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Original Research Article

Comparison of Ultrasound Vs Chest-Ray for Lower Respiratory Tract Infections in Children

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Abstract:

Objective: This study was designed to evaluate the efficacy of ultrasound and chest X ray among children with low respiratory tract infection.

Methodology: In this retrospective study, 100 children with lower respiratory tract infections were recruited aged 6 months to 6 years. Children diagnosed with symptoms of respiratory distress, persistent cough, prolonged fever, abnormal auscultatory findings, and acute wheezes were included. Chest X-ray of frontal view was performed in antero-posterior lie-down or posteroanterior upright view depending on the age of the patients. To avoid unnecessary radiations lateral radiographs were not performed.16 A chest X-ray was performed to report inflammatory infiltrate, pneumothorax, Interstitial infiltrates, and lung hyper expansion. Meanwhile, a sonography examination was performed to diagnose Small subpleural consolidations < 10 mm in diameter, interstitial syndrome –B7 lines

Results: The study involved 100 patients with lower respiratory tract infections, with 41% pneumonia, 36% bronchiolitis, and 23% bronchitis cases. The major symptoms included nasal discharge, respiratory distress, Bronchial breathing, fever, crackles, prolonged expiration, and decreased air entry. Chest X-rays showed consolidation and interstitial infiltrates in pneumonia cases, while chest ultrasound revealed numerous B3 and B7 lines. Lung ultrasound had more sensitivity and specificity than chest X-ray.

Conclusion: Our results concluded that chest ultrasound has better sensitivity and specificity for the diagnosis of pneumonia and bronchiolitis than a chest X-ray. Ultrasound can easily detect the small consolidations and numerous B lines than chest X-ray. Hence, chest ultrasound can be used as an alternative method for diagnosing lower respiratory tract infection.

Keywords: Lower Respiratory Tract Infection, Pneumonia, Bronchitis, Ultrasound, Chest X-ray.

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Introduction

Lower respiratory tract infections are one of the leading causes of mortality and morbidity worldwide. Children under 5 years of age are more vulnerable to these infections. [1] In Egypt, health care professionals marked lower tract infection as the second leading cause of death. [2] These infections include bronchitis, bronchiolitis, and pneumonia which cause pediatric emergency hospitalization. [3] In diagnosing a wide range of respiratory infections and imaging play a massive role in detecting and in the evaluation process. [4] However, pediatric radiology is a complex issue. A wide range of imaging modalities is used for the timely diagnosis of different diseases found in a pediatric chest. [5,6] These modalities also enable the early treatment and saving of the lives of pediatrics. Traditionally plain chest X-rays were widely used and still play a great role in the diagnosis of respiratory diseases. [7] However, this procedure has several limitations for pediatrics, especially in terms of interpretation, increased medical cost, time consumption, and unnecessary radiation exposure. [8,9] To avoid these limitations, especially radiation exposure alternative technology has to be investigated. [10] Chest ultrasonography is an appealing alternative technology that can be repeated without difficulty. [11] Furthermore, new ultrasound devices are small, easy to handle, and less costly making ultrasound testing possible. Along with these advantages, ultrasound is cheaper than other imaging modalities in less developing countries. [12] Recent publications observed that ultrasound provided promising results in the assessment of lung parenchyma and can be easily replaced by chest radiographs. [3] In the pediatric group, lower respiratory tract infections are the most common and required effective diagnostic tools. For this

purpose, this study was designed to evaluate the efficacy of ultrasound and chest X ray among children with low respiratory tract infection.

Methodology

In this retrospective study, 100 children with lower respiratory tract infections were recruited aged 6 months to 6 years during the period September 2020 to June 2021. Children diagnosed with symptoms of respiratory distress, persistent cough, prolonged fever, abnormal auscultatory findings, and acute wheezes were included. However, cases of chronic lung diseases, congenital heart disease, and hemodynamic instability were excluded. Severe cases of the neuromuscular disease were not entertained in this work. Guidelines provided by the American Academy of Pediatrics were used to define the clinical symptoms of bronchiolitis in children under 2 years. [13] Patients having fever > 38.5˚C with chest in drawing and a high respiratory rate were categorized under the category of pneumonia. [14] Meanwhile, acute bronchitis was diagnosed when cough was associated with degrees of moist rales in both lungs and wheezing without evidence of pneumonia. [15] Research was conducted after obtaining ethical approval from the research department of institute. Patient guardians were well informed about the research objectives, and procedures. Written consents were obtained from guardians and volunteer participation was encouraged. All the principles of Helsinki declarations were followed throughout the study timeframe.

Radiological assessment: Chest X-ray of frontal view was performed in antero-posterior lie-down or posteroanterior upright view depending on the age of the patients. To avoid unnecessary radiations lateral radiographs were not performed.16 A chest X-ray was performed to report inflammatory infiltrate, pneumothorax, Interstitial infiltrates, and lung hyper expansion. Meanwhile, a ultrasonography examination was performed to diagnose Small subpleural consolidations < 10 mm in diameter, Interstitial syndrome –B7 lines, and Alveolar-interstitial syndrome –B3 lines. Consolidation >10 mm diameter was also analyzed by performing a chest ultrasound. [17,18] For this purpose chest was divided into three areas including the front, back, and sides to scan.

Statistical analysis: Data were analyzed by using student software version 23.0. Student t-test and Mann Whitney test were used for continuous variables whereas qualitative variables were analyzed by using Fisher exact test or Chi-square formula. P-value was set as < 0.05 for statistical significance.

Results

In this study total of 100 patients suffering from lower respiratory tract infection were recruited. In this study, 41% cases of pneumonia, 36% of bronchiolitis, and 23% bronchitis were observed. The mean age of children was observed as 34.2 ± 11.5 months. In current work, male cases were more frequent than females. The major symptoms were nasal discharge in 97% of cases, respiratory distress (65%), Bronchial breathing (15%), fever (92%), crackles and prolonged expiration in 52% of cases, and decreased air entry in 74% was observed (Table 1).

All the patients reported cough however, the persistent cough was reported in 11% of cases. Regarding chest, x-ray current work found consolidation in 68% along with 20% interstitial infiltrates in pneumonia cases. Patients with bronchiolitis had interstitial infiltrates in 50% of cases and lung hyper-expansion in 20% of cases. In 82.5% of cases of bronchitis, normal X-ray findings were observed.

Chest ultrasound revealed numerous B3 lines and increase B7 lines (Table 2). Table 3 represents the diagnostic performance of both techniques. Lung ultrasound had more advantages over chest X-ray in terms of sensitivity and specificity.

Table 1: Demographic and clinical representation of patients

Variables	Control group (n=100)	Case group (n=100)	Fisher or Chi square test	p-value
Age in months	36.1 ± 13.4	34.2 ± 11.5	1.07	0.28
Sex			0.51	0.47
Females	47 (47%)	42 (42%)		
Males	53 (53%)	58 (58%)		
Fever	37.1 ± 0.22	38.12 ± 0.67	14.5	<0.001
C-reactive protein	2 (1 - 3)	12 (4.5 - 18)	11.1	<0.001
Heart rate	107.4 ± 12.5	123.6 ± 18.3	7.3	<0.001
Lymphocytes count	3.12 ± 1.47	4.87 ± 1.25	4.34	<0.001
Respiratory rate	27.89 ± 4.66	43.65 ± 13.8	10.8	<0.001
Neutrophils count	4.83 ± 1.23	6.35 ± 2.51	5.43	<0.001
Total leukocytes	7.45 ± 2.02	11.71 ± 2.40	13.5	<0.001

Table 2: Radiological assessment of lower tract infections

Variables	Bronchitis (n = 23)	Pneumonia (n = 41)	Bronchiolitis (n = 36)
Chest ultrasonography			
Negative lung ultrasound	18 (78%)	1 (2.5%)	3 (8%)
Consolidations > 10 mm	0 (0%)	28 (68%)	1 (3%)
Pleural effusion	0 (0%)	4 (10%)	1 (3%)
Sub-pleural consolidations	2 (8.5%)	3 (7.5%)	8 (22%)
Numerous B7 lines	3 (13%)	1 (2.5%)	9 (25%)
Numerous B3 lines	0 (0%)	4 (10%)	14 (39%)
Chest X-ray findings			
Negative chest radiography	19 (82.5%)	3 (7.5%)	8 (22%)
Consolidation, non-interstitial infiltrates	0 (0%)	28 (68%)	3 (8.5%)
Pleural effusion	0 (0%)	2 (5%)	0 (0%)
Increased interstitial markings	2 (8.5%)	8 (19.5%)	18 (50%)
Lung hyper-expansion	2 (8.5%)	0 (0%)	7 (19.5%)

Table 3: Sensitivity and specificity of Chest x-ray vs ultrasonography

Variables	Chest X-ray		Chest ultrasonography	
	Pneumonia	Bronchiolitis	Pneumonia	Bronchiolitis
Sensitivity	92.7%	77.8%	97.6%	91.7%
Specificity	95.6%	89.7%	95.9%	95.9%
Positive predictive value	84.4%	66.7%	88.9%	86.8%
Negative predictive value	98.1%	93.8%	99.1%	97.5%

Discussion

Diagnosis of lower respiratory tract infections is based on clinical symptoms however some cases required radiological assessment. Lung ultrasound has advantages in terms of low cost, less radiation exposure, and lessened emergency stay. [19] In this study, the case group reported 42% cases of consolidation, along with 31% cases of numerous B lines on lung ultrasound. However, 22% of cases of negative ultrasound were also reported in the case group. Previous studies related to lung ultrasound in the determination of lower respiratory tract infection show heterogeneity which causes hurdles in making longitudinal comparisons. A study by Buonsenso et al [20] explored 91% cases of consolidation in lower respiratory tract infected patients along with the 28% cases of pleural effusion and 72% of vertical deep artifacts. However, their study failed to differentiate between B3 and B7 lines. The pediatric study of Ellington et al [21] revealed normal ultrasound findings in 36.5% of children having lower respiratory tract infection moreover they also found 16.5% cases had large while 33% cases of small consolidation were also reported.

They did not comment on B3 line frequency. In developing countries, ultrasonography is one of the effective techniques to examine the patients due to low cost than the other imaging tools. Ultrasound can be easily learned by health care professionals and can be operated by a single operator. [22] Due to these advantages, ultrasound is an attractive option for clinical application in developing countries. [23] Comparing the chest X-ray and sonography results of this study researcher examined the frequent frequency of consolidation in both techniques. However, the sensitivity of consolidation was better in ultrasonography than in x-ray. To examine pediatric pneumonia ultrasound is widely used. Positive findings of pneumonia involved pleural effusion, lung consolidation, pleural line abnormalities, and confluent B lines.

In the past huge amounts of literature produced which highlights the role of ultrasound in pediatric pneumonia. In 98% of pediatric pneumonia, at least one area of consolidation was detected with positive X-rays. [10] Ultrasound identified 91% of consolidations on X-ray. A study by Yadav et al [24] revealed 98.02% sensitivity, 64.71% specificity, 84.62 negative predictive values, and 94.29 positive predictive values for diagnosing community-acquired pneumonia. In a study by Ellington et al., [21] a total of 79% of pneumonia showed normal ultrasound findings.

Contrastingly, the study by Biagi et al [25] observed positive findings in 98% of cases of parenchymal consolidation consistent with pneumonia in a chest x-ray. In the current research chest, X-rays had 96% sensitivity and 87.1% specificity in diagnosing bronchiolitis in children affected by concurrent bacterial pneumonia. In these cases, the negative predictive value was observed at 98.2% while the positive predictive value was observed at 75%. However, ultrasonography had 83.9% specificity, 100% sensitivity, and 100% negative predictive value. Interestingly positive predictive value of ultrasonography was less than chest X-ray (71.4%

vs 75%) in current research. Comparing the results with international literature we found that Berce et al [26]., diagnosed 76.7% of cases of pneumonia on chest X ray while multiple consolidation and bilateral consolidations were detected on ultrasound (40.8% vs 20.8%).

Similar results were found in a study by Bloise et al [27] in which bilateral and multiple consolidations were detected on chest X ray.

However, this study confirms that ultrasonography is better able to diagnose community-acquired pneumonia in 97% of cases with 97% sensitivity and 96% specificity. One of the systematic reviews also observed the better outcomes of ultrasonography in diagnosing pneumonia. [28] During the Covid, pandemic ultrasonography was used to diagnose pneumonia cases worldwide. [29,30] In the current study bronchiolitis and interstitial infiltrate were the major findings of chest X ray while B lines were the major findings of ultrasonography.

Conclusion

Our results concluded that chest ultrasound has better sensitivity and specificity for the diagnosis of pneumonia and bronchiolitis than a chest X-ray. Ultrasound can easily detect the small consolidations and numerous B lines than chest X-ray. Hence, chest ultrasound can be used as an alternative method for diagnosing lower respiratory tract infection.

References

1. Korsun, N., Angelova, S., Trifonova, I., Georgieva, I., Voleva, S., Tzotcheva, I., Mileva, S., Ivanov, I., Tcherveniakova, T. and Perenovska, P. Viral Pathogens Associated with Acute Lower Respiratory Tract Infections in Children Younger than 5 Years of Age in Bulgaria. Brazilian Journal of Microbiology. 2019; 50:117-125.
2. GBD 2017 Child and Adolescent Health Collaborators. Diseases, Injuries, and Risk Factors in Child and Adolescent Health, 1990 to 2017: Findings from the Global Burden of Diseases, Injuries, and Risk Factors 2017 Study. JAMA Pediatrics. 2019; 173: e190337.
3. Poutanen, R., Virta, T., Heikkilä, P., Pauniaho, S. L., Csonka, P., Korppi, M., Renko, M. and Palmu, S. National Current Care Guidelines for Paediatric Lower Respiratory Tract Infections Reduced the Use of Chest Radiographs but Local Variations Were Observed. Acta Paediatrica. 2021; 110: 1594-1600.
4. Dong, D., Tang, Z., Wang, S., Hui, H., Gong, L., Lu, Y., Xue, Z., Liao, H., Chen, F., Yang, F., Jin, R., Wang, K., Liu, Z., Wei, J., Mu, W., Zhang, H., Jiang, J., Tian, J. and Li, H. The Role of Imaging in the Detection and Management of COVID-19: A Review. IEEE Reviews in Biomedical Engineering. 2021; 14: 16-29.
5. Lovrenski, J. Pediatric Lung Ultrasound—Pros and Potentials. Pediatric Radiology. 2020; 50: 306-313.
6. Kermany, D.S., Goldbaum, M., Cai, W., Valentim, C., Liang, H., Baxter, S.L., McKeown, A., Yang, G., Wu, X., Yan, F., Dong, J., Prasadha, M.K., Pei, J., Ting, M., Zhu, J., Li, C., Hewett, S., Dong, J., Ziyar, I., Shi, A., et al. Identifying Medical Diagnoses and Treatable Diseases by Image-Based Deep Learning. Cell. 2018; 172: 1122-1131.
7. Karimi, E. Comparing Sensitivity of Ultrasonography and Plain Chest Radiography in Detection of Pneumonia: A Diagnostic Value Study. Archives of Academic Emergency Medicine. 2019; 7: e8.
8. Jaworska, J., Komorowska-Piotrowska, A., Pomiecko, A., Wisniewski, J., Wozniak, M., Littwin, B., Kryger, M., Kwasniewicz, P., Szczyrski, J., Kulińska-Szukalska, K., Buda, N., Doniec, Z. and Kosiak, W. Consensus on the Application of Lung Ultrasound in Pneumonia and Bronchiolitis in Children. Diagnostics. 2020; 10: Article ID: 935.
9. Jaszczolt, S., Polewczyk, T., Dolega-Kozierowska, M., Wozniak, M. and Doniec, Z. Comparison of Lung Ultrasound and Chest X-Ray Findings in Children with Bronchiolitis. Journal of Ultrasonography. 2018; 18: 193-197.
10. Claes, A.S., Clapuyt, P., Menten, R., Michoux, N. and Dumitriu, D. Performance of Chest Ultrasound in Pediatric Pneumonia. European Journal of Radiology. 2017; 88: 82-87.
11. Karkar, A.M., Zannoun, M.A., Eldeek, A.M.F. and Sakr, M.M.A. 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. 2021; 3: 938-945.
12. Heuvelings, C.C., Bélard, S., Familusi, M.A., Spijker, R., Grobusch, M.P. and Zar, H.J. Chest Ultrasound for the Diagnosis of Paediatric Pulmonary Diseases: A Systematic Review and Meta-Analysis of Diagnostic Test Accuracy. British Medical Bulletin. 2019; 129: 35-51.
13. Ralston, S.L., Lieberthal, A.S., Meissner, H.C., Alverson, B.K., Baley, J.E., Gadomski, A.M., Johnson, D.W., Light, M.J., Maraqa, N.F., Mendonca, E.A., Phelan, K.J., Zorc, J.J., Stanko-Lopp, D., Brown, M.A., Nathanson, I., Rosenblum, E., Sayles, S., Hernandez-Cancio, S. and American Academy of Pediatrics. Clinical Practice Guideline: The Diagnosis, Management, and Prevention of Bronchiolitis. Pediatrics. 2014; 134: e1474-e1502.

14. Harris, M., Clark, J., Coote, N., Fletcher, P., Harnden, A., McKean, M., Thomson, A. and British Thoracic Society Standards of Care Committee. British Thoracic Society Guidelines for the Management of Community Acquired Pneumonia in Children: Update 2011. Thorax. 2011; 66: ii1-ii23.
15. Kinkade, S. and Long, N.A. Acute Bronchitis. American Family Physician. 2016; 94: 560-565.
16. Zar, H.J., Moore, D.P., Andronikou, S., Argent, A.C., Avenant, T., Cohen, C., Green, R.J., Itzikowitz, G., Jeena, P., Masekela, R., Nicol, M.P., Pillay, A., Reubenson, G. and Madhi, S.A. Diagnosis and Management of Community-Acquired Pneumonia in Children: South African Thoracic Society Guidelines. African Journal of Thoracic and Critical Care Medicine. 2020; 26: 98-116.
17. Basile, V., Di Mauro, A., Scalini, E., Comes, P., Lofù, I., Mostert, M., Tafuri, S. and Manzionna, M.M. Lung Ultrasound: A Useful Tool in Diagnosis and Management of Bronchiolitis. BMC Pediatrics. 2015; 15: Article No. 63.
18. Elkhazragy, E.S.E., Fahmy, S.A.H., Attaya, M.S.M. and Elrahman, A.M.A. Chest Ultrasound versus Chest X-Ray in Children with Respiratory Tract Infections. of Pediatrics, 1 Lower Open Journal. 2021; 1: 597-607.
19. Allinovi, M., Parise, A., Giacalone, M., Amerio, A., Delsante, M., Odone, A., Franci, A., Gigliotti, F., Amadasi, S., Delmonte, D., Parri, N. and Mangia, A. Lung Ultrasound May Support Diagnosis and Monitoring of COVID-19 Pneumonia. Ultrasound in Medicine & Biology. 2020; 46: 2908-2917.
20. Buonsenso, D., Musolino, A., Ferro, V., De Rose, C., Morello, R., Ventola, C., Liotti, F.M., De Sanctis, R., Chiaretti, A., Biasucci, D.G., Spanu, T., Sanguinetti, M. and Valentini, P. Role of Lung Ultrasound for the Etiological Diagnosis of Acute Lower Respiratory Tract Infection (ALRTI) in Children: A Prospective Study. Journal of Ultrasound. 2021: 1-13.
21. Ellington, L.E., Gilman, R.H., Chavez, M.A., Pervaiz, F., Marin-Concha, J., Compen-Chang, P., Riedel, S., Rodriguez, S.J., Gaydos, C., Hardick, J., Tielsch, J.M., Steinhoff, M., Benson, J., May, E.A., Figueroa-Quintanilla, D., Checkley, W. and Lung Ultrasound for Pneumonia Assessment (LUPA) Study Investigators. Lung Ultrasound as a Diagnostic Tool for Radiographically-Confirmed Pneumonia in Low Resource Settings. Respiratory Medicine. 2017; 128: 57-64.
22. Buonsenso, D. and De Rose, C. (2021) Implementation of Lung Ultrasound in Low- to Middle-Income Countries: A New Challenge Global Health? European Journal of Pediatrics. 2021: 1-8.
23. Stewart, K.A., Navarro, S.M., Kambala, S., Tan, G., Poondla, R., Lederman, S., Barbour, K. and Lavy, C. Trends in Ultrasound Use in Low and Middle Income Countries: A Systematic Review. International Journal of MCH and AIDS. 2020; 9: 103-120.
24. Yadav, K.K., Awasthi, S. and Parihar, A. Lung Ultrasound Is Comparable with Chest Roentgenogram for Diagnosis of Community-Acquired Pneumonia in Hospitalised Children. The Indian Journal of Pediatrics. 2017; 84: 499-504.
25. Biagi, C., Pierantoni, L., Baldazzi, M., Greco, L., Dormi, A., Dondi, A., Faldella, G. and Lanari, M. Lung Ultrasound for the Diagnosis of Pneumonia in Children with Acute Bronchiolitis. BMC Pulmonary Medicine. 2018; 18: Article No. 191.
26. Berce, V., Tomazin, M., Gorenjak, M., Berce, T. and Lovrencic, B. The Usefulness of Lung Ultrasound for the Aetiological Diagnosis of Community-Acquired Pneumonia in Children. Scientific Reports. 2019; 9: Article No. 17957.
27. Bloise, S., La Regina, D.P., Pepino, D., Iovine, E., Laudisa, M., Di Mattia, G., Nicolai, A., Nenna, R., Petrarca, L., Mancino, E., Frassanito, A. and Midulla, F. Lung Ultrasound Compared to Chest X-Ray for the Diagnosis of CAP in Children. Pediatrics International. 2021; 63:448-453.
28. Pereda, M.A., Chavez, M.A., Hooper-Miele, C.C., Gilman, R.H., Steinhoff, M.C., Ellington, L.E., Gross, M., Price, C., Tielsch, J.M. and Checkley, W. (2015) Lung Ultrasound for the Diagnosis of Pneumonia in Children: A Meta-Analysis. Pediatrics. 2015; 135: 714-722.
29. Volpicelli, G. and Gargani, L. Sonographic Signs and Patterns of COVID-19 Pneumonia. The Ultrasound Journal. 2020; 12: Article No. 22.
30. Buonsenso, D., Parri, N., De Rose, C., Valentini, P. and Gemelli-Pediatric COVID-19 Team toward a Clinically Based Classification of Disease Severity for Paediatric COVID-19. The Lancet: Infectious Diseases. 2021; 21: 22.