Heat Injuries

Objectives

After reading this article you will be able to:

1. Describe the ways heat can be dissipated.
2. Distinguish between heat cramps, heat exhaustion and heat stroke.
3. Explain the treatment for heat injuries.

Case

It is a brutally hot Friday afternoon in August, with the temperature soaring around 100 degrees and the humidity is close to 70%. You are a medic for a hospital-based ambulance service, and as you near mid-shift, the workload is exhausting. Heat-related emergencies are making up the bulk of your calls.

No denying the discomfort – you've been sweating heavily all day. To compensate, you've been drinking lots of water. But as you work to resuscitate the day's second cardiac arrest patient, you start to feel extremely fatigued. You assist your fellow medics in resuscitating and transporting the patient to the hospital, then finally admit you are too tired to continue. A nurse notices your pale color and sweating and suggests you lie down while she checks your vital signs.

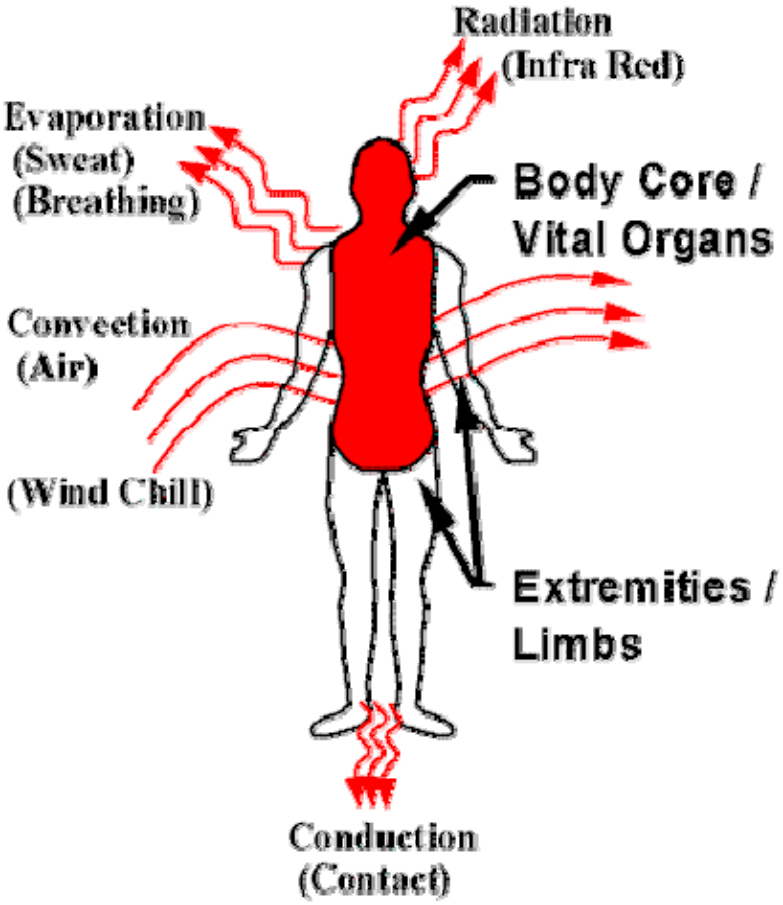
A moment later, she reports to the physician treating you that your blood pressure is 80/60, pulse rate is 120 and temperature is 102 F. She says you're experiencing heat exhaustion and starts an IV of lactated Ringer's. After several hours you begin to feel better. You're released from the hospital and go home to recuperate.

Introduction

Heat is produced by the body's muscular activity, metabolic reactions and endocrine activities. A certain amount of heat is required to sustain normal body temperature, and heat not needed for temperature maintenance is removed from the body through the skin, lungs and excretions. The most important of these in regulating heat loss is the skin. When the body's core temperature rises, peripheral blood vessels dilate. This means more blood – thus more heat – reaches the skin, where the heat can be dissipated by the following four main mechanisms.

- Convection: This is heat loss that takes place when moving air picks up heat and carries it away. It is hindered by clothing; the more clothing a person wears the less effective convection has on heat removal.

- Radiation: This occurs when heat is emitted from the body into the atmosphere.



- Conduction: This is the transmission of heat from warmer to cooler objects that come into contact with the skin. In humans, it is not a major mechanism of heat loss unless clothing is removed and the individual lies on a cool surface or is immersed in cold water.
- Evaporation: This is the loss of heat at the surface or from the lungs through vaporization of liquid.

Convection, radiation and conduction require a thermal gradient between the body and surrounding atmosphere. In other words, skin temperature must be higher than that of the outside environment for these mechanisms to work. When the outside temperature approaches or exceeds the skin's temperature, radiation no longer effectively dissipates heat. In fact, heat is absorbed by the body via conduction and convection. In these circumstances, increased blood flow to the tissues is counterproductive since it promotes the rate of heat absorption.

At high temperatures, evaporation becomes the only effective method of heat dissipation. During exercise or vigorous activity in hot weather, the body can lose up to 1 liter an hour or more of sweat. Sweat contains fluid and electrolytes (sodium and chloride) that are needed by the body. High humidity, however, seriously impairs heat dissipation since evaporation occurs slowly as the air is already saturated with water.

Heat-related injuries fall into three major categories: heat cramps, heat exhaustion, and heat stroke. You must be especially aware of the potential for these injuries during heat emergencies, like those that struck Chicago and other parts of the Midwest and Northeast in the summer of 1995. Heat emergencies occur most frequently on the days when the temperature is 95 to 100 F, humidity is higher than 75 percent, and there is little or no breeze. It is also essential to note that most heat injuries occur early in the summer season, before people become acclimated to rising temperatures.

Who’s at risk for heat-related injuries? Athletes, outdoor laborers and those who work near furnaces or ovens are examples. People in poor physical shape, suffer from conditions like heart, kidney or cerebrovascular disease, thyroid gland disorders, malnutrition, obesity or diabetes, are another example. Those taking certain drugs and medications, ranging from alcohol, cocaine and diuretics to barbiturates, hallucinogens and medications that hamper sweating, are yet another group. Finally, the elderly and infants are highly susceptible to heat’s dangers.

The ability of the prehospital provider to properly assess and treat heat-related emergencies is essential to a patient's ultimate survival. The prehospital provider must be able to:

- Scan during a scene evaluation for evidence that a patient may be suffering from a heat-related emergency.
- Differentiate between various levels of heat emergencies.
- Assess the patient for characteristic signs and symptoms of various heat emergencies.
- Use appropriate out-of-hospital interventions for various heat emergencies.
- Recognize the presence of heat stroke and need for immediate transport to the proper medical facility.

- Undertake appropriate field interventions while initiating rapid transport.

Now, let’s go into detail discussing the various types of heat-related injuries and appropriate treatments.

Heat Cramps

Heat cramps are defined as cramps or pains in the muscles, especially of the abdomen and lower extremities. They occur when the body loses too much salt during profuse sweating or when inadequate salt is taken into the body, for example, when a person drinks large quantities of water. This results in an electrolyte imbalance called hyponatremia, which is a deficiency of sodium in the blood. Cramps usually occur in a young person unacclimated to heat who engages in exercise or heavy labor in hot climates and sweats profusely, though hot weather is not necessarily a prerequisite to heat cramps. Heat cramps usually come on suddenly, and can signal oncoming heat exhaustion.

Signs and symptoms of heat cramps include severe muscular cramps and incapacitating pain, especially of the leg, calf and abdomen. Faintness, dizziness, exhaustion, nausea, vomiting, and diaphoresis can also occur. In general, a patient experiencing heat cramps remains alert and oriented. To care for a patient with heat cramps, follow these steps:

- Provide for ambient cooling. Move the patient to a cool environment like an air-conditioned room or the rear of an air-conditioned ambulance. If a location like this is not immediately available, move the patient out of the sun and into the shade.
- Remove or loosen as much clothing as possible. Remember, heat dissipation is inhibited by clothing.
- Keep the patient at rest as activity acts only to increase body temperature and aggravate muscle cramping.
- If the patient is completely conscious and not nauseated, administer sips of cool water. Some protocols call for adding one-half teaspoon of salt to the water. You may also give the patient

balanced electrolyte solutions like Gatorade. Avoid liquids that are extremely cold, salty, or sweet, since they may cause nausea or vomiting.

- If the patient is too nauseated to take liquids by mouth, start an IV lifeline of normal saline and infuse it rapidly. This will often decrease pain; follow local protocols.
- Do not give the patient salt pills as they may cause or worsen nausea.
- Continue to reassess the patient's vital signs and response to treatment.

Heat Exhaustion

This condition results from a prolonged period of fluid loss via sweating, bout of diarrhea or use of diuretics plus exposure to a warm environment without adequate fluid and electrolyte replenishment. Additionally, prolonged sweating causes loss of water and salt, and this contributes to hypovolemia and electrolyte imbalances. This condition can be accompanied by a mild state of shock brought on by pooling of blood in the skin and lower extremities. As a result, blood flow is reduced to major organs. Heat exhaustion may be accompanied by heat cramps.

There is a high incidence of heat exhaustion among young children and individuals on water pills (diuretics). Debilitated individuals who are unable to maintain adequate water intake orally or are experiencing prolonged bouts of diarrhea also are susceptible. Signs and symptoms include headache, dizziness, weakness, faintness, brief loss of consciousness, dilated pupils, fatigue and difficulty walking. Other symptoms and signs include appetite loss, thirst, nausea, vomiting, rapid and shallow breathing, profuse sweating, skin that is pale, cool and ashen, normal or slightly elevated temperature, hypotension (especially with positional changes), and a weak rapid pulse. To care for a patient experiencing heat exhaustion, follow these steps:

- Remove the patient to a cool environment, like the patient module of an air-conditioned ambulance.
- Give high-concentration oxygen by face mask – 15 L/minute flow – to treat accompanying shock.
- Do not give anything by mouth.
- Loosen or remove clothing to facilitate cooling the patient by fanning. Do not chill the patient as shivering leads to significant heat production.
- Keep the patient at rest as activity only acts to increase body temperature.
- Start an IV lifeline of normal saline or lactated Ringer's solution and infuse rapidly if signs of shock are present. A macrodrip administration set should be employed. Reassess for signs of circulatory overload after every 300 cc
- Place the patient in a supine position with legs elevated.
- Continue to reassess the patient's vital signs and response to treatment.
- Monitor the patient's ECG. Follow appropriate protocols if any dysrhythmias are seen.
- Transport the patient to the hospital as soon as possible.

Heat Stroke

Heat stroke is the least common of all heat-related emergencies but the most deadly – with a mortality rate as high as 70 percent. Heat stroke is caused by a breakdown of the body's heat regulating system and failure to cool the body sufficiently. Unlike the heat exhaustion patient, the person with heat stroke sweats little or not at all. Overheating results when sweating ceases and heat then is retained. As heat accumulates, body temperature can reach a dangerously high level. Permanent

disability or death may result from brain damage if the patient is not cooled.

Two types of heat stroke exist: classic and exertional. Classic heat stroke strikes during periods of sustained high ambient temperatures and high humidity. The illness commonly affects the young, debilitated, older adults, those living in poorly ventilated housing without air conditioning and children left in cars with the windows shut. Many of these patients suffer from chronic diseases like diabetes, heart disease, alcoholism or schizophrenia. They take prescribed medications like diuretics, anti-hypertensives, tranquilizers and anticholinergics that further impair ability to tolerate heat. In these situations, high environmental temperatures initially trigger the usual heat removal mechanisms, and the patient sweats profusely. But eventually the patient becomes too dehydrated to sweat anymore. The core body temperature then begins to soar and heat stroke occurs.

In contrast, the patient with exertional heat stroke is usually young and healthy. Commonly afflicted groups are athletes, laborers and military recruits who work or exercise in hot and humid conditions. In these situations, heat accumulates since it cannot be dissipated into the environment. You'll recall that for radiation and convection to work, ambient temperature must be lower than body temperature. Likewise, for evaporation to work, humidity must not exceed 75 percent. If a person continues exercising in hot temperatures with corresponding high humidity, he/she will continue generating heat – without any means of dispelling it. Heat will build up within the body and body temperatures will soar. Unlike patients experiencing classic heat stroke, those experiencing exertional heat stroke often sweat heavily. An additional concern is that patients with this type of heat stroke may also suffer from severe metabolic acidosis caused by lactic acid accumulation. Hyperkalemia may also develop because of potassium release from injured cells, renal failure or metabolic acidosis.

Some heat stroke patients may experience one or two days of lethargy, fatigue, weakness, nausea, vomiting and dizziness prior to developing

full-blown heat stroke. Other cases develop rapidly. These victims become so confused or irrational, losing consciousness within a few minutes.

Signs and symptoms of heat stroke include confusion, headache, dizziness, weakness, muscular twitching and an altered level of consciousness. Other symptoms and signs include convulsions, collapse and possible coma, pupils initially constrict then dilate, nausea and vomiting, dry mouth, and deep, rapid snoring respirations that become weak and shallow. Shortness of breath, hot, dry and red skin, body temperature equal to or greater than 105 F, rapid, bounding pulse greater than 160 that can become weak and bradycardic, and hypotension are also characteristic. Heat stroke should be suspected in any individual who becomes unconscious in a hot environment. Breath sounds should be auscultated; the presence of rales and rhonchi are indicative of accompanying heart failure.

When treating a heat stroke patient, timely reduction of body temperature is essential. If the patient’s body temperature is not quickly lowered, brain damage may result. The longer the delay, the more permanent the damage. Left untreated, a heat stroke patient will die. To care for a patient experiencing heat stroke, follow these steps:

- Move the patient to a cool environment, like the patient module of an air conditioned ambulance.
- Remove the patient's clothing.
- Keep the patient at rest.
- Cool the patient immediately by wetting down the individual, fanning briskly and applying ice packs to the neck, axillary (armpits), wrists and groin. If an air conditioner is available, it should be run at its highest level. Do not let the patient become chilled, however, as shivering raises body temperature.

- If the patient is breathing adequately, administer 100 percent high-flow oxygen – 10 to 15 liters by non-rebreather mask – if the patient can tolerate the mask.
- If respiratory depression or inadequacy is present, assist the patient's breathing with a bag-valve-mask device supplied with 15 liters of 100 percent oxygen, or use a demand-valve resuscitator. Insert an oropharyngeal or nasopharyngeal airway or implement an advanced airway procedure if there is a need to keep the airway open and prevent aspiration of vomitus.
- Continue to reassess the patient's vital signs and response to treatment.
- Start an IV lifeline of normal saline or lactated Ringer's solution and infuse rapidly if signs of shock are present. Reassess for signs of circulatory overload after every 300 cc.
- Monitor the patient's ECG. Follow appropriate protocols if dysrhythmias are seen. S-T segment depression, non-specific T-wave changes with occasional PVCs and supraventricular tachycardia are common.
- Diazepam may be used to sedate the patient or manage seizures.
- Transport the patient to a hospital as soon as possible.

When to Transport

If there is any question about the patient's condition, the patient should be transported to the emergency department. Failure to arrest the process during heat exhaustion could lead to the more deadly condition of heatstroke.

When to Call for ALS Assistance

Activate ALS intercept, if deemed necessary and if available on any patient that you suspect to be suffering from heat exhaustion, heat stroke or patients with heat cramps that are showing signs and symptoms of faintness, dizziness, nausea or vomiting. Signs and symptoms that could

indicate your patient could soon decompensate are hypotension, tachypnea, agitation, and altered mental status.

Case Study

I had been a runner for about 7 years but hadn't tried any distance above about 15 kilometers. In January 2001, a friend and I decided we would give the July marathon a shot. We were running everyday and were confident that with some extra work we could make the 21 kilometers. Unfortunately my friend caught a bad cold a couple of days before race day and his doctor advised him against running. This was a bit of a blow as you fellow runners would know, there are times when you rely on your friends to keep going. Anyhow I kept training and felt fairly confident. The early start meant I didn't bother with breakfast or even a drink (this came back to haunt me). Well, the race started and the first few kilometers seemed to fly. I had teamed up with a runner from Dallas who was running his sixth marathon for the year! I was well ahead of schedule. That should have been my first warning sign. I had gone out too fast, I was still on the adrenaline rush and was running faster that my training pace. I also ignored a couple of drinks stations - completely stupid.

I had read in all the books about the importance of drinking but on the day I didn't want to break my rhythm. Anyway I was going OK until we turned down Travis Street and hit the headwind. I started to struggle a bit. By the time I got to the linear track my friend from Dallas had left me and I was tiring. The closer I got to the end, the more determined I became. Somewhere near the capital it happened - I passed out. I woke up in the back of an organizer's car with a couple people peering in the window at me. I remember saying that I felt better now and could I

please continue! They said I was out of consciousness for about 10 minutes, apart from being incredibly thirsty I had a massive pain in my right thigh - I just couldn't move it, bend it or bear anyone touching it - it also appeared swollen. This is where I first met Doctor Wallace - one of the doctors on call at the finish. Well they decided to get an ambulance and take me to the ER. I was very dehydrated, tired, and thirsty and my leg was in agony. Initially the thinking was that I broke it when I collapsed but X-rays at the hospital didn't show anything.

By this stage I had been given some painkillers and I was quite groggy. They decided I would be admitted for the night. About mid -afternoon I had my first 'wee' since the race. It was as black as Coca-Cola and this is when everybody seemed to panic. Within a few minutes I was put on a drip (on the highest setting) and told to drink, drink, drink. It appears I had suffered rhabdomolysis or as it is more commonly know 'Muscle Meltdown'. It was caused by dehydration and my body basically overheated. Dr. Wallace said it was the same as people who take ecstasy pills and the body starts to melt down as it overheats. In severe cases death can occur but the worry to me apparently was kidney failure. Apparently, we have these things in our urine called creatinine. I had 81,000 and the norm is about 200! At 120,000 you risk kidney failure. Anyhow I stayed on the drip day and night for 5 days plus I had to drink 3 liters of water per day. Boy did I learn how to wee in a bottle!! Gradually with physical therapy my thigh started to recover. I had X-rays, ultrasounds, massages etc. etc. - what a nightmare - all because I didn't drink enough and went out too fast.

On my release from hospital (complete with walking stick) Dr. Wallace said no physical activity for 6 weeks. That seemed an eternity and my first few jogs were quite tentative. Although I have recovered fully it is now a mental thing as I worry when I'm running if it could happen again. I don't know if I will ever finish a marathon now - and boy I admire those who can run them. I am running again but so far I have restricted myself to 10/12 kilometers.

Summary

Heat-related injuries fall into three major categories: heat cramps, heat exhaustion and heat stroke. The ability of the prehospital care provider to properly assess and treat heat-related emergencies is essential for a patient's ultimate survival. Treatment of heat cramps is usually limited to ambient cooling and giving sips of cool water or balanced electrolyte solutions. Treatment of heat exhaustion is usually more aggressive, as the patient may be in shock secondary to excessive sweating and peripheral pooling of blood. Moving the patient to a cool environment, administering oxygen, loosening or removing clothing, placing an IV lifeline, positioning the patient supine with legs elevated, and timely transport to a hospital are all indicated.

Heat stroke is the most serious heat-related injury. Quick action is necessary to prevent permanent brain damage or death. Treatment includes moving the patient to a cool environment, cooling the patient by wetting down, fanning briskly and applying ice packs, and administering oxygen. Other steps include placing an IV lifeline, monitoring the ECG rhythm, treating seizures and transporting the patient to the hospital quickly.

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