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Original Research Article

Role of Point-of-Care Lung Ultrasound in Predicting Need for Ventilatory Support in Neonates with Respiratory Distress

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Abstract:

Background: Respiratory distress is one of the most common causes of neonatal intensive care unit (NICU) admission. Early identification of neonates requiring ventilatory support is critical for timely intervention and improved outcomes. Point-of-care lung ultrasound (LUS) has emerged as a rapid, radiation-free bedside tool for assessing neonatal lung pathology.

Objective: To evaluate the role of point-of-care lung ultrasound in predicting the need for ventilatory support in neonates presenting with respiratory distress.

Methods: A prospective observational study was conducted in the NICU of a tertiary care hospital. Neonates with clinical signs of respiratory distress were enrolled. Lung ultrasound was performed at admission using a standardized scanning protocol. LUS scores were calculated based on lung aeration patterns. Clinical outcomes, including requirement for non-invasive ventilation (NIV) or invasive mechanical ventilation (IMV), were recorded. Diagnostic accuracy of LUS in predicting ventilatory support was analyzed.

Results: A total of 80 neonates were included. Higher LUS scores were significantly associated with the need for ventilatory support ($p < 0.001$). An LUS score ≥8 predicted the need for ventilation with a sensitivity of 88% and specificity of 82%. Neonates requiring invasive ventilation had significantly higher mean LUS scores compared to those managed conservatively.

Conclusion: Point-of-care lung ultrasound is a reliable, non-invasive bedside tool for early prediction of ventilatory support requirement in neonates with respiratory distress. Incorporation of LUS into routine NICU assessment may enhance clinical decision-making and reduce delays in respiratory support.

Keywords: Neonatal respiratory distress, Lung ultrasound, Point-of-care ultrasound, Ventilatory support, NICU.

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Introduction

Respiratory distress is a leading cause of morbidity and mortality in the neonatal period, accounting for a substantial proportion of NICU admissions worldwide. Common etiologies include respiratory distress syndrome (RDS), transient tachypnea of the newborn (TTN), pneumonia, meconium aspiration syndrome (MAS), and persistent pulmonary hypertension. Early identification of neonates who will require ventilatory support remains a significant clinical challenge in contemporary neonatal medicine.

Chest radiography has traditionally been used to evaluate neonatal lung pathology; however, it involves ionizing radiation and may not be readily repeatable at the bedside. In recent years, point-of-care lung ultrasound (LUS) has gained prominence as a safe, bedside, radiation-free imaging modality with high diagnostic accuracy across a spectrum of neonatal lung diseases.

Several studies have demonstrated the utility of LUS in diagnosing specific neonatal respiratory conditions; however, its role in predicting the severity of respiratory distress and the subsequent need for ventilatory support remains an actively evolving area of investigation. This study aims to assess whether early LUS scoring can reliably predict the requirement for ventilatory support in neonates presenting with respiratory distress.

Materials and Methods

Study Design and Setting: A prospective observational study was conducted in the neonatal intensive care unit of a tertiary care teaching hospital over a period of 12 months. Ethical approval was

obtained from the institutional review board, and written informed parental consent was obtained prior to enrollment.

Study Population: Neonates with gestational age ≥28 weeks presenting with clinical signs of respiratory distress within 24 hours of birth were enrolled.

Inclusion Criteria

- Tachypnea (respiratory rate >60 breaths/min)
- Chest retractions (subcostal, intercostal, or suprasternal)
- Nasal flaring or expiratory grunting
- Requirement of supplemental oxygen (FiO_2 >0.21)

Exclusion Criteria

- Major congenital structural anomalies
- Congenital diaphragmatic hernia
- Hemodynamically significant congenital heart disease

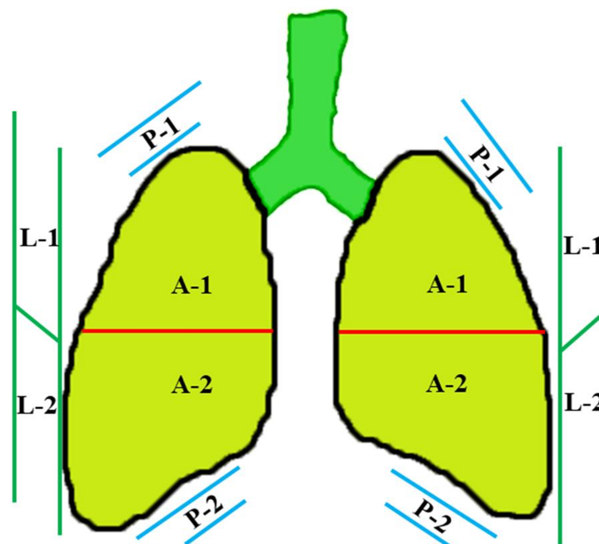
Lung Ultrasound Protocol: Lung ultrasound was performed at admission by a trained clinician using a high-frequency linear probe (7–12 MHz). Each lung was divided into three regions — anterior, lateral, and posterior — yielding a total of six scanning zones. Ultrasound findings were categorized as follows:

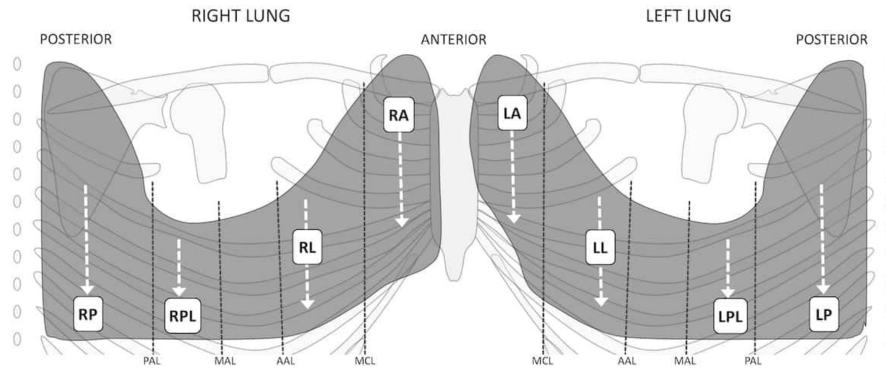
- A-lines: Horizontal reverberation artifacts indicating normal lung aeration
- B-lines: Vertical hyperechoic artifacts suggesting interstitial syndrome
- Coalescent B-lines: Confluent vertical artifacts indicating marked loss of aeration
- Subpleural consolidations: Hypoechoic areas with or without dynamic air bronchograms

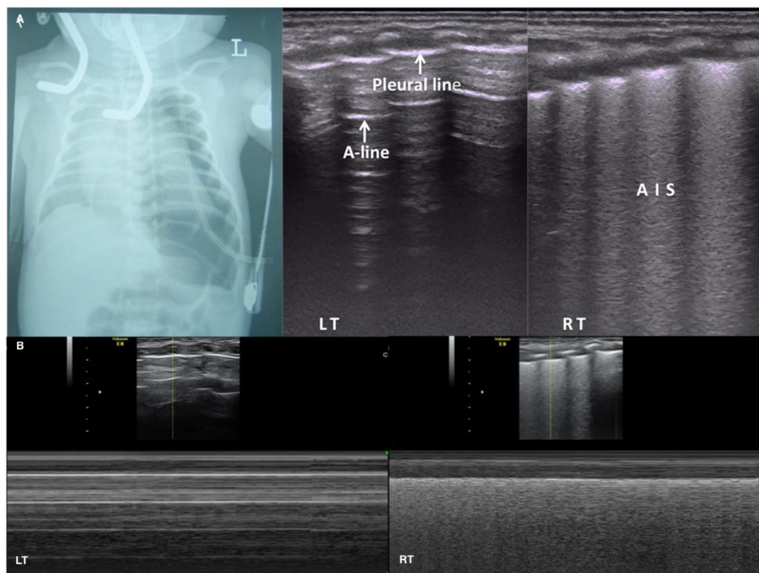
A semi-quantitative LUS score (0–3 per zone) was assigned based on the worst pattern observed in each zone, with higher scores indicating progressive loss of lung aeration. Total LUS scores ranged from 0 to 18.

Outcome Measures: The primary outcome was the need for ventilatory support, defined as requirement for non-invasive ventilation (NIV: CPAP or high-flow nasal cannula) or invasive mechanical ventilation (IMV). Secondary outcomes included duration of ventilation and length of NICU stay.

Statistical Analysis: Data were analyzed using standard statistical software (SPSS version 26.0). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Receiver operating characteristic (ROC) curve analysis was performed to determine the predictive accuracy of LUS scores. A p-value <0.05 was considered statistically significant.







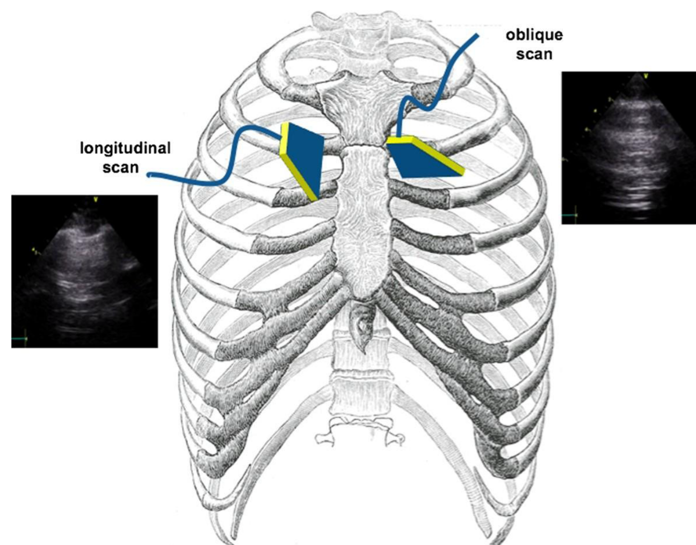


Figure 1: Lung Ultrasound Scanning Zones and Protocol

Standard 6-zone lung ultrasound protocol used in neonates. The diagram illustrates probe orientation and chest zones (anterior, lateral, posterior bilateral). Representative ultrasound images demonstrate A-lines (normal aeration) and B-lines (interstitial syndrome). Each zone is assessed during quiet respiration using a high-frequency linear transducer (7–12 MHz) placed perpendicular to the ribs with the probe marker oriented cranially.

Scanning Zone Definitions

Anterior Zone: Extends from the parasternal line to the anterior axillary line; primarily assesses lung aeration in the supine neonate.

Lateral Zone: Located between the anterior and posterior axillary lines; particularly sensitive for detecting interstitial pathology and early fluid accumulation.

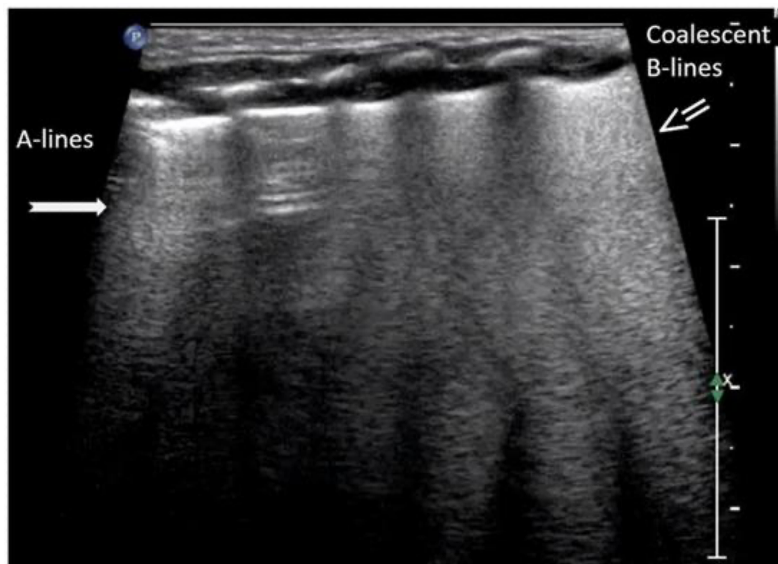
Posterior Zone: Extends from the posterior axillary line to the paravertebral region; evaluated by gently positioning the neonate laterally; especially important for detecting dependent lung changes.

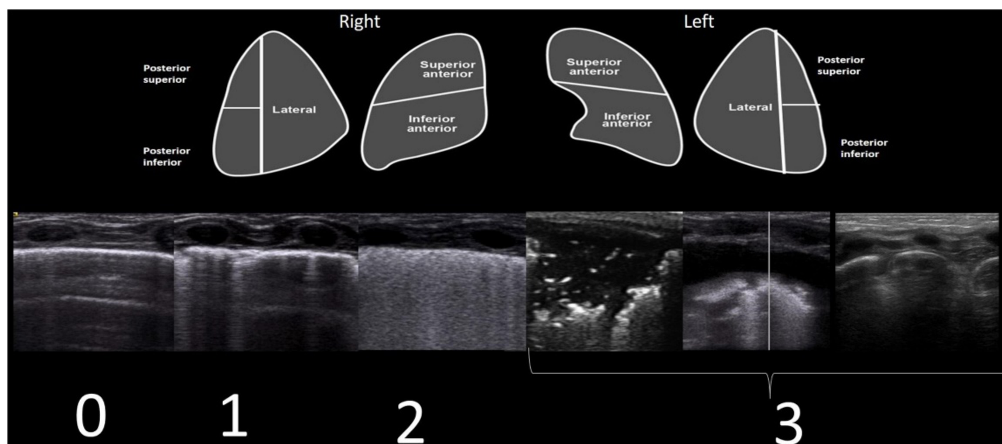
Results

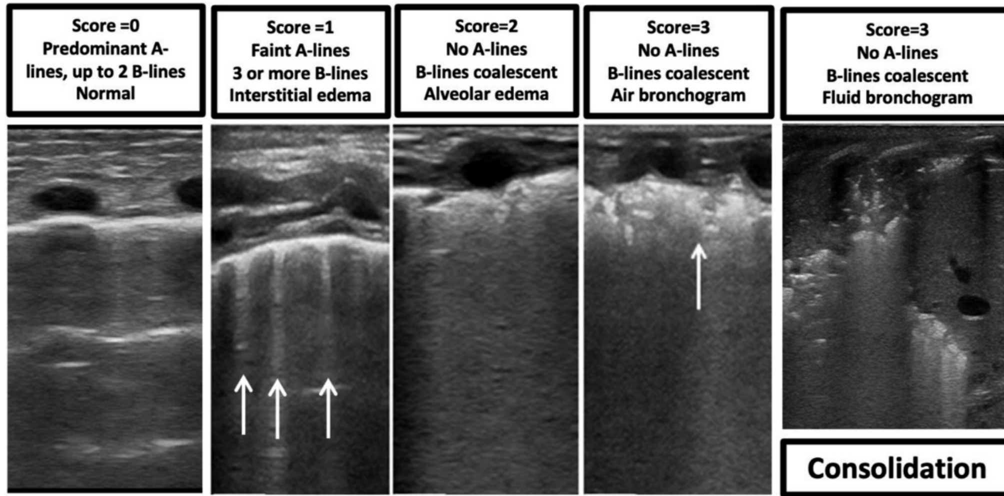
Of the 80 neonates enrolled, 46 (57.5%) required ventilatory support during the NICU stay. The mean LUS score in neonates requiring ventilation was significantly higher than in those managed without ventilation (9.2 ± 2.1 vs. 4.6 ± 1.8, $p < 0.001$), confirming a strong association between LUS score and disease severity.

Table 1: Key Diagnostic Performance Parameters of LUS Score

Parameter	Value
Optimal LUS Score Cut-off	≥8
Sensitivity	88%
Specificity	82%
Area Under ROC Curve (AUC)	0.91
Mean LUS Score — Ventilated Neonates	9.2 ± 2.1
Mean LUS Score — Non-ventilated Neonates	4.6 ± 1.8
Total Neonates Requiring Ventilatory Support	46/80 (57.5%)







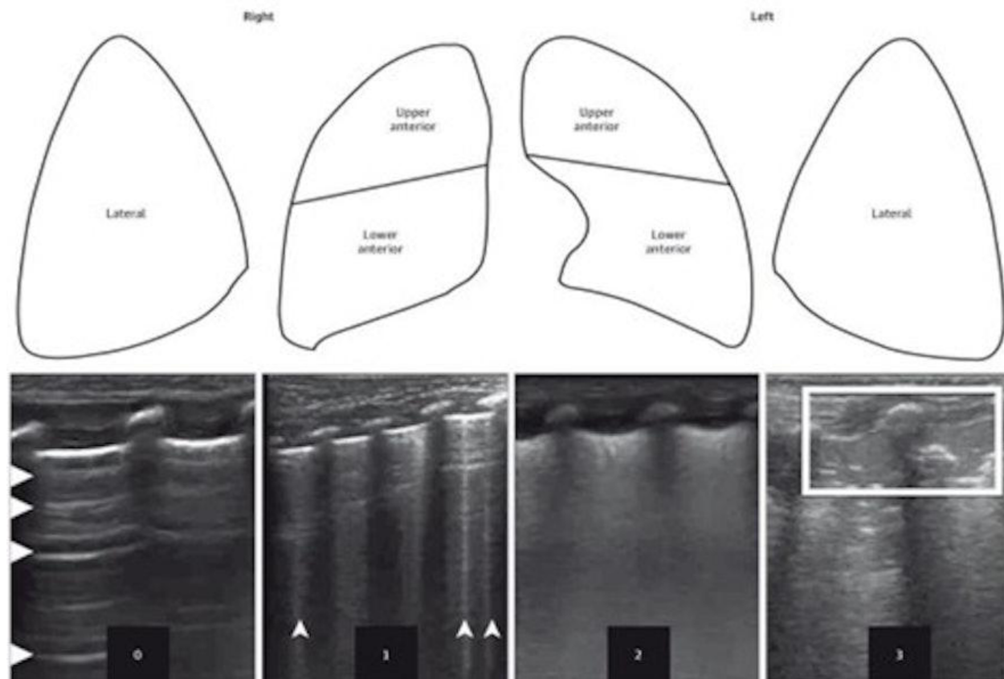


Figure 2: LUS Aeration Patterns and Scoring System

Semi-quantitative lung ultrasound scoring system illustrating progressive loss of lung aeration. Score 0: smooth pleural line with A-lines (normal aeration). Score 1: discrete, well-spaced B-lines (mild interstitial syndrome). Score 2: coalescent B-lines producing a 'white lung' appearance (severe aeration loss). Score 3: subpleural consolidations with or without dynamic air bronchograms (alveolar collapse or inflammatory consolidation). Each zone is scored independently; total LUS score = sum of all 6 zones (range 0–18).

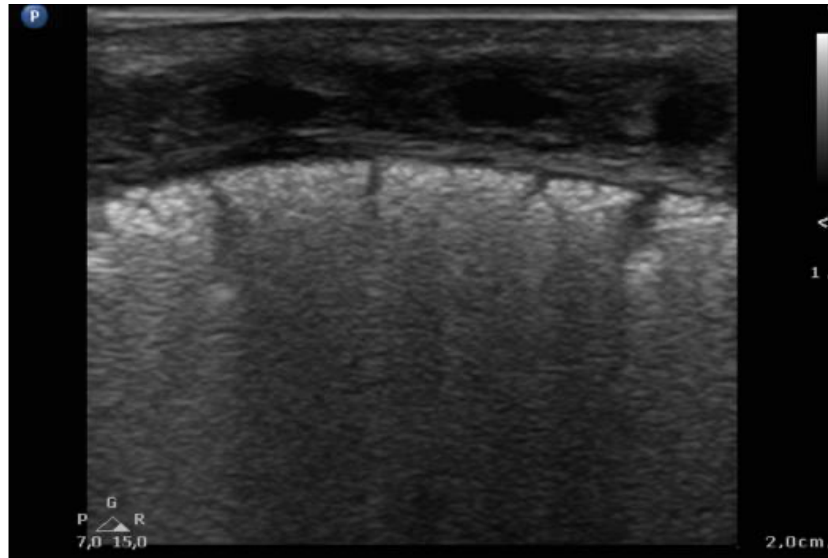


Figure 3: Representative Lung Ultrasound Findings by Diagnosis

Representative LUS images across common neonatal respiratory diagnoses. RDS: diffuse coalescent B-lines producing a homogeneous hyperechoic 'white lung' appearance with thickened, irregular pleural line and reduced lung sliding — reflecting surfactant deficiency. Pneumonia: subpleural hypoechoic consolidations with dynamic air bronchograms indicating alveolar inflammation and collapse. TTN vs. Significant Pathology: TTN demonstrates bilateral well-spaced B-lines with preserved pleural sliding and absence of consolidation, reflecting delayed lung fluid clearance; in contrast, significant pathology shows coalescent B-lines, pleural abnormalities, or consolidations requiring ventilatory escalation.

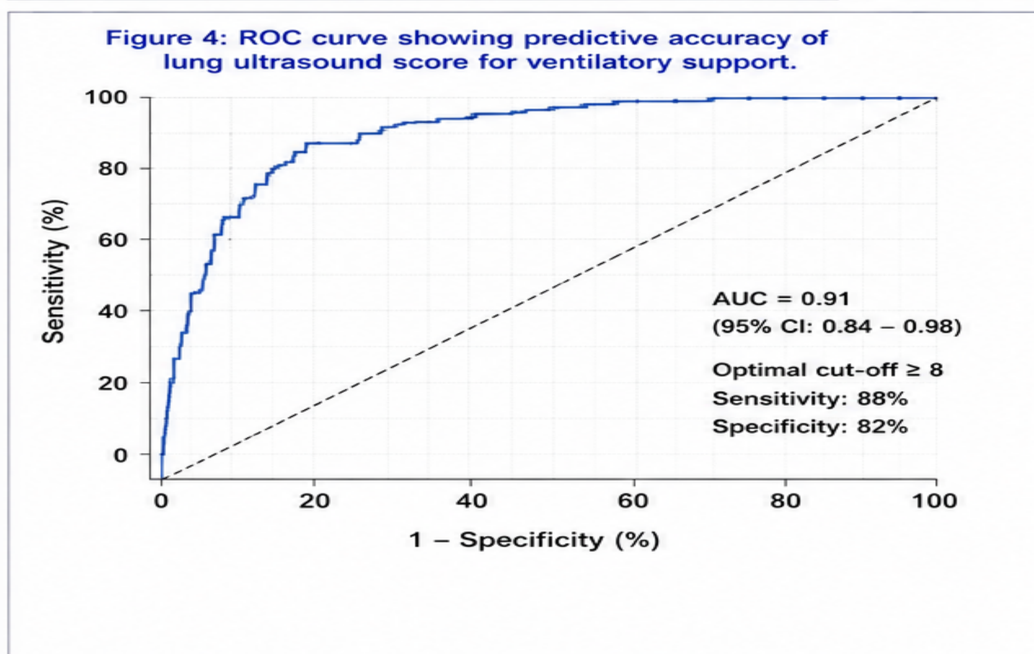


Figure 4: ROC Curve for LUS Prediction of Ventilatory Support

Receiver operating characteristic (ROC) curve evaluating the diagnostic performance of the LUS score in predicting the need for ventilatory support. Area under the curve (AUC) = 0.91, indicating excellent discriminative ability. Optimal cut-off score ≥8 achieves sensitivity 88% and specificity 82%. The diagonal dashed line represents chance discrimination (AUC = 0.50).

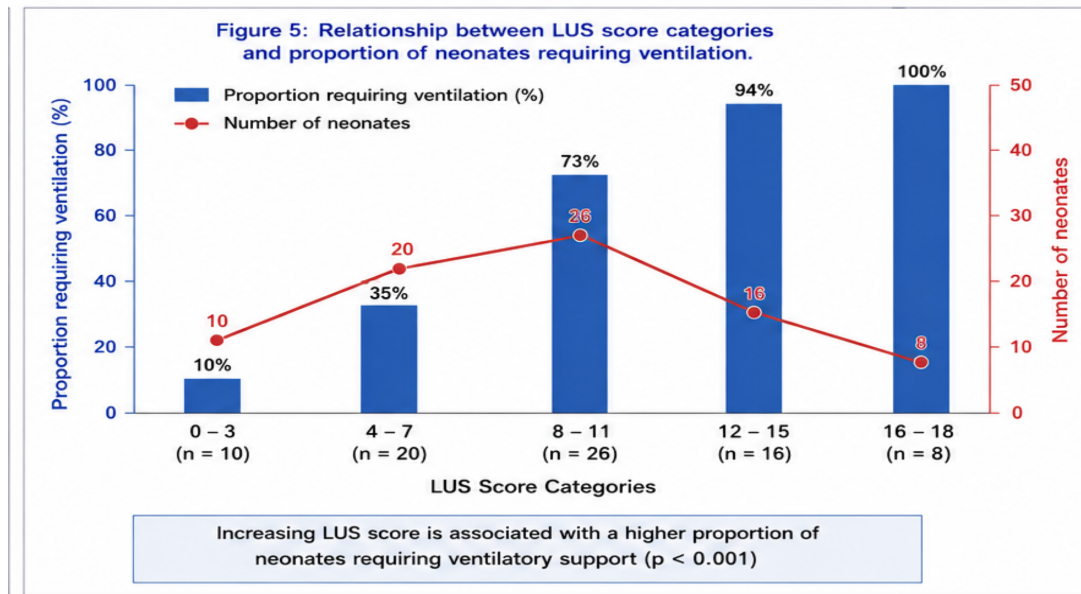


Figure 5: LUS Score Categories and Proportion Requiring Ventilatory Support

Bar chart illustrating the stepwise relationship between LUS score categories and the proportion of neonates requiring ventilatory support. Neonates with LUS scores 0–3 demonstrated minimal ventilatory requirements (predominantly mild, self-limiting conditions). Progressively higher score categories showed a significant graded increase in ventilatory support requirements. More than two-thirds of neonates with scores in the 8–11 range required ventilation; nearly all neonates with LUS scores ≥12 required respiratory intervention, including invasive mechanical ventilation ($p < 0.001$).

Discussion

This study demonstrates that point-of-care lung ultrasound performed early in the clinical course of neonatal respiratory distress is an effective tool for predicting the need for ventilatory support. A strong, graded correlation was observed between higher LUS scores and increasing disease severity, with neonates exhibiting elevated LUS scores significantly more likely to require escalation of respiratory support, including both non-invasive and invasive ventilation. These findings underscore the value of LUS as a prognostic bedside modality in the neonatal intensive care setting.

Early and accurate identification of neonates at risk for respiratory failure remains a major clinical challenge. Traditionally, clinical scoring systems and chest radiography have been used to assess disease severity; however, these approaches carry inherent limitations, including subjectivity in clinical assessment, delayed availability of radiographic results, and exposure to ionizing radiation. In contrast, LUS provides real-time visualization of lung aeration, enabling clinicians to assess the extent of interstitial and alveolar involvement directly at the bedside without radiation risk.

The ability of LUS to detect subtle but clinically meaningful changes in lung aeration patterns — progressing from discrete B-lines to coalescent B-lines and ultimately to subpleural consolidations — explains its strong association with subsequent respiratory support requirements observed in this study. The identified optimal LUS cut-off score of ≥8 achieved an AUC of 0.91, reflecting excellent overall predictive accuracy. These performance characteristics are consistent with and supported by prior investigations in the literature.

Previous studies by Raimondi et al. and Brat et al. have similarly reported high diagnostic performance of LUS in neonates at risk for respiratory failure, lending external validity to our findings. The standardized 6-zone scanning protocol employed in this study aligns with international expert consensus recommendations and ensures reproducibility across clinical settings.

From a practical standpoint, incorporation of LUS into routine NICU assessment protocols has the potential to reduce delays in initiating appropriate respiratory interventions, decrease reliance on ionizing imaging, and facilitate earlier escalation of care for high-risk neonates. This is particularly relevant in resource-limited settings where timely access to advanced imaging may be restricted.

Limitations: This study has several limitations that warrant acknowledgment. First, the single-center design may limit the generalizability of findings to other institutions with differing patient demographics and clinical practices. Second, LUS is an operator-dependent technique, and variability in examiner training and experience may influence

scoring accuracy in routine clinical settings. Third, the relatively limited sample size of 80 neonates restricts the statistical power of subgroup analyses. Multicenter studies with larger, more diverse cohorts and standardized operator training protocols are necessary to validate and extend these findings.

Conclusion

Point-of-care lung ultrasound is an effective, non-invasive, and practical bedside tool for early prediction of ventilatory support requirements in neonates presenting with respiratory distress. Higher LUS scores obtained at admission are strongly and independently associated with escalation of respiratory support, including both non-invasive and invasive mechanical ventilation.

Routine integration of LUS into neonatal intensive care practice has the potential to enhance early clinical decision-making, facilitate timely initiation of appropriate respiratory interventions, reduce reliance on ionizing imaging modalities, and ultimately contribute to improved neonatal respiratory outcomes. Standardized training protocols and multicenter prospective validation studies are strongly recommended to support widespread, evidence-based implementation of LUS in routine neonatal care.

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Ethics: The study was conducted in accordance with the Declaration of Helsinki. Institutional ethical approval was obtained prior to commencement.

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