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A Study of lung Ultrasonography in Infants with Acute Lower Respiratory Tract Infection as a Quick and Safe Alternative Tool in a Group of Egyptian Infants

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Abstract

Background: Acute lower respiratory infections (ALRI), such as pneumonia and bronchiolitis, are the leading cause of morbidity and mortality in children under five years of age. **Aim of the Work:** To study ultrasonography findings in infants with acute lower respiratory tract infection and to test its sensitivity and specificity in comparison to clinical and conventional x- ray for diagnosis of childhood acute lower respiratory tract infection. **Patients and Methods:** The present cross sectional study was conducted on sixty patients were chosen according to inclusion criteria (fever with signs of respiratory distress) to compare chest ultrasonography to chest x-ray in diagnosis of children with acute lower respiratory tract infection. **Results:** In our study, diagnostic Accuracy of ultrasound was 93.45%, while diagnostic Accuracy of chest X- ray was 81% in patients' group. Sensitivity of ultrasound in cases of Bronchiolitis was 87.5% in comparison to chest X-ray was 78.1%, sensitivity of ultrasound in cases of pneumonia was 84.2% in comparison to chest X- ray was 52.6%. According to specificity, there is no difference in specificity between all patients' group **Conclusion:** In view of our study it can be concluded that, chest US offers an important contribution to the diagnostic procedures of acute lower respiratory tract infection in children, as Bronchiolitis, pneumonia and pleural effusion with higher sensitivity, specificity and positive predictive index comparable to chest X-ray.

Key words: lung ultrasonography, infants, acute lower respiratory tract infection, pneumonia, bronchiolitis

Introduction

Standard definition of childhood Acute Lower Respiratory Infection (ALRI) is inflammation of the airways/ pulmonary tissue, due to viral or bacterial infection, below the level of the larynx. ALRI, such as pneumonia and bronchiolitis, are the leading cause of morbidity and mortality in children under five years of age [(1)]. According to recent estimates, every year about 120–156 million cases of ALRI occur globally with approximately 1.4 million resulting in death. More than 95% of these deaths occur in low and middle income countries (LMIC) [(2)]. In 2015 there were about 291 million cases around the world. These resulted in 2.74 million deaths down from 3.4 million deaths in 1990. This was 4.8% of all deaths in 2013 [(3)]. In Egypt, it was estimated that 10% of children deaths below the age of 5 years is likely caused by pneumonia and other acute respiratory infections [(4)]. Community-acquired pneumonia (CAP) is one of the most common serious infections in children. Its incidence among children aged less than 5 years in developing countries reached 0.29 child per year, with a mortality rate of 1.3–2.6% [(5)]. For many years, Transthoracic Ultrasound (TUS) was limited exclusively to the examination of pleural effusions. *However*, over the past few years ultrasonography of the pleural space and lung parenchyma is gaining a wide consensus in different conditions in clinical practice, particularly in emergency [(6)]. Chest

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ultrasound allows prompt management based upon reproducible data and generates fewer computed tomography (CT) examinations, therefore decreasing irradiation, delays, cost and discomfort to the patient [7] Point-of-care ultrasound imaging, performed at the patient's bedside, decreases the delays of chest radiography in diagnosis of pulmonary diseases [8].

Aim of the Work: To study ultrasonography findings in infants with acute lower respiratory tract infection and to test its sensitivity and specificity in comparison to clinical and conventional X- ray for diagnosis of childhood acute lower respiratory tract infection.

Patients and Methods

The present cross sectional study was designed to compare chest ultrasonography to chest X-ray in diagnosis of children with acute lower respiratory tract infection attended Paediatric Emergency Department and were admitted, Children's hospital, Ain Shams University Hospitals, during the period between October 2016 and March 2017.

Sixty patients were chosen according to inclusion criteria (fever with signs of respiratory distress), after performing clinical examination on all sixty patients, thirty two patients were finally diagnosed as clinical bronchiolitis while nineteen patients were finally diagnosed as clinical pneumonia and other nine cases of acute respiratory distress other than pneumonia and bronchiolitis.

Table 1: Final diagnoses of studied patients with acute respiratory distress

Diagnosis	***Case number***
Bronchiolitis	32
Pneumonia	19
Other respiratory distress	9
Total	60

The study protocol was approved by the Ethics Committee of Ain Shams University. Informed consent was obtained from at least one parent of the child or caregiver before enrolling the children in the study.

Inclusion criteria:

Presence of fever together with increased respiratory rate more than expected for their age and other signs of respiratory distress like tachypnea, subcostal, intercostal retraction, grunting and cyanosis [9].

These criteria were proved by respiratory distress (RD) score [10]:

Table 2: Score of RD in infant with acute lower respiratory infection

(Scalini *et al.*, 2011)

Clinical parameter	**0**	**1**	**2**	**3**
RR	<40	40-60	60-70	More than 70
Use of accessory muscle	none	1 muscle used	2muscle used	More than 3 muscle used
Color	Pink in room air	Cyanosed with crying	Pink with o2	Cyanosed with o2 or arrest
Auscultation	Normal	Decrease air entry, no Ronchi	Decrease air entry, heard Ronchi, wheezy	Silent chest

Healthy =0, **mild RD** =1-4, **Moderate RD**=5-8, **severe RD** =9-12.

Exclusion criteria: Patients with co-existing chronic lung disease or predisposing congenital abnormalities were excluded from the study.

- **All included patients were subjected to:**

Full history taking stressing on: Demographic data included age, sex, residence, smoking habits in the families, and past history of respiratory illness, socioeconomic score for families [11].

Symptoms of respiratory tract infection before hospitalization were recorded upon admission, including the onset and duration of cough, fever, dyspnea, tachypnea, and rhinorrhea. Feeding, hydration status and urine output were considered.

2- Complete physical examination including:

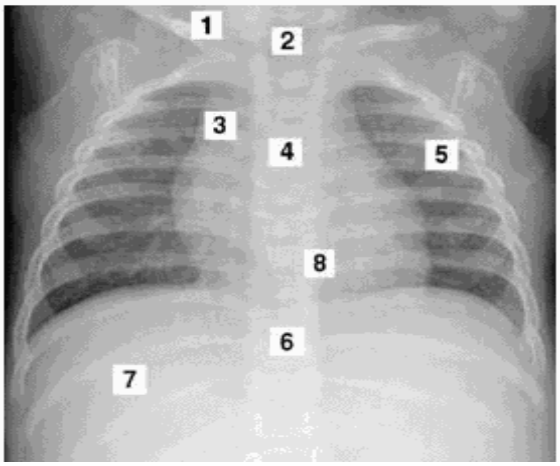
a) General examination: with special emphasis on:

Vital signs: assessment of temperature, heart rate, respiratory rate and capillary refilling time [12].

b) Systemic Examination:

Standardized clinical assessment was done laying stress on chest examination:

- Chest inspection of both sides (decreased chest movement on affected side).
- Chest percussion (dullness over affected part).



- Auscultation: air entry (diminished on affected area), breath sound (bronchial breathing on consolidating part) and adventitious sounds (wheeze/ crepitations).

Figure 1:Acoustic windows for thoracic sonography: (1) supraclavicular (2) suprasternal, (3) parasternal, (4) transsternal, (5) intercostals, (6) subxyphoid, (7) subdiaphragmatic, and (8) posterior paraspinal [13].

2-*Chest X-ray (PA view):*

Postero-anterior CXR were done to patients in supine position and recorded by commercially available X-ray machines. In accordance with the British thoracic Society guidelines [13] in children lateral radiograph were not obtained.

In a PA view, the X-ray source was positioned so that X-rays enter through the posterior (back) aspect of the chest and exit out of the anterior (front) aspect where they are detected. This view was done with the subject's chest up against the film holder or detector plate. The X-ray tube was behind the patient, and X-ray beam passed in from the back and exits out from the front of the chest [13].

3-blood tests:

On admission, a blood samples were taken for assessment of total white blood cell count with manually verified differential count, hemoglobin, platelet count, Quantitative assessment of serum C-reactive protein (CRP) was done [13].

4- Chest ultrasound: Lung US immediately was done after plain X-ray by a certified pediatric radiologist who was blinded to chest X -ray.

CUS was performed using a Mindray Z6 with 3–5 MHz convex transducer, which can visualize deeper lung structures. A high-frequency 5–12 MHz linear array probe was most effective in visualizing the chest wall, pleura, and the lung peripheral parenchyma.

Technique [13]:

1) Small infants are examined with high frequency (*linear transducers*), smaller footprint sector or vector transducers were used to insonate between ribs, below the diaphragm, or from the suprasternal notch.
2) Linear transducers were used for examining chest wall lesions
3) Useful acoustic windows were depicted in the relatively unossified thorax of infant, along with the presence of a relatively large thymus, allows imaging of the anterior chest and thymus, sternal and costochondral cartilages.
4) Suprasternal or supraclavicular approaches may also be useful in examining the anterior mediastinum and thoracic vessels.

The probe was placed lightly on the skin of the body area being tested, which has been prior spread with a layer of ultrasound gel to eliminate any air that may be eventually present (air, like any other gas, and bony structures are barriers to ultrasound waves, creating interfaces with high acoustic impedance). The echo (reflection) was generated by the difference in the acoustic impedance which in turn was caused by the different composition of the structures invested by the sound wave. This echo was picked up by the probe itself [14].

The signal picked up by the probe was then elaborated by a calculator and converted into a two-dimensional image on a screen [15].

Conventionally lung sonography was performed with the patient in a sitting position taking longitudinal scans starting anteriorly from the parasternal zone and posteriorly from the paravertebral/posterior axillary zones. In these scans, as one penetrates in depth from the surface one can visualize the skin and hypodermis, the pectoral muscles, 1 or 2 ribs according to their short axis, the intercostal

muscles and the pleural line, at a deeper level with respect to that of the ribs, as a hyperechogenic line that moves [14].

Below the pleural line, the normally aerated lung appears "black"; there can be present the above-mentioned A lines, horizontal reverberations without any pathologic implication, and sometimes a few vertical artifacts which, if limited in number, do not indicate any pathology [14].

Additional scans that allow better characterizing and investigating eventual lesions or pathologic alterations are the transverse or, better still, intercostal scans [15].

I. Bronchiolitis was diagnosed by:

A. **Chest X-rays:** Children with a clear clinical diagnosis of bronchiolitis do not require a chest x-ray. CXR in bronchiolitis will show signs of hyperinflation, peribronchial thickening, and often patchy areas of consolidation and collapse. This may lead to some confusion with pneumonia, however if hyperinflation and wheeze are present the diagnosis should be regarded as bronchiolitis. CXR is indicated in severe cases or where the diagnosis uncertain [16].

B. *Distribution of B-lines according to ultrasound score.*

Table 3: US SCORE of Bronchiolitis [10]

Score	0	1	2
Antero-lateral data	Normal with A-lines	Multiple pathological B lines and spared areas	Diffuse interstitial $ and sub pleural consolidation
Para-vertebral (Interstitial $)	Individual B –lines or absent	Focal multiple B-lines	Multiple B-lines
Para-vertebral (Extension on Interstitial $)	0-6 bilaterally involved intercostal spaces	6-12 bilaterally involved intercostal spaces	More than 12 bilaterally involved intercostal spaces
Para-vertebral (Sub pleural consolidation)	absent	Sub centimeter Sub pleural lung Consolidation	Sub pleural lung Consolidation of 1 cm or more

Healthy =0, **mild bronchiolitis** =1-3, **Moderate bronchiolitis**=4-6, **severe bronchiolitis** =7-8

II. Pneumonia was diagnosed by according to [17]:

a) Presence of hepatisation (consolidation)
b) Presence of dynamic air bronchogram
c) Presence of fluid bronchogram
d) Presence of pleural line irregularity
e) Presence of multiple B-lines.

III. Other respiratory distress (acute bronchitis) diagnosed by:

Acute bronchitis leads to the cough lasts around three weeks and sputum production that often follows upper respiratory tract infection. This occurs because of the inflammatory response of the mucous membranes within the lungs 'bronchial passages [18].

Acute bronchitis is almost always a self-limited process in the otherwise healthy child acute bronchitis is generally caused by respiratory infections; approximately 90% are viral in origin, and 10% are bacterial [19].

These viruses may be spread through the air when people cough or by direct contact. Risk factors include exposure to tobacco smoke, dust, and other air pollution [20].

Viral infections include the following:

Adenovirus, Influenza, Parainfluenza, Respiratory syncytial virus, Rhinovirus, Human bocavirus, Coxsackievirus, Herpes simplex virus.

A small number of cases are due to high levels of air pollution or bacteria such as Mycoplasma pneumonia or Bordetella pertussis [20].

Diagnosis is typically based on a person's signs and symptoms, the color of the sputum does not indicate if the infection is viral or bacterial. Determining the underlying organism is typically not needed. Other causes of similar symptoms include asthma, pneumonia, bronchiolitis, bronchiectasis. A

chest X-ray may be useful to detect pneumonia [21].

5- Statistical analysis:

IBM SPSS statistics (V. 22.0, IBM Corp., USA, 2013) was used for data analysis. Data were expressed as Mean± SD for quantitative parametric measures in addition to both number and percentage for categorized data.

RESULTS

Table 4: Demographic comparison between different patient groups:

		Pneumonia	Bronchiolitis	Other RD	Chi-square test	
					X^2	P-value
Age	Median (IQR)	11 (4 – 18)	4 (2 – 8)	15 (10 – 18)	11.409	**0.003***
	Range	2 – 24	1 – 24	6 - 24		
Gender	Females	5 (26.3%)	12 (37.5%)	4 (44.4%)	1.071	0.585
	Males	14 (73.7%)	20 (62.5%)	5 (55.6%)		
Passive smoking	Positive	14 (73.7%)	17 (53.1%)	6 (66.7%)	2.244	0.326
	Negative	5 (26.3%)	15 (46.9%)	3 (33.3%)		
Consanguinity	positive	12 (63.2%)	22 (68.8%)	5 (55.6%)	0.579	0.749
	negative	7 (36.8%)	10 (31.2%)	4 (44.4%)		

* Chi-square test:

- P-value > 0.05: Non significant
- P-value < 0.05: Significant
- P-value < 0.01: Highly significant

❖ There was a significant difference in age in different patient groups

❖ Range of age In Bronchiolitis was (1-24 months) and in pneumonia was older (2-24 months) and in other RD (acute bronchitis) was the oldest (6-24)

Table 5: Comparison between different patient groups as regard clinical signs:

		Pneumonia	Bronchiolitis	Other RD	Chi-square test	
					X^2	P-value
RR	mean±SD	64.32 ± 9.21	65.16 ± 8.56	60.67 ± 7.79	0.944	0.395
	Range	47 – 77	45 – 80	50 – 77		
RR	1	9 (47.4%)	5 (15.6%)	4 (44.4%)	13.927	**0.007***
	2	2 (10.5%)	19 (59.4%)	4 (44.4%)		
	3	8 (42.1%)	8 (25.0%)	1 (11.1%)		
Use of accessory muscle	0	0 (0.0%)	0 (0.0%)	1 (11.1%)	7.527	0.274
	1	8 (42.1%)	15 (46.9%)	4 (44.4%)		
	2	9 (47.4%)	12 (37.5%)	4 (44.4%)		
	3	2 (10.5%)	5 (15.6%)	0 (0.0%)		
Color	0	15 (78.9%)	31 (96.9%)	7 (77.8%)	4.863	0.088
	1	4 (21.1%)	1 (3.1%)	2 (22.2%)		
Auscultation	0	1 (5.3%)	16 (50.0%)	2 (22.2%)	12.672	**0.013***
	1	9 (47.4%)	8 (25.0%)	5 (55.6%)		
	2	9 (47.4%)	8 (25.0%)	2 (22.2%)		
Clinical score	mean± SD	5.32 ± 2.08	4.44 ± 1.72	4.44 ± 2.19	1.366	0.263
	Range	2 – 9	2 – 9	2 – 8		
Index	Control	0 (0.0%)	0 (0.0%)	0 (0.0%)	8.103	0.088
	Mild respiratory distress	8 (42.1%)	17 (53.1%)	8 (88.9%)		
	Moderate	8 (42.1%)	14 (43.8%)	1 (11.1%)		
	Severe	3 (15.8%)	1 (3.1%)	0 (0.0%)		

❖ 42.1% of patients with pneumonia were found to have respiratory rate more than 70 (the worst).

❖ 15.6% of patients with bronchiolitis were found to use more than three accessory muscles (the worst).

❖ 47.4% of patient with pneumonia were found to have decreased air entry, heard ronchi and wheezy chest on chest auscultation

Table 6: Comparison between different patient groups as regard chest auscultation:

		Pneumonia	Bronchiolitis	Other RD	Chi-square test	
					X^2	P-value
Air entry	Diminished air entry Good air entry	17 (89.5%) 2 (10.5%)	5 (15.6%) 27 (84.4%)	4 (44.4%) 5 (55.6%)	26.482	**0.001***
Fine crepitation	Negative Positive	0 (0.0%) 19 (100.0%)	32 (100.0%) 0 (0.0%)	9 (100.0%) 0 (0.0%)	60.000	**0.001***
Coarse crepitation	Negative Positive	5 (26.3%) 14 (73.7%)	12 (37.5%) 20 (62.5%)	4 (44.4%) 5 (55.6%)	1.071	0.585
Wheezy chest	Negative Positive	19 (100.0%) 0 (0.0%)	0 (0.0%) 32 (100.0%)	9 (100.0%) 0 (0.0%)	60.000	**0.001***

- There was significant difference between patient groups in diminished air entry, presence of fine crepitation and wheezy chest.
- 89.5% of patient with pneumonia were found to have diminished air entry.
- 100%of patient with pneumonia were found to have fine crepitation.
- 100% of patient with Bronchiolitis were found to have wheezy chest.

Table 7: Distribution of clinical diagnosis between different patient groups:

Patients group Total No.=60		
	No.	**%**
Pneumonia	19	31.7%
Bronchiolitis	32	53.3%
Other causes of respiratory distess	9	15.0%

* Independent t-test

- The previous table showed that 53.3% of patient group found clinically to have Bronchiolitis.
- 31.7% of patient group were found clinically to have pneumonia.
- 15% of patient group were found clinically to have other respiratory distress.

Table 8: Frequency of ultrasound finding in patients group:

Ultrasound abnormalities	**Patients group**
Normal lung sliding with horizontal artifacts (A-lines), and vertical artifacts (B-lines) in limited number or absent.	5 (55.5%)
Individual B-lines or absent	4 (6.6%)
Focal multiple pathological B -lines	4 (6.6%)
multiple pathological B -lines and spared areas	30 (50%)
multiple B -lines	27 (45%)
0-6 bilateral involved intercostal spaces	19 (31.6%)
6-12 bilateral involved intercostal spaces	14 (23.3%)
more than 12 bilateral involved intercostal spaces	2 (3.3%)
Diffuse interstitial and subpleural consolidation	2 (3.3%)
sub centimeter Subpleural consolidation	9 (15%)
Subpleural consolidation 1cm or more	5 (8.3%)
No Subpleural consolidation	28 (46.6%)
U/S Score of bronchiolitis Median (IQR) Range	 2 (0 – 4) 0 – 7
Index Non bronchiolitis Mild bronchiolitis Moderate Severe	 4 (12.5%) 14 (43.7%) 13 (40.6%) 1 (3.1%)

- 50 % of patients with Bronchiolitis found to have multiple B lines and spared area, 45% of patients with Bronchiolitis were found to have multiple B lines.

Table 9: Distribution of ultrasound diagnosis among patient:

Patients group Total No.=60		
	No.	**%**
pneumonia	16	26.7%
bronchiolitis	28	46.7%
Other causes of respiratory distress	8	13.3%

- The previous table show that 46.7% of patient group found by ultrasound to have Bronchiolitis,
  26.7% of patient group were found by ultrasound to have pneumonia,
  13.3%of patient group were found by ultrasound to have other respiratory distress.

Table 10: Ultrasound finding in pneumonic group of patients:

Patients group Total No.=19		
	No. (+ve)	**%**
Hepatization with air bronchogram	16	84.2%
Pleural effusion	7	36.8%

- This table shows that 84.2% of patient with pneumonia had consolidation

  With air bronchogram while 36.8% of patient with pneumonia had pleural effusion.

Table 11: Chest X-ray findings in patients group:

		Patient group	
		No.=60	**%**
Increased BVM	Negative	3	5.0%
	Positive	57	95.0%
peribronchial thickening	Negative	45	75%
	Positive	15	25%
Consolidation	negative	50	83.3%
	Positive	10	16.7%
Atelectasis	Negative	56	93.3%
	Positive	4	6.7%
Pleural effusion	Negative	57	95%
	Positive	3	5 %

Table 12: Distribution of chest X-ray diagnosis among patient group:

Patients group Total No.=60		
	No.	**%**
Pneumonia	10	16.7%
Bronchiolitis	25	41.7%
Other causes of respiratory distress	5	8.3%

Table 13: Diagnostic accuracy of US and X-ray in prediction of clinical findings:

		Pneumonia by clinical		Chi-square test	
		Positive		X^2	P-value
		No.	%		
Pneumonia by US	Negative	3	15.8%	47.081	0.001
	Positive	16	84.2%		
Pneumonia by X-ray	Negative	9	47.4%	25.895	0.001
	Positive	10	52.6%		

* Chi-square test:

P-value > 0.05: Non significant
P-value < 0.05: Significant
P-value < 0.01: Highly significant

Kappa agreement between clinical and US = 87.9
Kappa agreement between clinical and X-ray = 60.3

- 19 cases were found clinically as pneumonia, 16/19 (84.2%) patients diagnosed by U/S as positive pneumonia, While 10/19 (52.6%) diagnosed by chest X-ray as positive pneumonia.

Table 14: Diagnostic accuracy of U/S and X-ray in prediction of clinical findings:

		Bronchiolitis by clinical		Chi-square test	
		Positive		X^2	P-value
		No.	%		
Bronchiolities by U/S	Negative	4	12.50%	45.938	0.001
	Positive	28	87.50%		
Bronchiolities by chest X-ray	Negative	7	21.90%	37.500	0.001
	Positive	25	78.10%		

Kappa agreement between clinical and U/S = 86.7
Kappa agreement between clinical and X-ray = 76.9

- 32 cases were found clinically as Bronchiolitis, 28/32 (87.50%) patients diagnosed by U/S as positive Bronchiolitis, While 25/32 (78.1%) diagnosed by chest X-ray as positive Bronchiolitis.

Table 15: Comparison between values of ultrasound and chest x ray in diagnosis of lower respiratory tract infection:

		Sensitivity	Specificity	PPV	NPV	Accuracy	P-value
Pneumonia	**U/S**	84.2%	100%	100%	93.18%	92.1%	0.040
	X-ray	52.6%	100%	100%	82.0%	76.3%	
Bronchiolitis	**U/S**	87.5%	100%	100.0%	87.5%	93.75%	0.317
	X-ray	78.1%	100%	100.0%	80.0%	89.1%	

- Sensitivity of ultrasound is more significant than chest x ray in diagnosis of patient group.
- Accuracy of ultrasound is more significant than chest x ray in diagnosis of patient group.
- P-value is significant in diagnosis of pneumonia and other respiratory distress.
- There is no difference in specificity between all patients group.

Discussion:

The present cross sectional study was designed to compare ultrasonography to chest x-ray in diagnosis of children with acute lower respiratory tract infection at Paediatric Emergency Department, Children's hospital, Ain Shams university hospitals, during the period between October 2016 and March 2017.

A total of 60 patients with age group (1-24 month) who presented to the emergency department with fever together with tachypnea and signs of respiratory distress and were admitted to the pediatric ward. Patients were classified into three groups: Thirty two patients (53.3%) were finally diagnosed as Bronchiolitis, nineteen patients (31.7%) were finally diagnosed as pneumonia and nine patients (15%) of acute respiratory distress were finally diagnosed as acute bronchitis.

In the present study in patient groups, male represented 65% while females were 35% with male to female ratio 1.9:1.

This gender predominance discussed by many studies, *Falagas et al.* [22] also reported a male predominance in LRTIs. Anatomic differences of the respiratory tract may partially explain the different prevalence of infections between males and females. There is also evidence that the peripheral airways are disproportionately narrower during the early years of life in males, which may predispose for lower RTIs.

In contrast to *Montasser et al.* [23] reported comparable ratio with slight predominance of females (51%).

In our series, of 32 children with a confirmed diagnosis of bronchiolitis, LUS showed findings consistent with bronchiolitis in (28) children with sensitivity 87.5%, specificity 100%, PPV 100.0%, whereas CXR was positive for bronchiolitis in (25) children: sensitivity 78.1%, specificity 100%, PPV 100.0%. **Similarly, in Basile *et al.* [24],** LUS permits the identification of those infants with bronchiolitis with a specificity of 98.7 %, sensitivity of 96.6 %.

Another 19 children with a confirmed diagnosis of pneumonia, LUS showed findings consistent with pneumonia in (16) children with sensitivity 84.2%, specificity 100%, PPV 100.0%, whereas CXR was positive for

pneumonia in (10) children with sensitivity 52.6%, specificity 100%, PPV 100.0%.

This comes in agreement with ***Reissig et al.*** [17] reported that ultrasonography had 93.4% sensitivity and 97.7% specificity for diagnosis of pneumonia. ***Also Sayed et al.*** [25] showed that among the studied group (17 cases of pneumonia), lung ultrasound was showing sensitivity of 82.4% while chest x-ray was showing sensitivity 64.7%.

In contrast to Rahmati *et al.* [26], in his study (100) children were included (53 males, and 47 females). Evidence of involvement supporting the analysis of pneumonia was recognized in 96% of their chest X-rays while the findings supporting pneumonia were observed in 9% of the cases in chest ultrasound. The end was also consistent with X-ray results.

This difference discussed that small sample size and evaluation of older children with thick chest wall don't show usefulness of ultrasound, also ultrasoungraphy easily detected pulmonary lesion reaching pleura, which missed in their studies.

In our series, sonographic finding in patients with bronchiolitis as follows:

Multiple B -lines and spared areas (50%), multiple B –lines (45%). **According to Scalini *et al.*, our US SCORE of degree of bronchiolitis** which discussed that presence of multiple B lines and spared area were in cases with mild to moderate bronchiolitis but multiple B lines fulfil the field were in moderate to severe bronchiolitis.

Similarity, in **Basile *et al.*** [24]**,** in his study, multiple B lines were in (30 %), multiple B lines and spared areas were in (41 %), also in **Moustafa *et al.*** [27] LUS in infants with bronchiolitis (n= 25) showed the Followings: Pleural line abnormalities and multiple B lines were in (32%), compact B lines and spared areas were in (24%).

In our study, chest X-ray finding were positive in (78.1%) of cases with bronchiolitis and findings were as follows:

Increased bronchovascular marking were found in (87.5%), peri bronchial thickening were in (25%).

In contrast to Moustafa *et al.* [38]**, in his study subjected that** CXR was positive in (40%) in the form of increased bronchovascular markings of the lung were in (24%), peri bronchial thickenings were in (4%).

In our series, 32 of cases were diagnosed as bronchiolitis (53.3%) as following: mild bronchiolitis (30%), moderate bronchiolitis (31.7%), and severe bronchiolitis (1.7%). This distribution of severity was due to selection of our cases which attended Paediatric Emergency Department and were admitted at ward not ICU so most of our cases were mild to moderate.

This come in agreement with **Basile *et al.*** [24]**,** US score performed by the radiologist sonographer showed: infants had mild bronchiolitis (61.3%), infants had moderate bronchiolitis (24.5%) and infants had severe bronchiolitis (2.8%). **The difference** in cases of mild bronchiolitis were due to one hundred six infants were studied which is large number of patient.

In our series significant sonographic finding in patients with pneumonia were:

Lung hepatisation with air bronchogram 16/19 (84.2%) and pleural effusion in 7/19 (36.8%).

While CXR findings were:

Lung consolidations were found in 10/19 (52.6%), pleural effusion was found in 3/19 (15.8%) in the form of Homogenous density, obliterated costopherinc angle, Loss of silhouette.

Similarity in ***Copetti and Cattarossi*** [28]**,** in LUS the following findings were observed: consolidation with air bronchograms were in (93.7%) and pleural effusion in (28.9%) ***In Reissig et al.*** [17] **reported** that 86.7% of patients with pneumonia had air bronchogram in ultrasound finding.

In our series, there were significant clinical findings in patients with acute bronchitis in the form of fever, cough, excessive mucous secretion and respiratory distress**.**

According to **Tackett *et al.*** [21]**,** diagnosis of acute bronchitis is typically based on a person's signs and symptoms, the color of the sputum does not indicate if the infection is viral or bacterial. Determining the underlying organism is typically not needed. Other causes

of similar symptoms include: asthma, pneumonia, bronchiolitis, and bronchiectasis.

Significant sonographic findings in patients with acute bronchitis were:

(5/9) of patient with acute bronchitis showed: horizontal artifacts (A-lines) and vertical artifacts (B-lines) in limited number or absent in (55.5%), (4/9) of patient with acute bronchitis showed normal lung ultrasound in (44.4%).

According to **Volpicelli *et al.*[(29)]**, B-lines originate from the lung interstitia, the demonstration of B-lines signifies that the lung is fully inflated and the visceral pleura being in contact with the parietal pleura. The pitfalls of using B-lines as evidence are: they are rare in healthy lungs (without parenchymal disease), especially the upper lung.

We acknowledge some limitations in this study. LUS can miss consolidation. The sample size is small and therefore confirmatory data on larger sample size are needed. Presence of LUS abnormalities not revealed by CXR was not confirmed by a gold standard such as chest CT, which cannot be routinely performed for obvious ethical reasons, although they were always consistent with the clinical course.

In order to minimize investigator and observer bias, we had a single sonologist perform all LUS prior to management. Finally, our sample size was relatively small, thereby that limiting accuracy of LUS in diagnosis.

Conclusion:

In view of our study it can be concluded that, chest US offers an important contribution to the diagnostic procedures of acute lower respiratory tract infection in children, as Bronchiolitis, pneumonia and pleural effusion with higher sensitivity, specificity and positive predictive index comparable to chest X-ray.

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