Original article

Role of pleural ultrasonographic diagnosis in treatment planning: A study of 3831 cases

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ABSTRACT

Background: Pleural effusions are suspected by physical examination and suggested by X-ray chest. Pleural aspiration is considered next to x-ray chest. If fluid is aspirated, it is dealt according to the guide-line. If no fluid is found, then next possibility is considered. Chest ultrasound has appeared as an invaluable modality for the assessment and management of pleuro-pulmonary disorders.

Objectives: To evaluate the usefulness of trans-thoracic ultrasonography for diagnosis and planning the management of pleuro-pulmonary disorders.

Patients and methods: This retrospective study included 3831 consecutive cases, scanned at OPD of Gulab Devi Chest Hospital, Lahore from October 2016 till February 2018. The undiagnosed cases suggestive of having pleural effusion on chest x-ray (CXR) were included. The records of the patients were retrieved, ultrasonographic findings and final diagnosis were recorded. Results were tabulated and statistical analysis was performed using SPSS 16. Categorical data was presented as percentage and quantitative data was expressed as mean with standard deviation.

Results: Pleural effusions were found in 2058/3831 (53.71%) cases; 915 (23.88%) with normal pleurae, 27 (0.70%) collapse, 303 (7.90%) consolidation, 366 (9.55%) pleural thickening, 87 (2.27%) pleuro-phrenic adhesions and the diagnosis of mass lesion was made in 27 (0.7%) patients. It eliminated the need of pleural aspiration in 1773 (46.28%) cases by ruling out pleural effusion in which attempted pleural aspiration and organ puncture was inevitable otherwise.

Conclusion: Trans-thoracic ultrasound is extremely useful for diagnosing and planning management for suggested pleuro-pulmonary disorders.

Keywords:
Trans-thoracic sonography, pleuro-pulmonary disorder, management plan

INTRODUCTION

Trans-thoracic ultrasonography is still under-utilized in our region because most of the physicians are not well aware of the usefulness of ultrasound in pulmonology. Many physicians believe that lungs are rich in air and due to the poor penetration of ultrasound waves through the air, ultrasonography of chest is not possible. Thoracic disorders are usually investigated using multiple view chest radiography and computed tomography.[1] More recently ultrasonography of the chest wall, lung and pleura has gained popularity in the diagnostic work-up of pleuro-pulmonary disorders.[2-3] Pleural effusions can be diagnosed successfully by this technique. Many cases on chest x-ray appear as pleural effusion due to technical errors in positioning, beam collimation, processing artifacts or the bulky and obese patients, female especially present with such problems when breast shadow overlies the (costophrenic) CP angle area. Similarly, some disease processes like basal segmental consolidations, pleural thickening, pleural masses, atelectasis, pleuro-phrenic adhesions, lung abscess, cyst and masses overlying the CP angle area also resemble pleural effusion. Several times, CT-thorax becomes essential for discrimination but it is expensive and associated the risk of exposure to ionizing radiation. Many studies have recently proved its efficacy in detecting and quantifying pleural effusions.[4] Chest ultrasound is capable of identifying even the physiologic amounts of pleural fluid, 10-20 ml pleural fluid can be diagnosed with good accuracy[5-6] This technique is feasible for performing in operation theatre, emergency room, or in ICU at the patient's bed. Because it is free of the hazards of ionizing radiations, it can be used liberally in pediatrics as well as on pregnant ladies. Moreover, it is highly cost effective, non-invasive, easily

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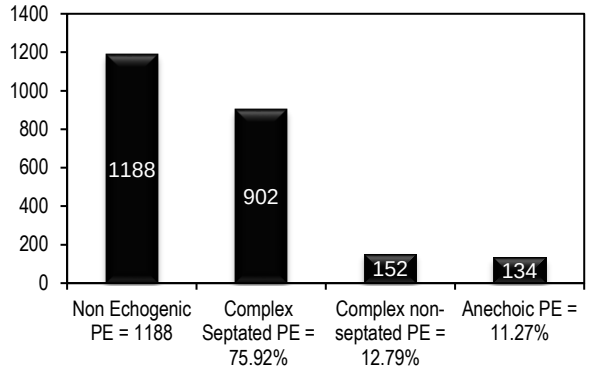

Figure 1. Distribution of non-echogenic pleural effusion (n = 1188)

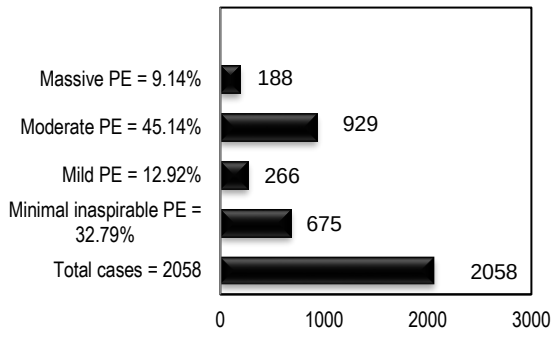

Figure 2. Frequency of quantitative distribution of pleural effusions (n = 2058).

available, and due to the possibility of real-time guidance for pleural aspiration, inter-costal tube placement and per-cutaneous biopsy of pleural as well as pulmonary lesions, has been proved as an important tool in a pulmonology clinic.[7-10] By real-time imaging the pleural fluid, it eliminates the need of putting a needle into the pleural space, in pleural effusion mimic cases and the management plan is altogether changed. This study aims to find the diagnostic yield of chest ultrasonography and its impact on management of pleuro-pulmonary disorders.

PATIENTS AND METHODS

This retrospective study was conducted at the out-patient Department of Respiratory Medicine, Gulab Devi Teaching Hospital Lahore- Pakistan, from October 2016 to February 2018. Total of 3831 adult undiagnosed patients, with age 14-84 years and chest x-ray suggestive of pleural effusion were included. Follow up cases and those with no suspicion of pleural effusion on clinical examination and/or chest x-ray, were excluded. The study was approved ethically by the IRB of the hospital vide No. Admin/GDEC/18.1106. Medical records of the study population were retrieved and reviewed retrospectively. All available informations were recorded in the study proforma. Patients were evaluated with grey scale (Toshiba-Japan) ultrasonography machine, using 3.5—5.5 MHZ convex probe. Anterior, posterior & lateral scans were obtained in sitting and supine positions. Both sides were scanned systematically. Depending upon sonographic morphology, anechoic pleural effusions were characterized as simple. Transudative pleural effusions were simple while complex effusions were more often exudative and were further classified as septated or non-septated. Four sonographic patterns were identified; 1. Anechoic: Effusion without any internal echoes (simple), 2. Complex non-septated: Complex effusion without any internal fibrous strands, 3. Complex septated: Complex effusion containing internal fibrous bands (septations), 4. Homogeneously echogenic effusion: pleural effusion rich in homogenous bright echoes. Successful pleural aspiration was labeled as the 'accepted standard' for pleural effusion. Pleural effusion

Table 1. Frequency of sonographic and clinical diagnosis (n = 1383).

Sonographic patterns	Character	Observed cases	Clinical diagnosis N (%)
Anechoic pleural effusion	Simple (transudate)	134/1188 (11.3%)	1. Hepatic 34 (25.4%) 2. Cardiac 57 (42.5%) 3. Renal 40 (29.9%) 4. Hypoproteinemia 2 (1.5%) 5. SLE 01(0.7%)
Complex septated pleural effusion	Exudate	902 /1188 (75.9%)	1. TB—776 (86.03%) 2. Para-pneumonic 89 (9.8%) 3. Malignancy 37 (4.1%)
Complex non septated pleural effusion	Exudate	152 /1188 (12.8%)	1. TB—32 (21.05%) 2. Para-pneumonic 29 (19.1%) 3. Malignancy 91 (59.8%)
Homogenously echogenic pleural effusion	Exudate	195 /1383 (14.1%)	1. Parapneumonic-104 (53.3%) 2. Empyema 73 (37.4%) 3. Hemothorax 18 (9.2%)

less than 50 ml was labeled as minimal-inaspirable pleural effusions, up to 300 ml was classified as mild pleural effusion and up-to 1000 ml was labeled as moderate while more than 1000 ml effusion was classified as massive pleural effusions. Normal pleurae, pleural thickening, pleuro-pulmonary adhesions, masses, consolidation and lung abscess were further diagnosed. Mediastinal lymphadenopathy, masses and cysts were identified. Empyema, pyothorax, pneumothorax and lung collapse were accurately detected. Final clinical diagnosis was made on history, general physical examination, and relevant diagnostic laboratory tests using hematology, sputum microbiology, cytology and gene-Xpert. Pleural fluid analysis included biochemistry, cytology, mycobacteriology, pyogenic culture sensitivity, adenosine deaminase estimation, pleural and lymph node biopsies. Bronchoscopy and broncho-alveolar lavage were conclusive in certain cases. Results were tabulated and analyzed by statistical methods and conclusion was drawn. SPSS 16 was used for statistical analysis. Categorical data was presented as percentage. Quantitative data were expressed as mean with standard deviation. Standard formulae were utilized for calculating sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy by considering aspirated pleural fluid as reference.

RESULTS

A total of 3831 patients underwent chest ultrasonography for suspected pleural effusions. Age group was 14-84 years with SD$\pm$21.48 and mean 49.5 years. Pleural effusion was identified in 2058 (53.71%) patients while in 1773 (46.28%) cases pleural effusion was excluded. Out of 2058 patients with effusion, 999 (48.54%) effusions were seen on the right side, 768 (37.31%) on left side while 291 (14.13%) were bilateral. 64.94% patients were male while 35.05% were female. Male to female ratio was 1.85:1. Total of 675 (32.79 %) pleural effusions were declared inaspirable and 1383 (67.20%) were labeled as aspirable. Of these 1383 pleural effusions, 195 (14.09%) effusions were homogenously echogenic while 1188 (85.90%) were non-echogenic pleural effusions. Distribution of non-echogenic pleural effusion is shown in Figure 1 and the frequency of quantitative distribution is depicted in Figure 2. It is clear from Figure 2 that majority of the cases belonged to the moderate pleural effusions group and minimal inaspirable class while mild (12.9%) and massive effusions (9.14%) were relatively less frequent. The ultrasound-based diagnostic yield is shown in Table 1. Total 1773 cases were declared as having 'no' pleural effusion and are summarized in Table 2. By considering aspirated pleural fluid as reference, the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy for pleural effusion is 100 % each by ultrasound.

DISCUSSION

Conventionally, patients suspected for pleural effusion on physical examination are sent for x-ray chest (CXR) PA and Lateral views. If CXR is suggestive, a needle is put into the pleural space, if fluid is found the case is declared as pleural effusion and pleural fluid is sent for laboratory analysis and followed further according to the standard guide-lines. If fluid is not found, a note is written on the medical record "Pleural aspiration tried, nothing came out" and further sophisticated modalities are deployed for further evaluation. This study showed that out of 3831-patients, suggesting pleural effusion on CXR, only 2058 cases had pleural effusion on chest ultrasound while in 1773 patients, pleural effusion was

Table 2. Pleural effusion mimics (n = 1773)

Ultrasound diagnosis	Observed cases	Percentage
Normal pleurae	915	51.6
Pleural thickening	366	20.6
Pleuro-phrenic adhesions	68	3.8
Pleural mass	19	1.1
Consolidation.	303	17.1
Lung abscess	45	2.5
Collapse	27	1.5
Lung mass	21	1.2
Destroyed lung	06	0.3
Hydatid cyst	03	0.1

excluded. This observation suggests that not all CXR-suggested cases are true-pleural effusion. Male to female ratio is 1.85:1 which showed that pleural effusion being more common in males than in female. This observation is in congruence with other reports. [11-12] The mean age of 49.5 years is well within those reported in various studies.[13-15] However, the median age in non-malignant patients was 22-years, this group included pyogenic infections and mostly fresh cases of tuberculosis. The median age for malignant group was 39 years which reflects that this age can be a risk factor for malignant disorders. Many cases of tuberculosis also belonged to this age-group which was mostly either due to re-infection or reactivation of previously healed lesions in old treated cases, Similar finding is reported by several other authors.[16-17] Pyogenic infections were mostly noted in diabetics and drug abusers and gram-negative infections were more frequent. In this study, chest ultrasound has successfully drawn a line between normal and diseased pleura. Total 915 (23.88%) patients with normal pleurae were successfully identified which shows the excellent capability of discrimination between the normal and abnormal pleurae, the same observation is also reported by other researchers.[18-20] By identifying normal pleurae, it has confidently eliminated the need for putting a needle into the pleural space in these cases which otherwise would have been inevitable in the absence of ultrasound. These patients were sent home with re-assurance and follow up advice. Thoracic ultrasound has very high sensitivity for pleural effusion. It can identify even minute pleural effusions (<5 ml).[21] It not only identified pleural effusion, but also classified quantitatively as shown in Figure-2. Efficient quantification has led to make decision about aspirable (1383) and inaspirable (675) cases. Furthermore, it suggested that 675 cases (17.61%) of inaspirable pleural effusion could only be aspirated under ultrasound guidance, otherwise there were more chances of procedure failure and organ puncture. Furthermore, these patients were at the risk of remaining undiagnosed, but ultrasound guidance provided the opportunity for diagnostic sampling and samples were sent for analysis and diagnostic algorithm was followed, which otherwise was impracticable without ultrasound assistance. About 50% cases presented at the stage of moderate pleural effusion. It can be correlated with the lack of awareness about seeking early health advice, prevalent in the community. Total 1383 aspirable pleural effusion cases (67.2%) were subjected to pleural aspiration and fluid was sent for analysis for further evaluation. Transudative pleural effusions were always anechoic while echoes inside the effusion were almost always found in exudative pleural effusions. In this way, just by finding the internal echoes, ultrasound pointed towards transudative and exudative nature and narrowed down the differential diagnosis.[22] Sonographic septations were noted in 902 of 1188 (75.9%) non-echogenic pleural effusion case. Chen and coworkers reported that sonographic septations are a useful diagnostic predictor for Tuberculosis.[23] So, by identifying complex septated pattern, ultrasound suggested tuberculosis in these cases. Similarly, homogenous echogenic pleural effusions pointed towards empyema, pyopneumothorax or malignant etiology and helped to further narrow down the differential diagnosis. In the current study, 366 of 1773 cases (20.64%) were diagnosed to have gross pleural thickening (>1.0 cm) without any associated pleural effusion. These patients were referred to the thoracic surgeon where these were further worked-up and selected cases were subjected to surgical decortications. Similarly, 63 cases of empyema and 21 cases of pyopneumothorax were efficiently diagnosed by typical homogenous echogenic character and were referred to thoracic surgery department for further diagnostic and therapeutic interventions. Many researchers reported that chest ultrasound is capable of identifying pleural thickening accurately.[24-25] Eighty seven of 1773 cases (4.9%) of pleura-phrenic adhesions were successfully picked up and were reassured that they had no serious issues. The shadows seen on CXR were the spots of old healed disease and patients were sent home without any treatment, with a piece of reassurance only. In this study, 303 of 1773 (17%) patients were accurately diagnosed as having consolidation with typical sonographic signs. This finding is supported by earlier reports which state that lung ultrasound is a non-invasive tool which can allow the distinction between pleural effusion and lung consolidations.[26] Recent reports show very high accuracy for the ultrasonic

diagnosis of community-acquired pneumonia.[27] These patients of pneumonia along with 45 cases with lung abscess were referred to the department of pulmonary medicine for medical treatment without undergoing any pleural intervention. Twenty-seven (1.52%) patients were diagnosed as atelectasis by static air-bronchograms sign.[28] These cases were referred to bronchoscopy department where mucus plugs and foreign bodies were removed and lung was expanded in majority of cases. Similarly, compression from out-side and endobronchial lesions were identified, and trans-bronchial or endobronchial biopsies were diagnostic in these patients. In this study, ultrasonography definitely differentiated the pulmonary from pleural lesions. Twenty-one cases of lung and mediastinal masses, 6 cases of destroyed lung and three cases of hydatid cyst, diagnosed by ultrasound, eliminated the need of pleural aspiration and these cases were further worked up by CT scan and other modalities. Thirty-nine more cases of pleuro-pericardial effusion were correctly picked up by ultrasound and were referred to cardiology department for further management. These observations are similar to earlier reports.[29]

Five cases showed irregular nodular pleural thickening and positive swirling signs, pointing towards the possibility of malignant nature.[30] These cases were subjected to ultrasound-guided sure-cut needle biopsy and were subsequently proven malignant by histopathology and immuno-staining. A number of abdominal pathologies like ascites, cholecystitis, cholelithiasis, hepatic and splenic focal defects, renal calculi, hydronephrosis and diaphragmatic lesions were identified during the course of pleural ultrasound, the management plan were diverted, and these patients were directed to their respective target departments. It is concluded that just by placing a probe in the intercostals space, ultrasonography can discriminate between normal and diseased pleura and help a lot in decision making whether to go for pleural aspiration or send the patient home with follow up or direct towards the relevant medical or surgical departments for definitive management.

Sonographic patterns, aid in planning guided-diagnostic and therapeutic procedures. It has ruled-out the need of putting a needle into the pleural space with confidence in 1773 cases (26.28%), thus preventing these patients from the complications of further undue invasive investigation, which otherwise would have been inevitable in the absence of ultrasonography. It has also eliminated the risk of remaining un-diagnosed for minimal inaspirable pleural effusions in 675 (32.8%) of 2058 cases by providing real-time guidance for sampling. It has successfully directed the pleural effusion mimics (46.28% cases) towards their specific treatments by changing the management plan.

The main limitation of this study is that it is a single center study. Similarly, chest sonography depends on the knowledge and skill of the operator as well efficiency of ultrasound machine. Anyhow, the results can bring about a change in the efficiency of any department of pulmonology in context with management of pleuro-pulmonary disorders. Not only the diagnosis can be improved, but also ultrasound-guided aspiration can minimize the frequency of interventional failure or organ puncture. Ultrasound has totally eliminated the chances of wrong side and wrong site just because of real time imaging. It is therefore recommended that (i) ultrasonography must be considered mandatory in the diagnostic algorithm of pleural effusion and must be done before putting a needle into the pleural space to isolate non-pleural effusion cases, (ii) trainees of pulmonary medicine must be trained adequately in this context before going to serve the community.

CONCLUSION

Trans-thoracic ultrasonography is an excellent, non-invasive, readily available and relatively low cost imaging modality for the management of pleural effusions. It is capable of identifying numerous pleuro-pulmonary pathologies and can change the direction of management plan altogether.

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