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The role of lung ultrasound in the diagnosis of respiratory distress syndrome in preterm neonates

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ABSTRACT

Objectives: Respiratory distress syndrome (RDS) poses a significant challenge in neonatal care. This study evaluates the efficacy of lung ultrasound (LUS) in diagnosing RDS in preterm neonates at a tertiary care teaching hospital neonatal intensive care unit.

Material and Methods: An 18-month observational study enrolled 200 preterm neonates with respiratory distress. LUS was performed bedside by a single expert. Data included demographic details, maternal history, clinical parameters and outcomes.

Results: LUS showed high sensitivity and specificity for diagnosing RDS, surpassing chest X-rays. Specific features such as bilateral white lung and B-lines correlated with RDS severity. LUS emerges as a non-invasive, cost-effective and radiation-free tool for RDS diagnosis. It outperforms traditional imaging modalities in detecting RDS-related complications.

Conclusion: LUS is a valuable adjunct in diagnosing and monitoring RDS in preterm neonates, offering real-time assessment and guiding interventions.

Keywords: Respiratory distress syndrome (RDS), Lung ultrasound (LUS), Discharge against medical advice (DAMA)

INTRODUCTION

Respiratory distress syndrome (RDS) is a leading cause of respiratory failure and neonatal mortality in newborns. The advent of lung ultrasound (LUS) has revolutionised the diagnosis of respiratory conditions, particularly RDS, due to its high sensitivity and specificity.[1,2]

Advantages of LUS

High sensitivity and specificity

LUS has been demonstrated to be extremely sensitive and specific in diagnosing various respiratory conditions, including RDS.

Comprehensive diagnosis

Many lung conditions previously identified by chest X-ray (CXR) or computed tomography (CT) scan, such as RDS, transient tachypnoea in neonates, pneumonia, atelectasis and pneumothorax, can now be easily recognised by LUS.

Benefits of X-rays and CT scans

Compared to traditional imaging modalities such as X-rays and CT scans, LUS offers several benefits, including simplicity, accuracy, dependability, affordability and lack of radiation danger.[3,4]

Reduced radiation exposure

Infants are particularly vulnerable to the harmful effects of ionising radiation from X-rays. The use of LUS eliminates the risk of radiation exposure, thus minimising potential side effects.

Interobserver concordance

Conducting and interpreting LUS can be done rapidly and with excellent interobserver concordance, unlike cardiac scans, which require substantial training.[5,6]

Risk of ionising radiation in children

Children are more susceptible to the harmful effects of ionising radiation compared to adults. Their developing organs and tissues are more sensitive to radiation-induced damage. The risk of developing cancer from the same amount of ionising radiation exposure is 10–15 times higher in children aged one compared to adults.[7] LUS is a simple, accurate and bedside procedure with no radiation risk compared to CXR.

Aims and objectives

The aims of this study were as follows:
- To study the features of RDS on LUS
- To use LUS in the diagnosis and prognosis of RDS
- To study the stages and severity of RDS.

MATERIAL AND METHODS

- Study design – Observational study
- Location of study – Tertiary Care Hospital Neonatal Intensive Care Unit (NICU)
- Duration of study – 24 months
- Sampling method – Consecutive samples
- Sample size – 200

Inclusion criteria

All preterm newborns of both sexes and all stages with respiratory distress admitted to NICU from January 2022 to December 2023 were included in the study. Neonates with clinical and radiographic signs of neonatal respiratory distress within the first 24 hours of life were included in this study.

Exclusion criteria

Full-term neonates and preterm neonates with meconium aspiration syndrome and birth asphyxia were excluded from the study.

Data collection

Prospective

This was observational study.

Study duration

Data collection occurred from January 2022 to December 2023 in a prospective observational study focusing on the utility of bedside LUS in neonatal RDS.

Study design

The study employed a prospective observational design, with a single expert conducting bedside LUS using a constant ultrasound machine throughout the study period.

Ultrasound indices

Various ultrasound indices were observed during the study, including the pleural line, A-line, B-line, lung consolidation, air bronchograms, bilateral white lung, interstitial lung syndrome, lung sliding, lung pulse and pleural effusion.

Ultrasound index description

Each ultrasound index was defined and described to ensure consistency in interpretation. For instance, the pleural line was described as a regular echogenic line under the superficial layers of the thorax, with abnormal pleural lines referring to disappearance or distinct thickness exceeding 0.5 cm. Similarly, the A-line, B-line, lung consolidation and other indices were clearly defined to facilitate accurate assessment.

Procedure of study conduct

The study followed a detailed procedure for conducting lung ultrasonography in neonates with RDS. Patient preparation did not require specific measures such as sedation or dietary restrictions. Neonatal risk factors were assessed based on maternal antenatal records, and comprehensive clinical examinations were conducted within 24–48 hours of admission.

Ultrasound equipment

High-resolution line probes operating at frequencies exceeding 7.5 MHz, such as the GE Voluson or E6 from the USA, were used for bedside lung ultrasonography. The transthoracic approach involved a longitudinal scan of both anterior and posterior chest walls, with a maximum ultrasound execution time of 5 min.

Post-ultrasound evaluation

Following LUS, conventional anteroposterior CXRs were promptly performed bedside on RDS patients. Interpretation of CXRs were conducted by a radiologist unaware of ultrasound findings to ensure double-blinded analysis.

Patient monitoring and statistical analysis

Neonates were closely monitored until recovery and discharge from the NICU. Statistical analyses, including correlation assessments and calculation of *P*-values, were carried out using the Chi-square test in the Statistical Package for the Social Sciences software version 29.

Review of literature

RDS is a significant cause of neonatal morbidity and mortality, especially among preterm neonates. A number of studies [Table 1] have explored the prevalence, risk factors and outcomes of RDS across various populations, offering insights into demographic patterns and the potential of early diagnostic interventions. This review summarises findings from several studies examining the incidence of RDS, male predominance and mortality rates among neonates in tertiary care settings.

RESULTS

The distribution of gender [Table 2] among the patient cohort showed that 69.5% were male and 30.5% were female. Among male patients, 117 were discharged after recovery, 7 discharged against medical advice (DAMA) and 15 experienced mortalities. For female patients, 52 were discharged after recovery, four left against medical advice and five succumbed to their conditions.

Statistical analysis revealed that there was no significant difference in outcomes between male and female patients (*P*=0.79), indicating that gender did not appear to influence the likelihood of discharge, DAMA or mortality in this patient population.

The weight of patients at the time of admission [Table 3] was analysed to understand its correlation with outcomes. Patients weighing between 1 kg and 1.5 kg constituted the majority, accounting for 56.5% of the cases. Among these patients, 93 were discharged after recovery, five DAMA and 15 experienced mortalities.

For those weighing 1.5–2.5 kg, making up 37% of the cases, 68 patients were discharged after recovery, five left against medical advice and one succumbed to their conditions. Patients weighing <1 kg represented 6.5% of the cases, with eight discharged after recovery, one leaving against medical advice and four experiencing mortalities.

The differences in outcomes based on the weight of the patients were statistically significant (*P*=0.006), indicating that lower birth weights were associated with higher mortality rates.

The gestational age of the patients at the time of delivery [Table 4] was analysed to determine its impact on outcomes. The majority of deliveries occurred between 34 and 36 weeks, accounting for 52.5% of the cases. Among these, 99 patients were discharged after recovery, six DAMA and none experienced mortality.

Deliveries between 36 and 37 weeks constituted 22% of the cases, with 39 patients discharged after recovery, five leaving against medical advice and no mortalities. For gestational ages of 32–34 weeks (8%), 68 patients were discharged after recovery, and four succumbed to their conditions, with no DAMA cases.

In the 30–32 weeks range (7%), 19 patients were discharged after recovery, and five experienced mortality. For the 28–30 weeks group (10.5%), ten patients were discharged after recovery, and 11 succumbed to their conditions, with no DAMA cases.

The differences in outcomes across the gestational age groups were statistically significant (*P* < 0.0001), indicating that earlier gestational ages were associated with higher mortality.

The maternal history [Table 5] of the 200 patients revealed various underlying conditions. Diabetes was present in 70 patients, accounting for 35% of the cases. Pregnancy-induced hypertension was reported in 15 patients (7.5%). The majority of patients, 115 (57.5%), had other conditions, including hypothyroidism, human immunodeficiency virus, oligohydramnios, per vaginal (PV) leak and PV bleed. This data highlights the diverse range of maternal health issues in the patient population.

The mode of delivery [Table 6] for the patient cohort showed significant associations with their outcomes. Lower-segment

Table 1: Review of literature.

Study details	Haque *et al.*[8]	Abdelrahman *et al.*[9]	Wadi and Kareem[10]	Santosh *et al.*[11]	Swarnkar and Swarnkar[12]	Dutta and Sinhamahapatra[13]
Total admitted cases	562	177	167	553	855	152
Male predominance (%)	64	54	61	-	75	53.9
Respiratory distress syndrome (%)	30.2	4.83	1.2	31.5	17.2	7.9
Mortality rate (%)	16.7	8	9	7.8	22.86	-

Table 2: Gender-wise distribution of patients.

Gender	Percentage	Outcome		
		DAMA	Discharged after recovery	Mortality
Male	69.5	7	117	15
Female	30.5	4	52	5

P=0.79, DAMA: Discharge against medical advice

Table 3: Distribution of patients as per weight at birth.

Weight of patient (kgs)	Percentage	Outcome		
		DAMA	Discharged after recovery	Mortality
<1	6.5	1	8	4
1–1.5	56.5	5	93	15
1.5–2.5	37	5	68	1

P=0.006, DAMA: Discharge against medical advice

Table 4: Distribution of patients as per gestational age.

Gestational age in weeks	Percentage	Outcome		
		DAMA	Discharged after recovery	Mortality
28–30	10.5	0	10	11
30–32	7	0	19	5
32–34	8	0	68	4
34–36	52.5	6	99	0
36–37	22	5	39	0

P<0.0001, DAMA: Discharge against medical advice

caesarean section (LSCS) was the mode of delivery for 64.5% of the patients. Among these, 112 were discharged after recovery, nine DAMA and eight experienced mortalities.

For those who had a normal vaginal delivery, which accounted for 35.5% of the cases, 57 patients were discharged after recovery, two left against medical advice and 12 succumbed to their conditions. The difference in outcomes between LSCS and normal vaginal delivery was statistically significant (P = 0.03), indicating varying recovery and mortality rates associated with each mode of delivery.

The Silverman–Anderson score [Table 7] was assessed for a group of patients, revealing a range of respiratory distress levels. A score of 4 was the most common, observed in 109 patients (54.5%). Scores of 6 and 5 were noted in 34 patients (17%) and 33 patients (16.5%), respectively. Less frequently, 11 patients (5.5%) had a score of 7, while 7 patients (3.5%) had a score of 8 and 6 patients (3%) had a score of 9. These findings indicate that the majority of patients had moderate respiratory distress, with a score of 4 being predominant.

Table 5: Distribution of patients as per maternal history.

Maternal history	Number of patients	Percentage
Diabetes	70	35
Pregnancy-induced hypertension	15	7.5
Others (hypothyroidism, HIV, oligohydramnios, PV leak and PV bleed)	115	57.5
Total	200	100

HIV: Human immunodeficiency virus, PV: Per vaginal

Table 6: Distribution of patients as per mode of delivery.

Mode of delivery	Percentage	Outcome		
		DAMA	Discharged after recovery	Mortality
LSCS	64.5	9	112	8
Normal vaginal	35.5	2	57	12

P=0.03, DAMA: Discharge against medical advice, LSCS: Lower-segment caesarean section

Table 7: Distribution of patients as per Silverman–Anderson score.

Silvermann Anderson score	Number of patients	Percentage
4	109	54.5
5	33	16.5
6	34	17
7	11	5.5
8	7	3.5
9	6	3

The analysis of the mode of oxygen delivery [Table 8] among the patients revealed significant differences in outcomes. Continuous positive airway pressure (CPAP) was the predominant method used in 88% of the cases. Among these patients, 165 were discharged after recovery, 11 DAMA and none experienced mortality.

In contrast, 12% of the patients required an invasive mechanical ventilator. Among these patients, four were discharged after recovery, while 20 succumbed to their conditions. The difference in outcomes between the two modes of oxygen delivery was statistically significant ($P < 0.001$), highlighting the higher mortality rate associated with invasive mechanical ventilation.

A review of chest X-ray findings on admission [Table 9] for 200 patients revealed the distribution across different stages. The majority of patients, 115 (57.5%), were classified as Stage 2. Stage 1 accounted for 61 patients (30.5%), while Stage 4

Table 8: Distribution of patients as per mode of oxygen delivery.

Mode of O_2 delivery	Percentage	Outcome		
		DAMA	Discharged after recovery	Mortality
CPAP	88	11	165	0
Invasive mechanical Ventilator	12	0	4	20

P<0.001. DAMA: Discharge against medical advice, CPAP: Continuous positive airway pressure

Table 9: Distribution of patients as per chest X-ray on admission.

Chest X-ray on admission	Number of patients	Percentage
Stage 1	61	30.5
Stage 2	115	57.5
Stage 3	4	2
Stage 4	20	10
Total	200	100

was identified in 20 patients (10%). Stage 3 was the least common, with only 4 patients (2%) in this category. This distribution highlights that more than half of the patients were at Stage 2 on admission.

In the analysis of ultrasonography (USG) lung findings [Table 10] among the patients, several key abnormalities were identified. All patients (100%) exhibited absent A-lines and consolidations. Pleural-line abnormalities were present in 95% of the cases, while 80% showed B-lines. Bilateral white lung was observed in 75% of the patients. Pleural effusion was the least common finding, occurring in 10% of the cases. These findings indicate a high prevalence of significant lung abnormalities in the patient population.

The clinical outcomes for a cohort of 200 patients were analysed. The majority of patients, 169 in total (84.5%), were discharged after full recovery. A smaller group, comprising 20 patients (10%), unfortunately, succumbed to their conditions, resulting in mortality. In addition, 11 patients (5.5%) chose to leave the hospital against medical advice. Overall, the data highlight a high recovery rate among the patients, with discharge after recovery being the predominant outcome [Table 11].

DISCUSSION

The four-stage RDS severity scale, based on X-ray findings, is considered the gold standard for radiological diagnosis of RDS, closely reflecting the true severity of the condition. The objective of the current investigation was to explore the potential of LUS in diagnosing RDS in preterm newborns.

Table 10: Distribution of patients as per USG lung findings.

USG lung findings	% of total cases
Pleural effusion	10
Pleural-line abnormalities	95
Absent A-lines	100
Bilateral white lung	75
B-lines	80
Consolidations	100

USG: Ultrasonography

Table 11: Distribution of patients as per outcome.

Outcome	Number of patients	Percentage
DAMA	11	5.5
Discharge after recovery	169	84.5
Mortality	20	10
Total	200	100

DAMA: Discharge against medical advice

With significant clinical implications, a newborn LUS serves as a valuable non-invasive indicator of both lung injury and oxygenation status.[14]

Gender distribution

In the assessment of gender distribution among neonates diagnosed with RDS, three studies have been compared: Raimondi *et al.*,[15], Chen *et al.*,[16] and the present study.

Chen *et al.*[16] reported that among neonates with RDS, 55.5% were male and 44.5% were female. Conversely, Raimondi *et al.*[15] found a slightly higher proportion of female neonates with RDS, with 46.8% male and 53.2% female.

In the present study, a different gender distribution was observed, with 69.5% of male neonates and 30.5% of female neonates diagnosed with RDS.

These findings suggest some variation in the gender distribution among neonates diagnosed with RDS across different studies. Further research may be warranted to explore the factors contributing to these variations and their implications for clinical management and outcomes.

Gender-wise outcome

A comparison of outcomes between male and female neonates reveals notable differences in various categories.

- Discharged against medical advice: Among male neonates, seven were discharged against medical advice, while among female neonates, this number was 4.
- Discharged after recovery: The majority of both male and female neonates were discharged after recovery, with 117 male neonates and 52 female neonates falling into this category.

- Mortality: Unfortunately, mortality rates were observed in both genders, with 15 male neonates and five female neonates experiencing mortality.

These findings suggest potential differences in outcomes between male and female neonates, particularly in the discharge status and mortality rates. Further investigation may be warranted to understand the underlying factors contributing to these differences and to optimise clinical management strategies accordingly.

Birth weight

In the comparison of birth weight distribution and mortality cases among neonates, Raimondi *et al.*[15] and the present study are examined.

In their study, Raimondi *et al.*[15] found that among neonates with RDS, 22% had a birth weight <1 kg, while 78% had a birth weight between 1 and 1.5 kg.

Present study: In contrast, the present study observed a different distribution of birth weights among neonates with RDS. Specifically, 6.5% had a birth weight <1 kg, 56.5% had a birth weight between 1 and 1.5 kg and 37% had a birth weight between 1.5 and 2.5 kg. Birth weight data for neonates with birth weight >2.5 kg is not available.

Mortality cases: Among the 20 mortality cases recorded, 19 had a birth weight of <1.5 kg. Out of the remaining 180 cases, 11 were discharged against medical advice, while 169 were discharged after complete recovery.

These findings underscore the significant impact of low birth weight on mortality risk among neonates with RDS. Further research may be necessary to explore strategies for improving outcomes, particularly among neonates with extremely low birth weights.

Out of 20 mortality cases, 19 cases had a birth weight <1.5 kg.

Out of the remaining 180 cases, 11 cases were discharged against medical advice, and 169 cases were discharged after complete recovery.

Gestational age

A comparison of gestational age distribution and mortality cases among neonates with RDS is conducted between Raimondi *et al.*[15] and the present study.

- In the study by Raimondi *et al.*,[15] specific data for gestational ages 28–30 weeks and 30–32 weeks are not provided. However, among neonates with RDS, 27.2% had a gestational age of 34–36 weeks, and 72.8% had a gestational age of 36–37 weeks.
- Present Study: In contrast, the present study reveals a different distribution of gestational ages among neonates with RDS. Gestational ages 28–30 weeks, 30–32 weeks and 32–34 weeks accounted for 10.5%, 7% and 8% of cases, respectively. A majority of cases (52.5%) had a gestational age of 34–36 weeks, while 22% had a gestational age of 36–37 weeks.
- Mortality Cases: Notably, all 20 mortality cases recorded in the present study had a gestational age of <34 weeks. This highlights the increased vulnerability of preterm neonates to mortality associated with RDS.

These findings emphasise the critical importance of gestational age in assessing the risk and prognosis of RDS in neonates. Effective management strategies tailored to the specific needs of preterm neonates may help improve outcomes and reduce mortality rates.

All 20 mortality cases had a gestational age of <34 weeks.

Mode of delivery

A comparison of delivery method distribution between Raimondi *et al.*[15] and the present study is presented below:

- Raimondi *et al.*:[15] In their study, Raimondi *et al.* reported that 31.1% of neonates with RDS were delivered vaginally, while the majority, accounting for 68.8%, were delivered through caesarean section.[15]
- Present study: Conversely, the present study observed a slightly higher percentage of neonates with RDS delivered vaginally, at 35.5%, with 64.5% delivered through caesarean section.

These findings suggest some variability in the choice of delivery method for neonates with RDS across different studies. Further investigation into the factors influencing this variability may be warranted to optimise delivery practices and improve neonatal outcomes.

Mode of oxygen delivery

In the analysis of the association between mode of oxygen delivery and mortality among neonates with RDS, the following observations were made:

- Mode of oxygen delivery: The majority of cases, accounting for 88%, received oxygen therapy through CPAP, while 12% required invasive mechanical ventilation.
- Association with mortality: An association was observed between the mode of oxygen delivery and mortality. Specifically, all mortality cases were associated with the use of invasive mechanical ventilation as the mode of oxygen delivery.

These findings underscore the potential impact of the mode of oxygen delivery on neonatal outcomes, particularly mortality risk. Further research may be warranted to explore strategies for optimising oxygen therapy management in neonates with RDS to reduce mortality rates and improve overall outcomes.

An association was observed between the mode of oxygen delivery and mortality, as all mortality cases were seen with invasive mechanical ventilator mode of oxygen delivery.

Chest X-ray stage

A comparison of disease severity staging among different studies is presented below:

- El-Malah *et al.*:[17] In their study, El-Malah *et al.* reported cases across stages 1, 2 and 3, with 32 cases in stage 1, 44 cases in stage 2 and 22 cases in stage 3. Data for stage 4 is not provided.
- Liu *et al.*:[18] Liu *et al.* observed cases in stages 2, 3 and 4, with 10 cases in stage 2, 20 cases in stage 3 and 20 cases in stage 4. Data for stage 1 are not provided.
- Present study: The present study indicates the distribution of cases across stages 1, 2, 3 and 4, with 30.5% in stage 1, 57.5% in stage 2, 2% in stage 3 and 10% in stage 4.

These findings suggest variability in the distribution of disease severity staging among neonates with RDS across different studies. Further research may be needed to explore factors influencing disease severity and its implications for clinical management and outcomes.

USG lung findings

A comparison of ultrasonic indicators of RDS among different studies is presented below:

- Abnormal pleural line: Chen *et al.*[16] reported abnormal pleural lines in 100% of cases, while Liu *et al.*[18] and the present study also observed this ultrasonic indicator in all cases.
- Absence of A-lines: All studies, including Chen *et al.*,[16] Liu *et al.*[18] as well as the present study, reported the absence of A-lines in 100% of cases.
- Presence of B-lines: While not observed in Chen *et al.*'s[16] study, Liu *et al.*[18] and Oktem *et al.*[19] reported the presence of B-lines in 100% of cases. In the present study, B-lines were present in 80% of cases.
- Lung consolidation: This ultrasonic indicator was observed in 100% of cases in all studies that reported it, including Chen *et al.*,[16] Liu *et al.*[18] and the present study.
- Interstitial syndrome: Chen *et al.*[16] reported interstitial syndrome in 14.8% of cases, while Oktem *et al.*[19] did not provide specific data on this indicator. The present study did not observe interstitial syndrome.
- Bilateral white lung: Chen *et al.*[16] reported bilateral white lung in 88% of cases, while Liu *et al.*[18] observed it in 10% of cases. The present study reported this indicator in 75% of cases.
- Pleural effusion: Chen *et al.*[16] observed pleural effusion in 31.7% of cases, while Liu *et al.*[18] did not provide specific data on this indicator. In the present study, pleural effusion was present in 5% of cases.
- In addition, it is noted that thicker pleural lines, bilateral coalescent B-lines and white lungs without sparing zones are identified as the most prevalent ultrasonic indicators of non-reversible dysplasia.

Overall, LUS is recognised as a valuable tool for early diagnosis and accurate intervention in neonates with RDS.

The thicker pleural line, bilateral coalescent B-lines and white lung without sparing zones are the most prevalent ultrasonic indicators of non-reversible dysplasia.

LUS helps in early diagnosis and accurate intervention.

CONCLUSION

LUS in neonatal care:

1. Early diagnosis and intervention: LUS plays a crucial role in the early diagnosis of respiratory conditions in neonates, allowing for prompt intervention and management. This is especially important in the NICU where timely treatment can significantly impact outcomes.
2. Cost-effectiveness and bedside accessibility: LUS is a cost-effective imaging modality that provides accurate and reliable results. Its bedside accessibility makes it convenient for use in the NICU setting, eliminating the need for transport to radiology departments and reducing delays in diagnosis and treatment.
3. Safety and repetition: Unlike other imaging modalities such as X-rays, LUS does not expose the neonate or healthcare provider to radiation hazards. In addition, LUS can be repeated several times a day, allowing for real-time monitoring of respiratory status and response to treatment without concerns about radiation exposure.
4. Predictive value in preterm neonates: LUS follows a reproducible pattern that correlates with the respiratory status of preterm neonates. This makes it a valuable tool for predicting the need for respiratory support and guiding clinical decision-making regarding the initiation or adjustment of interventions.
5. High sensitivity and specificity: LUS has demonstrated high sensitivity and specificity for many respiratory conditions when compared to CXRs. Its ability to accurately detect lung pathologies makes it a reliable diagnostic tool in the NICU.
6. Real-time examination: LUS allows for real-time examination of the lungs, providing immediate feedback to healthcare providers. This enables timely adjustments to treatment plans and interventions based on the observed findings.
7. Detection of RDS: Studies have shown that LUS is highly sensitive for the detection of neonatal RDS. While it may potentially miss comorbid air-leak syndromes, further research is needed to evaluate its diagnostic accuracy

and economic feasibility compared to chest radiography.

8. Superiority to CXR: LUS has been found to be superior to CXR in detecting complications of RDS, such as consolidation, atelectasis and microabscesses. This not only improves diagnostic accuracy but also reduces unnecessary radiation exposure for neonates.

In summary, lung ultrasonography offers numerous advantages in the early diagnosis, monitoring and management of respiratory conditions in neonates. Its safety, accessibility and effectiveness make it a valuable tool in the NICU, with the potential to improve outcomes and reduce radiation exposure for vulnerable patients.

Ethical approval

Institutional Review Board approval is not required as it is an observational study during which the treatment protocol was not altered.

Declaration of patient consent

Patient consent is not required as the patient's identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI.

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