Overview

• DEFINITION
• EPIDEMIOLOGY
• PATHOPHYSIOLOGY
• CLINICAL PRESENTATION
• DIAGNOSIS
• MANAGEMENT
• PREVENTION
LEARNING OBJECTIVES

• By the end of the presentation, the learner should be able to:

• 1. Recognize the signs and symptoms along the continuum of heat illness
• 2. Describe management protocols for severe cases of heat illness, primarily heat stroke
DEFINITION
Definition

- SPECTRUM
- Heat production/storage outpaces body’s ability to dissipate

Heat CRAMPS

Heat EXHAUSTION

HEAT STROKE
Heat

**PRODUCTION:**
- Muscle generated heat
- Intense exercise 15-20x more heat produced than at rest
- Can raise core temp 1°C every 5 min (if no heat is removed)

**DISSIPATION:**
- Evaporation
  - More efficient in acclimatized individuals
- Conduction
- Convection
- Radiation
Heat Exhaustion

• Physiologic exhaustion = inability to continue to exercise
• Heat exhaustion = exhaustion, often resulting in collapse, often in hot environment
  • Clumsiness, stumbling
  • Inability to walk
  • Extreme fatigue

• Interacting factors:
  • Decreased central activation (brain fatigue)
    • As cerebral temp \( \to 40^\circ \text{C} \), CBF decreases \( \to \) changes in brain wave activity and perceived exertion
  • Muscle fatigue (hyperthermia effect)
  • Energy store depletion
  • Electrolyte imbalance
  • Hydration status
Epidemiology

• True incidence? - limited data
  • Random, rare

• American football:
  • Fatal EHS incidence: 1/350,000 participants from 1995-2002
    • Roberts, WO; Physician in Sports Medicine; 2005
    • Often when air temp 26-30°C (78-86°F) and relative humidity 50-80%

• Running/long-distance endurance events
• Soccer, basketball, rugby
Epidemiology

- Can occur at any time, in any weather
- However, frequency correlates with wet bulb globe temperature

\[
\text{WBGT} = \text{Wet bulb temp} \times 0.7 + \text{Dry bulb} \times 0.1 + \text{Black bulb} \times 0.2
\]

Humidity + Air temp + Radiant heat
Epidemiology: Risk factors

**EXTRINSIC**
- Environment (hot, humid)
- Equipment, clothing
- Excessive exertion
  - Multiple, same-day sessions
  - Inadequate rest, access to fluids
- Medications
  - Anti-depressants, diuretics, antihistamines, amphetamines, anti-HTN
- Supplements/energy drinks
  - Caffeine, ephedra, alcohol

**INTRINSIC**
- Prior history heat illness
- Dehydration
- Illness, fever
- Lack of acclimatization
- Low fitness, sleep deprivation
- Increased BMI/obesity (>27 kg/m²)
- Sickle cell trait
- Spinal-cord injury
Environment

• Hot, humid = increased risk

• **Greatest risk for EHS:**
  • WBGT > 28°C (82°F)
    • Especially when relative humidity > 60%
  • High intensity (VO2max > 75%) exercise
  • Strenuous exercise > 1 hr duration

• **Risk increases when multiple stressors:**
  • Sudden increase training, vapor barrier clothing, sleep deprivation, inadequate hydration, poor nutrition, etc
Illness

- Athletes should not exercise in a hot environment if they have:
  - Fever
  - Respiratory infection
  - Diarrhea or vomiting

- Evidence:
  - 179 heat casualties @ 14 km race over 9 years
    - 23% reported h/o recent GI or respiratory illness
      - Richards et al, Medical Journal of Australia; 1979
  - 10 military patients with collapse
    - 3/10 had fever
    - 6/10 recalled symptom of illness
      - Armstrong et al; Medicine Science Sports Exercise; 1990
Lack of Acclimatization

• In American football, highest risk of EHS is in first 4 days of preseason practice
  • Hot, humid environment
  • Unfit, unacclimatized players
  • Vapor barrier equipment introduced before acclimatization
Dehydration

• Direct or indirect factor in HI
  • Reduces endurance performance,
  • Reduces time to exhaustion
  • Increases heat storage

• When fluid deficits > 3-5% BW, sweat production and cutaneous blood flow begin to decline

• Can have heat illness w/o dehydration and vice versa

• Exercise in 34-39°C at 40-50% VO₂max does not induce heat exhaustion unless dehydration present

• Combined effects of heat stress and dehydration reduce exercise capacity and performance to a greater degree than either alone
• **CRAMPS:**
  - Muscle fatigue
  - Body water loss
  - Sweat Na loss

• **EXHAUSTION/ EHS:**
  - Thermal threshold = 40°C
  - When cell temp rises > 40
    - Cell metabolism slows
    - Increased membrane permeability - can lead to release of intracellular contents
    - Acid-base disturbances

• **MULTI-ORGAN FAILURE IN EHS**
  - Cardiac -
    - Cardiac dysfunction/ insufficiency
  - GI -
    - Release lipopolysaccharide components of GN bacteria → endotoxic shock
  - Muscle -
    - Rhabdo
      - Myoglobin → RTA
      - K → Arrhythmias
  - Renal -
    - Renal failure
CLINICAL PRESENTATION / DIAGNOSIS
<table>
<thead>
<tr>
<th>Heat Stroke</th>
<th>Heat Exhaustion</th>
<th>Heat Cramps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental status changes (irritability, anxiety, confusion, disordered thoughts)</td>
<td>Headache, dizziness, nausea/vomiting, fatigue/weakness</td>
<td>Involuntary, painful muscle contractions during or after exercise</td>
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<tr>
<td>Heat Exhaustion</td>
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<tr>
<td><em>Heat cramps</em> +</td>
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<td><em>Convulsions</em></td>
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<tr>
<td>Heat Stroke</td>
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</tbody>
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Diagnosis: Based on symptoms

- High index of suspicion
  - Hot, humid weather
  - Cramping
  - Inability to compete
  - Mental status changes

- Rectal (core) temperature
Heat Cramps (EAMC)

• Incidence: tennis, football, distance running, skiing, skating

• **SYMPTOMS/SIGNS:**
  • Contracted, painful muscle groups
    • Legs, arms, abdomen
  • Most last 1-3 minutes
  • May last 6-8 hours
Heat Exhaustion

**SYMPTOMS**
- Not specific or sensitive
  - Pale, sweaty
  - HA, weakness, dizziness,
  - Heat sensation in neck, chills/ “gooseskin”
  - Nausea/vomiting/diarrhea, decreased coordination

**EXAM:**
- May have tachycardia, tachypnea and mild hypotension
Exertional Heat stroke (EHS)

Hyperthermia (core body temp > 40°C) + CNS disturbances / MS changes (disorientation, confusion, irrational/unusual behavior, inappropriate comments, apathy, impaired consciousness)

Multi-organ system failure - seizures - coma
MANAGEMENT
Heat Cramps (EAMC)

- Rest
- Prolonged stretch at muscle at full length
- Oral NaCl
  - 1-2 NaCl tablets in 300-500mL liquid
  - Foods

- If severe,
  - IV normal saline
  - IV benzodiazepines (to relieve muscle cramps)
Heat Exhaustion

- Move to cool area (shade, AC)
- Rest, supine position with legs elevated
- Remove excess clothing/equipment
- Monitor vitals and CNS status
  - Rectal temp may help:
    - If > 40 or cannot be accurately measured, treat as EHS (esp if MS changes)
- PO fluids
- If no improvement, should be transferred to ER
EHS

- Early recognition is key to survival!
- Rectal temperature
- Rapid cooling!
  - Cold water or ice water immersion
  - When cooling is rapid and body temp & cognitive function return to normal within an hour, most EHS patients recover fully - those who become lucid quickly have best prognosis
- Rule out other causes:
  - Hyopnatremia, hypoglycemia,
DISPOSITION

• EAMC:
  • If only cramps, could return same day or next day

• Exhaustion:
  • If no signs of CNS and recover well, can be sent home with family/friend
  • Can monitor fluid status at home (urine)
  • If severe, should f/u with physician

• EHS:
  • If identified and treated with ice water immersion, often recover fully and leave medical tent
  • If prolonged elevation of temperature, prolonged mental status changes, signs of MOF, transfer to tertiary care center
    • May need IVF, cardiac monitoring, medications (ie: dantrolene)
RTP after EAMC, exhaustion

- No evidence based guidelines on RTP after mild heat illness
- General guidelines:
  - If EMC,
    - Can likely return same day
  - If Exhaustion,
    - Can usually resume activities within 24-48 hours
    - Gradually increase exercise volume and intensity
RTP after EHS

- No evidence based guidelines on RTP after one episode EHS
- **General guidelines** (Casa & Armstrong, Exertional Heat Illness, 2003):
  - Refrain from exercise x min 7 days following release
  - F/U 1 wk for PE and labs
  - When cleared, begin exercise in cool environment and gradually increase intensity, duration, and heat exposure x 2 weeks
  - If RTP is difficult, consider laboratory exercise heat tolerance test (1 mo post-incident)
  - Clear if heat tolerance exists after 2-4 weeks of training
PREVENTION
ENVIROMENT

• Hydrate
  • Calculate individual sweat rate
  • Hydrate per ACSM guidelines
  • Salt losers may need supplemental NaCl
• Acclimatize
  • 10-14 days exercise training in the heat
Prevention

• ACTIVITY MODIFICATION
  • In high risk situations, modify or cancel activities
    • Unlimited fluid access
    • Longer or more frequent rest breaks
    • Shorter playing times
    • Less equipment
  • Look at WBGT
Prevention

• High index of suspicion
  • Unseasonably warm spring or fall days --> increase risk of heat illness due to lack of acclimatization
Thank you

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