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POSSIBILITIES OF PLEURAL LINE ULTRASOUND - ORIGINAL WORK

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ABSTRACT

Introduction: Ultrasonography is an accurate and reproducible tool for assessing the pleura. It represents a critical point, as the chest wall can be assessed directly, while the underlying lungs are only assessed through specific artifacts.
Methods: The work is based on our many years of experience in pleural line ultrasound and is additionally compared with literature information. We reviewed our patient databases and analyzed the ultrasound examinations performed.
Results: Imaging the pleural line provides valuable information for diagnosing and monitoring various disease entities. Importantly, it can be successfully used in virtually any patient group, without the exposure to harmful radiation used in conventional radiology. It is also a key component of a broader examination, namely chest ultrasonography, and is a crucial element assessed in emergency ultrasound protocols.
Conclusions: Pleural line ultrasound is an important and safe diagnostic tool worth using in clinical practice. Its safety and highly detailed imaging are key considerations. It's worth comparing this method with other imaging techniques.

KEYWORDS

Ultrasound, Lung, Pleura

CITATION

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Introduction:

The pleura is a very important structure in the chest, yet it is greatly underestimated diagnostically. This is due both to significant difficulties in its radiological assessment and the long-standing lack of scientific reports on the subject. Ultrasonography (USG) is a highly sensitive and accurate method for assessing the structure of the pleura, as well as the pleural cavities and the lungs themselves. Furthermore, the pleural line border is a critical location in ultrasound examinations, as below it lie the aerated lungs, which, according to the principles of physics, cannot be imaged ultrasound. Therefore, their assessment is performed using specific artifacts generated by the device. Above the pleural line, we see a real image of the skin, subcutaneous tissue, muscles, and other tissues, depending on the site of examination. These features clearly demonstrate why the pleural line is the border where "reality and illusion meet."[1] Currently, numerous literature studies are available on various applications of chest ultrasound, both in diagnosis and monitoring, as well as in the performance of certain procedures. The COVID-19 pandemic, in particular, has significantly increased the popularity of this technique, which has clearly demonstrated its effectiveness.[2]

This work summarizes and discusses the possible applications of pleural ultrasound in various disease entities and study groups (e.g., geriatric, neonatal, etc.), along with the developed ultrasound characteristics and criteria for potential diagnoses. Furthermore, information on current research on the diagnosis of various diseases and future directions for its use is included. A comparison of the use of pleural ultrasound and, in a broader understanding of the lungs, diagnostic protocols developed for emergency medicine is also developed. The first chapters of the work include a brief introduction to transthoracic ultrasound, which, due to its specific nomenclature and technique, is necessary for understanding the subsequent chapters.[3-5]

The pleural line is a term used in transthoracic lung ultrasound, which consists of the parietal pleura (Latin: pleura parietalis), the pleural cavity (Latin: cavum pleurae), and the pulmonary pleura, also known as the visceral pleura (Latin: pleura visceralis).

The pulmonary pleura is a thin membrane that closely covers the surface of the lung and, near the hilum, "folds" to form the parietal pleura.

The parietal pleura can be divided into four parts: the costal pleura, the diaphragmatic pleura, the mediastinal pleura, and the cupula. The costal pleura adheres to the inner surface of the chest and covers the ribs, part of the sternum, the transverse pectoralis muscle, the internal thoracic vessels, the intercostal vessels and nerves, and the vertebral column. The diaphragmatic pleura covers the diaphragm, specifically its domes and slopes. The structures covered by the mediastinum lie between the sternum and the thoracic spine and vary depending on the side. On the left, it covers: the thoracic aorta and its arch, the left half of the esophagus, the left subclavian and left common carotid arteries, the left brachiocephalic vein, the short azygos vein, and the accessory azygos vein, the left vagus nerve, and the initial segment of the recurrent laryngeal nerve. The right side covers: the right half of the esophagus, the trachea, the right vagus nerve, and the initial segment of the right recurrent laryngeal nerve. Both parts also cover the pericardium. The last part of the parietal pleura is the cupula, which extends beyond the upper thoracic aperture approximately 3-4 cm above the clavicle. It is attached to the suprapleural membrane, the vertebropleural and costopleural ligaments, and the scalene minimus. The pleural cavity is the space between the pulmonary and parietal pleura, containing a small amount of free fluid that allows the pleurae to slide freely against each other during respiration. The width of the pleural cavity is approximately 2-3 mm, except for the costophrenic recesses, the basal portions of the pleural cavities, where both the distance and the amount of fluid may be slightly greater (a larger amount of fluid occurs especially in the standing position, due to its gravitational distribution). [1-5]

The transducers dedicated to examining the pleural line are linear and convex. The sector transducer, when specifically focused on the pleural line, has little diagnostic value, but is nonetheless a valuable tool in lung ultrasound assessment. Before performing the examination, disable all image enhancement and artifact elimination programs built into the ultrasound system. Artifact suppression may contribute to false results.[3-5]

The examination technique involves scanning the entire accessible pleural surface using the intercostal spaces. The patient is preferably positioned in a supine position, or if this is not possible, in a semi-sitting position. The first application of the transducer is perpendicular to the first intercostal space to visualize the so-called "Merlin space," i.e., two ribs with acoustic shadows between which the pleural line is visible, and below it, the lungs or artifacts. This is the optimal projection for ruling out pneumothorax. The transducer is then rotated 90° and, with applications parallel to the pleural line, scanned from top to bottom across the entire lung surface. This is performed along the sternal, midclavicular, anterior and midaxillary lines, and, when examining the posterior surface of the chest, also along the posterior axillary, scapular, and paravertebral lines. Examination of the posterior surface is best performed in a sitting position, if possible. Depending on the patient's body structure and chest surface area, the number of scan lines may be smaller or larger. After scanning with one type of transducer, e.g., a convex transducer, it is worth switching to a linear transducer, for example, and rescanning the entire chest surface. This will allow for a complete image of the pleural and lung lines, which would not be possible to obtain in such detail using only one transducer. [3-7]

Physiologically, the pleural line on ultrasound is a thin, hyperechoic, linear structure visible just below the ribs. Its movement is called the sliding sign and is physiologically clearly visible. Using a linear transducer, the two pleural sheets and the cavity between them can be separately imaged (which is not always visible with a convex transducer). [3-5]

A-lines are reverberation artifacts resulting from multiple reflections of the ultrasound beam in a normally aerated lung (or in an air-filled chest in a pneumothorax). They appear as thin, hyperechoic lines parallel to the pleura. Their number is clinically insignificant; in older and obese individuals, they are often not visualized. [8]

B-lines are a typically pathological artifact resulting from the presence of subpleural fluid. They are hyperchogenic lines originating from the pleural line and moving with its movement. It is important that they extend to the very bottom of the screen (otherwise, they are Z or I lines, which are clinically irrelevant at this time). They may indicate pulmonary edema (cardiogenic or noncardiogenic), inflammation, fluid overload, or interstitial lung disease. It is generally accepted that pathology is indicated by >2 B lines in a single intercostal space. [3,8] C lines are an artifact originating from subpleural consolidation, extending to the bottom of the screen.

Consolidations represent an area of airless lung or a solid lesion. They are located subpleurally and may have different morphologies depending on the cause. Vascular analysis of the occurring flows using color Doppler or power Doppler is crucial for differentiating these lesions.[9]

The lung sliding sign is one of the first signs to be assessed before starting a transthoracic ultrasound examination, as its absence may indicate a life-threatening condition. Normal sliding involves the sliding of the parietal and pulmonary pleura relative to each other, which is compared in the literature to "wandering ants." In doubtful cases, the so-called M-mode, a function of the device that shows the relationship between movement and time, should be used. In a normal lung, sliding in the M-mode function is compared to the "seashore sign," where elements resulting from pleural movement and lung pulsation, i.e., the transmission of heartbeats to the lungs, can be distinguished. The absence of sliding is called the "barcode sign." Both signs are presented in Table 3. [10]

Methods:

The work is based on our many years of experience in pleural line ultrasound and is additionally compared with literature information. We reviewed our patient databases and analyzed the ultrasound examinations performed.

Results:

In addition to pleural morphology and sliding, diagnostics should also consider the presence of vertical and subpleural consolidation artifacts. Depending on the disease entity or clinical condition, changes can occur in all of these elements, making it important to analyze them in each examination, as subtle differences between them can determine the diagnosis. The following subsections list the diseases and patient groups for which pleural and lung ultrasound is useful. Diagnostic issues that are controversial and require additional clinical testing are also highlighted.[5]

Pneumothorax is a condition in which air enters the pleural cavity, impairing lung function. This is life-threatening in the case of a tension pneumothorax (air flows into the pleura without being able to escape) or massive open/closed pneumothorax. Its most common causes include high-energy trauma during a traffic accident or chronic interstitial lung disease associated with emphysema (rupture of the emphysematous bulla and air entering the pleural cavity). Clinically, the patient may complain of shortness of breath, difficulty breathing, and loss of consciousness. In cases of traumatic pneumothorax, cardiac arrest may even occur. Ultrasound shows: disappearance of the sliding sign (barcode sign) with the absence of "lung pulsation," which is the most important diagnostic criterion. The term "lung point" is used in the literature to describe the location where the sliding symptom is stopped ("seashore sign" → "barcode sign"). This allows for the determination of the limits of free air, but it will not be visible in cases of tension pneumothorax or mantle pneumothorax (air distribution over the entire pleural surface; no contact between the plaques). Therefore, in cases suggesting trauma, the "lung point" should not be sought, as it will most likely not be present, and a delay in therapeutic intervention may lead to the victim's death.[10-14]

The most common cause of pleural effusion is transudation in heart failure, liver cirrhosis, or nephrotic syndrome. Pleural effusion, on the other hand, most often occurs in the course of inflammatory lung diseases and cancer. Hemorrhage in the pleural cavity is less common and is most often traumatic or an iatrogenic complication of surgery in the chest or adjacent areas. Chylothorax (accumulation of lymph within the pleural cavity) is an extremely rare condition that occurs in the case of trauma, postoperative complications, or cancer infiltrating the lymphatic vessels. It is noteworthy that ultrasound can detect as little as 3-5ml of confined fluid and 20-30ml of free fluid, compared to X-rays with a minimum detectable amount of 150ml (anteroposterior view) and 75ml (lateral view). Ultrasound examination, particularly in the basal region, will reveal large amounts of anechoic fluid, which can cause atelectasis due to lung compression. In the case of localized fluid, typically occurring in pneumonia, separation of the pleural plaques will be visible, with attenuation or elimination of the sliding sign, along with pleural cavity dilation. Applying a color Doppler gate to the fluid may reveal chaotic flow within it resulting from excitation by respiratory movements of the lungs (the so-called color fluid sign). An M-mode gate can also be applied to the basal region, resulting in a sinusoidal pattern resulting from fluid movement over time. Small amounts of fluid may pass through the pleural line, resulting in the formation of B-lines emanating from the pleural space. Chronic inflammatory fluid persisting in the pleural cavities may become organized through the formation of fibrinous septa.

Currently, there are no criteria for the differential diagnosis of pleural effusion. In the case of fluid with numerous cells, they are visible as hyperechoic ballooning points in the anechoic fluid (the so-called "plankton sign"), which, after the patient remains in one position for a long time, causes the patient to sink due to gravity (the so-called "sedimentation sign").

It is an irreversible lung disease, most often the result of long-standing chronic obstructive pulmonary disease (centrilobular emphysema) or alpha-1 antitrypsin deficiency (panlobular emphysema). It is associated with chronic dyspnea, impaired ventilation, and often general wasting.[23]

Ultrasonographically, the pleural line can be characterized by abnormalities in its outline, meaning it may be interrupted, retracted, thickened (normal ≤ 2 mm), or blurred, and may also contain B lines, forming interstitial or interstitial-alveolar complexes. Emphysematous bullae located subpleurally may cause local attenuation of the sliding sign and thus be mistaken for pneumothorax. A characteristic artifact occurring in chronic interstitial lung diseases are so-called Am lines (on average 39% of cases). These are lines originating from the pleural line and running down the screen, resembling A lines, which are many times more numerous around the mid-depth, lying practically one under the other.[24-27]

This heterogeneous group of non-infectious and non-neoplastic diseases is characterized by the presence of diffuse changes within the chest on X-ray and CT scans, restrictive ventilation disorders, and reduced pulmonary diffusion and gas exchange. This group comprises approximately 300 diseases, with sarcoidosis and idiopathic pulmonary fibrosis accounting for 50% of cases. They typically begin asymptomatically or with nonspecific symptoms, making diagnosis challenging and typically taking 1-2 years to make a definitive diagnosis. [28]

Ultrasound is not included in current guidelines for the diagnosis of interstitial lung diseases. However, ultrasound images of the pleura and lungs can suggest diagnostic guidelines. Furthermore, it is an extremely effective and reproducible tool for frequent monitoring of progressive changes. In approximately 92% of cases, B lines unrelated to infection or pulmonary edema are observed, with nearly 70% having B lines greater than or equal to four in a single scan. Patients with advanced disease may present with a white lung sign, which is a very large number of B lines confluent into a single image. Am lines, which are characteristic of this group of diseases but occur primarily in advanced disease, are present in 39% of cases. The pleural line is the main structure assessed, therefore, a linear transducer should be used for its assessment. It is almost always irregular (~100%). Furthermore, it may be retracted (98%), fragmented (77%), thickened >2mm (23%), or diffuse (52%, mostly in severe forms). Subpleural consolidations occur in only 33% of cases but are characteristic of sarcoidosis (86%) and are usually small (<5mm).[29-36]

In pneumonia, the sliding sign is preserved or attenuated. In very small consolidations, less than 5 mm in diameter, visualization of flow may be impossible.

It is not necessary to meet all criteria to diagnose pneumonia. This test is particularly useful in daily practice because it demonstrates high sensitivity (87-95%) and specificity (80-96%). Furthermore, the widespread availability of ultrasound and its non-invasive nature allow for frequent monitoring of the disease.

Currently, it is impossible to make a definitive diagnosis regarding the etiology of pneumonia; therefore, therapeutic decisions must be supported by the clinical picture and other tests.[1-3, 5, 7-9, 3 7-42]

Lung abscess occurs as a complication of infectious lung diseases and is most often bacterial in origin. Individuals with impaired immunity are particularly susceptible to developing it. It presents as a collection of pus surrounded by a fibrous capsule, accompanied by symptoms such as high fever, cough with purulent sputum production, which in chronic abscesses may be blood-tinged. Ultrasonographically, it appears as a subpleural lesion with often uneven borders and mixed echogenicity (usually with a hypoechoic component). The most important differential diagnosis is the absence of flow within the lesion after activating color Doppler imaging. This structure should be carefully differentiated from pneumonia and pulmonary embolism.[39, 40-43]

Pleural empyema is a rare but serious complication of pneumonia and is a purulent-like pleural effusion. It is accompanied by general symptoms such as fever, cough, weakness, and weight loss, which worsen with increasing pleural volume. It is usually located basally and has a hyperechoic, oval-shaped structure, often with a visible smooth-walled capsule. In rarer cases, it has a mixed echostructure. It also occurs with pleural effusion, visible as an anechoic fluid, which, if persistent, leads to the formation of multiple septa. In some cases, small amounts of gas within the pleural effusion can be described. The pleural line in this area is thickened and heterogeneous. [39, 40-42]

“Dry pleurisy” is a complication of pneumonia or thoracic surgery, and one of its main symptoms is pleuritic pain. Ultrasound shows the lung line to be hypoechoic and irregular, with segmental thickening and, less frequently, retractions. The affected pleura is accompanied by subpleural consolidations up to 5 mm in size. [44-45]

Adhesions are a relatively rare clinical condition that can arise in the context of chronic inflammatory, infectious (pneumonia, abscess, tuberculosis) and non-infectious diseases. Ultrasound examination reveals the absence of the sliding sign, which is the most important diagnostic criterion, but it must be differentiated from pneumothorax (the distinguishing criterion is the presence of pulmonary pulsation, which is absent in pneumothorax). It is also possible to observe clear adhesions of the pleurae or fibrinous elements between them with a linear transducer.[44-45]

A lobectomy is a thoracic surgical procedure involving the removal of a lobe of the lung, while a pneumonectomy involves the removal of the entire lung. The most common cause of such procedures is non-small cell lung cancer, so it's important to remember that the patient being examined has a serious medical history. A second, much rarer cause is serious chest trauma requiring this type of procedure.

In most cases, a patient's medical history is available, but in cases where this is not available, such as a patient found unconscious on the street, diagnosing the absence of a lung or its segment is very difficult and can only be made after first ruling out a pneumothorax. No sliding sign will be visible on ultrasound (lobectomy

– locally eliminated, pneumonectomy – completely eliminated), and some basal fluid may be observed. After a lobectomy, minor consolidations and B lines may be visible in the area of the surgical site.[44-45]

Pleurodesis is a palliative procedure involving the induction of adhesion between the pleural sheets using irritants (e.g., talc, bleomycin). Pleurectomy, on the other hand, involves the complete removal of the parietal pleura, which leads to adhesion of the lung to the chest wall. Both procedures are performed extremely rarely.

In both cases, no pleural sliding is observed, only lung pulsation. Furthermore, due to the patient's serious condition, numerous B-line artifacts may be observed throughout the lung, with possible consolidation. The image is nonspecific, so the primary determinant of diagnosis is the patient's medical history and more detailed imaging studies, such as computed tomography. [44-47]

Pulmonary embolism is a life-threatening condition resulting from obstruction of flow in the pulmonary arteries by embolic material. Available literature data demonstrate very high sensitivity (81%) and specificity (99%) in the ultrasound diagnosis of pulmonary embolism. With the addition of echocardiography and a compression test of the lower extremity vessels, the sensitivity and specificity can reach 92%. [48]

Ultrasound images reveal hypoechoic, wedge-shaped consolidations adjacent to the pleura (i.e., widest peripleurally and tapering deeper into the lung). A hyperchogenic spot, representing a reflection of air trapped in the terminal bronchioles, can often be seen in the center. The pleura is often locally invisible (an image similar to a pleural rupture), and color Doppler imaging reveals amputation of the vascular supply at the border of the lesion—the so-called vascular sign. A small amount of fluid may be present in the area of the lesion. According to the literature, finding two or more typical lesions confirms pulmonary embolism. One lesion with a small amount of local fluid indicates probable pulmonary embolism. The finding of more than three small (< 5 mm), typical lesions indicates possible embolism.

Diagnosing pulmonary embolism with chest ultrasound is widely considered impossible. To refute this hypothesis, a complex meta-analysis was conducted in 2015[49], which found a sensitivity and specificity of 85%. By comparison, the gold standard for diagnosis, computed tomography angiography (CT Angiography), has a sensitivity of 83-100% and a specificity of 89-96%.[5, 48-51]

Acute respiratory distress syndrome (ARDS) is a life-threatening condition manifesting as a morphological and functional manifestation of lung damage caused by a variety of etiological factors. It manifests as pulmonary edema, pulmonary hypertension, and respiratory failure.

Ultrasound imaging reveals changes in the pleural line with reduced or absent sliding. Despite its absence, pulmonary pulsation is still visible, and its absence indicates an extreme form of the disease. Additionally, numerous B lines are present, creating interstitial, interstitial-alveolar syndromes, and even the "white lung sign." Effusion is observed at the base, often in large volumes.[6, 9, 26, 45, 52-55]

Hemangiomas (Latin: haemangioma) are most often diagnosed in young children and are dilated and chaotic small vessels with thin walls and a mixed echostructure. The presence of phleboliths with acoustic shadows in 50% of cases and an unusually rich vascularization on low-resistance color Doppler ultrasound are clues to the diagnosis.

Lipomas (Latin: lipoma) originate from mature adipocytes and are the most common benign lesion in adults, particularly in obese individuals in their 4th-6th decade of life. Clinically, they present as a solid structure, usually painless. On ultrasound, they appear homogeneously echogenic with clear boundaries, an oval shape, and scant vascularization (or even no vascularization). Parallel hypoechoic bands within the lipoma are characteristic (located vertically). Lymphangiomas (Latin: lymphangioma) are congenital lesions and present as well-defined fluid-solid lesions with numerous septa.

A subcutaneous abscess (Latin: abscess) is a poorly defined area, with areas of necrosis, visible gas bubbles, and a visible vascular supply surrounding it.

A schwannoma (Latin: schwannoma) is a hypoechoic lesion with visible anechoic cysts within it, also in contact with an intercostal nerve. It exhibits rich vascularity and characteristic echogenic enhancement behind the lesion. It is also characterized by significant pain during biopsy.

A neurofibroma (Latin: fibroma) is poorly studied by ultrasound; available data indicate a heterogeneous echostructure and poor vascularization.

Malignant lesions of peripheral nerve sheaths are difficult to differentiate from benign lesions. They are usually poorly demarcated, grow rapidly, and invade surrounding tissues.

Chondrosarcoma (Latin: chondrosarcoma) is the most common primary tumor of the chest wall. It is very similar to benign cartilage lesions, and clear differentiating criteria have not yet been developed.

Liposarcoma (Latin: liposacroma) is rarely found in the chest wall. It is very similar to lipoma but has a significantly faster growth rate and a richer vascular supply. Features that may distinguish it from a lipoma include the presence of thick septae (>2 mm), visible solid areas with an echogenicity different from that of adipose tissue, and the more frequent presence of calcifications (three times more common than in lipomas).

Rib metastases are the most common malignant tumors found in the chest wall and most often originate from the lung, kidney, breast, and prostate. They are characterized by heterogeneous echogenicity with a dominant hypoechoic structure and the appearance of destruction of surrounding bone tissue. Soft tissue metastases are significantly less common but have a poor prognosis. On ultrasound, they appear as oval, heterogeneous echogenic structures with a predominance of hypoechoic areas.

Lymphoma (from Latin: lymphoma) is an echogenically heterogeneous lesion (hypoechoic predominance) with uneven borders that infiltrates surrounding tissues. Furthermore, it is characterized by rich, chaotic vascularization, rapid growth, deep location, and pain. It should be noted that lymphomas do occur where no flow can be visualized, but this is not a very rare occurrence.

Peripherally located lung tumors may remain asymptomatic for many years, slowly infiltrating other tissues during this time. Research is currently underway on the use of ultrasound in the diagnosis and monitoring of lung cancer.

Lung tumors are most often mixed echogenicity with hypoechoic predominance, although this is not a necessary condition. Vascularization is usually poor and peripheral, while highly vascularized tumors are less common. Tumors located deeper may compress the bronchi, causing resorption atelectasis of the underlying tissues. Furthermore, signs of pleural infiltration may be visible, along with local changes in its echostructure. [45, 60]

Pleural mesothelioma is a malignant tumor originating from cells in the pleural plaques and is pathologically divided into two forms: limited and extensive. The extensive form has a significantly poorer prognosis, characterized by rapid tumor growth with a high potential for metastasis. A characteristic carcinogen leading to mesothelioma is long-term exposure to asbestos.

Ultrasound reveals a consolidation with mixed echogenicity arising from the pleural line and infiltrating the lung, pleural cavity, or the second pleura. Hyperechoic calcifications, characteristic of mesothelioma (compared to other tumors in this region), are visible within the tumor. Furthermore, local pleural effusion is present, and in advanced tumors, large amounts of parabasal fluid are also present. Another characteristic feature is local abolition or attenuation of pleural sliding. When a color Doppler gate is applied, a chaotic vascular pattern is visible.[60]

The lungs are a common site for cancer metastasis, which is associated with a poor overall prognosis.

Oval, subpleural consolidations, generally hypoechoic, with a central vascular pattern originating from the intercostal artery, are very characteristic features of metastatic tumors. [45, 53]

In addition to diagnostics, ultrasonography is very helpful in assessing the effectiveness of invasive mechanical ventilation. After intubation, if it is impossible to confirm the position of the endotracheal tube with a stethoscope, assessing for pleural slippage is extremely helpful and effective, as its presence indicates correct tube position. Furthermore, ultrasonography can be used to assess lung aeration during ventilation. Excessively low ventilation parameters will manifest as insufficient lung aeration in the form of consolidation. If a pneumothorax develops as a result of overly aggressive intubation, the slippage symptom will disappear due to rupture of the alveoli (locally in the case of a small pneumothorax or completely in the case of a large pneumothorax).[60]

Discussion:

Ultrasonography is now an integral part of modern medicine in virtually every field. Its undeniable advantages include non-invasiveness, low cost, increasing availability of ultrasound equipment, the ability to perform dynamic imaging and procedures guided by it.

The pleural line is a specific structure, constituting the boundary between a real image and an "illusion," which results from the physical properties of ultrasound in air. As has been demonstrated, a transthoracic ultrasound examination, even if focused on the pleura, cannot be performed without assessing the lungs and additional elements, the more numerous the greater the knowledge and experience of the examiner. Another distinguishing feature is dedicated nomenclature (e.g., A, B, etc.) and artifact-based diagnostics. Currently, the number of lung and pleural ultrasound examinations is very large, with a growing trend over many years. The disease entities presented in this work are the result of collecting and editing numerous original and review papers, which enabled the development and citation of numerous ultrasound features for a significant number of diseases. Many of these are very thoroughly documented and widely used in everyday clinical practice, such as the examination of pneumothorax, effusion, and pneumonia, while others are in the process of collecting literature data, developing them, and developing consensus, such as interstitial lung diseases, tumors, etc. [1-

5, 7]. Critical from the perspective of emergency medicine is the ability to confirm or rule out life-threatening conditions as quickly as possible. The differences compared to X-ray are significant, and the time to diagnosis is much faster with ultrasound. Therefore, there is no doubt why this method has been so enthusiastically received.[45]

Diagnosing pleural effusion allows for the detection of even very subtle amounts of fluid, ranging from 3-5 ml (confined fluid) to 20-30 ml (free fluid), while the minimum volumes for X-ray are many times larger (75 ml and 150 ml). Another advantage is the ability to perform ultrasound-guided pleurocentesis, which significantly increases the safety of the procedure. Furthermore, certain characteristics have been developed to determine the nature of the fluid, but these are guidelines rather than rigid criteria. [15-22, 45]

Pneumonia diagnostic capabilities are crucial in internal medicine and intensive care units, as well as surgical wards and family physicians' offices, as physicians encounter this condition in each of these settings. Thanks to the wide availability of ultrasound equipment, its non-invasive nature enabling frequent monitoring, and its high sensitivity (87-95%) and specificity (80-96%), it is slowly outperforming traditional X-ray. Currently, no clear criteria have been developed to clearly determine the microbiological etiology, making it crucial to relate the test results to the overall clinical picture of the patient. [1-3, 5, 7-9, 37-42, 45]

Interstitial lung diseases pose a significant challenge, not only therapeutically but also diagnostically. Diagnosis is typically time-consuming, and the procedure itself requires high-resolution computed tomography (HRCT), which leads to significant patient exposure. This is particularly problematic when monitoring the course of the disease and treatment outcomes, and therefore the use of ultrasound for this purpose is proving groundbreaking. Studies developed to date demonstrate many features that correlate well with the course of the disease compared to HRCT control scans. It is therefore expected that, as the number of publications on this topic increases, ultrasound will become the new standard in monitoring interstitial lung diseases. [24-27, 29-36]

Cancers of the chest wall and lungs are a relatively new topic in ultrasound diagnostics. The literature is currently too sparse to support the development of clear guidelines, but sufficient for the supportive use of ultrasound in these conditions as an adjunctive examination. The possibility of repeated monitoring of lesions and their response to treatment is particularly promising. This is certainly an area in which transthoracic examination will find its rightful place, as further confirmed by well-developed and high-quality studies, although currently few in number.[45, 56-65]

Pulmonary embolism is a very serious, life-threatening condition requiring immediate intervention. The gold standard for diagnosis is CT angiography, but literature reports clearly indicate the very high usefulness of ultrasonography in this condition. It is a very good alternative in cases where CT angiography is unavailable or contraindicated. With the constantly emerging new research results from leading authorities in the field of lung ultrasound, it is highly likely that it will be included in official treatment guidelines.[5, 48-51]

ARDS is a significant and complex medical problem associated with many conditions. It was one of the first conditions to be assessed by lung and pleural ultrasound. An example of its widespread use was the COVID-19 pandemic, during which the disproportionately high number of critically ill patients compared to the available staff necessitated the use of rapid, bedside methods. [6, 9, 26, 45, 52-55]

The physiological picture of the lungs in newborns differs significantly from that of adults and older children. Therefore, an inexperienced person should approach it with extreme caution and strictly relate the results to the overall clinical picture. The most important element of the examination in this group is observing the dynamics of changes and their direction. Physiologically, it should lead to lung aeration and a reduction in the number of B lines. This examination is also useful in diagnosing neonatal respiratory distress syndromes.[59]

Smokers and geriatric patients exhibit very different features in lung examination, especially of the pleura. In both cases, comorbidities should be considered. In the geriatric population, minor degenerative changes in the pleural line, after excluding comorbidities, are considered normal.[45, 60]

Conclusions:

Based on the literature review, the following conclusions can be drawn:

- Pleural line ultrasonography requires simultaneous ultrasound assessment of the lungs to obtain the most diagnostic information possible.
- Good knowledge of the relevant nomenclature and practical skills significantly contribute to a reliable diagnosis.
- Lung ultrasound can diagnose many life-threatening conditions in a very short time.
- Abundant literature clearly demonstrates the high effectiveness and sensitivity of this examination in numerous indications.
- The lack of invasiveness and wide availability of ultrasound equipment enable frequent monitoring of the disease course and its treatment.
- Ultrasound diagnosis of lung and thoracic cancers, as well as interstitial lung diseases, is extremely effective and should be subject to further clinical investigation.
- Pleural line ultrasonography is an effective examination that provides valuable information in all age groups.
- It is a future-proof examination that has the potential to become a new diagnostic standard.

Disclosure

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