Case Report

Management of heatstroke using the novel, reusable, CarbonCool® suit: a case report

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Abstract: Heatstroke is a life-threatening condition with high morbidity and mortality. Prompt recognition and institution of cooling measures has been shown to greatly improve outcomes. This is a case report demonstrating the use of a novel cooling suit (CarbonCool® suit) in a case of exertional heatstroke (EHS). The CarbonCool® suit is a half-body suit with cooling pads (MPad™) that are filled with a graphite water solution found to be 15 times more thermally conductive than ice. In this case report, a previously well 31-year-old male presented to the Emergency Department (ED) with EHS, subsequently requiring intubation. The CarbonCool® suit was used to reduce his core (rectal) temperature from 41 to 38.7 ℃ in two hours. Patient's core temperature subsequently normalized to 37 ℃ and he was discharged well and neurologically intact. The case report demonstrates that the suit can be easily worn and secured in place, while resuscitative measures are ongoing. This reduces the need for constant monitoring and replacement of ice packs, hence serving as a convenient alternative to ice packs for initial management of patients with EHS. While alternative cooling methods such as powered cooling devices may be utilized, these devices are often only available in the intensive care unit, with significantly higher operative costs. Use of the CarbonCool® suit as an adjunct to other cooling methods may be a simple solution for rapid initiation of cooling in the patient with heatstroke.

Keywords: Heatstroke; external cooling; pre-hospital care

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Introduction

Heatstroke is a life-threatening condition defined as core temperature above 40 ℃ and central nervous dysfunction (1). Rapid cooling measures are the cornerstone of heatstroke management, as the duration and degree of hyperthermia is a major determinant of outcome for these patients (1). External cooling methods such as evaporative and immersion cooling are widely used for heatstroke management (2). These methods are limited in their utility due to the need for infrastructure (i.e., body cooling unit), and difficulty in resuscitative procedures such as airway management, defibrillation and nursing when immersed in cold water. Singapore has a comprehensive, single-provider emergency medical services (EMS) system run by the Singapore Civil Defence Force (SCDF), activated by a centralized 9-9-5 dispatching system. Dispatchers consist of firefighters, paramedics and dispatch nurses (3). This is a case report of a patient brought in by the SCDF for exertional heatstroke (EHS) for whom a novel cooling suit (CarbonCool® suit), which was developed for use in

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targeted temperature management (TTM) in cardiac arrest, was utilized for cooling.

We present the following article in accordance with the CARE reporting checklist (available at http://dx.doi.org/10.21037/jeccm-20-107).

Case presentation

A previously well 31-year-old male was brought in to the Singapore General Hospital (SGH) Emergency Department (ED) for a case of heatstroke, which developed during a 10-kilometer mass participation run event. At the 6km mark, the patient was still observed to be well by his wife. However, he was subsequently found confused after sustaining a fall with head injury. The patient was brought to the medical tent where he was diagnosed with heat injury. External cooling was commenced on scene with wet towels and fans, and the patient was then transported to the ED. There was no recorded temperature on scene or en-route to SGH.

On arrival at ED, the patient was restless with a rectal temperature of 41 ℃ and Glasgow Coma Score of 9 (E2 V3 M4). Vital signs were as follows: heart rate at 168 beats/min, respiratory rate was 24 per minute, blood pressure was 106/68 mmHg and oxygen saturation was 92%. He was infused with one litre of cold intravenous normal saline and the cooling suit was applied for the entire duration that patient remained in the ED (for approximately 3 hours). The patient was intubated in view of agitation, and subsequently admitted to the medical intensive care unit (MICU).

Upon arrival at MICU, core temperature was noted to be 38.5 ℃. Intravenous cold saline infusion was continued, while the cooling suit was removed and replaced with Blanketrol®. Blanketrol® is a powered temperature control system that provides a non-invasive method of targeted temperature management for patients (4). The patient remained in MICU for two days, during which his temperature was charted every six hourly and normalized to 37 ℃ by the second day. EHS in this patient was complicated by multiple issues such as encephalopathy, acute kidney injury, rhabdomyolysis, disseminated intravascular coagulation, hepatic injury and cardiac stunning. Haematological investigations showed improvements during his inpatient stay, with creatinine kinase (6,942 to 735) and creatinine (522 to 252) downtrending. He was also extubated on the second day due to improvement in level of consciousness and orientation, and was subsequently discharged well and stable.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committees, and with the Helsinki Declaration (as revised in 2013). All attempts were made to contact the patient to obtain consent.

Discussion

Heatstroke is often complicated by multiple organ dysfunction such as renal and hepatic failure, disseminated intravascular coagulation, rhabdomyolysis and adult respiratory distress syndrome among others (5). Rapid, effective cooling methods are necessary in management of heatstroke as delayed cooling in EHS directly correlates with increased morbidity and mortality (1).

Cooling methods can be classified as invasive (e.g., gastric lavage, intravenous cold saline) or non-invasive (e.g., cold-water immersion, evaporative cooling). Ice-water immersion is the current gold standard for treatment of EHS (6), with studies on its use for EHS in military recruits and large-scale athletic events concluding with no fatalities, thereby demonstrating its effectiveness (7,8). However it is found to be poorly tolerated in elderly patients suffering from classic heatstroke, and contributes to increase morbidity and mortality (9). Practical or clinical constraints such as difficulty maintaining intravenous access or keeping the airway accessible may also preclude its use (10). Where ice-water immersion is not available, application of ice packs to the neck, axilla and groin coupled with spraying of lukewarm water over the patient's body is an acceptable alternative (11).

CarbonCool® suit is a wearable suit made of neoprene and thermoplastic polyurethane, with 12 MPads™ filled with a graphite water solution which is found to be 15 times more thermally conductive than ice (*Figures 1*,*2*). It was co-developed with a start-up company, Global Healthcare Pte Ltd (https://www.globalhealthcare.sg) and SGH. A recent study found that use of the CarbonCool® suit led to a significant reduction in time required to reach target temperature of 34 ℃ (12). It was initially developed for targeted temperature management post cardiac arrest. Its novelty lies in its effectiveness in targeted temperature management while remaining easy and safe to use, thereby allowing for rapid initiation of cooling measures in pre-hospital settings. The cooling vest is compact and can be carried along in the ambulances, making it suitable to be used in the pre-hospital setting. By decreasing the time to initiation of cooling measures, we aim to improve the

Figure 1 Application of CarbonCool® Suit on a model. Reprinted with permission from Global Healthcare SG.

Figure 2 MPad™: Cooling pads used in the CarbonCool® Suit. Reprinted with permission from Global Healthcare SG.

outcomes of patients with heatstroke.

Use of the cooling suit with intravenous cold saline successfully cooled the patient from 41.6 to 38.7 ℃ in approximately 150 minutes, demonstrating a similar efficacy of cooling with that achieved in ice pack application (0.028 ℃/min) (13). Compared to placing ice packs, which involves significant preparation, cleaning up, and continuous replacement due to melting, the suit is a simple one-stop solution that can be easily implemented. Significant advantages to the CarbonCool® suit include its ease of use and design—the entire suit is quickly and easily fitted onto the patient and secured snugly with VELCRO straps, ensuring optimal placement and maximizing body contact with cooling pads. Furthermore, the cooling suit is compatible with various forms of imaging such as X-rays, computed tomography (CT) and magnetic resonance imaging (MRI) scans, thus allowing for continuous cooling throughout the course of treatment.

Powered cooling devices such as Blanketrol® and other commercial devices have been shown to be highly effective in reducing core body temperature rapidly (4). However, these are primarily used in other settings such as the intensive care unit, and require prior knowledge and training to operate. These devices are also often large and bulky and require an external power source, making it impractical for field use.

A review of studies using solely unpowered cooling vests to treat hyperthermic individuals (Core body temperature (T_c) greater than 38 ℃) found no significant difference in T_c cooling rates between groups with or without the cooling suits (14). However, it should be noted that unlike the case in these studies, heatstroke patients are often cooled using a combination of methods concurrently.

Other invasive methods such as gastric, peritoneal or rectal cold-water lavage are less well studied, and not often used due to their more invasive nature (15).

This case highlights the use of the CarbonCool® suit as an adjunct to other cooling methods in the context of a patient with EHS. Due to its logistical simplicity and portability, there is also potential for deployment at mass participation events for first-aid of heat illnesses.

Conclusions

CarbonCool® suit is a novel reusable cooling suit that can be used for hypothermic resuscitation as well as for patients with heat stroke. Unlike cold-water immersion and ice packs, the suit allows for resuscitative procedures to take place simultaneously during cooling. Considering its low cost and portability, it can serve as an alternative to conventional cooling methods for rapid institution of cooling measures in the pre-hospital or emergency department setting and can deployed during heat injury susceptible events such as marathons.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at http://dx.doi.org/10.21037/jeccm-20-107

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jeccm-20-107). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committees, and with the Helsinki Declaration (as revised in 2013). All attempts were made to contact the patient to obtain consent.

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