Fig. 2. A- TEE probe coming out with bite-block inside the US prober cover. B- US probe cover covering the whole probe including controls except the part inserted in patient. C- Bite block as inserted inside the probe cover. D − Final setup in clinical use.

Conflict of Interest

None.

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The Role of Lung Ultrasound in the Assessment of Novel Coronavirus Pneumonia

To the Editor:

A NOVEL coronavirus was discovered in the lower respiratory tract of a group of patients with pneumonia in Wuhan, Hubei province, China, in December 2019.[1] The disease caused by this novel coronavirus officially was named coronavirus disease-2019 (COVID-19) by the World Health Organization on February 11, 2020, and it has a highly infectious rate and a high mortality rate. As of April 1, there were 754,948 global infections of COVID-19, with 36,571 deaths (https://www.who.int/diagnostics_laboratory/EUL/en/). Although symptoms for most patients with COVID-19 are mild (common type) and those patients can recover spontaneously without specific treatment, a substantial proportion of patients will develop a severe case. The management of such severe cases is challenging. Early identification, evaluation of disease progress, and timely treatment of patients with COVID-19 are the keys to reducing the mortality of these patients.

Characteristics of Pulmonary Ultrasound

Lung ultrasound, a rapid, convenient, radiation-free, economical, repeatable, and bedside visual examination technology for lung diseases, plays an essential role in the diagnosis and treatment of critically ill patients. Lung ultrasound has advantages in the differential diagnosis of pulmonary exudative diseases, the evaluation of pleural effusion, the recognition of pneumothorax, the evaluation of dyspnea and acute respiratory failure, the monitoring of treatment, the evaluation of curative effect, and the guidance of treatment, and has formed a consensus of many experts worldwide. Because of the high infectiousness of the novel coronavirus pneumonia, we should make full use of lung ultrasound to guide diagnosis and treatment during the different stages of the disease.

Main Findings of Lung Ultrasound in COVID-19[2-4]

- B-line: A linear hyperecho starts from and runs perpendicular to the pleura line and radiates longitudinally to the deep part of the lung field.
- Lung point sign: With real-time ultrasound and respiratory movement, the lung point is the boundary point between the existence of a pulmonary slip and the disappearance of a pulmonary slip.

- Pulmonary pulsation sign: This sign reflects the insufficient inflation of the lung with movement of the pleura line consistent with that of heart. The existence of this sign can exclude pneumothorax.
- Stratospheric sign: When lung slip disappears, the particle-like spot echo under the pleura line is replaced by a series of parallel lines with M-mode ultrasound.
- Alveolar interstitial syndrome: This occurs when there are more than 2 consecutive costal spaces in any scanning area with a fusion B-line.
- White lung: A dense B-line is found in each scanning area of both lungs.

Pathologic Changes of the Lung in COVID-19[5]

The lung of a COVID-19 patient will demonstrate the formation of serous, fibrinous exudate and hyaline membrane in the alveoli. The epithelial cells of type II alveoli proliferate significantly. The blood vessels of the alveoli septum are congested and edematous, and bleeding and necrosis of the pulmonary tissue also are present. Some alveoli exudates are organized, and pulmonary interstitial fibrosis may occur. Disease onset often starts from the lateral zone of the lung, close to the pleura; therefore, pulmonary ultrasound can more effectively demonstrate the pathologic and dynamic changes of the lung condition.

Different lesions with different ultrasound images[2-4]

The following lung pathological changes with different ultrasound signs in patients with COVID-19:

- Pulmonary consolidation: Solid tissue echo is present after the complete loss of lung tissue gasification, with patchy or “liverlike change” of different sizes, which may be accompanied by “signs of broncho inflation” or “signs of broncho fluid filling.”
- Pleural effusion: Hypoechoic or nonechoic areas are visible in the pleural cavity, with cordlike separation. When empyema occurs, it should be distinguished from solid lung tissue.

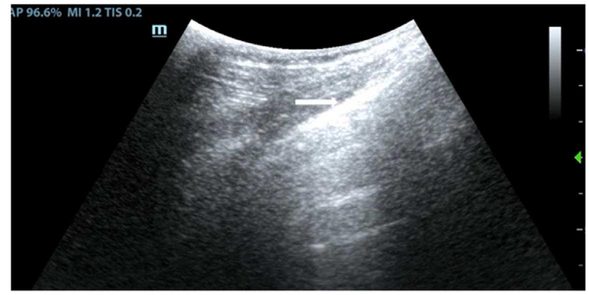

Fig. 1. The thickened pleura.

- Pneumothorax: This is demonstrated when areas of the pleura line, A-lines, and lung sliding sign disappear without the existence of B-lines. The lung point sign and stratospheric sign may be visible with M-mode.

Changes of Lung Ultrasound in Novel Coronavirus Pneumonia[6]

Changes of the lung ultrasound for novel coronavirus pneumonia include a thickened pleural line (Fig 1), B-lines in different degrees (Fig 2, A and B), and fusion B-lines (Fig 3). This can be manifested as focal B-lines and diffuse alveolar interstitial syndrome (Fig 4), according to the different divisions. Fragmentation can be found in subpleural consolidations (Fig 5). Tissue-like (Fig 6) and dynamic bronchiectasis can be seen in a large consolidation of the lung accompanied by bronchiectasis (Fig 7). There are many abnormal examination parts. B-lines are mainly focal in the early and mild stages of novel coronavirus pneumonia. Pulmonary interstitial syndrome and consolidation mainly occur in the progressive stage. Normal A-lines on pulmonary ultrasound can be completely recovered or the pleura line with pulmonary fibrosis accompanied with uneven B-line changes can be seen in the convalescent stage.

Main Observations

We should focus on the presence or absence of an abnormal pleura line (smooth, continuous); B-lines (number and

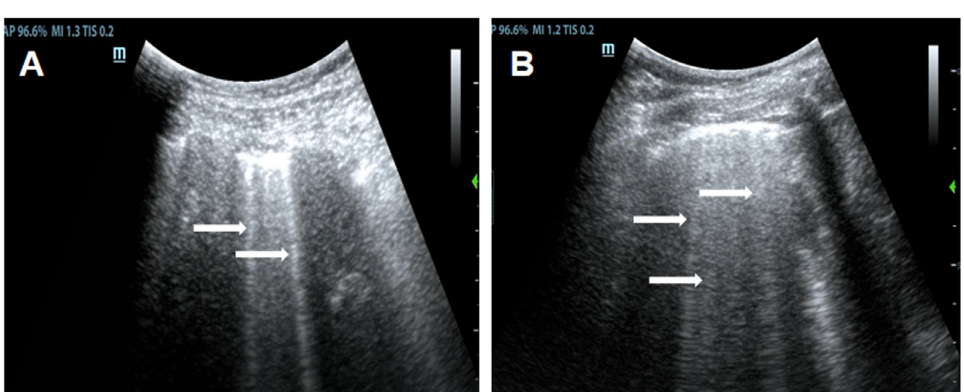

Fig. 2. (A) Separate B-lines. (B) Multiple B-lines.

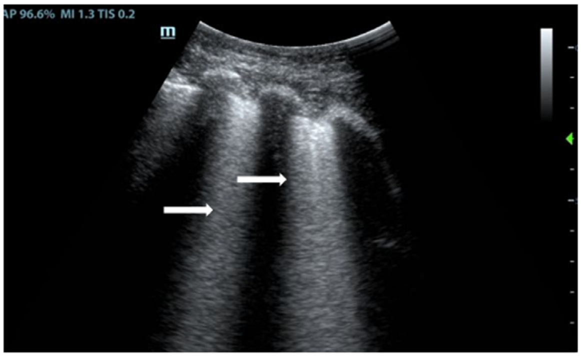

Fig. 3. Fusion B-lines.

distribution); consolidation (range, bronchiectasis); pleural effusion (nature); and pneumothorax, etc. The sonograms of B-lines, alveolus interstitial syndrome, and white lung reflect the degree of lung water from light to heavy.

Sezgin et al. reported that the sensitivity and specificity of pulmonary ultrasound in the diagnosis of pneumonia are 98.0% and 95.8%, respectively,[4] and the diagnostic rate of pneumothorax can reach 100%.[7] The lung ultrasound signs and pathologic signs already have been well-known by clinicians.

In addition, the novel coronavirus pneumonia is highly infectious. In order to reduce the transmission, it is better to perform the examination as infrequently as possible. With the limitation of bedside chest x-ray, which exposes medical personnel and patients to high radioactive activity, lung ultrasound is a better choice of bedside diagnostic equipment. With its convenient, noninvasive, repeatable, radiation-free, and rapid results, lung ultrasound has been used widely in the critical care area. Because the pneumonia with the novel coronavirus changes rapidly, combined with the characteristics of the pathology of this pneumonia, lung ultrasound is better suited to provide full and effective assessment of the lung condition, which can result in sufficient guidance for diagnosis and treatment.

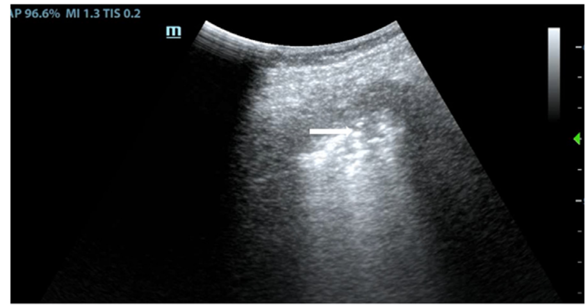

Fig. 5. Fragmentation sign.

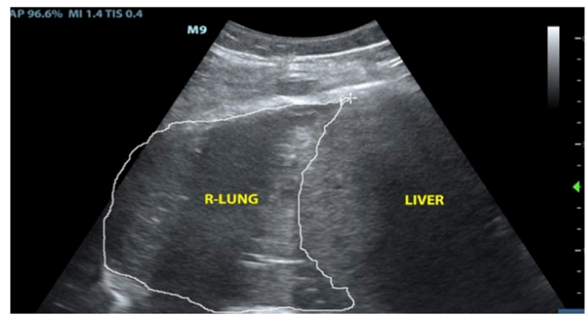

Fig. 6. Tissuelike.

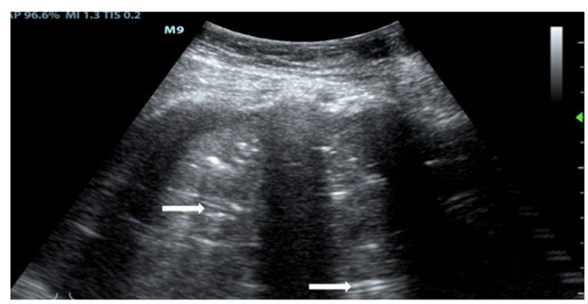

Fig. 7. Bronchiectasis in large consolidation of the lung.

Advantages of Lung Ultrasound

The advantages of lung ultrasound are summarized in the following. First, with its convenient, noninvasive, repeatable, and nonradioactive characteristics, lung ultrasound can be performed at the bedside, which is beneficial to the examiner and the patient by reducing the probability of transmission of the disease. Second, accurate information can be obtained to help provide a diagnosis on the basis of the ultrasound imaging. Third, if the patient's condition changes, ultrasound can

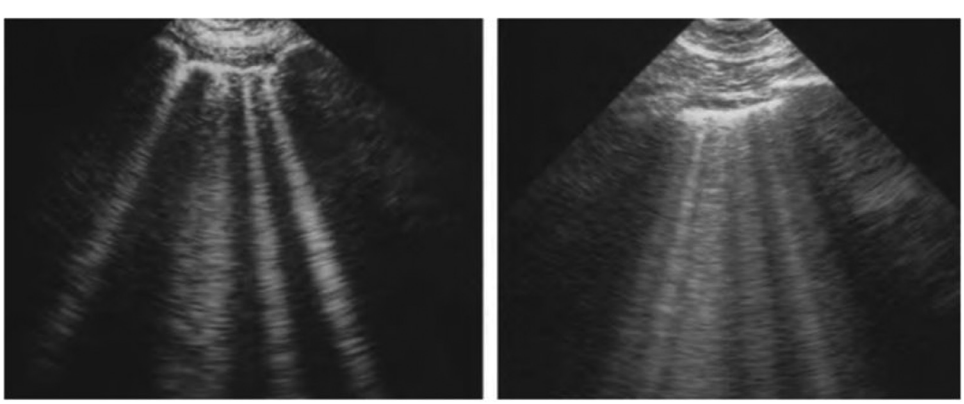

Fig. 4. Diffuse alveolar interstitial syndrome.

provide a quick examination to determine whether pneumothorax or increasing pleural effusion is present. Bedside puncture can be performed on the basis of the lung ultrasound. Ultrasound also can demonstrate whether there is an increase of lung edema and, combined with the parameters of oxygenation, can direct whether mechanical ventilation and other treatments are needed. Fourth, lung evaluation findings, combined with parameters of oxygenation, hemodynamics, and ventilation, can be used to determine the timing of implementation of extracorporeal membrane oxygenation. Fifth, for critically ill patients who have been treated with mechanical ventilation or extracorporeal membrane oxygenation, we can evaluate the condition of the lungs dynamically, further clarifying the prognosis. Sixth, the evaluation of the inferior vena cava and heart by ultrasound provides great value for the differential diagnosis when the patient's condition changes rapidly. Finally, it is easy to acquire and transmit images of the ultrasound, which are essential for remote diagnosis and treatment.

There are also limitations of lung ultrasound. When there are pathologic changes in the deep part of lung field and no pathologic changes of the pleural, its advantages are reduced significantly. However, in order to decrease the probability of transmission, to better perform dynamic diagnosis of the novel coronavirus pneumonia, and to provide better protection of medical workers and patients, lung ultrasound should be used to the fullest.

Conflict of Interest

None.

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POCUS to Guide Fluid Therapy in COVID-19

To the Editor:

PROVIDING ADEQUATE care to the large number of patients critically ill with coronavirus disease 2019 (COVID-19) with severe acute respiratory distress syndrome (ARDS) is a resource-intensive task. Reducing duration of mechanical ventilation may assist in decompressing intensive care units (ICUs). Standard of care in managing ARDS includes lung-protective ventilation and appropriate diuresis.[1,2] Recent literature regarding using portable ultrasonography at the bedside (point-of-care ultrasound or POCUS) on critically ill patients suggested current use in modern ICUs.[3] We propose that a focused lung and heart ultrasound may help follow progression of pneumonia and pulmonary edema and characterize volume status.

As anesthesiologists are being tasked to provide critical care, it is necessary to take the lessons of judicious fluid use from our operating rooms to the ICUs. Indeed, daily weights and fluid balance help guide diuretic and fluid therapy. However, the inflammatory state in COVID-19 patients may contribute to vascular permeability and intravascular depletion despite increased total body water. Periodic vasoplegia, high positive end-expiratory pressure, and cardiac dysfunction also confuse typical hemodynamic estimations of total body water such as blood pressure and central venous pressure.[4] Using an apical 4-chamber view and a parasternal short-axis view, we can obtain a quick estimation of left and right ventricular function and fluid status (Fig 1). These findings could then be

Fig 1. Apical 4-chamber view demonstrating an enlarged right ventricle consistent with elevated intravascular volume.