Original Research Article

Lung ultrasonography versus chest radiography for the diagnosis of Paediatric community acquired pneumonia

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Abstract
Introduction: Pneumonia remains the leading infectious cause of death globally among children younger than 5 years, considered for an estimated 9, 20,000 deaths every year. Pneumonia is a condition in which inflammation of lung parenchyma occurs.
Aim: To determine whether lung ultrasonography can serve as a useful alternative to CXR in diagnosing suspected cases of community acquired pneumonia in children.
Materials and Methods: The present study was an observational prospective study. This Study was conducted from March 2021 to July 2022 in Mahatma Gandhi medical college and hospital Jaipur (Raj.). Total 40 patients were included in this study. For analytical research data were entered into a Microsoft excel spreadsheet and then evaluated by SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) version 5 Graph Pad Prism.
Result: In our study we performed radiological investigation CXR and LUS at the time of hospital admission in clinically suspected CAP patients for early diagnosis and management, follow up of patients done to compare their efficacy and sensitivity to detect CAP with LUS to avoid radiation exposure in paediatric patients.
Conclusion: To conclude our study, we can suggest LUS may represent a good supplemental tool in the diagnostic work-up and follow up if CAP is suspected. Further studies are necessary to validate the diagnostic accuracy of LUS on larger population and to evaluate the impact of LUS on antibiotic use and stewardship in podiatric age group and reduce unnecessary radiation exposure from CR.

Keywords: PCAP, LUS, ultrasonography and CXR

Introduction

Pneumonia remains the leading infectious cause of death globally among children younger than 5 years, considered for an estimated 9, 20,000 deaths every year [1]. Pneumonia is a condition in which inflammation of lung parenchyma occurs.
Pediatric community acquired pneumonia (PCAP) is the most common infectious cause of death among children worldwide According to the World Health Organization. In children less than 5 years of age PCAP accounts for 18% of the total number of deaths, more than tuberculosis, acquired immunodeficiency syndrome (AIDS), and malaria combined [2].

At present, chest radiograph (CXR) is thought to be the test of choice for diagnosing pneumonia in children. CXR is harmful as it involves the use of ionizing radiations [2].

While PCAP is mainly a clinical diagnosis, radiologic confirmation is obtained commonly for the same. In clinical practice chest radiography (CR) may be advised by physicians for confirmatory diagnosis, differential diagnosis and further complication. So, despite the international guidelines, CR is frequently performed for children with clinically suspected PCAP, which increasing pediatric radiation exposure [3].

In children, the lung mass is small and they have a thinner chest wall. Therefore, Lung ultrasonography (LUS) appears to be good alternative to CXR in the evaluation of pneumonia. It avoids harmful radiation.

Since 1986, many studies have been done which suggested that use of lung ultrasonography (LU) in diagnosing pneumonia, first in the adult and recently now in pediatric age group (6-8). Features like being rapid, mobile, and repeatable and can easily performed bedside without radiation exposure makes LU particularly useful. Now a days numerous studies and meta-analyses have exhibited promising results on the authenticity of LU in diagnosing pneumonia and possibly replacing CR in pediatric population [4].

In the literature, previous studies establishing the accuracy of LU often used CR as reference standard and took in account different clinical settings all together. However, this might be unresolved to include studies with different clinical settings to establish the accuracy of LU in diagnosing PCAP. Meanwhile, CXR is not a sufficiently reliable reference standard in diagnosing PCAP due to its high inter-observer variability and relatively low sensitivity (71-87%) [5].

Although, chest radiography (CR) has many shortcomings. In detail, the results of CXR are greatly affected by internal and external factors such as the patient's posture and assessing physician. CR cannot be identified when consolidation in lung is less than 1.0 cm. This may be since chest radiographs are two-dimensional images of normal and abnormal lobes superimposed, making it difficult to observe small lesions [2]. CR is inexpedient and cost more and children exposed to radiations. Pediatric population is sensitivity to radiation damage at least 4 times that of adults. So, some clinicians are diligently inspecting to find an alternative method which can not only improve the accuracy of diagnosis outcome and follow up of pneumonia patients, but also reduce exposure to ionizing radiation.

The lung is an organ which contains gas and had been always a blind spot for ultrasound. Recent years, with the advancement of ultrasonography diagnostic methods, ultrasonography images have been used to asses pleural and lung tissue sonograms under pathologically affected lung field. So, it might be possible to apply ultrasonography in diagnosing of pneumonia. In 1986, Weinbeg *et al*., proposed initially that the use of type B pulmonary ultrasound for evaluating pneumonia patients, 5 because of the lung size in pediatric population, minor changes in the lungs can be undoubtedly reach the pleura, making it effortless to detect pathological signs while performing lung ultrasonography. 6 Many studies have investigated and suggested that lung ultrasonography (LUS) in pneumonia patients have diagnostic yield. As per these studies not only had wide disparity in sample size, but also suggested indecisive results.

Material and Methods

- **Study design:** This was observational, prospective study.
- **Settings:** Department of Pediatrics, Mahatma Gandhi Medical College and Hospital, Jaipur.
- **Sample size:** Subjects with age group of up-to 18 years of age with clinical diagnosis of CAP attending Mahatma Gandhi medical college and hospital between March 2021 to July 2022.
- **Subject:** Age group up-to 18 years with clinical diagnosis of CAP attending Mahatma Gandhi medical college and hospital between March 2021 to July 2022.

Inclusion criteria

- Subjects with clinical signs and symptoms suggestive of community acquired pneumonia of children aged up to 18 years.

Exclusion criteria
- Unwilling parents/guardian.
- Patient with congenital anomalies, other co-morbidities.

Methodology
- The current study was hospital based observational prospective study that had been conducted in Dept. of Pediatric in Mahatma Gandhi medical college and hospital.
- Cases fulfilling the inclusion and exclusion criteria were included in the study after obtaining informed written consent.
- All pneumonia patients attending pediatric department (IPD/OPD/Follow up) of MGMCH falling under the inclusion criteria was investigated by LUS and chest radiograph within 24 hours.
- Pneumonia initially was clinically diagnosed by two expert pediatricians.
- LUS is performed using 3-7 MHz linear probe. Six lung zone evaluation done i.e. anterior, lateral and posterior thorax (lower, upper) studied on both right and left side (in mid clavicular line, mid axillary line and paravertebral lines respectively) on day 1, then every 3-6 days till recovery.
- A pre-designed pre-structured proforma was used to collect information. Data was collected with clinical presentation, routine investigation, CXR findings and LUS findings.
- Statistical analysis was done using SPSS software.

Result and Discussion
The present study was an observational prospective study. This Study was conducted from March 2021 to July 2022 at Dept. of Paediatrics, Mahatma Gandhi Medical College and Hospital, Jaipur. Total 40 patients were included in this study. In our study, all 40 patients were <18 years of age, the mean Age of patients was [7.0500± 4.3657].
Shah VP et al., (2013) [5] showed that to determine the accuracy of point-of- care ultrasonography was done for the diagnosis of pneumonia in children and young adults by a group of clinicians. Participants Patients from birth to age 21 years were undergoing chest radiography for suspected community-acquired pneumonia. In our study male population [24 (60.0%)] was higher than the female population [16 (40.0%)] but it was statistically not significant (p=07346), (z=1.7889). Esposito S et al., (2014) [6] examined that there are few prospective evaluations of point-of-care ultrasonography (US) for the diagnosis of pediatric community-acquired pneumonia (CAP). The aim of this study was to bridge this gap in order to increase their knowledge of the performance of US in diagnosing CAP in childhood. A total of 103 children (56 males, 54.4%; mean age ± standard deviation 5.6 ± 4.6 years) were admitted to hospital with a clinical diagnosis of suspected CAP. Shah VP et al., (2013) [5] showed that to determine the accuracy of point-of- care ultrasonography for the diagnosis of pneumonia in children and young adults by a group of clinicians. Two hundred patients were studied (median age, 3 years; interquartile range, 1-8 years); 56.0% were male, and the prevalence of pneumonia by chest radiography was 18.0%. We found that, maximum number of patients were from middle class [21 (52.5%)]. It was statistically significant (p< .001), (z=4.6935). We examined that, majority of the patients had late Preterm delivery [3 (7.5%)] and it was statistically significant (p< .00001), (z=7.8483) no such study could be traced showing socioeconomically status and perinatal history of patients in their studies.
In our study, 40 (100.0%) patients had Fever, 40 (100.0%) patients had Cough, 27 (67.5%) patients had Nasal congestion, 8 (20.0%) patients had Conjunctivitis, 8 (20.0%) patients had Retraction, 10 (25.0%) patients had Vomiting,11 (27.5%) patients had Otitis, 23 (57.5%) patients had Wheezing, 19 (47.5%) patients had Dyspnea, 8 (20.0%) patients had Nasal flaring, 5 (12.5%) patients had Cyanosis and 20 (50.0%) patients had Chest pain in Clinical

findings of children. Hassen M *et al*., (2019) [7] observed that this study was designed to assess the role of lung ultrasonography in comparison of chest radiography for the diagnosis of pneumonia and assess the association of clinical characteristics such as tachypnea, fever, cough, nasal congestion, conjunctivitis with radiologic findings and predictors of hospitalization among children with severe community acquired pneumonia.

When we compared LUS and CR, majority of the patients had Abnormal USG [37 (92.50%)] and Abnormal Chest X-ray [35 (87.5%)] it was statistically highly significant (p< .001), (z=7.6026). Yan JH *et al*., (2020) [8] observed that the aim of this meta-analysis was to evaluate the diagnostic value of lung ultrasound (LUS) in comparison to chest radiography (CXR) in children. Radiological finding, including pulmonary consolidation on chest radiograph and on lung ultrasonography showed positive air bronchogram, abnormal pleural line, and pleural effusion were most frequently observed in the screening of children with pneumonia. Ciuca IM *et al*., (2021) [9] showed that pneumonia is the leading cause of death among children; thus, a correct early diagnosis would be ideal. The imagistic diagnosis still uses chest X-ray (CXR), but lung ultrasound (LUS) proves to be reliable for pneumonia diagnosis.

In our study we performed radiological investigation CR and LUS at the time of hospital admission in clinically suspected CAP patients for early diagnosis and management, follow up of patients done to compare their efficacy and sensitivity to detect CAP with LUS to avoid radiation exposure in pediatric patients.

Table 1: Chest Radiograph findings

Finding	Right lung			Left Lung		
	Upper zone	Middle zone	Lower zone	Upper zone	Middle zone	Lower zone
Lobar Opacity	7	7	5	0	8	5
Patchy Opacity	0	2	2	3	5	2

Table 2: LUS findings of Right Lung at Admission

No. of Patients	Finding		Anterior	Lateral	Posterior
20	A line	Seen	19	31	33
		Distorted	21	9	7
	B line	Seen	20	9	7
		Not seen	1	0	0
		+/-	1	0	0
	Consolidation	Present	20	9	7
		Absent	0	0	0

Table 3: LUS findings of Right Lung at Discharge

No. of Patients	Finding		Anterior	Lateral	Posterior
20	A line	Seen	40	34	37
		Distorted	0	6	3
	B line	Seen	0	2	1
		Not seen	20	6	4
		+/-	0	0	0
	Consolidation	Present	1	0	0
		Absent	0	0	0

Table 4: LUS findings of Left Lung at Admission

No. of Patients	Finding		Anterior	Lateral	Posterior
19	A line	Seen	20	20	35
		Distorted	19	18	5
	B line	Seen	17	17	5
		Not seen	1	0	0

		+/-	1	1	0
	Consolidation	Present	17	17	5
		Absent	0	0	0

Table 5: LUS findings of Left Lung at Discharge

No. of Patients	Finding		Anterior	Lateral	Posterior
21	A line	Seen	38	37	37
		Distorted	2	3	3
	B line	Seen	2	0	0
		Not seen	16	19	5
		+/-	1	0	0
	Consolidation	Present	0	0	0
		Absent	0	0	0

In our study 40 patients were taken all were clinically suspected PCAP in which LUS and CR done. In LUS 37 patients had positive findings such as distorted A line, presence of B lines, air bronchograms, mild pleural effusion. These findings suggested 92.5% sensitivity of LUS in diagnosing PCAP. The value of z is 7.6026. The value of p is $< .001$. The result is highly significant at $p < .05$. In 35 patients on CR had positive findings such as lobar opacity, patchy opacity, obliterated CP angle in few complicated patients. These findings suggested 87.5% sensitivity of CR in diagnosing PCAP.

Table 6: Comparison between LUS and CR

Total No.	Finding	Lung ultrasonography	Percent	Chest radiograph	Percent
40	Positive	37	92.5%	35	87.5
	Negative	3	7.5	5	12.5

El Dien HM et al., (2013) [10] found that the aim of this prospective study was to assess lung ultrasonography as an alternative to bedside radiography for the diagnosis of neonatal pneumonia. Principi N et al., (2017) [11] searched that early diagnosis of community-acquired pneumonia (CAP) is essential to reduce the total burden of this disease particularly when CR was performed only with postero-anterior/antero-posterior.

Conclusion
Our study was done to compare the efficacy of LUS and CR in diagnosing CAP which suggested the good accuracy of LUS in the clinical suspected CAP patients. LUS specificity was higher than CR (96% versus 87.1%). This data suggests that t a positive LUS in CAP patients may avoid the need to perform CR in paediatric patients. If our study results will be confirmed by further studies on larger number of paediatric populations, the routine use of LUS for children for confirming the diagnosis of bronchiolitis and suspected bacterial pneumonia could reduce the number of CR performed, would decrease the exposure to ionizing radiations and the medical costs. For the children with sub centimetre consolidations on LUS, we suggest careful clinical and ultrasound follow-up (at the time of discharge) to discriminate patients who will need antibiotic treatment from those who will achieve a spontaneous resolution. In this sense a watchful waiting approach can be adopted for enhance antibiotic stewardship.

Moreover, the good inter-observer harmony between the paediatrician and the radiologist highlights that LUS is a technique easy to learn, and it can be potentially performed by the clinician in every setting with immediate bedside availability of results and follow up for complicated patients. To conclude our study, we can suggest LUS may represent a good supplemental tool in the diagnostic work- up and follow up if CAP is suspected. Further studies are necessary to validate the diagnostic accuracy of LUS on larger population and to evaluate the impact of LUS on antibiotic use and stewardship in podiatric age group and reduce unnecessary radiation exposure from CR.

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