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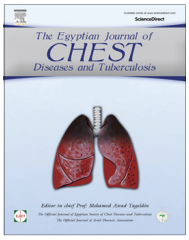

ORIGINAL ARTICLE

Accuracy of gray scale and color Doppler sonographic mapping in diagnosis of pneumonia in adult

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KEYWORDS

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Computed tomography

Abstract *Background:* Although the plain radiograph and computed tomography remain undoubtedly the primary imaging modalities in the investigation of pneumonia, ultrasound can play an important complementary role, in the diagnostic workup of the patients, and in their subsequent management.

Objective: To compare the accuracy of LUS with those of CXR and CT imaging in the diagnosis of pneumonia and compare color Doppler sonography and computed tomography (CT) for predicting necrotizing pneumonia.

Methods: Thirty-one patients with clinical suspicion of pneumonia were assessed by chest radiography, CT and sonography. Quantitative and qualitative sonographic examinations of the lesions were performed using grayscale and color Doppler imaging. The correlation between the color Doppler and CT findings was determined.

Results: LUS showed a high sensitivity (100%) and specificity (93.8%) and diagnostic accuracy was 96.8% in the diagnosis of pneumonia "which extend to pleural line". It was almost a perfect agreement with CT findings ($K = 0.93$). The sensitivity of chest X-ray was low (60%). It was moderately in agreement with CT findings ($K = 0.608$). A significant change was seen in the flow pattern in comparison to the severity of necrosis by CT (P value $= 0.038$).

Conclusions: Lung ultrasound imaging for the detection of pneumonia is highly accurate. Based on our results, LUS is a valid alternative for the diagnosis of pneumonia. By combined qualitative and quantitative impedance measurement, PA and bronchial artery (BA) can be differentiated from each other. Flow pattern of pulmonary arteries which was found in most of our cases was an indicative of benign lesions.

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Introduction

Pneumonia is considered a major healthcare and economic problem with a considerable effect on morbidity and mortality worldwide [1]. The incidence of community acquired pneumonia has remained constant over the last few decades affecting 3–5 people per 1000 person/year, predominantly among the young and elderly [2,3].

The diagnosis of pneumonia is made by a constellation of suggestive clinical features such as tachypnea, fever, and respiratory rales or reduced breath sounds on auscultation [4].

There is a strong consensus that chest X-ray (CXR) should be performed in all patients admitted with suspected pneumonia [5] because medical history and physical examination cannot provide sufficient evidence [6]. In emergency settings, however, the use of CXR may have major limitations due to patient conditions, waste of time, and interobserver variability [7].

Chest CT scan, considered the gold-standard imaging approach for pneumonia, has its own limitations: it is expensive; impractical, especially in the critically-ill; and, has higher radiation exposure than CXR [8,9].

Use of lung ultrasound (LUS) has long been limited to the diagnosis of pleural effusions, thoracentesis and biopsy-guided procedures; however, it has recently been shown to be highly effective in evaluating pulmonary conditions [4,10].

The use of LUS has gained popularity in intensive care units (ICUs) and EDs in the last decade, and has become increasingly recognized as a potentially useful diagnostic approach for community-acquired pneumonia [11,12].

The usefulness of US is in the differentiation of pleural abnormalities from pulmonary parenchymal lesions; when both pulmonary and pleural lesions are present, distinction between these two lesion types is not always easy at chest radiography [13].

Information about vascularization may be obtained by qualitative color Doppler sonography, by spectral curve analysis and by contrast enhanced sonography (CES). Pneumonia shows enhanced, tree-like vascularity extending from the center to the periphery [14].

Quantitative analysis of ultrasonography is an objective method that has been clinically applied to different organs but not yet to lungs [15].

Corradi et al. [16] reported that, quantitative lung ultrasonography (QLUS) proved to be an accurate method to evaluate extravascular lung water in a model of pulmonary edema. It can be hypothesized that QLUS may also be useful for the detection of pulmonary consolidations of different origins [17].

The aim of this prospective study was to assess whether lung ultrasonography could be an alternative to bedside chest radiography for diagnosing pneumonia, also, was to compare the accuracy of LUS with those of CXR and CT imaging, and lastly, was to evaluate the evidence and frequency of different arterial supplies of different pneumonic lesions especially pneumonia and lung abscess using qualitative and quantitative color Doppler sonography.

Patients and methods

Thirty-one adult patients were recruited and were admitted during the period from October 2013 to August 2015 in the pulmonary department of Minia University Hospital.

Inclusion criteria were as follows: enrollment of adult patients aged $\geqslant 18$ years with clinical suspicion of pneumonia based on respiratory symptoms and signs, and evaluation of pneumonia based on a combination of clinical data, laboratory results and chest imaging (lesion extend to pleural line) by CXR or a chest CT scan.

Exclusion criteria

The possibility of adult respiratory distress syndrome and patients with heart disease (CHD) were excluded from the study to rule out pulmonary edema secondary to heart disease.

The study was approved by the local ethics committee

All included patients were subjected to:-

- Detailed history, and examination.
- Laboratory investigations including complete blood count, sputum, pleural fluid analysis and culture for AFB and other microorganisms.
- Chest radiography: The extent of lung injury was assessed as the number of lung regions with radiologic signs suggestive of alveolar consolidation.

CT scans were obtained by a CT (GE BRIGHT SPEED), 16 detectors scanner (General electric Healthcare, USA). Reconstruction parameters were 5.0 mm slice thickness and medium smooth convolution kernel (B41s).

The CT findings on necrotizing pneumonia (NP) included the following:

(1) a consolidated area without loss of volume,
(2) a necrotic radiolucent image within the consolidated area, and
(3) the lack of contrast enhancement in CT after contrast administration. The severity of lung necrosis was determined by analyzing the relative ratio of the necrotic radiolucent space to the total consolidated lung area calculated using ImageJ, Version 1.47 (National Institute of Health, USA). This novel approach was a modification of the method for estimating the volume fraction of acute lobar nephronia [18]. Necrotic areas were categorized as mild (N1) if the ratio was less than 30%; moderate (N2) if the ratio was between 30% and 80%; and massive (N3) if the necrotic area was more than 80%.

Lung ultrasonography was performed immediately after the chest radiography, with a Philips, Clear Vue 350 Ultrasound Systems and a linear (5–12 MHz), and convex (curved) 2–5 MHz transductors. Patients were examined in the supine or sitting position, as clinically appropriate. Grayscale ultrasound was used first to localize the whole lesion, and then a color Doppler ultrasound examination was added.

Color flow imaging may be helpful in characterizing the lesion by demonstrating the vascularity and flow pattern.

The perfusion of consolidated lung was classified into various degrees of central vascularity based on the qualitative assessment of the area of color flow as follows:

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