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Published in:
Journal of Equine Veterinary Science

DOI:
10.1016/j.jevs.2021.103725

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

Link to publication

Citation for pulished version (HARVARD):
Launois, T, Moor, PL, Berthier, A, Merlin, N, Rieu, F, Schlotterer, C, Siegel, A, Fruit, G, Dugdale, A & Vandeweerd, JM 2021, 'Use of Negative Pressure Wound Therapy in the Treatment of Limb Wounds: A Case Series of 42 Horses', *Journal of Equine Veterinary Science*, vol. 106, 103725. https://doi.org/10.1016/j.jevs.2021.103725

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Download date: 26. oct.. 2022

Journal of Equine Veterinary Science 106 (2021) 103725

Contents lists available at ScienceDirect

Journal of Equine Veterinary Science

journal homepage: www.j-evs.com

Original Study

Use of Negative Pressure Wound Therapy in the Treatment of Limb Wounds: A Case Series of 42 Horses

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ARTICLE INFO

Article history:
Received 12 March 2021
Received in revised form 27 July 2021
Accepted 28 July 2021
Available online 31 July 2021

Keywords:
Negative pressure wound therapy
Wound care
VAC therapy system
Vacuum-assisted closure

ABSTRACT

Traumatic limb injuries are common in horses. Negative pressure wound therapy (NPWT) has been proven to promote wound healing in human medicine. It has also been described for the treatment of wounds in horses. In this retrospective study, clinical records of 42 (n = 42) animals were assessed. Categories of wounds, duration of NPWT application, frequency of resetting the NPWT device, technical complications, and tolerance to the procedure were recorded. 42 wounds were classified as bony (n = 15; 36 %), articular (n = 14; 33 %), tenosynovial (n = 9; 21%), muscular (n = 2; 5%) and cutaneous (n = 2; 5 %). NPWT was used to help (1) first intention healing by preoperative (n = 3; 7 %) or postoperative (n = 7; 17%) application, (2) second intention healing (n = 31; 74%), and (3) delayed primary closure (n = 1; 2%). Duration of NPWT application ranged from 2 to 36 days (mean 11.5), with the system staying in place for periods ranging from 1 to 7 days (mean 4.5). In 69% (n = 29) of the cases, healing was considered satisfactory at discharge. 26 % (n = 11) of horses were discharged whilst ideally NPWT should have been continued. 2 animals (n = 2; 5%) were euthanized after surgery due to unrelenting pain. The procedure was well tolerated except in 1 horse who showed signs of discomfort at the first application. This study demonstrated that NPWT with long periods of application can be used successfully to manage various types of limb wounds.

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1. Introduction

Traumatic injuries are common in horses and can result in extensive soft tissue deficits. Primary or delayed-primary closure is not always possible or can fail, and the wound must heal by second intention [1]. Wound healing can be a lengthy process of several weeks, especially with large wounds, and healing can be unsatisfactory with the development of exuberant granulation tissue, dense fibrogranuloma or scars.

Negative pressure wound therapy (NPWT) has been used in human surgery and refers to the application of sub-atmospheric pressure (around 125 mmHg) to the wound either continuously or intermittently. Reported beneficial effects of the technique include removal of exudate, increase in local tissue blood flow, reduction in local edema, faster granulation tissue formation, and reduction in the number of bacteria in the wound [2]. NPWT would also induce an anti-inflammatory cytokine profile in the wound bed combined with signaling effects on angiogenesis, remodeling of the extracellular matrix, and granulation tissue formation [3].

The use of NPWT in the horse has been described in a limited number of cases. The technique was first described in extensive wounds of the neck in a horse and reported to be successful with fast healing and no signs of infection [4]. It was used for skin wounds in combination with the Meek micrografting method in 2 horses [5], and with the punch graft method in 1 horse [6]. It was also used to manage a chronic distal limb wound and control exuberant granulation tissue [7], and in association with arthroscopic lavage, surgical debridement, and ultrasound assisted wound therapy, to treat a chronic septic osteoarthritis of the antebrachiocarpal joint [8]. NPWT was successful and well tolerated in three cases of open and infected subcutaneous olecranon bursa [9].

Conflicts of Interest Stetment: None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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https://doi.org/10.1016/j.jevs.2021.103725
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Table 1
Categories of wounds.

Category	Definition
Bony	Full thickness skin wound; bone underneath is visible; tendon and ligament may be involved; muscle and synovial structure are not involved
Articular	Wound with penetration of 1 or more articular synovial cavity; no tendon, ligament, muscle, sheath or bursa is involved
Muscular	Skin and muscle laceration; no joint, tendon, ligament, sheath or bursa is involved
Tenosynovial	Wound with penetration of a tendon sheath or a bursa
Cutaneous	Skin only is lacerated without penetration of adjacent structures

Table 2
Types of use of NPWT.

First intention healing	Healing that occurs when a clean laceration or a surgical incision is closed primarily with sutures, Steri-Strips, or skin adhesive.
Second intention healing	Healing that occurs when a wound is left open to heal by granulation, contraction, and epithelialization
Delayed primary closure	Delayed primary closure is a combination of healing by primary and secondary intention. The wound is first cleaned and observed for a few days to ensure no infection is present before it is surgically closed.

2 congress abstracts reported the results of experimental studies in horses. A controlled trial in 15 horses assessed the applicability and efficacy of NPWT in the management of surgical wounds after median laparotomy. Though easy to apply, the technique did not reduce the number of wound complications. Grades for edema and exudate, and size of wound dehiscence, was similar in treatment and control groups [10]. In addition, a randomized experimental study showed that there was no effect of NPWT in the late phase of healing on the dimensions of wounds surgically created on the dorsal aspect of the metacarpal regions; furthermore, no significant difference in bacterial load and local blood flow could be identified between groups [11].

Though case reports demonstrate the feasibility of the technique, it is sometimes stated that the cumbersome design of classic NPWT devices renders them inconvenient for equine practice. Recently a new minimalist lightweight, portable(canister-free) and disposable unit of NPWT, was assessed. The authors concluded that all horses readily tolerated the system but difficulties with adhesion and seal prevented the completion of the experimental wound study despite the use of many adjunctive adhesives [12].

We have been using NPWT for several years and developed technical strategies to improve adhesion and sealing. The objective of the current study was to demonstrate that NPWT can be used to help first, second and third intention healing of limb wounds. We hypothesized also that NPWT could be applied for longer periods than 3 to 4 days successively.

2. Material and Methods

A retrospective review of all medical records of horses treated with NPWT between October 2012 and August 2020 was conducted at our equine hospital. Wounds and use of NPWT were classified in categories described respectively in (Table 1) and in (Table 2).

Total duration of NPWT application, frequency of resetting the NPWT device and duration of periods of application, technical complications, and tolerance to the procedure were recorded. Classically, to apply NPWT (Fig.1), after clipping, the skin was shaved to remove small hairs. The surrounding skin was carefully cleaned with povidone iodine soap. After conventional asepsis with povidone iodine, sterile open-cell foam cut to fit the wound dimensions was packed into the wound. Polyurethane foam was used to improve debridement and drainage (due to larger pores, this foam would stick to tissue and both improve abrasion at removal and increase drainage). Polyvinyl alcohol foam was selected if existing granulating tissue should be preserved. The skin was dried with swabs. The barrier drape provided by the manufacturer was applied; an adhesive spray was used to enhance stickiness. An evacuation tube was seated into the foam dressing. The proximal end of the tube was connected to a drainage tube. Then, importantly, the foam and barrier drape were covered by several layers of waterproof 32 cm wide proprietary cellophane (ALBAL film fraîcheur, ALBAL) which formed an airtight seal with the skin at the wound margins. Cotton wool and elastic bandages (elastoplast) were then used to cover the limb, improve sealing and maintain the tube.

The draining tube was connected to spiral tubing using rotating adaptors (swivel connector) to prevent tangling of lines, directed via the ceiling towards the pump (VAC, KCI Medical B.V.) that provided 125 mmHg of continuous negative pressure. Horses were cross tied with 2 ropes. This system restrained the horse in a standing position with some lateral mobility. Once the vacuum was switched on, the air was sucked out of the foam causing it to collapse inwards. The canister was attached in an upright position. Horses treated by secondary intention were not administered antibiotics, whilst those treated by first and third intention were treated with antibiotics according to bacteriologic investigations and response to treatment.

3. Results

42 (n = 42) horses were treated with NPWT during the study period (25 Selle Français, 4 Thoroughbreds, 4 Hanoverians, 2 Standardbreds, 2 Arabs, 2 Quarter Horses, 2 Belgian Warmbloods and 1 Percheron). There were 24 mares, 14 geldings, 4 stallions. The average age was eight years (ranging from 1 to 25 years), and the average weight was 533 kg (ranging from 460 kg to 850 kg).

The wounds were classified as bony (n = 15; 36 %), articular (n = 14; 33 %), tenosynovial (n = 9; 21%), muscular (n = 2; 5%) and cutaneous (n = 2; 5 %). NPWT was used to help second intention healing (n = 31; 74%), first intention healing by preoperative (n = 3; 7 %) or postoperative (n = 7; 17%) application, and primary delayed closure (n = 1; 2%).

All bony wounds (10 (n = 10) at the metacarpus/metatarsus, 4 (n = 4) at the tarsus and 1 (n = 1) at the carpus), the2 (n = 2) muscular wounds (antebrachial region) and the (n = 1) cutaneous wound of the interphalangeal region were managed by second intention. It was also the case for 8 (n = 8) articular (3 (n = 3) tarsal, 2 (n = 2) metacarpo-phalangeal, 2 (n = 2) proximal interphalangeal, and 1 (n = 1) carpal joints) and 5 (n = 5) tenosynovial (1 (n = 1) calcaneal bursa, and 4 (n = 4) digital sheaths) wounds.

NPWT was applied postoperatively to help healing after surgical debridement and suturing, aiming for first intention healing, in 1 (n = 1) cutaneous (metacarpo-phalangeal region), 4 articular (2 (n = 2) distal-interphalangeal, 1 (n = 1) metacarpo-phalangeal and 1 (n = 1) tarsal joints) and 2 tenosynovial (1 (n = 1) digital and 1 (n = 1) tarsal sheaths) wounds. The objective was to reduce swelling and postoperative dehiscence, and to improve drainage when the wound was deliberately partly left open distally. It was applied preoperatively (2 days) to reduce swelling in

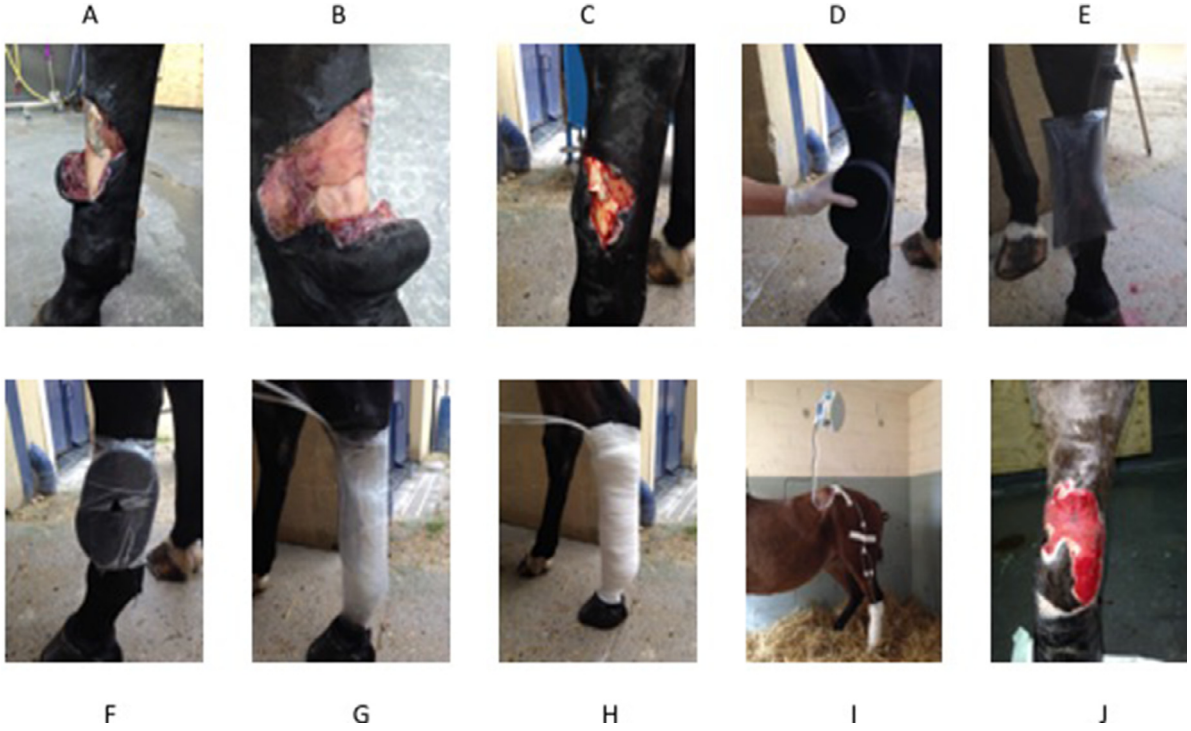

Fig. 1. To illustrate the technique, we present a case of use of NPWT to assist second intention healing of an extensive and contaminated wound of the metatarsal region. (A). Wound when the horse presented at the clinic 24 hours after he sustained the injury and after the application of a bandage soaked with 10 % NaCl. (B). Wound after another 24 hour application of a bandage with 10 % NaCl. (C). Local anesthesia is performed and the wound is surgically debrided. (D). The wound and its periphery are dried with sterile swabs and polyurethane foam applied to cover the entire wound. (E). 2 polyurethane foams are necessary to cover the entire wound. (F). The barrier drape is applied and the suction tube is sealed in the foam. (G). The foam is wrapped with proprietary cellophane to facilitate air tight sealing. (H). Bandage is used to secure the system around the limb. (I). The horse is cross tied. (J). Wound when the horse was discharged 28 days later. This wound would benefit from a graft or other plastic procedure, but this was not performed for cost reasons. It was managed subsequently by owners by conventional bandage changes

2 (n = 2) articular (metacarpo-phalangeal joint) wounds and 1 (n = 1) tenosynovial (digital sheath) wound.

NPWT was used for 4 days to improve granulation tissue before suturing (delayed primary closure) in 1 tenosynovial wound of the digital sheath.

Total duration of NPWT application ranged from 2 to 36 days (mean 11.5), with the system staying in place for periods ranging from 1 to 7 days (mean 4.5). In 69% (n = 29) of the cases, healing was considered satisfactory at discharge. 26 % (n = 11) of horses were discharged, for economic reasons, whilst ideally NPWT should have been continued. 2 animals (n = 2; 5 %) (1, a metacarpo-phalangeal wound in the 'articular' category, and the other, a digital tendon sheath injury in the 'tenosynovial' category) were euthanized after surgery due to unrelenting pain. No clinical complications occurred in the other horses.

All applications of the system were well tolerated, except in 1 horse (category 'articular', fetlock wound) which jumped forward through the ropes shortly after the application of the NPWT system. In two cases, exudate was foamy and blocked the tubing 3 times successively. Using the alternate mode of the pump and adequate cleaning of the tubing machine solved the problem.

Cross-tie was used to restrict movement to limit the risk of loss of sealing of the device to the limb. 2 ropes were connected to the halter, not on the noseband but at the rings behind the eyes so that more movement of the head was possible. Horses had access to water and hay at the door of their stable. Only 1 horse seemed to be nervous the first 2 days of application and needed repeated sedation.

3.1. Discussion

This study described the useful application and tolerance of NPWT in a large case series of limb wounds in horses. Wounds of the limb are especially at risk of involving a synovial structure (joint, tendon sheath, or bursa) and when they communicate with a synovial cavity can result in synovial infection, which may lead to permanent impaired function. This study demonstrated that NPWT is feasible in horses and has several possible applications in different types of limb wounds and different types of healing. Not only for conventional second intention healing, but also in association with surgery to obtain first intention healing, either by preoperative or postoperative application. NPWT can also be used to improve granulation before surgery for third intention healing. The current study showed that it can also be used to treat articular and tenosynovial wounds with success either by first, second or third intention healing.

Duration of NPWT application ranged from 2 to 36 days. Decision for discharge was based on a compromise between economic reasons raised by the owners (costs) and characteristics of the wound (healthy granulation bed). Therefore, epithelialization was not always present at discharge, but it did not seem to impact further healing of the wound. Owners seemed to be able to follow recommendations and to manage the post NPWT treatment at home. This is in accordance with a previous study that demonstrated that NPWT is useful in the early period of treatment but not in the late period after treatment [11].

In addition, the use of NPWT therapy was most often very well tolerated with no signs of discomfort or pain. Discomfort has been observed in human subjects with NPWT inconsistently [13,14]. In the cases described in previously published veterinary literature,

NPWT has been used at a pressure ranging from 50 to 125 mmHg [4-9]. It was well tolerated in most horses.

With the technique used in the current study, there were no major technical issues. It is important to obtain a good sealing of the system to the wound and its margins [9,12]. Shaving the skin to remove small hairs in addition to clipping, careful cleaning of the surrounding skin, drying the skin, application of an adhesive spray to enhance adhesiveness, complete coverage by adhesive spray on the surrounding skin as well as allowing time for the spray to air- dry prior to application of the adhesive drape have been perceived to be important to obtain a long-lasting seal. The current study showed that culinary cellophane can be very useful, by perfectly sealing the wound and creating an effective vacuum. While it might be apprehended that layers of cellophane film and surrounding bandages would create compression of the soft tissues and potential necrosis, this never occurred, probably because of the anti-edematous effect of the NPWT. Rarely, foamy exudate can occur and block the tubes; this can be solved by turning the system into its pulsatile mode.

Costs associated with NPWT are presumed to be high: equipment, drugs, dressings, work by staff members and length of hospitalization. But, where conventional wound management is centered on numerous dressing changes, NPWT demands less frequent dressing changes. Currently, there are no real recommendations for horses as to the duration of NPWT or the possible or desired time if a second application is necessary [12]. Interestingly, the current study showed that NPWT can be left in place for periods ranging from 1 to 7 days (mean 4.5) before resetting the system. A further study to compare cost and healing time between traditional dressings and NPWT therapy would be warranted.

We speculate that another benefit of NPWT could be its role in limiting nosocomial infection. In man, surgical site infection accounts for 15% of all nosocomial infections and, among surgical patients, represents the most common nosocomial infection [15]. There are indications that the environment is frequently contaminated during wound dressing change: 38% of the environmental samples (air and surfaces) that were obtained in the rooms of patients were positive in a research study [16]. 1 possible advantage of NPWT would be the reduction of the frequency of bandage changes and wound cleaning. NPWT therapy would seal the wound, prevent it from being infected by the external bacteria, and would limit external contamination.

Different types of foam can be used and are sometimes reported to have different antibacterial effects. A study compared three foams (silver-impregnated polyurethane foam, polyurethane foam, and polyvinyl alcohol foam) in an ex vivo equine perfused wound model [17]. Results indicated that wounds treated with polyvinyl alcohol had the greatest decrease in bacterial load; however, the authors indicated that the effect of that treatment on wound healing needed to be assessed in vivo.

4. Conclusions

The current study demonstrated that NPWT can be applied safely for more than 4 or 5 days and is well tolerated to manage various types of limb wounds. Further studies are necessary to determine its optimal time (with respect to wound age), and duration of application and to assess whether the use of NPWT could limit nosocomial infections, time spent at bandaging and cost by decreasing wound manipulation.

Ethical Statement

Use of negative pressure wound therapy in the treatment of limb wounds: a case series of 42 horses. This study is a descriptive study of clinical cases. No animals have been used for experimentation.

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