



A detailed account of heat stroke

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General Note



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ABSTRACT

Heat stroke is defined as hyperthermia or exceptionally high fever which occurs due to soaring body temperatures above 41.1°C (106°F) associated with pathophysiological changes that result in neurologic, multi-organ system dysfunction and death. Characterized by CNS dysfunction, it is also responsible for a number of organs malfunctioning of the body and is basically of two types. Various pathophysiological changes occur in the body which consequently leads to a heat stroke. The Iranian method has shown marked reduction in mortality among all other cooling techniques. A number of risk factors are responsible for aggravating the condition however proper knowledge and awareness can help in avoiding and managing a heat stroke. This article discusses heat stroke and its management in detail.

Keywords

Heat stroke; hyperthermia

1. INTRODUCTION

The phenomenon of global warming generates heat waves in temperate climates and raise temperatures above 38°C. This can develop a wide array of heat illness namely heat cramps, heat rash, heat edema, head syncope and heat exhaustion all of which are minor. However, heatstroke is most alarming among all heat illnesses. This illness referred to as heat stroke by a Roman physician in the 24th century BC is not new and is constant flash in the news during summers. It can be treated and adequately managed however, lack of knowledge and awareness is the main reason and one of the leading risk factors of suffering from a heat stroke.¹ Heat Stroke is defined as a hyperthermia or exceptionally high fever which occurs due to soaring body temperatures above 41.1°C (106°F) associated with pathophysiological changes that result in neurologic, multi-organ system dysfunction MOD and death.

Though, it presents with a combination of symptoms from all organ systems of the body, a characteristic feature of heat stroke is central nervous system CNS dysfunction. Initial symptoms may include ataxia as cerebellum controlled body movement is disturbed by high body temperature. Neurological disorders such as headache and dizziness is quite common however in severe cases delirium, coma and death may occur. Dermatological signs of heat stroke include dry skin, hot flushes and cyanosis. The gastrointestinal symptoms include nausea, vomiting, dyspepsia, diarrhea and internal bleeding. Tachycardia is also noticed and respiratory disorders may include breathlessness and wheezing. The multi-organ dysfunction MOD syndrome includes encephalopathy, moderate to severe renal insufficiency, rhabdomyolysis, intravascular coagulation, pancreatic, hepato-cellular and myocardial injury, intestinal ischemia, acute respiratory distress syndrome and intravascular coagulation with neurologic impairment which are the major complication faced by patients that leads to mortality.²

There are two major types of heat stroke; both of which are age-related. The first type is classic non-exertional heat stroke NEHS which occurs in geriatric and/ or pediatric population and paradoxically occurs in areas which have not experienced lengthy hot weather and/ or frequent heat waves before. The second type is exertional heat stroke EHS which is associated with rhabdomyolysis i.e. rapid breakdown of skeletal muscle leading to muscle injury and usually occurs in athletes and young populations which indulge in strenuous exercises and other physical activities. Both these type of heat stroke are fatal.³

Various pathophysiological changes occur in the body which consequently leads to a heat stroke. At first, a patient experiences a stress which gradually worsens due to thermoregulatory failure of the body, alteration in the expression of heat stroke protein, hypothalamic dopamine release and reduction in cerebral blood flow which increase the likelihood of heat stroke.

Micro thrombi and cytokine play a pathogenic role in cascade of events creating multi organ syndrome MOS. Metabolic acidosis with respiratory alkalosis is predominant acid base disorder while hyperglycemia and hyper-phosphatemia are major biochemical abnormalities. An imbalance between inflammatory and anti-inflammatory cytokines may result in inflammation associated injury.⁴ The blood flow to the skin is increased to facilitate heat loss and is an important negative feedback pathway to limit hyperthermia.⁵

A decrease in gut blood flow facilitates the redistribution of blood to the skin surface. Prolonged reductions in gut blood flow stimulate oxidative stress and cause the gut epithelial barrier membrane to become ischemic. Gut ischemia causes the tight junctions of the gut to become leaky allowing endotoxin to leak from the gut lumen into the systemic circulation.⁶

Elevated body temperature causes injury to the vascular endothelium and initiates the coagulation pathways that ultimately lead to occlusion of the arterioles and capillaries i.e. microvascular thrombosis. The interaction of systemic inflammatory response syndrome SIRS, coagulation pathways and production of tumor necrosis factor alpha TNF- α and interleukin-1, IL-1 in the central nervous system cause multi organ system failure and death if not rapidly treated and resolved. Direct activation of platelets by heat is a possible trigger factor of the coagulopathy of heat stroke. Cytokines such as IL-1 are important modulators of the acute phase response APR to stress, infection and inflammation. IL-6 and TNF- α play a major role in aggravating fever. Pathophysiological changes observed with heat stroke are not a consequence of heat exposure but are resultant of interactions between cytokines, heat shock protein and endotoxin.

2. DISCUSSION

The biochemical assay showed that TNF- α and IL-levels along with lipopolysaccharide LPS content due to gut leakage were elevated in patients with heat stroke which plays a vital role in pathogenesis of heat stroke. Initial lab work should include a complete blood count, electrolytes (including calcium), blood urea nitrogen BUN, serum creatinine, liver enzymes, creatine kinase, the pro-thrombin time PT, partial thromboplastin time and arterial blood gasses ABG. The computed tomography CT scan demonstrates cerebellar atrophy, which can give a clear picture whether cerebrum is adversely affected by heat wave or not.⁷

Heat stroke is accompanied with fever and often unconsciousness, caused by failure of the body's temperature regulating mechanism when exposed to excessively high temperatures.⁸ There is no drug as such that would be therapeutically beneficial in treatment; instead two main goals of therapy are normally focused for management of a heat stroke. One of the objectives is immediate cooling and the other is the organ system support. The therapeutic cooling is considered to transfer heat from patient skin to external environment without interrupting circulatory system.⁹

Hypothetically, cooling is accompanied by increasing the temperature gradient between the skin and the environment i.e. cooling by conduction or by increasing water vapor pressure i.e. cooling by environment. In addition, by increasing the velocity of air adjacent to the skin i.e. by convection, cooling is carried out more swiftly. Practically, cold water or ice is applied to the skin, which is also fanned. Rehabilitation of symptoms can occur to some extent. Awareness and knowledge regarding heat stroke can prevent the likelihood of suffering, but normally this awareness is lacked by society at large.¹⁰

The Iranian method has shown marked reduction in mortality among all other cooling techniques. This method is applied during annual Islamic holy event i.e. Hajj in Makkah, where pilgrims are subjected to scorching heat wave, the method also restore the electrolyte abnormalities which are found to be fairly common due to acute renal failure caused by rhabdomyolysis. Iranian practical method for cooling the patient is the immersion of a potential heat stroke patient in a tub containing ice and water. First the patient is immersed in 15°C cold water, and after few minutes when the patient's body adjusts to the cold water, ice is added. Massage of the body especially the limbs is performed simultaneously in order to prevent spasm in the superficial vessels. Rectal temperature is recorded every 3 – 5 minutes and immersion is continued until the body temperature of the patient is reduced to 38.5 degrees centigrade.

Normal saline is administered intravenously IV while the patient is immersed and this practice continues after the patient is been brought out of the tub and vital signs are recorded every 5 – 10 minutes. The mortality rate for heat stroke is only 3.5%. This method is considered to be cost effective and easy to manage. Hence, it is recommended to be used in heat stroke cases. The high incidence of heat stroke during Hajj in summers led to the development of a new method to tackle heat stroke. A cooling bed was devised which in experimental stages achieved a high rate of evaporative cooling by spraying patients with water at 15°C and warm air, which passed through the body surface at 30 – 35°C. The cooling bed also made the administration of ancillary treatment possible both efficiently and hygienically.¹¹

A Physician must monitor the electrolyte abnormalities and stay alert for any signs of renal and/ or hepatic failure. Most experts believe that physicians and public health officials should focus more attention on prevention. Moreover, not only physician but it is an adequate duty of every health care professional such as pharmacist to guide and aware the masses with heat stroke and its prevention. If the health care provider is not available one should take immediate action to overcome heat stroke. This is only possible if the public is aware of heat stroke. Sometimes an individual may have all the facilities to cope up a heat stroke but failed due lack of awareness.

This awareness can be spread by media, social media and other source of advertisement. The society must know that during an event of scorching heat wave, one must try to stay in shady environment and replenish body with adequate hydration. Some of the home remedies to avoid a heat stroke are routinely published by the news agencies during such times and valuable suggestions include not wandering too much outdoors during day time, drinking ample fluids and avoiding those foods which facilitate dehydration such as tea and coffee, wearing loose fitting clothes to facilitate air currents within close proximity to skin, light colored clothes to reflect sunlight, and light fabrics such as cotton which facilitate air to pass through and absorb sweat thereby giving cooling sensation to skin. It is beneficial to keep a hat and sunscreen during these times and try to stay in the shade outside whenever possible. Keeping the windows open at home can help air currents to pass through and take excessive heat away. It is very helpful to stay in an artificial cooling environment such as air conditioner.¹²

In India, a South Asian country, regulatory bodies of Ahmadabad have developed an early warning system against heat stroke i.e. health action plan that raised awareness of health risks from extreme heat wave among citizens as well as setting up water stations cooling spaces in public places.¹³ In this context, deaths due to heat stroke could have been avoided in Karachi, Pakistan which is also situated in South Asia. In Pakistan, if the government had given warnings in relation to the heat wave and had provided increased access to clean drinking water, many people would have been able to cope up with the recent heat wave. Concrete cover and acute lack of park and green belts in the city contributes to the scorching. An urban heat island effect where cities heat up more due to the excessive cement concrete is also exacerbating the mortality. Villages are less affected by heat wave as there is less concrete and much more forestation.¹⁴

Latest research demonstrates that administration of an IL-1 receptor antagonist or corticosteroids before the onset of heat stroke attenuates neurological injury and improves survival among animals. However, human data is absent. For future research baboons are believed to be the suitable model to study the inflammatory and coagulation cascades.¹⁵

Some of the social factors such as alcoholism, using major tranquilizers such as phenothiazine, butyrophenones, thioxanthenes, etc and those receiving medications that interfere with salt and water balance such as diuretics, anticholinergics and tranquilizers that impair sweating were factors associated with increased risk. Factors associated with decreased risk were using home air conditioning, increasing fluid intake, refraining from strenuous exercise, spending more time in air conditioned places and living in a residence well shaded by trees and shrubs.¹⁶

Furthermore, socially isolated, non-acclimatized homeless people and those who bound to stay outdoors are more likely to suffer by the heat wave. The ability to maintain core body temperature decreases with age, this is due to circulatory conditions and decreased sweat gland functioning. It is for these reasons that mortality rate is much higher in elderly.¹⁷⁻¹⁸

Heat stroke is also relatively common among persons with chronic mental disorders or cardiopulmonary disease. Chronic conditions/ diseases associated with a reduced ability to sweat or perspire such as Parkinsonism, dermatological conditions such as burn and obesity which inhibits the loss of heat from skin to environment due to insulation. Moreover, hyperthyroidism can markedly increase the basal metabolic rate BMR, leading to dramatic rise in body temperature from increased endogenous heat production. Thus all such conditions place the patient at a higher risk of suffering from a heat stroke.

Drugs which are contraindicated in such conditions are diuretics, barbiturates and β -blockers. They may impair the body's natural heat loss mechanisms. Some over the counter drugs such as antihistamines may also cause the body to be more prone to heat stroke. Anticholinergics, tricyclic antidepressants, antihistamines, anti-spasmodic, phenothiazine, and lithium can disrupt hypothalamic function and also reduce sweating.

Drugs of abuse such as cocaine; amphetamine and other stimulants can promote muscular and endogenous heat production. Paracetamol and aspirin are highly contraindicated.¹⁹

3. CONCLUSION

Heat stroke is a life threatening illness characterized by a rapidly increasing core body temperature (>40°C) which can progress to multiple organ dysfunction/ injury syndrome and subsequently death. Up to 30% of survivors may sustain permanent neurological damage with no recovery. The high mortality and neurological morbidity in heat stroke despite cooling and supportive treatment are largely due to the fact that the mechanisms of multiple organs disorder syndrome MODS are not well understood and no specific treatment is available. Appropriate advice and timely management can help reduce morbidity and mortality. Lack of awareness, urbanization and deforestation are supporting factors of heat stroke. Most people affected by classic heat stroke are either very young or elderly and deprived.

COMPETING INTERESTS

The authors declare no conflict of interests exists.

MEDICAL ABBREVIATIONS

BMR = Basal metabolic rate

MODS = Multiple Organ Disorder Syndrome

IL = Interleukin

BUN = Blood Urea Nitrogen

TNF- α = Tumor Necrotic factor alpha

IV = Intravenous

CT = Computed tomography

PT = Prothrombin time

LPS = Lipopolysaccharide

SIRS = Systemic inflammatory response syndrome

EHS = Exertional heat stroke

NEHS = Non exertional heat stroke

APR = Acute phase response

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