Wound Management and Skin Reconstruction

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Objectives:

- Review the concepts of wound healing and the various phases of healing.
- Provide information about wound dressings and their specific indication for use.
- Review cases that demonstrate both different types of wound management and skin reconstruction.

Review of wound healing:

Most wounds seen in veterinary practice originate from an initial trauma such as being struck by an automobile. Wounds incurred from this type of trauma can range from minor abrasions to severe, “degloving” wounds where there is loss of skin, muscle, neurovascular structures and bone. We commonly see these types of wounds over the extremities, but can also occur over the head, neck, chest and abdomen. Management of these types of wounds has progressed over the years, with many different methods being developed and having repeatable success. The first step is to determine the severity of the wound, prior to deciding on the type of wound management. Always, the patient’s systemic stability needs to be addressed prior to any advanced closure techniques.

In order to know which types of bandaging/management is appropriate, a basic understanding of wound healing on the cellular level is necessary. This will allow informed selection of appropriate dressings. The stages of wound healing can be thought of as three broad categories: 1. Inflammation and Debridement phase, 2. Repair phase, and 3. Maturation phase. The inflammatory/debridement phase begins when the wound occurs. Right after the wound occurs both blood and lymph fills the wounds in an attempt to cleanse the wound due to damage of regional vasculature. Vasoconstriction of surrounding vessels follows over the next 5-10 minutes, which is mediated by many factors such as catecholamines, serotonin, bradykinins and histamines. This action attempts to decrease the amount of blood loss from the wound. Immediately following, vasodilation occurs which allows cell migration and fluid to pass into the extravascular space and thus activating the clotting cascade as platelets become activated. Shortly after the initial insult (approximately 6 hours), leukocytes infiltrate the area and help with margination of the wound and extravasation of neutrophils into the wound. Neutrophils are present early and aid in removal of the damaged cells and bacteria from the initial contamination. The presence of neutrophils will form the purulent material noted during the early phases. Other constituents of pus are wound fluid and denatured tissue. In more mature wounds monocytes begin to congregate. Monocytes are attracted by cytokines being released and shortly become macrophages. Macrophages are an essential part of the wound in contrast to neutrophils.
The next phase encountered is termed the repair phase. The repair phase is thought of as the proliferative phase of the wound. During this time the following occurs: angiogenesis, fibroplasia, epithelialization and wound contraction. Fibroblasts invade the wounds and the amount of collagen increases. The biggest hallmark of this phase is the development of granulation tissue. Granulation tissue signifies the development of new capillaries, fibroblast and myofibroblast invasion, which aids in wound contraction, and development of fibrous connective tissue. The function of granulation tissue is to protect the wound, create a barrier to infection, and a substrate for epithelialization. Generally, granulation tissue has a deep red color, which is in part due to the presence of capillaries. Over time the deep red color becomes paler.

The last phase is termed the maturation phase. The hallmark of this phase is epithelialization of the wound. Mobilization of the epithelial cells begins at the periphery and moves inward. The epithelial cells will typically proliferate behind the leading cells. This generally begins after granulation tissue becomes present in full thickness wounds. This takes approximately 4-5 days (or longer) in the full thickness wound and within 24-48 hours in the opposed incision. Again recognition of the wound phases is important and it is important to note that there is considerable overlap of stages.

**Wound Management:**

When searching the literature on wound management, a plethora of techniques and information is available. Unfortunately, even this lecture just touches the high points of wound management; full texts have been written dedicated to this topic. One factor to bear in mind is does the product you are using address the stage of healing the wound is in currently? Some basic considerations to contemplate are as follows: Does the dressing enhance the natural process of wound healing? Always consider the size and location of the wounds, as well as the condition of the surrounding tissues.

When we approach a wound, the question that should be asked is: can the wound be successfully closed primarily at the time of presentation or is prolonged wound management necessary? Usually wounds that are very recent, small, free of debris and necrotic tissue can be closed primarily. Care should be taken in evaluation of the wound and associated structures and the wound copiously irrigated.

*Wet-to-dry bandages:*

Wet-to-dry bandages – used very commonly in both the debridement phase and early granulation phase. This type of dressing should be discontinued during the granulation phase, as it will actually remove the developing granulation tissue. These bandages generally consist of cotton gauze sponges that are moistened and
placed directly on the wound bed. Bandages should be changed every 8-24 hours (depending on effusiveness of wound). Until granulation tissue is present, the bandage changes can be painful, as the sponges typically adhere to the wound bed.

_Hypertonic Saline sponges:_

These sponges are useful during the debridement phase only, preferably in the heavily contaminated wounds. The sponges are soaked in a much higher concentration saline than normal and in addition to debriding necrotic tissue; it is also an unfavorable environment for bacteria. Care must be taken to place the sponges only in the wound, as there can be collateral damage to surrounding healthy tissue.

_Calcium-Zinc Alginate:_

After the debridement phase, advancement into the repair phase is desired. Calcium alginate dressings can be used to advance the development of granulation tissue within a wound. These dressings are very useful in the exudative wound and can promote granulation spread/development over bone and tendinous structures.

_Polyurethane Foam:_

Polyurethane foam can be used in wounds that are entering the maturation phase of healing and where epithelialization is desired. Also, if the wound is still producing exudate these dressings can be beneficial. Another indication for these dressings, since it is semi-permeable, is to deliver medications and ointments to the wound bed. Personally, I use these dressings during later stages in small wounds especially over joints and easily traumatized structures, because of the inherent padding they provide.

_Hydrocolloid sheets and gels:_

These gelatinous sheets are to be used in wounds with minimal exudate in the maturation phase. They can promote some granulation tissue, however, they are most commonly used for developing epithelial tissue. It is important to use on the wound only and not on the wound edges as this can delay wound contraction.

_Bismuth tribromophenate (Xeroflo):_

This type of dressing contains bismuth tribromophenate in an oil emersion. This tends to be an irritant to the epithelial cells at the wound edge and actively promotes wound contraction. I generally reach for this when the wound becomes indolent and contraction has slowed or stopped.
**Porcine small intestinal submucosa (BioSIS)**

This substance is produced in sheets; either 1 ply or 4 ply and is denatured collagen. It provides a bioscaffold for the body’s own stem cells and regenerative cells to adhere to. This can help speed up the recovery process. It is placed in the wound, much like a skin graft would be placed and secured. The advantages are that it can be stored on the shelf for a long time and can be easily applied. Also, the chance of tissue rejection is virtually non-existent, as it becomes the body’s own tissue. This substance must be placed after the inflammatory/debridement phase for proper uptake and tissue regeneration. I recommend protecting the graft with a soft padded bandage and recommend bandage changes every 3-4 days, similar to the management of skin grafts. This technique can be performed in small wounds or very large wounds. Rate of healing/closure is dependent on wound size.

**Amniotic Fluid (Healion)**

A new product by Vetrix is amniotic fluid. There has been recent experimental and human research performed on the use and effectiveness of amniotic fluid in regards to its utility in healing wounds. We know that there are many growth factors and pluripotent stem cells present in this fluid. The main mode of action is to decrease the inflammatory phase of the wound and increase angiogenesis. Healion is a powder, which can be applied to the wound bed. It is recommended that the wound be properly cleaned before application. It is different from the BioSIS in that granulation tissue is not needed for application. To the contrary it is more beneficial to apply this to the wound that is still in the inflammatory phase.

**Manuka Honey**

This is a time-tested substance shown to be quite effective and cost effective. While there have been reports of other honey variants being used, manuka honey has been shown to have one of the highest antimicrobial counts when compared to other types. Honey works in a few ways with regards to wound management. The acidity of honey increases the release of oxygen from hemoglobin, which decreases the activity of proteases (which can be destructive). Also, honey has a high osmolarity, which will draw fluid out of the wound, increasing the outflow of lymph.

One of the main features of honey is its antimicrobial activity. Most variants of honey have antimicrobial features due to hydrogen peroxide, however this can be inactivated by the enzyme catalase that the body/wound produces. Manuka honey’s antimicrobial activity is due to methylglyoxal, which does not get deactivated by the host. There is also thought that there are synergistic effects of methylglyoxal and systemic antibiotics (such as rifampin n), however this is currently being studied. Other features of honey include stimulation of the immune response, suppression of inflammation, and expediting autolytic debridement.
Other methods:

Other methods of wound management that are very successful include (but not limited to) vacuum assisted closure, cold laser treatments, shock wave therapy, etc. Unfortunately, there are many techniques in the literature; a full exploration of them is beyond the scope of this lecture.

Surgical Techniques

This following section is designed to give a brief overview of various surgical techniques in wound closures and reconstruction. This by no means gives an exhaustive list of all the techniques described. It is meant to accompany the lecture and give an overview of the techniques shown in the slides: skin stretching, vascular pedicle grafts, and a free skin graft (partial thickness). As was mentioned previously, the main considerations to contemplate prior to choosing the appropriate techniques are as follows: location (extremity vs. truncal, etc), size, tension on skin, phase of wound healing, location to major vasculature, etc.

Skin Stretching:

Skin stretching can be a very successful technique used for a delayed closure of a wound. Generally this technique is used for large truncal wounds. Skin stretching utilizes surrounding skin and takes advantage of two concepts of skin elasticity termed mechanical creep and stress relaxation. On a cellular level the collagen fibers change their alignment to be parallel with the constant force exerted, this then allows for relaxation of the skin and maximizes the elasticity.

Skin can be stretched either prior to the removal of a large mass (to ensure adequate skin availability) or in areas of large wounds over the dorsum or ventrum of the patient. This can be performed either with presuturing techniques, adjustable sutures, skin stretchers (Velcro straps – see Pavletic), and skin expanders. Personally, the use of Velcro skin stretchers has been most useful in my practice. Generally, the skin stretchers are placed for 2-7 days, dependent on the size of wound. The straps should be tightened every 6-8 hours and the patient kept in a small, enclosed area. Patients can be hospitalized during this time to ensure consistent tightening of the straps. Also, the straps can be used after closure of a wound to relieve tension on the apposed skin edges.

Vascular pattern flaps:

This technique utilizes a major, intact blood supply to a full thickness skin segment (typically as an island flap), in which the elevated skin with pedicle (artery and venous supply) are used to cover a defect. The success of this flap is directly related to the viability of the vasculature during this process. These flaps typically have a
high success rate. Pedicle flaps must be created around large vessels that can be mobilized. Full descriptions of reliable vasculature has been reported.

The reverse saphenous conduit flap is a type of pedicle flap, however there are some differences worthy to note. The vascular supply comes from the medial saphenous vessel. The big difference is that there are no direct cutaneous vascular supply as in other flaps. The medial saphenous vessel serves as a vascular conduit, which will in time form small cutaneous branches as the blood flow reverses. This flap is useful for distal hind limb extremity wounds. It is paramount that the patency of the medial saphenous vessel is verified. It is important to ligate the medial saphenous artery and vein at its origin from the femoral artery and vein. Always leave the cranial tibial nerve alone when performing the dissection. A bridging incision can be used to connect the donor and recipient sites.

The post-operative period is very important to promote survival of the flap. It usually will take 5-7 days for venous circulation to resume and during this time the flap will appear very edematous and even cyanotic. Patience is of the utmost importance – do not debride too soon. Immobility of the limb is very important. Excess movement will increase the amount of edema and seroma formation, which will counteract acceptance of the flap. Stabilization of the limb with a cast or splint is recommended, as well as the use of sedatives during healing.

*Partial thickness skin graft:*

The use of skin grafts is typically indicated in very distal extremity wounds and sites where flaps cannot reach without compromising their blood flow. It is important that the wound has a healthy granulation bed. There is an increased risk to the viability of a graft with larger wounds. Techniques, such as meshing of partial thickness skin grafts have improved survival, epithelialization, and maximized coverage of larger defects.

When considering whether a graft is the proper choice consider the following: is the recipient site capable of a vascular response, is there evidence of necrotic tissue, and is there adequate granulation tissue present? Always debride the graft bed 24 hours prior to grafting to prepare the site. Acquiring a culture of the tissue is also important to counteract the presence of bacteria. When assessing the donor site, the most important question to ask: “is there enough skin to cover the wound bed and will I be able to close the donor site”?

Free graft success is dependent on four key factors. The first factor is adherence of the graft to the recipient bed. This is enhanced by the fibrin network and usually is very easy to disrupt. The second factor is called plasmatic imbibition, which is the nourishment of the graft, by the surrounding plasma. Too much edema and serosanguinous fluid production will cause elevation of the graft from the granulation bed and increase the risk of necrosis. The third factor is inosculation,
which is the infiltration of capillaries into the graft. This is followed by vascularization as the final step.

Much like the flap progression, the graft will undergo color changes too. If at anytime there are areas that appear black or gray, this signifies necrosis of that portion. It is very important that the limb be kept immobile with a cast or splint. Recently, vacuum placement has greatly improved the adherence and decreased seroma formation of grafts early on. This greatly increases graft survival.

**Key Points:**

- Knowledge of the phases of wound healing is key to choosing correct dressings.
- Granulation tissue coverage is necessary prior to proceeding to most surgical procedures.
- Detailed and careful mapping of the correct surgical procedure is key, as well as, adequate patient care following skin-closing techniques.

**References:**