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Independent lung ventilation combined with HFOV for a patient suffering from tracheo-gastric roll fistula

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Abstract
This case report describes the difficult respiratory management of an esophageal cancer patient with acute respiratory distress syndrome (ARDS) and systemic inflammatory response syndrome (SIRS) caused by a postoperative tracheo-gastric roll fistula. A single-lumen tracheal tube could not seal the fistula, and therefore a double-lumen tracheal tube (DLT) for the left side was used. Although the proximal cuff of the DLT failed to seal the fistula, independent lung ventilation (ILV) improved blood gas levels. During right thoracotomy, the left lung was ventilated conventionally with 5 cmH_2O positive end-expiratory pressure (PEEP), and in addition, high-frequency oscillation ventilation (HFOV) to the right lung was employed. This combination allowed the maintenance of adequate oxygenation, and the HFOV to the right lung decreased the Pa_{CO_2} level during surgery without interruption of the surgical field. These techniques provided the opportunity to successfully remove a necrotic gastric roll and achieve closure of the fistula using an intercostal muscle flap. This report documents and discusses the difficulty of performing appropriate anesthetic management of a patient with these complex complications after esophageal surgery.

Key words Tracheo-gastric roll fistula · ARDS · SIRS · Independent lung ventilation · HFOV

Introduction

A fistula between the airway and the esophagus or the pleural space may occur after thoracic trauma, or in patients suffering from advanced esophageal carcinoma, or as a post-surgical complication of esophageal carcinoma. Because this fistula generally causes lung injury and air leakage, it is a dilemma to resolve either problem. To prevent further lung injury, positive pressure ventilation with a large tidal volume or high peak pressure should be avoided. By contrast, unexpected hypoventilation may occur because of air leakage from the fistula. Furthermore, the size and location of the fistula may vary, and therefore the method of treatment may also vary; no optimal treatment strategy has been established. This complication happens rarely after the surgical treatment of esophageal cancer, but it can be fatal. In general, it is necessary to perform an urgent surgical procedure even in the presence of adverse conditions such as systemic inflammatory response syndrome (SIRS), acute respiratory distress syndrome (ARDS), and malnutrition.

The present report describes the perioperative respiratory management, using independent lung ventilation (ILV) combined with high-frequency oscillation ventilation (HFOV), while thoracotomy was performed for a patient suffering from ARDS and SIRS caused by a tracheo-gastric roll fistula.

Case report

A 62-year-old man with mid-lower esophageal cancer underwent resection and reconstruction of the esophagus, with the use of a gastric roll through the posterior mediastinum. He was extubated on day 1 after the surgery, however, pneumonia in the right lung continued for more than 1 week and the bronchoscope examination revealed edema in the trachea and the right main bronchus. On day 20, he complained of respiratory distress and the trachea was re-intubated. A chest X-ray revealed obvious infiltrations in the right lower lobe and scattered infiltrations in the left lung. Tracheal suction fluid contained gastric contents, and a tracheo-gastric roll fistula was discovered 2 cm above the carina. Blood tests revealed a white blood cell count of 18500/μl, C-reactive protein, 27 $mg \cdot dl^{-1}$ and a $Pa_{O_2}/F_{I_{O_2}}$ (P/F) ratio of 150 mmHg; SIRS and ARDS were also diagnosed. To

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avoid further aspiration during spontaneous inspiratory effort, the patient was sedated and paralyzed continuously, and the lungs were mechanically ventilated. The cuff of a single-lumen tube could not seal the fistula. A double-lumen tracheal tube (DLT; 37 Fr; Broncho-cath, Mallinckrodt Medical, Athlone, Ireland, for the left lung) was inserted towards the left main bronchus. However, conventional ventilation using the DLT (peak pressure / positive end-expiratory pressure [PEEP] × respiratory rate [RR] = 18–20 / 7–10 × 20) caused hypercapnea and resulted in respiratory acidosis (P/F ratio, 115–150; Pa_{CO_2}, 58–70 mmHg; pH, 7.2–7.25, Fig. 1; #1, #2). Although the DLT could not seal the fistula, we started to ventilate each lung with two ventilators (Vela; Viasys, CA, USA). Each lung was ventilated with the following ventilator setting: peak pressure / PEEP × RR: 20–30 / 7–10 × 15–20 for the left lung and 5–20/3–7 × 10 for the right lung. Thereafter, the P/F ratio increased to 180–250 mmHg and the Pa_{CO_2} decreased to 40–45 mmHg (Fig. 1; #3). Single-lung ventilation with 100% oxygen was performed, with the patient in the left lateral decubitus position, before surgery. The patient's oxygen saturation (Sp_{O_2}) could not be maintained at more than 90% for more than 5 min (Fig. 1; #4). After the resuming of lower peak-pressure controlled ventilation to the right lung, the P/F ratio increased to 240–300, while Pa_{CO_2} was between 53 and 60 mmHg (Fig. 1; #5–#7). These results indicated that we would be able to manage the patient with supplementary ventilation to the right lung during surgery. Because right lung compression and air leakage through the fistula were expected during thoracotomy, we used HFOV for the right lung, combined with conventional one-lung ventilation for the left lung during the right thoracotomy. The patient was anesthetized with fentanyl, midazolam, and propofol, and paralysis was induced with vecuronium. Continuous monitoring, using pulse-oximetry, ECG, the bispectral index (BIS), and near-infrared spectrometry (NIRO-200; Hamamatsu Photonics, Hamamatsu, Japan), was employed for measuring the oxygen saturation of the bilateral frontal lobes. A catheter was inserted in the left radial artery and a pulmonary artery catheter was inserted through the right jugular vein. After the patient had been placed in the left lateral decubitus position,

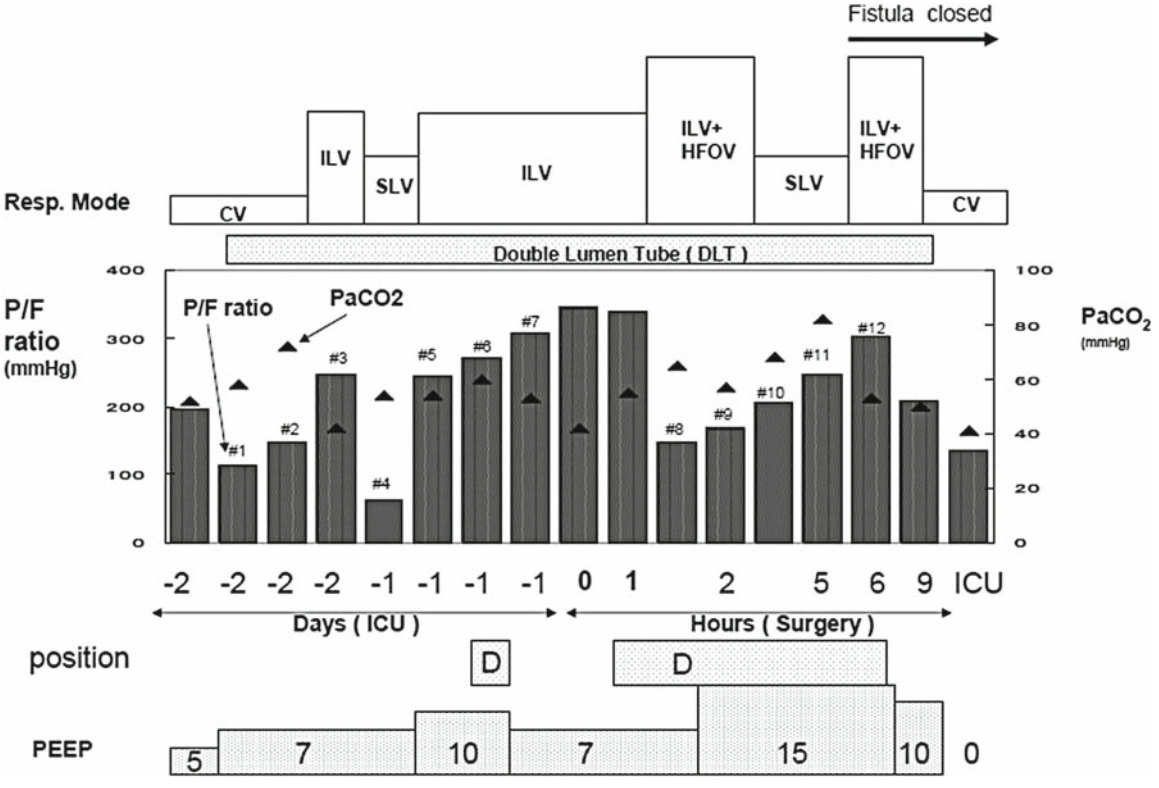

Fig. 1. This figure shows the types of intubated tracheal tubes, ventilation modes, positive end-expiratory pressure (PEEP) levels, the position of the patient, and blood gas levels during the perioperative period. Inducing independent lung ventilation (*ILV*) with a double-lumen tracheal tube dramatically improved the $Pa_{O_2}/F_{I_{O_2}}$ (*P/F*) ratio and the Pa_{CO_2} after conventional ventilation with a single-lumen tracheal tube. During right thoracotomy, the administration of high-frequency oscillation ventilation (*HFOV*) to the right lung (including the fistula), in addition to conventional ventilation with 15 cmH_2O PEEP for the left lung, was found to be useful for the prevention of hypercapnea and respiratory acidosis. *CV*, Conventional ventilation; *SLV*, single-lung ventilation; *ICU*, intensive care unit; *D*, lateral decubitus position; *Resp.*, respiratory

high-frequency oscillation ventilation (HFOV 3100A, Viasys, CA, USA) for the right lung was started, with a setting of pressure amplitude (ΔP) = 54, % inspiratory duration (%I) = 33, frequency = 5 Hz; and mean airway pressure (Paw) = 16. The P/F ratio decreased to 150 mmHg, but oxygen saturation saturation continued to be more than 98%. Pa_{CO_2} was 50–70 mmHg and pH was maintained at 7.20–7.30 during HFOV (Fig. 1; #8). Oxygen saturation decreased to 95% after right lung compression, and so 100% oxygen was administered and the PEEP for the left lung was increased to 15 cmH_2O. This successfully maintained the P/F ratio at more than 150 (Fig. 1; #9). Pa_{CO_2} increased to 80 mmHg and the pH decreased to 7.13 after the discontinuation of HFOV and during left single-lung ventilation alone performed for the closing of the fistula (Fig. 1; #10, #11). However, the hypercapnia was resolved by resuming HFOV for the right lung (Fig. 1; #12). Because of the severe SIRS, the patient showed poor peripheral perfusion and hyperthermia. The cardiac index (CI) decreased gradually, from 4.3 to 2.1 $l \cdot min^{-1} \cdot m^{-2}$, in spite of adequate fluid infusion and blood transfusion with the continuous administration of 1.0–3.0 $\mu g \cdot kg^{-1} \cdot min^{-1}$ dopamine, 0.001 $\mu g \cdot kg^{-1} \cdot min^{-1}$ human atrial natriuretic peptide (hANP), and 0.08 $mg \cdot kg^{-1} \cdot h^{-1}$ neutrophil elastase inhibitor. After the surgery, independent lung ventilation was discontinued and the DLT was exchanged for a single-lumen tube. Because the fistula opened again 3 days after this surgery, the air leakage through the fistula was not alleviated. The patient was continued on mechanical ventilation for more than 2 months after the surgery, and he subsequently died due to sepsis.

Discussion

The present report presents the difficult anesthetic management of surgery for closure of a tracheo-gastric roll fistula located 2 cm above the carina. Tracheo-gastric roll fistula is reported to be a fatal complication of the surgical treatment of esophageal cancer with the use of a gastric roll through the posterior mediastinum. This complication presents several difficulties in perioperative management, for the following reasons [1, 2]: first, insufficient ventilation may occur, due to air leakage through the fistula. Second, aspiration pneumonia may occur, and this can lead to systemic inflammation or sepsis. Third, most patients tend to demonstrate malnutrition. These situations can easily lead to ARDS. The present patient had already presented with ARDS and SIRS when the fistula was diagnosed. Before considering surgery, it was necessary to improve the P/F ratio and confirm whether adequate blood gas levels could be maintained with left single-lung ventilation with the patient in the left decubitus position. However, surgery for the repair was urgent and there was insufficient time to resolve the inflammation.

Several reports have described various procedures for the respiratory management of a patient with an airway leakage. Single or independent lung ventilation using a double-lumen tube [2, 4], HFOV with a single-lumen tracheal tube [5], and the induction of extracorporeal lung assist (ECLA) [3] have been employed to ventilate these patients.

The use of a DLT for single-lung ventilation is a common and useful strategy to isolate and protect one side of the lung from the other side. However, it is difficult to maintain the appropriate position of the DLT for prolonged periods. Furthermore, single-lung ventilation may not be established if the bilateral lungs are damaged. The induction of independent lung ventilation may be beneficial for patients in whom each lung has a different levels of damage or compliance. It is necessary to use a second ventilator to establish this technique [4].

The benefit of HFOV for such patients with damaged lungs is to provide adequate gas exchange with low tidal volume and low peak pressure. HFOV can also work for patients with a large bronchopleural fistula. However, HFOV has been recommended only as a secondary option after the failure of conventional ventilation for managing such patients with tracheo-esophageal fistula (TEF) or broncho-pleural fistula (BPF), because of the high success rate of conventional ventilation, and because of general unfamiliarity with the use of HFOV [6].

ECLA is the final choice to ventilate a patient when gas exchange cannot be maintained with conventional respiratory management. However, the disadvantage of this technique is a the possibility of massive bleeding due to the use of heparin during surgery.

In the present patient, although the bilateral lungs were injured, DLT was chosen to protect the left lung and ventilate the left lung for right thoracotomy. Because the P/F ratio could not be maintained adequately with left single-lung ventilation, ILV was established and this improved the blood gas levels. The compliance of the lungs was obviously different because of the different degrees of lung damage and air leakage through the fistula. Therefore, different ventilation settings and ventilation monitoring for each lung were beneficial to prevent further lung injury and improve gas exchange [5].

HFOV for the right lung was combined with ILV during surgery. Because HFOV can provide a much smaller tidal volume than that provided by conventional ventilation, HFOV may be beneficial for reducing air leakage into the surgical field while maintaining gas exchange during surgery. The blood gas levels during the surgery in our patient indicated that the benefit of

this technique was not an improvement of oxygenation, but rather, improvement of CO_2 elimination and alleviation of respiratory acidosis.

In conclusion, the present report has described, the management of a difficult respiratory complication caused by a tracheo-gastric roll fistula that formed after surgical treatment for esophageal cancer. Independent lung ventilation (ILV) combined with HFOV through a DLT made it possible for the patient to undergo a second surgery to repair the fistula and to remove the necrotic gastric roll, in spite of the presence of ARDS and SIRS.

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