Treatment of Heat Stroke in the Field

CASE PRESENTATION

An 80-year-old male was working in his yard when he collapsed and developed convulsions of all extremities. On EMS arrival he was unresponsive, with a tympanic temperature of 102.5, and HR of 124. He was treated for presumed heat stroke with iced saline and cold packs applied to the axillae. An air medical team was dispatched to the scene and arrived within approximately 25 minutes of the initial event. At that time the patient had a GCS of 11, HR 123, BP of 182/90, RR of 28, and oxygen saturation of 99%. He was noted to have hot, dry, flushed skin and had received 500mL of saline from the local EMS providers. He was loaded into the aircraft and surface cooling was initiated. He then received an additional liter of saline by rapid infusion with the LifeFlow® device [see Fig. 1] through a 20G antecubital IV. His mental status subsequently improved. Upon arrival to the receiving hospital the patient was awake and alert, with an axillary temperature of 99.1, HR 132, BP 160/86, and RR 24.

Fig.1 LifeFlow Fluid Infuser

Diagnosis and Treatment of Heat Stroke

Heat stroke is a life-threatening illness that occurs when the body loses the ability to dissipate heat and core temperature reaches greater than 40°C (104°F), usually as a result of physical exertion and dehydration in a hot environment. Athletes, military personnel, and outdoor workers are particularly at risk.[1] Patients with heat stroke can present with altered mental status, seizures, hot and dry skin, tachycardia, tachypnea, and in some cases hypotension. Immediate and aggressive cooling measures are required to lower core temperature in order to prevent permanent neurologic consequences, organ failure, or death.[2,3] A core temperature of <39°C is ideally achieved within 30 minutes of patient presentation.

The preferred treatment for heat stroke is ice water immersion, but this therapy is typically available only at athletic training facilities.[2] Surface cooling and cold intravenous fluids are therefore the best management options for immediate treatment in the field. If direct application of ice or cold towels is not possible, evaporative cooling can be achieved by spraying water onto the patient's torso and extremities and augmented by fanning. Interestingly, helicopter rotor wash has been used successfully for this purpose to achieve more rapid cooling than by other methods of fanning.[4] Additional cooling may be achieved by application of cold packs to the axillae and over the femoral vessels, though this has not been shown to significantly reduce core temperature. Ideally the cold packs are applied to as much body surface area as possible.

Infusion of crystalloid fluid reduces core temperature and improves peripheral perfusion, thereby augmenting evaporative cooling. Cold fluid is preferred since 1L of iced saline at 4°C will reduce core temperature by 1°C as compared to 0.5°C for room-temperature fluid.[3] In one US military study, cold saline administered in the field was shown to significantly reduce heat stroke complications when compared to room temperature saline.[5] EMS providers therefore have the ability achieve target temperature prior to hospital arrival by rapidly administering 1-2 liters of saline in the field, as described in the case above. Cold saline will produce an even more significant reduction of core temperature.

Though a rectal temperature was not noted in this patient's case, he almost certainly had a core temperature of >40°C given his hot and dry skin, seizures, and altered mental status. Since axillary temperature may underestimate true core temperature by as much as 4°C, the measurement of rectal temperature is crucial in heat stroke.[6] This patient's rapid improvement and near-normal neurologic condition on hospital arrival were facilitated by the immediate administration of saline in the field within 30 minutes of his initial collapse. Slower administration of fluids would have likely delayed his recovery and could have led to additional complications, especially since iced saline was not available in this case.

The administration of adequate volume of fluid is often difficult during the transport of critically ill patients. As an example, only 30% of EMS patients with severe sepsis receive any prehospital fluid, and those who do receive approximately 500mL.[7] This is most likely because gravity infusion of 1L of saline through an 18G or 20G IV requires more than 20 minutes, an unacceptably long period of time for a patient with shock, hypotension, or severe hyperthermia.[8,9] While this infusion rate can be shortened to 10-15 minutes with application of a pressure bag, the cuff must be continually re-inflated to maintain constant infusion speed. This task is often neglected during complex clinical scenarios.[8] Also, with continual inflation of the pressure cuff, inattention to the presence of air in the saline bag can lead to fatal air embolism if all air has not been removed prior to infusion.[10–12]

The LifeFlow device facilitates rapid yet controlled infusion of fluids, allowing 1L to be delivered in less than 5 minutes if necessary, even through smaller-gauge vascular access. The early infusion of an adequate volume of saline played an important role in improving this patient's outcome.

References

1. Gauer R, Meyers BK. Heat-Related Illnesses. *Am Fam Physician*. 2019;99(8):482-489.
2. Lipman GS, Eifling KP, Ellis MA, et al. Wilderness Medical Society practice guidelines for the prevention and treatment of heat-related illness. *Wilderness Environ Med*. 2013;24(4):351-361. doi:10.1016/j.wem.2013.07.004
3. Gaudio FG, Grissom CK. Cooling methods in heat stroke. *J Emerg Med*. 2016;50(4):607-616. doi:10.1016/j.jemermed.2015.09.014
4. Poulton TJ, Walker RA. Helicopter cooling of heatstroke victims. *Aviat Space Environ Med*. 1987;58(4):358-361.
5. Mok G, DeGroot D, Hathaway NE, Bigley DP, McGuire CS. Exertional heat injury: effects of adding cold (4°C) intravenous saline to prehospital protocol. *Curr Sports Med Rep*. 2017;16(2):103-108. doi:10.1249/JSR.0000000000000345
6. Casa DJ, Becker SM, Ganio MS, et al. Validity of devices that assess body temperature during outdoor exercise in the heat. *J Athl Train*. 2007;42(3):333-342.
7. Seymour CW, Cooke CR, Heckbert SR, et al. Prehospital intravenous access and fluid resuscitation in severe sepsis: an observational cohort study. *Crit Care*. 2014;18(5):533. doi:10.1186/s13054-014-0533-x
8. Coté CJ, Lerman J, Anderson BJ. *A Practice of Anesthesia for Infants and Children*. 6th ed. Philadelphia, PA: Elsevier,; 2019.
9. Tintinalli JE, Stapczynski JS, Ma OJ, Cline D, Meckler GD, Yealy DM. *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*. 8th ed. New York: Mcgraw-hill Education,; 2016.
10. Bakan M, Topuz U, Esen A, Basaranoglu G, Ozturk E. Inadvertent venous air embolism during cesarean section: Collapsible intravenous fluid bags without self-sealing outlet have risks. Case report. *Braz J Anesthesiol*. 2013;63(4):362-365. doi:10.1016/j.bjane.2012.09.001
11. Shamim F, Abbasi S. Fatal vascular air embolism during fluid resuscitation as a complication of pressure infuser bag. *J Emerg Trauma Shock*. 2016;9(1):46-47. doi:10.4103/0974-2700.161659
12. Fibel KH, Barnes RP, Kinderknecht JJ. Pressurized intravenous fluid administration in the professional football player: A unique setting for venous air embolism. *Clin J Sport Med*. 2015;25(4):e67-9. doi:10.1097/JSM.0000000000000150