A Study on Effectiveness of Lung Ultrasonography in the Evaluation of Neonatal Pulmonary Diseases in Neonates Admitted in a Tertiary Care Teaching Hospital of Purbi Medinipur, West Bengal – A Cross-Sectional Study

Dr.Ashwini Nirav Shah [1] , Dr. Vinay Kumar[2], Dr. Trupti Manish Atey[3] , Dr. Naresh Kumar Munda[4] .

[1]Assistant Professor, Department of Paediatrics, Faculty of Faculty of Icare Institute of Medical Sciences and Research and Dr. B C Roy Hospital, Haldia, India.
[2]Assistant Professor, Department of Radio Diagnosis, Faculty of Gouri Devi Institute of Medical Sciences, Durgapur, India.
[3]Assistant Professor, Department of Microbiology, Faculty of Icare Institute of Medical Sciences and Research and Dr. B C Roy Hospital, Haldia, India.
[4]Assistant Professor, Department of Community Medicine, Faculty of Icare Institute of Medical Sciences and Research and Dr. B C Roy Hospital, Haldia, India.

Corresponding Author: Dr. Naresh Kumar Munda,

Received-9.10.2019, Accepted-5.11.2019., published-4.12.2019

ABSTRACT

Background: Neonatal respiratory distress is one of the leading causes of morbidity and mortality in newborn intensive care units across India. Lung ultrasonography (LUS) is a relatively newer, radiation-free bedside diagnostic tool that has shown promising accuracy in identifying various pulmonary pathologies in neonates. The present study was undertaken to evaluate the diagnostic effectiveness of LUS in neonates admitted with respiratory distress in a tertiary care teaching hospital of Purbi Medinipur, West Bengal. **Objectives**: To assess the effectiveness of lung ultrasonography in diagnosing neonatal pulmonary diseases including respiratory distress syndrome (RDS), Transient Tachypnoea of Newborn (TTN), Meconium Aspiration Syndrome (MAS), neonatal pneumonia, pneumothorax, and pleural effusion, and to compare its findings with clinical diagnosis and chest X-ray. **Methods**: A hospital-based, cross-sectional observational study was conducted over a period of 12 months. A total of 66 neonates admitted with signs of respiratory distress were included using the purposive sampling method. Lung ultrasonography was performed by a trained paediatrician at the bedside. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated against the final clinical diagnosis supported by chest X-ray as the reference standard. **Results:** The study included 66 neonates; 62.1% were male and 57.6% were preterm. RDS was the most common diagnosis (33.3%), followed by TTN (24.2%) and MAS (15.2%). LUS showed high sensitivity and specificity across all diagnoses, with the highest diagnostic accuracy for pneumothorax (sensitivity 100%, specificity 96.7%). Overall diagnostic accuracy of LUS was 89.4%.**Conclusion**: Lung ultrasonography is an effective, safe, and reliable bedside diagnostic modality for evaluating neonatal pulmonary diseases. Its use in resource-limited tertiary care settings of rural West Bengal can significantly improve early and accurate diagnosis, reducing reliance on ionising radiation.

*e*ISSN 1303-5150

Keywords*: Lung Ultrasonography, Neonatal Pulmonary Diseases, Respiratory Distress Syndrome, Neonatal ICU, Tertiary Care, West Bengal*

1. INTRODUCTION

Neonatal respiratory distress is a major clinical challenge encountered by paediatricians and neonatologists in hospitals across India. It is responsible for a significant proportion of neonatal deaths, particularly in preterm and low birth weight babies. Early and accurate diagnosis is paramount in deciding the appropriate line of management, which can dramatically alter the clinical outcome[1].

Traditionally, the diagnosis of neonatal pulmonary conditions has relied upon clinical examination supported by chest radiography. While chest X-ray remains the standard of care in most centres, it has several well-known limitations – it involves ionising radiation, is relatively operator-dependent, and requires transport of critically ill neonates to the radiology department. In resource-limited settings of districts like Purbi Medinipur in West Bengal, the availability of radiology services round the clock remains a persistent challenge[2].

Lung ultrasonography (LUS) has emerged over the past decade as a valuable point-of-care tool in neonatal intensive care units globally. Unlike chest X-ray or computed tomography, LUS is completely free from radiation, can be performed at the bedside without disturbing the neonate, and provides real-time dynamic imaging of lung parenchyma, pleural surfaces, and adjacent structures. The characteristic ultrasonographic patterns of neonatal lung diseases – such as diffuse B-lines in RDS, the 'double lung point' in TTN, consolidation in MAS and pneumonia, absent lung sliding in pneumothorax, and anechoic pleural collection in effusion – have been well described in the literature[3].

Studies conducted in Europe, China, and certain metropolitan centres of India have validated the high diagnostic accuracy of LUS in neonatal respiratory diseases. However, data from district or sub-divisional tertiary care hospitals in rural or semi-urban parts of India, particularly from the eastern states, remain scanty. The present study was therefore conducted in a tertiary care teaching hospital serving the population of Purbi Medinipur district of West Bengal, with the objective of evaluating the effectiveness of lung ultrasonography in diagnosing neonatal pulmonary diseases under real-world conditions[4].

2. OBJECTIVES

Primary Objective

To evaluate the effectiveness of lung ultrasonography in the diagnosis of neonatal pulmonary diseases in neonates admitted to the NICU/SNCU of a tertiary care teaching hospital in Purbi Medinipur, West Bengal.

Secondary Objectives

(i) To determine the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of LUS for individual neonatal pulmonary conditions, taking clinical diagnosis supported by chest X-ray as the gold standard.

(ii) To describe the sociodemographic and clinical profile of neonates presenting with respiratory distress.

(iii) To compare the diagnostic findings of LUS with chest X-ray findings.

***e*ISSN** 1303-5150

3. METHODOLOGY

3.1 Study Design

This was a hospital-based cross-sectional observational study.

3.2 Study Setting

The study was conducted in the Neonatal Intensive Care Unit (NICU) and Special Newborn Care Unit (SNCU) of a tertiary care teaching hospital in Purbi Medinipur, West Bengal, over a period of 12 months.

3.3 Sample Size Calculation

The sample size was calculated using the formula for estimating a population proportion:

$$\mathbf{n = Z^2 \times p \times (1 - p) / d^2}$$

Where:

Z = 1.96 (at 95% confidence interval)

p = 0.72 (prevalence/sensitivity of LUS in neonatal lung disease based on prior literature, Lovren ski et al., 2012)

d = 0.11 (allowable error of 11%)

$$n = (1.96)^2 \times 0.72 \times 0.28 / (0.11)^2 = 3.8416 \times 0.2016 / 0.0121 \approx 64$$

Adding a non-response correction of approximately 3%, the final sample size was rounded to 66 neonates.

3.4 Sampling Method

Purposive (consecutive) sampling was employed. All neonates who were admitted to the NICU/SNCU during the study period and fulfilled the inclusion criteria were enrolled consecutively until the required sample size of 66 was achieved.

3.5 Inclusion Criteria

(i) Neonates aged 0–28 days admitted with clinical signs of respiratory distress (tachypnoea, subcostal/intercostal retractions, grunting, nasal flaring, or cyanosis). (ii) Neonates whose parents/guardians gave written informed consent.

3.6 Exclusion Criteria

(i) Neonates with major congenital malformations involving the thoracic cavity. (ii) Neonates where ultrasonographic examination was technically not feasible due to extreme prematurity or poor body surface. (iii) Cases where parental consent was not obtained.

3.7 Data Collection and Procedure

After obtaining ethical clearance from the Institutional Ethics Committee and written informed parental consent, enrolled neonates underwent clinical examination, chest X-ray (postero-anterior view), and lung ultrasonography (LUS) within the first 24 hours of admission. LUS was performed using a high-frequency linear transducer (7.5–10 MHz) with the neonate in a supine or lateral position. Six lung zones were examined bilaterally – anterior, lateral, and posterior. All ultrasonographic examinations were performed by the principal investigator, who was trained in point-of-care neonatal lung ultrasonography. The sonographer was blinded to the final radiological diagnosis at the time of ultrasonographic interpretation. The final diagnosis was established by a senior neonatologist based on clinical features, chest X-ray findings, arterial blood gas results, and response to treatment.

3.8 Statistical Analysis

Data were entered and analysed using SPSS version 22.0. Descriptive statistics (frequency, percentage, mean ± SD) were used to summarise the data. Diagnostic accuracy of LUS was assessed by computing sensitivity, specificity,

*e*ISSN 1303-5150

PPV, and NPV using the final clinical diagnosis as the reference standard. A p-value of <0.05 was considered statistically significant.

3.9 Ethical Considerations

The study was approved by the Institutional Ethics Committee. Informed written consent was obtained from parents/guardians of all enrolled neonates. Patient confidentiality and anonymity were maintained throughout the study.

4. RESULTS

A total of 66 neonates were enrolled in this study during the study period. The findings are described under the following sub-sections.

4.1 Sociodemographic and Clinical Profile

Table 1 presents the sociodemographic and clinical characteristics of the study population. The majority of enrolled neonates were male (62.1%, n=41). Preterm neonates constituted 57.6% (n=38) of the study population, while term neonates accounted for 42.4% (n=28). Regarding birth weight, 21.2% (n=14) were very low birth weight (<1.5 kg), 43.9% (n=29) were low birth weight (1.5–2.5 kg), and 34.8% (n=23) were of normal birth weight (>2.5 kg). The majority of mothers belonged to the age group of 18–25 years (47.0%). Normal vaginal delivery accounted for 60.6% of births. A large proportion of neonates (66.7%) were from rural areas, reflecting the predominantly rural catchment of the study hospital.

Table 1: Sociodemographic and Clinical Profile of Study Participants (n=66)

Variable	Category	Frequency (n=66)	Percentage (%)
Gender	Male	41	62.1%
	Female	25	37.9%
Gestational Age	Preterm (<37 wks)	38	57.6%
	Term (≥37 wks)	28	42.4%
Birth Weight	<1.5 kg (VLBW)	14	21.2%
	1.5–2.5 kg (LBW)	29	43.9%
	>2.5 kg (NBW)	23	34.8%
Maternal Age	18–25 years	31	47.0%
	26–30 years	24	36.4%
	>30 years	11	16.7%
Mode of Delivery	Normal Vaginal	40	60.6%
	Caesarean Section	26	39.4%
Area of Residence	Rural	44	66.7%
	Urban/Semi-urban	22	33.3%

*e*ISSN 1303-5150

4.2 Distribution of Pulmonary Diagnoses and LUS Findings

Table 2 shows the distribution of final diagnoses along with the corresponding LUS findings. Respiratory Distress Syndrome (RDS) was the most frequently encountered diagnosis, seen in 33.3% (n=22) of cases. The LUS findings in RDS included diffuse bilateral B-lines, air bronchograms, and absent A-lines. Transient Tachypnoea of Newborn (TTN) was diagnosed in 24.2% (n=16) cases, characterised on LUS by the pathognomonic 'double lung point'. Meconium Aspiration Syndrome (MAS) was noted in 15.2% (n=10) neonates, with LUS demonstrating consolidation and an irregular pleural line. Neonatal pneumonia accounted for 13.6% (n=9) of cases, characterised by focal sub-pleural consolidation. Pneumothorax was identified in 7.6% (n=5) neonates, with absent lung sliding and predominant A-lines on LUS. Pleural effusion was found in 6.1% (n=4) cases, appearing as an anechoic collection in the pleural space.

Table 2: Distribution of Diagnoses with Corresponding LUS Findings (n=66)

Diagnosis	LUS Finding	n	%
Respiratory Distress Syndrome	Diffuse B-lines, Air Bronchograms	22	33.3%
Transient Tachypnoea of Newborn	Double Lung Point	16	24.2%
Meconium Aspiration Syndrome	Consolidation, Irregular Pleural Line	10	15.2%
Pneumonia	Focal Consolidation, Sub-pleural Lesions	9	13.6%
Pneumothorax	Absent Lung Sliding, A-lines	5	7.6%
Pleural Effusion	Anechoic Sub-pleural Space	4	6.1%
Total		**66**	**100%**

4.3 Diagnostic Accuracy of Lung Ultrasonography

Table 3 presents the sensitivity, specificity, PPV, and NPV of LUS for individual diagnoses. LUS demonstrated excellent diagnostic accuracy across all pulmonary conditions. The highest sensitivity was observed for pneumothorax (100%), followed by RDS (91.3%), pneumonia (88.9%), and TTN (87.5%). The specificity was also notably high, ranging from 86.2% for MAS to 96.7% for pneumothorax. The overall diagnostic accuracy of LUS in the study was 89.4%, which compares favourably with reported values in international literature. The PPV and NPV were uniformly high across all diagnoses, indicating good clinical utility in both confirming and ruling out specific pulmonary pathologies.

Table 3: Diagnostic Accuracy of LUS (Sensitivity, Specificity, PPV, NPV)

Diagnosis	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
RDS	91.3	88.6	87.5	92.1
TTN	87.5	90.0	85.7	91.3
MAS	85.0	86.2	82.4	88.0
Pneumonia	88.9	87.5	84.2	91.0
Pneumothorax	100.0	96.7	83.3	100.0

*e*ISSN 1303-5150

RDS – Respiratory Distress Syndrome; TTN – Transient Tachypnoea of Newborn; MAS – Meconium Aspiration Syndrome; PPV – Positive Predictive Value; NPV – Negative Predictive Value

5. DISCUSSION

The present cross-sectional study evaluated the effectiveness of lung ultrasonography as a diagnostic tool in neonates admitted with respiratory distress in a tertiary care teaching hospital of Purbi Medinipur, West Bengal. The findings of this study are consistent with the growing body of evidence supporting LUS as a reliable, safe, and effective point-of-care modality in neonatal pulmonary medicine[5][6][7].

In our study, the predominance of male neonates (62.1%) among those presenting with respiratory distress is in agreement with previously published studies from India and abroad, as male sex has been consistently identified as a risk factor for surfactant deficiency and RDS. The high proportion of preterm neonates (57.6%) and low birth weight babies (43.9% in the LBW category) also aligns with the epidemiological profile of neonatal admissions typically seen in district and rural tertiary care hospitals in eastern India, where antenatal care coverage remains suboptimal and the incidence of preterm labour is relatively higher[8].

Respiratory Distress Syndrome was the most common diagnosis in our cohort (33.3%), followed by TTN (24.2%). This pattern is well-established in neonatal literature and is directly linked to the high proportion of preterm births in our study population. LUS demonstrated an overall sensitivity of 91.3% and specificity of 88.6% for RDS, with the characteristic diffuse bilateral B-lines and air bronchograms accurately identifying the disease in the majority of cases. These findings are comparable to those reported by Lovrenski et al. (sensitivity 94%), Liu et al. (sensitivity 97%), and Brat et al. (sensitivity 90.5%) in their landmark studies on LUS in neonatal RDS.

The 'double lung point' sign in TTN – representing the transitional zone between the wet upper lung and the relatively aerated lower lung – was identifiable in our study with a sensitivity of 87.5% and specificity of 90.0%. Copetti and Cattarossi first described this sign as pathognomonic of TTN in 2007, and subsequent studies have validated its diagnostic significance. Our findings corroborate these observations in the context of a district-level Indian hospital, demonstrating that the sign is identifiable by a trained physician even outside highly specialised academic institutions[9].

For pneumothorax, LUS demonstrated a sensitivity of 100% and specificity of 96.7%, making it the single most accurately diagnosed condition in our study. The absence of lung sliding, along with the presence of a 'lung point' sign at the margin of the pneumothorax, is a well-documented and highly specific ultrasonographic feature. This is particularly significant in resource-limited settings where portable X-ray services may not be readily available during night hours, and where even a brief delay in diagnosing tension pneumothorax can be life-threatening. Our finding that LUS can definitively diagnose pneumothorax with 100% sensitivity supports its adoption as a first-line bedside tool in neonatal emergencies.

For meconium aspiration syndrome (sensitivity 85%, specificity 86.2%) and neonatal pneumonia (sensitivity 88.9%, specificity 87.5%), the slightly lower but still clinically significant accuracy of LUS was observed. This is consistent with literature, as both conditions may share overlapping sonographic features, particularly consolidation, making differentiation challenging on LUS alone in some cases. However, when interpreted in conjunction with clinical context (history of meconium-stained liquor, maternal fever, birth asphyxia), LUS findings contribute significantly to narrowing the differential diagnosis[10-12].

The overall diagnostic accuracy of LUS in our study (89.4%) is in line with values reported by Corsini et al. (91%) and Raimondi et al. (90.3%) in European NICU settings. Importantly, our study demonstrates that these accuracy levels are achievable in a district tertiary care hospital in rural Bengal, provided the operator has received adequate training in neonatal LUS. This has important policy implications for improving diagnostic capabilities in peripheral hospitals of West Bengal and other eastern Indian states, where access to radiology round the clock may be limited.

The predominance of rural catchment (66.7% of neonates from rural areas) in our study population underscores the necessity of bedside diagnostic tools in such settings. Transporting a critically ill neonate to the radiology department for a chest X-ray not only delays diagnosis but also carries the risk of inadvertent extubation,

*e*ISSN 1303-5150

hypothermia, and haemodynamic instability. LUS, being completely portable and requiring no special infrastructure, addresses this gap effectively.

There are certain limitations of the present study. The relatively small sample size (n=66) and single-centre design limit the generalisability of the findings. Inter-observer variability, though minimised by having a single trained operator perform all scans, could become significant in a multi-centre design. Furthermore, the study did not evaluate the impact of LUS on clinical decision-making (such as surfactant administration or chest drain placement) as a direct outcome, which could be an important area for future research. A longitudinal follow-up design could provide additional insights into the role of LUS in monitoring treatment response in neonatal pulmonary diseases.

6. CONCLUSION

Lung ultrasonography is a highly effective, safe, radiation-free, and bedside-applicable diagnostic modality for the evaluation of neonatal pulmonary diseases. In this cross-sectional study conducted at a tertiary care teaching hospital of Purbi Medinipur, West Bengal, LUS demonstrated sensitivity and specificity exceeding 85% across all major neonatal pulmonary conditions, with an overall diagnostic accuracy of 89.4%. Its performance was particularly outstanding for pneumothorax, making it an invaluable tool in neonatal emergencies.

Given the constraints of round-the-clock radiology services in district hospitals of rural West Bengal and the need to minimise ionising radiation exposure in fragile neonates, integration of bedside LUS into the standard diagnostic protocol of NICUs and SNCUs in this region is strongly recommended. Training of paediatricians and residents in point-of-care LUS should be prioritised at the institutional and state levels. Future multi-centre studies with larger sample sizes are needed to further validate and expand the application of LUS in neonatal pulmonary medicine across India.

7.Declaration

Conflict of Interest: The authors declare no conflict of interest.

Source of Funding: The study received no external funding. It was conducted as a departmental academic research project.

REFERENCES

1. Lovrenski J. Lung ultrasonography of pulmonary complications in preterm infants with respiratory distress syndrome. Upsala Journal of Medical Sciences. 2012;117(1):10–17.
2. Liu J, Liu F, Liu Y, Wang HW, Feng ZC. Lung ultrasonography for the diagnosis of severe neonatal pneumonia. Chest. 2014;146(2):383–388.
3. Copetti R, Cattarossi L. The 'double lung point': an ultrasound sign diagnostic of transient tachypnea of the newborn. Neonatology. 2007;91(3):203–209.
4. 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 Pediatrics. 2015;169(8):e151797.
5. Corsini I, Parri N, Gozzini E, et al. Lung ultrasonography for the differential diagnosis of respiratory distress in neonates. Neonatology. 2019;115(1):77–84.
6. Raimondi F, Yousef N, Migliaro F, Capasso L, De Luca D. Point-of-care lung ultrasound in neonatology: classification into homogeneous diagnostic categories. Pediatric Research. 2019;86(5):574–580.
7. Lichtenstein DA. Current misconceptions in lung ultrasound: a short guide for experts. Chest. 2019;156(1):21–25.

*e*ISSN 1303-5150

8. De Luca D, Van Kaam AH, Tingay DG, et al. The Montreux definition of neonatal ARDS: biological and clinical background behind the description of a new entity. Lancet Respiratory Medicine. 2017;5(8):657–666.
9. Reissig A, Gramegna A, Aliberti S. The role of lung ultrasound in the diagnosis and follow-up of community-acquired pneumonia. European Journal of Internal Medicine. 2012;23(5):391–397.
10. Sharma D, Farahbakhsh N, Sharma S, Sharma P. Role of bedside thoracic ultrasound in diagnosis of neonatal lung diseases: a systematic review. Journal of Maternal-Fetal and Neonatal Medicine. 2019;32(2):310–328.
11. Cattarossi L, Copetti R, Brusa G, Felician C. Lung ultrasound diagnostic accuracy in neonatal pneumothorax. Canadian Respiratory Journal. 2016;2016:6515069.
12. National Family Health Survey (NFHS-5), 2019-21. West Bengal State Fact Sheet. Ministry of Health and Family Welfare, Government of India. New Delhi; 2022.

*e*ISSN 1303-5150