Abebe Habtamu ,Tesfaye Kebede, Assefa Getachew, Tigist Abate , Asfaw Atinafu. *Ethiop Med J, 2018, Vol. 56, No. 4*

ORIGINAL ARTICLE

DIAGNOSTIC VALUE OF CHEST ULTRASONOGRAPHY IN DETECTION OF COMMUNITY ACQUIRED PNEUMONIA IN UNDER FIVE CHILDREN

Abebe Habtamu, MD[1*],Tesfaye Kebede, MD[2], Assefa Getachew,MD[2], Tigist Abate, MD[2], Asfaw Atinafu, PhD[2]

ABSTRACT

Introduction: *Chest radiography is routinely used for the diagnosis of community-acquired pneumonia in children. Ultrasound has been reported to be safe, inexpensive, and relatively easier to use for diagnosis and minimizes exposure to ionizing radiation.*

Objective: *We aimed to assess the feasibility and diagnostic value of chest ultrasonography in the diagnosis of community-acquired pneumonia as an alternative to chest radiography in a hospital setting in Addis Ababa, Ethiopia.*

Methods: *We conducted a cross sectional study among under five children with a clinical diagnosis of pneumonia who visited the radiology department of Tikur Anbessa Specialized Hospital for chest x-ray examination from February to August, 2016. Chest ultrasonography examinations were performed using SonoScape ultrasound machine with 5-10 MHZ high resolution US probe.*

Results: *Seventy two patients were included in the study with a mean age of 22.1 months (standard deviation ± 19.6 months) and 42/72 (58%) were males. We identified 44/72 (61%) and 48 (66%) CAP cases by CXR and chest US, respectively. Four cases with negative CXR were found positive using chest US-while two patients with negative chest US had positive CXR findings. The sensitivity, specificity, positive predictive value and negative predictive value of chest US as compared to CXR were 95% (95% CI, 89-100), 86% (95% CI, 80-92), 91% (95% CI, 85-97) and 92% (95% CI, 86-98), respectively.*

Conclusion: *Chest ultrasonography has a high sensitivity and specificity in identifying cases of community-acquired pneumonia and is technically easier and feasible. Chest ultrasonography could be used as an alternative modality in the diagnosis of community-acquired pneumonia in our setting where access to x-ray is limited.*

Key words*: Chest ultrasound, chest-x-ray, community acquired pneumonia, Ethiopia, low-income country.*

INTRODUCTION

In low - and middle-income countries, severe pneumonia is among the most common reasons for hospital admission of children. Childhood pneumonia is the leading causes of death globally and in Ethiopia (1, 2). Effective management requires early identification of cases and providing appropriate antibiotic treatment, and is one of the key strategies to reduce pneumonia-related morbidity and mortality in children (3).

In low-income countries (LICs), childhood pneumonia is usually diagnosed based on clinical parameters such as cough and increased respiratory rate (4). Decisions based on clinical parameters results in increased number of children identified and treated empirically (high sensitivity), but lacks specificity (5). Besides clinical parameters, chest radiography (CXR) is the most common imaging modality for the diagnosis of community -acquired pneumonia (CAP) (6). Imaging has multiple roles including confirmation or exclusion of pneumonia, characterization and prediction of the infectious Furthermore, the absence of CXR confirmation leads to over estimation of CAP and irrational use of antibiotics (7).

Despite its benefits, cautious use of CXR is recommended for various reasons. Ionizing radiation in young children may have potential late adverse effects, and absence of findings on CXR may not rule out the diagnosis of pneumonia, especially in early presenters (8).

In 1986, Weinberg et al. described a new method of evaluating CAP by using chest US (5). Initially, its use was limited exclusively to the examination of pleural effusions. However, over the past few years, US of the pleural space and lung parenchyma is gaining wide acceptance (5,9,10).

US is a low cost diagnostic modality which can be performed at bed side of critically ill patients. Additionally, the ability to recognize even a small amount of fluid and the lower risk of exposure to ionizing radiation makes US preferable to CXR (6-11). Several studies have demonstrated that combining chest US with clinical parameters could effi-

1. Addis Ababa University Medical Faculty- College of Health Sciences. Department of pediatrics and child health.
2. Addis Ababa University Medical Faculty- College of Health Sciences. Department radiology.
* Corresponding Author: tamireabebe05@gmail.com

Data comparing the diagnostic value of chest US with CXR is scarce. Several studies conducted elsewhere have demonstrated a comparable sensitivity of US and CXR in detection of CAP (7,12,13). However, there is no study to demonstrate the diagnostic value and feasibility of chest US in diagnosing CAP in Ethiopia. Therefore, we conducted this study to compare diagnostic accuracy of chest US with that of CXR and describe the pattern of chest US appearance of CAP in a hospital setting in Ethiopia.

PATIENTS AND METHODS

Study design and patients: The study was a cross sectional survey with prospective data collection conducted to evaluate the value of chest US in the diagnosis of CAP. It was performed in the department of radiology, Tikur Anbessa Specialized Hospital (TASH) from February to August, 2016. All consecutive patients two to sixty months of age, seen at the radiology department with clinical suspicion of CAP and had chest radiography requested were included in the study.

Patients with the following conditions were excluded from the study: CXR taken 24 hours prior to chest US, patients with congenital abnormalities, and patients who had coexisting lung disease and associated co-morbidities.

Examination technique: Chest US was performed either before or after the CXR, but within a period of 24 hours. To avoid bias, examination and interpretation of both the chest US and CXR were done independently by different senior radiology residents. CXR reporting was performed in accordance with the World Health Organization (WHO) criteria for the standardized interpretation of pediatric chest radiographs (14).

The findings and the images were recorded on a pre-prepared format for further analysis. Chest US examination was performed as recommended by Caiulo et al. and Copetti et al. (15, 16). We used a 5 –10 MHz linear probe on SonoScape ultrasound machine to scan all patients. All CXR were Antero-posterior and supine done by digital radiography machine using routine standard technique. Lateral CXR was optional.

Statistical analysis: We computed the sensitivity, specificity and predictive values, including 95% confidence intervals, of chest US in identifying CAP among under five children in comparison with CXR.

The concordance of chest US and CXR in identifying CAP and patterns of pneumonia (i.e. consolidation, interstitial pleural B lines and mixed) and pleural effusion was evaluated using Cohen's weighted kappa (k) statistics and percent agreement. We used the following Cohen's grading: κ grades of 0-0.2 = poor agreement, 0.21-0.40 = fair agreement, 0.41-0.6 = moderate agreement, 0.61-0.80 = substantial agreement and 0.81-1.0 = nearly perfect agreement (17). Data analysis and test performance characteristics were computed using SPSS version 20.0 for Windows.

RESULTS

Seventy two children were included in the study and 42/72 (58%) were males. Their mean age [± standard deviation (SD)] was 22.1 (±19.6) months. The age and sex distribution of study participants is shown in Table 1.

Table1: Age and sex distribution of study participants (N=72)

Age (months)	Male	Female	Total
2-12	20 (28%)	16 (22%)	36 (50%)
13-60	22 (21%)	14 (19%)	36 (50%)
Total	42 (59%)	30 (41%)	72 (100%)

Agreement between the two imaging modalities: Final diagnosis of pneumonia was made in 44/72 (61%) and 48/72 (66%) cases by CXR and Chest US, respectively. There is an almost perfect agreement between the two methods, k = 0.82 (95% CI, 0.76 to 0.88) with 91% agreement.

The sensitivity and specificity of chest US as compared to CXR for the diagnosis of CAP were 95.4% and 85.7%, respectively. Details of sensitivity, specificity and positive and negative predictive values of the test are presented in Table- 2.

Table 2: Comparison of diagnostic accuracy of chest US with CXR for the diagnosis of community acquired pneumonia (N = 72)

		Chest US		*Sensitivity (95% CI)*	*Specificity (95% CI)*	*Positive predictive value (95% CI)*	*Negative predictive value (95% CI)*
		Positive	*Negative*				
CXR	*Positive*	42	2	95.4% (89.4-100)	85.7% (79.7-91.7)	91.3% (85.3-97.3)	92.3% (86.3-98.3)
	Negative	6	22				

Six patients with positive chest US had negative CXR results. The CXR in two patients were of poor quality for reporting and were regarded as negative. While the other four cases with positive chest US had negative CXR findings with conclusive discordance (Figure 1). Chest US missed two cases with evidence of lung consolidation on CXR.

While the other four cases with positive chest US had negative CXR findings with conclusive discordance (Figure 1). Chest US missed two cases with evidence of lung consolidation on CXR.

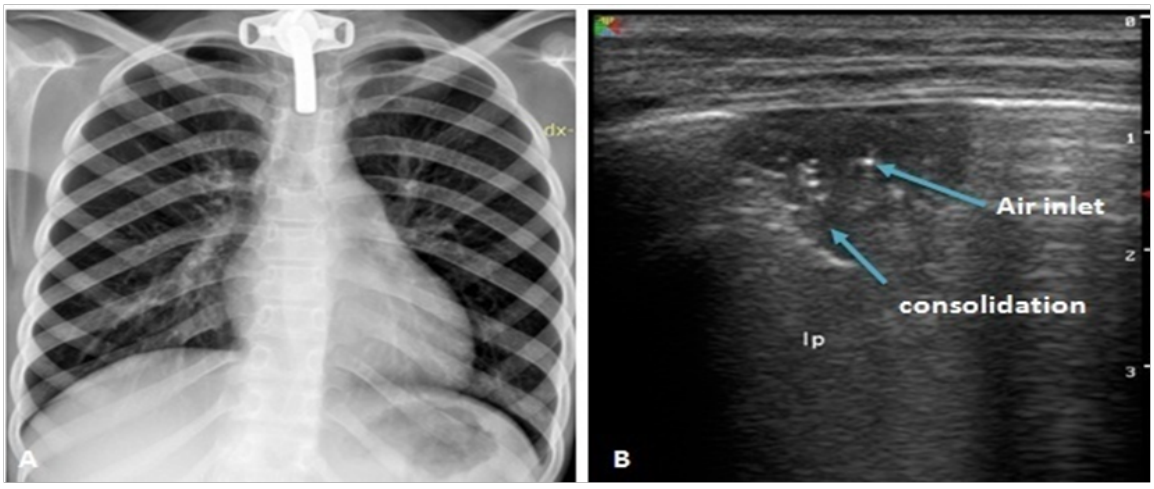

Figure 1: An example of discordant finding between CXR and chest US**.** Panel A: Negative CXR in 59 months old female child on tracheostomy tube for upper air way obstruction with signs and symptoms of CAP; Panel B: the same patient with evidence of pneumonia on chest US.

Sonographic and radiologic findings: Chest US and CXR examinations revealed pathologies compatible with pneumonia in 48 and 44 of the study participants, respectively.

The predominant pathology identified in both chest US and CXR was lung consolidation. Details of identified pathologies are presented in Table 3.

Table 3: Comparison of the pattern of chest US and CXR findings among study participants

Description of identified lung abnormality	*Chest US*	*CXR*
	Number (%)	Number (%)
Normal	24 (33%)	28 (39%)
Consolidation	35 (49%)	37 (51%)
Others*	13 (18%)	7 (10%)
Total	72 (100%)	72 (100%)

*Others types of lung abnormalities include confluent B lines, pleural effusion and interstitial infiltrates.

Multiple lung consolidations were identified in 18/72 (38%) and 11/72 (25%) of chest US and CXR findings, respectively. There is substantial agreement between the CXR and chest US in identifying patterns of parenchymal findings; k=0.68 (95% CI, 0.623 to 0.743). Pleural effusion was identified in five cases using chest US and in four cases by CXR.

DISCUSSION

This study has shown that chest US is a sensitive and specific tool in identifying CAP as compared to CXR. Our result is comparable to previous results by Esposito et al and Iorio G, which demonstrated a 94% to 97% sensitivity of chest US as compared to CXR for the diagnosis of CAP (7, 13). Furthermore, Copetti et al. and Ho MC. et al. have shown that chest US is more sensitive than CXR in diagnosing pneumonia in children (9, 11). The sensitivity and specificity of chest US in our study is better than what has been reported by Shah VP et al, with a sensitivity and specificity of 86% and 89%, respectively (18).

In our study, chest US detected four additional cases of pneumonia that were not identified by CXR. All the four cases that were not identified by CXR had small lung lesions (consolidations less than a centimeter) that may be related to an early stage of the pneumonic process and could be missed due to the limited radiographic resolution.

Similar findings were reported by others (13,18). On the contrary, chest US failed to detect two cases of pneumonia which were identified by CXR. The failure in chest US to detect lesions can be attributed to lesions that have not reached the pleural line or the inability to explore area of the lung covered by the scapula.

We found multiple lung consolidations in 18 (38%) of the patients identified by chest US, while 11 (25%) patients had such lesions on CXR. Caiulo et al in their study on chest Ultrasound Characteristics of CAP in Children have identified multiple pneumonic consolidations on chest US than CXR (16). A possible reason to explain this finding is, in CXR standard projection gives a summation image resulting from superimposed normal and abnormal or partially affected lobules, where as chest US allows examination along the circumference of the lung, which may differentiate between single affected parenchymal sections.

Although this result may have been affected by the experience of the physician performing the chest US, studies which were performed by a non-radiologist clinician after only a short period of training, achieved good results in terms of overall efficiency in comparison with CXR (18).

The availability of ultrasound machines as compared to chest radiography in our setting makes chest US a feasible alternative for the diagnosis of pneumonia in children.

This is also in line with the recent recommendation of the International Liaison Committee on chest US to use bedside chest ultrasound in the emergency setting, particularly in terms of minimizing radiation exposure (19).

Limitations of the study: Our study is not without limitations. First the number of suspected CAP cases is limited to draw a definitive conclusion on the utility of chest US. Second, we didn't use computerized tomography scan as reference for the diagnosis of pneumonia (and as a tie breaker for discordant results) because of its high cost and large radiation exposure.

Conclusions: Despite these limitations, our study has shown that chest US is technically feasible and is a sensitive and reliable test in the diagnosis of community acquired pneumonia in children under five years old. Besides its role in reducing exposure to ionizing radiation in growing children, it has a huge potential to promote rational use of antibiotics. Our results could serve as baseline for future studies and also highlights the potential of chest US as a first line diagnostic modality in our setting.

ACKNOWLEDGEMENTS

The authors thank radiology residents and radiology technologists who participated in the study and helped in data collection. The authors' sincere gratitude goes to all parents who gave proxy consent and children who participated in the study.

REFERENCES

1. Walker CF, Rudan I, Liu L, et al. Global burden of childhood pneumonia and diarrhea. Lancet 2013;381:1405–16.
2. Gill CJ, Young M, Schroder K, et al. Bottlenecks, barriers, and solutions: results from multicountry consultations focused on reduction of childhood pneumonia and diarrhoea deaths. Lancet 2013;381:1487–98.
3. Theodoratou E, Al-Jilaihawi S, Woodward F, et al. The effect of case management on childhood pneumonia mortality in developing countries. International Journal of Epidemiology 2010;39:i155–i171.
4. Revised WHO classification and treatment of pneumonia in children at health facilities: evidence summaries. World Health Organization 2014.
5. Seif El Dien HM, Abd ElLatif DAK. The value of bedside Lung Ultrasonography in diagnosis of neonatal pneumonia. The Egyptian Journal of Radiology and Nuclear Medicine. 2013 , 339–347.
6. S. FYGETAKI, I. Tritou, S. Stefanaki, S. Antonopoulos, E. Sfakianaki, Heraklion, GR/GR, Heraklion/GR , Pediatric chest: From x-ray to ultrasound. A pictorial review of 173 patients". European society of radiology 2014.
7. Esposito S, Papa SS, Borzani I, Pinzani R, Giannitto C, Consonni D, et al. Performance of lung ultrasonography in children with community-acquired pneumonia. Italian Journal of Pediatrics. 2014 April 17;40 (1):37.
8. Pereda M, Chavez M, Hooper-Miele C, Gilman R, Lung Ultrasound for the Diagnosis of Pneumonia in Children: A Meta-analysis. Pediatrics 2015;135(4), 714-723.
9. Ho MC, Ker CR, Hsu JH, Wu JR, Dai ZK, Chen IC. Usefulness of lung ultrasound in the diagnosis of community-acquired pneumonia in children. Pediatrics and neonatology. 2015 Feb;56(1):40-5.
10. Alkhayat AF, Value of chest ultrasound in diagnosis of community acquired pneumo nia. The Egyp tian Society of Chest Diseases and Tuberculosis 2014;63:1047-1051
11. Copetti R, CattarossiL, Ultrasound diagnosis of pneumonia in children. Radiol Med 2008;113(7):1079-80
12. Taghizadieh A, Ala A, Rahmani F, Nadi A. Diagnostic accuracy of chest x-ray and ultrasonography in detection of community acquired pneumonia; a brief report. Emergency. 2015;3(3):114-16.
13. Iorio G. Lung ultrasound in the diagnosis of pneumonia in children: proposal for a new diagnostic algorithm. Peer J 3:e1374; DOI 10.7717/peerj.1374
14. World Health Organization Pneumonia Vaccine Trial Investigators' Group: Standardization of Interpretation of Chest Radiographs for the Diagnosis of Pneumonia in Children. WHO/V&B/01.35. Geneva: World Health Organization; 2001. Available at: http://whqlibdoc.who.int/hq/2001/WHO_V&B_01.35.pdf. Accessed 11 October 2013.

15. Copetti R, Cattarossil. Ultrasound diagnosis of pneumonia in children. Radiol Med.2008;113(7):1079-80

16. Caiulo VA, Gargani L, Caiulo S, et al. Lung Ultrasound Characteristics of Community-Acquired Pneumonia in Hospitalized Children. Pediatr Pulmonol 2013;48:280–287
17. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas 1960;20:37-46.
18. Shah VP, Tunik MG, Tsung JW. Prospective evaluation of point-of-care ultrasonography for the diagnosis of pneumonia in children and young adults. JAMA Pediatric 2013;16:119-25.
19. Volpicelli G, Elbarbary M, Blaivas M, et al. International Liaison Committee on Lung Ultrasound (ILC-LUS) for International Consensus Conference on Lung Ultrasound (ICC-LUS): International evidence based recommendations for point-of-care lung ultrasound. Intensive Care Med 2012, 38:577–591.