Lung ultrasound: a valuable tool for assessing COVID-19 patients with different severity

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To the Editor: Lung ultrasound (LUS) may be a promising technique to assess lung injury from coronavirus disease 2019 (COVID-19). However, the LUS characteristics and their assessment value have not been well described. We aimed to explore the LUS characteristics and their assessment value in COVID-19 patients with different levels of disease severity.

We conducted a single-center retrospective, observational study on COVID-19 patients in Hankou Hospital (Wuhan, China). Patients confirmed with COVID-19 who underwent LUS examination within 24 hours after being admitted to the sixth isolation wards from January 26, 2020 to March 19, 2020, were enrolled. The diagnosis and clinical classification were assessed according to the seventh version of the guidelines issued by the National Health Commission of China on Diagnosis and Treatment of COVID-19.[1] The Ethics Commission of Hankou Hospital approved this study (HKYY-2020-028) and the requirement for informed consent was waived by the ethics committee.

LUS was performed using a venue (GE Healthcare, Chicago, IL, USA) with a linear (5–13 MHz) or convex probe (2.0–5.5 MHz) for visualization of pleural line or tissue-like patterns, respectively. The international consensus conference recommended an eight-region approach for anterolateral field examination in the emergency department.[2] We also examined the areas inferior to bilateral scapulas to evaluate the posterior lungs.[3] Therefore, a total of ten regions were examined, each of which was characterized by the most severe ultrasound abnormality.

According to the ultrasound pattern, the LUS was scored as follows: the presence of A-lines alone with lung sliding or ≤2 B-lines (0 point), ≥3 well-spaced B-lines (1 point), coalescent B-lines (2 points), and lung consolidation (3 points).[4] The LUS score of each zone ranged from 0 to 3 and the global LUS score was calculated as the sum of the ten regions’ scores, ranging from 0 to 30. Interobserver reproducibility of the LUS score was performed by analyzing patient LUS data stored in videos by two different blinded investigators.

The Kolmogorov–Smirnov test was used to assess the normality of the data distribution. Continuous data with a normal distribution are expressed as the mean and standard deviation, and data without a normal distribution are presented as medians and interquartile (first-third quartile) ranges. Categorical data were described as counts and percentages. Continuous variables were analyzed using Student t-test if normally distributed, or the Wilcoxon signed-rank test if the distribution was skewed. Categorical variables were compared using the Chi-squared test. Interobserver agreement in the LUS score for each region was assessed using the kappa coefficient test. Receiver-operating characteristic (ROC) curves were plotted and the area under the curve (AUC) was used to assess the discriminative capacity of the LUS scores. A P value < 0.05 was considered statistically significant with 95% confidence intervals (CIs). These statistical analyses were performed using SPSS 19.0 software (Chicago, IL, USA).

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Chinese Medical Journal 2022;135(9)
A total of 215 patients were hospitalized in the sixth isolation ward of Hankou Hospital, 55 of whom underwent LUS examination within 24 hours of admission. After excluding 13 patients who could not be confirmed as having COVID-19, we included 42 patients in the final analysis. The median age was 62 years (interquartile range [IQR], 51–68; range, 28–86 years), and 21 (50%) were male. All patients were classified into moderate (n = 14, 33.3%), severe (n = 22, 52.4%), and critical (n = 6, 14.3%) groups. Among the 42 patients, 37 (88.1%) patients were discharged and 5 (11.9%) patients died in the hospital. [Supplementary Table 1 and Table 2, http://links.lww.com/CM9/A868].

The LUS of patients with COVID-19 was characterized by A-lines, B-lines (including isolated B-lines, multiple separated B-lines, and coalescent B-lines), and lung consolidation. No pleural effusions were found [Figure 1A]. The A-lines were predominantly detected in moderately ill patients, which were significantly higher than that in severely and critically ill patients (72.9% vs. 27.3% vs. 5.0%; P < 0.001). Conversely, coalescent B-lines were most commonly observed in critically ill patients compared with severely and moderately ill patients (76.7% vs. 25.4% vs. 4.3%, P < 0.001). In addition, the proportion of lung consolidation significantly increased with the severity of the disease (0.7% vs. 4.1% vs. 8.3%, P = 0.024).

Among the patients who survived, >40% and nearly 20% of lung area were represented as A-lines or ≤2 B-lines, which was significantly higher than that of patients who did not survive (A-lines: 44.3% vs. 4.0%, P < 0.001; ≤2B-lines: 16.2% vs. 2.0%, P < 0.001). However, the proportion of coalescent B-lines was significantly higher in nonsurvivors than in survivors (84.0% vs. 18.1%, P < 0.001). From anterior to dorsal regions of the lung, the proportions of A-lines significantly decreased (anterior zone: 64.2% vs. lateral zone: 33.1% vs. posterior zone: 27.0%, P < 0.001) and the proportion of coalescent B-lines significantly increased (anterior zone: 3.4% vs. lateral zone: 21.6% vs. posterior zone: 40.5%, P < 0.001) [Figure 1B].

The interobserver agreement for LUS score was demonstrated with a kappa of 0.872 (95% CI: 0.765–0.973). For different groups of patients, the global LUS scores and regional LUS scores were significantly higher in critically ill...
patients than in moderately and severely ill patients (global LUS scores: critical, 19.5 [15.25, 21.25] vs. severe, 9.0 [6.0, 12.25] vs. moderate, 1.0 [0.0, 3.0]; \( P < 0.001 \)). And the global LUS scores and regional LUS scores of nonsurvivors were also significantly higher than those of survivors (global LUS scores: nonsurvivors, 20.0 [16.0, 21.5] vs. survivors, 6.0 [1.5, 10.5]; \( P < 0.001 \)) [Supplementary Table 3 and Table 4, http://links.lww.com/CM9/A868].

The AUC of LUS scores in discriminating severely and critically ill patients from moderately ill patients was 0.948 (95% CI: 0.879–1.016), and an LUS score cut-off of 4.5 had a sensitivity of 89.3% and a specificity of 92.9% [Figure 1C]. The AUC of LUS scores for diagnosing critically ill patients was 0.984 (95% CI: 0.947–1.020), and the LUS score cut-off of 15.0 had a sensitivity of 83.3% and a specificity of 100% [Figure 1D]. In addition, an LUS score higher than 17.5 points could predict the mortality of COVID-19 patients with an AUC of 0.975 (95% CI: 0.922–1.028), a sensitivity of 80%, and a specificity of 100% [Figure 1E].

This retrospective study describes the LUS characteristics of COVID-19 patients with different severity, mainly manifesting as varying degrees of A-lines, B-lines, lung consolidation, and rarely pleural effusion. First, in the case of increased severity of disease, LUS showed aggravated lung injury, presenting as significantly reduced A-lines and increased coalescent B-lines or consolidation. Second, the patients who survived had 60% normal aeration and the presence of lung sliding with A-lines or \( \leq 2 \) B-lines, whereas those who died lost 90% of lung aeration resulting from coalescent B-lines or lung consolidation. Third, our study indicated that the global LUS score is valuable for rapidly assessing the severity of lung injury and assessing the prognosis of the COVID-19 patients. A global LUS score of \( >4.5 \) could distinguish severely and critically ill patients from moderately ill patients, whereas a global LUS score of \( >15 \) could identify critically ill patients. Moreover, a global LUS score of \( >17.5 \) could predict the mortality of COVID-19 patients with a sensitivity of 80%, specificity of 100%, and AUC of 0.975.

The use of LUS scores to quantify the severity of lung involvement has been described in critically ill patients with ARDS.\(^4\) Recently, researchers in Italy also proposed using LUS scores to classify the severity of COVID-19.\(^5\) Similarly, we estimated the severity of lung involvement by LUS scores and found that the global LUS scores were significantly higher in critically ill patients than in moderately and severely ill patients. This method of semi-quantification may be used in the early stage to identify COVID-19 patients with more extensive pulmonary involvement who should probably be referred to the intensive care unit (ICU). It may also be useful for estimating the extent of lung injuries and triaging patients for invasive vs. noninvasive ventilation.

Our study has some limitations. First, only 42 patients with confirmed COVID-19 were included, and this was a retrospective observational study. However, the population was similar to studies previously published, therefore the findings may be generalized to a wider population with similar characteristics.\(^6\) We also believe that our findings can provide a proof-of-concept pending further validation in larger observational studies or clinical trials. Second, the LUS examination was performed by the 10-partition method, whereas a more comprehensive 12-region approach is commonly used in the ICU. However, because of the influx of patients and lack of medical staff at that time, it was difficult to scan two posterior areas per side and the international consensus conference suggested that an eight-region approach for anterolateral fields examination in the emergency department could also be useful. Therefore, we added one region below each scapula to analyze the posterior lungs.

In conclusion, LUS is a valuable tool for rapid assessment of the severity of lung injuries in patients with COVID-19. The LUS score has a high discriminatory capacity to reflect clinical classification and predict prognosis.

Acknowledgments

Xiang Si wants to thank his wife Daiyin Cao and daughter Wei Si, who have given him support during 2 months fight against with COVID-19 in Wuhan. Xiang Si also wants to thank his classmates Caiyun Liao for her kind help with the manuscript.

Funding

The study was supported by the grants from Wu Jieping Medical Foundation (Nos. 320.6750.18037, 320.6750.18068) and Guangdong Medical Research Foundation (No. A2020300).

Conflicts of interest

None.

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How to cite this article: Si X, Yi H, Liu D, Wang R, Liu Y, Wu J, Guan X. Lung ultrasound: a valuable tool for assessing COVID-19 patients with different severity. Chin Med J 2022;135:1114–1116. doi: 10.1097/CM9.000000000001921