ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

Educating the Next Generation of Pulmonary Fellows in Transbronchial Needle Aspiration: Leading the Blind to See

Christopher R. Gilbert[1], D.O., M.S., Lonny Yarmus[2], D.O., and David Feller-Kopman[2], M.D.

[1]Penn State College of Medicine-Milton S. Hershey Medical Center, Division of Pulmonary, Allergy, and Critical Care Medicine, Bronchoscopy and Interventional Pulmonology, Hershey, PA
[2]The Johns Hopkins University School of Medicine, Division of Pulmonary and Critical Care Medicine, Interventional Pulmonary, Baltimore, MD

Christopher R. Gilbert, D.O., M.S. (corresponding author)
Penn State College of Medicine-Milton S. Hershey Medical Center
Department of Pulmonary, Allergy, and Critical Care Medicine
Bronchoscopy and Interventional Pulmonology
Mail Code H0141
500 University Drive
Hershey, PA 17033-0850
cgilbert1@hmc.psu.edu
(T) 7175316525
(F) 7175315785

Running Head: TBNA Education of Pulmonary Fellows

Unstructured Abstract – 127
Manuscript Word Count – 1660
Tables/Figures – 0
References – 71

There is no funding available for this study. All work and manuscript writing was performed at The Penn State College of Medicine and The Johns Hopkins School of Medicine. There are no disclosures or potential conflicts of interest related to this work.

CRG is the guarantor of this manuscript, taking responsibility for the integrity of the work as a whole, from inception to published article. CRG, LY, and DFK all contributed in manuscript writing and review.

Dr. Gilbert has no conflicts of interest related to this manuscript.
Dr. Yarmus has no conflicts of interest related to this manuscript.
Dr. Feller-Kopman has no conflicts of interest related to this manuscript.

ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

Abstract

Transbronchial needle aspiration remains an invaluable diagnostic tool in the evaluation of mediastinal and hilar abnormalities, specifically in the evaluation of patients with lung cancer. Training in transbronchial needle aspiration has remained integral in pulmonary fellowship programs, but unfortunately the training methods, volumes, and outcomes have been variable. This has subsequently led to wide variations in practice patterns, diagnostic yield, and operator confidence. The introduction of endobronchial ultrasound guided transbronchial needle aspiration appears to have stimulated a resurgence in training and performance of transbronchial needle aspiration. However, with this new technology many questions have surfaced regarding training methods, volumes, and who should receive training. Within this context, we describe the history, current state, and future directions of the education of transbronchial needle aspiration during pulmonary fellowship training.

Conventional transbronchial needle aspiration (cTBNA) and endobronchial ultrasound guided-transbronchial needle aspiration (EBUS-TBNA) have revolutionized the evaluation and management of patients with intrathoracic lymphadenopathy, including those with suspected lung cancer. The initial descriptions of cTBNA via flexible bronchoscopy by Dr. Ko Pen Wang(1-4) led to widespread dissemination of the technique and subsequent training of the next generation of pulmonary fellows in TBNA.

Diagnostic bronchoscopy, including the performance of transbronchial needle aspiration remains an important procedural competency in the field of pulmonary medicine(5), yet no clear recommendations exist regarding fellow education, whereas general procedural number based competencies exist from sub-specialty societies(6, 7). As described in a recent commentary, debate still exists over the current role of cTBNA and EBUS-TBNA education(8). We sought to describe the current state of TBNA education and offer suggestions for the future training of pulmonary and interventional pulmonary fellows.

History of Transbronchial Needle Aspiration Training

Literature pertaining to the education of pulmonary fellows in endoscopy prior to the 1990's is relative sparse. In the late 1990's and early 2000's a number of surveys and review articles became available suggesting that training in flexible bronchoscopic procedures existed, however clear inadequacies were identified, specifically in regards to the education and underutilization of cTBNA(9-11).

ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

Current State of Transbronchial Needle Aspiration Training

Training in TBNA has remained a tenet of basic diagnostic bronchoscopy and cTBNA continues to be taught in the majority of PCCM fellowship programs(12), however surveys demonstrate that bronchoscopy education remains quite variable, including the instruction of TBNA(12-14). Surveys also indicate that cTBNA remains a poorly practiced procedure during and after fellowship(9, 10, 14, 15). Many experts have offered potential explanation including poor diagnostic yields, inability to target small lymph nodes, fear of injuring major vessels or the bronchoscope, and inadequate teaching(9, 16-18).

As noted above, cTBNA continued to remain a requirement for ACGME fellowship training however in the mid to late 2000's EBUS-TBNA, a novel alteration of the TBNA procedure was introduced. The use of EBUS-TBNA has revolutionized the approach to patients with intrathoracic lymphadenopathy(19-22), demonstrating comparable and in some studies, superior results to mediastinascopy (19, 23, 24), a fact that cTBNA has never been able to claim.

This resultant change occurring in many high-volume centers has also impacted the education and exposure of cTBNA in PCCM trainees. In 2005, EBUS-TBNA was offered in only 2% of pulmonary training programs(12), but by 2012 that number had skyrocketed to 89%(25). Some centers appear to be teaching EBUS-TBNA in addition to, or in place of cTBNA(25), and a recent study identified that the introduction of an EBUS-TBNA program leads to a

decrease in the number of opportunities for pulmonary fellows to perform cTBNA(26).

Although debate will continue, EBUS-TBNA is firmly established and should be the standard for TBNA sampling of intrathoracic lymphadenopathy and centrally located lesions. Detractors will continue to promote the “benefits” of cTBNA such as low cost, ease of performance and training, as well as diagnostic yield(8, 27).

The Future of Transbronchial Needle Aspiration Training

The American Thoracic Society Task Force on Competencies in Pulmonary and Critical Care Medicine, has recommended the teaching of TBNA as a procedure requiring attention(5). This statement outlines the need for TBNA training to include the appropriate knowledge and procedural skills fundamental to the practice of TBNA, with proficiency or expertise in the procedure being expected at the completion of pulmonary fellowship training (with no description of cTBNA versus EBUS-TBNA). We enthusiastically agree with a need for proper training in TBNA skills of fellows, however, remain concerned in the face of data that basic TBNA skills are not widely taught to pulmonary fellows during their training(12, 25). The authors strongly believe that every pulmonary fellow needs to understand the importance of lymph node staging in lung cancer, mediastinal anatomy, the appropriate evaluation of the pulmonary nodule, and demonstrate an understanding of the risks, benefits, alternatives, and limitations of TBNA, EBUS-TBNA, mediastinoscopy and thoracic surgery in in patients with

ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

intrathoracic abnormalities. Upon completion of fellowship, graduates should also understand the importance of appropriate referrals to other colleagues / institutions if they do not possess the skills or institutional support to perform this evaluation themselves.

If TBNA is to be taught to our pulmonary fellows, how is this best accomplished? The mentor-mentee relationship remains important, however the old model of see one, do one, teach one is more than likely not the best paradigm(28, 29). Numerous studies and new evaluation tools have been recently published, utilizing the help of simulation(30-35), didactic lectures(33, 36, 37), and validated assessment tools(33, 37). The introduction of the B-STAT / EBUS-STAT training and evaluation modules now offer objective evaluation of trainees' performance as well as standardized nationwide evaluation(33, 37). It would be ideal to develop a standardized curriculum that addresses the necessary knowledge base, procedural and infrastructure requirements that will lead to improved patient care.

The use of ultrasound continues to demonstrate advantages in various fields of medical care. Invasive procedures previously taught utilizing "landmark" techniques have, for good or bad, become antiquated. The evolving role of ultrasound in guidance for procedures such as thoracentesis(38), paracentesis(39), arthrocentesis(40), and central line placement(41, 42) have all demonstrated better outcomes and decreased complication rates. Detractors have often cited concerns for over-reliance on technology and although this

cannot be entirely discounted, the data clearly demonstrates improved outcomes with the use of ultrasound guided techniques.

We believe the future of TBNA training lies in EBUS-TBNA education. EBUS-TBNA remains a safe, efficient tool, demonstrating excellent diagnostic yield, accuracy and overall performance, even when compared to surgical sampling (43, 44). EBUS-TBNA offers a significant advantage in the learner-teacher relationship. The visualization of the learner inserting the needle into the correct (or potentially incorrect) area provides immediate feedback to both the learner and teacher. This type of teaching situation has demonstrated its importance in resident teaching (45, 46).

The Future of EBUS-TBNA Training

EBUS-TBNA is a procedure that most pulmonologists and thoracic surgeons can perform, however current recommendations for EBUS-TBNA competency/proficiency remain a work in progress(6, 7, 25, 47-50). It remains well accepted that numbers alone do not define competency and data suggests that learning curves for EBUS-TBNA vary widely among practitioners (18, 49-52), therefore the ability to provide adequate training volumes in addition to a structured curriculum within a teaching institution remains paramount.

If the often proposed 50 EBUS-TBNA procedures remains the identified benchmark for competency, this may prove difficult for many pulmonary fellows. In 2012, 423 new applicants matched into pulmonary and critical care fellowship programs within the United States(53). In order to accomplish the 50 EBUS-

ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

TBNA procedures for each new fellow, over 21,150 TBNA procedures would need to be available. Review of one of the largest diagnostic bronchoscopy registry's available (AQuIRE Diagnostic Bronchoscopy Registry) notes that even some "high volume" centers may have difficulty doing more than 200 cases per year(54), enough to only support four fellows. This remains concerning because of two additional points, 1) A 2012 survey of fellowship programs offering EBUS-TBNA noted 93% were performing <50 cases per year(25), 2) Many fellows (more than 30%) are not even obtaining 25 TBNA procedures at completion of their training (12).

Considering the above data, and although disappointing to some, we believe that it will be impossible to train *all* PCCM fellows to become technically proficient in TBNA skills (EBUS-TBNA and cTBNA) at the completion of their PCCM fellowship. This concept is not new to procedural based medicine specialties as the American Society for Gastrointestinal Endoscopy has previously acknowledged "not all trainees should pursue…nor should all programs offer advanced training", and that "…training should be concentrated in those programs that have a combination of both patient volume and faculty expertise."(55) It appears that not all fellows will be able to receive the appropriate time, supervision, and caseload at all institutions to be proficient in TBNA – cTBNA and/or EBUS-TBNA.

The Role of Interventional Pulmonology

Although not well studied, the presence of an Interventional Pulmonology (IP) program most likely also has an impact on the education of PCCM fellows. There are currently 26 programs within the United States offering advanced training in Interventional Pulmonology (53, 56, 57). Data suggests that the presence of an IP program leads to an increased volume of procedures, including cTBNA and EBUS-TBNA (25, 26), also identified as a marker of proficiency and improved outcomes(54). We suggest that the exposure of PCCM fellows to the various basic and advanced diagnostic bronchoscopy skills brought by IP training programs will complement and enhance their training, however there are currently no data to support this statement.

Cost of TBNA

The use of cTBNA is often marketed as a low cost and widely available tool (8, 58, 59) compared to EBUS-TBNA. While standard TBNA needles are available at most institutions the data clearly demonstrates that cTBNA training does not lead to widespread availability and successful practice of cTBNA(9, 10). Though the initial investment to establish an EBUS-TBNA program is not insignificant(60), the cost associated with non-diagnostic or incomplete mediastinal staging from cTBNA procedures cannot be discounted(61, 62). It also appears that data continues to demonstrate improved diagnostic yields in higher volume EBUS-TBNA centers(54) with numerous other studies suggesting procedural volumes impact outcomes (54, 63-71). We therefore believe that while TBNA training is important in the education of pulmonary fellows, the

ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

improved patient outcomes and greater diagnostic yield of EBUS TBNA in high volume centers trumps the otherwise laudable desire to provide such education in cTBNA, and efforts should be focused on teaching lymph node anatomy and the importance of mediastinal staging.

Conclusion

The authors believe that the current state of TBNA training remains problematic in that there is an inherent lack of effective teaching standards and global volume to support mastering this technique throughout all training programs. Dedicated techniques including simulation in conjunction with adequate center based volumes are essential in creating a successful clinical TBNA program. We hope these more objective education and testing methods continue to gain in popularity and become accepted in future procedural guidelines.

References

1. Wang KP, Terry P, Marsh B. Bronchoscopic needle aspiration biopsy of paratracheal tumors. Am Rev Respir Dis. 1978;118(1):17-21.
2. Wang KP, Marsh BR, Summer WR, Terry PB, Erozan YS, Baker RR. Transbronchial needle aspiration for diagnosis of lung cancer. Chest. 1981;80(1):48-50.
3. Wang KP, Terry PB. Transbronchial needle aspiration in the diagnosis and staging of bronchogenic carcinoma. Am Rev Respir Dis. 1983;127(3):344-7.
4. Wang KP, Brower R, Haponik EF, Siegelman S. Flexible transbronchial needle aspiration for staging of bronchogenic carcinoma. Chest. 1983;84(5):571-6.
5. Buckley JD, Addrizzo-Harris DJ, Clay AS, Curtis JR, Kotloff RM, Lorin SM, et al. Multisociety Task Force Recommendations of Competencies in Pulmonary and Critical Care Medicine. American Journal of Respiratory and Critical Care Medicine. 2009;180(4):290-5.
6. Bolliger C, Mathur P, Beamis J, Becker H, Cavaliere S, Colt H, et al. ERS/ATS Statement on interventional pulmonology. Eur Respir J. 2002;19:356-73.
7. Ernst A, Silvestri GA, Johnstone D, American College of Chest P. Interventional pulmonary procedures: Guidelines from the American College of Chest Physicians. Chest. 2003;123(5):1693-717.
8. Mehta AC, Wang KP. Teaching conventional transbronchial needle aspiration. A continuum. Ann Am Thorac Soc. 2013;10(6):685-9.
9. Haponik EF, Shure D. Underutilization of transbronchial needle aspiration: experiences of current pulmonary fellows. Chest. 1997;112(1):251-3.
10. Haponik EF, Russell GB, Beamis JF, Jr., Britt EJ, Kvale P, Mathur P, et al. Bronchoscopy training: current fellows' experiences and some concerns for the future. Chest. 2000;118(3):625-30.
11. Kvale PA, Mehta AC. Training bronchoscopists for the new era. Clin Chest Med. 2001;22(2):365-72, ix.
12. Pastis NJ, Nietert PJ, Silvestri GA. Variation in training for interventional pulmonary procedures among US pulmonary/critical care fellowships: a survey of fellowship directors. Chest. United States; 2005:1614-21.
13. Lucarelli MR, Lucey CR, Mastronarde JG. Survey of current practices in fellowship orientation. Respiration. 2007;74(4):382-6.
14. Stather DR, Jarand J, Silvestri GA, Tremblay A. An evaluation of procedural training in Canadian respirology fellowship programs: program directors' and fellows' perspectives. Can Respir J. 2009;16(2):55-9.
15. Prakash UB, Offord KP, Stubbs SE. Bronchoscopy in North America: the ACCP survey. Chest. 1991;100(6):1668-75.
16. Hsu LH, Liu CC, Ko JS. Education and experience improve the performance of transbronchial needle aspiration: a learning curve at a cancer center. Chest. 2004;125(2):532-40.
17. Chin R, Jr., McCain TW, Lucia MA, Cappellari JO, Adair NE, Lovato JF, et al. Transbronchial needle aspiration in diagnosing and staging lung cancer: how many aspirates are needed? Am J Respir Crit Care Med. 2002;166(3):377-81.

ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

18. Hermens FHW, Limonard GJM, Termeer R, van den Berg W, Visser FJ, Hol BEA, et al. Learning Curve of Conventional Transbronchial Needle Aspiration in Pulmonologists Experienced in Bronchoscopy. Respiration. 2008;75(2):189-92.
19. Annema JT, van Meerbeeck JP, Rintoul RC, Dooms C, Deschepper E, Dekkers OM, et al. Mediastinoscopy vs endosonography for mediastinal nodal staging of lung cancer: a randomized trial. JAMA. United States; 2010:2245-52.
20. Yasufuku K, Pierre A, Darling G, de Perrot M, Waddell T, Johnston M, et al. A prospective controlled trial of endobronchial ultrasound-guided transbronchial needle aspiration compared with mediastinoscopy for mediastinal lymph node staging of lung cancer. Journal of Thoracic and Cardiovascular Surgery. 2011;142:1393-400.
21. De Leyn P, Lardinois D, Van Schil PE, Rami-Porta R, Passlick B, Zielinski M, et al. ESTS guidelines for preoperative lymph node staging for non-small cell lung cancer. Eur J Cardiothorac Surg. Germany; 2007:1-8.
22. Silvestri GA, Gonzalez AV, Jantz MA, Margolis ML, Gould MK, Tanoue LT, et al. Methods for staging non-small cell lung cancer: Diagnosis and management of lung cancer, 3rd ed: american college of chest physicians evidence-based clinical practice guidelines. CHEST Journal. 2013;143(5_suppl):e211S-e50S.
23. Sharples LD, Jackson C, Wheaton E, Griffith G, Annema JT, Dooms C, et al. Clinical effectiveness and cost-effectiveness of endobronchial and endoscopic ultrasound relative to surgical staging in potentially resectable lung cancer: results from the ASTER randomised controlled trial. Health Technol Assess. 2012;16(18):1-75, iii-iv.
24. Tournoy KG, De Ryck F, Vanwalleghem LR, Vermassen F, Praet M, Aerts JG, et al. Endoscopic ultrasound reduces surgical mediastinal staging in lung cancer: a randomized trial. Am J Respir Crit Care Med. 2008;177(5):531-5.
25. Tanner N, Pastis NJ, Silvestri GA**.** Training for Linear Endobronchial Ultrasound among US Pulmonary/Critical Care fellowships. Chest. 2013;143(2):423-8.
26. Feller-Kopman DJ, Brigham E, Lechtzin N, Gilbert C, Akulian J, Yarmus L**.** Training perspective. Ann Am Thorac Soc. 2013;10(2):127-30.
27. Huang JA, Browning R, Wang KP**.** Counterpoint: Should endobronchial ultrasound guide every transbronchial needle aspiration of lymph nodes? No. Chest. 2013;144(3):734-7.
28. Lenchus JD**.** End of the “See One, Do One, Teach One” Era: The Next Generation of Invasive Bedside Procedural Instruction. JAOA: Journal of the American Osteopathic Association. 2010;110(6):340-6.
29. Rodriguez-Paz JM, Kennedy M, Salas E, Wu AW, Sexton JB, Hunt EA, et al. Beyond "see one, do one, teach one": toward a different training paradigm. Postgraduate Medical Journal. 2009;85(1003):244-9.
30. Colt HG, Crawford SW, Galbraith O, 3rd**.** Virtual reality bronchoscopy simulation: a revolution in procedural training. Chest. 2001;120(4):1333-9.
31. OST D, DE ROSIERS A, BRITT EJ, FEIN AM, LESSER ML, MEHTA AC**.** Assessment of a Bronchoscopy Simulator. American Journal of Respiratory and Critical Care Medicine. 2001;164(12):2248-55.

32. Davoudi M, Wahidi MM, Zamanian Rohani N, Colt HG. Comparative Effectiveness of Low- and High-Fidelity Bronchoscopy Simulation for Training in Conventional Transbronchial Needle Aspiration and User Preferences. Respiration. 2010;80(4):327-34.
33. Wahidi MM, Silvestri GA, Coakley RD, Ferguson JS, Shepherd RW, Moses L, et al. A Prospective Multicenter Study of Competency Metrics and Educational Interventions in the Learning of Bronchoscopy Among New Pulmonary Fellows. CHEST Journal. 2010;137(5):1040-9.
34. Stather DR, Lamb CR, Tremblay A. Simulation in flexible bronchoscopy and endobronchial ultrasound: a review. J Bronchology Interv Pulmonol. 2011;18(3):247-56.
35. Stather DR, Mac Eachern P, Chee A, Dumoulin E, Tremblay A. Evaluation of clinical endobronchial ultrasound skills following clinical versus simulation training. Respirology. 2012;17(2):291-9.
36. Unroe MA, Shofer SL, Wahidi MM. Training for endobronchial ultrasound: methods for proper training in new bronchoscopic techniques. Curr Opin Pulm Med. 2010;16(4):295-300.
37. Davoudi M, Colt HG, Osann KE, Lamb CR, Mullon JJ. Endobronchial Ultrasound Skills and Tasks Assessment Tool: Assessing the Validity Evidence for a Test of Endobronchial Ultrasound-guided Transbronchial Needle Aspiration Operator Skill. American Journal of Respiratory and Critical Care Medicine. 2012;186(8):773-9.
38. Diacon AH, Brutsche MH, Soler M. Accuracy of pleural puncture sites: a prospective comparison of clinical examination with ultrasound. Chest. 2003;123(2):436-41.
39. Nazeer SR, Dewbre H, Miller AH. Ultrasound-assisted paracentesis performed by emergency physicians vs the traditional technique: a prospective, randomized study. The American Journal of Emergency Medicine. 2005;23(3):363-7.
40. Sibbitt W, Kettwich L, Band P, Chavez-Chiang N, DeLea S, Haseler L, et al. Does ultrasound guidance improve the outcomes of arthrocentesis and corticosteroid injection of the knee? Scandinavian Journal of Rheumatology. 2012;41(1):66-72.
41. Miller AH, Roth BA, Mills TJ, Woody JR, Longmoor CE, Foster B. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. Acad Emerg Med. 2002;9(8):800-5.
42. Froehlich CD, Rigby MR, Rosenberg ES, Li R, Roerig P-LJ, Easley KA, et al. Ultrasound-guided central venous catheter placement decreases complications and decreases placement attempts compared with the landmark technique in patients in a pediatric intensive care unit*. Critical Care Medicine. 2009;37(3):1090-6.
43. Gu P, Zhao Y-Z, Jiang L-Y, Zhang W, Xin Y, Han B-H. Endobronchial ultrasound-guided transbronchial needle aspiration for staging of lung cancer: A systematic review and meta-analysis. European Journal of Cancer. 2009;45(8):1389-96.

ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

44. Wallace MB, Pascual JM, Raimondo M, Woodward TA, McComb BL, Crook JE, et al. Minimally invasive endoscopic staging of suspected lung cancer. JAMA. 2008;299(5):540-6.
45. Jensen AR, Wright AS, Kim S, Horvath KD, Calhoun KE. Educational feedback in the operating room: a gap between resident and faculty perceptions. Am J Surg. 2012;204(2):248-55.
46. Yarris LM, Fu R, LaMantia J, Linden JA, Gene Hern H, Lefebvre C, et al. Effect of an educational intervention on faculty and resident satisfaction with real-time feedback in the emergency department. Acad Emerg Med. 2011;18(5):504-12.
47. Folch E, Majid A. Point: Are greater than 50 supervised procedures required to develop competency in performing endobronchial ultrasound-guided transbronchial needle aspiration for mediastinal staging? yes. CHEST Journal. 2013;143(4):888-91.
48. Kinsey CM, Channick CL. Counterpoint: Are >50 supervised procedures required to develop competency in performing endobronchial ultrasound-guided transbronchial needle aspiration for lung cancer staging? no. CHEST Journal. 2013;143(4):891-3.
49. Kemp SV, El Batrawy SH, Harrison RN, Skwarski K, Munavvar M, Roselli A, et al. Learning curves for endobronchial ultrasound using cusum analysis. Thorax. 2010;65(6):534-8.
50. Wahidi MM, Hulett C, Pastis N, Shepherd RW, Shofer SL, Mahmood K, et al. LEarning experience of linear endobronchial ultrasound among pulmonary trainees. CHEST Journal. 2014;145(3):574-8.
51. 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. The Annals of Thoracic Surgery. 2008;86(4):1104-10.
52. Abu-Hijleh M, El-Sameed Y, Eldridge K, Vadia E, Chiu H, Dreyfuss Z, et al. Linear Probe Endobronchial Ultrasound Bronchoscopy with Guided Transbronchial Needle Aspiration (EBUS–TBNA) in the Evaluation of Mediastinal and Hilar Pathology: Introducing the Procedure to a Teaching Institution. Lung. 2013;191(1):109-15.
53. Program NRM. About Medical Specialties Matching Program (MSMP).
54. Ost DE, Ernst A, Lei X, Feller-Kopman D, Eapen GA, Kovitz KL, et al. Diagnostic Yield of Endobronchial Ultrasound-Guided Transbronchial Needle Aspiration: Results of the AQuIRE Bronchoscopy Registry. CHEST Journal. 2011;140(6):1557-66.
55. Eisen GM, Dominitz JA, Faigel DO, Goldstein JL, Kalloo AN, Petersen BT, et al. Guidelines for advanced endoscopic training. Gastrointest Endosc. 2001;53(7):846-8.
56. Pulmonology AAoBaI. Membership in AABIP. 2012.
57. Lamb CR, Feller-Kopman D, Ernst A, Simoff MJ, Sterman DH, Wahidi MM, et al. An approach to interventional pulmonary fellowship training. Chest. 2010;137(1):195-9.

58. Crocket JA, Wong EY, Lien DC, Nguyen KG, Chaput MR, McNamee C. Cost effectiveness of transbronchial needle aspiration. Can Respir J. 1999;6(4):332-5.
59. Medford AR, Agrawal S, Free CM, Bennett JA. A prospective study of conventional transbronchial needle aspiration: performance and cost utility. Respiration. 2010;79(6):482-9.
60. Pastis NJ, Simkovich S, Silvestri GA. Understanding the economic impact of introducing a new procedure: calculating downstream revenue of endobronchial ultrasound with transbronchial needle aspiration as a model. Chest. 2012;141(2):506-12.
61. Wahidi MM, Yasufuku K. Point: Should endobronchial ultrasound guide every transbronchial needle aspiration of lymph nodes? yes. CHEST Journal. 2013;144(3):732-4.
62. Grove DA, Bechara RI, Josephs JS, Berkowitz DM. Comparative cost analysis of endobronchial ultrasound-guided and blind TBNA in the evaluation of hilar and mediastinal lymphadenopathy. J Bronchology Interv Pulmonol. 2012;19(3):182-7.
63. Adamczyk P, Attenello F, Wen G, He S, Russin J, Sanossian N, et al. Mechanical Thrombectomy in Acute Stroke: Utilization Variances and Impact of Procedural Volume on Inpatient Mortality. J Stroke Cerebrovasc Dis. 2012.
64. Markar SR, Penna M, Karthikesalingam A, Hashemi M. The impact of hospital and surgeon volume on clinical outcome following bariatric surgery. Obes Surg. 2012;22(7):1126-34.
65. Wouters MW, Gooiker GA, van Sandick JW, Tollenaar RA. The volume-outcome relation in the surgical treatment of esophageal cancer: a systematic review and meta-analysis. Cancer. 2012;118(7):1754-63.
66. Holzhey DM, Seeburger J, Misfeld M, Borger MA, Mohr FW. Learning minimally invasive mitral valve surgery: a cumulative sum sequential probability analysis of 3895 operations from a single high-volume center. Circulation. 2013;128(5):483-91.
67. West RM, Cattle BA, Bouyssie M, Squire I, de Belder M, Fox KA, et al. Impact of hospital proportion and volume on primary percutaneous coronary intervention performance in England and Wales. Eur Heart J. 2011;32(6):706-11.
68. LaPar DJ, Bhamidipati CM, Lau CL, Jones DR, Kozower BD. The Society of Thoracic Surgeons General Thoracic Surgery Database: establishing generalizability to national lung cancer resection outcomes. Ann Thorac Surg. 2012;94(1):216-21; discussion 21.
69. Ellis MC, Diggs BS, Vetto JT, Schipper PH. Intraoperative oncologic staging and outcomes for lung cancer resection vary by surgeon specialty. Ann Thorac Surg. 2011;92(6):1958-63; discussion 63-4.
70. Pata G, Casella C, Nascimbeni R, Cirillo L, Salerni B. Modifiable risk factors in colorectal surgery: central role of surgeon's volume. Ann Ital Chir. 2008;79(6):427-32; discussion 32-3.

ANNALSATS Articles in Press. Published on 24-April-2014 as 10.1513/AnnalsATS.201403-112OI

71. Cheung MC, Koniaris LG, Perez EA, Molina MA, Goodwin WJ, Salloum RM. Impact of hospital volume on surgical outcome for head and neck cancer. Ann Surg Oncol. 2009;16(4):1001-9.