LARGE ANIMAL WOUND MANAGEMENT

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A wound is defined as an injury, usually involving division of tissue or rupture of the integument or mucous membrane, due to external violence of some mechanical agency rather than disease. Wound healing is classified as the restoration of the normal anatomical continuity to disrupted tissue. There are three classifications of wounds. They are referred to as clean, contaminated, and infected. A clean wound is considered to be created under "aseptic conditions" such as a surgical incision. A contaminated wound generally has $>10^5$ bacteria per gram of tissue. These wounds include bites, road rash, and punctures. The final classification is the infected wound. These tissues become infected secondarily to contamination. There are multiple types of wounds. Any wound or breach in tissue requires four stages of healing. There are four phases of healing are hemostatic, inflammatory, proliferative, and remodeling.

Hemostatic phase - The term hemostasis is defined as the process of stopping the flow of blood. This phase involves coagulation which is when blood changes from a liquid to a gel. Hemostasis normally occurs rapidly when small blood vessels are injured (such as those within the skin layer). It begins with a vascular spasm or vasoconstriction characterized by intense and rapid contraction of blood vessels. This is followed by the formulation of a plug of platelets which slows the hemorrhage. Activation of clotting factors then reinforces this platelet plug with fibrin to produce a mature blood clot.

The inflammatory phase – When tissue is interrupted or damaged within the body, a series of events automatically begins. The inflammatory phase begins the cascade of healing. During the inflammatory period, the body focuses on destroying bacteria and removing debris. At this time, the body is preparing the wound bed for the growth of new tissue. Wounds can become "chronic" as a result of perpetually being in the inflammatory phase. This can occur for a variety of reasons some of which include underlying medical issues such as vascular disease, diabetes, or location of wound.

The proliferative phase – During the proliferative phase, angiogenesis and contraction occur. Angiogenesis refers to the process during which blood vessels are regrown within the wound. Angiogenesis is activated by macrophages which are the white blood cells that are formed by the immune system following an injury or breach in tissue. During angiogenesis, collagen deposition, granulation tissue, epithelialization, and finally contracture occur.

The remodeling phase – The remodeling phase is also referred to as the maturation phase. This is the final stage of wound healing. Remodeling occurs after the wound has closed and can take anywhere from two weeks up to two years. During the remodeling phase, the dermal tissue is re-organized to enhance the tensile strength and non-functional fibroblasts are replace with functional ones. At the final part of the remodeling phase, the wound will lose its pink or purple color as capillary and fibroblast density decrease.

A wound can occur for multiple reason. The origin of the wound will dictate the course of action required to assist in healing that wound.

A clean wound is defined as a surgical cut or incision that is usually created by a scalpel during a surgical or medical procedure. Great care is taken to minimize infection. Typically, the area is aseptically prepared to reduce the surface bacteria infiltrating the site. Sterile instruments are utilized to reduce risk of infection. These wounds are not immune to infection. Great lengths are taken to avoid it; however, should infection occur, appropriate action will be taken for convalescence.

Contaminated wounds occur as a result of trauma. Some types of contaminated wounds are bites, abrasions, burns or any unintentional rupture or breach in the tissue, such as a simple laceration.

Infected wounds are localized areas of skin in which pathogenic organisms have overtaken viable tissue surrounding a wound. This infection of tissue initiates the body's inflammatory response. The inflammatory process can

manifest clinical signs such as heat, redness, pain, swelling, purulent discharge, and fever. Once a wound is classified as infected, precautions should be taken. Culture and sensitivity may be indicated. It is advisable to culture the wound prior to beginning a course of antibiotics as they may interfere with the culture results. If antibiotics have been started, and the wound seems to be progressing in a favorable fashion, it is safe to assume that the infection is susceptible to the chosen antibiotic and care should continue in the same manner. Gloves should always be worn when working with any wound but especially when working with infection. Some infections can be zoonotic such methicillin-resistant Staphylococcus aureus, (M.R.S.A).

Methods of managing wounds

The mainstay of wound management involves cleaning, debridement, and repair of a wound. Cleaning and debridement may occur at the same time with the same process but traditionally cleaning involves a dilute scrub solution and lavage while debridement describes the surgical removal of necrotic or foreign debris.

Simple tap water can act as one of the greatest aids to promote wound healing. The act alone of lavaging a wound with plain water can remove bacteria and necrotic tissue. Depending on the type of wound, cold water can decrease inflammation and swelling.

Closure

Primary closure is the fastest, most desirable form of wound closure. It is also known as healing with primary intention. If a wound heals by primary intention, there is usually a smaller, cleaner defect that minimizes the risk of infection. When primary closure occurs, the new blood vessels and keratinocytes have a smaller distance of travel, resulting in a smaller, finer scar.

Secondary closure or healing with secondary intention is not as desirable as primary closure, although in some cases, this cannot be avoided. Secondary closure occurs when the wound edges are not opposed to one another. Secondary closure requires a granulation bed to form. This is not as organized as primary closure resulting in a larger secondary scar. In horses, wounds can become hypercellular resulting in what is referred to as “proud flesh” or exuberant granulation tissue. Proud flesh wounds tend to occur on the more distal portions of all limbs. It can occur where there is minimal soft tissue between skin and bone. Proud flesh is more likely to occur in places where there is an increase in movement such as over joints or perhaps less vasculature and blood supply.

There are many different types of suture with which to close a wound. Choosing suture depends on many things such as location, available skin, clinician preference, and much more. Tissue may need to be undermined to assist with closure if there is a lot of tension on the repair or if a large amount of skin is missing. Sometimes small incisions may need to be created to alleviate tension on the surgical site. Tension relieving suture patterns are most commonly used to combat excessive tension when repairing a wound. Contaminated or infected wounds may require placement of a drain to allow drainage (see drains below).

Monofilament suture material is a single strand suture. Monofilament suture can be absorbable or non-absorbable and is thought to be more resistant to harboring microorganisms. There is less drag incurred while passing through tissue but there is more memory to the strand of suture and thus decreased handling.

Multifilament suture material is either braided or rolled strands of suture to form one piece. It can also be absorbable or non-absorbable and tends to have better handling but more drag than monofilament. As with everything, there are pros and cons to using multifilament suture.

Surgical staples can be a useful tool for incisional closure. The use of staples over suture can reduce the localized inflammatory process. They are also desirable since they are administered from a gun and closure can be rapid. If a wound dehisces or falls apart, staples can aid in the closure while healing by secondary intension commences.

When repairing a wound, it is important to minimize dead space. If dead space is left, the body will try to fill the space one way or another. To minimize dead space, it may be indicated to place a drain. The purpose of a drain is to

let fluid continue to discharge from an area. If the wound closes prematurely and there is dead space under the skin, the body may try to fill the space with fluid and create a seroma which will prevent full healing. Tacking down the dead space with tacking sutures can also decrease the likelihood of a seroma and allow primary closure of the wound.

There are two types of drains: open and closed. Both types of drains are placed using aseptic technique; however, once placed, only closed drains are considered "sterile". Open drains are those that allow fluid that has built up to exit the wound directly into the outside environment. Closed drains allow fluid to exit the wound (or surgical site) where it is then collected into a receptacle without exposure to the outside environment.
An example of an open drain is a Penrose drain. The Penrose drain is sterile when placed but once it touches the outside world, it is no longer sterile. When caring for a wound with an open drain, it is important to clean the drain daily to prevent ascending infection of the wound from normal environmental bacteria traveling up the drain.

An example of a closed drain is a Jackson Pratt (JP) drain. This type of drain provides continuous negative pressure. A JP drain is typically connected to a bulb that provides continuous suction. However, a 60 mL syringe can also be used to collect fluid. A three-way stop valve can be used at the junction of the drain tubing to the fluid collection receptacle for ease of use. The plunger has a hole in it at the closest point to the rubber plunger head and while the stop valve is closed to the tubing, drawback for negative pressure and place a cotter pin through the plunger. While using the bulb syringe type, close the stop-valve and squeeze the bulb syringe as tight as possible, reconnect to the stop-valve open the stop valve and release the bulb syringe. The Jackson Pratt drain allows the evacuation of fluid in a mostly closed circuit.

If an incisional infection occurs, it will be within the first 30 days following the surgery. The Center for Disease Control describes three types of incisional infections: superficial, deep, and organ or space infection. A superficial incisional infection typically only causes redness, delayed healing, some discomfort, and swelling. Purulent material may ooze from the site. If the superficial infection persists, culture may be necessary, and antimicrobials may be required. Typically, with superficial infection, cleaning with water and disinfectant ointment tend to resolve the issue. A deep incisional infection may also have purulent discharge. The primary surgical site may rupture, and tissue may be compromised. This may require secondary surgical debridement. These types of wounds typically heal with secondary closure. An organ or space incision may manifest as discharge of purulent material. The patient may present septic with fever. An accumulation of pus may organize. This may wall off as an abscess. Further diagnostic tests may be required to find the source of infection. A secondary surgery may be required to correct the lesion.

Adjunctive Wound Therapy

There are several cases in which antimicrobials may be appropriate. Depending on the type of wound, duration and if it was cultured, antibiotics may be indicated. There are several different routes of administration: oral, IV, IM, topical, or intraarticular, just to name a few. Another mechanism of delivery is via IV regional limb perfusion, which provides high concentrations of antimicrobials to an area without using a full systemic dose. This procedure is usually performed on patients with a distil limb wound. Ideally, the wound is cultured, and the appropriate antimicrobial has been chosen. The patient is heavily sedated. A tourniquet is placed proximal to the wound. An IV injection of the desired antimicrobial is injected into a vein in the leg below the tourniquet. The tourniquet is left in place for approximately 20-30 minutes to allow the antimicrobial to remain in the local or affected area. The tourniquet is then removed at the end of the procedure.

Depending on the type of wound, analgesia may be desired. In minor wounds, non-steroidal anti-inflammatory drugs may be adequate. With more extensive wounds, such as an attack by a dog, more potent therapy such as opioids may be indicated. Fentanyl patches can be used but additional analgesia is necessary before the Fentanyl takes effect. Local nerve blocks using mepivacaine can be used for distal limbs. For long term blocks, bupivacaine liposome injectable suspension may be used. It is not currently labeled for use in horses, but we have used it off label use with excellent success. Viscous lidocaine can be applied topically for patients that self-mutilate

Bandaging is a crucial component of wound management. The location of a wound will dictate whether a bandage can be used. An area near a joint or on a foot where there is constant movement may require a bandage to keep the wound clean as well as minimize movement of the tissue in order to allow it to heal. Whether or not you use a bandage, it should be kept clean and dry (unless you are using manuka honey or antibiotic ointment. A wound that is covered by a bandage needs to be visually inspected regularly and have the dressing changed. This is especially important for wounds that are draining as the accumulation of fluid under a bandage can cause skin maceration. With horses, sometimes a limb is casted to immobilize the area so that the wound can heal. Horses generally adapt well to wearing a cast.

Maggot therapy involves the introduction of live medical grade disinfected maggots into the non-healing skin and soft tissue. The maggots clean out the necrotic tissue within the wound and aid in disinfection. As with physical debridement, the irritation to the area aids in healing.

Tilapia skin therapy is a relatively new therapy used to treat burns. The tilapia is thought to transfer collagen, a healing protein to the tissue or skin of the recipient.

Honey therapy has been used for centuries to treat wounds, burns, and sores. Multiple studies indicate that Manuka honey can enhance wound healing, increase tissue regeneration, and decrease pain.

A sugar paste can be made with granulated sugar and water. When applied to a wound, the paste liquifies. This enables it to break down necrotic tissue and assist with the creation of granulation tissue. The osmotic effects of the sugar also have the ability to inhibit bacteria to reproduce.

Hydrogen peroxide has not been typically recommended for use in wound cleaning as it is toxic to live tissues as well as pathogens. It does kill pathogens through and oxidation burst and by localized oxygen production. It can be useful in certain cases where delayed healing is desired but should not be considered safe for all wounds.

Cold laser therapy may enhance the rate of wound healing in certain patients. It increases blood flow using specific wavelengths of light to increase circulation and promote healing. The laser stimulates the tissue and by increasing circulation, also increases the oxygenation of the tissues. It has also been shown to decrease surface bacteria. Cold laser therapy is most effective in non-pigmented skin.

Wound management is a true testament to the nursing care of the veterinary technician. Some wounds can be catastrophic and career ending. These patients tend to require long term care. It is our job to keep them as comfortable as possible in the monitoring of the incision or wound, pain care management, and keeping the dressings clean and dry.