



Contribution of Bedside Lung Ultrasonography to Diagnose in Cases Considered COVID-19 in the Emergency Department

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Abstract: -

Objective: In this study, we applied the “Six-Zone Lung Point of Care Ultrasonography Scanning Protocol” (6-ZONE), in which the patient is in a sitting position and the lung parenchymal tissue is evaluated from 6 different regions, in order to reduce the risk of droplet transmission to the practitioner. Our aim is to determine the diagnostic value of 6-ZONE in the emergency department (ED) and to determine the correlation between 6-ZONE and computed tomography (CT) results.

Material and Methods: This prospective observational clinical study included 50 patients who presented to the ED with suspicion of COVID-19. All participants underwent thorax CT, 6-ZONE and Real-Time Polymerase Chain Reaction (RT-PCR) test, but the reference diagnostic method was determined as thorax CT.

Results: According to 6-ZONE, 52% of the patients (n=26) were evaluated as COVID-19 pneumonia. However, 6-ZONE was found to be false positive in 2 patients and false negative in 3 patients. Accordingly, the sensitivity of 6-ZONE was calculated as 96.3%, specificity as 89.6%, positive predictive value as 94%, and negative predictive value as 86.6%.

Conclusions: 6-ZONE performed in the ED for suspected COVID-19 diagnosis has high sensitivity and specificity, and 6-ZONE application may preferred.

Keywords: COVID-19; coronavirus; safety; lung.

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1. Introduction

Real-Time Polymerase Chain Reaction (RT-PCR) test is used as the gold standard in the diagnosis of COVID-19 disease, which was first identified in China in 2019 and quickly affected the whole world (1) Lung computed tomography (CT) is frequently used in emergency departments (ED) to support the diagnosis, identify parenchymal damage and make a differential diagnosis in patients who clinically present with pneumonia and have a negative PCR test (2)

The fact that the disease is common all over the world, the CT device is not available in every hospital, the need to sterilize

the device and the environment after each scan to prevent contamination, and radiation exposure during the scan are the factors that limit the use of CT (3).

On the other hand, in COVID-19 cases with interstitial pneumonia, the use of Focused Lung Ultrasonography (FL-USG) performed at the bedside in the ED provides advantages in terms of diagnosis and follow-up. These are fast and easy to apply, low cost and no radiation effects (4).

The use of FL-USG has become widespread during the pandemic period, especially in areas such as ED where patient diagnosis and stabilization must proceed synchronously (3). Studies have shown that FL-USG provides information in

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correlation with CT about lung involvement in patients with difficulty diagnosing COVID-19 (3). Pathological changes seen in COVID-19 are particularly suitable for evaluation with FL-USG due to their peripheral and peripleural location (5, 6, 7).

COVID-19 pneumonia is an interstitial pneumonia, and the use of FL-USG in diagnosis is common in China and Italy. In studies, FL-USG shows an excellent correlation with CT findings and is always the ideal alternative method to an imaging method that includes radiation. The sensitivity of x-ray radiography is low in COVID-19 (59%) (8). However, USG may be a valid alternative to both RT-PCR and CT scanning (3).

In the studies, we saw that the 6-ZONE, which prioritizes imaging of the lung areas, is fast and reduces contamination due to the practitioner-patient position, and we decided to test the validity of this protocol in our own clinic (9). In this protocol, unlike other protocols, the main point is to reduce contact and droplet exposure thanks to the sitting patient position. FL-USG imaging usually occurs in the supine position. The sitting position is more comfortable for patients in situations such as acute respiratory distress and makes it easier to reach the posterior lung areas. Additionally, there are publications reporting that the sitting position can reduce mortality in non-COVID-19 acute respiratory distress syndrome (ARDS) patients. In hypoxemic patients with COVID-19, an awake sitting position can improve oxygenation and, in some cases, prevent intubation. Our null hypothesis was that FL-USG would be an alternative diagnostic method to CT among suspected patients screened for COVID-19 in the ED. The primary outcome measure was 6-ZONE's diagnostic value in the ED. Secondary outcome measures were the consistency between 6-ZONE and CT results for COVID-19 diagnosis. In addition, the use of 6-ZONE in the diagnosis of COVID-19 increases patient comfort, reduces the need for carrier personnel, contamination and radiation exposure (9).

In this study, we applied 6-ZONE to our patients, in which the patient is in a sitting position and the lung parenchymal tissue is evaluated from 6 different regions, in order to reduce the risk of contamination to the practitioner and to minimize the impact on droplet spread. Our aim in our study is to determine the diagnostic value of 6-ZONE in the ED. It also aims to determine the correlation between 6-ZONE and CT results for the diagnosis of COVID-19.

2. Methods

2.1. Study design

This prospective observational clinical study was conducted in the emergency department of Antalya Training and Research Hospital, a tertiary care hospital, between December 15, 2020 and February 15, 2020, after receiving approval from the ethics committee of the same hospital. The study protocol did not interfere with the patients' treatment and diagnostic methods, and the patients were not exposed to any risks. Written consent forms were obtained from all patients or their relatives included in the study.

2.2 Study population

Inclusion criteria are being 18 years of age or older, having symptoms suspicious for COVID-19 according to the Turkish Scientific Board Guide (10) (shortness of breath, fever, cough, flu-

like symptoms, extreme fatigue, worsening of symptoms if there is a chronic respiratory disease, loss of smell and taste, diarrhea) and being able to tolerate the sitting position were determined. Exclusion criteria were determined as patients who were unstable, in need of resuscitation, lung malignancy/metastasis, previous operation history, chronic obstructive pulmonary disease, patients with heart failure, pregnant women, trauma patients and patients previously diagnosed with COVID-19. The sample size was consistent with previous studies. We assumed that lung ultrasound has 80% sensitivity and 80% power with $\alpha=0.05$. Therefore, it was planned to include at least 50 patients in the study (11) (Figure 1).

First of all, symptom evaluation and physical examination were performed by the emergency physician. Demographic data (age, gender), vital signs (pulse, fever, blood pressure, respiratory rate, oxygen saturation), symptoms (dyspnea, tachypnea, fever, cough, flu-like symptoms, extreme weakness, worsening of symptoms, if there is chronic respiratory disease, new loss of smell and taste, diarrhea, sore throat) were recorded in the standardized study form. Then, before performing diagnostic tests, FL-USG was performed according to the 6-ZONE technique (9) and the findings detected for each lung region (pleural thickening/disorder/effusion, subpleural consolidation, increase/fusion of B lines, air bronchograms, hepatization, absence of lung sliding movement) was noted on the data collection form by the same practitioner. Later, lung CT findings interpreted by physicians unaware of the study were obtained from the hospital information management system.

All patients included in the study were tested for COVID-19 using the RT-PCR method. The main hypothesis of this study is to evaluate the accuracy of lung ultrasound in diagnosing COVID-19 pneumonia. For this reason, it is more important whether the patients included in the study have a pathology related to COVID-19 in their lungs rather than their positive RT-PCR tests.

FL-USG scans of each area were recorded as ten-second videos, and the findings were confirmed by at least two doctors upon replay. Cases in which there was disagreement about the findings were excluded from the study.

Bedside FL-USG application was applied by physicians who were certified by the Turkish Emergency Medicine Association for 8 hours of theoretical and 8 hours of practical training. In the study, FL-USG application was provided by 2 different physicians blinded to RT-PCR and thorax CT findings. A standard USG (Mindray DC-T6, Germany) 7.5 MHz linear probe was used.

2.3 Study protocol (6-ZONE)

When we looked at the literature on lung FL-USG protocols in COVID-19, we saw that there are many different methods. The reason why we use the bilateral 6-ZONE protocol is that it is fast, the risk of contact with the patient is reduced, it is diagnostic and it is an easily applicable method. In addition, the researchers who discovered the method stated that the 6-ZONE application time was less than 10 minutes, excluding the cleaning time (9).

In 6-ZONE application, we used (12) double gloves as recommended by Lichtenstein et al. We covered the entire USG device and the outer surface of the probe with a disposable transparent plastic cover. We used small, disposable packets of gel

during application, and the plastic cover of the device and the outer pair of gloves were removed after imaging. The emergency physician wiped down the entire machine with sodium hypochlorite while the inner pair of gloves was worn (12).

During the application, the patient was in a sitting position with his back turned in front of the practitioner and the USG device. This position was preferred because it would minimize the risk of contamination due to prolonged exposure. This position was preferred because it would minimize the risk of contamination due to prolonged exposure. In addition, the sitting position is more comfortable for many patients, especially those with respiratory distress, and makes it easier to reach the posterior lung areas. There are studies reporting that the awake sitting position prevents alveolar collapse, increases oxygenation, and in some cases protects against intubation (4). While scanning the patient's lung zones, a comparative scan was performed with the other side (9).

While the probe was in the sagittal plane and the notch was pointing at the patient's head, scanning was started by sliding the probe backwards and forwards along the half of the thorax, between the posterior axillary line and the paravertebral line, up to the mid-scapular line. Afterwards, scanning was performed using the lawn mower technique, starting from the most posterior and lower point of the thorax, to evaluate the distance between the posterior and anterior axillary lines. We repeated these for the upper and lower lateral zones. Since COVID-19 disease usually shows bilateral involvement, the other half of the thorax was also scanned in the same way (Figure 2).

We know that lung lesions in COVID-19 are generally located posteriorly and laterally (4). However, if no lesion is found in the scanned zones and the patient is still a suspicious case for COVID-19, the physician can also scan the anterior areas.

2.4. Measures

This study aimed to evaluate the competence of FL-USG performed with 6-ZONE in the diagnosis of COVID-19 in suspected patients who were screened for COVID-19 in the emergency department and to compare it with CT results.

The primary outcome measure was the diagnostic value of 6-ZONE the ED. Secondary outcome measures were the consistency between 6-ZONE and CT results for COVID-19 diagnosis.

2.5. Statistical Analysis

Continuous variables are presented as mean $\pm$ SD or median (inter-quartile range) for variables with a normal distribution. Categorical variables are presented as number and percentage. Group comparisons were performed with χ^2 -test or Fisher's exact test for categorical variables appropriately. All p values were two-sided, and P <0.05 was regarded as statistically significant. Statistical analyses were performed using SPSS statistical software version 26 (SPSS Inc., Chicago, Ill., USA).

3. Results

3.1. Characteristics of study subjects

The study included 50 patients. Demographic characteristics of the participants according to COVID-19 pneumonia status are shown in Table 1. Of the 50 participants whose data were

evaluated, 58% (n=29) were male, the average age was 68 (+14.3), 42% (n=21) were female, and the average age was 77 (+10.4).

3.2. Main results

Lung imaging evaluations are shown in Table 2. According to thorax CT, findings in favor of pneumonia were detected in 58% of the cases (n=29), 27 of which were reported as COVID-19 pneumonia and 2 patients as bacterial pneumonia.

Based on 6-ZONE, the most common findings of COVID-19 pneumonia were pleural thickening (86% (n=43)), followed by pleural irregularity (76% (n=38)), and increase/convergence of B lines 74% (n=37) (Figure 3).

According to FL-USG, 52% of the patients (n=26) were evaluated as COVID-19 pneumonia. However, FL-USG lung was found to be false positive in 2 patients and false negative in 3 patients. Accordingly, the sensitivity of FL-USG was calculated as 96.3%, specificity as 89.6%, positive predictive value as 94%, and negative predictive value as 86.6% (Table 3).

3.3. Limitations

A certain amount of operator experience and training is required to perform FL-USG and can lead to misinterpretations in inexperienced hands. Additionally, evidence linking FL-USG findings to the diagnosis or prognosis of COVID-19 is lacking. Therefore, all FL-USG findings in patients with suspected COVID-19 should be correlated with the overall clinical picture. Other limitations of our study included its small sample size, single-center nature, and a single reviewer. PCR testing was not performed on any patient by bronchoalveolar lavage.

Much more detailed and formalized lung ultrasound protocols have been described specifically for use in COVID-19 patients (13). Abbreviated protocols are preferred in community practice and may lead to missed diagnoses. This biases our study from our actual findings (14).

4. Discussion

A normal lung US optimal image includes A-lines, a few B-lines (<3 B-lines per intercostal space), and the pleural line, which appears as a smooth and thin line (12). The most common FL-USG findings associated with COVID-19 are isolated or diffuse B-lines, an irregular pleural line, areas of consolidation under the pleura, and edema around the pleura (Figure 1) (4). Findings are typically bilateral and most commonly seen in the posterior and lateral lung zones (4). Pathological changes seen in COVID-19 are particularly suitable for evaluation with FL-USG due to their peripheral and peripleural location. As is true with other viral or bacterial pneumonias, sonographic findings of COVID-19 may occur before radiographic findings (4).

Lung ultrasound has emerged as a clinical tool in medicine, with some advocates calling for it to replace the stethoscope (4). This study used a rapid protocol to perform FL-USG in patients with suspected COVID-19. This protocol is a bilateral six-site protocol that emphasizes image acquisition from the posterior and lateral lung fields. This focused protocol, which minimizes time spent on screening and optimizes provider positioning, is advocated to reduce the risk of exposure to the virus for healthcare workers (15).

Classically, in a supine patient, several USG protocols have been described to evaluate dyspneic patients in the ED. The first is a 12-point lung FL-USG that includes two anterior field regions, two lateral field regions, and two posterior field regions (16). This approach has also been recommended for use in patients with suspected COVID-19 (17). Recently, in addition to the above 12 zones, a new 14-zone lung scan has been described for patients with suspected COVID-19, adding two zones posteriorly adjacent to the bilateral scapula (18).

Huang et al reported the first recognized lung ultrasound features that follow a distinctive pattern across the chest in an upper anterior to lower posterior crescendo distribution. Shortly thereafter, Peng and colleagues described the correspondence between lung ultrasound findings and corresponding CT scan images in COVID-19 patients. In particular, they reported the relationship between lung ultrasound consolidations and CT images, as well as between ground-glass opacities and discrete or multifocal B-lines (15).

In 6-ZONE, patient positioning that reduces exposure to possible respiratory droplets is the key. For many patients with acute respiratory distress, an upright position may be more comfortable and provides easier access to the posterior lung fields. Additionally, placing patients in the prone position provided a mortality benefit in severe cases of acute respiratory distress syndrome not related to COVID-19 (19). Similarly, in hypoxemic patients with COVID-19, awake pronation may improve oxygenation and, in some cases prevent intubation (20-22). Both of these patient positions will optimize the operator's ability to scan both the posterior and lateral lung fields with less exposure to possible respiratory droplets.

This study revealed that 6-ZONE had a sensitivity of 96.3% and a specificity of 89.6% when using thorax CT as a reference in detecting lung pathology due to COVID-19 infection. Among all patients in this study, the positive predictive value of 6-ZONE was 94% and the negative predictive value was 86.6%. These findings are consistent with published case series and social media reports on the use of lung ultrasound in the diagnosis of COVID-19 (23, 24).

5. Conclusions

6-ZONE performed in the ED for the diagnosis of suspected COVID-19 has high sensitivity and specificity. Additionally, the use of the 6-ZONE should be favored as a standard training and imaging protocol for emergency physicians to use bedside FL-USG to aid in the diagnosis and exclusion of COVID-19 in the ED setting.

References

1. Ai T, Yang Z, Hou H, Zhan C, et.al. Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. *Radiology*, 296(2), E32-E40.
2. Meng H, Xiong R, He R, et al. (2020). CT imaging and clinical course of asymptomatic cases with COVID-19 pneumonia at admission in Wuhan, China. *Journal of Infection*, 81(1), e33-e39.
3. Walsh P, Hankins A, Bang H (2020). Point of care lung ultrasound is useful when screening for CoVid-19 in Emergency Department patients. *MedRxiv*.
4. Boero E, Schreiber A, Rovida S, et al. (2020). The role of lung ultrasonography in COVID-19 disease management. *Journal of the American College of Emergency Physicians Open*, 1(6), 1357-1363.
5. Bouhemad B, Rouby JJ (2012). Reply-Bedside Ultrasound Assessment of Positive End Expiratory Pressure-induced Lung Recruitment. *American Journal of Respiratory and CriticalCare Medicine*, 185(4), 456.
6. Soummer A, Perbet S, Brisson H, et al. (2012). Ultrasound assessment of lung aeration loss during a successful weaning trial predicts postextubation distress. *Critical care medicine*, 40(7), 2064-2072.
7. Marini JJ, Gattinoni L. (2020). Management of COVID-19 respiratory distress. *Jama*, 323(22), 2329-2330.
8. Borakati A, Perera A, Johnson J, Sood T. (2020). Diagnostic accuracy of X-ray versus CT in COVID-19: a propensity-matched database study. *BMJ open*, 10(11), e042946.
9. Duggan NM, Shokoohi H, Liteplo AS, et al. (2020). Best practice recommendations for point-of-care lung ultrasound in patients with suspected COVID-19. *The Journal of emergency medicine*, 59(4), 515-520.
10. Republic of Turkey Ministry of Health, Coronavirus Scientific Advisory Board COVID-19 Guide. 2023. Available from: <https://covid19.saglik.gov.tr/TR-66301/covid-19-rehberi.html>. Accessed December 18, 2023.
11. Lomoro P, Verde F, Zerboni F, et al. (2020). COVID-19 pneumonia manifestations at the admission on chest ultrasound, radiographs, and CT: single-center study and comprehensive radiologic literature review. *European journal of radiology open*, 7, 100231.
12. Lichtenstein DA (2015). BLUE-protocol and FALLS-protocol: two applications of lung ultrasound in the critically ill. *Chest*, 147(6), 1659-1670.
13. Sultan LR, Sehgal CM. (2020). A review of early experience in lung ultrasound in the diagnosis and management of COVID-19. *Ultrasound in Medicine & Biology*, 46(9), 2530-2545.
14. Kirkpatrick AW, Sirois M, Laupland KB, et al. (2004). Hand-held thoracic sonography for detecting post-traumatic pneumothoraces: the Extended Focused Assessment with Sonography for Trauma (EFAST). *Journal of Trauma and Acute Care Surgery*, 57(2), 288-295.
15. Soldati G, Demi M, Smargiassi A, et al. (2019). The role of ultrasound lung artifacts in the diagnosis of respiratory diseases. *Expert review of respiratory medicine*, 13(2), 163-172.
16. Lichtenstein DA. (2014). Lung ultrasound in the critically ill. *Annals of intensive care*, 4, 1-12.
17. POCUS 101. Complete GUIDE to LUNG ultrasound in COVID-19 (Coronavirus) Patients. Available at: <https://pocus101.com/complete-guide-to-lung-ultrasound-in-covid-19-coronavirus-patients/>. Accessed April 10, 2024.

18. Soldati G, Smargiassi A, Inchingolo R, et al. (2020). Proposal for international standardization of the use of lung ultrasound for patients with COVID-19: a simple, quantitative, reproducible method. *Journal of Ultrasound in Medicine*, 39(7), 1413-1419.
19. Guérin C, Reignier J, Richard JC, et al. (2013). Prone positioning in severe acute respiratory distress syndrome. *New England Journal of Medicine*, 368(23), 2159-2168.
20. Sun Q, Qiu H, Huang M, Yang Y. (2020). Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province. *Annals of intensive care*, 10, 1-4.
21. Slessarev M, Cheng J, Ondrejicka M, et al. (2020). Patient self-proning with high-flow nasal cannula improves oxygenation in COVID-19 pneumonia. *Canadian Journal of Anesthesia/Journal canadien d'anesthésie*, 67, 1288-1290.
22. Caputo ND, Strayer RJ, Levitan R. (2020). Early self-proning in awake, non-intubated patients in the emergency department: a single ED's experience during the COVID-19 pandemic. *Academic Emergency Medicine*, 27(5), 375-378.
23. Van Doremalen N, Bushmaker T, Morris DH, et al. (2020). Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England journal of medicine*, 382(16), 1564-1567.
24. American Institute of Ultrasound in Medicine (AIUM). Official statements. Guidelines for cleaning and preparing external- and internal use ultrasound transducers and equipment between patients as well as safe handling and use of ultrasound coupling gel. Available at: <https://www.aium.org/officialStatements/57>. Accessed April 10, 2020.

Table and Figure Legends

Table 1. Demographic characteristics, symptoms and outcomes of participants.

Patient	n=50 (%100)
Female	21 (%42)
Male	29 (%58)
Mean Age (SD)	72 (13,4)
Female	77 (10,4)
Male	68 (14,3)
Symptoms	
Shortness of breath	41 (%82)
Cough	19(%38)
Fever	16(%32)
Weakness	15(%30)
Myalgia	7 (%14)
Chest pain	4 (%8)
Cold	3 (%6)
General condition disorder	2 (%4)
Hemoptysis	1 (%2)
Patient Outcome	
Intensive care hospitalization	19 (%38)
Service hospitalization	18 (%36)
Discharge	12 (%24)
Death in the emergency department	1 (%2)

n: number, SD: Standard Deviation

Table 2. Findings on FL-USG lung for COVID-19 pneumonia

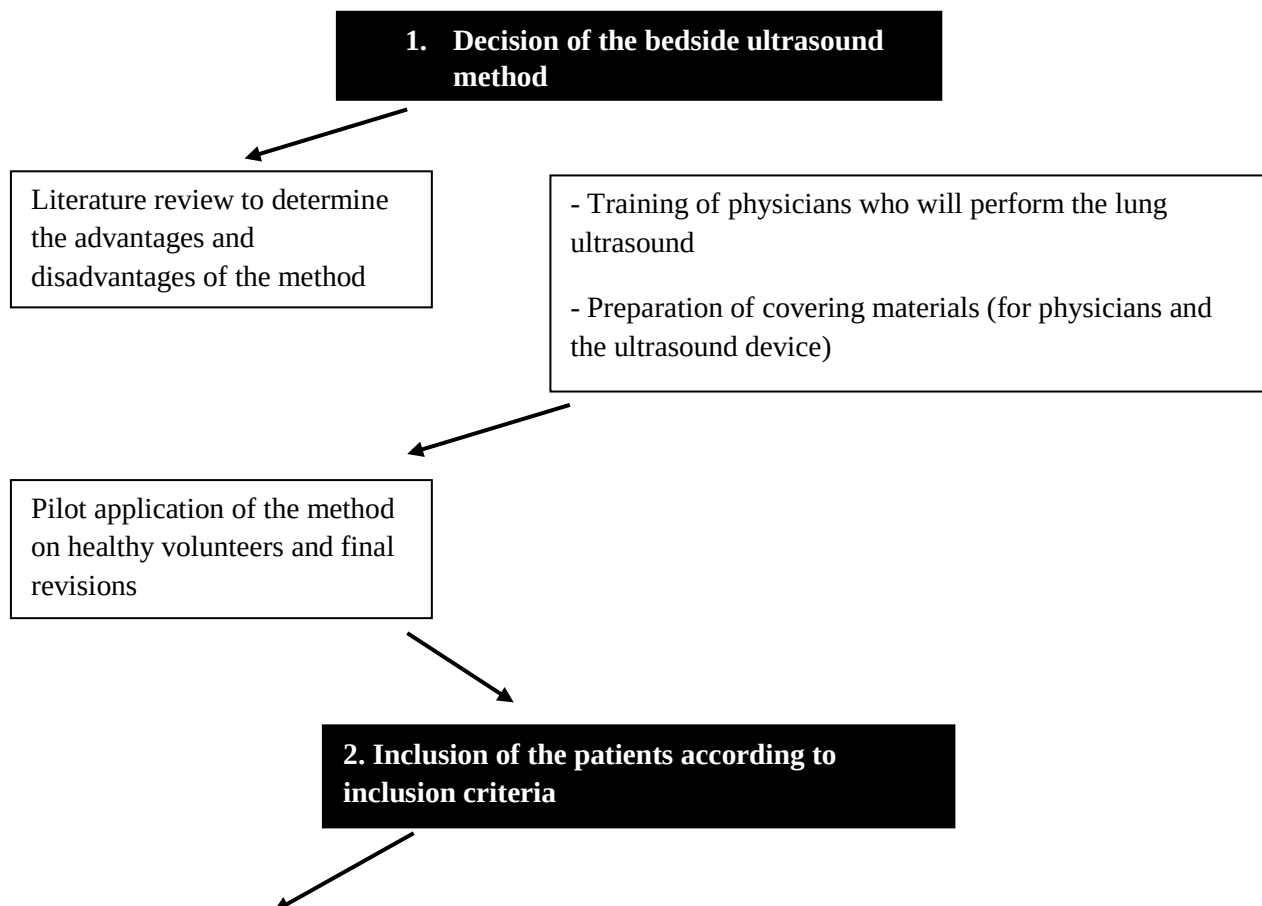
Finding	n (%)
Pleural thickening	43 (86%)
Pleural irregularity	38 (76%)
Increase/convergence of B lines	37 (74%)
Subpleural consolidation	26 (52%)
Pleural effusion	18 (36%)
Hepatization	8 (16%)
Absence of pleural sliding movement	4 (8%)
Air bronchograms	3 (6%)

FL-USG: Focused Lung Ultrasonography, n: number

Table 3. Test characteristics of FL-USG in diagnosing COVID-19 pneumonia.

	Value	95% CI
Sensitivity	96,3	81,30-99,91%
Specificity	89,6	86,60-94,20%
Positive likelihood ratio	0,03	0,01-,028
Negative likelihood ratio	5,54	3,7-9,4
Positive predictive value	94	84,40-98,20%
Negative predictive value	86,6	79,10-90,30%

FL-USG: Focused Lung Ultrasonography, CI: Confidence Interval



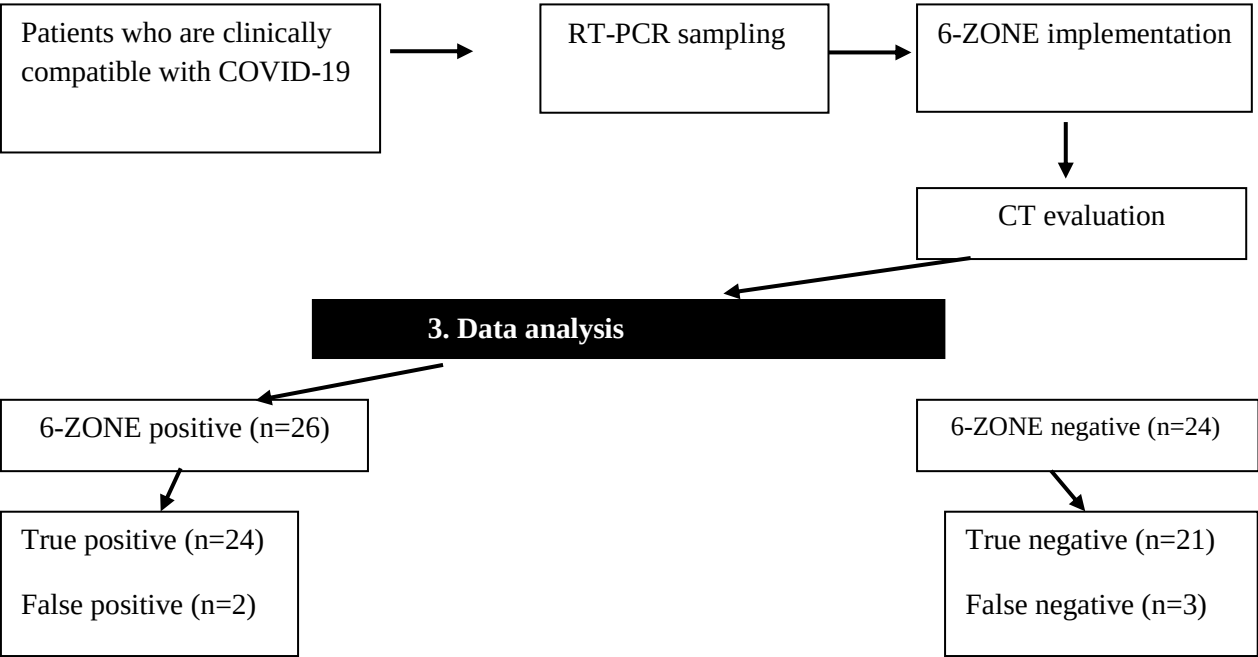


Figure 1. Study Framework

RT-PCR: Real-Time Polymerase Chain Reaction, 6-ZONE: Six-Zone Lung Point of Care Ultrasonography Scanning Protocol, CT: Computed Tomography, n: number

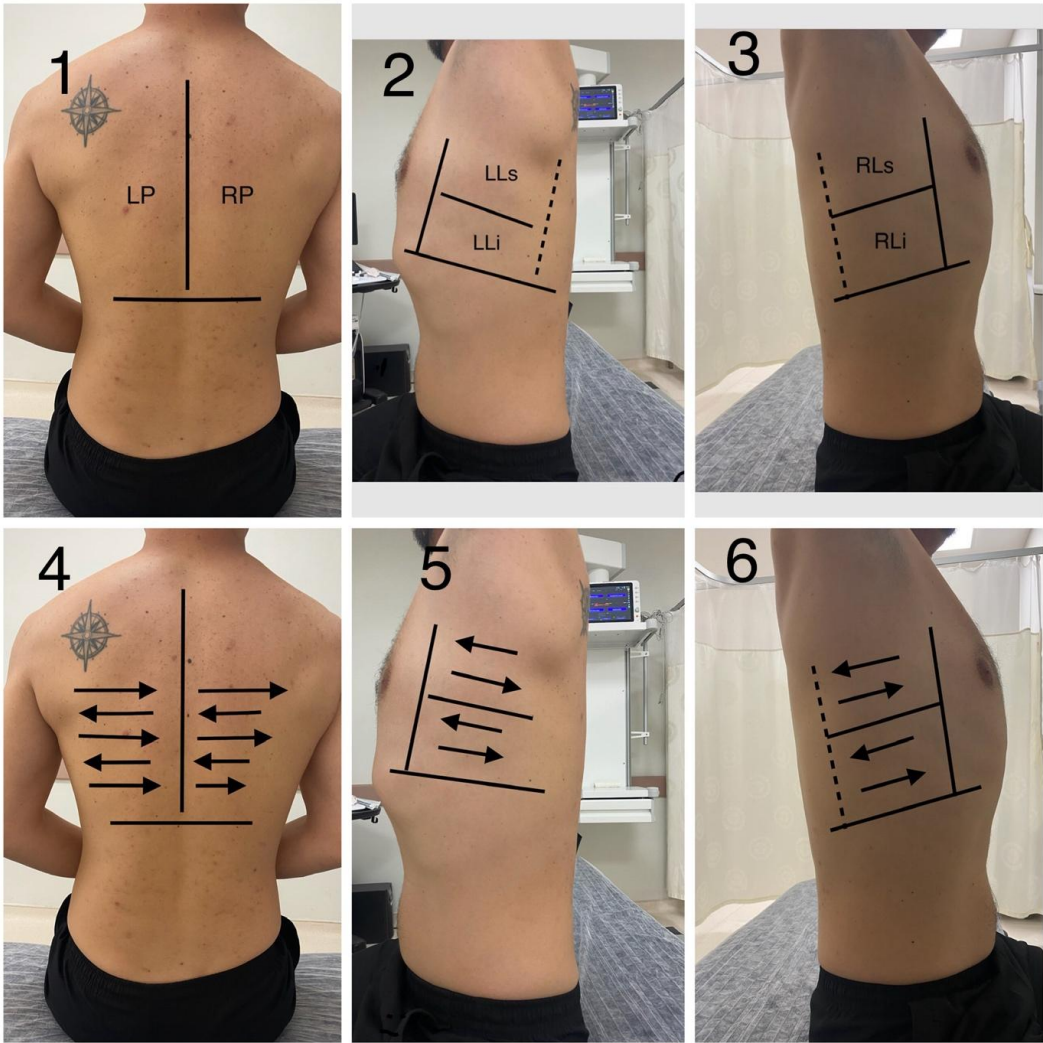


Figure 2: Anatomy and scanning technique for FL-USG in patient with suspected COVID-19.

(1) Landmarks for scanning include the inferior thorax at the level of the diaphragm, the spine, the scapula, and the posterior axillary line. Lung zones to be scanned include the areas under the scapula border known as the right posterior (RP) and left posterior (LP) zones. Laterally, landmarks include the posterior axillary line to the anterior axillary line. Lateral lung zones to be scanned include the right lateral superior (RLs) and (3) right lateral inferior (RLi), and on the left include the left lateral superior (LLs), and (2) left lateral inferior (LLi). (4) To obtain scans, position a linear or curvilinear probe sagittal with probe marker cranially to the patient and slide the probe across the posterior surfaces. Repeat this technique in the (6) right and (5) left lateral zones.

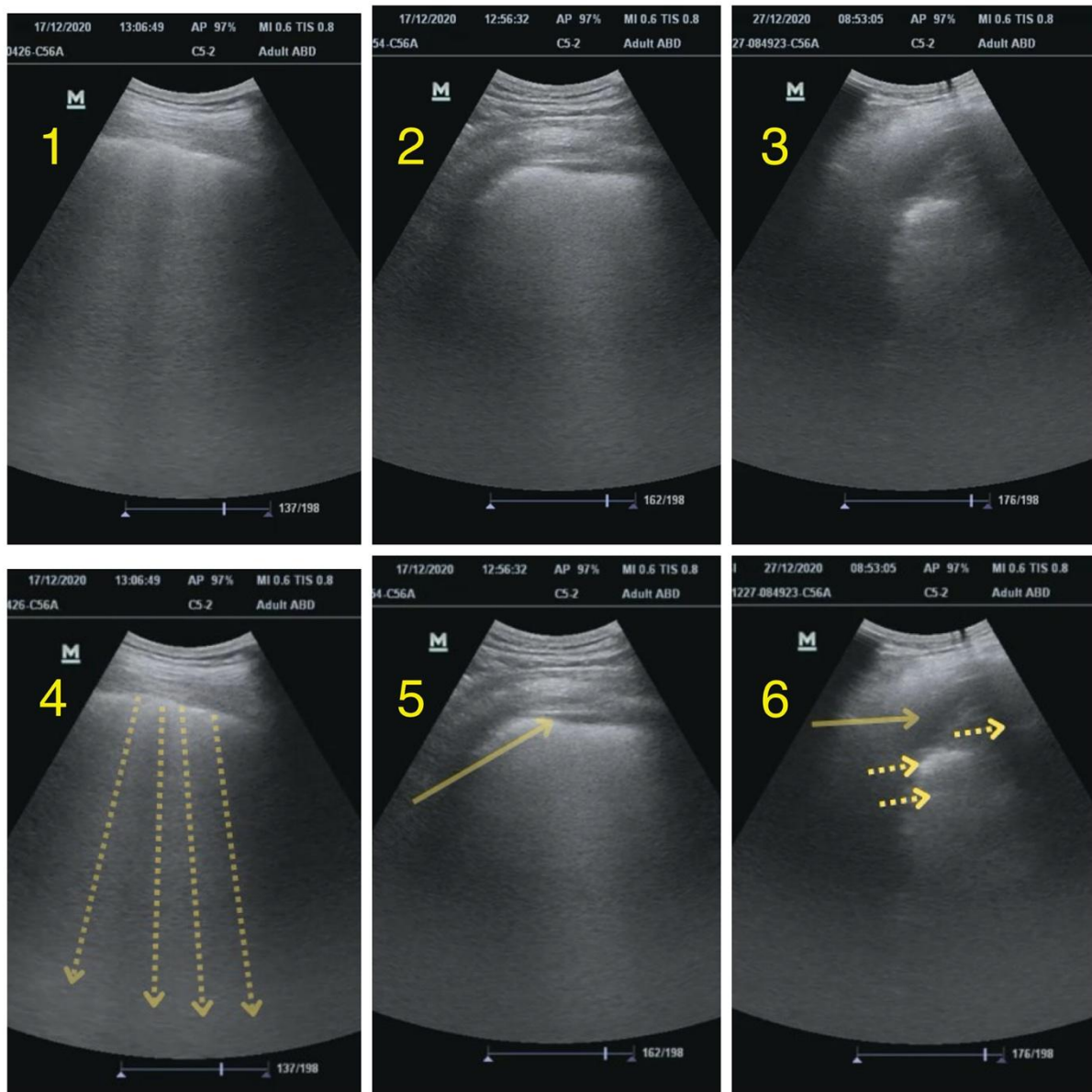


Figure 3. Some imaging examples of COVID-19 patients.

(1, 4) Dashed yellow arrows indicate the increase in B lines. (2, 5) The yellow continuous arrow indicates subpleural consolidation. (3, 6) Solid yellow arrows indicate consolidation, while multiple dashed yellow arrows indicate air bronchograms.