“Barkley’s Been Broken”

Joshlyn Winstead
Mississippi State University College of Veterinary Medicine
Class of 2020

Clinicopathological Conference

May 10th, 2019

Advisor: Hayley Gallaher, DVM

Introduction

Appropriate wound management is critically important for the successful outcome of patients that present with expansive, deep wounds that cannot be immediately closed. Common wounds seen in canine patients include lacerations, bite wounds, degloving injuries, penetrating wounds, or burns. Lacerations and degloving injuries in the canine patient are most often the result of vehicular trauma.[1] Wounds are classified as clean, clean-contaminated, contaminated, or dirty/infected. For the purposes of this case report, the focus will be on management of a contaminated wound. Contaminated wounds are recent wounds with an established infection, and are usually traumatic in origin, containing debris and foreign material. Basic treatment goals for wounds include reducing further contamination by keeping the area covered, removing gross contamination and debris, debridement of dead or compromised tissue, providing an environment that promotes healing, and determining an ideal method of closure.[4,5] Vacuum-assisted closure (VAC) therapy is useful for managing a variety of wounds and may shorten hospitalization times.[8] Vacuum-assisted closure applies continuous negative pressure to a special dressing overlying a wound bed to promote healing. VAC therapy can be used for wound management until healthy granulation tissue has formed, and the wound is healthy enough for the selected type of closure. If use of the VAC therapy extends beyond the formation of granulation tissue, the healthy granulation bed will be removed with the change of the VAC dressing and healing is delayed.[1] The approach and management of a wound and closure depends on the degree of contamination and location of the wound. This case report explores the pathophysiology, treatment, and management of a contaminated, open wound using vacuum-assisted closure therapy in a patient that presented to MSU-CVM after being hit by a car.

History and Presentation

Barkley was an almost 2-year-old female intact Australian Shepherd that presented to MSU-CVM's emergency service on November 26, 2018 after being hit by a car. Barkley's owner had returned home that afternoon to find that Barkley was missing and immediately began contacting Animal Control and local shelters to find her. Animal Control had found Barkley shortly after she was hit by a car and had taken her to a local animal clinic. There, Barkley received a dose of meloxicam and, due to the extensiveness of her injuries, was referred to MSU-CVM.

Upon presentation, Barkley was non-ambulatory, laterally recumbent, extremely painful, and in unstable condition. She was tachycardic with a heart rate of 170 beats per minute, had a respiratory rate of 44 breaths per minute with increased respiratory effort, and had a temperature 100.8 degrees Fahrenheit. Her mucus membranes were pale pink and tacky, and her capillary refill time was 2 seconds. She had anisocoria, but an intact pupillary light reflex and palpebral reflex, bilaterally. A large wound was located in her left inguinal region that had deep pocketing at the caudal aspect that, later, was found to communicate with her abdominal cavity. Another wound was located on the cranial aspect of her right forelimb that had approximately 2 cm pocketing on palpation. She had bruising and abrasions on the left side of her neck and the medial and lateral aspect of her left hindlimb. Extensive bruising was present at the base of her tail and between the toes of her left hind paw. A laceration was present on the left side of her mouth, subsequent lacerations on the underlying buccal mucosa, and gingival avulsion was present above her upper 4th premolar. Her lungs sounds were decreased on the right side. On rectal examination, multiple pelvic fractures were palpated. She had intact patellar reflexes. Withdrawal reflexes, pain sensation, and motor function was observed in all 4 limbs. On thoracic FAST scan, diffuse lung rockets were seen on the right side. On abdominal FAST scan, free fluid was noted in 1/4 quadrants. Radiographs were taken of Barkley's thoracic cavity to evaluate her lungs and the cervical and thoracic portion of her spinal column. These radiographs revealed pulmonary contusions, a fractured 7th rib on the left side, a fractured caudal end-plate of C6, and pneumothorax. Abdominal radiographs were also taken and revealed peritoneal effusion, microhepatica, pneumoperitoneum, and a right sacroiliac luxation.

The large wound in Barkley's inguinal region was thoroughly lavaged with warm sterile saline and gentle explored using sterile technique. While exploring the caudal aspect of the wound, omentum was discovered, and communication of the wound with the abdomen was confirmed.

Pathophysiology

Wound healing occurs in four stages. The first stage of wound healing, the inflammatory phase, begins immediately after the integrity of tissue has been disrupted. The vasculature in the area initially constricts to provide hemostasis, and then vasodilation occurs to allow the migration of cells, fluid, and inflammatory mediators into the area. This results in edema. The second stage of wound healing is debridement. This stage begins 6-12 hours after injury and involves the influx of neutrophils and monocytes into the wound to phagocytize bacteria and release enzymes that further degrade necrotic tissue. Monocytes are also responsible for secreting factors that promote tissue healing. This is the stage that can be manipulated by external factors to provide an environment that facilitates the development of a healthy tissue bed as quickly as possible. The third stage of wound healing is the repair phase which begins approximately 3-5 days following injury. Fibroblasts are recruited into the tissue, followed by new capillaries. Capillaries, fibroblasts, and fibrous tissue combine to form granulation tissue. Granulation tissue provides a bed for epithelialization to occur. The fourth stage of wound healing is maturation. This occurs when the wound is closed, and granulation tissue is replaced by connective scare tissue. Type III collagen fibers are gradually replaced by Type I collagen fibers and collagen fibers are reoriented to provide an increase in strength of the tissue. The maturation phase may last months to years.[4,5]

There are multiple factors that affect the ability of a wound to heal including host, wound, and environmental factors. Animals that are old, debilitated or immunocompromised do not heal as quickly as young, healthy animals. Delayed healing also occurs when animals have concurrent systemic diseases such as hepatic or endocrine diseases. Animals that are not receiving adequate nutrition or have low serum protein values also show a propensity for delayed healing. When wounds occur in conjunction with other comorbidities that require surgical intervention, it is important to note that the longer an animal remains under anesthesia, the more likely it is that infection will occur in any open wounds. Prolonged anesthesia is associated with hypothermia and decreased blood pressure, both which result in peripheral tissue hypoxia and compromise immune function. Anesthetic drugs also interfere with inflammatory mechanisms and reduce the patient's ability to fight infection. Prolonged procedures result in greater bacterial exposure for open wounds and an increase risk of breaks in sterile technique causing further contamination.[4] Wounds heal best when they are kept warm and moist. An appropriate vascular supply provides cells with the nutrition and oxygen to heal. Gross contamination and foreign material increase inflammation and delay the proliferative (repair) phase of healing. Cellular migration is inhibited by large amounts of dead space and fluid in wound beds. This also increases the risk of infection, which can delay healing by causing inflammation and promoting cellular necrosis.[4,6] External factors that may inhibit wound healing include the use of immunosuppressive drugs, anti-inflammatory agents, or chemotherapeutics.[5]

Diagnostic Approach/Considerations

Initial management of a patient that presents due to trauma should include assessment of the patient's systemic condition. Monitoring such as oscillometric blood pressure measurements, pulse oximetry, and electrocardiography can be used while the patient is being stabilized to determine the effectiveness of initial treatments. Arterial blood gas samples may be obtained to determine the patient's oxygenation status and further evaluate how well the animal is perfusing. Venous samples may be collected to determine the patient's acid/base status. Blood collected for packed cell volume and total protein analysis can be used to determine the degree of blood loss, although these values are not truly accurate until 24 hours after hemorrhage has occurred. This is because red blood cells and plasma are both lost equally, and it takes several hours for interstitial fluid to expand the vascular space. When an appropriate circulating volume is reached, the packed cell volume will accurately reflect the proportion of red blood cells that are remaining. Electrolyte and chemistry analysis are useful for evaluating electrolyte disturbances and well as renal values.[7] For all wounds, the area surrounding the wound should be clipped, cleaned, and the wound should be gently explored using sterile technique to reduce further contamination. Any pocketing around the wound should be measured, and, if communication with a body cavities is suspected, additional diagnostics can be used to determine the extent of involvement.[6] Radiographs and ultrasound are useful imaging modalities for evaluating internal structures that may be damaged or for diagnosing suspected communication of an external wound with the thoracic or abdominal cavity.

Treatment and Management

There is no step-by-step guide for the management of traumatic wounds. Each case should receive a treatment protocol that has been designed specifically for that patient for the best outcome. For patients presenting due to vehicular trauma, stabilization of the patient is critical.

Initial treatment should be aimed at ensuring the animal has a secured airway, is breathing appropriately, and maintaining an adequate circulating volume.[6] Active hemorrhage should be controlled as soon as possible. The patient should be thoroughly evaluated for any additional injuries before exploring any wounds.

Wounds must be thoroughly lavaged and debrided if they are deemed to be contaminated. Foreign material and debris lead to an increase in inflammatory mechanisms that delays the forward progression of wound healing. Wounds should not be lavaged with antiseptic solutions such as .1% povidone-iodine or .05% chlorhexidine, as this may cause chemical irritation and have cytotoxic affects that delay healing. Sterile, buffered solutions such as saline or Lactated Ringer's solution are appropriate choices for lavaging wounds.[2] Debridement can be accomplished in a variety of ways. The natural progression of wound healing involves that influx of white blood cells into the area of the wound to phagocytize bacteria and clean debris and dead tissue from the wound bed. Debridement can also occur surgically or mechanically. Surgical debridement involves the excision of unhealthy tissue or tissue that is classified as severely compromised. Mechanical debridement consists of placing wet-to-dry or dry-to-dry gauze dressings on top of the wound and pulling them away once the tissues have adhered to the gauze.[2,4]

Wounds should be bandaged appropriately if they are not considered clean and healthy enough for primary closure. Bandages consist of three layers. The primary or contact layer, the secondary layer, and the tertiary layer. The primary layer may be used for debridement purposes, to remove exudate from the wound, contain medications, and provide protection for the wound bed from further contamination. This layer may be adherent or nonadherent based on the current status of the wound. Adherent contact layers are used only in the initial phases of the wound when debridement is a central goal. Nonadherent contact layers are always utilized after the development of a granulation bed. The secondary layer consists of thick cotton or roll padding and is used to absorb fluid from the wound. The tertiary layer holds the other layers in place and provides structure and support.[2]

Medicated wound dressings are a controversial topic. It is now widely accepted that for most wounds, even those that may be severely contaminated upon presentation, less is more when it comes to topical solutions, ointments, and creams that may be applied to wounds. Honey has been used in wound treatments for hundreds of years and recently regained popularity due to the rise of antimicrobial resistance as well as new studies that support its effectiveness in wound therapy. It has a variety of antimicrobial properties including the production of hydrogen peroxide, hypertonicity, and low pH. Manuka honey is produced from a specific plant, *Leptospermum Scopartum*, and contains an additional antibacterial component, methyglyoxal. There are several brands of medical grade Manuka honey that have been filtered and sterilized to eliminate gross contaminates and bacteria. The osmotic effects of a sugar dressing may also be beneficial during this time to reduce edema. Sugar creates a hyperosmotic environment that is bacteriocidal and provides a nutritional source for cells within the wound. Both honey and sugar have been shown to increase the migration of macrophages and promote the growth of a granulation bed.[2,5,6]

The use of vacuum-assisted closure (VAC) has been shown to decrease healing times throughout two basic mechanisms: removal of fluid and mechanical deformation.[1] The continuous application of negative pressure to all surfaces in contact with the VAC dressing accelerates mitotic rates and angiogenesis. The removal of fluid allows for more efficient cellular migration and decreases interstitial fluid which increases blood flow through local capillaries.[1,3] Wound fluid may also contain factors that inhibit mitosis and protein and collagen synthesis.[1]

Wounds that are less than six hours old, relatively clean, and have enough skin for an appropriate closure without tension may be lavaged, debrided and closed primarily. Delayed primary closure is reserved for wounds that are more contaminated and need multiple sessions of lavage and debridement before closure. Patients may also be treated with systemic antibiotics. Delayed primary closure usually happens 3-5 days after an injury has occurred and before granulation tissue has formed. Secondary closure occurs after a healthy bed of granulation tissue has formed. The wound usually contains heavy contamination or severe tissue or vascular damage and must be left open for the control of infection and to allow the wound to declare itself. Healing by second intention occurs when a wound is not closed and is left open to re-epithelialize on its own.[4,5,6]

Case Outcome

Barkley's initial stabilization included several boluses of intravenous isotonic fluids to treat shock and immediate pain control using hydromorphone. Her vital parameters were closely monitored while initial diagnostics were being performed to assess the extent of her injuries. A MILA chest tube was placed to evacuate air and a small amount of fluid from Barkley's thoracic cavity to improve the quality of her respiration.

After determining that Barkley's left inguinal wound communicated with her abdominal cavity, emergency surgery was performed to repair the defect in her abdominal wall. Her pelvis was stabilized, her left prepubic tendon was reattached, and the rent on the caudoventral aspect of her abdominal wall was sutured closed. Barkley received a 500 ml volume whole blood transfusion during surgery. The wound in her left inguinal region was thoroughly flushed with warm, sterile saline and the edges of the wound were debrided. A urinary catheter and Jackson-Pratt drain were placed following surgery. A tie-over bandage was secured over the wound after surgery and remained in place for several hours. Due to the large amount of exudate the wound was producing, it was decided to manage the wound using vacuum-assisted closure therapy, or a wound VAC. A foam dressing was placed in the wound and sealed with a special sterile adhesive. The surrounding skin was further sealed using adhesive spray and sterile Ioban. The VAC tubing was connected to a port that was attached to the foam dressing. An appropriate seal was recognized when the VAC was turned on and the dressing and adhesive layers crinkled, shrunk, and exudate started traveling through the VAC tubing. Any areas that were noticed to be leaking air were covered with more Ioban.

Following her first surgery, Barkley remained in ICU on supplemental oxygen for several days. Her pain was controlled using fentanyl, lidocaine, and ketamine constant rate infusions. She was placed on gastroprotectants to prevent any gastrointestinal ulceration, and she remained on aggressive fluid therapy. On her second day of hospitalization, a nasogastric tube was placed, and she began receiving a slurry of Science Diet a/d to meet her nutritional demands. The initial antibiotic Barkley was placed on was cefoxitin at 30mg/kg intravenously every 6 hours. On November 29, 2018 Barkley had a CT performed to evaluate the fractures of her spinal column and pelvis. The CT revealed a complete body fracture of T6, and incomplete fracture of the right scapula, right sacroiliac luxation, bilateral acetabular fractures, and multiple fractures of the ischium and pubis.

On November 30, 2018, the culture and sensitivity for the abdominal fluid taken on the day of Barkley's presentation confirmed the growth of *Bacillus cereus* and *Enterococcus faecalis* that were not susceptible to her current antimicrobial medication. She was subsequently placed on Unasyn (ampicillin with sulbactam) at 30 mg/kg intravenously every 8 hours.

On December 5th 2019, another sample of Barkley's wound was obtained and submitted for culture and sensitivity. The results returned on December 9th with the growth of three organisms: *Enterbacter cloacae*, *Enterococcus faecalis*, and *Stenotrophomonas maltophilia*. Barkley was briefly placed on meropenem at 10 mg/kg intravenously every 12 hours for several days before the final results of the culture were received and revealed that the organisms were susceptible to trimethoprim sulfa. She remained on trimethoprim sulfa for the duration of her hospitalization at 30 mg/kg orally every 24 hours.

Barkely was heavily sedated every three days for a total of three times after the initial placement of the VAC dressing before her wound was declared healthy enough to be closed. At the last evaluation of her wound before surgery, Barkely's right hindlimb was put through a range of motion and assessed for stability. The joint was determined to be stabilized and surgical repair of her right sacroiliac luxation was not warranted.

On December 6th, 2018 Barkley was placed under general anesthesia, and the wound in her left inguinal region was closed by direct apposition. Two Jackson-Pratt drains were placed in the wound during surgery. Barkley did well under anesthesia and recovered from the procedure uneventfully. Her pain was managed with fentanyl, lidocaine, and ketamine constant rate infusions. In the days following this procedure, these medications were discontinued, and she was started on Tylenol 4 at 1.5 mg/kg every 8 hours, gabapentin at 8 mg/kg every 8 hours, and carprofen at 2.2 mg/kg every 12 hours.

Two days following surgical closure of the wound in Barkley's left inguinal region, an area in the cranial portion of the wound began to dehisce. On December 13th, Barkley was again placed under general anesthesia, and the 12 cm in length area of dehiscence located cranial to the wing of her ilium was closed using a rotational flap. The two Jackson-Pratt drains remained in place until Barkley was discharged.

Barkley continued to improve over the next few days and after no additional areas dehisced, was subsequently discharged to go home on December 18th, 2019. She was sent home with instructions to continue activity restriction and with the medications trimethoprim sulfa, Clavamox, gabapentin, and Tylenol 4. At the time of her discharge, Barkley's multiple fractures and wounds were determined to be healing or resolved.

Barkley returned for a recheck appointment on December 20th. Her wounds were continuing to heal appropriately, and no dehiscence was noted.

On January 8th, Barkley returned for a recheck appointment and recheck radiographs of her pelvis. These radiographs revealed changes consistent with healing of her right sacroiliac luxation, right and left acetabular fractures, and the fractures of her ischium and pubis. The adductor muscles of Barkley's left hindlimb were very tight while being palpated and while her limbs were placed through passive range of motion. It was suggested that Barkley return for physical therapy to help improve the strength and range of motion of her left hindlimb.

She has returned for several sessions of rehabilitation since her recheck appointments, with her last visit on April 22, 2019. Barkley continues to walk with a shortened stride and with her left limb tucked under her body due to the formation of thick scar tissue in her left inguinal region.

References

1. Ben-Amotz R, Lonz OI, Miller JM, et al. The use of vacuum assisted closure therapy for the treatment of distal extremity wounds in 15 dogs. Journal of Veterinary Surgery 2007; 36:684-690.
2. Bohling MW, Swaim SF. Management of Traumatic Wound by Primary Closure. In: Birchard SJ, Sherding RG, eds. Saunders Manual of Small Animal Practice. 3rd ed. St. Louis: Saunders Elsevier, 2006: 541-548.
3. Demaria M, Stanley BJ, Hauptman JG, et al. Effects of negative pressure wound therapy on healing of open wounds in dogs. Journal of Veterinary Surgery 2011; 40:658-669.
4. Fossum TW. Surgery of the Integumentary System. In: Dewey CW, Horn CV, Johnson AL, MacPhail CM, Radlinsky MG, Shultz KS, Willard MD, eds. Small Animal Medicine and Surgery. 4th ed. St. Louis: Mosby Elsevier, 2013; 9498-12973.
5. Harari J. Small Animal Surgery Secrets. 2nd ed. Philadelphia: Hanley and Belfus, 2004; 1-45.
6. Knapp DW. Management of the Open Wound. In: Birchard SJ, Sherding RG, eds. Saunders Manual of Small Animal Practice. 3rd ed. St. Louis: Saunders Elsevier, 2006:549-555.
7. Macintire, DK. Manual of Small Animal Emergency and Critical Care Medicine. 2nd ed. Chichester: John Wiley and Sons 2012:3 -16.
8. Pritt KA, Bryden JS. Negative pressure wound therapy: Experience in 45 dogs. Vet Surg 2014, 43:380-387.