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# Contralateral Pneumonectomy 27 Years After Right Single-Lung Transplantation for Emphysema: A Case Report

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Data Collection B  
Statistical Analysis C  
Data Interpretation D  
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**Patient:** Female, 74-year-old  
**Final Diagnosis:** Native lung hyperinflation  
**Symptoms:** Dyspnea  
**Medication:** —  
**Clinical Procedure:** —  
**Specialty:** Anesthesiology • Pulmonology • Transplantology




**Objective:** Unusual clinical course  
**Background:** Following single-lung transplantation, native lung inflation can progressively develop in patients with emphysema.  
**Case Report:** A 74-year-old female patient presented with worsening dyspnea during daily activities. She underwent a right single-lung transplantation for emphysema 27 years ago. Despite recurrent episodes of acute rejection of the grafted lung, the patient had satisfactory recovery of physical fitness during that period and did not report any serious complications or respiratory symptoms. Her recent dyspnea was due to hyperinflation of the native emphysematous lung with mediastinal shift, reduction of venous blood return, and compression of the grafted lung. Although surgical lung volume reduction had resulted in temporary functional improvement 2 years ago, a completion contralateral pneumonectomy was deemed necessary to allow re-expansion of the grafted lung. After anesthesia induction and placement of a double-lumen tube, selective ventilation of the left emphysematous native lung confirmed the absence of gas exchange based on near-zero end-expiratory carbon dioxide fraction. During selective ventilation of the grafted lung, satisfactory gas exchange was achieved and pneumonectomy proceeded uneventfully under minimally-invasive thoracotomy. Immediately after anesthesia emergence and tracheal extubation, the patient experienced respiratory improvement. Continuous thoracic epidural blockade allowed pain-free mobilization and respiratory therapy to facilitate re-expansion of the grafted lung.

**Conclusions:** After single-lung transplantation in COPD patients, native lung hyperinflation is a well-described rare complication. Lung volume reduction including pneumonectomy can be considered a valuable treatment option.

**Keywords:** Emphysema • Pneumonectomy • Lung Transplantation

**Abbreviations:** BLT – bilateral lung transplant; COPD – chronic obstructive pulmonary disease; CT – computed tomography; DLCO – carbon oxide diffusing capacity; ET<sub>CO<sub>2</sub></sub> – end-tidal CO<sub>2</sub>; FEV<sub>1</sub> – forced expiratory volume in 1 second; FiO<sub>2</sub> – inspiratory oxygen fraction; FVC – forced vital capacity; IV – intravenous; OLV – one-lung ventilation; PFT – pulmonary functional test; SaO<sub>2</sub> – arterial oxygen saturation; SLT – single-lung transplant

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## Background

Lung transplantation improves survival and quality of life of patients with chronic obstructive pulmonary disease (COPD). Given the shortage of donor lungs and the risk of death due to a prolonged waiting period, offering one pair of donor lungs for 2 candidates is an efficient way to optimize donor organs distribution based on medical urgency and recipient demographic parameters [1]. Short- and long-term survival after single and bilateral lung transplant (SLT, BLT) are quite similar in patients older than 65 years, whereas functional parameters related to lung volume capacity and diffusion capacity, as well as exercise tolerance and health-related quality of life, are better at all follow-up times in patients undergoing BLT compared to SLT [2].

Besides allograft dysfunction and surgical complications that occur within the first weeks following lung transplantation, non-small cell lung carcinoma and progressive hyperinflation can develop later in the native emphysematous lung [3]. Thoracic surgery with one-lung ventilation (OLV) is particularly challenging in patients with severe emphysema owing to dynamic gas trapping and alterations in hemodynamics that

can compromise perioperative gas exchange. Given the high procedural risk and uncertain clinical benefits, this case report illustrates the “shared decision making” that brings patient’s values and preferences together with clinician expertise to determine the best care package for the individual concerned [4].

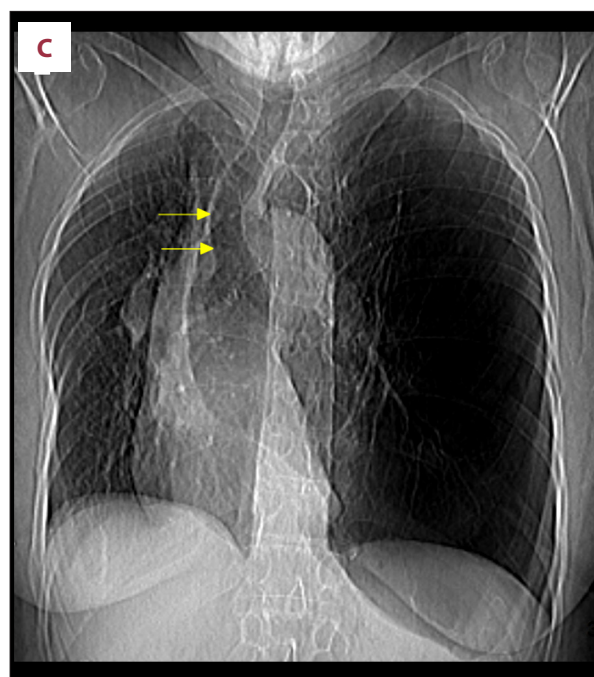
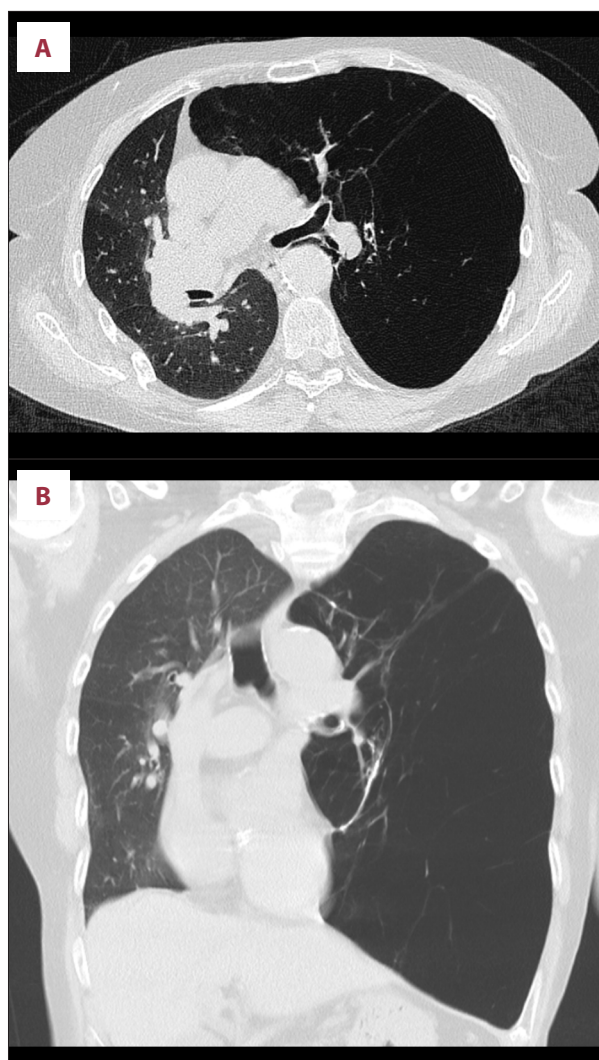
## Case Report

In 1994, a woman weighing 58 kg and 169 cm tall with tobacco-associated emphysema underwent a right SLT. After several episodes of acute graft rejection, she exhibited marked improvement in pulmonary functional tests (PFTs) with adequate recovery of her physical fitness. Over the last 4 years, the immune tolerance to the SLT was well controlled under low doses of prednisone (5 mg) and tacrolimus (1 mg), but she had increasing dyspnea on mild exercise, attributed to hyperinflation of the native lung. In May 2019, she underwent non-anatomical lung volume reduction under video-assisted thoracic surgery, which resulted in temporary functional improvement. In July 2021, although gas exchange was satisfactory at rest, this 74-year-old patient was referred to our hospital with severe dyspnea (Borg dyspnea score 8/9), and walking limitation

**Table 1.** Patient’s pulmonary function tests preoperatively.

| Spirometry parameters                              | Preoperative | % of reference value | Z score |
|--|--------------|----------------------|---------|
| FEV1 (L)   | 0.56         | 29%                  | -3.93   |
| FVC (L)  | 0.93         | 37%                  | -3.87   |
| SVC (L)  | 0.98         | 39%                  | -3.71   |
| FEV1/FVC (%)                                       | 61           | 78%                  | -2.00   |
| FEV1/SVC (%)                                       | 57           | 73%                  | -2.37   |
| PEF (L/s)  | 1.38         | 26%                  | -4.36   |
| FEF25-75 (L/s)                                     | 0.26         | 16%                  | -3.04   |
| <b>Volumes (plethysmography)</b>                   |              |                      |         |
| TLC (L)  | 5.29         | 116%                 | 1.19    |
| RV (L)   | 4.22         | 209%                 | 6.28    |
| RV/TLC (%)   | 80           | 183%                 | 6.20    |
| FRC (L)  | 4.43         | 171%                 | 3.68    |
| <b>Carbon dioxide (CO) diffusion capacity (DL)</b> |              |                      |         |
| DLCO (Mmol/kPa/min)                                | 1.63         | 27%                  | -8.53   |
| DLCO(Hb) (Mmol/kPa/min)                            | 1.76         | 30%                  | -7.90   |
| Kco (Mmol/kPa/min/l)                               | 1.24         | 88%                  | -0.82   |
| Kco(Hb) (Mmol/kPa/min/l)                           | 1.34         | 95%                  | -0.32   |
| Hb (g/dl)  | 11.1         |                      |         |

FEV1 – forced expiratory volume in the first second; FVC – forced vital capacity; SVC – slow vital capacity; PEF – peak expiratory flow; FEF25-75% – forced expiratory flow at 25 and 75% of the pulmonary volume; TLC – total lung capacity; RV – residual volume; FRC – functional residual capacity; DLCO – diffusing capacity of the lung for carbon monoxide; DLCO(Hb) – DLCO adjusted for hemoglobin; Kco – carbon monoxide transfer coefficient; Kco (Hb) – Kco adjusted for hemoglobin; Hb – hemoglobin.



**Figure 1.** (A) Preoperative axial chest computed tomography scan. (B) Preoperative coronal chest computed tomography scan. (C) Preoperative plain chest radiography illustrating rightward mediastinal deviation and compression of the grafted lung; arrows pointing at the border of the trachea showing right deviation.

(<10 m), unresponsive to oxygen therapy. Echocardiography revealed normal left ventricular ejection fraction with no sign of pulmonary arterial hypertension. As summarized in **Table 1**, the PFTs confirmed a pattern of severe lung hyperinflation and non-reversible flow obstruction along with limitation in carbon oxide diffusing capacity (27% predicted value). The plain chest radiography and thoracic computed tomography scan showed bullous emphysema of the native left lung, causing rightward mediastinal deviation and compression of the grafted lung, as well as the vena cava and the heart (**Figure 1**). Lung scintigraphy showed very low flow in the left lung (<6% of cardiac output) with thromboembolic occlusion of the inferior left lobar artery. Besides immunosuppressive drugs, the patient was treated with inhaled bronchodilators (glycopyrronium, formoterol, beclomethasone), losartan (100 mg), and rosuvastatin (20 mg).

A completion pneumonectomy of the hyperinflated native lung was planned to allow re-expansion of the right transplanted

lung. During the 3 weeks preceding surgery, the patient's physical condition was optimized through daily home sessions of volume incentive spirometry, deep breathing exercise, and muscle strengthening of the upper and lower limbs using elastic bands. Psychological support was also provided by her family and regular phone calls with physiotherapists and the medical team.

Before surgery, nebulized salbutamol was administered and the patient was equipped with a thoracic epidural catheter (T5-T6), 2 intravenous (i.v.) lines, and a radial artery catheter for blood pressure monitoring. Epidural analgesia was initiated with bupivacaine 0.25% and fentanyl 0.002% (bolus of 6 ml) and maintained throughout surgery (5 ml/h). General anesthesia was induced with sufentanil (10 mcg), etomidate (20 mg), and rocuronium (30 mg). A double-lumen tube was inserted and proper positioning was confirmed by fiberoptic bronchoscopy. During selective ventilation through the tracheal port, the end-tidal CO<sub>2</sub> (ETCO<sub>2</sub>) dropped to near 0, whereas during selective ventilation through the bronchial port, ETCO<sub>2</sub> stabilized at around 4.5% and arterial oxygen saturation (SaO<sub>2</sub>) was 98-100% with an inspiratory oxygen fraction (FiO<sub>2</sub>) of 0.8. Anesthesia was maintained with inhaled sevoflurane and 100 mg hydrocortisone was administered

**Table 2.** Perioperative hemodynamic and respiratory data.

|   | Awake  | 2-LV post-induction | OLV-0 | OLV-30 | OLV-60 | (2-1)-LV | Post-extubation |
|---|--------|---------------------|-------|--------|--------|----------|-----------------|
| HR (beat/min)                             | 81     | 70                  | 64    | 56     | 58     | 60       | 65              |
| MAP (mmHg)                                | 102    | 76                  | 80    | 72     | 81     | 92       | 95              |
| SaO <sub>2</sub> /FiO <sub>2</sub>        | 100/40 | 97/50               | 99/50 | 99/50  | 99/50  | 100/50   | 94.5/25         |
| FeCO <sub>2</sub>                         | –      | 4.9                 | 4.7   | 4.5    | 4.5    | 5.8      | –               |
| Vt (ml)                                   | –      | 380                 | 340   | 340    | 340    | 390      | –               |
| RR (cycle min)                            | –      | 12                  | 14    | 14     | 14     | 12       | –               |
| P <sub>plateau</sub> (cmH <sub>2</sub> O) | –      | 10                  | 13    | 12     | 12     | 11       | –               |
| PEEP (cmH <sub>2</sub> O)                 | –      | 5                   | 7     | 7      | 7      | 5        | –               |
| C <sub>Dyn</sub> (ml/cmH <sub>2</sub> O)  | –      | 37                  | 26    | 29     | 28     | 30       | –               |
| pH (u)                                    | 7.45   | –                   | –     | –      | –      | 7.37     | 7.41            |
| PaCO <sub>2</sub> (kPa)                   | 4.45   | –                   | –     | –      | –      | 5.2      | 4.9             |
| PaO <sub>2</sub> (kPa)                    | 11.4   | –                   | –     | –      | –      | 39.3     | 9.12            |

HR – heart rate; MAP – mean arterial pressure; SaO<sub>2</sub>/FiO<sub>2</sub> – oxygen saturation to fraction of inspired oxygen ratio; FeCO<sub>2</sub> – fractional content of expired CO<sub>2</sub>; Vt – Tidal volume; RR – respiratory rate; P<sub>plateau</sub> – plateau pressure; PEEP – positive end-expiratory pressure; C<sub>Dyn</sub> – dynamic compliance; PaCO<sub>2</sub> – partial pressure of carbon dioxide; PaO<sub>2</sub> – partial pressure of oxygen; LV – lung ventilation; OLV – one-lung ventilation.

i.v. Pressure-controlled volume-guaranteed ventilation (Aisys CS2 workstation, GE Healthcare) was initiated after performing an alveolar recruitment maneuver and setting a tidal volume of 5.5 ml/kg of predicted body weight. A positive end-expiratory pressure of 7 cmH<sub>2</sub>O was selected, which achieved the highest lung compliance. The inspiratory: expiratory ratio (1: 2) and respiratory rate (14/min) were adjusted to allow complete alveolar emptying and normocapnia. Right pneumonectomy was carried out through an antero-lateral intercostal approach. Hemodynamics, oxygenation index (SaO<sub>2</sub>/FiO<sub>2</sub>) and ETCO<sub>2</sub> remain within normal physiological range, even following clamping of the right pulmonary artery (Table 2). At the end of a 70-min uneventful procedure, complete recovery of the neuromuscular block was confirmed (Train-Of-Four ratio > 0.9 upon stimulation of the ulnar nerve). The estimated blood loss was less than 150 ml and 650 ml i.v. crystalloids was given. After a last alveolar recruitment maneuver, the patient was extubated and transferred to the Post-Anesthesia Care Unit.

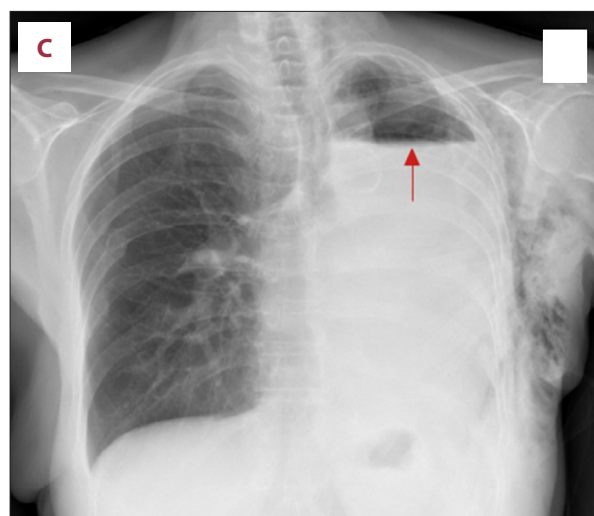
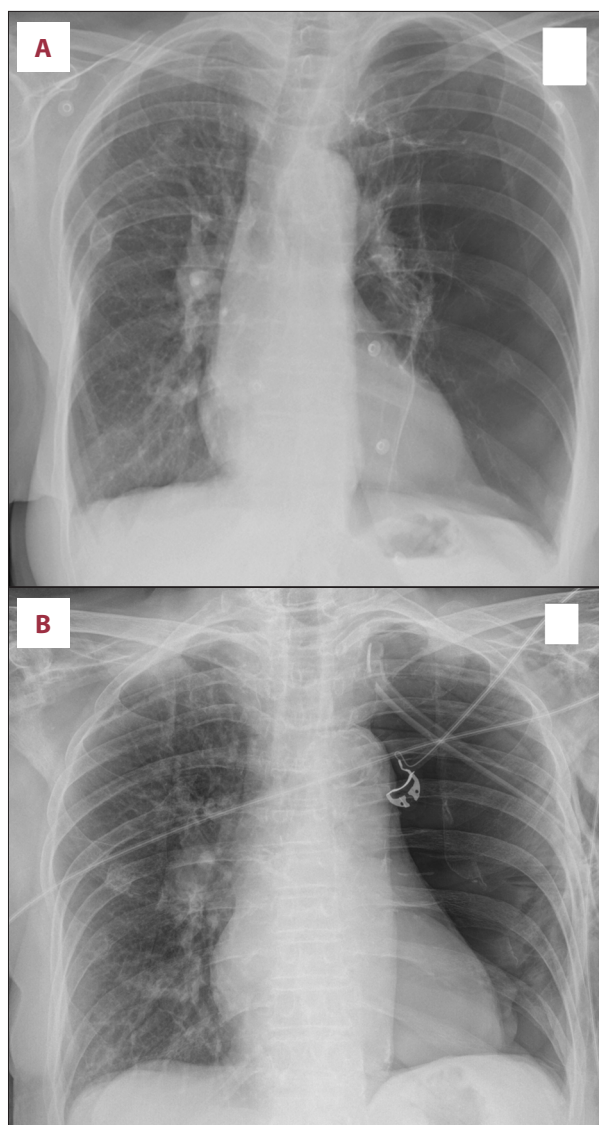
Postoperatively, the patient reported immediate improvement in spontaneous breathing, with normocapnia and satisfactory oxygenation (Table 2), while chest X-rays showed re-expansion of the grafted lung and a shift of the trachea and heart to a more central position. The chest tube was removed 6 h postoperatively and 4 h later the chest radiogram demonstrated fluid accumulation in the left pleural cavity (Figure 2)

that required a thoracocentesis to remove 500 ml of clear fluid with no evidence of infection. On the third day after surgery, the onset of atrial fibrillation required pharmacological cardioversion (amiodarone 300 mg i.v.). The patient was discharged to a rehabilitation center on the tenth postoperative day. One month later, her 6-minute walking capacity had increased above 300 m and she had full autonomy in her daily functional activities.

## Discussion

According to the International Society for Heart and Lung Transplantation Registry, SLT is performed in up to 40% of patients with end-stage COPD [5]. Native lung hyperinflation compressing the grafted lung represents a unique complication that develops in 5-30% of COPD patients following SLT [6,7]. Dead space ventilation, restricted functional alveolar areas, and impaired venous blood return all contribute to produce dyspnea, respiratory muscle fatigue, and poor exercise capacity. Several case series have reported functional improvements after surgical lung volume reduction that was associated with high early morbidity (eg, infection, air leaks, and renal failure) requiring intensive care, and reduced survival at 1 year (58%) [8].





**Figure 2.** Antero-posterior chest radiographs: (A) Before surgery. (B) 2 hours after extubating the patient. (C) Ten hours postoperatively showing fluid accumulation in the left pleural cavity; red arrow pointing at the upper limit of the fluid level.

Contralateral pneumonectomy after SLT has been reported in only 3 patients (ages 46, 56, and 66 years (**Table 3**) [9-11]. Intractable air leak was incriminated in 1 case (17 days after SLT) [11] and progressive hyperinflation of the native lung in the other 2 patients (3 years and 12 years after SLT) [9,10]. In our patient, clinical improvement was achieved transiently after lung volume reduction and she underwent completion pneumonectomy 27 years after right SLT.

Preoperatively, the expected clinical benefits associated with removal of the native hyperinflated lung lead the multidisciplinary board involving thoracic surgeons, anesthesiologists, and chest physicians to propose a pneumonectomy via a minimally-invasive thoracotomy. Pulmonary hypertension, significant cardiovascular disease (eg, heart failure and coronary artery disease) or other organ failure (eg, liver and kidney) that could have contraindicated surgery were absent, and the fully

informed patient chose to undergo surgery [12]. Besides advanced age, immunosuppression, and poor pulmonary function, muscular deconditioning was the only potentially reversible risk factor. Accordingly, a home-based physical training program with psychological support was initiated 3 weeks before surgery to empower the patient as an active partner in her health care process and to strengthen respiratory muscles to prevent postoperative pulmonary complications [13]. To reduce the administration of opiates and allow a smooth anesthesia emergence, thoracic epidural analgesia was used intraoperatively and was continued in the early postoperative period to facilitate re-expansion of the grafted lung with exercise [14]. Alternatively, a paravertebral thoracic block might have been considered [15]. Inhalational anesthesia was preferred to intravenous anesthetics given the bronchodilating and organ preconditioning effects of volatile anesthetic agents resulting in fewer postoperative pulmonary and neurocognitive disturbances [16,17]. After anesthesia induction, the lungs were isolated with a double-lumen tube and the sharp drop end-tidal  $\text{CO}_2$ , while ventilating the left native lung confirmed the absence of blood flow through the left pulmonary artery and total non-functionality of the left lung. On the grafted right lung, an open protective ventilatory strategy was applied, including low  $V_T$ , titrated PEEP, and alveolar recruitment maneuver to minimize ventilation-induced lung injury [18]. Interestingly, Friedrich et al recently reported their unique experience using laryngeal masks and providing assisted ventilation in 20 patients undergoing anatomical lung resection, including 1 pneumonectomy- via video-assisted thoracoscopic surgery [19]. Compared with controlled mechanical ventilation, assisted spontaneous breathing can lower the risk of ventilatory-lung injuries by reducing inspiratory

**Table 3.** Reported cases of pneumonectomy after single-lung transplantation and native lung hyperinflation.

| Author (year)               | Indication for SLT                  | Time to respiratory symptoms | Complications in the native lung                      | Respiratory symptoms                        | Thoracic procedure                            | Postoperative course   |
|-----------------------------|-------------------------------------|------------------------------|---|---|---|--|
| Boulos et al [current case] | Broncho-emphysema                   | 27 years                     | Hyperinflation<br>Mediastinal shift                   | Dyspnea                                     | Pneumonectomy by minimal-invasive thoracotomy | Atrial fibrillation; hospital discharge on POD10 with improved walking capacity                                    |
| Abi Jaoude et al (2016) [9] | Alpha-1-antitrypsin deficiency      | 12 years                     | Hyperinflation<br>Mediastinal shift                   | Hemoptysis                                  | Pneumonectomy by VATS                         | Hospital discharge on POD4   |
| Liu et al (2014) [10]       | Pulmonary lymphangio-Leiomyomatosis | 3 years                      | Hyperinflation<br>Mediastinal shift                   | Dyspnea                                     | Anatomical bilobectomy (RM and RLL)           | Hospital discharge on POD21 with improved PFTs   |
| Novick et al (1991) [11]    | Alpha-1 antitrypsin deficiency      | 17 days                      | Multiple leaking bullae requiring chest tube drainage | Dependent on mechanical ventilatory support | Pneumonectomy by thoracotomy                  | Polyneuropathy requiring mechanical ventilatory support for 11 weeks<br>Weaned from supplemental oxygen on POD 105 |

PFTs – pulmonary function tests; POD – postoperative day; RM and RLL – right middle and right lower lobectomy; VATS – video-assisted thoracic surgery.

support pressure, ensuring stable hemodynamics by improving venous return and facilitating postoperative recovery by reducing the need for neuromuscular-blocking drugs. These advantages have to be weighed against unexpected ventilator-patient asynchrony during surgical manipulation and the need to proceed to urgent intubation in case of severe adverse events (eg, acute bleeding and hypoxemia) [20].

## Conclusions

Postoperatively, our patient exhibited impressive functional improvements allowing her to resume her daily activities and to ensure her complete autonomy at home. After SLT in

COPD patients with native lung hyperinflation, lung volume reduction and pneumonectomy as a last resort are considered valuable treatment options. Given the high risk of adverse events in these unusual situations, a patient-oriented multidisciplinary approach should include preoperative patient counseling and physical fitness preparation as well as perioperative protective interventions by experienced thoracic surgeons and anesthesiologists.

## Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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