Heart & Lung 45 (2016) 258–260

Contents lists available at ScienceDirect

Heart & Lung

journal homepage: www.heartandlung.org

Independent lung ventilation in the management of ARDS and bronchopleural fistula

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ARTICLE INFO

Article history:
Received 3 January 2016
Received in revised form
21 February 2016
Accepted 23 February 2016
Available online 2 April 2016

Keywords:
Independent lung ventilation
Acute respiratory distress syndrome
Bronchopleural fistula
Pneumothorax
Necrotizing pneumonia
Lung protective strategy

ABSTRACT

Independent lung ventilation is a decades-old, but infrequently used technique for physiological separation in critically-ill patients with asymmetric lung disease. Here we present a case report of bilateral necrotizing pneumonia complicated by acute respiratory distress syndrome and bronchopleural fistula, which was successfully managed with independent lung ventilation. The use of independent lung ventilation allowed for adequate oxygenation with use of high positive end expiratory pressure in the "good lung" while simultaneously allowing for closure of the bronchopulmonary fistula in the contralateral lung by maintaining relatively low airway pressures.

Introduction

Independent lung ventilation (ILV) is indicated for either anatomic or physiologic lung separation. Anatomic lung isolation prevents harmful contaminants from the diseased lung entering into the normal lung (e.g. massive hemoptysis). Physiologic lung separation is used for the management of asymmetric lung disease by allowing each lung to be ventilated independently with unique strategies for mechanical ventilation. ILV has been used in asymmetric lung disease resulting from post-operative single lung transplant complications, unilateral pulmonary contusion, and other asymmetric parenchymal lung disease, such as aspiration pneumonitis.[1–3] ILV has also been described in the treatment of bronchopleural fistula complicating chest trauma or surgery.[4] However, scant literature exists to outline the role of ILV in managing bronchopleural fistula complicating ARDS. Here we describe the successful management of ARDS and bronchopleural fistula using ILV.

Case report

A 66 year-old female with a history of depression and attention deficit hyperactivity disorder presented to her primary care physician's office with two weeks of cough, fever and rhinorrhea. A chest radiograph showed a right lower lobe infiltrate and she was treated as an outpatient with oral levofloxacin. The following day she presented to the emergency department with worsening dyspnea and was found to be in respiratory distress with a PaO_2 of 85 mmHg on a non-rebreather mask. She was placed on non-invasive positive pressure ventilation, and intravenous ceftriaxone and azithromycin were administered for community acquired pneumonia. She developed worsening respiratory distress, hypoxia, and progressive infiltrates on chest radiograph and was intubated on hospital day five. Antibiotics were changed to vancomycin and cefepime. Post-intubation, a moderate-sized right pneumothorax was identified and a chest tube was placed. Repeat chest radiograph showed a small apical right pneumothorax and a second chest tube was placed. A fiberoptic bronchoscopy was performed, which showed copious, purulent secretions and erythematous airways. Bronchoalveolar lavage cultures were positive for methicillin-resistant *Staphylcoccus aureus* and influenza B. She was subsequently transferred to our hospital for tertiary care.

On volume assist-control ventilation with a tidal volume of 420 mL (6 mL/kg predicted body weight), respiratory rate of 28, positive end expiratory pressure (PEEP) of 10 cmH_20 and an FiO_2 of 100% the arterial blood gas showed a pH of 7.32, PCO_2 of 61 mmHg and a PaO_2 of 58 mmHg. A persistent air leak from the chest tubes of approximately 100 mL per breath was noted. The basilar chest tube

Funding: None.
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0147-9563/$ – see front matter © 2016 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.hrtlng.2016.02.007

was removed and replaced with a posteriorly directed chest tube by Thoracic Surgery to try to achieve better drainage. She was started on a cisatracurium infusion and antibiotics were changed to linezolid and oseltamivir. She had a drop in oxygen saturation to 84% and 20 parts per million of inhaled nitric oxide was started with improvement in the oxygen saturation to the low 90s. Given her conflicting requirements of low airway pressure necessary to promote closure of the bronchopleural fistula in the right lung, and the need for high PEEP in the left lung in the setting of severe ARDS, a double lumen endotracheal tube was placed under bronchoscopic guidance and asynchronous ILV was initiated (Fig. 1). The right lung was placed on pressure assist-control with an inspiratory pressure of 10 cmH_20 to achieve a tidal volume of approximately 100 cc, a PEEP of 8 cmH_2O, and a respiratory rate of 10 with almost immediate resolution of the air leak. The left lung was placed on volume assist-control with a tidal volume of 200 mL, a PEEP of 12 cmH_20 and an FiO_2 of 100%, achieving a plateau pressure of approximately 30 cmH_2O. Repeat arterial blood gas during ILV showed a pH of 7.24, PCO_2 77 mmHg and a PaO_2 105 mmHg. The inhaled nitric oxide was weaned and discontinued. The lung compliance and chest radiograph gradually improved over the course of a few days. The PEEP was subsequently gradually increased in the right lung and no air leak was noted. After a total of 6 days of ILV, both ventilators were changed to volume assist-control with a PEEP of 12 cmH_20 and a tidal volume of 200 mL with a plateau pressure close to 30 cmH_2O in both lungs. The double lumen endotracheal tube was subsequently exchanged for a single lumen endotracheal tube. Adequate gas exchanged was maintained with conventional ventilation through a single lumen tube and there was no air leak from the chest tubes. Neuromuscular blockade was discontinued. The FiO2 and PEEP were slowly weaned.

The patient had a prolonged ICU course complicated by septic shock and acute kidney injury requiring continuous renal replacement therapy. After 17 days in our ICU, a percutaneous tracheostomy was performed under bronchoscopic guidance. Bronchoscopic inspection of the airways during the percutaneous tracheostomy showed no evidence of bronchial damage from the double lumen endotracheal tube. She slowly improved from a respiratory standpoint, with resolving airspace disease on chest radiograph (Fig. 2) and the FiO_2 was weaned to 30% and PEEP to 5 cmH_2O. The chest tubes were discontinued and follow-up chest radiograph showed no pneumothorax. After 20 days in our ICU, she was tolerating pressure support ventilation and eventually tolerated brief tracheostomy collar trials. Unfortunately, the patient subsequently developed recurrent septic shock resulting in severe multiorgan failure. She required mechanical ventilation and high dose vasopressors. Medical treatment was eventually withdrawn and the patient expired.

Discussion

Mechanical ventilation in patients with ARDS with bronchopleural fistula can be particularly challenging given the conflicting goals: the need to maintain adequate oxygenation using high levels of PEEP and the need to minimize airway pressures in order to decrease fistula air leak. In such cases of asymmetric lung disease when conventional modes of mechanical ventilation have failed, intubation using a double lumen endotracheal tube can allow for ILV. There is a paucity of recent literature describing the use of ILV in the management of bronchopleural fistula in the setting of ARDS. There are many, decades-old case reports describing the successful use of ILV for the management of bronchopleural fistula. However, in the majority of cases reported, the unaffected lung had no significant pathology, allowing for adequate gas exchange using conventional ventilator settings in the “good lung.” [2–6] Furthermore, many case reports employing the use of ILV for the treatment of bronchopleural fistula used high frequency oscillatory ventilation in the “injured lung.” [4,7–9] Although recent studies have shown little benefit to high frequency oscillatory ventilation in ARDS, this technique may still have a role in select cases, such as bronchopleural fistula.[10] In a more contemporary case report, ILV was combined with extracorporeal membrane oxygenation (ECMO) for the management of bronchopleural fistula.[11] Ultimately, we were able to achieve the intended goal by providing adequate gas exchange and promoting closure of the fistula using conventional ventilator techniques without the need for high frequency oscillatory ventilation or ECMO. Unfortunately for our patient, her critical illness nevertheless led to her demise despite initial improvement in her lung function.

In our patient, ILV was used for treatment of necrotizing pneumonia that was complicated by ARDS and bronchopulmonary fistula with significant pathology in both lungs. In order to provide adequate oxygenation, our patient required a relatively high mean airway pressure, which caused a bronchopleural fistula and loss of

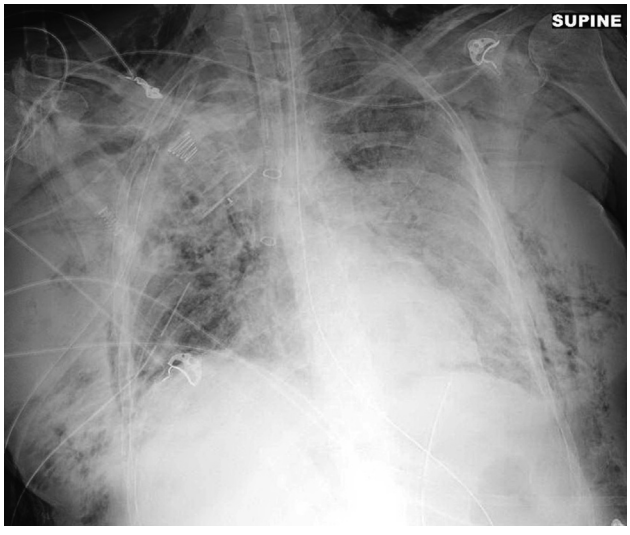

Fig. 1. Chest radiograph shows bilateral infiltrates and marked subcutaneous emphysema. Two chest tubes have been placed on the right side. Note that the double lumen endotracheal tube terminates in the right mainstem bronchus.

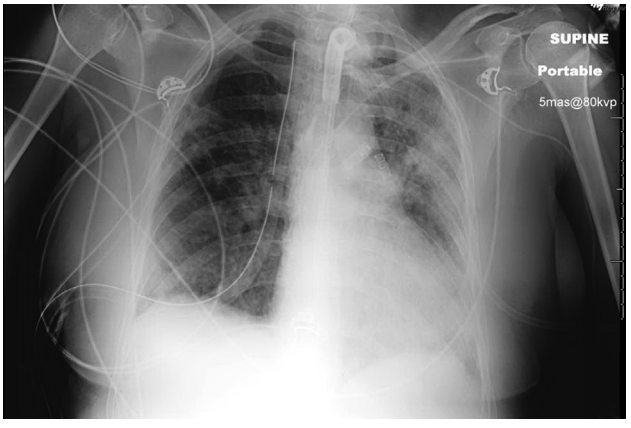

Fig. 2. Chest radiograph shows significant improvement in the bilateral infiltrates and subcutaneous emphysema. The double lumen endotracheal has been removed and a tracheostomy tube has been placed.