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In the Field Equine Wound Management Part II

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This is part II of equine wound management, where wound closure and further management will be discussed.

Types of closure

First intention primary closure

Suited to fresh wounds with minimal contamination or tissue loss. Care must be taken to follow Halstead's principles. Haemostasis, gentle and accurate anatomic dissection, debridement, dead space closure and minimal wound tension, are the main factors in successful surgery of wounds. Debridement is the first stage of surgical wound treatment, where the majority of devitalised tissue and bacterial load is removed. Soil and other foreign material dramatically increase the chances of wound infection; it has to be removed, even if embedded in vital structures.

Picture 1. A heavily contaminated wound that will require debridement and cleaning before any attempt at closure is made.

First intention healing is the ideal scenario, but not always possible. It is often attempted, and we end up with a combination of primary and secondary healing.

• Minimal bacterial contamination
• All devitalised tissue, foreign bodies and blood clots have been removed
• There is no dead space, haematomas or areas of ischaemia
• Need precise realignment of tissue edges

Table 1. Conditions required for primary closure to be considered possible

Wherever practical, fresh wounds in the distal limb are best managed by primary closure because second intention healing is poor in horses compared to ponies, resulting in large slow healing granulating wounds. Clients should be warned about the significant risk of wound breakdown and high costs of managing open wounds in the distal limb. Avoiding excess skin tension and minimising movement is the key to success, failure commonly occurs due to these two factors.

Delayed primary closure

Contaminated/infected wounds, or wounds with large tissue deficits can be cleaned up and debrided and managed until there is no longer necrotic tissue present. Once healthy granulation tissue is developing this can be trimmed to form fresh apposable edges and the wound then closed. This is a useful technique for heel bulb lacerations.

Second intention healing

This occurs when a wound cannot heal by primary closure. This may be due to:

- Infection
- Severe soft tissue damage
- Large skin deficits

After initial cleaning and evaluation, the wound is left to heal by the normal physiological process of granulation, epithelialisation and wound contraction. Wounds with severe skin deficits and tension have no choice but to heal by second intention.

These cases require regular wound management, dressings and bandage care.

Picture 2. This series demonstrates a large dorsal carpal wound with extensive soft tissue damage and intercarpal joint involvement. Following surgical debridement (including removal of the large devitalised non-viable skin flap) and synovial lavage, the wound was managed to optimise granulation, epithelialisation and wound contraction.

Picture 3. The wound at its final stage of healing

Picture 4. Large limb wounds require time, patience and meticulous bandage care. Immobilisation is a vital part of successfully obtaining a healthy granulation bed from which healing can progress.

Wound infection

Infection will prevent healing and will induce pain, swelling and lameness. Thinking was that $>10^5$ counts of bacteria per gram of tissue will cause a wound to be infected, but it is better to consider a wound infected once the hosts immune response has been triggered. The 'golden period' is often discussed and thought to be 3-5 hours. In practice this time has often passed before the vet see's the wound. Flushing and debridement will reduce the bacterial load. The use of systemic antimicrobials should also be considered. This is where you need knowledge of the potential bacteria involved and their antimicrobial sensitivities to make an educated decision in what antimicrobials to use. Gram-positive bacteria are the most common skin commensals, but many wounds are heavily contaminated by organic matter such as soil, faeces and sand, bringing along with them gram-negative bacteria and a whole range of other pathogens. It must be stressed that the use of antimicrobials is NOT a replacement for good wound cleaning, debridement and management. Chronically infected wounds will not progress through the normal steps of healing. Bacteria have several ways in which they can induce persistent infections. In human studies, *S. aureus* and *E. coli* have been reported to act via specific adherence proteins to suppress the influx of inflammatory cells and to enhance bacterial attachment to human cells, respectively. *Pseudomonas aeruginosa* has been widely reported as an opportunistic wound pathogen in human studies. By residing deep within the wound *P. aeruginosa* manages to keep the wound in a prolonged inflammatory state. Synergistic interaction between bacteria can result in an increased pathogenicity of both organisms.

Chronic, non-healing wounds may result from bacteria that survive within an antimicrobial "barrier", a 'biofilm'. These are diverse, dynamic, and unique, reflecting their local environment and inhabiting species. Single species bacteria can form biofilms. More commonly, biofilms result from combinations of multiple species of aerobes and anaerobes that interact via intra-cellular communication. Biofilms have been reported to exist deep in the wound bed, which significantly prevents their isolation and identification. Some biofilms are naturally beneficial, unwanted biofilms have been linked to a number of human disorders including cystic fibrosis, endocarditis, catheter-related infections, surgical site infections, and chronic wounds. The latter include pressure sores, diabetic ulcers, venous ulcers, and ulcers secondary to ischaemia. These human wounds share certain common characteristics with chronic equine wounds. Like the human wounds, equine wounds have shown evidence of biofilms. Treatment focuses around the removal of the infecting biofilm.

March 2019

Primary closure can then be reconsidered if, following removal of the biofilm, vascular supply and healthy tissue are plentiful. Currently, the most effective management of a wound that is complicated by biofilm formation involves sharp surgical debridement of the biofilm and its inhabiting bacteria. Topical treatment without debridement may not adequately remove a biofilm. Following removal topical antimicrobials can be applied to the wound to prevent bacterial re-attachment and limit the extent of re-infection.

To suture or not?

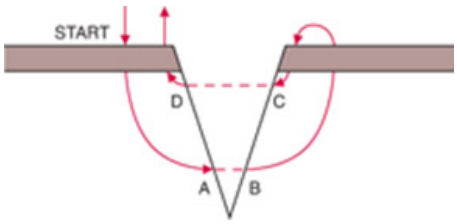
Many factors need to be considered, including location and depth of wound, degree of contamination/ infection, structures involved.

Wounds to the body are often best left unsutured. Due to the nature of how wounds heal on distal limbs, it is always tempting to attempt primary closure on distal limb wounds. The site should be accessible (general anaesthesia may be necessary). There should be little or no gross contamination (i.e. early or clean). Blood supply should be intact (beware horizontal wounds, proximally pointing flaps, excessive oedematous swelling or severe contusions). Skin should be readily available to suture the lacerations. The process should be simple (i.e. no involvement of tendons, ligaments, joints etc). Large skin flaps can be sutured, but will often break down, but by replacing the flap it does provide an initial protective layer for the tissue to heal underneath. It can be cheaper and simpler to remove the flap. Leaving devitalised skin *in situ* may promote infection. Attempting to reduce the area of a wound by placing sutures under tension are likely to fail, possibly at the expense of further trauma to the epithelialising margins.

In clean fresh body wounds, subcutaneous dead space should be minimised using a simple continuous pattern with 3 metric absorbable material. Skin is closed using simple interrupted sutures with 3.5 metric monofilament suture. In contaminated wounds, subcutaneous sutures increase the risk of infection, as the sutures are seen as foreign.

Skin should never be sutured under high tension. The more vertical a leg wound, the less tension there will be as the horse moves. Staples are only useful in areas of no tension. Ideally skin is sutured under moderate tension, reducing the open wound area but without placing undue tension on the edge. The remaining open wound heals by second intention. Moderate tension can be managed using a small number of vertical mattress sutures placed approximately 1 cm away from the wound edge.

These can be threaded through 1cm sections of drip tubing to further spread tension. The wound edges can then be sutured normally. Several surgical techniques are described to reduce skin tension at the wound edge and facilitate primary closure, *e.g.* parallel stab incisions, Z and H plasty, but it is often best to keeps thing simple.



vertical mattress suture

Drains

Drains allow continued debridement through the discharge of cellular debris, preventing seroma formation within tissue plains. Considered for any open contaminated wound, especially where dead space is encountered during treatment, they are normally left in place for 2 to 4 days, after which they can stimulate a foreign body response, manifesting as an increase in discharge after initial decrease. They provide a direct route for invading bacteria, so should be covered wherever possible. Penrose drains are used most commonly. Closed suction drains are useful and are superior to the former in removing exudate. Drains should enter/exit wound spaces through separate portals, one of which should be placed from the most dependent part of the wound.

Dressings

There are many different types of dressings available. The type of dressing required should change as the wound changes. Covering wounds can reduce oxygen supply, but the benefits outweigh the negatives. They provide protection from further trauma and contamination, provide pressure to minimise fluid build-up and swelling, provide immobilisation which in turn provides pain relief and the increased temperature and localised build-up of carbon dioxide decrease pH which enhances oxygen release from haemoglobin.

The bandage is divided into primary, secondary and tertiary layers, the primary layer being directly in contact with the wound. Primary dressings can be divided into occlusive/non-occlusive, adherent/non-adherent, passive/biologically active and interactive dressings. Non-adherent dressings can be occlusive, semi-occlusive or biologically active. Due to the continually changing nature of the wound it is best to think of how the dressings can help the wound heal:

- debridement dressings to rid infection
- moistening dressings to moisten the wound
- granulation and wound contraction dressings to encourage early stages of healing
- epithelialisation dressings that encourage skin formation.

Most newer dressings create a moist healing environment allowing wound fluids and growth factors to remain in contact with the wound, promoting autolytic debridement. The idea that a wound kept moist will heal more quickly with fewer dressing changes when compared to a wound that is left exposed to the air and allowed to dry out is becoming more and more popular. In most circumstances, the wound area discharges exudate, which contains substances that help the horse's body fight infection supporting the growth of healthy tissue. When a wound is kept moist, this allows exudate to help support an environment that stimulates healing. Clinical studies have shown that wounds kept in a moist environment have lower infection rates than wounds treated with agents that tend to dry the wound.

Debridement. The simplest adherent dressing is a gauze swab which may be useful in wounds from which heavy exudation is anticipated. Exudate flows into the dressing. Necrotic debris sticks to it, allowing removal when the dressing is peeled off. Unfortunately, layers of newly forming cells are also removed which is why such dressings are only indicated in the early, exudative, debridement phase of wound healing. Aqueous solutions of antibacterials (e.g. crystalline penicillin, metronidazole) can be used to moisten gauze swabs and facilitate the flow of exudate into the absorbent layers of the bandage. 'Intrasite' gel or silver based creams ('Flamazine', 'Silbecor') can also be used to great effect. Where there is heavily infected tissue that's requires debridement, hypertonic saline may be used to soak the gauze swabs to kill bacteria and remove the necrotic tissue. These dressings can be traumatic to the wound, only being used whilst there is dead or infected tissue around that needs removing. 'Melolin' dressings are semi-occlusive non-adherent dressings which allow exudate to flow away from the wound, yet they maintain a moist environment. These are particularly useful during the reparative phase. Petrolatum impregnated gauze dressings ('Jelonet') can inhibit epithelialisation so should be limited to the early phase of healing in exudative wounds. For large wounds with large amounts of exudate the use of sterilised disposable nappies can be especially useful. 'Allevyn' is a non-adherent hydrophilic dressing that allows absorption of wound exudate, whilst maintaining a moist healing environment. 'Ligasano' claims to absorb exudate, maintain a moist healing environment, reduce bacterial colonisation and promote granulation and epithelialisation.

Moistening dressings are used in wounds that have dried out. These dressings supply moisture to the wound through a mixture of water and glycerin. They are effective in providing moisture in dry wounds. They completely seal the wound and so should only be used in dry wounds. Once the wound has been moistened, they should be discontinued in favour of a different type of dressing.

Granulation and wound contraction dressings are used to encourage healing granulation tissue formation, and to stimulate the wound to close. A good example of this type of dressing is the calcium alginate dressings ('kaltostat', 'c stat'). These dressings are made from a derivative of seaweed creating a mild inflammatory response, sending infection fighting cells to the area that will encourage a healthy bed of granulation tissue. Once the wound

has enough granulation tissue present, they should be discontinued in favour of an epithelialisation dressing.

They can also 'kick start' chronic non-healing wounds by activating the healing cascade.

Epithelialisation dressings are designed to help normal healthy skin tissues form over the wound. These dressings increase the surface temperature of the wound by 1-2 degrees, encouraging the skin cells to migrate across the wound.

Occlusive dressings stick to the surrounding skin-usually badly in horses due to the hair. They are available as hydrogels, hydrocolloids and silicone dressings ('nu-gel', 'tegaderm', 'solugel', 'carravet').

Antimicrobial impregnated dressing should be considered for heavily contaminated/ infected wounds and wounds over open synovial cavities.

Tips
Use adherent, hydrophilic and antimicrobial impregnated dressings for heavily contaminated/infected exudative wounds in the initial phases. Stop with these dressings once a healthy bed of granulation tissue has formed.
Use gauze swabs to pack undermined tissue and close dead space.
Use alginate dressings to kick-start chronic non-healing wounds.
Use acemannan products ('Carravet') to promote granulation in areas of large tissue deficits or where bone is exposed.
Use semi-occlusive dressings once the healthy granulation bed is present.

Topical agents

Often, 'less is more'. Scarlet oil, aloe vera, sugar, honey, gentian violet spray, aluminium spray, vitamin E, live yeast cell derivative are to name but a few. Only sugar and honey have any proven benefits in horse wound healing. Gentian violet has been shown to be carcinogenic.

Honey is antibacterial, attracts tissue macrophages, provides anti-oxidants, regulates some inflammatory cytokines and accelerates wound repair. It should ideally be unpasteurised and not heated to over 37 degrees ('Manuka honey', 'meloderm').

Sugar is bacteriostatic, decreases oedema, attracts tissue macrophages, debrides, provides energy and creates a moist healing environment. It is best applied as a 1cm thick layer beneath an absorbent dressing to infected, necrotic wounds.

Platelet rich plasma (PRP)

PRP can be made very easily and quickly using autologous anticoagulated blood. PRP should contain 3-5 times physiological numbers of platelets . PRP contains at least 4 major groups of native growth factors with the potential to enhance wound healing.

Exuberant granulation tissue (EGT)/proud flesh

Distal limb wounds with large tissue deficits are prone to EGT. This is encouraged by excessive contamination/infection, chronic inflammation, movement, lack of soft tissue cover, poor vascular perfusion with hypoxia and body size (>365kg). Horses are more prone than ponies. Casts and bandages, even though they decrease movement, if not applied correctly can in fact enhance EGT due to increased angiogenesis and fibroplasia due to altered wound oxygen levels. Prevention of EGT is better than treatment.

Treatment should involve:

Debride to a flat bed of granulation tissue that is flush with the surrounding epithelialising edges. Apply a steroid-antibiotic ointment followed by a pressure bandage. 2-3 applications of the steroid-based cream should be all that is required. For large amounts of EGT, debriding may need to be done on more than one occasion. It may be worth applying a tourniquet whilst debriding large areas. Caustics and astringents (e.g. copper sulphate) prevent and remove EGT but they are non-selective therefore destroy migrating epithelial cells and can therefore delay healing further.

Skin Grafts

Finally, skin grafting should briefly be mentioned. It doesn't form part of emergency 'on-farm' wound management but it is an important technique to understand and utilise later on in wound care cases.

This should be considered for large tissue deficit wounds once there is a bed of healthy, non-infected granulation tissue. It will promote healing where the tissue deficit is so large that healing by second intention cannot occur/ is struggling.

Suggested reading for skin grafting:

Schumacher J, Wilmink JM. Free skin grafting. *In* Stashak TS, Theoret CL, (eds): Equine Wound Management 2nd ed, Blackwell Publishing Co. Ames, Iowa, 2008, pp 509-542.

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QUESTION 1

The conditions required for primary closure to be considered are:

a. minimal bacterial contamination
b. that all devitalised tissue, foreign bodies and blood clots are removed
c. that there is no dead space, haematomas or areas of ischaemia
d. precise realignment of tissue edges
e. all of the above

QUESTION 2

The most common group of bacterial skin commensals are:

a. Gram-positive
b. Gram-negative
c. a mixed population of gram-positive and -negative
d. anaerobes only
e. aerobes only

QUESTION 3

Most commonly, wound biofilms are:

a. anaerobic
b. aerobic
c. gram-negative organisms
d. an overgrowth of skin commensals
e. a combination of multiple species of aerobes and anaerobes

QUESTION 4

Currently, unwanted biofilms are best treated:

a. with topical antibiotics only
b. by surgical debridement
c. with systemic antimicrobials only
d. with daily superficial lavage
e. with daily cleaning with an antiseptic agent

QUESTION 5

A disadvantage of debridement dressings is:

a. they maintain a moist environment
b. they allow wound fluids to remain in contact with the wound
c. they remove layers of newly forming cells when removed
d. they remove necrotic debris
e. they are occlusive dressings

QUESTION 6

Epithelialisation dressings increase the temperature of the wound by:

a. 0.001-0.002 degrees
b. 0.01-0.02 degrees
c. 0.1-0.2 degrees
d. 1-2 degrees
e. 10-20 degrees

QUESTION 7

Honey as a topical wound agent:

a. is antibacterial
b. attracts tissue macrophages
c. provides anti-oxidants
d. upregulates inflammatory cytokines
e. all of the above

QUESTION 8

Sugar, a as topical wound agent:

a. is bacteriocidal
b. is bacteriostatic
c. has no proven benefits in horse wound healing
d. increases oedema
e. inhibits tissue macrophages

QUESTION 9

Platelet rich plasma (PRP) should contain:

a. 1-2 x physiological values
b. 3-5 x physiological values
c. 6-8 x physiological values
d. 8-10 x physiological values
e. > 10 x physiological values

QUESTION 10

Distal limb wounds are prone to exuberant granulation tissue due to:

a. poor vascular perfusion
b. lack of soft tissue cover
c. movement
d. excessive contamination/infection
e. all of the above

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