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Novel One Lung Ventilation Strategy (OLV) for a Patient with Complete Unilateral Endobronchial Obstruction Causing Hypoxic Respiratory Failure

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

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Conflict of interest: None declared

Patient: Male, 67
Final Diagnosis: Lung cancer
Symptoms: Short of breath
Medication: —
Clinical Procedure: Mechanical ventilation
Specialty: Critical Care Medicine

Objective: Unusual setting of medical care

Background: Mechanical ventilation strategies for one lung ventilation (OLV) differ from conventional modalities in that it can adapt to greater degrees of ventilation/perfusion (V/Q) mismatch. We present a case of cancer causing complete unilateral endobronchial obstruction with refractory hypoxia that improved with OLV strategy.

Case Report: Our patient was an elderly male, admitted to our intensive care unit (ICU) on mechanical ventilation with worsening hypoxic respiratory failure secondary to lung mass and post-obstructive atelectasis. The patient developed refractory hypoxia on high conventional ventilator settings. Chest x-ray (CXR) showed opacification on left lung with ipsilateral mediastinal shift. Bronchoscopy revealed complete obstruction of the left main stem bronchus by a fungating mass. OLV strategy was then implemented. The patient had improved hypoxia despite unchanged CXR.

Conclusions: We propose that ventilating a patient with a complete unilateral endobronchial obstruction is physiologically similar to ventilating a patient with OLV. In such cases, OLV strategies may improve refractory hypoxia by minimizing V/Q mismatch and should be considered.

MeSH Keywords: Lung Neoplasms • One-Lung Ventilation • Ventilators, Mechanical

Full-text PDF: http://www.amjcaserep.com/abstract/index/idArt/901101

Background

During conventional mechanical ventilation, both lungs inflate and deflate simultaneously. The mode of mechanical ventilation when there is mechanical separation of the two lungs and one lung is allowed to ventilate and the other lung is allowed to passively deflate is characteristic of one lung ventilation (OLV). OLV strategies are commonly used for thoracic and cardiac surgeries, where differential ventilation is achieved by the use of bronchial blockers or double lumen tubes. This differential ventilation causes a greater degree of ventilation perfusion (V/Q) mismatch. Mechanical ventilation strategies for OLV differ from conventional modalities to the ability to adapt to this increased degree of V/Q mismatch [1].

We present a case of cancer causing complete unilateral endobronchial obstruction with refractory hypoxia on conventional ventilation modalities, which improved with OLV strategy. To our knowledge, this is the first known case of utilizing this strategy in patients with complete endobronchial obstruction to improve oxygenation.

Case Report

We present a case of a 67-year-old male patient with a hundred pack-year smoking history, who presented to the emergency department for worsening shortness of breath. He had been recently diagnosed with a lung mass and was scheduled for an endobronchial ultrasound-guided fine needle aspiration (EBUS) of his mediastinal lymphadenopathy. However, due to acutely worsening hypoxia and hypercapnia, he was admitted to the intensive care unit (ICU). The working diagnosis included respiratory failure secondary to chronic obstructive pulmonary disease (COPD) exacerbation and endobronchial narrowing and atelectasis due to the lung mass. A chest computerized tomography (CT) scan was notable for a large right upper lobe mass, lymphadenopathy, and endobronchial narrowing of bilateral main stem bronchi. The patient was started on treatment for COPD exacerbation (Figure 1). He continued to deteriorate and required intubation and mechanical ventilation on day 2 of admission for worsening hypoxic respiratory failure. Post-intubation chest x-ray (CXR) was significant for extensive opacification on the left side likely secondary to complete lung collapse (Figure 2). Despite utilization of incrementally increased mechanical ventilator settings of assist control/pressure control ventilation with positive end expiratory pressure (PEEP) of 14 cm H_2O, driving pressure (Pi) of 15 cm H_2O, and fraction of inspired air (FiO2) of 1.00, the patient continued to deteriorate with worsening hypoxia. He was spontaneously breathing over the set rate on the ventilator and generating tidal volumes of approximately 450 mL (6 mL/kg body weight). Arterial blood gas (ABG) showed pH of 7.37, PaCO2 of 33.9 mmol/L and PaO2 of 40 mmol/L at oxygen saturation of 86%. Repeat CXR was significant for worsening left-sided opacification and ipsilateral mediastinal shift consistent with left lung collapse possibly secondary to a mucous plug causing obstruction versus complete obstruction by an endobronchial mass. The patient was started on scheduled bronchodilator treatments with frequent chest physiotherapy to mobilize secretions and improve atelectasis of the left lung. The patient did not respond to these treatment modalities and the decision was made to perform a bedside flexible bronchoscopy with bronchoalveolar lavage (BAL). Bronchoscopy revealed partial obstruction of right main stem bronchus and complete obstruction of the left main stem bronchus by fungating masses. There was no presence of mucous plugs noted during the

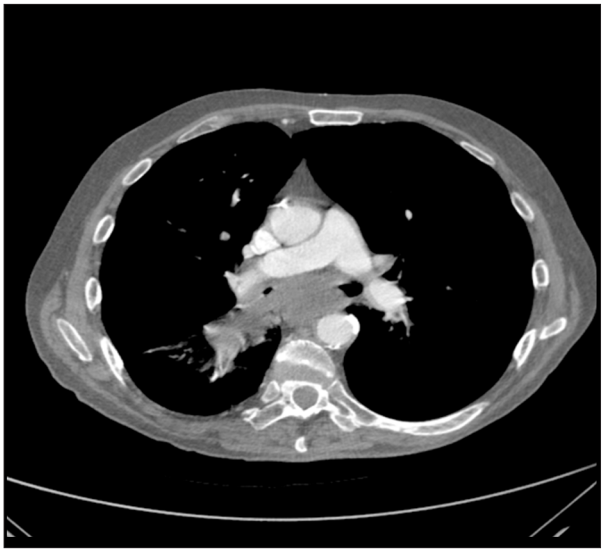

Figure 1. CT scan showing narrowing of both the right and left bronchus on day 1 of admission to the hospital.

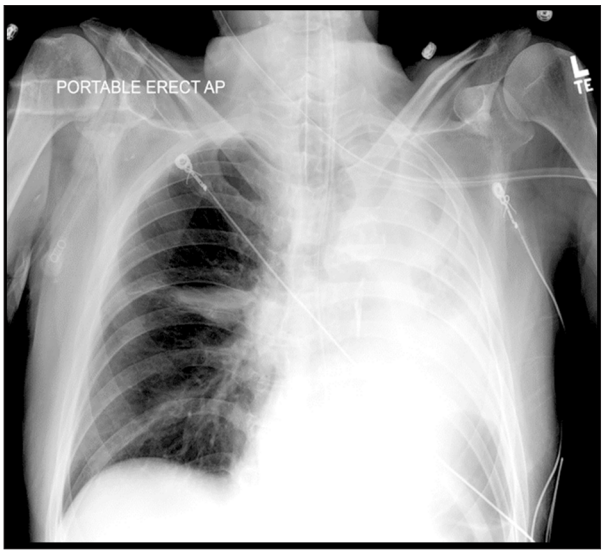

Figure 2. CXR on day 2 of admission after intubation.

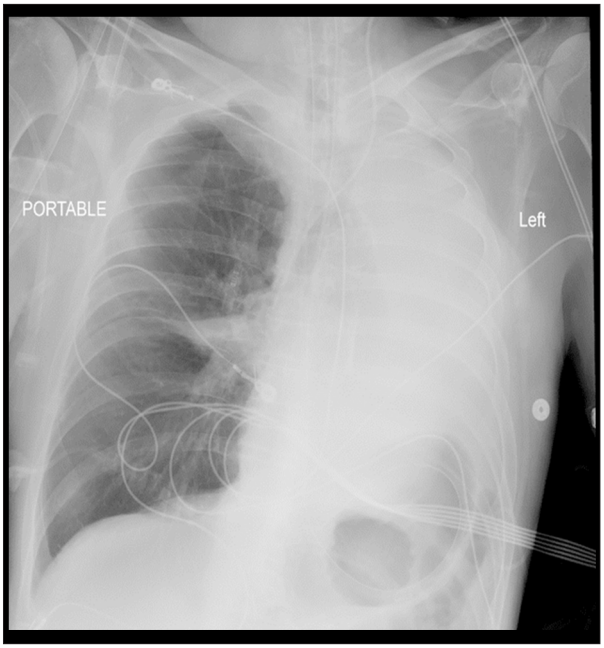

Figure 3. CXR on day 3 of intubation after implementation of OLV strategies and improved hypoxia.

procedure. The washings from the masses were sent for pathological evaluation and were consistent with a squamous cell lung cancer. No biopsies were taken as the mass was friable and bleeding and the patient could not tolerate a longer procedure without worsening desaturation.

As the refractory hypoxic respiratory failure continued to worsen, OLV strategy was implemented. The ventilation mode was changed to assist control/volume control with a rate of 16, inspiratory time of one second, FiO2 of 0.7, tidal volume of 350 mL (<6 mL/kg body weight) and PEEP of 5 cm H2O. The patient responded rapidly within hours with dramatically improved oxygenation with ABG of pH of 7.37, PaCO2 of 50 mmol/L and PaO2 146 mmol/L with pulse oximetry of more than 92%. The CXR remained unchanged (Figure 3). The patient was then stable to be transferred for endobronchial stenting of the right main bronchus at a tertiary referral center with interventional pulmonary capabilities.

Discussion

Ventilation and perfusion are well matched anatomically during normal spontaneous ventilation. There is greater blood flow to the dependent parts of the lung with greater perfusion in these areas in the setting of normal respiratory system compliance. In a patient with functionally one aerated lung, there is a greater degree of V/Q mismatch due to a 20% to 30% increased right to left shunt causing worsening hypoxemia [2]. To minimize this V/Q mismatch, some strategies have been adapted from studies on acute respiratory distress syndrome (ARDS) patients.

A review of lung ventilation strategies that was done by Lohser and Slinger demonstrated that during OLV, the ventilated lung can be exposed to large nonphysiological tidal volumes in addition to the loss of normal functional capacity of the lung, thus making it more susceptible to ventilator induced lung injury. The ventilated lung is also exposed to oxidative stress and capillary sheer stress secondary to hyperperfusion. Re-expansion can also cause ischemia-reperfusion injury [1]. Strategies such as very low tidal volume ventilation (4–6 mL/kg) and low PEEP (between 5–10 cm of H2O) help to decrease barotrauma or volutrauma to the lung and improve hypoxia [1]. In a study by Mascotto et al., application of PEEP caused redistribution of blood to both the ventilated and non-ventilated lung and caused worsening of the shunt fraction [3]. Application of excessive PEEP can worsen this further and cause lung over distension [4,5]. Other strategies include lateral positioning to increase the effect of gravity to improve perfusion to the open ventilated lung, limiting plateau inspiratory pressures to less than 30 cm of H2O and FiO2 to maintain oxygen saturation greater than 90%, and recruitment maneuvers to help decrease the amount of V/Q mismatch observed [6,7]. These strategies are especially important for ventilation of the left lung compared to the right lung, as the left lung is smaller in size [8].

Our findings suggest that complete lung collapse secondary to complete endobronchial obstruction due to a lung mass is physiologically similar to lung collapse with an endobronchial block placement. In such patients, application of OLV strategies help to improve hypoxia by decreasing the right to left shunt and V/Q mismatch.

Conclusions

We propose that ventilating a patient with a complete unilateral endobronchial obstruction is physiologically similar to ventilating a patient with OLV. In such cases, for patients presenting with refractory hypoxia and complete unilateral endobronchial obstruction, application of this strategy should be considered to mitigate the increased degree of V/Q mismatch and prevent ventilator induced lung injury to the aerated lung parenchyma. We believe that the observations in this case pave the way for further studies in this group of patients.

Conflict of interest

None declared.

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