Trans-Thoracic Ultrasound: An Excellent Decision Making Tool in Pulmonary Emergency (Study of 2873 Cases)

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Abstract

Background: Pleural effusions, pneumonia, pneumothorax and cardiac problems are commonly encountered in pulmonary emergency. Imaging is suggested for timely diagnosis. Chest x-ray is the usual option but thoracic ultrasound can also provide useful imaging and is procuring admiration gradually in our region. Furthermore, pediatric and newborn disease can be worked up by detecting congenital or acquired chest disease. Similarly, pregnant patients can also be worked up without any fear of exposure to ionizing radiation and teratogenicity. Additionally, thoracic ultrasound finds very useful therapeutic application of guiding during pleural aspiration or chest drain insertion.

Objectives: To determine the efficacy of thoracic ultrasound in pulmonary emergency.

Materials and Methods: This analytical cross sectional study included 2873 consecutive cases, scanned in the Emergency of Gulab Devi Chest Hospital, Lahore from January 2019 to February 2020. Patients suggesting an acute respiratory illness on history, physical examination and chest x-ray (CXR) were included. While those with clear chest x-ray, cardiac issues and without suspicion of any chest pathology were excluded. The records of the patients were retrieved and reviewed retrospectively, ultrasound findings and final diagnosis were recorded. Results were tabulated and statistical analysis was performed using SPSS-21. Categorical data was represented as percentage. P-value was calculated by chi-square test and $p < 0.05$ was considered significant.

Results: Pleural effusions were diagnosed in 1522/2873 (52.97%) cases. 640 cases (22.27%) with normal pleurae, 65 (2.26%) pneumothorax, 260 (9.04%) consolidation, 212 (7.37%) pleural thickening, 35 (1.21%) cases of covid-19 pneumonia, 17 (0.59%) lung abscess, 27 (0.93%) atelectasis, destroyed lung 11 (0.38%) and diagnosis of mass lesion was made in 84 (2.92%) patients. Thoracic ultrasound eliminated the need of pleural aspiration in 1351 (47.03%) cases with obvious radiographic signs of pleural effusion for which attempted pleural aspiration and organ puncture was inevitable otherwise.

Conclusion: Trans-thoracic ultrasound is a tremendous tool for any pulmonary emergency, capable of diagnosing an array of pleuro-pulmonary maladies and providing solid foundations for precise treatment.

Keywords: *Diagnostic; Emergency; Efficacy; Pleuro-Pulmonary Disorders; Therapeutic; Thoracic Ultrasonography*

Abbreviations

PE: Pleural Effusion; CXR: Chest X-ray; CT: Computerized Tomography

Introduction

Chest pain and shortness of breath is usually a diagnostic dilemma in pulmonary emergency. Pleuritis with or without pleural effusion, pneumothorax, consolidation and several times pleural thickening, mass lesion and cardiac issues present with such complaints. After history and physical examination patients are subjected to chest x-ray (CXR) but many a times, patients are unable to comply with the instructions of radiographer in context with positioning and breath-holding during exposure. Furthermore, in neonates, pediatric and pregnant patients, exposure to ionizing radiation is always a matter of concern. Although trans-thoracic ultrasonography is gaining popularity day by day for the diagnosis of pleuro-pulmonary afflictions but some people still lack adequate understanding of correct technique and effectiveness of this modality. Although thoracic disorders are investigated in routine, by multiple view conventional radiography and computed tomography (CT) [1,2]. Latterly, ultrasound of the chest wall, lung and pleura has shown exceedingly promising results [3]. Many radiographs show an opacity in costo-phrenic angle area due to errors in positioning, beam collimation, artifacts, obesity or breast shadows overlying CP angle area. Such cases can be isolated successfully by using this modality. Similarly basal segmental consolidation, pleural thickening, pleuro-pulmonary mass lesions, atelectasis and large lower lobe lung abscess, mimicking pleural effusion can also be worked up efficiently. Many a times, the need of a CT- thorax arises for solving these issues but the cost, availability and the risk of exposure to ionizing radiations are matters of apprehension.

The regional and international literature supports the usefulness of thoracic ultrasound in detecting and quantifying pleural effusions, even the physiologic amounts (10 - 20 ml) can be detected successfully with good accuracy [4-6]. Moreover, this modality is feasible for use in emergency room or ICU at bed side and can be used liberally in pediatrics and pregnant patients. In addition, it is easily available and can be used as real-time guidance for thoracentesis, inter-costal drain insertion and per-cutaneous biopsy of pleural as well as pulmonary lesions [7-10]. Several times, it eliminates the need of thoracentesis suggested by CXR owing to the meticulous detection of the disease process.

Objectives of the Study

The study aims to determine the diagnostic yield of trans-thoracic ultrasound and its influence on the management plan for pleuro-pulmonary disorders in emergency.

Materials and Methods

This analytical cross sectional study was conducted in the Emergency Department of Pulmonology, Gulab Devi Tertiary Care Hospital Lahore-Pakistan from January, 2019 to February 2020. Ethical approval was obtained from the IRB of the hospital vide No. Admin/GDEC/18.1106. Total 2873 adult patients with history of respiratory illness of sudden onset, suggesting pleural effusion on clinico-radiographic assessment, were included while those with chronic illness, follow up cases and with no suspicion of pulmonary involvement were excluded. Patients were subjected to CXR and subsequently judged with chest ultrasonography before going for any interventional procedure.

Patients were evaluated with grey scale (Toshiba-Japan) ultrasonography machine, using 3.5 - 5.5 MHZ convex probe. Anterior, posterior and lateral scans were obtained in sitting and supine positions. Both sides were scanned systematically. Pleural effusion was diagnosed by presence of fluid in pleural space, separating parietal and visceral pleural layers. Simple pleural effusion showed anechoic pattern without any internal echoes while complex effusions displayed internal echoes & were usually found in exudates while septated pleural effusion was diagnosed by the presence of fibrous bands inside effusion. Depending upon quantity, pleural effusions were classified as minimal with less than 50 ml, mild up-to 300 ml, moderate up-to 1000 ml while more than 1000 ml were labelled as massive pleural effusions. Normal pleura, thickened pleura, mass lesions, consolidation, lung abscess, empyema and pneumothorax were diagnosed by their peculiar sonographic features and subsequently managed by the required interventions. The patients requiring hospitalization were

admitted while rest were sent home on domiciliary treatment. Precise diagnosis was made by correlating the findings of history, physical examination, and relevant laboratory tests, using hematology, sputum microbiology, cytology and Gene-Xpert. Pleural fluid was tested for biochemistry, cytology, mycobacteriology, pyogenic culture and adenosine deaminase estimation. Bronchoscopy was done in pertinent cases and broncho-alveolar lavage was conclusive in certain cases. Pleural and lymph node biopsies were also performed in some cases to clench the precise diagnosis. Medical records of the patients were retrieved from the hospital registry and reviewed retrospectively. All information were recorded in a pre-formed pro-forma. Results were summarized, tabulated and statistical analysis was done to arrive at the conclusion. SPSS-21 was used for statistical analysis. Categorical variables were represented as frequency while quantitative data was computed as mean with + standard deviation. Sensitivity, specificity and diagnostic accuracy were calculated for the diagnosis of pleural effusion, considering 30 ml diagnostic aspirate as done under sonographic guidance as reference. P-value was calculated by chi-square test and $p < .05$ was considered significant for comparing the capability of diagnosing non pleural effusion cases.

Results and Discussion

A total of 2873 patients with suspicion of pleural effusion underwent trans-thoracic ultrasonography. 1686 (58.68%) patients were male while 1187 (41.31%) female. Male to Female ratio was 1.4:1. Age range was 14 - 86 years with mean age 38.94 ± 17.38 years. 2378 patient presented with symptoms of acute respiratory illness (Table 1). All cases had suspicion of pleural effusion on clinical and radiographic grounds but ultrasound detected pleural effusion only in 1522/2873 (52.97%). Anechoic pleural effusion 256 (16.81%) cases, complex non-septated 202 cases (13.27%), Complex septated 1034 cases (67.93%) and Homogenous echogenic type 30 cases (1.97%) were noted. Quantitative classification was done (Figure 1). Remaining 1351 cases (47.02) were reported as "no pleural effusion seen" but alternative diagnosis was catered (Table 2). The efficacy of ultrasound for diagnosing pleural effusion was calculated (Table 3). A chi-square test was performed to examine the difference of diagnostic capability for pleural effusion and non-pleural effusion cases. The p-value was 1 which is not significant at $p < .05$. Similarly, a p-value of < 0.00001, significant at $p < .05$ was calculated for the diagnostic efficacies of clinico-radiographic assessment and ultrasonography.

Nos	History Findings	Observed cases	Percentage
1.	Dry cough.	1867	64.98.0%
2.	Productive cough	632	21.99%
3.	High grade fever	1292	44.97%
4.	Shortness of breath	1522	52.970%
5.	Chest pain	2122	73.86%
6.	Hemoptysis	373	12.98%
7.	Drowsiness	73	2.54%
8.	Weight loss	1637	56.97%

***Table 1:** Frequency of clinical manifestations in 2873 patients.*

Sr. No.	Ultrasound Diagnosis	Observed cases	Percentage
1.	Normal pleurae	640	47.37%
2.	Pleural thickening	212	15.69%
3.	Pneumothorax	65	4.81%
4.	Pleural Mass	21	1.55%
5.	Consolidation.	260	19.24%
6.	Atypical Viral Pneumonia (Covid-19)	35	2.59%
6.	Lung Abscess	17	1.25%
7.	Collapse	27	1.99%
8.	Lung Mass	63	4.66%
9.	Destroyed Lung	11	0.81%
	Total =	1351	

***Table 2:** Sonographic diagnosis in pleural effusion ruled-out cases (n = 1351).*

Statistic	Value	95% CI
Sensitivity	100.00%	99.76% to 100.00%
Specificity	100.00%	99.73% to 100.00%
Diagnostic accuracy	100.00%	99.87% to 100.00%

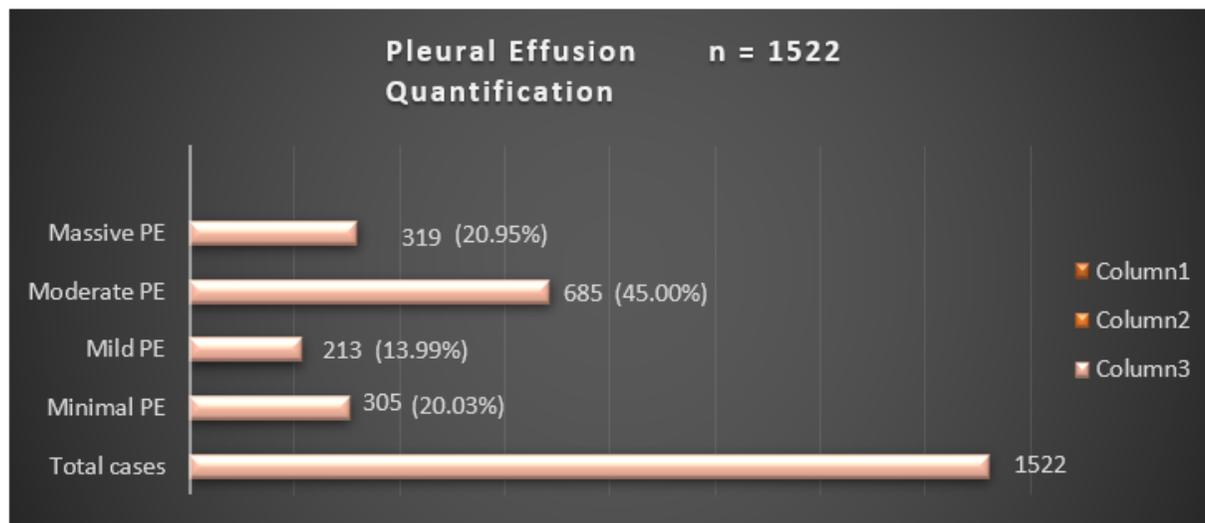***Table 3:*** *Ultrasound efficacy for pleural effusion.*

Figure 1: *Frequency of quantitative distribution of pleural effusions (n = 1522).*

Discussion

Total 16,920 patients reported in pulmonology emergency with acute respiratory complaints during the study period, while 2873 case were suggested pleural effusion by clinico-radiographic appraisal. Conventionally, x-ray chest is the main diagnostic tool in pulmonology emergency. If CXR suggests pleural effusion, thoracentesis is tried and on successful aspiration, the case is declared as pleural effusion. If thoracentesis is not successful, a note is written on the medical record "Pleural aspiration tried, nothing came out" and further sophisticated modalities are deployed in search of diagnosis. In this way, by putting a needle into the chest in the absence of pleural fluid in pleural space, we are actually puncturing the lung and iatrogenic manifestations are most likely to occur. So, there must be a tool for confirmation of fluid, separating the parietal and visceral pleurae before putting a needle inside.

Male to female ratio 1.4:1 conveys that pleural effusion being more common in males than in female. This observation is in congruence with reports of Burgess Lesley & colleagues and Luis Valdes and associates [11,12]. Mean age of the study-population: 38.94 years, is in fair agreement with reports of many researchers [13-15].

This study conveyed that out of 2873 patients with suspicion of pleural effusion, only 1522/2873 cases were diagnosed pleural effusion on chest ultrasound which were successfully aspirated under ultrasound guidance. All cases were true positive, no false positive or false negative case encountered. So, 1522 cases were diagnosed pleural effusion with sensitivity and specificity 100% each (Table 3) while in 1351 patients, pleural effusion was ruled-out, indicating that all CXR suggested-cases are not actually pleural effusion. A p-value of <

0.00001, significant at p < .05 revealed the ultrasound has superior differentiating power between pleural effusion and non-pleural effusion as compared to clinico-radiographic assessment while the p-value of 1 which is not significant at p < .05, shows that there is not much difference in decision making for the two categories, so ultrasound is equally good for diagnosing pleural effusion as well as pathologies other than pleural effusions. In such manner, it has confidently abolished the need for putting a needle into the chest of these patients, which otherwise would have been inevitable in the absence of ultrasound and successfully saved these patients from lung trauma.

Because ultrasound has very high sensitivity for liquid that is why it does not miss even minute pleural effusions (< 5 ml) [16]. In addition, quantification by ultrasound enables us for treatment planning about to go for aspiration or not [17]. Furthermore, by thoracentesis under ultrasound guidance especially in small effusions, it has minimized the chances of procedure failure and organ puncture. Additionally real time guidance has totally eliminated the mishaps of wrong side and wrong site [18]. The cases with minimal pleural effusion which often used to be remained undiagnosed because of unavailability of fluid sample, can now be worked up successfully, using sonographic guidance.

Sonographic picture of transudative PE were always anechoic but exudative PE usually displayed echoes inside. Thus, by finding an anechoic pattern, the differential diagnosis is narrowed down and transudative effusion can be speculated. In this way, chest ultrasound enables us just by looking at the monitor of ultrasound machine, to guess about exudative or transudative nature before the arrival of fluid chemistry report [19].

This study displayed septated PE in 1034 case (67.93%). Qureshi AR and associates concluded that by finding sonographic-septations in an exudative-lymphocytic pleural effusion, TB can be predicted. So, a complex-septated pattern, spots towards the possibility of tuberculosis which should be kept on the top of differential diagnosis list [20]. No doubt, 1034 cases is a big number, it can be explained by the fact that we are among the high burden countries. Similarly, homogenous echogenic pattern pointed towards the likelihood of empyema and malignancy and further minimized the differential diagnosis list [21].

In this study, 640 cases with normal pleurae were isolated successfully, indicating that trans-thoracic ultrasound is capable of discriminating between normal and diseased pleura. This finding is in agreement with reports of several authors [22-24].

The current study manifested gross pleural thickening (> 1.0 cm) in 212 cases, presenting with pain which after providing first-aid, were referred to the thoracic surgery for surgical evaluation where selected cases were subjected to decortication. This was made possible by non-invasive measurement of pleurae by ultrasonography [25]. Two hundred and sixty patients suspected with pleural effusion were accurately diagnosed as consolidation with typical sonographic signs, having solid texture and echogenic air-bronchogram sign, demonstrating the discriminating capability between consolidation and pleural effusion [26]. Just because of the diagnostic informations, provided by ultrasonography, these patients were treated as pneumonia and were saved from undue thoracic puncture. Similarly, 17 cases of lung abscess were rightly diagnosed, treated and discharged while those requiring hospitalization were shifted to pulmonology ward. According to the current reports, ultrasound can diagnose pneumonia with very high accuracy [27]. By using ultrasonography, 27 cases were diagnosed as atelectasis by static air-bronchogram sign and were referred to bronchoscopy department where foreign bodies pulled out, mucus plug removed, lung expanded and no further treatment was required. Likewise, exotic compression and intraluminal lesions were detected and endobronchial biopsies were diagnostic in these patients. This is the beauty of ultrasound that it unfolded the mystery and pleural effusion appearing cases were diagnosed rightly as collapse and correctly treated owing to its diagnostic usefulness [28].

Pneumothorax was diagnosed accurately in 65 cases by typical sonographic signs which is an easily treatable life-threatening emergency by minor surgical intervention, displaying the marvelous life-saving character of ultrasound. This observation is in agreement with the report of Nagarsheth K and associate [29]. Detection of 21 pleural and 63 lung mass lesions communicates that ultrasonography is capable of differentiating pulmonary from pleural mass lesions [30].

Thirty five patients with suspicion of pleural effusion on chest x-ray, were diagnosed atypical viral pneumonia owing to its signs like pleural irregularity, B-lines, sub-pleural consolidation, bilateral symmetrical, posterior & lower zone involvement. Diagnosing covid-19 pandemic pneumonia is really an unbelievable peculiarity of thoracic ultrasound which can be very useful during a pandemic [31-33]. This modality diagnosed even those cases which were missed by Covid-19 PCR.

In the light of this discussion, it can be commented without any hesitation that just by placing a probe on the chest wall, ultrasonography enables us to discriminate between normal and diseased pleura or lung and help a lot in therapeutic 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 of pleuro pulmonary maladies.

The limitation of this study is that it is a single center study, multiple center studies with more number of patients, the subject can be explored more efficiently and reproducibility of the findings can be evaluated more precisely. As trans-thoracic ultrasound depends on the skill of the operator as well as on the efficiency of ultrasound machine, so inter observer variations can come across.

However, it is fairly justified to remark that the availability of ultrasound in a pulmonary emergency can bring about a dramatic revolution in the diagnostic capability of department. It not only enhances the diagnostic efficiency, also provides therapeutic assistance as a guiding tool, minimizing the frequency of interventional failure or organ puncture [34]. As it does not involve any ionizing radiation, it can be used with confidence for pregnant and pediatric patients, safely [35]. It is, therefore, recommended that pulmonary students must be trained adequately before going to serve the community [36].

Conclusion

Trans-thoracic ultrasonography is an excellent decision-making tool for a pulmonary emergency. It is non-invasive, readily available and capable of identifying numerous pleuro-pulmonary pathologies and directs rightly towards the correct management plan.

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Conflict of Interest

There is no conflict of interest among the authors.

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