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Lung Point-of-Care Ultrasound as a Predictor of Respiratory Support Duration in the Neonatal Intensive Care Unit: A Pilot Study

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Abstract

Objective

To evaluate whether lung ultrasound scores (LUS) obtained via lung POCUS can predict duration of respiratory support in neonates admitted to the neonatal intensive care unit (NICU), and to assess the prognostic utility of serial lung ultrasound examinations across the early neonatal period.

Study Design

This prospective observational cohort study enrolled neonates admitted to a level III NICU at the University of Illinois Chicago (UIC). Serial, standardized lung ultrasound examinations were performed within 6 hours of life (E1), at 24 hours (E2), and daily thereafter while on respiratory support. A quantitative four-point scoring system was used across six anatomical lung regions to evaluate associations between LUS and duration of respiratory support.[8,16] Analysis included the Pearson correlation, linear regression, logistic regression, and a linear mixed-effects model.

Results

Twenty-nine neonates were enrolled for a total of 96 examination sessions. LUS at E1 correlated significantly with respiratory support duration (Pearson $r = 0.425$, $R^2 = 0.181$, $p = 0.021$). The association was strongest at E2 (Pearson $r = 0.650$, $R^2 = 0.423$, $p < 0.001$). A LUS ≥ 2 at E2 was associated with an 18-fold increased odds of requiring ≥48 hours of respiratory support (OR = 18.0). Serial LUS declined sharply from E1 to E2, with 93% of patients demonstrating improvement. A linear mixed-effects model incorporating gestational age, respiratory rate, and

LUS histogram confirmed the independent association between LUS and respiratory support duration.

Conclusion

Lung ultrasound scores obtained within the first 24 hours of life are significantly associated with duration of respiratory support in neonates. Exam 2 (E2), or the 24-hour examination, demonstrated the strongest predictive performance. Serial lung ultrasounds showed a significant decline in lung ultrasound score from the first to final exam, which matched the expected clinical course in transient tachypnea of the newborn. However, the study was not powered adequately to examine the significance of slopes of LUS decline. The positive findings from our study support early lung POCUS as a useful, noninvasive prognostic tool in neonatal transitional respiratory care. Future studies in larger cohorts using serial lung ultrasound scores to evaluate disease progression could help calibrate the timing and extent of exams further to improve clinical course prediction.

Introduction

Point-of-care ultrasound (POCUS) has emerged as a valuable bedside tool in neonatology, offering real-time, noninvasive assessment without ionizing radiation. Over the past decade, neonatal POCUS has expanded rapidly, supported by increasing evidence and formal endorsement by professional societies. The American Academy of Pediatrics and the European Society for Pediatric and Neonatal Intensive Care (ESPNIC) now recognize POCUS as an important adjunct for diagnostic and procedural applications in the NICU, including pulmonary assessment.[1–3] Recent consensus statements emphasize standardized acquisition, training, and quality assurance to support safe and effective implementation, yet POCUS remains underutilized, particularly in the setting of respiratory evaluation of neonates.[4–5]

Respiratory distress remains one of the most common indications for NICU admission and respiratory support in both term and preterm infants, occurs in approximately 7% of deliveries[6]. Accurate early assessment of lung aeration and disease severity is critical for prognostication and for guiding respiratory management, including escalation of support and weaning strategies. Clinical signs of respiratory distress, such as tachypnea, retractions, grunting, and nasal flaring, are sensitive but nonspecific. Traditional assessment tools including chest radiography (CXR), blood gas analysis, and clinical scoring systems such as monitoring of respiratory rate and SpO2, are limited by radiation exposure, intermittent availability, or imperfect correlation with underlying lung aeration and clinical trajectory.

Lung ultrasound findings reflect the air–fluid ratio within the lung parenchyma, allowing clinicians to assess lung aeration at the bedside. Sonographic patterns including A-lines, discrete

B-lines, coalescent B-lines, and consolidations can be translated into numerical lung ultrasound scores (LUS) that have been correlated with disease severity in both the adult and pediatric population. A lines are horizontal lines reflecting the pleura in a well aerated lung while B lines are vertical artifacts extending down to the pleura reflecting lung fluid burden.[7-8] In neonates, postnatal lung fluid clearance begins within minutes of birth, and serial lung ultrasound tracking of B-line burden has been used to characterize this physiologic process. It has also been successful in distinguishing pathologic from normal aeration, where Transient Tachypnea of the Newborn (TTN) can be diagnosed with a "double lung point" showing increased fluid in the lower zones with normal aeration in the upper zones and Respiratory Distress Syndrome (RDS) can be diagnosed with coalescent B-lines throughout.[8] Recently, validated LUS systems have been applied to predict surfactant requirement, bronchopulmonary dysplasia (BPD) development, and extubation readiness.[11-15]

Despite widespread interest, heterogeneity still exists among LUS scoring systems, especially in neonatology, and the role of early LUS in predicting the duration of respiratory support, including noninvasive ventilation, remains underexplored. Furthermore, limited data exist on whether a clinically actionable LUS threshold can identify neonates at risk for prolonged respiratory support early in their clinical course. The predictive use also primarily focuses on neonates with RDS rather than with other lung pathologies, such as TTN. To address these gaps, we conducted a prospective observational pilot study to evaluate whether LUS obtained via POCUS can predict duration of respiratory support in neonates admitted to the neonatal intensive care unit (NICU) and to assess the prognostic utility of serial lung ultrasound examinations across the early neonatal period.

Methods

Study Design and Setting

This pilot study was a prospective observational cohort study conducted in the Level III NICU at the University of Illinois Chicago (UIC). The study was conducted from November 2025 through April 2026 and was approved by the UIC Institutional Review Board (IRB Protocol No. [STUDY2025-0046-MOD002]). Written informed consent was obtained from a parent or legal guardian within 4 hours of life, prior to the first ultrasound examination.

Study Population

Neonates admitted to the NICU were screened for eligibility. Inclusion criteria were: (1) NICU admission at UIC, (2) birth weight greater than 1500 g, (3) a parent or legal guardian present and able to provide consent within 4 hours of life, and (4) ability to perform the first lung ultrasound by qualified research personnel within 6 hours of birth. Neonates admitted in room air were eligible for enrollment alongside those requiring respiratory support at birth, as a deliberate design decision to capture baseline LUS values and monitor serial aeration trajectories across the full spectrum of initial respiratory status. Exclusion criteria included: birth weight ≤1500 g, hemodynamic instability, major chest wall anomaly or skin aberration precluding ultrasound acquisition, inability to obtain parental consent within 4 hours of life or to perform the first lung ultrasound within 6 hours of birth, and families whose primary language was neither English nor Spanish as the consent forms were only available in those two languages. Clinical management decisions were made by the treating medical team who were not privy to lung ultrasound findings.

Lung Ultrasound Acquisition

Lung ultrasound examinations were performed at the bedside using a Sonosite ultrasound machine with a high-frequency linear transducer by two certified physicians trained in lung POCUS. Examinations were performed at the following predefined intervals: Exam 1 performed within 6 hours of life (E1), Exam 2 at approximately 24 hours of life (E2), and daily exams while the infant remained on any form of respiratory support (E3, E4, etc), with a final examination at 7 days of life or prior to discharge, whichever came first. Six standardized anatomical lung regions were examined—consistent with the acquisition framework endorsed in the 2025 ESPNIC consensus guidelines: right and left upper anterior, right and left lower anterior and right and left lateral. Three views per side and three images per view were obtained for a total of 18 images per exam. Infants were scanned in the supine position with minimal handling. All images were stored and reviewed offline every ten patients by two independent reviewers blinded to clinical outcomes. Discrepancies were resolved by a third reviewer.

Lung Ultrasound Scoring

A semiquantitative five-point lung ultrasound scoring system was applied to each lung region based on the predominant sonographic pattern observed, as follows: Score 1, no artifact (A-lines present, normal aeration); Score 2, B-lines present in less than 25% of the scanning area (SA); Score 3, B-lines present in 25-50% of the SA; Score 4, B-lines present in 50-75% of the SA; Score 5, B-lines present in greater than 75% of the SA. For each examination, an overall composite LUS was calculated by averaging the highest score obtained across all six anatomical regions. This five-step system was initially selected to provide one additional level of granularity

compared with the four-step method, enabling discrimination between intermediate stages of aeration impairment. However, these scores were easily converted to the four-step method for cross-study comparison and generalizability when the EPNIC 2025 consensus statement was released. The four step scoring method quantifies lung aeration loss by assigning 0 points (normal A-lines, fewer than 3 B-lines), 1 point (3 or more B-lines), 2 points (coalescent B-lines), or 3 points (tissue consolidation/white lung) to each scanned region, with the total score being the sum of the 6 zones for a total score between 0-18.[7,16]

Data Collection

Baseline variables collected included mode of delivery, respiratory support during admission, birth weight, sex, gestational age, Apgar scores, cord blood gas values, admission blood gas values and antenatal steroid administration. Other secondary variables included surfactant administration, respiratory rate, SpO2, and histogram at the time of each LUS, FiO_2 at the time of first ultrasound, and admission chest radiograph findings. Chest radiographs obtained at the time of respiratory support initiation were blinded and reviewed independently by a neonatologist for comparison with concurrent LUS findings.

Outcome Measures

The primary outcome was total duration of respiratory support, defined as the cumulative number of hours requiring any form of invasive or noninvasive respiratory assistance from birth until final cessation. A clinical threshold of ≥48 hours of respiratory support was used to represent prolonged respiratory support for the purposes of logistic regression and odds ratio

calculation. Secondary outcomes included the association between LUS findings and concurrent chest radiograph interpretation and the feasibility of performing standardized early and serial lung ultrasound examinations within routine NICU workflows.

Statistical Analysis

Descriptive statistics were used to summarize demographic and clinical characteristics. For normally distributed continuous data, mean (±SD) is reported; for non-normally distributed data, median [range] or median (IQR) is reported. Categorical variables are reported as n (%).

The primary association between LUS and duration of respiratory support was assessed using Pearson correlation coefficient (r) and simple linear regression (R^2) at each examination time point (E1, E2, and a composite of the last available examination per patient). To evaluate the clinical utility of a LUS threshold, logistic regression via ROC analysis was performed with a binary outcome of prolonged respiratory support (≥48 hours) and a predictor of average LUS ≥2 at E2. Fisher exact test was performed with results reported as odds ratio (OR) with 95% confidence interval. To assess the independent contribution of LUS to respiratory support duration while accounting for repeated measures and relevant covariates, a linear mixed-effects model was constructed with gestational age, respiratory rate at examination, and LUS histogram pattern as fixed effects. Statistical significance was defined as a two-tailed p value < 0.05. All statistical analyses were performed using Stata [version 19]. Figures were generated in Stata and subsequently enhanced for visual presentation using AI-assisted tools; AI assistance was limited to visual formatting and did not contribute to data analysis, interpretation, or manuscript content.

Results

Patient Characteristics and Enrollment

Seventy-two neonates were screened for eligibility during the study period. Of these, 36 were not approached for enrollment due to birth weight ≤1500 g, hemodynamic instability, or inability to obtain parental consent within 4 hours of life. Of the 36 approached, 6 families declined participation; parental concerns due to preferences such as "I don't want more things done to my baby than there needs to be done in the NICU." Thirty neonates were enrolled and consented. One was subsequently excluded because the initial ultrasound examination was not completed within the 6-hour window due to research personnel time constraints, yielding a final analytic cohort of 29 participants who completed a total of 98 examination sessions. However, two exams were lost due to technical issues, so the final total was 96 examinations (see Figure 3).

The cohort was predominantly late preterm and term, with a median gestational age of 37 weeks and 5 days [range, 33w2d–41w0d]. Fewer than 4% of infants were born before 34 weeks. Median birth weight was 2870 g [range, 1800–4085]. Fifty-five percent of infants were male, and 83% were delivered by cesarean section. Regarding race and ethnicity, 58.6% were White, 41.4% were Black or African American, and 51.7% identified as Hispanic or Latino. Full demographic and clinical characteristics are presented in Table 1.

Regarding respiratory status at admission, 86.2% of infants were initially placed on continuous positive airway pressure (CPAP), 10.3% were admitted in room air, and 3.4% required synchronized intermittent mandatory ventilation (SIMV). At the time of the first ultrasound examination, 62.1% of infants were breathing room air (FiO_2 21%), 24.1% required FiO_2 of 22–30%, and 13.8% required FiO_2 of 31–40%. Median respiratory rate at first examination was 50

breaths per minute [range, 20–75]. One infant was found to have a small pneumothorax on chest radiograph, prior to the lung ultrasound. This infant was subsequently transitioned directly to room air without further respiratory requirement. One infant received surfactant therapy (3.4%), and antenatal steroids were administered in two patients (6.9%). Antenatal steroids were not widely administered in this cohort, consistent with the predominantly late preterm and term gestational age distribution.

Serial Lung Ultrasound Trends

Serial lung ultrasound examinations demonstrated consistent improvement in lung aeration over time. The most pronounced change was observed between E1 and E2, with 93% of patients demonstrating a reduction in LUS at the 24-hour examination. This rapid early decline in LUS is consistent with physiologic postnatal lung fluid clearance following birth. LUS scores at later examination time points showed further gradual decline, with progressive convergence toward lower scores across the cohort, suggesting a floor effect as aeration normalized during clinical recovery. Individual patient trajectories are depicted in Figure 1.

Association Between LUS and Duration of Respiratory Support

LUS obtained within the first 6 hours of life (E1) demonstrated a significant positive linear association with duration of respiratory support (Pearson $r = 0.425$, $R^2 = 0.181$, $p = 0.021$; Figure 2a). The association was substantially stronger at the 24-hour examination (E2) (Pearson $r = 0.650$, $R^2 = 0.423$, $p < 0.001$, shown in Figure 2b). A statistically significant association was also observed when using the last available LUS per patient across all serial time points (Pearson $r = 0.395$, $R^2 = 0.156$, $p = 0.034$; Figure 2c). Initial power analysis estimated that 50 patients

would provide greater than 80% power to detect a Pearson correlation of 0.40 or greater. Due to enrollment constraints over the study period, the final analytic cohort comprised 29 participants. Post-hoc power analysis indicated that this sample size provided 80% power to detect correlations of 0.49 or greater, representing a modest upward shift in the minimum detectable effect size relative to the original target. Therefore, E2 is found to be both statistically significant with a p value of <0.001 and well powered with an r of 0.650. While E1 and the final exam results are found to be statistically significant, the observed effect is below the minimum detectable threshold of 0.49, making it slightly underpowered to detect an effect this size reliably.

Logistic regression demonstrated that an average LUS ≥ 2 at E2 was associated with an 18-fold increased odds of requiring ≥ 48 hours of respiratory support (OR = 18.0; Figure 2d). This threshold represents a clinically interpretable decision point that may be useful for early risk stratification.

Analysis included a comparison of early LUS findings with admission chest radiograph interpretation. Chest radiographs for patients diagnosed with TTN (n=27; of 29 patients, one patient was diagnosed with RDS and one did not have a CXR on admission) were retrospectively reviewed independently for comparison with concurrent LUS findings, rated as mild, moderate or severe TTN. Results suggest that mild CXR babies had a median of 24 hours of respiratory support and moderate CXR babies had 25 hours (there were no images that were graded as severe), demonstrating no significant difference. Similarly, LUS scores showed a mean of 4.2 versus 3.8 when compared to the mild TTN vs moderate TTN group respectively, ultimately suggesting that CXR showed no correlation with respiratory support duration or LUS scores.

A linear mixed-effects model incorporating gestational age, respiratory rate at the time of examination, and LUS histogram pattern as fixed effects confirmed a significant independent association between LUS and respiratory support duration, accounting for repeated measures across multiple examination time points and relevant clinical covariates (Figure 4).

Discussion

In this prospective, observational pilot study of 29 neonates admitted to a level III NICU, LUS obtained at the 24-hour examination (E2) demonstrated the strongest association with duration of respiratory support (Pearson $r = 0.650$, $R^2 = 0.423$, $p < 0.001$), and an average LUS ≥2 at that time point was associated with an 18-fold increased odds of requiring ≥48 hours of support. The initial 6-hour examination (E1) also correlated significantly with respiratory support duration, though with a more modest effect size. Serial LUS declined sharply from E1 to E2 in 93% of patients, consistent with rapid postnatal lung fluid clearance, and continued to decline across later time points. These findings support early lung POCUS as a clinically informative prognostic adjunct in neonatal respiratory care.

Early Lung Ultrasound and Prognostic Value

Both E1 and E2 demonstrated statistically significant associations with respiratory support duration, but the stronger correlation at E2 is an important finding that has direct clinical implications. These results, however, must be interpreted within broader and still-evolving literature on optimal LUS timing—one that does not uniformly converge on the 24-hour examination as the most informative window.

The earliest foundational study in this area, by Raimondi et al.,[13] performed initial scans at 60–120 minutes after birth in term and late preterm neonates, with serial examinations at 12, 24, and 36 hours thereafter. Using a three-category qualitative profile—white lung, B-line predominance, and A-line predominance—rather than a quantitative scoring system, they found that the longitudinal ultrasound pattern tracked the respiratory trajectory and predicted the need for respiratory support and NICU admission. This study established that serial LUS is feasible and clinically meaningful in the early postnatal period, but its reliance on qualitative pattern classification and NICU admission as a binary endpoint limits direct comparison with the more quantitative and duration-based approach used in the current study. Notably, the overlap between the 12- and 24-hour time points examined by Raimondi et al. and our E2 examination supports the convergent validity of the 24-hour window as a clinically relevant assessment point.

More recent work has pushed the question of optimal LUS timing toward earlier examinations. Lin and Chen (2023)[17] performed serial lung ultrasound at six predefined time points from the first hour through 48 hours of life in a prospective cohort of healthy transitioning neonates. They found that the correlation between LUS and clinical respiratory severity was poor within the first hour of life (Pearson $r = 0.15$, $p = 0.389$), but strengthened substantially after the 2-hour mark, leading them to conclude that 2 hours may represent the optimal window for the first clinical lung ultrasound examination. This finding is mechanistically consistent with the sharp E1-to-E2 decline in LUS observed in 93% of our patients: the first hours after birth are characterized by highly dynamic and variable lung fluid clearance, during which LUS reflects transitional physiology as much as true pathology. Critically, however, the Lin and Chen cohort comprised healthy transitioning neonates without respiratory morbidity, whereas our cohort included NICU-admitted infants with established respiratory distress. Even within this highly

dynamic early window, our E1 examination still retained statistically significant predictive value for respiratory support duration ($r = 0.425$, $p = 0.021$), suggesting that disease severity amplifies the early LUS prognostic signal. All ultrasounds were ultimately obtained between 1-6 hours of life (after consent was obtained and patient was brought to the NICU). Therefore, it's unclear from the current study if the 2-hour recommendation derived from healthy neonates translates directly to neonates with respiratory pathology as well.

Gross and Engel (2024)[18] extended this further, evaluating LUS at 30 and 60 minutes postnatally in 130 newborns ≥36 weeks with respiratory distress. They found that a LUS score greater than 5, FiO_2 above 0.21, and respiratory acidosis at 30 minutes postnatally were each independently associated with CPAP duration of at least one hour, with their combined predictive model achieving an AUC of 0.87 and good inter-rater reliability (ICC 0.76–0.77). While these results are compelling, Gross and Engel defined prolonged respiratory support as CPAP lasting ≥1 hour which is a substantially lower threshold than the ≥48-hour cutoff used here. The current study targets clinically significant prolonged support rather than the immediate postnatal stabilization period. Overall, the E1 window of ≤6 hours balances early assessment with workflow constraints and still captures meaningful prognostic signal.

Taken together, this study and the existing literature suggest that the optimal timing for prognostic LUS assessment in NICU-admitted neonates with respiratory distress is not yet definitively established and likely depends on the clinical question being asked and the population studied. The current study data suggests that the 24-hour examination (E2) provides the most robust and actionable predictive performance in this context, likely as transitional-physiology noise that attenuates early LUS signal has largely resolved by that time point, and residual B-line burden more accurately reflects true pulmonary pathology. This study supports

prioritization of E2 for prognostic LUS assessment, while retaining E1 as an important baseline reference. Serial lung ultrasound beyond 24 hours warrants further investigation in larger cohorts.

The E2 LUS threshold of ≥2 conferring an 18-fold increased odds of prolonged respiratory support (≥48 hours) represents a potentially actionable clinical decision rule. A threshold of ≥2 on the five-point scale corresponds to the presence of B-lines in more than 25% of the scanning area, indicating measurable but not yet severe aeration impairment. With only 5 cases of RS > 48h at E2, this cutoff is mathematically derived but not yet clinically validated. The wide confidence interval on the odds ratio (1.56–207.46) reflects that as well. If validated in larger cohorts, this threshold could support early identification of infants who are unlikely to wean rapidly from respiratory support, informing family counseling, care planning, and resource allocation.

When comparing CXR to LUS scoring, results suggest that CXR severity at admission does not predict respiratory support duration or LUS aeration score in our cohort. Early LUS may provide prognostic information for assessing lung aeration severity in neonates with respiratory distress, while avoiding ionizing radiation and offering the additional advantage of real-time bedside availability.

The association between early LUS and respiratory support duration extends the existing literature, which has largely focused on predictive use in the setting of surfactant administration, extubation readiness or BPD development rather than on overall respiratory support duration, including other pathologies such as TTN. The ongoing use with serial LUS for disease progression has also been underexplored in the clinically ill neonatal population.[7–14] The current findings suggest that LUS may be used not only to characterize lung aeration at a single time

point but also to prognosticate the expected clinical course, which is an application that may carry particular value when counseling families in the early hours after birth.

The inclusion of neonates admitted in room air as well as those on respiratory support at birth was an intentional design decision. This approach enabled capture of baseline LUS values and serial aeration trajectories across the full spectrum of initial respiratory status—including patients who subsequently required escalation of support despite initial room air management, as observed in multiple twin pairs in this cohort.

Limitations

Restriction to anterior and lateral lung zones is a meaningful limitation of this study. Posterior fields are subject to gravitational redistribution of lung fluid and dependent atelectasis in supine neonates — a principle recognized by the ESICM–ESPNIC consensus[15] and supported by two neonatal studies: Guo et al.[19] found posterior B-lines significantly more abundant than anterior within 3 hours of birth ($P < 0.001$), and Szymański et al.[20] confirmed across 619 serial scans in preterm RDS that posterior fields carried substantially higher scores than anterior fields (ls mean 4.0 vs. 2.2, $P < 0.001$). Of note, ESPNIC consensus recommends including posterior lung zones after 48 hours. Future iterations of this protocol should incorporate posterior zones, particularly at later time points when dependent fluid redistribution becomes increasingly relevant.

Serial Lung Ultrasound Trends and Feasibility

Serial LUS declined substantially across examination time points, with the greatest improvement observed between E1 and E2. This pattern is consistent with the established

physiology of postnatal lung fluid clearance, which occurs predominantly within the first 4–24 hours of life in term infants.[13–14] The progressive convergence of LUS scores at later time points likely reflects both clinical recovery and a floor effect as aeration normalizes. The absence of significant associations between later LUS values and respiratory support duration is consistent with this interpretation: once lung aeration has substantially recovered, the discriminatory value of LUS for predicting continued respiratory support diminishes.

Serial LUS acquisition was generally feasible within routine NICU workflow. The use of two certified sonographers and offline blinded image review every ten patients provided a level of standardization appropriate for a pilot study. Variability in the consenting and exact timing of serial examinations, imposed by staffing availability and competing care demands, represents an inherent limitation of POCUS research protocols in active clinical settings, and is acknowledged as a source of heterogeneity in the serial data.

Alignment with Evolving Consensus

This study was initiated in 2023, prior to the publication of several key neonatal POCUS consensus statements from the Neonatal POCUS Collaborative and ESPNIC.[1–4] Since then, consensus guidelines and systematic reviews have emphasized standardized acquisition, validated pediatric lung ultrasound scoring systems (though still not specific to the neonatal population), and structured training and credentialing.[1–4,6] The six anatomical lung regions examined in this study (right and left upper anterior, lower anterior, and lateral zones) are consistent with the acquisition framework endorsed in the ESPNIC 2025 consensus guidelines,[16] supporting the reproducibility and external validity of the protocol used. As mentioned previously, these guidelines recommend expanding to posterior lung zones after 48 hours of life

to capture fluid and atelectasis affected by gravity, which can be a consideration for future studies.

The five-point scoring system used here provides one additional level of granularity compared with the four-step system recommended in the most recent ESPNIC systematic review.[6] This study pre-dated that recommendation, and scores are convertible to the four-step system for cross-study comparison. Both scores resulted in the same predictive outcome during analysis which is reassuring as there is still not neonatal specific consensus regarding scoring methods. The LUS threshold identified here (score ≥2 at E2) and the strong effect size observed suggest that the scoring systems retain meaningful discriminatory power for predicting respiratory support duration.

Future Directions

Limitations of this study include the single-center design, modest sample size with limited statistical power, specifically for the early and later timepoints, and predominantly late preterm and term gestational age distribution, which limits generalizability to extremely preterm infants and those with more severe respiratory pathology. However, this simultaneously remains a strength as the predictive value of LUS scores in this population has been underexplored prior to this study. Lung ultrasound findings were not used to guide clinical decision-making, and causality cannot be inferred. Inter-rater reliability between the two blinded reviewers was not formally reported in the current analysis but was found to be consistent. Staffing constraints introduced variability in the timing of serial ultrasound examinations. One enrolled participant was excluded post-consent because the initial ultrasound was not completed within the 6-hour

window due to research personnel time constraints, highlighting a practical challenge inherent to early-window POCUS in research protocols.

Future directions include larger, multicenter studies with more diverse gestational age ranges, formal inter-rater reliability analysis, and evaluation of LUS-guided respiratory management as an interventional study design. The identification of actionable LUS thresholds, particularly the LUS ≥2 at E2 finding reported here, warrants prospective validation. With a larger cohort, future studies could prospectively evaluate discrete later time points—specifically 48, 72, and 96 hours of life—to characterize LUS trajectories during the transition from respiratory support to room air. These time points are clinically meaningful because they correspond to the windows in which many late preterm and term infants with TTN or mild-to-moderate RDS are typically weaned, and LUS assessment at these intervals could help distinguish infants on a trajectory toward near-term discontinuation from those likely to require continued support.

Future work should also evaluate including posterior lung zones, as well as implementation in resource-limited settings and the potential role of AI-assisted automated LUS scoring to reduce inter-rater variability and enhance standardization.

Beyond predicting whether respiratory support will be needed, a key unanswered question is whether LUS can predict how much longer (in hours or days) an infant is likely to require supplemental respiratory support at any given assessment point. Such a predictive model, if validated, would have meaningful implications for clinical decision-making, parental counseling, and resource planning in the NICU, and represents an important direction for future quantitative LUS research.

Conclusions

In this prospective, observational pilot study, LUS obtained within the first 24 hours of life was significantly associated with duration of respiratory support (>48 hours) in neonates admitted to a level III NICU with likely TTN. The 24-hour examination (E2) demonstrated the strongest predictive performance, with an average LUS ≥2 conferring an 18-fold increased odds of requiring ≥48 hours of respiratory support. Serial LUS declined rapidly from E1 to E2 and continued to fall across subsequent assessments, consistent with postnatal lung fluid clearance. Lung POCUS was feasibly integrated into routine NICU workflow without disruption to clinical care while navigating the research consent process. These findings support early lung POCUS as a promising objective, noninvasive and prognostic adjunct in neonatal respiratory care and provide the foundation for larger, prospective studies evaluating LUS-guided respiratory management.

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Table 1. Demographic and Clinical Characteristics of the Study Cohort

Patient characteristics	n (%) or median [range]
Sex	
Male	16 (55.2%)
Female	13 (44.8%)
Mode of delivery	
Cesarean section	24 (82.8%)
Vaginal delivery	5 (17.2%)
Birth weight	
Median, g	2,870 [1,800 – 4,085]
<2,500 g	8 (27.6%)
2,500–2,999 g	10 (34.5%)
3,000–3,499 g	6 (20.7%)
≥3,500 g	5 (17.2%)
Gestational age	
Median GA, weeks+days	37+5 [33+2 – 41+0]
<34 weeks	1 (3.4%)
34w0d – 36w6d	5 (17.2%)
37w0d – 40w0d	19 (65.5%)
>40 weeks	4 (13.8%)
Ethnicity	
Hispanic or Latino	15 (51.7%)
Not Hispanic or Latino	14 (48.3%)
Race	
White	17 (58.6%)
Black or African American	12 (41.4%)

Respiratory & imaging variables	n (%) or median [range]
Surfactant administration	
Yes	1 (3.4%)
No	28 (96.6%)
Respiratory support on admission	
Room air (RA)	3 (10.3%)
CPAP	25 (86.2%)
SIMV	1 (3.4%)
FiO_2 at time of first ultrasound	
21% (room air)	18 (62.1%)
22–30%	7 (24.1%)
31–40%	4 (13.8%)
Respiratory rate at time of ultrasound (breaths/min)	
Median RR	50 [20 – 75]
20–39	5 (17.2%)
40–49	8 (27.6%)
50–59	7 (24.1%)
60–75	9 (31.0%)
LUS Aeration Score	
Median LUS Aeration Score	4 [0 – 11]
0–4	16 (55.2%)
5–9	10 (34.5%)
10–14	3 (10.3%)
15–18	0 (0.0%)

n = 29 patients | 96 exam sessions | Level III NICU

bpm = breaths per minute; CPAP = continuous positive airway pressure; SIMV = synchronized intermittent mandatory ventilation; IQR = interquartile range.
Data are presented as median [range] or n (%), as appropriate.

Figure Legends

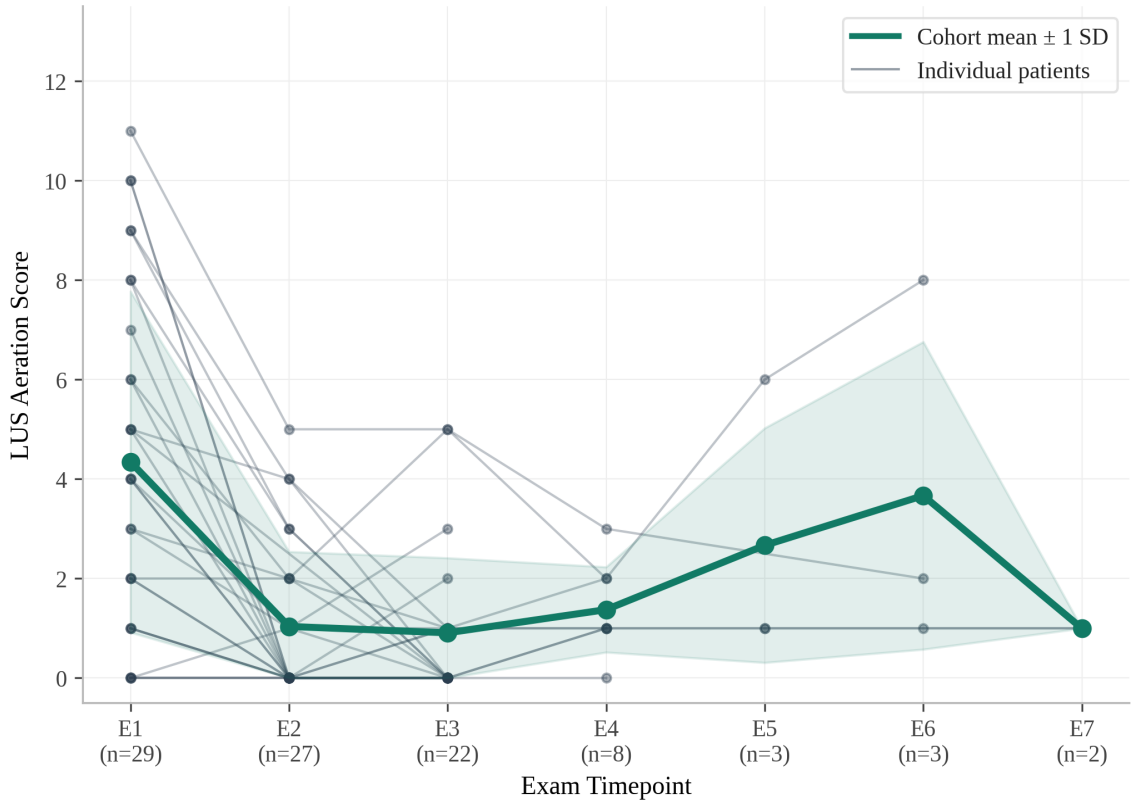


Figure 1. Serial Lung Ultrasound Scores by Patient Over Time. Line plot depicting individual patient LUS trajectories across serial examinations (E1 through E7). Bold line represents cohort mean ± 1 SD. Lines are colored by total respiratory support duration. Patient numbers are labeled at E1. The sharpest improvement is observed between E1 and E2, with 93% of patients demonstrating score reduction at the 24-hour examination. E1, within 6 hours of life; E2, approximately 24 hours of life; E3+, subsequent daily assessments.

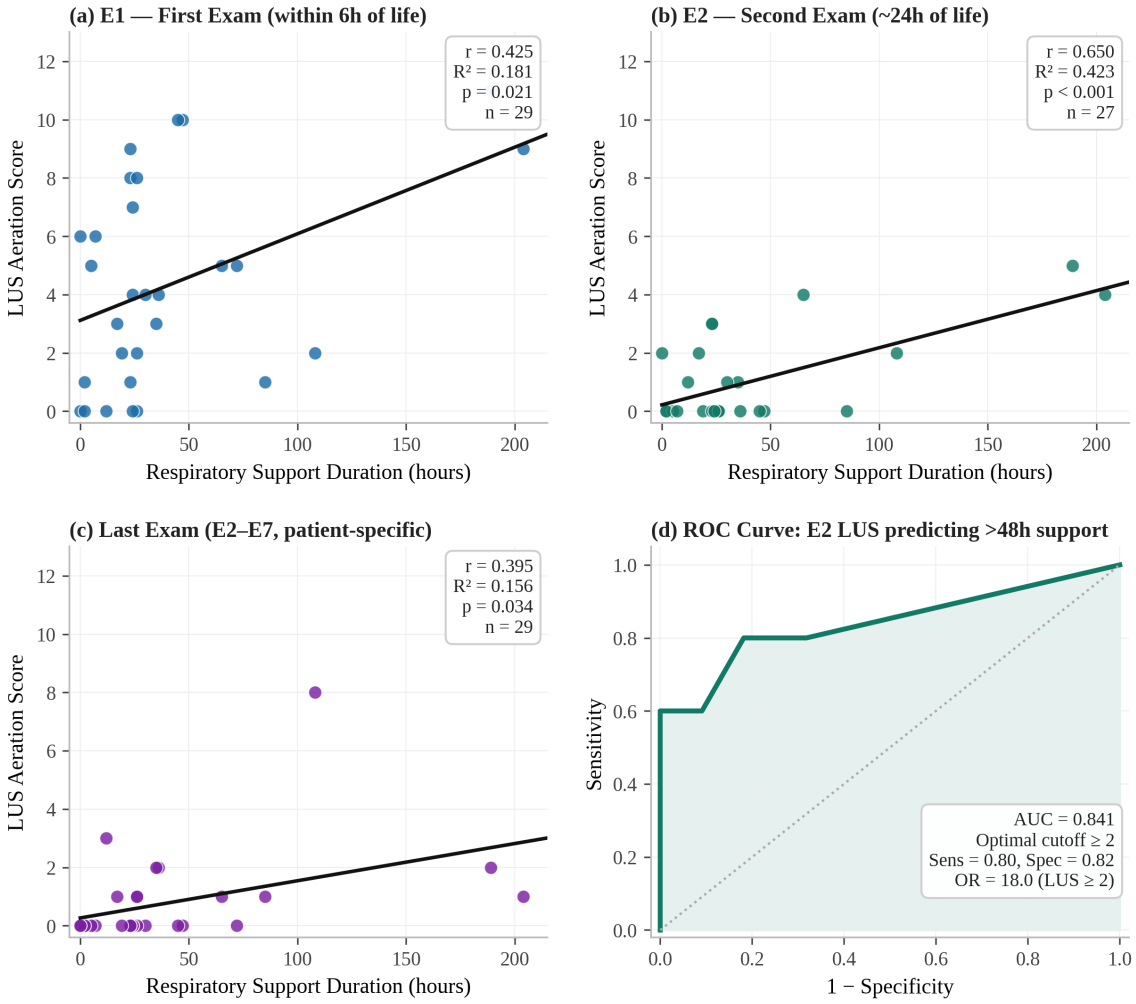
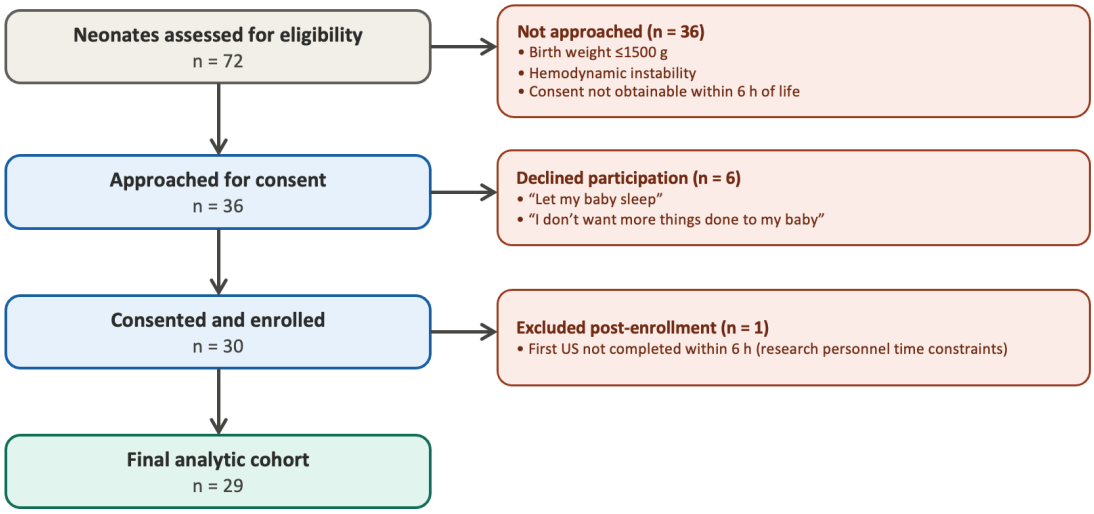


Figure 2. Association Between Lung Ultrasound Score and Duration of Respiratory Support. (a) Scatter plot at E1 (Pearson r = 0.425, R^2 = 0.181, p = 0.021). (b) Scatter plot at E2 (Pearson r = 0.650, R^2 = 0.423, p < 0.001). (c) Scatter plot at last available examination (Pearson r = 0.395, R^2 = 0.156, p = 0.034). (d) Logistic regression: E2 average LUS ≥2 vs. prolonged respiratory support (≥48 hours); OR = 18.0.

Figure 3. CONSORT Enrollment Flow Diagram. Screening and enrollment flow from 72 assessed neonates to the final analytic cohort of 29 participants completing 96 examination sessions.



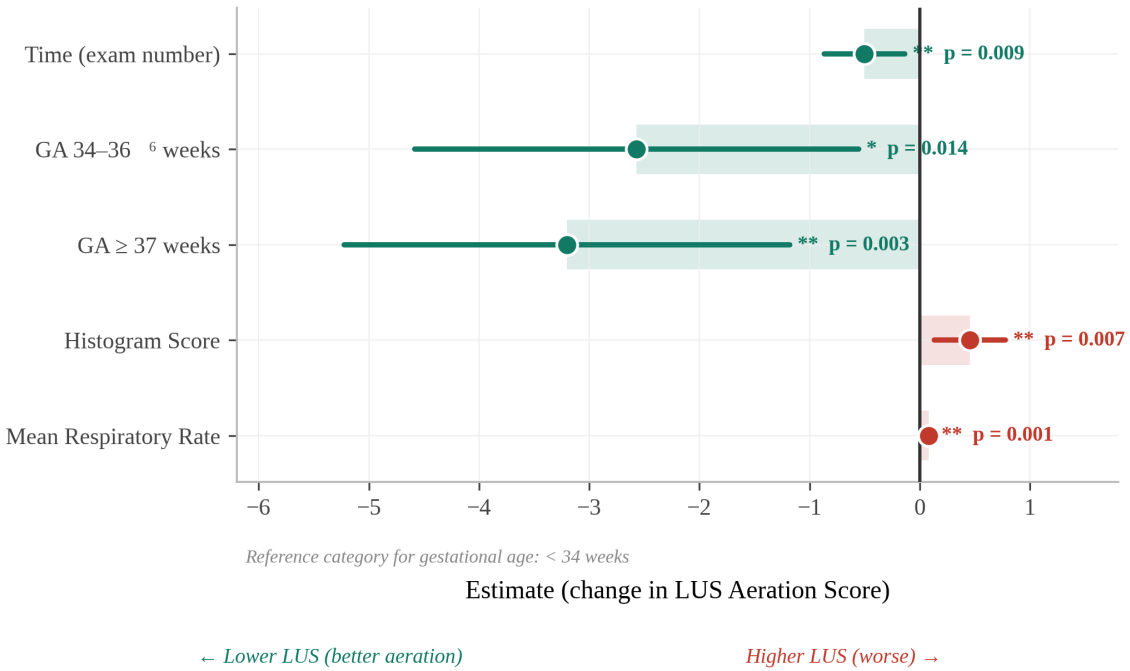


Figure 4. Linear Mixed-Effects Model: Fixed Effects on Respiratory Support Duration. Fixed-effects estimates from a linear mixed model with gestational age, respiratory rate, and LUS histogram pattern as covariates, showing the independent association between LUS and duration of respiratory support across repeated measures.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementalMaterialsManuscript.docx