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Heat Related Illness - Practical Considerations in Prehospital Treatment and Prevention on the Firegrounds

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Heat related illnesses affect multitudes of people and can become life threatening emergencies if not rapidly identified and treated.

Persons who engage in strenuous physical activity especially when temperatures and humidity are increased are at greatest risk. Those involved in active training in the military (1,2,3) and athletes (4,5,6) are at acute risk for developing heat related illnesses.

The very young and very old (1,7) are highly susceptible to heat. The young because their surface area is larger in relation to their size and their lack of fat layers required for insulation (1,8). The elderly have difficulty compensating due to decreased circulation and other physiologic changes associated with aging.

Also at risk are individuals with diseases such as diabetes mellitus, cystic fibrosis, alcoholism, and those suffering from obesity or cardiopulmonary disorders (1,8).

Certain medications affect the body's ability to regulate heat production. Phenothiazines, diuretics, propranolol, amphetamines, anticholinergics, MAO inhibitors (2) and many others interfere with the ability to dissipate heat. Persons taking any of these drugs need to be well monitored.

At ultimate risk are firefighters, who not only engage in strenuous physical activity, but don heavy, insulated suits for entry onto burning buildings with temperatures often in excess of 1,200°F. For this group we will define the scope of the problem, attempt to establish criteria for unsafe operations, and discuss definitive therapy for restoration of acceptable functional ability.

PATHOPHYSIOLOGY

To maintain a constant core temperature, heat loss must equal heat production. Heat loss through radiation, conduction, evaporation, convection, exercise, and work must equal heat produced through metabolism (4,6,9). If heat production exceeds heat loss, the temperature will rise. When the temperature increases, the hypothalamus, the body's temperature control center, is stimulated to increase sweating and peripheral vasodilation so that the blood can bring excess heat to the surface where it can be dissipated by convection, evaporation, or radiation (1,8,9). The cardiac output also increases, thereby increasing the rate of heat dissipation (10).

As long as the outside temperature remains lower than that of the skin and the humidity stays below 75%, the mechanisms remain functional (21). As temperatures and humidity increase, heat loss diminishes and heat may begin to be absorbed by the body. This excess heat can now only be diffused by evaporation (9,11). As the humidity increases, the rate of evaporation decreases, as the air is already saturated.

A normal individual loses approximately one liter of fluids per hour during exertion through sweating (4). Thermo-regulatory failure may halt sweat production, causing body temperature to increase, often above 106°F (6,8). During extreme heat, losses of two to three liters per hour may occur (8). If the cycle is not broken, electrolyte imbalances may result in significant hypokalemia and hyponatremia (7,12).

There are three basis disorders of heat regulation - heat cramps, heat exhaustion, and heat stroke.

Heat cramps are painful muscular spasms that involve muscle groups that have been strenuously exercised. Generally, there are no problems associated with mental processes or orientation. Heat cramps are thought to be caused by sodium depletion despite adequate water replacement (1,2,9). Murphy suggests that cramps are caused by a fluid volume problem which can be prevented by providing copious amounts of water (6).

Heat exhaustion is by far the most common heat-related illness. It occurs when the body loses excessive sodium and water due to profuse sweating (9,13). Symptoms of heat exhaustion include extreme thirst, headache, fatigue, dizziness, weakness and cool, pale skin with profuse sweating. In addition, altered levels of consciousness, irritability, postural hypotension, tachycardia, and mild elevations in body temperature have been reported (9).

Heat stroke is a life-threatening medical emergency. It occurs when physiologic mechanisms are unable to compensate for heat produced or the environmental temperature (2). Heat stroke can be categorized as non-exercise or exercise induced. Both are characterized by hyperthermia, with temperatures often greater than 106°F (6,8,9), altered levels of consciousness, hot dry skin, and tachycardia. Severe central nervous system disturbances such as seizures or coma

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may present (9,12). Electrocardiographic changes may include ST depression, T wave inversion, conduction disturbances, and ventricular tachycardia (1,2). If temperatures persist above 106°F, brain damage may result (2,9,12).

PREVENTION

Prevention is the key to treating heat-related illnesses. Rest is necessary to promote normal recovery from exhaustion, as well as for general well being (3,14).

Food is important because it supplies the individual with the calories necessary to create energy for muscular effort. Proteins are important in the diet, however, they don't significantly contribute to quick energy requirements (15).

Fats in the diet should equal about 25% to 30% of the total daily caloric intake (15). This doesn't necessarily mean that the diet should be supplemented with additional fats because the content in a normal diet provides a sufficient amount. The total elimination of fats from the diet is not recommended. Muscles, including the heart, require certain fatty acids for energy (15). An absence of all fats in the diet can result in permanent disabilities or death (15,16).

Fats and proteins are important for maintaining overall health, but carbohydrates are the major source of energy. Carbohydrates should make up at least 55% of the daily caloric intake. The majority of these should be from complex carbohydrates (starches) rather than simple sugars (55). Complex carbohydrates take longer to digest and are therefore available for more sustained energy. They also help to provide necessary fiber, vitamins, and minerals.

Along with good nutrition, it is necessary to maintain proper salt and water balance. Dehydration is a serious problem for those involved in strenuous activities. Extreme exertion can cause the loss of several liters of water as sweat To compensate, water is pulled from the plasma to control body heat (8). Unless this water is replaced, serious consequences may develop. To prevent dehydration, Dr. Richard Gerson, Director of St. Anthony's Hospital Wellness Center, claims that it is important to prehydrate, hydrate, and rehydrate. This is corroborated by a American College of Sports Medicine position statement on prevention of thermal injuries during distance running (17). Furthermore, trainers for the Tampa Bay Buccaneers maintain that "constant hydration is the way to go to combat heat-related illness." They have observed that the leaner the person, the faster they tend to cramp. Until recently, it was thought that excessive water intake could cause cramps. It is now advised that individuals drink cold water, perhaps in unlimited amounts (6). Cold water is palatable and is absorbed quickly from the stomach.

There is considerable controversy regarding the amount of electrolytes that are really lost in sweat. The consensus suggests that water is the most significantly depilated factor lost in sweat (1,7,12). Williams believes that adding sugars and electrolytes to water just delays its emptying from the stomach (17). Water may be the rehydration fluid of choice. Electrolytes lost in sweat will be replaced with the next meal. Humans can survive over thirty days without electrolytes. Without water, survival may be limited to as little as seventy-two hours (13).

EMS and fire personnel work schedules that usually interfere with normal rest, sleep and eating patterns. It is recognized that operational requirements may not allow for control over the timing of rest periods. If this is a constant situation, compensation via other means such as food and fluid intake should be instituted (3).

It has been observed that after several days to weeks, persons may become acclimated to hot climates, increasing their capacity for strenuous activity. Careful attention has reduced the incidence of heat stroke in athletes (6,17) and military personnel (3).

Acclimatization increases the metabolic efficiency of the body resulting in improved aerobic efficiency and an increased cardiac output (2). Acclimatized individuals sweat more efficiently, losing less sodium per volume of sweat (9).

On the firegrounds, a paramedic should be assigned the role of safety officer, working closely with the incident commander. The responsibility of the safety officer includes continuous assessment of personnel for the subtle, early signs of heat illness. Some of the responsibility must also be placed on the individual. Personnel should be instructed in recognition of early warning symptoms that precede heat illness. Recognition of symptoms, cessation of activities, and proper treatment can prevent serious heat illness. Early warning symptoms include piloerection on the chest and/or upper arms, chilling, throbbing pressure in the head, unsteadiness, nausea, and dry skin (17).

It is further advised that working personnel have a standing blood pressure of at least 90 torr. The hyperthermia factor of heat illness reduces cardiac output. Young, healthy and physically fit persons can compensate for long periods of decreased cardiac output. The standard tilt test can be used as a guide to prevent further injury. Individuals unable to satisfy the standing blood pressure or tilt test screening tests should be rehydrated, monitored, and reassessed. Return to duty should not be granted until there is clinical improvement (3,14,17).

As a prophylactic measure, susceptible individuals should be identified. Persons with large muscle masses seem to be particularly susceptible to loss of body water. Baseline weights may be helpful, because a fluid loss of greater than 3% of total body weight can signal danger (6).

TREATMENT

Heat cramps are easily managed in the field. Treatment includes removing the individual to a cooler environment,

rest, and administration of water (6), saline (8, 9), or electrolyte solutions (1,14,17).

Persons suffering from heat exhaustion should be withdrawn from activities. They should rest in a cool environment. If possible, fan the individual to speed the cooling process. Provide oral or intravenous replacement of water and sodium (1,8) or electrolyte solutions (14,17).

Heat stroke is characterized by a body temperature of at least 105° F (40.6° C). Successful management depends on early recognition and aggressive therapy. Clinical findings often include hyponatremia, hypokalemia, metabolic acidosis, hypophosphatemia, hypocalcemia, and hypomagnesemia (7). All of these are common and potentially lethal (88). Treatment is aimed at immediate cooling by immersion in an ice bath, use of a hypothermia blanket, ice packs to the axillae and groin, or ice water lavage (1). Management in the field may include submersion in water, spraying with water from a hose, or applying ice packs to the axillae or groin (12). Severe cases of heat stroke require management in an intensive care setting.

During the heat stroke cooling process, the temperature must be carefully monitored. Treatment of metabolic acidosis with oxygenation and ventilation (2) may be preferable to sodium bicarbonate (1,12). Mannitol may be administered to decrease cerebral edema and promote urine flow through diuresis (1,12). Potassium may be given for hypokalemia (12). However, potassium should never be given prophylactically due to the risk of preexisting hyperkalemia (1). To prevent shivering when the victim is on a cooling blanket, chlorpromazine is often recommended (1,12). Intake, output, and central venous pressures should be monitored to evaluate the effectiveness of fluid replacement. The ECG must be monitored for arrhythmias induced by either the heating or cooling process. Complications of heat stroke include coagulation disorders, convulsions, cardiopulmonary difficulties, and disorders of multiple organ systems (12).

The military and organized athletics have already resolved many of the logistics regarding exertional heat illness and task performance. The fire service could derive great benefit from their prior research. Therefore, I suggest that some attention be given to determining standards to be followed on the firegrounds to promote individual safety in this unstable environment.

REFEREE COMMENTARY

Don Seiler (Exercise Physiologist, Director of Health Promotion, St. Joseph's Hospital) - The description of temperature balance in the body may cause some confusion. Certainly heat is lost through evaporation of sweat, but it can be gained or lost through radiation, conduction, and convection. Exercise is always on the side of the equation that increases body temperature. Firefighters must be aware that as their physical activity increases, their potential for injury increases.

Firefighters must also be aware that exercise induced heat stroke may occur before cessation of sweating. Marathon runners have been observed with body core temperatures in excess of 42°C in the presence of profuse sweating. Disorientation and piloerection are probably more reliable warning signs of serious problems.

Two important nutritional factors were overlooked when discussing prevention. These are the effects of alcohol and caffeine. Both drugs act as diuretics and promote dehydration. As Dr. Gerson Notes, prehydration is an important aspect of prevention. Alcohol consumption on the night before shift change can result in severe dehydration and an early firecall could be hazardous. The constant intake of caffeine containing beverages can result in the same problem. In terms of prevention, it is also important to recognize the effect that body composition has upon heat regulation. Firefighters with a high percentage of body fat are at special risk for heat injury and should be counseled on ways to reduce this risk. Fitness level is another important preventative factor. Thermoregulation is greatly improved in trained individuals. Especially if they train in similar environmental conditions.

Gordon W. Yaudes, REMT-P (District Commander and Paramedic, Clearwater Fire Department, Pinellas County EMS) - It is well documented that firefighting is the most physically demanding and dangerous profession in the United States. Danger exists not only from smoke, fire, collapse, chemicals, and electricity but also from fatigue and dehydration. Fireground commanders will agree the safety of the firefighters is of primary concern. This often involves the assignment of a Safety Officer. Because of the scope of the Safety Officer's responsibilities, many departments fill this position with a staff officer. The individual assigned must be familiar with all techniques of firefighting. A qualified individual which readily comes to mind is the Training Officer. The Safety Officer cannot limit his/her thinking to just fatigue, dehydration vs. relaxation, rehydration but must be concerned with entire fire scene safety. I feel the Safety Officer's job should be more "fire" oriented than "medically" oriented.

As the incident escalates, a rehabilitation area needs to be established under the Safety Officer. The area needs to be away from the actual firefighting activities. The area should be air conditioned or at very least shady. Liquids and paramedical support should be provided. Crews should be rotated to this area to receive rest, liquids, food if necessary, and medical evaluation. A convenient rotation time is the use of one breathing apparatus bottle. In order for the rotation to be feasible, the fireground commander must summon additional fire apparatus (alarms) as soon as possible. Once through rehabilitation, crews can be reassigned, held in reserve, released, or targeted for hospital exam.

The previous article stresses the importance of prevention. Firefighters must be educated to drink liquids in rehab even when not thirsty. They also should cool down and rest even though they badly want to be "back in the action."

The present shows many apparatus carry liquids/coolers/water so rehab areas can be set up with arrival of the first apparatus. Fireground Commanders are being trained in the Incident Command System including the importance of the Safety officer and the Rehabilitation Area. Firefighters attitudes are changing regarding safety and rehabilitation. Fire Departments are developing S.O.P.s regarding firefighter safety and incident management.

The future may bring air conditioned, crew cabbed apparatus

where crews can be rehabilitated in a climate controlled environment.

Ms. Pierson's Response - In researching the paper, I did not find specific mention of caffeine or alcohol, but Mr. Seiler's comments about their diuretic actions certainly make alot of sense. Caffeine intake is a common morning activity at a firehouse. Mr. Seiler brings up a good point about sweating and and heat exhaustion. Persons coming out of bunker gear will be wet regardless of anhidrosis, due to retained perspiration in the fabric liner. This can give a false sense of security about the absence of heat stroke. Re-education may be appropriate for fire and EMS personnel to look for disorientation and piloerection as early clinical signs of heat stroke. It is important for individual firefighters to watch for these signs in themselves and their colleagues. To ignore them invites disaster.

The organizational structure used to perform medical screenings for heat illness isn't important, so long as all the bases are covered. The potential problem must be identified and someone must be assigned to address it, whether its a safety or a rehabilitation officer.

I would like to hear from the fire departments and EMS agencies about the validity of these ideas in daily practice. All this may be fine in theory, but does it really have an impact on the incidence of heat related illness? There is already so much we learn in the classroom that has no practical application in the field. Both reviewers make excellent points worthy of further consideration. Let's make this something we can really benefit from rather than letting it die on the vine. I would like to thank Mr. Seiler and Mr. Yaudes for their input.

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