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Research Article

Efficacy and adverse events of early high-frequency oscillatory ventilation in adult burn patients with acute respiratory distress syndrome

Sabah Abdel-Raouf Mohamed *, **Nashwa Nabil Mohamed**

Anesthesia Department, Faculty of Medicine, Cairo University, Egypt

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KEYWORDS

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Abstract *Background:* High-frequency oscillatory ventilation (HFOV) is one of lung protective strategies in acute respiratory distress syndrome (ARDS). It is not recommended to be used as initial mode of ventilation. Previous studies showed conflicting results for late use of HFOV (after prolonged period of conventional mechanical ventilation (CMV)). This study investigated the use of HFOV as an early therapy (after 24 h of CMV) in the management of ARDS due to burn.
Methods: 70 burned ARDS patients were ventilated by CMV during the first 24 h (Day 0). Then, patients were randomly allocated into two equal groups (35 each):
Group 1 (G 1 or CMV): they continued on CMV.
Group 2 (G2 or HFOV): HFOV was instituted for 72 h (Days 1, 2, 3). Then, patients were shifted to CMV on Day 4 to continue on CMV. Ventilator settings, gas exchange parameters, hemodynamics, sedatives, vasoactive and paralytic requirements, barotraumas and hospital mortality were recorded and compared between the two groups.
Results: In **Day 0**: Demographic data, ventilator settings, gas exchange parameters, and hemodynamics showed no significant difference between both groups. **Days 1, 2, 3**: there was statistically significant decrease of FiO_2 and OI accompanied by an increase in PaO_2, PaO_2/FiO_2 and $PaCO_2$ in G2. **Day 4**: while both groups on CMV, G2 patients showed statistically significant decrease in PEEP and mPaw with same gas exchange findings on Days 1, 2, 3 between two groups. During the study period, Hypotension was observed following HFOV in G2 and was most significant in Day 1. G2 showed statistically significant increase in barotraumas and required more midazolam, atracurium and norepinephrine. There was no statistically significant difference in 30 days mortality between both groups.
Conclusions: Early HFOV therapy is effective in improving oxygenation in burn patients with ARDS, but it failed to reduce hospital mortality.

* Corresponding author at: Zahraa Madi, 7 Maka St Cairo, Egypt. Mobile: +20 1001993900.
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1. Introduction

Acute respiratory distress syndrome (ARDS) is characterized by severe deterioration in oxygenation following acute insult, as severe inflammation causes permeability changes in the alveolar capillary membrane leading to fluid shifts into the alveolar and interstitial spaces [1]. It is manifested by hypoxemia and bilateral infiltrates on chest radiographs with normal pulmonary capillary wedge pressures. ARDS can be classified into mild ($PaO_2/FiO_2 \leqslant 300$ mmHg with PEEP 5 cm H_2O), moderate ($PaO_2/FiO_2 \leqslant 200$ mmHg with PEEP 5 cm H_2O) and severe ($PaO_2/FiO_2 \leqslant 100$ mmHg with PEEP 5 cm H_2O) [2].

Burn is associated with an average mortality rate of 0.8% [3]. It may predispose to ARDS in critically ill burn patient due to factors leading to lung injury such as smoke inhalation, sepsis, ventilator-induced lung Injury or a systemic inflammation in response to burn [4,5]. Lung protection plan in ventilating ARDS patients is to maintain low inspiratory driving pressures, with lower tidal volumes (4–6 ml/kg) and the use of limited airway pressure, with the synchronized prevention of alveolar collapse through the use of high PEEP to keep end-expiratory pressures above the lower inflection point on the static pressure–volume curve of the respiratory system [6]. Conventional mechanical ventilation (CMV) may lead to tidal hyperinflation and shear stress effect, even when it is administered according to a 'lung protective strategy' that limits tidal volumes and plateau pressure [7].

In spite of advances in critical care and understanding of ARDS pathophysiology, ARDS mortality remains as high as 48% as was reported by Villar et al., [8] and 41% as was reported by Wang et al. [9].

So, a number of ventilation modes have been recommended like high-frequency oscillatory ventilation (HFOV) which requires the use of a specific designed ventilator that has been approved by Food and Drug Administration. HFOV theory is to deliver a continuous distending mean airway pressure (mPaw), around which oscillations of predefined amplitude at a high frequency (usually between 3 and 15 Hz) are obtained by using a diaphragm. These pressure oscillations result in very small tidal volumes (1–4 ml/kg) smaller than the anatomical dead space. Therefore, theoretically, HFOV is the ideal "lung protective" ventilation strategy since it provides very low pressure swings, thus minimizing volutrauma and atelectrauma and maximizing alveolar recruitment [10].

Using HFOV in ARDS patients after prolonged period of CMV has been tried by many researchers [10–19]. They used it as a rescue therapy for patients who remained hypoxemic and required high levels of inspired oxygen, or those who have plateau pressures >35 cm H_2O despite 4 ml/kg tidal volumes on CMV, and the results were conflicting. Others [11–18] demonstrated improvement of oxygenation on HFOV in ARDS patients with increased risk of barotraumas and unfavorable hemodynamics due to high airway and intrathoracic pressure and a decreased venous return [19–21].

1.1. Aim of the study

The aim of this study was to evaluate the efficiency and complications of HFOV as an early therapy (after 24 h of CMV) for a determined period (72 h) for management of ARDS in adult burn patients without smoke inhalation injury compared to CMV.

1.2. Outcome measures

The primary outcome included determination of hospital mortality (30-day mortality) [22]. Secondary outcomes included assessment of gas exchange parameters and adverse events (barotraumas and unfavorable hemodynamic).

1.3. Patients and methods

The study was performed on 70 burn patients with ARDS (PaO_2/FiO_2 ratio of 200 mmHg or less) who were admitted to ICU in north zone in KSA from 2007 to 2011. Approval of the hospital institutional review board and obtaining a written consent from every patient or next of kin were done.

Inclusion criteria: male or female, age 18–60 years old, burn patients with 40% TBSA burned or more.

Patients were excluded when the patient's age was less than 18 or over 60 years and weight was less than 35 kg, asthmatic, pregnant and the patients with smoke inhalational injury that was diagnosed by fiber-optic bronchoscopy when suspected.

Tracheal intubation was done to all included patients in the first 24 h from the onset of burn as was suggested by Cancio LC [23].

In the first 24 h (Day 0), patients were ventilated by lung protective strategy (LPS) [24] (tidal volumes 4–6 ml/kg, RR 12–22 breaths per minute, plateau airway pressure <32 cm H_2O and PEEP 10–12 cm H_2O). The patients were divided randomly using computer generated number and concealed using sequentially numbered, sealed opaque envelope technique into two equal groups (35 patients each):

Group 1 (CMV): patients continued on CMV by LPS for days 1, 2, 3 and 4.
Group 2 (HFOV): patients were shifted to HFOV strategy for 72 h for days 1, 2 and 3. Then, patients were shifted to CMV on day 4 either for weaning or to continue on LPS.

G2 Patients were assessed after 3 h on HFOV, if they could not achieve improvement of oxygenation parameters or could not tolerate HFOV during study period (Days 1, 2, 3) due to severe hypoxemia, severe hypercarbia, severe barotrauma and severe hypotension, HFOV was terminated and they were shifted to CMV and excluded from the study.

2. Institution of HFOV

Initial patient preparation was confirmation of ET tube patency and airway suctioning. Continuous infusion of midazolam (0.02–0.1 mg/kg/h), atracurium (0.4–0.8 mg/kg/h), norepinephrine (if needed: 0.05–1 μg/kg/min) and correction of intravascular volume status were done. Any imaging (CT) or interventions outside ICU (any operating theater procedure), bronchoscopy, echocardiography, insertion of arterial and central venous lines were performed before starting HFOV.