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Evaluation of lung ultrasound in the diagnosis of respiratory distress in neonates

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ABSTRACT

Background: Respiratory distress (RD) is a leading cause of morbidity and mortality among neonates in neonatal intensive care units (NICUs). Traditionally, clinical criteria combined with chest X-ray have been considered the gold standard for diagnosing respiratory distress. This study aims to assess the efficiency of lung ultrasound in diagnosing respiratory distress, with a focus on preventing neonates from unnecessary radiation exposure.
Methods: A multicentric prospective study was performed where neonates with gestational age 28-40 weeks were included based on presence of clinical signs of respiratory distress. Neonates with congenital anomalies or those who received surfactant therapy were excluded. Within 6 hrs of birth, these neonates underwent X ray chest and ultrasound. Final interpretation of chest x-ray was done by the blinded radiologist. A trained neonatologist used transthoracic view in ultrasound for the initial interpretation.
Results: A total of 80 neonates were enrolled in the study, among whom 49 were diagnosed with respiratory distress syndrome, 22 with transient tachypnoea of the newborn, 4 with pneumonia, and 5 classified as normal. Lung ultrasound exhibited a sensitivity of 95.9% and a specificity of 90.3% for the diagnosis of respiratory distress, with a positive predictive value of 94% and a negative predictive value of 93.3%.
Conclusions: Lung ultrasound proves to be a highly efficient diagnostic tool for respiratory distress in neonates, offering the added advantage of avoiding harmful radiation exposure associated with chest X-rays. Early detection of respiratory distress can facilitate timely management and significantly improve neonatal outcomes. Further adoption and validation of point of care lung ultrasound in clinical practice hold the potential to enhance neonatal care.

Keywords: Chest X-ray, Diagnosis, Lung ultrasound, Neonatal respiratory distress

INTRODUCTION

Respiratory distress is a common and significant problem affecting both premature and term neonates in NICUs, often necessitating their admission for specialized care.[1-2] Approximately one-third of preterm neonates experience some degree of respiratory distress, making it a critical health concern.[3] Early and accurate diagnosis is paramount for initiating appropriate interventions and improving neonatal outcomes.

Traditionally, the gold standard for diagnosing respiratory distress has involved clinical criteria combined with a chest X-ray.[4] However, this approach has drawbacks, primarily the exposure of neonates to ionizing radiation, which poses potential risks, especially in this vulnerable population. In recent years, lung ultrasound has emerged as a promising and radiation-free diagnostic tool for assessing respiratory distress in neonates.[5] This low-cost and non-invasive technique not only aids in diagnosing respiratory distress but also helps differentiate between various etiologies.

While existing literature supports the efficacy of lung ultrasound in diagnosing respiratory distress, studies have often been limited by small sample sizes, restricting the generalizability of their findings.[4] Therefore, there is a need for comprehensive research to evaluate the efficiency and reliability of lung ultrasound as a diagnostic modality on a larger scale.

The present study aims to fill this research gap by investigating the efficacy of lung ultrasound in diagnosing respiratory distress in neonates by involving multiple centres. By comparing the results of lung ultrasound with chest X-ray, we seek to determine the diagnostic accuracy of lung ultrasound while focusing on the potential benefits of eliminating radiation exposure. The findings of this study will provide valuable insights into the utility of lung ultrasound as a safe and effective tool for diagnosing respiratory distress in neonates, ultimately contributing to improved clinical decision-making and the overall well-being of these vulnerable patients.

Aim of this study was to assess the effectiveness of lung ultrasound as a diagnostic tool in neonates experiencing respiratory distress when compared to clinical and radiographic criteria. Also, to ascertain the diagnostic accuracy of Point of Care Ultrasonography (USG) in detecting respiratory distress (RD) in neonates.

METHODS

A multicentre prospective observational study was conducted in NICUs of three hospitals namely Punjab Institute of Medical Sciences, Ankur hospital and PMG Hospital in Punjab, India from May to July 2023. The study enrolled neonates born between 28 to 42 weeks of gestation who exhibited respiratory distress, characterized by symptoms such as rapid breathing (respiratory rate >60/min), retractions, grunting, and a need for oxygen supplementation above 21% (FiO2 >21%). Neonates with significant congenital malformations or hydrops, as well as those born outside the participating institutions who had already received surfactant therapy, were excluded from the study. Non-pulmonary causes of respiratory distress were also excluded.

In the study conducted by Rachuri et al, the sensitivity was determined to be 98%.[5] To calculate the minimum sample size, the formula N = [Z/2]2 x [PQ]/E2 was used, with a type 1 error rate set at 5%, a prevalence (p) of 23.2%, and q (1-p) as the complement of p. The acceptable error was set at 10%, resulting in a minimum required sample size of 80 participants.

Before commencing the study, ethical approval was obtained from the institutional ethics committee at the originating institution (IEC/PIMS/23/19). A written informed consent in vernacular language was obtained from the parents of the eligible participants.

Methodology

Proforma for the data collection was prepared. Ultrasound chest and chest x-ray (CXR) were done within 6 h of birth and within a maximum gap of not more than 4 h between them. To streamline data collection across participating hospitals, a dedicated meeting was organized, bringing together the neonatologists from each institution. During this meeting, the proforma was shared to facilitate standardized data collection. Additionally, an online group was created, encompassing all the authors involved in the study for the purpose of data sharing.

Immediate management and interpretation of the radiographs and ultrasound images were performed by the treating neonatologists at their respective hospitals. However, to maintain objectivity, the final interpretation of the CXR for study purposes was carried out by a blinded radiologist who had no access to the patients' details.

USG based scoring was done to evaluate the requirement of surfactant. During the study, LUS examination was done using the following LUS score: every lung was divided into 3 areas (upper anterior, lower anterior and lateral) and a linear microprobe was used in lung examination through both transverse and longitudinal scans. For every lung area, a point score from 0 to 3 was applied (total score varying from 0 to 18). The ultrasound scoring used: 0-only A lines present, >/=3 well spaced B lines, 2- presence of crowded and coalescent B lines with or without consolidations limited to subpleural space, 3- extended consolidations.

In this study, a high-resolution linear probe with a frequency exceeding 7.5 MHz (typically ranging from 11 to 12 MHz) was utilized. The lung ultrasound examination was conducted at the patient's bedside by a single expert at their respective center's Neonatal Intensive Care Unit (NICU) immediately after admission. The transthoracic approach was employed, involving longitudinal scans of both the anterior and posterior chest walls.

Subsequently a traditional point-of-care antero-posterior chest radiograph was conducted. The radiographic assessment was conducted in isolation by a radiologist

who remained uninformed about the findings derived from the ultrasonographic investigation.

Ultrasound indexes: The pleural line is a consistent echogenic line located beneath the surface layers of the thorax, exhibiting continuous movement during respiration. Abnormal pleural lines, on the other hand, pertain to instances where the pleural line disappears, becomes indistinct, or widens beyond 0.5 cm. The A-line is characterized by a sequence of equidistant, echogenic, horizontal lines positioned beneath the pleural line, which stem from reverberation artifacts originating from the pleural line.

B-lines, also known as ultrasound lung comets, manifest as hyperechoic, narrow-based artifacts that radiate in a manner reminiscent of laser beams from the pleural line to the screen's edge. Lung consolidation refers to areas displaying hepatization (tissue pattern), accompanied by the presence of air or fluid bronchograms. Pleural effusion involves anechoic-dependent collections confined by the diaphragm and pleura. The comet-tail artifact, resembling the ring-down artifact, yet shorter and tapering akin to a comet's tail, emerges due to the reverberation mechanism. Interstitial syndrome is diagnosed when more than 3 B-lines are present, or areas of 'white lung' are observed in each examined region. Bilateral white lung is characterized by compact B-lines in all 6 areas without horizontal reverberation. Lung pulse entails the replacement of lung sliding with pulsations synchronized with heart activity, signifying early ultrasound evidence of complete atelectasis.[6]

Following data collection, the information was transferred to an excel sheet, and the results were meticulously prepared for further analysis and interpretation.

Data analysis

The results were expressed as frequency and percentage distribution. Diagnosis accuracy of the LUS and Chest x-ray was computed using standard formulae. The final/gold standard diagnosis is the diagnosis set by the treating consultant depending on the x-ray picture and clinical course of the neonate (clinic-radiological diagnosis). A Receiver operating characteristic (ROC) analysis was used to evaluate the ability of the LUS score to predict RDS. A value of $p < 0.05$ is considered as significant with two sided tails. The analysis was carried out using the statistical package for social sciences (SPSS ver. 26.0).

RESULTS

A total of 58.7% of cases were born as pre-term and 62.5% were of low birth weight. LSCS delivery was required in 61.3% cases while in 51.3% cases resuscitation was required at birth. Maternal and other baseline characters of the study cohort was shown in Table 1. Final diagnosis of RDS was given in 61.3% cases as compared to 62.5% and 61.3% by LUS and chest X-ray respectively (Table 1).

Table 1: Baseline characters of study cohort.

Baseline variable (n-80)		N	%
Gestation age (weeks)	<32	8	10.0
	32-37	39	48.8
	>37	33	41.3
Gender	Female	44	55.0
	Male	36	45.0
Birth weight (Kg)	<1	2	2.5
	1-1.5	9	11.3
	1.5-2.5	39	48.8
	>2.5	30	37.5
Maternal characteristics	PPROM	24	30.0
	PIH	25	31.3
	GDM	4	5.0
	Antenatal steroids	61	76.3
Mode of delivery	LSCS	49	61.3
	Assisted vaginal	5	6.3
	Normal vaginal	25	31.3
Resuscitation required at birth	No	41	51.3
	Yes	39	48.8
Chest X-ray diagnosis	RDS	49	61.3
	TTN	20	25.0
	Pneumonia	5	6.3
	Normal	6	7.5
LUS diagnosis	RDS	50	62.5
	TTN	23	28.8
	Pneumonia	3	3.8
	Normal	4	5.0
Final diagnosis	RDS	49	61.3
	TTN	22	27.5
	Pneumonia	4	5.0
	Normal	5	6.3

On analyzing the LUS characteristics (Table 2), we found thickened pleura (100%) and whiteout lung (78%) as the common LUS feature in RDS, followed by interstitial syndrome in 14% cases and DLP in 6%. The median (IQR) of modified LUS score was 47 (40-54) in neonates with RDS, suggestive of increased extravascular lung water content and improper clearance of fetal lung water.

On ROC analysis, we found that the LUS score has an area under curve (AUC) of 0.821, and a LUS score of 40 or above alone has a sensitivity of 90% and specificity of 88% for the diagnosis of RDS.

Overall, LUS has a sensitivity of 95.9% and a specificity of 90.3% for the diagnosis of RDS as compared to 87.8% and 80.6% for chest X-ray (Table 3).

Table 2: Features of respiratory distress syndrome on LUS.

RDS Features on LUS (n-50)	N	%
Thickened pleura	50	100.0
Interstitial syndrome	7	14.0
Double lung point (DLP)	3	6.0
Bilateral white lung	35	70.0
Unilateral whiteout lung	4	8.0
LUS score (Median & IQR)	47	40-54

Table 3: Diagnostic accuracy of lung ultrasound and chest X-ray for diagnosis of RDS.

Variable		Final diagnosis			Diagnostic accuracy (%)			
		RDS (n-49)	No RDS (n-31)	Total	Sensitivity	Specificity	PPV*	NPV**
LUS	RDS	47	3	50	95.9	90.3	94.0	93.3
	No RDS	2	28	30				
CXR	RDS	43	6	49	87.8	80.6	87.8	80.6
	No RDS	6	25	31				

*Positive Predictive Value, **Negative Predictive Value

DISCUSSION

The findings of our study provide valuable insights into the diagnostic performance of lung ultrasound (LUS) in neonates with respiratory distress syndrome (RDS). Our cohort comprised a significant proportion of pre-term births (58.7%) and low birth weight neonates (62.5%), which are well-known risk factors for RDS. Additionally, a considerable proportion of cases required cesarean section deliveries (61.3%), and approximately half of the cases necessitated resuscitation at birth (51.3%), highlighting the prevalence of the neonatal condition.[8]

We included 80 neonates with respiratory distress within 6 hours of life. In our study (mean gestational age 36.1+/- 2.3 weeks, mean birth weight 2243+/- 417.1 g). 49 infants had a final diagnosis of RDS and 22 of TTN. In the research conducted by Vergine et al, an ultrasound of the chest was performed within the first hour following admission. The study included fifty-nine newborns (with mean gestational age of 33±4 weeks and mean birth weight of 2,145±757 g). Among the infants, twenty-three were diagnosed with respiratory distress syndrome (RDS), while thirty were diagnosed with transient tachypnea of the newborn (TTN).[9]

Analyzing the LUS characteristics of neonates with RDS, we observed thickened pleura (100%) and whiteout lung (78%) as the most common features, followed by interstitial syndrome in 14% of cases and double lung point in 6%. These findings are consistent with previous literature on LUS features in RDS, emphasizing the utility of LUS in visualizing lung abnormalities associated with respiratory distress. The work performed by Gupta V. et al supports the above findings.[4]

Vergine et al research findings indicate that lung ultrasound (LUS) demonstrated a sensitivity of 95.6% and specificity of 94.4% for identifying respiratory distress syndrome (RDS), along with a positive predictive value (PPV) of 91.6% and a negative predictive value (NPV) of 97.1%.[9] These findings corroborate with our findings of sensitivity and specificity of 95.9% and 90.3% respectively with regards to RDS. PPV and NPV in our case were in similar range with value of 94.0% and 93.3%.

Calculation of LUS score can also reliably demonstrate the need for surfactant administration or additional respiratory support in RDS patients. Our study observed a LUS score of 40 or above alone has a sensitivity of 90% and specificity of 88% for the diagnosis of RDS on ROC analysis. A meta-analysis conducted by Razak A, and few other studies also had similar findings regarding LUS score and need for intervention.[10-12]

These findings support our idea of usage of lung ultrasound instead of chest X Ray owing to its advantage of being nonionizing which is also an important factor to consider when repeated evaluation is required to monitor the condition of the neonate.[6] Furthermore lung ultrasound can estimate the severity of the disease by calculation of LUS score and hence can guide the treatment.[13-14]

Nevertheless, as with any diagnostic modality, there may be limitations to the application of lung ultrasound in neonatal respiratory distress. Operator expertise and training in lung ultrasound are crucial factors that can influence its diagnostic accuracy. Ensuring that neonatologists are adequately trained and proficient in performing and interpreting lung ultrasound can enhance its effectiveness in clinical practice. The drawback in this study is that etiology based differentiation using point of care ultrasound of lungs should be conducted on large scale to help achieve the more accurate diagnosis.

CONCLUSION

Lung ultrasound holds promise as a reliable and accurate diagnostic tool for neonatal respiratory distress. Its high sensitivity and specificity, along with the ability to provide real-time imaging, make it a valuable addition to the diagnostic repertoire. LUS can aid in the early detection of RD, enabling timely interventions and improved neonatal outcomes.

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REFERENCES

1. Edwards M, Kotecha SJ, Kotecha S. Respiratory distress of the term newborn infant. Paediatr Respir Rev. 2013;14:29-36.
2. Gupta R. Diagnostic Utility of Bedside Lung Ultrasonography in Neonates with Respiratory Distress. Asian J Pediatr Res. 2022;10(4):56-66.
3. Kartikeswar G, Ankula P G, Parikh T, Pandya D, Pandit A. Lung ultrasound (LUS) in pre-term neonates with respiratory distress: A prospective observational study. Lung India. 2022;39(5):417-21.
4. Gupta V, Panigrahy N, Venkatlakshmi A, Chirla DK, Pandita A. Diagnostic ability of bedside lung Ultrasound in neonates with respiratory distress. J Pediatr Neonatal Care. 2018;8(6):308-12.
5. Rachuri H, Oleti TP, Murki S, Subramanian S, Nethagani J. Diagnostic performance of point of care ultrasonography in identifying the etiology of respiratory distress in neonates. Indian J Pediatr. 2017;84:267-70.
6. Liu J, Cao HY, Wang HW, Kong XY. The role of lung ultrasound in diagnosis of respiratory distress syndrome in newborn infants. Iran J Pediat. 2015;25(1):e323.
7. Hiles M, Culpan AM, Watts C, Munyombwe T, Wolstenhulme S. Neonatal respiratory distress syndrome: chest X-ray or lung ultrasound? A systematic review. Ultrasound. 2017;25(2):80-91.
8. Kommawar A, Borkar R, Vagha J, Lakhkar B, Meshram R, Taksandae A. Study of respiratory distress in newborn. Int J Contemp Pediatr. 2017;4(2):490-94.
9. Vergine M, Copetti R, Brusa G, Cattarossi L. Lung ultrasound accuracy in respiratory distress syndrome and transient tachypnea of the newborn. Neonatol. 2014;106(2):87-93.
10. Razak A, Faden M. Neonatal lung ultrasonography to evaluate need for surfactant or mechanical ventilation: a systematic review and meta-analysis. Arch Dis Child Fetal Neonatal Ed. 2020;105(2):164-71.
11. 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.
12. Perri A, Riccardi R, Iannotta R, Di Molfetta DV, Arena R, Vento G, et al. Lung ultrasonography score versus chest X-ray score to predict surfactant administration in newborns with respiratory distress syndrome. Pediatric Pulmonol. 2018;53(9):1231-6.
13. Pang H, Zhang B, Shi J, Zang J, Qiu L. Diagnostic value of lung ultrasound in evaluating the severity of neonatal respiratory distress syndrome. Europ J Radiol. 2019;116:186-91.
14. Gregorio-Hernández R, Arriaga-Redondo M, Pérez-Pérez A, Ramos-Navarro C, Sánchez-Luna M. Lung ultrasound in preterm infants with respiratory distress: experience in a neonatal intensive care unit. Europ J Pediat. 2020;179(1):81-9.

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