Bedside Ultrasound for the Interventional Pulmonologist

Kenneth E. Lyn-Kew, MD[a,*], Seth J. Koenig, MD[b]

KEYWORDS

• Ultrasound • Pleural effusion • Percutaneous tracheostomy • Thoracentesis • Lung ultrasound • Pleural ultrasound

KEY POINTS

- Thoracic ultrasonography allows the interventional pulmonologist to both identify and characterize pleural abnormalities while providing real-time guidance for therapeutic intervention. This reduces complications and improves opportunities for pleural drainage.
- Ultrasound allows the interventional pulmonologist to accurately and safely biopsy pleural-based masses.
- Ultrasound improves the safety of percutaneous tracheostomy by identifying aberrant anatomy.

Thoracic ultrasonography is a powerful diagnostic and therapeutic tool for the interventional pulmonologist (IP). Ultrasound allows for the rapid identification, characterization, and therapeutic decision making of thoracic disorders at the point of care. Thoracic ultrasonography allows the IP to strategically place all types of chest tubes and to needle biopsy pleural-based thoracic masses. Before percutaneous tracheostomy, ultrasound defines aberrant vasculature, such as a high-riding innominate artery, and allows direct visualization of needle insertion into the trachea. Preprocedural and postprocedural assessment for pneumothorax obviates the need for chest radiography, saving time, ionizing radiation exposure, and cost allocation. Thoracic ultrasonography is easy to perform and has a steep learning curve. This article summarizes the current literature regarding thoracic ultrasonography and specifically guides the IP in use of thoracic ultrasound for practical applications. The article supplements the text with ultrasound images from real cases, with the correlation of other imaging modalities when applicable.

INTRODUCTION

Thoracic ultrasound is an ideal imaging modality for the IP. It is portable, used at point of care by the treating physician, uses no ionizing radiation, and has no inherent delay between the ordering of an imaging study and its performance. Importantly, there is no clinical dissociation between the treating physician and the physician interpreting the imaging study. Common procedures for the IP include management of pleural effusions, assessment and biopsy of pleural-based masses, and percutaneous tracheostomy. Ultrasound allows the IP to diagnose, strategize, and perform these procedures at the point of care. This requires a paradigm shift in the approach to thoracic imaging, extends the physical examination, and allows the IP to better characterize disease processes. In conjunction with clinical history,

Funding Sources: None.
Conflict of Interest: None.
[a] Department of Medicine, National Jewish Health, 1400 Jackson Street, M320, Denver, CO 80206, USA; [b] Department of Medicine, Long Island Jewish Medical Center, Hofstra-North Shore Long Island Jewish Health System, 410 Lakeville Road, Suite 107, New Hyde Park, NY 11040, USA
* Corresponding author.
E-mail address: Lyn-KewK@NJHealth.org

Clin Chest Med 34 (2013) 473–485
http://dx.doi.org/10.1016/j.ccm.2013.04.004
0272-5231/13/$ – see front matter

physical examination, and other imaging modalities, such as chest radiography and chest computerized tomography (CT) scan, ultrasound will undoubtedly find its place for the IP.

MACHINE REQUIREMENTS

Modern day portable ultrasound machines are capable of performing all aspects of thoracic ultrasonography. With the expense of ultrasound machines rapidly dropping and the requirement of all pulmonary and critical care training programs to teach both guided vascular access and thoracentesis, ultrasound machines should be readily accessible. A phased array transducer (3.5–5.0 MHz) with a small "footprint" designed for cardiac imaging allows for most thoracic examinations. For detailed examination of the pleural surface, for instance to determine thoracic extension of a pleural-based mass, a high-frequency (7.5–10.0 MHz) linear vascular probe is necessary. This will optimize the near field structures but sacrifices the depth of ultrasound penetration needed for examination of alveolar consolidation, pleural-based masses, and pleural effusions. Doppler capability is not a requirement for comprehensive thoracic ultrasonography but may be helpful for evaluating vascular structures when performing biopsies and during the assessment of aberrant vessels before percutaneous dilational tracheostomy.

PERFORMANCE OF THORACIC ULTRASOUND

Thoracic ultrasonography is best performed with the patient in a seated position, although for the IP this may not always be practical, as in the instance of patients receiving mechanical ventilation. A longitudinal scanning plane is preferred with the transducer indicator held in the cephalad position. Standard machine setup for thoracic ultrasonography would mean that images on the left side of the screen would be cephalad structures. Knowledge of machine controls, such as gain and depth, must be adjusted to maximize image quality.

Image acquisition begins with firm perpendicular pressure applied to the chest wall over a rib interspace. Adjacent interspaces are then examined creating a longitudinal scan line. Multiple adjacent longitudinal scan lines are performed to create a 3-dimensional model of the thorax (**Fig. 1**). Abnormalities identified by the IP are then focused in on and may include the use of a high-frequency linear probe.

Bone blocks the transmission of ultrasound so focal abnormalities that lie under ribs may not be seen. By angling the transducer to "look" above or below the rib space, the sonographer may reveal the area of interest. Aerated lung also blocks transmission of ultrasound such that abnormalities that do not extend to the pleural line will remain "invisible." The use of the liver or spleen as an acoustic window may allow visualization of some parenchymal abnormalities. In addition, consolidated lung and pleural effusion transmit ultrasound well and may allow visualization of the mediastinum and lung.

Although the interventionalists are usually called to perform therapeutic or diagnostic procedures, as opposed to making diagnostic decisions on patients presenting with cardiopulmonary failure, thoracic ultrasound scanning techniques remain constant. For a more detailed overview of diagnostic strategies outside of the IP specialty, excellent reviews are available.[1]

LUNG ULTRASONOGRAPHY

The integration of lung ultrasound into the physical examination, other radiologic studies, and clinical history has great practical application to the pulmonologist. Immediate diagnostic information regarding a patient's symptoms and signs of thoracic pathology become apparent without delay or clinical dissociation between the treating physician and the physician performing the examination. Acute pulmonary edema, alveolar consolidation, pneumothorax, or pleural effusions are readily apparent. Although practical skill and knowledge of the acquisition and interpretation of lung ultrasound should be learned by the IP, this article focuses on the aspects of lung ultrasound particular for the IP. These include identification of pleural-based lung masses, lung abscess, differentiation of complex pleural disease from alveolar consolidation, and determination of postprocedure pneumothorax.

Dr Daniel Lichtenstein developed the standard seminology of lung ultrasound and his original work defined all the important findings of lung ultrasonography. Although he continues to define the field of lung ultrasonography, others have validated his previous work (**Fig. 2**).[2–6]

Performance of lung ultrasound begins at the pleural line. With the transducer placed over an interspace, the pleural line is identified approximately 5 mm deep to the rib cortex, with rib shadows on either side (**Fig. 3**). The pleural line appears as a shimmering echogenic linear structure and is examined for respirophasic or cardiac movement, representing movement of the visceral pleura against the parietal pleura. This movement is called lung sliding when derived from respiratory