

# Seattle-King County EMS

Seattle-King County Emergency Medical Services Division Public Health - Seattle/King County 401 5th Avenue, Suite 1200 Seattle, WA 98104 (206) 296-4863

January 2008

# CBT/OTEP 385 Environmental Emergencies

Print version of EMS Online Course www.emsonline.net

©2008 Seattle-King County EMS

# Introduction

Heat and cold illnesses are triggered when the body is unable to maintain a constant temperature.

A fundamental knowledge of heat mechanisms and factors that affect the body's ability to maintain a constant temperature will improve your skill at assessing and treating environmental emergencies. In addition to heat and cold-related illnesses, this course addresses diving emergencies, stings and bites, and gas poisoning.

# Before You Begin

This is a continuing education and recertification course for EMTs. It covers fundamental EMT-Basic concepts and terminology as well as advanced material. We highly recommend completing the practice exam before completing the exam.

We also recommend that you review EMT textbook chapters covering this topic as a refresher before taking the exam, for example: Chapter 16 - Allergic Reactions and Chapter 18 - Environmental Emergencies in Emergency Care and Transportation of the Sick and Injured, 9th edition (AAOS).

# Practical Skills

To receive CBT or OTEP credit for this course a trained skills evaluator must evaluate your ability to perform the following hands-on practical skills including:

- Patient assessment
- Emergency care for heat-related emergencies
- Emergency care for cold-related emergencies

#### Objectives

CBT 385 is an EMT continuing education and recertification course. After completing this course you will be able to:

- 1. Identify the ways the body produces and loses heat.
- 2. Identify examples of conduction, convection, radiation and evaporation.
- 3. Identify factors that affect heat production and heat loss.
- 4. Identify signs and symptoms of heat-related emergencies.
- 5. Identify signs and symptoms of cold-related emergencies.
- 6. Identify emergency care for heat- and cold-related emergencies and drowning.
- 7. Identify the two primary components of anaphylaxis and emergency care for the condition.

# Terms

Terms You Should Know

core temperature — The operating temperature of an organism. Also, the temperature of the body's internal structures.

diuretic — A drug such as Lasix (furosemide) and HCTZ (hyrdrochlorothiazide) used in treating congestive heart failure and other ailments. They can cause dehydration making a person more susceptible to heat stress.

evaporation — The conversion of a liquid to a gas.

LOC — Abbreviation for level of consciousness.

metabolism — The human body produces heat by converting food to energy. All bodily functions such as digestion, muscle contractions, and breathing require energy. Heat is a by-product of these processes. The body's temperature-control mechanism, located in the hypothalamus region below the brainstem, maintains a core temperature of about 98°F (37°C). There is a balance between production and loss.

tachypnea — A rapid respiratory rate.

#### New Terms

conduction — Conduction is a transfer process by which heat moves between two touching objects from the warmer object to the colder object. It is the motion of molecules bumping into one another, like billiard balls, that spreads heat.

convection — Convection is the transfer of heat due to movement of a gas or liquid in response to a temperature or pressure differential. It occurs when a moving gas (e.g., air) or liquid carries heat from a warmer body to a cooler body. It can also work in reverse, carrying heat from a warmer environment to a cooler one. Rising warm air from the earth's surface is an example of convection.

radiation — Radiation occurs when a warm body releases energy without direct contact with another body. Not only can heat energy travel by bumping molecules (as in conduction), it can also travel through electromagnetic waves. .

# Heat Production

The human body tries to maintain a constant temperature by releasing and producing heat. There are four ways in which the body can produce heat:

- Metabolism
- Shivering
- Exercise
- External heat sources

The body produces heat through the conversion of food to energy and through the activity of bodily functions (such as circulation, respiration, and muscle tone). This process is called metabolism. It is all the chemical processes that happen in a living cell or organism that are necessary for maintaining life. Some substances are broken down to create energy while other substances are synthesized into tissue-building material.

Rapid contraction and expansion of muscle tissues is another method that the body uses to produce heat. Shivering can produce 40 times more heat than baseline metabolism.

The body can also produce heat through exercise. This happens as long as there is activity, fuel (for instance, glucose or fat), oxygen, and water.

External heat sources come from the environment, such as the sun, fire, and chemical sources.

# **Factors That Affect Heat Production**

While there are four ways to produce heat, there are many factors that affect how well the body can produce heat. They include:

- Core temperature
- Medical conditions
- Body fluid status
- Drugs and chemicals

#### Heat Loss

There is constant "tug of war" in the body between heat production and heat loss. The four heat loss mechanisms are:

- Conduction
- Convection
- Radiation
- Evaporation

Under normal conditions, heat loss mechanisms are balanced with heat production mechanisms.

Conduction is the transfer of heat energy through physical contact. When two objects are touching, heat moves from the warmer object to the colder object. An example of conduction is when you touch the handle of a hot frying pan.

Heat energy is transferred between a body and the air or water that surrounds it via conduction. As the air warms it rises and cooler air replaces it. The body then warms the cool air. This cycle of heat loss is called convection. An example is when you blow on your food to cool it.

Radiation occurs when a warm body releases energy through electromagnetic waves. The heat of the sun is an example of radiation. There is no direct contact between you and the sun but you receive the sun's warmth. Human bodies also radiate heat to the environment. Over half of a body's heat loss is due to radiation.

Evaporation is the conversion of a liquid to a vapor. If you heat a pan of water, the energy applied to the water will cause it to evaporate. This process absorbs a lot of heat because it takes a lot of energy to break water molecules apart and convert the liquid to vapor. The process of sweating is an example.

# Conduction

Conduction is a transfer process by which heat moves between two touching objects from the warmer object to the colder object. It is the motion of molecules bumping into one another that spreads heat. The molecules bump around like balls on a billiards table.

An example of conduction is lying on a cold concrete floor. The heat energy produced by your body transfers to the floor. The concrete conducts heat from your body.

Conduction accounts for only a small percentage of heat loss under normal conditions. It is a major source of heat loss in the case of cold-water immersion because water conducts heat 25 times more quickly than air.

# Convection

As air warms, it rises and cooler air replaces it. So too, the cool air then is warmed. This cycle of heat loss is called convection. An example is when you blow on your food to cool it.

Convection is the transfer of heat between a body and the air or water that surrounds it. It occurs when a gas or liquid carries heat away. A body's heat energy is lost more rapidly in moving air or water. Rising warm air from the earth's surface is an example of convection.

Conduction and convection provide the major route of heat loss in cold-water immersion and strong wind.

Elaboration – Example of Convection

Another example of convection occurs on a cold, windy day. Your body warms the layer of air surrounding it (by conduction). This warm, less-dense layer of air is rapidly

removed by the wind. The body must produce more heat to warm the surrounding air. This process is commonly referred to as the "wind chill effect." The same principle applies in moving water.

# Radiation

Radiation occurs when a warm body releases energy without direct contact. Not only can heat energy travel by bumping molecules (as in conduction), it can also travel through electromagnetic waves. The sun is the best known example of heat transfer through radiation.

Be aware of the intense heat energy radiated by the sun when you are assessing a heat illness patient. In a dry, comfortable environment, most heat is lost from the body through radiation (50% - 60%) compared to other mechanisms

# **Evaporation**

Evaporation is the conversion of a liquid to a gas. If you heat a pan of water, the energy applied to the water will cause it to evaporate. This process requires a lot of heat because it takes a lot of energy to break water molecules apart and convert the liquid to a gas.

The human body takes advantage of evaporation's heat loss powers by sweating. This process releases excess heat. Since it requires a lot of energy to convert water to water vapor, evaporation rapidly releases heat from the body. Skin moisture, relative humidity and wind speed are important variables in evaporation.

# **Heat Cramps**

Heat cramps, heat exhaustion, and heatstroke are progressive phases of the same disorder—called heat illness. Any medical condition that increases heat production or inhibits heat loss can lead to heat illness.

Heat cramps or muscle cramps result from an uneven distribution of body fluids and salts. Muscle cramps from this condition can be mild to severe, involving the extremities or the abdomen. Cramps can be accompanied by dizziness, weakness, and nausea.

# **Heat Exhaustion**

Heat exhaustion is named for the feeling of exhaustion that people experience with this condition. It is the result of excessive heat and dehydration that reduce circulating blood volume and increase peripheral pooling due to vasodilation. The cooling mechanisms of radiation and evaporation become inefficient due to loss of fluids. The clinical findings associated with heat exhaustion include:

- Dizziness, weakness and nausea
- Rapid, weak pulse
- Cool, clammy skin
- Profuse sweating
- Altered LOC

# Heatstroke

Heatstroke is a life-threatening emergency that occurs when the body's heat-regulating ability fails. This can happen when the body is subjected to more heat than it can deal with and the four heat loss mechanisms are overwhelmed.

The early stages of heatstroke can look similar to heat exhaustion. In later stages you may see signs of central nervous system depression (such as a decreased LOC) and hot, dry skin.

Clinical findings of heatstroke include:

- Altered LOC (including confusion, disorientation or unconsciousness)
- Rapid, bounding pulse
- Rapid, deep respirations
- Hot, dry, flushed skin\*
- Dilated pupils
- Seizures

\*Can be damp if rapid onset.

Elaboration – Phenothiazines and Body Temperature

Phenothiazines are a class of drugs used to treat nervous, mental, and emotional disorders. In overdose situations, they can greatly increase body temperature. Examples of phenothiazines are: Haldol (haloperidol) Mellaril (thioridazine), Stelazine (trifluoperazine), and Thorazine (chloropromazine).

# **Emergency Care for Heat-Related Emergencies**

You should manage heat-related emergencies in the field by reducing core temperature. The preferred methods of cooling are as follows:

- Provide a cool environment
- Apply cold packs
- Remove or loosen clothing

In addition to cooling, care for a heat-related illness requires standard BLS measures such as: request paramedics when ALS indicators are present, provide oxygen and/or ventilatory assistance, position patient appropriately and monitor vital signs. If the patient is responsive and not nauseated, consider giving water.

#### Elaboration – Cooling Strategies

#### Provide a Cool Environment

As soon as time allows, move the patient to the back of your air-conditioned aid car with the air conditioner running on maximum. Fan the patient aggressively if staffing allows. Keep the skin wet by applying cool water with a sponge or wet towel.

#### Apply Cold Packs

Apply cold packs to the neck, groin, and armpits. Remember that hospitals generally have the tools necessary to properly lower core temperature so do not delay transport. Notify the hospital early to allow ED staff time to prepare.

#### **Remove Clothing**

Loosen or remove clothing to promote efficient convection. Consider applying water with a sponge or wet towels on the patient's skin. If you apply water to the skin to encourage evaporation, use room temperature water so that you do not induce shivering.

# Hypothermia

Hypothermia is cooling of the core temperature below 98.6°F. It is caused by either loss of body heat or decreased heat production. You will find hypothermia when there is exposure to a cool environment, for example, an immobile, elderly person lying on a floor or a drowning victim who has been submerged.

You should try to distinguish between mild and severe hypothermia. The key is to watch for an altered LOC in someone who has been exposed to a cool environment. Early recognition of hypothermia increases the chances of survival.

Elaboration – Stages of Hypothermia

Mild Hypothermia (90 – 95°F)

In someone with mild hypothermia the skin becomes numb, pale, and waxy in appearance. Muscles become tense and shivering generally is present. Fatigue and signs of weakness begin to show. The person will remain awake, however coordination becomes poor.

Moderate Hypothermia (80 – 90°F)

At 85 - 90°F, shivering stops and confusion and lethargy set in. Speech is impaired and breathing becomes slow and shallow. The victim experiences drowsiness and impaired judgment. You can see weakness, slurred speech, and exhaustion. The victim also can appear drunk, rigid or stiff.

Severe Hypothermia (less than 80°F)

The core temperature is now 80°F and the vital signs become slow. There is a gradual loss of consciousness. As the temperature gets lower there may be little or no apparent breathing and the person can appear dead.

# Frostbite

Frostbite injuries are classified as either superficial or deep depending on the extent of tissue death found after re-warming. There is little apparent difference on initial exam. All frostbite initially appears very pale and involves some numbness. Pain and tingling are common.

Superficial Injury - Clinical Findings

- Blanching of skin
- Loss of feeling and sensation in injured area
- Tingling sensation if re-warmed

Deep Injury - Clinical Findings

- White, waxy skin
- Swelling and/or blisters
- Skin can appear flushed with areas of purple and blanching or mottled and cyanotic

# **Emergency Care for Cold-Related Emergencies**

Prehospital emergency care for a hypothermic patient is as follows:

- Remove patient from cold environment
- Protect from heat loss
- Provide high flow oxygen

Emergency care for frostbite includes the following:

- Protect affected area from further injury
- Remove constricting or wet clothing and jewelry
- Cover with a dry bulky dressing
- Splint the affected extremity, prevent use of extremity

Elaboration - Emergency Care for Hypothermia

Remove from Cold/Protect from Heat Loss

Move the patient to an aid car warmed to 80°F. Keep the patient flat and remove wet clothing. You also may need to protect from heat loss by insulating the patient with blankets.

Provide High Flow Oxygen

Provide high flow oxygen via pocket facemask or BVM for a non-breathing patient. We recommend the use of a pocket facemask when ventilating a non-breathing hypothermic patient. This helps warm the patient more effectively.

Oxygen administered through a BVM is of ambient air temperature and low humidity. It causes increased heat loss (through evaporation) when compared to warm, moist oxygen/air via a pocket facemask. However, you can use a BVM if necessary.

#### Elaboration – Transport Times Over Two Hours

Do not re-warm frozen tissue unless transport time will exceed 2 hours and you are certain that the thawed tissue will not refreeze. Obtain medical direction prior to initiating re-warming. Re-warming should be done with 100 – 105°F water. Do not use dry heat—it heats unevenly and can burn frozen tissue. Stop re-warming when the tissue turns red-purple and becomes pliable.

# **Drowning and Near Drowning**

Drowning is death caused by hypoxia following submersion in water. Near drowning is submersion in water that does not result in death.

One of two things can happen when a person drowns. First, the water can stimulate spasms in the larynx and bronchi. This prevents water from entering the lungs. Second, the victim can aspirate water into the lungs. In either case, without oxygen, hypotension, bradycardia, and cardiac arrest ensue.

There are several things you should determine:

- Length of submersion
- Temperature of water
- Depth of water

#### Elaboration – Length of Submersion

Include the length of submersion in your report to the hospital staff. You may have to estimate this based on bystander testimony and other indicators.

In situations where the submersion is of short duration (2 minutes or less), a short period of CPR likely will result in successful resuscitation. Be aware that a significant number of near-drowning patients who look fine initially develop pulmonary edema several hours later. This non-cardiac related condition is called acute respiratory distress syndrome (ARDS).

#### Elaboration – Water Temperature

The temperature of the water is an important factor in how long someone can survive without oxygen. Cold water drowning victims (less than 70°F) can survive for up to 1 hour without oxygen. The record for a successful resuscitation was for a 3-year-old child who was immersed for 66 minutes in 33°F water. Children often survive longer because they cool faster than adults. Some studies indicate that temperatures need to be below 50°F for any significant chances of survival to occur after long immersion.

Submersion times of greater than 10 minutes make successful resuscitation unlikely in most warm water drowning situations. Survival from long submersion times is more likely when the brain cools fast enough to receive protection from hypoxia. People who cool before they drown (e.g., hanging onto the ice or an overturned boat) may have a better neurological outcome.

In general, the colder the water, the greater the chances of survival for drowning victims. Regardless of submersion time, remember that the hypothermic victims are not considered dead until they are warm and dead.

Elaboration – Depth of Water

Spinal injuries are seen in many water-related accidents. Diving into shallow water is a common mechanism for head and spinal injury and subsequent drowning. If there is a potential for a spinal injury, stabilize the cervical spine while in the water, if possible.

Other conditions associated with drowning include skeletal and soft tissue injuries, drug or alcohol intoxication, and underlying medical conditions.

# **Emergency Care for Drowning/Near Drowning**

Management of drowning and near drowning requires prompt basic life support and the following measures:

- Safely remove victim from the water
- Stabilize c-spine and place patient on a backboard\*\*
- Follow resuscitation protocols for cardiac or pulmonary arrest
- Administer oxygen and/or ventilatory assistance
- Place in a supine position to avoid cerebral edema
- Prepare suction and expect vomiting
- Warm up the aid unit
- Monitor vital signs

\*\*If spine injury is suspected or patient is unresponsive. If possible, initiate stabilization during removal from water.

# Air Embolism

Most SCUBA dives occur without incident, but the use of compressed air or other gases in an underwater environment can be hazardous. In addition to drowning, common diving-related hazards include air embolism and decompression illness.

An air embolism is the presence of gas bubbles in the bloodstream that obstruct circulation. It occurs during ascent when pressure in the lungs forces air bubbles into the bloodstream.

Elaboration – Air Embolism

An air embolism is the presence of gas bubbles in the bloodstream that obstruct circulation.

Air embolism typically occurs in ascending divers. If a diver does not fully exhale during ascent, the air in the lungs expands as the pressure decreases. This overinflates the lungs and forces air bubbles into the bloodstream. Blockage of the arteries to the brain then occurs.

An air embolism is frequently caused when a diver holds his or her breath during ascent. The signs include:

- Dyspnea
- Unconsciousness
- Paralysis
- Mottling of the skin
- Severe pain in muscles, joints or abdomen
- Irregular pulse
- Red, frothy sputum

#### **Decompression Illness**

Decompression illness occurs when nitrogen in the blood forms bubbles due to a rapid ascent. The bubbles collect in the tissues and interfere with blood flow.

Significant history for all diving emergencies includes:

- Number of dives in past 24 hours
- Depth of dive
- Length of time underwater
- Problems encountered while diving
- Significant medical history (including meds)

Elaboration – Decompression Illness

Decompression illness, also called "the bends" or DCI, occurs when nitrogen that is dissolved in the blood forms bubbles that interfere with blood flow.

In order for DCI to occur, the dive must have occurred at a depth of at least 33 feet. The longer and deeper the dive, the more nitrogen dissolves in the blood. Dehydration, exertion and air travel within 12 hours after diving all increase the probability of DCI.

Symptoms of DCI vary widely depending on where the bubbles collect. Joint pain, abdominal pain and neurological symptoms are common. A diver who complains of feeling ill after diving should be evaluated for DCI. Symptoms can appear within a few minutes of surfacing or it may take hours.

#### **Stings and Bites**

Some insects and spiders inject a poison when they bite or sting. The severity of the reaction depends on the type of animal and the age, size, and health of the victim. In the United States, there are two types of spiders that can deliver life-threatening bites: the brown recluse and the female black widow.

Many marine animals, such as sharks or urchins, have spines that contain proteins that can cause a local reaction and occasionally, an anaphylactic reaction. Some tropical species found in aquariums (e.g., the Lionfish) can cause envenomation.

A significant history should include:

- Type of animal or insect
- Behavior of the animal
- Time of day the bite occurred
- Location of the animal

Elaboration – Man's Best Friend?

An estimated 5 million animal bites occur annually in the US. These typically result in lacerations and punctures and carry a risk of infection. Dog bites account for most bite injuries (over 300,000 per year). Wound infection from bacteria is the most common cause of morbidity. Each year up to 50,000 people are bitten by poisonous snakes in the US, however, only about 20 deaths occur.

# **Allergic Reactions**

An allergy is the body's exaggerated response to a foreign material, called an allergen. The term anaphylaxis or anaphylactic shock refers to a severe, often life-threatening allergic reaction. There are two primary components of anaphylaxis:

- Severe respiratory distress
- Hypotension

Elaboration – Severe Respiratory Distress and Hypotension

Signs of severe respiratory distress include shortness of breath, dyspnea, stridor, wheezing, cyanosis, and a decreased level of consciousness due to hypoxia and hypotension.

In anaphylaxis, hypotension is caused by dilation and leaking of the blood vessels and the problem is compounded by hypoxia.

Elaboration – Differentiating Allergic Reaction and Anaphylaxis

You must differentiate between a minor or moderate allergic reaction and true anaphylaxis. Anaphylaxis is a severe reaction that often affects several body systems. There are two primary components to life-threatening anaphylaxis: severe respiratory distress and hypotension.

Allergic reactions can be localized, such as a raised area on the skin from a sting or bite, or they can become systemic and affect the respiratory and circulatory systems.

Both allergic reaction and anaphylaxis can present with hives, swelling of the skin, abdominal cramps, vomiting, and diarrhea.

# **Gas Poisoning**

Most gas poisonings deaths are the result of exposure to carbon monoxide, a colorless and odorless gas that blocks the body's ability to deliver oxygen to the tissues. Exposure to cleaning products, industrial chemicals and gases also contribute to many injuries and deaths.

Signs and symptoms of carbon monoxide poisoning include:

- Headache
- Tachypnea
- Nausea and vomiting
- Altered LOC
- Pink, flushed mucus membranes
- Coma

Note that pulse oximetry readings can be unreliable in a gas poisoning situation.

# **Emergency Care**

Stings and Bites

It is important to distinguish between a normal reaction to a bite or sting and a severe allergic reaction. A normal reaction may include bleeding, swelling, and/or pain. A severe allergic reaction can progress to life-threatening anaphylaxis.

The most important thing you can do in the case of a sting or bite is to treat any respiratory difficulties by maintaining the ABCs and administering oxygen as needed. Other care measures include:

- Request paramedics if indicated
- Scrape the sting site to remove the stinger
- Wash area
- Remove jewelry from affected limb before swelling begins, if possible
- Bandage and immobilize site of injury
- Treat for shock
- Administer epinephrine via EpiPen if indicated

#### Anaphylaxis

After you have determined that a patient is indeed in severe respiratory distress and hypovolemic, emergency care for anaphylaxis includes the following:

- Request paramedics
- Provide oxygen and/or ventilatory assistance
- Position patient appropriately
- Administer epinephrine via EpiPen
- Monitor vital signs

#### Gas Poisoning

Emergency care for inhaled poisons includes the following:

- Scene safety
- Remove patient from toxic environment
- ABCs
- Monitor airway and provide high flow oxygen
- Request paramedics if necessary
- Contact poison control if needed

#### Summary

The four mechanisms that cause heat loss are conduction, convection, radiation, and evaporation.

Heat cramps, heat exhaustion and heatstroke are progressive phases of heat illness that should be managed in the field by reducing core temperature.

The key to distinguishing between mild and severe hypothermia is an altered LOC.

Steps for prehospital emergency care for a hypothermic patient include remove patient from the cold environment, protect the patient from heat loss, and provide high flow oxygen.

Management of drowning and near drowning includes:

- Safely remove victim from the water
- Stabilize c-spine and place patient on a backboard
- Follow resuscitation protocols for cardiac or pulmonary arrest
- Administer oxygen and/or ventilatory assistance
- Position patient in a supine position to avoid cerebral edema
- Prepare suction and expect vomiting
- Warm the aid unit
- Monitor vital signs

The two primary components of anaphylaxis are severe respiratory distress and hypotension.

Emergency care for anaphylaxis includes:

- Request paramedics
- Provide oxygen and/or ventilatory assistance
- Position patient appropriately
- Administer epinephrine via EpiPen
- Monitor vital signs