LETTER TO THE EDITOR

Diaphragm ultrasound to stratify COVID-19 patients in the emergency department?

Dear Editor

The COVID-19 affects particularly the respiratory system with the onset of pneumonia that can lead to acute respiratory insufficiency. Patients with COVID-19 pneumonia disclose a hypoxemic respiratory failure associated with an increase of the work of breathing.1 Ultrasound can be used to evaluate the work of breathing with the analysis of the diaphragm.2 This technique is particularly used in the context of weaning from mechanical ventilation in Intensive Care Unit (ICU) patients.2 In critically ill patients, respiratory muscle weakness is associated with an increase of mortality.3 In the emergency department, diaphragm excursion has been reported to be a prognostic parameter in patients admitted because of a hypercapnic respiratory failure since diaphragm excursion can predict non-invasive ventilation issue.4

SARS-CoV-2 viral RNA was found in the diaphragm tissue in post mortem studies5 and a low diaphragm mass was associated with poorer outcomes in COVID-19 pneumonia.6 In addition, diaphragm dysfunction has been reported to predict the onset of invasive mechanical ventilation in COVID-19 pneumonia7 and ultrasound diaphragm thickening can predict the response to noninvasive ventilation therapy in COVID-19 pneumonia.8 In the context of COVID-19 pneumonia, diaphragm dysfunction can be related to sepsis, lung insult severity, hypoperfusion in relation with severe cardio-circulatory failure. In the context of fewer availability ICU beds, stratifying COVID-19 patients in crucial and diaphragm ultrasound may help physicians. Diaphragm ultrasound can assess diaphragm motion, diaphragm thickening, and diaphragm rapid shallow breathing index. This technique is non-invasive and reproducible.9

Diaphragm thickness is measured classically using a liner probe localized at the apposition zone, perpendicular to the chest wall at mid axillary line. The diaphragm thickening is correlated with respiratory effort.2 The diaphragm thickening calculated using the equation:

\[ \text{diaphragm TF} = \frac{\text{diaphragm thickness end inspiratory} - \text{diaphragm thickness end expiratory}}{\text{diaphragm thickness end expiratory}} \times 100. \]

Diaphragm dysfunction is defined by a diaphragm TF < 30%.10

The diaphragm excursion is measurement using a cardiac probe or a curvilinear probe localized at the subcostal anterior area. From the anterior subcostal view, the diaphragm moves caudally toward the transducer during inspiration. From M-mode ultrasound, an upward motion tracing is recorded (Figure 1). Diaphragm dysfunction is present in case of a diaphragmatic motion less than 11 mm.11 A paradoxical displacement may be present in patient with diaphragm paralysis. The Figure 2 shows a paradoxical displacement in a patient with Guillain-Barré syndrome following a COVID-19 infection. Finally, the diaphragm rapid shallow breathing index (D-RSBI) can be used as a radiological index to assess patients. The D-RSBI is calculated using the equation: respiratory rate/diaphragmatic motion (mm). The D-RSBI is derived from the rapid shallow breathing index (RSBI) that is the ratio respiratory frequency to tidal volume. The RSBI is a parameter used in ICU to predict weaning outcome in patients on mechanical ventilation.12 This parameter integrates the respiratory rate and the status of respiratory muscles that include diaphragm and accessory respiratory muscles. The D-RSBI is correlated with RSBI and a D-RSBI >1.6 breaths/min/mm reflects diaphragm dysfunction.12 The Figure 1 shows an increase of the diaphragmatic inspiratory motion pattern (>20 mm), to overcome the respiratory load, in a patient admitted with an acute respiratory distress in relation with interstitial pneumonia. The D-RSBI calculated was at 1.65 breaths/min/mm (Figure 1). In the context of lung injury, a failure to increase the diaphragm motion to overcome the respiratory load, can lead to a reduction of diaphragm motion. In ICU, the D-RSBI can be used to predict

![FIGURE 1](image)

Diaphragm ultrasound pattern in a 70-year-old patient admitted because of an acute respiratory distress, due to bilateral interstitial pneumonia and acute heart failure. The respiratory rate was at 33/min and the oxygen saturation at 88% with nasal oxygen therapy at 10 L/min, without hypercapnia. Here, look at the respiratory system response with an increase of diaphragm motion and respiratory rate. The record scale was at 33.33 mm/s. The D-RBI was at 33 breaths/20 mm = 1.65 breaths/min/mm. ARF, acute respiratory failure; LVEF; left ventricular ejection fraction.
weaning outcome and a value at 2.7 breaths/min/mm in patients is associated with a weaning failure. This ultrasound parameter may help clinicians to stratify patients in the emergency department. Prospective studies will provide more clarifications about applications of diaphragm ultrasound in the context of COVID-19 pneumonia.

CONFLICT OF INTEREST
The authors have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT
Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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