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A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound – Fine Needle Aspiration (EBUS-FNA)

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Abstract

Background—Cytopathologic interpretation of EBUS-FNA samples by a pathologist can be time-consuming and costly, and an onsite cytopathologist may not always be readily available. A telecytopathology system was instituted and evaluated to examine the impact on operative time for EBUS.

Methods—A prospective study was performed of sequential patients undergoing EBUS-FNA for the evaluation of mediastinal lymphadenopathy. The control group involved transportation of specimens to the pathology lab followed by remote cytologic interpretation. A subsequent cohort utilized a telecytopathology system with intra-op transmission of real-time live video microscopy to a remote cytopathologist (TCP group). The primary outcome was time to confirmation of cytology results.

Results—Of 46 patients entered into the study, 23 underwent traditional analysis (Control group) while 20 were analyzed using telecytopathology (TCP group). Lung cancer was the most common malignancy in both groups (12 TCP, 12 Control). There was no difference in mean number of lymph node stations sampled (1.3 TCP vs. 1.8 Control, $p=0.76$). Use of TCP was associated with fewer needle passes (4.9 vs. 7.3, $p=0.02$) and fewer slides for interpretation (8.4 vs. 13.5, $p=0.01$) per procedure.

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Time to result confirmation was significantly shorter in the TCP group (19.0 vs. 46.7 minutes, $p<0.001$). A diagnostic specimen was obtained in 70% of patients in the TCP group compared with 65% in the control group ($p=0.5$). False negative rates in patients undergoing both EBUS-FNA and mediastinoscopy were similar between the two groups (0 in TCP vs. 2 in Control, $p=0.49$). Mean procedural costs (excluding cost of the telecytology system and OR time) were equivalent between the two groups (\$888 TCP vs. \$887 Control).

Conclusions—Telecytopathology provides rapid interpretation of EBUS-FNA samples with diagnostic accuracy comparable to traditional methods, shortens procedure time, and is a more efficient model for delivery of on-site EBUS-FNA interpretation.

INTRODUCTION

Endobronchial ultrasound with fine-needle aspiration (EBUS-FNA) has become an important modality for the staging of patients with thoracic malignancies. The cytologic specimens obtained from mediastinal lymph nodes can be examined to identify the presence of malignant cells with high sensitivity.^{1–4} These results can be critically important in deciding which treatment alternatives would be most beneficial for a given patient.

Cytologic specimens obtained from EBUS-FNA are currently evaluated using several different logistical methods. Traditionally, aspirated cells were fixed and stained in the procedure suite or operating room, only to be evaluated by a cytopathologist at a later time outside of the operating room. More recently, rapid on-site evaluation (ROSE) has proven beneficial in providing real-time feedback to the surgeon or proceduralist. Current evidence suggests that the use of ROSE results in fewer sites biopsied by the operator and fewer slides for examination by the cytopathologist.^{5–7} These improvements may translate into higher efficiency, potential cost reductions, and better overall delivery of health care services.⁷

The potential disadvantage of ROSE is that in many cases it requires the cytopathologist to remain in the operating room or procedure suite for the duration of the evaluation. This can be particularly time-consuming and disruptive to the cytopathologist's work-flow, especially if multiple procedures are being performed over the course of a day. In addition, current Medicare compensation schedules fail to adequately compensate the cytopathologist for on-site evaluation when considered on a time cost basis.⁸

Telecytopathology was proposed as a possible means to alleviate the time burden of an on-site EBUS-FNA evaluation approach. Using this method, a cytotechnologist is present in the operating room or procedure suite where they prepare and stain slides for evaluation. The technician's microscope in the operating room is fitted with a camera for remote transmission of live real-time video to a cytopathologist's workstation. Aspirated samples can be interpreted in real-time by the cytopathologist and feedback regarding diagnosis and quality of the material can be immediately relayed to the operator.

This approach has previously been shown to decrease time commitments on the part of the cytopathologist.⁹ However, using a prospective clinical evaluation comparing a telecytopathology system with conventional cytopathologic evaluation, we sought to further

investigate whether telecytopathology could decrease procedure duration, operating room or procedure suite utilization, and other variables relevant to the surgeon.

MATERIAL AND METHODS

We designed a single center, prospective non-randomized trial at Barnes-Jewish Hospital – Washington University in St. Louis School of Medicine. Following IRB approval, eligible patients were identified by the authors in their patient clinics or from in-hospital consultations. For inclusion in the study, patients must fulfill all of the following criteria: mediastinal and/or nodal pathology requiring EBUS-FNA for diagnosis or staging, ability to tolerate general anesthesia, age ≥ 18 years, capacity to understand the study procedures and give informed consent. Procedures that needed to be done urgently or emergently were excluded.

Prior to enrollment, all patients underwent either dedicated CT scan of the chest or whole body PET/CT as part of their evaluation. The majority of patients underwent both imaging modalities. All procedures were performed under general anesthesia. Procedures in this study were performed by four surgeons, with the senior author (TDC) contributing the majority of cases. Overall surgeons contributed equivalent numbers of patients to the control and TCP groups (TDC 17,12; BFM 2,4; GAP 3,3; VP 1,1; respectively).

The number of FNA biopsies performed at each site was at the discretion of the treating physician and based upon their assessment of the adequacy of the biopsy using real-time visualization of the target lesion. Cytologic specimens were prepared intra-operatively by a dedicated cytotechnologist and then reviewed by a cytopathologist for assessment of the adequacy and viability of the specimen, cytologic diagnosis, and confirmation of the presence or absence of nodal tissue in the event of biopsy of a suspicious lymph node. Additional biopsies to confirm diagnosis, or for creation of a cell block of tissue, were performed at the discretion of the treating physician based on cytologic interpretation. Each aspirate pass performed was split between alcohol fixed smear (Papanicolaou staining) and air dried methanol fixed (modified Wright-Giemsa) per standard cytology practice for FNA biopsy.

The study was conducted in three phases. The lead-in phase of the study (control group) utilized standard cytologic examination techniques at our institution. Processed specimens were transported to the reviewing pathologist at a remote site outside the operating room and the results are called back into the operating room. The transitional phase involved the implementation of the telecytopathology system (Nikon Corporation, Tokyo, Japan). Specimens were processed in the operating room and reviewed using a microscope with a high definition (2560×1920 pixels) video camera (Nikon Digital Sight, DS-Fi2) and a video controller (Nikon Digital Sight, DS-L3) capable of transmitting real-time live video imaging of the cytologic slide over an encrypted network to the reviewing remote cytopathologist. The transitional phase was deemed complete once OR staff and the cytology technician were comfortable using the equipment and the cytopathologists ensured the adequacy of the technique using internal validation. The final phase evaluated a cohort of patients using the new telecytopathology system.

The primary endpoint of the study was operative time from the insertion of the EBUS bronchoscope to the confirmation of results communicated to the operating room. Secondary endpoints included mean time from bronchoscope insertion to withdrawal, procedural costs, number of nodal stations sampled, number of needle passes made, and number of slides generated.

All analyses were performed using SPSS 21.0. Descriptive statistics were expressed as a mean $\pm$ standard deviation unless otherwise specified. Independent samples t tests and one-way ANOVA were used to compare continuous variables. Chi-square tests were used to compare categorical data. P-values less than 0.05 were considered statistically significant.

RESULTS

From May through August 2013, 23 patients were evaluated using the conventional method (control group). The transitional phase was carried out from September through mid October of 2013 and utilized 17 patients to familiarize the cytology team and operating room staff with the telecytology equipment (Figures 1A and 1B). These patients were not included in the data analysis. The telecytology phase of the study involved an additional 20 patients and was carried out from late October 2013 through the end of February 2014 (TCP Group). Therefore a total of 43 patients were included for analysis. The majority of patients (86%) underwent pre-operative evaluation that included both a dedicated CT scan of the chest as well as PET/CT imaging. In total, PET/CT was performed in 22/23 patients in the control group and 18/20 in the TCP group.

Clinical and procedural information for these 43 patients is shown in Table 1. The majority of patients were male (27/43, 63%) and lung cancer was the most common clinical diagnosis prompting biopsy (24/43, 56%). Subcarinal lymph nodes (level 7) were the most common location for initial sampling (15/43, 35%). Right paratracheal lymph nodes (level 4) were the next most common (8/43, 19%) and the primary tumor was biopsied in one patient.

Comparisons between the control and TCP groups are displayed in Table 2. Procedure length was significantly shorter in the TCP group when considered both in terms of time until scope removal (18.1 vs. 26.3 minutes, $p=0.02$) and time until results confirmation (19.0 vs. 46.7 minutes, $p<0.001$).

The mean number of lymph node stations sampled per procedure did not differ significantly between the groups (TCP = 1.3, Control = 1.83; $p=0.76$). There was a significant difference in the mean number of needle passes made per procedure when using TCP (TCP = 4.9, Control = 7.3; $p=0.02$). Use of TCP was also associated with fewer slides submitted for pathologic review per procedure (TCP = 8.4, Control = 13.5; $p=0.01$). There appeared to be no significant difference when examining the frequency of patients undergoing biopsies at second or third sites [5/20 (25%) TCP, 10/23 (43%) control; $p=0.34$].

Additional procedures were performed in combination with EBUS-FNA in 14 cases. Insertion of an infusion port for chemotherapy was performed in 5 patients in each group. EBUS-FNA was performed prior to thoracotomy and pulmonary resection in one patient. There were no major complications in either group.

A diagnostic specimen was obtained in 70% of patients in the TCP group compared with 65% in the control group ($p=0.5$). Due to diagnostic uncertainty, subsequent mediastinoscopy was performed on 2 patients in the control group and 3 patients in the TCP group. In those patients who also had mediastinoscopy, there were two false negatives in the control group and none in the TCP group.

Due to difficulty in obtaining institutional cost estimates of operating room time, a basic cost comparison was made using direct materials costs for the two procedures. There was no significant difference in the direct materials costs of procedures performed using each method (\$888 for TCP, \$887 for control; $p=1.0$).

COMMENT

EBUS-FNA has become an important tool for the staging of lung cancer as well as the evaluation and diagnosis of other intrathoracic pathology. Institutional practices regarding the evaluation of EBUS-FNA specimens obtained during these procedures vary widely. Pathologic interpretation of the specimens is provided by a cytopathologist and is the preferred method at our institution. This is particularly important if additional procedures are planned based on the biopsy results. This applies not only to other therapeutic interventions such as insertion of chemotherapy infusion ports or surgical resection, but also to further diagnostic maneuvers such as gathering material for microbiologic studies and flow cytometry. With the current emphasis on targeted therapy in thoracic oncology, immediate feedback regarding specimen quality can also be particularly valuable when creating high-quality cell blocks for molecular testing and tumor genotyping.

In institutions such as ours where cytopathologic interpretation is preferred, rapid on-site evaluation (ROSE) of specimens has been shown to offer several advantages. In addition to providing real time direct feedback to the operator regarding specimen quality, ROSE has been shown to reduce the number of sites biopsied and improve the quality of diagnostic specimens.^{5,6,10} Additional evidence suggests that this can contribute to higher efficiency and cost savings.^{7,11}

However, factors such as high procedure volume or significant distance between the procedure suite and the pathology laboratory may create an excessive burden on the diagnostician. As a result, a dedicated intra-operative pathologist may be impractical at large institutions or those with limited resources. Telecytology provides an attractive alternative which allows for real time feedback to the operator while decreasing the time commitment on behalf of the cytopathologist. Previous studies have focused on the merits of telecytopathology for the cytotechnologist and pathologist, but none to our knowledge have primarily evaluated the potential benefits for surgeons and proceduralists.⁹ We hypothesized that the use of the telecytopathology system could potentially shorten procedure duration, leading to improved operating room efficiency and surgeon work flow.

The results from this prospective analysis suggest that use of the telecytopathology system shortens procedure duration and improves procedural efficiency. In our analysis, this technique shortened each procedure by an average of 27.7 minutes from scope insertion to the

time that the confirmatory result was communicated to the operating room. Use of TCP resulted in fewer needle passes made and fewer slides for analysis by the cytopathologist.

Similar rates of malignancy detection between the TCP and control groups suggest that these improvements in efficiency do not detract from the diagnostic accuracy of EBUS-FNA and support the equivalency of these procedures. We performed additional analyses involving quantification of the cellularity of the cell blocks using each method but these also failed to show any significant difference. Given the small sample size, it is possible that a larger analysis might reveal differences in specimen quality using the two methods.

The economic impact of this technology is difficult to properly evaluate. We performed a basic cost comparison considering only the direct materials cost of procedures done using both the traditional and TCP methods. As the technical aspects of the procedure remain the same regardless of the method used for cytologic interpretation, it is not surprising that materials costs were similar. In terms of start-up costs, the Nikon system we currently use retails for approximately \$7,000. The system requires a fixed IP address installed in the operating room which costs an additional \$200. Although difficult to quantify, others have estimated the cost of running an operating room in the range of \$15–20 per minute, with over half of this expense being fixed overhead costs.^{12–13} Therefore using a conservative assumption of \$450 in variable OR costs per hour and a time savings of 28 minutes per procedure, use of TCP could potentially generate a savings of \$200 per procedure and create a break-even point of around 35 procedures. It is worthwhile to note that as procedural volume increases, cost efficacy would improve further. In addition, cost saving generated by less slide preparation and processing as well as enhanced productivity by the surgeon might make this technology even more cost effective.

There are several limitations to this analysis. The study was powered to detect a significant difference in procedure length. However, the sample size is not sufficient to detect more subtle differences in lymph node stations sampled and diagnostic accuracy. Perhaps future studies with a larger cohort of patients would reveal additional differences between the two methods. In addition, our cost analysis of the two methods is fairly rudimentary. However, in the current healthcare environment, transparency in regards to procedural costs and charges is a common problem. As a result, accurate comparisons of cost-efficacy in regards to healthcare technology remain difficult.

The results of our prospective clinical trial suggest that telecytopathology may be a useful tool for balancing the increasing time demands of surgeons and pathologists while still providing equivalent results compared with traditional evaluation methods. This technology allows for the real-time feedback of ROSE while limiting the time requirement of the diagnostician. The most important beneficiary, however, is the patient, who experiences a shortened procedure, decreased time under anesthesia, fewer biopsies, and ultimately improved delivery of care.

Discussion

55. A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound (EBUS). Paper presented by Matthew Bott, MD, St. Louis, MO. E-mail: bottm@wudosis.wustl.edu

Discussion by Joshua Robert Sonett, MD, New York

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Dr. J. Sonett (New York, NY):

Matt, that was an excellent presentation, and particular kudos to setting it up as a prospective study. It would be easy not to do it and just sort of present the data. So congratulations.

I have two questions. As you know, one of the most important things about early diagnosis in tissue samples is to get a molecular staging. So did this affect your ability to get complete molecular staging with EBUS? We've shown that we can get 90%, and a lot of that is because we have the cytopathologist, or the pathologist, there helping us, because we're not going to save every cell for working at it. So have you looked at that?

55. A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound (EBUS). Response by Matthew Bott, MD, St. Louis.

DR. BOTT We didn't look specifically at the molecular data from the tissue, but we did look at the quality of the cell blocks. There's no difference in the quality of the cell blocks between the two methods; however we used a fairly gross estimate of the cellularity of the sample.

DR. SONETT I would just encourage you to look at that and encourage everybody to try to use EBUS for complete molecular diagnostic, because it can be done. And, two, have you equipped this in the bronch suite for those that are doing it in the bronch suite? I would imagine the same technology can work just as well.

DR. BOTT I believe our bronchoscopy suite is where this technology was first implemented. So we are applying it to different areas of the hospital as well, absolutely.

55. A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound (EBUS). Paper presented by Matthew Bott, MD, St. Louis, MO. E-mail: bottm@wudosis.wustl.edu

Discussion by William R. Mayfield, MD, Georgia

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Dr. W. Mayfield (Marietta, GA):

I enjoyed your presentation. I'm somewhat interested in the process for the following reason. We have a multi-disciplinary thoracic oncology clinic. We try to get patients biopsied within three or four days at the time they are seen in the clinic, whether they go to EBUS, whether they go to radiology for a needle biopsy or they go to bronchoscopy. Our

average rate of diagnosis is about 70%, all-comers, and it's extremely frustrating to me, because a third of these patients come back and need a second procedure. We don't have onsite cytology, and for the life of me I can't get our pathologists to develop that program. We do these biopsies in the bronch lab, the GI lab, radiology suites, and in the operating room, so they're pretty spread out.

Question number one. Do you have your cytopathologists on site and not finish the procedure until you have diagnostic tissue?

55. A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound (EBUS). Response by Matthew Bott, MD, St. Louis, MO.

DR. BOTT In most cases, yes. The feedback in that regard is very helpful. We generally will not finish the procedure until either there is a diagnosis of malignancy or there is confirmed nodal tissue on the biopsy.

DR. MAYFIELD So even with that process, it appears to me that you get a diagnosis 70% of the time.

DR. BOTT Sorry, the presentation wasn't entire clear in that regard. According to our pre-specified definitions, a "diagnostic" specimen was one that showed malignancy. So in the vast majority of "non-diagnostic" cases, there was still nodal tissue on the biopsy specimen.

55. A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound (EBUS). Paper presented by Matthew Bott, MD, St. Louis, MO. E-mail: bottm@wudosis.wustl.edu

Discussion by Min Kim, MD, Texas E-mail:

mpkim@tmhs.org Dr. M. Kim (Houston, TX):

Have you seen a difference between what you get as rapid onsite versus cell block a couple of days later? There are couple of reports in the literature that talk about even though they might say they might not have a diagnosis on rapid onsite but a couple of days later they make a diagnosis from cell block. Have you seen that in your analysis?

55. A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound (EBUS). Response by Matthew Bott, MD, St. Louis, MO.

DR. BOTT I think there were instances where the pathologist couldn't definitively call it, saying that it was suspicious for this or that. In some of these cases, the final analysis was more definitive. Now, the numbers in this study are small and I don't have the data as far as how many cases had this sort of ambiguity, but it does happen at our institution from time to time, yes.

55. A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound (EBUS). Paper presented by Matthew Bott, MD, St. Louis, MO. E-mail: bottm@wudosis.wustl.edu

Discussion by Shanda Blackmon, MD, Minnesota

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Dr. S. Blackmon (Rochester, MN):

Do you make the slides yourself?

55. A Prospective Clinical Trial of Telecytopathology for Rapid Interpretation of Specimens Obtained During Endobronchial Ultrasound (EBUS). Response by Matthew Bott, MD, St. Louis, MO.

DR. BOTT No, the cytotechnologist makes the slides.

DR. BLACKMON The technician is there and they are moving the slide around. And can you communicate realtime with the pathologist?

DR. BOTT Yes, if you look at this photo, the technician is wearing a headset and there is a Voice over IP, so he can talk with the pathologist as they are reviewing the slide.

DR. BLACKMON Did you consider potentially just running the slide to them rather than making them waste time and come into the room, the quick trip of running it? Because it seems to me that it was frustrating to the pathologist to not be able to move the slide around themselves, and they said that they could process it with more help and a better environment if we took the five seconds to run it downstairs just directly to their lab.

DR. BOTT So you make the slides in the operating room yourself and then have it transported to pathology?

DR. BLACKMON Yes.

DR. BOTT That's essentially what the traditional method was. Under the way that we used to do it, the tech is there in the OR and makes the slide, and then a runner brings it to pathology and the pathologist can interpret it there.

DR. BLACKMON So you are saving time by using this?

DR. BOTT Essentially. Whether or not this is beneficial for you depends on a lot of things, such as the distance to the pathology lab, the case volume, etc.

References

1. Groth SS, Whitson BA, D'Cunha J, Maddaus MA, Alsharif M, Andrade RS. Endobronchial Ultrasound-Guided Fine-Needle Aspiration of Mediastinal Lymph Nodes: A Single Institution's Early Learning Curve. *Ann Thorac Surg*. 2008; 86:1104–1110. [PubMed: 18805141]
2. Wallace MB, Pascual JMS, Raimondo M, Woodward TA, McComb BL, Crook JE, Johnson MM, Al-Haddad MA, Gross SA, Pungpapong S, Hardee JN, Odell JA. Minimally Invasive Endoscopic Staging of Suspected Lung Cancer. *JAMA*. 2008; 299(5):540–546. [PubMed: 18252884]
3. Annema JT, van Meerbeeck JP, Rintoul RC, Dooms C, Deschepper E, Dekkers OM, De Leyn P, Braun J, Carroll NR, Praet M, deRyck F, Vansteenkiste J, Vermassen F, Versteegh MI, Veselic M, Nicholson AG, Rabe KF, Tournoy KG. Mediastinoscopy vs. Endosonography for Mediastinal

- Nodal Staging of Lung Cancer – A Randomized Trial. *JAMA*. 2010; 304(20):2245–2252. [PubMed: 21098770]
4. Hwangbo B, Lee G, Lee HS, Lim K, Lee S, Kim H, Lee HS, Kim MS, Lee JM, Nam B, Zo JI. Transbronchial and Transesophageal Fine-Needle Aspiration Using an Ultrasound Bronchoscope in Mediastinal Staging of Potentially Operable Lung Cancer. *Chest*. 2010; 138(4):795–802. [PubMed: 20348194]
5. Trisolini R, Cancellieri A, Tinelli C, Paioli D, Scudeller L, Casadei GP, Parri SF, Livi V, Bondi A, Boaron M, Patelli M. Rapid On-site Evaluation of Transbronchial Aspirates in the Diagnosis of Hilar and Mediastinal Adenopathy – A Randomized Trial. *Chest*. 2011; 139(2):395–401. [PubMed: 21030491]
6. Baram D, Garcia RB, Richman PS. Impact of Rapid On-site Cytologic Evaluation During Transbronchial Needle Aspiration. *Chest*. 2005; 128:869–875. [PubMed: 16100180]
7. Collins BT, Chen AC, Wang JF, Bernadt CT, Sanati S. Improved Laboratory Resource Utilization and Patient Care With the Use of Rapid On-Site Evaluation for Endobronchial Ultrasound Fine-Needle Aspiration Biopsy. *Cancer Cytopathol*. 2013; 121(10):544–551. [PubMed: 23825066]
8. Layfield LJ, Bentz JS, Gopez EV. Immediate On-Site Interpretation of Fine-Needle Aspiration Smears – A Cost and Compensation Analysis. *Cancer Cytopathol*. 2001; 93:319–322.
9. Marotti JD, Johncox V, Ng D, Gonzalez JL, Padmanabhan V. Implementation of Telecytology for Immediate Assessment of Endoscopic Ultrasound-Guided Fine-Needle Aspirations Compared to Conventional On-Site Evaluation: Analysis of 240 Consecutive Cases. *Acta Cytologica*. 2012; 56:548–553. [PubMed: 23075898]
10. Witt BL, Schmidt RL. Rapid Onsite Evaluation Improves the Adequacy of Fine-Needle Aspiration for Thyroid Lesions: A Systematic Review and Meta-Analysis. *Thyroid*. 2013; 23(4):428–435. [PubMed: 23043247]
11. Diacon AH, Schuurmans MM, Theron J, Louw M, Wright CA, Brundyn K, Bolliger CT. Utility of Rapid On-Site Evaluation of Transbronchial Needle Aspirates. *Respiration*. 2005; 72:182–188. [PubMed: 15824529]
12. Macario A. What does one minute of operating room time cost? *J Clin Anesthesia*. 2010; 22:233–236.
13. Brodsky JB. Cost Savings in the Operating Room. *Anesthesiology*. 1998; 88:834. [PubMed: 9523833]

Figure 1.

A: Cytotechnologist evaluating EBUS-FNA samples using the telecytopathology workstation. The cytotechnician is corresponding with the remote cytopathologist via the headset while navigating the slide for review.

B: Telecytopathology controller used to view and transmit high-definition live video images to the telecytopathologist's remote location via a secure IP web-based Java browser.

Table 1

Clinical and procedural data for patients undergoing EBUS-FNA with conventional (Control group) and telecytopathologic (TCP group) analysis – Continuous variables are displayed as a mean. Categorical variables are displayed as number (% total).

Clinical and Procedural Characteristics	Control Group (n=23)	TCP Group (n=20)	p-Value
Mean Age (years)	64.7	64.5	0.966
Male Gender	15 (65 %)	12 (60%)	0.724
Clinical scenario prompting biopsy			
Lung cancer	12 (52%)	12 (60%)	
Head and neck cancer	4 (17%)	2 (10%)	
Granulomatous disease	2 (9%)	2 (10%)	
Esophageal cancer	2 (9%)	1 (5%)	
Lymphoma	1 (4%)	0 (0%)	
Other malignancy	2 (9%)	2 (10%)	
Benign NOS	0 (0%)	1 (5%)	
Initial site for EBUS-FNA			
Primary tumor	0 (0%)	1 (5%)	
Lymph Node Station 2	3 (13%)	4 (20%)	
Lymph Node Station 3	0 (0%)	2 (10%)	
Lymph Node Station 4	5 (22%)	3 (15%)	
Lymph Node Station 7	10 (43%)	5 (25%)	
Lymph Node Station 10	2 (9%)	4 (20%)	
Lymph Node Station 11	3 (13%)	1 (5%)	

Table 2

Prospective comparison of conventional cytologic assessment (control group) versus telecytology assessment (TCP group) for the evaluation of EBUS-FNA specimens – Continuous variables are displayed as a mean. Categorical variables are displayed as number (% total).

Outcome measure		Control Group (n=23)	TCP Group (n=20)	p-Value
Number of nodal stations sampled (mean)		1.83	1.3	0.76
Number of nodal stations sampled	1	13 (57%)	15 (75%)	0.10
	2	4 (17%)	4 (20%)	
	3	6 (26%)	1 (5%)	
Total number of needle passes per procedure (mean)		7.3	4.95	0.02
Total number of slides per procedure (mean)		13.5	8.4	0.01
Time from EBUS scope insertion to removal (min)		25.3	18.1	0.02
Time from EBUS scope insertion to results confirmation – min		46.7	19.0	<0.001
Total materials cost per case (mean)		\$887	\$888	1.00