

Heat stroke and heat exhaustion – An update

Edited by Gopinath K. Gopal, Associate Professor of Geriatrics, CMC, Vellore

Heat related illnesses are an important cause of death and morbidity in a tropical country like India. The current heat wave has contributed to about 1600 deaths, most of them from the states of Andhra Pradesh and Telangana (this may be an underestimate according to some sources). Manual labourers, children and the elderly are particularly susceptible. Most heat-related illnesses are preventable if proper precautions are taken and deaths can be avoided if the condition is suspected early and managed with rapid cooling and supportive measures. Heat-related illnesses are part of a continuum with heat cramps, heat exhaustion, heat syncope and heat stroke in ascending order of severity. Heat stroke, the most severe form, which is characterized by neurological symptoms, if not managed efficiently, can lead to a series of metabolic events ending in multi-organ failure, coagulopathy and death. Heat exhaustion is milder and more common than heat stroke and does not manifest neurological symptoms.

TYPES OF HEAT RELATED ILLNESSES

Heat stroke:

Heat stroke is an illness caused by failure of thermoregulation with elevation of core temperature to 40°C (104°F) or more, associated with central nervous system dysfunction. Heat stroke may be categorized as exertional and non-exertional.

Non-exertional (Classic): This type of heat stroke usually affects the very young or elderly, particularly during heat waves. Young children are susceptible because of their high surface-to-volume ratio, relatively inefficient sweat glands and dependent status. The elderly, especially those who have physical disability, living in ill-ventilated rooms, those with cardiovascular diseases, dementia etc are particularly susceptible. The use of medications like anticholinergics, anti-parkinsonian drugs, alcohol and diuretics predispose to heat strokes. Patients with classic heat stroke usually respond slowly to treatment and require hospital admission.

Exertional heat stroke: This occurs in individuals exercising at warm temperatures and/or humidity. It mainly strikes manual labourers, soldiers in training and athletic competitors. Exertional heat stroke may occur at moderate temperature, especially if humidity is high. Even in healthy individuals, dehydration or the use of common medications (e.g., antihistamines with anti-cholinergic side effects) may precipitate heat stroke.

KEY POINTS

- Heat exhaustion is the milder and more common heat related illness.
- Heat stroke is characterized by high temperatures (>104°F) and neurological dysfunction.
- Immediate cooling is the most important intervention in the management of heat stroke. Evaporative cooling is the easiest and most effective method in classical heat stroke while cold water immersion is very helpful in exertional heat stroke.
- Management of heat stroke includes: stabilization of ABC, cooling measures, management of dehydration and hypotension, renal function monitoring, prevention and management of complications.
- Investigations and other interventions should not be done at the expense of initiation of cooling measures.

DIAGNOSIS OF HEAT STROKE

Diagnosis is clinical

History of exposure to hot environment

+

Elevated core temperature

+

Neurological symptoms/signs

MANAGEMENT OF HEAT STROKE – Key points

1. Remove patient from the hot area and transfer to a cool room immediately.
2. Initiate cooling measures immediately. Investigations should not be at the expense of cooling the patient.
3. Supportive treatment – manage dehydration, blood pressure, urine output, cardiovascular function, coagulopathy, seizures.

Box 1: Initial Investigations

Blood:

- Serum hemoglobin, electrolytes, creatinine,
- coagulation parameters (PT, APTT, Platelet count),
- Creatine Kinase, Liver function tests, Blood culture,
- Test for Malarial parasite, Dengue etc. according to geographical area

Radiological:

- Chest x-ray to look for ARDS,
- ultrasound abdomen if clinically indicated to rule out infections

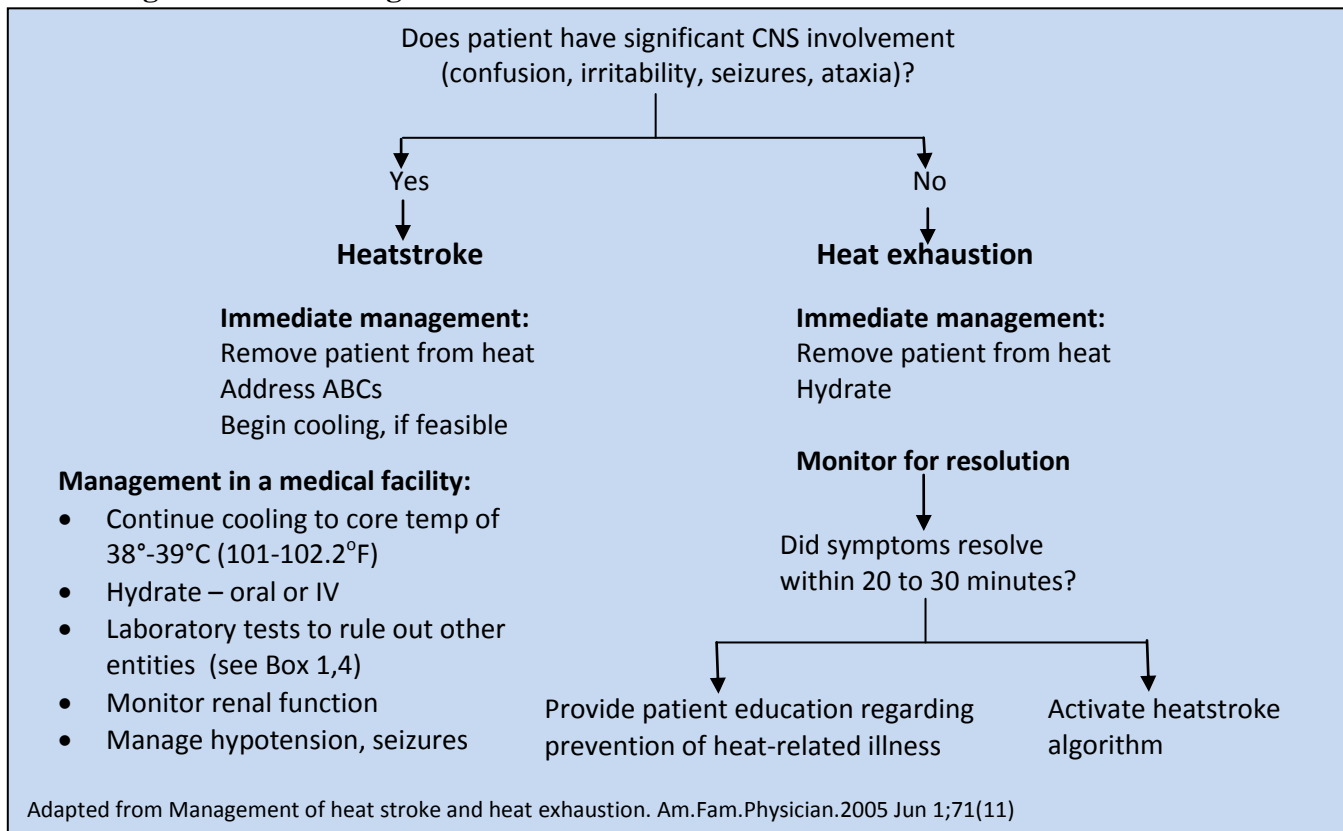
Box 2: Anti-convulsant therapy for immediate seizure control

IV Lorazepam- up to 0.1 mg/kg (4 mg, repeat 2mg after 5-10 mins in adults if necessary)

or

IV Diazepam up to 0.25–0.4 mg/kg (5mg, repeat 5mg after 5-10 mins in adults if necessary)

Box 3: Algorithm for management of heat stroke and heat exhaustion ⁽³⁾



Heat exhaustion:

Heat exhaustion is a more common and milder manifestation of heat-related illness in which the core temperature is between 37°C (98.6°F) and 40°C. Patients usually present with excessive sweating, dizziness, thirst, weakness, headache, and malaise and on clinical examination have tachycardia. Patients with heat exhaustion do not present with the symptoms of central nervous system derangement found in those with heatstroke. Their symptoms typically resolve promptly with proper hydration and cooling.

PATHOPHYSIOLOGY

Excessive heat is a noxious agent that causes direct cell-injury. Conduction, convection, radiation and evaporation are the means by which excess body heat is exchanged with the environment. Of these, evaporation through perspiration is the body’s most effective method of cooling under most circumstances. This heat exchange becomes less efficient with increase in the ambient temperature and moisture content. Thus hot, humid weather confers the highest risk of heat injury as it impairs

cooling by evaporation. Normally, the body generally adapts to a hot environment over several days using mechanisms like salt retention and increased fluid secretion through the sweat glands, increased circulating plasma volume and enhanced glomerular filtration rate. Heat stroke and heat exhaustion occur when these thermoregulatory mechanisms are inadequate or overwhelmed.

Exercise lowers the thermal threshold for heat stroke as blood flow is directed away from organs to active muscles and skeletal systems. Gut ischemia occurs as a result of this shunting of blood. This, along with a complex interplay of factors like cytokines, bacterial polysaccharides and heat shock proteins results in activation of the coagulation pathway and vascular dilation resulting in complications like hypotension and disseminated intravascular coagulation.

Because the brain is extremely sensitive to heat stress, the first signs of heat stroke are neurologic. Medications such as vasoconstrictors and beta blockers can profoundly impact thermoregulation by decreasing the body’s ability to shunt large volumes of hyperthermic blood away from the core and to the skin.

Table 1: **Diagnosis, symptoms and signs of heat stroke and heat exhaustion**

	Heat stroke	Heat exhaustion
Diagnosis	1. Temperature – 40°C (104°F) 2. Central nervous system abnormalities (see below)	Temperature – 37 – 40° C History of exposure to hot environments and generalized signs and symptoms
Symptoms and signs	CNS: anxiety, confusion, agitation, altered consciousness/coma, headache, seizures, ataxia Others: Nausea, fatigue, malaise Hot dry skin, dry tongue, sunken eyes, tachycardia, Reduced urine output, Complications: Hypotension, shock Pulmonary crepitations, Bleeding from multiple sites (epistaxis, intravenous site etc.) Signs of hepatic failure, renal failure, rhabdomyolysis	Nausea, fatigue, malaise, headache Decreased urine output, excessive sweating Anxiety and agitation may be seen. Dehydration may be seen.

CLINICAL FEATURES

Heat exhaustion:

Heat exhaustion is the milder form of heat-related illness. Persons with heat exhaustion usually have a history of exposure to hot environments with some form of exertion (exercise or work). They may present with nonspecific signs and symptoms like nausea and malaise, mild pyrexia and features of circulatory collapse. Signs of dehydration may or may not be present. Oliguria is an important indicator of dehydration. Anxiety and agitation may be seen but symptoms of profound central nervous system dysfunction are absent. (See Table 1 for common signs and symptoms)

Heat stroke:

Heat stroke is the more severe and dangerous form of heat-related illness. The diagnosis is clinical and is based on two features: an elevated core body temperature (generally $>40^{\circ}\text{C}$ [104°F]) and central nervous system dysfunction. Signs of central nervous system dysfunction are essential to the diagnosis of heatstroke. Judgment is impaired leading to confusion, irritability and agitation. Seizures, coma and ataxia are seen in severe cases.

Other systemic abnormalities on examination include tachycardia, tachypnea, hypotension, features of dehydration, oliguria, and pulmonary crepitations. Core body temperature (rectal) readings are more reliable than other peripheral temperatures. Seizures may occur and must be treated immediately. A history of prodromal symptoms like dizziness, nausea and malaise should be sought and information about medications that predispose to heat stroke must be obtained. Bleeding

Box 4: Differential Diagnosis of Hyperthermia and Mental Status Changes

Environmental – Heat stroke, heat exhaustion
 Infections – Sepsis, meningitis, encephalitis, malaria
 Endocrine – Hyperthyroid storm, Pheochromocytoma
 Neuroleptic malignant syndrome
 Drugs and toxins – anti-cholinergic poisoning, Salicylate poisoning, alcohol withdrawal, Malignant hyperthermia

Box 5: Medications and other agents that can predispose to heat stroke

Anti-cholinergics
 Anti-histamines
 Benzodiazepines
 Alcohol
 Anti hypertensives: Beta blockers, calcium channel blockers
 Diuretics
 Phenothiazines
 Thyroid agonists
 Tricyclic antidepressants

from intravenous sites and epistaxis are indicative of consumptive coagulopathy. Pulmonary crackles may be present and indicate non cardiogenic pulmonary oedema.

MANAGEMENT OF HEAT STROKE

Heat stroke is a medical emergency and if not treated immediately can result in complications and death.

The two important principles in management of heat stroke are

1. Lower core temperature (measured using a rectal thermometer ideally) immediately to 38.9°C (102.2°F)
2. Support organ systems injured by heat, hypotension, inflammation and coagulopathy

Treatment initiated in the first '**golden hour**' after the onset of heat stroke can be extremely effective.

TREATMENT OUTSIDE HOSPITAL

- Remove patient to a shaded area
- Remove clothes
- Cover patient with water or water wipe with a soaked cloth and use a fan to aid evaporation. If possible, immerse in a shallow tub of water with head, arms and legs outside the tub.
- Seek medical attention as soon as possible

IN-HOSPITAL TREATMENT

1. **Assess and stabilize airway, breathing and circulation.** Insert intravenous line to initiate fluid resuscitation and to collect blood samples. (Box 3)
2. **Initiate immediate cooling**
Initiate immediate cooling by evaporation - spray patient with water or place water soaked thin gauze pads all over the person's body and position under a fan to aid in evaporation(Evaporative cooling) is an effective method in classical heat stroke. In exertional heat stroke, Immersion therapy in ice water is well tolerated and should be offered if available.
In exertional heat stroke, temperatures must be measured every 5-10 minutes till temperature reaches 101 to 102.2° F (38.3 to 38.9° C) after which cooling measures are stopped to prevent "overshoot" hypothermia. In non exertional (classical) heat stroke, the goal temperature is 100 to 102°F. Keep the patient in an air-conditioned room if available. Applying ice packs to the axillas, groin, trunk can be useful.
3. **Hydration** – Normal Saline or Ringer's Lactate are the preferred crystalloids. Most patients need 1 liter in the first hour. Further rehydration needs to be guided by estimated water losses. Over-hydration may promote cerebral oedema, pulmonary edema and hyponatremia. A central venous line may be useful both to hydrate patients as well as assess hydration.
4. **Seizures** – Manage with diazepam or Lorazepam. Consider starting phenytoin if seizures do not cease. (See box 2 For dosage)
5. **Hypotension** – must be treated with volume expansion using IV fluids. An adult will need at least one liter of fluid in the first hour. After this, fluid requirements should be titrated according to fluid deficit and serum electrolyte levels. If blood pressure is persistently low, appropriate vasopressor support may be needed.
6. **Agitated delirium:** Short acting benzodiazepines such as Midazolam (2.5mg-5mg) can be given.
7. **Antipyretic therapy:** Medications to reduce temperature such as paracetamol are not useful because the hypothalamic thermostat is not reset in these patients. Moreover, these drugs may be harmful and precipitate liver and renal dysfunction.
8. **Antibiotics:** It is prudent to consider broad spectrum antibiotics pending blood cultures in older patients with hyperthermia if infection is a possible etiology.

COMPLICATIONS

- Seizures
- Hypotension
- Disseminated intravascular coagulation–This is a result of consumptive coagulopathy and presents with bleeding from multiple sites.
- Adult respiratory distress syndrome
- Renal failure – May require hemodialysis
- Rhabdomyolysis – Volume depletion, renal injury and muscle injury can lead to rhabdomyolysis. It presents with myoglobinuria.
- Multi-organ failure

Box 6: **Monitoring**

Temperature: Check temperature every 10 minutes in the first 2 hours. Stop cooling measures if temperature reaches 102°F to avoid overshoot hypothermia.

Blood pressure: Measure BP every 15-30 minutes in the first hour. If blood pressure is persistently low, consider using pressor support.

GCS score, Breathing and airway: Noisy breathing is the hallmark of compromised airway in a patient with poor level of consciousness. Consider airway protection interventions in such situations.

Serum electrolytes, creatinine: At least once a day. Sodium levels are an indicator of hydration status. Avoid hyponatremia at all costs. Potassium and creatinine levels may be deranged in renal failure.

Coagulation parameters: PT, APTT and serum Fibrinogen for the first three days to monitor for DIC.

A note on heat cramps and heat syncope

Heat cramps

Heat cramps usually occur in individuals like athletes who exercise in hot, humid weather. Being the least serious of the heat related illnesses, they present as involuntary muscle spasms of the large muscles such as calf, hamstrings, arms etc. The body temperature may be normal or mildly elevated. Treatment involves removal to a cool area, stretching of muscles, rest and oral rehydration with water and salt supplementation.

Heat syncope

Heat syncope can be described as a transient loss or near-loss of consciousness due to the indirect effects of high temperature. It usually occurs in the first few days that someone is exposed to high environmental temperatures. In heat syncope, venous return suddenly reduces due to cessation of muscle activity abruptly causing drop in blood pressure leading to lightheadedness and syncope. Other signs and symptoms associated with these forms of heat syncope include tunnel vision, pale and sweaty skin, and decreased pulse rate. This is usually self-limiting and patients generally recover rapidly with removal to a cool environment and oral rehydration with salt supplementation.

Sources:

1. Disturbances due to heat. John F. Coyle. Conn's Current Therapy 2013 (Bope, Kellerman) 2013, Elsevier, Saunders.
2. Fever and hyperthermia, Charles A. Dinarello, ReuvenPorat. Harrison's Principles of Internal Medicine, 18th Edition, Longo, McGraw Hill.
3. James L Glazer. Management of heat stroke and heat exhaustion. Am Fam Physician. 2005 Jun 1;71(11):2133-2140
4. Lee-Chiong TL Jr, Stitt JT. Heatstroke and other heat-related illnesses. The maladies of summer. Postgrad Med. 1995;98:26-8,31-3,36
