HEAT EMERGENCIES

Dehydration and Heat Stroke

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Objectives

- Define heat emergencies
- Appreciate the impact dehydration has on heat emergencies.
- Differentiate between heat stroke and other heat emergencies
- Describe the treatment of heat stroke
- List methods to prevent heat emergencies

Definitions

- **Dehydration**—Loss of body fluid is more than consumption of fluid.
- **Heat Cramps**—Cramping of abdominal and limb muscles due to the loss of fluid and electrolytes.
- **Heat Exhaustion**—Weakness due to dehydration.
- **Heat Stroke**—Life threatening condition due to the loss of control of internal temperature control.
- Heat stroke may occur as a progression of dehydration, heat cramps and heat exhaustion, or it may occur without previous heat illnesses.

Dehydration and Heat Stroke

- Common heat-related diseases that can be life-threatening if left untreated.

Epidemiology

- Heat waves claim more lives each year than all other weather-related exposures combined.
- According to the CDC, over three hundred per year.
- In the record hot year of 1980—1700 deaths were attributed to the heat.
- Deaths from heat may be underestimated, because of poor reporting.
- People from cold environments who travel to hot environments are at risk.
- Pilgrimage to Mecca in 1998 resulted in 2600 deaths in 10 weeks.

Epidemiology

- African Americans deaths are higher than Caucasian deaths
- Males die more than females
- Very old and very young are at higher risk
Thermoregulation

- Humans are mammals and require a constant temperature.
- Temperature is maintained by a balance of heat production and heat loss.
- Temperature is a component of Homeostasis.

Heat Production

- Basal rate of metabolism
- Increased metabolism caused by muscle activity
- Increased metabolism caused by the effect of thyroxine and other hormones
- Increased metabolism caused by the SNS
- Increased metabolism caused by the increase of temperature in the cell itself.

Metabolism

- Heat is a bi-product of metabolism.
- Metabolism is only 25% efficient.
- 75% of the energy produced by metabolism is heat.

How the body controls heat

- Radiation
- Conduction
- Convection
- Evaporation
- Respiration

Radiation

- Heat transferred through electromagnetic waves.

Conduction

- Gaining or losing heat from direct contact with a physical source.
Convection
- Heat gain or loss through contact with moving air or water molecules across the skin

Evaporation
- Only involved with heat loss. The loss of heat through the change of liquid to gas.

Respiration
- Heat and moisture loss.

Hypothalamus
- SNS
- Vasoconstriction/dilation
- Sweating
- Metabolism
- Hormonal

Hyperthermia
- Fever
  - > 100.4 F or 38 C
  - Controls bacteria production and the action of viruses
  - Enhances the immune response
- Environmental heat emergencies
  - Heat production far exceeds heat loss
  - May be fatal if untreated
### Dehydration

- 60% of the total body composition is water
  - Intracellular 45%
  - Extracellular 15%
  - Intestinal 10.5%
  - Intravascular 4.5%

- Water
  - Essential nutrient
  - Required for all cellular function

- Water is important constituent in thermoregulation
  - Major component of blood volume
  - Water is lost through sweat, respiration and waste

### Dehydration

- Sensible and nonsensible
  - Sensible loss
    - Active sweating
    - Urine
    - Vomiting
    - Diarrhea
  - Insensible loss
    - Normal sweating
    - Respiration
    - Feces

### Dehydration

- When the body is dehydrated, a greater percentage of volume is lost through the intravascular space
- Symptoms of hypovolemic shock may occur

### Signs and Symptoms of Dehydration

- Reduction in urination
- Dry skin
- Fatigue
- Light-headedness
- Confusion
- Dry mucous membranes
- Tachycardia and Tachypnea
- Poor skin turgor

### Treatment of Dehydration

- Mild dehydration
  - Oral fluids
- Severe dehydration
  - IV fluids
  - Treat the underlying cause

### Sweating

- Water can be lost by many mechanisms but in heat related illnesses, sweating is the common mechanism
- Sweat is made up of water and electrolytes (Na, K, Cl)
- When the hypothalamus senses and increase in body temperature, it increases the blood flow to the skin stimulating the sweat glands.
- When evaporation is minimal, the body can reabsorb the electrolytes from the skin.
Sweating

- During high-intensity exercise, 2 liters of water per hour
- Depends on
  - Environment temperature
  - Humidity
  - Type of clothing
  - Fitness level of individual
  - Acclimation of the individual to environment

Sweating

- Signs of dehydration
  - Dark colored urine
  - Muscle cramps
  - Fatigue
  - Do not depend of thirst to indicate dehydration!

Differentiating Heat Emergencies

Heat Stroke

- Sometimes referred to as Sun Stroke
- The body cannot sweat enough to lower the body temperature.
- Develops rapidly
- Types
  - Classic—Non exertional (NEHS)
  - More common in the elderly and young
  - Exercise induced—Exertional (EHS)
  - More common in the young athletes
  - All types of exercise can cause increased heat production

Risks Factors NEHS

- Older people living without AC or good air flow
- Dehydration
- Chronic disease (renal, HTN, heart disease, sickle cell diabetes)
- Medications (HTN, antipsychotics, sedatives, seizure)
- Alcohol abuse
- Illegal drugs (cocaine, meth)
- Non Mobile
- Obesity
- Outdoor workers

Children’s body temperatures can rise up to five times faster than that of an adult.
Heat Stroke in Children
- Do not leave children in automobiles!
- On a 83 F day, with the windows rolled down 2 inches, the inside of the car reaches 109 within 15 minutes!

Heat Island Effect
- Urban areas
  - Stagnant atmosphere with poor quality of air
  - Asphalt and concrete absorb the heat and gradually release it.

Occupational Risks
- Athletes
- Fire Fighters
- Soldiers
- Out door workers

Heat Stroke
- Core temperatures greater than 104 F 40 C
- Heat stroke is diagnosed by the signs and symptoms in an individual exposed to extreme temperatures
- Syncope may be the first symptom

Symptoms of Heat Stroke
- Other symptoms
  - Headache
  - Dizziness and lightheadedness
  - Lack of sweating
  - Muscle cramps
  - N/V
  - Tachycardia
  - Tachypnea
  - Confusion
  - Seizure

Heat Stroke
- One of the leading preventable causes of death in sports.
- EHS
- 2/3 of deaths are high school athletes occur in August

Risk factors
- Playing in hot weather
- Ignorance
- Lack of adequate hydration
- Overweight
- Lack of acclimatization
**Acclimation**
- Takes 7-10 days
- Allows individuals to sweat sooner and more profusely
- Increases the ability of sweat glands to reabsorb sodium

**Pathophysiology**
- Excessive heat:
  - Denatures protein
  - Destabilizes phospholipids and lipoproteins
  - Liquefies membrane lipids
  - Causes cardiovascular collapse
  - Causes SIRS and MODS
  - Ultimately may cause death!

**Treatment**
- Heat Stroke is an EMERGENCY!
- Time
  - Duration of hyperthermia is determinant of outcome
  - Rapid reduction of core body temperature is the cornerstone of treatment.

**Other Cooling Methods**
- Peritoneal, thoracic, rectal and gastric lavage with ice water
- Cold intravenous fluids
- Cold oxygen
- Cooling blankets
- Cardiopulmonary bypass

**Treatment**
- The American College of Sports Medicine recommends that treatment begin on scene.
- Cool to approximately 102°F 39°C
  - Prevents rebound hyperthermia.
  - Rectal temperatures are most accurate in assessment

**Treatment**
- Scene Safety and ABC
- Remove restrictive clothing
- Spray water on body
- Cover the body with iced wet sheets
- Ice packs in highly vascular areas
- R/O hypoglycemia
Pharmacological Interventions

- ASA and NSAIDS have no value and may be harmful
- Dantrolene has been studied
- Benzodiazepines have been given to reduce agitation and shivering
- Neuroleptics are not used
  - Lower the seizure threshold
  - Anticholinergic properties
  - Hepatotoxicity
- Benzodiazepine and barbiturates for seizures
  - Phenytoin is not indicated for seizures
  - Nonpolarizing paralytics
  - Monitor for seizures with EEG

Ongoing care

- Internal temperature monitoring
- NG tube to monitor gastric bleeding and fluid loss
- Monitor intake and output
- Temperature control may be impaired for several days to weeks
  - The goal is to cool the patient to 39 C at the rate of 0.2 C per minute.
  - IV therapy—monitor carefully

Ongoing care

- Monitor for rhabdomyolysis
  - May occur in 25-30% of EHS

Rhabdomyolysis

- Large amounts of myoglobin precipitates in the kidneys resulting in AKI
- Infuse large amounts of fluid—urine output 3 ml/kg/hr
- Alkalization of the urine (ph 7.5-8.0)
  - Prevents myoglobin precipitation in the kidneys
  - Controls acidosis and hyperkalemia
- Mannitol
  - Improves renal blood flow
  - Prevents fluid accumulation in interstitial compartment (osmotic)
  - Free radical scavenger

Metabolic support

- Muscle necrosis in EHS can lead to cardiac dysrhythmias due to:
  - Hyperkalemia
  - Hypocalcemia
  - Hyperphosphatemia
- Renal dialysis may be necessary
- Hypertonic dextrose and bicarbonate may be used to shift potassium.
- Insulin may cause liver failure in EHS
- Calcium should be used judiciously
  - May cause more muscle damage
  - May be indicated with ventricular dysrhythmias

Hepatic Injury

- Common but usually reversible
- Elevations of transaminase levels and bilirubin
  - May result in hypoglycemia, coagulopathies, cerebral edema
  - DIC and ARDS
- Treatment
  - Dextrose
  - Replacement of clotting factors, FFP, Platelets
  - Meticulous Respiratory support
  - Immunomodulators
**Pulmonary Injury**
- Fluid overload
  - Aggressive fluid resuscitation
  - Renal failure
  - CHF
- ARDS
  - Heat induced pulmonary damage
  - Aspiration
- Treatment
  - Ventilation with PEEP

**Cardiovascular Injury**
- Myocardial muscle damage
  - Dysrhythmias
  - Cardiac Arrest
- Increased pulmonary hypertension
  - Right heart failure

**Renal Injury**
- Direct thermal injury
- Myoglobinuria
- Hypotension and shock
- Treatment
  - IV fluids
  - Diuretics (Mannitol is the diuretic of choice)
  - Correct acid base and electrolytes
  - Dialysis

**Prognosis**
- Delay in treatment increases mortality by 80%
- Mortality is highest among:
  - Elderly
  - Individuals with pre-existing conditions
  - Individuals confined to bed
  - Individuals who are socially isolated
  - Thermal maximum

**Prognosis**
- Poor prognosis
  - Initial temperature higher than 106 F 41 C
  - Unable to get the temperature below 102 F 39 C
  - Prolonged coma
  - Pulmonary edema
  - Prolonged hypotension
  - Lactic acidosis in patients with NEHS
  - Acute kidney injury and hyperkalemia
  - High levels of Aminotransferase

**Education**
- Media
- Public education
- School programs
- Athlete safety programs
Prevention

- Rehydrate on schedule
- Cooling breaks
- Frequent visits to air-conditioned places
- Limit alcohol and caffeine beverages
- Modify physical activity
- Fans alone are NOT adequate

You can prevent heatstroke!

References