

Successful recruitment in severe unilateral pneumonia using airway pressure release ventilation and lateral decubitus position

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Abstract

We report a case of post-operative, severe, unilateral pneumonia in a tetraplegic in whom there was difficulty in ventilating and recruiting the affected lung. Airway pressure release ventilation (APRV) was applied to create a pan-inspiratory recruitment effort and the patient was positioned with the affected lung non-dependent

to facilitate drainage of secretions. This resulted in a dramatic improvement in recruitment and gas exchange, allowing ventilatory requirements to be weaned rapidly. We highlight the difficulties in lung recruitment for unilateral lung disease and discuss how APRV may be the ideal technique in such situations.

Key words: Airway pressure release ventilation, positioning, lung recruitment.

Case history

A 25 year-old Caucasian male with no past medical history of note presented with tetraplegia after hitting his head following a dive into a shallow pool. An MRI of the cervical spine showed bilateral facet dislocation of C4/C5 with spinal cord injury and edema from C4 to C6. A posterior facet joint reduction, instrumentation and fusion, anterior C4/C5 discectomy and fusion was performed forty-eight hours later and he was transferred to the surgical intensive care unit (SICU) for postoperative ventilation.

On day two of SICU admission, he developed left sided pneumonia as evident by fever, purulent secretions and

new infiltrates in the left middle and lower lung fields on the chest x-ray. The patient also experienced multiple episodes of desaturation and required hourly suctioning and intensive chest physiotherapy. Augmentin was empirically started after trans-tracheal cultures were taken. There was however, no growth of any pathogen. He was ventilated with synchronized intermittent mandatory ventilation and pressure support (SIMV-PS) with the following support: tidal volume 8 ml/kg, pressure support 15 cmH₂O, PEEP 10 cmH₂O, FiO₂ 0.6. An arterial blood gas done on these ventilatory settings revealed a PaO₂ of 80 mmHg and PaCO₂ of 44 mmHg.

Despite this treatment, the pneumonia worsened as the patient progressed to spiking fever, a rising white cell count, copious purulent secretions, and worsening oxygenation. At this time, he was on pressure support ventilation, with a pressure support of 15 cmH₂O, PEEP 15 cmH₂O and FiO₂ 0.7. The arterial blood gas showed a PaO₂ of 70 mmHg and PaCO₂ of 55 mmHg. Non pulmonary sources of sepsis were also excluded and trans-tracheal cultures repeated. Antibiotics were escalated to piperacillin/tazobactam. Intensive chest physiotherapy and lung recruitment manoeuvres were performed. A spiral computed tomography of the thorax ordered to exclude a concomitant pulmonary

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embolism showed a collapse and consolidation of the left lower lobe. There was also extensive mucus plugging in the left lower lobe bronchus with partial occlusion of the left upper lobe bronchus (**Figure 1**). The repeat trans-tracheal culture isolated methicillin resistant staphylococcus aureus (MRSA). Vancomycin and mucolytics were started and a bronchoscopic alveolar lavage (BAL) was performed. MRSA was again isolated from the BAL cultures.

However, in spite of treatment, there was still no improvement. At day fourteen, he continued to spike fever with a maximum temperature of 39 °C. His white cell count remained elevated at $22.1 \times 10^9/L$. The antibiotics were further escalated to linezolid and meropenem. The mode of ventilation was changed from pressure support ventilation to assist control/pressure control mode of ventilation with a FiO_2 0.6, inspired pressure 15 cmH₂O and PEEP 15 cmH₂O. An arterial blood gas showed a PaO₂ of 82 mmHg and PaCO₂ 52 mmHg. In view of the limited progress, we decided to use a combination of airway pressure release ventilation (APRV) and lateral decubitus positioning to recruit the diseased lung. This involved placing the patient in a right lateral position with the normal lung dependent and the diseased lung superior. In addition, towel rolls were placed below the dependent chest to reduce the compliance of the dependent chest in the hope that gas flow would preferentially be directed to the diseased lung in the upper position to recruit it. The patient was left in this position for 2 hours at least 3 times a day. Intensive chest physiotherapy and suctioning were also performed in this position. The initial settings for the patient on the APRV mode was FiO_2 0.6, P_{high} 28 cmH₂O, T_{high} 4.7 s, P_{low} 0 cmH₂O, T_{low} 0.7. Bronchodilators were also started in view of possible bronchoconstriction in the patient with a high cervical spine injury. Mucolytics were continued as well.

A marked improvement in oxygenation and ventilation was observed the next day. The FiO_2 requirements had decreased to 0.4 while the other ventilator settings remained the same. The arterial blood gas showed PaO₂ 156 mmHg and PaCO₂ 42 mmHg. By 36 hours, there was almost full recruitment of the diseased lung as evident by a reducing FiO_2 requirement to 0.3 and a repeat CT thorax (**Figure 2**). APRV was continued to day seventeen by which a tracheostomy was performed. By then, the ventilatory settings had been weaned to FiO_2 0.3, P_{high}

18 cmH₂O, T_{high} 5.5 s, P_{low} 0 cmH₂O, T_{low} 0.9 s. The white cell count normalized by day twenty and antibiotics were stopped after an eight day course.

Discussion

End-inspiratory overdistension and end-expiratory airway collapse are thought to contribute to ventilator induced lung injury. An open lung protective ventilatory strategy of low tidal volumes to reduce overdistension and adequate PEEP to prevent cyclical collapse has been shown to reduce mortality in ARDS. (1)

Recruitment maneuvers have been recommended as an adjunct to the protective ventilatory strategy as a means to prevent the tendency towards derecruitment in ARDS. (2) This is especially so when frequent suctioning is necessary, as suctioning promotes atelectasis. This posed a problem in our case as secretions were copious.

Mechanical ventilation and lung recruitment in unilateral lung disease poses special challenges. Application of global positive intra-thoracic pressure may overdistend the healthy, compliant lung, resulting in increased perfusion to the injured lung, (3) resulting in an increased shunt fraction and worsening V/Q mismatch. During inflation to total lung capacity in unilateral lung disease, the impaired lung does not inflate fully.

Current ventilatory strategies for unilateral lung disease includes differential ventilation with selective PEEP, ventilation with the healthy lung dependant.

APRV is a ventilatory strategy that applies a continuous airway pressure (P_{high}) to maintain adequate lung volume and alveolar recruitment. A time-cycled release phase to a lower pressure (P_{low}) is integrated to augment CO₂ removal and reduce the metabolic burden of breathing. In addition, spontaneous breathing is possible throughout the ventilatory cycle. (4)

The application of APRV in unilateral lung disease is novel yet logical. As APRV has been shown to result in lower peak inspiratory pressures, (5) the risk of overdistension of the healthy lung with diversion of pulmonary blood flow to the injured lung is decreased. There are a multitude of threshold opening pressures in the injured lung (6) and as lung units

recruit, there is a progressive and sustained recruitment of nearby units resulting in a pan-inspiratory recruitment process. (7) Thus, APRV maximizes lung recruitment as the majority of the ventilatory cycle is in the high pressure state.

APRV has also been shown to require less sedation. (8) As excessive sedation has been shown to increase duration of mechanical ventilation in acute respiratory failure, (9) APRV may result in shorter duration of ventilation and ICU stay.

Lateral decubitus positioning with the diseased lung non dependant also helps in recruitment and drainage of the collapse-consolidation. The compliance in the dependant lung decreases due to the weight of the mediastinum, cephalic movement of the abdominal viscera against the diaphragm and the jackknife position as result of the towel rolls. In the non dependent lung, compliance improves conversely. (10) In addition, this position also leads to improved postural drainage of secretions.

We have also note from this case that once recruitment occurs, secretions become copious as previously unventilated units start draining. Hence, a nurse or respiratory therapist must be at hand for frequent suctioning to avoid contamination

of the healthy lung.

The dramatic improvement in ventilation and oxygenation with the corresponding airway recruitment as evidenced on the pre/post CT thorax in our patient, suggests the utility of our strategy of APRV and decubitus lateral positioning in unilateral lung disease. However, we note that the strength of case reports as evidence is weak and acknowledge that the escalation of antibiotics to linezolid and meropenem at the same time probably also contributed to the clinical improvement.

We used APRV and decubitus lateral positioning as a strategy of last resort after failing a conventional strategy. We believe that there could have been a benefit if our regimen was started earlier. The role and timing of this strategy can be better defined by further research.

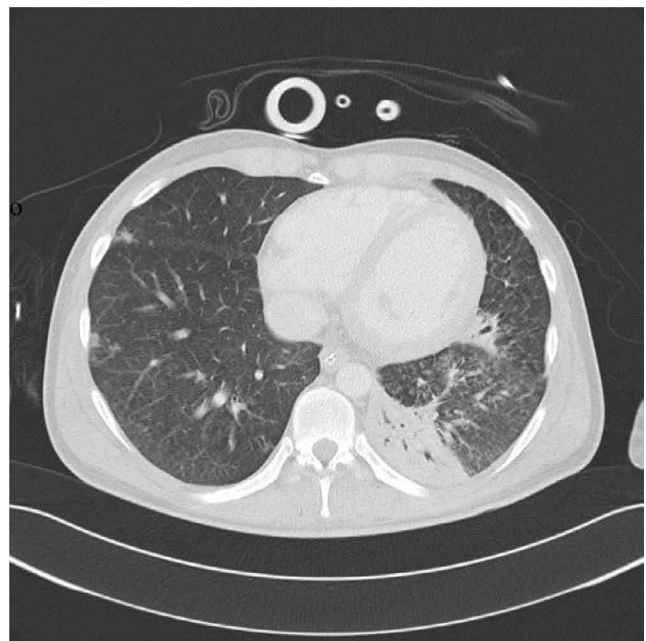
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Figure 1. Collapse-consolidation of left lower lobe on post-operative day 9



Figure 2. Recruitment of left lower lobe post APRV and lateral decubitus positioning



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