the patients were stable at the time of their visit, we did not add another anti-thrombotic agent.

We ceased or continued the anti-thrombotic agents in patients who had undergone PCI > 3 months previously according to the cardiologist's opinion. The cardiologist decided to continue or cease the medication for several days before EBUS-TBNA based on cardiac function, the severity of coronary artery disease, and the extent of coronary intervention. We recommended the medications the day after EBUS-TBNA in patients who had stopped taking the anti-thrombotic agent. Two patients in this group
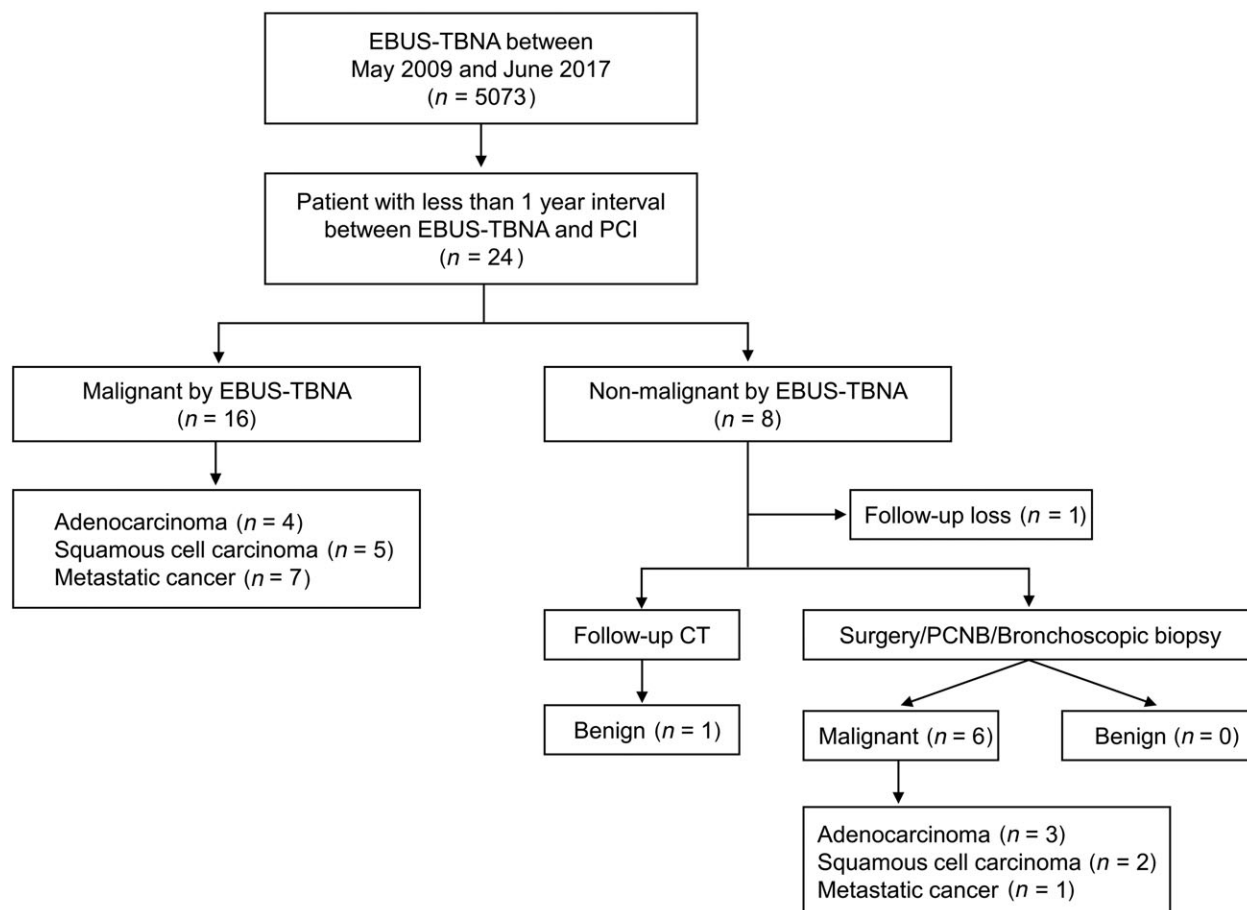
Figure 1 Enrolled patients, pathologic results of endobronchial ultrasound-guided-transbronchial needle aspiration (EBUS-TBNA), and final clinical and/or histologic diagnosis. CT, computed tomography; PCI, percutaneous coronary intervention; PCNB, percutaneous needle biopsy.

received intravenous heparin for bridging therapy during the medication cessation period.

Clinical outcomes

The primary outcome of interest was the incidence of cardiovascular complications within 24 hours after EBUS-TBNA. The cardiovascular complications were death, MI, arrhythmia, or acute heart failure. The secondary outcome was the incidence of procedural-related complications during or after EBUS-TBNA, including hypoxia ($< 90\%$ SpO$_2$ for $\geq$ 60 seconds), high blood pressure (increase of $\geq$ 30 mmHg from baseline systolic blood pressure), tachycardia (increase of $\geq$ 20% from baseline heart rate), hemoptysis, fever, and pneumothorax.

All patients were admitted to our hospital at least one day before EBUS-TBNA to evaluate these complications and baseline status. We also checked cardiac enzymes, ECG, and echocardiography before admission. During the procedure, we continuously monitored ECG and SpO$_2$, and measured blood pressure every 15 minutes. After the

procedure, vital signs and SpO$_2$ were monitored for 24 hours. A chest X-ray was taken the day after the procedure to assess pneumothorax, and patients were discharged if there was no complication.

Statistical analyses

We used the median and interquartile range (IQR) for descriptive statistics to summarize the demographics and clinical characteristics of all patients. Frequencies were used for categorical data and data were compared using Fisher's exact test. The Kruskal–Wallis test was used for nonparametrically distributed data. P values < 0.05 were considered significant, and all tests were two-tailed.

Results

Study patients

Twenty-four of the 5073 cases in the EBUS-TBNA registry were included in the analysis (Fig 1). All patients received

EBUS-TBNA for lung cancer diagnosis or staging. Table 1 lists the demographic and clinical characteristics, as well as the procedural profiles. Most patients were male (23/24, 95.8%). Pulmonary function was relatively preserved (median forced expiratory volume in 1 second/forced vital capacity

70% [57–75], median diffusing capacity of the lungs for carbon monoxide 71% [49–82]), and no significant abnormalities were observed in the anticoagulation profile.

Percutaneous intervention before endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA)

Table 2 lists the cardiovascular characteristics of the patients. Left ventricular systolic function was preserved (median left ventricular ejection fraction measured by echocardiography was 61%) in most patients, and all patients were hemodynamically stable at the time of EBUS-TBNA. We divided the patients into four categories based on the interval between PCI and EBUS-TBNA: (i) < 30 days ($n = 4$), (ii) 31–90 days ($n = 3$), (iii) 91–180 days ($n = 11$), and (iv) 181–360 days ($n = 6$). Figure 2 shows the number of patients in each category and the type of coronary artery disease treated by PCI with insertion of a stent. Overall, 20 (83.4%) patients had acute coronary syndrome (ACS), including ST elevation MI ($n = 7$), non-ST elevation MI ($n = 3$), or unstable angina ($n = 10$). Two patients had silent ischemia and two had stable angina.

EBUS-TBNA

Table 3 lists the characteristics of the LNs sampled by EBUS-TBNA. Approximately half of the sampled LNs (29/62, 46.8%) were lower paratracheal LNs (4L or 4R), and 27.4% (17/62) were subcarinal LNs (7). The median value of the short-axis diameter of the LN on chest CT was 8.0 mm (IQR 6.0–12.3). Of the 62 LNs, 20 (32.3%) were malignant.

The primary mass was approachable with an EBUS needle in three patients, and the mass was aspirated. The median number of aspirated LNs was three. The median duration of the procedure, defined as the time from insertion to removal of the EBUS scope, was 20 minutes (Table 1).

Clinical outcomes

Table 4 lists patient characteristics and outcomes in each group based on the interval between PCI and EBUS-TBNA. Only one cardiovascular complication occurred. The patient was a 75-year-old male, and the complication was atrial fibrillation with rapid ventricular response

Table 1 Demographic and clinical characteristics of patients and procedure profiles

Characteristics	Total ($n = 24$)
Age	68.5 (64.0–72.8)
Gender (male)	23 (95.8)
Smoking	
Never smoker	1 (4.2)
Ex-smoker†	13 (54.2)
Current smoker	10 (41.7)
Lung function‡	
FEV1/FVC (%)	70 (57–75)
FEV1 (%pred)	77 (73–90)
FVC (%pred)	81 (73–101)
DLco (%pred)	71 (49–82)
Platelet (k)	222 (188–260)
PT (INR)	1.07 (1.00–1.13)
aPTT (second)	37.5 (35.0–42.3)
Clinical stage on PET-CT	
I	3 (12.5)
II	2 (8.3)
III	11 (45.8)
IV	8 (33.3)
Indication for EBUS-TBNA	
Staging	5 (20.8)
Diagnosis (tissue confirmation)	13 (54.2)
Diagnosis and staging	6 (25.0)
Tissue acquisition site by EBUS-TBNA	
Lymph node	23 (96)
Primary mass	3 (12.5)
Metastatic mass	0 (0)
Aspirated LNs per patient	3 (2–3)
Duration of procedure (minute)	20 (15.3–22.8)

†Patients who had not smoked for more than a year. ‡Pre-bronchodilator. Data are presented as median (interquartile range) or N (%) unless indicated otherwise. %pred, percentage predicted; aPTT, activated partial thromboplastin time; DLco, diffusing capacity of the lungs for carbon monoxide; EBUS-TBNA, endobronchial ultrasound-guided-transbronchial needle aspiration; FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity; INR, international normalized ratio; LN, lymph node; PET-CT, positron emission tomography-computed tomography; PT, prothrombin time.
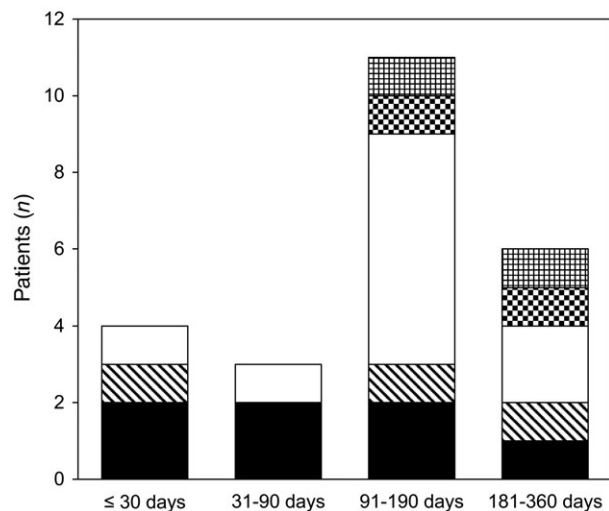
(AF RVR). He had underlying persistent AF and peripheral arterial occlusive disease in multiple vessels, and received PCI with stents in the right coronary artery and left anterior descending artery 165 days before EBUS-TBNA. He was taking warfarin and clopidogrel, but the medication had been ceased and altered to intravenous unfractionated heparin seven days before EBUS-TBNA. Several hours after EBUS-TBNA, AF RVR occurred, but was relieved by antiarrhythmic drugs (amiodarone and flecainide). Despite AF RVR, he was hemodynamically stable, except for tachycardia.

Seven patients experienced procedural-related complications: oxygen supplementation as a result of hypoxia, hypertension, sinus tachycardia, hemoptysis, fever, and

Table 2 Cardiovascular characteristics of patients

Characteristics	Total ($n = 24$)
Co-morbidity	
Hypertension	11 (45.8)
Dyslipidemia	1 (4.2)
Diabetes	11 (45.8)
Prior MI (more than one year before)	2 (8.3)
Prior PCI	2 (8.3)
Prior CABG	1 (4.2)
Prior stroke	2 (8.3)
Prior ESRD on dialysis	1 (4.2)
Left ventricular ejection fraction (%)	61 (44.5–64.8)
Extent of CAD	
1 vessel disease	10 (41.7)
2 vessel disease	8 (33.3)
3 vessel disease	6 (25.0)
Types of coronary artery disease	
Silent ischemia	2 (8.3)
Stable angina	2 (8.3)
Unstable angina	10 (41.7)
NSTEMI	3 (12.5)
STEMI	7 (29.2)

Data are presented as median (interquartile range) or N (%) unless indicated otherwise. CABG, coronary artery bypass graft; CAD, coronary artery disease; ESRD, end-stage renal disease; MI, myocardial infarction; NSTEMI, non-ST elevation MI; PCI, percutaneous coronary intervention; STEMI, ST elevation MI.

Table 3 Lymph node characteristics sampled by EBUS-TBNA

Characteristics	Total ($n = 62$) (%)
Lymph node station	
2R	7 (11.3)
4L	13 (21.0)
4R	16 (25.8)
7	17 (27.4)
10L	1 (1.6)
10R	1 (1.6)
11L	2 (3.2)
11R	5 (8.1)
Short axis diameter of LN on CT (mm, median [IQR])	8.00 (6.00–12.25)
Histology by EBUS-TBNA	
Adenocarcinoma	7 (11.3)
Squamous cell carcinoma	6 (9.7)
Small cell carcinoma	7 (11.3)
No evidence of malignancy	42 (67.7)

Lymph node stations are based on the International Association for the Study of Lung Cancer lymph node map developed in 2009. CT, computed tomography; EBUS-TBNA, endobronchial ultrasound-guided-transbronchial needle aspiration; IQR, interquartile range; LN, lymph node.

radiological intervention, antibiotics or transfusion, were not required, except oxygen supplementation via a nasal prong for mild hypoxia.

Maintenance of antiplatelet treatment

To compare the incidence of complications with anti-thrombotic therapy, we divided the patients into two groups. The maintenance group was defined as patients who were taking an anti-thrombotic agent (including anti-platelet and anticoagulant) or had discontinued the agent for ≤ 3 days before EBUS-TBNA. The stop group had ceased taking the medications for > 3 days (Table 4). None of the seven patients who underwent PCI within 90 days stopped taking their antiplatelet agent, and maintained DAPT. Among the maintenance group, nine of 19 (47.4%) patients were on DAPT (aspirin and clopidogrel); no significant bleeding events were encountered, even in patients who were taking anti-thrombotic agents.

Discussion

Most contraindications for EBUS-TBNA are relative rather than absolute and do not differ from FB.[8] Several previous studies have investigated the safety of EBUS-TBNA in patients with special medical conditions, such as a bleeding tendency or a space occupying brain lesion.[10,11] However, no study has been conducted in patients with coronary artery disease.

Bronchoscopy in patients with ischemic heart disease increases cardiovascular risk from hypoxia, tachycardia, or

Figure 2 Distribution of patients according to the interval between percutaneous coronary intervention (PCI) and endobronchial ultrasound-guided-transbronchial needle aspiration (EBUS-TBNA) and types of coronary artery disease treated with PCI. NSTEMI, non-ST elevation myocardial infarction; STEMI, ST-elevation myocardial infarction. (▦) Stable angina ($n = 2$), (▨) Silent ischemia ($n = 2$), (▢) Unstable angina ($n = 10$), (▧) NSTEMI ($n = 3$) and (■) STEMI ($n = 7$)

non-anginal chest pain (Table 5). However, all of these complications were transient and did not require an elevated level of care. Additional therapies, such as surgical or

Table 4 Characteristics and outcomes based on the interval between PCI and EBUS-TBNA

	Interval between PCI and EBUS-TBNA				
Characteristics	≤ 30 days (*n* = 4)	31–90 days (*n* = 3)	91–180 days (*n* = 11)	181–360 days (*n* = 6)	*P*
Age	68 (58–73)	65 (61–65)	68 (64–73)	69 (63–72)	0.98
Gender (male)	4 (100)	3 (100)	11 (100)	5 (83)	0.54
LVEF, %	61 (46–63)	37 (34–37)	60 (55–65)	66 (60–70)	0.06
Types of CAD					0.93
Silent ischemia	0 (0)	0 (0)	1 (9)	1 (17)	
Stable angina	0 (0)	0 (0)	1 (9)	1 (17)	
Unstable angina	1 (25)	1 (33)	6 (55)	2 (33)	
NSTEMI	1 (25)	0 (0)	1 (9)	1 (17)	
STEMI	2 (50)	2 (67)	2 (18)	1 (17)	
Anti-thrombotic therapy					0.66
Stop	0 (0)	0 (0)	3 (27)	2 (33)	
Maintenance†	4 (100)	3 (100)	8 (73)	4 (67)	
Aspirin	0 (0)	0 (0)	3 (38)	1 (25)	
Clopidogrel	0 (0)	1 (33)	1 (13)	1 (25)	
Aspirin + clopidogrel	4 (100)	2 (67)	1 (13)	2 (50)	
DAPT + NOAC	0 (0)	0 (0)	1 (13)	0 (0)	
Heparin	0 (0)	0 (0)	2 (25)	0 (0)	
Primary outcome					1.00
Death	0 (0)	0 (0)	0 (0)	0 (0)	
Myocardial infarction	0 (0)	0 (0)	0 (0)	0 (0)	
Arrhythmia	0 (0)	0 (0)	1 (100)	0 (0)	
Heart failure	0 (0)	0 (0)	0 (0)	0 (0)	
Secondary outcome					0.71
Hypoxia	0 (0)	0 (0)	1 (9)	0 (0)	
Hypertension	0 (0)	0 (0)	1 (9)	0 (0)	
Tachycardia	0 (0)	0 (0)	2 (18)	0 (0)	
Fever	1 (25)	0 (0)	2 (18)	0 (0)	
Hemoptysis	1 (25)	0 (0)	1 (9)	0 (0)	
Pneumothorax	0 (0)	0 (0)	1 (9)	0 (0)	

†Patients who were taking the anti-thrombotic agent (including antiplatelet and anticoagulants) or had discontinued the agent for ≤ 3 days on the day of endobronchial ultrasound-guided-transbronchial needle aspiration (EBUS-TBNA). Data are presented as median (interquartile range) or N (%) unless indicated otherwise CAD, coronary artery disease; DAPT, dual anti-platelet therapy; LVEF, left ventricular ejection fraction; NOAC, novel oral anti-coagulants; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST elevation myocardial infarction.

Table 5 Procedure-related complications

	Interval between PCI and EBUS (days)	Procedure related complications
Patient 1	3	Hemoptysis, fever
Patient 2	98	Fever
Patient 3	120	Tachycardia, fever
Patient 4	124	Chest pain (non-anginal)
Patient 5	127	Hypoxia, hypertension
Patient 6	165	Tachycardia
Patient 7	170	Hemoptysis

arrhythmia, which aggravate myocardial ischemia.[12] As mentioned previously, current guidelines recommend that bronchoscopy should not be performed in patients who have suffered an MI within four to six weeks. Additionally, because anti-thrombotic therapy increases the bleeding risk from a bronchoscopic biopsy,[13] discontinuing clopidogrel seven days prior to endobronchial biopsy (EBB) or transbronchial lung biopsy (TBLB) is recommended. Low-dose aspirin alone can be continued according to the current guidelines.[9] Discontinuing anti-thrombotic therapy is a better strategy to prevent bleeding complications, but it may cause a significant cardiac complication (stent thrombosis). According to current cardiology studies, the minimal duration of DAPT tends to be getting shorter in patients undergoing implantation of safer, new generation drug-eluting stents. A previous study suggested a minimum DAPT duration of three to six months to prevent early stent-related thrombotic events, but extending DAPT beyond 12 months entails a tradeoff.[14] Despite the trend of shortening the minimum duration of anti-thrombotic therapy, the 2016 American College of Cardiology and American Heart Association guidelines suggest a minimum DAPT duration of six months in patients with stable

ischemic heart disease and 12 months in those with ACS after PCI.[15]

However, the invasive procedure for lung cancer staging and diagnosis in patients with suspected lung cancer who have undergone PCI cannot be delayed if the cancer seems aggressive and rapidly progressive. In our study of 24 patients, only one significant cardiovascular complication (4.2%) was observed after EBUS-TBNA. This seemed to be a crucial result, but the patient was old and had many underlying cardiovascular comorbidities. The event was not fatal and was controlled within several hours by medication.

The other procedural-related complications were minor and transient, and did not require further treatment. The incidence rate of procedural-related complications was similar to that of general bronchoscopy. Post bronchoscopic fever (PBF) was common after FB, particularly after bronchoalveolar lavage, and a rate of 5–10% has been reported.[16,17] In our study, three cases (3/24, 12.5%) of PBF occurred. One case (1/24, 4.2%) of hypoxemia after EBUS-TBNA required oxygen supplementation in our study, and the reported rate of hypoxemia related to bronchoscopy is 5–32%.[18,19] In previous studies, the rate of bronchoscopic biopsy-related bleeding in patients with abnormal coagulation status was 11%[20] in our study, minor bleeding occurred in two cases (2/24, 8.3%).

No significant bleeding was observed during or after the procedure in the 19 patients receiving anti-thrombotic therapy in our study. In a previous prospective cohort study by Ernst *et al.* that examined the effects of clopidogrel after transbronchial biopsy, antiplatelet agents caused significantly higher bleeding incidence rates, at 89% and 100% in the clopidogrel and DAPT groups, respectively.[13] Despite the small number of patients in our study (*n* = 19), significantly less bleeding occurred in patients who underwent EBUS-TBNA than in those who underwent EBB or TBLB. This may be the result of several characteristics of EBUS-TBNA. Because TBNA is needle aspiration, tissue is damaged less than when performing a biopsy using forceps. Additionally, because EBUS-TBNA is a procedure under real-time ultrasound-guidance, the operator can avoid significant damage to grossly invisible vascular structures that can be damaged by EBB or TBLB.

Several limitations in our study should be mentioned. First, this was a retrospective, single-center study design and patient sample was very small. Additionally, because some patients received PCI in other hospitals, we could not confirm the types of coronary artery stents. Second, because our hospital registry only includes patients who underwent EBUS-TBNA, we could not evaluate patients with poor performance or unstable cardiopulmonary conditions or cases that were candidates for EBUS-TBNA but could not undergo the procedure for other reasons. Finally,

it is difficult to definitively conclude that EBUS-TBNA is a safe procedure in patients on anti-thrombotic therapy, as only 19 patients were included in our study. However, to the best of our knowledge, this is the first study to examine the safety of EBUS-TBNA in patients with coronary artery disease treated with PCI, and we expect further studies will be conducted based on our results.

In conclusion, if coronary artery disease is stable, EBUS-TBNA can be performed safely in patients who have undergone recent PCI; however, further studies are required to evaluate the safety for patients on anti-thrombotic therapy.

Disclosure

No authors report any conflict of interest.

References

1 Gaga M, Powell CA, Schraufnagel DE *et al.* An official American Thoracic Society/European Respiratory Society statement: The role of the pulmonologist in the diagnosis and management of lung cancer. *Am J Respir Crit Care Med* 2013; **188**: 503–7.

2 Adams K, Shah PL, Edmonds L, Lim E. Test performance of endobronchial ultrasound and transbronchial needle aspiration biopsy for mediastinal staging in patients with lung cancer: Systematic review and meta-analysis. *Thorax* 2009; **64**: 757–62.

3 Um SW, Kim HK, Jung SH *et al.* Endobronchial ultrasound versus mediastinoscopy for mediastinal nodal staging of non-small-cell lung cancer. *J Thorac Oncol* 2015; **10**: 331–7.

4 Asano F, Aoe M, Ohsaki Y *et al.* Complications associated with endobronchial ultrasound-guided transbronchial needle aspiration: A nationwide survey by the Japan Society for Respiratory Endoscopy. *Respir Res* 2013; **14**: 50.

5 Choi YR, An JY, Kim MK *et al.* The diagnostic efficacy and safety of endobronchial ultrasound-guided transbronchial needle aspiration as an initial diagnostic tool. *Korean J Intern Med* 2013; **28**: 660–7.

6 Varela-Lema L, Fernández-Villar A, Ruano-Ravina A. Effectiveness and safety of endobronchial ultrasound-transbronchial needle aspiration: A systematic review. *Eur Respir J* 2009; **33**: 1156–64.

7 Dhooria S, Aggarwal AN, Gupta D, Behera D, Agarwal R. Utility and safety of endoscopic ultrasound with bronchoscope-guided fine-needle aspiration in mediastinal lymph node sampling: Systematic review and meta-analysis. *Respir Care* 2015; **60**: 1040–50.

8 Ernst A, Silvestri GA, Johnstone D, American College of Chest Physicians. Interventional pulmonary procedures: Guidelines from the American College of Chest Physicians. *Chest* 2003; **123**: 1693–717.

9 Du Rand IA, Blaikley J, Booton R *et al.* British Thoracic Society guideline for diagnostic flexible bronchoscopy in adults: Accredited by NICE. *Thorax* 2013; **68** (Suppl 1): i1–i44.

10 Stather DR, MacEachern P, Chee A, Tremblay A. Safety of endobronchial ultrasound-guided transbronchial needle aspiration for patients taking clopidogrel: A report of 12 consecutive cases. *Respiration* 2012; **83**: 330–4.

11 Grosu HB, Morice RC, Sarkiss M *et al.* Safety of flexible bronchoscopy, rigid bronchoscopy, and endobronchial ultrasound-guided transbronchial needle aspiration in patients with malignant space-occupying brain lesions. *Chest* 2015; **147**: 1621–8.

12 Dweik RA, Mehta AC, Meeker DP, Arroliga AC. Analysis of the safety of bronchoscopy after recent acute myocardial infarction. *Chest* 1996; **110**: 825–8.

13 Ernst A, Eberhardt R, Wahidi M, Becker HD, Herth FJF. Effect of routine clopidogrel use on bleeding complications after transbronchial biopsy in humans. *Chest* 2006; **129**: 734–7.

14 Evidence Review Committee Members, Bittl JA, Baber U, Bradley SM, Wijeysundera DN. Duration of dual antiplatelet therapy: A systematic review for the 2016 ACC/AHA guideline focused update on duration of dual antiplatelet therapy in patients with coronary artery disease: A report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. (Published erratum appears in *Circulation* 2016; **134**: e195–7). *Circulation* 2016; **134**: e156–78.

15 Levine GN, Bates ER, Bittl JA *et al.* 2016 ACC/AHA guideline focused update on duration of dual antiplatelet therapy in patients with coronary artery disease: A report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *J Am Coll Cardiol* 2016; **68**: 1082–115.

16 Sharif-Kashani B, Shahabi P, Behzadnia N *et al.* Incidence of fever and bacteriemia following flexible fiberoptic bronchoscopy: A prospective study. *Acta Med Iran* 2010; **48**: 385–8.

17 Um SW, Choi CM, Lee CT *et al.* Prospective analysis of clinical characteristics and risk factors of postbronchoscopy fever. *Chest* 2004; **125**: 945–52.

18 Attaran D, Towhidi M, Amini M, Toosi M. The relationship between peak expiratory flow rate before bronchoscopy and arterial oxygen desaturation during bronchoscopy. *Acta Med Iran* 2008; **46**: 95–8.

19 Jones AM, O'Driscoll R. Do all patients require supplemental oxygen during flexible bronchoscopy? *Chest* 2001; **119**: 1906–9.

20 Kozak EA, Brath LK. Do "screening" coagulation tests predict bleeding in patients undergoing fiberoptic bronchoscopy with biopsy? *Chest* 1994; **106**: 703–5.