Wilderness EMS Institute

Appalachian Search and Rescue Conference
Center for Emergency Medicine of Western Pennsylvania

Wilderness EMT Lesson Plan

Part VI: Thermal Regulation

Draft Version 1.32 September 4, 1992 (reprinted August 1994)
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Verbose Outlines

We develop our WEMT Lesson Plans in a **verbose outline format** (what you see here). Why? Because the material is new to enough reviewers that the usual terse ("telegraphic") lesson plan format might be incomprehensible or misleading.

Our Task Groups use these "verbose" outlines. Each part of the WEMT curriculum (about twenty in all) has a Task Group of five to twenty selected consultants. A Coordinator guides the Task Group in revising the section.

Each Task Group provides references to support its statements and for further reading. They also provide glossary entries for any new terms they introduce. (New, that is, to a reader with basic EMT and SAR training.)

Background material that should appear in the Textbook (see below), but instructors need not present in class, will appear *in a small, italic font.*

Splitting the Outlines

When the outline satisfies the Task Group, it goes to our **Editorial Board**. This Board includes officers of the Appalachian Search and Rescue Conference and Center for Emergency Medicine of Western Pennsylvania, our two sponsors. It also includes experts in emergency medicine, search and rescue, and education. The Editorial Board reviews the verbose outline, and requests any necessary revisions. Once it is acceptable to the Board, we reformat the outline, into two distinct new versions.

We rewrite the material in the standard lesson plan format, which becomes a terse "telegraphic" outline. This version will be briefly reviewed by the Project Coordinator and then released to the public. It is the result of extensive review and testing, and will be used in all our classes. But, we still publish it as a draft, because we expect many good suggestions from the public. We distribute these drafts as widely as possible. After each year of public review, the Task Groups reviews comments, and submits revisions to the Editorial Board. Once all outlines have withstood a year of public scrutiny, we will prepare a single comprehensive curriculum with a Course Guide. We will continue to review and revise the curriculum regularly.

On to a Textbook

As explained above, once the Editorial Board approves the verbose outline, we split it into two versions. Besides the terse teaching outline, it will also become the basis for a textbook chapter. The Project Coordinator is the textbook Editor-in-Chief, and works closely with the Task Groups to consolidate and revise the verbose outlines into a comprehensive textbook. All who have contributed to the curriculum will be acknowledged as contributors. The textbook will be commercially published when completed. Until the textbook is available, we will distribute the verbose outlines or drafts of the textbook at classes.

Notes: *Thermal Regulation*

This part of the curriculum provides an overview of the physiology of human heat regulation, a necessary prelude to the sections on cold and heat injuries. Students should have had some exposure to this material in their search and rescue and EMT training. However, a deeper understanding is important to allow the students to master the more complex and controversial topics in heat and cold illness.

We have omitted details of environmental stresses, including windchill and wetchill. These are covered in the Wilderness Environment section. We have also omitted any discussion of clothing materials or cold/wet survival techniques. These are covered in search and rescue training.

The unanimous opinion of students at our pilot classes was that material on the modes of heat loss should appear in the Lesson Plan, but need not be covered in class. This material, they said, should have been adequately covered in the search and rescue prerequisite, and to a lesser extent in basic EMT training. It should only be covered (in an extra remedial session) if the students' preparation was inadequate. The educational objective regarding modes of heat loss will remain as part of the Lesson Plan. Instructors will need to make a quick assessment that students have an adequate grasp of these concepts.

VI. Thermal Regulation

A. Educational Objectives

1. Describe normal human temperature homeostasis (balance), including
   a. the role of the hypothalamus,
   b. defining "fever,"
   c. defining basal metabolic rate, and
   d. describing the relationship of body core and periphery to heat balance and core temperature.
2. Describe how the human body senses temperature stresses, including
   a. the roles and relative balance of peripheral and central receptors,
   b. the suggested role of central vs. peripheral clothing, and
   c. arguments for and against giving hot drinks to a mildly hypothermic person.
3. Give wilderness rescue-related examples of the following physical modes of heat loss, the approximate amount of heat loss possible through each mode, and methods to counter such heat loss in a wilderness patient:
   a. conduction,
   b. convection,
   c. radiation,
   d. evaporation, and
   e. respiration, including the relative effect of air humidification.
4. Explain the concept of the body as a heat reservoir, and relate daily food intake to the amount of heat that can be lost from the body before hypothermia sets in.
5. Describe how blood circulation is related to heat loss control; specifically,
   a. local versus central control of blood vessel size,
   b. shifts between deep and superficial veins and the end results of artery-vein countercurrent heat exchange,
   c. areas where the deep vein circulation is close to the surface, and
   d. consequences of vasoconstriction and vasodilation, including cold diuresis.
6. Explain the role of sweating in temperature balance, including
   a. the major constituents of sweat and seasonal variation, and
   b. the consequences of prolonged sweating.
7. Explain the role of shivering in temperature balance, including
   a. consequences of prolonged shivering, including exhaustion and fatigue,
   b. the nature of body energy reserves, including glycogen, fat, and protein,
   c. the appropriateness of giving sugar to hypothermic patients, and
   d. the nature of fatigue.
8. Identify the effects of the following on normal temperature homeostasis:
   a. tobacco,
   b. alcohol, and
   c. aspirin, acetaminophen, and ibuprofen.

B. Temperature balance

1. **Temperature balance** (temperature **homeostasis**) is an essential concept for the WEMT. Homeostasis refers to a system that uses **feedback** controls to maintain a constant state. For example, a house thermostat uses a thermometer to feed back information to the central heat or air conditioning systems to keep the house temperature within a set range. As with a thermostatically-controlled house, the human "thermostat"

acts to keep the core temperature within an acceptable range.

2. Your "thermostat" is in your **hypothalamus** (a part of the lower anterior brain). A part of your hypothalamus controls heat loss and heat production, thus keeping your body core at a constant temperature. Your hypothalamus is normally "set" at 99°F (37°C).

3. Turning up a house thermostat causes the furnace to come on. Similarly, turning up the set-point of your hypothalamus results in shaking chills. For example, byproducts of an infection may reset your hypothalamus to a higher temperature. Once your core temperature stabilizes at a higher level, your chills (which are, after all, just shivering) subside. The end result is that you have a stable but higher core temperature (a **fever**).

4. Your body always produces heat, as an inescapable byproduct of metabolism (even while at rest). If no heat were lost, your body would get hotter and hotter until it "melted down." To keep your body's temperature from rising continuously, you must continuously lose heat.

   a. For an analogy, let's use water instead of heat. Imagine a sink with an open faucet above it. In this analogy, the level of water in the sink is the equivalent of your core temperature, the water produced by the faucet is your heat production, and the sink's drain is your heat loss. (See Figure 1.) Water pours from the faucet into the sink at a varying rate, and a valve on the drain controls rate at which water drains out of the sink. To make the analogy proper, the faucet is leaky: we may turn it down, but never shut it off completely. Why? Because your body is always producing heat. This is your **basal metabolic rate.**

   b. Your basal metabolic rate is about We humans are **homeotherms**. *Unlike poikilotherms such as reptiles, our metabolism works properly only within a narrow range of core temperatures. Why? Because the chemical reactions that form our metabolism have, over the millennia, become specialized to work properly only within that range. Does this make us inferior to the reptiles? No. The evidence of*

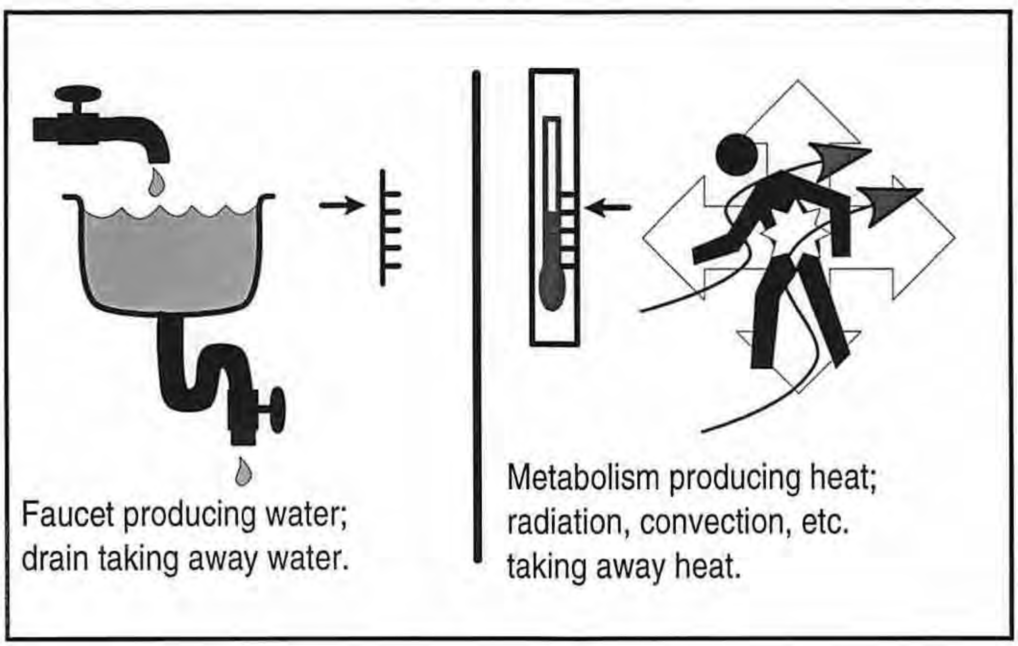

Figure 1: Heat Balance/Sink Analogy (see text)

evolution shows homeothermic mammals to be better survivors than reptiles. We use a lot of energy keeping our internal temperature constant. But, the improvement in efficiency of our metabolism, and the increased flexibility this allows us, make a big difference: we can hunt in winter conditions that a reptile cannot. Reptiles must also expend considerable time and energy finding environments that help maintain their core temperature, because their homeostatic mechanisms are not as well developed as ours. However, being a homeotherm has its disadvantages, too: if we are exposed to too much cold, we run out of energy and die, whereas a reptile can just go into cold-induced torpor and survive a bit longer.

C. Body temperature sensors

1. Body temperature sensors provide the input for the thermostat in the hypothalamus. Most of the sensors are in the body core, especially in the hypothalamus itself, but there is some input from the skin. We know that putting a hand in cold water will produce a shiver, but we also know that the central sensors have greater influence than those in the hands and feet.

2. Putting your hand in cold water causes a reflex shiver even with a normal core temperature. Therefore, some recommend that you put most of your insulating clothing on the core (a down vest, for example) rather than on the extremities (gloves). The idea is to not suppress shivering.

3. Thinking along these lines, one doctor recommended putting the arms into cold water as a treatment for hypothermia (to increase endogenous heat production, presumably). This is a **totally unapproved therapy**. Wilderness patients are usually hypothermic because they are exhausted. They cannot produce more heat, and they have arms that are already very cold. Increasing the cold stress by putting the arms in cold water is unlikely to do anything but drive the core temperature down further. (But, see the section below on **warming** of hands and feet, rather than arms or legs.)

4. Some authors recommend against giving hot drinks because they add little heat; they lull the central sensors into a false sense of warmth, and decrease heat production. But, usually you only give warm drinks in a safe, warm environment, and they have definite psychological value.[1] Most people with hypothermia symptoms in the wilderness are exhausted whether or not they are actually hypothermic. (See the description of incipient hypothermia in section on *Cold-Related Disorders*.) Even if they contribute little heat, warm sweet drinks are an easily-digested source of food energy, and food energy is just what is needed for cold, exhausted wilderness travelers. Most such wilderness travelers are also fluid depleted, and warm drinks are also fluid replacement. So, **give warm drinks to those who are cold, exhausted, or hypothermic**. The only exceptions would be those who have contraindications to oral fluids.*

5. Sometimes search teams find bodies of those who have been lost, and the person has apparently removed all of his or her clothing before death. Some hold that hypothermia can, in later stages, result in a loss of control of vascular tone, causing a last rush of heat from

* These include a decreased level of consciousness, probable need for surgery in the near future, or an ileus. The medical concept of an ileus is discussed in the section on *Burns and Lightning*.

the core to the periphery, resulting in the "paradoxical warmth" mentioned in some literary sources.

D.Physical modes of heat loss

1. You should already be familiar with the physical modes of heat loss from your EMT and SAR training. However, a detailed review is presented here to refresh your memory.
   a. *When physiologists or dietitians talk about heat or food energy, they both talk in terms of* **Calories**.
   b. *To give an idea of what a kilocalorie means, here are some common search and rescue foods and the number of calories they provide. Note that fat-rich nuts provide twice as much energy as an equivalent weight of sweet apricots or starchy bread.*
      (1) *4 oz. of nuts: 700 Kcal.*
      (2) *4 oz. of dried apricots: 350 Kcal.*
      (3) *4 oz. of whole wheat bread: 300 Kcal.*
   c. *The normal adult diet is about 1500-2000 Kcal per day. With strenuous exercise, though, you can use up 4000 Kcal or more in a day. A patient with a burn of 70% BSA (body surface area) may require more than 6000 Kcal/day for healing.*
2. **Conduction** *causes heat loss by direct contact of hot and cold. A caver sitting on a cold, wet, muddy slope will lose heat through the buttocks. So will a backpacker who takes a rest sitting on the snow. A patient whose Wilderness First Responders hesitate to move him enough to place insulation underneath will quickly chill.**
3. **Convection** *causes heat loss through mass movement of heated fluids or air.*
   a. *When you come into a room and sit down, the air near your skin is warmed by conduction, radiation, and evaporation. This forms an insulating layer of warm air next to your skin.*
   b. *However, simple convection occurs even when you are sitting in still air. As the air near your skin is warmed, it expands and becomes lighter. It rises, and then is replaced by cold air from below.*
   c. *Forced convection occurs when wind blows the warm air away even faster than with simple convection. Too, wind may force its way into the holes in clothing, and remove warm air from within the clothing as well as from around it. This is the "wind chill effect," discussed in the* Wilderness Environment *section.*
4. **Radiation** *occurs when photons of invisible infrared light are given off by the body. Incoming infrared radiation makes your hands warm at a campfire, and your whole body warm when lying on the beach. On a clear night, you will be warmer under the trees than in a meadow, because the trees will reflect back infrared radiation from you and from the ground. (This explains why, many mornings, you find frost or dew in the meadow, but not in the woods.) Infrared is blocked by almost any clothing. Aluminized "space" blankets do little to retain heat compared with a similar sheet of uncoated plastic. In most situations, the extra protection from convection provided by a leaf bag makes it far superior shelter to a "space" blanket.*
5. **Evaporation** *of water causes great loss of heat. Much of this heat loss is unnoticed, as the body continuously produces* **insensible perspiration** *even when cold. Thus, evaporation of a liter of water results in the loss of the same amount of energy as provided by a small breakfast (580 Kcal). The daily insensible loss, even with no exertion, is about 500 cc. from the skin and 400 cc. from the lungs, or close to a liter.[2] The evaporation of a single cc (1 gram) of water causes the loss of over half of a kilocalorie.*
6. **Respiration** *is another source of heat loss.***
   a. *After radiation from the ears and paws, respiration is the major method of heat loss in many*

* Insulating under a patient is very important for WEMTs during practical exercises in class, as in real life.

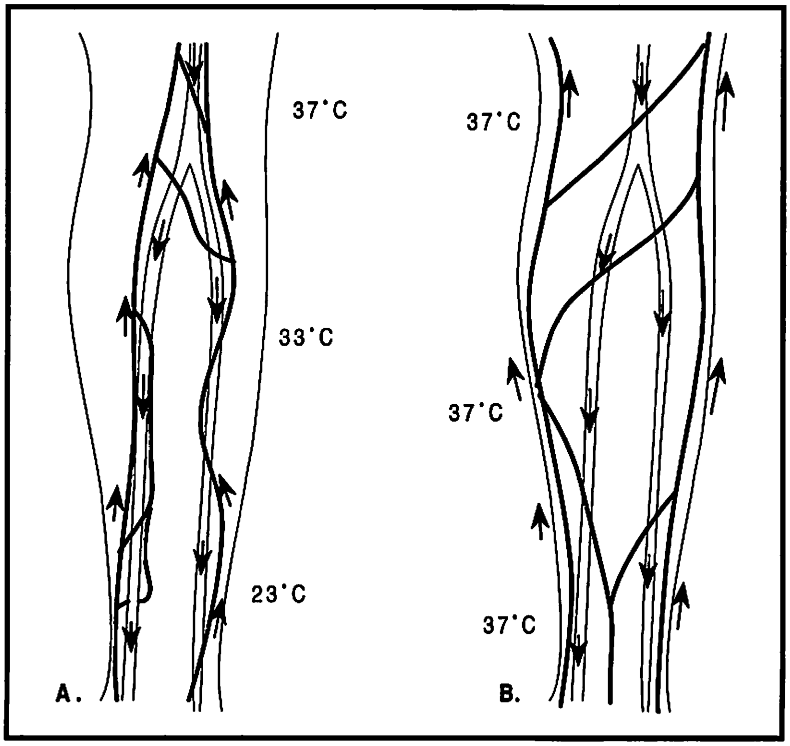

Figure 2. Deep (A) versus superficial (B) veins

mammals, especially dogs, who pant instead of sweating.

b. *The lungs are quite delicate. They operate well only with air that is at the core temperature and 100% humidity. Thus, we have a complex air-conditioning system in the nose, mouth, and trachea that warms (or cools) all inspired air to the core temperature, and brings it to 100% humidity. The omnipresent winter "runny nose" is a side effect of this efficient system. Due to the low heat capacity of air, warming air to core temperature causes the body to lose little heat. However, we humidify the dry air by evaporation, which causes large heat losses from evaporation. Your "steamy" winter breath is visible confirmation of your respiratory heat loss.*

c. *By respiration, at room temperature and at rest, you can lose up to 25 Kcal/hr. (600 Kcal/day) At -30°F (-34°C), you can lose up to 50 Kcal/hr. (1200 Kcal/day) from respiration, and even more with exertion. Rebreathe flaps over the mouth and nose (e.g., a scarf, or the bottom of a balaclava) are used by many deep-winter travelers to minimize this heat loss.*

d. *Though the heat content of dry air is quite small, the water vapor in it can carry a fair amount of heat. Thus, warm* **humidified** *air can provide some heat for rewarming a hypothermic patient, though warm dry air contributes little. And, though warm humidified inspired air systems cannot add much heat, they will certainly cut down patient heat losses in a cold environment.*[3]

E. The body heat reservoir

1. For purposes of this discussion, we can divide the body into just two parts: the core and the periphery. (This is a gross oversimplification, but as Bacon said: "We are more likely to reach the truth through error than through confusion.")

** "Transpiration" is the scientific term, meaning heat loss from evaporation.

2. Students should be familiar with the heat balance equation from their SAR training. But, when we set up a heat balance equation such as:

   Core Temp = Heat input - Heat output

   we must also think about the transfer of heat between core and periphery. You may start out quite warm, and lose heat from the periphery for quite a long time, before the core starts cooling. In other words, the periphery can serve as a large reservoir of heat. (Or cold: that's why your toes take so long to warm up in your the sleeping bag at night.)[4]*

F. Heat, cold, and blood vessels

1. The blood vessels of the extremities are our main means to regulate heat loss.
   a. Part of this is a local reflex of blood vessels to heat or cold. If you put your

* Let's assume that the periphery is half of your body (i.e., the arms and legs). Let's say this cools from a normal 85 degrees F down to 55 degrees F (29 to 13 degrees Centigrade). If so, then getting it back up to a comfortable 85 degrees will take over five hundred kilocalories (the equivalent of a trail lunch). Calculating the exact heat capacity (how much heat a given mass will hold) of the core and periphery is difficult. However, a useful approximation is to call the body just 70 kilograms of water. So, we want to raise the temperature of the peripheral half of the 70 kilo body, which is then 35 kilos of water, which is the same as 35 liters of water. To raise this 30 degrees F, which is 17 degrees C, will take 17 times 35 = 595 kilocalories. Thus, it is possible for you to lose over five hundred kilocalories of heat simply by cooling the periphery. This is an important point: you can become "chilled" with no change in the core temperature. You still have lost five hundred kilocalories, and will have to add it back to bring yourself back to a comfortable temperature.

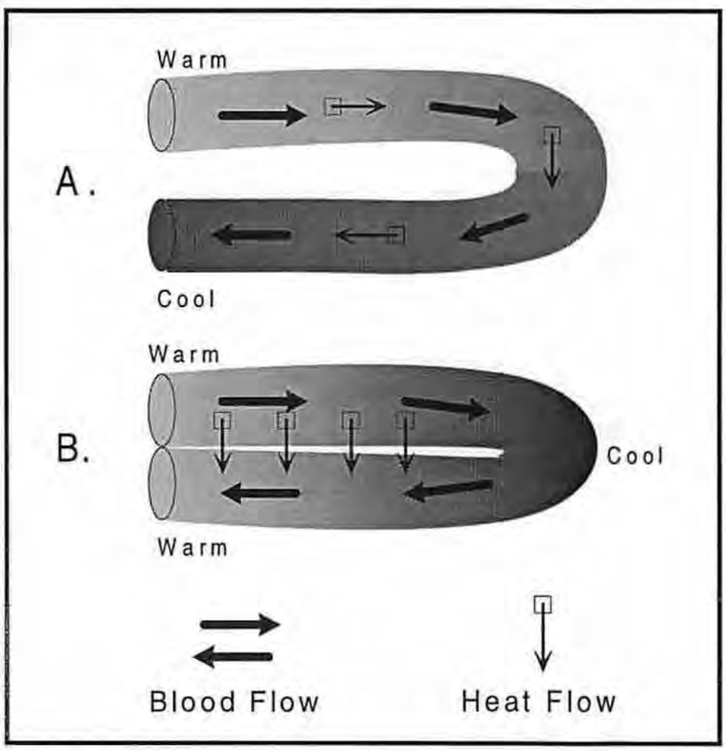

Figure 3. Countercurrent heat exchange.

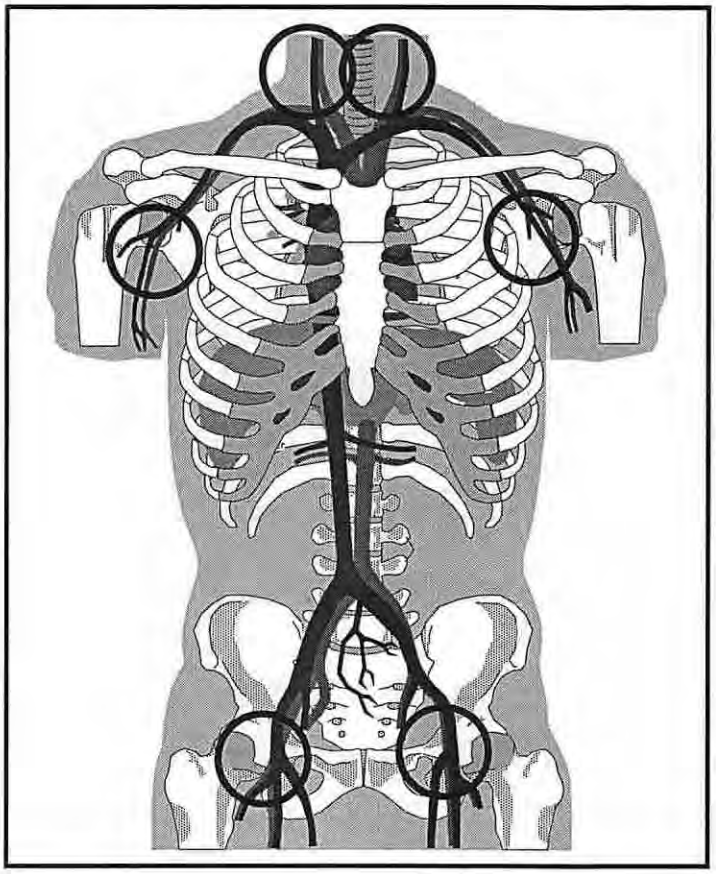

Figure 4. Areas of high heat exchange with core

hand in a bucket of cold water, the blood vessels of your hand vasoconstrict. If you put your hand in a bucket of warm water, it flushes as the blood vessels dilate.

b. Another part of vasodilation is due to central control by the brain. If your hand is in a bucket of warm water, yet your core is chilled, the hand will flush much less than if you were at a comfortable temperature.

2. The blood vessels of the extremities do not simply dilate and contract in response to heat or cold stress. In order to keep the size of the vascular system roughly the same, the body responds to shifts in heat stress by switching blood between the deep and superficial venous systems. The "switch" is probably in a small complex structure in the skin called a **glomus**.

a. The deep veins of the arms and legs are directly next to the arteries, deep within the extremity. The superficial veins are far from the arteries.

b. By switching blood flow from the deep veins to the superficial ones, the warm venous blood is closer to the surface and can cool more quickly (Figure 2).

c. By switching blood back to the deep veins when you are cold, less heat is lost because the blood stays deeper.

d. Also, when the blood is flowing back in the deep veins, heat can flow directly from the artery to the vein beside it. The blood in the vein is warmed by the artery as it returns toward the core. This **countercurrent heat exchange** allows the blood to circulate out to the tips of the fingers and toes, but keeps the blood's heat close the core. Even if the blood is cool at the hand or foot (e.g., 23°C=73°F), it warms back to core temperature (37°C=99°F) by the artery as it returns to the core (Figure 3).[5]

e. The deep veins are close to the skin surface in three areas: the axilla, the groin, and the sides of the neck. These are areas where heat or cold applied to the skin will exchange readily with the core, without interference from the countercurrent heat exchange in the extremities. These are areas EMT's are taught to apply hot packs for hypothermic patients (Figure 4).

f. The "core" includes the organs that are vital to survival, including the heart, lungs, and liver. However, the brain, too, is important to survival. Though, in deep hypothermia, blood flow to the extremities might slow to a trickle, the blood flow in the great vessels of the neck will continue. Unlike the arms and legs, there is no countercurrent heat exchange in the neck. Therefore, when the body is trying to conserve heat, and the limbs are cold, the neck and head will continue to lose heat at a fast rate. The old adage "if your feet are cold, put on a hat" has physiologic justification.

g. An interesting corollary of the division between deep and superficial veins is that they come together not just at the core, but also in the hands and feet. Thus, it is theoretically possible to warm the core by warming the hands and feet but **not** the arms and legs. However, no practical wilderness application of this has been developed. One First Responder text recommended placing the arms in warm water as treatment for hypothermia.[6] As with placing the arms in cold water as mentioned above, **this is a totally unapproved treatment**. Even if this were possible in the wilderness (say in a tent), you would most likely have to sit the patient up to place the arms in a pan of warm water— and the combination of extremity warming and sitting posture would likely cause severe rewarming shock and possibly even death.

3. The first response to cold is mild vasoconstriction and shunting of blood to the deep veins. With more severe cold stress, blood flow to the extremities decreases. However, even in severe hypothermia, with almost complete shutoff of blood to the extremity, the small blood vessels will dilate every few seconds. This **hunting phenomenon**, first observed in 1930,[7,8] is thought to protect against frostbite.

4. Vasoconstriction and vasodilation have effects other than just changing heat loss.

   a. The constriction of blood vessels due to cold results in a smaller total volume of the blood vascular system. Thus, the body senses that it has more blood volume that it needs, and tells the kidneys to excrete more water. Combined with some direct effects on the kidneys, this **cold diuresis** causes volume loss in hypothermic patients, so the WEMT should assume that all hypothermic patients are volume depleted.

   b. Dilation of superficial veins increases the size of the blood vascular system, causing a state of **relative hypovolemia** or possibly even shock; sudden heat stress is known to cause fainting in some people (**heat syncope**).

G.Sweating

1. "Horses sweat, men perspire, and women glow."
   Though horses may at times sweat, a sweating horse is severely overheated, and probably feels quite ill. Humans, on the other hand, generally enjoy working up a sweat playing tennis, climbing a cliff, or cross-country skiing. And, hu-

mans are built to sweat. There is good evolutionary evidence that our ability to sweat was important to our survival on the savannas of Africa and the Middle East. Though many animals can run faster than us, sweating allows us to keep running when the animal we're chasing finally falters of heatstroke.[9]

2. Sweating is very effective in dry climates: each liter of sweat evaporating carries with it about 500 kilocalories[10] (the equivalent of a light lunch; enough to lower the body temperature more than 7 degrees, all other things being equal). A well-trained human can sweat two liters an hour. (In humid air, sweating is much less effective.)

3. Sweating leads to loss of water and salts (sodium chloride, and to a lesser extent, potassium chloride).

   a. A major part of acclimatization to heat is an increase in the maximal amount of sweat but a decrease in the salt concentration of sweat. This helps conserve salt, allowing increased cooling from sweat without increased salt loss.

   b. After prolonged sweating and resulting salt and water depletion, replacing water but not salt can lead to electrolyte imbalances (low sodium and potassium). These imbalances are thought to lead to heat cramps.

   c. Even slight dehydration causes a marked decrease in performance. Five percent dehydration is equivalent, according to one source, to the loss of 15% of muscle mass.

H. Shivering

1. Shivering increases heat production up to about seven times the basal metabolic rate, but at the cost of probable exhaustion and fatigue.

   a. Exhaustion refers to the using up of readily available energy stores.

      (1) The body stores energy in several forms.

         (a) Glycogen

         (b) Fat is a more concentrated form of energy than glycogen, but it is not as readily available. Muscles cannot "eat" fat as well as glucose from glycogen, and the brain cannot "eat" fat at all: it can only use glucose.

         (c) Protein is the building block of cells. Proteins can, if needed, be broken down into fat and glucose, but not very efficiently.

      (2) Although some studies have identified high blood sugars in hypothermia patients, the best evidence is that victims of subacute (mountain) hypothermia should have glucose in their IV's, or receive sugar by mouth, if able to tolerate oral feedings.

   b. Fatigue is the buildup of waste products.

      (1) Muscles that use energy faster than the blood can supply oxygen can create an "oxygen debt" by converting glycogen to lactic acid. Lactic acid is later oxidized back to glucose or glycogen. This may occur in the muscle, but lactic acid may also travel through the blood to the liver to be oxidized. Buildup of lactic acid in muscles is a major cause of acute fatigue. Acute fatigue is usually relieved by a few minutes of rest.

      (2) Other waste products build up after strenuous exertion, in the muscles and elsewhere. Longer rest is needed to clear these other waste products.

2. Shivering increases heat production, but it also increases heat loss, probably by about 25%, by drawing blood to the muscles of the periphery. Different people have different shivering responses

to cold, and indeed a few people seem to have no shiver response.

3. Those who are exhausted and fatigued may be unable to shiver.

I. Acclimatization

1. **Heat Adaptation:** In addition to the various short-term responses to heat stress (vasodilation, sweating), humans can make long-term adaptations to hot environments.
   a. As mentioned above, the increase in maximal amount of sweat, and decrease in salt content, is very important.
   b. Changes may also occur in the efficiency of metabolism at the cell level (to use food while producing less heat) and in the cardiovascular system (increased ability to pump blood faster; equivalent to putting a better water pump in your car's cooling system).
   c. Significant acclimatization to heat can occur with only a brief daily exposure to heat over 1-3 weeks, but full acclimatization may take up to 8 weeks.[11]
2. Humans can do very little physiologically to acclimatize to the cold (other than reversal of the heat-acclimatization processes described above). However, humans can adapt to sleeping in the cold without discomfort, at the cost of a decreasing core temperature throughout the night.[12] Out primary adaptation to cold is through behavior, clothing, and shelter. One other adaptation is diet: an increased amount of fat in the diet allows more heat production and is recommended (and, according to some, craved) in the diet of winter travelers.[12]

J. Drugs and Diseases

1. A great many drugs and diseases affect the ability of the body to maintain a normal temperature. Though many of these are discussed in the section on hypothermia, three classes of commonly used drugs should be mentioned here.
2. Tobacco contains nicotine, which is a stimulant similar, in many ways, to "uppers" such as amphetamines and cocaine. A major side effect of tobacco abuse is vasoconstriction. When the body is trying to vasodilate to cope with heat, tobacco abuse decreases heat loss, and may contribute to heat illness. In the cold, tobacco abuse may decrease the hunting phenomenon (described above) that protects cold extremities against frostbite. (In southeast Asia, tobacco abuse is a major contributor to Berger's disease, which results in vasoconstriction so severe that fingers and toes turn black and necrotic.)
3. Alcohol reputedly directly causes peripheral vasodilation (the flushed face and nose of a drunk is a good example). In the heat, this could aggravate the relative hypovolemia of heat exposure. In the cold, it could lead to increased heat loss from the core, despite a feeling of warmth as additional core heat flows out past skins temperature sensors. The idea of alcohol causing any significant vasodilation has been put in doubt. Even though alcohol intoxication may provide some protection from severe hypothermia, alcohol certainly predisposes to hypothermia by causing skin anesthesia and thus a decreased sensation of, and awareness of, cold; and, it certainly leads to errors of judgment that are the cause of many hypothermia deaths.[13]

4. Aspirin, acetaminophen, and ibuprofen are all effective in reducing a fever, by interfering with the normal function of the temperature regulators in the hypothalamus. In a similar way, they are thought by some to interfere with the ability to withstand heat illness and hypothermia; however, there is no good evidence one way or the other.

Glossary

Axilla: armpit.

Basal metabolic rate: the rate the human body makes heat "at idle."

Berger's disease: Berger's Disease, found mostly in heavy smokers of Asian origin, is essentially severe vasoconstriction that causes necrosis of fingers.

Calorie: the calorie (with a small c) is the amount of energy needed to raise one gram of water one degree Centigrade. The Calorie (with a large C), also known as the kilocalorie or kilogram-calorie, is the amount of energy needed to raise a **kilo**gram of water (1000 grams, or a liter) one degree Centigrade.

Cold diuresis: the effect of cold on the vascular system and kidneys to cause an increase in urine output.

Countercurrent heat exchange: when the deep arteries and veins of the arms and legs can exchange heat with one another, allowing perfusion of cold extremities without loss of heat.

Feedback: a type of control system that measures a quantity (e.g., temperature), then changes things based on that quantity. A house thermostat is a good example of a (negative) feedback system.

Fever: an elevation in body temperature **due to a higher set-point of the body thermostat**, usually due to an infection. An increase in temperature due to overheating despite the best efforts of body cooling mechanisms is heat illness, not fever.

Glomus: a small organ in the skin that is thought to act as a switch to switch blood between the superficial and deep circulation.

Glycogen: Also known as "animal starch," glycogen is a complex carbohydrate found in muscle and liver. It is an important source of "quick energy."

Heat syncope: fainting from sudden heat stress.

Homeostasis: the state of dynamic equilibrium. More simply, keeping something the same despite things that tend to disturb it. An example is human thirst: when we get dehydrated, our thirst drives us to drink and replenish body water stores. Thirst is one of the homeostatic mechanisms that tends to keep body water at a stable level.

Homeotherm: a "warm-blooded" animal, including mammals, but not reptiles, which are poikilotherms ("cold-blooded"). Homeotherms keep their body temperatures very constant via sophisticated control mechanisms. The core temperature of poikilotherms, however, varies more widely with the surrounding temperature.

Hunting phenomenon: sudden bursts of blood flow in a very cold extremity.

Hypothalamus: the part of the brain that serves as a control center for many bodily functions, including temperature and water balance.

Insensible perspiration: When sweat builds up on our skin, we are aware that we are sweating. However, we are always losing water through the skin, and there is a minimum level of sweating which we are never aware of, yet causes fluid and heat losses even when we are cold.

Kcal: kilocalorie. The amount of energy needed to warm a liter of water one degree Centigrade. Daily food consumption and energy expenditure averages about 2000 Kcal, but ranges up to 4000 Kcal when on difficult field tasks.

Poikilotherm: "cold-blooded." See **homeotherm.**

Relative hypovolemia: a normal total volume of blood in a vascular system that is expanded beyond normal; seen in heat stress, neurogenic shock from spinal injuries, or from psychogenic shock (fainting).

Temperature balance: also known as temperature **homeostasis.** Refers to keeping the body core temperature at a constant temperature near 99°F (37°C), and the mechanisms and control systems that assure this.

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