Heat Illness

Dr. Meghan Garnett, PGY–3 ER

Dr. Matthew Davis
Medical Director of Education
Objectives

• Physiology and pathophysiology

• Risk factors and prevention

• Various heat disorders

• Heat illness in BLS & ALS PCS
Physiology and Pathophysicsiology
Mechanisms of Heat Transfer

1) Conduction – By direct physical contact (ex. object)

2) Convection – Through air and water molecules beside the body (ex. swimming)

3) Radiation – By electromagnetic waves (ex. sun)

4) Evaporation – Conversion of liquid to a gas (ex. sweat)
EVAPORATION: Person is sweating and losing heat into the air.

CONDUCTION: Body heat transferred to something in contact with the human body.

CONVECTION: Cool air makes contact with the body; body heat warms the air which is carried away by convection currents (in the process, the body loses heat).

RADIATION: Body loses heat to table by movement of heat waves from warmer body to cooler table.
Mechanisms of Heat Transfer

• Thermal conductivity of water is 25x greater than air

• Once air temp > body temp, heat is gained instead of lost by convection

• Radiation accounts for 65% of heat loss in cool environments, but is a source of heat gain in hot climates

• Evaporation becomes more important for heat loss as temps rise
Ever wonder why dogs pant?

- Some mammals like dogs have an oropharyngeal countercurrent flow mechanism

- Dogs pant at 300–400 bpm (cool air in, hot air out)

- Panting also increases evaporation from the upper respiratory tract
Heat Regulation

- Thermosensors
  - Peripheral (skin) and central (hypothalamus)

- Central integrative area
  - Central thermostat

- Thermo-regulatory effectors
  - Sweating, peripheral vasodilation
Acclimatization

- Physiologic adaption after repeated heat exposure
- Daily exposure to working in a hot environment for 100 min / day for 1–2 weeks
- Easier to acclimatize with a low salt diet
- Acclimatization is quick (to achieve, and to lose)
Acclimatization

- Plasma volume expansion
- Improved cutaneous blood flow
- Earlier onset of sweating (i.e. at a lower body temp)
- Increased sweat volume
- Lower sweat electrolyte concentration
Fever vs. Hyperthermia

- Fever – Elevated body temperature from a reset thermal set point in the hypothalamus
- Hyperthermia – Elevated body temperature from failed thermoregulation
Fever vs. Hyperthermia

• Fever – Treat with antipyretics

• Hyperthermia – Whole-body cooling

• Trying to cool a febrile patient will cause violent shivering and discomfort

• Similarly, antipyretics will not help a hyperthermic patient
“IF YOU SAW A HEAT WAVE, WOULD YOU WAVE BACK?”
STEVEN WRIGHT
Risk Factors and Prevention
Risk Factors for Heat Illness

• Elderly
• Children
• Mental illness
• Chronic diseases (ex. heart disease, diabetes)
• Skin disorders
• Medications (ex. B–blockers, CCB, anticholinergics)
• Drug use (ex. cocaine)
• Dehydration
• Exercise in hot environment (ex. military, athletes)
• Obesity
Preventative Measures

• Wear loose-fitting or ventilated clothing
• Wear light-coloured clothing
• Stay hydrated with cool, low osmolality fluids
• Use work–rest cycles
Fluid Intake

• The goal is to increase gastric emptying – Want fluid to reach the small intestine where it is absorbed

• Factors that promote gastric emptying:
  • Large fluid volume (> 500 mL)
  • Cool temps (10–15°C)
  • Low osmolality (< 200 mOsm/kg)
Fluid Intake – Osmolality

- Water: 0 mOsm/kg
- Blood: 290 mOsm/kg
- Gatorade: 350–400 mOsm/kg
- Powerade: 400–430 mOsm/kg
- Pedialyte: 250–270 mOsm/kg
Remember during the heat wave to stay indoors and exert minimal energy like every other day of your life.
Heat Illnesses
# Heat Illnesses

<table>
<thead>
<tr>
<th>Minor</th>
<th>Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat cramps</td>
<td>Heat exhaustion</td>
</tr>
<tr>
<td>Heat edema</td>
<td>Heat stroke</td>
</tr>
<tr>
<td>Heat syncope</td>
<td></td>
</tr>
<tr>
<td>Prickly heat</td>
<td></td>
</tr>
</tbody>
</table>
Heat Cramps

• Brief, intermittent, severe muscle cramps in heavily worked muscles

• Muscle cramps develop after work in a hot environment

• Cause: Salt deficiency
Heat Cramps

• Clinical clues:
  • Occur after exertion (not during)
  • Copious sweating during exertion
  • Drinking lots of hypotonic fluid (leading to ↓ Na)
  • Systemically well

• Different than the cramps athletes experience during exercise, which are shorter-lived and resolve spontaneously
Heat Cramps

• Treatment: Salt solutions (ex. electrolyte drinks, NS bolus)

• Salt tablets delay gastric emptying and are not recommended
Heat Edema

- Mild feet and ankle swelling in non-acclimatized patients
- Occurs after prolonged sitting or standing
- No underlying cardiac, hepatic, venous, or lymphatic disease
Heat Edema

• Cause: Cutaneous vasodilation and orthostatic pooling lead to accumulation of fluid in the lower extremities

• Clinical clue:
  • No functional impairment – The patient is well otherwise
Heat Edema

• Always consider other causes for leg edema (DVTs, CHF, lymphedema, etc.)

• Treatment: Leg elevation, support stockings

• Will resolve with acclimatization or return to temperate climate (ie. by the time your vacation is over)
Heat Syncope

• Temporary LOC in a hot environment

• Cause: Peripheral venous pooling, volume loss, peripheral VD lead to ↓ venous return and ↓ cerebral perfusion → Syncope

• Many causes of syncope – Heat syncope is a diagnosis of exclusion
Heat Syncope

- S&S:
  - Lightheadedness
  - Tunnel vision
  - Pale and sweaty skin
  - Bradycardia
  - Normal or near-normal temp
Heat Syncope

• Treatment: Horizontal position

• Prevention is key:
  • Do not stand for prolonged time in the heat
  • Flex leg muscles often to increase venous return
  • Lie down if prodromal symptoms occur
Prickly Heat
aka. miliaria rubra, lichen tropicus, heat rash

- Acute inflammatory disorder of the skin in tropical climates
- Cause: Blocked sweat gland pores with dead skin cells become secondarily infected by *staphylococcus*
Prickly Heat

1) Acute Phase
   • Dilation and rupture of obstructed sweat glands
   • Produces intensely pruritic vesicles on an erythematous base
   • Rash confined to clothed areas
   • Sweat glands can be entirely blocked leading to anhidrosis in that area
2) Profunda Phase

- Keratin plug fills vesicles and causes deeper obstruction of the sweat gland
- 2\textsuperscript{nd} rupture occurs, producing deeper vesicle in the dermis
- Lasts for weeks
- No pruritus (unlike acute phase)
Prickly Heat

• Treatment:
  • Chlorhexidine cream or lotion
  • Salicylic acid 1% topical (caution salicylate toxicity)
  • Erythromycin

• Prevention: Light, loose-fitting, clean clothing

• Routine use of talcum or baby powder should be avoided
Major Heat Illnesses

Death

Heat Stroke

Heat Exhaustion
Heat Exhaustion

• Volume depletion and fatigue under conditions of heat stress

• Water depletion vs. salt depletion

• Clinical features:
  • Malaise, fatigue
  • Headache, N/V, vertigo
  • Normal or low-grade temp
  • Tachycardia, orthostatic hypotension, dehydration
  • Diaphoresis
Heat Exhaustion

- **What they do not have:**
  - Temp $\geq 40^\circ$ C
  - Altered mental status
  - Seizure
  - Coma

- **Treatment:**
  - Rest from the environment
  - Fluids (PO or IV) based on clinical volume assessment and serum electrolytes
Heat Stroke

• Life-threatening condition with body temperature ≥ 40.5°C resulting from failed homeostatic thermoregulatory mechanisms

• Multisystem tissue damage and organ dysfunction

• While body temp may rise in other heat illnesses, the thermoregulatory mechanisms fail in heat stroke
Heat Stroke

• At first, heat is dissipated from peripheral VD

• Hypovolemia is avoided by compensatory splanchnic and renal VC
  • Explains the universal hepatic damage in heat stroke

• When thermoregulatory compensation fails, heat storage rises dramatically

• ↑ ICP and ↓ MAP leads to ↓ cerebral blood flow (bad)
Heat Stroke

- Tissue damage depends on temperature and duration of exposure

- Clinical features:
  - Exposure to heat stress
  - CNS dysfunction (coma, seizure, delirium)
  - Core temp usually $\geq 40.5^\circ$ C
  - Hot skin ± sweating
  - N/V/D
  - Marked elevation of hepatic transaminases

- Neurologic dysfunction is the hallmark of heat stroke
Heat Stroke

- Heat exhaustion can progress to heat stroke
- Onset is sudden in 80% of cases of heat stroke
- Interesting that 50% of patients continue to sweat (so loss of sweat mechanism is not the cause)
Heat Stroke

• Taking a temperature in the field can be very helpful to hospital staff!

• By the time patients reach the hospital, significant cooling may have taken place
# Heat Stroke

<table>
<thead>
<tr>
<th>Classic</th>
<th>Exertional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elderly, poor, vulnerable population</td>
<td>Athletes, military recruits</td>
</tr>
<tr>
<td>Underlying medical conditions</td>
<td>Generally healthy</td>
</tr>
<tr>
<td>During heat waves</td>
<td>During intense exercise</td>
</tr>
<tr>
<td>Sweating often ceases</td>
<td>Sweating often persists</td>
</tr>
<tr>
<td>Myocardial enzyme release</td>
<td>Renal failure and rhabdomyolysis</td>
</tr>
<tr>
<td>Respiratory alkalosis</td>
<td>Lactic metabolic acidosis</td>
</tr>
</tbody>
</table>
Heat Stroke

• What else could it be?
  • Meningitis / encephalitis
  • Cerebral falciparum malaria
  • Thyroid storm
  • Drug–induced (sympathomimetics, anticholinergics)
  • Typhoid fever
  • Delirium tremens
  • Hypothalamic hemorrhage
  • Malignant hyperthermia
  • Neuroleptic malignant syndrome or serotonin syndrome
Treatment of Heat Stroke
Cooling

• Immediate cooling is the cornerstone of treatment

• Heat stroke has a mortality of 21–63%
## Cooling

### All Pre-Hospital Environments

<table>
<thead>
<tr>
<th>Action</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remove patient from hot environment</td>
<td>Remove clothes</td>
</tr>
<tr>
<td>Initiate cooling</td>
<td>Continuous core temperature monitoring</td>
</tr>
<tr>
<td>Loosen tight clothing</td>
<td>Body cooling unit</td>
</tr>
<tr>
<td>Remove excess clothing</td>
<td>Atomized water at 40° C and cooling fans</td>
</tr>
<tr>
<td>Use fans / wind</td>
<td>Immersion in ice water to &lt; 39° C</td>
</tr>
<tr>
<td>Use AC where available</td>
<td>Cooling blankets</td>
</tr>
<tr>
<td>Cover in wet sheets</td>
<td>BZDs for shivering</td>
</tr>
<tr>
<td>Ice packs to neck, groin, axillae</td>
<td>Cardiopulmonary bypass</td>
</tr>
</tbody>
</table>
Resuscitation

• Aspiration – Airway management

• Seizures

• Hypoxemia

• Pulmonary edema vs. hypotension (dehydration, peripheral VD)

• Tachydysrhythmias
May your outdoor summer wedding be filled with minimal heat stroke fatalities.
BLS PCS on Heat–Related Illness
Heat–Related Illness

• Consider heat–related illness in a hot environment with any of the following complaints:
  • Fainting or syncope
  • Muscle cramps
  • Non–specific complaints (headache, N/V, malaise)
  • Excessive sweating or dry skin
  • Fever
  • Altered mental status
  • TCA, antihistamine, beta–blocker, cocaine, amphetamine OD
Heat–Related Illness

• Assume the potential for life threats from heat stroke or hypovolemic shock

• Scene survey and primary survey

• Make a transport decision

• Initiate cardiac monitoring
Heat–Related Illness

• History and physical exam

• If heat stroke suspected → Head-to-toe survey

• Otherwise, do a focused exam:
  • Vital signs
  • CNS – GCS, pupils
  • Mouth/skin – Dehydration, skin temp, colour, condition
  • Extremities – Inspect, palpate if muscle cramps
Heat–Related Illness: General Management

• Move patient to cooler environment

• Position supine if syncope, hypotension, shock

• Remove heavy or excess clothing

• Massage cramped muscles

• Consider small quantity of salt–containing fluid PO
Heat-Related Illness: Heat Exhaustion

- Administer high concentration O₂

- Implement rapid cooling if temp seems very high:
  - Move patient to ambulance and remove as much clothing as possible
  - Turn AC on high
  - Cover patient with wet sheets
  - Massage extremities to increase VD and prevent shivering
  - Transport minimum priority Code 3
Heat–Related Illness: Heat Stroke

• Administer high concentration O$_2$ and initiate rapid transport

• Implement rapid cooling as per previous slide, plus:
  • Withhold oral fluids
  • Apply cold packs to axillae, groin, neck, and head
  • Use minimum force required to restrain a combative patient
  • Manage seizures, emesis, shock, agitation, coma, cardiac arrest
Heat–Related Illness: Management

• If transport time > 30 min, continually reassess patient to determine when cooling should be discontinued:
  • Skin temp feels normal
  • Shivering develops
  • LOC improves
ALS PCS Medical Directives
IV and Fluid Therapy Medical Directive

- Patients with heat illness may require an IV for fluids

- Fluid bolus of 20 mL/kg is indicated if hypotensive (SBP < 90 mmHg), to a max of 2,000 mL
Seizure Medical Directive

• Patients with heat stroke may have a seizure

• Remember to check BG before administering midazolam

• Midazolam 0.1 mg/kg IV or 0.2 mg/kg IM/IN/buccal q 5 min x 2 max

• Important to remove the patient from the hot environment (the cause)!
Nausea / Vomiting Medical Directive

• Patients with heat exhaustion and heat stroke may feel nauseous or vomit

• Dimenhydrinate (Gravol)
  • < 25 kg – Patch
  • 25–49.9 kg – 25 mg IV/IM
  • ≥ 50 kg – 50 mg IV/IM

• Remember to dilute the dimenhydrinate if giving IV!
Combative Patient Medical Directive

- Patients with altered mental status (heat stroke) may become combative

- May give midazolam in adult patients 2.5–5 mg IV/IM q 5 min x 2 max

- Mandatory patch point if you cannot measure BP or rule out reversible causes (ie. hypoxia, hypoglycemia)
I TOLD you to wear sunscreen.
Take Home Points

• The body loses heat by conduction, convection, radiation, and evaporation

• Fever and hyperthermia are caused by different mechanisms, and treated differently
  • Fever = Antipyretics
  • Hyperthermia = Immediate rapid cooling
Take Home Points

• Minor heat illnesses: Heat cramps, edema, syncope, and rash

• Major heat illnesses: Heat exhaustion and stroke

• Neurologic dysfunction is the hallmark of heat stroke

• Immediate cooling is the cornerstone of treatment in heat stroke
Questions / Comments

• (2012). ACP Medical Directives Paramedic Handbook. London Health Sciences Centre: Southwest Ontario Regional Base Hospital Program.