Evaluation of Pneumonia using Lung Ultrasound in children with Acute Bronchiolitis

Ahmed Taleb Mohamed lemine[1], Hassan Albana Mohammed Salim[1], Khalid Mohammed Salah Abdelmeged[1], Sameh Saber Bayoumi[2]

[1]Pediatrics Department, Faculty of Medicine, Zagazig University, Egypt.
2RadiodiagnosticDepartment, Faculty of Medicine, Zagazig University, Egypt.
Corresponding author:Ahmed T. lemine,
Email:ahmed6331137@gmail.com

ABSTRACT
Background: Bronchiolitis usually occurs during the first year of life, with a peak incidence between 3 and 6 months of age, and represents the main reason for hospitalization in the young population. Currently, chest Ultrasound is not considered in the diagnostic algorithm for assessment of pneumonia in children with acute bronchiolitis even though its usefulness has been tested in several studies in the last years as an emerging diagnostic tool.The aim of the current study was to evaluate the diagnostic accuracy of LUS for the detection of pneumonia in children with acute bronchiolitis.**Patients and methods:**This study involved 30children of both sexes in age from 1to 24 months who enrolled to Pulmonology and Allergy Unit, Pediatric Hospital of Zagazig University and diagnosedwith bronchiolitis.Steps of performance included consent from relatives to participate in the study, complete history taking, full clinical examination, laboratory investigation including complete blood count, C-reactive protein, chest X-ray and chest Ultrasound.**Results:** There was 76.7% of the studied group had bronchiolitis and 23.3% had bronchiolitis with pneumonia. There was no statistical agreement between US and X- ray in diagnosis of the studied cases. US can diagnose bronchiolitis while X-ray can't. US can diagnose more pneumonia cases. There was a highly statistical significant agreement between clinical and US in diagnosis of pneumonia cases (sensitivity 100%) and non-pneumonia cases (sensitivity 95.7%).There was a statistical significant increase in frequency of sever RD among pneumonia cases compared to bronchiolitis cases. **Conclusion:**Lung ultrasonography offers better detection of consolidations and other pneumonia associated lung abnormalities, thus reducing radiation exposure in this age group and it may become the next line investigation of choice prior to x-ray chest**.**

Keywords: Bronchiolitis;Pneumonia; Lung ultrasonography

INTRODUCTION

Childhood pneumonia is a leading cause of death in both developed and non-developing countries. In developed countries, the annual incidence is 33 per 10,000 in children 0 to 5 years of age with a mortality rate of less than one per 1,000 children per year **(1)**. In non-developing countries, however, the estimated annual incidence is 2,900 per 10,000 in children 0 to 5 years of age with a mortality rate of approximately 26 per 1,000 live births per year (**2**).Radiographic images interpretation varies significantly among observers (**3**).CXR is widely used in bronchiolitis, resulting in children exposure to ionizing radiations, increased medical costs, time spent, and potential complications due to unnecessary antibiotic prescription **(4)**.

Moreover, even if in clinical practice alveolar infiltration is considered to be secondary to bacterial infection and bilateral interstitial infiltrates to atypical bacterial or viral infections, CXR is too insensitive to distinguish bacterial from viral pneumonia **(1)**.For this reason, in the last years, many quality improvement methodologies have been attempted to minimize X-ray use in these patients **(5)**.

Chest computed tomography (CT) has outstanding diagnostic accuracy for pneumonia, but its excessive radiation exposure, high cost, and possible need for sedation limits its routine use in diagnosing uncomplicated pneumonia **(6)**. Moreover, in resource-poor settings, there is limited access to CXR and CT **(7)**.In the last years, there has been great interest in using Lung Ultrasound (LUS) to differentiate bacterial pneumonia from viral infections **(8)**. Studies measuring the diagnostic accuracy of LUS for childhood pneumonia generally report excellent sensitivity and specificity **(9)**.Ourstudy aimed to evaluate the diagnostic accuracy of LUS for the detection of pneumonia in children with acute bronchiolitis.

PATIENTS AND METHODS

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This study involved 30 children of both sexes in age from 1to 24 months who enrolled to Pulmonology and Allergy Unit, Pediatric Hospital of Zagazig University and diagnosed with bronchiolitis at Pulmonology and Allergy Unit, Pediatric Department, Zagazig University Hospital (ZUH) during the period.Consent from relatives to participate in the study.

Inclusion criteria:

Children diagnosed with bronchiolitis according to the American Academy of Pediatrics guideline and undergone posteroanterior CXR because of clinical suspicion of bacterial pneumonia**(5)**.Bacterial pneumonia was defined as lung consolidation with air bronchograms.In pneumonia, air bronchograms appear in a scattered dot-like and branching pattern. By contrast, in atelectasis, the airless lung is similar in echogenicity to liver and the bronchograms appear crowded and parallel. Moreover in pneumonia air bronchograms can have intrinsic dynamic centrifugal movements due to breathing. The finding of dynamic air bronchogram on LUS attests bronchial patency and rules out atelectasis **(10).** For purposes of analysis, sub centimeter bacterial pneumonia was defined as focal lung consolidations with air bronchograms with a size of less than one centimeter. According to literature small subpleural consolidations with no air bronchograms (typically < 0.5 cm) with associated pleural line abnormalities, single or confluent B lines were considered associated with bronchiolitis or viral pneumonia **(11).**

Exclusion criteria:

Childern with hronic respiratory disease, congenital heart diseases,congenital or acquired immunodeficiencyandsevere neuromuscular disease were excluded.

Clinical assessment:

Steps of performance included consent from relatives to participate in the study, complete history taking, full clinical examination, laboratory investigation including complete blood count, C-reactive protein, chest X-ray and chest Ultrasound.

Severity of respiratory distress by Downes' Score**(12)** revealed thatmild bronchiolitis score is (0–3), moderate bronchiolitis score is (4–6) andsevere bronchiolitis score is (7-10).

X ray was performed in the Radiology unit of the hospital.Chest US was performed in the Pulmonology and Allergy Unit of the hospital Using LOGIQ V5 device Chest US was performed. BLUE points and 'posterolateral alveolar and/or pleural syndrome point', or PLAPS point were identified.

Statistical analysis:

Data imported into Statistical Package for the Social Sciences (SPSS version 20.0) software. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD. Validity test was used. Differences between quantitative independent multiple by ANOVA or Kruskal Wallis, P value was set at <0.05 for significant results &<0.001 for high significant result.

RESULTS

The present study showed there was no statistical significant relation between pneumonia and Socio-demographic data of the studied group **(Table 1).**

About 76.7% of the studied group had bronchiolitis and 23.3% had bronchiolitis with pneumonia**(Figure 1)**.

There was a statistical significant increase in frequency of sever RD among pneumonia cases compared to bronchiolitis cases. No difference was founded between pneumonia and bronchiolitis in other clinical data**(Table 2)**.

There was a statistical significant increase in WBCs, neutrophil and CRP among pneumonia cases compared to bronchiolitis cases. No difference was founded between pneumonia and bronchiolitis in other laboratory data**(Table 3)**.

Abnormal findings of x ray showed 13.3% hadPeri-bronchial thickening,13.3% had lung consolidation and 10% hadhyperinflation **(Figure 2)**.

Abnormal findings of ultrasound showed 53.3%compact B line, 26.7% hadsubpleural lung consolidation and3.3% irregular Pleural Lines**(Figure 3)**.

There was no statistical agreement between US and X ray in diagnosis of the studied cases. US can diagnose bronchiolitis while x ray can't. Also US can diagnose more pneumonia cases **(Table 4)**.

Table (1): Relation between pneumonia and Socio-demographic data of the studied group:

Variable	Bronchiolitis (N=30)	Pneumonia (N=7)	MW	P
Age:(months)				

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mean ± SD (Range)median		4.39±3.68 3.5(1-18)		3.55±1.66 4(0.83-6)	0.15	0.89 NS
Variable	**No**	**%**	**No**	**%**	**χ^2**	**P**
Age distribution:						
1-6 months	19	73.1	7	26.9	1.41	0.50
7-12 months	3	100	0	0		NS
13-18 months	1	100	0	0		
Sex:						
Male	14	93.3	1	6.7	3.66	0.08
Female	9	60	6	40		NS
Residence:						
Rural	11	78.6	3	21.4	0.05	0.82
Urban	12	75	4	25		NS
Socio-economic class:						
Low	17	73.9	6	26.1	0.42	0.52
Moderate	6	85.7	1	14.3		NS
Family history of asthma:						
Positive	2	100	0	0	0.65	0.42
Negative	21	75	7	25		NS

Sd: standard deviation MW: Mann Whitney test χ^2: Chi square test NS: Non significant (P>0.05)

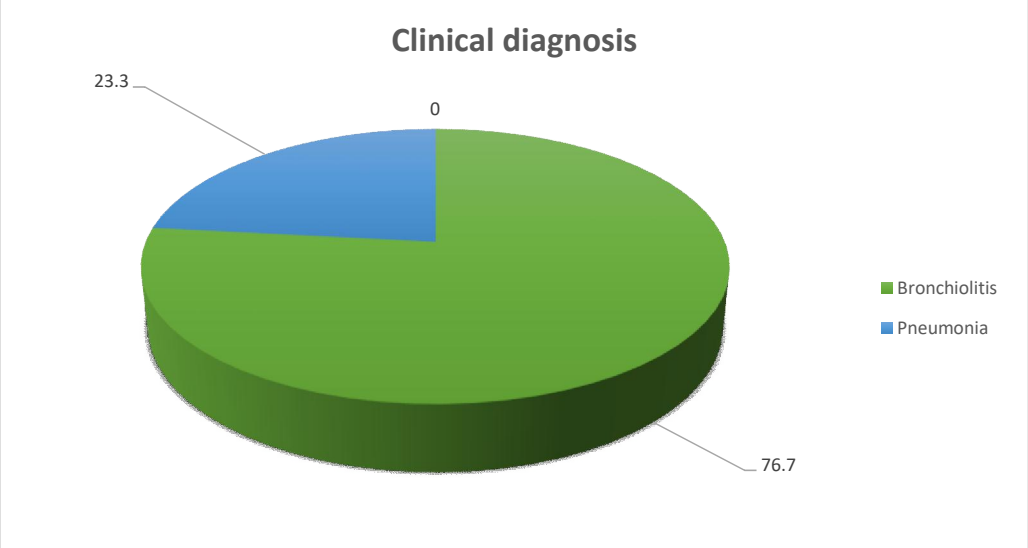

Figure (1): Pie chart for clinical diagnosis among the studied group.

Table (2): Relation between pneumonia and clinical data of the studied group:

Variable	**Bronchiolitis (N=30)**		**Pneumonia (N=7)**		**MW**	**P**
Hospital stay: mean ± SD (Range)median		4.91±2.78 4(2-11)		5.29±3.45 4(3-12)	0.12	0.90 NS
Variable	**No**	**%**	**No**	**%**	**χ^2**	**P**
Wheezes:						
Positive	22	75.9	7	24.1	0.32	0.58
Negative	1	100	0	0		NS
Crepitation:						
Positive	8	80	2	20	0.09	0.76
Negative	15	75	5	25		NS
Fever:						
Positive	15	83.3	3	16.7	1.12	0.29
Negative	8	66.7	4	33.3		NS

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Refusal of feeding:						
Positive	6	85.7	1	14.3	0.42	0.52
Negative	17	73.9	6	26.1		NS
RD grade:						
Mild	7	87.5	1	12.5	**10.99**	**0.004***
Moderate	16	84.2	3	15.8		
Sever	0	0	3	100		

Sd: standard deviation MW: Mann Whitney test χ^2: Chi square test NS: Non significant (P>0.05) *: Significant (P<0.05)

Table (3): Relation between pneumonia and Laboratory investigations among the studied group:

Variable	Bronchiolitis (N=30) mean ± SD Median (Range)	Pneumonia (N=7) mean ± SD Median (Range)	Test	P
Hb: (gm/dl)	9.90±1.53 9.9(6.8-13.3)	10.61±0.89 11.2(9-11.3)	t=1.16	0.26 NS
WBCs: (x10^3/mm^3)	11.26±3.62 10.6(5.5-19.4)	13.63±6.19 13.2(8-22.4)	**MW=2.40**	**0.01***
Neutrophils: (x10^3/mm^3)	2.44±1.24 2.5(0.7-5.1)	6.41±5.69 6.1(1.6-14.1)	**MW=2.22**	**0.03***
Lymphocytes: (x10^3/mm^3)	7.7±2.86 6.4(4.2-15.4)	6.39±2.31 6.8(1.9-8.9)	MW=0.39	0.69 NS
Platelets: (x10^3/mm^3)	354.39±100.6 318(180-549)	365.57±176.82 287(164-669)	MW=0.37	0.71 NS
CRP: (mg/dl)	3.63±3.61 1.7(0.6-11.56)	47.46±65.19 12.42(0.6-182.96)	**MW=2.38**	**0.02***

Sd: standard deviation MW: Mann Whitney test t: Independent t test NS: Non significant (P>0.05) *: Significant (P<0.05)

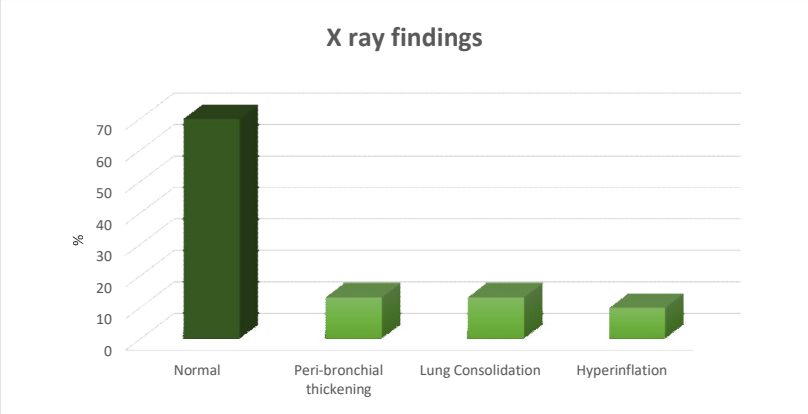

Figure (2): Bar chart for X ray findings among the studied group.

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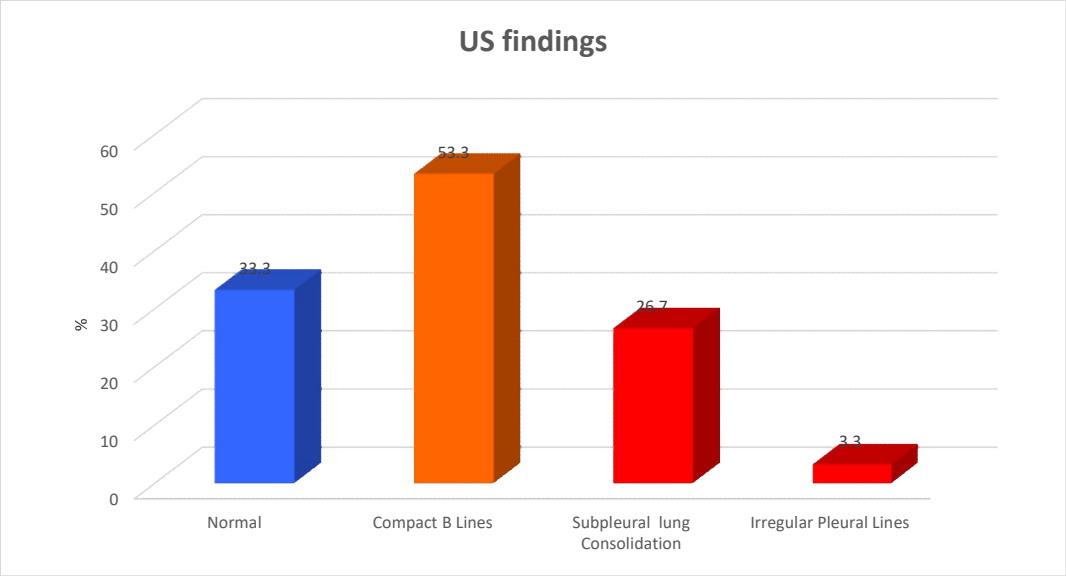

Figure (3): Bar chart for US findings among the studied group.

Table (4): Diagnosis according to X-ray findings and US findings among the studied group:

Diagnosis	X ray (N=30)		US (N=30)		Kappa	P
	No	%	No	%		
Normal	21	70	10	33.3		
Pneumonia	4	13.3	8	26.7	0.12	0.40
Bronchiolitis	0	0	12	40		NS
Other	5	16.7	0	0		

Kappa: Test of agreement P: non-significant (P>0.05)

DISCUSSION

Pneumonia is an infection that pathologically affects the lung parenchyma and involves alveoli in variable proportions resulting in the air replacement in the alveoli by exudative fluid or pus**(1)**. Community-acquired pneumonia (CAP) is the most common cause of death in children below 5 years. In Egypt, pneumonia and other acute respiratory infections are responsible for at least 10% of deaths in children under 5 years **(13).**Unlike adults, CAP's diagnosis in children depends mainly on clinical criteria. These criteria rely on the child's age and include high temperature, tachypnea, difficulty in breathing, cough, tachycardia, wheeze, abdominal pain, or chest pain **(14).**

Based on international guidelines, a chest x-ray (CXR) is not routinely needed in all children with mild clinical symptoms and signs of CAP, but only in severe cases requiring hospital admission or in cases resistant to medical therapy. In addition, lateral x-rays were not always performed. A confluent opacification in the X-ray image is considered pneumonia's radiologic hallmark. It is also confirmed by interstitial infiltrates, which are considered evidence of pneumonia. There are two major disadvantages in using CXRs for the diagnosis of pneumonia in children; the first is radiation exposure and, the second is the great intraobserver and interobserver variability in the interpretation of the findings. Current data suggest that the risk of fatal cancer in children due to radiation exposure is not negligible because of great life expectancy and high tissue radio-sensitivity **(15).**

Starting treatment without confirming the diagnosis or knowing the underlying pathology's extent usually results in antibiotics' overuse. Therefore, alternative free radiation diagnostic tools should be encouraged when evaluating CAP in children, and LUS offers this advantage. For a long time, the lung was considered off-limits for an ultrasound. However, recently, LUS has been growing in multiple settings and evaluated different lung conditions, including diagnosing CAP of children. Many studies have reported its reliability and accuracy in diagnosing this pathology in infants and children**(16)**.

This current study involved 30 infant with bronchiolitis to evaluate the diagnostic accuracy of LUS for the detection of pneumonia in infants with acute bronchiolitis.

Chest ultrasound is a feasible, portable, easy to learn and non-ionizing radiation technique. In the last decades it has become an emerging diagnostic tool for diagnosing pneumonia in adults and

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children, with remarkable sensitivity and specificity **(17).** Moreover, in the last years there has been great interest in using chest ultrasound to differentiate bacterial pneumonia from viral infections **(18).**Conducted a meta-analysis, which confirmed that LUS has an overall sensitivity of 96% and a specificity of 93% for the diagnosis of pneumonia in children. Another study also promoted lung ultrasound to be the first choice or recommend it as a valid alternative tool to replace CXR **(19).**

Two meta-analyses further support the diagnostic accuracy of LUS for pneumonia (**16,20**). However, ultrasound's accuracy varies by user skill and training, as evidenced in studies of pediatric appendicitis (**21**), while other applications such as skin and soft tissue infections have been demonstrated to only require minimal training (**22**).

Our results are disagrees with **Behrooz et al.(23)** reported a percentage of (34%) of family history of asthma in cases of bronchiolitis. This difference may be due patient education about asthma.

The current study showed that 76.7% of the studied group had bronchiolitis and 23.3% had bronchiolitis with pneumonia.**Biagi et al. (24)** found that 71.23% of the studied group had bronchiolitis and 28.7% had pneumonia.

Karkar et al. (15) reported that CXR was able to detect consolidation in 107 patient (88.90%) and missed 13 cases with pneumonia and only detect 5 cases with pleural effusion. CXR may fail to detect these lesions either due to their relatively small sizes at the early stage of the disease, or these lesions are difficult to reach as, beyond the heart or mediastinum.

The present study agree with **Mohamed et al., (25)** reported that the most common symptom of pneumonia was cough (95%) and most common sign was tachypnea (99.23%). Most common finding on auscultation was crepitation (58.99%).

Our studydisagrees with **Caiuloet al., (26)**found that (7.8%) of cases were mild, (40.4%) of cases were moderate and (51.9%) of cases were severe. This difference may be due to different criteria for admission.

In a study of **Yan et al., (27)**reported that mean White blood cell/dl 12.55±3.41, Procalcitonin (µg/l) 2.11±0.54, Serum reactive protein (mg/dl) 13.18±14.2.

Biagi et al. (24)found that of the 25 patients with bacterial pneumonia, CXR was positive for parenchymal consolidation consistent with pneumonia in 24 cases. CXR showed false-positive findings in 8 children. In the only patient with a false-negative CXR, LUS showed a subcentimeter pneumonia in the posterior basal retrocardiac region of the left lung. **Mohamed et al., (25)**reported that consolidation was reported in 130 (93.53%) patients by LUS and in 107 (76.97%) patients by CXR and the difference was statistically highly significant ($p<0.001$). A synpneumonic pleural effusion was reported in 22 (15.83%) patients by LUS as compare to 15 (5.03%) by CXR.

The current study showed that there was no statistical agreement between US and X ray in diagnosis of the studied cases. US can diagnose bronchiolitis while x ray can't. Also US can diagnose more pneumonia cases. **Urbankowska et al. (28)** reported that there was showed overall agreement between LUS and CXR in terms of pneumonia diagnosis (Cohen kappa coefficient of 0.89), with consistent findings in 101 patients. **Ellington et al.(29)** reported that CXR identified abnormalities consistent with pneumonia in 360 (79%) children, and 191 (42%) were found to have consolidations and 169 (37%) had an interstitial abnormality.Moreover,**Karkar et al. (15)** reported that there was a statistically significant good agreement between LUS and CXR in diagnosis of the studied cases. **Yan et al. (27**) reported that Lung ultrasound displayed 65 (7%) false-positive results, whereas chest X-ray resulted in 89 (9%) false-positive results (P=0.053) for the diagnosis of pneumonia. However, these results were not in line with a prospective observational cohort study investigating the use of ultrasound for children and young adults **(30).**

Biagi et al. (24) found that CXR showed a sensitivity of 96% (95% CI 88.8–98.8%) and specificity of 87.1% (95% CI 77.8–93.0%) in identifying children with bronchiolitis affected by a concomitant bacterial pneumonia, while LUS had a sensitivity of 100% (95% CI 94.7–99.9%) and a specificity of 83.9% (95% CI 74.1–90.6%).

Urbankowska et al. (28) reported that the diagnostic performance of LUS in demonstration of lung involvement was calculated as follows: sensitivity of 93.4%, specificity of 100%, positive predictive value (PPV) of 100%, negative predictive value (NPV) of 85.7% and accuracy of 95.3%.

Karkar et al. (15) reported that LUS had a sensitivity of 95.6% and specificity of 93.3%, compared to the sensitivity of 88.9.0% and specificity of 86.7%% by CXR. Similarly, **Pereda et al. (16)** found that LUS had a sensitivity of 96% and specificity of 93%. Also, a study was done by **Balk et al. (31)** including 1510 patients showed that LUS had a mean sensitivity of 95.5% (93.6-97.1) and specificity of 95.3% (91.1-98.3) while, CXR had a sensitivity of 86.8% (83.3-90.0) and specificity of 98.2% (95.7-99.6).

Our study demonstrates that chest ultrasound is a reliable tool for the diagnosis and follow-up of bronchiolitis. Chest ultrasound can identify lung abnormalities that are not revealed by CXR, with the

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advantages of a shorter time-delay necessary to have the final medical report and avoiding ionizing radiation. Furthermore, there is a good correlation between clinical and ultrasound findings. The diagnosis of bronchiolitis is mainly based on the patient's medical history and physical examination. However, in the most severe cases, oximetry, a complete blood count, and serum electrolyte evaluation may be needed.

Our study had some limitations. First, this was a single center study with a relatively small numbers of children. Therefore, more studies with a larger sample size are required to confirm our data. The second limitation of the study is the lack of a true diagnostic reference standard due to ethical reasons. This is a common limitation in all studies assessing the diagnostic performance of chest ultrasound compared to CXR for the diagnosis of complicated bronchiolitis in children. CXR is not widely considered a crucial step in the diagnosis of bronchiolitis, nevertheless it is not 100% sensitive or specific, and variation exists in intra and inter-observer agreement among radiologists. Another limitation is that the presence of chest ultrasound 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. The sonographer was not blinded to clinical data

Despite these limitations, this study found useful results that support the reliability of chest ultrasound complicated cases in children affected by bronchiolitis, providing arguments for reducing CXR achievement.

CONCLUSION

Lung ultrasonography offers better detection of consolidations and other pneumonia associated lung abnormalities, thus reducing radiation exposure in this age group and it may become the next line investigation of choice prior to x-ray chest

No Conflict of interest.

REFERENCES

1- **Ambroggio, L., Brokamp, Mantylaet al.,2019.** Validation of the British Thoracic Society severity criteria for pediatric community-acquired pneumonia. The Pediatric infectious disease journal, 38(9), 894.
2- **Aheto, J. M. K. 2019.** Predictive model and determinants of under-five child mortality: evidence from the 2014 Ghana demographic and health survey. BMC public health, 19(1), 1-10.
3- **Elemraid MA, Muller M, Spencer DA, et al. 2014.** North East of England Paediatric Respiratory Infection Study Group. Accuracy of the interpretation of chest radiographs for the diagnosis of paediatric pneumonia. PLoSOne ; 9(8):e106051.
4- **Christopher CR, Raja AS, Brown MD 2015.**Overtesting and the downstream consequences of overtreatment: implications of "preventing overdiagnosis" for emergency medicine. AcadEmerg Med 2015; 22: 1484–92
5- **Ralston SL, Garber MD, Rice-Conboy E, et al. 2016** Value in inpatient pediatrics network quality collaborative for improving hospital compliance with AAP bronchiolitis guideline (BQIP). A multicenter collaborative to reduce unnecessary care in inpatient bronchiolitis. Pediatrics 137:1–9.
6- **Meulepas, J. M., Ronckers, et al., 2019.** Radiation exposure from pediatric CT scans and subsequent cancer risk in the Netherlands. JNCI: Journal of the National Cancer Institute, 111(3), 256-263.
7- **Tsou P-Y, Chen KB, Wang Y-H.**Diagnostic accuracy of lung ultrasound performed by novice versus advanced sonographers for pneumonia in children: A Systematic Review and Meta-analysis. Academic Emergency Medicine,2019; 26, (9): 1075-1087
8- **Chavez MA, Shams N, Ellington LE, et al.** Lung ultrasound for the diagnosis of pneumonia in adults: a systematic review and meta-analysis. RespirRes 15(1):50.
9- **Yilmaz HL, Ozkaya AK, Sari Gokay S, et al.** Point-of-care lung ultrasound in children with community acquired pneumonia. Am J Emerg Med 2017; 35:964–9.
10- **Inchingolo, Copetti, Smargiassi, A., et al., 2021.** Air bronchogram integrated lung ultrasound score to monitor community-acquired pneumonia in a pilot pediatric population. Journal of Ultrasound, 24(2), 191-200.
11- **Basile V, Di Mauro A, Scalini E et al., 2015.** Lung ultrasound: a useful tool in diagnosis and management of bronchiolitis. BMC Pediatr. 15:63.
12- **Supino, M. C., Buonsenso, D.** Point-of-care lung ultrasound in infants with bronchiolitis in the pediatric emergency department: a prospective study. European Journal of Pediatrics, 2019; 178(5), 623-632.

DOI: 10.9756/INT-JECSE/V14I3.750

13- **El Seify, M. Y., Fouda, et al.,2016.** Microbial etiology of community-acquired pneumonia among infants and children admitted to the pediatric hospital, Ain Shams University. European Journal of Microbiology and Immunology, 6(3), 206-214.
14- **Mackenzie, G. 2016.** The definition and classification of pneumonia. Pneumonia, 8(1), 1-5.
15- **Karkar, A. M., Zannoun, et al., 2021.** A comparison between the Use of Chest X-ray and Lung Ultrasound in the Diagnosis of Pneumonia in Children in Damietta Governorate. International Journal of Medical Arts, 3(1), 938-945.
16- **Pereda, M. A., Chavez, et al.,2015.** Lung ultrasound for the diagnosis of pneumonia in children: a meta-analysis. Pediatrics, 135(4), 714-722.
17- **Jones BP, Tay ET, Elikashvili I, et al. 2016** Feasibility and safety of substituting lung ultrasonography for chest radiography when diagnosing pneumonia in children: a randomized controlled trial. Chest.;150(1):131–8.
18- **Tsung JW, Kessler DO, Shah VP**. Prospective application of clinician performed lung ultrasonography during the 2009 H1N1 influenza a pandemic: distinguishing viral from bacterial pneumonia. Crit Ultrasound J. 2012;4:16.
19- **Basile V, Di Mauro A, Scalini E et al., 2015.** Lung ultrasound: a useful tool in diagnosis and management of bronchiolitis. BMC Pediatr. 15:63.
20- **Orso D, Ban A, Guglielmo N.** Lung ultrasound in diagnosing pneumonia in childhood: a systematic review and meta-analysis. J Ultrasound 2018; 21:183–95.
21- **Nicole M, Desjardins MP, Gravel J.** Bedside sonography performed by emergency physicians to detect appendicitis in children. AcadEmerg Med 2018; 25:1035–41.
22- **Marin JR, Abo AM, Arroyo AC, et al. 2016** Pediatric emergency medicine point-of-care ultrasound: summary of the evidence. Crit Ultrasound J; 8:16.
23- **Behrooz, L., Balekian, D. S., Faridi, M. K., et al., 2018.** Prenatal and postnatal tobacco smoke exposure and risk of severe bronchiolitis during infancy. Respiratory medicine, 140, 21-26.
24- **Biagi, C., Pierantoni, L., Baldazzi, M.,** Lung ultrasound for the diagnosis of pneumonia in children with acute bronchiolitis. BMC Pulmonary Medicine, 2018;18(1), 1-10.
25- **Mohamed, A. E. S. M., Kamel, O. F et al.,2018.** Accuracy of lung ultrasonography in diagnosis of community acquired pneumonia as compared to chest x-ray in pediatric age group. The Egyptian Journal of Hospital Medicine, 72(8), 4977-4983.
26- **Caiulo, V. A., Gargani, L., et al., 2014.** Response to lung ultrasound as an additional imaging tool for the evaluation of pneumonia. Pediatric Pulmonology, 49(6), 619-620.
27- **Yan, C, & Zhou, et al.,2020.** Lung ultrasound vs. chest X-ray in children with suspected pneumonia confirmed by chest computed tomography: A retrospective cohort study. Experimental and Therapeutic Medicine, 19(2), 1363-1369.
28- **Urbankowska, E., Krenke, K et al., 2015**. Lung ultrasound in the diagnosis and monitoring of community acquired pneumonia in children. Respiratory medicine, 109(9), 1207-1212.
29- **Ellington LE, Gilman RH, Chavez MA, et al. 2017** Lung ultrasound as a diagnostic tool for radiographically-confirmed pneumonia in low resource settings. Respir Med; 128:57–64.
30- **Shah, V. P., Tunik, S.** Prospective evaluation of point-of-care ultrasonography for the diagnosis of pneumonia in children and young adults. JAMA pediatrics,2013; 167(2), 119-125.
31- **Balk, D. S., Lee, C, et al., 2018.** Lung ultrasound compared to chest X-ray for diagnosis of pediatric pneumonia: a meta-analysis. Pediatric pulmonology, 53(8), 1130-1139.

DOI: 10.9756/INT-JECSE/V14I3.750