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ORIGINAL STUDY

Role of Transthoracic Ultrasound in Diagnosis and Follow-up of Pneumonia

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Abstract

Objectives: **To assess the role of transthoracic ultrasound (TUS) in the diagnosis and follow-up of pneumonia compared with chest radiography (CXR) and high-resolution computed tomography (HRCT).**

Background: **Pneumonia is a serious health problem. TUS is quickly becoming one of the most useful nonionizing radiation diagnostic techniques for identifying various lung illnesses.**

Methods: **This prospective observational study was carried out in the Menoufia University Hospitals' Chest Diseases Department. From December 2022 to June 2023, it covered 50 patients who were clinically suspected of having pneumonia. The diagnosis was based on symptoms, signs, and chest HRCT. TUS and CXR were done and follow-up TUS after 7, 14, and 30 days.**

Results: **TUS was able to identify consolidations in 44 out of 45 cases with HRCT consolidation, in which an air-bronchogram appeared in 37 cases, and a shred sign was in 17 cases. In addition, TUS revealed increased B lines in 7 of the 9 interstitial pneumonia patients, and pleural effusion was found in 14 cases. TUS had a sensitivity and specificity of 97.8% and 100% in the diagnosis of consolidation, with an accuracy of 98%, positive predictive values (PPV) 100%, and negative predictive values (NPV) 83.3%, compared with 70% and 100% in the diagnosis of interstitial pneumonia, with an accuracy of 94%, positive predictive values 100%, and negative predictive values 93%.**

Conclusion: **TUS is more reliable than CXR for diagnosing pneumonia patients. It might also be used as a secure follow-up instrument.**

Keywords: Air-bronchogram, Consolidation, Pleural effusion, Pneumonia, Transthoracic ultrasound

1. Introduction

Since early diagnosis and treatment are crucial to reducing morbidity and mortality from pneumonia, it is a serious global health issue [1].

The clinical symptoms, signs, and examination are used to make the diagnosis of pneumonia. The clinical characteristics of pneumonia may resemble those of other illnesses, and pneumonia may occur unusually, making a diagnosis challenging. Blood tests including the complete blood count with differential and acute phase reactants are no different. Pneumonia is not always present even with low C-reactive protein (CRP) and a normal white blood cell count [2].

The most common diagnostic test for patients with pulmonary symptoms is a chest radiography (CXR), however, it has poor specificity and sensitivity. Additionally, it has processing-related practical delays. The likelihood of treatment errors increases if a characteristic radiological sign is not visible on a CXR [3].

Despite being the most effective method for diagnosing pneumonia, high-resolution computed tomography (HRCT) is not always the first option for radiological investigation of all cases with possible pneumonia because of its high ionizing radiation levels, high cost, and regional limitations [4].

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Transthoracic ultrasound (TUS) is nonionizing, less expensive, allows for follow-up exams, can track the results of therapy, and has higher patient compliance. This diagnostic procedure is also quick, simple to learn, portable, and used as a point-of-care method right away. TUS has good diagnostic accuracy for many thoracic diseases, such as pneumonia, pulmonary embolism, and pleural effusion [5,6].

The aim of this work was to assess the role of TUS in the diagnosis and follow-up of pneumonia compared with CXR and HRCT.

2. Methods

This prospective observational study was carried out in the Menoufia University Hospitals' Chest Department (from December 2022 to June 2023) on 50 patients diagnosed with pneumonia by clinical examination and HRCT chest. Prior to the study, all participants had to give informed written consent that was accepted by the Menoufia institutional review board (IRB number: 11/2022CHES 2).

Patients with complicated pneumonia with abscesses, cavitation's, necrosis, or patients who had bronchiectasis or interstitial lung diseases were excluded from the study. Patients who received treatment for pneumonia, patients who refused participation, patients less than 18 years old, or couldn't complete follow-up were also excluded.

All patients got a thorough medical history interview, a thorough general and local examination, standard laboratory tests, a CXR by ECORAY machine, Seoul, South Korea (lateral and posterior-anterior views), a TUS, and a high-resolution chest computed tomography. The gold standard for radiological diagnosis was thought to be chest HRCT.

The following symptoms are present in patients, all of which are suggestive of pneumonia: cough, expectoration, fever, dyspnoea, and unusual auscultatory findings.

Using a computed tomography (CT) scanner (Toshiba, Alexion, 16 detectors, Otawara, Japan), a chest HRCT was performed to check the presence of consolidation, air-bronchogram, associated pleural effusion, and interstitial infiltrations that indicate interstitial pneumonia.

With a 3–5 MHz convex probe and an US machine (Philips Affinity 50 G, Saarbrucken, Germany), TUS was accomplished. Patients were evaluated from the front while in a supine position, and from the back when seated or lying on their side. Each hemithorax was separated into posterior areas that extend from the paravertebral line to the posterior axillary line and anterior-lateral areas that extend from the posterior axillary line to the parasternal line. The third intercostal gap was used to divide each area into upper and lower parts. The convex probe was angled, parallel, and perpendicular to the ribs. To assess the blood perfusion of the damaged lung tissue, Doppler US was used. In areas of lung consolidation, the pulmonary arterial and venous vasculature are clearly visible. The presence of hypoechoic or isoechoic areas with dynamic air-bronchogram that are recognized as punctiform or straight hyper-echogenic artifacts with the centrifugal inspiring dynamics and/or the shred sign (which is a static ultrasonographic indicator of consolidated lung and manifests as a hypoechoic subpleural area with an irregular deep border bordered by normally aerated lung) were required for the diagnosis of pneumonic consolidation [7]. The occurrence of static air-bronchogram or the absence of air-bronchogram within the tissue-like consolidation served to distinguish lung collapse from pneumonia [8]. B-lines, which are hyperechoic, well-defined, indefinitely spreading artifacts that begin from the pleural line, moving in sync with the lung sliding. As a sign of interstitial infiltrations, more B-lines (around 3/intercostal gap) were noted. The echo texture of a parapneumonic pleural effusion (simple: anechoic or complex: echogenic either nonseptated or septated) was observed [9].

Follow-up of pneumonic consolidation, air-bronchograms, B-lines, and pleural effusion at 7, 14, and 30 days was done using TUS. Although there is no evidence of clarity in the diagnostic criteria of nonresolving pneumonia, it has been described by numerous studies as an inability to achieve radiological resolution by 50% in 2 weeks or absence of full resolution by 1 month despite sufficient antibiotic treatment [10,11].

2.1. Statistical analysis

Using SPSS 22.0, all data were gathered, tabulated, and statistically examined. Categorical data were expressed as numbers and percentages, whereas quantitative data were expressed as the mean, SD, and range. To compare between two tools, the χ^2 test was used. When more than 20% of the cells had an anticipated count of less than 5, the Fisher Exact test was instead used. At the 5% level, the results' significance was determined. Diagnostic validity was used to determine the reliability of TUS in the identification of pneumonia. Calculations were made for the 95% confidence intervals for the sensitivity, specificity, positive, and negative predictive values (PPV and NPV), and accuracy.

3. Results

This study included 50 patients diagnosed with pneumonia with a mean age of 53.2 ± 13.2 years (15 females and 35 males). The Socio-demographic and clinical data of the studied patients are shown in Table 1.

Table 2 presents the radiological findings in all patients in which CXRs showed consolidation in 34 (68.0%) patients, pleural effusion in 5 (10.0%) patients, and interstitial infiltrates in 2 (4.0%). While HRCT revealed that consolidation was present in 45 (90.0%) patients. Pleural effusion was diagnosed by HRCT in 14 (28.0%) patients and interstitial infiltrates in 10 (20%) patients. TUS showed that consolidation, air bronchogram, and pleural effusion were present in 44 (88.0%) patients, 37 (74.0%) patients, and 14 (28.0%), respectively. Types of pleural effusion were free anechoic in eight (16.0%) patients, nonseptate echogenic in three (6.0%) patients, and septate echogenic in three (6.0%) patients. Other findings by TUS showed that B lines were increased in seven (14.0%) patients and a Shred sign was present in 17 (34.0%) patients.

The comparison between the radiological findings of CXR, HRCT, and TUS was indicated in Table 3 in which there were statistical significant variations between HRCT and CXR as regards the detection of consolidation, pleural effusion, and interstitial pattern (*P* value 0.007, 0.022, and 0.028, respectively) and between TUS and CXR regarding only the consolidation, and pleural effusion (*P* value 0.016 and 0.022, respectively). However, there were no statistically significant differences between TUS and CXR regarding interstitial pattern (*P* value 0.160) and between HRCT and CXR regarding all radiological findings.

Table 1. Characteristics and symptoms of the studied patients N = 50.

variables	Studied patients $n = 50$
Age (y):	
Range	19–70
Mean ± SD.	53.2 ± 13.2
Sex: No (%)	
Male	35 (70.0)
Female	15 (30.0)
Smoking No (%)	
Yes	27 (54.0)
No	23 (46.0)
Symptoms:	
Fever	41 (82.0)
Dyspnea	27 (54.0)
Cough	47 (94.0)
Hemoptysis	11 (22.0)
Expectoration	39 (78.0)
Total leucocytic count (cell/mm^3)	
Mean ± SD.	14.10 ± 5.29
Min-Max	3.9–23
Range	19.1
C-reactive protein (mg/l)	
Mean ± SD.	79.4 ± 43.8
Min-Max	6–184
Range	178

Table 2. Radiography, high-resolution computed tomography, and ultrasound findings among the studied patients (n = 50).

Radiological findings	Number (%)
Radiography	
Consolidation	34 (68.0)
Pleural effusion	5 (10.0)
Interstitial pattern	2 (4.00)
HRCT	
Consolidation	45 (90.0)
Pleural effusion	14 (28.0)
Interstitial pattern	10 (20.0)
TUS	
Consolidation	44 (88.0)
Air bronchogram	37 (74.0)
Pleural effusion:	14 (28.0)
simple anechoic	8 (16.0)
Complex Nonseptate echogenic	3 (6.00)
Complex Septate echogenic	3 (6.00)
Increased B-line	7 (14.0)
Shred sign	17 (34.0)

The sensitivity and specificity of TUS and CXR in the diagnosis of consolidation, pleural effusion, and interstitial pneumonia were indicated in Table 4 in which TUS was better in the diagnosis of consolidation than CXR with a sensitivity of 97.8%, specificity of 100%, accuracy of 98%, positive predictive value (PPV) 100%, negative predictive value (NPV) 83.3%.

There was a high validity of TUS in the diagnosis of pleural effusion than CXR with sensitivity, Specificity, Accuracy, PPV, and NPV were 100% for all while for CXR were 35.7%, 100%, 82%, 100, and 80%, respectively.

Furthermore, the sensitivity and specificity of TUS in the diagnosis of interstitial pneumonia were 70%, and 100%, respectively, with an accuracy of 94%, PPV 100%, and NPV 93% while the sensitivity and specificity of CXR were 20 and 100%, respectively with an accuracy of 84%, PPV 100%, and NPV 83.3% as presented in Table 4.

Follow-up by TUS after 7 and 14 days of the studied patient was done as shown in Table 5. After 7 days, consolidation decreased in size in 12 (27.3%) patients out of 44 positive cases. Air-bronchogram became less pronounced in 24 (64.9%) patients out of 37 positive cases. Pleural effusion decreased in 4 (28.6%) out of 14 positive cases and the Shred sign disappeared in 5 (29.4%) out of 17 positive cases. Furthermore, B lines decreased in 4 (57.1%) out of 7 positive cases.

Follow-up after 14 days, consolidation decreased in size in 33 (75%) out of 44 positive cases, Air-

Table 3. Comparison between radiological findings of radiography, high-resolution computed tomography, and transthoracic ultrasound among the studied patients (n = 50).

Radiological findings	CXR	HRCT	Test of significance	*P* value
Consolidation	34 (68.0)	45 (90.0)	$\chi^2 = 7.294$	0.007**
Pleural effusion	5 (10.0)	14 (28.0)	$\chi^2 = 5.263$	0.022*
Interstitial pattern	2 (4.00)	10 (20.0)	$\chi^2 = 6.060$	0.028* FE
	CXR	**TUS**	**Test of significance**	***P* value**
Consolidation	34 (68.0)	44 (88.0)	$\chi^2 = 5.828$	0.016*
Pleural effusion	5 (10.0)	14 (28.0)	$\chi^2 = 5.263$	0.022*
Interstitial pattern	2 (4.00)	7 (14.0)	$\chi^2 = 3.053$	0.160FE
	TUS	**HRCT**	**Test of significance**	***P* value**
Consolidation	44 (88.0)	45 (90.0)	$\chi^2 = 0.102$	0.749
Pleural effusion	14 (28.0)	14 (28.0)	$\chi^2 = 0.00$	1.00
Interstitial pattern	7 (14.0)	10 (20.0)	$\chi^2 = 0.638$	0.424

*significant, ** highly significant, χ^2: chi-square test, FE: Fisher Exact test.

Table 4. Validity of radiography and U/S in the diagnosis of consolidation, pleural effusion, and interstitial pneumonia versus high-resolution computed tomography.

%(95%CI)	Consolidation		Pleural effusion		interstitial pneumonia	
	TUS	X-ray	TUS	X-Ray	TUS	X-Ray
Sensitivity	97.8 (88.2–100)	75.6 (60.5–87.1)	100 (76.8–100)	35.7 (12.8–64.9)	70 (34.8–93.3)	20 (2.5–55.6)
Specificity	100 (47.8–100)	100 (47.8–100)	100 (90.3–100)	100 (90.3–100)	100 (91.2–100)	100 (91.2–100)
Accuracy	98 (89.4–100)	78 (64–88.5)	100 (92.9–100)	82 (68.6–91.4)	94 (83.5–98.8)	84 (70.9–92.8)
PPV	100 (92–100)	100 (89.7–100)	100 (76.8–100)	100 (47.8–100)	100 (59–100)	100 (15.8–100)
NPV	83.3 (41.9–97.2)	31.2 (21.4–43.2)	100 (90.2–100)	80 (73–85.5)	93 (83.8–97.2)	83.3 (78.6–87.2)

CI, confidence interval.

Table 5. Follow-up of the studied patients who were positive for transthoracic ultrasound.

	After 7 days No. (%)	After 14 days No. (%)
Consolidation decreased in size: (no = 44)		
Yes	12 (27.3)	33 (75.0)
No	32 (72.7)	11 (25.0)
Bronchogram became less pronounced: (no = 37)		
Yes	24 (64.9)	35 (94.6)
No	13 (35.1)	2 (5.4)
Pleural effusion decreased: (no = 14)		
Yes	4 (28.6)	11(78.6)
No	10 (71.4)	3 (21.4)
The shred sign disappeared. (no = 17)		
Yes	5 (29.4)	17 (100.0)
No	12 (70.6)	0
B line decrease: (no = 7)		
Yes	4 (57.1)	7 (100.0)
No	3 (42.9)	0

bronchogram became less pronounced in 35 (94.6%) out of 37 positive cases, pleural effusion decreased in 11 (78.6%) out of 14 positive cases while the Shred sign disappeared in all positive 17 patients and B line decrease in all positive seven patients (Fig. 1).

After 1 month, follow-up by TUS was done for residual participants, which showed that only 2 (4%) cases were still unresolved while 48 (96%) cases were completely resolved.

4. Discussion

In critical care and emergency medicine, TUS is gaining more popularity. A significant amount of research has shown that the US is quite useful in assessing a variety of lung illnesses [12–14]. It is increasingly being used to assess pneumonia, and each clinical context demonstrates improved effectiveness. Even though many conventional imaging applications are still indicated and will continue to be used indefinitely for patients with possible pneumonia, using the TUS imaging may substantially minimize the postpones that accompany the CXR and, in some cases, may reduce the demand for HRCT when an accurate diagnosis is obtained. When pneumonia is one of the differential diagnoses, it should frequently be carried out first [15].

This study aimed to assess the role of TUS in the diagnosis and follow-up of pneumonia compared with CXR and HRCT.

In this current study, TUS could detect consolidation in 44 out of 45 cases in which an air-bronchogram was found in 37 cases and a shred sign was found in 17 cases. Furthermore, TUS showed increased B lines in 7 out of 9 interstitial pneumonia cases, and pleural effusion was detected in 14 cases. In comparison, CXR detects lung

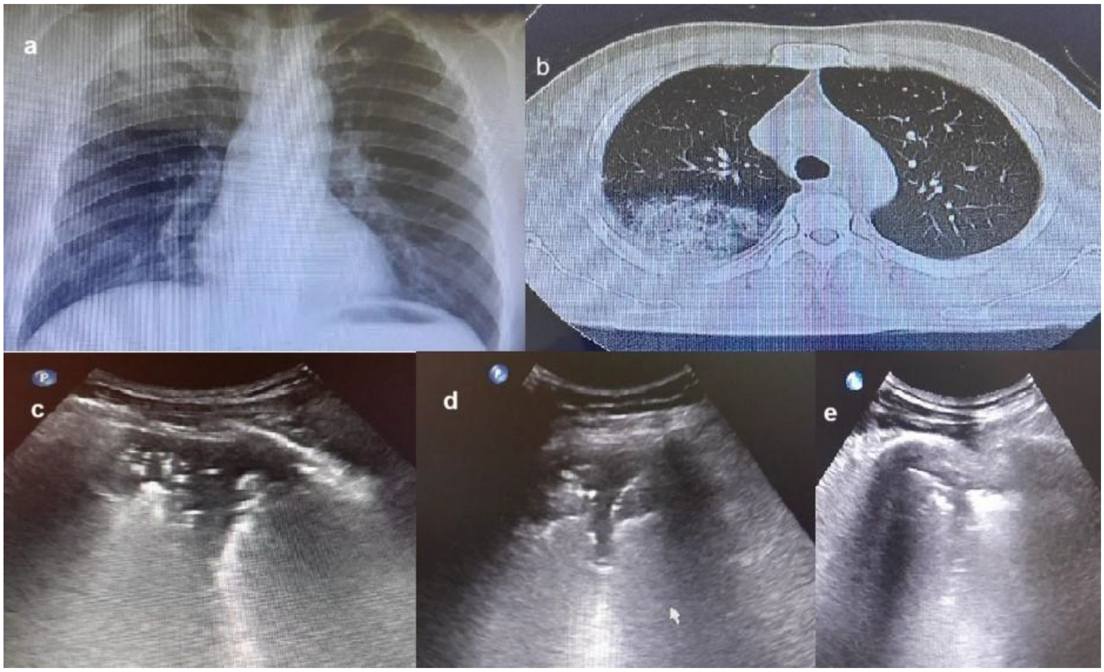

Fig. 1. Figure shows the chest radiography (a) and, computed tomography (b) of right-sided consolidation, transthoracic ultrasound (c) shows the consolidation with air-bronchograms with pleural effusion and shred sign. Follow-up of transthoracic ultrasound on day 7 (d), and day 14 (e) shows gradual improvement of each finding.

consolidation in 34 cases interstitial infiltrate in 2 cases, and pleural effusion in 5 cases. There were statistically significant variations between TUS and CXR in the identification of both lung consolidation and associated pleural effusions and highly statistically significant variations between HRCT and CXR in the identification of lung consolidation, associated pleural effusion, and interstitial infiltrations.

Although it is not always present, consolidation is a frequent US finding for pneumonia. An interstitial pattern (increased B line) in the US has been shown in several cases to be suggestive of pneumonia [16,17], and patients who have this alteration might have widespread ground glass opacity on the chest CT. The B lines associated with interstitial lung edema might be diffuse (cardiogenic or noncardiogenic pulmonary edema), or focal (pneumonia, lung contusion)). According to Cortellaro et al. [16], 52.5% of patients with alveolointerstitial syndrome and 91.3% of cases with pneumonia displayed a consolidation pattern using a dynamic air-bronchogram. Pleural effusion has been confirmed as a nonspecific symptom because it was found in 39% of cases with confirmed pneumonia and 15% of cases with no pneumonia.

In line with Moghawri et al. [18], who found that the US could diagnose pneumonia in 96.7% of patients. They added that there was no significant variation between TUS and CT in the identification of pneumonia, but that there was a highly significant variation with P value = 0.001 between US and CXR. US and CT both revealed pneumonia in 96.7% of the patients. In addition, TUS exhibited a sensitivity and PPV for pneumonia of 97.4%, a specificity of 25%, and 95% accuracy.

Similar conclusions were reached by Parlamento et al. [19], after looking into a group of 49 patients in the emergency department (ER) who had been suspected of having community-acquired pneumonia (CAP). While CXR was only diagnostic in 75% of the 32 cases with a diagnosis of CAP, the US was positive in 96.9% of those cases. The 8 cases who had a positive US but a negative CXR underwent additional testing with a chest CT, which in all cases revealed pneumonia.

Patients who reported to the ER with the possibility of pneumonia underwent US, CXR, and chest CT scans by Agmy and Ahmed [20]; 82% of cases with definite pneumonia had air-bronchograms. In the study of Lichtenstein et al. [21], on 32 cases admitted to the ICU with acute respiratory distress syndrome of various causes and 10 healthy individuals, they discovered that CXR had 47 and 75% diagnostic accuracy for the identification of pleural effusion and consolidation, respectively, and 72% for alveolointerstitial syndrome.

According to Alkhayat and Alam-Eldeen [22], air-bronchograms were detected in 87% of cases, whereas pleural effusions were present in 54%. This disparity may be related to the current study's selection of patients with no clinical data suggesting pneumonia even early.

In this current study, the sensitivity and specificity of TUS in the diagnosis of consolidation were 97.78 and 100%, respectively with an accuracy of 98%, PPV 100%, and NPV 83.3% while 70, and 100%, respectively with an accuracy of 94%, PPV 100%, NPV 93.02% in the diagnosis of interstitial pneumonia. Contrary to the CXR, the sensitivity and specificity was 75.56 and 100%, respectively in the diagnosis of consolidation with an accuracy of 78%, while 20%, and 100%, respectively with an accuracy of 83.33%, in the diagnosis of interstitial pneumonia.

Furthermore, the sensitivity and specificity of TUS was 100% in the diagnosis of pleural effusion in association with pneumonia while for the CXR were 35.71% and 100%, respectively.

These findings were comparable to those of Lichtenstein et al. [21], who found that TUS had a 93% accuracy rate for pleural effusion, 97% for consolidations, and 95% for alveolointerstitial syndrome in the same participants.

As reported by Mohammed et al. [23], CXR has a sensitivity of 83.81% and specificity of 95.79% for the identification of pneumonia, with PPV of 95.9%, NPV of 83.4%, and accuracy of 81.42%. In contrast to chest CT, the US demonstrated a sensitivity of 93.33% and specificity of 94.74% for the identification of pneumonia, respectively, with PPV of 95.4%, NPV of 92.4%, and 93.91% accuracy. These findings agreed with Andrea et al., who found that LUS had a higher diagnostic accuracy than CT but not CXR.

Similar findings were reported by Agmy and Ahmed. [20], with 97% US sensitivity in pneumonia diagnosis, and Parlamento et al. [19], also said that whilst CXR exhibited a sensitivity of 69%, the US had a sensitivity of 96%.

The US was diagnostic for pneumonia in the study of Amatya et al. [3], having a 91% sensitivity while CXR was 73%. Compared with CXR, the US has a much higher sensitivity. At 61% and 50%, respectively, the specificity of the US and CXR was comparable. The US had an 85% PPV, compared with 78% for CXR, and had a 73% VPP compared with 43% for CXR. Furthermore, in contrast to the sensitivity and accuracy of 72.3% and 81%, respectively for CXR in diagnosing pneumonia, Haggag et al. [8], observed that the US had a sensitivity of 100% and an accuracy of 95%.

TUS demonstrated a high sensitivity of 88% and specificity of 86% for the identification of adult pneumonia in the meta-analysis by Long et al. [24], compared with CXR or chest CT. The diagnostic utility of TUS in pneumonia was also observed by Bourcier et al. [25]. In particular, this study found that the US had a considerably greater sensitivity for diagnosing acute pneumonia than CXR (95% vs. 60%).

After 7 days, follow-up TUS on the patients in this current study revealed that 12 (27.3%) patients out of 44 positive cases had reduced consolidations, 24 (64.9%) patients had less pronounced air-bronchogram, and the shred sign vanished in five (29.4%) patients out of 17 positive patients. Additionally, pleural effusion decreased in 4 (28.6%) patients out of 14 positive cases while the increased B lines decreased in 4 (57.1%) patients out of 7 positive cases.

Follow-up after 14 days, consolidations were either decreased in size or completely resolved in 33 (75%) patients, air-bronchogram became less pronounced in 35 (94.6%) patients, the pleural effusion decreased in 11 (78.6%) patients while the shred sign and increased B-line completely resolved in all positive cases.

After a month, the remaining cases were monitored, and only 2 patients were diagnosed to have unresolved pneumonia.

These findings corroborated the findings of studies by Mohammed et al. [23], Reissig et al. [26], and Saraya et al. [27], which concluded that the TUS is a helpful method for diagnosing and monitoring pneumonia.

The limitations of this study included the small number of participants, the amount of pleural effusion was not accurately calculated, and the complicated cases e.g., with lung abscess or necrosis were excluded from the study, so could not assess the diagnostic accuracy of TUS in their diagnosis. So further studies on a larger number together with complicated cases are recommended with the assessment of TUS in the calculation of the associated pleural effusion.

In conclusion, TUS is an additional imaging method that can be used to confirm the diagnosis in patients who have pneumonia suspicions and is more accurate than CXR. It also could be used as a safe follow-up technique for the re-evaluation of pneumonia patients.

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Conflicts of interest

No conflict of interests.

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References

[1] Wunderink RG, Waterer GW. Clinical practice. Community-acquired pneumonia. N Engl J Med 2014;370:543−51.
[2] Eccles S, Pincus C, Higgins B, Woodhead M. Diagnosis and management of community and hospital acquired pneumonia in adults: summary of NICE guidance. BMJ (Clinical Research Ed) 2014;349:g6722.
[3] Amatya Y, Rupp J, Russell FM, Saunders J, Bales B, House DR. Diagnostic use of lung ultrasound compared to chest radiograph for suspected pneumonia in a resource-limited setting. Int J Emerg Med 2018;11:8.
[4] Ticinesi A, Lauretani F, Nouvenne A, Mori G, Chiussi G, Maggio M, et al. Lung ultrasound and chest x-ray for detecting pneumonia in an acute geriatric ward. Medicine 2016;95:e4153.
[5] Blaivas M. Lung ultrasound in evaluation of pneumonia. J Ultrasound Med 2012;31:823−6.
[6] Lichtenstein DA. Ultrasound in the management of thoracic disease. Crit Care Med 2007;35(5 Suppl):S250−61.
[7] Volpicelli G. Lung sonography. J Ultrasound Med: Official J American Institute of Ultrasound in Medicine 2013;32:165−71.
[8] Haggag YI, Mashhour K, Ahmed K, Samir N, Radwan W. Effectiveness of lung ultrasound in comparison with chest X-ray in diagnosis of lung consolidation. Open access Macedonian J Med Sci 2019;7:2457−61.
[9] Miller A. Practical approach to lung ultrasound. BJA Education 2015;16:39−45.
[10] Chaudhuri AD, Mukherjee S, Nandi S, Bhuniya S, Tapadar SR, Saha M. A study on non-resolving pneumonia with special reference to role of fiberoptic bronchoscopy. Lung India official organ of Indian Chest Society 2013;30:27−32.
[11] Rome L, Murali G, Lippmann M. Nonresolving pneumonia and mimics of pneumonia. Med Clin 2001;85:1511−30 [xi].
[12] Ding W, Shen Y, Yang J, He X, Zhang M. Diagnosis of pneumothorax by radiography and ultrasonography: a meta-analysis. Chest 2011;140:859−66.
[13] Prina E, Ranzani OT, Torres A. Community-acquired pneumonia. Lancet (London, England) 2015;386:1097−108.
[14] Xia Y, Ying Y, Wang S, Li W, Shen H. Effectiveness of lung ultrasonography for diagnosis of pneumonia in adults: a systematic review and meta-analysis. J Thorac Dis 2016;8:2822−31.
[15] Reissig A, Gramegna A, Aliberti S. The role of lung ultrasound in the diagnosis and follow-up of community-acquired pneumonia. Eur J Intern Med 2012;23:391−7.
[16] Cortellaro F, Colombo S, Coen D, Duca PG. Lung ultrasound is an accurate diagnostic tool for the diagnosis of pneumonia in the emergency department. Emerg Med J : Eng Manag J 2012;29:19−23.
[17] Lichtenstein DA, Mezière GA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol. Chest 2008;134:117−25.
[18] Saied Moghawri M, Mansour W, Lakouz KA, Hussein RM. Role of chest ultrasonography in the diagnosis and follow-up of community-acquired pneumonia at Zagazig University Hospitals. Egyptian J Bronchology 2017;11:29−35.
[19] Parlamento S, Copetti R, Di Bartolomeo S. Evaluation of lung ultrasound for the diagnosis of pneumonia in the ED. Am J Emerg Med 2009;27:379−84.
[20] Agmy G, Ahmed Y. Role of transthoracic sonography in diagnosis and follow up of community acquired pneumonia in emergency department. Eur Respir J 2013;42(Suppl 57):P228.
[21] Lichtenstein D, Goldstein I, Mourgeon E, Cluzel P, Grenier P, Rouby JJ. Comparative diagnostic performances of auscultation, chest radiography, and lung ultrasonography in acute respiratory distress syndrome. Anesthesiology 2004;100:9−15.
[22] Alkhayat KF, Alam-Eldeen MH. Value of chest ultrasound in diagnosis of community acquired pneumonia. Egypt J Chest Dis Tuberc 2014;63:1047−51.
[23] Mohammed Fekry El-Deek A, Mohamed Abd El-Hamid Hassan E-S, Shawky R. Role of lung ultrasound in diagnosis and follow up of pneumonia in adults: is it significant? Al-Azhar Medical Journal 2021;50:603−14.
[24] Long L, Zhao H-T, Zhang Z-Y, Wang G-Y, Zhao H-L. Lung ultrasound for the diagnosis of pneumonia in adults: a meta-analysis. Medicine 2017;96:3.
[25] Bourcier JE, Paquet J, Seinger M, Gallard E, Redonnet JP, Cheddadi F, et al. Performance comparison of lung ultrasound and chest x-ray for the diagnosis of pneumonia in the ED. Am J Emerg Med 2014;32:115−8.
[26] Reissig A, Kroegel C. Sonographic diagnosis and follow-up of pneumonia: a prospective study. Respiration 2007;74:537−47.
[27] Saraya S, El Bakry R. Ultrasound: can it replace CT in the evaluation of pneumonia in pediatric age group? Egyptian J Radiology and Nuclear Med 2017;48:687−94.