Lung ultrasound in the reexpansion of pulmonary atelectasis

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Case report

A 60-year-old man was admitted to our hospital complaining of dyspnea and productive cough that had been present for 24 h. One year prior, the patient had been diagnosed with amyotrophic lateral sclerosis. On admission, he was bedridden, had a tracheotomy, was ventilator-dependent and fed by enteral nutrition by means of a gastrostomy tube.

The vital signs were: blood pressure 120/80 mmHg, heart rate 110 beats/min, temperature 37°C. Percutaneous oxygen saturation was 85% on 80% ventilator-delivered oxygen. Physical examination revealed decreased breath sounds over the right lung and rales compatible with the presence of bronchial secretions over the left lung.

A Chest x-ray study showed an opacification of the lower half of the right lung fields with mild homolateral mediastinal displacement suggesting pulmonary atelectasis (Fig. 1). Electrocardiography was unremarkable. Blood gas

analysis revealed hypocapnic respiratory failure. Other laboratory tests were normal except for a mild leucocytosis. The emergency physician performed a lung ultrasound (US), which confirmed the presence of a right pulmonary atelectasis appearing as an area of pulmonary parenchyma with a tissue-like pattern and abolished lung sliding in the presence of lung pulse (Fig. 2, Online Resource 1).

In order to remove secretions, a bronchoscopy was performed while simultaneously checking for adequate pulmonary reexpansion with US imaging. As airway clearing progressed, the US study showed the appearance of an air bronchogram near the hilar pulmonary structures (Fig. 3, Online Resource 2), gradually advancing toward the peripheral parenchyma (Fig. 4, Online Resource 3) till pulmonary reexpansion was completed, as evidenced by the appearance of lung sliding and the disappearance of the tissue-like pattern (Fig. 5, Online Resource 4).

After the procedure, the oxygen saturation was 95% on 40% ventilator-delivered oxygen. The physical examination revealed bilateral breath sounds.

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Discussion

Pulmonary atelectasis is the loss of lung volume resulting from bronchial obstruction (obstructive atelectasis) or from parenchymal compression (nonobstructive atelectasis). Atelectasis produces a ventilation–perfusion mismatch, an intrapulmonary shunt, an increase in pulmonary vascular resistance and arterial hypoxemia. Furthermore, loss of aerated lung may increase the risk of pneumonia and ventilator-induced lung injury by overstretching of the aerated lung.

US imaging study seems to be a useful tool for diagnosing and evaluating pulmonary atelectasis, and more

Fig. 1 Chest radiography: opacification of the lower half of the right lung fields with mild homolateral mediastinal displacement suggesting pulmonary atelectasis

Fig. 2 Lung US study (transverse scan in the fourth intercostal space in the right mid-clavicular line): pulmonary atelectasis appearing as an area of pulmonary parenchyma with a tissue-like pattern

generally, alveolar consolidation. In patients with total or nearly total opacification of the hemithorax on a chest x-ray study, US imaging shows high sensitivity in detecting pleural and parenchymal lesions making it possible to differentiate between pleural effusion and consolidation [1].

Atelectasis appears on the US study as a consolidated area of pulmonary parenchyma with a tissue-like pattern. Lung sliding, the synchronized movement of the pleural line with breathing, is abolished, and the pulmonary parenchyma moves synchronous with the heart beats producing a dynamic sign defined as lung pulse. Appearance of a tissue-like pattern is a delayed sign, and relies on the

Fig. 3 Lung US study (transverse scan in the fourth intercostal space in the mid-clavicular line): air bronchogram near the hilar pulmonary structures

Fig. 4 Lung US study (transverse scan in the fourth intercostal space in the mid-clavicular line): air bronchogram toward the peripheral parenchyma

complete absorption of the air trapped in the lung. On the contrary, the lung pulse is immediately visible as it results from the absence of air exchange. For example, during selective right bronchus intubation, ventilation of the left lung is suddenly interrupted, and this determines the disappearance of lung sliding and appearance of a lung pulse in the absence of a tissue-like pattern.

Air bronchogram is another sonographic sign consisting of hyperechoic artifacts located within an area of alveolar consolidation. It can be either dynamic, resulting from air movement due to respiratory acts and indicating airway patency, or static, secondary to air trapping. In most cases, a dynamic air bronchogram is lacking in the atelectatic lung, while a static air bronchogram may be present. The presence of a dynamic air bronchogram allows the distinction between inflammatory and atelectatic alveolar

Fig. 5 Lung US study (transverse scan in the fourth intercostal space in the mid-clavicular line): B lines pattern suggesting pulmonary reexpansion

consolidation, and shows a high specificity and high positive predictive value in the correct diagnosis of pneumonia [2].

Atelectasis, pneumonia and lung contusion are common causes of respiratory failure inducing loss of lung aeration with alveolar consolidation. Reexpansion of the pulmonary parenchyma is the goal of treatment, and its evaluation is useful in assessing the response to treatment itself, and in determining appropriate therapeutic strategies. For example, in patients with adult respiratory distress syndrome (ARDS), evaluation of alveolar recruitment is crucial to a correct management of ventilation.

At present lung computed tomography (CT scan) is the gold standard for the assessment of pulmonary reaeration, but it requires patient transportation, radiation exposure and can be difficult to repeat. An US imaging study provides useful information about lung aeration status, distinguishing between normal pattern, interstitial syndrome and consolidation. In patients with ventilator-associated pneumonia, an US study is an accurate tool for reaeration

assessment showing a highly significant correlation with the CT scan [3]. In patients with ARDS, the US study adequately estimates PEEP-induced lung recruitment compared with the pressure–volume curve method [4]. Furthermore, in patients undergoing whole lung lavage, US imaging clearly distinguishes the different states of aeration determined by alveolar flooding, (interstitial alveolar syndrome followed by consolidation), and reventilation (interstitial alveolar syndrome followed by normal pattern) [5].

Our case demonstrates that US imaging may be a useful tool for assessing pulmonary reexpansion in patients with obstructive atelectasis, providing immediate bedside information during a bronchoscopic procedure. US imaging is a fast, low-cost, repeatable, radiation free and point of care technique. These features make US imaging a useful method to diagnose alveolar consolidation, to assess appropriate treatment and response to therapy.

Conflict of interest None.

References

1. Yu CJ, Yang PC, Wu HD et al (1993) Ultrasound study in unilateral hemithorax opacification. Image comparison with computed tomography. *Am Rev Respir Dis* 147:430–434
2. Lichtenstein D, Mezière G, Seitz J (2009) The dynamic air bronchogram. A lung ultrasound sign of alveolar consolidation ruling out atelectasis. *Chest* 135:1421–1425
3. Bouhemad B, Liu ZH, Arbelot C et al (2010) Ultrasound assessment of antibiotic-induced pulmonary reaeration in ventilator-associated pneumonia. *Crit Care Med* 38:84–92
4. Bouhemad B, Brisson H, Le-Guen M et al (2011) Bedside ultrasound assessment of positive end-expiratory pressure-induced lung recruitment. *Am J Respir Crit Care Med* 183:341–347
5. Via G, Lichtenstein D, Mojoli F et al (2010) Whole lung lavage: a unique model for ultrasound assessment of lung aeration changes. *Intensive Care Med* 36:999–1007