ORIGINAL ARTICLE

Randomized Trial of Endobronchial Ultrasound–guided Transbronchial Needle Aspiration under General Anesthesia versus Moderate Sedation

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Abstract

Rationale: Data about the influence of the type of sedation on yield, complications, and tolerance of endobronchial ultrasound–guided transbronchial needle aspiration (EBUS-TBNA) are based mostly on retrospective studies and are largely inconsistent.

Objectives: To determine whether the type of sedation influences the diagnostic yield of EBUS-TBNA, its complication rates, and patient tolerance.

Methods: Patients referred for EBUS-TBNA were randomized (1:1) to undergo this procedure under general anesthesia (GA) or moderate sedation (MS). Pathologists were blinded to group allocation.

Measurements and Main Results: The main outcome was "diagnostic yield," defined as the percentage of patients for whom EBUS-TBNA rendered a specific diagnosis. One hundred and forty-nine patients underwent EBUS-TBNA, 75 under GA and 74 under MS. Demographic and baseline clinical characteristics were well balanced. Two hundred and thirty-six lymph nodes (LNs) and six masses were sampled in the GA group (average, 3.2 $\pm$ 1.9 sites/patient), and 200 LNs and six masses in the MS group (average, 2.8 $\pm$ 1.5 sites/patient) ($P = 0.199$). The diagnostic yield was 70.7% (53 of 75) and 68.9% (51 of 74) for the GA group and MS group, respectively ($P = 0.816$). The sensitivity was 98.2% in the GA group (confidence interval, 97–100%) and 98.1% in the MS group (confidence interval, 97–100%) ($P = 0.979$). EBUS was completed in all patients in the GA group, and in 69 patients (93.3%) in the MS group ($P = 0.028$). There were no major complications or escalation of care in either group. Minor complications were more common in the MS group (29.6 vs. 5.3%) ($P < 0.001$). Most patients stated they "definitely would" undergo this procedure again in both groups ($P = 0.355$).

Conclusions: EBUS-TBNA performed under MS results in comparable diagnostic yield, rate of major complications, and patient tolerance as under GA. Future prospective multicenter studies are required to corroborate our findings.

Clinical trial registered with www.clinicaltrials.gov (NCT 01430962).

Keywords: endobronchial ultrasound; moderate sedation; anesthesia; interventional pulmonology

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At a Glance Commentary

Scientific Knowledge on the Subject: Data about the influence of the type of sedation on yield, complications, and tolerance of endobronchial ultrasound–guided transbronchial needle aspiration are based mostly on retrospective studies and are largely inconsistent.

What This Study Adds to the Field: Our randomized trial shows that the use of general anesthesia does not improve any of the aforementioned outcomes. These findings are of critical importance because general anesthesia is not accessible to all bronchoscopists, and it implies a greater use of resources.

Endobronchial ultrasound–guided transbronchial needle aspiration (EBUS-TBNA) has become one of the most important tools in the armamentarium of pulmonologists and thoracic surgeons. It is a safe and effective technique for sampling of hilar and mediastinal lymph nodes and masses (1–4), and it is now considered the initial choice for histologic sampling of the mediastinum in lung cancer staging (5). Two common types of sedation used for EBUS-TBNA include moderate sedation (MS) and general anesthesia (GA). Although accurate information regarding physician's use of sedation in EBUS-TBNA is unavailable, lack of uniform access to GA in the majority of clinical practice settings has favored the use of MS (3). A remaining question concerns the impact of the type of sedation on the diagnostic yield of EBUS-TBNA. Although initial retrospective analysis of these two types of sedation suggested there was no significant difference in the diagnostic yield, a more recent study from Yarmus and coworkers reported a much greater diagnostic yield when EBUS was performed under GA (6). These findings may generate concern among many physicians who perform EBUS-TBNA in nontertiary settings where access to GA is limited or not available.

Another important factor in physician's choice for use of GA or MS centers on the rate of complications associated with sedation used; however, little is known about the complications related to the type of sedation used for EBUS-TBNA. The Quality Improvement Registry, Evaluation, and Education (AQuIRE) Data Registry found an association between GA and greater need for post-procedure escalation of care (7). Unfortunately, the available data are also based on retrospective studies and are somewhat inconsistent. Given the widespread use of EBUS-TBNA and the fact that GA is not readily available for bronchoscopy in many institutions, it is important to assess the effect of the type of sedation on EBUS-TBNA outcomes.

We conducted a randomized clinical trial to evaluate the impact of the type of sedation (GA vs. MS) on the diagnostic yield of EBUS-TBNA, on complications, and on patient tolerance. Some of the results of this study have been previously reported in the form of an abstract (8).

Methods

Subjects

We enrolled both outpatients and hospitalized patients older than 18 years of age requiring EBUS-TBNA based on suspicion of either benign or malignant disease in mediastinal or hilar lymph nodes (LNs) or masses, or requiring EBUS-TBNA for mediastinal staging of lung cancer. Exclusion criteria included the following: suspected need for additional procedures other than EBUS-TBNA during planned bronchoscopy (e.g., need for navigational bronchoscopy, endobronchial biopsies, therapeutic bronchoscopy), history of intolerance to moderate sedation, allergies to any of the involved sedatives or anesthetic agents, comorbidities contraindicating the EBUS procedure, pregnancy, or inability to obtain informed consent. The study was performed at the Michael E. DeBakey Veterans Affairs Medical Center, and it was approved by the Baylor College of Medicine (Houston, TX) Institutional Review Board. Written informed consent was obtained before enrollment of all patients.

Study Design

The study was a prospective randomized controlled trial of EBUS-TBNA performed under either GA versus MS with a 1:1 computer-generated randomization. Cytologists were blinded to the type of sedation used for EBUS-TBNA. The primary end point was diagnostic yield of EBUS-TBNA, defined as the number of subjects in whom EBUS-TBNA provided a specific diagnosis. A specific diagnosis was defined as any kind of malignancy, infection (i.e., histoplasmosis, tuberculosis), or sarcoidosis. The presence of lymphocytes was considered only an adequate sample, not a specific diagnosis. Sample adequacy was evaluated as a secondary end point. For LNs, an "adequate" sample was defined as either a specific diagnosis or lymphocytes, whereas an "inadequate" sample was one with blood, bronchial cells, or necrosis, and without a diagnosis or lymphocytes. Only samples with a specific diagnosis were considered "adequate" when lung masses were biopsied. Sensitivity of EBUS-TBNA to detect a specific diagnosis was another secondary end point. A "true negative" result required either confirmation by surgery (surgical lymph node dissection or mediastinoscopy) or 6 months of radiographic follow-up by computed tomography (CT) or integrated positron emission tomography–CT demonstrating stability or decrease in size without new lesions. Other secondary end points included the following: "procedure time" as measured from the initial bronchoscope introduction until last bronchoscope removal from the airway; "EBUS-TBNA time," measured from the insertion to the final removal of the EBUS bronchoscope; number of LNs sampled per patient; number of biopsies per LN; size of LN; EBUS-related complications (i.e., bleeding, pneumothorax, mediastinitis, or mediastinal abscess); sedation/anesthesia-related complications such as hypotension (defined as a drop in systolic blood pressure to $<$90 mm Hg requiring intervention—fluids or vasopressors), hypertension (an increase in mean arterial pressure of $>$30% from baseline in three separate readings), hypoxemia (oxygen saturation of $<$90% for $>$1 min, or hypoxemia requiring intervention such as a nonrebreathing mask, "bagging," or mechanical ventilation), arrhythmia requiring antiarrhythmic medications, excessive coughing that prevented the procedure from being completed, and inadequate sedation despite maximal predefined sedative doses. Major complications were those that resulted in life-threatening conditions, disability, additional interventions required to prevent death or disability, need for escalation of care postprocedure (such as admission for

outpatients or intensive care unit admission for any patient), extended hospital length of stay, and death. Time to recovery from anesthesia was assessed with Aldrete's score (defining time 0 when patient is transferred from surgical table to stretcher, and checking score every 15 min until a score of 8 points was reached) (*see* the online supplement) (9). Patient tolerance to procedure was also evaluated as a secondary end point with an anonymous Likert's scale–type questionnaire provided to patients before discharge (*see* the online supplement).

Study Procedures

Randomization was achieved with a computer program, and results were made available to the study personnel after enrollment of each patient but before the procedure, to have the anesthesia team available when indicated. All procedures were performed in a single bronchoscopy suite. Patients randomized to the GA group received total intravenous anesthesia in a standard fashion and had a laryngeal airway mask placed (a combination of the following drugs was allowed: propofol, ramifentanil, etomidate, ketamine, cisatracurium, rocuronium, succinylcholine). In accordance with the definitions of the depth of sedation from the American Society of Anesthesiologists, our patients were allowed to fluctuate between deep sedation and general anesthesia as needed (10). Deep sedation was defined as a drug-induced depression of consciousness during which patients cannot be easily aroused but respond to repeated or painful stimulation, with potential impairment of independent ventilation and potential need for an artificial airway. General anesthesia was defined as drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation, they cannot maintain spontaneous ventilation, and they require an artificial airway (10). Those who were randomized to the MS group, in addition to topical 1% lidocaine, received a combination of midazolam (up to 0.1 mg/kg) and fentanyl (up to 150 μg) in accordance with local hospital sedation policies aiming at a moderate degree of sedation (Richmond Agitation-Sedation Scale [RASS] score of 2–3). Moderate sedation was defined as a drug-induced depression of consciousness during which patients respond purposefully to verbal commands or light tactile stimuli, with no interventions required to maintain a patent airway or ventilation (10). EBUS-guided transbronchial needle biopsy was performed with a real-time ultrasound biopsy bronchoscope (BF-UC-180F; Olympus Ltd., Tokyo, Japan). A 7.5-MHz linear ultrasound transducer with a maximal penetration of 50 mm was linked to a processor (EU-ME1; Olympus Ltd.). Transbronchial needle biopsies were performed with a dedicated 22-gauge needle (NA-201SX; Olympus Ltd.). Two needles were used for every patient as part of our standard practice (while the assistant is retrieving the sample from the first needle, the operator is already taking a new sample with the second needle). Rapid onsite cytology examination (ROSE) was available in all procedures. When staging for lung cancer, all LNs that were greater than or equal to 5 mm in short axis by EBUS (both mediastinal and hilar) were sampled in the standard N3 to N2 to N1 fashion. A minimum of three needle biopsies was performed at each target (a maximum of six was allowed, particularly for patients who, based on the onsite report, required additional testing such as cultures, molecular testing, or flow cytometry) (11). One slide was prepared from each pass and the rest of the material was placed in Saccomanno solution for cell-block preparation. EBUS-TBNA was performed by an interventional pulmonologist (R.F.C.), and no trainees were involved. Whereas ROSE was performed by various staff pathologists, all final cytology results were assessed by a single experienced lung cytopathologist (L.K.G.). All pathologists were blinded to the group assignment.

Statistical Analysis

The primary analysis of this study was diagnostic yield, defined as the percentage of patients for whom EBUS-TBNA biopsy rendered a specific diagnosis. Using Bayesian analysis, a sample size of 75 patients per study group has a probability of 91% to detect a 10% difference in diagnostic yield, assuming a noninformative β (1.0, 1.0) prior distribution for diagnostic yield for each study group. Summary statistics were used to describe the study population in each group. Pearson's chi-squared test (or Fisher's exact test) and *t* test (or Wilcoxon's rank-sum test) were used to determine the significance of differences between the study groups. Results were calculated using an intent-to-treat analysis.

Statistical analysis was performed with Stata/SE version 13.1 statistical software (Stata Corp. LP, College Station, TX).

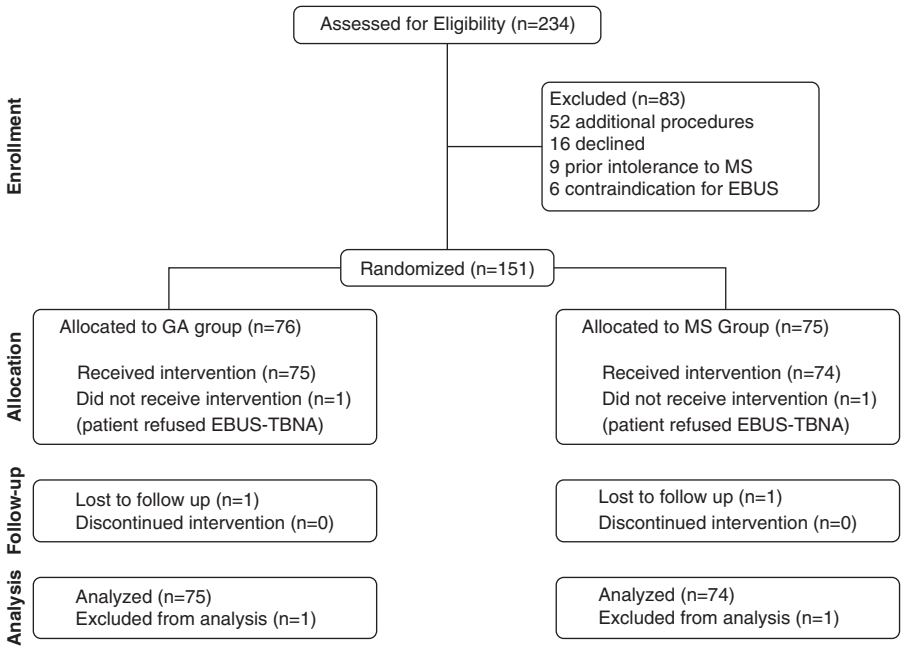

Figure 1. Patient flow. EBUS-TBNA = endobronchial ultrasound–guided transbronchial needle aspiration; GA = general anesthesia; MS = moderate sedation.

Results

Between November 2011 and July 2013, 234 consecutive patients referred for EBUS-TBNA were assessed. A total of 149 patients were randomized and underwent EBUS-TBNA: 75 patients to the GA group and 74 to the MS group (Figure 1). In the MS group, the average dose of midazolam was 4.14 ± 0.82 mg and that of fentanyl was 100 ± 22.18 μg. Both groups were well balanced for all major clinical characteristics (Table 1). A total of 242 targets (236 LNs and six masses) were sampled in the GA group (3.2 ± 1.9 per patient), and 206 targets (200 LNs and six masses) were sampled in the MS group (2.8 ± 1.5 per patient) ($P = 0.199$). The LN locations, their size, and number of biopsies per target are depicted in Table 2. Samples were deemed "adequate" in all targets of the GA group (100%) and in 202 of 206 targets in the MS group (98%) ($P = 0.04$). The diagnostic yield of EBUS-TBNA was 70.7% (53 of 75) and 68.9% (51 of 74) for the GA group and MS group, respectively ($P = 0.816$). Malignancy was found in 60% (45 of 75) in the GA group versus 54% (40 of 74) in the MS group ($P = 0.463$) (Table 3). The sensitivity of EBUS-TBNA was 98.15% in the GA group (confidence interval, 97–100%) and 98.08% in the MS group (confidence interval, 97–100%) ($P = 0.979$). True negative results were confirmed by surgery (GA group, n = 11; MS group, n = 10) or radiographic follow-up (GA group, n = 20; MS group, n = 23). The total procedure duration was 27.2 ± 15.3 minutes (median, 27; range, 6–64) in the GA group and 20.6 ± 9.7 minutes (median, 18.5; range, 7–54) in the MS group ($P = 0.020$). The EBUS duration was 23.2 ± 14.6 minutes (median, 22; range, 4–60) in the GA group and 16.1 ± 9.4 minutes (median, 14, range, 4–51) in the MS group ($P = 0.008$). Additional procedures were performed in six patients (8.1%) in the GA group and three patients (4.3%) in the MS group ($P = 0.49$). EBUS was completed in all patients in the GA group, and in 69 patients (93.3%) in the MS group ($P = 0.028$). Regarding time to recovery post-procedure, 93.3% of patients reached a score of 8 at time 0 in the GA group versus 95.6% in the MS group ($P = 0.406$), and 100% of patients reached an Aldrete's score of 8 by 15 minutes in both groups. There were no major complications or escalation of care in either group. Regarding EBUS-related complications, there were none in the GA group, and only one—excessive bleeding in a patient with fibrosing mediastinitis—in the MS group ($P = 0.868$). Minor complications were more common in the MS group (29.6 vs. 5.3%) ($P < 0.001$) (Table 4). Patients in the MS group recalled the procedure more often ($P < 0.001$), and patients in the GA group had greater shortness of breath post-procedure ($P = 0.016$). However, the majority of the patients would agree to undergo the same procedure again in the future in both groups ($P = 0.355$) (Table 5).

Table 1. Baseline Characteristics

	GA Group (*n* = 75)	MS Group (*n* = 74)	*P* Value
Age			
Mean (SD)	64.5 (6.4)	65.3 (8.4)	0.565
Median	65	66	
Min–max	46–77	38–84	
Sex			
Female	5 (6.7)	4 (5.4)	0.999
Male	70 (93.3)	70 (94.6)	
BMI			
Mean (SD)	28.2 (9.8)	27.9 (6.2)	0.363
Median	27	27	
Min–max	17–47	15–47	
ECOG			
0	29 (38.7)	22 (30.1)	0.168
1	34 (45.3)	38 (52.1)	
2	7 (9.3)	12 (16.4)	
3	5 (6.7)	1 (1.4)	
ASA score			
1	1 (1.4)	2 (2.7)	0.571
2	22 (29.7)	27 (36.5)	
3	50 (67.6)	45 (60.8)	
4	1 (1.4)	0	
Mallampati score			
1	10 (13.5)	6 (8.1)	0.104
2	34 (45.9)	23 (31.1)	
3	26 (35.1)	38 (51.4)	
4	4 (5.4)	7 (9.5)	
OSA			
No	67 (89.3)	65 (87.8)	0.774
Yes	8 (10.7)	9 (12.2)	
Baseline malignancy			
No	29 (38.7)	31 (41.9)	0.688
Yes	46 (61.3)	43 (58.1)	
Prior chemotherapy			
No	67 (89.3)	66 (89.2)	0.977
Yes	8 (10.7)	8 (10.8)	
Prior radiotherapy			
No	66 (88)	67 (90.5)	0.616
Yes	9 (12)	7 (9.5)	
Indication for EBUS			
Diagnostic	20 (26.7)	21 (28.4)	0.961
Staging	24 (32)	21 (28.4)	
Restaging	6 (8)	7 (9.5)	
Diagnostic/staging	25 (33.3)	25 (33.8)	
Clinical N of NSCLC*			
0	16 (35.6)	17 (34)	0.966
1	9 (20)	9 (18)	
2	14 (31.1)	18 (36)	
3	6 (13.3)	6 (12)	

Definition of abbreviations: ASA score = American Society of Anesthesiologists score; BMI = body mass index; EBUS = endobronchial ultrasound; ECOG = Eastern Cooperative Oncology Group, referring to performance status; GA = general anesthesia; min–max = minimum–maximum; MS = moderate sedation; NSCLC = non–small cell lung cancer; OSA = obstructive sleep apnea. Numbers in parentheses represent percentages.

*Clinical N of NSCLC, clinical nodal staging of non–small cell lung cancer as determined by computed tomography (CT) chest scan, positron emission tomography–CT, or both.

Table 2. Characteristics of Lymph Nodes and Masses

	GA Group (*n* = 75)	MS Group (*n* = 74)	*P* Value
LNs or masses			
n	242	206	0.199
Mean (SD)	3.2 (1.9)	2.8 (1.5)	
Median	3	2.5	
Min–max	1–6	1–6	
Biopsies per LN or mass			
Mean (SD)	3.5 (0.6)	3.6 (0.7)	0.131
Median	3	3	
Min–max	3–6	3–6	
LN or mass size (mm/short axis)			
Mean (SD)	13.2 (6.4)	14.1 (7.2)	0.513
Median	12	11.6	
Min–max	5–26.5	5–38.3	
LN stations/masses*			
12R	0	1	
11Rs	31	34	
11Ri	1	0	
10R	12	5	
4R	56	44	
2R	5	6	
11L	35	26	
10L	8	5	
4L	33	30	
2L	2	0	
1L	0	1	
7	52	43	
3p	1	0	
8	0	1	
Mass	6	6	

Definition of abbreviations: GA = general anesthesia; LN = lymph node; min–max = minimum–maximum; MS = moderate sedation.
*LN stations: i = inferior; L = left; p = posterior; R = right; s = superior.

Discussion

This is the first randomized study that aimed to determine the contribution of two commonly used modes of sedation to the outcome of EBUS-TBNA. Previous publications that address the impact of the types of sedation on EBUS-TBNA outcomes have been predominantly based on retrospective analyses, and have provided inconsistent information (2, 3, 6). In this randomized controlled trial we demonstrate for the first time that GA and MS do not significantly affect the diagnostic yield and sensitivity of EBUS-TBNA. Consistently, we demonstrate that there are no significant differences in patient tolerance or major complications associated with GA or MS in patients undergoing EBUS-TBNA.

Initial retrospective reports suggested no difference in diagnostic yield of EBUS-TBNA performed under either MS or GA (2, 3). However, these data came from subgroup analysis or analysis of sedation type as one of multiple factors that can influence the yield of EBUS-TBNA. Yarmus and coworkers specifically evaluated the influence of the type of sedation on the diagnostic yield of EBUS-TBNA, and reported a greater diagnostic yield when EBUS was performed under deep sedation (patients had a laryngeal mask airway or endotracheal tube, were monitored by anesthesiologists, but were allowed to breathe spontaneously) (6). This study compared EBUS-TBNA performed in two different centers of excellence in interventional pulmonology, one performing all cases under MS and the other performing all cases under deep sedation. The authors recognized their main limitation as the fact that procedures were done in two different institutions. This can potentially lead to multiple confounding factors influencing their results (potentially different populations, different individuals performing EBUS, different pathologists, etc.). The authors speculate that deep sedation allowed more LNs to be sampled and more needle passes per site, resulting in improved overall diagnostic yield (80 vs. 66%). Interestingly, the fact that GA allows for biopsy of more LNs was also noticed in the AQuIRE Data Registry (3). In contrast to these findings, our study has found no significant differences in diagnostic yield between study groups, and also no difference in the number of LNs that were sampled, their size, or the number of biopsies per LN. Moreover, the average number of LNs sampled per patient in our MS group was as high or even higher than the average number of LNs sampled in the deep sedation group of the study by Yarmus and colleagues (6). Our diagnostic yield rates are comparable to those previously reported (3). Although we found a statistically significant difference in sample adequacy between the two groups, we do not consider the 2% difference (98 vs. 100%) clinically relevant.

In our study, both the total duration of bronchoscopy and the EBUS-TBNA time were shorter for the MS group. The duration of our procedures was well within the ranges that have been previously reported (1, 2, 4, 12). But our findings are in sharp contrast of those reported by Yarmus and coworkers, who found longer procedural time associated with MS (46.9 vs. 36.4 min) (6). A potential explanation might be the lack of trainees in our study, speculating that trainees can potentially take a longer time to sample LNs under MS with patients possibly moving or coughing. We believe that the difference we found (shorter procedures in the MS group) might have been secondary to the fact that the bronchoscopy team might have acted more expeditiously when patients were not deeply sedated. For obvious reasons the bronchoscopy team could not be blinded to the group allocation to avoid this bias. In addition, we used two needles for each procedure, which may have shortened our procedure duration.

Our study is also the first to compare post-procedure recovery time in patients undergoing EBUS-TBNA under MS and GA. The shorter time to recovery expected with GA (due to the shorter half-life of drugs) was not seen in our study, in which all patients in both groups reached an Aldrete's score of 8 within 15 minutes of recovery.

Five patients in the MS group (6.7%) did not tolerate the procedure because of inadequate sedation despite reaching

Table 3. Diagnostic Yield of Endobronchial Ultrasound–guided Transbronchial Needle Aspiration

	GA Group (*n* = 75)	MS Group (*n* = 74)	*P* Value
Diagnostic yield			
No	22 (29.3)	23 (31.1)	0.816
Yes	53 (70.7)	51 (68.9)	
Malignancy			
n	45 (60)	40 (54)	0.463
Lung, adenocarcinoma	17	17	
Lung, squamous cell	11	10	
Lung, NSCLC (NOS)	2	3	
Lung, small cell	9	6	
Lung, carcinoid	1	0	
Renal	1	1	
Melanoma	1	0	
Prostate	2	1	
Colon	0	1	
Lymphoma	1	1	
Inflammation/infection			
n	8 (10.7)	11 (12.9)	0.442
Sarcoidosis	6	9	
Tuberculosis	1	1	
Histoplasmosis	1	1	

Definition of abbreviations: GA = general anesthesia; MS = moderate sedation; NOS = not otherwise specified; NSCLC = non–small cell lung cancer.
Numbers in parentheses represent percentages.

maximal preestablished doses of sedatives. The results of these patients in the MS group were analyzed after the intention-to-treat analysis. Most of these patients were previously taking either benzodiazepines as anxiolytics or sedatives (two patients) or opioids for pain management (two patients). EBUS-TBNA was completed under GA in all five of these cases, without changing the final results for any of them. Nevertheless, it is important to highlight that a small percentage of cases may not tolerate the procedure under MS and may require GA.

Table 4. Endobronchial Ultrasound–guided Transbronchial Needle Aspiration and Sedation-related Complications

	GA Group (*n* = 75)	MS Group (*n* = 74)	*P* Value
EBUS-related complications			
No	75 (100)	73 (98.6)	0.868
Yes	0	1 (1.4)	
Sedation/anesthesia-related complications			
n	4 (5.3)	21 (29.6)	<0.001
Hypotension	4	1	
Hypertension	0	6	
Hypoxemia	0	2	
Excessive cough	0	4	
Arrhythmia	0	3	
Aspiration	0	1	
Inadequate sedation	0	4	
Escalation of care			
No	75 (100)	74 (100)	
Yes	0	0	

Definition of abbreviations: EBUS = endobronchial ultrasound; GA = general anesthesia; MS = moderate sedation.
Some patients experienced more than one complication. Numbers in parentheses represent percentages.

Data on the impact of the type of sedation on EBUS-TBNA complications are scant and retrospective in nature. The AQuIRE Data Registry found in multivariate analysis that the use of GA was associated with greater escalation of care, but they reported only 1.4% escalation of care under GA versus 0.4% escalation of care under MS (7). None of our patients in either group experienced a major complication or required escalation of care. We found a greater amount of minor sedation-related complications in the MS group. All complications that occurred in either group were resolved by the end of the procedure and, by definition, resulted in no escalation of care, prolonged length of stay, disability, or death. Some patients experienced more than one complication. Whereas the most common minor complication was hypotension in the GA group (common during the induction phase of anesthesia), in the MS group hypertension, tachyarrhythmia, and transient hypoxemia were found more often. These are likely due to the inability to sedate or keep the patients sedated at the target RASS score (2, 3) during the entire length of the procedure. We also believe that the high rate of minor complications may be due to the use of strict definitions and thorough documentation, which are an essential component of prospective studies.

Steinfort and Irving prospectively studied patient's satisfaction after EBUS-TBNA under MS (13). In their study, satisfaction was extremely high, with 40 patients (98%) reporting they would "definitely return" for EBUS-TBNA in the future if required. It is important to highlight that 68% (28 of 41) of their patients received propofol as part of their moderate sedation. Unlike in other parts of the world, in the United States propofol is typically considered an anesthetic drug and it can be administered only by anesthesiologists. In our study, we found no significant difference in patient satisfaction between both groups. Not surprisingly, more patients recalled the procedure in the MS group.

The main limitation of our study is that it was performed in a single center with a highly experienced operator, limiting the generalizability of its results to experienced operators. The latter are becoming more common with the rapid adoption of EBUS training in pulmonary and thoracic surgery

Table 5. Patient Satisfaction and Tolerance of Endobronchial Ultrasound Procedure

Question	GA		MS		*P* Value
	n	%	n	%	
Would you undergo this procedure again in the future?					0.355
Definitely not	3	4	0	0	
Probably not	0	0	1	1.5	
Unsure	6	8	3	4.4	
Probably would	15	20	13	19.1	
Definitely would	51	68	51	75	
How much do you recall the procedure?					<0.001
None	60	80	31	45.6	
Small amount	14	18.7	20	29.4	
Significantly	1	1.3	17	25	
How would you rate your cough?					0.727
None	29	38.7	25	36.8	
Small	32	42.7	33	48.5	
Significant	14	18.7	10	14.7	
How would you rate your sore throat?					0.092
None	35	46.7	44	64.7	
Small	31	41.3	20	29.4	
Significant	9	12	4	5.9	
How would you rate your chest pain?					0.280
None	69	92	66	97.1	
Small	6	8	2	2.9	
How would you rate your shortness of breath?					0.016
None	53	70.7	58	85.3	
Small	15	20	10	14.7	
Significant	7	9.3	0	0	

Definition of abbreviations: GA = general anesthesia; MS = moderate sedation.

fellowships, and with the increase in the number of interventional pulmonology fellowships. We did not allow trainees to participate in our study because their level of training and EBUS proficiency are heterogeneous. In our experience, teaching EBUS prolongs procedures and that could directly affect our outcomes. Hence, our results do not apply to procedures in which novice trainees are being taught how to perform EBUS-TBNA. Another limitation mentioned previously is the unavoidable lack of blinding of the operator. Our population differs from the general population, with the vast majority of subjects being male and with greater comorbidities as evidenced by a high American Society of Anesthesiologists score. Although these factors might affect complication rates and patient tolerance, they are highly unlikely to impact the diagnostic yield of EBUS-TBNA.

In daily practice the choice of type of sedation should be tailored to factors associated with the operator, the patient, and the procedure itself. Less experienced operators or teaching facilities may benefit from the use of GA. Patient's history of intolerance to moderate sedation or significant home use of benzodiazepines or opioids may also indicate the need for GA. GA may also be preferable in prolonged cases when additional procedures are required (i.e., sampling of peripheral tumor, fiducial marker placement).

In conclusion, in this prospective randomized trial, we show that the type of sedation used does not impact the diagnostic yield, rate of major complications, or patient tolerance of EBUS-TBNA. We believe our results are highly relevant because many centers do not have access to GA in bronchoscopy suites, sometimes requiring the use of operating rooms, which could potentially lead to higher costs. Future prospective multicenter studies are required to corroborate our findings. ■

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