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Review Article

Point-of-care lung ultrasound: A useful diagnostic tool in the management of COVID-19

Neerja Bharti[1,*], **Amit Kumar**[2], **Karan Singla**[1]

[1]*Dept. of Anaesthesia and Intensive Care, Post Graduate Institute of Medical Education and Research, Chandigarh, India*
[2]*Dept. of Anaesthesia and Intensive Care, Fortis Hospital, Mohali, Punjab, India*

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ABSTRACT

Patients with COVID-19 disease frequently present with severe respiratory distress and hypoxia in emergency department. Point-of-care lung ultrasound has proven its efficacy in the diagnosis and management of various clinical conditions including pneumonia, acute respiratory distress syndrome and pulmonary oedema. Incorporating bedside lung ultrasound as an imaging tool for the diagnosis and management of COVID-19 pneumonia can help in quick assessment of the severity of lung damage and to track the evolution of disease during follow-up. Serial lung ultrasounds may be particularly useful in assessing the clinical response to the respiratory interventions and guiding the appropriate medical therapy.

1. Introduction

Pulmonary involvement is the primary cause of morbidity and mortality in COVID-19 disease which ranges from destruction of type-2 epithelial cells to diffuse alveolar damage eventually leading to acute respiratory distress syndrome (ARDS) and respiratory failure.[1] Pulmonary imaging plays important role in the diagnosis and management of COVID-19 patients.

Recently, lung ultrasonography has shown its utility in detection of various pathologic conditions including pulmonary oedema, pneumothorax and interstitial lung disease (ILD).[2] In experienced hands, pulmonary ultrasonography has been found comparable with CT-chest for identifying various medical conditions.[3] The major advantages of lung ultrasonography are its safety, immediate availability of results and repeatability over time.

2. Applications of Lung Ultrasonography in COVID-19 Disease

Point-of-care lung ultrasonography allows direct bedside examination of patients, therefore, it can make a substantial contribution in the management of COVID-19 disease.[4] COVID-19 pneumonia mainly involves the peripheral pulmonary zones which can easily be detected by ultrasonography, using either low-frequency curved transducer or high-frequency linear transducer according to the body habitus.[5,6]

3. Lung Ultrasonographic Findings in COVID-19 Disease

1. The initial findings consist of thickened and broken pleural line, presence of comet-tail artifacts or focal B-lines and subpleural consolidations involving peripheral pulmonary zones (Figure 2).
2. During progression of the disease, the multifocal or confluent and melted B-lines, known as “White lung” may be seen depending upon lung involvement

* *Corresponding author*.
E-mail address: bhartineerja@yahoo.com (N. Bharti).

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(Figure 3).

3. The pleural effusions can be seen in more critically ill patients.
4. The reappearance of A-lines represents recovery phase of the disease (Figure 4).

Fig. 1: Broken pleural line (red arrow) and subpleural consolidation (yellow arrow)

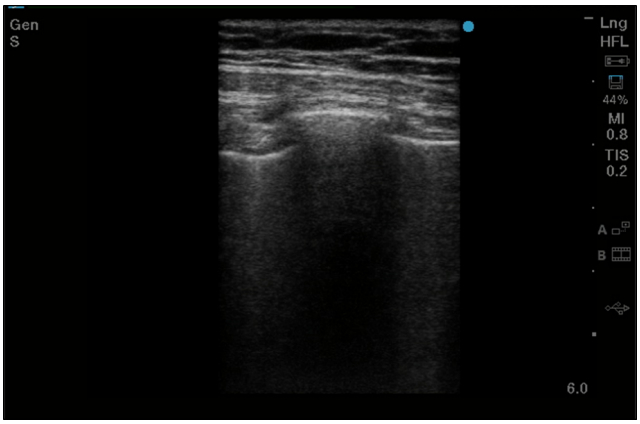

Fig. 2: Presence of B lines (Patient on high - flow nasal oxygenation)

All areas (anterior, lateral and posterior) of both lungs should be evaluated as bilateral, diffuse multifocal involvement is common. The presence of above sonographic findings in ≥2 zones considered as diagnostic. After initial diagnosis, repeated lung examinations may be helpful in tracking further clinical course and guiding suitable treatment options.[7] The progression of disease, represented by multifocal B-lines and increase in number of affected lung zones, can guide about the escalation of care. The appearance of new consolidation with dynamic air bronchograms shows development of superimposed bacterial pneumonia and suggests for initiation of antibiotic therapy. The presence of "White lung" areas and/or pleural

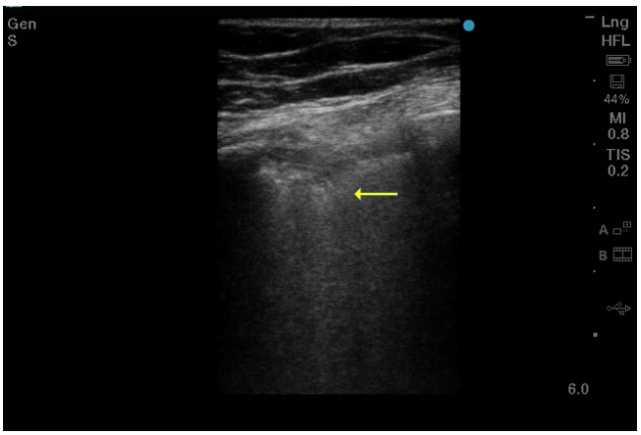

Fig. 3: Confluent and melted B lines (white lung), patient on non-Invasive ventilatory (NIV) support

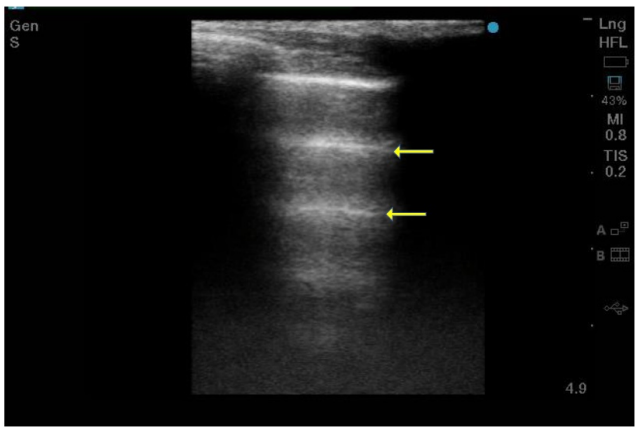

Fig. 4: Presence of A lines during recovery phase (maintaining saturation on Venti Mask)

effusions suggest poor prognosis.

Serial lung ultrasonography can also help in taking decisions about the oxygenation and mechanical ventilation strategies. Patients presenting with pleural defects and focal B-lines can be managed with high-flow nasal oxygenation. However, appearance of confluent B-lines and subpleural consolidation suggest the need for pressure-support ventilation. Similarly, presence of posterior consolidations may advocate for prone positioning and, the presence of lung atelectasis suggests the requirement of recruitment maneuvers. Although, resolution of consolidations, reduction in B-lines and, reappearance of A-lines advocates to wean respiratory support.

Lung ultrasonography can also help to differentiate COVID pneumonia from other causes of dyspnea while waiting for confirmatory testing.[8] The presence of intact pleural line, gravity-dependent B-lines and pleural effusion suggest the diagnosis of cardiogenic pulmonary oedema while isolated large lobar consolidation indicates towards

bacterial pneumonias. The diffuse abnormalities of pleural line are more likely seen in chronic interstitial pulmonary fibrosis. The presence of atelectatic consolidations with large pleural effusion also make the diagnosis of COVID-19 less likely.

4. Grading System of Severity

Soldati et al[9] proposed a grading system for the assessment of severity of COVID pneumonia using lung ultrasonography after reviewing 60,000 ultrasound frames from 30 patients. The authors suggested that total 14 areas (3 posterior, 2 lateral, and 2 anterior, on each side) to be scanned and a 0-3 grading should be applied to every lung area scanned.

Score 0 = presence of A-lines with continuous pleural line

Score 1 = a broken pleural line with small-to-large consolidated areas

Score 2 = presence of associated white lung areas below the consolidated area

Score 3 = presence of large dense consolidation area signifying complete loss of aeration

5. 36-point Lung Ultrasound Score (LUS)

Vetrugno et al[10] proposed a 36-point LUS after scanning of 12 lung areas (six on each hemithorax) for assessment of progression of lung involvement and guide eventual respiratory weaning. One point has been assigned to the presence of focal B-lines, while confluent B-lines with the appearance of "white lung" image achieved two points; the presence of consolidation was scored as 3 points. The higher score reflect decrease in lung aeration and the progression of disease severity, suggesting the need for escalation of ventilatory support.

6. Diagnostic Accuracy of Lung Ultrasonography

Sorlini et al[11] evaluated the sensitivity and specificity of diagnostic accuracy of lung ultrasound for COVID-19 pneumonia as 92.0% (95% CI 88.2–94.9%) and 64.9% (95% CI 54.6–74.4%) respectively and suggested that lung ultrasound can be used as first-line screening tool in suspected COVID-19 patients. In another study, Bianchi et al[12] demonstrated the positive predictive value of 97% and the negative predictive value of 98% of lung ultrasound for predicting COVID-19 disease and suggested that it may help in identifying false-negative RT-PCR cases in emergency department.

Recently, an international multicenter study[13] showed an overall sensitivity of lung ultrasound as 90.2% (95% CI 88.23–91.97%) for diagnosis of COVID-19 pneumonia in positive RT-PCR patients. The authors found that lung ultrasonography with clinical characteristics of patients allow to rule-in or rule-out COVID-19 pneumonia in suspected cases with high accuracy and can expedite the management during pandemic surge.

7. Lung Ultrasonography Versus Chest X-Ray and CT-chest

Frequent thoracic imaging is required in COVID-19 patients due to fast progression of disease. Although, x-ray chest is the most commonly used imaging technique due to its easy availability, it plays a limited role in the initial phase of COVID-19.[14] Lung ultrasonography has been found to be more useful in detecting early COVID pneumonia as compared to x-ray chest in symptomatic patients.[15,16]

Many emerging studies have proven the efficacy of lung ultrasonography comparable to CT-chest for diagnosis of COVID-19 pneumonia.[17–20] In a multicenter study comparing lung ultrasound with HRCT-chest to assess the prognosis of COVID-19, a strong positive linear correlation was observed between LUS and CT scores ($r = 0.754$; $p < 0.001$). According to the multivariate regression analysis, LUS was the sole independent predictor of in-hospital mortality among COVID-19 patients presenting with a score ≥ 20 ($p= 0.003$; 95% CI: 2.22-43.83).

Therefore, these emerging data, together with previous ultrasound findings in similar lung diseases (ARDS, ILD, pneumonia), strongly support the potential rationale of lung ultrasonography in the management of COVID-19 pneumonia.

8. Limitations

Lung ultrasound consists of high sensitivity for detecting pleural line defects and sub-pleural consolidations, characteristics of COVID-19 pneumonia, almost equivalent to the CT- lung. However, the lung ultrasonographic signs of COVID pneumonia are not specific and can be present in other respiratory diseases also. Therefore, it is important that repeated examinations should be performed and all areas of lungs should be covered. The ultrasound findings should always be corelated with clinical data for patient's management.

9. Conclusion

Point-of-care lung ultrasound may play a potential role in the management of COVID-19 due to its high sensitivity and dynamic nature of observation. Lung ultrasonography can be useful for early diagnosis of COVID pneumonia, to assess the severity of lung involvement, to monitor the appropriateness of oxygen therapy and ventilatory support, to guide for escalation of care, and to track the evolution of disease during follow-up. The associated hazards of transportation for CT-scan in high-risk patients can be minimized by the increasing use of bedside lung ultrasonography. Moreover, this radiation-free imaging

technique may also play an important role in pregnant patients.

10. Source of Funding

None.

11. Conflict of interest

None.

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Author biography

Neerja Bharti, Professor https://orcid.org/0000-0002-3075-8109

Amit Kumar, Additional Director

Karan Singla, Assistant Professor

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