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IATROGENIC THERMAL INJURY MANAGEMENT IN A GERIATRIC DOG - A CASE REPORT

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Abstract

This case report aims to propose a wound healing protocol for iatrogenic thermal wounds in small animals. Thermal injuries in small animals are most frequently caused by domestic accidents, as a result of contact with hot surfaces, liquids or fire. Burns can also be inflicted during surgery by the use of faulty heating pads or grounding plates. An 11 years old female dog was presented for a post-surgical check-up after undergoing mastectomy. At this check-up, two-weeks after surgery, extensive burn wounds on the dorsal cervical and thoracic areas were discovered. Over 80% of the affected area was covered by eschars. The injured area was still covered with hair but nociception was absent. Wound management aimed to promote secondary intention healing by using a complex protocol that included an initial escharectomy followed by the use of honey dressings, hydrocolloid dressings, paraffin-impregnated tulle and sulfadiazine ointment. The wound healed in 8 weeks, mainly by contraction; a small percent healed by epithelialization. We concluded that during each phase the dressings should be adapted to the specific phase of wound healing and that combining multiple products offers a superior result.

Key words*: iatrogenic, burn wound, thermal injury, wound management, secondary intention healing.*

INTRODUCTION

The management of burn wounds is one of the most active areas of research that is constantly devising new and improved treatment protocols. It is widely accepted that burns, especially severe burns, are not limited to the local injury, but also inflict a systemic imbalance known as "burn disease". In veterinary medicine, the frequency of burn wounds is considerably lower than in human patients, and injuries are often not life-threatening.

A burn injury is defined as tissue (most frequently, the skin) damage inflicted by thermal, electrical, chemical or radiation exposure. Thermal injuries are a consequence of direct contact with fire, boiling water, hot steam, and hot objects, or secondary to prolonged contact with a source of moderate heat. In small animals, burns usually occur consecutive to domestic accidents. They can also be associated with various heating devices used during anaesthesia or cage rest to increase the body temperature in low mobility patients.

The classical system used in human medicine classifies the severity of burn wounds into four degrees. However, in veterinary medicine, burns are more commonly classified according to the depth of the injury, as follows (Pavletic, 2010):

- Superficial burns (first degree) – when lesions only include the epidermis;
- Partial-thickness burns (second degree) – both epidermis and superficial dermis are affected;
- Full-thickness burns (third degree) – the epidermis, full dermis and subcutaneous tissues are affected;
- When the injuries extend to deeper tissues such as muscle or bone, a fourth degree can be described.

The severity of a burn wound is not only determined by the depth of the lesion, but also by the percentage of the total body surface that was affected. Jackson's burn model describes three concentric zones in full-thickness burns: a central area of coagulation and necrosis, an intermediate area of stasis and an outer zone of hyperemia (Hettiaratchy & Dziewulski, 2004).

The therapy of burn patients has two directions: patient stabilization and monitoring (fluid therapy, multimodal analgesia, nutritional support) and wound management.

Superficial and partial thickness burns can heal through re-epithelialization either from surviving germinal epidermal cells or from the cells of the root sheath of the hair follicle. In injuries accompanied by loss of the entire skin structure, healing can be obtained either through contraction and epithelization or secondary to surgical reconstruction.
This article aims to draw attention to the importance of adapting the wound management protocol to the healing phase, and emphasize that proper wound closure can be obtained exclusively by secondary intention, even in burns that involve large body surfaces. Care should be taken when using warming devices, given that associated iatrogenic injuries occur with a significant frequency.

MATERIALS AND METHODS

The patient presented in this case study is a 10-year-old mixed breed medium sized (12 kg) intact female dog.
The history revealed that the dog underwent mastectomy for a solitary ulcerated necrotic mammary mass (4th mammary gland on the left side) with secondary infection, 10 days before it was presented for skin lesions. The mass had been carefully resected with clean margins and the skin closure posed little tension on the wound margins.
The pre-anaesthetic work-up had been normal (blood work within the reference range, no cardiac pathology and no visible metastasis on the thoracic and abdominal imaging). The patient had been discharged the following day after the mastectomy, and two evaluations of wound healing had been performed on the third and 10th day at the first clinic. Wound dehiscence, behavioural changes, loss of appetite or malaise were not observed during this period. However, at the second check-up on the postoperative day 10, the skin on the dorsal trunk and lateral side of the neck appeared modified and the patient was referred.
At the first consultation of the animal, 10 days after the surgery, the temperature, heart and respiratory rates were within physiologic limits. No pain behaviour was exhibited during manipulation of the animal and palpation of the affected area. Once the hair was clipped, a burn-like lesion was observed, involving a large area of the dorsal and lateral part of the thorax and neck. This area was mostly covered by a black leathery eschar, and surrounded by small areas of stasis and hyperemia.
Blood tests at this time revealed low albumin, mild hyperkalemia, leukocytosis, neutrophilia and lymphocytosis, all consistent with the pathophysiological process of a burn lesion, accompanied by extensive cell death and ongoing inflammation. A bacterial wound culture was not performed at that point because the skin was either intact or covered by the eschar. No signs of secondary infection such as exudate, redness not correlated to the burn injury or pain could be observed. Although the patient had no cardiac, pulmonary or other associated diseases that would impede the anaesthesia or surgery, the owner opted for a conservative approach.

Figure 1. Inflmatory and debridement phase. A. day 1- initial aspect. B. day 2; C. day 3; D. day 4; E. day 4.

The wound could not be properly assessed while the eschar covered the affected area. Thus, the first purpose of local therapy was to promote autolytic debridement and facilitate escharectomy. To avoid further bacterial conta-

mination and multiplication and simultaneously aid debridement, raw honey was used for the first four days (Figure 2-A). Secondary and tertiary layers were applied to finish the thoracic bandage. The bandage was applied in such a manner as to prevent excessive movement of the skin, ensure moisture and absorb the exudate while the separation between the eschar and the healthy tissue occurred. Sedation was not required as the animal exhibited no discomfort or aggressive behaviour.

The entire eschar was gradually eliminated over the following four days, by removing the areas where the eschar was loosely attached to the tissue underneath and had no vascular connection.

As the injury had occurred two weeks prior and the animal was not in a hypermetabolic state or affected by systemic alterations associated with the wound, limited general support was initiated. In the first few days, patient management included fluid therapy and opioid analgesia; systemic anti-infective drugs were not used. This decision was guided by the the clean aspect of the wound, the absence of fever, the frequent change of bandages, and low exudate production.

The animal had a good appetite and its vital signs were within physiologic limits at each bandage change. This was not considered a patient with complex burn disease, so once the eschar was removed, the skin lesion was treated as any other large open wound.

Once the escharectomy was performed, the subcutaneous fat was exposed on the dorsal area of the trunk. This tissue, due to the lack of vascular supply, was expected to become necrotic and undergo autolysis and treatment was continued with topical honey (Figure 2-B). However, the tissues that presented healthy granulation tissue were treated with silver sulfadiazine cream (Dermazin).

The bandage was changed daily for the first week and every other day for the following two weeks. Starting on day 6, a combination of tulle dressing impregnated with chlorhexidine (Bactigras) and silver sulfadiazine cream was used (Figure 2-C). Each of these dressings was conceived for use as the primary layer of a bandage. In this case, the tulle dressing was used as a non-adhesive network to hold the cream in place. Both of them promote healing and have a satisfactory antibacterial effect. This combination was used during the second week.

Although at the first assessment of the wound, the hair on the surrounding area was clipped properly to accurately assess the extent of the lesions, a week later new necrotic foci were encountered. At this point, to confirm the diagnosis, biopsies were taken from this tissue and from the margins of the largest defect. The pathology report supported the initial clinical diagnosis and excluded other differential diagnoses such as toxic epidermal necrolysis, vasculitis, that had been previously considered. Histopathology identified necrosis, inflammation and signs of tissue regeneration.

Once a healthy granulation tissue was established across the entire wound surface, a hydrocolloid dressing was used to further promote healing by assuring a moist environment and to act as a barrier for external contamination (Figure 2-D). The use of this dressing allowed a reduction of the frequency of bandage change. However, as this dressing can impede contraction, its use was alternated with the Bactigras-Dermazin combination.

Figure 2. Types of dressings.
A. Honey dressing. B. Honey dressing+ Silver sulfadiazine cream; C. Tulle dressing+Silver sulfadiazine cream; D. Hydrocolloid

The use of these dressings as part of a bulky bandage allowed the patient's discharge and subsequent outpatient therapy. The progression of healing was monitored every two to four days at each bandage change.

Although at home the patient continuously wore an Elizabethan collar and the bandages were kept in place between check-ups, there was a small setback on day 34, when the dog

rubbed against various surfaces due to pruritus (Figure 3-G). The perilesional skin was hyperemic and the wound surface was larger compared to the previous evaluation.

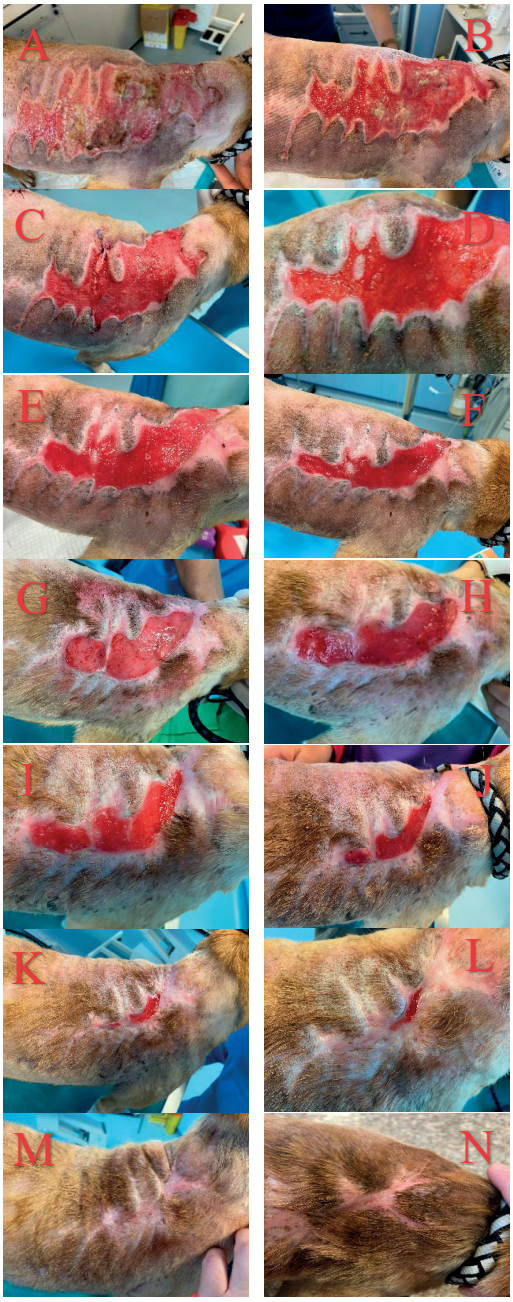

Figure 3. Healing process.
A. Day 7; B. Day 10; C. Day 15; D. Day 18; E. Day 21; F. Day 32; G. Day 36; H. Day 38; I. Day 43; J. Day 46; K. Day 50; L. Day 53; M. Day 56; N. Day 76

To prevent other accidents from occurring and properly monitor wound healing, the bandages were changed every other day from that day onward.

On day 56, the wound was entirely closed (Figure 3 - M). After a skin defect is entirely covered by epithelium, the wound healing continues. Due to this consideration, we advised the owner to apply silver sulfadiazine cream every two or three days to maintain skin moisture. To avoid any trauma to the fragile new scar tissue, the owner was advised to keep the area covered with light shirt.

RESULTS AND DISCUSSIONS

Radiant heat injuries in small animals have a low rate of occurrence. Although some of the warming systems used in veterinary medicine are known to be a burning hazard, accidents related to them continue to happen.

Case series and articles on this topic date back more than 50 years, but they are not numerous (Crino & Nagel, 1968; Dunlop et al., 1989). Since thermal injury is not frequent in veterinary medicine, the existing data regarding burn management is scarce compared to the body of literature from human medicine (Johnson & Richard, 2003; Pretorius et al., 2011; Mullally et al., 2010; Sheridan, 2012; Rowan et al., 2015). Most guidelines for burn wound management in use are veterinary adaptations of the protocols used in human hospitals (Pavletic, 2010; Pavletic & Trout, 2006; Vaughn & Beckel, 2012; Vaughn et al., 2012; Vigani & Culler, 2017).

The severity of a burn is dictated by the temperature of the heat source, duration of contact, and size of the affected area. In this patient, the heat source had a low temperature (most heat pads reach ~35-40ºC) and the duration was estimated at 1-2 hours (surgical intervention and recovery from anesthesia). As previously mentioned, the degree of severity of a burn lesion is also correlated with the depth of the lesion. In this case, depth could not be described initially, due to the fact that the wound was covered by dry necrotic tissue.

Sometimes, radiant heat injuries represent a diagnostic challenge. The evolution of this case is similar to data found in scientific literature

for this type of burn injury. The skin changes can go unnoticed for long periods (up to 7-10 days) if the affected area is covered by a thick haircoat that conceals the initial signs. In our patient, the lesions were observed once the scab began to develop, ten days after contact with the heat source.

Small animals are more vulnerable to heat exposure and prone to radiant heat injuries due to the lack of a well represented superficial vascular plexus of the skin that is well defined in humans (Wohlsein et al., 2016).

When uncertainties exist related to the aetiology of a lesion, like in this case, biopsies may establish diagnostic certainty. In this case, the biopsy was performed late in the course of disease, when the wound was already in the healing phase. Biopsies can identify anatomic depth precisely and even describe the presence and extent of microbial infection (Gross et al., 2005). However, burn wounds often have an irregular surface and variable depth, therefore the pathology report may not be valid for the entire wound. In this case, the biopsy report described a deep partial-thickness wound, eliminated other differential diagnoses such as toxic epidermal necrolysis, vasculitis, and confirmed the clinical diagnosis.

Clinically, burns unlike other skin injuries, do not progress beyond the fifth day and often have irregular shapes. The burn wound presented here had a "drip" configuration, a pattern that is typical for a burn lesion (Figure 1). This dog, like other patients with similar lesions described in the literature, presented with a good clinical state. This differentiates burn patients from those with other types of skin disease that are associated with severe systemic disorders.

The initial focus when managing a burn patient is stabilization. The importance of this step varies with different types of burn wounds. In this case, the patient was stable throughout the entire postoperative period and stabilization only included fluid therapy and analgesia. Since the burns were observed 10 days after the injury, cooling was not required.

Current recommendations in human medicine focus on controlling the infection, preventing sepsis, providing enteral nutrition and analgesia, and locally, on rapid escharectomy. This approach is often applied to small animals. When the process is acute, fluid therapy, analgesia, oxygen supplementation and assessment and management of metabolic imbalances should be rapidly initiated. In this case, the mild hyperkalemia, anaemia, hypoalbuminemia and neutrophilia were secondary to the massive cell destruction, inflammation and protein loss. Anaemia is expected to occur 1-2 weeks after the burn, secondary to cell destruction, blood loss and also due to a reduced cell lifespan associated with the burn (Efimova et al., 2019). Occasionally, loss of plasma can lead to an increased hematocrit. The increased packed cell volume in this patient was corrected using fluid therapy over the first couple of days. Although severe systemic complications have been described, small animals are often stable without fluid therapy. Enteral nutrition also played an important role in the management of this burn patient. A high-protein high-calorie diet was recommended to promote wound healing.

Another major goal in burn wound therapy is wound closure. A correct assessment of the burn has to be made to develop an appropriate treatment strategy. In most burn wounds, early assessment can be difficult due to the presence of the eschar. When evaluating a burn, one should note the aspect of the wound (colour, size), depth, surface affected, the presence of pain, unpleasant odour and/or hair.

To accurately approximate the percentage of the total body surface affected, various charts and formulas are used in human medicine. The most frequently employed of these is called the "rule of nines". This chart divides the body surface into areas of 9% or a multiple of 9 to estimate the surface area based on the various body regions. The "rule of nines" was adjusted for veterinary medicine, as follows (Pavletic, 2010):

- ✓ Each forelimb: 9%;
- ✓ Each hind limb: 18%;
- ✓ Head and neck: 9%;
- ✓ Dorsal half of the trunk: 18%;
- ✓ Ventral half of the trunk: 18%.

Using this rule, we estimated the burn surface area in our patient to be around 15%. This formula does not correlate well with age and body surface changes; thus, to assess burn

injuries in children, the scientific literature quotes the Lund-Browder chart as more accurate (Murari & Singh, 2019). In small animals, it is easy to overestimate the affected surface, due to the higher elasticity and looseness of the skin as compared to humans.

In this dog, the appearance of the lesion was characteristic for an eschar secondary to a full-thickness burn. Since this injury was inflicted by prolonged contact with a low-temperature heat source, hair was still present on the affected skin. The fissure that delineated necrotic from viable tissue that was present in this case is frequently associated with third-degree burns.

The history and signalment of the animal, such as the age of the dog, the recently performed mastectomy, the anatomical location of the burn, the animal's general state, the cost of multiple surgical interventions and postoperative care were taken into account before opting for a conservative approach. The strategy used to close this wound involved only non-invasive and minimally invasive techniques (Figure 3). Literature often advises early escharectomy for a positive outcome. Since most of the necrotic tissue in this patient was represented by the eschar, debridement focused on removing the black, leathery, thick escharotic tissue.

In injuries such as the one presented, two main approaches can be used. Conservative debridement relies on the physiological process of autolytic debridement as part of the initial phase of wound healing. To promote this process and accelerate the removal of non-viable tissue, enzymatic debriding agents and wetting agents in combination with antibacterial substances can be used. An escharotomy may be useful to facilitate the penetration of the debriding agents underneath the eschar. While this process helps obtain a selective debridement, when there is no clear demarcation, it is a slow process.

Aggressive debridement envisions the removal of the entire burn or eschar through surgical excision. The arguments that support this type of non-selective approach are that necrosis impedes granulation tissue development and increases the risk of infection. Spontaneous separation (delamination) may occur after long periods, even weeks. In the case presented here, the eschar was removed over 4 days by selective debridement, a result considered satisfactory. Scientific data mentions that if no other impeding factors intervene post-escharectomy, the granulation bed develops in 5 to 7 days (Pavletic, 2010). Once the granulation tissue develops (in our case 1-2 days after eschar removal) the type of wound closure has to be chosen. From this point onward, the approach is similar to wounds with other etiologies.

The option used here was secondary intention healing, where healing occurs through contraction and epithelialization from bordering skin. The other option is reconstructive surgery, which is invasive but offers a faster closure (eg. flaps, grafts). An important factor in the decisional process is the location of the lesion. Patients with burns in areas with loosely attached, highly elastic skin (trunk, abdomen) represent good candidates for secondary intention healing. In this case secondary closure occurred mainly by contraction with a satisfactory cosmetic outcome and no major complications or need for long term care. The conservative approach was chosen due to the size of the patient (that made bandaging manageable), the recently performed mastectomy and the potential need to remove the other mammary chain, which diminished the possibility to perform large flaps involving the neighbouring skin. These considerations, as well as the invasive nature of reconstructive surgery, the risk of dehiscence, the more demanding postoperative care in order to prevent necrosis, and the higher cost discouraged the owner from opting for a surgical approach.

The use of dressings and bandages as described previously made possible the evaluation of the gradual and visible reduction of the affected surface during healing. The animal had an optimal level of comfort throughout this process. When choosing secondary intention healing as a closure option for large wounds, certain complications have to be taken into account. Wound contraction may result in a poor aesthetic outcome and a lack of hair over the scar that the owner must be informed about. Similar to the case described here (Figure 3-M.), skin creases can develop, which can lead to dermatological lesions. The scar tissue undergoes further remodelling during the maturation phase, partially correcting these

defects after wound closure. Since the new epithelium is scar tissue and doesn't have the same characteristics as the skin, it is more prone to injury due to its higher fragility. In this case, only in a small percentage did the wound heal by epithelialization, so long term management is not expected to be demanding. Complications are not only encountered after wound closure, but throughout the healing phase if the animal is not properly monitored, precautions are not taken to protect the wound and the injury is not properly managed.

There are a few case reports describing similar wounds that healed by secondary intention, but the high variability of the patients makes it difficult to compare protocols and healing time (Sogebi et al., 2017; Lima & Bahr Arias, 2015; Maravelis et al., 2015). Most of the cases identified in the literature healed over a period of 60 to 100 days and were approached using a combination of medical and surgical treatments. Delays were reported due to complications such as dehiscence, infection, or the patients' general status. Maravelis and his team obtained a one-month healing time using medical-grade honey in a similar case to the one presented.

Many articles regarding burn wound management mention that systemic antibiotics are not entirely effective against microorganisms that multiply at the level of the avascular burn necrosis (Salyer et al., 2021). Systemic broad-spectrum antibiotics are unable to penetrate the eschar or reach any affected area where the vascular supply was compromised (Sevgi et al., 2014). They should be introduced in the burn management protocol when there is evidence of infection (eg. pneumonia or sepsis) or immunosuppression (Barajas-Nava et al., 2013). This case had a positive outcome using only topical antimicrobials. One of the most commonly used topical antibiotic is silver sulfadiazine (Momoh et al., 2009; Boekema et al., 2013). Its use is recommended in partial and full-thickness burns to prevent infection. This sulfonamide has a broad antibacterial spectrum which includes the most common bacteria found at the wound level. The silver ions released inhibit bacterial growth and multiplication. Silver sulfadiazine has the ability to penetrate necrotic, escharotic tissue. Additionally, throughout the debridement phase, the antiseptic properties of honey were also employed (Eroglu et al., 2018; Rozaini et al., 2004).

Improper use of most heating devices can inflict a thermal injury. Studies have shown that one of the safest devices used is the forced air system, which evenly disperses heat across the body's surface, prevents loss of warm air heat, and gives superior results compared to other systems, while decreasing patient burn risk (Clark-Price et al., 2013; Waterman, 1975).

CONCLUSIONS

Although thermal injuries are the topic of numerous studies in human medicine, little has been published regarding treatment guidelines in veterinary medicine.

Further research is needed to better understand the pathophysiology of the burn disease and its systemic and local implications in animals, to serve as a starting point for novel therapeutic protocols.

When promoting secondary intention healing in a wound, the treatment has to be adjusted and altered for each phase of the healing process, to obtain the best closure time. In this case, a satisfactory time was obtained (56 days) to close a wound that initially affected approximately 15% of the total body surface.

Raw honey used as a debriding and antimicrobial agent may be a proper dressing for full-thickness burns during the initial healing phase.

The combination of chlorhexidine impregnated tulle dressing and silver sulfadiazine cream may be superior to the individual use of these products. This combination provides the non-adhesive characteristic of the dressing while keeping the cream in place for longer periods.

Radiant heat injuries may be a diagnostic challenge, thus biopsies may help confirm the diagnosis.

Full-thickness burns of the neck and trunk can be managed exclusively by a minimally invasive approach.

Maintaining normothermia during anaesthesia remains challenging but special attention should be paid when using heating devices during surgery, due to the risk of burn injury to the patient, even at low device temperature.

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