Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 32s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Diagnostic Value of Chest Ultrasound in Detecting Complicating Pneumonia in Comparison to CT scan

Dr. Yasser Farouk Abdel-Rahem Rezk[1], Prof. Fatma Abdel-Fatah Ali Hassan[2], Dr. Sahar Farghly Youssif[3], Dhekra Ashour Aboud Salem[4], Dr. Mohamed Gamil M. Aboelela[5]

[1]Ass. Professor of Pediatrics, Faculty of Medicine Assiut University, Egypt.

[2]Professor of Pediatrics, Faculty of Medicine Assiut University, Egypt

[3]Ass. Professor of Chest Diseases and Tuberculosis, Faculty of Medicine Assiut University, Egypt

[4]M.S.C of Pediatrics, Faculty of Medicine, Aden University, Republic of Yemen

[5]Ass. Professor of Pediatrics, Faculty of Medicine Assiut University, Egypt

Cite this paper as: Dr. Yasser Farouk Abdel-Rahem Rezk, Prof. Fatma Abdel-Fatah Ali Hassan, Dr. Sahar Farghly Youssif, Dhekra Ashour Aboud Salem, Dr. Mohamed Gamil M. Aboelela, (2025) Diagnostic Value of Chest Ultrasound in Detecting Complicating Pneumonia in Comparison to CT scan. *Journal of Neonatal Surgery*, 14 (32s), 6941-6949.

ABSTRACT

Introduction: Lung diseases are the most prevalent condition in pediatric medicine. While chest X-rays are typically the initial imaging method used to assess chest diseases, thoracic computed tomography (CT) is regarded as the gold standard for diagnosing and monitoring chest opacities and masses. Chest ultrasound, on the other hand, offers a valuable complementary diagnostic tool. It is widely available, quick, free of radiation, repeatable, and cost-effective, making it highly accurate for detecting chest lesions.

Objective: To assess the accuracy of chest ultrasound for diagnosis of complicated pneumonia among kids in comparison to the gold standard (chest CT scan).

Methods: This observational, cross-sectional investigation has been conducted in Assiut University Children's Hospital. This study included 114 patients with symptoms and signs of complicated pneumonia who admitted in ER & pulmonology unit during the period from 1st of January 2021 to thirty-one of August 2022 but others who diagnosed with Acute simple pneumonia were excluded.

Results: It was found that LUS had 99%, 88.6%, 91% and 99.2% overall accuracy for diagnosis of pleural effusion, lung abscess, cavitary lesions and necrotizing pneumonia respectively. LUS is able to detect additional findings which couldn't be detected by chest CT, in form of complex septated effusion, empyema and complex non septated in 21 (36.2%) ,10 (17.2%) and 8(13.8%) patients respectively.

Conclusion: The application of ultrasound has proven useful in diagnosis of complication of pneumonia in children with the significant advantage of not utilizing ionizing radiation.

Keywords: *chest ultrasound, thoracic computed tomography, pneumonia*

1. INTRODUCTION

Lung diseases are among the most common conditions in pediatric patients [1]. While chest X-rays are typically the first-line imaging tool for evaluating chest diseases and identifying pulmonary opacities [2], they have limitations in accurately determining the location and nature of areas of raised opacity [3]. Therefore, thoracic computed tomography (CT) is considered the diagnostic gold standard for following up opacities and masses detected by pediatric chest X-rays [4]. However, CT is not recommended as the first-line evaluation due to the high radiation exposure, with each scan delivering an effective dose of approximately eight mSv, equivalent to 400 chest X-rays [5].

Chest ultrasound (sonography) is the preferred initial investigation for assessing diaphragmatic, pleural, and chest wall lesions in pediatric patients, owing to the minimal superficial adipose tissue in children [6]. Despite being undervalued for lung lesions for many years, due to concerns that ribs, the sternum, and aerated lungs would obstruct ultrasound waves [7], chest sonography has since proven to be a valuable complementary diagnostic tool. It offers several advantages, including ease of use, speed, lack of radiation, repeatability, and low cost, while providing high diagnostic accuracy for detecting pediatric chest lesions [4,7].

Aim of the work:

To evaluate the accuracy of chest ultrasound for diagnosis of lung opacities in complicated pneumonia (lung abscess, parapneumonic effusion, empyema and necrotizing pneumonia) in comparison to the gold standard (chest CT scan) among children.

1. Patient and methods:

This observational, cross-sectional investigation has performed out in Assiut University Children's Hospital. This study included 114 patients with respiratory diseases who admitted in ER & pulmonology unit during the period from first of January 2021 to thirty-one of August 2022.

a. *Inclusion criteria*:

Age more than 28 days up to 18 years.

Patients admitted in ER &chest wards, with symptoms and signs of complicated pneumonia.

Chest X ray opacity on recent admission.

b. *Exclusion criteria*:

Neonates

Patients admitted in ER & pulmonary unit, diagnosed as acute simple pneumonia.

***Each patient was subjected to the following*:**

History and Clinical presentation in the form of; Cough pattern, Fever (pattern & duration), and not responding to 48 h treatment with intravenous antibiotics.

On examination, there were respiratory distress, oxygen saturation, dullness to percussion over the affected area, decreased air entry by auscultation: crepitation &/or wheezing were heard.

Lab investigation in the form of complete blood count, WBCs total and differential, BUN, creatinine, C-reactive protein and erythrocyte sedimentation rate.

- Radiological study in the form of**:**

1- *Chest Xray*: were done for all patients.

2-*Chest ultrasound*:

It was performed in pulmonary ward at Assiut University Children's Hospital by LOGIQ E9 machine, using curvilinear probe (3-5 MHz) and linear probes (8-12 MHz) for all patients with complicated pneumonia and chest x ray opacity. The patient was examined in supine position with completely exposed chest area through six zone scan.

3-*Chest CT scan*: Done after patient admission.

2. STATISTICAL ANALYSIS

Data was gathered and processed utilizing SPSS (Statistical Package for the Social Sciences, version 20, IBM, Armonk, New York). The Shapiro test has been utilized to assess the data's compliance to a normal distribution. Quantitative data exhibiting a normal distribution are represented as mean ± standard deviation (SD). Nominal data are presented as numerical values (n) and percentages (%). Accuracy of LUS and chest X-ray has been assessed with receiver operator characteristics (ROC) curve. The confidence level was maintained at ninety-five percent; hence a P value was deemed significant if it was less than 0.05.

Ethical committee:

Approval from the Ethics of Scientific Research Committee, Faculty of Medicine Assiut University was obtained.

Verbal and written consents were obtained from all the caregivers of the patients.

Privacy and confidentiality of all obtained information was observed without intervention in the prescribed treatment.

IRB NUM: 17200458

3. RESULTS

Regarding the Clinical presentation among the studied patients (n= 114) as shown in table [1]:

Most of 112 (98.2%) of cases had fever while flu-like symptoms in 84 (73.7%)

Respiratory distress (RD) manifestation occurred in 76 (66.7%) patients where mild in 52 (45.6%), moderate in 22 (19.3%) and severe was found in 2 (1.8%) patients.

Based on clinical examination; decreased air entry, crepitation and wheezing were found in 77 (67.5%), 97 (85.1%) and 2 (1.8%) patients, respectively.

Regarding the diagnosis based on plain chest radiograph among the studied patients (n= 114) as shown in figure [1]:

The most frequent diagnosis based on plain chest radiograph was consolidation with parapneumonic effusion 67(58.5%) followed by consolidation only 20 (17.5%). Cavitary lesions were detected in 14 (12.3%) and 13 (11.4%) patients had lung opacity.

Regarding the Final diagnosis among the studied patients based on CT chest (n= 114) as shown in figure [2]:

Based on CT chest, the most frequent diagnoses were pleural effusion 59(51.8%) and abscess 30 (26.3%). 11(9.7%) patients had cavitary lesions and 9 (7.9%) patients had necrotizing pneumonia, 5(4.4%) patients had encysted pleural effusion.

Regarding the accuracy of LUS and x-ray in prediction of pleural effusion in the studied patients in comparison to chest CT scan as shown in figure [3]:

It was found that LUS has 99% overall accuracy for diagnosis of pleural effusion with area under curve was 0.99. Meanwhile, chest radiograph has 84.5% overall accuracy for diagnosis of pleural effusion with area under curve was 0.84.

Regarding the accuracy of LUS and x-ray in prediction of cavitary lesions in the studied patients in comparison to chest CT scan as shown in figure [4]:

It was found that LUS has 91% overall accuracy for diagnosis of cavitary lesions with area under curve was 0.87. Meanwhile, chest radiograph has 81.2% overall accuracy for diagnosis of cavitary lesions with area under curve was 0.53.

Regarding the accuracy of LUS in detection of lung abscess, encysted effusion and necrotizing pneumonia in comparison to chest CT scan as shown in figure [5]:

It was found that LUS has 88.6% overall accuracy for diagnosis of lung abscess with area under curve was 0.82. For detection of necrotizing pneumonia and encysted effusion, LUS had 99.2% overall accuracy with area under curve was 0.99.

Regarding the added findings with LUS that aren't detected with chest CT as shown in table [2]:

From 58 cases diagnosed as parapneumonic effusion by both LUS and chest CT scan, LUS is able to detect additional findings in form of complex septated effusion in 13(22.4%) patients, empyema in 10 (17.2%) patients and complex non septated effusion 8 (13.8%). These findings couldn't be detected by chest CT.

4. DISCUSSION

Published research mostly compares lung ultrasound (LUS) with chest X-ray (CXR) for pneumonia diagnosis, lacking evidence on its effectiveness in diagnosing severe pneumonia. So, the current study tried to fill this gap and evaluate accuracy of chest ultrasound for diagnosis of complicated pneumonia among kids.

A total of 114 kids having complicated pneumonia have been enrolled in the study. Mean age of the studied cases was 5.96 years old with range between 11 months and 15 years. Out of the examined cases; 68 (59.6%) cases were men and 46 (40.4%) cases were women.

The latest investigation revealed a mean symptom period of 11.11 days, with a range of one to thirty days. The majority of cases, 112 (98.2%), had fever, whereas flu-like symptoms were observed in 84 (73.7%) cases, and cyanosis was evident in 4 (3.5%) cases. Respiratory distress was seen in 76 (66.7%) cases, categorized as mild in 52 (45.6%), moderate in 22 (19.3%), and severe in 2 (1.8%) cases. The diagnosis of pneumonia, previously determined via physical examination, history-taking, and particular auscultation results, has increasingly depended on imaging techniques [8].

langely et al (2008) did a retrospective analysis of medical records illustrated that kids younger than five years comprised 143 (57%) of the 251 kids had complicated pneumonia [9].

In this study had been used the CT of chest as gold standard for diagnosis of complicated pneumonia. The most frequent diagnoses were pleural effusion59 (51.8%) and abscess30 (26.3%). 11(9.7%) patients had cavitary lesions and 9 (7.9%) patients had necrotizing pneumonia. 5(4.4%) patients had encysted pleural effusion.

Our result agreement with the study of Ionescu et al (2022) who enrolled 45 children with pneumonia. Several complications diagnosed by LUS, including: empyema (15.6 percent), encapsulated pleurisy (11.1 percent), lung abscess (6.7 percent) and necrotizing pneumonia (2.2 percent) [10].

In this study LUS had 98.3% and 100% sensitivity and specificity respectively, and CXR with 92%and 76.4% sensitivity and specificity respectively in comparison to chest CT for diagnosis of pleural effusion, and LUS has 99% overall accuracy for diagnosis of pleural effusion with area under curve was 0.99. Meanwhile, CXR has 84.5% overall accuracy for diagnosis of pleural effusion with area under curve was 0.84.

In agreement with Bloise et al. (2023), who stated that lung ultrasonography had a sensitivity and specificity approaching 100% in diagnosing pleural effusion, surpassing the accuracy of chest X-ray (11), also Ahmed et al (2017) US demonstrated significant detection of pleural effusion in 84 (100%) of cases, which is greater than that for CXR at 80 (95.2%) [12]. From our study and previous studies represent the lung ultrasound appears to be a superior modality to rule in a pleural effusion when compared with chest CT and CXR.

In current study we found 6 (5.3%), diagnosed as encysted effusion, by LUS with sensitivity 100%, specificity 99.1%, and accuracy 99.1% in comparison to chest CT scan, and chest X ray failed to identify any cases.

In agreement with Rao et al. (2019), studied 60 pleural effusion cases, represents both LUS and chest CT scan shown equal number of encysted effusions 17 (28.3%) [13].

Contrary to these findings, Abu-Youssef et al. (2014) showed that ultrasound (US) was superior to computed tomography in identifying encysted effusion, successfully detecting 11/11 , whereas CT identified just 4/11cases. This may be due to their characterization of encysted effusion, since they classified all fluid with septations observed on ultrasound as encysted effusion [14]. Also Ahmed et al. (2017), found a statistically significant difference between chest CT scans and chest ultrasounds in the diagnosis of encysted effusion, with CT identifying 28 cases (100%) and ultrasound identifying 17 cases (60.7%) [12].

In current study, we found 24 (21.1%) by LUS has 88.6% accuracy ,69% sensitivity and 95.3% specificity in diagnosis of lung abscess in comparison to chest CT scan that detect 30 (26.3%), CXR failed to detected any cases of such diagnoses, but the CXR found 13(11.4%) opacity, and 20(17.5%) consolidation in comparable to such findings, a previous study concluded that LUS had 100% accuracy for diagnosis of lung abscess Table 3,4,5

Our findings agree with those of El-Sheikh et al. (2014) research including 52 ICU cases suspected of having severe pneumonia, based on clinical examination and chest radiography, indicated that LUS was almost comparable to chest CT in diagnosing pulmonary consolidation, necrosis, and abscess. Lung abscess was detected in three cases via ultrasound, but confirmed in two cases through computed tomography; the third case had pyopneumothorax on CT [15].

The current study represent that LUS is superior to chest CT in detecting the internal echogenicity of pleural effusion. The chest ultrasound identified four sonographic patterns of internal echogenicity in pleural effusion: anechoic in 27(46.5%), complex septate in 13(22.4%), complex non-septate in 8(13.8%), and homogeneous echogenic in 10 (17.2%)

Consistent with El-Sayed et al. (2022), research shown that chest ultrasonography was superior to CT chest in identifying septation and loculation in 23.3% of cases, whereas diaphragmatic pleural nodules were seen in 80% of cases. These outcomes were identified via ultrasonography in accordance with the operational results, although were not observed by chest CT in any of the them [16].

The findings of the current study agree with those of Khalil et al. (2014), who demonstrated that chest ultrasonography was superior to chest CT in cases including fibrin strands and multiloculation. Seventeen (70.8%) demonstrated fibrous septation and multiloculation, whereas seven (29.1%) demonstrated few fibrin strands. Lung ultrasound (LUS) failed to detect fibrous septation and multiloculation in one patient in comparison with the surgical findings, attributable to morbid obesity that compromised the quality of the image. The results were not demonstrated in the chest CT [17].

The findings of the current investigation indicated that ultrasound (U/S) is superior to chest CT in detecting the internal echogenicity of pleural effusion. Chest ultrasound identified four sonographic patterns of pleural effusion internal echogenicity: anechoic in 27 cases (46.5%), complex septate in 13 cases (22.4%), complex non-septate in 8 cases (13.8%), and homogeneous echogenic in 10 cases (17.2%).

Khalil et al. (2014) demonstrated that pleural effusion was anechoic in 32.7%, complex non-septated in 13.5%, complex septated in 46.1%, and homogeneously echogenic in 7.7%. A uniformly echogenic pattern was seen in hemorrhagic effusion (17). Yang et al. (2014) identified four fundamental sonographic patterns of internal echogenicity: 53.7% were anechoic, 15.6% were complex non-septated, 23.7% were complex septated, and 6.8% were homogeneously echogenic (18). Kearney et al. (2016) indicated that ultrasonography revealed nineteen percent of pleural collections as anechoic, fourteen percent as hyperechoic without septae, and sixty-seven percent as hyperechoic with septae (19).

In the comparison of CT and LUS for the visualization of septations in pleural effusions, we agree with Trinavarat et al. (2014), who delineate the markedly superior efficacy of LUS (62.5% on LUS versus 20.8% on CT), particularly significant prior to determining the necessity and placement of a pleural drain. In some cases, the CT scan can be helpful in determining whether air-containing lesions are indicative of a pneumatocele or a loculated hydro-pneumothorax (20).

Lung ultrasound has introduced promising opportunities for treating, diagnosing, following up , and prognosticating multiple causes and disease presentations; however, it is crucial for operators to recognize both the inherent limitations of the technique and their own limitations in interpreting scans [21].

Ultrasound has demonstrated efficacy in several kids' diseases, including parapneumonic effusion, empyema, lung abscess,

and necrotizing pneumonia. with the significant advantage of not utilizing ionizing radiation. It is a focused assessment conducted and analyzed at the patient's bedside, permitting real-time enrichment and completion of the objective evaluation [22].

The application of this method for diagnostic and therapeutic reasons may enhance pediatric emergency care by establishing rapid identification of time-sensitive critical conditions, identifying children requiring comprehensive assessment, and reducing delays in treatment and procedural complications [22].

5. CONCLUSION

Ultrasound has proven to be an effective tool in diagnosing complications of pneumonia in children, offering the significant benefit of avoiding ionizing radiation. This focused examination is performed and interpreted at the patient's bedside, providing real-time insights and enhancing the overall physical assessment.

6. RECOMMENDATIONS

The primary use of LUS for diagnosis of the complicated pneumonia than the chest X ray, because the high sensitivity and specificity.

Superiority to use LUS in detection of septations in pleural effusions vs chest CT scan.

Priority to use LUS in detect the echogenicity of effusions to avoid unnecessary exposure to ionizing radiation and determine the type of intervention either VATS or chest tube.

7. LIST OF TABLES AND FIGURES

Table (1): Clinical presentation among the studied patients

	N= 114
Duration (days)	11.11 ± 8.60
Range	1-30
Fever	112 (98.2%)
Flu like symptoms	84 (73.7%)
Cyanosis	4 (3.5%)
Respiratory distress manifestation	76 (66.7%)
Mild	52 (45.6%)
Moderate	22 (19.3%)
Severe	2 (1.8%)
Decreased air entry	77 (67.5%)
Crepitation	97 (85.1%)
Wheezing	2 (1.8%)
Pulse O_2 saturation (%)	95.36 ± 1.59

Data expressed as frequency (percentage), mean (SD), range.

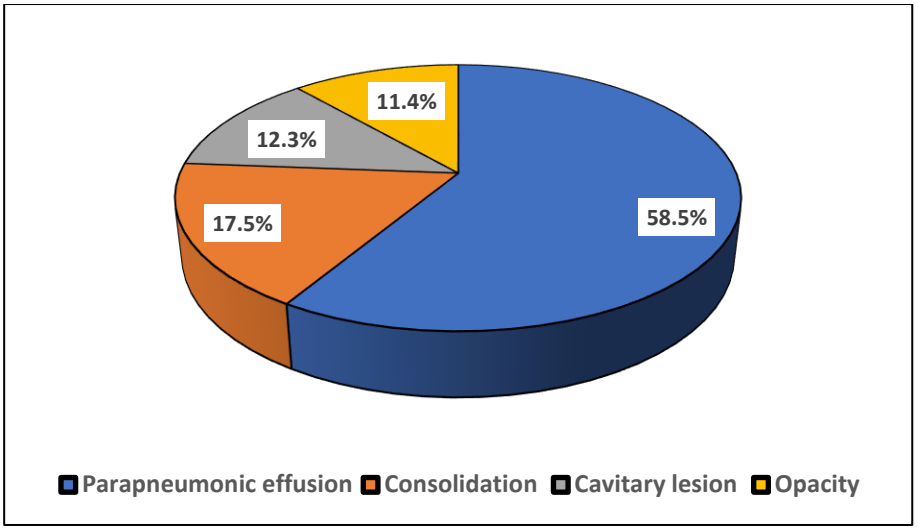

Figure [1]: Diagnosis based on plain chest radiograph among the studied patients

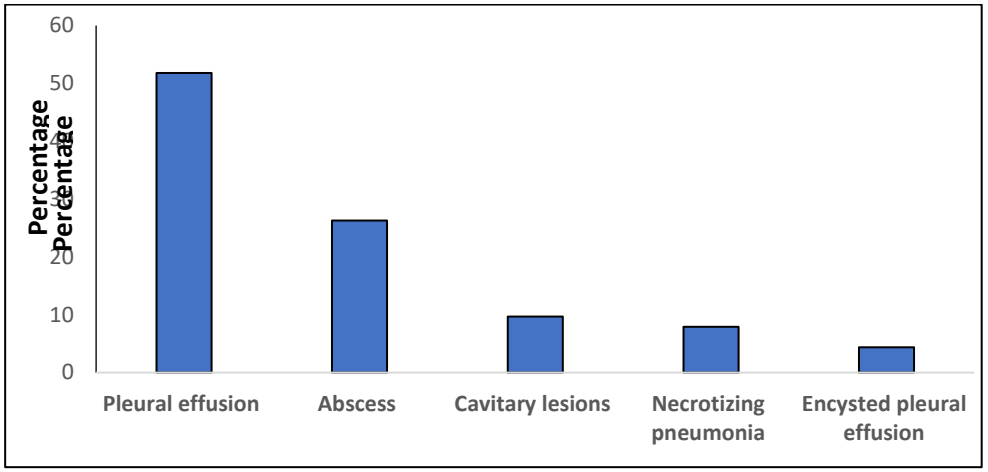

Figure [2]: Diagnosis of studied patients based on computed tomography

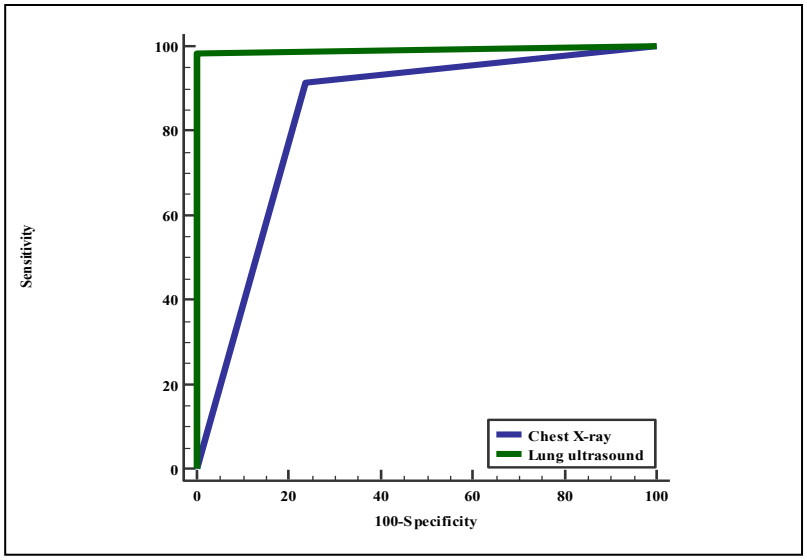

Figure (3): Accuracy of LUS and x-ray in prediction of pleural effusion

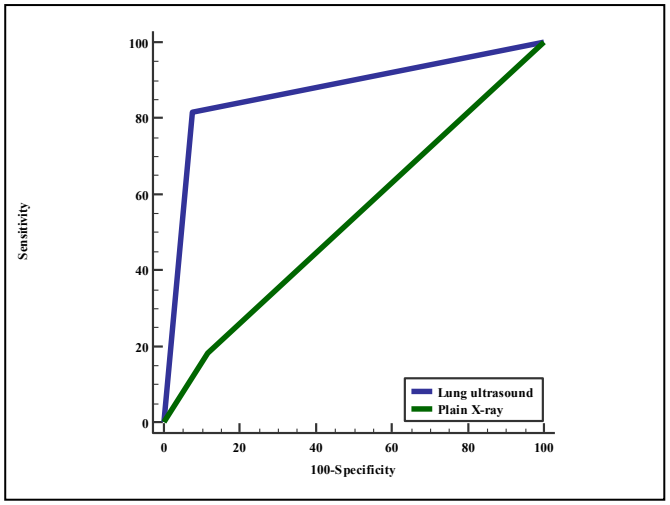

Figure (4): Accuracy of LUS and x-ray in prediction of cavitary lesions

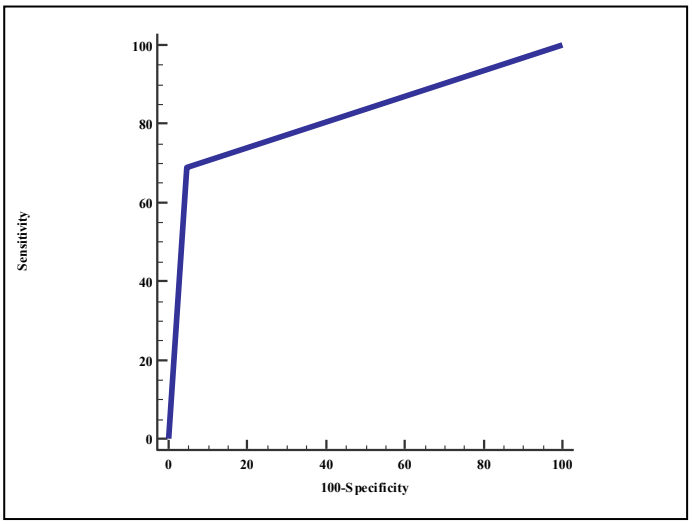

Figure (5): Accuracy of LUS in detection of lung abscess

Table (2): Added findings with LUS that aren't detected with chest CT

Findings	N= 58
Complex septated effusion	13(22.4%)
Empyema	10 (17.2%)
Complex non septated effusion	8 (13.8%)

Data expressed as frequency (percentage).

Table (3): Accuracy of LUS in detection of lung abscess, encysted effusion and necrotizing pneumonia in comparison to chest CT scan

	Lung abscess	Encysted effusion	Necrotizing pneumonia
Sensitivity	69%	100%	100%
Specificity	95.3%	99.1%	99.1%
Positive predictive value	83.3%	83.3%	88.9%

Negative predictive value	90%	100%	100%
Accuracy	88.6%	99.1%	99.2%
Area under curve	0.82	0.99	0.99
P value	< 0.001	< 0.001	< 0.001

P value was significant if < 0.05. LUS: lung ultrasound

Table (4): Diagnosis based on LUS among the studied patients

	n= 114
Parapneumonic effusion	58 (50.9%)
Abscess	24 (21.1%)
Cavitary lesion	17 (14.9%)
Necrotizing pneumonia	9 (7.9%)
Encysted pleural effusion	6 (5.3%)

Data expressed as frequency (percentage). LUS: lung ultrasound

Table (5): Final diagnosis among the studied patients based on CT chest

	n= 114
Pleural effusion	59 (51.8%)
Abscess	30 (26.3%)
Cavitary lesions	11 (9.7%)
Necrotizing pneumonia	9 (7.9%)
Encysted pleural effusion	5 (4.4%)

Data expressed as frequency (percentage). CT: computed tomography

Table (6): Diagnosis based on plain chest radiograph among the studied patients

	n= 114
Parapneumonic effusion	67 (58.5%)
Consolidation	20 (17.5%)
Cavitary lesion	14 (12.3%)
Opacity	13 (11.4%)

Data expressed as frequency (percentage).

REFERENCES

[1] Chen S, Zhang M, Liu J. (2015). Application of lung ultrasonography in the diagnosis of childhood lung diseases. Chinese medical journal.;128 (19):2672-2678.

[2] Kim O, Kim W, Kim M, Jung J, Suh J. (2000). US in the Diagnosis of Pediatric Chest Diseases. RadioGraphics.;20(3):653-671.

[3] Barillari A, De Franco F. and Colonna F. (2011). Chest Ultrasound Helps to Diagnose Pulmonary Consolidations in Pediatric Patients. Journal of Medical Ultrasound;19(1):27-31.

[4] Lameh, A., Seyedi, S., Farrokh, D., Lavasani, S. and Alamdaran, S. (2019). Diagnostic Value of Ultrasound in Detecting Causes of Pediatric Chest X-Ray Opacity. Turkish Thoracic Journal;20(3):175-181.

[5] Prithviraj D. (2014). Chest Ultrasonography - A Quick and Accurate Diagnostic Tool in Pediatric Emergency Department and Intensive Care Unit. International Journal of Scientifi c Study.;2(2):59-69.

[6] Goh Y, Kapur J. (2016). Sonography of the Pediatric Chest. Journal of Ultrasound in Medicine.;35(5):1067-1080.

[7] Dietrich C, Mathis G, Cui X, Ignee A, Hocke M, Hirche T. (2015). Ultrasound of the Pleurae and Lungs. Ultrasound in Medicine & Biology.;41(2):351-365.

[8] Amatya Y, Russell FM, Rijal S, Adhikari S, Nti B, House DR. (2023). Bedside lung ultrasound for the diagnosis of pneumonia in children presenting to an emergency department in a resource-limited setting. Int J Emerg Med; 16:2:1-5

[9] Langley JM, Kellner JD, Solomon N, Robinson JL, Le Saux N, McDonald J, Ulloa-Gutierrez R, Tan B, Allen U, Dobson S, Joudrey H. (2008). Empyema associated with community-acquired pneumonia: a Pediatric Investigator's Collaborative Network on Infections in Canada (PICNIC) study. BMC Infect Dis; 8:129.

[10] Ionescu MD, Balgradean M, Filip C, Taras R, Capitanescu GM, Berghea F, Berghea CE, Cirstoveanu CG (2022). The role of lung ultrasonography in predicting the clinical outcome of complicated community-acquired pneumonia in hospitalized children. Medical Ultrasonography ;24(1):19-26.

[11] Bloise S, Marcellino A, Sanseviero M, Martucci V, Testa A, Leone R, Del Giudice E, Frasacco B, Gizzone P, Ciolli CP , Ventriglia F , Lubrano R . (2023). Point-of-Care Thoracic Ultrasound in Children: New Advances in Pediatric Emergency Setting. Diagnostics (Basel) ;13(10):1765.

[12] Ahmed, E. S., Abou Bakr, S. M., Eid, H. A., Shaarawy, A. T., & Elsayed, W. T. (2017). Role of ultrasonography in the diagnosis of pleural effusion. Egyptian Journal of Bronchology; 11(2):120–127

[13] Rao DrJM, Naidu DrJ, Raju DrNK, Raju DrD. (2019). Efficacy of ultrasonography in diagnosis of pleural effusion. International Journal of Radiology and Diagnostic Imaging;2(2):28–31.

[14] Abu-Youssef H, Kamel K, Selim S, El-Deen SM. (2014). Study of the added value of transthoracic ultrasound in staging of lung cancer. Egypt J Chest Dis Tuberc; 63:1025–1034

[15] El Sheikh, H. and Abd Rabboh, M.M. (2014) 'Chest ultrasound in the evaluation of complicated pneumonia in the ICU patients: Can be viable alternative to CT?', The Egyptian Journal of Radiology and Nuclear Medicine;45(2):325–331.

[16] El-Sayed Ibrahim El-Sayed, I., Farouk Awad, N., Shawky Basiony, F., Salah El-Feshawy, M. (2022). Chest ultrasound versus chest computed tomography for assessment of undiagnosed pleural effusion before medical thoracoscopy. Al-Azhar Medical Journal; 51(4): 2143-2156.

[17] Khalil M, Diab, H.S and Hosny H (2014): Chest Ultrasonography versus CT for imaging assessment before medical thoracoscopy. Egyptian Journal of Bronchology;8: 149 -152.

[18] Yang PC, Luh KT, Chang DB, Wu HD, Yu CJ, Kuo SH. (1992). Value of sonography in determining the nature of pleural effusion: analysis of 320 cases. AJR Am J Roentgenol;159(1):29-33.

[19] Kearney SE, Davies CW, Davies RJ, Gleeson FV. (2000). Computed tomography and ultrasound in parapneumonic effusions and empyema. Clin Radiol;55(7):542-7.

[20] Trinavarat P, Riccabona M. (2014). Potential of ultrasound in the pediatric chest. Eur J Radiol;83(9):1507-1518.

[21] See KC, Ong V, Wong SH, Leanda R, Santos J, Taculod J, Phua J, et al. (2016) Lung ultrasound training: curriculum implementation and learning trajectory among respiratory therapists. Intensive Care Med;42(1):63-71.

[22] Mattei P, Julian L Allen. (2006). Treatment of empyema in children from Hippocrates' time to the present and back again. Editorial Am J Res Crit Care Med; 174:110-111