International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Predictive Value of Lung Ultrasound Scoring System in ARDS Severity and Mortality

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Abstract: ***Background**: Acute Respiratory Distress Syndrome (ARDS) is characterized by diffuse alveolar damage leading to hypoxemia and respiratory failure. Accurate bedside assessment of ARDS severity is challenging with conventional imaging. Lung ultrasound (LUS) is emerging as a promising radiation-free, repeatable modality capable of providing real-time lung aeration evaluation. **Objective**: To evaluate the lung ultrasound scoring system as a predictive tool for clinical severity and 28-day outcomes in patients with ARDS. **Methods**: In this single-center observational study conducted from January to June 2024, 30 adult patients with ARDS (Berlin criteria) underwent standardized lung ultrasound scoring across 12 thoracic regions. LUS scores were correlated with oxygenation parameters (PaO_2/FiO_2 ratio), need for mechanical ventilation, and 28-day mortality. Statistical analysis included correlation coefficients and receiver operating characteristic (ROC) curve analysis. **Results**: Lung ultrasound scores demonstrated a moderate to strong inverse correlation with oxygenation ($r = –0.69$), indicating that higher LUS scores reflect worse gas exchange. Patients who died within 28 days had significantly higher mean LUS scores (22.7 ± 3.0) than survivors (17.8 ± 3.9; $p < 0.05$). ROC analysis yielded an area under the curve (AUC) of 0.84 for predicting mortality, with a cutoff score of ≥20 showing 81.6% sensitivity and 71.4% specificity. LUS scores poorly predicted the need for mechanical ventilation (AUC = 0.55). **Conclusion**: Lung ultrasound scoring is a valuable bedside tool for assessing ARDS severity and predicting 28-day mortality. Implementing LUS can facilitate timely risk stratification and personalized management, reducing reliance on radiation-based imaging.*

Keywords: ARDS, lung ultrasound, mortality prediction, bedside assessment, oxygenation

1. Introduction

Acute Respiratory Distress Syndrome (ARDS) remains a critical challenge in intensive care units, characterized by widespread pulmonary inflammation and impaired oxygenation. Despite advances in supportive care, mortality remains high. The Berlin Definition standardizes ARDS diagnosis based on timing, chest imaging, origin of edema, and oxygenation impairment, but quantifying disease severity in real-time remains problematic.

Conventional imaging modalities like chest X-ray and computed tomography (CT) have limitations—poor sensitivity, radiation exposure, logistical difficulties, and challenges in unstable patients. Lung ultrasound (LUS), with its safety, bedside applicability, and ability to provide detailed evaluation of lung aeration, is gaining global attention as a prognostic tool in ARDS and other acute respiratory conditions. Recent multicenter studies demonstrate strong correlations between LUS scores and CT findings, validating its clinical utility.

This study aims to evaluate the effectiveness of a standardized LUS scoring system in predicting clinical severity assessed by oxygenation and critical outcomes including ventilator requirement and 28-day mortality in patients with ARDS.

2. Materials and Methods

Study Design and Population

A prospective, observational, single-center study was conducted at Saraswathi Institute of Medical Sciences, Hapur, Uttar Pradesh, between January and June 2024. Thirty adult patients diagnosed with ARDS based on Berlin Criteria were enrolled after informed consent.

Lung Ultrasound Protocol

Lung ultrasound was performed within 24 hours of ARDS diagnosis. Each hemithorax was divided into six zones—anterior, lateral, and posterior, each subdivided into upper and lower parts—resulting in 12 zones total. Each zone was scored:
Score 0: Normal aeration (A-lines or fewer than 3 B-lines)
Score 1: ≥3 well-spaced B-lines covering <50% of the screen
Score 2: Coalescent B-lines or B-lines covering >50% of the screen
Score 3: Consolidation (hepatisation pattern)

The total LUS score was summed across all zones.

Data Collection and Outcomes

Patients were monitored for oxygenation parameters (PaO_2/FiO_2 ratio), need for mechanical ventilation, and survival status at 28 days.

Statistical Analysis

Pearson correlation coefficient assessed the relationship between LUS score and oxygenation. ROC curve analysis determined the predictive accuracy of LUS scores for 28-day mortality and ventilation requirement. Sensitivity, specificity, and cutoff values were calculated. Analysis was performed using SPSS and R software.

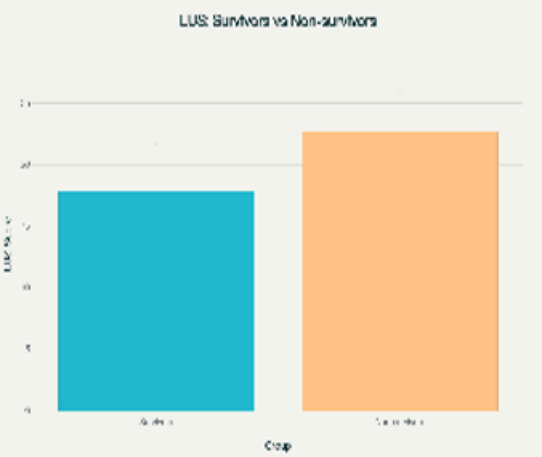
3. Results

Patient Characteristics

Thirty patients with ARDS were included.

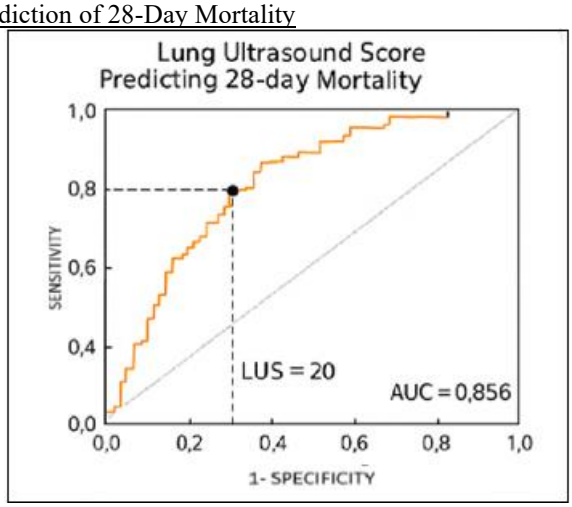
Lung Ultrasound Score Correlation with Oxygenation

LUS scores inversely correlated with oxygenation ($r = –0.69$), indicating higher LUS scores corresponded with worsening hypoxemia (Figure 1).



Clinically meaningful difference: Patients who died within 28 days had substantially higher mean LUS scores (22.7 ± 3.0) compared to survivors (17.8 ± 3.9)

Prediction of 28-Day Mortality



Survivors (n=18) had mean LUS score: 17.8 ± 3.9
Non-survivors (n=12) had mean LUS score: 22.7 ± 3.0 ($p < 0.05$)
ROC curve for mortality showed AUC = 0.84 (95% CI: 0.76–0.92), with a cutoff ≥20 yielding sensitivity 81.6% and specificity 71.4%.

Prediction of Mechanical Ventilation Requirement
Mean LUS scores were similar between ventilated and non-ventilated groups (19.3 ± 2.7 vs 18.6 ± 2.5), with poor discrimination (AUC = 0.55).

Lung Ultrasound Score vs Need for Mechanical Ventilation
The receiver operating characteristic (ROC) curve analysis revealed an area under the curve (AUC) of 0.546, indicating poor discriminative ability ie very limited ability to differentiate between those who ultimately required mechanical ventilation and those who did not

4. Discussion

Our findings confirm that lung ultrasound scoring correlates well with the severity of hypoxemia in ARDS patients, supporting its role as an effective bedside imaging tool. The moderate to strong inverse correlation with oxygenation aligns with existing literature, including Lichtenstein et al. and meta-analyses emphasizing LUS's diagnostic accuracy in ARDS and critical illness.

Importantly, the significant prognostic accuracy (AUC 0.84) of LUS scores for predicting 28-day mortality strengthens the argument for integrating LUS into routine assessment protocols. The cutoff score of ≥20 is consistent with recent studies, offering actionable guidance to identify high-risk patients who may require closer monitoring and intensive interventions.

The limited predictive ability of LUS scores for mechanical ventilation need suggests that additional clinical parameters impact ventilator decisions, which may not be captured by LUS alone.

Ultimately, LUS offers numerous advantages over chest X-ray and CT, including no radiation exposure, repeatability, bedside feasibility, and rapid results, enabling personalized, dynamic ARDS management especially in resource-limited or critical care settings.

5. Conclusion

Lung ultrasound scoring is a promising, non-invasive, and effective tool to assess clinical severity and predict mortality in ARDS patients. Incorporation of LUS scoring into standard ARDS management pathways may improve risk stratification and patient outcomes while minimizing radiation exposure. Future larger multicenter studies are warranted to validate these findings and expand its clinical application.

Acknowledgments:
We thank the Emergency and Radiology departments of Saraswathi Institute of Medical Sciences for their support and all patients who consented to participate.

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