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REVIEW

Management of heat stroke

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SUMMARY

Heat stroke is a life threatening condition that is more of an issue during hot summers especially during heat waves. It also affects athletes undergoing intense exercise where their organizers fail to prepare them appropriately to cope with heat issues.

Strategies to prevent the condition include education of care providers to recognize the threat earlier, to pressure relevant authorities to have appropriate policies in place to guide coordination of care and provide assistance to the vulnerable groups. Providers should institute cooling by external cooling methods and oversee threats to the airway, breathing and the cardiovascular system when patients deteriorate to the stage of heatstroke. Patients are also likely to need further support in intensive care facilities.

1. Introduction

Heat related illness is a cause for morbidity and mortality amongst patients. It is especially so during periods of hot summers where the environmental situation predisposes a large segment of the population to the condition.[1,2]

This condition is also seen in athletics/military personnel training especially in the summer months without the necessary precautions taken to reduce the incidence or the consequences of the illness. Press discussions[3,4] of the issue especially the unnecessary deaths associated with it have bought this to the forefront as a matter that should be taken seriously.

An even more tragic aspect is in the heat stroke of young children left unintentionally in cars[5] by their care givers. In the equatorial countries, it is a year round event but in the temperate countries, these occur mostly during the summer months.

Many care providers are however not well trained to recognize the condition early enough or how best to advise the vulnerable group to prevent the problem from arising. Heat exhaustion when detected early is remediable but with onset of heat stroke, it can potentially be life threatening.[6] The latter is associated with neurological presentations with multi -organ dysfunction and may often be misleadingly diagnosed as sepsis by care providers managing these patients.

2. Definitions

The heat related conditions of heat exhaustion and heat stroke are part of a continuum. Heat exhaustion is characterised by a body temperature of 37–40 °C[6,7] and the patient complains of thirst, malaise, dizziness, headache and weakness. In heat stroke[6] the core temperature is higher than 40 °C and there is obvious neurological dysfunction in the form of convulsions, delirium and coma.

Heat stroke can be further divided[6] into classical heatstroke or exertional heat stroke. Classical heatstroke affects the older age group or those with chronic illness and the condition develops over days when the heat loss from the body is hampered. This usually occurs when the environmental temperatures are high.[8]

Exertional heat stroke occurs in those involved in prolonged excessive activities like marathons where the heat loss does not match the heat production. The condition occurs very rapidly over a few hours.[9]

3. Prevalence

It is difficult to estimate the true prevalence of the condition but in Japan [10] there were 33 deaths recorded due to heat stroke in 2014, with more than 18,000 seeking emergency care for heat related illness. In 2012 and 2013 there were 28 and 114 deaths respectively.

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In July 2013, it was estimated that 760 people in the United Kingdom [11] lost their lives due to heat stroke and heat related illness when temperatures reached beyond 32 °C for a few days. These numbers pale into insignificance compared to the estimated 15,000 excess deaths in the heatwaves of Paris in 2003.[12]

Deaths following marathons[13] have also attracted a lot of attention. The true prevalence of this exertional heatstroke is difficult to estimate but is of concern to those who organize these events. It has been reported as the third[9] most common cause of mortality in athletes behind cardiac events and head/neck trauma.

In America the statistics collected by the National Highway Traffic Administration[14] flagged that there has been more than 600 deaths between 1998 and 2013 of children dying of heat stroke after they have been inadvertently left behind in vehicles.

4. Pathophysiology

Cell metabolism produces body heat. Some organs produce more heat than others. The cardiovascular system distributes the heat from organs with high heat production to sites where the heat production is lower so that the body temperature stays on an average level of 36.6–37.2 °C. This maintenance of normal temperature is important for optimal enzyme function and therefore for the wellbeing of all the organs in the body.

The cardiovascular system is also responsible for moving heat from the core to the skin where heat is lost by several physical processes in the form of conduction, convection, radiation and evaporation of sweat. In addition the body heat load must be dissipated at a rate equal to its production to maintain the body's normal physiological range of temperatures. This ability to remove heat by increasing the skin blood flow may see a shift of cardiac output up to near 30% to the skin,[7] reaching levels of up to 6–8 L/min[15] resulting in a proportionate drop in flow to the gastrointestinal tract,[16] leading to gut ischaemia and increased gut permeability.

When heat loss cannot keep up with heat production, the temperature rises. This may occur especially during periods of intense activity like during intense exercise where the production of heat may be up to 15–20 times[17] that during normal activity or during periods when the dissipation of heat does not keep up with the heat production. This may be exacerbated by dehydration[7,18] and inability to sweat as sweating is one of the most efficient heat dissipation processes representing three quarters of the heat loss rate when the environmental temperature is about 20 °C.

The physical processes of heat loss from the body are dependent on a gradient of temperature between the body and the environment. When the gradient is reduced as during high environment temperatures, heat loss becomes inefficient. In high environmental temperatures there may even be heat gain.[7] When the gradient of temperature for heat transfer narrows, sweating becomes the only means to lose heat. Fluid losses in this condition can be as high as 1–2 litres per hour.[7]

The metabolic heat load causes the temperature to rise when the body's normal thermoregulatory mechanisms fail to adequately compensate for elevations in body core temperature. The damage is a result not only of thermal load but that of inflammatory changes that this elevated temperature induces.[19] Disturbances in the immune system and inflammatory changes in the gastrointestinal tract predisposes to endotoxemia, a feature in the condition.[20] Cellular hypoxia[20] occurs with the inflammatory changes and the coagulation system is often affected. These render organs[20] dysfunctional and the two most important systems affected are the cardiovascular and the central nervous system.

Clinical manifestations[6] include temperatures of 40 °C or higher with reduction or cessation of sweating, tachycardia, tachypnoea and hypotension. The central nervous system manifestations can present with unsteady gait, confusion, reduced consciousness, convulsion and coma. Heat stroke is a life threatening heat-related disorder and a medical emergency.[6]

5. Factors associated with prevalence

There are several factors associated with the prevalence of heat stroke that care providers should acquaint themselves with.

a) High environmental temperatures.
   Heat stroke occurs in greater frequency[2,10,11] during heat waves and we are increasingly seeing more of this kind of temperature elevation in the summer months. When the environmental temperatures reach 35 °C,[21] the body is unable to utilise sweating as a physical mode of temperature loss. If the humidity is high in addition to the hot environment, the gradient for evaporation of sweat as a means of heat loss from the body is further reduced.
   Certain occupations[22] e.g., those working outdoors especially construction workers in hot environment, are associated with greater heat stroke risk. Those working in hot indoor environment as in bakeries and in the steel and glass industry where personal protective clothing or equipment reduce risk of damage from fire, have increased risk of heat stroke due to inability to lose heat in the situation. This is made worse by the great amount of heat produced as a result of activities in the various processes e.g. blowing of glass in the latter industry.
b) Vulnerable groups.
   Socially isolated groups, those who have medical conditions like cardiovascular diseases, respiratory diseases and challenged individuals are particularly susceptible.[23]Those staying in houses with black roofs[24] should realize these types of accommodation trap more heat. Young children accidentally left in cars under the hot sun[14] are also similarly exposed to the same conditions especially if they have been locked in and have no means to resort for help.
   Obese individuals[25] and those in poor physical health are particularly at risk. Those who are dehydrated and those taking anticholinergics, sympthomimetics and neuroleptic medications[26] likewise are vulnerable.
c) High metabolic load
   The prevalence of exertional heat illness may be greater in those who undertake sports events like the triathlon. Participants of the ultra-endurance Ironman triathlon may utilize as much as 10 thousand kilocalories[27] in the 8–17 h of activity, 75% of which is converted to heat.[28]
   Those who train for prolonged periods in physiologically challenging environmental conditions are especially vulnerable and more so if they are not adequately hydrated.[29]

6. Prevention and early recognition

In heat related illness, prevention[30] is the key. It is therefore important to recognize and prevent the possible damage of heat related illness before the onset of heat exhaustion and life threatening heat stroke.

The 2003 heat wave[12] in Europe that caused 15,000 to succumb has brought about many public health measures to reduce the potential damages. Heat health warning systems[2] link the high risk