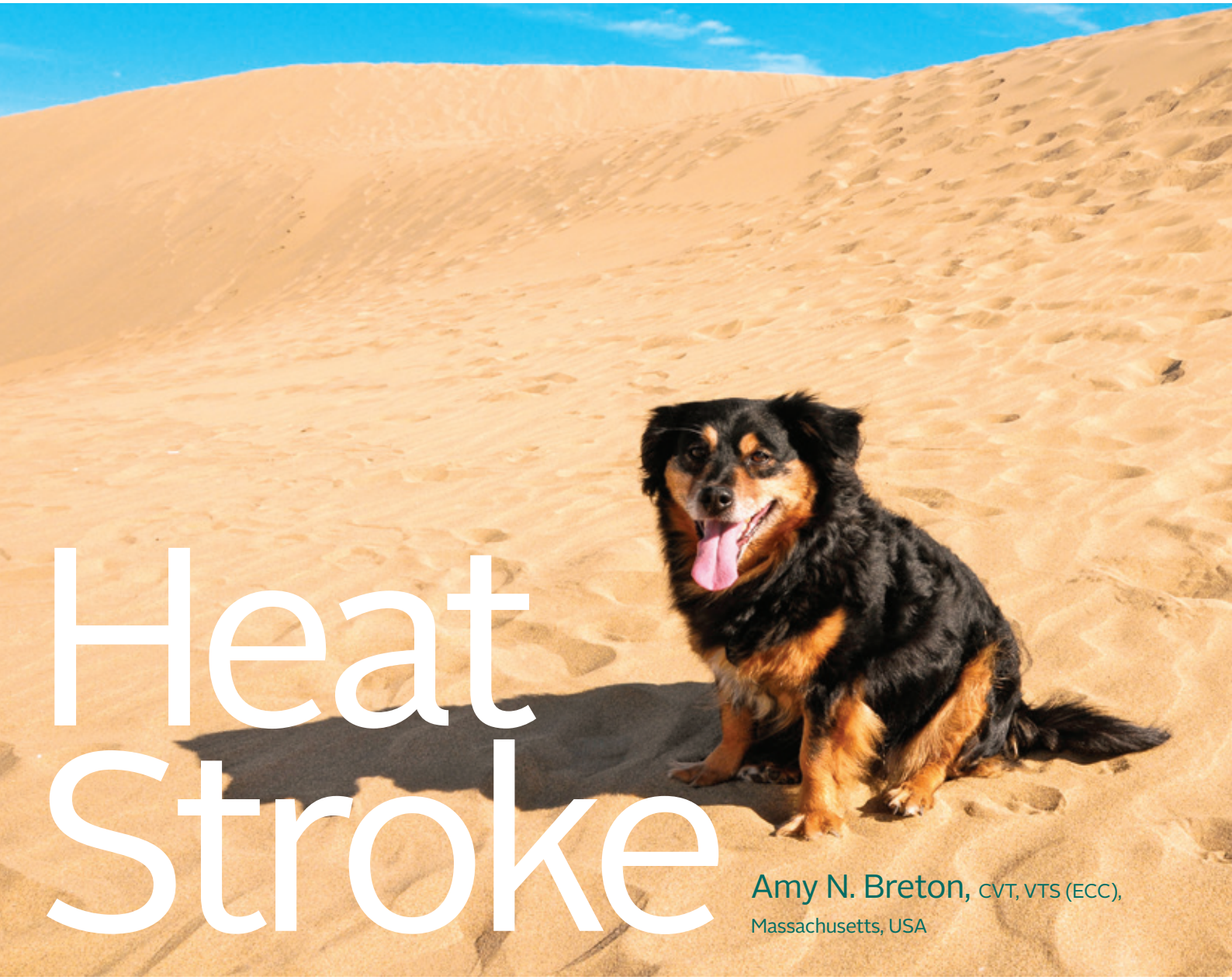

Heat Stroke

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INTRODUCTION

Thermoregulation is the ability of an animal to maintain body temperature within certain boundaries, even when the surrounding temperature is very different. This process is one of the most important aspects of homeostasis. Pets may experience large changes in environmental temperatures and, while their bodies may first be able to regulate normal temperature, at some point the body may not be able to keep up with the demand. Summer months usually cause increasing temperatures outside resulting in heat stroke in pets. As a veterinary nurse you are likely to deal with the client and pet first and be responsible for performing the diagnostics, treatment and nursing care of these patients.

PHYSIOLOGY

The body's temperature is regulated almost entirely by a nervous system feedback mechanism which reports to the temperature-regulating centre located in the hypothalamus.[1] There are three times as many heat-sensitive neurons than cold-sensitive neurons located in the hypothalamus.[1] These neurons function as temperature sensors for the body.[1] As the body comes in contact with cold stimulation, the heat-sensitive neurons will increase their firing rate.[1] Conversely, the cold-sensitive neurons will increase their firing rate when the body experiences heat stimulation.[1] Ultimately it is these signals that will cause the body to lose or increase body heat.

Heat loss occurs from four main mechanisms: convection, conduction, radiation, and evaporation. In animals most heat loss occurs from convection (occurs from cooler circulating air moving over the body) and conduction (occurs from a pet lying directly on a colder surface).[2] Pets can also experience heat loss through radiation (when cooler air disperses through the environment not forced) and evaporation (panting and sweat loss), though these are not as common. Ultimately, if the body needs to lose heat, vasodilation, sweating, panting and a decrease in chemical thermogenesis occurs.[1]

Heat production occurs from cellular metabolism, skin vasoconstriction, piloerection and voluntary muscle activity (shivering).[1, 2] Piloerection allows for the hair to trap a layer of "insulated air" next to the skin which allows for a decrease of heat tranferance.[1] Shivering works by increasing muscle movement which allows for the body's heat production to increase. When the body is cold, the hypothalamus will release thyrotropin-releasing hormone which acts to release thyroid-stimulating hormone from

the pituitary gland.[2] Thyroid-stimulating hormone, in turn, increases the release of thyroxine which works to increase the rate of cellular metabolism throughout the body.[1] The liver is one of the largest organs in the body. Through cellular metabolism the more active the cells, the more they produce heat. Simply because of its size and therefore the number of cells involved, the liver helps to regulate the body's heat.[3] This is why liver failure pets may experience hypothermia.

HYPERTHERMIA

A disease process or temperatures in the surrounding environment may cause the pet to no longer be able to thermoregulate. The pet's temperature will increase to a point above normal (39.2˚C / 102.5˚F). There are two causes of hyperthermia: pyrogenic and nonpyrogenic.[4] Pyrogenic hyperthermia is caused by inflammation or infection, while nonpyrogenic is caused by damage to the hypothalamus (e.g. tumour) or an alteration to the temperature-regulating centre itself.[4] Certainly some forms of hyperthermia can be beneficial, as in the case of inflammation.

When the core temperature increases above 41.1˚C / 106˚F neurological and organ dysfunction can occur.[5] It is around this temperature that the term heatstroke is applied due to the failure of systems which may occur. While temperatures above 41.1˚C / 106˚F can lead to neurological and organ dysfunction, it isn't until the core temperature increases to 43˚C / 109.4˚F that the body experiences actual cellular death in the brain.[6] There are two types of heatstroke: exertional and nonexertional.[7]

Exertional heatstroke occurs because a dog or cat will actively be playing, running or walking in an environment that is too hot for their body condition. Certain breeds, such as brachycephalic breeds, have a much lower tolerance for high temperatures compared to other breeds. Obesity and certain conditions, such as laryngeal paralysis and heart disease, may also play a factor in the pet's inability to thermoregulate in hotter temperatures.

Nonexertional heatstroke is caused by the pet's inability to dissipate heat because of a decrease in airflow (closed car) or lack of shade or water. Generally if pets are provided shade, water and an environment with an adequate amount of circulating air, they will be able to thermoregulate appropriately.

When temperatures exceed above 41.1˚C / 106˚F, the pet may experience central nervous system, gastrointestinal, cardiovascular, hepatobiliary, renal, hematologic and muscular dysfunction.[4] While there is no set point at which each of these system fails, the higher the temperature and the longer the exposure results in more systems dysfunction and an increase in mortality rate. It is important to note that each pet responds differently. There are some dogs that may suffer little organ dysfunction with a core temperature of 43˚C / 109˚F, while others may experience life threatening hematologic and renal disorders.

Heatstroke signs include incessant or noisy panting, collapse, inability to walk/staggering, altered mentation and/or gastrointestinal signs (vomiting/diarrhea). As temperature increases, swelling in the brain can occur leading to cerebral edema.[4] Localized areas of intercerebral bleeding may occur.[4] Pets may present with neurologic signs including seizures, nystagmus, anisocoria or they may be comatose.

Gastrointestinal (GI) dysfunction occurs secondarily to ischemia and poor perfusion during heatstroke.[4] Some animals may experience GI signs even during mild hyperthermic episodes. Pets may experience hematachezia, melena, vomiting, hematemesis and GI sloughing.

Initially during heatstroke, vasodilation and an increase in cardiac output occurs.[8] Cardiac failure can occur because of the increased demands on the heart due to the increased metabolic demands and redistribution of blood flow, which leads to body-wide hypoxia.[4] Myocardial ischemia, due to the hypoxia, can lead to ventricular arrhythmias which can lead to cardiac failure.[8]

One of the most life-threatening problems with heatstroke is the thermal injury to the renal system.[4] Renal failure is initially caused by the decrease in cardiac output and renal vasoconstriction.[8] This results in a decrease in renal perfusion causing tubular necrosis.[8] Dehydration can also exacerbate renal failure. Liver and muscular damage occur from the hypoxia the pet experiences.[8] Excessive heat can also cause injury to the hepatocytes leading to worsening liver failure.[8] Even if a patient recovers from heatstroke, they may have permanent renal and liver damage which require lifelong treatment.

As heatstroke progresses, pets may experience disseminated intravascular coagulation (DIC), systemic inflammatory response syndrome (SIRS), multiple organ dysfunction syndrome (MODS) and rhabdomyolysis.

Disseminated Intravascular Coagulation

DIC is a pathological process where the blood starts to coagulate throughout the whole body. The end result is that it depletes the body of platelets and coagulation factors, causing the body to be at risk for increased bleeding.[9] Petechiae, ecchymosis and excessive bleeding are often noted with DIC. DIC is generally triggered whenever there is a major disruption in the intravascular system as is the case with heatstroke.[4] When the endothelial cells are damaged, they expose substances that activate the clotting cascade. Eventually an unbalance occurs between clotting and bleeding, which is DIC.

Systemic Inflammatory Response Syndrome

The cytokines produced during an inflammatory response act as the mediators of SIRS. SIRS can occur from hyperthermia alone (temperatures above 41.1°C / 106°F) if there is an inciting incident. SIRS is an inflammatory response of the entire body and can result in death. The diagnosis of SIRS can be made if the animal has two or more of the following criteria[10]:

- Heart rate: >160 bpm in the dog and >250 bpm in the cat or <140 bpm in the cat
- Respiratory rate: >20 bpm in the dog and >40 bpm in the cat
- Body temperature: <37.8°C / 100°F or >39.7°C / 103.5°F
- White blood cell count: >12,000 or <4,000 or >10% bands

Multiple Organ Dysfunction Syndrome

Just as it sounds, it is the altered organ function of two or more organ systems. Organ dysfunction can occur during heatstroke or may occur because of a disease process causing hyperthermia. MODS may also occur due to complication from sepsis or SIRS.[9] If MODS occurs in conjunction with SIRS, the prognosis becomes very poor.[10] The number of organs involved decreases the chances of survival.[10]

Rhabdomyolysis

Rhabdomyolysis is the rapid breakdown of muscle fibers due to traumatic injury to the skeletal muscles. In the case of heat stroke, this is due to muscle necrosis.[4] The principal result is the release of muscle fiber contents, such as myoglobin, into the blood stream. Myoglobin is then circulated through the bloodstream and eventually through the kidneys where it blocks the structures of the kidneys causing acute tubular necrosis or kidney failure.

TREATMENT FOR HEATSTROKE

Initial stabilization should be aimed at decreasing the temperature to prevent further injury, restoring tissue perfusion and minimizing further neurologic injury.[11] If an owner has called on the phone and reported signs of heatstroke, they should be instructed to pour cool (not cold) water over the pet and immediately transport to the closest veterinary hospital. Be sure to instruct the owner not to submerge the pet as it will not be able to breathe. Remember that not only how high the temperature was, but how long the pet was hyperthermic plays a role in how many complications the pet will experience.

The goal of cooling is to reduce the temperature of the patient slowly as to cause the least amount of stress on the body as possible. A sudden drop in body temperature will cause further complications. If the body temperature is dropped too quickly, iatrogenic hypothermia can occur.[4] Ice and cold water baths should be avoided because they can cause peripheral vasoconstriction. This causes blood to be forced back to the organs and causes the heat-sensitive neurons to fire more frequently.[8] Because of cerebral edema, the temperature-regulating centre located in the hypothalamus may cause thermoregulation dysfunction and the pet may not have the ability to thermoregulate.[4] If the

temperature is dropped too quickly, the pet may not be able to warm itself up due to the impaired temperature-regulating centre. The cooling end point should be 39.4°C / 103°F over 30 to 60 minutes.[4] Cooling should be stopped at 39.4°C / 103°F to avoid iatrogenic hypothermia.

There have been many reported methods on how to cool patients. Some of these include pouring rubbing alcohol on the pads, leaving a wet towel on the pet, cold water gastric lavage, cold water peritoneal lavage and cold intravenous fluids. There have been no reported real advantage to using any of these methods over noninvasive, peripheral cooling.[4] It has been this author's experience that anything other than hosing or pouring cool water on the pet causes the temperature to drop too quickly and iatrogenic hypothermia is more likely to occur. Studies have shown that dogs that experience iatrogenic hypothermia have a higher mortality rate.[4]

Oxygen supplementation improves tissue perfusion and decreases the risk of ischemia.[8] Therefore oxygen should be provided because most patients experience some level of ischemia, hypoxia and/or dyspnea. This is particularly true in brachycephalic breeds because of the swelling in and around the throat. It is not uncommon that these breeds must be intubated or have an emergency tracheostomy performed because their airway has swollen shut from excessive panting. The most effective ways to administer oxygen are through the use of a face mask (removing the diaphragm to allow for panting) or an oxygen hood.[12] Flow-by oxygen is generally ineffective and oxygen cages should be avoided because treatment cannot occur and the pet needs adequate circulating air to cool.[12]

An intravenous catheter should be placed to help support cardiac output. Fluids should be used judiciously to avoid fluid overload. Large volumes of fluids may lead to the worsening of cerebral and/or pulmonary edema. When the catheter is placed, baseline bloodwork should be drawn at the same time. Minimally packed cell volume, total solids, blood glucose, electrolytes, venous blood gas and lactate evaluation should be performed immediately to assist in guiding fluid therapy.[11] It has been shown that pets with hypoglycemia during the initial stages of heatstroke have a higher mortality rate.[5] Patient temperature, heart rate and blood pressure should be monitored throughout fluid resuscitation.[4] It is best to have the patient monitored on an ECG to look for any arrhythmias that may occur secondarily from the heatstroke. Colloids may need to be considered if the patient is hypoproteinemic or has a decreased colloid osmotic pressure.[8] Plasma should be considered in patients suspected of having DIC. Albumin can be administered if the patient is hypoalbuminemic. The use of corticosteroids and NSAID drugs are usually contraindicated because of the decrease in GI integrity.[4] These patients are typically at risk for GI ulceration and ischemic injury and administration of either usually causes worsening problems.

Ultimately these patients require constant and intensive nursing care. If the patient is recumbent, the nurse will need to lubricate the eyes, moisten the mucous membranes, turn the pet, keep the pet dry and free of bed sores and perform passive range of motion exercises. Ideally, unless DIC is present, a central line should be placed in these patients to monitor central venous pressures and for the administration of parental nutrition if needed later. A urinary catheter should be placed in down pets to keep them clean and dry.

Pets should be monitored for GI signs and all vomiting and diarrhea should be noted. GI protectants, antiemetics and antidiarrheals should be considered in any heatstroke patient. Nurses should monitor for signs of DIC such as increase bleeding times, petechiae or ecchymosis. Even if the patient doesn't have a urinary catheter, nurses should monitor urine output. This is easily done by using a non-absorbent litter in cats or catching the urine produced from dogs. A decrease in urine production may indicate kidney failure. It is equally important that nurses look for signs of icterus in patients by monitoring gum colour, inspecting the colour of the sclera, pinna of the ear and underbelly of the pet. Throughout the pet's hospitalization, blood work should be constantly monitored and treatment should be tailored to the pet accordingly. Clients should be informed that their pets are at risk for DIC and organ failure up five to seven days post heatstroke.[4]

CONCLUSION

As a veterinary nurse you will likely encounter a patient who is experiencing hypo- or hyperthermia. You will need to communicate effectively and quickly to the client. Understanding the needs of your patient will allow you to provide the best nursing care possible. Since every second counts with these patients, it is important that treatment begins quickly and intensive nursing care is provided in order to ensure the patient's best chance of survival.

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