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Heat Illnesses in the Emergency Department: A Hot Topic

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The Case

It is mid-August and you are working in a Midwestern urban, emergency department (ED) when J. B., a 15 year old, Caucasian male is received via ambulance with complaints of confusion, abdominal pain and vomiting. According to an adult who arrived with the patient, the patient had been running laps during late morning football drills when he began to complain of abdominal pain, which then progressed to vomiting. His coach became concerned when the patient looked flushed, felt hot to the touch and was dazed while lying on the locker room floor. Because the patient was not able to answer simple questions, 9-1-1 was called. The mother was notified about the patient's transport but has not yet arrived to the ED.

Upon arrival, J.B. has an 18-gauge IV infusing normal saline wide open. Paramedics have applied ice packs to his head, axilla and groin in response to an oral temperature of 40°C (104°F). A blood glucose obtained prior to arrival was 67 mg/dL. Vital signs are: rectal temperature 40° C (104°F), pulse 130 beats per minute and regular, blood pressure 100/60, and respirations 24 and non-labored. A copy of the patient's recent sports physical examination revealed no significant medical problems, a body mass index of 31, resting pulse of 72 and blood pressure of 128/68.

On presentation the patient is moaning and agitated. When questioned he complains of chest, abdominal, and back pain. He is oriented to person but not to situation or to time, is unable to provide any medical history information, is shivering, and vomits during the assessment. Physical exam findings include hot, moist, flushed skin with dry, red mucous membranes. Pupils are 4 mm, round, equal and reactive to light, sclerae are without icterus. Heart rate is regular and tachycardic without murmurs, gallops or rubs. Abdomen is round, soft, mild and diffusely tender with hyperactive bowel sounds. His neurological exam is grossly intact and non-focal but limited due to his inability to stand or comply consistently with commands. All other physical exam findings are normal for his age. An electrocardiogram (ECG) is obtained showing sinus tachycardia with a rate of 132, normal axis and intervals with no evidence of hypertrophy. Of concern is his febrile state and altered mental status. Differential diagnoses include: febrile illness, exertional hyponatremia, rhabdomyolysis, gastroenteritis, appendicitis, and heat illness, most worrisome, heat stroke vs. heat exhaustion. His work-up includes a complete blood count (CBC) to check for an elevated white blood cell count indicative of an infectious process, creatinine kinase to assess for exertional rhabdomyolysis, serum electrolytes to check for

sodium or potassium abnormalities and renal function, a urine drug screen because of his altered mental status, and a urinalysis to check for dehydration, hematuria and infection. Because of his elevated rectal temperature, cooling measures are continued, and he is medicated with lorazepam 1 mg IV to reduce shivering and the risk of seizure.

The patient's mother arrives within 30 minutes and states that the patient was feeling fine when he left to go to football practice. She adds that he is generally well but tested positive for sickle cell trait (SST) as a newborn. She adds that his pediatricians have advised that, although unusual in Caucasians, SST is generally a benign condition, unlike sickle cell disease (SCD), and does not preclude participating in sports activities. This morning prior to leaving for practice the patient drank a protein shake for breakfast and took a bottle of water to drink during practice. The mother adds that she has been a little worried about the team exercising outside during the past week given the recent heat wave. The air temperature at the time the patient was running laps was already 84°F (28.9°C) with a relative humidity of 85% and heat index of 96°F (35.6°C). This range is considered potentially dangerous for prolonged exposure or strenuous exercise by the American College of Sports Medicine (n.d.).

Research Article

Hess, J., Saha, S., & Luber, G. (2014). Summertime acute heat illness in U.S. emergency departments from 2006 through 2010: Analysis of a nationally representative sample. *Environmental Health Perspectives*, 122(11), 1209–1215.

Purpose/Methods

The purpose of this study was to examine rates of and factors associated with acute heat illness among ED patients. Using a representative sample from the Nationwide Emergency Department Sample (NEDS) and Census data, the authors analyzed the number and characteristics of patients presenting to the ED with any condition along the heat illness spectrum during the months of May through September between 2006 and 2010. Cases where acute heat illness was listed as a secondary diagnosis were also included in the sample.

The sample was analyzed using descriptive statistics to establish population-based rates of ED visits related to acute heat illness. Patient demographic factors included age, gender, comorbid conditions and insurance status. Data were further stratified by region of the country, including regional income averages and urban-rural classification. Rates of ED visits for acute heat illness were then correlated with extreme weather events. Extreme weather events were determined by first obtaining average daily maximal temperatures for each state from the National Oceanic and Atmospheric Administration (2015) for the study years and compared to 30-year baseline averages to identify temperature anomalies (Hess et al., 2014). The higher the anomaly value, the hotter the year, indicating an extreme weather event.

Logistic regression was used to identify the key factors related to acute heat illnesses (Hess et al., 2014). Logistic regression calculates odds ratios based on how strongly independent

predictor variables (key factors) are associated with a particular event (outcome variable; Polit & Beck, 2004). The primary outcome variables of interest for heat illness cases included in this study were ED disposition: treated and released, admitted to the hospital, or died in the ED. Predictor variables included demographics, diagnosis code, chronic disease index, county of residence, urban-rural designation, and insurance status. Finally, the authors examined case fatality rates (CFR), i.e., the number of deaths in patients with a diagnosis of heat illness divided by the total number of patients with a diagnosis of heat illnesses in the sample to compare the CFR for heat illness with that from other illnesses.

Results

The authors identified a total of 326,497 ED cases of acute heat illness from 2006–2010, indicating an average annual rate of 5/10,000 ED visits during the study months (Hess et al., 2014). Acute heat illness was the primary, first-listed diagnosis in 68% of cases. For those cases with a primary acute heat illness diagnosis, 74.7% were diagnosed with heat exhaustion and 5.4% with heat stroke. Patients with a primary heat illness diagnosis were twice as likely to be treated and released compared to those with a secondary diagnosis of acute heat illness (Hess et al., 2014). Treat-and-release rates were highest for patients 18–45 years of age. Rates of adverse outcomes (hospital admission or death in the ED) were highest among males, pediatric patients 18 years of age or younger, adults 65 years of age or older, and for those residing in the Midwest. Although it has been established that age can predispose a person to heat-related illness, this study found that extremes of age also affect the likelihood of hospital admission or death in the ED, which has not been previously documented in the literature. The authors also claim that, although heat illness rates are less than those of other clinical conditions, their analysis provides novel information that the CFR for heat stroke in the ED is twice that of the clinical disease category with the next highest CFR: neurological conditions (Hess et al., 2014).

Other factors associated with an increased risk of adverse heat illness outcomes included: residing in a low-income area, being uninsured and having a diagnosis of heat stroke (Hess et al., 2014). Chronic disease burden was also strongly associated with hospitalization or death in the ED for patients with any type of acute heat illness. Further, having a chronic hematologic condition was associated with a nine-fold increase in the odds of having an adverse outcome. Geographic regional analysis identified interesting regional differences. The highest overall rates of acute heat illness occurred in rural areas, the highest rates of hospital admissions and treat-and-release dispositions occurred in the South, and the highest rates of death in the ED occurred in the West. Not unexpectedly, there was a dose response relationship between exceptionally warm years and ED visit rates.

Conclusions

The authors (Hess et al., 2014) concluded that there are a substantial number of ED visits for heat illness in the U.S. each year, and the frequency of these presentations is correlated with extreme high heat weather events. Predictors of adverse outcomes include chronic disease burden, especially chronic hematological conditions, ages 18 years or younger or 65 years or older, male gender, living in low-income or rural areas, and residing in the West, South or

Midwest. Based on these findings, the authors suggest that analysis of ED visits across the acute heat illness spectrum may be a useful surveillance indicator of the impact of extreme weather events and heat illness burden. They assert that their data reinforces current evidence about the illness impact of extreme weather events and that these findings may help inform health policy, community education, and relief efforts to mitigate the adverse effects of climate change on public health.

Strengths/Limitations

Study strengths include the fact that this was the first in-depth analysis of factors associated with fatal and non-fatal acute heat illness, across the heat-illness continuum, using a national database of ED visits. Another strength is that the authors examined heat illness outcomes using a broad definition of heat illness, and by including chronic disease burden, they were able to better identify predictors of adverse outcomes irrespective of a heat-related diagnosis. Study limitations include those threats to validity consistent with retrospective study designs such as (1) selection bias influencing the diagnoses selected related to extreme weather conditions; and (2) missing data, such as comorbid conditions that may not have been included in the final diagnosis, that may have resulted in an over or underestimation of factors related to adverse heat related outcomes. Additionally, the authors did not analyze the costs associated with heat-related ED visits that may better inform the most cost-effective treatments for acute heat illness conditions.

Valerie's Perspective

As an emergency nurse practitioner student and researcher in the area of environment and occupational health, I find this article to be well executed with definite implications for practice. Heat illness occurs when the body's natural mechanisms for dissipating heat become overburdened. Heat is released from the body via evaporative cooling through perspiration through which fluid evaporates from the skin surface (Glazer, 2005). In hot environments that are also humid, the high water content of the air can make that evaporation of liquid from the skin's surface more difficult, resulting in a diminished ability to cool the body's core temperature (Howe & Boden, 2007). Heat sources include extrinsic sources from environmental heat exposure and intrinsic sources which includes a person's metabolic processes (Brotherhood, 2008). Thus, when treating heat illness, patients must be moved away from the environmental heat source to decrease metabolic heat. Hess et al.'s (2014) findings reinforce that heat exhaustion is the most common acute heat illness, and heat stroke is the most serious. Heat stroke occurs at body temperatures 40°C (104°F) or higher which can induce neurologic changes including encephalopathy, delirium, convulsions and coma, whereas normal mentation is maintained in cases of heat exhaustion (Becker & Stewart, 2011).

The information provided by Hess and colleagues (2014) is also pertinent because their findings support an association between sickle cell disease or trait and heat illness (Smith, Coyne, Smith & Mercier, 2003) by providing evidence of a markedly increased risk of heat illness in those with hematologic disease. Their findings also support that heat illness

differentials should be considered when caring for patients who are most vulnerable to heat illness including older adults and pediatric patients.

The mainstay of treatment for patients with heat illness in the ED is rapid cooling measures including the whole body or iced bath immersion (LoVecchio, 2011; Smith, 2005) until core body temperature is reduced to 38°C (100.4°F) (LoVecchio, 2011; Wexler, 2002). Upon discharge patients should be advised to avoid the heat, that acclimation to heat can take up to two weeks, and that exertion in the heat should be approached incrementally in order to help prevent future episodes (Binkley, Beckett, Casa, Kleiner & Plummer, 2002).

Only one other nationwide estimate of acute heat illness visits in the ED exists (Sanchez, 2010), and the findings of that analysis are consistent with Hess et al. (2014). These studies are also relevant as the data may improve how EDs are able to predict and plan for patient surges and increased utilization of the ED for acute heat illness during extreme weather events.

Dian's Perspective

I agree that Hess et al.'s (2014) study has important implications for practice for APRNs working in emergency and urgent care settings. Knowledge that extreme weather events are associated with an increased risk of non-exertional heat related illnesses should alert APRNs to consider heat-related diagnoses when triaging and evaluating patients, especially those known to be most vulnerable to hyperthermia. APRNs must maintain a high degree of suspicion for heat illnesses when otherwise healthy adults and adolescents present to the ED with fever, cramping, signs of dehydration and altered mentation during hot weather extremes. Hess et al.'s (2014) finding that individuals with hematological disorders have a nine-fold increased risk of having adverse outcomes from heat stress is not well known, suggesting that APRNs query all patients suspected of having a heat illness about a history of hematological disorders so that appropriate diagnostic studies and treatment can be promptly initiated.

Heat illness encompasses a continuum of conditions resulting from an imbalance and dysregulation of normal thermoregulatory processes (Lipman, et al., 2014). Classification of heat illness ranges from those with mild symptoms such as heat edema, heat rash and heat cramps to moderate severity conditions including heat tetany, heat syncope and heat exhaustion to heat stroke, the most severe condition characterized by an altered mental status and complete loss of thermoregulatory functioning leading to progressive multi-organ failure (Lipman, et al., 2014). Heat illness is further classified as non-exertional or exertional. Regardless of severity or cause, treatment of heat illnesses requires supportive care, rapid cooling (antipyretics are not effective), rehydration with oral or intravenous fluids, and use of benzodiazepines in severe cases to control shivering which increases core body temperature and the risk of seizures (Lipman, et al., 2014). Table 1 lists heat illness conditions by severity and the recommended treatment.

Another important consideration for APRNs working in emergency, urgent and school-based settings is that heat illness is the third leading cause of death and a major cause of disability among high school athletes in the United States, with football players being the

most affected (Coris, Ramirez & Van Durme, 2004; Gilchrist, et al. 2010). Risk factors for adverse outcomes from heat stress among high school athletes include obesity, inadequate hydration, exercising without acclimatization during the immediate summer pre-season period (Gilchrist, 2010), and having a hematological disorder such as sickle cell disease or sickle cell trait (SST) (American College of Sports Medicine, n.d.).

Although most common in blacks, SST also occurs in Hispanic, Asian and Caucasian populations; in fact, about 1.5% of infants in the U.S. are born with SST (Ojodu, Huilhan, Pope, & Grant, 2010). Individuals with SST are generally asymptomatic with no abnormal physical findings, they do not typically experience vaso-occlusive crises, and are not restricted from sports participation since serious medical problems resulting from sports are rare. However, exercising in extreme heat or at high altitudes (over 5,000 feet) can trigger a sickle cell crisis, rhabdomyolysis, splenic infarction, acute chest syndrome and exercise related sudden death in persons with either SCD or SST (American College of Sports Medicine, n.d.). Therefore, athletes with SST must be cautioned to avoid dehydration and to condition slowly before engaging in endurance exercise during extremes of heat and humidity to reduce their risk of adverse medical consequences (American College of Sports Medicine, n.d.). Educational resources for parents and their teenagers with SST can be accessed at the Sickle Cell Information Center (2011) and provided during healthcare visits. This resource also publishes clinical practice guidelines for clinicians to inform the care of patients with SCD or SST.

Case Revisited

Based on J.B.'s history of SST and the results of his physical examination, he was treated with a presumptive diagnosis of acute heat exhaustion vs. heat stroke. Cooling by ice bath was initiated with the awareness that rapid cooling can trigger red cell sickling and vasoconstriction leading to tissue hypoxia. To reduce these risks, supplemental oxygen was administered via a non-rebreather mask with continuous pulse oximetry monitoring. The IV rehydration solution was changed from normal saline to D₅½ normal saline, a hypotonic solution, which drives free water into red cells to reverse sickling (Platt, 2013). Emergency airway equipment was readied at the bedside in the event intubation was required. Cooling measures continued until the patient's core temperature reached 38 °C (100.4°F) at which time he became more alert and responsive. Morphine 4 mg and ondansetron 4 mg were administered IV for pain, nausea and vomiting, and a second dose of lorazepam 1 mg IV was administered to reduce shivering. Additional diagnostic studies included: a reticulocyte count since a sickle cell crisis stimulates reticulocyte production; an arterial blood gas and lactic acid to assess for acidosis and/or sepsis; a prothrombin (PT) and partial thromboplastin time (PTT) because hyperthermia can induce hypercoagulation; and a chest radiograph to assess for lung infarction secondary to acute chest syndrome.

Once stabilized, J.B. was transferred to the intensive care unit for close monitoring and continued supportive therapy. When he is ultimately discharged from the hospital, the discharge plan should include following up with hematology to monitor his CBC, PT, PTT and reticulocyte count to ensure his condition continues to improve and for recommendations regarding continuing with sports participation. He should also be

cautioned to avoid exercising in hot weather, to remain in a cool environment until rechecked by hematology, and of the importance of avoiding excessive fluid loss and maintaining adequate hydration when exercising (Eckman & Platt, 2010). Finally, he needs education about the conditions that can precipitate a sickle cell crisis and how to avoid and prevent future occurrences.

Summary

With the growing evidence of the health consequences of climate change and hot weather extremes, APRNs will likely see an increase in numbers of patients presenting with heat related illnesses. Therefore it is essential to be prepared to initiate prompt and appropriate treatment to obtain optimal clinical outcomes. Additionally, APRNs should be pro-active in educating patients during the summer months about how to prevent heat illness by maintaining adequate hydration and avoiding excessive heat exposure and prolonged exercise during hot weather.

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Table 1

Continuum of Heat Illness, Symptoms and Management. Adapted with permission from “Wilderness Medical Society practice guidelines for the prevention and treatment of heat-related illness: 2014 update,” by G. Lipman, K. Eifling, M. Ellis, G. Flavio, G. Gaudio, E. Otten, & C. Girssom, 2014, *Wilderness & Environmental Medicine*, 25, p. S59.

Conditions (From Mild to Severe)	Symptoms	Treatment
Heat rash “prickly heat”	Acute inflammatory erythematous, blanching, rash, may be pruritic	Move to a cool environment, apply cool compresses, cool bath and antihistamines as needed.
Heat edema	Mild swelling of hands and feet. May take days to improve.	Move to a cool environment, elevate extremities, remove constricting jewelry.
Heat cramps	Painful muscle cramps and spasms that can occur during physical activity or following exertion in a hot environment	Move to cool environment, hydrate with isotonic oral solutions containing electrolytes, consider salt replacement, analgesics. May need intravenous fluid resuscitation. Consider a creatine kinase to rule out rhabdomyolysis.
Heat tetany	Paresthesias, tingling, from hyperventilation	Move to cool environment, hydrate with isotonic oral solutions containing electrolytes, consider salt replacement, analgesics. May need intravenous fluid rehydration. Consider a creatine kinase to rule out rhabdomyolysis. Encourage slow deep breathing to reverse hyperventilation.
Heat syncope	Decreased vasomotor tone, dizziness, nausea, vomiting	Move to cool environment, hydrate with isotonic oral solutions containing electrolytes, consider salt replacement, analgesics. May need intravenous fluid rehydration. Consider a creatine kinase to rule out rhabdomyolysis. May require intravenous fluid resuscitation. Rule out other causes of syncope.
Heat exhaustion	Tachycardia, tachypnea, core temperature elevation, dehydration, may have elevated blood urea nitrogen, potassium and sodium abnormalities. Mental status will be normal.	Initiate rapid evaporative and convection cooling measures, administer benzodiazepines to control shivering, intravenous fluid rehydration, correct electrolyte abnormalities.
Heat stroke	Core temperature greater than 104°F (40°C), ALTERED MENTAL STATUS, tachycardia, tachypnea	Initiate rapid evaporative and convection cooling measures and airway, breathing and circulatory support, administer benzodiazepines to control shivering, intravenous fluid rehydration, correct any electrolyte abnormalities, assess for coagulopathy and end organ damage