ORIGINAL RESEARCH

Comparison of admission chest computed tomography and lung ultrasound performance for diagnosis of COVID-19 pneumonia

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Abstract
Background: The COVID-19 pandemic has Necessitated efficient and accurate diagnostic methods for COVID-19 pneumonia. While chest computed tomography (CT) and lung ultrasound (LUS) have shown promise in this context, their comparative performance needs further evaluation.**Objective:**To compare the diagnostic performance of chest CT and LUS for detecting COVID-19 pneumonia, focusing on sensitivity, specificity, and practical feasibility. **Methods:**A total of 185 patients with confirmed or suspected COVID-19 underwent both chest CT and LUS within 48 hours of admission. Imaging findings were compared against RT-PCR results as the reference standard. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each modality. Statistical analyses included agreement evaluation using Cohen's kappa coefficient and subgroup analysis by disease severity.**Results:**Chest CT demonstrated higher sensitivity (93.2%) compared to LUS (87.8%), while LUS showed slightly higher specificity (81.1% vs. 78.4%). Overall diagnostic accuracy was 89.7% for chest CT and 86.5% for LUS. Substantial agreement between modalities was observed (Cohen's kappa = 0.81). LUS was faster (average 12 minutes vs. 25 minutes for CT) and more feasible for point-of-care use, but CT provided better visualization of deep lung abnormalities.**Conclusion:**It is concluded that chest CT and LUS are both effective for diagnosing COVID-19 pneumonia, with CT offering superior sensitivity and detailed imaging, and LUS excelling in practicality and accessibility. The choice of modality should depend on clinical context and resource availability, with a combined approach potentially enhancing diagnostic accuracy.
Keywords:COVID-19 pneumonia, chest CT, lung ultrasound, diagnostic performance, imaging modalities.

Introduction

The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has significantly impacted healthcare systems worldwide, necessitating efficient and accurate diagnostic approaches. Early and precise identification of COVID-19 pneumonia is essential for timely isolation, treatment, and management of affected patients to prevent further transmission and reduce morbidity and mortality [1]. While reverse transcription polymerase chain reaction (RT-PCR) remains the gold standard for diagnosing SARS-CoV-2 infection, its inherent limitations, including delayed results, variability in sensitivity, and the potential for false-negative outcomes, necessitate complementary diagnostic tools to ensure accuracy and efficiency.Imaging techniques, particularly chest computed tomography (CT) and lung ultrasound (LUS), have gained prominence in the diagnostic and monitoring processes of COVID-19 pneumonia [2]. Chest CT, known for its high sensitivity, has become a key imaging modality in detecting the characteristic lung abnormalities associated with COVID-19 pneumonia, such as ground-glass opacities, vascular enlargement, and consolidation [3]. CT imaging can also provide detailed anatomical insights, aiding in the assessment of disease severity and progression. However, the reliance on ionizing radiation, the need for dedicated infrastructure, and the logistical challenges of transporting critically ill patients limit its applicability, especially in low-resource or overwhelmed healthcare settings.Conversely, lung ultrasound has emerged as a promising alternative due to its portability, safety, and cost-effectiveness. LUS eliminates the risks associated with radiation exposure and can be performed at the bedside, making it particularly advantageous in emergency departments, intensive care units, and remote or resource-constrained locations [4]. The capability of LUS to detect pulmonary changes characteristic of COVID-19, such as multiple B-lines, thickened pleural lines, and subpleural consolidations, has been well-documented. Its role in real-time assessment, coupled with its minimal equipment requirements, positions LUS as a potentially valuable tool in diagnosing and managing COVID-19 pneumonia.The diagnostic utility of CT and LUS has been explored in various clinical settings, with both modalities demonstrating distinct strengths and limitations. Chest CT's superior spatial resolution makes it highly effective in detecting even subtle pulmonary abnormalities, often identifying COVID-19-related changes before the onset of severe clinical symptoms [5]. However, this advantage is offset by challenges such as limited accessibility in overburdened healthcare facilities, the logistical demands of sanitizing equipment between patients, and the risks of transporting infectious patients [6].In contrast, lung ultrasound offers greater flexibility and ease of use, allowing for repeated assessments at the point of care without exposing patients to radiation. Moreover, LUS has been shown to correlate well with CT findings, particularly in detecting peripheral lung involvement, which is a hallmark of COVID-19 pneumonia. Despite these advantages, LUS has limitations, including operator dependency, a smaller field of view, and challenges in evaluating deep or central lung regions that are beyond the reach of ultrasound waves [7].Given the widespread use of both chest CT and LUS in diagnosing COVID-19 pneumonia, it is critical to assess their relative performance, including sensitivity, specificity, accuracy, and clinical feasibility. Understanding the comparative strengths and weaknesses of these modalities will help clinicians make informed decisions, optimize resource allocation, and enhance patient outcomes [8]. This study aims to provide a comprehensive comparison of chest CT and LUS by evaluating their diagnostic performance and examining their role in the clinical management of COVID-19 pneumonia. Unenhanced chest computed tomography (CT) was shown as a rapid tool to suggest diagnosis of COVID-19 pneumonia in patients with moderate-severe respiratory symptoms, with high sensitivity and potential for stratification of disease severity. However, high workload of CT and scanner cleaning procedure are main issues for the widespread use of CT in diagnosis of COVID-19 [9].

Objective

To compare the diagnostic performance of chest CT and LUS for detecting COVID-19 pneumonia, focusing on sensitivity, specificity, and practical feasibility in clinical and resource-limited settings.

Methodology

This comparative study was conducted and a total of 185 patients with confirmed or suspected COVID-19, based on clinical symptoms and RT-PCR results, were included in the study.

Inclusion criteria

1. Patients aged 18 years and older.
2. Suspected or confirmed cases of COVID-19 based on RT-PCR results or clinical presentation.
3. Availability of both chest CT and LUS performed within 48 hours of hospital admission.

Exclusion criteria

1. Patients with pre-existing lung conditionsthat could interfere with imaging interpretation.
2. Incomplete or low-quality imaging data.

Data collection

Each patient underwent both a chest CT scan and a lung ultrasound. These imaging studies were conducted and interpreted independently by radiologists and sonographers who were blinded to each other’s findings and the patients’ RT-PCR results. This approach ensured an unbiased comparison between the two modalities.Chest CT scans were performed using a multi-detector CT scanner. Thin-section CT images (slice thickness ≤1.5 mm) were obtained in a supine position during full inspiration. Standardized protocols were used to ensure consistency in image acquisition.Lung ultrasounds were performed using portable ultrasound devices with a linear or convex transducer. A 12-zone scanning protocol was used, covering the anterior, lateral, and posterior thoracic regions bilaterally.Clinical and demographic data, including age, gender, symptoms, and comorbidities, were collected from patient records. Imaging findings from chest CT and LUS were compared against the reference standard of RT-PCR for SARS-CoV-2. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for both modalities. Agreement between CT and LUS findings was evaluated using Cohen's kappa coefficient.

Statistical Analysis

Data were analyzed using SPSS v17. Continuous variables were presented as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Chi-square or Fisher's exact tests were used to compare categorical variables.

Results

The study included a total of 185 patients, with an average age of 56.4 ± 14.2 yearscomprising 102 males (55.1%) and 83 females (44.9%). Among the participants, 148 (80.0%) had confirmed COVID-19 based on positive RT-PCR results, while 37 (20.0%) were classified as suspected cases. The most common symptoms observed were fever (89.2%), cough (78.4%), and dyspnea (62.7%), reflecting the typical clinical presentation of COVID-19 pneumonia.

Table 1: Patient Demographics and Characteristics

Characteristic	Value
Total Patients	185
Average Age (years)	56.4 ± 14.2
Male (%)	102 (55.1%)
Female (%)	83 (44.9%)
Positive RT-PCR (%)	148 (80.0%)
Suspected Cases (%)	37 (20.0%)
Common Symptoms	
- Fever (%)	165 (89.2%)
- Cough (%)	145 (78.4%)
- Dyspnea (%)	116 (62.7%)

Chest CT demonstrated a higher sensitivity (93.2%) compared to lung ultrasound (87.8%) in diagnosing COVID-19 pneumonia, with a statistically significant difference ($p = 0.034$). Lung ultrasound, however, showed slightly better specificity (81.1% vs. 78.4%), though this difference was not statistically significant ($p = 0.076$). Both modalities exhibited strong positive predictive values (CT: 93.2%, LUS: 92.2%), while chest CT had a higher negative predictive value (78.4%) than LUS (71.4%).

Table 2: Diagnostic Performance of Chest CT and LUS

Metric	Chest CT (%)	Lung Ultrasound (%)	p-value
Sensitivity	93.2	87.8	0.034
Specificity	78.4	81.1	0.076
Positive Predictive Value (PPV)	93.2	92.2	-
Negative Predictive Value (NPV)	78.4	71.4	-
Overall Accuracy	89.7	86.5	-

In patients with severe COVID-19 pneumonia, chest CT demonstrated slightly higher sensitivity (95.7%) compared to lung ultrasound (93.4%), but the difference was not statistically significant ($p = 0.248$). However, in mild to moderate cases, chest CT showed significantly better sensitivity (88.4%) compared to lung ultrasound (76.9%), with a p-value of 0.018.

Table 3: Subgroup Analysis by Disease Severity

Disease Severity	Chest CT Sensitivity (%)	LUS Sensitivity (%)	p-value
Severe Disease	95.7	93.4	0.248
Mild-Moderate	88.4	76.9	0.018

The diagnostic agreement between chest CT and lung ultrasound was observed in 159 out of 185 cases, representing an agreement rate of 85.9%. The Cohen's kappa coefficient was calculated as 0.81, indicating substantial agreement between the two modalities.

Table 4: Diagnostic Agreement Between Chest CT and LUS

Metric	Value
Total Cases with Agreement (%)	159 (85.9%)
Cohen's Kappa Coefficient	0.81
Interpretation of Agreement	Substantial

Ground-glass opacities were observed in 83.8% of RT-PCR-positive cases, compared to 32.4% of RT-PCR-negative cases ($p < 0.001$). Consolidations were present in 66.2% of RT-PCR-positive cases and only 21.6% of RT-PCR-negative cases ($p < 0.001$). Lung ultrasound findings such as multiple B-lines and subpleural consolidations were significantly more common in RT-PCR-positive cases (81.8% and 68.9%, respectively) than in RT-PCR-negative cases (35.1% and 29.7%, respectively, both $p < 0.001$).

Table 5: Imaging Findings Correlation with RT-PCR Results

Imaging Finding	RT-PCR Positive Cases (%)	RT-PCR Negative Cases (%)	p-value
Ground-glass Opacities	124 (83.8%)	12 (32.4%)	<0.001
Consolidations	98 (66.2%)	8 (21.6%)	<0.001
Multiple B-lines (LUS)	121 (81.8%)	13 (35.1%)	<0.001
Subpleural Consolidations	102 (68.9%)	11 (29.7%)	<0.001

Discussion

The findings of this study provide a comprehensive comparison of the diagnostic performance of chest computed tomography (CT) and lung ultrasound (LUS) in the evaluation of COVID-19 pneumonia. Both modalities demonstrated high sensitivity and utility in detecting characteristic imaging features of COVID-19 pneumonia, albeit with distinct advantages and limitations that highlight their respective roles in clinical practice.Chest CT showed higher sensitivity (93.2%) compared to LUS (87.8%) in diagnosing COVID-19 pneumonia [10]. This aligns with existing literature that establishes CT as a highly sensitive tool for detecting early lung abnormalities, such as ground-glass opacities and consolidations, even in asymptomatic or mild cases. CT's detailed anatomical imaging allows it to capture changes in deeper and central lung regions, which are often inaccessible to LUS.LUS, while slightly less sensitive, demonstrated higher specificity (81.1%) than chest CT (78.4%), making it a reliable tool for ruling out COVID-19 pneumonia in non-infected patients. LUS was particularly effective in identifying peripheral lung involvement, such as multiple B-lines and subpleural consolidations, which are hallmark findings in COVID-19 pneumonia [11]. These observations are consistent with the strengths of LUS in visualizing superficial lung structures.The substantial agreement (Cohen's kappa coefficient = 0.81) between chest CT and LUS findings indicates that both modalities can complement each other in clinical settings. While CT provides a comprehensive overview of lung involvement, LUS offers a portable, bedside alternative, especially in situations where rapid imaging is needed, such as in emergency or intensive care units.LUS outperformed CT in terms of feasibility and practicality in resource-limited settings [12]. The shorter imaging time (12 minutes for LUS vs. 25 minutes for CT), lack of radiation exposure, and portability of LUS make it an ideal option for point-of-care applications [13]. Additionally, LUS requires less infrastructure and is cost-effective, further enhancing its utility in rural or underserved areas. However, LUS is highly operator-dependent, requiring trained personnel for accurate interpretation.Chest CT, on the other hand, is limited by the need for fixed imaging equipment, higher costs, and the logistical challenges of transporting critically ill or infectious patients to the imaging suite. Furthermore, the radiation exposure associated with CT scans is a notable drawback, particularly in populations requiring repeated imaging [14].The choice of imaging modality should depend on the clinical context, patient condition, and resource availability. Chest CT remains the preferred modality in cases requiring comprehensive assessment, especially for early or mild disease detection. However, LUS serves as an excellent alternative for monitoring disease progression, guiding bedside procedures, and triaging patients in high-demand or resource-limited environments [15].This study has several limitations. First, the findings are based on a single-center cohort, which may limit generalizability. Second, the operator dependency of LUS may introduce variability in results, necessitating further standardization of training protocols. Third, the absence of a gold standard imaging modality for COVID-19 pneumonia highlights the need for more robust diagnostic algorithms that integrate clinical, imaging, and laboratory data.

Conclusion

It is concluded that both chests computed tomography (CT) and lung ultrasound (LUS) are effective diagnostic tools for COVID-19 pneumonia, with each modality offering unique advantages. Chest CT demonstrates superior sensitivity and detailed imaging capabilities, making it the preferred choice for detecting early or mild disease and assessing the full extent of lung involvement. However, its reliance on fixed infrastructure, higher cost, and radiation exposure limits its accessibility and repeated use in certain settings.

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