168 Days of Hollywood

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Introduction

Burn fire injury is a relatively uncommon cause of injury in horses. It is estimated that approximately 1,200 barn fires and 50,000 wildfires occur each year, making this the most common cause of thermal burn injury in horses. Other causes of thermal burn injury include sunburn, friction (rope burn), frostbite, electrocution, and lightning strike. Equine thermal burn injury ranges drastically in severity and treatment options vary. Prognosis depends greatly on the extent and structures involved in the burn, complications that occur secondary to the burn, and treatment availability.[3] In human medicine, burn injuries are classified based on depth and body surface area involved. This system is routinely used in horses and helps play a role in prognosis and treatment considerations.[2] In addition to injury to the skin, common comorbidities of thermal burn injury include inhalation injury, burn shock, ophthalmic complications, and sepsis.[1] Before pursuing treatment of an extensive burn injury, owners should be aware of potential complications, loss of athletic function, cost of therapy, and prognosis.[2,3]

Signalment, History, and Presentation

Hollywood is an approximately 16-year-old American Quarter Horse gelding that presented to Mississippi State University College of Veterinary Medicine (MSU-CVM) Equine Surgery Service on February 11, 2021, after suffering thermal burn injures in a barn fire 10 days prior to presentation. Hollywood initially presented to his primary veterinarian on the evening of the incident, January 31, 2021. He was stabilized and was receiving the following medications prior to arrival at MSU-CVM: Tucoprim, Excede, Vitamin E, silver sulfadiazine on the skin wounds, and neopolybac ophthalmic ointment and chloramphenicol into his eyes. Hollywood was referred to MSU-CVM for further evaluation and treatment.

Upon presentation, Hollywood was quiet, alert, and responsive. He weighed 962 pounds and had a body condition score of 5/9 (ideal). He had a normal temperature of 100.8 degrees Fahrenheit, an elevated heart rate of 56 beats per minute, and a normal respiratory rate of 16 breaths per minute. The oral mucous membranes were pink and moist with a normal capillary refill time of less than two seconds. Heart and lung sounds auscultated normally with no murmurs, arrythmias, crackles, or wheezes. Normal borborygmi (gut sounds) were present in all four quadrants of the abdomen. Normal digital pulses were palpated in all four limbs and steel shoes were present on the forelimbs. Skin burns varying in severity from first to third degrees were present along the dorsum, extending down the dorsal and lateral aspect of the neck, and covering the face and the ears involving approximately 50% of his skin surface. Silver sulfadiazine cream was present covering the wounds.

Pathophysiology

Burn wound pathophysiology is characterized as an inflammatory reaction. The effect of direct heat causes damage and loss of skin and the microvascular system resulting in initiation of the inflammatory and coagulation cascades. Local inflammation resulting in the production of prostaglandins occurs initially followed by vasodilation, increased venous permeability, and eventually necrosis.[2,4,5] Extensive injuries result in a systemic response where continual loss of fluid from the damaged tissue can result in decreased cardiac output and hypoperfusion. This event is termed *burn shock* and resembles hypovolemic shock.[2]

In the initial phase of burn shock, there is a decrease in cardiac output, constriction of the arteries and veins, and dilation of the capillaries locally in the areas of damage resulting in protein loss. As a result of capillary permeability, endothelial damage, and the release of various mediators (neutrophils, prostaglandin, histamine, and oxidants), the formation of edema

ensues.[2,4,5] Fluid loss causes a reduction in blood volume, resulting in increased pulmonary vascular resistance and decreased tissue perfusion, which can lead to organ failure.[2] Fluid loss also results in increased evaporation causing loss of body heat resulting in an increased metabolic rate as the body tries to generate more heat. Metabolic rate and caloric expenditure are greater in burn injury than in any other state.[2] Therefore, body condition of the patient prior to injury is important for prognostic consideration. Shifts in fluid and protein also result in electrolyte disturbances. Hyperkalemia results immediately after the burn resulting in mineralocorticoid production which causes hypokalemia 3-5 days after the burn. Hypernatremia may then occur because of sodium reabsorption.

Horses that suffer burns covering more than 30% of their body are susceptible to developing anemia.[2] Initially, anemia is caused by local destruction of red blood cells at the site of injury. Blood loss can also occur from oozing of wounds and eschar removal. Thrombocytopenia can also occur from platelets aggregating at the site of the wound.[2]

Finally, burn patients lose the primary barrier to infection – the skin. The burn wound provides an excellent area of entry for bacteria due to neutrophil and bactericidal disfunction, complement opsonization, decreased IgG concentration, and defective fibronectin.[2,5] These factors predispose burn patients to developing sepsis. In human medicine, sepsis is the leading cause of death in the burn patient.[6]

Diagnostic Approach

At presentation, Hollywood first received a thorough physical examination. In the early phase of injury, it is difficult to determine the extent of tissue damage because heat is slow to dissipate from burn wounds.[8] A complete physical examination should be performed on all burn

patients prior to assessing the extent of tissue of damage.[2] Important parameters to closely examine in burn patients include mucus membrane color, capillary refill time, and temperature, as these are helpful indicators of perfusion, and burn patients often become hypothermic. Special attention should be paid to thoracic auscultation because inhalation injury is common. A thorough ophthalmic examination should also be performed. It is important to thoroughly examine tendon sheaths, joints, the perineum, and major vessels of the lower limbs for injury.[8] Recommended diagnostics to initially perform include complete blood count, serum chemistry, serum lactate, urinalysis, clotting profile, arterial blood gas, and carbon monoxide concentration.[1,2] Hollywood presented clinically stable and had already received initial stabilization 10 days prior to arrival to MSU-CVM. Blood was collected from the cephalic vein for complete blood count and serum chemistry. Abnormalities included a mild leukocytosis and neutrophilia, decreased platelet count due to platelet clumping, mildly decreased chloride and phosphorus, and mildly increased alkaline phosphatase. Abnormalities commonly seen on bloodwork include hyperkalemia initially, followed by hypokalemia, and hypernatremia, hypoalbuminemia, low total protein, hemoglobinuria, anemia, and thrombocytopenia.[1,2] Serial analysis of serum chemistries and complete blood counts are useful during the first several days to evaluate for potential organ dysfunction. Twenty-four hours later, another complete blood count was performed to recheck Hollywood's platelet count. The platelet count was severely decreased, but confirmatory manual counting revealed significant platelet clumping and therefore an adequate number of platelets.

In human burn trauma, determining the extent of surface area involved in the burn is an important diagnostic tool that helps determine treatment and prognosis.[1] A common schematic used is called the Rule of Nines, which has been extrapolated from human medicine. The Rule of

Nines provides an estimate of body surface area burned by assigning percentages to different body areas.[7] For example, the head is 9%, each forelimb 9%, each hindlimb 18%, and the dorsal and ventral halves of the trunk each being 18%.[7,2] Based on this information, Hollywood's burns were estimated to cover roughly 50% of his body. The percentage of total body surface area involved is thought to correlate with mortality whereas depth correlates with morbidity.[2] It is suggested that euthanasia be recommended for patients with deep partial to full-thickness burns covering 30-50% or more of their body.[2]

After thorough physical examination, an ophthalmic examination was performed. Initial diagnostic procedures included slit lamp biomicroscopy and fluorescein stain, which revealed superficial corneal ulceration of the right eye, inability to fully close the eyelids, and potential meibomian gland damage bilaterally. Based on examination, a major concern was eyelid contracture, which long-term would prevent Hollywood from being able to blink appropriately, predisposing him to chronic corneal ulceration. Ophthalmic examinations were performed routinely throughout Hollywood's treatment at MSU-CVM.

Other useful diagnostic tools that were not warranted in Hollywood's case include thoracic radiographs, bronchoscopy, and bronchoalveolar lavage to evaluate the extent of respiratory injury. These tests can be performed serially and used as prognostic aids.[1]

Treatment and Management

In general, treatment of burn injuries consists of initial stabilization, management of secondary effects, and local wound care.[8] Hollywood received initial stabilization by his primary veterinarian, so this was not included in his treatment at MSU-CVM. However, initial stabilization largely involves treatment of burn shock and smoke inhalation. Intravenous fluid

therapy is the mainstay of managing burn shock and mainly includes the administration of large amounts of a balanced electrolyte solution based on the results of serum biochemistry panel or hemogram.[8] The respiratory system should be carefully evaluated to determine if smoke inhalation injury has occurred. Any horse involved in a barn fire or any horse with extensive burn injuries to the face should be assumed to have inhalation injury.[3] Treatment mainstays include maintaining airway patency, oxygen supplementation, and ventilation. Careful monitoring for pneumonia as well as the development of pulmonary edema is essential.[3] Smoke inhalation injury predisposes to the development of pneumonia, but prophylactic antibiotic use is controversial.[3]

After the patient is stabilized, wound care should be initiated. There are many options for burn wound care. Determining burn depth is helpful in establishing healing potential and treatment options. Hollywood was determined to have burns varying from first to third degree, with the most severe wounds affecting his face and dorsum. Burn depth is classified as first, second, third, and fourth degree. First degree burns only involve the superficial layers of the epidermis, are painful, and result in erythema and edema. These burns typically heal without complication because the basal layer is undamaged. Second degree burns are divided into two subcategories: superficial and deep. Superficial second degree burns involve the epidermis and some cells of the basal germinal layer of the epidermis.[3,8] These burns typically heal rapidly, without complication. Deep second degree burns involve all layers of the epidermis and typically require skin grafting to prevent scarring. Third degree burns involve all layers of the epidermis and dermis and loss of adnexal structures. Pain receptors are lost, making it nonpainful at the site of the burn. Complications are common with this degree of burn and include septicemia, bacteremia, burn shock, fluid loss, and eschar formation. Fourth degree burns involve all skin

and muscle layers, as well as the underlying ligaments, fascia, and even bone. Healing occurs by contracture from the wound margins.[3,8]

First degree burns are typically managed with cold water therapy and wound coverings. Second degree burns are best treated with the application of topical antimicrobials, such as silver sulfadiazine cream, to allow eschar formation. Several treatment methods exist for third degree burns including closed, semi-open, and open. The closed technique involves application of sterile dressings that are frequently changed with daily debridement. The closed technique is best for small, focal easily covered wounds and was not a practical option in Hollywood's case. Semi-open method involves the daily application of antimicrobial soaked dressings. The open wound method involves leaving the eschar intact with continual application of topical antimicrobials. The eschar forms a natural bandage of dead skin, collagen, and exudate, but does not protect against bacterial contamination.[2] Based on the severity and extent of Hollywood's skin wounds, treatment via the open wound method was elected. This is the most practical and effective method for large burn wounds like Hollywood's.

Silver sulfadiazine cream is a broad-spectrum water-soluble cream that can penetrate eschar, making it a common choice for use on burn wounds.[2] Application to wounds does not cause significant pain but it must be applied twice daily due to it becoming inactivated by tissue secretions.[2] Systemic antimicrobial therapy is not warranted to prevent wound infection because systemic antimicrobials cannot penetrate the avascular eschar.[3] Other topical antimicrobials commonly used include aloe vera, nitrofurazone, povidone-iodine, gentamicin sulfate ointment, and, more recently, medical grade honey.

Skin grafting can be used to improve healing time and can help relieve pain. Skin grafting promotes angiogenesis at the recipient bed and thus decreases bacterial colonization.[9] Skin

grafting can occur from tissue of the same individual's body (autograft), tissue of another individual's body of the same species (allograft), or tissue from another species (xenograft). Autograft quantity can be limited, especially in severely burned patients with large wounds, but provide the most physiologically normal graft. Autografts are most commonly used in equine practice. Full thickness grafts can be used early in the course of burn healing, whereas split thickness grafts can only be applied once healthy granulation tissue is formed.[2] Skin grafts are gradually reinnervated, and elastin and collagen are slowly replaced by the host.[11] Tilapia skin used as a xenograft dressing has been readily used in human medicine with many studies showing improvement in wound healing, prevention of wound infection, and pain relief. Tilapia skin contains a large amount of type 1 collagen that aids in wound healing. There are many reports of its use in veterinary medicine and the conclusion remains the same: it accelerates wound healing. One study in human medicine concluded that complete reepithelization occurred in fewer days, the need for dressing changes was reduced, and pain intensity lowered.[12] The use of amniotic membrane has also been shown to significantly improve healing time. Amnion is thought to prevent fluid and protein loss and help prevent bacterial contamination.[9] Amnion has a large amount of collagen and fibroblasts, which aids in wound healing. Amnion sheets were attempted to be used several times on the burn wounds on Hollywood's body throughout treatment but keeping them attached proved to be a challenge, so healing potential was never able to be assessed.

Management of pain and pruritis are very important in treatment of the burn patient. Flunixin meglumine and pentoxifylline are commonly used to provide analgesia, decrease inflammation, and improve blood flow to small capillary networks.[2] Dimethylsulfoxide (DMSO) administered intravenously for the first 24 hours has also been thought to decrease inflammation and

pulmonary edema.[2] Pruritis is a common complication within the first several weeks of burn injury. Horses can greatly damage themselves through self-mutilation during this time. It is recommended for horses to be restrained in cross-ties or kept sedated.[8] Resperine at 4-6 mg/500 kg can be used to reduce pruritis, but horses vary greatly in sensitivity to this drug and side effects are common.[8] Medications for sedation can include a combination of a benzodiazepine and gabapentin and should be adjusted according to the patient's response and clinicians experience.

Case Summary

Once daily, Hollywood was gently washed with 0.05% chlorohexidine solution and patted dry. Only water was used around his face and eyes, to prevent chlorohexidine from entering his eyes. Devitalized tissue and eschar were slowly loosened and debrided over several months once daily during the bathing process. Slow removal of the eschar ensures that the germinal tissue layers remain intact.[8] Silver sulfadiazine cream was applied to the open skin wounds and eschar twice daily.

Hollywood was given flunixin meglumine (1.1 mg/kg) intravenously once and started on pentoxifylline (10 mg/kg) orally twice daily. After the initial intravenous dose of flunixin meglumine, Hollywood was changed to oral flunixin meglumine once daily for the next 28 days, as venous access was limited due to the location and severity of his wounds. Within the first 24 hours, Hollywood became pruritic and began to self-mutilate by excessively scratching himself along the stall walls, shavings, and buckets. To achieve mild sedation, he was started on alprazolam (0.032 mg/kg) and gabapentin (20 mg/kg) by mouth every 12 hours. Additionally, it was attempted to keep him distracted by offering flakes of alfalfa hay at frequent, regular

intervals, alternated with small grain offerings. The medications provided adequate sedation and appeared to help resolve Hollywood's pruritis for the time being.

After 16 days of hospitalization, on February 26th, a new topical product was started in addition to silver sulfadiazine cream. Corona ointment was applied to the delicate, pink areas of exposed granulation tissue, while silver sulfadiazine cream was applied to the eschar and open wounds. Corona ointment is composed of 30% lanolin and provides protection and promotes healing of minor wounds. On the same day, sterilized tilapia skin was applied to the deep burn wounds on Hollywood's poll. Hollywood was sedated with detomidine (5 mg) and butorphanol (5 mg) intravenously. The sites were prepped first by gentle cleansing with 0.05% chlorohexidine solution with removal of the remaining eschar. Then the fibrinous tissue was gently debrided with a #20 scalpel blade to promote blood flow. Using aseptic technique, the sterilized tilapia skin was then applied to the debrided areas and secured in place with skin staples. Sterile gauze followed by elasticon bandage were applied over the tilapia skin. Three days later, the tilapia skin was removed and the wounds evaluated. The wounds appeared significantly improved.

On March 13, after 31 days of hospitalization, Hollywood was observed to be unusually uncomfortable, pruritic, shaking his head, and circling in his stall. He was taken for a walk and began thrashing and attempted to roll in the hallway. He was placed back in his stall and appeared to be frequently blinking. His eyes were examined, and the decision was made to increase the alprazolam dose frequency to every 8 hours. Oral flunixin meglumine was changed from once daily to intravenously twice daily for 3 days, then resumed to orally once daily. This seemed to help resolve Hollywood's discomfort. On April 8, flunixin meglumine was discontinued and only used as needed during times of increased discomfort. On day 60 in the

hospital, Hollywood became excessively pruritic again, so diphenhydramine and aloe + lidocaine spay was topically applied every 6 hours for 10 days, then decreased to every 12 hours. This controlled Hollywood's pruritis adequately.

Medical grade honey (Medi Honey) was placed on the open, raw wounds and eschar beginning on April 23, after 72 days of hospitalization. Silver sulfadiazine was discontinued at this time. Corona ointment continued to be applied to the delicate, healed areas. Alprazolam dosage weaning began on April 24, and Hollywood was no longer receiving alprazolam by June 4. The dosage was slowly decreased each week for 6 weeks by approximately 15%. This is because long term use of benzodiazepines, such as alprazolam, may induce physical dependence and abrupt cessation can result seizure activity which can be life threatening. It is recommended to decrease the dose by 25% per week for 1 month for patients who have received a benzodiazepine for longer than a week's duration.[10]

All eschar had loosened and been debrided by May 9, after 88 days of hospitalization. At this point, all wounds appeared to be healing appropriately, but healing of the wounds of the dorsal thoracolumbar region were significantly delayed in comparison. Two days later, on May 11, these wounds underwent debridement in preparation for skin graft procedure. Hollywood was brushed and then bathed with Dermallay oatmeal shampoo in preparation for the procedure. The Medi Honey layer covering the granulation bed was washed off with water and clean pieces of cotton roll. The site was scrubbed with 4% chlorhexidine for 5 minutes. The site was then lavaged with sterile saline solution to remove the chlorhexidine, and it was dried with sterile gauze. The top layer of fibrous granulation tissue was debrided with a #20 scalpel blade and sterile gauze. The site was covered with Adaptic non-adherent dressings that were coated in Unisyn ampicillin/sulbactam powder. The Adaptic layer of dressing was covered with sterile roll.

The sterile roll was then secured with Elastikon and white tape. On May 13, the first skin graft procedure was performed. The donor sites at the distal semimembranosus region on the caudal aspect of the right and left hindlimbs were prepared. The sites were shaved and then were scrubbed with 4% chlorhexidine for 5 minutes. The chlorhexidine was then washed off with sterile gauze soaked with sterile saline. Flunixin meglumine (1.1 mg/kg) was given IV into the jugular vein. Line blocks were performed at the medial, lateral, and proximal borders of each donor site. About 375 mL of mepivacaine was used in total for the blocks at the two donor sites. Using #11 scalpel blades and 14-gauge needles, 3-4 mm in diameter pinch grafts were taken from the most distal aspect of the right hindlimb donor site, working in rows from most distal to proximal. The bevel of the needle was inserted under the subcutis and used to elevate the skin. The elevated section of skin (approximately 3 mm in diameter) was excised with the #11 blade. The pinch grafts were transferred onto a piece of sterile gauze soaked with sterile saline. At the recipient site on the back, # 15 scalpel blades were used to make small pockets 0.5 cm deep in the granulation bed. The pinch grafts were oriented so that hair growth matched hair growth of the back. One pinch graft was placed into each pocket with the hair side facing dorsally/outward. The surgeons worked in rows from the center of the granulation tissue cranially, making pockets and placing grafts. For additional sedation, 6 mg of butorphanol was given, and 10 mg of detomidine, intravenously. The graft site was covered with Adpatic non-adherent dressing coated with Unisyn ampicillin/sulbactam powder. The Adaptic dressing layer was covered with a sterile cotton roll that was folded in half. The sterile cotton roll was held in place with Elastikon. The donor site on the right hindlimb was sprayed with Alushield aerosol bandage spray. Recovery from sedation was uneventful. Hollywood underwent two more grafting procedures of the wounds on his dorsal thoracolumbar region following the steps mentioned above on May 27 and

June 10, with granulation bed preparation occurring 2 days before each of the grafting procedures. Hollywood was prescribed Flunixin meglumine (1.1 mg/kg) orally once per day for three days after each grafting procedure to help with post-operative pain. Bandage changes occurred every other day, with careful attention to avoid incidental removal of the grafts from them sticking to the bandage. Approximately 86% of the grafts from the first procedure remained embedded, 93% of the second graft procedure, and 98% of the third graft procedure.

Hollywood remained on gabapentin and pentoxifylline throughout hospitalization. The gabapentin dosage was slowly decreased beginning June 18 and was discontinued on July 3. Hollywood became more pruritic overnight as a result, but the pruritis subsided after 48 hours. By July 9, Medi Honey application, pentoxifylline, and lidocaine/Benadryl sprays were discontinued. All wounds appeared to be healing appropriately, with no signs of infection. The bandage covering the graft site was removed on July 24 and not replaced. At that time, Hollywood was receiving corona ointment application twice daily to protect and moisturize the delicate skin and all oral medications had been discontinued.

Case Outcome

After 168 days in hospital, Hollywood was discharged on July 28, 2021. He currently resides in South Mississippi, living in a climate-controlled barn during the day and receiving pasture turn-out at night, to avoid sun exposure. Eye lubrication is placed in his eyes every other day and corona ointment placed on his skin as needed. Hollywood luckily made a full recovery, without any major long-term complications and currently has an excellent quality of life. However, he will never be able to be ridden or used for performance and will always have to be protected from sun exposure.

Resources

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