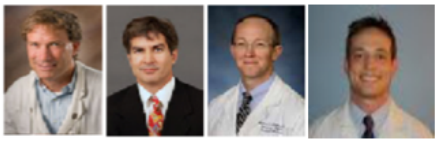
critical care perspectives in emergency medicine



Resuscitation & Management of the Patient with Heat Stroke

Key Article

- *Hifumi T, Kondo Y, Shimizu K, Miyake Y. Heat stroke. J Intensive Care. 2018;6:30.*

Patient Case

- 20 year-old male is brought to your emergency department after collapsing on a local football field during practice. He was in his 2nd workout of the day and approximately 1.5 hours in became unresponsive.
- On arrival his VS were: T: 105, HR: 145, BP: 85/45, RR: 28, SpO2: 96%
- Ultrasound: A quick RUSH exam shows an underfilled RV/LV, hyperdynamic LV, flat IV.
- Exam: He is obtunded, dry skin with cool extremities on exam
- Labs: are notable for a CPK of 200,000, Creat: 5, acute liver injury, and a K of 5.8
- CT head: No intracranial hemorrhage

Introduction

- In the US alone, there have been over 3,300 deaths attributed to heat stroke between 2006 and 2010 in the US.
- According to the CDC, approximately 650 deaths per year are directly the result of heat exposure.
    - Most frequent age group were ≥ 65 years old
    - Most often occur in urban areas
- Outcomes are poor
    - 28-day mortality is up to 60%
    - Permanent neurologic deficit up to 15%

Definition & Classification

- Traditional Definition of Heat Stroke:
    - Core body temp > 40 °C
    - Hot, **dry skin** – patients with heat "exhaustion" will still sweat and have no organ dysfunction
    - CNS abnormalities (Delirium, seizure, coma)
- In Japan, alternative definition proposed as several fatal cases of heat stroke presented without a core temp > 40!
    - Patients exposed to high environmental temperature who met one or more of the following criteria:
        - Central nervous system manifestation (GCS < 14, cerebellar symptoms, convulsions, or seizures);
        - Hepatic/renal dysfunction (Creat or total bili > 1.2)
        - Coagulation disorder [diagnosed as disseminated intravascular coagulation (DIC)]

- Can result from environmental temp exposure *or* strenuous exercise

Features	Classic	Exertional
Common		
Hyperthermia	> 40°C	> 40°C
Central nervous system alteration	Delirium, convulsion	Delirium, convulsion
Hypotension	20%–30%	Unknown
Distinctive		
Age	Elderly	Young
Skin	**Hot, dry**	**Hot, profuse sweating**
Rhabdomyolysis	Mild/moderate	Severe
Renal failure	Uncommon	Common
Lactic acidosis	Mild/moderate	Severe
Glycemia	Hyperglycemia	Hypoglycemia
Disseminated intravascular coagulation	Mild/moderate	Severe

Adapted from Bouchama et al. Cooling and hemodynamic management in heatstroke: practical recommendations. *Critical Care.* 200711:R54

Why does this happen?

- **Thermoregulation**: As the body temp increases, cutaneous vasodilation leads to sweating and volume loss. Over time, if not addressed, visceral perfusion is shunted to the skin resulting in organ failure.
    - Observational studies suggest that the critical thermal maximum in humans is a body temperature of 41.6°C to 42°C can be tolerated for 45 minutes to 8 hours
    - At extreme temperatures (49°C - 50°C), all cellular structures are destroyed and cellular necrosis occurs in less than five minutes.
- **Endotoxin leakage**: With excessive heat exposure and organ injury, gut endotoxins are released into systematic circulation causing a worsening SIRS response.
- **Capillary microthombosis**: Caused by endothelial injury where platelet activation, thrombocytopenia from platelet consumption, and eventual DIC.
- **Acute circulatory failure**: Occurs in 20 – 65% of patients**.** Largely occurs from overt hypovolemia, blood flow shunting toward the periphery, and microthrombosis.
- **Beware in athletes**
    - Stimulants (amphetamines, ephedra, methylphenidate, etc.) can increase the brain's "set point" and place athletes at higher risk for hyperthermia.
    - Ephedra may increase risk by activation of dopaminergic receptors and impairing heat dissipation through vasoconstriction.

Initial Resuscitation & Treatment

- **Target:** If evidence of true end-organ dysfunction, use active cooling methods to get temp below 40 °C ASAP; Can usually be discontinued once temp 38 - 39 °C
- **Methods of cooling** – none have been proven superior than the other in terms of outcomes,
    - Evaporation: Cold water blankets, fans, etc.
    - Bladder lavage, rectal lavage, gastric lavage
    - Intravascular cooling systems or cold IV fluids
    - Surface cooling systems (Gaymar, Arctic Sun – 2 commercial brands)
    - Ice water immersion (water temp of 2-15 C)
        - If started within 10 minutes of the onset of exertional heatstroke, mortality can be significantly reduced.
        - May not be well tolerated if pt is altered
        - Can produce a 0.5 ° C lowering of body temperature in the first 3 minutes
- **General pharmacologic therapy**
    - Dantrolene, Tylenol, other antipyretics are *not recommended* as they do not appear to be useful and may exacerbate organ injury.
    - Can consider benzodiazepines for seizures and shivering.
- **CNS dysfunction**
    - Patients with seizures and AMS unlikely to benefit from antiepileptic therapies
    - Can consider continuous EEG, however literature suggests that neuro dysfunction secondary to metabolic disturbance – not epileptic seizures
- **Cardiovascular dysfunction & Hemodynamic management**
    - Hypotension more often a *distributive* form of shock
    - Hemodynamic profile similar to sepsis
    - Start with balanced fluid resuscitation to perfusion-based end-points
    - Pay particular attention to volume resuscitation if concomitant rhabdomyolysis is present
- **Renal dysfunction**
    - May benefit patient beyond clearance of CPK in rhabdomyolysis
    - Early continuous renal replacement therapy (CRRT) has been reported a significantly lower 30d mortality in observational study (15% vs. 45%) (Chen, 2015)
    - Additional benefit of CRRT is the availability to rapidly cool patient as machines often can be set to blood temp.
- **Hepatic dysfunction and failure**
    - Excessive temperatures can cause hepatic necrosis
    - Extracorporeal liver therapy (MARS, ELAD, etc.): Unclear if any benefit, but may be able to provide temporizing bridge to liver transplantation.

Selected References

1. Bouchama A, Knochel JP. Heat stroke. N Engl J Med. 2002;346:1978–88.
2. Hifumi T, Kondo Y, Shimizu K, Miyake Y. Heat stroke. J Intensive Care. 2018;6:30.
3. Chen GM, Chen YH, Zhang W, Yu Y, Chen JH, Chen J. Therapy of severe heatshock in combination with multiple organ dysfunction with continuous renal replacement therapy: a clinical study. Medicine (Baltimore). 2015;94:e1212.