Comparison Between Lung Ultrasonography, Plain X-ray, and Computed Tomography in Acute Bronchiolitis

Mohamed Mahmoud Rashad[1], Shaimaa Magdy Hussein[2], Fatma Elzahraa Hamdy Abdelrazek[1], Heba Rasmy Abdelbaset[1]

Departments of [1]Pediatrics and [2]Pulmonology, Faculty of Medicine, Benha University, Egypt

*Corresponding author: Fatma Elzahraa Hamdy Abdelrazek, **Mobile:** (+20)01116377136, **Email:** felzahraa69@gmail.com

ABSTRACT

Background: A viral upper airway infection usually precedes a viral lower airway infection, which is known as acute bronchiolitis. When children visit emergency rooms, this respiratory system illness is among the most prevalent ones. Lung ultrasonography (LUS) has been demonstrated to be a useful diagnostic method for a variety of cardiopulmonary conditions. Alternative diagnostic methods that do not include the use of ionising radiation should be considered during the examination of young individuals in order to lower their risk of cancer.

Objective: Comparing the effectiveness of LUS, plain X-ray, and CT in diagnosing acute bronchiolitis in children and the degree of the illness.

Patients and Method: A single-centre comparative study included 53 infants aged less than 24 months admitted in the Pediatric Department (Benha University Hospital). All children will be subjected to full medical history taking, clinical examination, plain chest X-ray, CT chest (performed prior to admission in infants experiencing respiratory distress in order to rule out COVID-19 infection), and LUS examination on admission.

Results: In cases of severe bronchiolitis, chest US can accurately predict CT chest subpleural consolidation with a PPV of 72.22%, NPV of 100%, and accuracy of 90.57%. There was a significant agreement between the prevalence of subpleural consolidation between chest US and CT chest, with a kappa (κ) of 0.77. Regarding plain chest x-ray, 47 (89%) of the patients under study had bronchovascular markings (BVM), 23 (43.4%) had hyperinflation, and 3 (5.7%) had minimal subpleural consolidation.

Conclusion: Implementing LUS as an initial diagnostic tool could lead to more safe, efficient, and cost-effective management of acute bronchiolitis in pediatric patients.

Keywords: Bronchiolitis, Lung ultrasound, Chest X-ray.

INTRODUCTION

Acute respiratory infections like bronchiolitis are most frequent in children under 24 months of age, with 1-3 month olds being more susceptible to severe cases. Initial symptoms of infection include coryza and occasionally low-grade fever, which develop into cough, tachypnea hyperinflation, chest retraction, and/or broad crackles and wheezes within a few days. Bronchiolitis is a clinical diagnosis. Most of the time, routine laboratory testing provides little useful information. 20% to 96% of chest X-rays (CXRs) show abnormalities [1].

Ultrasound has just recently been used to analyse the lungs. LUS has shown to be a helpful diagnostic tool for a wide range of cardiopulmonary disorders [2]. LUS is particularly useful because it is a quick, portable, repeatable, and non-ionizing application of echography [3]. Other diagnostic methods that don't include ionising radiation should be considered in order to lower the risk of cancer in young individuals [4].

PATIENTS AND METHODS

This single-centre comparative study included 53 infants aged less than 24 months admitted in the Pediatric Department (Benha University Hospitals).

Inclusion criteria: All infants aged less than 24 months (more than 1 month up to 24 months) admitted in the Pediatric Department with acute bronchiolitis with exclusion of patients with Bacterial superinfection.

All studied cases were subjected to detailed history taking including Personal history; name, age, gender, weight, gestational age, type of feeding and age of weaning, full clinical examination including vital signs (pulse, respiratory rate, temperature, rhinorrhea and cough).

Laboratory investigations:

CBC, CRP, ABG, and Blood culture. Within the first 12 hours following CXR, all patients had a bedside LUS. The linear probe on a Philips ultrasound machine, which had frequencies ranging from 7.5 MHz to 12 MHz, was used to perform LUS.

The pulmonologist performing the LUS had specialized training in LUS and was not aware of the patients' clinical, laboratory, or radiographic information. LUS score can be used to diagnose and manage bronchiolitis in children. A clinical score and a sonographic score can be used to describe the severity of the condition. LUS can indicate the requirement for PICU hospitalisation in patients with bronchiolitis. The severity of the condition was determined using five clinical parameters: respiratory rate, inspiratory breath sounds, usage of auxiliary muscles, expiratory wheezing, and PO2 (the partial pressure of oxygen generally drops owing to airway constriction).

After assigning a number between 0 and 2 to each criterion, the total score was determined. The Lung Ultrasound Score for Bronchiolitis (LUSBRO) is a tool used to assess the severity of bronchiolitis. It has four scores: 0 for A lines and fewer than three B lines, 1 for more than three spaced B lines, 2 for coalescent B lines, and 3 for subpleural consolidation.

CXR examination:

A posterior anterior CXR was obtained from infants while they were in the supine position. In accordance with the British Thoracic Society Guidelines recommendations, lateral radiographs were not taken to reduce radiation exposure [5]. The attending pediatric radiologist identified viral infections on CXR by looking for "possible viral infiltrates," "peri-bronchial infiltrates," "peri-bronchial cuffing," "peri-bronchial thickening," or "increased interstitial markings."" [6].

CT chest examination:

A CT scanner measures X-ray attenuation, or the decrease in force or intensity of radiation, several times at various rotational angles over the thoracic cross-sectional plane. After that, it makes use of this data to create a digital reconstruction of the cross-section, with each picture pixel serving as a gauge for the average attenuation over the preset segment's thickness.

Ethical approval:

Before the children were enrolled in the study, the parents gave parental agreement and the study was granted ethical authorization. The parents were fully informed about all study procedures. The ethics committee of Benha University Hospital's faculty of medicine gave its approval to this investigation (MS.20.1.2022). The Helsinki Declaration was followed throughout the study's conduct.

Statistical analysis:

The computer was given data, and IBM SPSS software package V. 20.0 was used for analysis. Numbers and percentages were used to describe the qualitative data. The distribution's normality was confirmed using the Kolmogorov-Smirnov test. The terms range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR) were used to characterise quantitative data. The results were deemed significant at the 5% level. P value was fixed at 0.05 for statistical significance and <0.001 for high significant result.

RESULTS

The mean weight of the studied patients was 9.6 kg (±2.04 SD) with the range of 6-15 kg. The mean gestational age was 37.85 weeks (±1.49 SD) with the range of 34-40 weeks. Twenty patients (37.7%) had artificial feeding, 28 (52.8%) had exclusive breast feeding and 5 (92.8%) had both. Fifty-one patients were weaned. The mean age of weaning was 5.16 months (±0.78 SD) with the range of 4-6 months. Thirty-four patients (64.2%) had family history of asthma, 52 (98.1%) had history of (upper respiratory tract infection) URTI and 27 (50.9%) were living with smokers (Table 1).

Table (1): Distribution of the studied cases according to Preliminary data.

History data	Subjects (n = 53)	
Weight in kg		
Range.	6 – 15	
Mean ± SD.	9.6 ± 2.04	
Gestational age in weeks		
Range	34 – 40	
Mean ± SD.	37.85 ± 1.49	
Feeding	No.	%
Artificial	20	37.7
Breast	28	52.8
Both	5	9.4
Age of weaning in months		
Range.	4 – 6	
Mean ± SD.	5.16 ± 0.78	
	No.	%
Family history of asthma	34	64.2
History of URTI	52	98.1
Smoker at home	27	50.9
Comorbidities	0	0.0

The median modified bronchiolitis severity score was 4 with the interquartile range of 3-7 and the range of 1-11. According to severity, the disease was mild in 24patients (45.3%), moderate in 27 patients (50.9%) and severe in 2 patients (3.8%) (Table 2).

Table (2): Distribution of cases according to modified bronchiolitis severity score.

Modified bronchiolitis severity score	Subjects (n = 53)	
Total score		
Range.	1 – 11	
Median (IQR)	4 (3 – 7)	
Severity	No.	%
Mild	24	45.3
Moderate	27	50.9
Severe	2	3.8

According to LUSBRO, 14 patients (26.4%) had 0, 16 (30.2%) had 1, 4 (7.5%) had 2 and 19 (35.8%) had 3 (Table 3).

Table (3): Lung ultrasound of bronchiolitis (LUSBRO) score

LUSBRO score	Subjects (n = 53)	
	No.	%
0	14	26.4
1	16	30.2
2	4	7.5
3	19	35.8

Among the studied patients, 47 (89%) had BVM, 23 (43.4%) had hyperinflation and 3 (5.7%) had consolidation (Table 4).

Table (4): Plain chest X-ray (CXR) findings of the studied patients

CXR findings	Subjects (n = 53)	
	No.	%
Increased BVM's	47	89.0
Hyper inflation	23	43.4
Consolidation	3	5.7

Among the studied patients, 5 (9.4%) showed pleural irregularity, 6 (11.3%) B-line, 9 (17%) B-line (compact), 19 (35.8%) B-line (isolated) and 18patients (34%) showed consolidation (Table 5).

Table (5): Chest ultrasound (US) findings of the studied patients

Chest US findings	Subjects (n = 53)	
	No.	%
Pleural irregularity	5	9.4
B-lines		
0	19	35.8
1	6	11.3
1 (Compact)	9	17.0
1 (isolated)	19	35.8
Consolidation	18	34.0
Air broncho gram	0	0.0

Regarding the prevalence of consolidation, CXR agreed with chest US with PPV of 100%, NPV of 70% and accuracy of 71.7%. This agreement was fair with kappa (κ) 0.21 (Table 6).

Table (6): Agreement between CXR and chest US regarding the prevalence of subpleural consolidation

		chest US		Predictive value		kappa (κ)	P
		Negative	Positive				
CXR	Negative	True negative 35 (66.0%)	False negative 15 (28.3%)	Negative PV	70.0	0.21	0.013[*]

Positive	False positive 0 (0.0%)	True positive 3 (5.7%)	Positive PV	100.0		
Accuracy			71.70			

κ: **Kappa agreement test**, p: p value for comparing between studied groups, *: Statistically significant at p ≤ 0.05.

Regarding the prevalence of subpleural consolidation, chest US agreed with chest CT with PPV of 72.22%, NPV of 100% and accuracy of 90.57%. This agreement is considered fair with kappa (κ) 0.77 (Table 7).

Table (7): Agreement between chest US and chest CT regarding prevalence of consolidation

		CT chest		Predictive value		kappa (κ)	P
		Negative	**Positive**				
Chest US	**-ve**	True negative 35 (66.0%)	False negative 0 (0.0%)	-ve PV	100.0	0.774	<0.001*
	+ve	False positive 5 (9.4%)	True positive 13 (24.6%)	+ve PV	72.22		
Accuracy			90.57				

κ: Kappa agreement test

Regarding O2 support, 3 patients (5.7%) were put on CPAP, 22 (41.5%) had HFNC and 12 (22.6%) had nasal cannula (Figure 1).
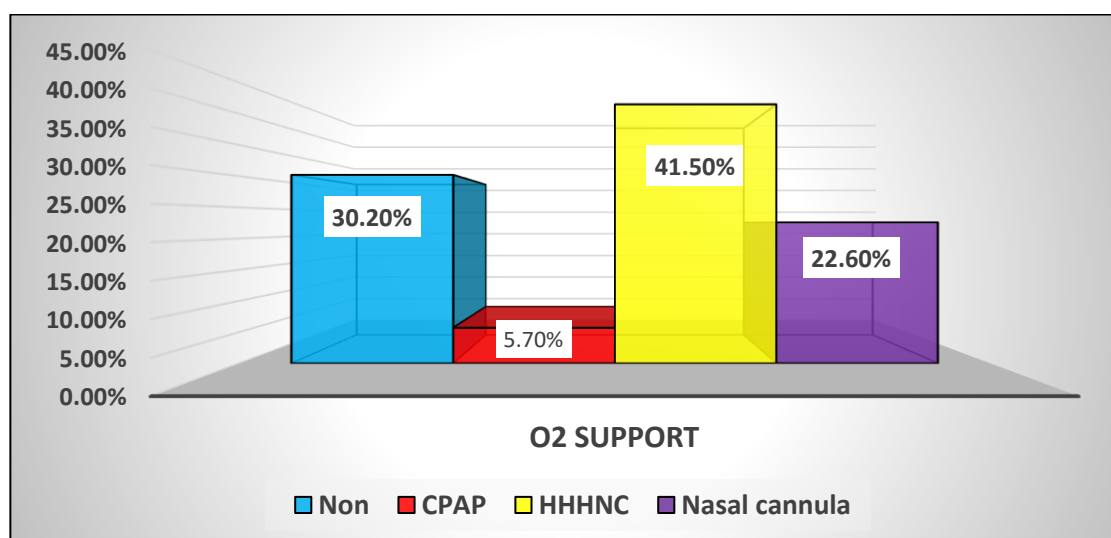

Figure (1): Methods of O2 support for the studied patients

DISCUSSION

The most common cause of hospitalisation for babies under 24 months of age is bronchiolitis, a viral lower respiratory tract infection. The main cause of illness is RSV, which often causes

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recurring seasonal epidemics [7]. LUS is a workable, portable, simple to understand, and radiation-free method. Furthermore, there has been a lot of interest in employing LUS in recent years to distinguish between viral and bacterial pneumonia [8].

In this regard, LUS might be the most effective method for determining which children with clinical bronchiolitis would benefit from antibiotics and for diagnosing or ruling out bacterial pneumonia. However, LUS is not now part of the bronchiolitis diagnosis process. Actually, only a small number of research have looked at the sonographic characteristics of bronchiolitis; however, none have investigated the role of LUS in children with clinical bronchiolitis and a potential co-infection with bacteria in their lungs [9].

This study aimed to compare the effectiveness of LUS, plain X-ray, and CT in diagnosing acute bronchiolitis in children and the degree of the illness. So, we can choose the tool of best diagnostic value and least side effects. This single-centre comparative study included 53 infants aged less than 24 months.

In this research, among the studied cases there were 35 (66%) with age 0-1 year and 18 (34%) with age 1-2 years, according to sex there were 27 (50.9%) male and 26 (49.1%) females. In **Atay et al.** [10] study 101 kids with clinical bronchiolitis, ages two months to two years, were enrolled. The average age was found to be 9±2.4 months. There were 25 (24.8%) patients between the ages of 2 and 6 months, 28 (27.7%) between 7 and 12 months, and 48 (47.5%) between 13 and 24 months.

The mean weight of studied cases was 9.6 (±2.04 SD) with range (6-15) kg, the mean gestational age of studied cases was 37.85 (±1.49 SD) with range (34-40) weeks, among the studied cases there were 20 (37.7%) who had artificial feeding, 28 (52.8%) who had breast feeding and 5 (92.8%) who had both, among 51 who were weaned the mean age of weaning was 5.16 (±0.78 SD) with range (4-6) months, there were 34 (64.2%) who had family history of asthma, 52 (98.1%) who had history of URTI and 27 (50.9%) who lived with smoker in home. **Hendaus et al.** [11] included hospitalised patients with acute bronchiolitis ranging in age from one month to twenty-four months. A total of 142 babies (17.1%) were born before 35 weeks of gestation, with a mean gestational age of 37.01±3.37 weeks (range 25 to 42 weeks).

52 patients with bronchiolitis (28 males) who had received a CXR for clinical purposes participated in the study by **Caiulo et al.** [12] The ages varied from 1 to 16 months (median 2.1 months, interquartile range 1.5–5.4), according to the article.

Additionally, **La Regina et al.** [13] compared CXR and LUS results in babies hospitalised with bronchiolitis, as well as connected a LUS score with a clinical score. They studied 92 newborns in a prospective, longitudinal, single-center research. Nineteen out of the ninety-two babies (controls) and sixty-three out of the ninety-two patients (cases) with acute bronchiolitis were admitted to the hospital. At diagnosis, the patient was 2.7 (±1.60) months old. Of the 41, 65% were male.

This study showed that the median modified bronchiolitis severity score was 4 with interquartile range (3-7) and range (1-11) and according to severity there were 24 (45.3%) mild, 27 (50.9%) moderate and 2 (3.8%) severe. In line with our investigation, **Basile et al.** [14] examined 106 infants who had a history, signs, and symptoms suggestive of bronchiolitis. Based on their clinical score, thirty infants had moderate bronchiolitis, two had severe bronchiolitis, and seventy-four infants had mild bronchiolitis. However, **La Regina et al.** [13] concluded that according to clinical score, nine infants had mild, 37 moderate, and 17 severe bronchiolitis. According to LUSBRO (lung ultrasound score of bronchiolitis) there were 14 (26.4%) 0, 16 (30.2%) 1, 4 (7.5%) 2 and 19 (35.8%) 3, according to O_2 support among the studied cases there were 3 (5.7%) with CPAP, 22 (41.5%) with HFNC(high flow nasal cannula) and 12 (22.6%) with nasal cannula, there were 29 (54.7%) who were admitted to PICU, 29 (54.7%) who needed parenteral nutrition, 27 (50.9%) who needed steroid and 19 (35.8%) who needed nebulizer.

Children hospitalised for acute bronchiolitis aged one month to two years were included in **Siraj et al.** [15] study. They reported that a mean hospital LOS (length of stay) of 3.2 ± 1.6 days was

observed, and reliability evaluations took place in the general paediatric ward (65%) and PICU (35%). 38% of children were using noninvasive ventilation at the time the BSS (bronchiolitis severity score) was calculated, 13% were ordered to receive no oxygen at all, 6% were simultaneously febrile, and 30% were sleeping.

In the present study, among the studied cases there were 47 (89%) with BVM (broncho-vascular markings), 23 (43.4%) with hyperinflation and 3 (5.7%) consolidation. **La Regina et al. [13],** reported that of the newborns, 54 (85%) had subpleural consolidations; the most common types in these individuals were consolidations >1 cm and/or numerous forms. Ultimately, 13 (21%) newborns had aberrant pleural lines, and 1 (2%) child had a minor pleural effusion.

According to this study, among the studied cases there were 5 (9.4%) with pleural irregularity, there were 6 (11.3%) with B-line, 9 (17%) with B-line (compact) and 19 (35.8%) with B-line (isolated) and there were 18 (34%) with consolidation. Moreover, **Basile et al. [14],** demonstrated that no one of the 25 infants had subpleural lung consolidations or compact B-lines, and 5 had an individual B line that was not pathologically significant.

According to literature **Tsung et al. [6] and Basile et al. [14]**, small subpleural consolidations without air bronchograms (usually less than 0.5 cm) and related abnormalities in the pleural line, such as single or confluent B lines, were linked to viral pneumonia or bronchiolitis.

In the present, CXR can predict chest US subpleural consolidation with PPV of 100%, NPV of 70% and accuracy of 71.7% and CXR and chest US showed fair agreement regarding prevalence of subpleural consolidation with kappa (κ) 0.21.

LUS and CXR were done on 23 bronchiolitis patients. In 14 (61%) and 12 (52%) of the 23 babies, respectively, lung consolidation and air trapping were seen. There was agreement (k = 82%) between the subpleural lung consolidations seen with LUS and CXR. Additionally, a strong connection (k = 75%) was discovered between anomalies of the pleural line LUS and air trapping X-ray [13].

In the present work, Chest US can predict CT chest consolidation with PPV of 72.22%, NPV of 100% and accuracy of 90.57% and chest US and CT chest showed substantial agreement regarding prevalence of consolidation with kappa (κ) 0.77. According to **Ambroggio et al. [16],** when compared to a CT scan, lung US and radiographs showed statistically equivalent sensitivity for identifying pleural effusion, interstitial disease, and consolidation, while radiographs had a significantly greater sensitivity for abnormalities like masses.

CONCLUSIONS

In conclusion, our study demonstrates that LUS holds promise as a valuable and safe diagnostic tool for acute bronchiolitis in infants. Its accuracy in predicting subpleural consolidation on CT scans shows its potential as an alternative to CXR and CT, especially in less severe cases. Therefore, implementing LUS as an initial diagnostic tool could lead to more efficient and cost-effective management of acute bronchiolitis in pediatric patients.

LIMITATIONS

This was a single center study with a relatively small sample size of 53 infants which may limit the generalizability of our findings to a broader population. The interpretation of imaging results, especially in CXR and LUS, might be influenced by inter-observer variability, potentially affecting the accuracy and consistency of the findings.

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