PHYSICAL HAZARDS

Basic Course in Occupational Medicine
Part II
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Common Types
- Thermal
- Radiation
- Noise
- Vibration
- Barometric
- Physical Trauma

Occupational Deaths
- 2008 - 5,071
- 2009 - 4,551
- Currently 12 workers per day die on the job

Thermal Hazards - Heat
- Integral part of many industrial operations and processes
- Waste byproduct in other operations
- Can be an environmental hazard, especially accompanied by personal protective garments
- Can result in either localized injuries (burns) or systemic problems

Role of Evaporation
- The most important source of heat loss. It depends on relative humidity.
  - The higher the humidity, the less efficient the heat loss.
  - Therefore, high ambient humidity (which decreases the cooling effect of sweating) and prolonged strenuous exertion (which increases heat production by muscle) increase the risk of developing heat disorders.
Thermal Regulation

- Age, obesity, chronic alcoholism, debility, and many drugs (e.g., anticholinergics, antihistamines, phenothiazines, numerous psychoactive drugs, alcohol, cocaine) increase susceptibility to heat disorders, particularly heatstroke.

**THERMAL HAZARD**

Skin Disorders
- Heat Cramps
- Heat Exhaustion
- Heat Stroke

Heat-Related Skin Disorders

- Miliaria (heat rash)
  - Caused by sweat retention resulting from obstruction of the sweat gland duct.
  - 3 forms (in order of increasing severity)
    1. Miliaria crystallina: barely perceptible vesicles
    2. Miliaria rubra: firm papulovesicular lesions
    3. Miliaria profunda: vesiculonodular lesions

Heat Cramps

- Exercise-induced cramps of striated muscle resulting from excessive fluid intake without sodium replacement.
- Skin is moist and cool
- Characterized by slow painful contractions lasting 1-3 minutes
- Treatment: cool environment, balanced salt solution or oral saline solution of 4 tsp salt per gallon of water. Rest 1-3 days.

Heat Exhaustion

- Excessive fluid and electrolyte loss due to sweating, resulting in hypovolemia and electrolyte imbalance.
- Excessive sweating without concomitant fluid replacement causes heat exhaustion with increasing fatigue, weakness, and anxiety.
- Circulatory collapse ensues, with a slow, thready pulse; low or imperceptible BP; cold, pale, clammy skin; and disordered mentation followed by a shock-like unconsciousness.
- Core temperature ranges from 38.3 to 40.6° C (101 to 105° F).
- Mild heat exhaustion, precipitated by prolonged standing in a hot environment (because blood pools in heat-dilated vessels in the legs), is manifested by a subnormal body temperature and simple syncope.

Heat Stroke

- Inadequacy or failure of heat loss mechanisms resulting in dangerous hyperpyrexia.
- An abrupt onset is sometimes preceded by headache, vertigo, and fatigue. Sweating is usually decreased, and the skin is hot, flushed, and usually dry. The pulse rate increases rapidly and may reach 160 to 180 beats/min; respirations usually increase. Disorientation may briefly precede unconsciousness or convulsions. The temperature climbs rapidly to 40 to 41° C (104 to 106° F), causing a feeling of burning up. Circulatory collapse may precede death; after hours of extreme hyperpyrexia, survivors are likely to have permanent brain damage.

OSHA educational resources:
http://www.osha.gov/SLTC/heatillness/edresources.html
Thermal Hazard - Burns

- Do to any external heat source capable of raising the temperature of skin and deeper tissues to a level that causes cell death and protein coagulation or charring.
- Most common causes are flame, scalding liquids, and hot objects or gases contacting the skin. The extent and depth of the damage depends on the amount of energy transferred from the source.

Thermal Burns

- 1st Degree
  - Tissue blanches with pressure, damage is minimal, usually no blistering or scarring
- 2nd Degree
  - Partial thickness, associated pain, blistering, sensation is intact
- 3rd Degree
  - Completely through skin to subcutaneous tissue, skin charred or translucent white. Pain often from surrounding 2nd degree burns but burn is painless to touch.

THERMAL HAZARD
HEAT PREVENTION

Engineering
Administrative
Personal/Safe Work Practices
Personal Protective Equipment

Hazard Prevention and Control

Permissible Heat Exposure Limits

<table>
<thead>
<tr>
<th>Work area</th>
<th>Light</th>
<th>Moderate</th>
<th>Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous work</td>
<td>90.0°F</td>
<td>105.0°F</td>
<td>110.0°F</td>
</tr>
<tr>
<td>25% work</td>
<td>90.0°F</td>
<td>105.0°F</td>
<td>110.0°F</td>
</tr>
<tr>
<td>50% work</td>
<td>90.0°F</td>
<td>105.0°F</td>
<td>110.0°F</td>
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</tbody>
</table>

Adapted from American Conference of Governmental Industrial Hygienists' Thermal stress and heat exposure guidelines, 2012 [1].

THERMAL HAZARD - COLD

Generated in some chemical processes
Commonly used in storage and product life extension
Common environmental hazard
Has localized and systemic effects
THERMAL HAZARD - COLD INJURIES

- Frostnip
- Frostbite
- Immersion Foot
- Chilblains (Pernio)
- Hypothermia

Frostnip
- Reversible injury due to exposure to subfreezing conditions.
- First stage of frostbite
- Skin turns red and feels very cold
- May feel pain and tingling as skin rewarms
- Can be treated by warming the affected area with an unaffected hand or a warm object.

Frostbite
- Injury due to freezing of tissue cells.
- Frostbite of extremities occurs in extreme cold, especially at high altitude, and is aggravated if core temperature is subnormal, even though hypothermia may not be apparent.
- Ice crystals form within or between tissue cells. Vasoconstriction occurs to reduce heat loss from skin and peripheral tissues. Much of the damage occurs during rewarming (reperfusion injury).
- The affected area is cold, hard, white, and anesthetic; when warmed, it becomes blotchy red, swollen, and painful. Blisters form within 4 to 6 h. If filled with clear serum and located distally on the digits, blisters indicate superficial damage; if blood-filled and proximal, they indicate deep damage and tissue loss. Freezing of deeper tissue causes dry gangrene and less commonly wet gangrene. All degrees of frostbite may produce long-term symptoms—sensitivity to cold, excessive sweating, faulty nail growth, and numbness.

Immersion Foot (Trench Foot)
- Injury due to prolonged exposure to wet cold at temperatures above freezing.
- Immersion (trench) foot causes soggy edema, blotchy cyanosis, paresthesias, and pain due to autonomic dysfunction.
- 3 clinical stages
  1. Ischemic
  2. Hyperemic
  3. Posthyperemic (recovery)
- Hyperhydrosis may persist for years
**Immersion Foot**

- **Mild**
- **Severe**

**Chilblains (Acute Pernio)**

- Result of exposure to cold or dampness
- Painful erythematous, pruritic skin lesions caused by inflammation
- Prolonged exposure can lead to chronic pernio or “blue toes”
- Scarring, fibrosis and atrophy can follow

**Hypothermia**

- A generalized lowering of body temperature.
- Hypothermia results from prolonged exposure to any temperature when body heat loss is greater than heat production. Hypothermia is most common during cold weather or immersion in water, but it may occur on a summer day or in warm climates if metabolic and exertional heat (shivering) cannot sustain core temperature.
- Hypothermia causes physiologic deceleration of all functions.
- The falling core temperature leads to lethargy, clumsiness, mental confusion, irritability; hallucinations; slowed or arrested respiration; and slowed, irregular, and, finally, arrested heartbeat. However, a victim should not be considered dead until he has been warmed. Ordinary clinical thermometers cannot measure the very low core temperature of hypothermia; a special low-temperature thermometer must be used. If only a standard clinical thermometer is available, failure of the mercury to rise above 34°C (93.2°F) indicates hypothermia.

**THERMAL HAZARD - COLD**

- **Engineering**
- **Administrative**
- **Personal/Safe Work Practices**
- **Personal Protective Equipment**

**Radiation**

- **Ionizing**
  - Alpha
  - Beta
  - Gamma
- **Nonionizing**
  - Microwave
  - Radiofrequency
  - Ultraviolet
  - Laser
IONIZING RADIATION

- Multiple uses in industry, including medical
- Can be byproduct of certain processes
- Exposed workers include those in Nuclear Industry, Medicine, Uranium Miners and the Military
- NRC (Nuclear Regulatory Commission) develops regulations governing nuclear reactor and nuclear material safety
- EPA and OSHA also involved in standards

Ionizing Radiation

- Harmful sources of ionizing radiation include high-energy x-rays used for diagnosis and therapy, radium and other naturally occurring radioactive materials (e.g., radon), nuclear reactors, cyclotrons, linear accelerators, alternating gradient synchrotrons, sealed cobalt and cesium sources for cancer therapy, and numerous other artificially produced radioactive materials used in medicine and industry.
- Large amounts of radiation have accidentally escaped from reactors several times—e.g. the well-publicized accidents at Three Mile Island in Pennsylvania in 1979 and at Chernobyl in the Ukraine in 1986. The latter resulted in > 30 deaths and many radiation injuries; significant radiation was detected in most of Eastern Europe and in parts of Western Europe, Asia, and the USA. Most recently Japan.

Ionizing Radiation

- Ionizing radiation (e.g., x-rays, neutrons, protons, alpha or beta particles, gamma rays) damages tissue directly or by secondary reactions. High doses of radiation can produce observable somatic effects within days. Many years later, DNA changes due to smaller doses may lead to chronic disease in exposed persons or to a genetic defect in their offspring. Relationships between the degree of damage and the healing or death of a cell are complex.
- Commonly used units of measurement are the roentgen, gray, and sievert. The roentgen (R) is the amount of ionizing radiation in air. The gray (Gy) is the amount of energy absorbed by a tissue or substance and applies to all types of radiation (1 gray=100 rads).

E-6
IONIZING RADIATION

GAMMA/XRAYS

Highly Penetrating
External and Internal Hazard
Cell damage measured in cms

Radiation Pearls

Rad: “Radiation Absorbed Dose”
1 rad = 0.01 Gy
Rem: “roentgen equivalent in man”
  ▪ Unit of dose, taking into account biological effects
  ▪ Rem = rads x QF (quality factor which takes into account type of radiation)
  ▪ Flight from LA-NY = 2mREM
  ▪ Skull X-ray = 8mREM
  ▪ Max Occupational Dose = 5 REM

IONIZING RADIATION

Engineering
Administrative
Personal Work Practices
Personal Protective Equipment

NON-IONIZING RADIATION

¬ Microwave and Radiofrequency
¬ Ultraviolet
¬ Lasers

Noise

NOISE
Why is Noise Considered a Health Problem

- Hearing Loss
- Noise is generally viewed as being one of a number of general biological stressors.
- It is felt that excessive exposure to noise might be considered a health risk in that noise may contribute to the development and aggravation of stress related conditions such as high blood pressure, coronary disease, ulcers, colitis, and migraine headaches.
- There is also evidence suggesting that noise may be related to birth defects and low birth-weight babies.
- There are also some indications that noise exposure can increase susceptibility to viral infection and toxic substances.
- Used as a tactic in war: stressor

Noise and its Effects

<table>
<thead>
<tr>
<th>Frequency (Db)</th>
<th>Effect</th>
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<tbody>
<tr>
<td>0</td>
<td>Threshold of Hearing</td>
</tr>
<tr>
<td>65</td>
<td>Average Human Conversation</td>
</tr>
<tr>
<td>85</td>
<td>Damage Limit</td>
</tr>
<tr>
<td>120</td>
<td>Threshold of Discomfort</td>
</tr>
<tr>
<td>140</td>
<td>Threshold of Pain</td>
</tr>
<tr>
<td>160</td>
<td>Eardrum Rupture</td>
</tr>
</tbody>
</table>

Impulse Noise

Weapon fire produces this type of noise. It is an explosive sound that builds rapidly to a high intensity and then falls off rapidly. Although the entire cycle usually lasts only milliseconds, this sound is detrimental to hearing when the intensity exceeds 140 decibels.

Noise - Auditory

- Noise induced hearing loss leading diagnosis for disability of occupationally related diseases
- Noise is ubiquitous in the work and outside environment
- Common exposures above acceptable levels (85dB on a 8 hour TWA; A scale)
- Hearing protection is least used form of personnel protective devices in workplace.

Noise - Auditory

- Caused by erosion of nerve hair sensors in inner ear
- Permanent
- Preventable in many cases
- OSHA requires ear protection and medical surveillance in work places with noise levels above 85dB (8 hour TWA)
- All permanent STS must be reported
When worn alone, the SPH-4B Helmets reduce the noise exposure to safe limits for most aircraft in the Army inventory except for the UH-60 (Black Hawk) and CH-47 (Chinook).

**Vibration Effects**

- Vibration can cause short-term acute effects because of the biomechanical properties of the body.
- The human body acts like a series of objects connected by springs.
- The connective tissue that binds the major organs together reacts to vibration in the same way as springs do.
- When the body is subjected to certain frequencies, the tissue and organs will begin to resonate (increase in amplitude).
- When objects reach their resonant frequencies, they create a momentum, which increases in intensity with each oscillation.
- Without shock absorption, vibration will damage the mass or organ.

**Vibration-Induced White finger Disease (Hand-Arm vibration Syndrome)**

- caused by segmental vibration of the hands
- usually frequencies of 125-300 Hz
- characterized by spasms of the digital artery caused by vibration
- Early symptoms: tingling followed by numbness
- Later: fingers turn white in the cold, followed by reactive hyperemia
- Advanced disease: degeneration of bone and cartilage

**Anti-vibration Glove**

**Altitude Hazards**

- Humans readily adapt to changing pressures, however, we cannot respond quickly to these changes
- Biggest effect is on hollow organs and gas transport capability
- Issues in aviation and space industries
- Issues in diving, mining and tunnel industries

**Decreased O₂ Tensions**

![Graph showing decreased O₂ tensions](image-url)
Altitude

- 1500 – 3500m (4921 – 11483 ft) ‘high altitude’
- 3500 – 5500m (11,483 – 18,045 ft) ‘very high altitude’
- 5500 – 8850m (18,045 – 29,035 ft) ‘extreme altitude’

Altitude Sickness - mountain sickness; soroche; puna; marea.
- About 20% of persons ascending above 8000 ft (2500 m) in < 1 day develop some form of altitude sickness.
- Most persons acclimatize to altitudes of up to 10,000 ft (3000 m) in a few days. The higher the altitude, the longer full acclimatization takes. Above 17,000 ft (5100 m), deterioration is more rapid; no one can live at that altitude permanently.
- Features of acclimatization include sustained hyperventilation with persistent partially compensated alkalosis, an initial increase in cardiac output (which is lower than normal maximum cardiac output), increased RBC mass, and increased tolerance for anaerobic work.
- HAPE and HACE are complications

HYPOXIA

- Hypoxia stimulates breathing, increasing tissue oxygenation but also causing respiratory alkalosis, which contributes to symptoms until loss of HCO₃⁻ in urine partially compensates. The basic pathophysiology of altitude sickness is disturbance of water and electrolyte balance. Capillary permeability is increased, allowing fluid to accumulate in various locations; the cause is thought to be vascular endothelial damage. In susceptible persons, increased ADH secretion results in tissue fluid retention, and plasma volume is decreased, simulating an increase in Hct.

BAROTRAUMA

- In modern jet aircraft, the cabin pressure is equivalent to atmospheric pressure at 5000 to 8000 ft regardless of altitude.
- At such pressures, free air in body cavities expands by about 25%.
- Upper respiratory inflammation or allergy may result in obstructed eustachian tubes, and may result in barotitis media or barosinusitis. Facial pain of dental origin may occur when air pressure changes.

Increased Pressures

- A diver at 33 ft (10 m) in seawater is exposed to a pressure of 14.7 lb/sq in (760 mm Hg, 1 atm) higher than the barometric pressure at the surface. The total pressure at 33 ft is 2 atm, which is the weight of the water plus the barometric pressure at the surface. Every additional 33 ft of descent adds 1 atm. The pressure in a caisson or tunnel (in which compressed air is used to exclude water from the work site) reflects the pressure of the water outside.
Increased Pressures

- Deep-sea and scuba (self-contained underwater breathing apparatus) divers can develop medical problems due to high pressure, as can construction workers in tunnels or caissons (pressurized work areas). A patient with almost any disorder that develops during or especially after exposure to high pressure may have decompression illness (arterial gas embolism or decompression sickness) and urgently needs recompression. Physicians who see such patients must be alert for these problems and may seek advice from the Divers Alert Network (DAN), coordinated by the Duke University Medical Center, at any hour (919-684-8111).

Physical Trauma

- The workplace has many directly hazardous processes and operations
- Injuries due to falls, crushes, lacerations, lifting & contact with moving objects are by far the most common
- Foreign bodies most common eye problems in industry (e.g.: grinding, hammering)
- Ergonomic Injuries becoming more common
- Workplace violence

Personal Protective Equipment

**Penetrating Eye Trauma**

**WHY ARE ERGONOMICS IMPORTANT?**

- Injury & Illness Prevention
- Quality of Life
  - Fully participating in favorite activities and sports
  - Picking up children/grandchildren
- Cost savings to the business
  - Direct costs - Medical treatments
  - Lost time pay
  - Indirect costs - Substitute workers

http://www.osha.gov/SLTC/ergonomics/guidelines.html
CURRENT ERGONOMIC GUIDELINES

Guidelines are voluntary but a company can be cited by OSHA under the General Duty clause if an ergonomic hazard exists without an attempt to correct it whether or not a standard exists for that industry

- Shipyards industry, February 28, 2008
- Poultry processing industry, September 2, 2004
- Retail grocery stores industry, May 28, 2004
- Nursing home industry on March 13, 2003

WORKSTATION INVENTORY:
Example of Proper Positioning

- Adjust workstation so that angles of body are approximately 90°
- Neck not flexed
- Arms supported
- Seat back supports "lazy" “S” curve of spine
- Adjust chair so that thighs are parallel to floor and feet are flat on floor or a footrest
- Thighs fully supported, chair seat doesn’ hit back of legs


Electrical Injuries

- Electrical burns result from the generation of heat, which may reach 5000° C (9032° F). Because most of the resistance to electric current occurs where the conductor contacts the skin, electrical burns usually affect the skin and subjacent tissues; they may be of almost any size and depth. Progressive necrosis and sloughing are usually greater and affect deeper tissues than the original lesion indicates. Electrical injury, particularly from alternating current, may cause immediate respiratory paralysis, ventricular fibrillation, or both

Electrical - Continued

- The type of current affects the severity of the injury. DC tends to cause a convulsive contraction, often forcing the victim away from the current’s source. AC at 60 Hz (household current) produces muscle tetany, often freezing the hand to the current’s source
- Generally, the higher the voltage and amperage, the greater the damage from either type of current.
- Body resistance - If skin resistance is low, few, if any, extensive burns occur. If skin resistance is high, much energy may be dissipated at the surface as current passes through the skin, and large surface burns can result at the entry and exit points, with charring of tissues in between
Thank YOU

Thank You!
Dr. G
Dr. Clark Contact 210-289-8607