Hot Diggity Dog

Jessica Sherman
Mississippi State University
College of Veterinary Medicine
Class of 2020
Clinicopathologic Conference
January 31, 2019

Advisor:
Alyssa Sullivant, DVM, MS, DACVIM

Introduction

Heatstroke is an acute, rapidly progressive, life-threatening condition that is a form of heat injury.[1,4-6,8] The characterization of heatstroke in dogs is a state of hyperthermia with the core temperature at or above 105.8˚F (41˚C) with central nervous system (CNS) dysfunction and organ dysfunction. At this temperature, brain damage begins to occur; however, when the core temperature is above 120˚F (40˚C) for five minutes, all cellular processes and structures are destroyed. The effects of prolonged hyperthermia cause a systemic inflammatory response syndrome (SIRS), leading to multiple organ dysfunction. The four most affected organ systems are the brain, renal, coagulation, and gastrointestinal tract, and organ failure may occur. Other systems that may be affected are hepatic, pulmonary, and cardiovascular. The mortally rate is about 50% but is significantly increased if there is acute renal failure or disseminated intravascular coagulation (DIC).

Heatstroke is a result of strenuous physical exercise (exertional heatstroke) or exposure to hot and humid environments (classic heatstroke).[1-8] There are several factors that cause predisposition to cause heatstroke from the previous two situations. Animals with obesity, brachycephalic syndrome, or upper respiratory tract disease have an impaired ability to dispense heat normally from the body. Obesity causes an increased risk of mortality. Those with upper respiratory tract disease, including brachycephalic breeds, also have increased muscular effort and energy expenditure to breathe, which increases the body temperature and further negates the body's attempt to dispense heat. Those that live in high environmental temperature and humidity have an increased risk of heatstroke, along with working dogs and competition dogs. Owners and trainers should closely monitor any dog while working under these conditions. Heatstroke typically occur from May through October, but the summer months June, July, and August, are

when the majority of cases present, and the ambient temperature will most likely will be at or above 100.4˚F (38˚C). Along with this, fitness and acclimation are important for any dog that is active in the above environments. It takes the body up to 60 days to adjust the several body systems needed to dissipate heat. Several studies have also found larger dogs that have a body weight over 15kg are predisposed. However, it was mentioned these dogs are often more active and may be working dogs compared to small or toy breeds and may be overrepresented.[1-3,5,7,9] A study on racing greyhounds also found that dogs with dark coat color and males were predisposed to heatstroke. Other articles agree that dark coat color absorbs light, instead of reflecting it, allowing the core temperature of a dog to rise. This study discussed how, in women, the effects of estrogen and progestogen on core temperature during the menstrual cycle and the interaction between norepinephrine and estrogen on the brain in women effects heat dissipation and there may be similar relationship in female dogs, allowing them to have lower core temperature after intense exercise.[9]

History and presentation

Bella is an approximately 7-month-old female chocolate Labrador mix who was presented to Mississippi State College of Veterinary Medicine (MSU-CVM) Internal Medicine department after suffering a heat stroke. On May 15, 2019, Bella presented to the rDVM very lethargic with bloody diarrhea. The rDVM reports that she was being transported by a shelter when the heat was accidentally left on in the cargo area where she and other dogs were located. On the morning of May 15, 201 9, at the rDVM, Bella received 1 liter of intravenous fluids, 250 mg ampicillin, Cerenia, and 5 mg famotidine. That afternoon, the patient received another liter of fluids with 2.5% dextrose. The patient was also treated with 250mg ampicillin, 125 mg

metronidazole, and 3 ml of Pro-pectalin. Bella was vaccinated on May 5, 2019 with DA2PP vaccination. Upon arrival, Bella was quiet, alert, and responsive. She was mildly dehydrated with pale pink mucous membranes and a capillary refill time (CRT) of 2 seconds. She had diffuse petechiation coalescing to ecchymosis across all skin surfaces. She was tachycardic with intermittent VPCs seen on ECG. Her abdomen was tense and painful, and she had melena.

Diagnostics Approach

There are varying clinical signs based on the severity and presence of predisposing factors. A thorough history, physical exam, and bloodwork is critical to both diagnose and begin immediate treatment for any dog with possible heat-related illnesses. Often the history will include exposure to extreme temperatures, strenuous exercise, or both. However, questions about previous medical history such as cardiovascular abnormalities, neurologic or neuromuscular diseases, and laryngeal paralysis will predispose the animal to heat stress and need to be asked and addressed.

During the physical exam there should be close examination of the cardiovascular system, airway, and breathing for signs of shock. Many patients may present with tachycardia (>120 beats per minute), tachypneic with severe panting, arrhythmias, pale mucous membranes, poor CRT, poor pulse quality, sunken eyes, or in varying stages of shock. After the patient is considered stable, a thorough neurological examination should be conducted. If the dog's mentation is just lethargic or depressed with progressing ataxia, there must be careful watch that it is does not progress to collapse, seizures, or coma. Altered mentation, coma, seizures, or a combination are common clinical signs on presentation, but unfortunately, with theses signs the risk of death is increased. Unlike in human medicine, neurologic dysfunction is common but not

necessary for a diagnosis of heatstroke. Other clinical signs that may be seen on physical examination are petechia or ecchymosis, which may be noted anywhere on the body, melena, hematochezia, hematemesis, unilateral or bilateral epistaxis, and vomit with or without blood. DIC greatly increases the risk of death and the signs to watch for and immediately treat are petechia or ecchymosis, melena, hematochezia, hematuria, vomit with blood, schistocytes, thrombocytopenia, increased PT, PTT. Even though the characterization of heatstroke is based on hyperthermia, a dog may present with hyper-, normo-, or hypothermic. If the dog presents in a hypothermic state, then the chances of death are increased. Hypothermia may happen due excessive active cooling below 103.1 F (39.5 C) or shock.

The bloodwork that should be performed is packed cell volume/total solids (PCV/TP), blood glucose, chemistry panel, electrolytes, blood gases, lactate, kidney values such as blood urea nitrogen (BUN) and creatinine, and coagulation parameters such as partial thromboplastin time (PTT), prothrombin time (PT), and platelet count. Common abnormalities seen are thrombocytopenia, increased nucleated red blood cells (nRBC), hypoglycemia, metabolic acidosis, hypernatremia, hyperkalemia, hypophosphatemia, hypocalcemia, and elevations in PCV, creatine kinase (CK), alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), total bilirubin, creatinine, BUN, PT, and PTT. There are significantly higher mortality rates for the following abnormalities: prolonged PT, PTT, hypoglycemia, nRBC, and increased creatinine (>1.5mg/dL) after fluid therapy. Pathologically, the most common lesions found post mortem is hyperemia, edema, hemorrhages, and necrosis in various organs including brain, lungs, gastrointestinal tract, kidneys, bone marrow, urinary bladder, and mesentery. The liver and spleen may both be enlarged due to congestion. [1-6,9]

Through the gross and microscopic changes, DIC was diagnosed in all dogs in a retrospective study of 54 heatstroke cases.[3]

Pathophysiology

A heatstroke occurs when the body's mechanism to dissipate heat is overwhelmed. As mentioned previously, this happens due to strenuous exercise, a hot, humid environment, or even a combination. No matter the cause, as the core temperature increases, the body begins to dispense heat. For dogs 70% of body heat is lost through radiation and convention; however, as this becomes inefficient, the body becomes reliant on evaporation through panting to help maintain body temperature. However, once these systems are overwhelmed and the core temperature reaches high levels, the blood flow shifts in the body to the muscles, skin, and spleen to meet oxygen demands and to help dissipate heat. Unfortunately, the blood is routed away from the mesenteric circulation causing ischemia, hypoxia, and hyperpermeability within the internal organs. This hypoperfusion starts the body to descend into SIRS or shock from the secretion inflammatory cytokines and highly reactive oxygen and nitrogen species which begin to break down organs. As the core temperature rises and more intestine becomes ischemic, the gut epithelium becomes weakened and permeable; this allows bacteria and the release of LPS into the bloodstream causing endotoxemia and higher production of cytokines and activation of neutrophils. The gastrointestinal clinical signs and affects seen such as gastrointestinal hemorrhage, mucosal sloughing, hematochezia, or melena may be due to the development of sepsis and may activate DIC and even multiorgan dysfunction (MOD) due to the endothelial injury and subsequent release of thromboplastin and factor XII. However, these processes may appear hours to days after the initial onset; therefore, coagulation abnormities and clinical signs

of DIC need to be monitored for the first 24 hours after onset. Coagulation abnormalities can be enhanced by injury to the liver through hypoxia and microembolism. Within the heart, these changes, specifically DIC and shock, cause injury to the endocardium and myocardium which causes arrythmias. These changes cause injury to the pulmonary interstitial capillaries causing vasculitis and create pulmonary edema, infarcts, and hemorrhage, which can lead to acute respiratory distress syndrome then respiratory failure. The renal system's injury is due to hypoxia, hypovolemia, endotoxemia, microthrombosis, and cytokines causing renal swelling, severe necrosis, and tubular degeneration. Although the dog brain appears resistant to lethal hyperemia the effect of hypoperfusion, vascular damage, and infarction is seen in widespread edema, hemorrhage, and neuronal necrosis. During exposure to high heat, heat shock proteins are released, which provide protective tolerance by maintaining intracellular function and structural protein integrity and reduces production of proinflammatory cytokines. It was found that dogs that were healthy and hydrated had lower mortality rates comped to does with compromised immune system and dehydration. Dehydration worsens the effects of heat accumulation due to decreased plasma volume and while a compromised immune system allowed help trigger SIRS. [1-5,7-9]

Treatment and Management

Treatment for heatstroke should begin with the owner actively cooling the dog as quickly as possible. Dogs that arrived at the clinic 90 minutes after onset of heatstroke had increased survival rate and lower risk of developing DIC.[3,4] The following are different methods to actively cool a patient. Cool water can be applied with a hose, presoaked towels, spraying, or sponging the dog's thinly haired regions such as the neck, ventral abdomen, and inner things. However, careful care should be taken when dog's have thick haircoats because wet hair can become an

insulation barrier and limit heat dissipation. At the same time, fans, open windows, or air conditioning can be used to circulate the air around the dog. While traveling to the hospital, open windows or air condition should be used. Ice packs and full body immersion in cold water is not recommended due to the vasoconstriction of the peripheral vessels increasing core temperatures further. Also, for full immersion if the dog is neurologically impaired, there is a risk of drowning. Other treatments that are not recommended due to complications that either cause higher mortality rate or have negative effects on organ function include cold water enemas, gastric lavage, peritoneal lavage, and pharmacological agents.[5,6] Once the dog reaches rectal temperatures of 103.1 F (39.5 C), all cooling methods need to be stopped to prevent hypothermia due the body to continue to cool itself, as the rectal temperature lags behind the core temperature. [2,6] Cooling jackets in the study on racing greyhounds found that those who used the cooling jackets immediate post-race had a higher temperature compared to those who did not. This study mentioned another study on military dogs showing the opposite result; therefore, further research is needed on use of these as treatment or prevention options.[9]

Aggressive fluid therapy is important to correct dehydration, hemoconcentration, and hypovolemic-distributive shock. The type of fluids depends on each situation, but the most commonly used are crystalloids such as lactated Ringer's solution (LRS) or Plasmalyte with an incremental boluses 10 to 20 mL/kg over 10 to 15 minutes;(up to a total shock dose) however, physiological parameters needs to be assessed often to watch any needs of additional treatment. If there is hypotension after adequate crystalloid therapy, colloids such as Hetastarch, then vasopressin agents such as dopamine, dobutamine, norepinephrine, or vasopressin may be used. Dextrose solution in a single bolus of 1mL/kg of 50% or as a continuous infusion of dextrose is needed for cases with hypoglycemia, but care should be taken to avoid rapid increase to avoid

cerebral edema. Levels should be checked often. If there is central nervous system dysfunction or a potential for intracranial hypertension, mannitol solution or hypertonic saline may be used, respectively. Early renal injury treatment is important for heatstroke patients. Treatment includes indwelling urinary catheter to monitor the ins and outs of fluid along with aggressive fluid therapy as mentioned previously. If there is adequate fluid therapy and blood pressure remains below 60mm Hg, dopamine, furosemide, and mannitol may be used in combination for support.

Antibiotics and gastrointestinal protectants such H2-receptor blocks or proton pump inhibiters should be started soon after admission to the clinic as support for the intestinal tract and protection against endotoxemia and sepsis, even if there are not apparent clinical signs of gastrointestinal abnormalities seen on presentation. Antibiotics will need to be broad-spectrum for effectiveness against the bacteria of the gut and should be given until there is adequate enteral nutrition, cardiovascular status is stable, and resolving gastrointestinal signs are seen. To fully restore the gastrointestinal health, nutritional support through enteral nutrition or parenteral nutrition is important and should be started as soon as possible. Parenteral nutrition is needed for patients that are neurologically compromised or cannot tolerant enteral feeding.

Blood products such as whole blood, packed red blood cells, and fresh frozen plasma should be given when indicated based on bloodwork and clinical signs. Some indications for whole blood or packed red blood cells would be anemia, for example. Dogs with coagulation abnormalities or DIC will preferably need fresh frozen plasma. PT and PTT levels should be checked for need of additional blood products. As mentioned before, it is important to monitor for signs of DIC 24 hours after the initial insult. Things that need to be assessed are temperature, pulses, CRT, hydration or shock status, PT, PTT, PCV/TP, CBC, glucose, blood gas, lactate, blood pressure, and urine output.[1-6,9]

Case Outcome

Once Bella was admitted to MSU-CVM intensive care unit, a coagulation profile, NOVA, blood gas, and Parvo SNAP test were performed. Based on the coagulation profile, she received a fresh frozen plasma transfusion of 240mLs. Repeat coagulation times post-transfusion were still prolonged, and she was then crossmatched and found to be DEA 1.1 Positive. She then received a whole blood transfusion of 450mls. A second blood gas and coagulation profile were performed. Bella remained tachycardic and became tachypneic post-transfusion. It took two more fresh frozen plasma transfusions equaling 480mls to stabilize her coagulation times. Bella was diagnosed with DIC based on her clinical signs and bloodwork. Therefore, she started the following medications to protect her gastrointestinal tract and prevent sepsis, pantoprazole, Cerenia, Unasyn, Enrofloxacin, ondansetron, sucralfate, metoclopramide.

Despite aggressive fluid resuscitation, Bella remained azotemic, indicating an acute kidney injury secondary to her heat stroke. A urinary catheter was placed to measure her ins-outs and to more accurately manage her fluid therapy. At the end of her first week in hospital, a nasoesophageal tube was placed to facilitate feedings since Bella was unwilling to eat and she was diagnosed with pancreatitis on abdominal ultrasound. She was fed four times daily through the tube. The tube was kept in place for 3 days. During the first week of her stay in ICU, Bella's temperature began to fluctuate daily beyond the high range of normal, even reaching 105.9*F, but she remained bright, alert, and responsive and she was diagnosed with phlebitis. At this point, Clavamox was added and all her intravenous catheters, urinary catheter, and Unasyn were removed. She had a CBC, chemistry panel, urinalysis, and urine culture and sensitive performed. These test revealed her azotemia was resolved, but had developed severely elevated liver enzymes that was treated with Denamarin. Approximately 8 days after her initial insult, she

again developed petechiae on her mucous membranes and ear pinna suspected secondary to platelet dysfunction. A slide agglutination test was performed and ruled out IMHA; in addition, a CBC, chemistry panel, and coagulation panela was repeated and revealed improved values compared to past values. On blood smear examination, our pathologist noted one platelet with what appeared to be an inclusion that was suspicious for Anaplasma platys. However, a 4DX test was negative. After the removal of Bella's nasoesophageal tube, she began eating, drinking, urinating, and defecating normally, but she also began to exhibit ocular and nasal discharge, which worsened over time. Her upper respiratory signs became worse with increased oculonasal discharge and an occasional cough. Consultation with the MSU-CVM ophthalmology department revealed a high positive for canine herpes-1 viral infection from a nasal swab. Her ocular lesions included discharge and hyperemia and Famciclovir, triple antibiotic eye ointment, and tramadol were added to her treatments. Bella was moved into isolation and her treatment plan was modified accordingly.

Throughout her stay in the ICU, Bella remained bright, alert, responsive, and active despite her clinical signs. Complications following her initial heat stroke insult involved DIC, pancreatitis, acute kidney injury, and severe phlebitis. Bella was discharged on May 28, 2019, with minimal oculonasal discharge and vitals within normal limits. At the time of discharge, she was bright, alert and responsive, eating, drinking, urinating, and defecating normally. Bella was adopted by Chase Waldrip, a 4th year veterinary student and his wife Julie. At discharge she was still taking the following medications Denamarin, Ondansetron, Doxycycline, Famciclovir, Tramadol, and Triple Antibiotic Ophthalmic Ointment. Since her adoption she is enjoying life with her dog siblings Bilbo and Allie.

References

1. Bhavani, Sandhya, et al. “Coagulation parameters in dogs with heat stroke – A short study.” *Journal of Animal Research*. June 2015. V.5, N.2, pp. 381-383. DOI: 10.5958/2277-940X.2015.00065.0.
2. Bruchim, Y. “Canine Heatstroke.” *Israel Journal of Veterinary Medicine*. June 2012. V. 67, N. 2, pp 92-95.
3. Bruchim, Y, et al. “Heat Stroke in Dogs: A Retrospective Study of 54 Cases (1999–2004) and Analysis of Risk Factors for Death.” *J Vet Intern Med*. July 2006. V. 20, pp 38–46.
4. Bruchim, Y, et al. “Pathological Findings in Dogs with Fatal Heatstroke.” *J Comp. Path.* 2009. V. 140, pp. 97-104. DOI: 10.1016/j.jcpa.2008.07.011
5. Hall, Emily. “Heatstroke - providing evidence based advice to dog owners.” *Veterinary Nursing Journal*. November 2016. http://doi.org/10.1080/17415349.2016.1245119.
6. Hemmelgarn, Carey and Kristi Gannon. “Heatstroke: Clinical Signs, Diagnosis, Treatment, and Prognosis.” Compendium: Continuing Education for Veterinarians. 2013. Vetlearn.com.
7. Hemmelgarn, Carey and Kristi Gannon. “Heatstroke: Thermoregulation, Pathophysiology, and Predisposing Factors.” Compendium: Continuing Education for Veterinarians. 2013. Vetlearn.com.
8. Lim, Chin Leong and Suzuki K. “Systemic Inflammation Mediates the Effects of Endotoxemia in the Mechanisms of Heat Stroke.” *Biol Med (Aligarh)*. December 2016. V. 9, N. 1, pp. 1-4. DOI: 10.4172/0974-8369.1000376.
9. McNicholl, Jane, et al. “Influence of the Environment on Body Temperature of Racing Greyhounds.” *Frontiers Veterinary Science*. June 2016. V. 3, N. 53. DOI: 10.3389/fvets.2016.00053.