Ace's Unlucky Gamble

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Class of 2021

Clinicopathological Conference

July 24th, 2020

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Introduction

Wounds to the distal limb of the horse are commonly seen by veterinarians and are predisposed to nonhealing. Distal limb wounds are at a greater risk of complications compared to trunk wounds. They are more likely to become contaminated and thus infected, there is limited vasculature in the skin, and there is a higher chance of the wounds including vital structures as they are more superficial in the distal limb.[1] These wounds are also more likely to have the healing cascade interrupted by movement disrupting capillary buds, collagen deposits, and new epithelium as they are laid down resulting in an extended inflammation phase.[2] Veterinarians must evaluate and prepare the wound thoroughly. Structural stability of the horse needs to be obtained before determining the best course of action in treating or managing the wound.[3,4] Some of the characteristics of the wound that must be evaluated are the type of wound, age of the wound, contamination level of the wound, and what anatomical structures are included in the wound.[5]

After the wound has been evaluated, the next step is to determine the best method of managing the wound.[5] This step involves deciding if the wound is a candidate for primary closure, or if delayed primary or secondary closure would be more appropriate. Management decisions need to be made if the wound is in an area of motion or if special tension relieving techniques need to be used. The type of bandaging or casting after the wound has been closed needs to be determined based on the desired purpose of the bandaging. Prognosis can be variable depending on the use of the horse and the severity of the wound but is usually fair to excellent for most horses.

History and Presentation

KM Slot Machine, “Ace”, is a 2-year-old sorrel Quarter Horse stallion that presented to MSU-CVM Equine Services on January 28th, 2020 for a non-healing wound on his right forelimb over the superficial digital flexor tendon. The original wound was the result of Ace kicking through a fence on December 17th, 2019 and lacerating his distal limb. The primary care veterinarian attempted to close the wound, but necrosis of the skin around the closure site resulted in dehiscence. The primary care veterinarian attempted to close the wound a second time, but it reopened again a few days later.

On presentation Ace was bright, alert, and responsive. He weighed 1120 lbs. and had an ideal body condition score of five out of nine. He had a heart rate of 48 beats per minute and a respiratory rate of 12 breaths per minute. On thoracic auscultation normal bronchovesicular sounds were auscultated. He had normal gastrointestinal motility in all four quadrants. On visual exam he appeared comfortable and was moving well on his bandaged leg.

Diagnostics

The afternoon of January 28th, Ace was sedated with detomidine and butorphanol to allow for bandage removal and wound examination of his right forelimb. The wound was localized to the palmar area over the superficial digital flexor tendon mid metacarpal region. The laceration appeared to be superficial and did not affect the superficial digital flexor tendon in the injury. The wound was then scrubbed with 4% chlorhexidine solution. Cephapirin sodium ointment was rubbed over the wound and a bandage cast was placed on the distal limb, extending from the hoof to just below the carpus.

Pathophysiology

A wound is defined as the disruption of the continuity of anatomical and cellular tissue and can be the result of an accident or an intentional disruption as with surgical incisions.[6] Wounds of the distal limb of equine species are the most common wounds seen, account for more than 60% of all wounds, and are often accompanied by more problematic characteristics. The classification of a wound is important in assessing the healing ability of the wound. The first step in assessing a wound is determining if it is an open or closed wound. Open wounds include incisions, lacerations, and punctures which disrupt the full thickness of the skin layers, these wounds commonly include deeper structures such as tendons and ligaments.[1,6] The most common type of open wound is a laceration, which is characterized by irregular cutaneous margins and extensive damage to underlying tissue and are accompanied by large amounts of bruising resulting in pain.[1] Closed wounds are wounds that extend part of the way into the skin thickness, and include abrasions, bruises, and burns.[1,6]

There are four stages of wound healing that all wounds go through, and each stage overlaps with the previous stage resulting in a single wound being at multiple stages of healing as time progresses. The first stage is the inflammatory stage, which occurs in the first 2-3 days after the wound is acquired. This stage is necessary for protecting the wound from infection and to begin the repair process.[6,7] This is the stage of healing where blood and fibrin form fibrocellular clots that build a scaffold for cell migration in later stages of healing, and where leukocytes, predominantly neutrophils in the early phase, are brought into the wound site. This stage rids the body of foreign materials and eliminated dead tissue, while participating cells begin to mediate the next stage in the healing cascade.[8] The inflammatory phase is crucial in building the network for proper repair, but when this phase continues for an extended amount of

time and becomes unregulated pathological wound healing results in accumulation of fibrous scar tissue.[8]

The second stage in the healing cascade is the debridement phase which begins in the first 6-8 hours of injury and lasts for a variable duration based on the level of contamination and debris in the wound.[6] This is the stage where monocytes develop into macrophages and induce fibroblasts and provide cytokines and growth factors necessary to stimulate fibroplasia and angiogenesis.[6] The debridement stage is particularly important in the distal limb as it assists in the demarcation of nonviable tissue and controlling the length of the inflammatory stage.[7]

The third phase of healing is the repair phase which proceeds after debridement is complete.[6] This is the stage where granulation tissue, made of fibroblasts, vascular endothelial cells, and macrophages within a matrix of collagen and fibrin, is produced, leading to the increasing strength of the wound.[6,7] The repair phase leads to protection of the wound surface by the formation of granulation tissue and new epithelial layers, and by restoring the vascular network to nourish these tissues.[8] Wound collagen forms quicker in the horse than other species and predisposes horses to have proliferation of granulation tissues in wounds with increased retraction.[7] The prolonged inflammation phase of wounds in the distal limbs of horses results in deficient wound contraction leading to deficient epithelialization and the development of exuberant granulation tissue (proud flesh).[7]

The final phase of wound healing is the maturation phase. This phase begins 2 weeks after the inciting cause and continues for 6 to 12 months, resulting in reduction of wound size and enhancement of the cosmetic appearance and strength of the resulting scar.[6,7] This is the stage of healing where the wound contracts, granulation tissue decreases and collagen production declines.[6,7] This final stage of healing results in the final scar tissue formation, but owners should

be made aware that the new tissue will be 15 to 20% weaker than uninjured tissue, and those wounds that heal fully by second intention only reach a maximum tensile strength of 60% of normal skin strength.[6,8] The maturation phase can last for up to 2 years following initial injury, during which time collagen fibers rearrange and type III collagen fibers laid down early in the healing process are replaced by type I fibers until the normal skin ratio is achieved.[8]

Nonhealing (chronic) wounds present a unique problem with wound management. A nonhealing wound is defined as a wound that has failed in the normal stages of healing and is not progressing in a timely fashion.[9,10] Nonhealing wounds typically present one of three ways: persistent infection, wound desiccation, or excessive granulation tissue.[9,10] The key to resolving nonhealing wounds is in activating the healing cascade again and preventing recurrence of the inciting cause that made them fail the first time. In the distal limb of the horse excessive granulation tissue is a common result of a prolonged inflammation stage of healing, and chronic inflammation stops the healing cascade resulting in nonhealing wounds. [4,7] This exuberant granulation tissue results in a significant barrier to epithelialization, and makes delayed primary closure difficult in most situations.[10] Sometimes the simplest way of managing these wounds is by debriding them and making them fresh wounds that are more amenable to primary closure once infection has been handled.[9]

In the management of nonhealing wounds, debridement and lavage are important first steps leading to wound closure. In lavage of the wound the concentration of povidone iodine or chlorhexidine should remain low to avoid the cytotoxic effects and adversely affecting the healing ability of the tissue.[3] Debridement is used to clean the wound and take it from contaminated to clean contaminated and finally clean, with the goal of closing the wound primarily.[3,11] There are multiple techniques for debridement, and the technique chosen needs to

suit the goal set for the wound.[11] The preferred debridement techniques in the equine distal limb are sharp, one of the least traumatic methods of removing contaminated tissue but must be done conservatively; and autolytic, the least traumatic debridement technique which uses the body's own cells in wound fluid but is limited to moist wounds, because the other types of debridement result in more trauma and thus increase the healing time.[3,11] When performing sharp debridement, the criteria of tissue to be removed must be understood, so that only discolored and barely attached tissue is removed, and the horse has a limited supply of skin and tissue.[3] In nonhealing wounds of the distal limb, debridement should include judicious undermining of wound edges to maintain the blood supply and reduce tension on the suture line when the wound is closed.[11] After the wound has been debrided it can be closed. The three types of wound closure are primary, delayed primary, or delayed secondary; the type of wound determines which closure type is chosen.[11] Primary closure is the preferred method because the immediate closure of wounds using aseptic technique results in the most cosmetically acceptable and best functional result.[3,11] This closure type is acceptable in wounds with minimal tissue loss, minimal bacterial contamination, and minimal tension on the wound edges after closure, which can be difficult in the distal limb of a horse where there is limited skin to close.[3,11] As tension is a major factor in nonhealing of the distal limb, tension relieving suture patterns (far-near-near-far or mattress patterns) should be used whenever possible, and the wound should be closed as much as possible without putting undue tension on the tissue.[3,11] Unfortunately, even with all of these techniques in place there is still a high chance of dehiscence in a distal limb wound, in one study only 26% of horses had complete healing by primary intention with no dehiscence, but this is still the preferred method to avoid the development of exuberant granulation tissue.[3] An interesting adjunctive therapy to the traditional methods of dealing with chronic wounds is the addition of

platelet rich plasma (PRP) gel into the wound site.[12,14] Platelets increase the efficiency of hemostasis, reepithelization, angiogenesis, growth, and rapid healing.[14] PRP is rich in growth factors that have a direct anabolic effect on muscle-skeletal tissues, is high in fibrin which forms a scaffold that is crucial for appropriate healing of wounds, and when locally applied ultimately promotes healing of nonhealing wounds and the development of organized collagen.[12,13,14] Wounds that include tendons, ligaments, and bones require more detailed healing closure methods that are outside the scope of this paper.

Bandaging is an important part of the management of any wound and, when appropriately applied, greatly assists in the healing process. Bandaging protects the wound from contamination by the environment and aids in producing an ideal environment for healing, but must be used appropriately as it can also increase the risk of exuberant granulation tissue in the distal limb.[15] Although bandaging alone can decrease movement in the distal limb, casts and splints are more appropriate when immobilization is necessary for appropriate healing of a nonhealing wound due to tension and motion disrupting the healing cascade.[15] In the situation of a superficial nonhealing wound a bandage-cast is a more appropriate choice, to allow for more frequent access to the wound.[15,16] Bandage-cast are made of four layers, with the casting material being placed over the bandage taking care to avoid overly thick or loose bandages, which can slip and predispose the horse to developing pressure sores. [15,16] The bandage should extend from the coronary band to just below the carpus or tarsus, then the cast material is placed leaving the proximal bandage exposed and extending distally to include the hoof.[15] Hoof acrylic should cover the bottom of the hoof to provide traction for the horse, and elastic adhesive tape should loosely be wrapped around the proximal bandage to prevent foreign matter from entering the bandage-cast.[15] Finally, a shoe should be added to the contralateral limb to ensure the limbs are

the same length to prevent the horse from bearing more wight on one limb and predisposing them to laminitis.[15]

Wounds of the distal limb that do not include supporting structures or a synovial cavity have a good prognosis for cosmetic appearance and soundness.[16] In the case of nonhealing wounds, once the underlying complications are controlled the wounds cam heal appropriately and the outcome is successful.[9] The key to success in managing nonhealing wounds is in determining what caused the healing cascade to fail and managing the wound accordingly.

Treatment and Management Options

On January 31st, 2020 Ace was taken to surgery for debridement and closure of his wound. The distal limb was surgically prepped from the carpus to the coronary band and scrubbed with dilute betadine and alcohol. Due to the extent of the wound and its location, a portion of his chest was clipped, leaving enough hair to see the direction of follicular growth, in preparation for a skin graft if necessary. The laceration was debrided and extended proximally and distally in an S shape. The wound was then lavaged with sterile saline and a curet was used to further debride the wound. Upon examination of the wound it was determined that the edges could be apposed and closed with a sliding S configuration. Towel clamps were used to close the wound edges and stretch the skin to allow for complete closure. The towel clamps were then removed from the center of the wound and the center of the wound was closed using 3 Vicryl in a vertical mattress pattern. The ends of the wound were closed using 0 PDS on a cutting blade in a vertical mattress pattern. Blood was drawn from the right jugular vein and was spun down to produce platelet rich plasma. The PRP was then infused intradermally around the center of the

wound, where the tension was highest. PRP was then spread on the edges of the wound and the limb was wrapped.

A cast was placed on the right forelimb to immobilize the limb from the hoof to just below the carpus. A standing wrap was placed on the left forelimb. Recovery from anesthesia was uneventful. After the patient was standing a soft ride boot was placed on the left forelimb and wrapped with elasticon to maintain it.

On February 6, 2020, Ace was sedated with detomidine and butorphanol and the cast on his right forelimb was removed and the wound was seen to be healing appropriately; no dehiscence was noted. There were two cast sores found which were cleaned with 4% chlorohexidine scrub and covered with triple antibiotic cream. The leg was then wrapped well with padding and a cast was reapplied. The left forelimb was rewrapped, and no bandage sores were noted on that limb. Ace was ambulating well, and no signs of lameness were noted on either front limb.

On February 15, 2020 Ace was sedated with detomidine and butorphanol for a second bandage change and to assess the healing of his non-healing wound. On examination of his wound it was determined that the sutures could be removed. The skin around the wound had lost all hair, but was healing was progressing better than on presentation. The bandage on the left forelimb was removed, and both forelimbs were then bandaged with modified wedge shoes. That afternoon Ace began showing signs of colic. A nasogastric tube was placed, and no net reflux was obtained. He was administered buscopan and banamine, then walked for ten to fifteen minutes. Blood work was unremarkable, as were abdominal ultrasound and rectal palpation. Ace had another bout of colic later that evening, but then was noted to be resting comfortably in his stall.

Case Outcome

Ace was discharged on February 17, 2020 with no signs of lameness or discomfort. His wound has continued to heal appropriately with a mild amount of exuberant granulation tissue present, which was expected based on the location and type of wound. The most recent update is that Ace is back in training and doing well.

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