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Benefit of extracorporeal membrane oxygenation in major burns after stun grenade explosion: Experience from a single military medical center

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ABSTRACT

Introduction: Explosion injury is very common on the battlefield and is associated with major burn and inhalation injuries and subsequent high mortality and morbidity rates. Here we report six victims who suffered from explosion injuries caused by stun grenade; all were treated with extracorporeal membrane oxygenation (ECMO) as salvage therapy. This study was aimed to evaluate the indications and efficacy of ECMO in acute and critically ill major burn patients.

Methods: This was a retrospective analysis of six patients from Tri-Service General Hospital, National Defense Medical Center in Taiwan. All suffered from major burns with 89.0±19.1% average of total body surface area over second degree (TBSA; range, 50–99%). ECMO was used due to inhalation injury in five patients and cardiogenic shock in one patient. The average interval to start ECMO was 26.5±19.0 h (range, 14–63 h). Venoarterial ECMO was used on in four patients due to unstable hemodynamic status, whereas venovenous ECMO was used in two patients for sustained hypoxemia.

Results: All patients had rhabdomyolysis with acute renal failure. The average duration of ECMO was 169.6±180.9 h (range, 27–401 h). All patients developed coagulopathy and needed debridement surgery during ECMO support, and five underwent torso escharotomy due to inspiratory compromise. Only one patient whose second and third degree burns covered 50% TBSA was successfully weaned from ECMO and survived; he was discharged after 221 hospital days. All patients who died had second and third degree burns covering over 90% of their TBSA. Three patients died of multiple organ failure, one died of septic shock, and the other died of cardiogenic shock. Overall survival rate was 16.7%.

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Conclusions: In acute and critically ill major burn patients, ECMO could be considered as a salvage therapy, particularly in those with inhalation injury and burn-related acute respiratory distress syndrome. However, ECMO does not seem to provide benefits for circulatory support in those with hemodynamic compromise. The use of ECMO in these patients is still investigational, as our data provided no benefit in terms of the outcomes or survival, particularly in those with more than 90% TBSA burns.

1. Introduction

Explosion injury is very common on the battlefield and is increasingly encountered during terrorist attacks. The stun grenade consists of a pyrotechnic metal-oxidant mix of magnesium or aluminum, and an oxidizer such as ammonium perchlorate or potassium perchlorate. The boiling point of magnesium is 1110°C and the core temperature can rise up to 1982°C during ignition. In addition to explosion injury, stun grenade leads to sequential, potentially lethal complications, including thermal injury, inhalation injury, hemorrhagic hypovolemic shock, rhabdomyolysis, and severe infections [1]. Most victims of explosion injury are hemodynamically unstable and suffer from respiratory compromise. Although extracorporeal membrane oxygenation (ECMO) has been considered as a lifesaving modality for respiratory failure in patients with pediatric burn [2,3], its use in adults remains controversial [4]. We present our experience on the utilization of ECMO in managing critically ill adult patients with major burns due to stun grenade explosion.

2. Materials and methods

2.1. Patient characteristics

This retrospective study was conducted using the database of the Department of Surgery at Tri-Service General Hospital, a military medical center in Taiwan, and six patients with major burns due to stun grenade explosion were identified. The local ethical committee approval was obtained to review these cases, and informed consent was collected from the patients or their relatives. The patient characteristics are shown in Table 1. Five patients were male and one was female, with a mean age of 43.3±11.6 years (range, 29–59 years). The average total body surface area (TBSA) with second and third degree burns was 89.0±19.1% (range, 50–99%). Four patients had hypovolemic shock; three of these needed cardiopulmonary resuscitation. Two patients had barotrauma pneumothorax, and one had open fracture. One patient (patient no. 6) had underlying diabetes mellitus and coronary artery disease.

2.2. Pre-ECMO status

All patients were intubated and transferred to our burn center for intensive care. Fluid resuscitation was aggressively applied with crystalloid fluids, albumin, and blood products. Both peripheral arterial and central venous lines were used for continuous monitoring of the hemodynamic status. Adequate topical wound care with silver sulfadiazine was administered under local analgesia with intravenous broad-spectrum antibiotics to prevent secondary infections. The pre-ECMO status of patients is shown in Table 2. All patients had leukocytosis, hyperglycemia, and elevated creatinine. Despite the aggressive administration of albumin, only patient no. 1 maintained an albumin level of 4.5 g/dL. Patient no. 4 and 6 had serum creatine kinase levels of more than 20,000 U/L. In addition, patient no. 6, who was diagnosed with diabetes and coronary artery disease, had abnormally high levels of troponin-I. All patients had lactic acidosis. The ventilation parameters before ECMO were as follows: the average positive end-expiratory pressure (PEEP) was 12.0±1.2 cmH_2O, peak inspiratory pressure was 37.6±2.2 cmH_2O, mean airway pressure (MAP) was 27.1±2.6 cmH_2O, tidal volume was 366.6±103.2 mL, ratio of partial arterial oxygen pressure to fractional inspired oxygen (PaO_2/FiO_2) was 66.6±16.6, oxygen index[($FiO_2 \times MAP$)/PaO_2]

Table 1 – Patient characteristics.

Patient	1	2	3	4	5	6
Age/gender	49/M	32/M	40/M	29/M	59/F	51/M
TBSA burned (≥second degree)	50	97	99	94	96	98
BAUX score (Age+TBSA)	99	129	139	123	155	149
Hypovolemic shock (SBP<90 mmHg)	–	+	–	+	+	+
CPR	–	+	–	+	+	–
Explosion comorbidity	Open fracture	Pneumothorax	–	–	–	Pneumothorax
DM	–	–	–	–	–	+
CAD	–	–	–	–	–	+

M—male; F—female; TBSA—total body surface area; BAUX Score—the sum of age and TBSA burned; SBP—systolic blood pressure; CPR—cardiopulmonary resuscitation; DM—diabetes mellitus; CAD—coronary artery disease.

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