MCoE and the Heat Center

Presents

4th Annual Heat Forum

McGinnis Wickham

12 Feb 2020
### TUE, 11 FEB

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>0800-0810</td>
<td>TRADOC VIDEO – MCoE Safety</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>0810-0820</td>
<td>OPENING REMARKS – COL VINCENT</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>0910-0940</td>
<td>KEY NOTE ADDRESS – Mr Ari Cowen, Assistant Athletic Trainer for the Atlanta Falcons</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>0950-1000</td>
<td>MOVEMENT TO ROUND ROBIN BREAKOUT ROOMS</td>
<td></td>
</tr>
</tbody>
</table>

*Breakout Rooms: W110, W120, W139*

### WED, 12 FEB

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>0800-0805</td>
<td>Clinicians &amp; Researchers Welcome – MAJ DeGroot</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>0820-0830</td>
<td>Exertional Collapse Associated with Sickle Cell Trait (ECAST) – COL Meyering</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>0915-0945</td>
<td>Heat Surveillance Explorer – Dr. White</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>0945-1010</td>
<td>Killer Heat in the USA – Dr Shana Udvardy (Union of Concerned Scientists)</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>1015-1045</td>
<td>Advances in Exertional Heat Stroke Treatment – CPT Konfe</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>1100-1120</td>
<td>Care of Acute Hyponatremia Patients – LTC Will</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>1120-1140</td>
<td>Within Season Distribution of Exertional Heat Illness – MAJ DeGroot</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>1140-1200</td>
<td>Update: Non-invasive Markers of Heat Related Illness During Rigorous Military Training – Ms Driver/Dr Buller</td>
<td>Marshall Auditorium</td>
</tr>
<tr>
<td>1200-1240</td>
<td>Title TBD-Mr. Montez</td>
<td>Marshall Auditorium</td>
</tr>
</tbody>
</table>

### Who’s Who in the Zoo

- **COL Vincent**: MCoE Chief of Staff
- **Ms. Jill Carlson**: Director MCoE Safety
- **MAJ DeGroot**: Director Heat Center
- **Mr Ari Cowen**: Assistant Athletic Training for the Atlanta Falcons
- **CPT Arnold**: Chief, Emergency Department, MACH
- **SSG Stine**: MCoE Surgeon Cell, 68W
- **LTC Will**: Deputy Commander for Clinical Services
- **COL Oh**: Chief, Department of Family Medicine | Director, Leader and Faculty Dev. Fellowship | Madigan Army Medical Center
- **MAJ Bury**: Madigan Army Medical Center
- **COL Meyering**: Command Surgeon, TRADOC
- **Dr. Maule**: Epidemiologist-Team CNSP contracted to the Defense Health Agency - US Army Satellite
- **Dr. Ambrose**: Armed Forces Health Surveillance Branch
- **CPT Konfe**: Martin Army Community Hospital
- **Dr. White**: Armed Forces Health Surveillance Branch (AFHSB)
- **Shana Udvardy**: Union of Concerned Scientists
- **Ms. Driver**: US Army Research Institute of Environmental Medicine (USARIEM)
- **Mr. Montez**: LA County Fire Department
Heat vs Non-Heat Related Rhabdomyolysis

COL Robert C. Oh, MD, MPH, CAQSM
MAJ David C. Bury, DO
Madigan Army Medical Center
• The views expressed are those of the author(s) and do not reflect the official policy of the Department of the Army, the Department of Defense or the U.S. Government.

• This research protocol was reviewed and approved by the Institutional Review Board of the Uniformed Services University in accordance with all applicable Federal regulations.

• The information contained herein reflects a work-in-progress and contains unpublished, unverified data and conclusions.
Introduction

When HEAT meets EXERTION

Photo credit: health.mil
Introduction

When HEAT meets EXERTION
Introduction

Pathophysiology
- Heat Injury
- Exertional Rhabdomyolysis

Risk Factors
- Creatine Kinase
- Electrolyte imbalance

Precipitating Events
- Length of Stay
- Readmission

Treatment
Specific Aims

1. Describe serum markers length of stay, and admission rates
2. Determine independent risk factors for length of stay
3. Compare exertional vs. heat-related
4. Identify appropriate discharge criteria
Methods

Design: retrospective cohort study of all active duty service members admitted for rhabdomyolysis

403 SM Admitted for Rhabdomyolysis

14 Insufficient Data

126 Exertional

232 Heat-Associated

31 Medical/Other
## Results

<table>
<thead>
<tr>
<th></th>
<th>Average Age</th>
<th>Length of Stay (days)</th>
<th>CK initial</th>
<th>CK max</th>
<th>CK min</th>
<th>Creatinine max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exertional</td>
<td>26.0</td>
<td>2.48</td>
<td>16,103</td>
<td>18,543</td>
<td>8,604</td>
<td>1.78</td>
</tr>
<tr>
<td>Heat-Associated</td>
<td>25.2</td>
<td>2.43</td>
<td>5,513</td>
<td>11,039</td>
<td>3,075</td>
<td>1.47</td>
</tr>
<tr>
<td>Medical/Other</td>
<td>24.4</td>
<td>3.68</td>
<td>7,636</td>
<td>10,413</td>
<td>4,797</td>
<td>1.41</td>
</tr>
</tbody>
</table>
• Preliminary analysis: rhabdomyolysis associated with heat injury can behave differently from rhabdomyolysis associated with exertion
  - CK trends
  - Renal function
  - Length of stay
  - Variations by age and rank

• Discharge criteria analysis limited due to lack of readmissions

• Ongoing analyses: independent risk factors for length of stay
Discussion

- Inpatient management
- Return to duty
- Further study
Exertional Collapse Associated with Sickle Cell Trait (ECAST); Preparation and Recognition to Prevent Catastrophic Consequences

COL Christopher Meyering, D.O.
Command Surgeon
U.S. Army Training Doctrine Command
Joint Base Langley Eustis
12 Feb 20
Agenda

• ECAST Video
• Sickle Cell Trait is Inherited
• Sickle Cell Trait vs. Sickle Cell Disease
• Exertional Collapse Associated with Sickle Cell Trait (ECAST)
• ECAST in U.S. Military Training
• ECAST vs. other Exertional Collapse
• ECAST Presentation
• Collapse Comparison
• Prevention and Treatment of ECAST
• Way Ahead
• SCT Sources and References
ECAST VIDEO

- Need to get video clip from Dr. O’Connor
Sickle Cell Trait is Inherited

Inherited condition

If both parents have SCT
- 50% of their kids will have SCT
- 25% of their kids won’t have SCT
- 25% of their kids will have sickle cell disease (SCD)

All newborns in the United States are now tested for SCD and SCT
Sickle cell disease (SCD) is a genetic condition that is present at birth where red blood cells become hard and sticky and look like the crescent-shaped tool.

Sickle cells die early and cause a constant shortage of red blood cells. In addition, sickle red blood cells get trapped in small vessels and clog blood flow.

Disqualifying condition limiting military Service

People who inherit one sickle cell gene and one normal gene have sickle cell trait (SCT). They have red blood cells that have normal hemoglobin and abnormal hemoglobin.
SCT is an inherited blood disorder that affects 1 to 3 million Americans. SCT is present in 8-10% of the African American population. **Anyone can have SCT**

- Most people with SCT do not have any health problems related to the condition

- ECAST **can be** an issue for athletes and military members
  - An **ASSOCIATION** has been linked to SCT but the **CAUSAL** mechanism(s) for several deaths are under investigation

- SCT **is not a disqualifier** for military enlistment
ECAST in U.S. Military Training

• **4 ECAST deaths** in the U.S. Navy since summer 2019 at Great Lakes Navy Training Facility

• **5 ECAST deaths** in U.S. Air Force since June 2018

• SCT is clearly associated with an increased relative risk of exercise-related sudden death in Service members. The risk of exercise-related death in Service members with SCT is about 40 times higher than those without SCT.
  • *Causal mechanism being investigated*

• The U.S. Army currently does not screen recruits, cadets, or trainees for SCT (policy under review)

• The Army has fortunately not had any ECAST incidents. Potentially attributed to prevention and response plans for other heat-related injuries.

• The Army focus has been on universal precaution measures
ECAST vs. Other Exertional Collapse

• **Sudden Cardiac Arrest (SCA)**
  • Generally abrupt with an **immediate loss of consciousness**, sometimes with brief seizure-like movements
  • Activate Emergency Medical Services (EMS), begin high-quality cardiopulmonary resuscitation (CPR), and deploy an Automatic Electronic Defibrillator (AED)

• **Exertional Heat Stroke**
  • Heat stroke has a similar progression to other heat related conditions
  • Hallmark that defines heat stroke is an **altered mental status** and an elevated temperature (may not be recorded before cooling measures begun)
ECAST Presentation

- May have been a front runner or off to a strong start, but will be noted to be slowing down, falling behind, and struggling

- Begins to lose smooth coordination, evolving into an awkward running posture and gait, with legs that may look wooden or wobbly (Bambi legs)

- May complain of progressive weakness, pain, cramping, or shortness of breath

- Lucid at first (conscious collapse) with progression to confusion and unconsciousness
  - Eventually death if treatment is not initiated

- Distinct from the cramping of exercise associated muscle cramping
  - Generally no visible muscle twitching and muscles do not "lock up"

- Muscle cramping pain is generally excruciating, whereas the predominant symptom of ECAST is weakness over pain.
### Collapse Comparison

Different presentations following service member collapse

<table>
<thead>
<tr>
<th>ECAST</th>
<th>EHS Exertional Heat Stroke</th>
<th>Acute Cardiac Event</th>
<th>Asthma/Respiratory Collapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conscious, can talk</td>
<td>Altered mental status</td>
<td>Unconscious</td>
<td>Breathless, anxious</td>
</tr>
<tr>
<td>Slumps to ground</td>
<td>Bizarre behavior</td>
<td>Sudden collapse</td>
<td>Prior episodes</td>
</tr>
<tr>
<td>Temp often &lt; 104°F</td>
<td>Temp often &gt; 104°F</td>
<td>Often normothermic</td>
<td>Auscultate – poor air movement</td>
</tr>
<tr>
<td>May have cramping muscles</td>
<td>May have cramping muscles</td>
<td>Muscles normal</td>
<td>Excessive use of respiratory muscles</td>
</tr>
<tr>
<td>No seizure activity</td>
<td>May have seizure activity</td>
<td>May have seizure activity</td>
<td>May have seizure activity</td>
</tr>
<tr>
<td>Occurs early in training</td>
<td>Occurs late in training</td>
<td>No warning</td>
<td>Usually after high intensity</td>
</tr>
</tbody>
</table>
Prevention and Treatment of ECAST

- Identify those personnel who are susceptible to heat conditions
- **ALL heat illness prevention methods** for all training events (e.g., proper hydration, nutrition intake and sleep/rest; adjust training event(s) time and uniform for heat category conditions, etc.)
- Rest often in between repetitive sets and drills
- Keep the body temperature cool when exercising in hot and humid temperatures by misting the body with water, arm-immersion, or use air conditioned area during breaks or rest periods
- Monitor Soldiers closely during intense training events; especially **timed events of significance** (e.g., Ranger, Sapper, EFMB, Army Combat Fitness Test – ACFT, etc.).
- **STOP ACTIVITY**
- Alert cadre and/or medic
- Activate EMS

*Continued exertion in both ECAST and heat stroke will eventually lead to collapse*

*Absence of prompt intervention can be life threatening!!*
Way Ahead for ECAST

- Continue employing heat illness prevention and treatment methods during training events
- Expand education/awareness and training of personnel
- Possible future identifying/testing of Army recruits and cadets
SCT Sources and References

Centers for Disease Control and Prevention:
https://www.cdc.gov/ncbddd/sicklecell/traits.html

Soldiers with SCT, first responders and medical personnel:
https://www.hprc-online.org/articles/sickle-cell-trait-awareness
Questions

COL Chris Meyering

Command Surgeon
U.S. Army Training Doctrine Command
Joint Base Langley Eustis
12 Feb 20
Surveillance of Heat Injuries in the Army Population using the Weather-related Injury Repository

Dr. Alexis Maule, Dr. John Ambrose, Ms. Julie Kebisek

Armed Forces Health Surveillance Branch
Army Satellite
The reporting of important preventable medical events has long been a cornerstone of public health surveillance rooted in international and national regulations to prevent the introduction, transmission, and spread of communicable diseases.
Timely, accurate reporting of probable, suspected, or confirmed cases ensures proper identification, treatment, control, and follow-up of cases.
The Disease Reporting System internet (DRSi) is a web-based system, designed to input and track disease within the Department of Defense.

DRSi is the main passive surveillance system used in the DoD for Reportable Medical Events (RMEs), to include heat and cold weather illnesses.

All Army, Air Force, and Navy military treatment facilities report RMEs to the DRSi.
Surveillance Case Definitions

• Surveillance case definitions establish **uniform, standardized criteria** for reporting RMEs across the DoD healthcare systems.

• Uniform criteria ensure the usefulness of surveillance data for analysis and interpretation, which affects policy change and public health action.

• The DoD case definitions are written using established case definitions from the Centers for Disease Control and Prevention, or other public health agency as needed. When an existing case definition cannot be adopted, a team of subject matter experts write the case definition according to the most recent science available.

• Medical diagnoses are often not a critical piece of a case definition.
Heat Illness Surveillance

- Rates of heat illness (heat exhaustion and heat stroke) have increased among the active component of the U.S. Armed Forces since 2014 (AFHSB, 2019).
- Weather-related injuries have been included as a reportable condition for Service Members since 2010.
- Armed Forces Reportable Medical Events
  - Heat exhaustion
  - Heat stroke
- A reportable medical event may not equate to a clinical diagnosis in all cases
  - *Ex*: A recruit may be treated for a heat-related illness, with a diagnosis of “Effects of heat and light”. If this recruit had a temperature $\geq 104^\circ$F and experienced loss of consciousness, that recruit would meet the DoD case definition for a confirmed heat stroke, even though the provider did not diagnose that recruit with heat stroke.
Heat Illness Surveillance
Case Definitions

• **Confirmed Heat Exhaustion**
  - A case that meets the clinical description of heat exhaustion occurring during/immediately after exertion or heat exposure with **ALL** of the following:
    • Core body temperature $>100.5^\circ F$ and $<104^\circ F$ **OR** evidence of elevated core body temperature if cooling was initiated in the field
    • And short-term physical collapse or debilitation occurring during or shortly after physical exertion that rapidly resolves with minimal cooling intervention
    • And **no evidence of CNS dysfunction** or only minor CNS symptoms (e.g., headache, dizziness) that rapidly resolves with minimal cooling intervention

(Armed Forces Reportable Medical Events Guidelines and Case Definitions, January 2020)
Heat Illness Surveillance
Case Definitions

• **Probable Heat Stroke**
  – A case that meets the clinical description of heat stroke occurring during/immediately after exertion or heat exposure with all of the following:
    • Evidence of elevated core body temperature (even if cooling was initiated in the field)
    • And CNS dysfunction (change in mental status, delirium, stupor, loss of consciousness or coma)

• **Confirmed Heat Stroke**
  – A case that meets the clinical description occurring during/immediately after exertion or heat exposure with all of the following:
    • Core body temperature $\geq 104^\circ$F
    • And CNS dysfunction (change in mental status, delirium, stupor, loss of consciousness or coma)

(Armed Forces Reportable Medical Events Guidelines and Case Definitions, January 2020)
Heat Illness

Did event occur during/immediately after exertion or heat exposure and require medical intervention or change in duty status?

No

Core body temp >100.5°F and < 104°F?

No

Core body temp >104°F

Yes

CNS dysfunction?

No

Not a case

Yes

Clinical evidence of CNS dysfunction?

No

Not a case

Yes

Short-term physical collapse or debilitation?

No

Not a case

Yes

PROBABLE Heat Stroke

No

CONFLICTED Heat Stroke

Yes

CONFLICTED Heat Exhaustion

When reporting in DRSi

- Specify type of illness (HS vs HE)
- Document the circumstances under which the case patient was exposed; i.e., duty exposure, occupational activities, environmental exposures, or other high risk activities
- Enter wet bulb globe temperature, if available
- Enter the core body temperature
Weather-related Injury Repository

- DHA Army Satellite established the Weather-Related Injury Repository (WRIR) to serve as a comprehensive surveillance system
  - Aims to identify additional cases that may not have been reported through the passive surveillance system (DRSi)
- Heat illness surveillance covers all Army service members during the period 1 January 2014 to present
Weather-related Injury Repository

• Primary function to provide timely and accurate heat illness surveillance for Army customers
  – Regular surveillance reports
  – Customized reports and requests for information
• Reports can be tailored by installation, time period, training population
WRIR Data Sources

Military Health System Data Repository

- Disease Reporting System internet
- Direct Care Records
- Purchased Care Records
- Inpatient Admissions and Outpatient Records
- Weather-Related Injury Repository

Army Training Data

In-Theater Medical Records
Heat Illness Case Definition

• Heat illness cases found in the medical data are defined using the March 2018 Armed Forces Health Surveillance Division case definition
  – One hospitalization or outpatient medical encounter with any of the case defining diagnoses in the primary or secondary diagnostic position
  – Or one record of a reportable medical event
  – An individual can be a heat illness case only once per calendar year
  – For individuals with more than one heat illness diagnosis in a calendar year, heat stroke is prioritized over heat exhaustion
**WRIR Capabilities & Product Examples**

- **TRADOC 2019 Annual Heat Illness Report**
  - Restricted to Army Active Duty and Active Guard/Reserve personnel
  - Data from the WRIR was used to identify heat illness cases (heat exhaustion and heat stroke)
  - Soldiers in training at the time of their illness were identified using Army Training Requirements and Resource System course rosters
    - Relevant course codes were identified by TRADOC Surgeon’s Office
Heat Illnesses at TRADOC Installations, 2014-2019

- Heat exhaustion
- Heat stroke
- TOTAL HEAT ILLNESS RATE

Number of cases vs. Rate (per 10,000 Soldiers)
Heat Illness Cases by Training Status, 2019

HE = heat exhaustion; HS = heat stroke
Heat Illness Counts by Training Course, 2019

<table>
<thead>
<tr>
<th>Training Course</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSUT – Infantryman</td>
<td>245</td>
</tr>
<tr>
<td>BCT</td>
<td>243</td>
</tr>
<tr>
<td>Airborne</td>
<td>45</td>
</tr>
<tr>
<td>OSUT – Calvary Scout</td>
<td>34</td>
</tr>
<tr>
<td>OSUT – Indirect Fire Infantryman</td>
<td>33</td>
</tr>
<tr>
<td>Infantry Basic Officer Leader - Branch</td>
<td>24</td>
</tr>
<tr>
<td>Ranger</td>
<td>21</td>
</tr>
<tr>
<td>OCS</td>
<td>12</td>
</tr>
<tr>
<td>Reception Battalion Attrition</td>
<td>12</td>
</tr>
<tr>
<td>Warrant Officer Candidate</td>
<td>12</td>
</tr>
<tr>
<td>OSUT – Armor Crewman</td>
<td>11</td>
</tr>
</tbody>
</table>

*The remaining courses had fewer than 10 HI cases in 2019*
Heat Illnesses, TRADOC YTD 2019

- <10
- 11 - 50
- 51 - 200
- >200

Prepared by APHC GIS Office
16 January 2020
• Questions?
• Contact Us
  – john.f.ambrose4.civ@mail.mil
  – alexis.l.maule.ctr@mail.mil
  – usarmy.apg.medcom-aphc.mbx.disease-epidemiologyprogram13@mail.mil
Advances in Exertional Heat Stroke Treatment

Early initiation of NAC to treat acute liver failure in severe heat strokes

CPT Audrie Konfe, MD
Objectives

- Literature review for non-acetaminophen induced ALF
- Proposed mechanism of NAC
- Trends identified at BMACH
  - Femoral cooling catheter
  - Early initiation of NAC
- Case series
- Proposed protocol
N-acetyl Cysteine for Non-Acetaminophen Induced ALF

• Review of Literature

NIH Public Access
Author Manuscript
Gastroenterology. Author manuscript; available in PMC 2011 October 9.
Published in final edited form as:

INTRAVENOUS N-ACETYL Cysteine IMPROVES TRANSPLANT-FREE SURVIVAL IN EARLY STAGE NON-AcETAMINOPHEN ACUTE LIVER FAILURE

WM Lee1, LS Hynan1, L Rossaro2, RJ Fontana3, RT Stravitz4, AM Larson5, TL Davern II6, NG Murray7, T McCashland8, JS Reisch1, PR Robuck9, and the Acute Liver Failure Study

MILITARY MEDICINE, 00, 00:01, 2019

N-Acetylcysteine (NAC) for the Prevention of Liver Failure in Heat Injury-Mediated Ischemic Hepatitis

LTC Joshua S. Will*; CPT Christopher J. Snyder, MD†; MAJ Katie L. Westerfield‡

Published online: 13 February 2017© Springer International Publishing Switzerland 2017
Mechanism of NAC

- Multi-organ dysfunction in ALF
  - oxidative stress (primarily generated by reactive oxygen and nitrogen)
  - inflammatory response mediated by specific cytokines
- Source of glutathione – free radical neutralization
- Source of sulfate
- Anti-inflammatory effects
- Inotropic effects
Historical Cases with Severe Acute Liver Failure

- Early rise in LFTs
- Early coagulopathy
- Outcomes
  - Fulminant DIC
  - Liver Transplant List
  - Death
# Summary of Historic Cases

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>18 M</td>
<td>39 M</td>
<td>25 M</td>
</tr>
<tr>
<td><strong>Training status</strong></td>
<td>BT</td>
<td>BT (week 3)</td>
<td>RASP</td>
</tr>
<tr>
<td><strong>Tmax in field</strong></td>
<td>108</td>
<td>108</td>
<td>107.9</td>
</tr>
<tr>
<td><strong>Temp on arrival to ED</strong></td>
<td>106</td>
<td>103</td>
<td>104.9</td>
</tr>
<tr>
<td><strong>Cooling Method</strong></td>
<td>Ice bath in field, ice sheet in ED</td>
<td>Ice Sheets, cooled saline</td>
<td>Ice sheets, cooled saline, Femoral cath</td>
</tr>
<tr>
<td><strong>Time to normothermia</strong></td>
<td>45 min</td>
<td>3 hours</td>
<td>45 min</td>
</tr>
<tr>
<td><strong>Duration of LOC</strong></td>
<td>Persistent</td>
<td>7 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td><strong>Intubation u</strong></td>
<td>3 days</td>
<td>2 days</td>
<td>2 days</td>
</tr>
<tr>
<td><strong>NAC started from TOI</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Max AST</strong></td>
<td>1646</td>
<td>9506</td>
<td>3857</td>
</tr>
<tr>
<td><strong>Max ALT</strong></td>
<td>1877</td>
<td>7259</td>
<td>3857</td>
</tr>
<tr>
<td><strong>Min platelets</strong></td>
<td>53</td>
<td>21</td>
<td>&lt;79</td>
</tr>
<tr>
<td><strong>Complications</strong></td>
<td>Cardiac arrest in ED- resuscitated</td>
<td>Troponin elevation, DIC --&gt; death</td>
<td>Fulminent ALF --&gt; On transplant list, recovered</td>
</tr>
</tbody>
</table>
### Summary of Case Series

<table>
<thead>
<tr>
<th></th>
<th>SM-A</th>
<th>SM-B</th>
<th>SM-C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>20 male</td>
<td>22 male</td>
<td>34 male</td>
</tr>
<tr>
<td><strong>Training status</strong></td>
<td>Day 1 of RASP</td>
<td>End of RASP</td>
<td>Ranger</td>
</tr>
<tr>
<td><strong>T_{\text{max}} \text{ in field}</strong></td>
<td>109°F</td>
<td>108°F</td>
<td>108.8°F</td>
</tr>
<tr>
<td><strong>Temp on arrival to ED</strong></td>
<td>108.8°F</td>
<td>106.6°F</td>
<td>102.2°F</td>
</tr>
<tr>
<td><strong>Cooling Method</strong></td>
<td>Ice sheets x 10 minutes, Femoral cooling cath, Bladder cooling</td>
<td>Ice sheets x 30 minutes, Peripheral IV iced saline, Femoral cooling cath</td>
<td>Ice sheets x 15 minutes, Peripheral IV iced saline</td>
</tr>
<tr>
<td><strong>Time to normothermia</strong></td>
<td>75 minutes</td>
<td>65 minutes (+ time down)</td>
<td>42 minutes (+ time down)</td>
</tr>
<tr>
<td><strong>Duration of LOC</strong></td>
<td>3-5 minutes</td>
<td>Unknown (found down)</td>
<td>Unknown (found down)</td>
</tr>
<tr>
<td><strong>Intubation</strong></td>
<td>6 hours (intubated in ED)</td>
<td>Total time 22h (intubated in ICU 75 minutes after injury)</td>
<td>Not intubated</td>
</tr>
<tr>
<td><strong>NAC started from TOI</strong></td>
<td>18 hours</td>
<td>24 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td><strong>Max AST</strong></td>
<td>1170</td>
<td>728</td>
<td>813</td>
</tr>
<tr>
<td><strong>Max ALT</strong></td>
<td>1174</td>
<td>654</td>
<td>737</td>
</tr>
<tr>
<td><strong>Min platelets</strong></td>
<td>46</td>
<td>93</td>
<td>121</td>
</tr>
<tr>
<td><strong>Complications</strong></td>
<td>Septic thrombus – MSSA bacteremia</td>
<td>Aspiration pneumonia</td>
<td>CK increase-possible mild compartment</td>
</tr>
</tbody>
</table>

Met discharge criteria from hepatic standpoint by HD 3
AST Trends
ALT Trends

Maneuver Center of Excellence - Team of Soldiers, Families, and Civilians from the Best Army in the World!
Liver Function Trends - INR

[Graph showing liver function trends over time with INR values at different time points.]

- SP
- MH
- AB

[Graph showing liver function trends with NAC controls.]
Liver Function Trends - Platelets
Current NAC Protocol

Protocol for the Inpatient Management of Exertional Heat Illness

Complete Initial Evaluation. Mental Status, HR, PE, CXR, Check CK, Chem30, UA, Urine electrolytes, LDH + Lactate, uric acid, PT/PTT/INR, troponin if/otherwise.

**Heat Stroke**
- High Risk: Continued (heat)
- CV circulatory
- MT + 2x SB
- Deep hypothermia
- Metabolic abnormalities
- Use normal intravascular fluids

**Heat Exhaustion, Syncope, Cramps**
- Low Risk: Mild elevation, mild cramps, no nausea
- No major circulatory
- No metabolic abnormalities

**Exertional Rhabdomyolysis**
- Low Risk: CV circulatory
- No major circulatory abnormalities
- No metabolic abnormalities

**Consider Discharge**
- UTI present + diaphoresis
- UTI present + diaphoresis + no hypothermia
- Electrolytes normal
- HR not requiring high volume IV
- Symptomatically improved
Current NAC Protocol

Hyperkalemia
- EKG then consider:
  - D50, Insulin
  - Inhaled β agonist
  - Calcium/Kayexalate

Severe or Symptomatic Electrolyte Abnormalities and/or Worsening Acute Renal Failure
- Consult Nephrologist For Possible Dialysis

Hypoxic hepatitis
- LFT’s triple in 24H AND Coagulopathy
- Consult GI and consider N-Acetyl Cysteine
## Current NAC Protocol

### Medications

<table>
<thead>
<tr>
<th>RE Start Time</th>
<th>Name</th>
<th>Dose</th>
<th>Route</th>
<th>Freq</th>
<th>V/O</th>
<th>R/B</th>
<th>MD Comment</th>
<th>Order Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 30 Jan 2020</td>
<td>ACETYLCYSTEINE-200MG/ML SOLN (IV)</td>
<td>150 mg/kg</td>
<td>INTRAVENOUS (IV)</td>
<td>STAT</td>
<td>N..</td>
<td>Mixed in 100mL DSW-give over 30 min</td>
<td>1014 30 Jan 2020</td>
<td></td>
</tr>
<tr>
<td>1000 30 Jan 2020</td>
<td>ACETYLCYSTEINE-200MG/ML SOLN (IV)</td>
<td>150 mg/kg</td>
<td>INTRAVENOUS (IV)</td>
<td>Q24 HRS</td>
<td>N..</td>
<td>Mixed in 300mL DSW-give over 24 hours</td>
<td>1015 30 Jan 2020</td>
<td></td>
</tr>
<tr>
<td>1000 30 Jan 2020</td>
<td>ACETYLCYSTEINE-200MG/ML SOLN (IV)</td>
<td>70 mg/kg</td>
<td>INTRAVENOUS (IV)</td>
<td>X1</td>
<td>N..</td>
<td>Mixed in 500mL DSW-give over 16 hours</td>
<td>1015 30 Jan 2020</td>
<td></td>
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<tr>
<td>1000 30 Jan 2020</td>
<td>ACETYLCYSTEINE-200MG/ML SOLN (IV)</td>
<td>70 mg/kg</td>
<td>INTRAVENOUS (IV)</td>
<td>X1</td>
<td>N..</td>
<td>Mixed in 500mL DSW-give over 4 hours</td>
<td>1015 30 Jan 2020</td>
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<td>ACETYLCYSTEINE-200MG/ML SOLN (IV)</td>
<td>150 mg/kg</td>
<td>INTRAVENOUS (IV)</td>
<td>STAT</td>
<td>N..</td>
<td>Mixed in 100mL DSW-give over 30 min</td>
<td>1015 30 Jan 2020</td>
<td></td>
</tr>
</tbody>
</table>

### Labs

<table>
<thead>
<tr>
<th>RE Start Time</th>
<th>Name</th>
<th>Freq</th>
<th>V/O</th>
<th>R/B</th>
<th>MD Comment</th>
<th>Order Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 30 Jan 2020</td>
<td>CBC</td>
<td>Q6HRS-S</td>
<td>N..</td>
<td>Pathology to perform peripheral smear review</td>
<td>1015 30 Jan 2020</td>
<td></td>
</tr>
<tr>
<td>1000 30 Jan 2020</td>
<td>COMPREHENSIVE METABOLIC PANEL (CMP)</td>
<td>Q6HRS-S</td>
<td>N..</td>
<td></td>
<td>1015 30 Jan 2020</td>
<td></td>
</tr>
<tr>
<td>1000 30 Jan 2020</td>
<td>PT/INR</td>
<td>Q6HRS-S</td>
<td>N..</td>
<td></td>
<td>1015 30 Jan 2020</td>
<td></td>
</tr>
<tr>
<td>1000 30 Jan 2020</td>
<td>RTT</td>
<td>Q6HRS-S</td>
<td>N..</td>
<td></td>
<td>1015 30 Jan 2020</td>
<td></td>
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</table>

### Treatments

<table>
<thead>
<tr>
<th>Name</th>
<th>Freq</th>
<th>MD Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notify MOD</td>
<td>STAT</td>
<td>N.. If patient develops following symptoms: fever (1°C increase in baseline temperature), chills, puritis, urticaria, respiratory distress, loss of consciousness, hyper/hypotension, fever, and headache. Call NAC MOD (12) and MOD (11)</td>
</tr>
<tr>
<td>Stop Transfusion</td>
<td>STAT</td>
<td>N.. Concern for transfusion reaction and call MOD (11)</td>
</tr>
<tr>
<td>Rapid Response Team</td>
<td>STAT</td>
<td>N.. RN/LVN to activate RTT</td>
</tr>
<tr>
<td>Vital Signs</td>
<td>Q1 HRS</td>
<td>N..</td>
</tr>
<tr>
<td>I&amp;O</td>
<td>Q1 HRS</td>
<td>N..</td>
</tr>
<tr>
<td>Obtain/Maintain Peripheral IV</td>
<td>X2</td>
<td>N.. Large (Greater than 18GU)</td>
</tr>
</tbody>
</table>
Call for Further Research

• Does initiation of NAC protocol within the first 24 hours of heat stroke-associated ALF improve clinical outcomes for Servicemembers?

• Possible outcomes
  – Severity of Injury
  – Hospital Length of Stay
  – Retention in Military
Acknowledgements

- LTC Joshua Will, DO
- MAJ Mary Noel, MD
- LTJG John Thompson, PA-C
- CPT Cordell Hachinsky, MD
- MAJ Juan Martinez Ross, MD
References

- Will JS, Snyder CJ, Westerfield KJ. N-Acetylcysteine (NAC) for the Prevention of Liver Failure in Heat Injury-Mediated Ischemic Hepatitis. Military Medicine, 00, 0/0:1, 2019
Questions??

Contact Info:
Audrie.I.Konfe.mil@mail.mil
Aggressive use of hypertonic saline in exercise-associated hyponatremia

JOSHUA WILL, DO
REBECCA DAVIS, MD
Definitions

- Hyponatremia: serum sodium below normal reference range (<135mmol/L)
  - ‘mild’ = 130-135mmol/l
  - ‘moderate’ = 125-129mmol/l
  - ‘severe’ = <125mmol/l
  - ‘acute’ = exists <48 hours
  - ‘chronic’ = exists for at least 48 hours
- Symptomatic
  - ‘moderate’ = presence of nausea without vomiting, confusion, headache
  - ‘severe’ = presence of vomiting, cardiorespiratory distress, Glasgow coma score < 8, seizures, deep somnolence
- Exertional hyponatremia: hyponatremia occurring during or up to 24 hours after exercise/physical activity
Presenting Overview

- 27 yo M Trainee presents via ambulance for episode of seizure activity in setting of severe hyponatremia and intake of >9L free water.

- PMHx: per AHLTA review, prior episode of hyponatremia in May 2019

- Meds: none

- Allergies: none

- Surgeries: none

- Family: non-pertinent

- Social (Relevant): Infrequent Alcohol, Denies tobacco, drugs
History of Presenting Illness: Prior to ER arrival

- ~1300 hours: Muscle pain and cramping
  - “getting smoked”
- 1830 hours -> RTB Aid Station
  - Istat Na = 123
    - A&Ox3
    - normothermic
    - No head injury
    - Oral rehydration tablet x 1; 750cc normal saline
- 2030 hours -> generalized tonic clonic seizure
  - No abortive agents needed
- Medic report: consumed three 3L camelbacks, unsure about canteen or other sources of fluid intake
History of Presenting Illness: At the ER

- **2049 hours:** Arrival to ER, A&Ox4
  - Serum Na = 125
  - Normothermic
  - Non-focal neurological examination
  - One 100cc hypertonic saline bolus administered at 2049 hours
- **2130 hours:** CT head -> mental status declines (obtunded)
  - Intraparechymal hemorrhage near left internal capsule
  - Non-surgical management
- **2140 hours:** one 100cc hypertonic saline administered
  - Begins to open eyes to verbal stimulus
- **2145 hours:** two 100cc hypertonic saline boluses administered
  - Mental status improves
    - Awake, follows simple commands, non-verbal
    - Istat Na persistently <130
- **2210:** 100cc hypertonic saline bolus administered
  - Awake, continues to follow commands, verbal
History of Presenting Illness: ICU

- 2326 hours: Admitted to ICU
- 0031 hours: +100cc hypertonic saline via peripheral intravenous line
  - Central line debate
  - Received total of 600ml hypertonic saline
- 0113 hours: Agitated, combative when urge to urinate was present -> sedation and rapid sequence intubation
  - Urine specific gravity = 1.003
  - Large volume dilute urine
- Sodium stabilized in the low to mid 130s without further hypertonic saline
- Extubated following morning
- Intact neurological function and mentation
- Total water intake: 18-20L
  - 4x Camelbaks (12L) + 4x Canteens (~8L)
Learning Points

- **Amount of hypertonic saline**
  - more than 300ml of hypertonic saline is safe
  - case report: 600ml hypertonic saline

- **Rate of correction and cerebral demyelination**
  - Animal data
  - Co-morbid factors
  - Extreme increases in serum sodium
    - >20mEq/L in 24 hours
  - Cerebral edema and herniation
    - Untreated patients

- **Route of administration**
  - Peripheral intravenous line vs central line
    - Phlebitis, regional necrosis
    - Short vs long term
Clinical Army Practice

- Improved training and SOPs
  - Identify symptomatic hyponatremia -> treat in the field/en route
    - Allowed to give more than 100ml bolus

- Expedited and ease of treatment
  - In the field; in the ER
  - Quicker treatment -> better outcomes

- Save money
  - Peripheral IV = ~$30-50
  - Central line = ~$1000

Decrease complications
References

Within-Season Distribution of Exertional Heat Illness in the US Army

David DeGroot, MAJ(P), MS
Director, FOA Heat Center

Robyn Martin, MPH
ORISE Contractor in support of APHC
Exertional Heat Illness risk is multi-factorial
- Environment
- Individual
- Mission-related

Anecdotally we know that EHI can occur any time of the year

‘Heat Season’ is generally considered to run 1 MAY- 30 SEP
- MCoE Reg 40-14 (2012) 1 MAY – 30 SEP
- 198th Infantry Brigade Brave and Bold Standards- ‘April to October’
Installations varying in several important ways
- Weather – New York vs Georgia
- Population – Initial Entry Training, cadre, FORSCOM
- Activity – PRT, testing for a school, field exercises

Research Questions
- Is the definition of the ‘Heat Season’ appropriate?
- How many EHI do we see outside the bounds of the Heat Season?
- How much between-installation variation is there?
Methods

- 10 Army bases with highest frequency of EHI were identified (2008-2012)
- EHI were defined as any medical encounter (primary or secondary diagnosis) with ICD-9 codes 992.0 through 992.9, inclusive
- Installation demographic data were obtained from the Defense Manpower Data Center and incidence per 1,000 soldier-months was calculated
- Piecewise regression was performed in order to determine the inflection points in the week-by-week EHI incidence rate that would suggest the start and end of the ‘heat season’
### Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Levels</th>
<th>Number</th>
<th>% of all EHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>5388</td>
<td>78.8</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1450</td>
<td>21.2</td>
</tr>
<tr>
<td>Age</td>
<td>&lt; 20</td>
<td>1674</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td>20-29</td>
<td>4073</td>
<td>59.6</td>
</tr>
<tr>
<td></td>
<td>30-39</td>
<td>895</td>
<td>13.1</td>
</tr>
<tr>
<td></td>
<td>40+</td>
<td>196</td>
<td>2.9</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td>White, non-Hispanic</td>
<td>3891</td>
<td>56.9</td>
</tr>
<tr>
<td></td>
<td>Black, non-Hispanic</td>
<td>1292</td>
<td>18.9</td>
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<tr>
<td></td>
<td>Hispanic</td>
<td>595</td>
<td>8.7</td>
</tr>
<tr>
<td></td>
<td>Asian/Pacific Islander</td>
<td>271</td>
<td>4.0</td>
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<tr>
<td></td>
<td>Unknown</td>
<td>789</td>
<td>11.5</td>
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<tr>
<td>Rank</td>
<td>E1-E4</td>
<td>5295</td>
<td>77.4</td>
</tr>
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<td></td>
<td>E5-E9</td>
<td>1005</td>
<td>14.7</td>
</tr>
<tr>
<td></td>
<td>O1-O5</td>
<td>517</td>
<td>7.6</td>
</tr>
<tr>
<td></td>
<td>O6-O10</td>
<td>2</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td>W1-W5</td>
<td>22</td>
<td>0.3</td>
</tr>
</tbody>
</table>

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Results

All 10 Installations

Rate of EH per 1,000 pm

Week

APHC Public Health Report WS.002479-15
Results

Ft Jackson

[Graph showing the rate of E.H. per 1000 pm from week 0 to week 50]

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Results

Ft Benning

APHC Public Health Report WS.0022479-15
Results

Ft Bragg

APHC Public Health Report WS.002479-15
Results

Ft Stewart

APHC Public Health Report WS.002479-15
Results

Ft Riley

APHC Public Health Report WS.002479-15
Results

Ft Hood

Rate of EHI per 1,000 pm

Week

APHC Public Health Report WS.002479-15
# Results

<table>
<thead>
<tr>
<th>Location</th>
<th>Heat Season Start</th>
<th>Heat Season End</th>
<th>% of EHI outside Heat Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ft Benning</td>
<td>15 APR</td>
<td>23 SEP</td>
<td>16.9</td>
</tr>
<tr>
<td>Ft Bragg</td>
<td>6 MAY</td>
<td>12 AUG</td>
<td>29.9</td>
</tr>
<tr>
<td>Ft Campbell</td>
<td>22 APR</td>
<td>2 SEP</td>
<td>13.6</td>
</tr>
<tr>
<td>Ft Hood</td>
<td>1 APR</td>
<td>23 SEP</td>
<td>17.7</td>
</tr>
<tr>
<td>Ft Jackson</td>
<td>15 APR</td>
<td>2 SEP</td>
<td>10.9</td>
</tr>
<tr>
<td>Ft Leonard Wood</td>
<td>6 MAY</td>
<td>2 SEP</td>
<td>7.4</td>
</tr>
<tr>
<td>Fort Polk</td>
<td>22 APR</td>
<td>9 SEP</td>
<td>10.1</td>
</tr>
<tr>
<td>Fort Riley</td>
<td>6 MAY</td>
<td>23 SEP</td>
<td>12.4</td>
</tr>
<tr>
<td>Ft Sill</td>
<td>6 MAY</td>
<td>16 SEP</td>
<td>4.7</td>
</tr>
<tr>
<td>Ft Stewart</td>
<td>8 APR</td>
<td>7 OCT</td>
<td>14.8</td>
</tr>
<tr>
<td>Overall</td>
<td>22 APR</td>
<td>9 SEP</td>
<td>17.7</td>
</tr>
</tbody>
</table>

APHC Public Health Report WS.0022479-15
Conclusions

• Is the definition of the ‘Heat Season’ appropriate?
  • Yes, we do not recommend revision
  • Expanding to earliest (Ft Hood) and latest (Ft Stewart) piecewise regression encompassed 88% of all EHI

• How many EHI do we see outside the bounds of the Heat Season?
  • 17.7% or 1 in every 6

• How much between-installation variation is there?
  • Ft Bragg: 70% within the Heat Season
  • Ft Sill: 95% within the Heat Season

• Key Takeaway Messages
  • Considerable between-installation variation
  • Risk of EHI is year-round
Exertional heat illness management using wearable sensors

Kyla Driver MSc & Mark Buller PhD  Biophysics and Biomedical Modeling Division  U.S. Army Research Institute of Environmental Medicine  mark.j.buller.civ@mail.mil

February 2020

The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views of the Army or the Department of Defense.
Wearable monitors could provide a means to assess exertional heat illness (EHI) risk

» Identify those at highest risk of heat illness
» Adjust tempo of training based on real-time risk of EHI
» Accurately measure physiology and gait of high risk events
» Capture data from heat injuries as they occur
» Use physiology and gait to develop accurate and actionable risk indicator
USARIEM Heat Study - Design

- Collaborative study:
  - Martin Army Community Hospital - Ft. Benning, GA
  - 75th Ranger Regiment RASP 1 and 2
  - Sapper School - Ft. Leonard Wood
  - Branch Health Clinic MCRD – Parris Island
- N>2100 male military trainees completing high risk training events:
  - 5 Mile Run, 12 Mile Ruck
- Objectives:
  - Capture Heat Injuries as they occur
    - N=6 Heat Strokes
  - Develop appropriate thresholds for assessing and managing risk for: Estimated Core Temperature and Heat Strain Index
  - Develop exertional heat injury prediction algorithms
• Estimates body core temperature from measures of heart rate
• Validate from >500 military subjects
• IV&V with Marines on Okinawa
• Licensed to Equivital, Zephyr,
• Used on Garmin Phoenix 5 for Best Warrior Competition
Algorithms: Accelerometry (Gait) – Wobble Index

For forward Axis

Side to Side Axis

Gait becomes chaotic

5 Seconds of 128Hz Accelerometry

<table>
<thead>
<tr>
<th></th>
<th>Predicted Heat Stroke</th>
<th>Predicted No EHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Heat Stroke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual No EHI</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mark Buller, PhD, mark.j.buller.civ@mail.mil
Real-Time Heat Injury Prevention Management / Data Collection

- **Heat Injury Prevention**
  75th Ranger Regiment (All RASP 1 and RASP 2 high risk events)
  Sapper School – Ft. Leonard Wood (All 12 Mile Ruck and FTX)

- **Heat Illness Management**
  MCRD – Parris Island Crucible
  MCRD – San Diego (Simple COTS buddy display)

- **Data Collection - Baselining**
  OSUT Ft. Benning
  Forge Ft. Leonard Wood

Mark J. Buller, PhD, Research Psychologist, mark.j.buller.civ@mail.mil

UNCLASSIFIED
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