CASE REVIEW

Severe Post-Traumatic Hypothermia in a Burned Patient

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CE Earn Up to 7.5 Hours. See page 109.

Contribution to Emergency Nursing Practice

- The current literature on post-traumatic hypothermia indicates that burned skin loses its thermoregulatory properties.
- This article contributes an example of the onset of severe hypothermia in burn victims due to negligence in thermal insulation.
- Key implications for emergency nursing practice found in this article are the awareness of the impact of post-traumatic hypothermia on mortality and the need of careful insulation in burn victims. Maintaining normothermia can increase the chances of patient's survival.

Accidental hypothermia is defined as an involuntary drop in core body temperature (Tc) below 35°C (95°F).[1] However, hypothermia associated with trauma should be diagnosed at ≤36°C (96.8°F) because of its impact on mortality.[2] The classification of post-traumatic hypothermia covers 3 stages. These include mild: 36 to 34°C (96.8–93.2°F); moderate: 34 to 32°C (93.2–89.6°F); and severe: <32°C (89.6°F). The heat loss in healthy humans usually does not exceed 60 to 75 kcal/h, but trauma patients can lose 400 kcal/h. The common factors that increase heat loss are hemorrhage, open wounds, opioid and paralytic drugs, and large burns. The skin plays an important role in thermoregulation, but this function becomes inefficient after thermal injury.[2] Post-traumatic hypothermia is an independent risk factor for mortality in trauma victims, especially when combined with coagulopathy and acidosis (the lethal triad).[3–5] The incidence of hypothermia in burn victims is estimated at 1.6% to 46%.[6–9]

We present a patient with large burns in whom lack of thermal insulation led to severe post-traumatic hypothermia.

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Clinical Presentation

A 56-year-old man was severely burned by a gas cylinder explosion in his house. Initially, the injury was assessed at 70% to 80% total body surface area (TBSA) of second and third degree. Endotracheal tube placement was impossible because of inhalation injury, and cricothyrotomy was performed by a physician with the Helicopter Emergency Medical Service (HEMS) team. The patient was anesthetized and mechanical ventilation started. The medication consisted of fentanyl, midazolam, and propofol. There are no data documenting whether initial cold-water cooling was applied. Rescue interventions were realized in the winter weather conditions. Total prehospital phase time was 1 hour, 40 minutes.

In the emergency department, analgosedation was continued with midazolam and morphine, and the patient still required mechanical ventilation. Tracheostomy, bronchoscopy, and chest escharotomy were performed. Surgical and burn wounds were covered by a sterile gauze soaked with normal saline and cold hydrogel dressings. Intravenous fluids were not warmed and neither thermal insulation nor rewarming was applied. The patient spent 6 hours in this emergency department.

During fixed-wing aeromedical transport to the burn center, the patient's core body temperature was measured with an esophageal probe (Propaq, Welch Allyn, Skaneateles, New York). The medical team diagnosed severe post-traumatic hypothermia; Tc was 30.0°C (86°F) and active rewarming was started using an electric blanket. Noninvasive blood pressure was 120/80 mm Hg. Attempts of arterial line insertion were unsuccessful because of vasoconstriction; thus, precise blood pressure monitoring was not possible. For the same reason, a pulse oximetry signal could not be obtained. Electrocardiographic monitoring revealed atrial fibrillation with a heart rate of 90 to 105 beats per minute. End-tidal CO_2 varied between 26 and 31 mm Hg. Continuous infusion of morphine and midazolam was applied as analgosedation; paralytic drugs were not required.

In the burn center, active rewarming was continued with continuous veno-venous hemodiafiltration (CVVHDF). Normothermia—Tc 36°C (96.8°F)—was achieved after 5 hours of active rewarming. However, precise data about the measurement schedule and location are lacking. The initial pH on admission to the burn center was 6.9. The area of burn was assessed at 70% TBSA of third degree, and further chest and limb escharotomies were required. Symptoms of sepsis were present on the third day of stay. During the stay, the patient received norepinephrine, 60 units of fresh frozen plasma, 40 units of packed red blood cells (10 leukoreduced), 14 units of cryoprecipitate, and antibiotics: colistin and carbapenem. CVVHDF was continued all the time. The patient died on the sixth day.

Discussion

This case reveals that rapid drop of core body temperature in severe burns is very probable unless careful insulation and active warming are provided. To the best of the authors' knowledge, this is the second case of hypothermia in burns with Tc ≤30°C (86°F) described in the literature. Livingston and Groggins described another spectacular case of severe hypothermia—rectal temperature 28°C (82.4°F)—in a 12-month-old boy, induced by cooling the scald with cold water.[10]

The medical staff is usually focused on urgent and complex procedures, especially in critically ill patients; therefore, it is likely to neglect as simple a procedure as thermal insulation. Meanwhile, low ambient temperature in the ambulance or in the emergency department is an additional factor that increases patients' cooling. In this case, the estimated temperature in the emergency department averaged 18 to 20°C (64–68°F), in the helicopter did not exceed 15°C (59°F) during the flight, and was the same as the ambient temperature during the stay on the ground. The heat loss in anesthetized trauma victims can be so high that active rewarming should be provided to prevent further cooling.[11] However, even in countries with cold climate, less than one third of ground ambulances and less than two thirds of HEMS teams have the equipment to provide active warming.[12,13]

The risk of onset of hypothermia in burn patients depends on burn severity and is associated with a 20-fold greater incidence when the area of injury exceeds 70% TBSA.[6–8] It is also associated with anesthesia and mechanical ventilation, as in other types of trauma.[2,11,14] Moreover, the use of some methods of active external rewarming may be limited in large burns to avoid worsening thermal injuries of the skin, such as chemical heating pads in which the temperature may exceed 50°C (122°F). Active external rewarming was reported to be effective to prevent hypothermia in trauma victims;[11] active internal and extracorporeal rewarming seem to be the best method of treatment of severe accidental hypothermia.[15,16] Continuous renal replacement therapy (CRRT) may be also used to rewarm hypothermic patients with spontaneous circulation. Although there are some controversies pertaining to the impact of CRRT on body temperature,[17] rewarming rate may be as high as 4°C/h.[18] In this case, CRRT appeared an effective method of rewarming. However, regarding the risk of the cooling effect of this therapy, Tc should be continuously monitored.

Hypothermia at admission is an independent factor that increases mortality in burn victims.[19] Sherren's study shows that mortality among hypothermic patients is significantly higher than among normothermic (33.3% vs. 9.5%, $P = 0.0024$).[9] Singer's study (60% vs. 3%, $P < 0.001$) also supports this findings.[6] However, the knowledge about consequences of hypothermia may be limited among medical staff. In a survey study conducted among physicians and nurses at trauma center, only 27% of respondents indicated coagulopathy as a possible consequence of hypothermia, and only 12.5% knew about the correlation of hypothermia with mortality in trauma.[20]

Summary

Unintentional drop of body temperature increases mortality in trauma victims. Thermally injured skin loses its thermoregulatory properties, contributing to the potential for hypothermia. Although burns are caused by the impact of a large amount of heat, protecting victims against heat loss must always be kept in mind. Very important tasks of ED staff are to insulate a patient, to use flow warmers for

TABLE 1
Warming strategies in trauma

Tc	Temperature monitoring	Warming methods
36–37°C (96.8–98.6°F)	Every 15 minutes	Avoid cold surfaces Thermal insulation Warm IV fluids Forced-air blanket
32–36°C (89.6–96.8°F)	Every 5 minutes	Underbody heating pads Radiant warmer Circulating water garment
<32°C (<89.6°F)	Continuous	Body cavity lavage Extracorporeal rewarming

Based on Perlman et al.[2]

infusions, to avoid using cold dressings, and to maintain a warm ambient temperature during transport and in the emergency department. Tc monitoring should be a standard procedure in severely injured patients (Table 1). Neglecting thermal insulation and/or active warming in patients with large burns, especially those treated with opioids or those who are anesthetized, may easily lead to hypothermia and increase the risk of death.

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