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CASE REPORT

General Medicine

A body bag can save your life: a novel method of cold water immersion for heat stroke treatment

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Abstract

Non-exertional heat stroke is a life-threatening condition characterized by passive exposure to high ambient heat, a core body temperature of 40°C (104°F) or greater, and central nervous system dysfunction. Rapid cooling is imperative to minimize mortality and morbidity. Although evaporative and convective measures are often used for cooling heat stroke patients, cold water immersion produces the fastest cooling. However, logistical difficulties make cold water immersion challenging to implement in the emergency department. To our knowledge, there is no documented case utilizing a body bag (ie, human remains pouch) as a cold water immersion tank for rapid resuscitation of heat stroke. During a regional heat wave an elderly woman was found unconscious in a parking lot with an oral temperature of 40°C (104°F) and altered mental status. She was cooled to 38.4°C (101.1°F) in 10 minutes by immersion in an ice- and water-filled body bag. The patient rapidly regained normal mentation and was discharged home from the ED. This case highlights a novel method for efficient and convenient cold water immersion for heat stroke treatment in the emergency department.

1 | INTRODUCTION

Heat stroke is a medical emergency with in-hospital mortality rates as high as 33%.[1] From 1999–2010, the United States averaged 618 heat exposure-related deaths per year.[2] In 2003, a heat wave in Europe is estimated to have caused 15,000 excess deaths in France alone.[3] Climate models predict increased frequency and severity of heat waves,[4] and with July 2019 the hottest month recorded on earth,[5] emergency departments (ED) must be prepared for epidemics with a convenient method for optimal treatment of heat stroke.

Non-exertional heat stroke is most common in elderly patients, whose comorbid conditions and medications can impair thermoregulation. Non-exertional heat stroke is characterized by passive exposure to high ambient temperatures, loss of thermoregulatory function resulting in core temperatures of 40°C (104°F) or greater, and central nervous system dysfunction.[6,7] Heat stroke requires prompt cooling to minimize morbidity and mortality, with higher in-hospital mortality seen with delayed cooling.[1,8] Cold water immersion is considered the gold standard for rapid cooling of exertional heat stroke as it consistently provides cooling rates (>0.15°C/min [0.27°F/min]) not achieved by evaporative or convective cooling methods, such as fans applied to patients misted with water.[9,10] However, evaporative and convective techniques are often used for treatment of non-exertional heat stroke due to logistical obstacles to cold water immersion in many EDs.[8] Additionally, it has been suggested that cold water immersion may be poorly tolerated by elderly patients;[7,11] however, this hypothetical concern has not, to our knowledge, been empirically characterized or quantified. By contrast, the mortality risk of delayed cooling is well known,[1,8] and cold water immersion demonstrably shortens time to cooling, compared to evaporative or convective techniques.[9,10]

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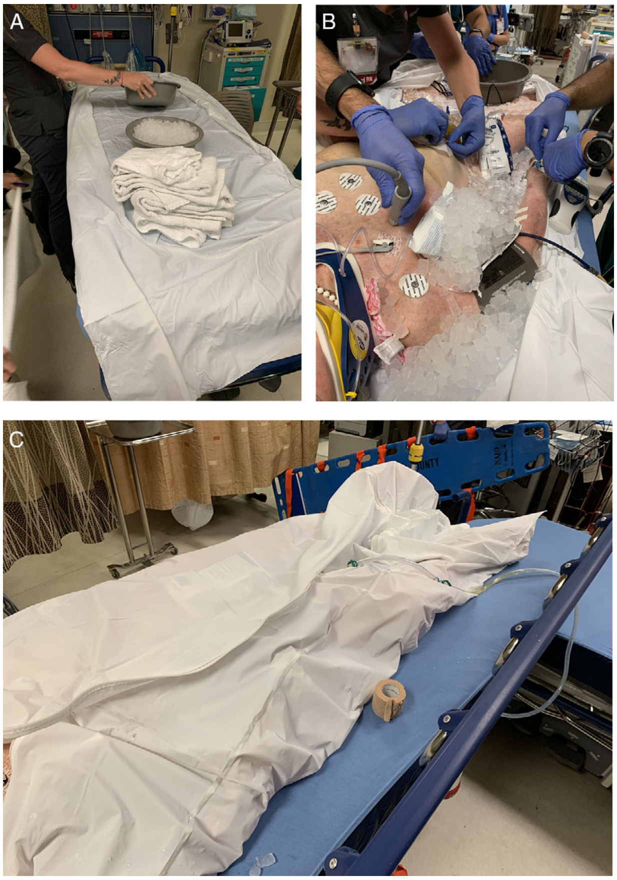

FIGURE 1 Selected steps of cold water immersion in the ED. A, The disposable body bag and buckets of ice are prepared on the bed in advance of the patient's arrival. B, The patient is transferred from EMS stretcher directly into the body bag, monitors and a temperature-sensing bladder catheter are applied, and buckets of ice and tap water are poured into the body bag to initiate cooling. C, After initial resuscitative measures are completed, the body bag is loosely closed (up to the patient's neck) until the patient is cooled to 38˚C, whereupon the patient is transferred from the bag to another bed

2 | CASE REPORT

An 87-year-old woman with a medical history of ductal carcinoma in situ on tamoxifen and a surgical history of rectal cancer with resection and colostomy was found unconscious in a parking lot during a record-setting regional heat wave. Emergency medical services (EMS) responded and reported an oral temperature of 40°C (104°F) and an altered mental status. The ambient temperature was 37°C (99°F) with 29% humidity. The patient did not recall how she had fallen and was unable to provide a history of events. EMS initiated cooling by application of chemical cold packs applied to the patient's skin during transport.

On arrival to the ED, we transferred the patient from the stretcher to an opened waterproof body bag (ie, human remains pouch) that we had prepared upon pre-arrival notification (Figure 1A). The patient's initial vital signs were: heart rate of 98 beats per minute, 28 respirations per minute, blood pressure of 151/65, SpO_2 of 97% (2 liters nasal cannula), and an oral temperature of 40°C (104°F). We could not obtain a rectal temperature due to the patient's proctectomy. On examination, the patient had left periorbital ecchymosis, scattered abrasions, a 15 cm skin tear of the left forearm, a right lower quadrant colostomy bag containing stool, and was confused without focal neurologic deficits.

We applied monitors including a temperature-sensing bladder catheter, and filled the body bag with ice cubes followed by water to the level of the anterior axillary line, to preserve access to the anterior chest for cardiac monitoring and ultrasonography (Figure 1B). We continued our initial assessment and resuscitation during initial cooling, maintaining supine patient positioning and cervical spine immobilization. Upon immersion, the bladder sensor began reporting implausibly low core temperatures (<30°C [86°F]), so we removed it and relied on oral temperatures for the remainder of the resuscitation. We performed an eFAST (extended focused assessment with sonography for trauma) study, which showed no free fluid in the abdomen, pericardial effusion, or pneumothorax, began administration of a 1 liter bolus of 0.9% sodium chloride, and closed the body bag to the patient's neck (Figure 1C). The zipped-up body bag retained all of the ice and water and allowed intravenous tubing and cardiac monitoring wires to run through the open portion at the patient's neck. Within 10 minutes of ice water immersion, the patient's mental status had normalized, her oral temperature had decreased to 38.4°C (101.1°F), and she was transferred from the body bag to a neighboring dry gurney. We closed and discarded the used bag, which retained the ice water slurry without spillage after patient removal. Laboratory evaluation revealed creatine kinase of 176 U/L, and otherwise normal liver function tests, serum chemistry, complete blood count, and venous blood gasses. Computerized tomography of the head, face, and cervical spine showed no acute injury, and subsequent neurologic exams were normal. We administered tetanus immunization and repaired the patient's skin tear. The patient declined hospital admission and was discharged home. On follow-up by telephone 1 week after discharge, the patient reported feeling well without any residual issues.

3 | DISCUSSION

We report a resuscitation of an elderly patient with non-exertional heat stroke by cold water immersion in a disposable body bag. To our knowledge, this is the first report of cold water immersion in a body bag for the treatment of heat stroke. Waterproof body bags are stocked in all hospitals, easy to prepare, portable, scalable for mass casualty incidents, and inexpensive (generally less than USD $25) compared to conventional 150 gallon full body cold water tubs (more than USD $100), which are cumbersome and interfere with patient access and monitoring due to deeper immersion. Alternative cold water immersion techniques include tarp-assisted cooling,[12] or specially designed water-impervious whole body cooling bags,[13] but these are neither readily available in EDs, nor have they been used in published heat stroke resuscitations. Cold water immersion in the body bag served to quickly cool the heat stroke patient, with complete resolution of her encephalopathy, and after ruling out comorbid and traumatic conditions, she was discharged home.

Effective cooling is dependent on rapid heat dissipation from the core to the skin and from the skin to the environment. The most efficient method of this heat transfer is through cold water immersion, which involves submerging the patient in an ice water slurry with a temperature of 2–10°C (35.6–50°F), with colder water temperature producing faster cooling and less shivering.[10] Cold water immersion exploits the high thermal gradient between ice water and hyperthermic skin, and water's high thermal conductivity, which is 24 times greater than air's.[9] Although cold water immersion might be expected to induce peripheral vasoconstriction and shivering thermogenesis, potentially impeding cooling,[10] the thermoregulatory response is driven primarily by core and not skin temperature changes. Therefore, the high core temperatures of heat stroke tend to prevent shivering even in the setting of rapid skin cooling.[9] Likewise, the thermal gradient between ice water and the large area of immersed skin easily overcomes the potential heat retention from cold-induced peripheral vasoconstriction.

Cold water immersion has been studied almost exclusively in exertional heat stroke, which affects a younger and healthier population than non-exertional heat stroke,[7] and for which cold water immersion cooling is considered the gold standard.[9] Published data on in-hospital treatment of non-exertional heat stroke by conductive cooling are limited. We are aware of a single case series, with mostly intubated and hypotensive patients, with 93% cooled to target temperatures within 30 minutes and 14% mortality.[8] Another conductive cooling series implemented ice packs, cold sheets, and cooling blankets, with 69% cooled within 60 minutes and 15% mortality, compared to the 33% mortality in the group requiring more than 60 minutes to reach goal temperatures.[1] In contrast, the largest evaporative cooling series reported an average of 78 minutes to reach target temperatures and 15% mortality.[14] Although similar reported mortality rates with conductive and evaporative cooling methods may suggest comparable efficacy,[11] directly comparative studies are lacking, and experience with exertional heat stroke shows that cold water immersion produces at least twice the cooling rates (0.15–0.35°C/min [0.27°F–0.63°F/min]) of evaporative cooling (0.05–0.075°C/min [0.9–0.14°F/min]).[9]

Our case presented several challenges. The patient's proctectomy precluded rectal thermometry, the standard method of core temperature measurement.[6] Due to concerns of artifactual temperatures from the bladder catheter after ice water immersion, we relied on oral thermometry, which may have underestimated the core temperature.[15] Otherwise, monitoring was identical to a dry resuscitation, with pulse oximetry, cardiac monitoring, and automatic sphygmomanometry fully functional while the patient was immersed to the level of the anterior axillary line, and the body bag closed to the patient's neck. In addition to its lower cost and superior availability, the body bag demonstrated clinical advantages over conventional immersion tubs, for instance, by allowing fully supine patient positioning during immersion with unimpeded access to the anterior chest for cardiac monitoring or ultrasonography, as well as immobilization of a potentially threatened cervical spine in a traumatic situation.

Pre-arrival notification from EMS allowed us to set up the body bag and ice buckets prior to the patient's arrival, which facilitated rapid cooling. We suggest that body bags and a cold water immersion protocol be readily available in any ED where heat stroke patients may be encountered. Because of its low cost, ease of patient access and monitoring, single-use hygiene, and scalability, cold water immersion by body bag has the potential to become the new standard for cooling heat stroke in emergency medicine.

4 | CONCLUSION

We describe a case in which an elderly patient with non-exertional heat stroke was rapidly cooled in the ED via cold water immersion in a body bag. This case highlights the efficacy and logistical ease of this cooling method.

CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

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