SHORT COMMUNICATION

Cold-Water Dousing with Ice Massage to Treat Exertional Heat Stroke: A Case Series

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Introduction: We sought to determine the rate of cooling via a novel water ice therapy (WIT) as an alternative to cold-water immersion for the acute treatment of exertional heat stroke (EHS). ***Methods:*** Observations were made at the 2004-2008 Marine Corps Marathons (mean ± SD: 16.3 ± 4.9°C dry bulb, 32 ± 6% RH). Nine (seven men, two women) EHS patients (33 ± 6 yr of age; 268 ± 54 min average race time for six who finished) were observed during on-site treatment. Patients were treated while lying supine on a porous stretcher resting on a tub filled with cold water (~10-12°C). Medical personnel monitored T_{re}, doused the patient with water and massaged major muscle groups with ice bags until T_{re} decreased to 38.9°C. Patients were not immersed in water. Serial T_{re} and time were used to calculate cooling rates. ***Results:*** Final T_{re} (39.12 ± 0.63°C) was significantly lower than initial T_{re} (41.43 ± 0.71°C, $P < 0.05$). Cooling rates were $0.13 \pm 0.04°C \cdot min^{-1}$. The decrease in T_{re} for the initial 6 min of WIT (0.38 ± 0.13°C) was significantly less than for the subsequent 6-min time period (1.31 ± 0.34°C, $P < 0.001$). Cooling rates for these time periods were significantly different ($0.06 \pm 0.02°C \cdot min^{-1}$ and $0.22 \pm 0.06°C \cdot min^{-1}$, respectively, $P < 0.05$). Initial T_{re} was not correlated with overall cooling rate ($r = 0.434$, $P = 0.244$), or total cooling time required (17 ± 4 min; $r = 0.207$, $P = 0.593$). Survival rate was 100%. ***Conclusion:*** WIT provided cooling rates that were 70% as effective as those published for cold-water immersion with 8°C water ($0.19°C \cdot min^{-1}$) and resulted in 100% patient survival.

Keywords: hyperthermia, cold-water immersion, heat illness, whole-body cooling.

RAPID COOLING of exertional heat stroke patients is critical for patient survival and the avoidance of lasting sequelae. Recovery from heat stroke depends on how long a patient's core body temperature (most commonly measured rectally) remains above a critical threshold (40-41°C) (1,3,4,6–8,13). Therefore, the faster the patient is cooled, the better. In fact, survival rates for heat stroke of 100% are achieved with efficient recognition and treatment (8–10). Furthermore, it seems recovery from heat stroke is facilitated by appropriate acute treatment (9,11,17).

The recommendation regarding whole-body cooling for heat stroke victims via cold-water immersion (CWI) is prevalent. For a variety of reasons, some have inappropriately questioned the use of CWI. Various reasons included patient comfort, potential peripheral vasoconstriction, and sanitation (9). However, CWI is now labeled as the "gold standard" of heat stroke treatment based on survival rates and cooling research and the potential negatives of CWI have been refuted (9). There is a vast body of evidence supporting ice/cold-water immersion, which led sports medicine organizations (American College of Sports Medicine, National Athletic Trainers' Association, International Amateur Athletic Federation) and the military to publish recommendations for CWI (1,4,6). Recent reviews found that CWI provides superior cooling, is safe, and can be completed with minimally trained staff (16,19).

However, there are some situations in which CWI may not be possible. In these circumstances, alternative cooling methods are required to assure patient survival and reduce sequelae. One potential downfall of CWI is the potential for cardiac fibrillation during cooling, in which case an AED may be required (the authors are unaware of a documented case where this has occurred) (12). The use of an AED may be delayed if a patient had to be removed from the tub, dried, and connected to the unit. Some physicians and healthcare professionals continue to seek an alternative to CWI for this reason (5). This caused military physicians to begin utilizing water ice therapy (WIT) to treat heat stroke patients. The medical literature does not currently include citations documenting the efficacy of this method. The purpose of this case series was to determine the rate of whole body cooling via a novel WIT therapy, and assess if it is a viable alternative to CWI for the acute treatment of heat stroke.

METHODS

This observational study examined the acute management of heat stroke in the finish line medical tent at the

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2004 - 2008 Marine Corps Marathons in Washington, DC (26.22 mi, 42.2 km). Nine (seven men, two women) heat stroke patients (33 ± 6 yr of age, 268 ± 54 min average race time for six who finished) were observed during emergency WIT treatment. Physicians used the presence of a rectal temperature (T_{re}) greater than 40°C combined with central nervous system dysfunction as diagnostic criteria for exertional heat stroke. An Institutional Review Board was consulted and deemed the protocol of data analysis unnecessary for review due to the absence of potential patient identification within the data.

WIT Therapy

Patients were treated while lying supine on a porous stretcher that rested on a tub filled with cold water (10-12.8°C). Rectal temperature (T_{re}) was continuously monitored throughout treatment via indwelling rectal thermistor (Model 700, Yellow Springs Instruments, Yellow Springs, OH). Measurements for T_{re} were recorded every 3 min. Six to eight medical personnel continually doused the entire patient (except the head, which was wrapped in an ice towel) with water from the tub and massaged major muscle groups (pectorals, abdominals, quadriceps, gastrocnemii) with ice bags until T_{re} decreased to approximately 38.9°C; at this point, WIT therapy ceased. At no point during WIT were patients immersed in water.

Serial T_{re} and time measures were used to quantify cooling rates. Repeated measures ANOVA statistical testing (SPSS, version 16.0, Chicago, IL) was used with a post hoc *t*-test using a Bonferroni correction to identify significant differences over time. Pearson r correlations were utilized to test for relationships between initial T_{re} and cooling rates, and cooling time required.

RESULTS

Ambient temperatures at the time of heat stroke collapse were 20.44 ± 1.9°C (68.8 ± 3.5°F) dry bulb with 34 ± 6% RH. Cooling trends are shown in **Fig. 1**. Cooling rates were $0.13 \pm 0.03°C \cdot min^{-1}$ ($0.24 \pm 0.05°F \cdot min^{-1}$). The degree change in T_{re} for the initial 6 min of WIT (0.38 ± 0.13°C, 0.68 ± 0.23°F) was significantly less than T_{re} decrease for the subsequent 6-min time period (1.31 ± 0.34°C, 2.36 ± 0.61°F; $P < 0.001$). Cooling rates for these time periods were significantly different as well [$0.06 \pm 0.02°C \cdot min^{-1}$ ($0.11 \pm 0.04°F \cdot min^{-1}$) and $0.22 \pm 0.06°C \cdot min^{-1}$ ($0.40 \pm 0.11°F \cdot min^{-1}$), respectively; $P < 0.05$]. Initial T_{re} (41.43 ± 0.71°C, 106.57 ± 1.28°F) was not statistically correlated with overall cooling rate ($r = 0.434$, $P = 0.244$), or total cooling time required (17 ± 4 min; $r = 0.207$, $P = 0.593$). Total mean reduction in T_{re} was 2.31 ± 0.81°C (4.16 ± 1.46°F). Survival rate for this treatment was 100%.

DISCUSSION

We attempted to observe and quantify the cooling effectiveness of WIT therapy in the finish line medical tent of a popular marathon road race. This method of whole-body cooling, exclusive of water immersion, provided cooling rates that were approximately 70% as fast as those published for CWI with 8°C water ($0.19°C \cdot min^{-1}$) (18). We decided to compare our results to the results of Proulx et al. (18), due to the similar water temperatures utilized. CWI should be the first option of cooling for heat stroke patients, given its superior rate of cooling (16). If CWI is not possible, WIT can be considered a viable cooling modality for heat stroke when there are adequate staff to provide care immediately. This WIT modality could be provided in many athletic settings since it is similar to a cold shower with ice massage.

The cooling rates quantified with this case series are comparable to CWI with warmer water, but not as effective as very cold water ($0.35°C \cdot min^{-1}$) (10,18). CWI continues to be considered a superior cooling modality for heat stroke patients. However, in this study, the effectiveness of WIT was validated with 100% survival, most likely because extremely rapid and appropriate recognition and treatment occurred in every case. The time from collapse to treatment initiation was not measured, but was estimated to be no more than 5 min in seven of nine cases, and 15 min in all cases. This immediate recognition and treatment should be adopted with all suspected cases of heat stroke to maximize survival and facilitate recovery (1–4,6,7,9,11,13,17).

Our finding that initial cooling (first 6 min) was inferior to subsequent cooling (minutes 6 to 12) is consistent with previous studies on hyperthermic subjects in a research setting (18). In the research of Proulx et al. (18) and Clements et al. (10), subjects did not experience heat stroke, but thermoregulatory responses were similar to our findings. This delay in whole body temperature reduction suggests that with aggressive cooling, there is a temporary delay while a temperature gradient is established. Initial cooling rates reported by Proulx et al. (18) were about half of later cooling rates for cold-water immersion at 2°C, while we found initial cooling to be roughly one-third that of later cooling. Previous researchers utilized the 1st degree of cooling for initial, while we defined initial cooling as the first 6 min of cooling. Alternative modalities aimed at avoiding the temporary delay in cooling (i.e., preventing peripheral vasoconstriction to speed cooling) have yet to be shown effective (5,14–16). Aggressive cooling should remain the goal, with initiation of such treatment being expedited as much as feasible.

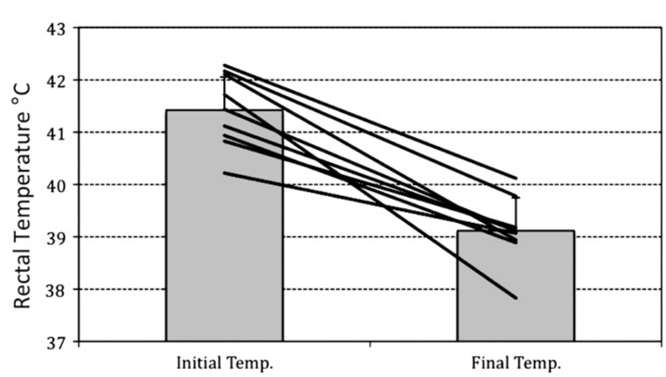

Fig. 1. Mean (± SE) and individual heat stroke patient responses to cold-water dousing ice massage therapy. Total cooling time = 17 ± 4 min.

We found that the initial T_{re} (maximal) was not correlated with total cooling time required or the rate of cooling. Cooling rates seem to be individualized in response to heat stroke and rapid cooling. Overall cooling rates are most likely related to body mass, body fat percentage, or body mass to surface area ratio rather than maximum T_{re}. The initial temperature recorded does not correspond to the specific amount of time required to cool to 38.9°C, but cooling time for all patients was between 12 and 24 min. This suggests that the starting T_{re} in a medical situation should only be used as a general indicator to determine the length of cooling for a particular patient. It is important that an indwelling temperature monitor be utilized throughout treatment (1,4,6). This will allow continual monitoring, and decrease the chance of potential T_{re} hypothermic overshoot when cooling ceases, as long as WIT is terminated when T_{re} reaches approximately 38.9°C.

The primary and obvious goal of treating heat stroke is to save lives. In this case, WIT resulted in success. Similarly, other reports have maximized survival with the use of CWI (2,3). Future studies may demonstrate a faster recovery and return to activity following certain modalities, but the importance of fatality avoidance should not be overlooked.

Our novel approach to acute exertional heat stroke treatment using WIT provided efficient whole-body cooling and would have allowed simultaneous supplemental medical care if needed. In conclusion, WIT provided effective cooling for our patients, but warrants further investigation for broad-spectrum recommendations for heat stroke treatment.

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