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Role of Chest Ultrasound in Detection of the Cause of Pleural Effusion and Guidance for Thoracentesis

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Abstract

Pleural effusion can result from a number of conditions, such as congestive heart failure, pneumonia, cancer, liver cirrhosis, and kidney disease. The characteristics of the fluid depend on the underlying pathophysiologic mechanism. The fluid can be transudate, nonpurulent exudate, pus, blood, or chyle. Imaging studies are valuable in detecting and managing pleural effusions but not in accurately characterizing the biochemical nature of the fluid. Ultrasound is more sensitive than physical exam and chest radiography to detect and characterize pleural fluid, and avoids many negative aspects of computerized tomography (CT). Ultrasound can be used to assess pleural fluid volume and character, revealing possible underlying pathologies and guiding management.. Objective. To review the use of ultrasound for the detection of pleural effusions and guidance of the thoracentesis procedure. Pleural aspiration describes a procedure whereby pleural fluid or air may be aspirated via a system inserted temporarily into the pleural space. This may be for diagnostic purposes (usually removing 20–50 ml fluid) or therapeutic to relieve symptoms. In the literature it is varyingly called thoracocentesis, thoracentesis or pleural aspiration.

Keywords: Pleural effusion, Lung, Ultrasonography, Catheters, Critical care

Introduction

A pleural effusion is a buildup of fluid in the pleural space, an area between the layers of tissue that line the lungs and the chest wall. It may also be referred to as effusion or pulmonary effusion[1].

Patients may be asymptomatic but often present with dyspnea, chest pain, cough, or other signs or symptoms of underlying disease. Dyspnea is a result of altered diaphragmatic and chest wall mechanics and compression of the lung. Pleuritic chest pain indicates disease involvement of the parietal pleura[2]

There are also complicated and uncomplicated pleural effusions. Uncomplicated pleural effusions contain fluid without signs of infection or inflammation. They're much less likely to cause permanent lung problems. Complicated pleural effusions, however, contain fluid with significant infection or inflammation. They require prompt treatment that frequently includes chest drainage[3].

It was thought that ultrasound could not be used to assess the chest. The main organs of the chest contain air, which does not transmit ultrasound properly, associated with the fact that the ribs block it. Ultrasonography has, however, become a very valuable resource in the evaluation of the abnormal chest, in which liquid and solid densities are interposed between the chest wall and the lung, making it an excellent means for transmitting sound waves, making this method was extended to a series of morbidities [4]

Portable ultrasonography devices are used at the bedside to evaluate pleural abnormalities and to guide thoracentesis and related procedures such as pleural drainage, catheter placement, and needle aspiration biopsy of pleural or sub pleural lung masses.[5]

Many indications for the use of ultrasonography beyond the visualization of the pleura and related conditions (including effusions, thickening and pneumothorax) have been validated in the last few decades. These include the assessment of diaphragmatic dysfunction, pulmonary consolidation, interstitial syndromes, pulmonary embolism, and pulmonary and mediastinal tumours, provided they abut the pleura.[6]

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. Ultrasound allows the detection of small amounts of pleural locular fluid, with positive identification of amounts as small as 3-5 mL, that cannot be identified by radiographs, which is only capable of detecting volumes above 50 mL of liquid.[7]

Prompt diagnosis of the presence and nature of pleural effusion is vital in order to evaluate the best therapeutic choice (diuretics, invasive procedures). The use of thoracic ultrasound (TUS), a safe and non-invasive bedside procedure with good accuracy, can help clinicians to visualize the effusion and also to distinguish between different types (exudative, transudative empyema, hemothorax). [8]

Lung imaging in critically ill patients is usually performed either by bedside CXR or thoracic CT, but both techniques have limitations which constrain their usefulness. Ultrasound has quite similar performances to

CT. Nowadays, bedside thoracic ultrasound is increasingly used in critically ill patients[9].

Thoracentesis is a procedure of aspiration of fluid from the pleural space by percutaneous insertion of a needle through the chest wall with or without the insertion of a catheter.[10]

The aim of this study is to evaluate the role of chest ultrasound in detection of the cause of pleural effusion and guidance for thoracentesis.

1. Patients and methods

This study was carried out on 40 patients with pleural effusions from those admitted in radiology department of Benha university hospitals between May 2019 to June 2020.

Inclusion criteria :

- Any adult Patient with chest manifestations suspecting to have pleural effusion like dyspnea and chest pain.
- Patients with previous history of pleural effusions.
- Patients confirmed to have pleural effusion.

Exclusion criteria:

- Patients on mechanical ventilation.
- Patients below 18 years old.
- In cooperative patients.

Carful history taking and chest examination with revision of all data that the patient had are all necessary to be done at first. then performing chest ultrasound for evaluation of the pleural effusion as regard; amount ,characters and if accessible to perform thoracentesis when the patient accept.

The following was done when required:

-Pleural aspiration from the effusion

-Pleural biopsy from any suspicious lesion.

-Laboratory analysis of the specimens.

-Data collection and recording.

2.1.Statistical analysis

The statistical analysis was conducted using the Software, Statistical Package for Social Science, (SPSSInc. Released 2009-PASW Statistics for Windows Version 21.0. Chicago: SPSS Inc.) The collected data were summarized in terms of mean ± Standard Deviation (SD) and range (minimum - maximum) for quantitative data and frequency and percentage for qualitative data. Comparisons between proportions were carried out using the Chi-square test (χ^2) when appropriate) and the Fisher Exact Test (FET) to compare proportions as appropriate. Cohen's kappa coefficient (κ) statistic used to measure inter-rater reliability (agreement) for qualitative (categorical) items. After the calculation of each of the test statistics, the corresponding distribution tables were consulted to get the "P" (probability value). Statistical significance was accepted at P value <0.05 (SS). A P value <0.001 was considered highly significant (HS) while a P value > 0.05 was considered non-significant (NS).

2. Results

Forty patients were assessed in this study. Sixty five percent of them were males and 35 % were females. The mean age of the studied group was 43.8± 13.2 and the age range between 26 and 76 years. Table 1

Table (1) Demographic characteristics of the studied group.

Variable		Frequency (n = 40)	
		No.	**%**
Sex	Male	26	65
	Female	14	35
Age	**Mean ±SD(Range)**		
	43.8 ±13.2 (26 -76)		

50% of the studied group had left-sided pleural effusion, 40% had right-sided pleural effusion and 10% showed bilateral effusion. Marked pleural effusion has been dedicated in 50% of examined patients compared to 5% of patients who showed minimal effusion, 20% showed mild effusion and 20 % moderate effusion. Encysted effusion has been found in 5% of examined patients. Fig 1

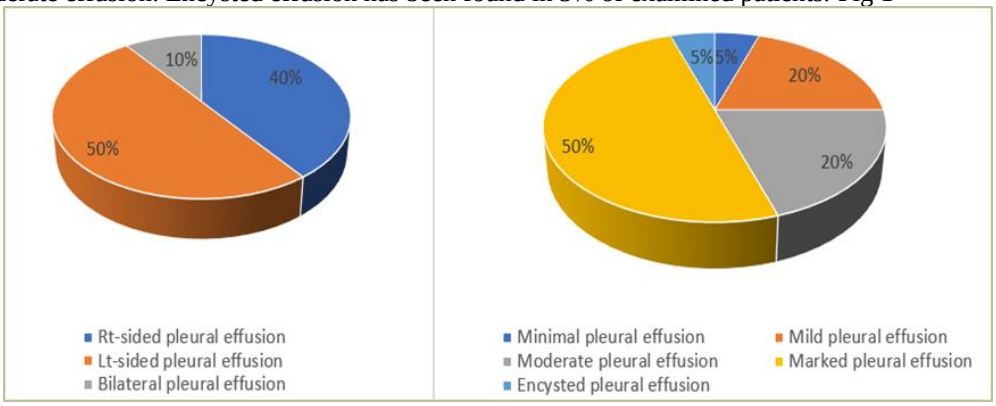


Fig (1) Pie chart shows frequency distribution of the studied patients as regard side and volume of pleural effusion.

Very strong highly statistically significant correlation between US and Lab findings regarding in detection of the cause of pleural effusion in the studied group.(P<0.001).

Variable / Statistic *(nominal by nominal)*	ϕc	CC	P value
US&Lab. findings	0.67	0.80	**<0.001**

ϕc = Cramer's V coefficient CC = Contingency coefficient

Table (6): Correlation between Sonographic findings in relation of Lab. Diagnosis in the studied group.

T the sensitivity of US in diagnosis of transudate effusion was 75% and specificity 93.7%, the positive predictive value was 75% and the negative predictive value was 93.7%. the total accuracy was 90%.

Lab / US	positive	negative	Total
Positive	6	2	8
Negative	2	30	32
Total	8	32	40

Test of significant is Chi square (X2) =18.9

P value < 0.001(highly significant)

Table (7): Predictability of US in diagnosis of transudate effusion:

The sensitivity of US in diagnosis of parapneumonic effusion was50% and specificity75%, the positive predictive value was 33.3% and the negative predictive value was 85.7%. the total accuracy was 70%.

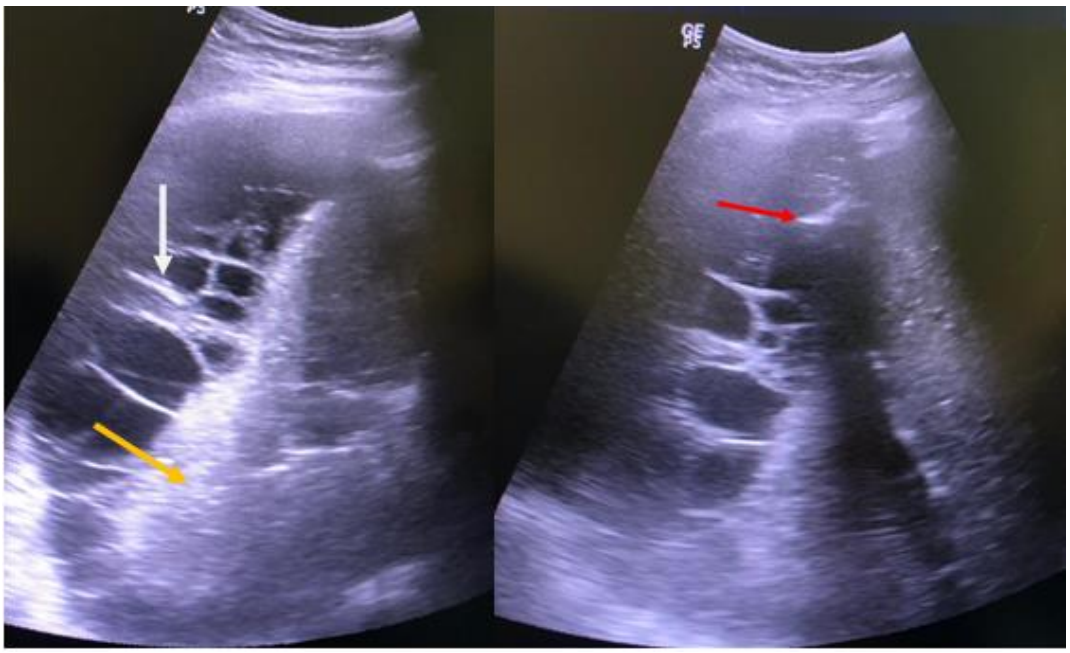
Lab / US	positive	negative	Total
Positive	4	8	12
Negative	4	24	28
Total	8	32	40

Test of significant is Chi square (X2) =1.9

P value = 0.16 (non-significant)

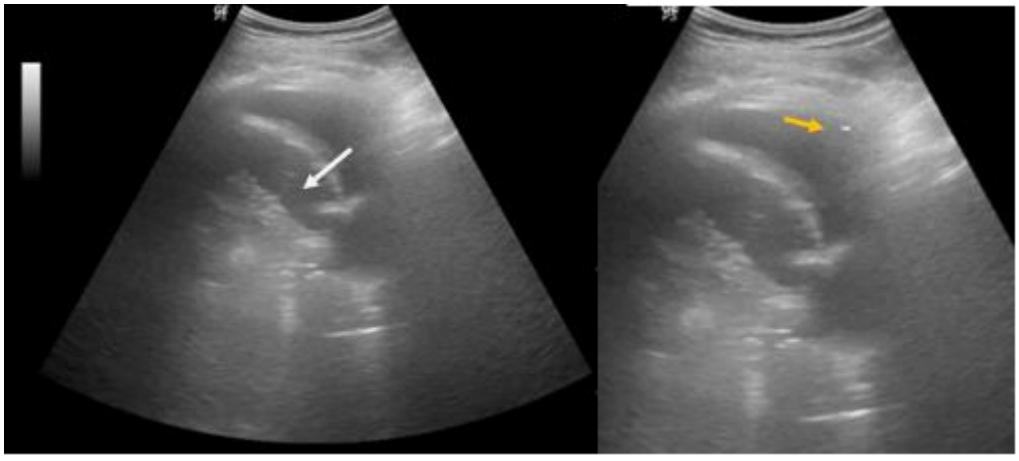
Table (8): Predictability of US in diagnosis of parapneumonic effusion: -

Figure 8



Case 1 : Transthoracic ultrasound low frequency convex probe B-mode image showed moderate pleural effusion with septations (white arrow) , no pleural thickening with normal adjacent lung (yellow arrow) .thoracentesis needle tip (red arrow)

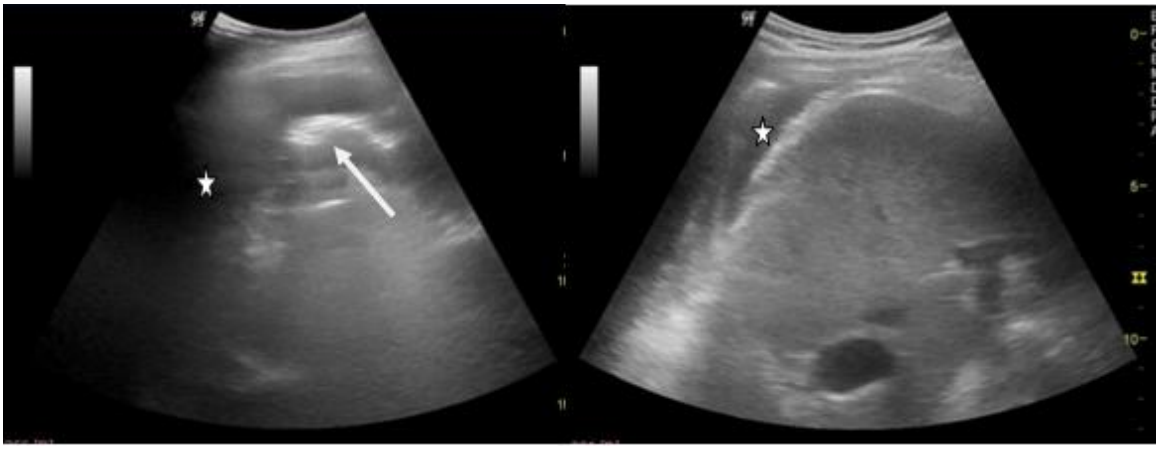
Figure 10



Transthoracic ultrasound low frequency convex probe B-mode image showed mild anechoic pleural effusion ,no septations, no pleural thickening .Normal adjacent

lung(white arrow).The needle tip (yellow arrow) is seen within the effusion.

Figure 14



Transthoracic ultrasound low frequency convex probe B-mode image showed minimal anechoic pleural effusion (star) ,no septations ,no pleural thickening with normal adjacent lung (white arrow) .

3. Discussion

Our study was carried out on forty patients of which 26 (65%) were males and 14 (35%) were females while the study of Nabil F A, et al.[11] was carried out on 18(60%) males and 12(40%) females.

As regard side of the effusion, the current study showed that (50%) had left sided pleural effusion and (40%) had right sided pleural effusion. while in Kabil ,et al.[12] study (56.67%) had right sided pleural effusion and (43.33% %) had left sided pleural effusion.

Our study revealed that (25%) had parapneumonic effusion while Terry L L , et al. [13] showed that (19%) had parapneumonic effusion.

In relation to type of effusion, the current study detected that 8 (20%) were transudates and 32 (80%) were exudates. While Ramya C. ,et al.[14] found that that 24 (30%) were transudates and 56 (70%) were exudates.

Concerning causes of effusion, Bugalho A., et al. [15] study was carried out on 133 patients (age 67 ± 16 years) with the final diagnosis was malignant pleural effusion in 66 cases and non-malignant pleural effusion in 67 cases with an overall sensitivity of 80.3%, a specificity of 83.6%, and positive and negative predictive values of 82.8 and 81.2%, respectively, for the detection of malignancy. In contrast to the current study that showed that 8 cases were malignant effusion and 32 cases were non malignant pleural effusion with an overall sensitivity of 50%, a specificity of 87.5%, and positive and negative predictive values of 50 and 87.5%, respectively, for the detection of malignancy.

In diagnosing parapneumonic pleural effusion, the current study showed a sensitivity

of 50%, specificity of 75%, PPV of 33.3% and NPV of 85.7% .While the study of Ibrahim I.Elmahalawy, et al.[16] showed a sensitivity of 94%, specificity of 96%, PPV of 97% and NPV of 90%.

The current study detected that 0% of cases had developed pneumothorax following ultrasound guided thoracentesis procedure while Tonolini Massimo[17] stated that 3% of cases in his study developed pneumothorax following the procedure

4. Conclusion

TUS is an efficient, quick, inexpensive, radiation-free method for the evaluation of pleural diseases..

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