The Egyptian Journal of Hospital Medicine (October 2020) Vol. 81 (5), Page 1937-1947

Role of Ultrasonography in Diagnosis of Pleuropulmonary Diseases in Adults

Tarek MA Elziat [(1)], Salah MA Maklad [(1)],
Shaimaa RM Ali [(1)], Sayed AE Mohammed [(2)],
(1) Department of Diagnostic Radiology, (2) Department of Chest Diseases
Faculty of Medicine, Aswan University
Corresponding author: Shaimaa RM Ali, **Mobile:** 01063416805; **Email:** shaimaaragab20@gmail.com

ABSTRACT

Introduction: The advantage of transthoracic ultrasound (TUS) includes the absence of ionizing radiation, easy performance, rapid, accurate, safe, short time of examination, lower cost, bedside availability and high sensitivity in detecting pleural and pulmonary diseases. **Aim of this study:** Aim of the current study was to assess of the role of transthoracic ultrasound in pleuropulmonary diseases in adults.

Patients and methods: The present study included 50 patients who fulfilled the selection criteria and formed the study population. The present study was conducted in Radiology Department, Aswan University Hospital in the period from December 2016 to November 2017. All patients were subjected basically to full history taking, full clinical examination, chest x-ray, chest ultrasonography, CT chest and histopathological correlation for some cases. **Results:** In this study, patients were classified into 2 groups based on the final diagnosis. The first group included 28 cases with pleural diseases that the US reported sensitivity of 96.43%, specificity of 81.8%. The second group included 22 patients with pulmonary diseases that the US reported sensitivity of 95.45%, specificity of 78.57%.

Recommendations: TUS has a valuable role at diagnosis of pleuropulmonary diseases.

Keywords: TUS, pleural diseases, pulmonary diseases, BLUE protocol, pleural effusion, pneumothorax, pneumonia, pleural masses, pulmonary masses, TUS guided interventions.

INTRODUCTION

Ultrasonography is currently underutilized as an imaging method in the respiratory field despite the fact that it is an easy-to-learn method with simple, straight forward signs [(1)].

Thoracic ultrasound examination was considered less useful [(2)]. This theory was mainly based on the less capacity of the ultrasound in penetrating the air filled structures, because the air is very low penetrated by the ultrasound beam [(3)].

The sonographic diagnostic impact of the chest is limited by its bony limitation (ribs, spinal column, sternum, and clavicle) and the gas content of the lung. So the normal lung cannot be judged [(4)].

As lung contains air and air is a poor medium for sound transmission interface between chest wall and normal lung with different acoustic densities reflects most of the ultrasound waves, preventing a direct examination of an otherwise healthy lung. In pathological conditions such as tumor invasion, consolidation or atelectasis, the alveoli are replaced with denser tissue allowing better sound conduction. When the pleural space is occupied with fluid or the consolidated lung reaches the chest wall, it opens an acoustic window permitting ultrasound examination of the lung [(5)].

The newest theories are sustaining and recommending this technique as the fastest and non-invasive method for the diagnosis of the affected structures in the thoracic cavity. It is also easy for learning and performing, without any complications and do not involve financial efforts. In addition, it can provide in real time diagnostic information and can establish the proper and the most efficient therapeutic management measures in many cases [(2)].

Ultrasonic examination of the chest is a rapidly developing application and may be used to evaluate a wide range of peripheral, parenchymal, pleural and chest wall diseases. The technique is particularly suited to bedside use in the intensive care unit, where suboptimal radiography may mask or mimic clinically significant abnormalities and where differentiation of pleural from parenchymal changes can be challenging [(6)].

Furthermore, US is increasingly used to guide interventional procedures of the chest, such as biopsy and placement of intercostal chest drains. Pathological modifications can be detected, if they are situated in the chest wall, the diaphragm or the upper chest aperture [(7,8)].

Although ultrasound can be used to explore multiple districts for different purposes (especially in emergency and intensive care) in the respiratory setting, the routine use of ultrasound is as a tool at the patient's bedside to aid and confirm the diagnosis of diseases suspected following and integrating the objective examination; it can be completed by the common techniques of chest imaging; as well it can help guide eventual interventional procedures that the clinician may decide necessary [(1)].

Transthoracic ultrasonography could evaluate abnormalities in the peripheral lung parenchyma, pleura and chest wall. Thoracic ultrasonography may also be utilized as guidance in performing invasive procedures, such as pleural puncture, transthoracic biopsy and chest tube insertion [(9,10)].

Advantages of ultrasound in respiratory diseases [(11,12)].

- Easy to learn
- Fast, non-invasive and easily reproducible

Received:20 /3 /2018
Accepted:30 /3 /2018

- Portability: bed-side evaluation eliminates the need for transporting the patient.
- Widely available.
- No exposure to radiation
- Good accuracy
- Aids in establishing the diagnosis and in monitoring the response to treatment.
- Low cost
- Real-time imaging, and the ability to perform dynamic imaging.

Disadvantages of ultrasound in respiratory diseases

Thoracic ultrasound is an operator dependent technology. Focused, supervised training is needed to ensure that the operator correctly interprets the sonographic findings. Inadequate training may increase the risk of complications [13,14].

One important limitation of ultrasound waves has been the barrier of air, which is a poor conductor of ultrasound waves. As such, ultrasonography of lung was long considered impossible [11]. This limitation was responsible for underutilization of this revolutionary technology in respiratory diseases. However, large number of studies have changed this view and have demonstrated that ultrasonography of lung is useful in the diagnostic evaluation of critically ill patients [15,16] more so after pulmonologists started using this technique by themselves [12,17].

AIM OF THE WORK

The aim of this study was the assessment of the role of US in the detection and diagnosis of different pleuropulmonary diseases in adults. Also we tried to demonstrate the spectrum of ultrasonographic patterns of different pleuropulmonary diseases.

PATIENTS AND METHODS

This present study was done on 50 patients attended the Radiology Department of Aswan University Hospital in the period from December 2016 to November 2017.

Study Design:

This study included 50 patients with different pleuropulmonary diseases, at adult age who fulfilled the selection criteria and formed the study population.

- **Inclusion Criteria**: Patients with chest symptoms need ward or ICU admission.
- **Exclusion Criteria:** patients with difficult ultrasonographic window.

Methodology:

The included patients were subjected to the following:

Patients were evaluated by

- Full history taking
- Full clinical data.
- Radiological investigations:

A- Chest X-ray.

B- Chest ultrasound.

C- Multidetector CT.

- Histopathological correlation for some cases.

Technique:

A- Plain chest x-ray:

Was done by using (TOSHIBA X-ray beam limiting device, model BLR-1000A).

B- Chest ultrasound:

In this study chest ultrasound done by using (Philips HD 11XE). The used transducers were curved transducer with frequency 2-5MHz and linear transducer with frequency 5-12MHz.

Technique of chest ultrasound

1- Proper explanation of the procedure to the patient.

2- Patient position:

- Sitting (dorsal and lateral images).
- Supine (ventral images).
- Right lateral position (dorsal and lateral images). -
- Left lateral position (dorsal and lateral images).
- Raising the arms and crossing them behind the head causes intercostal spaces to be extended and facilitates access.

3- The probe was cleaned and water-based transducing gel was used to improve the interface.

4- Scanning techniques that were used in transthoracic ultrasound:

- Subcostal: The liver serves as an acoustic window for the transducer.
- Intercostal: The transducer was oriented parallel to the ribs.

5- Landmarks were established and a search was made for the lesion.

The position of the patient was supine or sitting with elevated arm and clasping the hand behind the neck and using the probe at the intercostal spaces to detect any chest lesions.

Conventionally lung sonography is performed with the patient in a sitting position taking longitudinal scans starting anteriorly from the parasternal zone and posteriorly from the paravertebral / posterior axillary zones [1].

Lightly on the skin of the body area being tested the probe was placed which was already covered with a layer of ultrasound gel to eliminate any air that may be eventually present.

C-Chest CT: Done as gold standard study, by using (MDCT 160 slice TOSHIBA AQuilion Prime).

In this study (50 cases) were classified based upon the final diagnosis as:

- Pleural diseases (28 Cases)
- Pulmonary diseases (22 cases)

Statistical analysis

Data were analyzed by using SPSS version 22. Summary of measures was reported as mean ± standard deviation (SD) for quantitative variables such as age and weight, while categorical variables such as sex and Tanner stage were represented as percentages. A comparison between 2 quantitative data was analyzed by independent t-test. The correlation between two variables was done by using the Pearson correlation test to identify the degree of correlation of numerical variables. P-value ≤ 0.05 was considered statistical significance.

RESULTS

The present study included 50 patients who fulfilled the selection criteria and formed the study population. The present study was conducted in Radiology Department, Aswan University Hospital in the period from December 2016 to November 2017.

- **Demographic data of the study group:**

The present study included 50 patients (30 males and 20 females) with different pleuropulmonary diseases, whose age ranged from (18 – 73 years), with mean age (45.62 ± 15.03).

Table (1): Demographic data of the study group (N=50)

Demographic data		
Age	Range Mean ± SD	18-73 45.62 ± 15.03
Gender Male Female	 No (%) No (%)	 30 (60%) 20 (40%)
Smoking status Smoking Non smoking	 No (%) No (%)	 32 (64%) 18 36%)

- **The final diagnosis of the studied groups:**

As regard the final diagnosis of the studied groups based on clinical, radiological, sonographic and histopathological correlation (for some cases) there were 28 cases (56%) presented with pleural diseases and 22 cases (44%) presented by pulmonary diseases.

Table (2): The final diagnosis of the studied groups

Groups at This study	NO.	Percentage %
Group A- Pleural diseases	28	56
Group B-Pulmonary diseases	22	44
Total	50	100

- **Complaint:**

Patients had (cough 42%, fever 46%, expectoration 6%, shortness of breath 82%, chest pain 22%, associated with other system pathology 16%, and trauma 20%).

Table (3): Complaint of the study group (N=50)

Complaint	Number	Percentage (%)
Cough	21	42
Fever	23	46
Expectoration	3	6
Shortness of breath	41	82
Chest pain	11	22
Associated with other system pathology	8	16
Trauma	10	20

- **Pleural diseases:**

In this study there were (28 cases) with different pleural diseases that (16 cases) have pleural effusion, (2 cases) with pleural thickening, (7 cases) with pneumothorax, (2 cases) with hydropneumothorax and (1 case) with pleurisy.

Table (4): Types of pleural diseases at this study

Group A (pleural diseases)	Number	Percentage (%)
Pleural effusion: -	16	57.1
Anechoic	7	25
Complex septated	4	14.3
Complex non septated	2	7.1
Empyema	2	7.1
Hemorrhagic	1	3.6
Pleural thickening: -	2	7.1
Mesothelioma	1	3.6
Chronic infection (abscess)	1	3.6
Pneumothorax	7	25
Hydropneumothorax	2	7.1
Pleurisy	1	3.6
Total	28	100

At this study, there were four different sonographic appearance of pleural effusion according to internal echogenicity, 43.75% from patients with pleural effusion (7 out of 16) showed anechoic effusion, while the remaining 9 patients presented with complex septated, complex non septated and echogenic effusion respectively (25, 12.5 and 18.75%).

Three patients had echogenic effusions two of them with empyema (12.5%) and one had hemorrhagic effusion (6.25%).

Table (5): Sonographic appearance of pleural effusion

Sonographic appearance of pleural effusion	Number	Percentage (%)
Anechoic	7	43.75
Complex septated	4	25
Complex non septated	2	12.5
Echogenic	3	18.75
Total	16	100

- **Efficacy of chest ultrasound in diagnosis of pleural effusion:**

The sensitivity of TUS for diagnosis of pleural effusion was 93.75%, the specificity was 85.7%, the positive predictive value was 75% and negative predictive value was 96.8%.

Table (6): Efficacy of chest ultrasound in diagnosis of pleural effusion

Data	Results
True positive value	15
True negative value	30
False positive value	5
False negative value	1
Sensitivity	93.75%
Specificity	85.7%
Positive predictive value	75 %
Negative predictive value	96.8%

At this study, TUS was useful in detecting pneumothorax in seven patients (7 out of 28 pleura diseased patients) 25%, all of them showed the sonographic signs for diagnosis of pneumothorax including absent lung sliding, exaggerated horizontal artifacts and loss of comet tail artifacts.

In addition to the previous signs, three patients showed the lung point sign.

Table (7): Sonographic signs of pneumothorax

Signs of pneumothorax	Number	Percentage (%)
Absent lung sliding	7	100
Exaggerated horizontal artifact	7	100
Loss of tail artifact	7	100
Lung point	3	42.86

- **Efficacy of TUS in diagnosis of pneumothorax**

The sensitivity of TUS for diagnosis of pneumothorax was 85.7%, the specificity was 97.7%, the positive predictive value was 85.7% and negative predictive value was 97.7%.

Table (8): Efficacy of TUS in diagnosis of pneumothorax

Data	Results
True positive value	6
True negative value	42
False positive value	1
False negative value	1
Sensitivity	85.7%
Specificity	97.7%
Positive predictive value	85.7%
Negative predictive value	97.7%

Also in this study, there were 2 cases (7.1%) with pleural thickening one showed sonographically diffuse irregular pleural thickening associated with hypoechoic mass lesion diagnosed mesothelioma with biopsy taken under US guidance, the other case showed focal pleural thickening adjacent to chronic lung abscess. There were 2 cases (7.1%) with hydropneumothorax diagnosed sonographically as upper lung scan showed absent lung sliding, exaggerated horizontal artifacts and loss of comet tail artifacts and lower lung scan revealed anechoic free fluid, patients were in sitting position at the scan.

There was one case of pleurisy (3.55%) which was not diagnosed sonographically, but US helped at exclude some causes of chest pain e.g. pneumothorax.

Table (9): Cases of pleural diseases at this study (N=28)

disease	ases			
Anechoic pleural effusion	7	Non-significant	Anechoic free fluid pleural collection with fluid color sign	Pleural effusion
		Obliteration of costophrenic angle raising toward the axilla		
		Total opacification of hemithorax with central mediastinum	Anechoic free fluid pleural collection with underlying lung in homogenous and isoechoic to liver echo pattern with jelly bag cap sign	Pleural effusion with underlying lung collapse
Complex septated pleural effusion	4	Obliteration of costophrenic angle raising toward the axilla	Pleural fluid collection with internal echoes and septations	Pleural effusion
		Total opacification of hemithorax with central mediastinum	Pleural fluid collection with internal echoes and septations with underlying lung in homogenous and isoechoic to liver echo pattern with jelly bag cap sign	Pleural effusion with underlying lung collapse
Complex non septated pleural effusion	2	Obliteration of costophrenic angle raising toward the axilla	Pleural fluid collection with internal echoes	Pleural effusion
Empyema (echogenic pleural effusion)	2	Lenticular shaped opacity with obtuse angle with lung parenchyma	Loculated thick turbid hypoechoic collection	Oval pocket of thick fluid density
Hemorrhagic (echogenic pleural effusion)	1	Total opacification of hemithorax widened ipsilateral intercostal space	Pleural free fluid collection with internal echoes and in homogenous and isoechoic to liver echo pattern	Pleural effusion
Pneumothorax	7	Non-significant	Absent lung sliding, exaggerated horizontal artifact and loss of comet tail artifact +/- lung point	Pneumothorax
		Visible visceral pleural line with peripheral radiolucency without vascular marking		
		Radiolucency of hemithorax with loss of vascular marking and depression of ipsilateral hemidiaphragm	Absent lung sliding, exaggerated horizontal artifact and loss of comet tail artifact	
Hydropneumothorax	2	Homogenous opacity with air fluid level	Upper lung scan show Absent lung sliding, exaggerated horizontal artifact and loss of comet tail artifact, while lower lung scan show pleural free fluid collection	hydropneumothorax
Pleural thickening	2	leural thickening with ogenous opacity	rregular thickening of pleura lefied non homogenous echo leurally based soft tissue lesion	lioma (diffuse irregular ickening with mass
		lung lesion with air	ural thickening adjacent to lesion	ural thickening to chronic lung abscess
		nificant	nificant	nificant

- **Efficacy of chest ultrasound in diagnosis of pleural diseases:**

The sensitivity of chest ultrasound for diagnosis of pleural diseases was 96.43%, the specificity was 81.8%, positive predictive value was 87.1% and negative predictive value was 94.7%.

Table (10): Efficacy of TUS in diagnosis of pleural diseases

Data	Results
True positive value	27
True negative value	18
False positive value	4
False negative value	1
Sensitivity	96.43%
Specificity	81.8%
Positive predictive value	87.1%
Negative predictive value	94.7%

- **Pulmonary diseases:**

In this study there were 22 cases with different pulmonary diseases; of them 12 cases had pneumonia (54.5%), 3 cases with primary lung neoplasm (13.7%), 2 cases with lung abscess (9.1%), 2 cases with secondary lung neoplasm (9.1%), 2 cases with ILD (9.1%) and 1 case with emphysema (4.5%).

Table (11): Pulmonary diseases at this study (N=22)

Group B (Parenchymal lung diseases)		Number	Percentage (%)
Pneumonia		12	54.5
Lung neoplasm	Primary	3	13.7
	Secondary	2	9.1
Lung abscess		2	9.1
ILD		2	9.1
Emphysema		1	4.5
Total		22	100

- **Pneumonia**

Pneumonia is considered the most common cases of parenchymal diseases in this study. It was recorded in 12 out of 22 cases (54. 5%) in which TUS recorded sensitivity (91.67%), specificity (92.1%), positive predictive value (78.6%) and negative predictive value (97.2%).

Table (12): Efficacy of TUS in diagnosis of pneumonia

Data	Results
True positive value	11
True negative value	35
False positive value	3
False negative value	1
Sensitivity	91.67%
Specificity	92.1%
Positive predictive value	78.6%
Negative predictive value	97.2%

Table (13): Cases of pulmonary diseases at this study (N=22)

Pulmonary diseases	No. of cases	X-ray	US	CT
Pneumonia	12	Homogenous patchy opacity	Homogenous hypo to isoechoic Soft tissue echogenicity with thin hyperechoic lines (air bronchogram)	Pneumonia
		Homogenous patchy opacity with obliteration of costophrenic angle raising toward the axilla	Homogenous hypo to isoechoic soft tissue echogenicity with thin hyperechoic lines (air bronchogram) associated with pleural free fluid collection	Pneumonia + parapneumonic effusion
Primary lung neoplasm	3	Non homogenous patchy opacity with obliteration of costophrenic angle	Non homogenous hypoechoic parenchymal soft tissue mass with invasion of chest wall with bilateral pleural effusion (complex septated) with lung collapse	Lung malignant neoplasm extend to anterior chest wall with bilateral pleural effusion and lung collapse
		Total opacification of hemithorax	Large heterogeneous lung parenchymal mass which show cystic degeneration associated with pleural effusion	Lung malignant neoplasm with cystic degeneration and pleural effusion
		Thick walled cavitary lesion	Thick irregular wall of hypoechoic cavitary lesion	Lung malignant neoplasm
Secondary lung neoplasm	2	Multiple bilateral scattered nodules	Multiple variable sized hypoechoic rounded lesions associated with bilateral pleural effusion	Lung Metastasis + pleural effusion
Lung abscess	2	Cystic rounded opacity	Thick wall rounded hypoechoic cystic lesion with hick fluid content, no vascularity inside	Lung abscess
		Large oval shaped cystic lesion with air fluid level	An to Hypoechoic cystic lesion with air foci echoes	Lung abscess
ILD	2	Non-significant	Multiple B lines> 3 lines associated with pleural thickening	ILD (ground glass changes)
		Reticular pattern of ILD	Multiple B lines> 3 lines with pleural thickening and irregular pleural line	ILD (Reticular pattern)
Emphysema	1	Flattened copula of diaphragm, hyperinflated lung and widened intercostal space	Non-significant	Emphysema (hyperinflated lung, flattened diaphragm and multiple bilateral focal >1cm lucencies

- **Efficacy of chest ultrasound in diagnosis of pulmonary diseases:**

The sensitivity of chest ultrasound for diagnosis of pulmonary diseases was 95.45%, the specificity was 78.57%, positive predictive value was 77.78% and negative predictive value was 95.65%.

Table (14): Efficacy of TUS in diagnosis of pulmonary diseases

Data	Results
True positive value	21
True negative value	22
False positive value	6
False negative value	1
Sensitivity	95.45%
Specificity	78.57%
Positive predictive value	77.78%
Negative predictive value	95.65%

CASE 1

Case 1: Male patient 45 years old presented by high grade fever, cough, bad foul expectoration.

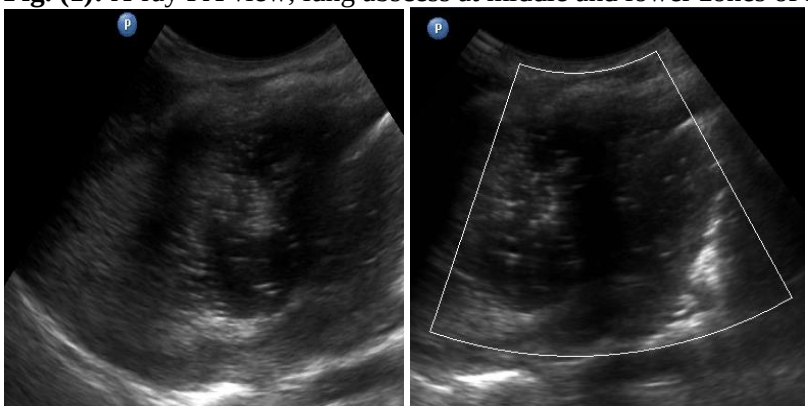
Imaging finding:

X-ray: PA view show cavitary lesion with thick wall and air fluid level at middle and lower zone of right lung.

US: Hypo to anechoic thick turbid fluid collection at lower lobe of right lung with internal air foci echoes.

CT: Thickened wall cavitary lesion with thick fluid density content and air fluid level.

Fig. (1): X-ray PA view, lung abscess at middle and lower zones of right lung.



A **B**

Fig. (2): US lung abscess at right lung with a) grayscale image and b) color Doppler image.

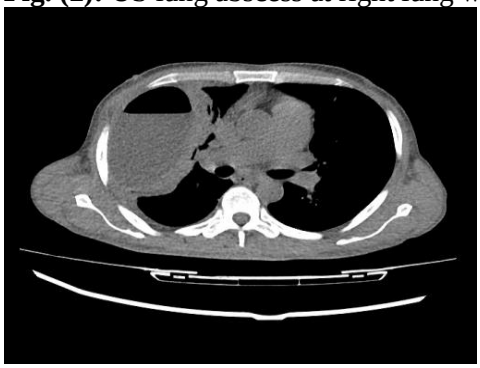


Fig. (3): CT Lung abscess with air fluid level.

Final diagnosis: Right lung abscess.

CASE 2

Case 2: Male patient 55 years old with cancer pancreas presented by chest pain and shortness of breath.

Imaging finding:

X ray: Multiple scattered bilateral nodules with obliteration of right costophrenic angel**.**

US: Multiple variable sized hypoechoic rounded lesions associated with pleural effusion on both sides.

CT: Multiple bilateral variable sized nodules with bilateral pleural effusion.

Fig. (4): X ray PA view show lung metastasis with right pleural effusion.

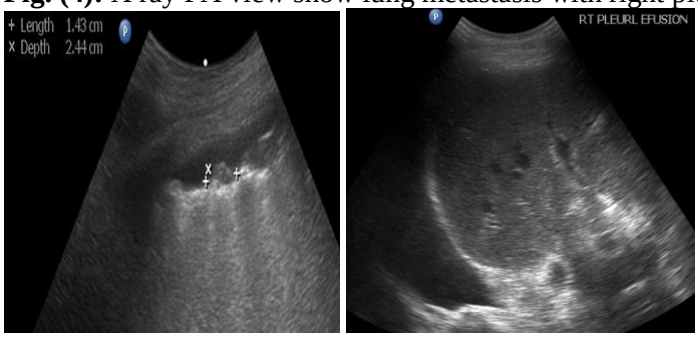


Fig. (5): US on right lung side show pleural effusion (Right side of the split-screen), lung nodule (left side of split-screen).

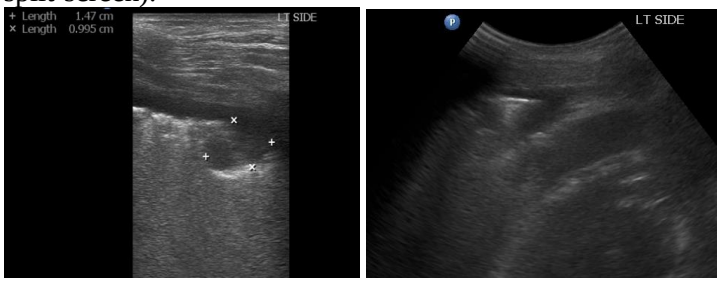
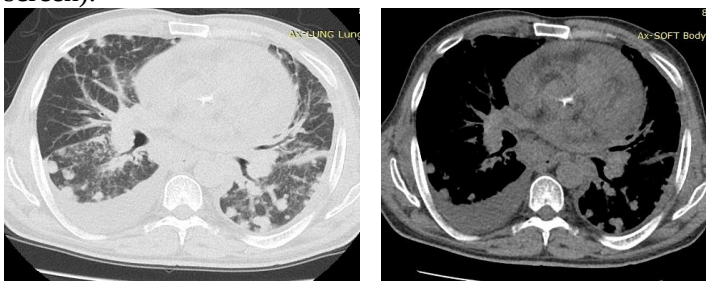


Fig 60: US on left lung side show pleural effusion (right side of the split-screen), lung nodule (left side of split-screen).



A **B**

Fig. (6): CT shows lung metastasis a) pulmonary window. b) mediastinal window.

Final diagnosis: Lung metastases.

DISCUSSION

Transthoracic ultrasound (TUS) has been proved to be a reliable, efficient tool for evaluation of a wide variety of thoracic diseases [(18)].

For some time, it was thought that the air inside the lungs is the major hindrance for ultrasound signals.Also bony framework considered challenging,and sometimes interfere with accessibility to proper assessment of pleuro-pulmonary disease [(19)].

Also;from advantages of US it can be used in pregnant women,children and in follow up of lung lesions [(20)]. The aim of the present study was to assess the role of chest ultrasound in the diagnosis of pleuropulmonary diseases.

In the present study pleural diseases (56%) were more frequent findings detected by US in the studied patients, than pulmonary diseases (44%). These results agree with **Bugalho *et al.*** [21] in 2014 who stated that ultrasonography can be used to clarify the nature of pleural densities, pleural effusions and pleural thickening. It can also differentiate pleural from parenchymal lesions, visualize ill parenchyma obscured by pleural effusion and detect pleural septations and other pleural abnormalities**.**

Ultrasound has been proved to be valuable for the evaluation of a wide variety of chest diseases, particularly when the pleural cavity is involved. Pleural effusion, pleural thickening, pleural tumors and pneumothorax can be detected easily and accurately with chest ultrasound [22].

In the present study chest US had sensitivity of (96.43%) and specificity (81.8%) for pleural diseases. This agrees with findings obtained by **Yu *et al.*** [23] who found that US had a sensitivity of 95.1% for pleural lesions and 82.8% for parenchymal lesions**.**

In this study, out of 28 cases with pleural diseases, pleural effusion was detected in 16 cases (57. 1%). This agrees with the authors who stated that ultrasonography is primarily used to confirm an effusion in a patient with normal or abnormal chest radiographs [24] being able to detect as little as 5-50 ml of pleural fluid. With 100% sensitivity for effusions of 100 ml or more [25].

As regard the result of transthoracic ultrasonography, in the current study it was found that chest US had sensitivity of (96.43%) for pleural lesions. This agrees with **Wu *et al.*** [26] who found that chest ultrasound had sensitivity of 89.2% and specificity of 100% in minimal fluid collections. This result also agrees with **Qureshi *et al.*** [27] who stated that US correctly diagnosed pleural effusion with an overall sensitivity of 79%, specificity of 100%.

In this study also there were four different sonographic appearance of pleural effusion: anechoic (43.75%), complex septated (25%), complex non septated (12.5%) and echogenic (18.75%). It was found that if a lesion changed shape with respiratory excursion and if it contained movable strands or echo densities, the lesion contained fluid and could be aspirated. These could be the best criteria to distinguish effusion from solid pleural lesion with gray scale US [28]. The present study showed that transthoracic ultrasound has sensitivity (93.75%) and specificity (85.7%) of gray scale US for pleural effusion against that of chest X-ray. Using CT as a reference standard [29,30], they demonstrated sensitivity 92%, 92%and 100% respectively and specificity 93%, 95% and 100% respectively. In contrast, **Kelam *et al.*** [31] study demonstrated high sensitivity (100%) but with low specificity than our study (60%) of gray scale US for pleural effusion.

In the present study, there was high sensitivity (96.43%) and specificity (81.8%) of chest US in diagnosing of pleural diseases like pneumothorax and hydropneumothorax. This finding is supported by result obtained by **Herth *et al.*** [32] who stated that pneumothorax can be reliably excluded with US (sensitivity 100%, specificity 83%), as pneumothorax can be diagnosed by means of the absence of normal lung sliding, exaggerated horizontal reverberation artifacts and the loss of comet-tail artifacts.

In the present study pneumothorax was detected sonographically in 7 cases (25%) of pleural diseases, all of them showed the sonographic signs for diagnosis of pneumothorax including absent lung sliding, exaggerated horizontal artifacts and loss of comet tail artifacts, in addition to the previous signs, 3 patients showed the lung point sign.

These results are similar to the findings of **Ashton-Cleary** [33] who found that the diagnosis of pneumothorax on TUS is defined by an absence of B-lines and lung sliding and the presence of A-lines with or without lung point. **Wu *et al.*** [26] also agree with this current study as use of a combination of absent lung comet tail artifact have a reported sensitivity of 100%, specificity of 96.5%.

The present study demonstrated that the sensitivity of TUS for pneumothorax was (85.7%) and its specificity was (97.7%). These results agree with ***Xirouchaki et al.*** [34]. The sensitivity and the specificity of these studies range from 75-100% and 93-100% respectively. This also agrees with **Lichtenstein and Menu** [35] who stated that bedside US is useful for excluding pneumothorax.

In the present study, chest ultrasound showed a sensitivity (95.45%) and specificity (78.57%) in detection of pulmonary diseases that were mainly in the form of pneumonia. These results agree with **Yu *et al.*** [23] who found that US had a sensitivity of 82.8% for parenchymal lesions.

In this study TUS for pneumonia had sensitivity (91.67%) and specificity (92.1%). Also these results were similar to the results of **Tsai and Yang** [22] who reported that the sensitivity was from 72-92%. Also in agreement with present study **Xirouchaki *et al.*** [34] showed that the sensitivity was (100%) while the specificity (77.8%), which was less than that recorded in present study.

CONCLUSION AND RECOMMENDATIONS

1) Transthoracic US has important role in diagnosing of different pleuropulmonary diseases.
2) US has a valuable role, yet, it is operator dependent and training is required.
3) Transthoracic US is relatively inexpensive, no exposure to radiation and easy to handle so it is recommended to be performed at the bedside in critically ill patients and pregnant women.
4) The advantages of transthoracic ultrasound as rapid, real time, low cost, bedside availability, safe, on invasive and no radiation exposure have made ultrasound an indispensable diagnostic tool in modern pulmonary medicine, in detecting pleuropulmonary diseases.

5) So, TUS should be used in wide scale in diagnosis of different pleuropulmonary diseases especially in critically ill patients, and in intensive care unit.

REFERENCES

1. **Koenig S, Narasimhan M, Mayo P (2011):** Thoracic ultrasonography for pulmonary specialist. Chest, 140(5): 1332–41.
2. **Badea R, Dudea S, Mircea P, Zdrenghea D(2006) :** A Practical Guide (Clinical Sonography: A Practical Guide (Sanders)) 4th (fourth) Edition by Sanders, Roger C., Winter MD, Tom C. published by Lippincott Williams & Wilkins .
3. **Green W (1996):** Small Animal Ultrasound. Lippincott Williams & Wilkins, Pp. 2093-2111
4. **Mathis G (1997):** Thorax sonography. I. Chest and pleura. Ultrasound Med Biol., 23: 1131–9.
5. **Lichtenstein D (2007):** Ultrasound in management of thoracic disease. Crit Care Med., 35: S250–S261.
6. **Yu C, Yang P, Chang D , Luh K (1992):** Diagnostic and therapeutic use of chest sonography: Value in critically ill patients. AJR., 159: 695–701.
7. **Ghaye B , Donediliner R (2001):** Imaging guided thoracic interventions. Eur Respir J., 17: 507–28.
8. **Mathis G , Gehmacher O (2001):** Lung and pleural Ultrasound. Schweiz Rundsch Med Prax., 90: 616–681.
9. **Anantham D ,Ernst A (2010):** Ultrasonography. In: Mason RJ, Broaddus VC Murray JF, Nadel JA, editors Murray and Nadel's Textbook of Respir-atory Medicine; 5th edition. Philadelphia: Saunders-Elsevier.
10. **Islam S and Tonn H (2009):** Thoracic ultrasound overview. In: Bolliger CT, Herth FJF, Mayo PH, Miyazawa T, Beamis JF, eds. Clinical Chest Ultrasound. Sidney: Karger.
11. **Lichtenstein D (2010):** Should lung ultrasonography be more widely used in the assessment of acute respiratory disease? Expert Review of Respiratory Medicine, 4: 533-8.
12. **Via G, Lichtenstein D, Mojoli F, Rodi G, Neri L and Storti E (2010):** Whole lung lavage: a unique model for ultrasound assessment of lung aeration changes. Intensive Care Med., 36: 999-1007.
13. **Mayo P, Goltz H, Tafreshi M and Doelken P (2004):** Safety of ultrasound-guided thoracentesis in patients receiving mechanical ventilation. Chest, 125: 1059.
14. **Mayo PH, Beaulieu Y, Doelken P *et al.* (2009):** American College of Chest Physicians/La Societe de Reanimation de Langue Francaise statement on competence in critical care ultrasonography. Chest, 135(4): 1050-60.
15. **Bouhemad B, Zhang M, Lu Q and Rouby J (2007):** Clinical review: bedside lung ultrasound in critical care practice. Crit Care, 11: 205.
16. **Lichtenstein D (2005):** General Ultrasound in the Critically Ill. New York: Springer-Verlag Berlin Haidelberg.
17. **Gargani L and Volpicelli G (2014):** How I do it: Lung ultrasound. Cardiovascular Ultrasound, 12: 25.
18. **Beckh S, Bölcskei P,Lessnau K (2002):** Real-time chest ultrasonography: a comprehensive review for the pulmonologist. Chest, 122: 1759-73.
19. **Blank W (2011):** Interventional chest sonography. In Chest sonography. Edited by Mathis G. Springer-Verlag.
20. **Reissig A, Görg C and Mathis G (2009):** Transthoracic sonography in the diagnosis of pulmonary diseases: asystematic approach. Ultraschall Med., 30: 438–54.
21. **Bugalho A, Ferreira D, Dias S, Schuhmann M, Branco J, Gomes MJ, Eberhardt R (2014):** The diagnostic value of transthoracic ultrasonographic features in predicting malignancy in undiagnosed pleural effusions: a prospective observational study. Respiration, 87(4):270-8.
22. **Tsai T and Yang P(2003):** Ultrasound in the Diagnosis and Management of Pleural Disease. Curr Opin Pulm Med., 9(4): 282-90.
23. **Yu C, Yang P, Wu H *et al.*(1993):** Ultrasound study in unilateral hemithorax opacification: image comparison with CT. Am Rev Respir Dis., 147: 430-3.
24. **Lababede O (2007):** Effusion, Pleural Imaging, e medicine Specialties> Chest. http: //emedicine.medscape.com/article/355524-imaging.
25. **Abrahamian F (2008):** Pleural effusion: differential diagnosis & workup, eMedicine Specialties>Emergency Medicine> Pulmonary. Available at: http: //emedicine. medscape. com/article/807375-diagnosis.
26. **Wu R, Yang P, Kuo S , Luh K (1995):** 'Fluid color' sign: a useful indicator for discrimination between pleural thickening and pleural effusion. J Ultrasound Med., 14: 767.
27. **Qureshi N, Rahman N,Gleeson F (2008):** Thoracic ultrasound in the diagnosis of malignant pleural effusion. Thorax, 64: 139-43.
28. **Alptekin B, Tran DT, Lisbon A, Kaynar A (2006):** Bedside ultrasonography in the differential diagnosis of pulmonary pathologies in the intensive care unit. Journal of Clinical Anesthesia, 18(7): 534-6.
29. **Lichtenstein D, Goldstein I, Mourgeon E *et al.* (2004):** Comparative diagnostic performances of auscultation, chest radiography, and lung ultrasonography in acute respiratory distress syndrome. Anesthesiology, 100: 9-15.
30. **Rocco M, Carbone I, Morelli A *et al.* (2008):** Diagnostic accuracy of bedside ultrasonography in the ICU: feasibility of detecting pulmonary effusion and lung contusion in patients on respiratory support after severe blunt thoracic trauma. Acta Anaesthesiologica Scandinavica, 52(6): 776-84.
31. **Kelam M, Ganie F, Shah B *et al.* (2013):** The diagnostic efficacy of adenosine deaminase in tubercular effusion. Oman medical journal, 28(6):417.
32. **Herth F, Eberhardt R, Becker H , Ernst A (2004):** Diagnosis of pneumothorax by means of transthoracic ultrasound: a prospective trial. Eur Respir J., 24: S491.
33. **Ashton-Cleary D (2013):** Is thoracic ultrasound aviable alternative to conventional imaging in the critical care setting? British Journal of Anaesthesia, 1-9.
34. **Xirouchaki N, Magkanas E , Vaporidi K (2011):** Lung ultrasound in critically ill patients: comparison with bedside chest radiography. Intensive Care Med., 37: 1488-93.
35. **Lichtenstein D , Menu Y (1995):** A bedside ultrasound sign ruling out pneumothorax in the critically ill. Lung sliding. Chest, 108: 1345-1348.