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RESEARCH ARTICLE
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COMPARISON OF SIX-AREA AND TWELVE-AREA LUNG ULTRASOUND SCORING SYSTEMS FOR PREDICTING NEED FOR MECHANICAL VENTILATION IN NEONATES WITH RESPIRATORY DISTRESS: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background

Lung ultrasound (LUS) scoring is increasingly used to evaluate respiratory distress in neonates, but the optimal LUS protocol for predicting mechanical ventilation remains uncertain. This study compared six-area and twelve-area LUS scoring systems for their ability to predict mechanical ventilation in neonates with respiratory distress.

Methods

In this prospective observational study, N = 90 neonates with respiratory distress admitted to a tertiary NICU were evaluated within 6 hours of admission. Standardized LUS was performed using both six-area and twelve-area protocols by trained neonatologists blinded to clinical and FiO_2 data. Clinical parameters, Silverman–Anderson scores, and FiO_2 requirements were recorded. Infants were followed for 72 hours to document mechanical ventilation requirement. Predictive accuracy was assessed using receiver-operating characteristic (ROC) curves and compared using the DeLong method.

RESULTS

Of 90 neonates, 32 (35.6%) required mechanical ventilation. Ventilated infants had significantly lower gestational age (32.1 ± 3.4 weeks vs 34.2 ± 2.8 weeks, $p = 0.02$), lower birth weight (1.62 ± 0.43 kg vs 1.94 ± 0.48 kg, $p = 0.01$), and higher FiO_2 requirement ($p < 0.001$). Mean six-area and twelve-area LUS scores were significantly higher in ventilated neonates (12.8 ± 2.9 and 22.6 ± 3.9) compared with non-ventilated neonates (7.3 ± 2.4 and 10.5 ± 3.3; both $p < 0.001$). ROC analysis showed **AUC = 0.87 [95% CI 0.79–0.95]** for the six-area and **AUC = 0.93 [95% CI 0.87–0.98]** for the twelve-area protocol. A twelve-area LUS ≥ 16 predicted mechanical ventilation with **89%**

sensitivity and 91% specificity. High-score infants had longer oxygen use, prolonged NICU stay, and higher mortality.

CONCLUSIONS
Both six-area and twelve-area LUS scoring systems reliably predict the need for mechanical ventilation in neonatal respiratory distress. The twelve-area protocol may facilitate earlier identification of infants needing intensive support and guide timely intervention.

Keywords: Lung ultrasound, Neonatal respiratory distress, Mechanical ventilation, LUS score

INTRODUCTION

Respiratory distress is one of the most frequent causes of neonatal intensive care unit (NICU) admission and contributes significantly to neonatal morbidity and mortality [1–3]. Early identification of infants likely to deteriorate and require mechanical ventilation is critical to guide timely intervention and minimize ventilator-induced lung injury.

Chest radiography has traditionally been used to assess lung aeration, but it exposes neonates to ionizing radiation and poorly captures dynamic changes [4]. Lung ultrasound (LUS) is a reliable, radiation-free bedside tool with high reproducibility [5]. Various LUS scoring systems have been proposed, differing mainly in the number of thoracic zones examined [6,7]. International consensus recommendations have outlined standard lung zones and terminology for neonatal and pediatric point-of-care LUS [9].

The six-area protocol enables rapid assessment but may underestimate posterior or lateral pathology [8]. The twelve-area protocol offers a more comprehensive evaluation, including posterior lung fields, but is slightly more time-consuming [10].

We hypothesized that the twelve-area LUS scoring system would demonstrate higher predictive accuracy for mechanical ventilation than the six-area protocol.

METHODS

Study Design and Setting

This was a prospective observational study conducted over 4- months 15 days(June1st to October 15th-2025) in the Level III NICU in GEMS Hospital, Srikakulam, India. The NICU admits approximately 250–300 neonates annually, including preterm and term infants with respiratory distress.

Study Population

Inclusion criteria:

- Gestational age ≥ 28 weeks
- Respiratory distress within 6 hours of birth (Silverman–Anderson score ≥ 3)
- Written informed parental consent

Exclusion criteria:

- Major congenital anomalies (cardiac or pulmonary)
- Congenital diaphragmatic hernia
- Pneumothorax prior to initial scan
- Refusal of consent

SAMPLE SIZE DETERMINATION
Assuming an expected AUC difference of 0.08 between the two protocols, with $\alpha = 0.05$ and 80% power, a minimum of 85 neonates was required. Ninety were enrolled to account for possible attrition. **The sample size was calculated using MedCalc software based on ROC comparison methodology.**

Lung Ultrasound Examination

LUS was performed within 6 hours of NICU admission by neonatologists trained in neonatal ultrasonography and **blinded to clinical parameters and FiO_2 levels to prevent observer bias**. A high-frequency linear probe (10–12 MHz) was used.

Each neonate underwent both:

- **Six-area protocol:** upper and lower anterior zones bilaterally plus lower lateral zones.
- **Twelve-area protocol:** anterior, lateral, and posterior zones of upper and lower lung fields bilaterally.

Each zone was scored as follows:

Score	Ultrasound Finding	Interpretation
0	Presence of A-lines	Normal aeration
1	Multiple well-spaced B-lines	Mild interstitial syndrome
2	Coalescent B-lines	Severe interstitial syndrome
3	Consolidation with air bronchogram	Alveolar collapse

Inter-observer reliability was verified between two neonatologists by independently scoring 10% of scans, showing >90% agreement.

Clinical Data and Outcomes

Demographics, gestational age, birth weight, Apgar scores, delivery mode, FiO_2 requirement, and type of respiratory support were recorded. The **primary outcome** was need for mechanical ventilation within 72 hours of admission.

Statistical Analysis

Data were analyzed using SPSS v26. Continuous variables were expressed as mean ± SD and compared using independent t-tests after checking for normality by the **Shapiro–Wilk test**. Categorical variables were compared using Chi-square or Fisher's exact test. Pearson correlation coefficients assessed relationships between LUS scores and ventilation need. ROC curves were plotted for both protocols; AUCs were compared using the DeLong method, and **95% confidence intervals were calculated for sensitivity, specificity, and AUC values**. $p < 0.05$ was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee**.** Written informed consent was obtained from parents or guardians before enrollment.

RESULTS

Study Population

Of 90 neonates, 32 (35.6 %) required mechanical ventilation and 58 (64.4 %) were managed non-invasively. **The common causes of respiratory distress were respiratory distress syndrome 52 %, transient tachypnea of the newborn 28 %, and neonatal pneumonia 20 %.**

Table 1. Baseline Characteristics of the Study Population (n = 90)

Parameter	Total (n = 90)	Non-Ventilated (n = 58)	Ventilated (n = 32)	p-value
Gestational age (weeks)	33.6 ± 3.1	34.2 ± 2.8	32.1 ± 3.4	0.02
Birth weight (kg)	1.86 ± 0.52	1.94 ± 0.48	1.62 ± 0.43	0.01
Male sex n (%)	52 (57.8)	33 (56.9)	19 (59.3)	0.84
Cesarean delivery n (%)	38 (42.2)	22 (37.9)	16 (50.0)	0.24
Silverman–Anderson ≥ 5 n (%)	61 (67.8)	35 (60.3)	26 (81.2)	0.04
FiO_2 requirement	0.46 ± 0.12	0.39 ± 0.09	0.60 ± 0.10	<0.001

LUS Scores

Ventilated neonates had significantly higher mean six-area and twelve-area scores ($p < 0.001$).

Table 2. Comparison of Six-Area and Twelve-Area LUS Scores

Score Type	Non-Ventilated (n = 58)	Ventilated (n = 32)	p-value
6-Area LUS	7.3 ± 2.4	12.8 ± 2.9	<0.001
12-Area LUS	10.5 ± 3.3	22.6 ± 3.9	<0.001

Data are mean ± SD.

Predictive Accuracy

ROC analysis including 95 % confidence intervals demonstrated excellent discriminatory ability for both scoring systems.

Table 3. Predictive Accuracy of LUS Scoring Systems

Scoring System	Optimal Cutoff	AUC	Sensitivity (%)	Specificity (%)
6-Area LUS	≥ 10	0.87	82	84
12-Area LUS	≥ 16	0.93	89	91

AUC = area under curve.

DeLong test showed a statistically significant difference between the two AUCs, p = 0.03.

Figure 1. ROC curves comparing six-area and twelve-area LUS protocols with corresponding AUCs.

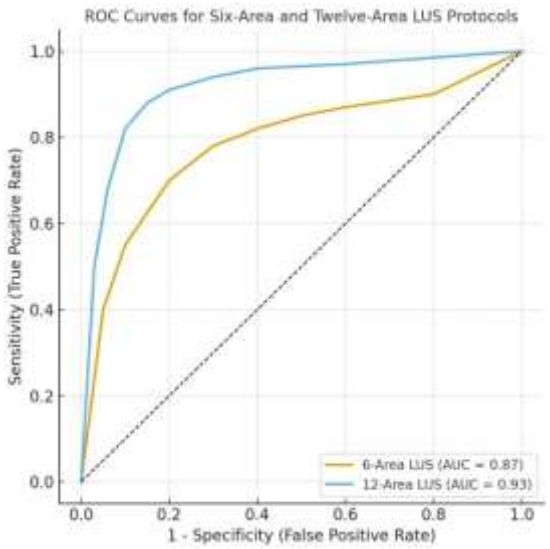

Figure 1. Receiver Operating Characteristic (ROC) Curves Comparing Six-Area and Twelve-Area Lung Ultrasound (LUS) Scoring Systems for Predicting Need for Mechanical Ventilation in Neonates

Legend:
The ROC curves illustrate the diagnostic performance of the six-area and twelve-area LUS protocols in predicting mechanical ventilation among neonates with respiratory distress.
The **twelve-area LUS protocol (AUC = 0.93, 95% CI 0.87–0.98)** demonstrated superior predictive accuracy compared with the **six-area protocol (AUC = 0.87, 95% CI 0.79–0.95)**.
The diagonal dashed line represents the line of no discrimination (AUC = 0.5).
The DeLong test indicated a statistically significant difference between the two AUCs, p = 0.03.

Clinical Outcomes

High LUS scores correlated with prolonged oxygen therapy, extended NICU stay, and higher mortality.

Table 4. Association of High LUS Score (≥ Cutoff) with Clinical Outcomes

Outcome	LUS < Cutoff (n = 58)	LUS ≥ Cutoff (n = 32)	Relative Risk (95 % CI)	p-value
Oxygen duration (days)	2.5 ± 1.2	6.7 ± 2.4	2.7 (1.9–3.8)	<0.001
NICU stay (days)	6.6 ± 2.7	11.5 ± 3.4	1.7 (1.3–2.4)	0.01
Mortality n (%)	3 (5.2)	7 (21.8)	4.2 (1.2–9.8)	0.03

Data are mean ± SD or n (%). $p < 0.05$ significant.

Infants with high LUS scores also had prolonged oxygen therapy, longer NICU stay, and higher mortality ($p < 0.05$).

DISCUSSION

This study confirms that both six-area and twelve-area LUS scoring systems are strong predictors of the need for mechanical ventilation in neonates with respiratory distress. **Among 90 infants, one-third required invasive ventilation, consistent with published series** [11–13]**..**

Posterior and basal lung zones frequently develop dependent atelectasis in supine neonates, which explains the higher predictive accuracy [17] of the twelve-area protocol. Our findings align with previous reports correlating LUS scores with oxygen requirement and disease severity [14–16].

Our findings align with previous reports correlating LUS scores with oxygen requirement and disease severity [14–16]. Furthermore, a recent systematic review has confirmed the overall high diagnostic accuracy of neonatal lung ultrasound across multiple protocols and clinical settings, supporting our results [19]. The inclusion of posterior zones has been emphasized by Brat et al. and Raimondi et al. [5,18], and our findings further support this.

The DeLong comparison confirmed the superiority of the twelve-area method, emphasizing that inclusion of posterior zones enhances sensitivity without compromising bedside feasibility.

The twelve-area protocol, although slightly longer to perform, allows early recognition of infants needing escalation to CPAP, surfactant therapy, or mechanical ventilation. The six-area approach remains useful in emergency or resource-limited settings.

Integration of LUS scoring with FiO_2 requirement and Silverman–Anderson score could form a combined respiratory severity index for real-time clinical decision-making.

This is the first Indian prospective comparison of six- and twelve-area LUS protocols, providing region-specific validation of international findings.

STRENGTHS AND LIMITATIONS

Strengths:

- Prospective design with blinded sonographers.
- Application of standardized validated scoring systems.
- Comparison performed within the same population minimizing bias.

Limitations:

- **Single-center study and moderate sample size limit generalizability.**
- **Inter-observer reproducibility tested only once and not across full cohort.**
- **Absence of long-term respiratory follow-up data beyond NICU discharge.**

Future multicenter studies including longitudinal outcome tracking are warranted.

CLINICAL IMPLICATIONS

LUS scoring can help clinicians anticipate the need for advanced respiratory support, reduce unnecessary radiographs, and optimize NICU resource utilization.
Routine bedside use after standardized training may improve early detection of deterioration.

CNCLUSION

Both six-area and twelve-area LUS scoring systems accurately predict the need for mechanical ventilation in neonates with respiratory distress. **The twelve-area method demonstrated superior sensitivity and specificity and should be adopted when comprehensive scanning is feasible in tertiary care settings.**
Routine incorporation of LUS scoring in NICU protocols may reduce radiograph exposure and support timely decision-making.

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ETHICAL APPROVAL

Approved by Institutional Ethics Committee.
Written informed consent obtained from all parents/guardians.

Conflict of Interest: Nil

Source of support: Ni

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