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Evaluating the diagnostic efficacy of 12-point lung ultrasound in detecting COVID-19 lung lesions: a comparative study with low-dose chest CT scan

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Abstract: **Objective:** Chest computed tomography (CT) scans are the gold standard for identifying pulmonary involvement in pneumonia-like COVID-19 cases, albeit with certain drawbacks such as radiation exposure and high costs. This research aims to evaluate the diagnostic precision of a 12-point lung ultrasound (LUS) against a low-dose chest CT scan in identifying lung lesions associated with COVID-19.

Methods: The study incorporated 100 consecutive patients, aged over 18 years, exhibiting suspected clinical symptoms of COVID-19 or inpatients requiring a low-dose chest CT scan for diagnosing asymptomatic COVID-19 lung lesions. All participants underwent a 12-point LUS, followed by a low-dose chest CT scan. Data analysis was conducted using STATA-16, with descriptive results presented as mean and standard deviation.

Results: The study comprised 60 males and 40 females, with an average age of 43.0±16.9 years. The mean distribution of the patients' clinical features was calculated. The LUS demonstrated a sensitivity, specificity, and positive and negative predictive values of 97.5%, 86.4%, 83.3%, and 98%, respectively.

Conclusion: The 12-point LUS exhibited high sensitivity and specificity in assessing pulmonary involvement in COVID-19 patients. Therefore, lung ultrasound results, combined with medical history and clinical examination, can serve as an effective triage tool for COVID-19 patients. The LUS, a swift, safe, and effective ionization tool, can potentially replace chest CT scans in scenarios such as CT scan unavailability, intensive care management, and patient follow-up.

Keywords: COVID-19; Imaging; Lung Diseases; Tomography Scan

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1. Introduction

In light of the global impact of the COVID-19 outbreak, the need for rapid and accurate diagnostic methods remains crucial in identifying and triaging patients (1-5). As the pandemic has evolved, the effectiveness of clinical and epidemiological features for patient screening has diminished, particularly with the rise in asymptomatic cases and increased transmission rates (4,5). The overwhelming influx of patients in emergency departments during peak periods has further escalated the risk of infection for healthcare personnel and non-COVID patients (4,5). Therefore, it is essential to develop alternative clinical screening tools capable of promptly diagnosing suspected COVID-19 cases, even in the absence of typical symptoms (4,5).

The most prevalent diagnostic techniques currently employed include polymerase chain reaction (PCR) analysis of ribonucleic acid (RNA) from sputum samples or nasopharyngeal swabs, complemented by chest imaging (6). Chest CT scans are recommended for moderate to severe COVID-19 cases, particularly when PCR results are not immediately available and patient isolation is unfeasible until results are returned (6). In some healthcare facilities facing diagnostic and bed shortages, chest CT scans are used for COVID-19 symptomatic patients (6). However, this approach entails radiation risks, high costs, and potential exposure of non-COVID patients to the virus due to challenges in fully sterilizing the CT scan room amidst high patient traffic (4,7,8). Moreover, immediate availability of radiologists for reporting suspected cases may not be guaranteed in underserved areas (4,7,8).

A promising alternative that has emerged is lung ultrasound (LUS), which demonstrates efficacy comparable to chest CT

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scans and superior to chest X-rays (10). LUS offers benefits such as cost-effectiveness, faster results, and elimination of radiation exposure (10). Previous studies have validated the high accuracy of lung ultrasound in COVID-19 screening and other pulmonary parenchymal diseases (9).

The objective of this study is to compare the results of 12-point lung ultrasound techniques with chest CT scans in patients suspected of having COVID-19 in the emergency room. This comparison aims to enhance the diagnosis of pulmonary involvement in these patients, thereby improving the efficiency and safety of COVID-19 patient management.

2. Methods

2.1. Study design

This prospective diagnostic accuracy study was conducted from July 2021 to January 2022 in the third and fourth referral hospitals. The study population consisted of 130 consecutive patients over 18 years of age who presented to the emergency department (ED) with suspected COVID-19 symptoms. The patients were recruited during random shifts to ensure a randomized sample. Out of 130 patients, 100 patient consented to participate in the study.

2.2. Ethical considerations

All research stages adhered to relevant ethical considerations. Informed consent was obtained from patients or their family members. Informed consent was obtained from all study participants. Ethical approval was granted by the Ethical Committee of Kurdistan University of Medical Sciences (approval number IR.MUK.REC.1400.168) on September 29, 2021.

2.3. Participants

Patients with a history of pneumonectomy, pleurodesis, pulmonary fibrothorax, chronic obstructive pulmonary disease, heart failure, tuberculosis, pneumonia, or previously known COVID-19 with pulmonary involvement were excluded. Patients with a history of diastolic heart failure (DHF) or chronic obstructive pulmonary disease (COPD), as determined by their past medical history, were excluded from the study. The inclusion criteria encompassed patients with moderate to severe symptoms consistent with COVID-19 (including fever, cough, dyspnea, presence of sputum, headache, hemoptysis, myalgia, diarrhea, and fatigue) who were admitted to the ED and underwent a chest CT scan. The eligibility assessment was carried out by emergency board-certified physician participating in the research.

2.4. Data gathering

Patients were managed by a healthcare team specializing in COVID-19 management. All patients received appropriate treatment and isolation in accordance with the national health ministry protocol. The ultrasound results did not influence treatment decisions. Patients suspected of having COVID-19 with any indication were admitted to the COVID-19 management group/team. Patients with negative chest CT scans and normal clinical conditions were discharged with scheduled outpatient follow-up.

2.5. Procedure and definitions

Upon initial supportive care and stabilization in the triage unit, patients were transferred to an appropriate bed in the ED. Low-dose chest CT scans were performed for admitted patients with moderate to severe clinical presentations of COVID-19, as part of standard care. Patients with emergency severity index (ESI) level 1, who required immediate airway management, multiple traumas, or suspected chest trauma, were excluded from the study. Only patients with ESI level 2, indicating moderate severity, were included as they required a chest CT scan.

A board-certified emergency physician with 5 years of point-of-care ultrasound (POCUS) experience conducted bilateral 12-point ultrasounds of the lungs (Figure 1). The physician performing the lung ultrasounds was blinded to the results of the chest CT scans at the time of examination. The chest was divided into six segments in each lung for the ultrasound assessment.

LUS examination was reported normal in case of presence of A-lines without any abnormal finding. Illustration and LUS with B-line or confluent B-line with/without irregular or thickened plural line, subpleural consolidation, plural effusion, and air bronchogram was considered positive. Pathological B-lines were defined as the presence of three or more B-lines in a single image between two ribs.

The chest CT scans of all patients were interpreted by a radiologist with 10 years of experience, following the guidelines provided by the radiologic society of North America (RSNA).

2.6. Statistical analysis

Demographic information, vital signs, ultrasound results, and CT scan reports of patients were collected in a designed questionnaire. Statistical analysis was performed using STATA-16. Descriptive results were expressed as a mean and standard deviation. Sensitivity, specificity, and positive and negative predictive values were calculated for CT and ultrasound results.

3. Results

3.1. Baseline characteristics

A total of 100 patients, 60% of whom were male, with a mean age of 43.0 ± 16.9 years (range: 18 -89 years) and clinical manifestations of COVID-19 were enrolled in the study. The mean distribution of clinical features is presented in table 1.

Abnormal findings in LUS were detected as B-lines in 40 (40.0%) cases and stabilization in 8 (8.0%) cases. Suspected irregular collection lines were 3 to 5 focal B lines, and 3 of them were positive chest CT scans with small lung involvement. The sensitivity of ultrasound to detect pulmonary

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Table 1 Mean distribution of clinical features

Variables	Min	Max	Mean (SD)
Age, year	18	89	43±16.9
Oxygen Saturation (So2), %	80	99	95.8±2.8
Systolic blood pressure (BP), mmHg	86	200	123±17.7
Diastolic BP, mmHg	55	104	78.6±10
Pulse Rate (PR), beats/min	60	134	87.4±14
Respiratory rate (RR), breaths/min	16	26	18.2±1.6
Temperature, °C	36	39.4	3±0.4

Screening performance with 95% Confidence interval; Min: Minimum; Max: Maximum; SD: Standard deviation

Table 2 Frequency distribution of positive and negative cases of COVID-19 based on the results of LUS and chest CT scan

	Low dose lung CT-scan-positive	Low dose lung CT-scan-negative	Total
Lung US positive	40	8	48
Lung US negative	1	51	52
Total	41	59	100

CT scan: Computed tomography scan; US: Ultrasound

involvement of COVID-19 was 97.5%, with a specificity of 86.4%, a positive predictive value of 83.3%, and a negative predictive value of 98%. The frequency distribution of positive and negative cases of COVID-19 based on the results of LUS and chest CT scan is presented in table 2.

4. Discussion

The diagnostic value of Lung ultrasound (LUS) in detecting COVID-19 has been the subject of several studies. Volpicelli G et al., first published the ultrasound manifestation of COVID-19 in 20 patients, where 12-point LUS was performed by two experienced physicians (10). Xing C et al., reported pleural and B line involvement in all 36 patients with COVID-19 in their study, with 64% showing consolidation (11). They concluded that while these manifestations are not specific to COVID-19 and can be seen in other viral pneumonias, combining these results with history and clinical signs during a COVID-19 epidemic can be very helpful for diagnosing infected cases (10).

Amatya et al. investigated the diagnostic value of LUS versus Chest X-ray (CXR) for diagnosing pneumonia compared with chest CT-scan. They reported a sensitivity and specificity of ultrasound at 91% and 61%, respectively, compared to 73% and 50% in lung X-ray (1).

Brenner et al. assessed the diagnostic accuracy of ultrasound for diagnosing COVID-19 in 174 patients, with PCR as the standard diagnostic test. They reported a sensitivity, specificity, and positive and negative predictive values of 90.9%, 75.6%, 87.2%, and 82%, respectively (12). They found that a higher body mass index (BMI) was associated with false-negative ultrasound results, and a significant relationship existed between false-positive cases and a history of previous interstitial lung disease (ILD), the presence of systolic heart failure, and ejection fraction (EF) less than 35% (12,13).

Haidan et al. reported that LUS may play strategic roles in the management of COVID-19 patients, with a sensitivity, specificity, and positive and negative predictive values of 66.67%, 100%, 100%, and 85.71%, respectively (14). LUS has proven useful in monitoring the progression of pulmonary involvement, early diagnosis of ventilator-dependent pneumonia, and has reduced the need for CT scan and pulmonary imaging (15). It can replace chest CT-scan in situations where CT-scan is not feasible, such as in pregnant women or unstable patients (3,4,16).

In our study, the sensitivity, specificity, and positive and negative predictive values were 97.5%, 86.4%, 83.3%, and 98%, respectively.

The differences in statistics obtained from various studies can be attributed to several factors: 1) the operator-dependent nature of ultrasound, 2) the sample size, and 3) the number of points examined on ultrasound (12). One of the limitations of our study is the small sample size due to the dissatisfaction of some patients with participating in the study and ultrasound scans performed by emergency department personnel in the emergency room.

5. Limitations

This study had several limitations. First, the PCR results of patients and the course of the disease were not followed up, which could have provided additional insights into the diagnostic accuracy of LUS. Second, the sample size was relatively small due to the inclusion criteria and the importance of quick examination and accurate diagnosis of patients. This may limit the generalizability of our findings. Lastly, the ultrasound was performed by a single individual in the emergency room. Given that other specialists in emergency medicine may not have sufficient experience with LUS, this could potentially introduce bias into the results. Future studies should consider these limitations and aim to include a larger sample size and multiple ultrasound operators to enhance the robustness and applicability of the findings.

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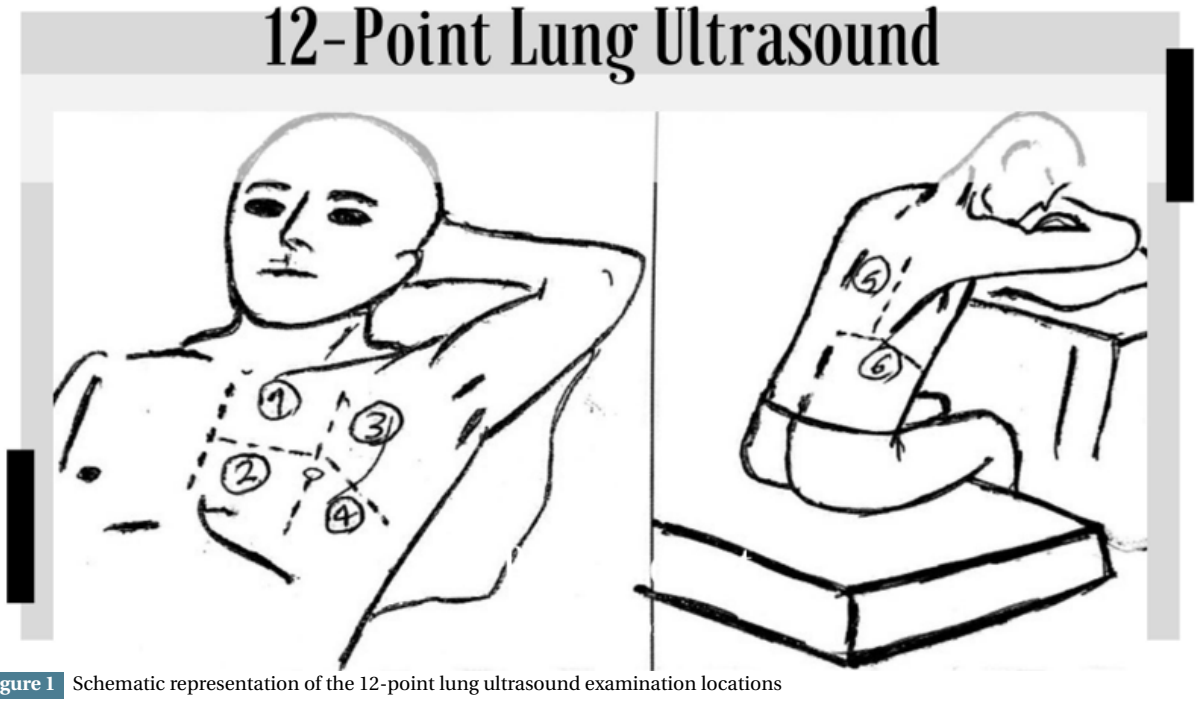

Figure 1 Schematic representation of the 12-point lung ultrasound examination locations

6. Conclusion

This study highlights the utility of lung ultrasound (LUS) in the context of the COVID-19 pandemic. LUS, being a fast, effective, and non-ionizing tool, can be a valuable alternative to chest CT scans in situations like CT scan unavailability, pediatric and pregnant populations, and intensive care management. It can be used alongside clinical examination, history, and rapid coronavirus testing for patient triage. However, more extensive studies with larger patient populations are needed to further validate these findings.

7. Declarations

7.1. Acknowledgement

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7.2. Authors' contribution

AP and FJ contributed to the conception and design of the study, data acquisition, analysis and interpretation, and drafting of the work. SHA contributed to the conception and design of the study and article writing. MGH, MG and KA contributed to the conception, data analysis, and critical revision of the work. All authors approved the submitted version and agreed to be accountable for their own contributions and for ensuring the integrity of the work.

7.3. Conflict of interest

None.

7.4. Funding

None.

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