

Lung Ultrasound for Diagnosis of Pneumonia in Acute Bronchiolitis Children

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Abstract

Background: The most common cause of hospitalization for infants under 24 months of age is bronchiolitis, a viral lower respiratory tract infection. In recent decades, lung ultrasound has emerged as a new diagnostic technique for identifying pneumonia, so, the study's objective was to evaluate the diagnostic precision and dependability of LUS in identifying acute pneumonia in bronchiolitis children who were admitted to the hospital. **Materials and methods:** This cross sectional study was conducted in Souq Al Khamis Hospital in Al Khoms City, Al-Marqab University, during the period from January 2024 to June 2024 on 30 children from birth to age 18 months. **Results:** 86.7% of the cases in the study were between the ages of 1 and 6 months, with a mean age of 4.20 months. The most prevalent clinical symptoms in the group under study were fever (60%), followed by wheezes (96.7%). Significant respiratory distress was experienced by 10% of the population under study, mild by 26.7%, and moderate by 63.3%. Hyperinflation, lung consolidation, and peri-bronchial thickening were abnormal X-ray findings. Subpleural lung consolidation, uneven pleural lines, and compact B line (53.3%, 26.7%, and 3.3%, respectively) were abnormal ultrasonographic findings. **Conclusion:** When diagnosing probable instances of pneumonia in children, lung ultrasonography is more sensitive and reliable more chest X-rays. When diagnosed community-acquired pneumonia (CAP) in children, LUS is a very specific and sensitive diagnostic technique. Thus, we speculate that in infants suspected of having CAP, LUS might be the first imaging test to be performed.

Keywords: Lung ultrasound, Pneumonia, Bronchiolitis

INTRODUCTION

The most common cause of hospitalization for infants under 24 months of age is bronchiolitis, a viral lower infection of the respiratory tract (1). RSV, or respiratory syncytial virus is the primary causative agent, and infections usually manifest as recurring sea-sonal epidemics (2). To reduce the severity of the clinical course and limit the viral infection, no particular etiological medication is frequently used.; instead, the treatment is mostly supportive. (3).

The American Pediatrics Academy reported that bronchiolitis is diagnosed clinically, and chest x-rays (CXRs) must only be performed in extreme patients where there are indications of pulmonary complications or when the admission to the intensive care unit (ICU) is required due to the severity of breathing effort. (4).

However, the usage of diagnostic tests varies greatly throughout hospitals, CXR is used in roughly 50% of cases of bronchiolitis, primarily to rule out or diagnosis bacterial pneumonia. Due to the comparable radiographic appearance of atelectasis and infiltrate, Radiography has been shown to increase the likelihood that children with clinical bronchiolitis would be prescribed antibiotics (5). Additionally, even if bilateral Atypical bacterial or viral infections cause interstitial infiltrations occur in clinical practice, CXR is more insensitive for

distinguishing between bacterial and viral pneumonia and alveolar infiltration are thought to be subsequent to bacterial infections. Lastly, observers' interpretations of radiographic pictures differ greatly (6).

CXR is frequently used to treat bronchiolitis in spite of these well-known drawbacks, which exposes kids to ionizing radiation, increases medical expenses and time, and may cause difficulties from the overprescription of antibiotics (7). Because of this, numerous quality improvement techniques have been tried in recent years to reduce the amount of x-rays these patients get (8). No appreciable improvement in clinical practice has been achieved in spite of these efforts.

Lung Ultrasound (LUS) is a non-ionizing radiation technology that is practical, portable, and simple to learn. With exceptional sensitivity and specificity, in recent years, it was a novel diagnosis tool for pneumonia in both adults & children. The use of LUS has also generated a lot of curiosity. in recent years to distinguish between viral infections and bacterial pneumonia. (9).

In this regard, LUS might be the best method for determining whether children with clinical bronchiolitis might benefit from drugs and for diagnosing or ruling out bacterial pneumonia. However, LUS is now excluded from the diagnostic process for bronchiolitis. Actually, no research has examined the LUS's role in infants with probable lung bacterial co-infection and clinical bronchiolitis, despite the fact that less studies have described the sonographic features of bronchiolitis (10).

So, the aim of this study was evaluate the diagnostic precision and dependability of LUS in identifying acute pneumonia in children with bronchiolitis

PATIENTS AND METHODS

This cross sectional study carried out at Pulmonology and Allergy Unit, Pediatric Department, Souq Al Khamis Hospital in Al Khoms City, Al-Marqab University, during the period from January 2024 to June 2024 on 30 children aged from birth to 24 months with acute bronchiolitis, mean age = 4.19 ± 3.32 months. A posteroanterior chest X-ray (CXR) was performed on all patients because to asymmetric breath sounds on auscultation, persistent oxygen saturation (SatO_2) < 90%, and clinical suspicion of concurrent bacterial pneumonia.

Al-Marqab University's research ethics committee (international review board) approved the study, and patients or their first-degree relatives gave their informed approval in writing. Interstitial invades abnormal The Declaration of Helsinki and the Code of Ethics of the World Medical Association for research or viral infections involving humans, was followed in the conduct of this study.

Sample size:

Assuming that all cases fit the inclusion criteria during the study period (5 cases/month) 30 cases was included as a comprehensive sample.

Inclusion criteria:

- (1) Children of both sexes admitted to Souq Al Khamis Hospital in Al Khoms City, Al-Marqab University, from birth to 24 months
- (2) Due to a clinical suspicion of concurrent bacterial pneumonia, children who diagnosed bronchiolitis in accordance with the American Pediatrics Academy guideline (11) had posteroanterior CXR.
- (3) Patients with White blood cells (WBC) > 15,000/mm³ and/or C-Reactive Protein (CRP) > 6 mg/dl, a temperature ≥ 38.5 °C or > 38 °C for two or more days, asymmetric breath sounds on auscultation, and a persistent oxygen saturation (SatO_2) < 90% were suspected of having bacterial pneumonia..
- (4) Following the criteria of the British Thoracic Society Guidelines, the study's gold standard for diagnosis was based on clinical presentation, laboratory test, CXR, and clinical course (12).

- (5) The discovery of a hypoechogenic region with underlying artifacts that are compact and perpendicular to the pleural line and poorly defined borders, known as B lines, was the criteria used to identify pneumonia on LUS (13). Similar to earlier research, there is reduced echogenicity in the pleural line in the region of interest via lung sliding and consolidation is either absent or diminished. (14).

Exclusion criteria:

- (1) Bronchopulmonary dysplasia, or chronic respiratory illness.
- (2) Heart conditions that are congenital.
- (3) Congenital or acquired immunodeficiency patients in hospitals.
- (4) Neuromuscular illness of severe severity.
- (5) Individuals whose parents declined to take part in the research.

All patients were subjected to the following:

Operative Assessment:

Every registered child had their whole medical history collected from their family members, information such as name, age, sex, hospitalization date, residence, socioeconomic status, and length of hospital stay. The clinical evaluation included measurements of temperature, oxygen saturation, heart rate, and breathing rate. Local respiratory evaluations include things like wheezes, crepitations, air entrance, subcostal retractions & respiratory distress assessment..

Severity of respiratory distress according to Downes' Score (11):

- (1) Score, 0–3 for mild, bronchiolitis.
- (2) Score, 4–6 for moderate, bronchiolitis.
- (3) Severe bronchiolitis: 7–10 points.

Laboratory tests:

An IV was used to draw 1 cm of blood for the complete blood count. The Sysmexx 500 cell counter was used to assess the blood as quickly as possible after the collection of blood in a test tube containing 20 µl of EDTA for the RBC count, hemoglobin level, hematocrit value, WBC count (Total and differential), and platelet count.

Using a Siemens machine, latex agglutination was used to measure C-reactive protein (CRP). A simple test tube was used to collect 3 cm of blood after the skin was treated with antiseptic. The blood was then allowed to coagulate for ten minutes at 1500 rpm, after which Turbox Plus was used to extract and analyze the serum. Positive results were defined as those that exceeded 10 mg/l.

Chest X-ray: it is completed in the hospital's Radiology Unit.

Chest Ultrasound: The hospital's Pulmonology and Allergy Unit conducted a chest ultrasound using the LOGIQ V5 instrument. Following the protocol, the anteromedial points are referred to as lower BLUE points & the anterior points as upper BLUE points. This posterior points were referred to as the PLAPS point, or "posterolateral alveolar and/or pleural syndrome point." Furthermore, the procedure allows for the optional determination of "lung points."

The upper anterior points is the bottom of the ring and middle fingers on the hand. This higher lobe is covered by it.

The lower anterior point, which is near a man's nipple, is the middle of the lower hand's palm. It is situated above the lingular or middle lobe. The left heart will be missed by these points.

Posterolateral point: As far below the posterior axillary line (bounded by the bed) as you can, move laterally and posteriorly from the lower anterior point. Over the lower lobe, it is located. By slightly twisting the curvilinear probe to lie between the ribs, rib shadows can be reduced (the cephalad was on the left image side).

Probe selection:

Linear probe: To identify pleural effusion, pneumothorax, & uneven pleural lines, a linear probe is utilized to examine superficial structures such as the pleura.

Curvilinear probe: Due to its good penetration and wide sector width, the curvilinear probe was utilized to examine deep structures such as the diaphragm, lung parenchyma, and interstitial tissue in order to identify diaphragmatic movement, B-lines, and lung consolidation. Furthermore, More thorough scanning methods have been explained and are suggested for practitioners with greater experience..

STATISTICAL ANALYSIS

Every piece of information was gathered, tabulated, and statistically examined using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., 2015; Armonk, NY). Qualitative data were presented as numbers and percentages, whereas quantitative data were presented as the mean $\pm$ SD and median (range). Using the paired t test, continuous normally distributed variables were compared. When comparing more than two sets of normally distributed variables, the Anova test was employed. The quantitative characteristics were correlated using Pearson's correlation coefficient (r). When two variables have a r value greater than 0.7, the link is usually regarded as strong. A number between -1 and 1 is usually the correlation coefficient, or r. When there is a positive correlation between the variables, the r-value is positive; when it is negative, the r-value is negative. Every test had two sides. P-values < 0.05 was considered statistically significant, whereas > 0.05 was regarded as statistically non-significant (NS).

RESULTS

Table (1) : demographic characteristic of studied patients (N=30)

Age	N=30	
Age:(months)	4.20 $\pm$ 3.50	
mean $\pm$ SD	4.2 $\pm$ 3.5	
Variable;	No	%
Age distribution:		
1-6, months	24	80
7-12, months	4	13.3
13-18, months	2	6.7
Sex:		
Male	15	50
Female	15	50
Presentation symptoms:		
wheezes	24	80
Fever	18	60
crepitation	8	26.6
respiratory distress:		
Moderate	20	66.7
Low	7	23.3
Severe	3	10
Family history of asthma:		
Positive	3	6.7
Negative	27	93.3

Eighty percent of the cases in this study were between the ages of one and six months, with a mean age of 4.20 $\pm$ 3.50 months. About half of them were men, and the other half were women. In the population under observation, wheezes accounted for 90% of the most prevalent presentation, followed by fever (60%), and

crepitation (33.3%). 10% of the group under study experienced severe respiratory distress, 23.3% mild respiratory distress, and 66.7% moderate respiratory distress. Lastly, 6.7% of people have a family history positive asthma.

Table (2): Laboratory investigations among the studied group (N=30)

Variable	Mean± SD
Hb: (gm/dl)	10.07±1.43
WBCs: (x103/mm3)	11.81±2.35
Neutrophils: (x103/mm3)	3.37±0.28
Lymphocytes: (x103/mm3)	7.4±1.77
Platelets: (x103/mm3)	357±19.3
CRP: (mg/dl)	13.86±3.28

The current study revealed that mean Hb (gm/dl) was 10.07±1.43, mean WBCs (x103/mm3) was 11.81±2.35, mean Neutrophils (x103/mm3) was 3.37±0.28, mean Lymphocytes (x103/mm3) was 7.4±1.77, mean Platelets (x103/mm3) was 357±19.3 and CRP: (mg/dl) was 13.86±3.28.

Table (3): X-ray results in the studied patients (N=30)

X-ray findings	No	%
Normal:	21	70
Peri-bronchial thickening, Positive, Negative,	4 26	13.3 86.7
Lung Consolidation, Positive, Negative,	4 26	13.3 86.7
Hyperinflation, Positive, Negative,	3 27	10 90

The current study showed that in around 21 cases, the X-ray was normal. Hyperinflation, lung consolidation, and peribronchial thickening were abnormal X-ray findings.

Table (4): Ultrasound findings among the studied group

Ultrasound findings	(n=30)	
	No	%
Normal Pattern	10	33.3
Compact B Lines: Positive Negative	16 14	53.3 46.7
Subpleural lung Consolidation: Positive Negative	8 22	26.7 73.3
Irregular Pleural Lines: Positive Negative	1 29	3.3 96.7
Pleural Effusion: Positive Negative	0 30	0 100
Occult Pneumothorax: Positive	0	0

Negative	30	100
Focal Multiple B-Lines:		
Positive	0	0
Negative	30	100

The present study revealed that the US was normal in 10 cases. Subpleural lung consolidation, uneven pleural lines, and compact B line (26.7%, 3.3% 53.3% respectively) were abnormal ultrasonographic findings. Occult pneumothorax, Pleural effusion and localized numerous B-Lines were absent in all patients.

Table (5): X ray validity for diagnosis of pneumonia compared to clinical as gold standard

X ray	Clinical		Total,	Kappa,	P
	+ve	-ve			
+ve,	3	1	4	0.45	0.009*
-ve,	4	22	26		
Total,	7	23	30		
Validity,	Sensitivity: 42.9% PPV: 75% Specificity: 95.7% NPV: 84.6% Accuracy: 83.3%				

Kappa: Agreement test PPV: the positive expected value NPV:-ve expected value, *: Notable

The current study showed that there was a statistical considerable agreement between clinical and X ray in identification of non-pneumonia patients (specificity 95.7%) but sensitivity of pneumonia diagnosis by X ray was only 42.9%

ultrasound validity for diagnosis of pneumonia compared to the clinical gold standard

Table (6): ultrasound validity for diagnosis of pneumonia compared to the clinical gold standard

US	Clinical		Total	Kappa	P
	+ve	-ve			
+ve	7	1	8	0.91	<0.001**
-ve	0	22	22		
Total	7	23	30		
Validity	Sensitivity: 100% PPV: 87.5% Accuracy: 96.7% Specificity: 95.7% NPV: 100%				

Kappa: Agreement test PPV: the positive expected value NPV:-ve expected value, *: Very important

The current study showed that when diagnosing pneumonia patients (sensitivity 100%) while non-pneumonia cases (sensitivity 95.7%), there were very statistically significant agreement between clinical and ultrasonography.

DISCUSSION

The most prevalent lower respiratory tract infection caused by a virus in infants under the age of two is bronchiolitis (1). Since the diagnosis is clinical, routine use of CXR is not currently advised by guidelines (4). Nonetheless, CXR is still used in many situations, mostly to identify and exclude bacterial pneumonia that needs antibiotic therapy. According to published research, Between 9.7% and 42% in severe cases, the occurrence of lung bacterial co-infection in bronchiolitis ranges that require intensive care unit admission. The children age, the bronchiolitis severity, the different support settings, the proportion of cases whom had CXR, the standards used to identify aberrant CXR could all be contributing factors to these discrepancies. (13).

Respiratory Syncytial Virus (RSV), the primary causative agent, usually manifests as recurring seasonal epidemics (2). It is mostly managed with supportive care; no particular etiological medication is frequently employed to lessen the severity of the clinical course and viral infection. Based on the latest guidelines from the

American Academy of Pediatrics, bronchiolitis is diagnosed clinically, and chest X-rays (CXRs) should only be performed in situations of severe pulmonary problems or when clinical deterioration results in the intensive care unit (ICU) admission (4).

These days, treating baby pulmonary illness does not involve chest ultrasonography. Chest ultrasonography, however, has been shown in numerous studies to be helpful in some pulmonary conditions. Since all of them exhibit had diffuse B-lines, minor subpleural lung consolidation, occult pneumothorax, minimal pleural effusion, bilateral white lung & parts with normal pattern. Biagi et al. (13) showed that chest ultrasonography is valid method for assessing respiratory distress syndrome patients.

In order to evaluate the A cross-sectional research on the LUS's diagnostic precision in detecting pneumonia in children suffering from acute bronchiolitis was carried at Souq Al Khamis Hospital in Al Khoms City, Al-Marqab University, between January 2024 to June 2024 on 30 children ages 0–18 months who were admitted to the hospital's pulmonology and allergy unit..

In terms of sex, half of the cases in the current study was males, and half were females. The mean age of the cases under study was 4.20 ± 3.50 months, and 80% of them were between the ages of 1 and 6 months. This is consistent with a research by Karkar et al. (15), which found that of the 120 pneumonia cases they included, 77 (64.4%) were diagnosed in boys and 43 (35.6%) in females. The patients' ages were bryeem 12 to 60 months, mean age of 24.11 ± 7.42 months. Also, Mohamed et al., (16) who investigated the accuracy of LUS diagnosis of against chest X-ray (CXR) in 139 children with CAP. They stated that there were 48 (34.5%) girls and 91 (65.5%) males, with an average age of 3.28 ± 0.62 years.

According to the current study, wheezes accounted for 90% of the group under investigation, followed by fever (60%), and crepitation (33.3%). This aligns with the conclusions of Raita et al. (17), who found that the majority of individuals had wheezes at presentation, whereas more severe cases have asthma with crepitations..

63.3% of the group under research experienced moderate respiratory distress, 26.7% have mild respiratory distress, and 10% have severe respiratory distress, according to the current study. In the same line Biagi et al. (13) discovered that 37.9% of the population under study had severe respiratory distress, 47.1% have significant respiratory distress, while 15% have light respiratory distress.

Shetty & Sabapathy (18) found that severe pneumonia was the most prevalent, accounting for 66.2% of cases (n=139). Ten percent (n=21) had pneumonia and 23.8% (n=50) had extremely acute pneumonia. According to this study, 66.2% (n=139) of the participants had severe pneumonia, 23.8% (n=50) had acute pneumonia, while 10% (n=21) had pneumonia.

The current study revealed that the average Hb (gm/dl) was 10.07 ± 1.43 , the average WBCs ($\times 10^3/\text{mm}^3$) were 11.81 ± 2.35 , the average neutrophils ($\times 10^3/\text{mm}^3$) were 3.37 ± 0.28 , the average lymphocytes ($\times 10^3/\text{mm}^3$) were 7.4 ± 1.77 , the average platelets ($\times 10^3/\text{mm}^3$) were 357 ± 19.3 , and the average CRP (mg/dl) was 13.86 ± 3.28 . Regarding the average hemoglobin level (10.7 ± 0.92), the average total leucocytic count (11.8 ± 4.1), the average DC-N (41.5), the average DC-L (57.5), and the average platelet count (579.1 ± 100.9), these results are nearly identical to those of Ramagopal et al. (19). The same line, Ellington et al. (20) reported that the mean platelets were 414 ± 146 , the mean white blood cells were 11.7 ± 5.1 ($\times 10^3/\text{mm}^3$), and the mean hemoglobin level were 10.6 ± 1.3 gm/dl.

According to the current study, 21 instances had normal x-rays. Unusual x-ray findings included hyperinflation, lung consolidation, and peri-bronchial thickening (13.3%, 13.3%, and 10%, respectively).

Karkar et al., (15). Found that CXR loosed 13 cases of pneumonia and detected 5 episodes of pleural effusion, while it can detect consolidation in 107 patients (88.90%). Because these lesions are difficult to access because they are beyond the heart or mediastinum, or because they are very small in the early stages of the disease, CXR may not be able to detect them.

Biagi et al., (13) discovered that 24 out of 25 patients with bacterial pneumonia had parenchymal consolidation compatible with pneumonia, as indicated by CXR. Eight children had false-positive results with CXR. The lone patient with LUS had a false-negative CXR, which revealed subcentimeter pneumonia in the left lung's posterior basal retrocardiac area.

The current study revealed that the US was normal in 10 cases. Subpleural lung consolidation, uneven pleural lines, and compact B line (53.3%, 26.7%, and 3.3%, respectively) were abnormal ultrasonography findings. Occult pneumothorax, Pleural effusion, or localized numerous B-Lines were absent in all patients. Although According to a study by Caiulo et al. (21) subpleural lung consolidations was seen in 84.6% of babies with bronchiolitis on chest ultrasonography ($p < 0.001$ compared to the control group). The anterior and lateral scans showed the most lung consolidations. In the vicinity of the consolidation, Comet-tail artifacts of vertical reverberation were frequently observed. Numerous compact B-lines (areas of white lung; $p < 0.001$ compared to control group) were present in 65.3% of babies. Pleural line abnormalities were present in 44.2% of babies ($p < 0.001$ compared to the control group). A little pleural effusion that was not visible on CXR was discovered in 5.8% of newborns. A little pneumothorax that was not visible by CXR was discovered in 1.9% of newborns. A small number of isolated B-lines were present in 9.6% of neonates with bronchiolitis.

Karkar et al. (15) revealed that 114 cases (95.6%) had positive consolidation results, 104 patients (86.7%) had positive air bronchogram results, 37 patients (31.1%) had fluid bronchogram results, 68 patients (56.7%) had numerous B-lines, and 29 patients (24.4%) had pleural effusion results in LUS.

Biagi et al. (13) discovered that LUS could detect all bronchiolitis cases with concurrent bacterial pneumonia, with 5 out of 25 cases being subcentimetric pneumonia.

Also, Milner and Tsung (22), found that the most of pneumonia patients (16/25, 64%) exhibited posterior lung zones with sonographic consolidation. Of the 31 ultrasonography consolidations that were found to be consistent with pneumonia, 21 (67.8%) were located in the posterior lung zones. LUS was able to detect two concurrent consolidations linked to bronchograms in 6 patients. In ten cases, LUS produced false-positive results; all but one of these cases involved subcentimetric pneumonia. Respiratory syncytial virus pneumonia was the final diagnosis made for the lone patient whose ultrasonography showed a false-positive consolidation greater than 1 cm.

Urbankowska et al., (23) revealed that, in terms of diagnosing pneumonia, Overall, LUS and CXR agreed (Cohen kappa coefficient of 0.89), and 101 cases showed consistent outcomes.. According to Ellington et al. (20), 360 (79%) of the children showed abnormalities consistent with pneumonia detected by CXR, while 191 (42%) had consolidations while 169 (37%) have abnormal interstitially.

Mohamed et al., (16) found that out of 139 individuals with a clinical diagnosis of pneumonia, 126 (90.64%) had CXR suggestive of pneumonia and 136 (97.84%) had LUS suggestive of pneumonia ($p = 0.01$). Eleven patients with negative CXR exhibited LUS findings suggestive of pneumonia with a clinical history consistent with pneumonia ($p < 0.01$), while one patient with negative LUS had abnormal CXR. While CXR was unable to identify any abnormalities in 13 patients, LUS was negative in 3 patients with a clinical history compatible with pneumonia. There was a noticeable difference.

The current study demonstrated that despite the sensitivity of X-ray pneumonia diagnosis was only 42.9%, In identifying patients who did not have pneumonia, there were a significant statistical similar between clinical & X-ray (specificity 95.7%).

Biagi et al., (13) discovered that whereas When it came to identifying children with bronchiolitis, LUS had a 100% (95% CI 94.7–99.9%) sensitivity and an 83.9% (95% CI 74.1–90.6%) specificity, whereas CXR had a 96% (95% CI 88.8–98.8%) sensitivity and an 87.1% (95% CI 77.8–93.0%) specificity who also had bacterial pneumonia.

The current study demonstrated that a highly statistically significant difference was found between sensitivity of the clinical and US diagnosis of non-pneumonia cases (95.7%) and pneumonia cases (100%).

Karkar et al., (15) showed that although CXR have a sensitivity of 88.9.0% and a specificity of 86.7%, LUS had a sensitivity of 95.6% & a specificity of 93.3%. Similarly, LUS showed a 96% sensitivity & a 93% specificity, according to Pereda et al. (24). An meta-analysis conducted by Balk et al. (25) showed that CXR have a sensitivity of 86.8% (83.3-90.0) and specificity of 98.2% (95.7-99.6), whereas the mean sensitivity and specificity of LUS were 95.5% (93.6-97.1) and 95.3% (91.1-98.3), respectively.

CONCLUSION

When diagnosing probable instances of pneumonia in children, lung ultrasonograph was high sensitive & reliable versus chest X-rays. For children with CAP, LUS is a very specific and sensitive diagnostic technique. Thus, we speculate that in infants suspected of having CAP, LUS might be the first imaging test to be performed.

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