



Hyperthermia & Heat Stroke: Heat-Related Conditions

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Heat-related conditions occur when excess heat taxes or overwhelms the body's thermoregulatory mechanisms. Heat illness is preventable and occurs more commonly than most clinicians realize. Heat illness most seriously affects the poor, urban-dwellers, young children, those with chronic physical and mental illnesses, substance abusers, the elderly, and people who engage in excessive physical activity under harsh conditions. While considerable overlap occurs, the important syndromes are: heat stroke, heat exhaustion, and heat cramps. Heat stroke is a life-threatening emergency and occurs when the loss of thermoregulatory control results in hyperpyrexia (very high fever) and severe damage to many internal organs.

Epidemiology

Heat illness is generally underreported, and the true incidence is unknown. Death rates from other causes (e.g. cardiovascular, respiratory) increase during heat waves but are generally not reflected in the morbidity and mortality statistics related to heat illness. Nonetheless, heat waves account for more

deaths than all other natural disasters combined in the USA. The elderly, the very poor, and socially isolated individuals are disproportionately affected by heat waves. For example, death records during heat waves invariably include many elders who died alone in hot apartments. Age 65 years, chronic

*The exposure to the heat and the concrete during the hot summer months places many rough sleepers at great risk for heat stroke and hyperthermia.
Photo by
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illness, and residence in a poor neighborhood are all associated with higher risk of death during heat waves.

From 1979 through 1999, 8015 deaths in the USA were directly attributed to excessive environmental heat exposure. During the 7-day Chicago heat wave of 1995, the death rate increased by 85%, with the majority of deaths among the poor and socially isolated. Interestingly, northern cities have greater increases in death rates during hot weather than southern cities. Northern cities have wider swings in temperature, fewer air conditioners, and the citizens are not as well acclimated to the heat.

Thermoregulation

Metabolism, muscle activity, and the environmental temperature all contribute to the generation and maintenance of body heat. When the body temperature rises, peripheral vessels dilate and cardiac output increases, shunting blood flow closer to the surface of the skin where it can be cooled. Sweating provides water on the skin's surface, which then evaporates and further cools the body. This cooling process by evaporation depends on the gradient between the body temperature and the atmospheric temperature. Humidity and high environmental temperatures hinder heat dissipation. Behavioral factors play an important role in cooling, including seeking a cooler environment or shade from the sun, reducing physical activity, and replacing the water and salt lost through sweating. People with impaired mobility or impaired judgment may not be able to engage in these behaviors, and are at risk for heat illness.

After 7-14 days of persistent heat exposure, the body becomes acclimated and adjusts to the heat through increased sweating, avid retention of salt by the kidneys, and an increase in cardiac stroke volume. Even with adequate water and salt intake, homeostatic mechanisms may break down and cause severe hyponatremia and cerebral edema.

Heat Disorders

When the body's ability to dissipate heat is overwhelmed and/or too much water and salt are lost, the core body temperature rises and several distinct heat syndromes may develop (see Table 1). Many risk factors can increase a person's susceptibility for developing a heat syndrome, including: generalized skin conditions (e.g. sunburn, psoriasis) that interfere with sweating; dehydration; alcoholism; mental illness; cardiopulmonary disease; and age

greater than 65. In addition, children absorb more heat relative to their body mass and do not sweat as much as adults, thereby rendering them particularly vulnerable to heat disorders. Asphalt and concrete in cities absorb and retain heat, creating the "urban heat phenomenon" which also interferes with nighttime cooling in cities. Numerous drugs affect heat dissipation and heat production, most notably anticholinergics, beta-blockers, antipsychotics, tricyclic antidepressants, lithium, ethanol, and diuretics. Stimulants also generate excess heat: cocaine, amphetamines, MDMA (Ecstasy), and supra-therapeutic doses of thyroxine (see Table 2).

Heat Stroke

Heat stroke is a life-threatening febrile illness due to the breakdown of the body's heat control systems and the subsequent acute immunologic and metabolic reactions to elevated body temperatures. When simple exposure to high environmental temperature overwhelms thermoregulatory mechanisms, the condition is called "classic" or non-exertional heat stroke. When the body temperature rises in a healthy person who exercises strenuously in a hot environment, this is referred to as "exertional heat stroke."

Risk factors may be present but are not requisite. The onset of heat stroke is rapid, and patients may have a prodrome of weakness, headache, chills, ataxia, and nausea. Chest pain may be present, as well as shortness of breath and abdominal pain. Thirst is not a reliable indicator of impending heat stroke. The body temperature rises rapidly, sweating ceases, and multiple system failure ensues (usually heralded by neurological problems). An acute phase inflammatory reaction appears to be involved in the progression from heat exhaustion to heat stroke.

During heat stroke fever is 104°F (40°C) or greater. Sweating usually ceases and the skin becomes hot and dry. Confusion, delirium, and ataxia are followed by loss of consciousness. Some patients will have seizures that usually occur during cooling. Tachycardia and hyperventilation are common vital sign changes. Laboratory examination reveals an elevated hematocrit (secondary to hemoconcentration), electrolyte and acid-base disturbances (typically hyponatremia, metabolic acidosis, and hypokalemia), and evidence of muscle, renal, and hepatic damage. The electrocardiogram and cardiac enzymes may indicate myocardial injury. Thrombocytopenia can be profound if disseminated intravascular coagulation has occurred.

Table 1: Major Heat Syndromes

Disorder	Mechanism	Clinical	Treatment	Comments
Heat Stroke				
<p>Classic: Inability to compensate for hot environment. Occurs in patients with impaired homeostatic mechanisms</p> <p>Exertional: Failure to dissipate the heat generated by strenuous exercise. Occurs in otherwise healthy persons who overexert under heat stress conditions</p>	<p>Failure of thermoregulatory systems resulting in severe hyperthermia and multi-system damage</p> <p>Usually accompanied by electrolyte imbalance and cardiac arrhythmias. Often seizures, neurological damage, DIC, rhabdomyolysis, renal and hepatic failure</p>	<p>Often rapid onset</p> <p>May be preceded by headache, nausea, weakness, and myalgias</p> <p>High fever 105°-107°F (40.6°C - 46.7°C)</p> <p>Dilated pupils</p> <p>Hot dry skin</p> <p>Lack of sweating (classic)</p> <p>Confusion, ataxia and/or loss consciousness</p> <p>Fast thready pulse</p> <p>Hypotension</p> <p>Heart failure</p>	<p>Support airway, breathing, & circulation</p> <p>Patient must immediately be moved to a cooler environment and transported to the hospital</p> <p>Hospital treatment consists of aggressive cooling, fluid and electrolyte replacement, and support of vital functions</p>	<p>Highly lethal</p> <p>20% or more have residual neurological damage</p> <p>Patients with exertional heatstroke may continue to sweat</p>
Heat Exhaustion				
<p>Fluid and electrolyte imbalance due to sweating resulting in hypovolemia</p>	<p>Water and/or salt depletion from excessive sweating that is inadequately replaced</p> <p>Hypovolemia causes weakness and collapse</p>	<p>Insidious or sudden onset</p> <p>Weakness, lightheadedness, syncope, sweating, nausea</p> <p>Low-grade fever</p> <p>Pale, cool, clammy skin</p> <p>Sweating</p> <p>Thready pulse</p> <p>Low BP</p> <p>May be ataxic and confused</p>	<p>Patient should lie down in a cool area</p> <p>Fluid and salt should be replenished. Slightly salty or sports drinks can be given in sips over 2-4 hours. IV's needed if very ill or unable to take oral fluids</p>	<p>May be similar in presentation to insulin shock, alcohol/drug abuse/withdrawal, or hypovolemia from occult blood loss</p> <p>Usually benign, but may progress to heat stroke</p>

Therapy includes immediate cooling, support of failing organ systems, and repletion of fluids with correction of electrolyte abnormalities. Time is critical, and patients should be immediately transported to a hospital. If possible, remove the patient from the hot environment while awaiting the ambulance. Once airway, breathing, and circulation are secure, cooling should begin as soon as possible. This includes removal of clothing, applying water and ice to the skin, and fanning. The initial target temperature is 102°F (38.9°C).

Any individual with a history of heat stroke is at increased risk for future episodes.

Heat Exhaustion

Heat exhaustion is profound weakness caused by the loss of water and salt due to sweating during heat exposure. The manifestations of heat exhaustion can be similar to several other conditions, including insulin shock, hyperthyroidism, toxic ingestions, alcohol withdrawal, arrhythmias, and hypovolemia from bleeding or diarrhea. The major signs and symptoms of heat exhaustion are thirst, malaise, headaches, myalgias, shortness of breath, and nausea. Most patients with heat exhaustion are alert, although anxiety is common and some people become slightly confused. The vital signs may show

Drug	Mechanism	Comments
Anticholinergics benztropine (Cogentin™) atropine	Decreases cholinergic mediated sweating Increases heart rate	Often given to counteract the side-effects of antipsychotics
Antihistamines diphenhydramine (Benadryl™)	Anticholinergic Antihistamine	Newer antihistamines less of a problem
Tricyclic Antidepressants amitryptiline (Elavil™) imipramine (Tofranil™)	Anticholinergic	
Antipsychotics Phenothiazines chlorpromazine (Thorazine™) fluphenazine (Prolixin™) Butyrophenones haloperidol (Haldol™) Atypical Antipsychotics clozapine (Clozaril™) risperidone (Risperdal™) olanzapine (Zyprexa™)	Anticholinergic Antihistamine Dopamine blocking	Specific antipsychotics vary in anticholinergic properties Often taken together with other anticholinergics with an additive effect Increased involuntary muscle activity can increase body temperature Increased thirst can lead to water intoxication Neuromuscular Malignant Syndrome is a febrile idiosyncratic reaction to antipsychotics that is similar to heat stroke
Beta-blockers	Reduced cutaneous blood flow	
Diuretics hydrochlorothiazide (HCTZ™) furosemide (Lasix™)	Increased excretion of salt and water	Patients with underlying cardiovascular disease at higher risk from heat stress
Ethanol	Dehydration from diuresis Impaired judgement and awareness	Adrenergic and muscle hyperactivity occur during alcohol withdrawal increasing heat production
Lithium	Increased excretion of salt and water	Patients on lithium should increase both salt and fluid intake during hot weather
Stimulants cocaine amphetamine	Increases adrenergic and muscle activity with increased heat production	Deaths from cocaine overdose increase during heat waves

a normal or slightly elevated temperature with a thready pulse and orthostatic hypotension. The exam generally reveals cool and moist skin, and the legs may be swollen if prolonged standing preceded the episode.

The patient should lie down in a cool area. Fluid and electrolytes can usually be replaced with small frequent sips of slightly salty fluid over several hours. Salt, juice, and water can be added to ginger ale to give it a salty taste. Premixed sports drinks such as Gatorade™ are adequate. Intravenous saline is needed for acutely ill patients and those unable to take oral fluids. Untreated heat exhaustion can progress to heat stroke if sweating stops. Patients should be advised to avoid heat and exertion for at least 24 hours after an episode of heat exhaustion. Eating salted foods and drinking enough fluid can prevent heat exhaustion.

Heat Cramps

Heat cramps are deep and painful spasms in the most actively used muscles and are a direct result of salt depletion. The affected muscles harden and become tender. Spasms of the upper or lower extremities can be debilitating, and abdominal muscle spasms may mimic an acute abdomen. Patients should move to a cool area and replenish salt and fluid. Eating salted foods and drinking enough fluid in the heat can usually prevent heat cramps.

Sunburn

Sunburn is not considered a heat disorder but occurs with overexposure to ultraviolet (UV) sunrays. The skin becomes tender and reddened several hours after exposure and may blister and later peel. Limiting skin exposure to direct

sunlight, especially at midday, and the application of a sunscreen are the best ways to prevent sunburn. Para-aminobenzoic acid (PABA) and/or benzophenone-containing sunscreens, with a sun protection factor (SPF) rating of 15, should be applied 30-45 minutes prior to exposure to the sun. Opaque zinc oxide and titanium oxide creams can be used to completely block sunrays in highly exposed areas like the bridge of the nose. Cool moist compresses are soothing, and aspirin or non-steroidal anti-inflammatories help relieve mild to moderate discomfort. Corticosteroids may be needed for more severe sunburns.

Special Considerations for Homeless Populations

Simple community and individual measures, based on the awareness of keeping cool and drinking plenty of fluids during hot weather, can effectively prevent heat disorders. Shelter and street outreach nurses should be trained to detect the early signs of heat illness and intervene promptly. Educational materials for staff and shelter guests can be very effective. All clinicians should ask their patients how they cope with the heat and discuss with them how to seek cool places and drink fluids during hot days. Ideally, vulnerable homeless persons should go to shelters with air-conditioning when the weather is hot. Formerly homeless individuals who live alone in hot rooms are more vulnerable to heat illness than persons living outdoors or in shelters. These vulnerable individuals include those living in group homes for the mentally ill or congregate living programs, as well as families with young children housed in motels. Whenever possible, we recommend that clinicians schedule at least one office visit and possibly a home assessment in the spring or early summer for all newly-housed patients. Plans to deal with the heat can be reviewed at that time. The vulnerability for heat-related illness should be an essential part of the risk assessment performed by clinicians who visit families housed in hotels. Cool baths or showers can help dissipate heat for those living in rooms without air-conditioning. Individuals suffering from paranoia or impaired temperature perception frequently wear heavy winter clothes on hot days and are extremely susceptible to heat-related illness. Many of these individuals are amenable to a creative discussion about dressing more lightly. Remind patients taking psychotropic medications to avoid excess heat. Advise parents not to leave children alone in hot rooms or vehicles. Counsel patients to avoid swimming when intoxicated.

Local regions vary in the specific criteria for instituting public health warnings and activating response systems. In Boston, community cooling centers are opened whenever the temperatures are expected to reach 90°F (32.2°C) or more for 3 consecutive days.

Hydration is clearly critical during hot weather. Individuals with poorly controlled diabetes and alcoholism are often chronically dehydrated. Remind patients to drink water, sodas, or sports drinks throughout the day. Many patients restrict their fluid intake because of a lack of bathroom facilities in the city, and a discussion about safe and available places to urinate is helpful.

Excess sun exposure and heavy physical exertion should always be avoided in the hot weather and especially during the hours before and after noon. Sun-blocking creams should be readily available in clinics as well as in the shelters.

Many homeless people obtain daily work through labor pools and often this requires strenuous work for many hours. These individuals should be counseled about ways to keep hydrated while avoiding overheating at their job sites. ■■

Heat-Related Syndromes Medication List

Generic	Brand Name	Cost
amitriptyline	Elavil	\$
benztropine	Cogentin	\$
chlorpromazine	Thorazine	\$
clozapine	Clozaril	\$\$\$\$\$
diphenhydramine	Benadryl	\$
fluphenazine	Prolixin	\$\$
furosemide	Lasix	\$
haloperidol	Haldol	\$
hydrochlorothiazide	HCTZ	\$
imipramine	Tofranil	\$
olanzapine	Zyprexa	\$\$\$\$\$
risperidone	Risperdal	\$\$\$\$\$

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