Can transthoracic ultrasound differentiate between simple and obstructed pneumonia?

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Background The advantages of low cost, bedside availability, and no radiation exposure have made ultrasound an indispensable diagnostic tool in modern pulmonary medicine. Color Doppler ultrasound demonstrates normal or increased flow in the normal vessels of the consolidated lung and may be helpful in distinguishing simple pneumonia from postobstructive pneumonia.

Aim of the work The aim of this work was to describe sonographic features of simple and obstructed pneumonia and discuss the value of transthoracic ultrasound to differentiate between both diseases.

Results The study included 18 patients with simple pneumonia and seven patients with obstructed pneumonia. The sonographic findings were as follows: positive air bronchogram recorded in 100% of the cases of simple pneumonia, but not found in any case of obstructed pneumonia; fluid bronchogram not found in any case of simple pneumonia and present in 100% of obstructed pneumonia ($P = 0.005$). Oval and rounded shape, irregular shape, sharp well-demarcated, blurred-border, homogenous, heterogeneous, and hypoechoic echo patterns were found in 38.9, 61.1, 33.3, 66.7, 11.1, 88.9, and 100% of the cases of simple pneumonia and in 42.9, 57.1, 28.6, 71.4, 0, 100, and 85.7% of the cases of obstructed pneumonia, respectively. Pleural effusion was present in 44.4 and 42.9% of cases of simple and obstructed pneumonia, respectively. Fluid bronchogram was seen in the bronchial obstruction, as a result of either impacted secretions or a proximal tumor.

Conclusion The presence of signs of fluid bronchogram in the appropriate clinical context should raise the suspicion of postobstructive pneumonitis. Transthoracic ultrasound helps in distinguishing the central obstructing tumor as a hypoechoic mass from distal more echogenic consolidations. *Egypt J Broncho* 2014 8:87–90

Egyptian Journal of Bronchology 2014 8:87–90

Keywords: obstructed pneumonia, simple pneumonia, transthoracic ultrasound

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Received 23 February 2014 **Accepted** 09 March 2014

Introduction

Examination of the chest is a rapidly developing application of ultrasound (US) and may be used to evaluate a wide range of peripheral parenchymal, pleural, and chest wall diseases. Suboptimal radiography may mask or mimic clinically significant abnormalities, and differentiation of pleural from parenchymal changes can be challenging [1].

The advantages of low cost, bedside availability, repeated reproducibility, and no radiation exposure have made US an indispensable diagnostic tool in modern pulmonary medicine [2,3]. Transthoracic ultrasound (TUS) has emerged as a diagnostic tool in various diffuse and focal pulmonary diseases [4].

TUS can be performed with any modern US unit. A 2–5-MHz curvilinear probe allows the visualization of deeper structures, and the sector scan field allows a wider field of view through a small acoustic window. The chest wall, the pleura, and the lungs may be surveyed quickly with the curvilinear probe. Once an abnormality has been identified, a high-resolution 7.5–10-MHz linear probe can be used to provide detailed depiction of any chest wall, pleural, or peripheral lung abnormality. Both gray-scale and color Doppler imaging are useful for the assessment of pleural and parenchymal abnormalities [5].

Before performing the US examination, it is important to review the patient's chest radiograph to localize the area of interest. Maximum visualization of the lung and the pleural space is achieved by scanning along the intercostal spaces [5].

In healthy individuals, visualization of the lung parenchyma is not possible because the large difference in acoustic impedance between the chest wall and the air within the lung results in near total reflection of the US waves. However, in parenchymal diseases that extend to the pleural surface, replacement of the air within the lung creates an acoustic window, allowing assessment of lung tissue [5].

Lobar pneumonia, segmental pneumonia affecting the pleura and pleural-based consolidations are detectable by TUS. In general, the size of the pneumonia appears smaller on TUS than on radiographs [2]. This is because the periphery of the pneumonia is more air filled, which results in more artifacts, thus limiting complete visualization of the extent of consolidation. In the early phase of consolidation, the lung appears diffusely echogenic, resembling the sonographic texture of the liver. The shape of the pneumonia is rarely well defined, often showing irregular or serrated outlines [5].

Color Doppler US demonstrates normal or increased flow in the normal vessels of the consolidated lung and may be helpful in distinguishing simple pneumonia from postobstructive pneumonia.

The aim of this work was to describe sonographic features of simple and obstructed pneumonia and discuss the value of TUS in differentiating between both diseases.

Patients and methods

The study was performed in the Chest Department, Assiut University Hospital. A total of 25 patients (17 male and eight female) referred to the chest ultrasonic unit for evaluation of their symptoms, signs, and abnormal chest radiographic findings suggestive of pneumonia were studied sonographically during the period from April 2009 to March 2011. Of them, 18 patients had simple pneumonia (cough, expectoration of purulent sputum, and fever of acute onset in addition to signs of consolidation clinically and radiologically) and seven patients had obstructed pneumonia (cough, expectoration of sputum, and fever of acute onset in addition to signs of consolidation clinically and signs of collapse on chest radiography). Aloka ultrasound diagnostic equipment prosound SSD-3500 (Tokyo, Japan), was used for sonographic evaluation of the study patients.

Techniques for chest ultrasound examination

The US equipment used for US imaging were 3.5- and 7.5-MHz, convex and linear transducers respectively. A higher frequency (7.5 MHz) transducer provided a better resolution of proximal structures such as the chest wall and the pleura. Otherwise, a 3.5-MHz transducer was more suitable as it usually provides a broad view of the field.

The examined areas were selected from a recent chest radiograph. During chest US examination, patients were scanned in the sitting or the supine positions. Bedridden patients were examined by turning them to the oblique or the decubitus position. The patient raises his or her arms and places the hands at the back of the head to slightly extend the intercostals spaces and rotate the scapula outward. The probe was moved in transverse or longitudinal positions along the intercostal spaces to avoid interference by bony ribs. Normal areas on the chest radiograph were also scanned for control comparisons. Before the procedure, a clear, water-based gel was applied to the skin to allow for smooth movement of the transducer over the skin and to eliminate the air between the skin and the transducer. Scanning should be performed during quite respiration, to allow for assessment of normal lung movement, and in suspended respiration, to allow lesions to be examined in detail with gray-scale or color Doppler US. On gray-scale images, the echogenicity of a lesion can be compared with that of the liver and characterized as hypoechoic, isoechoic, or hyperechoic.

The main diagnostic sonographic criteria of TUS are defined as follows. An air bronchogram impresses as a small air inlet within a consolidation measuring a few millimeters in diameter or as a tree-shaped echogenic structure. A fluid bronchogram represents an exudate-packed conducting airway. It occurs less frequently than an air bronchogram, and is characterized by echo-free tubular structures along the airways. The fluid bronchogram indicates a postobstructive pneumonia. Pleural effusions are characterized by an echo-free space between the visceral and the parietal pleura [5]. In this study, effusion reflects pleura adjacent to the pneumonic infiltration.

The institutional ethical committee, Faculty of Medicine, Assiut University, approved the protocol of the study. All patients gave informed consent to participate in the study.

Statistical analysis

Data were analyzed using the appropriate software SPSS, version 16.00 (SPSS Inc., Chicago, Illinois, USA). *P*-value of less than 0.05 was considered statistically significant.

Results

In all cases studied, differentiation between sonographic signs of simple and obstructed pneumonia (Table 1) revealed a positive air bronchogram in 100.00% of the cases with simple pneumonia, but was not found in any case of obstructed pneumonia. However, fluid bronchogram was recorded in 100.00% of obstructed pneumonia but was not found in any case of simple pneumonia (P = 0.005). Oval and rounded shape, irregular shape, sharp well-demarcated, blurred-border, homogenous, heterogeneous, and hypoechoic echo patterns were found in 38.9, 61.1, 33.3, 66.7, 11.1, 88.9, and 100% of the cases of simple pneumonia and in 42.9, 57.1, 28.6, 71.4, 0, 100, and 85.7% of the cases of obstructed pneumonia, respectively. Pleural effusion was present in 44.4 and 42.9% of cases of simple and obstructed pneumonia, respectively.

Cases presentation

Case 1

A 40-year-old man presented with cough, expectoration, right-sided chest pain, and high-grade fever. Clinical examination suggested pneumonia as a provisional diagnosis. TUS demonstrated an area of consolidation in the right lower lobe. The texture of the consolidated lung appeared isoechoic to the liver (Fig. 1).

Case 2

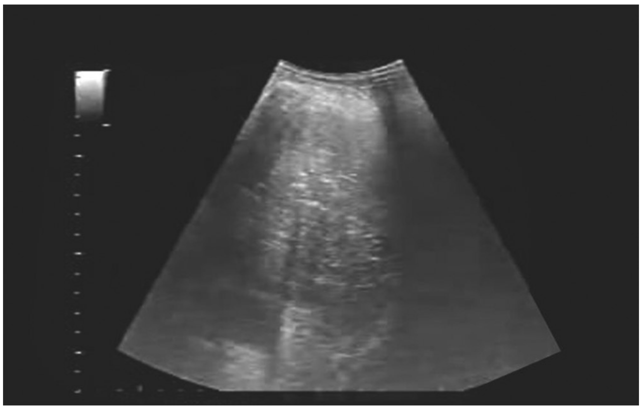
A 54-year-old man presenting with cough and hemoptysis. A computed tomography (CT) scan revealed a central perihilar mass with collapse and consolidation of the lower lobe. US clearly demonstrated fluid-filled bronchi (long arrows) as anechoic branching structures of the obstructed pneumonia. The central tumor (short arrows) appears as a well-circumscribed mass, slightly hypoechoic compared with the adjacent consolidated lung (Fig. 2).

Table 1 Sonographic signs to differentiate between simple and obstructed pneumonia

Different Sonographic signs	Simple pneumonia (n = 18) [n (%)]	Obstructed pneumonia (n = 7) [n (%)]	P-value
Parenchymal criteria			
Fluid bronchogram	0 (0.0)	7 (100.0)	0.000*
Air bronchogram	18 (100.0)	2 (28.6)	0.001*
Shape			0.865
Oval and rounded	7 (38.9)	3 (42.9)	
Irregular	11 (61.1)	4 (57.1)	
Border			0.865
Sharp well-demarcated	6 (33.3)	2 (28.6)	
Blurred	12 (66.7)	5 (71.4)	
Echo pattern			
Homogenous	2 (11.1)	0 (0.0)	0.922
Heterogeneous	16 (88.9)	7 (100.0)	0.922
Hypoechoic	18 (100.0)	6 (85.7)	0.617
Pleural effusion			0.943
With effusion	8 (44.4)	3 (42.9)	
Without effusion	10 (55.6)	4 (57.1)	

The values are calculated using χ^2-test; *Statistical significant difference (P < 0.05).

Fig. 1



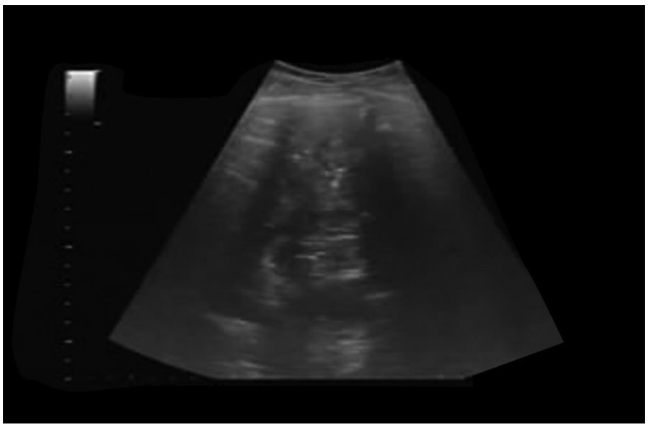
Transthoracic ultrasound demonstrates the texture of the consolidated lung, which appears isoechoic to the liver. Multiple echogenic foci are seen within the consolidated lung and correspond to air-filled airways.

Discussion

TUS has been proven to be a reliable, efficient, and informative modality for the evaluation of a wide variety of chest diseases [6]. Major advantages of US include the absence of radiation, low cost, flexibility, and bedside availability where suboptimal radiography may mask or mimic clinically significant abnormalities and short examination time compared with CT. Indeed, at present, pneumonia is mostly diagnosed by radiography, and CT is considered the gold standard for the diagnosis of infectious lung diseases. However, in the case of a chest radiograph on only one plane, or in the case of a patient in the lying position, the summation image often cannot provide exact information. The use of CT is limited by its high-radiation exposure and cost. TUS has several advantages, such as its feasibility, low cost, and the possibility of monitoring disease progress, because it can either document resolution or detect complications such as lung abscesses, parapneumonic effusion, empyema, and pleural fibrosis. Moreover, TUS is the method of choice to guide transthoracic aspiration or drainage of pleural effusion, empyema, and pulmonary abscesses in contact with the pleura, playing a very useful role in both the diagnosis and the treatment of infectious diseases and their complications. In this regard, TUS has recently been reported to be as effective as chest CT in detecting loculated effusion and lung necrosis or abscess that result from complicated pneumonia in children [7].

Meanwhile, community-acquired pneumonia affects 2/1000 persons per year in Europe and is a leading cause

Fig. 2



Transthoracic ultrasound demonstrates the area of obstructive pneumonia with a fluid bronchogram and a central tumor.

of hospital admission in Western countries, with 31.8% patients with community-acquired pneumonia (mostly children and elderly people) requiring hospitalization. The in-hospital mortality rate is still high (about 6%), namely in elderly patients with multiple comorbid conditions [8]. Although pneumonia is the most common cause of lung consolidation, its appearance is nonspecific. Infarction, hemorrhage, vasculitis, lymphoma, and bronchoalveolar carcinoma can result in consolidations that appear similar to that of pneumonia on radiology and US [9].

The most characteristic finding of simple pneumonia in this study was the presence of air bronchogram in 100% of the included patients. In agreement with our study, Rrissig and Kroegel (2007) reported that 97% of their patients (32/33) demonstrated a positive air bronchogram. Positive air bronchogram is a common radiographic finding in conventional radiograms [10]. The development of this phenomenon essentially requires the replacement of the alveolar lung tissue around the bronchi with fluid or soft-tissue density and most often indicates alveolar disease. Therefore, multiple air inlets within the hypoechogenic area suggest that the lesion detected by TUS indeed represents the alveolar lung infiltration typically observed in pneumonia. Multiple lenticular echoes, representing air inlets and measuring a few millimeters in diameter and extending to the pleural surface, are also observed frequently. These lenticular echoes vary with respiration [2].

The characteristic finding in this study regarding obstructed pneumonia was the presence of fluid bronchogram in 100%, where this finding may also be observed in other studies (16–92%) [2,11]. These are identified as anechoic tubular structures representing fluid-filled airways. The fluid bronchogram is seen in bronchial obstruction, which can result from either impacted secretions or a proximal tumor [12]. Although the fluid bronchogram may be seen in isolated pneumonia, the presence of this sign in the appropriate clinical context should raise the suspicion of postobstructive pneumonitis [13].

A number of limitations in our analysis should be noted. The major study aim was to evaluate the potential of TUS imaging in depicting acute pneumonic lesions of patients with established pneumonia. The major inclusion criteria used in this study was the demonstration of pneumonic lesions in a conventional plain radiograph of the chest precluding comparison of TUS with the established radiographic technique. Thus, the sensitivity and the specificity of TUS imaging compared with chest radiography in detecting early pneumonia could not be established. Therefore, the results of our study need to be confirmed by prospective studies with a larger number of patients. Finally, as some of the pneumonic lesions may not extend to the pleural surface of the lung, centrally located pneumonic infiltrates are not assessable by sonography. Yet, the results presented indicate that pneumonia can be recognized in about 90% of the patients, which is in good agreement with a previously published report [10]. Therefore, inconspicuous sonographic images in patients with suspected pneumonia cannot fully exclude the condition.

Conclusion

The TUS-based procedure should be added to the tools of diagnostic techniques used when pneumonia is suspected as simple and obstructed pneumonia cannot be differentiated.

Acknowledgements

Conflicts of interest

None declared.

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