STUDY OF THE ACCURACY OF CHEST ULTRASONOGRAPHY VERSUS CHEST RADIOGRAPHY IN THE DIAGNOSIS OF NEONATAL RESPIRATORY DISORDERS

By

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ABSTRACT

Background: *Respiratory distress is one of the most common reasons for admission to the neonatal intensive care unit. Differentiation of the causes of respiratory distress is important for the neonatologist as treatment differs with different etiologies. Conventionally, chest X-ray has been used to identify the etiology of neonatal respiratory distress but these modalities have several limitations which make their use in neonatal intensive care unit (NICU) questionable. In recent decades, there has been increased use of lung ultrasound to identify and differentiate the etiologies of neonatal respiratory distress.*

Objective: *this study was designed to determine the diagnostic accuracy of lung ultrasonography in identification of neonatal respiratory disorders in comparison with chest radiography.*

Patients and Methods: *this is a cross sectional comparative study that was carried out during the period from September 2019 to March 2021 on 100 neonates who were suffering from respiratory distress and were admitted to neonatal intensive care unit at Bab-Elshereya University Hospital, they were selected by simple random method. Each included patients were submitted to medical history taking, complete clinical examination, laboratory investigations, chest radiography and chest ultrasonography.*

Results: *In the present work, males were 62/100 (62%) while; females were 38/100 (38%). Mean gestational age was 36.05 ± 2.70 weeks and mean birth weight was 2720.40 ± 678.52 grams. Patients were finally diagnosed according to clinical, laboratory and radiological findings. From the transient tachypnea of newborn (TTN) patients (36), 33 were diagnosed by chest ultrasound and 29 were diagnosed by chest radiography. Patients with respiratory distress syndrome (RDS) (29 patients), 28 were diagnosed by chest ultrasound and 26 were diagnosed by chest radiography. From the cases with neonatal pneumonia (16 patients), 14 were diagnosed by chest ultrasound and 13 were diagnosed by chest radiography. From the finally diagnosed meconium*

aspiration syndrome (MAS) 14 patients, 12 were diagnosed by chest ultrasound and 11 were diagnosed by chest radiography. All cases with pneumothorax (4 cases) and congenital diaphragmatic hernia (CDH) (one case) were diagnosed equally by chest ultrasound and chest radiography.

Conclusion: *Chest ultrasound is a simple, safe, low-cost and widely used tool that can be done by clinician with no need for too much training with high specificity and sensitivity. The accuracy of chest ultrasonography in screening and diagnosis of neonatal respiratory disorders is the same as chest radiography (chest X-ray).*

Keywords: *Respiratory distress, Chest X ray, Chest ultrasound.*

INTRODUCTION

Respiratory distress is one of the most common reasons for admission to the neonatal intensive care unit. Respiratory distress is common in the early neonatal period, occurring in up to 7% of newborn infants. Fifteen percent of term infants and 29% of late preterm infants need admission to neonatal intensive care units due to respiratory distress **(Edwards et al., 2013)**. Respiratory distress is defined as difficulty in achieving adequate oxygenation despite increasing the breathing efforts. It usually presents as increased breathing rate more than 60 breath/minute, nasal flaring, chest wall retractions, grunting and may progress to respiratory failure if not early recognized and managed **(Reuter et al., 2014)**.

Transient tachypnea of newborn (TTN), respiratory distress syndrome (RDS), meconium aspiration syndrome (MAS) and pneumonia are the most common etiologies of respiratory distress in newborn, due to their similar clinical presentations, it is often difficult to differentiate one from the other **(Brun et al., 2014)**.

Transient tachypnea of the newborn (TTN) is a parenchymal lung disease. It is mainly characterized by presence of lung oedema which results from delayed absorption of fetal lung fluids. It is considered the most common cause of respiratory distress in the early neonatal period, affecting 0.5% to 4% of all term and late preterm neonates. It usually present among the early few hours after birth with symptoms of respiratory distress. Studies have consistently demonstrated that risk factors for TTN include delivery by CS, maternal diabetes, and male sex **(Jain et al., 2009)**.

Respiratory distress syndrome (RDS) is one of the most common causes of neonatal intensive care unit admissions. It occurs in 60-

80% of infants less than 28 week of gestational age, in 15-30% of those between 32 and 36 weeks, in about 5% beyond 37 weeks, and rarely at term **(Mally et al., 2013)**. Despite of increased incidence of RDS in premature infants, other risk factors could affect the development and the severity of RDS such as gender, ethnicity and maternal diseases **(Jo, 2014)**.

Congenital pneumonia is another but a less common cause of respiratory distress presenting in the early neonatal period. Causative organisms include group B streptococci (GBS), streptococcus pneumonia, staphylococcus aureus and gram-negative enteric rods. In contrast to TTN and RDS, congenital pneumonia takes time to develop, with respiratory manifestations occurring hours to days after birth **(Hermansen and Lorah, 2007)**.

Meconium aspiration syndrome is a common cause of severe respiratory distress in neonates especially in full-term or post-term infants, with an associated highly variable morbidity and mortality. Meconium aspiration syndrome accounts for about 10% of all cases of respiratory failure with a 39% mortality rate in developing and newly industrialized countries **(Swarnam et al., 2012)**.

Radiographs are considered gold standard in understanding the etiology of respiratory distress in newborns. However excess exposure to radiation in a growing neonate early in life may have long term consequences. So there is a need for a non-invasive, bedside test, more babies friendly, and even if performed repetitively it is safe. Chest ultrasonography appears to be the ideal choice in diagnosing the etiology of respiratory distress in newborn **(Rachuri et al., 2017)**.

Lung ultrasound is not included in the diagnostic work-up of respiratory distress in the early neonatal period **(Liu et al., 2014)**. However, after improvement of the chest ultrasound techniques, the lung ultrasound became widely used by neonatologists for bedside diagnosis of respiratory problems **(Raimondi et al., 2012)**. Several studies have demonstrated that lung ultrasonography is an accurate and reliable technique for the diagnosis of neonatal lung diseases. Other advantages of lung ultrasonography include that it is non-ionizing, easy to operate, and the imaging is performed in real-time, thus making it as a potential tool to be used in neonatal intensive care units **(Chen et al., 2017)**.

AIM OF THE WORK

This study aimed to determine the diagnostic accuracy of chest ultrasonography in identification of neonatal respiratory disorders in comparison with chest radiography.

Ethical Consideration:

1. A written informed consent was obtained from parents or the legal guardians before the study.
2. An approval by the local ethical committee was obtained before the study.
3. The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.
4. All the data of the patients and results of the study are confidential & the patients have the right to keep it.

Financial Disclosure/ Funding:

The authors received no financial support for the research, authorship and/ or publications of this article.

PATIENTS AND MATERIALS

This cross sectional comparative study included a total of 100 neonates who presented with respiratory distress and were admitted to NICU at Bab-Elshereya University Hospital, during the period from September 2019 to March 2021, they were selected by simple random method.

Inclusion criteria:

1. Patients: all neonates with respiratory distress as defined by tachypnea (RR >60 C/minute), nasal flaring, retractions and/or grunting.
2. Age: neonatal period (neonates from birth till 28 day_old).
3. Gestational age: 32 weeks or more.

Exclusion criteria:

1. Other causes of respiratory distress e.g. Central nervous system: as perinatal asphyxia, Cardiovascular system: as congenital heart disease, etc…
2. Age: > 28 day_old infants.
3. Gestational age: < 32 weeks.
4. Apparent signs suggesting chromosomal abnormalities and major malformations.
5. A baby with a bleeding diathesis.

Methodology:

Each enrolled neonate subjected to the following:

1. Full history taking:

Gestational age, gender and birth weight. Full maternal history including: age, parity, gravidity and previous abortions, still births &/or neonatal deaths. Detailed perinatal history including maternal acute and/or chronic medical problems, maternal drug intake, maternal fever, maternal urinary tract infections (UTIs), premature rupture of membranes (PROM), history of chorioamnionitis, antepartum hemorrhage, duration of labor and mode of delivery. Apgar score at 1&5 minutes as well as methods and duration of resuscitation. Full detailed medical history especially of pulmonary symptoms including cough, dyspnea, feeding difficulties and fever. Family history: Consanguinity and similar conditions in other siblings.

2. Thorough clinical examination:

- Assessment of the gestational age using New Ballard Score.
- General examinations: including weight, length, head circumference, and vital signs assessment as temperature, pulse, respiratory rate and blood pressure.
- Local examination:
  - Chest examination: including assessment of respiratory rate, chest retractions, nasal flaring, grunting and cyanosis. Chest auscultation was done and auscultatory findings as intensity of air entry breathe sounds and presence of adventitious sounds was assessed.
  - Neurological, cardiac and abdominal examination.

3. Investigations:

A. Laboratory:

- Complete blood count by Sysmex x5-800 (Sysmex Corporation, Japan).
- C-reactive protein (CRP) by latex agglutination test (TURBOX plus Orion Diagnostica, Finland).
- Blood urea, serum creatinine, ALT and AST by BIOBASE, Automatic Chemistry Analyzer (BIOBASE Corporation, China).
- PT, PTT and INR by BIOBASE Auto Coagulation Analyzer BK1000B (BIOBASE Corporation, China).
- Arterial blood gases by Cobas b 221 system, USA.
- Blood cultures 1-3 ml blood were collected from those with suspected sepsis in commercially available

Paediatrics blood culture BACTEC vial (Becton, Dickinson and Company Sparks, Ireland) under complete aseptic technique (Chessbrough, 2000) and were placed into the BACTEC 9050 then incubated for at least 7 days according to the manufacturers protocol.

B. Radiological:

- **Chest X-ray:**

- Chest X ray was performed while the patient is in supine position as anteroposterior view, lateral view was done in selected cases using portable x-ray device (Primax, model: R108, Germany).

All Studied neonates with respiratory distress was classified according to medical history, clinical examination, laboratory investigations and chest radiography findings into five groups; Group 1: Transient tachypnea of newborn (TTN), Group 2: Respiratory distress syndrome (RDS), Group 3: Neonatal pneumonia, Group 4: Meconium aspiration syndrome (MAS) and Group 5: Others (congenital anomalies of the lung, etc.…).

- **Chest Ultrasonography:**

Chest ultrasound was done for all patients by using ultrasound machine (a SonoScape, SSI, model: L743, China) at the Ultrasound unit in Chest diseases department, Bab-Elshereya University hospital in Cairo, AL-Azhar University.

Chest ultrasound was performed by the candidate who was blinded to the clinico-laboratory and radiological data of included cases, using Basic (B-mode) real time US and sometimes the Motionless (M-mode) imaging when needed as in the evaluation of pneumothorax. A high-frequency 5–12 MHz linear array probe was used and the patients was examined by transthoracic approach using twelve region method in which each hemithorax was divided into 3 areas anterior, lateral and posterior. Anterior area is located between parasternal line and anterior axillary line, lateral one is between anterior and posterior axillary lines while posterior area is beyond the posterior axillary line to the midline posteriorly. Each area is further divided into upper and lower halves, so each side of the chest contains six zones. Chest ultrasound was performed while the patient in the supine, prone, or lateral decubitus position. Images are obtained in the transverse, longitudinal, inclined transverse or inclined

longitudinal planes to maximize demonstration of the lesion.

Chest ultrasound was assessing mainly the following: pleural line abnormalities, sliding sign, A lines, B lines, alveolar interstitial syndrome (AIS), double lung point, white lung, regular consolidations, irregular consolidations, air bronchogram, lung point, seashore sign and barcode sign.

Chest ultrasonography was done immediately within a maximum gap of not more than 4 hours after performing chest radiography for all cases. If surfactant was given, it was always after obtaining a chest x ray and chest ultrasonography.

The diagnostic findings detected by chest ultrasound were correlated with the radiological findings of chest radiography to detect the diagnostic accuracy for each of them in diagnosis of neonatal respiratory disorders.

Statistical analysis:

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when parametric and median, inter-quartile range (IQR) when data found non-parametric. Also qualitative variables were presented as number and percentages.

The comparison between groups regarding qualitative data was done by using Chi-square test and/or Fisher exact test when the expected count in any cell found less than 5. The comparison between groups regarding quantitative data and non-parametric distribution was done by using Mann-Whitney test.

The comparison between more than two groups regarding quantitative data and parametric distribution was done by using One Way ANOVA test while with non-parametric distribution was done by using Kruskall-Wallis test.

Receiver operating characteristic curve (ROC) was used to assess the best cut off point with its sensitivity, specificity, positive predictive value, negative predictive value and area under curve (AUC) of the studied marker.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

P-value>0.05: Non significant (NS).

P-value<0.05: Significant (S).

P-value<0.01: Highly significant (HS).

RESULTS

This study included 100 neonates (62 males and 38 females) having respiratory distress and admitted to neonatal intensive care unit at Bab-Elshereya University Hospital, during the period from September 2019 to march 2021.

Table (1): Classification of studied patients according to final diagnosis*

Final diagnosis	Total no. = 100
Transient tachypnea of newborn (TTN) (group 1)	36 (36.0%)
Respiratory distress syndrome (RDS) (group 2)	29 (29.0%)
Neonatal pneumonia(group 3)	16 (16.0%)
Meconium aspiration syndrome (MAS) (group 4)	14 (14.0%)
Pneumothorax(group 5)	4 (4.0%)
Congenital diaphragmatic hernia (CDH) (group 6)	1 (1.0%)

Data expressed as number (percentage).
*the patients were finally diagnosed according to clinical, laboratory and radiological findings.

Table (2): Demographic data of different studied groups included in the study

		Transient tachypnea of newborn (TTN) (group 1)	Respiratory distress Syndrome (RDS) (group 2)	Neonatal pneumonia (group 3)	Meconium aspiration syndrome (MAS) (group 4)	Pneumothorax (group 5)	Test value	P-value	Sig.
		No. = 36	No. = 29	No. = 16	No. = 14	No. = 4			
Gender	Female	12 (33.3%)	12 (41.4%)	7 (43.8%)	6 (42.9%)	1 (25.0%)	1.115*	0.892	NS
	Male	24 (66.7%)	17 (58.6%)	9 (56.2%)	8 (57.1%)	3 (75.0%)			
Gestational Age (weeks)	Mean ± SD	37.83 ± 0.88	32.59 ± 0.78	36.06 ± 1.98	38.57 ± 1.91	35.75 ± 2.22	78.512•	0.000	HS
	Range	37 – 40	32 – 34	32 – 39	35 – 42	33 – 38			
Birth Weight (grams)	Mean ± SD	3238.89 ± 388.06	1904.14 ± 281.00	2710.63 ± 532.11	3075.00 ± 351.78	2575.00 ± 512.35	51.311•	0.000	HS
	Range	2750 – 4050	1550 – 2530	1650 – 3600	2400 – 3600	1900 – 3100			

Post hoc analysis and multi-comparison between groups										
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Gestational Age (weeks)	0.000	0.000	0.080	0.004	0.000	0.000	0.000	0.000	0.674	0.000
Birth Weight (grams)	0.000	0.000	0.183	0.002	0.000	0.000	0.002	0.012	0.533	0.025

Data expressed as mean ± SD except gender expressed as number (percentage).
P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant, *: Chi-square test; •: One Way ANOVA test; ≠: Kruakal-Wallis test
P1: TTN Vs RDS
P2: TTN Vs Congenital pneumonia
P3: TTN Vs MAS
P4: TTN Vs Pneumothorax
P5: RDS Vs Congenital pneumonia
P6: RDS Vs MAS
P7: RDS Vs Pneumothorax
P8: Congenital pneumonia Vs MAS
P9: Congenital pneumonia Vs Pneumothorax
P10: MAS Vs Pneumothorax

Table (2): demonstrates that there is statistically high significant difference between different studied groups regarding gestational ages and birth weight while regarding gender there was no statistically significant differences.

Table (3): Clinical characteristics of different studied groups included in the study

		Transient tachypnea of newborn (TTN) (group 1)	Respiratory distress Syndrome (RDS) (group 2)	Neonatal pneumonia (group 3)	Meconium aspiration syndrome (MAS) (group 4)	Pneumothorax (group 5)	Test value	P-value	Sig.
		No. = 36	No. = 29	No. = 16	No. = 14	No. = 4			
Inspection	RD grade I	3 (8.3%)	3 (10.3%)	2 (12.5%)	1 (7.1%)	0 (0.0%)	0.769*	0.942	NS
	RD grade II	9 (25.0%)	5 (17.2%)	3 (18.8%)	3 (21.4%)	1 (25.0%)	0.675*	0.954	NS
	RD grade III	16 (44.4%)	9 (31.0%)	5 (31.2%)	4 (28.6%)	1 (25.0%)	2.126*	0.713	NS
	RD grade IV	8 (22.2%)	12 (41.4%)	6 (37.5%)	6 (42.9%)	2 (50.0%)	3.938*	0.414	NS
Equal airentry	No	19 (52.8%)	25 (86.2%)	13 (81.2%)	11 (78.6%)	4 (100.0%)	12.207*	0.016	S
	Yes	17 (47.2%)	4 (13.8%)	3 (18.8%)	3 (21.4%)	0 (0.0%)			
Diminished air entry	No	17 (47.2%)	4 (13.8%)	3 (18.8%)	3 (21.4%)	0 (0.0%)	12.207*	0.016	S
	Yes	19 (52.8%)	25 (86.2%)	13 (81.2%)	11 (78.6%)	4 (100.0%)			
Crepitation	No	36 (100.0%)	23 (79.3%)	8 (50.0%)	8 (57.1%)	4 (100.0%)	23.401*	0.000	HS
	Yes	0 (0.0%)	6 (20.7%)	8 (50.0%)	6 (42.9%)	0 (0.0%)			

Post hoc analysis and multi-comparison between groups

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Equal air entry	0.004	0.051	0.095	0.070	0.660	0.404	0.428	0.856	0.882	0.310
Diminished air entry	0.004	0.051	0.095	0.070	0.660	0.404	0.428	0.856	0.882	0.310
Crepitation	0.004	0.000	0.000	–	4.133	0.129	0.315	0.696	0.068	0.109

Data expressed as number (percentage).
P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant
*: Chi-square test
P1: TTN Vs RDS
P2: TTN Vs Congenital pneumonia
P3: TTN Vs MAS
P4: TTN Vs Pneumothorax
P5: RDS Vs Congenital pneumonia
P6: RDS Vs MAS
P7: RDS Vs Pneumothorax
P8: Congenital pneumonia Vs MAS
P9: Congenital pneumonia Vs Pneumothorax
P10: MAS Vs Pneumothorax

Table (3): demonstrates that there is statistically significant difference between group 1 and group 2 as regard air entry, with no statistically significant difference between other groups.

Table (4): Management plan and outcome data of different studied groups included in the study

		Transient tachypnea of newborn (TTN) (group 1)	Respiratory distress Syndrome (RDS) (group 2)	Neonatal pneumonia (group 3)	Meconium aspiration syndrome (MAS) (group 4)	Pneumothorax (group 5)	Test value	P-value	Sig.
		No. = 36	No. = 29	No. = 16	No. = 14	No. = 4			
Nasal pronge	No	21 (58.3%)	21 (72.4%)	10 (62.5%)	5 (35.7%)	2 (50.0%)	5.528*	0.237	NS
	Yes	15 (41.7%)	8 (27.6%)	6 (37.5%)	9 (64.3%)	2 (50.0%)			
Continuous positive airway pressure (CPAP)	No	16 (44.4%)	17 (58.6%)	12 (75.0%)	14 (100.0%)	4 (100.0%)	17.224*	0.002	HS
	Yes	20 (55.6%)	12 (41.4%)	4 (25.0%)	0 (0.0%)	0 (0.0%)			
Mechanical ventilation (MV)	No	35 (97.2%)	20 (69.0%)	10 (62.5%)	9 (64.3%)	2 (50.0%)	14.091*	0.007	HS
	Yes	1 (2.8%)	9 (31.0%)	6 (37.5%)	5 (35.7%)	2 (50.0%)			
Duration of respiratory support (days)	Median (IQR)	3 (3 – 4)	6 (5 – 8)	8 (7 – 10.5)	5.5 (5 – 10)	9 (7.5 – 11)	68.990≠	0.000	HS
	Range	2 – 6	4 – 16	6 – 11	4 – 12	7 – 12			
Outcome	Improvement	36 (100.0%)	27 (93.1%)	14 (87.5%)	13 (92.9%)	3 (75.0%)	6.072*	0.194	NS
	Death	0 (0.0%)	2 (6.9%)	2 (12.5%)	1 (7.1%)	1 (25.0%)			

Post hoc analysis and multi-comparison between groups

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Continuous positive airway pressure (CPAP)	0.256	0.041	0.000	0.035	0.272	0.005	0.107	0.044	0.264	–
Mechanical ventilation (MV)	0.002	0.001	0.001	0.001	0.660	0.759	0.451	0.920	0.648	0.605
Duration of respiratory support (days)	0.000	0.000	0.000	0.001	0.010	0.780	0.053	0.042	0.472	0.102

Data expressed as number (percentage) except duration of respiratory support expressed as median (range).
P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant
*: Chi-square test; ≠: Kruakal-Wallis test
P1: TTN Vs RDS
P2: TTN Vs Congenital pneumonia
P3: TTN Vs MAS
P4: TTN Vs Pneumothorax
P5: RDS Vs Congenital pneumonia
P6: RDS Vs MAS
P7: RDS Vs Pneumothorax
P8: Congenital pneumonia Vs MAS
P9: Congenital pneumonia Vs Pneumothorax
P10: MAS Vs Pneumothorax

Table (4): demonstrates that there is statistically highly significant difference between studied groups regarding respiratory support (Continuous positive airway pressure and Mechanical ventilation) and their duration. Regarding respiratory support with nasal prongs and outcome data there was no statistically significant differences between different studied groups.

Table (5): Comparison between chest X-ray findings and chest ultrasound findings in diagnosis of different studied groups included in the study

	Chest X ray	Chest ultrasound	Test value	P-value	Sig.	Kappa agreement (95% CI)
	No. (%)	No. (%)				
Transient tachypnea of newborn (TTN) (group 1)	29 (29.0%)	33 (33.0%)	0.374*	0.541	NS	0.813 (0.690 to 0.937)
Respiratory distress syndrome (RDS) (group 2)	26 (26.0%)	28 (28.0%)	0.101*	0.751	NS	0.899 (0.801 to 0.996)
Neonatal pneumonia (group 3)	13 (13.0%)	14 (14.0%)	0.043*	0.836	NS	0.786 (0.606 to 0.966)
Meconium aspiration syndrome (MAS) (group 4)	11 (11.0%)	12 (12.0%)	0.049*	0.825	NS	0.853 (0.690 to 1.000)
Pneumothorax (group 5)	4 (4.0%)	4 (4.0%)	0.000*	1.000	NS	1.000 (1.000 to 1.000)
Congenital diaphragmatic hernia (CDH) (group 6)	1 (1.0%)	1 (1.0%)	0.000*	1.000	NS	1.000 (1.000 to 1.000)

Data expressed as number (percentage).
P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant
*: Chi-square test

Table (5): demonstrates that no statistical significant difference between chest x ray findings and chest ultrasound findings in diagnosis of different studied groups included in the study.

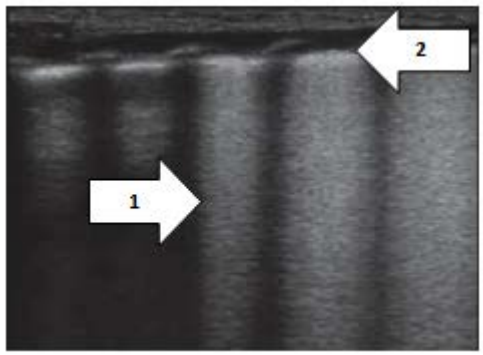

Figure (1): Chest ultrasound of a case with TTN showing double lung point sign (Arrow 1) and thickened pleural line (Arrow 2).

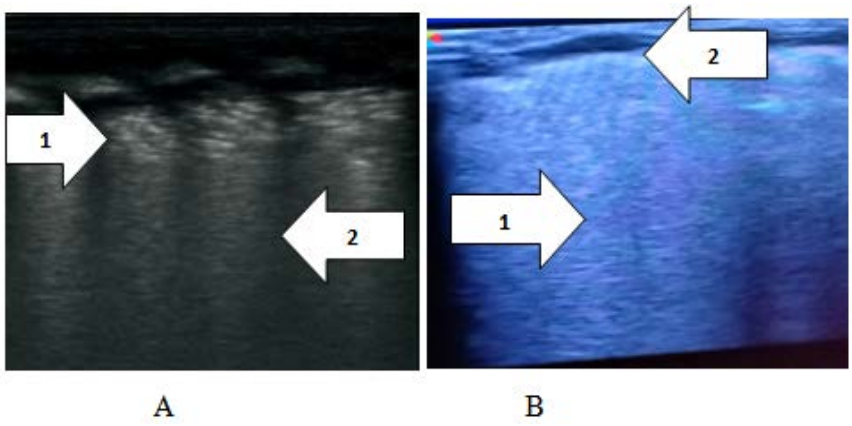

Figure (2): A) Chest ultrasound for RDS patient showing absent A lines, regular consolidations with air bronchogram (Arrow 1) and intervening alveolar interstitial syndrome (AIS) (Arrow 2). B) Chest ultrasound of RDS case showing compacted B-lines (Arrow 1) and pleural line abnormalities (Arrow 2).

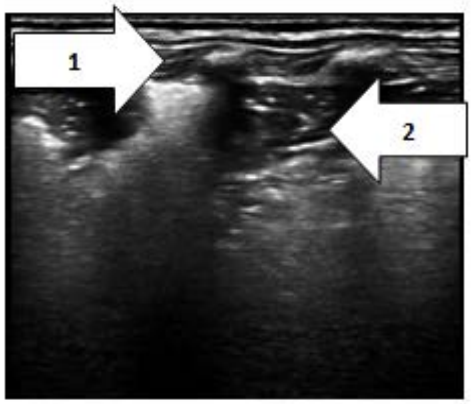

Figure (3): Chest ultrasound for neonatal pneumonia patient showing deformed pleural line (Arrow 1) and irregular consolidations with air bronchogram (Arrow 2).

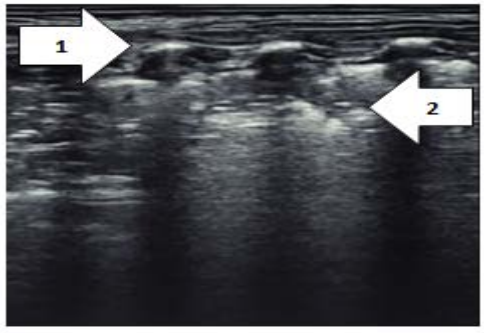

Figure (4): Chest ultrasound for MAS patient showing disrupted pleural line (Arrow 1), absent A lines, irregular consolidations with air bronchogram (Arrow 2).

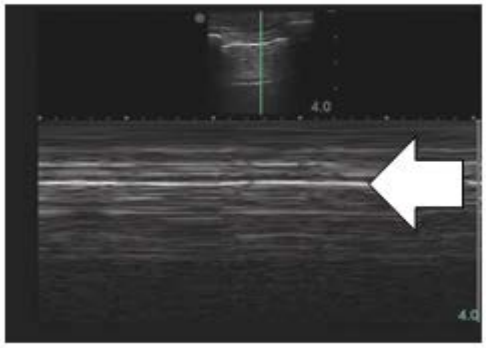

Figure (5): Chest ultrasound for pneumothorax patient showing barcode or stratosphere sign in M mode.

Table (6): Comparison between chest X-ray findings and chest ultrasound findings in relation to final diagnosis among patients.

	Final diagnosis*	Chest X-ray	Chest Ultrasound	Test value	P-value	Sig.
	No. (%)	No. (%)	No. (%)			
Not diagnosed	0 (0.0%)	16 (16.0%)	8 (8.0%)	17.391*	0.000	HS
Transient tachypnea of newborn (TTN) (group 1)	36 (36.0%)	29 (29.0%)	33 (33.0%)	1.121*	0.571	NS
Respiratory distress syndrome (RDS) (group 2)	29 (29.0%)	26 (26.0%)	28 (28.0%)	0.233*	0.890	NS
Neonatal pneumonia (group 3)	16 (16.0%)	13 (13.0%)	14 (14.0%)	0.380*	0.827	NS
Meconium aspiration syndrome (MAS) (group 4)	14 (14.0%)	11 (11.0%)	12 (12.0%)	0.432*	0.806	NS
Pneumothorax (group 5)	4 (4.0%)	4 (4.0%)	4 (4.0%)	0.000*	1.000	NS
Congenital diaphragmatic hernia (CDH) (group 6)	1 (1.0%)	1 (1.0%)	1 (1.0%)	0.000*	1.000	NS

Data expressed as number (percentage).

*the patients were finally diagnosed according to clinical, laboratory and radiological findings.

Table (6): demonstrates that there is no statistical significant difference between final diagnosis, chest US findings and chest x ray findings in diagnosis of neonatal respiratory disorders with higher sensitivity of chest ultrasound than chest x ray in diagnosis of most of them.

Table (7): Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of chest ultrasound findings in diagnosis of different studied groups included in the study in comparison with chest X-ray findings

	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Accuracy
Transient tachypnea of newborn (TTN) (group 1)	27	65	6	2	93.1%	91.5%	81.8%	97.0%	0.920
Respiratory distress syndrome (RDS) (group 2)	25	71	3	1	96.2%	95.9%	89.3%	98.6%	0.960
Neonatal pneumonia (group 3)	11	84	3	2	84.6%	96.6%	78.6%	97.7%	0.950
Meconium aspiration syndrome (MAS) (group 4)	10	87	2	1	90.9%	97.8%	83.3%	98.9%	0.970
Pneumothorax (group 5)	4	96	0	0	100.0%	100.0%	100.0%	100.0%	1.000
Congenital diaphragmatic hernia (CDH) (group 6)	1	99	0	0	100.0%	100.0%	100.0%	100.0%	1.000

Data expressed as number (percentage).
Abbreviations: TP: true positive, TN: true negative, FP: false positive, FN: false negative, PPV: positive predictive value, NPV: negative predictive value.

DISCUSSION

In recent years, lung ultrasound has strengthened its role in the evaluation of many neonatal diseases **(Liu, 2014)**. This supported by the fact that neonates have a thinner thoracic wall and smaller width of the thorax and lung volume, which enables a better image quality and visualization of almost the entire surface of the lungs when compared to the adult population **(Bedetti et al., 2006)**. Lung ultrasound has been increasingly used as a point-of-care method in recent years, it has numerous advantages compared to traditional imaging tools such as chest X-ray (radiography): it is faster and portable, does not use ionizing radiation, is performed by the same physician who cares for the patient, and can be repeated to follow the progress of the disease and the response to treatment. There is a large body of evidence that lung ultrasound has an excellent diagnostic effectiveness compared to chest X-ray, not only in adults and children, but also in neonates **(Corsini et al., 2020)**.

In the present study, according to final diagnosis, neonatal

respiratory disorders included in our study showed 36 (36%) cases with transient tachypnea of newborn (TTN), 29 (29%) cases with respiratory distress syndrome (RDS), 16 (16%) cases with neonatal pneumonia,14 (14%) cases with meconium aspiration syndrome (MAS), 4 (4%) cases with pneumothorax and one (1%) cases with congenital diaphragmatic hernia (CDH), this was in agreement with the study of **Hermansen and Lorah (2007)** who stated that the most common causes of respiratory distress in newborns are TTN, RDS, pneumonia, sepsis, MAS, pneumothorax, and delayed transition. Rare causes include diaphragmatic hernia; choanal atresia; tracheoesophageal fistula; congenital heart disease; and neurologic, metabolic, and hematologic disorders **(Hermansen and Lorah, 2007)**. On the other hand, in the study done by **Kumar & Bhat (1996)**, TTN was found to be the commonest (42.7%) cause of respiratory distress followed by infection (17.0%), MAS (10.7%), RDS (9.3%) and birth asphyxia (3.3%) **(Kumar & Bhat, 1996)**.

After analysis of the demographic data of neonates included in our study, there was high significant difference between studied groups as regard gestational age and birth weight .We found that gestational age and birth weight of TTN group were significantly higher than of RDS group. This was in agreement with **Vergine and his colleagues (2014)** who reported that mean gestational age for neonates with TTN was 34.5±2.6 weeks while that for RDS neonates was 30.3±3.7 weeks. Meanwhile, mean birth weight was 2442 ±609 grams for TTN neonates and 1616±604 grams for RDS neonates included in their study **(Vergine et al., 2014)**.

In our study, Gestational age of neonatal pneumonia cases was 36.06 ± 1.98 weeks and their birth weight was 2710.63 ± 532 grams. This results supported by results in the study of **Yang and his colleagues (2018)** who found that gestational age of neonatal pneumonia in their study was 36.3 ± 1.75 weeks but birth weight was 3300 ± 1100 grams which is higher than the birth weight of our study **(Yang et al., 2018)**. **Rosenkrantz (2016)** reported that neonatal pneumonia has higher rates in the settings of prematurity and low birth weight **(Rosenkrantz, 2016)**.

Gestational age in our meconium aspiration syndrome (MAS) cases was 38.57 ± 1.918

weeks and their birth weight was 3075.00 ± 351.78 grams. This was in agreement with **Swarnkar & Swarnkar (2015)** who reported that mean gestational age for neonates with MAS was 38.6 weeks. Meanwhile, mean birth weight was 2964 grams for neonates included in their study **(Swarnkar & Swarnkar, 2015)**.

Auscultatory findings in our study were statistically significant between different studied groups. Chest auscultation of TTN cases revealed fair air entry in 52.8% with no crepitation while in neonates with RDS, diminished intensity of breath sounds was affecting 86.2% of patients with crepitations affecting 20.7% of cases. Similar to our results, **Zaazou and his colleagues (2011)** reported that 90.6% of neonates with RDS showed diminished intensity of breath sounds associated with chest crepitations but in TTN cases, 92.3% of neonates revealed fair air entry **(Zaazou et al., 2011)**. According to **Johnson (2014)**, breath sounds in neonates diagnosed as TTN are typically clear **(Johnson, 2014)** while in neonates with RDS, breath sounds are usually decreased as stated by Martin in 2014 **(Martin, 2014)**.

As regards auscultatory chest findings in neonatal pneumonia, MAS and pneumothorax there was diminished air entry in 81.2%, 78.6% and 100% of these cases respectively with crepitations only found in neonatal pneumonia and MAS. this was same as found in the study done by **Dargaville & Copnell (2006)** who reported predominantly diminished air entry and crepitations of MAS patients **(Dargaville & Copnell, 2006)**, neonatal pneumonia similarly showed same findings as demonstrated by **Reiterer in 2013 (Reiterer, 2013)**.

All neonates included in our study required respiratory support in the form of nasal cannula, continuous positive airway pressure (CPAP) or mechanical ventilation (MV), with high significance between different groups as regards the use of CPAP or MV. In TTN group, the application of nasal cannula and CPAP was higher than in RDS group, but mechanical ventilation was used in 9 cases (31%) of the RDS group and only one case of the TTN group required it. These findings were consistent with **Copetti and cattarossi (2007)** who reported that neonates diagnosed as TTN included in their study required significantly higher application of CPAP as explained by the severity of the clinical condition of the cases included **(Copetti and Cattarossi, 2007)**. Additionally, these findings

were consistent with **Copetti and his colleagues (2008)** who reported that most neonates diagnosed as RDS included in their study required mechanical ventilation **(Copetti et al., 2008)**. These results were different with **Vergine and his colleagues (2014)** who found that MV and CPAP requirement was higher among neonates diagnosed with RDS than those diagnosed with TTN included in their study with no difference as regards oxygen therapy **(Vergine et al., 2014)**.

In our study, 37.5%, 25% and 35.7% of neonatal pneumonia cases need respiratory support by nasal pronge, CPAP and MV respectively. In a study done by **El Dien & Abd ElLatif (2013)**, neonatal pneumonia respiratory support was needed using mechanical ventilation in 20 cases (26.6%); nasal continuous positive airway pressure (CPAP) in 15 cases (20%) and 40 neonates (53.3%) were treated by nasal prongs **(El Dien & Abd ElLatif, 2013)**.

Supplemental oxygen administration is the mainstay of treatment for meconium aspiration syndrome (MAS) and in many less severe cases is the only therapy required **(Singh et al., 2009)**. In our study, 64.3% and 35.7% of MAS cases need respiratory support by nasal pronge and MV respectively with near similar results reported by **Wiswell and his colleagues (2000)** who stated that depending on the severity of MAS, respiratory support may vary, 50% require only oxygen by nasal cannula or hood. However, 40 % of infants require mechanical ventilation and only 10% require continuous positive airway pressure **(Wiswell et al., 2000)**.

In our study, from the 36 neonates finally diagnosed as TTN, 33 cases diagnosed by chest ultrasound as TTN where the double lung point (DLP) was detected in 69.7%, pleural line abnormalities in 93.9%, absent A-lines in 87.9% of finally diagnosed TTN cases. Near findings were found in a study done by **Ibrahim and his colleagues (2018)** in which the pleural line was disrupted in 93.7%, DLP was seen in 68.8%, partial or complete disappearance of A lines were present in 89.6% and white lung was seen in only 25% of TTN group cases, **(Ibrahim et al., 2018)**. According to **Liu and his colleagues (2014)** TTN cases showed DLP in 76.7% of neonates, but pleural line abnormalities and abnormal A-lines were described in 100 % of TTN cases **(Liu et al., 2014)**. On

the other hand, the study done by **Copetti and cattarossi (2007)**, showed that the diagnostic ultra sonographic finding for TTN is the DLP, with the pleural line is well defined, not thickened and hyperechogenic and A-lines are normal variants **(Copetti and Cattarossi, 2007)**.

In our study the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of chest ultrasound in diagnosis of TTN was 93.1 %, 91.5%, 81.8% and 97% respectively with accuracy reaching up to 92%. Similar results was reported by **Vergine and his colleagues (2014)** who demonstrated that thirty neonates were diagnosed as TTN and the results showed that LUS had a sensitivity of 93.3%, a specificity of 96.5% with a PPV of 96.5%, and a NPV of 93.4% for TTN, thus showing chest US having good sensitivity and specificity in diagnosis of TTN **(Vergine et al., 2014)**.

According to **Copetti and his colleagues (2008)** chest ultrasound findings diagnostic for RDS were B-lines, pleural line abnormalities and consolidations **(Copetti et al., 2008)**. In our study, variable chest ultrasound findings diagnostic for RDS were B-lines, pleural line abnormalities, regular consolidations with air bronchogram and white lung. These results are in agreement with **El-Malah and his colleagues (2015)** who concluded that chest US findings in the form of B-lines, pleural line abnormalities and consolidations had sensitivity of 98% and specificity of 92% in detection of pulmonary manifestations of RDS **(El-Malah et al., 2015)**.

In our study the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of chest ultrasound in diagnosis of RDS was 96.2%, 95.9%, 89.3% and 98.6% respectively with accuracy reaching up to 96%. This was in agreement with **Vergine and his colleagues (2014)** who reported that lung ultrasound showed a sensitivity of 95.6%, a specificity of 94.4%, a PPV of 91.6%, and a NPV of 97.1% for RDS **(Vergine et al., 2014)**.

Chest ultrasound findings for neonates included in the study and diagnosed as neonatal pneumonia revealed patchy asymmetrical irregular consolidation with air bronchograms in 100% of cases, pleural line abnormalities in 78.6 %, absent A lines in 57.1 % and B-lines or alveolar interstitial syndrome (AIS) in areas around consolidation in 64.3 % of cases with 84.6% sensitivity and 96.6% specificity in diagnosis of neonatal

pneumonia findings. This was in agreement with **Liu and his colleagues (2014)**, who found that large areas of lung consolidation with irregular margins had 100% sensitivity and 100% specificity for the diagnosis of neonatal pneumonia. Pleural line abnormalities and interstitial syndrome are common, but are nonspecific ultrasound findings in neonatal pneumonia and are related to both the inflammatory reaction. In severe cases, there may also be pleural effusion Thus, this study showed that lung ultrasound being a reliable tool for diagnosing neonatal pneumonia **(Liu et al., 2014)**. According to **Seif El Dien and Abd El-Latif (2013)**, they reported that consolidations were found in 90.6% of neonates diagnosed as congenital pneumonia **(Seif El Dien and Abd El-Latif, 2013)**.

In our study, chest ultrasound findings of meconium aspiration syndrome (MAS) cases showed widespread irregular consolidation with air bronchogram in all cases while pleural line abnormalities, absence of A lines and presence of B lines or alveolar interstitial syndrome (AIS) was observed in most of cases. This was in agreement with the study done by **Liu and his colleagues (2016)** who showed that the lung ultrasound findings in MAS were pulmonary consolidation with air bronchogram (100%); pleural line anomalies and the disappearance of the A-line (100%); AIS or B-line in the non-consolidation area (100%); and pleural effusion (13.7%). **(Liu et al., 2016)**. While **Cattarossi (2013)** reported that images seen by lung ultrasound are coalescent B-lines, irregular subpleural consolidations along with few spared areas and white out lung in severe MAS **(Cattarossi, 2013)**.

In our study, four cases with pneumothorax were included and chest US findings were presence of pleural line and A line, absence of the sliding sign, absence of B lines, presence of lung point and barcode sign,(in M-mode), these findings were positive in all (100%) pneumothorax patients with sensitivity, specificity, PPV and NPV of was 100 % for all. this was in agreement with **Raimondi and his colleagues (2016)** who reported that pneumothorax signs in chest US include absence of the sliding sign (B mode), presence of the lung point (B mode), absence of B lines in the affected area (B mode) and presence of stratosphere sign (M mode) and conclude that Lung ultrasound is accurate in diagnosing pneumothorax with

sensitivity 100%, specificity 100%, positive predictive value 100% and negative predictive value 100% **(Raimondi et al., 2016)**. But in a study done by **Grimaldi and his colleagues (2019)**, chest US showed 100% sensitivity for the diagnosis of pneumothorax, specificity was 97%, NPV was 100% and PPV was 50% **(Grimaldi et al., 2019)**.

In our study one hundred cases were included and finally diagnosed, 84 of these cases were diagnosed radiologically and 92 cases were diagnosed by chest ultrasound with higher sensitivity of chest ultraspund than chest radiography in diagnosis of neonatal respiratory disorders. This was in agreement with **Chavez and his colleagues (2014)** who found that lung ultrasound is more sensitive than traditional chest radiography in finding lung lesions (Chavez et al., 2014).

Limitation Of The Study:

According to these results, we must take in consideration that the main limitation of this study include: small number of the sample included with only four cases with pneumothorax and one case with congenital diaphragmatic hernia (CDH) and therefore, future researches with larger sample size are needed, narrow variations of the respiratory disorders assessed, delay in timing of chest ultrasound performance in some cases, lack of further chest ultrasound follow up of cases as well as the fact that although the adult and pediatric pulmonologist were blinded to the clinic_ laboratory diagnosis and chest X-ray findings of the cases, bias could not be excluded in relation to the size of the neonate as small sized neonates were more likely to be RDS while larger sized ones were more likely to be under other study categories, also, meconium staining of nails, skin and umbilical stump increase the possibility for diagnosis of MAS. Another limitation was that; abnormalities not revealed by chest X-ray were not confirmed by chest computed tomography scans, as it cannot be routinely performed in neonates due to clinical obstacles and it is harmful effects.

CONCLUSION

Chest ultrasound is a simple, safe, low-cost and widely used tool that can be done by clinician with no need for too much training with high specificity and sensitivity. The accuracy of chest ultrasonography in screening and diagnosis of neonatal respiratory disorders is the same as chest radiography (chest X-ray).

RECOMMENDATION

1. Chest ultrasound should replace chest x ray as the first-line imaging investigation in evaluating neonates with different respiratory disorders as it is a simple, non- invasive and easy to operate.It can be repeatedly and rapidly performed at the bedside with subsequent reduction of ionizing radiation.

2. Continuous training neonatologists on chest ultrasound performance and interpretation of it is sonographic findings, can help in accurate and rapid diagnosis of neonatal respiratory disorders with minimal handling of patients.

3. Further different studies including large numbers of neonates with respiratory distress are needed, as different questions need be answered such as effectiveness as a diagnostic tool and its role in the follow up of more diverse causes of neonatal respiratory disorders.

4. Further studies needed to evaluate ultrasonography role in other aspects in NICU for promotion of it is use instead of harmful radiography.

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دراسة مدى دقة تشخيص الموجات فوق الصوتيه على الصدر مقارنة بالأشعه التشخيصيه لمعرفة أمراض الجهاز التنفسى فى الأطفال حديثى الولاده

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الهدف من البحث: تهدف هذه الدراسة إلى معرفة مدى الدقه التشخيصيه للتصوير بالموجات فوق الصوتيه على الصدر في التعرف على أمراض الجهاز التنفسى فى الأطفال حديثى الولاده مقارنة بالتصوير الشعاعي على الصدر(الاشعه السينيه على الصدر).

الوسائل والادوات: هذه دراسة مقطعية مقارنه تم إجراؤها خلال الفترة من سبتمبر 2019 إلى مارس 2021 و شملت 100 مولود ممن يعانون من ضائقة تنفسيه (معدل التنفس أكثر من ٦٠ نفسا/دقيقة، اتساع الأنف، ارتداد جدار الصدر، الشخير والزرقة) في أول 28 يومًا من حياتهم ممن كانت أعمارهم الوليديه تساوى 32 اسبوع أو أكثر،وتم اختيارهم بطريقة عشوائية بسيطة، حيث تم إخضاعهم جميعا لأخذ التاريخ الطبي كاملا، والفحص السريري الشامل، وعمل الفحوصات المخبرية اللازمه، بالاضافه الى عمل تصوير شعاعي على الصدر وتصوير بالموجات فوق الصوتية على الصدر لهم جميعا.

نتائج البحث: في البحث الحالي، كانت نسبة الذكور 100/62 (62٪) بينما كانت الإناث 100/38 (38٪) و كان متوسط العمر الوليدى للحالات 36.05 ± 2.70 أسبوعًا بينما كان متوسط وزن الولادة للحالات 2720.40 ± 678.52 جرامًا. وقد تم تشخيص جميع المرضى تشخيصا نهائيا وفقًا لنتائج الفحص السريرى ونتائج المعامل المخبريه ونتائج التصوير الشعاعى على الصدر، حيث تم تشخيص 36 حاله تشخيصا نهائيا بتسرع النفس العابر لحديثى الولاده منهم 33 حاله تم تشخيصها عن طريق الموجات فوق الصوتية على الصدر و 29 حاله تم تشخيصها عن طريق التصوير الشعاعي على الصدر، وتم تشخيص 29 حاله تشخيصا نهائيا بمتلازمة الضائقه التنفسيه منهم 28 حاله تم تشخيصها عن طريق الموجات فوق الصوتية على الصدر و 26 حاله تم تشخيصها عن طريق التصوير الشعاعي على الصدر، وتم تشخيص 16 حاله تشخيصا نهائيا بالالتهاب الرئوي لحديثي الولاده منهم 14 حاله تم تشخيصها عن طريق الموجات فوق الصوتية على الصدر و 13 حاله تم تشخيصها عن طريق التصوير الشعاعي على الصدر، وتم تشخيص 14 حاله تشخيصا نهائيا بمتلازمة شفط العقى منهم 13 حاله تم تشخيصها عن طريق الموجات فوق الصوتية على الصدر و 12 حاله تم تشخيصها عن طريق التصوير الشعاعي على الصدر بينما تم تشخيص جميع حالات استرواح الصدر (4 حالات) وفتق الحجاب الحاجز الخلقي (حالة واحدة) بالتساوي باستخدام الموجات فوق الصوتية على الصدر والتصوير الشعاعي على الصدر.

الاستنتاج: تعتبر الموجات فوق الصوتيه على الصدر أداة بسيطه وآمنة ومنخفضة التكلفه ومستخدمه على نطاق واسع ويمكن أن يقوم بها الطبيب دون الحاجة إلى الكثير من التدريب مع وجود خصوصيه وحساسيه عاليه

في التشخيص. وجد أن دقة التصوير بالموجات فوق الصوتية على الصدر في فحص وتشخيص اضطرابات الجهاز التنفسي لحديثي الولادة مساويه لدقة التشخيص باستخدام التصوير الشعاعي على الصدر (تصوير الصدر بالأشعة السينية).