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● *Review*

ULTRASOUND OF THE PLEURAE AND LUNGS

Christoph F. Dietrich,* Gebhard Mathis,† Xin-Wu Cui,* Andre Ignee,* Michael Hocke,‡ and Tim O. Hirche§

*Department of Internal Medicine 2, Caritas-Krankenhaus, Bad Mergentheim, Germany; †Rankweil, Austria; ‡Department of Internal Medicine 2, Hospital Meiningen, Meiningen, Germany; and §Department of Pulmonary Medicine, German Clinic for Diagnosics, Wiesbaden, Germany

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Abstract—The value of ultrasound techniques in examination of the pleurae and lungs has been underestimated over recent decades. One explanation for this is the assumption that the ventilated lungs and the bones of the rib cage constitute impermeable obstacles to ultrasound. However, a variety of pathologies of the chest wall, pleurae and lungs result in altered tissue composition, providing substantially increased access and visibility for ultrasound examination. It is a great benefit that the pleurae and lungs can be non-invasively imaged repeatedly without discomfort or radiation exposure for the patient. Ultrasound is thus particularly valuable in follow-up of disease, differential diagnosis and detection of complications. Diagnostic and therapeutic interventions in patients with pathologic pleural and pulmonary findings can tolerably be performed under real-time ultrasound guidance. In this article, an updated overview is given presenting not only the benefits and indications, but also the limitations of pleural and pulmonary ultrasound. (E-mail: christoph.dietrich@ckbm.de) © **2015 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Ultrasound, Pleural effusion, Consolidations, Pneumonia, Atelectasis, Malignancies, Pulmonary thrombembolism, Interstitial syndrome.**

INTRODUCTION

Ultrasound of the lungs has been undervalued for many years. Because the ribs, sternum and aerated lungs had been considered obstacles to ultrasound waves, the prevailing opinion was that the lungs were not accessible to sonographic examination. By the laws of physics, sonographic evaluation of the chest is restricted by significant changes in impedance, and access to deeper structures is hampered by artifacts, for example, absorption, reflection, ring-down artifacts, mirroring and acoustic shadowing (Bonhof et al. 1983a, 1983b, 1984a, 1984b, 1984c; Dietrich et al. 2011b; Tsai and Yang 2003). However, many pathologic processes within the chest wall, pleurae and lungs result in profound changes in tissue composition. Inflammatory, traumatic or neoplastic processes often provide significantly improved acoustic transmission and allow for adequate sonographic evaluation. Under these conditions, non-invasive, real-time ultrasound examination serves as a powerful complementary diagnostic tool with the advantage of saving time and money in addition to easy availability and the virtual absence of complications, side effects and radiation exposure.

Ten years after initially reviewing the subject (Dietrich et al. 2003), we aim to provide an updated overview covering not only the indications and potential advantages, but also the limitations of pleural and pulmonary ultrasound. Other domains of chest ultrasound such as transthoracic ultrasound (Dietrich and Hocke 2008; Dietrich et al. 1997) and endoscopic sonography of the mediastinum and (endo)bronchial system (Dietrich 2011a, 2011a; Dietrich and Jenssen 2011), as well as contrast-enhanced ultrasound and strain imaging (Dietrich 2011b, 2012a; Piscaglia et al. 2012), have similarly increased in importance and are reviewed elsewhere.

EXAMINATION TECHNIQUES

Evaluation of the chest, lungs and associated pathologies by ultrasound requires detailed knowledge of the

Address correspondence to: Christoph F. Dietrich, Medizinische Klinik 2, Caritas-Krankenhaus, Uhlandstrasse 7, 97980 Bad Mergentheim, Germany. E-mail: christoph.dietrich@ckbm.de

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regional anatomy and potential pathologies of the chest wall, pleurae and lungs. In addition, high competence in the interpretation of results generated by complementary imaging techniques, particularly chest X-ray (CXR) and computed tomography (CT), is indispensable.

Equipment and technical requirements

The chest wall and the peripheral lungs are examined by ultrasound (linear array) transducers of higher frequency (5–17 MHz). Multifrequency transducers are of practical value. For evaluation of the lungs from the intercostal, subcostal or parasternal approach, 3.5- to 5-MHz convex or sector transducers should be used for optimimum depth penetration (Dietrich et al. 1997). In the case of narrow intercostal spaces, sector scanners might be more suitable for the evaluation of pleural and peripheral pulmonary lesions.

Lungs, pleurae and diaphragm

In general, the examination does not call for any specific preparation on the part of either the investigator or the patient. Depending on the indication, the patient remains in the supine position (for exploration of the ventral chest) or is asked to sit or stand (to assess the lateral and posterior chest). Bedridden and intensive care patients can often be examined in an oblique position. With the patient's arm lifted above the head or his or her hand positioned on the contralateral shoulder, the relative narrow intercostal spaces are expanded and the subscapular region is accessed this way.

Lungs and pleurae are best evaluated by modified application of the transducer in a the longitudinal, transverse and oblique inter- and subcostal positions (Fig. 1). The apex of the lung is additionally studied via the suprasternal and supra- and infraclavicular approaches (Dietrich et al. 2001, 2003). The brachial plexus (Wilckens et al. 2011) and the subclavian vessels can be explored with an axillary approach. The lung is identified by respiration-related movements of the visceral pleura, the so-called lung-sliding phenomenon. The diaphragm appears as a hypo-echoic (muscular) 1- to 2-mm structure with a brighter central echo line that contracts with inspiration. Contrary to common assumption, the diaphragm is not a bright line moving with respiration; the bright line merely indicates the reflection (acoustic impedance) between the air-filled lung and adjacent tissues. Sonographic examination generally makes use of the transhepatic and transplenic windows. A curtain sign can be revealed at the costophrenic angle, when air-filled lung tissue is obscuring the sonographic window on underlying tissues during deep inspiration (Dietrich 2012b; Dietrich et al. 2001).

A good view of most anatomic parts of the chest, pleure and diaphragm and/or numerous pulmonary pathologies requires careful angulation and tilting of the ultrasound probe, steady interaction with the patient and observation of her or his breathing maneuvers.

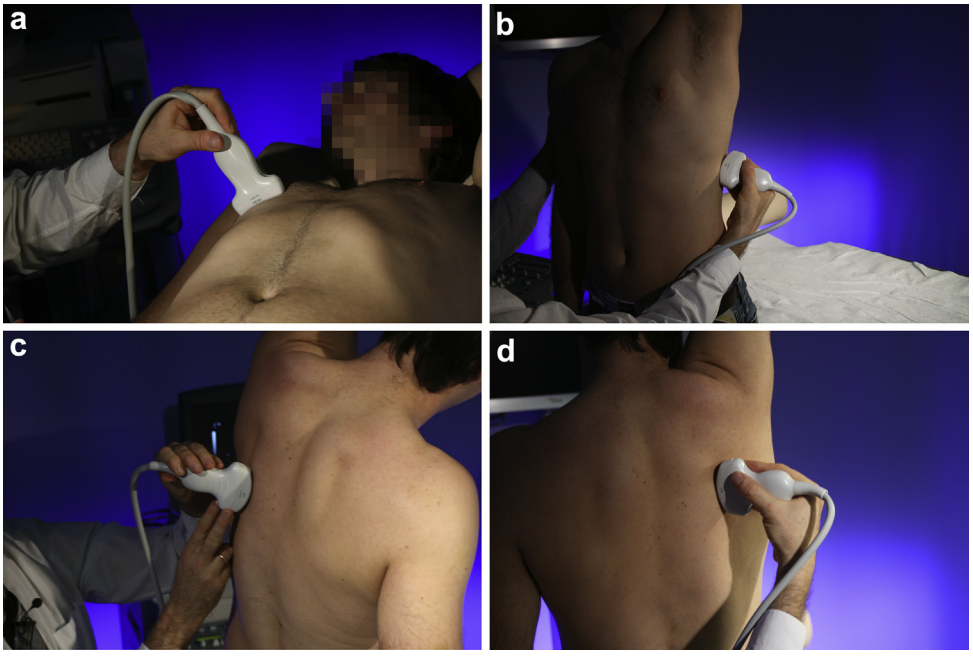

Fig. 1. Examination techniques. The supine position is used for exploration of the ventral chest (a). The sitting or standing position is suitable for assessment of the lateral and posterior chest (b, c). With the patient's arm lifted above the head, or his or her hand positioned on the contralateral shoulder, the relative narrow intercostal spaces are expanded and the subscapular region is accessed in this way (b, c). Lungs and pleurae are best evaluated by modified application of the transducer in the longitudinal (c), transverse (a) and oblique intercostal (d) and subcostal (b) positions.