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Extracorporeal membrane oxygenation support may be a lifesaving modality in patients with burn and severe acute respiratory distress syndrome: Experience of Formosa Water Park dust explosion disaster in Taiwan☆

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ABSTRACT

Background: Extracorporeal membrane oxygenation (ECMO) has been reported to improve outcomes in patients with refractory respiratory failure. These successful experiences have stimulated interest in using ECMO as a potential therapy for patients with acute pulmonary failure resulting from burn and inhalation lung injury. Current literature has supported the use of ECMO in critically-ill, pediatric burn patients. On the other hand, it is controversial to apply ECMO in adult burn patients, and the evidence is limited by the shortcomings of small sample size. We share our successful experience of ECMO treatment in the casualties of the Formosa Water Park Dust Explosion Disaster.

Methods: We investigated the data from the dust explosion event, which happened on June 27, 2015, in New Taipei, Taiwan. The medical records of five patients with severe acute respiratory distress syndrome receiving ECMO were evaluated.

Results: The mean study subject age was 21.8 years, with a mean total body surface area burned of 82.9%. The average time to ECMO setup was 48.6 days. Survivors and non-survivors averaged four days and 77.7 days, respectively. The overall mortality rate was 40%. Three survivors were discharged without any ECMO-related complications or pulmonary sequelae after one year of follow up.

Abbreviations: ECMO, extracorporeal membrane oxygenation; ARDS, acute respiratory distress syndrome; TBSA, total body surface area; P/F ratio, PaO_2/FiO_2 ratio; $AaDO_2$, alveolar-arterial O_2 difference; VV, venovenous; V-VA, veno-venoarterial.

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Conclusions: ECMO may be a lifesaving modality for burn patients with severe lung injury who are nonresponsive to maximal medical management, especially for young patients with early ECMO intervention.

1. Introduction

Major burn and severe inhalation injury are substantial contributors to morbidity and mortality in burn victims [1]. An overwhelming cascade of airway inflammation, pulmonary shunting and augmented micro-vascular pressure gradient result in severe respiratory failure. Once acute respiratory distress syndrome (ARDS) occurs, mortality rates becomes extraordinarily elevated, up to 35%–46% [2]. Mechanical ventilation is the primary therapy to correct arterial hypoxemia in burn patients with ARDS. It has been reported that using a lung-protective strategy is an effective treatment to avoid superimposing additional damage on the already-injured pulmonary alveoli [3]. However, such ventilation is unable to provide life-saving respiratory support when a critical volume of alveolar units has failed [4]. Refractory respiratory failure is one of the most prevalent causes of death in burn patients, even superseding burn wound sepsis [5].

If arterial hypoxemia is still unimproved despite high-pressure ventilation, extracorporeal membrane oxygenation (ECMO) can be considered as an alternative treatment to solve this problem without overstretching the injured lungs [6]. Several observational studies and randomized clinical trials have demonstrated that ECMO treatment might improve outcome in children and adults with severe respiratory failure [7–12]. Although there is presently an absence of level one evidence for its efficacy, recent guidelines and reviews have suggested patient referrals to ECMO centers if they meet the criteria of pH<7.2 or Murray lung injury score >2.5 with potentially reversible respiratory failure (FiO2 not >0.8 and peak pressure and plateau pressure not >30 cm H_2O for 7 days) [13–16].

These several promising investigations stimulate interest in using ECMO as potential therapy for patients with severe ARDS resulting from burn and inhalation lung injury. Overall, however, the evidence base for these interventions is sparse. To date, few retrospective studies and case reports in the field of burn and/or smoke inhalation have been published. Asmussen et al. in 2013 conducted a systematic review of ECMO in hypoxemic respiratory failure resulting from burn and/or smoke inhalation injury. Overall, the data suggest a tendency of higher rate of ECMO therapy survival than non-survival of burn patients suffering acute hypoxemic respiratory failure. However, the data obtained and level of evidence generated were limited by the small number of clinical trials, with inadequate numbers of patients [1]. On the other hand, the currently available literature is predominantly focused on the pediatric population. Recently, Soussi et al. reported a case series of eleven adult burn patients receiving ECMO in patients with refractory ARDS. In-hospital mortality was 91%, resulting from burn injury and/or septic shock [17]. Hsu et al. reported another retrospective analysis of six adult patients receiving ECMO treatment. Overall survival rate was 16.7% [18].

In order to elucidate the benefit associated with the use of ECMO in the patients with severe hypoxemic respiratory failure, specifically post-burn and smoke inhalation injury, we investigated the data from a recent dust explosion event. This event occurred on the evening of June 27, 2015, at the Formosa Water Park in New Taipei, Taiwan, when a firestorm erupted as a flammable starch-based powder, which then blew up over a stage. The tragic accident injured 499 young people, and over 75% of the victims suffered 2nd to 3rd degree burns over 20% TBSA. In our study, we reported five cases and six events receiving ECMO support. Our results revealed favorable outcomes of ECMO-treated patients, especially for early ECMO intervention. We are eager to share our experience with the world.

2. Methods and patients

2.1. *Status before ECMO initiation*

A total 43 patients were thereafter sent to our institution from the dust explosion event. Of those patients, 38 patients were admitted to burn center and the mean TBSA was 45.8%. There were 24 patients with large surface burns (TBSA ≥40%) and suspicion of inhalation injury, who were immediately intubated at the emergency department. We applied fluid resuscitation protocol under modified Parkland formula, and colloid was added early. The fluid support was subsequently adjusted for each patient according to urine output per hour and hemodynamic monitoring [19–21]. Prompt escharotomy for most patients with circumferential burns in extremities was performed in the first 24 h to release pressure and facilitate circulation. However, ARDS developed in several patients a few days later. To avoid ventilator-induced lung injury, we utilized limited peak inspiratory pressure to ventilate the lungs, low tidal volumes, higher positive end-expiratory pressure and sedation with neuromuscular blockade. However, there remained five patients with severe hypoxemia under lung-protective strategy, who were treated with ECMO (Sorin, Modena, Italy; Maquet, Rastatt, Germany) as rescue therapy. All of the patients met the ECMO indications for respiratory support, including potentially reversible respiratory failure, a Murray lung injury score ≥3.0, without high FiO2 (>0.8) and peak inspiratory pressure (>30 cm H_2O) for less than seven days [16,22,23]. Patient 5 twice experienced episodes necessitating ECMO support. The characteristics of patients prior to ECMO initiation are summarized in Table 1, which includes the following: the mean patient age was 21.8 years (range, 17–32 years); the percentage of TBSA of burn was 82.9% (range, 70–92%) combined with inhalation injury; PaO_2/FiO_2 ratio (P/F ratio) was 87.1 (range, 55.6–103); alveolar-arterial

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