Lung Point-of-Care Ultrasound as a Predictor of Respiratory Support Duration in Neonates with Respiratory Distress: A Pilot Study

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Abstract

- Lung point-of-care ultrasound (POCUS) offers a bedside, radiation-free tool to assess neonatal respiratory status in real time.
- This prospective pilot study enrolled 30 neonates admitted to the NICU to evaluate whether lung fluid index (LFI) scores, derived from B-line quantification, correlate with clinical outcomes such as duration of respiratory support. Data from the first 10 patients are presented here. Lung POCUS exams were performed at standardized timepoints, with strong adherence to protocol and high image quality.
- Exam 1, conducted within 6 hours of life, demonstrated a statistically significant correlation with the duration of respiratory support, whereas subsequent exams did not show similar predictive value. Inter-rater scoring consistency was high, supporting the reliability of the methodology.
- These findings suggest that early lung POCUS may be a valuable prognostic tool in neonatal respiratory management.

Introduction

- Point of Care Ultrasound (POCUS) has become an invaluable tool in pediatric and neonatal intensive care units (NICU), more widely used for bedside hemodynamic assessment and procedural guidance
  - Benefits:
    - Noninvasive
    - Immediate and portable
    - Lack of radiation exposure
- Lung POCUS requires the use of artifact to diagnose pathology such as pulmonary edema, pneumothorax, or differentiating respiratory distress pathology (seem Image 1):
  - B lines- vertical lines reflecting subpleural interstitial edema
  - A lines- horizontal lines representing artifactual repetition of pleural lines
- A persistent problem in the managing infants on respiratory support is not objectively knowing when to wean. This could lead to re-escalation of support causing further distress to parents. Lung ultrasound can quantify extravascular lung water via B-line analysis, generating a lung fluid index (LFI). It can offer a real-time, radiation-free method to assess readiness for weaning. Although this is widely used in adults, its ability to predict respiratory illness course and duration of respiratory support is yet to be established in neonates.
- **Objective:** To assess whether using LFI using lung POCUS can serve as an accurate tool in estimating lung fluid burden and predicting duration of respiratory support in the early neonatal period.

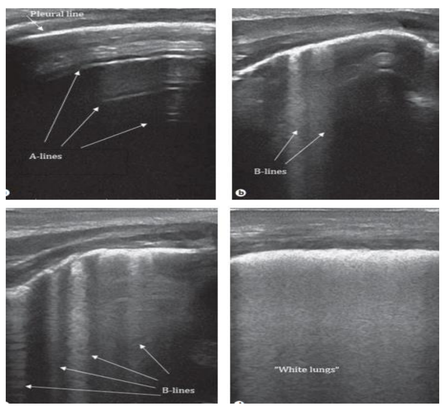

Image 1: Top left panel showing horizontal artifact: A-lines. Top right and bottom left panel showing vertical artifact: B-lines. Bottom right panel showing coalesced B-lines.

Methods

- **Design:** Prospective, observational, pilot study
- **Setting:** Level III NICU, University of Illinois Hospital, Chicago, Illinois
- **Eligibility criteria:**
- Inclusion: Infants consented for a lung ultrasound within 4 hours of life. Infants that are hemodynamically stable without chest wall abnormalities/skin lesions.
- Exclusion: Infants not consented for a lung ultrasound within 4 hours of life or if lack of personnel available to perform ultrasound by 6 hours of life.
- **Intervention:** Serial lung POCUS exams (Linear transducer, see Image 2) with 6 anatomical views per exam (see image 3):
  - Exam 1 (E1): within 6 hours of life
  - Exam 2 (E2): around 24 hours of life
  - Exam 3 (E3): daily until off respiratory support
  - Exam 4 (E4): prior to discharge or 1 week of life
- **Scoring:** Lung fluid burden quantified using (highest average across 6 lung zones, see Image 2). LFI scores are recorded based on B-line quantification on ultrasound (a 5-step scoring method). Images are scored blindly by two different reviewers for inter-rater reliability after every 5 patients have been enrolled and scanned.
- **Analysis:** Utilized Pearson and Spearman correlation between score and respiratory support duration (in hours).
- Clinical data including mode of delivery, gestational age, respiratory support duration, and other relevant parameters were collected.

Image 2: A high-frequency (10–14 MHz) linear transducer, used to visualize shallow structures, is preferred for neonatal lung imaging (AI generated image).

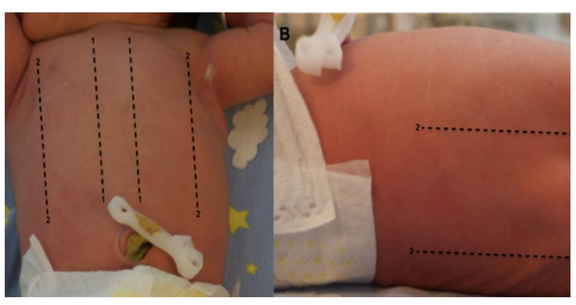

Image 3: The left image shows the anterior chest with right and left midclavicular zones (superior to inferior). The right image demonstrates the lateral thoracic zones along the midaxillary line, also viewed from superior to inferior.

Results

- Of 36 neonates screened, 6 declined participation and 30 were enrolled; this analysis presents the first 10 patients with completed scoring and analysis. Image quality was consistently high, with minimal inter-rater variability.
- Of the 10 patients, key clinical variables included gestational age (36–40 weeks), birth weight (2430–3580g), and length of stay (2–10 days). None received surfactant or antenatal steroids. One patient (ID #6) was incidentally found to have a small pneumothorax on chest X-ray.
- Average Score-H was calculated by taking the highest score from each of the six anatomical lung zones (right and left: superior, lateral and inferior), then averaging those six values to represent overall lung fluid burden per exam.
- Exam 1 (within 6 hours of life) scores demonstrated a statistically significant correlation with total duration of respiratory support (Pearson r = 0.633, p = 0.049; Spearman ρ = 0.676, p = 0.032). In contrast, no significant correlation was found with later exams (Exam 2-4). All patients were delivered via cesarean section and received similar respiratory support strategies, yet early LFI scores varied and proved clinically meaningful.
- Trend analysis showed a general decline in scores over time, suggesting resolution of lung fluid burden.

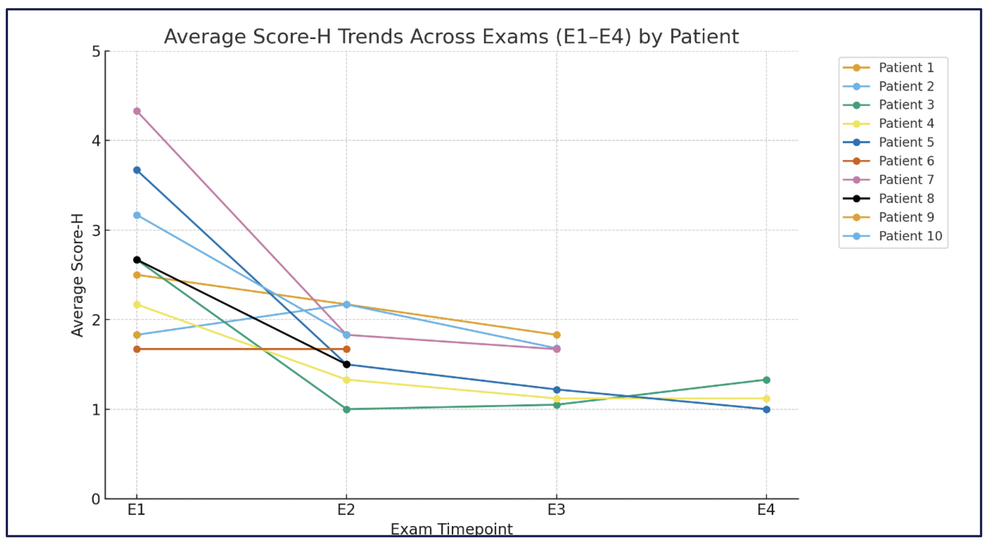

Figure 1: Most patients show a decline in Average Score-H over time, reflecting improvement in lung fluid burden.

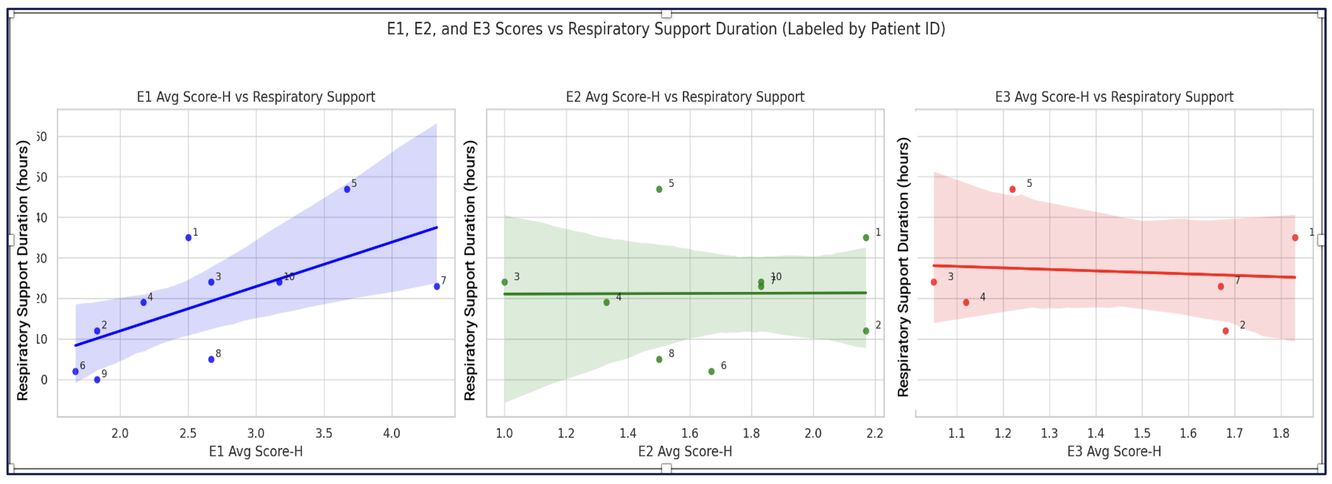

Figure 2: Here is a side-by-side visualization showing the correlation between lung fluid index scores at each exam timepoint (E1, E2, E3) and duration of respiratory support. E1 (left panel) shows a positive linear correlation, confirming that higher initial scores are associated with longer durations of support. E2 (middle) and E3 (right) show weak or no clear trend, indicating these later scores have minimal predictive value for respiratory duration.

Discussion

- Our findings indicate that early lung POCUS may serve as a valuable predictor of respiratory support needs in neonates with respiratory distress. These results align with prior literature supporting the diagnostic value of lung ultrasound ,confirm the decline of lung fluid burden in the early neonatal period and extend its utility to prognostication. The observed correlation between early scores and clinical trajectory supports incorporating early POCUS into standardized NICU protocols.
- The serial lung ultrasounds after the first ultrasound showed no significant correlation with respiratory support duration at this time. However, further data analysis is pending for the remaining 20 patients that could change these results. Importantly, the difficulty in consistently performing the 24-hour scan (E2) and its limited predictive value suggest that resource prioritization may favor early imaging (E1), especially in high-acuity settings.
- Lung POCUS performed within the first 6 hours of life may offer early prognostic insight into the respiratory course of neonates with respiratory distress. These preliminary findings support its potential role in guiding clinical management and reducing reliance on radiography. Additionally, ultrasound access can be more readily available and accessible in rural or low resource areas.
- Further analysis of gestational age, surfactant administration, birth weight and chest radiography interpretation is ongoing. Larger prospective studies are needed to further define its impact on neonatal outcomes.

References

1. Blank DA, Kamlin COF, Rogerson SR, et al. Lung ultrasound immediately after birth to describe normal neonatal transition: an observational study. Arch.Dis.Child.Fetal Neonatal Ed. 2018;103(2):F157-F162. doi:10.1136/archdischild-2017-312818
2. . Martelius L, Suvari L, Janer C, et al. Lung Ultrasound and Static Lung Compliance during Postnatal Adaptation in Healthy Term Infants. Neonatology. 2015;108(4):287-292. doi:10.1159/000438453
3. Brat R, Yousef N, Klifa R, Reynaud S, Shankar Aguilera S, De Luca D. Lung Ultrasonography Score to Evaluate Oxygenation and Surfactant Need in Neonates Treated With Continuous Positive Airway Pressure. JAMA Pediatr. 2015;169(8):e151797. doi:10.1001/jamapediatrics.2015.1797
4. Enghard P, Rademacher S, Nee J, et al. Simplified lung ultrasound protocol shows excellent prediction of extravascular lung water in ventilated intensive care patients. Crit.Care. 2015;19(1):36-5. doi:10.1186/s13054-015-0756-5
5. Parri N, Allinovi M, Giacalone M, Corsini I. To B or not to B. The rationale for quantifying B-lines in pediatric lung diseases. Pediatr Pulmonol. 2023;58(1):9-15. doi:10.1002/ppul.26185
6. To B or not to B. The rationale for quantifying B-lines in pediatric lung diseases. https://onlinelibrary-wiley-com.proxy.cc.uic.edu/doi/epdf/10.1002/ppul.26185. Accessed Jan 24, 2024
7. Lung ultrasound in infants with bronchiolitis - PMC. . https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6708215/. Accessed Jan 24, 2024
8. Kaskinen AK, Martelius L, Kirjavainen T, Rautiainen P, Andersson S, Pitkanen OM. Assessment of extravascular lung water by ultrasound after congenital cardiac surgery. Pediatr.Pulmonol. 2017;52(3):345-352. doi:10.1002/ppul.23531
9. Liu J, Cao H, Liu Y. Lung ultrasonography for the diagnosis of neonatal respiratory distress syndrome: a pilot study. Zhonghua Er Ke Za Zhi. 2013;51(3):205-210
10. Chen S, Fu W, Liu J, Wang Y. Routine application of lung ultrasonography in the neonatal intensive care unit. Medicine (Baltimore). 2017;96(2):e5826. doi:10.1097/MD.0000000000005826

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