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# Lung Volume Reduction Under Spontaneous Ventilation in a Patient with Severe Emphysema

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Study Design A  
Data Collection B  
Statistical Analysis C  
Data Interpretation D  
Manuscript Preparation E  
Literature Search F  
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**Conflict of interest:** None declared

**Patient:** Male, 71  
**Final Diagnosis:** Left-side secondary spontaneous pneumothorax • chronic obstructive pulmonary disease  
**Symptoms:** Chest pain • shortness of breath • dyspnea • persistent bubbles extravasation  
**Medication:** Antibiotic drugs  
**Clinical Procedure:** Lung volume reduction surgery under spontaneous ventilation  
**Specialty:** Anesthesiology

**Objective:** Unusual setting of medical care  
**Background:** One-lung ventilation under general anesthesia is necessary for most thoracic surgical procedures. However, adverse effects may derive from mechanical ventilation in emphysema patients. At present, lung volume reduction surgery under spontaneous ventilation may attenuate these adverse effects.

**Case Report:** We present a case of left-side secondary spontaneous pneumothorax in a 71-year-old male who had a history of chronic obstructive pulmonary disease for 12 years, combined with a contralateral giant bulla. After conservative therapies, bubble extravasation still persisted on the left side of the drainage tube. Lung volume reduction surgery under spontaneous ventilation was considered. The patient recovered fast though intraoperative critical respiratory management, effective pain control, and suitable sedation, and he was discharged from the hospital 3 days after the operation.

**Conclusions:** Video-assisted thoracic surgery under spontaneous ventilation may be an alternative method for lung volume reduction surgery in emphysema patients who also have secondary spontaneous pneumothorax and a contralateral giant bulla.

**MeSH Keywords:** Pneumonectomy • Pneumothorax • Pulmonary Emphysema • Thoracic Surgery, Video-Assisted

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## Background

Emphysema patients with secondary spontaneous pneumothorax (SSP) are often poor surgical candidates due to poor pulmonary function and high risk of complications from general anesthesia (GA) with one-lung ventilation. The postoperative morbidity rate is 15–27.7% [1]. It has been reported that a 3-fold rise in airway pressure results in elevation of pulmonary vascular resistance during one-lung ventilation [2]. One-lung ventilation can aggravate air-trapping and progressive hyperinflation due to the loss of elastic recoil and premature closure of peripheral airways in emphysema patients. Institution of positive-pressure ventilation may lead to bullae rupture, life-threatening pneumothorax, and hypoxia in emphysema patients [3]. Ventilation for chronic obstructive pulmonary disease (COPD) patients also can cause dynamic pulmonary hyperinflation and auto-positive end-expiratory pressure [4], and both of these conditions can cause hemodynamic consequences such as left ventricular dysfunction and a tamponade effect on the right ventricle [5,6]. Moreover, as COPD patients show a high incidence of bronchial hyperreactivity, avoiding tracheal intubation can prevent bronchospasm [7]. Thus, avoidance of one-lung ventilation and tracheal intubation might offer several advantages, particularly in functionally compromised emphysematous patients.

Currently, video-assisted thoracic surgery (VATS) under spontaneous ventilation is widely performed a variety of thoracic procedures, and even lung volume reduction surgery (LVRS) is able to be safely and feasibly performed using the awake VATS technique [8]. Mineo has hypothesized that awake LVRS is associated with a less morbidity and more rapid recovery due to the avoidance of general anesthesia-related adverse effects [9]. Pompeo found that perioperative breathing pattern, oxygenation, promptness of resumption of daily-life activities, hospital stay, and costs are dramatically better in patients undergoing awake LVRS [10,11].

The combination of SSP and a contralateral giant bulla increase the difficulty of intraoperative management for thoracoscopic LVRS under spontaneous ventilation, and this has not been reported in the past. Thus, we describe how to perform LVRS under VATS with spontaneous ventilation and how to institute intraoperative management for these patients.

## Case Report

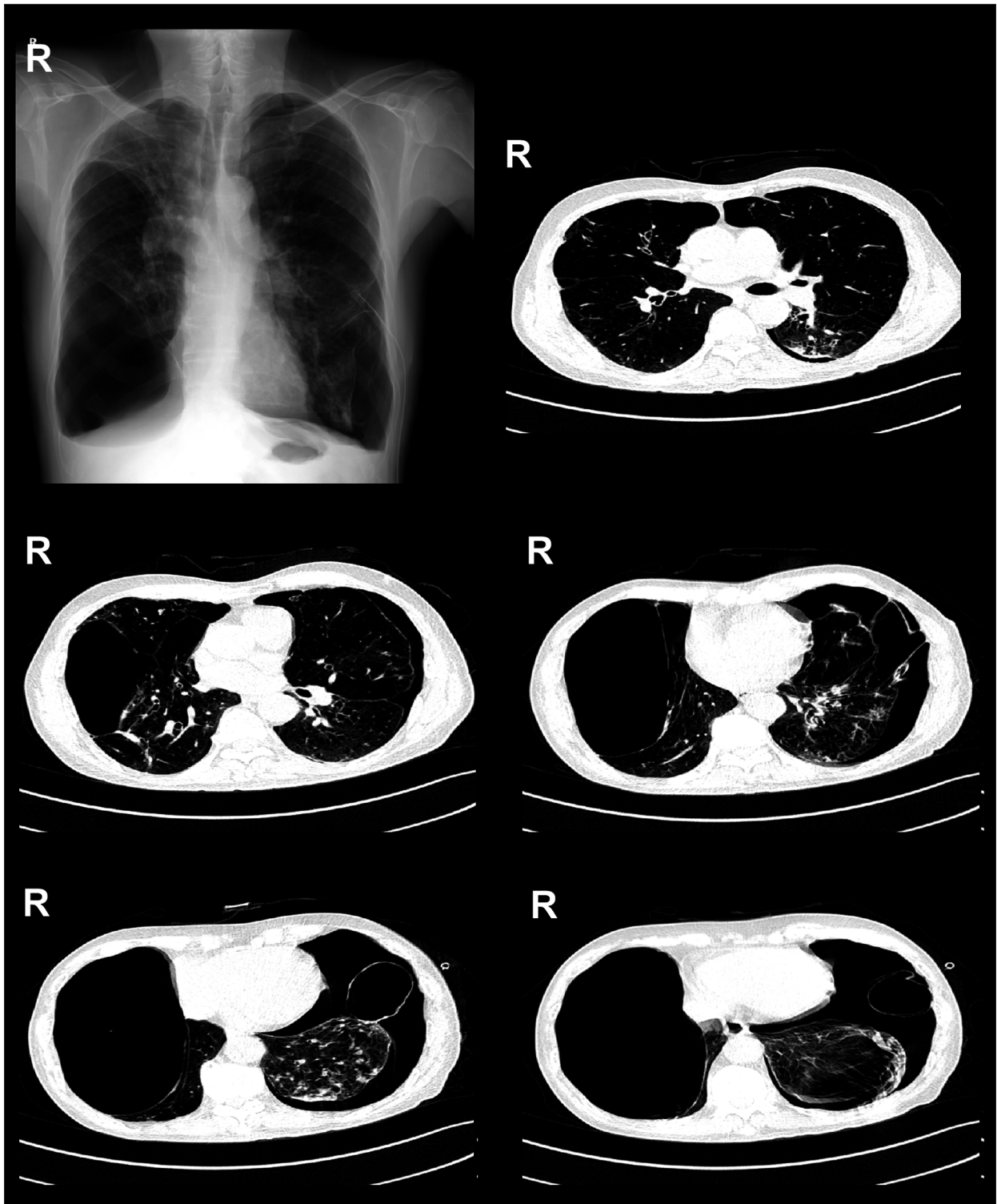
A 71-year-old man, weight 60 kg and height 172 cm, presented to a primary care center with acute onset of chest pain, shortness of breath, and dyspnea. He was found to have left-sided pneumothorax by chest radiograph, and received therapies by insertion of an intercostal drainage and antibiotic drugs.

After conservative treatments, persistent bubbles extravasation existed on the left side of the drainage tube for 1 month, and he still had dyspnea.

When he was admitted to our hospital, a computed tomography scan revealed chronic bronchitis, emphysema, and multiple bullae in bilateral lungs, with a giant bulla (8.7×17.5×12.7) cm in the right lower lung and hydropneumothorax in left lung, with left lung compression 35%–40%, and a small amount of pleural effusion (Figure 1). Arterial blood gas was pH 7.431, PaO<sub>2</sub> was 93 mm Hg, PaCO<sub>2</sub> was 38.6 mm Hg, standard bicarbonate was 24 mEq·L<sup>-1</sup>, and SaO<sub>2</sub> was 96.2% (oxygen 2 L/min). A left thoracoscopic LVRS under spontaneous ventilation was conducted for symptomatic relief.

Anesthesia was initiated and maintained by target-controlled infusion propofol combined with remifentanyl and dexmedetomidine. A laryngeal mask airway (LMA) (Ambu Inc., Glen Burnie, USA) was inserted. Assisted ventilation through LMA was applied to improve air exchange if the SpO<sub>2</sub> declined below 90% or if end-tidal carbon dioxide partial pressure (P<sub>ET</sub>CO<sub>2</sub>) was >60 mmHg. A radial arterial and central venous line was placed for measuring continuous arterial blood pressure and central venous pressure. Thoracoscopy was performed using 3-port VATS. After skin local anesthesia with 2% lidocaine, the utility incision for VATS exploration at the 6th intercostal space was performed, followed by anesthetization of the surface of visceral pleura and intercostal nerve blocked with 5 ml 2% lidocaine, then the left vagal nerve was infiltrated with 2.5 ml 2% lidocaine and 2.5 ml 0.75% ropivacaine under direct vision to inhibit the cough reflex. Low-dose remifentanyl (0.03–0.05 µg/kg/min) combined with dexmedetomidine (0.5–1.0 µg/kg/h) can effectively enhance pain relief without breathing depression. No assisted ventilation was required for this patient. The patient maintained spontaneous breathing throughout the operation, with stable hemodynamics, bispectral index 44–60, tidal volume 150–250 ml, respiratory rate 18–20 bpm/min, peak airway pressure 2 cm H<sub>2</sub>O, SpO<sub>2</sub> 96–100%, P<sub>ET</sub>CO<sub>2</sub> 36–50 mmHg, and inspired oxygen flow rate 3–6 L/min. Pulmonary pressure collapsed within a few minutes by iatrogenic pneumothorax. It seemed adhered and presented blistering emphysema after exploration, and giant pulmonary bullae were found on anterior basal segment of left lower lobe and the apical part of left upper lobe. Consequently, LVRS was performed by staple resection of the anterior basal segment of left lower lobe and the apical part of the left upper lobe. Two 22-Ch chest drainages were inserted at the end.

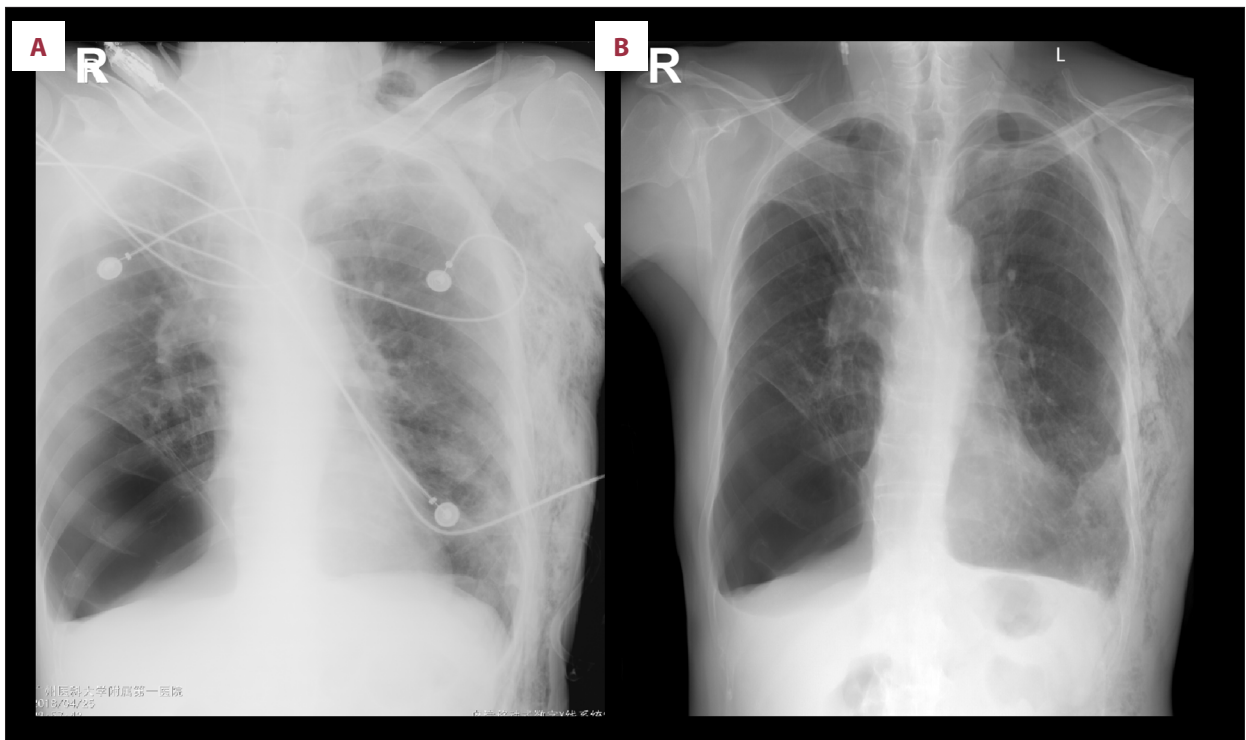
The patient woke up and removed the LMA without pain after arriving at the post anesthesia care unit (PACU) for 10 min. He was directly transferred to the ward with stable vital signs and SpO<sub>2</sub> 97% (oxygen 2 L/min) 50 min later. The chest tube was removed on the 1<sup>st</sup> postoperative day, with 50 (up)/100 (down) ml



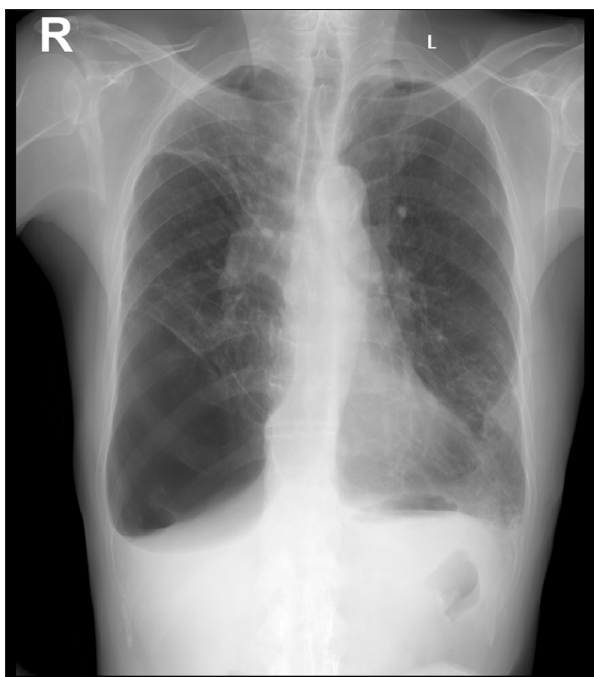
**Figure 1.** Preoperative chest radiograph and computed tomography.

drainage and no air leakage, and chest radiography showed an expanded left lung and no pneumothorax in the right side (Figure 2). He was discharged from hospital on the 3<sup>rd</sup> postoperative day, without complications. At the 1-month follow-up

visit, the patient had no discomfort. Chest radiograph showed the left lung was fully expanded, and the right side had no obvious change (Figure 3). A chest ultrasound showed no dark liquid area.



**Figure 2.** Postoperative chest radiographs on the first day and third day. (A) 1<sup>st</sup> day after operation. (B) 3<sup>rd</sup> day after operation.



**Figure 3.** The postoperative chest radiograph 1 month after operation.

## Discussion

LVRS under GA with one-lung ventilation is the traditional method. One-lung ventilation can be performed with a

double-lumen tube (DLT) or with endobronchial blockers. With the smaller internal diameters of DLTs, plateau pressure and peak inspiratory pressure increase in a 42% and 55% respectively, with the inherent risk of bulla rupture with high plateau pressure [12]. Use of an endobronchial blocker can improve intraoperative oxygenation by selective lobar blockade in patients with severe pulmonary dysfunction [13]. However, bronchial blockage easily shifts due to the surgical traction, which affects lung collapse. Use of positive-pressure ventilation is mandatory for one-lung ventilation, and may produce lung injury. Our patient has a giant bulla in the right side, which could have ruptured under positive mechanical ventilation. Postoperative long-term ventilator dependency, prolonged hospital stay, and financial burden are also higher in emphysema patients who also have SSP and a contralateral giant bulla [14,15]. Thus, VATS under spontaneous ventilation may be a desirable alternative to GA with one-lung ventilation.

A critical anesthetic consideration for VATS under spontaneous ventilation is respiratory management. Use of a face mask with supplemental oxygen is sufficient to prevent hypoxemia in patients without severe pulmonary comorbidities. Otherwise, LMA is recommended for assisted ventilation when necessary in patients with pulmonary dysfunction. Intraoperative hypercapnia may unavoidably occur in emphysema patients, but this ‘permissive hypercapnia’ is generally well tolerated and oxygenation is typically equal or better. However, ‘permissive hypercapnia’ is not infinitely permissive, and the  $P_{ET}CO_2$  usually

underestimates the real PaCO<sub>2</sub> concentration when under VATS with spontaneous ventilation. Blood gas analysis is required at this time, and auxiliary low tidal volume ventilation (4–5 ml/kg) by LMA to avoid excessive carbon dioxide is necessary. Our patient tolerated the thoracoscopic LVRS well under spontaneous ventilation without inadvertent pneumothorax on the contralateral side. Low concentration of sedation, analgesia, and effective nerve block provided satisfactory anesthesia. No hypoxemia or unstable hemodynamics were noted.

Noda and Galvez have reported out that VATS combined with spontaneous breathing can be performed for SSP patients, with a lower incidence of postoperative respiratory complications [16,17]. Nezu suggests that awake surgery can be considered for some SSP patients with underlying pulmonary disease who also have significant associated risks [18]. Both Minto and Pompeo reported that spontaneous ventilation is feasible for LVRS, with a fast postoperative recovery [9–11]. VATS under spontaneous ventilation can preserve the diaphragm motion and conserve the pulmonary compliance of the dependent lung, which is perfusion-favored during lateral decubitus; thus, the ventilation-to-perfusion match results are less affected, decreasing the risk of hypoxemia. It also reduces the risk of atelectasis in the dependent lung by maintaining diaphragm contraction. The use of propofol and local anesthetics (such as ropivacaine) instead of volatile inhalation anesthetic seems to preserve the physiological mechanism of hypoxic pulmonary vasoconstriction, which favors perfusion on the dependent lung. Avoiding orotracheal intubation and mechanical ventilation clearly diminishes the risk of barotrauma, volutrauma, atelectrauma, and the inflammatory conditions [17].

But at present, we still lack deeply and large scale investigated studies on awake LVRS for emphysema patients. Some negative effects resulting from VATS under spontaneous ventilation really deserve us to pay attention. First, mediastinum dropping above the dependent lung due to the atmospheric pleural pressure and rebreathing mechanism of expired air into the dependent lung can produce some degree of hypoxemia, and hypercapnia [19]. Second, lung inflation under spontaneous ventilation anaesthesia is not as sufficient as that with an endotracheal tube for surgeons to routinely inflate the lung underwater to identify air leakage [20]. Thus, the incidence of postoperative atelectasis may be higher. Furthermore, the

specific respiratory physiology is still unknown when VATS under spontaneous ventilation. Other questions are still needed to be concern about, such as the incidence of gastroesophageal reflux when under LMA in lateral position, the probability of conversion spontaneous ventilation to intubation, the effect of prolonged hypercapnia on cell metabolism.

VATS under spontaneous ventilation without positive-pressure ventilation can reduce the incidence of right-sided pneumothorax, which would have been a disastrous consequence for our patient. If right-sided pneumothorax occurs during the operation, we do not hesitate to intubate the tracheal tube to ensure oxygenation. Our patient just underwent left LVRS without concurrent resection of the right giant pulmonary bulla. The consensus of anesthesiologists and surgeons is as follows. First, the patient's right lung is able to maintain adequate oxygenation according to preoperative arterial blood gas values, meaning it can tolerate left LVRS even under one-lung ventilation, but it still unknown whether the left lung can maintain oxygenation during right-sided bulla resection. Second, bilateral simultaneous VATS prolongs the operation time and increases the intraoperative risk. Third, it is hard to speculate whether elderly patients with severe pulmonary dysfunction would tolerate a simultaneous bilateral operation, due to lack of preoperative pulmonary function evaluation.

## Conclusions

VATS under spontaneous ventilation may be a desirable alternative to perform LVRS in emphysema patients who have SSP and a giant bulla. The need for general anesthesia and endotracheal intubation to perform LVRS may need to be re-examined, and this issue requires in-depth research.

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## Conflict of interest

None.

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