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Lung Ultrasound characteristics of patients presenting to the Emergency Department with suspected COVID-19 infection

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Purpose

We aimed to describe the diagnostic accuracy of COVID-19 by lung ultrasound (LUS) in patients presenting to the emergency department with high suspicion of COVID-19 infection. We also evaluated the inter-rater agreement of interpretation of ultrasound scans between an attending and resident physician.

Methods

The study was a single-centre, descriptive study, with a sample of patients presenting to the emergency department at Akershus University hospital in Norway.

Study subjects were enrolled from May 28, 2020, to December 1, 2020.

All patients who presented to the ED were screened for the risk of COVID-19 infection based on a questionnaire used in triage. Patients were eligible for inclusion if they met any of the following criteria: new onset of airway symptoms, flu-like symptoms, abdominal pain, decreased consciousness, or had been in contact with COVID-19 positive individuals preceding debut of presenting symptoms. Exclusion criteria were age < 18, critically ill patients with severe respiratory or circulatory instability, and patients with symptoms of an obvious aetiology other than COVID-19.

RT-PCR nasopharyngeal swabs were collected and sent to the hospital laboratory and LUS with an eight-zone protocol was recorded by emergency physicians. The recorded ultrasound scans were retrospectively reviewed and evaluated by two investigators, an attending physician and resident physician. The inter-rater agreement between attending and resident physician was calculated.

Archived lung scans with thickened or indented pleural line, B-lines or subpleural consolidation in at least one lung zone were interpreted as pathological and suggestive of COVID-19 infection. The RT-PCR served as a reference standard test to calculate the accuracy of diagnosing COVID-19 by LUS.

Results

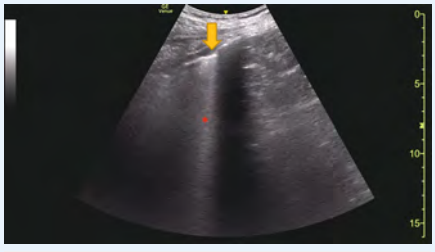
29 patients were included in the study. 21 tested positive for COVID-19 and 8 tested negative by RT-PCR. LUS scans interpreted by the attending physician had sensitivity 95,2 %, specificity 25,0 %, PPV 76,9 %, NPV 66,7 % and accuracy of 75,9 %. In comparison, scans interpreted by the resident physician yielded a LUS sensitivity 81,0 %, specificity 25,0 %, PPV 73,9 %, NPV 33,3 %, and accuracy of 65,5 % (▶ **Table 1**). There was a substantial agreement (kappa value 0,613) on the ultrasound interpretation between the investigators.

B-lines and thickened or indented pleural line (▶ **Fig. 1, 2**) were the most predominant ultrasonographic findings in RT-PCR positive patients. Presence of pleural fluid and larger consolidation were uncommon.

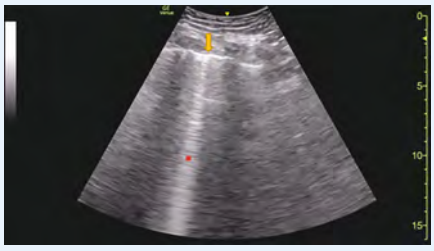
▶ **Table 1** Test characteristics of lung ultrasound diagnosing COVID-19.

	Attending Physician interpretation	Resident physician interpretation
Sensitivity	95,2 %	81,0 %
Specificity	25,0 %	25,0 %
PPV	76,9 %	73,9 %
NPV	66,7 %	33,3 %
Accurracy	75,9 %	65,5 %

PPV, positive predictive value; NPV, negative predictive value.



▶ **Fig. 1** LUS findings in patient with COVID-19. Thick indented, asymmetrical pleural line (yellow arrow), with pathological vertical B-line (red asterisk).



▶ **Fig. 2** LUS findings in patient with COVID-19. Indented pleural line with small subpleural consolidation (yellow arrow), with pathological vertical B-line (red asterisk).

In the RT-PCR negative group, pathological LUS findings were present in 75 % (n = 6). Of these, 5 were diagnosed with bacterial pneumonia and one with malignant neoplasm of the lung.

Discussion

Earlier studies examining the diagnostic accuracy of LUS in COVID-19 patients have shown a high degree of variation. In a meta-analysis conducted by Matthies et al. the sensitivity of LUS in adult patients with suspected COVID-19 ranged between 68 to 96 % and specificity between 21 to 91 % [1].

A single centre study conducted by Hankins et al. with a similar patient population as ours found a sensitivity of 100 % and specificity of 80 % for LUS interpreted bedside [2]. The discrepancy in performance characteristics of LUS between this study and ours can be explained by the access to real-time clinical data during the LUS interpretation. In the same study, interpretation by a physician relying only on archived LUS scans yielded a poorer test characteristic with a sensitivity and specificity of 92 % and 37 % respectively, which is in line with our study. Thus, integrating imaging findings bedside with clinical data may enhance the diagnostic accuracy of LUS.

It is also possible that the high sensitivity and low specificity in our study is related to the low diagnostic threshold used to diagnose COVID-19 by LUS. Presence of at least one abnormal LUS finding is reported to generate low diagnostic thresholds for COVID-19 [3]. On the contrary, using a diagnostic threshold for COVID-19 with at least 2 abnormal ultrasonographic findings is considered to generate a more balanced sensitivity and specificity.

Moreover, it is likely that the eight-zone scanning protocol used in our study could have affected the performance characteristics of LUS. The eight-zone protocol is known to be a quick scanning modality and ideal in the emergency department where patients might be immobilized and not able to maintain a sitting position. However, it limits the examination to four zones per lung where the posterior lung zones are omitted. Using a twelve-zone LUS examination has shown to be more sensitive and specific for diagnosing COVID-19.

Ultrasonographic findings in patients with COVID-19 are also known to correlate with the clinical stage and severity of the infection [4]. Delayed lung ultrasound can allow COVID-19 associated lesions to develop and might be better visualized when repeated after admission [5]. Studies have shown that lung changes are related to the stage of the disease and peak on day 9–13 after onset of symptoms [6]. Hence, we acknowledge that LUS performed early during the admission or pre-hospital might have resulted in false negative scans.

LUS is known to be a diagnostic modality which can be performed by novice sonographers and physicians after a short period of training and lecturing [7]. Our study showed a substantial agreement of detecting COVID-19 pathology of LUS reviewed by physicians with different clinical experience.

Our study was conducted during a phase of the pandemic when the Omicron gene variant had not yet emerged. The Omicron variant is the dominant subtype of SARS-CoV-2 today and reported to be associated with fewer lower respiratory tract infection and less involvement of the lungs [8]. Since LUS is used to evaluate for pulmonary manifestations of COVID-19 infection, the diagnostic performance of LUS found in our study may not be applicable in a setting with high prevalence of the omicron variant.

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