Journal of Ultrasound (2008) 11, 39—46

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journal homepage: www.elsevier.com/locate/jus

Role of thoracic ultrasound in the assessment of pleural and pulmonary diseases

M. Sperandeo [a,*], P. Filabozzi [a], A. Varriale [a], V. Carnevale [a], M.L. Piattelli [a], G. Sperandeo [b], E. Brunetti [c], M. Decuzzi [d]

[a] *Department of Internal Medicine, IRCCS ''Casa Sollievo della Sofferenza'' Hospital, San Giovanni Rotondo (FG), Italy*
[b] *Department of Radiology, IRCCS ''Casa Sollievo della Sofferenza'' Hospital, San Giovanni Rotondo (FG), Italy*
[c] *Division of Infectious and Tropical Diseases, University of Pavia, IRCCS ''S. Matteo'' Hospital Foundation, Pavia, Italy*
[d] *Department of Nuclear Medicine, University of Bari, Italy*

KEYWORDS
Ultrasonography;
Chest;
Pleura;
Lung;
Biopsy.

Abstract Although numerous studies have been conducted on the use of ultrasonography (US) for the examination of thoracic structures, this procedure is not as widely accepted as abdominal US. The newer portable scanners can be used at the bedside to detect pleural malignancies and effusions, as well as peripheral lung nodules of the lung, even in seriously ill patients. Focal thickening of the pleura can be easily detected with US and further investigated with a US-guided biopsy. US guidance can also be used during percutaneous drainage of pleural effusion or transthoracic biopsy of peripheral lung lesions, thus reducing the incidence of procedure-related pneumothorax to almost zero. We review the current literature on thoracic US and present our clinical experience with the technique in large groups of patients with pleural and peripheral lung diseases.

Sommario L'ecografia del torace non è ancora diffusa quanto quella addominale, nonostante una notevole quantità di studi ne attesti l'importanza. Le apparecchiature più recenti permettono di diagnosticare neoplasie, versamenti pleurici e noduli polmonari periferici al letto del paziente, anche nei casi più gravi. L'ispessimento pleurico focale è facilmente messo in luce dall'ecografia e può essere ulteriormente studiato tramite la biopsia ecoguidata. Questa può essere praticata anche su lesioni polmonari periferiche, riducendo quasi a zero il rischio di pneumotorace. In questo articolo esaminiamo la letteratura recente sull'ecografia del torace e presentiamo la nostra esperienza clinica su numerosi pazienti con patologia pleurica e della periferia polmonare.

* Corresponding author. Dipartimento di Medicina Interna, IRCCS, Istituto ''Casa Sollievo della Sofferenza'', viale Cappuccini, 71013 San Giovanni Rotondo (FG), Italy.
E-mail address: sperandeom@libero.it (M. Sperandeo).

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doi:10.1016/j.jus.2008.02.001

Introduction

Ultrasonography (US) can be used to explore the surfaces of the lungs through the intercostal spaces, but the presence of the ribs and of air in the expanded lung reduces the value of this imaging modality in the examination of deeper thoracic structures. Nevertheless, US is considered a reliable, inexpensive, safe, and reproducible diagnostic method for the work-up of patients with diseases of the diaphragm (neoplasms, paresis), thoracic wall (abscesses, fistulas, neoplasms), lung (atelectasis, pulmonary consolidation), anterosuperior mediastinum (neoplasms, lymphoma, cysts), the region between the thorax and the abdomen, and above all, the pleurae (extrapleural masses, pleural effusions) [1].

Thanks to the recent diffusion of sophisticated US scanners equipped with color and power Doppler technology and special transducers for transesophageal and endobronchial examinations, US can now be used to investigate disorders involving the esophagus, bronchi, bronchial blood vessels, mediastinum, and the large vessels of the heart [2]. Although computed tomography is still the imaging method of choice for the diagnosis of these conditions, thoracic US can be considered an important supplementary tool in this setting [3]. Today, thoracic US is mainly used to guide transthoracic biopsy of peripheral lung lesions and the drainage of pleural effusions [4]. The increasingly widespread use of second-generation ultrasound contrast agents is further expanding the role of thoracic US, and it is producing promising results in the characterization of peripheral lung masses [5].

Technique

The US examination of the chest requires a scanner equipped with a sector or convex small array probe with medium to high frequency (3.5—7.5 MHz). In most cases, conclusive information can be obtained with a 3.5-MHz transducer. However, a high-frequency (8—10 MHz) linear array probe is needed to study the chest wall, the pleurae, and the superficial structures of the lung. Color Doppler technology is not essential during the initial thoracic US examination, but it is a must during minimally invasive procedures such as biopsy or drainage.

The thoracic US examination can be performed at the bedside, and no specific patient preparation is needed. However, patients with respiratory failure should receive drug therapy and oxygen to relieve their symptoms during the examination and reduce the risk of motion-related artifacts caused by labored breathing. Scans of the basal pleurae and the diaphragm should be obtained with the patient seated and then (when possible) in the supine position. In rare cases, the patient may be asked to stand during the examination (e.g., when the costophrenic recess is being explored for a possible effusion) [6,7]. Various scanning planes can be used: intercostal, longitudinal, transversal, and paravertebral scans can be used to explore the posterior chest wall, whereas the anterior wall is usually investigated with intercostal, longitudinal, supra- and parasternal, sub-xiphoid, and supraclavicular scans. Specific acoustic windows are exploited to improve visualization of the examined structures. On the right side of the body, the liver provides a good window for observing the basal pleurae and the diaphragmatic dome (The patient should be placed in the supine position and instructed to inhale deeply). The spleen provides a similar window for examination of structures in the left side of the chest. Each pathological finding must be documented in two perpendicular projections. In some cases, US can also be used to further explore thoracic lesions that have already been visualized on chest radiographs or on CT scans.

We currently perform most of our thoracic US examinations with a Toshiba SSA340 scanner (Toshiba, Tokyo, Japan) and both convex (3.5 Mhz) and linear (8 MHz) probes. In some cases, however, we use a multifrequency scanner (Esaote Technos MPX, Esaote, Genoa, Italy) with convex (3.5 MHz) and linear (8 MHz) transducers and special software for the analysis of second-generation ultrasound contrast agent signals.

Clinical applications

The thoracic structures that can be explored by US are (starting at the surface) (1) skin, (2) derma, (3) intercostal muscles and endothoracic membrane, (4) extrapleural fat and the parietal and visceral pleurae (Fig. 1). Once the US beam has penetrated the visceral pleura, it is completely dispersed by the air in the lungs. The elevated acoustic impedance generated at the interface between the superficial soft tissues and the air in the lung results in a thin (<3 mm) echogenic line known as the pleural line. The parietal pleura is immobile, whereas the visceral pleura moves during respiration (''gliding or sliding sign''). In healthy subjects, the marked difference in the acoustic impedance levels of soft tissue and air-filled structures usually produces two types of artifact: [8] the ''comet-tail'' artifact, which consists in parallel, hyperechoic reverberations extending vertically from the pleural interface to the

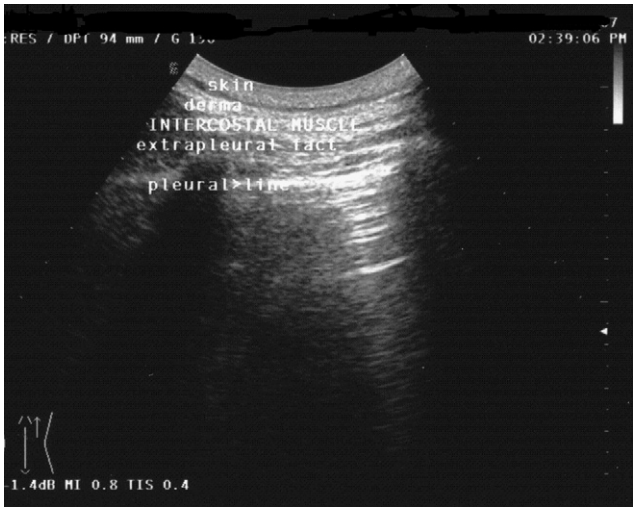

Fig. 1 The structures that can be explored by thoracic US include (from the surface) (1) skin; (2) derma; (3) intercostal muscles, endothoracic membrane; (4) extrapleural fat, parietal and visceral pleura.