

# Everyday Practice

## Heatstroke: Causes, consequences and clinical guidelines

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In India, deaths due to heatstroke rose to more than 2500 in 2015—five times that in 2001.<sup>1</sup> Odisha, Telangana, Andhra Pradesh, Punjab, Uttar Pradesh and West Bengal were the most affected by heatstroke. This increase in the number of deaths due to heatstroke is probably related to climate change and increase in frequency and intensity of heatwaves.<sup>2</sup> Over the years, heatwave conditions have tended to begin early and diurnal temperatures across India rise to 40–43 °C. The Indian Meteorological Department (IMD) often predicts temperatures to be above normal across large parts of India.<sup>3</sup> To reduce mortality due to heatstroke, the government, hospitals and the public should adopt safe practices, preventive habits, early diagnosis and effective management of heatstroke.

The guidelines on when to declare a heatwave vary. The National Disaster Management Authority guidelines combine temperature, humidity and altitude.<sup>4</sup> Heatwave conditions according to IMD are defined as any increase in temperature above the normal. An increase of >5–6 °C is considered to be a moderate heatwave; >7 °C as a severe heatwave or >45 °C for more than 2 consecutive days.

Preparedness should be based on local experiential assessments of doctors and hospital personnel of subjective discomfort, malaise and exhaustion, the maximum temperature rise, its rapidity and the duration. The number of days of extreme heat is more important than the absolute rise of temperature in predicting vulnerability. Due to climate change, onset of summer heatwave conditions may occur earlier or prolonged later than usual.

We highlight the importance of a classical heatstroke, widely prevalent among the poor and marginalized in tropical countries. There is little research or policy directions on this important public health issue.

Most western literature is on exertional heatstroke of athletes, gymnasts and soldiers due to strenuous exertion causing endogenous heat generation above the level that is being lost to the environment. Exertional heatstroke occurs in young healthy people, not exclusively in high ambient humidity and temperature.

### TERMINOLOGY AND PATHOPHYSIOLOGY OF THE HEAT EXHAUSTION–HEATSTROKE SPECTRUM

The inability to sweat and initiate evaporative heat loss leads to increase in core body temperature.

Heat exhaustion is associated with fatigue, dizziness, headache, nausea, vomiting, malaise, hypotension and tachycardia and signs of dehydration with core temperature varying from 37 °C to 39 °C. Infants and newborns may be too hot to touch and drowsy during the day and older children (having played outdoors) may be brought by their parents with adult-like complaints. Unless rehydration is initiated and intravascular volume corrected, it can progressively worsen leading to heatstroke.

Other milder manifestations of heat-related stress are heat cramps and heat syncope. Heat cramps (painful and spasmodic contractions of the skeletal muscles) occur in individuals who are doing heavy muscular work in high temperature and humidity due to loss of circulatory sodium and chloride. Heat syncope occurs when standing in the sun due to vasodilatation and pooling of blood in lower limbs leading to reduced cardiac output and is common among armed forces, police personnel and school students.<sup>5</sup>

The distinguishing feature of heatstroke is hyperpyrexia (>40 °C) with altered sensorium, hot, red, dry skin and dehydration.<sup>6</sup> When hyperpyrexia is severe and prolonged, organ dysfunction including hypotension, kidney injury, coagulopathy, rhabdomyolysis, liver injury and coagulopathy may set in. Persistent high core body temperature of 41–42 °C even for a few hours leads to thermal injury of cells with derangement of metabolic systems and membranes, cell death, release of cytokines and activation of the coagulation cascade, all producing a syndrome of multi-organ system dysfunction. The brain's susceptibility to thermal stress makes encephalopathy the first symptom of heatstroke. If the core temperature is not rapidly reduced, this leads to irreversible brain damage. The redistribution of blood volume to the skin results in lower splanchnic and renal perfusion that increases the risk of complications. Effective cooling helps in redistribution of the cardiac output.

The success in managing heatstroke is through prevention of its progression from heat exhaustion.

### WHO ARE SUSCEPTIBLE?

Outdoor workers such as vegetable vendors, auto repair mechanics, drivers of bicycle rickshaws, autorickshaws and cabs, self-employed artisans, wage labourers, construction workers, police personnel and roadside kiosk operators, are somewhat susceptible, but usually take care of themselves and avoid a heatstroke. Those especially vulnerable to heatstroke are:

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- The elderly, children especially infants, and pregnant women<sup>7</sup>
- Patients on drugs such as diuretics, vasoconstrictors, beta-blockers, anticholinergics, calcium channel blockers, thyroxine, benzodiazepines, antipsychotic drugs
- Patients admitted with fever, chronic cardiac, respiratory and neurological illnesses, history of alcohol abuse, presence of skin diseases which impair sweating
- Heatstroke can be superimposed on other illnesses such as pneumonia, urinary tract infection (UTI) and alcohol withdrawal
- Individuals not physiologically adapted and not systematically prepared for heat but exposed unexpectedly to high ambient temperatures are especially vulnerable. For example, summer tourists, those who had to walk or stand in a queue unexpectedly in the hot sun, inexperienced sports person participating in social sports events especially in hot weather.

#### DIAGNOSTIC CRITERIA FOR HEATSTROKE

1. Hyperpyrexia (>40 °C core body temperature) with alteration in mental status:
  - a. Subtle: mild confusion, inappropriate behaviour, impaired judgement
  - b. Severe: delirium, encephalopathy, convulsions, coma
2. High ambient temperature
  - a. Non-exertional heatstroke occurs in high ambient temperature (heatwave conditions)
  - b. Exertional heatstroke usually occurs in the setting of unaccustomed heavy exercise or strenuous physical activity with or without high ambient temperature.
3. Predisposing conditions: Extremes of age/underlying predisposing chronic illness
4. Associated clinical findings: Hot, dry skin, absence of sweating, clinical signs of dehydration.

#### DIAGNOSIS

Heatstroke should be suspected in any patient presenting to an emergency room or hospital with altered consciousness, confusion or seizure in heatwave or high ambient temperature conditions, especially in summer. Record the rectal temperature immediately using a rectal thermometer.<sup>8</sup> If it exceeds 40 °C, a presumptive diagnosis of heatstroke is made. Emergency cooling measures should be initiated till temperatures are reduced below 39 °C. Simultaneously other causes of hyperpyrexia and altered consciousness should be excluded (e.g. malaria, encephalitis, UTI, pneumonia, viral fever and neuroleptic malignant syndrome) through clinical evaluation and laboratory investigations.

*Important.* Heatstroke can occur superimposed on an acute infection or alcohol withdrawal state.

Key tests include white blood cell count, chest X-ray, urine microscopy and malarial parasite. Cerebrospinal fluid examination and brain imaging may be required if central nervous system infection or stroke are suspected.

To assess complications, the investigations required include serum electrolytes, urea and creatinine, blood gas, liver function tests, prothrombin time and creatine phosphokinase and lactate dehydrogenase.

#### PREVENTING PROGRESSION OF HEAT EXHAUSTION TO HEATSTROKE

To avoid heat exhaustion, drink water (up to a litre an hour), salted buttermilk, rice water, lime or mango juice, lentil soup till



FIG 1. A garden water spray that could be used to manage heatstroke

thirst is quenched and there is adequate urine output; avoid alcohol and carbonated beverages; avoid sun; wear light, loose clothing and cover the head; limit exertion; rest in shade; spray water and lie down under the fan or rest in an air-conditioned room, if available; have cool baths to lower temperature; rest at shorter intervals during work hours.

Move the victim to a cool place and rapidly cool the body as described under therapeutic cooling.

*When should patients be referred to a higher level of medical care?*

After initial stabilization and cooling, patients with heatstroke and altered consciousness should be quickly transported to a hospital with emergency facilities and intensive care.

#### *Hospital preparedness*

Hospitals should establish the following steps to diagnose, treat and prevent heatstrokes at the onset of summer:

1. Administrative planning meetings, weekly review and daily tracking of cases and mortality during an epidemic
2. Develop and disseminate 'heatstroke protocol' to all medical and nursing staff
3. Ensure cooling supplies and equipment: Ice blocks, refrigerated intravenous (i.v.) fluids, spraying devices (gardening sprays, Fig. 1), air coolers, pedestal fans, sponges
4. Convenient designated cooling areas, preferably air-conditioned and with adequate nursing staff
5. Nursing staff and doctors to watch for heatstroke among inpatients with fever and predisposing factors. Increase fluid intake of all inpatients based on estimated insensible losses
6. *Outpatient area measures:* Avoid long queues, triage and fast track patients who are chronically ill, ensure availability of drinking water, warn all patients and relatives about prevention and early recognition of heat exhaustion
7. Alert public health authorities and media about the status of epidemic.

#### MANAGEMENT OF HEATSTROKE

Heatstroke is a life-threatening emergency that should be managed aggressively.

1. Assess airway, breathing and circulation and stabilize the patient. Manage hypotension with isotonic saline; if unresponsive start inotropic agents. Appropriate oxygen

therapy in case of hypoxaemia and desaturation. Patients with low sensorium may require intubation

2. The most important step is rapid therapeutic cooling at 1 °C every 10 minutes till a core temperature of 38 °C (100.4 °F) is reached. Doctors and nurses should not leave the patient till this therapeutic target is achieved. Delayed cooling can lead to irreversible neurological damage. Shift the patient to an air-conditioned environment if this is feasible, it can significantly reduce mortality.

Different approaches to therapeutic cooling may be adopted in combination.

#### *Conductive cooling*

1. *External cooling:* Ice cold water packs, ice or ice blocks in the groins, axillae and neck to cool arterial blood. Massage skin vigorously to counter cutaneous vasoconstriction.
2. *Internal cooling:* Parenteral cooling through refrigerated intravenous (i.v.) fluids (normal saline, 5% dextrose or Ringer lactate)<sup>9</sup> is preferred because of safety and rapidity of effect. Cooled fluids can be administered through nasogastric tube, but large volumes should be avoided to prevent aspiration in an unconscious patient. Cooled fluids may be administered through the Foley's catheter into urinary bladder or through an enema tube into the rectum though these are not commonly done.

#### *Evaporative cooling*

1. Remove clothing and drape body with wet sheets loosely.
2. Spray body continuously with a cool mist of water at about 15 °C. A pedestal fan or heavy-duty blower drives air over the body to facilitate evaporation.<sup>10</sup> Domestic air coolers can be used and are well accepted by patients. Effective cooling requires concerted effort between nursing/medical team and relatives.

Once these steps are initiated, rule out other causes of hyperpyrexia and altered consciousness. Where the probability of underlying infection is high, empirical antibiotic therapy may be necessary pending results of investigations.

The goal is to bring down the temperature to 38–39 °C within the first hour and cooling measures should not be stopped till this is achieved. Once the core body temperature is 39 °C, therapeutic measures are reduced and core temperature checked every hour to watch for hypothermia and rebound hyperthermia.

There is no role of antipyretic agents such as paracetamol or aspirin or other drugs such as dantrolene<sup>11</sup> in bringing down the body temperature in heatstroke.

#### *Management of complications*

Congestive heart failure (CHF) and myocardial injury may occur and often resolve rapidly with rapid cooling. The use of antiarrhythmic agents or drug treatment of CHF is rarely required. Respiratory complications are far more common and range from acute respiratory distress syndrome to pulmonary haemorrhage to bronchospasm, and aspiration pneumonia may require ventilatory support. For convulsions, treat with midazolam 0.1–0.2 mg/kg i.v. to a maximum dose of 4 mg. This will start working within 5 minutes and last up to 6 hours; repeat dose every 6 hours until neurological recovery. Cooling reduces recurrence of seizures.

Fluids should be given if there is hypotension but with caution since there may be renal or cardiac compromise.<sup>12</sup> Thus,

i.v. boluses of 250–500 ml saline may be given with careful monitoring. Monitor renal functions and urine output for up to 5 days. If rhabdomyolysis occurs, acute kidney injury can be prevented by alkalization (to pH of 7.5–8.0) of the urine with i.v. sodium bicarbonate. Alkalization of the urine prevents the precipitation of myoglobin in the renal tubules and may control acidosis and hyperkalaemia in acute massive muscle necrosis. Occasionally, dialysis may be needed. On days 2 and 3, there may be coagulopathy leading to disseminated intravascular coagulation (DIC) for which platelet concentrates and fresh frozen plasma may be required.

The presence and seriousness of persistent complications is indicative of the severity of the heatstroke and a negative outcome in terms of mortality or irreversible brain damage.

#### PROGNOSIS

Time taken to seek care and to cool down are critical determinants of survival.<sup>13</sup> If consciousness is regained within a few hours of hospitalization, prognosis is good.<sup>14</sup> Mortality ranges from 20% to 60% in heatstrokes.<sup>15</sup>

#### POLICY-LEVEL PREVENTION

Countries, states and regions with annual heatwave disasters have begun to develop government policies to minimize heat exposure.<sup>16–18</sup> In India, Odisha state, Ahmedabad city and the National Disaster Management Authority have heatwave action plans.

#### PREVENTIVE MEASURES

1. Activate early warning systems by IMD to disaster management cell and administration
2. *Public information dissemination:* People should be informed and educated when a heatwave occurs, how to prevent heatstroke, who is at risk, warning symptoms of heat exhaustion and when to access a doctor, through media such as bulk cell phone messaging services, radio, television, newspapers and community groups
3. Primary health centre, community health centre, district hospitals and private hospitals need to establish hospital-level preparedness
4. *Government and civil society responses:* Provide drinking water supplies in all public spaces. Provide temporary shelters and screens from direct sunlight. It is recommended to close schools, colleges, public offices, shops and business establishments between 11 a.m. and 4 p.m. during the hottest months
5. Stop all outdoor hard labour when day temperatures rise above 44 °C, such as road and canal works, constructions and quarrying.

#### WHAT YOU NEED TO KNOW

##### *General public*

Watch weather forecast; drink sufficient water; wear light-coloured and loose cotton clothes; keep head covered; use umbrellas, shades, caps, carry water with you; stay at home in the afternoons and avoid direct sun; use fan; frequent baths when possible, avoid long and strenuous work and have rest breaks; keep home cool with shutters and curtain, avoid sitting in parked vehicles in the sun.

##### *Persons at risk*

1. *Preventive:* Drink plenty of fluids (water, buttermilk and

juices). Stay or work in the shade, avoid direct sunlight exposure

2. *Response:* If you perspire too much, or are feeling too hot, drink fluids and rest in the shade with some airflow till you feel better. If symptoms persist, or there is dry skin, dizziness, vomiting or nausea, or confusion, seek emergency medical care.

#### *Emergency medical care*

Clear airway, bring down body temperature, shift patient to an air-conditioned space, use ice packs, cold water baths, spray water and fans, etc., and avoid antipyretics.

*Watch for complications and manage energetically:* Convulsions, respiratory failure, myocardial dysfunction, renal failure, rhabdomyolysis, seizures, hepatic injury, hypotension, DIC and coma and respond appropriately.

Hospital preparedness for heatwave emergencies.

#### *Administrative institutions*

*Public education by local governments:* dissemination of who is at risk, how to prevent heatstrokes, when to seek emergency care, etc. Establish a protocol for declaration of a heatwave condition. Close schools or alter schedule to avoid the peak heat of afternoon. Ban work during the middle of the day. Provide compensatory relief for non-formal workers who lose work during heatwave. Engage drinking water supplies in public places. Arrange free emergency transportation of victims, e.g. 108 services.

If epidemic prevails, collaborate with private clinics and doctors to provide first-level medical care.

All labour contractors must comply with minimal heatwave regulations such as providing water to drink and cool the body, shady areas with fans and emergency contact numbers. In extreme heatwave conditions, enforce cessation of work.

#### CONCLUSION

In summary, the key to prevent deaths due to heatstroke is dissemination of advance information to the public on preparedness and prevention and, if it still occurs, arrange for early diagnosis, rapid cooling and management of complications.

*Conflicts of interest.* None declared

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