Ultrasound As The Guiding Light: Establishing A Lus Cut Off For Surfactant Use In Preterm Neonates With Respiratory Distress.

Dr. Sonakshi[1], Dr. Shashi Bhushan[2], Dr. Praneta Swarup[3*], Dr. Amit Gupta[4], Dr. Khemendra Kumar[5], Dr. Rajeev Kumar Thapar[6], Dr. Bindu T Nair[7]

[1]*Senior Resident ,Department of Paediatrics Pt. B.D. Sharma Post Graduate Institute of Medical Sciences, Rohtak.*
[2]*Professor, Department of Pediatrics, School of medical Sciences & research, Sharda Hospital, Sharda University, Greater Noida*
[3]**Associate Professor, Department of Pediatrics, School of medical Sciences & research, Sharda Hospital, Sharda University, Greater Noida (Corresponding Author)*
[4]*Associate Professor, Department of Radiology, School of medical Sciences & research, Sharda Hospital, Sharda University, Greater Noida*
[5]*Associate Professor, Department of Radiology, School of medical Sciences & research, Sharda Hospital, Sharda University, Greater Noida*
[6]*HOD & Professor, Department of Pediatrics, School of medical Sciences & research, Sharda Hospital, Sharda University, Greater Noida*
[7]*Professor, Department of Pediatrics, School of medical Sciences & research, Sharda Hospital, Sharda University, Greater Noida*

ABSTRACT

AIM-To estimate cut off value of lung ultrasound score for neonates less than 34 weeks of gestation with Respiratory Distress Syndrome.

METHODOLOGY- All preterm neonates (<34 weeks gestation), both inborn and outborn, admitted to the NICU with respiratory distress were prospectively enrolled after obtaining informed parental consent. Antenatal and perinatal history, delivery details, and risk factors were recorded. Lung ultrasound (LUS) was performed within 4 hours of admission using a GE LOGIQ P3 portable ultrasound machine with a high-frequency linear probe (6–12 MHz).

Each lung was divided into anterior, lateral, and posterior zones (six zones total), and examined in longitudinal and transverse planes. Each zone was assigned a score from 0 to 3 based on lung aeration pattern: 0 = A-lines only (normal aeration); 1 = ≥3 well-spaced B-lines; 2 = coalescent B-lines with or without limited subpleural consolidation; 3 = extended consolidation/white lung. The total LUS score ranged from 0 to 18.

RESULT- In our study of 78 neonates, LUS scores ranged from 3 to 13, with 55.1% requiring surfactant. Most neonates (85.9%) were managed with CPAP, while 14.1% required mechanical ventilation (MV); all MV cases also needed surfactant and had higher mortality (27%) and LUS scores. A LUS cut-off >9 was statistically significant ($p < 0.001$) for predicting surfactant need, with 93.02% sensitivity and 91.43% specificity. Surfactant use increased with higher LUS scores, and all neonates with LUS >11 required it. Lower LUS scores (3–8) were observed in those with antenatal steroid coverage. A significant correlation was found between LUS and SAS, with higher scores in neonates needing surfactant.

CONCLUSION- Lung ultrasound (LUS) is a non-invasive, bedside, and repeatable tool that is increasingly recognized for its effectiveness in managing neonatal respiratory distress. It offers greater predictive value for intubation than chest x-ray, with key findings like lung consolidation, pleural line abnormalities, and absence of A-lines being highly specific for respiratory distress syndrome (RDS). LUS also reduces reliance on chest radiographs, thereby minimizing radiation exposure in vulnerable preterm infants. As a reliable and radiation-free imaging modality, LUS is valuable for both diagnosing and monitoring RDS and should be used alongside x-rays to improve neonatal care.

How to cite this article: Dr. Sonakshi, Dr. Shashi Bhushan, Dr. Praneta Swarup, Dr. Amit Gupta, Dr. Khemendra Kumar, Dr. Rajeev Kumar Thapar, Dr. Bindu T Nair: Ultrasound As The Guiding Light: Establishing A Lus Cut Off For Surfactant Use In Preterm Neonates With Respiratory Distress....Int J Drug Deliv Technol. 2026; 16(5s): 943-949; DOI: 10.25258/ijddt.16.5s.116

Source of support: Nil.

Conflict of interest: Nil.

INTRODUCTION

Respiratory distress is a leading cause of neonatal intensive care unit (NICU) admissions, affecting about 15% of full-term and 29% of late preterm infants, with even higher rates in those born before 34 weeks of gestation. It presents with a respiratory rate over 60/min, subcostal and

**Author for Correspondence:* Dr. Praneta Swarup

intercostal retractions, grunting, nasal flaring, and decreased air entry on auscultation.[1]

Common causes include transient tachypnoea of the newborn (TTN), hyaline membrane disease (HMD), meconium aspiration syndrome (MAS), pneumonia, persistent pulmonary hypertension, and systemic conditions like cardiac or neurological anomalies. Surfactant deficiency remains the main cause of neonatal respiratory distress syndrome (NRDS).[2]

NRDS predominantly affects premature, low birth weight infants due to immature lung development.3 Incidence correlates with gestational age, ranging from 92% at 24–25 weeks to 57% at 30–31 weeks. Mortality is highest in infants under 1.0 kg (50%) and negligible in those over 4.0 kg.4,5 Management typically involves pulmonary surfactant and CPAP, with possible mechanical ventilation.[6,7]

The severity of distress is evaluated using the Silverman-Anderson score for preterm and Downe's score for term infants. Chest X-rays are standard but pose radiation risks due to neonates' sensitivity.[8]

Lung ultrasound (LUS), once thought unsuitable for lung imaging, is now a reliable, non-invasive, and radiation-free bedside tool for diagnosing NRDS, TTN, pneumonia, MAS, and pneumothorax. It distinguishes between normal aeration and interstitial or alveolar pathology. LUS is especially effective in neonates due to their thin chest walls and small lungs.[9-12]

Point-of-care LUS (POC-LUS) is increasingly replacing chest X-rays in NICUs, offering higher accuracy, real-time assessment, and no radiation exposure. It is also used for semi-quantitative lung aeration scoring and can guide surfactant therapy decisions.13-16 LUS has a reported sensitivity of 95.6% and specificity of 94.4% for RDS diagnosis.[17]

Though no universally validated LUS cutoff for surfactant therapy exists, identifying one could support timely treatment and reduce morbidity in preterm infants.

METHODOLOGY

This hospital-based prospective observational study was conducted in the NICU of Sharda Hospital, School of Medical Sciences and Research, Sharda University, Greater Noida, from May 2023 to November 2024, after Institutional Ethics Committee approval. A total of 78 preterm neonates (<34 weeks gestation), both inborn and outborn, admitted with respiratory distress were enrolled.

Neonates >34 weeks gestation, with major congenital anomalies, sepsis, perinatal asphyxia, respiratory distress due to other causes, prior surfactant administration at birth, or refusal of parental consent were excluded. Written informed consent was obtained from parents/guardians.

Antenatal and perinatal details, mode of delivery, and risk factors for respiratory distress were recorded. Lung ultrasound (LUS) was performed within 4 hours of admission to assess lung aeration. The study aimed to evaluate the role of LUS in predicting the need for surfactant therapy and its correlation with clinical parameters in preterm neonates with respiratory distress.

Lung ultrasound (LUS) was performed and interpreted by the principal investigator in consultation with a radiologist using a GE LOGIQ P3 portable ultrasound machine equipped with a high-frequency linear probe (6–12 MHz). Respiratory distress was diagnosed clinically using the Silverman Anderson Score (SAS) and supported by radiological evidence.

For ultrasound examination, a high-frequency linear probe (≥9 MHz) was used for detailed assessment of the pleural line, while a low-frequency phased array probe (4–8 MHz) was employed for evaluation of deeper lung parenchyma to ensure optimal image resolution. Standard infection control precautions were followed, with probe disinfection before and after each examination. Ultrasound gel was applied to minimize air artifacts, and all scans were performed with the neonate in the supine position.

Each lung was divided into anterior, lateral, and posterior regions and examined in both longitudinal and transverse planes for systematic assessment.

It was examined using a linear microprobe in both longitudinal and transverse planes. Each region was assigned a score ranging from 0 to 3, yielding a total Lung Ultrasound Score (LUS) between 0 and 18.[15]

On ultrasonography, the pleura appeared as a smooth, regular echogenic line (pleural line). A-lines were identified as horizontal, equidistant reverberation artifacts parallel to the pleural line, indicating preserved aeration. B-lines were defined as vertical, hyperechoic, laser-like artifacts arising from the pleural line and extending to the bottom of the screen without fading. The number of B-lines correlated with increased interstitial fluid and decreased lung aeration.

B lines are vertical reverberation artifacts occurring due to decrease in air content and there is subpleural edema causing acoustic mismatch between fluid and air.

The LUS score was given as follows:

0-Indicates A-pattern (defined by the presence of the only A-lines)

1-B-pattern (defined as the presence of ≥3 well-spaced B-lines)

2-Severe B pattern (defined as the presence of crowded and coalescent B lines with or without consolidations limited to the sub pleural space)

3-Extended consolidations / White Lung[10]

The total Lung Ultrasound Score (LUS) was calculated by summing the scores of all six lung zones. All ultrasound findings were systematically recorded. Surfactant therapy was administered according to standard NICU protocol.

LUS was determined for all enrolled neonates irrespective of surfactant administration. At the end of the study, neonates were categorized into two groups: those who received surfactant and those managed without surfactant. The groups were compared with respect to clinical outcomes, including need for surfactant therapy, continuous positive airway pressure (CPAP), and supplemental oxygen via nasal prongs. LUS was analyzed to determine the optimal cut-off value for predicting surfactant requirement. The study was financially supported by SMSR, Sharda Hospital.

Figure 1

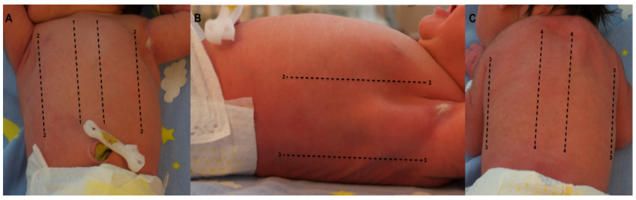
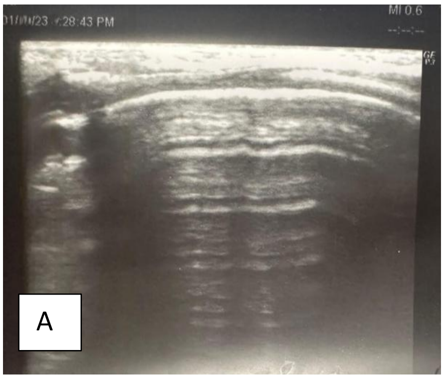
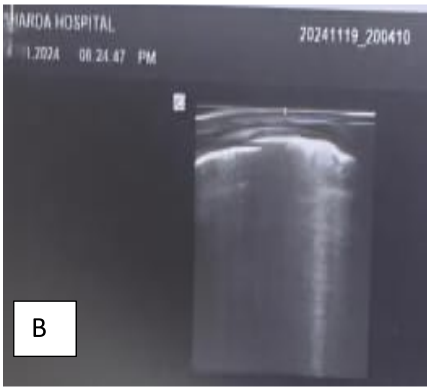
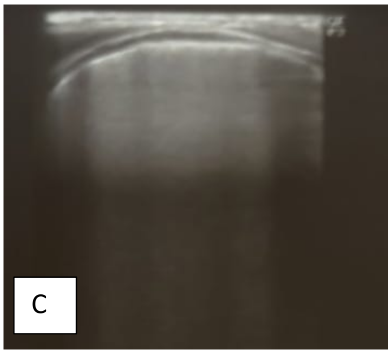


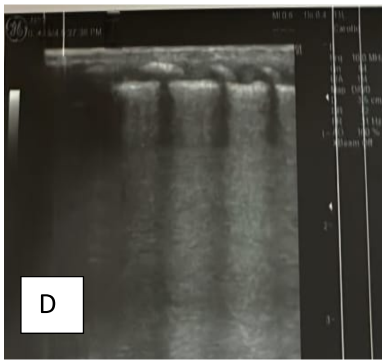
Figure 1 illustrates the standardized lung ultrasound scanning zones in a neonate, divided into anterior (A), lateral (B), and posterior (C) regions.

Dashed lines mark the anatomical boundaries used for systematic Lung Ultrasound Score (LUS) assessment.









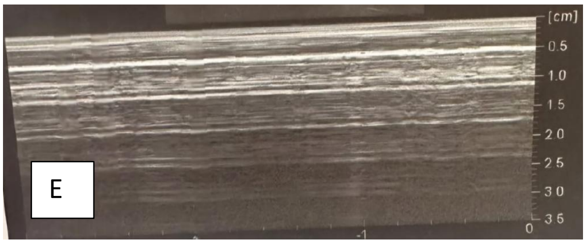


Figure 2: LUS findings showing-

A - Pleural line and A lines
B - Widely spaced B lines
C - More than three crowded and coalescent B lines
D - Extended consolidation / Whiteout lung
E - Barcode sign

STATISTICAL ANALYSIS

The collected data was entered in Microsoft Excel and then analysed and statistically evaluated using SPSS-22 version. Normality of each variable was assessed by using the Kolmogorov- Simirnov test. Quantitative data was expressed by mean, standard deviation or median with interquartile range and depends on normal distribution, difference between two groups was tested by student t test or Mann Whitney U test. Qualitative data was expressed in percentage and difference between the proportions was tested by chi square test or Fisher's exact test. ROC curve was prepared using lung ultrasound score in predicting the need of surfactant in RDS babies. Cut off value was calculated and based on cutoff value, sensitivity, specificity, positive predictive value and negative predictive value of lung ultrasound score in predicting the need of surfactant in RDS babies was calculated. 'P' value less than 0.05 was considered statistically significant.

RESULTS

The majority of neonates in the study were delivered via lower segment cesarean section (LSCS), accounting for 61.5%, while 39.5% were born through vaginal delivery. In terms of birth status, 46 neonates (59%) were singletons, whereas 32 (41%) were twins. The study population was evenly divided between males and females, each comprising 50%. Most neonates had a gestational age of 32–33+6 weeks (44.9%), followed by 30–31+6 weeks (32.1%), with only 10.3% born before 28 weeks. The majority had a birth weight between 1000–1499 grams (39.7%), followed by 1500–1799 grams (29.4%) and 1800–2499 grams (19.2%); 11.5% weighed less than 1000 grams. A total of 67 neonates (85.9%) were managed with CPAP, while 11 (14.1%) required mechanical ventilation. Surfactant was administered to 43 neonates (55.1%), whereas 35 (44.9%) were managed conservatively. The Silverman Andersen Score (SAS) ranged from 2 to 7, with the majority scoring 6 (32.1%) or 7 (21.8%). Scores of 2, 3, 4, and 5 were seen in 1.3%, 14.1%, 19.2%, and 11.5% of neonates, respectively. The mean duration on CPAP was 35.28 hours, compared to 79.71 hours on mechanical ventilation.

Table1: Lung Ultrasound Findings and Their Association with Surfactant Requirement (n = 78)

Parameter	Surfactant Not Needed	Surfactant Needed	P value
LUS score (mean ± SD)	5.89 ± 1.90	10.84 ± 1.44	<0.001
SAS score (mean ± SD)	4.03 ± 1.09	6.23 ± 0.71	<0.001
A-lines, n (%)	33 (42.3)	—	—
B1 lines, n (%)	41 (52.5)	—	—
B2 lines, n (%)	43 (55.1)	—	—
B3/White lung, n (%)	37 (47.4)	—	—

Table 1 shows that among the 78 preterm neonates, B-line patterns predominated over A-lines, with B2 lines observed in 55.1% and B3/white lung pattern in 47.4% of cases.

Table 2 : Distribution of Surfactant Requirement According to LUS Score

LUS Score Range	Surfactant Required n (%)
3–6	0 (0%)
7	3 (42.9%)
8	0 (0%)
10	13 (92.9%)
11	14 (87.5%)
12–13	13 (100%)

Table 2 shows that neonates requiring surfactant had significantly higher mean LUS and SAS scores compared to those not requiring surfactant (10.84 ± 1.44 vs. 5.89 ± 1.90 and 6.23 ± 0.71 vs. 4.03 ± 1.09, respectively; $p < 0.001$).
Surfactant requirement increased with rising LUS scores: none with scores ≤6 required surfactant, whereas all neonates with scores ≥12 required therapy, indicating a strong predictive association between higher LUS scores and surfactant need.

Table 3 -Diagnostic value of LUS score for prediction of surfactant need

	Value (95% CI)
AUC	0.95 (0.91-1.0)
P value	<0.001
Cut off value	≥9
Sensitivity	93.02%
Specificity	91.43%
PPV	93.02%
NPV	91.43%

Table 3 shows that a cut off value of ≥ 9 of LUS was found statistically significant ($p<0.001$) at which surfactant was required with a sensitivity of 93.02%, sensitivity of 91.43% and PPV and NPV of 93.02% and 91.43% respectively.

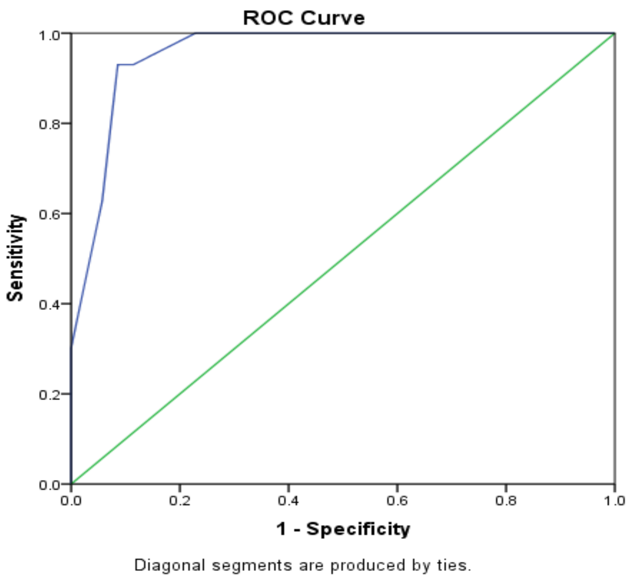


Figure-3 ROC showing LUS score for prediction of surfactant need

The ROC curve demonstrates excellent diagnostic performance of the Lung Ultrasound Score (LUS) in predicting surfactant requirement. The curve lies well above the diagonal reference line, indicating strong discriminatory ability.With an area under the curve (AUC) of approximately 0.95, LUS shows high accuracy. At the optimal cut-off (≥9), sensitivity and specificity are both above 90%, suggesting that LUS is a reliable predictor of surfactant need in preterm neonates with respiratory distress.

DISCUSSION

This prospective study focused exclusively on preterm neonates, a high-risk group in whom timely intervention is crucial. Lung ultrasound (LUS), long established in adult critical care, has gained increasing acceptance in neonatology for evaluating conditions such as respiratory distress syndrome (RDS), congenital pneumonia, and transient tachypnea of the newborn.9–12,16 Brat et al.[10] first proposed a standardized LUS scoring system for assessing RDS severity in preterm neonates. Subsequently, Perri et al.[18] demonstrated that LUS scoring was superior to chest radiography in predicting the need for surfactant therapy in RDS.

In the present study, LUS scores ranged from 3 to 13 (maximum 18), and 55.1% of neonates required surfactant therapy. Mechanical ventilation was required in 14.1% of neonates, all of whom had higher LUS scores and increased mortality (27%). Comparable findings were reported by Moolimani et al.[19], where 12% of neonates required mechanical ventilation and had poorer outcomes.

A progressive increase in surfactant requirement was observed with rising LUS scores. At a score of 10, 92.8% of neonates required surfactant; at 11, 87.5% required therapy; and all neonates with scores ≥12 required surfactant. A cut-off value of >9 was statistically significant ($p < 0.001$) for predicting surfactant administration. Similar cut-offs have been reported by Roy et al.[21] (≥9), Gupta et al.[22] (≥8), Chan et al.[23] (≥10), De Luca et al.[24] (≥9), and Nosrati et al.[25] (≥9). Kelner et al.[26] further reported that a score >9 predicted surfactant need with 100% sensitivity and 91% specificity.

In our study, a cut-off of ≥9 demonstrated high diagnostic accuracy, with sensitivity of 93.02% and specificity of 91.43%. These findings align with Perri et al.[27], who reported higher sensitivity, specificity, and predictive values for LUS compared to chest X-ray in guiding surfactant therapy. Given concerns regarding radiation exposure in neonates,8,13 LUS offers a safer and repeatable bedside alternative.

A significant positive correlation was observed between LUS and Silverman-Anderson Score (SAS). Neonates requiring surfactant had significantly higher mean LUS (10.84 ± 1.44) and SAS (6.23 ± 0.71) scores compared to those managed conservatively (LUS 5.89 ± 1.90; SAS 4.03 ± 1.09). Aiswarya et al.[28] similarly reported a significant correlation between LUS and SAS, while Raimondi et al.[29] demonstrated that LUS could predict respiratory support failure. These findings highlight the complementary role of LUS alongside clinical scoring systems in assessing disease severity.

Strengths

Surfactant administration is critical. Early LUS assessment within 4 hours of admission and standardized scoring enhanced clinical applicability. The use of a portable ultrasound system (GE LOGIQ P3) with appropriate high-frequency probes and robust statistical analysis, including ROC curve evaluation, strengthens the validity of the findings. LUS proved to be a rapid, bedside, radiation-free modality with strong predictive value compared to conventional chest radiography.

Limitations

The primary limitation of this study is the relatively small sample size (n=78) and single-center design, which may limit generalizability. Larger multicentric studies are required to validate the proposed cut-off and establish standardized recommendations for integrating LUS into routine management protocols for neonatal RDS.

Despite these limitations, our findings support the use of LUS as a reliable tool for early prediction of surfactant requirement and optimized management of preterm neonates with respiratory distress.

REFERENCE

1. Reuter S, Moser C, Baack M. Respiratory distress in the newborn. Pediatrics in review. 2014 Oct;35(10):417.
2. Mishra KN, Kumar P, Gaurav P. Aetiology and Prevalence of Respiratory Distress in Newborns Delivered at DMCH, Darbhanga, Bihar, India. Journal of Evolution of Medical and Dental Sciences. 2020 Nov 30;9(48):3655-60.
3. Koivisto M, Marttila R, Kurkinen-Räty M, Saarela T, Pokela ML, Jouppila P, et al. Changing incidence and outcome of infants with respiratory distress syndrome in the 1990s: a population-based survey. Acta Paediatr 2004;93:177-84.
4. Sweet DG, Carnielli V, Greisen G, Hallman M, Ozek E, Plavka R, et al. European Association of Perinatal Medicine. European consensus guidelines on the management of neonatal respiratory distress syndrome in preterm infants--2013 update. Neonatology 2013;103:353-68.
5. Qian LL, Liu CQ, Guo YX, Jiang YJ, Ni LM, Xia SW, et al. Chinese collaborative study group for neonatal respiratory diseases. Current status of neonatal acute respiratory disorders: a one-year prospective survey from a Chinese neonatal

network. Chin Med J (Engl) 2010;123:2769-75.
6. Roberts CL, Badgery PT, Algert CS, Bowen JR, Nassar N. Trends in use of neonatal CPAP: a population-based study. BMC Pediatr 2011;11:89.
7. Schmölzer GM, Kumar M, Pichler G, Aziz K, O'Reilly M, Cheung PY. Non-invasive versus invasive respiratory support in preterm infants at birth: systematic review and meta-analysis. Br Med J 2013;347:5980.
8. Hall E, Brenner D. Cancer risks from diagnostic radiology: The impact of new epidemiological data. Br J Radiol 2012;85:1316-7.
9. Pang H, Zhang B, Shi J, Zang J, Qiu L. Diagnostic value of lung ultrasound in evaluating the severity of neonatal respiratory distress syndrome. Eur J Radiol 2019;116:186-91.
10. Brat R, Yousef N, Klifa R, Reynaud S, Aguilera SS, De Luca D. Lung ultrasonography score to evaluate oxygenation and surfactant need in neonates treated with continuous positive airway pressure. JAMA pediatrics. 2015 Aug 1;169(8):e151797-.
11. Liang HY, Liang XW, Chen ZY, Tan XH, Yang HH, Liao JY, Cai K, Yu JS. Ultrasound in neonatal lung disease. Quantitative Imaging in Medicine and Surgery. 2018 ;8(5):535.
12. Liu J, Cao H, Wang H. The role of lung ultrasound in diagnosis of respiratory distress syndrome in newborn infants. Iran J Paediatr 2014;24:147-54.
13. Cattarossi L, Copetti R, Poskurica B. Radiation exposure early in life can be reduced by lung ultrasound. Chest 2011;139:730-1.
14. Kurepa D, Zaghloul N, Watkins L, Liu J. Neonatal lung ultrasound exam guidelines. J Perinatol 2018;38:11-22.
15. Chen SW, Fu W, Liu J, Wang Y. Routine application of lung ultrasonography in the neonatal intensive care unit. Medicine (Baltimore) 2017;96:e5826.
16. Lichtenstein DA, Mauriat P. Lung Ultrasound in the critically ill neonate. Curr Pediatr Rev 2012;8:217-23.
17. Liang HY, Liang XW, Chen ZY, Tan XH, Yang HH, Liao JY, Cai K, Yu JS. Ultrasound in neonatal lung disease. Quantitative Imaging in Medicine and Surgery. 2018 Jun;8(5):535.
18. Perri A. Lung ultrasonography score versus chest X-ray score to predict surfactant administration in newborns with respiratory distress syndrome. Pediatr Pulmonol. 2018 Jun;53(9).
19. Moolimani LR, Kale O, Koraddi G. The role of lung ultrasound in the diagnosis of respiratory distress syndrome in preterm neonates. Karnataka Paediatric Journal. 2024;39(4):137-144.
20. Lung Ultrasound and Ultrasound Score: A Useful Tool in Neonatal Intensive Care Units for the Diagnosis and Therapeutic Management of Newborns With Respiratory Pathology. Cureus. 2024 Aug;16(8):e66064.
21. Roy T, Pal S, Sardar S, Mukherjee S, Ghosh M. Prediction of surfactant requirement in Indian preterm infants by lung ultrasound scores: a diagnostic accuracy study from a developing country. Eur J Pediatr. 2022 ;182
22. Gupta D, Priyadarshi M, Chaurasia S, Singh P, Basu S. Lung ultrasound for prediction of surfactant requirement in Indian preterm neonates: a diagnostic accuracy study. Eur J Pediatr. 2024;183(1):1-7.
23. Chan B, Torsitano C, Gordon S, Konana O, Singh Y. Substantiating and Adopting Lung Ultrasound Scores to Predict Surfactant Need in Preterm Neonates with Respiratory Distress Syndrome within an Institution. Pediatr Res. 2024;95(1):89-94.
24. De Luca D, Bonadies L, Alonso-Ojembarrena A, Martino D, Gutierrez-Rosa I, Loi B, etal. Quantitative Lung Ultrasonography to Guide Surfactant Therapy in Neonates Born Late Preterm and Later. JAMA Netw Open. 2024;7(1):e2413446.
25. Nosrati M, Akhoundi N, Khalili Pouya E, et al. The Role of Lung Ultrasonography Scoring in Predicting the Need for Surfactant Therapy in Neonates with Respiratory Distress Syndrome. J Diagn Med. 2023 May 2.
26. Kelner J, Moote D, Shah R, et al. Lung Ultrasound Score for Prediction of Surfactant Administration in Preterm Infants with Respiratory Failure. J Perinatol. 2024;44(8):1258-1263.
27. Perri A. Lung ultrasonography score versus chest X-ray score to predict surfactant administration in newborns with respiratory distress syndrome. Pediatr Pulmonol. 2018 Jun;53(9).
28. Aiswarya R, Palanivelraja T, Anurekha V, Gobinathan S, Kumaravel KS, Sampathkumar D. Early lung ultrasound scores in neonates with respiratory distress: A cross-sectional study from South India. Department of Pediatrics, Government Mohan Kumaramangalam Medical

College, Salem, Tamil Nadu, India.

29. Raimondi F, Migliaro F, Sodano A, Ferrara T, Lama S, Vallone G, et al. Use of neonatal chest ultrasound to predict noninvasive ventilation failure. Pediatrics 2014;134:e1089-94.