Successful use of non–invasive positive pressure ventilation in a complicated flail chest

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ABSTRACT

The current advanced trauma life support manual states that patients with significant hypoxia (namely, SaO_2 <90% on room air) as a result of pulmonary contusion should be intubated and ventilated within the first hour of injury. Recently, several researchers have shown improved outcomes when patients with acute respiratory failure are managed with non-invasive positive pressure ventilation (NIPPV). Trauma patients may also benefit from this therapy. We report a case of 15-year-old boy with isolated flail chest and pulmonary contusion, who was intubated in the emergency room, and was managed successfully with the NIPPV in the intensive care unit (ICU) despite, having had aspiration pneumonia early in the course of his stay. After initial stabilization, he failed a spontaneous breathing trial. Due to absence of contraindications to the use of NIPPV, the patient was extubated on day 7 (from pressure support ventilation of 15 cmH_2O and positive end expiratory pressure of 8 cmH_2O) to immediate NIPPV use. Three days later (after a total of 50 hours of NIPPV use in the ICU) the patient was successfully discharged home.

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Non-invasive positive pressure ventilation (NIPPV) has been suggested for use in chest trauma patient.[1] Patients suffering from severe trauma are at high risk of developing respiratory failure: both acute lung injury (ALI), and the acute respiratory distress syndrome. Direct cause of ALI caused by aspiration or contusion carries a mortality of 22%.[2] Invasive mechanical ventilation can increase the risk of lung injury, and mortality as a result of ventilator associated pneumonia. Every attempt should be made to liberate intubated patients from the invasive mechanical ventilation as soon as possible. Ventilator weaning guidelines are not one size fits all. Guidelines are intended to enhance, not replace, clinical judgment. We report a case of thoracic trauma with flail chest, which was intubated in the emergency room and was managed successfully with the NIPPV in the intensive care unit (ICU), despite, having had aspiration pneumonia and failure to pass the spontaneous breathing trial. In contrast to other reported use of NIPPV in chest trauma, our case has an exceptional part of having complicated chest trauma; aspiration pneumonia.

Case Report. A 15-year-old (50 kg) pedestrian boy was involved in a car accident. On arrival to the emergency department he was conscious and awake with good oxygen saturation. Diagnostic work up revealed fractures of ribs 4, 5, 6 and 7 producing flail chest, left pulmonary contusion, left glenoid fracture, and left pneumothorax necessitating a chest tube insertion (**Figures 1 & 2**). There was no other associated injury. He was intubated while in the emergency department, due to tachypnea, and drop in oxygen saturation to 85% with partial pressure of oxygen/concentration of inspired oxygen (Po_2/Fio_2)

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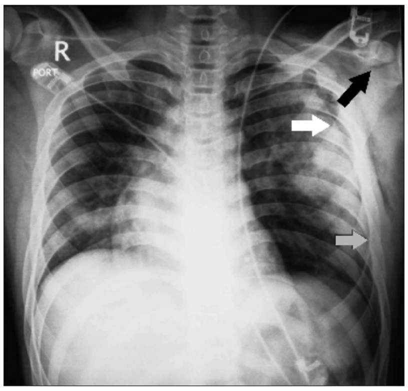

Figure 1 - Chest x-ray on arrival to the emergency showing left glenoid (black arrow) and left rib 4, 5, 6, and 7 fractures (gray arrow points to the fracture in rib number 7) as well as left lung contusion and pneumothorax (white arrow).

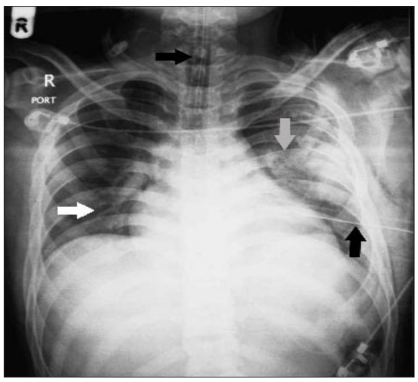

Figure 2 - Chest x-ray after endotracheal intubation and left chest tube insertion (black arrow). Note the resolution of pneumothorax, worsening of left pulmonary contusion (gray arrow) and clear right lung field (white arrow).

ratio of 240. His mechanical ventilator management in the ICU included pressure support ventilation to produce a tidal volume of around 250-300 ml and end expiratory pressure (PEEP) of around 7 cmH_2O. In addition, adequate patient controlled analgesia and semi-recumbent position with head of the bed at 30 degrees was always assured. His FiO_2 requirement slowly decreased to 40% and PEEP to 7 cmH_2O over 72 hours. On day 3, and while on continuous enteral feeding, he had few episodes of vomiting. On day 4, his oxygen requirement increased dramatically with Po_2/Fio_2 ratio of 180. Along with this, there was a new chest infiltrate on the right side associated with fever and increase in white cell count (**Figure 3**). These findings were consistent with aspiration pneumonia in view of the vomiting a day earlier. He was treated accordingly with antibiotics and open lung concept strategies to prevent further lung injuries. As he was improving, he was shifted again to pressure support

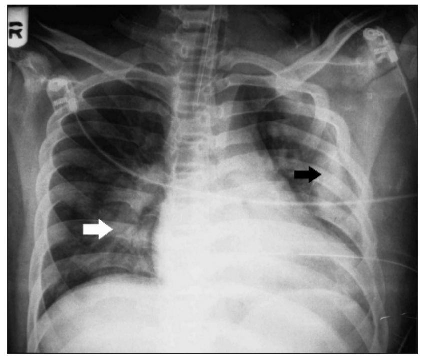

Figure 3 - Chest x-ray showing right lower lobe infiltrate (white arrow) in addition to the left pulmonary contusion (black arrow).

ventilation (PSV), and was put on PSV of 15 cmH_2O, PEEP of 10 cmH_2O, and Fio_2 of 60% with Po_2/Fio_2 ratio of 250 on day sixth. On this day, a spontaneous breathing trial for 30 minutes on PSV of 8 cmH_2O, and PEEP of 5 cmH_2O was given with respiratory rate/tidal volume ratio of 130 at the end of the trial. As the patient before the trial was conscious, comfortable, and hemodynamically stable with good inspiratory efforts, the decision was made to extubate to NIPPV with the same previous settings. He continued to use patient controlled analgesia. Reversible causes that may have contributed to the ventilator dependence were searched for and dealt with. He continued to have spikes of low-grade temperatures of 38 degree for 2 days. Cultures were repeated and he was closely monitored for another septic episode. His general condition did not suggest an infectious cause of fever as fever settled after 48 hours. Over the next 72 hours, the NIPPV support was gradually weaned off to maintain oxygen saturation above 90% and tidal volume of 6 ml/kg. An increasing period of NIPPV mask release was allowed, first during night and then over the day. Arterial blood gas (ABG) analysis within the first hour of NIPPV showed a PO_2 of 78, pulse oximetry (Pox) of 95%, and a PH of 7.4. Eight hours later, ABG showed PO_2 of 96, Pox of 97%, and a PH of 7.38. His subsequent daily ABGs were showing constant improvement. He tolerated complete liberation from the NIPPV on the third day post extubation after a total of 50 hours of NIPPV use. Next day, day 10, he was discharged to general surgical ward. Two days later, the chest tube was removed and he was discharged from the hospital.

Discussion. In this case report, we have demonstrated a successful use of NIPPV after early extubation in a patient with a left flail chest complicated by right aspiration pneumonia who failed a spontaneous breathing trial. Extubation failure

Table 1 - Most recent studies which used non-invasive positive pressure ventilation in chest trauma patients.

Reference	Study type	Number of patients	Nature of chest injury	Result
9	Retrospective review	75	Blunt traumatic pulmonary contusion	Patients were managed safely using non-invasive ventilatory support. Some were intubated for reasons other than respiratory failure.
10	Randomized control clinical trail	25	Flail chest	CPAP led to lower mortality and a lower nosocomial infection rate.
Current case	Case report	1	Pulmonary contusion complicated by aspiration pneumonia	Successful and safe.

CPAP - continuous positive airway pressure

should clearly be avoided as the need for reintubation carries high risk of nosocomial pneumonia and mortality. On the other hand, maintenance of invasive ventilatory support carries its own burden of patient risk for infection and other complications.

Use of NIPPV to treat patients with acute respiratory failure has increased substantially in recent years. In the acute setting, evidence now supports the use of NIPPV for acute deteriorations of chronic obstructive airway disease, respiratory insufficiency after postoperative extubation, and acute respiratory failure in patients who decline intubation. Indications in patients with respiratory failure caused by conditions other than COPD have not been fully established, but anecdotal experience suggests that selected patients with acute asthma, acute pulmonary edema, restrictive lung disease, and pneumonia may also benefit from using NIPPV.[3] The idea of using NIPPV in this case from high ventilatory setting has stemmed from an evolution of ideas regarding pathophysiology, and treatment of the flail-chest injury. In his prospective, Gregoretti et al,[4] found that equal pressure values in intubated trauma patients is comparable, in terms of blood gases and respiratory pattern, to spontaneously breathing patients who were switched over to non-invasive pressure support. Dimopoulou et al,[5] found that bilateral chest injuries were one of the predictors of prolonged (>7 days) mechanical ventilation. In our patient, the injury on the other side was caused by the aspiration pneumonia. We thought, by the early extubation of this patient, we might be able to save few days longer of ICU stay with its attendant risk of sepsis and associated mortality.

The incidence of acute respiratory distress syndrome (ARDS) in the trauma population has been reported to be 12-39% with pulmonary contusion and gastric aspiration being greatest risk factors.[6] Patients with significant hypoxemia are at risk of requiring extended period of invasive ventilation. In these patients, ICU length of stay could reach 14 days.[2] With the use of NIPPV in our patient, who had ARDS secondary to pulmonary contusion and aspiration pneumonia, we were able to shorten the duration of his stay in the ICU to 10 days. Being feed enterally, our patient was at risk of pneumonia. Appropriate and timely antibiotic therapy, and the lung protective ventilatory strategy contributed to the better outcome in our patient. High PEEP/low tidal volume ventilation was seen to reduce inflammatory mediators, compared with low PEEP/high tidal volume ventilation in mechanically ventilated ARDS patients. This strategy was associated with survival rate of 62% in contrast with a survival rate of only 29% with conventional ventilation (low PEEP with tidal volume of 12 mL/kg).[7]

In our patients, the early use of spontaneous mode of ventilation, and NIPPV could also have contributed to the shorter ventilatory support requirement, and therefore, ICU stay.[8] Traditionally, spontaneous breathing in ALI/ARDS patients is discouraged. Controlled ventilation frequently mandates neuromuscular blockade or heavy sedation, which eliminates the diaphragm's potential to facilitate dependent lung ventilation. Furthermore, lack of diaphragmatic tone compounds the cephalad displacement of the diaphragm. The summation of these forces results in disproportionate under ventilation of dependent lung regions. Therefore, initial lung injury combined with traditional management practices may further amplify lung heterogeneity. Research has demonstrated that spontaneous ventilation opens more alveoli, improves regional gas exchange, and reduces atelectasis. The finding of successful use of NIPPV in chest trauma patient is consistent with other studies (**Table 1**). Exceptional part in our case is the use of NIPPV, despite the presence of aspiration pneumonia, and the early extubation after failure of spontaneous breathing trial.

In conclusion, in well-monitored settings, NIPPV could safely be used in patients with severe chest trauma complicated by aspiration pneumonia. Looking at available evidence, there could be a chance for better utilization of NIPPV in patients with flail chest. A randomized controlled clinical trial identifying well known criteria (for example, absence of facial injuries), is required to draw conclusion and make a recommendation on the use of NPPV after early extubation in isolated chest trauma patients.

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