

Environmental Medical Concerns Hypothermia and Cold Injury

Skeet Glatterer, M.D.

Skeet Glatterer, M.D.
Hypothermia and Cold Injury

Who Is This Guy?



- " M.D. Cardiothoracic and Vascular Surgeon
- " CMC (Colorado Mountain Club)
 - WTS (Wilderness Trekking School) and BKPS (Backpacking school) Instructor
 - MOFA Instructor (Mountain Oriented First Aid), MOFA School Co-director
 - HAMS Instructor (High Altitude Mountaineering School . For Altitude Illness and Hypothermia)
- " WMS (Wilderness Medical Society)
 - Expedition Physician, AWLS (Advanced Wilderness Life Support), AWLS Instructor, Adventure-Med
- " OEC Instructor (Outdoor Emergency Care)
- " Copper Mountain Ski Patrol (OEC Instructor and Medical Support)
- " Alpine Rescue Team (OEC Instruction)

Skeet Glatterer, M.D.
Hypothermia and Cold Injury

Hypothermia

- “ Too little heat
- “ When exposed to a cold environment . The bodies ability to generate and conserve heat is overcome by heat loss to the environment
- “ Body core temperature drops to an abnormally low level
- “ Impairs neurological / intellectual, muscular, and cardiac function
- “ Poor judgment / inability to make a rational decision, lack of coordination . related to more back country injuries and death than any other cause

- ” $JQ = EK(T_s^4 - T_a^4)$ Radiation Heat Loss
- ” $Q_t = K \times A \times (t_1 - t_2 / L)$ Heat Transfer

Mechanisms of heat exchange

- “ Conduction
- “ Evaporation
- “ Radiation
- “ Convection

Conduction

- “ Transfer of heat energy from a warmer object to a colder one by direct contact
- “ Heat lost easier to good conductors: Water, snow, rocks, cold ground
- “ Insulators: Poor conductors, vacuum, air . nonmoving, fragmented into small pockets, foams, fibrous materials
- “ With current clothing / insulators . conductive heat loss alone is rarely a major cause of hypothermia
- “ Conductive heat losses become greater when clothing is wet

Evaporation

- “ Heat loss that occurs on converting liquid water to a water vapor (gas)
- “ One BTU (252 Calories) to raise the temperature of one pound of water by one degree F
- “ Evaporation of that pound of water requires about 1,000 times the energy
- “ ~~Don't~~ Sweat+

Evaporation

“ Heat loss:

Sensible: overheating / sweating

Insensible: normal (maintenance) perspiration breathing .
evaporation, convection bmr 70 calories / hour, breathing
42 calories / hour 4 liters water, 2300 K cal heat per day

“ Prevention:

Breathing: Face mask, snorkel hood

Sweating: Decrease activity, decrease insulation,
ventilation, vapor-barrier systems

Radiation

- “ Direct thermal energy emission as infrared radiation
- “ Ground temperature colder on clear nights
- “ Prevention:
 - Radiant heat reflectors
 - Reduction of clothing ability to radiate
 - Neither very successful
- “ Only a problem in extreme cold, and if clothing inadequate otherwise

Convection

- “ The transfer of heat by movement of a fluid or gas
- “ Greatly increased by moving air (wind, wind chill)
- “ The major cause of wilderness hypothermia
- “ Prevention:
 - Air is the best insulator If not moving

Slow the movement: Thickness of insulation, windproof outer layer, protect against forced convection and %Chimney Effect+

Table 23-1 Wind Chill Chart

| WIND (MPH) | EQUIVALENT TEMPERATURE (DEGREES FAHRENHEIT) | | | | | | | | | | | | | |
|-------------------|--|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|
| WIND (KPH) | EQUIVALENT TEMPERATURE (DEGREES CELSIUS [CENTIGRADE]) | | | | | | | | | | | | | |
| Calm | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 | -10 | -15 | -20 | -25 | -30 |
| | 2 | -1 | -4 | -7 | -9 | -12 | -15 | -18 | -21 | -23 | -26 | -29 | -32 | -34 |
| 5 mph | 33 | 27 | 21 | 16 | 12 | 7 | 1 | -6 | -11 | -15 | -20 | -26 | -31 | -35 |
| 8 kph | 1 | -3 | -6 | -9 | -11 | -14 | -17 | -21 | -24 | -26 | -29 | -32 | -35 | -37 |
| 10 mph | 21 | 16 | 9 | 2 | -2 | -9 | -15 | -22 | -27 | -31 | -38 | -45 | -52 | -58 |
| 16 kph | -6 | -9 | -13 | -17 | -19 | -23 | -26 | -30 | -33 | -35 | -39 | -43 | -47 | -50 |
| 15 mph | 16 | 11 | 1 | -6 | -11 | -18 | -25 | -33 | -40 | -45 | -51 | -60 | -65 | -70 |
| 23 kph | -9 | -12 | -17 | -21 | -24 | -28 | -32 | -36 | -40 | -43 | -46 | -51 | -54 | -57 |
| 20 mph | 12 | 3 | -4 | -9 | -17 | -24 | -32 | -40 | -46 | -52 | -60 | -68 | -76 | -81 |
| 32 kph | -11 | -16 | -20 | -23 | -27 | -31 | -36 | -40 | -43 | -47 | -51 | -56 | -60 | -63 |
| 25 mph | 7 | 0 | -7 | -15 | -22 | -29 | -37 | -45 | -52 | -58 | -67 | -75 | -83 | -89 |
| 40 kph | -14 | -18 | -22 | -26 | -30 | -34 | -38 | -43 | -47 | -50 | -55 | -59 | -64 | -67 |
| 30 mph | 5 | -2 | -11 | -18 | -26 | -33 | -41 | -49 | -56 | -63 | -70 | -78 | -87 | -94 |
| 48 kph | -15 | -19 | -24 | -28 | -32 | -36 | -41 | -45 | -51 | -53 | -57 | -61 | -66 | -70 |
| 35 mph | 3 | -4 | -13 | -20 | -27 | -35 | -43 | -52 | -60 | -67 | -72 | -83 | -90 | -98 |
| 56 kph | -16 | -20 | -25 | -31 | -33 | -37 | -42 | -47 | -51 | -55 | -58 | -64 | -68 | -72 |
| 40 mph | 1 | -4 | -15 | -22 | -29 | -36 | -45 | -54 | -62 | -69 | -76 | -87 | -94 | -101 |
| 64 kph | -17 | -16 | -26 | -30 | -34 | -38 | -43 | -48 | -52 | -56 | -60 | -66 | -70 | -74 |

Predisposing Conditions

- “ Thin build
- “ Inadequate clothing
- “ Getting wet
- “ Poor cardiovascular condition
- “ Lack of proper nutrition and hydration
- “ Illness
- “ Injury
- “ Lack of sleep, nervous tension, fatigue

Physiological limitation of Heat Loss

“ Shell / Core Effect

Cutaneous Vasoconstriction

Arm / Leg surface area

Skin temperature as cold recognition

Cold Diuresis

“ Shivering

Paradoxical Undressing

Temperature Afterdrop

Stages of Hypothermia

Mild

98-95 Deg F

(37-35 Celsius)

Sensation of chill, numb skin, minor impairment muscular performance-fine motor, shivering

95-93 Deg F

(35-34 Celsius)

Obvious uncoordination and weakness, stumbling, slow pace, mild confusion and apathy, loss of problem solving ability, little effort to protect self, little recognition of situation

93-90 Deg F

(34-32 Celsius)

Gross uncoordination, frequent stumbling, falling, inability to use hands, mental sluggishness with slow thought and speech, retrograde amnesia.

Stages of Hypothermia

Severe

90-86 Deg F

(32-30 Celsius)

Cessation of shivering, severe uncoordination with stiffness and inability to walk or stand, incoherence, confusion, irrational, metabolic ice box

86-82 Deg F

(30-28 Celsius)

Severe muscular rigidity, semi consciousness, dilation of pupils, inapparent heart beat or respirations

Below 82 Deg F

(Below 28 Celsius)

Unconscious, eventual death due to cessation of cardiac function . below 68 Deg F (20 Celsius) ventricular fibrillation

Treatment . Mild Hypothermia

- “ Recognition
- “ Decrease Heat Loss:
 - Add clothes, remove from cold environment and use shelter, replace wet clothing
- “ Heat Production:
 - Exercise, avoid afterdrop; Fuel: Food, hot fluids; fire, hypothermia (Burrito) wrap, hot water bottles, Tropical Rainforest

Fearsome Five

1. Food (Hypoglycemia)
2. Fluids (Dehydration)
3. Fahrenheit (Hypothermia and Hyperthermia)
4. Fatigue (Exercise Exhaustion)
5. Feet (Altitude . Hypoxia)

Treatment . Severe Hypothermia

“ Patient Assessment: Mental status, physical ability

“ Goals:

Stabilize - Minimal movement and kept flat, gentle handling

Prevent Further Cooling - clothing change or addition, hypothermia wrap, fire, hot water bottles, tropical rainforest

Evacuation . Consider %field rewarming+Risky ?

“ CPR:

Prolonged exam for vital signs, not really dead until warm and dead, no CPR if any vitals present, protective effect of hypothermia

“ No vital signs: %half speed CPR+

Consider . Expertise and number of rescuers, CPR with transport, time to evacuation, overall success very low



Skeet Glatterer, M.D.
Hypothermia and Cold Injury

Frostbite

- “ Localized injury or death of tissue due to freezing of cells
- “ Severe prolonged vasoconstriction, ice crystal formation within / between cells, vascular endothelial damage causes plasma leaks and promotes clotting
- “ Hands, feet, ears, nose / face

Frostbite

“ Associated with:

Hypothermia, high winds / altitude, tobacco-alcohol-drugs, contact with heat conductive materials (Metal, water, gasoline), overexertion / exhaustion / sweating, previous frostbite injury

“ Prevention: Numbness

Skin exposure, tight boots / hand wear, preserve head / neck heat, use mittens- not gloves, hydration, nutrition, keep dry, avoid direct skin contact to metal / fluid contact, numbness!

Frostnip

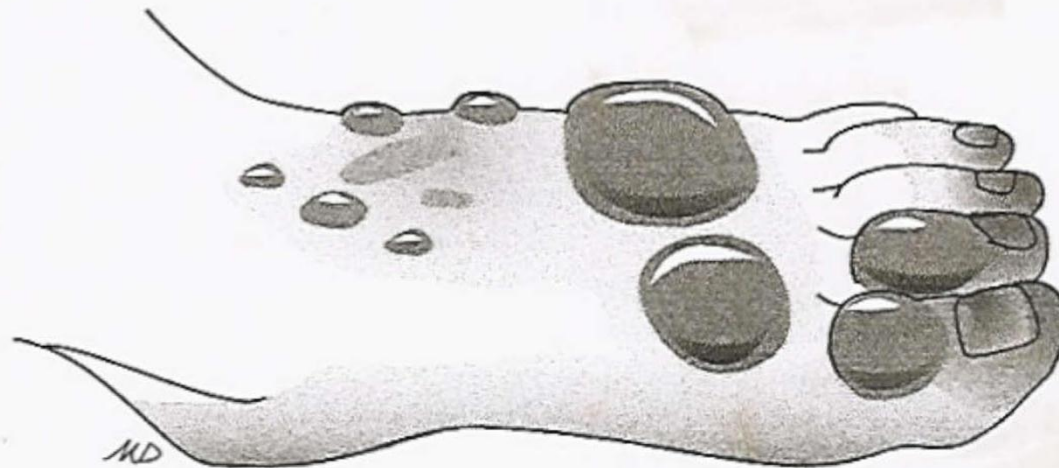
- “ Superficial, no permanent damage, may progress
- “ Initially red and painful, may become pale, white and numb. Stays soft
- “ Fingers, toes, nose, ears
- “ Rapid reversal with self rewarming. No blistering

Frostbite

- “ Variable Severity . Skin, subcutaneous tissue, muscle, bone
- “ White, frozen, variable amount resilience
- “ Blisters form 2-4 days. Clear or blood filled. May extend to digit tips
- “ May remain dark, mottled, no blisters



FIGURE 23-4. Frostbite of the thumb and fingertips one and eight days after injury



Skeet Glatterer, M.D.
Hypothermia and Cold Injury

Frostbite Treatment

- “ True frostbite best treated in hospital
- “ Rapid rewarming by warm water (104 F) by immersion in large bath for an hour, avoid improper rewarming
- “ Antibiotic or aloe Vera gel. Skin protection
- “ Analgesic, ant-inflammatory control
- “ Splint, elevate, hydration, nutrition
- “ Avoid:
 - Rubbing (especially with snow), nicotine, too hot water, open flame heating, refreezing, trauma
- “ Delay surgical intervention: Blister care

Frostbite Controversies

“ Self evacuate on frozen extremity?

Longer duration of freezing equals worse injury, usually minimal damage walking, difficult to keep frozen if no other severe problems, rewarming may incapacitate

“ Field rewarming?

Refreezing and trauma very harmful, cannot use warmed extremity, able to keep person warm, facilities available



Skeet Glatterer, M.D.
Hypothermia and Cold Injury