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Original article

Lung Ultrasonography in Evaluation of Neonatal Respiratory Distress

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Abstract

Background: Survival depends on the newborn baby's capacity to adjust to the extra-uterine environment. When a baby is born, significant physiological changes occur in all of the body's systems. The development of the lungs may be the one adaptation that is most important for survival. The placenta and umbilical veins give the foetus with oxygen and nutrients continuously, and the mother circulation controls the expulsion of carbon dioxide. The neonate begins extra-uterine gas exchange by filling the airways with air at the first gasp just after birth. Currently, clinical indicators plus a simple chest X-ray are used to diagnose neonatal respiratory illness (CXR). **Objectives:** The purpose of the thesis was to demonstrate how lung ultrasonography can be used to assess newborns' respiratory distress. **Patients and methods**: Prospective study including Lung Ultrasound (LUS) examination for one hundred neonates (according to statistical role) using GE logic e ultrasound with linear probe done at Benha university departments of pediatrics and radiology. **Results:** Based on lung US, the most common diagnosis was pneumonia in 30% of cases followed by Transient Tachypnea of Newborn (TTN) in 26%, Respiratory Distress Synonym (RDS) in 18%, pneumothorax in 14%, and meconium aspiration in 7% and pulmonary hemorrhage in5%. RDS was categorized into RDSI in 2%, RDSII in3%, RDSIII in 13%. **Conclusion**: LUS is a safe, non-invasive technology that can be used to diagnose RDS, monitor the effectiveness of treatment, and minimise the need for X-ray procedures.

Keywords: Lung Ultrasonography; neonatal respiratory distress; meconium aspiration; neonates.

Introduction:

Survival depends on the newborn baby's capacity to adjust to the extra-uterine environment. When a baby is born, significant physiological changes occur in all of the body's systems [1] . The development of the lungs may be the one adaptation that is most important for survival[2]. The placenta and umbilical veins give the foetus with oxygen and nutrients continuously, and the mother circulation controls the expulsion of carbon dioxide. The neonate begins extra-uterine gas exchange by filling the airways with air at the first gasp just after birth[2].

At the same time, the pulmonary vascular pressure is reduced to allow for increased blood flow to the lungs, and the foetal lung fluid is reabsorbable[3]. Both full term and preterm newborns are the most frequently admitted to a neonatal unit for respiratory issues[4]. According to one study, respiratory issues were the main cause of hospitalisation for 33.3% of all neonatal admissions at >28 weeks' gestation, excluding children with syndromes and those who had congenital or surgical illnesses [4]. Currently, clinical indicators plus a simple chest X-ray are used to diagnose neonatal respiratory illness (CXR). Recent years have seen an expanded and successful use of ultrasonography in the detection of various lung illnesses [5] .

Patients and Methods

This is a prospective study on LUS Examination for one hundred neonates (according to statistical role) using GE logiq e ultrasound with linear probe done at Benha University Departments of Pediatrics and Radiology from (1/2021) to (1/2022).

Ethics approved: The Benha University Faculty of Medicine's ethical committee gave its approval to the study. Rec code and number (MS19-12-2020) . Because LUS is a non-invasive treatment and was sought as part of a normal evaluation, written informed consent was not required.

Inclusion criteria: newborns exhibiting radiological and clinical indications of respiratory distress, neonates with birth weights between 2000 and 3000g, neonates without multiple congenital anomalies or severe gross retardation. Also, neonates without a mother's history of chronic diseases, and those who don't need for special preparation, sedation, food or fluid restrictions.

Exclusion criteria: Neonates with birth weights less than 2000 g, those with multiple congenital defects or severe gross retardation, and those whose mothers had a history of chronic illnesses were all considered to be neonates.

Statistical analysis design: Data collected were reviewed and coding of the collected data was done manually. These numerical codes were fed to the computer where statistical analysis was done using the Statistic Package for **Social Science Version 22 (SPSS 22) for windows.**

A) Descriptive statistics:

1- Quantitative data: were presented as mean and standard deviation (mean ± SD)

2- Qualitative data: were expressed as numbers and percentages.

B) Analytical statistics

Comparing groups was done using

1- Chi square-test (X^2) :for comparison of qualitative data

2- Student's " t "- test for comparison of quantitative data of 2 independent sample with normal distribution and homogeneity of variance

3- Mann Whitney test for comparison of quantitative data of 2 independent sample with not normally distributed variable

4- Study of the relationship between variables was done using correlation coefficient "Pearson correlation".

5- The coefficient interval was set to 95%. The level of significance was calculated according to the following probability (*p*) values:

- $p<0.05$ was considered statistically significant.
- $p<0.001$ was highly significant.
- $p>0.05$ was considered non-significant.

Results

The current study included 100 neonates; 41 of them were males (41%) and 59 were females (59%). Their gestational age ranged from 34 – 39 weeks. 57% were pre term and 43% were full term.

The commonest maternal risk factor among our studied neonates was maternal UTI in 30% followed by breech and meconium stained liquor and severe intrauterine infection in 7% for each. 67% were born via caesarean section and 33% were born via normal vaginal delivery.

The mean birth weight of the included neonates was 3038.13 ± 548.11 gm.

The postnatal age at the time of radiological evaluation of the studied neonates ranged between immediately after birth up to 10 days after birth. The most common clinical presentation at the time of radiological evaluation was tachypnea, retraction in 39% of cases followed by tachypnea, retraction and grunting in 31% of cases. In 33% of neonates have coarse crepitation all over the chest while 30% have coarse crepitation more on the right side,(**Table, 1).**

Based on chest X ray, the most common diagnosis was pneumonia in 30% of cases followed by TTN in 26%, RDS in 17%, pneumothorax in 14%, meconium aspiration in 7% and pulmonary hemorrhage in 6%. RDS was categorized into RDSI in 2%, RDSII in 5%, RDSIII in 7% and RDSIV in 3% (**Table, 2)**.

Based on lung US, the most common diagnosis was pneumonia in 30% of cases followed by TTN in 26%, RDS in 18%, pneumothorax in 14%, meconium aspiration in 7% and pulmonary hemorrhage in 5%. RDS was categorized into RDSI in 2%, RDSII in 3%, RDSIII in 13% (**Table, 3).**

There is high agreement between the diagnosis detected by chest X ray and lung ultrasound in cases of pneumonia, TTN, pneumothorax and meconium aspiration syndrome while there is disagreement in the diagnosis of pulmonary hemorrhage (1 cases was wrongly diagnosed by ultrasound as RDS) and in RDS (3 cases US could not rightly categorize RDS severity) (**Table, 4) .**

There is high degree of agreement between chest US and chest X ray for diagnosis of RDS however, chest US could not accurately categorize RDS severity **(Table, 5)**.

Table (1): Postnatal age and clinical presentation at the time of radiological evaluation of the studied neonates

		No.= 100
Postnatal age (hours)	Mean ± SD	35.82 ± 83.01
	Range	At birth – 10 days
	Median [IQR]	2 [4]
Clinical presentation	tachypnea , retraction (RDll)	39(39%)
	tachypnea , retraction , grunting (RDlll)	31 (31%)
	tachypnea and cyanosis (RDlV)	16 (16%)
	refusal of feeding , vomiting , tachypnea	14 (14%)
Physical examination findings	Decreased air entry with coarse crepitation all over	33 (33%)
	Mild to moderate dehydration with tachypnea , intercostal retraction , diminished air entry bilaterally more on the upper with fine crepitation all over	14 (14%)
	Meconium stained skin and nails, diminished air entry more on the right side with mixed crepitation more on the right	7 (7%)
	Decreased air entry with coarse crepitation more on the right side	30 (30%)
	Cyanosis , intercostal retraction , tachypnea , diminished air entry bilaterally and fine crepitation all over	16 (16%)

Table (2): Chest X ray findings and diagnosis in the studied neonates

		No.= 100
Chest X ray finding	Mild , symmetrical lung overaeration , prominent perhilar interstitial markings which improved in 2-3 days. this confirms the diagnosis of **transient tachypnea of newborn**	26 (26%)
	Reticular opacities with numerous air bronchogram, this confirms the diagnosis of **pneumonia**	30 (30%)
	Ground glass opacities ranging in severity from mild to complete white lung. This finding confirm the diagnosis of **RDS** that was categorized according to severity into**:**	17 (17%)
	RDS1 : fine homogenous ground glass shadowing	**2 (2%)**
	RDS II : bilateral widespread air bronchogram	**5 (5%)**
	RDS III confluent alveolar shadowing	**7 (7%)**
	RDS IV Alveolar shadowing obscuring cardiac border (complete white lung)	**3 (3%)**
	hyper inflated chest with patchy opacities unilateral and bilateral confirm with **meconium aspiration syndrome**	7 (7%)
	unilateral or bilateral areas of increased lucency (hyper lucent hemithorax or medial stripe sign) confirm with **pneumothorax**	14 (14%)
	Non specific features (scattered patches or diffuse infiltrative opacification pattern) suggestive **pulmonary hemorrhage**	6 (6%)
Diagnosis based on chest X ray	Pneumonia	30 (30%)
	TTN	26 (26%)
	Pneumothorax	14 (14%)
	meconium aspiration syndrome	7 (7%)
	pulmonary hemorrhage	6 (6%)
	RDSI	2 (2%)
	RDSII	5 (5%)
	RDSIII	7 (7%)
	RDSIV	3 (3%)

Table (3): Lung ultrasound finding and diagnosis in the studied neonates

		No.= 100
Lung US findings	**zones of normal aeration, interstitial pattern or even fields of white lung, double lung point in about 70 %.**	26 (26%)
	Loss of aeration with a homogeneous AI pattern and an irregular or thickened pleural line, hyperechoic lung field (white lung),13 with condensations ranged from small subpleural collapses to large consolidations with air bronchogram (atelectasis) suggestive of RDS.	18 (18%)
	Stag 1 Retrophrenic striped patterns of hyperechogenicity (B lines) diverging radially, observed only on expiration	2 (2%)
	Stage 2 Retrophrenic striped patterns of hyperechogenicity diverging radially, observed only on inspiration, also merging together into areas of homogenous echo enhancement on expiration.	3 (3%)
		13(13%)
	Stage 3 Retrophrenic homogenous hyperechogenicity (white lung) observed irrespective of respiratory phase with or without some consolidations	
	Consolidations	
	Consolidations with bronchograms ,B lines	43 (43%)
	consolidations with air bronchograms (bilateral, disperse and of variable size). In 3 cases a bilateral AI pattern, diffuse or patchy,with an irregular pleural line with areas of normal aeration .These features are dynamic, and their location changed with the course of disease in some cases	30 (30%)
		14 (14%)
	shred sign , consolidation with air bronchogram, pleural line abnormalities in all cases and alveolar interstitial pattern in some cases.	5 (5%)
	lung point , absence of lung sliding (movement of the pleural line synchronized with respiratory movement produced by the change in the relative positions of the chest wall [parietal pleura] and the lung surface [visceral pleura**])**	14 (14%)
Diagnosis based on lung US	Pneumonia	30 (30%)
	TTN	26 (26%)
	Pneumothorax	14 (14%)
	Meconium aspiration syndrome	7 (7%)
	pulmonary hemorrhage	5 (5%)
	RDS I	2 (2%)
	RDSII	3 (3%)
	RDSIII	13 (13%)

Table (4): Comparison between results obtained by ultrasonography and plain radiography

	Ultrasonography diagnosis	
	Same as X ray	**Missed cases/ Wrong diagnosis**
Pneumonia	30 (100%)	0 (0%)
TTN	26 (100%)	0 (0%)
pneumothorax	14 (100%)	0 (0%)
meconium aspiration syndrome	7 (100%)	0 (0%)
pulmonary hemorrhage	5 (83.3%)	1 (16.6%) Wrongly diagnosed as RDSIII
RDS	17 (94.4%)	1 (5.5%) 1 case correct diagnosis was pulmonary hemorrhage 3 cases US could not rightly categorize RDS

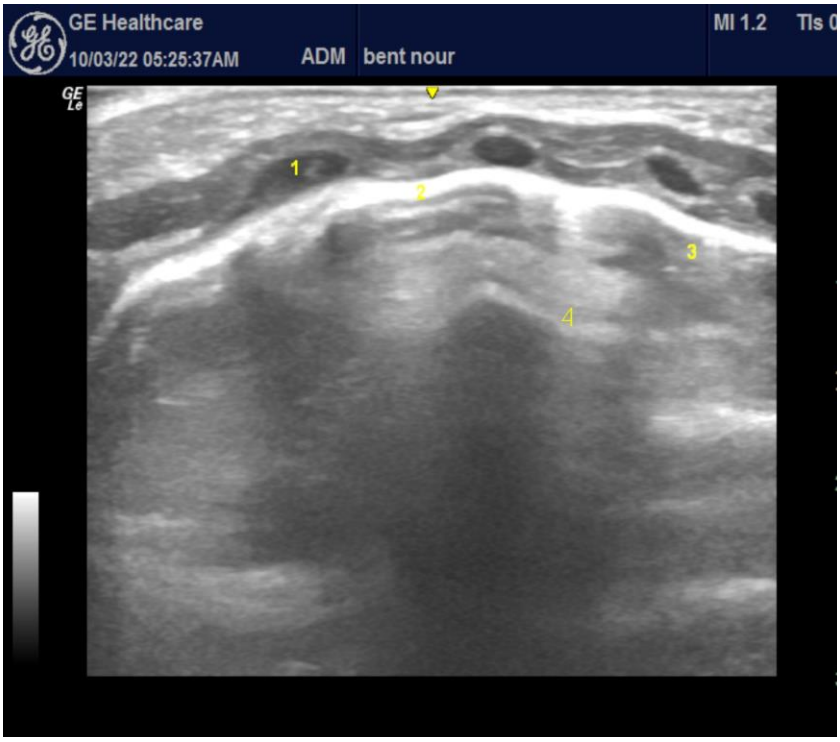
Table (5): Comparison of diagnosis obtained by ultrasonography and plain radiography in RDS

RDS severity stage assessed on LUS (N = 18)	**RDS severity stage assessed on chest X ray (N = 17)**
Stage I (N=2)	**RDI (N=2)** **100% agree with US**
Stage II (N=3)	RDII (N=5) 60% agree with US 3 cases US could not rightly categorize RDSII
Stage III (N=13)	RDIII (N=7) 53.8% agree with US
----	RD VI (N=3) 2 cases US could not rightly categorize RDSIV 1 case correct diagnosis was pulmonary hemorrhage

Discussion

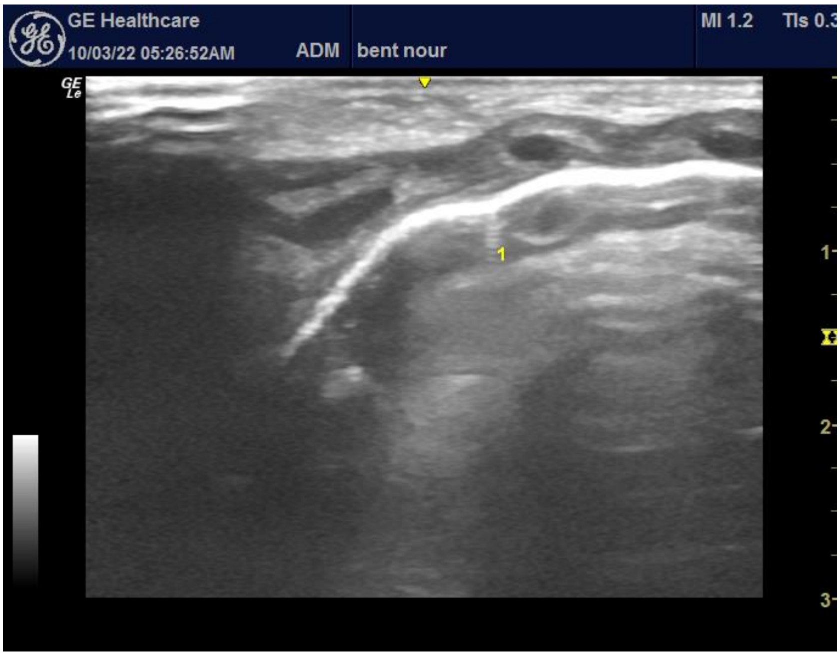
Clinical signs, CXR findings, and arterial blood gas readings are typically used to make the diagnosis of NRDS. However, exposing a developing neonate to damaging ionising radiation in excess during the first few years of life could have long-term effects. People who are exposed early in life have disproportionately high relative risks for numerous malignancies, and the risk of solid tumours associated with radiation exposure seems to last a lifetime. Finding a different diagnostic procedure without ionising radiation is necessary [6].

This prospective investigation was conducted at Pediatric Department and Radiology Departments of Benha University Hospital. The study included LUS examination for one hundred neonates. The duration of the study ranged from 6-12 months. As shown in **figure (1a,1b)** apart of normal chest US Examination and in **figure (2a,2b)** an example of chest US Examination of a case of transient tachypnea of newborn



1- Ribs **2- pleura** **3- lung** **4- A Line**

Figure 1-a : normal US Examination of chest



1- normal B Line

Figure 1-b : normal US Examination of chest

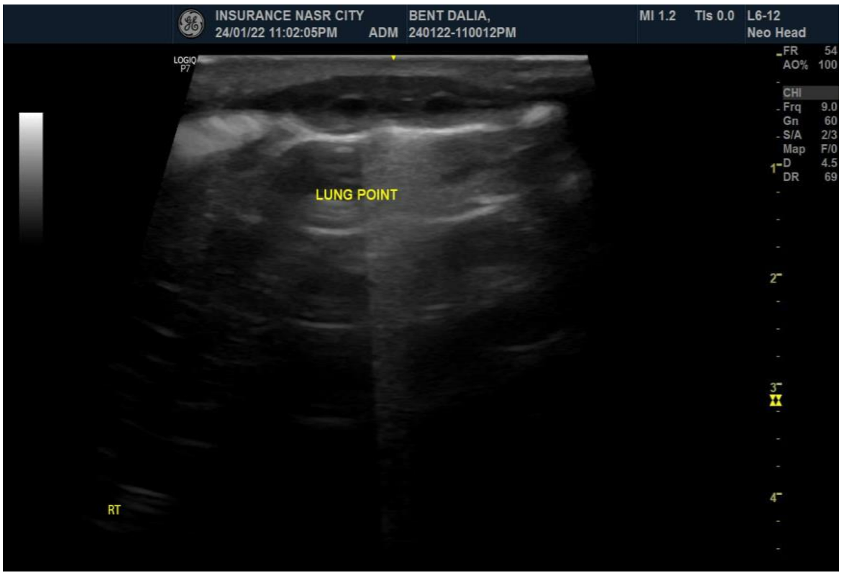


Figure 2-a : LUS Examination of transient tachypnea of newborn

Figure 2-b : LUS Examination of transient tachypnea of newborn

The current study included 100 neonates; 41 of them were males (41%) and 59 were females (59%). Their gestational age ranged from 32 – 39 weeks. 57% were preterm and 43% were full term.

The gestational age ranged from 26 to 35 weeks (mean=30.24);were males and females represented 60.3% and 39.7% respectively.

Whereas in the study of [8]; they conducted LUS examinations on 100 neonates (66 male and 44 female). The gestational age of neonates ranged from 36 weeks to full term. The present study showed that the commonest maternal risk factor among our studied neonates was maternal UTI in 30% followed by breech and meconium-stained liquor and severe intrauterine infection in 7% for each. 67% were born via CS and 33% were born via NVD.

Our results were supported by study of [9] They stated that there is a strong correlation between full-term neonatal RDS and risk factors for RDS in term newborns, such as selective caesarean delivery, severe birth hypoxia, maternal-fetal infection, and female sex.

Also, in the study of [7], 23/68 (33.8%) were delivered vaginally while 45/68 (66.2%) were delivered by cesarean section.

The current study showed that the mean birth weight of the included neonates was 3038.13 ± 548.11 gm. APGAR score ranged between 1 – 5 at the 1st min and 4 – 7 at the 5th min.

[8] study declared that the mean birth weight of the neonates they evaluated ranged from 2100 g to 3000 g, provided confirmation for our findings (8). However, in the study by [10], the study comprised 120 preterm newborns (birth weight, mean value: 1594.9 g (SD 626.79, CI 1481.59-1708.23 g); weeks of gestation (WG) ranged from 23.86 to 36.89; mean value: 30.97 WG (SD 3.16, confidence interval (CI) 30.4-31.55 WG). Also, in the study of [11], the birth weight of their studied cases was with average: 1113 ±140 g and range from: 700-1582 g.

The study in our hands, showed that; the postnatal age at the time of radiological evaluation of the studied neonates ranged between immediately after birth up to 10 days after birth. The most common clinical presentation at the time of radiological evaluation was tachypnea, retraction in 39% of cases followed by tachypnea, retraction and grunting in 31% of cases. In 33% of neonates have coarse crepitation all over the chest while 30% have coarse crepitation more on the right side

In the study of[7], 59 out of 68 (86.8%) of the admitted patients presented with moderate respiratory distress and 9 out of 68 (13.2%) presented with severe respiratory distress.

The present study showed that based on chest X ray, the most common diagnosis was pneumonia in 30% of cases followed by TTN in 26%, RDS in 17%, pneumothorax in 14%, meconium aspiration in 7% and pulmonary hemorrhage in 6%. RDS was categorized into RDSI in 2%, RDSII in 5%, RDSIII in 7% and RDSIV in 3%. Based on lung US, the most common diagnosis was pneumonia in 30% of cases followed by TTN in 26%, RDS in 18%, pneumothorax in 14%, and meconium aspiration in 7% and pulmonary hemorrhage in 5%. RDS was categorized into RDSI in 2%, RDSII in 3%, RDSIII in 13% and.

Also, [7], found that 68/68 patients with lung ultrasonography had RDS on the first day. LUS demonstrated a 100% sensitivity, specificity, PPV, and NPV for diagnosing RDS when compared to the CXR. In terms of detecting the persistence or clearance of RDS on the fifth day of follow-up, LUS outperformed CXR with 100% specificity and PPV, 90% sensitivity, and 90.2% NPV.

Our results are in agreement with [12], who described the ultrasound findings for NRDS; pleural line abnormalities, absent A-lines, and bilateral compact B-lines. Lung consolidation correlated with stages III and IV NRDS by CXR.

In concordance with results of [13], they also found that lung consolidation was found in severe NRDS (stages III and IV NRDS by CXR). While [9], noted that the most significant sign of RDS is lung consolidation, which can be detected in all individuals but whose severity is correlated with the grade of RDS. In mild RDS (stage II), consolidation is usually focal and limited to the subpleural area with or without air bronchograms. Compared to severe RDS (stages III and IV), the area of consolidation is extended with obvious air bronchograms.

[10], a high reliability of the approach in premature infants with RDS by showing that in 45 of 47 cases the same diagnosis of complication was diagnosed with LUS as with CXR. Partial pneumothorax was the subject of the two sole false negative findings. LUS had a 100% positive predictive value. Both the right and left hemithoraces showed a statistically significant difference in LUS observations between the anterior and posterior lung areas. In another metanalysis carried out by [14], it comprised nine studies involving 703 infants. LUS has a pooled specificity of 0.95 and a sensitivity of 0.99 (CI: 0.92-1.00). (CI: 0.87-0.98). For LUS, the areas under the curve were 0.99. (0.98-1.0). LUS had a considerable diagnostic

accuracy for NRDS, according to meta-regression. Ten papers totaling 887 neonates were included in this meta-analysis, which [15] also held. Significant variability was detected across the examined studies. Combining sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, and LUS for the diagnosis of NRDS and diagnostic odds ratio were 0.92 (95% confidence interval [CI], 0.89-0.94), 0.95 (95% CI, 0.93-0.97), 20.23 (95% CI, 8.54-47.92), 0.07 (95% CI, 0.03-0.14), and 455.30 (95% CI, 153.01-1354.79), in that order.

Conclusion:

LUS is a safe, non-invasive technology that can be used to diagnose RDS, monitor the effectiveness of treatment, and minimise the need for X-rays.

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