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ORIGINAL ARTICLE

Lung ultrasound as early diagnostic tool in neonatal respiratory distress syndrome (RDS)

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KEYWORDS

Respiratory distress syndrome (RDS);
Down score;
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Abstract *Aim of the work:* To study the value of lung ultrasound as early diagnostic tool in RDS.

Subjects and methods: Forty preterm neonatal patients were admitted to the neonatal intensive care unit in Madina national hospital suffering from respiratory distress syndrome (RDS). Diagnosis of RDS was based on clinical features, radiographic findings and arterial blood gases analysis. All patients were subjected to full maternal history including: age, parity, gravidity, and previous abortions, still births, neonatal deaths, and acute and/or chronic medical problems, thorough clinical examination including weight, length, head circumference and abdominal circumference, vital signs, systemic (neurological, cardiovascular and abdominal) and local examination, pulse oximetry, Down score at first 6 h of life. Laboratory investigations (complete blood count, C-reactive protein, random blood sugar, Blood culture, arterial blood gases, kidney and liver function, Serum electrolytes, plain chest X-ray (P.A. and lateral views) and chest ultrasound) were performed.

Results: A significant correlation was found between ultrasound and radiographic assessments of RDS but ultrasound tends to overestimate the diagnosis. From our study ultrasonography can be used as a diagnostic tool in the diagnosis of RDS and to follow up the effect of treatment.

Conclusions: Chest ultrasound cannot replace standard chest X ray in diagnosing potential causes of neonatal respiratory failure because of its tendency to over-diagnose RDS, but useful for excluding RDS and as a screening method for diagnosis of RDS.

Introduction

Neonatal respiratory distress syndrome (RDS) also known as hyaline membrane disease, is a condition of increasing respiratory distress, commencing at, or shortly after, birth and increases in severity until progressive resolution among the survivors, usually between the 2nd and 4th day [1]. It is due at least in part, to insufficiency of pulmonary surfactant and

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is mainly confined to preterm infants. RDS patients present with respiratory distress (tachypnea, grunting, recession and cyanosis) and respiratory failure. Edema is frequently seen on the 2nd day due to fluid retention and capillary leak. The diagnosis can be confirmed by X-ray showing ground glass appearance and air bronchograms, although these radiological features are not pathognomonic of RDS [2]. Enormous efforts have been made to understand the pathophysiology of RDS and to optimize the care of those infants, which has led to improvement in the morbidity and mortality. The mortality rate of RDS decreased by approximately 50% during the last decade with the advancement of surfactant therapy [3]. The diagnosis of RDS is usually based on the clinical picture and the chest X-ray, which expose the infant to ionized radiation [3]. Now, lung ultrasound is not included in the diagnostic work-up of neonatal respiratory disease. Only a few studies have addressed this topic [4].

Aim of the work

To establish the role of lung ultrasound as early diagnostic tool in RDS, hence reducing the number of chest X-ray exposures in the neonates.

Patients and methods

This study was conducted on 40 preterm neonates. They were delivered in Madina national hospital and were admitted in the Neonatal Intensive Care Unit Suffering from respiratory distress syndrome, during the period from October 2013 to October 2014. Twenty-seven neonates representing 67.5% were males and thirteen cases representing 32.5% were females. Fifteen were delivered vaginally and Twenty-five delivered by section. Their Gestational age (GA) ranged from 29 weeks to 35 weeks with a mean of 33 weeks. Their birth weight ranged from 1 kg to 2.5 kg with a mean of 1.6 kg. Diagnosis of RDS was based on clinical features, radiographic findings and arterial blood gas analysis.

Inclusion criteria:

- Preterm neonates (< 37 weeks) suffering from respiratory distress within the first 6 h of life.
- Birth weights appropriate for gestational age.

Exclusion criteria:

- Full term newborns.
- Preterm neonates suffering from respiratory distress after 6 h of life.
- Preterm admitted in NICU for other causes than respiratory distress syndrome e.g. congenital anomalies, neonatal sepsis, and birth trauma.

For all cases the following was done:

(1) Complete maternal history:
Full maternal history including: age, parity, gravidity, and previous abortions, still births, neonatal deaths, and acute and/or chronic medical problems.
Detailed perinatal history was obtained including antenatal history, drug intake, antepartum hemorrhage, premature rupture of membranes, duration of labor, mode of delivery, Apgar score at 1 & 5 min as well as methods and duration of resuscitation.

(2) Thorough clinical examination:
- Measurements: weight, length, head circumferences and abdominal circumference.
- Assessment of the gestational age using new Ballard score.
- Vital signs: temperature, pulse, respiratory rate and blood pressure.
- *System examination*:
  - Neurological evaluation including activity, fontanels and reflexes.
  - Cardiovascular: heart rate, rhythm, peripheral perfusion in both upper and lower limbs, heart sounds and murmurs.
  - Abdominal: umbilicus, hernia, liver, spleen, kidneys, voiding of urine and passage of stools.
  - Lungs: Respiratory rate, presence or absence of retractions and grunting, air entry, additional sounds.
  - Noninvasive oxygen monitoring, pulse oximetry.
  - Down score: the score at 12–18 h of age provided the best estimate of prognosis (see Table 1).
  - Score:
    - < 4 = follow up.
    - 4–7 = clinical respiratory distress; monitor arterial blood gases.
    - > 7 = respiratory failure [5].

(3) Laboratory investigations:
- Complete blood count.
- C-reactive protein.
- Random blood sugar.
- Blood culture.
- Blood gases: (pH-PCO_2-PO_2-HCO_3-BE).
- Kidney function tests (urea, creatinine).
- Liver function tests aspartate aminotransferase (AST) alanine aminotransferase (ALT).
- Serum electrolytes: Na^+, K^+, Ca^{++}.

(4) Chest radiography:
- Chest X-ray:
- Posterior anterior view was taken within 6th hours after birth.
- X-ray findings were classified according to severity into:
  - Mild RDS: hypovolemic lung reticulogranular mottling or without air bronchograms.

Table 1 Down score.

	0	1	2
Cyanosis	None	In room air	In 40% FIO2
Retractions	None	Mild	Severe
Grunting	None	Audible with stethoscope	Audible without stethoscope
Air entry	Clear	Decreased or delayed	Barely audible
Respiratory rate	Under 60	60–80	Over 80 or apnea

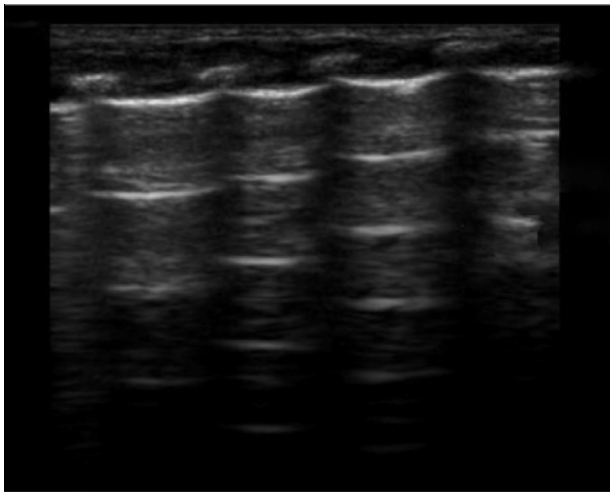

Figure 1 Normal ultrasonographic appearance of healthy neonatal lung.

- Severe RDS: bilateral confluent opacification of lungs.

(5) Chest ultrasonography:
- Chest ultrasound was done within six hours after birth using a commercially available GE logic 9 Ultrasound machine with either 5 MHZ convex probe or 9 MHZ superficial probe.
- U/S findings in respiratory distress syndrome:
  - Mild RDS: lung consolidation limited to subpleural region with or without air bronchogram, associated with pleural line abnormalities (coarse thickened pleural line).
  - Severe RDS: expanded lung consolidation with obvious air bronchogram, associated with pleural line abnormalities.

Statistical analysis

Statistical analysis was performed using statistical soft ware (SPSS, statistical package for scientific sciences, version 12 [6].

Results

See Fig. 1.

Discussion

Respiratory-distress syndrome (RDS) in the newborn is a major cause of neonatal mortality and morbidity. Although prematurity is the most important risk factor for RDS, the syndrome does not develop in many premature infants [7]. Chest X-ray is one of the most frequently requested radiological examinations in neonatal intensive care units (ICU), representing an essential tool in the diagnosis of pulmonary diseases in preterm and term neonates [8]. Chest ultrasonography has emerged in recent years as a very promising technique for the high sensibility it has shown in the detection of different lung and pleural pathological states [9]. Particularly, different studies have addressed the ultrasonographic appearance of RDS but non have yet been able to give a detailed characterization of the syndrome permitting a differential diagnosis from the ultrasonographic appearance of APE [10]. In the present study, the sex distribution was 27 male neonates (67.5%) and 13 females(32.5%) which revealed significant difference (p value < 0.013) (Table 2), this was in agreement with Mlay and Maitji (2000) who found that respiratory distress syndrome is more in males than females. Bindle et al. (2003) reported that the ratio between male and females in RDS is 2.8:1 .Regarding the mode of delivery, 15 patients (37.5%) were delivered vaginally and 25 patients (62.5%) were delivered by section, we found that RDS is significantly more common (p value < 0.013) in neonates delivered by cesarean section (Table 2). In agreement with the study done by Levine et al. (2001) who found that newborn delivered by cesarean section have a fivefold increase in the incidence of respiratory disorders and persistent pulmonary hypertension than those delivered vaginally. The weight of the neonate in our study ranged from 900 g to 2700 g with the mean of 1600 ± 435 g. Thirty-one neonates (77.5%) were weighing <2500 mg, 12 neonates (30%) were weighing <1500 g, 19 neonates (47.5%) were weighing 1500–2500 g and 9 neonates (22.5%) were weighing >2500 g. We found that RDS is significantly more common in low birth weight and very low birth weight (p value < 0.001) (Table 2). This in agreement with Levine et al. (2001) who reported results of the National Institute of Child Health and Human Development (NICHD) Neonatal Research Network study. Rates of RDS were 42% in infants weighing 501–1500 g, 71% in those 501–750 g, 54% in those 751–1000 g, 36% in those 1001–1250 g, and 22% in those 1251–1500 g. The mean gestational age (GA) in studied groups ranged from 28 weeks to 36 weeks with the mean 32.9 ± 2.057 weeks 33 weeks; the incidence and severity are related inversely to the gestational age of the infant. 31 neonates (77.5%) were <34 weeks gestation and 9 neonates

Table 2 Characteristics of studied groups.

Characteristics		No.	%
Sex	Male	27	67.5
	Female	13	32.5
Mode of delivery	Vaginal	15	37.5
	Cesarean	25	62.5
Characteristics		**Range**	**Mean ± SD**
Gestational age (week)		28.0–36.0	32.975 ± 2.057
Birth weight (kg)		0.9–2.7	1.681 ± 0.435
Apgar score at 1 min		3.0–6.0	4.075 ± 0.764
Apgar score at 5 min		5.0–8.0	6.600 ± 0.871

Table 3 Respiratory distress score (Down score) at presentation among studied groups.

Down score	No	%
<4	16	40
4–7	20	50
>7	4	10
Total	40	100

Table 4 Blood gases values at presentations.

	Range	Mean ± SD
PH	7.15–7.37	7.278 ± 0.060
$PaCO_2$ (mm Hg)	40.0–75.0	53.600 ± 6.883
PaO_2 (mm Hg)	35.23–51.23	42.81 ± 12.029
HCO_3 (mmol/L)	5.0–26.0	20.725 ± 3.374
B.E. (mmol/L)	13.0–3.0	2.6 ± 4.873

Table 5 Chest radiography grades at presentation.

Chest radiography grades	No	%
Mild	22	55
Severe	18	45
Total	40	100
t-Test	2.81	
p-Value	>0.05	

(22.5%) were from 34 to 36 weeks gestation which revealed that RDS is significantly more common in neonates <34 weeks gestation (p value < 0.001) (Table 2). In accordance with our study Minino et al. (2006) stated that the incidence of RDS occurs in 60% of babies born at less than 28 weeks gestation, 30% of those born at 28–34 weeks and fewer than 5% of those born after 34 or more weeks. Full-term pregnancy is defined as lasting between 37 and 42 weeks,

Table 6 Chest ultrasound grades at presentation.

Chest radiography grades	No	%
Mild	17	42.5
Severe	23	57.5
Total	40	100
t-Test	3.61	
p-Value	>0.05	

Table 7 Comparison between radiographic findings grades and ultrasonographic finding grades.

Chest X-ray		Chest U/S		*F*-value	*p*-Value
		Mild	Severe		
Mild					
No	22	17	5	2.223	>0.05
%	100	77.3	22.7		
Severe					
No	18	0	18	1.5647	>0.05
%	100	00	100		

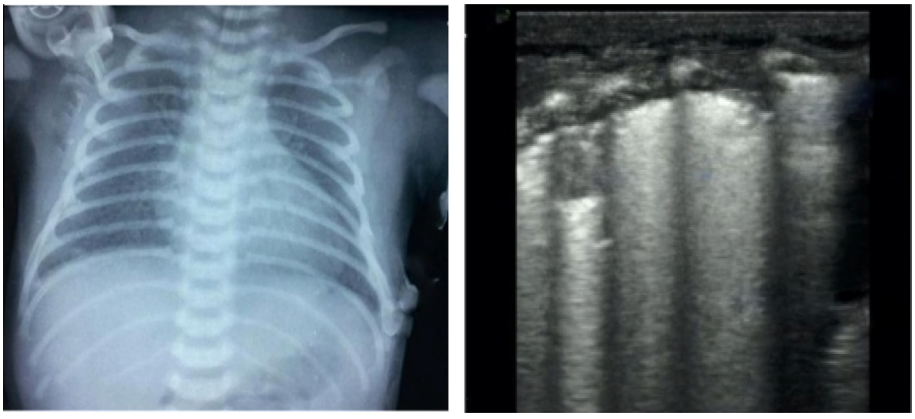

Figure 2 X-ray and ultrasonographic appearance of mild RDS.

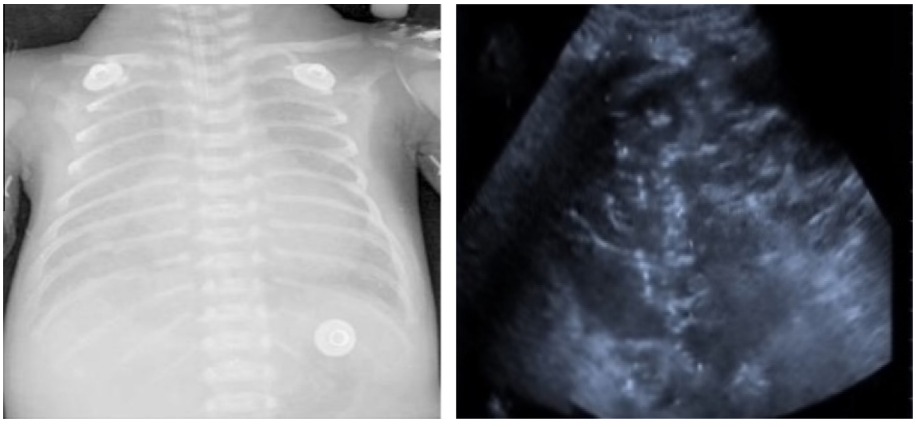

Figure 3 X-ray and ultrasonographic appearance of severe RDS.

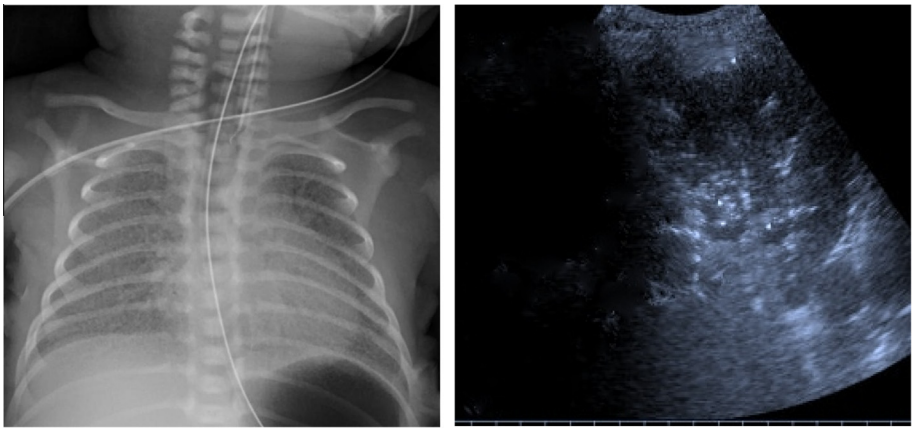

Figure 4 A case of severe RDS by ultrasonography proved to be mild RDS by X-ray.

but babies born after 35 weeks rarely develop RDS. Regarding apgar score among studied cases, they ranged from 3 to 6 with the mean 4.075 ± 0.764 at 1st minute and ranged from 5 to 8 with mean 600 ± 0.871 at 5th minute which revealed normal result (Table 2). This is in agreement with Hamvas (2006) who stated that apgar score is normal in RDS. Regarding respiratory distress score (Down score), all patients suffered from respiratory distress at presentations with Down score <4 in 16 neonates (40%), from 4–7 in 20 neonates (20%) and >7 in 14 neonates (10%) (Table 3). This is in agreement with Vidyasagar et al. (1977) who ruled that, Down score <4 = follow up, 4–7 = clinical respiratory distress and need monitoring of arterial blood gases while Down score >7 = respiratory failure. The arterial blood gases (ABG) of studied group showed: pH ranged from 7.15 to 7.37 with mean of 7.278 ± 0.060, $PaCO_2$ ranged from 40.00 mmHg to 75.00 mmHg with mean of 53.600 ± 6.883 mmHg, PaO_2 ranged from 35.23 mmHg to 51.23 mmHg with mean of 42.81 ± 12.029 mmHg, HCO_3 ranged from 15.00 mmol/L to 26.00 mmol/L with mean of 20.725 ± 3.374 mmol/L, base excess (BE) ranged from −13.00 mmol/L to 3.00 mmol/L with mean of −2.600 ± 4.8 73 mmol/L. The detailed results of ABG revealed Thirty-six patients (90%) had respiratory or mixed acidosis, 32 patients (80%)had hypoxemia ($paO_2 \leqslant 50$ mmHg), 31 patients (77.5%) had hypercapnia ($PaCO_2 > 45$ mmHg), and 31 patients (77.5%) had combined acidosis and hypercapnia (Table 4). In concordance with our results Wells et al. (2005) found that ABG showed respiratory and metabolic acidosis with hypoxemia, respiratory acidosis due to alveolar atelectasis and/or over distension of terminal airways. Metabolic acidosis is primarily lactic acidosis which results from poor tissue perfusion and anaerobic metabolism. Hypoxia occurred from right to left shunting of blood through pulmonary vessels, PDA and/or foramen ovale. All the neonates included in our study had respiratory distress syndrome according to the clinical assessment (Down score), arterial blood gases and chest radiography. Regarding chest radiography finding/grades at presentation this study revealed that mild RDS was present in 22(55%) patients while severe RDS was present in 18(45%) patients (Table 5, Figs. 2 and 3). Bober et al. (2006) found in their study that chest radiography has been considered to be the standard diagnostic tool for RDS. In clinical practice, there is a continuous need for exposing a neonate to roentgen radiation in order to evaluate effectiveness of administrated therapy and this carries the risk of long-term adverse effects. Moreover in some clinical circumstances a chest X-ray is not useful for making the final diagnosis. One may encounter this in cases of congenital pneumonia caused by group B hemolytic streptococci, where X-ray findings imitate those seen in severe RDS. As regarding chest ultrasonography findings/grades at presentation these results revealed that mild RDS was present in 17(42.5%) patients while severe RDS was present in 23(57.5%) patients (Table 6, Figs. 2 and 3). However, Bober et al. (2006) found that lack of contraindications for ultrasound examination, its low costs and patient safety have contributed a lot to the clinical and diagnostic utility .On the other hand Bedetti et al. (2006) demonstrated that the ability of unexperienced doctors to detect the presence of ultrasound is reached after training with less than 10 clinical examinations and total time of 30 min. Gargani et al. (2007) stated that lung ultrasound at birth may detect infants with RDS before clinical deterioration, and demonstrated that ultrasound abnormalities on lung appearance precede PaO_2/FiO_2 changes. As regarding the comparison between chest radiography finding/grades and chest ultrasonography findings/grades at presentation, chest X-ray diagnosed mild RDS in 22(55%) patients while, chest ultrasound diagnosed mild RDS in 17(77.3%) patients, and also chest X-ray diagnosed severe RDS in 18(45%) patients also chest ultrasound diagnosed severe RDS in 18(100%) patients, these results revealed non significant differences between both of them, also these results mean ultrasonography tends to overestimate the diagnosis of RDS i.e. some mild RDS cases by chest X-ray diagnosed as severe while all severe cases by chest X-ray diagnosed as severe by ultrasound (Table 7 and Fig. 4).

Conclusions

(1) A significant correlation was found between ultrasound and radiographic assessments of RDS.
(2) Chest Ultrasound cannot replace standard chest X-ray in diagnosing neonatal RDS because of its tendency to over-estimate RDS, but useful for its exclusion.
(3) Chest Ultrasound may be considered as screening method for diagnosis of RDS.

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