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Comparative study of Ultrasound and chest X-ray in diagnosis of pneumonia in Intensive Care Unit

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Abstract

Background: Pneumonia is one of the leading infectious disease-related causes of death and a leading cause of severe sepsis and septic shock. However, pneumonia is sometimes difficult to diagnose in the emergency environment due to the lack of distinct clinical, biochemical, and imaging indications. Our study's objective was to compare the diagnostic usefulness of LUS and CXR for the early diagnosis of clinically suspicious cases of pneumonia in ICUs with limited resources. Methods: This study was carried out on patients with clinical suspesion of pneumonia who were collected from those admitted at intensive care unit of Benha University Hospitals and intensive care unit of Sheikh Zayed Hospital during the period from February 2022 to July 2022. Results: We discovered that LUS was better than CXR for detecting pneumonia in patients. In addition, we discovered that LUS was more effective than CXR in diagnosing pneumonia in individuals with hemodynamic instability. CXR was more time-consuming than LUS regarding imaging duration. In light of the fact that early antibiotic delivery in pneumonia patients is linked with improved results, particularly in terms of morbidity and mortality, it is crucial to identify a less time-consuming diagnostic method. Conclusion: Lung ultrasonography performed better than chest X-ray for the early identification of pneumonia when performed at the bedside.

Key words: Ultrasound, chest X-ray, pneumonia, Intensive Care Unit

1. Introduction

Pneumonia is one of the top causes of mortality worldwide, and it is the leading cause of death in low-income nations. Early diagnosis and focused antibiotic medication might avert these fatalities. It is the only acute respiratory infection in which delayed antibiotic treatment has been shown to increase the risk of mortality; consequently, an accurate and prompt diagnosis is required [1].

In distant places with inadequate imaging capabilities, doctors rely on physical examinations, which have poor sensitivity (47– 69 percent). Because the physical symptoms of pneumonia are equivocal, imaging plays a crucial role in the diagnosing process. Chest X-rays, thoracic ultrasonography, and thoracic computed tomography (CT) scans are common imaging procedures. While the latter has the maximum sensitivity, it is also the most expensive and produces the most radiation. [2].

Despite its poor sensitivity (43– 78 percent), chest X-ray remains the primary diagnostic tool for pneumonia due to these limitations. CXR may have significant limitations, particularly in the ICU, related to patient circumstances, time waste, and interobserver variability in its interpretation [3].

In lung consolidations, air is replaced by fluid, resulting in effective US transmission if the lesion is in direct contact with the pleural surface [4].

Multiple studies in high-income countries have shown that ultrasonography is a more sensitive and specific method for diagnosing pneumonia than chest X-ray. Ultrasound is a safe, affordable, noninvasive imaging technology that may supplement the physical examination and clinical assessment in situations of acute respiratory failure. The primary benefit of bedside ultrasound is its quick diagnostic use for thoracic diseases. Other benefits include postponing or even eliminating the need for patient transport to the radiology suite, radiation exposure, and directing life-saving therapy in severe emergency situations [5].

This study aimed to evaluate Lung Ultrasound against Chest x-ray in terms of diagnosis accuracy for pneumonia patients in the Intensive Care Unit (ICU) and time savings between the two modalities.

2. Patients and Methods

This study was conducted on patients with clinical suspicion of pneumonia who were admitted to the intensive care units of Benha University Hospitals and Sheikh Zayed Hospital between February and July 2022. Ethical committee approval and written informed consent were obtained from all patients prior to the commencement of the study.

72 individuals of either gender between the ages of 18 and 70 with clinically suspected pneumonia. Suspicion was raised clinically (fever 38.0°C, cough, purulent expectoration, dyspnea) and on the basis of typical auscultation findings (rales or bronchial breath sounds) if the patient was not intubated, and fever, change in the colour or quantity of secretions, auscultatory findings, and drop in oxygen saturation below 92% if the patient was intubated.

Exclusion criteria;-

1. Patient or relatives' non-consenting. 2- Lung Malignancy.
2. Acute Respiratory Distress Syndrome.
3. Pleural malignancy or effusion.
4. Heart disease.

Assessment and preparation:

A careful medical history was taken from the medical records and relatives . General examination including (heart rate, mean arterial blood pressure, systolic blood pressure, CVP if present , recorded body temperature and peripheral arterial oxygen saturation) and Chest examination including inspection and auscultation of chest wall were carried out. Investigations were done such as complete blood count, C- reactive protein, prothrombin time, partial thromboplastin time, liver and renal functions, electrolytes and sputum cultures.

The final diagnosis of Pneumonia was established by surgical ICU staff according to **Center for Disease Control (CDC) guidelines (6)**

For ANY PATIENT, at least *one* of the following:

- Fever (>38.0°C or >100.4°F)
- Leukopenia (≤4000 WBC/mm3) or leukocytosis (>12,000 WBC/mm3)
- For adults >70 years old, altered mental status with no otherrecognized cause

And at least *two* of the following:

- New onset of purulent sputum or change in character of sputum , or increased respiratory secretions, or increased suctioning requirements
- New onset or worsening cough, or dyspnea, or tachypnea.
- Rales or bronchial breath sounds.
- Worsening gas exchange (for example: O2 desaturations (for example: PaO2/FiO2 <240) , increased oxygen requirements, or increased ventilator demand)

PLUS Two or more serial chest imaging test results with at least *one*
of the following :

New and persistent or Progressive and persistent

- Infiltrate
- Consolidation
- Cavitation
- Pneumatoceles, in infants ≤1 year old

Equipments and drugs used in the study:

1. The ultrasound machine and scanning probe should be prepared (Sonosite M turbo ultrasound system. Lung Ultrasound (LUS) was done using both (1-5MHz) micro convex probe and (13-6 MHz) linear probe forlung and pleura examination.
2. Portable X-ray machine.

Study modalities:

All Patients were subjected to radiological examination using chest ultrasound and chest x-ray on day 1, 3, 5 after admission to ICU.

PROCEDURES:

Lung Ultrasound (LUS):

On the first, third, and fifth day of clinical suspicion, TUS was done on all patients.

Each patient got a thorough TUS evaluation, covering the anterior and posterolateral chest wall aspects. Patients were examined in a supine posture if they were intubated, or in a seated position with their arms raised above their heads to enlarge the intercostal gap if they were not intubated.

Lung ultrasonography was done at six precise sites known as the BLUE spots, three on each hemithorax, with the transducer perpendicular or transverse to the chest wall.

The BLUE-protocol identified three standard places on the chest wall: the upper BLUE-point, the lower BLUE-point, and the PLAPS-point.

Two hands (without thumbs) are joined as seen in Fig ().

The upper hand is placed with the ring finger on the lower border of the clavicle (along its long axis), and the finger tips are in contact with the midline. The lower hand is placed underneath the first, with the thumbs disregarded. The upper BLUE point is at the base of the middle and ring fingers of the upper hand (upper cross), while the lower BLUE point is in the centre of the palm of the lower hand (lower cross), and the bottom border of the lower hand represents the phrenic line, which represents the end of the lung (arrow). The PLAPS-point is the junction of a horizontal line at the level of the lower BLUE-point and a vertical line at the posterior axillary line.

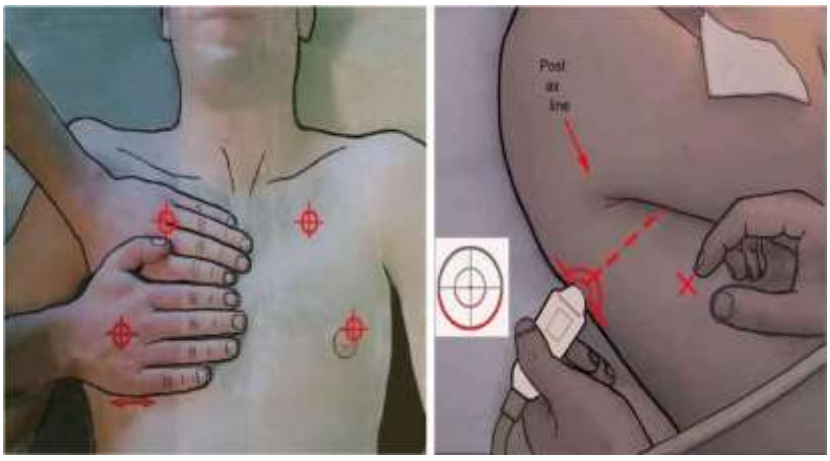


Fig. (1) showing the BLUE points on the left panel , PLAP point on the right panel (black arrow)and phrenic point (cross mark) **[*7*]**

The following Sonographic profiles were interpreted as pneumonia:

B′- profile = B profile with abolished lung sliding.

A/B - profile = anterior predominant B+ lines at one side, predominantA lines at the other.

C- Profile = anterior alveolar consolidation(s)

PLAPS = posterior-lateral alveolar consolidation and/or pleuraleffusion syndrome .

Ultrasonography chest examination was done using real time (B)mode, motion mode(M) .

2-Chest X-Ray

Xrays are a form of radiation like light or radio waves. X-rays pass through most objects, including the body. Once it is carefully aimed at the part of the body being examined, an x-ray machine produces a small burstof radiation that passes through the body, recording an image on photographic film or a special detector.

Different parts of the body absorb the x-rays in varying degrees. Dense bone absorbs much of the radiation while soft tissue, such as muscle, fatand organs, allow more of the x-rays to pass through them. As a result, bones appear white on the x-ray, soft tissue shows up in shades of gray and air appears black.

On a chest x-ray, the ribs and spine will absorb much of the radiation and appear white or light gray on the image. Lung tissue absorbs little radiation and will appear dark on the image.

Patients were positioned supine on a bed for chest x-rays. Films are repeated every other day for follow up.

Measured Parameters:

1. Ultra-sonographic & X-ray findings

Findings in ultrasound used for diagnosis of pneumonia (the upper BLUE-point, lower BLUE-point and PLAPS-point (A, A′, B, B′, AB andC profile) were compared with findings in chest x-ray as consolidation in.

2. Duration of imaging

Duration of imaging (time/minutes) were calculated from start of study to appearance of findings and compared between all patients

3. Frequency of Sonographic findings of pneumonia

Frequencies of of the 4 pneumonia profiles were recorded.

The study outcome:

Primary end points

were Ultra-sonographic & X-ray findings and pneumonia scoring , whileduration of imaging were Secondary end points .

The sample size

Number of patients was determined prior to the field work after a power calculation according to Data gathered from a previous study **(8)** .A total sample size of 72 patients was determined to provide 90% power for chi square tests at the level of significance 5% using G power 3.1 9.2 software.

Power analysis: A priori: compute required sample size

Input:

Effect size = 0.479

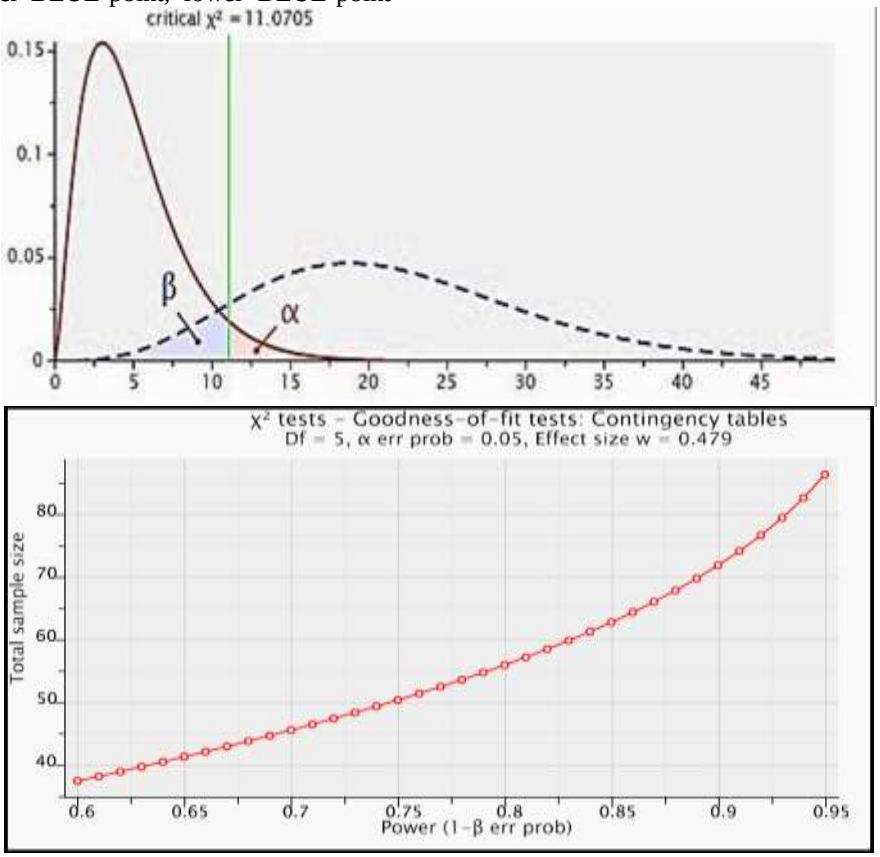
α error probability = 0.05

Power (1-β error probability) = 0.9

Output:

Noncentrality parameter λ = 16.5197 Critical χ^2 = 11.0705

Total sample size = 72 Actual power = 0.901006



Statistical analysis

Data were collected, coded, revised and entered to the Statistical Package for Social Science (IBM SPSS) version 22. The data were presented as number and percentages for the qualitative data, mean, standard deviations and ranges for the quantitative data with parametric distribution and median with inter quartile range (IQR) for the quantitative data with non parametric distribution.

Descriptive statistics:

- For qualitative data: number (N) and percentage (%)
- For quantitative data: mean (X~) and standard deviation(SD).

Analytical statistics:

Normally distributed variables (parametric) between two study groups were analyzed using:

- Independent sample t-test for analysis of quantitative data.
- Paired t-test for comparison of Dependent quantitative data.
- Chi – square (x2) for analysis of qualitative data.
- Analysis of quantitative non parametric data between two groups by Mann-Whitney test
- Analysis of dependent data among each group by Wilcoxon sign ranked test for all tests probability (p) was considered:
- Non-significant if ≥ 0.05
- Significant if < 0.05

Highly significant if < 0.01 Very Highly significant if < 0.001

3. Results

Among the 72 cases enrolled, a total of 21 cases of pneumonia were detected using CXR, whereas LUS identified 61 cases; 44 lesions detected by LUS were not detected by CXR. CXR detected 4 cases that were not detected by LUS. Only 7 cases could not be detected by both modalities. There is significant difference between LUS and CXR as P-value < 0.05 when using mcnemar test as in table 1 and when using oneway annova test as in table 1

Table (1) demonstrates Ultra-sonographic & X-ray findings in thestudied groups using mcnemar test.

LUS +veCXR -ve	LUS –ve CXR +ve	LUS +veCXR +ve	LUS –veCXR -ve	*P - value*
44 (61.1%)	4 (5.6%)	17 (23.6%)	7 (9.7%)	< 0.001*

Table (2) demonstrates Ultra-sonographic & X-ray findings in **thestudied groups.**

Total No	No detected by LUS	No detected by CXR	P - value
72	61 / 72	21 / 72	< 0.001*

Frequencies of Pneumonia profiles encountered during the study :

As illustrated in table (3) , of the 61 cases that were positive by LUS the predominant LUS profile was A + PLABS which was present in 38 cases . AB profile was present in 9 cases. 7 cases with B' profile also 7cases with C profile .

Table (3) illustrates LUS profiles of pneumonia and their frequencies inthe studied cases in comparison to CXR

LUS profile	No and percentage of cases
AB profile	9 (14.7%)
B' profile	7 (11.5%)
C profile	7 (11.5%)
A+ PLABS profile	38 (62.3%)
Total	61 (100 %)

Comparison between LUS and CXR in diagnosing pneumonia inhemodynamiclly unstable patients .

Hemodynamic instability is defined as systolic blood pressure below 90 mmhg or the need of vasopressors. So, 46 cases were considered unstable . While CXR only diagnosed 14 cases, LUS was able to detect 32 cases. There was significant difference between LUS and CXR in detecting consolidation in hemodynamically unstable patients as p-value < 0.05

Table (4) demonstrates difference between LUS and CXR in diagnosing pneumonia in hemodynamiclly unstable patients .

LUS +ve CXR -ve	LUS –ve CXR +ve	LUS +ve CXR +ve	LUS –ve CXR -ve	*P - value*
24 (52.1%)	0 (0%)	14 (30.5%)	8 (17.4%)	**< 0.001***

Amongst the 61 cases diagnosed by LUS table (5) and figure () illustrates the different profiles generated with each bacteria. It is clear that A + PLABS is the predominant profile overall. However, Klebsiellagenerated B' profile more than other organisms and AB profile was present most with gram negative bacteria and staph aureus.

Table (5) culture results in relation to LUS profile

Culture results	AB profile	B' profile	C profile	A+ PLABS
Gram negativebacilli (5)	1	0	0	4
Klebsiella (23)	1	5	2	15
Mixed gramnegative (14)	4	1	3	6
Pseudomonas (3)		1	1	1
Staph aureus (17)	3	0	1	12

As regard duration of imaging there is significant rise in values betweenultrasonography and chest x-ray p-value <0.05.

Table (6) summarized average duration of performing Ultrasound &X-ray.

Imaging modality	LUS	CXR	p-value
	Mean ±SD	**Mean ±SD**	
Duration	12min ±0.54	127 min±47	<0.001*

4. Discussion

In the present research, ultrasonography was more successful than traditional chest radiography in identifying pneumonia patients on the first day after the onset of clinical symptoms, but on the fifth day they were almost as efficient in confirming the diagnosis. Also, ultrasonography was more effective than chest x-ray in the early diagnosis of mild and moderate types of pneumonia based on the SMARTCOP score, although both were equally effective in the detection of severe and very severe forms of pneumonia.

This is consistent with the findings of Amatya et al. [5], who examined the Diagnostic use of lung ultrasound compared to chest radiograph for suspected pneumonia in a resource-limited setting in 62 patients with suspected pneumonia who were evaluated with bedside lung ultrasound, single posterioranterior chest radiograph, and computed tomography (CT). Using CT as the gold standard, McNemar's test for paired samples was used to evaluate the sensitivity of lung ultrasonography to chest X-ray for the diagnosis of pneumonia. Each test's diagnostic features were computed. CT revealed that 44 patients (71 percent) were diagnosed with pneumonia. Compared to chest X-ray, lung ultrasonography had a sensitivity of 91% (p = 0.01), while chest X-ray had a sensitivity of 73% (p = 0.01). In addition, they determined the specificity of lung ultrasonography and chest X-ray to be 61% and 50%, respectively.

Ellington et al. [9] examined children aged 2 to 59 months with primary respiratory problems in the outpatient clinics, emergency department, and inpatient wards at the Instituto Nacional de Salud del Nio in Lima, Peru. Our findings are consistent with their findings. Each individual was evaluated clinically by a paediatrician and received lung ultrasonography by one of three general practitioners. In addition, they included sequentially youngsters without respiratory symptoms. Chest x-rays were taken of children with respiratory complaints. Final clinical diagnosis revealed that 453 children had pneumonia, 133 had asthma, 103 had bronchiolitis, and 143 had upper respiratory infections. CXR was able to confirm the diagnosis in 191 (42%) of the 453 children with clinical pneumonia. In addition, they discovered that a consolidation on lung ultrasonography exhibited a sensitivity of 88.5%, specificity of 100%, and area under the curve of 0.94 when compared to radiographically confirmed clinical pneumonia. When any lung ultrasound anomaly was compared to radiographically verified clinical pneumonia, the sensitivity improved to 92.2% and the specificity declined to 95.2%, with an area under the curve of 0.89.

Reissig et al. [10] investigated Lung Ultrasound in the Diagnosis and Follow-up of Community-Acquired Pneumonia, confirming our findings. In fourteen European institutions, 362 individuals with suspected CAP were recruited. History, clinical examination, laboratory tests, and LUS were conducted at baseline, along with the reference test, which was a radiograph in two planes or a low-dose CT scan in the event of equivocal or negative radiographic findings but positive LUS results. Patients with CAP were scheduled for follow-up between days 5 and 8 and 13 and 16. They discovered that CAP had been diagnosed in 229 cases (63.3 percent). LUS demonstrated a sensitivity of 93.4 percent (95 percent confidence interval [CI], 89.2 percent -96.3%), a specificity of 97.7 percent (95 percent CI, 93.4 percent -99.6 percent), and likelihood ratios (LRs) of 40.5 percent (95 percent CI, 13.2-123.9) for positive results and 0.07 percent (95 percent CI, 0.04-0.11) for negative results. A combination of auscultation and LUS boosted the positive LR to 42.9 (95 percent confidence interval: 10.8-170.0) and lowered the negative LR to 0.04. (95 percent CI, 0.02-0.09). We discovered that 97.6% (205 of 211) of patients with CAP had breath-dependent motion of infiltrates, 86.7% (183 of 211) had an air bronchogram, 76.5% (156 of 204) had blurred margins, and 54.4% (105 of 193) had a basal pleural effusion. During follow-up, median C-reactive protein levels declined from 137 mg/dL to 6.3 mg/dL between days 13 and 16; CAP symptoms reduced from 15.3 cm2 to 0.2 cm2; and pleural effusion decreased from 50 mL to 0 mL.

In agreement with the findings of our investigation, Parlamento et al. [11] assessed lung ultrasonography for the diagnosis of pneumonia in the emergency department by performing lung US on adult patients admitted with a pneumonia suspicion. After that, a chest radiograph

(CXR) was performed on each patient. Patients with a positive lung ultrasound and negative CXR had a thoracic computed tomography (CT) scan. Ten days after administering antibiotics to individuals with proven pneumonia, they did a follow-up evaluation to assess clinical conditions. In 32 of the 49 individuals investigated, the presence of pneumonia was established (65.3 percent). In this group, 31 (96.9%) of lung ultrasounds and 24 (75%) of CXRs were positive. In 8 (25 percent) instances, the lung US was positive while the CXR was negative. In this group, CT scan results invariably corroborated US findings. In one instance, the US was negative but the CXR was positive. The follow-up was consistently consistent with the diagnosis.

Bourcier et al. [12] compared lung ultrasonography and chest x-ray for the diagnosis of pneumonia in the ED. Our findings were similar. They examined 144 individuals who were adults. One of five certified emergency doctors conducted the ultrasound examination, and a radiologist analysed the chest x-ray. The main outcome measure was the hospital discharge diagnosis. The ultrasonic examination was found to be 0.95 times more sensitive than radiography (P .05). The negative predictive value for radiography was 0.67 vs 0.25 (P .05).

Also, Liu et al. [13] examined the ultrasonographic features of community-acquired pneumonia (CAP) and its diagnostic effectiveness in comparison to chest X-ray (CXR) in 179 patients. The research comprised patients who arrived to the Emergency Department with suspected CAP. Bedside ultrasonography was performed at each intercostal space in the midclavicular, anterior axillary, midaxillary, and paravertebral lines. Pulmonary consolidation, focal interstitial pattern, pleural-line abnormalities, and subpleural lesions were recorded, as well as the number of subpleural lesions and intercostal spaces with pleural-line abnormalities. All patients underwent CXR and CT at the bedside. Using CT scan as the gold standard, ultrasonography results were compared between the CAP group and the non-CAP group, as well as between CAP patients with CT demonstrating consolidation or diffuse ground-glass opacification. For the diagnosis of CAP, the sensitivity of ultrasonography was compared to that of CXR. CT revealed that 112 patients were diagnosed with CAP. On ultrasonography, patients with CAP were more likely to exhibit consolidation (p 0.001), localised interstitial pattern (p 0.001), subpleural lesions (p 0.001), and intercostal gaps with pleural-line abnormalities (p 0.001) than patients without CAP. CAP patients with consolidation on CT were more likely to have consolidation (p 0.001) and had fewer subpleural lesions and intercostal gaps with pleural-line abnormalities (p 0.001) than those with diffuse ground-glass opacification. The diagnostic sensitivity, specificity, and accuracy for ultrasonography and CXR were, respectively, 94.6 percent vs 77.7 percent (p0.001), 98.5 percent compared 94.0 percent (p=0.940), and 96.1 percent versus 83.8 percent (p0.001).

Consistent with our findings, Iorio et al. [14] evaluated LUS findings in children with CAP that were missed by chest x-ray. By evaluating the medical records of patients hospitalised to the paediatric ward between January 2014 and December 2016, they chose only instances discharged with a diagnosis of CAP and lung ultrasound (LUS) and CR conducted within 24 hours. All radiologic and sonographic pictures of the chosen patients were evaluated blindly by an experienced radiologist and sonographer. In 47 instances of pneumonia, 28 lung lesions discovered by LUS were not detected by CR. They decided that LUS should be the primary imaging technique for CAP.

In contrast to our research, Ambroggio et al. [15] examined children aged 3 to 18 years with a CXR and LUS, with or without a clinical diagnosis of pneumonia. Four paediatric radiologists who were blinded to clinical information interpreted the CXR and LUS pictures. The interobserver reliability (IRR) of 50 LUS and CXR pictures was calculated. The primary outcome was the CT finding ordered clinically or the likelihood of a CT finding in patients needing CT for clinical reasons. Two radiologists analysed CT images to establish a conclusion. Latent class analysis was used to assess the sensitivity and specificity of LUS and CXR results relative to CT. Of the 132 individuals in the group, 36 (27 percent) had a CT conducted for a clinical purpose, according to the researchers' findings. 47 people were clinically documented as having pneumonia (36 percent). The incidence rate ratio (IRR) for lung consolidation was 0.55 (95 percent confidence interval [CI], 0.40-0.70) for LUS and 0.36 (95 percent CI, 0.21-0.51) for CXR. In comparison to CT, the sensitivity of LUS and CXR for identifying consolidation, interstitial disease, and pleural effusion was statistically equivalent; however, CXR had a greater specificity. The negative predictive value for CXR and LUS was comparable.

Regarding the duration between the beginning of the operation and the diagnosis, lung ultrasonography might be conducted and analysed quickly at the bedside. In this context, when chest X-rays took an average of almost 2 hours to complete, bedside lung ultrasonography may offer a speedier diagnosis and prompt, appropriate treatment. Amatya et al. [5] obtained comparable results.

Concerning the frequency of LUS profiles observed in pneumonia patients, we discovered that 59 percent of the 61 cases identified by LUS had an A+PLABS profile. The percentages for the AB, B, and C profiles were 14.7%, 11.4%, and 11.4%, respectively. This finding was similar to that of Lichtenstein et al. [16], who conducted ultrasonography on 260 dyspneic patients admitted to the ICU with acute respiratory failure and compared the initial lung ultrasonography results to the final diagnosis made by the ICU doctors. Artifacts (horizontal A or vertical B lines suggesting interstitial syndrome), lung sliding, alveolar consolidation, and/or pleural effusion were evaluated. In conjunction with venous analysis, these components. They discovered that A+PLAPs (42.1 percent) were the most prevalent profile, followed by C-profile (21.6 percent) and AB profile (14.4 percent).

Another research Elkholy et al., [17] indicated that the A+PLAPs profile was highly prevalent, whereas other profiles were insignificant.

Concerning the influence of hemodynamics on the diagnostic precision of chest radiographs Capp et al. (18) conducted a 12-month retrospective analysis of 1,400 ED patients diagnosed with severe sepsis or septic shock and admitted to an intensive care unit. They investigated the diagnostic accuracy of first chest radiography for pneumonia. 170 individuals were determined to meet the criteria for severe sepsis and septic shock. There were 85 individuals with a confirmed pneumonia diagnosis. For the diagnosis of pneumonia, the sensitivity and specificity of first chest radiography were 58 percent (95 percent CI: 0.46–0.68) and 91 percent (95 percent CI: 0.81–0.95), respectively. In patients with severe sepsis and septic shock, the chest radiograph was shown to have limited sensitivity.

Following rehydration, a further chest radiograph reveals an infiltration indicative of pneumonia. This impact is more prevalent in elderly individuals whose cultures include non-streptococcus pneumonia Gram-positive and Gram-negative bacteria and organisms. In order to obtain a high central venous pressure, patients with severe sepsis and septic shock are more likely to need large-volume resuscitation. This is one possible explanation for why the sensitivity of the first chest radiograph is so poor in the research and why so many patients exhibit pneumonia-like features on subsequent chest radiographs within 48 hours of admission.

5. Conclusion

In our investigation, we evaluated the diagnostic utility of LUS and CXR in patients with hemodynamic instability (in ICU, this is mostly due to hypovolemia or sepsis) and found that LUS was superior to CXR in this patient group (P 0.05). LUS did not demonstrate the restriction of missing pneumonia patients with hypovolemia.

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