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Role of Grey Scale and Color Doppler Ultrasound in Diagnosis of Lung Abscess

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Abstract
The main purpose of this work is to compare the diagnostic accuracy (DA) of chest X ray (CXR), chest computerized tomography (CT)and lung grey scale ultrasonography (US)in evaluation of lung abscess and determine the role of color doppler ultrasound in diagnosis of lung abscess.
Sixteen patients with suspected lung abscess were evaluated by CXR, chest CT, grey scale and colour doppler chest sonography. Chest CT revealed the highest DA (98.5%) with 100% sensitivity, 98.3% specificity, 88.9% PPV and 100% NPV. The specificity, sensitivity, PPV, NPV and DA of chest X ray were 98.3%, 75%, 85.7%, 96.6% and 95.5% respectively. Grey scale US had the least sensitivity (53.3%), specificity was 98.2%, PPV 96.7%, NPV 67.7% and DA 93.1%. CDS showed absent vascularity were observed in 9 lesions (60%), scanty and marked vascularity were equally detected each in 3 lesions (20%) with 66.7% showing THI flow and 33.3% showing MHI flow. The present study revealed that chest CT is considered the most accurate radiological procedure for diagnosis of lung abscess. Although its low sensitivity, grey scale US has a relatively high specificity in diagnosing lung abscess.
Keywords: *Lunggrey scale ultrasonography, Lung abscess, Chest X ray, Computed tomography, Color Doppler sonography.*

Introduction

Lung abscess is defined as an area of suppurative or necrotic tissue in the lung parenchyma, which leads to a cavitation, and after development of bronchopulmonary fistula, an air-fluid level within this cavitary lesion ***(Seo et al., 2013).*** Acute lung abscess is usually circumscribed with not so well-defined surrounding to lung parenchyma, filled with thick necrotic detritus. Chronic abscess of the lung is usually irregular star-like shape with well-defined margin, filled with grayish thick necrotic tissues ***(Kuhajda et al., 2015).***

The CXR is an old radiological procedure and also still the one most frequently used for diagnostic purposes in the pulmonary diseases ***(Wielpütz et al., 2014).*** Multidetector CT (MDCT) is widely distributed and is characterized by high, almost isotropic resolution (pixel size 0.5 to 1 mm in every spatial direction), allowing the image data to be seen in any plane desired ***(Biederer et al., 2008).***

Ultrasonography can also be used to guide the sampling of lung abscesses to obtain biopsies for microbiological examination and to drain the pulmonary cavitary lesions ***(Patradoon-Ho and Fitzgerald, 2007).***

Patients and Methods

Sixteen adult patients from both outpatient chest clinic and inpatient chest department of Al-Minia university hospital from October 2013 to August 2016.This study was approved by ethics committee of the faculty of medicine of our university.

Study Inclusion Criteria: Patients aged ≥ 18 years old with radiologically confirmed peripheral pulmonary lesions, and cooperative patients who are able to hold breaths temporarily to decrease interference from the chest wall movement while the flow signal was being acquired.

Exclusion Criteria: Patients with isolated pleural lesions, patients with chest wall lesions, possibility of ARDS, or patients with cardiac disease.

All studied patients were subjected to:

- Full history taking and clinical examination
- Laboratory tests including complete blood picture, sputum and pleural fluid examination and culture for acid fast bacilli and other pathogens.
- Chest radiographposterior-anterior view was done using a commercially available radiograph apparatus and a standard method ***(model Ralcos.r.i, model R302/A, Italy)***. The film was read by a good and an independent radiologist who was unaware of ultrasonoraphy and clinical data of our patients.
- Chest computed tomography (CT) scan was done. Either high-resolution CT, contrast-enhanced CT scans or CT-pulmonary angiography were done according to the suspected diagnosis and analyzed by an independent radiologist, who was unaware of results of other tests and clinical data using a commercially available CT machine and a standard technique (***model GE*** *BRIGHT* ***Speed 16 slices)*** (General electric Healthcare, USA). Reconstruction parameters were 5.0 mm slice thickness and medium smooth convolution kernel (B41s).
- Lung ultrasound was performed immediately after the chest radiograph with ***(***a Philips, Clear Vue 350 Ultrasound Systems) using (2–5 MHz) convex probe for lung examination and (5–12 MHz) linear probe for pleural evaluation. The examination of patients was done either supine or sitting position as clinically appropriate. First, Greyscale ultrasound was used to localize the entire lesion, and then a color Doppler sonography examination was added.

Sonographic findings were recorded including; lung sliding, pleural thickening, irregularities or effusion, presence of hypoechoic or isoechoic lesions or presence of air bronchogram.

Methods of Statistical Analysis

Data were collected, revised, verified, coded, then entered PC for statistical analysis done by using SPSS statistical package version 20.

For Quantitative Data: Mean (X~) and standard deviation (SD). For qualitative data: number (n) and percentage (%). Kolmogorov- Smirnov for normality test was used to compare between parametric data and non-parametric data. Independent sample t-test for analysis of quantitative data. Chi square (X^2) test, Fisher Exact test for analysis of qualitative data. Cross tabulation was done for the estimation of sensitivity, specificity, PPV, NPV and DA.

Results

Sixteen adult patients were included in this current study; 10 males (62.5%) and 6 females (37.5%), their ages ranged from 18 to 56 years with a mean ± standard deviation (SD) of 45.6 ± 11.54 years. The demographic and clinical data of all studied patients were shown in table 1.

Cases were presented by cough and expectoration in (93.3%), tachypnea in (86.7%), toxic manifestations in (73.3%), signs of consolidation in (66.7%), fever in (60%), dyspnea and chest pain each in (40%), haemoptysis in (33.3%), clubbing and signs of collapse each in (13.3%) and signs of pleural effusion in (6.7%). Low SaO_2 was present in (26.7%) of cases.

The variable features of lung abscess by CXR, CT and grey scale US were demonstrated in table 2.

The most frequent CXR findings were air-fluid level (75%), opacity with air bronchogram was present in (37.5%), loss of lung volume and pleural effusion were equally presented each in (6.25%) of cases.

Chest CT showed air-fluid level in all cases, then opacity with air bronchogram in (75%) and associated pleural effusion was present in 6.25%.

Grey scale US showed air bronchogram in 93.3%, breath dependent motion in 86.7%, pleural involvement in 26.7% and pleural effusion with internal echoes in 18.75%, while one case (6.75%) showed normal lung parenchyma.

Regarding colour doppler sonographic findings, 60% of cases showed absent vascularity, 20% had scanty vascularity and 20% had marked vascularity. Vascular flow signals showed that 66.7% of cases had THI flow and 33.3% had MHI.

Table (1): Demographic and clinical data of participant

Variable	**M±SD.**	
Age (years)	45.6 ± 11.54 (18-56 years)	
Variable	**Frequency**	**Percentage (%)**
Gender:		
-Males	10	62.5%
-Females	6	37.5%
Initial presentation:		
-Cough	14	93.3%
-Expectoration	14	93.3%
-Hemoptysis	5	33.3%
-Dyspnea	6	40%
-Chest pain	6	40%
-Toxic findings	11	73.3%
-Fever (≥38° c)	9	60%
-Tachypnea (Breath/min. >20)	13	86.7%
-Signs of Consolidation	10	66.7%

M±SD=Mean ± standard deviation

Table (2) Radiological findings of all studied patients

Variable	**Frequency**	**Percentage (%)**
CXR:		
- Homogenous opacity without air bronchogram	1	6.25%
- Opacity with Air bronchogram	6	37.5%
- Loss of lung volume	1	6.25%
- Pleural effusion	1	6.25%
- Air-Fluid level	12	75%
CT chest:		
- Opacity with air bronchogram	12	75%
- Air fluid level	16	100%
- Pleural effusion	1	6.25%
Grey scale US:		
- Normal parenchyma	1	6.25%
- Irregular margin	9	60%
- Homogenous echotexture	1	6.7%
- Heterogenous echotexture	14	93.3%
- Hypoechoic echogenicity	12	80%
- Air Bronchogram	14	93.3%
- Pleural Involvement	4	26.7%
- Breath dependent motion	13	86.7%
- Pleural effusion with internal echoes	3	18.75%
Vascularity:		
- Absent	9	60%
- Scanty	3	20%
- Marked	3	20%
Flow signals:		
- THI	4	66.7%
- MHI	2	33.3%

Sensitivity, specificity, PPV, NPV and DA of CXR, chest CT and grey scale US regarding diagnosis of lung abscess were compared (Table 3). Chest CT revealed the highest DA (98.5%) with 100% sensitivity, 98.3% specificity, 88.9% PPV and 100% NPV. The sensitivity, specificity, PPV, NPV and diagnostic accuracy of chest X ray were 75%, 98.3%, 85.7%, 96.6% and 95.5% respectively. Grey scale US had the least sensitivity (53.3%), specificity was 98.2%, PPV 96.7%, NPV 67.7% and DA 93.1%.

Table (3) Calculated sensitivity, specificity, PPV, NPV and accuracy *of chest X ray, CT and grey scale US* in diagnosis of abscess

Lesion	Sensitivity	Specificity	PPV	NPV	Accuracy
CXR	75%	98.3%	85.2%	96.6%	95.5%
CT	100%	98.3%	88.9%	100%	98.5%
US	53.3%	98.2%	96.7%	67.7%	93.1%

CXR: Chest X ray, **CT:** computed tomography, **US:** Ultrasonography. **PPV:** Positive predictive value, **NPV:** Negative predictive value. Analysis made by qui square test

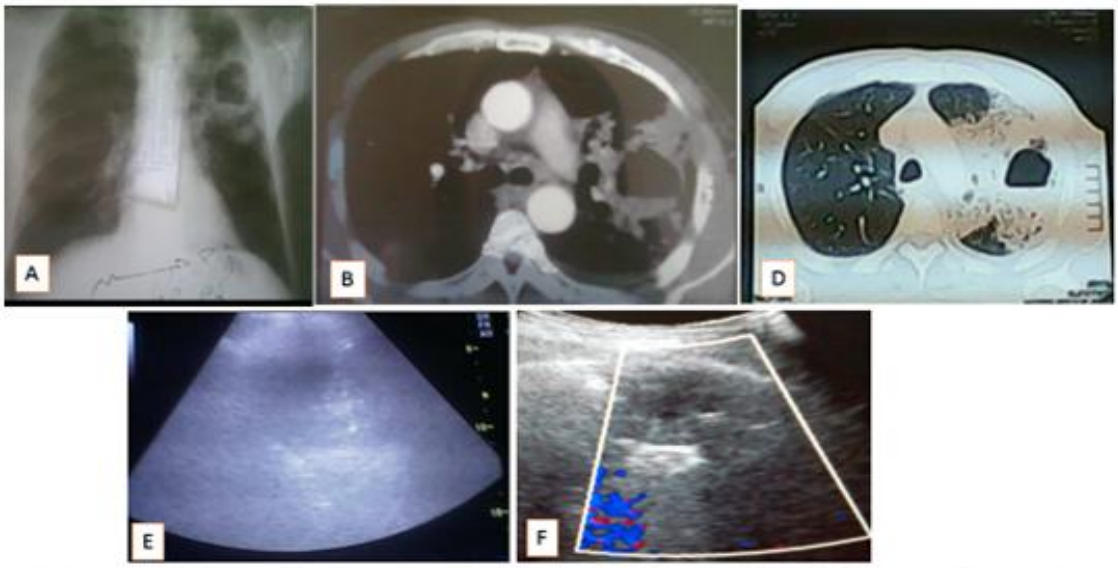

Fig.1: Lung consolidation with abscess formation. Male patient 45y old . A) CXR PA view revealed segmental consolidation with regular wall cavitary lesion with air fluid level at the lingula. B) Axial post contrast CT mediastinal window and D) pulmonary widow revealed thin wall cavity with air fluid level within a consolidation area of the left lung. E) US examination Grey scale and F) Color Doppler showed anechoic area with no color flow within

Discussion

Most of patients were presented by cough and expectoration (about 93%). Associated tachypnea was present in about 87% of cases. Toxic manifestations were present in about 73% of patients. About 67% of cases showed signs of consolidation on local chest examination. Sixty percent of patients were presented with fever. Dyspnea and chest pain were equally presented each in 40% of cases. About 33% of patients were presented by hemoptysis.

These findings are supported by ***Moreira et al., 2006*** who reported that lung abscess presented with cough and fever and that cough can be productive and associated with foul smelling purulent sputum or less frequently accompanied with blood tinged sputum in 33% of cases and that on chest examination of cases of lung abscess there will be features of consolidation such as localized dullness during percussion and bronchial breathing.

Lung abscess was radiologically presented mainly by air fluid level which was apparent in 75% of CXR of lung abscesses and it was detected in CT in 100% of cases associated with opacity with air bronchogram apparent in 75% of cases while CXR was able to show these air bronchogram in 37.5% of cases and one CXR showed opacity devoid of air bronchogram and another one was associated with loss of lung volume. Chest X ray and CT showed associated pleural effusion in only one case. In concordance with the present results, ***Lange and Walsh, 2007*** informed that on plain CXR most abscesses originate within areas of pneumonic consolidation and are marked by the development of a discrete area of low density necrosis and cavitation and rupture of an abscess into a draining bronchus produces a cavity with an air-fluid level and that CT allows earlier detection of abscess formation within areas of pulmonary consolidation than does the standard chest

radiograph and this can explain why the cavities were more apparent in CT films than CXR films.

Moreover, ***Albert et al., 2009*** described radiologic appearance of lung abscess as a peripheral cavity in the dependent lung regions. Also, ***Reynolds et al., 2010*** & ***Reed et al., 2010*** reported that the usual CT findings of a lung abscess include a spherical cavity with a thick wall that destroys the surrounding lung.

Regarding grey scale US, lung abscesses showed irregular margin in 60% of cases. This agrees with ***Tsai et al., 2008*** who described lung abscess to have a blurred outer margin. ***Islam & Tonn, 2009***also reported that the boundary wall of lung abscess adjacent to the pleura can be assertive or irregular. Results of ***Chen et al., 2009*** showed irregular abscess wall in 91% of cases. The results also agree with ***Koenig et al., 2011*** who reported that typical features of a peripheral abscess demonstrate irregular hyperechoic borders abutting the surface of the pleura at an acute angle. ***Yang,*** **1997** said that lung abscess can be identified at US having a well-defined or irregular wall.

Heterogenous echotexture was found in more than 90% of abscess lesions and these results are supported by ***Yang et al., 1991*** who reported that the dependent fluid portion of the abscess is in homogenous and ***Koenig et al., 2011*** who reported that the abscess cavity will be heterogeneous with relatively anechoic areas with echogenic foci, corresponding to both air and tissue necrosis.

Eighty percent of abscess lesions showed hypoechoic echogenicity and this is also in concordance with ***Koh et al., 2002*** who documented that lung abscess can be seen at US as a hypoechoic area and ***Bouhemad et al., 2007*** who also reported that lung abscess appears as rounded hypo-echoic lesions with outer margins. Moreover, ***Sartori and Tombesi, 2010*** who reported that lung abscesses typically appear as a largely anechoic lesions and

In the early stages of lung abscess, small abscesses are seen as pathological collections of fluid in the consolidated liver-like infiltrate ***(Mathis, 2007)*** and this can explain the presence of air bronchogram in 93.3% of lung abscess lesions.

Twenty percent of cases of lung abscess were associated with pleural effusion with internal echoes. ***Sartori and Tombesi, 2010*** reported that a small pleural effusion is commonly associated with lung abscesses.

Pleural involvement was seen in 26.7% of lung abscess lesions. ***Reissig and Kroegel, 2007*** described pleural affection of pneumonia that the pleural line can appear interrupted, fragmented, and hypoechoic. ***Caiulo et al., 2013*** found pleural line abnormalities in 20.2% of patients with pneumonia. Lung abscess usually develop on top of consolidating lung lesion and this also explain the possibility of pleural affection.

Majority of cases showed positive breath dependent motion. ***Lichtenstein and Menu, 1995*** described normal lung anatomy with positive lung sliding sign.

Absent vascularity was shown in 60% of cases, while scanty and marked vascularity each was present in 20% of cases. ***Reissig et al., 2012*** informed that necrotizing pneumonia is characterized by absent colour flow signals and this also can explain the absent vasculature in abscess lesion. But vasculature can be detected in the pericavitary consolidation as in the current study and this is in agree with ***Chen et al., 2009*** who found that identification of color Doppler ultrasound vessel signals in pericavitary consolidation was the most useful and specific for identifying lung abscesses and differentiating it from empyema.

Regarding flow signals, 66.7% showed THI flow and 33.3% showed MHI flow. ***Civardi et al., 1993*** showed that benign lesions had a triphasic pattern derived from pulmonary arteries. The pulmonary artery has a predominantly high-impedance flow pattern ***(Spirathi and Mahajan, 2013).*** Also, ***Yuan et al., 1994*** reported that benign lesions usually have high impedance flow.

Chest X ray was found to give a sensitivity and specificity of 75% and 98.3% respectively with

DA of 95.5%, PPV of 85.7% and NPV of 96.6%. ***Stark et al., 1983*** studied 70 inflammatory lesions in 63 patients (12 lung abscesses and 58 empyema) and diagnostic information not available from conventional CXR was obtained in 47% (33/70) of cases.

Sensitivity, specificity and diagnostic accuracy of chest CT were 100%, 98.3% and 98.5% respectively with PPV of 88.9% and NPV of 100%. Agree with these results are the results of the study performed by ***Stark et al., 1983*** in which chest CT was able to diagnose 100% of lung abscess cases.

Chest ultrasound showed a sensitivity of 53.3%, specificity of 98.2% with diagnostic accuracy of 93.1%. PPV and NPV were 96.7% and 67.7% respectively. Better than these results, in ***Yang et al., 1991*** study as 94% of abscess cases were demonstrated at US. This can be attributed to different size of lesions and different number as they studied 35 cases while abscess lesions were represented in this study in only 16 lesions.

Conclusion

The most frequent clinical presentations of lung abscess were cough & expectoration, followed by tachypnea, toxic manifestations, then signs of consolidation, fever, dyspnea, chest pain, haemoptysis, and finally clubbing, signs of collapse and signs of pleural effusion.

The most common CXR findings were air-fluid level, followed by opacity with air bronchogram, then loss of lung volume and pleural effusion. Chest CT showed air-fluid level in all cases, then opacity with air bronchogram and associated pleural effusion. Grey scale US showed air bronchogram in most cases, then breath dependent motion, pleural involvement and pleural effusion with internal echoes, while one case (6.75%) showed normal lung parenchyma.

Chest CT showed the highest diagnostic accuracy regarding diagnosis of lung abscess followed by CXR then grey scale ultrasound. Grey scale US has a relatively low sensitivity for diagnosis of lung abscess. It can be helpful in certain situation especially helpful if combined with color-Doppler sonographic examination.

Recommendation

On the basis of the current study, it is recommended to use chest CT for accurate diagnosis of lung abscess. It is also recommended to use grey scale US in patients who are susceptible to the adverse effects of radiation, such as pregnant women, children, and in patients with limited mobility, such as those in intensive care units.

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