The Egyptian Journal of Bronchology

RESEARCH

Open Access

The value of rapid on-site evaluation during conventional and endobronchial ultrasound needle aspiration in the diagnosis of mediastinal lymphadenopathy and lung cancer

Omnya Magdy[1*], Aya AbdelDayem[1], Ashraf ELMaraghi[1], Maryam Ali[1] and Fatma Hafez[2]

Abstract

Background The endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) has revolutionized pulmonology by identifying cancer spread in lung cancer patients. It is now used for diagnosing sarcoidosis, tuberculosis, and lymphoma. Rapid onsite evaluation (ROSE) is a crucial tool for pathologists, assisting in sample adequacy, accuracy, and prompt decision-making. This study aimed to evaluate the efficacy of ROSE in identifying mediastinal lymphadenopathy and lung cancer during EBUS-TBNA and cTBNA.

Methods Our research was a prospective study in which we examined sixty cases that were separated into two groups of similar size. The rapid onsite evaluation group and the non-rapid onsite evaluation group were subjected to either Conventional TBNA or endobronchial ultrasound-guided transbronchial needle aspiration.

Results The total diagnostic yield of conventional and endobronchial ultrasound-guided transbronchial needle aspiration in both groups was 83.3% (50/60 cases). Twenty-eight cases (46.7%) were positive for malignancy, 22 cases (36.6%) were positive for benign lesions, and 10 cases (16.6%) were not conclusive. Regarding diagnostic accuracy, it was greater in the rapid onsite evaluation group than in the non-rapid onsite evaluation group (100% in the rapid onsite evaluation group vs. 66.7% in the non-ROSE group).

Conclusions Rapid onsite evaluation during conventional or endobronchial ultrasound-guided transbronchial needle aspiration improves diagnostic accuracy of mediastinal lesions by excluding suspicious or nondiagnostic specimens and can reduce unnecessary punctures or eliminate the need for additional bronchoscopy procedures when reaching preliminary diagnosis.

Keywords EBUS-TBNA, ROSE, Mediastinal lymphadenopathy

Background

Endobronchial ultrasound-guided transbronchial needle aspiration is a minimally invasive procedure that enables real-time TBNA with the use of ultrasound imaging. The primary purpose of its development was for the staging of lymph nodes in patients with non-small cell lung cancer. However, its application has now expanded to

*Correspondence:
Omnya Magdy
Omnya199050@yahoo.com
[1] Department of Chest Diseases, Faculty of Medicine, Ain Shams University, Cairo, Egypt
[2] Department of Pathology, Faculty of Medicine, Ain Shams University, Cairo, Egypt

include the diagnosis of mediastinal lymphadenopathy and lung masses [1].

ROSE throughout EBUS-TBNA/cTBNA permits evaluation of the adequacy of the samples and material sufficiency for definitive histopathological diagnosis [2].

The purpose of the research was to assess the value of rapid onsite evaluation throughout EBUS-TBNA and cTBNA in the diagnosis of mediastinal lymphadenopathy and lung cancer.

Methods

This prospective research was performed on 60 cases with undiagnosed mediastinal lymphadenopathy or centrally located lung tumors who were referred to the bronchoscopy unit at Ain Shams University Hospital during the period between September 2021 and September 2023.

Inclusion criteria

1. An informed written consent was obtained from the cases before enrollment in the research.
2. Patients referred for EBUS or cTBNA with either undiagnosed mediastinal lymphadenopathy or peribronchial mass.

All patients were subjected to the following:

1. *Routine laboratory tests*:CBC, bleeding profile ,kidney function and liver function Tests.
2. *Radiological assessment*: CT chest with contrast or PET Scan.
3. *Algorithmic approach*: All patients underwent Transbronchial needle aspiration either with EBUS bronchoscopy (EB-19-J10U; ARIETTA V60, ALOKA, HITACHI Ltd., Tokyo, Japan) or Conventional method using flexible bronchoscopy according to following algorithm (Fig. 1) [3]:

Then, the studied patients were divided into two groups: each one 30 patients.

Group 1: underwent EBUS-TBNA or conventional transbronchial Needle Aspiration with ROSE.

(ROSE group).

Group 2: underwent EBUS-TBNA or conventional transbronchial Needle Aspiration without ROSE

(non-ROSE group).

The procedure

The patient was assessed, and vital data were recorded (noninvasive blood pressure, heart rate, and pulse oximetry).

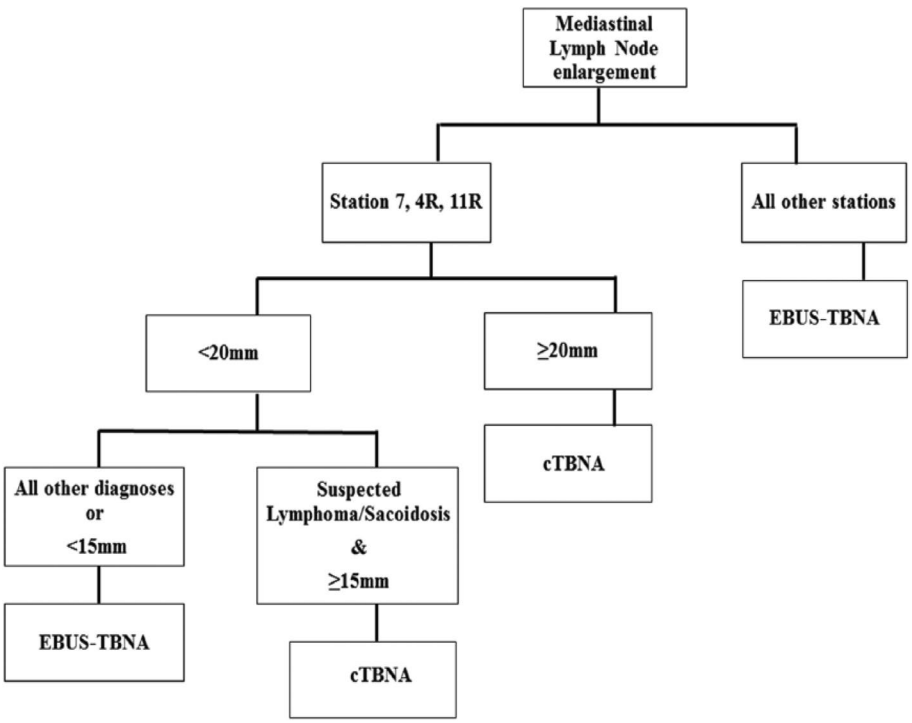

Fig. 1 Algorithmic sampling approach for mediastinal lymph node enlargement either with cTBNA or EBUS-TBNA

I. *Anesthesia*: the technique was done under general anesthesia.
II. *Bronchoscopy technique*: prior to performing EBUS, the flexible bronchoscope is introduced either through a laryngeal mask or an endotracheal tube. The initial airway examination enables a full and direct assessment of all bronchial segments and subsegments, and the removal of secretions through aspiration. Subsequently, the flexible bronchoscope was extracted, and the endobronchial ultrasound-guided bronchoscope was inserted into the airway. Regarding the size and location of LN as mentioned before, The sampling technique would be either by EBUS-TBNA or by Conventional methods using flexible bronchoscopy (EBUS-assisted TBNA).

In EBUS-TBNA (ECHO-HD-22-EBUS-P), once the targeted lymph node was detected and measured, the needle advanced through the channel of the bronchoscope. Subsequently, following puncturing the lymph node, the stylet was removed and then an auto-aspiration syringe was applied. To and fro movements were performed 15–20 times. Average 3 to 5 punctures were described as a standard number in the research protocol from each lymph node, and the exact location within the lymph node that should be biopsied.

In conventional TBNA after localization of the exact site of LN by EBUS scope, we removed the EBUS scope and then reinserted the conventional bronchoscope (EBUS-assisted TBNA).

In contrast to EBUS, which allows for the attachment of a needle to the bronchoscope, conventional TBNA does not provide a designated location for needle fixation. We ensured the precise insertion of the needle into the intended spot, followed by securing the needle end and attaching suction. We had punctures ranging from three to six times.

Specimen handling: for patients assignedto ROSE: following each pass, the needle was withdrawn, and a small amount of material was applied to a slide for preparation using rapid hematoxylin and eosin stain that used for the ROSE technique.

Then, ROSE preliminary diagnoses were categorized into the following [4]:

a Inadequate:
   i. Material present on slides is not sufficient and consistent with a definitive final diagnosis.
b Adequate:
   i. Material present on the slides is diagnostic of some process.
c Atypical:
   i. Cytologic features are present that may or not be associated with a pathologic process.
d Suspicious:
   i. Cytologic features suspicious but not definitive for malignancy, are present.
e Malignant:
   i. Cytologic features present on the slides are consistent with a malignant [5].

In cases assigned to the non-rapid onsite evaluation group, all cytologic specimens that were smeared were preserved in 95% alcohol for cytologic analysis.

III. All samples were sent for cytological and histopathological examination.

Statistical analysis

The SPSS program (Statistical Package for Social Sciences) software version 26.0, Microsoft Excel 2016, and MedCalC program software version 19.1 were employed to tabulate and statistically analyze the information gathered.

Results

The age of cases varied from 15 to 81 years with mean age ± SD being 58.37 ± 7.63 years. More than half of cases (56.7%) were males while 26 (43.3%) were women with men to women ratio was 1.31:1.

Hypertension was the most frequent chronic disease found in 25% of cases followed by DM in 13.3% of cases then COPD in 3.3% of cases.

Regarding site and type of lesions in our study, station 7 was the most frequent site found in 43.3% of cases followed by 4R in 23.3% of cases then peri-bronchial mass in 15% of cases as described in Table 1.

Regarding ROSE results. Non-caseating granuloma (Fig. 2) was the most frequent benign lesion found in 30% of cases while adenocarcinoma was the most frequent malignant lesion found in 30% of cases while 3 cases showed suspicious lesions with no atypical cases as shown in Table 2

As regards malignant lesions, 14 (23.3%) had adenocarcinoma (Fig. 3), 4 (6.7%) had lymphoma (Fig. 4), three (6.3%) large cell carcinoma, and three (6.3%) small cell carcinoma out of the 15 cases with a positive malignancy diagnosis. total diagnostic yield in the rapid onsite evaluation group was 100% while 66.7% in the non-rapid onsite evaluation group 0.63.3% and 30% of cases were ultimately diagnosed with a malignancy

Table 1 Distribution of studied patients regarding type and site of lesion

Parameters		Studied patients (*N* = 60)	
		No.	%
Type of lesion	Lymph node	41	68.3%
	Mass	15	25.0%
	Mass and lymph node	4	6.7%
Site of lesion (L.N station)	Station 7	26	43.3%
	4R	14	23.3%
	Peri-bronchial mass	9	15.0%
	11R	4	6.7%
	4L	3	5.0%
	10R	2	3.3%
	10L	1	1.7%
	11L	1	1.7%

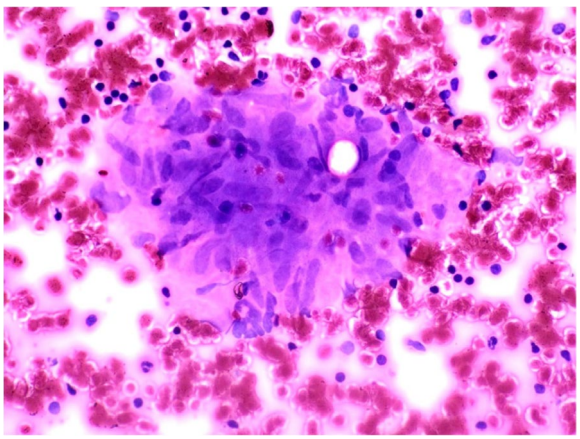

Fig. 2 Non-caseating granuloma as seen through a microscope on a glass slide during rapid H&E stain

in the rapid onsite evaluation and non-rapid onsite evaluation groups respectively and benign etiologies accounted for 36.7% of cases in both groups. Significant variations were detected among both groups regarding diagnostic yield as seen in Table 3

Based on the final diagnosis as a reference standard, the initial rose diagnosis identified malignant lesions in 19 patients (true positives) and benign lesions in 11 patients (true negatives). We found that the initial rose diagnosis had overall specificity, sensitivity, and diagnostic accuracy of 100%, 100%, and 100% respectively. The negative predictive value was 100%, while the positive predictive value was 100%, as illustrated in Table 4.

There was no significant deviation was found among both groups regarding bronchoscopy duration used and the number of punctures as seen in Table 5.

Table 2 Preliminary ROSE results among studied patients

Parameters		ROSE group (*N* = 30)	
		N	%
Preliminary ROSE results	Benign	**11**	**36.66%**
	• Non-caseating granuloma	9	30%
	• Suppurative granuloma	1	3.3%
	• Neuroendocrine	1	3.3%
	Malignant	**16**	**53.3%**
	• Adenocarcinoma	9	30.0%
	• Lymphoma	3	10.0%
	• Squamous cell carcinoma	2	6.7%
	• Metastatic adenocarcinoma (from LN biopsy)	2	6.7%
	Suspicious	**3**	**10.0%**
	• Adenocarcinoma	1	3.3%
	• Small cell carcinoma	2	6.7%
	Atypical	**0**	**0%**

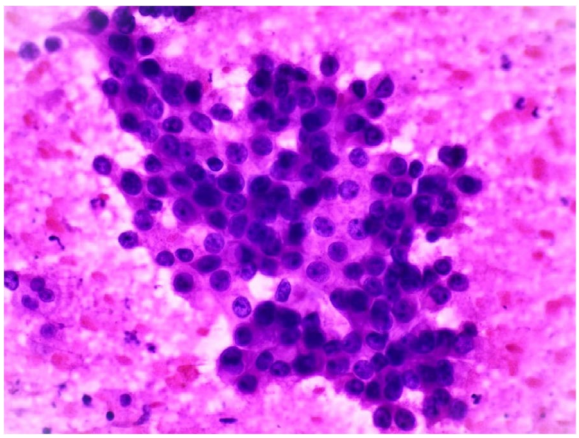

Fig. 3 Typical features of adenocarcinoma on rapid H&E stain

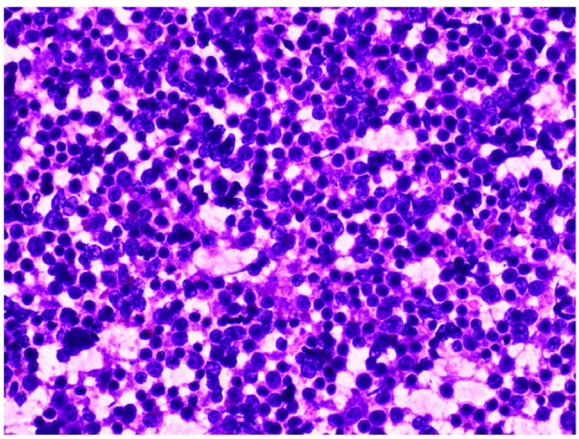

Fig. 4 Features of lymphoma on rapid H&E stain

Table 3 Diagnostic yield among the studied population

Parameters		Group (1)ROSE group (*N* = 30)		Group (2)Non-ROSE group (*N* = 30)		Chi-square test	
		No.	%	No.	%	Test value	*P* value
Diagnostic yield	Benign lesion	11	36.7%	11	36.6%	0.282	0.585
	• Sarcoidosis (non-caseating granuloma)	8	26.7%	10	33.3%	0.675	0.411
	• Tuberculosis (caseating granuloma)	2	6.7%	1	3.3%	FET	1.00
	• Glomus tumor	1	3.3%	0	0.0%	FET	1.00
	Malignant lesion	19	63.3%	9	30.0%	6.674	**0.010**
	• Adenocarcinoma	11	36.7%	3	10.0%	5.963	**0.015**
	• Lymphoma	3	10.0%	1	3.3%	FET	0.612
	• Squamous cell carcinoma	3	10.0%	0	0.0%	FET	0.237
	• Round cell tumor	1	3.3%	1	3.3%	FET	1.00
	• Metastatic malignant cells	1	3.3%	1	3.3%	FET	1.00
	• Large undifferentiated carcinoma (bronchogenic)	0	0.0%	2	6.7%	FET	0.492
	• Small cell lung carcinoma	0	0.0%	1	3.3%	FET	1.00
	Total diagnostic yield	30	100.0%	20	66.7%	7.067	**0.008**
	Not conclusive	0	0.0%	10	33.3%		

Table 4 Accuracy measures of initial rose diagnosis in relation to final diagnosis

Initial ROSE	Final diagnosis					Sensitivity	Specificity	PPV	NPV	Accuracy
	Malignant		Benign		Total					
	No.	%	No.	%						
Preliminary malignant	19	63.3%	0	0.0%	19	100%	100%	100%	100%	100%
Preliminary benign	0	0%	11	36.7%	11					
Total	19	63.3%	11	36.7%	30 (100%)					

Table 5 Comparison between the two studied groups regarding number of punctures and bronchoscopy duration

		Group (1) ROSE group (*N* = 30)	Group (2) Non-ROSE group (*N* = 30)
Number of punctures	Mean ± SD	3.43 ± 1.36	3.77 ± 0.86
	Median (IQR)	3.5 (2.0–5.0)	4.0 (3.0–4.0)
	Range	2.0–5.0	3.0–5.0
Bronchoscopy duration (min)	Mean ± SD	32.83 ± 6.11	29.17 ± 6.83
	Median (IQR)	32.5 (30.0–35.0)	30.0 (25.0–35.0)
	Range	25.0–45.0	20.0–40.0

Table 6 Comparison of the diagnostic yield of cTBNA versus EBUS-TBNA in the non-ROSE group

		cTBNA (*N* = 13)		EBUS (*N* = 17)	
		No	%	No	%
Diagnosis	Benign	3	38.5%	8	47.1%
	Malignant	5	38.5%	4	23.5%
	Total	8	61.5%	12	70.6%
	Non-conclusive	5	38.4%	5	29.4%

Also in Table 6, regarding the overall diagnostic yield of cTBNA versus EBUS-TBNA there is increased sensitivity of (cTBNA) in our study to reach 61.5% while EBUS TBNA was 70.6% in the non-ROSE group.

Discussion

The present research was performed on 60 cases (34 males and 26 females with a mean age being 58.37 years. This was consistent with the research performed by Harris et al. [6] who enrolled twenty-six cases (14 men, 12 women) with a mean age of 61.4 ± 22 years, and similar to the Puriet al. [7] study registered 52 cases (thirty 33 men, nineteen women), with a mean age of 64 ± 12 years.

Furthermore, the most common sampled lesions was the subcarinal lymph node (station 7) followed by 4R in 23.3% of cases then peri-bronchial mass in 15% of cases This is similar to Kassirian et al. [8]. research and the Dhooria et al. [9] research. However, it was unlike the Mohan et al. [10], Casalet al. [11], and YarmusL.B et al. [12], studies in which the most sampled lymph node was the right paratracheal (4R) lymph node.

In the current study, the total diagnostic yield of Conventional and Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration in both groups was 83.3% (50/60 cases). Twenty-eight cases (46.7%) were positive for malignancy, 22 cases (36.6%) were positive for benign lesions, and 10 cases (16.6%) were not conclusive. The diagnostic yield and sample adequacy rates closely match the figures provided in the AQuIRE registry, with a rate of 50% in sarcoidosis cases and 90% in malignancy cases. This registry has given data from real-world scenarios Ost et al. [13]. This was in alignment with the study performed by Dhooriaet al. [9] which presented that the diagnostic yield of endobronchial ultrasound-guided transbronchial needle aspiration was 61.2%. It was also like the research performed by Tremblay et al. [14] which proved that the diagnostic yield was 83.3%. This study was also in concordance with the research done by Adams et al. [15] which presented that the diagnostic yield was 88%, and another study by Herthet al. [16] which proved that the diagnostic yield was 71%.

Regarding diagnostic accuracy, the rapid onsite evaluation group had a greater accuracy rate compared to the non-rapid onsite evaluation group (100% in the rapid onsite evaluation group versus 66.7% in the non-rapid onsite evaluation group, $p=0.10$). Similar findings were stated by Cardoso et al. [17], who demonstrated a greater diagnostic success rate in the rapid onsite evaluation group (93%) compared to the non-rapid onsite evaluation group (77%).

Guo et al. [18] conducted a meta-analysis and observed a tendency for improved outcomes with rapid onsite evaluation. However, the presence of heterogeneity among the studies hindered the achievement of satisfactory outcomes. However, Okiet al. [19] conducted a randomized trial while Griffinet al. [20] conducted a retrospective investigation, both of which concluded that rapid onsite evaluation did not have a significant impact on the diagnostic yield of endobronchial ultrasound-guided transbronchial needle aspiration.

Regarding the number of punctures, there is no disparity between both groups. Griffin et al. found that rapid onsite evaluation throughout endobronchial ultrasound-guided transbronchial needle aspiration did not reduce the number of lesions sampled per case, which aligns with our findings. Conversely, Oki et al. andBediwy et al. [21] proposed that rapid onsite evaluation decreased the number of punctures required for each lesion or the number of lesions that needed to be aspirated. Furthermore, Cardoso et al. observed that the utilization of rapid onsite evaluation throughout EBUS-TBNA resulted in a reduction in the number of punctures required per procedure. Nevertheless, the rise in punctures within the non-rapid onsite evaluation group did not correlate with a high rate of complications. In our work, we addressed the issue surrounding literature by employing both Conventional and EBUS TBNA procedures, with various needle diameters to acquire smears. Typically, we adjust the procedure by altering the location, depth, or angle of the puncture based on the ROSE results. As a result, the rapid onsite evaluation group suffers a greater percentage of punctures.

The average time of bronchoscopy was longer in the rapid onsite evaluation group. This finding aligns with the research carried out by Oki et al., who concluded that using ROSE did not result in a reduction of bronchoscopy time due to the time-consuming process of preparing and reviewing slides for ROSE.

Out of the thirty cases in the ROSE group, only three cases were found to be suspicious, while the remaining twenty-seven cases were strongly indicative of either malignant or benign lesions, as previously described. Guo et al. confirmed the benefit of rapid onsite evaluation in their research. They found that the ROSE group had a lower percentage of suspicious results (8.7%) compared to the non-rapid onsite evaluation group (14.6%) ($P=0.038$). Additionally, the use of rapid onsite evaluation led to a higher diagnostic yield of pathologic samples, with a success rate of 90.5% compared to 81.2% in the non-rapid onsite evaluation group ($P=0.003$). The diagnostic precision of rapid onsite evaluation in determining the presence or absence of malignancy in the final pathological diagnosis was assessed on a per-lesion base. The initial rose diagnosis correctly diagnosed malignant lesions in nineteen cases (true positives) and benign lesions in eleven cases (true negatives), resulting in a sensitivity and specificity of 100% each. The findings were consistent with the research conducted by Bediwyet al. which documented a specificity of 94.12%, a sensitivity of 94.87%, and a diagnostic accuracy of 94.57%.

Yasufukuet al. [22] found that the sensitivity and specificity were 95.7% and 100%, correspondingly, which indicates a better level of accuracy. Ye et al. [23] reported a sensitivity of 95% and a specificity of 100%. Al Sharifet al. [24] and Parmaksiz et al. [25] reported an 89.2% sensitivity and a 100% specificity, correspondingly. Guo et al. found a high level of agreement (98.6%) among the onsite observations and the final pathology diagnosis.

Conclusion

The use of ROSE throughout Conventional or endobronchial ultrasound-guided transbronchial needle aspiration enhances the precision of diagnosing mediastinal lesions by avoiding specimens that are suspicious or inconclusive. This technique can also minimize the need for excessive punctures or subsequent bronchoscopy procedures when making a preliminary diagnosis.

Abbreviations

CBC	Complete blood count
CT	Computed tomographic
EBUS	Endobronchial ultrasound
EBUS-TBNA	Endobronchial ultrasound-guided transbronchial needle aspiration
cTBNA	Conventional transbronchial needle aspiration
PPV	Positive predictive value
HE	Hematoxylin and eosin
LN	Lymph node
NPV	Negative predictive value
ROSE	Rapid on-site evaluation
Station 7	Subcarinal lymph node
4R	Right lower paratracheal lymph node
11L	Left interlobar lymph node
10R	Right hilar lymph node
4L	Left paratracheal lymph node
11R	Right interlobar lymph node
10L	Left hilar lymph node

Acknowledgements
Inapplicable.

Authors' contributions
The authors read and approved the final manuscript.

Funding
Inapplicable.

Availability of data and materials
Available.

Declarations

Ethics approval and consent to participate
The local ethical committee has granted its approval.

Consent for publication
Inapplicable.

Competing interests
The authors declare that they have no competing interests.

Received: 22 June 2024 Accepted: 27 August 2024
Published online: 06 September 2024

References

1. Medford AR, Bennett JA, Free CM, Agrawal S (2010) Endobronchial ultrasound guided transbronchial needle aspiration. Postgrad Med J 86(1012):106–115
2. Cameron SEH, Andrade RS, Pambuccian SE (2010) Endobronchial ultrasound-guided transbronchial needle aspiration cytology: a state of the art review. Cytopathology 21(1):6–26
3. Liran L, Rottem K, Gregorio FZ, Avi A, Neville B (2019) A novel, stepwise approach combining conventional and endobronchial ultrasound needle aspiration for mediastinal lymph node sampling. Endosc Ultrasound 1:31–32
4. VanderLaan PA, Wang HH, Majid A, Folch E (2014) Endobronchial ultrasound- guided transbronchial needle aspiration (EBUS-TBNA): an overview and update for the cytopathologist. Cancer Cytopathol 122:561–576
5. Gupta N, Klein M, Chau K, Vadalia B, Khutti S, Gimenez C, Das K (2019) Adequate Rapid on-site evaluation (ROSE), but inadequate on final cytologic diagnosis: Analysis of 606 cases of endobronchial ultrasound-guided trans bronchial needle aspirations (EBUS-TBNA). Diagnost Cytopathol 47(5):367–73.
6. Harris K, Maroun R, Attwood K, Chalhoub M (2015) Comparison of cytologic accuracy of endobronchial ultrasound transbronchial needle aspiration using needle suction versus no suction. Endoscopic ultrasound 4(2):115
7. Puri R, Vilmann P, Săftoiu A, Skov BG, Linnemann D, Hassan H, Garcia ES, Gorunescu F (2009) Randomized controlled trial of endoscopic ultrasound-guided fine-needle sampling with or without suction for better cytological diagnosis. Scand J Gastroenterol 44(4):499–504
8. Kassirian S, Mitchell MA, McCormack DG, Zeman-Pocrnich C, Dhaliwal I (2022) Rapid On-site Evaluation (ROSE) in Capillary Pull Versus Suction Biopsy Technique With Endobronchial Ultrasound-transbronchial Needle Aspiration (EBUS-TBNA). Journal of Bronchology & Interventional Pulmonology 29(1):48–53
9. Dhooria S, Agarwal R, Aggarwal AN, Bal A, Gupta N, Gupta D (2014) Differentiating tuberculosis from sarcoidosis by sonographic characteristics of lymph nodes on endobronchial ultrasonography: a study of 165 patients. J Thorac Cardiovasc Surg 148:662–667
10. Mohan A, Iyer H, Madan K, Hadda V, Mittal S, Tiwari P, Jain D, Pandey RM, Garg A, Guleria R (2021) A randomized comparison of sample adequacy and diagnostic yield of various suction pressures in EBUS-TBNA. Advances in Respiratory Medicine 89(3):268–276
11. Casal RF, Lazarus DR, Kuhl K et al (2015) Randomized trial of endobronchial ultrasound-guided transbronchial needle aspiration under general anesthesia versus moderate sedation. Am J Respir Crit Care Med 191:796–803
12. Yarmus L, Akulian J, Gilbert C (2013) Optimizing endobronchial ultrasound for molecular analysis. How many passes are needed?. Ann Am Thorac Soc 10:636–643.
13. Ost DE, Ernst A, Lei X, Feller-Kopman D, Eapen GA, Kovitz KL, Herth FJ, Simoff M (2011Dec 1) Diagnostic yield of endobronchial ultrasound-guided transbronchial needle aspiration: results of the AQuIRE Bronchoscopy Registry. Chest 140(6):1557–1566
14. Tremblay A, Stather DR, MacEachern P, Khalil M, Field SK (2009Aug 1) A randomized controlled trial of standard vs endobronchial ultrasonography-guided transbronchial needle aspiration in patients with suspected sarcoidosis. Chest 136(2):340–346
15. Adams K, Shah PL, Edmonds L, Lim E (2009) Test performance of endobronchial ultrasound and transbronchial needle aspiration biopsy for mediastinal staging in patients with lung cancer: systematic review and meta-analysis. Thorax 64:757–762
16. Herth FJ, Lunn W, Eberhardt R, Becker HD, Ernst A (2005) Transbronchial versus transesophageal ultrasound-guided aspiration of enlarged mediastinal lymph nodes. Am J Respir Crit Care Med 171:1164–1167
17. Cardoso AV, Neves I, Magalhães A, Sucena M, Barroca H, Fernandes G (2015) The value of rapid on-site evaluation during EBUS-TBNA. Revista Portuguesa de Pneumologia (English Edition) 21(5):253–258
18. Guo H, Liu S, Guo J, Li B, Li W, Lu Z et al (2016) Rapid on-site evaluation during endobronchial ultrasound-guided transbronchial needle aspiration for the diagnosis of hilar and mediastinal lymphadenopathy in patients with lung cancer. Cancer Lett 371:182–186
19. Oki M, Saka H, Kitagawa C, Kogure Y, Murata N, Adachi T et al (2013) Rapid on-site cytologic evaluation during endo- bronchial ultrasound-guided transbronchial needle aspiration for diagnosing lung cancer: a randomized study. Respiration 85:486–492
20. Griffin AC, Schwartz LE, Baloch ZW (2011) Utility of on-site evaluation of endobronchial ultrasound-guided transbronchial needle aspiration specimens. Cytojournal 8:20
21. Bediwy AS, Zamzam K, Hantira M, El-Sharawy D, ElSaqa A, Zamzam Y (2017) The value of rapid on-site evaluation during endobronchial ultrasound-guided transbronchial needle aspiration in the diagnosis of mediastinal lesions. Egyptian Journal of Bronchology 11:336–341
22. Yasufuku K, Pierre A, Darling G, de Perrot M, Waddell T, Johnston M et al (2011) A prospective controlled trial of endobronchial ultrasound-guided transbronchial needle aspiration compared with mediastinoscopy for

mediastinal lymph node staging of lung cancer. J Thorac Cardiovasc Surg 142:1393–1400
23. Ye T, Hu H, Luo X, Chen H (2011) The role of endobronchial ultrasound guided transbronchial needle aspiration (EBUS-TBNA) for qualitative diagnosis of mediastinal and hilar lymphadenopathy: A prospective analysis. BMC Cancer 11:100
24. Alsharif M, Andrade RS, Groth SS et al (2008) Endobronchial ultrasound-guided transbronchial fine needle aspiration: the University of Minnesota experience, with emphasis on usefulness, adequacy assessment, and diagnostic difficulties. Am J Clin Pathol 130:434–443
25. Parmaksiz ET, Caglayam B, Salepci B, Comert SS, Kiral N, Fidan A et al (2012) The utility of endobronchial ultrasound guided transbronchial needle aspiration in mediastinal or hilar lymph node evaluation in extrathoracic malignancy: Benign or Malignant? Ann Thorac Med 7:210–214

Publisher's Note