Medical and Surgical Management of a Large Thermal Burn in a Dog

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ABSTRACT

Background: Thermal wounds are relatively uncommon in veterinary practice and most of them are the result of accidental burns. Patients with severe burns are among the most challenging cases presented to veterinarians, because severe burn injury leads to significant hemodynamic instability, massive fluid shifts, and hypovolemia requiring prompt and aggressive therapy. Because severe burn injury in small animals has been poorly described in the veterinary literature, this case study describes the presentation, complications, medical and surgical treatment of a female dog with an accidental severe burn wound caused by a thermal mattress during an elective surgery.

Case: A 6-month-old 9.6 kg female crossbred was referred with 20% total body surface area burned by a thermal mattress during an ovariohysterectomy procedure two days before. The dog presented a severe burn and systemic complications as anemia, leukocytosis, total protein at the lower limit and hyperlactatemia, which were managed with intensive medical care, including administration of crystalloid fluids, colloids, antibiotics, analgesics and enteral nutrition. The large wound was treated with debridement and the use of different kind of dressing to obtain a healthy granulation tissue. As a large portion of the trunk was lost, it was not possible to use axial pattern flaps, so skin-stretching devices and multiple surgical procedures were used until complete wound healing occurred, which took almost six months.

Discussion: Burns in small animals are presented in a wide clinical range, from mild to large and deep burns, and carry a serious to grave prognosis. Deep burn injuries that encompass more than 20-30% of the body are classified as severe burn injury, and patients with severe burns are among the most challenging cases presented to veterinarians, and usually they require emergency supportive therapy. It was estimated that the patient in this case had 20% of her total body surface burned, and according to the depth of tissue destruction, burn was classified as a full-thickness burn. Most burns seen by veterinarians do not involve more than 20% of the body surface area, and as a result, major metabolic derangements, including fluid and electrolyte imbalances, red blood cell destruction, and increased susceptibility to systemic infection, are not likely to be noted. The severity and complexity of the burn demands a thorough knowledge of burn pathology and the highest level of medical and surgical care to ensure a positive outcome. The hypermetabolic state induced by severe burn injury predisposes patients to systemic inflammatory response syndrome, sepsis and multiple organ dysfunction syndrome, as observed in the present report. Full-thickness burns result in complete destruction of all cutaneous structures making surgical intervention necessary to perform excision of necrotic tissue and posterior reconstructive surgery. The skin-stretching device used in the case reported here was useful to help closing many parts of the wound, however, the wound over the dorsal lumbosacral region was less amenable to lateral undermining and advancement, because of the less mobile lateral thigh skin and lacks a panniculus muscle layer. The case described in this report represented a significant management challenge and an expensive treatment because of the several systemic problems and extensive loosening of dorsal trunk skin. Although warming systems are effective in maintaining normothermia in surgical patients, they pose burning hazards to patients, so veterinarians should pay more attention to the probability of burns during surgery.

Keywords: burns, wound management, skin reconstruction, dogs.
INTRODUCTION

Burns are one of the most common accidental injuries treated by human emergency departments [12]. Thermal wounds are relatively uncommon in veterinary practice, and most of them are the result of accidental burns associated with the application of supplemental heat in patients under general anesthesia [3,11]. Most treatment recommendations for animals with burns come from the knowledge garnered from clinical studies involving human burn victims. The severity and complexity of the response to a severe burn demands a thorough knowledge of burn pathology and the highest level of medical and surgical care to ensure a positive outcome [3,12].

Full-thickness burns result in complete destruction of all cutaneous structures, making surgical intervention necessary to perform early excision of necrotic tissue [11,16]. After initial wound care, specific recommendations for wound management depend on the depth and severity of the burn, but it is necessary to carry out methodical decontamination, debridement and dressing of the wound, and then to make use of reconstructive techniques for the closure of resulting large skin defects [9,12,17].

Because severe burn injury in small animals has been poorly described in the veterinary literature, the aim of this case study is to describe the presentation, complications, and medical and surgical treatment of a female dog with an accidental severe burn wound caused by a thermal mattress during an elective surgery.

CASE

A six-month-old 9.6 kg female crossbred dog was referred to our facility because the owner was concerned about the emergence of skin pruritus and alopecic lesions in the dorsal region of the trunk after the dog underwent an elective ovariohysterectomy procedure performed by a colleague two days before. A physical examination revealed moderate dehydration, the presence of crusts and changes in skin color in various locations of the trunk, extending from the neck to the base of the tail. It was concluded that the trunk wound was caused by a thermal mattress used during the surgery; this was later confirmed by the veterinarian who performed the surgery. The initial complete blood count and serum biochemistry profile results revealed the following abnormalities: mild anemia, leukocytosis, total protein levels at the lower limit, and hyperlactatemia. The initial problem list included the burn wound, dehydration likely secondary to burn wound injury, granulocytic leukocytosis likely secondary to systemic inflammation caused by burn injury, and hypoproteinemia secondary to tissue edema and wound exudate.

The initial therapy included administration of crystalloidal fluids (Ringer’s lactate® solution). Anesthesia was induced with propofol (Propovan®) and maintained with isoflurane (Isoforine®) in oxygen. Hair was clipped from the dorsal trunk, revealing small areas of tissue inflammation and necrosis along the surface of the trunk. The wound was debrided of devitalized skin and necrotic subcutaneous fat, and irrigated with sterile saline. Silver sulfadiazine ointment (Dermazine®) was applied to the wounds and wet-to-dry bandages were placed on them. Due to the severity of the case, the patient was hospitalized and received crystalloidal fluids, analgesia with fentanyl (Fentanest®), lidocaine (Xylestesin®), and ketamine (Ketamin®) through continuous rate infusion (administered at a rate of 5 mL/kg/h intravenously [IV] for nine days) and antibiotic therapy with amikacin (amikacin sulphate) (10 mg/kg twice a day [BID] IV for seven days). An esophageal feeding tube was used to provide enteral nutrition. The patient was initially fed with canned dog food (Faro®) and a high-calorie diet (Nutralife intensiv®), and was supplemented with oral feedings (Recovery®) via the esophageal tube, calculating the daily energy requirements in 716 kcal/day.

On the fourth day after the burn occurred (second day post admission), a surgical exploration was performed under general anesthesia, revealing large areas of skin necrosis (Figure 1A). All affected tissue was excised by surgical debridement (Figures 1B and 1C). The wound was irrigated with a physiological solution and covered with a dressing composed of sodium carboxymethylcellulose and ionic silver (Aquacel Ag®). A secondary layer made with absorbent cotton and a tertiary layer of tubular gauze were placed over the bandage. On the ninth day after the burn occurred, hyperthermia (temperature 39.5°C) was detected. Laboratory tests revealed leukocytosis with a left shift as well as worsening of anemia and hypoproteinemia. Treatment with ceftriaxone (30 mg/kg intramuscularly [IM] BID for seven days) was initiated, and the patient improved. The sodium carboxymethylcellulose and ionic silver dressing was replaced on the eighth day. On the 11th day, the analgesic protocol was transitioned to...
tramadol cloridrate\(^2\) (4 mg/kg three times a day [TID] by mouth [PO] for 36 days).

The patient was released from the hospital, and recheck examinations were performed over the following days. On the 13\(^{th}\) and 15\(^{th}\) days, granulation tissue (Figure 1D) was observed and a hydrocolloid dressing (Comfeel\(^6\)) was used for the wounds. On the 17\(^{th}\) day after the burn, the presence of granulation tissue, epithelialization of the wound edges, and the start of wound contraction (Figure 1E) were observed. Then, the bandages were changed every three days.

On day 20, the animal showed apathy, hyporexia, and fever, and there was a purulent green discharge from the wound. Due to the suspicion of infection caused by gram-negative bacteria, irrigation of the wound with sterile saline mixed with gentamicin (4 mg/kg once a day [SID] for five days) was started. The patient was hospitalized and received fluid and gentamicin (4mg/kg SID IV for five days); after six days, she was in good condition, so she was discharged. After that, open-wound management was continued with the use of a nonadherent bandage with nitrofurazone-impregnated gauze. This bandage was changed every other day.

On day 32, the wound had contracted and showed a healthy bed of granulation tissue with no signs of remaining infection (Figure 1F), so the first plastic surgery was performed (Figure 2A) under general anesthesia. With the patient in sternal recumbence, the wound edges were freshened in the cranial, medium, and caudal portions and advancement of the lateral thoracic skin was done using walking sutures with polyglactine 3-0. The subcutis was closed with a vertical mattress using polyglactine 3-0, and the skin was closed with nylon 3-0 with single interrupted sutures. Three Penrose drains were used to provide wound drainage, and they were removed five days following surgery. In the caudal portion of the wound, islands of epithelium harvested from the lateral thoracic region with 6 mm punch were reimplanted as punch grafts in the remaining granulation bed.

On day 39 (Figure 2B), dehiscence was observed at the medium and caudal part of the wound, and on day 42, in the cranial portion of the wound (Figure 2C). An external skin-stretching device made with Velcro pads was fixed to the skin with cyanoacrylate glue and skin sutures with nylon 3-0. A nonadherent bandage with nitrofurazone-impregnated gauze was placed over the wound. Then, Velcro strips were connected under tension over the Velcro pads and tension was applied on the skin edges of the wound that had dehiscence (Figure 2D), and secondary and tertiary layers of dressing were wrapped around the trunk of the dog.

On the 45\(^{th}\) day, there was great improvement in the wound appearance and size. The patient was anesthetized with the same anesthesia used previously and the skin defect in the medium part was closed with a bipedicle advancement flap. The subcutis was closed with polyglactine 3-0 and the skin was closed with nylon 3-0 with single interrupted sutures. Then, the external skin-stretching devices were replaced to minimize wound tension (Figure 2E). Open-wound management was continued on the caudal part of the wound, with nitrofurazone-impregnated gauze. There was epithelialization of the punch grafts that were previously placed, and the external skin-stretching devices were removed.

On day 53 (Figure 2F), the wound on day 53 was doing well; however, on the 58\(^{th}\) day dehiscence had begun in the cranial portion of the wound edges, which worsened on the 64\(^{th}\) day. On day 67, a hydrocolloid dressing was used in the wound (Figure 3A), and it was replaced every five days. On day 91, the external skin-stretching device was placed again. On day 94 (Figure 3B), the patient was anesthetized and the wound wedges were approximated again (Figure 3C). The wounds of the cranial thoracic region healed uneventfully, but on day 99, dehiscence of the caudal portion of the wound occurred again (Figure 3D). A full-thickness mesh skin graft procedure was performed; however, the graft underwent necrosis. A nonadherent bandage with nitrofu-
razone-impregnated gauze was placed over the wound and changed every other day for 21 days. On day 118 a healthy bed of granulation tissue had appeared, with good contraction of the wound (Figure 3E). Then the wound was covered with a hydrocolloid dressing that was changed every four days, from day 124 until day 146. After that, nitrofurazone-impregnated gauze was used. On day 176, the wound had healed completely (Figure 3F). The patient showed a good esthetic result and no functional impairment; however, hair regrowth did not occur in some parts of the trunk.

**Figure 2.** A- Image of the patient after the first plastic surgery. Black arrows indicates islands of epithelium harvested from the lateral thoracic region with 6 mm punch that were implanted as punch grafts in the remaining granulation bed; B- Dehiscence at the medium and caudal part of the wound, and the beginning of dehiscence at the cranial part of the wound are seen; C- Dehiscence in the cranial portion of the wound; D- An external skin-stretching device made with Velcro pads was glued to the skin (arrow), then Velcro strips were connected under tension over the Velcro pads and tension was applied on the skin edges of the wound that suffered dehiscence (arrows); E- Realization of the second plastic surgery. The arrow indicates the Penrose drain exiting ventral to the wound. An external skin-stretching device was fixed again. F- Good wound evolution is seen in comparison with C.

**Figure 3.** A- Hydrocolloid dressing placed over the wound; B- Good evolution of the wound; C- Realization of the third plastic surgery; D- Dehiscence of the caudal portion of the wound occurred again E- Wound evolution, showing the contraction and epithelialization of the wound; F- Complete healing, with the presence of a thin white epithelium over the lumbar region.

**DISCUSSION**

Anesthesia and surgery cause significant hypothermia, so warming devices are utilized in the perioperative period to maintain a patient’s normal body temperature; however, thermal burn injuries can occur, as observed in this case. The severity of a thermal burn is dependent on the temperature of the heat source and the duration of the exposure [13]. Although ovariohysterectomy is a short surgery, if the heater device is poorly regulated it can cause severe burns.

Burn treatment encompasses the initial first aid, treatment of systemic complications, and treatment of the wound [3]. First aid includes immediate cooling of the affected areas to limit further extension of the thermal damage [3,12]. However, cooling was not done in this case because the dog arrived to the hospital two days after the burn had occurred.

Based on the “rule of nines,” which divides the surface area of the body into segments of 9% [11,16], it was estimated that the patient in this case had 20% of her total body surface burned, and according to the depth of tissue destruction, the burn was classified as a full-thickness burn [16]. Burn injuries that encompass more than 20% to 30% of the body are classified as severe [17], which leads to systemic derangements [16] - such as anemia, infection, hypoproteinemia, metabolic abnormalities, dehydration, systemic inflammatory response syndrome, pain, cardiac abnormalities, renal failure, and liver failure [3,7,12] - that require intensive management [16]. The next step was the restoration of volume and perfusion, because in addition to local vascular leakage, systemic extravasation of fluid from the vascular space is one of the early pathophysiological changes seen with serious burns [16]. The patient showed signs of hypoperfusion on presentation, so she was treated with aggressive fluid therapy including crystalloids and colloids, because 20% total body surface area burns can cause a 28% loss of plasma volume within six hours after the burn [3,11]. An isotonic crystalloid fluid, such as lactated Ringer’s solution, remains the fluid of choice for initial resuscitation [7,11,12]. The fluid adjustments were based on feedback from patient monitoring, such as mental status, body weight, respiratory rate and effort, heart rate and pulse quality, mucous membrane color and moisture, and capillary refill time, and the goal of fluid resuscitation was to maintain organ perfusion and avoid tissue ischemia [3].
The metabolic alterations in major burns cause a hypermetabolic state, increased energy consumption and catabolism of body protein stores [3,12], predisposing the patient to systemic inflammatory response syndrome, sepsis, and multiple organ dysfunction syndrome [13]. The patient had persistent hypoproteinemia during the initial period of hospitalization, which is common in burn patients [11]. The tremendous increase in metabolic demand must be met by early and aggressive nutritional support; in addition, early enteral feeding is also important in preventing gastric and duodenal ulceration. Nutrition may be used to modulate the inflammatory response and associated oxidative stress, and to improve gastrointestinal barrier function, immune function, and wound healing [3,12], so the dog was placed on enteral nutrition at the beginning of the treatment.

Anemia is one of the expected alterations in patients with severe burns, as found in this report. It is the result of direct destruction and reduced life span of red cells [11]. Hemolysis from sepsis, internal bleeding, and related complications can enhance anemia. Bone marrow suppression and inhibition of erythropoiesis contribute to anemia, wherein impairment of hematopoiesis persists until the burn wound is closed [3,9,11,12].

The third treatment step in this case was the burn wound care, which involved cleaning, wound debridement, daily decontamination, and wound dressing [17]. Early burn wound excision decreases the release of proinflammatory mediators and limits bacterial growth. Full-thickness burns require eschar removal and application of a topical antimicrobial agent, until wound closure is possible [17], and this was done on the second and fourth day after the burn had occurred. There is consensus in the literature regarding the use of silver sulfadiazine 1% for the treatment of burns, because it is effective against gram-negative microorganisms and gram-positive bacteria [11,17,18]. However, due to the severity of this case and the high anesthetic risk, dressings with sodium carboxymethylcellulose and silver coverage were used, because this kind of dressing can remain in place for three to seven days, eliminating manipulation of the burn site and the need to anesthetize the patient for dressing changes. The silver-associated Hydrofiber interacts with wound exudate to form a non-adherent layer between the wound and the dressing, promoting autolytic debridement of necrotic tissue and an ideal microenvironment for healing [19].

Systemic antibiotics are normally not indicated for burn wound management unless the patient is considered to be septic [11]. Immediately after injury, burn wounds are sterile, but because dead tissue of burn eschar is ideal for bacterial growth, between three and seven days after injury, aerobic gram-negative bacteria start to predominate [12]. Therefore, based on the knowledge of the susceptibility of pathogens in our veterinary hospital [2], amikacin sulphate was introduced because it is an antibiotic indicated for the short-term treatment of severe infections caused by susceptible strains of gram-negative bacteria, including *Pseudomonas* spp., *Escherichia coli*, *Proteus* spp., *Klebsiella* spp. and *Enterobacter* spp. [15]. However, due to alterations of the clinical conditions of the patient and in the color of the exudate, and because it was not possible to perform an exudate culture, it was necessary to make two empirical changes in antibiotic therapy, and a broad-spectrum antibiotic was chosen both times, with good results.

After 13 days, the use of hydrocolloid dressing was introduced because it stimulates angiogenesis and collagen synthesis, and contributes to epithelialization of the wound by providing a moist wound environment while absorbing exudate and avoiding iatrogenic damage to granulation tissue. It may be left in place for two to four days, so less manipulation of the patient is required [5]. The use of dressings enables the patient to be released from the hospital sooner and improves the patient’s quality of life during healing.

After resolution of the infection, improvement of the general condition of the patient, and formation of the granulation tissue, treatment with surgeries to close the wound was initiated. Because the kind of wound was not amenable to closure with traditional surgical techniques, places under tension considered at risk of disruption were managed several times with external stretchers [10]. These devices can be used to close moderate to large wounds prior to surgical procedures or during the course of open wound management [9,14]. With this technique, it is possible to mechanically stretch skin sufficiently to facilitate wound closure by the processes of mechanical creep and stress relaxation [9]. These devices were also used postoperatively to minimize incisional tension [9,14], and this noninvasive continuous-tension skin-stretching device helped
close the wound by using viscoelastic properties of the dermis [9]. The cables were useful in maintaining bandages applied over the wound too [9]; they were inexpensive, noninvasive, and easy to apply, having advantages over more costly and complicated flap, grafting, or tissue-expanding techniques [4]. Use of Penrose drains helped to limit dead space formation and fluid accumulation [14].

Wounds over the dorsal lumbosacral region are less amenable to lateral undermining and advancement because of the less mobile lateral thigh skin and lack of a panniculus muscle layer [6,10]. Due to the difficulty of closing the wound over the lumbosacral region, a full-thickness mesh skin graft was performed; however, the graft underwent necrosis. The most common cause of graft failure is movement that disrupts the delicate fibrin bonds that bind the graft to the bed, and without adherence, the revascularization and organization are impossible [7]. Consequently, the wound was allowed to heal by second intention, which took a long time.

The extent of medical and surgical management that may be anticipated in patients with severe burns will vary. In a case report of a severely burned dog, with the use of a nanocrystalline silver dressing and vacuum-assisted closure, it took seven months for all burn wounds to heal completely [8]. In another report, two dogs with smaller burns were treated with partial-thickness skin grafting, which took less time for the wounds to heal [1]. However, there are few case reports of large dorsal wounds in the veterinary literature to compare healing times.

The case described in this report represented a significant management challenge and an expensive treatment because of the multiple systemic problems and extensive loosening of the dorsal trunk skin. Although warming systems are effective in maintaining normothermia in surgical patients, they pose burning hazards to patients, so veterinarians should pay more attention to the probability of burns during surgery.

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