Continuing Education

Heatstroke: A serious summer risk in Texas

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Objectives

At the end of the CE module, the EMS provider will be able to:

1. Understand the pathophysiology of heatstroke.
2. Differentiate heatstroke from other less serious types of heat illness.
3. Identify groups at highest risk for heatstroke.
4. Quickly provide appropriate treatment for a patient who is experiencing heatstroke.

Case study

Your ALS ambulance is dispatched to a local sports venue in response to a person "passed out" in a vehicle. On arrival, you find a male in his mid-twenties in a locked car that is not running. The outside temperature is 85°F and the car is parked in the sun. In an attempt to rouse the patient, you rock the car, knock on the window and shout. Getting no response, you break the window and unlock and open the door, feeling a rush of hot air. Your initial assessment of the patient reveals that he responds only to pain, has hot, red, dry skin, has a respiratory rate of 50 and a pulse rate of 150. You quickly move the patient to your ambulance to continue your assessment and begin treatment.

Introduction

According to the Centers for Disease Control, from 1979 to 2003, excessive heat exposure caused 8,015 deaths in the United States. During this period more people died from extreme heat than from hurricanes, lightning, tornadoes, floods and earthquakes combined. Additionally, hundreds are treated in emergency departments each year for lesser forms of heat illness, including heat exhaustion and heat cramps. These numbers may not seem excessively high, but they can rise rapidly during a heat wave in areas where people are not accustomed to high temperatures. For example, more than 40,000 Europeans died as a result of the heat wave in the summer of 2003 that primarily affected France, Portugal, the Netherlands, Spain, Italy, Germany, Switzerland and the United Kingdom.

Weather in Texas includes a variety of extremes, but generally speaking, the southern half of the state is extremely hot. Houston, for example, has a climate that is usually considered subtropical, much like that of the Philippines and Central America. Houston averages 99 days per year on which the temperature reaches 90°F, and the average daily high peaks at 94°F by the end of July. The Heat Index, which is a combination of temperature and humidity and is an indicator

of "how hot it feels" is frequently above 110°F. Heat illnesses, including heatstroke, are a significant concern in such an environment, which makes recognizing true heat emergencies and initiating rapid, appropriate treatment crucial as the hot summer months approach.

Risk factors for heatstroke

Generally speaking, heatstroke strikes all races and genders equally; however, notable differences related to social demographics can be seen. For example, more men in the United States participate in labor intensive jobs, leading to men having a higher incidence of heatstroke than women. Additionally, socioeconomic factors contribute to a death rate from heat related illnesses that is three times higher in blacks than in whites. Infants, children and the elderly have a higher incidence of heatstroke than young, healthy adults. Infants and children are at risk due to inefficient sweating and a higher metabolic rate, while the elderly are at risk due to limited cardiovascular reserves, pre-existing illness and the use of medications that may decrease the ability to sweat (*see table*). Heatstroke most commonly occurs in areas where heat waves are infrequent, such as the northern United States, northern Europe and Japan, but it is less common in subtropical climates.

Pathophysiology

Even when subjected to wide variations in ambient temperatures, healthy people typically maintain a constant body temperature by balancing heat gain with heat loss. This is known as *thermoregulation*. Homeostasis occurs when supply and demand for heat are balanced. This homeostasis is driven by the hypothalamus, which functions as the primary thermostat, guiding the body through heat production or heat dissipation, thereby maintaining the body temperature at a constant 98.6°F (37°C) in most individuals. The core temperature does not fluctuate much from this under normal conditions; however, temperature at the skin varies greatly, making it an integral part of thermoregulation.

Thermoregulation is controlled primarily by the hypothalamus with assistance from both the sympathetic and parasympathetic nervous systems. Thermosensors located in the skin, muscles and spinal cord send information regarding the core body temperature to the anterior hypothalamus, where the information is processed and appropriate physiologic responses are generated. These responses may include an increase in the blood flow to the skin, dilatation of the peripheral venous system or stimulation of the sweat glands to produce more sweat.

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At rest the body produces heat mainly through the metabolism of nutrients, referred to as the basic metabolic rate. Heat in excess of the basic metabolic rate may be acquired from internal and external mechanisms. Strenuous physical activity is an example of an internal mechanism. If the heat-dissipating mechanisms are not working properly, strenuous activity can increase heat production more than

Drugs that may increase risk factors for heatstroke

Alcohol, cocaine, heroin, LSD, PCP
Alpha agonists
Amphetamines
Anticholinergic medications (such as atropine sulfate, scopolamine, belladonna)
Antihistamines
Antiparkinsonian agents
Antipsychotics (such as haloperidol)
Beta blockers and calcium channel blockers
Diuretics (such as furosemide)
Laxatives
Lithium
Monoamine oxidase inhibitors (MAOIs)
Phenothiazines (such as promethazine)
Sympathomimetic medicines (such as epinephrine, ephedrine)
Thyroid agonists (such as levothyroxin)
Tricyclic antidepressants (such as amitriptyline)

Table adapted from Emergency Care in the Streets *by Nancy Caroline.*

10 times the basic metabolic rate. Fever, shivering, tremors, convulsions and many other internal conditions can increase heat production, thereby increasing body temperature. The body can also acquire heat from the environment through conduction, convection and radiation.

Classic, also known as passive heatstroke, primarily affects young children, the elderly and those taking certain medications.

Several factors can interfere with heat dissipation including inadequate intravascular volume, high ambient temperatures, high ambient humidity, hypothalamic dysfunction and many medications. When heat gain overwhelms the body's mechanisms of heat loss for whatever reason, the body temperature rises, leading to heat illness. Excessive heat will eventually destroy cells, leading to cardiovascular collapse, multiorgan failure and, ultimately, to death. The exact temperature at which cardiovascular collapse occurs varies among individuals because chronic illness, medications and other factors may contribute to organ dysfunction. Core body temperatures exceeding 106°F (41.1°C) are generally considered life threatening and require immediate aggressive treatment.

Clinical presentation of heatstroke

There are two types of heatstroke syndromes: classic and exertional. Classic, also known as passive heatstroke, primarily affects young children, the elderly and those taking the medications indicated in the table on page 31. Patients with chronic illnesses such as diabetes and heart disease are particularly susceptible as well. Classic heatstroke is typically driven by excessive environmental temperatures and develops over a few days. It usually begins as heat exhaustion, which can easily be mistaken for a cold, the flu or sepsis. If left untreated, the heat exhaustion will progress to heatstroke. A common example of this type of heatstroke might occur in an elderly shut-in without air conditioning during a heat wave.

Exertional heatstroke typically occurs in young or elite athletes exercising in hot, humid conditions and generally develops over a few hours. When the ambient temperature approaches body temperature, radiation and convection are no longer effective means of dissipating excess heat. If relative humidity rises above 75 percent, evaporative cooling becomes ineffective as well. An athlete who continues to exercise in these conditions will continue to generate heat with no means of excreting that heat. Exertional heatstroke is the second most common cause of death among high school athletes, surpassed only by spinal cord injury.

Both classic and exertional heatstroke will present with similar signs and symptoms that may or may not appear to be related to heat exposure.

Exertional heatstroke typically occurs in young or elite athletes.

Central nervous system

It is unlikely that patients will be able to give a coherent history because they will be confused, delirious or comatose. Symptoms of central nervous system dysfunction are present universally in persons with heatstroke and may include convulsions, hallucinations, ataxia (wobbliness, incoordination or unsteadiness), tremors, dysarthria (a motor speech disorder characterized by poor articulation), decerebrate or decorticate posturing, or they may be limp. Examination of the eyes may reveal nystagmus, a condition in which the eyes make repetitive, involuntary movements from side to side, up and down, or in a circular pattern. The pupils may be fixed, dilated, constricted or normal, though constricted is most common.

Vital signs

Temperature: Typically, the patient's temperature exceeds 104°F (40°C), but body temperatures lower than this are possible. Often, higher core temperature readings are

seen with exertional heatstroke than with classic. Additionally, elite athletes may become acclimated to a significantly elevated core temperature and may exhibit no signs or symptoms of heat-related illness despite having an elevated core temperature. Ensure that you are obtaining an accurate measure of temperature. Although oral temperatures are often used in the field, they may be difficult to obtain during a heatstroke emergency if the patient is unable to hold a thermometer in his mouth. In addition, oral temperatures may be inaccurate if the patient has been breathing through his mouth or drinking hot or cold liquids. If heatstroke is suspected, core temperature should be measured rectally if possible. Otherwise, the temperature can be obtained from the tympanic membrane of the ear if your service carries a tympanic thermometer.

Respiration: Patients with heatstroke commonly exhibit tachypnea and hyperventilation caused by central nervous system stimulation, acidosis or hypoxia. Breathing may be described as panting as the patient tries to blow off excess heat.

Pulse: Heat stress places a tremendous burden on the heart. Patients with pre-existing myocardial dysfunction do not tolerate heat stress for prolonged periods. Tachycardia exceeding 130 beats per minute is common.

Blood pressure: Patients are often normotensive; however, hypotension is also common. Hypotension can be caused by vasodilation, pooling of the blood in the venous system or dehydration. Hypotension may also be due to myocardial damage and may signal impending cardiovascular collapse, but this process may be slowed or corrected as the body is cooled.

Other systems

- Gastrointestinal hemorrhage is possible.
- Hepatic injury is common and is evidenced by jaundice.
- Rhabdomyolysis, the breakdown of muscle fibers resulting in the release of muscle fiber contents into the bloodstream, is a common complication of exertional heatstroke.
- Acute renal failure is a common complication of heatstroke. Patients may exhibit oliguria (low urine output) and/or change in the color of urine in the hospital setting where urine output is monitored.

Heatstroke, heat cramps or heat exhaustion?

Variable	Heatstroke	Heat cramps	Heat exhaustion
Pathophysiology	Failure of heat regulating mechanisms	Sodium and water loss	Sodium and water loss, hypovolemia
Mental status	Altered, delirium, seizures	Normal	Normal or mild confusion
Temperature	> 104°F (40°C)	May be mildly elevated	Usually mildly elevated
Skin	Dry, hot but sweating may persist, especially with exertional heatstroke	Cool, moist	Pale, cool, moist
Muscle cramping	Absent	Severe	May or may not be present

Table adapted from Emergency Care in the Streets *by Nancy Caroline.*

What's not *heatstroke*

There are less serious forms of heat illness, including heat cramps and heat exhaustion, but these are rarely life threatening. The table on page 33 compares the presentation of heatstroke to that of heat cramps and heat exhaustion.

The most rapid whole-body cooling rates have been obtained with cold water and ice water immersion therapy.

Treatment

Morbidity and mortality from heatstroke are related to the duration of the temperature elevation. When therapy is delayed, the mortality rate may be as high as 80 percent; however, it can be reduced to 10 percent with effective cooling early on. Treatment for heatstroke begins with supporting the ABCs, removing the patient from the hot environment and initiating the cooling process as quickly as possible. Correcting the temperature problem will begin to correct any problem you may find with the breathing or circulation. Evaluate the ABCs, administer supplemental oxygen, assist ventilations if needed and be prepared to intubate or administer another type of airway adjunct per your local protocol. Then change your focus to cooling.

The most rapid whole-body cooling rates have been obtained with cold water and ice water immersion therapy, and both seem to have the lowest morbidity and mortality rates of all the cooling methods; however, immersion is impractical in an ambulance. Further, conscious patients do not tolerate immersion very well and the core body temperature must be constantly monitored to avoid shivering and hypothermia. A more practical approach in the prehospital setting is an aggressive combination of rapidly rotating ice water-soaked towels to the head, trunk and extremities and ice packs to the neck, axillae and groin while fanning. Refer to local protocols for what method of cooling is preferred in your system, but all provider levels can typically administer this treatment. Continue cooling efforts until the rectal temperature has fallen below 102°F (39°C) but use caution and monitor for shivering. If the patient begins shivering, cooling efforts are counterproductive and the shivering must be stopped with muscle relaxants, anti-convulsants or sedatives before the cooling process can continue.

If your crew has advanced life support capabilities, monitor cardiac rhythm. Start an IV line, give normal saline and check the blood glucose level. Use caution when administering fluids—pulmonary edema is a known complication of heatstroke, and many of those affected by classic heatstroke have underlying cardiac problems (as discussed previously). Be prepared to treat seizures per your local protocol.

Additionally, there is controversy regarding the treatment of endurance athletes. Use caution in administering a large quantity of IV or oral fluids. In addition to a heat emergency, these patients may be hyponatremic, a body condition where there is not enough salt in the fluid outside the cells. If that is the case, aggressive IV therapy or a large amount of oral fluid could dilute the patient's blood even further, increasing the level of hyponatremia, which can lead to an irritable heart and dysrhythmias.

Some treatments of heatstroke should be completely avoided. Covering the patient in water soaked blankets may impede heat loss by evaporation. Massaging muscles to combat vasoconstriction from cooling is not beneficial. Additionally, antipyretics such as acetaminophen and aspirin should not be used for treating heatstroke because they are designed to work on a hypothalamus that is battling an infection, not a healthy hypothalamus that has been overloaded. Because antipyretics may aggravate bleeding, they may be harmful in patients who develop hepatic, hematologic and renal complications.

Education and prevention

If heat illness is caught early, it is rarely life threatening and unlikely to progress to heatstroke. Many things can be done to protect you, your crew and the community you serve from heat-related illnesses.

- Wear appropriate clothing. Clothing should be light-weight, light-colored and loose-fitting when possible.
- Wear sunscreen. Sunburn decreases the body's ability to cool itself.
- Increase fluid intake. During heavy exercise or in a hot environment, drink 16 to 32 ounces of cool fluid every hour. Avoid sugary, caffeinated or alcoholic drinks.
- Install or carry a portable fan in the ambulance to improve convection and supplement air conditioning. The fan can be used when treating patients with heat illnesses as well.
- Carry a portable cooler. Stock it with ice and sports drinks or other salt containing beverages for patients and the ambulance crew.
- Educate high-risk populations about the dangers of and how to prevent heat illness.
- Be alert for early symptoms of heat illness such as headache, nausea, cramps and dizziness. If you experience any of these symptoms, get out of the hot environment immediately and inform your supervisor.
- Educate athletes about the importance of slowly building endurance and acclimatization. Non-acclimated individuals can only produce about one liter of sweat per hour, whereas acclimated individuals can produce two to three liters of sweat per hour. Acclimatization to hot environments usually occurs over seven to 10 days and enables individuals to begin sweating sooner, increase sweat production and increase the capacity of the sweat glands to reabsorb sweat sodium, thereby increasing the efficiency of heat dissipation. Given this, the most dangerous times for athletes are the first few days of intensive practice before they are fully acclimatized.

Case study

Now that we can recognize heatstroke, can differentiate it from other, less-serious illnesses and have reviewed the appropriate treatments, let's finish the case study from the beginning of the article.

Your partner begins bagging the patient with oxygen attached at a rate of 15 liters per minute while you attempt to obtain a core temperature. A passerby who says he knows the patient tells you that the patient had been drinking beer all day long and was "passing out," so his friends left him in the car to sleep it off while they attended the sporting event. The passerby stated the friends left the patient in the vehicle approximately three hours ago with the air conditioning running. Some time during that period, the vehicle stopped running.

You obtain a core temperature of 106.0°F. You partner intubates the patient while you undress him, cover him with icy towels from a cooler in your ambulance, apply ice packs to his groin, axillae and neck and turn on a portable fan. You attach the cardiac monitor and determine that the rhythm is sinus tachycardia, then you start a large bore IV. You draw up diazepam in anticipation of possible seizures and initiate transport. During transport you monitor the airway and every five minutes reassess vitals, including core temperature. You also rotate the towels from the patient back to the cooler to ensure they stay very cold and continue the cooling process. Upon arrival at the hospital, the core temperature is 103.4°F, pulse rate is 134 and the patient is becoming agitated.

Conclusion

Heatstroke is the most serious form of heat illness and is a true life-threatening emergency. The diagnosis of heatstroke can be easy to miss, especially since the ambient temperature does not need to be extremely hot to affect at-risk populations. It may develop rapidly in a patient whose heat exhaustion was mistaken for another illness

such as a cold or the flu or it may present as a coma of unknown origin. Unless you keep the possibility of heatstroke constantly in mind during the hot months of the year, it could be easily overlooked and could cost the patient precious time before treatment. Routinely taking temperature as part of patient vital signs can prevent less severe heat illnesses from escalating into this deadly syndrome and aid in the early diagnosis of heatstroke.

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