HEATSTROKE IN BRACHYCEPHALIC DOGS AFTER A PETSHOP VISIT - REPORT OF TWO CASES

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SUMMARY: Heatstroke is a fatal syndrome that develops when body temperature increases, and extrinsic and intrinsic heat production exceeds the ability to dissipate heat. Brachycephalic dogs are more likely to develop heatstroke. However, lack of adequate acclimatization, and exposure to a hot environment, especially with high humidity, are considered predisposing factors. Heatstroke is an increase in body temperature above 41º C. It is associated with dysfunctions of the Central Nervous System (CNS) and the production of inflammatory mediators that initiate and modulate the acute phase response, activating the endothelium, which culminates in coagulation and fibrinolysis, similar to what occurs in sepsis. This paper describes two cases of heatstroke in brachycephalic dogs treated at a pet shop. After the consultations, the animals were panting, and one of them had an increase in body temperature (42.9ºC). Both died and were referred to the Veterinary Pathology Service (SPV) of UNESP-FCAV, Campus of Jaboticabal-SP. During the necroscopic examination, the main findings were hemorrhage in subcutaneous tissue, frothy fluid in the trachea and lungs, and diffusely reddened parenchymal organs. Microscopic examination showed pulmonary edema, congestion, and hemorrhage in multiple organs. The cause of death was a cardiorespiratory shock. This paper shows the importance of strict temperature control environments in pet shops and animal transport vehicles, especially when it comes to brachycephalic dogs, to avoid the development of heatstroke, a fatal syndrome.

KEYWORDS: Heat, hyperthermia, cardiorespiratory shock, stress.

HEAT STROKE EM CÃES BRAQUICEFÁLICOS APÓS PASSAGEM POR PETSHOP: RELATO DE DOIS CASOS

RESUMO: O *Heat Stroke* ou intermação é uma síndrome fatal que se desenvolve em casos em que há aumento da temperatura corpórea, quando as produções de calor extrínsecas e intrínsecas excedem a capacidade de dissipar calor. Cães braquicefálicos estão mais propensos a desenvolver intermação, no entanto, ausência adequada de aclimatação, exposição a um ambiente quente, especialmente com umidade elevada, são considerados fatores predisponentes. O *Heat Stroke* caracteriza-se por aumento da temperatura corpórea acima de 41º C e está associado a disfunções do Sistema Nervoso Central (SNC), bem como a produção de mediadores inflamatórios que dão início e modulam a resposta de fase aguda, ativando o endotélio, que culmina com coagulação e fibrinólise, semelhante ao que ocorre na sepse. Este trabalho descreve dois casos de intermação em cães braquicefálicos, que foram atendidos em *petshop.* Após os atendimentos os animais apresentavam-se ofegantes, um deles teve aumento da temperatura corporal (42,9º C). Ambos vieram a óbito e foram encaminhados para o Serviço de Patologia Veterinária (SPV) da UNESP-FCAV, Campus de Jaboticabal-SP. Durante o exame necroscópico, os principais achados foram hemorragia em tecido subcutâneo, presença de líquido espumoso na traqueia e pulmões e órgãos parenquimatosos difusamente avermelhados. O exame microscópico mostrou edema pulmonar, congestão e hemorragia em múltiplos órgãos. A causa *mortis* foi choque cardiorrespiratório. Este trabalho mostra a importância de ambientes com controle rígido da temperatura nos estabelecimentos *petshops* e/ou nos veículos de transporte de animais, principalmente quando se trata de cães braquicefálicos, a fim de evitar o desenvolvimento de *Heat Stroke*, uma síndrome fatal.

Palavras-Chave: Calor, hipertermia, choque cardiorrespiratório, estresse.

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INTRODUCTION

Heatstroke is a potentially fatal syndrome due to increased central body temperature when the production of extrinsic and intrinsic heat exceeds the capacity to dissipate heat, as in cases of increased temperature generated by the animal's metabolism, environmental conditions, or intense physical exercise (HALL *et al*., 2022).

Heat-related diseases are prevalent in humans and animals (HEMMELGARN; GANNON, 2013) and more reported in dogs than cats (HOLLOWAY, 1992; FLOURNOU; MACINTIRE, 2003; REBOLLADA-MERINO *et al*., 2020). Trappler and Moore (2011) and Hall *et al*. (2022) state that brachycephalic dogs have reduced evaporative capacity since they have an elongated soft palate, stenotic nostrils, and hypoplasia of the trachea and are, therefore, more prone to develop heat-related diseases. Labrador Retrievers and other large breeds are also highly susceptible to heatstroke. Dogs of the Golden Retriever, Galgo, and Border Collie breeds, which presented hereditary exercise-induced collapse (EIC), were susceptible to heatstroke; these animals have a mutation in the enzyme Dynamin 1 (DNM1), which is involved in synapse and neurotransmission. These animals show episodic limb weakness, ataxia, and collapse induced by physical exercise, which triggers heatstroke (BRUCHIM; HOROWITZ; AROCH, 2017).

In addition, other predisposing factors associated with heatstroke cases are obesity, high body weight, lack of adequate acclimatization, poor physical conditioning, as well as exposure to a hot environment, especially with high humidity (CALDAS; BARBOSA DA SILVA; BARAUNA JUNIOR, 2022; HALL *et al*., 2022). A study in the United Kingdom used multivariate analysis to identify the main risk factors related to heatstroke in dogs. The most related factors were breed (Chow Chow, Bulldog, French Bulldog), animals over two years old, and higher body weight, especially in animals over 50 kg (HALL; CARTER; O'NEILL, 2020a). The same authors found that physical exercise was the main trigger for triggering heatstroke, with a similar effect to cases of dogs that stayed inside cars with high temperatures (HALL; CARTER; O'NEILL, 2020b).

This syndrome is characterized by increased body temperature above 41ºC and is associated with dysfunction of the Central Nervous System (CNS) (BRUCHIM, 2006; KALAISELVAN *et al*., 2015). During a heat stress condition, some cellular and systemic compensatory mechanisms are activated, such as thermoregulation, acclimatization, acute phase response, and induction of heat shock proteins (HEMMELGARN; GANNON, 2013).

Under physiological conditions, the dog loses heat by radiation and convection on the body's surface. When these animals are exposed to heat stress, cardiac output increases due to splenic contraction and increased vascular resistance in parenchymal organs (spleen, liver,

kidneys) and the gastrointestinal tract; in this way, the redistribution of blood flow to the skin occurs, to increase heat dissipation (BRUCHIM; HOROWITZ; AROCH, 2017).

Heatstroke is a complex syndrome because it leads to the production of cytokines and chemokines. These inflammatory mediators initiate and modulate the acute phase response, activating the endothelium, which culminates in coagulation and fibrinolysis, like in sepsis (JOHNSON; MCMICHAEL; WHITE, 2006; JUNG *et al*., 2020). Multiple organ dysfunction (MOD) is the main complication of heatstroke (HU *et al*., 2021). It involves circulatory collapse, acute renal failure, encephalopathy, disseminated intravascular coagulation (DIC), rhabdomyolysis, liver failure, myocardial injury, intestinal ischemia, acute respiratory distress syndrome (ARDS), and endothelial dysfunction (COSTEA, 2019; WILL; SNYDER; WESTERFIELD, 2019). Aroch *et al*. (2009) observed that dogs with heatstroke have increased absolute and relative values of nucleated red cells in peripheral blood. The presence of these immature cells was correlated with secondary systemic complications and may indicate animal death.

The pet industry in Brazil has had a significant expansion in recent years and provides numerous aesthetic, health, and vaccination services for pets. However, this provision of services requires care with animal welfare to avoid situations that offer risks or even cause the death of animals (MARIA *et al*., 2013).

The present study aims to describe two cases of heatstroke. The first is a three-year-old English Bulldog, and the second is a two-year-old male Shih-Tzu.

CASE REPORT

Case 1: A male dog, an approximately three years old English Bulldog, was taken to an establishment for bathing and grooming, around 2 pm, on October 28, 2020, in a city in the central region of São Paulo. On this day, the maximum temperature in the region reached 34ºC (ACCUWEATHER, 2021).

According to the responsible veterinarian, the animal arrived well at the pet shop but was slightly out of breath. During the bath and grooming, there were no intercurrences, and later, the animal was taken to the kennel, already presenting moderate panting, which intensified even more around 3 pm.

The animal was returning home when the employees transporting it noticed intense and thick salivation. About eight minutes later, the driver observed the dog breathing heavily and gasping for breath. He then removed the animal from its crate and noticed that the breathing difficulty worsened considerably.

Upon returning to the veterinary establishment, the animal had a temperature of 42.9ºC. The veterinarian reports that during the attempt to resuscitate the patient, she used oxygen, dexamethasone, dipyrone, and ice to reduce the body temperature. The veterinarian also claimed difficulty in finding venous access. The animal died and, on the same day, was sent to the Veterinary Pathology Service (SPV) of UNESP for a necroscopic examination.

Case 2: A two-year-old male Shih-Tzu dog was taken to a pet shop on January 20, 2022, in a city in the interior of São Paulo at around 1 pm and returned home at 4 pm. On this day, the maximum temperature in the city was 32ºC (ACCUWEATHER, 2021).

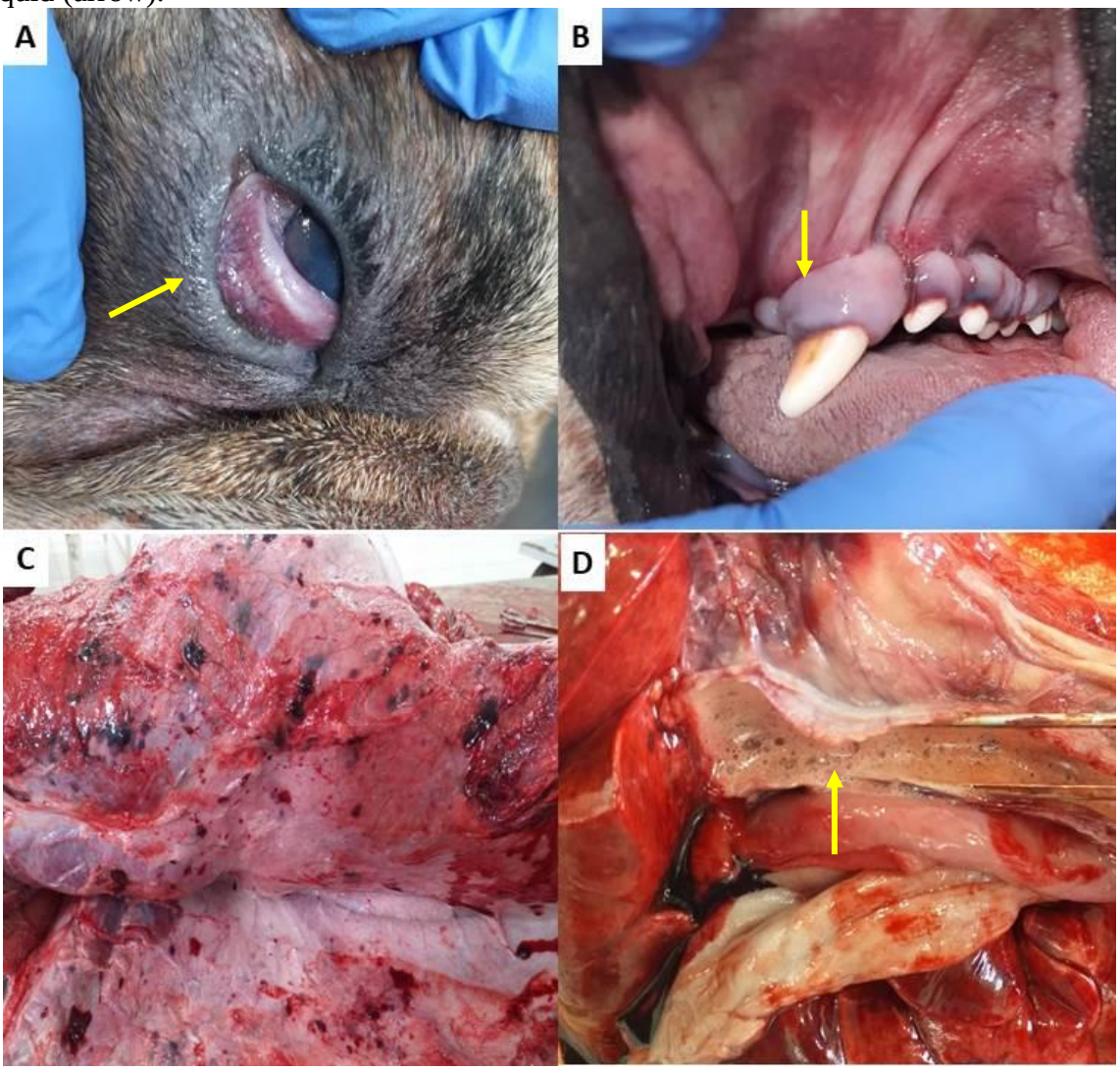
The tutor reported that she received the animal panting and apathetic and that the skin of the abdomen was bluish. Given this, the animal was referred for veterinary medical care, but it evolved to death and was sent to the SPV for necroscopic examination.

RESULTS

Case 1: During the macroscopic evaluation, we noted markedly reddened (congested) conjunctival (Figure 1A), penile, and anal mucosae. In the oral mucosa, the gingival region was moderately cyanotic (Figure 1B). Upon folding the skin of the cervical region, multiple areas of hemorrhage (petechiae and ecchymoses) were noted in the subcutaneous tissue, extending to the dorsal-caudal region (Figure 1C).

A discrete amount of reddish-free fluid was observed in the thoracic cavity. Along the length of the trachea, there was a large amount of foamy, whitish fluid (Figure 1D). The lungs were moderately dark red, with whitish, hypocreptate areas. There were also regions with reddish, firm plaques. On cutting the lung parenchyma, whitish, foamy fluid flowed.

Figure 1 - Macroscopic lesions of brachycephalic dog with heatstroke (case 1). **A)** Intensely reddish ocular mucosa (arrow). **B)** Diffusely purplish gingiva (arrow). **C)** Subcutaneous tissue with multiple areas of hemorrhage (petechiae and ecchymoses) extended to the dorsal and caudal regions. **D)** Trachea with considerable foamy, whitish liquid (arrow).



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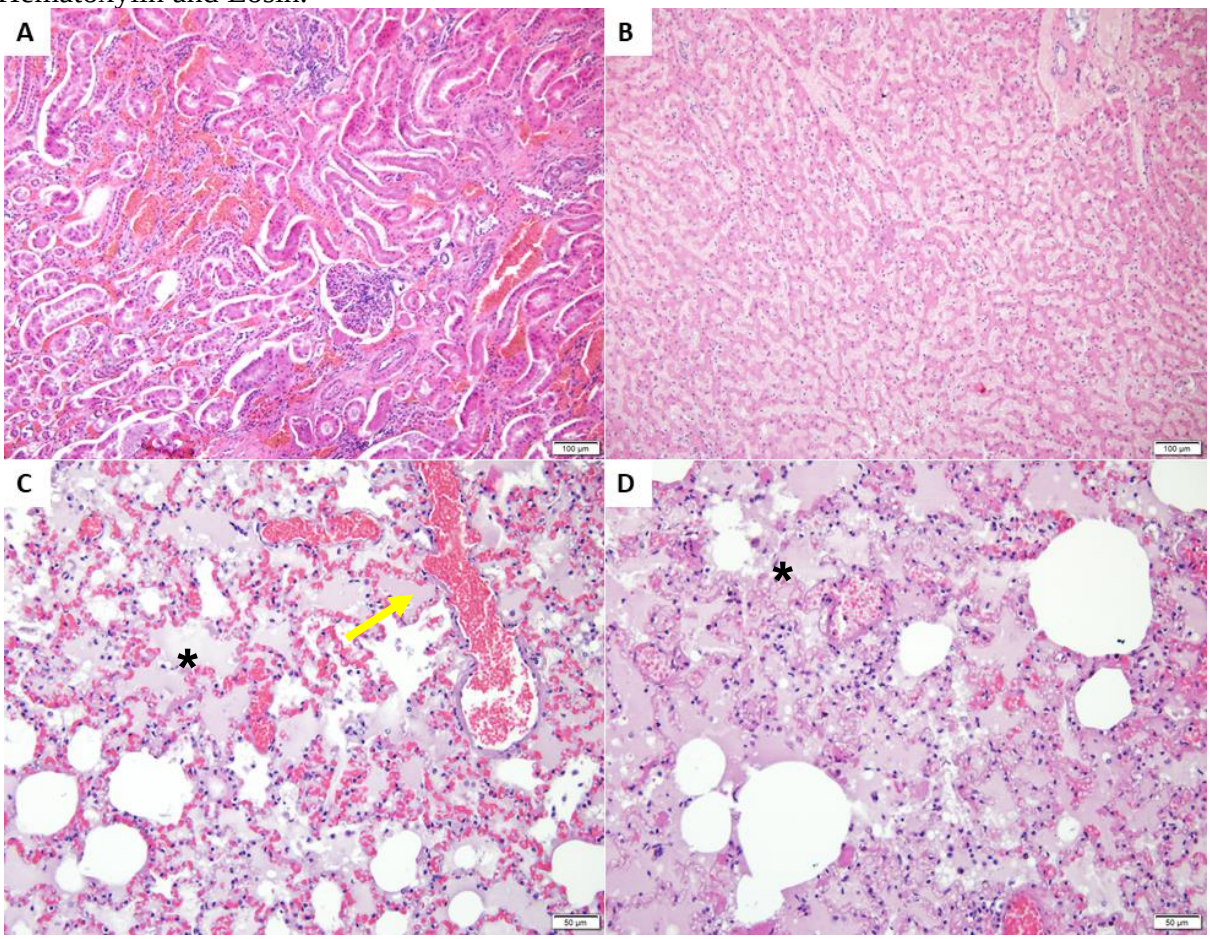
The mucous membranes of the stomach and intestines were moderately reddened. In the liver, a moderate increase in volume, bulging edges, and dark red coloration was observed, and the cut surface showed a moderate amount of blood flowing. The kidneys were markedly dark red, and a moderate amount of blood flowed on cutting.

During the microscopic analysis, generalized congestion of parenchymatous organs such as lungs, kidneys (Figure 2A), liver (Figure 2B), testicles, muscles, prostate, pancreas, intestines, lymph nodes, and encephalon was observed. The lungs had severe alveolar edema and multifocal areas of congestion (Figures 2C and 2D). In the kidneys, there was moderate necrosis of the tubular epithelium. In the thalamus and mesencephalon, multifocal areas of perivascular hemorrhage were noted.

The cause of death was a cardiorespiratory shock due to severe pulmonary edema and diffused and marked congestion of the viscera.

Figure 2 - Microscopic lesions of brachycephalic dog with Heatstroke. **A)** Kidney showing marked congestion (Obj. lens 4x). **B)** Liver with marked, diffuse congestion (Obj. lens 4x). **C/D)** Lung with marked edema (*) and diffuse congestion (yellow arrow) (Obj lens 20x). Hematoxylin and Eosin.



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Case 2: Macroscopically, the skin was diffusely reddened, mainly in the ventral region of the abdomen (Figure 3A) and on the limbs. On the left lateral aspect of the cervical region, there was a hematoma measuring approximately 5.0 cm in diameter (Figure 3B). On the lateral aspect of the right pelvic limb, there was a hematoma measuring approximately 2.0 cm. Ocular, oral, and penile mucosae were markedly reddened. Upon folding the skin, subcutaneous tissue and musculature exhibited dark red coloration.

On opening the sets, a discrete amount of reddish foamy content was observed in the bifurcation of the trachea. The lung was reddish, with dark red edges and hypocreptate consistency,

and when cut, drained a moderate amount of reddish foamy content. The spleen and liver had bulged edges and a dark red color (Figure 3C). In the stomach and intestines, the serosa and mucosa were intensely reddish. In addition, the kidneys were also diffusely dark red (Figure 3D), as was the brain, which also had evident and markedly engorged meningeal vessels.

Figure 3 - Macroscopic lesions of brachycephalic dog with heatstroke (case 2). **A)** Skin of the abdominal region diffusely reddened. **B)** Cervical region with hematoma measuring about 5.0 cm (arrow). **C)** Liver enlarged, with bulging borders and dark red coloration. **D)** Intensely reddish kidneys.

Source: Personal archive

DISCUSSION

In both cases, the animals were referred to a pet shop and began to present panting. Heat loss through radiation and convection reduces when the external temperature increases and approaches body temperature (POTTER; BERGLUND; O'BRIEN, 2020). The main form of heat dissipation is through evaporation, manifested by panting (GOGOLSKI; O'BRIEN; LAGUTCHIK, 2020). Bruchim; Horowitz; Aroch (2017) highlighted that the mucosa of the nasal turbinates and oral cavity (including the tongue) help dissipate heat during panting and

hypersalivation, as its large surface allows water evaporation. The increase in the relative humidity of the environment (above 35%) hinders or inhibits (greater than 80%) the cooling of the animal's body. The progressive increase in core body temperature leads to a metabolic imbalance and a decrease in cardiac output, favoring the accumulation of body heat.

The animals in the present report were taken to the pet shop in the afternoon during high temperatures. In the first case, on October 28, 2020, the maximum temperature in the county was 34ºC. In case 2, the ambient temperature reached 32ºC on January 20, 2022 (ACCUWEATHER, 2021). The literature highlights that global warming has caused high thermal oscillations (HALL; CARTER; O'NEILL, 2020a). High temperatures have caused high mortality in people around the world. Therefore, veterinarians must be prepared to identify animal heat-related illnesses (BRUCHIM; HOROWITZ; AROCH, 2017; HALL; CARTER; O'NEILL, 2020ab).

According to Maria *et al*. (2013), cases of death during pet care occur more frequently in small breeds, such as Shit-Tzu and English Bulldog, as seen in this study. The two dogs in this report are brachycephalic. It is known that these animals have a greater chance of developing heat-related diseases because they have a lower evaporative capacity due to anatomical changes characteristic of the breeds, such as stenotic nostrils, prolongation of the soft palate, and hypoplasia of the trachea (TRAPPLER; MOORE, 2011; BRUCHIM; HOROWITZ; AROCH, 2017).

During a necroscopic examination, the main alterations observed in cases of hyperthermia are diffuse hemorrhagic diathesis, hemorrhage in the lungs, kidneys, myocardium, and central nervous system, acute tubular necrosis, jaundice, and pancreatitis (STERN, 2019; BOSAK, 2004; BRUCHIM *et al.*, 2006; DROBATZ; MACINTIRE, 1996). In both cases reported, it was possible to observe systemic congestion and extensive hemorrhages in subcutaneous tissue and kidneys during macroscopic evaluation.

Furthermore, a study by Bruchim *et al.* (2009) showed that dogs had dermatological lesions, such as petechiae and hyperemia, pulmonary edema and congestion, frothy exudate in trachea and bronchi, diffuse hemorrhages in the peritoneum, intraperitoneal serosanguinolent content congestion and hemorrhage in intestines, splenic congestion, kidneys with interstitial and glomerular congestion, interstitial hemorrhage, tubular degeneration, and necrosis, hyperemia and edema of the meninges as well as the brain parenchyma. These lesions were observed in both dogs in this case report. According to Bruchim; Horowitz; Aroch (2017), heatstroke causes tissue hypoperfusion due to respiratory alkalosis and shock, resulting in hemorrhage, edema, and necrosis in various organs, including the central nervous system. In the heart, myocardial damage results in arrhythmia. In the kidney, acute renal failure results from damage to the tubules and

glomeruli. In the lung, circulatory changes (edema, hemorrhage, infarction) lead to primary respiratory failure. Hypoperfusion of the gastrointestinal tract leads to loss of the intestinal circulatory barrier, which facilitates the translocation of bacteria and toxins to the vascular bed, progressing to sepsis.

The cause of death of the animals in this study was a cardiorespiratory shock due to diffuse and accentuated pulmonary edema and organ congestion. In a survey by Maria *et al*. (2013), necroscopic alterations were studied in animals that died after bath and grooming procedures. Among the cases of death without signs of trauma, 69% presented alterations characterized by pulmonary congestion, edema, and hemorrhage. Systemic congestion results in hypotension and shock, causing anoxia and endothelial hyperpermeability, favoring the development of lesions secondary to endothelial damage (BRUCHIM; HOROWITZ; AROCH, 2017).

Dogs with hyperthermia develop a series of inflammatory, hemostatic, and tissue damage reactions in dogs. The activation of inflammation and hemostasis cascades triggers a systemic inflammatory response syndrome, often progressing to multiple organ dysfunction. Thus, heatstroke is responsible for several alterations, such as significant hypovolemia, distributive shock, metabolic acidosis, neurological dysfunction, endotoxemia, and disseminated intravascular coagulation (DIC), which culminate in reduced organ perfusion, tissue necrosis, and hemorrhagic diathesis, as reported in necropsies of dogs with hyperthermia (ZUROVSKI; ECKSTEIN L; HOROWITZ, 1991; BRUCHIM *et al*., 2009; BRUCHIM; HOROWITZ; AROCH, 2017; COSTEA, 2019; WILL; SNYDER; WESTERFIELD, 2019).

Besides predisposed to develop hyperthermia due to anatomical characteristics specific to the breeds, the animals in the reports were also submitted to a stressful situation, with bathing and grooming on days with high temperatures. External factors such as confinement in places with limited shade and ventilation, high humidity, lack of acclimatization, application of specific medications, and water deprivation may facilitate the development of hyperthermia (CALDAS; BARBOSA DA SILVA; BARAUNA JUNIOR, 2022; HALL *et al*., 2022; REBOLLADA-MERINO *et al*., 2020).

In the first case, there was information that the animal showed clinical worsening during transport home after the bathing and grooming procedure. According to Jardine (2007), in less than 40 minutes, the temperature in an automotive vehicle can reach 62.7º C during the summer, and the exposure of animals to high temperatures in cars is a typical report.

CONCLUSION

The paper deals with two cases of heatstroke in brachycephalic dogs. This syndrome is critical in these animals, especially when placed in a stressful environment with high temperatures. The cause of death is associated with cardiorespiratory shock and systemic circulatory alterations.

The cases describe animals in a stressful environment on days with high temperatures. Therefore, it is essential to emphasize that veterinary establishments should know the humidity and temperature conditions suitable for their patients, especially on hot days. This care must be doubled with animals prone to the development of hyperthermia syndrome, as in brachycephalic dog breeds.

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