
*ROLE OF LUNG ULTRASONOGRAPHY VS CHEST
X-RAY IN EVALUATION OF PEDIATRIC
PNEUMONIA*

By

Hala H. Mansour*, Ezzabouha F. Abd Al-Rahman*, Maha F. Sheba,
Iman A. Abd El-Aziz***

*Department of Paediatrics, ** Department of Ultrasonography, New Children
Hospital, Faculty of Medicine, Cairo University, Egypt

Corresponding Author: Iman Aly <http://orcid.org/0000-0001-5753-7181>

Postal/ mailing address: 1 Gamaa Street, Giza, Egypt, **Postal Code:** 12613

E-mail: iman.omar@kasrlainy.edu.eg

ABSTRACT

Background: *Pneumonia is one of the most common chief complaints for which children seek medical care. Lung ultrasound (LUS) may be a comparable way in detecting extent of lung consolidation in comparison to the current gold standard chest X-rays.*

Aim of work: *To study lung ultrasound findings and test its sensitivity and specificity in comparison to clinical and conventional x-ray for diagnosis of childhood pneumonia. Using the lung ultrasound as safe as valuable and convenient tool in management and follow up of pneumonia.*

Patient and methods: *It is comparative study, performed on 100 children (65 males and 35 females), and admitted during the period from August 2018 to August 2019 in the general pediatric wards and PICUs of our tertiary hospital.*

Results: *The patient's mean age was 5.05 ± 2.50 years, males were 65% of studied patients and 35% of studied patients were females and concerning residence, 80% of patients were from urban areas and 20% were from rural areas. For every child incorporated in the study, a chest x-ray and a LUS were performed. The detection rate of consolidative patches, air bronchogram, pleural effusion and lung abscesses was higher in ultrasound compared to the x-ray technique. Also, LUS was more accurate in detection of extension of pneumonia.*

Conclusion: *Lung ultrasound is useful for detection of extension of pneumonia, and it is more sensitive than chest X-ray and allows a radiation free technique for detection of consolidations in children, thus reducing radiation exposure in this population.*

Keywords: *Chest X-Ray; Lung ultrasound; Pneumonia.*

INTRODUCTION

Respiratory infections have always been considered a worldwide health problem and a major cause of morbidity and mortality, with infants and young children especially susceptible (**Zar and Ferkol, 2014**). Among these infections, pneumonia stays the predominant cause of childhood mortality, causing nearly 1.2 million deaths each year in children younger than 5 years. Most of these deaths occur in developing countries (**Izadnegahdar et al., 2013**). In our country, it was estimated that 19% of children deaths below the age of 5 years is likely caused by pneumonia and other acute respiratory infections (**World Health Organization, 2014**). The current guidelines suggest that the diagnosis of pneumonia can only be made on the clinical history, respiratory rate, fever, respiratory signs and symptoms reserving the use of radiography only in severe or complicated cases (**Harris et al., 2011**), (**Bradley et al., 2011**). Despite these latest indications chest radiography (CR) is commonly considered the best choice for the diagnosis of pneumonia among physicians and its execution is also requested for mild cases because of the poor reliability of the history and physical examination (**Shah et al.,**

2010), (**Ayalon et al., 2010**). **Weinberg et al., 1986** described a new method of evaluating community acquired pneumonia (CAP) by the use of lung ultrasonography (LUS). Numerous later studies have shown that it is an accurate, reliable and radiation-free tool in the diagnosis of pneumonia (**Copetti et al., 2008**), (**Reissig et al., 2012**), (**Caiulo et al., 2013**).

For several years, Transthoracic Ultrasound (TUS) was restricted exclusively for examination of pleural effusions. However, over the past few years ultrasonography of the pleural space and lung parenchyma is getting widespread consensus in different conditions in clinical practice, particularly in emergency conditions (**Smargiassi et al., 2013**). Point-of-care ultrasound imaging, performed at the patient's bedside, decreases the delays of chest radiography in diagnosis of pulmonary diseases (**Al-khayat and Alam-Eldeen, 2014**).

PATIENTS AND METHODS

This comparative study was performed on 100 children (65 males and 35 females), admitted during the period from August 2018 to August 2019 in the general pediatric wards and PICUs of our tertiary hospital they were

recruited by simple random method. The study design and methodology were approved by the scientific research committee of the Department of Pediatrics, Faculty of Medicine, University of Cairo. The study protocol was approved by the Local Ethics Committee of Scientific Research, Faculty of Medicine, Cairo University.

Sample size:

Sample Size: Epi Info STATCALC was used to calculate the sample size by considering the following assumptions: 95% two-sided confidence level with power of 80%. & an error of 5% odds ratio calculated the final maximum sample size taken from the Epi-Info output was 60, it was preferred to enroll larger number of patients according to availability of cases.

Inclusion criteria:

Age from 2 years to 12 years, both genders, presenting with acute onset of; fever, cough, lethargy and chest pain, with respiratory distress signs; tachypnea, retractions, grunting, cyanosis, diminished air entry, fine rales and bronchial breath sounds.

Exclusion criteria:

Children less than 2 years or have contraindications to

radiological exposure (chromosomal breaking syndromes, e.g. (ataxia telangiectasia, fragile X syndrome and Wiskott Aldrich syndrome).

All studied cases were subjected to the following:

History and clinical examination to confirm clinical diagnosis of pneumonia, then chest X-ray (CXR) and a thoracic US will be performed. When assessing one of the two examinations, investigators will be blinded to the other examination. CXR will be performed in frontal view, either in the anteroposterior reclining or in the posteroanterior upright projection, depending on the age of the patient. Thoracic US examinations 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. [15] 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 or in a sitting position, facing away from the examiner. 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, where each consolidation will be characterized in terms of laterality (right-left) and projection (superior-inferior, medial-lateral, and anterior-posterior). The initial observation that several small areas of consolidation identified on US are not visible on the corresponding CXR, leads to the measurement of the size of consolidation on US. The purpose was to compare the size of the consolidations visible on both techniques and those visible only on US. One axis was measured for each lesion: the distance between the superficial

and deep limit of the consolidation, perpendicular to the pleural surface (Al-khayat and Alam-Eldeen, 2014).

Statistical analysis:

Data were coded and entered using the statistical package for the Social Sciences. (SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc). Data were summarized using mean and standard deviation for quantitative variables, and frequencies for categorical variables. P-values >0.05 were considered as statistically significant.

RESULTS

This study was conducted on 100 pediatric patients, diagnosed clinically as pneumonia, attending inpatient ward of our

tertiary hospital. Our results will be demonstrated in the following tables.

Table (1): Sociodemographic Data of The Studied Group

| | |
|--|--------------------------|
| | Total no. = 100 |
| Age (years) Mean ± SD Range | 5.05 ± 2.50 2 – 12 |
| Gender Female Male | 35 (35.0%) 65 (65.0%) |
| Residence Urban Rural | 80 (80.0%) 20 (20.0%) |

This table shows that pneumonia was more common in males (65%) than females and in

urban areas (80%) than in rural ones.

Table (2): Clinical Characteristics of the Studied Group

| Clinical characteristics | Number (%) |
|--------------------------|--------------|
| Cough | 90 (90%) |
| Fever | 80 (80.0%) |
| Tachypnea | 100 (100.0%) |
| Wheezes | 66 (66.0%) |
| Crepitation | 85 (85.0%) |
| Working ala nasi | 40 (40.0%) |

The most commonly present clinical symptom was cough (90%) of patients, while the most common sign was tachypnea (100%) among studied group.

Table (3): Comparison between Chest X-Ray and Lung Ultrasound in detecting Consolidation, Air Bronchogram, Pleural Effusion and Lung Abscess

| | | CXR | LUS | P-value |
|------------------|------------------|------------|------------|---------|
| Consolidation | no consolidation | 56 (56.0%) | 0 (0.0%) | 0.0 |
| | 1 lobe | 33 (33.0%) | 70 (70.0%) | |
| | 2 lobes | 11 (11.0%) | 30 (30.0%) | |
| Air bronchogram | Negative | 76 (76.0%) | 39 (39.0%) | 0.0 |
| | Positive | 24 (24.0%) | 61 (61.0%) | |
| Pleural effusion | Negative | 97 (97.0%) | 95 (95.0%) | 0.47 |
| | Positive | 3 (3.0%) | 5 (5.0%) | |
| Lung abscess | Negative | 98 (98.0%) | 97 (97.0%) | 0.651 |
| | Positive | 2 (2.0%) | 3 (3.0%) | |

There was statistically significant difference between CXR and LUS indicating superiority of LUS in detection of consolidation (one or more lobes) and air bronchogram

Table (4): Sensitivity and Specificity of lung ultrasound

| | TP | TN | FP | FN | Sensitivity | Specificity |
|------------------|----|----|----|----|-------------|-------------|
| Abscess | 2 | 97 | 1 | 0 | 100.00% | 99.00% |
| Pleural effusion | 3 | 95 | 2 | 0 | 100.00% | 97.90% |
| Air bronchogram | 24 | 39 | 37 | 0 | 100.00% | 51.30% |

TP: true positive, TN: true negative, FP: false positive, FN: false negative

Sensitivity of LUS in detection of pleural effusion, air bronchogram and lung abscess was 100%. Specificity of ultrasound in detection of pleural effusion was 97.9%, and for air bronchogram were 51.3% and for lung abscess was 99.0%

Illustrative cases:

Case 1: Five years old boy presented with cough, dyspnea, tachycardia, wheezes in right lower lung and fever so suspected clinically to be pneumonia **Figure (1)**.



Figure (1)

CXR: Showing an area of consolidation in the right lower lung zone.

LUS: Showing lower right echogenic lung and pleural thickness with absent B line and positive A line.

Case (2): Three years old girl presented with cough, dyspnea, tachycardia, wheezes all over the chest and fever so suspected clinically to be pneumonia **Figure (2)**.

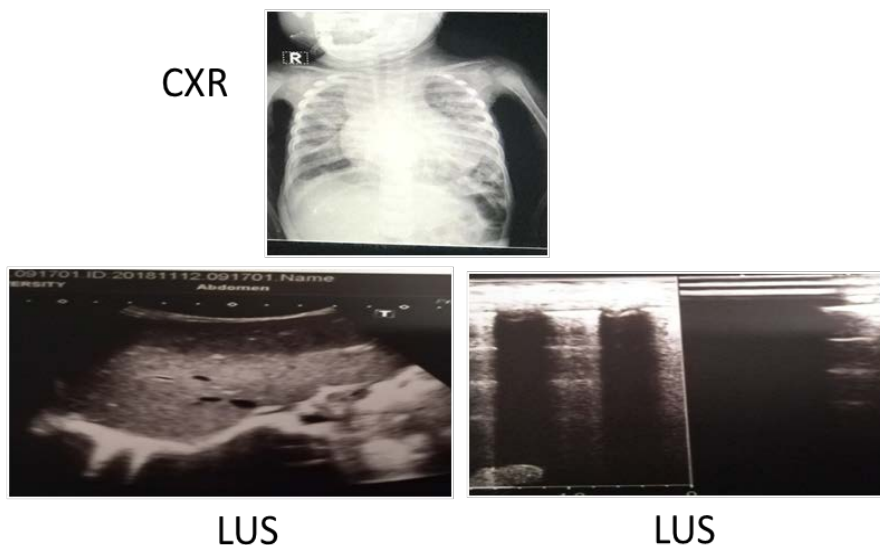


Figure (2)

CXR: Showing bilateral lung pneumonia.

LUS: Showing sub pleural consolidation in both lungs and left lung consolidation with minimal pleural effusion, abnormal lung sliding is noted and both A line and B line are presented.

DISCUSSION

In our study, LUS was able to detect consolidation in 100 (100%) patients as compared to 45 (45%) patients by CXR of total 100 patients. LUS was abnormal in all patients while CXR failed to detect abnormality in 55 patients. This was similar to **Metwally et al., 2018** who aimed to assess Accuracy of lung ultrasonography in diagnosis of community acquired pneumonia as compared

to CXR in pediatric age group, where they found that LUS was able to detect consolidation in 88% of patients as compared to 46% of patients by CXR.

Ho et al., 2015 also found that CXR was able to detect 151 (92.6%), whereas LUS detected 159 (97.5%) out of 163 patients with pneumonia. **Tirdia et al., 2016** found that the detection of pneumonia using LUS was better (97.84%) than with chest

radiography (90.64%). LUS was able to detect consolidation in 130 (93.53%) patients as compared to 107 (76.97%) patients by CXR of total 139 patients, the difference between these two studies and our study could be attributed to different sample size.

Also, in our study 24 patients (24%) were positive for air bronchogram in the consolidated areas by CXR, while 61 patients (61%) were positive by lung Ultrasound, and according to the study done by **Hajalioghli et al., 2016**; they declared that the presence of air bronchogram is an important finding that significantly increased the diagnostic accuracy of US in their work as sonographic air bronchogram were indicative of pneumonia. This result disagreed with **El Zayat et al., 2018** who aimed to asses' LUS versus CXR for diagnosing pneumonia in children with fever and respiratory distress and found that (43%) were positive for air bronchogram by LUS and (40%) were positive for air bronchogram by chest x ray with no significant difference.

Also, in our study 3 patients (3%) were positive for pleural effusion by CXR, while 5 patients (5%) were positive by LUS. This result agreed with **Rahmati et al., 2015** who aimed to assess the

significance of lung ultrasound and CXR in the diagnosis of children clinically suspected of pneumonia and found that there is significant difference between LUS and CXR in detecting pleural effusion.

In our study sensitivity of LUS in detection of pleural effusion, air bronchogram and lung abscess was 100%. Specificity of ultrasound in detection of pleural effusion was 97.9%, and for air bronchogram were 51.3% and for lung abscess was 99.0%. **Pereda et al., 2015**, in meta-analysis found that LUS had a sensitivity of 96% and specificity of 93% for diagnosis of pneumonia by consolidation. Other published data also showed that LUS is more sensitive than CXR in the diagnosis of pneumonia in children (**Caiulo et al., 2013**), (**Ianniello et al., 2016**).

Before concluding, it is worth mentioning that there are some limitations to this study. In our study US scans were performed by a single expert operator, and it is sensible to hypothesize that equivalent results cannot be immediately achieved by less experienced operators. However, it should be considered that learning the technique and image. Interpretation is relatively simple and fast process. Unfortunately,

not all radiologists are minded with pediatric lung ultrasonography, and their knowledge is limited only to pleural findings, especially pleural effusions, so this issue added an extra-limitation in examining our cases as the experienced operator was not always available. Also, in our pediatric radiology department, to limit the radiation exposure as much as possible, a lateral chest X-ray is never done routinely, but only when the interpreting radiologist consider it necessary.

CONCLUSION

Our study shows that LUS is safe and accurate for the diagnosis of suspected cases of pneumonia and it is more sensitive than CXR and allows a radiation free technique for detection of consolidations in children, thus reducing radiation exposure in this population. Some technical advantages such as shorter thoracic width, thinner chest wall, and small lung mass theoretically enable LUS examination in children easier than in adults. The short duration of lung ultrasound imaging supports the assumption that US can be performed in everyday practice, depending on the setup of each radiology department.

STUDY LIMITATIONS

LUS scans were performed by a single expert operator, and it is sensible to hypothesize that equivalent results cannot be immediately achieved by less experienced operators. However, it should be considered that learning the technique and image Interpretation is relatively simple and fast process. Unfortunately, not all radiologists are minded with pediatric lung ultrasonography, and their knowledge is limited only to pleural findings, especially pleural effusions, so this issue added an extra-limitation in examining our cases as the experienced operator was not always available. Also, in our pediatric radiology department, to limit the radiation exposure as much as possible, a lateral chest X-ray is never done routinely, but only when the interpreting radiologist consider it necessary

ACKNOWLEDGMENTS

We would like to thank the parents and children for their cooperation in this study.

Credit Author Statement:

Hala Mansour: Writing-
Reviewing and Editing.

Ezzabouha Abd Al-Rahman: Data curation, Writing- Original draft preparation.

Maha Sheba: Visualization, Investigation.

Iman Abd El-Aziz: Conceptualization, Methodology, Software, Reviewing and Editing

All authors have read and agreed to the published version of the manuscript.

Availability of data and materials: the data sets used and/or analyzed in the current study are available from the corresponding author on reasonable request.

Conflict of interest: The authors declare no conflict of interest in connection with the study.

Funding source: No financial or nonfinancial benefits were obtained or will be obtained from any party related directly or indirectly to the subject of this article.

REFERENCES

1. **Al-khayat KF, and Alam-Eldeen MH (2014):** Value of chest ultrasound in diagnosis of community acquired pneumonia: Egyptian Journal of Chest Diseases and Tuberculosis, 63: 1047-51.
2. **Ayalon I, Glatstein MM, Zaiden Berg-Israeli G, Scolnik D, BenTov A, Ben Sira L and Reif S (2013):** The role of physical examination in establishing the diagnosis of pneumonia: *Pediatr Emerg Care*, 29:893–896.
3. **Bradley JS, Byington CL, Shah SS, Alverson B, Carter ER, Harrison C, et al (2011):** The management of community acquired pneumonia in infants and children older than 3 months of age: clinical practice guidelines by the pediatric infectious diseases' society and the infectious diseases society of America: *Clinical Infectious Diseases.*; 53: 25-76.
4. **Caiulo VA, Gargani L, Caiulo S, Fisicaro A, Moramarco F, Latini G, et al (2013):** Lung ultrasound characteristics of community-acquired pneumonia in hospitalized children: *Pediatr Pul*, 48:280–287.
5. **Copetti R and Cattarossi L (2008):** Ultrasound diagnosis of pneumonia in Children: *Radiol Med*, 113: 190-198.
6. **El Zayat RS, Bahbah WA, Mousa WA (2018):** Lung Ultrasonography Versus Chest X Ray for Diagnosing Pneumonia in Children with Fever and Respiratory Distress: A Prospective Blind Study, 4:15-20
7. **Hajalioghli P, Nemati M, Dinparast SL, Fouladi DF (2016):** Can chest computed tomography be replaced by lung ultrasonography with or without plain chest radiography in pediatric pneumonia? *Journal of Thoracic Imaging*, 31: 247-252.
8. **Harris M, Clark J, Coote N, Fletcher P, Harnden A, Mc Kean M, Thomson A (2011):** British Thoracic Society guidelines for the management of community acquired pneumonia in children: *Thorax*,

- 66:1-23.
9. **Ho MC, Ker CR, Hsu JH, Wu JR, Dai ZK, Chen IC (2015):** Usefulness of lung ultrasound in the diagnosis of community acquired pneumonia in children: *Pediatr Neoantol*, 54: 40-45.
 10. **Ianniello S, Piccolo CL, Buquicchio GL, Trinci M, Miele V (2016):** First-line diagnosis of pediatric pneumonia in emergency: lung ultrasound (LUS) in addition to Chest-X-ray and its role in follow up: *The British Journal of Radiology*, 89: 1061.
 11. **Izadnegahdar R, Cohen AL, Klugman KP, Qazi SA (2013):** Childhood pneumonia in developing countries: *Lancet Respir Med*, 1:574-84
 12. **Metwally AE, Kamel OF, Ghazy MS (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.*, 72:4977-4983.
 13. **Pereda MA, Chavez MA, Hooper-Miele CC, Gilman RH, Steinhoff MC, Ellington LE, Checkley W (2015):** Lung Ultrasound for the Diagnosis of Pneumonia in Children: A Meta-analysis. *PEDIATRICS*, 135:714–722.
 14. **Rahmati MB, Ahmadi M, Malekmohamadi, Hasanpur S, Zare SH, and Jafari M (2015):** The significance of chest ultrasound and chest X-ray in the diagnosis of children clinically suspected of pneumonia *Med Life*, 8: 50–53.
 15. **Reissig A, Gramegna A and Aliberti S (2012):** The role of lung ultrasound in the diagnosis and follow-up of community-acquired pneumonia: *Eur J Intern Med*, 23: 391-397.
 16. **Shah S, Bachur R, Kim D and Neuman MI (2010):** Lack of predictive value of tachypnea in the diagnosis of pneumonia in children: *Pediatr Infect Dis J*, 29: 406-9.
 17. **Smargiassi A, Inchingolo R, Soldati G, Copetti R, Marchetti G, Zanforlin A, et al (2013):** The role of chest ultrasonography in the management of respiratory diseases: document II: *Multidiscip Respir Med*, 8: 55.
 18. **Tirdia PR, Vajpayee S, Singh J, Gupta RK (2016):** Accuracy of lung ultrasonography in diagnosis of community acquired pneumonia in hospitalized children as compared to chest x ray: *International Journal of Contemporary Pediatrics*, 3: 1026-31.
 19. **Weinberg B, Diakoumakis EE, Kass EG, Seife B and Zvi ZB (1986):** The air bronchogram: sonographic demonstration: *AJR Am J Roentgenol*, 147:593–595.
 20. **World Health Organization (2014):** World Health Statistics. Available at <http://www.who.int/maternal-child-adolescent/epidemiology/profiles/neonatal-child/egy.pdf>. Last accessed at Oct 2016.
 21. **Zar HJ and Ferkol TW (2014):** The global burden of respiratory disease-impact on child health: *Pediatr Pulmonol*.2014;49:430-4

دور التصوير بالموجات فوق الصوتية للصدر مقابل الأشعة السينية في تقييم الالتهاب الرئوي لدى الأطفال

هالة منصور*، عز أبوها عبد الرحمن*، مها شيبية**، إيمان عبد العزيز*

*قسم طب الأطفال، **قسم التصوير بالموجات فوق الصوتية، مستشفى الأطفال الجديد،
كلية الطب، جامعة القاهرة، مصر

المقدمة: الالتهاب الرئوي هو أحد الشكاوى الرئيسية الأكثر شيوعاً التي يطلب الأطفال الرعاية الطبية بسببها. قد تكون الموجات فوق الصوتية للرئة طريقة مماثلة للكشف عن أمراض الرئة مقارنةً بالأشعة السينية على الصدر وهي الطريقة القياسية الحالية.

الهدف من البحث: هو دراسة نتائج الموجات فوق الصوتية للرئة واختبار حساسيتها ونوعيتها مقارنةً بالأشعة السينية السريرية والتقليدية لتشخيص الالتهاب الرئوي في مرحلة الطفولة. وإمكانية استخدام الموجات فوق الصوتية للرئة كأداة آمنة وقيمة في تشخيص ومتابعة الالتهاب الرئوي.

المرضى والأساليب: دراسة مقارنة أجريت على 100 طفل (65 ذكر و35 أنثى)، تم قبولهم خلال الفترة من أغسطس 2018 إلى أغسطس 2019 في أجنحة الأطفال العامة ووحدات العناية المركزة للأطفال في مستشفى الأطفال الجامعي، جامعة القاهرة.

النتائج: كان متوسط عمر المريض 5.05 ± 2.50 سنة، كان 65% من المرضى الخاضعين للدراسة من الذكور و35% من المرضى الخاضعين للدراسة من الإناث وفيما يتعلق بالسكن، كان 80% من المرضى من المناطق الحضرية و20% من المناطق الريفية. لكل طفل مدرج في الدراسة، تم إجراء أشعة سينية للصدر وفحص بالموجات فوق الصوتية على الرئة. كان معدل الكشف عن الالتهاب الرئوي، ورسم القصبات الهوائية، والارتشاح البلوري وخراجات الرئة أعلى في الموجات فوق الصوتية مقارنة بتقنية الأشعة السينية. أيضاً، كان فحص الموجات فوق الصوتية أكثر دقة في الكشف عن امتداد الالتهاب الرئوي.

الخلاصة: الموجات فوق الصوتية للرئة مفيدة للكشف عن امتداد الالتهاب الرئوي، وهي أكثر حساسية من أشعة الصدر السينية وتسمح بتقنية خالية من الإشعاع للكشف عن أمراض الرئة عند الأطفال، وبالتالي تقليل التعرض للإشعاع في هذه الفئة من العمر.