Wounds and Wound Care in Elephants

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Topics

- Describing wounds
- How wounds heal
- Factors that ↓ wound healing
- Wound care principles
- Wound treatment agents

Wounds are common in elephants, so we need to have an understanding of how they occur, how they heal, and the best way to treat them. I will be talking about these topics.

Describing Wounds

1. Cause of the injury
2. Type of injury
3. Sanitary condition
4. Appearance of the tissue

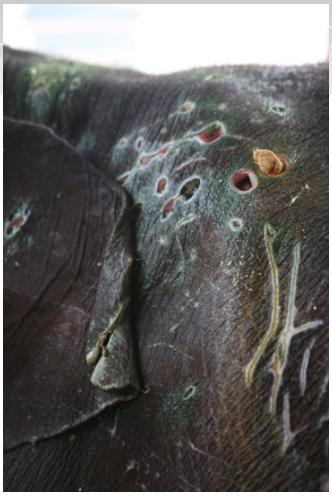
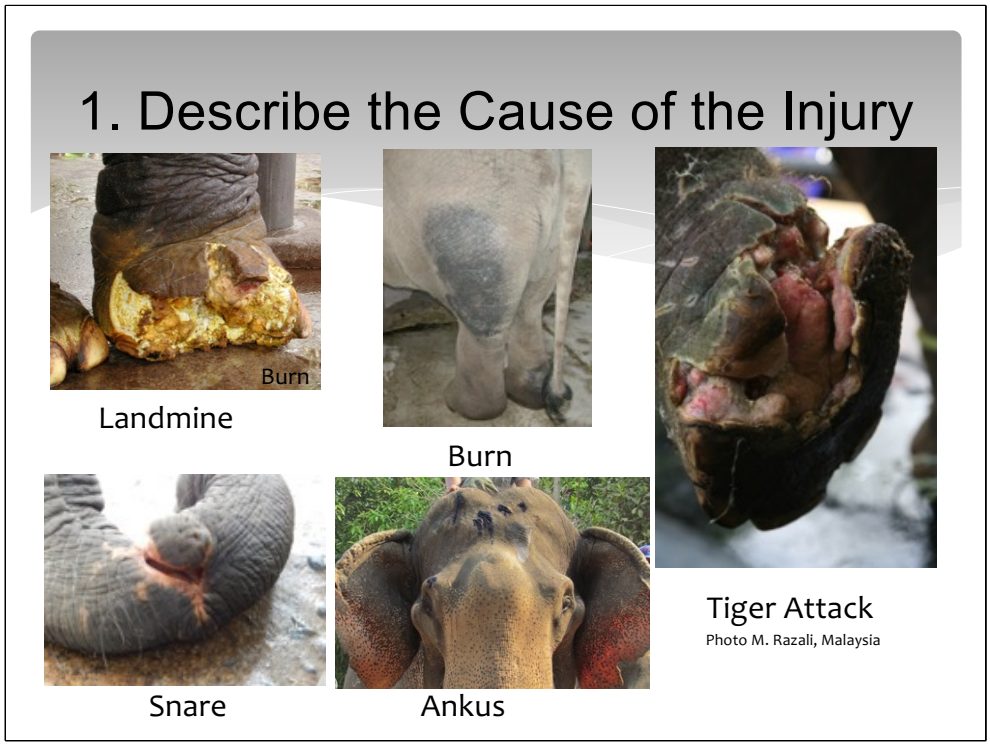
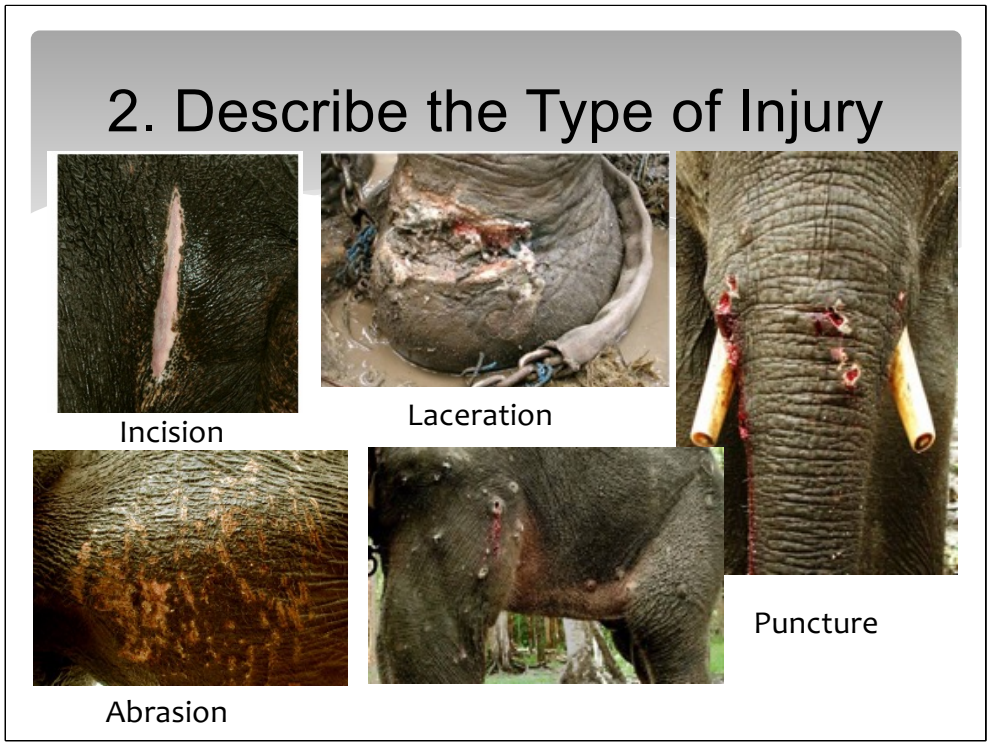


Photo courtesy of M. Razali, Malaysia

It is good to have a standard vocabulary when describing wounds so that the medical records are clear. We can describe wounds in these 4 ways: the cause of the injury, the type, the sanitary condition- meaning whether it is clean or infected, or how the tissue looks.



Causative factors for injuries may include things like snares, ankus injuries, burns, landmines, or in the case of this elephant calf, a tiger attack.



Another way to describe wounds is to note the type of injury. Incisions are **c**lean wounds with little damage to the surrounding tissues. They are usually caused by something sharp. Abrasions are wounds in which the epidermis – the outer layer of the skin - is removed, and the underlying dermis is exposed. They are usually caused by friction. Lacerations are irregularly shaped wounds and may involve muscle, nerves, tendons, and blood vessels. Punctures, caused by sharp objects, are small on the surface, but they can be deep and difficult to clean. In the case shown on the slide, the punctures were caused by a shotgun inflicted by angry villagers.

Contusion / Hematoma

In a contusion or hematoma, blood vessels beneath the skin rupture, bleed and clot. Contusions and hematomas are usually caused by blunt trauma.

Avulsion / De-gloving

Avulsion occurs when areas of skin are forcibly torn away. De-gloving occurs in a similar way however, the tissue usually dies (becomes necrotic) and sloughs away from the bone, due to damage to the local blood vessels.

Decubital Ulcers (Pressure Sores)

Elbow hygroma

Pressure sores may occur on the hips, elbows, or other areas from prolonged or repeated contact on hard surfaces. They may be dry and painful or swollen and irritated.

Abscesses

Abscesses result from penetrating injuries, tusk wounds, injections, or improper use of the ankus.

3. Describe the Sanitary Condition

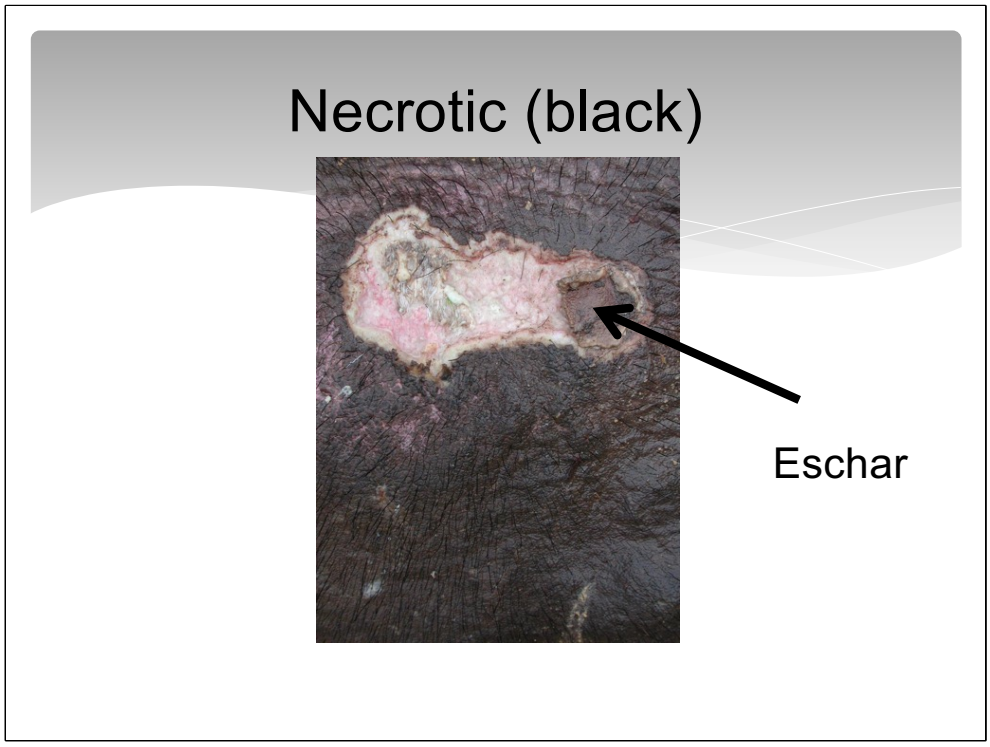
- Clean
  - no inflammation or infection
- Contaminated
  - dirt or foreign material
  - +/- inflammation
- Infected
  - Pus, inflammation, bad odor

A third way to describe wounds is based on their sanitary condition. Clean wounds have no signs of inflammation or infection. Contaminated wounds contain dirt or foreign material. Infected wounds have a purulent discharge and inflammation. They may also have a bad odor. The wound may contain heavy amounts of debris or necrosis may be present.

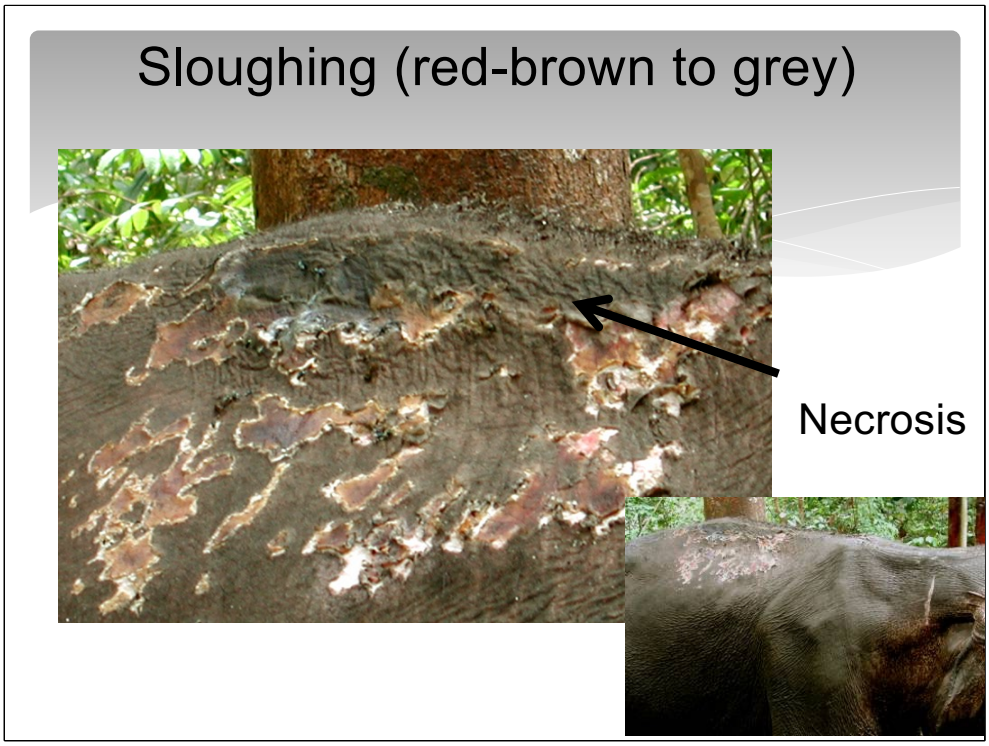
4. Describe the Appearance of the Tissue

- Necrotic (black)
- Sloughing (red-brown to dark grey)
- Granulation (bright red)
- Granulation (dark)
- Epithelialization (pink/red)

And the fourth way we can describe wounds is by the appearance of the tissue. In the following slides we will look at examples of all of these.



Necrotic tissue is black in appearance due to the presence of “eschar” - a black leathery material that cannot be easily removed by normal cleansing of the wound. It is made of dead cells and blood vessels. Necrotic tissue forms a barrier to new tissue formation and delays healing. Escher is also an excellent medium for bacterial growth and should be removed.



Slough is made up of tissue, fibrin, pus, and bacteria. It also provides a medium for bacteria. The production of harmful enzymes can perpetuate a cycle of bacterial growth and tissue breakdown. This elephant developed an infection from a dart wound in her hip and the infection moved forward beneath the skin along the back.

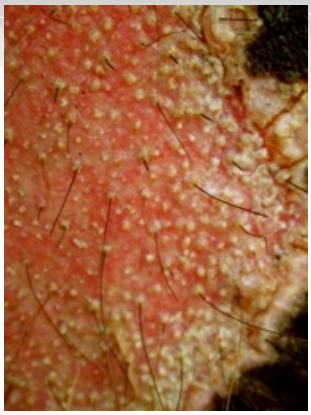
Granulation (bright red)

Granulating tissue is a bright red color. When granulation tissue is present, the wound bed is healthy. New collagen and new blood vessels are being formed.

Granulation (dark)

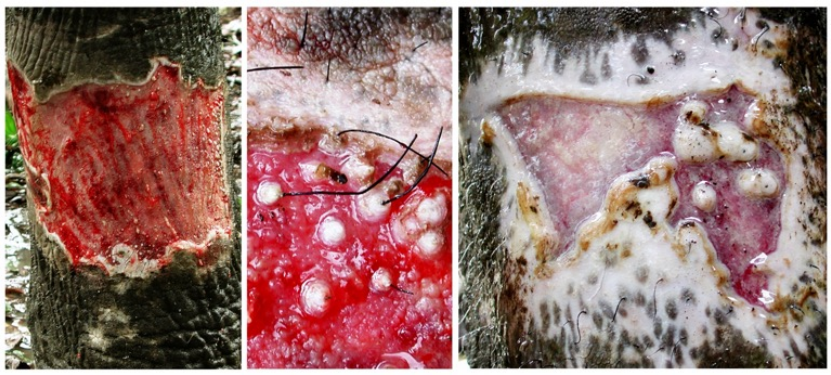
Darker granulating tissue indicates an inadequate blood supply. This type of wound needs to be debrided.

Epithelialization (Pink/Red):



Epithelialization is the re-surfacing of the wound by epithelial cells. It generally starts from the edges of the wound and spreads to the middle in most mammals.

Wound Healing in Elephants

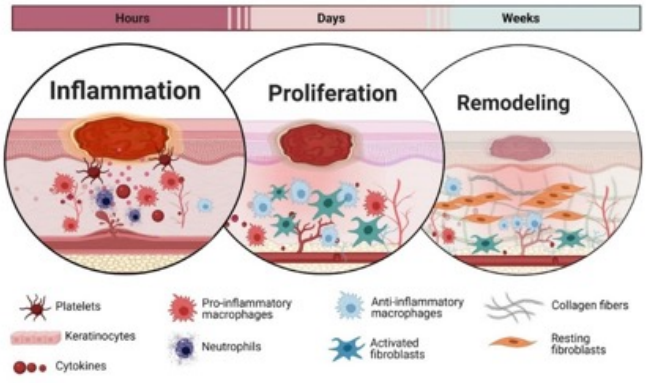


In elephants with very large wounds, instead of healing from the edges, the process can start from the center. Multifocal beds (of fibroangiomatosis) originating from around hair follicles coalesce to achieve healing.

HOW WOUNDS HEAL

Wound Healing: 3 Phases

1. Inflammatory phase: redness, swelling, pain
2. Repair phase: granulation and re-epithelialization
3. Maturation phase:↑layers of epithelium and ↑collagen



There are 3 major stages of wound healing. This is not a linear process and wounds can progress both forward and backward through the stages. Inflammation is the first stage. Vasoconstriction occurs immediately to control hemorrhage, followed within minutes by vasodilation. Blood vessels near the surface of the wound dilate and exudate starts to leak into the wound bed. This exudate contains enzymes, antibodies, and phagocytic cells.

In the repair phase (also called the granulation phase) migrating capillaries deliver a blood supply to the wound. Fibroblasts proliferate and create a collagen matrix that helps to strengthen the wound. As these processes are taking place, the wound starts to contract.

Maturation (also called remodeling) is the final stage. It can last days to months. It begins once the levels of collagen production and degradation are in equilibrium. Gradually the collagen in the wound strengthens, and the the blood vessels that were created for wound healing begin to die. The strength of the wound increases slowly over a long period (up to 2 yr). Most wounds remain 15-20% weaker than the original tissue.

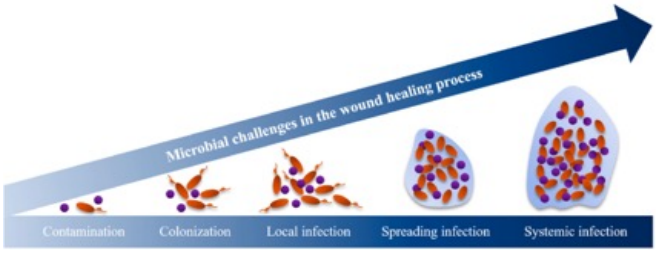
Factors That Interfere w Wound Healing

- Physical
  - Temperature 30°C (86°F) ideal
  - Low Oxygen
- Internal
  - Anemia
  - Hypoproteinemia
  - Malnutrition
- External
  - Steroids

Physical, internal, or external factors can interfere with healing. Temperature affects the tensile strength of wounds. The ideal temperature for wound healing is 30°C / 86°F. Low oxygen levels can be caused by internal factors like anemia. Because wound healing is a function of protein synthesis, malnutrition may alter the healing process. External factors can include chemicals or drugs. Corticosteroids are well known to delay healing.

Infection Continuum in Wounds

- Contamination: non-replicating organisms
- Colonization: contaminating bacteria adhere and multiply; no host injury
- Infection: replicating organisms cause host injury

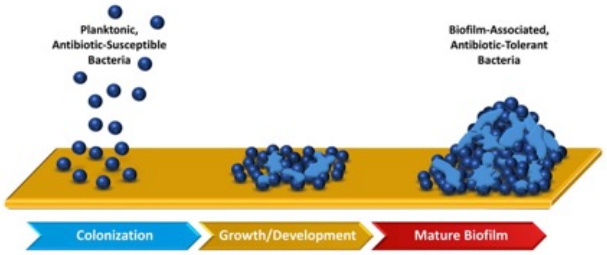


There is a continuum of infection in wounds characterized by increasing numbers of microbes. In a contaminated wound there are organisms, but they are unable to multiply. Surprisingly, most organisms in the soil won't grow in a wound. When a wound is colonized, microorganisms are replicating and have adhered, but there is no injury to the host. Most of these organisms are normal skin flora like Staphylococcus epidermidis, other coagulase negative Staph., Corynebacterium sp., and others. If the host's immune system is working, the wound does not become infected and heals uneventfully.

However, there is a point along this continuum where critical colonization occurs. Replicating microorganisms can no longer be controlled by the immune system and may spread beyond the wound to surrounding tissues. Wound infection might finally result in systemic infection or sepsis.

Why Some Wounds Don't Heal

- Bioburden
- Virulence
- Poor host immune response
- Necrotic or foreign material
- Presence of anaerobes
- Biofilms



The main reason wounds fail to heal is because of the bioburden – the quantity of microbes present and the effects of microbial toxins. Outcome also depends on the host's immune response, the virulence of the bacteria, and the presence of foreign or necrotic material. Chronic wounds often contain more anaerobes than aerobes and are likely to be polymicrobial. Biofilms are another factor that we will discuss.

How Do You Know When a Wound is Infected?

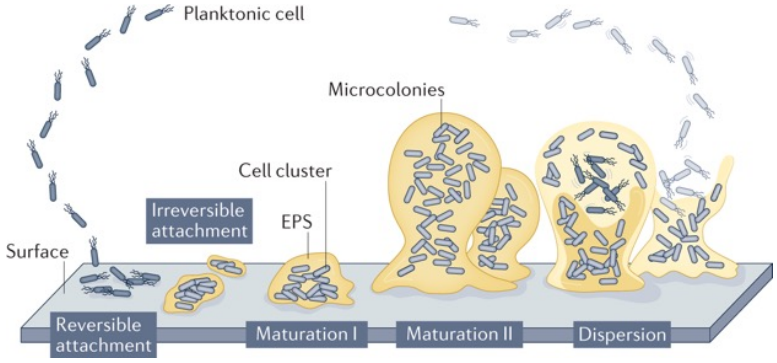
- ↑ exudate
- ↑ swelling
- ↑ redness
- ↑pain
- ↑local temperature
- Cellulitis
- Change in granulation bed

Infection = > 105 microorgansims / gram of tissue or per ml of exudate

Knowing when a wound is infected is not always obvious. Technically an infection is >105 microorganisms per gram of tissue or per ml of exudate. Of course, in clinical settings, we can't really measure this. But we can use microbiologic testing to confirm the diagnosis and guide the selection of appropriate antimicrobial therapy. Even if the results of microbiologic testing do not indicate infection, a wound should be considered infected if typical clinical signs of infection are present - increases in exudate, swelling, redness, pain, and local temperature. Cellulitis may develop around the wound or there may be a change in the appearance of granulation bed – it may become discolored, bleed, or become friable.

Biofilms: Adherent Multicellular Units of Bacteria

- Stage 1:reversible attachment of free-floating bacteria (minutes)
- Stage 2: bind irreversibly and multiply (2-4 h)
- Stage 3: secrete EPS (6-12 h)
- Stage 4: bacteria shed (24 h); daughter biofilms form (2-4 days)



Biofilms are VERY important to understanding and treating chronic wounds. In most wounds, bacteria are free-floating and act as individual organisms. But in chronic wounds, microbes attach and form multicellular units called biofilms. There are 3 stages to biofilm formation. In stage 1, free-floating bacteria reversibly attach to a surface within minutes. In stage 2, which occurs within 2-4 h, bacteria bind irreversibly then multiply and change patterns of gene expression. In stage 3, after 6-12 h, the bacteria adhere to each other and to other surfaces by secreting an extracellular polysaccharide matrix – EPS. At 24 h, the biofilm is mature. It dissolves to shed free-living cells, microcolonies, and biofilm fragments. These disperse and attach to other parts of the wound bed, forming metastatic daughter biofilms in the surrounding area. This occurs within 2–4 days, depending on the species and growth conditions. Plaque on dental enamel is an example of a biofilm.

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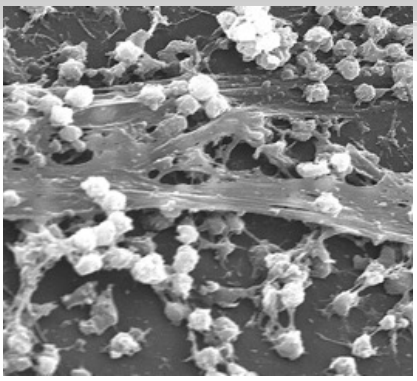
What Do Biofilms Look Like?



Wikepedia

Staphylococcus aureus biofilm on an IV catheter

- Not visible to naked eye
- Single or multiple bacterial species
- Aerobic, anaerobic bacteria
- +/- yeast, fungi, protozoa
- Culture may not detect all organisms

Biofilms cannot be seen with the naked eye. Single species of bacteria can make up a biofilm, but, more often, biofilms are composed of multiple species of aerobic and anaerobic bacteria, and, occasionally, yeast, fungi, or protozoa. These organisms interact and develop stable, symbiotic relationships through complex intercellular communications called quorum sensing. Culture may not always detect all the organisms in a biofilm. *Staphylococcus*, *Pseudomonas*, and *Enterococcus* are the predominant organisms in the biofilm of chronic wounds in humans.

What Do Biofilms Do?

- Impair healing
- Induce chronic non-healing phase
- Protect bacteria from host defenses
- Impervious to antiseptics, alcohols, acids, bleach, hydrogen peroxide

Biofilms are a therapeutic challenge!

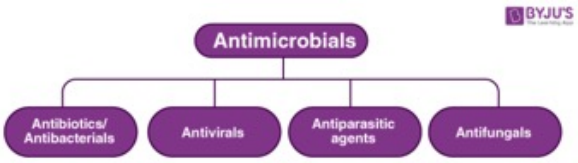
Barman, Nagendra Nath et al. 2013. Bacterial Infection, Antibiogram and Wound Treatment in Domesticated Asian Elephants. Gajah 39: 40-43.

Biofilms impair healing by competing for metabolic resources and by interfering with the inflammatory response. They protect the bacteria from the host's defenses and from antibiotics. A mature biofilm is relatively impervious to common antiseptics, alcohols, bleach, and hydrogen peroxide, unless these products are used at a concentration toxic to the host's cells. Human WBCs easily kill free-living *S. aureus*, but when the same microorganism resides in a biofilm, a 1000-fold increase in WBCs is needed. Similarly, *S. aureus*, growing within a biofilm, is up to 100-fold more resistant to antimicrobial therapy when compared to infections with free-living bacteria. Neither phagocytes nor antimicrobial agents may be able to readily penetrate the slimy layer. You can see why biofilms present a therapeutic challenge!

PRINCIPLES OF WOUND MANAGEMENT

Definitions

- Antimicrobial: substance that eradicates microbes. Umbrella term for antibacterial, antibiotic, antiviral, antifungal, and antiprotozoal agents.
- Antiseptics (antibacterials): Biocidal agents with multiple targets that slow, inhibit, and eliminate the growth of pathogens. For external use only.
- Antibiotics: drugs that inhibit or eradicate bacteria, fungi or yeasts, or protozoa. Generally given systemically. Selective – act on a single target.
- Disinfectants: antimicrobials used on environmental surfaces only.

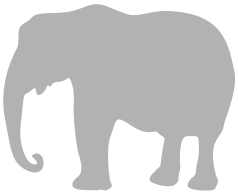


Let's review a few definitions. Antimicrobial is an umbrella term for antibacterial, antibiotic, antiviral, antifungal, and antiprotozoal agents. Antiseptics are biocidal agents with a broad spectrum of activity. They are for external use only. Antibiotics are selective, acting on a specific target. Disinfectants are antimicrobial agents for use on environmental surfaces only.

Goals of Wound Management

Create an environment to support the formation of a healthy vascular bed by

- Preventing further contamination
- Removing debris
- Debriding dead tissue
- Establishing drainage
- Lavage (flushing, irrigation)



The goals of wound management are to create an environment that supports the formation of a healthy vascular bed. This is achieved by preventing further contamination, removing debris, debride dead tissue, provide drainage, and irrigating the wound.

Practice Good Hand Hygiene

- ↓ cross-contamination and transfer of zoonotic pathogens
- Wash your hands
- Use alcohol hand sanitizer
- Wear gloves

Veterinarians and staff need to practice good hand hygiene to reduce the chances of cross-contamination to our patients or transfer of zoonotic pathogens. So, wash your hands like you have been doing for Covid - or use alcohol hand sanitizer- and wear gloves when treating wounds.

Basic Wound Management Steps

1. Use aseptic techniques to collect a culture
2. Prepare the skin around the wound
3. Establish drainage
4. Wound irrigation – single most important!
5. Debridement – also important!
6. Monitor and document

This slide summarizes the basic steps to manage wounds. If this is a new injury, you should assess the overall stability of the elephant. Large open wounds may detract attention from other problems that could be potentially life-threatening. Control any active bleeding by applying direct pressure. We will go over each of these steps in detail.

Step1.Use Aseptic Techniques to Collect a Culture Sample

- Clean surrounding tissue w surgical scrub
- Irrigate surface w sterile saline if there is pus or slough
- Avoid touching skin margins or superficial areas
- Wear sterile gloves!

Theoret, C.and Schumacher, J. 2017. Equine wound management. 3rd edition. John Wiley & Sons, Inc.

Not all wounds need to be cultured but cultures are essential if you are dealing with an infected or non-healing wound. If you are going to culture the wound, use aseptic technique. Wear sterile gloves. Clean the tissue around the wound with a scrub to avoid contaminating your sample with organisms from the surrounding skin. Avoid getting the scrub in the wound. If there is pus or slough, irrigate the surface with sterile isotonic fluid to remove the more superficial material. When you insert your culture swab, avoid contacting the skin margins.

Sample Areas That are Likely to Have Pathogens

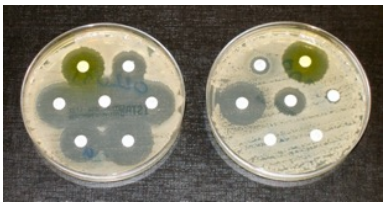
- Sample deepest and multiple sites
- Swab across surface if biofilm suspected
- Submit tissue samples
- Submit foreign bodies
- May need multiple samples

Theoret, C.and Schumacher, J. 2017. Equine wound management. 3rd edition. John Wiley & Sons, Inc.

Collect samples from the deepest areas of the wound and sample multiple sites if there are pockets, fissures, or layers. If you suspect a biofilm, draw the swab across the surface of the wound with enough pressure to collect a sample of the biofilm but avoid causing any bleeding. When possible, include tissue samples from the wound. For example, debride the wound and submit some of the debrided material. Tissue samples are more likely to yield reliable culture results. Also submit any other material removed from the wound, such as a foreign body. Use a separate swab for each sample type – exudate, tissue, biofilm.

Consult your lab

- Proper sample collection, transport media, shipping
- Submit the sample ASAP
- Provide clinical information
- Request cytology, aerobic and anaerobic culture and antibiotic sensitivity testing
- Request quantitative Ab sensitives that provide MICs for the drugs tested



Theoret, C. and Schumacher, J. 2017. Equine wound management. 3rd edition. John Wiley & Sons, Inc.

It's a good idea to consult your lab for any special instructions on collection, transport, or shipping. When you submit samples, provide clinical information. Request cytology, aerobic and anaerobic culture, and antibiotic sensitivity testing. If available, request quantitative sensitives that provide MICs for the drugs tested. If you suspect a fungal pathogen, request fungal cytology and culture. Collect all samples before starting or changing antibiotic therapy. If the elephant is already receiving antibiotic therapy, either suspend treatment, or collect the samples before the next scheduled dose. Ideally, stop treatment for a period that is at least 8 hours longer than the dosing interval. For example, for an antibiotic administered every 12 hours, stop treatment for at least 20 hours before collecting samples for culture. This interval allows the residual bacteria to re-enter the log phase of active growth.

2. Prepare the Skin

- Prepare the skin around the wound as if for aseptic sx
- Use an antiseptic scrub (chlorhexidine or povidone iodine)
- Removes oil, dirt, and debris
- Alternate CH with rinses of sterile 0.9% saline
- Alternate PI with rinses of 70% alcohol.

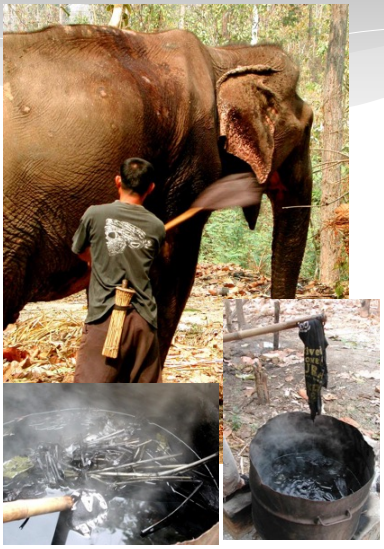
Antiseptic scrubs and isopropyl alcohol are cytotoxic and should not contact the wound itself.

Next, prepare the skin around the wound as if for aseptic surgery by scrubbing with an antiseptic detergent – either chlorhexidine or povidone iodine. The purpose is to remove oils, dirt, and debris. Rinse the skin around the wound with sterile saline if you are using chlorhexidine or with 70% alcohol if you are using povidone iodine. Antiseptic scrubs and isopropyl alcohol are cytotoxic and should not contact the wound itself.

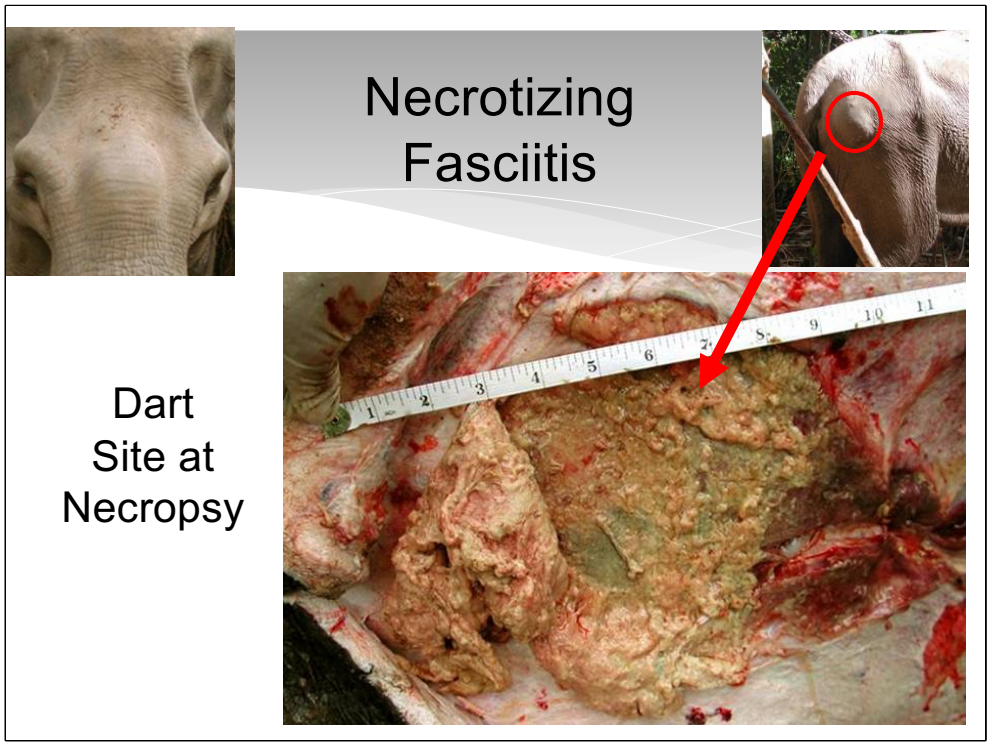
3. Establish Drainage

if you re dealing with an abscess, the next step is to establish drainage. If there is a swelling and you are going to aspirate it to see if it is an abscess, use a large 14-gauge needle - as purulent material can be quite thick. Incise ventrally to provide drainage and make a dorsal incision that you can use to flush. Inserting soft rubber tubing, as we did in this temporal gland abscess will keep the tract open for treatment. Cut the ends short to discourage the elephant from pulling it out or suture in place.

Fomentation / Compresses

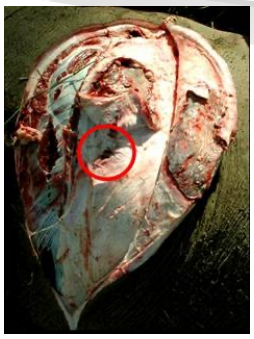


Warm compresses are a good way to reduce swelling, draw infection to the surface, relieve pain, and encourage the blood supply. The image on the right is from Thailand where they are applying a warm herbal solution.

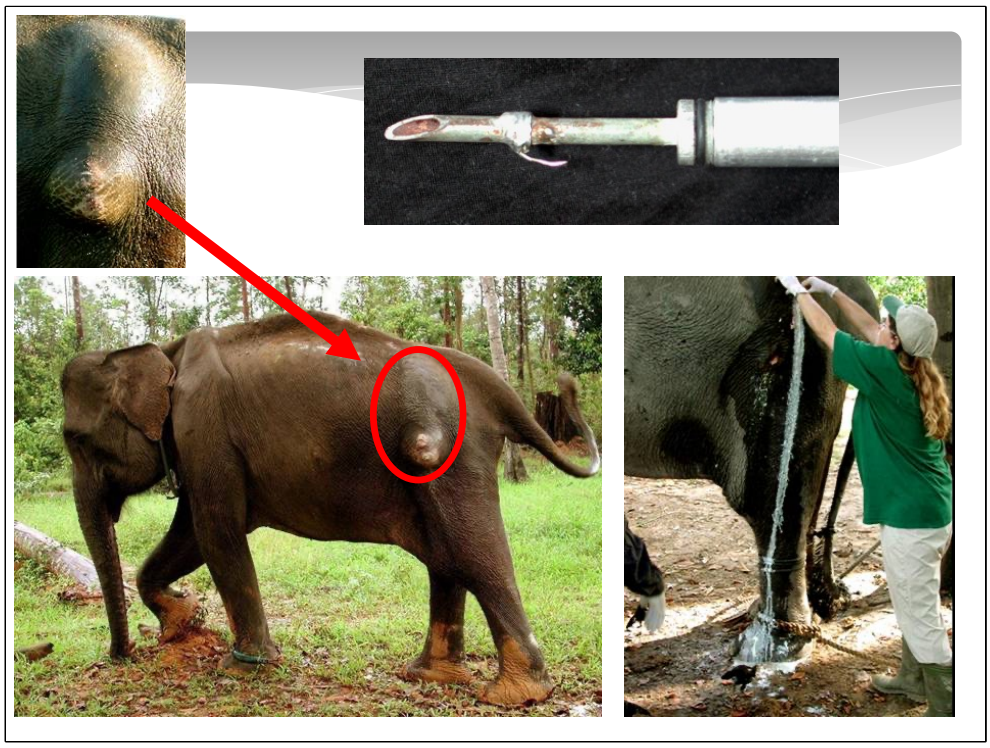


I want you to be aware of a possible consequence of abscesses. I worked with newly captured elephants in Sumatra years ago. The capture equipment and techniques used lacked hygiene, and many elephants developed abscesses at the dart site. Some of the darted elephants died. It seems that in elephants there is a tendency for abscesses to spread beneath the skin. Infection may progress (often undetected) for months resulting in necrotizing fasciitis, sepsis, and death. Care should be taken to thoroughly clean the skin when giving intramuscular injections. Wounds created when elephants are darted in the field should be cleaned and if conditions are unhygienic, this is one situation where I would consider giving a prophylactic antibiotic injection, and instilling an antibiotic paste designed for intra-mammary use in cattle.

Necrotizing Fasciitis


Here is another example of necrotizing fasciitis. In these cases, the WBC may be very high.



This is Epi - one elephant we were able to save. We treated her for two months.

4. Wound Irrigation (Lavage, Flushing)

- Removes contaminants
- Allows visualization of the wound
- Less damaging than swabbing or scrubbing
- One of the most important aspects of wound care

Wound irrigation, also called lavage or flushing is an important step in wound management. The purpose is to remove contaminants and allow you to clearly visualize and assess the wound. Wound irrigation is less traumatic to tissue, less painful, and more effective than swabbing. Wounds require repeated irrigation as long as they contain superficial slough, excess exudate, or visible debris that might delay healing. Irrigation may be used before, after, or as an alternative to debridement, depending on the amount of contamination or tissue damage.

Wound Irrigation Devices

- Large syringes
- Raised fluid bag
- Saline bottle
- Garden sprayer

There are several devices that you can use including bulb syringes, a 35 or 60 cc syringe with a blunt needle or tubing attached, and hand-held or back-pack style garden sprayers. If you are using a garden sprayer it should be dedicated for wound treatment and not used for anything else. The stream should feel somewhat like the stream from a home shower. Keep a distance of at least 6 inches from the sprayer tip to the wound and direct the stream at an oblique angle to the surface of the wound.

Pressures and Volumes

- 8 to 15 psi ideal
- 35- or 60-ml syringe + 18-19 ga needle or IV catheter delivers 10-15 psi
- > 20 psi forces bacteria into the tissue
- Wound size and the degree of contamination determine volume needed
- Use ~ 50-100 ml /cm of wound

Irrigation fluid should be delivered at a pressure of 8 to 15 psi. This amount of pressure overcome the adherence of bacteria to a wound while avoiding tissue damage or driving bacteria deeper into tissues. This pressure can be achieved with a 35- or 60- ml syringe and an 18- or 19 ga needle or IV catheter. Pressures above 20 psi may traumatize the wound and force bacteria into the tissue. There may be times when higher pressures are needed to remove necrotic tissue and in these cases the benefits may outweigh the risk of injuring the tissue – you just have to use your judgement. As far as the volume of fluid, use an amount that removes visible debris and contamination without causing the tissue to become swollen or waterlogged. One guideline suggests 50-100 ml/cm of wound.

Time is Important

- Treat wounds early
- Effectiveness of irrigation ↓ as the wound ages
- Due to biofilm forming

Age of wound	Reduction in bacterial counts w irrigation
3 hours	70%
6 hours	52%
12 hours	37%

The effectiveness of irrigation decreases as the wound ages. A study in goats found that irrigation resulted in a 70%, reduction in bacterial counts at 3 h but only 52% at 6 h and 37 % at 12 h after the wounds were inoculated with *Pseudomonas.* This is because bacteria invade tissue and aggregate to form a biofilm that becomes more resistant to irrigation over time.

Irrigation Solutions

Ideal: Sterile, isotonic, nontoxic, gentle to tissues, compatible w additives

- 0.9% saline
- Lactated ringers

No surgical scrubs or alcohol in open wounds!

The ideal lavage fluid is antiseptic, nontoxic, gentle to tissues and compatible with anything you plan to add. Sterile balanced electrolyte solutions, such as lactated Ringer's or saline are commonly used.

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Saline, however, does have mild cytotoxic effects in vitro on canine fibroblasts after 10 minutes of exposure. This results from the slightly acidic pH of normal saline and the lack of a buffering system. Lactated Ringer solution does not result in fibroblast damage; therefore, the use of such isotonic solutions may be preferred over the use of 0.9% sodium chloride. Clinics NA

Can You Use Tap Water?

- Tap water is safe for wound cleansing if the water is potable (safe to drink)
- Boiled and cooled water or distilled water are alternatives
- To make home-made saline: 2 teaspoons salt/liter

Fernandez R, Griffiths R. Tap water for wound cleansing. *Cochrane Database Syst Rev.* 2012 Feb 15;**2**:CD003861

Sterile saline and LRS are expensive when large volumes are needed for multiple treatments. So, can you use tap water? The answer is yes - as long as the water is safe to drink. A study in humans found that using tap water is as effective as using saline solution in cleansing acute and chronic wounds, and that using tap water does not increase the risk of infection or delay healing. Where potable tap water is not available, boiled and cooled water or distilled water are acceptable alternatives. Because tap or boiled water is cheap there will be less tendency to skimp on the volume needed. And you can make your own saline by adding 2 teaspoons of salt to every liter of potable, boiled, or distilled water.

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Fernandez R, Griffiths R. Tap water for wound cleansing. *Cochrane Database Syst Rev.* 2012 Feb 15;**2**:CD003861. doi: 10.1002/14651858. CD003861.pub3

One source said that: Although irrigating wounds with tap water does not increase microbial colonization, the use of tap water is reported to be cytotoxic to skin fibroblasts. The cytotoxic effects of tap water are attributed to alkaline pH, hypotonicity, and presence of cytotoxic trace elements. Clinically, however, in humans the use of tap water to clean wound does not delay healing.

Adding Antiseptics to Lavage Solution

- For chronic or heavily contaminated wounds
- Broad spectrum
- Less likely to cause resistance than antibiotics
- Use the correct concentration
- Use solutions not scrubs!

Dilute is better!

Although irrigation may be all we need to clean a fresh wound, many wounds we encounter are not fresh. Heavily contaminated wounds may benefit from the addition of antiseptics to the irrigation solution. Antiseptics have a broad range of activity and are less likely to induce bacterial resistance than antibiotics. It is important to use the right concentration that will optimize the anti-bacterial effect and keep any cytotoxic effects to a minimum. Dilute is better! Chlorhexidine and povidone iodine are the most commonly used.

Chlorhexidine or Povidone Iodine

- 2% Chlorhexidine: dilute to 0.05% (25-ml / liter of irrigation soln)
- Do not use chlorhexidine near the eye or open joints
- 10% povidone iodine: dilute to 0.1% to 0.2% (10-20 ml / liter of irrigation solution)

Must be diluted!

These are the recommended dilutions for wound treatment in horses. You should not just add these agents to a bucket until they are a pretty color! They both have advantages and disadvantages. Chlorhexidine at 0.05% has sustained residual activity against a broad spectrum of bacteria and causes minimal tissue inflammation. However, gram-negative bacteria may become resistant. Stronger solutions of chlorhexidine are toxic to healing tissue and should not be used. Chlorhexidine should not be used near the eye or open joints, as its use can result in corneal edema and scarring.

Povidone-iodine has a broad antimicrobial spectrum, but it has minimal residual activity, and it can be inactivated by blood, serum proteins, and other organic matter. Overall, chlorhexidine is recommended over povidone- iodine, because it is less cytotoxic and has superior bacterial killing. Also, In my experience, PI will clog a garden sprayer. Clinics NA

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Povidone-iodine has a broad antimicrobial spectrum and is effective against Gram-positive and Gram-negative bacteria, as well as viruses, fungi, yeasts, molds, and protozoans.

Formula to Dilute Concentrated Solutions: C1V1=C2V2

C1 = % of the concentrated solution

V1 = the unknown volume of concentrate to use

C2 = the % of desired dilution

V2 = the amount of the solution you need

How much 10% povidone iodine to add to 4 liters to make a dilution of 0.2% ?

10 x V1 = .2% x 4000 ml

10 x V1 = 800

X = 80

80 cc of 10% povidone iodine added to 4000 ml water to = 0.2%

This is an easy formula to use when you have a concentrated solution, and you need to dilute it. The formula is on the top and on the bottom is an example of how to dilute a 10% solution of povidone iodine to 0.2 % which is the recommended dilution for wound flushing.

Quiz: Which of the following lavage solutions can result in a lower wound infection rate?

- A. Sterile saline
- B. Tap water
- C. Distilled water
- D. Infection development does not differ for any of these solutions.

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The answer is D. Studies in humans and animals show no difference in the development of wound infection when irrigated with any of these solutions, Remember, the main function of irrigation is to physically remove gross contamination. Sterility of the solution is less important.

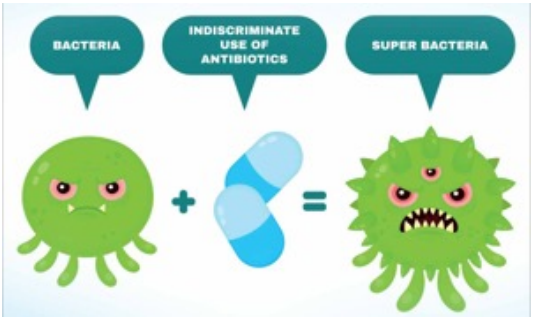
What About Adding Antibiotics?

- Do not add antibiotics to irrigation solutions
- If systemic antibiotics are indicated, base selection on culture results
- Avoid empiric use of antibiotics for open wounds without evidence of infection

What about adding antibiotics? The short answer is No! Antibiotics are only indicated for infected wounds.

Antimicrobial Resistance

- Global health concern
- Mis-use and overuse of antibiotics main cause
- Even simple infections may be fatal
- One-Health issue



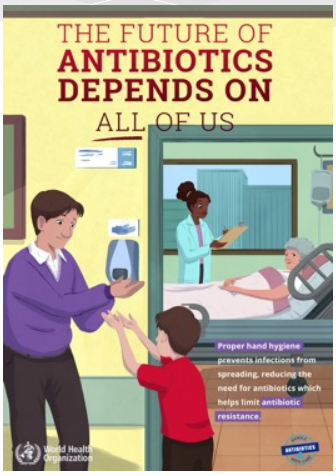
Antimicrobial Resistance (AMR) occurs when pathogens are no longer respond to typical medicines. Even common infections are becoming difficult or impossible to treat. The WHO has declared that AMR is one of the top 10 global public health threats facing humanity. Misuse and overuse of antimicrobials are the main reasons for drug-resistant pathogens emerging. Sadly, we may be headed toward a post-antibiotic era in which common infections, which have been treatable for decades, can once again kill. This is a one-health issue.

Antimicrobial Stewardship

- Antibiotics only effective against bacteria
- Culture if infection suspected
- Select the right antibiotic
- Use the appropriate dose
- Follow up / re-culture

HANDOUTS: **Interpretation of Culture and Susceptibility Reports**
Patricia Dowling, DVM, MSc, DACVIM (Large Animal), DACVCP

Correct Use of Antimicrobial Therapy
J. Scott Weese, DVM, DVSc, DACVIM



As veterinarians, we have a responsibility to use antibiotics wisely. Remember antibiotics are only effective against bacteria. If you suspect an infection, collect a culture and select the right antibiotic based on the sensitivity results. Try to use antibiotics that have been studied in elephants so that you use the right dose. And follow-up and re-culture if necessary.

5. Debridement

- Removes infected or necrotic material
- Mainly during inflammatory phase
- May need to repeat
- Surgical – scalpel
- Physical – gauze sponges
- Combine with lavage
- Ensures blood supply at edges
- Extensive debridement requires sedation

Remove: white, tan, black, green, and poorly attached tissues
Leave: pink to dark purple and well attached tissues

Debridement occurs naturally within wounds by autolysis, a process whereby devitalized tissue is softened or liquefied by the body's own enzymes. Autolytic debridement is selective - only devitalized tissue is liquefied - and virtually painless for the patient. If the wound is heavily contaminated or chronic, however, the autolytic process becomes overwhelmed by the sheer number of microbes or by endotoxins released from devitalized tissue. So, we need to intervene.

Debridement is the process of removing infected, necrotic, or devitalized tissue that has no chance of healing. The aim is to create a well-vascularized bed. Debridement should be done early during the inflammatory phase. It may need to be repeated during the healing process or if you are dealing with a biofilm. Sharp debridement using a scalpel is the best method. Don't be afraid to cause some bleeding – you want to stimulate the blood supply especially at the edges. Noting the color and attachment of tissues can help you decide what to debride and what not to. Remove white, tan, black, and green tissues and any tissue that is poorly attached. Leave pink to dark purple or attached tissues.

Mechanical Debridement (Scrubbing)

- May damage normal tissue and delay healing
- Try to limit scrubbing to intact skin around the wound
- Use minimal force on injured tissue
- Cotton, non-woven gauze best
- Surgical scrub brush - sponge side OK
- Rinse w saline-soaked sponges or saline squeeze bottle

Woven

Non-woven

Surgical scrub brush

In the past, “scrubbing” the wound was the most common form of physical debridement, and it can effectively reduce the bacterial load in a wound. However, in some cases, the physical damage to the wound is more traumatic than beneficial. It is best to limit scrubbing to the skin around the wound. Apply minimal force to the wound itself. Cotton, nonwoven gauze is preferred over woven gauze which can be traumatic to tender granulating tissue. You can also use the the moistened sponge portion (not the bristles) of a surgical scrub brush as a low friction cleaning tool. Rinse the scrubbed area with sponges soaked in sterile saline. Larger areas can be rinsed by puncturing 3 to 4 holes in the top of a 1-L bottle of saline with a 14-gauge needle and using it as a squeeze bottle.

6. Monitor and Document

- Monitor at each treatment
- Check for adverse reactions
- Re-evaluate at 7 days
- If no progress at 14 days change treatment

Monitor progress each time you treat. Check for infection and any adverse reaction. Watch for progression to systemic infection. Do a thorough reevaluation 7 days after treatment is initiated and then weekly or whenever there is a change. Continue a given treatment for 14 days; if there is no progress by that time, change your treatment.

Document

- Measure and photograph weekly
- Record specific observations
- Use objective terms

12 September

13 October

It is helpful to photograph the wound regularly. You can use a date stamp on your photos to make it easier. Include a ruler in the frame. Be specific when you record your observations regarding progress. Avoid writing things such as “healing well,” which is not objective or legally defensible. This is a pressure sore on an elephant that I treated with honey. Pressure sores heal very slowly but notice the progress between September and October. In the image on the left the tissue is swollen and irritated. In the image on the right – one month later, the open part of the wound has contracted, and the swelling has decreased.

Methicillin-Resistant *S. aureus* (MRSA)

- Resistant to penicillins, cephalosporins, flouroquinolones, tetracyclines, aminoglycosides, sulfonamides
- Zoonotic
- Reported in elephant calf at San Diego Zoo
  - 5 confirmed human infections
  - 3 colonized humans
  - 15 suspected infections

Anon. Methicillin-resistant Staphylococcus aureus skin infections from an elephant calf--San Diego, California, 2008. MMWR 2009. 58 (8): 194-198.

You are probably familiar with methicillin-resistant *S. aureus* (MRSA). People with MRSA infections are 64% more likely to die than people with drug-sensitive infections. MRSA was reported in the U.S. in an elephant calf that was being hand-raised. The investigation also found 5 confirmed, 15 suspect and 3 caretakers who were colonized. The calf was likely infected from one of the colonized keepers, but the infections went back and forth between the elephants and the staff.

MRSA Lesions in Humans

Photo credit: Public Health Image Library

This is what MRSA lesions look like in people.

CDC Recommendations for Preventing MRSA Transmission in Zoo Settings

- 1) train employees about their risks for infection and the recommended work practices to reduce them
- 2) perform proper hand hygiene before and after animal contact
- 3) use personal protective equipment (PPE) when working with ill or infected animals, especially during wound treatment
- 4) clean and disinfect contaminated equipment and surfaces

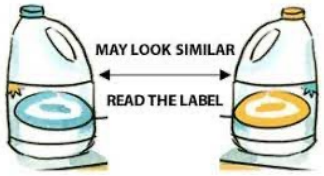
After the investigation at the San Diego Zoo, the CDC made these recommendations for preventing MRSA. Refer to slide. These are good reminders for all of us treating any animal with wounds.

TOPICAL ANTIMICROBIALS

Recommended and Not Recommended

Selecting the Right Agent

- Antiseptic vs antibiotic
- Broad spectrum
- Specific to the target organisms if known
- Good quality product
- Minimal absorption, no systemic adverse effects
- Will not impede or delay healing
- Painless



If you are going to apply something topically to a wound, the product you select should cover a broad spectrum of pathogens. Most wounds are polymicrobial. So, select one that covers both Gram-negative and Gram-positive microbes. Although antibiotics administered topically are less likely to lead to resistance than antibiotics given systemically, you still need a good reason to use them, and the wound must be debrided first. Culture results can help in your selection. A good quality product should not delay healing, should not have any systemic effects, and should be painless to apply.

Nitrofurazone

- Limited antimicrobial activity
- Decreases epithelialization and delays wound contraction in horses
- Causes tumors in rodents
- Not allowed in food-producing animals
- May be carcinogenic for humans
- Not recommended

Nitrofurazone is an inexpensive broad-spectrum antimicrobial with primarily bacteriostatic effects. Nitrofurazone can delay wound contraction in horses. It is a suspected as carcinogen for humans; there are better topical antimicrobials. Source: Clinics NA

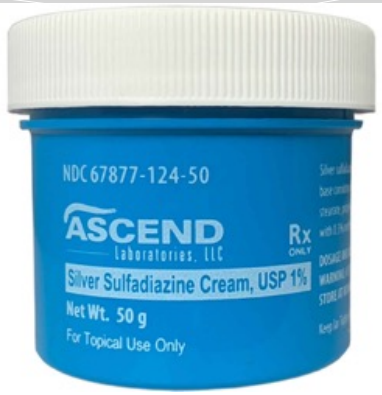
Triple Antibiotic Ointment

- Combination of neomycin, polymyxin B, and bacitracin
- Works well in humans
- Delays wound healing in horses
- Better choices

One of the classic topical antimicrobials used in both humans and animals is triple antibiotic ointment. It is a combination of neomycin, polymyxin B, and bacitracin. Triple antibiotic ointment has a broad spectrum, but it is ineffective against *Pseudomonas* spp. Triple antibiotic ointment results in faster wound healing in humans but not in horses. So, it gets a thumbs down. Source: Clinics NA.

Silver Sulfadiazene

- Broad-spectrum
  - Anti-bacterial
  - Anti-fungal
  - Anti-viral
- ↓Bioburden
- ↑Epithelialization
- Resistance rare
- Burns /other wounds
- Apply daily



One good choice is silver sulfadiazine. Silver has broad-spectrum antibacterial, antifungal, and antiviral activity. It is active against many antibiotic-resistant bacteria, including MRSA, *Enterococcus faecalis*, *Pseudomonas aeruginosa*, and *E. coli.* Topical use of silver in infected wounds will reduce the bioburden. It seems to help with epithelialization and resistance is rare. It is excellent for burns but can be used in other wounds as well. The cream form may not adhere well. It should be applied daily, because the silver ions can quickly become inactive once they react with wounded tissue. A good product to have in your pharmacy.

Potassium Permanganate $KMNO_4$

Crystals | Concentrated solution | Therapeutic solution

- Oxidizing agent
- Disinfectant, astringent
- 1:10,000 (one 400 mg tablet: 4 liters water)
- Soak gauze and place on wound 20-30 min

Potassium permanganate is not used much in the U.S. although I found a few articles from India where it was used in a pony with thrush and in horses for exuberant granulation tissue. I also found a recent article where it was used in humans for diabetic foot ulcers. Has anyone here used KMNO4 in elephants? It is an oxidizing agent with disinfectant and astringent properties and the main indication is to dry out weeping ulcers or abscesses.

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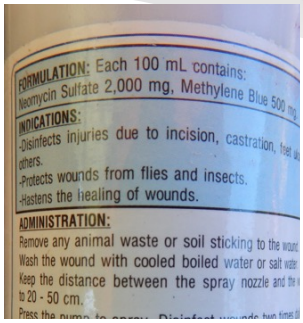
A potassium permanganate concentration of 1:10,000 can be made by adding one 400mg tablet to 4L of hot water. Strips of cotton or gauze can be soaked in the solution and wrapped around the affected area for 20-30 minutes.

Purple, Red, Blue and Yellow Sprays



Placebo for the veterinarian?

Most countries have some version of a topical spray that is usually purple in color. In the U.S. we have blue, red, and yellow sprays that veterinarians like to use. These products may contain neomycin, methylene blue, acriflavine (a coal tar product) or gentian violet. Whether any of these really help wound healing is questionable. There have been no studies in horses that I could find. One source I read suggested these products may be a placebo for veterinarians who feel better when they put something on a wound. I am not saying don't use these products, but unless you know why you are using a particular product for a particular reason, remember that nothing may be better than something,

Hydrogen Peroxide

- No longer recommended
- Cytotoxic at 3%
- No antibacterial effect
- Use only for chemical debridement
- 1% hydrogen peroxide cream OK

How many have used hydrogen peroxide on wounds? I certainly have. You really feel like you are doing something good when it bubbles up! Experts in wound care no longer recommend hydrogen peroxide. Numerous studies suggest that it is cytotoxic. It is not recommended for general wound cleaning. However, hydrogen can be used occasionally as a chemical debriding agent. Hydrogen peroxide rapidly decomposes into water and oxygen when it combines with organic tissue or blood. During this breakdown, hydrogen peroxide mechanically cleanses wounds. Hydrogen peroxide cream is OK – and has demonstrated improved healing of equine wounds. Clinics NA

Dakin's Solution

- Developed during WWI
- Kills bacteria by driving chlorine and oxygen into tissues.
- Use as a debriding agent
- Non-infected wounds
- Various strengths
- Dilute the commercial 0.0125% product 1:50 to equal a 0.00025% solution
- Inactivated by light and heat

Dakin's Solution was developed during WWI to treat soldiers with infected wounds. It is basically a very dilute bleach solution. It is effective against a broad spectrum of aerobic and anaerobic organisms, as well as fungi. Use as a debriding agent or for wounds that are not colonized or infected. It has limited penetration, so it is not indicated for deep wounds. Dakin's solution is cytotoxic but diluting the commercial product 1:50 will balance efficacy vs toxicity. Sodium hypochlorite kills bacteria and liquefies necrotic tissue by driving chlorine and oxygen into tissues.

Home-made Dakin's Solution

- Boil 950 ml tap water for 15 minutes.
- Remove from heat
- Add ½ teaspoon baking soda and 95 ml unscented 5.25% bleach.
- Dilute this full-strength (0.5%) solution 40-fold: add 20 ml to 800 ml boiled water.

Theoret, C.and Schumacher, J. 2017. Equine wound management. Third edition. John Wiley & Sons, Inc.

Here is a recipe for home-made Dakin's.

Hypochlorous Acid

- Rapid bacterial kill
- Low toxicity
- Ready-to-use spray
- Initial wound cleansing acute wounds
- Daily cleaning chronic wounds.
- May disrupt biofilm
- Many brand names

0.003% hypochlorous + 0.004% sodium hypochlorite

Hypochlorous acid gets a thumbs up. Hypochlorous acid is very active against all Gram-positive and Gram-negative bacterial, viral and fungal pathogens, including drug-resistant staph. It can kill spore-forming and non-spore-forming bacteria. It may also disrupt biofilms It has low toxicity, and you can use it for the initial cleaning of acute wounds or daily cleaning of chronic wounds. There are a number of brand names including Vetericyn. Another good product to have on hand.

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There are a number of commercial products, including Dermacyn, Puracyn, Oxum, Microdacyn60, Innovacyn, and Vetricyn/Vetericyn

Home-made Low Concentration Hypochlorous Acid

- 1.5 ml concentrated bleach solution (8.25% sodium hypochlorite) + 1-liter distilled water = 0.012% hypochlorous acid
- As good as Vetericyn inhibiting S. aureus and E. coli *in vitro*
- Solution good for one week

You can also make a home-made version by mixing 1.5 mL of concentrated bleach solution (8.25% sodium hypochlorite) and 1 L of distilled water. This has been shown to be as effective as Vetericyn in inhibiting growth of *Staphylococcus aureus* and *Escherichia coli in vitro*. The home made solution retains its antibacterial effect for at least 1 week.

Polyhexamethylene biguanide (PHMB)

- Biocompatible
- Low toxicity
- No resistance
- Promotes healing (humans)
- May remove biofilm
- Infected and chronic wounds
- Irrigation solution and gel: Prontosan

Very expensive

Polyhexamethylene biguanide (PHMB) (also called poly hexanide) is an antiseptic that is highly rated by equine experts. it has very good biocompatibility and low toxicity. It is very effective against susceptible and resistant strains of common bacteria, as well as fungi found in chronic wounds, and resistance is non-existent. It promotes healing in humans. Protosan is the brand name. The down-side is that it is very expensive.

Sugar

- Antimicrobial effect via hyperosmolarity
- Pseudomonas susceptible
- Use in early inflammatory stage for infected or sloughing wounds with ↑↑ exudate
- Stop when healthy granulation bed forms.
- Usually bandaged in horses
- Sugardine = sugar (1/4 cup) + povidone iodine (3 tablespoons) for hoof abscesses in horses
  (use on nails only not open wounds)

Sugar is widely available and inexpensive. It is hypertonic so it draws exudate from the wound. It also promotes debridement. *Pseudomonas* species seem particularly susceptible. It is best in infected or sloughing wounds. Stop using it once a healthy granulation beds forms. For wounds in horses, large amounts of sugar are used, and the area is bandaged, which is not something we can do easily in elephants, so it may have limited use. Adding povidone-iodine to sugar creates a product known as Sugardine, used for treating hoof abscesses in horses. One recipe says to use ¼ cup of sugar and ~ 3 tablespoons of povidone iodine to form a paste the consistency of peanut butter. This might be worth trying on elephant nail abscesses.

Honey

- Multiple synergistic properties
- Hyperosmolar, low pH
- Antimicrobial
- Anti oxidant
- Anti-inflammatory
- Immunomodulatory
- Promotes debridement
- ↓Edema
- ↓Exudate
- ↓Pain

Wild honey was used to treat wounds for centuries but fell out of favor when commercial antimicrobial products became available. Honey has multiple synergistic properties that make it an excellent topical treatment. It is hyperosmolar so it draws fluid out not only from microbes, resulting in desiccation and death, but also from the subcutaneous tissues which helps to remove debris and necrotic tissue and reduce edema.

Medicinal Manuka Honey

- Honey from Leptospermum spp of plants have greatest antimicrobial activity
- Antibacterial activity due to methylglyoxal (MGO) derived from nectar and is standardized
- Unique Microbial Factor (UMF) = antibacterial rating (choose UMF>10)

Not all honeys are equal. Honey derived from the *Leptospermum* species of plants that grow in Australia and New Zealand have the best antibacterial activity. Honey from the Manuka bush (*L. scoparium*) found in New Zealand has been most extensively studied. The UMF is an anti-bacterial rating. Choose a product with a UMF of 10 or greater

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The antibacterial activity of Manuka-derived honey Is due to methylglyoxal (MGO), derived from dihydroacetone in the nectar of the Manuka flower and referred to as the Unique Manuka Factor (UMF), which you will see on commercial Manuka honey products. The UMF is an antibacterial rating, determined by comparing the antibacterial activity of a honey to a standard concentration of phenol: the higher the UMF rating, the greater the spectrum and efficacy. Honey with a UMF rating >10 will have better therapeutic outcomes but will be more expensive. In one equine study of distal limb wounds, Manuka honey with a UMF of 20 was superior to honey with a UMF of 5.23 and wounds healed faster.

Local Store Honey or Raw Manuka

- May contain *Clostridium botulinum* spores or aerobic bacteria or fungi
- Best to use only gamma sterilized medical grade honey for wounds

What about using local honey that you can buy in the store? While all honey has antimicrobial properties, you do need to be cautious as store bought honey may be contaminated with bacteria, fungi, or Clostridium. Even some non-medicinal Manuka honeys are raw, and even if they are pasteurized this process does not eliminate *Clostridium botulinum* spores. Only medical grade manuka honey is filtered to remove contaminants, and cold sterilized by gamma radiation. This sterilization process, inhibits spores, but preserves beneficial enzymes that would be denatured by pasteurization. That said, I have used store-bought honey.

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The amount of honey to depends on the amount of fluid exuding from the wound. Large amounts of exudate require substantial amounts of honey. The frequency of treatment depends on how rapidly the honey is being diluted by the exudate. This should become less frequent as the honey starts to work on healing the wound. It is best to spread the honey on a dressing pad if the wound is in a location that will allow this. Abscesses, cavity or deep wounds need more honey to adequately penetrate. The gel form may not run as much.

Honey Used to Treat Elephant Wound

Use of unpasteurized honey for treatment of a deeply infected wound in an African elephant. Singleton, C, Ramer, J., and Proudfoot, J. 2004. Proc AAZV Conf. p 622-624.

A number of years ago I was asked to consult on a deep laceration to the neck of an African elephant that was inflicted by a tusk. The wound was unresponsive to aggressive topical and systemic therapy, so I advised them to try honey which they started on Day 52, first lavaging the wound and then applying honey BID. Within 4 days of beginning topical treatment with honey, subjective scores of purulent exudate, necrotic tissue, and malodor began to improve. By day 29, the wound was no longer malodorous. Minimal necrotic tissue remained in the wound on day 37, and purulent discharge had resolved by day 90. The wound was considered completely healed at 143 days.

Fly Repellents

- Many products
- Citronella cedar, or eucalyptus oil
- Pyrethrins
- Never spray *in* a wound
- Apply around a wound

If flies are a problem, there are a lot of products available – they usually contain citronella, cedar, or eucalyptus oil. Or they may contain insecticides like pyrethrins. There are no studies in horses looking at using these products on or near wounds. Because the effects of these products on wound healing are unknown, never spray them directly in a wound, only apply them around the wound. Ointments or wipe-on products may be better than sprays to avoid getting these in the wound.

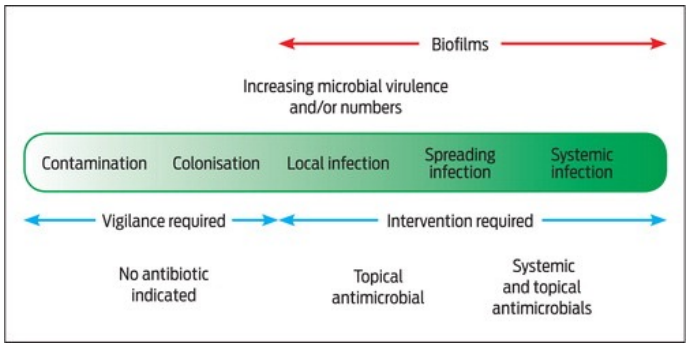
Removing Maggots from Wounds

- Manual removal
- Flush w saline or water
- Hydrogen peroxide
- Suffocate w thick layer of petrolatum
- Ethyl chloride spray

Wound myiasis occurs when a fly lays eggs in a wound. Medical maggots are sometimes used in wound debridement, but wild maggots are contaminants that can cause and spread infection and they should be removed. Maggots can be removed manually or by flushing with saline or water. Several sources said hydrogen peroxide works well so this might be one situation where it is OK to use it. You can also suffocate the maggots by applying a thick layer of petrolatum which encourages them to come out of their holes and then you can manually remove them. Ethyl chloride, a topical anesthetic spray can work too.

When to Use Systemic Antibiotics

- For severe infected wounds
- If biofilms have formed (sometimes)



Theoret, C.and Schumacher, J. 2017. Equine wound management. Third edition. John Wiley & Sons, Inc.

Judicious use of systemic antibiotics for the treatment of wounds is strongly recommended, because of the issues with antimicrobial resistance. Keep this continuum of infection in mind. Wounds that are only contaminated and colonized do not need antibiotics. Once the wound becomes infected, healing is delayed, or biofilms develop, topical and / or systemic antibiotics may be indicated. Remember, if the infected wound is poorly perfused or contains a biofilm, topical antimicrobial therapy may better than the same drug administered systemically, because topical application delivers a higher concentration of medication directly to the desired area and is less likely to cause bacterial resistance.

Which Antibiotics to Use While Waiting for Culture Results?

- Penicillin G and gentamicin used in horses
- Enrofloxacin may be a better choice for elephants
- 86% of elephant wounds in Assam study sensitive to enrofloxacin; 69% sensitive to gentamycin

2.5 mg/kg PO sid

Barman, Nagendra Nath et al. 2013. **Bacterial Infection, Antibiogram and Wound Treatment in Domesticated Asian Elephants**. Gajah 39: 40-43.

Sanchez, C.R. et al. 2005. Pharmacokinetics of a single dose of enrofloxacin administered orally to captive Asian elephants (Elephas maximus). Am J Vet Res. 66.

If you are going to use systemic antibiotics, be sure and culture the wound. You can select a broad-spectrum antibiotic while you wait for results if you feel that is necessary. A combination of penicillin G and gentamicin is commonly used in horses. Enrofloxacin may be a better choice for elephants because there has been a pK study, so we have a good dosage. Also, a study of elephant wounds in Assam found that 86% of the isolates were sensitive to enrofloxacin vs 69% to gentamicin.

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In the Assam study, The authors collected 31 samples from wounds on the legs or back of elephants. Staphylococcus aureus was the main organism isolated; pseudomonas was isolated from one tail wound. Twenty seven out of 29 *Staphylococcus* isolates were coagulase positive, while two were negative. Coagulase positive *Staphylococcus aureus* is considered pathogenic. Of the *Staphylococcus* isolates, 86% were sensitive to enrofloxacin, followed by gentamicin 69%, and norfloxacin and cefataxim 52%. The *Pseudomonas* isolate showed a similar trend of antibiotic sensitivity. Both *Staphylococus* and *Pseudomonas* isolates were resistant to co- trimoxazole, ampicillin, cloxacillin, tetracycline, oxytetracycilne, neomycin, and amikacin. Use of enrofloxacin cleared exudates within 10 days and completed healing of the wounds in15-20 days.

Managing Biofilms

Step1. Physically degrade the biofilm using debridement

- Remove pus and necrotic tissue
- Minor bleeding OK
- May require sedation at times

Goal: remove as much of the biofilm as possible to expose the remaining bacteria to a biocode

We mentioned the problems biofilms cause in chronic wounds so let's talk about how to manage them. Debridement is the most critical step in the care of wounds that have biofilms. The goal is to remove as much of the biofilm and bacteria as possible and to expose the remaining bacteria to a biocide. Vigorously debride the wound to remove purulent discharge and necrotic tissue, even if it causes minor bleeding. Fresh blood contains antibacterial components that may help with the next step.

Managing Biofilms

- Step 2. Apply biocode topically
  - PHMB, honey, hypochlorous acid
  - Topical antimicrobials based on culture
  - Broad-spectrum antibacterial cream while waiting for culture results: silvadene, chlorhexidine, povidone iodine, 1% hydrogen peroxide
  - Systemic antibiotics if necessary

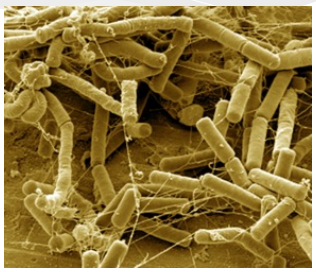
Goal: Prevent of delay the biofilm reforming

In Step 2 you are trying to prevent or delay the biofilm from reconstituting. Surfactants, such as PHMB help because they reduce the surface tension of the biofilm, which facilitates degradation and removal. Honey or hypochlorous acid can also be used. After the protective matrix has been removed or significantly degraded, most of the bacteria within the biofilm assume their “planktonic” or free-living antibacterial sensitivities. If you have current culture and sensitivity results, use the most appropriate antibiotic topically and systemically if you think it is necessary. Topical antibiotics are most effective immediately after the biofilm has been degraded. If sensitivity results are still pending, you can use use a broad-spectrum antibacterial cream, such as, 1% silver sulfadiazine, povidone–iodine, chlorhexidine, or 1% hydrogen peroxide. Gels, creams, or honey are better than sprays because they stick to the wound and have a residual effect.

Managing Biofilms

Step 3: Repeat Steps 1 and 2 daily or every other day until the infection is under control

- Biofilms can re-form in 24 h
- 72 h window (at most) for drugs to ↓ bacteria
- Observe for ↓ infection and ↑ healing



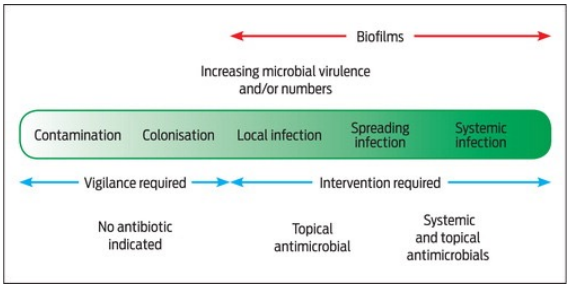
SEM image of *Bacillus subtilis* biofilm. Image credit: A. Bridier *et al*, doi: 10.1371/journal.pone.0044506.

Goal: Control infection and facilitate healing

Step 3 is to repeat steps 1 and 2 frequently for as long as necessary. Mature biofilms can re-form in as little as 24 h after debridement, so there is a narrow window of opportunity (at most, 72 h) during which bactericidal drugs can reduce the bacterial population within the wound. Repeat Steps 1 and 2 daily or every other day until the infection is well under control, as evidenced by a reduction in the signs of infection and the resumption of healing.

Managing Biofilms: Summary

- 1. Physically degrade the biofilm (may require sedation)
- Step 2. Prevent or delay the biofilm reforming
  - PHMB /Topical antimicrobials based on culture /+/- systemic antibiotics
- Step 3: Repeat Steps 1 and 2 daily or every other day until the infection is under control



Theoret, C.and Schumacher, J. 2017. Equine wound management. Third edition. John Wiley & Sons, Inc.

Here is a summary of the steps.

Pain Medications – Don't Forget!

6 mg/kg PO BID

Just a reminder to remember pain meds for serious wounds. It is an important part of healthcare.

References

- Theoret, C.and Schumacher, J. 2017. Equine wound management. Third editon. John Wiley & Sons, Inc.
- Frees K.E. 2018. Equine practice on wound management: wound cleansing and hygiene. *Veterinary Clinics of North America: Equine Practice* 34(3):473-484.
- Leise, B.S. 2018. Topical wounds medications. *Veterinary Clinics of North America: Equine Practice* 34(3):485-498.
- Acello, B. MS, RN. 2013. Chronic Wounds: Providing Efficient and Effective Treatment. Danvers, MA: HCPro, a division of BLR.

These are the main equine references that I consulted for this presentation.

Thank-you for your attention!

Elephant Health & Welfare *India!*

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