EFFICACY OF CHEST ULTRASONOGRAPHY VERSUS CHEST X RAY IN THE DIAGNOSIS OF PEDIATRIC PNEUMONIA

By

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ABSTRACT

Background: *Pneumonia is a major public health and economic problem with a considerable impact on morbidity and mortality in children. The single largest and the most common infectious cause of death in children worldwide.*

Aim and objectives: *to evaluate the ultrasound efficacy in assessment of pneumonia in pediatric age group, Compared to chest x ray technique.*

Subjects and methods: *the study was a cross sectional comparative study of 60 Egyptian children with pneumonia in the general ward and PICU of Al-Hussein hospital Al-Azhar University during period from May 2021 to November 2021 ,they were selected by simple random method & according to inclusions criteria*

Result: *the most prevalent finding on X-ray and US was consolidation (46.7%, 81.7%)) followed by air bronchogram (25%, 63.3%) with statistically significant difference regarding consolidation, air bronchogram and pleural effusion.*

Conclusion: *Chest ultrasound may also influence medical decision-making in the emergency department. In a small series of patients presenting with acute dyspnea, the use of chest ultrasound changed the diagnosis in 44% and altered management in 58%, it is more sensitive than x ray , allow free radiation technique in detecting consolidatin.*

Keywords: *Chest ultrasound; pneumonia; pediatric; Chest X Ray.*

INTRODUCTION

Pneumonia is a major public health and economic problem with a considerable impact on morbidity and mortality in children **(Shah, et al., 2017)**.

It is the single largest and the most common infectious cause of

death in children worldwide **(Yilmaz, et al., 2017)**.

Every year, it kills an estimated 1.4 million under the age of five years, it is estimated that pneumonia Accounts for 18% of the total number of deaths less than five years old worldwide more than tuberculosis, acquired immunodeficiency syndrome (AIDS) and malaria combined **(Pereda, et al., 2015)**.

While Pneumonia considered a clinical diagnosis, radiologic confirmations often obtained. In clinical practice chest radiography (CR) may be requested by physicians in terms of diagnosis, differential diagnosis and complications **(Ho and Kerm, 2015)**.

Therefore, despite the international guidelines, CR is frequently performed for children with suspected pneumonia, thus increasing unnecessary pediatric radiation exposure **(Bowen and Thomson, 2013)**.

For many years transthoracic ultrasound was limited exclusively to the examination of pleural effusion. However, over the past few years ultrasonography of pleural space and lung parenchyma is gaining a wide consensus in different conditions in clinical practice particularly in emergency conditions **(Stefan et al., 2017)**.

Characteristics such as being rapid, mobile, repeatable, easily per formed at the bedside, inexpensive, portable, nonionizing image tool and it is relatively easy for teaching **(Vito Antonio, et al., 2011)**.

Lung ultrasound may be used to distinguish viral from bacterial pneumonia **(Shah et al., 2012)**.

Chest ultrasound may also influence medical decision-making in the emergency department. In a small series of patients presenting with acute dyspnea, the use of chest ultrasound changed the diagnosis in 44% and altered management in 58% **(Shah et al., 2012)**.

The aim of this study: was to evaluate the ultrasound efficacy in assessment of pneumonia in pediatric age group. Compared to chest x ray technique.

PATIENTS AND METHODS

There is a cross sectional comparative study that include 60 Egyptian children, they were selected from the general ward and PICU of Al-Hussein hospital Al-Azhar University during the period from May 2021 to November 2021 by simple random method according to the

mentioned sample size and the following inclusion criteria.

Inclusion criteria: Age: from 2 years up to 12 year, symptoms suggestive of pneumonia. E.g; Fever, cough, dyspnea and signs respiratory distress, diminished air entry, crackles.

Exclusion criteria: Children < 2 years or > 12 years, children with chronic diseases e.g.: hepatic, renal diseases or congenital heart diseases, the caregivers of the patients who will agree to share in this clinical study will give informed consent after being fully informed about the study and its circumstances. The study will be conducted after the approval of the Committee of Ethics in Faculty of Medicine, Al-Azhar University.

Tools of Assessment: The including children subjected to the following:

I. Detailed history: especially of pulmonary symptoms including cough, purulent expectoration, dyspnea, hemoptysis and fever > 38 C and symptoms of other systems affection.

II. General and local examination: including vital signs (heart rate, respiratory rate body temperature) and signs of respiratory distress and local chest examination.

III. Investigations: CBC with differential, ABG, CRP, chest X-ray and chest Ultrasound.

Chest Ultrasound examination: Chest Ultrasound examination will be performed in all children during illness.

Technique of chest ultrasound: it will be performed. To cover the whole lung surface, the thorax will be divided into three regions, anterior, Posterior and lateral. Each region will be scanned in the longitudinal and the transverse plane, up-down and medial-lateral, respectively.

The anterior and lateral regions of the chest will be examined with the patient in supine position, The posterior region will be examined in prone position. Each area of consolidation will be represented in the location identified by the examiner on one or several of the three regions.

The results of US imaging will be compared to the interpretation of CXR. The purpose was to compare the size of the consolidations visible on both techniques and those visible only on US.

Ethical considerations:

1. An informed consent taken from all parents before getting involved in study.

Confidentiality of all data ensured.

2. The parents have the right to withdraw from the study at any time without giving any reasons.
3. The study was done after approval of ethical committees of Pediatrics department & faculty of medicine for Al-Azhar University.
4. The author declared that there is no conflict of interest or financial support regarding to study and publication.

Statistical Analysis: All data were collected, tabulated and statistically analyzed using SPSS 22.0 for windows (SPSS Inc., Chicago, IL, USA) & MedCalc 19.4 for windows (MedCalc Software bvba, Ostend, Belgium).

Sample Size: This study base on study carried out by Cerbo et al., 2015 Epi Info STATCALC was used to calculate the sample size by considering the following assumptions: - 95% two-sided confidence level, with a power of 80%. & an error of 5% odds ratio calculated. The final maximum sample size taken from the Epi-Info output was 60.

RESULTS

Table (1): Demographic data of the studied patients

Variable		**Patients** (n=60)
Age (years) Mean ± SD Range		 7.25 ± 2.16 2 – 12
Sex	Male	28 (46.7%)
	Female	32 (53.3%)
BMI (kg/m^2) Mean ± SD		24.12 ± 3.54
Residence	Rural	35 (58.3%)
	Urban	25 (41.7%)

This table shows the demographic data of the studied cases.

Table (2): Clinical presentations of the studied patients

Clinical data	The studied patients (n=60)
Cough	54 (90%)
Fever	48 (80%)
Tachypnea	60 (100%)
Wheezes	39 (65%)
Crepitation	51 (85%)

This table shows that the most prevalent symptom presented was tachypnea (100%) followed by cough (90%) and crepitation (85%).

Table (3): X-ray and US finding among the studied cases

	X-ray (n=60)		US (n=60)		x^2	P
	N	%	N	%		
Consolidation	28	46.7	49	81.7	**16**	**<0.0001**
Air bronchogram	15	25	38	63.3	**18**	**<0.0001**
Pleural effusion	4	6.7	21	35	**15**	**.0001**
Lung abscess	2	3.3	3	5	.209	.648
Pneumothorax	1	1.7	1	1.7	--	1

This table shows that the most prevalent finding on X-ray and US was consolidation (46.7%, 81.7%)) followed by air bronchogram (25%, 63.3%) with statistically significant difference regarding consolidation, air bronchogram and pleural effusion.

Table (4): Comparison between x-ray &US among the studied cases regarding Consolidation distribution

	X-ray (n=60)		US (n=60)		x^2	P
	N	%	N	%		
No consolidation	32	53.3	11	18.3	**16.4**	**<0.001**
One lobe	21	35	40	66.7		
More than one lobe	7	11.7	9	15		

This table shows that the consolidation was mostly in one lobe (35%) on X-ray and (66.7%) on US with statistically significant difference.

Table (5): Efficacy of ultrasound in detection of consolidation compared to x-ray

US	X-ray				Total	x^2	P
	Positive		Negative				
	N	%	N	%			
Positive	28	100%	21	65.6%	49 (81.7%)	**12**	**.0004**
Negative	0	--	11	34.4%	11 (18.3%)		
Total	28	100%	32	100%	60 (100%)		

Chest US was significant in detecting consolidation with sensitivity of 100% and specificity of 34.4% besides NPV was 100% and PPV was 57.14% with accuracy of 65%.

Table (6): Efficacy of ultrasound in detection of Pleural effusion compared to x-ray

US	X-ray				Total	x^2	P
	Positive		Negative				
	N	%	N	%			
Positive	4	100%	17	30.4%	21 (35%)	**8**	**.003**
Negative	0	--	39	69.4%	39 (65%)		
Total	4	100%	56	100%	60 (100%)		

Chest US was significant in detecting pleural effusion with sensitivity of 100% and specificity of 69.6% besides NPV was 100% and PPV was 19% with accuracy of 71.7%.

Table (7): Efficacy of ultrasound in detection of lung abscess compared to x-ray

US	X-ray				Total	x^2	P
	Positive		Negative				
	N	%	N	%			
Positive	2	100%	1	1.7%	3 (5%)	**40**	**<0.0001**
Negative	0	--	57	98.3%	57 (95%)		
Total	2	100%	58	100%	60 (100%)		

Chest US was significant in detecting lung abscess with sensitivity of 100% and specificity of 98.28% besides NPV was 100% and PPV was 66.7% with accuracy of 98%.

DISCUSSION

Chest X-ray is considered as the most common diagnostic tool that has been used traditionally in daily practice for diagnosis of pneumonia, especially in critical conditions. Many limitations in using portable chest X-ray have been well described and noticed such as quality of an X-ray film in addition to the risk of repetitive radiation exposure. Some reports claim that removal of chest radiography from daily practice may not affect intensive care unit mortality **(Camelo et al., 2021)**.

This cross-sectional comparative study was conducted on 60 Egyptian children in the general ward and PICU of Al-Hussein hospital Al-Azhar University. The study duration was from May 2021 to November 2021.

As regard socio-demographic data of the studied group. Patients included 28 males and 32 females with mean age 7.25 years with mean BMI 24.12 kg/m2. Moreover, 58.3% of the patients were rural.

While in the study of **Mohamed et al., 2018** a total of 40 patients were included in the study, 24 male (60%) and 16 female (40%), The mean patient age was 3.82 ± 4.3 years (range: 0.08 (1 month) -15 years).

In the study of **Hegazy et al., 2020**, the study comprised 63 patients who met the inclusion criteria, 30 (47.6%) males and 33 (52.4%) females. The mean age was 12 months with range 4-24 months.

The present study showed that as regard clinical presentation; the most prevalent symptom presented was tachypnea (100%) followed by cough (90%) and crepitation (85%).

However, in the study of **Yan et al., 2020**, dyspnea and cough were the most commonly reported symptoms among the patients, followed by expectoration of purulent sputum, fever and pleuritic chest pain.

In the study of **Ianniello et al., 2016**, they evaluated 84 children admitted to the emergency department with the clinical suspect of pneumonia, presenting with fever (>38° C for more than 3 days) and cough.

In our study, the most prevalent finding on X-ray and US was consolidation (46.7%, 81.7%)) followed by air bronchogram (25%, 63.3%) with statistically significant difference regarding consolidation, air bronchogram and pleural effusion.

Our results agreed with study of **Mohamed et al., 2018** as they

reported that there was statistically significant difference between chest X-Ray and chest ultrasound in detection of consolidation, air bronchogram and pleural effusion.

Ho et al. 2015 also found that chest radiography able to detect 151 (92.6%), whereas LUS detected 159 (97.5%) out of 163 patients with pneumonia.

Furthermore, **Ianniello et al., 2016** revealed that CXR showed 47/84 pneumonic findings. LUS showed 60/84 pneumonic findings; 34/60 pneumonic findings had a typical pattern of lung consolidation; 26/60 pneumonic findings showed association of multiple B-lines, findings consistent with interstitial involvement, and small and hidden consolidations not achievable by CXR. One case was negative at LUS because of retro scapular location. 60 patients were followed up with LUS; 28/60 patients showed a complete regression of the disease; 23/60 patients had a significant decrease in size of consolidation; 9/60 patients showed disease stability or insignificant decrease in size, thus requiring adjunctive LUS examinations.

In addition, **Amatya et al., 2018** stated that forty-four (71%) patients had pneumonia based on CT. Ultrasound was positive in 40 of the 44 patients with pneumonia, demonstrating a sensitivity of 91%. Chest X-ray was positive in 32 of the 44 patients with pneumonia, yielding a sensitivity of 73%. The sensitivity of ultrasound was significantly better than chest X-ray ($p = 0.01$). Specificity of ultrasound and chest X-ray were similar at 61 and 50% respectively ($p = 0.62$). The positive predictive value of lung ultrasound was 85% and chest X-ray was 78%. The negative predictive value of ultrasound was 73% while chest X-ray was 43%. The positive likelihood ratio for diagnosing pneumonia with lung ultrasound was 2.34, while the negative likelihood ratio was 0.15. Chest X-ray had a positive and negative likelihood ratio of 1.45 and 0.55 respectively.

The present study showed that consolidation was mostly in one lobe (35%) on X-ray and (66.7%) on US with statistically significant difference. Chest US was significant in detecting consolidation with sensitivity of 100% and specificity of 34.4% besides NPV was 100% and PPV was 57.14% with accuracy of 65%.

In the study of **Shah et al., 2013** found that LU is more sensitive than CR in detection of small lung consolidation. In their study, all 13 sub-centimeter lung

consolidations detected by LU were found to be negative on CR. Similarly, in an adult study, the authors compared the accuracy of LU and CR in the detection of lung consolidation, taking computed tomography (CT) scan as the gold standard. They demonstrated that the sensitivity of LU (81.4%) was significantly higher than that of CR (64.3%) **(Nazerian et al., 2015)**.

Mohamed et al., 2018 reported that 13 patients (33%) show consolidation limited to one lobe by chest X-Ray, while 16 patients (40 %) show consolidation limited to one lobe by chest Ultrasound. 7 patients (43.75 %) were positive for consolidation by chest X-Ray, 11patients (68.8%) were positive by chest Ultrasound, while 13 patients out of 16 patient (81.25%) proved to have consolidation by CT.

In the study conducted by **Biagi et al., 2018** CXR was positive for parenchymal consolidation consistent with pneumonia in 98% cases. CXR showed a sensitivity of 96% and specificity of 87.1% in identifying children with bronchiolitis affected by a concurrent bacterial pneumonia, with a PPV of 75% and a NPV of 98.2%. LUS had a sensitivity of 100% and a specificity of 83.9%; the PPV and NNV were 71.4% and 100% respectively.

Yan et al., 2020 reported that for the detection of pneumonia, lung ultrasound displayed 0.906 sensitivity and 0.661 specificity, while chest X-ray displayed 0.793 sensitivity and 0.559 specificity.

In the study of **Amatya et al., 2018**, of 62 patients included in the study, 44 (71%) were diagnosed with pneumonia by CT. Lung ultrasound demonstrated a sensitivity of 91% compared to chest X-ray which had a sensitivity of 73% ($p = 0.01$). Specificity of lung ultrasound and chest X-ray were 61 and 50% respectively.

In addition, **Nazerian et al., 2015** compared the accuracy of LUS in the detection of lung consolidation, taking CT scan as the gold standard: they demonstrated that in a subgroup of patients who underwent CXR also (in addition to CT and LUS), the sensitivity of LUS (81.4%) was significantly higher than that of CXR (64.3%), whereas specificity remained similar (94.2% vs 90%), showing that LUS can be a reliable alternative to CXR for the diagnosis of lung consolidation at the bedside of the patient.

The current study showed that chest US was significant in detecting air bronchogram with

sensitivity of 100% and specificity of 48.9% besides NPV was 100% and PPV was 39.5% with accuracy of 61.7%.

In the study of **Mohamed et al., 2018**, 25 patients (63%) show pleural line irregularities detected by chest ultrasound, while fluid bronchogram is seen in one patient (3%).

In the study in our hands, Chest US was significant in detecting pleural effusion with sensitivity of 100% and specificity of 69.6% besides NPV was 100% and PPV was 19% with accuracy of 71.7%.

In the study of **Mohamed et al., 2018**, nine patients (23%) were positive for pleural effusion by chest X-Ray, while 19 patients (48%) were positive by chest Ultrasound.

Moreover, **Agmy et al. 2014** who studied 200 mechanically ventilated patients, comparing three imaging techniques (CXR, lung US, and chest CT); they reported 100% sensitivity and specificity of chest US in detecting pleural effusion compared with 55 and 84% (the sensitivity and specificity of CXR in detecting pleural effusion).

In the study of **Mohamed et al., 2018**, two patients (5%) were positive for lung abscess by chest X-Ray, while 3 patients (8%) were positive by chest Ultrasound.

CONCLUSION

Chest ultrasound may also influence medical decision-making in the emergency department. In a small series of patients presenting with acute dyspnea, the use of chest ultrasound changed the diagnosis in 44% and altered management in 58%.

RECOMMENDATION

* Further studies on large geographical scale and on larger sample size to emphasize our conclusion.
* Further studies to confirm role of chest ultrasonography in diagnosis and management of pediatric pneumonia.

LIMITATION OF THE STUDY

* Ultrasound was performed by single expert operator and some errors presented &not revised by other expert.
* Unfortunately not all radiologists are minded with pediatric chest ultrasound.

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