Heatstroke due to Vehicular Entrapment: An Autopsy Case Report

Razuin R[1,2]., Julina M. N[3], Nurquin F. S.[2], Amirul A. H.[2]

[1]Centre for Pathology Diagnostic & Research Laboratories, Faculty of Medicine, Universiti Teknologi MARA, Selangor, Malaysia, [2]Department of Forensic Medicine, Hospital Sungai Buloh, Ministry of Health Malaysia, [3]Department of Emergency Medicine, Faculty of Medicine, Universiti Teknologi MARA, Selangor, Malaysia

Abstract

Heatstroke is defined as severe heat illness with elevated body temperature greater than 40.6ºC associated with central nervous system dysfunction. In children, heatstroke as a result of vehicular entrapment is commonly encountered. We report a case of a six-year-old boy who was accidentally left in a school van under scorching hot afternoon for several hours. Upon discovery, he was rushed to a hospital where he was pronounced dead. His body temperature taken at the Emergency Department was 40.3ºC. The body felt warm in spite of apparent presence of post mortem changes such as rigor and livor mortis. His clothes were drenched in sweat. A medico-legal autopsy was performed. On general examination, his body was pale and the lips were also parched and pale. Internally, there was subdural haemorrhage and petechial haemorrhages on the lungs and the epicardial surface of the heart. The cause of death was given as heatstroke as a result of vehicular entrapment. We wish to emphasize and appeal to the public that this tragic incident is preventable. Public and private sectors should help creating awareness of dangers in leaving a child unattended in a car.

Keywords*: Heatstroke; Hyperthermia; Automobile; Paediatric; Autopsy*

Introduction

Heatstroke is a life-threatening condition which is characterized by an elevated core body temperature above 40.6ºC accompanied by central nervous system dysfunction, multi-organ failure and potentially result in death.[1,2] Hyperthermia causing heatstroke as a result of excessive metabolic heat production usually during exercise is known as exertional heatstroke.[3] Another type of heatstroke which is known as classical heatstroke is a result of poor heat dissipation which occurs in the event of heat waves or entrapped in a vehicle.[4,5]

In young children, heat related deaths are mostly caused by vehicular entrapment, intentionally or unintentionally.[6,7] The National Highway Traffic Safety Administration (NHTSA) of the United States recorded 793 deaths of entrapped children between 1990 and 2016, with an average of 37 deaths per year.[8,9] In Malaysia, data of vehicular entrapment cases were obtained from local newspaper reports, showing much lesser incidence of approximately one case per year. In many instances, the events include caretaker forgotten about the child in a vehicle or the child gaining access to the vehicle without the parents or guardians knowledge. In short, lack of adult supervision was determined as the most common contributing factor worldwide.

The diagnosis of heatstroke relies heavily on the history of circumstances of death. At autopsy, findings of heatstroke may be subtle and non-specific. Internal examination may demonstrate cerebral oedema, pulmonary oedema and internal organs congestion.[2,6,10] Typical autopsy findings in adult or children with heatstroke include diffuse petechiae and haemorrhages as well as pulmonary involvement.[4] Therefore, in the absence of good anamnesis, heatstroke as a cause of death could have been inadvertently missed.

We report a case of a child who was accidently left in a school van on a scorching hot afternoon for a

Corresponding author:
Dr Nurquin Fasya, Department of Forensic Medicine, Hospital Sungai Buloh, Jalan Hospital, 47000 Sungai Buloh, Selangor, Malaysia.Tel.:+60 18 2066014; Fax: +60 3 61401632. Email address: fashahrir@gmail.com.

few hours. He was found unconscious and immediately rushed to a hospital where resuscitation efforts were commenced, to no avail. The aim of this case report is to describe the pathology findings of an autopsy performed on a child who died of heatstroke as a result of vehicular entrapment. We also wish to highlight that this tragic incident is entirely preventable.

Case Report

In mid-August 2017, a six-year-old boy was found unconscious and unresponsive in a school van. He was picked up from home to attend a preschool in a hot sunny afternoon. After dropping off the children, the van driver proceeded to a restaurant nearby for lunch. About two and a half hours later, he returned to the van in order to pick up the children from school and send them back to their homes. This was when he realized that one child never actually alighted off the van. He immediately rushed the child to a nearby clinic which subsequently referred him to a hospital.

At the Emergency Department (ED), the child was noted to be warm and the rectal temperature measured was 40.3ºC. Rigor mortis was present as evidenced from the fixed flexion of both arms and legs. Cardiorespiratory resuscitation (CPR) was commenced while the patient was in an ambulance en route to the hospital and continued for several minutes upon arrival. He was eventually pronounced dead and a police order for medico-legal autopsy was issued.

Autopsy examination showed a well-nourished and appropriately built male child measuring 107 cm in length and 39 kg in weight. The clothes were drenched in sweat. The lips were parched and pale. Bluish discolouration was noted on the nail beds, indicating cyanosis. Rigor mortis was present in spite of the relatively warm body. Internal examination of the head and neck revealed cerebral oedema, minimal subdural haemorrhages and markedly congested cerebral blood vessels. Examination of the lungs revealed subpleural petechial haemorrhages, pulmonary oedema and blood vessels congestion. Froth was also present on the trachea, in keeping with pulmonary oedema. Petechial haemorrhages were also observed on the epicardial surface of the heart. Sago-spleen like appearance was observed.

Tissue samples from the brain, heart, lungs, liver, kidneys and adrenal glands were obtained for microscopy examination. On histology, the organs showed dilated and congested blood vessels. The cause of death was concluded as heatstroke as a result of vehicular entrapment. The mechanism of death was hyperthermia leading to neurological dysfunction and cardio-circulatory failure.

Discussion

Children are vulnerable to heatstroke due to their under-developed thermoregulatory system, hence impairing the body's ability to dissipate heat effectively. Their small body size also contributes to large surface area, resulting in high rate of heat absorption. On top of that, their small blood volume restricts the potential for heat conductance, thus resulting in higher heat accumulation. Eventually, their small physique also means smaller sweat glands, lower metabolic capacity and lower sensitivity of sweating mechanism to thermal stimuli.[4,11]

Autopsy findings in fatal hyperthermia include widespread haemorrhages, pulmonary congestion and oedema. In both children and adults, the features of heatstroke are relatively similar, regardless of the circumstances leading to it. Essentially, these findings are non-specific and could be attributed to other causes such as septicaemia, burn injuries, barotrauma and electrocution.[4] Therefore, history of the case which includes detailed police investigation and relevant witness statement will be of ultimate key evidence leading to heatstroke diagnosis.

In children, vehicular entrapment is the most common cause of fatal heatstroke. Studies have shown that the interior of a closed vehicle heats up very quickly. Within 15 minutes, the interior of a parked vehicle may reach the maximum temperature of 51-67ºC, from the ambient temperature of 36.8ºC. Within 5 minutes of closing the doors, 75% of the maximal value could be reached.[4]

In our case, the child has most probably fallen asleep during the short journey to school causing him to fail to alight from the van. When he was discovered two and a half hours later, he was already deceased as rigor mortis had already set in. Meteorological report showed that on the fateful day, the sunny afternoon temperature fetched 33ºC. As the school van was parked in an open area and under direct sunlight, it is hypothesized that the interior temperature of the van could have gone up to almost 70ºC in less than 15 minutes. Hyperthermia may cause death when the body temperature reaches 41.7ºC.[11] As

the temperature inside the van reached more than 60ºC in short period of time, heatstroke and death could have occurred in short period of time too. A study by Walter and Carrareto has found that hyperthermia with body temperature of 38.8ºC, cognitive impairment may occur in one to two hours after insult. In a case on vehicular entrapment, the excessive high temperature in the vehicle will remain until the doors are opened.[12] Therefore, the core body temperature will also rise within the relatively similar time frame. We postulated that death occurred in less than one hour of entrapment, in keeping with acute and extreme temperature elevation inside the school van. At the early stage, heat-regulating mechanisms such as excessive sweating, rapid breathing and fast, weak pulse were in place, as evidenced by his sweat-drenched clothes. Eventually, the body's thermoregulation became overwhelmed, the blood pressure dropped as the heart attempted to maintain adequate circulation to the vital organs. Decrease in blood pressure and vasoconstriction resulted in pale appearance of the body. At the ED, the body was pale and warm despite presence of rigor mortis. Another key finding in this case is rigor mortis, as it is not only an indication of death, but also, a sign of death associated with hyperthermia.

A study by A Guard found that almost three quarters of the cases were actually children who were left by adults. More than 50% of these cases resulted from adults who forgot or unaware that they were leaving the children inside the vehicle. About 13% of these cases involved childcare providers and drivers.[13] In our case, the van driver was a replacement driver who happened to be on his first day at work. While he himself was a youth, inexperience and lack of proper guidance imparted to him about the job have resulted in a lifetime of regret.

Conclusion

Heatstroke fatality resulted from vehicular entrapment is an entirely preventable tragedy. Parents, caregivers including school van drivers should be regularly reminded to take heed of important tips such as looking at the backseat before exiting and checking the vehicle before locking the doors. Increased public awareness could help averting the tragic incident from claiming life of another child.

Declaration

Consent for Publication

Not applicable.

Availability of data and material

Not applicable.

Conflict of Interest: The authors declare that they have no competing interests.

Funding: None.

Ethical approval: Not applicable.

Acknowledgment: The authors would like to thank the Director General of Health Malaysia for his permission to publish this article.

References

1. Cheshire W. P. Thermoregulatory disorders and illness related to heat and cold stress. Autonomic Neuroscience: Basic and Clinical Journal 2016; 196: 91-104.
2. Avinash K., Dhattarwal S. K., Sharma L., Nil K. Heat stroke in closed car. Sch J Med Case Rep Apr 2017; 5.4:295-297.
3. Epstein Y., Moran D.S., Shapiro Y., Sohar E., Shemer J. Exertional heat stroke: a case series. Medicine and Science in Sports and Exercise Journal 1999; 31.2: 224-228.
4. Adato B. Fatal heat stroke in children found in parked cars: autopsy findings. European Journal of Pediatrics 2016; 175.9: 1249-1252.
5. Glazer J. L. Management of heatstroke and heat exhaustion. American Family Physician 2005; 71.11: 2133-2140.
6. Onah S. K., Ndukwu C. I., Ogbuefi N. A. Fatal heat stroke in vehicle entrapped siblings. Afrimedic Journal 2013; 4.1: 32-34.
7. Leon L. R., Bryan G. H. Heat stroke: Role of the systemic inflammatory response. Journal of Applied Physiology 2010; 109.6: 1980-1988.
8. Monica L., Corpus C. National Heat Stroke Prevention Day Reminds Parents To "Look Before You Lock" [homepage on the internet]. http://www.KidsAndCars.org. Accessed 11 April 2018.
9. Arbogast K. B., Belwadi A., Allison M. Reducing the potential for heat stroke to children in parked motor vehicles: Evaluation of reminder technology 2012; No. HS-811 632.
10. Ozcetin M., Arslan M. T., Yilmaz R. Rare cause of cerebral damage: Child with heatstroke found

inside an enclosed vehicle. Hong Kong Journal of Emergency Medicine 2012; 19.2: 126-129.

11. John N. B. III, Gregory G. D., John W., Gerald M Jr. Hyperthermia deaths among children in parked vehicles: an analysis of 231 fatalities in the United States, 1999-2007. Forensic Sci Med Pathol 2010; 6: 99-105.
12. Edward J. W., Mike C. The neurological and cognitive consequences of hyperthermia. Journal of Critical Care 2016; 20: 199.
13. Guard A., Gallagher S. S. Heat related deaths to young children in parked cars: an analysis of 171 fatalities in the United States, 1995-2002. Journal of Injury Prevention 2005; 11: 33-37.