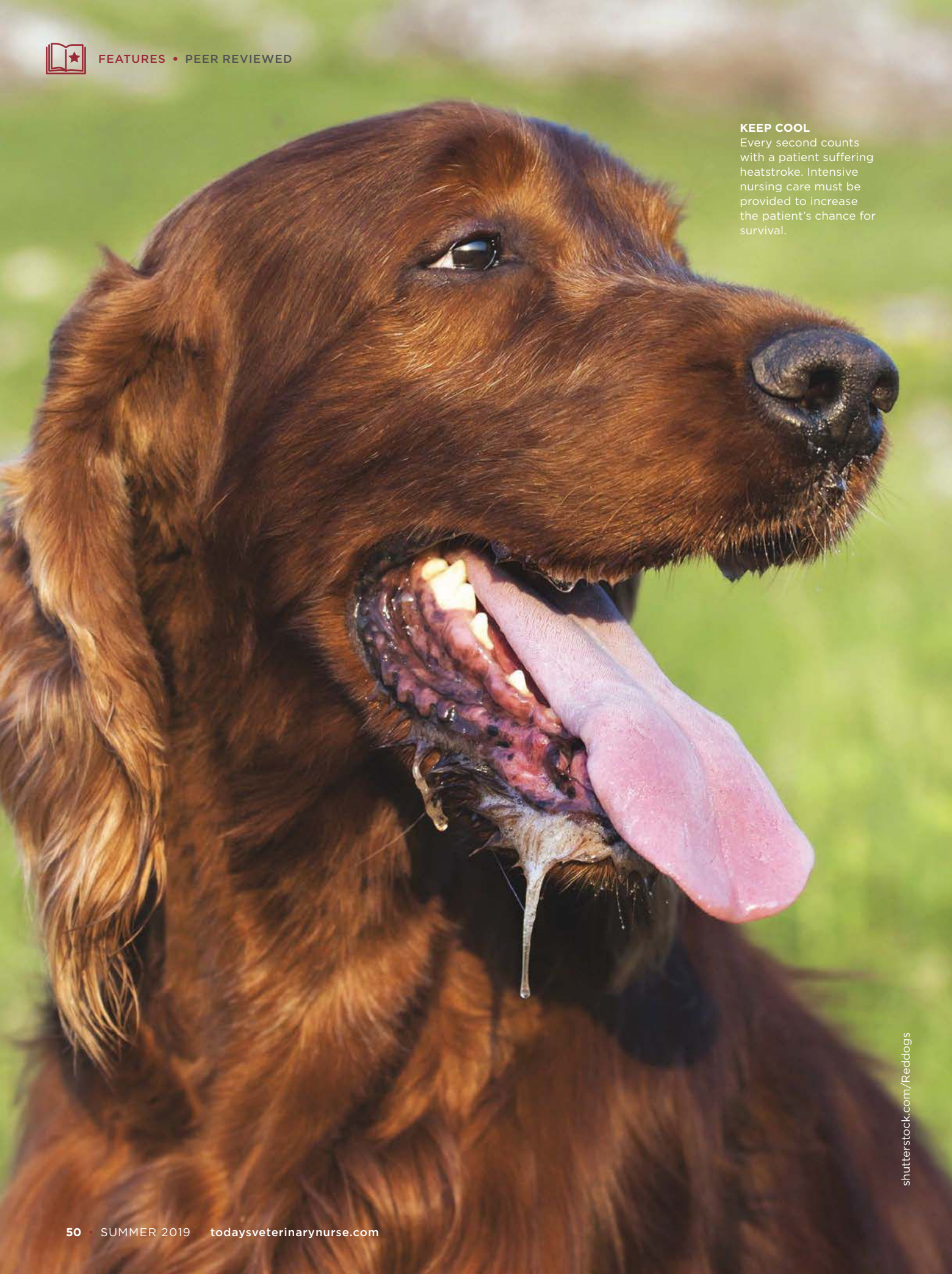

KEEP COOL
Every second counts with a patient suffering heatstroke. Intensive nursing care must be provided to increase the patient's chance for survival.

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CRITICAL CARE

Providing Care to Dogs with Heatstroke

MEET THE AUTHOR

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Amy is employed by BluePearl Veterinary Partners as a Training Project Manager. After working in general practice, she found her passion in emergency medicine and in 2003 became a Veterinary Technician Specialist in Emergency and Critical Care. She has held several board positions in the Academy of Veterinary Emergency & Critical Care Technicians & Nurses, including president. Amy has published numerous articles, is an international speaker, has received numerous awards (including 2 Speaker of the Year awards), and is highly involved in her community. She and her wonderful furry kids live in Massachusetts, where you can find her eating chocolate, running in the woods, competing her dogs in agility, and scuba diving in the ocean.

Thermoregulation is the ability to maintain body temperature within certain boundaries, even when the surrounding temperature is very different. This ability is a major aspect of homeostasis. Companion animals may experience large changes in environmental temperature, and although their bodies may initially be able to regulate the temperature to within normal range, at some point they may not be able to keep up with the demand. When this happens, and if the core body temperature reaches 41.1°C (106°F) or above, the animal is said to have heatstroke.

Most commonly (although not the only cause), the increasing outside temperatures of summer can result in heatstroke in companion animals. As a veterinary nurse or assistant, you are likely to be the first person to deal with the client and the heatstroke patient and to perform the diagnostic testing, treatment, and nursing care for these critical patients. This article describes the physiology of normal thermoregulation; the pathophysiology of heatstroke; and how to recognize, treat, and care for the heatstroke patient.

THERMOREGULATION

Body temperature is regulated almost entirely by a nervous system feedback mechanism that responds to the temperature-regulating center in the hypothalamus, where there are 3 times as many heat-sensitive as cold-sensitive neurons, which function as temperature sensors.[1] The signals sent by these sensors cause the

body to lose or increase body heat. When heat loss is needed, the body can respond with vasodilation, sweating, panting, and decreased chemical thermogenesis.[1]

Heat loss occurs by 4 main mechanisms: convection, conduction, radiation, and evaporation.

- Convection is the process of losing heat through movement of air or water across the skin.
- Conduction is the process of losing heat through physical contact with another object or body.
- Radiation is the process of heat transfer from one object to another, without physical contact.
- Evaporation is the process of losing heat through conversion of water to gas.

In animals, most heat loss occurs from convection (cooler air moving over the body) and conduction (lying directly on a colder surface).[1] Less commonly, animals also lose heat through radiation and evaporation (panting and sweating).

HYPERTHERMIA

An animal becomes hyperthermic when physiologic thermoregulation is no longer adequate. Causes include disease or changes in environmental temperature. Hyperthermia is considered to be a body temperature above normal (39.2°C /102.5°F). There are 2 categories of hyperthermia: pyrogenic and nonpyrogenic.[2]

Pyrogenic hyperthermia is caused by inflammation or infection, in which the body responds to a new temperature set point, ultimately producing a fever. Some fevers are beneficial and help the immune system and inflammatory response act appropriately so the body can heal. Unless the temperature rises above 41.1°C/106°F, hyperthermia in these patients should not be reduced.[2] Treatment of the illness or injury will decrease the temperature most of the times in these cases.

Nonpyrogenic hyperthermia is caused by damage to the hypothalamus (e.g., by a tumor) or an alteration to the temperature-regulating center itself.[2] When the damaged hypothalamus no longer triggers heat-disseminating mechanisms, body temperature rises. Temperatures above 41.1°C /106°F (heatstroke) can lead to neurologic and organ dysfunction, and temperatures of 43°C /109.4°F or above can lead to brain cell death.[3,4]

TYPES OF HYPERTHERMIA

Heat Stress

Heat stress is associated with increased thirst, hyperthermia, and panting.[2] The patient is still mentally aware and generally is ambulatory.

Heat Exhaustion

Heat exhaustion is a more severe form of heat stress and is usually associated with markedly increased thirst, generalized weakness, and heavy panting.[2] These patients may or may not be ambulatory or may collapse. They are mentally aware but too tired to react.

Heatstroke

Heatstroke is more serious than heat exhaustion. Problems that occur when temperatures exceed 41.1°C/106°F include dysfunction of the central nervous, gastrointestinal, cardiovascular, hepatobiliary, renal, hematologic, and muscular systems.[4] Although there is no set point at which each of these systems will fail, higher temperatures and longer durations of heat exposure will lead to more system dysfunctions and risk of death. Some animals will have elevated liver and kidney enzymes at the time of presentation.[2] The consequences of heatstroke, however, vary among individuals. For example, at a core temperature of 43°C/109°F, some dogs may suffer organ dysfunction while others may experience life-threatening hematologic and renal disorders.

Heatstroke can be further subdivided into 2 types: exertional and nonexertional.[5]

Exertional heatstroke occurs when a dog or cat is playing, running, or walking in an environment that is too hot for their body condition. Tolerance for any exertion in high temperatures is much lower for animals of certain breeds (e.g., brachycephalic breeds), those that are obese, and those with certain medical conditions (e.g., laryngeal paralysis or heart disease). The nares of brachycephalic dogs are stenotic rather than open and round, resulting in the need for more force to suck in the same amount of air than is needed by dogs of other breeds.[5] In addition, the trachea of brachycephalic breeds is often one-third the diameter of the trachea of nonbrachycephalic dogs of similar weight, further restricting air flow and ventilation.[5] A hot and humid environment may cause the upper

airway of brachycephalic dogs to swell, thereby partially or completely closing the airway.

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

SIGNS AND SYMPTOMS OF HEATSTROKE

Heatstroke signs and symptoms include incessant or noisy panting, collapse, inability to walk (e.g., staggering), altered mentation, and/or gastrointestinal (GI) signs (e.g., vomiting/diarrhea). These signs result from changes to the nervous, GI, cardiac, renal, and hepatic systems.

Neurologic

As temperature increases, the brain swells (i.e., cerebral edema)[2,4] and may bleed in localized areas.[4] Neurologic signs include seizures, nystagmus, anisocoria, or coma.

Gastrointestinal

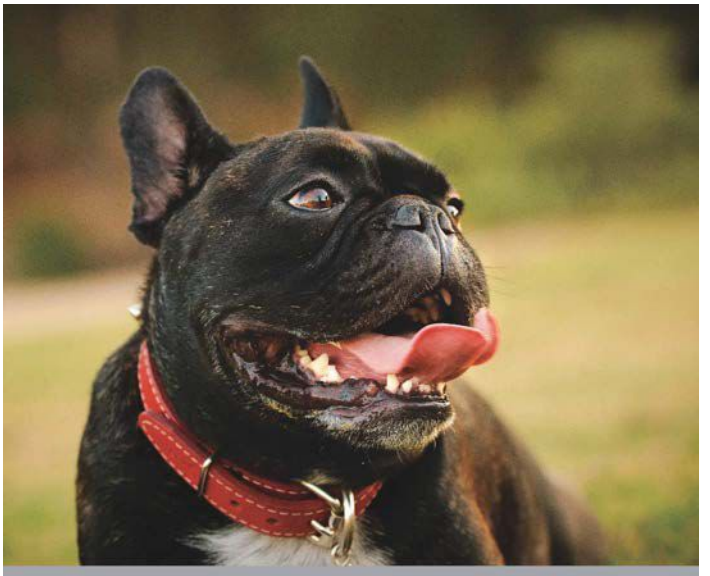
During heatstroke, GI dysfunction results from ischemia and poor GI perfusion.[4] Some mildly hyperthermic animals may experience GI signs (e.g., hematochezia, melena, vomiting, hematemesis, and GI mucosa sloughing).

Cardiac

Initially during heatstroke, blood vessels dilate and cardiac output increases.[1] Cardiac failure can result from increased demands placed on the heart by increased metabolic requirements and redistribution of blood flow, which lead to bodywide hypoxia.[6] Lack of oxygen delivery to the myocardium can lead to ventricular arrhythmias, which can lead to cardiac failure.[7]

Renal and Hepatic

One of the most life-threatening heatstroke symptoms is thermal injury to the renal system.[4] Renal failure is initially caused by decreased cardiac output and renal vasoconstriction,[1] which results in decreased renal perfusion and tubular necrosis.[1] Dehydration can also exacerbate renal failure. Liver and muscle damage result from hypoxia.[1] Excessive heat can also injure hepatocytes, leading to worsening liver failure.[1] Even if a patient recovers from heatstroke, the animal may have permanent renal and liver damage requiring lifelong treatment.



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WHY HEAT IS DANGEROUS FOR BRACHYCEPHALIC BREEDS
Factors that predispose animals to heatstroke include obesity, genetics, heart disease, humidity, water immersion, not being acclimated to a warm climate, and being a brachycephalic breed (such as pugs, Boston terriers, and English bulldogs). Unlike humans, who sweat when they're hot, dogs use their respiratory system to pant and get rid of heat. Flat-faced breeds are at a huge disadvantage because their airway abnormalities and bone structure of their faces make their airways like a tight maze; with each breath, they have to work much harder than non-brachycephalic dogs to get air to reach the lungs. Summer months are a particularly dangerous time for these popular breeds.

OTHER COMPLICATIONS

Disseminated intravascular coagulation (DIC) is a pathologic process in which the blood starts to coagulate throughout the whole body, depleting the body of platelets and coagulation factors, increasing the risk for bleeding.[8] DIC is generally triggered by a major disruption in the intravascular system, as occurs with heatstroke. Petechiae, ecchymosis, excessive bleeding, or multiple organ failure may be noted.[8] DIC in a heatstroke patient increases the risk for death.

Systemic inflammatory response syndrome (SIRS) is an inflammatory response of the entire body and can result in death. The cytokines produced during an inflammatory response mediate and control the SIRS response. SIRS can occur from hyperthermia alone if there is an inciting incident,

such as sepsis. Heatstroke patients experiencing SIRS are also at risk for organ failure.

Multiple organ dysfunction syndrome (MODS) is altered function of 2 or more organ systems. Organ dysfunction can result from heatstroke or a disease process causing hyperthermia. If MODS occurs in conjunction with SIRS, the prognosis becomes very poor.[9] A higher number of involved organs decreases survival chances.[9]

Rhabdomyolysis is the rapid breakdown of injured muscle fibers. In patients with heatstroke, muscle necrosis[1] is followed by release of muscle fiber contents (e.g., myoglobin) into the bloodstream, where they eventually block the structures of the kidneys, causing acute tubular necrosis or kidney failure. Patients with heatstroke may exhibit myoglobinuria.

DIC, SIRS, and MODS are all intertwined in patients experiencing heatstroke. A combination of more than one of these complications increases the risk for death.

TREATMENT FOR HEATSTROKE

The initial stabilization goal should be to lower the dog's body temperature to prevent further injury, restore tissue perfusion, and minimize further neurologic injury.[2,3] Subsequent treatment involves oxygen supplementation, fluid therapy, and treatment of complications.

Cooling the Patient

If clients phone to report signs of heatstroke in their dog, they should be instructed to pour cool (not cold) water over the dog and immediately bring it to the closest veterinary hospital. Instruct them to not submerge the dog and to keep the dog's nose and mouth above water at all times.

After the dog is in the hospital, the goal of cooling is to reduce body temperature slowly in a way that stresses the body the least. A sudden drop in body temperature will cause further complications (e.g., iatrogenic hypothermia[1]). Avoid ice and cold water baths because they can cause peripheral vasoconstriction, which forces blood back to the organs.[1] The body feels cold and, in response, will try to warm itself up. Even if cooling methods are applied carefully and slowly, cerebral swelling may be present. Cerebral edema may lead to dysfunction of the temperature-regulating center in the hypothalamus, and the patient may not be able to thermoregulate in either direction.[1] If the temperature is dropped too quickly, the impaired temperature-regulating center may prevent the animal from being able to re-warm itself. Regardless of how careful the veterinary team is, if the hypothalamus is damaged, the patient may not be able to thermoregulate.

Ineffective methods for peripheral cooling have included pouring rubbing alcohol on the footpads and leaving a wet towel on the patient. If a wet towel is left on a patient it will quickly heat up and not allow for heat to escape from the patient. The best and most effective method to decreasing body temperature is pouring cool water over the body. When pouring water, place the patient on a cool metal table.[3] A wet sink with a grate is best because water can constantly drain off the patient. If the water pools under the patient, it will very quickly heat up to the body's temperature. Constant cool water is best. A grated wet sink table also allows for ventilation under the patient, as opposed to a smooth metal table, which can heat up quickly from the patient. However, if a wet sink table is not available, a solid metal table is preferable over a laminated table. Fans can be used to circulate cool air or room-temperature air around the patient. During cooling, the patient's temperature should be monitored continuously or, if that is not possible, taken every 5 minutes until the desired stopping point (39.4°C /103°F) is obtained.[3] Cooling beyond 39.4°C /103°F can lead to iatrogenic hypothermia, which increases risk for death.[3] The cooling process should take 30 to 60 minutes.[3]

Other ineffective methods that have been tried include cold water gastric lavage, cold water peritoneal lavage, and cold intravenous fluids. However, these methods have no real reported advantage over noninvasive, peripheral cooling.[2]

The best and most effective method to decreasing body temperature is pouring cool water over the body. When pouring water, place the patient on a cool metal table.[3]

Oxygen Supplementation

Most heatstroke patients experience some level of ischemia, hypoxia, and/or dyspnea, and therefore benefit from supplemental oxygen, especially brachycephalic dogs. It is not uncommon for dogs of these breeds to require intubation or emergency tracheostomy because their airway has swollen shut from excessive panting. The most effective ways to administer oxygen are through a face mask (removing the diaphragm to allow for panting) or an oxygen hood.[10] Flow-by oxygen is generally ineffective, and oxygen cages should be avoided during the initial emergency because you cannot work on your patient and the patient needs adequate circulating air to cool.[10]

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Fluid Therapy

An intravenous catheter should be placed so that fluids can be given to help support cardiac output; however, fluids should be used judiciously to avoid fluid overload.[3] Large volumes may worsen cerebral and/or pulmonary edemas. Blood should be collected at the time of catheter placement to determine baseline values, which should include packed cell volume, total solids, glucose, electrolytes, venous blood gas, and lactate to assist in guiding fluid therapy.[2,3] Mortality rates are higher among patients that are hypoglycemic during the initial stages of heatstroke.[3] Throughout the fluid resuscitation process, the patient's temperature, heart rate, and blood pressure should be monitored.[11]

Other Treatment

Ideally, an ECG should be run to check for any arrhythmias secondary to the heatstroke.[11] Plasma transfusions should be considered for patients suspected of having DIC.[11] Albumin can be administered to hypoalbuminemic patients.[11]

Contraindications

Use of corticosteroids and nonsteroidal anti-inflammatory drugs is usually contraindicated because of their tendency to decrease gastrointestinal integrity.[11] Heatstroke patients are typically at risk for gastrointestinal ulceration and ischemic injury, which can be worsened by administration of these drugs.

NURSING CARE

Heatstroke patients require constant and intensive nursing care. Monitor these patients for trends; even if a patient seems to be stabilizing, notify the veterinarian of any changes in vital parameters.

If the patient is recumbent, lubricate the eyes, moisten the mucous membranes, turn the patient, keep them dry and free of bed sores, and perform passive range of motion exercises.[11] For patients unable to rise, a urinary catheter can help keep them clean and dry.

Because glucose, electrolyte, and acid-base abnormalities are common, check blood values frequently.[11] Ideally, unless DIC is present, a central line should be placed to preserve veins and can be used to administer parental nutrition if needed later.

Blood pressure of heatstroke patients must be monitored closely, directly or indirectly. Direct (invasive) arterial pressure monitoring is standard[11] and requires an arterial catheter, which can also be used to obtain arterial blood gas samples. Indirect methods provide less accurate readings, but they are more readily available and noninvasive (e.g., oscillometric devices or Doppler ultrasound flow detectors). If mean arterial pressure falls below 60 mm Hg, the kidneys and other organs are not appropriately perfused, putting them at risk for failure.[11] The goal is normalization of blood pressure (i.e., mean arterial pressure of 80 to 120 mm Hg or systolic pressure of 110 to 160 mm Hg).[11]

Patients should be monitored for GI signs; all vomiting and diarrhea should be noted. GI protectants, antiemetics, and antidiarrheals should be considered for any heatstroke patient.

Even for patients without a urinary catheter, veterinary nurses should monitor urine output[11] by using

nonabsorbent litter for cats or direct catch for dogs. Decreased urine production might indicate kidney failure. Look for signs of icterus by monitoring the color of the gums, sclera, ear pinnae, and underbelly. Throughout the pet's hospitalization, blood values should be constantly monitored and treatment tailored accordingly. Veterinary nurses should monitor for signs of DIC, such as increased bleeding times, petechiae, or ecchymosis. Clients should be informed that heatstroke patients are at risk for DIC and organ failure up to 5 to 7 days after experiencing the heatstroke.[3]

Because heatstroke patients are at risk for cardiac arrhythmias, running a continuous or periodic ECG should be considered. Auscultation of the heart every 2 to 4 hours will help identify heatstroke-related cardiac issues early.

Veterinary nurses and assistants should pay close attention to their patient's mental state. Central nervous system abnormalities can result from cerebral swelling. Watch for nystagmus, anisocoria, miotic pupils, or blindness. Seizures are rare.

For patients in very critical condition, having one veterinary nurse or assistant assigned to the patient may help detect subtle changes. The nursing care may be so intense that it requires one veterinary nurse to be with the patient throughout its care.

CONCLUSION

As a veterinary professional, you will probably encounter a patient who is experiencing heatstroke. You will need to communicate effectively and quickly to the client. Understanding the needs of your patient will enable you to provide the best nursing care possible. Because every second counts with these patients, treatment must be administered quickly and intensive nursing care must be provided to increase the patient's chance for survival. TVN

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