Man's Best Buddy: A Bond Beyond the Dermis

Burn Management and Animal Welfare

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Introduction

The occurrence of severe burn injuries in veterinary medicine is relatively rare and can be the result of accidental or intentional injury. Burns are characterized by origin, depth, and total body surface area (TBSA).[3, 14, 15] Each of these characterizations impacts the prognosis of burn victims, especially when multiple organ systems are affected by the burn injury. Many burn management strategies have been described, all of which involve the prevention of burn shock, diligent wound management, and adequate pain intervention .[3, 13] Ideally, a veterinary general practitioner would not have to deal with the complicated medical and emotional trauma of a burn victim. When a burn injury results from intentional harm to an animal, another layer of veterinary medicine and legal implications is created. Fortunately, the United States government has statutes in place that criminalize the unnecessary harm of animals; however, there is ample room for improvement.

History and Presentation

Buddy, an approximately two-year-old male intact mixed breed dog presented to the Mississippi State University (MSU) College of Veterinary Medicine Surgery Service on April 26, 2021. He was an owned dog, with no known medical history that was allowed to freely roam the neighborhood. He was found on April 23, 2021 with severe burns to the face, pinnae, and neck. He had an electrical cord tied around his neck that was used to restrain him. Buddy was taken to an emergency clinic in Memphis, Tennessee where he was triaged. A thick layer of black tar-like debris covered his face; marked facial swelling prevented extensive evaluation of his eyes but portions of his corneas were visualized bilaterally. Initial treatments involved placement of an intravenous catheter, administration of butorphanol (0.2 mg/kg IV), one liter of sodium chloride IV bolus, cefpodoxime (8.5 mg/kg PO), Galliprant (2 mg/kg PO), ciprofloxacin

and atropine ophthalmic drops OU. Thoracic radiographs were taken to evaluate pulmonary pathology, which did not reveal any abnormalities. A complete blood count (CBC) bloodwork showed an inflammatory leukogram, characterized by a marked leukocytosis (30,440 /uL), moderate neutrophilia (23,960 /uL), and mild eosinophilia (11,400 /uL). The serum chemistry showed a mildly increased ALT (197 U/L). Buddy was also determined to be heartworm positive via 4Dx snap test; however, no microfilaria were noted on blood smear. Throughout the evening, Buddy vomited multiple times and maropitant citrate was added to his treatments. On April 24th and April 26th, 2021, he was anesthetized by the referring veterinarian for sharp debridement to remove the loose tissue.

Buddy was transported to the Mississippi State University College of Veterinary Medicine Animal Health Center in Starkville, MS on April 26, 2021. On presentation, Buddy was bright, alert, and responsive. He weighed 38.5 kilograms (84.7 pounds) and had a body condition score of 5/9. His temperature was 103.2 Fahrenheit, his heart rate was 120 beats per minute, and a respiratory rate could not be obtained due to panting. Cardiothoracic auscultation revealed no murmurs, arrhythmias, crackles, or wheezes. Buddy's abdomen was soft and nonpainful on palpation. His head was wrapped in a bandage as described above with only his nasal planum and rostral muzzle visible. His mucous membranes were pink with a capillary refill time of less than 2 seconds, and he had approximately 1 cm x 1 cm gingival ulcers dorsal to both canine teeth. He had an approximately 4 cm x 2 cm burn on the medial aspect of his right antebrachium and carpus. There were multiple areas of singed hair on his dorsum and ventrum.

Pathophysiology

When heat energy occurs faster than tissue can absorb and dissipate it, a burn occurs. The most common type of burn is thermal; however, electrical, chemical, and radiation injuries can

also occur in animals. Causes of thermal burns range from wildfires to heating pads and exhaust pipes. Electrical burns are often caused by animals chewing on electrical cords, sending a current through the body with no exit point. The history may include owners finding animals in a collapsed, tonoclonic state having urinated and defecated. On physical exam, there may be burns in and around the mouth or dyspnea from pulmonary edema. Chemical injuries can vary widely depending on the type of chemical, it's strength and concentration, contact time with the skin, and the volume of chemical. Radiation burns occur secondary to radiation therapy and should always be mentioned to owners before beginning radiation therapy. [3] While all burn injuries are classified and treated similarly, the scope of the pathophysiology discussed here will focus on thermal injuries as they pertain more closely to Buddy's case.

Modern burn classification is determined by burn depth and the TBSA affected. Burn depth is described as superficial, superficial partial thickness, deep partial thickness, and full thickness; the "degree" system (i.e., first-degree, second-degree, and third-degree) no longer accurately describes the tissue layers involved, although these terms are still used by many veterinarians. Superficial burns involve only the epidermis and will appear dry, flakey, and erythematous; these burns will heal vie re-epithelialization in 3-5 days with minimal scaring. Histopathologically, dilation and hyperemia of vasculature is less common; however, epidermal cells may display cytoplasmic vesiculation and necrosis.[12, 14] Superficial partial thickness burns include the epidermis and the papillary layer of the dermis. Blister formation, erythema, and edema are common with accumulation of serum, coagulative necrosis, and some granular debris. There is minimal scar formation, however the healing takes 1-2 weeks.[12, 14] Deep partial thickness burns involve the epidermis and the entire dermis, creating a red to waxy white appearance often under eschar formation. Only the adnexal structures remain intact, which

indicates reduced pain sensation. Surgical intervention is recommended to prevent extreme scar formation and can take 2-4 weeks for healing to occur.[12, 14] Healing can be delayed by the various biochemical changes that occur with a deep partial thickness burn, sometimes even causing the burn to progress to a full thickness injury.[3] Full thickness injuries include the epidermis, dermis, and subcutaneous tissue. The destruction causes coagulative necrosis of vasculature, vasculitis and thrombosis, and concurrent edema. A thick leathery eschar formation occurs with surrounding hyperemia predisposing the skin to infection. Within 4-5 days of eschar formation, gram negative bacteria, most commonly *Pseudomonas* species, have typically invaded the wound.[3] Surgical intervention is required, as early eschar removal is vital to wound healing and preventing infection. Full thickness burns can take from weeks to months for healing to occur.[3, 12, 14]

Currently in veterinary medicine, no formal, standardized schematic exists to evaluate TBSA. Vets often extrapolate the human schematic which utilizes the “Rule of Nines” for adults and the Lund-Browder chart for children. In summary, different anatomical regions of the body count for a certain percentage, and any burns encompassing less than 20 percent of the body are considered local burns, while any burns greater than 20-30 percent are considered severe burn injuries (SBI). Severe burn injuries can cause a variety of derangements, especially in the cardiovascular, respiratory, and metabolic realms.[14, 15] Caution should be taken when using these schematics, as they were not developed for or validated in small animals. One recent study suggests that as little as 10 percent of TBSA in small animals can yield the same biochemical and pathologic consequences as a burn encompassing greater than 30 percent TBSA in small animals.[1]

One of the syndromes that describes these biochemical and pathologic derangements is called “Burn shock”. The hallmark of “burn shock” is hypotension, decreased cardiac output, and increased vascular resistance. There are two distinct phases: 1) the resuscitation phase, and 2) the hyperdynamic hypermetabolic phase. The resuscitation phase lasts for 24-72 hours and consists of increased vascular permeability, edema formation, and fluid shifts leading to hypotension; this phase can be mitigated by administering hypertonic fluids (i.e., lactated ringer’s or hypertonic saline). [3, 14] The hyperdynamic hypermetabolic phase does not begin until approximately 3-5 days after the initial injury. This phase of burn shock has been documented to extend up to two years post injury in humans and is characterized by hyperdynamic circulation and increased metabolic rates.[14]

Other sequela of thermal burn injuries include respiratory and ocular pathology. If smoke inhalation is suspected, respiratory parameters should be closely monitored to evaluate for decreased oxygen carrying capacity and pulmonary edema. The effects of smoke inhalation are often identified within the first 24 hours following injury; however, disease processes can progress up to 36 hours post exposure. Different diagnostic modalities should be utilized in concurrence with the clinical manifestation of inhalation injury (i.e., bronchoscopy versus radiographs). In veterinary medicine, radiographic imaging is more readily available. Abnormalities seen on radiographs may include pulmonary edema, diffuse interstitial pattern, focal alveolar pattern, or severe atelectasis. Lung lobe collapse secondary to main stem bronchi obstruction has also been reported in small animals. [15,14]Additionally, burn patients can often have ocular complications including corneal ulceration, exposure keratopathy, increased intraocular pressure, eyelid contracture, and blindness.[15]

When triaging a thermal injury, good wound management and preventing shock contribute significantly to a positive outcome.[3,15] Cooling burned areas with tap water within two hours of injury can decrease tissue injury by reducing edema formation, increasing the speed of re-epithelialization, and improving cosmetic appearance. Fluid resuscitation can prevent multi-organ damage and shock, therefore improving overall prognosis. Finally, pain management should always be implemented in burn injury cases. A multimodal pain management strategy most effectively mitigates burn pain, as it can often be a combination of procedural pain, background pain, and breakthrough pain. Evaluating the efficacy of pain management is important as opioid tolerance has been shown to increase during the hyperdynamic hypermetabolic phase of wound healing.[3,15]

Diagnostics and Management

Severe burn injury patients can have numerous bloodwork abnormalities, most notably hypoalbuminemia, hyperglycemia, and indicators of sepsis.[1] Shortly after Buddy's arrival, blood was drawn and submitted for a complete blood count, chemistry panel, and a coagulation profile. Bloodwork revealed a slight anemia with a PCV of 33% and decreased red blood cell count of 5.35×10^6/ uL, with a marked inflammatory leukogram characterized by a mild neutrophilia (13,917 /uL), moderate lymphocytosis (8403 /uL), and eosinophilia (2101 /uL). The chemistry showed moderate hypoalbuminemia, at 2.2 g/dL, and slight hypomagnesemia at 1.5 mg/dL. Coagulation times were within normal limits.

A peripheral intravenous catheter was placed, and Buddy was sedated with butorphanol at 0.2 mg/kg IV and dexmedetomidine at 5 mcg/kg IV in preparation for thoracic radiographs. Thoracic radiographs were obtained to evaluate for pulmonary edema, a common sequela of electrical burns and smoke inhalation.[3, 15] No pulmonary edema was noted in Buddy's case.

While still sedate, the outer layer of Buddy's head bandage was removed, and he became extremely agitated. Buddy was bolused 0.2 mg/kg ketamine, 2 mcg/kg dexmedetomidine, and 5 mcg/kg fentanyl followed by endotracheal intubation. A jugular catheter was placed. During induction, additional burn areas were noted, and Buddy's entire thorax and abdomen were shaved to identify all burn areas. Samples of the black tarry substance and singed hairs were taken for forensic pathology. Buddy was moved to the operating room (OR) where remainder of his bandage was removed, revealing a thick coat of black substance and eschar formation from his nose to approximately one centimeter caudal to his ear pinna. Using Brown Adson forceps and a number 10 scalpel blade, approximately ninety percent of the debris covered area was removed, leaving only pieces that were not easily debrided. A sample was taken for culture and sensitivity, and Buddy's face was lavaged with a dilute betadine solution. With local blood supply impaired, the immune system is susceptible to infection. Buddy was determined to have deep partial thickness burns on the majority of his face. He had full thickness burns located at dorsal midline of the frontal bone, on the lateral face rostral and ventral to both ears, the concave surface of both pinnae, and rostral to the medial canthus of Buddy's left eye. His eyes were unable to be evaluated as the palpebra were severely swollen and the eyes were retracted into the globe. Neo-poly-bac was administered into both eyes.[15] A head bandage was created with petroleum gauze, silver sulfadiazine cream (SSD), lap sponges, cast padding, vet wrap, and elastikon. SSD is a considered the gold standard for topical burn treatment, as it has broad spectrum antimicrobial coverage and good eschar penetration. [3, 13, 15] Buddy's recovery from anesthesia was marked with extreme dysphoria and so he was maintained on constant rate infusions (CRI) of fentanyl at 3 mcg/kg/hr intravenously and ketamine at 0.2 mg/kg/hr intravenously, with dexmedetomidine at 1 mcg/kg/hr. Buddy was started on LRS at 60

mL/kg/day, and ampicillin sulbactam (Unasyn) at 30 mg/kg intravenously every eight hours. An objective pain score using Glasgow composite measures pain scale was taken every four hours to ensure that Buddy's pain was managed.

In less than 12 hours, the lap sponges and vet wrap had obvious strike through, so Buddy was sedated once again for a bandage change. During this bandage change, an ophthalmologist evaluated his eyes and did not find any evidence of ulceration or burns. However, his eyelids did not have any obvious meibioan tissue remaining on either upper palpebrae. Vision assessment was unattainable, as Buddy was anesthetized during the ophthalmic exam. Buddy's culture and sensitivity confirmed a *Pseudomonas* infection, and an amikacin gel was compounded by MSU-CVM Pharmacy to use in place of SSD. Buddy underwent a bandage change on his third day in hospital as well. At this point, Buddy's case had gained national attention which led to the donation of fish skin, a product that is currently being used as the frontline resource in human burn wound management. The company, Kerecis, sent acellular fish skin developed from North Atlantic Cod fish to be utilized in Buddy's full thickness burns. Fish skin has antiviral and antibacterial properties, has shown faster healing times, and is cost effective. [4]

On his fourth day in hospital, Buddy was anesthetized, taken to the OR, and prepped for his first fish skin placement. In the OR, his head bandage was removed, and his face was lavaged with a dilute betadine solution. An 18-gauge needle was used prick the areas of full thickness burns to draw blood in order for the fish skin to incorporate appropriately. The grafts were soaked in warm saline, cut using Mayo scissors to fit the desired areas, and sutured to the subcutaneous tissues. Buddy's head was rebandaged as previously described.

Animal Abuse Legislation

On the same day that Buddy received his first fish skin placement, headlines were made when a juvenile under the age of 12 confessed to torturing Buddy. The correlation between perpetrators of animal abuse and partner/child abuse has been proven through numerous studies.[2] The psychological and sociocultural factors that contribute to violent crimes are often the same regardless of the victim type. Legislators should more closely consider the correlation of between abused partners, children, and pets.[7] Within the American judicial system, animal abuse does not garner much attention considering other felony charges (like deadly assault, robbery, fraud, and domestic violence) that carry more severe sentences in terms of both time and money. While human abuse cases are of utmost importance, the strong correlation between animal abuse and abuse of other humans should reinforce the necessity of stronger anti-animal cruelty legislation.[11]

Initial animal welfare laws in the United States concerned livestock animals. Those laws included the 28 Hour Law, which was passed in 1873, protected production animals during their travel to slaughter. Almost 100 years later, the Humane Methods of Slaughter Act was passed, requiring animals to be rendered unconscious prior to slaughter. Most veterinarians are familiar with the Animal Welfare Act, signed into law in 1966, placing regulations on animals that are kept in zoos, research facilities, or commercial breeding facility.[5,8] However, until recently, federal laws prohibiting animal cruelty against small animals were lacking. The Preventing Animal Cruelty and Torture Act was signed into law in 2019 creating a federal statute that resembled those already in place at the state level. This law made animal cruelty a federal crime. Animal protection laws are still carried out at the state level. This is due to the variety of opinions and beliefs surrounding the definitions of an “animal” and the definition of “cruelty”. The Animal Legal Defense Fund, an animal law advocacy non-profit, ranks each of the 50 states,

from best to worst, anti-animal cruelty legislation. Currently, Mississippi is ranked 47th.[8] In 2020, Mississippi Senate Bill 2658 was signed into law, strengthening the previously signed Mississippi Dog and Cat Pet Protection Law of 2011 by making animal cruelty a chargeable felony. The revisions more clearly outlined what forms of abuse would qualify for criminal charges, including: that intentional torture, mutilation, maiming, burning, starving, crushing, disfiguring, drowning, suffocating, or impaling a domesticated animal, specifically dogs and cats. While the law only covers domesticated dogs and cats, it does include animals that are considered feral or stray. Should a person be convicted of these crimes, they can be fined up to $5,000, sentenced to three years in prison, or both; if they are convicted for subsequent offenses, the fine doubles and they can be sentenced to one to ten years in prison. [10] However, regardless of the crime, a child under the age of 13 in the state of Mississippi cannot be charged with a misdemeanor or felony.[6]

Case Outcome and Conclusion

The first weeks of Buddy's admittance in the hospital were extremely challenging both medically and emotionally, and yet remarkably rewarding. During that time, Buddy had daily blood work, bandage changes, and medication adjustments to ensure he would have the best outcome possible. Buddy has remained in hospital for 145 days to complete his treatment regimen and has responded well. He had a total of four fish skin applications and has undergone several bilateral tarsorrhaphies with concurrent tension relieving techniques on superior and inferior eyelids as his skin contracts, to maximize eyelid function. He has undergone over 40 bandage changes to date, has been neutered and has begun heartworm treatment. Although Buddy is now an affectionate dog who only cares about his toys and treats, as animal advocates we must remember what he has been through and focus on prevention of such atrocities in the

future. Triaging and managing severe burn injuries requires diligent monitoring and wound management on behalf of the veterinarian. With proper treatments, successful outcomes can be expected, as in Buddy's case. Nevertheless, a veterinarian's job does not end with simply treating burn injuries, we must continue to advocate for animal welfare. In regard to animal cruelty prevention, there are still strides to be taken in the legislative arena both at the state and national level. Specifically, veterinarians can and should lobby for the enactment and enforcement of stronger anti-abuse laws.

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