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Case Report

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The Experience of Respiratory Care for a Patient with Bilateral Endobronchial Tumors Complicated by Lung Collapse and ARDS

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Therapeutic algorithm regarding early acute respiratory distress syndrome (ARDS) management includes a low tidal volume (≤ 6 mL/kg PBW), high PEEP, and $P_{plateau}$ ≤ 30 cmH_2O. We present a case of germ cell tumor with endobronchial metastasis and ARDS, complicated by airway occlusion, which caused right lung atelectasis and mixed respiratory failure. Lung protective strategy included the activation of ventilator volume guarantee mode to maintain a proper tidal volume, thereby avoiding excessive airway pressure and reducing pulmonary volutrauma. Although the patient eventually succumbed to septic shock and multiple organ failure, we still gained considerable insight into patient care through combining the ventilator setting for ARDS with the application of volume guarantee mode to alleviate carbon dioxide retention from bronchial tumor obstruction.

Key words: acute respiratory distress syndrome, lung protective strategy, volume guarantee, endobronchial tumor

Introduction

We report a case of germ cell tumor with endobronchial metastasis and acute respiratory syndrome (ARDS) complicated by airway occlusion, that caused right lung atelectasis and mixed respiratory failure. A previous study has identified "tumor-associated ARDS" as a rare cause of severe respiratory failure in patients with cancers.[5] Although the prognosis is poor and the mortality rate is high, early and aggressive management could be justified when respiratory distress occurs. This type of ARDS should be managed in a manner similar to ARDS seen in other settings. Lung protection with ventilator volume guarantee mode (VG) was applied to maintain a proper tidal volume, thereby avoiding excessive airway pressure and preventing pulmonary volutrauma.

Case Report

A 25-year-old man was diagnosed as having germ cell tumor status post chemotherapy with bilateral lung metastases. He suffered from frequent nausea, vomiting, and dyspnea for several days. In our emergency department, brain computed tomography showed newly discovered left brain metastasis with tumor hemorrhage. He was admitted to our general

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ward on the same day due to repeated seizure episodes in the emergency department.

Respiratory distress with poor oxygen saturation developed two days later. Blood gas analysis showed respiratory acidosis and hypoxemia with complete compensation (pH 7.425; $PaCO_2$ 47.8 mmHg; PaO_2 31.8 mmHg). Although bi-level positive airway pressure (BiPAP) was given for acute respiratory failure, dyspnea and respiratory distress persisted. Endotracheal intubation with ventilator support was immediately performed and sedatives were administered for alleviating agitation and ventilator asynchrony.

The ratio of arterial oxygen partial pressure to fractional inspired oxygen [PaO_2/FiO_2 (P/F)] ratio was set at 71.5. Chest x-ray showed pulmonary edema compatible with ARDS (Fig. 1A). Continuous sedatives pump infusion was applied for improving ventilator synchrony. A low tidal volume (6 – 8 mL/kg) and high positive end-expiratory pressure (PEEP) were applied as a lung protection strategy. The goal was to keep oxygen saturation above 90%. Initial ventilator settings on arrival at the intensive care unit were oxygen fraction (FiO_2) 100%, positive end-expiratory pressure (PEEP) 10 cmH_2O, arterial oxygen pressure (PaO_2) 30.3 mmHg, and P/F ratio 30.3. He was found to have unstable tidal volume, poor oxyhemoglobin saturation by pulse oximetry (SpO_2) (range, 80 – 85%), and a respiratory pattern of air hunger.

Next morning, desaturated oxygenation and a low tidal volume (200 – 250 mL) were noted. Physical examination showed decreased

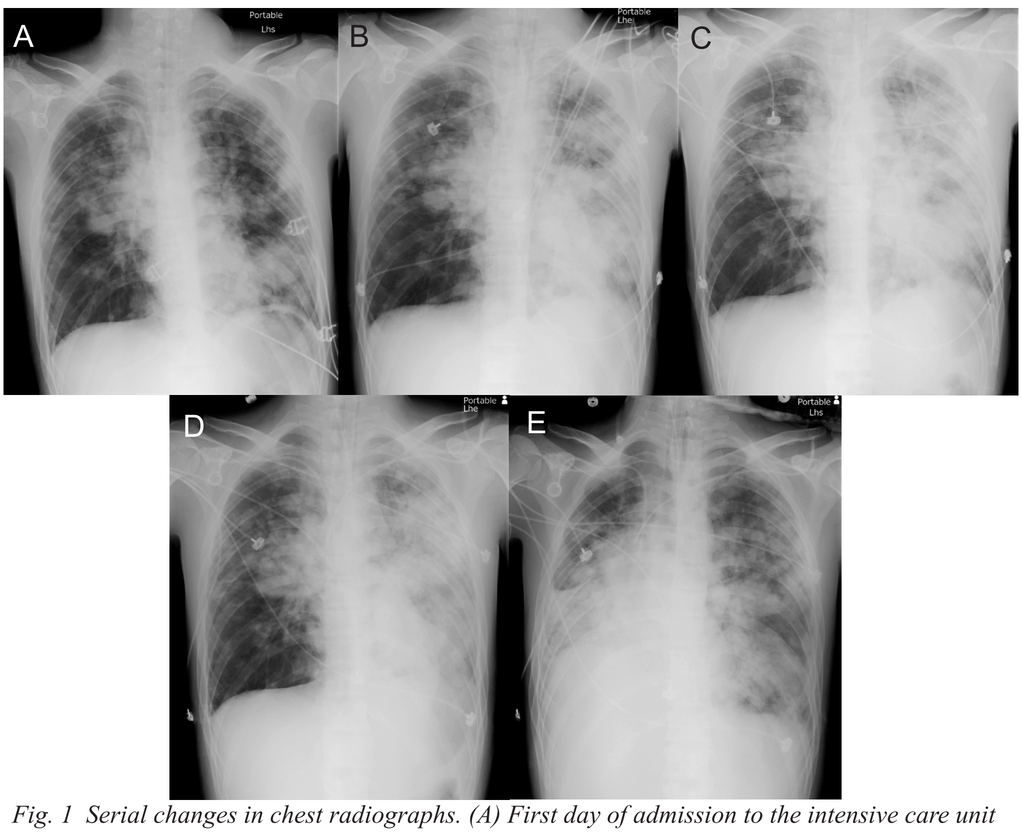

Fig. 1 Serial changes in chest radiographs. (A) First day of admission to the intensive care unit (ICU): Multiple nodular opacities of variable sizes in bilateral lung fields, suggesting metastatic lesions. Infiltration in right lung field also noted. (B) On the morning of second day of ICU admission: Infiltrations in bilateral lungs with consolidation over left lung with bilateral pulmonary nodules. (C) On the afternoon of second day of ICU admission: Progressive consolidation of bilateral lung fields. (D) Third day of ICU admission collapse of left middle and lower lobes. (E) Fourth day of ICU admission: New patchy consolidation in right lower lung field.

left side breath sound. At the same time, calculation of ventilator parameter showed reduced lung compliance (13.7 L/cmH_2O), increased airway resistance (29 L/cmH_2O), and marked elevation of peak inspiratory pressure (> 45 cmH_2O). Due to unstable tidal volume and high peak pressure, we switched the ventilator to the following settings: volume guarantee, target tidal volume 450 mL (tidal volume 6 mL/kg; patient ideal body weight 74 kg), FiO_2 90% – 100%, SpO_2 ≥ 90%, peak inspiratory pressure about 37 – 40 cmH_2O, lung compliance 12 – 17 L/cmH_2O, and airway resistance 19 – 23 L/cmH_2O).

Further oxygen desaturation down to 80% and decreased right side breath sound then occurred. Besides, much bloody sputum was noted from endotracheal suction. Chest x-ray (Fig. 1B & 1C) showed left lung white-out, enlargement of right hilum, and persistent right lung field consolidation. Intravenous tranexamic acid 0.5 gm every 8 hours was given for hemostasis, and FiO_2 was increased from 90% to 100%. SpO_2 was improved to above 95% and artery blood gas analysis showed a P/F ratio of 230.8.

One day later, desaturation and right side breath sound decreased again, together with a reduced tidal volume to 300 – 370 mL as well as collapse of left middle and lower lobes (Fig. 1D). Due to collapse of the right lung and recurrent desaturation down to 80% in spite of PaO_2 > 100 cmH_2O on arterial blood gas analysis, bronchoscopy was performed and showed a right endobronchial tumor with nearly total occlusion (Fig. 2). Taking into account the concomitant obstructive pneumonitis with bilateral lung collapse, we fully explained the poor prognosis to the patient's wife who insisted on aggressive treatment.

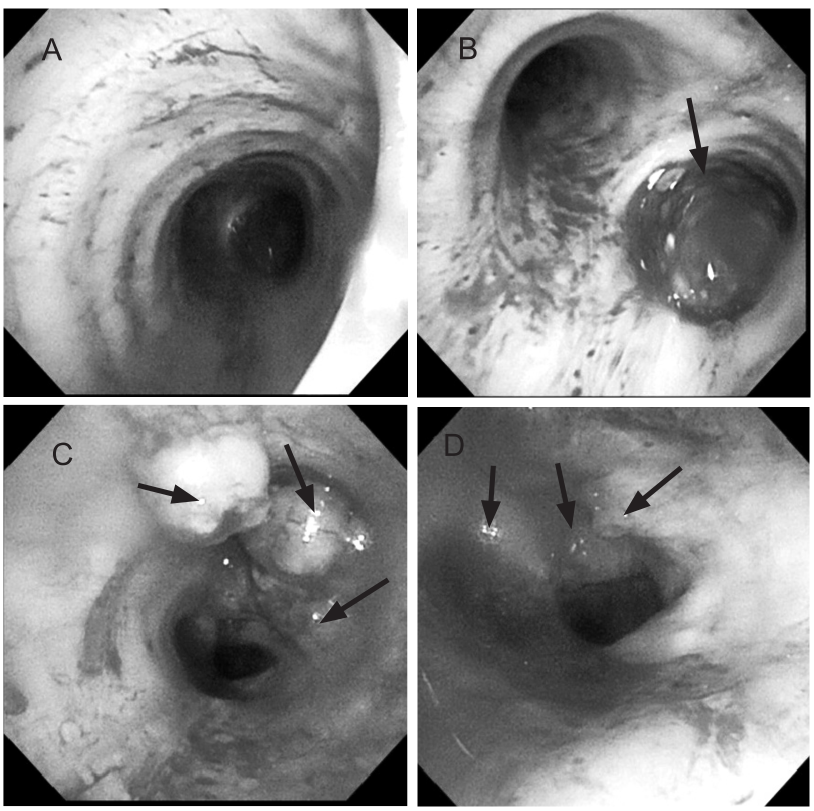

Fig. 2 Bronchoscopy showing (A) normal carina without notable lesion, (B) right endobronchial tumor with nearly total occlusion of the right main bronchus, (C) endobronchial tumor with nearly total occlusion of the upper lobar bronchus, and (D) small endobronchial tumors in left lower lobar bronchus with partial obstruction

Table 1. Algorithm for early ARDS management.[2]

		ARDS severity
The ratio of arterial oxygen partial pressure to fractional inspired oxygen [PaO_2/ FiO_2 (P/F)] ratio < 80	Discuss Veno-Venous extracorporeal membrane oxygenation	High ↑
The ratio of arterial oxygen partial pressure to fractional inspired oxygen [PaO_2/ FiO_2 (P/F)] ratio < 150	Neuromuscular blockers Prone positioning	
The ratio of arterial oxygen partial pressure to fractional inspired oxygen [PaO_2/FiO_2 (P/F)] ratio < 200	High level of PEEP (≥ 12 cmH_2O) Plateau pressure < 30 cmH_2O	
Confirmed ARDS	Tidal volume about 6 mL/kg of body weight Plateau pressure < 30 cmH_2O PEEP ≥ 5 cmH_2O Check for hypercapnea	Low
Reassessment of ventilator settings and of the managements strategy at least every 24 hours		

ARDS: acute respiratory distress syndrome, PEEP: positive end-expiratory pressure

However, the patient succumbed to active airway tumor bleeding and septic shock four days after admission to the intensive care unit despite cardiopulmonary resuscitation for two hours.

Discussion

Guidelines for the management of acute respiratory distress syndrome

Severe ARDS is defined as a P/F ratio < 100.[1] A moderate level of evidence has suggested a reduction in mortality and hospital stay in patients with moderate to severe ARDS subject to a relatively low tidal volume (≤ 6 mL/kg body weight) and a relatively high PEEP (≥ 12 cmH_2O) through reducing the probability of volutrauma. Another review study has demonstrated strong evidence in favor of the use of a low tidal volume (≤ 6 mL/kg body weight) and a low plateau pressure (≤ 30 cmH_2O) together with a relatively high PEEP (≥ 12 cmH_2O) in patients with moderate to severe ARDS[2] (Table 1). Nevertheless, there is no clear definition of a high PEEP which is recommended to be adjusted according to the condition of the patient. Some studies have suggested a range of high PEEP about 15.6 ± 3.6 cmH_2O and that of moderate PEEP about 9.1 ± 2.7 cmH_2O.

In respect of pharmacological intervention for ARDS, there is strong evidence in support of the use of neuromuscular blocking agents in patients with moderate to severe ARDS (P/F ratio < 150) within 48 hours of diagnosis. Nevertheless, re-evaluation of the patient's condition is mandatory at least every 24 hours regardless of the management strategy.

Volume guarantee mode (VG mode)

Volume Guarantee (VG), which is one of the patient-triggered modes of ventilation originally applied to neonates, was designed to combine the advantages of pressure-limited and volume-controlled ventilation without the inherent disadvantages of either modality.[4] It enables the clinician to take absolute control of airway pressures but at the same time allows the ventilator to monitor changes of the patient and make appropriate breath-to-breath adjustments of the peak airway pressure within the absolute set maximum to achieve the desirable tidal volume. Relevant data are collected for making adjustments to the peak inspiratory pressure of the next breath to deliver a tidal volume as close as possible to the preset value.

Clinically, patients with low lung compliance and high airway resistance, such as those with ARDS, usually have a wide fluctuation in their tidal volume. The downside of using the pressure control mode for this patient population is that while high pressure settings may induce volutrauma, low pressure settings may also result in inappropriate tidal volume and insufficient ventilation, even carbon dioxide retention. On the other hand, merely setting the target tidal volume using the volume control mode may also result in volutrauma. In contrast, previous studies have demonstrated that VG mode can ensure a sufficient but low tidal volume (≤ 6 mL/kg body weight) to prevent carbon dioxide retention (i.e., $PaCO_2$ > 35 mmHg) while automatically adjust airway pressure to avoid excessive airway pressure.[3] For instance, the initial settings of a ventilator (e.g., Drager V500, the model used at our hospital) may include a tidal volume ≤ 6 mL/kg body weight and a respiratory rate 10 – 14 breath per minute taking into account the patient's condition including the level of sedation, information from artery blood gas analysis, and ideal minute ventilation. Because the preset peak inspiratory pressure of the ventilator is high pressure alarm minus 5 cmH_2O, setting a high pressure alarm at 40 cmH_2O means a peak inspiratory pressure of 35 cmH_2O. For patients with ARDS, a low plateau pressure (i.e., $P_{plateau} \leq 30$ cmH_2O) is appropriate. The high pressure alarm setting can be adjusted according to the actual tidal volume of the patient. For patients who cannot reach the target tidal volume because of poor lung compliance or a high airway resistance, we can adjust the high pressure alarm settings according to the situation or initiate permissive hypercapnia. Early sedation is suggested for those with high airway pressure. PEEP setting is recommended to follow the ARDS management guidelines with the minimum being 5 cmH_2O.

Conclusion

The recommendations for the management of patients with moderate to severe acute respiratory distress syndrome (ARDS) include a mechanical ventilator setting of a low tidal volume (≤ 6 mL/kg), a high PEEP (≥ 12 cmH_2O), and early use of neuromuscular blocking agent. For patients with low lung compliance and high airway resistance (e.g., ARDS), mechanical ventilation may induce volutrauma due to their unstable tidal volume and variable airway pressure. In this aspect, volume guarantee mode can provide a stable tidal volume to avoid ventilator-induced lung injury and reduce carbon dioxide retention. Although our patient eventually died of septic shock and multiple organ failure, we showed that a combination of an ARDS ventilator setting of a low tidal volume and high PEEP with the use volume guarantee mode to relieve carbon dioxide retention from bronchial tumor obstruction could be a treatment strategy for patients in this particular clinical setting.

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