SIGNA VITAE 2012; 7(1): 46 - 48

CASE REPORT

# High frequency oscillatory ventilation as the most appropriate treatment for life threatening thoracic trauma

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## ABSTRACT

*Acute respiratory failure is common in trauma patients and can be a threat to life in severe thoracic injury. We represent a case of severe respiratory failure after blunt thoracic injury with uncontrollable bleeding and massive air leak which was successfully managed with high frequency oscillatory ventilation. In our opinion high frequency oscillatory ventilation represent a safe and effective treatment of life threatening acute respiratory failure in trauma patients.*

**Key words: traumatic lung injury, hypoxemic respiratory failure, air leak, cardiac arrest**

## Introduction

Acute respiratory failure is common in adult trauma patients. Sometimes it is so severe that conventional ventilatory support fails. In this case high frequency oscillatory ventilation (HFOV) represents a rescue therapy. (1,2) It is an alternative technique of ventilation in which small tidal volumes (1- 4 mL/kg) are delivered at high frequencies (3-15 Hz) with an oscillatory pump. (3) There are some studies and case reports in the literature of successful use of HFOV in acute respiratory distress syndrome (ARDS) of non-traumatic aetiology (4-7) however its use in trauma patients is limited. (1,2) We represent a case of severe respiratory failure after blunt thoracic trauma where high frequency oscillatory ventilation dramatically improved patient oxygenation without any serious complications.

## Case report

A 52-years old male, injured in a motorcycle traffic accident, was brought to emergency department in haemorrhagic shock, with severe respiratory distress. He was immediately intubated. Ultrasound of the abdomen revealed no free fluid. Chest x-ray revealed multiple rib fractures on both sides with bilateral haemo-pneumothorax. After chest tube insertion, abundant bleeding was present on the left side. Therefore an urgent left thoracotomy was undertaken. Thoracic surgeon found heavy bleeding originating from lacerations of the lungs, fractured ribs and lacerated intercostal muscles. A 5 centimetres long tear of the pericardium without injured myocardium underneath was found. All the lacerations were sewed over. After operation bleeding through the thoracic drains continued. Therefore a re-thoracotomy was undertaken, during which complete surgical haemostasis could not be achieved. Because of this packing of the bleeding site was performed and thoracotomy closed. After turning the patient from the right lateral decubitus to supine position ventricular fibrillation ensued. Following successful defibrillation and return of spontaneous circulation the patient was admitted to surgical intensive care unit (ICU). Throughout initial assessment and management patient received 24 units of packed red blood cells and other blood components.

After hemodynamic stabilization computed tomography (CT) of the head, chest, abdomen and whole spine was performed. It revealed bilateral serial rib fractures (from 1st to 11th on the right and from 1st to 12th on the left), a persistent haemo-pneumothorax on the left side, a large hematoma in the left lung with active leakage of contrast and surrounding lung contusion. Contusions were also visible in the right lung (figure 1). CT also revealed small laceration of the spleen, fracture of the left scapula and body of the 6th thoracic vertebra. There was also a fracture of the 12th thoracic and 1st lumbar vertebra with spinal canal stenosis (Injury Severity Score (ISS) 33).

In the first hours of ICU stay the patient was ventilated with volume controlled mode (tidal volume of 550 mL, frequency 24 /min, positive end expiratory pressure (PEEP) 4 cm $H_2O$, inspirati-

on to expiration ratio 1:1.3) and 100% oxygen in inspired gas mixture. He had inserted three chest tubes (one on the right and two on the left side). Due to massive air leak on both sides a low PEEP of 4 cm $H_2O$ was used. Despite an attempt to ventilate the patient with a higher PEEP value (8 cm $H_2O$) and the addition of inhaled nitric oxide the patient's oxygenation deteriorated during the first 24 hours. Partial pressure of oxygen in arterial blood fell to 6.8 kPa. At this time oxygenation index was 47 and Murray score 3. HFOV was introduced. After some hours of HFOV (mean airway pressure 25 cm $H_2O$, frequency 5 Hz, pressure amplitude 48 cm $H_2O$) oxygenation dramatically improved (table 1). A slight increase in subcutaneous emphysema on both sides of the chest was observed, without visible pneumothorax on chest x-ray. The patient remained haemodinamically stable all the time.

On the third day the packing from the left chest cavity was removed in the ICU. The patient was ventilated with HFOV for twelve days, subsequently pressure controlled mode of mechanical ventilation was introduced. The weaning process was prolonged because of flail chest and he needed ventilatory support for 35 days. In the following days spondylodesis of the 6th, 12th thoracic and 1st lumbar vertebra was performed. After 43 days of ICU stay he was transferred to the high dependency unit. He was breathing with the addition of 1 liter of oxygen through the binasal catheter.

During ICU stay critical illness myopathy and thrombosis of the right iliac vein were diagnosed. Because of the later a removable filter was placed in the lower caval vein.

After six month of follow up the patient had no difficulties with breathing and on the chest x-ray only serial rib fractures were seen without pulmonary infiltrates or obliteration of costo-diafragmal recesses.

**Table 1. Arterial blood gas analyses and oxygenation index at ICU admission and in the following first four days of high frequency oscillatory ventilation.**

| | Admission day | 1st day | HFOV initiation | 2nd day | 3rd day | 4th day |
|---|---|---|---|---|---|---|
| $FiO_2$ | 1.0 | 1.0 | | 0.55 | 0.40 | 0.40 |
| mPaw (cm $H_2O$) | 24 | 24 | | 20 | 20 | 20 |
| pH | 7.14 | 7.43 | | 7.55 | 7.52 | 7.39 |
| $PaCO_2$ (kPa) | 7.6 | 4.8 | | 4.4 | 4.4 | 5.8 |
| $PaO_2$ (kPa) | 9.7 | 6.8 | | 13.4 | 12.3 | 13.8 |
| $PaO_2/FiO_2$ | 72.7 | 51 | | 182 | 230 | 259 |
| OI | 33 | 47 | | 11 | 8.7 | 7.7 |

HFOV, high frequency oscillatory ventilation; ICU, intensive care unit; mPaw, mean airway pressure; OI, oxygenation index = ($FiO_2$ x mPaw)/$PaO_2$ (mmHg).

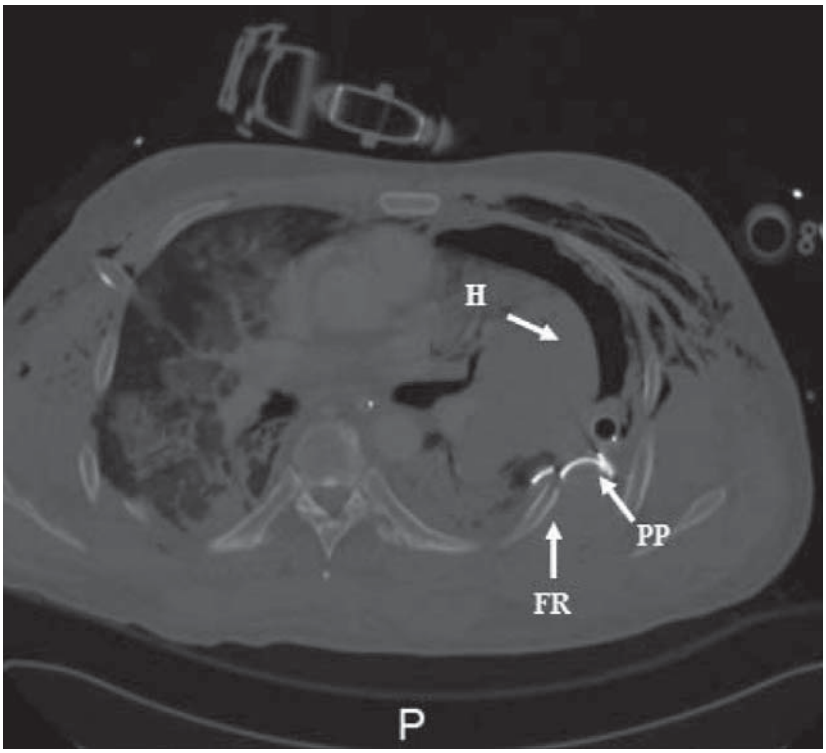


**Figure 1. Computed tomography of the chest following initial surgical management demonstrates extensive bilateral pulmonary contusions with active bleeding into a hematoma (H) in the left lung. A displaced fractured 5th rib (FR) with adjacent pleural packing (PP) is also seen.**

## Discussion

ARDS is common in trauma patients. Its aetiology is multifactorial and involves extra- and intrapulmonary factors. In the case of severe thoracic trauma hypoxemic respiratory failure is often a threat to life. Conventional lung protective ventilation is usually successful in reversing hypoxemia, sometimes with the use of adjunctive therapy (inhaled vasodilators, prone position). When even this fails HFOV (1,2) or extracorporeal membrane oxygenation (ECMO) (8) are the option, the later with concomitant anticoagulation therapy (8,9) which in our case was contraindicated.

There is limited data available on successful use of HFOV in hypoxemic respiratory failure in trauma patients. Briggs et al. (1) performed a retrospective analysis of 24 adult trauma patients with ARDS and concluded that HFOV is a safe alternative mode of ventilation which should be considered as a

rescue therapy for oxygenation failure in severely injured patients with ARDS. In this analysis, however, survival was related to the extent of initial injury and was not affected by the use of HFOV. In another retrospective analysis Funk et al. (2) concluded that early use of HFOV appears to be safe and efficacious in blunt trauma patients sustaining pulmonary contusions. Galvin et al. (10) reported a case of successful use of HFOV in a patient with non-traumatic ARDS complicated by bilateral pneumothoraces and air leaks.

In our case HFOV dramatically improved oxygenation of the patient without serious adverse events. After initiation of HFOV air leaks increased (greater subcutaneous emphysema), which could be the result of higher mean airway pressures used with initiation of HFOV. After improvement in oxygenation and the use of lower mean airway pressures subcutaneous emphysema decreased.

## Conclusion

In our opinion high frequency oscillatory ventilation represents an effective and safe ventilation technique which should be considered in severe respiratory failure after thoracic trauma. This is especially the case if the lung injury is associated with severe air leak and uncontrollable bleeding, where anticoagulation, which is necessary for extracorporeal membrane oxygenation, is contraindicated.

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