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“Diagnostic Role Of Chest Ultrasound In Children Presenting With Respiratory Distress In PICU Compared To Chest X-Ray”

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Abstract:

Background & Aim: Children who experience respiratory distress (RD) risk losing their lives. Morbidity and mortality are negatively impacted by delayed diagnosis. In emergency protocols, bedside lung ultrasonography (LUS) can be utilized as a screening technique for children with RD. As a result, less risky equipment is required, such as computed tomography (CT) scans and chest X-rays. This study compared the effectiveness of bedside lungs and portable chest X-rays in determining the cause of pediatric respiratory disease (RD).

Methods: The current study was conducted at the Pediatric Intensive Care Unit of Assiut University Children's Hospital. It was conducted during the period between March 2020 and March 2022. 150 children with acute respiratory distress were enrolled in the study. All children were subjected to lung ultrasound evaluation.

Results: The mean age of enrolled children was 3.69 ± 2.81 (years), and 76 were males (50.7%). The pediatric respiratory severity score showed moderate and severe RD in 30 (20%) and 120 (80%) children, respectively. The most frequent final diagnosis was pneumonia (92.7%), followed by pneumothorax (3.3%). Three patients had bronchial asthma, while bronchiolitis was found in only one child. Pulmonary embolism was detected in two children. Lung ultrasound had 100% accuracy in predicting pneumothorax or pulmonary embolism as a cause of respiratory distress in children. Meanwhile, lung ultrasound had a comparable accuracy in predicting pneumonia and asthma/bronchiolitis (99.3%).

Conclusion: Compared to chest X-rays, LUS enables quick and precise bedside diagnosis of acute respiratory diseases in children. It permits etiology to be determined using a pathophysiological approach. It is recommended to perform such studies on a large number of patients in multiple centres to draw a firm conclusion as regard the efficacy and applicability of lung ultrasound in such case.

Keywords: pediatric intensive care unit, radiological modalities, comparative analysis, pediatric respiratory disorders.

1. Introduction

Point-of-care ultrasound (POCUS), defined as the physician in charge's bedside ultrasound evaluation of the patient, has become more common in recent years in pediatric patients to look into pulmonary, pleural, and diaphragmatic disorders [1]. Compared to adult critical care, the use of POCUS in pediatrics is still very infrequent. Lung POCUS has high sensitivity and specificity for diagnosing pneumonia, bronchiolitis, pleural effusion, and pneumothorax, according to growing pediatric data [2]. As a result, the successful care of pneumonia significantly depends on an early and accurate diagnosis. According to studies and a meta-analysis, POCUS has high sensitivity and specificity for diagnosing pneumonia [3]. The danger of being exposed to ionizing radiation is present during computed tomography scan imaging and chest X-ray. The area of the child's body that is examined the most frequently is the chest. Data indicate that CT scans, which make up 8% of tests in the pediatric population, are frequently conducted without taking weight into account for exposure parameters, which can waste up to 50% of the dosage [4]. On the other hand, point-of-care ultrasonography is growing in importance as an essential bedside tool that enables prompt decision-making, particularly in critically sick patients, is non-invasive, and involves no radiation exposure [5]. This study evaluated the use of bedside lung ultrasonography to portable chest X-ray in order to ascertain the 'sensitivity', 'specificity', safety, and accuracy in identifying the cause of respiratory distress in children referred to the pediatric intensive care unit (PICU).

Literature Review

Pediatric patients frequently have respiratory distress, which is a significant therapeutic problem that frequently necessitates an early and precise diagnosis for care [6]. The chest X-ray is the conventional imaging technique used to evaluate these patients. But as ultrasound technology has developed and become more widely available, there is an increasing desire to assess the diagnostic value of chest ultrasound in young patients with respiratory distress [7]. This evaluation of the literature intends to investigate the available data regarding the diagnostic value of chest ultrasound in comparison to chest X-ray in this particular group.

Benefits of chest ultrasound

In the assessment of pediatric respiratory distress, chest ultrasound has a number of advantages over chest X-ray. Ionizing radiation is not present, which is one of the main advantages [8]. This is important for pediatric patients because they are more vulnerable to radiation-related dangers. Because of this, ultrasound is a safer option, particularly for ongoing monitoring and evaluation. Additionally, ultrasound can be done right at the patient's bedside, removing the need to transport patients to radiology departments and providing in-the-moment analysis [9].

Diagnostic Accuracy

The effectiveness of chest ultrasonography in identifying different respiratory problems in children has been investigated in a number of research. In comparison to chest X-ray, ultrasound exhibited a 'sensitivity' of 96% and a 'specificity' of 100% in diagnosing pneumothorax, according to a research by Copetti et al [10]. This observation is especially important because pneumothorax can be a serious condition that needs prompt attention. In a different study, Xirouchaki discovered that ultrasound was more accurate than chest X-rays at diagnosing pleural effusions, particularly in cases with complicated or loculated effusions [11].

Etiological Diagnostic

Chest ultrasonography can help determine the underlying cause of respiratory distress in addition to detecting anatomical abnormalities [12]. Ultrasound allows for the visualization

and characterization of lung consolidation, a characteristic of pneumonia. According to a study by Zhang, ultrasound may distinguish between bacterial and viral pneumonia using particular sonographic patterns [13]. This helps with proper diagnosis and provides information for focused treatment plans.

Challenges

Although chest ultrasonography has many benefits, there remain obstacles to its broad use [14]. For images to be of excellent quality and be diagnostically useful, operator skill is essential. It is crucial to educate healthcare professionals in pediatric lung ultrasonography to guarantee accuracy and consistency. Additionally, some diseases, like asthma, may not have clear sonographic signs, which restricts the use of ultrasonography in some circumstances [15].

The literature analysis highlights the promising use of chest ultrasonography in the PICU setting to identify respiratory distress in children. It is positioned as a significant tool for quick and precise diagnosis due to its safety, bedside accessibility, and dynamic imaging capabilities. However, standardized procedures, substantial training of medical staff and extensive research to define precise sonographic criteria for diverse respiratory diseases are necessary for successful deployment. Chest ultrasound, in addition to chest X-rays, has the potential to improve the accuracy of the diagnosis and general care of pediatric patients with respiratory distress.

Methodology

'Study setting & design'

The Pediatric Intensive Care Unit of the Children's Hospital of Assiut University served as the site of this prospective **cross-sectional investigation between March 2020 and March 2022**, it was completed.

Inclusion criteria: All patients with acute respiratory distress, whose ages varied from greater than one month to less than eighteen, were admitted to the PICU, whether or not they were attached to mechanical ventilation.

Exclusion criteria: Neonatal patients, patients with congenital disabilities of the respiratory tract, patients with inherited or acquired heart illnesses, and patients with post-traumatic respiratory distress were all excluded from the research.

Sample size calculation

Based on Jones et al. [16], who reported that the frequency of pneumonia among children presented with respiratory distress in children below five years was 11.9%, the minimum sample size was 108 children with the following assumptions; 80% power, 0.04 alpha error with a significant *p*-value at 0.05 level.

During the study period, 170 cases were eligible for the study. Out of those cases, 20 patients were excluded, secondary to congenital heart diseases (16 cases) and tracheoesophageal fistula (four cases). So, 150 subjects were finally recruited for the study analysis.

Methods

The evaluation process commenced with a meticulous history-taking session. This involved collecting pertinent information, such as the patients' age, gender, place of residence, and familial smoking patterns. A thorough review of their medical history was conducted, with a specific focus on any prior episodes of respiratory ailments. Notably, symptoms indicative of respiratory tract infections that manifested before hospitalization were carefully documented. These symptoms encompassed the timing and duration of coughing, fever, difficulty breathing,

rapid breathing, wheezing, bluish discoloration, and nasal discharge. Concurrently, the patients' nutritional intake, hydration status, and urine output were also assessed. Subsequently, a comprehensive physical examination was carried out. This encompassed measurements related to the patients' physical dimensions, vital signs, and oxygen saturation levels. All the recorded data were comprehensive and accurate. A systemic examination was performed, encompassing thorough assessments of the chest, heart, and abdomen. Particular attention was given to a detailed chest examination, which played a pivotal role in the standardized clinical assessment. To gauge the severity of pediatric respiratory conditions, the study employed the Pediatric Respiratory Severity (PRESS) score, as outlined in reference [17]. Laboratory investigations formed another crucial aspect of the study. These investigations included a complete blood count with a differential count, along with measurements of C-reactive protein (CRP) levels. The acquisition of cultures, whether from blood samples or endotracheal aspirations, was a pivotal step. Additional investigations, including chest computed tomography (CT) scans, were pursued as required. Lastly, radiological evaluations were executed on the patients' first day of admission. These evaluations provided valuable initial insights into the patients' respiratory status, contributing to the overall assessment process.

Plain chest radiograph: Postero-anterior chest X-ray (CXR) was done on all patients and recorded by commercially available radiography machines.

Chest ultrasound: A pediatric intensivist blind to the CXR performed lung ultrasonography within 24 hours of or after plain radiography. A mindray with a 3-5 MHz convex transducer was used for the chest ultrasonography, which could see deeper lung tissues. The chest walls, pleura, and lung peripheral parenchyma could best be seen with a high-frequency 5–12 MHz linear array probe. The dominating profiles (A, B, or C) were used to classify each quadrant. Lung ultrasonography was used to examine every part of the lungs. If found at one or more locations, an ultrasound anomaly characterized the region of interest. To ascertain the cause of RD, the bedside lung ultrasound in emergency (BLUE) method was created. The dominant profiles (A, B, or C) were used to classify each quadrant. The original BLUE guideline recommended that, in order to avoid missing the diagnosis of pulmonary embolism, a normal profile (bilateral lung sliding with A-lines) be combined with a leg vein thrombosis screening [18].

Chest computed tomography (CT) (if indicated)

All patients with low radiation exposure underwent high-resolution chest CT cuts using a GE Bright Speed 16 Detector Scanner (USA) at 120 kV, 20 to 40 mA with a reconstructed layer thickness of 4 mm (multi-slice CT scan; effective radiation dose in the range of 0.4 mSv), or at 120 kV, 50 mA with a reconstructed layer thickness of 5 mm. A chest radiology specialist examined the CT scans without being aware of the sonographic and radiographic information.

Statistical analysis

SPSS version 16 was the statistical program used for the analysis. The mean values and accompanying standard deviations for continuous data were shown. Nominal information was presented using frequency and percentages. Through the receiver operating characteristic (ROC) curve, the accuracy of Point-of-Care Ultrasound (POCUS) in detecting respiratory distress was evaluated. Statistical significance was defined as a p-value less than 0.05.

Results

Baseline data of the studied children:

The mean age of enrolled children was 3.69 ± 2.81 (years), and 76 (50.7%) were males. The most frequent presentations among those children were dyspnea (96.7%), fever (86%) and

cough (86%). The mean PRESS was 3.34, ranging between 1 and 5 points. Based on PRESS, moderate and severe RD are present in 30 (20%) and 120 (80%) children, respectively.

Table 1: Baseline data of the studied children

N= 150	
Age (years)	3.69 ± 2.81
Range	One month-17 years
Sex	
Male	76 (50.7%)
Female	74 (49.3%)
Complete immunization	67 (44.7%)
Clinical presentation	
Respiratory distress	145 (96.7%)
Fever	129 (86%)
Cough	129 (86%)
Wheeze	72 (48%)
Chest pain	7 (4.7%)
Vital signs	
Respiratory rate (c/minute)	50.80 ± 14.97
Heart rate (b/minute)	139.99 ± 24.01
Systolic blood pressure (mmHg)	89.60 ± 13.75
Diastolic blood pressure (mmHg)	57.33 ± 11.45
Temperature (°C)	37.69 ± 4.95
Oxygen saturation (%)	94.57 ± 3.36
PRESS	3.34 ± 1.27
PRESS class	
Moderate	30 (20%)
Severe	120 (80%)

Data expressed as frequency (percentage) and mean (SD). PRESS: pediatric respiratory severity score.

Baseline laboratory data and cultures among the studied children:

Based on blood culture, 15 (10%), 10 (6.7%), 9 (6%), 8 (5.3%), 5 (3.3%), and 3 (2%) patients had Staph. Aureus, Klebsiella species, methicillin-resistant Staph.aureus (MRSA), Acinobacter species, Pseudomonas and methicillin-resistant coagulase-negative Staph.aureus (MRCONS), respectively. Based on the culture of broncho-alveolar lavage (BAL), Klebsiella species, Pseudomonas and Acinobacter species were present in 35 (23.3%), 25 (16.7%), and 20 (13.3%) patients, respectively. Twelve (8%) patients had Staph. Aureus and another 8 (5.3%) patients had E. coli.

Table 2: Baseline laboratory data and cultures among the studied children.

N= 150	
White blood cells ($10^3/\text{ul}$)	50.80 \pm 14.97
NLR	4.56 \pm 2.22
C-reactive protein (mg/dl)	55.56 \pm 14.56
Blood culture	
No growth	100 (66.7%)
Staph. aureus	15 (10%)
Klebsiella species	10 (6.7%)
MRSA	9 (6%)
Acinobacter species	8 (5.3%)
Pseudomonas	5 (3.3%)
MRCONS	3 (2%)
Endotracheal aspiration culture	
No growth	50 (33.3%)
Klebsiella species	35 (23.3%)
Acinobacter species	25 (16.7%)
Pseudomonas	20 (13.3%)
Staph. aureus	12 (8%)
E. coli	8 (5.3%)

Data expressed as frequency (percentage) and mean (SD). NLR: neutrophil/lymphocytes ratio; MRSA: methicillin-resistant Staph.aureus, MRCONS; methicillin-resistant coagulase-negative Staph.aureus.

Final diagnosis and outcome among the studied children:

Based on clinical data, chest x-ray and chest CT if needed, the most frequent diagnosis was pneumonia (92.7%) followed by pneumothorax (3.3%). Three patients had bronchial asthma, while bronchiolitis was found in only one child. Pulmonary embolism was detected in two children.

Table 3: Final diagnosis and outcome among the studied children.

N= 150	
Final Diagnosis	
Pneumonia	139 (92.7%)
Pneumothorax	5 (3.3%)
Bronchial asthma	3 (2%)
Pulmonary embolism	2 (1.3%)
Bronchiolitis	1 (0.7%)
Length of hospital stay (days)	9.88 \pm 4.44
Outcome	
Were discharged	100 (66.7%)
Died	50 (33.3%)

Data expressed as frequency (percentage)

The final diagnosis in the studied children based on POCUS:

Based on POCUS, pneumonia was the most frequent diagnosis (92%). Five patients had pneumothorax. Bronchial asthma/bronchiolitis based on A profile without venous thrombosis

in the lower limb was diagnosed in five patients. Also, pulmonary embolism was suspected in two children based on the A profile.

So, based on the final diagnosis, the POCUS incorrectly diagnosed only one case to have bronchiolitis, but, based on the final diagnosis, the same case had pneumonia.

Table 4: Final diagnosis in the studied children based on POCUS.

POCUS's diagnosis	Findings in POCUS	N (%)	Final Diagnosis
Pneumonia	A/B profile	138 (92%)	139 (92.7%)
	C profile	120 (80%)	
	A plus PLAPS	15 (10%)	
		3 (2%)	
Pneumothorax	A' profile with lung point	5 (3.3%)	5 (3.3%)
Bronchial asthma/ bronchiolitis	A profile without venous thrombosis in the lower limb	5 (3.3%)	4 (2.7%)
Pulmonary embolism	A profile in addition to venous thrombosis in the lower limb	2 (1.3%)	2 (1.3%)

Data expressed as frequency (percentage). POCUS: point of care ultrasound; PLAPS: posterolateral alveolar and pleural syndrome.

Accuracy of POCUS in prediction cause of RD in children:

POCUS was found to have 100% accuracy in predicting pneumothorax or pulmonary embolism as a cause of respiratory distress in children. Meanwhile, POCUS had a comparable accuracy in predicting pneumonia and asthma/bronchiolitis (99.3%).

Table 5: Accuracy of POCUS in prediction cause of RD in children.

	Pneumothorax or pulmonary embolism	Pneumonia	Asthmas and bronchiolitis
Sensitivity	100%	99.3%	100%
Specificity	100%	100%	99.3%
PPV	100%	100%	75%
NPV	100%	91.7%	100%
Accuracy	100%	99.3%	99.3%
AUC	1	0.993	0.997
P value	< 0.001	< 0.001	< 0.001

RD: respiratory distress; POCUS: point of care ultrasound; PPV: positive predictive value; NPV: negative predictive value; AUC: area under the curve.

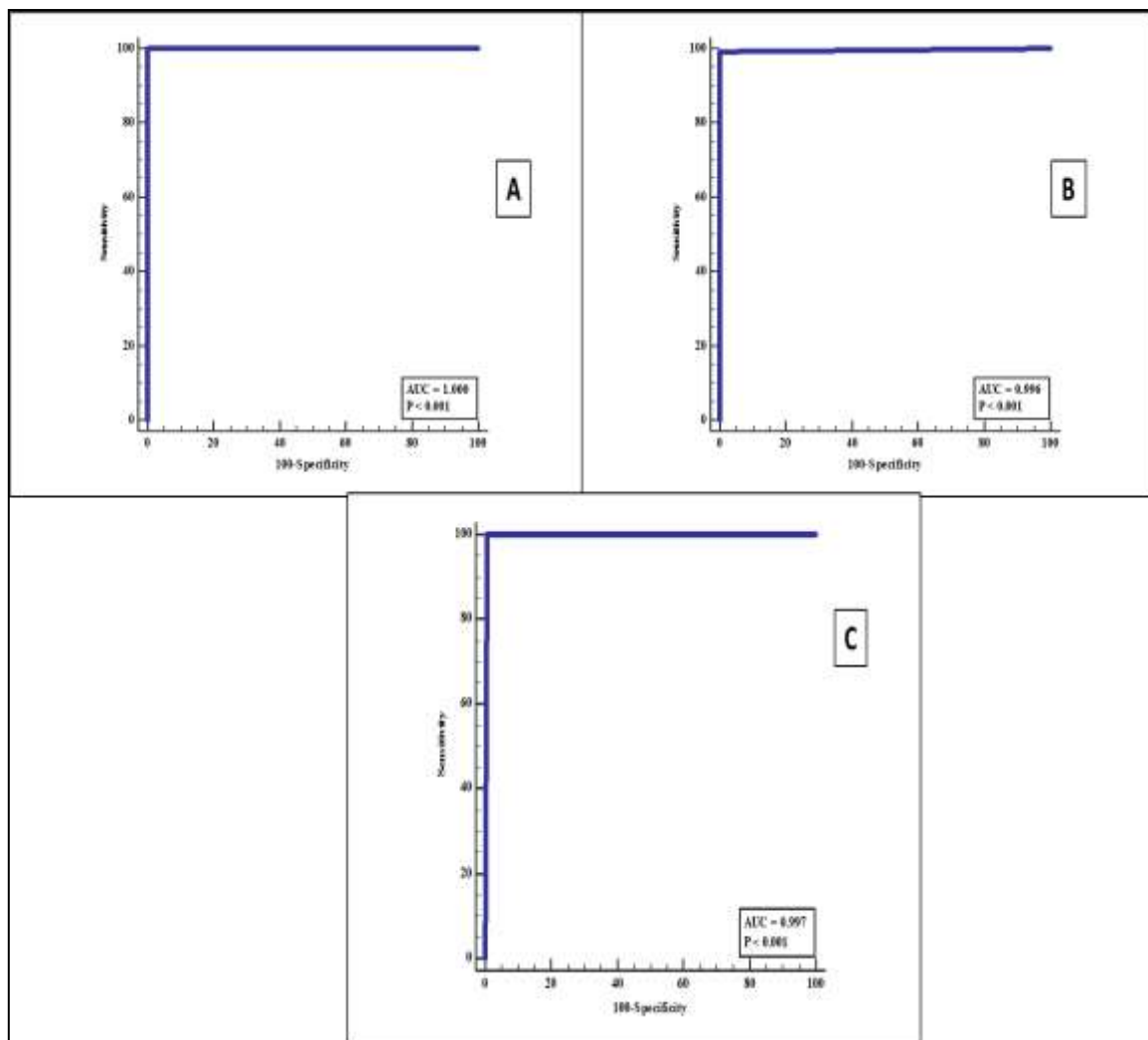


Figure 1: Accuracy of POCUS in the prediction of A) pneumothorax or pulmonary embolism, B) pneumonia as a cause of respiratory distress in children and C) bronchial asthma/bronchiolitis as a cause of respiratory distress in children.

Discussion

The safe and effective lung ultrasonography (LUS) technology is used to diagnose respiratory distress (RD) in emergencies. In children with acute dyspnea or hypoxia, the bedside lung ultrasound in emergency (BLUE) method can be utilized as a screening tool to quickly evaluate the condition and determine the best course of treatment [19-21]. This reduces the need for risky technology like computed tomography (CT) scans and CXR. The methodology analyses lung regions to identify abnormal ultrasonography and generates seven profiles specific to the associated clinical diagnosis. This technique is a strategy component that also involves a fundamental physical examination, a fundamental laboratory test, and a fundamental history [22].

Chest ultrasound has been shown by Biagi et al. (2018) to be a reliable tool for evaluating patients with respiratory distress syndrome because all of the patients with this condition have bilateral white lung, diffuse B-lines, small sub pleural lung consolidation, occult pneumothorax, minimal pleural effusion, and areas with a normal pattern [23].

In our area, there is a dearth of POCUS evaluations of children with RD. This study examined the use of bedside lungs and portable chest X-rays in the US in order to examine the sensitivity, specificity, safety, and accuracy of identifying the cause of respiratory distress in children sent to the pediatric intensive care unit (PICU). The study included 150 RD-affected kids in total.

76 (50.7%) of the registered children were male, with a mean age of 3.69 ± 2.81 (years). The current study's male predominance was comparable to that of Ismail et al. (2023), who discovered that 57/100 (57%) of the patients in their study were males [24]. Additionally, according to Buonsenso et al. (2022), out of the 186 youngsters enrolled in their research, 103 (55.4%) were males [25].

The current study's mean PRESS was 3.34, ranging between 1 and 5 points. Based on PRESS, mild, moderate and severe RD are present in 24 (16%), 30 (20%) and 120 (80%) children, respectively. According to Lemine et al. (2022), pneumonia-related respiratory distress affected 63.3% of the study group in a moderate, 26.7% in a mild, and 10% in a severe way [26]. Additionally, according to Biagi et al. (2018), 37.9% of the group under study experienced severe respiratory distress, 47.1% had moderate respiratory distress, and 15% had light respiratory distress [27].

Blood culture was positive in 50 (33.3%) children, while BAL was positive in 100 (66.7%) children. Based on blood culture, the most frequent isolates were Staph. Aureus (10%), Klebsiella species (6.7%) and methicillin-resistant Staph. Aureus (6%). Meanwhile, based on the culture of BAL, Klebsiella species, Pseudomonas, and Acinobacter species were present in 35 (23.3%), 25 (16.7%), and 20 (13.3%) patients, respectively.

In a previous study, Nathan et al. (2020) stated that the etiology of pneumonia in children present with RD; the most frequently isolated organisms were H. influenzae (29.3%), S. aureus (24%) and S. pneumoniae (22.7%) [17]. Also, another study found that the most frequent isolates for pneumonia were S. aureus (30.6%) dominated, followed by S. pneumoniae (20.4%) and K. pneumoniae (12.2%) [28].

In the current study, based on clinical data, chest x-ray and chest CT if needed; the most frequent diagnosis was pneumonia (92.7%), followed by pneumothorax (3.3%). Three patients had bronchial asthma, while bronchiolitis was found in only one child. Pulmonary embolism was detected in two children. The mean hospital stay was 9.88 ± 4.44 (days). The majority (66.7%) of children improved and discharged, and 50 (33.3%) children deteriorated and died. Similarly, prior research found that pneumonia (47.7%) was the primary cause of childhood respiratory disease (RD), with pulmonary edema or interstitial syndrome accounting for 22.2% of the children examined. Pneumothorax was the least prevalent cause of RD, accounting for 12.7% of cases, whereas bronchiolitis and asthma affected 17.4% of patients [29]. This was in line with the study of Ismail et al. (2023), which noticed 39/100 (39%) neonates with RD had pneumonia [30].

The main findings in the current study included based on POCUS; pneumonia was the most frequent diagnosis in 138 (92%). Five patients had pneumothorax. Bronchial asthma/bronchiolitis was diagnosed in five patients. Also, pulmonary embolism was suspected in two children. So, based on the final diagnosis, the POCUS incorrectly diagnosed only one case to have bronchiolitis, but, based on the final diagnosis, the same case had pneumonia. Following these findings, Hegazy et al. (2020) found that according to the bedside lung ultrasound, either pleural syndrome or pneumonia, the primary cause of RD in children was found to be 47.7%, with pulmonary edema or interstitial syndrome accounting for 22.2% of the cases. Pneumothorax was the least prevalent cause of RD, accounting for 12.7% of cases, whereas bronchiolitis and asthma affected 17.4% of patients [31].

In the current study, we found that POCUS had 100% accuracy in predicting pneumothorax or pulmonary embolism as a cause of respiratory distress in children. Meanwhile, POCUS had a comparable accuracy in predicting pneumonia and asthma/bronchiolitis (99.3%). Pereda et al. (2015) performed a meta-analysis to confirm the information regarding the diagnostic effectiveness of LUS for pediatric pneumonia. The meta-analysis included 765 children. The authors discovered that LUS had a sensitivity of 96% and a specificity of 93% for identifying pediatric pneumonia in comparison to the final diagnosis [32].

Lichtenstein (2014) demonstrated the application of the BLUE technique on critically ill patients with dyspnea who would be admitted to the ICU in order to identify the cause of the condition. They found that the four profiles (C profile, B' profile, A with PLAPS, and A/B profile) had sensitivity of 89%, specificity of 94%, PPV of 88%, and NPV of 95% for the diagnosis of pneumonia [33].

In a recent study, pneumonia was found to be the main cause in 47.7% of children with RD. When compared to the final diagnosis, LUS had sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of 93.9% in 30 of the 31 kids, whose pneumonia diagnosis had been confirmed by the BLUE protocol, including 12 patients who had para-pneumonic pleural effusion [19]. An Italian study found that of 79 children with suspected pneumonia, 60 had pneumonia detected by ultrasound and 53 had pneumonia diagnosed by CXR; 4/7 of these children who had pneumonia detected by ultrasound but not by CXR had pneumonia confirmed by CT, and 3/7 had a clinical course consistent with bacterial pneumonia, with 86% sensitivity and 97% specificity for CXR's ability to detect pneumonia.

Lichtenstein and Mauriat (2012) employed LUS in critically unwell newborns utilising the BLUE protocol to quickly determine the cause of acute respiratory failure because there has never been a radiological differentiation between adults and infants. They demonstrated that the specificity of the LUS for pneumonia was 98%, with a sensitivity of 90% [34].

Here, our study concluded that POCUS had 99.3% overall accuracy in diagnosing bronchiolitis as a cause of RD in children. Similar to this, Hegazy et al. (2020) reported that LUS had a sensitivity of 90.9%, specificity of 98%, positive predictive value (PPV) of 90.9%, and negative predictive value (NPV) of 98% in 11 cases, respectively, [19]. In babies with bronchiolitis, Basile et al. (2015) reported an excellent 90.6% agreement between the clinical and sonographic diagnoses, with a statistically significant interobserver ultrasound diagnostic concordance of 89.6% [35]. In the current study, based on the final diagnosis, five patients had pneumothorax. POCUS was able to detect all of them with 100% accuracy. This was comparable with many previous studies that revealed 100% overall accuracy of POCUS in diagnosing pneumothorax in children with RD [36, 37, 38, 39].

Another important finding in our study was that pulmonary embolism was suspected in two children based on the A profile in POCUS. Comert et al. (2013) showed that TUS was true positive in 27 patients with pulmonary embolism, false positive in eight, true negative in 12, and false negative in three. For individuals with a clinical suspicion of having a pulmonary embolism, TUS had a diagnosis accuracy of 78% [40].

Chaitra et al. (2022) found that the diagnostic acuity of the ultrasound lung emergency protocol was 100% for pneumothorax, 93.85% for pneumonia, 96.92% for chronic obstructive pulmonary disease, and 99.23% for pulmonary embolism [41].

Due to the study's cross-sectional nature, it is unable to adequately address the initial inference made on the frequency of various diagnoses in a hospital setting due to the seasonality of respiratory illnesses. Using a cross-sectional method underestimates some and overestimates other respiratory illnesses since the seasonal incidence of various acute and exacerbations of chronic respiratory disorders is the main driver of their health resource consumption.

Additionally, we skipped the computed tomography chest exam, the go-to procedure in CXR-negative cases, to look for any radiological anomalies. Additionally, the operator influences the findings and their interpretations, and the choice of probe is crucial. As a result, ultrasound interpretation should always consider the patient's clinical state. Finally, because our study was limited to a single site, we could not rule out type II errors, necessitating more research to ensure the accuracy of the findings.

Conclusion

LUS is a rapid, non-invasive tool with good diagnostic accuracy for the etiology of RD in children. It permits etiology to be determined using a pathophysiological approach. It is recommended to perform such studies on many patients in multiple centers to draw a firm conclusion regarding the efficacy and applicability of lung ultrasound in such cases.

Ethical considerations

The study was authorized by the medical school's ethical committee at Assiut University with IRB and registered it on *clinicaltrials.gov* with NCT04328220. Any patient's relative could decline the research without negatively affecting the service or clinical treatment. Additionally, they were able to inquire about the study at any time. The secrecy and privacy of all data were guaranteed.

Limitation

The study's generalizability is limited due to its focus on a single center and two-year period, with a small sample of 150 children, and may not account for operator expertise or diagnostic biases.

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