Lung Recruitment Guided by Ultrasonography in Unilateral Lung Injury

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Abstract

Atelectasis is a common problem in the critical care setting and when it causes acute life-threatening hypoxemia it is necessary its re-expansion. Ultrasonography is capable to diagnose atelectasis at the bedside and accurately assesses lung aeration changes after reexpansion maneuver. We describe a case in which a male patient receiving mechanical ventilation developed acute hypoxemia due atelectasis, being applied recruitment maneuver guided by ultrasonography combined with lateral decubitus positioning to reexpansion of collapsed region.

Case Report

A 56-year-old male patient with history of epilepsy was admitted to the ICU due to severe pneumonia resulting from infection with the SARS-CoV-2 coronavirus. He evolved with acute hypoxemic respiratory failure and was intubated 2 days after his admission.

After 12 days of mechanical ventilation, he had a sudden drop in peripheral arterial oxygen saturation. The patient was sedated, well adapted to the ventilator and hemodynamically stable. Blood gas analysis revealed PaO₂/FiO₂ ratio of 140. A chest X-ray was performed which showed opacification of the left hemithorax with erasure of the contours of the cardiac area and the left phrenic dome.

Thoracic ultrasound was performed at the bedside and visualized volumetric reduction of the pulmonary segment above left diaphragm and the presence of tissue-like echotexture [1]. Additional sonographic signs may help to differentiate this one from other causes of lung consolidation such as abolition of lung sliding with a lung pulse, and static air bronchogram. The dynamic demonstration of the absence of lung expansion is the advantage of lung ultrasound in comparison with radiography and computed tomography [2]. In addition to its role in the diagnosis, lung ultrasound accurately assesses lung aeration changes following positive end-expiratory pressure (PEEP) [3].

In this case, acute hypoxemia occurred in patient admitted to intensive care unit (ICU) due to coronavirus disease and receiving mechanical ventilation. Bedside lung ultrasonography was very useful to obtain the diagnosis, to evaluate the patient response to therapy and to guide fine-tune the ventilator.

Introduction

The loss partial or total of lung volume is named atelectasis. In the critical care setting, atelectasis is a common problem and when it causes acute life-threatening hypoxemia it is necessary its re-expansion.

Ultrasonography is capable to diagnose atelectasis at the bedside. This condition appears sonographically as a subpleural echo-poor region or one with tissue-like echotexture [1]. Additional sonographic signs may help to differentiate this one from other causes of lung consolidation such as abolition of lung sliding with a lung pulse, and static air bronchogram. The dynamic demonstration of the absence of lung expansion is the advantage of lung ultrasound in comparison with radiography and computed tomography [2]. In addition to its role in the diagnosis, lung ultrasound accurately assesses lung aeration changes following positive end-expiratory pressure (PEEP) [3].
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After lung recruitment and PEEP titration, the PaO$_2$/FiO$_2$ ratio increased to 190 and a new chest radiograph showed evident pulmonary reexpansion (Figure 3).

On the 17th day of mechanical ventilation, the patient was extubated, and he was discharged from the hospital 40 days after admission.

Discussion

Acute hypoxemia during mechanical ventilation is a result of the mismatch between ventilation and perfusion [4] and atelectasis is a common cause of acute hypoxemia in the setting of critical care [5]. Atelectasis is defined as collapse of alveoli with loss of aeration [6]. The pathophysiologic effects of loss of lung volume are decreased compliance, impaired gas exchange, and increased work of breathing.

We decided to adopt Open Lung Approach strategy guided by ultrasonography combined with lateral decubitus positioning (affected lung positioned superiorly) to re-expansion of collapsed region.

After bolus dose of cisatracurium, PEEP was increased from 8 to 20 cmH$_2$O. A curvilinear probe located at posterior axillary line showed the disappearance of the tissue-like pattern and the appearance of lung sliding with A lines indicating reversal of atelectasis (Figure 1). This PEEP level was maintained for 4 minutes and no hemodynamic instability occurred during this recruitment phase.

Once the reaeration has been achieved, decremental PEEP titration was performed that consisted of decrease of PEEP from 20 to 10 cmH$_2$O in 2 cmH$_2$O steps each one lasting two minutes (Figure 2). The PEEP of 12 cmH$_2$O was chosen because it preserved normal lung aeration, in addition to generation greater compliance of the respiratory system and lower driving pressure.

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PEEP when the ultrasound tissue pattern characteristic of lung consolidation is replaced by the visualization of the pleural line with preserved lung sliding and presence of horizontal A-line.

Once there was a positive response to the alveolar recruitment maneuver, next step is to identify PEEP level capable of avoiding new collapse. During this phase of decremental PEEP titration, the probe is kept in the same position as before and the reduction of PEEP is interrupted when normal lung aeration images transform into a B1-B2 pattern and consolidation pattern [15].

Although the ultrasonography allow to personalize the maneuver recruitment and the PEEP titration, this tool cannot detect over distension resulting from an increase in intrathoracic pressures [16]. At the bedside, the compliance of the respiratory system ($C_{rs}$) helps to monitor the overinflation because $C_{rs}$ is directly related to the size of the lung participating in ventilation [17], i.e., $C_{rs}$ tends to increase with recruitment but decreases once over-inflation begins.

**Conclusion**

Lung ultrasound is an image method that can be used to individualize ventilatory management of unilateral lung injury because it allows to monitor lung aeration changes following applying PEEP.
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No funding was received for this case series.

Availability of Data and Materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate
The patients consented to participate in the case report.

References