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Comparison of Lung Ultrasound Score with Pao2:Fio2 Ratio in Patient of Acute Respiratory Distress Syndrome – A Cross Sectional Observational Study.

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Abstract

Background: Acute Respiratory Distress Syndrome is associated with significant morbidity and requires accurate assessment of lung involvement and oxygenation status. Lung ultrasound score has emerged as a promising bedside tool for evaluating lung aeration. ***Objective:*** To correlate lung ultrasound score with PaO_2:FiO_2 ratio in patients with ARDS. Methods: A cross-sectional observational study was conducted on 100 ARDS patients. Lung ultrasound scoring was performed using a standardized protocol, and PaO_2:FiO_2 ratio was calculated from arterial blood gas analysis. The correlation between LUS and oxygenation status was assessed statistically. ***Results:*** Mean LUS increased progressively with severity of ARDS, with values of 9.24 ± 2.15 in mild, 16.82 ± 3.04 in moderate, and 23.36 ± 2.88 in severe ARDS. A strong negative correlation was observed between LUS and PaO_2:FiO_2 ratio ($r = -0.72$, $p < 0.001$), indicating worsening oxygenation with increasing lung aeration loss. ***Conclusion:*** Lung ultrasound score shows a significant inverse correlation with PaO_2:FiO_2 ratio and can be used as a reliable, non-invasive bedside tool for assessing severity and monitoring ARDS patients.

Keywords: Acute respiratory distress syndrome, lung ultrasound score, PaO_2:FiO_2 ratio, hypoxemia.

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INTRODUCTION

Acute Respiratory Distress Syndrome (ARDS) is a life-threatening form of acute hypoxemic respiratory failure characterized by diffuse alveolar damage, increased pulmonary permeability, and severe impairment in gas exchange. Despite advances in critical care management, ARDS continues to be associated with high morbidity and mortality worldwide. The recently updated global definition of ARDS has emphasized the importance of early diagnosis and objective assessment of severity, incorporating clinical, radiological, and oxygenation parameters [1,2].

The severity of ARDS is conventionally assessed using the PaO_2:FiO_2 (P/F) ratio, which reflects the efficiency of oxygen transfer across the alveolar-capillary membrane. Based on the Berlin criteria and its subsequent refinements, ARDS is categorized into mild, moderate, and severe forms according to the P/F ratio. Although widely used, the P/F ratio has certain limitations, including variability with ventilatory settings, dependence on positive end-expiratory pressure, and inability to provide regional information about lung aeration [3,4]. These limitations necessitate the exploration of adjunctive tools that can provide more dynamic and bedside assessment of lung pathology.

Lung ultrasound (LUS) has emerged as a valuable, non-invasive, radiation-free bedside imaging modality for the evaluation of critically ill patients. It allows real-time assessment of lung aeration by identifying characteristic patterns such as A-lines, B-lines, consolidation, and pleural abnormalities. The lung ultrasound score (LUS), which quantifies the degree of lung aeration loss based on standardized scanning protocols, has gained increasing attention as a reliable tool in ARDS assessment [5,6]. Studies have demonstrated that LUS correlates well with computed tomography findings and can effectively monitor disease progression and response to therapy.

Recent literature has highlighted the prognostic and diagnostic utility of LUS in ARDS patients. Higher LUS values have been associated with increased disease severity, poor oxygenation, and higher mortality rates [7,8]. Furthermore, LUS provides regional information about lung involvement, which is not captured by the global P/F ratio, thereby offering a more comprehensive understanding of lung pathology. The integration of LUS into routine critical care practice has been further supported by studies demonstrating its high sensitivity and specificity in diagnosing ARDS [9].

Importantly, emerging evidence suggests a significant correlation between lung ultrasound score and oxygenation indices such as the $PaO_2:FiO_2$ ratio. As lung aeration worsens, reflected by increasing LUS, a corresponding decline in oxygenation is observed. This inverse relationship underscores the potential of LUS as a surrogate marker for ARDS severity and highlights its role in guiding clinical decision-making [10]. However, despite growing evidence, there remains a need for further studies to establish the strength and clinical applicability of this correlation in diverse patient populations.
Therefore, the present study was undertaken to evaluate the correlation between lung ultrasound score and $PaO_2:FiO_2$ ratio in patients with acute respiratory distress syndrome, with the aim of determining whether LUS can serve as a reliable bedside tool for assessing disease severity and guiding management.

MATERIALS AND METHODS

This study was conducted after obtaining approval from the Institutional Ethics Committee and was designed as a cross-sectional observational study carried out over a defined study period in a tertiary care hospital. A total of 100 patients diagnosed with acute respiratory distress syndrome (ARDS) were included in the study. Patients of either sex aged above 18 years who fulfilled the diagnostic criteria for ARDS were enrolled.

Patients were selected based on the Berlin definition of ARDS, which includes acute onset of respiratory symptoms, bilateral opacities on chest imaging, and hypoxemia not fully explained by cardiac failure or fluid overload. Patients with pre-existing chronic lung diseases such as chronic obstructive pulmonary disease, interstitial lung disease, pulmonary fibrosis, or those with hemodynamic instability and poor echocardiographic window were excluded from the study. Pregnant patients and those not willing to participate were also excluded.

All patients underwent detailed clinical evaluation including history taking and physical examination. Baseline investigations included complete blood count, renal function tests, liver function tests, serum electrolytes, and arterial blood gas analysis. The $PaO_2:FiO_2$ ratio was calculated from arterial blood gas values and corresponding fraction of inspired oxygen at the time of assessment.

Lung ultrasound examination was performed at the bedside using a portable ultrasound machine with a convex or linear probe. The thorax was divided into standardized regions for scanning, typically including anterior, lateral, and posterior zones on both sides, resulting in a total of 12 lung regions. Each region was evaluated for lung aeration patterns and assigned a score based on the presence of A-lines, well-defined B-lines, coalescent B-lines, or consolidation. A score ranging from 0 to 3 was given for each region, with 0 representing normal aeration and 3 indicating complete loss of aeration. The total lung ultrasound score (LUS) was calculated by summing the scores from all examined regions, with higher scores indicating greater loss of lung aeration.

Simultaneously, the $PaO_2:FiO_2$ ratio was recorded for each patient under standardized ventilatory settings. Care was taken to ensure that measurements were taken under stable clinical conditions to avoid variability. The correlation between lung ultrasound score and $PaO_2:FiO_2$ ratio was then assessed.

All data were recorded in a structured proforma. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. The correlation between lung ultrasound score and $PaO_2:FiO_2$ ratio was analyzed using appropriate statistical tests such as Pearson or Spearman correlation coefficient depending on data distribution. A p-value of less than 0.05 was considered statistically significant. Statistical analysis was performed using SPSS software.

RESULTS

In the present study, 100 patients diagnosed with ARDS were included. Table 1 shows the age distribution of patients. The majority of patients were in the age group of 51–60 years, comprising 38 patients, followed by 41–50 years with 27 patients. The least number of patients were in the 18–30 years group (12 patients). This indicates that ARDS was more prevalent in the older age group in the study population.

Table 2 represents gender distribution. Out of 100 patients, 64 were males and 36 were females, showing a male predominance in ARDS cases in this study.

Table 3 shows the distribution of ARDS severity based on PaO_2:FiO_2 ratio. Mild ARDS (P/F ratio 200–300) was seen in 28 patients, moderate ARDS (P/F ratio 100–200) in 46 patients, and severe ARDS (P/F ratio <100) in 26 patients. This demonstrates that the majority of patients belonged to the moderate ARDS category.

Table 4 depicts the mean Lung Ultrasound Score (LUS) across ARDS severity categories. Patients with mild ARDS had a mean LUS of 9.24 ± 2.15, moderate ARDS had 16.82 ± 3.04, and severe ARDS had 23.36 ± 2.88. The increasing LUS values with worsening ARDS severity were statistically significant ($p < 0.001$), indicating progressive loss of lung aeration.

Table 5 shows the correlation between Lung Ultrasound Score and PaO_2:FiO_2 ratio. A strong negative correlation was observed ($r = –0.72$, $p < 0.001$), indicating that as LUS increased, the PaO_2:FiO_2 ratio decreased significantly. For example, patients with LUS above 20 had mean P/F ratio around 92.4 ± 18.6, while those with LUS below 10 had mean P/F ratio of 248.6 ± 32.4, demonstrating a clear inverse relationship.

Table 1: Age Distribution of Study Participants

Age Group (years)	Number of Patients	Percentage (%)
18–30	12	12
31–40	23	23
41–50	27	27
51–60	38	38
Total	100	100

Table 2: Gender Distribution

Gender	Number of Patients	Percentage (%)
Male	64	64
Female	36	36
Total	100	100

Table 3: Distribution According to ARDS Severity (PaO_2:FiO_2 Ratio)

ARDS Severity	PaO_2:FiO_2 Ratio	Number of Patients	Percentage (%)
Mild	200–300	28	28
Moderate	100–200	46	46
Severe	<100	26	26
Total	—	100	100

Table 4: Comparison of Lung Ultrasound Score Across ARDS Severity

ARDS Severity	Mean LUS Score ± SD	P Value
Mild	9.24 ± 2.15	<0.001
Moderate	16.82 ± 3.04	<0.001
Severe	23.36 ± 2.88	<0.001

Table 5: Correlation Between Lung Ultrasound Score and PaO_2:FiO_2 Ratio

LUS Score Range	Mean PaO_2:FiO_2 Ratio ± SD	Correlation Coefficient (r)	P Value
<10	248.6 ± 32.4	—	—
10–20	158.2 ± 27.6	–0.72	<0.001
>20	92.4 ± 18.6	—	—

DISCUSSION

The present study was conducted to evaluate the correlation between lung ultrasound score (LUS) and PaO_2:FiO_2 ratio in patients with acute respiratory distress syndrome (ARDS). The findings of the study demonstrated a strong inverse correlation between LUS and oxygenation status, indicating that increasing lung aeration loss is associated with worsening hypoxemia. This relationship highlights the clinical utility of lung ultrasound as a reliable bedside tool for assessing disease severity in ARDS.

In the present study, the majority of patients were in the older age group, with 38% belonging to 51–60 years, and a male predominance of 64%. These demographic findings are consistent with previous studies that have reported higher incidence of ARDS in older populations and males, possibly due to increased prevalence of comorbid conditions and risk factors. A study by Zhao et al. observed similar demographic patterns in ARDS patients, emphasizing the role of age-related decline in pulmonary reserve and increased susceptibility to severe lung injury [11].

The classification of ARDS severity based on PaO_2:FiO_2 ratio in the present study revealed that 46% of patients had moderate ARDS, followed by 28% with mild and 26% with severe ARDS. This distribution is in agreement with previous observational studies that have reported moderate ARDS as the most commonly encountered category in critical care settings. The PaO_2:FiO_2 ratio remains a cornerstone in ARDS classification; however, it does not provide regional information about lung involvement. Bouhemad et al. highlighted that oxygenation indices alone may underestimate the extent of lung aeration loss, thereby necessitating adjunct imaging modalities such as lung ultrasound [12].

The lung ultrasound score in the present study showed a progressive increase with worsening ARDS severity, with mean values of 9.24 ± 2.15 in mild ARDS, 16.82 ± 3.04 in moderate ARDS, and 23.36 ± 2.88 in severe ARDS, which was statistically significant ($p < 0.001$). These findings are consistent with the study by Soummer et al., who demonstrated that LUS is a quantitative marker of lung aeration and correlates closely with the degree of lung injury. Their study established that higher LUS values are indicative of extensive alveolar consolidation and interstitial syndrome [13].

A key finding of the present study was the strong negative correlation between LUS and PaO_2:FiO_2 ratio ($r = –0.72$, $p < 0.001$). Patients with LUS less than 10 had mean PaO_2:FiO_2 ratio of 248.6 ± 32.4, whereas those with LUS greater than 20 had significantly lower values of 92.4 ± 18.6, indicating severe impairment in oxygenation. This inverse relationship is supported by the findings of Chiumello et al., who demonstrated that lung ultrasound findings correlate well with computed tomography and oxygenation indices in ARDS patients. Their study further emphasized that LUS can serve as a surrogate marker for evaluating lung recruitability and disease severity [14].

Furthermore, lung ultrasound offers the advantage of bedside applicability, repeatability, and absence of radiation exposure, making it particularly useful in critically ill patients. In a study conducted by Volpicelli et al., lung ultrasound was found to have high sensitivity and specificity in detecting interstitial and alveolar syndromes, and its scoring system showed significant correlation with clinical severity indices [15]. This reinforces the role of LUS as a valuable tool not only for diagnosis but also for monitoring disease progression and response to therapy in ARDS.

Overall, the findings of the present study strongly support the use of lung ultrasound score as a reliable and non-invasive indicator of ARDS severity. The significant inverse correlation with PaO_2:FiO_2 ratio highlights its potential role in complementing traditional oxygenation indices, thereby enhancing clinical assessment and guiding management decisions.

CONCLUSION

The present study concludes that lung ultrasound score has a strong negative correlation with PaO_2:FiO_2 ratio in patients with acute respiratory distress syndrome. As lung aeration decreases, reflected by increasing LUS values, there is a corresponding decline in oxygenation status. Lung ultrasound, being a bedside, non-invasive, and radiation-free modality, can serve as a reliable tool for assessing disease severity and monitoring ARDS patients. Integration of LUS into routine clinical practice may improve early diagnosis, guide therapeutic interventions, and enhance patient outcomes.

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