

Pleural Ultrasound for Detection of Postbronchoscopy Pneumothorax in Lung Transplant Recipients

Nilam J. Soni, MD, MS,*† Robert E. Winsett, DO,* Maria I. Velez, MD,*
Preeti Singhal, MD,‡ Kevin C. Proud, MD,*§ Ali Abedi, MD,*
Marcos I. Restrepo, MD, MS, PhD,*§ and Luis F. Angel, MD§

Key Words: lung transplantation, ultrasound, pneumothorax, bronchoscopy

(*J Bronchol Intervent Pulmonol* 2021;00:000–000)

Pleural ultrasound is a well-established modality for ruling out pneumothorax,^{1,2} including postbronchoscopy pneumothorax.^{3–5} Currently, some bronchoscopists use pleural ultrasound to assess for postbronchoscopy pneumothorax in lung transplant recipients, but the accuracy of this approach has not been well studied. One study demonstrated a pleural ultrasound examination 2 hours postbronchoscopy can rule out pneumothorax in lung transplant recipients; however, waiting 2 hours postbronchoscopy limits the

practicality of implementing this study's approach.⁶ To determine whether an *immediate* postbronchoscopy pleural ultrasound examination can accurately rule out pneumothorax in lung transplant recipients in a clinical practice setting, we reviewed pleural ultrasound examinations of lung transplant recipients postbronchoscopy at our institution.

METHODS

A retrospective observational study of adult lung transplant recipients who underwent a bronchoscopy with multiple transbronchial biopsies that included an immediate prebronchoscopy and postbronchoscopy pleural ultrasound examination was conducted. Inclusion criteria included age above 18 years; history of lung transplantation; performance of a fiberoptic bronchoscopy for routine surveillance or clinical indications; and sampling of 8 to 10 peripheral transbronchial biopsies from the right upper, middle, and lower lobes. Exclusion criteria included lack of available prebronchoscopy and postbronchoscopy pleural ultrasound images; preexisting pneumothorax; and lack of an available postbronchoscopy chest x-ray (CXR). The University of Texas Health—San Antonio's Investigational Review Board approved this study (HSC20160258H).

Pleural ultrasound images were acquired by 2 academic interventional pulmonologists proficient in point-of-care ultrasound using a high-frequency linear-array transducer on a single portable ultrasound machine (Sonosite Edge; L-38 10–5 MHz transducer; Bothell, WA). Using a vascular preset, longitudinal views of the pleura were acquired along the right mid-clavicular line from the clavicle to the diaphragm. Both B-mode and M-mode ultrasound video clips and still images, respectively, were acquired immediately pre-bronchoscopy and postbronchoscopy (<10 min) with the subject in a supine position on the bronchoscopy table.

Received for publication February 10, 2021; accepted July 6, 2021.

From the *Division of Pulmonary Diseases & Critical Care Medicine, University of Texas Health—San Antonio; †Section of Pulmonary Medicine, South Texas Veterans Health Care System, San Antonio, TX; ‡Department of Medicine, University of Southern California, Los Angeles, CA; and §Division of Pulmonary, Critical Care, and Sleep Medicine, NYU Langone Health, New York, NY.

R.E.W., M.I.V., L.F.A., P.S., K.C.P., A.A., M.I.R., and N.J.S.: contributed substantially to the study design, data analysis and interpretation, and writing of the manuscript. M.I.V., L.F.A., and A.A.: performed lung ultrasound examinations. N.J.S. and K.C.P.: reviewed all ultrasound images of each subject. N.J.S.: has full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Previously presented as an abstract at the American Thoracic Society Conference 2020, May 15–20, 2020, Virtual Meeting.

N.J.S. receives funding from the US Department of Veterans Affairs, Quality Enhancement Research Initiative (QUERI) Partnered Evaluation Initiative Grant (HX002263-01A1). This material is the result of work supported with resources and the use of facilities at the South Texas Veterans Health Care System in San Antonio, TX. The contents do not represent the views of the US Department of Veterans Affairs or the United States Government.

Disclosure: There is no conflict of interest or other disclosures.

Reprints: Nilam J. Soni, MD, MS, University of Texas Health—San Antonio, South Texas Veterans Health Care System, 7703 Floyd Curl Drive, MC 7885, San Antonio, TX 78229 (e-mail: sonin@uthscsa.edu).

Copyright © 2021 The Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

DOI: 10.1097/LBR.0000000000000799

Images were interpreted independently by 3 blinded ultrasound expert reviewers, and disagreements were adjudicated by 2 study investigators. Pleural sliding was categorized as present, absent, or indeterminate. A pneumothorax was defined by an acute loss of pleural sliding from prebronchoscopy to postbronchoscopy on B-mode or M-mode images or detection of a lung point. Presence of pleural sliding, comet-tails, or lung pulse ruled out pneumothorax. All subjects underwent a postbronchoscopy 1-view anterior-posterior CXR, followed by either 1-view or 2-view CXRs during their first follow-up visit. Pneumothoraces were categorized as small (<15%) versus large (≥15%) on CXR using a formula described by Collins et al.⁷

RESULTS

A total of 206 bronchoscopies with transbronchial biopsies performed on adult lung transplant recipients were reviewed. Ten subjects were excluded for preexisting pneumothoraces, lack of available ultrasound images, or non-performance of transbronchial biopsies. Data were analyzed from 196 subjects.

The mean age of the subjects was 54 years, and 51% were male. Most bronchoscopies were for surveillance (73%), and 53% of subjects were >90 days postlung transplantation.

The incidence of postbronchoscopy pneumothorax was 5.6% (n=11). Of the 11 pneumothoraces, 3 (27%) were diagnosed immediately (<10 min) postbronchoscopy by ultrasound, 4 (36%) were diagnosed early (10 min to 3 h) by CXR, and 4 (36%) were delayed diagnoses (≥3 h) (Fig. 1).

Most postbronchoscopy pneumothoraces (55%) were managed expectantly. Tube thoracostomy was required in 2 of 3 subjects with an immediate pneumothorax (<10 min) detected by pleural ultrasound and 3 of 4 subjects with a delayed pneumothorax (≥3 h) detected by CXR.

DISCUSSION

Our study is the largest retrospective review of postbronchoscopy pneumothorax in lung transplant recipients in the United States and the first to report findings of an *immediate* postbronchoscopy pleural ultrasound examination to rule out pneumothorax. An immediate postbronchoscopy pleural ultrasound examination detected 3 pneumothoraces but may have missed

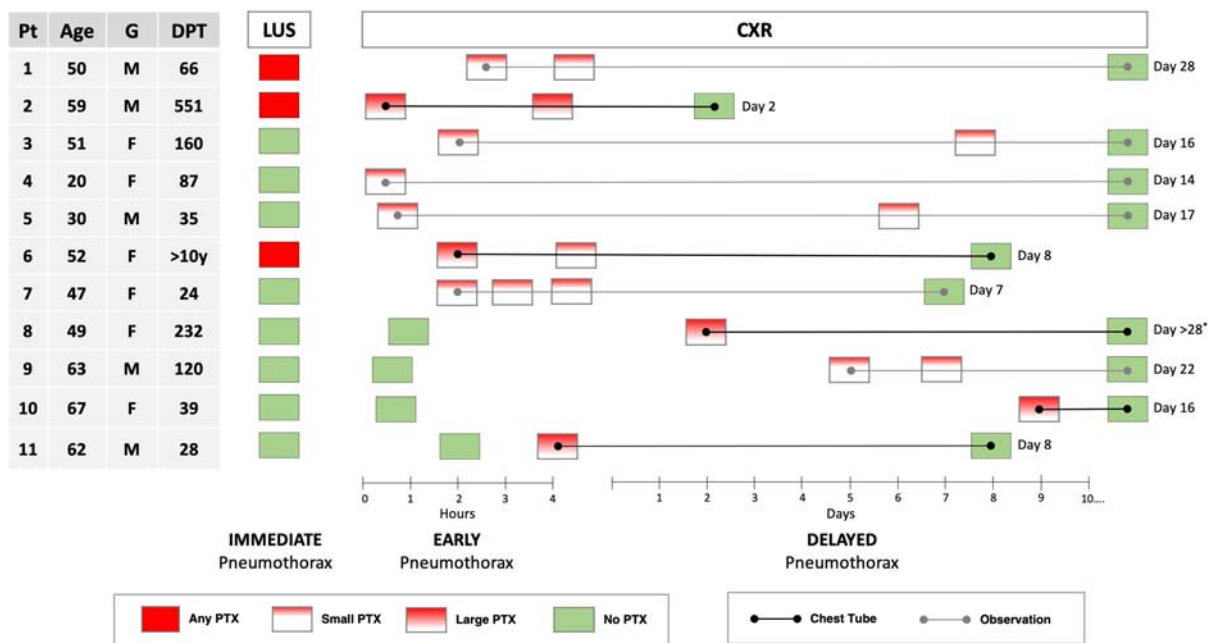


FIGURE 1. LUS and CXR for detection of immediate, early, and delayed PTXs postbronchoscopy in lung transplant recipients. An immediate postbronchoscopy LUS examination detected 3 early PTXs (<10 min), and 2 of these were large and required tube thoracostomy. CXR detected 4 early PTXs (10 min to 3 h) that were small, and none required tube thoracostomy. Delayed PTXs (≥3 h) were seen in 4 subjects, and 3 required tube thoracostomy. Day of resolution of the PTX is noted to the right of each line. Large PTX was defined by size >15% using Collins formula.⁷ *Heimlich valve placed and resolved after >4 weeks on CXR. CXR indicates chest x-ray; DPT, days postlung transplant; F, female; G, gender; LUS, lung ultrasound; M, male; Pt, patient; PTX, pneumothorax.

4 small pneumothoraces that were detected by CXR within 3 hours postbronchoscopy. Most delayed pneumothoraces were detected a few days postbronchoscopy and were large in size requiring tube thoracostomy.

Few studies have reported the incidence of postbronchoscopy pneumothorax among lung transplant recipients undergoing transbronchial biopsies. Our study found an incidence of 5.6%, while another study reported an incidence of 9.6% in this population.⁶

Pleural ultrasound has demonstrated higher sensitivity and similar specificity compared with CXR for diagnosis of pneumothorax in general,² but few studies have assessed the accuracy of pleural ultrasound to detect postbronchoscopy pneumothorax.^{3,4,6} Compared with one study that included lung transplant recipients, our study had a lower sensitivity of pleural ultrasound for detecting immediate or early pneumothoraces (43% vs. 75%). This difference may be explained by the delay between the pleural ultrasound examination and CXR in our study which allowed pleural air to accumulate in patients with slow air leaks. Whether serial pleural ultrasound examinations can detect small postprocedure pneumothoraces should be evaluated in future studies.

Approximately one third of pneumothoraces were delayed (> 3 h), and neither the immediate pleural ultrasound examination nor initial postbronchoscopy CXR detected these pneumothoraces. Most important, 3 of the 4 subjects with delayed pneumothoraces required tube thoracostomy for several days.

Delayed pneumothoraces can have potentially life-threatening consequences. The right and left pleura are anatomically contiguous after lung transplantation, and a unilateral pneumothorax can rapidly expand bilaterally causing hemodynamic compromise. In addition, patients that use noninvasive positive pressure ventilation can develop a tension pneumothorax requiring emergent decompression. Lung transplant patients often travel long distances to transplant centers, and delayed pneumothoraces manifesting a few days postbronchoscopy can be challenging to promptly diagnose and manage. The literature on delayed pneumothorax after transbronchial biopsy is limited to case reports and warrants further investigation.⁸⁻¹⁰

Our study has limitations. As a retrospective study, pleural ultrasound and CXR were not

performed simultaneously at prespecified times postbronchoscopy; however, our findings represent the real-world experience of an active lung transplant center. Further, the pleural ultrasound examination was limited to scanning the right lung where biopsies were performed. Perhaps a more extensive pleural ultrasound examination could have detected additional small pneumothoraces that may have been missed.

In conclusion, an immediate postbronchoscopy pleural ultrasound examination can detect large pneumothoraces in lung transplant recipients. However, relatively slow air leaks leading to delayed pneumothoraces may be missed by an immediately postbronchoscopy pleural ultrasound examination. Delayed pneumothoraces are an important consideration in lung transplant recipients, and performing a pleural ultrasound examination just before discharging the patient may be the safest approach.

REFERENCES

1. Alrajab S, Youssef AM, Akkus NI, et al. Pleural ultrasonography versus chest radiography for the diagnosis of pneumothorax: review of the literature and meta-analysis. *Crit Care*. 2013;17:R208.
2. Ding W, Shen Y, Yang J, et al. Diagnosis of pneumothorax by radiography and ultrasonography: a meta-analysis. *Chest*. 2011;140:859–866.
3. Eisenmann S, Winantea J, Karpf-Wissel R, et al. Thoracic ultrasound for immediate exclusion of pneumothorax after interventional bronchoscopy. *J Clin Med*. 2020;9:1486.
4. Kumar S, Agarwal R, Aggarwal AN, et al. Role of ultrasonography in the diagnosis and management of pneumothorax following transbronchial lung biopsy. *J Bronchology Interv Pulmonol*. 2015;22:14–19.
5. Shostak E, Brylka D, Krepp J, et al. Bedside sonography for detection of postprocedure pneumothorax. *J Ultrasound Med*. 2013;32:1003–1009.
6. Bensted K, McKenzie J, Havryk A, et al. Lung ultrasound after transbronchial biopsy for pneumothorax screening in post-lung transplant patients. *J Bronchology Interv Pulmonol*. 2018;25:42–47.
7. Collins CD, Lopez A, Mathie A, et al. Quantification of pneumothorax size on chest radiographs using interpleural distances: regression analysis based on volume measurements from helical CT. *AJR Am J Roentgenol*. 1995;165:1127–1130.
8. Narula N, Siddiqui F, Siddiqui AH, et al. Delayed pneumothorax: a potential complication of transbronchial lung biopsy. *Respir Med Case Rep*. 2018;23:170–172.
9. Kwan AC, Pipavath S, Leary PJ, et al. Delayed pneumothorax after bronchoscopy in a lung transplant patient. *Respir Care*. 2013;58:e18–e19.
10. Levy H, Kallenbach JM, Feldman C, et al. Delayed pneumothorax after transbronchial lung biopsy. *Thorax*. 1986;41:647–648.