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Full-thickness injury of skin, coronary band, and hoof in a horse; successful treatment by secondary intention healing

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Abstract

One of the main problems in veterinary medicine is wounds and skin injuries. In addition to the high cost of treating skin lesions and the resulting complications in equine medicine, some wounds do not respond well to current treatments and cause pain, higher costs, and even death. Since the knowledge of the natural mechanism of wound healing and the failure of these processes lead to chronic unhealed wounds, efforts are being made to diagnose and treat the cause of these types of wounds with new treatments. A 1-year-old male Mixed-breed foal with a left hind limb deep full-thickness wound involving the skin, coronary band, and hoof wall as a result of traumatic force, was managed through a mixture of kind of treatments such as topical utilization of antimicrobial cream, special bandage, and allowing the wound to heal by the secondary intention healing method. Parallel to topical therapy, systemic antibiotics, and non-steroidal anti-inflammatory drugs were used for seven days. Bandage and topical treatment were changed every four days. After 35 days, no lesions were seen on the affected limb. A significant ability to bear weight was seen in the affected limb without signs of swelling and pain during palpation. It seems that the suggested treatment method used in this case will be suitable for similar cases.

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Introduction

The cost of treating skin wounds in horses is not properly documented, but treating skin wounds is one of the most common complications in equine medicine (Theoret, 2016). According to a report published in the United States, 16-27% of horses under the age of 20 are euthanized due to untreated chronic wounds and injuries (Harman, 2021).

The Skin creates a resistant and protective barrier against pathogens and toxins, in addition to playing an important role in regulating body temperature, preventing dehydration, and creating a sense of touch

(Proksch, 2008). For this reason and since healthy skin is necessary for health, the treatment of skin wounds will be of great importance (Harman, 2021). The stages of full-thickness skin wound healing are much more complex than the description of the four classical stages of wound healing. Each of the four stages of wound healing (homeostasis, inflammation, proliferation, and remodelling) involves interdependent events triggered by skin cells, immune cells, extracellular matrix, cytokines, growth factors, and chemokines released by the surrounding environment (George Broughton, 2006). The process

required for complete wound healing involves a chain of events that begins with wound formation and continues long after wound healing (Xue and Jackson, 2015). The goal in treating human and horse skin wounds is to increase the quality of the wound bed by reducing pathogens, increasing humidity, and increasing or decreasing pressure in that area according to the type of wound (Han and Ceilley, 2017). In equine patients, the anatomical location of the wound is effective in choosing the type of cutaneous treatments. The healing of skin wounds in different areas is formed with different approaches. For example, in the lower neck and trunk areas in horses, it occurs with the contraction of the thin striated muscle that is located under the superficial fascia and brings the edges of the wound together. While in the areas of the face and legs, wound closure occurs with epithelialization and migration of keratinocytes on the granulation tissue (Harman, 2021).

In general, the skin consists of two main layers that protect the underlying structures and organs against mechanical damage and pathogenic factors. The outer epidermis, which is derived from the embryonic ectoderm, is a delicate cell layer and a waterproof barrier against the external environment. The dermis under the epidermis is made up of two structures, the papillary dermis and the reticular dermis. The dermis layer has fibroblast cells that are responsible for the production and regeneration of connective tissue and collagen which cover a large part of the skin tissue. In the dermis layer of the skin, we also see blood and lymph vessels and sweat and sebaceous glands. It should be noted that hair follicles also originate from this layer. In both epidermis and dermis layers, resident and infiltrating immune cells can be found. The lower layer of the dermis is called the hypodermis, which generally consists of connective tissue, fat tissue, and blood vessels. The hypodermis helps to connect the skin to the underlying tissues and also acts as an insulating layer, however, it is not considered part of the skin layers (Harman, 2021).

To achieve successful healing of skin wounds in horses, as in other mammals, coordinated biological events must occur to resolve skin damage. The healing process of skin wounds after full-thickness injuries is divided into four phases (Fig. 1). The intensity and duration of each of these stages vary depending on the animal species, anatomical location, and extent of the wound (Harman, 2021).

In the hemostasis phase, the rapid response to

injury through vasoconstriction and the initiation of the coagulation process leads to the cessation of bleeding and the initiation of the healing process. The next stage, which is the inflammatory stage, is characterized by the presence of immune cells, they control the infection by penetrating the tissue, and then growth factors and cytokines induce the next stage or the proliferation phase with their secretions (Janis, 2010). In the proliferation phase, epithelial cells from the areas surrounding the wound cover the surface of the wound, and also in this phase, tumor necrosis factor-alpha, platelet-derived growth factor, transforming growth factor beta 1, and mechanical stimuli in the wound bed lead to activation skin fibroblasts (Darby, 2014). Activated skin fibroblasts can secrete collagen and other extracellular matrix proteins and may further differentiate into myofibroblasts to aid in wound contraction. In the final stage or remodelling stage, the extracellular matrix proteins are produced and degraded many times until we finally see a regular and coordinated structure (Janis, 2010) (Fig. 1).

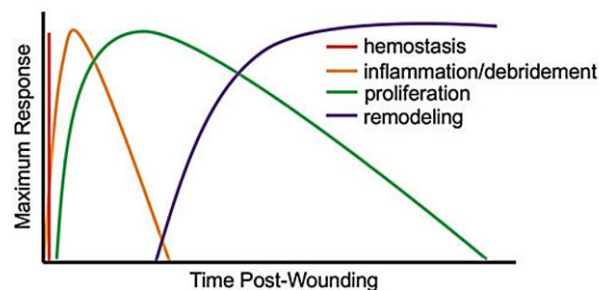


Fig. 1. Stages of wound healing. The wound-healing process in mammals involves overlapping events. Immediately after the injury, the bleeding stops with the activation of the hemostasis mechanism. In the following, we see a severe inflammatory reaction that leads to the elimination of pathogens and the induction of the production of cells needed at the site. The remodelling phase continues even after wound healing (Harman, 2021).

However, in many cases, the stage of regeneration and maturation is not fully formed and the wound has scar tissue and becomes a chronic unhealed wound. Some of the details of the different stages of wound healing were described, but it is clear that each of the four stages of wound healing is not separate from each other and is a continuous process that begins with wound formation and continues long after wound healing (Xue and Jackson, 2015).

To experience a high-quality life, having healthy and undamaged skin on the horse is necessary. A lack of understanding of normal and abnormal skin wound healing processes means that current treatments are inadequate and need to be developed. In addition to the economic cost, this issue imposes many physical complications on the veterinary health system because veterinary patients suffer a lot of pain and suffering due to unhealed wounds. In terms of physiology, the horse is an animal species that can be used as a model to describe the mechanism of wound healing in humans. Increasing research in the basic and clinical sciences in the field of equine skin wound healing is producing data that will increase the level of health in this field in medicine and veterinary medicine (Harman, 2021).

Lacerations of the coronary band are common and occur for a myriad of reasons. The chronicity of the trauma, the amount of tissue lost, and the degree of contamination or infection, will dictate the mode of treatment in each situation (Smyth, 2015). If no vital structures (such as the coffin joint or tendon sheath) are damaged and the coronary band is stabilized, horses with lacerations of the coronary band have a good prognosis for healing and returning to their intended use (Smyth, 2015). Having said that the time required returning to complete soundness may be as long as a year (Smyth, 2015). The purpose of presenting the following case was to suggest our successful experience regarding the treatment of this case.

Case description

A 1-year-old male Mixed-breed foal was referred to the Teaching Hospital of the Faculty of Veterinary Medicine, Amol University of Special Modern Technologies, with a left hindlimb deep full-thickness wound involving the skin, coronary band, and hoof wall as a result of a traumatic force (Fig. 2). The horse could not bear weight on the injured limb. No problems were observed in the general physical examination and examination of the horse's vital and clinical signs. Before the examination, the horse's owner was fully informed about the study and treatment process, and her full consent was obtained.

Following intravenous catheterization and fluid therapy acepromazine (Neurotrang 1%, Alfasan, Woerden, Holland) (0.05 mg/kg intravenous) and xylazine (as HCL 2%, Alfasan, Woerden, Holland) (1 mg/kg intravenous) has been used. After sedation, the lesion was prepared aseptically and was lavaged

copiously through the wound with normal saline and povidone-iodine 10% (NAJO 10% 250 ML. Tehran. Iran) to remove all debris (applied 12 ml syringe with 22 g needle). An inspection was carried out to cauterize the vein that makes bleeding (Electrosurgery, ERBE, T175E, Germany). Then, the skin was sutured with nylon (size: 2USP) suture in a simple interrupted pattern on day 0 after injury (Fig. 3). After suturing oxytetracycline spray was applied, and the wound was bandaged with a vet-wrap (Fig. 4).

The horse received no further medical treatment until the third day when the dressing was removed for examination. Unfortunately, the result was catastrophic; because in addition to the non-healing of the wound, we saw purulent secretions at the wound site. So, we decided to improve the treatment procedure to secondary intention healing. For this purpose, some simple interrupted suture (Nylon, size: 2USP) was applied only to keep loosely close and hold of the wound edges (Fig. 5). This technique prevented the hoof from breaking and separating.



Fig. 2. Wound on the coronary strip (The initial clinical sign is usually that of a haemorrhage with obvious tissue loss accompanied by a varying degree of lameness).



Fig. 3. Place simple interrupted pattern suture (day 0).



Fig. 4. Place vet-wrap bandage (day 0).



Fig. 5. Place lose suture to support the wound edge and start the secondary intention healing procedure (day 3).

Before dressing the wound silver sulfadiazine cream (1%, Sobhan Darou, Rasht, Iran) was applied to the wound surface, abundantly. The first layer of dressing was a sterile tampon. The second and third layers were respectively vibril, and a vet-wrap bandage (Fig. 6). This process was repeated every four days until day 35. Parallel to topical treatment, systemic antibiotics, and non-steroidal anti-inflammatory drugs (NSAIDs) were utilized. As an antibiotic the pen-strep (100 ml, Norbrook, Irland) along with gentamicin (80 ml, Sina Daru, Tehran, Iran), and as an NSAID, flunixin meglumine (50 ML, Razak, Tehran, Iran) was used for one week.



Fig. 6. Used topical treatment and bandage to accelerate the secondary intention healing.

Results

As seen in Fig. 7 after 35 days, no lesions were seen on the hoof and coronary band. A significant ability to bear weight was seen in the affected limb without signs of swelling and pain during palpation. During the visual examination, no obvious lameness was observed. The horse's owner was instructed to keep it in a confined space for at least two months and plan a short daily walk for this case.



Fig. 7. Wound healing process in days A: 7, B: 11, C: 15, D: 19, E: 23, F: 27, G: 31, and H: 35.

Discussion

Skin ulcers are known as the second most common emergency complication in equine medicine. The types of treatment can be different and controversial due to the variety in the location, severity, and shape of the wound, as well as the lack of evidence regarding the best treatment methods (Freeman, 2021).

Repairing a damaged hoof wall in a horse's locomotor system is similar to the repair of other skin wounds in other areas. That is, partial-thickness

injuries primarily heal by epithelialization, whereas full-thickness injuries follow the four classical steps of inflammation, debridement, repair, and maturation (Parks, 2008).

During the treatment, the goal is to improve the quality of the damaged tissues and improve their performance during the healing process. The practical treatment of these wounds in terms of bandaging, the use of systemic antibiotics, and topical antibiotics or antiseptics follow the same guidelines used to treat other limb wounds in horses, (Parks, 2008) which was

done in the same way in the present study. Horses are skilled athletes and natural runners, with hearts that can beat anywhere from 16 beats per minute to about 240 beats per minute. Compared to humans, this amazing power in horses causes the spleen to contract and red blood cells enter the blood circulation, which increases the oxygen-carrying capacity of the blood (Harman, 2021). Considering this capacity in horses, we strongly suggest the use of vet-wrap bandages because we should not worry about reducing the oxygen level in the wound tissue. For this reason, one of the advantages of the treatment method of the present study was the use of a vet-wrap bandage that did not need to change it in the short term.

For lavage, there was no evidence of the effectiveness of tap water vs saline in equine wounds. Tap water should be considered for the lavage of equine wounds rather than sterile saline, based on strong evidence in the human literature; the use of povidone-iodine may be beneficial for contaminated wounds (Freeman, 2021). In line with this, we also used povidone-iodine to lavage the infected wound. Based on the human literature, a pressure of 13 psi (12 ml syringe with 22 g needle) is effective at reducing infection and inflammation in lacerations and traumatic wounds (Freeman, 2021).

Silver sulfadiazine reduces the microbial load in wounds, but has limited or no effect on the rate or quality of wound healing in horses (Freeman, 2021). One study suggested that silver sulfadiazine may not be suitable for use in acute skin wounds due to its cytotoxicity. At the same time, there is not enough evidence that silver sulfadiazine is not suitable for the treatment of chronically infected wounds (Freeman, 2021). Since silver sulfadiazine is mostly used in veterinary medicine, more studies are needed in this field. Although there is no control group in this case report, considering the chronic nature of the wound maybe it can be said that silver sulfadiazine along with other therapeutic agents lead to improvement.

There is currently insufficient evidence to determine if the use of staples compared to sutures affects the likelihood of wound infection (Freeman, 2021). Therefore, according to the availability and efficiency of the suture, we suggest it in such cases. The choice of the type of suture used depends on various aspects such as the elasticity of the skin in the area, the cost of consumables, and the time of surgery.

Several treatments have been tried for hoof and coronal band injuries in horses for example Smyth T et

al in 2015 showed that the coronary band grafting was unsuccessful (Smyth, 2015). Therefore, it seems that the treatment method proposed in this study is very practical at the same time.

It is recommended to take radiographs to determine damage to internal structures such as the navicular bone, and distal phalanx and maintain the alignment of the phalanxes (Parks, 2008). However, due to the lack of access to X-rays in field conditions, this was not possible in this case.

Considering the importance of locomotor organs in horses and also the importance of successful treatment of acute and chronic wounds in these organs, it seems that the treatment performed in the present study was practical, useful, and economical at the same traumatic injuries, and the result was also very satisfactory.

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Conflict of Interest

None of the authors has any financial or personal relationships that could inappropriately influence or bias the paper's content.

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