p-ISSN 1859 - 3461
e-ISSN 3030 - 4008

SUCCESSFUL TREATMENT OF A PATIENT WITH 98% TOTAL BODY SURFACE AREA BURNS COMPLICATED BY ACUTE RESPIRATORY DISTRESS SYNDROME AND SEPTIC SHOCK

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ABSTRACT

Septic shock and acute respiratory distress syndrome (ARDS) are common complications that significantly increase mortality in patients with severe burns. Advances in hemodynamic resuscitation, rational antibiotic therapy, continuous blood purification using adsorptive membranes, prone-position ventilation with low tidal volumes, and the combined use of aerosolized and intravenous antibiotics in the treatment of pneumonia caused by multidrug-resistant gram-negative bacteria have markedly improved survival outcomes in severe burn patients.

Keywords: *Severe burns, septic shock, ARDS*

1. INTRODUCTION

Septic shock and acute respiratory distress syndrome (ARDS) are common complications that significantly increase mortality in patients with severe burns. With recent advances in critical care - including optimized hemodynamic resuscitation, rational antibiotic therapy, continuous renal replacement therapy using adsorptive membranes, lung-protective mechanical ventilation, and prone positioning - survival has markedly improved among burn patients complicated by septic shock and ARDS.

In this report, we present a case of a patient with extensive burn injury involving 98% of total body surface area (TBSA), including 10% full-thickness burns, who developed acute respiratory distress syndrome and septic shock, and was successfully treated through comprehensive intensive care at the National Burn Hospital Lê Hữu Trác.

2. CASE PRESENTATION

Patient: Nguyễn Thế M., 39 years old

Hometown: Nội Duệ, Tiên Du District, Bắc Ninh Province, Vietnam

Diagnosis: T29.3 - T31.9; X10 - Extensive hot-water burns involving 98% of total body surface area (10% full-thickness), degree II, III, IV, complicated by ARDS and septic shock.

Date of Admission: March 4, 2025

Date of Discharge: April 23, 202

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Ngày gửi bài: 08/10/2025; Ngày nhận xét: 15/11/2025; Ngày duyệt bài: 26/11/2025
https://doi.org?10.54804/

p-ISSN 1859 - 3461
e-ISSN 3030 - 4008

Summary of Clinical Course and Treatment Progress:

- The patient was working at a company when he fell into a cooling water tank used in the production process of Hao Hao instant noodles, resulting in extensive thermal burns (the water temperature was approximately 80°C). After the accident, coworkers poured cool water over his body, and he received initial first aid at a local medical station with intravenous fluid resuscitation and analgesics.

He was transferred to the National Burn Hospital Lê Hữu Trác, two hours after injury in a state of burn shock, spontaneously breathing, with a respiratory rate of 25 breaths/min and SpO_2 of 99%. On examination, the patient had thermal burns involving 98% of the total body surface area, including 10% full-thickness burns localized mainly on both thighs.

Laboratory findings on admission: Red blood cells (RBC): 5.37 T/L; Hemoglobin (Hb): 166 g/L; Hematocrit (Hct): 46.6%; White blood cells (WBC): 27.3 G/L; Albumin: 38.5 g/L; Glucose: 12.8 mmol/L; Lactate: 8.1 mmol/L

Figure 1. Clinical presentation of the patient's burn injuries

The patient received intensive resuscitation according to the standardized burn management protocol, including active warming, supplemental oxygen, fluid resuscitation with Ringer's lactate solution based on the Parkland formula, and plasma transfusion initiated 12 hours post-burn. Comprehensive management also included systemic analgesia, broad-spectrum antibiotic therapy, early enteral nutrition, and initial burn wound care.

- After approximately 22 hours post-injury, the patient developed hoarseness and progressive dyspnea, indicating upper airway involvement. Endotracheal intubation was promptly performed, and invasive mechanical ventilation (IMV) was maintained. Intensive care measures were continued, focusing on shock resuscitation, mechanical ventilation support, analgesia and sedation, while ensuring that vital parameters remained within acceptable ranges.

For local wound management, advanced dressing materials were applied to cover the burn surfaces, preserve intact blisters whenever possible, and daily sterile dressing changes were performed under aseptic conditions to prevent infection and promote optimal healing.

p-ISSN 1859 - 3461
e-ISSN 3030 - 4008

- On day 7 post-burn (March 10, 2025), the patient's condition deteriorated markedly, presenting with sepsis and septic shock. He developed high-grade recurrent fever (> 39^0C), generalized edema, restlessness with ventilator asynchrony, and tachypnea (respiratory rate 35 - 40 breaths/min). Minute ventilation increased to 16.7 L/min, PaO_2/FiO_2 = 231 mmHg.

Hemodynamic parameters revealed tachycardia (130 - 140 beats/min), blood pressure 106/55 mmHg, requiring norepinephrine infusion at 0.15 µg/kg/min.

Laboratory findings: WBC: 13.5 $\times 10^9$/L; Lactate: 2.2 mmol/L; Procalcitonin (PCT): 9.71 ng/mL; Glucose: 9.7 mmol/L; Albumin: 22 g/L; SOFA score: 8 points

Locally, the burn wounds produced copious purulent exudate with a foul odor, suggesting severe wound infection. Blood and wound pus cultures were obtained, and antibiotic therapy was adjusted toward Gram-negative bacterial coverage with meropenem (4 g/day) and colistin (9 million IU/day).

The patient was initiated on continuous renal replacement therapy (CRRT) using an oXiris adsorptive hemofilter to remove inflammatory cytokines and endotoxins. Concurrently, daily wound dressing changes, cleansing, and application of advanced wound-covering materials were maintained.

Following these interventions, the patient's clinical condition gradually improved - norepinephrine dose was tapered, PaO_2/FiO_2 ratio increased progressively, and SOFA score decreased, indicating recovery from septic shock and improving organ function.

On day 9 post-burn, vasopressor support was successfully discontinued after a total duration of 30 hours on norepinephrine. The patient's oxygenation improved significantly, with a PaO_2/FiO_2 ratio exceeding 300 mmHg, indicating resolution of respiratory failure. Sedation and analgesia were maintained for comfort and ventilator synchrony, and the patient continued on mechanical ventilation under stable hemodynamic and respiratory conditions.

- On day 21 post-burn (March 22, 2025), the patient's condition worsened again with clinical and laboratory signs of acute respiratory distress syndrome (ARDS). The patient developed persistent high fever (> 39^0C), tachycardia (118 beats/min), and blood pressure 140/78 mmHg.

Arterial blood gas analysis: pH: 7.36; $PaCO_2$: 53.5 mmHg; PaO_2: 101.4 mmHg; PaO_2/FiO_2 ratio: 144.86 mmHg (consistent with moderate ARDS); Lactate: 1.6 mmol/L

Ventilator parameters: Plateau pressure (Pplat): 25 cmH_2O; Mean airway pressure (mPaw): 19 cmH_2O; Peak airway pressure (Ppeak): 32 cmH_2O; Static compliance (Cstatic): 28 mL/cmH_2O; Oxygenation Index (OI): 13.12

Laboratory findings: WBC: 20.4 $\times 10^9$/L; Lactate: 1.6 mmol/L; Procalcitonin (PCT): 0.63 ng/mL

Bronchial aspirate culture grew multidrug-resistant Acinetobacter baumannii, which was only sensitive to colistin (MIC = 1).

Chest X-ray revealed diffuse bilateral opacities involving the lower half of both lung fields and perihilar regions.

p-ISSN 1859 - 3461
e-ISSN 3030 - 4008

At the burn site, the second-degree and partial third-degree burn wounds had healed, while approximately 50% of the third- and fourth-degree burns on the trunk and extremities remained unhealed.

Treatment: The patient was placed in the prone position with a low tidal volume ventilation strategy (Tidal Volume - VT: 5 mL/kg of ideal body weight), administered muscle relaxants, and received inhaled colistin at a dose of 2 million IU every 8 hours. The patient's condition improved, with better oxygenation and improved pulmonary mechanics; bronchial secretion cultures showed no bacterial growth. Prone positioning was maintained for 16 hours, followed by a supine position; muscle relaxants were administered for a total duration of 40 hours.

- On post-burn day 24, blood oxygenation and pulmonary mechanics were satisfactory; chest X-ray showed clear lung fields. Gradual reduction of analgesics and sedatives was initiated, followed by weaning from mechanical ventilation. On day 25, the endotracheal tube was removed. After extubation, the patient was alert, responsive, breathing spontaneously, and vital parameters remained within normal limits.

On post-burn day 30, the patient's condition remained stable. Burn wounds accounted for 35% of total body surface area, including 10% of third- and fourth-degree burns on the back and lower limbs; the patient was transferred to a lower-acuity unit. On post-burn day 37, all superficial burns had healed. Approximately 10% of the fourth-degree burn areas had developed dry necrosis, for which surgical necrotomy and autologous skin grafting were performed. By April 23, the patient was stable, the burn wounds had completely healed, and the patient was discharged from the hospital.

3. DISCUSSION

Mortality rate is an important indicator for evaluating the effectiveness of burn patient management. To date, studies have shown that mortality in burn patients depends on multiple factors, including age, total burn surface area, extent of deep burns, presence of inhalation injury, complications, financial accessibility to treatment, as well as the capability and equipment of the medical facility. Septic shock is a common complication and remains the leading cause of death among burn patients, accounting for approximately 58.44% to 69.14% of all burn-related fatalities [1]. Improving the management of septic shock plays a crucial role in enhancing the survival rate of patients with severe burns. The treatment of septic shock is a comprehensive strategy that includes hemodynamic resuscitation, appropriate antibiotic therapy, pathophysiology-based interventions, and local wound management.

The pathophysiology of septic shock involves an excessive systemic inflammatory response, characterized by the massive release of cytokines into the bloodstream triggered by bacterial endotoxins, resulting in a so-called "cytokine storm". This uncontrolled immune activation leads to multi-organ dysfunction. Endotoxins play a key role in activating leukocytes and stimulating the production of pro-inflammatory cytokines, which in turn cause pathological disturbances in vital

p-ISSN 1859 - 3461
e-ISSN 3030 - 4008

organs such as the circulatory, respiratory, renal, hepatic, and endothelial systems...[2]. Continuous blood purification using adsorptive membranes helps remove cytokines and bacterial endotoxins from the body, thereby attenuating the excessive systemic inflammatory response and stabilizing hemodynamics. This method has been proven to be an effective adjunctive therapy in the management of septic shock. Adsorptive membranes act on one or both of the following therapeutic targets: 1) Reducing cytokine concentrations below the “toxic threshold,” thereby limiting the local harmful effects of cytokines; 2) Eliminating endotoxins or pathogen-associated antigens before they activate leukocytes and trigger the immune cascade [3]. Studies have demonstrated that hemofiltration using adsorptive membranes rapidly mitigates the “cytokine storm,” leading to clinical improvement, shorter time to reversal of septic shock, prevention of further organ injury, and reduction in mortality rates [4], [5], [6], [7], [8]. In addition, studies conducted in intensive care burn units worldwide have shown that bloodstream infections caused by multidrug-resistant Gram-negative bacteria are the most common at all stages of burn injury [9], [10].

In our patient, adsorptive hemofiltration was performed using the oXiris membrane after the diagnosis of septic shock, in combination with empiric antibiotic therapy targeting Gram-negative bacterial infection (blood cultures showed no bacterial growth), along with hemodynamic resuscitation and local wound care. The patient’s condition improved significantly, with shock reversal achieved after 30 hours, which was shorter than the duration reported in previous studies conducted at the National Burn Hospital [11], [12]. The earlier reversal of shock, reduction in peripheral vasoconstriction, and improvement in tissue oxygenation created favorable conditions for the healing of superficial burns and the formation of granulation tissue in deeper burn areas. This contributed to a faster overall wound healing process. These findings highlight the positive role of continuous blood purification with an adsorptive membrane in improving overall treatment outcomes.

In addition to septic shock, acute respiratory distress syndrome (ARDS) is also a common complication that significantly increases mortality in patients with severe burns. According to various studies, the incidence of ARDS among burn patients ranges from 20% to 56%, depending on the severity of the burn injury [13], [14]. The lung-protective ventilation strategy, employing a low tidal volume (VT) and maintaining a plateau pressure ≤ 30 cmH_2O, is a globally accepted and widely recommended approach in the management of ARDS [15], [16]. In combination with low tidal volume ventilation, prone mechanical ventilation is considered the most effective approach in the treatment of ARDS, contributing to improved survival rates. Prone ventilation markedly enhances oxygenation and pulmonary mechanics, reduces pressure-induced lung injury, and improves hemodynamic stability by redistributing transpulmonary pressure and promoting a more uniform distribution of stress and strain within the lungs [16], [17]. In 2017, the European Society of Intensive Care Medicine (ESICM) and the American

p-ISSN 1859 - 3461
e-ISSN 3030 - 4008

Thoracic Society (ATS) issued joint recommendations advocating the use of prone mechanical ventilation as part of the standard management for patients with ARDS [15]. In our patient, prone positioning was maintained for 16 hours, which led to a significant improvement in oxygenation parameters and pulmonary mechanics, with no complications related to prone ventilation observed.

An additional noteworthy point in this patient was that, at the time of ARDS diagnosis, bronchial secretion cultures still yielded multidrug-resistant Acinetobacter baumannii (sensitive only to colistin, MIC = 1), despite ongoing antibiotic therapy with meropenem (4 g/day) and colistin (9 million IU/day). We maintained the same systemic antibiotic regimen but added inhaled colistin at a total dose of 6 million IU per 24 hours (2 million IU every 8 hours). After three days, repeat bronchial cultures showed no bacterial growth. Inhaled colistin can thus be considered an effective adjunctive rescue therapy to systemic colistin in the management of multidrug-resistant Gram-negative pneumonia in critically ill burn patients. [18], [19].

4. CONCLUSION

The application of advanced techniques in the management of septic shock and acute respiratory distress syndrome (ARDS) - including continuous hemofiltration with adsorptive membranes, prone position ventilation with low tidal volume, and inhaled colistin therapy for multidrug-resistant Gram-negative infections - has contributed significantly to improving the survival outcomes of patients with severe burns.

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